Delaware Estuary Benthic Inventory (DEBI) Program

Quality Assurance Project Plan

Delaware Estuary Benthic Community Characterization Project

Date: June 18, 2008

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Prepared for: EPA Office of Research and Development
Atlantic Ecology Division

A. PROGRAM MANAGEMENT

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A2. Quality Assurance Project Plan Approval Sheet

Project Title: Delaware Estuary Benthic Inventory

Organization name: Partnership for the Delaware Estuary

Effective date: May 1, 2008[1]

Approval:

Project Start Date: May 1, 2008

Project End Date: April 30, 2010

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[1] Effective date may be changed to reflect the date of signature of agreement between EPA Region 2 and 3 and the Partnership

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A4. Project Orientation and QAPP

This project will collect and analyze benthic samples from the Delaware Estuary in support of a biological assessment program, the Delaware Estuary Benthic Inventory (DEBI). The goals are to characterize the different biological communities associated with different bottom types and to begin to map their whereabouts. This project is synergistic with contemporary acoustic mapping surveys that are defining the physical substrate conditions across the tidal system, and the eventual goal of DEBI will be to directly compare physical-biological conditions.

The principal focus of DEBI (more than 80-90% of the effort) will be to characterize biological conditions in soft-bottom benthic habitats. For this component of the project, standard methodologies and quality assurance protocols have already been established and approved as part of the EPA National Coastal Assessment (NCA) Quality Assessment Program[2].

Sampling and analysis of biological communities associated with hard-bottoms (including shell reefs) is less well developed. Hard-bottom sampling will therefore form a secondary, more exploratory component of DEBI. This research element will seek to establish which methodologies are most promising for potential future expansion of hard-bottom sampling in the Delaware Estuary. A variety of methods will therefore be used to sample and document biota on hard bottoms, and the information quality of these approaches will be contrasted to compare effectiveness.

Since an established Quality Assurance Project Plan (NCA QAPP) exists for the bulk of this work (soft-bottom sampling), in Section B below this QAPP:

1) references the NCA QAPP,
2) describes any amendments to the methods for the NCA approach, and
3) documents the quality assurance approach to be used for the hard-bottom research component.

The main project elements and methods descriptions below are separated for the soft-bottom and hard-bottom habitat sampling.

[2] U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan 2001-2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL.

A5. Project Definition/Background

The science and management community in the Delaware Estuary region has identified a fundamental need for a benthic ecosystem assessment that would inventory both the physical and biological conditions of the bottom of the open water tidal system. This priority need was articulated in early 2005 at a two-part conference attended by more than 250 scientists, managers and science-interested people to summarize the current state of science and to identify and prioritize science and management needs for the Estuary. Consensus views from the conference were summarized in the “White Paper on the Status and Needs of Science in the Delaware Estuary” (Kreeger, et al 2006) that called for a better understanding of benthic conditions.

In order to increase the understanding of the Delaware Estuary’s physical environment and better inform management decisions, the Delaware Coastal Programs of Delaware Department of Natural Resources and Environmental Control (DNREC) has initiated a benthic habitat and sub-bottom sediment mapping project using remote acoustics (i.e., Roxann Seabed Classification, Chirp Sub-Bottom Profiler, and multi-bean surface imaging system). This work will ultimately be completed on both the Delaware and New Jersey sides of the Estuary and is being supported by multiple Federal and State agencies, non-profits, and academic institutions. This highly detailed bottom substrate map is furnishing important new information about the diversity and geospatial character of physical conditions across the estuary. However, a comprehensive benthic assessment will also require insight into the biological communities that are associated with these diverse physical conditions, and perhaps also associated chemical conditions.

Estuarine benthic communities are made up of organisms that live in and on the bottom of the estuary floor. These organisms play an important role in the Delaware Estuary’s food chain as food for more than 200 migrant and resident finfish species that use the Estuary for feeding, spawning, or nursery grounds (Dove and Nyman 1995). They are also important in maintaining water and sediment quality by cycling nutrients and contaminants between sediments and the water column. Hard-bottom reefs also deliver ecosystem services such as providing habitat for a diverse array of species, improving water quality as they filter algae for food, and protecting shorelines from wave energy and erosion. Biological information on these diverse communities is therefore necessary to confirm or refute hypotheses about physical-biological relationships and to develop a comprehensive characterization of the benthic environment.

The purpose of this study is to conduct a survey of benthic invertebrate communities in the Delaware Estuary to help address key data gaps in our existing biological understanding. Integration of past, ongoing and new physical and biological assessments of bottom habitats and communities into a comprehensive and linked assessment is the central objective of the Delaware Estuary Benthic Inventory (DEBI) being advanced as a strategic initiative by the Partnership for the Delaware Estuary. DEBI is expected to be of value for diverse decision-makers, managers and policy-makers. For example,

- Monitoring and Assessment. Programs that track environmental health often look to benthic community conditions as a leading indicator of environmental conditions, and DEBI would provide detailed information on best approaches and locations to monitor depending on program goals
- Environmental Protection. DEBI would describe and pinpoint where and when key natural resources and biological communities exist so that they can be prioritized for conservation and safeguarding during emergency response and for natural resource damage assessment.
- Fishery and Shellfishery Management. Benthic communities help to support secondary production, and a better understanding of where and when benthic communities are most productive would inform ecosystem and fisheries modelers.
- Restoration. By comparing current information on the location of "biological hot spots" and ecologically significant species or habitats to projections on past and future conditions, DEBI would help prioritize restoration such as oyster reef revitalization.

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A comprehensive, geospatially referenced map and inventory of both biological and physical conditions is the long-term goal of the DEBI inventory. Ultimately, this benthic characterization is envisioned to consist of a complete bathymetric image of the Estuary's bottom conditions, including spatial and temporal distributions of principal physical and biological components. For example, maps and descriptive keys of bottom habitats would be developed that consider attributes for substrate conditions, biological communities, dominant flora and fauna, functional processes, and locations of species or habitats of special concern.

A6. Project/Task Description and Station Sampling Approach

This benthic survey will be conducted in the Delaware Estuary mainly during the July-September, 2008, period to capture the most biologically productive season. Approximately 200-250 stations will be sampled in soft bottom habitats with standardized methods, yielding various sample types and hydrographic data per station. As a second, exploratory component, additional stations will be visited having hard-bottoms where a variety of methods will be tested and compared for future use. If any funds are available to continue the sampling in 2009 or beyond, a similar time period will be sampled.

Soft bottom sample collection stations are expected to be visited and sampled during summer, 2008, using an EPA vessel. The sample design was probabilistic, covering three salinity strata and approximately three substrate types (based on acoustic survey data available to date.) Twenty-five sampling stations have been assigned using the probabilistic approach to each of these nine strata. In addition, 25 sampling stations were added in the upper freshwater tidal portion of the estuary for soft-bottom sampling, to be analyzed by the Delaware River Basin Commission (or paid for by them). The overall design will therefore include up to 250 soft-bottom sampling stations. Traditional benthic samples will be collected by boat using a 0.04 m^2 Young stainless steel grab (see below).

Hard-bottom sampling will initially be targeted rather than probabilistic, tested preliminary in the Broadkill Slough during an interim week in July when visibility conditions are most likely to be conducive for photodocumentation and diver visibility (see below.) The design of subsequent hard bottom sampling later in 2008 or in future years will be contingent on funding and will be based on results from this first hard bottom survey Laboratory analysis and photointerpretation of hard bottom samples will be performed by academic researchers using experimental procedures yet to be determined.

The overall design for the sampling for DEBI has been developed by a collaborative team, including scientists from EPA's Atlantic Ecology Division, EPA Regions II and III, the Partnership for the Delaware Estuary (PDE), the Coastal Programs from DRNEC and NJDEP, and other estuarine experts. A chief science officer from both EPA and PDE will be on the sampling vessel at all times, along with support staff. A modifiable cruise plan has been prepared by EPA (see Appendix A for 6/15/08 draft version), describing the expected sequence of sampling stations. Initial work will be based in Lewes, DE (beginning 7/7/08) and lasting for approximately 3 weeks. Thereafter, the sampling effort will progressively shift from the lower Delaware Bay to the middle and upper estuary, with approximately 1 week based at Bowers Beach, DE, 2 weeks based at Fortescue, NJ, and 1 week based at Delaware City, DE.

A7. Data Quality Objectives for Measurement Data

Data quality objectives for the soft-bottom work will follow the same approach as described in the QAPP for the National Coastal Assessment (Section A7, U.S. EPA. 2001.) Initial data quality objectives for the hard-bottom sampling are provided below, although it is understood that these may evolve over time due to the more experimental nature of the hard-bottom sampling effort.

<u>Representative.</u> The hard bottom sampling effort will initially be a small "pilot" effort to determine which sampling approach and gear yields the highest quality data. Therefore, the overall data quality objective is to obtain a complete listing of the various macroscopic flora and metazoan fauna species that exist attached or associated with the bottom in hard-bottom (defined as substrates that cannot

be sampled effectively with the grab sampler.) An attempt will be made to also quantify the relative abundance and biomass of these organisms. Since the hard-bottom sampling effort will initially be undertaken only at limited locations on a small scale, the representativeness will be confined to only those locations that are sampled (e.g. the Broadkill Slough). Each site will be chosen based on best available information regarding the bottom type, such as acoustic survey data and anecdotal information from fishermen or other studies. Although data collected will represent only the areas actually sampled, it is reasonable to expect that the relative effectiveness of different gear and sampling approaches demonstrated therein will be representative of their relative utility elsewhere.

Comparability. Comparability is defined as the extent to which data from one data set can be compared directly to similar or related data sets and/or decision making standards. All metrics measured in the hard bottom sampling will be collected in a format that can be reported for comparison to other hard bottom studies in the literature.

Completeness. As described in the NCA QAPP (U.S. EPA. 2001), this project will strive for a completeness goal of 100% for the soft bottom sampling; however, it is understood that the sampling design for the 2008 DEBI project is ambitious relative to season sampling optima, weather, and available funding. Due to the uncertainty in whether we can visit every station in the design due to potential weather, funding, or other logistical constraints, data for the soft bottom project element will be considered complete when at least 80% of the sampling stations are visited and sampled as best as possible, and the resulting data are validated. For hard bottom sampling, data will be considered complete when the sampling period or funding ends and any data collected are validated.

Accuracy and Precision. The NCA QAPP describes the approach for ensuring appropriate accuracy and precision for soft-bottom sampling elements. A YSI system will be used rather than a Hydrolab for water quality sampling (see below); however, the same approach will be used to determine instrument accuracy and precision, as that described in the NCA QAPP for the Hydrolab. For hard bottom sampling, the same standards described in the NCA QAPP will be applied; for example, biotic samples will be subjected to 10% recounting and species identification for each technician's work, and hydrographic sampling will be assessed identically to the soft bottom sampling.

A8. Special Training Requirements/Certification

All field crew will be required to attend and participate in a one-day field training program on July 8th, 2008. No formal certification will be required; however, the Senior Project Scientists from PDE and EPA will ensure that all prospective crew members participate and demonstrate an understanding of the project goals, sampling scheme, and competence with the field methods that they will be expected to assist with.

A9. Documentation and Records

The NCA QAPP describes the approach for recording and documenting sampling activities, metadata, and primary data. Except as noted below, the same approach used for soft-bottom sampling will be used for hard-bottom sampling.

<u>Amendment to NCA QAPP</u>

A10- Documentation and Records - Field Activities (pg20)

No water quality samples (nutrient load - P and N; chlorophyll-a content; total suspended solids) or fish trawls will be completed as part of DEBI.

B. MEASUREMENT/DATA ACQUISITION

B1. Sampling Process Design

As described in the NCA QAPP (U.S. EPA 2001), there are three basic phases to the DEBI program: field collection of environmental data and samples, laboratory analyses of samples, and data analysis and dissemination. The same approach described in the NCA QAPP will be followed in DEBI, with the exception that sampling is not being undertaken by the states. For DEBI, sampling will be undertaken by a collaborative team from U.S, EPA, PDE, academic researchers, and potentially assisted by state staff. Additional modifications to the collection of environmental data and sample types are described throughout this document as “Amendments to NCA QAPP.”

<u>Amendment to NCA QAPP</u>

B*1- Sampling Process Design*

The overall experimental design for DEBI is explained above. It is consistent with the NCA approach in use of randomly generated probabilistic sample locations. However, for DEBI, these were determined within targeted strata to ensure sufficient characterization of different soft bottom types and regions, such as in the less expansive freshwater tidal regions. The three salinity strata are shown in Figure 1. Although salinities will vary with climate and flow conditions, for DEBI soft bottom sampling purposes, three salinity strata were selected: oligohaline (between River Miles 58-75), mesohaline (between River Miles 31-75), and polyhaline (below River Mile 31.) The oligohaline area is the area that has been best mapped by the DBBMP mapping. As noted above, 25 additional stations will be sampled in the upper freshwater tidal area of the estuary (above River Mile 75) at the end of the sampling run.

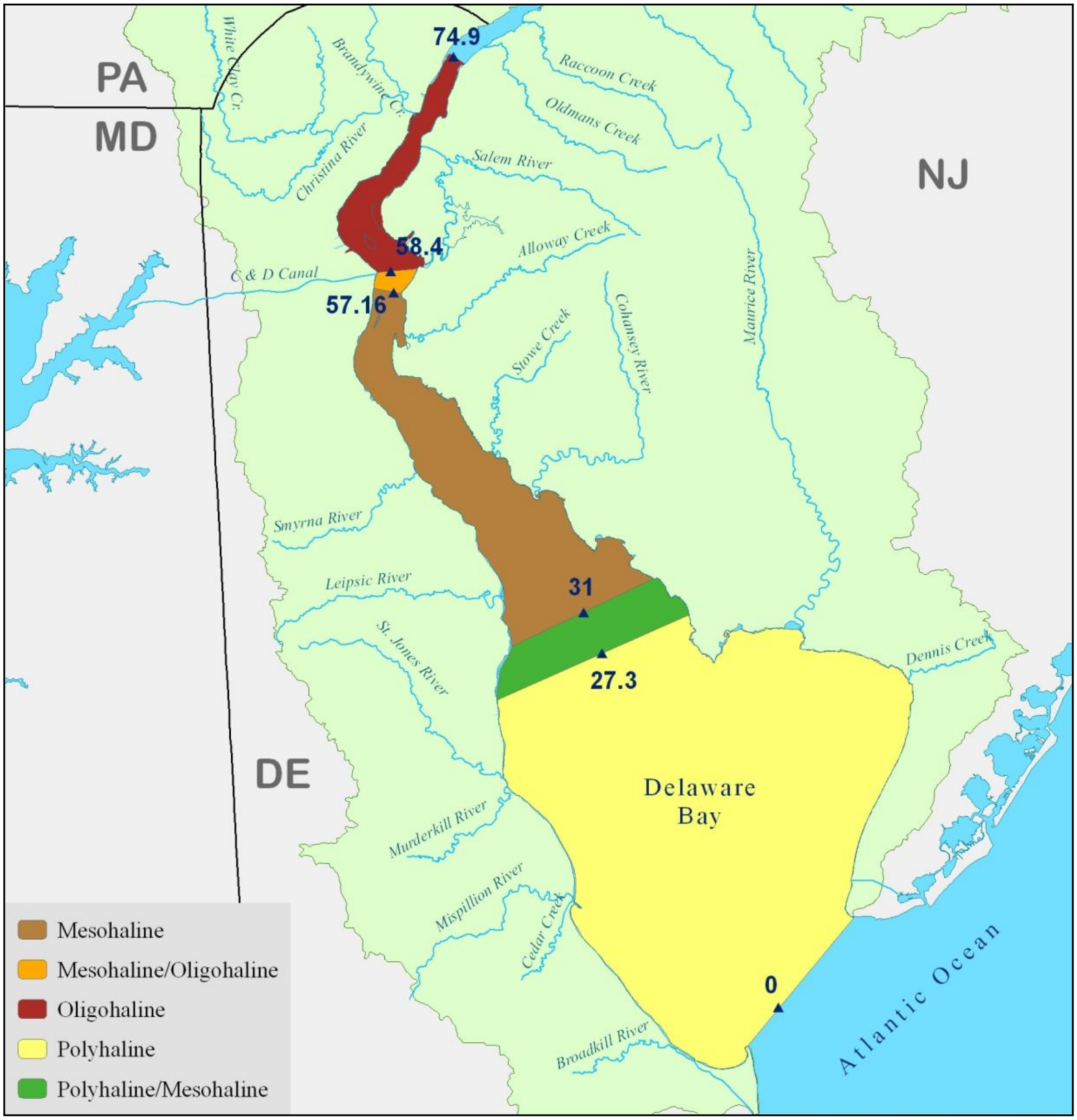

Figure 1*. Map of the general salinity zones of the Delaware Estuary. For DEBI, the three salinity strata were freshwater/oligohaline (above River Mile 75,) mesohaline (between River Miles 31-75), and polyhaline (below River Mile 31).*

Based on existing substrate characterization from the acoustic survey work, three sediment strata were also chosen within each salinity strata; mud, mixed sediment, and sand. For each of the nine primary salinity-substrate strata pairings, 25 random stations were selected using the probabilistic approach that is the basis for the NCA approach (n=225 total). Together with the 25 additional freshwater tidal stations, 250 stations have been selected to be sampled. This number is sufficient to allow for some deletion of stations per stratum if sampling conditions prevent collection (i.e., up to 250 stations will be sampled), and only a subset of sampled stations may be analyzed for one or more parameters depending on budget considerations.

B2. Sampling Methods Requirements – Soft Bottom Habitats

The same sampling methods will be used as described in the NCA QAPP (U.S. EPA 2001), except for the amendments noted below. The following is a general summary of the DEBI sampling approach and methods for each soft bottom station.

<u>Amendments to NCA QAPP</u>

B2- Sampling Method Requirements
Site Location (pg30)

Field teams will have a degree of onsite flexibility to relocate sampling sites when confronted with unexpected obstacles or impediments. For example, it is likely that some sites may be in water that is too shallow to effectively sample. Because the sites are randomly selected, if the site cannot accommodate sampling, the boat will move 50 m to the north of the nominal station. If that doesn't work, then the boat will move 50 m to the east, then south then west. If none of these work, the station will be deleted from the design.

B2-Sampling Method Requirements
Hydrographic Profile (pg32)

Light measurements taken with hand-held light meters will not be taken at every station. Neither will secci depth.

B2-Sampling Method Requirements
Benthic Infaunal Communities
Composited Surficial Sediment (pg34)

The only sediment contaminant analyses to be performed in this study are summarized below in Figure 2.

Analyses of Chemical Contaminants in Environmental Samples

Although we will collect samples for sediment contaminant analysis by Delaware River Basin Commission, those samples will be treated as part of a separate study and not analyzed as part of this RARE DEBI study. The Delaware River Basin Commission (DRBC) has a separate QAPP[3] for those analyses and will provide a simple standard operating procedure for sample collection. In short, a pre-washed and individually wrapped stainless steel spoon will be used to collect a sample from the center of the sediment in the grab so as not to touch the grab. Samples will be added to individual pre-washed jars, held on ice and then refrigerated, and transferred to DRBC for analysis of PCB's (in a subset of the samples) and archiving of a portion for potential future use.

[3] QAPP for the Delaware River Basin Commission collection and analysis of benthic sediment PCB concentrations.

