

SOP 11 – Quality Assurance and Quality Control

Version 1.0 (August, 2007)

The following table lists all changes that have been made to this Standard Operating Procedure since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, please refer to Instructions for Recording Revisions in SOP 13.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

The goals of estuarine monitoring within coastal parks of the NPS Northeast Region are to determine whether nutrient loads to park estuaries are increasing over time, and to assess how estuarine natural resources are affected by changing nutrient inputs. Data collected through the implementation of this monitoring protocol are intended to generate assessments of estuarine condition to address these questions, and successive assessments will allow NPS to track changes in condition through time. Non-uniform data that are inconsistent with regard to precision and accuracy will result in greater sampling variability and interfere with the ability to detect differences between successive assessments. Poor or inconsistent data quality may also promote analyses that are flawed and result in sub-optimal or wholly inappropriate management decisions.

As with any quality assurance (QA) program, the foundation for assuring data quality is created by clearly and explicitly documenting the monitoring procedures and by rigorous adherence to those protocols. Hence, the Standard Operating Procedures (SOPs) forming the bulk of this monitoring protocol constitute the QA program for estuarine monitoring within NPS NER parks. Program components include sampling design, personnel training, instrument maintenance and calibration, and detailed field and laboratory procedures for each vital sign measure. Data quality is also assured by carefully defining measurement quality objectives (MQOs) and by instituting a Quality Control (QC) program to ensure data meet these quality objectives. This SOP describes the procedures for implementing the quality control program and evaluating attainment of MQO's. It is modeled after the Quality Assurance Project Plan of the U.S. EPA National Coastal Assessment (U.S. EPA 2001). Measurement quality objectives are established for five aspects of data quality including representativeness, completeness, comparability, accuracy and precision (Stanley and Vener 1985).

Representativeness and Target Populations

The concept of representativeness within the context of this monitoring protocol refers to the ability of the program to precisely characterize estuarine condition within coastal NPS Northeast Region parks. Target sampling populations are discussed in great detail in the protocol narrative sections dealing with this topic (Sampling Designs and Target Populations).

Monitoring responses to estuarine nutrient enrichment incorporates several spatial sampling designs to address questions at a hierarchy of scales. The vital sign of seagrass distribution is measured completely within each park unit, while that of seagrass condition is sampled using a probability design along depth zones within selected seagrass beds. Vital signs related to estuarine water quality, water clarity, water chemistry, and sediment organic carbon are all sampled using a probability design within entire park estuaries coupled with continuous monitoring at selected sites. Thus, coarse measurements of entire estuaries are combined with high resolution measurements of selected areas. This mixture of sampling approaches and intensities enhances the likelihood of detecting changes in response to nutrient enrichment.

Target populations are also identified with respect to their temporal resolution. Measures related to seagrass distribution and condition are assessed at the approximate annual peak of seagrass biomass. Sampling related to the vital signs of estuarine water quality, water clarity, and water chemistry is conducted annually during an index period consisting of any four consecutive weeks during July and August. This is the portion of the year when estuarine vital signs are expected to show the greatest response to nutrient over-enrichment. The timing of sample collection is restricted to within three hours of local apparent noon in order to ensure the accuracy of water clarity data. Resolution of medium and high frequency temporal variability is assessed using trend stations and continuous logging stations deployed during the index period. Thus the major emphasis of the temporal target populations is geared toward characterizing daytime condition during critical time periods of the year. Higher temporal resolution is achieved at a subset of trend stations (weekly) and continuous stations (15-minute).

Completeness

Sampling completeness is defined following Stanley and Verner (1985) as “a measure of the amount of data collected from a measurement process compared to the amount that was expected under the conditions of measurement.” A completeness goal of 100% has been established for the various measures included in this protocol. Spatial sampling for the vital signs of water clarity, water chemistry, water clarity, and sediment organic carbon is designed to be consistent with that of the EPA National Coastal Assessment (U.S. EPA 2001), which also maintains a completeness goal of 100%. Since sampling is based upon a probability design, failure to meet this goal will not preclude within or between-year assessments of condition, but would result in loss in statistical power (U.S. EPA 2001). The same is true for within-transect measures of seagrass condition.

