QUALITY ASSURANCE/QUALITY CONTROL PLAN

BENTHIC BIOLOGICAL MONITORING PROGRAM

OF THE LOWER CHESAPEAKE BAY

July 1, 2003 to June 30, 2004

Approved by:

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Daniel M. Dauer, Project Manager **ODU, Biological Sciences**	**Date**
______________________________	________________
Michael F. Lane, QA Officer **ODU, Biological Sciences**	**Date**
______________________________	________________
F.A. Hoffman, Project Officer **Virginia, DEQ**	**Date**
______________________________	________________
Project Officer **EPA Chesapeake Bay Program**	**Date**
______________________________	________________
Richard Batiuk, QA Officer **EPA Chesapeake Bay Program**	**Date**

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BENTHIC BIOLOGICAL MONITORING PROGRAM

OF THE LOWER CHESAPEAKE BAY

PREPARED BY

DANIEL M. DAUER

DEPARTMENT OF BIOLOGICAL SCIENCES

THE BENTHIC ECOLOGY LABORATORY

OLD DOMINION UNIVERSITY

NORFOLK, VIRGINIA 23529

July 1, 2003 to June 30, 2004

TABLE OF CONTENTS

I. PROJECT DESCRIPTION

A. Objectives and Scope Statement

The objectives of the Benthic Biological Monitoring Program of the Virginia Chesapeake Bay Program as presented in this proposal are:

1. to characterize the health of regional areas of the lower Chesapeake Bay as indicated by the structure of the benthic community. These characterizations will be based upon application of the benthic restoration goals to data collected by a probability-based sampling design within the lower Chesapeake Bay. A probability-based sampling design allows calculation of confidence intervals around estimates of condition of the benthic communities. Confidence intervals provide managers with full knowledge of the strength or weakness of the data upon which their decisions will be based. In addition, probability-based data allows managers to estimate the actual area (number of acres) throughout the system (e.g., tributaries, areas of concern) in which ecological conditions differ from reference areas.

2. to conduct trend analyses on long-term data at fixed-point stations to relate temporal trends in the benthic communities to changes in water and/or sediment quality. Trend analyses will be updated annually as new data are available.

3. to warn of environmental degradation by producing an historical data base that will allow annual evaluations of biotic impacts by comparing trends in status within probability-based strata and trends at fixed-point stations to changes in water and/or sediment quality.

B. Data Usage

Data will be used to meet objectives 1-3 listed above.

C. Study Design and Rationale

1. Rationale

The health of any aquatic system can be addressed by using a variety of abiotic and biotic variables. Abiotic variables are generally direct physical or chemical parameters of water quality (dissolved oxygen, turbidity, nitrates, phosphates, heavy metals, chlorinated hydrocarbons, aromatic hydrocarbons, etc.). Measuring these variables is necessary to evaluate and detect sources of pollution and to provide a means for evaluating the effectiveness of control or abatement measures. However, from man's point of view the ultimate evaluation of the health of any body of water must emphasize the living resources.

A wide variety of biotic variables can be measured. Estimates of the benthic macrofaunal community (organisms retained on a 0.5 mm screen) are used to indicate environmental health because benthic animals (1) are relatively sedentary, (2) have relatively long life spans, (3) consist of different species that exhibit different tolerances to stress, (4) are economically important or are important food sources for economically important or recreationally important species, and (5) have an important role in recycling nutrients or other chemicals between the sediment and the water column. Recent reviews of the rationale for pollution monitoring studies have confirmed the importance and priority of benthic biological monitoring in meeting the primary objectives of most marine and estuarine monitoring programs (Bilyard 1987).

Sedentary benthic organisms represent optimal indicator species because motile species (such as fish) are able to leave or avoid stressed habitats. The relatively long life span of many macrobenthic species (compared to short-lived planktonic species) enables an evaluation of water quality conditions integrated over time.

2. Sampling Locations (Fixed-Point Stations)

Twenty one fixed-point stations in the lower Chesapeake Bay are currently sampled as part of the Benthic Biological Monitoring Program of the Chesapeake Bay Program. Stations are located in the mainstem of the Bay and within the major tributaries - the James, York and Rappahannock Rivers (see Figure 1). Stations coordinates are listed in Table 1. In the tributaries, stations are located within the tidal freshwater zone (TF5.5, TF4.2, TF3.3), the turbidity maximum (transitional) zone (RET5.2, RET5.2B, RET4.3, RET3.1), the lower estuarine mesohaline mud zone (LE5.4, LE4.1, LE3.2, LE3.4) and the lower estuarine polyhaline silty-sand zone (LE5.4, LE4.3, LE4.3B). In the mainstem of the Bay three stations are located off the mouths of the major tributaries (CB8.1, CB6.4, CB6.1) and two stations in the deeper channels near the Bay mouth (CB7.3E) and above the Rappahannock River (CB5.4). All of the above stations have been sampled since March 1985, with the exception of Stations RET5.2B, LE4.3B and LE3.4 which have been sampled since September 1988. In March 1988, two stations were added in the Southern Branch of the Elizabeth River (SBE2, SBE5).

Fixed-point benthic monitoring stations were selected to represent regions of the lower Chesapeake Bay that are different in major factors, such as water circulation and salinity that affect ecological processes (for further justification see U.S.E.P.A. 1983, Appendix F).

3. Sampling Locations (Probability-Based Strata)

Probability-based sampling within selected strata is proposed to supplement data collected at fixed-point stations. Because of the emphasis on development of tributary-based strategies for improvement of the Chesapeake Bay, it is proposed that four strata be sampled - (1) the James River, (2) the York River, (3) the Rappahannock River and (4) the mainstem of the Bay. A total of 25 samples will be allocated to each stratum in order to produce a 95% confidence interval of ∀10%. Sampling design and methodologies for probability-based sampling are based upon procedures developed by EPA's Environmental Monitoring and Assessment Program (EMAP, Weisberg et al. 1993) and will allow unbiased comparisons of conditions (1) between strata (e.g. tributaries) of the lower Chesapeake Bay within the same collection year and (2) within tributaries for data collected between different years. The consistency of sampling design and methodologies for probability-based sampling between the Virginia and Maryland benthic monitoring programs will allow bay-wide characterizations of the condition of the benthos for the Chesapeake Bay. In order to assess long-term trends in status, a certain number of the 25 probability-based sample locations within each stratum will be repeated between years in order to quantify the spatial component of inter-year variation in benthic community condition.

The condition of the benthic communities within a stratum can be assessed in two ways - (1) mean condition and (2) percent of area exceeding threshold values. The Benthic Restoration Goals and the Benthic Index of Biotic Integrity (BIBI: Weisberg et al. 1997) will be used to characterize the condition of each probability-based sampled stratum. The mean and variance of the BIBI can be estimated and the confidence intervals for estimates of percent of area exceeding the Benthic Restoration Goals can be estimated from the binomial distribution using the formula of Hollander and Wolfe (1973).

The final selection of probability-based strata will be based upon annual reviews of the staff of the Chesapeake Bay Office of the Department of Environmental Quality (DEQ) and the Benthic Ecology Laboratory of Old Dominion University. The selection of probability-based sampled strata allows the DEQ to change strata of concern to reflect changing priorities of the Chesapeake Bay Restoration Program.