Flow Chart Summarizing Sample Collection Per Station

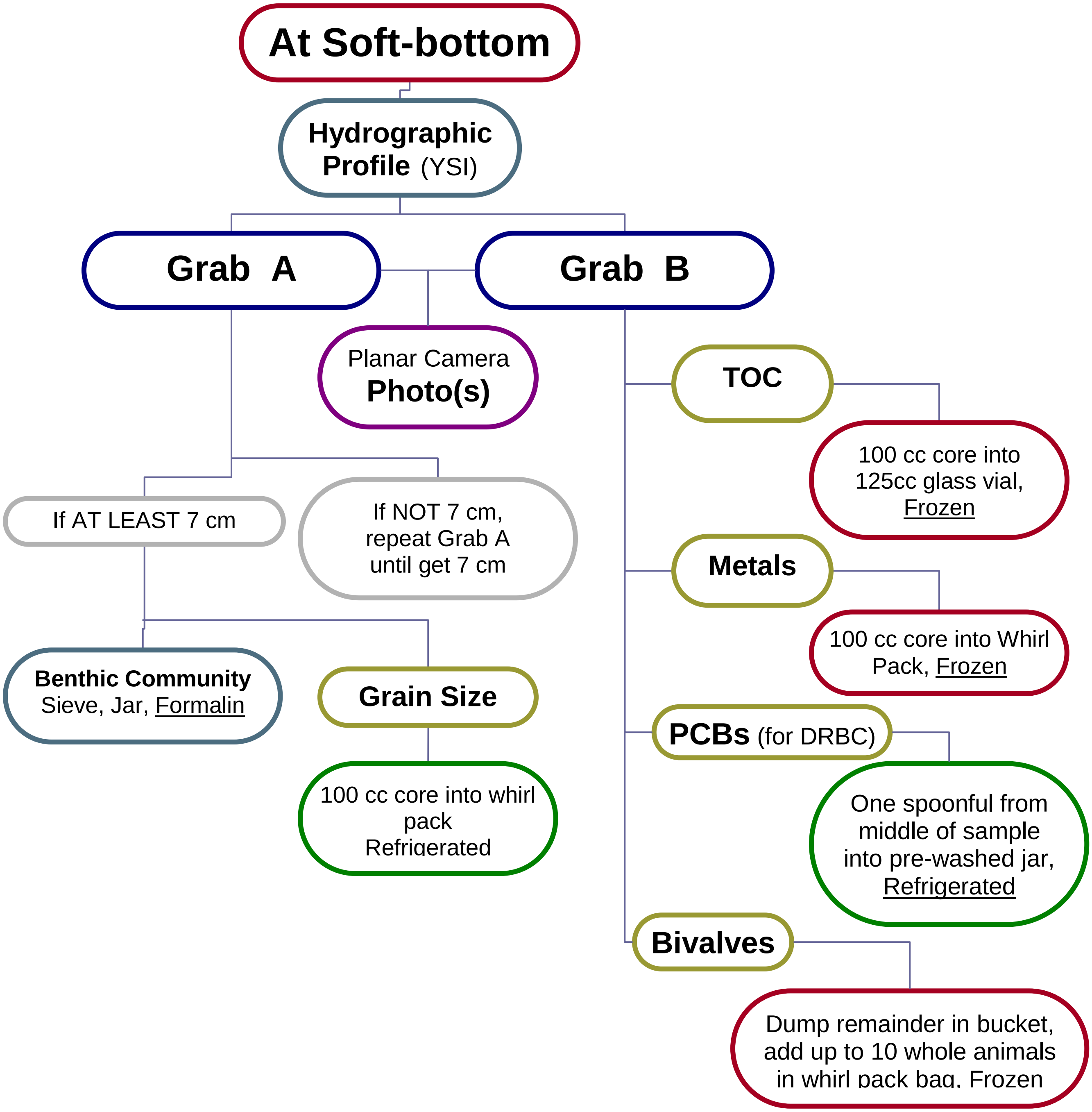

***Figure 2**. Schematic summarizing the types of physical and biological samples to be collected at each soft bottom sampling station.*

At each soft-bottom sampling station, two benthic samples will be collected by boat using a 0.04 m^2 Young stainless steel grab. The material collected in these two grab samples will be processed as summarized in Figure 2.

As noted above, standard operating procedures for sample collection and analysis of soft-bottom samples will adhere to those described in the National Coastal Assessment Quality Assessment Project Plan (NCA QAPP) for field collection of environmental data and samples; laboratory analyses of samples; and data analysis and assessment. The following summary is provided to capture the most important elements.

Hydrographic Data

The same approach and methods will be followed for collecting hydrographic data at each station that are described in the NCA QAPP (U.S. EPA 2001), with regard to the equipment used for those analyses that are included in DEBI. The exception is that a YSI system will be used instead of a Hydrolab system (see Section B7.)

Grab Samples

Two grabs will be collected at each station, along with hydrographic data and a video (from this digital still images can be obtained later) wherever visibility permits. The contents of the first grab (Grab A in Figure 1) will be subsampled for grain size by removing a 100 cc core. The balance of the Grab A sample will be sieved to 0.5 mm, and the material retained by the sieve will be transferred to a jar and preserved in 10% buffered formalin, stained with Rose Bengal.

For Grab B, a small core will be removed for sediment organic analyses and placed on ice. A second small core will be removed and placed on ice for metals analyses. A pre-washed and treated stainless steel spoon will be used to collect a sample for contaminants analysis (for PCB’s by DRBC in a separate but linked project, see above), which will be added to a pre-cleaned jar and stored on ice.

The remainder of Grab B will be dumped in a 5 gallon bucket for a brief search for examples of any whole bivalves larger than 1 cm shell height. Handlers will wear latex gloves. If encountered, up to 10 individual bivalves (per species) per station will be added to whirl pak sample bags, placed in ice, and later frozen for archiving.

Photographs

In addition to collecting the benthic grab samples, where visibility permits PDE will also obtain a digital video of the same bottom area from a camera mounted on the grab frame. Where hard bottoms are targeted, visibility is sufficient, and benthic grab samples are not possible, benthic image sampling will be used to capture best possible data on benthic communities. The methods associated with capturing and interpreting digital images from video of bottom communities are not yet well standardized, but EPA is currently developing such protocols. It is understood that those working with photographic and image analysis samples will be developing new expertise.

<u>Post-Collection Processing</u>

At the end of each day's cruise, samples will be transferred to either a freezer, refrigerator, or air-tight and double-boxed plastic storage bins (formalin-fixed samples). Samples will be transferred to PDE offices in Wilmington, DE, for storage in a refrigerator, freezer, or air-tight containers, until they are hand delivered to consultants handling the various analyses.

Formalin-fixed samples will be sent to a contract lab for analysis. Samples for grain size, TOC, and metals will be analyzed by EPA R3.

Samples for contaminants (PCB's) will be transferred to the Delaware River Basin Commission which will oversee analysis.

Samples of whole bivalves will be archived for potential future use in calculating benthic functional services or other purposes.

<u>Taxonomic Analyses</u>

Formalin fixed samples will be sent to a qualified contract laboratory for processing. Quality control can be distinguished as being of two types. Sorting QC will be associated with the physical picking of major taxonomic groups from the grab sample debris, and this will be the responsibility of the contract laboratories. QC associated with species and taxonomic identification will be performed according to NCA QAPP requirements as an in kind service by staff in EPA Region 3 (D. Russell, Person. Communications.), and this will involve re-identifying and re-counting a randomly selected 10% sub-sample of each taxonomists work by contract laboratories, and then calculating a taxonomic efficiency based on the number of errors. This latter QC will be independent of the contract laboratory and performed "blind" to their original ids and counts.

Each laboratory conducting analysis of benthic grab samples must have previous experience in the conduct of these analyses on marine samples and shall employ methods equivalent to those described in US EPA (1995)

B3. Sampling Methods Requirements – Hard Bottom Habitats

For hard bottom sampling sites there are no current approved protocols, and we have no definitive plan for the number of samples to be collected with different sampling methodologies. Our goal is to attempt to collect benthic biological information using as many sampling techniques as possible, concurrently from the same location. Then, we will compare the data quality, information, and feasibility of the different approaches to better design future hard bottom survey work as part of DEBI. Therefore, amendments to this QAPP are expected to be needed as the hard bottom work is adaptively managed into the future and sampling design and methods become more clear.

Timing of Hard Bottom Sampling

The hard bottom sampling approach for DEBI during 2008 will be limited to a one-week “pause” in the soft-bottom sampling series during the middle of July. During this week, we will examine the hard bottom “coral beds” in the Broadkill Slough, offshore from Lewes, DE. In this region, there are suspected bottom communities consisting of various calcareous worms, bryozoans, and possibly other shell-bearing, sessile organisms. If time permits, additional hard bottom areas will be sampled during this one week venture, targeting ecologically meaningful communities living in bottom types that cannot be sampled with the grab.

Hard bottom sampling will potentially resume later in the season after soft bottom samples are collected, targeting additional sampling locations with a step-wise approach in both Delaware and New Jersey based on local oral tradition and best scientific judgment. The study will focus on natural reefs and not attempt to sample hard rock or artificial substrate.

Hard Bottom Sampling Methods

Hard bottom sampling will consist of 1) photodocumentation with the grab-mounted planar camera, 2) hand-sampling scrapes and photodocumentation by divers, 3) dredge sampling, and possibly also 4) sled sampling (Figure 3). The dredge and sled are expected to be most effective at sampling large areas as well as murky waters where divers and cameras are ineffective. On the other hand, small material is known to be missed by dredges and sleds, and if visibility permits the divers are expected to be more effective at documenting fine scale communities.

Flow Chart Summarizing Sample Collection Per Station

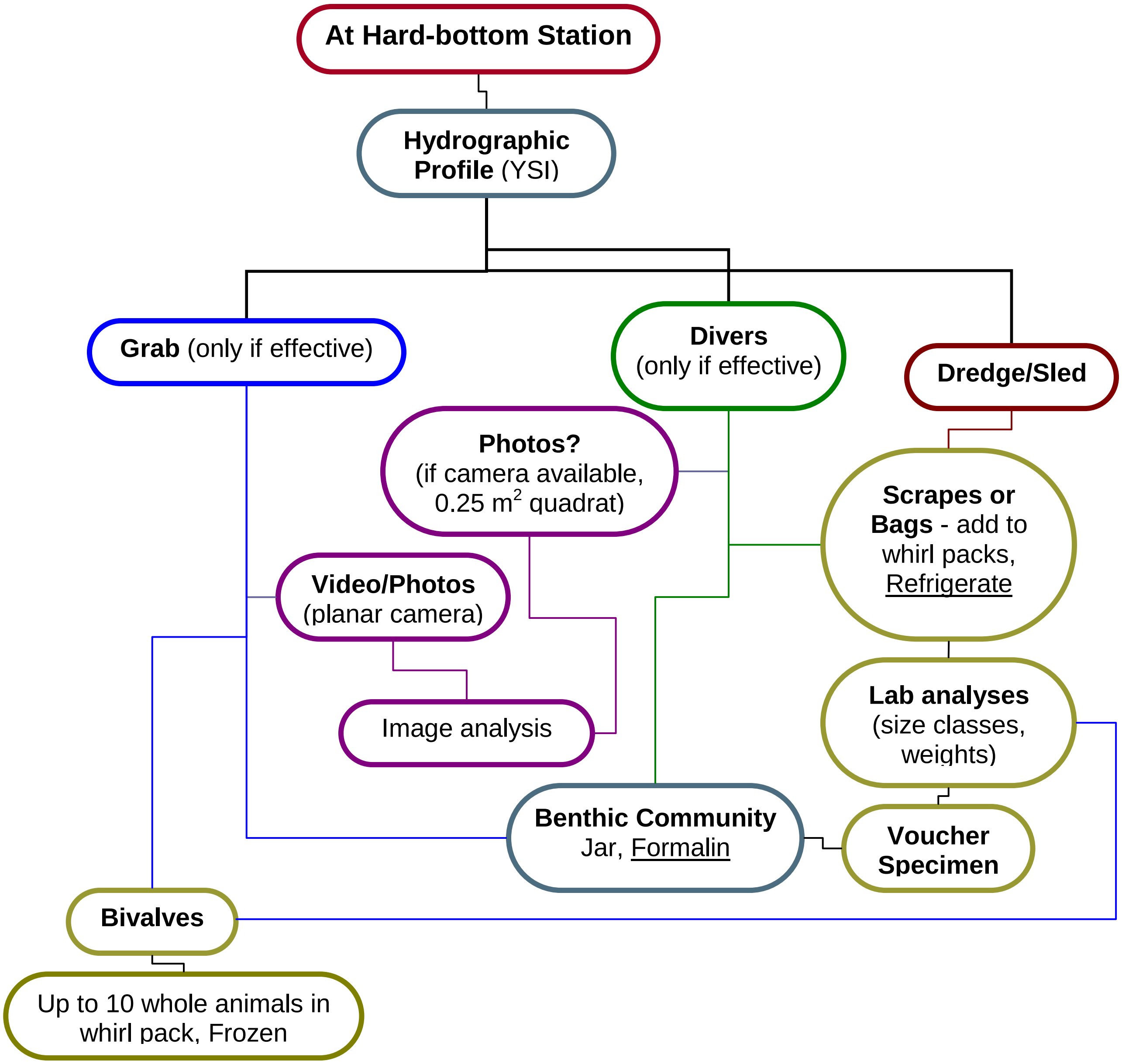

Figure 3. Schematic summarizing the types of samples to be collected at each hard bottom sampling station.

Divers

Contingent on obtaining suitable visibility and hydrodynamic conditions during the designated period for hard bottom sampling (i.e., mid July, 2008). EPA certified divers will attempt to collect photographs and hand collections of benthic organisms in the targeted areas. The techniques to be used will follow the same approach as those used in recent artificial reef surveys in Delaware Bay (see Appendix B.) A 0.25 m2 quadrat will be placed over the bottom for size standardization in photographs, unless the dive camera has a similar reference frame.

Dredge and Sled

The dredge has a mouth width of 62 cm and basket mesh of 5 cm. The benthic sled has a mouth width of 42 cm and a basket mesh of 0.5 cm. The following methodology will be used with both pieces of equipment. The gear will be lowered to the bottom, and water depth and GPS coordinates of the starting location will be recorded. Temperature and salinity measurements at the surface will also be recorded.

The dredge will be towed for 2 kilometers along the local isobath (i.e., constant depth) and returned to the surface; the depth and GPS of the stopping location will also be recorded. The length of the tow may be increased or the tow may cross the bathymetry if needed to return a sufficient sample, approximately one half of the basket filled. Two replicate (i.e., same gear and tow length and approximate orientation) at each site will be taken. If possible a grab will be dropped to return a bottom sediment sample and check its sampling ability.

<u>Benthic Organism Sample Processing</u>

Biological specimens will be hand-picked from the basket and sorted by species. Individual animals will be counted and bagged for wet weights on return to the laboratory. Colonial animals and algae will be bagged and weighed in the laboratory. Voucher specimens of each species will be preserved in formalin after weighing (Figure 3).

<u>Adaptive Management of Hard Bottom Sampling</u>

Sufficient samples (pictures, diver scrapes, dredge/sled material, see Figure 3) will be taken to get as much information as possible on biological community structure and functional relevance (e.g. water filtration per unit area, fish attraction hotspots, etc). The findings from the initial work in July, 2008, will be preliminarily analyzed by the project team and academic consultants at the University of Delaware, potentially guiding additional hard bottom sampling for late August early September. Although the top priority for DEBI project team will be to complete the soft bottom sampling before the end of the sample season, the team will maintain an opportunistic approach regarding hard bottom sampling, potentially photographing additional areas if/when visibility clears and currents are favorable.

Updates to hard bottom sampling protocols will be conveyed by memo to the Quality Assurance Officer and Program Officer informing them of any significant change of plans.

B4. Sample Handling and Custody Requirements

PDE and all laboratories must adhere to strict sample tracking procedures to ensure samples are handled in an expeditious manner, following the general approach of the NCA QAPP (U.S. EPA 2001). PDE will be responsible for sample chain-of-custody and eventual shipping or transferring samples to staff at destination facilities where they will either be analyzed or archived. Details of the tracking procedures will be negotiated within 10 days of contract award, but shall include, at a minimum, immediate notification of shipment arrival followed within 24 hours by an electronic listing of the samples received. Copies of chain-of-custody forms must be maintained by PDE and shared with EPA. A draft PDE chain-of-custody form is shown in Figure 4.

Project Name	Project leader:
Samplers:	

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Wilmington, DE 19801
(800) 445-4935 or (302) 655-4990

Sta. No.	Date	Time	Station location		TOC	Metals	PCB	Bivalve	Benthic # samples	Pic #	Notes

Relinquished by:	Date/Time	Received by:	Remarks:
Relinquished by:	Date/Time	Received by:	
Relinquished by:	Date/Time	Received by:	

Figure 4. Draft chain-of-custody form for sample tracking for DEBI.

A reference collection for this project will be generated during the specimen identification process by the contract laboratory(ies). As each new species is encountered, a voucher specimen of that species will be set aside for this reference collection to document species and taxonomic nomenclature. This reference collection representing all dominant taxa will thereafter be retained for a minimum of three years. QA/QC procedures for macro invertebrate recounts and re-identifications will follow US EPA (2001b).

All samples shall be retained at the facilities of any contract laboratory for a minimum of two years following final report submission. EPA may request these samples be sent to EPA at the end of this holding period.

B5. Analytical Methods Requirements

All collaborating parties will follow the sample analysis methodologies described in the NCA QAPP (U.S. EPA 2001) for those analyses that are included in DEBI.

B6. Quality Control Requirements

All collaborating parties will follow the sample analysis methodologies described in the NCA QAPP (U.S. EPA 2001) for those analyses that are included in DEBI.

A Quality Assurance/Quality Control (QA/QC) program shall be in place at each laboratory analyzing project samples, and shall address, at a minimum, the following topics:

- replicates
- sorting efficiency (benthic grab samples only)
- re-identification and re-enumeration
- physical processing of samples (benthic grab samples only)
- analytical methods utilized
- QA/QC samples
- electronic data storage and back-ups

Each laboratory is required to submit a copy of their Quality Assurance/Quality Control protocols to PDE, which will compile them for the EPA Project Officer as part of their submission.

Each laboratory must permit a QA audit of laboratory and/or data entry procedures by an authorized agent of EPA at any time during the conduct of analyses (given advance notification).

<u>Amendment to NCA QAPP</u>

B5-Quality Control Requirements
Lab Analysis (pg54)
Analyses of Chemical Contaminants in Environmental Samples

Although we will collect samples for sediment contaminant analysis by Delaware River Basin Commission, those samples will be treated as part of a separate study and not analyzed as part of this RARE DEBI study. The Delaware River Basin Commission which has a separate QAPP[4] for those analyses.

B7. Instrument/Equipment Testing, Inspection, Maintenance and Calibration Requirements

The same approach and methods will be followed that are described in the NCA QAPP (U.S. EPA 2001), with regard to the equipment used for those analyses that are included in DEBI.

Amendment to NCA QAPP

A YSI system (using an optical probe for measuring dissolved oxygen concentration) will be used instead of a Hydrolab system for collecting hydrographic information. The YSI system will be calibrated at least daily using the calibration sheet shown in Figure 4. Station data from the YSI system will be recorded on hydrographic profile data sheets in the same way as that for NCA using a Hyrolab.

The same standards for quality control and frequency of calibration will be followed as used by NCA, and cross-calibration between the YSI and either Winkler titration or Hydrolab units will be established at the outset of the sampling program.

[4] QAPP for the Delaware River Basin Commission collection and analysis of benthic sediment PCB concentrations.

CALIBRATION WORK SHEET

Date of Calibration: ________________ Technician: ________________________

DO membrane changed? Y N Note: Should wait 6 to 8 hours before final DO calibration, run sensor for 15 minutes in Discrete Run to accelerate burn-in.

Turbidity wiper changed? Y N Wiper parks ≈ 180° from optics? Y N Note: Change wiper if probe will not park correctly.

Chlorophyll wiper changed? Y N Wiper parks ≈ 180° from optics? Y N Note: Change wiper if probe will not park correctly.

Record battery voltage: ____________

Record the following diagnostic numbers after/during calibration.

				Record Calibration Values	
				Actual	After calibration
Conductivity cell constant	________	Range 5.0 ± .5	Conductivity	________	________
pH MV Buffer 7	________	Range 0 MV ± 50 MV	pH 7	________	________
pH MV Buffer 4	________	Range +177 from 7 buffer MV	pH 4	________	________
pH MV Buffer 10	________	Range –177 from 7 buffer MV	pH 10	________	________
NOTE: Span between pH 4 and 7 and 7 and 10 millivolt numbers should be ≈ 165 to 180 MV			ORP	________	________
NOTE: Check response time in buffer change & in Tap Water			Depth	________	________
DO charge	________	Range 50 ± 25	Turbidity	________	________
DO gain	________	Range 1.0 .7 to 1.5	Turbidity	________	________
			Chlorophyll	________	________
Pressure Offset	________	Range –14.7 ± 6 (non-vented)	Chlorophyll	________	________
Pressure Offset	________	Range 0 ± 6 (vented)	DO	________	________
ORP mV Offset	________	Range 0 ± 100			

DISSOLVED OXYGEN SENSOR OUTPUT TEST (after DO calibration probe in saturated air)

The following tests will confirm the proper operation of your DO sensor. The DO charge and gain must meet spec before proceeding.

610/650– Turn off the 610/650, wait 60 seconds. Power up 610/650 and go to the Run mode, watch the DO % output; it must display a positive number and decrease with each 4 second sample, eventually stabilizing to the calibration value in approximately 60 to 120 seconds. **Note:** You can disregard the first two samples they can be affected by the electronics warm-up.

PC – Stop discrete and unattended sampling. Confirm that auto-sleep RS-232 is enabled (found in Advanced Menu under Setup). Wait 60 seconds. Start discrete sampling at 4 seconds. Watch the DO % output, it must display a positive number and decrease with each 4 second sample, eventually stabilizing to the calibration value in approximately 60 to 120 seconds. **Note:** You can disregard the first two samples they can be affected by the electronics warm-up.

