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February 1993

PROCEEDINGS

Estuarine and Near Coastal Bioassessment and Biocriteria Workshop

November 18–19, 1992
Annapolis, Maryland

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November 18–19, 1992
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U.S. Environmental Protection Agency
Office of Water
Washington, DC

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Introduction

This workshop was sponsored by the EPA's Office of Science and Technology and Office of Wetlands, Oceans, and Watersheds. It was the second workshop held to provide an opportunity for experts in estuarine and marine ecology, and staff from the States and EPA's Regional and Headquarters program offices to discuss the development of a technical guidance document for bioassessment and biocriteria for estuarine and near coastal marine systems. The results of discussions held at this workshop have been used to identify areas needing further research and to develop a draft outline of the guidance document. In addition, a subcommittee was formed and charged with drafting the technical guidance document.

The first section of these proceedings contains summaries of the workshop presentations as well as copies of the slides and graphics used by the speakers. The next section contains the workshop agenda and the names and addresses of all workgroup members.

Workshop Summary

The one-and-a-half day workshop was designed to initiate discussion of elements to include in a technical guidance document by reviewing related projects conducted during this year and using these contributions as stimuli for further deliberation.

Day One • November 18, 1992

During the first day of the workshop, the following talks were presented:

Introduction and Goals of Workshop

George Gibson, *U.S. EPA Office of Science and Technology*

George Gibson welcomed participants to the workshop. He stated that EPA was sponsoring this meeting to initiate the preparation of a technical guidance document to assist States in conducting biological assessments and developing biological criteria in estuaries and near coastal marine waters. One outcome of this meeting will be a list of individuals interested in participating on the "drafting subgroup." George stressed that EPA is interested in bioassessment methods that are direct, straightforward and that can be used in an efficient manner by the States.

George mentioned the key elements/issues which the guidance document must address:

1. working definition of biological integrity,
2. establishing reference conditions,
3. biological community measurement (i.e., which communities do we pick and how do we measure them?),
4. habitat assessment,
5. survey techniques,
6. metrics, and
7. development of biocriteria and their applications.

In addition to these technical issues, George highlighted other characteristics that the developed guidance document must have:

1. material must be robust and broad based so basic techniques can be applied on all three coasts;
2. material must be reliable, simple, cost effective, and appropriate to the States' resources; and
3. material must be experience-based rather than theoretical (i.e., we need to think in terms of practical application).

Synoptic Interviews with Researchers

Dan Campbell, *University of Rhode Island*

Dan Campbell summarized the results of two workshops held to address the question: "What is biological integrity in an estuary?" This question was addressed by regional experts in the field of estuarine ecology. The first workshop was held at the University of Rhode Island in Narragansett. A broad range of ideas on integrity was expressed, but the Narragansett workshop participants concentrated their discussion on refinement and definition of the concept. The second workshop was held at the Chesapeake Biological Laboratory in Solomons, Maryland. Participants in this workshop defined and characterized the concept of biological integrity and explored approaches to use it in water resource investigations. (See next page for visuals Mr. Campbell used during his presentation.)

The discussion following Dan's presentation noted that we must be able to operationally define and measure biological integrity for it to have practical utility.

DEFINITIONS OF BIOLOGICAL INTEGRITY

"The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region."

— Karr and Dudley, 1981

"The condition of the aquatic community inhabiting the unimpaired waterbodies of a specified habitat as measured by community structure and function".

— U.S. EPA, 1990

". . . is the degree to which a community is similar to natural (unimpacted) communities in the same environment or habitat. There is an element of balance in the concept that implies that the biological community utilizes inputs of matter and energy in an efficient coupling."

— Stevenson and Cornwall, 1992

INDICATORS OF BIOLOGICAL INTEGRITY INCLUDE

- Species richness.
- Diversity.
- Degree of interaction (connectivity).
- Degree to which a community efficiently assimilates and utilizes allocthanous inputs.
- Degree to which essential nutrients are retained and recycled.

CHARACTERISTICS OF BIOLOGICAL INTEGRITY IN ESTUARINE SYSTEMS

- Diversity of species and ecological processes is maximized.
- Disease and stress on constituent organisms is minimum.
- The community includes large, long-lived species.
- Trophic transfer up the food chain is maximized.
- Variability of system parameters is maintained within a "natural range", that is without shifts in the long term baseline.
- A successful recruitment schedule is maintained as appropriate for the species.
- Export of raw materials is minimized ("leakiness").

ADDITIONAL FACTORS TO CONSIDER WHEN DETERMINING THE BIOLOGICAL INTEGRITY OF ESTUARINE SYSTEMS

- In some ecosystems key species exist that deserve extra consideration.
- Biological integrity of a community must include all habitats necessary to support each life history stage of the component organisms.
- The physical basis for community organization must be included.

COMPONENTS OF BIOLOGICAL "RESPONSE" TO ANTHROPOGENIC IMPACTS

- Absence of biological catastrophes.
- Biopurification.
- Body burdens of toxic chemicals.
- Biochemical markers of stress or exposure.
- Absence of gross pathology.
- "Desirable" species richness.

Summary of Selected Estuarine Monitoring Programs

Mike Bowman, *Tetra Tech*

Mike Bowman presented results of a review of several existing long-term monitoring programs across the country. The purpose of this review was to look at various alternatives to technical issues related to bioassessment in estuaries. The key issues addressed in the presentation and recommendations for each, based on the data review, are as follows:

- **biological assemblage**—benthic macroinvertebrates;
- **habitat selection**—soft sediment;
- **metrics**—various benthic indices;
- **sampling methods**—Van Veen or Ponar grab samplers, screen mesh of 0.5 mm, and composite of 2 to 4 grabs;
- **index period**—East (summer) and West (spring); and
- **how to assess habitat quality**—several parameters including temperature, dissolved oxygen, salinity, and grain size.

Mike concluded by mentioning other issues for consideration, the most important being the method(s) for establishing a reference condition.

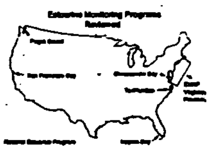
After Mike's presentation, concern was expressed over the use of an index period and the relative insensitivity of the benthic community compared with some other assemblages (e.g., epifaunal community on seagrasses in Florida).

Summary of Selected Estuarine Monitoring Programs

A Basis for Bioassessment Methods

Presented at USEPA Estuarine Bioassessment Workshop
Annapolis, MD
November 18-19, 1992

Programs Across US Were Reviewed



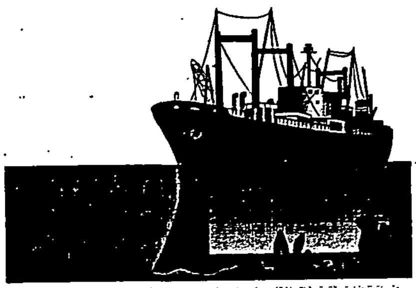
Key Issues:

- Assemblage
- Habitat Selection
- Metrics
- Sampling Methods
- Index Period
- Habitat Quality

Task Objectives

- Review long-term data sets for methods applications.
- Using the results from these programs, assess valid alternatives to key technical issues.

Recommendations for Estuarine RBP Attributes



Data Sets and Reports Reviewed

	Program Duration	Period Reviewed
Chesapeake Benthos	1971 - present	1984 - 1990
Chesapeake Plankton	1984 - present	1984 - 1991
Tar/Pamlico	1983 - present	1991 - 1992
EMAP Virginian	1990 - present	1990
Naples Bay	1976 - 1977	1976 - 1977
San Francisco Bay	1988 - present	1992
Puget Sound Ambient	1988 - present	1988 - present
Puget Sound Estuary	1991 - present	1991(a)
NEP	1987 - present	1992(a)

(a) Guidance Document

Assemblage

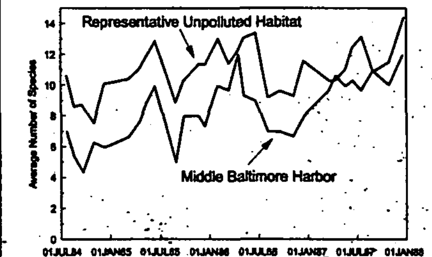
Assemblage - *Benthic Macroinvertebrates*

- Benthic organisms are sensitive to pollutant exposure and integrate exposure over relatively long time periods.
- Benthos are composed of diverse taxa which respond to changes in environmental conditions in various ways.
- Important mediators for nutrient cycling; prey items for species at higher trophic levels.
- Easily sampled with both core and grab samples.

Habitat - *Soft Sediments*

- Easily sampled; cost-effective and well-documented methods exist.
- Distinct species groups associated with major sediment types.

Benthic Sampling Can Discriminate Polluted From Reference Sites



Adapted from Holland et al., 1989

Habitat - *Soft Sediments* cont'd

- Soft sediments (e.g., mud) may be associated with contaminant accumulation or may be most prevalent in deeper, depositional environments most likely to experience low dissolved oxygen concentrations. Thus, sampling this habitat is likely to show the effects of stresses to the estuarine system.

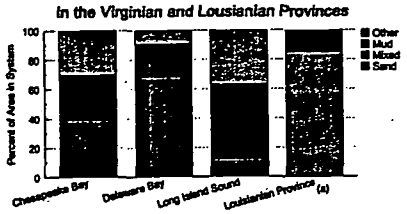
Habitat Selection

Habitats Sampled in Reviewed Programs

	Rocky Shore: Gravel/Cobble	Sand	Sandy-Mud	Muddy-Sand	Mud
Chesapeake Bay		X	X	X	X
Tar/Pamlico		X	X	X	X
EMAP Virginian		X	X	X	X
Naples Bay		X	X	X	X
San Francisco Bay	X	X	X	X	X
Puget Sound	X	X	X	X	X

Soft Sediments Are Widely Found in the East and Gulf of Mexico

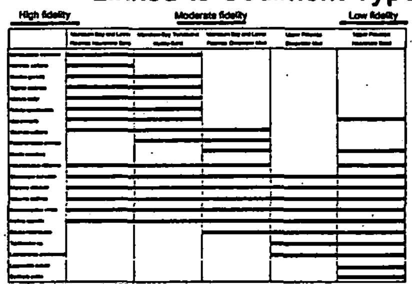
Sediment Types in Major Estuarine Systems in the Virginian and Lousianian Provinces



Adapted from Weisberg et al., 1992 (a) K. Summers, pers. comm., 1992

Metrics

Species Groups Are Linked to Sediment Type



Adapted from Holland et al., 1987

Possible Indicators and Metrics

- Benthic index
- Species richness
- Relative abundance of pollution tolerant and pollution sensitive species
- Biomass estimates for each pollution sensitivity group
- Presence/absence of larger, longer-lived organisms
- Organism-sediment index

Key Fauna in Major Habitats in Puget Sound

Emergent Marsh	Mudflat	Nearshore Soft Bottom	Sandflat	Eelgrass
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Sampling Methods

Sampling Methods - *Equipment*

- Van Veen or Ponar samplers, depending on sediment type and depth. Both are easily deployed from small boats.
- Benthic samples should be field sieved using a 0.5-mm screen.
- Total sampled area of 0.2 - 0.3-sq. m., composite of 2 - 4 grabs. Depth of sampled sediment dependent on sediment type.

Index Period

Index Period - *Summer (East), Spring (West)*

- In east coast estuaries, a period following recruitment with high benthic abundance.
- In west coast estuaries, a period prior to recruitment with stable benthic communities.

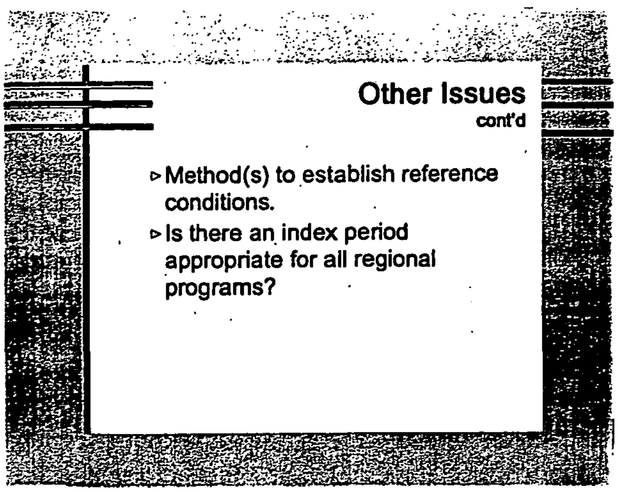
Habitat Quality

Habitat Quality Assessment

- Temperature
- Salinity
- DO
- Conductivity
- Turbidity/transparency
- Grain size distribution
- Sediment profile
- Shorezone stability

Other Issues

- Other assemblages such as nekton, plankton?
- Can cost-effective methods to collect and use fish community data be developed?
- Are cost-effective methods of subsampling composited samples appropriate for assessing benthic assemblage attributes?



Overview of U.S. EPA EMAP—Estuaries Indicator Strategy

John Scott, *SAIC, Narragansett, RI*

John Scott stated that EMAP's development of some of its indicators was very relevant to this group's efforts to develop biocriteria and bioassessment methods. EMAP has a large database on ecological variables, along with data on exposure and habitat variables, that could be used by this program to test some of the bio-indicator concepts. John indicated the desire for EMAP and this program to work more closely.