D. Monitoring Parameters and Frequency of Collection

At each fixed-point station four replicate box core samples are collected during the months of June and September. Box core samples are collected using a spade-type coring device consisting of a rectangular corer (10.5 cm X 17.5 cm X 35 cm) with a hinged cutting arm which seals the box sample *in situ*. Each box core sample has a surface area of 182 cm^2 and a minimum depth of penetration of 25 cm. One of the four replicate samples is archived and the other three replicates are analyzed to quantitatively characterize the macrobenthic community. A subsample of the surface sediment from the archived replicate is taken for sediment particle size analysis and for determination of total volatile solids. Bottom temperature, salinity and dissolved oxygen are measured at each sampling station.

Within each stratum-of-concern a probability-based sampling design is applied. The number of samples within each stratum will be 25 and sites will be selected by simple random sampling within each stratum. At each of the 25 randomly allocated sites a sample of the benthic community will be collected using a 0.04m^2, Young grab. A subsample of the surface sediment is collected from a second Young grab sample for sediment particle size analysis and for determination of total volatile solids. Bottom temperature, salinity and dissolved oxygen are measured at each sampling station. Sampling within the probability-based strata will occur between July 15 and September 30 of each year to allow the application of the Benthic Restoration Goals. The Benthic Restoration Goals were developed from data sets limited to the July 15 through September 30 time period.

Estimating areal extent of the benthic condition departs from traditional approaches to environmental monitoring which generally estimate average condition without know confidence intervals. Random sampling within a stratum allows the calculation of a known confidence interval for the stratum.

E. Parameter Table

Benthic community structural parameters that will be measured include:

- Species diversity
- Species richness
- Species evenness
- Community abundance
- Community biomass
- Abundance of all species
- Biomass of all species
- Abundance of pollution indicative species
- Biomass of pollution indicative species
- Abundance of pollution sensitive species
- Biomass of pollution sensitive species
- Depth distribution of species
- Depth distribution of abundance

Depth distribution of biomass

II. PROJECT ORGANIZATION AND RESPONSIBILITY

All sample processing and data analysis are performed by the Benthic Ecology Laboratory (BEL) under the direction of Dr. Daniel M. Dauer who is the Project Manger (Principal Investigator) and Director of the BEL.

A. Project Manager (Principal Investigator)

The **Project Manager (PM)**, Dr. Daniel M. Dauer, is responsible for the overall supervision of activities associated with the project. The PM conducts regular staff meetings with all personnel to discuss the progress of the program, problems encountered, report preparation and any other matters that affect the successful continuation of the program. The PM reviews the overall results of the analyses and approves the quality assurance/quality control (QA/QC) protocols to insure the quality of the results. The PM administers the financial and technical aspects of the program at the BEL. The PM is responsible for the review and submission of all data products transmitted to the contracting agency. The PM or his representative participates in meetings, workshops, and coordinating sessions with the contracting agencies.

B. Benthic Ecology Laboratory Supervisor

The **Benthic Ecology Laboratory Supervisor** (BELS), Mr. Anthony J. Rodi, Jr., is responsible for all aspects of the sorting, identification, and enumeration of macrobenthic taxa collected in the samples. The BELS is responsible for all aspects of the analysis of sediment samples for particle size distribution and total volatile solids. The BELS is responsible for implementing all of the appropriate laboratory QA/QC procedures, maintaining supplies and equipment necessary for analyses, and training of all lab and field personnel. The BELS is also the chief scientist for the BEL field operations, supervising all aspects of field work and validating data as it is generated. As chief scientist the BELS ensures that all field activities transpire within BEL policies, guidelines and protocols, and has ultimate decision-making authority over all technical and logistical matters which arise during sampling events. The BELS reports to the PM.

C. Benthic Laboratory Experts (Research Assistants)

Research Assistants (RA) are responsible for performing field measurements; sample collection, handling, transport, and storage; and data logging, reduction and transmittal.

Research Assistants are responsible for performing all duties within the BEL QA/QC guidelines protocol.   RAs report to the BELS.

D. Laboratory Assistants

Laboratory Assistants (LA) are responsible for assisting in the collection and preparation of samples and data entry and processing. The LAs also participate, under supervision, in some of the routine analytical procedures. LAs report to the BELS.

III. QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES AND CRITERIA

The quality assurance/quality control (QA/QC) program at the BEL is designed to ensure that data of the highest quality possible for estimates of field parameters are being generated and transferred to the funding agency. The fundamental parameter being measured in any biological monitoring program is what species are present (Ellis 1988). "The fundamental accuracy in biological surveys is getting the species identification right, getting the correct Linnean name, and doing so consistently" (Ellis 1988, p. 507). Indeed, all other estimates of field parameters (e.g., densities and biomass of populations) can not truly be tested for accuracy because standards are meaningless. Accuracy can only be approximated by inter-laboratory calibrations (see e.g. Ellis and Cross 1981) which are not part of the present program because (1) accepted protocols do not exist and (2) fiscal resources are limited.

The QA/QC program is designed to manage sample handling, documentation and custody, proper data generation, and quality control actions. The QA/QC program tracks and monitors the fate of a sample from collection to data submission and analysis assuring that the proper samples have been analyzed by the appropriate methods and that necessary QC measures have been taken to ensure that data of definable quality have been produced.

For all parameters measured a discrepancy of less than 5.0% from reanalyzed samples is considered acceptable, except for estimates of weight, where a discrepancy of less than 2 mg from reanalyzed samples is considered acceptable.

IV. SAMPLING PROCEDURES

A. Collection of Samples

Each box core or Young grab sample is visually inspected to ensure that the sample collected is undisturbed. Disturbed samples are discarded. At each sampling station a Field Data Sheet (Figure 2) is completed including date, time of day, station number, geographic coordinates, replicate number, sample penetration depth, identification number and storage location of each replicate. The comment section of each Field Data Sheet includes visual descriptions of the sediment and/or fauna (e.g. obvious tubes or burrows, flocculation, sediment color, depth of RPD, etc.).

B. Processing Procedures

1. Macrofaunal Samples (unpartitioned)

All replicates are handled and processed separately. Samples are transferred to a 0.5 mm sieve bucket. The bottom of the sieve bucket is immersed in a 30 gallon trash can filled with ambient water, and shaken and swirled to suspend the larger material, allowing fine sands, silts and clays to pass through the sieve screen. The residual material on the sieve screen is washed into cloth bags pre-labeled with indelible ink. After sieving, the screen is inspected for any organisms not washed into the bag. Such organisms are removed with dissecting forceps and placed into the appropriate cloth bag. Samples are relaxed for 15 minutes in dilute isopropyl alcohol and then fixed in a 10% buffered ambient water-formalin solution. A 1% solution of rose bengal stain is premixed into the formalin solution.

2. Macrofaunal Samples (partitioned)

For depth distribution analysis, one of the four box core samples is partitioned as follows: 0-5 cm and 5-25 cm. A metal box with horizontal slits on one side at the desired interval is used to partition this replicate. The slit is covered with adhesive tape prior to sampling. After collection of the sample, a flat metal plate is pushed through the slit at the 5 cm depth interval. Each depth fraction is sequentially removed from the bottom of the box into pre-labeled plastic buckets. Each depth-interval sample is handled and processed individually as described above.

