Data Collection Protocol
Tidal Wetland Sediment Contamination

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Introduction

Concerns about intertidal sediment contamination are increasing in the Bay Area. There is concern that ambient levels of contamination have not been adequately assessed as the context for setting project performance criteria, and that the breaching of levees to restore tidal wetlands might release contaminants from diked sediments into the estuary ecosystem.

This protocol is based primarily on the work in 1994 and1995 for the wetlands contamination pilot study of the Regional Monitoring Program for Trace Substances (SFEI 1997, p. 257–280).

Personnel

It is desirable to have a methodology that can be used by supervised personnel with little or no previous experience in contaminant monitoring, such that many people, including those more familiar with ecological or hydro-geomorphic work, might be available to conduct the contaminant studies in many places throughout the region. Therefore, this protocol was designed to allow the use of trained volunteers in the field. Using volunteers can be an excellent way to conserve funds or increase sampling coverage or frequency.

Sampling Plan

Sampling Strata

This protocol regards the tidal marsh as composed of discrete geomorphological components that probably differ with respect to sediment contamination. These components include channels of various orders[1], the vegetated plain, levees, and pannes

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[1] For a definition of channel order, see Strahler, 1957.

(see WRMP version 1 Part 1 Science Framework). In keeping with most other types of tidal marsh research, these parts of the marsh should be recognized as discrete sampling *strata*, or subregions to sample and characterize.

This protocol is written for sampling tidal marsh channels, but could be applied to any other stratum in tidal marsh.

For each selected stratum, only unconsolidated fine-grain sediments of recent deposition should be sampled. This is because sediments accumulate over time in tidal wetlands and samples of varying depths therefore represent different time periods. Such sediment in channels lacks a diatom felt and is very easily penetrated. This sediment type is common on the surface of recent slump blocks and the surface of actively accreting point bars on the inside of meander bends (Figure 1).

Selection of Sampling Sites, Stations, and Units

Sites are marshes; stations are examples of each stratum to be characterized, and each sample unit is a composite of 10 sub-units from a single station.

The plan outlined here assumes that there is a need to compare one marsh site to another, or to track changes within a marsh over time, based on the sediment contamination levels within the channel network. The approach outlined here can also be applied to any other stratum. It should be noted that the channel strata can be further classified as either having direct fluvial inputs (i.e., the tidal marsh channel leads from a creek or stormdrain), or not having such direct inputs.

At each marsh, three replicate stations should be randomly chosen for each stratum. For example, in order to characterize the sediments of a large channel network, one station for each of three small channels (e.g., first- or second order channels), and three reaches in one large channel should be randomly selected. The stations should be selected at random from population of all possible stations at the site. The population of stations can be enumerated from aerial photos of 1:12,000 or smaller scale. Locations of each selected station should be carefully recorded on maps and with GPS, and not reused in subsequent sampling periods.

Each station should consist of a reach of channel about 20-m long. Sub-sampling should occur at random locations within each station The randomness of sub-sample locations can be informal, chosen by eye in the field just prior to sampling.

A sample sub-unit is defined as sediment collected in a single sediment core from the surface of the sediment to a depth that corresponds to the anoxic horizon. The horizon is typically indicated by a distinct darkening in sediment color. Our field tests have shown that this horizon is usually about 5 cm deep. If no color change is apparent, the upper 5 cm of sediment should be recovered at the rest of the core discarded. Thus, with a

5cm diameter core, each sub-sample will have a volume of about 100 cm^3, and each sample unit will have a volume of about 1000 cm^3.

A sample is defined as a composite of the 10 sub-units taken from one station within one stratum during one sample period. The 10 sample sub-units for each sample are thoroughly mixed and then split into three equal parts for separate analyses of trace element, mercury, and organic contaminant content. Mixing together the sample sub-units for a given sample serves to minimize the effects of very small-scale heterogeneity across the channel substrate at a station. Also, by randomly selecting sub-units within a relatively large sample station, the impacts of fieldwork on the fragile plant cover of the tidal marshlands are minimized. Photographic accounts of the 1995-1996 sampling effort revealed no residual visual impacts that lasted between sample periods.

The three samples for each stratum are processed separately to yield a mean and variance estimate for each stratum at each site. This allows comparison between strata within a site and between sites.

Timing

The sampling effort should occur during low tide at the end of a neap tide cycle. Sampling must occur when the tide level is low enough to expose the sediments to be sampled. Ideally, all sampling at all stations within a marsh should happen during one ebb tide. If this is not possible, then sampling should be completed the following day. Sampling should occur at the end of a neap cycle because surficial sediments tend to accumulate in channels during neap tides and then are scoured during subsequent spring tides. The objective is to sample the material most recently deposited before it is re-worked by the tides. This helps assure that the data describe recent conditions.

