PS/SS: Development of Benthic Community Condition Indices for Mesohaline Environments of the San Francisco Bay.

Estimated Total Cost: $125,800 (two-year study 2012 and 2013)
$50,000 has been to 2012 activities

Oversight group: Exposure and Effects workgroup
Proposed by: Eric Stein SCCWRP

Funding requested for 2013: $75,800

Introduction and Background

Benthic community assessment is often used as an indicator of ecosystem condition and has become a central element of regulatory programs such as the California's sediment quality objectives for bays and estuaries. Benthos are the indicators of choice for monitoring and assessment for several reasons, including:

- Limited mobility makes them indicative of impacts at the site where they are collected.
- Several animal phyla and classes are sensitive to impacts to their environments and can be used to differentiate certain types of effects.
- Life-histories are short enough that the effects of one-time impacts disappear within a year but long enough to integrate the effects of multiple impacts occurring within seasonal time scales.
- Living in the bottom sediments, benthos have high exposure to common anthropogenic impacts, such as sediment contamination, high sediment organic carbon, and low bottom dissolved oxygen.
- They are important components of aquatic food webs, transferring carbon and nutrients from suspended particulates in the water column to the sediments by filter feeding and serving as forage for bottom-feeding fishes.

For benthic data to be useful in a regulatory context, they must be interpreted in relation to scientifically valid criteria or thresholds that distinguish "healthy" from "unhealthy" benthic communities. While reducing complex biological data to index values has disadvantages, the resulting indices remove much of the subjectivity associated with data interpretation. Such indices also provide a simple means of communicating complex information to managers, tracking trends over time, and correlating benthic responses with stressor data.

To date, benthic indices have been calibrated and validated for two nearshore habitats in California, 1) southern California marine bays, and 2) polyhaline (high salinity) portions of San Francisco Bay. Indices have not been developed for other habitats such as the low salinity mesohaline and tidal freshwater environments. These habitats are particularly challenging because they are naturally subject to relatively broad ranges of conditions (e.g. salinity and dissolved oxygen) and hence the resident organisms are adapted to tolerate environmental stress.

These challenges can be addressed through compilation of robust data sets, careful identification of reference conditions to anchor indices and development of multiple indices that can be used to increase overall sensitivity to detect change in condition.

The objective of this project is to develop and calibrate a minimum of three benthic indices for the mesohaline environments of San Francisco Bay. To the extent possible, we will use the initial consultations with experts to provide a foundation for future work on developing an index for the tidal fresh environment. We do not anticipate that the currently available funds are sufficient for full index development. Therefore, we have divided this proposal into two phases that could be independently funded and would each produce defined products.

Study Objective and Applicable RMP Management Questions:

The objective of this effort is to develop an index for the mesohaline portions of the Bay. This study would assist in our ability to answer the following priority questions for benthos:

1. What are the spatial and temporal patterns of impacts of sediment contamination?
2. Which pollutants are responsible for observed impacts?
3. Are the toxicity tests, benthic community assessment approaches, and the overall SQO assessment framework reliable indicators of impacts?

Overall Study Approach

We will focus on the development of three indices. The first two indices are based on species composition of large numbers of species: the Benthic Response Index (BRI; Smith et al., 2001; Smith et al., 2003; Ranasinghe et al., 2009) and the River Invertebrate Prediction and Classification System (RIVPACs; Wright et al., 1993; Van Sickle et al., 2006; Ranasinghe et al., 2009). The third index will be a multimetric index (MMI) based on community measures and indicator species (e.g. the Index of Biotic Integrity; IBI; Thompson and Lowe, 2004; Ranasinghe et al., 2009).

Index development will be divided between two phases that can be independently funded and that each have independent products.

Phase 1 (to be completed in 2012 with already approved 2012 funding)

Task 1: Update database. Update the existing 2,200 sample 1992 to 2008 standardized taxonomy benthic database with recently collected benthic data and associated habitat (salinity, depth, sediment grain size distribution, and total organic carbon), chemical contaminant, and sediment toxicity data.