3. Sediment Subsamples

An 8 dram subsample of the surface sediment is taken from the archived replicate prior to sieving at fixed-point stations and from the second grab sample at probability-based stations. Each 8 dram sample is placed into pre-labeled plastic self-locking bags with the station number and date. The sediment subsamples are stored on ice for transport to the laboratory.

If there is a marked visual change in sediment between replicate box core samples at a station, additional sediment subsamples are taken.

4. Additional Field Measurements

Bottom salinity, temperature and dissolved oxygen are measured in-situ at each station with a YSI Model 85 meter and recorded on the Field Data Sheets.

V. SAMPLE CUSTODY

A. Field Sampling Operations

Field labeling procedures of the BEL are designed to ensure that parameter estimates from field collected samples are associated with the proper field collection site. All sample residues for benthic community analyses are washed into pre-labeled cloth bags. Each bag label consists of a code that identifies the sample as collected (1) from one of the three tributaries or the mainstem, (2) the collection site within the tributary or mainstem and (3) the replicate number. For example the label "2-J-1" indicates the second station downstream ("2") in the James River ("J" - RET5.2) and the first replicate ("1"). All samples from a particular tributary or the mainstem or probability-based stratum are placed into 5 gallon plastic buckets that are pre-labeled with a tributary or mainstem code. After each sampling station is completed the bucket is sealed. After all stations of each tributary or the mainstem or probability-based stratum are sampled the bucket is sealed and stored below deck until off loaded at the end of the cruise.

The archived sampled is handled as above except that all archived samples are placed into a separate 5 gallon bucket that is pre-labeled to record the date of the cruise. Cruise dates are not indicated on the pre-labeled bags or buckets for the non-archived replicates. All replicates from one cruise are completely analyzed prior to the next cruise and the same pre-labeled bags and buckets are reused. All of the above information is recorded on the Field Data Sheets for each sampling station.

Sediment samples for particle size and total volatile solids analysis are placed into pre-labeled plastic bags that use the same labels as above. New pre-labeled bags are used for each cruise. All sediment samples are completely analyzed prior to the next cruise.

The chief scientist is responsible for ensuring that all samples are (1) placed into the proper pre-labeled bags, (2) into the proper pre-labeled sealed buckets, and (3) securely stored on shipboard. On return of the vessel to the dock the chief scientist is responsible for the loading of all samples onto the trucks, the transportation of the samples to the BEL and the storage of the samples in the BEL immediately upon arrival at the BEL.

For each deployment of the camera frame, the date and time the image is taken is recorded on every film frame. The clock in the sediment profile camera is synchronized with the chief scientist's clock and for each deployment the time is recorded in a field log along with the count on the camera's film counter. When the film is removed from the camera it will be labeled as to date and general region sampled.

B. Laboratory Operations

1. Sorting Procedure Custody

Sample sorting refers to the procedures used to remove the macrobenthic animals from the sediment residue of each replicate. After removing a sample from the sealed bucket containing the sample bags, each Laboratory Assistant (LA) must sign their name, identify the sample to be removed, the date the sample was removed for sorting and the date the sample was completed and record all this information on a Sample Processing Log sheet (Figure 3). The animals removed from the sediment residue during the sorting procedure are placed into pre-labeled 8 dram glass vials organized into specific spatial arrays in specially designed trays. Each label of the glass vials contains the same codes as the bag and must be matched by the LA prior to beginning the sorting procedure. All sorted residues, the sample bag and the glass vials of organisms are checked by the BELS to ensure accuracy. The procedure is also used so that LAs are never aware of which samples will be selected for quality control checks.

See Section VII. A. 1. for additional details.

2. Identification Procedure Custody

Sample identification refers to procedures used to place valid scientific names on all specimens in the collected samples. Prior to beginning the identification procedure each Research Assistant (RA) must sign their name, identify the sample to be identified, the date the sample was removed for identification and the date the sample was completed and record all this information on a Sample Processing Log sheet (Figure 3). As each specimen is identified the complete scientific name is entered on a Lab Data Sheet (Figure 4) and the animal placed into a labeled aluminum pan for biomass analysis. The exact label on the glass vial is recorded on each weighing pan (each label contains the station number, the tributary, the replicate number, and the depth interval if appropriate). In addition a unique code for each taxon identified is also placed on each weighing pan.

3. Biomass Analysis Procedure Custody

Sample biomass analysis refers to procedures used to estimate the weight of each taxon from each replicate. RAs place all the weighing pans from all replicates of a sampling station into the same enamel tray. All trays are immediately placed into the drying oven. All samples are tracked by their unique codes that now include the complete station code and a taxonomic code. Upon completion of recording dry weights, trays are placed back into the drying oven prior to the ashing procedure. All weighing pans from the same sampling station are placed directly into the muffle furnace for ashing. After ashing, pans are reweighed and all data recorded on standard BEL Lab Data Sheets (Figure 4).

See Section VII. A. 3. for further details.

VI. CALIBRATION PROCEDURES AND FREQUENCY

A. Field Sampling Operations

Calibration procedures in the field apply to the measurement of (1) bottom salinity and temperature using the YSI Model 33 S-C-T meter and (2) bottom dissolved oxygen using the YSI model 58 oxygen meter. All procedures follow the manufacturer's instructions. The YSI Model 33 S-C-T meter is redlined prior to each sampling station and does not require daily field calibration. The YSI oxygen meter is field calibrated each day of the collection cruise prior to reaching the first sampling station of the day.

B. Laboratory Operations

Calibration procedures in the laboratory apply to (1) the YSI model 33 S-C-T meter and (2) the analytical balance used in weighings for biomass and sediment analyses. All procedures follow the manufacturer's instructions. The S-C-T meter is calibrated against a standard salinity solution and corrections calculated according to manufacturer's instructions prior to each cruise. The analytical balance is calibrated professionally each year by a manufacturer's representative with written documentation of the accuracy of the balance.

We use only established and reputable labs to develop film. Even with the most careful control on development we have found that there is variation in either the film lots or processing that causes subtle color differences. To correct for this problem the first and last picture taken each field-day is a standard color card (Macbeth Colorchecker™) with red, green, blue, white, and neutral gray densities. From these color card images we can see if variation in color from day to day or film to film is occurring. Color variations can then be accounted for in the computer image analysis.

Control of the computer image analysis includes system preparation, actual image analysis, and data reduction. In setting-up the image processor a set of standard instructions is followed. Included are system warm-up time, video camera to slide distance, light table color check, and cleaning of lens and color filters. Once the system is on and functioning a standardized scale slide is measured to insure the linear measurements made on the profile images are accurate.

VII. ANALYTICAL PROCEDURES

A. Macrofaunal Analysis

1. Sorting

Prior to sorting, each sample is recorded (initialed and dated by the sorter) on the Sample Processing Log (Figure 3). Sorters shall remove a cloth sample bag from one of the tributary/mainstem buckets containing a buffered 10% formalin solution with rose bengal stain. Each bag is labeled in the manner of **N-TR-REP(PARTITION)** as in 4-YP-2 or 4-J-3D(2-5) where **TR** is the tributary, mainstem or probability-based stratum designation (e.g.. J - James River, YP - York River, R - Rappahannock River, CB - mainstem of the Bay, or SB - Southern Branch of the Elizabeth River), **N** is the station number for the tributary or mainstem, **REP** is the replicate number for that station and **(PARTITION)** is the upper and lower bounds of a section of the partitioned 3D replicate.

