Workplan for Phase 2 San Diego Sediment Mapping Study of the Point Loma Ocean Outfall Monitoring Region

Prepared by

The City of San Diego, Public Utilities Department, Environmental Monitoring & Technical Services Division [1]

and

Southern California Coastal Water Research Project [2]

June 13, 2012

[1] Tim Stebbins (tstebbins@sandiego.gov) and Dawn Olson (dolson@sandiego.gov), City of San Diego Marine Biology Laboratory, 2392 Kincaid Rd., San Diego, CA 92101

[2] Ken Schiff (kens@sccwrp.org) and Kerry Ritter (kerryr@sccwrp.org), Southern California Coastal Water Research Project, 3535 Harbor Blvd., Costa Mesa, CA 92626

Introduction

Maps provide environmental managers with useful tools to assess patterns and change in sediment conditions (e.g., sediment quality, biotic communities) over time, including being able to distinguish reference from impacted areas. Despite their potential utility, however, most maps have traditionally been built using simple statistical tools to contour the data derived from relatively coarse sampling grids. If the sample density is too low and combined with unsophisticated statistical tools, the accuracy of the resultant map or maps may difficult to determine. For example, most current maps of sediment condition (such as contaminant concentrations or grain size distributions) represent interpolations that do not include confidence estimates of their predictions.

Kriging is one of the more powerful statistical tools for mapping. With kriging methods maps are constructed using spatial variance among neighboring sampled locations to predict values in unsampled areas located between the sampled sites. Just as importantly, spatial variance also enables calculation of confidence.

Ultimately, spatial variance helps determine optimal distances between sampling sites for mapping. If the spatial variance is high, then samples should be collected closer together to increase confidence at unsampled locations. In contrast, if spatial variance is low, then samples can be spaced further apart to achieve the same confidence. Unless spatial variance is characterized, the sample locations will likely be placed inefficiently, suffering from imprecision if samples are spaced too far apart or wasted resources if samples are placed too close together.

The San Diego Sediment Mapping Study was conceptualized as a two-phased project to achieve two primary goals: 1) estimate spatial variance; and 2) create a map of sediment condition using kriging and an optimized sampling grid. Phase 1 was expansive in that it was designed to estimate spatial variance for both sediment quality and benthic macrofaunal community condition in two distinct areas of interest off San Diego, the Point Loma Ocean Outfall and South Bay Ocean Outfall monitoring areas (Stebbins et al. 2004). This phase has been completed. This work plan summarizes the results of Phase 1 and proposes a sampling design for a more focused Phase 2 study to create a scientifically defensible map of sediment condition in the Point Loma outfall region.

Work Completed To Date (Phase 1)

Estimating spatial variance was a prerequisite to creating statistically defensible maps of sediment quality surrounding the Point Loma and South Bay ocean outfalls, and this task was accomplished during the first phase of the project. The Phase 1 sample design leveraged a multi-lag cluster approach to capture variability (and any directionality to that variability) at a range of spatial scales (see Stebbins et al. 2004, Ritter & Leecaster 2007). Almost 200 sites were sampled offshore of San Diego with distances between stations ranging from <100m to greater than >10,000m. Samples were analyzed for sediment grain size, chemistry, and infaunal biology. Two important outcomes resulted. First, various kriging models were evaluated and the best models of spatial variance were used to optimize future mapping designs. These models were then used to construct **Figure 1**, a cost efficiency model (curve) which illustrates the relationship between percent of total error (i.e., statistical confidence) and distance between samples for estimating grain size (% fines) and biological condition (benthic response index or BRI). This curve shows about a 5-10% increase in confidence for every 500m reduction in spacing. The second outcome was a preliminary map of the study area. We used this map to identify areas of contamination concern. These two outcomes formed the basis for refined mapping in Phase 2.