John gave an overview of the EMAP-Estuaries Indicator strategy. The strategy is based on the premise that indicators must relate to assessment endpoints. Three types of indicators are measured:

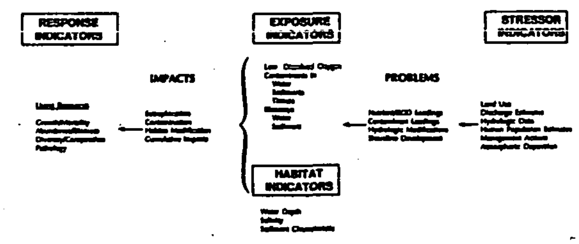
- **stressor indicators** (e.g., land use, discharge estimates);
- **exposure-habitat variables** (e.g., sediment toxicity, water clarity) and
- **response indicators** (e.g., benthic community parameters).

John suggested that certain elements of the process used for selecting the indicators may be useful to our program. This process of "indicator evolution" includes several stages:

- **candidate indicators** are chosen, prioritized and screened for robustness, interpretability, relationship to assessment endpoints and their responsiveness to habitat or exposure stressors;
- select candidate indicators are then moved to the **research stage** to evaluate their responsiveness under field conditions (i.e., tested in "good" and "bad" sites);
- those indicators that pass progress to the **developmental stage** where their performance is evaluated on a regional scale (e.g., Virginian Province); and finally
- indicators are assigned **core status**. EMAP is still evaluating these indicators and will not assign core status until baseline information has been gathered over a four-year period.

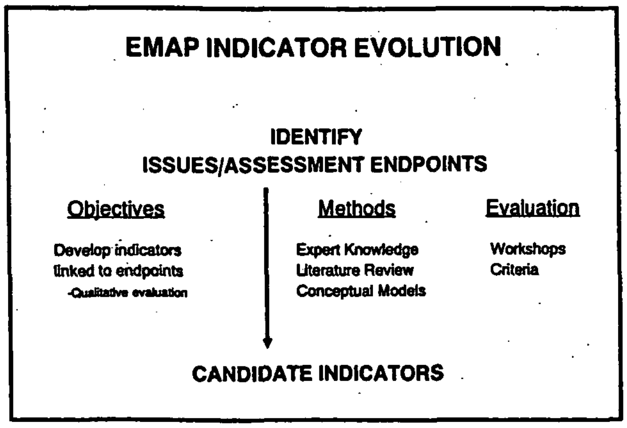
Discussion after John's presentation revolved around the willingness of EMAP to work with this program and the applicability of EMAP indicators on regional and state levels. John reiterated the willingness of EMAP to collaborate and also the similarity of EMAP indicator goals and biocriteria needs (i.e., we both are charged with developing indicators that discriminate good versus bad sites, are responsive, relate to biotic integrity, are cost effective, interpretable and simple).

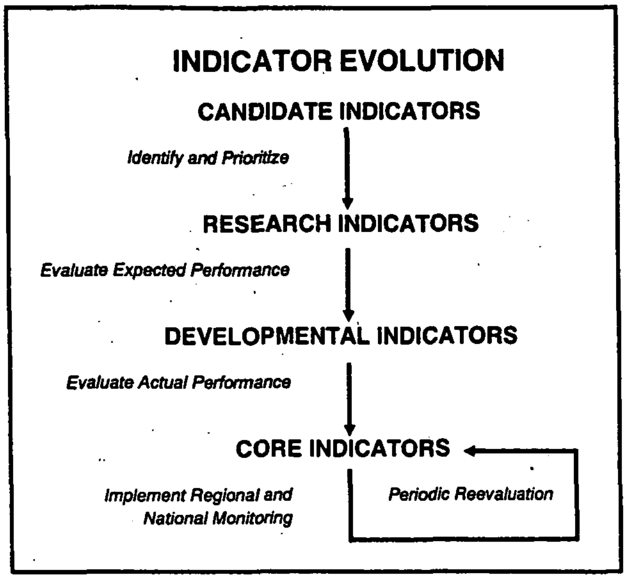
EMAP-NC INDICATOR STRATEGY



EMAP INDICATOR TYPES

Response Indicator:	Measurements of biological condition
Exposure/Habitat Indicator:	Diagnostic measures of * Exposure * Physical attributes of habitat
Stressor Indicator:	Measures of human activities and natural processes that effect exposure and habitat indicators





Virginia Benthic Biological Monitoring Program

Dan Dauer, *Old Dominion University*

Dan Dauer described statistical properties of assessment methods/metrics that he believes should be considered. These statistical properties are:

- **Type I error** (i.e., power of the test), robustness, and alpha or
- **Type II error** (i.e., how conservative the test is). For example, early warning type of assessments will be powerful, while definitive assessments will be conservative.

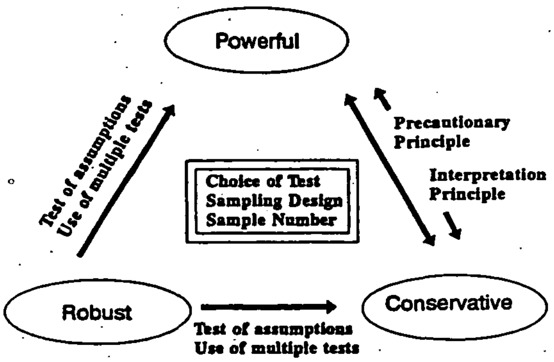
Dan applied the following six benthic metrics to data from the mouth of the Rappahannock River:

1. biomass of opportunistic species;
2. biomass of equilibrium species;
3. biomass;
4. diversity;
5. depth distribution of organisms;
6. abundance.

These metrics were plotted as a function of salinity. He suggested all these metrics except abundance have some merit as indicators.

The geographic specificity of metrics was acknowledged in the discussion. These types of limitations should be recognized; however, metrics as data interpretation should not be dismissed because they're not applicable to every situation. Hence, the importance of allowing States flexibility when developing biocriteria.

I. Warning System (Powerful)
II. Definitive Test (Conservative)



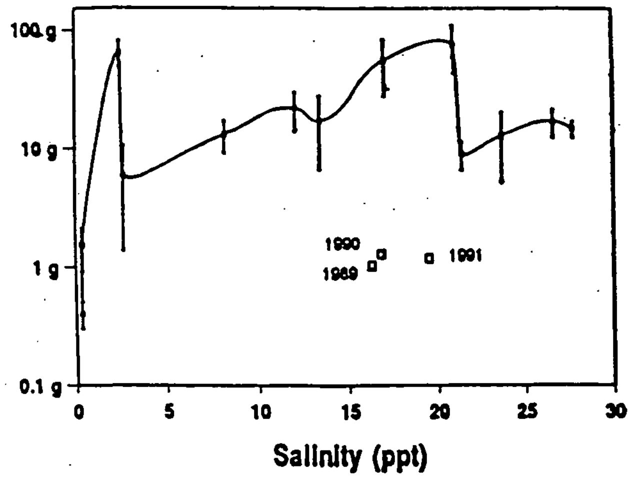
Models of Expected Values

Metrics	Technical Skills	Sensitivity
Biomass	Low	High
Diversity	High	High
% Opportunists	Moderate-High	High
% Equilibrium	Moderate	Moderate
Depth Distribution	Low	Moderate
Abundance	Moderate	Low

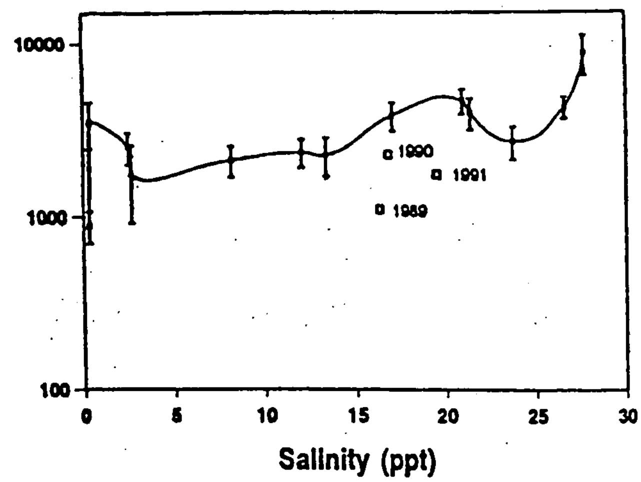
Abundance Biomass Comparison

	Unexpected Absence	Unexpected Presence
Biomass Dominant	Inadequate Sampling	1. Extensive Sampling 2. Highly Stressed
Abundance Dominant	Highly Stressed	Dense Recuitment

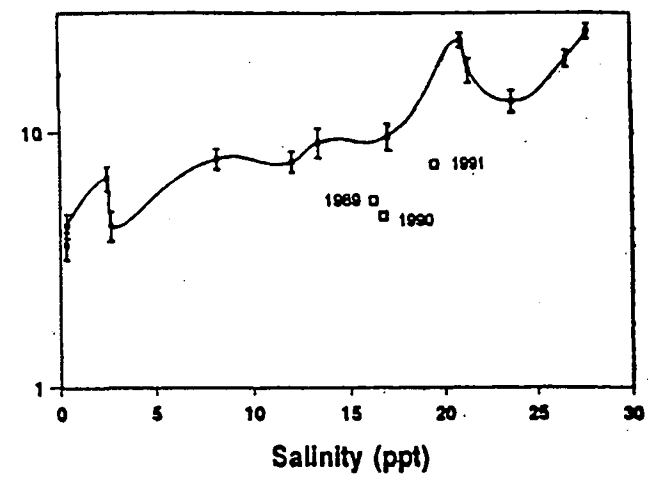
A. Biomass (LE3.4)



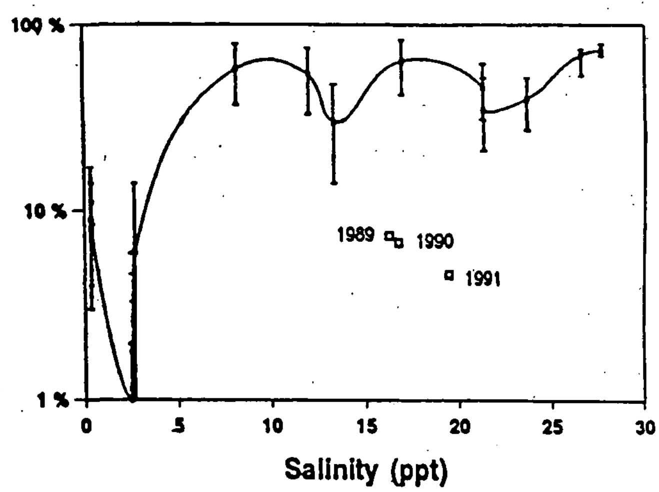
B. Individuals per m2 (LE3.4)



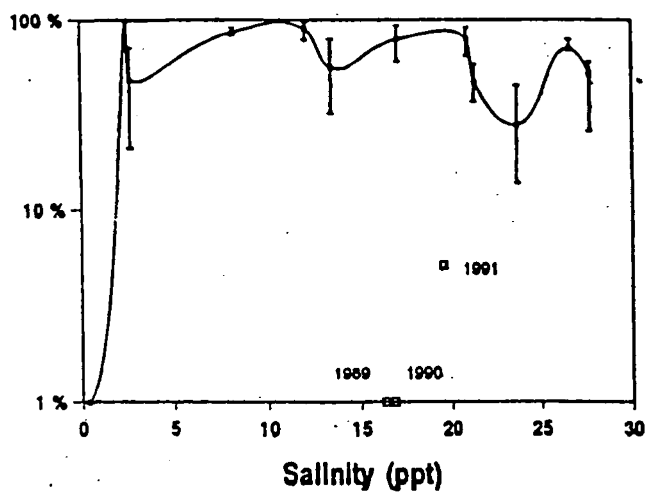
C. Species Diversity (LE3.4)



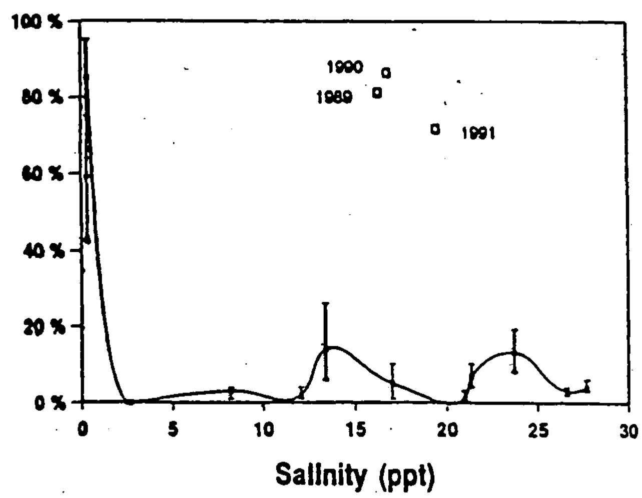
D. Depth Distribution of Biomass (LE3.4)

