ANNUAL REPORT

ASSESSMENT OF OFFSHORE SAND RESOURCES FOR POTENTIAL USE IN RESTORATION OF BEACHES IN CALIFORNIA

Year-One Activities

Prepared by the California Geological Survey

Under

CGS/MMS Cooperative Agreement Number 1435-01-03-CA-73201
CGS/CDBW Standard Agreement Number 02-106-096

2005

Oceanside Pier, San Diego County

INTRODUCTION

This report summarizes activities performed during the first year of a project funded by two cooperative agreements between the U.S. Minerals Management Service (MMS), California Department of Boating and Waterways (CDBW), and California Geological Survey (CGS). The purpose of the project was to assess sand resources on the continental shelf beyond the 3-nautical mile State/Federal boundary for potential use in beach replenishment along the coast of California. The agreement with the MMS was part of a national program to assess offshore sand and gravel resources. The agreement with the CDBW was to provide additional cost-share funding to support the MMS agreement. In addition, activities of the project were integrated into goals and activities of the California Coastal Sediment Management Workgroup (CCSMW). The CCSMW is a consortium of federal and state agencies responsible for preparing a master plan and companion GIS to study and manage sediment issues along the entire coast of the state. The workgroup offered guidance on what segments of the coast may be in most need of beach replenishment in the near future.

Year One of the project involved three main tasks, which are presented below in this summary as Parts A, B, and C. In brief, the parts consisted of the following activities:

Part A – literature review of seven technical issues of interest to the CCSMW in its preparation of the statewide sediment master plan.

Part B – collection of information on current and future feasibility of offshore sand dredging, including technologies and maximum water depths.

Part C – collection, integration, and interpretation of available data and information on the occurrence and nature of Quaternary sediments in offshore areas determined to be high priority by the CCSMW. These activities are leading to specific definition of areas of potential sand resources and indicate where additional work, including high-resolution geophysical surveys and sediment sampling, will be needed to demonstrate the volume and suitability of the resources for beach replenishment.

The three sets of tasks were conducted over the period of late 2003 to early 2005. The expectation was that results from Parts B and C would lead to selection of specific sites of sand deposits that would be more intensively investigated in subsequent years.

GEOGRAPHIC FOCUS OF ACTIVITIES

In the Year-One phase of the project, the CGS worked with the CCSMW, MMS, CDBW, and other organizations to select priority areas along the coast of California on which to focus study for offshore sand deposits. After a brief reconnaissance of the entire coast of the state, the focus of the project was narrowed to the coastal segment in southern California from Point Conception to the border with Mexico. Criteria used to define the focus included distribution of population and coastal development, economics, distribution of current and anticipated projects in beach replenishment, and sites of problems with erosion. Specific areas of most interest to the State of California for beach replenishment included local segments in Orange County (Surfside/Sunset Beach to San Clemente), San Diego County (Oceanside to Imperial Beach), and Santa Barbara and Ventura counties (Carpinteria to Ventura region).

TYPES OF ACTIVITIES

Activities during Year One consisted largely of research on the location and content of technical data for coastal and offshore California. Methods of this research mainly comprised investigation of library holdings and Internet resources as well as interviews with experts in government, academia, and private industry. We compiled part of this research through a GIS inventory, which is described below under Part C.

Ancillary activities included attendance/presentations at various meetings of the CCSMW and technical conferences. We also participated in a research cruise conducted by the U.S. Geological Survey on San Pedro Shelf to collect seafloor samples and arranged to have 20 additional samples collected during that campaign.

SUMMARY OF RESULTS

Research on current capabilities of the U.S. dredging industry to extract sand from offshore California for beach replenishment indicates that maximum water depths for economical operation of hydraulic dredges (cutterhead-suction and trailing-suction hopper, which are standard for offshore sand extraction) are typically limited to about 100 feet. One U.S.-based trailing-suction hopper dredge reportedly can operate in 140 feet of water. Outside of the U.S., there are larger hopper dredges, termed “jumbos,” one of which is claimed to operate in up to 500 feet of water. Reportedly the jumbos cannot be used in the United States because of legal requirements on construction and ownership of dredges allowed to operate in navigable U.S. waters (Federal Dredging Act and Jones Act).

The continental shelf off California is notable for its irregularity in width and its general narrowness compared to the East and Gulf coasts of the U.S. Along much of the shelf, water depths drop off rapidly inshore of the 3-nautical mile limit that separates the jurisdiction of the Federal government (MMS) and the State of California. Furthermore, based on the technological, economic, and legal conditions related to dredging in the U.S. discussed above, there are currently few areas under MMS jurisdiction along the coastal shelf in southern California that would be accessible to potential extraction of sand <u>under the present conditions</u>. The most promising of these areas include:

- San Pedro Shelf, particularly near the Surfside/Sunset Beach area (Long Beach-Huntington Beach area in Orange and Los Angeles counties)
- Imperial Beach to Pacific Beach, particularly near Imperial Beach because of beach erosion there (San Diego County)

- Ventura Shelf, particularly near the Carpinteria area (Oxnard to Santa Barbara in Ventura and Santa Barbara counties)
- Santa Monica Shelf (Los Angeles County)
- San Onofre area (San Diego County)

Details on the first four areas are presented in Part C presented below. All five areas are in proximity to past, current, or potential future projects of beach replenishment of high interest to the State of California and local jurisdictions. These areas also comprise the widest sections of the continental shelf along the southern California coast, which translates to larger areas of relatively shallow water depths under jurisdiction of the MMS compared to adjacent segments of the shelf. Consequently, we recommend that the next phase of study focus on these areas because they are ones that could most likely be targets of extraction under the present or very near-future conditions for offshore dredging.

Because technology, economics, and legal aspects could change in the future, other areas of the coast of California could become candidates for extraction of sand for beach nourishment.

ACKNOWLEDGEMENTS

The California Geological Survey thanks the following individuals for their assistance and guidance through various aspects of this project: John Smith, Tony Giordano, and John Rowland of the U.S. Minerals Management Service; Kim Sterrett of the California Department of Boating and Waterways; and Clif Davenport, project manager for the California Coastal Sediment Management Workgroup.

We also thank the numerous specialists in marine and coastal studies and issues who generously shared their time and knowledge in providing information during research for the project.

PART A

LITERATURE SEARCH AND REVIEW OF SELECTED TOPICS RELATED TO COASTAL PROCESSES, FEATURES, AND ISSUES IN CALIFORNIA

Prepared for the
California Coastal Sediment Management Workgroup

By

Chris T. Higgins, Cameron I. Downey, and John P. Clinkenbeard

California Geological Survey
California Department of Conservation

2004

SECTIONS

TABLES
(as separate .xls files)

OVERVIEW OF ASSIGNMENT

INTRODUCTION

In 2004, the California Coastal Sediment Management Workgroup (CSMW) requested that the California Geological Survey (CGS) conduct research and prepare brief summaries of literature on various topics and geographic locations related to physical properties of sediment management along the coast of California. The CSMW, a consortium of state and federal agencies, is charged with preparing the Coastal Sediment Management Master Plan, a dynamic document that will guide the future coordination of local, regional, state, and federal approaches to coastal sediment management in California. The goal of the plan is to manage regionally, from a natural-systems approach, rather than locally, from a site-specific approach.

As prepared and prioritized by Clif Davenport, the state's project manager for the CSMW, this research was divided into seven tasks, which are listed below. The tasks were distributed among three staff geologists of the CGS. Because of the interest of the CSMW in completing this research quickly so that other phases of the Master Plan could move forward, the assignment was limited to a few months for research and preparation of results. Correspondingly, the research on the seven tasks was neither intensive nor comprehensive. Nonetheless, the results of the research should provide foundations for follow-up detailed research and direction for the CSMW Master Plan.

The results of this literature search are symptomatic of what the CSMW Master Plan will attempt to resolve, namely, that the studies and reports related to coastal activities have historically been done largely from a local, project-by-project approach. There is abundant information and documentation, but much of it has been accomplished and presented in piecemeal, isolated (rather than integrated) fashion.

There are many hundreds of published and unpublished technical reports and documents pertinent to the topics addressed in the seven tasks of this assignment. Many of those listed in the attached bibliographies were not reviewed. Nonetheless, they are presented here as examples of the literature as well as what we interpreted to be potentially the most important sources of information on the respective topics. We have not attempted to cull all pertinent data and information from these many reports. Rather, the bibliographies are presented as starting points for future detailed research on each of the topics as needed.

We researched literature and information for this project from the following sources:

- Standard hard-copy reports and maps
- Visits to libraries
- On-line search engines (e.g., GEOREF, ASCE, USACE, NTIS, AGU, Google)
- Web sites (e.g., NOAA, USGS, CERES)
- Personal interviews and correspondence

At the end of this overview are lists of selected Web sites for information on marine and coastal topics. We used some of these regularly to aid our research. Regarding search engines, we found many instances where journal articles were missed by on-line searches.

Within the main body of this report, we have broken each task into two sections: results and bibliography. For some of the tasks, we have included recommendations for continued related work to assist the Master Plan. For the tasks that are geographically oriented, we have divided the bibliographies into two sections. The first lists general references that the reader may want to use for related background or further education. The second lists references that apply directly to the coast of California. Several of the tasks include accompanying tables (Tables 1-5), which are included here as separate Excel spreadsheet files. Some of the tables have blank columns for latitude and longitude, which will allow the data in the tables to be georeferenced in GIS format. Values for latitude and longitude were not determined during this assignment.

Finally, we greatly appreciate the information and assistance provided by many individuals, particularly those at the California Coastal Commission, California Geological Survey Library, California Department of Boating and Waterways, California State Lands Commission, Orange County Public Facilities and Resources Department, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Geological Survey, U.S. Minerals Management Service, and several academic institutions. We especially thank Melanie Coyne for sharing insights on her table of beach-nourishment projects in California.

SUMMARIES BY TASK

The following sections list the seven tasks and briefly summarize findings for each of them:

Task 1 - Compile available and known beach nourishment needs along the entire California coast (locations, reasons, severity of need, and consequences); identify critical beaches that would benefit most from beach nourishment and compile a list of known erosion hot spots.

Erosion along the coast of California manifests itself through two types of processes: natural and man-induced. The former is expected because of the dynamic geology of the state. The latter has resulted from many coastal and inland modifications that have disrupted or exacerbated the natural processes. Coastal erosion in the state affects beaches, cliffs/bluffs, and steep mountain slopes adjacent to the ocean; overall, the first two are of most concern.

The severity of erosion can be viewed from a purely geologic perspective or a cultural perspective. From a cultural perspective, many factors affect the need for intervention to reduce or halt erosion. They fall into the categories of public safety and economic/recreation. These are largely driven in California by the disparate distribution of population and associated development along the coast. The two segments of the coastline with the greatest need for intervention to protect the public from erosion are from the Santa Barbara area to the border with Mexico and from the San Francisco Bay region to the Monterey area.

There appears to be no consistent definition of the term “erosion hot spot.” Although the National Research Council has defined it in one of its technical publications, how the term is used can depend on context and need.

Literature on coastal erosion in California covers from statewide to the local site-specific level. Some reports are published and widely available; others are more obscure and require more effort to locate and obtain. The documentation of locations and features of erosion are probably greater for cliffs and bluffs than for beaches.

An up-to-date, systematic, detailed inventory of rates and locations of erosion along the entire coast is warranted. A database for cliff/bluff erosion is in preparation, but one for beach erosion remains to be developed.

Task 2 - Gather studies that investigate the transport and depositional fate of fine-grained materials associated with natural and anthropogenic turbidity plumes; focus on what’s currently known about the densities and duration of “natural” turbidity plumes, and similar information on plumes associated with beach nourishment or other sediment management activities.

“Turbidity” as related to marine/coastal environments falls into two main categories, natural and anthropogenic. If the subcategory of turbidity currents is excluded from the natural category, then the volume of research and literature for the anthropogenic category by far exceeds that for the natural category.

Natural turbidity plumes in the marine environment generally fall into one of three categories: 1) classical turbidity currents, which transport sediment from the shelf slope to the deep abyssal environment, 2) hypopycnal (surface) and hyperpycnal (bottom-flowing) turbidity plumes at river mouths, and 3) storm-related turbidity plumes.

The primary sources of anthropogenic, open-water turbidity are channel-maintenance dredging, disposal of dredged material, beach replenishment, mining of aggregate by dredge, and coastal construction activities. Many studies have been conducted by the U.S. Army Corps of Engineers (USACE) on maintenance dredging and disposal activities in enclosed waters such as estuaries and embayments, locations where the presence of a high fine-sediment fraction is conducive to elevated turbidity. Studies have demonstrated that most dredge-induced turbidity plumes are localized, spreading less than a thousand meters from their source; the plumes are short-lived, dissipating to ambient water quality within several hours after dredging is completed. In many cases, suspended-sediment concentrations are less than those generated by commercial shipping operations or during severe storms. In some infrequent cases involving high fine-sediment content and strong tidal or riverine currents, surface plumes can be visible for distances of many kilometers.

Considerably less research has been conducted in unprotected marine waters where most of the literature has focused on the effect of turbidity on specific marine species and biosystems or on the transport dynamics of coarse sand, rather than on the temporal or spatial characteristics of re-suspension of fine sediment.

Few attempts have been made to quantify turbidity conditions during beach-nourishment activities. Nonetheless, it is generally agreed that turbidity that results from placement of sand on the beach face is even more localized and transitory than that during offshore or enclosed-water operations. In some studies, elevated turbidity was rarely observed outside the surf zone and was not discernable from normal turbidity caused by waves in the surf zone. In another study, elevated turbidity was limited to a narrow swath in the swash zone in the immediate vicinity of the operation. These results are largely attributable to the use of nourishment material that is low in clay and silt and resembles as closely as possible the indigenous beach sand.

Recent efforts have concentrated on modeling to predict suspended-sediment behavior. Most notable of these are the USACE PLUme MEasurement System (PLUMES) model, which documents the movement of sediment plumes using sediment concentrations and three-dimensional fluid velocity data; the Short-Term FATE (STFATE) model which evaluates the short-term behavior of surface discharges in open water; the Long Term FATE (LTFATE) model designed to assess the long-term fate of seabed accumulations of disposed material; and more recently, the Suspended Sediment FATE (SSFATE) numerical modeling system, which allows the running of multiple simulations to determine those scenarios with the least potential for adverse environmental impact.

Task 3 - Compile known and available information on: the types and grain size distribution of sands that have been used for nourishment projects along the important California beaches; observed end results of nourishment projects; the basis for limitation placed on the percentage of allowable finer grained materials in nourishment projects. Include any information gathered on existing grain size distributions at those important beaches.

Beach nourishment began in the early 1900s in California and has since encompassed hundreds of episodes at dozens of beaches along the coast. Most of the projects have been in southern California from Santa Barbara County to the Mexico border.

Data and information on the physical character of sediment (fill and native materials) involved in these projects range from sparse to well documented. This range results

largely from the purpose and time period of the individual projects; those designed as purely nourishment (rather than disposal) projects and that are relatively recent tend to have more data and information. Sources of data include academic studies as well as site-specific reports prepared by government agencies and private consultants.
To date, the overall results of beach nourishment in California have been mixed. Regarding documentation of results, it appears that early projects were either not monitored or monitoring was more qualitative in nature; documentation of results in the literature has been spotty. Rigorous quantitative monitoring (e.g., beach profiling, fill-volume measurements) of fill performance has become more routine in the last 10-20 years.

Various parameters can affect the performance of beach fills. There is some question as to the importance of the continued use of grain-size comparisons between fill and native materials as measures of beach performance.

Task 4 - Compile available information which identifies the presence of fine-grained "mud belts", potential sand source areas, and sandy and rocky bottom habitats in the offshore vicinity of potential beach nourishment locations.

Because of its diverse and dynamic setting along an active plate margin, the seafloor off California is underlain by a complex distribution of geologic materials. Areas of mud, sand, and bedrock are interspersed, with sand prevalent along most of the coast at shallow depths.

The available data and information on the locations and character of these materials ranges from very sparse to highly detailed. There are a few statewide compilations of offshore geology. These were prepared from many historic observations, geophysical surveys, and samples collected by numerous institutions, both public and private. At the regional and local level along the coast, many academic and government groups have conducted studies of seafloor materials. The density and scale of coverage of these studies vary from place to place depending on funding and purpose. The most-detailed studies have been done in the San Francisco-Monterey Bay region and along the Southern California Bight from Santa Barbara County to the Mexico border.

Volumes of sand deposits using hypothetical thicknesses have been estimated for sand deposits along the entire coast of the state. Many sand deposits have been studied locally along the coast of southern California through direct sampling and vibracoring. Such deposits have served and could continue to serve as sources of sand for beach-nourishment projects nearby.

Task 5 - Research any studies assessing the 80/20 coarse-to-fines "rule-of-thumb" ratio used by various regulatory agencies to determine whether potential source sands are compatible with a given beach. Identify the origin of the rule-of-

thumb and nourishment projects where variances from the rule of thumb were allowed, including the basis for each variance.

There is a common misperception that beach-nourishment operations must conform to an 80/20 coarse-to-fines ratio, which prohibits the use of material containing more than 20% fines (silt and clay). This arises from the U.S. Corps of Engineers' (USACE) and U.S. Environmental Protection Agency's (EPA) use of this arbitrary cut-off for applying testing exclusions to marine disposal projects regulated under the Marine Protection, Research, and Sanctuaries Act (MPRSA). Beach nourishment is considered a fill activity and thus jointly regulated by the USACE and EPA under the under Section 404 of the Clean Water Act (CWA), which imposes no specific limits on sediment grain size. Instead, the 404(b)(1) guidelines require site-specific determinations that dredged material be demonstrably compatible with the receiving beach. Compatibility of dredged material is determined through a tiered testing protocol outlined in the Inland Testing Manual of the USACE and EPA.

It is necessary to proceed through the tiers only until enough information is obtained to make factual determinations. Tier-one testing evaluates the compatibility of grain-size distribution. If there is a reason to believe that the dredged material might contain contaminants, which are commonly adsorbed to the fine-clay fraction, then a second, and possibly third, tier of testing is required to identify potential adverse chemical and biological impacts. In California, to preclude second- and third-tier chemical and biologic testing, the USACE generally requires that the overall percentage of silt and clay in the dredged material be no more than 10% higher than that of the finest beach sample. Sediments containing more than this can be approved for beach nourishment provided that the additional testing demonstrates they pose no adverse environmental or health effects.

In recent years, there have been some beach nourishment projects in California that have been approved to use dredged material with greater than 20% fines, but only after complying with the 404(b)(1) guidelines and Inland Testing Manual protocols.

We were unable to determine why the values of 80% and 20% were originally selected.

Task 6 - Compile known information on debris-basin locations, contacts, volumes, and cleanout frequencies. Focus efforts outside of Ventura and Los Angeles Counties, since debris basins in those counties are already included within the SMP GIS.

We contacted officials in San Diego, Orange, San Luis Obispo, and Monterey counties to collect information on debris basins. Of these, only Orange County has debris basins, which are classified by local officials as retarding basins to trap fines and slow runoff during storms.

We did not collect information from Santa Barbara, Ventura, Los Angeles, San Bernardino, and Riverside counties because these were documented in detail in a study published in 2002.

Task 7 - Document known information (i.e., case studies, etc.) regarding the natural seasonal movement of sand from the beach to nearshore and back.

Numerous morphological studies of beach profiles and the hydrologic and hydraulic conditions that form them have demonstrated the phenomenon of seasonal cross-shore (onshore-offshore) transport of beach sediments on wave-dominated beaches. Seasonal beach erosion and accretion are natural mechanisms that allow the beach profile to adjust itself to the prevailing wave forces in order to effectively dissipate wave energy.

In winter, California's beaches are subjected to pounding by tall, high-energy short-wavelength "storm waves" generated by local storms. Beaches respond by reducing their overall slope through erosion of the beach face and berm and the transport and redeposition of the sand in an offshore bar. This shifts the breaker zone farther offshore and produces a "winter" beach profile. At this point, the surf zone is at its widest and the breaker heights greatest. In summer, low, long-wavelength "swell waves", generated by distant storms, reverse this process by eroding and redelivering the sand stored in the offshore bar to the beach face and berm (summer profile). Decreasing wave energy also causes beaches to narrow and steepen. The critical wave conditions that govern the shift between summer and winter profiles are largely a function of critical wave steepness (ratio of wave height to wavelength). Storm waves have high steepness values, while long swell waves have low steepness values. Up until the late 1990s, it appeared that no study had yet identified critical wave-steepness values that would dictate when a summer profile would revert to a winter profile and vice versa.

While the complete cycle between fully developed seasonal profiles is uncommon, southern California beaches are examples that generally experience the full sequence.

SELECTED WEB SITES FOR INFORMATION ON MARINE AND COASTAL TOPICS

Presented here are lists of Web sites that contain pertinent information and avenues for additional research on the seven tasks.

Web sites for marine and coastal data:

http://www.ngdc.noaa.gov/mgg/mggd.html (repository for marine geophysical and geologic data – NOAA National Geophysical Data Center – free)

http://www.nodc.noaa.gov/ (site for ocean data – NOAA National Oceanographic Data Center – free)

http://ceres.ca.gov/ocean/ (site for ocean and coastal data and information – California Environmental Resources Evaluation System – free)

http://www.netlobby.com/beachapprops05_table.htm (proposed 2005 funding for beach nourishment projects in California)

http://www.ngdc.noaa.gov/mgg/geology/mmdb.html (database for marine minerals - NOAA National Geophysical Data Center – free)

http://geopubs.wr.usgs.gov/dds, IN REVIEW (a Web-based GIS project that covers the central California coast from Cape Mendocino to Point Conception – U.S. Geological Survey: contact Mimi D'Iorio at mmdiorio@usgs.gov)

Web sites for bibliographic references for marine and coastal studies:

http://webspirs.silverplatter.com/cgi-bin/login.cgi (GEOREF database - highlights geologic studies - American Geological Institute – subscription service for CGS, not free)

http://www.spn.usace.army.mil/library.html (listing of holdings for technical library - U.S. Army Corps of Engineers – free)

http://www.lib.noaa.gov/ (list of library holdings and NOAA publications – NOAA Central Library – free)

http://www.csc.noaa.gov/ (list of library holdings and publications of Coastal Services Center – NOAA Coastal Services Center – free)

http://www.ntis.gov/search/index.asp?loc=3-0-0 (list of miscellaneous publications since 1990 – National Technical Information Service – free search, but charge for download of document) http://grc.ntis.gov/daypass.htm (list of miscellaneous publications since 1964 – National Technical Information Service - $15 per day charge plus download costs)

http://www.pubs.asce.org/chrhome2.html (list of journal articles since 1970 – American Society of Civil Engineers – free)

http://www.mms.gov/library/ (list of publications – U.S. Minerals Management Service – free – many publications on-line, but appear to be limited to fairly recent) plus http://www.mms.gov/itd/pacpubs.htm

http://scilib.ucsd.edu/sio/ (information and services – Scripps Institution of Oceanography Library – free and cost?)

http://www.coastalconservancy.ca.gov/Publications/pubs.htm (list of agency publications some of which are about California beaches and wetlands) Also on CCC Web site are two pages for "Southern California Wetlands Recovery Project" and "Southern California Wetlands information Station"

http://gis.ca.gov/catalog/BrowseRecord.epl?id=1532 (catalog of publications held by CDBW related to coastal hazards – California Department of Boating and Waterways – free)

Miscellaneous Papers on Beach Erosion, Nourishment, and Performance

http://www.coastal.ca.gov/pgd/pgd-mon.html (main text)

http://www.coastal.ca.gov/web/pgd/pgd-mon2.html (appendix)

http://resources.ca.gov/ocean/html/chapt_5c.html

http://bigfoot.wes.army.mil/6720.html (Orange County 1998)

http://ceres.ca.gov/ceres/calweb/coastal/beaches.html (General discussion of California beaches)

http://cdip.ucsd.edu/SCBPS/Torrey/homepage.shtml#top (Torrey Pines Beach nourishment project)

http://www.eurekalert.org/pub_releases/2000-12/UoCS-Hrrl-1612100.php (UCSC studies on coastal erosion related to storms)

http://www4.nationalacademies.org/onpi/oped.nsf/0/25D22ABB0CCB005F852566750073B95C?OpenDocument (General on eroding beaches) http://www.beacon.dst.ca.us/goleta_beach_restoration.htm (Goleta Beach restoration project)

RESULTS FROM CSMW TASK 1

(Coastal Erosion – Needs for Beach Nourishment)

TASK 1 – Compile available and known beach nourishment needs along the entire California coast (locations, reasons, severity of need, and consequences); identify critical beaches that would benefit most from beach nourishment and compile a list of known erosion hot spots.

BACKGROUND

The issues of coastal erosion and beach replenishment/nourishment are commonly related. Coastal erosion manifests itself through two processes: natural and man-induced. An important challenge is our capability to separate the two for a given geographic location or episode. Beach replenishment or nourishment has increasingly become a preferred method of reducing or halting erosion along coastlines throughout the world. The reasons can range from purely economic (e.g., recreation; tourism) to public safety (e.g., collapse of cliffs above occupied beaches; destruction of houses and businesses).

One of the first steps to manage sediment along a regional coastline is to identify the physical locations and rates of erosion from a geologic perspective only, regardless of cultural conditions and influences. After this identification is complete, a next step would be to then overlay the cultural conditions and influences. These could include such variables as population, development, jurisdiction (public, private), economics, safety, and anticipated future conditions, among others. These variables could be weighted and then combined in a quantitative fashion to rank “severity of need” for intervention with beach replenishment/nourishment.

An issue related to severity of need is that of “erosion hot spots.” Erosion hot spots can be defined from a scientific perspective (high erosion rates with no “value” assigned) or from a cultural perspective (erosion is causing economic or safety hardships even though actual amount of erosion may not be severe compared to other locations). The National Research Council (1995) defined an “erosion hot spot” as one or more areas along a beach project that will erode more rapidly than their neighbors and more rapidly than predicted using accepted methodologies. Indeed, the definition of an erosion hot spot can be different depending on one’s purpose and interests. Is it based on purely geologic variables such as measured erosion rates? Is it based on economic losses? Is it based on jurisdictional location (public land or private property)?

The “benefit” of beach replenishment/nourishment is also an important part of ranking locations along a coastline for intervention. If considering economic benefits (tourism, recreation), King’s study (California Department of Boating and Waterways and State Coastal Commission, 2002, Part 1, Chapter 3) provides an example of a monetary benefit/cost approach to ranking. If considering public safety benefits (which do not as easily lend themselves to monetary benefit/cost analysis), the approach would have to consider human exposure at sites (e.g., potential injuries or fatalities from collapse of cliffs or structures because of erosion).

EROSION ALONG THE COAST OF CALIFORNIA

Because of its dynamic geologic setting, the coast of California is subject to the natural processes of erosion along its entire length. Uplift of the coastal land mass by geologic forces in combination with rising sea level since the last ice age have created a complex interplay of erosion and deposition of sediment that varies from place to place. This coastal environment differs substantially from the more passive environments of the U.S. Atlantic and Gulf Coasts.

With the advent of man's intense settlement and development of the state since the 1800s, this natural condition has been significantly modified: the rate of erosion has been exacerbated in many places by the construction of inland dams and artificial channeling of rivers (which block or hinder movement of sediment to the ocean) and of coastal structures such as harbors, jetties, and seawalls/revetments.

Whether natural or man-induced, erosion along the coast of California affects beaches; cliffs and bluffs associated with terraces; and steep mountain slopes that front the ocean. The first two categories of features are by far the most important to humans because they are the sites where many people live, work, and pursue recreation. The coastline from the Oregon border to Point Conception is characterized generally by short, narrow beaches and rocky shorelines; the segment from Carmel to San Simeon is notably rugged. The coastline from Point Conception to the Mexico border is generally more subdued with longer, wider beaches, and bluffs and terraces interspersed with alluvial plains.

The significance of erosion along the coast largely correlates with the location of population centers. Population is relatively sparse north of the San Francisco Bay region. From the San Francisco Bay region to Monterey, population and development are much higher. The segment from the Monterey area to the San Simeon region is sparsely populated. Farther south, there is a cluster of population centers and associated development in the Morro Bay-San Luis Obispo region. The most intensively populated and developed part of the coast is from the Santa Barbara area to the Mexico border. Correspondingly, concerns and complaints about erosion are greatest along this part. To the north, concerns about erosion are less overall, with most expressed in the San Francisco Bay and Monterey Bay regions.

Statewide Documentation of Erosion

Documentation and interpretation of erosion along the entire coast of California are summarized in inventories published inventories by the U.S. Army Corps of Engineers and Dames and Moore (1971), Habel and Armstrong (1977), and Griggs and Savoy (1985). Each of these reports provides observations and interpretations of erosion plotted on base maps for the entire length of the coastline. Each has an advantage of observation at different periods of time, which can be important because of changes in coastal development. These reports represent relatively consistent "baseline" views of the coastline of the state.

Our research did not reveal a detailed systematic statewide survey of erosion done subsequently to the inventory of Griggs and Savoy (1985). In the last few years, however, two reports (Noble Consultants, 2000; California Department of Boating and Waterways and State Coastal Commission, 2002) have documented the locations of several dozen sites of critical erosion that are threatening the economic/recreational well-being and/or public safety of citizens along the coast of California. These sites include both beach and cliff/bluff erosion and are briefly summarized in Table A1. This list is not comprehensive, but it does give an idea of the distribution of erosion problems based on a cultural perspective.

Currently, the California Coastal Commission is developing a database of cliff and bluff erosion rates and locations of armoring along the entire state coastline. The database, which is being prepared by Jennifer Dare (jdare@coastal.ca.gov), a National Oceanographic and Atmospheric Administration (NOAA) Fellow with the Commission, is being designed in a GIS format. One of the main sources of data being researched for data on erosion rates is the large collection of consultant reports in the files of the Commission. As of April 2004, detailed research and population of the database was underway for San Diego County, which is serving as a template for the project. When completed, this GIS layer will be a valuable source of information for incorporation into the statewide Coastal Sediment Management Master Plan.

Concerning erosion of beaches in California, there is relatively poor understanding of both this phenomenon and the character of sediment budgets along the coast (Griggs and others, 2003). To improve understanding of these phenomena, Gary Griggs at the University of California, Santa Cruz, is researching beach erosion and sediment budgets along selected segments of the coast of California (Gary Griggs, personal communication, 2003).

Regional and Local Documentation of Erosion

Coastal managers and researchers have increasingly recognized the importance of studying and managing the coast of California from a regional and statewide approach, with focus on natural (system) boundaries rather than jurisdictional boundaries. Correspondingly, relatively recent reports reflect this perspective. Among the most noteworthy are those associated with the Coast of California Storm and Tidal Wave Study prepared by the U.S. Army Corps of Engineers (e.g., 1991, 1993, 2002). The first two installments of this study cover the San Diego and Orange County coastlines. In particular, the 1991 report for San Diego County identified the coastal segments from Oceanside to La Jolla and from Imperial Beach to the border with Mexico as locations of “critical erosion.” Another important study is that of Flick (1994), which is a detailed atlas of erosion along the coast from Dana Point in southernmost Orange County through all of San Diego County to the Mexico border.

Historically, academic researchers have studied some topical issues related to coastal erosion as exemplified by some of the references included in the accompanying bibliography. More recently, local government, as exemplified by the San Diego Association of Governments (SANDAG) and the Beach Erosion Authority for Central Operations and Nourishment (BEACON) in Santa Barbara and Ventura Counties, have embraced the concept of regional management of sediment and correspondingly prepared reports that identify locations of erosion and strategies to manage them (Noble Consultants, 1989; San Diego Association of Governments, 1993).

At the local, or project, level, numerous published and unpublished reports and information are available that document beach and cliff/bluff erosion along the coast of California. The three main sources of this literature are the U.S. Army Corps of Engineers (some are readily available; others are difficult to obtain), private-consultant reports (the California Coastal Commission has a large holding related to permit applications), and academic/professional journals (generally readily available at university libraries where coastal and marine studies are emphasized). Examples from each group are in the accompanying bibliography.

Compilation of Information from Reports

Because of the short length of the present study, detailed research and compilation of information from the wide array of literature and files on coastal erosion was beyond the scope of this study. Not only must the information be located, it must be evaluated for its timeliness; commonly, present conditions are not the same as when the information was gathered and reported for the individual studies.

The importance of compiling the available information on statewide beach and cliff/bluff erosion from the sources described above into a GIS format cannot be overestimated. The integration of the observations and interpretations, particularly those of the three state inventories published between 1971 and 1985, can significantly aid a modern systematic compilation and evaluation of erosion along any segment of the coast of California. The systematic compilation for cliff/bluff-erosion locations and rates is already underway through Jennifer Dare’s project. The systematic, detailed compilation for beach-erosion locations and rates remains to be accomplished.

NEED FOR BEACH NOURISHMENT

Coastal managers and researchers of the coast of California are increasingly looking to replenishment/nourishment as a way to maintain the size of beaches and to protect the landforms and associated development behind the beaches. The progressive diminishment of beaches along the coast, particularly in southern California, can negatively affect recreation and tourism as well as lead to hazardous cliff/bluff failure and flooding that affects public safety.

The need for replenishment/nourishment at any particular beach in the state depends on many variables as described previously. To establish a list of beaches requires evaluation and weighting of these variables. As one approach, Coyne (2000) presented a GIS-based decision-support tool for identifying potential sites of beach nourishment, with examples focused on southern California. Also, the "need" of many beaches in California has been met by a history of successive nourishment episodes (e.g., Surfside/Sunset). These beaches are either on a prescribed schedule of nourishment or may be irregularly nourished because they depend on receiving fill from sources that are defined as "opportunistic" (e.g., harbor dredging or channel maintenance, which must dispose of the excavated material). Need can also be "performance-dependent." In other words, timeliness of the next nourishment episode can depend on how well the fill from the previous episode has performed according to design specifications.

For the coast of California, Table A1 lists selected beaches identified in previous reports as having a critical need for replenishment/nourishment. Also listed are the potential consequences if there is no intervention. Nearly all sites are in southern California, from Point Conception to the Mexico border. The main reason for this geographic bias is the distribution and density of coastal population and development. This list is not necessarily comprehensive, but represents sites evaluated and selected by consulting specialists and government officials in recent years. To prepare a comprehensive list would require research and evaluation of many published and unpublished reports and documents on all individual beaches along the coast. Furthermore, we believe at this point in development of the Master Plan that severity of need cannot be rigorously established for individual sites along the coast of California until a protocol for ranking is established. Consequently, we have not made judgments on severity of need for the sites listed in Table A1.

RECOMMENDATIONS

- For the CSMW Master Plan, prepare a clear definition of the term "erosion hot spot."
- For the CSMW Master Plan, prepare a set of criteria to clearly define and rank needs for beach nourishment according to severity. To identify and rank based on economic effects, a benefit/cost analysis could be one approach. To identify and rank based on public health and safety will require other criteria such as previous fatalities or injuries.
- As part of CSMW Master Plan, annually maintain a GIS-based list of beach-nourishment needs, perhaps categorized by littoral cell.

- Digitize and attribute in GIS-format the data and interpretations from the following reports to establish baselines to aid interpretation of beach erosion and needs for nourishment. This process should be coordinated with the current project of Jennifer Dare at the California Coastal Commission.

  U.S. Army Corps of Engineers and Dames and Moore (1971)
  Habel and Armstrong (1977)
  Griggs and Savoy (1985)

CSMW TASK ONE

Bibliography

GENERAL

Bascom, W., 1980, Waves and beaches: The dynamics of the ocean surface: Anchor Books/Doubleday, Garden City, New Jersey (2nd edition), 366 p.

Caldwell, J.M., 1967, Coastal processes and beach erosion: U.S. Army Corps of Engineers, Coastal Engineering Research Center Reprint 1-67, p. 142-157.

Dolan, R.B. and others, 1983, Erosion of U.S. shorelines, *in* Komar, P.D., editor, CRC Handbook of Coastal Processes and Erosion: Boca Raton, Florida, CRC Press, p. 285-299.

Inman, D.L., 1987, Accretion and erosion waves on beaches: Shore & Beach, v. 55, no. 3-4, p. 61-65.

Inman, D.L., in press, Littoral cells, *in* Schwartz, M.L., editor, Encyclopedia of coastal science: Kluwer Academic Publishers, Dordrecht, The Netherlands.

Komar, P.D., 1983, Beach processes and erosion--An introduction, *in* Komar, P.D., ed., CRC Handbook of Coastal Processes and Erosion: Boca Raton, Florida, CRC Press, p. 1-20.

Komar, P.D., 1996, The budget of littoral sediments – Concepts and Applications: Shore & Beach, vol. 64, p. 18-26.

Komar, P.D., 1997, Beach processes and sedimentation: Prentice Hall, Upper Saddle River, New Jersey, 2nd edition, 544 p.

Komar, P.D., 2000, Coastal erosion--underlying factors and human impacts: Shore and Beach, v. 68, p. 3-16.

Krumbein, W.C., 1947, Shore processes and beach characteristics: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 3, 35 p.

National Academy Press, 1990, Managing coastal erosion: National Academy Press, Washington, D.C., 182 p.

National Research Council, 1995, Beach nourishment and protection: Washington, D.C., National Academy Press, 334 p.

Stauble, D.K., and Brumbaugh, R.W., 2003, An assessment of the nation's shorelines, USA: Shore and Beach, v. 71, p. 11-18.

U.S. Army Corps of Engineers, 2002, Coastal Engineering Manual: U.S. Army Corps of Engineers Engineer Manual 1110-2-1100, Washington, D.C., 6 volumes. (http://bigfoot.wes.army.mil/cem001.html)

Williams, S.J., Dodd, K. and Gohn, K.K., 1990, Coast in crisis: U.S. Geological Survey Circular 1075, 32 p.

COAST OF CALIFORNIA

Baird, B. and others, 1995, California’s ocean resources: an agenda for the future: Resources Agency of California, draft report.

Baird, B. and others, 2001, Draft policy on coastal erosion planning and response and background material: Resources Agency of California, draft report.

BEAR Task Force, 1999, Procedural guidance document: Beach erosion and response, California Coastal Commission, p. 177.

Benumof, B.T. and Griggs, G.B., 1999, The dependence of seacliff erosion rates on cliff material properties and physical processes, San Diego County, California: Shore & Beach, v. 67, no. 4, p. 29-41.

Benumof, B., Moore, L.J., and Griggs, G.B., 1998, FEMA and state of the art coastal erosion mapping along the San Diego County, California shoreline, *in* Ewing, L., and Sherman, D., eds., California's coastal natural hazards: Santa Barbara, California, University of southern California Sea Grant program, p. 86-97.

Benumof, B.T., Storlazzi, C.D., Seymour, R.J., and Griggs, G.B., 2000, The relationship between incident wave energy and seacliff erosion rates: San Diego County, California: Journal of Coastal Research, v. 16, p. 1162-1178.

Best, T.C. and Griggs, G.B., 1991, A sediment budget for the Santa Cruz littoral cell: p. 35-50, *in* Osborne, R.H., editor, From shoreline to abyss, Society for Sedimentary Geology (SEPM) Special Publication 46, p. 35-50.

Bowen, A.J. and Inman, D.L., 1966, Budget of littoral sands in the vicinity of Point Arguello: U.S. Army Corps of Engineers, Coastal Engineering Research Center, Technical Memorandum 19, 41 p.

Brownlie, W.R. and Taylor, B.D., 1981, Coastal sediment delivery by major rivers in southern California, Sediment management of southern California mountains, coastal plains, and shorelines (Part C): California Institute of Technology, Environmental Quality Laboratory Report 17-C, 314 p.

California Department of Boating and Waterways (CDBW) and State Coastal Conservancy (SCC), 2002, California beach restoration study: Sacramento, California.

California State Lands Commission, 2001, Shoreline protective structures: California State Lands Commission, Staff Report, 23 p.

Coastal Data Information Program (CDIP), 2004, Coastal Data Information Program, monthly reports: U.S. Army Corps of Engineers and California Department of Boating and Waterways, Scripps Institution of Oceanography Reference Series. (http://cdip.ucsd.edu)

Coastal Frontiers Corporation, 1992, Historical changes in the beaches of Los Angeles County, Malaga Cove to Topanga Canyon, 1935-1990: County of Los Angeles, Department of Beaches and Harbors, 105 p.

Coyne, M., 2000, Identifying potential beach nourishment sites in California: A decision support tool: California Coastal Commission and California Department of Boating and Waterways, CD.

Crampton, W.F., 2001, Sand beaches versus seawalls--A geomorphic perspective, An introduction to the shoreline of San Diego: Annual Coastal Tour Guidebook: San Diego, California, San Diego Association of Geologists, p. 1-13.

Crampton, W.F., and Smillie, B.R., 2001, National Marine Fisheries Service Center: Effects of tectonics and faulting on coastal erosion, An introduction to the shoreline of San Diego: Annual Coastal Tour Guidebook: San Diego, California, San Diego Association of Geologists, p. 1-8.

Dean, R.G., Armstrong, G.A. and Sitar, N., 1984, California coastal erosion and storm damage during the winter of 1982-83: National Academy Press, Washington, D.C., 74 p.

Dettle, M. and others, 1987, California coastal literature inventory system, *in* Magoon, O.T. and others, editors, Coastal zone ’87: American Society of Civil Engineers, Proceedings of the Symposium on Coastal and Ocean Management, vol. 3, p. 2297-2305.

Diener, B.G., 2000, Sand contribution from bluff recession between Point Conception and Santa Barbara, California: Shore & Beach, v. 68, no. 2, p. 7-14.

Dingler, J.R., and Reiss, T.E., 2002, Changes to Monterey Bay beaches from the end of the 1982-83 El Niño through the 1997-90 El Niño: Marine Geology, v. 181, p. 249-263.

Domurat, G.W., and Wakeman, T.H., 1991, The California coastal zone experience, *in* Symposium on Coastal and Ocean Management, 7th, Long Beach, CA, 1991, Proceedings: Long Beach, CA, Am. Soc. Civ. Eng.,, p. 311.

Drake, J., 1981, Tropical storm swell and seasonal beach erosion – implications for southern California: Association of Pacific Coast Geographers Yearbook, 43rd Annual Meeting, p. 149.

Everts, C.H., 1991, Seacliff retreat and coarse sediment yields in Southern California, *in* Kraus Nicholas, C., Gingerich Kathryn, J., and Kriebel David, L., eds., Coastal sediments '91.: New York, NY, United States, Am. Soc. Civ. Eng., p. 1586-1598.

Ewing, L. and Sherman, D., editors, 1998, California's coastal natural hazards: California Shore and Beach Association and University of Southern California Sea Grant Program, Proceedings volume, November 12-14, 1997, Santa Barbara, California, 162 p.

Flick, R.E., 1993, The myth and reality of southern California beaches: Shore and Beach, v. 61, p. 3-13.

Flick, R.E., editor, 1994, Shoreline erosion assessment and atlas of the San Diego Region: California Department of Boating and Waterways and San Diego Association of Governments (two volumes), 135 p. plus atlas.

Fulton, K., 1981, A manual for researching historical coastal erosion: 56 p.

Griggs, G.B., 1994, California's coastal hazards, *in* Coastal hazards; perception, susceptibility and mitigation: Journal of Coastal Research, v. Special Issue 12, p. 1-15.

Griggs, G.B., 1995, Relocation or reconstruction of threatened coastal structures: a second look: Shore & Beach, v. 63, no. 2, p. 31-37. *Has table with percentage of armored coastline for coastal cities in California.*

Griggs, G.B., 1998, California needs a coastal hazards policy: California Coast and Ocean, v. 13, p. 30-33.

Griggs, G.B., 1998, California's coastline: El Niño, erosion and protection, *in* Ewing, L., and Sherman, D., eds., California's Coastal Natural Hazards: Santa Barbara, California, University of southern California Sea Grant program, p. 36-55.

Griggs, G.B., 1999, Bringing back the beaches--A return to basics, *in* Ewing, L., Magoon, O.T., and Robertson, S., eds., Sand Rights '99: Bringing back the beaches: Reston, Virginia, American Society of Civil Engineers, p. 276-285.

Griggs, G.B., 1999, The protection of California's coast: Past, present, and future: Shore and Beach, v. 67, no. 1, p. 18-28.

Griggs, G.B. and others, 2003, Challenges to understanding littoral sand budgets along active margin, high energy coastlines: Geologic Society of America Abstracts with Programs, v. 35, no. 6, p. 285.

Griggs, G.B., and Brown, K.M., 1998, Erosion and shoreline damage along the central California coast: A comparison between the 1997-98 and 1982-83 ENSO winters: Shore and Beach, v. 1998, p. 18-23.

Griggs, G.B., and Johnson, R.E., 1979, Erosional processes and cliff retreat along the northern Santa Cruz County coastline: California Geology, v. 32, p. 67-76.

Griggs, G.B., Moore, L.J., Tait, J.F., Scott, K., and Pembrook, D., The effects of the storm waves of 1995 on beaches adjacent to a long-term seawall monitoring site in northern Monterey Bay, California: Shore and Beach, p. 34-39.

Griggs, G.B. and others, 1992, California's coastal hazards: A critical assessment of existing land use policies and practices: California Policy Seminar Program, Special Publication, 224 p.

Griggs, G.B., and Savoy, L., 1985, Living with the California Coast: Durham, North Carolina, Duke University Press, p. 393.

Griggs, G.B., and Scholar, D., 1997, Coastal erosion caused by earthquake-induced slope failure: Shore and Beach, v. 65, p. 2-7.

Griggs, G.B., and Tait, J.F., 1988, The effects of coastal protection structures on beaches along northern Monterey Bay, California: Journal of Coastal Research, Special Issue No. 4, p. 93-111.

Griggs, G.B., Tait, J.F., and Corona, W., 1994, The interaction of seawalls and beaches: Seven years of monitoring, Monterey Bay, California: Shore and Beach, v. 62, no. 3, p. 21-28.

Group Delta Consultants, 1993, Shoreline Erosion Study, Encinitas Coastline, San Diego County California, p. 53.

Gustaitis, R., 1996, Trying to balance the sand budget: California Coast and Ocean, v. 12, p. 3-10.

Guza, R.T. and others, 2002, Southern California beach processes study: Scripps Institution of Oceanography, 7th Quarterly Report, November 30, 2002. http://cdip.ucsd.edu.

Habel, J.S. and Armstrong, G.A., 1977, Assessment and atlas of shoreline erosion along the California coast: California Department of Navigation and Ocean Development, 69 p. plus atlas (277 p.).

Hamilton, M., 1998, Grains of sand – GPS survey-grade technology provides critical data to understanding beach erosion: Earth Observation Magazine, vol. 7, no. 4, p. 12-14.

Hampton, M.A., and Dingler, J.R., 1998, Short-term evolution of three coastal cliffs in San Mateo County, California: Shore and Beach, v. 66, p. 24-30.

Hampton, M.A., Dingler, J.R., Sallenger, A.H., Jr., and Richmond, B.M., 1999 (in press), Storm-related change of the northern San Mateo County Coast, California, Coastal Sediments '99: Hauppauge, NY, p. 13.

Hapke, C., 2000, Geology and coastal hazards of the northern Monterey Bay, California: U.S. Geological Survey Open-File Report OF 00-0438, p. 18.

Inman, D.L., 1949, Report on beach study in the vicinity of Mugu Lagoon, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 14, 30 p.

Inman, D.L., 1953, Areal and seasonal variations in beach and nearshore sediments at La Jolla, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 39, 134 p.

Inman, D.L., 1985, Damming of rivers in California leads to beach erosion: Marine Technological Society and Institute of Electrical and Electronic Engineering, Oceans ’85, Ocean Engineering and the Environment, vol. 1, p. 22-26.

Inman, D.L. and Frautschy, J.D., 1966, Littoral processes and the development of shorelines: American Society of Civil Engineers, Proceedings of the Coastal Engineering Specialty Conference, Santa Barbara, California, p. 511-536.

Inman, D.L. and Masters, P.M., 1991, Budget of sediment and prediction of the future state of the coast, *in* U.S. Army Corps of Engineers, State of the coast report, San Diego region, Coast of California storm and tidal waves study: U.S. Army Corps of Engineers, Los Angeles District, vol. 1, chapter 9, p. 1-105.

Inman, D.L. and others, 2002, Facing the coastal challenge: Modeling coastal erosion in southern California, *in* Magoon, O.T. and others, editors, California and the World Ocean ’02: American Society of Civil Engineers, Reston, Virginia.

Inman, D.L. and Rusnak, G.S., 1956, Changes in sand level on the beach and shelf at La Jolla, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 82, 30 p.

Jenkin, P., 1998, On the edge: Robbed by dams, scoured by seawalls, devoured by winter storms, Ventura County may soon lose one of its most precious resources, *in* Ewing, L., and Sherman, D., eds., California's coastal natural hazards: Santa Barbara, California, University of southern California Sea Grant program, p. 151-158.

Johnson, J.W., 1959, The supply and loss of sand to the coast: American Society of Civil Engineers, Journal of Waterways and Harbors Division, vol. 85, p. 227-251.

Judge, C.W., 1970, Heavy minerals in beach and stream sediments as indicators of shore processes between Monterey and Los Angeles, California: U.S. Army Corps of Engineers Coastal Engineering Research Center, Technical Memorandum 33, 44 p.

Kennedy, M.P., 1973, Sea-cliff erosion at Sunset Cliffs, San Diego: California Geology, v. 26, p. 27-31.

Knur, R.T. and Kim,Y.C., 1999, Historical sediment budget analysis along the Malibu coastline, *in* Sand Rights ‘99-Bringing Back the Beaches: American Society of Civil Engineers, Ventura, California, 292 p.

Krumbein, W.C., 1947, Shore processes and beach characteristics: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 3, 35 p.

Kuhn, G.G., 2000, Sea cliff, canyon, and coastal terrace erosion between 1887 and 2000: San Onofre State Beach, Camp Pendleton Marine Corps Base, San Diego County, California, *in* Legg, M.R., Kuhn, G.G., and Shlemon, R.J., eds., Neotectonics and Coastal Instability: Orange and Northern San Diego Counties, California, Volume 1: Long Beach, California, AAPG-Pacific Section and SPE-Western Section, p. 31-87.

Kuhn, G.G., Baker, E.D., and Campen, C., 1980, Greatly accelerated man-induced coastal erosion and new sources of beach sand, San Onofre State Park and Camp Pendleton, northern San Diego County, California: Shore and Beach, v. 48, p. 9-13.

Kuhn, G.G., and McArthur, D.S., 2000, Beaches and sea cliffs of central and northern San Diego County, *in* Legg, M.R., Kuhn, G.G., and Shlemon, R.J., eds., Neotectonics and coastal instability: Orange and northern San Diego Counties, California, Volume 1: Long Beach, California, AAPG-Pacific Section and SPE-Western Section, p. 104-122.

Kuhn, G.G., and Osborne, R.H., 1989, Historical climatic fluctuations in Southern California and their impact on coastal erosion and flooding; 1862 to present, *in* Magoon Orville, T., Converse, H., Miner, D., Tobin, L.T., and Clark, D., eds., Coastal zone '89; proceedings of the Sixth symposium on Coastal and ocean management., Volume 6: Proceedings of the Symposium on Coastal and Ocean Management: New York, NY, United States, American Society of Civil Engineers, p. 4391-4405.

Kuhn, G.G., and Shepard, F.P., 1979, Coastal erosion in San Diego County, California, *in* Abbott, P.L., and Elliott, W.J., eds., Earthquakes and other perils, San Diego region.: San Diego, Calif., United States, San Diego Assoc. Geol., p. 207-216.

Kuhn, G.G. and Shepard, F.P., 1979, Accelerated beach-cliff erosion related to unusual storms in southern California: California Geology, vol. 32, no. 3, p. 58-59.

Kuhn, G.G. and Shepard, F.P., 1980, Coastal erosion in San Diego County, California, *in* Edge Billy, L., ed., Coastal zone '80, Volume 3: Proceedings of the Symposium on Coastal and Ocean Management. 2, Vol: New York, NY, United States, American Society of Civil Engineers, p. 1899-1917.

Kuhn, G.G. and Shepard, F.P., 1983, Beach processes and sea cliff erosion in San Diego County, California, *in* Komar, P.D., ed., CRC Handbook of Coastal Processes and Erosion: CRC Series in Marine Science: Boca Raton, Florida, CRC Press, p. 267-284.

Kuhn, G.G. and Shepard, F.P., 1984, Sea cliffs, beaches, and coastal valleys of San Diego County: University of California Press, Berkeley, California, 193 p.

Lajoie, K.R., and Mathieson, S.A., 1998, 1982-83 El Nino Coastal Erosion, San Mateo County, California: Menlo Park, California, U.S. Geological Survey, p. 4.
Lee, L., Pinckney, C.J., and Bemis, C., 1976, Seacliff base erosion, San Diego, California, American Society of Civil Engineers, National Water Resources and Ocean Engineering Conference, p. 1-13.

Lilly, K., and Kingery, D., 1998, Ocean Beach, San Francisco: Protection and management of an eroding shoreline, *in* Ewing, L., and Sherman, D., eds., California's coastal natural hazards: Santa Barbara, California, University of southern California Sea Grant program, p. 106-131.

Magoon, O.T. and others, editors, 1997, California and the world ocean, ’97: American Society of Civil Engineers.

Maloney, N.J., and Alba, C.A., 1978, Oriented coastal erosion patterns and pocket beach formation, Corona Del Mar, California: Eos, Transactions, American Geophysical Union, v. 59, p. 1114.

McGee, T., 1987, Coastal erosion along Monterey Bay: U.S. Naval Postgraduate School and California Department of Boating and Waterways, 89 p.

McGrath, J., 1985, California's battered coast: San Diego, California, California Coastal Commission, p. 403.

McGrath, J., 1996, Why it makes sense to take sand to the beaches: California Coast and Ocean, v. 12, p. 11-17.

Moore, L.J., Benumof, B.T., and Griggs, G.B., 1999, Coastal erosion hazards in Santa Cruz and San Diego counties, California: Journal of Coastal Research, v. 28, p. 121-139.

Noble Consultants, 1989, Coastal sand management plan, Santa Barbara/Ventura County coastline: Main Report, Prepared for Beach Erosion Authority for Control Operations and Nourishment (BEACON), 186 p.

Noble Consultants, 2000, California shoreline protection survey 2000: Report prepared for California Department of Boating and Waterways, 13 p. plus appendix (37 p.).

Nordstrom, C.E. and Inman, D.L., 1975a, Physical criteria for coastal planning concerning beach erosion and sand management in California: California Department of Navigation and Ocean Development, 29 p.

Nordstrom, C.E. and Inman, D.L., 1975b, Sand level changes on Torrey Pines Beach, California:, U.S. Army Corps of Engineers, Coastal Engineering Research Center Miscellaneous Paper 11-75, 166 p.

O'Brien, M.P., 1936, The coast of California as a beach-erosion laboratory: Shore & Beach, vol. 4, no. 3, p. 74-79.

Perg, L.A., Anderson, R.S., and Finkel, R.C., 2003, Use of cosmogenic radionuclides as a sediment tracer in the Santa Cruz littoral cell, California, United States: Geology, v. 31, p. 299-302.

Pipkin, B.W., Robertson, H.S., and Mills, R.S., 1992, Coastal erosion in Southern California; an overview, *in* Pipkin Bernard, W., and Proctor Richard, J., editors., Engineering geology practice in Southern California: Special Publication - Association of Engineering Geologists: Sudbury, MA, United States, Association of Engineering Geologists, p. 461-483.

Powers, M.G., 1991, A regional approach to beach erosion in California: Formation, organization, and operation of B.E.A.C.O.N.: American Society of Civil Engineers, Proceedings of The Coastal Zone Experience, Coastal Zone '91, p. 187-197.

Resources Agency of California, 2001, Draft policy on coastal erosion planning and response and background material: Sacramento, California. (http://ceres.ca.gov/cra/ocean/coastal_erosion_draft.html)

Rice, R.M. and others, 1976, Relationships between sand input from rivers and the composition of sands from the beaches of southern California: Sedimentology, vol. 23, p. 689-703.

San Diego Association of Governments, 1993, Shoreline preservation strategy for the San Diego region: San Diego Association of Governments, 43 p.

San Diego Association of Governments, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

Shepard, F.P., 1950, Beach cycles in southern California: U.S. Army Corps of Engineers, Beach Erosion Board, Technical Memorandum 20, 26 p.

Shepard, F.P., and Grant, U.S., IV, 1947, Wave erosion along the southern California coast: Bulletin of the Geological Society of America, v. 58, p. 919-926.

Shepard, F.P. and LaFond, E.C., 1940, Sand movements along the Scripps Institution pier: American Journal of Science, v. 238, p. 272-285.

Shepard, F.P. and Wanless, H.R., 1970, Our changing coastlines: McGraw-Hill Book Company, New York, New York, 539 p.

Storlazzi, C.D., and Griggs, G.B., 1998, The 1997-98 El Nino and erosion processes along the central coast of California: Shore and Beach, v. 1998, p. 12-17.

Storlazzi, C.D., and Griggs, G.B, 2000, Influence of El Niño-Southern Oscillation (ENSO) events on the evolution of central California's shoreline: Geological Society of America Bulletin, v. 112, p. 236–249.

Taylor, A.C., and Domack, C.R., 1997, A study of coastal erosion along the Santa Barbara, California coastline with emphasis on the impacts of human development, *in* Anonymous, ed., Geological Society of America, Northeastern Section, 32nd annual meeting., Volume 29; 1: Abstracts with Programs - Geological Society of America: Boulder, CO, United States, Geological Society of America (GSA), p. 84.

U.S. Army Corps of Engineers, 1960, Beach erosion control report on cooperative study of San Diego County, California: Los Angeles, U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers, 1965, Technical report on cooperative beach erosion study of coast of northern California – Point Delgada to Point Ano Nuevo: U.S. Army Corps of Engineers, San Francisco District, Appendix VIII, Contract No. W-04-193-ENG 5196 (4 documents).

U.S. Army Corps of Engineers, 1967, Beach erosion control report on cooperative study of southern California, Cape San Martin to Mexican boundary: U.S. Army Corps of Engineers, Los Angeles District, Appendix VII, Contract No. W-04-193-ENG-5196, 42 p. plus plates.

U.S. Army Corps of Engineers, 1970, Beach erosion control report, cooperative research and data collection program of coast of southern California, Cape San Martin to Mexican boundary: U.S. Army Corps of Engineers, Los Angeles District, Three-Year Report for 1967-1969.

U.S. Army Corps of Engineers, 1984, Littoral zone sediments, San Diego region, *in* Coast of California storm and tidal waves study: Los Angeles District, U.S. Army Corps of Engineers, CCSTWS 84-5.

U.S. Army Corps of Engineers, 1985a, Sediment sampling, Dana Point to Mexican border, *in* Coast of California storm and tidal waves study: Los Angeles District, U.S. Army Corps of Engineers, CCSTWS 85-11.

U.S. Army Corps of Engineers, 1985b, Southern California coastal processes annotated bibliography: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study 85-4, 401 p.

U.S. Army Corps of Engineers, 1986, Southern California coastal processes data summary: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study 86-1, 572 p.

U.S. Army Corps of Engineers, 1987a, Coastal cliff sediments, San Diego region, Dana Point to the Mexican border: Los Angeles, California, U.S. Army Corps of Engineers, Los Angeles District, Planning Division, Coastal Resource Branch.

U.S. Army Corps of Engineers, 1987b, Northern California coastal processes annotated bibliography: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study No. 87-5, 491 p.

U.S. Army Corps of Engineers, 1988, Santa Barbara County beach erosion and storm damage reconnaissance study: U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers, 1990, Sediment budget report- Oceanside littoral cell: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 1991, State of the coast report, San Diego region: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study, Volume 1 - Main Report, Final.

U.S. Army Corps of Engineers, 1993, Existing state of Orange County: U.S. Army Corps of Engineers, Coast of California Storm and Tidal Waves Study, CCSTWS 93-1, Los Angeles District.

U.S. Army Corps of Engineers, 1995, Silver Strand shoreline, San Diego County, California: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 1996, Encinitas Shoreline, San Diego County, California: Los Angeles, U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers, 2000a, Encinitas-Solana beach shoreline feasibility study draft management plan: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 2000b, Huntington Beach Blufftop Park storm damage reduction study, Orange County, California: U.S. Army Corps of Engineers, Los Angeles District, Project Study Plan, 56 p.

U.S. Army Corps of Engineers, 2000c, San Clemente shoreline feasibility study draft management plan: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 2000d, San Gabriel to Newport Bay, California, 905(b) draft reconnaissance report: U.S. Army Corps of Engineers, Los Angeles District, 14 p.

U.S. Army Corps of Engineers, 2001, Carpinteria shoreline initial appraisal report, Santa Barbara County, California: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 2002a, Silver Strand shoreline, Imperial Beach , California: U.S. Army Corps of Engineers, Los Angeles District, General Evaluation Report, Appendixes A and B.

U.S. Army Corps of Engineers, 2002b, South Coast region (Orange County): U.S. Army Corps of Engineers, Coast of California Storm and Tidal Wave Study, Final Report.

U.S. Army Corps of Engineers and Dames and Moore, 1971, National shoreline study – California regional inventory: U.S. Army Corps of Engineers South Pacific Division Regional Inventory Report, 103 p.

Welday, E.E., c1972, The southern Monterey Bay littoral and coastal environment and the impact of sand mining: California Division of Mines and Geology unpublished open-file report to D.J. Everitts, 44 p.

RESULTS FROM CSMW TASK 2

(Natural and Anthropogenic Turbidity)

TASK 2 – Gather studies that investigate the transport and depositional fate of fine-grained materials associated with natural and anthropogenic turbidity plumes; focus on what's currently known about the densities and duration of "natural" turbidity plumes, and similar information on plumes associated with beach nourishment or other sediment management activities.

BACKGROUND

The issue of "turbidity" related to marine/coastal environments falls into two main categories, natural and anthropogenic. If the subcategory of turbidity currents is excluded from the natural category, then the volume of research and literature for the anthropogenic category by far exceeds that for the natural category. Our research revealed little information for turbidity in the nearshore environment caused by the artificial placement of sand on beaches.

NATURAL TURBIDITY

Natural turbidity plumes in the marine environment generally fall into one of three distinct categories: 1) classical turbidity currents, which transport sediment from the shelf slope to the deep abyssal environment, 2) hypopycnal and hyperpycnal turbidity plumes at river mouths, and 3) storm-related turbidity plumes.

Classical turbidity currents are submarine phenomena that are responsible for transporting the majority of sediment to the oceanic basins. Usually triggered by earthquakes and slumping of oversteepened delta fronts or submarine canyon walls, bottom sediment is re-suspended increasing the density of the nearby water, which then flows down the continental slope, entraining more sediment as it goes. When it encounters a decrease in slope, its velocity slows allowing the suspended particles to settle. Since a large portion of the world's petroleum reserves occur in these mixed clastic deposits (turbidites), voluminous research and literature exist. Therefore, turbidity currents and turbidites are excluded from this literature search.

