



Tampa Bay Estuary Program
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TAMPA BAY BENTHIC MONITORING PROGRAM REDESIGN ASSESSMENT

FINAL REPORT

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Tampa Bay Estuary Program Technical Memorandum

Tampa Bay Benthic Monitoring Program Redesign Assessment

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Tampa Bay Benthic Monitoring Program Redesign Assessment

The Tampa Bay Estuary Program (TBEP) has established a comprehensive and long-term monitoring program to assess benthic habitat and biota conditions in Tampa Bay. This program has collected annual data from 1993 to present, and the data provide a comprehensive baseline dataset. Recently, the TBEP has completed a redesign assessment to re-evaluate the objectives and approach for the monitoring program. This Technical Memorandum summarizes the results and recommendations of this redesign assessment to date.

Section 1.0 presents the details of the new Tampa Bay Benthic Monitoring Design, and Section 2.0 presents the background, rational and recommendations leading to these changes.

1.0 Revised Monitoring Design (2002 and Future Years)

Basic Baywide Sampling Effort

Starting in 2002, the TBEP will increase the reporting period from 1-year to 4-years for all segments, and will reduce sampling effort by approximately one-half. The TBEP will continue to collect samples on an annual basis. This design will provide approximately equitable effort and coverage in each bay segment, and still allow estimation for the Bay as a whole every year. It would also assist with tracking conditions in anomalous years, such as droughts, El Nino or storms.

Bay Segment	Sites Sampled Per Year	Responsible Party
Old Tampa Bay	9	Pinellas County
Hillsborough Bay	11	EPCHC
Middle Tampa Bay	11	EPCHC
Lower Tampa Bay	9	Manatee County
Boca Ciega Bay	13	Pinellas County
Manatee River/Terra Ceia Bay	11	Manatee County
All Tampa Bay	64	

In addition to the Basic Baywide Benthic Monitoring Program, some counties may desire additional stations for specific objectives not included in the Basic Design (such as EPC to track conditions for Minimum Flows and Levels or the HIMP, or Pinellas County for effects of Joe's Creek discharge into Boca Ciega Bay). Although we encourage the use of the Baywide Design and protocols, these additional samples would not be the responsibility of the partners. Individual partners are encouraged to work out equitable compensation if they wish to request services above the Basic Program from other partners.

Special Studies

In 2002, four Special Study areas were sampled (responsible party for sampling as noted in parentheses): 20 samples in Ybor and Seddon Channel areas (EPCHC); 10 samples in the Bayside Bridge area (Pinellas County); 4 samples in the Bayboro Harbor area (Pinellas County); and 20 samples collected in Bishop Harbor (Manatee County- collected in June 2002).

In 2003, two special study areas are planned to be sampled: 10 samples in East Bay (EPCHC), and 10 samples in Long Bayou (Pinellas County).

Future years after 2003 would see a reduction in sample collection to 64, unless additional Special Study areas are identified.

Responsibilities

The Benthic Monitoring group agreed to the following in-kind services and responsibilities be considered in the processing of samples, starting in 2002:

- a. Rough sorting:** EPC will continue to conduct all rough sorting. Manatee County will lend EPC a sorting scope to assist with this work.
- b. Taxonomic:** EPC will continue to conduct the taxonomic identification for all samples collected in the Basic Program and Special Studies. To assist with the cost for the taxonomic work, TBEP staff will commit to providing \$20,000 per year to EPC, for 2002-2005, subject to annual approval by the TBEP Policy Board.
- c. Grain size analysis:** Manatee County will continue to provide silt-clay analyses for the Basic Program and Special Studies. TBEP has committed to provide \$10,000 to Manatee County to assist with silt-clay analyses of samples from the Base Program and additional samples collected in 2001. Manatee County will also provide training and quality assurance checks to EPC, for silt/clay analysis.

d. Sediment chemistry: EPC will continue to conduct the sediment chemistry analyses for the Basic Program and Special Studies. To assist with the cost for the sediment chemistry analyses, TBEP staff will commit to providing \$10,000 per year to EPC for 2002-2005, subject to annual approval by the TBEP Policy Board.

e. Site selection and Data Management: Site selection and database management will be conducted by Pinellas County, starting in 2002. The database will be available to all partners. To assist with this effort, TBEP will commit to providing \$5,000 per year (2002-2005) to Pinellas County to help support SAS licensing.

f. Reporting: The Benthic Monitoring partners will report results in the BEMR every four years, at a minimum. Publication in scientific literature of any aspect of this program is also encouraged. Depending upon final targets for sediment quality, reporting may also include a yearly update of progress towards targets (to be determined after targets are finalized). TBEP would be responsible for reporting on targets.