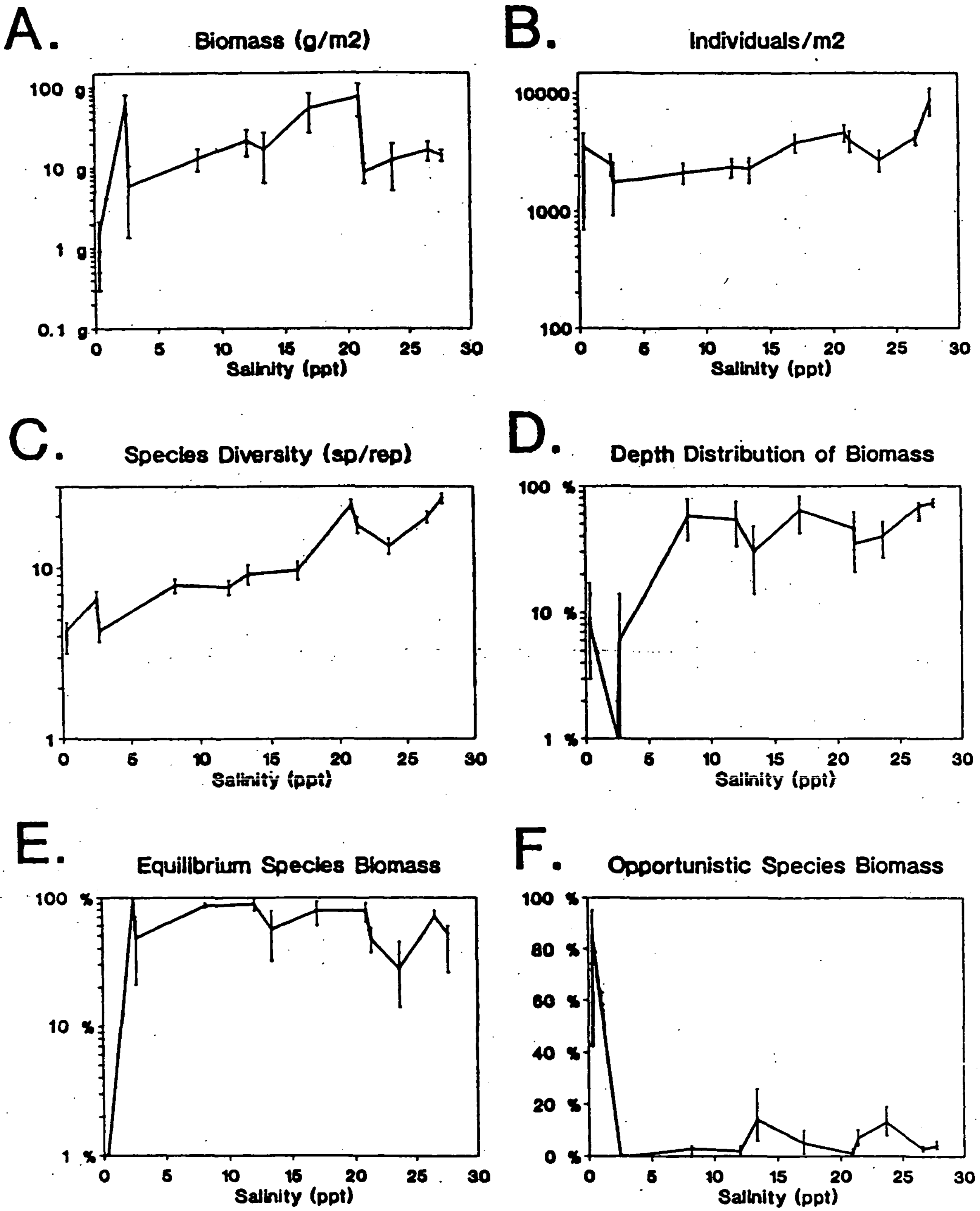


E. Equilibrium Species Biomass (LE3.4)



F. Opportunistic Species Biomass (LE3.4)





A.
Biomass (g/m2)
100 g
10 g
1 g
0.1 g
0 5 10 15 20 25 30
Salinity (ppt)
B.
Individuals/m2
10000
1000
100
0 5 10 15 20 25 30
Salinity (ppt)
C.
Species Diversity (sp/rep)
10
1
0 5 10 15 20 25 30
Salinity (ppt)
D.
Depth Distribution of Biomass
100 %
10 %
1 %
0 5 10 15 20 25 30
Salinity (ppt)
E.
Equilibrium Species Biomass
100 %
10 %
1 %
0 5 10 15 20 25 30
Salinity (ppt)
F.
Opportunistic Species Biomass
100 %
80 %
60 %
40 %
20 %
0 %
0 5 10 15 20 25 30
Salinity (ppt)

EMAP-Estuaries

Steve Weisberg, *VERSAR*

Steve Weisberg discussed the process that EMAP-Estuaries used to develop a single benthic index for the Virginian Province sampling area. The index was to be on a numerical scale from 1 to 10. The process to develop this index involved six steps:

1. **Develop a test data set.** That is, one which contains good and bad sites. These sites were operationally defined by sediment quality and ambient dissolved oxygen. Three types of bad site were defined: (1)low dissolved oxygen, (2) sediment contamination as indicated by elevated chemical concentrations or sediment toxicity or (3) a combination of (1) and (2).
2. **Identify candidate measures.** That is, what works on a local scale. Habitat specific indicators were avoided.
3. **Normalize data to account for habitat gradients.** For example, salinity. To do this, one must have representative types of habitat in the calibration data set.
4. **Identify metrics.** That is, pick which metrics are useful in discriminating between good and bad sites.
5. **Combine metrics.** Discriminant analysis can be used to determine which metrics give you the most information, which are redundant, and others. Discriminant analysis can also be used to weight metrics if desired. The following five metrics ended up in the final benthic index for the Virginian Province: (1) number of species adjusted for salinity, (2) average weight per individual polychaete, (3) number of deposit feeders, (4) number of bivalves, and (5) number of amphipods.
6. **Validation.** Three methods were used to validate the benthic index: (1) pull-out data from existing data set and see if method is still valid; (2) resample a subset of original sites; and (3) apply to a new data set (with good and bad sites).

This type of approach may have application to development of indicators by this workgroup.

Chesapeake Bay Benthic Restoration Goals

Carin Bisland, *U.S. EPA Chesapeake Bay Program Office*

Carin Bisland briefly discussed the Chesapeake Bay Program's Benthic Restoration Project (CBBRP), noting that Ana Ranasinghe of VERSAR has the lead on this effort. With respect to benthic organisms, the project is attempting to establish restoration goals using quantitative descriptions of healthy, unimpacted areas in Chesapeake Bay.

In the discussion that followed, the difference between the EMAP and CBBRP approaches to benthic community assessment were highlighted. EMAP is as independent of habitat as possible, while the CBBRP is based on assessing many different habitats. Also, EMAP used discriminant analysis to identify useful metrics while CBBRP relies more on "best professional judgment."

Day Two • November 19, 1992

During the second day of the workshop, scheduled presentations continued. George Gibson began the session by giving a brief overview of day one.

Habitat Measurements and Index of Biotic Integrity Based on Fish Sampling in Northern Chesapeake Bay

Steve Jordan, John Carmichael, and Brian Richardson,
Maryland Department of Natural Resources

Steve Jordan described efforts to develop a fish Index of Biotic Integrity (IBI) for use in Maryland tributaries of the Chesapeake Bay. Necessary steps in the process included salinity calibration of the method, identification of reference tributaries, and modification of the RBP stream habitat assessment method. Fish collection is by beach seining and trawling from a small boat. Sampling is conducted three times a year (July, August, and September), and the data from these samples are added. The following metrics comprise the IBI:

- total number of species collected;
- species collected in the bottom trawl;
- number of estuarine spawners;
- number of anadromous spawners;
- number of fish (excluding Menhaden, because they are too variable);
- number of species it takes to make up 90 percent of individuals; and
- proportion of benthic feeders, piscivores and planktivores.

This method has been calibrated in salinities from 0 to 16 ppt. The index appears responsive to water quality and land use. Future plans include applying the IBI to aid in the development of nonpoint source tributary management strategies.

It was noted in the ensuing discussion that submerged aquatic vegetation (SAV) may have some application as a useful indicator. However, in some areas (such as Florida), it may not be sensitive enough to serve as an early warning of environmental degradation.

SUMMARY OF PROCEDURES

- Sampled eight tributaries, 1988-1992.
- Developed and tested various indexing methods.
- Developed salinity calibration method.
- Analyzed long term juvenile survey data, 1958-1989.
- Identified reference tributaries.
- Adapted habitat assessment method from stream RBP.
- Compared fish metrics to dissolved oxygen, land use, and habitat quality.

INDEXING TOOLS

- Index of Biotic Integrity (IBI) . . . nine metrics.
- Number of species in bottom trawl.
- Water quality . . . dissolved oxygen (DO).
- Habitat assessment.
- Percentage of major land uses in watershed.

IBI METRICS

- Richness:
  - — Total number of species.
  - — Number of species in bottom trawl.
- Abundance:
  - — Number of estuarine spawners.
  - — Number of anadromous spawners.
  - — Total fish exclusive of Atlantic Menhaden.
- Dominance:
  - — Number of species comprising 90% of individuals
- Trophic Composition:
  - — Proportion planktivores.
  - — Proportion benthic feeders.
  - — Proportion piscivores.

RESULTS

- Metrics and IBI calibrated for tidal waters, 0-16 ppt salinity.
- Can index spacial and temporal trends in biological integrity.
- Indexes respond to water quality (DO) and land use.
- Applying IBI to map biological integrity in Maryland portion of Chesapeake Bay will aid tributary management strategies.

> **CONCLUSIONS**
>
> - Fish assemblages can index biological integrity cheaply, rapidly, and effectively.
> - Other measures are needed . . . plankton, SAV, benthos.
> - Biological integrity of northern Chesapeake Bay ranges from very poor to excellent.
> - Most areas score poor, fair, or good.
> - Wide spread high IBI scores may reflect late 1950's conditions or better.

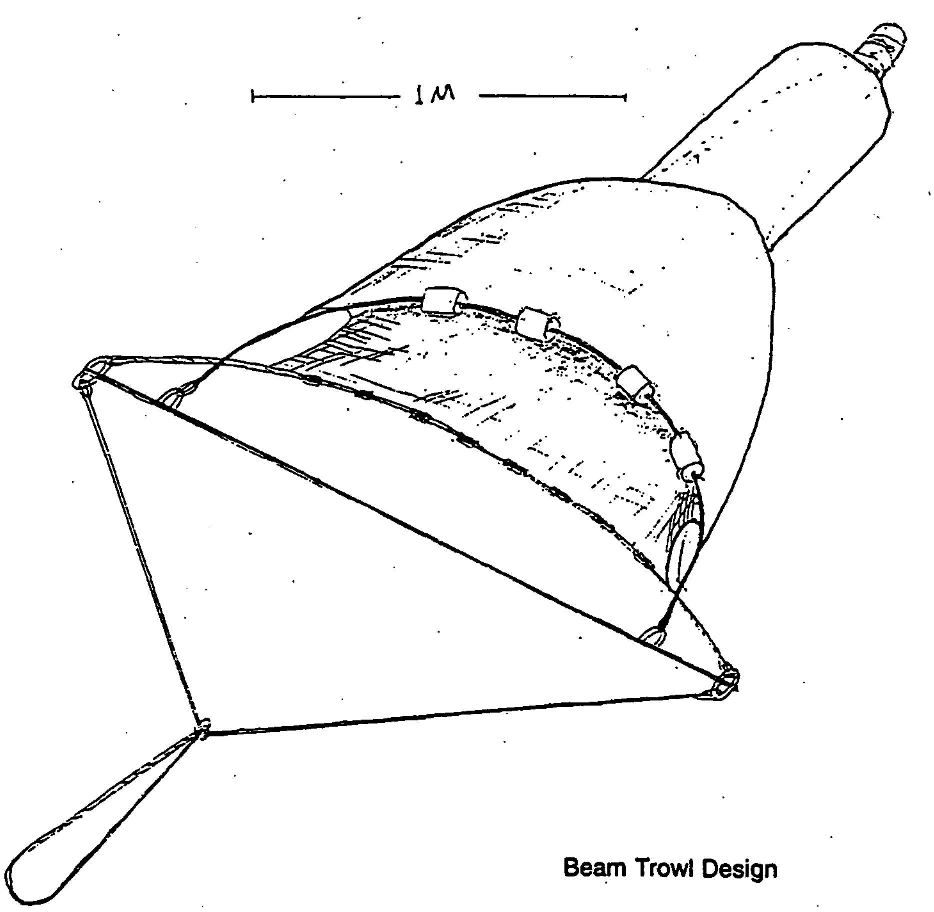
Bioassessment in Florida

Doug Farrell, *Florida Department of Environmental Regulation*

In Florida, biological criteria has been set at a 25 percent decrease in Shannon-Weiner diversity of benthic communities in test versus reference sites. Data are the sum of three Ponar grab samples. But evidence suggests this criteria is not sensitive enough. Doug Farrell presented biological data from areas surrounding outfalls from treatment plants. By classifying organisms according to their sensitivity/tolerance to pollution, he developed an index value for each of the test and reference sites. Using this method, he could detect differences between test and reference sites that were not evident using the State criterion of a 25 percent decrease in diversity.