The **ACCEPT/REJECT** criteria as follows:
The DO output in % must start at a positive number and decrease during the warm up. Example: 117, 117, 114, 113, 110, 107, 104, 102, 101, 100, 100. Should the output display a negative number or start at a low number and climb up to the cal point, the probe is rejected and must not be deployed.

_____ **ACCEPT** _____ **REJECT**

Notes:

1

Figure 4. Calibration datasheet for YSI system used to assess hydrographic conditions.

B8. Data Management

The same approach and methods will be followed that are described in the NCA QAPP (U.S. EPA 2001) with the following additional notes. Original field data (either paper log books and/or electronic forms and digital photos) will be collected by EPA and PDE while on cruise. Approximately every evening back onshore, data hand entered into log books during the day will be entered into Excel spreadsheets on field lap top computers. Secondary people will QC this transcription by random check of 10% for data entry errors. Spot checks for transcription and calculation errors will be preformed periodically through out the project.

Raw field notebooks will also be photocopied at least weekly and shared between EPA and PDE to maintain redundant copies of data. Electronic files will be backed up by burning to CD's or USB drives, and saved on servers at both EPA and PDE.

Sample and data numbering will incorporate the station numbers, which are assigned in Appendix C.

C. ASSESSMENTS/OVERSIGHT

C1. Assessment and Response Actions

The Partnership for the Delaware Estuary will maintain a DEBI Workgroup affiliated with its Science and Technical Advisory Committee (see Appendix D; STAC Members) as a peer review panel. The entire STAC will also be invited to review and comment on major DEBI reports.

<u>Amendment to NCA QAPP</u>

C1-Assesment and Responsive Action
Field Monitoring (pg 53)

Field crew will complete a one day field training on July 8th, 2008. A letter of certification will not be issued from the Regional QA Coordinator to the State Project manager. If a crew member does not demonstrate competence with the field methods they will not be allowed to participate in the study

C2. Reports to Management

Results of sample analyses shall be compiled by PDE from contractors, and PDE will track and coordinate results. Semi-annual reports (twice per year) from PDE to the EPA Project Office are required under the terms of this agreement. These interim reports will document progress, describe any changes required and approved to this statement of work, and discuss any problems encountered.

A final report shall be presented to the EPA Project Officer no later than 180 days after the completion of all sample analyses (i.e., receiving benthic community and sediment data from subcontractors and partners). The final report product shall consist of an inventory of the taxonomic diversity and best measures of relative abundance for benthic invertebrate communities in all of the habitat types and areas that are sampled in the Delaware Estuary as part of this project. Concurrent sediment chemistry and grain size data will be shown for each sample station as well. This report will include maps showing the exact locations of sampling activities, and for those areas PDE will also work with EPA assessment staff to describe the overall condition of those communities.

It is understood that the probabilistic nature of this survey might also permit interpolation between sampling locations, perhaps when paired with other data collected in the past. Compilation of past data on benthic communities and condition (e.g. from NCA and other projects) and integration with new data from this project to form biological community maps, will be considered as additional effort to be undertaken contingent on additional funding as well as assistance from EPA's Atlantic Ecology Division. If such additional products are developed, they will be included in the final report.

Results presented in the final report shall follow the electronic format detailed in the MAIA-Estuaries data format manual (US EPA, 1997). PDE shall also provide a hard-copy output of data files (i.e., excel spreadsheets) for the purpose of quality assurance. The final report will of course also summarize all methods used, and any problems encountered will be included as an appendix to this report.

Original records, such as laboratory notebooks and field data sheets, shall be sent to PDE from all contractors prior to completion of the project, and exact copies of these will be furnished to EPA upon completion of the project.

The Partnership will work with the DEBI Workgroup to prepare and revise the report and make any adjustments deemed necessary. One eventual goal will be to develop the results into a format for submission as a publication in a peer reviewed journal. It is the hope that findings from this project will provide the basis for additional benthic community assessments, particularly in areas that will be lightly examined in the initial sampling program.

D. DATA VALIDATION AND USABILITY

D1. Data Review, Validation, and Verification Requirements

Data will be reviewed by at least one uninvolved member of the STAC who has expertise with either shellfish, benthic ecology or data management.

REFERENCES

DNREC. 2006. Delaware Bay Benthic and Sub-Bottom Mapping for Coastal Resource Management. Delaware Coastal Programs, Division of Soil and Water Conservation. 4 pp. http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/dcmp/Benthic%20Mapping.pdf

Dove, L.E., and R.M. Nyman. 1995. Living Resources of the Delaware Estuary. DELEP Report Number 95-07.

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U.S. EPA. (1997) MAIA-Estuaries 1997 Laboratory Data Format and Transmittal Guidance Document. United States Environmental Protection Agency, Atlantic Ecology Division. Narragansett, RI.

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U.S. EPA. 2001b. Environmental Monitoring and Assessment Program (EMAP). National Coastal Assessment Quality Assurance Project Plan 2001-2004. United States Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. http://www.epa.gov/emap/nca/html/docs/qaprojplan.html

APPENDIX A – Cruise Plan

Cruise Plan for 2008 Sampling for the Delaware Estuary Benthic Inventory

Draft

Note: The Cruise Plan will be a living document that will be periodically updated as needs arise. Please contact the EPA Senior Project Scientist for a current version.

CRUISE PLAN

Delaware Estuary Benthic Community Characterization Study
2008 CRUISE

EPA R.V. Lear
July 8, 2008

RENEE SEARFOSS AND

JIM GOUVAS

OCEANS TEAM
US EPA REGION III
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APPENDICES 38

Appendix A – National Coastal Assessment Field Operations Manual
Appendix B - Coordinates for Delaware Estuary Benthic Inventory Samples
Appendix C – Sediment Data Logs
Appendix D– Hydrographic Data Logs
Appendix E – QAPP
Appendix F – Scientific Party Schedule
Appendix G - Vessel Safety Plan

1.0 General

Project Title: Delaware Estuary Benthic Community Characterization Study
Survey Title: Primary Collection of Soft Bottom Sediment Samples and Secondary Collection of Hard Bottom Samples in the Delaware Estuary

Work Assignment Manager: Renee Searfoss
Organization: U.S. EPA Region III

Survey Chief Scientists: R. Searfoss/J. Gouvas A. Padeletti/
D. Kreeger
Organization: U.S. EPA Region III Partnership
for DE Estuary
Organization Address: 1650 Arch St. One
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Philadelphia, PA 19103 Wilmington, DE
19801
Organization Telephone No.: (215)-814-2728 (800) 445-
4935
FAX Number: (215)-814-2783
Email: last name.first@epa.gov

Contractor Organization: None

2.0 Schedule of Operations

Mobilization Date: 7 July 2008
Location: Indian River Marina, DE
Departure Date: 8 July 2007

Planned Survey Duration: 35 days
Weather/Breakdown Days: 10 days (in addition to 35 days)
Demobilization Date: 2nd week of September, 2008
Location: Ft. Mifflin, PA

3.0 Background Information

The science and management community in the Delaware Estuary region has identified a fundamental need for a benthic ecosystem assessment that would inventory both the physical and biological conditions of the bottom of the open water tidal system. The purpose of this RARE study is to conduct a survey of benthic invertebrate communities in the Delaware Estuary to help address key data gaps in their existing biological understanding. Contingent upon additional funding, data from this RARE study will be combined with those from other previous biological assessments and overlayed with physical substrate maps being produced to establish relationships between physical and biological conditions. A comprehensive, geospatially reference map and inventory of both biological and physical conditions is the long-term goal of the Delaware Estuary Benthic Indices (DEBI) inventory.

Regions II and III granted monies to the Partnership for the Delaware Estuary to conduct this study. Region III also volunteered a boat (the R.V. Lear), sampling equipment, captain and scientific staff as a cost saving measure. Representatives from Region III will be participating in this study, along with volunteers from the Partnership for the Delaware Estuary.

4.0 Survey Justification and Rationale

It is recognized that additional information regarding the physical, biological, and chemical characteristics of the Delaware Estuary are needed. The Partnership for the Delaware Estuary received grant money through a cooperative agreement to conduct a two year study. The Partnership needed a boat and expertise associated with collecting sediment samples. The Region III Oceans Team agreed to provide the above mentioned resources to the Partnership as part of the cooperative agreement.

5.0 Objectives

1. Delaware Estuary Benthic Community Characterization Study

    a. Approximately 250 soft-bottom grab samples will be collected according to methods described in the National Coastal Assessment Field Operations Manual (US EPA, 2001a).

b. Two benthic samples will be collected at each station using an EPA-provided 0.05m^2 Young Dredge grab sampler. A small core, consisting of a minimum depth of 7cm, will be collected for invertebrates and grain size analyses.
c. A second benthic grab will be taken and collected for metals and total organic carbon (TOC) analyses.
d. In addition, blanks and duplicate sample will also be collected and analyzed as per the requirements of the National Coastal Assessment Field Operations Manual (**Appendix A**).
e. A hydrocast will be conducted at each location. The hydrocasts will specifically be performed to note the halocline at the site of the sample location. Additional data (DO, temp, depth, pH, etc.) will also be collected at the same time.
f. To collect and compare data collection of hard bottom (photographic vs. dredge vs. sled vs. grab sampler with camera) associated with hard bottoms in the Broadkill Slough area.

6.0 Environmental Questions Asked by This Study

1. What levels of metals are present in the sediment in the Delaware Estuary?
2. What levels of total organic carbon are present in the sediment?
3. What type of biological organisms are present in the samples? How many of each species were identified?
4. What is the grain size of the sediment collected at each site?
5. What do the sample results of this segment of the study suggest in terms of diversity and health of the Delaware Estuary?
6. Where are the hard bottom habitats located and what is the condition of the habitats?
7. Which method (see objectives above) is best for the collection of hard bottom habitat?
8. What is the biological and functional relevance of hard bottom habitats?

7.0 Survey Location and Description

Survey Area: The mouth of the Delaware Estuary as far north as Bristol, PA if the funding and weather conditions allow. The stations identifications are associated with the closest coast. The samples will be collected along three state coasts. Therefore, all samples collected on the Delaware State side of the estuary will start out with DE. The second two digits of the samples will be 08, indicating the year in which the sample was collected. After a dash, the last four digits are associated with the location of the sample compared to the latitudinal coordinates (minutes) on the map. See Section 7.1 for the latitude and longitude coordinates of each sampling location.

7.1 Coordinates for Delaware Estuary Benthic Inventory Samples

See **Appendix B.**

8.0 Survey/Sampling Methodologies

Method Descriptions: All sampling activities will follow standard EPA procedures and the manufacturer's specifications for insuring acceptable data collection. The sampling method protocols are presented in Section 8.1. All activities relating to data and sample collection will be documented on the sediment logs and hydrographic logs in **Appendices C and D**.

Diving on Survey: ___X__ Yes _____No

A separate dive survey plan will be created for purposes of this study.

8.1 Sampling Method Protocols

A. Hydrographic Sampling
See National Coastal Assessment Field Operations Manual in **Appendix A.**

B. Sediment Sampling
See National Coastal Assessment Field Operations Manual in **Appendix A.**

9.0 Navigation and Positioning Control

All controls will be under the direction of the Bridge using the vessel's available equipment.

10.0 Equipment and Supplies

The U.S. EPA Region III will supply the R.V. Lear. Sampling equipment will include YSIs, a secchi disk, and a 0.05m^2 modified Van Veen grab sampler. All charts, log sheets, and portable computer capabilities will also be furnished by Region III. The Region will also provide sampling apparatus for water quality monitoring. All reagents, sample containers, etc. will be provided by the Partnership for the Delaware Estuary.

11.0 QA/QC Procedures

The QA/QC point of contact is _________________. They will be responsible for overseeing all activities associated with QA/QC during this scientific study.

QA/QC Procedures for Collection Equipment:

The activities covered in previous sections accounts for the quality assurance of sampling procedures. All standard EPA procedures will be followed to ensure this quality assurance. All instrumentation will be tested and calibrated prior to the survey. Calibration sheets will be included as part of the QAPP. All sampling activities will be documented in a field notebook and laptop computer.

QA/QC Procedures for Collection Methods:

All samples will be prepared, preserved, and stored using identified standard procedures. The samples are under the ownership of the Partnership for the Delaware Estuary. The Partnership will follow the proper procedures, as outlined in the Quality Assurance Project Plan (**Appendix E**).

12.0 Scientific Party

See **Appendix F.**

13.0 Lodging and Transportation

The following locations will be used for lodging during the nine week benthic study:

University of Delaware
Address:
Phone number:
Point of Contact:
Length of time:

Fortescue
Address:
Phone number:

Point of Contact:
Length of time:

Dover
Address:
Phone number:
Point of Contact:
Length of time:

Bauer's Beach?
St. Joan's Reserve?

Transportation will be provided either through EPA or Partnership for the Delaware Estuary for those driving down for the week. Both vehicles will be used to go to and from the boat and to any other locations (restaurants, drug stores, hospital, etc.) deemed necessary.

14.0 Proposed Reporting Requirements

Debriefing Telephone Call:	Not necessary
Survey Report Due Date:	Not applicable
Final Report:	Data will be shared with public after completion of study by Partnership for DE Estuary

Appendix A – National Coastal Assessment Field Operations Manual

Appendix B – Coordinates for Delaware Estuary Benthic Inventory Samples

Oligohaline Sample Locations

STNDRDID	Estuary	GRID_CODE	BotmType	Longitude DD	Latitude DD
DE08-0500	DELAWARE RIVER	2	Mixed Sediments	-75.4292	39.8030
DE08-0501	DELAWARE RIVER	3	Sands	-75.4192	39.7998
DE08-0502	DELAWARE RIVER	3	Sands	-75.4167	39.7978
DE08-0503	DELAWARE RIVER	3	Sands	-75.4378	39.7963
DE08-0504	DELAWARE RIVER	3	Sands	-75.4502	39.7945
DE08-0505	DELAWARE RIVER	3	Sands	-75.4331	39.7906
DE08-0506	DELAWARE RIVER	3	Sands	-75.4441	39.7899
DE08-0507	DELAWARE RIVER	1	Mud Bottom	-75.4281	39.7896
DE08-0508	DELAWARE RIVER	1	Mud Bottom	-75.4308	39.7882
DE08-0509	DELAWARE RIVER	2	Mixed Sediments	-75.4318	39.7869
DE08-0510	DELAWARE RIVER	1	Mud Bottom	-75.4345	39.7862
DE08-0511	DELAWARE RIVER	3	Sands	-75.4601	39.7858
DE08-0512	DELAWARE RIVER	1	Mud Bottom	-75.4408	39.7857
DE08-0513	DELAWARE RIVER	2	Mixed Sediments	-75.4668	39.7840
DE08-0514	DELAWARE RIVER	3	Sands	-75.4501	39.7830
DE08-0515	DELAWARE RIVER	2	Mixed Sediments	-75.4702	39.7802
DE08-0516	DELAWARE RIVER	3	Sands	-75.4602	39.7787
DE08-0517	DELAWARE RIVER	1	Mud Bottom	-75.4722	39.7778
DE08-0518	DELAWARE RIVER	1	Mud Bottom	-75.4619	39.7765
DE08-0519	DELAWARE RIVER	2	Mixed Sediments	-75.4497	39.7753
DE08-0520	DELAWARE RIVER	1	Mud Bottom	-75.4535	39.7740
DE08-0521	DELAWARE RIVER	3	Sands	-75.4753	39.7707
DE08-0522	DELAWARE RIVER	3	Sands	-75.4610	39.7702
DE08-0523	DELAWARE	2	Mixed	-75.4727	39.7691

	RIVER		Sediments		
DE08-0524	DELAWARE RIVER	1	Mud Bottom	-75.4603	39.7688
DE08-0525	DELAWARE RIVER	2	Mixed Sediments	-75.4625	39.7678
DE08-0526	DELAWARE RIVER	3	Sands	-75.4732	39.7649
DE08-0527	DELAWARE RIVER	1	Mud Bottom	-75.4824	39.7641
DE08-0528	DELAWARE RIVER	2	Mixed Sediments	-75.4654	39.7600
DE08-0529	DELAWARE RIVER	3	Sands	-75.4675	39.7600
DE08-0530	DELAWARE RIVER	3	Sands	-75.4751	39.7575
DE08-0531	DELAWARE RIVER	1	Mud Bottom	-75.4680	39.7561
DE08-0532	DELAWARE RIVER	2	Mixed Sediments	-75.4767	39.7553
DE08-0533	DELAWARE RIVER	3	Sands	-75.4855	39.7539
DE08-0534	DELAWARE RIVER	2	Mixed Sediments	-75.4677	39.7537
DE08-0535	DELAWARE RIVER	2	Mixed Sediments	-75.4918	39.7520
DE08-0536	DELAWARE RIVER	1	Mud Bottom	-75.4683	39.7511
DE08-0537	DELAWARE RIVER	2	Mixed Sediments	-75.4863	39.7499
DE08-0538	DELAWARE RIVER	2	Mixed Sediments	-75.4753	39.7474
DE08-0539	DELAWARE RIVER	1	Mud Bottom	-75.4858	39.7467
DE08-0540	DELAWARE RIVER	1	Mud Bottom	-75.4835	39.7458
DE08-0541	DELAWARE RIVER	2	Mixed Sediments	-75.4718	39.7456
DE08-0542	DELAWARE RIVER	1	Mud Bottom	-75.4877	39.7445
DE08-0543	DELAWARE RIVER	1	Mud Bottom	-75.4820	39.7444
DE08-0544	DELAWARE RIVER	1	Mud Bottom	-75.4982	39.7424
DE08-0545	DELAWARE RIVER	2	Mixed Sediments	-75.4833	39.7413
DE08-0546	DELAWARE RIVER	1	Mud Bottom	-75.4873	39.7397
DE08-0547	DELAWARE RIVER	3	Sands	-75.4799	39.7391
DE08-0548	DELAWARE RIVER	1	Mud Bottom	-75.4920	39.7390
DE08-0549	DELAWARE RIVER	3	Sands	-75.4969	39.7383
DE08-0550	DELAWARE RIVER	2	Mixed Sediments	-75.5005	39.7378

DE08-0551	DELAWARE RIVER	3	Sands	-75.4860	39.7317
DE08-0552	DELAWARE RIVER	3	Sands	-75.5007	39.7312
DE08-0553	DELAWARE RIVER	3	Sands	-75.4872	39.7304
DE08-0554	DELAWARE RIVER	2	Mixed Sediments	-75.5011	39.7296
DE08-0555	DELAWARE RIVER	2	Mixed Sediments	-75.5037	39.7281
DE08-0556	DELAWARE RIVER	2	Mixed Sediments	-75.4904	39.7216
NJ08-0511	DELAWARE RIVER	1	Mud Bottom	-75.3717	39.8212
NJ08-0512	DELAWARE RIVER	2	Mixed Sediments	-75.3826	39.8199
NJ08-0513	DELAWARE RIVER	3	Sands	-75.3785	39.8185
NJ08-0514	DELAWARE RIVER	2	Mixed Sediments	-75.3830	39.8160
NJ08-0515	DELAWARE RIVER	3	Sands	-75.3856	39.8143
NJ08-0516	DELAWARE RIVER	2	Mixed Sediments	-75.3933	39.8130
NJ08-0517	DELAWARE RIVER	3	Sands	-75.3956	39.8088
NJ08-0518	DELAWARE RIVER	3	Sands	-75.3960	39.8064
NJ08-0519	DELAWARE RIVER	2	Mixed Sediments	-75.4048	39.8062
NJ08-0520	DELAWARE RIVER	2	Mixed Sediments	-75.4001	39.8053
NJ08-0521	DELAWARE RIVER	3	Sands	-75.4109	39.8034
NJ08-0522	DELAWARE RIVER	2	Mixed Sediments	-75.4067	39.8013
NJ08-0523	DELAWARE RIVER	1	Mud Bottom	-75.4437	39.7782
PA08-0514	DELAWARE RIVER	1	Mud Bottom	-75.3972	39.8148
PA08-0515	DELAWARE RIVER	1	Mud Bottom	-75.3999	39.8142
PA08-0516	DELAWARE RIVER	1	Mud Bottom	-75.4055	39.8121
PA08-0517	DELAWARE RIVER	1	Mud Bottom	-75.4142	39.8054
PA08-0518	DELAWARE RIVER	1	Mud Bottom	-75.4179	39.8052