Task 2: Refine Habitat Definitions. Refine the San Francisco estuary and delta habitat definition scheme to facilitate the application of SQOs. The original SQO habitat boundary definitions were based on about 140 San Francisco Bay samples in a 714 sample U.S. west coast data set (Ranasinghe et al., In Press). A subsequent study based on more than 501 San Francisco Bay samples (Thompson et al., In Revision) identified potential subtle differences that should be evaluated and defined for SQO implementation. The differences include (1) potential differences in the areal definitions of existing habitats, especially at the Bay margins, and (2) potential addition of an oligohaline habitat between the mesohaline and tidal freshwater habitats in the Suisun Bay region.

Task 3: Identify and Withhold Validation Data and conduct BPJ study. For each new habitat, identify about 20 samples covering the entire range of habitat conditions for inclusion in a BPJ benthic expert study. These samples will be withheld from the calibration data set in order to assure independence of the two data sets. Experts will be asked to (1) rank the validation samples from least to most disturbed, based on species abundance and minimal habitat data, (2) assign each sample to one of four assessment categories, based on existing narrative definitions, and (3) identify sample characteristics used to rank and categorize the samples.

Budget, Schedule, and Deliverables

The main products of Phase 1 would be the database of organisms and their associated habitats and the results of the BPJ study, which would allow the designation of "good" vs. "bad" locations based on taxonomic composition. At the conclusion of Phase 1, we would also produce a general roadmap for next steps in constructing the benthic indices.

The total cost to complete the Phase 1 tasks would be $35,323 (Table 1). We anticipate the work would take approximately 3-4 months to complete depending on quality of the data sets and the availability of the expert panel for the BPJ exercise.

Table 1. Phase 1 Budget

Task	Description	Total
1	Update Database	6,894
2	Refine Habitat Definitions	2,219
3	Identify and Withhold Validation Data and conduct BPJ study	26,209
Total		35,323

Phase 2 (to be initiated with 2012 funds; however, bulk of the funding is being requested from 2013 funds)

Task 4: Develop and Calibrate Benthic Indices. Develop and calibrate indices based on relative site conditions using the standard statistical methods appropriate for each index.

Task 5: Assure Independence of Indices and Habitat Factors. Each calibrated benthic index will be tested for independence from habitat variables such as salinity, sediment grain size distribution, sample depth, latitude, longitude, and total organic carbon. While it is generally accepted that current models of benthic response do not discriminate between chemical contamination and other sources of stress (Borja et al., 2003) this approach will ensure that indices are not driven by habitat factors. The goal is an index responsive to benthic community condition, rather than being driven by one or two habitat factors such as sediment grain size distribution or sample depth.

Task 6: Calculate Benthic Index Values. Benthic index values will be calculated for the validation samples, recently acquired data, and new indices for previously acquired data by applying formulae developed during index calibration.

Task 7: Evaluate and Validate Benthic Indices. The BPJ study results and index values calculated by applying formulae developed by index calibration will be used to validate the indices, establish threshold index values for assessment category assignment, and select the most accurate index or combination of indices for application of SQOs.

Task 8: Prepare Summary Report/Journal Article: Results of the study will be written up for publication to a peer-reviewed journal. The journal manuscript will serve as the final project deliverable.

Budget, Schedule, and Deliverables

The main products of Phase 2 would be validated benthic indices for the mesohaline habitat and the journal manuscripts that document their development and testing process.

The total cost to complete the Phase 2 tasks would be $90,508 (Table 2**); $75,800 is being requested for work in 2013.** We anticipate the work would take approximately 6 months to complete following the completion of Phase 1.

Table 2. Phase 2 Budget

Task	Description	Total
4	Develop and Calibrate Benthic Indices	26,354
5	Assure Independence of Indices and Habitat Factors	8,785
6	Calculate Benthic Index Values	8,785
7	Evaluate and Validate Index	20,459
8	Prepare Journal Article/Project Report	26,126
Total		90,508

Literature Cited

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