Doug also expounded on the advantages of sampling epifaunal communities using a Renfro Beam Trawl. The advantages are as follows:

- epifaunal community is a more sensitive indicator than benthic community or SAV;
- subsampling of material collected is fairly easy though species level identification is important;
- sampling can be made quantitative by trawling for a specified period of time; and
- trawling can be done by hand (in wadable waters) or by boat.



Beam Trowl Design

FT. DESOTO STUDY

Data from the following tables were summarized from two different draft manuscripts. The water quality and benthic data were developed from a short-termed study of the effects three small package plants on the seagrass communities at Ft. Desoto Park in Tampa Bay, Florida (sources). Three control stations were located on Joe Island on the southern shore of Tampa Bay (controls), and an additional station was located on a small island adjacent to Ft. Desoto, and presumably, under the potential influence of the far-field effects (secondary).

Information from this study was based on two sampling methods, the petite ponar and a modified Renfro beam trawl. Two sampling sites were located at each station, one at the shoreline (end of the pipe) and a second at 50 meters from the shore. Four ponar replicates were collected at each site, but only three were analyzed for macroinvertebrates. This is consistent with Florida's biological integrity standard as currently defined in the Florida Administrative Code. After the grab samples were collected, the beam trawl was also towed for a distance of four meters at each location, and these samples were analyzed for macroinvertebrate components. Samples from the offshore site at the secondary station were lost due to improper preservation, but this had no effect on original purpose of the study.

The index values are a somewhat subjective evaluation of the relative tolerance, or intolerance, to environmental stress. These are taken from an ongoing effort to assign index values to all marine and estuarine macroinvertebrates identified from the west coast of Florida. Sources include agency monitoring data, published records, grey literature, anecdotal information and 18 years of personal experience in the area. Wherever possible, all potential stress factors including sensitivity to toxic substances was taken into account, but the dominant factor for most of the species was the relative sensitivity to dissolved oxygen (DO) depression. As a result, this index in its current form is probably most sensitive to organic pollution and eutrophication with associated wide swings in DO.

The criteria for the index in terms of DO requirements are listed below:

(0) Insufficient data to make an evaluation.
(1) Very Tolerant. Can withstand short periods of anoxia.
(2) Tolerant. Can withstand brief excursions to 1.0-1.5 mg/L.
(3) Slightly tolerant-slightly sensitive. Can withstand brief excursions to 2.5-3.0 mg/L.
(4) Sensitive. Can withstand brief periods below 4.0 mg/L.
(5) Very sensitive. Basically intolerant of anything below 5.0 mg/L, but some species may tolerate brief excursions below this provided no other stress factors are involved.

Calculation of the index requires that the appropriate value be assigned to individual taxa in the sample. These values are then added, and the summation is divided by the total number of taxa utilized from the sample. Taxa with a value of (0) are omitted from the calculations. This approach is not new, and it has been advocated by several investigators working in freshwater.

EPIFAUNAL/FACULTATIVE INFAUNAL COMMUNITY

In advocating the use of a beam trawl which predominately samples the epifaunal and facultative infaunal communities, one basic assumption has to be made. "Provided that the recruitment potential for the individual components exists, within a given set of natural environmental parameters an expected community of organisms will inhabit any predetermined environmental segment". In estuaries and many other marine environments, populations of different species vary significantly over the seasons, and even from year to year, but these variations follow predictable patterns.

In Florida waters, numerical domination may vary among the annual cycles, but species composition generally remains stable. Seasonal cycles account for the greatest degree of natural variations in benthic populations. In terms of both density and diversity benthic macroinvertebrates reach their peak during the late winter to early spring, and as might be expected, this peak occurs earlier in the southern part of the State. Population minima for most species occur during the summer months. While they are dramatic, these seasonal cycles are predictable, and they can be factored into efforts to establish biological criteria.

The reason for targeting the epifaunal and facultative infaunal community is simple. Components of this community appear to be both persistent and very sensitive to environmental stress. Within an estuary and adjacent near-shore areas physicochemical parameters such as temperature, salinity and DO will vary significantly over an annual cycle. Sessile and relatively immobile organisms, which includes most of the infaunal components, have evolved either mechanisms which allow them to tolerate these varying conditions, or breeding cycles which allow them to avoid periods of high stress. The more motile members of the community, which includes the epifauna and facultative infauna, have the option of avoidance. During periods of stress these organisms can move to deeper water, or other areas where the stress factors are mollified, and return when conditions improve. The response to anthropogenic sources of stress is identical. When an area is being affected by relatively low levels of anthropogenic stress, only the most sensitive members of the benthic community will respond, and these are found among the epifaunal and facultative infaunal components. A method which is truly sensitive to low levels of pollution must target this community.

THE BEAM TRAWL

A beam trawl is a conical shaped net, open at the large end, which is nominally towed over the surface of the substrate. The net is maintained in the open position by attaching it to a rigid pole or beam. Most conventional trawls are maintained in an open position with the use of pressure planes or boards, and these are set at oblique angles to the line of tow. Pressure from the moving water while the net is being towed will spread the boards and keep the net open.

In an effort to develop a device to effectively sample post-larval penaeid shrimp, Renfro (1962) designed a small beam trawl which could be towed by hand in wadable depths, or pulled with a boat in deeper water. Before Renfro's paper was published, Baxter (1962) tested the net, and he suggested that the abundance of post-larval shrimp could be used to predict shrimp fishing success. At about the same time the fisheries staff at the Gulf Coast Research Laboratory, using the beam trawl design, initiated an extensive study of post larval shrimp in Mississippi Sound (Christmas, et al, 1966). The statistical reliability of different towing methods has also been examined (Caillouet, et al, 1968), but one important fact was noted by all investigators. While the beam trawl has been effective in providing quantitative samples of postlarval shrimp, it is also very effective in sampling all members of the epibenthic and shallow infaunal communities.

The net is constructed in two parts. The body is constructed of nylon bolting cloth (50 openings/ sq. cm.), and this tapers to a plankton net which is fitted with a removable bucket. The net used for present purposes has been reduced in size to allow its use by a single individual. The effective width of the swath is 1.25 meters.

The tow length required to collect statistically reliable samples for postlarval shrimp is about 150 meters, and the sample density and bulk has tended to discourage the use of this device for community studies. However, reducing the tow length has reduced the sample size and the time required for analyses. In the present study the time required for analyses of three ponar samples was about 20 hours, and the time required to analyze a trawl sample was a little less than 10 hours. As indicated earlier, tow length was only 4 meters, effectively sampling about 5 square meters of bottom. In offshore areas, it has been necessary to increase the tow length to get good representation. This is because densities in the offshore areas tend to be significantly lower than in the estuaries. However, should excessive bulk or high densities be a problem, beam trawl samples lend themselves to sub-sampling. Sorting quadrants in a graduated pan is probably the simplest method of sub-sampling, and it has proven effective for trawl samples.

The marine index that I have used here is certainly not the only metric that could be applied to beam trawl or similar samples.

In fact, the precedent established for treating these as quantitative samples. At the very least, they can be treated as comparative samples, and information theory indices can be applied. It is also clear that this method will not meet all needs. However, it can be successfully used anywhere on level bottoms, and I believe that it will prove to be an effective screening method, if not more.

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Caillouet, C.W., R.J. Dugas, and B.J. Fontenot, Jr. 1968. Effects of radius and direction of semicircular tow near shoreline on catch of postlarval shrimp (Penaeus spp.) with the Renfro beam trawl. Transactions of the American Society. 97(2): 127-130.

Christmas, J.Y., Gordon Gunter, and Patricia Musgrave. 1966. Studies of the annual abundance of post larval penaeid shrimp in the estuarine waters of Mississippi, as related to subsequent commercial catches. Gulf Research Reports. 2(2): 177-212.

Renfro, William C. 1962. Small beam net for sampling postlarval shrimp. U.S. Fish and Wildlife Service circular. 161: 86-87.

SPECIES SUMMARY

TAXA	CONTROL	SOURCE	SECONDARY	INDEX
NEMERTEA				
Tubulanus sp. 1	x			0
Nemertea sp. 1	x	x		0
Nemertea sp. 2		x		0
ANNELIDA				
OLIGOCHAETA				
Limnodriloides sp. 1	x	x	x	0
POLYCHAETA				
Aricidea philbinae	x	x	x	2
Axiothella mucosa	x	x	x	2
Brachioasychis americana			x	0
Capitella capitata	x	x	x	1
Ceratonereis sp. 1	x			0
Chone cf. americana	x	x	x	3
Cirriformia sp. 1	x	x	x	2
Cirriformia sp. 2	x		x	3
Dentasyllis carolinae	x	x	x	2
Eteone heteropoda		x		2
Exogone dispar	x	x	x	3
Glycera robustus		x		2
Laeonereis culveri	x		x	2
Leitoscoloplos foliosus	x	x	x	2
Lietoscoloplos fragilis	x			3
Lietoscoloplos robustus	x			3
Lumbrinereis sp. 1		x		0
Mediomastus ambiseta	x	x		1
Megalomma sp. 1	x			3
Neanthes acuminata	x	x	x	2
Nothria sp. 1	x	x		0
Onuphis sp. 1	x	x	x	0
Ophelia sp. 1		x		0
Parapionosyllis sp. 1 (s setae)	x	x	x	3
Paraprionospio pinnata		x		1
Pectinaria gouldi	x	x		2
Phyllodoce fragilis		x		2
Podarke obscura	x		x	3
Polydora ligni	x	x	x	1
Prionospio heterobranchia	x	x	x	3
Streblosoma sp. 1	x			0
Syllis cornuta	x		x	3
Tharyx sp. 1	x	x		0

TAXA	CONTROL	SOURCE	SECONDARY	INDEX
MOLLUSCA				
POLYPLACOPHORA				
Ischnochiton papilosus	x	x		3
PELECYPODA				
Abra aequalis			x	2
Anomalocardia auberiana	x	x		1
Carditamera floridana	x		x	3
Chione cancellata	x			3
Cumingia tellinoides	x			3
Laevicardium laevigatum	x			3
Lucina nassula	x			3
Lyonsia floridana	x	x		2
Musculus lateralis	x			3
Mysella planulata	x			3
Parastarte triquetra	x	x	x	2
Tellina tampaensis	x	x		2
Tellina texana	x	x	x	2
Transenella stimpsoni		x		2
GASTROPODA				
Acteocina caniculata	x	x	x	2
Anachis semiplacata	x			3
Aplysia sp. 1	x			3
Bittium varium	x	x	x	2
Bulla striata	x		x	3
Caecum puchellum	x	x		3
Cerithium atratum	x	x	x	2
Conus sternsi	x	x	x	3
Crassispira leucocyma	x	x	x	2
Crepidula maculosa	x	x	x	2
Crepidula fornicata	x			3
Doridella obscura		x		3
Epitonium sp.1		x		0
Granulina ovuliformis	x	x	x	2
Haminoe succinea	x	x		3
Haminoe elegans	x			4
Hyalina avenacea	x			4
Kurtziella diomedia	x	x	x	3
Marginella aureocinta	x			4
Marginella apicina	x	x	x	2
Marginella lavalleena	x	x	x	2
Mitrella lunata	x	x	x	2
Modiolus modiolus	x	x	x	3
Nassarius vibex	x	x	x	2

TAXA	CONTROL	SOURCE	SECONDARY	INDEX
GASTROPODA continued...				
Odostomia sp.1	X			0
Olivella pusilla	X	X		2
Sayella fuscus	X			3
Turbonilla dalli	X	X	X	2
Turbonilla hemphilli	X			3
ARTHROPODA				
CRUSTACEA				
MYSIDACEA				
Metamysidopsis swifti	X			5
Mysidopsis bahia	X	X	X	4
Taphromysis bowmani	X			3
CUMACEA				
Cyclaspsis varians	X			3
Oxyurostylis smithi	X			3
TANAIDACEA				
Leptochelia rapax	X	X	X	2
ISOPODA				
Amakusanthura magnifica	X	X	X	3
Harrieta faxoni	X			4
Edotea montosa	X	X		3
Erichsonella filiformis	X	X		3
Sphaeroma quadridentata			X	3
AMPHIPODA				
Acuminodeutropus nagleyi	X	X		3
Ampelisca abdita	X	X	X	2
Amphilocus sp.1	X			0
Ampithoe longimanna	X			4
Ampithoe rubricata	X			4
Argissa hamiteps	X			4
Autone setosus	X			5
Cerapus tubularis	X			3
Corophium sp. 2	X			4
Corophium ellisi	X	X	X	2
Cymadusa compta	X	X	X	2
Elasmopus levis	X			4