When sediment-laden river water enters the ocean, it can generate a "hypopycnal" plume (overflowing surface plume) or "hyperpycnal" plume (bottom-flowing plume). Hypopycnal plumes are more common since river outflows are typically fresh and warm relative to the ocean. Hyperpycnal plumes occur when the density of sediment-laden river water exceeds that of the ambient seawater and descends to the sea floor as a result of the excessive sediment load (Mulder and Syvitski, 1995; Parsons and others, 2001). Hyperpycnal plumes are predominantly seasonal and require unusually high sediment concentrations exceeding 40 kg m^3.

Smaller-scale storm-related turbidity plumes can also be generated by storm-wave re-suspension of either fine seafloor sediments in shallow marine environments or sediments along a wave-dominated beach or other shoreface.

ANTHROPOGENIC TURBIDITY

The primary sources of anthropogenic open-water turbidity are channel-maintenance dredging, disposal of dredged material, beach replenishment, aggregate mining, and coastal construction activities. The main environmental effects of increased turbidity levels from these operations are a reduction in penetration of light into the water column and suspended-sediment impacts on filter-feeding organisms and fish. Most studies have focused on maintenance dredging and disposal activities in enclosed waters such as estuaries, embayments, and navigational channels where there is a high percentage of fine-grained sediment (often 75% or more), which results in larger dispersion plumes than similar activities in offshore waters. Hitchcock and others (1999) cite numerous dredge-related plume studies from around the world in their report on benthic and surface plumes prepared for the U.S. Minerals Management Service. However, the largest inventory of research and literature on dredge-induced turbidity, was produced by the U.S. Army Corps of Engineers (USACE) through its Dredging Research Program (DRP), Dredged Material Research Program (DMRP), and Dredging Operations and Environmental Research Program (DOER) administered through the U.S. Army Engineer Research and Development Center (ERDC) and its predecessor, the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi.

Considerably less research has been conducted in unprotected offshore waters. Most of the available literature regarding suspended-sediment studies in the swash, surf, and nearshore zones has dealt with either the effect of turbidity on specific marine species and biosystems or on coarse-sand transport dynamics. This focus is largely because offshore disturbances generally produce fewer turbidity-related impacts since offshore sands tend to be coarser, cleaner, and have been winnowed of most clay and silt. In California and many other parts of the world, sands in high-energy offshore areas commonly contain less than 5 percent clay and silt (Nielsen, 1997). This is one reason beach-nourishment projects favor offshore borrow sites. The offshore hydrodynamic environment also favors prompt plume dispersion. Additionally, offshore organisms are more adapted to higher-energy natural sediment transport processes, which can create turbidity under normal conditions (storms, waves, etc).

Dredge and Material-Disposal Turbidity

Turbidity from marine dredging and disposal arises from disturbance of bottom sediments (benthic plumes), overspill of surplus or screened sediment mixtures from the surface dredge (surface plumes), and open-water disposal of dredged sediments (surface and benthic plumes). Generally overspill from spillways, screening, and open-water disposal generates a far greater quantity of suspended material and larger plumes than bottom disturbances (Herbich and Brahme, 1991; LaSalle and others, 1991; Herbich, 2000).

Turbidity is generally not an issue when dredging deposits of clean offshore sands with little fine-grained material. Studies also suggest that dredge-induced turbidity is of little concern in areas with high natural background levels of turbidity, such as at the mouth of estuaries, or in high-energy areas close to eroding coastlines since ecosystems are well-adapted to naturally high loads of suspended sediment caused by tides and wave action.

The majority of studies and monitoring efforts of dredge-induced turbidity has demonstrated that turbidity plumes are, more often than not, localized, spreading less than a thousand meters from their sources and dissipating to ambient water quality within several hours after dredging is completed (Schubel and others, 1978; Byrnes and others, 2003, LaSalle and others, 1991; McClellan and others, 1989; Pennekamp and Quaak, 1990). These results are characteristic of both offshore operations and those in enclosed waters.

Numerous observations and models by the USACE support the conclusion that dredge plumes are localized and of short duration. In one model of a turbid plume of re-suspended sediment generated by an operating hopper dredge in 90 meters of water in San Francisco Bay, a benthic plume extended 700-730 meters downcurrent from the dredge. In the immediate vicinity of the dredge, an overspill surface plume merged into the lower plume, becoming a single plume about 300 meters behind the dredge.

Infrequently, surface plumes can be visible for distances of many kilometers. In these cases, plumes are usually associated with enclosed waters with high fine-sediment content and strong tidal or riverine currents, which carry the plume marineward. In an instance of peak spring tidal velocities of 1.75 m/s, H.R. Wallingford reported that very fine sand could be carried up to 11 km from a dredging site (Hitchcock and others, 1999). Another extreme case was reported by Hitchcock and others (1999) wherein detailed monitoring associated with construction of the Storebaelt Link Bridge in Denmark detected suspended sediment up to 35 km from the source.

Measurements around properly operated dredges show that elevated levels of suspended bottom sediments can be confined to several hundred meters from the cutterhead location and dissipate exponentially towards the surface with little turbidity actually reaching surface waters (Herbich and Brahme, 1991; LaSalle and others, 1991; Herbich, 2000). In many cases, the suspended sediment concentrations are no greater than those generated by commercial shipping operations or during severe storms. Storms, floods, and large tides can increase suspended sediments over much larger areas and for longer periods than dredging operations, which makes it very difficult to distinguish between dredging-induced turbidity and that generated by marine natural processes or normal navigation activities (Pennekamp and others, 1996).

Both surface and benthic plumes are usually associated with marine disposal of dredged material (open-water pipeline discharges or hopper dredge releases). Upon release, the fines can behave either as a density current (dynamic plume), or mix with the water increasing turbidity throughout the water column (passive plume). In passive plumes, concentrations are generally low and sediment falls at the settling velocity of the single particles. In dynamic plumes, the bulk density of sediment-water mixture, relative to the ambient water, determines the rate of fall.

A dense, sediment-laden dynamic plume descends rapidly through the water column as a well-defined jet of high-density fluid, entraining ambient seawater as it falls. At the same time, a passive plume arises from turbidity-induced entrainment of sediment along the perimeter of the dynamic plume. It has been estimated that 95-99 percent of most discharged sediment loads descend to the bottom within 30 meters of the point of discharge with only the remaining few percent being stripped from the outside of the dynamic plume (Schubel and others, 1978; Neal and others, 1978).

In extremely strong current velocities and/or in deep water, where the bottom may be thousands of feet down, a descending dynamic plume may entrain so much water that it mixes entirely with the surrounding water and loses its integrity, thus becoming a passive plume. When this occurs, sediment concentrations become relatively low and fine particles usually stay in the water column for several hours, but may remain for as much as several days before settling out. The settling zone of the passive plume can cover several kilometers resulting in no significant bottom buildup.

Passive plumes will move away from the point of discharge by three separate mechanisms, all of which are a function of hydrodynamics and particle size and shape: advection by tidal currents; diffusion by turbulence; and settling. The fine particles in a plume are advected by the current and also undergo settling. Coarser sediments will be transported a lesser distance away from the point of discharge. Non-cohesive sediments, or those greater than sand size (>2mm) are generally considered to fall to the seabed immediately (Hitchcock and others, 1999). As the current velocity increases, advection becomes relatively more important in spreading the suspended sediment. Concentrations rapidly decrease with increasing distance downstream or downcurrent from the discharge point and laterally away from the plume center line due to settling and horizontal dispersion of the suspended solids (Bernard, 1978). Barnard (1978) presents a plot showing the relationship of suspended-solids concentrations along the plume centerline and distance down-current from several open-water pipeline disposal operations.

The duration of turbidity in water is largely based on the fall velocity of the sediment particles. Fall velocity depends on size, shape, and density of the particles as well as the fluid density, viscosity, and several other parameters. When a particle falls through water, it accelerates until it reaches its fall velocity, or the terminal velocity that a particle reaches when the retarding drag force on the particle just equals the downward gravitational force. While low concentrations of silt and clay (with diameters <0.03 mm) settle very slowly and cause more persistent plumes, under certain conditions, clay particles may collide to form aggregates or flocs with diameters of 0.1 to 2.0 mm. The formation of flocs increases settling velocity, which results in a more rapid decrease in suspended-sediment concentration with distance from the source (Barnard, 1978).

When a dynamic plume impacts the seafloor, it causes a horizontal, radially-spreading bottom surge outward across the seabed as a density underflow plume until its velocity and turbulence are sufficiently reduced to permit deposition. The greater the thickness and solids content of the layer, the greater the density flow effect. Generally, these underflow plumes originate as turbulent flows, characterized by chaotic motions and a billowing head just behind the leading edge and decay with deceleration to laminar underflow after spreading a short distance (Thevenot and others, 1992). Since turbulent underflows generally entrain ambient water, they grow vertically and tend to have lower concentrations than laminar underflows (Teeter, 2000a). The sediments ultimately form a low-gradient circular or elliptical fluid mud mound consisting of high-density (nonflowing) mud overlain by a surface layer of low-density (flowing) fluid mud (Barnard, 1978). Depending on the volume of material, these mounds can measure several feet thick (Holliday, 1978).

Tides also affect plume dispersion with plumes extending landward and seaward during the incoming flood tides and the outgoing ebb tides, respectively (Barnard, 1978).

Beach-Nourishment Turbidity

Suspended-sediment related issues are often a concern during beach-nourishment activities and afterward, while the new beach responds to the prevailing wave regime. Surprisingly, few attempts have been made to actually monitor and quantify turbidity conditions. Most of the literature regarding suspended sediments in the swash, surf, and nearshore environments addresses sand-transport dynamics and faunal effects rather than the distribution of re-suspended fine sediments. However, based on observations and the available studies, it is generally agreed that turbidity resulting from placement of sand on the beach face in beach nourishment and other sediment management projects is even more localized and transitory than offshore or enclosed-water operations. This is largely attributable to the use of nourishment material that is low in clay and silt and resembles as closely as possible the indigenous beach sand.

Generally, beach-nourishment projects on high-energy beaches quickly equilibrate with the current wave regime. Finer sediments are promptly winnowed from the nourishment material, causing only a short period of elevated turbidity. Parr and others (1978) noted that the silt and clay fractions were quickly winnowed from the nourishment material placed on Imperial Beach, California, and that after four months, the grain-size distribution of the nourishment fill was comparable to the indigenous beach sand.

In another study of beach nourishment on North Carolina beaches during 2001 and 2002, it was concluded that plumes caused by sand placement and de-watering on the beach face were small, short-lived, and did not create large increases in turbidity over background conditions (Versar, Inc., 2004). Sampling conducted immediately following nourishment and again one year later, demonstrated that turbidity generated by the pipeline discharge hugged the shoreline following the long-shore currents. While elevated turbidity spikes were associated with the discharge pipe itself, in most cases the plumes were not discernable from turbidity created by breaking waves in the surf zone a few hundred meters away or turbidity when dredging operations were temporarily shut down. Elevated suspended-sediment loads outside of the surf zone were rarely observed. Increases in turbidity detected during the second year of sampling were attributed to storm events and high surf conditions.

Perhaps one of the more definitive studies was conducted by the USACE between 1997 and 1999. During this period, the Corps completed one of the largest beach-nourishment projects on record, placing 19.39 million cubic meters of sand (<10% silt and clay) on 47 km of high-energy New Jersey beaches. Detailed sampling revealed little evidence of short-term elevated turbidity in the nearshore environment. Elevated turbidity was limited to a narrow swath (less than 500 m) in the swash zone in the immediate vicinity of the operation with a lateral extent on the order of several hundred meters. While discharge effluents ranged as high as 1048 g/l, observed concentrations decayed rapidly with dispersal through the surf zone to concentrations between <10mg/l to 34 mg/l, which are levels that many of the indigenous fish and invertebrate species experience in estuaries or during storm-induced turbidity (Burlas and others, 2001).

Post-storm monitoring of the swash, surf, and nearshore zones after hurricanes Dennis and Floyd in 1999 indicated that beach sediments at both recently filled and undisturbed beaches were equally susceptible to re-suspension. Suspended-sediment concentrations were generally comparable to slightly higher in the swash, surf, and near shore zones adjacent to the newly restored beaches as compared to undisturbed reference beaches. Only in a few samples from the swash zone of the nourished beach were suspended solids concentrations markedly elevated (Burlas and others, 2001).

DIFFICULTIES IN PLUME-PREDICTION AND MODELING

While many turbidity plumes have been qualitatively described both during and after dredging and beach-nourishment activities, it is difficult to ascribe the results of many studies in more than a general way. Few quantitative studies of short- and long-term plume behavior have been conducted. As a result, development of an accurate and universally applicable model of turbidity induced by dredging, beach nourishment, or other activities associated with largely cohesive sediments is considered nearly impossible (Pennekamp and others, 1996). This is largely because plumes, driven by tidal, wave, and current forces, can change dynamically over large spatial scales (both horizontally and vertically) and short time scales. Data collected at points in time at fixed locations are generally insufficient to rigorously assess the potential dispersion of suspended sediments. The development of widely applicable models is also hindered by the large number of parameters involved and the complications introduced by the dynamic temporal and spatial nature of plumes. Suspended-sediment dispersion is controlled by both operational parameters (dredge type and technique, method of overboard returns, speed) and the interaction of environmental parameters and physical properties. Water properties include depth, temperature, viscosity, stratification, and salinity; sediment properties include background levels of suspended solids, material composition, density, size, particle size distribution (individual grains or flocs), and solids concentration of the slurry; hydrodynamic forces include currents, waves, turbulence, all of which cause horizontal and vertical mixing; and other influences include buoyancy (entrapped air or gas), initial momentum on entering the water body, etc. The behavior and characteristics of a turbidity plume can only be evaluated if the complex interactions between the parts are taken into consideration.

Barnard (1978) offered one of the earlier methods of prediction of turbidity plumes from open-water sediment disposal activities requiring only six input parameters including dredge size, water depth, current velocity, sediment diameter or settling velocity, diffusion velocity, and the “age” of the plume to determine the worst case dimensions of the plume.

More recently, the USACE developed models and software in an effort to evaluate several aspects of suspended sediment behavior. The Dredging Research Program developed the PLUme MEasurement System (PLUMES) model (Kraus and Thevenot, 1992), which utilized commercially available broad-band acoustic Doppler current profiling equipment to measure sediment concentration and three dimensional (3-D) fluid velocity at dredging sites and to document the actual movement of sediment plumes.

The Dredging Research Program also developed the Short-Term FATE (STFATE) model (Johnson and others, 1993; Johnson and Fong 1993) as one module of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) (Schroeder and Palermo, 1990). The STFATE software evaluates the short-term behavior of dredged material discharges in open water during and immediately after a surface discharge. The model was primarily designed to model disposed hazardous material mounds on the seafloor, but it can also be used to predict what portion of the discharge is dispersed as a passive plume. The model output includes a time history of the descent and collapse phases of the discharge and suspended-sediment concentrations for various particle-size ranges as a function of depth and time. At the conclusion of the model simulation, the thickness of the deposited material on the bottom is given.

The STFATE model was followed by development of the Long Term FATE (LTFATE) model (Scheffner and others, 1995). LTFATE modeling software was designed to assess the long-term fate and stability of dredged material disposal sites with an emphasis on seabed accumulations of disposed material.

More recently, the USACE, in conjunction with Applied Science Associates (ASA), developed the Suspended Sediment FATE (SSFATE) numerical modeling system to model suspended sediment plume behavior from dredging operations (Johnson and others, 2000). The software allows the running of multiple simulations in a short period of time so that alterative scenarios can be evaluated to determine those with the least potential for adverse environmental impact. The program evaluates sediment sources resulting from the operation of cutterhead, hopper, or clamshell dredges and differentiates the relative contribution of each type of suspended sediments to the water from bottom re-suspension and surface discharges. While this application is available to USACE staff, ASA has retained the distribution and marketing rights for non-USACE users. The model is currently undergoing upgrading following field testing, after which ASA intends to market the application.

Our research of the literature did not reveal reliability or success of these models as determined by any field-testing.

RECOMMENDATIONS

- Follow up on the field testing and potential availability of the updated SSFATE model.

CSMW TASK TWO

Bibliography

REFERENCES CITED

Barnard, W.D., 1978, Prediction and control of dredged material dispersion around dredging and open-water pipeline disposal operations: U.S. Army Corps of Engineers Waterways Experiment Station Technical Report DS-78-13, Vicksburg, MS., 112 p. http://www.wes.army.mil/el/dots/pdfs/ds78-13/ds78-13a.pdf

Burlas, M., Ray, G., and Clarke, Douglas, 2001, The New York District's biological monitoring program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project: U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
http://www.nan.usace.army.mil/business/prjlinks/coastal/asbury/manual/Title.pdf

Byrnes, M.R., Hammer, R.M., Vittor, B.A., Kelley, S.W., Snyder, D.B., Côté, J.M., Ramsey, J.S., Thibaut, T.D., Phillips, N.W., and Wood, J.D., 2003, Collection of environmental data within sand resource areas offshore North Carolina and the environmental implications of sand removal for coastal and beach restoration: U.S. Department of the Interior, Minerals Management Service, OCS Report MMS 2000-056, Leasing Division, Sand and Gravel Unit, Herndon, VA., Volume I: 256 p. + Volume II (Appendices), 69 p.
http://www.oceanscience.net/mms_nj_ny/related_nc.htm

Herbich, J.B., 2000, Handbook of dredging engineering (2nd ed.): McGraw-Hill Inc., New York, New York.

Herbich, J.B. and Brahme, S.B., 1991, Literature review and technical evaluation of sediment resuspension during dredging: Contract Report HL-91-1 for U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS, 87 p.

Hitchcock, D.R., Newell, R.C. & Seiderer, L.J., 1999, Marine aggregate mining benthic and surface plume study– Final Report: MMS OCS Study 99-0029, Contract Report for the U.S. Department of the Interior, Minerals Management Service. Contract Number 14-35-0001-30763. Coastline Surveys Ltd., 168 p.
http://www.mms.gov/itd/pubs/1999/99-0029/plumestudy.htm

Holliday, B. W., 1978, Processes affecting the fate of dredged material: Technical Report DS-78-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/pdfs/ds78-2.pdf

Johnson, B.H., Andersen, E., Isaji, T., Teeter, A. M., and Clarke, D. G., 2000, Description of the SSFATE numerical modeling system: *DOER Technical Notes*

Collection TN-DOER-E10, U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS.
http://www.wes.army.mil/el/dots/doer/pdf/doere10.pdf

Johnson, B.H., and Fong, M.T., 1993, Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water: Report 2, theoretical developments and verification results, Technical Report DRP-93-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Johnson, B.H., McComas, D.N., McVan, D.C., and Trawle, M.J., 1993, Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water; report 1, physical model tests of dredged material disposed from a split-hull barge and multiple bin vessel: Technical Report DRP-93-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Kraus, N.C., and Thevonot, M.M., 1992, The PLUme Measurement System (PLUMES): first announcement: Technical Report DRP-1-06, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/drptnote/drp1-06.pdf

LaSalle, M. W., Clarke, D. G., Homziak, J., Lunz, J. D., and Fredette, T. J., 1991, A framework for assessing the need for seasonal restrictions on dredging and disposal operations: Technical Report D-91-1, U.S. Army Corps of Engineers Waterway Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/pdfs/trd91-1.pdf

McClellan, T. N., Havis, R. N., Hayers, D. F., and Raymond, G. L., 1989, Field studies of sediment resuspension characteristics of selected dredges: Technical Report HL-89-9, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Mulder, T. and Syvitski, J.P.M., 1995, Turbidity currents generated at river mouths during exceptional discharges to the world oceans: Journal of Geology v. 103, p. 285-299.

Neal, R.W., Henry, G., and Greene, S.H., 1978, Evaluation of the submerged discharge of dredged material slurry during pipeline dredged operations: Technical Report D-78-44, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Nielsen, P.E., 1997, Sediment spill and sedimentation in connection with dredging and construction work in marine environments: Report submitted to the 1997 meeting of the ICES Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem, Copenhagen.

Parr, T., Diener, D. and Lacy, S., 1978, Effects of beach replenishment on the nearshore sand fauna at Imperial Beach, California: Miscellaneous Report 78-4. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.

Parsons, J.D., Bush, J.W.M., and Syvitski, J.P.M., 2001, Hyperpycnal plume formation from riverine outflows with small sediment concentrations: Sedimentology, v. 48, p. 465-478. (Good discussion of sediment dispersal from river generated hypopycnal density currents).

Pennekamp, J.G.S., Epskamp, R.J.C., Rosenbrand, W.F. , Mulle, A., Wessel, G.L., Arts, T., and Deibel, I.K., 1996, Turbidity caused by dredging: viewed in perspective: Terra et Aqua 64, p. 10-17.

Pennekamp, J.G.S. and Quaak, M., 1990, Impact on the environment of turbidity caused by dredging: Terra et Aqua, v. 42, p. 10-20

Scheffner, N.W., Theviot, M.M., Tallent, J.R., 1995, LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; user's guide: Internal Report DRP-95-I, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS (Detailed user guide LTFATE modeling software). www.wes.army.mil/el/elmodels/pdf/drp-95-1.pdf

Schroeder, P. R., and Palermo, M. R., 1990, Automated dredging and disposal alternatives management system (ADDAMS), User's Guide: Technical Note EEDP-06-12, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. http://www.wes.army.mil/el/elmodels/pdf/ee-06-12.pdf
(Users guide for the Automated Dredging and Disposal Alternatives Management System (ADDAMS) software suite including the Short Term Fate of Dredged Material Disposal (STFATE) application.)

Schubel, J.R., Carter, H.H., Wilson, R.E., Wise, W.M., Heaton, M.G., and Gross, M.G., 1978, Field investigations of the nature, degree, and extent of turbidity generated by open-water pipeline disposal operations: Technical Report D-78-30, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. http://www.wes.army.mil/el/dots/pdfs/trd78-30/cover.pdf

Teeter, A.M., 2000a, Underflow spreading from an open-pipeline disposal: Technical Report DOER-N7, U.S. Army Research and Development Center, Vicksburg, MS. (A discussion of the mixing and dispersion processes, with emphasis on underflow spreading, involved in open-water pipeline discharges from hydraulic dredging operations).
http://www.wes.army.mil/el/dots/doer/pdf/doern7.pdf

Thevenot, M.M., Prickett, T.L., and Kraus, N.C., 1992, Tylers Beach, Virginia, dredged material plume monitoring project: 27 September to 4 October 1991: Technical Report DRP-92-7, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Versar, Inc., 2004, Year two recovery from impacts of beach nourishment on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina – final study findings: Report prepared for the U.S. Army Corp of Engineers, Wilmington District under contract No. DACW54-00-D-0001, 128 p.
http://www.saw.usace.army.mil/wilmington-harbor/WilmingtonYear2.pdf

ADDITIONAL REFERENCES

Bokuniewicz, H.J., Gerbert, J., Gordon, R.B., Higgins, J.L., Kaminsky, P., Pilbeam, C.C., Reed, M., and Tuttle, C., 1978, Field study of the mechanics of the placement of dredged material at open-water disposal sites: Technical Report D-78-7, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Brandsma, M.G. and Divoky, D.J., 1976, Development of models for prediction of short termed fate of dredged material discharged in the estuarine environment: Contract Report D-76-5, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Brooks, N.H., 1973, Dispersion in hydrologic and coastal environments: Pacific Northwest Water Quality Laboratory, Northwest Region, U.S. Environmental Protection Agency, Corvallis, OR.

Burks, S. A., and Engler, R. M., 1978, Water quality impacts of aquatic dredged material disposal (laboratory investigations): Technical Report DS-78-4, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Burt, T.N. and Csiti, A., 1999, Reuse, recycle or relocate: International Association of Dredging Companies (IADC)/Central Dredging Association (CEDA) Guidebook No. 5, The Hague, Netherlands, 104 p. (Guidebook covering the disposal of all types of dredged material and potential control measures to reduce or eliminate unacceptable impacts.

Clausner, J.E., Palermo M.R., Banks, D., and Palmerton, J., 1996, Potential application of geosynthetic fabric containers for open water placement of contaminated dredged material: Environmental Effects of Dredging Technical Note EEDP-01-39, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/pdfs/eedp01-39.pdf

Dankers, P.T.J., 2002, The behaviour of fines released due to dredging - a literature review: Delft University of Technology, the Netherlands, 59 p. (A technical review literature pertaining to fine sediment settlement in passive and dynamic sediment plumes).
http://sandpit.wldelft.nl/reportpage/right/SandpitLiteratureReviewDankers.pdf

Dortch, M.S., Hales, L.Z., letter, J.V., and McAnally, W.H., Jr., 1990, Methods of determining the long-term fate of dredged material for aquatic disposal sites: Technical Report D-90-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/pdfs/trd90-1/cover.pdf

Drapeau, G., Lavallee, D., Dumais, J.F., and Walsh, G., 1992, Dispersion model of dredge spoil dumped in coastal waters, *in* Edge, B.L., ed., Coastal Engineering 1992: Proceedings of the Twenty-third International Conference Venice, Italy, October 4-9, New York, American Society of Civil Engineers, p. 3054-3067.

Fredette, T.J., Bohlen, W.F., Rhoads, D.C., and Morton, R.W., 1989, Erosion and resuspension effects of Hurricane Gloria at Long Island Sound dredged material disposal sites: Environmental Effects of Dredging Information Exchange Bulletin Volume D-89-2, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Gailani, J. Z., 2002, Improved sand transport model for LTFATE version 2.0: DOER Technical Notes Collection, ERDC TN-DOER-N15, U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS.
www.wes.army.mil/el/dots/doer/pdf/doern15.pdf
(Improved Sand Transport Model for LTFATE (Version 2.0)

Gailani, J. Z., Howlett, E., Isaji, T., and Galagan, C., 2001, Graphical user interface for LTFATE Version 2.0: DOER Technical Notes Collection, ERDC TN-DOER-N8, U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS.
www.wes.army.mil/el/dots/doer/pdf/doern8.pdf
(Graphical user interface for LTFATE Version 2.0)

Gajewski, L.S. & Uscinowicz, S., 1993, Hydrologic and sedimentologic aspects of mining marine aggregate from the Slupsk Bank (Baltic Sea): Marine Georesources and Geotechnology v. 11, p. 229-244.

Gordan, R., 1974, Dispersion of dredged spoil dumped in near-shore waters: Estuarine and Coastal Marine Science, v. 2, pp. 349-58.

Hales, L.Z., 1996, Analysis of dredged material disposed in open water: summary report for technical area 1: U.S. Army Corps of Engineers Research and Development Center Dredging Research Program (DRP) Technical Report TR-DRP-96-4, U.S. Army Research and Development Center, Vicksburg, MS.
http://libweb.wes.army.mil/uhtbin/cgisirsi/x/0/49/1?new_gateway_db=HYPERION

Hitchcock, D.R. and Drucker, B.R. 1996, Investigation of benthic and surface plumes associated with marine aggregate mining in the United Kingdom, *in* The Global Ocean – Towards Operational Oceanography: Proceedings of the Oceanology International 1996 Conference, Spearhead Publications, Surrey, U.K., p. 221-234.

Hitchcock, D.R., Newell, R.C., and Seiderer, L.J., 2002, Integrated report on the impact of marine aggregate dredging on physical and biological resources of the sea bed: U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), OCS Report Number 2000-054.

Holliday, B. W., Johnson, B.H., and Thomas, W.A., 1978, Predicting and monitoring dredged material movement: Technical Report DS-78-3, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/pdfs/ds78-3.pdf

Hoyal, D.C.J.D., Bursik, M.I. and Atkinson, J.F., 1999a, Settling-driven convection: a mechanism of sedimentation from stratified fluids: Journal of Geophysical Research, v. 104, p. 7953-7966.

Hoyal, D.C.J.D., Bursik, M.I. and Atkinson, J.F., 1999b, The influence of diffusive convection on sedimentation from buoyant plumes: Marine Geology, v. 159, p. 205-220.

Huppert, H.E. and Simpson, J.E., 1980, Slumping of gravity currents: Journal of Fluid Mechanics, v. 99, p. 785-789.

Jensen, A and Mogensen, B, 2000, Effects, ecology and economy 2000: International Association of Dredging Companies (IADC)/Central Dredging Association (CEDA) Guidebook No. 6, The Hague, Netherlands, 120 p. (Guidebook examining the natural and anthropogenic effects of dredging and reclamation projects, environmental and socioeconomic effects, and remedial dredging with in-depth international case studies).

Johnson, B.H., 1979, Application of the instantaneous dump dredged material disposal model to the disposal of San Diego Harbor material at the 45 and 100 fathom disposal sites: Internal Working Document, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Johnson, B.H., 1990, User's guide for models of dredged material disposal in open water: Technical Report D-90-5, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
http://www.wes.army.mil/el/dots/pdfs/trd90-5.pdf

Johnson, B.H., Trawle, M.J., and Adamec, S.A., Jr., 1988, Dredged material disposal modeling in Puget Sound: Journal of Waterway, Port, Coastal and Ocean Engineering, v. 114, p. 700-713.

Kerr, S.J., 1995, Silt, turbidity and suspended sediments in the aquatic environment: an annotated bibliography and literature review: Technical report TR-008, Ontario Ministry of Natural Resources, Southern Region Science and Technology Transfer Unit, 277 p.

Keunen, Ph.H., 1968, Settling convection and grain-size analysis: Journal of Sedimentary Petrology v. 38, p. 817-831.

Koh, R.C.Y. and Chang, Y.C., 1973, Mathematical model for barged ocean disposal of waste: Environmental Protection Technology Series, U.S Environmental Protection Agency, Washington, D.C.
Kuo, A.Y., and Hayes, D.F., 1991, Model for turbidity plume induced by bucket dredge: Journal of Waterway, Port, Coastal and Ocean Engineering, v. 117, p. 610-623.

Kuo, A.Y., Welch, C.S., and Lukens, R.J., 1985, Dredge induced turbidity plume model: Journal of Waterway, Port, Coastal and Ocean Engineering, v. 111, p. 476-494.

Kraus, N.C., 2000, Mobile, Alabama, Field Data Collection Project, 18 August-2 September 1989: Report 1, Dredged Material Plume Survey Data Report, Technical Report DRP-91-3, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Land, J., Kirby, R. & Massey, J.B., 1994, Recent innovations in the combined use of acoustic doppler current profilers and profiling silt meters for suspended solids monitoring: Proceedings of the 4th Nearshore and Estuarine Cohesive Sediment Transport Conference, Hydraulics Research Wallingford, U.K., 10 p.

Maxworthy, T., 1983, The dynamics of double-diffusive gravity currents: Journal of Fluid Mechanics, v. 128, p. 259-282.

Maxworthy, T., 1999, The dynamics of sedimenting surface gravity currents: Journal of Fluid Mechanics, v. 392, p. 27-44.

Moore, P.G., 1977, Inorganic particulate suspensions in the sea and their effects on marine animals: Oceanographic Marine Bulletin, v. 15, p. 225–364.

Morehead, M.D. and Syvitski, J.P., 1999, River plume sedimentation modeling for sequence stratigraphy: application of the Eel Shelf, California: Marine Geology, v. 154, p. 29-41.

Mulder, T., Syvitski, J.P.M., and Skene, J., 1998, Modeling of erosion and deposition by sediment gravity flows generated at river mouths: Journal of Sedimentary Research, v. 67, p. 124-137.

Nakai, O., 1978, Turbidity generated by dredging projects: Proceedings of the 3rd U.S./Japan Experts Meeting, EPA-600/3-78-084, p. 31-47.

Naqvi, S.M. and Pullen, E.J., 1995, Environmental issues associated with beach nourishment, *in* Beach nourishment and protection, Committee on Beach Nourishment and Protection, Marine Board, Commission on Engineering and Technical Systems, National Academy Press, Washington, D.C., p. 107-126.
http://www.nap.edu/books/0309052904/html/

Newell, R.C. Seiderer, L.J. and Hitchcock, D.R., 1998, The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed: Oceanography and Marine Biology, An Annual Review, v. 36, p. 127-178.

Nichols, M.N., Thompson, G.S., and Faas, R.W., 1978, A field study of fluid mud dredged material; its physical nature and dispersal: Technical Report D-78-40, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Ogston, A.S., Cacchione, D.A., Sternberg, R.W. and Kineke, G.C., 2000, Observations of storm and river flood-driven sediment transport on the northern California continental shelf: Continental Shelf Research, v. 20, p. 2141-2162.

Palermo, M.R., Williams, G. L., Fredette, T.J., and Randall, R.E., 1998, Guidance for subaqueous dredged material capping: Technical Report DOER-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS., 151 p.
http://www.wes.army.mil/el/dots/doer/pdf/trdoer1.pdf
(A good discussion of the short and long term fate of subaqueous dredged material disposal dispersion in the water column over time. Includes a description of, examples, and sources for the Short-Term Fate (STFATE) modeling software which calculates and displays sediment dispersal in the water column versus time).

Peddicord, R.K. and McFarland, V.A., 1978, Effects of suspended dredged material on aquatic animals: Technical Report D-78-29, U.S. Army Corps of Engineers Waterways Experiment Station, Dredged Material Research Program, Vicksburg, MS, 102 p.

Pequegnat, W. E., 1978, An assessment of the potential impact of dredged material disposal in the open ocean: Technical Report D-78-2, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Puckett, T.P., 1998, Evaluation of dredged material plumes – physical monitoring techniques: DOER Technical Notes Collection DOER-E5, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS (Discussion of the available technologies available for monitoring turbidity plumes).
http://www.wes.army.mil/el/dots/doer/pdf/doere5.pdf

Reine, K.J., Clarke, D.G., and Dickerson, C., 2000, Acoustic characterization of suspended sediment plumes resulting from barge overflow, DOER Technical Note DOER-E15, U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS.
www.wes.army.mil/ed/dots/doer/pdf/doere15.pdf

Roberts, P.J.W., Ferrier, A., and Johnson, B.H., 1994, New techniques for experimental studies of dredged material dispersion: Proceedings of Dredging '94, American Society of Civil Engineers, New York, p. 1192-1200.

Rodolfo, K., 1964, Suspended sediment in southern California waters: M.S. thesis, University of Southern California.

Scheffner, N.W. and Tallent, J.R., 1994, Dispersion analysis of the Charleston, South Carolina, ocean dredged material disposal site: Miscellaneous Paper DRP 94-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Sherk, J.A., Jr., 1971, The effects of suspended and deposited sediment on estuarine organisms: Literature summary and research needs: University of Maryland Natural Resources Institute, Chesapeake Biological Laboratory Contribution No. 43, 73 p.

Skene, K., Mulder, T., and Syvitski, J.P.M., 1997, INFLO1: A model predicting the behaviour of turbidity currents generated at a river mouth: Computers and Geoscience, v. 23, p. 975-991

Stern, E.M., and Stickle, W.B., 1978, Effects of turbidity and suspended material in aquatic environments: literature review: Technical Report D-78-21, U.S. Army Corps of Engineers Waterways Experiment Station, Dredged Material Research Program, Vicksburg, MS., 117 p.

Sternberg, R.W., Berhane, I. and Ogston, A.S., 1999, Measurement of size and settling velocity of suspended aggregates on the Northern California continental shelf: Marine Geology, v. 154, p. 43-53.

Syvitski, J.P.M., 1995, Turbidity currents generated at river mouths during exceptional discharge to the world oceans: Journal of Geology, v. 103, p. 285-298.

Teeter, A.M., 2000b, Simulating underflow spreading from a shallow-water pipeline disposal: Technical Note DOER-N11, U.S. Army Research and Development Center, Vicksburg, MS. (Discusses a numerical model for predicting the footprint, concentration, and fate of the density driven underflow of pipeline disposal sediments) http://www.wes.army.mil/el/dots/doer/pdf/doern11.pdf

Teeter, A.M., 2002, Sediment dispersion near dredge pipeline discharge in Laguna Madre, Texas: Technical Report DOER-N16, U.S. Army Research and Development Center, Vicksburg, MS. (A discussion of the mixing and dispersion processes involved in shallow water pipeline dredge discharges).
http://www.wes.army.mil/el/dots/doer/pdf/doern16.pdf

Thevenot, M.M. & Johnson, B.H., 1994, Verification of numerical modeling of the fate of disposed dredged material, *in* Clarke McNair, E., ed., Dredging '94: Proceedings of the 2nd International Conference on Dredging & Dredged Material Disposal, p. 180-189.

Thistle, D. 1981. Natural physical disturbances and communities of marine soft bottoms: Marine Ecology Progress Series, v. 6, p. 223-228.

Truitt, C.L., 1986, Fate of dredged material during open-water disposal: Environmental Effects of Dredging Programs Technical Note EEDP-01-2, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. http://www.wes.army.mil/el/dots/pdfs/eedp01-2.pdf

Tubman, M., Brumley, B. & Puckette, P., 1994, Deep water dredged material disposal monitoring offshore of San Francisco using the Plume Measurement System (PLUMES), *in* Clarke McNair, E., ed., Dredging '94: Proceedings of the 2nd International Conference on Dredging & Dredged Material Disposal, p. 86-95.

U.S. Army Corps of Engineers, 1978, Predicting and monitoring dredged material movement: U.S. Army Engineer Research and Development Center Environmental Effects of Dredging Program (EEDP) Technical Report TR-DS-78-3, U.S. Army Research and Development Center, Vicksburg, MS. http://libweb.wes.army.mil/uhtbin/cgisirsi/x/0/49/1?new_gateway_db=HYPERION

U.S. Army Corps of Engineers, 1983, Dredging and dredged material disposal**,** U.S. Army Corps of Engineers Engineering Manual EM 1110-2-5025, Washington, D.C., p. 4.4-4.16 (Excellent discussion of parameters affecting sediment suspension, turbidity plumes, and dispersion behavior by various types of dredging and disposal operations). http://www.usace.army.mil/publications/eng-manuals/em1110-2-5025/toc.htm

U.S. Army Corps of Engineers, 1986, Fate of dredged material during open-water disposal: U.S. Army Engineer Research and Development Center Environmental Effects of Dredging Program (EEDP) Technical Note - EEDP-01-2, U.S. Army Research and Development Center, Vicksburg, MS. http://libweb.wes.army.mil/uhtbin/cgisirsi/x/0/49/1?new_gateway_db=HYPERION

U.S. Army Corps of Engineers, 1987, Beaches and beach nourishment, *in* Engineering and Design - Beneficial Uses of Dredged Material**:** U.S. Army Corps of Engineers Engineering Manual EM 1110-2-1204, Washington, D.C., pp. 4.5-4.11 (Provides an overview of potential impacts of fine sediment turbidity from beach replenishment and their relative duration on marine flora and fauna. Numerous references to studies regarding impacts on fauna). http://www.usace.army.mil/publications/eng-manuals/em1110-2-1204/entire.pdf

U.S. Army Corps of Engineers, 2002, Coastal sediment properties, U.S. Army Corps of Engineers Engineering Manual 1110-2-1100 (Part III), Washington, D.C., p. 21-26 (A concise summary of the mathematics and variables determining fall velocity of sediments in the water column, with example calculations). http://www.usace.army.mil/publications/eng-manuals/em1110-2-1100/PartIII/PartIII.htm

WBM Oceanics Australia, 1995, Spitfire Channel Dredging Turbidity Monitoring Report: Prepared for Port of Brisbane Corporation.

WBM Oceanics, 2002, Moreton Bay sand extraction study – phase I: Queensland Environmental Protection Agency/Queensland Parks and Wildlife Service, Moreton Bay Sand Extraction Study Steering Committee, Queensland, Australia, 236 p. (Includes results of turbidity plume monitoring for coarse sand dredging in Moreton Bay, Queensland, Australia).
http://www.epa.qld.gov.au/environmental_management/coast_and_oceans/beaches_and_dunes/moreton_bay_sand_extraction_study/

Weiergang, J., 1995, Estimation of suspended sediment concentrations based on single frequency acoustic doppler profiling: Proceedings of the 14th World Dredging Congress, Amsterdam, p. 865-875.

Whiteside, P.G.D, Ooms, K. and Postma, G.M., 1995, Generation and decay of sediment plumes from sand dredging overflow: Proceedings of the 14th World Dredging Congress, Amsterdam, Netherlands, p. 877-892.

Willoughby, M.A., Crabb, D.J. ,1983, The behaviour of dredge generated sediment plumes in Moreton Bay: Proceedings of the Sixth Australian Conference on Coastal and Ocean Engineering, Gold Coast, July 13-15, p. 182-186.

RESULTS FROM CSMW TASK 3

(Beach Nourishment Projects – Performance and Sediment Characteristics)

TASK 3 – Compile known and available information on: the types and grain size distribution of sands that have been used for nourishment projects along the important California beaches; observed end results of nourishment projects; the basis for limitation placed on the percentage of allowable finer grained materials in nourishment projects. Include any information gathered on existing grain size distributions at those important beaches.

BACKGROUND

There are many variables that affect the success or failure of beach replenishment/nourishment projects. One of the main criteria for defining the "success" of such projects is the longevity of the "fill," or borrow material, placed during individual episodes of nourishment. For example, given a volume of fill emplaced in a beach system, managers and engineers want to know what percentage of that fill is retained in the littoral cell after a given period of time. How a fill performs with time is a function of the interaction of several conditions and properties. Some of these include local wave and current conditions; technique and location of fill placement; and the reliability of the monitoring method. The interactions will determine if a fill remains in the system longer or shorter than expected.

One property of interest in the performance of fills is the physical compatibility between the fill material and the "native" material of the beach where the fill is to be placed. "Compatibility" refers to the degree of similarity of the two materials and includes the size, type (mineralogy), color, density, and shape of the component sediment grains. Typically, size is the most commonly evaluated in trying to match a fill material with a native material mainly because of its potential mechanical performance within the dynamics of the beach environment. Grain type and color can locally be important because of aesthetic or health/safety concerns. A textbook on beach nourishment and protection published by the National Research Council (1995) presents a brief discussion of sand compatibility; various papers are cited that discuss the pros and cons of continued use of grain-size comparisons between fill and native materials as measures of beach performance. Also, the Coastal Engineering Manual (U.S. Army Corps of Engineers, 2002) has sections on beach-fill design and performance.

There are three main concerns with grain size. First, if the percentage of fines (clay- and silt-sized grains) in the fill is too high, a correspondingly larger volume of fill material must be emplaced in the beach system to allow for loss of the fines with time caused by winnowing action of the waves. Second, too high of a percentage of fines in a beach sand is recreationally undesirable – there may be clumping of the material, for example.

Third, fines can harbor or attract contaminants, which may be hazardous to humans and sea life; placement of a contaminated material on a beach system can be detrimental.

Beach Replenishment/Nourishment in California

Beach replenishment/nourishment began in California at least as early as 1919 (Coyne, 2000). Several hundred episodes of replenishment and periodic nourishment have occurred at several dozen beach systems along the coast. Most of these have been in southern California, particularly in the Santa Barbara and Ventura areas, and along the coastlines of Santa Monica Bay, Orange County, and San Diego County.

Currently (2004), there is reportedly only one beach replenishment/nourishment project currently underway in the San Francisco District of the U.S. Army Corps of Engineers, which extends from the Oregon border to just north of the San Luis Obispo-Monterey County line. This project consists of disposal of dredge material at Ocean Beach in San Francisco. In the Los Angeles District, which covers the remainder of the coast to the Mexico border, there are many on-going projects. Some are related to harbor maintenance: those at Santa Barbara, Ventura, Channel Islands, and Oceanside are done annually, while those at Morro Bay, Playa del Rey, and Mission Beach are done infrequently. As an example unrelated to disposal of dredged material, nourishment was recently accomplished at Goleta in Santa Barbara County.

Tracking the history and performance of these projects and individual episodes of replenishment/nourishment is a challenge largely because of the inconsistent documentation and because the information is commonly in unpublished files or reports. Through sponsorship of the California Coastal Commission and California Department of Boating and Waterways, Melanie Coyne, a National Oceanographic and Atmospheric Administration (NOAA) Fellow, researched and compiled the most comprehensive list of beach nourishment projects along the coast of California (Coyne, 2000). Presented here in modified form as Table A2, this list covered projects up to the year 2000. Also included here as Table A3 is Coyne's list of references that she consulted to compile the data and information. As an update to the list since 2000, we have added the individual replenishment/nourishment episodes of the SANDAG Regional Beach Sand Project as documented by Coastal Frontiers Corporation (2004).

Historically, most of the replenishment/nourishment activities in California have been pursued as local, rather than regional, projects. They have been dominantly "opportunistic" projects, meaning that beach restoration was not the primary purpose of the placement of fill. Rather, the beach systems were the receiving (disposal) sites for dredged material from other primary activities such as harbor construction or channel maintenance. Only in recent years has the number of "deterministic" projects become more common. In these projects, beach restoration through replenishment and nourishment is the primary purpose. The recently instituted Regional Beach Sand Project of the San Diego Association of Governments (SANDAG) is the first regional deterministic beach-nourishment program on the Pacific Coast of the United States.

CHARACTER OF FILL MATERIAL AND NATIVE MATERIAL

Data and information on the physical character of sediment involved in beach replenishment/nourishment projects along the coast of California range from sparse to well-documented. One of the main influences on documentation is whether a project is deterministic or opportunistic. Deterministic projects generally have greater testing of materials because of regulatory or economic considerations and requirements; the fill materials are commonly taken for a fee from virgin sources, which have unknown or poorly known characteristics. In contrast, testing is commonly less rigorous in opportunistic projects, particularly if a source for the fill material has been used previously and there are few or no reported problems of compatibility with the native material. The receiver beaches are generally very close to the sources of fill (e.g., bypassing operations) because of the desire to minimize transportation costs. Consequently, the fill material may be very similar in character to what would have been deposited naturally at the receiver beach.

Another factor that affects documentation of the physical character of sediment is the age of the projects. Older projects were under less regulation and thus may not have the quantity and quality of test data like those of modern projects.

Types of information reported for replenishment/nourishment projects can include size, type, color, density, and shape of the component grains. Grain size is by far the most dominant characteristic analyzed and reported; results are typically presented as percentage distribution of sizes within each sediment sample based on sieve analysis. In some reports, the percentage composition by mineral type is presented.

Regarding the character of native material on beaches, many pure- and applied-research studies have been conducted at several sites along the coast of California. Some of these studies are published and thus readily available (e.g., Hutton, 1959; Trask, 1952), Other sources include more-obscure or less-easily obtained reports (e.g., Straughan, 1981; reports of the Hydraulic Engineering Laboratory at the University of California, Berkeley) As a group, this category of studies is neither systematic nor consistent in content and presentation because of differences in researchers' purposes and interests. Nonetheless, they can provide background and baseline information, particularly at beaches that have not yet been replenished.

Regarding the character of both fill materials and native materials, much data and information are also available in geotechnical reports prepared for specific replenishment/nourishment projects. For example, data on grain characteristics are commonly presented in documents, such as environmental impact reports, submitted to the California Coastal Commission as part of its permit process. Also, the U.S. Army Corps of Engineers conducts detailed sampling and analyses of sediments, which are presented in its geotechnical reports (e.g., U.S. Army Corps of Engineers, 1989; 1995; 2002b). Some of its reports are readily available, while others are not; some reside in the project files of the geotechnical branches of both the Los Angeles and San Francisco District offices, while others are at archive centers in Laguna Niguel (Los Angeles District) and San Bruno (San Francisco District).

The character of fill material and, to a much lesser extent, native material at some of the replenishment/nourishment projects in California is summarized in Table A2 (modified from Coyne, 2000) under the column heading of "dredge/fill characteristics." These entries were extracted from research of a few hundred reports. Most are qualitative descriptions rather than quantitative data.

It is worth noting that at many southern California beaches (Santa Barbara County to the Mexico border) there is probably not much truly pristine, "native" material still present. Episodes of nourishment have diluted the original natural character of the beaches, particularly where nourishment has taken place frequently over many decades. Also, because of the inherent variability in the physical nature of natural sediments, it is difficult to generalize or define representative grain characteristics for individual beaches and fill material.

To prepare a comprehensive list of grain characteristics of fill material and native material will require systematic, detailed research of published literature as well as unpublished reports and files in agencies such as the U.S. Army Corps of Engineers and the California Coastal Commission, among others.

RESULTS OF BEACH REPLENISHMENT/NOURISHMENT IN CALIFORNIA

Of paramount importance in a replenishment/nourishment project is how well the emplace material performs compared to the engineering specifications of the project. To make reliable comparisons requires the use of systematic, quantitative monitoring of the performance of beach fills. Unfortunately, it was not until about 10-20 years ago that monitoring became more routine (Leonard and others, 1989; Komar, 1997). Up to the end of the 1980s, performance data for projects on the Pacific Coast of the U.S. were less prevalent than for those for the Atlantic Coast (Leonard and others, 1989). Since then, agencies in California have been taking more coordinated, regional approaches to protecting beaches. Part of this process has been institution of monitoring programs. One example is the Regional Beach Monitoring Program of the San Diego Association of Governments (SANDAG), which began in the middle 1990s (Coastal Frontiers Corporation, 2004). Associated with this project is the Southern California Beach Processes Study (Guza and others, 2002) at Torrey Pines State Beach, which is attempting to improve understanding of how and where a recent beach fill there is being transported by waves and currents. What is learned here could be applied to design and maintenance of replenishment/nourishment projects else where along the coast of California.

Historically, written documentation of the results of beach replenishment/nourishment projects along the coast of California has been inconsistent. Commonly, results have been reported from a site-specific perspective, with an emphasis on qualitative rather than quantitative observation and measurement. Examples are presented in Cahill (1989), Clayton (1989), Leonard and others (1989), Leidersdorf and others (1993, 1994), Mesa (1996), California Department of Boating and Waterways and State Coastal Conservancy (2002), U.S. Army Corps of Engineers (2002b), and Coastal Frontiers Corporation (2004). Important overview papers for results and performance in California include those by Hall (1952), Shaw (1980), Herron (1987), Clayton (1989), and Leonard and others (1989).

The performance of beach fills at various sites in the state is briefly summarized in Table A2 (modified from Coyne, 2000) under the column heading “duration of fill.” Similar to the entries in the table for “fill characteristics” described earlier, the reported results are largely qualitative descriptions rather than quantitative measurements. Many cells in this column are blank, either because monitoring was not conducted or because the research did not discover pertinent documents with recorded results.

To date, the overall results of beach nourishment in California have been mixed. As a current example of performance and monitoring of beach fills, Coastal Frontiers Corporation (2004) recently reported results of monitoring of a major nourishment program in San Diego County. In this program, administered by the San Diego Association of Governments, twelve beaches received nourishment in 2001. During the 2003 monitoring year, the performance of the individual fills at the twelve beaches reportedly varied considerably; at some beaches, previous gains in shorezone volumes persisted, while at others, the gains were short-lived.

Despite the spotty record of documented results of replenishment/nourishment projects in California, Leonard and others (1989) attempted to determine the overall success of various projects as of the late 1980s. As part of this determination, they also evaluated how five physical parameters might influence the success of fill episodes as measured by longevity, or “durability,” of the emplaced fills. Some of their major conclusions for Pacific Coast beaches (nearly all are evidently in southern California) were:

- Longevity of fills at Pacific Coast beaches has overall been higher than those at Atlantic Coast and Gulf Coast beaches.

- Of those beaches measured, 48% were successfully maintained, 15% were not, and 36% were unknown.

- The Pacific Coast management philosophy of nourishment by periodic “maintenance” was advantageous over the Atlantic/Gulf Coast management philosophy of nourishment by “crisis.”

- Project monitoring must be a mandatory part of each replenishment project.

Regarding replenishment parameters:

- **Length:** There was no relationship between longevity of replenished beaches and their lengths.

- **Density:** Pacific Coast beaches had higher cumulative densities of fill than Atlantic Coast and Gulf Coast beaches. For the Pacific Coast, there didn't appear to be a correlation between fill density and fill durability.

- **Grain Size:** The data suggested that grain size was not of particular importance in determining durability.

- **Groins:** These structures have aided stabilization of certain nourished beaches on the Pacific Coast.

- **Storms:** There was a correlation between high erosion rates on nourished beaches of the Pacific Coast and the passage of major storms.

RECOMMENDATIONS

- With some editing and modification, use Coyne's (2000) spreadsheet (Table A2) as a foundation to annually compile data and information on all beach replenishment/nourishment projects along the coast of California. Georeference this table so that it can be incorporated into the GIS of the CSMW Master Plan.

- Determine if the influence of grain-size on fill performance is significant enough to devote CSMW resources to the task of compiling detailed data on grain-size characteristics of fill materials and native materials for beach-nourishment projects along the coast of California.

CSMW TASK THREE

Bibliography

GENERAL

D'Angremond, K., De Jong, A.J., and Van Oorschot, J.H., 1988, Beach replenishment - design elements and implementation: Terra et Aqua, no. 37, p. 19 - 27.

Davison, A.T., Nocholls, R.J., and Leatherman, S.P., 1992, Beach nourishment as a coastal management tool: an annotated bibliography on developments associated with the artificial nourishment of beaches: Journal of Coastal Research, v. 8, no. 4, p. 984 - 1022.

Dean, R.G., 1974, Compatibility of borrow material for beach fills: American Society of Civil Engineers, Proceedings of the 14th Coastal Engineering Conference, p. 1319-1330. *Compatibility.*

Dean, R.G., 1983, Principles of beach nourishment, *in* Komar, P.D., editor, CRC handbook of coastal processes and erosion: CRC Press, Boca Raton, Florida, p. 217-232. *Compatibility.*

Dean, R.G., 1988, Managing sand and preserving shorelines: Oceanus, vol. 31, p. 49-55.

Dean, R.G., 2003, Beach nourishment: Theory and practice: World Scientific Publishing Company, River Edge, New Jersey, 420 p.

Dean, R.G., and Abramian, J., 1993, Rational techniques for evaluating the potential of sands for beach nourishment: U.S. Army Corps of Engineers, Coastal Engineering Research Center Technical Report CERC-DRP-93-2, 179 p.

Dean, R.G. and Dalrymple, R.A., 2004, Coastal processes with engineering applications: Cambridge University Press, 487 p.

Dette, H.H., 1977, Effectiveness of beach deposit nourishment: American Society of Civil Engineers, Coastal Sediments ’77, p. 211-227.

Eitner, V., 1996, The effect of sedimentary texture on beach fill longevity: Journal of Coastal Research, v. 12, p. 447-461. *Compatibility.*

Garland, G.G., 1990, Sand mass density and borrow material compatibility for beach nourishment: Ocean and Shoreline Management, v. 23, no. 2, p. 89-98.

Giordano, A., and Rowland, J., 1999, Use of federal sand for beach nourishment and shore protection projects: Marine Georesources and Geotechnology, v. 17, no. 2-3, p. 91-97.

Giordano, A.C., 1993, Coastal states marine mining laws: U.S. Dept. of the Interior, Minerals Management Service OCS Report MMS 93-0063, 48 p.

Houston, J.R., 1991, Beachfill performance: Shore & Beach, v. 59, p. 15-24.

Houston, J.R., 1995, Beach nourishment: Shore & Beach, v. 63, no. 1, p. 21-24.

Houston, J.R., 2000, Beach and coastal restoration: World Dredging – Mining and Construction, v. 36, no. 2, p. 6-7, 14-15, 20.

James, W.R., 1974, Beach fill stability and borrow material texture: American Society of Civil Engineers, Proceedings of the 14th Coastal Engineering Conference, p. 1334-1349.

James, W.R., 1975, Techniques in evaluating suitability of borrow material for beach nourishment: U.S. Army Corps of Engineers Technical Memorandum 60, p. 95-102.

Komar, P.D., 1997, Beach processes and sedimentation: Prentice Hall, Upper Saddle River, New Jersey, 2nd edition, 544 p.

Krumbein, W.C. and James, W.R., 1965, A lognormal size distribution model for estimating stability of beach fill material: U.S. Army Corps of Engineers Technical Memorandum 16.

Mugler, M.W., 1981, Beach nourishment with dredged material: U.S. Army Engineer Institute for Water Resources Policy Study 81-0110, 66 p.

National Academy Press, 1990, Managing coastal erosion: National Academy Press, Washington, D.C., 182 p. *Has short discussion of sand compatibility.*

National Research Council, 1995, Beach nourishment and protection: Washington, D.C., National Academy Press, 334 p.

Pilkey, O.H., 1990, A time to look back at beach nourishment: Journal of Coastal Research (editorial), v. 6, p. iii-vii.

Pilkey, O.H. and Clayton, T.D., 1989, Summary of beach replenishment experience on U.S. East Coast barrier islands: Journal of Coastal Research, v. 5, p. 147-159.

Ramsey, K.W., 1999, Beach sand textures from the Atlantic coast of Delaware: Delaware Geological Survey Open-File Report 41, 6 p.

Rosen, D.S., 2000, Geotechnical aspects of beach restoration: Geological Society of America Abstracts with Programs, Southeastern Section, v. 32, no. 2, p. 70.

Schorr, H.R., Jr., 2001, Beach nourishment: World Dredging, Mining and Construction, v. 37, no. 2, p. 10-11, 24-25.

Smith, A.W.S., 1992, Description of beach sands: Shore and Beach, v. 60, no. 3, p. 23-30.

Stauble, D.K., 1991, Recommended physical data collection program for beach nourishment projects: U.S. Army Engineer Waterways Experiment Station CETN II-26, 14 p.

Stauble, D.K. and Grosskopf, W.G., 1993, Monitoring project response to storms: Ocean City, Maryland, beach fill: Shore & Beach, v. 61, no. 1, p. 22-33.

Stauble, D.K., and Holem, G.W., 1991, Long term assessment of beach nourishment project performance, *in* Symposium on Coastal and Ocean Management, 7th, Coastal Zone '91, Long Beach, CA, American Society of Civil Engineers, p. 510-524.

Stauble, D.K., and Kraus N.C., editors, 1993, Beach nourishment engineering and management considerations, *in* Coastlines of the World Series, Coastal Zone '93, American Society of Civil Engineers, 245 p.

Stauble, D.K., and Nelson, W.G., 1985, Guidelines for beach nourishment: A necessity for project management, *in* Symposium on Coastal and Ocean Management, 4th, Coastal Zone '85, Baltimore, MD, American Society of Civil Engineers, p. 1002-1021.

Swart, D.H., 1991, Beach nourishment and particle size effects: Coastal Engineering, v. 16, p. 61-81.

Trembaniz, A.C., Valverde, H.R., Haddad, T.C., O'Brien, M.K., and Pilkey, O.H., 1998, The U.S. national beach nourishment experience [abs.]: Journal of Coastal Research, Special Issue 26, p. A29.

U.S. Army Corps of Engineers, 1984, Shore protection manual: U.S. Army Corps of Engineers, Coastal Engineering Research Center Publication No. 008-002-00218-9, 4th edition, two volumes, 1,262 p.

U.S. Army Corps of Engineers, 1995, Design of beach fills: U.S. Army Corps of Engineers Engineering Manual 1110-2-3301, 86 p.

U.S. Army Corps of Engineers, 2002, Coastal Engineering Manual: U.S. Army Corps of Engineers Engineer Manual 1110-2-1100, Washington, D.C., 6 volumes. (http://bigfoot.wes.army.mil/cem001.html)

Wiegel, R.L., 1992, Beach nourishment, sand by-passing, artificial beaches: Bibliography of articles in the ASBPA Journal Shore and Beach: Shore & Beach, v. 60, no. 3, p. 3 - 5.

COAST OF CALIFORNIA

Andrassy, C.J., 1991, Monitoring of a nearshore disposal mound at Silver Strand State Park: American Society of Civil Engineers, Coastal Sediment ’91, p. 1970-1984.

Anonymous, 2000, Restoration of southern California's beaches: World Dredging - Mining and Construction, v. 36, no. 2, p. 8 - 9, 16.

Asmon, E., 1960, Heavy minerals of southern California: Ph.D dissertation, University of Southern California, 98 p.

Bowen, A.J. and Inman, D.L., 1966, Budget of littoral sands in the vicinity of Point Arguello: U.S. Army Corps of Engineers, Coastal Engineering Research Center, Technical Memorandum 19, 41 p.

Cahill, J.J. and others, 1989, Beach nourishment with fine sand at Carlsbad, California, *in* Magoon, O.T. and others, editors, Coastal Zone ’89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2092-2103.

California Department of Boating and Waterways and State Coastal Conservancy, 2002, California beach restoration study: Sacramento, California. (www.dbw.ca.gov/beachreport.htm)

California Department of Navigation and Ocean Development, 1977, Study of beach nourishment along the southern California coastline: California Department of Navigation and Ocean Development, 151 p.

Chambers Group, Inc., 1992, Final environmental impact report/environmental assessment for the BEACON beach nourishment demonstration project: Beach Erosion Authority for Central Operations and Nourishment, SCH No. 91011072.

Clayton, T., 1989, Artificial beach replenishment on the U.S. Pacific shore – A brief overview, *in* Magoon, O.T. and others, editors, Coastal Zone ’89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2033-2045.

Coastal Frontiers Corporation, 1992, Historical changes in the beaches of Los Angeles County, Malaga Cove to Topanga Canyon, 1935-1990: County of Los Angeles, Department of Beaches and Harbors, 105 p.

Coastal Frontiers Corporation, 2004, SANDAG 2003 regional beach monitoring program: Annual Report prepared for San Diego Association of Governments by Coastal Frontiers Corporation, Chatsworth, California, 122 p.

Comellick, R.A., 1976, Petrology and economic value of beach sand from southern Monterey Bay, California: M.S. thesis, University of Southern California, 73 p.

Coyne, M., 2000, California beach nourishment history: California Coastal Commission and California Department of Boating and Waterways, unpublished spreadsheet of compiled data on beach nourishment projects in California.

Domurat, G.W. and others, 1979, Beach erosion control study, Ocean Beach, San Francisco: Shore & Beach, v. 47, no. 4, p. 20-32.

Dunham, J.W., 1965, Use of long groins as artificial headlands: American Society of Civil Engineers, Coastal Engineering, Santa Barbara Specialty Conference, p. 755-762.

Everts, C.H. and Eldon, C., 2000, Beach retention structures and wide sandy beaches in southern California: Shore & Beach, v. 68, no. 3, p. 11-22.

Flick, R.E., 1993, The myth and reality of southern California beaches: Shore and Beach, v. 61, p. 3-13.

Gadd, P.E., and Eschen, D.L., 1999, Low cost sand re-nourishment to combat chronic beach erosion, Long Beach, California, *in* Bringing Back the Beaches, Sand Rights '99, Ventura, CA, 1999, American Society of Civil Engineers, p. 152-160.

Gorsline, D.S., Mineral composition of river, beach and shelf sands from Point Conception to the Mexican border: Geological Society of America Special Paper 121, p. 115.

Guza, R.T. and others, 2002, Southern California beach processes study: Scripps Institution of Oceanography, 7th Quarterly Report, November 30, 2002. (http://cdip.ucsd.edu).

Hall, J., Jr., 1952, Artificially constructed and nourished beaches: American Society of Civil Engineers, Coastal Engineering 1952 Proceedings, Chapter 10, p. 119-133.

Hamilton, M., 1998, Grains of sand – GPS survey-grade technology provides critical data to understanding beach erosion: Earth Observation Magazine, vol. 7, no. 4, p. 12-14.