The sample bag is placed, unopened, into a 0.5 mm sieve bucket that has been rinsed and examined for any residual material left on the sieve. The unopened sample bag is rinsed with fresh water to remove the formalin. It is then emptied onto the sieve and rinsed to remove any remaining fine material. The sample bag should be turned inside out and rinsed thoroughly. Care should be taken to ensure that nothing remains in the seams of the bag. The formalin-free residue is emptied into a white enamel pan. (In samples with a large volume of detritus the sample is to be placed into several pans.)

In coarse sediments a very large sediment residue remains after field sampling. To decrease sorting time, use an "elutriation" technique which washes out and concentrates small organisms from the sediment. Samples are placed into white enamel pans and the sediment vigorously agitated with a stream of water from a small hose. The "supernatant" water is poured onto a 0.5 mm screen which retains the organisms. This process is continued for approximately five minutes, after which both the elutriate and the coarse fraction are sorted. Usually only large bivalves and gastropods remain in the coarse fraction.

All macrobenthic specimens including broken parts are removed and placed into pre-labeled vials containing 70% isopropyl alcohol. Fiber optic illuminators, flourescently lighted magnifiers and binocular dissecting microscopes are used in the sorting process.

After sorting, the residual sediment is left in the enamel pan with a label added and presented to the BELS as part of the QA/QC program. The first five samples of all new sorters are resorted by the BELS. The results of these QC tests are not recorded. Any systematic deficiencies in sorting quality are discussed and corrected. After this probationary period only samples from the predetermined Quality Control Log for each cruise are resorted. The Quality Control Log is a random list of 10% of the samples for each cruise. The list is generated for each cruise using the BEL program entitled **BENTHIC** (see example in Figure 5).

2. Identification and Enumeration

All specimens are identified to the lowest practical taxonomic level. For approximately 90% of the specimens this is the species level. Juvenile specimens are often difficult to identify to the specific level because they have not developed all of the characteristics used to identify adults. This is most often a problem with bivalves, certain polychaete families (e.g. Nephtyidae) and oligochaetes (where reproductive organs are the primary specific characters). In tidal freshwater areas, insect larvae (primarily the Chironomidae) are often poorly known and typically identification is to the generic level.

For biomass analysis, parts of individuals will be identified when possible. Broken tail ends of annelids and dropped appendages of crustaceans can often be identified as belonging to a dominant species.

All species counts are recorded on Lab Data Sheets (Figure 4). Species counts are recorded separately for each unpartitioned replicate and for each depth interval in partitioned replicates.

3. Biomass Analysis

At each station/replicate/partition combination all individuals of each species are placed in labeled species-specific aluminum pans. All pans are then oven dried at 60^{o}C for at least 24 hr in a Boekel model 107801 drying oven. Large bivalves should be cracked open and left in oven for at least 48 hr. The drying oven is continually maintained at 60^{o}C and periodically checked. Adjustments are made as necessary.

After drying, the pans are allowed to cool to room temperature and a dry weight is obtained. The proper procedure for use of the Sartorius BPS121S balance to obtain weights is as follows:

1) **Level the Balance.** The bubble level on the back of the balance can be adjusted by turning the front two legs as needed.

2) **Turn on the Balance.** The on/off button is located at the far botton left of the keypad.

3) **Zero the balance.** Do not lean on table, this will affect the balance reading. Close both side doors. With no weight on the pan, press the tare button located at the upper right of the keypad. The LCD display will show 0.0000 g when the balnced is properly zeroed. **Check the zero after every ten weights.**

4) **Weigh the Sample**. Place sample to be weighed on balance pan and close doors. The correct weight has been obtained when the LCD display shows a steady number.

Dry weights are recorded to the nearest milligram (mg) on Lab Data Sheets (Figure 4).

After a dry weight is obtained the pans are placed in a Thernolyne 62700 muffle furnace for ashing. Furnace operation is as follows:

1) **Place sample in furnace and close door.**

2) **Plug in furnace and turn on.** On/off switch is located on the front bottom left of the furnace. urn top dial to set needle at 550^{o}C.

3) **Set furnace temperature.** Set the furnace to 550^{o}C using the LCD keypad located on the upper front right of furnace. The LCD display should show the furnace reaching the set temperature in approximately 20 minutes.

4)Ash Sample. Sample should be left in oven for 4 2 hours. This allows ample time for the furnace to reach the ashing temperature. After this time transfer the sample to the drying oven. **CAUTION!** Oven is very hot, you must use safety gloves for removing sample.

Weight for each ashed sample is obtained in the same manner as for dry weight. The ash-free dry weight biomass (AFDW) is the difference between the dry and ash weights for each variable measured.

Ash weights are recorded to the nearest milligram (mg) on Lab Data Sheets (Figure 4).

4. Reference Collection

A reference collection of all macrobenthic species will be established. Up to 10 representative specimens of each taxon will be placed in labeled vials and archived in 70% ethyl alcohol with glycerol. When specimens are removed from replicate samples for the reference collection, it will be noted on the appropriate Lab Data Sheet. Attempts will be made to include a variety of size classes for each species. For problematic and/or poorly known taxa, reference specimens will be verified by appropriate taxonomic experts. Specimens requiring clearing procedures for identification will be maintained as permanent mounts in slide storage trays.

B. Sediment Analysis

A sediment sample (approximately 40 ml) will be taken from the surface of the archive replicate at each fixed-point station and from the second grab sample at each probability-based site. The sample will be placed in pre-labeled plastic bags and immediately frozen. Samples will be stored in a BEL freezer until analyses are performed. Each sample will be defrosted and homogenized prior to analysis. Two sediment analyses will be performed: (1) particle size and (2) organic content (volatile solids).

1. Particle-Size Analysis

Particle-size analysis will be conducted using the techniques of Folk (1974). Each sediment sample is first separated into a sand fraction (> 63 Φm) and a silt-clay fraction (< 63 Φm). The sand fraction will be dry sieved and the silt-clay fraction quantified by a pipette analysis. Particle-size distribution parameters will be determined by the graphic and moment measures methods using a computer program developed at ODU. Results will include sand-silt-clay composition by weight, mean and median diameters, sorting coefficients, skewness and kurtosis.

Sand/Silt-Clay Separation. A 15 ml sediment sample is placed on a 63 Φm sieve and placed in a small enamel pan. Deionized (DI) water is used to pass the finer particles through the sieve. Care should be taken during the sieving process to break up sediment aggregates. The volume of water used should be conserved by shaking and elutriating the sample on the sieve in the pan. The use of water in excess of 1000 ml will required a double pipette analysis and is to be avoided. The sediment residue on the sieve is the Sand Fraction. The resultant water and fine particle mixture in the pan is the Silt-Clay Fraction.

