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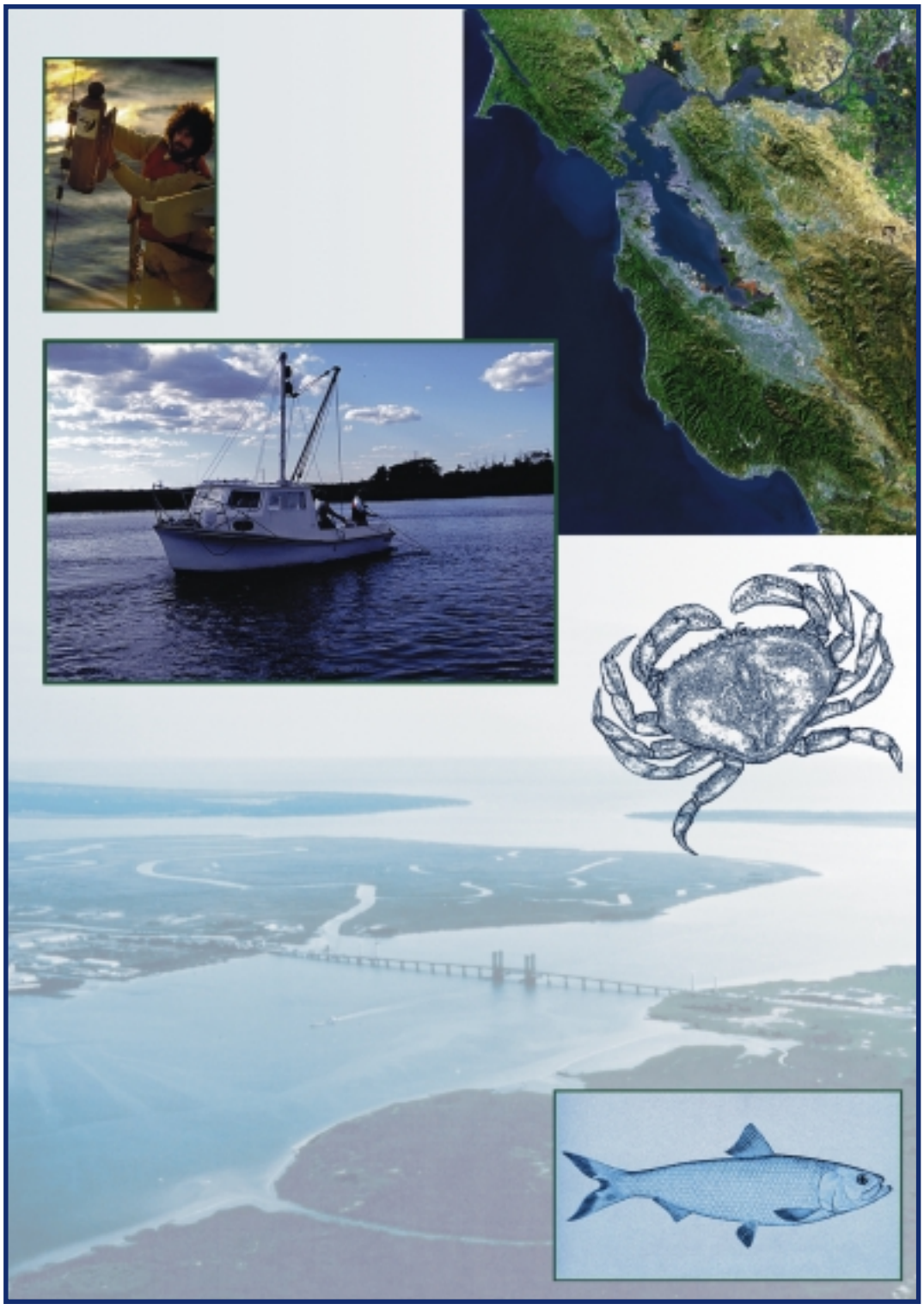
Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance



Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance

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This document is dedicated to the memory of Dr. Douglas Farrell of the Florida Department of Environmental Protection and Dr. Donald Lear, U.S. Environmental Protection Agency (retired). It is fitting that this effort to which they volunteered so much of their invaluable experience and expertise be so dedicated. The benthic community index which Doug developed is also cited here as the "Farrell Index" in further recognition of his unselfish contribution to the protection and management of our coastal resources. Much of the methodology described in the coastal survey portion of this guide was developed from Don Lear's pioneering efforts.

The contributors to this manual sincerely hope that the good common sense, attention to scientific veracity, and practical application of the information to protect our marine resources - so ably personified by Don and Doug - is adequately reflected in these pages.