Handin, J.W., 1951, The source, transportation, and deposition of beach sediment in southern California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 22, 113 p.

Hands, E.B. and Allison, M.C., 1991, Mound migration in deeper water and methods of categorizing active and stable berms: American Society of Civil Engineers, Coastal Sediments '91, p. 1985-1999. *Results of nourishment at Santa Barbara.*

Herron, W.J., 1987, Sand replenishment in southern California: Shore & Beach, v. 55, nos. 3-4.

Hutton, C.O., 1952, Accessory mineral studies of some California beach sands: U.S. Atomic Energy Commission, RMO-981, 112 p.

Hutton, C.O., 1959, Mineralogy of beach sands between Half Moon and Monterey bays, California: California Division of Mines Special Report 59, 32 p.

Inman, D.L., 1953, Areal and seasonal variations in beach and nearshore sediments at La Jolla, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 39, 134 p.

Jantz, S., Webb, C.K., and Lindquist, A.-L., 1999, Opportunistic beach fill program, Carlsbad, California: Shore & Beach, v. 67, no. 2/3, p. 44 - 49.

Judge, C.W., 1970, Heavy minerals in beach and stream sediments as indicators of shore processes between Monterey and Los Angeles, California: U.S. Army Corps of Engineers Coastal Engineering Research Center, Technical Memorandum 33, 44 p.

Knur, R.T. and Kim,Y.C., 1999, Historical sediment budget analysis along the Malibu coastline, *in* Sand Rights '99-Bringing Back the Beaches: American Society of Civil Engineers, Ventura, California, 292 p.

Leidersdorf, C.B. and others, 1993, Beach enhancement through nourishment and compartmentalization: The recent history of Santa Monica Bay: American Shore and Beach Preservation Association, Proceedings, 8th Annual Symposium on Coastal and Ocean Management, p.71-85.

Leidersdorf, C.B. and others, 1994, Human intervention with the beaches of Santa Monica Bay, California: Shore & Beach, v. 62, no. 3, p. 29-38.

Leonard, L. and others, 1989, U.S. beach replenishment experience – A comparison of the Atlantic, Pacific, and Gulf Coasts, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 1994-2006.

Lilly, K., and Kingery, D., 1998, Ocean Beach, San Francisco: Protection and management of an eroding shoreline, *in* Ewing, L., and Sherman, D., eds., California's coastal natural hazards: Santa Barbara, California, University of southern California Sea Grant program, p. 106-131.

Luepke, G., 1994, Variations in titanium and chromium concentrations in magnetite separates from beach and offshore separates, San Francisco and San Mateo counties, California: U.S. Geological Survey Open-File Report 95-15, 6 p.

Mesa, C., 1996, Nearshore berm performance at Newport Beach, California, USA: American Society of Civil Engineers, Proceedings, 25th International Conference on Coastal Engineering, p.4636-4649.

Moffatt and Nichol Engineers, 1982, Balboa Island beach replenishment study: City of Newport Beach, Public Works Department, 31 p.

Moffatt and Nichol Engineers and others, 2001, Regional beach sand retention strategy: Final Report prepared for San Diego Area Governments.

Moore, D.B., 1965, Recent coastal sediments, Double Point to Point San Pedro, California: M.A. thesis, University of California, Berkeley, 86 p.

Noble, R., 2002, Beach nourishment construction at twelve San Diego County, California receiver beach sites: World Dredging, Mining and Construction Magazine, v. 38, no. 2, p. 7-20.

Noble Consultants, 1989, Coastal sand management plan, Santa Barbara/Ventura County coastline: Main Report, Prepared for Beach Erosion Authority for Control Operations and Nourishment (BEACON), 186 p.

Noble Consultants, 2000, California shoreline protection survey 2000: Report prepared for California Department of Boating and Waterways, 13 p. plus appendix (37 p.).

Page, G.B., 1950, Beach erosion and composition of sand dunes, Playa del Rey-El Segundo area, California: M.S. thesis, University of California, Los Angeles.

Parr, T., Diener, D. and Lacy, S., 1978, Effects of beach replenishment on the nearshore sand fauna at Imperial Beach, California: U.S. Army Corps of Engineers, Coastal Engineering Research Center, Miscellaneous Report 78-4, 125 p.

Patterson, D.R. and Young, D.T., 1989, Monitoring the beach nourishment project at Surfside-Sunset Beach, *in* Magoon, O.T. and others, editors, Coastal Zone '89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 1963-1977.

Pollard, D.D., 1979, The source and distribution of beach sediments, Santa Barbara County, California: Ph.D. dissertation, University of California, Santa Barbara, California, 245 p.

Powers, M.G., 1991, A regional approach to beach erosion in California: Formation, organization, and operation of B.E.A.C.O.N.: American Society of Civil Engineers, Proceedings of The Coastal Zone Experience, Coastal Zone '91, p. 187-197.

San Diego Association of Governments, 1993, Shoreline preservation strategy for the San Diego region: San Diego Association of Governments, 43 p.

San Diego Association of Governments, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

San Diego Association of Governments, 2000, San Diego regional beach sand project, Draft Environmental Impact Report/Review Environmental Assessment: San Diego Association of Governments, SCH No. 1999041104.

Shaw, M. J., 1980, Artificial sediment transport and structures in coastal Southern California: University of California, San Diego, Scripps Institution of Oceanography, SIO Ref. No. 80-41, 109 p.

Straughan, D., 1981, Inventory of the natural resources of sandy beaches in southern California: Allan Hancock Foundation Technical Report No. 6, Institute for Marine and Coastal Studies, University of Southern California, 447 p.

Trask, P.D., 1952, Source of beach sand at Santa Barbara, California as indicated by mineral grain studies: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 28, 24 p.

Trask, P.D., 1955, Movement of sand around southern California promontories: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 76, 60 p.

Trask, P.D., 1959, Beaches near San Francisco, California, 1956-1957: U.S. Army Corps of Engineers Beach Erosion Board Technical Memorandum 110, 89 p.

U.S. Army Corps of Engineers, 1953, Coast of California – Carpinteria to Point Mugu, beach erosion control study: 83rd U.S. Congress, first session, House Document 29.

U.S. Army Corps of Engineers, 1962, Coast of southern California – Special interim report on the Ventura area, cooperative beach erosion control study: 87th U.S. Congress, second session, House Document 458, 80 p.

U.S. Army Corps of Engineers, 1962, San Gabriel River to Newport Bay, Orange County, California, beach erosion control study (Appendix 5, Phase 2): 87th U.S. Congress, second session, House Document 602, 167 p.

U.S. Army Corps of Engineers, 1965, Technical report on cooperative beach erosion study of coast of northern California, Point Delgada to Point Ano Nuevo: U.S. Army Corps of Engineers, San Francisco District, Appendix VIII, Contract No. W-04-193-ENG-5196 (4 documents).

U.S. Army Corps of Engineers, 1967, Beach erosion control report on cooperative study of southern California, Cape San Martin to Mexican boundary: U.S. Army Corps of Engineers, Los Angeles District, Appendix VII, Contract No. W-04-193-ENG-5196, 42 p. plus plates.

U.S. Army Corps of Engineers, 1970, Beach erosion control report, cooperative research and data collection program of coast of southern California, Cape San Martin to Mexican boundary: U.S. Army Corps of Engineers, Los Angeles District, Three-Year Report for 1967-1969.

U.S. Army Corps of Engineers, 1974, Hydraulic method used for moving sand at Hyperion Beach erosion project, El Segundo, California: U.S. Army Corps of Engineers, Coastal Engineering Research Center Miscellaneous Paper 4-74, 66 p.

U.S. Army Corps of Engineers, 1985a, Littoral zone sediments, San Diego region, Dana Point to Mexican border: October 1983 - June 1984: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study, CCSTWS 85-11, 152 p.

U.S. Army Corps of Engineers, 1985b, Southern California coastal processes annotated bibliography: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study 85-4, 401 p.

U.S. Army Corps of Engineers, 1986a, Oral history of coastal engineering activities in southern California, 1930-1981: U.S. Army Corps of Engineers, Los Angeles District, 223 p.

U.S. Army Corps of Engineers, 1986b, Southern California coastal processes data Summary: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study 86-1, 572 p.

U.S. Army Corps of Engineers, 1987, Northern California coastal processes annotated bibliography: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study No. 87-5, 491 p.

U.S. Army Corps of Engineers, 1989, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 5 p.

U.S. Army Corps of Engineers, 1990, Sediment budget report- Oceanside littoral cell: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Army Corps of Engineers, 1991, State of the coast report, San Diego region: U.S. Army Corps of Engineers, Los Angeles District, Coast of California Storm and Tidal Waves Study, Volume 1 - Main Report, Final.

U.S. Army Corps of Engineers, 1993, Existing state of Orange County: U.S. Army Corps of Engineers, Coast of California Storm and Tidal Waves Study, CCSTWS 93-1, Los Angeles District.

U.S. Army Corps of Engineers, 1995, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 8 p.

U.S. Army Corps of Engineers, 2002a, Silver Strand shoreline, Imperial Beach , California: U.S. Army Corps of Engineers, Los Angeles District, General Evaluation Report, Appendixes A and B.

U.S. Army Corps of Engineers, 2002b, South Coast region (Orange County): U.S. Army Corps of Engineers, Coast of California Storm and Tidal Wave Study, Final Report.

Waldorf, B.W. and Flick, R.E., 1982, Monitoring beach erosion control alternatives – southern California examples: Marine Technological Society and Institute of Electrical and Electronic Engineering, Oceans ’82, Ocean Engineering and the Environment, p. 973-979.

Welday, E.E., c1972, The southern Monterey Bay littoral and coastal environment and the impact of sand mining: California Division of Mines and Geology unpublished open-file report to D.J. Everitts, 44 p.

Wiegel, R.L., 1994, Ocean beach nourishment on the USA Pacific Coast: Shore & Beach, v. 62, no. 1, p. 11-36.

Woodell, G.J. and others, 1989, Beach nourishment project compatible with multiple concerns, Santa Monica Bay, California, *in* Magoon, O.T. and others, editors, Coastal Zone ’89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2076-2091.

RESULTS FROM CSMW TASK 4

(Offshore Materials for Beach Nourishment)

TASK 4 – Compile available information which identifies the presence of fine-grained "mud belts", potential sand source areas, sandy and rocky bottom habitats in the offshore vicinity of potential beach nourishment locations.

BACKGROUND

The observation and mapping of the geologic materials on the ocean floor can lead to discovery of deposits of sand. Where of acceptable grain characteristics, volume, degree of consolidation, depth of submergence, and distance from shore, such deposits have been and will continue to be sources of material for beach replenishment/nourishment. The most desirable deposits are unconsolidated, have large volumes, are similar in physical character to the material on the receiving beaches, are in shallow water close to the receiving beaches, and are free of contaminants and debris. Also, mining of them would produce minimal environmental disturbance.

Typically, the identification and characterization of submarine geologic materials relies on both direct and indirect observation and measurement. Direct methods include visual observation, via submersible vehicles or cameras, and collection of samples through diving, dredging, or coring. Indirect methods include various geophysical techniques that can characterize the seafloor as well as the material beneath it. These data lead to maps and calculations that determine the locations, areal extents, volumes, and physical properties of the materials at and below the ocean floor. Furthermore, because of economic and technological limitations, the depth of sand deposits below the sea surface is of major interest, which requires reliable bathymetric measurements.

The identification and characterization of materials is also important for understanding and management of benthic habitat for marine organisms. The mapping of such habitats, which has become common in recent years, relies on the same techniques for exploration and characterization of sand deposits. Consequently, submarine geologic mapping and benthic habitat mapping are complementary and in some ways might be considered one and the same.

OVERVIEW OF OFFSHORE GEOLOGY OF CALIFORNIA

The complex geology that makes up onshore coastal California continues offshore beneath the continental shelf. In contrast to the U.S. Atlantic and Gulf Coasts, the shelf off California is notably narrow and irregular, a reflection of the active geologic forces there. It is commonly dissected by submarine canyons and, in some places, is only 1-2 miles wide. In simplified view, offshore California is underlain by diverse types of bedrock covered or surrounded by mantles of unconsolidated sand, mud, and gravel.

Available geologic mapping of offshore California is spotty as to areal coverage and detail. Some areas have been intensively studied and mapped, while others have been covered only by limited reconnaissance. Generally, areas close to shore and near large harbors and population centers have received more attention than those near less-developed parts of the coast.

At the statewide level, there are two sets of published maps that cover the entire offshore length of the state. The first, by Welday and Williams (1975), portrays at a scale of 1:500,000 the surficial geology of the offshore, with the greatest detail limited generally to within five miles of the coastline. The strength of this map is that the authors interpreted geologic bottom-types based on thousands of direct and indirect geologic observations made by various organizations. Especially noteworthy was use by the authors of the many historic observations of bottom type made during a suite of hydrographic surveys by the U.S. Coast and Geodetic Survey. Despite its age, this map is still a valuable aid to studies along many parts of offshore California. The second publication, a collaboration between the California Division of Mines and Geology (CDMG, now the California Geological Survey) and the U.S. Geological Survey, consists of seven map sheets that portray at a scale of 1:250,000 details of local geology among other geologic-related information for the continental margin (see Kennedy and others, 1987). The sheets that cover the offshore north of San Francisco have very little geologic detail, while those south of San Francisco have much greater detail. This distribution mainly reflects the focus, intensity, and availability of offshore study by different institutions. Also, the CDMG-USGS map series does not display the mapping of Welday and Williams (1975), therefore, investigators should consult both sets of maps when studying all or part of offshore California. The digitized version of the CDMG-USGS map series can be downloaded from the Seafloor Mapping Lab Website at California State University, Monterey Bay (http://seafloor.csumb.edu/).

In addition to the statewide maps discussed above, the California Geological Survey (CGS) and U.S. Geological Survey have published or are nearing publication of several regional geologic maps at a scale of 1:100,000 that include offshore areas. Some of these have newly compiled offshore geologic data, others do not. A few examples include the following quadrangles, from north to south: Monterey (CGS – published, new offshore data), Long Beach (CGS – in preparation, some new offshore data), and Oceanside (CGS – in preparation, no new offshore data).

Maps of surficial geology along portions of the coast are presented in Howard (1974), but we were unable to obtain and evaluate this report at the time of the CSMW study.

At local levels, various institutions and agencies have conducted detailed ocean floor surveys and mapping. These studies have been mainly in the Monterey Bay-San Francisco area in northern California and at several localities along the Southern California Bight, which extends from Point Conception to the Mexico border and includes the Channel Islands. In recent years, seafloor mapping in California has focused on benthic habitats. Much of this work has used multibeam mapping systems to produce "backscatter" images that display seafloor properties such as areas of mud and bedrock (e.g., Gardner and Dartnell, 2002). Although generally not termed "geologic" mapping, these activities have collected information on the geologic character of the seafloor through their qualitative descriptions of materials as "sand," "mud," and "bedrock." The U.S. Geological Survey, Moss Landing Marine Laboratory, Seafloor Mapping Lab, and Scripps Institution of Oceanography as well as private companies are some of the groups that have conducted this type of work in California. Examples of benthic habitat mapping for the nearshore zone of San Diego County can be viewed or downloaded on-line at http://sccoos.ucsd.edu/nearshore/. The U.S. Geological Survey has published several reports on its offshore mapping in the Monterey Bay-San Francisco and southern California regions. Several are listed in the accompanying bibliography (e.g., Wong and Eittreim, 2001; Gardner and Dartnell, 2002).

DISTRIBUTION OF SEAFLOOR MATERIALS ALONG THE COAST

The geologically active and diverse interior coast of California has profoundly influenced the geologic character of the adjacent seafloor. The high topographic relief, numerous watersheds that drain into the ocean, and the great variety of rock types all have contributed to the many types and complex distribution of materials that make up the coastal seafloor from Oregon to Mexico. This diversity is apparent from the geologic maps of Welday and Williams (1975) and the CDMG-USGS continental margin series.

Documentation of seafloor materials along the coast is available for many local areas. Again, we emphasize that this information was most commonly collected from the Monterey Bay-San Francisco region and the segment of coast from Santa Barbara County to San Diego County. Except for the semi-reconnaissance work of Welday and Williams (1975), there has been no attempt to consistently map in detail the distribution of offshore geologic materials from Oregon to Mexico. This situation is more a result of insufficient resources (funds and time) rather than lack of interest. Correspondingly, the documentation of details has been mostly limited to local projects conducted through government and academic groups and, in some cases, private industry. Government reports and data are generally produced by agencies such as the U.S. Geological Survey, U.S. Army Corps of Engineers, and the National Oceanic and Atmospheric Administration (NOAA). Products from the academic community are typically in the form of theses and dissertations, and papers in technical journals. Studies by private industry typically are prepared as consulting reports to clients (public and private). Examples of some of these categories are presented in the accompanying bibliography.

Mapping of seafloor materials along the California coast has been greatly aided by collection of samples. These include surficial sediment and rock and shallow cores. The U.S. Geological Survey maintains a Website (http://coastalmap.marine.usgs.gov/regional/contusa/westcoast/usSEABED/) that catalogs offshore sample sites and associated data as part of a national database; the data can be viewed on-line through a map server. The U.S. Army Corps of Engineers has data from numerous vibracore samples taken to assess potential borrow sites for beach replenishment/nourishment. NOAA maintains a Website (http://www.ngdc.noaa.gov/mgg/mggd.html) that can be visited to obtain digitized seabottom observations collected during hydrographic surveys conducted between 1851 and 1965 as well as offshore geophysical and geological data. Academic institutions also have bottom sample and core data, some of which have been published. Examples include data collected by the University of Southern California in the Southern California Bight and by the Hydraulic Engineering Laboratory at the University of California, Berkeley, from various coastal localities. Still other data are available in disparate, sometimes obscure, published and unpublished documents.

Together, the technical reports and sets of data portray a pattern of distributed materials that reflect such things as source areas, geologic structure, variations in dynamics of transportation, energy conditions and geomorphology of the depositional areas, and variations of all of these factors with time. For example, deposits of sand are common in the nearshore regions of the state and where rivers have discharged material at their mouths (Welday and Williams, 1975). Mud belts are concentrated farther away from the shoreline or in nearshore areas where the energy of waves and currents are less because of protective coastal settings (e.g., Monterey Bay). Bedrock areas are often nearshore extensions of onshore features or where either relief is positive or current patterns do not favor deposition of sediment. Many of the sand deposits farther offshore are probably paleo-beaches, which originated when the shoreline was much farther west than today; since the last ice age the shoreline has migrated eastward from these locations as sea level has risen.

Finally, the techniques of mapping seafloor materials off the coast of California are evolving. Traditional mapping techniques (e.g., Welday and Williams, 1975) emphasize manual interpretation and drawing of map-unit boundaries based on data from sampling and/or backscattering properties of seafloor materials. Currently, there are attempts to map the boundaries of materials based on image-processing techniques (e.g., classification), which use the same sorts of datasets as the manual approaches. An example is the work in progress by the U.S. Geological Survey on the San Pedro shelf in southern California (Peter Dartnell, U.S. Geological Survey, personal communication, 2003).

POTENTIAL OFFSHORE SOURCES OF SAND

Historically, the sources of sand for beach replenishment/nourishment along the coast of California have predominantly been provided from non-offshore locations (see column labeled “fill source/site” in Table A2 (modified from Coyne, 2000). Included among these are inland sources as well as coastline sources, which have been related to such activities as harbor construction and channel maintenance or by-passing and back-passing operations. Interest in and use of offshore sand resources has generally occurred more recently in California.

Largely because of the abundant contributions from inland source areas and the prevailing southward-directed littoral drift along the entire coast, deposits of sand are prevalent in the offshore of California. Welday and Williams (1975) show numerous linear belts of sand that are dominantly fine-grained, with local areas that are medium- to coarse-grained as well. It is important to recognize, however, that these observations are for the seafloor surface only. Evaluation of sand deposits for potential beach replenishment/nourishment must also consider thickness of the deposits, which may or may not be known for any given location along the coast. To address this issue, Martindale and Hess (1979) and Luken and Hess (1979) used assumed thicknesses to calculate estimated volumes of sand and gravel deposits along the entire coast. The deposits they used for calculation were largely taken from the individual bottom-type areas shown on the maps of Welday and Williams (1975) and Howard (1974).

Because of the preponderance of historic beach replenishment/nourishment projects there, nearly all regional and local exploration and evaluation of offshore sand deposits have occurred in southern California from Santa Barbara County to the Mexico border. Also, because of limitations on dredging (cost, technology), most of this work has been done in shallow water close to shore. Some offshore borrow sites are used more than once because the excavations may be re-filled by natural sedimentation. Consequently, virgin borrow areas are not necessarily required for every episode of replenishment/nourishment, which lessens the overall need for their exploration and evaluation.

Various studies have identified many local offshore sand deposits in southern California that could serve as borrow sites for replenishment/nourishment. A list of selected sites is presented in Table A4. This list is not comprehensive, but gives an idea of the distribution and volumes of the deposits. Details of exploration, sampling, and analytical results for the deposits can be found in published and unpublished technical reports. The report by Osborne and others (1983) and many internal reports by the Geotechnical Branches of the U.S. Army Corps of Engineers (e.g., U.S. Army Corps of Engineers, 1989; 1995; 2002) are good examples of detailed study of individual deposits by use of vibracore data.

RECOMMENDATIONS

- Unless already accomplished, digitize and attribute the map of Welday and Williams (1975) for inclusion in the GIS of the CSMW Master Plan. Research files of the California Geological Survey to determine if the original 1:125,000-scale geology worksheets used to prepare the map are still available; these could be used for digitizing. Despite its age, this map is still a valuable statewide reference.

- Unless already accomplished, digitize and attribute the maps of Martindale and Hess (1979) and Luken and Hess (1979) for inclusion in the GIS of the CSMW

Master Plan. Original files for these reports may still be available in archives of the U.S. Geological Survey. This GIS product would be a companion layer to that for the Welday and Williams (1975) map discussed above.

- Unless already accomplished, digitize and attribute the maps associated with detailed studies of local sand deposits for inclusion in the GIS of the CSMW Master Plan. Examples of such reports would be those by Osborne and others (1983) and the U.S. Army Corps of Engineers (1989).

CSMW TASK FOUR

Bibliography

GENERAL

American Association of Petroleum Geologists, 1972, Continental shelves – Origin and significance: American Association of Petroleum Geologists Reprint Series No. 3, Tulsa, Oklahoma, 194 p.

Burk, C.A. and Drake, C.L., 1974, The geology of continental margins: New York, New York, Springer-Verlag, 1009 p.

Cronan, D.S., 2000, Handbook of marine mineral deposits: Marine science series: Boca Raton, FL, CRC Press, 406 p.

Groat, C., Banino, G., Gardner, C., Magnuson, G., Rusanowski, P., and Weaver, K., 1993, U.S. outer continental shelf sand and gravel resources: OCS Policy Committee's Subcommittee on OCS Sand and Gravel Resources, Final Report, 43 p.

Hartgen, C., and Rowland, J., 2000, State/federal cooperatives: evaluating continental shelf sand deposits for use in coastal public works: World Dredging - Mining and Construction, v. 36, no. 8, p. 8 - 9, 20 - 22, 28.

Hartgen, C., and Rowland, J., 2001, Offshore sand for coastal protection and beach restoration: World Dredging, Mining and Construction, v. 37, no. 2, p. 6 - 7, 14.

Holser, A.F., Rowland, R.W., and Goud, M.R., 1982, A compilation of subsea energy and mineral resources of the United States including its possessions and trust territory of the Pacific Islands, U.S. Geological Survey Miscellaneous Field Studies Map MF-1360, scale 1:20,000,000.

Knight, R.J., and McLean, J.R., editors, 1986, Shelf sands and sandstones, Canadian Society of Petroleum Geologists Memoir II, …………….p.

Lockwood, M. and McGregor, B.A., 1987, Proceedings of the 1987 Exclusive Economic Zone symposium on mapping and research: Planning for the next 10 years: U.S. Geological Survey Circular 1018, 175 p.

Luepke, G., 1985, Economic analysis of heavy minerals in sediments: Benchmark papers in geology: New York, NY, Van Nostrand Reinhold, v. 86, 321 p.

Marcus, L., and Bobrowsky, P.T., eds., 1998, Aggregate Resources; A Global Perspective: Rotterdam, Netherlands, A.A. Balkema, 470 p.

McKelvey, V.E., 1968, Mineral potential of the submerged parts of the U.S.: Ocean Industry, v. 3, no. 9, p. 37 - 43.

McKelvey, V.E., 1986, Subsea mineral resources U.S. Geological Survey Bulletin 1689-A, 106 p.

Mielke, J.E., 1987, Hard minerals in the U.S. Exclusive Economic Zone: resource assessment and expectations: Congressional Research Service, Library of Congress.

National Oceanic and Atmospheric Administration Ocean Assessment Division, 1990, Outer Continental Shelf Environmental Assessment Program; comprehensive bibliography: U.S. National Oceanic and Atmospheric Administration, Ocean Assessment Division Report MMS 90-0043, 648 p.

National Oceanic and Atmospheric Administration and Minerals Management Service, 1992, Marine minerals bibliography and geochemical database: National Geophysical Data Center, on-line database at http://www.ngdc.noaa.gov/mgg/geology/mmdb.html

Oele, E., 1978, Sand and gravel from shallow seas: Geology and Mining, v. 57, no. 1, p. 45 - 54.

Office of Technology Assessment, 1987, Marine minerals: exploring our new ocean frontier: Washington, D.C., U.S. Government Printing Office, 349 p.

Orr, R. and Rowland, J., 2003, 2003 continental shelf sand activities of the Minerals Management Service, U.S. Department of the Interior: World Dredging – Mining and Construction, v. 39, no. 8, 6-12.

Osborne, R.H., Ahlschwede, K.A., Broadhead, S.D., Cho, K., Feffer, J.R., Lee, A.C., Liu, J., Magnusen, C., Murrillo de Nava, J.M., Robinson, R.A., Yeh, C.-C., and Lu, Y., 1994, The continental shelf; a source for naturally-delivered beach sand, *in* International Conference on the Role of the Large Scale Experiments in Coastal Research, Coastal Dynamics '94, Barcelona, Spain, American Society of Civil Engineers, p. 335-349.

Poppe, L.J. and others, 2003, Surficial sediment data from the Gulf of Maine, Georges Bank, and vicinity: A GIS compilation: U.S. Geological Survey Open-File Report 03-001. (http://pubs.usgs.gov/of/2003/of03-001/index.htm)

Smith, J.B., 1995, Literature review on the geologic aspects of inner shelf cross-shore sediment transport: U.S. Army Corps of Engineers Coastal Engineering Research Center Technical Report WES/MS/CERC-95-3, 164 p.

Smith, J.D., 1969, Geomorphology of a sand ridge: Journal of Geology, v. 77, no. 1, p. 39-55.

Stanley, D.J. and Swift, D.J.P., eds., 1976, Marine sediment transport and environmental management: New York, NY, John Wiley & Sons, Inc., 602 P.

Stride, A.H., 1982, Offshore tidal sands: processes and deposits: London, UK, Chapman and Hall, 222 p.

Swift, D.J.P., 1974, Continental shelf sedimentation, *in* Burk, C.A. and Drake, C.L, editors, The geology of continental margins: Springer-Verlag, New York, New York, p. 117-135.

Swift, D.J.P., and Field, M.E., 1981, Evolution of a classic sand ridge field: Maryland sector, North American inner shelf: Sedimentology, v. 28, no. 4, p. 461-482.

U.S. Bureau of Mines, 1987, An economic reconnaissance of selected heavy mineral placer deposits in the U.S. Exclusive Economic Zone: Office of the Assistant Director--Mineral Data Analysis, Bureau of Mines, Open-File Report 4-87, 112 p.

Williams, S.J., 1986, Sand and gravel deposits within the United States Exclusive Economic Zone: resource assessment and uses, *in* Annual Offshore Technology Conference, 18th, p. 377 - 386.

Williams, S.J., Reid, J.M., and Manheim, F.T., 2003, A bibliography of selected references to U.S. marine sand and gravel mineral resources: U.S. Geological Survey Open-File Report 03-300, 67 p. http://pubs.usgs.gov/of/2003/of03-300/ *Over 800 references on offshore sand and gravel. Most references are for East Coast and Gulf Coast locations and topics.*

COAST OF CALIFORNIA

American Shore & Beach Preservation Association, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

Anderson, J.A., 1990, California's industrial-mineral resources: U.S. Geological Survey Bulletin 1958.

Anima, R.J., Tait, J., Griggs, G.B., and Brown, K.M., 1993, Nearshore morphology and sedimentation using side-scanning sonar and underwater video along the Central California coast, *in* American Geophysical Union, Fall Meeting, San Francisco, CA, American Geophysical Union, p. 348.

Baird, B. and others, 1995, California's ocean resources: an agenda for the future: Resources Agency of California, draft report.

Bandy, O.L., Ingle, J.C., Jr., and Resig, J.M., 1964, Facies trends, San Pedro Bay, California: Geological Society of America Bulletin, v. 75, no. 5, p. 403-424.

Cacchione, D.A., and Drake, D.E., 1990, Shelf sediments transport; an overview with applications to the Northern California continental shelf: The Sea, v. 9, Part B, p. 729-773.

California State Lands Commission, 1994, California comprehensive offshore resource study.

Cherry, J.F., 1965, Sand movement along a portion of the northern California coast: U.S. Army Corps of Engineers, Coastal Engineering Research Center Technical Memorandum 14, 125 p.

Chin, J.L., and Wolf, S.C., 1988, Reconnaissance high-resolution geophysical survey of the Monterey Bay, California, inner shelf: Implications for sand resources: U.S. Geological Survey Open-File Report 88-410, 33 p.

Darigo, N., 1984, Quaternary stratigraphy and sedimentation of the mainland shelf of San Diego County, California: Master's thesis, University of Southern California, 447 p.

Darigo, N.J. and Osborne, R.H., 1986, Quaternary stratigraphy and sedimentation of the inner continental shelf, San Diego County, California, *in* Knight, R.J. and McLean, J.R., editors, Shelf sands and sandstones: Canadian Society of Petroleum Geologists Memoir 11, p. 73-98.

Dartnell, P. and Gardner, J.V., 2004, Predicted seafloor facies of central Santa Monica Bay, California: U.S. Geological Survey Open-File Report 2004-1081. (http://pubs.usgs.gov/of/2004/1081/index.html)

Dartnell, P., Gardner, J.V., Mayer, L.A., Hughes Clarke, J.E., 2004, Los Angeles and San Diego margin high-resolution multibeam bathymetry and backscatter data: U.S. Geological Survey Open-File Report 2004-1221. (http://pubs.usgs.gov/of/2004/1221/)

Drake, D.E. and others, 1985, Bottom currents and sediment transport on San Pedro Shelf, California: Journal of Sedimentary Petrology, vol. 55, no. 1, p. 15-28.

Eittreim S.L. (ed.), 1997, Southern Monterey Bay continental shelf investigations; former Fort Ord restricted zone: U.S. Geological Survey Open-File Report 97-0450, 113 p.

Emery, K.O., 1952, Continental shelf sediments off southern California: Geological Society of America Bulletin, v. 63, p. 1105-1108.

Emery, K.O., 1960, The sea off southern California: John Wiley & Sons, New York, New York, 366 p.

Emery, K.O. and others, 1952, Submarine geology off San Diego: Journal of Geology, v. 60, p. 511-548.

Emery, K.O. and Shepard, F.P., 1945, Lithology of seafloor off southern California: Geological Society of America Bulletin, v. 56, p. 431-478.

Evans, J.R., Dabai, G.S., and Levine, C.R., 1982, Mining and marketing sand and gravel, outer continental shelf, southern California: California Geology, v. 35, no. 12, p. 259 - 276.

Field, M.E., 1974, Preliminary “quick look” report on offshore sand resources of southern California: U.S. Army Corps of Engineers, Coastal Engineering Research Center, unpublished report, 28 p.

Field, M.E., 1992, Mapping the California continental shelf: U.S. Geological Survey Yearbook, Fiscal Year 1991, p. 6-7.

Field, M.E., Barber, J.H., Jr., Cacchione, D.A., Drake, D.E., and Wong, F.L., 1992, Holocene sediment map of the Central California continental shelf, 1:250,000: U. S. Geological Survey Open-File Report 92-0338, 1 sheet.

Fischer, P.J., Kreutzer, P.A., Morrison, L.R., Rudat, J.A., Ticken, E.J., Webb, J.F., Woods, M.M., Berry, R.W., Henry, M.J., Hoyt, D.H., and Young, M., 1983, Study on Quaternary shelf deposits (sand and gravel) of Southern California: Submitted to State of California, Department of Boating and Waterways, Beach Erosion Control Project, FR 82-11, 66 p.

Fisher, M.A., Normark, W.R., Langenheim, V.E., Calvert, A.J., and Sliter, R., 2004, Marine geology and earthquake hazards of the San Pedro Shelf region, southern California: U.S. Geological Survey Professional Paper 1687, 33 p.

Gardner, J.V. and Dartnell, P., 2002, Multibeam mapping of the Los Angeles, California margin: U.S. Geological Survey Open-File Report 02-162. (http://walrus.wr.usgs.gov/reports/ofr02-162.html)

Gardner, J.V., Hughes Clarke, J. E., and Mayer, L.A., 1999, Cruise report: RV Coastal Surveyor Cruise C-1-99-SC, Multibeam mapping of the Long Beach, California, continental shelf: U.S. Geological Survey Open-File Report 99-360. **(**http://geopubs.wr.usgs.gov/open-file/of99-360/)

Gardner, J. V. and Mayer, L.A., 1998, Cruise report, RV Ocean Alert Cruise A2-98-SC, mapping the southern California continental margin, March 26-April 11, 1998: U.S. Geological Survey Open-File Report 98-475. (http://geopubs.wr.usgs.gov/open-file/of98-475/)

Gorsline, D.S., 1958, Geology of San Pedro and Santa Monica basins: Ph.D. dissertation, University of Southern California.

Gorsline, D.S., 1969, Mineral composition of river, beach and shelf sands from Point Conception to the Mexican border: Geological Society of America Special Paper 121, p. 115.

Gorsline, D.S., 1992, The geological setting of Santa Monica and San Pedro basin, California continental borderland, *in* Small, L.F., editor, California basin studies: Physical, geological, chemical and biological attributes: Progress in Oceanography, v. 30, no. 1-4, p. 1-36.

Gorsline, D.S. and Emery, K.O., 1959, Turbidity currents in San Pedro and Santa Monica basins: Geological Society of America Bulletin, v. 70, p.279-280.

Gorsline, D.S. and Grant. D.J., 1972, Sediment textural patterns on San Pedro shelf, California (1951-1971), Reworking and transport by waves and currents, *in* Swift, D.J.P. and others, editors, Shelf sediment transport: Process and pattern: Dowden, Hutchinson & Ross, Stroudsburg, Pennsylvania, p. 575-600.

Grant, D.J., 1973, Sediments of the San Pedro Shelf: M.S. thesis, University of Southern California, 93 p.

Greene, H.G. and others, 1975, Preliminary report on the environmental geology of selected areas of the southern California continental borderland: U.S. Geological Survey Open-File Report 75-596, 70 p.

Henyey, T., and Osborne, R., 1975, Offshore sand and gravel resources in California, Sea Grant Institutional Program Annual Report 1974-75, University of Southern California, Institute for Marine and Coastal Studies, p. 20 - 22.

Henyey, T., and Osborne, R., 1976, Offshore sand and gravel resources in California, Sea Grant Institutional Program Annual Report 1975-76, University of Southern California, Institute for Marine and Coastal Studies, p. 12-13.

Howard, C.L., 1974, Marine geology study – California undersea aqueduct report: U.S. Bureau of Reclamation, Appendix II, 53 p.

Inman, D.L., 1950, Submarine topography and sedimentation in the vicinity of Mugu submarine canyon, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 19, 42 p.

Karl, H.A. and others, 1980, Erosion and transport of sediments and pollutants in the benthic boundary layer on the San Pedro shelf, southern California: U.S. Geological Survey Open-File Report 80-386, 100 p.

Kendall, T.R., Vick, J.C., and Forsman, L.M., 1991, Sand as a resource; managing and mining the Northern California coast,, *in* Domurat, G.W., and Wakeman, T.H., eds., The California coastal zone experience: New York, NY, Am. Soc. Civ. Eng., p. 278-297.

Kennedy, M.P., Greene, H.G., and Clarke, S.H., 1987, Geology of the continental margin: California Division of Mines and Geology, Bulletin 207, 110 p. (companion to the California Continental Margin Geologic Map Series (7 areas), Greene, H.G. and Kennedy, M.P., editors, published by California Division of Mines and Geology in 1986-1989).

Kulm, L.D., Peterson, C.D., and Stribling, M.C., 1986, Inventory of heavy minerals and metals southern Washington, Oregon, and northern California continental shelf and coastal region: State of Oregon, Department of Geology and Mineral Industries Open-File Report 0-86-10, 111 p.

Lu, Y., and Osborne, R.H., 1993, Sources for Quaternary sand and the effects of selective transport on grain-shape composition, Santa Monica Bay, California [abs.]: Geological Society of America Abstracts with Programs, v. 25, no. 6, p. 274.

Luepke, G., 1989, Marine placer potential on the west coast of the United States from California to Washington: Marine Mining, v. 8, no. 2, p. 173 - 183.

Luepke, G., 1994, Variations in titanium and chromium concentrations in magnetite separates from beach and offshore separates, San Francisco and San Mateo counties, California: U.S. Geological Survey Open-File Report 95-15, 6 p.

Luken, M.D., and Hess, H.D., 1979, Sand, gravel and shell deposits of the Southern California Borderland: OCS Mining Policy Phase II Task Force, Program Feasibility Study, OCS Hard Minerals Leasing (Appendix 10): U.S. Geological Survey unpublished report, 69 p.

Magoon, O.T., Haugen, J.C., and Sloan, R.L., 1972, Coastal sand mining in northern California, U.S.A., *in* Coastal Engineering Conference, 13th, 1972, American Society of Civil Engineers, p. 1571 - 1597.

Martindale, S.G., and Hess, H.D., 1979, Resource assessment; sand, gravel and shell deposits on the continental shelf of Northern and Central California: OCS Mining Policy Phase II Task Force, Program Feasibility Study, OCS Hard Minerals Leasing (Appendix 9): U.S. Geological Survey unpublished report), 39 p.

McClain, C.E., 1992, Resource potential of offshore placer deposits, 1991 Exclusive Economic Zone symposium on mapping and research; working together in the Pacific EEZ: U.S. Geological Survey Circular 1052, p. 71.

Mokhtari-Saghafi, M., and Osborne, R.H., 1980a, Commercial profitability of offshore sand and gravel mining in southern California: an analysis for new entries, *in* An

International Forum on Ocean Engineering in the 80's, Oceans '80, Seattle, WA, Institute of Electrical and Electronics Engineers, p. 55-59.

Mokhtari-Saghafi, M., and Osborne, R.H., 1980b, An economic appraisal of mining offshore sand and gravel deposits: Southern California University Sea Grant Program Technical Report USC-SG-TR-80-01, 47 p.

Moore, D.B., 1965, Recent coastal sediments, Double Point to Point San Pedro, California: M.A. thesis, University of California, Berkeley, 86 p.

Nardin, T.R., 1976, Late Cenozoic history of the Santa Monica Bay area, California: M.S. thesis, University of Southern California, 189 p.

Noble Consultants, 1989, Coastal sand management plan, Santa Barbara/Ventura County coastline: Main Report, Prepared for Beach Erosion Authority for Control Operations and Nourishment (BEACON), 186 p.

Ocean Surveys, 1981, Final report, contract to CERC, coring survey, offshore coast of southern California: Ocean Surveys, Inc. Contract No. DACW72-80-R-0026, 16 p.

Orzech, K. and others, 2001, Core descriptions, core photographs, physical property logs and surface textural data of sediment cores recovered from the continental shelf of the Monterey Bay National Marine Sanctuary during the research cruises M-1-95-MB, P-2-95-MB, and P-1-97-MB: U.S. Geological Survey Open-File Report 01-107, 21 p. (http://geopubs.wr.usgs.gov/open-file/of01-107)

Osborne, R.H. and others, 1980a, Quaternary stratigraphy and depositional environments, Santa Monica Bay, southern California, *in* Field, M.E. and others, editors, Quaternary depositional environments of the Pacific coast: Society of Economic Paleontologists and Mineralogists, Pacific Section, Coastal Paleogeography Symposium 4, p. 143-156.

Osborne, R.H. and others, 1980b, Occurrence and sedimentological characteristics of offshore sand and gravel bodies in Santa Monica and San Pedro Bays, and their suitability as a source of material for beach nourishment and construction aggregate: University of Southern California, Sea Grant Publication.

Osborne, R.H. and others, 1979, Potential sand and gravel resources in Santa Monica and San Pedro Bays, southern California: Proceedings of Institute of Electrical and Electronics Engineers, Oceans ’79, p. 590-597.

Osborne, R.H., Darigo, N., and Scheidemann, R.C., Jr., 1983, Report of the potential offshore sand and gravel resources of the inner continental shelf of Southern California: California Department of Boating and Waterways, 302 p.

Osborne, R.H., Scheidemann, R.C., Jr., Nardin, T.R., and Harper, A.S., 1980, Quaternary stratigraphy and depositional environments, Santa Monica Bay, southern California, *in* Quaternary Depositional Environments of the Pacific Coast Paleography Symposium, 4th, Bakersfield, CA, Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 143-156.

Osborne, R.H., Scheidemann, R.C., Jr., Nardin, T.R., Harper, A.S., Brodersen, K.L., Kabakoff, J., and Waldron, J.M., 1979, Potential sand and gravel resources in Santa Monica and San Pedro Bays: southern California, *in* Oceans '79 Annual Combined Conference, San Diego, CA, Institute of Electrical and Electronic Engineers and The Marine Technology Society, p. 590 - 597.

Osborne, R.H., and Yeh, C.-C., 1991, Fourier grain-shape analysis of coastal and inner continental-shelf sand samples; Oceanside littoral cell, southern Orange and San Diego counties, Southern California, *in* Osborne, R.H., ed., From shoreline to abyss; contributions in marine geology in honor of Francis Parker Shepard: Tulsa, OK, Society of Economic Paleontologists and Mineralogists (Society for Sedimentary Geology), p. 51-66.

Peterson, 1988, Elemental content of heavy-mineral concentrations on the continental shelf off Oregon and northern California: Oregon Department of Geology and Mineral Industries Report O-88-04, 9 p.

Rutan, C., 1981, Isopach map: sand sized materials sand inventory study offshore Mission Beach to Leucadia Southern California: scale 1:24,000. (*Uncertain reference)*

Rutan, C., 1981, Seafloor texture and grain size contours sand inventory study offshore San Diego Southern California: scale 1:24,000. (*Uncertain reference)*

Rutan, C., 1981, Isopach map: sand sized materials sand inventory study offshore Leucadia to Oceanside southern California: scale 1:24,000. (*Uncertain reference)*

San Diego Association of Governments, 1993, Shoreline preservation strategy for the San Diego region: San Diego Association of Governments, 43 p.

San Diego Association of Governments, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

Savula, N.A., 1978, Light mineral petrology of sediments from Santa Monica and San Pedro bays, California continental borderland: M.S. thesis, University of Southern California.

Scholl, D.W., Gantz, A., and Vedder, J.G., 1987, Geology and resource potential of the continental margin of western North America and adjacent ocean basins - Beaufort Sea to Baja California: Earth science series: Houston, TX, Circum-Pacific Council for Energy and Mineral Resources, 7 v., v. 6, 799 p.

Sea Surveyor, Incorporated, 1999, San Diego regional beach sand project:: Offshore sand investigations: Final Report, Prepared for San Diego Association of Governments, 65 p.

Shepard, F.P. and Inman, D.L., 1951, Sand movement on the shallow inter-canyon shelf at La Jolla, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 26, 29 p.

Storlazzi, C.D., and Field, M.E., 2000, Sediment distribution and transport along a rocky, embayed coast; Monterey Peninsula and Carmel Bay, California: Marine Geology, v. 170, no. 3-4, p. 289-316.

Steinberger, A., Stein, E. and Schiff, K.C., 2003, Characteristics of dredged material disposal to the Southern California Bight between 1991 and 1997, *in* Weisberg, S.B. and Elmore, D., editors, Southern California Coastal Water Research Project Biennial Report 2001-2002: Southern California Coastal Water Research Project Authority, 419 p.

Tait, J., Anima, R.J., and Griggs, G.B., 1992, Shoreface storage and transport of littoral sediments along the central California coast, from the American Geophysical Union 1992 Fall Meeting: Eos, Transactions, American Geophysical Union, v. 73, no. 43, Suppl., p. 302.

U.S. Army Corps of Engineers, 1973, High-resolution geophysical and vibrating sampling project offshore southern California: U.S. Army Corps of Engineers Final Report Contract DACW 09-73-C-0098, 7 p.

U.S. Army Corps of Engineers, 1989, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 5 p.

U.S. Army Corps of Engineers, 1995, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 8 p.

U.S. Army Corps of Engineers, 2002, Silver Strand shoreline, Imperial Beach , California: U.S. Army Corps of Engineers, Los Angeles District, General Evaluation Report, Appendix A, Geotechnical Report.

U.S. Bureau of Mines, 1987, An economic reconnaissance of selected sand and gravel deposits in the U.S. Exclusive Economic Zone: Office of the Assistant Director--Mineral Data Analysis, Bureau of Mines, Open-File Report 3-87, 113 p.

University of Southern California, and Institute for Marine and Coastal Studies, 1980, An economic appraisal of mining offshore sand and gravel deposits: University of Southern California Sea Grant Program Technical Report, 47 p.

Vedder, J.G., 1990, Maps of California continental borderland showing compositions and ages of bottom samples acquired between 1968 and 1979: U.S. Geological Survey Map MF-2122, scale 1:250,000.

Welday, E.E. and Williams, J.W., 1975, Offshore surficial geology of California: California Division of Mines and Geology Map Sheet 26, scale 1:500,000.

Wilde, P., Lee, J., Yancey, T., and Glogoczowski, M., 1973, Recent sediments of the central California continental shelf, Pillar Point to Pigeon Point, Part C. interpretation and summary of results: University of California Hydraulic Engineering Laboratory Report 2-38, 83 p.

Wolf, S.C. and Gutmacher, C.E., 2004, Geologic and bathymetric reconnaissance overview of the San Pedro Shelf region, southern California: U.S. Geological Survey Open-File Report 2004-1049, version 1.0. (http://pubs.usgs.gov/of/2004/1049/)

Wong, F.L., 1995, Sediment distribution on a stream-dominated continental margin, Northern California; implications from heavy-mineral studies: U.S. Geological Survey Open-File Report 95-0614, 21 p.

Wong, F.L., 1996, Heavy mineralogy of effluent-affected sediment and other deposits, Palos Verdes shelf, Southern California [abs.]: EOS, Transactions, American Geophysical Union, v. 77, no. 3, Suppl., p. 50.

Wong, F.L., 2001, Heavy minerals from the Palos Verdes margin, southern California: Data and factor analysis: U.S. Geological Survey Open-File Report 01-153, 31 p. (http://geopubs.wr.usgs.gov/open-file/of01-153)

Wong, F.L. and Eittreim, S.L., 2001, Continental shelf GIS for the Monterey Bay National Marine Sanctuary: U.S. Geological Survey Open-File Report 01-179. (http://geopubs.wr.usgs.gov/open-file/of01-179/)

Woodward-Clyde Consultants, 1979, Southern California seismic survey final report on contract no. DACW72-79-C-0032: Woodward-Clyde Consultants for the Department of the Army Coastal Engineering Research Center Corps of Engineers Final Report on Contract No. DACW72-79-C-0032, Project No. 41205, 14 p.

RESULTS FROM CSMW TASK 5

(80/20 Coarse-to-Fines Rule of Thumb)

TASK 5 - Research any studies assessing the 80/20 coarse-to-fines "rule-of-thumb" ratio used by various regulatory agencies to determine whether potential source sands are compatible with a given beach. Identify the origin of the rule-of-thumb and nourishment projects where variances from the rule of thumb were allowed, including the basis for each variance.

80/20 COARSE-TO-FINES "RULE-OF-THUMB" RATIO

It appears that there is a widespread misperception, within both regulatory agencies and the regulated community, that an 80/20 coarse-to-fines "rule-of-thumb" ratio is an inviolate rule prohibiting the use of dredged material containing more than 20% fines for beach nourishment purposes. In actuality, the 80/20 ratio is merely a consensus view among regional offices of the U.S. Environmental Protection Agency and the Interagency National Dredging Team of what constitutes "predominantly" sand, for the purpose of applying the testing exclusion criteria of the Marine Protection, Research, and Sanctuaries Act (MPRSA or "Ocean Dumping Act") to the disposition of dredged material (memo from Brian Ross to Laura Johnson, April 2000). Specifics of the exemption are codified in 40 CFR –Part 227, Section 227.13 (b)(1) (U.S. Code of Federal Regulations, 2003a). When the 80/20 ratio is applied under MPRSA, dredged material that is less than 20% silt and finer material (i.e., "composed predominantly of sand") is deemed environmentally acceptable for ocean dumping or beach replenishment without further chemical or toxicity testing. Nonetheless, grain-size analysis of the dredged material must be done to make this determination. The desire to impose an upper limit of fine sediment content is premised on the fact that silts and clays, as opposed to coarser sediments, commonly contain adsorbed chemical contaminants that may have adverse impacts on marine environments or human health.

The U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (EPA) share regulatory responsibility for all discharges of dredged material in waters of the United States under Section 404 of the Clean Water Act (CWA), and section 103 of the MPRSA. Officials with both agencies agree that the 80/20 ratio is a "rule of thumb" only and that there is no statutory authority for its enforcement nor any known definitive studies or research from which a 20% cut-off was selected. Instead, it represents a national consensus value based on experience that such sediments are unlikely to be contaminated to an extent that would cause environmental damage (Brian Ross, "Beach Nourishment Questions", e-mail to author, June 7, 2004; Gregory Dombrosky, U.S. Army Corps of Engineers, personal communication, April 9, 2004). More importantly, the MPRSA testing exclusion in no way prohibits the use of material containing more than 20% silt and clay for beach nourishment. To the contrary, both the MPRSA and CWA 404(b)(1) guidelines (40 CFR – Part 230, U.S. Code of Federal

Regulations, 2003b) actually provide the means by which sediments containing a greater percentage of fines can be approved for beach replenishment on a site-specific basis. The EPA and USACE recognize a critical need for beach replenishment and encourage the use of dredged material (which might otherwise be disposed of) for beneficial nourishment projects. Both agencies also recognize that there is significant flexibility in allowing material with higher percentages of fines provided it meets the requirements of the 404(b)(1) guidelines that dredged material be demonstrated to be compatible with the receiving beach (memo from Brian Ross to Laura Johnson, April 2000).

Both the USACE and EPA define dredged material for beach replenishment as “fill” when the basic project purpose is beneficial beach nourishment and the project is determined to be necessary. In this case, regardless of whether the material is specifically dredged from borrow sites or is dredge waste material, it can be regulated under the 404(b)(1) guidelines rather than the MPRSA. This eliminates the need for a lengthy and formal designation as an official ocean disposal site for each and every receiving beach (memo from Brian Ross to Laura Johnson, April 2000). Hence, the guidelines become the primary criteria used by the USACE and EPA in evaluating beach nourishment projects. If no real need for nourishment can be demonstrated or if most of the material will not serve the intended purpose, the activity would be considered disposal (and thus regulated under MPRSA).

The 404(b)(1) guidelines allow for site-specific determinations regarding compatibility of dredged-sediment grain sizes with receiving beaches. Dredge or fill discharges must satisfy the requirements of sec 230.10 of the guidelines which, among other things, mandate that 1) the discharge site must be the least environmentally damaging alternative, 2) discharge will not result in significant degradation of ecosystems based on factual determinations, and 3) that all practicable means must be employed to minimize for adverse environmental impacts.

The Inland Testing Manual (Manual) was prepared by the USACE and EPA as a guidance document for implementing compliance with the 404(b)(1) Guidelines. It sets out the recommended protocols for three levels of tiered testing of dredged materials. It is necessary to proceed through the tiers only until information sufficient to make factual determinations has been obtained. Subpart G of the 404(b)(1) guidelines requires the use of available information to make a preliminary determination whether additional tiered chemical or biological testing of the material is necessary. Tier 1 emphasizes grain-size compatibility and chemical similarity of the dredged material to the receiving beach. If a first-tier analysis demonstrates grain-size compatibility with the receiving beach, dredged material can often be excluded from second- and third-tier chemical or biological testing. Such situations are most likely when the dredged material is composed primarily of sand, gravel and/or inert materials from a high-energy environment, the sediments are from locations far removed from contaminant sources, or the sediments are from pre-industrial age deposits not exposed to modern pollution sources (40 CFR Sec. 230.60(a), U.S. Code of Federal Regulations, 2003b). Additional testing is based on the concept of “reason to believe.” If there is a reason to believe that contaminants may be present, further evaluation is required.

From a regulatory standpoint, the physical compatibility of dredged material with the beach is the USACE’s primary basis for its decision regarding whether additional tiered chemical or biological testing is necessary. To make this decision, first-tier analysis of the dredged material grain-size distribution must be first be conducted and compared with the grain-size “envelope” of the receiving beach. When the material is determined to have an incompatibly high fine-sediment fraction, the second- and possibly third-tier chemical and biological testing are required to ascertain the degree of contamination in the fine fraction and the natural resources that might be impacted by the discharge or deposition of the fine-sediment fraction. Only then can the EPA and the USACE decide whether a relatively higher percentage of fines can be approved.

The Los Angeles District of the USACE regulates most California beach replenishment projects. In order to approve the use of dredged material for beach nourishment, the District requires the tiered testing approach as described in the Manual. The District’s tier-one testing is designed to determine if the dredged material is composed predominantly of sand, gravel, rock, or any other material greater than silt size and if the dredged material is compatible with the material on the receiving beach. Specific protocols for number and selection of dredge area and receiving beach sample sites, sampling methods, and data analysis methods are described in the District’s “Requirements for Sampling, Testing, and Data Analysis of Dredged Material Guidelines” (U.S. Army Corps of Engineers, undated; copy is available from CGS). To demonstrate compatibility with a given beach, the Los Angeles District requires that the overall percentage of silt and clay (grains less than 0.074 mm) in the dredged material must not exceed that of the finest beach sample by 10 percentage points. When a definitive determination of compatibility cannot be made, or, the dredged material contains a higher percentage of silt and clay, the tiered testing is then required. Satisfactory second- and third-tier test results may provide the USACE with the factual information from which it could approve using dredged material with 20% or more clay and silt for beach nourishment projects.

80/20 COARSE-TO-FINES “RULE-OF-THUMB” RATIO VARIANCES

Since the 80/20 ratio is an unenforceable rule of thumb, and applies to provisions of the MPRSA rather than the CWA, it becomes a futile exercise to identify beach nourishment projects that were permitted under a variance to this rule. While there may be isolated cases where the ratio was used to approve dredged sediment for replenishment, it is clear that most, if not all, projects that were implemented after enactment of the CWA in 1977 and development of the Inland Testing Manual required testing as required under the 404(b)(1) guidelines. Further, since it is agreed that the 80/20 ratio applied to provisions of the MPRSA, it could not have been applied to projects preceding enactment of the MPRSA in 1972.

In fact, in recent years there have been some beach nourishment projects in California that have been allowed to use dredged material with greater than 20% fines, but only after compatibility testing under the 404(b)(1) guidelines. In no case, however, has material exceeding 50% fines been approved. In one case, Santa Cruz Harbor was approved to use a maximum of 3,000 cubic yards per year of inner harbor material with fines ranging between 20-50%. It should be noted that this represents only 1% of the total material (generally 90%+ sand) placed on the beach every year (Brian Ross, “Beach Nourishment Questions”, e-mail to author, June 7, 2004).

Since records indicate that perhaps hundreds of site-specific nourishment episodes have been undertaken in California over the years (some as early as the 1920s), it would be a daunting task requiring many hours of research to identify all projects involving the use of sediments containing more than 20% fines. Consequently, it is considered beyond the scope of this project.

RECOMMENDATIONS

- Research the numerous beach-nourishment project files to identify projects that actually used a higher percentage of fines than 20%. Also research any post-nourishment monitoring of these beaches to determine the fate of the fine-sediment fraction and the long-term effects on beach profiles.

CSMW TASK FIVE

Bibliography

U.S. Army Corps of Engineers, undated, Requirements for sampling, testing, and data analysis of dredged material: U.S. Army Corps of Engineers, Los Angeles District, unpublished internal document, 14 p.

U.S. Code of Federal Regulations, 2003a, Title 40, Chapter 1, Part 227- Criteria for the Evaluation of Permit Applications for Ocean Dumping of Materials, revised as of July 1, 2003.
http://www.access.gpo.gov/nara/cfr/waisidx_00/40cfr227_00.html

U.S. Code of Federal Regulations, 2003b, Title 40, Chapter 1, Part 230- Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, revised as of July 1, 2003.
http://www.access.gpo.gov/nara/cfr/waisidx_00/40cfr230_00.html

U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, 1998, Evaluation of dredged material proposed for discharge in waters of the U.S. - testing manual (Inland Testing Manual), EPA-823-B-98-004, Washington, DC.
http://www.epa.gov/waterscience/itm/ITM/

RESULTS FROM CSMW TASK 6

(Debris Basins)

TASK 6 – Compile known information on debris-basin locations, contacts, volumes, and cleanout frequencies. Focus efforts outside of Ventura and Los Angeles Counties, since debris basins in those counties are already included within the SMP GIS.

INFORMATION ON DEBRIS BASINS

To identify debris basins in San Diego, Orange, San Luis Obispo, and Monterey counties, the public works departments/flood control districts in each county were contacted. Additionally, the California Department of Transportation was contacted regarding debris basins in San Luis Obispo and Monterey counties. Representatives of the public works departments/flood control districts in San Diego, San Luis Obispo, and Monterey counties stated that those counties do not have debris basins.

Orange County does not have debris basins like those in Los Angeles or Ventura counties that collect coarse material. However, it does have several retarding basins that are intended to slow runoff from storm events and reduce the amount of silt reaching Upper Newport Bay. These retarding basins are usually built by developers and turned over to the County for operation and maintenance. The retarding basins typically trap only silt and fines. Information on seven of these retarding basins is included in Table A5. Information for retarding basins in Orange County was provided by Mr. John Gietzen of the Orange County Public Facilities and Resources Department.

No efforts were made to collect information for Santa Barbara, Ventura, Los Angeles, San Bernardino, or Riverside counties as information on debris basins in these counties is summarized in a report prepared by the California Department of Boating and Waterways and State Coastal Conservancy (2002).

RECOMMENDATIONS

None

CSMW TASK SIX

Bibliography

California Department of Boating and Waterways (CDBW) and State Coastal Conservancy (SCC), 2002, California beach restoration study: Sacramento, California.

RESULTS FROM CSMW TASK 7

(Seasonal Cross-Shore Movement of Sand)

TASK 7 – Document known information (i.e., case studies, etc.) regarding the natural seasonal movement of sand from the beach to nearshore and back.

OVERVIEW

Numerous investigators and authors have documented and described the phenomenon of seasonal cross-shore transport of sand from the beach to nearshore and back again, a process that is particularly common along the coast of California. Most of what is known comes from morphological studies of beach profiles over time and the hydrologic and hydraulic conditions that form them. Little attention has been paid to differentiating between the transport patterns of the various sediment fractions, with the emphasis instead being focused on the effects of bulk coarse sediment transport.

Two types of sediment transport, determined by waves and currents, influence beaches and nearshore environments. “Cross-shore” transport describes the sediment transport perpendicular to the shoreline (onshore-offshore) and is the dominant mechanism by which beaches erode and accrete; it creates distinctly different seasonal beach profiles. “Longshore” transport carries sand parallel to the shoreline.

Excellent recent examples of seasonal cross-shore transport and the resultant change in beach profiles are described in the Regional Beach Monitoring Program Annual Reports of the San Diego Association of Government (Coastal Frontiers Corporation, 2000; 2004). During the 1999 one-year cycle, offshore sediment transport during the winter months resulted in beach transects exhibiting shoreline retreat of from 10 feet to 100 feet at transects on Imperial Beach, La Jolla, and Carlsbad. During the following summer season, the shoreline advanced more than 10 feet at 29 of 33 transects. Advances of more than 100 feet were recorded at locations near the Tijuana River mouth, La Jolla, Torrey Pines, and Carlsbad (Coastal Frontiers Corporation, 2000).

Beaches exist in a constant state of change undergoing both erosion and accretion in an attempt to come to equilibrium with the varying energy of the attacking waves. The beach profile is a natural mechanism that causes waves to break and dissipate their energy, in effect, adjusting itself to the prevailing wave forces. Faced with increasingly larger waves, a beach responds by reducing its overall slope and shifting the breaker zone farther offshore, thereby enhancing the dissipation of the waves before they reach the shore (Komar, 1997). Conversely, as wave energy decreases, beaches narrow and steepen. Average sediment size also impacts beach slope with finer material producing gentler slopes than coarse material. Short (1979) presented a model of beach erosion and accretion showing the various stages of this continuum whose end members are the winter “storm” profile and summer “swell” profile (“dissipative” and “reflective” profiles of Short, “bar” and “berm” profiles of Komar). Where a beach resides in the spectrum of beach profiles and the speed at which erosion and accretion remove and replace sand are largely a function of changes in wave height, period, and grain size (Short, 1999).

A total understanding of the critical wave conditions that govern the shift between summer and winter profiles is still incomplete. There are many field studies that demonstrate an increasing wave height leads to offshore sand transport and a bar profile, while low wave conditions cause a shoreward return of sand to the beachface and berm. However, no study has identified a critical wave steepness (ratio of wave height to wavelength, described below) that dictates when a summer profile will revert to a winter profile or vice versa (Komar, 1997).

Seasonal cross-sand transport is driven by major differences in the waves impinging on a beach. Waves are classified as either “storm” waves or “swell” waves. Storm waves are generated in the vicinity of a coast by storms and the interaction of strong winds on the ocean surface, while swell waves are generated by distant storms (Johnson, 1956; Silvester and Hsu, 1993). The two types of waves generally coexist simultaneously. Swells, however, can be completely obscured by local storm waves.

One of the most important factors in determining the character of a beach profile and the cross-shore transport of sand is the ratio of wave height to wavelength, or "wave steepness" (Johnson, 1949). Wave steepness is the ratio of deep-water wave height to wavelength, which is related to the wave period. Storm waves have high steepness values while long swell waves have low steepness values. Wave steepness can be increased either by an increase in the wave height or a decrease in the wave period. Physical parameters of the beach (i.e., grain-size distribution, cohesiveness, beach slope) also play an important role. In general, high, steep waves move beach sediments offshore, while low waves of long period (low steepness) move material onshore (USACE, 1989).