TAXA	CONTROL	SOURCE	SECONDARY	INDEX
AMPHIPODA Continued...				
Erichthonius brasiliensis	x	x		3
Grandidierella bonnieroides		x		2
Jassa falcata	x			4
Luconacia inserta	x			3
Lysianopsis alba	x		x	4
Melita longisetosa	x	x	x	3
Podocerus brasiliensis	x			4
Stenothoe crenulata	x			4
DECAPODA				
Ambidexter symmetricus	x			4
Eurypanopeus depressus	x			3
Hippolyte pleuracantha	x	x	x	3
Libinia dubia	x		x	3
Neopanope texana	x		x	3
Pagurus longicarpus	x			3
Pagurus stimpsoni	x	x	x	2
Palaemonetes pugio	x	x	x	3
Palaenonetes intermedius	x			4
Penaeus duorarum	x	x		3
Pitho lherminieri	x			4
Tozeuma carolinense	x			3
ECHINODERMATA				
ASTEROIDEA				
Echinaster sentus	x			4
OPHIUROIDEA				
Amphipholus squamata	x			4
Ophioderma sp. 1	x			0
SIPUNCULIDA				
Golfingia sp. 1	x	x	x	2

DUNCAN'S MULTIPLE RANGE TEST

SPECIES DIVERSITY

	SOURCES					CONTROLS	
STATIONS	6	5	4	7	2	3	1
MEANS	2.22	2.64	2.77	3.73	4.11	4.20	4.24
99%CL	———	———	———	———	———		
					———	———	———
95%CL	———	———	———	———	———	———	———

SPECIES RICHNESS

	SOURCES					CONTROLS	
STATIONS	6	5	4	7	3	2	1
MEANS	6.31	10.30	12.30	20.00	26.70	27.30	27.70
99%CL	———	———	———	———	———	———	———
95%CL	———	———	———	———	———		
					———	———	———

FLORIDA MARINE INDEX

BEAM TRAWL SAMPLES

	SOURCES				CONTROLS		
STATIONS	4	6	5	7	2	1	3
# TAXA	8	13	16	29	27	31	38
INDEX TOT.	15	27	35	69	72	84	106
INDEX	1.88	2.08	2.19	2.38	2.67	2.71	2.79

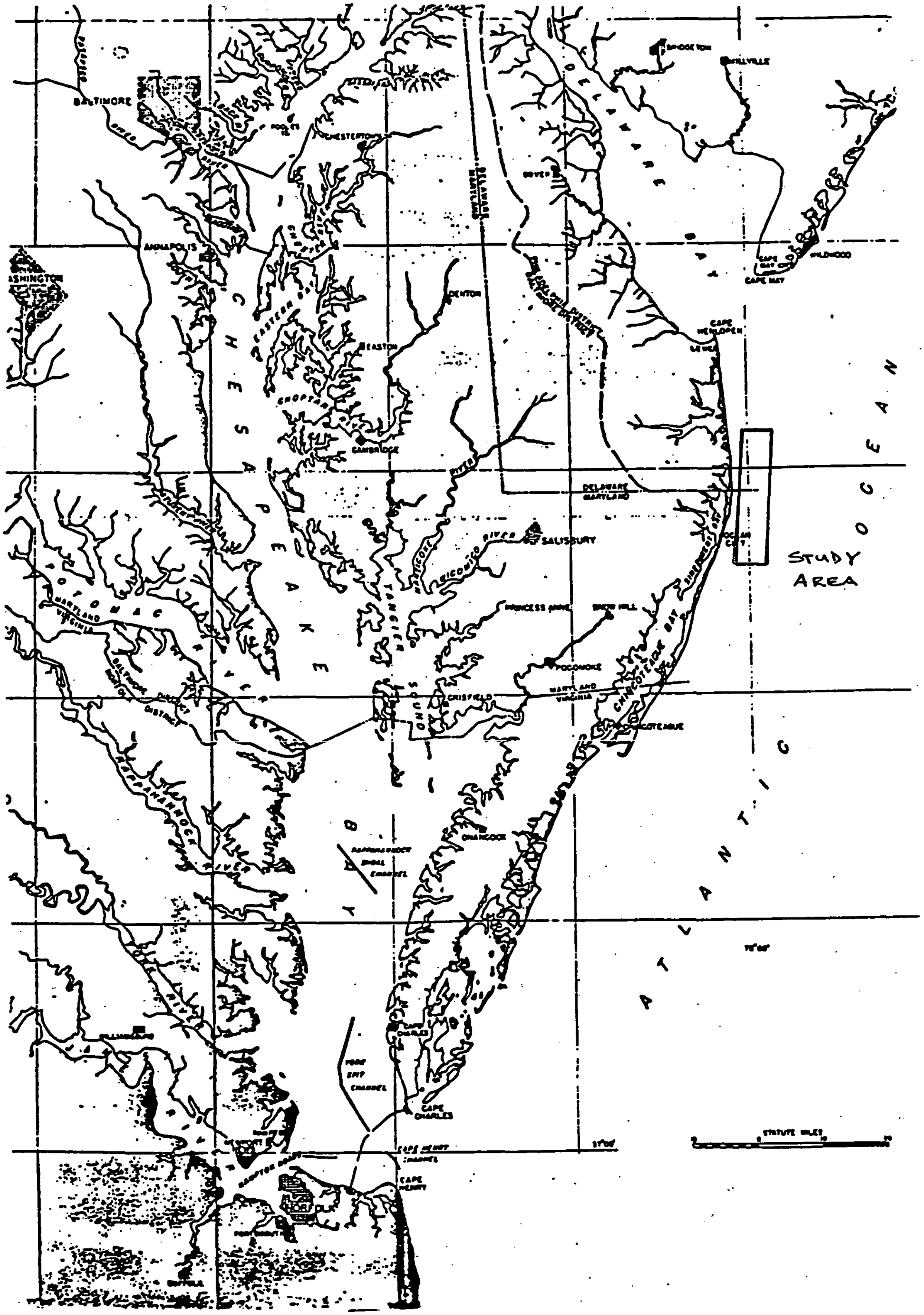
Near Coastal Marine Waters Pilot Project

George Gibson, *U.S. EPA, Office of Science and Technology*

George Gibson presented tentative results from a joint pilot project with Bill Muir in EPA Region III. They are applying standard bioassessment procedures to two mid-Atlantic Bight ocean sewage outfalls. A nine-station transect was established parallel to the coastline, about 1.5 miles offshore at approximately 1-mile intervals. The outfalls are located at the third and seventh stations. The remaining stations represent ambient conditions of a nearfield/farfield design.

Habitat characteristics of depth, salinity, and dissolved oxygen were comparable at all stations. Sediment grain size ranged from about 80 to 95 percent sand. Benthic macroinvertebrate characteristics were measured from three replicate Smith-McIntyre grabs at each station, with the entire grab counted in each case. Fish were surveyed using single half-mile otter trawl tows through each station. The results of this first attempt indicated a notable response of taxa richness and abundance at each outfall relative to the reference stations. Habitat variation, seasonality, and the relative magnitude of the effects are factors that need to be further addressed.

Study Area



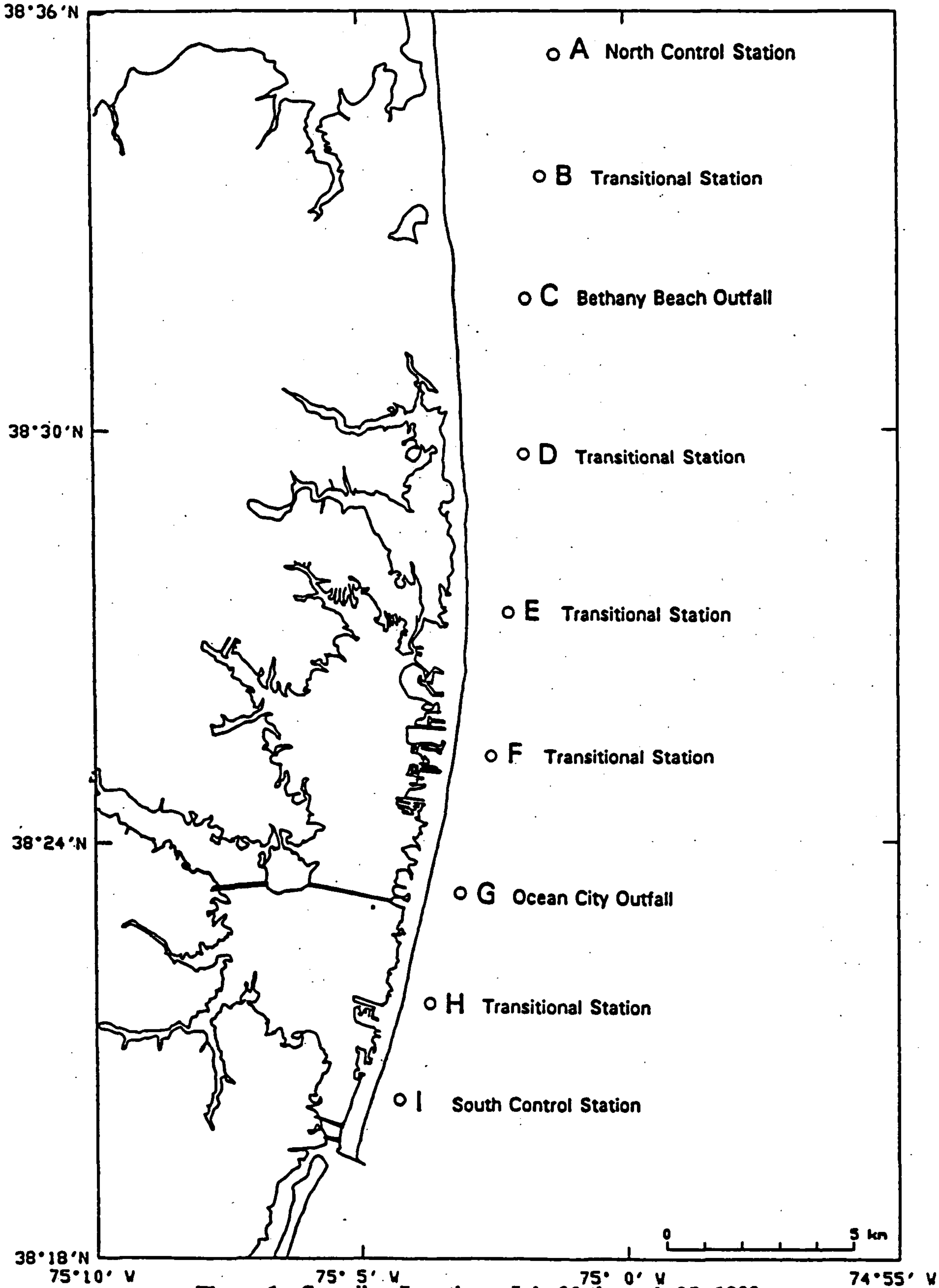
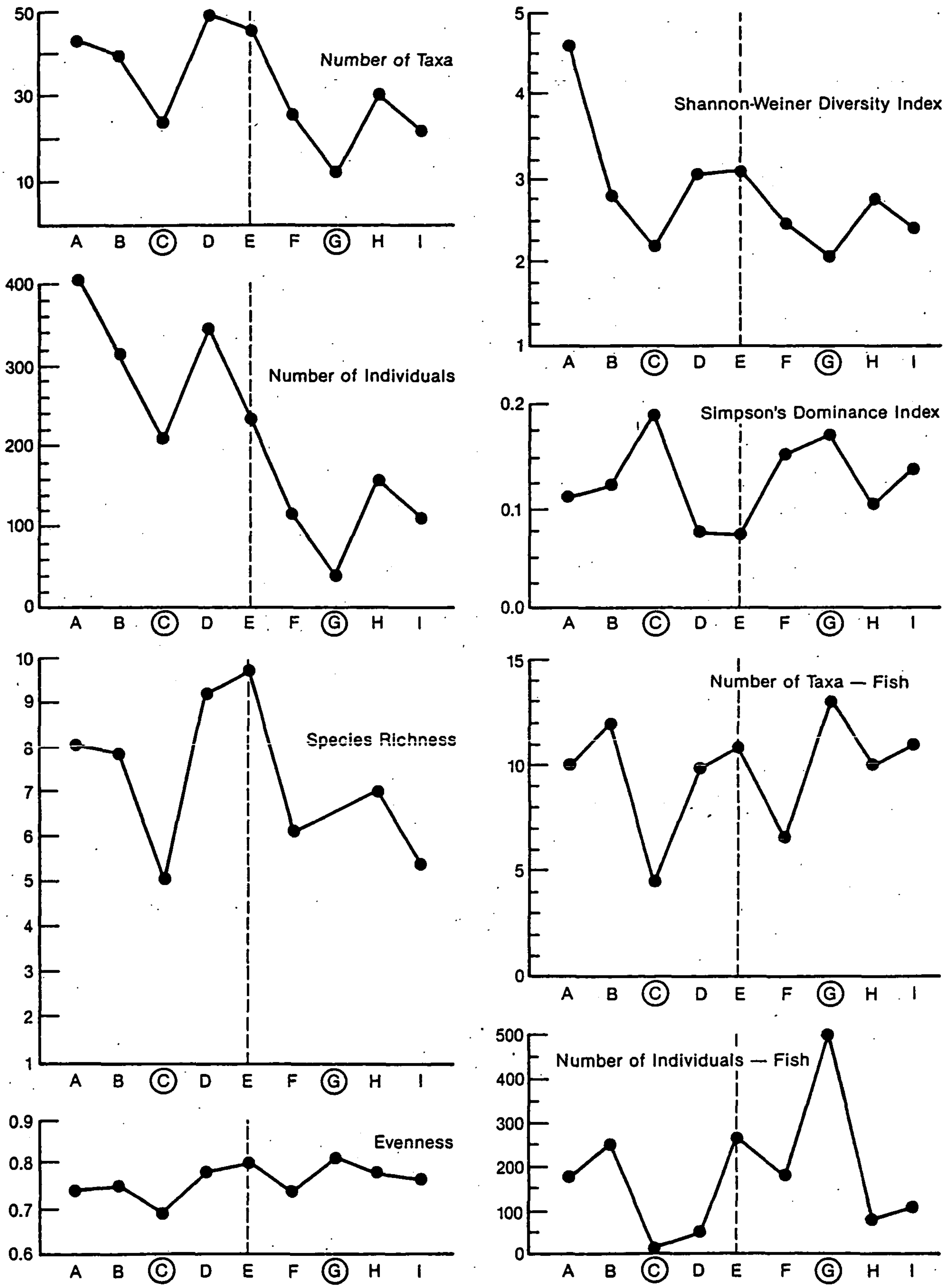


Figure 1. Sampling Locations, July 20 through 25, 1992.