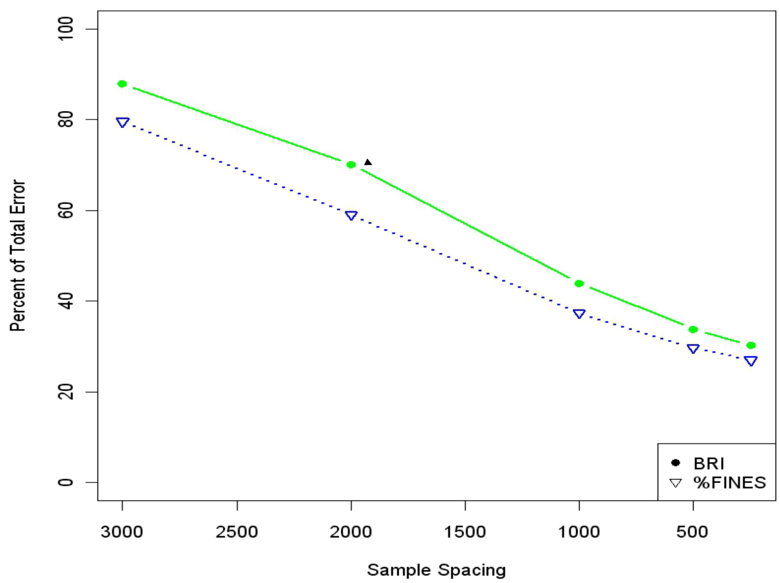

Figure 1. Relationship of sample spacing and statistical confidence for the Pt Loma outfall region based on cost efficiency model results. Sample spacing in meters; %fines = grain size fraction < 0.63 µm; BRI = benthic response index.

Work for this Year (Phase 2)

Project Design

Using our estimates of spatial variance, the directions of highest and lowest variance, and identified areas of interest from Phase 1, we will complete the second project goal in Phase 2: to create a cost efficient and statistically defensible map of sediment quality for the Point Loma outfall region. The optimized design utilizes a two-density sampling grid with additional "satellite" stations placed short distances (either 250m or 500m) away from their anchor points – a subset of the grid stations (**Figure 2**). The base grid will have sites spaced 800m apart in the cross-shore (greatest variability) direction and 1200m apart in the along-shore (least variability) direction. The enhanced grid, which surrounds the outfall, will have samples spaced 550m x 800 m apart (in the cross-shore and along-shore directions, respectively). The rotation (tilted placement) of the new grid stations is to account for the strong directionality to the spatial variability of the percent fines distribution in the Point Loma region derived from Phase 1. The map will be further enhanced with samples from the 12 regular, primary core Point Loma outfall benthic monitoring stations, which are sampled every six months at set distances away from the outfall in the north-south direction along the 100 m isobath. Finally, duplicate samples will be collected at a subset of the new grid stations in order to estimate measurement error and small scale variability.

