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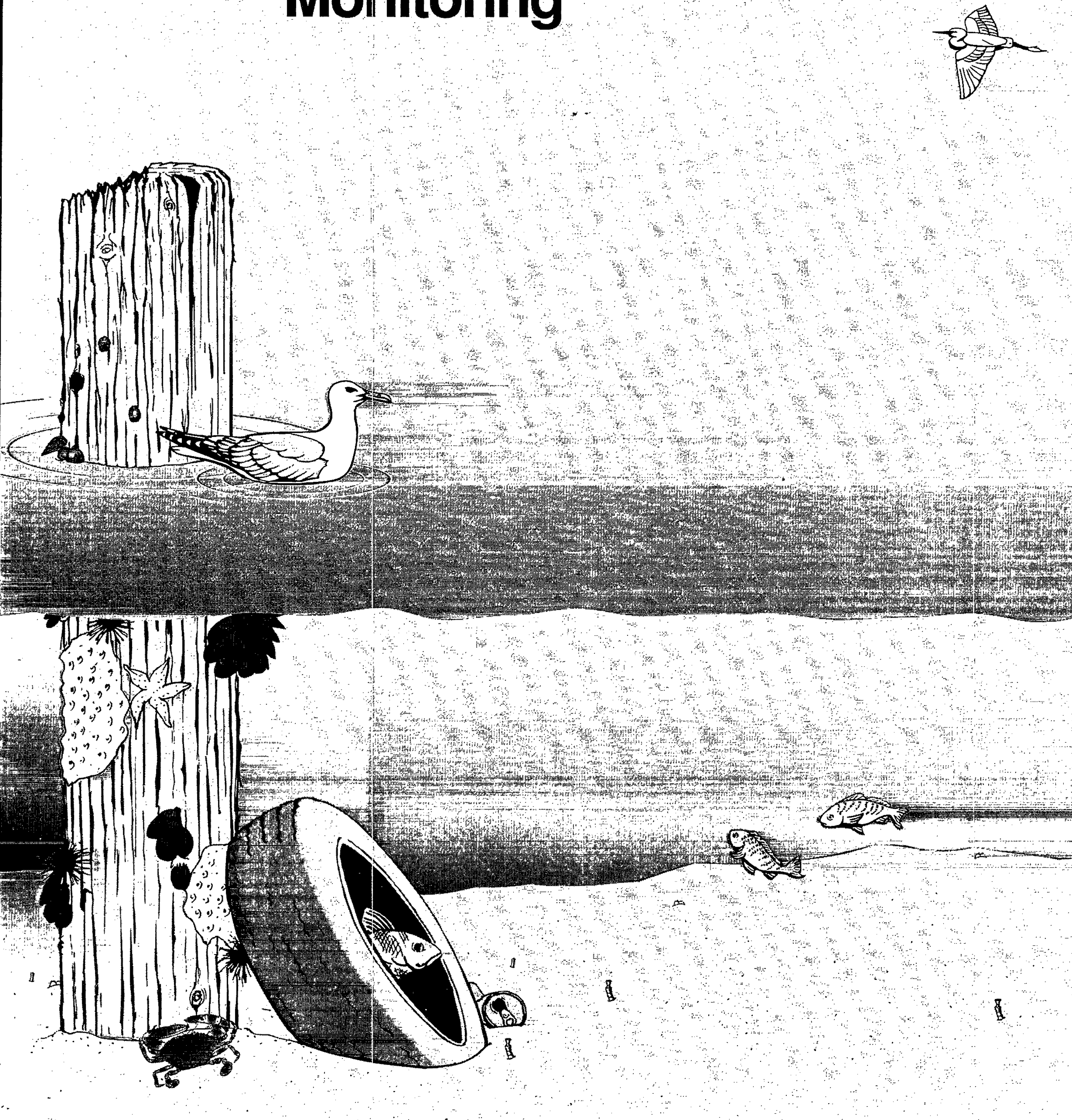
Bibliography of Methods for Marine and Estuarine Monitoring



BIBLIOGRAPHY OF METHODS FOR MARINE AND ESTUARINE MONITORING

April 1995

Ocean and Coastal Protection Division
Office of Wetlands, Oceans, and Watersheds
Office of Water
U. S. Environmental Protection Agency
Washington, D.C.

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Executive Summary

Purpose

This document is designed to give coastal managers a single reference for the broad spectrum of sampling and analytical methods that are in use today. Because of the complexity of estuarine and marine environments and associated issues, no single monitoring methods manual can be applied to all situations. This document, therefore, provides the coastal manager with a starting point for identifying and selecting appropriate methods for use in the National Estuary Program, Ocean Dumping Program and other coastal monitoring programs.

Document Elements

This document and the accompanying methods matrix provide an annotated bibliography that lists and describes references on sampling and analytical methods and related topics, including: monitoring plans, quality assurance, data interpretation and data management. To provide readers with the information needed to decide on the suitability of a reference for their needs, five elements have been provided for each reference:

1. Bibliographic Reference
2. Media for which the methods are appropriate
3. Keywords
4. Abstract
5. The Table of Contents from the reference

Selection Criteria

One hundred references were selected from numerous federal, state, and local organizations for inclusion in this document. Criteria for inclusion were: a focus on marine and estuarine environments, current use, and acceptance by professionals for use in saline environments.

Keyword Index

In addition, an index of all keywords and associated terms is included at the end of the document as an alternative technique for searching for references covering specific subject areas. A bibliography of all references, arranged by author and date, is also provided.

Summary Chart

The accompanying chart provides the user with a cross-reference of monitoring parameters to reference documents and identifies the applicable media (i.e., water column, sediment, or biota). This format affords the user a simple lookup table to quickly identify references that address the parameters and media of interest. In addition, a source for obtaining a copy of the reference is given for each entry in the bibliography.

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Introduction

Introduction

PURPOSE

This document provides a comprehensive reference list of available sampling and analytical methods pertinent to the monitoring of marine and estuarine environments. The listed references contain specific methods, standard practices, and established protocols for field sampling, laboratory analysis, and quality assurance/quality control (QA/QC) procedures appropriate for the environmental monitoring requirements of National Estuary Programs (NEPs). The references have been collected from a variety of sources, including existing NEPs, other regional monitoring efforts, local monitoring studies, and federal research laboratories. The purpose of this document is to provide an information resource for NEP committees and managers that can assist them in selecting field and laboratory methods for monitoring the parameters that are the most appropriate indicators of environmental quality within their program.

Several alternative methods exist for many of the field sampling, laboratory analyses, data analyses, and QA/QC procedures required within a NEP monitoring effort. The aim of this document is to present in one place relevant references, in which alternative methods and practices for field collection procedures, laboratory protocols, and data reporting and analyses requirements are outlined. It is not the aim of this document to compare, rate, or recommend different monitoring methodologies. This document is designed to be a single source of published information for NEP managers who have the responsibility for designing the field and laboratory components of the regional monitoring program, once monitoring objectives have been established and the environmental parameters to be monitored have been identified.

SCOPE

References have been limited to those manuals, guidance documents, standard operating procedures and protocols that specifically describe methodologies for sampling, analytical, QA/QC, and data analysis procedures. Emphasis has been placed on recently developed analytical methods and standards and protocols used by existing NEP and national monitoring programs such as the Puget Sound Estuary Program, the San Francisco Estuary Project, the Galveston Bay Estuary Program, EPA's 301(h) and 403 monitoring programs, EPA's Ecosystem Monitoring and Assessment Program, and NOAA's Status and Trends Program. Comparative discussions of methodologies, monitoring plans, or general guidance documents are not included unless they contain detailed examples of specific monitoring methods.

Approximately 200 documents were identified and collected for tentative inclusion in this bibliography. Using the criteria described above, a final selection of 100 references were chosen from the collected documents. The majority of references are EPA publications; others are published by other federal and state agencies. A small number of consultants' reports, published books, and technical reports and standards are also included.

The collection of appropriate references included searches of available corporate libraries and technical publications, such as the American Society for Testing and Materials (ASTM) and the American Public Health Association (APHA). EPA resources were also searched extensively. The Center for Environmental Research Information on-line document catalog and the EPA library network Online System Library provided information on the majority of the published EPA reports. Other EPA offices were contacted directly for details on unpublished reports and reports in press. The EPA resources contacted included the:

- Office of Research and Development,
  - Environmental Systems Monitoring Laboratory-Cincinnati
  - Environmental Systems Monitoring Laboratory-Duluth
  - Environmental Research Laboratory-Gulf Breeze
  - Environmental Research Laboratory-Narragansett
  - Environmental Research Laboratory-Newport
- Office of Science and Technology
- Office of Wetlands, Oceans, and Watersheds, Ocean and Coastal Protection Division

Other federal agencies contacted included the:

- National Park Service
- National Oceanic and Atmospheric Administration (NOAA) regional libraries
- NOAA National Marine Fisheries Service, Northwest Center
- NOAA Coastal Monitoring and Bioeffects Assessment Division
- U.S Army Engineer Waterways Experiment Station
- U.S. Army Corps of Engineers, San Francisco District
- U.S. Geological Survey regional library
- U.S. Food and Drug Administration National Shellfish Sanitation Branch.

State and local organizations contacted included the:

California State Water Resources Control Board
Chesapeake Bay Program
Galveston Bay Estuary Project
Maryland Department of the Environment
Puget Sound Estuary Program
San Francisco Estuary Institute
San Francisco Estuary Project
Southern California Coastal Water Resources Project
State of Maine Department of Environmental Protection
Texas Natural Resources Conservation Commission
Texas Parks and Wildlife Department
Washington State Department of Ecology.

Library catalogs were searched via on-line access to the University of California system and to Stanford University. These searches were directed towards journal articles and books.

FORMAT

This document is an annotated bibliography. This first section, the introduction, explains the organization of the document. The second section consists of a summary reference table or matrix. This cross-reference matrix is a concise display of the keywords for each reference. The keywords are grouped into logical divisions of physical parameters, chemical parameters, biological characterization, and related topics.

The third section, comprising the majority of the document, is the catalog of references. Each reference or entry is presented in standard format:

bibliographic information
keywords
abstract
contact telephone number
table of contents

The fourth section consists of a standard reference list, ordered by author and date. The last section is an index relating keywords and subject to appropriate entries in the bibliography, using reference numbers. Each entry has a unique reference number that is displayed at the top of each page of the catalog of references. The reference number is also used in the cross-reference matrix and reference list as a convenient means for the reader to find the bibliographic information pages of any document of interest.

Bibliographic Information

The references are arranged alphabetically by author or publishing agency or organization. Where a reference has both named authors and a publishing agency, the agency is generally given precedence and the entry is arranged alphabetically according to the agency name. Although not necessarily a standard approach, this format allows immediate recognition of the document as being a product of a local, state, or federal organization. References published by the same agency are arranged chronologically, by year of publication.

The majority of the references are federal government agency reports. Where possible both the agency publication number and the National Technical Information Service (NTIS) accession number have been included for the reader's convenience when ordering documents. Some recent documents will be available from the office of the sponsoring agency, but in general, requesting documents from NTIS will be more successful.

Keywords

A standard set of keywords were developed for this bibliography, based on the structure of the referenced methods manuals and protocols. Three major keywords or categories are used to denote the environmental media of interest:

Water Quality
Sediment Quality
Biological Characterization

Each reference contains at least one of these keywords, and many comprehensive documents contain methods addressing all three.

Keywords are further divided into environmental parameters and monitoring procedures. This division combines similar parameters under headings such as organic constituents, nutrients, and PCBs, and groups similar procedures, such as sampling, QA/QC, and bioaccumulation. These groupings are a logical combination of parameters that reflect the approach used in specific methods documents. The parameter and procedure keywords are shown in Table 1.

The majority of the secondary keywords can be associated with more than one major keyword or media category. For example, SAMPLING is used as a keyword for methods describing water column sampling, sediment sampling, and biological sampling; NUTRIENTS is used as a keyword for references discussing nutrient analyses of water and of sediments, but GRAIN SIZE refers only to a measure of sediment quality, and CHLOROPHYLL refers only to methods to measure the abundance of phytoplankton, a biological characterization monitoring method.

TABLE 1
PARAMETER AND PROCEDURE KEYWORDS

PHYSICAL PARAMETERS	
Current & Flow	(Includes methods of current and tidal measurements and stream flow)
Depth	(Methods of water depth measurements)
Dissolved Oxygen	(Methods applicable to water column and sediment pore water)
Grain Size	(Sediments)
pH	(Includes methods for water column and sediments, including eH)
Salinity	(Includes conductivity of the water column)
Total Solids	(Includes total suspended solids, total dissolved solids, total volatile solids, settleable solids, floating particulates)
Turbidity	(Includes water column transmissivity, transparency, color)
Temperature	(Water and sediment)
CHEMICAL PARAMETERS	
Inorganics	(Includes arsenic, asbestos, cyanide, sulfides: water, sediment)
Metals	(Dissolved, suspended, and total metals: water, sediment)
Organics	(Includes halogenated aliphatic hydrocarbons, halogenated ethers, monocyclic aromatic hydrocarbons, nitrosamines, and others: water, sediment)
Nutrients	(Includes ammonia-Nitrogen, Kjeldahl-Nitrogen, nitrite and nitrate, total nitrogen, dissolved nitrogen, organic nitrogen, orthophosphate, total phosphorus, dissolved phosphorus: water, sediment)
PAHs	(Polycyclic aromatic hydrocarbons and phthalate esters: water, sediment)
PCBs	(Polychlorinated biphenyls: water, sediment)
Pesticides	(Includes DDT and derivatives, dieldrin, heptachlor, chlordane, and other priority pollutant pesticides: water, sediment)
Oxygen Demand	(Includes biological oxygen demand [BOD], chemical oxygen demand [COD]: water, sediment)
Organic Carbon	(Total organic carbon [TOC]: water, sediment)
Organotins	(Includes tributyltin and others: water, sediment)
Radioactivity	(Water, sediment)
BIOLOGICAL PARAMETERS	
Bioaccumulation	(Biological characterization)
Chlorophyll	(Biological characterization)
Pathogenic Organisms	(Includes coliform and Enterococcus bacteria: water, sediment, biological characterization)
Population/Community	(Includes fish, macroinvertebrates, epibenthos, infauna, vegetation, habitat: biological characterization)
Tissue Analysis	(Water, sediment, biological characterization)
Toxicity/Bioassay	(Water, sediment, biological characterization)
RELATED ISSUES	
Data Analysis/Management	(Water, sediment, biological characterization)
QA/QC	(Water, sediment, biological characterization)
Sampling	(Water, sediment, biological characterization)
Volunteer Monitoring	(Water, sediment, biological characterization)

Abstract
For each entry in the bibliography an abstract has been provided. The abstract is copied from the referenced document if available. If not, a brief description of the document is provided by either excerpting relevant paragraphs from the introductory material or by composing an abstract from a review of the document. The purpose, type of method(s), expected sensitivity and accuracy (if appropriate), general level of detail, and information on the format of the document are outlined. The origin of the abstract is noted at the end of the abstract as follows:

[copied from document]	a reproduction of the abstract as it appears in the document
[extracted from document]	a compilation of statements from the Executive Summary, Preface, Introduction, statement of purpose, scope, etc.
[composed after review]	an abstract was written after a review of the document.

Contact
A telephone number is supplied for all references that are published by public agencies. Copies of the document or current information on how to obtain copies are available by calling the number shown. In many cases, reader's technical queries can also be addressed.

Table of Contents
A table of contents is included in a standardized format for each reference. Chapter or section headings and two or three levels of sub-headings have been included. However, where numerous levels of sub-headings or repetitive headings occur in the reference, they have been abridged in this section. Titled appendices are included, but lists of tables and figures are not included. The tables of contents are presented in a standard format to provide an indication of the level of detail of the document.

Cross Referencing Matrix
To enhance the utility of this document, a matrix cross referencing keywords and titles is included. This matrix enables the reader to identify all documents pertaining to specific parameters or, alternatively, to determine quickly the range of methods addressed in any particular document.

To avoid repetition in the cross reference matrix and to enhance the brevity of the matrix, three letters are used to denote the media for which the method was designed: **W** for water quality, **S** for sediment quality, and **B** for biota or biological characterization. These correspond to the three major keywords in the bibliographic information at the beginning of each entry.

Reference List

To further enhance ease of use for the reader, a reference list of all documents included in this bibliography is included. It contains standard reference information of:

- author
- year of publication
- title
- editor(s)
- publisher or publishing institution
- number of pages
- report number
- reference number

This reference list is sorted by author and year and can be cross-referenced to the annotated catalog listings by the reference number. This information is basically the same as that supplied at the beginning of each catalog entry; differing in that keywords, abstracts, and tables of contents are not included. The purpose of this reference list is to allow the reader to quickly search for a specific author and year, without the necessity of having to look through several pages per reference.

Index

An index to the catalog is included. Index entries include each of the keywords as well as the terms or monitoring and analytical parameters associated with the keywords. This includes specific physical and biological parameters and elements and compounds addressed in the references. The numbers listed with each index word are the reference numbers used to identify each document within the catalog. These reference numbers are repeated at the top of every page of each reference. This provides the reader with a convenient method to quickly locate a reference of interest, whether from the index or from the cross-reference matrix.

Poster

A fold-out poster, suitable for wall display, is included in a pocket at the back of this document. The poster displays a complete version of the cross-reference matrix presented in the following section.

