Preliminary Results of the San Diego Sediment Mapping Study: Sediment Conditions on the Mainland Shelf during 2004

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INTRODUCTION

Maps are useful tools for understanding, managing and protecting the environment, although there has been little success in developing statistically defensible maps of environmental conditions in marine coastal regions. In one of the first efforts to address this need in coastal waters, the City of San Diego and the Southern California Coastal Water Research Project implemented a 2-phased Sediment Mapping Study in 2004. Phase 1 was designed to a) document existing benthic conditions in the mapping region, b) evaluate spatial variability in sediment quality and infaunal communities surrounding the Point Loma and South Bay Ocean Outfalls (PLOO and SBOO, respectively) and an EPA-designated disposal site, and c) optimize sampling distances for use in a Phase 2 study to create detailed maps of specific areas and parameters. Preliminary results of the Phase 1 sediment quality analyses are presented here.

METHODS

Phase 1 introduced a multi-lag cluster design where groups of sites, spaced at various lag distances, were placed around fixed locations on existing sampling grids (**FIGURE 1**). Over 200 sediment samples were collected on the continental shelf off San Diego and northern Baja California at depths from 17 to 224m. These included samples from 40 regular fixed-grid PLOO and SBOO monitoring stations, and more than 150 additional stations positioned throughout the region to evaluate overall spatial variability. At each monitoring site, benthic samples were collected using a 0.1 m^2 chain-rigged VanVeen grab sampler. One sediment grab was collected at each site unless designated as a "field duplicate" site, where two grabs were taken. Field duplicates were treated as individual samples for data summaries to match their use in the spatial variability analyses. Sediments were analyzed for grain size, total organic carbon, total nitrogen, trace metals, pesticides, and PCBs.

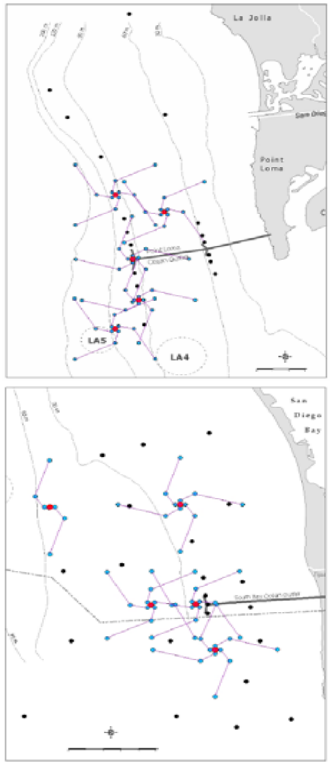

FIGURE 1.
Overview of site distribution for San Diego sediment mapping study; blue circles = new mapping sites, black circles = current or old PLOO and SBOO stations, red circles = cluster enhancement areas representing 3-5 sites, 50-m lag distances apart.

RESULTS

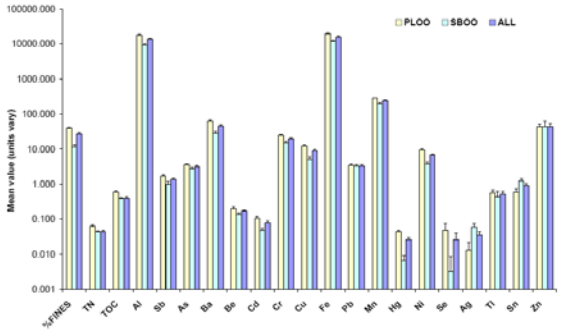

FIGURE 2.
Summary of results for PLOO region (n=112 samples, 101 sites), SBOO region (n=104 samples, 96 sites), and all samples combined. Values are means +/- 95% CI. %Fines=proportion of clay and silt; TN=total nitrogen, TOC=total organic carbon, Al=aluminum, Sb=antimony, As=arsenic, Ba=barium, Be=beryllium, Cd=cadmium, Cr=chromium, Cu=copper, Fe=iron, Pb=iron, Mn=manganese, Hg=mercury, Ni=nickel, Se=selenium, Ag=silver, Tl=thallium, Sn=tin, Zn=zinc. DDT and PCB were not included in these analyses because they were only rarely detected. No other chlorinated pesticides were detected in this study. Mean values for most parameters were higher for the PLOO region than the SBOO region. The few exceptions include silver and tin. The lower TN, TOC, and metals values in the SBOO region correspond to the sandier substrate (i.e., lower %Fines) in this region (see below).

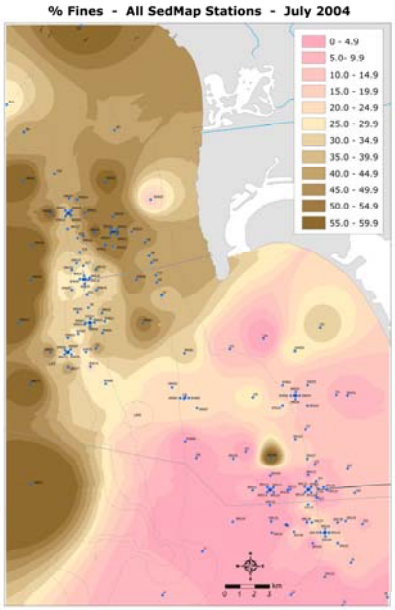

FIGURE 3.
GIS interpolated plot of %Fines using inverse distance weighting. Map clearly demonstrates substrate differences between PLOO and SBOO regions, as well as patchiness within each region. The sediments around the PLOO and to the south are slightly sandier than prior to construction of the outfall (i.e., preconstruction=38% fines vs. 34% fines in this study). It is possible that the physical presence of the outfall structure may have altered hydrodynamics in the region, and therefore affected substrate composition. More analyses are being performed to determine if this change is meaningful, and to determine what other substrate changes have occurred over the years.