The process of winter marineward sand transport can be illustrated by studies of pre- and post-storm event beach profiles. During winter storms, higher wind velocities generate high and steep storm waves that assail the beach, which is largely near equilibrium with the milder summer swell waves. The beach begins to rearrange itself to accommodate the larger waves. Storm “surges” (water pushed toward shore by winds associated with the storm) also raise water levels and expose higher parts of the beach to wave action (USACE, 1989). When the waves break, their excess energy is expended on erosion of the beach. The eroded material is carried offshore in large quantities and deposited on the nearshore bottom in the form of an offshore bar. The bar eventually grows large enough to break the incoming waves farther offshore, forcing the waves to expend their energy farther seaward (USACE, 1989). In simplistic terms, larger storm waves erode the beach berm and redeposit the sand offshore in the form of a bar. Once the bar is fully formed and is breaking the majority of incoming storm waves, the surf zone is at its widest and the breaker heights greatest. It is at this time that the littoral current plus littoral drift are at a maximum (Silvester and Hsu, 1993).

The milder swell waves remobilize the bar sand and sweep this material back from the bar redepositing the sand back onshore and reforming the beach. Littoral current and littoral drift decrease as the bar is removed, and the profile reverts back to the swell-built curve. Also, the surf zone is at its narrowest width. While the sand is stored in the beach berm, the waves can only re-suspend sand on the beach face or a small fraction of the total volume of sand available during a storm profile, and hence, littoral drift becomes negligible (Silvester and Hsu, 1993).

BEACH RESPONSE TO STORM WAVES

When a swell profile beach is subjected to the increasing wave height and decreasing period of storm waves it responds with erosion and offshore transport of sand. The high wind velocities of local storms can produce large waves and a wide spectrum of wave trains of varying period and height (Silvester and Hsu, 1993). Storm waves are steep and powerful, containing more water above the mean sea surface than swell waves. Storm waves break on a beach almost every second, much more frequently than during quiescent times. Erosion first occurs with beach material being placed into suspension by the strong plunging vertical motion of the breaking storm waves. The plunging motion creates sediment suspension and offshore sand transport over the seabed.

The repeated onslaught of storm waves quickly saturates the beach face and raises the water table until it is almost coincident with the beach face itself (Short, 1999). With the beach face saturated, there is nowhere else for the water to go and the downrush becomes almost equal to the uprush dragging much of the sand that was suspended in the breaking waves back down the beach face. Contributing to the downrush return of sand is the flow of excess groundwater back to the sea. At the waterline, it is moving vertically, which causes liquefaction, placing more sand in suspension and causing wave-induced slumping. This phenomenon undermines the toe of the beach face, which progressively retreats landward (Silvester and Hsu, 1993). The disappearance of the berm can happen rather quickly and can be removed in one or two days of unusually heavy erosional activity.

As wave heights increase, the combined action of berm-overwashing, berm-breaching, and strong swash action results in the slumping and collapse of the lower beachface. The sediment removed from the berm and beachface is deposited immediately seaward of the beach face where it begins to form an attached bar (Short, 1999). The increase of storm wave-heights accelerates beach erosion. which drives the beach profile to the fully erosional, winter, beach type and the offshore bar moves seaward, separated from the beach by a broad trough (Short, 1999).

BEACH RESPONSE TO SWELL WAVES

Swell waves are generated from far-away storms and continue to propagate radially outward across the ocean, dissipating their energy over an ever-increasing area. The energy dissipation associated with the radial wave front reduces wave heights to only 5-10% of their original height and increases wave period (Silvester and Hsu, 1993). Along the west coast of North America the largest storm waves and predominant swell travel in an east and southward direction towards the equator.

As swell waves replace storm waves, they dismantle the offshore bar and transport its sand shoreward infilling the trough and building the beach face. Swell waves are refracted at the continental shelf where their path becomes normal to the coast. During their traverse of the nearshore and surf zone, bottom material is suspended, most of it from the offshore bar (Silvester and Hsu, 1993). As each wave breaks and swashes up the beach face, its water percolates into the sand. The infrequent arrival of swell waves (often many seconds) relative to the higher frequency of storm waves allows much of the water to percolate to the water table before making its way back out to sea (Silvester and Hsu, 1993). The resulting downrush is smaller then the uprush and can’t carry much of the sediment load back down the beach face, hence, the beach accretes (Silvester and Hsu, 1993).

As wave heights continue to drop, increasing swell-wave dominance continues to move sand shoreward. The bar moves shoreward, and the width of the surf zone decreases. As more sand moves onto the beach, a berm crest develops which is characterized by a slightly landward sloping berm. The accretion of the beach face and berm will continue only so long as there is material available in the offshore bar to be fed into the breaking waves. By this time the bar has moved completely on to the beachface and a relatively deep, barless nearshore zone fronts the beach. In this fully accreted state, a beach will take on a parabolic curve characteristic of a summer swell-beach profile. The slope of the beach face depends on the size of available sediment: fine sand produces gentler slopes than coarse materials.

In nature, the complete erosional/accretional sequence is not common, since waves rarely stay low long enough to achieve the full transition. However, the southern California beaches are considered an example of beaches that generally experience the full sequence (Short, 1999).

IMPACT OF LONGSHORE CURRENTS

On most beaches, cross-shore sand transport is impacted by longshore currents, which are largely responsible for the net erosion of beaches that results in the need for beach replenishment. Wave-induced longshore currents are related to angle of incidence of the breaking wave fronts to the shoreline and become superimposed on the oscillatory nature of wave motion perpendicular to the shore. When a wave breaks at an angle to the shoreline, the longshore current it produces carries in a zigzag pattern some of the sand suspended by the breaking waves a short distance downshore in a process called littoral drift.

RECOMMENDATIONS

None

CSMW TASK SEVEN

Bibliography

REFERENCES CITED

Coastal Frontiers Corporation, 2000, SANDAG 1999 regional beach monitoring program: Annual Report prepared for San Diego Association of Governments by Coastal Frontiers Corporation, Chatsworth, California, 44 p.

Coastal Frontiers Corporation, 2004, SANDAG 2003 regional beach monitoring program: Annual Report prepared for San Diego Association of Governments by Coastal Frontiers Corporation, Chatsworth, California, 122 p.

Johnson, J.W., 1949, Scale effects in hydraulic models involving wave motion: Transactions of the American Geophysical Union, v. 30, p. 517-25 (Early discussion of the importance of wave steepness (ratio of wave height to wave length) to beach profiles, erosion and accretion).

Johnson. J.W., 1956, Dynamics of nearshore sediment movement, American: Association of Petroleum Geologists Bulletin, v. 40, no. 9, p. 2211-2232. (A good early overview of beach sand transport including discussions and references regarding seasonal cross-shore sand movement and longshore transport).

Komar, P.D., 1997, Beach processes and sedimentation (2nd edition): Prentice-Hall Inc., Upper Saddle River, New Jersey, 544 p. (Excellent summary of the state of knowledge regarding the seasonal cross-shore transport of beach sand and the establishment of seasonal storm and swell beach profiles)

Short, A.D., 1979, Three-dimensional beach-stage model: Journal of Geology, v. 87, p. 553-571.

Short, A.D., 1999, Wave-dominated beaches, *in* Short, A.D., editor, Handbook of beach and shoreface morphodynamics: John Wiley and Sons, West Sussex, England, p. 173-203.

Silvester, R., and Hsu, J.R.C., 1993, Coastal stabilization – innovative concepts: PTR Prentice Hall, Inc., Englewood Cliffs, N.J., 578 p.

U.S. Army Corps of Engineers, 1989, Environmental engineering for coastal shore protection, *in* U.S. Army Corps of Engineers, Coastal Engineering Manual: U.S. Army Corps of Engineers EM 1110-2-1204, Washington D.C.

ADDITIONAL REFERENCES

Aubrey, D.G., 1979, Seasonal patterns of onshore/offshore sediment movement: Journal of Geophysical Research, v. 84, p. 6347-6354.

Bascom, W., 1980, Waves and beaches: The dynamics of the ocean surface: Anchor Books/Doubleday, Garden City, New Jersey (2nd edition), 366 p. (Discussion of seasonal changes in cross-shore sand transport and beach profiles).

Bijker, E.W., van Hijum, W., Vellinga, P., 1976, Sand transport by waves: Proceedings of the 15th Coastal Engineering Conference, Amer. Soc. Civil Engineers, p. 1149-1167.

Brunn, P., 1954a, Coast erosion and the development of beach profiles: Beach Erosion Board Technical Memorandum 44, U.S. Army Corps of Engineers, Washington D. C., 79 p.

Brunn, P., 1954b, Use of small-scale experiments with equilibrium profiles in studying actual problems and developing plans for coastal protection: Trans. Amer. Geophys. Union, v. 35, no. 3, p. 445-52.

Dally, W.R., and Dean, R.G., 1984, Suspended sediment transport and beach profile evolution: Journal of Waterway, Port, Coastal, and Ocean Engineering, Amer. Soc. Civil Engineers 110, p. 15-33.

Dalrymple, R.A., 1992, Prediction of storm/normal beach profiles: Journal of Waterway, Port, Coastal, and Ocean Engineering, Amer. Soc. Civil Engineers, v. 118, p. 193-200.

Dean, R.G., 1991, Equilibrium beach profiles: characteristics and applications: Journal of Coastal Research, v. 7, no. 1, pp 53-84.

Dean, R. G., Kriebel, D., and Walton, T., 2002, Cross-shore sediment transport processes, *in* U.S. Army Corps of Engineers, Coastal Engineering Manual: EM 1110-2-1100 (Part III), pp. III-3-50 – III-3-79. (Comprehensive and up-to-date discussion of storm wave cross-shore sediment transport mechanisms and dynamics and it’s effect on beach profile).

Everts, C.H., 1973, Beach profile changes on western Long Island, *in* Coastal Geomorphology, Part 3: Applications of Geomorphology, State University of New York, p. 279-301.

Hayes, M.O., 1972, Forms of sediment accumulation in the beach zone, *in*, Meyer, R.E., editor, Waves on beaches and resulting sediment transport: Proceedings of an advanced seminar conducted be the University of Wisconsin Mathematics Research Center and the U.S. Army Coastal Engineering Research Center, Oct. 11-13, 1971, p. 297-356. (Good discussion of the affect of wave height and period on the erosional winter/accretionary summer cycle of beach and nearshore sedimentation)

Ingle, J.C., Jr., 1966, The movement of beach sand - an analysis using fluorescent grains: Developments in Sedimentology 5, Elsevier Publishing Co., Amsterdam, London, New York, 221 p. (Studies of tracer sand transport including annual beach profiles displaying seasonal transport of sand reflected in the winter erosion and summer accretion for five southern California beaches).

Inman, D.L. and Masters, P.M., 1991, Coastal sediment transport concepts and mechanisms, *in* Coast of California Storm and Tidal Waves Study, State of the Coast Report, San Diego Region, U.S. Army Corps of Engineers, Los Angeles District, Chapter 5, p 5.1-5.43.

King, C.A.M, 1959, Beaches and coasts: Arnold Publishing, London, 403 p.

Pruzak, Z., 1989, On-offshore bed-load sediment transport in the coastal zone: Coastal Engineering, v. 13, p. 273-292.

Rector, R. L., 1954, Laboratory study of equilibrium profiles of beaches: Beach Erosion Board Technical Memorandum 41, U.S. Army Corps of Engineers, Washington D.C., 38 p.

Scott, T., 1954, Sand movement by waves: U.S. Army Corps of Engineers, Beach Erosion Board, Technical Memorandum 48, Washington, D.C., 37 p. (Discusses relationship of wave steepness to cross-shore sand transport and establishment of equilibrium beach profiles.)

Shepard, F. P., 1950a, Longshore bars and longshore troughs: U.S. Army Corps of Engineers, Beach Erosion Board, Technical Memorandum 15, Washington, D.C.

Shepard, F. P., 1950b, Beach cycles in Southern California: U.S. Army Corps of Engineers, Beach Erosion Board, Technical Memorandum 20, Washington, D.C.

Smith, J.B., 1995, Literature review on the geologic aspects of inner shelf cross-shore sediment transport: U.S. Army Corps of Engineers, Miscellaneous Paper CERC-95-3, 161 p.

Taylor, A.D. and Meyer, R.E., 1972, Run-up in beaches, *in* Meyer, R.E., editor, Waves on beaches and resulting sediment transport: Proceedings of an advanced seminar conducted be the University of Wisconsin Mathematics Research Center and the U.S. Army Coastal Engineering Research Center, Oct. 11-13, 1971, p. 357-411. (A mathematical treatment of the effect of wave train frequency and amplitude on the maximum excursion of water onto a beach in the swash zone).

Thom, B.G., and Hall, W., 1991, Behaviour of beach profiles during accretion and erosion dominated periods: Earth Surface Processes and Landforms, v. 16, p. 113-127.

Watanabe, A., Riho, Y., and Horikawa, 1980, Beach profiles and on-offshore sediment transport: American Society of Civil Engineers, Proceedings of the 17th Coastal Engineering Conference, p. 1106-1121.

Wiegel, R. L., Patrick, D. A., and Kimberly, H. L., 1954, Wave, longshore current, and beach profile records for Santa Margarita River, Oceanside, California: Trans. Amer. Geophysical Union, v. 35, no. 6, p. 887-96.

PART B

PRELIMINARY OVERVIEW OF DREDGING TECHNOLOGY FOR OFFSHORE SAND RESOURCES, WITH APPLICATION TO CALIFORNIA

INTRODUCTION

The use of offshore sand deposits for nourishment of beaches along the coast of California relies directly on dredging technology. Such technology is currently the only means of moving sufficient quantities of sand to shore in a timely manner. This technology is used worldwide and is highly developed in several countries, particularly The Netherlands, Belgium, Japan, and Great Britain.

Those areas of sand resources that fall under Federal jurisdiction (Minerals Management Service) cover the offshore area beyond the 3-nautical-mile State-Federal boundary. Because the width of the continental shelf of California is very irregular and very narrow in many places, the water depths at this boundary vary significantly. Dredging technology and economics have various limitations dependent on water depths and distances from nourishment projects; consequently, shelf properties have an important influence on the practicality of dredging operations.

BACKGROUND ON OFFSHORE DREDGING

Dredges are classified under two main categories, hydraulic and mechanical. For production of offshore sand, especially in waters beyond the 3-nautical-mile limit, hydraulic dredges are used almost exclusively. This type of dredge is self-contained, meaning that it can both excavate the sand and dispose of it at the receiving site. Because of these two capabilities, such dredges are more efficient, versatile, and economical to operate than the mechanical type of dredges (Herbich, 2000).

Hydraulic dredges operate by pumping sand as slurry through a pipe that has either a cutterhead or draghead mounted at the end of the pipe where it meets the seafloor. Pumps to extract the sand are mounted in-board within the vessel or submerged as part of the dredge pipe itself.

Cutterhead-Suction Dredges

Cutterhead-suction (CS) dredges operate from a stationary site, pumping the sand slurry through a floating or submerged pipeline to a barge or to the actual site of nourishment along the shoreline.

In 2004, the largest cutterhead-suction dredge in the world was the JFJ de Nul, operated by the Jan de Nul Group of Belgium. It had a discharge pipe diameter of 1000 mm (40 inches) and a total power capacity of 27,240 kW (36,500 hp). The largest cutterhead-suction dredge in the U.S. in 2004, based on power capacity, was the Texas, operated by Great Lakes Dredge & Dock Company. It had a discharge pipe of 30 inches and a power capacity of 20,300 hp.

Table B1 lists the larger cutter-suction dredges operating in the U.S. as of 2004, as well as an example of the largest international dredges for comparison.

Trailing-Suction Hopper Dredges

Trailing-suction hopper (TSH) dredges operate as self-propelled units that sweep back and forth across a sand deposit in contrast to the stationary operation of the cutterhead-suction type of dredge. They also store the sand onboard in a hopper, which allows them to extract sand at distances farther from shore. They discharge their sand through on-board pumping systems, through bottom doors ("split-hull" design), or by mechanical removal at docks. These dredges overall are the best suited for offshore work (Herbich, 2000).

The most significant technological advancement in TSH dredges over the last 10-15 years is the development of submersible pumps that are mounted at the draghead. The design of increasingly larger pumps has allowed such dredges to dredge material from correspondingly greater water depths in the ocean.

Standard hopper dredges operate throughout the coastal United States. Currently, the largest ocean-going TSH dredge operational in the U.S. is the *Stuyvesant*, operated jointly by Bean Dredging and Royal Boskalis Westminster as the Bean-Stuyvesant Company. This dredge has a hopper capacity of about 11,000 yd^3, which is relatively small by international standards. The largest-capacity TSH dredge in the U.S. is the *Long Island*, operated by the Great Lakes Dredge & Dock Company; hopper capacity is 16,000 yd^3, but this vessel is no longer ocean going. In 2004, Manson Construction was building a TSH dredge of about 12,000-yd3 capacity, which is expected to be completed in another 1-2 years (Leonard Juhnke, Manson Construction, personal communication, 2004).

"Jumbo" hopper dredges are currently the largest dredges in operation internationally. In 2004, the largest dredge in the world was the *WD Fairway*, operated by Royal Boskalis Westminster of The Netherlands. It has a hopper capacity of about 36,500 m^3 (47,750 yd^3), with a total power capacity of 27,567 kW (36,984 hp). In the future, the Jan De Nul Group expects to retrofit its *Vasco da Gama* to a hopper capacity of 40,000 m^3 (52,320 yd^3).

Table B1 lists the larger trailing-suction hopper dredges operating in the U.S. as of 2004, as well as a few examples of the largest international dredges for comparison.

Offshore Dredging in Southern California

Offshore dredging for sand in California has historically been confined to State waters within the 3-nautical-mile State-Federal boundary. The two main goals of such projects are to dredge in shallow water and to be near the site of beach nourishment (as long as the dredging does not adversely affect the beach profile). In southern California, the site of most historic activity, dredging of offshore sand deposits generally takes place in water depths of about 30-60 feet. The greatest water depth reached during a project in California, as determined during research for this report, was about 80 feet, near the Port of Los Angeles (Mo Chang, U.S. Army Corps of Engineers, personal communication, 2004).

In 2001, the TSH dredge *Sugar Island* (see Table B1), operated by NATCO, a subsidiary of Great Lakes Dredge & Dock Company, was used to nourish 12 individual beaches along the coastline of San Diego County. A total of approximately two million cubic yards of sand were placed in a single campaign that moved from one beach to the next. This project extracted sand from six separate offshore borrow sites within State waters. As of 2004, it was the largest regional beach-nourishment project ever accomplished in California.

In late 2003, Manson Construction Company used the TSH dredge *Westport* (see Table B1) to move sand about 10 miles from a site at Santa Barbara Harbor to Goleta for nourishment of Goleta Beach (James Bailard, BEACON, oral communication, 2004). The dredge site was chosen after an initial offshore site only one mile from the beach was rejected because of the presence of kelp on the sand deposit. A cutterhead dredge was to be used at the initial site, but selection of the alternate site required use of a TSH dredge because of the long distance of transport to Goleta Beach. Approximately 59,000 yd^3 were moved by the *Westport* at a cost of about \$23/yd^3 (the cutterhead at the original site was projected to cost about \$4/yd^3). The *Westport* was unable to complete the project because it eventually encountered cobbles, which it could not remove. As a result, an additional 18,000 yd^3 of sand were trucked to Goleta Beach at a cost of about \$8/yd^3 from onshore sources to complete the nourishment. This project was reportedly the first beach-nourishment project in either Santa Barbara or Ventura counties other than those projects conducted by the U.S. Army Corps of Engineers (USACE).

LIMITATIONS AND RESTRICTIONS ON DREDGING

Although sand deposits may be present at many locations in the offshore beyond the State-Federal boundary, various issues will determine whether or not an individual deposit can be excavated for use in beach nourishment.

Technological Issues

- **Depths of Water** – the water depths at which dredges can pump sand are limited by the physics of pumps (barometric pressure in-board, cavitations). As of 2004 the greatest depth that was feasible was 155 meters (508 feet) on the TSH dredge *Vasco da Gama* (see Table B1); the greatest known actual depth reached was 134 meters (440 feet) in 2003 off Canada using this same vessel. The next near-term goal in design by one company is to develop a submerged pump of 10,000 kW (13,400 hp) that will allow dredging at 200 meters (656 feet) depth of water.

- **Length of Discharge Pipeline** – this issue applies mainly to cutterhead-suction dredges in that these dredges must pump the sand from dredge site to nourishment site via a floating or submerged pipeline. In 2004, a pipeline length of 25,000 feet (4 nautical miles) was commonly achievable in coastal areas of the U.S. other than California. Longer distances are possible, but booster pumps are needed (see economic issues).

- **Seafloor Characteristics** – the physical character of the seafloor material to be produced will in some instances determine what type of dredge is most appropriate. Cutterhead-suction dredges can be fitted with a variety of cutterheads that can produce from harder material.

- **Stability in Open Ocean** – swell and waves can significantly affect operations of a dredge. High swell, for example, can cause the dredge to rise and fall enough that it disrupts the efficiency of the cutterhead on the seafloor.

- **Draft of Trailing-Suction Hopper Dredges** – the draft of a trailing-suction hopper dredge determines how close it can approach the site of sand discharge. By virtue of their size, the largest hopper dredges have a large draft, which means they must anchor farther offshore from sites of beach nourishment to discharge their cargo of sand.

- **Structural Obstructions** – this category includes such features as infrastructure (seafloor pipelines, cables, drilling platforms), archeological sites (shipwrecks), and fish havens. Such features should be avoided by dredging activity.

Economic Issues

- **Depths of Water** – according to several individuals involved in dredging in southern California, dredging is economical in depths of water up to about 100 feet. This figure may be largely affected by the physical configurations and capabilities of the U.S. dredging fleet.

- **Distance to Nourishment Sites** – pertinent here are 1) the distance of transport when using trailing-suction hopper dredges and 2) pipeline lengths between nourishment-site and dredge-site when using cutterhead-suction dredges. Regarding TSH dredges, the most important costs result from travel time between dredge-site and nourishment-site, and from fuel used. Regarding CS dredges, the economic threshold of pipeline length is about 25,000 -30,000 feet (about 4-5 nautical miles). When these lengths are reached, however, it is probably more economic to use TSH dredges.

- **Size of Dredges** – to be most economical for a specific job of nourishment, a dredge must be of an appropriate size and capability. "Larger" does not necessarily translate to "cheaper" because of operating costs (e.g., mobilization, size of crew, fuel, etc.); the international jumbo TSH dredges can move large quantities of sand per trip, but they generally require large-scale projects to make their use economic. On the other hand, a small-capacity TSH dredge may have to make too many round trips to supply the required sand or may not have the capability to reach bottom in the desired offshore sand deposit.

- **Overall Cost to Dredge Sand** – the common standard for comparing costs of dredging offshore sand is the overall cost per cubic yard of sand. Listed below are some estimates of overall costs per cubic yard of sand as reported from different sources. Direct comparison of them is not justified, however, because of their different time periods, geographic locations, and uncertainty as to what factors were used to derive them.

  USACE (1990) (http://el.erdc.usace.army.mil/elpubs/pdf/drp4-02.pdf): $1.50 - $3.50 for USACE contracts on the Gulf and East Coasts.

  UNESCO (1998) (http://www.unesco.org/csi/pub/source/ero19.htm): $5.00 - $16.00 for projects in the Caribbean, plus mobilization costs.

  BEACON (2003) (James Bailard, BEACON, oral communication, 2004): $4.00 for a CS dredge one mile offshore; $23 for a small TSH dredge deployed about 10 miles from the nourishment site.

Legal Issues

Dredging in the United States is fundamentally governed by two pieces of federal legislation enacted in the early 1900s to protect the domestic maritime fleet from unfair foreign competition. The first piece is the Act of May 28, 1906, which is informally referred to as the Dredging Act. Most importantly, this act originally established requirements that all dredges engaged in dredging activities in navigable waters of the U.S. had to be U.S.-constructed and U.S.-documented (U.S. House of Representatives, 2003). The second piece of legislation is Section 27 of the Merchant Marine Act, 1920, which is informally referred to as the Jones Act. Provisions of this broad act originally resulted in the requirement that hopper dredges engaged in dredging activities in navigable waters of the U.S. also had to have at least 75% ownership by U.S. citizens (U.S. House of Representatives, 2003; U.S. Department of Transportation, 2003a). This requirement did not apply to non-hopper (e.g., cutterhead-suction) dredges because they did not transport dredged material ("merchandise") between two points along the coastal U.S. as do hopper dredges.

In 1992, the Dredging Act was amended through the Oceans Act of 1992 to apply the 75% citizenship requirements of the Jones Act to all dredges engaged in dredging in the navigable waters of the United States (U.S. House of Representatives, 2003). An exception to the requirements of U.S. citizenship was granted to the Bean-Stuyvesant Company to operate the TSH dredge *Stuyvesant*, a U.S.-constructed and U.S.-flagged vessel chartered to the company, which at the time of the amendment did not meet the U.S.-ownership requirements.

Provisions of the Jones Act have been controversial for a number of years, and there were attempts to modify or repeal the act during the 1990s. There has also been litigation during this period that stems from the 1992 amendment.

The importance of these two acts for present-day dredging of sand in waters offshore of the United States, and particularly California, is that they significantly restrict the pool of available dredges that can operate here. For example, it eliminates the use of foreign-owned jumbo hopper dredges, which are capable of producing sand from deeper shelf waters.

Other limitations on offshore dredging concern its exclusion from marine sanctuaries (protection of marine habitat), certain military and navigational zones (safety), and disposal sites (potential contaminants/debris and high variation in physical properties).

DREDGING COMPANIES AND DREDGES IN THE UNITED STATES

There are hundreds of dredging companies based throughout the world (Placer Management Corporation, 2004). Outside the United States, several countries have companies that operate dredges that are much larger than any in use in the U.S. Within the United States, most companies are small, local concerns that specialize in inland or coastal activities rather than offshore operations. Their most common work is in harbor and channel maintenance and in reclamation of shore areas for new construction projects. Relatively few companies engage in production of offshore sand deposits specifically for nourishment of coastal beaches. Generally, these companies are large, well-established enterprises that own or charter dredges capable of operation in ocean conditions.

In addition to private companies, the USACE has its own fleet of dredges, which are manned by members of the civil service (see Table B1).

There are two companies that currently conduct the majority of offshore dredging projects for beach nourishment in southern California: Operations for Manson Construction Company, which is headquartered in Washington State, is locally based in Long Beach, while Great Lakes Dredge & Dock Company is headquartered in Illinois. The other two largest U.S. companies, Weeks Marine (New Jersey) and Bean Dredging (Louisiana), have had little or no involvement in California.

PERMITTING OF DREDGE OPERATIONS

Offshore dredging is under jurisdiction of the U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (National Oceanic and Atmospheric Administration, 2004). Between the shoreline and the 3-nautical-mile State-Federal offshore boundary, the California State Lands Commission is also involved in the process of permitting of dredging.

THE FUTURE OF DREDGING IN THE U.S.

Other countries, most notably The Netherlands and Belgium, are sites of much of the leadership and innovation in the dredging industry. Much of the modern advancement of dredging technology has occurred outside the U.S.

To allow dredging at water depths greater than the current 100-150 feet maximum in the U.S. will require 1) changes in the present Dredging Act and Jones Act and/or 2) construction of U.S. dredges that can produce from greater water depths.

Regarding the first requirement, some experts do not see near-future repeal or modification of the current legal restrictions that are in place under the Dredging Act and Jones Act; changes to the acts could allow foreign-based vessels, capable of producing at greater water depths, to operate in the U.S.

Regarding the second requirement, it is commonly believed that the U.S. dredging industry will construct larger ocean-going vessels if there is a demand. As onshore and nearshore sand resources are locally depleted, there may be demand to extract sand that is farther offshore in waters under Federal jurisdiction. This situation is more common on the East and Gulf Coasts where the physical characteristics of the continental shelf offer more potential targets than do those of the West Coast, particularly in southern California.

An additional consideration is that the conventional dredging technology in place now could change in the future. As reported in a document published by the U.S. Minerals Management Service (1999), advances in the industry have been largely modifications of existing technology. Nonetheless, one example of an innovation is the “punaise” system developed in The Netherlands. In this technology, the punaise is a remotely operated dredge that resides on the seafloor and pumps sediment to the site of beach nourishment.

CONTACTS AND ACKNOWLEDGMENTS

The California Geological Survey appreciates assistance and information provided by the following individuals during preparation of this report: John Smith, John Rowland, and Barry Drucker of the Minerals Management Service; Greg Dombrosky, Jack Ferguson, Mo Chang, Jerry Gompers, Mark Durham, and Chuck Mesa of the U.S. Army Corps of Engineers; Dave Simonelli and Greg Sraters of Great Lakes Dredge and Dock Company; Leonard Juhnke of Manson Construction Company; Rick Smith of Weeks Marine; Mort Richardson of Placer Management Corporation; and Kim Sterrett of California Department of Boating and Waterways.

REFERENCES

Bean Dredging LLC, 2004, Miscellaneous Web pages available at http://www.cfbean.com/beandred/defaultcont.htm.

Chambers Consultants and Planners, 1979, Economic feasibility of OCS mining for sand and gravel, San Pedro shelf, offshore Los Angeles, and San Diego shelf, south of La Jolla Canyon: Final Report to U.S. Department of the Interior, Geological Survey.

GlobalSecurity.org, 2004, Dredges: Web page available at http://www.globalsecurity.org/military/systems/ship/dredges.htm.

Great Lakes Dredge and Dock Company, 2004, Miscellaneous Web pages available at http://www.gldd.com.

Herbich, J.B., 2000, Handbook of dredging engineering: McGraw-Hill, Inc., New York, New York.

IHC Holland, 2004, Miscellaneous Web pages available at http://www.ihcholland.com.

Jan De Nul Group, 2004, Miscellaneous Web pages available at http://www.jandenul.com.

Manson Construction Company, 2004, Dredging: Web page available at http://www.mansonconstruction.com.

National Oceanic and Atmospheric Administration, 2004, Dredging and disposal of marine sediments: Regulations and guidelines: Web page available at http://www.csc.noaa.gov/benthic/mapping/applying/regs.htm.

Placer Management Corporation, 2004, 38th annual directory of worldwide dredge fleets, suppliers, and engineers: World Dredging/Mining & Construction, v. 40, no. 3, 79 p.

Richardson, M.J., 2001, The dynamics of dredging: Placer Management Corporation, Irvine, California, 413 p.

Royal Boskalis Westminster nv, 2004, Miscellaneous Web pages available at http://www.boskalis.com.

U.S. Army Corps of Engineers, 1983, Engineering and design – Dredging and dredged material disposal: U.S. Army Corps of Engineers Engineer Manual 1110-2-5025.

U.S. Department of Transportation, 2003a, Compilation of maritime laws – Merchant Marine Act, 1920: Web page available at http://www.marad.dot.gov/publications/complaw03/Merchant%20Marine%20Act,%20of%201920.htm.

U.S. Department of Transportation, 2003b, Compilation of maritime laws – Statutory waivers of the Jones Act: Web page available at http://www.marad.dot.gov/publications/complaw03/Statutory%20Waivers%20of%20Jones%20Act.htm.

U.S. House of Representatives, 2003, Joint hearing on interpretations of existing ownership requirements for U.S. flag dredges: Subcommittee on Water Resources and Environment, Subcommittee on Coast Guard and Maritime Transportation, Web page available at http://www.house.gov/transportation/water/04-30-03/04-30-03memo.html.

U.S. Minerals Management Service, 1999, Environmental report: Use of federal offshore sand resources for beach and coastal restoration in New Jersey, Maryland, Delaware, and Virginia: Minerals Management Service OCS Study MMS 99-0036, prepared by The Louis Berger Group, Inc. under Contract No. 1435-01-98-RC-30820.

Visser, B., 2004, Directory of dredgers: Web page available at http://www.dredgers.nl.

Weeks Marine, Inc., 2004, Miscellaneous Web pages available at http://www.weeksmarine.com.

PART C

PRELIMINARY INVENTORY OF DATA PERTINENT TO OFFSHORE SAND DEPOSITS IN SOUTHERN CALIFORNIA

(Portions of this report were extracted and modified/expanded from summaries prepared for PART A)

INTRODUCTION

One of the Year-One activities begun by the California Geological Survey (CGS) during the MMS/CGS/CDBW offshore sand project included research and inventory of studies and data related to the geologic characteristics at and below the seafloor along the continental shelf of California. It also included research on cultural features that might affect where sand could or could not be extracted in the future for beach nourishment.

Many sources were researched and consulted to determine the types, breadth, residence, and geographic extent of data and information available. These sources generally came under the following categories:

- Libraries/Archives (Hard-Copy Holdings)
- World Wide Web (On-Line Services and Web Sites)
- Personal Interviews

BACKGROUND

The observation and mapping of the geologic materials on the ocean floor can lead to discovery of deposits of sand. Where of acceptable grain characteristics, volume, degree of consolidation, depth of submergence, and distance from shore, such deposits have been and will continue to be sources of material for beach replenishment/nourishment. The most desirable deposits are unconsolidated, have large volumes, are similar in physical character to the material on the receiving beaches, are in shallow water close to the receiving beaches, and are free of contaminants and debris. Also, mining of them would produce minimal environmental disturbance.

Typically, the identification and characterization of submarine geologic materials relies on both direct and indirect observation and measurement. Direct methods include visual observation, via submersible vehicles or cameras, and collection of samples through diving, dredging, or coring. Indirect methods include various geophysical techniques that can characterize the seafloor as well as the material beneath it. These data lead to maps and calculations that determine the locations, areal extents, volumes, and physical properties of the materials at and below the ocean floor. Furthermore, because of economic and technological limitations, the depth of sand deposits below the sea surface is of major interest, which requires reliable bathymetric measurements.

The identification and characterization of materials is also important for understanding and management of benthic habitat for marine organisms. The mapping of such habitats, which has become common in recent years, relies on the same techniques for exploration and characterization of sand deposits. Consequently, submarine geologic mapping and benthic habitat mapping are complementary and in some ways might be considered one and the same.

OVERVIEW OF OFFSHORE GEOLOGY OF CALIFORNIA

The complex geology that makes up onshore coastal California continues offshore beneath the continental shelf. In contrast to the U.S. Atlantic and Gulf Coasts, the shelf off California is notably narrow and irregular, a reflection of the active geologic forces there. It is commonly dissected by submarine canyons and, in some places, is only 1-2 miles wide. In simplified view, offshore California is underlain by diverse types of bedrock covered or surrounded by mantles of unconsolidated sand, mud, and gravel.

General Characteristics of the Offshore Regions of California

Presented here are some general characteristics about offshore California (shelf and coast) as divided into the seven regions portrayed in the CGS-USGS California Continental Margin Geologic Map Series (Figure C1). References to shelf-width are for the 90-meter (~300-foot) contour of water depth. This contour represents an intermediate water depth that is greater than the capability of current dredging in the U.S., but less than the capability of international dredging. The contour along the entire coast of California is displayed in Figure C2 along with other contour values (30-m, 40-m and 150-m) for the coast. The 30-m contour represents the current general economic limit for dredging off the coast of California. The 40-m contour represents the current technological limit of deepest operating dredge allowed to operate in the U.S. The 150-m contour represents the current deepest dredging capability of any international dredge operating today (the actual greatest depth reached was 440 feet in 2003). Also shown is the 3-nautical-mile boundary that represents the State/Federal jurisdictional boundary offshore of the state.

Overall, available geologic mapping of offshore California is spotty as to areal coverage and detail. Some areas have been intensively studied and mapped, while others have been covered only by limited reconnaissance. Generally, areas close to shore and near large harbors and population centers have received more attention than those near less-developed parts of the coast.

Inner-Southern (Region 1): From Newport Canyon to Point La Jolla, the shelf at 90-meter water depth is relatively narrow (less than 2 nautical miles, although it widens

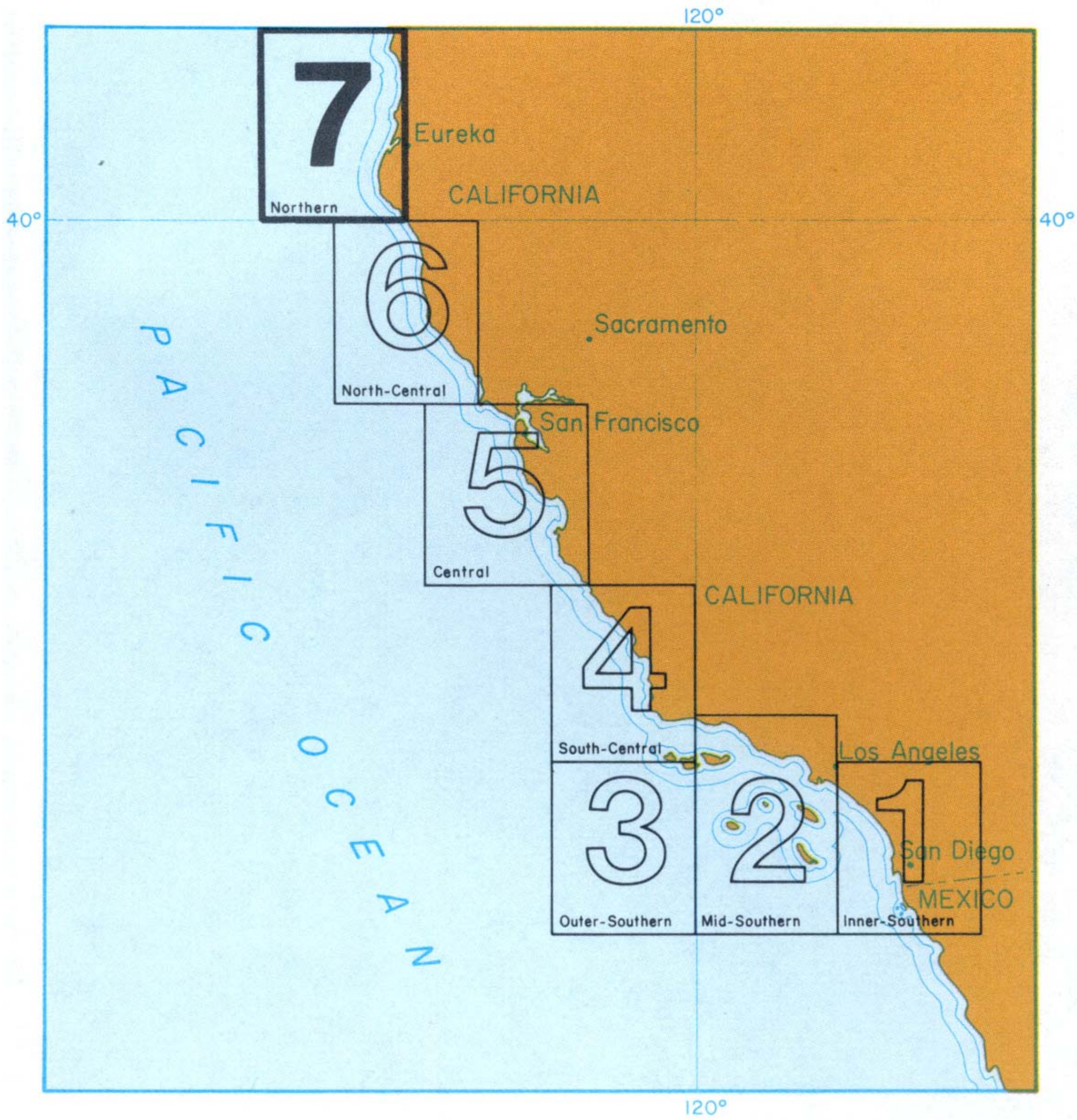


Figure C1 – Seven offshore regions discussed in text (graphic taken from the California Continental Margin Geologic Map Series published by the California Geological Survey/U.S. Geological Survey in 1986-1989).

somewhat north of Carlsbad Canyon to about 4 miles. South of Point La Jolla to the border with Mexico, there is a broadening of the 100-m shelf, particularly off Imperial Beach where it is up to about 8 miles wide. Geologic information about the shelf is extensive locally; it is probably one of most intensively studied areas because of proximity to marine labs. Many important recreational beaches are present along this map region; it probably has highest proportion of beach per unit length of coast of the seven map regions. The photograph below shows a typical beach (Oceanside) along this segment of the coast.

Photo by C. Higgins

Mid-Southern (Region 2): Much of the 90-m shelf from Newport Beach to just west of Santa Barbara is relatively narrow (less than 3 miles) except for areas at Ventura-Carpinteria, Santa Monica Bay, and San Pedro Bay where the shelf widens to as much as 10-11 miles. Geologic information is fairly extensive for selected local areas. Similar to Region 1, this region has numerous important beaches, some of which have been nourished.

Outer-Southern (Region 3): This region includes the islands, banks, and deep water of the continental borderland, away from the mainland coast. Although there is extensive geologic information for areas around the islands and banks, this region appears to be too far from the main coastline to be of interest for beach nourishment at this time.

South-Central (Region 4): The 90-m shelf from Cape San Martin in the north to San Luis Obispo Bay is fairly narrow (less than about 3 miles), but then widens from there south to Point Conception to as much as about 10 miles in places. Important recreational beaches are present between San Luis Bay and Point Sal. From Point Arguello to the south edge of the map the 100-m strip again narrows significantly. Geologic information is given for much of the immediate coastal area.

Central (Region 5): Within this region, broad shelf areas are present in the vicinity of both San Francisco Bay and northern Monterey Bay. The area from Point Reyes to Pescadero Point is very wide (nearly 25 miles off the Golden Gate) and may have potential if dredging technology at 90-m water depth is considered. From southern Monterey Bay to the southern map boundary (Big Sur coastline) the shelf is very narrow. Extensive geologic information is available for local areas, particularly for Monterey Bay to San Francisco Bay. Important beaches are in the Point Reyes area, along the San Francisco Peninsula, and along Monterey Bay. The photograph below shows a typical rugged portion (Big Sur coastline) of this segment of the coast.

Photo by C. Higgins

North-Central (Region 6): The 90-m shelf is very narrow over this segment of the coast, which extends from Point Reyes nearly to Point Delgada. With the exception of a wider section between Point Reyes and Fort Ross, the shelf is mostly less than 3 miles in width. The entire length is sparsely populated, and beaches are generally small and less used than those in southern California. This part of the coast, except at the Russian

River in the south and near Point Delgada in the north, is less affected by artificial restriction of sediment replenishment. Geologic information is relatively sparse compared to that along the central and southern California segments of the coast.

Northern (Region 7): The 90-m shelf from Point Delgada to Cape Mendocino is very narrow, but it broadens significantly from Cape Mendocino north to the border with Oregon; off the mouth of the Klamath River it is nearly 15 miles wide. This change is probably due in part to the large influx of sediment from the Eel, Mad, Klamath, and Smith rivers. Geologic information is sparse along this segment. Small population centers are at Eureka and Crescent City, and beaches are less used than those in central and southern California.

Based on information gathered for each of the seven regions summarized above and in consultation with various government agencies, the CGS decided at this time to limit its study of potential offshore sand resources to the Southern California Bight, which extends from Point Conception to the border with Mexico. The main reasons for this decision included the high percentage of beaches (and associated current and potential need for beach nourishment) and the distribution of population centers (tourism, residential and commercial development) in proximity to beaches in this region.

At the statewide level, there are two sets of published geologic maps that cover the entire offshore length of the state.

The first set, by Welday and Williams (1975), portrays at a scale of 1:500,000 the surficial geology of the offshore, with the greatest detail limited generally to within five miles of the coastline. The strength of this map is that the authors interpreted geologic bottom-types based on thousands of direct and indirect geologic observations made by various organizations. Especially noteworthy was use by the authors of the many historic observations of bottom type made during a suite of hydrographic surveys by the U.S. Coast and Geodetic Survey. Despite its age, this map is still a valuable aid to studies along many parts of offshore California. Figure C3 displays that portion of the map in southern California from Point Conception to the border with Mexico.

The second set, termed the California Continental Margin Geologic Map Series (CCMGMS), is a collaboration between the California Division of Mines and Geology (CDMG, now the California Geological Survey) and the U.S. Geological Survey. It consists of seven map sheets that portray at a scale of 1:250,000 details of local geology among other geologic-related information for the continental margin (see Kennedy and others, 1987). The sheets that cover the offshore north of San Francisco have very little geologic detail, while those south of San Francisco have much greater detail. This distribution mainly reflects the focus, intensity, and availability of offshore study by different institutions. Also, the CDMG-USGS map series does not display the mapping of Welday and Williams (1975), therefore, investigators should consult both sets of maps when studying all or part of offshore California. The digitized version of the CDMG-USGS map series can be downloaded from the Seafloor Mapping Lab Website at California State University, Monterey Bay (http://seafloor.csumb.edu/). Figure C4 displays that portion of the map in southern California from Morro Bay to the border with Mexico.

In addition to the statewide maps discussed above, the California Geological Survey (CGS) and U.S. Geological Survey have published or are nearing publication of several regional geologic maps at a scale of 1:100,000 that include offshore areas. Some of these have newly compiled offshore geologic data, others do not. See the discussion below under "Data Layers Pertinent to the Project."

Maps of surficial geology along portions of the coast are presented in Howard (1974) as part of a report by the U.S. Bureau of Reclamation to evaluate the feasibility of placing an undersea aqueduct that would carry fresh water from northern California to southern California. This mapping was based largely on the original Welday and Williams (1975) maps in their draft form. The original mylars for the Howard (1974) study are still available at a scale of 1:125,000. Although compiled many years ago like the Welday and Williams (1975) map, these maps are still valuable for highlighting possible regions of sand deposits. They could be scanned and digitized to capture the linework as a GIS layer (the Bureau of Reclamation is willing to scan them through a cost-share arrangement).

At local levels, various institutions and agencies have conducted detailed ocean floor surveys and mapping. These studies have been mainly in the Monterey Bay-San Francisco area in northern California and at several localities along the Southern California Bight, which extends from Point Conception to the Mexico border and includes the Channel Islands. In recent years, seafloor mapping in California has focused on benthic habitats. Much of this work has used multibeam mapping systems to produce "backscatter" images that display seafloor properties such as areas of mud and bedrock (e.g., Gardner and Dartnell, 2002). Although generally not termed "geologic" mapping, these activities have collected information on the geologic character of the seafloor through their qualitative descriptions of materials as "sand," "mud," and "bedrock." The U.S. Geological Survey, Moss Landing Marine Laboratory, Seafloor Mapping Lab, and Scripps Institution of Oceanography as well as private companies are some of the groups that have conducted this type of work in California. Examples of benthic habitat mapping for the nearshore zone of San Diego County can be viewed or downloaded on-line at http://sccoos.ucsd.edu/nearshore/. The U.S. Geological Survey has published several reports on its offshore mapping in the Monterey Bay-San Francisco and southern California regions. Several are listed in the accompanying bibliography (e.g., Wong and Eittreim, 2001; Gardner and Dartnell, 2002).

DISTRIBUTION OF SEAFLOOR MATERIALS ALONG THE COAST

The geologically active and diverse interior coast of California has profoundly influenced the geologic character of the adjacent seafloor. The high topographic relief, numerous watersheds that drain into the ocean, and the great variety of rock types all have contributed to the many types and complex distribution of materials that make up the coastal seafloor from Oregon to Mexico. This diversity is apparent from the geologic maps of Welday and Williams (1975) and the CDMG-USGS continental margin series.

Documentation of seafloor materials along the coast is available for many local areas. Again, we emphasize that this information was most commonly collected from the Monterey Bay-San Francisco region and the segment of coast from Santa Barbara County to San Diego County. Except for the semi-reconnaissance work of Welday and Williams (1975), there has been no attempt to consistently map in detail the distribution of offshore geologic materials from Oregon to Mexico. This situation is more a result of insufficient resources (funds and time) rather than lack of interest. Correspondingly, the documentation of details has been mostly limited to local projects conducted through government and academic groups and, in some cases, private industry. Government reports and data are generally produced by agencies such as the U.S. Geological Survey, U.S. Army Corps of Engineers, and the National Oceanic and Atmospheric Administration (NOAA). Products from the academic community are typically in the form of theses and dissertations, and papers in technical journals. Studies by private industry typically are prepared as consulting reports to clients (public and private). Examples of some of these categories are presented in the accompanying bibliography.

Mapping of seafloor materials along the California coast has been greatly aided by collection of samples. These include surficial sediment and rock, and shallow cores. The U.S. Geological Survey is developing a Website (http://coastalmap.marine.usgs.gov/regional/contusa/westcoast/usSEABED/) that catalogs offshore sample sites and associated data as part of a national database called usSEABED; the data will be viewable on-line through an interactive map server. The U.S. Army Corps of Engineers has data from numerous vibracore samples taken to assess potential borrow sites for beach replenishment/nourishment. NOAA maintains a Website (http://www.ngdc.noaa.gov/mgg/mggd.html) that can be visited to obtain digitized seabottom observations collected during hydrographic surveys conducted between 1851 and 1965 as well as offshore geophysical and geological data. Academic institutions also have bottom sample and core data, some of which have been published. Examples include data collected by the University of Southern California in the Southern California Bight and by the Hydraulic Engineering Laboratory at the University of California, Berkeley, from various coastal localities. The Southern California Coastal Water Research Project (SCCWRP), a consortium of public agencies responsible for water quality along the Southern California Bight, has periodically collected many sediment samples offshore through its survey program that began in 1977. Still other data are available in disparate, sometimes obscure, published and unpublished documents.

Together, the technical reports and sets of data portray a pattern of distributed materials that reflect such things as source areas, geologic structure, variations in dynamics of transportation, energy conditions and geomorphology of the depositional areas, and variations of all of these factors with time. For example, deposits of sand are common in the nearshore regions of the state and where rivers have discharged material at their mouths (Welday and Williams, 1975). Mud belts are concentrated farther away from the shoreline or in nearshore areas where the energy of waves and currents are less because of protective coastal settings (e.g., Monterey Bay). Bedrock areas are often nearshore extensions of onshore features or where either relief is positive or current patterns do not favor deposition of sediment. Many of the sand deposits farther offshore are probably paleo-beaches, which originated when the shoreline was much farther west than today; since the last ice age the shoreline has migrated eastward from these locations as sea level has risen.

Finally, the techniques of mapping seafloor materials off the coast of California are evolving. Traditional mapping techniques (e.g., Welday and Williams, 1975) emphasize manual interpretation and drawing of map-unit boundaries based on data from sampling and/or backscattering properties of seafloor materials. Currently, there are attempts to map the boundaries of materials based on image-processing techniques (e.g., classification), which use the same sorts of datasets as the manual approaches. An example is the work in progress by the U.S. Geological Survey on the San Pedro shelf in southern California (Peter Dartnell, U.S. Geological Survey, personal communication, 2003).

POTENTIAL OFFSHORE SOURCES OF SAND

Historically, the sources of sand for beach replenishment/nourishment along the coast of California have predominantly been provided from non-offshore. Included among these are inland sources as well as coastline sources, which have been related to such activities as harbor construction and channel maintenance or by-passing and back-passing operations. Interest in and use of offshore sand resources has generally occurred more recently in California.

Largely because of the abundant contributions from inland source areas and the prevailing southward-directed littoral drift along the entire coast, deposits of sand are prevalent in the offshore of California. Welday and Williams (1975) show numerous linear belts of sand that are dominantly fine-grained, with local areas that are medium- to coarse-grained as well. It is important to recognize, however, that these observations are for the seafloor surface only. Evaluation of sand deposits for potential beach replenishment/nourishment must also consider thickness of the deposits, which may or may not be known for any given location along the coast. To address this issue, Martindale and Hess (1979) and Luken and Hess (1979) used assumed thicknesses to calculate estimated volumes of sand and gravel deposits along the entire coast. The deposits they used for calculation were largely taken from the individual bottom-type areas shown on the maps of Welday and Williams (1975) and Howard (1974).

Deposits of offshore sand that may be most attractive for potential use in beach nourishment consist of two main types: 1) Those of relatively recent age (“modern” facies) that were deposited under submarine conditions and 2) those of older age (“relict” facies) that were deposited as beach sands or stream-channel deposits when the coastline was much farther west than at present because of decreased sea level associated with continental glaciation. Fischer and others (1983) believed that mainland shelf sediments form an elongated prism that parallels the coast of southern California. Maximum thickness of the prism is generally about 10-30 meters and is present near mid-shelf. Features that are sites of the greatest thicknesses are bases of relict sea cliffs, relict stream channels, and tectonic depressions.

The old beach sands and channel deposits are distributed to a farther extent offshore and thus have a higher chance of being present in Federal waters. Because of their age and different dynamics of formation, they may (or may not) have had different source areas than those of the modern streams that discharge into the ocean today. Thus may have different physical properties from the modern sands and associated beach deposits that are present along the present coastline.

Because of the preponderance of historic beach replenishment/nourishment projects there, nearly all regional and local exploration and evaluation of offshore sand deposits have occurred in southern California from Santa Barbara County to the Mexico border. Also, because of limitations on dredging (cost, technology), most of this work has been done in shallow water close to shore. Some offshore borrow sites are used more than once because the excavations may be re-filled by natural sedimentation. Consequently, virgin borrow areas are not necessarily required for every episode of replenishment, which lessens the overall need for their exploration and evaluation.

Various reports have identified many local offshore sand deposits in southern California that could serve as borrow sites for replenishment/nourishment. A list of selected sites is presented in Table C1. This list is not comprehensive, but gives an idea of the distribution and volumes of the deposits. Most of the deposits described in these reports do not extend into the Federal waters beyond the 3-nautical mile boundary, however. Details of exploration, sampling, and analytical results for the deposits can be found in published and unpublished technical reports. The two companion reports by Fischer and others (1983) and Osborne and others (1983) are still the most comprehensive regional reports for sand deposits along the mainland portion of the southern California Bight. The report by Osborne and others (1983) and many internal reports by the Geotechnical Branches of the U.S. Army Corps of Engineers (e.g., U.S. Army Corps of Engineers, 1989; 1995; 2002) are good examples of detailed study of individual deposits by use of vibracore data.

Candidate Areas in Federal Waters for Potential Future Study

Because of the irregularity and relative narrowness of the continental shelf off California, the locations of potential sites for dredging of sand deposits is restricted at present. Figures C5, C6, C7, and C8 respectively display statewide maps of areas beyond the 3-nautical-mile State/Federal boundary that are less than 30-, 40-, 90-, and 150-meter water depths as dictated by the limitations of the current dredging industry. As calculated from each of these four maps, the list below gives the offshore areas under federal jurisdiction that are less than the four selected water depths.

Water Depth	Area in Square Nautical Miles	Area in Square Statute Miles
<30 meters	97	128
<40 meters	232	307
<90 meters	1,727	2,287
<150 meters	3,584	4,747

From these mapped shelf areas and based on various technical and cultural criteria, we have selected four localities in southern California that are candidates for future detailed study. Characteristics of each are described below:

Ventura Shelf: This area is directly offshore from the cities of Ventura and Oxnard, but extends farther northwest toward Carpinteria and Santa Barbara (Figures C9, C10). Here, a lobe of the continental shelf extends broadly outward beyond the 3-nautical mile State/Federal boundary. At least in part , this lobe was probably formed from deltaic deposits built up by discharge from the Santa Clara and Ventura rivers, the mouths of which converge near the City of Ventura. The deeper portions of the shelf extend northwestward to the Carpinteria-Santa Barbara area. Much of the length of segment of the coastline has extensive public beaches.

Within the area of Federal jurisdiction, the map of Welday and Williams (1975) displays a complex distribution of surficial units including extensive sand deposits, although it is not indicated what the sand-size distribution is in many of these areas. The Continental Margin Geologic Map Series shows most of the shelf area as undifferentiated Quaternary and Tertiary sediments and sedimentary rock. The unpublished report by Field (1974) is the first known systematic study of the offshore sand resources of the Ventura Shelf. It was reconnaissance in nature, but served as a foundation for subsequent studies. The regional study by Fischer and others (1983) was the next to cover this area. These authors interpreted the sediment distribution in part of this shelf area to be controlled by active east-west-trending structures. They also showed thicknesses of Late Quaternary sediment reaching over 50 meters just offshore of the city of Ventura, which “may be predominantly sand.” Green and others (1978) show thicknesses to be at least 30 meters over most of the shelf in this area. Noble Consultants (1989a, b) followed up on the study by Fischer and others (1983) with a detailed study of potential offshore sand resources from Goleta to Point Mugu. Various geophysical and vibracoring surveys were conducted to define nearshore deposits of potential use for beach replenishment. The original datasets generated by this study were stored by Noble Consultants pending instructions by BEACON, which was the client for the project. Contact of either Noble Consultants or BEACON will likely determine if these datasets are still available for review by outside parties.

Various other studies conducted over the Ventura Shelf are listed in the accompanying bibliography.

Santa Monica Shelf: This area is offshore of a portion of the Los Angeles Basin that extends from the city of Santa Monica in the north to the city of Redondo Beach in the south, which is adjacent to the hilly coastal prominence known as the Palos Verdes Hills (Figures C11, C12). Although the 40-meter contour is entirely shoreward of the 3-nautical mile State/Federal boundary, there is a prominent east-west projecting lobe, informally called "Short Bank," that extends into Federal jurisdiction off El Segundo for at least another 6 miles to the 90-meter contour. Essentially the entire segment of the coastline adjacent to the shelf consists of public beaches.

Much of Short Bank is interpreted to be composed of exposed bedrock interspersed with unconsolidated sediments that are dominantly by sand of varying size distribution (Welday and Williams, 1975; Map Sheet 2A of the CCMGMS; and Dartnell and Gardner, 2004). The studies by Fischer and others (1983) and Osborne and others (1983) only marginally extended into Federal waters beyond the 3-nautical mile boundary and thus do not address the features of Short Bank. Sediment and bedrock characteristics of Short Bank have been documented in earlier studies (see references in Dartnell and Gardner, 2004), but the recent study by Dartnell and Gardner (2004) has led to a better understanding of the seafloor facies of this local feature of the continental shelf. Thicknesses of the facies are less well known, however.

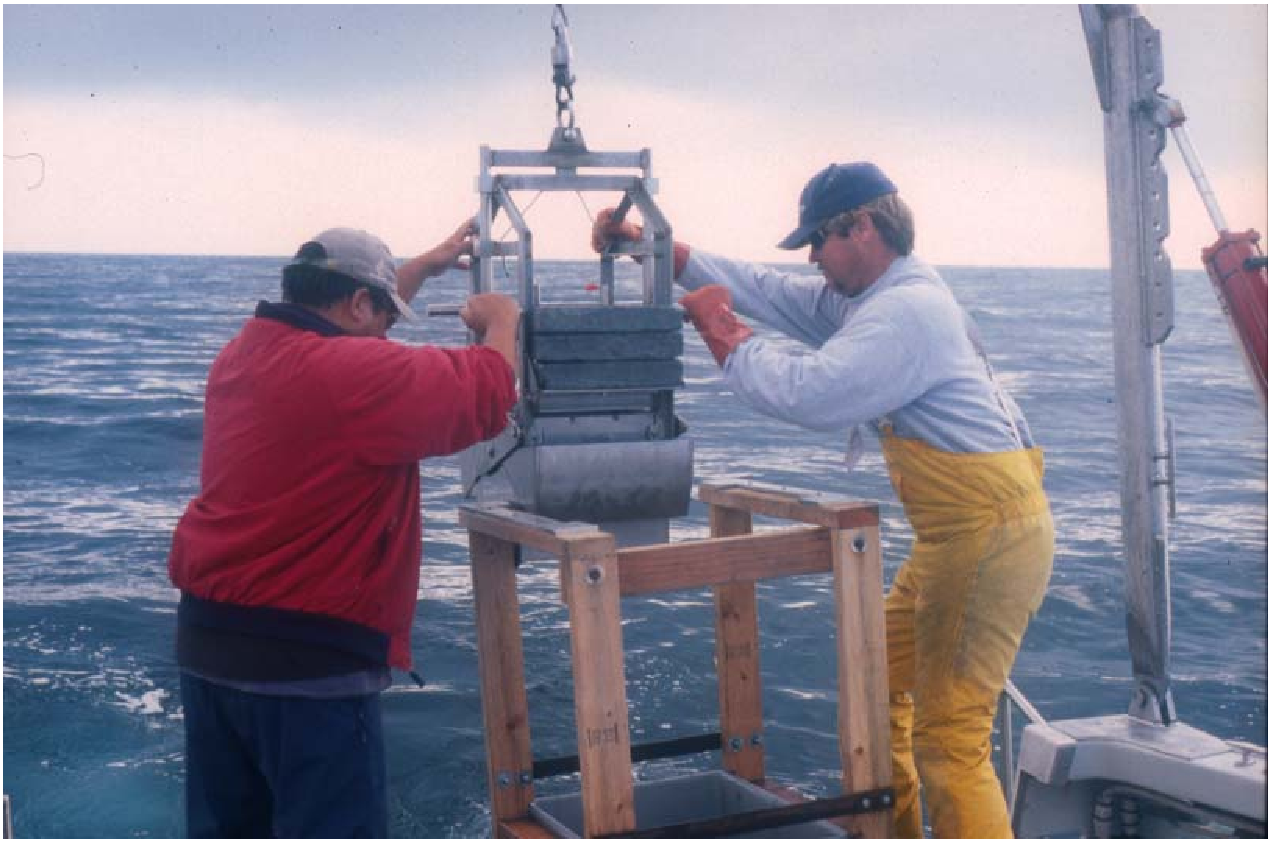
San Pedro Shelf: This area is offshore of the southern portion of the Los Angeles Basin, adjacent to a cluster of cities that extend from Long Beach in the northwest to Newport Beach in the southeast (Figures C13, C14). The shelf extends as much as 6 nautical miles beyond the 3-nautical boundary to where the continental slope begins to drop off rapidly at about the 90-meter contour. Much of the coastline consists of public beaches.

Because of both the complex, still-active tectonics and the convergence of three major rivers (Los Angeles, San Gabriel, and Santa Ana) that discharge into San Pedro Bay, the San Pedro Shelf has been the site of abundant sedimentation for thousands of years. These conditions and geophysical evidence led to the interpretation by Fischer and others (1983) that the San Pedro Shelf has a greater volume of Holocene sediment than that of any comparable area of the southern California shelf. Indeed, they calculated this amount to be 40% greater than that present over the entire shelf from Newport Beach to the border with Mexico. Of the total volume of Holocene sediment calculated by these authors for the San Pedro Shelf, over 80% is present in water deeper than the 30-meter contour. Most is within the "Wilmington Graben," a NW-trending structural basin in the center of the shelf. Much of the graben is within Federal jurisdiction.