Cross-Reference Matrix

Monitoring Methods Cross-reference Matrix

1. Recommended Procedures for Examination of Seawater & Shellfish (APHA, 1970)
2. Std Mtds for Examination of Water & Wastewater (APHA, 1989)
3. Annual Book of ASTM Stds v11.04 Water & Envir Tech: Pesticides, . . . Biol Effects (ASTM, 1993)
4. Annual Book of ASTM Stds v11.01&02 Water & Envir Tech: Water (I) & Water (II) (ASTM, 1994)
5. California Ocean Plan. (Calif State WRCB, 1990)
6. Procedures Manual for Tox Tests Developed by Marine Bioassay Proj (Calif State WRCB, 1990)
7. Chspke Bay Coordinated Split Sample Program Guide Rev 3 (Chesapeake Bay Program, 1991)
8. Chspke Bay Prog Data Management Plan (Chesapeake Bay Program, 1992)
9. Guide for Analysis of Water Quality Trends in Chspke Bay (Chesapeake Bay Program, 1992)
10. Guide to Using Chspke Bay Prog Water Quality Monitoring Data (Chesapeake Bay Program, 1993)
11. Recommended Guide Sampling & Analysis Chspke Bay Prog (Chesapeake Bay Program, 1994)
12. Statistical Methods for Environmental Pollution Monitoring (Gilbert,1987)
13. Methods for Study of Marine Benthos (Holme & McIntyre, 1984)
14. Testing Sediment Toxicity with Amphipodia & Diptera. (Ingersoll and Nelson, 1990)
15. A Compilation of Water Quality Goals (Marshack, 1991)

Reference No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Reference No.
PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow				W												Current & Flow
Depth																Depth
Dissolved Oxygen	W	W		W											W	Dissolved Oxygen
Grain Size				S							S					Grain Size
pH		W		W	W										W	pH
Salinity (Conductivity)	W	W		W	W										W	Salinity (Conductivity)
Total Solids		W			W						WS				W	Total Solids
Turbidity		W		W	W										W	Turbidity
Temperature	W	W													W	Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals		W			W									S	W	Metals
Inorganic Constituents		W		WS	W										W	Inorganic Constituents
Organic Constituents		W		WS	W										W	Organic Constituents
Total Organic Carbon		W		WS							S				W	Total Organic Carbon
Nutrients		W		WS							WS				W	Nutrients
Oxygen Demand		W		WS							WS				W	Oxygen Demand
PAHs		W		WS	W									S	W	PAHs
PCBs		W		WS	W									S	W	PCBs
Pesticides		W		WS	W										W	Pesticides
Organotins					W										W	Organotins
Radioactivity		W		WS	W										W	Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation																Bioaccumulation
Chlorophyll											WB					Chlorophyll
Pathogenic Organisms	WB	WB		WS	W											Pathogenic Organisms
Population/Community											B					Population/Community
Tissue Analysis			WSB													Tissue Analysis
Toxicity/Bioassays	WB	WB	WSB			WB								S		Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management			WSB	WS	W		W	WSB	W	W		WS			W	Data Analysis/Management
QA/QC			WSB	WS		WB	W	WSB			WSB	WS				QA/QC
Sampling	WB	W	WSB	WS		B	W				WSB	WS	B			Sampling
Volunteer Monitoring																Volunteer Monitoring

W = Water S = Sediment B = Biota

Monitoring Methods Cross-reference Matrix *(continued)*

16. Guidance for Analysis of Water Quality Trends in Chspke Bay (Maryland Dept Env, 1993)
17. Handbook of Techniques for Aquatic Sediment Sampling (Murdoch & MacKnight, 1991)
18. Compilation of EPA's Sampling & Analytical Methods (Mueller & Smith, 1991)
19. Plant Toxicity Testing with Sediments & Marsh Soils (National Parks Service, 1991)
20. Nat Status & Trends Prog Benthic Surveillance Proj: Cycle III Field Manual (NOAA, 1986)
21. Nat Status & Trends Prog Benthic Surveillance Proj: Specimen Bank Proj: Field Manual (NOAA, 1987)
22. Std Analytical Procedures of NOAA National Analytical Facility, New HPLC Cleanup (NOAA, 1988)
23. Standard & Reference Materials for Marine Science (NOAA, 1992)
24. Sampling & Analytical Methods for Nat Status & Trends Prog... Vols I-IV (NOAA, 1993)
25. Use of Stds and Reference Materials for Measuring Chlorinated Hydrocarbons (NOAA, 1994)
26. A Manual for Chemical & Biological Methods for Seawater Analysis (Parsons et al., 1984)
27. Procedures for Handling & Chemical Analyses of Sed & Water Samples (Plumb, 1981)
28. Data Validation Guidance Manual for Selected Sediment Variables (PTI, 1989)
29. PSDDA Guidance Manual; Data Quality Evaluation: Proposed Dredged Material... (PTI, 1989)
30. Recommended Protocols for Measur Select Envir Vars in Puget Sd (Puget Sd Estuary Prog, 1991)

Reference No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Reference No.
PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow									W							Current & Flow
Depth									W							Depth
Dissolved Oxygen									W		W				W	Dissolved Oxygen
Grain Size									S			S	S	S	S	Grain Size
pH									W			W			W	pH
Salinity (Conductivity)									W			W			W	Salinity (Conductivity)
Total Solids												W	S		W	Total Solids
Turbidity															W	Turbidity
Temperature									W						W	Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals			WS					WS	WS			WS	S	S	WS	Metals
Inorganic Constituents			WS					WS	WS			WS			WS	Inorganic Constituents
Organic Constituents			WS				S	WS	WS		W	WS	S	S	WS	Organic Constituents
Total Organic Carbon									WS		W	WS	S		WS	Total Organic Carbon
Nutrients								WS	WS		W	WS			WS	Nutrients
Oxygen Demand									WS			WS		S	WS	Oxygen Demand
PAHs			WS				S	WS	WSB	WS		WS		S	WS	PAHs
PCBs			WS				S	WS	WSB	WS		WS		S	WS	PCBs
Pesticides			WS					WS	WSB	WS		WS		S	WS	Pesticides
Organotins									WSB							Organotins
Radioactivity																Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation									WSB				S	S	WSB	Bioaccumulation
Chlorophyll											W					Chlorophyll
Pathogenic Organisms									WSB		W		S		W	Pathogenic Organisms
Population/Community									B						WSB	Population/Community
Tissue Analysis					WS	WS	S	WS	WB	WS			S		WSB	Tissue Analysis
Toxicity/Bioassays				S					WSB				S	S	WSB	Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management	W								WSB				S	S	WSB	Data Analysis/Management
QA/QC					WS	WS		WS	WSB	WS			S	S	WSB	QA/QC
Sampling		S	WS		WS	WS			WSB	WS	W	WS	S	S	WSB	Sampling
Volunteer Monitoring																Volunteer Monitoring

W = Water S = Sediment B = Biota

Monitoring Methods Cross-reference Matrix *(continued)*

31. QAPjP for Region Monitoring Program for Toxics in San Francisco Estuary (SFEI, 1994)
32. QA in Environmental Analyses Applied to SF Estuary (San Francisco Estuary Project, 1991)
33. Methods for Biological Sampling & Analysis of Maine's Water (State of Maine DEP, 1987)
34. Commercial Harvest Field Operations Manual (Texas PWD, 1989)
35. Marine Resource Monitoring Operations Manual (Texas PWD, 1993)
36. Marine Sport Harvest Monitoring Operations Manual (Texas PWD, 1993)
37. Water Quality Monitoring Procedures Manual (Texas Water Commission, 1993)
38. Assessment of Bioaccumulation in Aquatic Orgns Exposed to Contmd Seds (USACE, 1991)
39. QA Guidelines for Organic Analyses (USAEWES, 1989)
40. Environmental Monitoring Series: QA Guide for Biological Testing (USEPA, 1978)
41. Microbiological Mtds for Monitoring the Environment: Water & Wastes (USEPA, 1978)
42. Phytoplankton Sampling in Quantitative Baseline & Monitoring Programs (USEPA, 1978)
43. Handbook of Analytical QA in Water & Wastewater Laboratories (USEPA, 1979)
44. Methods for Chemical Analysis of Water & Wastes (USEPA, 1983)
45. Bioaccumulation Monitoring Guidance 3. Recomd Analytical Detection Limits (USEPA, 1985)

Reference No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Reference No.
PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow							W									Current & Flow
Depth	WS						W									Depth
Dissolved Oxygen	W						W							W		Dissolved Oxygen
Grain Size	S															Grain Size
pH	W						W						W	W		pH
Salinity (Conductivity)	W						W						W			Salinity (Conductivity)
Total Solids	W													W		Total Solids
Turbidity							W						W	W		Turbidity
Temperature	W						W							W		Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals	WSB						W							W	WS	Metals
Inorganic Constituents	WSB													W		Inorganic Constituents
Organic Constituents	WSB						W		WS				W	W	WS	Organic Constituents
Total Organic Carbon	WS													W		Total Organic Carbon
Nutrients	W													W		Nutrients
Oxygen Demand														W		Oxygen Demand
PAHs	WSB								WS							PAHs
PCBs	WSB								WS							PCBs
Pesticides	WSB								WS							Pesticides
Organotins	W															Organotins
Radioactivity													W			Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation	WSB							S							WSB	Bioaccumulation
Chlorophyll	W											B				Chlorophyll
Pathogenic Organisms							W				W		W			Pathogenic Organisms
Population/Community	SB		B	B	B	B	SB					B				Population/Community
Tissue Analysis	WSB														WSB	Tissue Analysis
Toxicity/Bioassays	WSB									WS			W			Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management	WSB	WSB	B	B	B	B	W	S	WS			B			WSB	Data Analysis/Management
QA/QC	WSB	WSB			B	B	W		WS	WS	W		W			QA/QC
Sampling	WSB	WSB	B	B	B	B	WSB		WS		W	B	W			Sampling
Volunteer Monitoring																Volunteer Monitoring

W = Water S = Sediment B = Biota

Monitoring Methods Cross-reference Matrix *(continued)*

46. Summary of EPA-Approved Mtds, Std Mtds, & Guidance 301(h) Monitoring Vars (USEPA, 1985)
47. Test Mtds for E. coli & Enterococci in Water: Membrane Filter Procedure (USEPA, 1985)
48. Anal Mtds for EPA Priority Pols & 301(h) Pesticides in Estuar & Marine Waters (USEPA, 1986)
49. Bioacc Monitoring Guide 4. Analytical Mtds for EPA Priority Pollutants (USEPA, 1986)
50. Quality Criteria for Water 1986 (USEPA, 1986)
51. Bioaccumulation Monitoring Guidance 1. Selected Target Species . . . (USEPA, 1987)
52. Bioacc Monitoring Guide 5. Strategies for Sample Replication and Composting (USEPA, 1987)
53. Guide for Conducting Fish Liver Histopathology Studies 301(h) Monitoring (USEPA, 1987)
54. Guidance for Sampling & Analyses of Organics in Sediments (USEPA, 1987)
55. QA/QC for 301(h) Monitoring Programs. Guidance on Field & Lab Methods (USEPA, 1987)
56. Recommended Biological Indices for 301(h) Monitoring Programs (USEPA,1987)
57. Guide for Preparation of QAPPs for National Estuary Program (USEPA, 1988)
58. Short-term Mtds for Est Chronic Tox of Efflts & Rec Waters to Marine & Estuar Orgns (USEPA, 1988)
59. Compendium of Mtds for Marine & Estuarine Environmental Studies (USEPA, 1989)
60. Guidance Manual: Bedded Sediment Bioaccumulation Tests (USEPA, 1989)

Reference No.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	Reference No.
PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow										W						Current & Flow
Depth																Depth
Dissolved Oxygen	W				W					W						Dissolved Oxygen
Grain Size	S									S					S	Grain Size
pH	W				W					W						pH
Salinity (Conductivity)					W					W						Salinity (Conductivity)
Total Solids	W				W					W					S	Total Solids
Turbidity	W				W					W						Turbidity
Temperature	W				W											Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals	WS		S	WS	W					WS						Metals
Inorganic Constituents	WS		S	WS	W					WS						Inorganic Constituents
Organic Constituents	WS		S	WS	W				S	WS						Organic Constituents
Total Organic Carbon	WS								S						S	Total Organic Carbon
Nutrients	WS				W					WS				W		Nutrients
Oxygen Demand	WS									WS						Oxygen Demand
PAHs	WS		S	WS	W				S							PAHs
PCBs	WS		S	WS	W				S							PCBs
Pesticides			S	WS	W				S	WS						Pesticides
Organotins																Organotins
Radioactivity																Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation	WSB			WS		WSB	WS			WSB		WSB			S	Bioaccumulation
Chlorophyll	W									W				W		Chlorophyll
Pathogenic Organisms	WSB	W								WSB						Pathogenic Organisms
Population/Community	B									B	B					Population/Community
Tissue Analysis				WS				B								Tissue Analysis
Toxicity/Bioassays												WSB	W			Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management			S	WS	W		WS	B		WSB	B	WSB	W		S	Data Analysis/Management
QA/QC			S	WS					S	WSB		WSB	W			QA/QC
Sampling			S	WS		WSB	WS	B	S	WSB		WSB			S	Sampling
Volunteer Monitoring																Volunteer Monitoring

W = Water S = Sediment B = Biota

Monitoring Methods Cross-reference Matrix *(continued)*

61. Methods Manual for Perdido Bay Citizen Monitoring Program (USEPA, 1989)
62. QA/QC Plan for Perdido Bay... Citizens Monitoring Program (USEPA,1989)
63. Rapid Bioassessment Protocols for Use in Streams & Rivers (USEPA, 1989)
64. Short-term Mtds for Est Chronic Tox of Efflts & Rec Water to F'water Orgms (USEPA, 1989)
65. Analytical Procedures and QA for the Determination of PCDD/PCDF in Fish (USEPA, 1990)
66. Analytical Procedures & QA for Determination of Xenobiotic Chemicals (USEPA, 1990)
67. Macroinvertebrate Field & Lab Mtds for Evaluating Biol Integrity of Surface Waters (USEPA, 1990)
68. Volunteer Water Monitoring: Guide for State Managers (USEPA, 1990)
69. Biological Criteria: Guide to Technical Literature (USEPA, 1991)
70. Mtds Aquatic Toxicity Identification Evaluations 1. Toxicity Characterization Procs (USEPA, 1991)
71. Mtds for Measur Acute Toxicity of Effluents & Rec Water to F'water & Marine Orgms (USEPA, 1991)
72. Mtds for Determination of Metals in Environmental Samples (USEPA, 1991)
73. Project Mgr's Guide to Requesting & Evaluating Chemical Analyses (USEPA, 1991)
74. Volunteer Lake Monitoring: A Methods Manual (USEPA, 1991)
75. Consumption Surveys for Fish and Shellfish. (USEPA, 1992)

Reference No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	Reference No.
PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow								W								Current & Flow
Depth																Depth
Dissolved Oxygen														W		Dissolved Oxygen
Grain Size																Grain Size
pH														W		pH
Salinity (Conductivity)																Salinity (Conductivity)
Total Solids																Total Solids
Turbidity														W		Turbidity
Temperature														W		Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals											W					Metals
Inorganic Constituents																Inorganic Constituents
Organic Constituents					B	B										Organic Constituents
Total Organic Carbon																Total Organic Carbon
Nutrients																Nutrients
Oxygen Demand																Oxygen Demand
PAHs						B										PAHs
PCBs						B										PCBs
Pesticides						B										Pesticides
Organotins																Organotins
Radioactivity																Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation					B	B										Bioaccumulation
Chlorophyll																Chlorophyll
Pathogenic Organisms														W		Pathogenic Organisms
Population/Community			WB						B					B	B	Population/Community
Tissue Analysis					B	B										Tissue Analysis
Toxicity/Bioassays				W						W	W	WS				Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management				W			WB		B		W	WS	WS	WSB	B	Data Analysis/Management
QA/QC		W		W	B	B	WB		B	W	W	WS	WS	WSB	B	QA/QC
Sampling	W	W	WB		B	B	WB		B	W	W	W		WB	B	Sampling
Volunteer Monitoring	W	W						W						WSB		Volunteer Monitoring

W = Water S = Sediment B = Biota

Monitoring Methods Cross-reference Matrix *(continued)*

76. Environmental Monitoring Methods Index (USEPA, 1992)
77. Field Operations & Safety Manual: EMAP-Estuaries 1992 Virginian Province (USEPA, 1992)
78. Mtds for Determination of Chemical Substances in Marine & Estuar Envir Samples (USEPA, 1992)
79. Monitoring Guidance for the National Estuary Program (USEPA, 1992)
80. Recomd Anal Techs & QA/QC Guide for Measur Org & Inorg Analytes in Marine Seds (USEPA, 1992)
81. Sediment Classification Methods Compendium (USEPA, 1992)
82. Std Operations & Field Mtds Used for Conducting Eco Risk Assessments (USEPA, 1992)
83. Synthesis of Methods to Predict Bioaccumulation of Sediment Pollutants (USEPA, 1992)
84. Guidance Assess Chemical Contmt Data in Fish Advisories 1. Fish Samp and Anals (USEPA, 1993)
85. Laboratory Methods Manual - Estuaries. EMAP (USEPA, 1993)
86. Mtds Aquatic Toxicity Identification Evaluations 2. Toxicity Identification Procs (USEPA, 1993)
87. Mtds Aquatic Toxicity Identification Evaluations 3. Toxicity Confirmation Procs (USEPA, 1993)
88. Methods for Determination of Inorganic Substances in Environmental Samples (USEPA, 1993)
89. QA/QC Guide Samp & Anal of Seds, Water & Tissue for Dredged Materials (USEPA, 1993)
90. Volunteer Estuary Monitoring: Methods Manual (USEPA, 1993)