Mesohaline Sample Locations

STNDRDID	Estuary	GRID_CODE	BotmType	Longitude DD	Latitude DD
DE08-0557	CHRISTINA RIVER	1	Mud Bottom	-75.5171	39.7193
DE08-0558	DELAWARE RIVER	1	Mud Bottom	-75.5159	39.7070
DE08-0559	DELAWARE RIVER	1	Mud Bottom	-75.4986	39.7058
DE08-0560	DELAWARE RIVER	3	Sands	-75.5313	39.6750
DE08-0561	DELAWARE RIVER	2	Mixed Sediments	-75.5363	39.6640
DE08-0562	DELAWARE RIVER	1	Mud Bottom	-75.5566	39.6611
DE08-0563	DELAWARE RIVER	1	Mud Bottom	-75.5684	39.6535
DE08-0564	DELAWARE RIVER	1	Mud Bottom	-75.5370	39.6516
DE08-0565	DELAWARE RIVER	1	Mud Bottom	-75.6082	39.6232
DE08-0566	DELAWARE RIVER	2	Mixed Sediments	-75.5846	39.6141
DE08-0567	DELAWARE RIVER	1	Mud Bottom	-75.5912	39.6108
DE08-0568	DELAWARE RIVER	3	Sands	-75.5787	39.5903
DE08-0569	DELAWARE RIVER	1	Mud Bottom	-75.5320	39.5878
DE08-0570	DELAWARE RIVER	2	Mixed Sediments	-75.5824	39.5848
DE08-0571	DELAWARE RIVER	1	Mud Bottom	-75.5277	39.5762
DE08-0572	DELAWARE RIVER	2	Mixed Sediments	-75.5679	39.5754
DE08-0573	DELAWARE RIVER	1	Mud Bottom	-75.5242	39.5724
DE08-0574	DELAWARE RIVER	3	Sands	-75.5454	39.5699
DE08-0575	DELAWARE RIVER	1	Mud Bottom	-75.5279	39.5689
DE08-0576	DELAWARE RIVER	2	Mixed Sediments	-75.5657	39.5341
DE08-0577	DELAWARE RIVER	2	Mixed Sediments	-75.5414	39.5266
DE08-0578	DELAWARE RIVER	3	Sands	-75.5685	39.5175
DE08-0579	DELAWARE RIVER	2	Mixed Sediments	-75.5673	39.4646
DE08-0580	DELAWARE RIVER	3	Sands	-75.5788	39.4537
DE08-0581	DELAWARE RIVER	2	Mixed Sediments	-75.5356	39.4295
DE08-0582	DELAWARE	2	Mixed	-75.5287	39.4194

	RIVER		Sediments		
DE08-0583	DELAWARE BAY	2	Mixed Sediments	-75.5116	39.4129
DE08-0584	DELAWARE BAY	3	Sands	-75.5159	39.3975
DE08-0585	DELAWARE BAY	1	Mud Bottom	-75.4975	39.3668
DE08-0586	DELAWARE BAY	2	Mixed Sediments	-75.4868	39.3524
DE08-0587	DELAWARE BAY	2	Mixed Sediments	-75.4847	39.3476
DE08-0588	DELAWARE BAY	2	Mixed Sediments	-75.4588	39.3373
DE08-0589	DELAWARE BAY	1	Mud Bottom	-75.4340	39.3216
DE08-0590	DELAWARE BAY	3	Sands	-75.4262	39.2990
DE08-0591	DELAWARE BAY	2	Mixed Sediments	-75.3988	39.2964
DE08-0592	DELAWARE BAY	1	Mud Bottom	-75.4130	39.2878
DE08-0593	DELAWARE BAY	1	Mud Bottom	-75.4205	39.2852
DE08-0594	DELAWARE BAY	2	Mixed Sediments	-75.3805	39.2793
DE08-0595	DELAWARE BAY	1	Mud Bottom	-75.4111	39.2781
DE08-0596	DELAWARE BAY	1	Mud Bottom	-75.4049	39.2775
DE08-0597	DELAWARE BAY	3	Sands	-75.4024	39.2688
DE08-0598	DELAWARE BAY	3	Sands	-75.3589	39.2626
DE08-0599	DELAWARE BAY	1	Mud Bottom	-75.3693	39.2423
DE08-0600	DELAWARE BAY	2	Mixed Sediments	-75.3688	39.2412
DE08-0601	DELAWARE BAY	2	Mixed Sediments	-75.3361	39.2393
DE08-0602	DELAWARE BAY	1	Mud Bottom	-75.3925	39.2352
DE08-0603	DELAWARE BAY	3	Sands	-75.3428	39.2301
DE08-0604	DELAWARE BAY	2	Mixed Sediments	-75.3804	39.2017
NJ08-0524	DELAWARE RIVER	3	Sands	-75.5532	39.4921
NJ08-0525	DELAWARE RIVER	1	Mud Bottom	-75.5225	39.4525
NJ08-0526	DELAWARE RIVER	3	Sands	-75.5149	39.4376
NJ08-0527	DELAWARE BAY	1	Mud Bottom	-75.4722	39.4318
NJ08-0528	DELAWARE BAY	3	Sands	-75.4942	39.4260
NJ08-0529	DELAWARE BAY	2	Mixed Sediments	-75.4737	39.4197
NJ08-0530	DELAWARE BAY	3	Sands	-75.4558	39.4156
NJ08-0531	DELAWARE BAY	3	Sands	-75.4652	39.3976
NJ08-0532	DELAWARE BAY	3	Sands	-75.4339	39.3701
NJ08-0533	DELAWARE BAY	2	Mixed Sediments	-75.4348	39.3631
NJ08-0534	DELAWARE BAY	3	Sands	-75.4387	39.3554
NJ08-0535	DELAWARE BAY	3	Sands	-75.3384	39.3469
NJ08-0536	DELAWARE BAY	3	Sands	-75.4301	39.3456
NJ08-0537	DELAWARE BAY	2	Mixed Sediments	-75.3513	39.3453

NJ08-0538	DELAWARE BAY	3	Sands	-75.3775	39.3427
NJ08-0539	DELAWARE BAY	1	Mud Bottom	-75.3316	39.3403
NJ08-0540	DELAWARE BAY	3	Sands	-75.3930	39.3366
NJ08-0541	DELAWARE BAY	2	Mixed Sediments	-75.4082	39.3343
NJ08-0542	DELAWARE BAY	2	Mixed Sediments	-75.3748	39.3339
NJ08-0543	DELAWARE BAY	3	Sands	-75.4039	39.3252
NJ08-0544	DELAWARE BAY	3	Sands	-75.3644	39.3040
NJ08-0545	DELAWARE BAY	1	Mud Bottom	-75.2670	39.3004
NJ08-0546	DELAWARE BAY	3	Sands	-75.2856	39.2905
NJ08-0547	DELAWARE BAY	2	Mixed Sediments	-75.2691	39.2878
NJ08-0548	DELAWARE BAY	3	Sands	-75.3314	39.2842
NJ08-0549	DELAWARE BAY	1	Mud Bottom	-75.2911	39.2806
NJ08-0550	DELAWARE BAY	2	Mixed Sediments	-75.3317	39.2741

Delaware Bay Sample Locations

STNDRDID	Estuary	SYSTEM	Longitude DD	Latitude DD
DE08-0605	DELAWARE BAY	DE BAY CENTER	-75.3088	39.1958
DE08-0606	DELAWARE BAY	DE BAY WEST	-75.3836	39.1949
DE08-0607	DELAWARE BAY	DE BAY WEST	-75.3804	39.1704
DE08-0608	DELAWARE BAY	DE BAY WEST	-75.4042	39.1399
DE08-0609	DELAWARE BAY	DE BAY CENTER	-75.3137	39.1333
DE08-0610	DELAWARE BAY	DE BAY WEST	-75.3988	39.1194
DE08-0611	DELAWARE BAY	DE BAY CENTER	-75.2135	39.1108
DE08-0612	DELAWARE BAY	DE BAY WEST	-75.3888	39.0791
DE08-0613	DELAWARE BAY	DE BAY CENTER	-75.1976	39.0683
DE08-0614	DELAWARE BAY	DE BAY WEST	-75.3900	39.0607
DE08-0615	DELAWARE BAY	DE BAY WEST	-75.3549	39.0584
DE08-0616	DELAWARE BAY	DE BAY CENTER	-75.3104	39.0457
DE08-0617	DELAWARE BAY	DE BAY WEST	-75.3267	39.0443
DE08-0618	DELAWARE BAY	DE BAY CENTER	-75.1667	39.0385
DE08-0619	DELAWARE BAY	DE BAY WEST	-75.3059	39.0119
DE08-0620	DELAWARE BAY	DE BAY WEST	-75.2986	39.0035
DE08-0621	DELAWARE BAY	DE BAY WEST	-75.2870	38.9960
DE08-0622	DELAWARE BAY	DE BAY CENTER	-75.1846	38.9913
DE08-0623	DELAWARE BAY	DE BAY CENTER	-75.2412	38.9761
DE08-0624	DELAWARE BAY	DE BAY WEST	-75.2842	38.9634
DE08-0625	DELAWARE BAY	DE BAY CENTER	-75.2086	38.9398
DE08-0626	DELAWARE BAY	DE BAY WEST	-75.3091	38.9294
DE08-0627	DELAWARE BAY	DE BAY WEST	-75.2926	38.9278
DE08-0628	DELAWARE BAY	DE BAY CENTER	-75.1184	38.9273
DE08-0629	DELAWARE	DE BAY WEST	-75.2546	38.9084

	BAY			
DE08-0630	DELAWARE BAY	DE BAY WEST	-75.2725	38.9008
DE08-0631	DELAWARE BAY	DE BAY CENTER	-75.1840	38.8956
DE08-0632	DELAWARE BAY	DE BAY WEST	-75.2205	38.8779
DE08-0633	DELAWARE BAY	DE BAY WEST	-75.2309	38.8767
DE08-0634	DELAWARE BAY	DE BAY WEST	-75.1928	38.8523
DE08-0635	DELAWARE BAY	DE BAY CENTER	-75.1279	38.8397
DE08-0636	DELAWARE BAY	DE BAY WEST	-75.1046	38.8287
DE08-0637	DELAWARE BAY	DE BAY WEST	-75.1933	38.8254
DE08-0638	DELAWARE BAY	DE BAY WEST	-75.1608	38.8214
DE08-0639	DELAWARE BAY	DE BAY WEST	-75.1443	38.7904
DE08-0640	DELAWARE BAY	DE BAY WEST	-75.1126	38.7898
DE08-0641	DELAWARE BAY	DE BAY WEST	-75.1316	38.7822
NJ08-0551	DELAWARE BAY	DE BAY EAST	-75.2458	39.2828
NJ08-0552	DELAWARE BAY	DE BAY EAST	-75.2407	39.2702
NJ08-0553	DELAWARE BAY	DE BAY EAST	-75.2011	39.2468
NJ08-0554	DELAWARE BAY	DE BAY EAST	-75.2066	39.2332
NJ08-0555	DELAWARE BAY	DE BAY CENTER	-75.2180	39.2243
NJ08-0556	DELAWARE BAY	DE BAY EAST	-75.1686	39.2125
NJ08-0557	DELAWARE BAY	DE BAY EAST	-75.0908	39.2042
NJ08-0558	DELAWARE BAY	DE BAY CENTER	-75.2795	39.2026
NJ08-0559	DELAWARE BAY	DE BAY EAST	-75.1147	39.2010
NJ08-0560	DELAWARE BAY	DE BAY EAST	-75.1205	39.1867
NJ08-0561	DELAWARE BAY	DE BAY EAST	-75.0335	39.1862
NJ08-0562	DELAWARE BAY	DE BAY CENTER	-75.2492	39.1855
NJ08-0563	DELAWARE BAY	DE BAY EAST	-75.1600	39.1745
NJ08-0564	DELAWARE BAY	DE BAY EAST	-74.9203	39.1734
NJ08-0565	DELAWARE BAY	DE BAY EAST	-74.9976	39.1690

NJ08-0566	DELAWARE BAY	DE BAY EAST	-74.9895	39.1688
NJ08-0567	DELAWARE BAY	DE BAY EAST	-75.1281	39.1679
NJ08-0568	DELAWARE BAY	DE BAY EAST	-74.9351	39.1624
NJ08-0569	DELAWARE BAY	DE BAY CENTER	-75.1043	39.1627
NJ08-0570	DELAWARE BAY	DE BAY CENTER	-74.9546	39.1584
NJ08-0571	DELAWARE BAY	DE BAY EAST	-74.9048	39.1579
NJ08-0572	DELAWARE BAY	DE BAY EAST	-74.9078	39.1303
NJ08-0573	DELAWARE BAY	DE BAY EAST	-74.9192	39.1063
NJ08-0574	DELAWARE BAY	DE BAY CENTER	-75.1563	39.1004
NJ08-0575	DELAWARE BAY	DE BAY CENTER	-74.9508	39.0959
NJ08-0576	DELAWARE BAY	DE BAY CENTER	-75.0319	39.0944
NJ08-0577	DELAWARE BAY	DE BAY EAST	-74.9439	39.0711
NJ08-0578	DELAWARE BAY	DE BAY EAST	-74.9398	39.0462
NJ08-0579	DELAWARE BAY	DE BAY CENTER	-74.9784	39.0425
NJ08-0580	DELAWARE BAY	DE BAY CENTER	-75.1048	39.0206
NJ08-0581	DELAWARE BAY	DE BAY EAST	-74.9502	39.0155
NJ08-0582	DELAWARE BAY	DE BAY EAST	-74.9811	38.9895
NJ08-0583	DELAWARE BAY	DE BAY CENTER	-75.0765	38.9826
NJ08-0584	DELAWARE BAY	DE BAY EAST	-74.9707	38.9768
NJ08-0585	DELAWARE BAY	DE BAY EAST	-74.9989	38.9439
NJ08-0586	DELAWARE BAY	DE BAY EAST	-74.9919	38.9168
NJ08-0587	DELAWARE BAY	DE BAY CENTER	-75.0733	38.9156
NJ08-0588	DELAWARE BAY	DE BAY CENTER	-75.0228	38.9134

Delaware River Sample Locations

STNDRDID	Estuary	Longitude DD	Latitude DD
NJ08-0500	DELAWARE RIVER	-74.8358	40.0950
NJ08-0501	DELAWARE RIVER	-74.8478	40.0881
NJ08-0502	DELAWARE RIVER	-74.9532	40.0580
NJ08-0503	DELAWARE RIVER	-75.0237	40.0150
NJ08-0504	DELAWARE RIVER	-75.0588	39.9914
NJ08-0505	DELAWARE RIVER	-75.0985	39.9632
NJ08-0506	DELAWARE RIVER	-75.1441	39.8851
NJ08-0507	DELAWARE RIVER	-75.1713	39.8787
NJ08-0508	DELAWARE RIVER	-75.3407	39.8437
NJ08-0509	DELAWARE RIVER	-75.3232	39.8399
NJ08-0510	DELAWARE RIVER	-75.3557	39.8322
PA08-0500	DELAWARE RIVER	-74.7514	40.1355
PA08-0501	DELAWARE RIVER	-74.9009	40.0735
PA08-0502	DELAWARE RIVER	-74.9264	40.0704
PA08-0503	DELAWARE RIVER	-74.9864	40.0421
PA08-0504	DELAWARE RIVER	-75.0874	39.9766
PA08-0505	DELAWARE RIVER	-75.1283	39.9616
PA08-0506	DELAWARE RIVER	-75.1340	39.9556
PA08-0507	DELAWARE RIVER	-75.1331	39.9034
PA08-0508	DELAWARE RIVER	-75.1638	39.8861
PA08-0509	DELAWARE RIVER	-75.2075	39.8724
PA08-0510	DELAWARE RIVER	-75.2722	39.8585
PA08-0511	DELAWARE RIVER	-75.2566	39.8557
PA08-0512	DELAWARE RIVER	-75.2736	39.8546
PA08-0513	DELAWARE	-75.3578	39.8416

	RIVER		

Appendix C – Example of Sediment Data Log

Sediment Data Log

Survey: Delaware Estuary Benthic Community Study Survey

Station ID	Date	Time	Depth (m)	Depth Sediment (≥7 cm)	Metals (100 g)	Grain Size (100 g)	TOC (100 g)	Comments

Appendix D – Example of Hydrographic Data Log

Hydrographic Data Log

Survey: Delaware Estuary Benthic Community Study Survey

Station ID	Date	Depth	Conductivity	Salinity	Temperature	D.O.	Turbidity	pH

Notes:

Appendix E – Quality Assurance Project Plan

Appendix F – Scientific Party Schedule

Schedule for Benthic Sampling of Delaware Estuary

Date	Chief Scientist (PDE)	Chief Scientist (EPA)	Volunteer	Volunteer	Volunteer	Volunte
9-Jul-08	Danielle Kreeger	Renee Searfoss	Amie Howell	Bill Muir	George Gibson	
10-Jul-08	Angela Padeletti	Renee Searfoss	Danielle Kreeger	Bill Muir	George Gibson	
11-Jul-08	Angela Padeletti	Renee Searfoss	Amie Howell			
12-Jul-08	-----------	-----------	-----------	-----------	-----------	
13-Jul-08	-----------	-----------	-----------	-----------	-----------	
14-Jul-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
15-Jul-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
16-Jul-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
17-Jul-08	Laura Whalen	Renee Searfoss				
18-Jul-08	Laura Whalen	Renee Searfoss	Katie Lamb			
19-Jul-08	-----------	-----------	-----------	-----------	-----------	
20-Jul-08	-----------	-----------	-----------	-----------	-----------	
21-Jul-08	Danielle Kreeger					
22-Jul-08	Danielle Kreeger					
23-Jul-08	Angela Padeletti					
24-Jul-08	Angela Padeletti					
25-Jul-08	Angela Padeletti					
26-Jul-08	-----------	-----------	-----------	-----------	-----------	
27-Jul-08	-----------	-----------	-----------	-----------	-----------	
28-Jul-08	Laura Whalen	Renee Searfoss	Katie Lamb			
29-Jul-08	Laura Whalen	Renee Searfoss	Katie Lamb			
30-Jul-08	Laura Whalen	Renee Searfoss	Katie Lamb			
31-Jul-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
1-Aug-08	Angela Padeletti	Renee Searfoss	Katie Lamb			

2-Aug-08	-----------	-----------	-----------	-----------	-----------	
3-Aug-08	-----------	-----------	-----------	-----------	-----------	
4-Aug-08	Danielle Kreeger					
5-Aug-08	Danielle Kreeger					
6-Aug-08	Angela Padeletti					
7-Aug-08	Angela Padeletti					
8-Aug-08	Laura Whalen					
9-Aug-08	-----------	-----------	-----------	-----------	-----------	
10-Aug-08	-----------	-----------	-----------	-----------	-----------	
11-Aug-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
12-Aug-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
13-Aug-08	Angela Padeletti	Renee Searfoss	Katie Lamb			
14-Aug-08	Laura Whalen	Renee Searfoss	Katie Lamb			
15-Aug-08	Laura Whalen	Renee Searfoss	Katie Lamb			
16-Aug-08	-----------	-----------	-----------	-----------	-----------	
17-Aug-08	-----------	-----------	-----------	-----------	-----------	
18-Aug-08	TBD					
19-Aug-08	TBD					
20-Aug-08	TBD					
21-Aug-08	TBD					
22-Aug-08	TBD					
23-Aug-08	-----------	-----------	-----------	-----------	-----------	
24-Aug-08	-----------	-----------	-----------	-----------	-----------	
25-Aug-08	TBD	Renee Searfoss	Katie Lamb			
26-Aug-08	TBD	Renee Searfoss	Katie Lamb			
27-Aug-08	TBD	Renee Searfoss	Katie Lamb			
28-Aug-08	TBD	Renee Searfoss	Katie Lamb			
29-Aug-	TBD	Renee Searfoss	Katie Lamb			

08						
30-Aug-08	-----------	-----------	-----------	-----------	-----------	
31-Aug-08	-----------	-----------	-----------	-----------	-----------	
1-Sep-08	TBD					
2-Sep-08	TBD					
3-Sep-08	TBD					
4-Sep-08	TBD					
5-Sep-08	TBD					

Dive Week for Hard Bottom Sampling at Broadkill Slough

Appendix F – Vessel Safety Plan

EPA Region III Vessel Safety Plan – 2008

This plan establishes general guidelines and procedures for safe and efficient vessel operation with EPA Region III. The intent is to provide written guidance for quick reference in the field by the vessel master and the survey team.