Benthic Sample Processing Backlog

EPC has completed analyses of all samples collected through 1999, and delivered the database to TBEP. All Year 2000 samples collected (129 total) and Year 2001 samples collected (124 total) have been sorted. Although some taxonomic work has been completed for Year 2000 samples (mollusks from HB, LTB and TCB), most taxonomic for 2000 and all taxonomic work for 2001 are backlogged (a total of most of 253 samples).

The 2002 Benthic Redesign sampling effort will be retroactively applied to Years 2000 and 2001 for the Basic Program, reducing the effort to 128 samples (total of the two years) allocated as shown in the table above between bay segments for each year. Additional samples which were collected in 2000 and 2001 will be archived. TBEP has committed \$12,734 to EPC for this effort. EPC has agreed to provide all Year 2000 results by December 2002, and 2001 results by October 2003 (in addition to many of the 2002 samples at this time). EPC agrees to be current with benthic identifications by mid FY2003, if provided with TBEP annual funds.

2.0 Background, Rationale, and Recommendations that led to the Revised Monitoring Program Design.

Section 2.0 presents the background, rational and recommendations leading to the revised monitoring program described in Section 1.0.

2.1 Previous Monitoring Program Design (1993 to 2001)

The sampling design for the benthic monitoring program is a probability based design (Coastal Environmental, 1994) that uses a stratified random sampling approach and estimation procedures based on those developed by the U.S. EPA's Environmental Monitoring and Assessment Program – Estuaries (EMAP-E) in sampling the Louisianan Province (Summers et al., 1991). Additional background information for the design history is presented in a report by Hochberge and others (1992), and statistical analysis details are presented in a report by Coastal Environmental (1996).

The objective of the Tampa Bay Benthic program is defined as:

To provide data to estimate the areal extent of specific benthic community conditions within and among bay segments (e.g., the area in Tampa Bay, or a segment of Tampa Bay, in which benthic communities are significantly stressed) (Coastal Environmental, 1994).

The bay segments were operationally defined as six geographic areas based on the original seven TBEP bay segments, and the annual sampling effort for each is as follows:

21 sites per year in Old Tampa Bay,
23 sites per year in Hillsborough Bay,
22 sites per year in Middle Tampa Bay,
17 sites per year in Lower Tampa Bay,
21 sites per year in Boca Ciega Bay,
22 sites per year in Terra Ceia Bay/Manatee River combined.

Thus, 126 total samples are intended to be sampled in each year. In recent years the number of samples has varied from 87 samples in 1993 (Boca Ciega Bay segment not sampled) to 134 samples in 1995.

In addition to this primary objective, the TBEP defined six specific monitoring recommendations (Coastal Environmental, 1994):

- *The sampling of the 126 sites should be undertaken at least once a year to assess status of the estuary in a statistically reliable manner.*

- Annual sampling ... is recommended during an index period from September to October; a time interval that should represent the worst-case conditions of the benthos each year.
- In order to provide information on worst case dissolved oxygen conditions at the benthic stations, bottom dissolved oxygen measurements should be taken at dawn on the same day as benthic samples are collected. These measurements of bottom dissolved oxygen may be incorporated into the once a year water quality monitoring program.
- The indicator of benthic conditions should be the benthic index that is currently under development by the EMAP-E program.
- If the TBNEP decides not to measure benthic biomass, it is recommended that samples be collected and archived so they can be analyzed at a later time if deemed appropriate.

The TBEP also stated in the design document (Coastal, 1994) that:

If logistical and/or cost constraints warrant a reduction in sampling intensity, one-quarter of all sites could be selected for sampling each year. Through a rotation whereby one-quarter of all sites are sampled each year, all sites would eventually be sampled every four years.

Indicators measured by the program include bottom water quality measurements (pH, temperature, conductivity, salinity, dissolved oxygen), silt/clay percent, benthic taxonomy, and sediment chemical analyses (metals and other chemical contaminants).