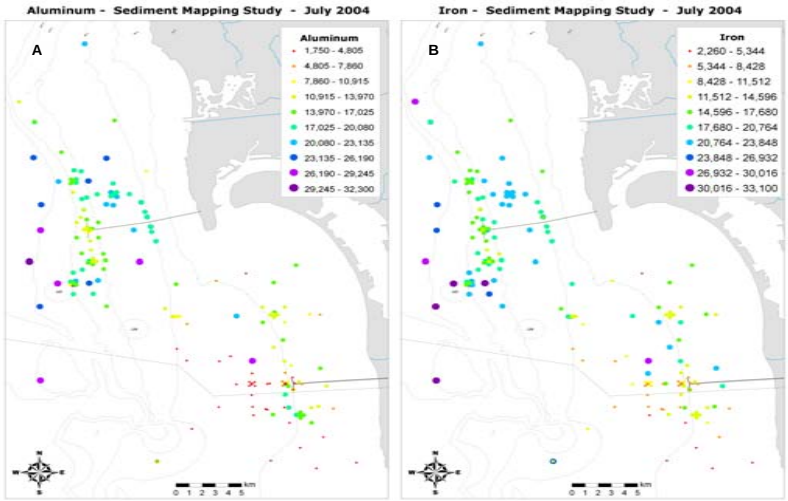

FIGURE 4.
GIS plots of A) aluminum and B) iron. Multivariate analyses were performed on metals data from the 216 samples using PRIMER software to examine spatio-temporal patterns. These analyses consisted of classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking and ordination by non-metric multidimensional scaling. SIMPER (similarity percentage) analysis was used to identify which metals typified each cluster group, as well as the difference between each cluster group pair. Concentrations of aluminum and iron were responsible for the similarity within and dissimilarity between all cluster groups. In addition, most other metals were correlated with either or both of these parameters (see below). Therefore, plots of the actual concentrations of aluminum and iron are provided as a proxy for the multivariate analysis and plots of the metals.

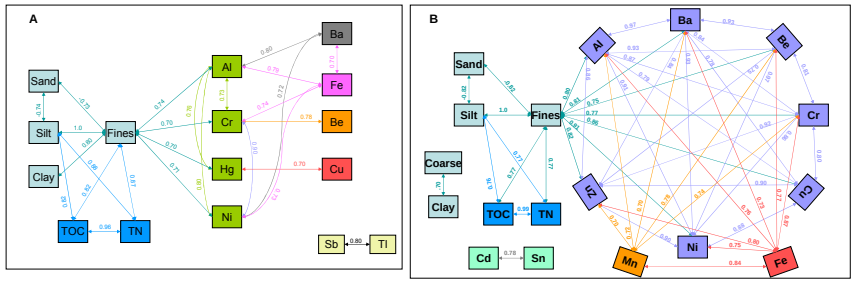

FIGURE 5.
Correlations between various parameters sampled at A) PLOO and B) SBOO sediment mapping stations where r ≥ 0.7. Values are from Spearman rank correlation analysis (SAS). Metals data were log transformed. Because the PLOO and South Bay regions were distinct from each other, these analyses were performed separately for each region. It is interesting that a greater number of metals were more strongly correlated to each other, and several metals were more strongly correlated with %Fines in the South Bay region than off Point Loma. The complicated relationships evident in this figure likely explain why a Principal Component Analysis (PCA) was found to be less than informative.

SUMMARY

This is the first time that the coastal continental shelf off both the Point Loma and South Bay regions have been sampled simultaneously to such an extent. Preliminary results clearly demonstrate that benthic conditions in these two regions are distinct, with different microhabitats (i.e., substrate) and different levels of contaminants. The higher levels of metals detected in the Point Loma region are likely due to the greater amount of finer sediments in the area. Sources of contaminants are quite different for each region as they are subject to inputs from separate watersheds. In addition, the South Bay outfall has only been operating since 1998, whereas there has been an outfall off of Point Loma since the 1960s. However, neither outfall showed a "footprint" of contaminants in the vicinity of the discharge.

Additional analyses are being performed with these data to examine any spatial patterns missed in the preliminary analysis. These additional analyses include maps of all parameters normalized to both %Fines and to iron. These maps may help identify areas where contaminant levels are not explained by substrate differences alone. Also, the SAS procedure Robust Regression was used to identify outliers in the relationships between parameters (data not shown). Consequently, the multivariate analyses and PCA will be re-run with these outliers removed. Finally, the variograms created from these data will allow the design of the sampling program for Phase II, with the intent of providing a scientifically defensible, comprehensive map of contaminants in both regions (see Ritter et al., Seafloor Mapping Session, Wednesday, 20 September 2006, CWO'06 Conference).