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PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow				W						W						Current & Flow
Depth				W												Depth
Dissolved Oxygen	W	W		W			W								W	Dissolved Oxygen
Grain Size	S			S			S			S						Grain Size
pH	W			W			WS									pH
Salinity (Conductivity)		W		W			W									Salinity (Conductivity)
Total Solids				W			W			WS						Total Solids
Turbidity				W									W			Turbidity
Temperature		W		W			W									Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals	WS		WS	WS	S		WS		B	WS	W					Metals
Inorganic Constituents	WS		WS	WS	S		WS		B	WS			W			Inorganic Constituents
Organic Constituents	WS		WS	WS	S		WS		B	WS	W					Organic Constituents
Total Organic Carbon				S						WS						Total Organic Carbon
Nutrients			WS	WS			WS						W		W	Nutrients
Oxygen Demand				WS									W		W	Oxygen Demand
PAHs	WS			WS	S				B	WS						PAHs
PCBs	WS			WS	S		WS		B	WS						PCBs
Pesticides	WS			WS	S				B	WS						Pesticides
Organotins							WS			WS						Organotins
Radioactivity																Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation				WSB			WSB	S								Bioaccumulation
Chlorophyll			W	W			W								W	Chlorophyll
Pathogenic Organisms				WS			WS								WB	Pathogenic Organisms
Population/Community				WSB			WSB			B					B	Population/Community
Tissue Analysis				WSB	S		WS		B	WSB				B		Tissue Analysis
Toxicity/Bioassays				WSB		S	WSB			WSB	W	W				Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management		WSB		WSB			WSB	S	B				W	WS		Data Analysis/Management
QA/QC		WSB	WS	WSB	S	S	WSB		B			W		WS	WB	QA/QC
Sampling		WSB	WS	WSB		S	WSB	S	B				W	WS	WB	Sampling
Volunteer Monitoring															WB	Volunteer Monitoring

W = Water S = Sediment B = Biota

Monitoring Methods Cross-reference Matrix *(concluded)*

	CWA Section 403: Procedural and Monitoring Guidance (USEPA, 1994)	Guidance Assess Chemical Contmt Data in Fish Advisories 2: Risk Assess & Fish . . . (USEPA, 1994)	Methods Measuring Toxicity of Sed Contaminants with Estuarine & Marine Amphipods (USEPA, 1994)	Methods Measuring Toxicity of Sed Contaminants with Freshwater Inverts (USEPA, 1994)	National Directory of Volunteer Environmental Monitoring Programs 4th Ed (USEPA, 1994)	Evaluation of Dredged Material Proposed for Ocean Disposal: Test Manual (USEPA & USACE, 1991)	Evaluation of Dredged Materials . . . Draft Inland Testing Manual (USEPA, 1994)	National Shellfish Sanitation Program Manual of Operations (USFDA,1990)	Mtds for Collection & Analysis Aquatic Biol & Microbiol Samples (US Geological Survey, 1987)	Mtds for Analysis of Inorganic Substances in Water & Fluvial Seds (US Geological Survey, 1989)						
Reference No.	91	92	93	94	95	96	97	98	99	100						Reference No.
PHYSICAL PARAMETERS																**PHYSICAL PARAMETERS**
Current & Flow	W									W						Current & Flow
Depth	W															Depth
Dissolved Oxygen	W															Dissolved Oxygen
Grain Size	S					S	S									Grain Size
pH																pH
Salinity (Conductivity)	W															Salinity (Conductivity)
Total Solids						WS	W									Total Solids
Turbidity	W									W						Turbidity
Temperature	W															Temperature
CHEMICAL PARAMETERS																**CHEMICAL PARAMETERS**
Metals	WS	B				WS	WS			WS						Metals
Inorganic Constituents	WS	B				WS	WS			WS						Inorganic Constituents
Organic Constituents	WS	B				WS	WS									Organic Constituents
Total Organic Carbon	S					WS	WS									Total Organic Carbon
Nutrients	W									WS						Nutrients
Oxygen Demand										WS						Oxygen Demand
PAHs	WS	B				WS	WS									PAHs
PCBs	WS	B				WS	WS									PCBs
Pesticides	WS	B				WS	WS									Pesticides
Organotins																Organotins
Radioactivity																Radioactivity
BIOLOGICAL PARAMETERS																**BIOLOGICAL PARAMETERS**
Bioaccumulation	WSB			S		WS	WS									Bioaccumulation
Chlorophyll	W															Chlorophyll
Pathogenic Organisms	WSB							WB	B							Pathogenic Organisms
Population/Community	WSB								B							Population/Community
Tissue Analysis	WSB	B				WS	W	B								Tissue Analysis
Toxicity/Bioassays			S	S		WS	WS	B								Toxicity/Bioassays
RELATED TOPICS																**RELATED TOPICS**
Data Analysis/Management		B				WS	WS									Data Analysis/Management
QA/QC	WSB	B	S	S		WS	WS	WB		WS						QA/QC
Sampling	WSB		S	S		WS	WS	WB	B	WS						Sampling
Volunteer Monitoring					WSB											Volunteer Monitoring

W = Water S = Sediment B = Biota

Catalog of References

APHA. 1970. ***Recommended Procedures for the Examination of Sea Water and Shellfish. 4th. ed.*** **American Public Health Association, Inc. New York, NY.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, biological characterization, sampling, pathogenic organisms, toxicity/bioassay, dissolved oxygen, salinity, temperature**

Abstract

The procedures set forth in this document for the examination of sea water and shellfish are intended to describe methods applicable to water and sanitary surveys of shellfish-growing areas and to bacteriologic surveys of commercial shellfish operations. The tests included are for index organisms indicative of fecal contamination and, as such, indicate a possible danger of transmission of enteric diseases.

Bacteriologic examinations have served a definite purpose in sanitary surveys of shellfish-growing areas and have aided in the assessment of the sanitary quality of shellfish as harvested or marketed. The Fourth Edition places special emphasis on the application of the various tests for the determination of coliform and fecal coliform organisms. These tests, combined, have indicated pollution probabilities in the shellfish-growing areas and potentially dangerous contamination of the product during harvesting, washing, packing, and marketing.

Chemical and physical tests for such parameters as salinity and temperature accompany the bacteriologic test for shellfish and growing areas. Since naturally occurring biotoxins may be present at certain seasons in various geographic locations, the toxin assay methods have been inserted.
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- Materials
- Preparation of Culture Media
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- Collection of Samples
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3 PROCEDURES FOR THE BACTERIOLOGIC EXAMINATION OF SEA WATER AND SHELLFISH
- Examination of Sea Water
- Examination of Shellfish
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4 MEMBRANE FILTER METHODS FOR THE BACTERIOLOGIC EXAMINATION OF SEA WATER
- Examination of Sea Water
- Bibliography

5 BIOASSAY FOR SHELLFISH TOXINS
- Bioassay for Paralytic Shellfish Poison
- Method for the Bioassay of *Gymnodinium breve* Toxin(s) in Shellfish
- Bibliography

APPENDIX DIFFERENTIATION OF COLIFORM AND FECAL COLIFORM ORGANISMS

APHA. 1992. ***Standard Methods for the Examination of Water and Wastewater. 18th ed.*** **Washington, DC. American Public Health Association, American Water Works Association, Water Pollution Control Federation.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, biological characterization, dissolved oxygen, pH, salinity, total solids, turbidity, nutrients, metals, organics, PAHs, PCBs, pesticides, inorganics, toxicity/bioassays, pathogenic organisms**

Abstract

The procedures described in these standards are intended for the examination and analysis of waters of a wide range of quality, including water suitable for domestic or industrial supplies, surface water, groundwater, cooling or circulating water, boiler water, boiler feed water, treated and untreated municipal or industrial wastewater, and saline water. Certain methods are intended for use with sludges and sediments. An effort has been made to present methods that apply as generally as possible. Where alternative methods are necessary for samples of different composition, the basis for selecting the most appropriate method is presented as clearly as possible. The document is divided into the following major parts:

Part 1000 - Introduction
Part 2000 - Physical and Aggregate Properties
Part 3000 - Metals
Part 4000 - Inorganic Nonmetallic Constituents
Part 5000 - Aggregate Organic Constituents
Part 6000 - Individual Organic Compounds
Part 7000 - Radioactivity
Part 8000 - Toxicity
Part 9000 - Microbiological Examination
Part 10000 - Biological Examination

For each new edition, both the technical criteria for selection of methods and the formal procedures for their approval and inclusion are reviewed. The methods presented here are believed to be the best available and generally accepted procedures for the analysis of water, wastewaters, and related materials. They represent the recommendations of specialists, ratified by a large number of analysts and others of more general expertise, and as such are truly consensus standards, offering a valid and recognized basis for control and evaluation. Most of the methods included here have been endorsed by regulatory agencies.

All methods are classified as "standard" or "proposed". Methods with standard status have been studied extensively and accepted as applicable within the limits of sensitivity, precision, and accuracy given. Tentative methods are those still under investigation that have not yet been evaluated fully. They may be designated as standard in a later edition.

In order to maintain the current status of the standards new editions of the standards are published regularly at reasonably short intervals (approximately every four years for the last three editions). For this reason, the reader is advised to verify the latest edition available.
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- Metals by Atomic Absorption Spectrometry
- Metals by Cold-Vapor Atomic Absorption Spectrometry

Metals by Electrothermal Atomic Absorption Spectrometry
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Sb - Antimony
As - Arsenic
Ba - Barium
Be - Beryllium
Bi - Bismuth
Cd - Cadmium
Ca - Calcium
Cs - Cesium
Cr - Chromium
Co - Cobalt
Cu - Copper
Au - Gold
Ir - Iridium
Fe - Iron
Pb - Lead
Li - Lithium
Mg - Magnesium
Mn - Manganese
Hg - Mercury
Mo - Molybdenum
Ni - Nickel
Os - Osmium
Pd - Palladium
Pt - Platinum
K - Potassium
Re - Rhenium
Rh - Rhodium
Ru - Ruthenium
Se - Selenium
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Tl - Thallium
Th - Thorium
Tn - Tin
Ti - Titanium
V - Vanadium
Zn - Zinc

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Cl^- - Chlorine (Residual)
Cl - Chloride
ClO_2 - Chlorine Dioxide
F^- - Fluoride
H^+ - pH Value
I - Iodine
I^- - Iodide
N - Nitrogen
NH_3 - Nitrogen (Ammonia)
NO_2^- - Nitrogen (Nitrate)
NO_3^- - Nitrogen (Nitrite)
N_{org} - Nitrogen (Organic)
O - Oxygen (Dissolved)
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S_3^{2-} - Sulfite
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Identification of Aquatic Organisms

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ASTM. 1993. ***Annual Book of ASTM Standards, 1993. Water and Environmental Technology. Vol. 11.04: Pesticides; Resource Recovery; Hazardous Substances and Oil Spill Responses; Waste Management; Biological Effects.*** **Philadelphia, PA. American Society for Testing and Materials.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, toxicity/bioassay, sampling, tissue analysis, data analysis, QA/QC**

Abstract

This volume covers biological effects and other topics (including pesticides, resource recovery, hazardous substances and oil spill responses, and waste management). Under the heading of biological effects, this volume contains 70 tests, practices, and guides establishing standard procedures for assessing biological effects and environmental fate.

The following partial table of contents contains over 50 entries relevant to marine and estuarine environmental monitoring methods. Included are standard practices for the collection or sampling of benthic macroinvertebrates, zooplankton, and phytoplankton. Guides for conducting various toxicity test procedures using a variety of organisms are listed also.
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Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, organics, total organic carbon, PAHs, pesticides, PCBs, radioactivity, salinity, pathogenic organisms, grain size, dissolved oxygen, inorganics, metals, nutrients, turbidity, flow, pH, oxygen demand, data analysis, QA/QC**

Abstract:

Section 11 of the ASTM Standards addresses the standardization of methods for:

- sampling and analysis of water, waterborne materials and wastes, water-formed deposits, and fluvial sediments
- surface water hydraulics and hydraulic measurements
- the determination of the performance of materials used to modify water characteristics
- the determination of the corrosivity or deposit-forming properties of water

Volume 11.01 is the first of two volumes containing standard procedures for assessing water. It is presented in four parts:

- Terminology, Reagents, and the Reporting of Results
- Sampling and Flow Measurement
- General Properties of Water (over 20 tests and practices for assessing such properties as pH, turbidity, corrosivity, and specific gravity)
- Inorganic Constituents (includes over 70 tests and practices)

Volume 11.02 is presented in six parts:

- Organic Constituents (40 standard procedures, including general analysis methods and tests for specific procedures and oils)
- Radioactivity (20 procedures for measuring radioactivity and specific radionuclides)
- Saline and Brackish Waters, Seawaters, and Brine (over 10 tests for determining specific constituents, such as barium, iodide, bromide, and chlorine ions)
- Microbiological Examination (14 standard tests and practices)
- Water-Formed Deposits
- Water-Treatment Materials

[extracted from document]

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Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, data analysis, pH, salinity, total solids, turbidity, temperature, metals, inorganics, organics, PAHs, PCBs, pesticides, organotins, radioactivity, pathogenic organisms**

Abstract

This is a State of California regulatory document commonly referred to as the California Ocean Plan. The document specifies regulatory water quality objectives for physical, chemical, biological, bacterial, and radioactive characteristics, as well as effluent quality requirements for discharges into state waters. Toxic material limitations are set out in terms of instantaneous maximum, daily maximum, and 6-month median values. Objectives for the protection of human health are stated as 30-day average maximum concentrations and estimates of chronic toxicity are given for metals. Minimum standard monitoring procedures for discharges into ocean waters are outlined.
[compiled after review]

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Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, biological characterization, sampling, toxicity/bioassays**

Abstract

This manual provides detailed instructions for conducting short-term toxicity tests developed by the Marine Bioassay Project (MBP). The MBP was initiated in 1984 by the California State Water Resources Control Board (State Board) to design and develop sensitive measures for testing toxicity of discharges to marine waters. Species selection emphasizes use of organisms present in California. Consistent with multispecies testing procedure, the MBP has developed protocols for an alga, a fish, and two invertebrates native to California's waters.

This manual consists of five chapters, which are summarized below:

Chapter 1 described basic quality assurance and quality control (QA/QC) requirements for conducting marine toxicity tests. Test-specific QA/QC requirements for conducting marine toxicity tests are included in the individual protocols.

Chapter 2 describes an invertebrate test, the abalone larval development protocol, which is a 48-hour static exposure test. The abalone tests protocol is one of seven tests approved by the State Board in March 1990 for measuring compliance with the chronic toxicity objectives of the California Ocean Plan.

Chapter 3 contains the algal test, the giant kelp germination and growth test. This 48-hour static exposure test has also been approved for measuring compliance with the California Ocean Plan.

Chapter 4 describes a 96-hour static renewal test using a crustacean. This protocol incorporates an endpoint of mortality to juvenile mysid shrimp. Test development is being continued on a non-lethal endpoint that measures mysid growth.

Chapter 5 contains a tentative protocol for a fish species, the topsmelt. This is a 12-day static renewal test measuring embryonic development.

While this manual contains the latest versions of protocols developed by the MBP, it is anticipated that all four will undergo further improvement and modification with continued testing by the MBP and other interested laboratories. Since test acceptability requirements are based on empirical observations performed with reference toxicants, continued repetitive testing may lead to modification of these acceptability requirements. Note that individual pages describing each toxicity test protocol are titled, dated, and paginated so that periodic updates issued by the MBP can be inserted directly into the manual.
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Chesapeake Bay Program. 1991. ***Chesapeake Bay Coordinated Split Sample Program Implementation Guidelines Revision 3.*** **U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis, MD. CBP/TRS 58/91 Revision 3. EPA X 8812-0030ZN.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, sampling, QA/QC, data analysis/management**

Abstract

In 1988, the Chesapeake Bay Program's Monitoring Subcommittee identified the need to assess the comparability of the water quality data produced by the many agencies participating in the basinwide data collection programs. The Monitoring Subcommittee's Analytical Methods and Quality Assurance Workgroup recommended the implementation of a basinwide coordinated split sample program to address this programmatic need. Although individual laboratories can evaluate the performance of their own analytical operations against standard reference materials, the most complete mechanism for the evaluation of total sampling and analysis system variability is through the use of field split samples. These include both field and laboratory sources of variability.

The major objective of the Coordinated Split Sample Program (CSSP) is to establish a measure of comparability between sampling and analytical operations for water quality monitoring basinwide. A secondary objective is to evaluate the in-matrix dilution of standard EPA reference materials. These standard reference materials are analyzed in appropriate matrix, fresh to saline, and concentration level to match the sample.

This document provides specific guidance to agency managers on the implementation of the split-sample program. This guidance includes suggested protocols for sample collection, sample analysis, and for data management and analysis. The focus of the guidelines is the Chesapeake Bay Program, and includes specific information such as point of contact and telephone numbers for each geographical component of the program. However, the descriptions of protocols could easily be adapted to other locales and programs.
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Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, QA/QC, data management**

Abstract

Data management has long been recognized as an integral part of the Chesapeake Bay Program (CBP). The efforts of all CBP partner agencies to manage the resources of the Chesapeake Bay require an extensive database of known and documented quality. The data must be easily accessed for analytical and reporting purposes. A key to achieving these goals is to acquire or create common data attributes in similar or translatable formats. This plan describes the data forms and procedures for the submission, storage, and retrieval of Chesapeake Bay data at the CBP.