Seasonality

To capture potential seasonal variation in contamination, sampling should occur at least twice a year, once during the wet season (January through March) and once during the dry season (July through September). If only one annual sample is to be taken then it should correspond to the period of maximum re-suspension of sediments from tidal flats, which usually occurs during spring. This helps to assure that the samples will capture the material imported into the sites from the nearby tidal flats and bays.

Sampling Gear and Procedure

Sampling Gear

Note: If simultaneous sampling of the three replicate stations per stratum is planned, using three separate sampling teams, then equipment quantities should be tripled. It is usually possible to avoid this redundancy (and increased cost) by starting the field work in small channels as soon as they dewater, and then proceeding downstream from small to large channels as the tide recedes.

Gear List

- 2 sampling scoops coated with Teflon® or other chemically-inert material such as Dykon®, about 30 cm3 volume each

- 1 thick walled glass tube, 5 cm inner diameter, 2 m length

- 1 10-liter Telflon or Dykon coated compositing bucket

- 2 1-liter glass jars

- Alconox detergent

- 10% HCL

- plastic wrap

- Ziploc bags

- measuring tape with cm increments

- large funnel

- large plastic cooler with ice

- 4 1-gallon plastic containers for in-field waste liquid disposal

Field Procedures

The following Procedure Should Be Followed for All Samples (assuming that the channel network is the stratum to be sampled. stratum to be sampled)

1. One week prior to sampling, all equipment should be thoroughly cleaned with Alconox® detergent. Teflon®-coated sampling scoops should be soaked in the detergent for two days, then rinsed three times with de-ionized water, soaked three days with 10% HCL, and finally rinsed with petroleum ether. The cleaned scoops should then be stored in sealed Ziploc® bags until used in the field. Following the detergent wash, the glass coring tubes and Teflon®-coated bucket should be rinsed with tap water, followed by three rinses with de-ionized water, a rinse with 10% HCL, and a final rinse with petroleum ether. The ends of the glass coring tubes and the top of the bucket should be sealed with aluminum foil.

2. All samples should be taken with the glass tube. Sample sub-units should be randomly selected in unconsolidated fine-grain sediment below the exposed root zone of the bank vegetation and above the bed of the channel.

3. The tube should be inserted through the upper layer of unconsolidated sediment and into the under-laying consolidated sediments. In practice, the tube is inserted to a depth of firm resistance from the stiff, consolidated sediments (this depth is typically about 15 cm). If the depth to resistance is less than 5 cm, then another nearby place for the sample sub-unit should be selected. As the glass tube is inserted, its top end should be kept uncovered, to prevent back-pressure that could inhibit the sediment from entering the bottom of the tube.

4. The tube should be extracted from the substrate by turning the tube in a twisting motion to break the connection between the tube and the stiff under-laying substrate. Before the tube is pulled from the substrate, a partial vacuum pressure within the tube should be created by inhaling from the tube and then quickly covering the tube end with one hand or a rubber stopper. The plug of stiff sediment at the base of tube and the partial vacuum in the tube helps the tube hold the core.

5. The total length of the core in the tube should be measured to the nearest 0.5 cm. The outside of the tube should be wiped clean with a dry cloth to clearly view the core.

6. The core should be slowly extruded from the tube by blowing on the top end of the tube until only the oxidized sediments (or the top 5 cm of the core, see discussion above) remain inside. The clean scoop should be used to cut the extruded portion of the core flush with the bottom of the tube. The extruded portion (representing anoxic conditions) should be discarded. The length of core retained should be recorded for each sample sub-unit.

7. The remaining portion of the sediment core within the tube should be extruded into the Teflon©-coated bucket. This procedure requires one person to blow into the top end of the tube and a second person to measure, cut, and otherwise direct extrusion of the core.

8. After all ten sub-units from a station have been combined in the bucket, then the clean scoop should be used to thoroughly stir the combined sediment into one homogenous mixture. The bucket is then sealed with plastic wrap.

9. Using the same scoop, about one liter of the homogenous mixture is placed into a clean glass jar, sealed and labeled, and the jar is placed on ice for short-term storage. Space should be left at the top of the sample jar to allow for expansion of the sediment due to freezing. The rest of the sample is discarded.

10. To avoid cross-contamination between stations and strata, prior to sampling a new station or stratum all utensils, buckets, and glass core

tubes should be rinsed with tide water, then scrubbed thoroughly with Alconox®, followed successively by one rinse with de-ionized water, one rinse with 1% HCL, and one rinse with methanol. Spent chemicals should be bottled separately and disposed of properly outside of the marsh.