2.2 Objectives of the Redesign Assessment

The objectives of the current redesign assessment were to revise the objective and associated monitoring recommendations of the benthic monitoring program based on the results of the monitoring program reported to date (particularly with respect to identified contamination hot spots), discussions with the principal investigators of the program, and a goal to reduce overall sampling effort.

2.3 Approach

The approach to completing the redesign assessment included the following four steps.

Review of Existing Design and Reported Benthic Data

First, the authors and the TBEP staff reviewed the existing design components, sediment quality, and biological information from the Tampa Bay benthic program and other monitoring efforts reported in the TBEP Benthic Database. Based on the results of this review and discussions with redesign group members, discussion topics and proposed redesign elements were prepared for presentation at a benthic monitoring program redesign workshop.

Benthic Monitoring Program Redesign Workshop

Second, the TBEP hosted a benthic monitoring program redesign workshop on June 10, 2002 to facilitate a discussion of the redesign options. Attendees at the workshop included Tom Cardinale, Dave Karlen and Stephen Grabe (Environmental Protection Commission of Hillsborough County), Andy Squires and Pamela Leasure (Pinellas County Department of Environmental Protection), Rob Brown (Manatee County Department of Environmental Protection), Robert McConnell (Tampa Bay Water), Kevin Summers (EPA Gulf Breeze Laboratory), Richard Eckenrod and Holly Greening (Tampa Bay Estuary Program), Anthony Janicki and David Wade (Janicki Environmental, Inc).

Sample Size Analyses

Third, the authors conducted a sample size analysis to support the decision making process for potentially reducing the number of samples collected and extending the annual reporting period to a multi-year reporting period. Statistical estimates and corresponding uncertainties were calculated for the cumulative percentage of bottom area as a function of the number of benthic species. An algorithm provided by the E.P.A. Gulf Breeze Laboratory (pers. comm. Virginia Engle, 2002) was used to compute the estimates. Cumulative area distributions and confidence limits were computed for each bay segment for 1 year (1998), 2 years (1997 to 1998), 3 years (1996 to 1998), 4 years (1995 to 1998), and 5 years (1994 to 1998) sets of samples.

Final Review by Working Group

Lastly, the TBEP is requesting the members of the benthic monitoring program redesign group to review the results and recommendations in this technical memorandum, and to develop a final set of recommendations for the redesign. It is anticipated that the group will meet once more prior to the 2002 September-October sampling event.

2.4 Results

Detailed data for the cumulative area distributions and 95% confidence limits are presented in Attachment A for each bay segment for 1 year (1998), 2 years (1997 to 1998), 3 years (1996 to 1998), 4 years (1995 to 1998), and 5 years (1994 to 1998) sets of samples. Results are also presented for all bay segments combined, and Terra Ceia Bay and Manatee River segments combined.

The level of uncertainty in the estimates of areal extent is primarily a function of the number of samples used to generate the estimate. This is summarized by plotting all of the results of the sample size analyses on a single plot (Figure 1).