This data management plan describes the Chesapeake Bay Program procedures and standards to acquire, store, and access Chesapeake Bay data. The plan contains:

- data submission procedures
- quality assurance practices for the data
- database summaries
- appendices, that include:
  - data submission forms (w/completed examples)
  - data quality assurance policies and definitions
  - data dictionary and code tables

For further information or clarification pertaining to this plan, please contact the Computer Sciences Corporation database administrator at (800) 532-2281 or (410) 267-0061, or write to:

Data Base Administrator
Computer Sciences Corporation
c/o U.S. Environmental Protection Agency
Chesapeake Bay Program Office
410 Severn Avenue, Suite 109
Annapolis, MD 21403

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Chesapeake Bay Program. 1992. ***Guidance for the Analysis of Water Quality Trends in Chesapeake Bay - Draft.*** **Prepared by the Data Analysis Workgroup of the Chesapeake Bay Program Monitoring Subcommittee for the State of Maryland, Department of the Environment, Baltimore, MD.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, data analysis/management**

Abstract

Environmental data typically have characteristics such as temporal variability, spatial heterogeneity, and measurement error which present problems when these data are analyzed. Compounding these problems is the long-term nature of trend detection which often means patching together a decade or more of investigations by several principal investigators, analytical laboratories, and managing agencies.

The intent of this document is to help guide data analysis through the process of analyzing trends in water quality, so that technically sound conclusions and interpretations can be reached to support program management decisions.

This guidance is also intended to foster a consistent approach to trend analyses among the various investigators and jurisdictions involved in the monitoring and analysis of Chesapeake Bay water quality information.

The scope of this report is limited to water quality data, although many of the principles can be used for other types of information. The reader is assumed to be familiar with estuarine water quality, basic statistical analysis, and environmental management. The guidance is generic since the range of variables, data availability, and long-term management actions, make it practically impossible to provide an approach that will work for all situations. By following this guidance, tailored to the needs and availability of data for a particular situation, the analyst should be able to avoid many of the problems that can undermine such analyses, or at least understand the limits and assumptions attendant to the conclusions.

Clearly this brief guidance document is not a handbook for statistical analysis. It provides "guidance" to the analyst as to where more information may be found for those methods which are of interest on the basis of the brief description in this document. In addition to cited references, there is a separate annotated bibliography of references for detail and rigor that cannot be provided here.
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- Attachment 1: Summary of DAITS Program and Issues

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Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, data analysis/management**

Abstract

The Chesapeake Bay Program, a cooperative effort between the federal government and the state and local governments in the Chesapeake Bay watershed, provides funds to the states of Maryland and Virginia for the routine monitoring of 19 directly measured water quality parameters at 49 stations in the mainstem Bay. The Water Quality Monitoring Program began in June 1984 with stations sampled once each month during the colder late fall and winter months and twice each month in the warmer months. The three collecting organizations coordinate the sampling times of their respective stations, so that data for each sampling event, or "cruise", represent a synoptic picture of the Bay at that point in time.

This document describes the Chesapeake Bay Mainstem Water Quality Monitoring Program in general and provides detailed information about the existing Program database. The two main purposes of this document are to assist those who wish to obtain monitoring data and to provide information to data analysts about the database.

Monitoring Program sampling locations are identified in the database by station name and by latitude and longitude. At each station, a hydrographic profile is made (including water temperature, salinity, and dissolved oxygen) at approximately 1- to 2-meter intervals. Water samples for chemical analysis (e.g., nutrients and chlorophyll) are collected at surface and bottom, and two additional depths depending on the existence and location of a pycnocline (region(s) of density discontinuity in the water column). Correlative data on sea state and climate are also collected and in some cases additional optional parameters are available.

Data in the primary database consist of all directly measured parameters. For user applications, however, calculated values, such as total nitrogen and total phosphorus, are provided if the requisite components are available.

Information in this document is essential for properly manipulating (sorting, subsetting) the data. Other facts are important in designing, implementing, and interpreting data analyses. Some topics are interrelated and may be discussed in more than one place in the Guide.

This document is designed to help the potential data user formulate a data request tailored to his or her needs. It serves as a common starting point for communication between the user and the data provider at the CBP Computer Center. Potential data users should review the document and fill out and submit the included data request form prior to any communication with CBPCC staff.
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Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, sampling, QA/QC, population/community, chlorophyll, organic carbon, oxygen demand, nutrients, grain size, total solids**

Abstract

The propose of this document is to provide field and laboratory methods and associated quality control (QC) procedures and criteria that will result in the generation of data of known and documented quality for use in the Chesapeake Bay Monitoring Program. Under this document, the Participant will conduct field measurements and collect and analyze water and sediment samples for specific physical, chemical, and biological parameters that are in accordance with previous data collection efforts. These monitoring data will be used in characterizing the health of the Virginia portion of the Chesapeake Bay and its tributaries, identifying long term trends, and providing data and guidance to managers and modelers during the restoration phase.

This document includes the requirements and procedures for field measurements, field sampling, and laboratory analysis in support of the Chesapeake Bay Monitoring Program. The first chapters provide general information regarding technical and contractual requirements, and the remaining chapters have been organized so as to correspond chronologically with the field and laboratory activities performed. *[extracted from document]*

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Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, QA/QC, data analysis**

Abstract

The application of statistics to environmental pollution monitoring studies requires a knowledge of statistical analysis methods particularly well suited to pollution data. This book attempts to help fill that need by providing sampling plans, statistical tests, parameter estimation procedure techniques, and references to pertinent publications. The book is written primarily for nonstatisticians (environmental scientists, engineers, hydrologists, etc.) who have had perhaps one or two introductory statistics courses. Most of the statistical techniques discussed are relatively simple, and examples, exercises, and case studies are provided to illustrate procedures. In addition to being a general reference, this book might be used in an upper undergraduate or lower graduate level applied statistics course or as a supplemental book for such a class.

The book is logically, though not formally, divided into three parts. Chapters 1, 2, and 3 are introductory chapters. Chapters 4 through 10 discuss field sampling designs and Chapters 11 through 18 deal with a broad range of statistical analysis procedures. Some statistical techniques given here are not commonly seen in statistics books. For example, methods for handling correlated data, for detecting hot spots, and for estimating a confidence interval for the mean of a lognormal distribution. Also, Appendix B lists a computer code that estimates and tests for trends over time at one or more monitoring stations using nonparametric methods. Unfortunately, some important topics could not be included because of their complexity and the need to limit the length of the book. For example, only brief mention could be made of time series analysis using Box-Jenkins methods and of kriging techniques for estimating spatial and spatial-time patterns of pollution, although multiple references on these topics are provided. Also, no discussion of methods for assessing risks from environmental pollution could be included.
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Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling**

Abstract

The object of this handbook is to indicate and evaluate the equipment and techniques which are at present in general use for studying marine benthos, and to provide a comprehensive reference list to relevant publications. While it is primarily intended as an aid to those approaching the field for the first time, it is hoped that some sections will be of use to established workers, and that the existence of this volume may help to produce a degree of uniformity in the collection and treatment of material and in the presentation of results, which will make data from laboratories in different parts of the world more readily comparable.

This handbook deals primarily with the sampling of sediments and their fauna, from the intertidal region to the deep sea. The division into macrofauna and meiofauna has been used as convenient way of separating the fauna into two size groups, which for the most part require different sampling and processing techniques, the division being made between those animals passing, and those retained on, a sieve of about 0.5 mm mesh.

Macrofauna here comprises mainly the infauna of compacted sediments. The epifauna of hard bottoms and the active epifauna, including bottom fish, are less fully treated. Meiofauna is taken to include mainly the smaller metazoans: protozoans and organisms of bacterial size comprising the microfauna are referred to only briefly. Study of the phytobenthos required special techniques where the sampling of different habitats and measurements of primary production by benthic plants are considered.
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Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, metals, PCBs, PAHs, toxicity/bioassay**

Abstract

Methods for testing the toxicity of whole sediments are described for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. Amphipod tests (static and flow-through) start with juvenile ($\leq$ third instar) and continue up to 29 days until reproductive maturation. Flow-through tests with the midge start with the first instar larvae (<24 hours old) and continue up to 29 days through adult emergence. Data obtained from these laboratory exposures can be used to assess the effects of contaminants in sediments on survival, growth, or emergence of amphipods and midges. The methods were used to assess the potential toxicity of field-collected contaminated sediment from two sites in Waukegan Harbor, IL, an inlet of Lake Michigan contaminated with polychlorinated biphenyls (PCBs), polycyclic aromatic compounds (PACs), and metals; and a single site at Homer Lake, a small recreational lake in the agricultural region of central Illinois. Survival of both species was reduced after short-term (10- to 13-days) and long-term (29 days) exposure to contaminated sediment. In addition, sublethal effects were indicated by reduced growth of amphipods and a delay in emergence of adult midges.
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Marshack, Jon B. 1991. ***A Compilation of Water Quality Goals.*** **Staff Report. California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, organics, salinity, dissolved oxygen, radioactivity, temperature, turbidity, PAHs, PCBs, pesticides, inorganics, metals, nutrients, data analysis/ management**

Abstract

This report was developed to assist the staff of the California Regional Water Quality Boards to select water quality goals for water bodies under their jurisdictions. Recently promulgated drinking water maximum contaminated levels (MCLs) and MCL goals from U.S. EPA, new and revised health advisories and cancer risk estimated from U.S. EPA, and numerical water quality objectives from the State of California *Inland Surface Water Plan* and *Enclosed Bays and Estuaries Plan* are included.

This manual is divided into six sections:

- Selecting Water Quality Goals
- Cross Reference
- Water Quality Goals - inorganic constituents
- Water Quality Goals - organic constituents
- Footnotes
- References

Selecting Water Quality Goals describes the process by which numerical values for water quality parameters and constituents may be selected to protect beneficial uses of the ground and surface waters of California.

The *Cross Reference* provides a list of the chemical constituents and parameters for which numerical limits are contained in the *Water Quality Goals* sections. Many chemical constituents are commonly referred to by more than one name.

The next two sections contain numerical water quality goals. These two sections are each divided into four subsections, which provide numerical values protective of:

- human health and welfare
- agricultural use, health & welfare, and freshwater aquatic life
- health & aquatic life -- inland surface waters and enclosed bays and estuaries
- marine resources

Many listings in these sections are followed by footnotes in parentheses.

References for the numerical water quality goals are provided, divided by topics which correspond to column headings in the *Water Quality Goals* tables.
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Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, data management/analysis**

Abstract

A fundamental objective of the Chesapeake Bay water quality monitoring program is to detect trends or changes in the system. This is necessary to determine the effectiveness of pollution control actions as well as to detect changes that could indicate deteriorating conditions.

Environmental data typically have characteristics such as temporal variability, spatial heterogeneity, and measurement error which present problems when these data are analyzed. Compounding these problems is the long-term nature of trend detection which often means patching together a decade or more in investigations by several principal investigators, analytical laboratories, and managing agencies.

To assist in the continuing data analysis to measure progress in the Bay restoration, the Chesapeake Bay Program Monitoring Subcommittee asked its Data Analysis Workgroup to prepare this document to help guide data analysts through the process of analyzing trends in water quality data. The intent of this document is to help analysts reach technically sound conclusions and interpretations through their trend analysis that will help support management decisions. This guidance is also intended to foster a consistent approach to trend analyses among the various investigators and jurisdictions involved in the monitoring and analysis of Chesapeake Bay water quality information. This is more critical now than ever before as the various jurisdictions charges with the responsibility of restoring the Bay work together in developing management solutions. To that end, it is hoped that this report will play a role in guiding some of the analyses required to evaluate progress in the Bay restoration and provide consistent, interpretable, and useful data to water quality managers.

The scope of this report is limited to water quality data, although many of the principles can be used for other types of information. The reader is assumed to be familiar with estuarine water quality, basic statistical analysis, and environmental management. This guidance is generic since the range of variables, data availability, and long-term management actions, make it practically impossible to provide an approach that will work for all situations. By following this guidance, tailored to the needs and availability of data for a particular situation, the analyst should be able to avoid many of the problems that can undermine such analyses, or at least understand the limits and assumptions attendant to the conclusions. *[extracted from document]*

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Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, sampling**

Abstract

Recently, contaminated sediments in rivers, lakes, and oceans have become a world-wide issue. It has been shown that sediment-associated contaminants can be transported by resuspension of sediment particles, may accumulate in the food chain or affect the health of biota and water quality in aquatic environment.

Assessment of impact of contaminated sediments on aquatic environment require collection of sediment samples to adequately define the physical and chemical characteristics of the sediments, transport of sediment-associated contaminants by resuspension of sediment particles or migration through sediment pore water, and test the effects of contaminated sediments on biota.

Sediment characterization plays an important role in many projects. These projects have been carried out for a wide variety of reasons, such as testing of scientific hypotheses, survey of environmental conditions, evaluation of fish habitats, or construction involving sediment removal or displacement. Adequate and representative characterization is a function of both sample collection and analyses. No matter how much care is taken in laboratory analyses, such factors as improperly located sampling sites, collection of inadequate number of quality of samples, and inappropriate sample handling can generate false information about the sediment process.

At present, there is no comprehensive monograph on sampling of bottom and suspended sediments and sediment pore water, and on handling of recovered samples prior to physico-chemical analyses and other tests. This book was written to provide the essential background information on these subjects to those interested in defining the physical and chemical characteristics of aquatic sediments and effects of contaminated sediments on aquatic ecosystems.
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Mueller, W., and D. Smith. 1992. *Compilation of E.P.A.'s Sampling and Analytical Methods.* Edited by L.H. Keith. Lewis Publishers, Chelsea, MI.

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, metals, inorganics, organics, pesticides, PCBs, PAHs**

Abstract

There is an increasing number of analytes and corresponding methods for measuring them in the environment, and this often makes selection of the most appropriate methods difficult. The objective of this database is to help EPA contractors and other researchers to select rapidly and easily the most appropriate methods of sampling and analysis for a particular situation without the necessity of becoming an expert in the use of the methods or without searching through many volumes of published EPA methods.

The database is commercial adaption and expansion of a d-Base III database developed at EPA's Risk Reduction Engineering Laboratory. More than 650 method/analyte summaries are included in the 3-volume, printed publication or in a DOS-compatible database file on eight diskettes.

However, not all analytes are covered. While many of the semivolatile methods are covered, they are not as completely addressed as the volatile (purgeable) compounds.
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Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Sediment quality, toxicity/bioassay**

Abstract

A short account of the principles and practices of toxicity testing with aquatic plants and sediments is given. Aquatic (wetland, marsh) plants have been shown to be sensitive to toxicants in natural and synthetic sediments, and advantages and disadvantages of each type of sediment in toxicity testing are described. Toxicological studies with *Echinochola crusgalli, Sesbania macrocarpa, Spartina alterniflora* are described, but other experimental species need to be adapted for use in impact analysis and risk assessment. It is concluded, after comparison of results from seed germination, hydroponic, and sediment tests, that the latter best simulates the unique field conditions under which plants are exposed to pollutants.

This report is designed as an introduction to the subject. Its basic assumptions are that structure and functions of wetlands can be affected by toxicants in sediments and that laboratory tests can detect possible or probable injury to aquatic plant under specific circumstances. The methods given here may be modified or used directly for routine toxicity testing or for experimental studies in which environmental variables are manipulated.
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APPENDIX 6: SYNTHETIC SEDIMENTS: A TOOL FOR RESEARCH

NOAA. 1986. ***National Status and Trends Program for Marine Environmental Quality Benthic Surveillance Project: Cycle III Field Manual.*** **National Oceanic and Atmospheric Administration, Coastal Monitoring and Bioeffects Assessment Division, Office of Ocean Resources Conservation and Assessment, National Ocean Service, Silver Spring, Maryland. pp. 32. Technical Memorandum NOS OMA 28.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, QA/QC, tissue analysis**

Abstract

The Benthic Surveillance Project (BSP) is a major component of NOAA's National Status and Trends (NS&T) Program. It is a collaborative effort between the Ocean Assessment Division (OAD) of the National Ocean Service and the National Marine Fisheries Service (NMFS).

The major goals of the Project are to describe present levels of chemical contamination in surficial sediments and bottom-feeding fishes at key sites in the nation's estuaries and nearshore zone, and to determine the incidence of disease in these benthic species.

Because this is a national program conducted by scientific teams from various laboratories around the country, it is important that sample collection and processing procedures be standardized as much as possible. This manual provides detailed information on the required collection and processing procedures. It is based both on the files experience gained by NMFS personnel during Cycles I and II, and the general expertise of OAD and NMFS scientists in conducting environmental quality surveys. The protocols in this manual are followed by all Benthic Surveillance Project participants. As data from the Project are evaluated, the procedures, specified herein, will be modified and improved.
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NOAA. 1987. ***National Status and Trends Program for Marine Environmental Quality Benthic Surveillance Project: Specimen Bank Project: Field Manual.*** **National Oceanic and Atmospheric Administration, Coastal Monitoring and Bioeffects Assessment Division, Office of Ocean Resources Conservation and Assessment, National Ocean Service, Silver Spring, Maryland. pp. 43. Technical Memorandum NOS OMA 37.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, QA/QC, tissue analysis**

Abstract

In 1980, a pilot National Environmental Specimen Bank Program was established in the United States at the National Bureau of Standards (NBS), sponsored in part by the U.S. Environmental Protection Agency. Since then, other Federal agencies, including the Food and Drug Administration, Department of Agriculture, National Cancer Institute, and the National Oceanic and Atmospheric Administration (NOAA), represented by the Ocean Assessments Division, have joined in the specimen banking activities at NBS.