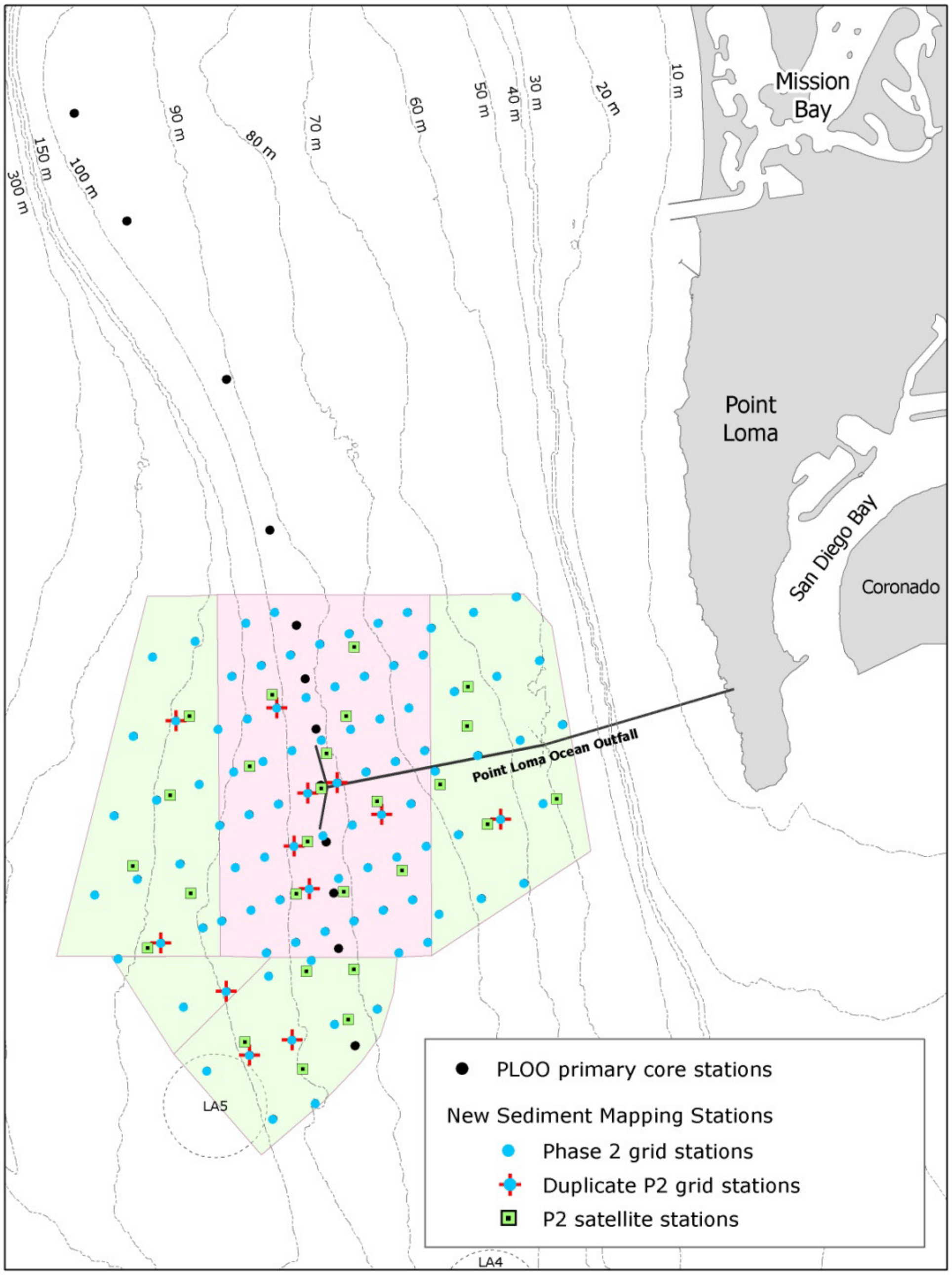

Figure 2. Optimized sample locations for sediment mapping of the Pt Loma outfall area. Green area = base grid (800m x 1200m spacing). Pink area = enhanced grid (550m x 800m spacing).

The sampling design has been subjected to iterative improvements in satellite station placement, most notably to balance areal coverage versus sampling density. The final design maximizes the area covered while still providing enough closely-spaced point pairs (see **Figure 3**: lag distance plot) to establish confidence in the final spatial model. The result will be a statistically defensible map of sediment grain size parameter and contaminant concentration contours, including estimates of statistical confidence based on a cost-effective sampling strategy. The results should confirm, refine and empirically define confidence limits for the Phase 1 variogram models. Future mapping surveys will be able to re-use this same design to determine spatial patterns in other areas of interest off San Diego or investigate temporal trends.