Sand Fraction. The coarse material left on the 63 Φm sieve is checked for obvious detrital material. If the wet sample has a large amount of detrital material, about 10 ml of bleach is added to digest the detritus. The sample is then rinsed on the 63 Φm sieve, transferred to a labeled dish and oven dried at 60^{o}C for at least 12 hr after all visible water has evaporated. After the coarse fraction is dry, any aggregates are broken up and the sample is emptied onto a nested standard sieve series of 2000, 1000, 500, 250, 125 and 63 Φm with a solid pan below to capture any residual material (< 63 Φm). The sieve series is placed on a vibra-pad for ten minutes on the "HI" setting. (**Note: longer than ten minutes will lead to motor burnout.**) The material retained on each sieve and the pan is emptied into a pre-weighed dish and weighed. Weights are recorded on sediment data sheets for later analysis.

Silt-Clay Fraction. The silt-clay fraction is poured into a pre-labeled 1000 ml cylinder. The cylinder is filled to 1000 ml with DI water. The sediment-DI water content of the cylinder is then thoroughly mixed with a specially designed plunger for at least one minute. A series of five timed 20 ml pipette extractions are then made. After the mechanical mixing of the column has ceased, the first extraction is at 20 s at a depth of 20 cm below the water's surface. The pipette is emptied into pre-weighed, pre-labeled glass beakers. The pipette is then refilled with DI water and emptied into the same beaker to rinse the pipette. The remaining four extractions are taken at 10 cm below the water's surface at times of 1 m 56 s, 7 m 44 s, 31 m and 2 h 3 m. The pipette is emptied and rinsed into separate pre-weighed pre-labeled beakers for each extraction in the same manner as the first extraction. The DI water in the beakers is evaporated in the drying oven (usually takes about 48 hours). The beakers are allowed to cool to room temperature and the sediment plus beaker weight is determined and recorded. The recorded weights for the coarse and fine sediments of each sample are entered into a fortran program which determines mean phi, sorting, % sand, % silt and % clay as well as other standard particle size parameters.

All weight are recorded on a Sediment Analysis Sheet.

2. Organic Content (Volatile Solids)

Organic content (volatile solids) of the sediment is estimated as the ash-free dry weight of a sediment subsample expressed as a percentage of the dry weight of the sediment.

Weights for pre-labeled aluminum pans are recorded for each station and a sediment subsample (approximately 10 ml) is placed in the appropriate pan. Dry weight and ash weight are determined for each sample (minus the pan weight) as per the biomass ash free dry weight (AFDW) method.

VIII. DATA MANAGEMENT PROCEDURES

A. Data Transcription, Verification and Reporting

Data transcription, verification and reporting procedures are designed to produce data sets that (1) have met the appropriate criteria of Section III and (2) have been verified as exactly reproducing all information from each Field Data Sheet (Figure 2), Lab Data Sheet (Figure 4) or Sediment Analysis Sheet. Three BEL data manipulation programs are used -

1. Raw Data Files

   Raw data files are created by the BEL program entitled **BENTHIC**. This is a unique data entry program that was written to eliminate data entry errors on all BEL projects. The use of this program requires no programming skills and has numerous places during data entry that require data verification. **BENTHIC** produces 7 types of data files used in this project.

   Project File - This is a master file created at the initiation of each BEL project. It contains a unique code for each project, the codes for each sampling station, the location of each sampling station (latitude and longitude), and the collection gear used in each project.

   Cruise File - This file is created for each sampling event for each BEL project. For this project a separate Cruise File exists for each of the quarterly cruises. For each sampling station of the cruise this file contains (1) hydrographic data (date of sampling, hour of day of sampling, water depth of station, bottom water salinity, bottom water temperature, and bottom water dissolved oxygen), (2) the sieve size used, (3) the total number of replicates collected, and (4) the depth of penetration into the sediment of the collection gear.

   Individuals File - This file contains the counts of number of individuals of each taxon in each replicate or depth partition interval. At data entry each count by taxon is coded with the station code, replicate number, partition interval, and the BEL species code. In addition each count by taxon is coded by the project code, cruise code, type of data code (individuals or biomass), sieve mesh used, gear type code, conversion factor to square meters, depth of penetration of the replicate and date of collection. All of the latter codes are automatically recalled from both the Project File and Cruise File after data entry for each replicate is completed.

Biomass File - This file contains the biomass data for each taxon in each replicate or depth partition interval. Data entered are the dry weight and ash weight of each taxon. This file automatically calculates the AFDW for each taxon. The AFDW for each taxon is also coded with the project code, cruise code, type of data code (individuals or biomass), sieve mesh used, gear type code, conversion factor to square meters, depth of penetration of the replicate, date of collection, station code, replicate number, partition interval, and the BEL species code as indicated above.

Particle Size File - This file contains data for sediment analysis in a linear array necessary for entry to the program that calculates particle size distribution parameters (e.g. mean grain size, sorting, skewness, kurtosis). The values in this file represent the data organized by weight in each phi class interval shown on the Sediment Data Sheet.
Volatile Solids File - This file contains all the weight data, intermediate calculations, and the final total volatile solids estimation.

Verification File - This file rearranges the information from the Particle Size File into a format that can be easily verified directly against the original Sediment Data Sheet.

2. SAS Data Files

After all data for each sampling event (quarterly collection cruise) is verified as accurate in the Raw Data Files, all data files are sent to the university mainframe computer via a hard line. A hard copy of all files is produced and all data entries verified directly against the original data sheets (Field Data Sheet, Lab Data Sheet, Sediment Sheet). All errors are now corrected on both the mainframe files and local BEL files before any further data handling. All 6 raw data files (Figure 6) and the appropriate Project File are loaded into the BEL program entitled **BENTHSAS** which converts all data file to SAS files.

3. Data Reports

All quarterly reports are produced from SAS files by the BEL program entitled **CBPSAS**. This program automatically generates final copy tables and text.

B. Data Storage

The Project File and all six Raw Data Files are stored in four locations - three locally at BEL and one at the University Computer Center. In addition the SAS Data Files and the Report Files are stored both locally at the BEL and at the University Computer Center.

At the BEL the Project Files and Raw Data Files are stored on magnetic tape, on Bernoulli cartridge and floppy diskettes. The SAS Data Files and Report Files are also stored on magnetic tape at the BEL.

At the University Computer Center all Project Files, Raw Data Files, SAS Data Files and Report Files are stored on magnetic tape.

All original raw data sheets are stored at the BEL.

C. Fixed-Point Stations Data Reports

1. Report Contents

Quarterly Progress Reports (QPR) are produced within 90 days of each collection cruise (June, September). Each QPR includes a narrative summary of any problems encountered in data collection and includes summary tables for (1) the physical data, (2) sedimentary data, (3) total community parameters, (3) numbers of individuals per station, (4) ash-free dry weight biomass by station, (5) depth distribution by station and (6) an updated list of all taxa collected in the monitoring program.

2. Physical Data Table

The Physical Data Table presents for each collection station the following information: (1) sampling date of the station, (2) water depth of station, (3) bottom water salinity in parts per thousand, (4) bottom water temperature and (5) bottom water dissolved oxygen in parts per million.

3. Sedimentary Data Table

The Sedimentary Data Table presents for each collection station summary statistics as detailed in section VII. B. 1. and VII. B. 2. as follows: (1) Percent silt-clay fraction, (2) mean grain size in phi units, (3) sorting coefficient and (4) percent volatile solids.