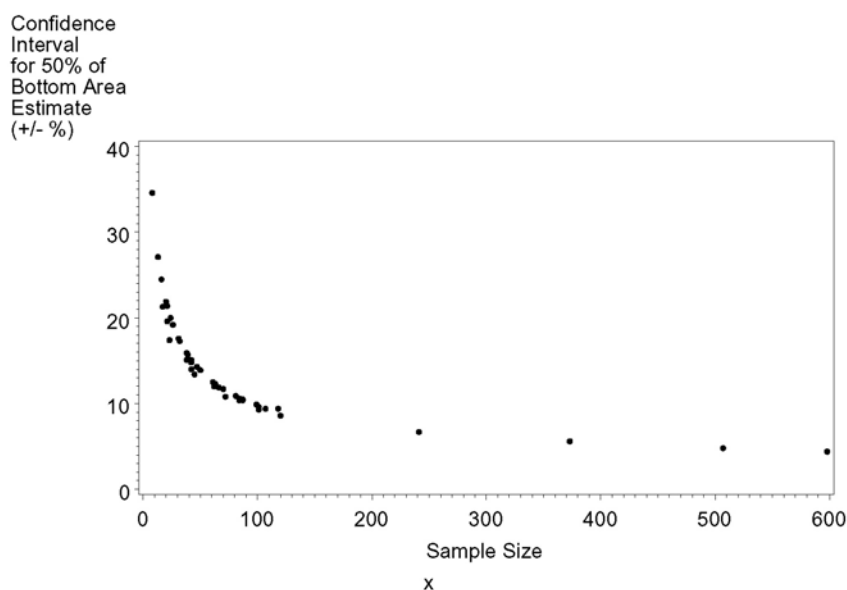


Figure 1 Level of Uncertainty in Estimates Plotted as a Function of Sample Size

Each point on this figure represents the 95% confidence interval for the estimate of 50% of bottom area for a particular set of years and bay segment(s). The value of 50% bottom area was chosen for illustration, the complete set of estimates and uncertainties is presented in Attachment A. For example, the point at the far right side of the figure indicates that for 600 samples (all of the Tampa Bay sites from 1994 to 1998), the estimate for 50% of the bottom area of Tampa Bay was predicted to have a particular number of benthic species (34 species) with a confidence interval of plus or minus 4%. Expressed in other words, between 46% and 54% of the bottom area of Tampa Bay is predicted to have a particular number of benthic species (34 species). This sample value can be found on the last table in Attachment A. The specific number of species predicted is not shown in this summary plot.

2.5 Recommendations

Recommendations for redesign of the Tampa Bay Benthic Program are presented as follows based on the review of the existing design and reported data, the discussions at the redesign workshop, and the sample size analysis.

Revise Program Objectives

The existing program objectives and associated monitoring recommendations should be revised as follows:

- The reporting periods for the individual bay segments should be changed from one year to four years. The reporting period for Tampa Bay should remain on an annual basis. The reason for this change is to redistribute the available sampling effort to allow for additional sampling in areas of special concern. Changing the reporting period to a greater interval such as 5-years, was deemed to be too long by the principal investigators assembled at the June 10 redesign workshop.
- The benthic index should be refined to specifically represent the reported data from the Tampa Bay Benthic Program (1993 to 1999). This strategy will be in keeping with the fourth monitoring recommendation (page 2), but will apply the most recent, and most local available data to the task.

Sampling effort reduction

Based on the recommended change to the program objectives and the relationship of sample size to the level of uncertainty in the estimates, the sampling effort should be reduced by changing the segment-specific reporting period from 1-year to 4-years. The reporting period for all of Tampa Bay combined should remain at 1-year.

Table 1 presents three alternatives for sampling effort reduction. Alternative 1 is not recommended, but it is presented for comparative purposes. Alternative 3 is the recommended alternative because it will reduce the overall sampling effort, provide the sampling effort redistribution for the special studies, and maintain the sampling effort in the bay segments for which water withdrawal projects will be conducted.

Additional special studies (sediment quality and benthos)

In order to support the primary objective of the Tampa Bay Benthic Monitoring Program to provide data on areas of Tampa Bay *in which benthic communities are significantly stressed*, special studies should be conducted on an as needed basis.

Based on the review of data collected to date and the discussions at the benthic program redesign workshop, three special studies are recommended for the year 2002 sampling:

- 10 sites to be sampled in Ybor and Seddon Channel area of Hillsborough Bay,
- 10 sites to be sampled in the Bayside Bridge area of Old Tampa Bay, and
- 4 sites to be sampled in the Bayboro Harbor area of Middle Tampa Bay.

Table 1 Three alternatives for future sampling effort. Expected confidence intervals are shown in parentheses for the reporting units expected to be reported under each alternative. Alternative 1 is not Recommended, but it is presented for comparative purposes.

**Alternative 1: Keep Sampling Effort as Currently (i.e., 2000) Conducted
– This Alternative is Not Recommended**

Reporting Stratum	Sites sampled per year	Sites sampled per 4-years	Cost Savings Expressed as Sites Not sampled in each year
Old Tampa Bay	19 ($\pm 22\%$ CI)	76 ($\pm 11\%$ CI)	0
Hillsborough Bay	22 ($\pm 20\%$ CI)	88 ($\pm 10\%$ CI)	0
Middle Tampa Bay	23 ($\pm 19\%$ CI)	92 ($\pm 10\%$ CI)	0
Lower Tampa Bay	17 ($\pm 22\%$ CI)	68 ($\pm 11\%$ CI)	0
Boca Ciega Bay	27 ($\pm 19\%$ CI)	108 ($\pm 9\%$ CI)	0
Manatee River/Terra Ceia Bay	22 ($\pm 20\%$ CI)	88 ($\pm 10\%$ CI)	0
All Tampa Bay	130 ($\pm 9\%$ CI)	520 ($\pm 5\%$ CI)	0

Alternative 2: Increase reporting period from 1-year to 4-years for all segments, and reduce sampling effort by approximately one half.

