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 2; 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 4. 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.

CGS RECOMMENDATIONS TO THE CSMW

- 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

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