4. Total Community Parameters Table

The Total Community Parameters Table presents for each collection station the following information: (1) total species collected at the stations, (2) the mean number of individuals per replicate presented in individuals per m^2, (3) the mean biomass per replicate presented in ash-free dry weight grams per m^2, and (4) the mean biomass per replicate with all bivalve species excluded presented in ash-free dry weight grams per m^2.

5. Number of Individuals Table

A Number of Individuals Table is presented for each collection station (21 tables) and includes: (1) the scientific name for each taxon organized by major taxa, (2) the number of individuals collected for each species in each replicate, (3) the total number of each species collected in all three replicates (row total) and (4) the total number of individuals collected in each replicate (column total).

6. Biomass Table

A Biomass Table is presented for each collection station (21 tables) and includes: (1) the scientific name for each taxon organized by major taxa, (2) the ash-free dry weight biomass in mg for each species in each replicate, (3) the total ash-free dry weight biomass of each species collected in all three replicates (row total) and (4) the total ash-free dry weight biomass collected in each replicate (column total).

7. Depth Distribution Table

A Depth Distribution Table is presented for each collection station (21 tables) and includes by each depth interval: (1) the cumulative percentage of individuals with depth, (2) the cumulative percentage of species with depth, and (3) the cumulative percentage of biomass with depth.

8. Updated Taxonomic List

Each QPR will include an updated list of all taxa collected in the monitoring program. The taxa in this list are organized by major taxa and the specific authority is given for all taxa identified to the species level. This quarterly updated list is exchanged with Maryland investigators on a regular basis in order to resolve and identification problems.

D. Probability-Based Sampling Data Reports

1. Report Contents

For the probability-based sampled strata a final report (PBFR) is produced within 120 days of completion of field collection (July 15 to September 30). The PBFR includes a narrative summary of any problems encountered in data collection and includes summary tables for (1) the physical data, (2) sedimentary data, (3) total community parameters, (3) numbers of individuals per station, (4) ash-free dry weight biomass by station, (5) an updated list of all taxa collected in each stratum, and (6) an estimate of condition of the benthos within each stratum through application of the Benthic Restoration Goals and the Benthic Restoration Goals Index.

2. Physical Data Table

The Physical Data Table presents for each collection station the following information: (1) sampling date of the station, (2) water depth of station, (3) bottom water salinity in parts per thousand, (4) bottom water temperature and (5) bottom water dissolved oxygen in parts per million.

3. Sedimentary Data Table

The Sedimentary Data Table presents for each collection station summary statistics as detailed in section VII. B. 1. and VII. B. 2. and includes only the percent silt-clay fraction.

4. Total Community Parameters Table

The Total Community Parameters Table presents for each stratum by the habitat types identified by Benthic Restoration Goals. Foe each habitat type the following information is presented: (1) total species collected in all samples, (2) the number of individuals per m^2, (3) the biomass per presented in ash-free dry weight grams per m^2, and (4) the mean Restoration Goals Index value.

5. Number of Individuals Table

A Number of Individuals Table is presented for each collection location and includes: (1) the scientific name for each taxon organized by major taxa, and (2) the number of individuals collected for each species the sample.

6. Biomass Table

A Biomass Table is presented for each collection location of each stratum and includes: (1) the scientific name for each taxon organized by major taxa, and (2) the ash-free dry weight biomass in mg for each species in each sample.

7. Updated Taxonomic List

Each PBFR will include an updated list of all taxa collected in the monitoring program within that stratum. The taxa in this list are organized by major taxa and the specific authority is given for all taxa identified to the species level.

8. Benthic Condition

The condition of the benthic communities within a stratum will be assessed in two ways - (1) mean condition and (2) percent of area exceeding threshold values. The Benthic Restoration Goals and the Benthic Index of Biotic Integrity (BIBI: Weisberg et al. 1997) will be used to characterize the condition of each probability-based sampled stratum. The mean and variance of the BIBI can be estimated and the confidence intervals for estimates of percent of area exceeding the Benthic Restoration Goals can be estimated from the binomial distribution using the formula of Hollander and Wolfe.

E. Annual Data Summaries and Statistical Analyses

1. Overview

When appropriate resources are provided by DEQ the data summaries and analyses listed below will be provided to the DEQ as needed for various reports required of the DEQ and include analyses and statistics for all data collected from the fixed-point stations sampled in June and September of each year.

2. Tributary/Mainstem Summary - Environmental Data

For each of the three major tributaries (James River, York River, Rappahannock River) and the Mainstem of the Bay a summary table of environmental parameters with means and standard errors calculated for the entire monitoring program collection period is presented by station including: (1) mean grain size in phi units, (2) sorting coefficient, (3) silt-clay content in percentage, (4) volatile solids in percentage, (5) salinity in parts per thousand, and (6) water depth in meters.

3. Tributary/Mainstem Summary - Community Parameters

For each of the three major tributaries (James River, York River, Rappahannock River) and the Mainstem of the Bay a summary table of community parameters with means and standard errors calculated for the entire monitoring program collection period is presented by station including: (1) number of individuals per replicate, (2) species per replicate, (3) total biomass in ash-free dry weight mg per replicate, (4) biomass without bivalves in ash-free dry weight biomass per replicate, (5) the Shannon Informational Diversity Index, (6) the Margalef Richness Index, and (7) the Pielou Evenness Index.

4. Species Abundance by Station Table

For each of the collection stations (21 tables) a summary table for each taxon collected is presented showing: (1) the mean number of individuals per replicate per collection year and a grand mean and (2) the number of occurrences in replicates for each year and the overall occurrences of each taxon.

5. Species Biomass by Station Table

For each of the collection stations (21 tables) a summary table for each taxon collected is presented showing: (1) the mean ash-free dry weight biomass per replicate per collection year and a grand mean and (2) the number of occurrences in replicates for each year and the overall occurrences of each taxon.

6. Species Abundance Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean number of individuals per replicate per collection year and standard error and (2) the grand mean number of individuals per replicate and standard error.

7. Species Diversity Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean number of species per replicate per collection year and standard error and (2) the grand mean number of species per replicate and standard error.

8. Total Biomass Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean total community biomass per replicate per collection year and standard error and (2) the grand mean total community biomass per replicate and standard error.

9. Biomass without Bivalves Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean community biomass without bivalves per replicate per collection year and standard error and (2) the grand mean community biomass without bivalves per replicate and standard error.

10. Shannon's Diversity Index Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean Shannon's Index per cruise per collection year and standard error and (2) the grand mean Shannon's Index per cruise and standard error.

11. Margalef's Richness Index Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean Margelef's Richness Index per cruise per collection year and standard error and (2) the grand mean Margelef's Richness Index per cruise and standard error.

12. Pielou's Evenness Index Annual Means Table

A summary table for each collection station (21) is presented showing: (1) the mean Pielou's Evenness Index per cruise per collection year and standard error and (2) the grand mean Pielou's Evenness Index per cruise and standard error.

13. Depth Distribution Annual Means Table

A summary table for each collection station (21) based on mean data for the entire collection period is presented showing: (1) the cumulative percentage of individuals with depth, (2) the cumulative percentage of species with depth, and (3) the cumulative percentage of biomass with depth.