Reporting Stratum	Sites sampled per year	Sites sampled per 4-years	Cost Savings Expressed as Sites Not sampled in each year
Old Tampa Bay	9 ($\pm 34\%$ CI)	36 ($\pm 15\%$ CI)	10
Hillsborough Bay	11 ($\pm 31\%$ CI)	44 ($\pm 14\%$ CI)	11
Middle Tampa Bay	11 ($\pm 31\%$ CI)	44 ($\pm 14\%$ CI)	12
Lower Tampa Bay	9 ($\pm 34\%$ CI)	36 ($\pm 15\%$ CI)	8
Boca Ciega Bay	13 ($\pm 27\%$ CI)	52 ($\pm 14\%$ CI)	14
Manatee River/Terra Ceia Bay	11 ($\pm 31\%$ CI)	44 ($\pm 14\%$ CI)	11
All Tampa Bay	64 ($\pm 12\%$ CI)	258 ($\pm 8\%$ CI)	66

Alternative 3: Increase reporting period to 4-years for all segments except Hillsborough Bay and Middle Tampa Bay, and reduce sampling effort in other segments by approximately one half.

Reporting Stratum	Sites sampled per year	Sites sampled per 4-years	Cost Savings Expressed as Sites Not sampled in each year
Old Tampa Bay	9 ($\pm 34\%$ CI)	36 ($\pm 15\%$ CI)	10
Hillsborough Bay	22 ($\pm 20\%$ CI)	88 ($\pm 10\%$ CI)	0
Middle Tampa Bay	23 ($\pm 19\%$ CI)	92 ($\pm 10\%$ CI)	0
Lower Tampa Bay	9 ($\pm 34\%$ CI)	36 ($\pm 15\%$ CI)	8
Boca Ciega Bay	13 ($\pm 27\%$ CI)	52 ($\pm 14\%$ CI)	14
Manatee River/Terra Ceia Bay	11 ($\pm 31\%$ CI)	44 ($\pm 14\%$ CI)	11
All Tampa Bay	87 ($\pm 10\%$ CI)	348 ($\pm 6\%$ CI)	43

Sediment quality (silt/clay), bottom water quality, sediment contaminants, and benthos should be sampled for each of these sites following a probability-based design similar to that used for the other bay segments.

Indicators

Based on the discussions at the benthic redesign workshop, it is recommended to maintain the current list of water quality and sediment quality indicators. Two exceptions are recommended to this recommendation.

- The LICOR light readings should be removed from the list of indicators.
- As recommended above, the existing benthic index should be revised based on the data reported by the Tampa Bay Benthic Program to date (1993-1999).

Exclusionary criteria

The exclusionary criteria (i.e., reasons why a particular sample should not be collected in the field such as a safety hazard, water too shallow, bottom obstruction that prevents sediment sampling) should be objectively defined and stated on the sample collection sheets. A checkbox should be also be provided for each exclusionary criterion to be recorded when it prevents a sample from being collected, and the instances should be recorded in the benthic database. For example, a checkbox should be provided to indicate when vessel traffic results in a navigational hazard that prevents sampling. The list of exclusionary criteria should be maintained on an ongoing basis.

Future considerations

In future years, consideration should be given to re-developing the sampling strata and the associated mathematical procedures for randomly selecting the sample sites. One potential redesign option was discussed at the June 10 redesign workshop, and it entailed creating a single finer scale grid of sampling hexagons for the entire bay, stratifying the new grid by bay segment, and proportionally allocating sampling effort to the strata. Dr. Summers indicated that a reduction of 3 to 4% could be expected in the confidence intervals of the areal estimates using this type of an approach.

During the redesign workshop, interest was also expressed in considering the addition of total organic carbon to the list of indicators in future years subsequent to the 2002 sampling.

3.0 Literature Cited

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