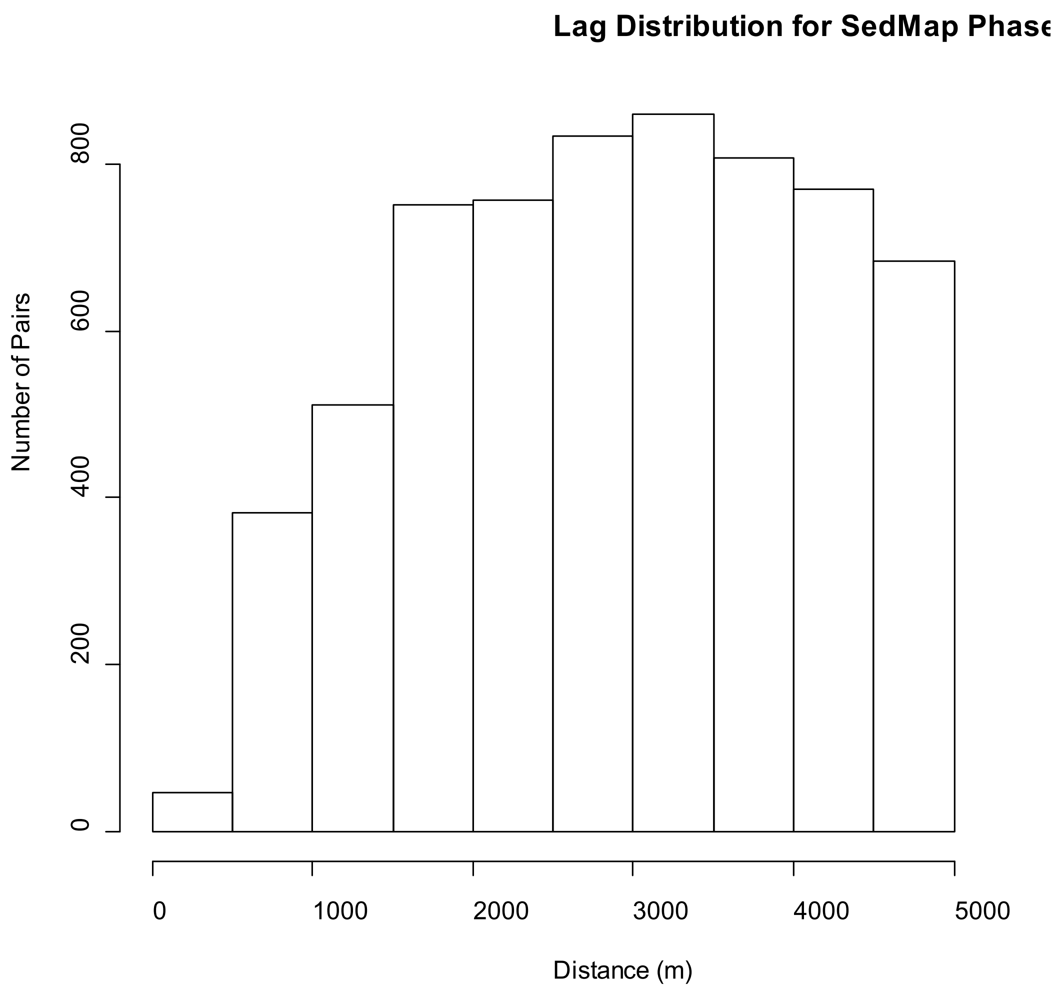

Figure 3. Lag distribution (station-to-station distances) for Phase 2 sediment mapping sampling locations.

Sampling and Analysis

Benthic samples will be collected using a 0.1 m^2 double VanVeen grab sampler at a total of 133 sites off Point Loma, San Diego, California (Figure 2 and **Table 1**). Criteria established by the USEPA to ensure consistency of grab samples will be followed with regard to sample disturbance and depth of penetration (USEPA 1987). Differential global positioning (dGPS) will be used for navigation, and the final sampling location will be recorded for each site at the time the grab hits bottom. One sediment grab will be collected at each site unless designated as a "duplicate" site in which case two sediment samples will be collected. All samples will be collected and processed according to existing protocols (see below).

Table 1. Sampling effort and distribution for Phase 2 San Diego Sediment Mapping Study (see Figure 2).