14. Trend analysis

Long-term trends in the benthic data set are analyzed by a series of nonparametric trend tests using replicate data. Overall trends in the data are analyzed by the seasonal intra-block sign test based on the Kendall Tau statistic described by Hirsch et al. (1982) and the aligned rank test described by Sen (1968). Trends unique to certain seasons, to certain stations, or to the interaction of stations and seasons are analyzed by a chi-square protocol described by Van Belle and Hughes (1984). The median slopes of significant trends are determined by the Seasonal Kendall slope estimator (Gilbert 1987). A recent study on representative data sets from the Chesapeake Bay monitoring program indicated that these tests are generally quite powerful and robust, even when data violate the assumptions of parametric statistics (Alden et al. 1990).

IX. INTERNAL QC CHECKS

A. Field Procedures

The Chief Scientist is responsible for (1) visual inspection and decision of acceptance of each box core sample collected, (2) assuring that each replicate is placed onto the proper pre-labeled collection bag, (3) assuring that bags from each station are placed into the properly labelled plastic bucket, (4) assuring that each sediment sample is placed into the properly pre-labeled plastic self-locking bags and properly stored on ice on the vessel, (5) assuring that additional sediment samples are collected if sediment type changes visually between replicate samples, (6) assuring that the Field Data Sheets are appropriately completed and filed, (7) assuring that all field equipment is properly calibrated and necessary maintenance is performed, and (8) assuring the all sample custody procedures are followed.

B. Laboratory Procedures

The Benthic Ecology Laboratory Supervisor is responsible for assuring that (1) all sampling custody procedures are followed each day by all staff of the BEL, (2) all analytical procedures are followed by each day by all staff of the BEL, (3) that the reference collection is properly maintained and checked each month for appropriate fluid levels, (4) that all field equipment is checked and serviced prior to each cruise, (5) that all laboratory equipment is properly maintained and serviced according to manufacture's instructions and (6) that all data transcription, verification and reporting procedures are followed.

X. PERFORMANCE AND SYSTEM AUDITS

A. Field Activities

The Chief Scientist is prepared on each cruise to accommodate any VADEQ or CBPO personnel that may audit the field collection procedures. On any cruise that an audit may be conducted the Chief Scientist will have available the QA/QC plan and will address all field activities as they relate to the objectives of the program.

B. Laboratory Activities

Internal audits of the Laboratory Activities are conducted once each year by the Principal Investigator. The PI reviews all procedures with the BELS as detailed in sections III through VIII of this QA/QC Plan. The BEL is prepared to participate in external audits by personnel of the VADEQ or the CBPO.

XI. PREVENTATIVE MAINTENANCE

A. Field Activities

The crew of the *RV Holton* maintains a regular schedule of maintenance for the vessel and all associated equipment of the vessel. All field equipment is checked prior to each cruise for proper operation or routine maintenance as required or recommend by the manufacturer. Spare parts for the collection gear are available on each cruise.

B. Laboratory Activities

All equipment required for this program is regularly checked and maintained as required or recommended by the manufacturer.

XII. SPECIFIC SOPS USED TO ASSESS DATA QUALITY OBJECTIVES (DQOs), DATA PRECISION, ACCURACY, AND COMPLETENESS

Data precision is assessed by the protocols presented in section IV. SAMPLING PROCEDURES. The data accuracy issue is addressed in section III. QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES AND CRITERIA. The fundamental parameter being measured in any biological monitoring program is what species are present (Ellis 1988). "The fundamental accuracy in biological surveys is getting the species identification right, getting the correct Linnean name, and doing so consistently" (Ellis 1988, p. 507). Indeed, all other estimates of field parameters (e.g., densities and biomass of populations) can not truly be tested for accuracy because standards are meaningless. Accuracy can only be approximated by inter-laboratory calibrations (see e.g. Ellis and Cross 1981) which are not part of the present program because (1) accepted protocols do not exist and (2) fiscal resources are limited. All Data Quality Objectives (DQOs) of the RFP as stated in Attachment B: Data

Quality Objectives will be met.

XIII. CORRECTIVE ACTION FOR OUT-OF-CONTROL SITUATIONS

Procedures to identify problems, their sources and implementation of corrective action are detailed in sections IV. SAMPLING PROCEDURES, V. SAMPLE CUSTODY, AND VII. ANALYTICAL PROCEDURES. Any problems, defects or corrective actions that are not specifically addressed in the present QA/QC plan must be acted upon by the Principal Investigator with the consultation and written approval of the VWCB.

XIV. QA REPORTING PROCEDURES TO MANAGEMENT

Any problems encountered or corrective actions taken are reported to the VWCB in the Quarterly Reports (see section VII. DATA MANAGEMENT PROCEDURES, C. Quarterly Data Reports). Quarterly Reports and Final Summary Reports are provided to the VWCB as required by the program and in a format as described in sections VII. DATA MANAGEMENT PROCEDURES, C. Quarterly Data Reports and D. Annual Data Summaries and Statistical Analyses.

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XVI. BIOGRAPHICAL DATA OF KEY PERSONNEL

DANIEL M. DAUER, Ph.D., Professor, Department of Biological Sciences, and Director of the Benthic Ecology Laboratory, Old Dominion University, Norfolk, Virginia, 23529, (757) 683-4709.

EDUCATION

B.S., Biology, Old Dominion University, Norfolk, VA, 1970
Ph.D., Biology, University of South Florida, Tampa, FL, 1974
Post-Doctoral Research Associate, Baruch Institute for Marine Biology and Coastal Research, Georgetown, SC, 1975

AREAS OF EXPERTISE

Dr. Dauer has over 30 years of professional experience in marine benthic ecology, environmental assessment using macrobenthic community structure, functional morphology and behavior of surface feeding benthos and the systematics and ecology of polychaetous annelids. Dr. Daniel M. Dauer has **54** papers published or in press, has published **96** Technical Reports, has been awarded **88** grants and contracts totaling **$7,050,119** as the Principal Investigator and **$12,218,179** including awards as a Co-Principal Investigator, has made **192** presentations at scientific meetings or invited seminars, and hosted three professional society meetings.

PREVIOUS RESEARCH EXPERIENCE

Dr. Dauer's applied marine research emphasizes the use of benthic (bottom-dwelling) communities in environmental impact assessment. He has successfully directed the Benthic Monitoring Program for the Department of Environmental Quality from 1985 through 1995. Research programs conducted by Dr. Dauer have played a key role in such environmental issues as the placement of open ocean disposal sites, dredging of the major ship channels of the lower Chesapeake Bay and determining the health of the biota of the entire lower Chesapeake Bay and its major tributaries as part of the cleanup effort of the Chesapeake Bay Restoration Program. This research is an important local and regional service to environmental regulatory and management agencies and has received funding from the Army Corps of Engineers, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Virginia Water Control Board, Virginia Commission of Game and Inland Fisheries, Virginia Port Authority, Virginia Department of Highways and Transportation and a variety of private firms. Dr. Dauer is experienced in data analysis of benthic community structure including univariate and multivariate analyses.