In fiscal year 1984, NOAA's Ocean Assessments Division initiated a new program, called the National Status and Trends (NS&T) Program, within which activities are being undertaken to quantify the current status and long-term temporal and spatial trends of key contaminant concentrations and biological indicators of contaminant effects in the nation's coastal and estuarine environments.

One of the elements of the NS&T Program is the archiving of samples for retrospective analyses. The methods of collection, preparation, and storage of samples for a specimen banking program are critical to the scientific accuracy of the analysis and comparison of these data. The methods used in the specimen banking component of NOAA's National Status and Trends Program are described in this report. Also summarized are the National Status and Trends Program specimen banking operations for its Benthic Surveillance and Mussel Watch component for fiscal years 1985, 1986, and 1987. Protocols used for preparation and storage of samples are also described in detail.
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Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, tissue analysis, organics, PAHs, PCBs**

Abstract

The Environmental Conservation (EC) Division of the Northwest and Alaska Fisheries Center conducts broad-ranging research into the nature and extent of pollution and its effects on marine and estuarine fish and their habitats. While functioning within the National Marine Fisheries Service, the EC Division maintains a strong research relationship with other units of NOAA such as the Office of Oceanography and Marine Assessment of the National Ocean Service. NOAA's National Status and Trends (NS&T) Program is a good example. For 4 years the EC Division has participated in the NS&T Program, which monitors marine environmental quality at approximately 200 sites along the nation's coastlines.

Wherever possible, standard methods are used to minimize the analytical variability among the participating laboratories. Many of these procedures, such as those for aromatic hydrocarbons and chlorinated hydrocarbons in sediments and tissues, are relatively laborious. To expedite these analyses, the EC Division's National Analytical Facility has developed a new instrumental method for the cleanup of sample extracts. The new method features (1) cleanup as effective as by former methods, (2) better precision, (3) less time required, (4) capability of monitoring the chromatographic conditions, (5) capability of being automated, and (6) less highly pure solvent required.

Through this Technical Memorandum, the new cleanup and revised extraction procedures are being made available to NS&T laboratories. A rapid, simple HPLC method, using a size-exclusion column is described. This method was developed to improve on the gravity-flow method by increasing efficiency, reducing costs, automating the analyses, and monitoring chromatographic conditions. This laboratory manual should also be useful to other federal, state, and local environmental programs which analyze for organic chemicals in sediments and organisms. These new procedures supersede Sections 7, 8, 10, and 11 of NOAA Technical Memorandum NMFS F/NWC-92 (MacLeod et al., 1985).

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MacLeod, W.D., Jr., D.W. Brown, A.J. Friedman, D.G. Burrows, O. Maynes, R.W. Pearce, C.A. Wigren, and R.G. Bogar (1985). Standard analytical procedures of the NOAA National Analytical Facility, 1985-86: extractable toxic organic compounds. Second Edition. NOAA Tech. Memo. NMFS F/NWC-92. NOAA/NMFS/NWAFC, Seattle, WA. 121 pp.

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Media in which methods can be used: ☑ Water ☑ Sediment ☐ Biota

Keywords: **Water quality, sediment quality, nutrients, metals, inorganics, organics, pesticides, PCBs, PAHs, tissue analysis, QA/QC**

Abstract

This is the third edition of the catalog of reference materials suited for use in marine science, originally compiled in 1986 for NOAA, IOC, and UNEP. The catalog lists close to 2,000 reference materials from sixteen producers and contains information about their proper use, sources, availability, and analyte concentrations. Indices are included for elements, isotopes, and organic compounds, as are cross references to CAS registry numbers, alternate names, and chemical structures of selected organic compounds. This catalog is being published independently by both NOAA and IOC/UNEP and is available from NOAA/NOS/ORCA in electronic form.
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GSR-1, Biotite Granite
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GBW 07309 - 07312, Stream Sediments
GBW 07313 Marine Sediment
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GBW 07401 - 07408, Soils
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GBW 08303, Polluted Farm Soil
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IAPSO Standard Seawater, Standard Seawater for Conductivity Measurements
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Index of Isotopes with Associated Reference Materials

Index of Organic Compounds with Associated Reference Materials

NOAA. 1993. ***Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992, Volumes I-IV.*** **National Oceanic and Atmospheric Administration, Coastal Monitoring and Bioeffects Assessment Division, Office of Ocean Resources Conservation and Assessment, National Ocean Service, Silver Spring, Maryland. NOAA Technical Memorandum NOS ORCA 71.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, depth, tides, temperature, salinity, grain size, organics, PAHs, PCBs, total organic carbon, organotins, tissue analysis, pathogenic organisms, inorganics, metals, sampling, QA/QC, bioaccumulation, data analysis**

Abstract

The quantification of environmental contaminants and their effects by the National Oceanic and Atmospheric Administration's national Status and Trends Program began in 1984. Polycyclic aromatic hydrocarbons, butyltins, polychlorinated biphenyls, DDTs and other chlorinated pesticides, trace and major elements, and a number of measures of contaminant effects are quantified in estuarine and coastal samples. There are two major monitoring components in this program, the National Benthic Surveillance Project which is responsible for quantification of contamination in fish tissue and sediments, and developing and implementing new methods to define the biological significance of environmental contamination, and the Mussel Watch Project, which monitors pollutant concentrations by quantifying contaminants in mollusk bivalves and sediments. Methods are described for sample collection, preparation, and quantification. The evolution of methods, method detection limits, and the Quality Assurance Project are also discussed.

This report consists of four volumes, of which three have been published. Volume I is not yet available. Each volume contains detailed descriptions of analytical methods and measurements as performed by the different laboratories participating in the National Status and Trends Program.

Volume II contains detailed descriptions of complementary methods used by cooperating laboratories participating in the NS&T Program for the determination of physical properties of the sampling site such as salinity and tidal horizon; ancillary parameters in sediments and tissues such as total organic carbon and percent dry weight; and histopahtological examination of tissues.

Volume III contains detailed descriptions of analytical methods used for the determination of major and trace elements in sediments and tissues by laboratories participating in the NS&T Program.

Volume IV contains detailed descriptions of the analytical methods used for the determination of trace organic compounds in sediments and tissues by laboratories participating in the NS&T Program.

The method of MacLeod *et al.* (1985) is placed first in this volume because all the NMFS and Battelle Ocean Sciences laboratories participating in the NS&T Program relied heavily upon it. Readers should note that the methods developed by MacLeod *et al.*, (1985) are no longer used by NMFS laboratories participating in the NS&T Program and <u>are not</u> to be considered NOAA protocols for the quantification of organic contaminants.

References:

MacLeod, W.D., Jr., D.W. Brown, A.J. Friedman, D.G. Burrows, O. Maynes, R.W. Pearce, C.A. Wigren, and R.G. Bogar (1985). Standard analytical procedures of the NOAA National Analytical Facility, 1985-86: extractable toxic organic compounds. Second Edition. NOAA Tech. Memo. NMFS F/NWC-92. NOAA/NMFS/NWAFC, Seattle, WA. 121 pp.

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NOAA. 1994. ***Use of Standards and Reference Materials in the Measurement of Chlorinated Hydrocarbon Residues - Chemistry Workbook.*** **Prepared by T.L. Wade and A.Y. Cantillo for the National Oceanic and Atmospheric Administration, Coastal Monitoring and Bioeffects Assessment Division, Office of Ocean Resources Conservation and Assessment, National Ocean Service, Silver Spring, Maryland. Technical Memorandum NOS ORCA 77.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, pesticides, PCBs, PAHs, tissue analysis, sampling, QA/QC**

Abstract

This document is a workbook on the use of standards and reference materials for a QA/QC program for marine pollution studies of chlorinated hydrocarbons. As part of their mission, the Group of Experts on Standards and Reference Materials (GESREM) developed this workbook for laboratories that are initiating organic contaminant analyses of environmental samples. The first sections of this workbook give details of sample collection, archival, extraction, instrumental analyses, and data reduction under proper QA/QC procedures. The last sections give examples of how the calculation and procedures are actually applied in a laboratory. This workbook was prepared under sponsorship of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO).
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List of Contributors and Reviewers

Parsons, T. R., Y. Maita, and C. Lalli. 1984. ***A Manual for Chemical and Biological Methods for Seawater Analysis.*** **1st ed. Pergamon Press, Toronto.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, nutrients, organics, total organic carbon, chlorophyll, pathogenic organisms, dissolved oxygen, sampling**

Abstract

This text is intended to serve as an introduction to the quantitative analysis of seawater. Biological and chemical techniques are described in detail and these are believed to be among those most often used by biological oceanographers. In general, the techniques require a minimum of prior professional training; in addition, methods requiring the use of very expensive equipment have been avoided. As such, it is intended that the techniques will be useful to students, environmentalists and engineers as well as to some other oceanographic disciplines.

The described techniques can generally be employed with a minimum outlay of capital equipment. This the use of a spectrophotometer, fluorometer, microscopes, Coulter Counter, and scintillation counter will cover most of the methods. The use of more sophisticated equipment, such as gas/liquid chromatograms, atomic absorption analyzers, and mass spectrometers, is not described since the operation of these pieces of equipment is usually specialized and well described by company brochures. In addition, however, some techniques are not described because there is equipment available which specifically measures the property without requiring further detailed explanations. Such equipment includes salinometers, light meters, and Autoanalyzers® (the latter being extensively adapted for nutrient analyses using basic colorimetric techniques which are reproduced here). In other cases, the measurement of a property may still be controversial and also require more expensive equipment; this appears to be the case with dissolved organic carbon (DOC).

Methods given in this text are described in terms of procedures and not in terms of interpretation of results. The latter is up to the individual investigator; in some methods, reference material quoted may assist in the interpretation of results.
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Plumb, R. H., Jr. 1981. ***Procedures for Handling and Chemical Analysis of Sediment and Water Samples.*** **Prepared by Great Lakes Laboratory, State University College at Buffalo, Buffalo, NY., for U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. Published by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. Technical Report EPA/CD-81-1. (NTIS: PB84-191048).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, grain size, pH, total solids, inorganics, organics, metals, nutrients, pesticides, PAHs, oxygen demand**

Abstract

The purpose of this handbook is to provide state-of-the-art guidance on the subjects of sampling, preservation, and analysis of dredged and fill material.

The information is presented in one of three major sections:

- a discussion of rationale for project managers
- a step-by-step protocol for sample handling and each test procedure
- a listing of analytical techniques, including sample pretreatment procedures

The purpose of the first section is to point out to a project director or project manager the types of trade-offs that have to be considered in developing an acceptable sampling program. If a project director is aware of the kind of information provided by use of each piece of equipment or testing procedure, and the present limitations of this information, he can then make a decision to use the equipment and/or procedures that are most suited to his particular project.

The second section of the handbook provides guidance to the laboratory and field personnel that will be implementing the sampling program. This includes a discussion of the types of sampling equipment to be used and when to use each type, a step-by-step description of the three general chemical tests considered, along with the required method of sample handling and a general quality control program, beginning with sample collection. The three chemical tests that are described are:

- a short-term water leaching test (the standard elutriate test)
- a strong acid digest or an organic solvent extract (bulk analysis)
- an elemental distribution test (sediment fractionation)

The third section presents for laboratory personnel a series of analytical techniques, including sample preparation, were required, for 44 parameters. Since the purpose of this manual was not to develop new methods, the methods are generally those found in *Standard Methods,* ASTM, and EPA manuals. The listed procedures are considered most appropriate for general use; it is recommended that they be utilized when it is decided to analyze samples for that particular constituent.
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PTI Environmental Services. 1989. ***Data Validation Guidance Manual for Selected Sediment Variables, Edited Draft Report.*** **Prepared by PTI Environmental Services for the Washington Department of Ecology, Sediment Management Unit, Olympia, WA.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, QA/QC, sampling, grain size, total solids, total organic carbon, metals, organics, toxicity/bioassays, population/community, bioaccumulation, data analysis/management**

Abstract

Data validation is the process by which a sample, measurement method, or data point is deemed useful for a specific purpose. The objective of the *Data Validation Guidance Manual for Selected Sediment Variables* is to provide a thorough description of the data quality review process, and a standardized format for assessing data accuracy, precision, completeness, and usability. This document is designed to be used by Washington Department of Ecology staff to assess the quality of sediment data collected throughout Puget Sound to determine if they are suitable for inclusion in Ecology's sediment quality values database.

Environmental variables in Puget Sound are measured by a wide variety of organizations, including government agencies, universities, and private institutions. However, comparisons of results from different studies frequently are limited because different methods are used to measure the same variable(s). The ability to compare data among different studies is highly desirable for developing a comprehensive management strategy for Puget Sound. A standardized, rigorous review process is essential to ensuring the quality and integrity of the sediment quality values database.

The approach to describing the data review process is organized by the major categories of analytes (i.e., conventional variables, metals, semivolatile organic compounds, and volatile organic compounds (VOC), bioaccumulation, bioassays, and benthic infauna). These major categories represent classes of chemical or biological variables that have similar analytical requirements. Only chemical and biological variables commonly used to characterize the quality of Puget Sound sediments are included in the guidance manual. The discussion of the data validation process if further focused by emphasizing the analytical techniques that best address the data quality requirements of the database or that have been recommended by the major programs that address data quality in Puget Sound [PSDDA, PSEP, Puget Sound Ambient Monitoring Program (PSAMP)]. Screening techniques, which generally have higher detection limits and less stringent precision and accuracy requirements, are not addressed in this manual.

General guidance on QA during field sampling is provided in Section 2. Section 3 summarized general data collection and reporting requirements. Sections 4 through 10 contain specific QA/QC requirements, evaluation procedures, and recommended actions for data on conventional variables, metals, semivolatile organic compounds, VOC, bioaccumulation, bioassays, and benthic community structure. A list of acronyms and a glossary are included in Appendix A to clarify terms used throughout the manual. *[extracted from document]*

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APPENDIX C: TREATMENT OF CHEMISTRY DATA: CALCULATIONS AND QUALIFIER CODES

PTI Environmental Services. 1989. ***Puget Sound Dredged Disposal Analysis Guidance Manual; Data Quality Evaluation for Proposed Dredged Material Disposal Projects.*** **Prepared by PTI Environmental Services for the Washington Department of Ecology, Sediment Management Unit, Olympia, WA.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, sampling, QA/QC, data analysis/management, grain size, oxygen demand, pH, metals, organics, pesticides, PCBs, PAHs, toxicity/bioassay, bioaccumulation**

Abstract

This manual provides guidance for the review of data submitted to the U.S. Army Corps of Engineers, Seattle District (Corps) by applicants for dredging permits. This data review process is termed QA1. The purpose of QA1, as described in the Puget Sound Dredged Disposal Analysis (PSDDA) management Plan (PSDDA 1988a), is to establish if data are acceptable for determining the suitability of sediments for unconfined, open-water disposal. The handling, organization, and synthesis of sediment data described here are designed to streamline the data review process. The goal of QA1 is to ensure that sediment data from proposed projects have received adequate quality assurance (QA) review prior to a determination of suitability. To meet this need, field and laboratory QA information relevant to PSDDA data review is compiled for each project by the field teams and analytical laboratories responsible for sample collection and testing.

The sequence of major QA activities associated with a project can be divided into four phases:

- project planning
- data collection
- data quality review
- data use

The process of reviewing chemical and biological data to determine if they are suitable for incorporation in the sediment quality values database is termed QA2. QA2 is described in detail in the *Data Validation Guidance Manual for Selected Sediment Variables* (PTI 1989). QA2 will follow QA1 to establish if the data are acceptable for incorporation into the sediment quality values database maintained by the Washington Department of Ecology.
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Puget Sound Estuary Program. 1991. *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound.* U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle WA.

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, sampling, QA/QC, pH, grain size, salinity, total solids, turbidity, temperature, nutrients, metals, dissolved oxygen, oxygen demand, organics, PAHs, PCBs, toxicity/bioassays, population/ community, pathogenic organisms, data analysis/management**

Abstract

This document presents recommended protocols for measuring selected environmental variables in Puget Sound. The objective is to encourage most investigators conducting studies such as monitoring programs, baseline surveys, and intensive investigations to use equivalent methods whenever possible. If this objective is achieved, most data from future sampling programs should be comparable among studies. It is recognized that alternative methods exist for many of the variables considered in this document and that those methods may produce data of equal or better quality than do the recommended methods. It is also recognized that future research or other circumstances may require modification or replacement of one or more of the recommended methods.

The recommendations in this document pertain primarily to the methodological specifications required to measure the selected environmental variables. Recommendations for study design and data analysis generally were not included because those considerations vary widely depending upon the objectives of individual studies.

Twelve groups of variables were identified as having the highest priority for protocol development or documentation. They include:

- station positioning considerations
- conventional sediment variables
- concentrations of organic compounds in sediment and tissue
- concentrations of metals in sediment and tissue
- sediment bioassays
- characteristics of soft-bottom demersal fish assemblages
- concentrations of chemicals in marine mammal tissue
- pathological conditions in fish livers
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Protocols to evaluate each of the environmental variables are prepared and are available as stand-alone reports. However, for the convenience of the user, all protocols are also available in a loose-leaf binder format. For conciseness in this bibliography, all protocols are presented as a single document.

In addition to the recommended protocols for each group of variables, a section on general quality assurance/quality control (QA/QC) procedures is included in this document. That section identifies the major QA/QC concerns that should be addressed when collecting and analyzing environmental samples from Puget Sound.