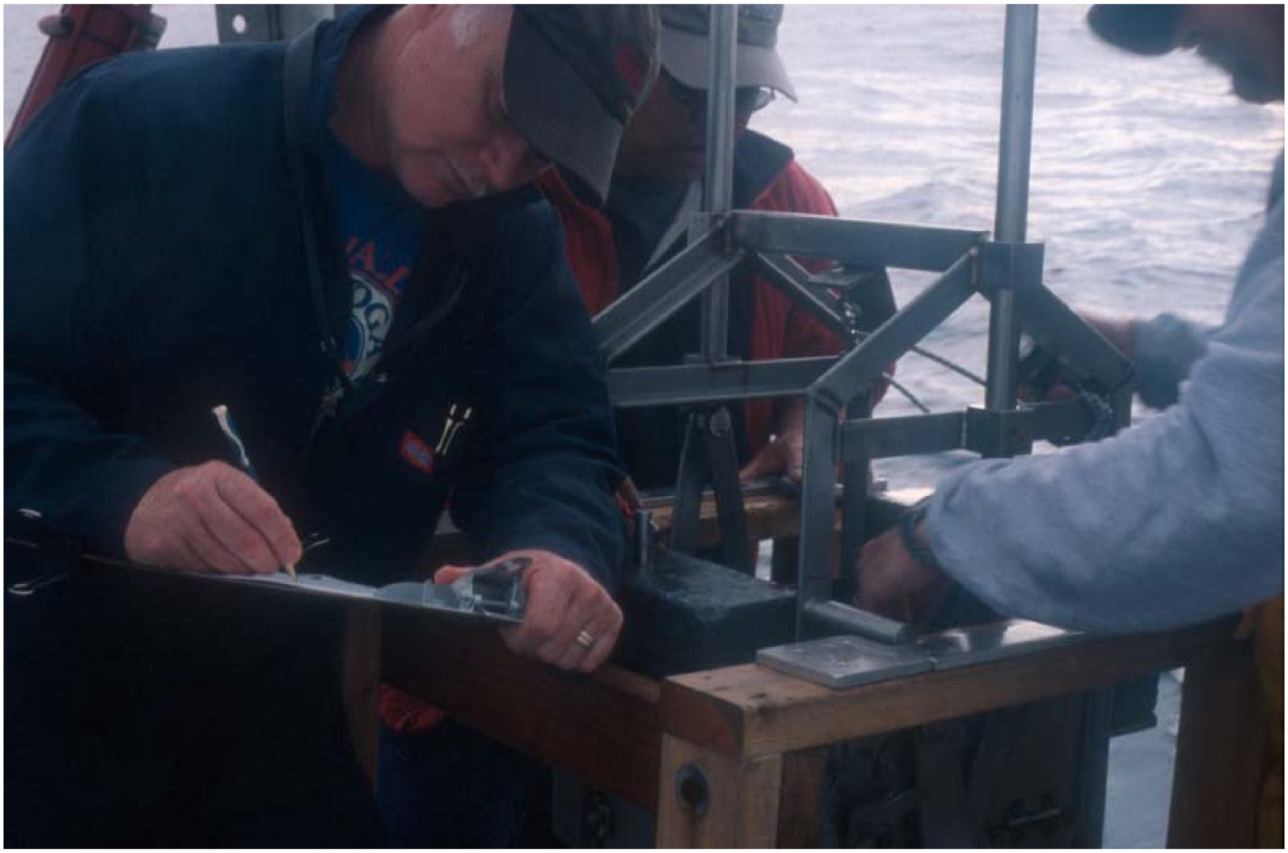
Because of its geologic and cultural importance, the San Pedro Shelf has been intensively studied by many groups for various purposes. The USGS alone has had many technical studies, some of which are still in progress. One project is use of multibeam surveys to map seafloor facies of the shelf similar to that described above on the Santa Monica Shelf. As part of the first phase of the CGS/MMS/CDBW study, the

CGS began working collaboratively with the USGS on this project as a means of aiding the CGS definition of sand deposits on the shelf. In December 2004, a major seafloor-sampling campaign was conducted on San Pedro Shelf by the USGS aboard the R/V Early Bird to aid the multibeam facies mapping. Approximately 200 bottom samples were collected; the USGS generously allowed CGS to research and define locations for twenty of the sampling sites. The following four photographs are from that sampling campaign.

Customized box-core sampler used for the USGS sampling campaign on San Pedro Shelf in December 2004. *Photo by C. Higgins*



Deployment of the box-core sampler by staff of the Orange County Sanitation District aboard R/V Early Bird during the sampling campaign on San Pedro Shelf. *Photo by C. Higgins*



USGS scientist recording observations of a retrieved sample during the sampling campaign on San Pedro Shelf. *Photo by C. Higgins*

Partially oxidized sand retrieved in box-core sampler during USGS sampling campaign on San Pedro Shelf. *Photo by C. Higgins*

Osborne and others (1983) defined several large areas of sand deposits on the San Pedro Shelf. As with the Santa Monica Shelf, however, these areas are mostly confined to the shoreward (State) side of the 3-nautical mile boundary. The USACE also defined specific borrow areas for offshore sand, but these are very near-shore in shallow water. In contrast to Santa Monica Shelf, Fischer and others (1983) prepared isopach contours that extend well into the waters under Federal jurisdiction on San Pedro Shelf. Areas of sand and gravel have been mapped in various other studies both in the graben area and as structurally ponded sediments on the uplifted bedrock high southwest of the graben. Correspondingly, it appears that knowledge about the overall distribution, thickness, and character of sand deposits in this shelf area may be better here than at Short Bank. A major task will be to build a composite facies map that draws on data and interpretations from all the previous sediment maps for this area in a manner that resolves differences in those interpretations.

San Diego Shelf: This area is offshore of several communities of the San Diego metropolitan region, extending from the La Jolla-Mission Bay area in the north to Imperial Beach near the border with Mexico in the south (Figures C15, C16). Of the four candidate shelf areas for future detailed study, this area is the smallest. Over much of its length, the shelf area between the 3-nautical mile boundary and the 90-meter contour is less than one mile in width. Only offshore of Imperial Beach does it broaden to about 4 miles. A sequence of public beaches extends over much of the length from La Jolla to the border with Mexico.

Welday and Williams (1975) mapped much of the San Diego Shelf area beyond the 3-nautical mile boundary as mud (silt and clay). Map Sheet 1A of the CCMGMS shows the area as mostly underlain by Quaternary and Tertiary sediments. Osborne and others (1983) have defined several deposits along the coast from La Jolla to Imperial Beach, but as previously, these deposits are almost entirely shoreward of the 3-nautical mile boundary. Fischer and others (1983) prepared isopach maps of the Late Quaternary sediment for most of the San Diego Shelf. Evans and others (1982) built on the work of Sprague (1971) to define a sand and gravel area directly west of Imperial Beach in waters under Federal jurisdiction. This area is generally in the 40-50-meter contour area and at this time represents the most likely site on the San Diego Shelf for future detailed investigation. In recent years, multibeam surveys (SANDAG, Neal Driscoll at SIO) have covered the nearshore parts of the shelf largely shoreward of the 3-nautical mile boundary. Multibeam surveys by the USGS were farther offshore in deeper water well beyond the shelf. An offshore-sand investigation conducted in the late 1990s for SANDAG (Sea Surveyor, Incorporated, 1999) included side-scan sonar, subbottom profiling, and vibracore sampling, but was confined to shallow waters shoreward of the 3-nautical mile boundary. The USACE also conducted study of sand deposits near those investigated for SANDAG (U.S. Army Corps of Engineers, 2002).

DATA LAYERS PERTINENT TO THE PROJECT

Part of the research and inventory during Year-One involved an initial compilation of a list of thematic digital layers that would form a GIS foundation for the mapping of sand deposits along or beyond the 3-mile State/Federal boundary. Some of these layers are readily available in digital form, while others are either not in digital form at all or only partially so. We expect that this compilation will continue in subsequent phases of the study.

Table C2 is a listing of data layers pertinent to the project. They are divided into two main categories: Base/Cultural and Geological. The Base/Cultural category includes themes such as geographic features of reference, jurisdictional boundaries, infrastructure, and controlled areas; many of these might influence whether or not a given sand deposit could be extracted or not. The Geological category includes technical themes that are restricted to the offshore marine environment – either in the water, on the seafloor, or beneath the seafloor. Themes such as sample sites, geophysical tracklines, and seafloor surface materials are included in this category and will be used to identify sites that are either lacking or are sparse in data and to map sand deposits. Comments on each thematic data layer are presented below.

BASE/CULTURAL DATA LAYERS

Bathymetry: Presented in 10-meter contour intervals. Aid in evaluation of where dredging could take place based on economic and technological limits.

Beaches: Locations are significant because they represent potential future locations of need for nourishment.

Cities: Important because the density of population can affect priorities of locations for beach nourishment and thus exploration for offshore sand resources. The location of cities/patterns of urbanization reflect the density of population.

Coastline: A means of geographic reference for determination of location.

Contaminants: This layer could represent the location of potentially serious hindrances to production of sand from offshore deposits. The extent of offshore contamination is unknown both as to type and location. An example of contamination is the DDT sediment material off the Palos Verdes Peninsula. There are two potential problems with removal of sands that are contaminated. First, the disruption of the deposit itself could spread the contamination to a larger physical area. Second, the placement of contaminated sand on a beach for nourishment purposes can pose health risks to humans.

Counties: A means of geographic reference for determination of location.

Disposal Sites: There are several officially regulated offshore disposal, or "dump," sites in southern California. These are portrayed on nautical charts as circular or polygonal areas. Some are active, while others are abandoned. Many are in deeper water beyond areas of interest for production of sand. They contain various debris that should be avoided during any production of sand for beach nourishment.

Drilling Platforms: The Southern California Bight contains a few dozen offshore drilling platforms for the production of oil and gas. They are dispersed within two main areas, Santa Barbara Channel (Point Conception to Ventura) and San Pedro Bay. Some are in deeper water beyond areas of interest for production of sand, while others are in the inner shelf regions in both State and Federal waters. A radius of safety around these structures is advisable when defining areas for potential production of sand.

Federal/State Boundary: This line extends the entire coast of California and represents the boundary between State and Federal jurisdiction. It measures 3 nautical miles from the shoreline and around islands. Production of sand from beyond this 3-mile boundary is under regulatory authority of the U.S. Minerals Management Service.

Geographic Points: A means of geographic reference for determination of location. These consist of named physical landmarks on the coastline.

Highways: A means of geographic reference for determination of location.

Infrastructure: This theme is a mixture of man-made structures that are on the seafloor. It includes pipelines, electrical cables, and sewer outfalls from coastal municipalities. As with drilling platforms, a minimum distance of safety adjacent to these features is advisable when defining areas for potential production of sand. These features are mapped on NOAA navigational charts.

International Boundary: Consists of a single line that defines the offshore boundary between the U.S. and Mexico.

Leases (developed): Consists of areas of developed offshore oil and gas leases that are under administration by the Federal government (Minerals Management Service). They coincide largely with the locations of the offshore drilling platforms described above.

Leases (undeveloped): Consists of areas of undeveloped offshore oil and gas leases that are under administration by the Federal government (Minerals Management Service). These are dominantly in the vicinity of Point Arguello, with a few in the Santa Barbara Channel; they are adjacent to the active leases described above.

Marine Sanctuaries: These may have restrictions or prohibition of any dredging, therefore their locations are important for determination of where any future exploration for or exploitation of sand deposits can take place. There are two extensive sanctuaries in southern California. One surrounds the northern Channel Islands, while the other is south of Santa Barbara. The largest off the coast of the state is the Monterey Bay National Marine Sanctuary, which extends from San Simeon to San Francisco.

Military Exercise Areas: As with marine sanctuaries described above, these may have restrictions or prohibition of any dredging, therefore their locations are important for determination of where any future exploration for or exploitation of sand deposits can take place. The Southern California Bight has various locations of military bases, particularly in San Diego County. Some of these have offshore zones for training activities.

Shipping Lanes/Areas: Similar to the military exercise areas described above, there are several designated areas along the Southern California Bight where navigational rules, restrictions, or warnings are in effect. The most extensive are shipping lanes in the San Pedro Shelf area and along the offshore areas of Santa Barbara and Ventura counties. Some of these designated areas have no restrictions on dredging, while others prohibit it. Commonly, the areas are designated because of congestion in ship traffic. All are mapped on NOAA navigational charts, and any rules or restrictions can be obtained from the Coast Guard Headquarters in Alameda (we have a contact there if research is needed on any particular designated area).

Shipwrecks: Submerged wrecks may present local problems for dredging operations. Also, wrecks may be treated as archeological sites that are protected from disturbance. There are a few databases that cover locations in California, but we do not know at this time the quality of the locations presented (they could be poorly known, or purposely obscured to protect the artifact in question).

Submerged Obstructions: Exclusive of shipwrecks, this category includes features that may be hazardous for dredging operations. These are identified in part on NOAA navigational charts and are largely within the 3-nautical-mile limit, but some may be present in Federal waters.

Submarine Topography: This theme can be generated from bathymetric data as shaded relief imagery, which can aid characterization of the seafloor both as to potential dredging environment and in definition and mapping of seafloor materials.

Urban Coastal Areas: This theme covers both identity and extent of urbanized areas along the coast of California, which can be useful in defining priorities of beach areas for potential remediation. Those beaches within or near densely developed segments of the coastline are more likely candidates for remediation because of the greater use of those beaches.

Watersheds: Represent the coastal drainage areas that supply sediment to coastal beaches. Where rivers and streams discharge into the ocean may be sites of larger volumes of sediment including sand. We have not decided at this time whether to use small-scale watersheds, rivers and streams, or both. Concerning exploration for sand deposits, only the larger streams that discharge along the coast would be used for interpretation.

GEOLOGICAL DATA LAYERS

Core-Sample Sites: Locations of cores (e.g., vibracores) that give information on the subsurface of the seafloor potentially to a depth of about 40 feet, although most are less than 20 feet. The data are from a variety of surveys and periods of time, so quality and consistency can be in question. Core data are available from academic institutions, the USACE, and published technical reports from other government agencies such as SANDAG and CDBW. The distribution of core sites is irregular along the coast; the highest densities of cores are typically concentrated within identified sand deposits of interest for potential exploitation.

Currents: Although there may be little data for this layer, the data can be useful in determination of where periodic influxes or removal of sediment may occur in given areas. Of most interest are bottom currents, but this category has the fewest recorded observations. This theme is pertinent to answering the question of how stable are seafloor sediments through time. Do certain deposits remain stable while others are eroded? Read Inman's work.

Geology (CGS/USGS Continental Margin Series): Divided into seven separate sets of 1:250,000-scale maps, this series varies in its level of geologic detail. All seven sets of maps were digitized by CSUMB and are on that university's Web site for Internet mapping and downloading. Figure C---- shows the mapping for southern California with bathymetric contours that are pertinent to dredging superimposed. In some locations, these maps are useful, but in others there is insufficient mapping or units are not differentiated sufficiently to aid interpretation of potential deposits of sand.

The CGS also has a 1:100,000-scale series of geologic maps, which includes integration of offshore geologic data with the adjacent onshore mapping for quadrangles that overlap the coastline of the state. The status of the CGS and USGS 1:100,000-scale maps completed or in progress to date for California is as follows:

Long Beach:	CGS	In progress	New plus previous mapping	
Los Angeles:	USGS	Released	No offshore mapping included	OF 97-483
Monterey:	CGS	Released	New plus previous mapping	
Oceanside:	CGS	Ready for release	Previous mapping only	
San Diego:	CGS	Ready for release	Previous mapping only	
Santa Ana:	USGS	Released	No offshore mapping included	OF 99-172

The offshore area of Santa Barbara County is expected to be compiled by CGS starting in another year.

Geology (CGS MS 26): The Welday and Williams statewide map of seafloor surficial materials, published in 1975, is still the only map that shows interpreted surficial seafloor geology for the entire coastline of the state. This mapping also formed the foundation of the mapping presented in the U.S. Bureau of Reclamation report on a proposed offshore aqueduct as described in Howard (1974).

Geophysical Surveys (Subbottom): Numerous geophysical surveys have been conducted over the continental shelf for different purposes. Seismic reflection surveys generally fall into two categories: Low-frequency techniques that penetrate to great depths in the subsurface, typically for oil and gas exploration, and high-frequency, high-resolution techniques that penetrate only to shallow depths. Because of their high resolution at shallow depth, the latter are of more utility for identification and characterization of sand deposits that can be dredged.

A useful resource for location of previous USGS geophysical surveys (as well as other marine surveys) off the coast of California is the on-line database called "InfoBank." Other sources of geophysical data include Geological Data Center at the Scripps Institution of Oceanography (http://gdc.ucsd.edu/requests.html) and the Center for Los Angeles Basin Subsurface Geology at California State University, Long Beach (http://seis.natsci.csulb.edu/deptweb/CLABSG.html).

Habitat Classification: This theme involves mapping of seafloor environments and materials that provide habitat for marine animals and plants. It relates in some instances to the multibeam backscatter and sidescan sonar categories described elsewhere, but these represent final derivative products that are equivalent to geologic maps that portray seafloor materials. Map units include such materials as mud, sand, bedrock, and gravel plus mixed categories. Gary Greene's group at Moss Landing Marine Laboratory and other organizations have conducted such mapping at various sites along the California coast.

Littoral Cells: The coast of California has been subdivided into a set of a few dozen self-contained irregular segments, or "cells," that are defined by supply and loss of sediment through longshore, or "littoral," drift.

Multibeam Backscatter: The "roughness" characteristics recorded in these datasets, in combination with the companion bathymetry, can be valuable for interpretation and mapping of seafloor materials at the time of the surveys. Backscatter imagery has been collected by several institutions along the Southern California Bight including, among others, USGS, MLML, MBARI, NOAA, CSUMB, SIO, and consultants for local government (e.g, SANDAG). Imagery is known to cover most of the shelf areas except for a gap between Port Hueneme and Point Dume, and in the region around Dana Point. The data were collected at different times and different resolutions.

Oil and Gas Seepage: Natural seeps of oil and gas have been mapped at a few locations in shelf areas of the Southern California Bight. Such seeps present two issues related to sand deposits and associated dredging. First, the hydrocarbon residue may or may not have degraded any sand deposits at these locations. Second, any dredging at these sites may disrupt the equilibrium of the seeps, perhaps increasing flow rates.

Sand Resources: Several studies have been conducted along the Southern California Bight to define sand resources for potential use in beach replenishment (Table C1). The study by Field (1974) appears to be the first attempt at identification and quantification of sand resources off the coast of southern California. This work was built upon by the Osborne-Fischer studies for CDBW in the early 1980s, which were the first systematic reconnaissance of this region. Locally, BEACON (Santa Barbara-Ventura counties) in the late 1980s and SANDAG (San Diego County) in the1990s conducted studies of resources adjacent to their jurisdictions. Maps with outlines and estimated quantities of sand are presented in each of these reports. The USACE has conducted resource assessments in small areas adjacent to beaches designated for nourishment. Likewise, these reports, which date from the 1980s, contain maps and data on sand resources. It appears that the scopes of these studies, and the resources identified by them, rarely overlapped into Federal waters beyond the 3-nautical-mile limit. Areas of sand bodies outlined in each of these studies can be digitized with varying degrees of effort. Some reports include data on the physical characteristics of the sand. It appears that many of the identified resources are not rigorously mapped, with some based on relatively few core holes and geophysical surveying.

Seabed Materials (NOAA): Distribution of materials on seafloor as historically mapped by NOAA hydrographic surveys. This dataset may be replaced by the "Seabed-Sample Sites" layer described below.

Seabed-Sample Sites: These datasets contrast with the categories of core-sample sites by representing samples collected only at the seafloor-water interface. Many of these have been documented in usSEABED, a USGS database system

Sediment Thickness (isopachs): Various studies have presented maps that show contour thickness of unconsolidated sediment in local shelf areas. These studies include those described above under the category of sand resources.

Sidescan Sonar: The traditional seafloor mapping technique before the advent of the multibeam version, there are many datasets for coastal California.

OVERALL COVERAGE OF TECHNICAL DATA ALONG THE COAST

During initial statewide reconnaissance for this project, discussion with Gary Greene at the Moss Landing Marine Laboratory and other sources produced a general summary of relative coverage of technical data for the shelf of California. From south to north:

Mexico Border to Oceanside: Interests of San Diego Association of Governments (SANDAG) and Scripps Institution of Oceanography (SIO) have spawned a number of offshore studies and surveys ranging from multibeam sonar to vibracore sampling. Much of this work is within the State waters, however.

Oceanside to Newport Beach: This segment has not been covered as well as the segment to the south. Some studies have been done by the USACE in the San Clemente area.

Newport Beach to Ventura: Extensive studies from Newport Beach to Santa Monica particularly on the San Pedro and Santa Monica shelves. Much less from Santa Monica to the Port Hueneme area, but increases again in the Oxnard-Ventura area.

Ventura to Point Conception: Studies and data are common over this segment.

Point Conception to Morro Bay: Some multibeam and side-scan data are available, but overall an area of less intensive study.

Morro Bay to Sur Canyon: Very sparse data over this segment.

Sur Canyon to Golden Gate: Many studies and data particularly related to the Monterey Bay National Marine Sanctuary and the area around the Farallones Islands (Gulf of the Farallones).

Golden Gate to Eel River: Very sparse data over this segment.

Eel River to Oregon Border: Various studies by Federal agencies and others over this segment particularly because of the tectonic significance of this area and the presence of an offshore spreading center.

REFERENCES

Alexander, C.R. and Venherm, C., 2003, Modern sedimentary processes in the Santa Monica, California continental margin: sediment accumulation, mixing and budget *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 177-204.

American Shore & Beach Preservation Association, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

Anderhalt, R., LeFever, R.D. and Reed, W.E., 1977, Texture versus depth, and mainland versus offshore relationships, southern California borderland: Geological Society of America Abstracts with Programs, v. 9, no. 4, p. 379.

Anderson, J.A., 1990, California's industrial-mineral resources: U.S. Geological Survey Bulletin 1958.

Anima, R.J., Tait, J., Griggs, G.B., and Brown, K.M., 1993, Nearshore morphology and sedimentation using side-scanning sonar and underwater video along the Central California coast, *in* American Geophysical Union, Fall Meeting, San Francisco, CA, American Geophysical Union, p. 348.

Ashley, R.J., 1974, Offshore geology and sediment distribution of the El Capitan-Gaviota continental shelf, northern Santa Barbara Channel, California: M.S. thesis, San Diego State University.

Ashley, R.J., Berry, R.W. and Fischer, P.J., 1977, Offshore geology and sediment distribution of the El Capitan-Gaviota continental shelf, northern Santa Barbara Channel, California: Journal of Sedimentary Petrology, v. 47, no. 1, p. 199-208.

Baird, B. and others, 1995, California’s ocean resources: an agenda for the future: Resources Agency of California, draft report.

Bandy, O.L., Ingle, J.C., Jr., and Resig, J.M., 1964, Facies trends, San Pedro Bay, California: Geological Society of America Bulletin, v. 75, no. 5, p. 403-423.

Bay, S.M., Zeng, E.Y., Lorenson, T.D., Tran, K. and Alexander, C.R., 2003, Temporal and spatial distributions of contaminants in sediments of Santa Monica Bay, California *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 255-276.

Booth, J.S., 1973, Early diagenesis in southern California continental borderland sediments: Ph.D. dissertation, University of Southern California.

Butcher, W.S., 1951, Lithology of the offshore San Diego area (Part 1); Foraminifera, Coronado Bank and vicinity, California (Part 2): Ph.D. dissertation, University of California, Los Angeles, 175 p.

Cacchione, D.A., and Drake, D.E., 1979, Sediment transport on the San Pedro Shelf, California: U.S. Geological Survey Professional Paper 1150, 147 p.

Cacchione, D.A., and Drake, D.E., 1990, Shelf sediments transport; an overview with applications to the Northern California continental shelf: The Sea, v. 9, Part B, p. 729-773.

California State Lands Commission, 1994, California comprehensive offshore resource study.

Chambers Consultants and Planners, 1979, Economic feasibility of OCS mining for sand and gravel, San Pedro shelf, offshore Los Angeles, and San Diego shelf, south of La Jolla Canyon: Final Report to U.S. Department of the Interior, Geological Survey.

Chen, K.Y. and Lu, J.C.S., 1974, Marine studies of San Pedro Bay, California: Part VII, Sediment investigations: sediment compositions in Los Angeles-Long Beach harbors and San Pedro Basin: University of Southern California Report No. USC-SG-8-74, 177 p.

Cherry, J.F., 1965, Sand movement along a portion of the northern California coast: U.S. Army Corps of Engineers, Coastal Engineering Research Center Technical Memorandum 14, 125 p.

Childs, J.R., Normark, W.R. and Fisher, M.A., 1999, Permit application and approval chronology for a small airgun survey offshore Southern California: U.S. Geological Survey Open-File Report 99-0572.

Chin, J.L., and Wolf, S.C., 1988, Reconnaissance high-resolution geophysical survey of the Monterey Bay, California, inner shelf: Implications for sand resources: U.S. Geological Survey Open-File Report 88-410, 33 p.

Clarke, S.H., Greene, H.G., Field, M.E. and Lee, W.H.K., 1983, Reconnaissance geology and geologic hazards of selected areas of the Southern California continental borderland: U.S. Geological Survey Open-File Report 83-0062.

Cleveland, M.N., 1985, Radiolarian densities, diversities, and taxonomic composition in Recent sediment and plankton of the Southern California continental borderland: Relationship to water circulation and depositional environments: M.S. thesis, Rice University, 90 p.

Cleveland, M.N. and Casey, R.E., 1986, Radiolarian indices of physical and chemical oceanographic phenomena in Recent sediments of the Southern California Continental Borderland, *in* Casey, M.N. and Barron, J.A., editors, Siliceous microfossil and microplankton of the Monterey Formation and modern analogs: Society of Economic Paleontologists and Mineralogists, Pacific Section, Field Trip Guidebook, v. 45, p. 21-30.

Dahlen, M.Z., 1988, Seismic stratigraphy of the Ventura mainland shelf, California – Late Quaternary history of sedimentation and tectonics: M.S. thesis, University of Southern California.

Dahlen, M.Z., 1992, Sequence stratigraphy, depositional history, and middle to late Quaternary sea levels of the Ventura Shelf, California: Quaternary Research, v. 38, no. 2, p. 234-245.

Dahlen, M.Z., Osborne, R.H., and Gorsline, D.S., 1990, Late Quaternary history of the Ventura mainland shelf, California: Marine Geology, v. 94, no. 4, p. 317-340.

Darigo, N., 1984, Quaternary stratigraphy and sedimentation of the mainland shelf of San Diego County, California: Master's thesis, University of Southern California, 447 p.

Darigo, N.J. and Osborne, R.H., 1986, Quaternary stratigraphy and sedimentation of the inner continental shelf, San Diego County, California, *in* Knight, R.J. and McLean, J.R., editors, Shelf sands and sandstones: Canadian Society of Petroleum Geologists Memoir 11, p. 73-98.

Dartnell, P. and Gardner, J.V., 2004, Predicted seafloor facies of central Santa Monica Bay, California: U.S. Geological Survey Open-File Report 2004-1081. (http://pubs.usgs.gov/of/2004/1081/index.html)

Dartnell, P., Gardner, J.V., Mayer, L.A., Hughes Clarke, J.E., 2004, Los Angeles and San Diego margin high-resolution multibeam bathymetry and backscatter data: U.S. Geological Survey Open-File Report 2004-1221. (http://pubs.usgs.gov/of/2004/1221/)

Dojiri, M., Yamaguchi, M., Weisberg, S. and Lee, H.J., 2003, Changing anthropogenic influence on the Santa Monica Bay watershed *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 1-14.

Drake, D.E., 1972, Distribution and transport of suspended matter, Santa Barbara Channel, California: Ph.D. dissertation, University of Southern California.

Drake, D.E., Fleischer, P. and Kolpack, R.L., 1971, Transport and deposition of flood sediment, Santa Barbara Channel, California, *in* Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970, Volume 2, Physical, chemical and geological studies, Allan Hancock Foundation, University of Southern California, p. 181-217.

Drake, D.E. and Kolpack, R.L., 1971, Sediment transport on the Ventura shelf, Santa Barbara Channel, California: Geological Society of America Abstracts with Programs, v. 3, no. 7, p. 549-550.

Drake, D.E., Kolpack, R.L. and Fischer, P.J., 1972, Sediment transport on the Santa Barbara-Oxnard Shelf, Santa Barbara, California *in* Swift, D.J.P. and others, editors, Shelf sediment transport: Dowden, Hutchinson & Ross, Stroudsburg, Pennsylvania, p. 307-331.

Drake, D.E., Cacchione, D.A. and Karl, H.A., 1985, Bottom currents and sediment transport on San Pedro Shelf, California: Journal of Sedimentary Petrology, vol. 55, no. 1, p. 15-28.

Edwards, B.D., Dartnell, P. and Chezar, H., 2003, Characterizing benthic substrates of Santa Monica Bay with seafloor photography and multibeam sonar imagery *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 47-66.

Eganhouse, R. and Kaplan, I.R., 1988, Depositional history of Recent sediments from San Pedro shelf, California: reconstruction using elemental abundance, isotopic composition and molecular markers: Marine Chemistry, v. 24, no. 2, p. 163-191.

Eittreim S.L. (ed.), 1997, Southern Monterey Bay continental shelf investigations; former Fort Ord restricted zone: U.S. Geological Survey Open-File Report 97-0450, 113 p.

Emery, K.O., 1952, Continental shelf sediments off southern California: Geological Society of America Bulletin, v. 63, p. 1105-1108.

Emery, K.O., 1954, General geology of the offshore area, southern California, *in* Jahns, R.H., editor, Geology of southern California: California Division of Mines Bulletin 170, p. 107-111.

Emery, K.O., 1960, The sea off southern California: John Wiley & Sons, New York, New York, 366 p. *Section on sediments useful; some detail on San Diego (see next reference) CGS library GC 83 E5*

Emery, K.O. and others, 1952, Submarine geology off San Diego: Journal of Geology, v. 60, p. 511-548.

Emery, K.O. and Shepard, F.P., 1945, Lithology of seafloor off southern California: Geological Society of America Bulletin, v. 56, p. 431-478.

Evans, J.R., Dabai, G.S., and Levine, C.R., 1982, Mining and marketing sand and gravel, outer continental shelf, southern California: California Geology, v. 35, no. 12, p. 259 - 276.

Field, M.E., 1974, Preliminary “quick look” report on offshore sand resources of southern California: U.S. Army Corps of Engineers, Coastal Engineering Research Center, unpublished report, 28 p.

Field, M.E., 1992, Mapping the California continental shelf: U.S. Geological Survey Yearbook, Fiscal Year 1991, p. 6-7.

Field, M.E., Barber, J.H., Jr., Cacchione, D.A., Drake, D.E., and Wong, F.L., 1992, Holocene sediment map of the Central California continental shelf, 1:250,000: U. S. Geological Survey Open-File Report 92-0338, 1 sheet.

Field, M.A., Bouma, A.H., Colburn, I.P., Douglas, R.G. and Ingle, J.C., editors, 1980, Proceedings of the Quaternary depositional environments of the Pacific Coast: Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium, no. 4.

Fisher, M.A., Normark, W.R., Bohannon, R.G., Sliter, R.W. and Calvert, A.J., 2003, Geology of the continental margin beneath Santa Monica Bay, Southern California, from seismic-reflection data: Bulletin Seismological Society of America, v. 93, no. 5, p. 1955-1983.

Fisher, M.A., Normark, W.R., Langenheim, V.E., Calvert, A.J., and Sliter, R., 2004a, Marine geology and earthquake hazards of the San Pedro Shelf region, southern California: U.S. Geological Survey Professional Paper 1687, 33 p.

Fisher, M.A., Normark, W.R., Langenheim, V.E., Calvert, A.J., and Sliter, R., 2004b, The offshore Palos Verdes fault zone near San Pedro, southern California: Bulletin of Seismological Society of America, v. 94, no. 2, p. 506-530.

Fischer, P.J., Kreutzer, P.A., Morrison, L.R., Rudat, J.A., Ticken, E.J., Webb, J.F., Woods, M.M., Berry, R.W., Henry, M.J., Hoyt, D.H., and Young, M., 1983, Study on Quaternary shelf deposits (sand and gravel) of Southern California: Submitted to State of California, Department of Boating and Waterways, Beach Erosion Control Project, FR 82-11, 66 p.

Gardner, J.V. and Dartnell, P., 2002, Multibeam mapping of the Los Angeles, California margin: U.S. Geological Survey Open-File Report 02-162. (http://walrus.wr.usgs.gov/reports/ofr02-162.html)

Gardner, J.V., Dartnell, P., Mayer, L.A., and Hughes-Clarke, J.E., 2003, Geomorphology, acoustic backscatter, and processes in Santa Monica Bay from multibeam mapping *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 15-46.

Gardner, J.V., Hughes Clarke, J. E., and Mayer, L.A., 1999, Cruise report: RV Coastal Surveyor Cruise C-1-99-SC, Multibeam mapping of the Long Beach, California, continental shelf: U.S. Geological Survey Open-File Report 99-360. (http://geopubs.wr.usgs.gov/open-file/of99-360/)

Gardner, J. V. and Mayer, L.A., 1998, Cruise report, RV Ocean Alert Cruise A2-98-SC, mapping the southern California continental margin, March 26-April 11, 1998: U.S. Geological Survey Open-File Report 98-475. (http://geopubs.wr.usgs.gov/open-file/of98-475/)

Gorsline, D.S., 1958, Geology of San Pedro and Santa Monica basins: Ph.D. dissertation, University of Southern California.

Gorsline, D.S., 1969, Mineral composition of river, beach and shelf sands from Point Conception to the Mexican border: Geological Society of America Special Paper 121, p. 115.

Gorsline, D.S., 1975, A review of the marine geology of the southern California offshore region, *in* Lavenberg, R.J. and Earle, S.A., editors, Recommendations for baseline research in Southern California relative to offshore resource development: Proceedings: Southern California Academy of Sciences, p. 63-81.

Gorsline, D.S., 1992, The geological setting of Santa Monica and San Pedro basin, California continental borderland, *in* Small, L.F., editor, California basin studies: Physical, geological, chemical and biological attributes: Progress in Oceanography, v. 30, no. 1-4, p. 1-36.

Gorsline, D.S. and Emery, K.O., 1959, Turbidity currents in San Pedro and Santa Monica basins: Geological Society of America Bulletin, v. 70, p.279-280.

Gorsline, D.S. and Grant. D.J., 1972, Sediment textural patterns on San Pedro shelf, California (1951-1971), Reworking and transport by waves and currents, *in* Swift, D.J.P. and others, editors, Shelf sediment transport: Process and pattern: Dowden, Hutchinson & Ross, Stroudsburg, Pennsylvania, p. 575-600.

Grant, D.J., 1972, Sediment textural patterns on the San Pedro Shelf: M.S. thesis, University of Southern California, 93 p.

Greene, H.G. and others, 1975, Preliminary report on the environmental geology of selected areas of the southern California continental borderland: U.S. Geological Survey Open-File Report 75-596, 70 p.

Greene, H.G., Wolf, S.C. and Blom, K.G., 1978, The marine geology of the eastern Santa Barbara Channel with particular emphasis on the ground water basins offshore from the Oxnard Plain, southern California: U.S. Geological Survey Open-File Report 78-305, 104 p.

Greenstein, D., Bay, S.M., Jirik, A., Brown, J. and Alexander, C.R., 2003, Toxicity assessment of sediment cores from Santa Monica Bay, California *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 277-297.
Hauksson, E. and Saldivar, G.V., 1989, Seismicity and active compressional tectonics in Santa Monica Bay, southern California: Journal of Geophysical Research – Solid Earth, v. 94, no. 7, p. 9591-9606.

Hein, J.R., Dowling, J.S., Schuetze, A. and Lee, H.J., 2003, Clay-mineral suites, sources, and inferred dispersal routes: Southern California continental shelf, *in* Lee, H.J.

and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 79-102.

Henry, M.J., The unconsolidated sediment distribution on the San Diego County mainland shelf, California: M.S. thesis, San Diego State University, 82 p.

Henyey, T., and Osborne, R., 1975, Offshore sand and gravel resources in California, Sea Grant Institutional Program Annual Report 1974-75, University of Southern California, Institute for Marine and Coastal Studies, p. 20 - 22.

Henyey, T., and Osborne, R., 1976, Offshore sand and gravel resources in California, Sea Grant Institutional Program Annual Report 1975-76, University of Southern California, Institute for Marine and Coastal Studies, p. 12-13.

Howard, C.L., 1974, Marine geology study – California undersea aqueduct report: U.S. Bureau of Reclamation, Appendix II, 53 p.

Hoyt, D.H., 1976, Geology and recent sediment distribution from Santa Barbara to Rincon Point, California: M.S. thesis, San Diego State University, 97 p.

Inman, D.L., 1950, Submarine topography and sedimentation in the vicinity of Mugu submarine canyon, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 19, 42 p.

Junger, A. and Wagner, H.C., 1977, Geology of the Santa Monica and San Pedro basins, California continental borderland: U.S. Geological Survey Miscellaneous Field Studies Map MF-820, scale 1:250,000.

Karl, H.A., 1975, Distribution and significance of sedimentary structures and bedforms on the continental shelf, southern California: Geological Society of America Programs with Abstracts, v. 7, no. 3, p. 331-332.

Karl, H.A., 1976, Agents of sediment dispersal, San Pedro continental shelf, southern California: American Geophysical Union EOS Transactions, v. 57, no. 3, p. 150.

Karl, H.A., 1977, Origin and significance of mesoscale current lineations on the continental shelf, southern California: Geological Society of America Programs with Abstracts, v. 9, no. 4, p. 443-444.

Karl, H.A., 1977, Processes influencing transportation and deposition of sediment on the continental shelf, southern California: Ph.D. dissertation, University of Southern California.

Karl, H.A., 1980, Speculations on processes responsible for mesoscale current lineations on the continental shelf, southern California: Marine Geology, v. 34, no. 1-2, p. M9-M18.

Karl, H.A., Cacchione, D.A. and Drake, D.E., 1978, Spatial variability of the sea-floor and near-bottom water properties of the San Pedro continental shelf: American Geophysical Union EOS Transactions, v. 59, no. 12, p. 1113-1114.

Karl, H.A., Cacchione, D.A. and Drake, D.E., 1980, Erosion and transport of sediments and pollutants in the benthic boundary layer on the San Pedro shelf, southern California: U.S. Geological Survey Open-File Report 80-386, 100 p.

Karl, H.A. and Plutchak, N., 1976, Sediment patterns as indicators of transport mechanisms, San Pedro Shelf, California: Geological Society of America Programs with Abstracts, v. 8, no. 6, p. 946.

Keller, F.B., 1991, The seismic expression of submarine fan deposits, San Pedro Bay, Southern California borderland *in* Weimer, P. and Link, M.H., editors, Seismic facies and sedimentary processes of submarine fans and turbidite systems: Springer-Verlag, New York, New York, p. 435-436.

Kendall, T.R., Vick, J.C., and Forsman, L.M., 1991, Sand as a resource; managing and mining the Northern California coast,, *in* Domurat, G.W., and Wakeman, T.H., eds., The California coastal zone experience: New York, NY, Am. Soc. Civ. Eng., p. 278-297.

Kennedy, M.P., Greene, H.G., and Clarke, S.H., 1987, Geology of the continental margin: California Division of Mines and Geology, Bulletin 207, 110 p. (companion to the California Continental Margin Geologic Map Series (7 areas), Greene, H.G. and Kennedy, M.P., editors, published by California Division of Mines and Geology in 1986-1989). *Has extensive bibliography of literature prior to about 1985.*

Kennett, J.P., 1982, Marine geology: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 813 p. *General text on sampling, seismic, shelf and nearshore, effects of bottom currents. CGS library QE 39 K46.*

Kettenring, K.N., Jr., 1981, The trace metal stratigraphy and Recent sedimentary history of anthrogenous particulates on the San Pedro Shelf, California: Ph.D. dissertation, University of California, Los Angeles, 173 p.

Kolpack. R.L., 1979, Distribution of suspended particulate matter near sewage outfalls in Santa Monica Bay, California *in* Palmer, H.D. and Gross, M.G., editors, Ocean dumping and marine pollution: Geological aspects of waste disposal: Dowden, Hutchinson & Ross, Stroudsburg, Pennsylvania, p. 205-239.

Kolpack, R.L. and Drake, D.E., 1985, Transport of clays in the eastern part of Santa Barbara Channel, California: Geo-Marine Letters, v. 4, no. 3-4, p.191-196.

Kolpack, R.L., 1986, Sedimentology of the mainland nearshore region of the Santa Barbara Channel, California *in* Knight, R.J. and McLean, J.R., editors, Shelf sands and sandstones: Canadian Society of Petroleum Geologists Memoir 11, p. 57-72.

Kolpack, R.L., 1987, Sedimentology of shelf and slope in Santa Monica Bay, California: American Association of Petroleum Geologists Bulletin, v. 71, no. 5, p. 578.

Kulm, L.D., Peterson, C.D., and Stribling, M.C., 1986, Inventory of heavy minerals and metals southern Washington, Oregon, and northern California continental shelf and coastal region: State of Oregon, Department of Geology and Mineral Industries Open-File Report 0-86-10, 111 p.

Lee, H.J., Edwards, B., Noble, M. and Clark, A., 2003, Sediment contamination issues in Santa Monica Bay, California *in* Natural science and public health: Prescription for a better environment: U.S. Geological Survey Open-File Report 03-0097, 62 p.

Lee, H.J. and Weisberg, S., editors, 2003, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, 342 p.

Leecaster, M., 2003, Spatial analysis of grain size in Santa Monica Bay *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 67-78.

Legg, M. and Kennedy, M.P., 1979, Faulting offshore San Diego and northern Baja California, *in* Abbott, P.L. and Elliott, W.J., editors, Earthquakes and other perils, San Diego region: San Diego Association of Geologists, San Diego, California, p. 29-46.

Lichtman, G.S., Shiller, G.I. and Pierson, L.J., 1985, Geophysical evaluation of submerged post-Wisconsin potential archaeological sites, Santa Barbara Channel, California: Geophysics, v. 50, no. 2, p. 289.

Lu, Y., 1993, Fourier grain-shape analysis of beach sand samples and associated sedimentary processes, Dockweiler and El Segundo beaches, Santa Monica Bay, southern California: Ph.D. dissertation, University of Southern California.

Lu, Y. and Osborne, R.H., 1993, Sources for Quaternary sand and the effects of selective transport on grain-shape composition, Santa Monica Bay, California [abs.]: Geological Society of America Abstracts with Programs, v. 25, no. 6, p. 274.

Luepke, G., 1989, Marine placer potential on the west coast of the United States from California to Washington: Marine Mining, v. 8, no. 2, p. 173 - 183.

Luepke, G., 1994, Variations in titanium and chromium concentrations in magnetite separates from beach and offshore separates, San Francisco and San Mateo counties, California: U.S. Geological Survey Open-File Report 95-15, 6 p.

Luken, M.D., and Hess, H.D., 1979, Sand, gravel and shell deposits of the Southern California Borderland: OCS Mining Policy Phase II Task Force, Program Feasibility Study, OCS Hard Minerals Leasing (Appendix 10): U.S. Geological Survey unpublished report, 69 p.

Luyendyk, B.P., Hajic, E.J. and Simonett, D.S., 1983, Side-scan sonar mapping and computer-aided interpretation in the Santa Barbara Channel, California: Marine Geophysical Researches, v. 5, no. 4, p. 365-388.

Magoon, O.T., Haugen, J.C., and Sloan, R.L., 1972, Coastal sand mining in northern California, U.S.A., *in* Coastal Engineering Conference, 13th, 1972, American Society of Civil Engineers, p. 1571 - 1597.

Majors, C.P. and Binkin, M., 1997, Magnitude and style of extensional features, offshore San Diego, California: American Association of Petroleum Geologists Annual Meeting Abstracts, v. 6, p. 75.

Majors, C.P., Wall, C, von Stein, C., Rigor, A. and Binkin, M., 1998, Interpretation of recently released seismic data; deformation styles of offshore San Diego: American Association of Petroleum Geologists, Pacific Section Meeting Abstracts, v. 82, no. 5A, p. 852.

Maldonado, C., Venkatesan, M.I., Phillips, C.R., and Bayona, J.M., 2000, Distribution of trialkylamines and coprostanol in San Pedro shelf sediments adjacent to sewage outfall: Marine Pollution Bulletin, v. 40, no. 8, p. 680-687.

Marlow, M.S., Gardner, J.V., and Normark, W.R., 2000, Using high-resolution multibeam bathymetry to identify seafloor surface rupture along the Palos Verdes fault complex in offshore Southern California: Geology, v. 28, no. 7, p. 587-590.

Marsaglia, K.M., Rimkus, K.C. and Behl, R.J., 1995, Provenance of sand deposited in the Santa Barbara Basin at Site 893 during the last 155,000 years, *in* Kennett, J.P. and others, editors, Proceedings of the Ocean Drilling Program, scientific results, Santa Barbara Basin: Covering Leg 146 of the cruises of the vessel JOIDES Resolution, Santa Barbara Channel, California, Site 893, 20 September-22 November 1992: Proceedings of the Ocean Drilling Program, Scientific Results, no. 146, Part 2, p. 61-75.

Martindale, S.G., and Hess, H.D., 1979, Resource assessment; sand, gravel and shell deposits on the continental shelf of Northern and Central California: OCS Mining Policy Phase II Task Force, Program Feasibility Study, OCS Hard Minerals Leasing (Appendix 9): U.S. Geological Survey unpublished report), 39 p.

Maurer, D. and Nguyen, H., 1997, The relationship between an ocean outfall and sediment properties from the San Pedro shelf, California: Southern California Academy of Sciences Bulletin, v. 96, no. 1, p.22-33.

May, J.D., Boss, S.K. and Zaiger, K.K., 1999, Seafloor characterization and mapping from apparent depth of acoustic penetration: Geological Society of America Abstracts with Programs, v. 31, no. 7, p. 460.

McClain, C.E., 1992, Resource potential of offshore placer deposits, 1991 Exclusive Economic Zone symposium on mapping and research; working together in the Pacific EEZ: U.S. Geological Survey Circular 1052, p. 71.

McCulloch, D.S., editor, 1980, A summary report of the regional geology, environmental geology, OCS resource appraisal, petroleum potential, and operational considerations in the area of proposed lease sale 73, offshore California: U.S. Geological Survey Open-File Report 80-2007, 41 p.

McCurdy, R., 1965, Water motion and sediments of northeast San Pedro Bay, California: M.S. thesis, University of Southern California.

Menard, H.W., 1964, Marine geology of the Pacific: McGraw-Hill Book Company, New York, New York, 271 p. *Some material on Pacific Coast shelf CGS library QE 567 M4*

Mertes, L.A.K. and others, 1998, Synoptic views of sediment plumes and coastal geography of the Santa Barbara Channel, California, *in* Gurnell, A.M. and Montgomery, D., editors, Hydrological applications of GIS: Hydrological Processes, v. 12, no. 6, p. 967-979.

Mokhtari-Saghafi, M., and Osborne, R.H., 1980a, Commercial profitability of offshore sand and gravel mining in southern California: an analysis for new entries, *in* An International Forum on Ocean Engineering in the 80's, Oceans '80, Seattle, WA, Institute of Electrical and Electronics Engineers, p. 55-59.

Mokhtari-Saghafi, M., and Osborne, R.H., 1980b, An economic appraisal of mining offshore sand and gravel deposits: Southern California University Sea Grant Program Technical Report USC-SG-TR-80-01, 47 p.

Moore, D.B., 1965, Recent coastal sediments, Double Point to Point San Pedro, California: M.A. thesis, University of California, Berkeley, 86 p.

Moore, D.G., 1952, The marine geology of San Pedro Shelf: M.S. thesis, University of Southern California.

Moore, D.G., 1954, Submarine geology of San Pedro Shelf: Journal of Sedimentary Petrology, v. 24, no. 3, p. 162-181.

Moore, G.W., 1975, Acoustic-reflection profiles, R/V Polaris, November-December 1970, offshore Southern California: U.S. Geological Survey Open-File Report 75-0269, 28 p.

Moore, G.W. and McCulloch, D.S., 1975, Single-channel subbottom acoustic reflection profiles M/V Oil City, June 1969, offshore Southern California: U.S. Geological Survey Open-File Report 75-0347.

Morrison, L.R., 1982, Surface sediment and seismic reflection profiling, outer Newport submarine canyon, southern California continental borderland: M.S. thesis, California State University, Northridge, 150 p.

Nardin, T.R., 1976, Late Cenozoic history of the Santa Monica Bay area, California: M.S. thesis, University of Southern California, 189 p.

Nardin, T.R. and others, 1981, Holocene sea-level curves for Santa Monica shelf, California continental borderland: Science, v. 213, p.331-333.

Noble Consultants, 1989a, Coastal sand management plan, Santa Barbara/Ventura County coastline: Main Report, Prepared for Beach Erosion Authority for Control Operations and Nourishment (BEACON), 186 p.

Noble Consultants, 1989b, Coastal sand management plan, Santa Barbara/Ventura County coastline: Appendix B (Offshore Sand Resources), Prepared for Beach Erosion Authority for Control Operations and Nourishment (BEACON), 80 p.

Noble, M.A. and Xu, J.P., 2003, Observations of large-amplitude cross-shore internal bores near the shelf break, Santa Monica Bay, CA *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 127-149.

Ocean Surveys, 1981, Final report, contract to CERC, coring survey, offshore coast of southern California: Ocean Surveys, Inc. Contract No. DACW72-80-R-0026, 16 p.

Orzech, K. and others, 2001, Core descriptions, core photographs, physical property logs and surface textural data of sediment cores recovered from the continental shelf of the Monterey Bay National Marine Sanctuary during the research cruises M-1-95-MB, P-2-95-MB, and P-1-97-MB: U.S. Geological Survey Open-File Report 01-107, 21 p. (http://geopubs.wr.usgs.gov/open-file/of01-107)

Osborne, R.H., Scheidemann, R.C., Jr., Nardin, T.R., and Harper, A.S., 1980, Quaternary stratigraphy and depositional environments, Santa Monica Bay, southern California, *in* Field, M.E. and others, editors, Quaternary depositional environments of the Pacific coast: Society of Economic Paleontologists and Mineralogists, Pacific Section, Coastal Paleogeography Symposium 4, p. 143-156.

Osborne, R.H. and others, 1980, Occurrence and sedimentological characteristics of offshore sand and gravel bodies in Santa Monica and San Pedro Bays, and their suitability as a source of material for beach nourishment and construction aggregate: University of Southern California, Sea Grant Publication.

Osborne, R.H., Darigo, N., and Scheidemann, R.C., Jr., 1983, Report of the potential offshore sand and gravel resources of the inner continental shelf of Southern California: California Department of Boating and Waterways, 302 p.

Osborne, R.H., Scheidemann, R.C., Jr., Nardin, T.R., and Harper, A.S., 1980, Quaternary stratigraphy and depositional environments, Santa Monica Bay, southern California, *in* Quaternary Depositional Environments of the Pacific Coast Paleography Symposium, 4th, Bakersfield, CA, Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 143-156.

Osborne, R.H., Scheidemann, R.C., Jr., Nardin, T.R., Harper, A.S., Brodersen, K.L., Kabakoff, J., and Waldron, J.M., 1979, Potential sand and gravel resources in Santa Monica and San Pedro Bays: southern California, *in* Oceans '79 Annual Combined Conference, San Diego, CA, Institute of Electrical and Electronic Engineers and The Marine Technology Society, p. 590-597.

Osborne, R.H., and Yeh, C.-C., 1991, Fourier grain-shape analysis of coastal and inner continental-shelf sand samples; Oceanside littoral cell, southern Orange and San Diego counties, Southern California, *in* Osborne, R.H., ed., From shoreline to abyss; contributions in marine geology in honor of Francis Parker Shepard: Tulsa, OK, Society of Economic Paleontologists and Mineralogists (Society for Sedimentary Geology), p. 51-66.

Peterson, 1988, Elemental content of heavy-mineral concentrations on the continental shelf off Oregon and northern California: Oregon Department of Geology and Mineral Industries Report O-88-04, 9 p.

Phillips, C.R., Venkatesan, M.I. and Bowen, R., 1997, Interpretations of contaminant sources to San Pedro shelf sediments using molecular markers and principal component analysis *in* Eganhouse, R., editor, Molecular markers in environmental geochemistry: American Chemical Society Symposium Series, v. 671, p. 242-260.

Pierson, L.J., Shiller, G.I., and Slater, R.A., 1987, California outer continental shelf: Archaeological resource study: Morro Bay to Mexican border: U.S. Minerals Management Service, OCS Study MMS 87-0025, prepared under Contract No. 14-12-0001-30272 by PS Associates, 199 p.

Pollard, D.D., 1979, The source and distribution of beach sediments, Santa Barbara County, California: Ph.D. dissertation, University of California, Santa Barbara, 293 p.

Ponti, D.J., 2000, An integrated approach toward a new Quaternary stratigraphic model for the Los Angeles Basin, California: A framework for refined seismic hazards and groundwater studies: Geological Society of America Abstracts with Programs, v. 33, no. 3, p. 41.

Reid, J.A., Marlow, M.S. and Normark, W.R., 2000, Multibeam image and new high-resolution seismic reflection profiles confirm recent deformation in the Loma Sea Valley, offshore San Diego: American Geophysical Union, EOS Transactions, v. 81, no. 48, p. 1068.

Ridgway, J.R., 1997, The development of a deep-towed gravity meter, and its use in geophysical surveys of offshore Southern California and an airborne laser altimeter survey of Long Valley, California: Ph.D. dissertation, University of California, San Diego, 231 p.

Rogers, K., Frost, E. and others, 1998, Mid-Tertiary crustal extension in the offshore California borderlands as demonstrated by major crustal tilt blocks from industry seismic profiles: American Association of Petroleum Geologists, Pacific Section Meeting Abstracts, v. 82, no. 5A, p. 856-857.

Roig, J.H., 1976, Use of heavy minerals as tracers of sand transport of the Santa Barbara-Oxnard shelf: Santa Barbara Channel, California: M.S. thesis, University of Southern California.

Rowland, R.W., Clarke, S.H., Jr. and Greene, H.G., 1982, Marine geological profiles in the southern California continental borderland collected in 1974 on the R/V S.P. Lee: U.S. Geological Survey Open-File Report 82-0975, 2 p.

Rudat, J.H., 1980, Quaternary evolution and seismic stratigraphy of the San Pedro shelf, southern California: M.S. thesis, California State University, Northridge, 137 p.

Rudat, J.H. and Fischer, P.J., 1979, Quaternary evolution and seismic stratigraphy of the San Pedro shelf, southern California: Geological Society of America Programs with Abstracts, v. 11, no. 7, p. 507.

Rutan, C., 1981, Isopach map: sand sized materials sand inventory study offshore Mission Beach to Leucadia Southern California: scale 1:24,000. (*Uncertain reference)*

Rutan, C., 1981, Seafloor texture and grain size contours sand inventory study offshore San Diego Southern California: scale 1:24,000. (*Uncertain reference)*

Rutan, C., 1981, Isopach map: sand sized materials sand inventory study offshore Leucadia to Oceanside southern California: scale 1:24,000. (*Uncertain reference)*

San Diego Association of Governments, 1993, Shoreline preservation strategy for the San Diego region: San Diego Association of Governments, 43 p.

San Diego Association of Governments, 1995, Shoreline preservation strategy for the San Diego region: Shore & Beach, v. 63, no. 2, p. 17-30.

Sanders, J.E., 1973, Map of parts of floor of Santa Barbara Channel California, compiled from side-scanning sonar records: American Association of Petroleum Geologists Bulletin, v, 57, no. 4, p. 802-803.

Savula, N.A., 1978, Light mineral petrology of sediments from Santa Monica and San Pedro bays, California continental borderland: M.S. thesis, University of Southern California.

Scholl, D.W., Gantz, A., and Vedder, J.G., 1987, Geology and resource potential of the continental margin of western North America and adjacent ocean basins - Beaufort Sea to Baja California: Earth science series: Houston, TX, Circum-Pacific Council for Energy and Mineral Resources, 7 v., v. 6, 799 p.

Schwab, W.C., Twichell, D.C., Rodriguez, R.W., Thieler, E.R., Allison, M.A., and Gayes, P.T., 1995, Linear ripple scour depressions in the nearshore: possible indicators of cross-shelf sediment transport?: Geological Society of America Abstracts with Programs, v. 27, no. 6, p. 77.

Sea Surveyor, Incorporated, 1999, San Diego regional beach sand project: Offshore sand investigations: Final Report, Prepared for San Diego Association of Governments, 65 p.

Shepard, F.P., 1973, Submarine geology: Harper and Row Publishers, New York, New York, 517 p. *Classic text on all aspects of marine geology CGS library has second edition (1963) QE 567 .S5 1963*

Shepard, F.P. and Inman, D.L., 1951, Sand movement on the shallow inter-canyon shelf at La Jolla, California: U.S. Army Corps of Engineers, Beach Erosion Board Technical Memorandum 26, 29 p.

Shepard, F.P. and McDonald, G.A., 1935, Sediments of Santa Monica Bay, California: Bulletin of the American Association of Petroleum Geologists, v. 22, no. 2, p. 201-216.

Sommerfield, C.K. and Lee, H.J., 2003, Magnitude and variability of Holocene sediment accumulation in Santa Monica Bay, California *in* Lee, H.J. and Weisberg, S., editors, Integrated assessment of an urban water body: Santa Monica Bay, California: Marine Environmental Research, v. 56, no. 1-2, p. 151-176.

Sommerfield, C.K. and Lee, H.J., 2004, Across-shelf transport since the last glacial maximum, Southern California margin: Geology, v. 32, no. 4, p. 345-348.

Sprague, D.W., 1971, Geology and economic significance of Pleistocene channel and terrace deposits on the San Diego mainland shelf, California: M.A. thesis, University of Southern California, 39 p.

Storlazzi, C.D., and Field, M.E., 2000, Sediment distribution and transport along a rocky, embayed coast; Monterey Peninsula and Carmel Bay, California: Marine Geology, v. 170, no. 3-4, p. 289-316.

Steinberger, A., Stein, E. and Schiff, K.C., 2003, Characteristics of dredged material disposal to the Southern California Bight between 1991 and 1997, *in* Weisberg, S.B. and Elmore, D., editors, Southern California Coastal Water Research Project Biennial Report 2001-2002: Southern California Coastal Water Research Project Authority, 419 p.

Swartz, R.C., Schults, D.W., Lamberson, J.O., Ozretich, R.J. and Stull, J.K., 1991, Vertical profiles of toxicity, organic carbon, and chemical contaminants in sediment cores from the Palos Verdes Shelf and Santa Monica Bay, California: Marine Environmental Research, v. 31, no. 3, p.215-225.

Tait, J., Anima, R.J., and Griggs, G.B., 1992, Shoreface storage and transport of littoral sediments along the central California coast, from the American Geophysical Union 1992 Fall Meeting: Eos, Transactions, American Geophysical Union, v. 73, no. 43, Suppl., p. 302.

Teng, L.S. and Gorsline, D.S., 1987, Neogene sedimentation of continental borderland basins, offshore Southern California: American Association of Petroleum Geologists Bulletin, v. 71, no. 5, p. 621.

Terry, R.D. and Stevenson, R.E., Microrelief of the Santa Monica Shelf, California: Geological Society of America Bulletin, v. 68, p. 125-128.

Terry, R.D. and Uchupi, E., 1957, Submarine geology of Santa Monica Bay, California: Geological Society of America Bulletin, v. 68, no. 12, Part 2, p. 1848.

Ticken, E.J., 1983, Geology of the inner basin margin: Dana Point to San Onofre, California: M.S. thesis, California State University, Northridge, 85 p.

U.S. Army Corps of Engineers, 1973, High-resolution geophysical and vibrating sampling project offshore southern California: U.S. Army Corps of Engineers Final Report Contract DACW 09-73-C-0098, 7 p.

U.S. Army Corps of Engineers, 1989, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 5 p.

U.S. Army Corps of Engineers, 1995, San Gabriel River to Newport Beach – Beach replenishment at Surfside-Sunset Beach: U.S. Army Corps of Engineers, Los Angeles District, Geotechnical Report, 8 p.

U.S. Army Corps of Engineers, 2002, Silver Strand shoreline, Imperial Beach , California: U.S. Army Corps of Engineers, Los Angeles District, General Evaluation Report, Appendix A, Geotechnical Report.

U.S. Bureau of Mines, 1987, An economic reconnaissance of selected sand and gravel deposits in the U.S. Exclusive Economic Zone: Office of the Assistant Director--Mineral Data Analysis, Bureau of Mines, Open-File Report 3-87, 113 p.

University of Southern California, and Institute for Marine and Coastal Studies, 1980, An economic appraisal of mining offshore sand and gravel deposits: University of Southern California Sea Grant Program Technical Report, 47 p.

Vedder, J.G., 1975, Acoustic reflection profiles, R/V Kelez, May-June 1973, Leg 3, offshore Southern California: U.S. Geological Survey Open-File Report 75-0265.

Vedder, J.G., 1990, Maps of California continental borderland showing compositions and ages of bottom samples acquired between 1968 and 1979: U.S. Geological Survey Map MF-2122, scale 1:250,000.

Vedder, J.G. and others, 1969, Geology, petroleum development, and seismicity of the Santa Barbara Channel region, California: U.S. Geological Survey Professional Paper 679, 77 p.

Wagner, H.C., 1975, Seismic reflection profiles, R/V Kelez, May 1973, Leg 2, offshore southern California: U.S. Geological Survey Open-File Report 75-0205, 60 p.

Wagner, H.C. and Junger, A., 1975, Geology of the San Pedro Basin and shelf, offshore southern California: Geological Society of America Abstracts with Programs, v. 7, no. 3, p.383-384.

Welday, E.E. and Williams, J.W., 1975, Offshore surficial geology of California: California Division of Mines and Geology Map Sheet 26, scale 1:500,000.

White, C.K.. 1969, Geology of the San Diego onshore-offshore area, southern California: M.S. thesis, University of Nevada, Reno, 90 p.

Wilde, P., Lee, J., Yancey, T., and Glogoczowski, M., 1973, Recent sediments of the central California continental shelf, Pillar Point to Pigeon Point, Part C. interpretation and summary of results: University of California Hydraulic Engineering Laboratory Report 2-38, 83 p.

Wildharber, J.L., 1966, Suspended sediment over the continental shelf (Southern California): M.S. thesis, University of Southern California.

Wilson, K. and Golden, B., 1979, Results of high resolution seismic reflection profiling, northern Santa Monica Bay, California: Geological Society of America Abstracts with Programs, v. 11, no. 7, p. 542.

Wolf, S.C. and Gutmacher, C.E., 2004, Geologic and bathymetric reconnaissance overview of the San Pedro Shelf region, southern California: U.S. Geological Survey Open-File Report 2004-1049, version 1.0. (http://pubs.usgs.gov/of/2004/1049/)

Wong, F.L., 1995, Sediment distribution on a stream-dominated continental margin, Northern California; implications from heavy-mineral studies: U.S. Geological Survey Open-File Report 95-0614, 21 p.

Wong, F.L., 1996, Heavy mineralogy of effluent-affected sediment and other deposits, Palos Verdes shelf, Southern California [abs.]: EOS, Transactions, American Geophysical Union, v. 77, no. 3, Suppl., p. 50.