Bethany Beach/Ocean City Outfalls, July 1992 — Invertebrates, Smith-MacIntyre Dredge.



Middle and Southern Atlantic Coast Estuarine Benthic Invertebrate Metrics Development

Robert Diaz, *Virginia Institute of Marine Science* and
Walter Nelson, *Florida Institute of Technology*

Bob Diaz and Walt Nelson are collaborating on a project to test the sediment depth distribution of benthic infauna as a potential metric. Two different geographic areas—Florida and Virginia and a range of sites (high to low impact) within each area will be sampled. The method involves measuring species abundance, biomass, and vertical distribution in core samples. In addition, they will evaluate the utility of using the depth of the redox potential discontinuity (RPD) layer as a surrogate biotic measure.

The sediment depth distribution of benthic infauna appears to have promise as an indicator because it integrates several functional parameters of benthic communities in determining a score. These include species life history, taxa/abundance ratios, major taxa biomass distribution, and vertical distribution of biomass. Data from sites in Virginia were used to illustrate the utility of this method in distinguishing good and bad sites. The pilot study is designed to address issues relating to test sensitivity, cross system comparisons, temporal variation, and comparability to more traditional methods of assessment.

The use of sediment profile cameras for quick initial assessments of benthic community health was also described. In this method, in situ photos are taken of sediment cross sections and evaluated based on depth of RPD layer, presence/absence/depth of burrowing organisms, and others. Bob presented photos illustrating the ability of this technique to identify a range of benthic habitat quality.

These methods are probably restricted sediment depositional areas from fine sand to mud. However, many workshop participants agreed that these methods have utility and at least are able to distinguish good sites from very bad ones. The "gray areas" are often difficult to discern and interpret.

OBJECTIVES

1) TEST SEDIMENT DEPTH DISTRIBUTION OF BENTHIC INFAUNA (ABUNDANCE, BIOMASS) AS POTENTIAL METRICS

2) EVALUATE VISUAL DETERMINATION OF APPARENT COLOR RPD DEPTH AS A SURROGATE BIOTIC MEASURE

ANALYSIS

SPECIES IDENTIFICATION AND COUNTING
BIOMASS (DRY WEIGHT)

APPARENT RPD DEPTH – DIRECT MEASUREMENT FROM CORES

CROSS SYSTEM EVALUATION

FIELD WORK

PARALLEL STUDIES IN TWO GEOGRAPHIC AREAS
VIRGINIAN PROVINCE – CHESAPEAKE BAY
CAROLINIAN / WEST INDIAN – INDIAN RIVER LAGOON

COMPARE 3 IMPACTED VS. 3 LOW IMPACT SITES
4" CORES, 15 cm DEPTH
0–5; >5–15 CM DEPTH FRACTIONS

ESTUARINE RAPID BIOASSESSMENT FOR BENTHIC HABITATS

Detection of change due to natural or anthropogenic sources is complicated by the general eurytopic nature of the fauna.

Organisms are well adapted to the physical stresses of estuaries and respond to any disturbance in subtle ways.

Methods for detecting changes in and assessing value of estuarine habitats need to consider two points:

1- They must be tuned to the adaptive nature of the organisms

2- They must provide a robust assessment within the ever shorting time interval required by environmental regulators.

Estuarine benthic communities present an integrated functional response to the quality of their habitat.

Rapid assessment methods can capitalize on the functional role of communities and provide an integrated view of community conditions.

Functional parameters of benthic communities most applicable to rapid assessment include:

1- Species life histories

2- Major taxa abundance ratios

3- Major taxa biomass distribution

4- Vertical distribution of biomass

Sampling design, data collection, and analysis strategies will concentrate on:

1- Testing sensitivity of methods for detecting a change.
2- Effect of small scale (meters) spatial variation.
3- Effect of large scale (different river systems) spatial variation.
4- Cross system comparisons (FL vs. VA)
5- Effects of temporal variation.
6- Applicability of rapid methods verses traditional approaches.

The place of rapid bioassessment in impact assessment hinges on the assumptions that:

1- It is possible to measure a communities intrinsic value, including an estimation of natural variation, for any parameter used.

2- That a cause effect relationship exists, but not necessary to prove, between community structure and the impact.

For benthic communities to be of practical use in assessing impacts links need to be established between:

1- Management goals and the definition of community.

2- Aspects of the community measured and community function.

3- How impacts, or other disturbances, alter this function.

4- Variability of the parameter measured in different communities.

The Benthic Assessment Method:

1 Developed for use in soft bottom estuarine habitats.

2 Is a stepped approach with three levels:
   1 Evaluation
   2 Identification
   3 Biomass determination

3 Is based on the premise that healthy areas contain well developed and diversely functioning communities.

4 Disturbed areas have communities with altered functions.

Application of the Benthic Assessment Procedure

Phase I - Evaluation

Phase II - Identification

Phase III - Biomass Determination

Phase I - BAM - Evaluation

Sieve, look, and score:

Is there fauna >5 cm?	yes 1	no 0
Is fauna >5 cm large in size? (>2 cm long)	yes 1	no 0

Phase II - BAM - Identification

From the same samples identify to major group and determine functional life style.

If present then score:

Only surface dwellers	0
Small burrowers	1
Long-lived large fauna	2

Phase III - BAM - Biomass Determination

From the same samples determine biomass of each layer.

0-5 cm layer + >5 cm layer = 100 % of biomass

Score percentage of total biomass in >5 cm layer as:

0 - 10 %	0
10 - 20 %	1
20 - 50 %	2
50 - 80 %	3
80 - 100 %	4

Add scores from all three Phases to get BAM assessment value.

For Virginia estuaries the operational range of scores can be from 0 to 8.

In general scores of:

- 0 - 1 Poor habitat, seriously disturbed
- 2 - 3 Moderately disturbed or stressed habitats
- 4 - 5 Slightly disturbed to moderately good habitats
- 6 - 8 Good habitats

Interpretation needs to be based on the possible range of BAM conditions within the system that is being studied.

Elizabeth River (ER) and James River (JR) cores, August 1990.

Data are total wet weight biomass in grams / 225 cm^2.

	DEPTH FRACTION			PERCENT OF TOTAL	
STATION	0-5	5-15CM	TOT.	% TOP	% BOT.
ER 210	0.22	0.10	0.31	69	31
ER 212	0.16	0.06	0.21	74	26
ER 214	0.03	0.01	0.04	69	31
ER 216	0.04	0.05	0.08	44	56
ER 217	0.03	0.00	0.04	94	6
ER LU	0.03	0.01	0.04	85	15
JR T-6	0.12	0.48	0.60	20	80
JR T-8	0.01	4.63*	4.65	0.3	99.7
JR T-9	0.11	1.13**	1.25	9	91
JR T-10	0.07	4.81*	4.88	1	99

* Bivalves ** Polychaetes

Note: Most of Elizabeth River biomass is small polychaetes.

Application of BAM to Elizabeth River (ER) and James River (JR) data, August 1990.

Data are total wet weight biomass in grams / 225 cm^2.

STAT.	IS >5	FAUNA LARGE	LIFE	% >5	TOTAL
ELIZABETH RIVER					
210	1	0	1	1	3
212	1	0	1	1	3
214	1	0	0	1	2
216	1	0	1	2	4
217	1	0	0	0	1
LU	1	0	0	1	2
JAMES RIVER					
T-6	1	1	1	4	7
T-8	1	1	2	4	8
T-9	1	1	2	4	8
T-10	1	1	2	4	8

The 403(c) Permit Process and Other Site Investigations

William Muir, *U.S. EPA Region III*
PRESENTED BY
Brigitte Farran, *U.S. EPA, Office of Wetlands, Oceans, and Watersheds*

Section 403(c) of the Clean Water Act regulates National Pollution Discharge Elimination System (NPDES) discharges to areas outside the baseline. It was originally applied mainly to offshore oil and gas facilities, but it was expanded to include any types of offshore discharges. The first step in the 403(c) permit process is to determine whether a discharge is likely to cause "unreasonable degradation." One definition of "unreasonable degradation" cited in the regulations refers to "significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities." Another section of the regulation indicates a discharge cannot cause "irreparable harm" to the marine environment. The problem is that there is no clear guidance to evaluate or define "unreasonable degradation" and "irreparable harm." Hence, one can see the applicability and the challenge of the bioassessment methods and biocriteria being developed by this workgroup to the 403(c) program.

Bill also described benthic monitoring of an ocean disposal site near Virginia Beach. The data were used to evaluate the suitability of the chosen dump site.

POTWs

•

Offshore Oil and Gas Facilities

•

Seafood Processors

•

Offshore Placer Mining

•

Log Transfer Facilities

•

Seawater Treatment Plants

•

Sugar Cane Mills

•

Petroleum Refineries

Clean Water Act
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Clean Water Act

403

The 403 Program

Office of Wetlands, Oceans and Watersheds
Oceans and Coastal Protection Division

Key Points

- The 403 Program: An Overview
- The 403 Problem Statement
- Key Players and Terms
- The Ocean Discharge Criteria
- The 403 Decision Process
- The Elements of an ODCE
- The 403 Solution

403 Authority

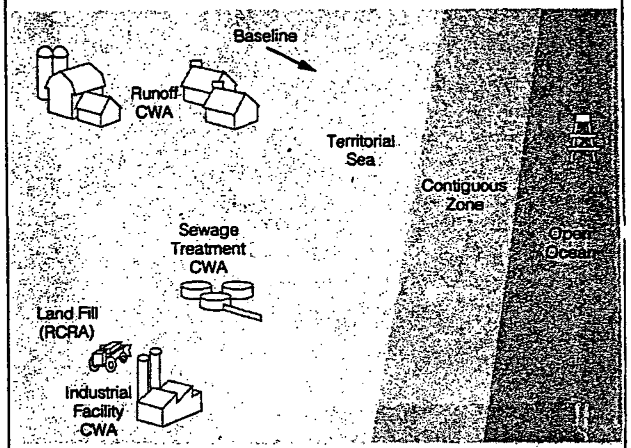
The 1972 Clean Water Act amendments:

- Authorize EPA to assess the impact of a discharge on the biological community to determine whether or not a discharge will cause "unreasonable degradation" of the marine environment.
- Allow EPA to determine the effects of a whole effluent in the natural state and impose limitations or conditions beyond those allowed by either technology-based effluent standards or water quality-based standards.

Program Overview

- Jurisdiction centers on discharges seaward of the baseline.
- Focus has been on the off-shore oil and gas industry.
- Provides an added tool for protecting biologically sensitive communities.
- Complements existing water quality-based permitting programs.
- Fits neatly into the Agency's shift toward risk-based approaches to environmental protection.