The formats for most protocols are similar to facilitate use of the entire document. The following major sections are presented for most protocols: **Use and Limitations**—Describes what a variable measures and major limitations to the use of the variable. **Field Procedures**—Describes container type, special cleaning procedures, collection techniques, sample quantity, preservation technique, storage conditions, and maximum holding time. **Laboratory Procedures**—Describes analytical procedures (or provides citations), laboratory equipment, sources of error, and QA/QC specifications. **Data Reporting Requirements**—Describes the kinds of data that the analytical laboratory should report and the units in which the data should be reported.
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San Francisco Estuary Institute. 1994. ***Quality Assurance Project Plan for the Regional Monitoring Program for Toxic Contaminants in the San Francisco Estuary.*** **San Francisco Estuary Institute, Richmond, CA. pp. 57.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, QA/QC, organics, inorganics, metals, bioaccumulation, toxicity/bioassay, salinity, nutrients, chlorophyll, temperature, pH, dissolved oxygen, total organic carbon, pesticides, PAHs, PCBs, organotins, population/community**

Abstract

A regional monitoring program for toxic contaminants in the San Francisco Estuary has been established by the San Francisco Bay Regional Water Quality Control Board. The objectives are to obtain data describing trace concentrations of toxic elements and organics within the estuary, to determine seasonal and annual trends in water quality, and to develop a database to determine long-term trends in concentrations of toxic contaminants in water and sediments.

This quality assurance project plan details the methods for the collection and analysis of water, sediment, and biological samples, including the collection and deployment of uncontaminated bivalves used for bioaccumulation studies, sampling equipment, transport of samples to analytical laboratories, sample holding times, preservation of samples until analyzed, analytical equipment, analysis of samples, storage of archived samples, and proper disposal of samples after analysis.

Data quality objectives, including, precision, accuracy, completeness, detection limits, frequency of quality control sampling, acceptance criteria, and corrective actions are summarized for water, sediment, and tissue analyses.

Analytical procedures are summarized with reference to peer-reviewed publications. An extensive list of references detailing these trace analytical methods for metals and organics is provided.
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San Francisco Estuary Project. 1991. ***Quality Assurance in Environmental Analysis Applied to the San Francisco Estuary.*** **Prepared by the Aquatic Habitat Institute for the San Francisco Estuary Project, Oakland, CA. pp. 72.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, QA/QC, sampling, data management**

Abstract

This report provides an overview of the key concepts of quality assurance (QA) as well as background material and definitions required for an effective discussion of QA. The report also discusses historical problems associated with environmental chemical analysis of elemental and organic contaminants, and highlights the fact that such problems arise as much from rapid advances in analytical methodology as from inadequate QA.

The report presents an outline QA program that might be applied to environmental analysis or monitoring of the San Francisco Estuary and which may be applied to other estuaries. The report does not provide a single or specific approach to quality assurance. But in view of the requirements to meet a variety of data quality objectives, the report provides a reasonably comprehensive listing of the elements of quality assurance as a part of a coherent, estuary-wide monitoring program and as it would apply to collecting, processing, and analyzing samples.

The report includes summaries of QA programs currently applied in the San Francisco Estuary for a number of contaminants of concern. The appendix contains information on existing QA programs employed in monitoring programs across the U.S., including contact names, addresses, and telephone numbers of personnel in charge of or involved in each QA program.
[extracted from document]

Contact: (510) 231-9539

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State of Maine Department of Environmental Protection. 1987. ***Methods for Biological Sampling and Analysis of Maine's Waters.*** **State of Maine Department of Environmental Protection, Augusta, ME. pp. 19.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, population/community, data analysis**

Abstract

The biological classification of Maine's inland waters was authorized by the Maine State Legislature with the passage of M.R.S.A. 39 Public Law Chapter 698 - The Classification System for Maine Waters (April, 1986). This law states that it is the State's objective "to restore and maintain the chemical, physical and biological integrity" of its waters, and establishes a water quality classification system to enable the State to manage its waters so as to protect their quality. The classification system further establishes minimum standards for each class, which are based on designated use, and related characteristics of those uses, for each class of water.

The Department of Environmental Protection, has collected a large, standardized database consisting of benthic macroinvertebrate samples from above and below all significant licensed discharges in the State, as well as from some relatively unperturbed areas. These sampling locations were chosen to represent the range of water quality conditions in the State. This information is necessary in order to develop criteria (numerical and character-related) which are specific to the natural biotic community potential of the State of Maine.

The sampling locations were also selected to provide information on the presumed worst case condition of all river and stream reaches known to be significantly affected by human activity, in order to assign classifications to those reaches. Thus, the benthic macroinvertebrate data collected to date are intended to serve two purposes:

- generation of qualitative and quantitative biological classification criteria specific to the sampling protocol adopted by the Department

- assignment of reach by reach attainment of biological class, using the presumed worst case location within the reach, and based upon protocol and criteria developed through analysis of the entire data set

This manual sets forth the standardized practices and procedures which will be used by the Department to acquire data to fulfill these two purposes.
[extracted from document]

Contact: (207) 289-3901

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Texas Parks and Wildlife Department. 1989. ***Commercial Harvest Field Operations Manual.*** **Texas Parks and Wildlife Department, Fisheries and Wildlife Division, Coastal Fisheries Branch, Austin, TX.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, data management, population/community**

Abstract

The Texas Parks and Wildlife Department (TPWD) and the National Marine Fisheries Service (NMFS) are responsible for gathering information on the commercial landings of seafood in Texas. The Texas code requires that all licensed seafood dealers report all seafood purchases on a monthly basis either to TPWD or NMFS. This manual specifies the data collection procedures and the duties of the TPWD agents in compiling and maintaining accurate marine landings data.

Instructions for completing the monthly reports, example forms and with data codes, and lists of licensed dealers and species codes are included.
[compiled after review]

Contact: (512) 389-4800

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Texas Parks and Wildlife Department. 1993. ***Marine Resource Monitoring Operations Manual.*** **Texas Parks and Wildlife Department, Fisheries and Wildlife Division, Coastal Fisheries Branch, Austin, TX.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, data management, QA/QC, population/ community**

Abstract

This manual is designed for use by Texas Parks and Wildlife personnel who are responsible for and who participate in finfish and shellfish monitoring programs. Specific operating procedures for bag seines, trawls, oyster dredges, beach seines, and gill nets are presented. The goals of the monitoring program are to provide statistically reliable long-term trend information on relative abundance, catch-per-effort, size, and species composition of both finfish and shellfish.

Procedures for sample site selection, sampling, tag and release studies, and data entry are described in detail. Further data analysis and management procedures for editing and computer entry of field sampling data are also included.

This manual is updated annually and contains procedures for special studies not included in the annual resource monitoring programs. Special studies included in this edition include fish kill assessments, a bottom longline study, and a specific area study to determine the presence and abundance of biota within the Rio Grande River.
[compiled after review]

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Texas Parks and Wildlife Department. 1993. ***Marine Sport Harvest Monitoring Operations Manual.*** **Texas Parks and Wildlife Department, Fisheries and Wildlife Division, Coastal Fisheries Branch, Austin, TX.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, data management**

Abstract

This manual is prepared by the Texas Parks and Wildlife Department as a procedures manual for Department personnel for the routine monitoring of marine resource landings within the bay systems and along the Gulf of Mexico. Estimates of total catch, catch per unit effort, and size composition by species are tabulated from launch site and catch inspections, and interviews with private-boat and party-boat sport fishermen. This monitoring effort is designed to assist ecosystem and fishery managers in effectively regulating harvests.

Specific and detailed procedures are presented on topics such as sport fisherman interviews, boat access site inspections and data submission and editing. Examples of field monitoring documents and instructions on how they are to be completed are included.

This manual is updated annually.
[compiled after review]

Contact: (512) 389-4800

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6 HISTORY OF PROCEDURES -- ORIGINAL DESIGN

7 HISTORY OF PROCEDURES -- CURRENT DESIGN

Texas Water Commission. 1993. ***Water Quality Monitoring Procedures Manual.*** **Water Quality Monitoring Team, Texas Water Commission, Austin, TX. pp. 262. Draft.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, QA/QC, sampling, pH, dissolved oxygen, depth, temperature, flow, salinity, turbidity, metals, organics, population/community, pathogenic organisms, data management**

Abstract

This document provides a single source of information describing procedures used by Texas Water Commission personnel in the collection of surface water quality data. Procedures include sampling instrument calibration and maintenance, field sampling of physical parameters, fecal coliform, benthic biota, plankton, nekton and macrophytes, and the collection of water samples for analysis of metals and organics.

This manual also documents the quality assurance procedures used to demonstrate that surface water quality data collected and analyzed by Texas Water Commission personnel are of known and adequate quality. Data management procedures are also outlined and sample data forms are included. Appendices include examples of field and laboratory data forms, and parameter codes for data reporting.

This manual is updated annually by the Texas Water Commission.
[extracted from document]

Contact: (512) 239-1000

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USACE. 1991. ***Assessing Bioaccumulation in Aquatic Organisms Exposed to Contaminated Sediments.*** **Prepared by J. Clarke and V. McFarland, U.S. Army Corps of Engineers, Waterways Experiment Station, Environmental Laboratory, Vicksburg, MS. pp. 82. Miscellaneous Paper D-91-2.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Sediment quality, bioaccumulation, data analysis**

Abstract

The purpose of this paper is to provide a working document for Corps regulators and others involved in the environmental assessment of impacts on the aquatic environment from dredging operations and dredged material placement. Emphasis is placed on explanation of basic concepts concerning, and factors influencing, sediment contaminant bioaccumulation and bioavailability. The paper presents several numerical methods for assessing bioaccumulation, including a simple method for estimating theoretical bioaccumulation potential from sediment chemistry for neutral organic chemicals. Methods are also given for projecting contaminant concentrations in organism tissues when steady state is achieved, based on laboratory or field exposures to contaminated sediments. These assessments are presented in the context of the U.S. Environmental Protection Agency's tiered testing approach for dredged material evaluation. The various numerical methods for bioaccumulation assessment are illustrated and compared using step-by-step example calculations with hypothetical and actual data.
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Contact: (601) 634-2571

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USAEWES. 1989. ***Quality Assurance Guidelines for Organic Analysis.*** **U.S. Army Corps of Engineers, Environmental Laboratory, Waterways Experiment Station, Vicksburg, MS. Technical Report EL-89-18.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, QA/QC, sampling, organics, PAHs, PCBs, pesticides, data analysis/management**

Abstract

The U.S. Army Corps of Engineers has a fundamental responsibility to produce analytical data that are precise and accurate and meet environmental regulations imposed by the Clean Water Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation and Recovery Act, the Superfund Amendments and Reauthorization Act, the Safe Drinking Water Act, and the Toxic Substances Control Act. Numerous analytical methods for organic analysis are promulgated to provide the same basic information with only slight variations in procedures.

This report was written to provide general quality assurance guidelines for organic analysis with specific quality assurance/quality control requirements for the various methods This report summarized the most commonly used organic analysis procedures and reference sources. The sequence of events involved with sample analysis is presented from sample handling in the field to the final reporting of data. Quality assurance/quality control procedures are recommended for every step in the analytical process. Sampling plans, with respect to numbers of samples, site locations, and sampling procedures are beyond the scope of this report.
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Aromatic Volatile Organics	8020
Base Neutral and Acid Extractable Compounds by GC/MS	625
Semivolatile Organics by Capillary Column GC/MS	8270
Organochlorine Pesticides and Polychlorinated Biphenyls	608
Organochlorine Pesticides and PCBs	8080
Chlorinated Herbicides	8150
Polynuclear Aromatic Hydrocarbons	8100

U.S. EPA. 1978. ***Environmental Monitoring Series: Quality Assurance Guidelines for Biological Testing.*** **U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Las Vegas, NV. pp. 475. EPA 600/4-78-043. (NTIS: PB78-285369).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, toxicity/bioassays, QA/QC**

Abstract

This guideline document was prepared to address the need for a manual of quality assurance practices aimed specifically at biological testing. These guidelines draw from the good practices published for analytical and clinical laboratories, and incorporate observations made in a number of U.S. EPA laboratories, contractor laboratories, and biological research laboratories in general. As quality assurance aspects of biological testing depend on the particular test systems being used, these guidelines cover the general aspects of quality assurance, and then devote whole, separate sections to field research, aquatic bioassay, microbiologic assay, and mammalian bioassay. Hopefully, attention to the principles presented in this document will assist in improving the validity and integrity of the data generated by biological testing. *[copied from document]*

Contact (702) 798-2100

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U.S. EPA. 1978. ***Microbiological Methods for Monitoring the Environment - Water and Wastes.*** **Edited by: R.H. Bordner, J.A. Winter, and P.V. Scarpino. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, OH. pp. 337. EPA 600/8-78-017. (NTIS: PB-290329).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, sampling, pathogenic organisms, QA/QC**

Abstract

This EPA manual provides uniform laboratory and field methods for microbiological analyses of the environment. The analytical methods are standardized procedures recommended for use in enforcement, monitoring, and research.

The environmental areas covered include:

- all waters – fresh, estuarine, marine, shellfish-growing, agricultural, ground, surface, finished, recreational, and industrial processing
- all wastewaters of microbiological concern – domestic waste effluents; industrial wastes such as food, dairy, meat, tanning, sugar, textile, pulp, and paper; shellfish processing; and agricultural wastes such as feedlot and irrigation runoff
- other areas of the environment – air, sediments, soils, sludges, oils, leachates, vegetation, etc.

This manual is intended for use by the supervisor or analyst who may be a professional microbiologist, a technician, chemist, engineer, or plant operator. Regardless of other skills, the supervisor and analyst should have received at least two weeks training in each parameter from a federal or state agency or from a university. To assist the new analyst, Part II has been prepared as a basic discussion on laboratory operations and for general guidance to permit use of the manual by those required to do microbiological analyses. The trained analyst will be familiar and knowledgeable of most of these techniques. The analytical procedures in Part III are written in a stepwise manner so that the manual can be used both at bench level and as a reference book. Part IV emphasizes the important, but often neglected need for quality control in microbiological analyses, while Part V describes general considerations for laboratory management.
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Contact: (513) 569-7562

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U.S. EPA. 1978. ***Phytoplankton Sampling in Quantitative Baseline and Monitoring Programs.*** **U.S. EPA, Office of Research and Development, Corvallis Environmental Research Laboratory, Newport, OR. EPA 600/3-78-025. (NTIS: PB78-279644).**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, population/community, chlorophyll, data analysis**

Abstract

Baseline and monitoring surveys of estuarine, coastal, and ocean waters have been widely employed as a means of obtaining biological and ancillary data needed in the assessing environmental impacts of various human activities. In view of their critical role in the food web and productivity of marine waters and of their rapid response to environmental perturbations, phytoplankton should be included in any survey designed to measure environmental impact.

An overview of phytoplankton sampling and analysis methods as they apply to quantitative baseline and monitoring surveys is provided. A need for inclusion of a preliminary field survey of the area under investigation and of flexibility in sampling design is stressed. An extensive bibliography pertinent to phytoplankton sampling and analysis is included in the report.

The report is intended primarily for the agency personnel requesting proposals and for the survey designer, rather than for the practicing phytoplanktologists.
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U.S. EPA. 1979. ***Handbook for Analytical Quality Control in Water and Wastewater Laboratories.*** **U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, OH. EPA-600/4-79-019. (NTIS: PB79-297451).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, QA/QC, pH, salinity, turbidity, sampling, organics, radioactivity, pathogenic organisms, toxicity/bioassay**

Abstract

This handbook is addressed to laboratory directors, leaders of field investigations, and other personnel who bear responsibility for water and wastewater data. Subject matter of the handbook is concerned primarily with quality control (QC) for chemical and biological tests and measurements. Chapters are also included on QC aspects of sampling, microbiology, biology, radiochemistry, and safety as they relate to water and wastewater pollution control. Sufficient information is offered to allow the reader to inaugurate or reinforce programs of analytical QC that emphasize early recognition, prevention, and correction of factors leading to breakdowns in the validity of water and wastewater pollution control data.
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U.S. EPA. 1983. ***Methods for Chemical Analysis of Water and Wastes. 3rd. ed.*** **U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH. EPA 600/4-79-020. (NTIS: PB84-128677).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, pH, turbidity, temperature, total solids, nutrients, metals, organics, inorganics, total organic carbon, dissolved oxygen, oxygen demand**

Abstract

This manual provides test procedures approved for the monitoring of water supplies, waste discharges, and ambient waters, under the Safe Drinking Water Act, the National Pollutant Discharge Elimination System, and Ambient Monitoring Requirements of Section 106 and 208 of Public Law 92-500. The test methods have been selected to meet the needs of federal legislation and to provide guidance to laboratories engaged in the protection of human health and the aquatic environment.