Disclaimer

This manual provides technical guidance to States, Indian tribes and other authorized jurisdictions to establish water quality criteria and standards under the Clean Water Act (CWA), to protect aquatic life from the effects of pollution. Under the CWA, States and Indian tribes are to establish water quality criteria to protect designated uses. State and Indian tribal decision makers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance when appropriate and scientifically defensible. While this manual constitutes USEPA's scientific recommendations regarding biological criteria to help protect resource quality and aquatic life, it does not substitute for the CWA or USEPA's regulations; nor is it a regulation itself. Thus, it cannot impose legally binding requirements on USEPA, States, Indian tribes or the regulated community, and might not apply to a particular situation or circumstance. USEPA may change this guidance in the future.

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Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance

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Acronym List

APHA	American Public Health Association
AVS	Acid Volatile Sulfides
BMP	Best Management Practices
CCA	Canonical Correspondence Analysis
CDF	Cumulative Distribution Function
CSREES	Cooperative State Research, Education, & Extension Service
CTD	Conductivity - Temperature - Depth Meter
CV	Coefficient of Variation
CWA	Clean Water Act
DFA	Discriminant Function Analysis
DGPS	Differential Global Positioning System
DMRs	Discharge Monitoring Reports
DNR	Department of Natural Resources
DO	Dissolved Oxygen
EMAP	Environmental Monitoring & Assessment Program
EPA	Environmental Protection Agency
ER-L	Effects Range-Low
ER-M	Effects Range-Median
FEI	Farrell Epifaunal Index
FTE	Full Time Equivalent
GIS	Geographic Information System
GPS	Global Positioning System
IBI	Chesapeake Bay Estuarine Index of Biotic Integrity
ITI	Infaunal Trophic Index

MDS	Multidimensional Scaling
NMDS	Non-metric Multidimensional Scaling
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NPDES	National Pollutant Discharge Elimination System
NS&T	National Status & Trends
PAHs	Polyaromatic Hydrocarbons
PCA	Principle Components Analysis
PCBs	Polychlorinated Biphenyls
PCE	Power Cost Efficiency
PCS	Permit Compliance System
POTW	Publically Owned Treatment Works
QA	Quality Assurance
QC	Quality Control
RBP	Rapid Bioassessment Protocol
RPD	Redox Potential Discontinuity
SAV	Submerged Aquatic Vegetation
SEM	Simultaniously Extracted Metals
SOP	Standard Operating Procedure
SPM	Suspended Particulate Matter
SQG	Sediment Quality Guidelines
SQT	Sediment Quality Triad
STORET	STOrage & RETrieval
TDN	Total Dissolved Nitrogen
TDP	Total Dissolved Phosphorus

TMDL	Total Maximum Daily Loads
TOC	Total Organic Carbon
TPC	Total Particulate Carbon
TPN	Total Particulate Nitrogen
TPP	Total Particulate Phosphorus
TSS	Total Suspended Solids
TVS	Total Volatile Sulfides
TWINSPAN	Two-Way INdicator SPecies ANalysis
UPMGA	Unweighted Pair Group Mean Averages
USDA CSREES	United States Department of Agriculture Cooperative State Research Education Extension Service
USGS	United States Geological Survey

Executive Summary

This technical guidance document is based on the concept that bioassessment and biocriteria programs for estuaries and near coastal waters are interrelated and critical components of comprehensive water resource protection and management. Understanding how estuarine ecosystems function and respond to human activity requires a holistic approach to protection and management that integrates biological assessments into the more traditional chemical and physical evaluations. Section 101 of the Clean Water Act requires federal and state agencies to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Relatively undisturbed aquatic ecosystems have high *biological integrity*, defined as

> *the condition of an aquatic community inhabiting unimpaired waterbodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota. Three critical components of biological integrity are that the biota is (1) the product of the evolutionary process for that locality, or site, (2) inclusive of a broad range of biological and ecological characteristics such as taxonomic richness and composition, and trophic structure, and (3) is found in the study biogeographic region* (USEPA 1996a)[1]

In water resource monitoring and protection, biological criteria are an important addition to the traditional physical and chemical criteria used by EPA. The relative biological integrity, or quality, of the resource can be assessed by comparing the health and diversity of its biological communities to the health and diversity of biological communities in waters with the same physical characteristics but which are relatively unimpacted by human development . There are basically four elements that comprise biocriteria:

1. Reference waters (relatively undisturbed areas that can be compared to study areas) serve as "benchmarks" of water resource quality decision making.

2. The historical record of the biological quality, diversity and productivity.

3. Model projection of the historical and reference condition data (if necessary).

4. The objective assessment of this information by a regional panel of specialists such as state,

[1] *Biological criteria: Technical guidance for streams and small rivers.* EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

academic, and federal estuarine ecologists, chemists, fisheries biologists, oceanographers, and resource managers.