Safety Standards

The safety standards which will apply and will be followed for all Region III operations are EPA's Operational Health and Safety Manual:

Emergency Telephone Numbers

General:
911

U.S. Coast Guard, Search and Rescue
VHF Ch 16

Delaware area:

Beebe Medical Center
424 Savannah Rd.
Lewes, DE
(302) 645-3300

New Jersey area:

South Jersey Hospital
1200 N High Street
Millville, NJ
(856) 825-3500

Philadelphia area:

Hahnemann University Hospital
230 N. Broad St.
Philadelphia, PA
(215) 762-7000

Directions to Hospital: See Attached

Emergency Points of Contact

Survey Person	Home Address	Contact	Special Needs
William C. Muir	225 N. Lansdowne Ave. Lansdowne, PA 19050	Karen Muir (610) 623-5159	None
Jim Gouvas	315 Kenmore Rd. Havertown, PA 19083	Ernie Gouvas (270) 782-8513	None

Survey Person	Home Address	Contact	Special Needs
Steve Donohue	30 Apple Valley Dr. Langhorne, PA 19047	Gale Donohue (215) 962-3256	None
Renee Searfoss	437 Oley Valley Rd. White Haven, PA 18661	Jeff Searfoss (484) 334-3578	None

APPENDIX B – Diver Survey Report

Delaware Bay Artificial Reef Study
Year 2 (1991)

DRAFT FINAL REPORT

DELAWARE BAY
ARTIFICIAL REEF STUDY
Year 2

EPA Contract No. 68-C8-0105
Work Assignment No. 2-135, Amendment 1

to

ENVIRONMENTAL PROTECTION AGENCY
Office of Wetlands, Oceans, and Watersheds
Region III

and

DEPARTMENT OF THE ARMY
United States Army Corps of Engineers
Philadelphia District

November 19, 1991

Prepared by

BATTELLE OCEAN SCIENCES
397 Washington Street
Duxbury, MA 02332
(617) 934-0571

DELAWARE BAY ARTIFICIAL-REEF STUDY
YEAR 2

K.L. Foster, R.K. Kropp, J.H. Ryther, and A.M. Spellacy

ABSTRACT

In partial fulfillment for mitigation of habitat loss in Wilmington Harbor South, Delaware, four prefabricated artificial-reef clusters were deployed by the United States Army Corps of Engineers in Delaware Bay in June 1989. The second annual investigation of the reefs, since reef deployment, took place during June and August 1991 to investigate the integrity of the reef units and characterize the artificial-reef area biota.

A visual assessment of the west cluster reef units in June 1991 and all the reef units in August 1991 revealed that the hydroids, bryozoans, and adult blue mussels *(Mytilus edulis)* that were present in June were either sparse or absent in August. In contrast, tubeworms were absent in June but were present in August. In addition, the numerous *Centropristis striata, Tautoga onitis, Choetodipterus taber, Stenotomus chrysops, and Opsanus tau* that were observed in June were either sparse or absent (e.g., *T. onitis*) in August.

Twenty-five finfish, five crustacean, and one mollusc species (733 total individuals) were collected in the area by using an otter trawl, modified lobster traps, and rods and reels. *Stenotomus chrysops* and *Raja eglanteria* were the most numerous species collected. Preliminary stomach-content analysis revealed that the most common prey items (by volume) were *Anchoa* sp. and a *Busycon* egg case. The most common prey items (by frequency of occurrence) were *Ensis directus, Anchoa* sp., *Neopanope sayi*, and *Mytilus edulis*. Two species, *Stenotomus chrysops* and *Centropristis striata*, contained two epifauna species, *Mytilus edulis* and *Neopanope sayi*. These prey were most dominant in fish that were collected on the reef in traps or while fishing over the reef using rods and reels.

In June 1991, the mean number of individuals per stations was 5571/m^2 and the mean biomass was 311.6 g wet weight/m^2. The infaunal community was characterized by large numbers of small razor clam, *Ensis directus*. In August 1991, the abundance of *Ensis* decreased substantially with a variety of annelid worms becoming dominant. The mean infaunal abundance in August was 2268/m^2 and the mean biomass 23.6 g/m^2. Epifaunal samples in June were dominated by *Mytilus edulis*, which accounted for 74% of the total abundance and 98.5% of the total biomass collected. *Mytilus* populations declined drastically by August, with crustaceans increasing in importance. Epifaunal biomass was estimated at 3867 g/m^2 in June and 163 g/m^2 in August.

These data indicate that the potential total biomass of the reef epifaunal community is approximately 100 times greater than the expected biomass of the infaunal community that was replaced. In addition, it appears that select fish are attracted to the reef for the physical habitat and food resources, although food resources are used from other areas (e.g., sediments).

The disposal of dredged material in the United States is regulated under the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), and the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA). Under these Acts, the Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE) have overlapping responsibilities for administering the permit process, which includes evaluation of disposal options. The order of selection of disposal options is to (1) utilize beneficial-use options, (2) minimize all impacts, and (3) compensate for all impacts that do occur. To adopt the best disposal option, it is important to evaluate the biological as well as chemical and physical impact of dredged-material disposal in targeted areas (e.g., wetlands, estuaries). If beneficial use is not feasible and if the preferred disposal option will result in habitat loss, identifying a means to compensate for habitat loss allows EPA and the USACE to maintain their goal of no net loss of wetlands.

The USACE, Philadelphia District, constructed a diked dredged-material disposal area at the Port of Wilmington, Delaware, in the Delaware River shore area, which is considered to be a productive aquatic habitat, and therefore requires mitigative action. The mitigation plan consists of two parts. The first part, which has been completed, was the planting of 12 acres of wetland vegetation on the dike berm and slope to compensate for the 12 acres of wetland vegetation lost as a result of project construction. The second part of the plan entailed an out-of-kind mitigation for constructing, installing, and monitoring 16 concrete artificial-reef structures near Brown Shoal in lower Delaware Bay, one of the richest fisheries areas in the Mid-Atlantic Bight. The construction and reef installation were completed in June 1989.

The monitoring phase of the project was developed through the combined efforts of the Artificial Reef Advisory Committee, which included representatives from the USACE Environmental Resources Branch, EPA, the National Marine Fisheries Service (NMFS), Delaware's Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife, and the [U.S] Fish and Wildlife Service (FWS). Although initiated and sponsored by the USACE, the project has evolved into a multiagency effort, with additional funds being contributed by EPA and technical expertise and advisory support being provided by EPA, NMFS, DNREC, and FWS. The 5-year Delaware Bay Artificial Reef Study project will investigate the feasibility of using these artificial reefs as compensation for shallow- and open-water habitat loss. Their effectiveness will be measured by monitoring over the 5-year period the increase in (1) overall biomass of benthos, (2) the productive habitat value of the artificial reefs for juvenile and adult fish species, and (3) the abundance of forage on the reef structures.

During the Delaware Bay Artificial Reef Study — Year 2, surveys were conducted June 2-3 and August 18-23, 1991. This was the second annual investigation of the reef units since their installation in June 1989. Infauna and sediment samples were collected during separate EPA surveys in May and August. The objective of this second survey was to (1) document the physical and biological status of the artificial-reef units by using still and video cameras, (2) collect epifauna and fisheries samples by using methods refined during the reconnaissance survey in September 1990, (3) collect sediments and benthic infauna within the artificial-reef area, and (4) conduct a visual assessment (e.g., reconnaissance) of all the artificial-reef units by using scuba divers. This draft final report presents the results of this second investigation and recently analyzed current-meter data collected during September 1990.

STUDY SITE AND METHODS

Study Site.—The Van Doren "20-20" (Van Doren, 1987) terrace-style artificial reefs are located in Delaware Bay within close proximity to Brown Shoal (some units in the North cluster are located on Brown Shoal) in approximately 10-13 m of water (Figure 1). Each reef unit comprises six pairs of stacked panels, 2.4 × 4.9 × 0.2 m, of waffled, precast concrete, joined by steel rods. The dimensions of each complete reef unit are 6.1 × 6.1 × 2.7 m (100.5 m^3) and each weighs approximately 20 metric tons. Each reef unit has approximately 407 m^2 of exposed surface and a 37-m^2 footprint. Therefore the reefs provide 11 times more surface area than they replaced. The reef structures are situated in four clusters (located in a north, south, east, and west configuration), with four reef units situated 9-18 m apart in each cluster (cluster dimension is approximately 81-324 m^2). The total dimension of the artificial-reef area is approximately 90 km^2.

Vessels.—Four vessels were used to conduct activities during Year 2.

- University of Delaware Research Vessel (R/V) *Skimmer*, a 12.8-m twin-diesel aluminum-hulled vessel, that was the main work platform used for fisheries sampling and processing, epifaunal sampling and processing, and as a dive platform for the video assessments.
- University of Delaware Research Vessel (R/V) *Shearwater*, an 8-m center-console fiberglass-hulled vessel, that was used for locating the reefs and conducting the reconnaissance survey.
- Environmental Protection Agency (EPA) #241, a 7.5-m Privateer® twin-engine workboat with a 2.4-m boom, that was used to locate the reefs and conduct the reconnaissance surveys, fisheries sampling, and epifauna sampling.
- EPA Ocean Survey Vessel (OSV) *Peter W. Anderson (Anderson)*, a 50-m diesel-powered aluminum-hulled vessel, that was used to collect infauna and sediment samples.

Reef Positions.—Although inclement weather prevented the verification of reef positions during the June survey, in August all reef units were located and buoyed. Due to the close proximity of the four reef units in a cluster, an accurate position was obtained only at one of the reef units designated as N-1, S-1, E-1, and W-1. The reef positions were confirmed using a Northstar model 800 Loran/GPS (global positioning system) and JRC JFF-100 color video echosounder. Positions and depths were stored and recorded when the artificial reef was detected on the echosounder. The echosounder transducer and navigation antennas were located in close proximity to one another to minimize position offsets. The geographic accuracy of the Loran/GPS is 30-100 m, and the depth measurement is accurate to 0.5 m. The revised positions and depths are plotted in Figure 2 and

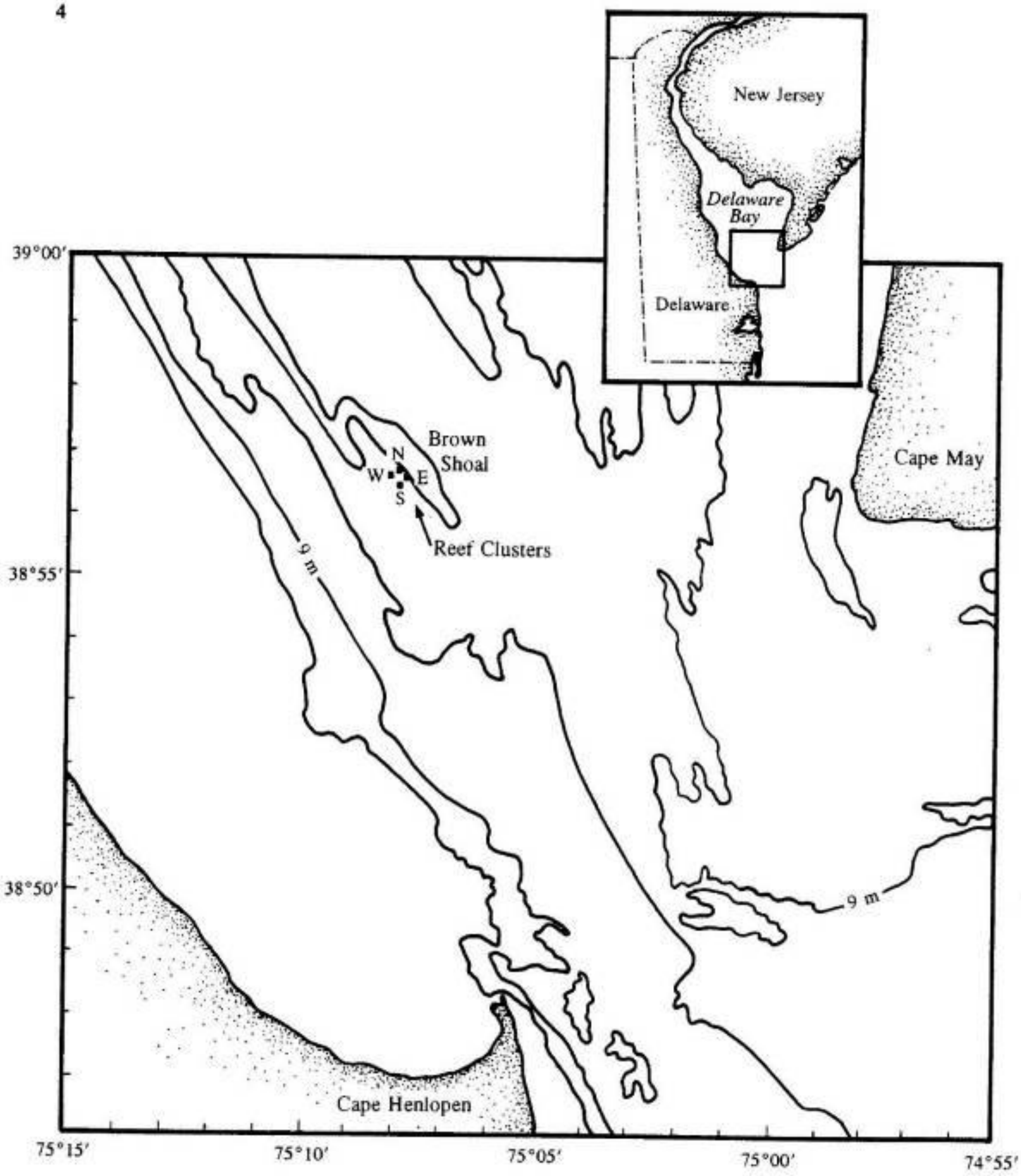

Figure 1. Artificial-Reef Deployment Area

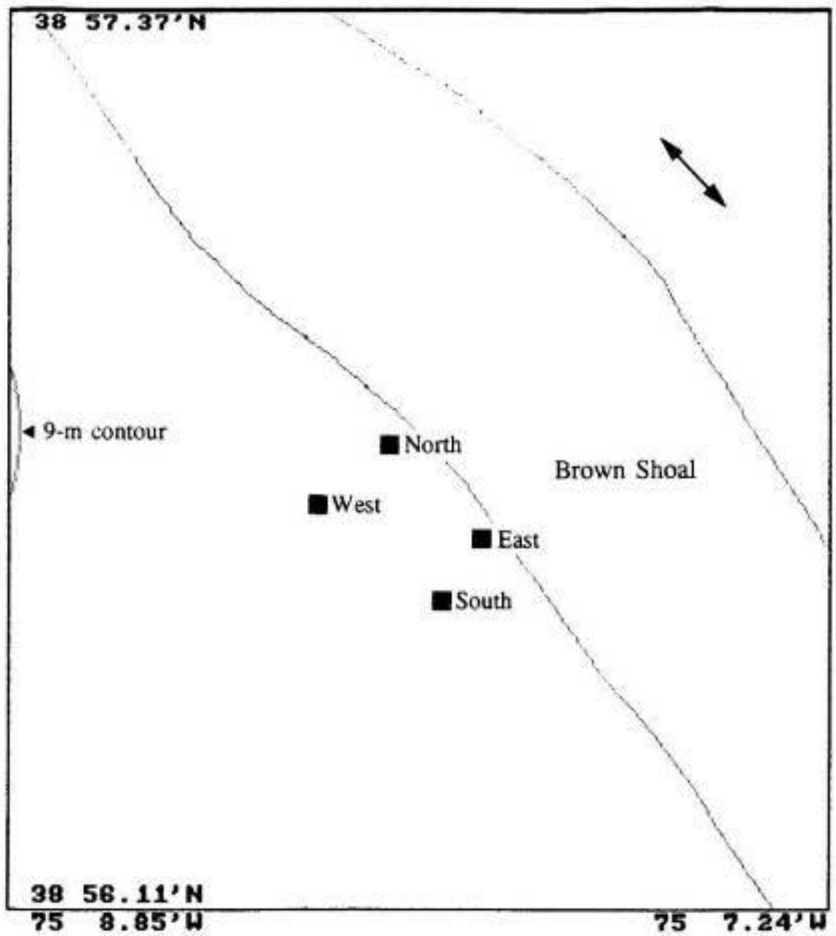

Figure 2. Positions of Artificial-Reef Clusters.
Arrows indicate current direction.

Table 1. Revised Positions of Artificial-Reef Clusters.

Reef Cluster	Coordinates Latitude (N) Longitude (W)	Loran C TD (N) TD (W)	Depth (m)
West	38°56.68′ 75°08.25′	27191.1 42735.0	13
South	38°56.54′ 75°08.02′	27189.5 42733.5	13
East	38°56.63′ 75°07.93′	27189.1 42734.5	10.5
North	38°56.76′ 75°08.12′	27190.5 42736.0	11

presented in Table 1. These positions replace all previously reported positions, including the position of the reef unit marked by the DNREC buoy, which was found to be submerged during the August survey.

Benthos Sample Collection: Infauna, Sediments, Epifauna.—To characterize the sediments and benthic infauna in the artificial-reef area as a reference for comparisons with the benthic epifauna on the reef units, sediment samples were collected from two sets (i.e., May and August) of randomly selected reference stations (Tables 2, 3) by using a 0.1-m^2 Smith-McIntyre grab sampler during an EPA survey in May and August 1991. The background infauna sampling design was based on a stratified sampling design to ensure complete coverage of the entire background area surrounding the clusters. A grid system was implemented to stratify the background area into 56 cells (Figure 3). Four of these cells contained the reef clusters; because these cells contain areas within the area of influence of the reefs, no samples were collected in these cells. Because of sampling difficulties, only 28 samples were collected during the May survey; 32 samples were collected during the August survey. Strong currents prevented the OSV *Anderson* from holding position at the proposed stations locations, which resulted in some of the August stations being offset to the northwest of the intended grid. In addition, sample locations for May could not be plotted because they were not available in latitude and longitude readings. Stations sampled during each survey were numbered sequentially beginning with the number 1; however, stations sampled in the two surveys having the same number do not represent the same location in the study area.

A sediment subsample (at least 50 g) was taken from each grab sample by using a plug (approximately 1.3 × 10.2 cm). After collection, samples were stored on ice until they were analyzed.

Table 2. Sediment-Sample Grab Station Coordinates, May 1991.

Station	Loran C[a]		Depth
	TD (N)	TD (W)	(m)
1	27187.0	42731.1	12.5
2	27186.7	42732.3	8.5
3	27187.5	42732.5	11.9
4	27187.9	42733.9	7.9
5[b]	—	—	—
6[b]	—	—	—
7	27188.1	42731.2	13.4
8	27187.8	42731.9	12.5
9	27187.7	42733.8	7.3
10	27188.9	42734.4	10.1
11[b]	—	—	—
12	27188.0	42731.3	13.4
13	27189.6	42733.1	12.8
14	27189.0	42734.4	11.0
15	27189.5	42734.8	11.3
16[b]	—	—	—
17	27188.8	42730.7	14.0
18	27189.4	42732.6	13.1
19	27189.2	42732.8	12.8
20	27188.9	42733.2	12.2
21	27190.2	42736.8	9.2
22	27189.7	42732.4	13.4
23	27189.2	42731.4	13.7
24	27190.0	42733.1	13.1
25	27189.4	42733.9	11.9
26	27190.5	42736.2	10.4
27	27189.5	42731.3	13.7
28	27190.5	42732.3	13.4
29	27189.4	42732.7	12.8
30	27190.6	42734.2	12.5
31	27190.5	42734.6	12.2
32	27190.8	42734.2	12.8

[a]Sample locations not available in latitude and longitude.
[b]No samples collected.

Table 3. Sediment-Sample Grab Station Coordinates, August 1991

Station	Latitude N	Longitude W	Depth (m)
1	38° 56.43′	75° 07.79′	a
2	38° 56.55′	75° 08.00′	10.7
3	38° 56.63′	75° 08.21′	a
4	38° 56.73′	75° 08.36′	12.5
5	38° 56.58′	75° 07.84′	a
6	38° 56.66′	75° 07.91′	9.8
7	38° 56.69′	75° 08.06′	a
8	38° 56.79′	75° 08.13′	12.5
9	38° 56.85′	75° 08.24′	10.7
10	38° 56.62′	75° 07.94′	11.0
11	38° 56.64′	75° 08.02′	11.9
12	38° 56.74′	75° 08.23′	12.2
13	38° 56.85′	75° 08.35′	11.3
14	38° 56.59′	75° 07.82′	8.5
15	38° 56.61′	75° 07.97′	12.8
16	38° 56.52′	75° 08.09′	12.8
17	38° 56.69′	75° 08.21′	12.2
18	38° 56.81′	75° 08.35′	12.2
19	38° 56.67′	75° 08.08′	12.5
20	38° 56.51′	75° 08.13′	13.1
21	38° 56.62′	75° 08.05′	12.5
22	38° 56.60′	75° 08.02′	12.8
23	38° 56.65′	75° 08.15′	12.8
24	38° 56.70′	75° 08.29′	12.8
25	38° 56.81′	75° 08.45′	12.8
26	38° 56.79′	75° 08.43′	12.8
27	38° 56.72′	75° 08.46′	12.8
28	38° 56.65′	75° 08.34′	12.8
29	38° 56.64′	75° 08.26′	13.7
30	38° 56.60′	75° 08.32′	13.4
31	38° 56.49′	75° 08.23′	14.0
32	38° 56.11′	75° 08.00′	13.7

[a]Depth not available.