Wong, F.L., 2001, Heavy minerals from the Palos Verdes margin, southern California: Data and factor analysis: U.S. Geological Survey Open-File Report 01-153, 31 p. (http://geopubs.wr.usgs.gov/open-file/of01-153)

Wong, F.L. and Eittreim, S.L., 2001, Continental shelf GIS for the Monterey Bay National Marine Sanctuary: U.S. Geological Survey Open-File Report 01-179. (http://geopubs.wr.usgs.gov/open-file/of01-179/)

Woodell, G.J., Egense, A.K. and Butcher, C.C., 1989, Beach nourishment project compatible with multiple concerns, Santa Monica Bay, California, *in* Magoon, O.T. and others, editors, Coastal Zone ’89: American Society of Civil Engineers, Proceedings of the Sixth Symposium on Coastal and Ocean Management, p. 2076-2091.

Woods, M.M., 1984, Seismic stratigraphy and fault activity of the inner San Pedro Shelf, California: M.S. thesis, California State University, Northridge, 90 p.

Woodward-Clyde Consultants, 1979, Southern California seismic survey final report on contract no. DACW72-79-C-0032: Woodward-Clyde Consultants for the Department of the Army Coastal Engineering Research Center Corps of Engineers Final Report on Contract No. DACW72-79-C-0032, Project No. 41205, 14 p.

Zalesny, E.R., 1956, Foraminiferal ecology of Santa Monica Bay (California): M.S. thesis, University of Southern California.

Zalesny, E.R., 1959, Foraminiferal ecology of Santa Monica Bay, California: Micropaleontology, v. 5, no. 1, p. 101-126.

TABLE 1 - Selected Sites of Important Coastal Erosion in California

SITE	LOCATION	LATITUDE	LONGITUDE	NEED FOR BEACH NOURISHMENT?	CONSEQUENCES OF NO NOURISHMENT	REFERENCE
Crescent City Beacl	Crescent City, Del Norte Count			No		Noble Consultants (2000
Ocean Beach	City of San Francisco, San Francisco County			Yes	Erosion of beach and seacliff by storm waves. Threat to major highway	CDBW and SCC (2002), U.S. Army Corps of Engineers (SF District)
Sharp Park	City of Pacifica, San Mateo Count			No		Noble Consultants (2000
El Granada State Beacl	San Mateo County			No		Noble Consultants (2000
Cliff Drive (various segments)	Santa Cruz County			?		U.S. Army Corps of Engineers (SF District)
The Hook	City of Santa Cruz, Santa Cruz Count			No		Noble Consultants (2000
Twin Lakes	City of Santa Cruz, Santa Cruz Count			No		Noble Consultants (2000
Moss Landing Harbor	Monterey County			?		U.S. Army Corps of Engineers (SF District)
San Simeon State Parl	San Luis Obispo County			No		Noble Consultants (2000
Cayucos	San Luis Obispo County			Yes	Inadequate protection of commercial area from storm waves and coastal flooding.	Noble Consultants (2000)
Price Street Pocket Beach	San Luis Obispo County			Yes	Street threatened by erosior of steep seacliff.	Noble Consultants (2000)
Refugio State Beach	Santa Barbara County			Yes	Current beach inadequate t protect back-beach from storm waves and coastal flooding	Noble Consultants (2000)
El Capitan State Beach	Santa Barbara County			Yes	Current beach inadequate t protect cliff toe and backlands from storm waves and coastal flooding.	Noble Consultants (2000)
Isla Vista	Santa Barbara County			Yes	Current beach inadequate t support recreation and to protect cliff toe and back-beach from storm waves and coastal flooding.	Noble Consultants (2000)
Goleta Beach County Park	Santa Barbara County			Yes	Beach erosion has caused loss of recreational area anc damage to park improvements	Noble Consultants (2000), CDBW and SCC (2002)
Leadbetter Beacl	Santa Barbara County			No		Noble Consultants (2000
Carpinteria City Beach	Santa Barbara County			Yes	Current beach inadequate t protect back-beach development from storm waves and coastal flooding.	Noble Consultants (2000), CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)
Carpinteria State Beacl	Santa Barbara County			No		Noble Consultants (2000

SITE	LOCATION	LATITUDE	LONGITUDE	NEED FOR BEACH NOURISHMENT?	CONSEQUENCES OF NO NOURISHMENT	REFERENCE
La Conchita	Ventura County			Yes	Beach compromised by encroachment of highway, railroad, which limits recreational access	Noble Consultants (2000)
Hobson County Park Beach	Ventura County			Yes	Beach compromised by encroachment of highway, railroad, which limits recreational access	Noble Consultants (2000)
Emma Wood County Beach	Ventura County			Yes	Beach compromised by encroachment of highway, railroad, which limits recreational access	Noble Consultants (2000)
Emma Wood State Beach	Ventura County			No		Noble Consultants (2000)
Surfers Point Park	Ventura County			No		Noble Consultants (2000)
San Buenaventura State Beac	Ventura County			No		Noble Consultants (2000)
Pierpont Beach	Ventura County			Yes	Current beach is chronically narrow, which limits recreational access	Noble Consultants (2000)
Marina Park	Ventura County			No		Noble Consultants (2000)
Hueneme Beach Mile 24	Ventura County			No		Noble Consultants (2000)
Hueneme Beach Mile 24.5	Ventura County			No		Noble Consultants (2000)
Leo Carrillo State Beach	Los Angeles County			Yes	Current beach inadequate to protect back-beach improvements from erosion by storm waves	Noble Consultants (2000)
Dan Blocker Beach	Los Angeles County			Yes	Current beach inadequate to protect highway from storm waves and coastal flooding.	Noble Consultants (2000)
Topanga Beach	Los Angeles County			No		Noble Consultants (2000)
Will Rogers State Beach	Los Angeles County			No		Noble Consultants (2000)
Venice Beach	Los Angeles County			No		Noble Consultants (2000)
Dockweiler Beach	Los Angeles County			No		Noble Consultants (2000)
Peninsula Beach	City of Long Beach, Los Angeles County			Yes	Waves erode beach, which is backed by oceanfront homes.	CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)
Seal Beach Mile 1	Orange County			No		Noble Consultants (2000)
Surfside-Sunset Beach	City of Seal Beach, Orange County			Yes	Erosion of this beach and downshore beaches if not periodically renourished.	CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)
Huntington Cliffs	City of Huntington Beach, Orange County			Yes	Lack of adequate beach has resulted in erosion of bluff with consequent loss of facilities at park	CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)
City of San Clemente Beach	City of San Clemente, Orange County			Yes	Continued reduction in beach width has allowed storm waves to cause damage to public and private development	CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)

SITE	LOCATION	LATITUDE	LONGITUDE	NEED FOR BEACH NOURISHMENT?	CONSEQUENCES OF NO NOURISHMENT	REFERENCE
Oceanside	City of Oceanside, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
Carlsbad State Beach	San Diego County			Yes	Current beach inadequate to protect back-beach improvements from erosion by storm waves	Noble Consultants (2000)
North Carlsbad	City of Carlsbad, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
South Carlsbad	City of Carlsbad, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
Batiquitos	San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
Leucadia State Beach	City of Encinitas, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
Moonlight State Beach	City of Encinitas, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
Cardiff State Beach	City of Encinitas, San Diego County			Yes	Narrow beaches allow coastal flooding of roads during storms.	CDBW and SCC (2002)
Encinitas	City of Encinitas, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	U.S. Army Corps of Engineers (LA District)
Solana Beach	City of Solana Beach, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)

SITE	LOCATION	LATITUDE	LONGITUDE	NEED FOR BEACH NOURISHMENT?	CONSEQUENCES OF NO NOURISHMENT	REFERENCE
Del Mar	City of Del Mar, San Diego County			Yes	On-going beach and seacliff erosion threatens public and private development as well as public safety.	CDBW and SCC (2002)
Torrey Pines State Beach	San Diego County			Yes	On-going beach and seacliff erosion threatens public safety.	CDBW and SCC (2002)
Mission Beach	San Diego County			Yes	On-going beach and bluff erosion and coastal flooding during storms threaten public and private development as well as public safety.	CDBW and SCC (2002)
Coronado	San Diego County			?		U.S. Army Corps of Engineers (LA District)
Imperial Beach	City of Imperial Beach			Yes	Current beach inadequate in places to protect back-beach development from storm waves and coastal flooding.	CDBW and SCC (2002), U.S. Army Corps of Engineers (LA District)

TABLE 2 - Beach Nourishment Projects in California (modified from Coyne, 2000)

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Whaler Island	Smith River	Crescent City, Del Norte Co.			FC	1998	70,000	Crescent City Harbor (inner Harbor Basin, entrance channels)	hopper dredge, hydraulic pipeline dredge or clamshell/barge.	sandy/silty	DR, R
Crescent City	Klamath River	Crescent City, Del Norte Co.			TC'89	every few years	3-4,000,000		harbor bypassing		B
Crescent City	Klamath River	Crescent City, Del Norte Co.			TC'91	every few years	~3,500,000				harbor bypassing
Humboldt Bay South Spit (Nearshore Ocean Disposal Site)	Eureka	Humboldt Bay, Humboldt Co.			FC	August to October, 1988	745,000	Humboldt Harbor Bar, Entrance, and North Bay Channels	maintenance and advance maintenance dredging using hopper dredge	expected to be >90% sand	N,DS, DR
Humboldt Bay (Nearshore Ocean Disposal Site)	Eureka	Humboldt Bay, Humboldt Co.			FC	August 1 - October 15, 1989	585,000	Humboldt Harbor Bar, Entrance, North Bay Channel	self-propelled hopper dredge		DS, DR
Doran Beach	Bodega Bay	Bodega Bay, Sonoma County			FC	1980	<80,000	Federal Channel, Bodega Harbor, Bodega Bay	placed above MHHW	mostly sand	DS, DR
Bolinas Bay	Bolinas Bay	Bolinas Bay			TC'91		~65,000				beach erosion control
Ocean Beach	San Francisco	San Francisco, San Francisco			TC'91			San Francisco sewage disposal "box"			upland excavation spoils
Capitola	Santa Cruz	Capitola, Santa Cruz Co.			TC'91	1970	~20,000				beach restoration
Capitola	Santa Cruz	Capitola, Santa Cruz Co.			TC'89	1969-70	2000 truckloads	local quarry sand	terminal groin with small beach fill delivered by truck		N
Capitola	Santa Cruz	Capitola, Santa Cruz Co.			SPCA'76	1970					groin and fill
Seabright Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			TC'89	periodically		Santa Cruz small craft harbor entrance	harbor dredging and beach placement		DR, N
Seabright Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			TC'91						harbor bypassing
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1965	70,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1966	34,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1967	57,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1968	60,500	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1969	79,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1970	94,700	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1971	108,300	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1972	90,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1973	109,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1974	60,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1975	91,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1976	98,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1977	52,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1977	147,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1978	55,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1979	162,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1980	190,250	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1981	187,687	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1982	138,188	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1983	154,498	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1984	79,479	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1985	145,237	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1986	207,315	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1987	212,410	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1988	230,351	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1989	214,544	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1990	173,567	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1991	163,250	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			RW'94	1992	160,000	Santa Cruz Harbor			
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			TC'89			Santa Cruz small craft harbor entrance	harbor dredging and beach placement		DR, N
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			TC'91						harbor bypassing
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			FC	October 81; October 82; October 83; October 84; October 85; October 86	230,000	Santa Cruz Yacht Harbor channel	maintenance dredging; transport by suction dredge and pipeline into surf zone		DR, R
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			FC	March/April/ May 1984	130,000	maintenance dredging of Santa Cruz Yacht Harbor	<16" diameter dredge pipeline, in water, discharging onto beach, followed by beach shaping		R, DS, DR
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			FC	12/15/84-2/10/85; 2/11/85-3/28/85; 4/15/85-5/17/85	176,000	Santa Cruz Yacht Harbor	<16" pipeline from E jetty of yacht harbor, then buried in beach w/ shifting discharge points either on beach or in surf zone		R, DS, DR
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			FC	11/22/85-12/22/85 1/6/86 - 2/6/86; 2/10/86 - 3/21/86; 4/7/86 - 5/7/86	230,000	Santa Cruz Yacht Harbor maintenance dredging	<16" diameter dredge pipeline, from E jetty, buried, discharging onto beach at multiple points		DS, DR
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			ACOE'90	1986	197,000	Santa Cruz Harbor	beach fill		DR, DS
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			ACOE'90	1987	212,000	Santa Cruz Harbor	beach fill		DR, DS

Applicant/Sponsor	**Duration of Fill/Performance**	**Funding**	**Environmental Effects**	**Monitoring**	**Notes**	**Ref. ID**	**Permit/FC Ref.**	**See Also**	
USACOE						CD-80-98			
					source: Armstrong 1987				
					sources: Armstrong				
USACOE			Gray Whale (scheduled outside of migration periods); commercial and recreational crab fishing (scheduled after season ends)	COE monitored nearshore site using bathymetric surveys (Aug., Oct. '88, March '89) and Seabed Drifter (Nov. '88)	"disposal of the dredged material directly on the beach was considered impractical due to high costs and unsafe wave conditions in the area." "the designation of a [nearshore site]…is viewed as a "test" to discover whether sand will be retained in the littoral system and provide beach nourishment."	CD-045-88		CD-21-87	
USACOE			turbidity, smothering of benthics	planned bathymetric and seabed drifter surveys of site:Aug. 89, post-deposition, Winter, '90, Spring '90; biological: June, Sept.'89, March '90	"preliminary data from bathymetric surveys and seabed drifter releases indicates that the dredge deposited the Nearshore Site (sic) in FY-1988 have dispersed and has remained in the littoral zone.."	CD-026-89		CD-5-88; CD-45-88; CD-31-86; CD-18-85; CD-21-87	
USACOE						CD-006-80			
					sources: Armstrong				
	washed away in '82-'83 storms				source: Armstrong				
city of Capitola	lost 3x '70-'86; present in '86	$146,100 (inc. groin)			source: CA Dept of Nav. And Ocean Dev. 1976; Griggs and Savoy '86; Shaw 1980				
city/CA Parks and Recreation		$146,000			source: CA-DNOD 1977; Griggs and Savoy 1986				
city/CA Parks and Recreation		$146,100			source: CA-DNOD 1976				
					source: CA-DNOD 1977; Griggs and Savoy 1986				
					source: Griggs and Savoy 1986				
					source: CA-DNOD 1977; Armstrong 1987				
	feader beach				source: CA Dept of Nav. And Ocean Dev. 1977 (atlas); Armstrong 1987				
USACOE						CD-012-81			
USACOE						CD-046-83			
USACOE						CD-059-84	CDP 3-84-13	CD-12-81, CD-46-83, CDP 3-59-84	
						CD-031-85	CDP 3-84-13	CD-59-84; CD-46-83	
USACOE		via navigation Project							
USACOE		via navigation Project							

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			ACOE'90	1988	210,000	Santa Cruz Harbor	beach fill		DR, DS
Twin Lakes State Beach	Santa Cruz	Santa Cruz, Santa Cruz Co.			FC	1994	<75,000	San Lorenzo River channels			N, DS, DR
Moss Landing State Beach	Southern Monterey Bay	Monterey Bay, Monterey County			FC	March/April '84	10-20,000	maintenance dredging of Moss Landing Harbor	hydraulic cutterhead dredge with submerged pipeline disposal intertidally (north of Sandholt Pier)	medium sand	R, DS, DR
Moss Landing State Beach	Southern Monterey Bay	Monterey Bay, Monterey County			ACOE'90	1987	29,000	Moss Landing Harbor	beach fill		DR, DS
Morro Bay beaches	Morro Bay	Morro Bay, San Luis Obispo			TC'89	since 1940s	120,000/yr	Morro Bay navigational channel			DR, N
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1949	822,000				
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1964	702,000				
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1968	406,000				
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1971	190,000				
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1982					
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1985					
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'89	1985	120,000	Morro Bay navigational channel	dredged, then pumped N of harbor entrance		DR, N
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1987					
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			ACOE'90	1987	400,000	probably Morro Bay	beach fill		DR, DS
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1941-1943	1,000,000		0.7 mi long fill		
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1942-1946	3,071,000				Harbor construction
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	1974?					
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'89	early 1940's		Morro Bay navigational channel			DR
Morro Bay	Morro Bay	Morro Bay, San Luis Obispo			TC'91	yearly	~120,000				harbor bypassing
Morro Dunes Natural Preserve	Morro Bay	Morro Bay, San Luis Obispo			FC	November '84 to February '85	50,000	Morro Bay entrance channel, Navy Channel, Morro Channel	hydraulic suction dredge, tractor with pipe lift attachment on beach	fine to medium grained, poorly sorted sands, 1-8% fines	R, DS, DR
Morro Dunes Natural Preserve	Morro Bay	Morro Bay, San Luis Obispo			FC	October 1, 1986 - February 15, 1987	350,000	Morro Bay Harbor	pipeline along sand spit to beach disposal site 3 miles S of harbor entrance	predominantly sand	R, DS, DR
Morro Dunes Natural Preserve	Morro Bay	Morro Bay, San Luis Obispo			FC	September '90 to 10/15/90-11/30/90	200,000	Morro Bay Entrance, Navy, Morro Channels and additional embayment near entrance	maintenance dredging by hopper dredge; deposition in no deeper than 40' MLLW (sand spit 8000' S of harbor) (nearshore disposal)	>97% sand	DS, DR
Morro Dunes Natural Preserve	Morro Bay	Morro Bay, San Luis Obispo			FC	August to December 1993	all or fraction of 840,000	Morro Bay Harbor mouth	hopper dredge; disposal by hopper dredge to nearshore no deeper than -40' MLLW (sand spit; 8000' S of harbor)		N, DS
Morro Strand State Beach (South)	Morro Bay	Morro Bay, San Luis Obispo			FC	November '84 to February '85	450,000	Morro Bay entrance channel, Navy Channel, Morro Channel	hydraulic suction dredge, 12-26" diameter pipeline on surface of beach (3.6 mi long)	fine to medium grained, poorly sorted sands, 1-8% fines	R, DS, DR
Morro Strand State Beach (South)	Morro Bay	Morro Bay, San Luis Obispo			FC	September '90 to 10/15/90-11/30/90	200,000	Morro Bay Entrance, Navy, Morro Channels and additional embayment near entrance	maintenance dredging by hopper dredge; deposition in no deeper than 40' MLLW (8000' N of harbor) (nearshore disposal)	>97% sand	DS, DR
Morro Strand State Beach (South)	Morro Bay	Morro Bay, San Luis Obispo			FC	August to December 1993	all or fraction of 840,000	Morro Bay Harbor mouth	hopper dredge; disposal by either hopper dredge or pipeline from hopper dredge to surf zone or nearshore no deeper than -40' MLLW; (8000' N of harbor)		N, DS
Morro Strand State Beach (South)	Morro Bay	Morro Bay, San Luis Obispo			FC	11/1/93 - 3/31/94	600,000	Morro Bay Harbor Entrance, Navy and Morro Channels	either cutterhead hydraulic pipeline dredge with surf zone disposal or hopper/clamshell combination dredge with nearshore disposal		DS, DR
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'89	1935	202,000	Santa Barbara Harbor	first sand-bypassing operation; created offshore ridge: 200' wide, 2000' long, 18' of water, 1000' offshore (nearshore)		B
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1935	202,000		0.4 mi long; deposited in ~20 ft water depth, ~1000 ft offshore		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1938	584,000		0.2 mi long; ~500 ft wide		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1940	697,700		0.5 mi long		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1942	600,110		1.0 mi long		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1945	717,773		1.0 mi long		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1947	642,977		1.0 mi long		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1949	638,152		1.0 mi long		harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1950-1952	2,476,098				harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1954-1972 (periodically)					harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1972	229,333				harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			Shaw'80	1972	224804	Santa Barbara Harbor	bypassing to downcoast of harbor		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			Shaw'80	1974	380337	Santa Barbara Harbor	bypassing to downcoast of harbor		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1974	388,000				harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1975	50,667				harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			Shaw'80	1975	49666	Santa Barbara Harbor	bypassing to downcoast of harbor		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			Shaw'80	1976	394714	Santa Barbara Harbor	bypassing to downcoast of harbor		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1976	402,667				harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			Shaw'80	1977	335899	Santa Barbara Harbor	bypassing to downcoast of harbor		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'91	1977	342,667				harbor bypassing
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			ACOE'90	1986	300,000	Santa Barbara Harbor	beach fill		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			ACOE'90	1987	225,000	Santa Barbara Harbor	beach fill		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			ACOE'90	1988	260,000	Santa Barbara Harbor	beach fill		
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			FC	2/24/86 - 5/15/86	250,000	Santa Barbara Harbor	discharge point = 2300' E of Stearn's Wharf within surf zone		DS, DR

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE		via navigation Project							
USACOE						CD-020-94			
USACOE			loss of benthic communities; loss of beach communities		80,000 - 90,000 yd^3 disposed of at end of pier in disposal site SF-12 in 20 ft below MLLW	CD-038-83		CD-11-81	
USACOE		lowest cost disp.alt.							
					source: Converse 1982				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
	lost w/in 2 years				source: Sears 1987				
	2 years				source: David Sears, Morro Beach State Park, CA dept of P & R, 1987				
USACOE		lowest cost disp.alt.							
		$155,000			source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974(Morro Bay)				
					source: Hall 1952; USACOE-LA 1974				
	sand lost to offshore off "reef"		little storm recovery observed		source: Converse 1982; Armstrong 1987; Sears 1987				
USACOE					location is site of dune blowouts; replenishment is paired with revegetation effort	CD-058-84	CDP 4-84-380	CD-39-86, CDP 4-86-218	
USACOE			potential impacts on: eelgrass beds, grunion, peregrine falcon, CA brown pelican, southern sea otter, Morro Bay kangaroo rat; project timed to avoid impacts, but dredging will impact clam feeding ground of otters in channel	Corps will monitor to define impacts to endangered sea otters		CD-039-86	CDP 4-84-380; CDP 4-86-218	CD-58-84; CD-11-87	
USACOE			impacts to: eel grass beds in bay, grunions, peregrine falcons, brown pelicans, southern sea otters	COE will monitor material using pre- and post- bathymetric surveys to determine fate of material	previous monitoring of effects of dredging on clams (otter food supply) revealed no detrimental effect.	CD-029-90		CD-39-86; CD-58-84; CD-11-87	
USACOE		$2,192,000 start-up; 80% Corps/20% City of Morro Bay	reefs in disposal area		more likely disposal choice; "Final disposal site will be selected prior to construction and based upon specific need for beach nourishment material, weather conditions, and other temporally variable factors."	CD-081-91		CD-9-90; CD-9-86; CD-8-84: ND-1-87	
USACOE			adverse impacts to Southern Sea Otter (dredging); area around Morro Creek left clear for steelhead; no dune disturbance		site is from 400' N of rock to 400' N of Morro Creek, from 5-20' below MLLW to 12' above MLLW; lead to rapid shoaling of harbor to S (CD-39-84)	CD-058-84	CDP 4-84-380	CD-39-86, CDP 4-86-218	
USACOE			impacts to: eel grass beds in bay, grunions, peregrine falcons, brown pelicans, southern sea otters	COE will monitor material using pre- and post- bathymetric surveys to determine fate of material	previous monitoring of effects of dredging on clams (otter food supply) revealed no detrimental effect.	CD-029-90		CD-39-86; CD-58-84; CD-11-87	
USACOE		$2,192,000 start-up; 80% Corps/20% City of Morro Bay	reefs in disposal area		less likely disposal choice; "Final disposal site will be selected prior to construction and based upon specific need for beach nourishment material, weather conditions, and other temporally variable factors."	CD-081-91		CD-9-90; CD-9-86; CD-8-84: ND-1-87	
USACOE			effects on clams -> otters			CD-044-93			
	still there		"The expectation was that this sand would be carried shoreward and downcoast by natural wave activity. Unfortunately, however, the ridge remained in place, slightly reduced in height, but essentially unaltered (USACOE 1986)."		source: Hall 1952; USACOE-LA 1986; Griggs and Savoy 1986				
	bar still visible in '86 offshore; no migration onshore	$26,260			source: Griggs and Savoy 1986; Hall 1952				
	sand out of disposal area by 1940	$122,787			source: O'Brien 1938; USACOE-CERC 1984; O'Brien 1940; USCOE-LA 1986 (oral history)				
					source: USACOE-LA 1986 (oral)				
		$131,424			source: Hall 1952				
		$170,112			source: Hall 1953				
		$109,306			source: Hall 1954				
		$122,525			source: Hall 1955				
					source: Shaw 1980; USACOE-CERC 1984				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
	erosion checked but beach not recovered				source: Shaw 1980; USACOE-LA 1986 (oral)				
		Section 111, RHA 1968							
		Section 111, RHA 1968							
		Section 111, RHA 1968							
USACOE			scheduled during grunion spawning, but deposition in surf zone; monitoring planned to determine impacts	beach profile monitoring to document impacts of single-pt surf zone disposal on grunion		CD-009-86			

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			FC	9/15/86 - 3/1/88	~100,000/yr	Santa Barbara Harbor	placement b/w sand dikes to enhance settling of sand		DS, DR
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			FC	Fall '89 to Spring '92	600,000	Santa Barbara Harbor mouth	(2300' S of Stearn's Wharf)		DS, DR
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			FC	Oct '92 - Feb '93 or March 1 - April 30 '93	600,000	Santa Barbara Harbor, including West Beach	maintenance and advance maintenance dredging; disposal either on beach or single-point discharge in surf zone	dredge spoils compatible w/ local sediment on East Beach	DS, DR
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			FC	10/1/94 - 4/30/95; 10/1/95 - 4/30/96; 10/1/96 - 4/20/97	600,000	Santa Barbara Harbor and sand traps	maintenance dredging; disposal either on beach or in surf zone via pipeline oriented perpendicular to shore below MHW		DS, DR
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			FC	Fall '99 to Spring '05	600,000	Santa Barbara Harbor mouth	beach and surfzone disposal		DS, DR
East Beach	Santa Barbara	Santa Barbara, Santa Barbara			TC'89	every 1-2 years since 1935		Santa Barbara Harbor	bypassing directly onto beaches		B, N
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			TC'89	1962	200,000		placed as part of groin project		R
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1962	197,500		~1.4 mi long, 139-261 ft wide		beach erosion control (groin)
San Buenaventura Beach	Santa Barbara	Ventura, Ventura County			Shaw'80	1962	196050	Ventura Harbor	initially formed beach area 42-79 m. by 1121 m long; deposited South of groins 5,4,and 2	migrated south	
San Buenaventura Beach	Santa Barbara	Ventura, Ventura County			Shaw'80	1963	522800	Ventura Harbor	deposited north of groins 4 and 7		
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1963	533,333				
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1965	235,000		0.5 mi long; 150-170 ft wide		beach erosion control (groin)
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			RW'94	1966	882,000	Ventura Marina			R (groin)
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1967	449, 800		1.0 mi long; 130-200 ft wide		beach erosion control (groin)
San Buenaventura Beach	Santa Barbara	Ventura, Ventura County			Shaw'80	1967	163375	Ventura Harbor	deposited north of groins 7 and 9		
San Buenaventura Beach	Santa Barbara	Ventura, Ventura County			Shaw'80	1973	5228	Ventura Harbor	emergency fill		
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1976					harbor bypassing
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			FC	January - March '90	100,000 - 150,000	Ventura Harbor	maintenance dredging (Ventura-Pierpont Groin Field)		N, R, DS, DR
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			SPCA'76	1967					7 groins & fill
San Buenaventura State Beach	Santa Barbara	Ventura, Ventura County			SPCA'76	1973					groin and fill
South Beach	Santa Barbara	Ventura, Ventura Co.			FC	March - July, 1983	150,000	dredging of Ventura Harbor	hydraulically dredge Harbor mouth; transport through pipe, deposit on dry beach until winter, then bulldoze onto active beach face (b/w Harbor and Santa Clara River mouth)		DS, DR
Ventura	Santa Barbara	Ventura, Ventura Co.			FC	June/July '84	200,000	Ventura Harbor	disposal area: 1000 ft long, high on beach, 2 discharge points	clean sand	
Ventura	Santa Barbara	Ventura, Ventura Co.			ACOE'90	1986	1,000,000	Ventura Harbor	beach fill		DR, DS
Ventura	Santa Barbara	Ventura, Ventura Co.			ACOE'90	1987	550,000	Ventura Harbor	beach fill		DR, DS
Ventura	Santa Barbara	Ventura, Ventura Co.			ACOE'90	1988	800,000	Ventura Harbor	beach fill		DR, DS
Ventura	Santa Barbara	Ventura, Ventura Co.			FC	1997	19,500	Ventura Harbor south jetty repair and modification	either cutter head pipeline dredge or hopper dredge (nearshore)	clean sandy sediments	DS, DR
Marina Park Beach	Santa Barbara	Ventura, Ventura County			FC	12/23/84 - 3/15/85	150,000	Ventura Harbor sand traps and entrance channel	hydraulic dredge	fine sand (>91% on 200 sieve)	R, DS, DR
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1970	249,333				harbor bypassing
McGrath State Beach Park	Santa Barbara	Ventura, Ventura County			Shaw'80	1970	244409	Ventura Harbor			
McGrath State Beach Park	Santa Barbara	Ventura, Ventura County			Shaw'80	1971	924049	Ventura Harbor			
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1971	942,667				harbor bypassing
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1973	764,000				harbor bypassing
McGrath State Beach Park	Santa Barbara	Ventura, Ventura County			Shaw'80	1973	748911	Ventura Harbor			
McGrath State Beach Park	Santa Barbara	Ventura, Ventura County			Shaw'80	1974	320215	Ventura Harbor			
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1974	326,667				harbor bypassing
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1975	154,667				harbor bypassing
McGrath State Beach Park	Santa Barbara	Ventura, Ventura County			Shaw'80	1975	151612	Ventura Harbor			
McGrath State Beach Park	Santa Barbara	Ventura, Ventura County			Shaw'80	1977	748911	Ventura Harbor			
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	1977	764,000				harbor bypassing
McGrath State Beach	Santa Barbara	Ventura, Ventura County				1981		dredging of Ballona Creek		black, odoriferous, trashy	DS, DR
McGrath State Beach	Santa Barbara	Ventura, Ventura County			FC	March - July, 1983	750,000	dredging of Ventura Harbor	hydraulically dredge Harbor mouth; transport through pipe, deposit on dry beach until winter, then bulldoze onto active beach face		DS, DR
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'91	periodically					harbor bypassing
McGrath State Beach	Santa Barbara	Ventura, Ventura County			TC'89	since 1970		Ventura Marina	maintenance dredging and beach replenishment		DR, N
McGrath State Beach	Santa Barbara	Ventura, Ventura County			FC	12/23/84 - 3/15/85	800,000	Ventura Harbor sand traps and entrance channel	hydraulic dredge; placed ~6100' S of entrance channel	fine sand (>91% on 200 sieve)	R, DS, DR
McGrath State Beach (nearshore)	Santa Barbara	Ventura, Ventura County			FC	9/15 - 3/15	600,000	Ventura Harbor	clamshell and hopper dredge alternatives proposed		DS, DR
McGrath State Beach (surf and/or nearshore)	Santa Barbara	Ventura, Ventura County			FC	9/15/94 - 3/15/95	800,000	Ventura Harbor sand traps and entrance channel	hydraulic, hopper and/or clamshell dredges; beach, surf zone, and/or nearshore disposal (<30'MLLW)	predominantly sandy	R, DS, DR
McGrath State Beach (surf and/or nearshore)	Santa Barbara	Ventura, Ventura County			FC	9/15/98 - 3/15/99; 9/15/99 - 3/15/00; 9/15/00 - 3/15/01; 9/15/01 - 3/15/02; 9/15/02 - 3/15/03; 9/15/03 - 3/15/04;	500,000	Ventura Harbor entrance, navigation channels and sand traps	hydraulic cutterhead pipeline dredge (maybe hopper or clamshell)	>80% sand	DR, R

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE			grunion			CD-025-86		CD-2-83; CD-12-84; CD-25-84	
USACOE						CD-046-89			
USACOE			impacts to grunion spawning if contingency dredging necessary; creation of sand traps in harbor intended to mitigate need for this dredging	effects of March disposal on grunion spawning		CD-040-92		CD-25-86; CD-46-89	
USACOE				April extension to monitor impacts of surf zone disposal on grunion		CD-032-93		CD-21-83; CD-25-86; CD-46-89; CD-58-90; CD-79-91; ND-4-92; CD-40-92	
USACOE				nightly surveys of grunion to detect onset of spawning		CD-048-98		CD-21-83; CD-25-86; CD-46-89; CD-58-90; CD-79-91; ND-4-92; CD-40-92; CD-32-93	
USACOE									
	"migrated south"		"impounded on N side of groins"		source: USACOE-LA 1976; Shaw 1980				
			"accretion on N side of groins"		source: Shaw 1980				
					source: USACOE-LA 1976				
		$2,157,000 (7 groins plus fill)	"accretion on N side of groins"		source: USACOE-LA 1976; CA Dept of Nav and Ocean Dev 1976;				
	current bypassing has problems				source: Herron 1987				
USACOE				beach profiles by Ventura Port District, annually in September		CD-036-89			
		$2,157,000			source: CA-DNOD 1976				
		$370,000			source: CA-DNOD 1976				
USACOE						CD-002-83	CDP 4-83-257A (in lieu of CD-43-84)	CD-25-84; CD-30-85; CD-42-88;CD-17-89	
USACOE			to mitigate impacts to access, Corps will fill beach in stages; will operate single discharge points to mitigate tern and grunion impacts		2600 ft beach frontage	CD-025-84	CP 4-83-257		
USACOE		Section 111, RHA 1968							
USACOE		Section 111, RHA 1968							
USACOE		Section 111, RHA 1968							
USACOE					sand dredged from around pier; will be placed either in sand trap to be dredged with next maintenance dredging or directly into nearshore somewhere downdrift.	CD-168-97			
USACOE			least turn nesting, brown pelican (dredging)	Corps will monitor to define erosion issues	disposal site ~1400 ft long, from first groin in Pierpont groin field	CD-030-85		CD-25-84; CD-42-88; CD-17-89	
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
LA Co/ USACOE			storing sand in backshore until winter to avoid grunion and least turn spawning season		noted in CD-02-83				
USACOE			storing sand in backshore until Sept. 1 to avoid grunion and least turn spawning season		dredging-induced opportunistic surf zone nourishment was conducted prior to this project	CD-002-83			
			"1977: Effect of bypassing overshadowed by extremely high sediment flows in Santa Clara River."		source: Shaw 1980				
					source: Shaw 1980				
USACOE			grunion spawning, salt marsh bird's beak, The Belding's Savannah Sparrow (nourishment); least turn nesting (dredging)		disposal site ~4400 ft long	CD-030-85		CD-25-84; CD-42-88; CD-17-89	
USACOE/Ventura Port District			increased turbidity, loss of O2, loss of benthics, impacts to least tern, grunion	beach profiles by Ventura Port District	nearshore disposal -> berm: -15' MLLW, 4300' long, 900' footprint, b/w -15' and -10' contours	CD-053-91	CDP 4-83-257	ND-42-88; CD-17-89	
USACOE			terns, grunions, plover		beginning 100' S of Santa Clara River mouth and extending S for 4300'	CD-054-94			
USACOE			grunion, least terns, snowy plovers; single point diked discharge to minimize turbidity; discharge further than 200' from mouth of Santa Clara River to minimize impacts to steelhead trout in estuary			CD-64-98		CD-54-94; CD-53-91; CD-42-88; CD-51-86; CD-30-85; CD-2-83	

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1973	75000	Channel Islands Harbor maintenance dredging			R
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1975	100000	Channel Islands Harbor maintenance dredging			R
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1977	100000	Channel Islands Harbor maintenance dredging			R
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1981	100000	Channel Islands Harbor maintenance dredging			R
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1983	150000	Channel Islands Harbor maintenance dredging			R
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1987	378000	Channel Islands Harbor maintenance dredging			R
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			FC	9/1/88 - 3/15/89; 9/1/90 - 3/15/91; 9/1/92 - 3/15/93	300,000	maintenance dredging of Channel Islands Harbor sand trap, entrance basin, channel	diesel or electric cutterhead hydraulic dredge; buried hydraulic pipeline (placed 800' downcoast of harbor S jetty)	initially black and smelly	DS, DR
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'89	occassionally	200,000/yr	nearby maintenance dredging			N
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	occassionally	200,000 cu/yr				harbor bypassing
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			FC	Sept. '83 to March '84	150,000	Channel Islands Harbor	dredged from harbor, transported via buried discharge pipeline	?	DS, DR
Silver Strand Beach	Santa Barbara	Port Hueneme, Ventura Co.			FC	10/94 - 3/95; 10/96 - 3/97; 10/98 - 3/99	6,900,000 (over 6 years)	Channel Islands Harbor and Port Hueneme	maintenance dredging	predominantly sandy	DR, R
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'89	1935-1940	1,500,000	excavation of Port Hueneme harbor			R
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1939	2,614,000	Port Hueneme			
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1940	1,360,000	Port Hueneme harbor excavation			Harbor construction
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1941					
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1953-1954	1,986,640	Port Hueneme	bypassed		
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1954	2,033,000				harbor bypassing
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			RW'94	1960	3,700,000	Channel Islands Harbor excavation			harbor construction
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'89	1960		Channel islands harbor excavation and bypassing			B, N
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1960-1961	6,234,390	Channel Islands Harbor sand trap			
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1961	6,000,000	Channel Islands harbor			Harbor construction
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1963	1,986,000				harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1963	1984026	Channel Islands Harbor sand trap			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1965	3524979	Channel Islands Harbor sand trap			
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1965	3,527,000				harbor bypassing
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1968	1,704,000				harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1968	1670346	Channel Islands Harbor sand trap			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1969-1970	2722481	Channel Islands Harbor sand trap	initially widened beach 30 m		
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1970	2,777,333		widened beach 99 ft		harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1971	2,533,333		widened beach 99 ft		harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1971	2483300	Channel Islands Harbor sand trap and entrance channel			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1973	2483300	Channel Islands Harbor sand trap and entrance channel			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1973	2,533,333				harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1975	109,788	Port Hueneme			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1975	1,768,000				harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1975	1623294	Channel Islands Harbor sand trap and entrance channel			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			Shaw'80	1977	2483300	Channel Islands Harbor sand trap and entrance channel			
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'91	1977	2,533,333				harbor bypassing
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'89	1941, 1943, 1954,					R
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	1985? In the future	61,000	Channel A, Port Hueneme, below +1' MLLW	hydraulic dredge from MLLW down to -20'; placed in surf zone unless grunion season; then placed above H20 line	compatible w/ local sediment	N, R, DS, DR
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura Co.			TC'89	every two years since 1960		Channel Island Harbor and Port Hueneme Harbor bypassing			B, N
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	October '84 to March '85	2,000,000	Channel Islands Harbor (sand trap and entrance channel)	hydraulic cutterhead dredge; deposited hydraulically via buried pipeline (+10 ft MLLW, 50 ft. from HWL); (downcoast of E Jetty to beyond pier)		R, DS, DR
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	Sept. '83 to March '84	1,350,000	Channel Islands Harbor	dredged from harbor, transported via buried discharge pipeline	?	DS, DR
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	Sept. '83 to March '84	200,000	Hueneme Harbor	dredged from harbor, transported via buried discharge pipeline	clean sand	DS, DR
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			ACOE'90	1987	2,000,000	Channel Islands Harbor	beach disposal		DR, DS

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
					source: USA/CESPL as given in Noble 89 as given in Wiegel '94				
					source: USA/CESPL as given in Noble 89 as given in Wiegel '94				
					source: USA/CESPL as given in Noble 89 as given in Wiegel '94				
					source: USA/CESPL as given in Noble 89 as given in Wiegel '94				
					source: USA/CESPL as given in Noble 89 as given in Wiegel '94				
					source: USA/CESPL as given in Noble 89 as given in Wiegel '94				
USACOE					3000' along beach	CD-004-89		CD-25-83; CD-53-84; CD-43-86/CD-60-86	
					source: CA-DNOD 1977; Armstrong 1987				
					source: Herron and Harris 1966; Armstrong 1987				
USACOE						CD-025-83	CDP 4-83-257		
USACOE			need to protect least terns, grunions, snowy plover; limit post-March 31 disposal to diked or single-point disposal; map for plovers pre-disposal; mitigate impacts to pismo clams			CD-052-94		CD-4-89; CD-7-89; CD-80-86; CD-43-86; CD-53-84; CD-25-83; CD-15-90; CD-12-85	
	3 years								
	total loss and beyond w/in 3 years	$295,800			source: USACOE-LA 1954				
					source: USACOE-LA 1954				
					"Plan only partially successful. Bypassed only half the planned volume, b/c of difficulty of dredging in surf zone. Gave temporary respite, but by 1958, city of Port Hueneme again building emergency seawall." source: USACOE-CERC 1984				
		$1,250,000			source: Herron 1987; Herron and Harris 1966				
		$951,000			source: Herron and Harris 1966				
			"Of 14M cy pumped to feeder beach b/w 1960 and 1966, some 9M cy have moved on downcoast."		source: Herron and Harris 1966				
		$852,000			source: Shaw 1980, Herron and Harris 1968				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
	bypassing has overcome problem				source: Shaw 1980; Armstrong 1987; Herron 1987; USACOE-CERC 1984				
					source: Hall 1952; Herron and Harris 1962)				
USACOE					additional 163,000 yd^3 needed to be dredged/disposed in 1986	CD-012-85	CDP 4-86-204		
					source: Shaw 1980				
USACOE			coverage/disturbance/elimination of benthic communities; turbidity; fish displacement			CD-053-84		CD-25-83; CD-12-85; CD-62-87	
USACOE			no fill deposition after March 31 due to grunion spawning; avoid least turn nesting			CD-025-83	CDP 4-83-473	CD-53-84; CD-12-85;	
USACOE						CD-025-83	CDP 4-83-257		
USACOE		Section 111, RHA 1968							

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	3/15/87 - 5/30/87	500,000	Channel Islands harbor entrance, basin, sand trap	routine dredging; diesel dredge; bermed disposal site >25' from highest contour of wave runup, 1700' long, 7' above MLLW; single return water discharge point	littoral drift material	DS, DR
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	1989	2,200,000	maintenance dredging of Channel Islands Harbor sand trap, entrance basin, channel	diesel or electric cutterhead hydraulic dredge; hydraulic pipeline on beach surface	initially black and smelly	DS, DR
Hueneme Beach Park	Santa Barbara	Port Hueneme, Ventura County			FC	10/94 - 3/95; 10/96 - 3/97; 10/98 - 3/99	6,900,000 (over 6 years)	Channel Islands Harbor and Port Hueneme	maintenance dredging	predominantly sandy	DR, R
Hueneme Beach	Santa Barbara	Port Hueneme, Ventura County			FC	1999-2000	630,000	Port Hueneme	maintenance dredging; on or nearshore disposal		clean sediment
Pacific Missile Range	Santa Barbara	Point Mugu, Ventura County			TC'89	1947	700,000	Mugu lagoon			DR, N
Pacific Missile Range	Santa Barbara	Point Mugu, Ventura County			TC'91	1947	709,333				
Pacific Missile Range	Santa Barbara	Point Mugu, Ventura County			Shaw'80	1947	695,324	Mugu Lagoon		fill degraded rapidly	
Pacific Missile Range	Santa Barbara	Point Mugu, Ventura County			RW'94	1961			3 groins constructed with fill	sand	groins and fill
Las Tunas Beach	Santa Monica	Malibu, Los Angeles Co.			TC'89	1960-1974	50,000				R
Las Tunas Beach	Santa Monica	Malibu, Los Angeles Co.			TC'91	1960-1974	~50,000				beach erosion control
Will Rogers State Beach	Santa Monica	Pacific Palisades, Los Angeles Co			TC'91						
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			TC'91	1939					
Santa Monica Beach	Santa Monica	Venice Beach, Los Angeles County			Shaw'80	1939	60,122	Santa Monica Breakwater	Ocean Park to Santa Monica Pier		
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			TC'91	1943	150,000				beach erosion control
Santa Monica Beach	Santa Monica	Venice Beach, Los Angeles County			Shaw'80	1949	396,021	Santa Monica Breakwater	deposited from Ocean Park Pier to Santa Monica Pier		
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			TC'91	1950	1,000,000				
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			TC'89	1939, 1949, 1950					R
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			RW'94	1945	150,000				R
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			LHW'94	1939	60,000	Santa Monica Breakwater bypassing	bypassed		
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			LHW'94	1949-50	960,000	Santa Monica Breakwater bypassing	bypassed		
Santa Monica State Beach	Santa Monica	Santa Monica, Los Angeles Co.			LHW'94	1957-58	780,000	Santa Monica Breakwater bypassing	bypassed		
Venice City Beach	Santa Monica	Venice, Los Angeles County			LHW'94	1945	150,000	Hyperion excavation			DS
Venice City Beach	Santa Monica	Venice, Los Angeles County			RW'94	1945	150,000	Hyperion sewage disposal plant			erosion control
Venice City Beach	Santa Monica	Venice, Los Angeles County			TC'89	1945	140,000	nearby dunes	trucked from dunes to beach		R
Venice City Beach	Santa Monica	Venice, Los Angeles County			TC'91	1945	140,000		0.6 mi long; 75 ft fill width		beach restoration
Venice Beach	Santa Monica	Venice Beach, Los Angeles County			Shaw'80	1945	148,998	Santa Monica Breakwater	Venice Pier to Washington St.		
Venice City Beach	Santa Monica	Venice, Los Angeles County			RW'94	1947		Hyperion sewage disposal plant			R
Venice Beach	Santa Monica	Venice Beach, Los Angeles County			Shaw'80	1948	1,390,648	Santa Monica Breakwater	El Segundo to Ocean Park; widened beach ~180 m (x ft)		
Venice City Beach	Santa Monica	Venice, Los Angeles County			RW'94	1973	17,000	entrance of Marina Del Rey			maintenance dredging
Venice City Beach	Santa Monica	Venice, Los Angeles County			TC'89	1975	11,000				R
Venice City Beach	Santa Monica	Venice, Los Angeles County			TC'91	1975	11,000				
Venice Beach	Santa Monica	Venice Beach, Los Angeles County			Shaw'80	1975	10,456	Marina Del Rey	bypassing		
Venice City Beach	Santa Monica	Venice, Los Angeles County			FC	March - May 1998	<123,00	Marina Del Rey Harbor (sand trap)	either hopper dredge, clamshell dredge with disposal barge or hydraulic cuttterhead with pipeline; pipeline w/ single-pt. discharge in intertidal zone	99% sand	DS, DR
Venice City Beach/Dockweiler	Santa Monica	Venice, Los Angeles County			LHW'94	1947	13,900,000	Hyperion excavation			DS
Venice City Beach/Dockweiler	Santa Monica	Santa Monica, Los Angeles Co.			RW'94	1946-48	~14,000,000	Hyperion sewage disposal plant excavation	hydraulically excavated from sand dunes		DS, R
Venice City Beach/Dockweiler	Santa Monica	Santa Monica, Los Angeles Co.			TC'89	1947-48	14,000,00	Hyperion sewage disposal plant excavation		sand from sand hills	R
Venice City Beach/Dockweiler	Santa Monica	Playa Del Rey, Los Angeles County			Shaw'80	1948	13,984,900	nearby sand hills (Hyperion excavation)	sand hydraulically removed from hills, transported to beach via discharge pipes		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1938	1,800,000	Hyperion excavation			DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles County			Shaw'80	1938	1,803,660	nearby sand hills			
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1969	389,000	Marina Del Rey Harbor (sand trap) bypassing	bypassed		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1975	10,000	Marina Del Rey Harbor (sand trap) bypassing	bypassed		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1981	217,000	Marina Del Rey Harbor (sand trap) bypassing	bypassed		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1987	35,000	Marina Del Rey Harbor (sand trap) bypassing	bypassed		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			TC'89	1938	1,800,000	nearby hills	Dockweiler: from El Segundo/LA City border to Marina Del Rey		R
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			TC'91	1938	1,840,000				upland excavation fill
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RW'94	1956	2,400,000	electric power plant excavation	"placed along 8,600 ft of Dockweiler beach southerly from the Ballona Creek jetties. Bulldozers, conveyor belts and dump trucks were used to move the sand."		upland excavation fill
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1956	2,400,000	Scattergood power plant			DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles County			Shaw'80	1962	3,202,150	Marina Del Rey	downcoast of Ballona Creek		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1960-62	3,200,000	Marina Del Rey			DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			TC'91	1962	3,000,000				harbor construction
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1963	6,900,000	Marine Del Rey			DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			TC'91	1963	<7,022,667				
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RW'94	1969	389,000	entrance of Marina Del Rey			maintenance dredging
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			TC'91	1975	10,667				
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RW'94	1981	217,000	entrance of Marina Del Rey			maintenance dredging
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RW'94	1987	35,000	entrance of Marina Del Rey			maintenance dredging

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE			disposal site diked to minimize impacts to grunion; return flow clearer due to dike decanting		notes ocean disposal is more costly than beach disposal	CD-060-86		CD-43-86; CD-25-83; CD-53-84	
			use of diked beach disposal proposed to minimize impacts to grunion spawning after March 15			CD-004-89		CD-25-83; CD-53-84; CD-43-86/CD-60-86	
USACOE			need to protect least terns, grunions, snowy plover; limit post-March 31 disposal to diked or single-point disposal; map for plovers pre-disposal			CD-052-94			
DR, DS	USACOE					CD-030-99			
	degraded rapidly								
	fill downgraded rapidly				source: Shaw 1980				
					source: USACOE-LA 1974				
					source: USCOE-LA (Las Tunas) 1974				
					source: Griggs and Savoy 1986				
					source: Shaw 1980				
		$88,000			source: USACOE-LA 1986 (oral)				
		$250,000	"Nullified downdrift erosion damage caused by Santa Monica breakwater and resultant. Today's beach is totally artificial & much wider today than natural beach of 50 years ago."		source: Hall 1952				
	major portion there after 4yrs				source: Johnson 1950				
	1949 still there; estimated life=10 yr	$10,500			sources: Johnson, 1950; Hall 1952; Shaw 1980				
					source: Shaw 1980				
		$7,000			source: Shaw 1980				
USACOE			severe impacts to least tern nesting			CD-002-98			
	1 mil.yd^3/yr initially				widened beach to avg. width of 600' (Johnson 1950) to 800' (Kenyon 1950)				
					source: Shaw 1980				
					source: Shaw 1980				
					placed in anticipation of downcoast erosion from Marina Del Rey jetties; no serious erosion in 1986. Source: USCOE-LA 1986				
					source: Shaw 1980				
					source: Shaw 1980				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			ACOE'90	1987	31,000	Marine Del Rey	beach fill		DR, DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			FC	February 2, 1987 - March 15, 1987	200,000	Marina Del Rey Harbor entrance and approach channels, and Ballona Creek mouth	electric or diesel dredge; discharge pipeline on sand above supratidal zone	predominantly sand	DS, DR
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RW'94	1988	155,000	Hyperion excavation expansion			
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			LHW'94	1988	155,000	Hyperion excavation expansion			DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RF '93	1989	1,097,880	Hyperion sewage disposal plant excavation	"transported by conveyor belt..across Pacific Coast Highway to Dockweiler Beach"		R
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			RW'94	1989	1,100,000	Hyperion sewage disposal plant excavation	"The sand was transported from the excavation site by a dry-haul conveyor system through a 9-ft diameter steel casing installed under the 4-lane coastal highway (Vista Del Mar) and the bicycle path seaward of the highway to the beach, then along the beach by conveyor to the placement site (either upcoast or downcoast), and finally handled by use of bulldozers."		R
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			FC	March - May 1998	<123,000	Marina Del Rey Harbor (sand trap)	either hopper dredge, clamshell dredge with disposal barge or hydraulic cuttterhead with pipeline; pipeline w/ single-pt. discharge in intertidal zone	99% sand	DS, DR
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			TC'89	occassionally		Marina del Rey	dredging		
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			FC	1999	150,000	Marina Del Rey Harbor		clean sand	DR, DS
Dockweiler Beach	Santa Monica	Playa Del Rey, Los Angeles Co			CDP	1999	215,655	Marine Del Rey	North Jetty dredging and related federal project; to widen beach by 100 ft at end of Torrance Blvd, Redondo Beach and Dockweiler	clean sand	DR, DS
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			TC'89	1936	1,800,000	nearby dunes			R
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			TC'91	1936	1,800,000		1.8 mi long; 200 ft wide		upland excav./ beach rest.
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			TC'89	early 1980s	750,000		in conjunction with groin construction		R
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			TC'91	early 1980s	750,000				beach widening
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			LHW'94	1984	620,000	offshore			nourishment
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			RW'94	1988	550,000	Hyperion excavation expansion	downcoast of Chevron groin		
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			RW'94	1989/90	945,000	Hyperion excavation expansion			R
El Segundo	Santa Monica	El Segundo, Los Angeles Co.			LHW'94	1989-90	945,000	Hyperion excavation expansion			DS
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			LHW'94	1947	100,000	onshore			nourishment
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'91	1947	57,000				beach restoration
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			RW'94	1947	?220,000				
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'89	once during 1940s					R
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'89	once during 1950s					R
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'91	1956-58					navigation/beach erosion control
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			RW'94	1962	?220,000				
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'89	1968	1,400,000	offshore	pumped		R
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'91	1968	1,405,961		1.2 mi long; increased beach to avg width of ~225 ft		beach erosion control
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			RW'94	1968	1,400,000	offshore	7800ft long; source was 30-60 ft below MLLW, ~1700' offshore; "A hopper dredge and floating pipeline operated in a water depth of about 37 ft, and pumped sand to shore."	fill: 0.4-0.7 mm med. Diameter; native 0.5 mm	
Redondo Beach	Palos Verdes	Redondo Beach, Los Angeles County			Shaw'80	1968	1,398,490	offshore	deposited on Redwood Beach, Topaz St. to Malaga Cove, using hydraulic pipeline from 9-20 m below MLLW	~400,00 cy migrated N into King Harbor by mid-1969	
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			LHW'94	1968-69	1,400,000	offshore			nourishment
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			SPCA'76	1970					groin and replenishment
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			TC'91	1971	1,020,000				
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles County			Shaw'80	1971	999,855	offshore	deposited beach using hydraulic pipeline from 9-20 m below MLLW		
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co			FC	proposed 1991	6,000	King Harbor, harbor side of N breakwater	disposal in surf zone	fine to medium grained sands, with only minor amounts of gravel and/or fines	R, DS, DR
Redondo Beach	Santa Monica	Redondo Beach, Los Angeles Co				2000	230,000	nearshore deposits from previous Harbor dredging	transported by barge from dredge site to dump site, then hydraulically pumped from nearshore to onshore		R
Santa Monica Bay Beaches	Santa Monica	Santa Monica, Los Angeles Co.			RF '93	1947	14,377,000	Hyperion sewage disposal plant excavation			upland excavation fill
Santa Monica Bay Beaches	Santa Monica	Santa Monica, Los Angeles Co.			RF '93	1960-1963	10,063,900	Marina Del Rey excavation			harbor excavation
Santa Monica Bay Beaches	Santa Monica	Santa Monica, Los Angeles Co.			TC'91	1947-1948	14,000,000		~7 mi. long; avg. beach width 600-800 ft		upland excavation fill
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			TC'89	1927					R
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			TC'91	1927	500,000		0.2 mi long; beach width 200ft		beach restoration
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			RW'94	1927	500,000	Outer LA Harbor			
Cabrillo Beach	San Pedro	Los Angeles, Los Angeles County			Shaw'80	1927	496660	Fillet south of San Gabriel River jetty		migrated E along breakwater into harbor	
Cabrillo Beach	San Pedro	Los Angeles, Los Angeles County			Shaw'80	1948	2866251	Fillet south of San Gabriel River jetty		migrated into harbor and offshore	
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			TC'91	1948	2,536,500		0.4 mi long; beach width 500 ft		beach restoration
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			RW'94	1948	2,900,000	Outer LA Harbor			
Cabrillo Beach	San Pedro	Los Angeles, Los Angeles County			Shaw'80	1963	1202440	Los Angles Harbor, West Basin		stabilized beach at groin	

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE		Section 111, RHA 1968							
USACOE			no effects on endangered species; time to accommodate grunion			CD-057-86	CDP 129-81		
					source: Woodell and Hollar, 1991				
USACOE			severe impacts to least tern nesting			CD-002-98		CD-23-88; CD-31-91; CD-53-92; CD-68-94; CD-88-94; ND-112-94; ND-22-96	
					result of periodic nourishment: "wide beach stabilized by groins and by the King Harbor breakwater (CA-DNOD 1977)."				
USACOE						CD-022-99			
LA County							App. #5-99-232 (PE-LB)		
					1.8 miles of beach; source: Hall 1952				
					source: Hall 1952				
Chevron USA, Inc				3 years required by permit; no report					
					source: Pratt 1984				
					source: Coastal Frontiers Corp. 1992				
		$7,000			source: Hall 1952				
LA County									
					source: USACOE-LA 1959 (So.Cal.)				
USACOE	by mid-1969 30% of fill had migrated N				source: USACOE 1970, Shaw 1980				
	30% lost in year 1; reshaped and terminated successfully	$1,500,000	sand tends to migrate N and S; causes shoaling in King Harbor, Redondo Harbor		sources: Shaw 1980; USACOE-LA 1970; Saville 1981				
		$2,400,000			source: CA-DNOD 1976				
	destroyed, winter 1983	$2,400,000			source: Pipkin 1986; questioned and doubted by Weigel 1994 for lacking original source				
USACOE			exceptionally dense marine fauna			CD-025-91			
city of Los Angeles			beach is 180 ft. wide		from http://beaches.co.la.ca.us/scripts/redondo1.htm				
					source: Flick 1993				
					source: Flick 1993				
	initial losses 1cm/yr				sources: Johnson, 1950; Kenyon, 1950; USACOE 1986 (oral)				
			sand migrated E into harbor						
	migrated E into LA harbor	$100,000			source: Hall 1952; Shaw 1980				
	"sand moved away"				source: USA/CESPL Cabrillo Report, 1989				
	migrated E into LA harbor and offshore	$1,014,600			source: Hall 1952; Shaw 1980				
	"sand moved away"				source: USA/CESPL Cabrillo Report, 1989				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			RW'94	1963	1,200,000	West Basin, LA Harbor	pumped		
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			TC'89	1964	1,300,000		in conjunction with terminal groin built in 1962		R
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			TC'91	1964	1,226,667				navigation
Cabrillo Beach	San Pedro	San Pedro, Los Angeles Co.			RW'94	1991	220,000	Hyperion facility	trucked	coarser than original sand	
Long Beach	San Pedro	Long Beach, Los Angeles Co.			TC'91	1955					harbor construction
Long Beach	San Pedro	Long Beach, Los Angeles Co.			TC'91	1942-43	>6,000,000		~4 mi long		beach widening/ navigation
Long Beach	San Pedro	Long Beach, Los Angeles Co.			TC'91	1945-46	800,000				navigation
Long Beach	San Pedro	Long Beach, Los Angeles Co.			RW'94	1943-46	~6,000,000	Los Angeles River delta	placed along 4 miles from Rainbow Pier east to ~ Belmont Pier		flood control dredging
Long Beach	San Pedro	Long Beach, Los Angeles Co.			RW'94	1945-46	800,000	channel dredged in Alamitos Bay	placed along beach updrift of entrance channel to Bay		
Long Beach City Beach	San Pedro	Long Beach, Orange Co.			Shaw'80	1946	794656	Alamitos Bay Channel			
Long Beach	San Pedro	Long Beach, Los Angeles Co.			TC'89	1946 to 1989	9,000,000 +				R
Long Beach	San Pedro	Long Beach, Los Angeles Co.			TC'91	1975-85	~2,026,670		beach 300-1200 ft wide		navigation
Long Beach	San Pedro	Long Beach, Los Angeles Co.			FC	1996-1998	109,000	Golden Shore Public boat launch	4000 truck trips (placed b/w 1st Pl and 15th Pl.)	90-95% sand = fill; 88.6 - 99.2% sand = site	DR, R
Long Beach (surf zone)	San Pedro	Long Beach, Los Angeles Co.			FC	1999	100-120,000	West Basin, Long Beach Harbor	disposal in surf zone west of Alamitos Bay west jetty		DR, R
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1954	800,000	?			
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1955	400,000	Long Beach Marina excavation			replenishment
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1956	200,000	Outer Anaheim Harbor			replenishment
Seal Beach	San Pedro	Seal Beach, Orange County			TC'91	1958	800,000				
Seal Beach	San Pedro	Seal Beach, Orange County			RW'94	1959	?250,000 or 200,000	San Gabriel River or Navy harbor	placed on SE section of beach bisected by groin		
Seal Beach	San Pedro	Seal Beach, Orange County			Shaw'80	1959	248330	Anaheim Bay			
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1959	225,000	?			replenishment
Seal Beach	San Pedro	Seal Beach, Orange County			SPCA'76	1960					groin and fill
Seal Beach	San Pedro	Seal Beach, Orange County			TC'91	1960	250,000		1.0 mi long		beach erosion control
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1967	70,000	San Gabriel River			replenishment
Seal Beach	San Pedro	Seal Beach, Orange County			TC'91	1968	70,000				
Seal Beach	San Pedro	Seal Beach, Orange County			LAD95	1983	250,000	Anaheim Bay Naval Weapons Station			R
Seal Beach	San Pedro	Seal Beach, Orange County			FC	1983	350,000	Anaheim Bay Naval Weapons Station	dredged via hydraulic suction dredge; discharged into intertidal zone from 16-26" diameter pipeline running from harbor entrance to beach; Sept. '82 - Feb. '83		R, DS, DR
Seal Beach	San Pedro	Seal Beach, Orange County			RW'94	1983	250,000	Anaheim Bay Naval Weapons Station	maintenance dredging		
Seal Beach	San Pedro	Seal Beach, Orange County			P,Y'89	1983	250,000	Anaheim Bay Naval Weapons Station			
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1983	80,000 - 250,000	Anaheim Bay Naval Weapons Station	dredged from Bay approach and placed on East Beach	very fine sand	replenishment
Seal Beach	San Pedro	Seal Beach, Orange County			LAD93-1	1988	110,000	Anaheim Bay Naval Weapons Station	dredged from Outer Bay and placed on East Beach		replenishment
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1945	202,000	Anaheim Bay Naval Weapons Station			R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1945	202,000	Anaheim Bay Naval Weapons Station			R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1945	202,000	Anaheim Bay Anaheim Bay Naval Weapons Station	new harbor construction		
Surfside-Sunset Beach	San Pedro	Huntington Beach, Orange Co.			Shaw'80	1945	201278	Santa Ana River		eroded steadily	
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1945	205,333				
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1947	1,220,000	Anaheim Bay Naval Weapons Station			R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1947	1,220,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1947	1,220,000	Anaheim Bay Anaheim Bay Naval Weapons Station	new harbor construction		
Surfside-Sunset Beach	San Pedro	Huntington Beach, Orange Co.			Shaw'80	1947	1220738	Santa Ana River		eroded steadily	
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1947	1,245,333				
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1956	874,000	Anaheim Bay Naval Weapons Station			R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1956	874,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1956	874,000	Anaheim Bay Anaheim Bay Naval Weapons Station			
Surfside-Sunset Beach	San Pedro	Huntington Beach, Orange Co.			Shaw'80	1956	873076	Santa Ana River		eroded steadily	
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1956	890,667				
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1961			restored beach buffer		emergency
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1964	4,000,000	Anaheim Bay Naval Weapons Station			R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1964	1,315,000	Anaheim Bay Naval Weapons Station			R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD99	1964	4,000,000	Seal Beach Naval Weapons Station	created feeder beach, 500' wide x 9200' long; June		R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1964	4,000,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1964	1,315,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1964	4,000,000	Anaheim Bay Anaheim Bay Naval Weapons Station	construction/channel deepening		
Surfside-Sunset Beach	San Pedro	Huntington Beach, Orange Co.			Shaw'80	1964	3999420	Anaheim Bay	initially expanded 150 m (x ft) in width (2790m/xft long)	migrated south	