11. Care must be taken throughout the sampling effort to avoid trampling vegetation or intensively working at one place along a channel.

Sample Analysis

Methods

Standardization of methods and parameters between the sediment monitoring of the Regional Monitoring Program for Trace Substances (RMP), which has been sampling Estuary bottom sediments since 1993, and the tidal marsh sampling allows the data from both programs to be directly compared to aid understanding of wetland-bay relations. To keep the data of the two programs comparable, all samples should be processed according to established RMP analytical methods using the same laboratories that process RMP sediment samples, and be subject to the same quality assurance and quality control procedures. Details on these methods and procedures can be found at the following to Internet sites:

http://www.sfei.org/rmp/1998/c06.html,

http://www.sfei.org/rmp/reports/1999_QAPP/99_QAPP.html.

Parameters

Samples should be analyzed for the following parameters, based on the RMP for Trace Substances.

Ag, Al, Cd, Co, Cu, Fe, Hg (total), CH_3Hg^+ (methylmercury), Mn, Ni, Pb, and Zn

PCBs (congener-specific analysis), PAHs, pesticides, and pesticide by-products

% clay, silt, and sand; % solids, pH, total ammonia, total organic carbon, and total sulfide.

Expected Cost

The expected labor cost for data collection at one marsh site, including equipment preparation, 1 hour of travel time, and the collection of 60 sample sub-units (10 per station, 3 stations per stratum, 2 strata per site) is $1000, based on a labor rate of $50/hr. Laboratory analysis of 1 sample for the parameters listed above might be $5,000. The expected cost for one set of the listed field equipment is expected to be $600. Total

estimated costs per site per sample period, excluding one-time gear costs, is therefore about $18,000.

Reporting Units

All concentrations of trace elements should be reported in parts per million, and all organic compounds in parts per billion.

Data Presentation

Contaminant concentrations for one marsh can be presented using a simple bar chart, one chart per contaminant, with the y-axis indicating concentration and the x-axis the stratum. In the interests of space, for most organics contaminants, only totals (total PCBs, DDTs, PAHs, and chlordanes) should be presented graphically. Time series data for multiple sampling periods can be presented using a line chart.

If results from multiple marshes are to be presented together, the preferred format is a map, with either color- or size-coded circles used to indicate contaminant concentrations.

In all graphics, an appropriate ecological guideline should be clearly indicated or compared to, to provide context for the values presented. The default guideline would be the Effects Range Low guideline by Long et al (1995).

Given the sparseness of the data generated (3 data points per stratum per marsh per sampling period), relative to the expected variance for any one sample period, initial statistical analyses will not have much power. However, when a sufficient time series is obtained (at least 5 years of data), trend analyses can be made, and pair-wise t tests can be used to look for seasonal differences within and between marshes.

References Cited

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1):81–97.

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Figure 1. Diagram of typical sampling point for unconsolidated sediment on the inside of a meander bend of second-order channel in tidal marsh.
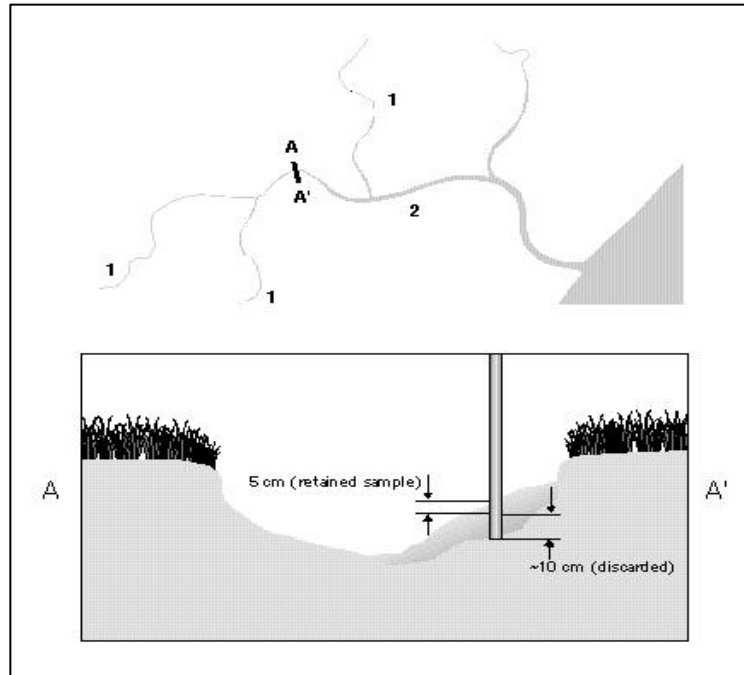

Figure 2: Example data sheet