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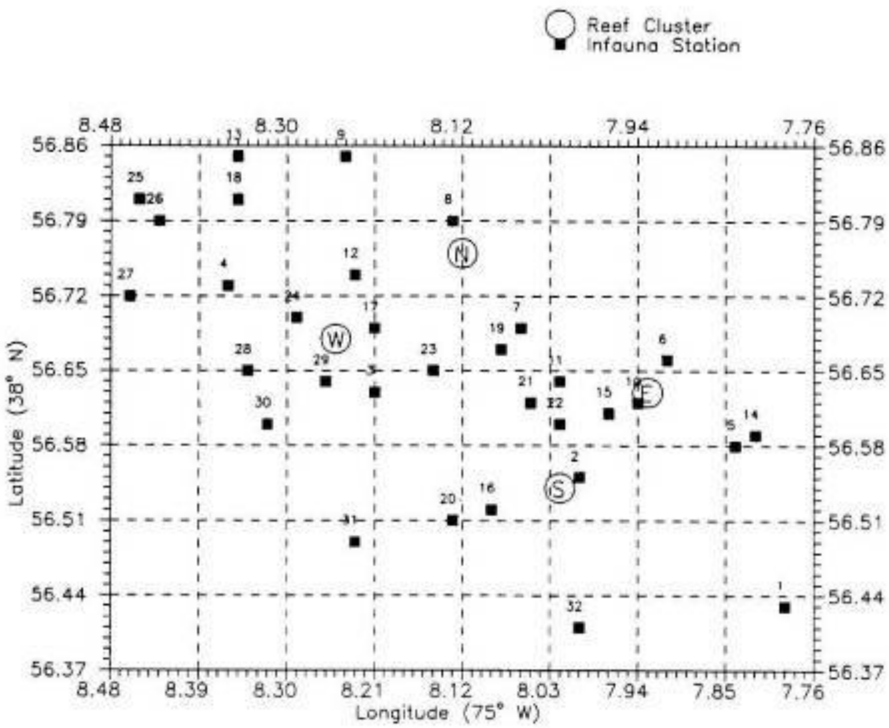


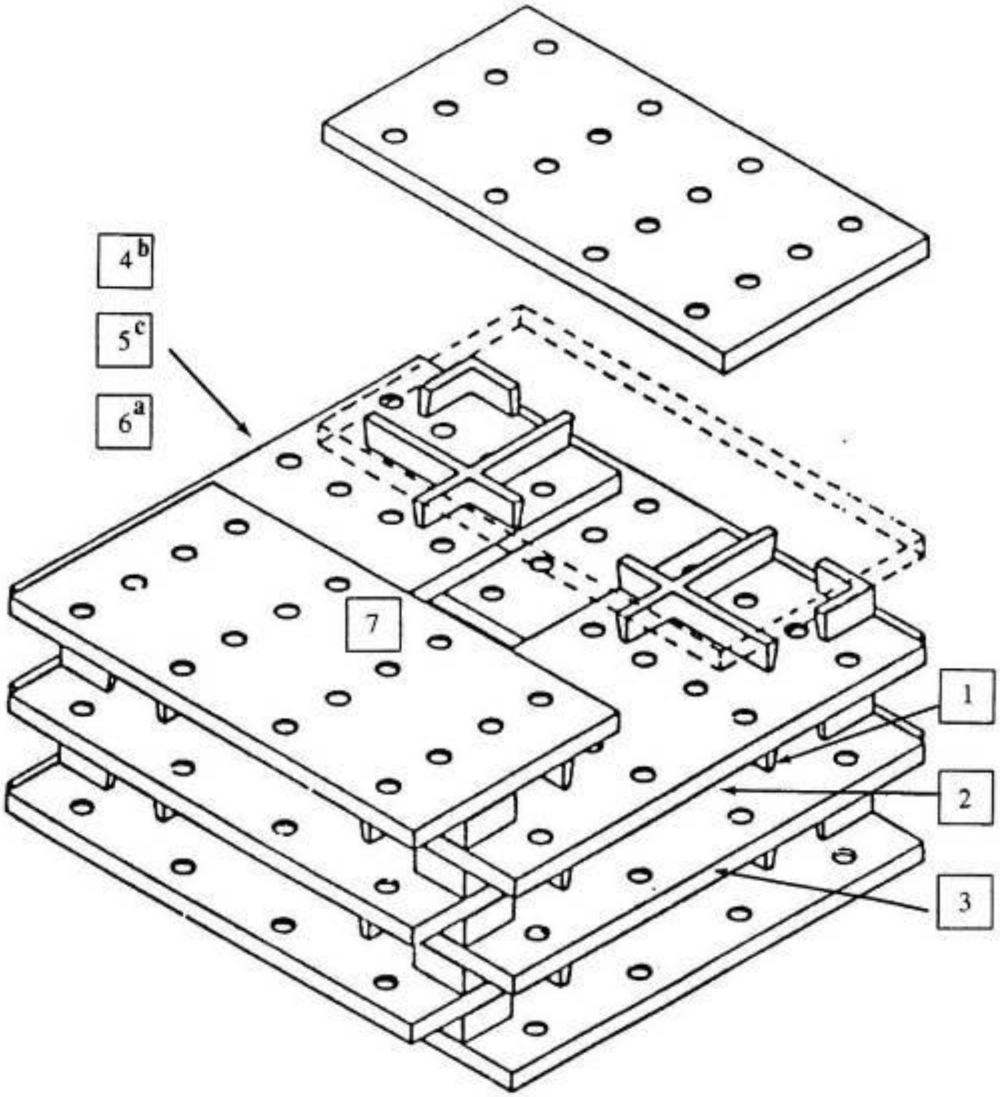
Figure 3. Locations of Reef Units and Infauna Stations Sampled during August 1991.

Because of the ineffectiveness of the suction system in collecting large concentrations of adult mussels, this system was abandoned for a scrape/sampler with a larger opening and sliding door as pictured in Figure 5. The proposed 56 August samples were collected using the scrape/sampler over a 0.05-m^2 area. Samples were collected by pushing the scrape/sampler, while exerting pressure, within the 0.05-m^2 quadrat. After scraping, the scrape/sampler with the mesh bag attached was positioned upright (the door was closed to prevent losing any of the sample). Once the sample was settled in the mesh bag, the bag was removed from the scrape/sampler and sealed along the edge with Velcro® fasteners. The units sampled in August 1991 were N-1, N-3, S-1, S-2, E-1, E-4, W-1, and W-3 (formerly W-1, on which the DNREC buoy was attached). The total reef area sampled in August 1991 was 2.8 m^2.

After sampling was completed at one reef unit, samples were delivered to the R/V *Skimmer*. Each sample was transferred from the collection bag into a labeled, plastic jar, relaxed with magnesium chloride, and fixed with a 10% buffered formalin in seawater solution. Sample collection bags were thoroughly rinsed with seawater before being used at the next reef unit. All pertinent sampling information was recorded on epifaunal logs (Appendix A).

Benthos Sample Processing: Infauna, Epifauna.—Upon receipt in the laboratory, all samples were rinsed over a 0.5-mm-mesh sieve, transferred to 70% ethanol, and sorted to remove all taxa. Whenever possible, all individuals from each sample were identified to species and counted. Pieces of colonial animals were not counted, but were included in the biomass estimates. Juveniles and damaged specimens not identifiable to species were included only in abundance and biomass estimates. A reference (voucher) collection of identified species was developed.

After identification, the wet weight of each taxon was determined to 1-mg accuracy. Prior to weighing, each taxon was placed on absorbent paper toweling and allowed to blot dry for about 2 min. The time required for blot-drying may have been less for small, less numerous taxa (e.g., amphipods). Care was taken not to allow samples to dry out completely. For large clams, the shell was opened and water allowed to drain before weight measurements were taken. To allow all taxa to be included in biomass analyses, taxa with weights less than 0.001 g were assigned a weight of 0.0005 g. Wet weights of large taxa — e.g., *Asterias* — were recorded separately. Biomass, as used in this report, is defined as total wet weight, uncorrected for any potential bias introduced by preservation of the animals in formalin. Total weight of *Mytilus* was converted to meat weight by dividing the total weight by 5.86, a conversion factor used by NMFS. Meat weight was used for any calculations including *Mytilus*. Conversion factors were not applied to the weight of any other taxa.



[a]Sample 6 was taken from the opposite side of the unit from sample 3.
[b]Sample 4 was taken from the opposite side of the unit from sample 1.
[c]Sample 5 was taken from the opposite side of the unit from sample 2.

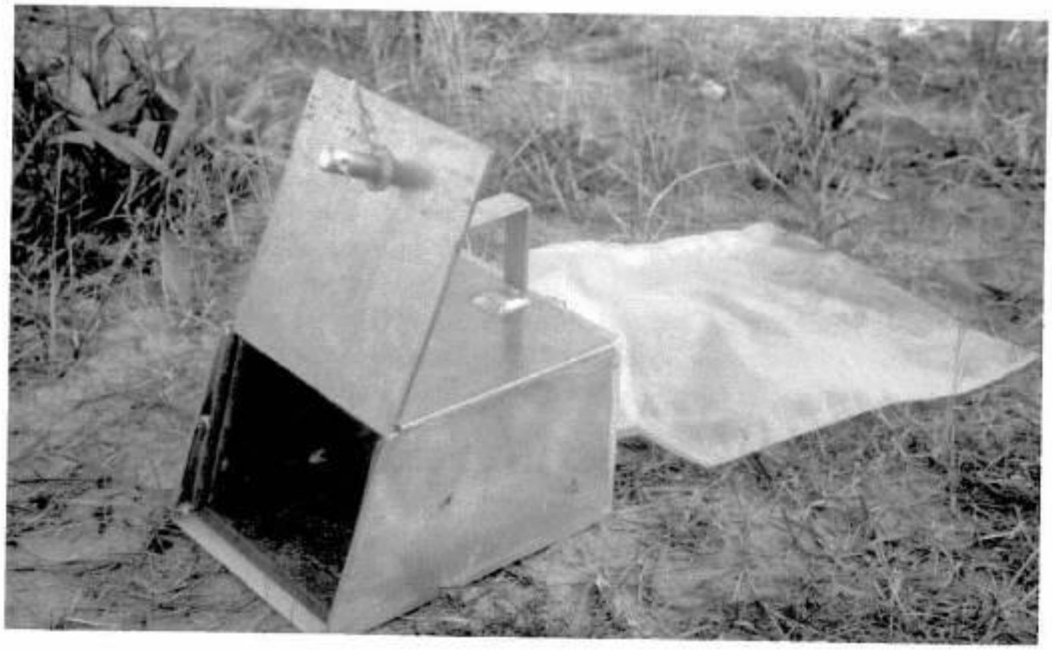
Figure 4. Locations of Epifaunal Scrape Samples Collected from the Artificial-Reef Units.

Grain-size analysis was performed by using a standard sieve and pipette method (Folk, 1974). The sediment remaining after the removal of the grain-size sample was then rinsed with filtered seawater over a 0.5-mm-mesh sieve and fixed with a 10% buffered formalin and seawater solution to which Rose Bengal had been added.

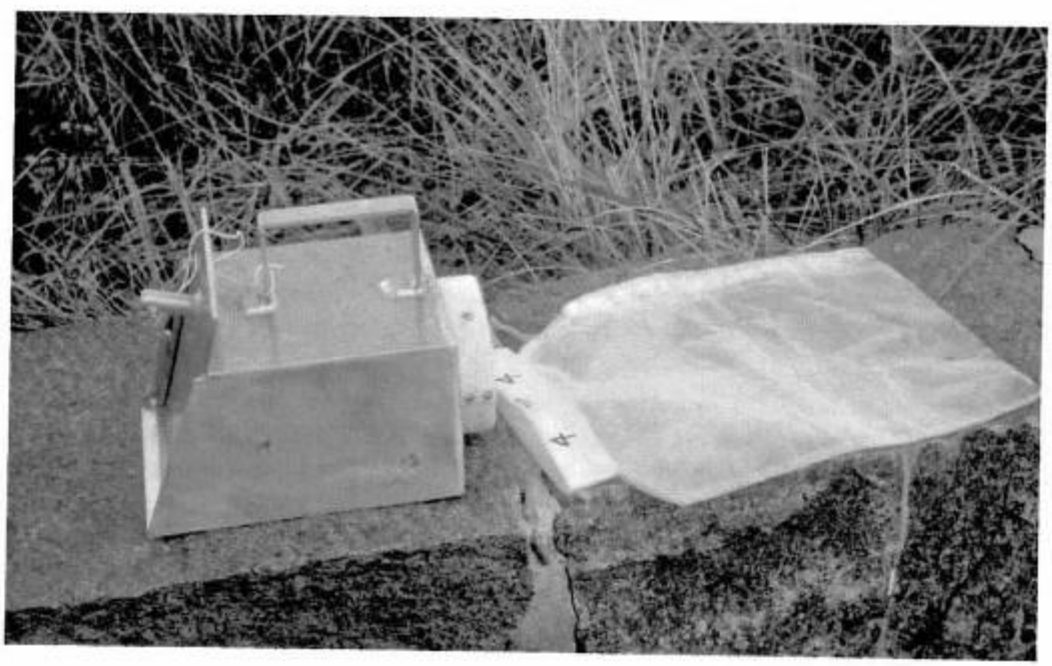
To characterize the epifaunal communities colonizing the artificial reefs, seven locations were selected for sampling by scuba divers. The areas were selected as most likely to be representative of the epifauna colonizing the reefs and included exposed and sheltered horizontal and vertical surfaces from the top and middle levels of the reef unit. The order of the sampling locations was rearranged from that used in 1990 to facilitate more efficient sampling by the scuba divers. To allow comparisons among reefs, samples were taken from two units within each reef cluster. The following seven predetermined locations (Figure 4) were sampled on each of two reef units per cluster.

1. Interior vertical wall of the third panel from the top on the crossbar that supports the upper panel along the same side as sampled in Location 6 (formerly Location no. 4)
2. Interior horizontal wall of the third panel from the top near the crossbar that supports the upper panel along the same side as was sampled in Location 6 (near the corresponding vertical scrape) (formerly Location no. 6)
3. Exterior vertical walls of the third panel from the top of the reef unit (formerly Location no. 1)
4. Interior vertical wall of the third panel from the top on the crossbar supporting the upper panel along the same side as was sampled in Location 3 (formerly Location no. 5)
5. Interior horizontal wall of the third panel from the top near the crossbar that supports the upper panel along the same side as was sampled in Location 3 (near the corresponding vertical scrape) (formerly Location no. 7)
6. Exterior vertical walls of the third panel from the top of the reef unit along the side opposite Location 3 (formerly Location no. 2)
7. Central areas on the exterior horizontal surface on the top panel (formerly Location no. 3)

Eleven of the 56 proposed samples to be collected during June were collected from the West cluster by using an airlift-suction device developed by Battelle. This system consisted of a 3-ft length of 2.5-in. PVC pipe attached to a 0.05-mm-mesh Nytex bag. Each mesh bag was prelabeled with the specific position (i.e., 1 through 7) on the reef unit from which samples were taken. Compressed air was delivered from a scuba tank on the surface through 200 ft of 0.25-in. compressor hose. Suction samples were collected within a 0.1-m^2 (seven samples) and 0.05-m^2 (four samples) quadrat frame. The quadrat size was decreased from 0.1 m^2 to 0.05 m^2 because it was determined (by EPA, USACE, and NOAA representatives and Battelle) that the 0.05-m^2 quadrat provided a sufficient volume of sample for analysis. Inclement weather and difficulty locating designated reef clusters prevented the collection of the remaining 45 samples. Samples (0.1-m^2) were collected from seven locations on unit W-1. These samples, designated Ep-1 through Ep-7, correspond to Locations 7, 5, 6, 4, 2, 1, and 3 as listed above. Samples (0.05-m^2) were also collected from four locations on unit W-2. These samples, designated Ep-8 through Ep-11, correspond to Locations 7, 6, 4, and 5 as listed above. The total reef area sampled in June 1991 was 0.9 m^2.



(a) With Mesh Bag Attached



(b) With Mesh Bay Detached

Figure 5. Scrape/Sampler Used for Epifaunal Sampling

Table 4. August Survey Otter Trawl Logistics.

Tow Number	Date	Time (start)	Time (end)	Length	Position (start)	Position (end)	Course
1	8/21	9:59	10:19	20 min	38°56.40′ 75°07.78′	38°56.71′ 75°08.24′	NW
2	8/21	11:47	12:04	17 min	38°56.39′ 75°07.94′	38°56.66′ 75°08.32′	NW
3	8/22	11:25	11:39	14 min	38°56.48′ 75°07.80′	38°56.63′ 75°07.99′	N/SW
4	8/22	12:03	12:22	19 min	38°56.24′ 75°08.19′	38°56.70′ 75°07.91′	NW

was completely covered by sediment. One trap each was deployed on two levels of the North (N-1 and N-3), South (S-1 and S-2), and East (E-1) clusters. Soak time varied for each set of traps:

- N-1: 7 h
- E-1: 5.5 h
- N-1, N-3, S-1, and S-2: overnight

Traps that were to be placed on W-1 were inadvertently placed on N-1 instead (the traps that fished 7 h). Therefore, the traps placed on N-1 served as replicate samples. Because diver deployment of the traps was limited to slack-tide periods, there was insufficient time to deploy additional traps on the East and West clusters. The string and reef traps were adjusted to enlarge the netted funnels to the back compartment of the trap to enable the trap to catch fish better.

The third sampling method was to tow an otter trawl through the reef area. Four tows were conducted in the artificial-reef area by towing a 9.7-cm^2-mesh otter trawl with a wing span of 7.3 m at a speed of 1.5-2 kn for approximately 14-20 min. Trawl timing began when the doors were in the water and ended when the trawl was beginning to be hauled back. All tows were made in a direction opposing the tide to keep the net erect and open. Trawl times and positions are listed in Table 4. To avoid snagging the net in the reefs, the tows were made 200-300 m from the reef units. All trawls were conducted in approximately 15-16 m of water with the exception of trawl 3, which was conducted on Brown Shoal in 10 m of water. Figure 7 shows the vessel track for each otter trawl tow and the outline of Brown Shoal.

The fourth method required that fishing rods with reels be used to catch species residing on or near the clusters and in the reef area (hereafter: hook-and-line study). Ten 2-m boat fishing rods with

13.6 kg-test line were baited with a variety of bait (e.g., squid, green crabs) and rigged with several combinations of tackle (e.g., high/low rigs, 62- to 93-g sinkers) were used. Fishing was conducted from the R/V *Skimmer* and the EPA #241 vessels as each vessel drifted over a reef unit in the West, East, and South (i.e., S-3) clusters. Fishing was also conducted in a control area (38°56.51'N Lat., 75° 07.90'W Long.) away from the clusters. This hook-and-line study was conducted as an experiment to determine which bait and tackle could be used most successfully to capture fish species residing in the reef area.

Samples were sorted and identified to species. Color pictures from NMFS fish guides and reference books [e.g., Bigelow and Schroeder, 1953, *Fishes of the Gulf of Maine* (first revision)] and fishkeys were used for reference, if needed. All individuals of each species were weighed collectively by using a Hanson® spring dial scale. All individuals were placed in either a preweighed bucket or a wire-mesh bushel basket and weighed. Lengths were determined by using a metric-rule measuring board or a meter stick for all individuals of each species by the following specific procedures:

Fish — fork-length method (i.e., tip of the snout to the fork in the tail)
Skates — total-length method (i.e., tip of snout to the end of the tail)
Crabs — carapace width (i.e., measure the widest width)
Rays — wing width (i.e., measure from tip to tip)
Squid — mantle length (i.e., tip of the mantle collar to tip of the fin)

All species caught were recorded on one type of log (Appendix A). The collection method — either "reef trap," "fish traps," (i.e., bay or reef traps), "otter trawl," or "hook-and-line" — was indicated on each individual log. Gill nets were not used.