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
	"successful" but lost in 82/82 and 1988								
					source: Shaw 1980				
			originally cobble beach; eventually covered by sand; stabilized by groin in 1962		source: Shaw 1980; USACOE-LA 1986 (oral)				
LA County	10,000 yd^3/yr lost								
	1987: beach is 250-300 ft wide				source: Kenyon 1950; Herron 1987				
					source: Kenyon 1950; USACOE-LA 1986 (oral)				
	"relatively stable"								
					source: USACOE 1986				
City of Long Beach						CC-98-96	CDP-96-124	CDP 5-94-103	
City of Long Beach									
USACOE					source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
USACOE					source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
USACOE					source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
					source: USACOE-LA 1980 (Seal Beach)				
USACOE					source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
		$286,000			source: CA-DNOD 1976				
		$286,000			source: USACOE-LA 1980 (Anaheim); CA Dept of Nav and Ocean Dev 1976				
USACOE					source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
					source: USACOE-LA 1980 (Anaheim)				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE			mortality of intertidal invertebrates; temporary increase in turbidity; nourishment timed to avoid grunion spawning			CD-011-82			
USACOE	quickly lost from littoral zone				source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
USACOE					source: USACOE-LAD 1993 Rep. 93-1 Table 5-26				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE									
	steady loss, <2yr				source: Shaw 1980; Marx 1967				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
	steady loss				source: Shaw 1980; Marx 1967				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
	steady loss				source: Shaw 1980; Marx 1967				
					source: Marx 1967; Shaw 1980				
USACOE		Stage 1, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE		Stage 1, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE		Stage 1			source: USACOE-LA 1999 CCSTWS Chapter 4 draft, December				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1964	4,000,000		1.7 mi long; ~450 ft wide feeder beach		beach erosion control
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1971	2,260,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD99	1971	2,300,000	Seal Beach Naval Weapons Station	May		R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1971	2,250,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1971	2,260,000	Anaheim Bay Anaheim Bay Naval Weapons Station			
Surfside-Sunset Beach	San Pedro	Huntington Beach, Orange Co.			Shaw'80	1971	2258496	Anaheim Bay	bypassing?		
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			SPCA'76	1971					replenishment
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1971	2,364,000		1.1 mi long		beach erosion control
Surfside-Sunset Beach	San Pedro	Huntington Beach, Orange Co.			Shaw'80	1978	1489980	offshore			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1979	1,664,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD99	1979	1,600,000	offshore borrow	June: onto feeder beach		DR, R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1979	1,544,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1979	1,644,000	offshore			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1979	1,664,000		1.7 mi long; 500 ft wide		beach erosion control
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			87-10	1982	1,500,000				
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1983	500,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1983	500,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1983	500,000	Anaheim Bay Anaheim Bay Naval Weapons Station			maintenance dredging
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1983	150,000	dredging of Anaheim Bay	discharged into intertidal zone from 16-26" diameter pipeline running from harbor entrance to beach; Sept. '82 - Feb. '83		R, DS, DR
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1984	1,500,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1984	650,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1984	1,500,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			P,Y'89	1984	650,000	Anaheim Bay Naval Weapons Station			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1984	1,500,000	offshore			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1984	650,000	Anaheim Bay Anaheim Bay Naval Weapons Station	construction		
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1984	1,500,000	3 borrow sites offshore of Anaheim Bay and Surfside Beach (155 acres)	hydraulic suction dredge; discharge via 16-26" diameter pipeline on surface of beach into surf zone; Oct. '83 - March '84	sand with 8% fines	N, R, DR
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1985	2,293,000		1.1 mi long; 480 ft wide		beach erosion control
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD99	1985	2,700,000	offshore borrow sites and Anaheim Bay Naval Weapons Station	dredged from offshore and from adjacent approach channel and placed on feeder beach		DR, R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			TC'91	1987					no project
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1988	180,000	Anaheim Bay Naval Weapons Station	maintenance dredging		
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1990	1,300,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1990	522,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD99	1990	1,800,000	offshore borrow			DR, R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1990	1,300,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			RW'94	1990	522,000	offshore borrow			
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD-BNSS	1990	1,826,000		26" cutter head suction dredge, dredged onto beach		DS
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1990	3,000,000	two borrow sites offshore of Anaheim Bay jetties	dredged by hydraulic suction dredge and transported to the beach by floating pipeline; mid-Sept. 1989 - mid-March 1990	slightly contaminated with PCBs and DDT; composite samples average 8% fines	R, DS, DR
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1997	1,600,000	offshore borrow	March-June		N, DS
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD95	1997	1,600,000	offshore borrow	Oct. '96 - March '97; cutterhead dredge in 30-45' H2O offshore of Bolsa Chica Beach; floating pipeline to beach disposal in berm 350-900' wide, 5700' long, +- 13' MLLW	slightly finer than receiver beach	R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			LAD99	1997	1,600,000	offshore borrow	dredged from -30' MLLW		DR, R
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1997			June-July		N
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1998		3 offshore borrow sites covered under CD-36-83	(East Jetty to Phillips St)		N, R, DS, DR
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1999	133,000	Anaheim Bay	pump over jetty, spread on beach using bulldozer		DR, DS
Surfside/Sunset Beach	San Pedro	Huntington Beach, Orange Co.			FC	1999	700,000	approach channel, Anaheim Bay	dredge offshore, then discharge behind training dike placed at ~+12 ft MLLW, return H20 downcoast (East Jetty to Phillips St)		N, R, DS, DR
Huntington Beach (Santa Ana River Project)	San Pedro	Huntington Beach, Orange Co.			FC	1988	1,000,000	Santa Ana River			N, DR

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
	~ half of fill lost in two years downcoast	$2,082,000			source: USACOE-LA 1969; 1986 (report)				
		Stage 4a, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE		Stage 4a			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
		$1,074,000			source: CA-DNOD 1976				
	"has controlled erosion in this area"				source: USACOE-LA 1980(equity study, unpublished); 1986 (report)				
		Stage 7, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE									
	"has controlled erosion in this area"				source: USACOE-LA 1980(Seal Beach); 1986 (report)				
USACOE					source: Corps of Engineers records, A. Fuentes, 1986				
					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE			mortality of intertidal invertebrates; temporary increase in turbidity; nourishment timed to avoid grunion spawning		CD report notes that USACOE replenished sand in '56, '64, '71, '79	CD-011-82			
					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
			offshore impacts minimized by creation of shallow multiple, rather than single, dredge pit		previous nourishments by Corps: 1956, 64, 71, 79	CD-036-83			
	"periodic beach nourishment maintains stability"				source: USACOE-LA 1986 (oral and report); CA Dept of Nav and Ocean Dev 1977 (atlas of erosion and study of nourishment)				
USACOE		Stage 8			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
	required interval: 5-6 years		"stable beach with seasonal variations….sand is eventually transported offshore and south…"		source: Armstrong 1987; Spencer 1987; USACOE-LA 1987(unpublished project summary)				
		Stage 9, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE		Stage 9			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
USACOE		$6.9 mill; $3.78/yd3			M. Change, pers. Communication in report				
USACOE						CD-027-89		CD-11-82; CD-36-83; CD-12-84; CD-40-89; CD-34-90; CD-52-90	
USACOE			single-point discharge to minimize impacts to grunion and least terns.	project extension; placement limited to non-public portion of beach; in addition, turbidity monitoring to determine efficacy of filter system		CD-028-97		ND-58-95; CD-27-89	
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/Newport)				
USACOE		Stage 10			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
USACOE			excavation of settling pond and discharge of sand on public beach with filter fabrics to minimize turbidity	turbidity monitoring; change in project due to unacceptable turbidity in previous design	modification to previously-approved beach replenishment project including relocation of discharge site, modification of discharge method, and extension of time.	CD-067-97		CD-27-89; CD-28-97; ND-58-95; ND-03-97; ND-20-97	
USACOE					project updates timing of CD-36-83; feeder beach area is 1700 ft long			CD-11-82; CD-36-83	
USACOE						CD-065-99		CD-21-88; CD-27-89; CD-52-90; CD-34-90	
USACOE			to minimize grunion impacts: 1) single discharge point; 2) material restricted to feeder beach; 3) no discharge after 3/1/84; 4) discharge behind dike on backbeach		updates/supplements CD-12-82	CD-012-84			
USACOE				COE will monitor turbidity and its effects on least terns in consultation w/ USFWS		CD-029-88		CD-13-81	

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Santa Ana River County Beach	San Pedro	Newport Beach, Orange Co.			LAD99	1997	-140,000	Newport Beach (adjacent)	excavated above MSL and transported downcoast to west Newport and placed above MSL		excavation
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1920					
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1929					
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1919-1930	1,594,540	Newport Harbor	between Newport Pier and Harbor entrance		
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1933-1935	1,895,150	Newport Harbor	46th St. to Newport Pier		
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1933-35	1,933,333				
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1934-1936	5,593,960	Newport Harbor	Newport Pier to Newport Harbor Entrance		
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1934-35	5,706,667				
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1935	3,700,000	Newport Harbor			R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1935	1,900,000	Newport Harbor			R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1935	3,700,000	Newport Harbor			
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1935	1,900,000	Newport Harbor			
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1935	3,700,000	Newport Harbor			
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1935	1,900,000	Newport Harbor			
Newport Beach	San Pedro	Newport Beach, Orange Co.			DS'85	1935	1,900,000	Newport Harbor	placed between Santa Ana River and Newport Pier		
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1965	124,000	Newport (Balboa)	36th - 47th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1965	124,000	Newport (Balboa)	36-47 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1965	124,000	Newport (Balboa)	36-47 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1965	124,000				
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1965-1967	333,285	Newport Harbor	deposited b/w Newport Pier and 50th St.		
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1966	60,000	Newport (Balboa)	36th - 47th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1966	60,000	Newport (Balboa)	36-47 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1966	60,000	Newport (Balboa)	36-47 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1966	60,000				
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1967	150,000	Newport (Balboa)	36th - 47th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1967	150,000	Newport (Balboa)	36-47 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1967	150,000	Newport (Balboa)	36-47 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1967	150,000				
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1968	494,000	Newport (Balboa)	36th - 47th St.s, with steel groins at 40, 44, 48th St.s)		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1968	264,000	Newport (Santa Ana)	40-46th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD99	1968	495,000		February:placed on beach between 32nd, 50th Streets with 258' steel sheetpile groin at 40th St.		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD99	1968	246,000		November: placed on beach between 32nd, 50th Streets with groins at 44th St. (191') and 48th St. (200')		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1968	494,000	Newport (Balboa)	36-47 St.s, with steel groins at 40, 44, 48 Sts		
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1968	264,000	Newport (Santa Ana)	40-46 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1968	494,000	Newport (Balboa)	36-47 St.s, with steel groins at 40, 44, 48 Sts		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1968	254,000	Newport (Balboa)	40-46 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1968	494,046	Newport Beach (adjacent)	placed around groin at 40th St.	upcoast eroded severely; downcoast stable	
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1968	240,488	Newport Harbor	44th St. groin; temporarily widened to 30 to 75 m (x to y ft)		
Newport Beach	San Pedro	Newport Beach, Orange Co.			SPCA'76	1968					2 groins & replenishment
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1968	494,000		"extended beach berm to avg. width of 250 ft"		beach erosion control
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1968	240,000		"beach widened to width of 99-248 ft."		beach erosion control
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1969	750,000	Santa Ana River	40-46th St.s, with rock groins at 36, 48, 52, 56th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD99	1970	874,000	Santa Ana River	February: placed on West Newport Beach between Santa Ana River and 36th St.		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1969	750,000	Santa Ana River	40-46 St.s, with rock groins at 36, 48, 52, 56 Sts		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1969	750,000	Santa Ana River	40-46 St.s, with rock groins at 36, 48, 52, 56 Sts		
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1969-1970	747,604	Santa Ana River	between groins at 36th, 48th, 52nd, 56th Streets; beach widened to 45 to 106 m (x to y ft)		
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1970	124,000	Santa Ana River	31-46th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1970	124,000	Santa Ana River	31-36 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1970	124,000	Santa Ana River	31-36 St.s		
Newport Beach	San Pedro	Newport Beach, Orange Co.			SPCA'76	1970					4 groins & replenishment
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1970	900,000	Santa Ana River	1.6 mi length; 150-360 ft wide		beach erosion control/flood control spoils
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1973	350,000	Santa Ana River	28-48ths Sts., with rock groins at 28, 32, 40, 48th St.s		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD99	1973	358,000		March: added on to existing groins at 40th (480') and 44th (470') Streets with rock; new rubblemound groins at 32nd (540') and 28th (600') Streets. Replenished b/w 32nd, 28th Streets		R
Newport Beach	San Pedro	Newport Beach, Orange Co.			Shaw'80	1973	355,504	Santa Ana River	between groins at 28th and 32nd Streets		
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1973	358,000	Santa Ana River	28-48 St.s, with rock groins at 40, 48, 28, 32 Sts		
Newport Beach	San Pedro	Newport Beach, Orange Co.			P,Y'89	1973	358,000	Santa Ana River	28-48 St.s, with rock groins at 40, 48, 28, 32 Sts		
Newport Beach	San Pedro	Newport Beach, Orange Co.			SPCA'76	1973					3 groins & replenishment
Newport Beach	San Pedro	Newport Beach, Orange Co.			TC'91	1973	358,000				beach erosion control
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1992	1,227,000	Santa Ana River	nearshore deposition		R, nearshore
Newport Beach	San Pedro	Newport Beach, Orange Co.			RW'94	1992	1,300,000	Santa Ana River	dredged from river channel; sieved; placed 300 ft offshore, 20 ft deep water, 3000 ft long mound	fine to medium sand with some rocks	dredging
Newport Beach	San Pedro	Newport Beach, Orange Co.			ACOE95	1992	1,227,000	Santa Ana River	placed in nearshore		

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE		Stage 10			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
	loss of 70,000 cy as of 1936; loss of 40,000 cy as of 1937;				source: Shaw 1980 ; USACOE-LA 1959 (Orange Co.)				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
					source: USACOE-LA 1969				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
					source: USACOE-LA 1969				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
	1965-68: 30 ft./yr avg				source: USACOE-LA 1969				
USACOE		Stage 2, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
USACOE		Stage 2, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
USACOE		Stage 2			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
USACOE		Stage 2			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
		$700,000			source: CA-DNOD 1976				
	upcoast portion: severe erosion	$700,000 (2 groins plus fill)			source: USACOE-LA 1969; Shaw 1980				
					source: USACOE-LA 1969				
USACOE		Stage 3, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
USACOE		Stage 3			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
USACOE		Stage 3, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
		$600,000			source: CA-DNOD 1976				
		$600,000 (4 groins and fill)			source: USACOE-LA 1986 (report); CA Dept of Nav and Ocean Dev 1976; Spencer 1985				
USACOE		Stage 4b & 5, Public Law 87-874 1962			source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				
USACOE		Stage 4b & 5			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
		$1,100,000			source: CA-DNOD 1976				
	beach is stable				source: USACOE-LA 1986 (oral and report)				
USACOE					source: USACOE-LA 1995 (Surfside-Sunset/ Newport)				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD95	1997	140,000	Santa Ana County Beach Park	proposed for '96/'97; transport via trucks from beach source site to disposal site 2000' downcoast. Fill characteristics: +2' to -13' MLLW	same as receiver beach	DR, R
Newport Beach	San Pedro	Newport Beach, Orange Co.			LAD99	1997	140,000	Santa Ana County Beach Park	excavated from above MSL, transported downcoast and placed above MSL		excavation
Corona State Beach	San Pedro	Newport Beach, Orange Co.			ACOE93	1935	?	Newport Bay entrance channel			N
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'91	1928-30	"considerable amount"				upland excavation spoils
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'89	1930					R
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			SPCA'76	1964					groin and fill
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			RW'94	1964	94,000	San Juan Creek	1400' pocket beach created between N training wall of creek and Dana Point Harbor E breakwater		
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'91	1964	94,000		0.3 mi. long; 100-300 ft wide beach		beach erosion control
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			NRC'94	1964	94,104		~1400 ft. long; constructed with sand tight rubblemound jetty to Dana Point Harbor		DS
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			Shaw'80	1964	94104	San Juan Creek	placed upcoast of creek and retained by groin (N training wall)		
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			RW'94	1966	690,000	Camp Pendelton terrace deposits	hauled by truck; placed E from San Juan Creek for ~4500 ft		
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			SPCA'76	1966					replenishment
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'91	1966	840,000		0.9 mi. long; 100-300 ft wide beach		beach erosion control
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			Shaw'80	1966	840401	San Juan Creek	downcoast bank creek	migrated south	
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			Shaw'80	1969	364653	San Juan Creek	upcoast of creek		
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'91	1969	365,000				
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			RW'94	1969	212,000	San Juan Creek flood control restoration dredging			
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'91	1970	128,000				
Doheny State Beach Park	Oceanside	Dana Point City, Orange Co.			TC'91	1970	906,667				
Capistrano Beach Park (nearshore)	Oceanside	Dana Point City, Orange Co.			Shaw'80	1970	125472	Dana Point Harbor	deposited downcoast of harbor as surfing reef		
Capistrano County Beach (nearshore)	Oceanside	Dana Point City, Orange Co.			CDP	1997	35,500	Dana Point Harbor (West Breakwater)		96% sand	DR, N
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'89	occasionally since 1964		SONGS power plant excavation	deposited as hump in 1984		R
San Onofre State Beach South	Oceanside	San Clemente, San Diego County			RW'94	1964	306,000	SONGS power plant excavation	placed SE of SONGS to nourish beach		
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1964	204,000				upland excavation fill
San Onofre State Beach	Oceanside	San Onofre, San Diego Co.			Shaw'80	1964	203892	SONGS bluff excavation	placed south of pipeline		
San Onofre State Beach	Oceanside	San Onofre, San Diego Co.			Shaw'80	1966	254865	SONGS bluff excavation	placed south of pipeline		
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1966	255,000				upland excavation fill
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1967	10,000				upland excavation fill
San Onofre State Beach	Oceanside	San Onofre, San Diego Co.			Shaw'80	1967	10456	SONGS bluff excavation	placed south of pipeline		
San Onofre State Beach	Oceanside	San Onofre, San Diego Co.			Shaw'80	1974	1601075	offshore	placed south of pipeline as nourishment		
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1974	1,605,000				
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1977	220,000				upland excavation fill
San Onofre State Beach	Oceanside	San Onofre, San Diego Co.			Shaw'80	1977	219576	offshore	placed south of pipeline as nourishment		
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1978	46,000				upland excavation fill
San Onofre State Beach	Oceanside	San Onofre, San Diego Co.			Shaw'80	1978	45745	offshore	placed south of pipeline as nourishment		
San Onofre State Beach	Oceanside	San Onofre, San Diego County			RW'94	1977-1980	270,000	offshore	placed SE of SONGS to nourish beach		
San Onofre State Beach	Oceanside	San Onofre, San Diego County			TC'91	1984	-				"laydown pad released"
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1944	1,530,667			contained cobbles	navigation byproduct
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1958	799884	Del Mar Boat Basin and Oceanside Harbor	disposed 6th to 9th St.	lost immediately; migrated North	
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1960	41824	Del Mar Boat Basin and Oceanside Harbor	disposed 6th to 9th St.	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1960	17,500				navigation byproduct
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1960	23,700				navigation byproduct
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1961	482283	Del Mar Boat Basin and Oceanside Harbor	disposed 6th to 9th St.	eroded 2.5 - 6.5 m/yr in width	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1961	222,350				navigation byproduct
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1961	265,333				navigation byproduct
Oceanside Harbor	Oceanside	Oceanside, San Diego County			RF '93	1961	3,921,000	placed on area beaches			DR
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1963	3809905	Del Mar Boat Basin and Oceanside Harbor	9th St.	eroded immediately	contained cobbles
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1963	265,333			cobbles	beach erosion control/ harbor construction
Oceanside City Beach	Oceanside	Oceanside, San Diego County			SPCA'76	1963					groin and replenishment
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1965	111095	Del Mar Boat Basin and Oceanside Harbor	disposed 9th to 3rd St.	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1965	110,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1966	683561	Del Mar Boat Basin and Oceanside Harbor	disposed 3rd to Minn. Ave	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1966	690,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1966	690,000				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1967	177752	Del Mar Boat Basin and Oceanside Harbor	disposed 3rd to Tyson St.	eroded	

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE		proposed Stage 10, Public Law 87-874 1962							
USACOE		Stage 10			source: USACOE-LA 1999 CCSTWS Chapter 4 draft				
USACOE					source: USACOE-LA 1993 "Existing State of the Orange Co. Coast"				
					source: USACOE-LA 1987(Oceanside); Shaw 1980				
					replenished as byproduct of upland excavation operations				
		$247,000			source: CA Dept of Nav and Ocean Dev 1976				
					source: Price, R.C., 1966. Statement of the CA Dept. of Water Resources. Shore and Beach, 34(1):22-32.				
		$247,000 (groin and fill)			source: USACOE-LA 1978 (Doheny); CA Dept of Nav and Ocean Dev 1976; Shaw 1980				
					source: Price, R.C., 1966. Statement of the CA Dept. of Water Resources. Shore and Beach, 34(1):22-32.				
		$713,000			source: CA Dept of Nav and Ocean Dev 1976				
	12/66 and 1/67: groin failed--stream runoff	$713,000			source: USACOE-LA 1978 (Doheny), 1986 (report); CA Dept of Nav and Ocean Dev 1976; Shaw 1980				
					source: USACOE-LA 1987 (Oceanside)				
					source: USA/CESPL and CA/DNOD 1978 inspection tour report				
					source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USACOE-LA 1987 (Oceanside)				
County of Orange			no disposal during grunion spawning; kelp beds and reefs in Doheny Marine Life Refuge	monitoring plan; turbidity must remain less than 20% above natural non-storm conditions (0-50 NTUs) and dissolved O_2 can't drop below 5.0 mg/l	15' depth, 1000' long	5-97-232	FC CC-138-97		
			substantial sand "hump" migrated downcoast, preceded by erosional wave larger in magnitude than hump itself	by Scripps; Grove et al. 1987					
					source: Flick and Wanetick, 1989, SIO Ref. No. 89-20, 51 pp.				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: Flick and Wanetick, 1989, SIO Ref. No. 89-20, 51 pp.				
			"1987: Sand hump migrated ~2m/day. Extremely rapid decay of volume (decreased to 1/2 every 200 days). Migrating hump preceded by erosion wave (8 km long in >2 years)…"		source: USACOE-LA 1987 (Oceanside); Grove et al. 1987				
	"held them for a year or two"				source: USACOE-LA 1986 (oral); 1987 (Oceanside)				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
	eroded				source: USACOE-LA 1987 (Oceanside)				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
	eroded 8-22 ft/yr				source: Shaw 1980				
	all fill lost by 1968				source: USACOE-CERC 1984; Moffat and Nichol 1983; Shaw 1980				
		$1,785,000			source: CA-DNOD 1976				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1967	180,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1967	177,900				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1968	433924	Del Mar Boat Basin and Oceanside Harbor	disposed San Luis Rey to Wisconsin Ave	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1968	430,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1968	433,900				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1969	352890	Del Mar Boat Basin and Oceanside Harbor	disposed San Luis Rey to 3rd St	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1969	350,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1969	353,000				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1971	551554	Del Mar Boat Basin and Oceanside Harbor	disposed 3rd St. to Wisconsin Ave	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1971	550,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1971	551,750				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1973	433924	Del Mar Boat Basin and Oceanside Harbor	disposed Tyson to Hay St	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1973	440,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1975	559396	Del Mar Boat Basin and Oceanside Harbor	disposed Pine to Witherby St.	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1975	560,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1975	559,750				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1976	550247	Del Mar Boat Basin and Oceanside Harbor	disposed Ash to Witherby St.	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1976	550,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1976	550,000				harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1977	320,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego Co.			Shaw'80	1978	318908	Del Mar Boat Basin and Oceanside Harbor	disposed Ash to Witherby St.	eroded	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1978	318,550		February	cobbles	harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1981	460,000	Oceanside Harbor			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1981	400,000	nearshore off Oceanside	placed SE from Harbor on beach		
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1981	463,000		1.5 miles long	not coarse enough	harbor bypassing
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1982	920,000				harbor bypassing/ beach erosion control
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RF '93	1982	1,300,000	San Luis Rey River bed	trucked		R
Oceanside City Beach	Oceanside	Oceanside, San Diego County			CE'99	1986	450,000	Oceanside harbor	placed on beach near Tyson St.		DR, DS
Oceanside City Beach	Oceanside	Oceanside, San Diego County			ACOE'90	1986	350,000	Oceanside harbor	beach fill		DR, DS
Oceanside City Beach	Oceanside	Oceanside, San Diego County			ACOE'90	1988	257,000	Oceanside harbor	beach fill		DR, DS
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'89	1944 (frequently since)		harbor excavation, harbor bypassing			R
Oceanside City Beach	Oceanside	Oceanside, San Diego County			TC'91	1951-58	700,000				nav. byproduct/ beach erosion control
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1962-1963	3,800,000	Oceanside Harbor excavation			
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1965-1981	~5,000,000			sand and riverine cobbles	
Oceanside City Beach	Oceanside	Oceanside, San Diego County			FC	1981 (12 mos)	800,000	San Luis Rey River (Whelan Lake to Murray Rd) (San Luis Rey Flood Control Project)	transported via surface roads, placed using bulldozers, graded, above and below MLLW datum	medium grain size (95% on 200 sieve)	R
Oceanside City Beach	Oceanside	Oceanside, San Diego County			RW'94	1981-1982	923,000	San Luis Rey riverbed	trucked from site 7 miles from coast		
Oceanside City Beach	Oceanside	Oceanside, San Diego County			FC	1983 August to November	450,000	Camp Pendelton/Oceanside Harbor	hydraulic pipeline dredge, pump, discharged in surf zone (Municipal Pier to Forster St.)	silty sand	R, DS, DR
Oceanside City Beach	Oceanside	Oceanside, San Diego County			FC	1984-1989	400,000	sediment bypasses Oceanside Harbor-one beach site and two harbor sites	jet-pumped sand bypassing with underwater slurry pipeline	sand and silt, clean and dirty, light and dark	R, DR
Oceanside City Beach	Oceanside	Oceanside, San Diego County			FC	3/15/90 - 7/30/90; 9/15/92 - 3/15/93; 9/15/94 - 3/15/95; 9/15/96 - 3/15/97	500,000	Oceanside Harbor entrance and navigation channels and sand trap	hydraulic dredge, buried/exposed pipeline (S of Oceanside Public Pier and S of Tyler St.)		DS, DR
Oceanside City Beach	Oceanside	Oceanside, San Diego County			FC	9/15/94 - 3/15/95	400,000	Oceanside Harbor (entrance, navagation channels, sand trap)	hydraulic or hopper dredge (south of Oceanside Pier) (beach or nearshore disposal)		R, DS, DR
Oceanside City Beach	Oceanside	Oceanside, San Diego County			FC	as of 1-11-98	102,000	San Diego Bay main channel (dredge area 1)		sand with munitions	DR, DS, R
Oceanside City Beach	Oceanside	Oceanside, San Diego County				Mar-00		Oceanside Harbor			
Oceanside City Beach*	Oceanside	Oceanside, San Diego County				8/24/01 - 9/23/01	421,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.62 mm	N
North Carlsbad	Oceanside	Carlsbad, San Diego County				7/6/01 - 8/2/01	225,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.14-0.62 mm	N

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded				source: USACOE-LA 1987 (Oceanside); Shaw 1980				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
	eroded 2/78				source: USACOE-LA 1987 (Oceanside) (Coastal Cliff Sediments)				
					source: USA/CESPL, 1987, Oceanside Littoral Cell Preliminary Sediment Budget Report, prepared by Tekmarine, inc, CCSTWS87-4				
					source: Ryan, Joe, personal communications with Weigel				
					source: USACOE-LA 1987 (Oceanside)				
	one season (expected 2-3 seasons)	$4,000,000	bypassing inadequate		source: USACOE-LA 1987 (Oceanside); Spencer 1987; USACOE-CERC 1984; Moffat and Nichol Engineers 1983				
					source: Coastal Environments 1999 Agua Hedionda Lagoon study				
USACOE		lowest cost disp. Alt.							
USACOE		lowest cost disp. Alt.							
					"Each time the fill has eroded, often quite rapidly."				
	total loss +300,000 add'l by 12/59		fill migrated upcoast into nav. Channel		source: USACOE-LA 1960; Shaw 1980				
					source: USACOE-LA 1987 (Oceanside); Shaw 1980				
USACOE		Congressional authorization for <$3,000,000		none		CD-006-81			
					source: Bagley and Whitson, Shore and Beach 1982				
USACOE			dredging: elimination of benthic organisms. DR and N: turbidity; timed after nesting season		3 prior coastal permits for same activity	CD-020-83		CD-6-81; Appeal #218-80	
USACOE		$11,447,000 total estimated cost	50 acres of continual disturbance at dredge pit	COE biological monitoring; sediment at downdrift beaches		CD-003-84			
USACOE			dike disposal if during grunion season	COE will monitor surface water turbidity at dredge & disposal sites to determine effects on sight-feeding birds	post-march disposal allowed due to lack of beach at site; final CCC recommendation unclear in light of objections to 6-year time period	CD-063-89		CD-8-90; CD-3-84; CD-3-89	
USACOE			no disposal after March 15 to minimize impacts to plover, grunion and terns	impacts to plover nesting; Surface Water Turbidity Monitoring Program		CD-053-94		CD-63-89; CD-3-84; CD-20-83; ND-8-90; ND-95-92	
USN		Congressional authorization				CD-009-98		CD-95-95; CD-140-97; CD-161-97	
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+72' Volume Change = +66 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004				
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+105' Volume Change = +33 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1954	4,080,000		1.0 mile long, widened beach 396 ft		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1955	111,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1957	232,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1960	371,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1961	225,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1963	308,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1965	223,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1967	160,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1969	97,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1972	200,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1974	341,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1976	392,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1954	3999420	Agua Hedionda Lagoon	placed from 1060 m upcoast of mouth to 600 m S of outlet; widened beach avg. 30m (x ft)		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1955	111095	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1957	231339	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1960	369881	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1961	224804	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1963	307145	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1965	222190	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1967	159454	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1969	96718	Agua Hedionda Lagoon	placed to south of Lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1972	199971	Agua Hedionda Lagoon	placed to N and S of lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1974	339820	Agua Hedionda Lagoon	placed to N and S of lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1976	390793	Agua Hedionda Lagoon	placed to N and S of lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego Co.			Shaw'80	1979	418240	Agua Hedionda Lagoon	placed to N and S of lagoon outlet		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1979	419,000				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'91	1979	430,667				
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			TC'89	frequently since 1944		Agua Hedionda Lagoon			R
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1954	~4,000,000	Agua Hedionda Lagoon	excavated for San Diego G&E Co. plant; placed from 3500 ft N of lagoon entrance jetties to 2000 ft S of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1955	110,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1957	230,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1960	370,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1961	225,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1963	307,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1965	222,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1967	159,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1969	97,000	Agua Hedionda Lagoon	pumped as slurry into surf zone; placed downdrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1972	200,000	Agua Hedionda Lagoon	pumped as slurry; placed downdrift and updrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1974	340,000	Agua Hedionda Lagoon	pumped as slurry; placed downdrift and updrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1976	391,000	Agua Hedionda Lagoon	pumped as slurry; placed downdrift and updrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1979	418,000	Agua Hedionda Lagoon	pumped as slurry; placed downdrift and updrift of discharge jetties		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1981	235,000	Agua Hedionda Lagoon	pumped as slurry		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1983	222,000	Agua Hedionda Lagoon	pumped as slurry		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1985	404,000	Agua Hedionda Lagoon	pumped as slurry		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1988	347,000	Agua Hedionda Lagoon	pumped as slurry into surf zone S of discharge jetties; also pumped behind dikes along beach		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1991	489,000	Agua Hedionda Lagoon			
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1992	126,000	Agua Hedionda Lagoon			
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			RW'94	1993	115,000	Agua Hedionda Lagoon			
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	Apr-91	459,000	Agua Hedionda Lagoon	placed on Middle and South Beaches		DR,DS
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	Feb.-Apr. 1991	115,395	Agua Hedionda Lagoon	placed on Middle beach (600-900 yd length)		DR,DS
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	Feb.-Apr. 1988	347,782	Agua Hedionda Lagoon?	placed on North, Middle and South Beaches		DR,DS
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	Apr-92	125,976	Agua Hedionda Lagoon?	placed on North Beach		DR,DS
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	1994	158,996	Agua Hedionda Lagoon?	placed on North, Middle and South Beaches		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	1996	443,130	Agua Hedionda Lagoon?	placed on North, Middle and South Beaches		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	1997	197,342	Agua Hedionda Lagoon?	placed on Middle Beach		
Carlsbad State Beach Park	Oceanside	Carlsbad, San Diego County			CE'99	1998	273,581	Agua Hedionda Lagoon?	placed on Middle and South Beaches		
Agua Hedionda Lagoon	Oceanside	Carlsbad, San Diego County			RF '93	1954	3,921,000	placed on area beaches			DR
South Carlsbad	Oceanside	Carlsbad, San Diego County				6/25/01 - 7/6/01	158,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.62 mm	N

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
		$2,500,000 dredging and jetty construction	"spoil immediately moved out into the surf zone.."		source: Shaw 1980; USACOE-LA 1987 (Oceanside) (Cliff Sediments)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Cliff Sediments)				
					source: USACOE-LA 1987 (Cliff Sediments)				
					source: USACOE-LA 1987 (Cliff Sediments)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
					source: USACOE-LA 1987 (Oceanside)				
			"Storm waves and high tides eroded beach and removed all sand south of Encina Power Plant, Carlsbad"		source: USACOE-LA 1987 (Oceanside) (Cliff Sediments)				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1980				
					source: Shaw 1981				
					source: Shaw 1982				
					source: Shaw 1983				
					source: Shaw 1984				
	>18 months				source: Coastal Environments 1999 Agua Hedionda Lagoon study				
	<6 months				source: Coastal Environments 1999 Agua Hedionda Lagoon study				
	<6 months				source: Coastal Environments 1999 Agua Hedionda Lagoon study				
	0-6 months				source: Coastal Environments 1999 Agua Hedionda Lagoon study				
					source: Coastal Environments 1999 Agua Hedionda Lagoon study				
					source: Coastal Environments 1999 Agua Hedionda Lagoon study				
					source: Coastal Environments 1999 Agua Hedionda Lagoon study				
					source: Coastal Environments 1999 Agua Hedionda Lagoon study				
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+31' Volume Change = -6 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004				

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Batiquitos	Oceanside	Leucadia, San Diego County				8/16/01 - 8/23/01	117,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.62 mm	N
Leucadia	Oceanside	Leucadia, San Diego County				6/4/01 - 6/15/01	132,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.62 mm	N
Moonlight Beach	Oceanside	Encinitas, San Diego County				8/10/01 - 8/16/01	105,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.34-0.62 mm	N
Cardiff	Oceanside	Cardiff-by-the-Sea, San Diego County				8/2/01 - 8/10/01	101,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.34 mm	N
Fletcher Cove	Oceanside	Solana Beach, San Diego County				6/15/01 - 6/24/01	146,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.14 mm	N
Del Mar	Oceanside	San Diego Co.			FC	as of 1-11-98	170,000	San Diego Bay main channel (dredge area 1)		sand with munitions	DR, DS, R
Del Mar	Oceanside	Del Mar, San Diego County				4/27/01 - 5/10/01	183,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.14 mm	N
Torrey Pines	Oceanside	Del Mar, San Diego County				4/6/01 - 4/27/01	245,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.14 mm	N
Pacific Beach	Mission Bay	Pacific Beach, San Diego Co.			TC'91	1948	613,333		beach widened 300 ft max		beach restoration
Pacific Beach	Mission Bay	Pacific Beach, San Diego Co.			RW'94	1948	~600,000	Mission Bay	placed North of North Jetty		
Pacific Beach	Mission Bay	Pacific Beach, San Diego Co.			Shaw'80	1948	601,220	Mission Bay	widened beach max. 91 m (x ft)	migrated south; lost by 1957	
Pacific Beach	Mission Bay	Pacific Beach, San Diego Co.			TC'91	1973	306,667				
Pacific Beach	Mission Bay	Pacific Beach, San Diego Co.			RW'94	1973	300,000	Mision Bay entrance			
Pacific Beach	Mission Bay	Pacific Beach, San Diego Co.			Shaw'80	1973	300,610	Mission Bay		migrated south	
Mission Beach	Mission Bay	Mission Beach, San Diego Co.			TC'91	1948	~600,000	Mission Bay	beach widened ~300 ft		DR, R
Mission Beach	Mission Bay	Mission Beach, San Diego Co.			RW'94	1958	150,000	Mission Bay			DR, R
Mission Beach	Mission Bay	Mission Beach, San Diego Co.			FC	October '83 to January '84	490,000	Mission Bay Harbor	cutter-head hydraulic suction or hopper dredge, discharged onto beachface from 16-26" surface pipeline (from N Jetty to Crystal Pier)	fine sand and silty sand	R, DS, DR
Mission Beach	Mission Bay	Mission Beach, San Diego Co.			RW'94	1984	246,000	Mission Bay entrance	placed N of jetties		R, DS, DR
Mission Beach	Mission Bay	Mission Beach, San Diego Co.			FC	as of 1-11-98	12,000	San Diego Bay main channel (dredge area 1)	(nearshore)	sand with munitions	DR, DS, R
Mission Beach	Mission Bay	Mission Beach, San Diego Co.				5/10/01 - 5/21/01	151,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.52 mm	N
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			RW'94	1950	67,000	Mission Bay			DR, DS, R
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			Shaw'80	1950	66,657	Mission Bay	Newport Ave. to Saratoga Ave.; widened beach max. 45 m (x ft)	migrated north; lost in 6 months	
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			SPCA'76	1955					groin and fill
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			RW'94	1955	275,000	Mission Bay entrance	1700 ft long beach		
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			Shaw'80	1955	274,470	Mission Bay	Niagara Ave. to Cape May Ave.; widened beach max. 109 m (x ft)	some migrated north; remainder stable	
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			87-10	1959	275,000		contained at N end by groin		
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			RW'94	1984	30,000	Mission Bay entrance	placed S of groin		
Ocean Beach	Mission Bay	Ocean Beach, San Diego Co.			FC	October '83 to January '84	50,000	Mission Bay Harbor	cutter-head hydraulic suction or hopper dredge, discharged onto beachface from 16-26" surface pipeline (from S Jetty to S Groin)	fine sand and silty sand	R, DS, DR
North Island Oceanside Beach	Silver Strand	Coronado, San Diego County			RW'94	1941	2,200,000	San Diego Bay			
North Island Oceanside Beach	Silver Strand	Imperial Beach, San Diego Co.			Shaw'80	1940-1941	2248040	San Diego Harbor	temporarily widened beach max. 272 m (x ft)		
Coronado City Beach	Silver Strand	Coronado, San Diego County			FC	July-December '85	1,100,000	offshore borrow site ~1500' offshore, 1 mi. downcoast of Amphibious base, 20-40' below MLLW	cutterhead hydraulic dredge, pumped through submerged pipeline to beach	sand	R, DR
Coronado Shores Beach	Silver Strand	Imperial Beach, San Diego Co.			Shaw'80	1946	26009300	San Diego Harbor	widened beach max. 333 m (x ft)	retreated back 152 m (199 ft) by 1958	
Gator Beach	Silver Strand	Coronado, San Diego County			RW'94	1977	1,100,000	San Diego Bay			
Gator Beach	Silver Strand	Coronado, San Diego County			RW'94	1985	1,100,000	San Diego Bay			

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+55' Volume Change = -5 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+28' Volume Change = +26 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+103' Volume Change = -27 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+97' Volume Change = +54 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+48' Volume Change = +10 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
USN		Congressional authorization				CD-009-98		CD-95-95; CD-140-97; CD-161-97
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+96' Volume Change = +11 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+73' Volume Change = +17 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
	by '57, returned to '40 width				source: Shaw 1980			
	fill moved south				source: Shaw 1980			
			sand migrated south to Mission beach					
USACOE	returned to '40 position by 1960		beachfill transported S; by 1958 shoreline had returned to 1948 position; shoreline retreated 200 ft. in reach S of Crystal Pier		source: USACOE-LAD 1960, 1964, 1987 (Cliff Sediments)			
USACOE					source: USACOE-LAD 1964			
USACOE			"Turbidity during dredging and disposal operations will reduce dissolved oxygen concentration in the water column and may temporarily clog respiratory and feeding mechanisms of fish and benthic animals."		suspended sediment levels w/ discharge flow regulated through use of weir system	CD-032-83		
USACOE	moved N after placement near amusement park				source: Castens, Corps of Eng. Records, per. Comm. (see CCSTWS 87-10)			
USN		Congressional authorization				CD-009-98		CD-95-95; CD-140-97; CD-161-97
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+91' Volume Change = +41 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004			
USACOE				migrated N, filled in mouth of San Diego River	source: Walker and Brodeur, 1993; USACE-LAD, 1970			
		$161,000			source: CA-DNOD 1976			
USACOE					source: USACE-LAD 1970			
USACOE			"Turbidity during dredging and disposal operations will reduce dissolved oxygen concentration in the water column and may temporarily clog respiratory and feeding mechanisms of fish and benthic animals."		suspended sediment levels w/ discharge flow regulated through use of weir system	CD-032-83		
					source: Shaw 1980; Walker and Brodeur, 1993			
USACOE			scheduled to avoid grunion spawning and least tern nesting	post-construction monitoring at borrow site for recolonization and sand movement into pit	receiver beach is ~3300' long;	CD-003-85		
					source: Shaw 1980; Walker and Brodeur, 1993			
					source: Shaw 1980; Walker and Brodeur, 1993			

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity
Gator Beach	Silver Strand	Coronado, San Diego County			FC	September 1986 to March 15, 1987	294,000	San Diego Bay, main channel, including Naval station piers	hopper dredge for main channel dredging (source of nourishment sediment), clamshell dredge for pier dredging; submerged and floating pipeline transport to pre-existing pipeline under Silver Strand Peninsula		N, R, DS, DR
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'89	b/w 1936 and 1946	40,000,000	San Diego Bay	dredging of Bay		R
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1940-41	2,260,000		1.0 mi long; "temporary maximum shoreline advance of 898 ft"		navigation byproduct/ recreational beach
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1941-46	26,200,000		2.0 mi long; advanced shoreline seaward >985 ft		navigational byproduct
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1936	14,000,000				navigation byproduct
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1944					
Silver Strand State Beach Park	Silver Strand	Coronado, San Diego County			RW'94	1946	26,000,000	San Diego Bay	2 mile long beach		
Silver Strand State Beach Park	Silver Strand	Coronado, San Diego County			RW'94	1967	40,000	San Diego Bay			
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1967	40,000				
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			Shaw'80	1967	41,824	San Diego Harbor		net migration to North	
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			Shaw'80	1976	3,467,471	San Diego Harbor		net migration to North	
Silver Strand State Beach Park	Silver Strand	Coronado, San Diego County			RW'94	1976	1,000,000	San Diego Bay			
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1976	3,500,000		2.0 mi long		
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1985	1,100,000		0.7 mi long		
Silver Strand State Beach Park	Silver Strand	Coronado, San Diego County			RW'94	1988	148,000	San Diego bay outer entrance Channel	placed in nearshore as submerged mound, 1200 ft. long, 600 ft. wide, ~7 ft high	fill median = 0.20 mm; native median = 0.25 mm	
Silver Strand State Beach Park	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1988	~1,000,000		"placed offshore in 25 ft water depth"		navigation byproduct
Silver Strand State Beach (nearshore disposal)	Silver Strand	Imperial Beach, San Diego Co.			DRP-1-01	1988-1989	190,000	San Diego bay outer entrance Channel	split-hull dredge disposal in nearshore; 1200 ft long, 600 ft wide from 800 to 1400 ft offshore (-10 to -30' MLLW)	med. 0.18 mm, <12% at No. 200 sieve	DR, DS
Silver Strand State Beach (nearshore disposal)	Silver Strand	Imperial Beach, San Diego Co.			FC	Feb-96	400,000	San Diego Bay (entrance and navigation channels)	Hopper dredge "Essayons"; nearshore disposal	92.4% sand or larger particles; low in total organic carbon	R, DS, DR
Silver Strand State Beach (nearshore disposal)	Silver Strand	Imperial Beach, San Diego Co.			FC	1987	450,000		ESSAYONS hopper dredge, then deposition in -35 to -40 MLLW offshore of Silver Strand Beach		R, DS, DR
Delta Beach (north side, ocean)	Silver Strand	Coronado, San Diego County			FC	1995	-60,000	disposal on bay side of Delta Beach	transport via truck		DR
Delta Beach (south side, bay)	Silver Strand	Coronado, San Diego County			FC	1995	60,000	ocean side of Delta beach	transport via truck		N
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			RW'94	1977	1,100,000				
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1977	1,100,000		1.0 mi long; ~150 ft wide		
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			Shaw'80	1977	999855	San Diego Harbor		net migration to North	
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			TC'91	1979	1,000,000			fill contained foreign matter	
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			TC'89	1977, 1979	2,100,000				R
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			FC	late 1984?	7,300	Tijuana slough and estuary	dragline and bulldozer dredging; placement on beach above MHW, leveling to grade	storm-deposited sands; no mud	DR
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			FC	1994	51,000	Ballast Point, Point Loma Peninsula, San Diego	nearshore disposal	97% sand	R, DS, DR
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			FC	1994	240,000	San Diego Bay, Naval Station, Pier 2	disposal in nearshore (>10' MLLW)	predominantly sandy	R, DS, DR
Imperial Beach	Silver Strand	Imperial Beach, San Diego Co.			RW '94	1994	<240,000	San Diego Bay, Naval Station, Pier 3		sandy portion of dredge spoils	R
Imperial Beach	Silver Strand	Imperial Beach, San Diego County				5/22/01 - 6/04/01	120,000	Offshore	Trailing suction hopper dredge	Median grain size of fill = 0.24-0.52 mm	N
Tijuana River National Estuary	Silver Strand	Imperial Beach, San Diego			FC	winter 96	?	connector channel between the Oneonta Slough and existing tidal lagoons	hydraulic cutterhead dredge for excavation; pipeline transport to surf zone; front end loader	65-75% sand	DS, DR

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
USACOE			scheduled around least tern nesting		Gator Beach selected b/c: 1) extant underground pipeline; 2) extant nourishment project in the area; 3) eroding condition 4) extant archeological and biological surveys BUT Gator Beach off-limits to public for military reasons	CD-033-85			
	eventually migrated N				source: Moffat and Nichol, Engineers 1987; Shaw 1980				
			"After 1960, shoreline behaved approximately as it had before 1933. Indicates the beachfill-forced shoreline adjusted to a dynamic equilibrium platform b/w 1954 and 1960."		source: Moffat and Nichol, Engineers 1987; Shaw 1980; Inman 1976; Converse 1982				
		$1,260,000			source: USACOE-LA 1986 (oral)				
					source: Inman 1976				
					source: Shaw 1980; Walker and Brodeur, 1993				
					source: Shaw 1980; Walker and Brodeur, 1993				
			"Net migration to N. Ultimately impounded by Zuniga Jetty or swept offshore to depths of 495-990 ft by ebb currents."		source: Moffat and Nichol, Engineers 1987; Shaw 1980				
					source: Shaw 1980; Walker and Brodeur, 1993				
			"1987: Since 1978, the beach has eroded and the buildings constructed on the 1941-1976 fill can be completely surrounded by the sea during even small storm events."		source: Moffat and Nichol, Engineers 1987				
					source: Moffat and Nichol, Engineers 1987				
	sand moved shoreward								
			"Since 1941, most of the fill has remained in the system. Appears 20-30% moved offshore because too fine to remain in dynamic equilibrium on shoreface. Somewhat <40% of the beachfill that was reworked was lost offshore."		source: Moffat and Nichol, Engineers 1987; Surfrider Foundation, 1987/88				
USACOE	migrated on and downshore				source: DRP-1-01, August 1990, "Construction and Monitoring of Nearshore Placement of Dredged Material at Silver Strand State…"				
USACOE						CD-071-95		CD-53-87; CD-3-87; CD-91-93	
USACOE			increased turbidity, loss of O2, loss of benthics, impacts to least tern, grunion, kelp; dredging activity modified to prevent turbidity in upper 1/3 of H2O column			CD-053-87			
USN						CD-128-95			
USN			to protect nesting tern colonies		to improve least tern nesting habitat; loss of sand from ocean-side littoral system to be offset by homeporting dredge spoils	CD-128-95			
	50% lost by 6/1978				source: Van Deerlin 1978; Shaw 1980; USACOE-LA 1983; Moffat and Nichol 1987				
			"demonstrated winnowing will clean sand." 1986: "Groins have not worked very well because of fine nature of sand."		source: USACOE-CERC 1984; Converse 1982; USACOE-LA 1986 (oral)				
			migrated to N		sources: Shaw 1980, Converse 1982, USACOE 1984, 198				
USFWS			work scheduled to avoid impacts to: light-footed clapper rails, CA least terns, Western snowy plovers; sited to avoid impacts to salt-marsh birds-beak			CD-041-84			
US Coast Guard			kelp beds avoided during disposal; pre-disposal survey w/ NMFS and demarcation of kelp area; nearshore disposal minimizes impacts to grunions			CD-026-94		CD-91-93	
USN			kelp beds	kelp bed monitoring		CD-091-93			
SANDAG	Indicator Transect (2003): MSL Shoreline Change =+137' Volume Change = +52 cy/ft			Part of annual Regional Beach Monitoring Program of SANDAG Regional Beach Sand Project.	source: CFC, 2004				
CA Coastal Conservancy			disposal during rainy season, during outgoing tides to simulate natural high turbidity situations			CC-054-96			
						R=REPLENISHMENT			
						DS=DISPOSAL			
						N=NOURISHMENT			
						DR=DREDGING			
						B=BYPASSING			
						M=MAINTENANCE			
						TC=TonyaClayton			
						SPCA=ShoreProtectionInCalifornia-DNOD1976			
						RF=RonFlick-S&B'93			
						RW=RobertWeigel-S&B'94			
						CE=Coastal Environments 1999 Agua Hedionda Lagoon Study			
						NRC=National Research Council Beach Nourishment and Protection			
						ACOE=US ACOE 1990 Beach and Nearshore Placement of Material Dredged from Federally authorized navigation projects			
						P,Y'89=Patterson and Young, Coastal Zone '89			

Site	Cell	City/County	Latitude	Longitude	Database	Date of project	Dredge/Fill Volume (yd^3)	Fill Source/Site	Dredge/Transport Method	Dredge/Fill Characteristics	Activity

Applicant/Sponsor	Duration of Fill/Performance	Funding	Environmental Effects	Monitoring	Notes	Ref. ID	Permit/FC Ref.	See Also	
						LHW'94=Leidersdorf, Hollar and Woodell, Shore and Beach 1994			
						Shaw'80=Martha Shaw 1980 Scripps Report			
						LAD95=ACOE LA District Surfside-Sunset/West Newport Beach Nourishment Project, Orange Co., CA; May 1995			
						DS'85=Donald Spencer, The Newport Beach Groin Field, Orange Co CA, in CA's Battered Coast, 1985			
						87-10=US ACOE 1987 CCSTWS 87-10 Shoreline Movement Investigations Report			
						LAD93-1=ACOE LA District CCSTWS Final Report 93-1			
						LAD-BNSS=Beach Nourishment Sediment Sources: Previous Studies and results from vibracoring field program, Orange Co. CA, Final Report, 1993			
						LAD99=ACOE LA District CCSTWS Chapter 4 Draft Report December 1999			

TABLE 3 - List of References to Accompany Table 2 (Beach Nourishment Projects in California)

have?	Authors	Year	Title	Journal	Vol.:No.	pages	topics	subtopic	locator code	sponsor	notes
yes	Nelson, Ross	1998	Beachfront Management on the Isle of Palms, Soutl	Coastal Managemen	26	315-325					
yes	-	1998	California's Coastal Natural Hazards	proceedings from the conference hosted by the CA Shore and Beach Preservation Association and the University of Southern CA Sea Grant Program, November 12-14, 1997, Santa Barbara	USCSG-TR-01-98	162 p.			Call numbers: UCB WRCA G4096 N8-	Lesley Ewing and Douglas Sherman, eds.	
yes	Li, R.; Cho, W.K.; Ramcharan, E.; Kjerfve, B.; and Willis, D.	1998	A Coastal GIS for shoreline monitoring and management--case study in Malasia	Surveying and Land Information Systems	58:3	157-166					
yes	Finkl, Charles W.	1996	What might happen to America's shorelines if artificial beach replenishment is curtailed: A prognosis for southeastern Florida and other sandy regions alon	Journal of Coastal Research	12:1	iii-ix					
yes	San Diego Association of Governments	1995	Shoreline preservation strategy for the San Diego regio	Shore & Beach	63:02	p. 17-30.			UCB WRCA 25.9 W; UCB Engin TC330.A1		
yes	Walker, J. R.; Brodeur, S. M.	1993	The CA Beach Nourishment Success Story	Beach Preservation Technology: 6th National Conference proceedings; Feb. 1993, St Petersburg FL		pp. 239-258.				FSBPA	
yes	Pilkey, Orrin H.	1990	A time to look back at beach replenishmer	Journal of Coastal Researcl	6:1	iii-vii					
yes	Pompe, Jeffrey J.; Rinehart, James R.	1999	Establishing Fees for Beach Protection: Paying for a Public Good	Coastal Management	27	57-67					
yes	Griggs, Gary B.	1999	The Protection of California's Coast: Past, Present and Future	Shore & Beach	67:1	18-28					
yes	Jones, Christopher P.; Hernandez, Debra L.; Eiser, William C.	1998	Lucas vs. South Carolina Coastal Council, Revisited	Annual Conference of the Assn. Of State Floodplain Managers	5/20/1998	9 pp.	policy	takings law/ Lucas			
yes	Hansch, Susan; Locklin, Linda; Willis, Cope; Ewing, Lesley	1998	Coastal Impacts of the 1997-98 El Nino and Predictions for La Nina	California Coastal Commission Memo	Tu-11		coastal erosion	CA/El Nino			
yes	Dobkowski, Aleksandra H.	1998	Dumptrucks versus Dredges: An Economic Analysis of Sand Sources for Beach Nourishmen	Coastal Management	26	303-314					
yes	Elwany, Hany; Flick, Reinhard; Reitzel, John; Lindquist, Anne-Lise; Deysher, Larry	1998	Possible Impacts of the Southern California Edison Kelp Reef off San Clemente on the Marine Environment	in Final Program Environmental Impact Report for the Construction and Management of an artificial reef in the Pacific Ocean near San Clemente, CA	Vol. II; 1999	32 p.			John Dixon personal library		
yes	Cialone, Mary A.; Stauble, Donald K	1998	Historical findings on ebb shoal minin	Journal of Coastal Researcl	14:02	537-563	beach nourishmen	dredging			
yes	Douglas, Bruce C.; Crowell, Mark; Leatherman, Stephen P.	1998	Considerations for Shoreline Position Prediction	Journal of Coastal Research	14:03	1025-1033	shoreline change	analysis			
yes	Makaske, Bart; Augustinus, Pieter G.E.F.	1998	Morphologic changes of a micro-tidal, low wave energy beach face during a spring-neap tide cycle, Rhone-Delta	Journal of Coastal Research	14:02	632-645	shoreline change	morphology			
yes	Masselink, Gerhard; Pattiaratchi, Charitha	1998	Morphodynamic Impact of Sea Breeze Activity on a beach with beach cusp morpholog	Journal of Coastal Research	14:02	393-406	shoreline change	morphology			
yes	Tanner, William F.	1998	Red Flags on the Beach	Journal of Coastal Researcl	14:02	iii-vi	beach concepts	analysis			
yes	Trembanis, Arthur C.; Pilkey, Orrin H.	1998	Summary of Beach nourishment along the US Gulf of Mexico Shoreline	Journal of Coastal Research	14:02	407-417	beach nourishment	US			
yes	Tait, James F.; Revenaugh, Justin	1998	Source-Transport Inversion: An application of geophysical inverse theory to sediment transport in Monterey Bay, C	Journal of Geophysical Research	103:C1	1275-1283					
yes	Kraus, Nicholas C; Larson, Magnus	1998	Numerical Simulation of beach-profile change accounting for hard-bottom features	Rethinking the role of structures in shore protection: proceedings of the 11th conference on beach preservation technolog	2/4-6/98	123-138				FSBPA	
yes	anonymous	1998	California's Beaches: Out to Sea	The Economist	6/20/1998	p. 34	beach loss	CA			
yes	Bixler, Mike; Sachs, Steve; Kramer, Ann	1997	Governing a river of sand--developing policies, plans and programs to manage the San Diego Region's beache	California and the World Ocean '97	2	1490-1493	policy	CZM			conference proceedings, San Diego
yes	Coleman, Howard D.	1997	The coastal boundary line in California: from certainty to chaos	California and the World Ocean '97	2	1152-1161	policy	morphology			conference proceedings, San Diego
yes	Ewing, Lesley	1997	Beach nourishment in the 21st Centur	California and the World Ocean '97	2	1366-1373	beach nourishmen	policy			conference proceedings, San Diego
yes	Flick, Reinhard E.; Elwany, M. Hany S	1997	Tide and beach fluctuations and the mean high water lir	California and the World Ocean '97	2	943-949	shoreline change	morphology			conference proceedings, San Diego
yes	Gadd, Peter E.	1997	Limitations of "Averaging" coastal survey data in the determination of coastal boundarie	California and the World Ocean '97	2	966-973	shoreline change/policy	morphology			conference proceedings, San Diego
yes	Griggs, Gary B.	1997	The armoring of California's Coas	California and the World Ocean '97	1	515-526	beach concepts	CA			conference proceedings, San Diego
yes	Inman, Douglas L.; Jenkins, Scott A.	1997	Changing wave climate and littoral drift along the California Coast	California and the World Ocean '97	1	538-549	beach concepts	CA			conference proceedings, San Diego
yes	Moore, Laura J.; Griggs, Gary B.	1997	Measuring Shoreline Erosion Rates: Strategy, Techniques and accuracy	California and the World Ocean '97	1	719-730	shoreline change	analysis			conference proceedings, San Diego
yes	Patterson, Jamee Jordan	1997	Public Beach or Private backyard: a case study of Del Mar Beach and how the sand was divided u	California and the World Ocean '97	2	950-957	policy	sand rights			conference proceedings, San Diego
yes	Seymour, Richard J.	1997	Implications for CA of the Marine Board Study on beach nourishment and shoreline protectio	California and the World Ocean '97	2	1361-1365	beach nourishment	policy			conference proceedings, San Diego
yes	Sherman, Douglas J	1997	Human Impacts on California's Coastal Sediment Supp	California and the World Ocean '97	1	550-560	beach concepts	CA			conference proceedings, San Diego
yes	Uzes, F.D. Bud	1997	Locating the landward limit of the MHWI	California and the World Ocean '97	2	958-965	shoreline change	morphology			conference proceedings, San Diego
yes	Washburn, Edgar B.; Flushman, Bruce S	1997	Private and Public rights in the beach and shore ir	California and the World Ocean '97	2	1162-1173	policy	sand rights			conference proceedings, San Diego
yes	Benumof, Benjamin T.; Griggs, Gary B.; Moore, Laura J.	1997	Coastal Erosion: the state of the problem and the problem of the state	California and the World Ocean '97: conference proceedings	1	505-514	coastal erosion	CA			conference proceedings, San Diego
yes	Tibbetts, John	1997	Armoring the Coast: Beachfront Battles over seawal	Coastal Heritage	Fall	3 to 12	beach loss	US			
yes	Amin, S.M.N.; Davidson-Arnott, Robin G.D.	1997	A statistical analysis of the controls on shoreline erosion rates, Lake Ontario	Journal of Coastal Research	13:04	1093-1101	shoreline change	analysis			
yes	Pope, Joan	1997	Responding to coastal erosion and flooding damage	Journal of Coastal Researcl	13:03	704-710	policy	CZM			
yes	Ackerman, Jennifer	1997	Islands at the edge	National Geographic	August	2 to 31	beach loss	US			
yes	Creed, Christopher G.; Bodge, Kevin R.; Suter, Carrie L.	1997	Construction Slopes for Beach Nourishment Projects	New Insights into Beach Preservation: proceedin from the 10th conference on Beach Preservation Technology	1/22-24/97	44-58					
yes	Fitch, Eric J.	1997	Organizational Structure of State and Federal Coastal Zone Management: Impacts on Public Trust Protection	New Insights into Beach Preservation: proceedin from the 10th conference on Beach Preservation Technology	1/22-24/97	278-289					
yes	Keehn, Stephen; Campbell, Thomas J.	1997	The renourishment planning and design process for Captiva Island, Florida	New Insights into Beach Preservation: proceedin from the 10th conference on Beach Preservation Technology	1/22-24/97	75-89					
yes	Kraus, Nicholas C.	1997	Distinguishing cross-shore and longshore processes in shoreline change evaluation	New Insights into Beach Preservation: proceedin from the 10th conference on Beach Preservation Technology	1/22-24/97	135-150					
yes	Zheng, Jie; Dean, Robert G.	1997	Shoreline and Dune Recession Variability and Cross-Shore Modeling	New Insights into Beach Preservation: proceedin from the 10th conference on Beach Preservation Technology	1/22-24/97	151-166					
yes	Everts, Craig H.	1997	Seizing the opportunity for CA sand managemer	Newsbreaker, newsletter of the CSBPA	March	2 pp.	policy	CZM			
yes	Novarro, Len	1997	Turning the Tide	San Diego Home/Garden lifestyle	Dec-97	12-20, 103	beach loss	CA			
yes	Brandon, Karen	1997	Swap for sand spotlights beach crisis	San Francisco Examine	10/29/1997	A-10	beach loss	CA			
yes	Griggs, Gary B.; Scholar, Deirdre	1997	Coastal Erosion caused by earthquake-induced slope	Shore & Beach	65:04	2 to 7	coastal erosion	CA			
yes	Komar, Paul D.	1997	Erosion of a massive artificial "landslide" on the California coast	Shore & Beach	65:04	8 to 14	coastal erosion	CA			
yes	Rinehart, James R.; Pompe, Jeffrey J	1996	Footing the bill for beach nourishmer	B&E Review	April/June	14-17	beach nourishmen	policy			
yes	Bay, John; Bay, Maile	1996	Reducing Hazards in shoreline areas: Policy and legal options	Coastal Acquisition Project, Phase II report	November	15 pp.	policy	CZM			
yes	Gaffney, Douglas A.; Kelly, Wilden A	1996	Under the Boardwalk: A Shore-Protection Plan Emerge	Geo Info Systems	6:10	22-29					
yes	Cleary, W.J.; Riggs, S.R.; Marcy, D.C.; Snyder, S.W.	1996	The influence of inherited geological framework upon a hardbottom-dominated shoreface on a high-energy shelf: Onslow Bay, NC, USA	Geology of Siliciclastic Shelf Seas	No. 117	249-266				Geological Society Special Publication, ed. De Batist, M. & Jacobs, P.	
yes	Kraus, Nicholas C.; McDougal, William G.	1996	The Effects of seawalls on the beach: Part I, an updated literature review	Journal of Coastal Research	12:03	691-701	beach loss	morphology			
yes	Finkl, Charles W.	1996	Beach fill from recycled glass: a new technology for mitigation of localized erosional 'hot spots' in FL	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	174-175	beach nourishment	alternatives			