PUBLICATIONS

Dr. Daniel M. Dauer has authored **150** published articles and technical reports. His works have been published in prestigious journals including *Estuaries, Marine Pollution Bulletin, Marine Biology, Journal of Experimental Marine Biology and Ecology, Bulletin of Marine Science,* and *Ophelia.*

ANTHONY J. RODI, JR, Benthic Ecology Laboratory Manager, Old Dominion University, Norfolk, Virginia, 23529, (757) 683-6090.

EDUCATION

B.S., Marine Science, Stockton State College, Pomona NJ (1983)
M.S., Biology, Old Dominion University, Norfolk, VA, (1990)

AREAS OF EXPERTISE

Mr. Rodi has extensive training in the identification of benthic invertebrates from the Chesapeake Bay, Gulf of Mexico and continental shelf of the East Coast of the United States. He is expert in the systematics of all major invertebrate phyla of marine, estuarine and freshwater habitats. Mr. Rodi has been the Benthic Ecology Laboratory Manager for the last 10 years supervising all employees and training staff in the standard operating procedures of the laboratory. He has over 10 years experience as the Chief Scientist on over 30 research cruises, supervising all field collection activities. He also has expertise in data handling, data verification, data transmission and submittal, and data management having produced over 35 technical reports electronically.

PREVIOUS RESEARCH EXPERIENCE

Mr. Rodi successfully managed the Benthic Monitoring Program for the Virginia Water Control Board from 1986 through 1995. He has also managed the staff of the laboratory on a wide variety of contracts funded by the Army Corps of Engineers, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Virginia Water Control Board, Virginia Commission of Game and Inland Fisheries, Virginia Port Authority, Virginia Department of Highways and Transportation and a variety of private firms.

PUBLICATIONS

Mr. Rodi authored or coauthored 37 published articles and technical reports.

XVII. TABLES

Table 1. Location of sampling stations in the lower Chesapeake Bay Benthic Biological Monitoring Program.

STATION	DESCRIPTION	LATITUDE	LONGITUDE
TF5.5	James River, Red Buoy 10	37 18.77	77 13.98
RET5.2	James River, Swann's Point	37 12.65	76 47.58
LE5.1	James River, Hog Point	37 12.47	76 42.25
SBE2	Elizabeth R. off Atl. Wood	36 48.88	76 18.07
SBE5	Elizabeth R. off VEPCO	36 46.03	76 18.62
LE5.2	James River, Buoy C 12-13	37 03.51	76 35.09
LE5.4	James River, Buoy 9	36 58.10	76 23.32
TF4.2	Pamunkey River	37 32.82	76 58.48
RET4.3	York River, C57	37 30.58	76 47.32
LE4.1	York River, N44	37 25.01	76 41.58
LE4.3	York River, off VIMS, shoal	37 14.45	76 29.10
LE4.3B	York River, off VIMS, channel	37 13.76	76 28.38
TF3.3	Rappahannock River, N40	38 01.14	76 54.62
RET3.1	Rappahannock River, N Buoy R10	37 55.21	76 49.26
LE3.2	Rappahannock River Upstream, Buoy R8	37 40.13	76 33.34
LE3.4	Rappahannock River, Orchard Pt	37 38.13	76 27.80
CB5.4	Main Bay, Upper	37 47.97	76 10.55
CB6.1	Main Bay, Off Rappahannock R.	37 35.31	76 09.71
CB6.4	Main Bay, Off York River	37 14.19	76 12.22
CB8.1	Main Bay, Off James River	36 59.13	76 10.12
CB7.3E	Main Bay, Off Old Plantation Fl.	37 13.48	76 03.27

XVIII. FIGURES

Figure 1. Map of stations in the lower Chesapeake Bay. See Table 1 for station coordinates.

Field Data Sheet

Bottom Water

Salinity (ppt)

Temp (^oC)

D.O. (ppm) ____________________

Site/Station

Date

Time

Replicate	Coordinates	Water Depth (ft)	Sample Bag Number	Sample Storage Location	Sediment Sample
1					
2					
3					
4					
5					

Replicate	Sediment Comments
1	
2	
3	
4	
5	

Figure 2. Field Data Sheet

Sample Processing Log Sheet -- Cruise

STATION	SORTER	START DATE	END DATE	TIME SPENT	COMMENTS

Figure 3. Sample Processing Log.

Program	Year	Cruise	Site	Depth	Total Count	Total Species

Species Code	**Species**	**Count**		**Dry Weight**		**Ash Weight**
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					
	20					

Comments:

Figure 4. Lab Data Sheet

QA/QC LOG FOR SAMPLE PROCESSING

PROJECT: YEAR: CRUISE:

SAMPLE	SORTER (Name/Date)	QC TYPE (Sorting/ID)	QC BY (Name/Date)	COMMENTS

Figure 5. Quality Control Log.

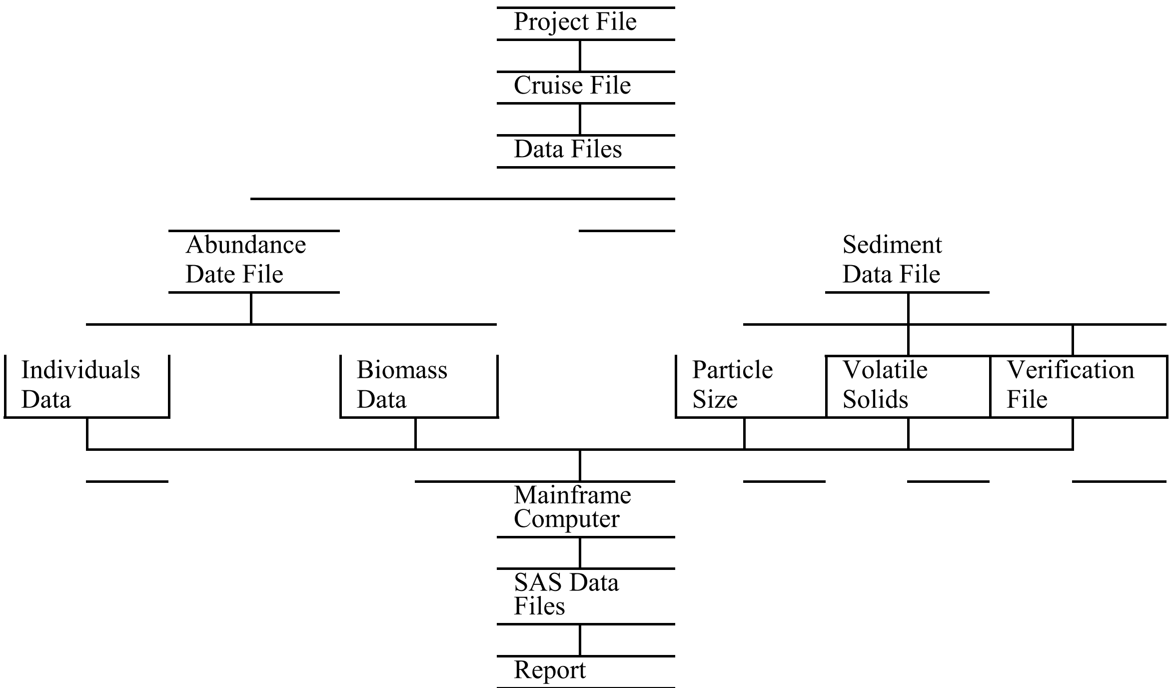

Figure 6. Data Management Organization