appendix E

Offshore Sources of Aggregate

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Potential sources of aggregate may be found in offshore sediment deposits. For completeness, as part of the inventory of possible sources of aggregate, we examined the regions offshore La Jolla. The Scripps Institution of Oceanography shared its database of offshore resources. Several known deposits of sand and gravel are observed offshore of the San Diego region. Here we present maps for the offshore sand distribution in and around La Jolla, California. The type sediment offshore is based on geophysical and geological data that have been loaded into the SANDAG GIS database as part of this project (Hogarth et al., 2007; LeDantec et al., 2010).

SEDIMENT CHARACTER AND DIFFERENTIATION

Three distinct types of sediment were identified on the shelf offshore of La Jolla and surrounding region: (1) a fine-grained clay and silt deposit formed in an estuarine/lagoonal environment, (2) a sandy-gravel deposit formed during the early sea-level rise, and (3) an overlying fine-grained sand formed since the last 6000 - 8000 years.

The fine-grained silt and clay deposits with interbedded sands are confined to the edges of submarine canyon heads in the region as shown by the red pattern in Figure 1 (Sequence I). The fine-grained nature of these deposits makes them a poor source for aggregate. The coarse-sands and gravels of Sequence II are deposited during the early sea-level rise when wave energy removes the fine-grained particles leaving behind a coarse "lag deposit." These deposits infill low lying regions with thicknesses up to 12 meters and have a characteristic acoustic signature in the seismic data, being highly reflective (Figure 1). These deposits could be good source for aggregate, however, they are mantled by fine-grained sediment in most regions that would make them largely inaccessible (Figure 1). Furthermore, many environmental issues would require careful study and consideration before excavating these sediments for aggregate.

The upper fine-grained sand package (Sequence III) exhibits the most regional distribution across the shelf with thicknesses in excess of 20 meters (Figures 1 and 2). This unit is fine-grained to very fine-grained, homogenous sands based on cores acquired in the area (ranging from 63 – 125 microns - Hogarth et al., 2007). This upper fine-grained unit accounts for the majority of sediment in the region and is potentially a source for aggregate. In San Diego region, there are several sources of sand. For example, alluvial sands are deposited onshore close to the sediment source near mountainous regions with relief. Fluvial sands are transported farther from the sediment source and as a result are usually better sorted and more rounded. Finally sand delivered to the beach and nearshore region undergoes additional sorting and rounding by wave activity and is usually finer grained than the associated onshore sand deposits. The fine-grained nature of the nearshore sand makes it more suitable for beach replenishment. Nevertheless, many additional studies would be required to define adequately the optimum characteristics for an offshore borrow site. For example, is the borrow site close to the beach area being considered for nourishment, is the grain size in the correct size range, and is the sand clean and free of contaminants. Finally, on the basis of discussions with the expert review panel, it was agreed that in general alluvial and fluvial sources of sand that are coarser and less well sorted are preferable for use in concrete than beach and nearshore sands.

A thickness map showing the combined thickness of Sequences II and III (Figure 1A) illustrates how these sequences infill low lying relief in the region. From south to north, we observe the following: 1) fine-grained sediment is absent on top of the hard grounds south of La Jolla Canyon, 2) a thick deposits of fine-grained sand containing >20 meters of sediment occurs between the two branches of the canyon, 3) a second thick lens of fine-grained sand exists to the north of Scripps Canyon and it also contains >20 meters of sediment, and 4) sediment thickness thins to <5 meters across the zone that extends between Scripps Canyon and the northern extent of the study area, which corresponds to a region of tectonic uplift identified by Hogarth et al. (2007).

Although dense high-resolution CHIRP mapping of shelf sediments has only been completed and interpreted from La Jolla to Del Mar, Scripps has acquired a regional grid of sub-bottom data northward to Dana Point. It is clear from the bathymetry of the margin and subsurface data that other areas of the shelf have varying thickness of fine-grained sand offshore that may be a source for aggregate, but appear to be better suited for beach nourishment programs in the region. Tectonics, sea-level fluctuations, and sediment supply govern the distribution of sediment on the shelf offshore San Diego. The main structural features of the area are best observed in the structure of the transgressive surface (Figure 1). This surface was formed due to erosion during the last subaerial exposure of the shelf (~20 ka) and due to wave action during the subsequent sea-level rise (~20 ka – present). In contrast to the seafloor, the transgressive surface shows much variability in topography and roughness in the along-shore and cross-shore directions. These variations in topography along the transgressive surface govern, in large part, where sediments are subsequently deposited and preserved.