have?	Authors	Year	Title	Journal	Vol.:No.	pages	topics	subtopic	locator code	sponsor	notes
yes	Goss, Chauncey; Gooderham, Kate	1996	The importance of citizen involvement in developing a local beach management plan	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	339-349	policy	CZM			
yes	Gray, Donald H.; Hryciw, Roman D.; Ghiassian, Hossein	1996	Protection of coastal sand dunes with anchored geonets	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	255-270	beach concepts	alternatives			
yes	Hamilton, Robert P.; Ramsey, John S.; Aubrey, David G	1996	Numerical Predictions of Erosional "Hot-Spots" at Jupiter Island, Florida	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	75-90	shoreline change	methodology			
yes	Kitsos, Thomas R.	1996	New Requirements for obtaining beach sand from federal waters	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	329-338	beach nourishment	methodology			
yes	Mann, Douglas W.	1996	Beach nourishment benefit estimates: Past Present and Future?	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	146-156	beach nourishment	economics			
yes	Nash, Lou; Sawyer, Rick	1996	Utilization of surveying technologies for efficient beach monitoring surveys	The Future of Beach Nourishment: Proceedings of the 9th conference on beach preservation technology	1/24-26/98	107-116	beach nourishment	monitoring			
yes	Hillyer, Theodore M.	1996	Shoreline Protection and Beach Erosion Control Study: Final Report: An Analysis of the U.S. Army Corps of Engineers Shore Protection Program	U.S. Army Corps of Engineers, Institute for Water Resources Policy Study 96-PS-1	June				Lesley Ewing - personal library	USACOE Water Resources Support Center	
yes	Lucas, David H. (et al.)	1996	Private Property Owner's Perspective			41-52	policy	takings law/ Lucas			
yes	U.S. Army Corps of Engineers, Los Angeles District	1995	Silver Strand Shoreline	Beach Erosion and Storm Damage Reconnaissance Study	15-Mar				Kim Sterrett - Boating and Waterways	USACOE Coastal Resources Branch	
yes	Lee, Guan-hong; Nicholls, Robert J.; Birkemeier, William A.; Leatherman, Stephen P	1995	A conceptual fairweather-storm model of beach nearshore profile evaluation at Duck, NC, USA	Journal of Coastal Research	11:04	1157-1166	shoreline change	morphology			
yes	National Research Council	1995	Beach Nourishment and Protection	National Academy Press, Washington DC		334 pp.					
yes	Wasserman, Elizabeth	1995	Coastal Erosion Crisis?	San Jose Mercury News	5/28/1995		coastal erosion	CA			
yes	Kraus, Nicholas C.	1995	The use of structures to hold beachfill: an overview	Sand Wars, Sand Shortages & Sand-Holding Structures: Proceedings of the 8th conference on beach preservation technolog	1/25-27/95	335-347				FSBPA	
yes	Peterson, Ivars	1995	Off the Beach: how waves create sand ridges on the continental shelf	Science News	148	120-121	shoreline change	morphology			
yes	Griggs, Gary B.	1995	Relocation or reconstruction of threatened coastal structures: a second look	Shore & Beach	63:02	31-36	policy	CZM			
yes	Houston, James R.	1995	Beach Nourishment	Shore & Beach	63:01	21-24	beach nourishment	policy			
yes	Stoddard, Gerard	1995	Coastal policy implications of right to rebuild question	Shore & Beach	63:01	25-33	policy	CZM			
yes	Stronge, William B.	1995	The Economics of Government funding for beach nourishment projects: the Florida case	Shore & Beach	63:03	4 to 6	beach nourishment	policy			
yes	Weggel, J.Richard	1995	A primer on monitoring beach nourishment project	Shore & Beach	63:03	20-24	beach nourishment	monitoring			
yes	Cordes, Joseph J. and Anthony M. Yezer	1995	Shoreline Protection and Beach Erosion Control Study: Economic Effects of Induced Development in Corps-Protected Beachfront Communities	U.S. Army Corps of Engineers, Institute for Water Resources Policy Study 95-PS-1	February				Lesley Ewing - personal library	USACOE Water Resources Support Center	
yes	Andrews, Jeffrey L.; Beachler, Kim E.; Beumel, Norman H.	1994	Application of sea sled survey and techniques to beach nourishment monitoring programs	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	429-441	beach nourishment	monitoring		FSBPA	
yes	Lin, Paul C.-P.; Hansen, Inger E.; Sasso, R. Harvey	1994	Regional sand movement and performance of successive beach nourishment projects	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	216-228	beach nourishment	monitoring		FSBPA	
yes	Spadoni, Richard H.; Cummings, Sandra L.	1994	Environmental considerations for beach nourishment projects in Florida	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	608-623	beach nourishment	policy		FSBPA	
yes	Stauble, Donald K.	1994	Evaluation of erosion "hot spots" for beach fill project performance	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	198-215	beach nourishment	monitoring		FSBPA	
yes	Stronge, William B.	1994	Beaches, Tourism and Economic Development	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	526-527	policy	economics		FSBPA	
yes	Ulrich, Cheryl P.; King, Mona J.; Brown, Evelyn H.; Miselis, Paul L.	1994	A Methodology for quantifying "hot spot" erosion benefits for shore protection projects	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	454-473	shoreline change	analysis		FSBPA	
yes	Wang, Ping; Davis, Richard A.	1994	Field measurement of longshore sediment transport rates i the surf zone: preliminary results	Alternative Technologies in Beach Preservation: 7th conference on beach preservation technology FSBPA	2/9-11/94	413-428	beach concepts	monitoring		FSBPA	
yes	California State Lands Commission	1994	California Comprehensive Offshore Resource Stud	CA Office of State Printing #93-83361-608	I & II				CCC 10-02-L15-R37 1994		
yes	Shih, S.M.; Komar, P.D.; Tillotson, K.J.; McDougal, W.G.; Ruggiero, P.	1994	Wave run-up and sea-cliff erosion	Coastal Engineering '94		2170-2182	coastal erosion	morphology		ASCE	Proceedings
yes	Chasten, Monica A.; McCormick, John W.; Rosati, Julie D.	1994	Using detached breakwaters for shoreline and wetland stabilization	Shore & Beach	62:02	17-22	shoreline protection	alternatives			
yes	Griggs, Gary B.; Tait, James F.; Corona, Wendy	1994	The Interaction of seawalls and beaches: seven years of monitoring, Monterey Bay, CA	Shore & Beach	62:03	21-28	shoreline change	morphology			
yes	Grosskopf, William G.; Kraus, Nicholas C	1994	Guidelines for surveying beach nourishment project	Shore & Beach	62:02	9 to 16	beach nourishment	monitoring			
yes	Inman, Douglas L.; Masters, Patricia M	1994	Status of research on the nearshore	Shore & Beach	62:03	11 to 20	policy	morphology			
yes	Leidersdorf, Craig B.; Hollar, Ricky C.; Woodell, Gregory	1994	Human Intervention with the beaches of Santa Monica Bay, California	Shore & Beach	62:03	29-38	beach loss	CA			
yes	Stronge, William B.	1994	Beaches, Tourism and Economic Developmen	Shore & Beach	62:02	6 to 8	beach nourishment	policy			
yes	Wiegel, Robert L.	1994	Ocean beach nourishment on the USA Pacific Coast	Shore & Beach	62:01	11 to 36	beach nourishment	history			
yes	Wiegel, Robert L.	1994	Beaches-Tourism-Jobs	Shore & Beach	62:02	4 to 5	beach nourishment	policy			
yes	Shoreline Protection and Beach Erosion Control Task Force	1994	Shoreline Protection and Beach Erosion Control Study: Phase 1: Cost Comparison of Shoreline Protection Projects of the U.S. Army Corps of Engineers	U.S. Army Corps of Engineers, Institute for Water Resources Policy Study 94-PS-1	January	119 pp.			Lesley Ewing - personal library	USACOE Water Resources Support Center; The Office of Management and Budget	
yes	U.S. Army Corps of Engineers, Los Angeles District	1993	Beach nourishment sediment sources: previous studies and results of vibracoring field program: final repo	Coast of CA Storm and Tidal Waves Study, South Coast Region, Orange Count	Report 94-2 December				UCB WRCA G4713 N3-1; CCC-ID: 89008430.SF.03-06C-C56-B31.1993	USACOE	
yes	U.S. Army Corps of Engineers, Los Angeles District	1993	Existing State of Orange County Coast	Coast of CA Storm and Tidal Waves Study, South Coast Region, Orange Count	Report 93-1 April						
yes	Dailey, Murray D.; Reish, Donald J.; Anderson, Jack W (eds)	1993	Human Impacts: Dredging, Filling and Offshore Disposal of Sediments	in Ecology of the Southern California Bight: a synthesis and interpretation. Univ. of California Press		pp 731-733			John Dixon personal library		
yes	Bruun, Per; Esposito, John	1993	What the "Jones Act" means to dredging in america	Journal of Coastal Research	9:?	v-vii	beach nourishment	policy			
yes	Pilkey, Orrin H.	1993	Can we predict the behavior of sand: in a time and volume framework of use to humankind	Journal of Coastal Research	9:?	iii-iv	beach concepts	morphology			
yes	Pilkey, Orrin H.; Young, Robert S.; Riggs, Stanley R.; Smith, A.W. Sam; Wu, Huiyan; Pilkey, Walter D	1993	The concept of shoreface profile of equilibrium: a critical review	Journal of Coastal Research	9:01	255-278	beach concepts	morphology			
yes	Camfield, Fred E.	1993	Different views of beachfill performance	Shore & Beach	61:04	4 to 15	beach nourishment	policy			
yes	Flick, Reinhard E.	1993	The Myth and Reality of Southern California Beaches	Shore & Beach	61:03	3 to 13					
yes	Grosskopf, William G.; Stauble, Donald K.	1993	Atlantic coast of Maryland (Ocean City) shoreline protection project	Shore & Beach	61:01	3 to 33	shoreline protection	projects			
yes	Grove, Robert S	1993	Coastal Mitigation at a nuclear generating static	Shore & Beach	61:03	31-36					
yes	Ware, Rick	1993	Eelgrass (*Zostera marina*) In Southern California Bays and Wetlands with Emphasis on Orange Co	Shore & Beach	61:03	20-30					
yes	Wiegel, Robert L.	1993	Dana Point Harbor, California	Shore & Beach	61:03	37-55					
yes	Wiegel, Robert L.	1993	Artificial beach construction with sand/gravel made by crushing rock	Shore & Beach	61:04	28-29	beach nourishment	alternatives			
yes	Coastal Frontiers Corporation	1992	Historical Changes in the beaches of Los Angeles County: Malaga Cove to Topanga Canyon, 1935-199	Agreement No. IS-10336, CFC-194-91	February				Lesley Ewing - personal library	County of Los Angeles, Department of Beaches and Harbors	
yes	Griggs, G.B., James E. Pepper and Martha E. Jordan	1992	California's Coastal Hazards: A Critical Assessment of Existing Land-Use Policies and Practices	California Policy Seminar Research Report		224 pp.			Lesley Ewing - personal library		

have?	Authors	Year	Title	Journal	Vol.:No.	pages	topics	subtopic	locator code	sponsor	notes
yes	Culliton, Barbara J	1992	Save the beaches, not the building	Nature	357	p. 535	beach nourishment	policy			
yes	Wiegel, Robert L.	1992	Beach nourishment, sand by-passing, artificial beaches: bibliography of articles in the ASBPA Journal Shore &	Shore & Beach	60:03	3 to 5	beach nourishment	projects			
yes	County of Los Angeles, Dept. of Beaches and Harbors	1992	Lost and found: beach sand renourishment in L.A. County.		video				UCB WRCA G46051 N2 Video	Executive producers, Ken Johnson, Greg Woodell; producer and director, Mark Erickson ; writer, Mark Erickson.	Describes historical and contemporary beach nourishment projects in Los Angeles County. Discusses the effects of flood control engineering works on beach loss. Provides a case study of Cabrillo Beach in San Pedro, which was created with a beach nourishment project and has recent been renourished
yes	Tait, James F.; Griggs, Gary B.	1991	Beach response to the presence of a seawall; comparison of field operations	CERC-91-1 final report		63 pp.	shoreline change	morphology			
yes	Armstrong, George A.	1991	Shore Protection Construction along the CA coast	Coastal Zone '91	1	246-260	shore protection	history			Proceedings of the Symposium on Coastal and Ocean Management
yes	Hales, Lyndell Z.; Byrnes, Mark R.; Dowd, Millard W.	1991	Numerical modeling of storm-induced beach erosion, Folly Beach, SC, beach fill alternatives	Coastal Zone '91	1	495-509	beach concepts	modeling			Proceedings of the Symposium on Coastal and Ocean Management
yes	Harker, Allen H.; Flick, Reinhard E.	1991	Beach and cliff erosion processes at Solana Beach, CA, 1984-1990	Coastal Zone '91	3	2122-2133	coastal erosion	history			Proceedings of the Symposium on Coastal and Ocean Management
yes	Ibe, A.C.; Awosika, L.F.; Ibe, C.E.; Inegbedion, L.E.	1991	Monitoring of the 1985/86 beach nourishment project at Ba Beach, Victoria Island, Nigeria	Coastal Zone '91	1	534-552	beach nourishment	monitoring			Proceedings of the Symposium on Coastal and Ocean Management
yes	Stauble, Donald K.; Holem, Garry W.	1991	Long term assessment of beach nourishment project performance	Coastal Zone '91	1	510-524	beach nourishment	monitoring			Proceedings of the Symposium on Coastal and Ocean Management
yes	Walker, James R.	1991	Downdrift effects of navigation structures on the California Coast	Coastal Zone '91	3	1889-1903	shore protection	history			Proceedings of the Symposium on Coastal and Ocean Management
yes	Woodell, Gregory; Hollar, Ricky	1991	Historical changes in the beaches of LA County	Coastal Zone '91	2	1342-1355	shoreline change	history			Proceedings of the Symposium on Coastal and Ocean Management
yes	Clayton, T.D.	1991	Beach Replenishment Activities on U.S. Continental Pacific Coast	Journal of Coastal Research	7:04	1195-1210	beach nourishment	history			
yes	Scientific Committee on Ocean Research Working Group 89	1991	The response of beaches to sea-level changes: a review of predictive models	Journal of Coastal Research	7:03	895-921	beach concepts	morphology			
yes	Leatherman, Stephen P.	1991	Modelling Shore response to sea-level rise on sedimentary coasts	Progress in Physical Geography	14	448-464	shoreline change	analysis			
yes	U.S. Army Corps of Engineers, Los Angeles District	1990	Sediment Budget Report: Oceanside Littoral Cell	Coast of CA Storm and Tidal Waves Study	Report 90-2 November				Kim Sterrett - Boating and Waterways	Coastal Resources Branch - Planning Division	
yes	Bottin, Robert R., Jr.	1990	Case study of a successful beach restoration projec	Journal of Coastal Research	6:01	p. 1-14					
yes	Leonard, L.; Clayton, T.; Pilkey, O.	1990	An analysis of replenished beach design parameters of US East Coast barrier islands	Journal of Coastal Research	6:01	15-36			UCB Earth Sci QH541.5.C65 J86		
yes	Tait, James F.; Griggs, Gary B.	1990	Beach response to the presence of a seawall; a compariso of field operations	Shore & Beach	58:02	11 to 28	shoreline change	morphology			
yes	Juhnke, Leonard; Mitchell, T. and M. Piszker	1990	Construction and Monitoring of Nearshore Placement of Dredged Material at Silver Strand State Park, San Diego	U.S. Army Corps of Engineers, Dredging Research Technical Notes DRP-1-01	August	11 pp.	nearshore disposal				
yes	Vallianos, Lim	1990	Beach and Nearshore Placement of Material Dredged from Federally Authorized Navigation Project	U.S. Army Corps of Engineers, Institute for Water Resources Policy Study 90-PS-1	April	66 pp.	beach nourishment		Lesley Ewing - personal library	USACOE Water Resources Support Center	
yes	Lewis, R.D. and K.K. McKee	1989	A guide to the artificial reefs of Southern California	CA Dept. of Fish and Game, Nearshore Sportfish Habitat Enhancement Program		73 pp.			CCC ID: 02 -02E -L39 -A67 1989		
yes	Eliot, Ian; Clarke, Des	1989	Temporal and spatial bias in the estimation of shoreline rat of-change statistics from beach survey informatio	Coastal Management	17:02	129-156	shoreline change	analysis			
yes	Clayton, T.D.	1989	Artificial beach replenishment on the US Pacific Shore: a brief overview	Coastal Zone '89	v. 6.	2033-2045	beach nourishment	history			Proceedings of the Symposium on Coastal and Ocean Management
yes	Cahill, John J.; Butcher, Chris C.; Dyson, William	1989	Beach nourishment with fine sand at Carlsbad, CA.	Coastal Zone '89	v. 6.	p. 2092-2103.			UCB WRCA 85.1.W-3	Magoon, Orville T.; Converse, Hugh; Miner, Dallas; Tobin, L. Thomas; Clark, Delores, eds.	Proceedings of the Symposium on Coastal and Ocean Management
yes	Leanard, L; Clayton, Tonya D; Dixon, Kathie; Pilkey, Orrin H.	1989	US Beach Replenishment Experience: a comparison of the atlantic, pacific, and gulf coasts	Coastal Zone '89		1994-2006			UCB WRCA 85.1.W-3		Proceedings of the Symposium on Coastal and Ocean Management
yes	Patterson, David R.; Young, Donald T.	1989	Monitoring the Beach Nourishment Project at Surfside-Sunset Beach	Coastal Zone '89	v. 6	p. 1963-1977.			UCB WRCA 85.1.W-3	Magoon, Orville T.; Converse, Hugh; Miner, Dallas; Tobin, L. Thomas; Clark, Delores, eds	Proceedings of the Symposium on Coastal and Ocean Management
yes	Woodell, Gregory J.; Egense, Anders K.; Butcher, Chris C.	1989	Beach nourishment project compatible with multiple concerns, Santa Monica Bay, CA.	Coastal Zone '89	v. 6	p. 2076-2091.			UCB WRCA 85.1.W-3	Magoon, Orville T.; Converse, Hugh; Miner, Dallas; Tobin, L. Thomas; Clark, Delores, eds.	Proceedings of the Symposium on Coastal and Ocean Management
yes	Griggs, Gary B.; Tait, James F	1989	Observations on the end effects of seawall	Shore & Beach	57:01	25-26	beach concepts	morphology			
yes	Schwartz, Maurice L	1989	Commentary: The rest of the stor	Shore & Beach	57:01	23-24	beach concepts	morphology			
yes	Smith, A. W. Sam	1989	Reflected Edge Waves	Shore & Beach	57:01	20-22	beach concepts	morphology			
yes	Stone, Steven J.	1989	The CA Coastal Act: A method of coastal protection, or does the Coastal Commission still live after Nollan	Shore & Beach	57:01	4 to 10	policy	CA			
yes	U.S. Army Corps of Engineers, Los Angeles District	1988	Coastal Cliff Sediments, San Deigo Region (1887-1947)	Coast of CA Storm and Tidal Waves Study, San Diego Region	88-8				Lesley Ewing, private library		
yes	U.S. Army Corps of Engineers, Los Angeles District	1988	Sedimentation in Submarine Canyons, San Diego County, California, 1984-1987	Coast of CA Storm and Tidal Waves Study, San Diego Region	88-2				Lesley Ewing, private library		
yes	Kraus, Nicholas C.	1988	The effects of seawalls on the beach: an extended literatur review	Journal of Coastal Research	SI4	1 to 28	beach concepts	morphology			
yes	Pilkey, Orrin H.; Wright, Howard L., II	1988	Seawalls versus beaches	Journal of Coastal Research	SI4	41-64	beach concepts	morphology			
yes	Terchunian, Aram V.	1988	Permitting Coastal Armoring structures: can seawalls and beaches coexist?	Journal of Coastal Research	SI4	65-75	beach concepts	morphology			
yes	Strobel, Caroline D.; Woodward, Douglas P.	1988	The economic impact of proposed coastal setback and renourishment legislation on south carolin	prepared for SC Coastal Council and SC Dept. of Parks, Recreation and Tourism	January	64 pp.	policy	economics			
yes	Dean, Robert G.	1988	Recommended modifications in benefit/cost sand management methodolog	Shore & Beach	56:04	13-19	policy	economics			
yes	Griggs, Gary B.; Fulton-Bennett, Kim	1988	Rip Rap revetments and seawalls and their effectiveness along the central california coas	Shore & Beach	56:02	3 to 11	shore protection	alternatives			
yes	Hotten, Robert D	1988	Sand mining on Mission Beach, San Diego, CA	Shore & Beach	56:02	18-21	beach nourishment	history			
yes	Pilkey, Orrin H.	1988	A "Thumbnail Method" for beach communities: estimation of long-term beach replenishment requirement	Shore & Beach	56:03	23-31	beach nourishment	policy			
yes	U.S. Army Corps of Engineers, Los Angeles District	1987	Coastal Cliff Sediments, San Deigo Region	Coast of CA Storm and Tidal Waves Study, San Diego Region	87-2				Lesley Ewing, private library		
yes	Egense, Anders K.; Sonu, Choule J.	1987	Assessment of beach nourishment methodologies	Coastal Zone '87	5(3)	p. 4421-4433.			UCB WRCA 85.1.W-3	Magoon, Orville T.; Converse, Hugh; Miner, Dallas; Tobin, L. Thomas; Clark, Delores; Domurat, George W., eds	Proceedings of the Symposium on Coastal and Ocean Management
yes	Tanner, William F.	1987	The Beach: Where is the "River of Sand"?	Journal of Coastal Research	3:03	377-386	beach concepts	morphology			
yes	Lawrence, Sally	1987	How to feed a beach: where sand comes from and where it's going	Oceans	20:02	42-47	shore protection	policy			
yes	Thompson, Roger	1987	Defending our Shores: about face for the ACOE	Oceans	20:02	34-41	shore protection	policy			
yes	Komar, Paul D.; Enfield, David B	1987	Short-term sea-level change and coastal erosic	SEPM Special Publication	41	17-27	coastal erosion	morphology			
yes	Herron, William J.	1987	Sand Replenishment in Southern Californi	Shore & Beach	55(3-4)	87-91					
yes	Domurat, George W.	1987	Beach Nourishment- A working solution	Shore & Beach	55(3-4)	92-95					
yes	Inman, Douglas Lama	1987	Accretion and Erosion Waves on Beaches	Shore & Beach	55(3-4)	61-66					
yes	Thompson, Warren C.	1987	Seasonal Orientation in California Beache	Shore & Beach	55(3-4)	67-70					
yes	Edge, Billy L.; Czlapinksi, Richard E.; Schlueter, Roger E.	1987	A Comprehensive Approach to Beach Management	Shore & Beach	55(3-4)	122-127					
yes	Reynolds, Suzanne	1987	Sediment Dynamics on the Palos Verdes She		1-Nov	59 p.			Lesley Ewing - personal librar	Los Angeles County Sanitation Distric	
yes	Komar, Paul D.; Holman, Robert A	1986	Coastal Processes and the development of shorelin	Annual Review of Earth and Planetary Science	14	237-265	beach loss	morphology			
yes	Griggs, G.B. and Savoy, L	1986	Living with the California Shore	Duke University Press		393p.					
yes	Fischer, David W.	1986	Beach Erosion Control: Public Issues in Beach Stablization Decisions, Florida	Journal of Coastal Research	2:01	51-59	shore protection	policy			
yes	U.S. Army Corps of Engineers, Los Angeles District	1986	Oral History of Coastal Engineering Activities in Southern California: 1930-1981		January				Lesley Ewing-personal library		
yes	Nelson, Walter G.	1985	Guidelines for beach restoration projects Part I: Biologic	Florida Sea Grant College Report 7	July	66 pp.	beach nourishment	methodology			
yes	Phillips, Jonathan D	1985	Estimation of Optimal Beach Profile Sample Interva	Journal of Coastal Research	1:02	187-191	shoreline change	methodology			

have?	Authors	Year	Title	Journal	Vol.:No.	pages	topics	subtopic	locator code	sponsor	notes
yes	Wright, L.D.; Short, A.D.	1984	Morphodynamic variability of surf zones and beaches: a synthesis	Marine Geology	56	93-118	beach concepts	morphology			
yes	Kuhn, G.G. and F.P. Shepard	1984	Sea Cliffs, Beaches and Coastal Valleys of San Diego County	Univ. of CA Press		193 pp.			Lesley Ewing - personal library		
yes	Fischer, Peter J.	1983	Study on Quaternary Shelf Deposits (Sand and Gravel) of Southern California	Beach Erosion Control Project Report	1-Jun				Lesley Ewing - personal library	CA Dept. of Boating and Waterways	
yes	Osborne, Robert H.; Darigo, Nancy J.; and Robert C. Scheidemann, Jr.	1983	Report of Potential Offshore Sand and Gravel Resources of the Inner Continental Shelf of Southern California (with map appendix)		June	302 pp.			Lesley Ewing - personal library	CA Dept. of Boating and Waterways	
yes	Taylor and Littler	1982		Ecology	63	135-146					
yes	Taylor, Phillip R. and Littler, Mark M.	1982	The roles of compensatory mortality, physical disturbance, and substrate retention in the development and organization of a sand-influenced, rocky-intertidal community	Ecology	63:1	135-146					
yes	Seapy and Littler	1982	Population and species diversity fluctuations in a rocky intertidal community relative to severe aerial exposure and sediment burial	Marine Biology	71	87-96					
yes	Shaw, Martha J.	1980	Artificial Sediment Transport and Structures in Coastal Southern California	Scripps Institution of Oceanography Reference Series	SIO 80-41, December	109 pp.			Kim Sterrett - Boating and Waterways	Shore Processes Lab, Center for Coastal Studies, SIC	
yes	CA Dept. of Boating and Waterways	1979	A Preliminary Investigation for Establishing Beach Sediment Supply Sites in Eastern Malibu		10-Oct				Lesley Ewing - personal library		
yes	Rosenberg, Rutger	1977	Effects of Dredging Operations on Estuarine Benthic Microfauna	Marine Pollution Bulletin	8:05	102-104			UCB Engin GC1080.M351		
yes	CA Dept. of Navigation and Ocean Development	1977	Assessment and Atlas of Shoreline Erosion along the California Coast	State of CA Resources Agency Report	July				Lesley Ewing - personal library		
yes	Morton, J.W.	1977	Ecological effects of dredging and dredge spoil disposal: a literature review	Technical Paper No. 94, US Fish and Wildlife Service					CCC ID: 02 -02D -07		
yes	CA Dept. of Navigation and Ocean Development	1977	Study of beach nourishment along the Southern California coastline		October	151 p.			CCC-ID: 89003689.SF.03-06-11; ID: 89004209.SF.03-06-11; ID: 89008808.SF.03-06-11; UCB Earth Sci TC330 .C3; UCB WRCA G421 K7-2	State of California - The Resources Agency	
yes	Soule, D.F. and M. Oguni	1976	Marine Studies off San Pedro, CA, Part II: Potential Effects of Dredging on the biota of outer LA Harbor	Toxicity, Bioassay, and recolonization studies: Rep. So. CA Sea Grant Program No. 2-8		325 pp.			CCC ID: 33 -204-M16 V.11		
yes	CA Dept. of Navigation and Ocean Development	1976	Shore Protection in California		April	51p.			CCC-ID: 89003188 3-6-7	State of California - The Resources Agency	
yes	Dames and Moore	1971	National Shoreline Study California Regional Inventory		August				Lesley Ewing - personal library	U.S. Army Corps of Engineers, South Pacific Division	
no	Hamilton, Megan	1998	Grains of sand; GPS survey-grade technology provides critical data to understanding beach erosion	Earth Observation Magazine	7(4)	p. 12-14					
no	Kellejian, J.; Apple, S.	1997	Restoring the State's Eroding Beaches: An Innovative Case Study-Sand Replenishment from a Railroad Grade Separation in the City of Solana Beach	California and the World Ocean '97		pp. 1499					conference proceedings, San Diego
no	U.S. Dept of the Navy	1997	Environmental assessment for beach replenishment at North Carlsbad, South Carlsbad, Encinitas, and Torrey Pines. San Diego, Cali	GOVDOC NO: D 201.45/3:B 35	May					Naval Facilities Engineering Command Southwest Division	
no	U.S. Dept of the Navy	1997	Environmental assessment for beach replenishment at South Oceanside and Cardiff/Solana Beach, CA	GOVDOC NO: D 201.45/3:B 365	April						
no	U.S. Dept of the Navy	1997	Beach sand transport and sedimentation report: Channel dredging, Naval Air Station North Island. Phase II: San Diego, CA. FY '97	MCON Project P-706, 28, May 1997. GOVDOC NO: D 201.2/2:C 36.						Naval Facilities Engineering Command Southwest Division	
no	Douglass, Scott L	1995	Estimating landward migration of nearshore constructed sand mounds	Journal of Waterway, Port, Coastal and Ocean Engineering	121(5)	p. 247-250.			UCB WRCA 11.7 WW; UCB Engin TA1.A47 W3		
no	Magnusen, Craig Ellsworth	1995	The characterization of Huntington Beach and Newport Beach through Fourier grain-shape, grain-size, and longshore current analyses	Thesis (M.S.)		178 p.			UCB WRCA G4714.N5-1	University of Southern CA	
no	Griggs, Gary B.; Tait, James F.; Corona, Wendy W.	1994	The interaction of seawalls and beaches; seven years of monitoring, Monterey Bay, CA	Shore & Beach	62:03	p. 21-28.					
no	Leidersdorf, Craig B., Ricky C. Hollar and Gregory Woodell	1993	Beach enhancement through Nourishment and Compartmentalization: The Recent History of Santa Monica Bay	Beach nourishment and Management Considerations		71-85				ASCE; ed. Donald K. Stauble and Nicholas C. Kraus	
no	Lu, Yi; Osborne, Robert H.	1993	Sources for Quaternary sand and the effects of selective transport on grain-shape composition, Santa Monica Bay, CA.	Geological Society of America, 1993 annual meeting Abstracts with Programs	25(6)	p. 274.				Geological Society of America	
no	Lee, Arthur C.	1993	Sources and relative fluxes for foreshore sand from Point Arguello to the United States-Mexico border: Fourier grain-shape analysis	Thesis (Ph. D.)		193p.				University of Southern CA	
no	Everts, C.H.	1991	Seacliff Retreat and coarse sediment yields in Southern California	Coastal Sediments '91		1586-1598					
no	Santa Barbara Dept. of Public Works	1989	shoreline inventory'								
no	Orme, A.R.	1988	Coastal dunes, changing sea level and sediment budget	Journal of Coastal Research	3	127-129					
no	U.S. Army Corps of Engineers, Los Angeles District	1985	Seal Beach - Anaheim Bay Harbor, Orange County, C	Beach Erosion Control Study	May	12 p.			Call numbers: UCB WRCA G4714 M5		
no	Dingler, John R.; Laband, B.L.; Anima, R.J	1985	Geomorphology Framework Report: Monterey Ba	Coast of California Storm and Tidal Waves Stud	CCSTWS85-2					USACOE	
no	U.S. Army Corps of Engineers, Los Angeles District	1978	Surfside-Sunset and Newport Beach Orange County, CA: final supplement to the final environmental stateme		June				Call numbers: UCI Main Lib TC225.S97 S9 1978 Government Information Loca		
no	U.S. Army Corps of Engineers, Los Angeles District	1978	Shore protection improvement design analysis for stage 7 construction : periodic beach nourishment at Surfside-Sunset Beach, Orange County, CA		June				UCB WRCA G4713 K8		
no	U.S. Army Corps of Engineers, Los Angeles District	1977	Surfside-Sunset and Newport Beach, Orange County, CA	environmental impact statement, draft supplement to the fina	December	92 p			UCI Main Lib TC225.S97 S9 1977 Government Information Loca		
no	U.S. Army Corps of Engineers, Los Angeles District	1974	Surfside-Sunset and Newport Beach, Orange County, CA: final environmental statement	environmental impact statement, final	September				UCI Main Lib TC225.S97 S9 1974 Government Information Loca		
no	U.S. Army Corps of Engineers, Los Angeles District	1972	Surfside-Sunset and West Newport Beach, Orange County, CA	environmental impact statement, draft	May				UCI Main Lib TC225.S97 S9 1972 Government Information Loca		
no	Price, R.C.	1966	Statement of the California Department of Wate	Shore and Beach	34:1	22-32					
no	Rubin, Howard	1999	Biological effects of beach nourishmen	ACOE-NY District							
no	Colgan, Chuck	1998	Sands of time running out: oceanographer seeks solution for CA's dwindling beaches	Explorations (La Jolla, San Diego, Calif.)	5(1) (summer)	p. 11-14, 16-17.			UCB WRCA 96.1 XU2-10		
no	Arzamendi, Moi.; Hemphill, Mike	1998	Geotechnical considerations for the Batiquitos Lagoon Enhancement Project	Ports	Vol. 1 (3/8-11/98)	pp. 581-590.			UCB Engin TC203.5.P67		Conference Proceedings, Long Beach, CA
no	Chang, H.H.	1997	Modeling fluvial processes in tidal inlet	J. HYDRAUL. ENG	123(12)	pp. 1161-1165			UCB Engin TA1.A47.HB; UCB WRCA 11.7WH		
no		1997	(coastal population	Science	5341	1211-1212			UCB Main Q1.S354		
no	Kadib, Andrew L	1996	Shoreline and volume changes along the Orange County coastline.	Coast of CA Storm and Tidal Waves Study, South Coast Region, Orange County	Report 96-5 February				Call numbers: UCB WRCA G4713 N6-4		
no	Everts Coastal	1996	Coast of Newport Beach: shoreline behavior and coastal processes		April	112p.			UCB WRCA G4713 N6	report prepared for city of Newport Beach, Public Works Dept.	
no	U.S. Army Corps of Engineers, Los Angeles District	1996	PORT OF LONG BEACH MAIN CHANNEL DEEPENING AND NAVIGATION IMPROVEMENTS, SAN PEDRO BAY, LOS ANGELES COUNTY, CA		EPA number 960275F, June 12	2 volumes					
no	U.S. Army Corps of Engineers, Los Angeles District	1995	Shore history, surveys and changes	Coast of CA Storm and Tidal Waves Study, South Coast Region, Orange County, Los Angeles, CA	Report 95-2. "October 1995 Preliminary report".				Call numbers: UCB WRCA G4713 N5 Note: At NRLF.		
no	Everts, Craig H.	1995	Seacliff erosion and its sediment contributions: Dana Point to the San Gabriel River.	Coast of CA Storm and Tidal Waves Study, South Coast Region, Orange County.	Report 95-1 November 1995.	41 p.			Call numbers: UCB WRCA G4713 N5-1		
no	Lee and Osborne	1995	something about grain shape correlated to sourc	Journal of Coastal Research	11	1366-1345					
no	Ambrose, Richard F.	1995	Rocky intertidal and subtidal resources, Santa Barbara County Mainland: final repor	MMS, Pacific OCS Region Study 95-0067	December	172 p.					

have?	Authors	Year	Title	Journal	Vol.:No.	pages	topics	subtopic	locator code	sponsor	notes
no	U.S. Army Corps of Engineers, Los Angeles District	1995	PORT OF LONG BEACH (DEEPENING) FEASIBILITY STUDY, LOS ANGELES COUNTY, CA		EPA number 950242D, June 6	313 pages.					
no	U.S. Dept of the Navy	1995	DEVELOPMENT OF FACILITIES TO SUPPORT THE HOMEPORTING OF ONE NIMITZ CLASS AIRCRAFT CARRIER, SAN DIEGO, SAN DIEGO COUNTY, CA.		EPA number 950509F, October 31	3 volumes				Naval Facilities Engineering Command Southwest Division	
no	U.S. Dept of the Navy	1995	DEVELOPMENT OF FACILITIES IN SAN DIEGO TO SUPPORT THE HOMEPORTING OF ONE NIMITZ CLASS AIRCRAFT CARRIER, SAN DIEGO COUNTY,		EPA number 950188D, May 5	2 volumes				Naval Facilities Engineering Command Southwest Division	
no	U.S. Dept of the Navy	1994	DREDGED-MATERIAL DISPOSAL, SAN DIEGO BAY, CA	environmental impact statement, final programmatic	EPA number 940036F, February 4	3 volumes				Naval Facilities Engineering Command Southwest Division	
no	Everts, Craig	1994	Comments on CCC Methodology to address impacts of seawalls on the beach								
no	San Diego Unified Port District	1994	Imperial Beach sand replenishment from U.S. Coast Guard dredging, Ballast Point: negative declaration.		Draft report, 7/26/1994 UPD #305.	32 p.			Call numbers: UCSD SSH C200 P83 I463 Documents San Diego		
no	U.S. Army Corps of Engineers, Los Angeles District	1994	Reconnaissance Report: Malibu/Los Angeles County Coastline, LA County, CA		April				Lesley Ewing - personal library		
no	U.S. Dept of the Navy	1993	DREDGED-MATERIAL DISPOSAL, SAN DIEGO BAY, CA	environmental impact statement, draft programmatic	EPA number 930006D, January 8	2 volumes				Naval Facilities Engineering Command San Diego, CA	
no	Jenkins, S.A.; Skelly, D.W.	1991	Development of a soft reef sandbar for offshore wave dissipation.	Bulletin of Marine Science: Proceedings of the 5th International Conference on Aquatic Habitat Enhancement, 1994	55(2-3)	p. 1338				Int. Conf. on Aquatic Habitat Enhancement: 3-7 Nov 1991, Long Beach, CA.	
no	Orme, A.R.	1991	Mass movement and seacliff retreat along the southern California Coast	Bulletin of Southern California Academy of Sciences	90	58-79					
no	Liu, C.C. et al	1991	Coastal Processes Study on BEACON shoreline	Coastal Sediments '91		2249-2261			UCB ENGIN GB450.2.S66; UCB WRCA 85		Proceedings
no	San Diego Association of Governments	1991	Shoreline preservation strategy for the San Diego region- volumes 1 and 2		September				CCC-ID#89008214; CCC-ID#89009193		
no	U.S. Army Corps of Engineers, Los Angeles District	1991	DEEP DRAFT NAVIGATION IMPROVEMENTS, LOS ANGELES AND LONG BEACH HARBORS, SAN PEDRO BAY, CA.		EPA number 920208D, June 4, 1992	2 volumes					
no	U.S. Dept of the Navy	1991	FAST COMBAT SUPPORT SHIP (AOE-6 CLASS) U.S. WEST COAST HOMEPORTING PROGRAM, CA AND WASHINGTON		EPA number 910116D, April 12	421 pages.				Naval Facilities Engineering Command Washington, D.C.	
no	U.S. Dept of the Navy	1991	FAST COMBAT SUPPORT SHIP (AOE-6 CLASS) U.S. WEST COAST HOMEPORTING PROGRAM, CA AND WASHINGTON		EPA number 910331F, September 13, 1991	2 volumes.				Naval Facilities Engineering Command Washington, D.C.	
no	Humboldt State University	1990	Sediment Characteristics, Benthic Infauna….Humboldt Bay, CA (August 1989)	report to USACOE							
no	Coats, Robert, Michael Josselyn and Robert Lavenberg	1990	Conceptual plan for enhancement of the Edison and Piccirelli properties at Huntington Beach.	Southern CA wetlands inventory	library #711, October 18, 1990.				Call numbers: UCI Main Lib QH76.5.C22 H84 1990 Government Information Local	Philip Williams & Associates,	
no	U.S. Army Corps of Engineers, Coastal Engineering Research Center	1990	Los Angeles and Long Beach Harbors Model Enhancement Program : three-dimensional numerical model testing of tidal circulation		CERC-90-16, September	124 p.			Call numbers: UCB WRCA G200 Y-21 no. CERC- 90-16		
no	U.S. Army Corps of Engineers, Los Angeles District	1990	BATIQUITOS LAGOON ENHANCEMENT PROJECT, CARLSBAD, CA		EPA number 900229F, June 27	5 volumes					
no	Leonard, L.; Pilkey, O.; Clayton, T	1989	An assessment of beach replenishment parameters	Beach Preservation Technology: 1st National Conference Proceedings: Problems and Advancements in Beach Nourishment, 1988 (ed. Tait)		115-124				FSBPA	
no	Oregon State University	1989	report on sediment budgets and physical processes for coastline between WA and N. CA								
no	U.S. Army Corps of Engineers, Los Angeles District	1989	PROPOSED BATIQUITOS LAGOON ENHANCEMENT PROJECT, CARLSBAD, CA		EPA number 890100D, April 20	369 pages					
no	Leonard, L.; Pilkey, O.H.; Clayton, T.D	1988	An assessment of parameters critical to beach	FSBPA Proceedings		115-124					
no	Barbato, Lucai Sabina	1988	Effect of beach replenishment at Coronado, CA 1985-8	Thesis (M.A.)		118p.			UCLA SRLF D0001728096	UCLA	
no	U.S. Army Corps of Engineers, Los Angeles District	1987	Oceanside Littoral Cell Preliminary Sediment Budget Report	Coast of CA Storm and Tidal Waves Study, San Diego Region	87-4	158 pp.					
no	Moffatt and Nichol, Engineers	1987	Silver Strand Littoral Cell preliminary sediment budget report	Coast of CA Storm and Tidal Waves Study, South Coast Region	Report 87-3 December	157 pp.			UCB WRCA G4115 M7	US Army Corps of Engineers, LA District, Planning Division, Coastal Resources Branch	
no	Grove, Robert S.; Sonu, Choule J.; Dykstra, David H.	1987	Fate of massive sediment injection on a smooth shoreline San Onofre, CA	Coastal Sediments '87					UCB ENGIN GB450.2.S64		
no	Griggs, G.B.	1987	Littoral cells and harbor dredging along the California Coa	Environ. Geol. Water Sci	10(1)	p. 7-20			UCB Earth Sci QE1.E56		
no	U.S. Army Corps of Engineers, Los Angeles Distric	1987	Coastal Project: Surfside-Sunset and Newport beac	Project Information summary	January						
no	U.S. Army Corps of Engineers, Los Angeles District	1986	San Gabriel River to Newport Bay (Surfside-Sunset and Newport Beach), Orange County, CA, Condition of Improvement	Beach Erosion Control Study: Unpublished							
no	Wilcoxen, Peter J.	1986	Coastal zone erosion and sea level rise: implications for Ocean Beach and San Francisco's Westside Transport Project	Coastal Zone Management Journal	14: no 3	p.173-91			UCB EnvDesign HT392.A1.C6; UCB WRCA 85.1 W (NRLF)		ABSTRACT: Estimated erosion resulting from the greenhouse effect: costs of beach nourishment to protect the sewer facility
no	Santa Barbara Dept. of Public Works	1986	Beach Erosion Authority for Control Operations and Nourishment	recommendation to the Mayor and Councilmembers	5/2/1986				UCSB Main Lib TC332.B43 Sci-Eng		
no	Griggs, G.B.	1986	Relocation or reconstruction: viable approaches for structures in areas of high coastal erosion	Shore & Beach	54(1)	p. 8-16					
no	Berrigan, Paul D.	1986	Statement of Paul D. Berrigan at public hearing of CA Coastal Commission on Ocean Beach sand replenishment			1 envelope			UCB WRCA JOHNSON 202-25		Notes: Regarding erosion protection, seawall construction within the boundaries of the Golden Gate National Recreation Area, etc
no	San Francisco Clean Water Program	1986	Ocean Beach beach nourishment plan		August	2 v.			UCB WRCA JOHNSON 202-26		
yes	Spencer, D	1985	The Newport Beach groin field, Orange Co. CA	California's Battered Coast	September	151-203			Lesley Ewing - personal library	McGrath, Jim (ed); California Coastal Commission	Proceedings from a conference on coastal erosion, San Diego, February 6-8 1985
no	Drake, D.E.; Cacchione, Dave A.; Karl, Herman A.	1985	Bottom currents and sediment tranport on San Pedro Shelf California	Journal of Sedimentary Petrology	55:1	15-28					
no	U.S. Army Corps of Engineers, Coastal Engineering Research Center	1984	Shore Protection Manual	Government Printing Office 008-022-00218-9							
no	Seymour, R.J; R. R. Strange III; D.R. Cayan and R.A. Nathan	1984	Influence of El Nino on California's Wave Climate	Proceedings of the 19th International Conference on Coastal Engineering		577-592				ASCE	
no	Massey, B.W. and J.L. Atwood	1984	Application of ecological information to habitat management for the California least tern	Progress Report No. 6, US Fish and Wildlife Service							
no	U.S. Army Corps of Engineers, Los Angeles Distric	1984	Coastal Storm Damage: Winter 1983			151p.					
no	Herbich, J.B. and S.B. Brahme	1983	Literature Review and Technical Evaluation of Sediment Suspension During Dredging	CDS Report No. 266, USACOE WES							
no	Littler et al	1983		Marine Ecology Progress Series	11	129-139					
no	Ecker, R. M., G. Whelan	1983	Littoral processes : U.S. Coast Guard Station, Fort Point, San Francisco	Pacific Northwest Laboratory, Richland, Wash.	October	84 p.			UCB WRCA JOHNSON 215	U.S. Coast Guard	
no	Inman, D.L. and S. A. Jenkins	1983	Oceanographic Report for Oceanside Beach Facilities	report for city of Oceanside	August	206 pp.	sediment budget				
no	U.S. Army Corps of Engineers, Los Angeles District	1983	Project Information Sheet: Imperial Beach, San Diego County, CA	unpublished	1/2/1983						
no	Moffat and Nichol Engineers	1983	Experimental sand bypass system at oceanside harbor, CA Phase 1 Report: Data Collection and Analysis	unpublished report for USACOE-LA District							
no	Naqvi, S.M.; Pullen, E.J.	1982	Effects of beach nourishment and borrowing on marine organisms	USACOE CERC Miscellaneous report; no. 82-14		43 pp.				USACOE, Coastal Engineering Research Center	

have?	Authors	Year	Title	Journal	Vol.:No.	pages	topics	subtopic	locator code	sponsor	notes
no	Jones & Stokes Associates, Inc.	1981	Ecological Characterization of the central and northern California coastal region	FWS/OBS-80/45	I - V					US Fish and Wildlife Service, Office of Biological Services and BLM, Pacific OCS Office	
no	Thistle, D.	1981	Natural physical disturbance and communities of marine soft benthos	Marine Ecology Progress Series	6	223-228			UCB BioSci QH541.5.S3 M26		
no	Dingler, John R.	1981	Stability of a very coarse-grained beach at Carme	Marine Geology	44:3-4	241-252				USGS	
no	Brownlie, W.R. and B.D. Taylor	1981	Sediment Management of Southern California Mountains, Coastal Plains and Shoreline - Part C, Coastal Sediment Delivery by Major Rivers in Southern Californ	Report No. 17-C		314 pp.				California Institute of Technology, Environmental Quality Laboratory	
no	Turner, Ronald Jay	1981	Ground water conditions in Encinitas, CA, as they relate to sea cliff stability	Thesis (M.S.)		81 p.			UCB WRCA G4781.M1	California State University, Fullerton	
no	U.S. Army Corps of Engineers, Los Angeles District	1980	Anaheim Bay Harbor, Orange County, CA, Condition of Improvement	Beach Erosion Control Study: Unpublished	9/30/1980						
no	U.S. Army Corps of Engineers, Los Angeles District	1980	Seal Beach - Anaheim harbor, Orange Co., CA	Beach Erosion Control Study: Unpublished Equity Study	March						
no	Littler, M.M.	1980	Overview of the rocky intertidal systems of southern California	The California Islands: proceedings of a multi-disciplinary symposium		265-306				ed. By D.M. Power, Santa Barbara Museum of Natural History	
no	Ecker, R M.	1980	Ocean Beach sand replenishment program.	Towill, Inc., San Francisco		83p.			UCB WRCA Johnson 202-15	San Francisco Clean Water Management Program	
no	Ecker, R. M.	1980	Ocean Beach littoral processes monitoring program	Towill, Inc., San Francisco		29 p.			UCB WRCA JOHNSON 202-16	City and County of San Francisco Clean Water Program	
no	Murray, S.N. and M.M. Littler	1979	Experimental studies of the recovery of populations of rock intertidal macro-organisms following mechanica	Southern California Baseline Study, Year 3, Bureau of Land Management, D.C	2				CCC 15-02-05C		
no	U.S. Army Corps of Engineers, Los Angeles District	1978	Ocean Beach, San Diego County, CA, Condition of Improvement	Beach Erosion Control Study: Unpublished							
no	U.S. Army Corps of Engineers, Los Angeles District	1978	Doheny Beach State Park, Orange County, CA, Condition of Improvemen	Beach Erosion Control Study: Unpublished							
no	Parr, Terence, Douglas Diener and Stephen Lacy	1978	Effects of beach replenishment on the nearshore sand fauna at Imperial Beach, CA	Miscellaneous report; no. 78-4. : Govt Doc No.: D 103.42/8:78-4. Contract DACW72-76-C-0007	final report December	150 pp.			UCB WRCA G200 Y-15 no.78-4; UCSB Main Lib D 103.42/8: 78-4 Govt Pub; GPO Item No.: 334-A-20 (microfiche)	U.S. Army Corps of Engineers, Coastal Engineering Research Center.	
no	Hirsch, N.D.; L.H. DiSalvo; and R. Peddicord	1978	Effects of dredging and disposal on aquatic organism	Technical Report DS-78-5, USACOE WES					UCB WRCA 22.55 Y-5 no. 78-5		
no	Littler, M.M.	1978		The annual and seasonal ecology of southern California rocky intertidal, subtidal, and tide pool biotas in the Southern California Bight						Dept. of the Interior, Bureau of Land Management, D.C.	
no	Van Deerlin, Congressman	1978	Remarks at Public Meeting for beach erosion control project at Imperial Beach, CA	unpublished	6/7/1978						
no	Habel, J.S.	1978	Shoreline subsidence and sand loss	Unpublished report, State of CA Resources Agency, Dept. of Navigation and Ocean Development		4 pp.					
no	O'Connor, J.S.; P.N. Slattery; L.W. Hulberg; and J.A. Sheik, Jr.	1977	Sublethal effects of suspended sediment on estuarine fish	Technical Paper No. 77-3, USACOE CERC		90 pp.					
no	Oliver, J.S.; P.N. Slattery; L.W. Hulberg; and J.W. Nybakken	1977	Patterns of Succession in Benthic Infaunal Communities following dredging and dredged material disposal in Monterey Bay	Technical Report D-77-27, USACOE Waterways Experiment Station		186 pp.					
no	McCauley, J.E.; R.A. Parr, and D.R. Hancock	1977	Benthic infauna and maintenance dredging: a case stud	Water Resources	II	233-242					
no	County of Los Angeles, Dept. of County Enginee	1977	environmental impact report: Whites Point		draft	36p.			UCB WRCA G46051 K7-1		
no	Inman, D.L.	1976	Summary Report of Man's Impact on the CA Coastal Zon	California Dept. of Nav. And Ocean Dev. Repo		150p.					
no	U.S. Army Corps of Engineers, Los Angeles District	1976	Beach Erosion Control: Ventura-Pierpont Area, Ventura County, CA, Condition of Improvemer			2p.					
no	Johnson, J.W.	1975	Littoral processes at some California shoreline harbo	Shore and Beach	October	17-22			UCB WRCA 25.9 W		
no	U.S. Army Corps of Engineers, Los Angeles District	1974	Small beach erosion control project, Las Tunas Beach Park, LA County, CA	Beach Erosion Control: Detailed Project Report	November						
no	Dean, R.G.	1974	Compatability of borrow material for beach fil	Coastal Engineering '74		1319-1330				ASCE	Proceedings, 14th conference
no	Inman, Douglas Lamar	1974	Nearshore processes along the Silver Strand littoral cell	Intersea Research Corporation, La Jolla, Calif.	18-Jul	1 volume			UCB WRCA G4215 K4-3	US Army Corps of Engineers, Los Angeles District	
no	U.S. Army Corps of Engineers, Los Angeles District	1974	Final EIS: Operation and Maintenance of Morro Bay Harbo San Luis Obispo County, CA	unpublished							
no	Maloney and Char	1974									
no	Ritter, John R.	1973	Bolinas Lagoon, Marin County, California : summary of sedimentation and hydrology, 1967-6	Water Resources Investigations, USGS		74 p.			UCB Earth Sci QE581 .R57; UCB WRCA G4624 K3	Bolinas Harbor District and Marin County	with a section on fluorescent-tracer study of sediment movement by William M. Brown, II
no	Ritter, John	1972	Sand Transport by the Eel River and Its effect on Nearby Beaches	Open File Report, USGS Water Resources Division, Menlo Park		17 p.			UCB Earth Sci QE581 .R571; UCB WRCA G4134 K2-1	California Dept. of Water Resources	
no	Johnson, J.W.	1971	The significance of seasonal beach changes in tidal boundaries	Shore and Beach	39:1	26-31					
no	U.S. Army Corps of Engineers, Los Angeles District	1970	Supplementary general design memorandum for beach protection and widening in the segment from Redondo Breakwater to Malaga Cor								
no	CA Dept. of Navigation and Ocean Development	1969	Interim report on the study of beach nourishment along the Southern California Coastline: memorandum repo	State of CA Resources Agency Report	July				CCC ID: 89003707.SF.03-06C-04		
no	U.S. Army Corps of Engineers, Los Angeles District	1969	Design Memorandum for Stage 3 Construction: Beach Stabilization with groins and beach fill at Newport Beach, Orange County, CA	unpublished							
no	Goldman, Harold B	1967	Can sand dredged from San Francisco Bay be used for beaches?	Addendum to Salt, sand and shells: marine mineral resources of San Francisco Ba	February, 1967.				Call numbers: UCB WRCA BCDC 7.3		
no	CA Dept. of Navigation and Ocean Development	1967	Progress report on study on beach nourishment along the southern CA coastline	State of CA Resources Agency Report		59 p.			Govt Document No.: W750.B38; UCB Main GB458.8 C153; UCB WRCA G421 J7-5		
no	Bowen, A.J.; Inman, D.L.	1966	Budget of littoral sands in the vicinity of Point Arguello, California	CERC Technical Memorandum No. 19		41 pp.	defined littoral cells				
no	Herron, William J.; Harris, Robert L.	1966	Littoral bypassing and beach restoration in the vicinity of Port Hueneme, CA	Coastal Engineering '66		651-675				ASCE	Proceedings
no	U.S. Army Corps of Engineers, Los Angeles Distric	1960	San Diego County, CA, Beach Erosion Control Stud	House Document 456/86/2							
no	Chamberlain, T.	1960	Mechanics of mass sediment transport in Scripps Submarine Canyon	Ph. D. dissertation, Scripps Institution of Oceanography		200 pp.					
no	Penfield	1960		Shore and Beach	28:1	9-15			UCB WRCA 25.9 W		
no	U.S. Army Corps of Engineers, Los Angeles District	1959	Cooperative Study of Southern California, Point Conceptio to Mexican Boundary	Beach Erosion Control Study: Unpublished							
no	U.S. Army Corps of Engineers, Los Angeles Distric	1959	Cooperative Study of Orange County, C.	Beach Erosion Control Study: Unpublishe							
no	Stevenson, E. et al.	1959	Comprehensive Survey of Southern California continental shelf area	State Water Pollution Control Board	Pub. No. 20						
no	U.S. Army Corps of Engineers, Los Angeles District	1957	Oceanside, Ocean Beach, Imperial Beach, and Coronado, San Diego County, CA	Beach Erosion Control Study							
no	U.S. Army Corps of Engineers, Los Angeles Distric	1954	Port Hueneme, CA	House Document 362/83/2							
no	Hall, J. Jr	1952	Artificially constructed and nourished beache	Coastal Engineering '52	ch.10	119-133				ASCE	Proceedings
no	Johnson, A.G.	1950	Santa Monica Bay Shoreline Development Plar	Coastal Engineering '50	Ch.30	271-276				ASCE	Proceedings
no	U.S. Army Corps of Engineers, Los Angeles District		Cooperative Study of Orange County, CA	Beach Erosion Control Study: unpublished; contract # W-04-193-ENG-5196							
no	U.S. Dept of the Navy		grain size analysis for Navy homeporting proje								

TABLE 4 - Selected Sites of Offshore Sand Deposits in Southern Californi:					
SITE	LOCATION	LATITUDE	LONGITUDE	ESTIMATED POTENTIAL VOLUME (Million Cu. Yds.)	REFERENCE
Isla Vista	Santa Barbara Count			24	Noble Consultants (1989
Santa Barbar	Santa Barbara Count			23.5	Noble Consultants (1989
Area C: Borrow Area C-II	Santa Barbara County (Santa Barbar			15	Field (1974)
Carpinteri	Santa Barbara Count			17.6	Noble Consultants (1989
Ventura	Santa Barbara Count			>250.0	Noble Consultants (1989
Area C: Borrow Area C-I	Ventura County (Port Hueneme			68 (marginal quality	Field (1974)
Area C: Borrow Area C-	Ventura County (Port Hueneme			25 (marginal quality	Field (1974)
Area I: B-I	Los Angeles County (Redondo Beach			20.9 - 34.0	Osborne and others (1983
Area I: B-II	Los Angeles County (Manhattan Beach			43.0 - 101.0	Osborne and others (1983
Area I: B-III	Los Angeles County (El Segundo			35.0 - 79.0	Osborne and others (1983
Area I: B-IV	Los Angeles County (Santa Monica Shelf			325	Osborne and others (1983
Area I: B-V	Los Angeles County (Santa Monica			18.0 - 66.0	Osborne and others (1983
Area II: A-I	Orange County (Newport Beach			80.0 - 133.9	Osborne and others (1983
Area II: A-II	Orange County (San Pedro Shelf			194.0 - 220.0	Osborne and others (1983
Area II: A-III	Los Angeles County (San Pedro Shelf			44.5 - 103.1	Osborne and others (1983
Area II: A-IV	Orange County (Huntington Beach			14.8	Osborne and others (1983
Area II: A-V	Orange County (San Pedro Shelf			8.5 - 28.5	Osborne and others (1983
Borrow Area E	Orange County (Surfside/Sunset Beach			1	U.S. Army Corps of Engineers (1989
Borrow Area C	Orange County (Surfside/Sunset Beach			1.4-2.5	U.S. Army Corps of Engineers (1989, 1995
Borrow Area C-2	Orange County (Surfside/Sunset Beach			0.2	U.S. Army Corps of Engineers (1995
Borrow Area C-3	Orange County (Surfside/Sunset Beach			1.6	U.S. Army Corps of Engineers (1995
Area IV: SD-I (SO-9)	San Diego County (Oceanside			32.6	Osborne and others (1983); SANDAG (1993
Area IV: SD-II (SO-8)	San Diego County (Oceanside			27.1	Osborne and others (1983); SANDAG (1993
Area V: SD-III (SO-7)	San Diego County (Carlsbad			16.5	Osborne and others (1983); SANDAG (1993
Area V: SD-IV (SO-6)	San Diego County (Encinitas			12.4	Osborne and others (1983); SANDAG (1993
Area V: SD-V (SO-5)	San Diego County (Solana Beach			10.3	Osborne and others (1983); SANDAG (1993
Area V: SD-VI (SO-4)	San Diego County (Del Mar			2.9	Osborne and others (1983); SANDAG (1993
Area VI: SD-VII (SO-3)	San Diego County (Torrey Pines			3.1	Osborne and others (1983); SANDAG (1993
SO-2	San Diego County (La Jolla			0.03 per yea	SANDAG (1993)
Area VI: SD-VIII (SO-1)	San Diego County (La Jolla			5	Osborne and others (1983); SANDAG (1993
Area VII: SD-IX (MB-1)	San Diego County (Mission Beach			192	Osborne and others (1983); SANDAG (1993
MB-2	San Diego County (Mission Beach			0.01 per yea	SANDAG (1993)
SS-3	San Diego County (North Island			0.12 per yea	SANDAG (1993)
Area VIII: SD-X (SS-2)	San Diego County (Silver Strand			347.5	Osborne and others (1983); SANDAG (1993
Area VIII: SD-XI (SS-1)	San Diego County (Imperial Beach			31.5	Osborne and others (1983); SANDAG (1993
Area VIII: SD-XII	San Diego County (Silver Strand			0.5	Osborne and others (1983
Borrow Area A	San Diego County (Imperial Beach			7.9	U.S. Army Corps of Engineers (2002)
Borrow Area E	San Diego County (Imperial Beach			8.1	U.S. Army Corps of Engineers (2002)

TABLE 5 - Retardation Basins in Orange County

Name	Year Built	Sediment Production Area (mi^2)	Capacity (yds^3)	Sediment Stored (yds^3)**	Sediment Removed (yds^3)	County	Maintained By	Latitude	Longitude
Trabuco Retarding Basin	1996	1.52	0*	na	na	Orange	OCPF&RD	33.6755	117.7628
Bee Canyon Retarding Basin	1995	1.31	62,900	25,577	29,660	Orange	OCPF&RD	33.7083	117.7100
Round Canyon Retarding Basin	1995	1.81	45,200	0	15,400	Orange	OCPF&RD	33.6983	117.6933
Hicks Canyon Retarding Basin	1997	1.24	29,400	467	4,460	Orange	OCPF&RD	33.7350	117.7233
E. Hicks Canyon Retarding Basin	1997	0.69	8,100	150	2,500	Orange	OCPF&RD	33.7350	117.7233
Orchard Estates Retarding Basin	1998	0.69	46,000	0	na	Orange	OCPF&RD	33.7361	117.7531
Auga Chinon Retarding Basin	1998	2.17	64,500	42,616	9,300	Orange	OCPF&RD	33.6950	117.6967

* no designed sediment capacity.
** as of September 22, 2003

OCPF&RD = Orange County Public Facilities & Resources Department. Contact - Mr. John Gietzen, (714) 538-5525