Fishery Sampling: Food Habits Analysis.—To determine to what extent fish were feeding on the reef epifauna, stomach contents of several fish species were analyzed according to a method (Bowman and Michaels, 1984) that has been used by the NMFS, NEFC, since 1960. A 3.7-m Zodiac®, which accompanied the R/V *Skimmer,* was used to assist in the retrieval of the fish traps. Stomach contents of predators of reef epifauna (any fish whose stomach contents were analyzed is considered a predator) were excised from the body cavity and placed in a petri dish. The sex and sexual maturity of the predator were determined. The total volume (in cubic centimeters) was determined by using volume-graduated variable-diameter cylinders and choosing the cylinder that best approximated the dimensions and volume of the stomach bolus. To separate the stomach contents in the petri dish, they were washed with a few drops of fresh water. The stomach contents were grouped by prey item and identified. The apparent stage of prey digestion was noted as fresh, partial, or well. An approximate percent of the total stomach contents was visually determined for each group of prey items (e.g., if the stomach contained five pieces of squid, the total amount of squid might comprise 50% of the total prey items found in the stomach). The stomach-contents data, as well as the sex and maturity of each predator, were recorded on modified NMFS feeding ecology logsheets (Appendix A). After

APPENDIX C – 2008 DEBI Sampling Stations

STNDRDID	Estuary	GRID_CODE	BotmType	Longitude DD	Latitude DD	Long Degrees	Long Dec	Lat Degrees	Lat Dec Min
DE08-0500	DELAWARE RIVER	2	Mixed Sediments	-75.4292	39.8030	-75	25.752	39	48.180
DE08-0501	DELAWARE RIVER	3	Sands	-75.4192	39.7998	-75	25.152	39	47.988
DE08-0502	DELAWARE RIVER	3	Sands	-75.4167	39.7978	-75	25.002	39	47.868
DE08-0503	DELAWARE RIVER	3	Sands	-75.4378	39.7963	-75	26.268	39	47.778
DE08-0504	DELAWARE RIVER	3	Sands	-75.4502	39.7945	-75	27.012	39	47.670
DE08-0505	DELAWARE RIVER	3	Sands	-75.4331	39.7906	-75	25.986	39	47.436
DE08-0506	DELAWARE RIVER	3	Sands	-75.4441	39.7899	-75	26.646	39	47.394
DE08-0507	DELAWARE RIVER	1	Mud Bottom	-75.4281	39.7896	-75	25.686	39	47.376
DE08-0508	DELAWARE RIVER	1	Mud Bottom	-75.4308	39.7882	-75	25.848	39	47.292
DE08-0509	DELAWARE RIVER	2	Mixed Sediments	-75.4318	39.7869	-75	25.908	39	47.214
DE08-0510	DELAWARE RIVER	1	Mud Bottom	-75.4345	39.7862	-75	26.070	39	47.172
DE08-0511	DELAWARE RIVER	3	Sands	-75.4601	39.7858	-75	27.606	39	47.148
DE08-0512	DELAWARE RIVER	1	Mud Bottom	-75.4408	39.7857	-75	26.448	39	47.142
DE08-0513	DELAWARE RIVER	2	Mixed Sediments	-75.4668	39.7840	-75	28.008	39	47.040
DE08-0514	DELAWARE RIVER	3	Sands	-75.4501	39.7830	-75	27.006	39	46.980
DE08-0515	DELAWARE RIVER	2	Mixed Sediments	-75.4702	39.7802	-75	28.212	39	46.812
DE08-0516	DELAWARE RIVER	3	Sands	-75.4602	39.7787	-75	27.612	39	46.722
DE08-0517	DELAWARE RIVER	1	Mud Bottom	-75.4722	39.7778	-75	28.332	39	46.668
DE08-0518	DELAWARE RIVER	1	Mud Bottom	-75.4619	39.7765	-75	27.714	39	46.590
DE08-0519	DELAWARE RIVER	2	Mixed Sediments	-75.4497	39.7753	-75	26.982	39	46.518
DE08-0520	DELAWARE RIVER	1	Mud Bottom	-75.4535	39.7740	-75	27.210	39	46.440
DE08-0521	DELAWARE RIVER	3	Sands	-75.4753	39.7707	-75	28.518	39	46.242
DE08-0522	DELAWARE RIVER	3	Sands	-75.4610	39.7702	-75	27.660	39	46.212
DE08-0523	DELAWARE RIVER	2	Mixed Sediments	-75.4727	39.7691	-75	28.362	39	46.146
DE08-0524	DELAWARE RIVER	1	Mud Bottom	-75.4603	39.7688	-75	27.618	39	46.128
DE08-0525	DELAWARE RIVER	2	Mixed Sediments	-75.4625	39.7678	-75	27.750	39	46.068
DE08-0526	DELAWARE RIVER	3	Sands	-75.4732	39.7649	-75	28.392	39	45.894
DE08-0527	DELAWARE RIVER	1	Mud Bottom	-75.4824	39.7641	-75	28.944	39	45.846
DE08-0528	DELAWARE RIVER	2	Mixed Sediments	-75.4654	39.7600	-75	27.924	39	45.600
DE08-0529	DELAWARE RIVER	3	Sands	-75.4675	39.7600	-75	28.050	39	45.600
DE08-0530	DELAWARE RIVER	3	Sands	-75.4751	39.7575	-75	28.506	39	45.450
DE08-0531	DELAWARE RIVER	1	Mud Bottom	-75.4680	39.7561	-75	28.080	39	45.366
DE08-0532	DELAWARE RIVER	2	Mixed Sediments	-75.4767	39.7553	-75	28.602	39	45.318
DE08-0533	DELAWARE RIVER	3	Sands	-75.4855	39.7539	-75	29.130	39	45.234
DE08-0534	DELAWARE RIVER	2	Mixed Sediments	-75.4677	39.7537	-75	28.062	39	45.222
DE08-0535	DELAWARE RIVER	2	Mixed Sediments	-75.4918	39.7520	-75	29.508	39	45.120
DE08-0536	DELAWARE RIVER	1	Mud Bottom	-75.4683	39.7511	-75	28.098	39	45.066
DE08-0537	DELAWARE RIVER	2	Mixed Sediments	-75.4863	39.7499	-75	29.178	39	44.994
DE08-0538	DELAWARE RIVER	2	Mixed Sediments	-75.4753	39.7474	-75	28.518	39	44.844
DE08-0539	DELAWARE RIVER	1	Mud Bottom	-75.4858	39.7467	-75	29.148	39	44.802
DE08-0540	DELAWARE RIVER	1	Mud Bottom	-75.4835	39.7458	-75	29.010	39	44.748
DE08-0541	DELAWARE RIVER	2	Mixed Sediments	-75.4718	39.7456	-75	28.308	39	44.736
DE08-0542	DELAWARE RIVER	1	Mud Bottom	-75.4877	39.7445	-75	29.262	39	44.670
DE08-0543	DELAWARE RIVER	1	Mud Bottom	-75.4820	39.7444	-75	28.920	39	44.664
DE08-0544	DELAWARE RIVER	1	Mud Bottom	-75.4982	39.7424	-75	29.892	39	44.544
DE08-0545	DELAWARE RIVER	2	Mixed Sediments	-75.4833	39.7413	-75	28.998	39	44.478
DE08-0546	DELAWARE RIVER	1	Mud Bottom	-75.4873	39.7397	-75	29.238	39	44.382
DE08-0547	DELAWARE RIVER	3	Sands	-75.4799	39.7391	-75	28.794	39	44.346
DE08-0548	DELAWARE RIVER	1	Mud Bottom	-75.4920	39.7390	-75	29.520	39	44.340
DE08-0549	DELAWARE RIVER	3	Sands	-75.4969	39.7383	-75	29.814	39	44.298
DE08-0550	DELAWARE RIVER	2	Mixed Sediments	-75.5005	39.7378	-75	30.030	39	44.268
DE08-0551	DELAWARE RIVER	3	Sands	-75.4860	39.7317	-75	29.160	39	43.902
DE08-0552	DELAWARE RIVER	3	Sands	-75.5007	39.7312	-75	30.042	39	43.872
DE08-0553	DELAWARE RIVER	3	Sands	-75.4872	39.7304	-75	29.232	39	43.824
DE08-0554	DELAWARE RIVER	2	Mixed Sediments	-75.5011	39.7296	-75	30.066	39	43.776
DE08-0555	DELAWARE RIVER	2	Mixed Sediments	-75.5037	39.7281	-75	30.222	39	43.686
DE08-0556	DELAWARE RIVER	2	Mixed Sediments	-75.4904	39.7216	-75	29.424	39	43.296
NJ08-0511	DELAWARE RIVER	1	Mud Bottom	-75.3717	39.8212	-75	22.302	39	49.272
NJ08-0512	DELAWARE RIVER	2	Mixed Sediments	-75.3826	39.8199	-75	22.956	39	49.194
NJ08-0513	DELAWARE RIVER	3	Sands	-75.3785	39.8185	-75	22.710	39	49.110
NJ08-0514	DELAWARE RIVER	2	Mixed Sediments	-75.3830	39.8160	-75	22.980	39	48.960
NJ08-0515	DELAWARE RIVER	3	Sands	-75.3856	39.8143	-75	23.136	39	48.858
NJ08-0516	DELAWARE RIVER	2	Mixed Sediments	-75.3933	39.8130	-75	23.598	39	48.780
NJ08-0517	DELAWARE RIVER	3	Sands	-75.3956	39.8088	-75	23.736	39	48.528
NJ08-0518	DELAWARE RIVER	3	Sands	-75.3960	39.8064	-75	23.760	39	48.384
NJ08-0519	DELAWARE RIVER	2	Mixed Sediments	-75.4048	39.8062	-75	24.288	39	48.372
NJ08-0520	DELAWARE RIVER	2	Mixed Sediments	-75.4001	39.8053	-75	24.006	39	48.318
NJ08-0521	DELAWARE RIVER	3	Sands	-75.4109	39.8034	-75	24.654	39	48.204
NJ08-0522	DELAWARE RIVER	2	Mixed Sediments	-75.4067	39.8013	-75	24.402	39	48.078
NJ08-0523	DELAWARE RIVER	1	Mud Bottom	-75.4437	39.7782	-75	26.622	39	46.692
PA08-0514	DELAWARE RIVER	1	Mud Bottom	-75.3972	39.8148	-75	23.832	39	48.888
PA08-0515	DELAWARE RIVER	1	Mud Bottom	-75.3999	39.8142	-75	23.994	39	48.852
PA08-0516	DELAWARE RIVER	1	Mud Bottom	-75.4055	39.8121	-75	24.330	39	48.726
PA08-0517	DELAWARE RIVER	1	Mud Bottom	-75.4142	39.8054	-75	24.852	39	48.324
PA08-0518	DELAWARE RIVER	1	Mud Bottom	-75.4179	39.8052	-75	25.074	39	48.312

STNDRDID	Estuary	GRID_CODE	BotmType	Longitude DD	Latitude DD	Long Degrees	Long Dec Min	Lat Degrees	Lat Dec Min
DE08-0557	CHRISTINA RIVER	1	Mud Bottom	-75.5171	39.7193	-75	31.026	39	43.158
DE08-0558	DELAWARE RIVER	1	Mud Bottom	-75.5159	39.7070	-75	30.954	39	42.420
DE08-0559	DELAWARE RIVER	1	Mud Bottom	-75.4986	39.7058	-75	29.916	39	42.348
DE08-0560	DELAWARE RIVER	3	Sands	-75.5313	39.6750	-75	31.878	39	40.500
DE08-0561	DELAWARE RIVER	2	Mixed Sediments	-75.5363	39.6640	-75	32.178	39	39.840
DE08-0562	DELAWARE RIVER	1	Mud Bottom	-75.5566	39.6611	-75	33.396	39	39.666
DE08-0563	DELAWARE RIVER	1	Mud Bottom	-75.5684	39.6535	-75	34.104	39	39.210
DE08-0564	DELAWARE RIVER	1	Mud Bottom	-75.5370	39.6516	-75	32.220	39	39.096
DE08-0565	DELAWARE RIVER	1	Mud Bottom	-75.6082	39.6232	-75	36.492	39	37.392
DE08-0566	DELAWARE RIVER	2	Mixed Sediments	-75.5846	39.6141	-75	35.076	39	36.846
DE08-0567	DELAWARE RIVER	1	Mud Bottom	-75.5912	39.6108	-75	35.472	39	36.648
DE08-0568	DELAWARE RIVER	3	Sands	-75.5787	39.5903	-75	34.722	39	35.418
DE08-0569	DELAWARE RIVER	1	Mud Bottom	-75.5320	39.5878	-75	31.920	39	35.268
DE08-0570	DELAWARE RIVER	2	Mixed Sediments	-75.5824	39.5848	-75	34.944	39	35.088
DE08-0571	DELAWARE RIVER	1	Mud Bottom	-75.5277	39.5762	-75	31.662	39	34.572
DE08-0572	DELAWARE RIVER	2	Mixed Sediments	-75.5679	39.5754	-75	34.074	39	34.524
DE08-0573	DELAWARE RIVER	1	Mud Bottom	-75.5242	39.5724	-75	31.452	39	34.344
DE08-0574	DELAWARE RIVER	3	Sands	-75.5454	39.5699	-75	32.724	39	34.194
DE08-0575	DELAWARE RIVER	1	Mud Bottom	-75.5279	39.5689	-75	31.674	39	34.134
DE08-0576	DELAWARE RIVER	2	Mixed Sediments	-75.5657	39.5341	-75	33.942	39	32.046
DE08-0577	DELAWARE RIVER	2	Mixed Sediments	-75.5414	39.5266	-75	32.484	39	31.596
DE08-0578	DELAWARE RIVER	3	Sands	-75.5685	39.5175	-75	34.110	39	31.050
DE08-0579	DELAWARE RIVER	2	Mixed Sediments	-75.5673	39.4646	-75	34.038	39	27.876
DE08-0580	DELAWARE RIVER	3	Sands	-75.5788	39.4537	-75	34.728	39	27.222
DE08-0581	DELAWARE RIVER	2	Mixed Sediments	-75.5356	39.4295	-75	32.136	39	25.770
DE08-0582	DELAWARE RIVER	2	Mixed Sediments	-75.5287	39.4194	-75	31.722	39	25.164
DE08-0583	DELAWARE BAY	2	Mixed Sediments	-75.5116	39.4129	-75	30.696	39	24.774
DE08-0584	DELAWARE BAY	3	Sands	-75.5159	39.3975	-75	30.954	39	23.850
DE08-0585	DELAWARE BAY	1	Mud Bottom	-75.4975	39.3668	-75	29.850	39	22.008
DE08-0586	DELAWARE BAY	2	Mixed Sediments	-75.4868	39.3524	-75	29.208	39	21.144
DE08-0587	DELAWARE BAY	2	Mixed Sediments	-75.4847	39.3476	-75	29.082	39	20.856
DE08-0588	DELAWARE BAY	2	Mixed Sediments	-75.4588	39.3373	-75	27.528	39	20.238
DE08-0589	DELAWARE BAY	1	Mud Bottom	-75.4340	39.3216	-75	26.040	39	19.296
DE08-0590	DELAWARE BAY	3	Sands	-75.4262	39.2990	-75	25.572	39	17.940
DE08-0591	DELAWARE BAY	2	Mixed Sediments	-75.3988	39.2964	-75	23.928	39	17.784
DE08-0592	DELAWARE BAY	1	Mud Bottom	-75.4130	39.2878	-75	24.780	39	17.268
DE08-0593	DELAWARE BAY	1	Mud Bottom	-75.4205	39.2852	-75	25.230	39	17.112
DE08-0594	DELAWARE BAY	2	Mixed Sediments	-75.3805	39.2793	-75	22.830	39	16.758
DE08-0595	DELAWARE BAY	1	Mud Bottom	-75.4111	39.2781	-75	24.666	39	16.686
DE08-0596	DELAWARE BAY	1	Mud Bottom	-75.4049	39.2775	-75	24.294	39	16.650
DE08-0597	DELAWARE BAY	3	Sands	-75.4024	39.2688	-75	24.144	39	16.128
DE08-0598	DELAWARE BAY	3	Sands	-75.3589	39.2626	-75	21.534	39	15.756
DE08-0599	DELAWARE BAY	1	Mud Bottom	-75.3693	39.2423	-75	22.158	39	14.538
DE08-0600	DELAWARE BAY	2	Mixed Sediments	-75.3688	39.2412	-75	22.128	39	14.472
DE08-0601	DELAWARE BAY	2	Mixed Sediments	-75.3361	39.2393	-75	20.166	39	14.358
DE08-0602	DELAWARE BAY	1	Mud Bottom	-75.3925	39.2352	-75	23.550	39	14.112
DE08-0603	DELAWARE BAY	3	Sands	-75.3428	39.2301	-75	20.568	39	13.806
DE08-0604	DELAWARE BAY	2	Mixed Sediments	-75.3804	39.2017	-75	22.824	39	12.102
NJ08-0524	DELAWARE RIVER	3	Sands	-75.5532	39.4921	-75	33.192	39	29.526
NJ08-0525	DELAWARE RIVER	1	Mud Bottom	-75.5225	39.4525	-75	31.350	39	27.150
NJ08-0526	DELAWARE RIVER	3	Sands	-75.5149	39.4376	-75	30.894	39	26.256
NJ08-0527	DELAWARE BAY	1	Mud Bottom	-75.4722	39.4318	-75	28.332	39	25.908
NJ08-0528	DELAWARE BAY	3	Sands	-75.4942	39.4260	-75	29.652	39	25.560
NJ08-0529	DELAWARE BAY	2	Mixed Sediments	-75.4737	39.4197	-75	28.422	39	25.182
NJ08-0530	DELAWARE BAY	3	Sands	-75.4558	39.4156	-75	27.348	39	24.936
NJ08-0531	DELAWARE BAY	3	Sands	-75.4652	39.3976	-75	27.912	39	23.856
NJ08-0532	DELAWARE BAY	3	Sands	-75.4339	39.3701	-75	26.034	39	22.206
NJ08-0533	DELAWARE BAY	2	Mixed Sediments	-75.4348	39.3631	-75	26.088	39	21.786
NJ08-0534	DELAWARE BAY	3	Sands	-75.4387	39.3554	-75	26.322	39	21.324
NJ08-0535	DELAWARE BAY	3	Sands	-75.3384	39.3469	-75	20.304	39	20.814
NJ08-0536	DELAWARE BAY	3	Sands	-75.4301	39.3456	-75	25.806	39	20.736
NJ08-0537	DELAWARE BAY	2	Mixed Sediments	-75.3513	39.3453	-75	21.078	39	20.718
NJ08-0538	DELAWARE BAY	3	Sands	-75.3775	39.3427	-75	22.650	39	20.562
NJ08-0539	DELAWARE BAY	1	Mud Bottom	-75.3316	39.3403	-75	19.896	39	20.418
NJ08-0540	DELAWARE BAY	3	Sands	-75.3930	39.3366	-75	23.580	39	20.196
NJ08-0541	DELAWARE BAY	2	Mixed Sediments	-75.4082	39.3343	-75	24.492	39	20.058
NJ08-0542	DELAWARE BAY	2	Mixed Sediments	-75.3748	39.3339	-75	22.488	39	20.034
NJ08-0543	DELAWARE BAY	3	Sands	-75.4039	39.3252	-75	24.234	39	19.512
NJ08-0544	DELAWARE BAY	3	Sands	-75.3644	39.3040	-75	21.864	39	18.240
NJ08-0545	DELAWARE BAY	1	Mud Bottom	-75.2670	39.3004	-75	16.020	39	18.024
NJ08-0546	DELAWARE BAY	3	Sands	-75.2856	39.2905	-75	17.136	39	17.430
NJ08-0547	DELAWARE BAY	2	Mixed Sediments	-75.2691	39.2878	-75	16.146	39	17.268
NJ08-0548	DELAWARE BAY	3	Sands	-75.3314	39.2842	-75	19.884	39	17.052
NJ08-0549	DELAWARE BAY	1	Mud Bottom	-75.2911	39.2806	-75	17.466	39	16.836
NJ08-0550	DELAWARE BAY	2	Mixed Sediments	-75.3317	39.2741	-75	19.902	39	16.446