Figure 1
CHIRP Seismic Profiles

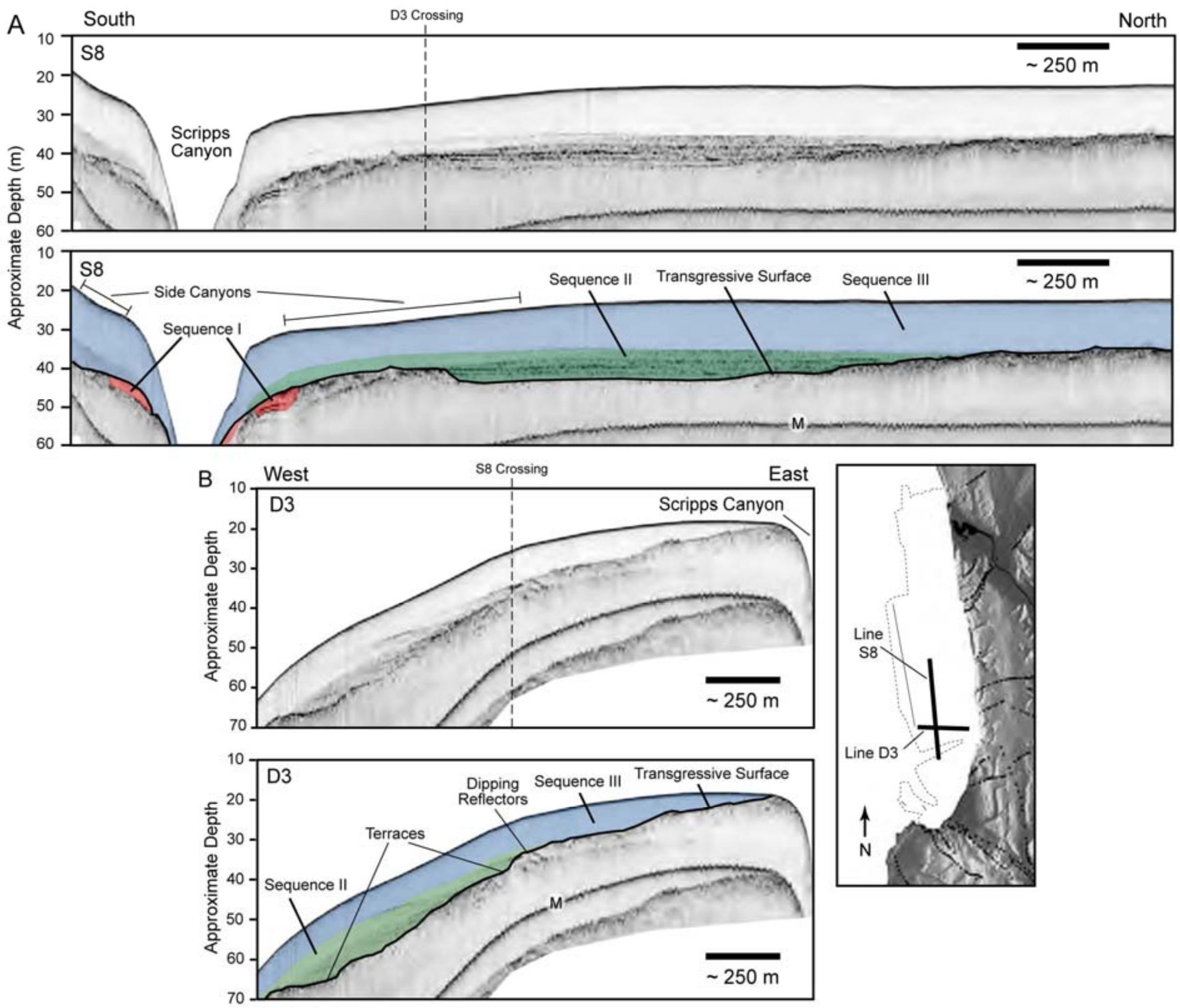

Figure 1. CHIRP profiles. A) Strike line 8 uninterpreted (top) and interpreted (bottom) shows Sequences I, II, and III. B) Dip line 3 uninterpreted (top) and interpreted (bottom) shows Sequences II and III. (M = Multiple). Color code is as follows: red = Sequence I, green = Sequence II, and blue = Sequence III. Thick black line traces the transgressive surface. Bold lines in inset show profile locations.