Station Type	No. of Stations by Area of Interest				No. of Samples
	Enhanced Grid	Base Grid	Outside Grid Area	Total Stations	
P2 Grid					
Regular (1 rep)	49	34	0	83	83
Duplicate (2 reps)	6	6	0	12	24
P2 satellite (1 rep)	11	15	0	26	26
PLOO Primary Core (1 rep)	7	1	4	12	12
TOTAL	73	56	4	133	145

Sediment samples from the new mapping sites will be processed according to the procedures (e.g., holding times, analyte list) established for the Southern California Bight 2008 Regional Monitoring Program (Bight'08 Coastal Ecology Committee 2008, Schiff et al. 2011). Samples from the 12 regular Pt Loma Ocean Outfall monitoring sites will be analyzed following similar procedures, although the analyte list will be expanded to include all constituents required in the City's NPDES permit (see City of San Diego 2011). All samples will be analyzed for grain size, total organic carbon (TOC), total nitrogen (TN), trace metals, chlorinated pesticides, polychlorinated biphenyl compounds (PCBs), and linear alkaline benzenes (LABs). The Bight'08 target lists for metals, pesticides and PCBs are specified in **Table 2**. Details of LAB analysis are still to be determined, but these samples will likely be analyzed on a contingency basis with the results from initial near-outfall sites determining if LABS can be effectively detected elsewhere in the region.

Table 2. Bight'08 target list of trace metals, pesticides and PCBs for sediment analyses (see Bight'08 Coastal Ecology Committee 2008).

Trace Metals	Pesticides	PCBs	
Aluminum	4,4'-DDT	PCB-18	PCB-128
Antimony	2,4'-DDT	PCB-28	PCB-138
Arsenic	4,4'-DDD	PCB-37	PCB-149
Barium	2,4'-DDD	PCB-44	PCB-151
Beryllium	4,4'-DDE	PCB-49	PCB-153
Cadmium	2,4'-DDE	PCB-52	PCB-156
Chromium	α-Chlordane	PCB-66	PCB-157
Copper	γ-Chlordane	PCB-70	PCB-158
Iron		PCB-74	PCB-167
Lead		PCB-77	PCB-168
Mercury		PCB-81	PCB-169
Nickel		PCB-87	PCB-170
Selenium		PCB-99	PCB-177
Silver		PCB-101	PCB-180
Zinc		PCB-105	PCB-183
		PCB-110	PCB-187
		PCB-114	PCB-189
		PCB-118	PCB-194
		PCB-119	PCB-201
		PCB-123	PCB-206
		PCB-126	

Project Schedule

This entire Phase 2 project will take approximately two years to complete (**Figure 4**). The first six months were used for finalizing the Phase 1 results and assessing the appropriate sampling design for Phase 2. Field sampling is planned to take place during July-August 2012. Sample processing and analysis will require about 10 months, followed by about three months of preliminary data analysis and interpretation. The final three months will be reserved for advanced data analyses such as model comparisons, development of visualizations to incorporate error/confidence statistics, and preparation of a final report. Project completion for Phase 2 is scheduled for December 2013 to early 2014.

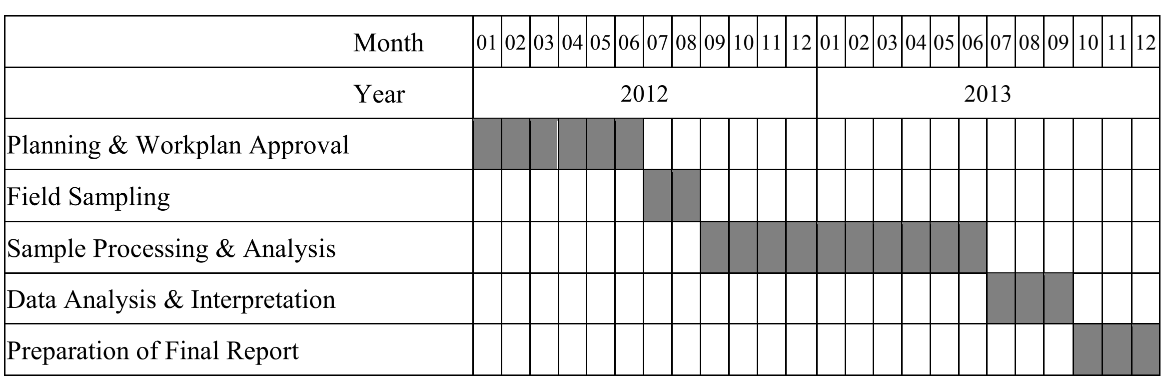

Figure 4. Schedule for Phase 2 San Diego Sediment Mapping Study.

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