Comparability

Data comparability refers to the confidence with which one data set can be compared to another. To achieve maximum utility, this protocol must yield data that are consistent and comparable from one year to the next, among NER coastal parks, with other NPS programs, and to the extent possible with other state and Federal programs. Comparability among parks and between assessment years is achieved through strict adherence to the standard operating procedures documented in this protocol. In conjunction with uniform standard methods, data quality indicators and quality control samples are used to assure data quality and comparability. Centralization of certain laboratory analyses has also been implemented to ensure data comparability and stability in methods.

To maximize comparability with other monitoring efforts and data sets, efforts were extended to ensure maximum consistency with NPS (Roman et al. 2003, Berounsky 2000) and other Federal programs. Spatial condition assessments of water quality were designed for consistency with the EPA National Coastal Assessment (Jackson et al. 2000, U.S. EPA 2001), and continuous water-quality monitoring was designed for consistency with the NOAA National Estuarine Research Reserve's System-Wide Monitoring Program (Sanger et al. 2002). Seagrass distribution mapping follows consistent and widely adopted methodology developed by the NOAA Coastal Services Center Coastal Change Analysis Program (U.S. NOAA CSC 2001), and seagrass condition assessment methods are derived from the SeagrassNet protocol for global seagrass monitoring (Short et al. 2004, www.seagrassnet.org). In each of these cases, consistency is achieved not only in measurement methodology, but also in sampling design. This will allow NPS to both interpret NER park data within a larger regional context as well as to contribute toward a larger scale assessment of estuarine condition.

Bias, Precision, Sensitivity

“Bias” is a systematic difference between a measured value and true values and represents an estimate of systematic measurement error (also called “accuracy”); “precision” is the degree of mutual agreement among repeated measurements and represents an estimate of random measurement error. Collectively these data characteristics provide an estimate of the total uncertainty surrounding any measurement, and combined with sampling completeness they influence the level of certainty surrounding an overall assessment of condition. Measurement Quality Objectives (MQOs) for the various measures of this protocol are defined in terms of goals for maximum allowable bias and maximum allowable precision (Table 18). Bias goals are expressed either as absolute difference or percent deviation from the true/expected value. Precision goals are expressed as relative percent difference, relative standard deviation, or percent misclassification between two or more replicate measurements. In some cases allowable bias goals are not meaningful because true values are not known. As an initial benchmark in assigning MQOs for this monitoring protocol, we have adopted those established by the U.S. EPA for the National Coastal Assessment (U.S. EPA 2001). Because of additional control over assessment methods, we are able to further tighten MQOs in some instances. These changes, as well as MQOs for measures unique to this protocol, were based upon experience gained during feasibility testing and early implementation of the protocol, anticipated gains from certain

Table 18. Measurement quality objectives for estuarine monitoring in NPS NER coastal parks. Bias goals are expressed either as absolute difference or percent deviation from the true/expected value. Precision goals are expressed as relative percent difference, relative standard deviation, or percent misclassification between two or more replicate measurements. Completeness goals are the percentage of expected measurements that are successfully obtained.