Figure 2
Thickness Maps of Sequences II and III

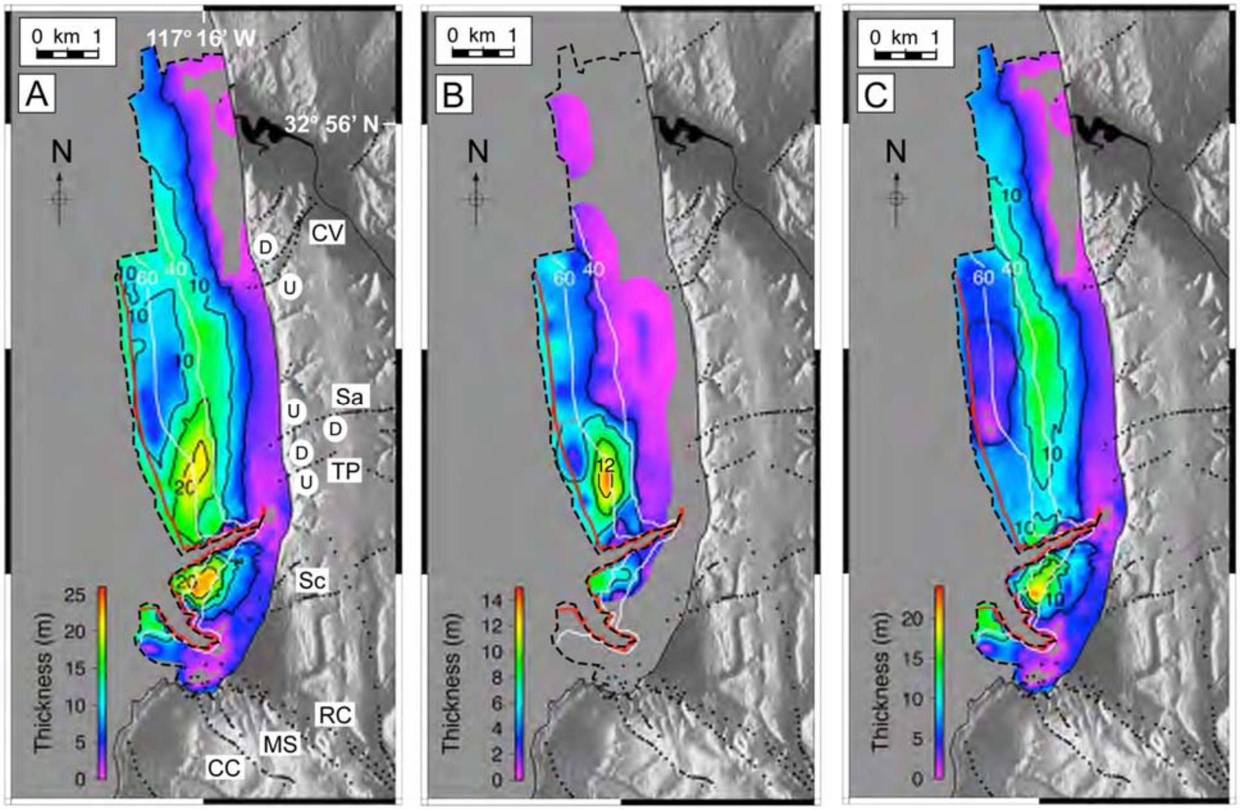

Figure 2. A) Thickness map of Sequences II and III. B) Thickness map of Sequence II. C) Thickness map of Sequence III. Note that Sequence II makes up most of the thickness in the north observed in A, whereas the inter-canyon thickness is predominantly composed of Sequence III. Sediment thicknesses are shown in black. For reference, the 40 meter and 60 meter structure contours to the top of the transgressive surface (white) and the outline of canyon (red) are superimposed. Note thickness scales vary for the different panels and were selected to highlight along-strike variability. Survey area is shown by dashed line, and gray regions within survey area are regions with zero sediment thickness.

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