PS/SS: Development of Benthic Community Condition Indices for Mesohaline Environments of the San Francisco Bay.
Phase II – Index Creation and Validation

Oversight group: Exposure and Effects workgroup
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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.

The development of any successful assessment tool requires: 1) the clear delineation of the habitat where it will be applied; 2) compilation of available benthic biotic and abiotic data; and 3) the identification of reference conditions to anchor the tool. Phase I of this work (Gillett et al. 2014) details the results of these activities. The work done to date provides the necessary information for the creation, calibration, and validation of an assessment tool(s) for the mesohaline habitats of San Francisco Bay.

However, during discussion of the Phase I results with the RMP advisory committee and interested stakeholders, concerns were raised about the complexity and heterogeneity of the mesohaline portions of the San Francisco Bay Estuary. In light of these concerns, the RMP advisory committee has suggested to first address only the South Bay sub-habitat of the mesohaline San Francisco Bay. Upon successful demonstration of an assessment tool that works in this sub-habitat, its applicability to the other mesohaline habitats can be investigated as well.

As such, the objective of this project will be to develop and calibrate an assessment tool for the evaluation of benthic habitat condition in the mesohaline South Bay sub-habitat of the San Francisco Bay Estuary. The assessment tool will focus on macrobenthic community structure and consist of one or more indices calibrated and validated for the macrobenthic fauna in the southeast portions of South San Francisco Bay, excluding the lower salinity tributaries in the east and south.

Study Objective and Applicable RMP Management Questions:

The objective of this effort is to develop an assessment tool for the mesohaline portions of the South Bay sub-habitat. This work will assist in our ability to answer the following priority questions for the 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?

Study Approach

Reference Definition - As noted above, the Phase I portion of this work began the development of a reference condition definition for the entire mesohaline habitat of the San Francisco Bay Estuary. Given the change in focus of the study to only the South Bay sub-habitat, additional refinement of this reference condition definition will be needed. The new, geographically conscribed area may have, as some of the RMP stakeholders suggest, subtly different reference expectations than the mesohaline habitat considered as a whole. As such, verification of the general mesohaline reference definition in the South Bay sub-habitat will be required. If ecologically meaningful differences in expected community structure are identified, then a new reference definition will be developed in conjunction with the best professional judgement (BPJ) panel assembled for Phase I of this study.

Index Creation and Calibration – Once a suitable reference definition is established for the South Bay, then an assessment tool will be developed to detect statistical and ecological departures from the reference expectation. There are a variety of technical approaches that can be used to measure these departures ranging from a tolerance-to-pollution approach (e.g., BRI [Smith et al. 2001], M-

AMBI [Muxika et al. 2007]) to an environmentally modeled expectation (e.g., RIVPACS [Wright et al. 1993], CSCI [Mazor et al. *in press*]). The final approach used in the assessment tool will be in part technical and in part what is most easily implemented in the RMP. The final assessment tool may consist of multiple indices, as Ranasinghe et al. (2009) have demonstrated that the redundancy of multiple indices can be useful in minimizing the occurrence of false-negatives in multi-stressor environments like estuaries.

Index Validation – First, 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. This process is necessary to ensure that the index performance is driven by community condition, not natural habitat factors. Secondly, each index will be tested against an independent set of samples with apriori designations of condition derived from the BPJ panel. This process ensures that the index correctly identifies the condition of novel data. Thirdly, the indices will be evaluated against known gradients of anthropogenic disturbance in the South Bay sub-habitat to ensure responsiveness to stressors observed in the habitat of application.

Index Applicability – Following successful validation in the South Bay sub-habitat, the assessment tool will be applied in other mesohaline habitats of the San Francisco Bay Estuary. If successful, a recommendation may be made to the RMP advisory panel to broaden the geographical application of this tool. If not, the approach used in developing this tool may provide insight into eventual development of an assessment tool for other habitats and sub-habitats of the estuary.

Tasks

Task 1 – Refine and verify reference condition for the South Bay
Task 2 – Create and calibrate indices for use in the assessment tool
Task 3 – Validate index independence, accuracy, and precision
Task 4 – Investigate assessment tool applicability to other mesohaline habitats in the estuary
Task 5 – Prepare final report on index development (Phase I and II) and peer reviewed journal article

Budget, Schedule, and Deliverables

The main products of Phase II would be a validated benthic assessment tool for the South Bay sub-habitat of the San Francisco Bay Estuary, as well as a report and journal manuscripts that document the development and testing process.

The total cost to complete the Phase II tasks would be $106,179 (Table 2**).** With a targeted delivery date of June 30th, 2015.

Table 2. Phase II Budget

Task	Description		Total
1	Refine and Verify Reference Condition	$	18,072
2	Create and Calibrate indices	$	27,521
3	Validate index	$	14,677
4	Index applicability	$	11,009
5	Final Report & Journal Article	$	34,900
	Total	$	106,179

Literature Cited

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