Data Type (by Vital Sign)	Measurement Increment	Maximum Bias Goal	Precision Goal	Completeness Goal
<u>Water Chemistry / Quality / Clarity</u>				
Dissolved Oxygen	0.01 mg L ⁻¹	± 0.5 mg L ⁻¹	10%	100%
Temperature	0.01 °C	± 0.2 °C	5%	100%
Salinity	0.01 psu	± 0.5 psu	5%	100%
Chlorophyll <i>a</i>	0.01 µg L ⁻¹	± 10%	30%	100%
Light (PAR)	1.0 µE m ⁻¹ s ⁻¹	± 5%	10%	100%
Turbidity	0.1 NTU	± 10%	30%	100%
Depth – water column (spatial)	0.001 m	± 0.5 m	10%	100%
– water column (continuous)	0.001 m	± 0.1 m	10%	100%
– light profiles	0.01 m	± 0.05 m	10%	100%
<u>Sediment Organic Carbon</u>				
Total OC	0.01%	± 10%	20%	100%
<u>Seagrass Condition</u>				
Vegetative shoot density	1/16 m ⁻²	± 5%	5%	100%
Reproductive shoot density	1/4 m ⁻²	± 5%	5%	100%
Canopy height	1 cm	± 5 cm	10%	100%
Percent cover of vegetation	5%	N/A	10%	100%
Ephiphyte index	N/A	N/A	10%	100%
Wasting index	N/A	N/A	10%	100%
Grazing index	N/A	N/A	10%	100%
Temperature	0.02 °C	± 0.2 °C	5%	100%
Salinity	0.01 psu	± 0.5 psu	5%	100%
Depth	0.01 m	± 0.1 m	10%	100%
Biomass (per core)	0.0001 g	N/A	N/A	100%
Sediment texture / grain size	0.1%	N/A	10%	100%

additional restrictions on methods and analytical laboratories, and manufacturer specifications for the water-quality instruments prescribed within this protocol.

In order to evaluate program achievement of MQOs, quality control samples are prescribed for most of the identified measures. The nature and frequency of QA/QC samples are outlined in Table 19. Additional details are provided in the following paragraphs and relevant SOPs.

Water Column Measures

Quality assurance measures for the vital signs of estuarine water quality, water chemistry and water clarity are all fully described within the relevant SOPs except for those aspects related to the laboratory analysis of chlorophyll *a* by extractive methods (SOP 6 – Chlorophyll *a* Sampling and Analysis). The additional QC procedures and documentation, which are relevant exclusively to the analytical laboratory, are described within the prescribed method (Arar and Collins 1997). QC for this method requires, at a minimum, an initial demonstration of laboratory capability and routine analysis of laboratory reagent blanks, field duplicates, and quality control samples. An initial demonstration of performance is used to characterize instrumental detection limits, linear dynamic range, and method detection limits.

Quality assurance steps for water column measures related to the vital sign of Seagrass Condition require that field instruments used to measure temperature of seawater at these stations (both logging sensors and spot check meters) be checked against an NBS traceable thermometer prior to each monitoring event (season and station). Similarly, the calibration of salinity meters used for this vital sign must be checked using either standard seawater, an appropriate conductivity standard, or against another salinity meter recently calibrated following an SOP in this protocol or the manufacturers instructions.

Sediment Measures

Sediment measures include analysis of total organic carbon (TOC) content of surficial sediments throughout the estuarine domain, and sediment grain size analysis as part of the seagrass condition vital sign. TOC is run in batches of 20-25 samples, and QC samples included with each batch are: method blank, at least one duplicated sample (and no less than 10% overall for each analyst), and a sample of certified marine reference material from the National Research Council of Canada's Marine Analytical Chemistry Standards Program (e.g. BCSS-1, MESS-2 or PACS-1). Additional QC criteria and reporting requirements for sediment TOC analyses are provided in U.S. EPA 2001. For sediment textural analysis, quality assurance and assessment of MQOs are achieved through analysis of sample splits and reference materials. Samples are run in batches of 20 samples or fewer, with no less than 10% of the samples for each analyst split for replicate laboratory analysis.

Table 19. Quality assurance sample types, frequency of collection and use.