This third edition of "Methods for Chemical Analysis of Water and Wastes" contains the chemical analytical procedures used in U.S. Environmental Protection Agency (EPA) laboratories for the examination of ground and surface waters, domestic and industrial waste effluents, and treatment process samples. Except where noted under "Scope and Application", the methods are applicable to both water and wastewaters, both fresh and saline water samples. The manual provides test procedures for the measurement of physical, inorganic, and selected organic constituents and parameters. The methods were chosen through the combined efforts of the EPA Regional Quality Assurance Coordinators, the staff of the Physical and Chemical Methods Branch, Environmental Monitoring and Support Laboratory, and other senior chemists in both federal and state laboratories. Method selection was based on the following criteria:

- the method should measure the desired property or constituent with precision, accuracy, and specificity sufficient to meet the needs of EPA, in the presence of the interfering materials encountered in water and waste samples
- the procedure should utilize the equipment and skills available in modern laboratories
- the selected method is in use in many laboratories or has been sufficiently tested to establish its validity
- the method should be rapid enough to permit routine use for the examination of a large number of samples

This manual is a basic reference for monitoring water and wastes in compliance with the requirements of the Federal Water Pollution Control Act Amendments of 1972. Although other test procedures may be used, as provided in the Federal Register issue of October 16, 1973 (38FR 28758) and in subsequent amendments, the methods described in this manual will be used by the Environmental Protection Agency in determining compliance with applicable water and effluent standard established by the Agency. *[extracted from document]*

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U.S. EPA. 1985. ***Bioaccumulation Monitoring Guidance: 3. Recommended Analytical Detection Limits.*** **U.S. Environmental Protection Agency, Office of Water, Washington, DC. pp. 23. EPA 503/6-90-001.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, metals, organics, bioaccumulation, tissue analysis, data analysis**

Abstract

The accumulation of toxic substances in marine organisms that may lead to adverse biological effect or affect commercial or recreational fisheries is one of the major concerns in the 301(h) program related to evaluating the effects of sewage discharges into marine and estuarine waters. Evaluation of differences between body burdens in organisms from relatively uncontaminated reference areas and those from contaminated estuarine and marine environments potentially impacted by the discharge is an important part of bioaccumulation studies. Such comparisons will generally require data that are reliable at low part per billion concentrations. Therefore, low but practically attainable detection limits are a minimum requirement to ensure the usefulness of bioaccumulation monitoring data.

This report reviews the factors that influence target pollutant detection limits and recommends minimum detection limits for bioaccumulation studies. Although this report is not designed to address specific analytical protocols, it serves as a companion document to the recommended analytical protocols in the Bioaccumulation Monitoring Guidance series.

This report is one element of the Bioaccumulation Monitoring Guidance Series. The purpose of this series is to provide Guidance for monitoring of priority pollutant residues in tissues of resident marine organisms. These guidance documents were prepared for the 301(h) sewage discharge permit program under the U.S. EPA Office of Marine and Estuarine Protection, Marine Operations Division. Two kinds of monitoring guidance are provided in this series: recommendations for sampling and analysis designs and aids for interpretation of monitoring data.

Although these guidance documents were prepared specifically for monitoring of sewage discharges under the 301(h) program, their potential use extends to assessment and monitoring of bioaccumulation resulting from other kinds of pollutant discharges into marine and estuarine environments.
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U.S. EPA. 1985. ***Summary of U.S. EPA-Approved Methods, Standard Methods, and Other Guidance for 301(h) Monitoring Variables.*** **U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, DC 20460. pp. 16. EPA 503/4-90-002.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, pH, temperature, turbidity, total solids, dissolved oxygen, grain size, nutrients, metals, organics, inorganics, bioaccumulation, chlorophyll, pathogenic organisms, oxygen demand, PAHs, PCBs, population/community**

Abstract

Monitoring programs for 301(h) dischargers should provide data with which to evaluate the impact of the modified discharge on marine biota, demonstrate compliance with applicable water quality standards, and measure toxic substances in the discharge. Thirty-two biological, sediment, and water quality variables may be included in 301(h) monitoring programs to provide such data. The biological and sediment variables are applicable to samples collected from the receiving environment. The water quality variables are applicable to samples collected from both effluent and receiving water.

Collection of high quality data that are comparable among dischargers requires that analytical methods for each monitoring variable follow established protocols. Available methods for each of the 32 variables are discussed. Methods are divided into three categories: U.S. EPA methods, standard methods, and additional methods available in the scientific literature. U.S. EPA methods are divided further into those that have been approved by the agency, those that have been suggested but not approved, and those for which there is an agency guidance document. Standard methods refer exclusively to American Public Health Association *Standard Methods* (i.e., APHA 1985). Additional methods are found in a variety of documents.
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U.S. EPA. 1985. ***Test Methods for*** **Escherichia coli** ***and*** **Enterococci** ***in Water by the Membrane Filter Procedure.*** **U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH. pp. 30. EPA 600/4-85/076. (NTIS: PB86-158052).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, pathogenic organisms**

Abstract

The methods described in this report can be used to measure the bacteriological densities of *E. coli* and enterococci in ambient waters. A direct relationship between the density of enterococci and *E. coli* in water and the occurrence of swimming-associated gastronenteritis has been establish through epidemiological studies of marine and freshwater bathing beaches. These studies have led to the development of criteria which can be used to establish recreational water standards based on recognized health effects-water quality relationships.
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Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, inorganics, organics, pesticides, PCBs, PAHs, metals, sampling, QA/QC, data analysis**

Abstract

The three analytical methods in this document have been designed to be consistent with probable uses of 301(h) monitoring data. Comparison of sediment contaminant concentrations from contaminated and relatively uncontaminated areas often require sensitive analytical techniques for a wide range of chemically diverse pollutants. The recommended 301(h) procedures allow for a sensitive analyses of the target compounds with a reasonable amount of laboratory effort.

The first method is designed to determine the concentrations of semivolatile priority pollutants listed under Section 301(h) of the Clean Water Act. The procedures can achieve detection limits in the low parts per billion range and are appropriate to detect and monitor differences between sediments from relatively uncontaminated reference areas and those from contaminated estuarine and marine environments.

The second method outlines the analyses of 301(h) volatile organic priority pollutants. Detection limits of these analytical procedures are dependent upon the extent of interference from other target and nontarget analytes present in the sample matrix, and the approximate range is from 5 - 10 parts per billion.

The third method is an analytical procedure for the determination of 301(h) priority pollutant metal and metallic concentrations in sediments and dredged material. These elements include antimony, arsenic, beryllium, cadmium, chromium, copper, led, mercury, nickel, selenium, silver, thallium, and zinc. The method involves wet oxidation (and digestion) process. The detection limits vary depending upon the target analyte, the method of detection, and instrument sensitivity. Typical detection limits for each metal and method are listed.

These 301(h) methods have been assembled according to guidelines for EMSL (Environmental Monitoring and Support Laboratory, Cincinnati) analytical methods (as specified in EPA-600/8-83-020). *[extracted from document]*

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Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, organics, inorganics, pesticides, PCBs, PAHs, metals, bioaccumulation, tissue analysis, sampling, QA/QC, data analysis**

Abstract

This report is one element of the Bioaccumulation Monitoring Guidance Series. The purpose of this series is to provide guidance for monitoring of priority pollutant residues in tissues of estuarine and marine organisms. These guidance documents were prepared for the sewage discharge program of Section 301(h) of the Clean Water Act under the U.S. EPA Office of Marine and Estuarine Protection, Marine Operations Division. Two kinds of monitoring guidance are provided in this series; recommendations for sampling and analysis designs, and aids for interpretation of monitoring data.

The three analytical methods in this document have been designed to be consistent with probable uses of 301(h) bioaccumulation monitoring data. Comparison of tissue contaminant concentrations from contaminated and relatively uncontaminated areas and estimation of the potential health effects of bioaccumulated substances often require sensitive analytical techniques for a wide range of chemically diverse pollutants. The recommended 301(h) procedures allow for a sensitive analyses of the target with a reasonable amount of laboratory effort.

These procedures are applicable when low part per billion detection limits are required to monitor differences between body burdens in organism from relatively uncontaminated reference sites and from impacted estuarine and marine environments. The procedures are also applicable when low detection limits are required for the estimation of potential health effects of bioaccumulated substances. However, detection limits for all analytes of interest, especially volatile organics, cannot be predetermined because of the probability of interference in the sample matrices, varying instrumental sensitivity, or differing methods of detection.

It should be recognized that the design of a monitoring program reflects the site-specific characteristics of the pollutant discharge and the receiving environment. Thus, site-specific considerations may lead to a modification of the generic recommendations herein. Finally, although these guidance documents were prepared specifically for monitoring of sewage discharges under the 301(h) program, their potential use extends to assessment and monitoring of bioaccumulation resulting from other kinds of pollutant discharges into marine and estuarine environments.

These methods have been assembled according to guidelines for EMSL (Environmental Monitoring and Support Laboratory, Cincinnati) analytical methods (as specified in EPA-600/8-83-020).
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U.S. EPA. 1986. *Quality Criteria for Water 1986.* U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA 440/5-86-001. (NTIS: PB87-226759).

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, dissolved oxygen, pH, salinity, temperature, total solids, turbidity, organics, inorganics, metals, PAHs, PCBs, nutrients, pesticides**

Abstract

Section 304 (a) (1) of the Clean Water Act (33 U.S.C. 1314 (a) (1)) requires the Environmental Protection Agency (EPA) to publish and periodically update ambient water quality criteria. These criteria are to accurately reflect the latest scientific knowledge (a) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, aesthetics, and recreation which may be expected from the presence of pollutants in any body of water including groundwater; (b) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and (c) on the effects of pollutants on biological community diversity, productivity, and stability, including information of the factors affecting rates of eutrophication and organic and inorganic sedimentation for varying types of receiving waters.

These criteria are not rules and they do not have regulatory impact. Rather, these criteria present scientific data and guidance of the environmental effects of pollutants which can be useful to derive regulatory requirements based on considerations of water quality impacts. When additional data has become available, these summaries have been updated to reflect the latest Agency recommendations on acceptable limits for aquatic life and human health protection.

In a continuing effort to provide those who use EPA's water quality and human health criteria with up-to-date criteria values and associated, this document *Quality Criteria for Water 1986* was assembled. This document includes summaries of all the contaminants for which EPA has developed criteria recommendations (Appendix A-C). The appropriate Appendix is identified at the end of each summary. A more detailed description of these procedures can be found in the appropriate Appendix.
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APPENDIX C: METHODOLOGY FOR DEVELOPING CRITERIA

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U.S. EPA. 1987. ***Bioaccumulation Monitoring Guidance: Selection of Target Species and Review of Available Data Volume 1 and Volume 2 (Appendices).*** **U.S. Environmental Protection Agency, Office of Water, Washington, DC. pp. 52. Vol. 1: EPA/430-86-005. (NTIS: PB87-221065). Vol. 2: EPA/430/9-86-006. (NTIS: PB87-221073).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, bioaccumulation, sampling**

Abstract

The primary purpose of this report is to provide guidance for selecting target species for bioaccumulation monitoring studies to be conducted as part of the 301(h) sewage discharge program. Consistency among the monitoring programs for individual 301(h) discharges ultimately will allow the development of regional and national perspectives on the effects of sewage discharges on marine and estuarine environments.

Monitoring the accumulation of toxic substances in tissues of marine organisms is useful for assessing environmental impacts of specific sources of pollution or evaluating water quality from a regional perspective. The choice of target species is a key element of any bioaccumulation monitoring program. Tissue concentrations of toxic substances in target species can serve as indicators of contamination throughout the biological system. At a minimum, the target species must be capable of accumulating toxic substances representative of the study area(s), abundant enough over time and space to allow adequate sampling, and large enough to provide adequate amount of tissue for analysis.

In addition to recommending target species for bioaccumulation monitoring, this report presents a compilation, evaluation, and summary of recent data on concentrations of priority pollutants in those species. For example, the data for a target species at a particular discharge site can be compared with historical data for that same species during different time periods and at various locations throughout the United States.
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APPENDIX E: HISTORICAL DATA SETS ON TISSUE CONCENTRATIONS OF PRIORITY POLLUTANTS IN RECOMMENDED SECONDARY SPECIES

U.S. EPA. 1987. ***Bioaccumulation Monitoring Guidance: 5. Strategies for Sample Replication and Compositing.*** **U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, DC. pp. 51. EPA 430/09-87-003.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, sampling, bioaccumulation, data analysis/ management**

Abstract

This report provides guidance on the selection of appropriate replication and compositing strategies for bioaccumulation monitoring studies. A statistical approach is presented for determining the levels of difference in bioaccumulation that can be reliably detected with varying levels of sampling effort. Example analyses are presented to demonstrate the effects of alternative sampling designs. These example analyses are based on historical data from bioaccumulation monitoring programs that used tissues from individual target species recommended in an earlier report in this series (U.S. EPA, 1987). The results of additional analyses employing simulation methods are used to provide a comparison of grab- and composite-sampling strategies.

This report is one element of the Bioaccumulation Monitoring Guidance Series. The purpose of this series is to provide guidance for monitoring of priority pollutant residues in tissues or resident marine organisms. These guidance documents were prepared for the 301(h) sewage discharge permit program under the U.S. EPA Office of Marine and Estuarine Protection, Marine Operations Division. Other documents in the series include:

- Selection of Target Species and Review of Available Bioaccumulation Data, Volumes I and II (U.S. EPA, 1987) EPA/430-86-005, EPA/430-86-006 *[Reference 051]*
- Analytical Methods for EPA Priority Pollutants (U.S. EPA, 1985) EPA 503/6-90-002 *[Reference 049]*
- Recommended Analytical Detection Limits (U.S. EPA, 1985) EPA 503/6-90-001 *[Reference 045]*

The information provided herein will be useful to U.S. EPA monitoring program reviewers, permit writers, permittees, and other organizations involved in performing nearshore monitoring studies. Bioaccumulation monitoring has become increasingly important in assessing pollution effects; therefore this guidance should have broad applicability in the design an interpretation of marine and estuarine monitoring programs.
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U.S. EPA. 1987. ***Guidance for Conducting Fish Liver Histopathology Studies During 301(h) Monitoring.*** **U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, DC. pp. 166. EPA 430/09-87-004.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, tissue analysis, data analysis, sampling**

Abstract

The purpose of this document is to provide guidance for designing and conducting field surveys of fish liver histopathology as part of 301(h) monitoring programs. Information derived from the surveys of fish liver histopathology can be used in conjunction with other kinds of environmental data to assess potential impacts of sewage and other discharges on marine biota.

The document is directed primarily at the non-pathologists involved in writing 301(h)-modified NPDES permits and in overseeing field studies of fish liver histopathology. Although this document is directed at non-pathologists, various sections may also be use for to pathologists.

This document addresses the following four major components of quantitative filed studies of fish liver histopathology:

- study design
- field sampling
- laboratory analysis
- data analysis and interpretation

Although the emphasis of this document is on liver histopathology, many of the considerations addressed for each component may also pertain to a variety of other kinds of pathological conditions in fishes.

General recommendations for each of the four major study components were made as detailed as possible without sacrificing their site-specific applicability. For example, because specific objectives generally vary among different studies, exact specifications for such considerations as sample sizes, station locations, staining procedures, and methods of data analysis could not be made. Instead, the various acceptable options for each feature are presented along with their respected benefits and limitations. Literature citations were used to support recommendations whenever possible.

Because many of the terms used in this document are unfamiliar to anyone without a background in pathology or cellular biology, a glossary is provided at the end of the document.

The information provided herein will be useful to U.S. EPA monitoring program reviewers, permit writers, permittees, and other organizations involved in performing nearshore monitoring studies. As fish liver histopathology frequently is assessed in other marine and estuarine monitoring programs, the guidance provided herein has broad applicability beyond the 301(h) program.
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U.S. EPA. 1987. ***Guidance for Sampling of and Analyzing for Organic Contaminants in Sediments.*** **U.S. Environmental Protection Agency, Office of Water, Regulation and Standards, Criteria and Standards Division, Washington, DC. pp. 80. EPA 440/4-87-010.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, sampling, QA/QC, total organic carbon, organics, PAHs, PCBs, pesticides**

Abstract

This report describes recommended procedures for collecting sediment samples and for measuring the concentration of nonpolar organic contaminants, organic carbon, and sediment dry weight. Sample preparation and preservation techniques are also recommended. Pre-collection activities of detailed sampling plan preparation and QA/QC plan preparation are addressed, as are the selection of appropriate sampling equipment and sample station positioning methods.

The procedures for analysis of semi-volatile organics are adapted from NOAA and EPA methods. Where the recommended extraction, cleanup, and analysis methods differ from established methods, explanation are given as to the advantages of the approach.
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APPENDIX C: SEDIMENT DEWATERING AND EXTRACTION

APPENDIX D: METHODS FOR SULFUR CLEANUP OF EXTRACTS

U.S. EPA. 1987. *Quality Assurance/Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods.* U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, DC. EPA 430/9-86-004. (NTIS: PB87-221164).

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, sampling, QA/QC, flow, dissolved oxygen, pH, salinity, total solids, turbidity, grain size, organics, inorganics, nutrients, metals, pesticides, oxygen demand, chlorophyll, population/ community, bioaccumulation, pathogenic organisms**

Abstract

This manual was prepared by EPA's Marine Operations Division, Office of Marine and Estuarine Protection in response to requests from EPA Regional Offices and coastal municipalities with sewage treatment plants discharging into estuarine and marine coastal waters. Under regulations implementing Section 301(h) of the Clean Water Act, municipalities are required to conduct monitoring programs to evaluate the impact of their discharge on marine biota, to demonstrate compliance with applicable water quality standards, and to measure toxic substances in the discharge. The collection and analysis of high quality data require that specific, established quality assurance and quality control (QA/QC) protocols be adhered to in each of these major monitoring programs.

QA/QC procedures are included in this document for environmental variables that may be measured in effluent, receiving water, sediment, and organism tissues sampled during 301(h) monitoring programs. Quality assurance and quality control procedures are provided for sample collection, field sample handling, and laboratory processing to implement specific monitoring program requirements provided in the 301(h) modified NPDES permit.