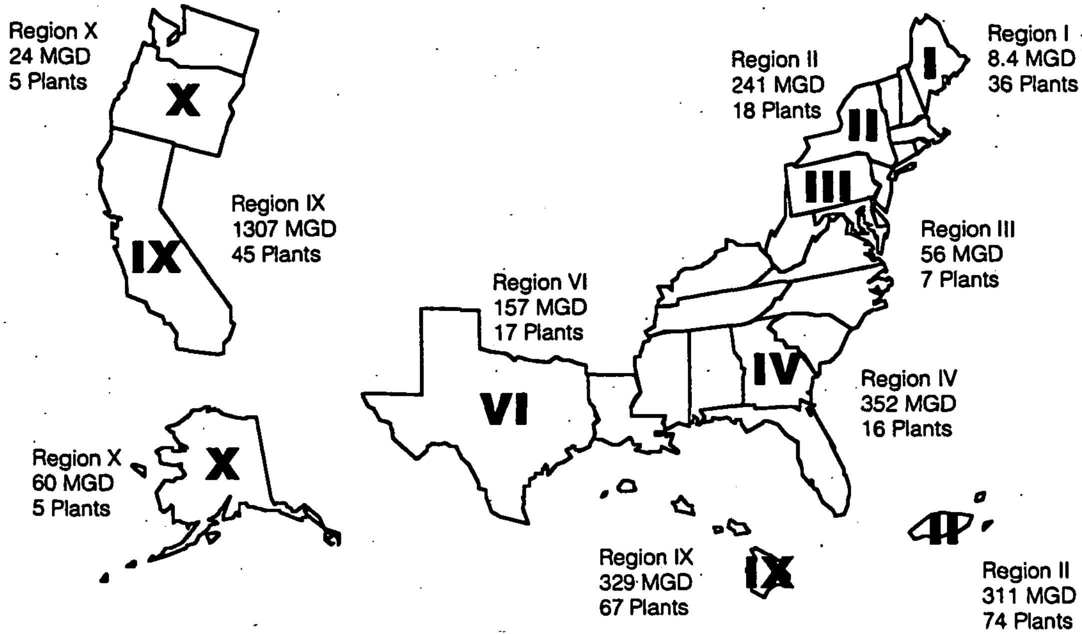
Program Jurisdiction



The 403 Universe

Category	*Number*	*Regions*	*Where*
POTWs	134	All	Numerous locations
Offshore Oil and Gas Facilities	1750	VI, IX, X	Gulf of Mexico, the Atlantic Coast
Seafood Processors	300	X	Alaska
Offshore Placer Mining	2	X	Alaska
Log Transfer Facilities	35	X	Alaska
Seawater Treatment Plant	3	X	Alaska
Sugar Cane Mills	8	IX	Hawaii
Petroleum Refineries	3	IX	California, Hawaii
Undefined Majors/Minors	46	All	Selected locations
Questionable Discharges	206	X	Alaska
Total	*2487*	*All*	

National Summary of 403 Discharges Under Individual Permits



The 403 Problem Statement

- Original 1980 regulations are broad; discretionary national application of the 403 program.
- Little technical and procedural guidance on how to conduct 403 evaluations.
- Lack of integration into the "mainstream" 402 permitting program.
- Although some criteria exist for evaluating 403 dischargers, no clear threshold values exist.

Key Terms

- Unreasonable Degradation
- Irreparable Harm
- Ocean Discharge Criteria Evaluation (ODCE)

The Ocean Discharge Criteria

1. Bioaccumulation
2. Transport of Pollutants
3. Exposed Biological Communities
4. Receiving Waters
5. Special Aquatic Sites
6. Human Health Effects
7. Fishing
8. Coastal Zone Management Plan (CZMP)
9. Other Factors as Appropriate
10. Marine Water Quality Criteria

The 403 Decision Process

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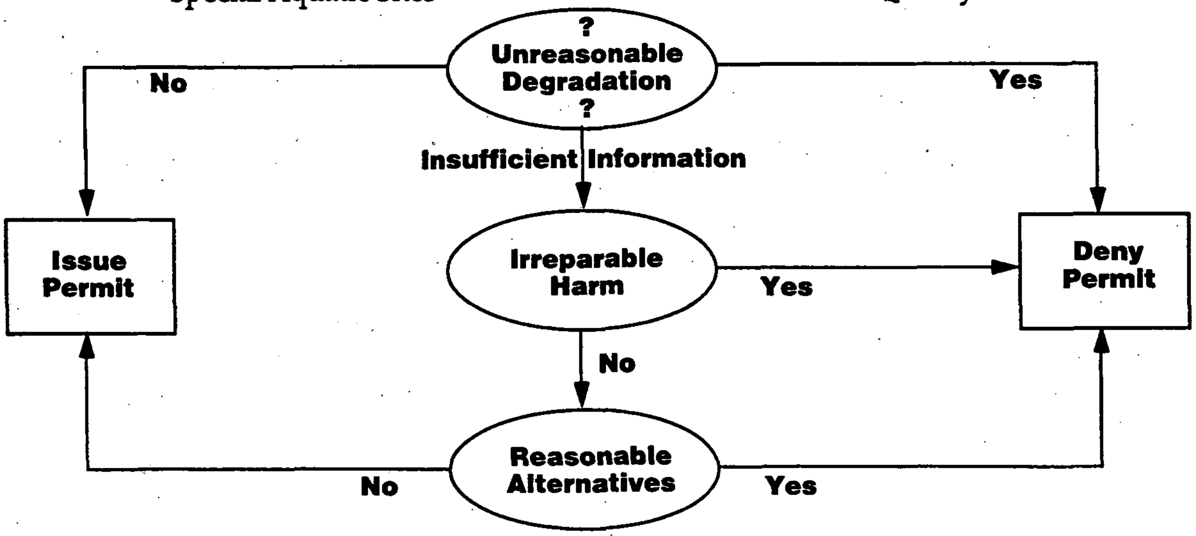

The Elements of an ODCE

1. Characterizing the Discharge and the Receiving Water
2. Discussing Potential Effects
3. Analyzing Other Statutory and Regulatory Requirements
4. Presenting the Findings
5. Recommending Process Modifications

The 403 Solution

- Additional research and definition of key terms will support the national application of the program.
- Technical and procedural guidance on conducting 403 evaluations is under development.
- A joint OWOW/OWEC policy statement will help integrate 403 into the "mainstream" 402 permitting program.
- A solid set of biocriteria would help refine the existing criteria and establish thresholds for evaluating ocean discharges.

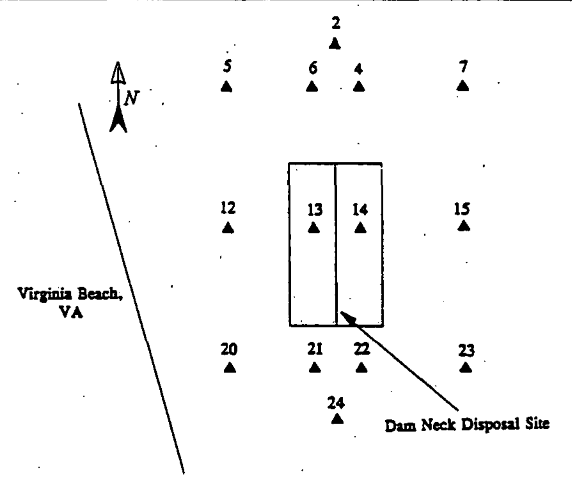

Figure 1. Map of Showing Boundaries of the Dam Neck Disposal Site and Locations of Benthic Infaunal Stations.

Table 3. Benthic Community Parameters at the Dam Neck Disposal Site, 1985-1989

Sta/ Year	Density per m²	Total Species	Species per 50 Indiv.	Species per 100 Indiv.	Species per 200 Indiv.	Species per 300 Indiv.	Species per 400 Indiv.	Species per 500 Indiv.	Shannon-Wiener Diversity (H')	Evenness (J')
2/85	5059	29	12.9	16.7	20.7	23.3	25.2	26.8	3.44	0.708
4/85	4600	35	10.9	15.6	21.6	25.8	29.2	32.2	2.46	0.479
86	4452	33	12.5	17.1	22.7	26.3	29.4	32.3	3.25	0.664
87	1341	30	16.6	23.7	*	*	*	*	3.58	0.731
88	4384	41	12.6	19.2	27.4	32.6	36.3	39.3	2.55	0.477
89	4378	28	7.7	11.4	16.7	20.6	23.7	26.3	1.91	0.396
5/85	3829	31	13.1	17.8	23.1	26.5	29.2	*	3.15	0.635
86	7888	50	14.4	20.7	27.5	32.0	35.6	38.7	3.23	0.572
87	815	16	11.9	*	*	*	*	*	2.89	0.721
88	2067	30	15.2	20.8	27.5	*	*	*	3.71	0.756
89	51612	40	3.4	5.4	8.5	10.7	12.4	13.8	0.53	0.099
6/85	3111	33	15.4	21.1	26.8	30.3	*	*	3.43	0.681
86	3459	38	15.9	22.3	30.0	34.9	*	*	3.58	0.683
87	1052	26	17.5	24.9	*	*	*	*	3.76	0.801
88	6252	36	11.2	16.1	22.1	25.8	28.6	30.8	2.62	0.507
89	2970	18	6.7	9.6	13.4	16.0	*	*	1.30	0.311
7/85	3412	27	13.9	18.5	22.8	24.9	26.5	*	3.20	0.674
86	7140	43	13.2	18.9	26.0	30.7	34.2	37.0	3.10	0.572
87	1992	31	14.9	21.0	28.4	*	*	*	3.35	0.677
88	3067	42	16.7	24.1	32.8	38.4	*	*	3.67	0.680
89	2163	35	18.6	25.5	32.2	*	*	*	3.96	0.771
12/85	2348	16	8.9	11.5	14.4	*	*	*	2.47	0.691
86	1222	16	11.7	14.4	*	*	*	*	3.10	0.776
87	674	14	10.2	*	*	*	*	*	2.26	0.593
88	1267	21	14.3	18.5	*	*	*	*	3.48	0.792
89	881	20	13.0	18.8	*	*	*	*	2.64	0.611
13/85	2311	21	10.3	14.0	18.4	*	*	*	2.59	0.589
86	1126	21	13.3	18.0	*	*	*	*	3.33	0.758
87	881	17	11.9	15.9	*	*	*	*	3.00	0.734
88	2933	29	13.3	18.2	24.0	28.0	*	*	3.14	0.646
89	1630	21	9.9	14.3	20.4	*	*	*	2.41	0.549

* Number of individuals is too low to calculate this parameter.

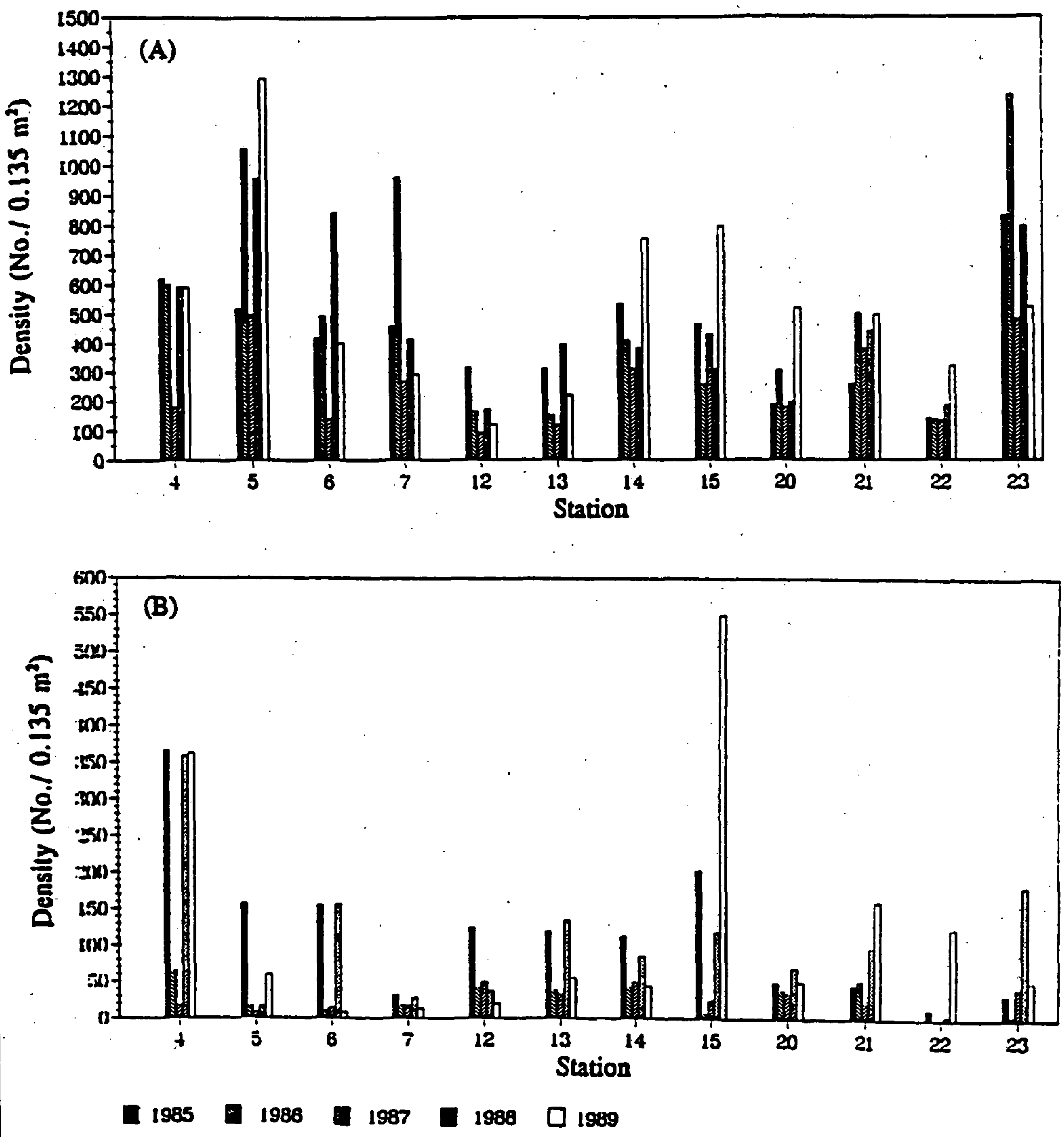

Figure 2. Density of Benthic Infauna at the Dam Neck Disposal Site. (a) Total Density. (b) *Spiophanes bombyx*.