Data Type (by Vital Sign)	QA Sample Type or Procedure	Frequency	Data Generated for Measurement Quality Objective
<u>Water Chemistry / Quality / Clarity</u>			
Dissolved Oxygen	Water-saturated air calibration check	Per station (spatial) or pre- and post- deployment (continuous)	Difference between sonde reading and saturation value
Temperature	Calibration check against NBS-traceable thermometer	Daily (spatial) or pre- and post-deployment (continuous)	Difference between sonde reading and standard thermometer
Salinity	Calibration check against conductivity standard	Daily (spatial) or pre- and post-deployment (continuous)	Difference between sonde reading and conductivity standard
Chlorophyll <i>a</i>	Duplicates and blanks	Per batch	Relative accuracy and precision
Light (PAR)	Intercalibration between sensors and secondary reference sensor	Pre and post- deployment (continuous)	Differences among sensors and drift during deployment period
Turbidity	Calibration check against conductivity standard	Daily (spatial) or pre- and post-deployment (continuous)	Difference between sonde reading and turbidity standard
Depth	Calibration check at zero depth	Daily (spatial) or pre- and post-deployment (continuous)	Difference between sonde reading and anticipated (corrected for atmospheric pressure)
	QC check against depth marking on cable or deployment piling	Per station	Difference between sonde reading and standard mark

Table 19. Quality assurance sample types, frequency of collection and use (continued).

Data Type (by Vital Sign)	QA Sample Type or Procedure	Frequency	Data Generated for Measurement Quality Objective
<u>Sediment Organic Carbon</u>			
Total OC	Duplicates and analysis of standards	10% per technician	Duplicate results and standard recoveries
<u>Seagrass Condition</u>			
All field length measurements, counts and categorizations	Duplicate measurements & counts per observer, and intercomparison between observers.	10% per observer	Duplicate results within and among observers
Temperature	Calibration check of instrument against NBS-traceable thermometer	Per monitoring event	Difference between field instrument reading and standard thermometer.
	Comparison between logging sensor and field temperatures	Per deployment of logging sensor	Difference between logger and field instrument readings
Salinity	Calibration check against standards	Per monitoring event	Difference between instrument reading and conductivity standard
Sediment texture / grain size	Sample splits	10% per technician	Duplicate results

Seagrass Measures

Seagrass condition measures involve numerous counts (shoot densities), measurements (heights, depths, distances), categorizations (wasting disease, grazing and epiphytization indices) and classifications (percent cover). These are often taken under challenging conditions by a minimum of two separate observers. In order to quantify intra and inter-observer variability, a minimum of 10% of each observer's quadrats measures shall be duplicated, and a minimum of 10% of all quadrat measures shall be replicated by all observers. Replication shall be performed in any logistically reasonable fashion that achieves the prescribed 10% for each monitoring event (site and season); however duplicate assessments of a quadrat by any observer must be separated in time by measurements at other quadrats (must not be sequential).

Methods used to estimate seagrass biomass for a given quadrat do not lend themselves to meaningful quality control. The largest potential sources of variability would be introduced by differences among field observers in collecting biomass cores, and differences among sample processors in cleaning and sorting seagrass tissues. Given the large number of possible personnel combinations involved in processing biomass samples, assessing data quality for this parameter is impractical. Toleration of the deficiencies of the technique is necessary in order to obtain an estimate of biomass while assuring the logistical feasibility of the sampling effort.

Seagrass Distribution

Producing seagrass maps that are thematically and geographically precise and accurate is very expensive, so measures are rarely replicated. All data have inherent errors, however, and this includes seagrass mapping data. Nevertheless, seagrass area is generally reported as a single value, and rarely are error terms included despite the fact that $n=1$ (Kurz 2000). Change analysis is complicated by the lack of a thorough understanding of the accuracy and error associated with individual maps. This can make it difficult to interpret with rigor the small change between sequential maps. C-CAP mapping protocols instead rely on carefully constraining the errors, and evaluating them with quality assurance measures. Caution is advised when analyzing change to incorporate the best available estimates of these error terms. Of particular concern are changes between successive assessments in the ability to resolve eelgrass patches. As imaging technology and capabilities evolve, so will the size of the smallest mappable patch of seagrass. If not properly considered, this may significantly bias the interpretation of changes in the resource. Since seagrass mapping is expensive, NPS is relying upon external mapping programs for as much of this data as possible. To the extent that it is feasible, NPS should endeavor to influence and/or participate in mapping efforts so that slight changes in sequential mapping method are properly evaluated for their influence on change detection capability.

References

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