STNDRDID	Estuary	SYSTEM	Longitude	Latitude DD	Long Degrees	Long Dec Min	Lat Degrees	Lat Dec Min
DE08-0605	DELAWARE BAY	DE BAY CENTER	-75.3088	39.1958	-75	18.528	39	11.748
DE08-0606	DELAWARE BAY	DE BAY WEST	-75.3836	39.1949	-75	23.016	39	11.694
DE08-0607	DELAWARE BAY	DE BAY WEST	-75.3804	39.1704	-75	22.824	39	10.224
DE08-0608	DELAWARE BAY	DE BAY WEST	-75.4042	39.1399	-75	24.252	39	8.394
DE08-0609	DELAWARE BAY	DE BAY CENTER	-75.3137	39.1333	-75	18.822	39	7.998
DE08-0610	DELAWARE BAY	DE BAY WEST	-75.3988	39.1194	-75	23.928	39	7.164
DE08-0611	DELAWARE BAY	DE BAY CENTER	-75.2135	39.1108	-75	12.810	39	6.648
DE08-0612	DELAWARE BAY	DE BAY WEST	-75.3888	39.0791	-75	23.328	39	4.746
DE08-0613	DELAWARE BAY	DE BAY CENTER	-75.1976	39.0683	-75	11.856	39	4.098
DE08-0614	DELAWARE BAY	DE BAY WEST	-75.3900	39.0607	-75	23.400	39	3.642
DE08-0615	DELAWARE BAY	DE BAY WEST	-75.3549	39.0584	-75	21.294	39	3.504
DE08-0616	DELAWARE BAY	DE BAY CENTER	-75.3104	39.0457	-75	18.624	39	2.742
DE08-0617	DELAWARE BAY	DE BAY WEST	-75.3267	39.0443	-75	19.602	39	2.658
DE08-0618	DELAWARE BAY	DE BAY CENTER	-75.1667	39.0385	-75	10.002	39	2.310
DE08-0619	DELAWARE BAY	DE BAY WEST	-75.3059	39.0119	-75	18.354	39	0.714
DE08-0620	DELAWARE BAY	DE BAY WEST	-75.2986	39.0035	-75	17.916	39	0.210
DE08-0621	DELAWARE BAY	DE BAY WEST	-75.2870	38.9960	-75	17.220	38	59.760
DE08-0622	DELAWARE BAY	DE BAY CENTER	-75.1846	38.9913	-75	11.076	38	59.478
DE08-0623	DELAWARE BAY	DE BAY CENTER	-75.2412	38.9761	-75	14.472	38	58.566
DE08-0624	DELAWARE BAY	DE BAY WEST	-75.2842	38.9634	-75	17.052	38	57.804
DE08-0625	DELAWARE BAY	DE BAY CENTER	-75.2086	38.9398	-75	12.516	38	56.388
DE08-0626	DELAWARE BAY	DE BAY WEST	-75.3091	38.9294	-75	18.546	38	55.764
DE08-0627	DELAWARE BAY	DE BAY WEST	-75.2926	38.9278	-75	17.556	38	55.668
DE08-0628	DELAWARE BAY	DE BAY CENTER	-75.1184	38.9273	-75	7.104	38	55.638
DE08-0629	DELAWARE BAY	DE BAY WEST	-75.2546	38.9084	-75	15.276	38	54.504
DE08-0630	DELAWARE BAY	DE BAY WEST	-75.2725	38.9008	-75	16.350	38	54.048
DE08-0631	DELAWARE BAY	DE BAY CENTER	-75.1840	38.8956	-75	11.040	38	53.736
DE08-0632	DELAWARE BAY	DE BAY WEST	-75.2205	38.8779	-75	13.230	38	52.674
DE08-0633	DELAWARE BAY	DE BAY WEST	-75.2309	38.8767	-75	13.854	38	52.602
DE08-0634	DELAWARE BAY	DE BAY WEST	-75.1928	38.8523	-75	11.568	38	51.138
DE08-0635	DELAWARE BAY	DE BAY CENTER	-75.1279	38.8397	-75	7.674	38	50.382
DE08-0636	DELAWARE BAY	DE BAY WEST	-75.1046	38.8287	-75	6.276	38	49.722
DE08-0637	DELAWARE BAY	DE BAY WEST	-75.1933	38.8254	-75	11.598	38	49.524
DE08-0638	DELAWARE BAY	DE BAY WEST	-75.1608	38.8214	-75	9.648	38	49.284
DE08-0639	DELAWARE BAY	DE BAY WEST	-75.1443	38.7904	-75	8.658	38	47.424
DE08-0640	DELAWARE BAY	DE BAY WEST	-75.1126	38.7898	-75	6.756	38	47.388
DE08-0641	DELAWARE BAY	DE BAY WEST	-75.1316	38.7822	-75	7.896	38	46.932
NJ08-0551	DELAWARE BAY	DE BAY EAST	-75.2458	39.2828	-75	14.748	39	16.968
NJ08-0552	DELAWARE BAY	DE BAY EAST	-75.2407	39.2702	-75	14.442	39	16.212
NJ08-0553	DELAWARE BAY	DE BAY EAST	-75.2011	39.2468	-75	12.066	39	14.808
NJ08-0554	DELAWARE BAY	DE BAY EAST	-75.2066	39.2332	-75	12.396	39	13.992
NJ08-0555	DELAWARE BAY	DE BAY CENTER	-75.2180	39.2243	-75	13.080	39	13.458
NJ08-0556	DELAWARE BAY	DE BAY EAST	-75.1686	39.2125	-75	10.116	39	12.750
NJ08-0557	DELAWARE BAY	DE BAY EAST	-75.0908	39.2042	-75	5.448	39	12.252
NJ08-0558	DELAWARE BAY	DE BAY CENTER	-75.2795	39.2026	-75	16.770	39	12.156
NJ08-0559	DELAWARE BAY	DE BAY EAST	-75.1147	39.2010	-75	6.882	39	12.060
NJ08-0560	DELAWARE BAY	DE BAY EAST	-75.1205	39.1867	-75	7.230	39	11.202
NJ08-0561	DELAWARE BAY	DE BAY EAST	-75.0335	39.1862	-75	2.010	39	11.172
NJ08-0562	DELAWARE BAY	DE BAY CENTER	-75.2492	39.1855	-75	14.952	39	11.130
NJ08-0563	DELAWARE BAY	DE BAY EAST	-75.1600	39.1745	-75	9.600	39	10.470
NJ08-0564	DELAWARE BAY	DE BAY EAST	-74.9203	39.1734	-74	55.218	39	10.404
NJ08-0565	DELAWARE BAY	DE BAY EAST	-74.9976	39.1690	-74	59.856	39	10.140
NJ08-0566	DELAWARE BAY	DE BAY EAST	-74.9895	39.1688	-74	59.370	39	10.128
NJ08-0567	DELAWARE BAY	DE BAY EAST	-75.1281	39.1679	-75	7.686	39	10.074
NJ08-0568	DELAWARE BAY	DE BAY EAST	-74.9351	39.1624	-74	56.106	39	9.744
NJ08-0569	DELAWARE BAY	DE BAY CENTER	-75.1043	39.1627	-75	6.258	39	9.762
NJ08-0570	DELAWARE BAY	DE BAY CENTER	-74.9546	39.1584	-74	57.276	39	9.504
NJ08-0571	DELAWARE BAY	DE BAY EAST	-74.9048	39.1579	-74	54.288	39	9.474
NJ08-0572	DELAWARE BAY	DE BAY EAST	-74.9078	39.1303	-74	54.468	39	7.818
NJ08-0573	DELAWARE BAY	DE BAY EAST	-74.9192	39.1063	-74	55.152	39	6.378
NJ08-0574	DELAWARE BAY	DE BAY CENTER	-75.1563	39.1004	-75	9.378	39	6.024
NJ08-0575	DELAWARE BAY	DE BAY CENTER	-74.9508	39.0959	-74	57.048	39	5.754
NJ08-0576	DELAWARE BAY	DE BAY CENTER	-75.0319	39.0944	-75	1.914	39	5.664
NJ08-0577	DELAWARE BAY	DE BAY EAST	-74.9439	39.0711	-74	56.634	39	4.266
NJ08-0578	DELAWARE BAY	DE BAY EAST	-74.9398	39.0462	-74	56.388	39	2.772
NJ08-0579	DELAWARE BAY	DE BAY CENTER	-74.9784	39.0425	-74	58.704	39	2.550
NJ08-0580	DELAWARE BAY	DE BAY CENTER	-75.1048	39.0206	-75	6.288	39	1.236
NJ08-0581	DELAWARE BAY	DE BAY EAST	-74.9502	39.0155	-74	57.012	39	0.930
NJ08-0582	DELAWARE BAY	DE BAY EAST	-74.9811	38.9895	-74	58.866	38	59.370
NJ08-0583	DELAWARE BAY	DE BAY CENTER	-75.0765	38.9826	-75	4.590	38	58.956
NJ08-0584	DELAWARE BAY	DE BAY EAST	-74.9707	38.9768	-74	58.242	38	58.608
NJ08-0585	DELAWARE BAY	DE BAY EAST	-74.9989	38.9439	-74	59.934	38	56.634
NJ08-0586	DELAWARE BAY	DE BAY EAST	-74.9919	38.9168	-74	59.514	38	55.008
NJ08-0587	DELAWARE BAY	DE BAY CENTER	-75.0733	38.9156	-75	4.398	38	54.936
NJ08-0588	DELAWARE BAY	DE BAY CENTER	-75.0228	38.9134	-75	1.368	38	54.804

STNDRDID	Estuary	Longitude DD	Latitude DD	Long Degrees	Long Dec Min	Lat Degrees	Lat Dec Min
DE08-0642	CHRISTINA RIVER	-75.574	39.717	-75	34.464	39	43.012
DE08-0643	C&D CANAL	-75.629	39.553	-75	37.746	39	33.170
DE08-0644	C&D CANAL	-75.756	39.541	-75	45.336	39	32.450
DE08-0645	ALLOWAY CREEK	-75.531	39.502	-75	31.854	39	30.124
DE08-0646	BLACKBIRD CREEK	-75.596	39.397	-75	35.736	39	23.795
DE08-0647	DUCK CREEK	-75.497	39.344	-75	29.832	39	20.633
DE08-0648	DUCK CREEK	-75.449	39.277	-75	26.934	39	16.602
DE08-0649	LEIPSIC RIVER	-75.477	39.250	-75	28.614	39	14.993
NJ08-0589	MANNINGTON MEADOW	-75.479	39.651	-75	28.752	39	39.053
NJ08-0590	MANNINGTON MEADOW	-75.475	39.633	-75	28.518	39	37.953
NJ08-0591	MANNINGTON MEADOW	-75.433	39.612	-75	25.980	39	36.734
NJ08-0592	MANNINGTON MEADOW	-75.458	39.601	-75	27.474	39	36.041
NJ08-0593	SALEM RIVER	-75.468	39.578	-75	28.092	39	34.658
NJ08-0594	ALLOWAY CREEK	-75.459	39.520	-75	27.558	39	31.181
NJ08-0595	COHANSEY RIVER	-75.266	39.380	-75	15.948	39	22.807
NJ08-0596	COHANSEY RIVER	-75.364	39.347	-75	21.852	39	20.814
NJ08-0597	Back Creek	-75.285	39.301	-75	17.124	39	18.075
NJ08-0598	MAURICE RIVER	-74.979	39.283	-74	58.758	39	16.969
NJ08-0599	MAURICE RIVER	-75.002	39.264	-75	0.102	39	15.827
NJ08-0600	MAURICE RIVER	-75.022	39.235	-75	1.320	39	14.111
NJ08-0601	MAURICE RIVER	-75.047	39.214	-75	2.808	39	12.814
NJ08-0602	West / East Creeks	-74.923	39.201	-74	55.368	39	12.057
NJ08-0603	West / East Creeks	-74.900	39.193	-74	53.994	39	11.570
NJ08-0604	Bidwell Creek	-74.851	39.113	-74	51.030	39	6.751
PA08-0519	SCHUYKILL RIVER	-75.190	39.893	-75	11.400	39	53.597

STNDRDID	Estuary	Longitude DD	Latitude DD	Long Degrees	Long Dec Min	Lat Degrees	Lat Dec Min
NJ08-0500	DELAWARE RIVER	-74.8358	40.0950	-74	50.148	40	5.702
NJ08-0501	DELAWARE RIVER	-74.8478	40.0881	-74	50.868	40	5.285
NJ08-0502	DELAWARE RIVER	-74.9532	40.0580	-74	57.192	40	3.481
NJ08-0503	DELAWARE RIVER	-75.0237	40.0150	-75	1.422	40	0.898
NJ08-0504	DELAWARE RIVER	-75.0588	39.9914	-75	3.528	39	59.485
NJ08-0505	DELAWARE RIVER	-75.0985	39.9632	-75	5.910	39	57.794
NJ08-0506	DELAWARE RIVER	-75.1441	39.8851	-75	8.646	39	53.105
NJ08-0507	DELAWARE RIVER	-75.1713	39.8787	-75	10.278	39	52.719
NJ08-0508	DELAWARE RIVER	-75.3407	39.8437	-75	20.442	39	50.623
NJ08-0509	DELAWARE RIVER	-75.3232	39.8399	-75	19.392	39	50.392
NJ08-0510	DELAWARE RIVER	-75.3557	39.8322	-75	21.342	39	49.931
PA08-0500	DELAWARE RIVER	-74.7514	40.1355	-74	45.084	40	8.131
PA08-0501	DELAWARE RIVER	-74.9009	40.0735	-74	54.054	40	4.412
PA08-0502	DELAWARE RIVER	-74.9264	40.0704	-74	55.584	40	4.221
PA08-0503	DELAWARE RIVER	-74.9864	40.0421	-74	59.184	40	2.528
PA08-0504	DELAWARE RIVER	-75.0874	39.9766	-75	5.244	39	58.597
PA08-0505	DELAWARE RIVER	-75.1283	39.9616	-75	7.698	39	57.698
PA08-0506	DELAWARE RIVER	-75.1340	39.9556	-75	8.040	39	57.335
PA08-0507	DELAWARE RIVER	-75.1331	39.9034	-75	7.986	39	54.201
PA08-0508	DELAWARE RIVER	-75.1638	39.8861	-75	9.828	39	53.164
PA08-0509	DELAWARE RIVER	-75.2075	39.8724	-75	12.450	39	52.343
PA08-0510	DELAWARE RIVER	-75.2722	39.8585	-75	16.332	39	51.511
PA08-0511	DELAWARE RIVER	-75.2566	39.8557	-75	15.396	39	51.340
PA08-0512	DELAWARE RIVER	-75.2736	39.8546	-75	16.416	39	51.277
PA08-0513	DELAWARE RIVER	-75.3578	39.8416	-75	21.468	39	50.493

APPENDIX D - STAC Membership

2007-2008 Membership of the PDE
Science and Technical Advisory Committee

2006-2007 Membership

Science and Technical Advisory Committee

Partnership for the Delaware Estuary: A National Estuary Program
www.DelawareEstuary.org

Contacts for STAC

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Kathy Klein (*ex officio* representative), Executive Director; Partnership for the Delaware Estuary; One Riverwalk Plaza; 110 S. Poplar Street, Suite 202; Wilmington, DE 19801; Phone, 302-655-4990 x102; Email, KKlein@DelawareEstuary.org

The Delaware Estuary
Science and Technical Advisory Committee
Membership List – 2006-2007

Please refer to the STAC Charter for more information on the purpose, roles and functions of STAC Chairperson, Science Advisor and other members, and terms of service for members.

The STAC is led by a **Chairperson** and **Science Advisor**. The Chair of the STAC is appointed by the EIC from the broader STAC membership (see Section V.D). The Science Advisor of the STAC is the science and technical lead on staff at the Partnership, or if an alternate is needed, a designee selected by the Partnership's Executive Director. Both the Chairperson and Science Advisor are voting members.

The balance of the STAC is comprised of **Standing Representatives** and **Elected Representatives**. Standing members are appointed as representatives from key partners and existing science and technical committees. These consist of the Delaware Department of Natural Resources and Environmental Control, the Delaware River Basin Commission, Delaware River Basin Fish and Wildlife Cooperative, New Jersey Department of Environmental Protection, Pennsylvania Department of Environmental Protection, Philadelphia Water Department, Monitoring Advisory Committee, and Toxics Advisory Committee. Members of the EIC will nominate these standing representatives. The balance of the membership of the STAC is comprised of representatives of the science and technical community who are elected by procedures specified in the STAC Charter.

Total membership is expected to initially be approximately 15 people. In selecting these individuals the Partnership worked with collaborating entities and the Estuary Implementation Committee to identify a group having a balance of technical expertise (e.g., water quantity, water quality, physical processes, chemical processes, shellfish, fish, vegetation, habitat) and geographical representation. Initial members will be asked to suggest names for additional members to fill any expertise needs, with potential for expansion of total membership to at most 21.

Chairperson

This position is appointed by the EIC from a slate of nominees put forth by members of the STAC. The term of service is 2-years, however the initial appointment will extend only until 6/30/07. The current Chair of the STAC is:

Daniel Soeder
United States Geological Survey; 8987 Yellow Brick Road; Baltimore, MD 21237
Phone: 410-238-4213
Email: dsoeder@usgs.gov
Expertise: wetlands, coastal processes
Represents: USGS, federal agency

Science Advisor

This is a standing position filled by the Partnership's science lead, who is currently:

Danielle Kreeger, Ph.D
Partnership for the Delaware Estuary; One Riverwalk Plaza; 110 South Poplar Street; Wilmington, DE 19801
Phone: 609-883-9500 x217
Email: DKreeger@DelawareEstuary.org
Expertise: wetlands, shellfish, ecosystem services
Represents: academia, non-profit

Standing Representatives

1. Delaware Department of Natural Resources and Environmental Control

Amy Jacobs
Delaware Department of Natural Resources and Environmental Control; Division of Water Resources, Watershed Assessment
Division of Water Resources
Phone: (302) 739-4590
Email: amy.jacobs@state.de.us
Expertise: wetland monitoring and restoration
Represents: DNREC, DE, state/regional agency

2. Delaware River Basin Commission

Thomas Fikslin, Ph.D
Delaware River Basin Commission; 25 State Police Drive; West Trenton, NJ 08628
Phone: 609-883-9500, Ext. 253
Email: Thomas.Fikslin@drbc.state.nj.us
Expertise: water quality, monitoring, modeling
Represents: DRBC, MAC, TAC, state/regional agency

3. Delaware River Basin Fish and Wildlife Cooperative

Larry Miller
U.S. Fish and Wildlife Service; Mid-Atlantic Fishery Resources Office; P.O. Box 67000; 1601 Elmerton Avenue ; Harrisburg, PA 17110-9299
Phone: 717-705-7838
Email: Larry_M_Miller@fws.gov
Expertise: fish passage, hydropower issues
Represents: DE River Basin F&W Co-op, federal agency

4. New Jersey Department of Environmental Protection

Gary Buchanan, Ph.D.
Division of Science, Research and Technology
New Jersey Department of Environmental Protection; PO Box 409; 401 East State Street, 1st floor; Trenton, NJ 08625-0409

Phone: 609-633-8457
Email: Gary.Buchanan@dep.state.nj.us
Expertise: contaminants, aquatic toxicology/biology
Represents: NJDEP, NJ, state/regional agency

5. Pennsylvania Department of Environmental Protection

Kenneth Anderson II
Phone: 484-250-5153
Email: kenanderso@state.pa.us
Expertise: wetland and stream restoration, aquatic ecology
Represents: PADEP, PA, state/regional agency

6. Philadelphia Water Department

Lance H. Butler
Office of Watersheds; Philadelphia Water Department; Philadelphia, PA 19107
Phone: 215-685-4947
Email: lance.butler@phila.gov
Expertise: aquatic ecology, community ecology, water quality, monitoring
Represents: PWD, City of Philadelphia

7. Monitoring Advisory Committee

Thomas Fikslin, Ph.D
Delaware River Basin Commission; 25 State Police Drive; West Trenton, NJ 08628
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Email: Thomas.Fikslin@drbc.state.nj.us
Expertise: water quality, monitoring, modeling
Represents: DRBC, MAC, TAC, state/regional agency

8. Toxics Advisory Committee

Thomas Fikslin, Ph.D
Delaware River Basin Commission; 25 State Police Drive; West Trenton, NJ 08628
Phone: 609-883-9500, Ext. 253
Email: Thomas.Fikslin@drbc.state.nj.us
Expertise: water quality, monitoring, modeling
Represents: DRBC, MAC, TAC, state/regional agency

B. Elected Representatives

Gregory Breese
U.S. Fish & Wildlife Service; 2610 Whitehall Neck Rd.; Smyrna, DE 19977
Phone: 302-653-9152
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Expertise: wildlife, conservation
Represents: USF&W, federal agency

Dewayne Fox

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Represents: academia

Jack Gallagher, Ph.D. (alternate = **Denise Seliskar**, Ph.D.)
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Expertise: wetlands, restoration, plant biology
Represents: academia

Simeon Hahn
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Represents: NOAA, federal agency

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Represents: NOAA, federal agency

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Expertise: aquatic toxicology
Represents: industry

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Expertise: plankton, food webs, nutrients
Represents: academia

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Expertise: shellfish, benthos, aquaculture
Represents: academia

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Jonathan Sharp, Ph.D.
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Represents: academia

Daniel Soeder
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Represents: USGS, federal agency

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Represents: academia

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Expertise: contaminants, biogeochemistry
Represents: non-profit, academia