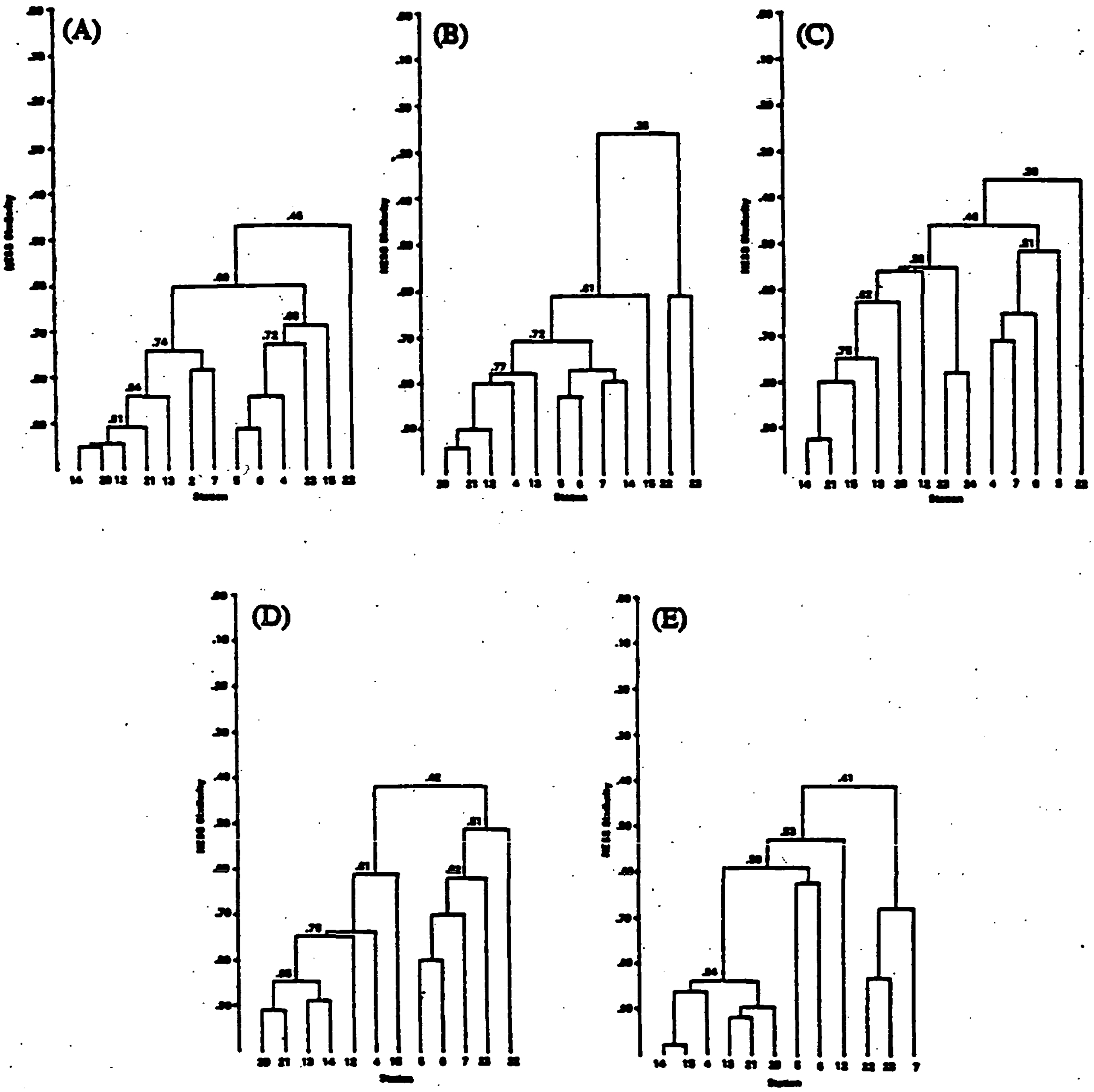

Figure 5. Similarity Analysis of Benthic Infaunal Stations at the Dam Neck Disposal Site (1985-1989) with Years Kept Separate Using NESS and Group Average Sorting. (a) 1985. (b) 1986. (c) 1987. (d) 1988. (e) 1989.

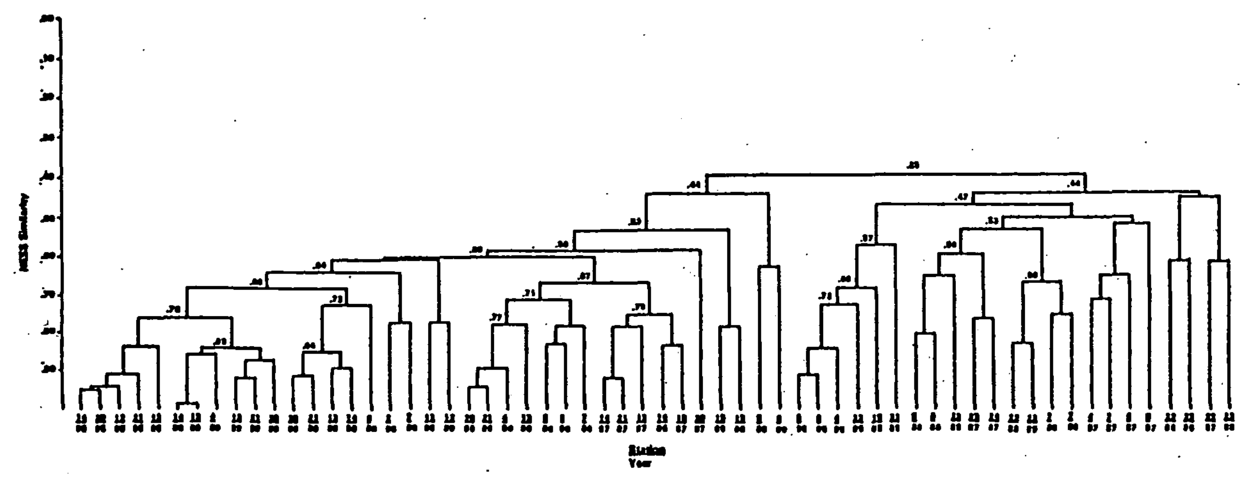

Figure 7. Similarity Analysis of Benthic Infaunal Stations at the Dam Neck Disposal Site (1988-1989) with All Years Combined Using NESS and Group Average Sorting.

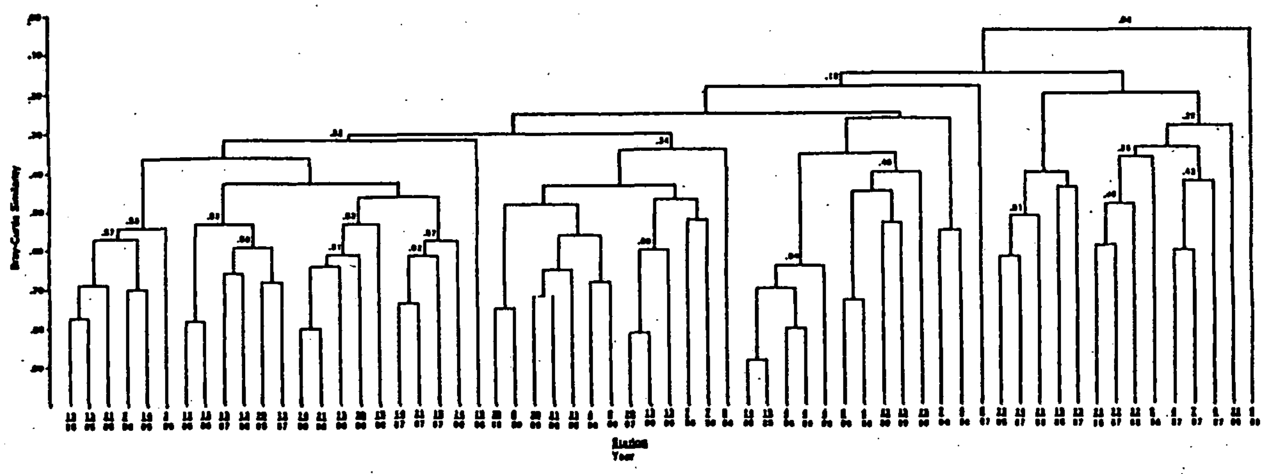

Figure 8. Similarity Analysis of Benthic Infaunal Stations at the Dam Neck Disposal Site (1988-1989) with All Years Combined Using Bray-Curtis and Group Average Sorting.

George Gibson, *U.S. EPA, Office of Science and Technology*

George initiated the dialogue among participants to summarize the key elements and issues discussed during the workshop. The technical guidance outline presented here has been compiled from that preliminary summary enhanced by the discussions which took place.

DRAFT OUTLINE FOR

Estuarine/Near Costal Bioassessment and Biocriteria Technical Guidance

I. Background

A. Definition of biological integrity

B. Purpose/objective of document

1. Who will be the users?
   - States (e.g., 305b, site specific assessments, developing monitoring programs)
   - NEPs, 403c, 301h, CZMP
2. What are their needs?
   - Screening tool for broad overall evaluation
   - To develop biocriteria
   - As early warning to detect degradation/recovery
   - Incorporation into monitoring programs (i.e., NEP, 305b or regulatory—that is, 403c, 301h)
   - Other intensive site specific assessments
   - Guide to States developing monitoring programs

II. Selection of Reference Condition

A. Definition of a reference condition—tied to biological integrity

B. Purpose (i.e., longterm trend monitoring, biocriteria development, one-time site specific assessment)

C. Method—two options

1. Presumed minimally impacted area (e.g., nearfield/farfield study)
2. Some top fraction of overall distribution of community characteristics (e.g., EMAP approach)

D. Considerations

1. Whatever method is used to define a reference condition must reflect a community with biological integrity as defined in the document
2. Consideration of factors that influence species' distribution i.e., salinity, depth, sediment type, temperature, and perhaps flow patterns—enclosed embayment vs.. open water)

III. Community Measurement

A. Communities included benthic invertebrates, fish, SAV, plankton? other?

B. Rationale for primary focus on benthic organisms and restricting habitat — primarily to subtidal, softbottom environs with or without vegetation

C. Matrix of pros/cons/applicability of various community measures including

1. Level of effort
2. Discriminatory ability
3. Sensitivity
4. Geographic applicability
5. Habitat restrictions
6. Others

IV. Habitat Assessment

A. Water quality (salinity, DO, temperature, Ph)

B. Sediment type (TOC, grain size, odor)

C. Depth

D. Vegetation/shelter

E. Sediment contamination (sediment toxicity or elevated chemical conc. as indication of habitat??)

F. Flow pattern/hydrography (i.e., enclosed vs. open water)??

G. Anything else?

V. Sampling Design and Technique

A. Incorporation of community and habitat variables to meet objectives and resources. Importance of considering both type I and type II errors, as well as robustness. The document will contain a matrix to help guide the users in choosing methods which are the most appropriate to their needs.

1. Screening or qualitative approach
2. Quantitative approach
3. Definitive investigation to determine cause and effect

B. Guidance for statistically evaluating various sampling designs and ability of these methods to detect differences, (e.g, 3 vs. 5 replicates, or 1 vs. 4 times a year, etc.; i.e., power analysis?)

C. Sampling design issues

1. Number of replicates
2. Type of analysis
3. Spatial and temporal distribution of samples
4. Others

D. Logistical issues

1. Grab type
2. Mesh size
3. Sorting
4. Subsampling
5. Level of taxonomic identification

E. Other

1. Evaluation of success of program in meeting user needs
2. Importance of natural history expertise
3. Comprehensive professionalism in the process

VI. Metrics

A. Both biological community and habitat

B. Scientific basis (i.e., What do they tell you?)

1. Functional (biomass, depth distribution)
2. Taxonomic (relationships of species and individuals)
3. Habitat indices
4. Others

C. Which ones can be used with which sampling methods?

D. Pros/cons/applicability

VII. Biocriteria Development and Application

A. "Narrative" and "numerical"

B. Variables or metrics to use

C. Issue of basing criteria on the data or on indices

D. Confidence limits for criteria

E. Applications

1. Assessment
2. Diagnostic
3. Regulatory

F. Illustrations and case histories

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