The summation of these four factors is the biological criterion for a given estuary or class of coastal water in a geographic region. Examples of the parameters included in a biocriterion are community measures or indexes drawn from dynamic assessments of resident fish, benthic invertebrate, macrophyte, and planktonic assemblages making up the biological community.

Many natural resource agencies throughout the United States have begun the process of developing and implementing bioassessments and criteria programs primarily for rivers and streams. This document is part of the effort to advance the use of these strategies with regard to estuaries and near coastal waters, thereby fostering the development of credible and practical bioassessment programs. This document is intended to provide managers and field biologists with functional methods and approaches for bioassessment and biocriteria development.

In developing biological information, it is imperative that the physical and chemical habitat be carefully measured and documented. Information such as salinity, depth, sediment grain size, and water quality (including pH, temperature, DO, nutrients, and toxicants) is essential to proper classification of the waters for comparison and to the potential subsequent investigation of possible causes of degradation so that responsible management can be initiated.

This guidance provides detailed descriptions of the appropriate habitat measurements to make the subsequent physical classification to be achieved. The document then describes four levels of investigative intensity or sampling tiers. These tiers are suggested as one possible approach to organizing the data gathering efforts and investigation needed to be able to establish biocriteria in a scientifically defensible manner. Other approaches using variations of these tiers may be appropriate depending on program objectives.

- Tier 0 is a preliminary review of existing literature and data available for the estuary or coastal water of concern. It provides candidate reference sites for the development of a reference condition;

- Tier I is a one-time site visit with preliminary data gathering to refine the information in Tier 0 and establish candidate biocriteria;

- Tier II repeats and builds on measurements initiated in Tier I and establishes the reference condition data which is combined with the historical record, possible models or other extrapolations, and a consensus of regional expert opinion to establish and employ the biocriteria for management decision making;

- Tier III is the diagnostic investigation requiring the most

sampling events and most extensive parameters to help establish management efforts for those waters which do not meet the biocriteria.

Biocriteria development is **not** a *one size fits all* proposition. Biocriteria can be developed on biogeographical province basis or on a smaller local basis to account for the geographic, climatologic, and biologic variation in the country. Reference conditions and biocriteria must be specific to each part of the country in order to be responsive and useful for decision making. It is important to remember that such circumstances vary and that this document cannot address every situation or experience. It is oriented toward practical decision making rather than research. Its primary audience is intended to be state and tribal resource managers. It is also intended to provide managers and biologists with functional methods and approaches to facilitate the implementation of viable bioassessment and biocriteria programs that meet their individual needs and resources.

Biocriteria can be used to help support and protect designated uses of water resources; expand and improve water quality standards; detect problems other water quality measurements may miss or underestimate; help water resource managers set priorities for management planning and, assess the relative success or failure of management projects.

Biocriteria do not supersede or replace physical or chemical criteria for water resource decision making and management. In fact biocriteria augment these established measures so USEPA and the States and Tribes are better informed about the quality of our nations extensive and coastal water resources. The bioassessment/ biocriteria process is a particularly cost effective screening tool to evaluate over all water quality and determine water resource status and trends. The following table shows the progression of the biocriteria process.

Sequential progression of the biocriteria process. Adapted from Paulsen et al. 1991.

Step 1	**Preliminary Classification to Determine Reference Conditions and Regional Ecological Expectations** • Resource classification • Determination of best representative sites (reference sites representative of class categories)
Step 2	**Survey of Reference Sites and Selected Impaired Sites** • Collection of data on biota and physical habitat • Compilation of raw data (taxonomic lists, abundance levels, and other direct measures and observations)
Step 3	**Final Classification** • Test preliminary classification • Revise if necessary
Step 4	**Metric Evaluation and Index Development** • Data analysis (data summaries) • Testing and validation of metrics by resource class • Evaluation of metrics for effectiveness in detecting impairment • Selection of biological endpoints • Aggregation of metrics into index. • Test the index for validity on another data set.
Step 5	**Biocriteria Development** • Adjustment by physical and chemical covariates • Adjustment by designated aquatic life use
Step 6	**Implementation of Monitoring and Assessment Program** • Determination of temporal variability of reference sites • Identification of problems
Step 7	**Protective or Remedial Management Action** • Initiate programs to preserve exceptional waters • Implement management practices to restore the biota of degraded waters and to identify and address the causes of this degradation
Step 8	**Continual Monitoring and Periodic Review of References and Criteria** • Biological surveys continue to assess efficiency of management efforts • Evaluate potential changes in reference condition and adjust biocriteria as management is accomplished