The information provided herein will be useful to U.S. EPA monitoring program reviewers, permit writer, permittees, and other organizations involved in performing nearshore monitoring studies. As the monitoring variables included in this document are commonly used in many marine and estuarine monitoring programs, the guidance provided herein has broad applicability beyond the 301(h) program.
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APPENDIX B RECOMMENDED METHODS FOR ORGANIC COMPOUNDS IN EFFLUENT

U.S. EPA. 1987. ***Recommended Biological Indices for 301(h) Monitoring Programs.*** **Prepared for U.S. Environmental Protection Agency, Marine Operations Division, Office of Marine and Estuarine Protection, Washington, DC. pp. 17. EPA 43019-86-002. (NTIS: PB87-221560).**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, population/community, data analysis/management**

Abstract

The 301(h) regulations require dischargers to conduct periodic surveys of those biological communities that are most likely to be affected by the modified discharge. The data from these surveys are used to compare biological conditions in the vicinity of the discharge with biological conditions in reference areas. One approach to making such comparisons involves the use of biological indices that reduce complex data sets into simple numerical relationships. There are numerous diversity, biotic, and similarity indices with which such comparisons may be made.

The purpose of this document is to develop recommendations of those indices that should be used in the interpretation of 301(h) biological monitoring data. The recommended indices are not intended to fully describe biological communities. Rather, they are intended to provide one approach in the overall assessment of compliance with the 301(h) biological criteria. Other indices may be included in individual monitoring programs to better characterize community structure, or to provide data relevant to specific biological conditions of concern. Key issues upon which various indices are often judged include:

- biological meaning
- ease of interpretation
- sensitivity to community changes caused by pollutant impacts

Each of these criteria was considered by Tetra Tech, Inc. and U.S. EPA Office of Research and Development in developing the recommendations contained herein.
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U.S. EPA. 1988. ***Guide for Preparation of Quality Assurance Project Plans for the National Estuary Program - Interim Final.*** **U.S. Environmental Protection Agency, Office of Water, Office of Marine and Estuarine Protection, Washington, DC. EPA 556/2-88-001.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, sampling, QA/QC, toxicity/bioassay, bioaccumulation, data analysis**

Abstract

The U.S. Environmental Protection Agency (EPA) requires participation by all Regional offices, Program offices, Laboratories, and States in a centrally managed Quality Assurance Program (Administrator's memorandum, May 30, 1979). This EPA policy for quality assurance includes all monitoring and measurement efforts mandated by or supported by EPA and therefore includes all research activities carried out under the National Estuary Program.

QA project plans for the National Estuary Program are written according to a format prescribed by EPA (1984) in OWRS QA-1, "Guidance for the Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring." The format described in OWRS QA-1 is designed to incorporate all information that will be necessary to conduct the research project and to eliminate the need for multiple documents, such as standard work plans and QA project plans.

This document presents guidance for completing the elements of a QA project plan specified by OWRS QA-1. Its format and philosophy are identical to OWRS QA-1, but the guidance and examples are extended to encompass the multifaceted research and monitoring conducted for and required by the National Estuary Program. The guidance presented in this document includes examples from projects similar to those that have been conducted under Comprehensive Estuarine Management – Pollution and Abatement (66.456, 40 CFR 29), commonly known as the "Bays Program."
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U.S. EPA. 1988. ***Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms.*** **Edited by C. I. Weber et al. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, OH. EPA-600/4-87/028. (NTIS: PB89-220503).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, toxicity/bioassay, data analysis/management, QA/QC**

Abstract

This manual describes six short-term (one-hour to nine-day) methods for estimating the chronic toxicity of effluents and receiving waters to five species:

- sheepshead minnow, *Cyprinodon variegatus*
- inland silverside, *Menidia beryllina*
- mysid, *Mysidopsis bahia*
- sea urchin, *Arbacia punctulata*
- red macroalga, *Champia parvula*

This manual is intended to serve as a companion to the freshwater and marine acute toxicity test manual (EPA-600/4-85-013) and the freshwater chronic toxicity test manual (EPA-600/4-85-014) published earlier by the Environmental Monitoring and Support Laboratory - Cincinnati (EMSL-Cincinnati) for use in the National Pollutant Discharge Elimination System (NPDES). These three toxicity test manuals have been prepared to assist the Agency in meeting the goals of the Federal Water Pollution Control Act Amendments of 1977, the Clean Water Act (CWA) of 1977 (PL 95-217), and the Water Quality Act of 1987, which were enacted to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Section 101[a]), and contained specific or implied requirements for the collection of biomonitoring data in at least 15 sections.

Four of the methods incorporate the chronic end points of growth or reproduction (or both) in addition to lethality. The sheepshead minnow 9-day embryo-larval survival and teratogenicity test incorporates teratogenic effects in addition to lethality. The sea urchin sperm cell test used fertilization as an end point and has the advantage of an extremely short exposure period (1 hour and 20 minutes).

These methods were developed to provide the most favorable cost-benefit relationship possible, and are intended for use in effluent toxicity test performed on-site, where time is very costly, and for toxicity tests with effluent samples shipped off-site to distant laboratories, requiring that the volume of waste shipped be kept to a minimum.

Also included are guidelines on laboratory safety, quality assurance, facilities and equipment, dilution water, effluent sampling and holding, data analysis, report preparation, and organism culturing and handling. Listings of computer programs for Dunnett's Procedures and Probit Analysis are provided in the Appendix.
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APPENDIX F: WILCOXON RANK SUM TEST

APPENDIX G: PROBIT ANALYSIS

U.S. EPA. 1989. ***Compendium of Methods for Marine and Estuarine Environmental Studies.*** **U.S. Environmental Protection Agency, Office of Water, Office of Marine and Estuarine Protection, Washington, DC. EPA 503/2-89/001. (NTIS: PB93-202570).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, nutrients, chlorophyll**

Abstract

This document represents a prototype for a compendium of methods recommended by the U.S. Environmental Protection Agency (EPA) for use in estuarine and marine environmental studies, and in designing and implementing marine monitoring programs.

The compendium is intended to be part of a cooperative sharing of methods among federal agencies, including EPA's Office of Marine and Estuarine Protection, Regional EPA Offices, EPA research laboratories, the U.S. Army Corps of Engineers, the National Oceanic and Atmospheric Administration, and the National Bureau of Standards.

In order to meet the immediate needs of the agencies, a candidate parameter -- nutrients in seawater -- was selected as the focus for the prototype compendium. This parameter was chosen because nutrients are a major concern in nearly all estuaries, and analysis of nutrients is often a problem due to the lack of validated methods. Therefore, this initial version of the compendium consists of selected methods for the analysis of nutrients; in particular, nitrogen, phosphorus, and chlorophyll.

The compendium of methods, when completed, would be available to investigators in both hardcopy and on-line format.
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U.S. EPA. 1989. ***Guidance Manual: Bedded Sediment Bioaccumulation Tests.*** **U.S. Environmental Protection Agency, Bioaccumulation Team, Pacific Ecosystems Branch, Environmental Research Laboratory, Newport, OR. pp. 232. EPA/600/X-89/302. ERLN-N111.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, bioaccumulation, sampling, grain size, total solids, organic carbon, data analysis/management**

Abstract

Bioaccumulation tests with bedded sediments are the most direct method of deriving tissue residue data required for evaluation of dredge materials and for quantitative ecological and human risk assessments. Bioaccumulation tests are also an important experiment tool for identifying the factors regulating the bioavailability of sediment-associated pollutants and to test various Sediment Quality Criteria approaches. However, the procedures for conducting such tests have not been standardized, making it difficult to compare studies. This manual gives detailed guidance on how to conduct "routine" bedded sediment bioaccumulation tests with marine or estuarine deposit-feeding organisms. All phases of the process are covered, from formation of the experimental design, through the actual exposures to statistical analysis and interpretation of the results.

Because the interpretation of tissue residue data is often relative to "control" and "reference" sites, the acceptability of such sites is considered. The importance of an appropriate experimental design, including sufficient statistical power and replication, is stressed. Methods to avoid or reduce "pseudoreplication", a common statistical problem in toxicity tests, are also discussed. Techniques for conducting long-term exposures (>28 days) and kinetic approaches based on uptake and depuration rates are also presented for cases when more accurate estimates of steady-state tissue residues are required.

Sediment collection and preparation, including spiking techniques, are discussed as are techniques for collecting and maintaining test species in the laboratory. Based on a number of criteria, including a required criterion for sediment-ingestion, five species are recommended as suitable for routine testing. Another eight species are identified as potential "secondary" species. The water quality and sediment requirements for exposure chambers are discussed, and in most cases, these requirements can be achieved with relatively simple static or flow-through systems. Specific sampling schedules and techniques are given for the routine 28-day exposures. To allow comparisons among studies, we recommend the Bligh-Dyer method as the standard lipid technique, or, if another lipid method is used, to intercompare with Bligh-Dyer.

The statistical analysis of the data is discussed, and the use of one-tailed tests is recommended when comparing a test tissue residue(s) to reference or control tissue residue(s), as would commonly be the case when testing for "no further degradation". Besides the "no further degradation" approach, other regulatory strategies for using tissue residue data are presented.
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U.S. EPA. 1989. *Methods Manual for Perdido Bay Citizens Monitoring Program.* U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL. pp. 28. EPA/600/4-89/030. (NTIS: PB89-224927).

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, volunteer monitoring, sampling**

Abstract

Citizen monitoring programs have become an important mechanism to involve citizens in environmental decision-making processes and provide data that are often otherwise unavailable to environmental managers. This Methods Manual and its companion quality assurance/quality control plan were developed in response to a request made by the Friends of Perdido Bay, Inc. (FPB). This document is part of the Gulf Breeze Laboratory's effort to support regional and local technology transfer efforts in addition to direct research activities.

The FPB plan to implement a citizens' volunteer monitoring project includes water quality and weather-based data. The monitoring and other activities of the FPB form an important component of the Agency's Perdido Bay Cooperative Management Project (PBCMP). The PBCMP is a pilot project of the Agency's Near Coastal Waters Initiative and the pilot project is geographically within the Agency's Gulf of Mexico Program. Thus, data obtained by the citizens volunteer monitoring project will be of interest to the local community and to various levels within the Agency.

This manual contains standard operating procedures (SOPs) for the measurement of dissolved oxygen (DO), Secchi disk, a measure of light penetration, temperature, and salinity.
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U.S. EPA. 1989. *QA/QC Plan for Perdido Bay Florida-Alabama Citizens Monitoring Program.* U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Gulf Breeze, FL. pp. 17.

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, volunteer monitoring, QA/QC, sampling**

Abstract

This document provides quality assurance objectives for the planned and opportunistic sampling of water and meteorological variables of the Perdido Bay system and its tributaries by volunteers under the Citizens Monitoring Programs. Water quality parameters include Secchi disk, dissolved oxygen, temperature, salinity, and water level ("tide"). Meterologic parameters include: air, and water temperature, wind speed and direction, and rainfall. A comprehensive quality assurance methodology is presented to address all aspects of the volunteer monitoring effort. This covers specific sampling procedures, data validation, and quality control checks.
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U.S. EPA. 1989. ***Rapid Bioassessment Protocols for Use in Streams and Rivers.*** **U.S. Environmental Protection Agency, Office of Water Assessment and Watershed Protection Division. pp. 185. EPA/444/4-89-001.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, water quality, sampling, population/community**

Abstract

The primary purpose of this document is to provide States with a practical technical reference for conducting cost-effective biological assessments of lotic systems. The protocols presented are not necessarily intended to replace those already in use by State agencies. Instead, they provide options for agencies that wish to implement rapid biological assessment techniques. Three macroinvertebrate and two fish protocols are presented: benthic Rapid Bioassessment Protocol I (RBP I) and fish Rapid Bioassessment Protocol IV (RBP IV) are cost-effective screening procedures that provide some supporting data; benthic Rapid Bioassessment Protocol II (RBP II) can help set priorities for more intensive evaluations; and benthic Rapid Bioassessment Protocol III (RBP III) and fish Rapid Bioassessment Protocol V (RBP V) are progressively more rigorous and provide more confirmational data, but also require more resources. The choice of a particular protocol should depend on the purpose of the bioassessment, the need to document conclusions with confirmational data, the degree of discrimination desired, and available resources. Although the benthic protocols were designed and tested in wadable freshwater streams rather than large rivers (or lakes, estuaries, or marine systems), the fundamental approach should be applicable to large freshwater rivers as well. The fish protocols were validated in freshwater streams and large rivers and are applicable to both.

The rapid bioassessment protocols can also be applied to other areas, for example:

- characterizing the existence and severity of use impairment
- helping to identify sources and causes of use impairment
- evaluating the effectiveness of control actions
- supporting use attainability studies
- characterizing regional biotic components

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U.S. EPA. 1989. ***Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, 2nd Ed.*** **Edited by C. I. Weber et al. U.S. Environmental Protection Agency; Office of Research and Development; Office of Modeling, Monitoring Systems, and Quality Assurance; Environmental Monitoring Systems Laboratory, Cincinnati, OH. EPA/600/4-89/001. (NTIS PB89-207013).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, toxicity/bioassay, data analysis/management, QA/QC**

Abstract

This manual described short-term (four- to seven-day) methods for estimating the chronic toxicity effluents and receiving waters. The four short term tests described in this manual are for use in the NPDES Program to estimate one or more of the following:

- the chronic toxicity of effluents collected at the end of the discharge pipe
- the chronic toxicity of effluents collected at the end of the discharge pipe consisting of non-toxic receiving water collected upstream from or outside the influence of the outfall, or with other uncontaminated surface water or standard dilution water having approximately the same hardness as the receiving water
- the toxicity of receiving water downstream from or within the influence of the outfall
- the effects of multiple discharges on the quality of the receiving water

The tests may also be useful in developing site-specific water quality criteria. These methods were developed to provide the most favorable cost-benefit relationship possible, and are intended for use in effluent toxicity tests performed on-site or off-site. The tests include:

- a seven-day, sub-chronic, fathead minnow *(Pimephales promelas)*, static renewal, larval survival, and growth test
- a three-brood, seven-day, chronic, cladoceran *(Ceriodaphnia dubia)*, static renewal, survival, and reproduction test
- a seven-day, sub-chronic, fathead minnow *(Pimephales promelas)*, static renewal, embryo-larval survival, and teratogenicity test
- a four-day, chronic, algal, *(Selenastrum capricornutum)*, static, growth test

Also included are guidelines on laboratory safety, quality assurance, facilities and equipment, dilution water, effluent sampling and holding, data analysis, report preparation, and organism culturing and handling. Supplementary information on statistical techniques for test design and analysis of toxicity test data is provided in the Appendices.
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U.S. EPA. 1990. *Analytical Procedures and Quality Assurance Plan for the Determination of PCDD/ PCDF in Fish.* U.S. EPA, Office of Research and Development, Environmental Research Laboratory, Duluth, MN. EPA 600/3-90-022.

Media in which methods can be used: ☐ Water ☐ Sediment ☑ Biota

Keywords: Biological characterization, bioaccumulation, sampling, tissue analysis, organics, QA/QC

Abstract

This document describes the analytical methods used for the determination of the level of contamination of 15 biosignificant polychlorinated dibenzo-p-dioxins and dibenzofurans in fish. These analyses are limited by lack of analytical standards: however, isomer specificity may be determined using specially developed standards. Concentrations are determined based on the assumption that the results for the molecular ion of all isomers in a class is equal to the response observed for the isomer for which standards have been developed.

The target minimum levels of detection for specific PCDD/PCDF isomers are:

TCDD, TCDF	1 pg/g
PeCDD, PeCDF	2 pg/g
HxCDD, HxCDF	4 pg/g
HpCDD, HpCDF	10 pg/g

This document is meant to be only a guideline for analyses and the procedures may be modified as needed to satisfactorily analyze any sample.
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U.S. EPA. 1990. ***Analytical Procedures and Quality Assurance Plan for the Determination of Xenobiotic Chemical Contaminants in Fish.*** **U.S. EPA, Office of Research and Development, Environmental Research Laboratory, Duluth, MN. EPA 600/3-90-023. (NTIS: PB90-192782).**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, bioaccumulation, sampling, tissue analysis, organics, PCBs, PAHs, pesticides, QA/QC**

Abstract

This document, developed for Phase II of the USEPA National Dioxin Study, describes the analytical procedures and quality assurance plan for the determination of xenobiotic chemical contaminants in fish. The analytical approach includes:

- a simple sample preparation methodology that produces a single extract that minimizes analytical losses
- a procedure that is cost effective in terms of manpower, chemical reagents, and instrumentation
- a characterization and quantification of a certain set of chemical contaminants
- an identification of unknown contaminants by screening the data

The set of analytes quantified was derived through consideration that included data from previous monitoring efforts, toxicology, persistence, bioavailability potential, total yearly production, and feasibility of analyses. Limits of quantification for the target analytes are 2.5 ppb except for PCBs, whose limits vary as follows:

Level of chlorination:	
1-3	1.25 ppb
4-6	2.50 ppb
7-8	3.75 ppb
9-10	6.25 ppb

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U.S. EPA. 1990. *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters.* U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring System Laboratory, Cincinnati, OH. pp. 268 EPA/ 600/4-90/030. (NTIS: PB91-171363).

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, water quality, sampling, data analysis, QA/QC**

Abstract

This manual described guidelines and standardized procedures for using benthic macroinvertebrates in evaluating the biological integrity of surface (fresh, estuarine, and marine) waters. Included are sections on quality assurance and quality control procedures, safety and health recommendations, selection of sampling stations, sampling methods, sample processing, data evaluation, and an extensive taxonomic bibliography of the benthic macroinvertebrate groups. Supplementary information on the pollution tolerance of selected species, examples of macroinvertebrate bench sheets and macroinvertebrate data summary sheets, and a list of equipment and supplies for conducting biomonitoring studies are provided in the Appendices.

The manual is a revision and enlargement of the chapter on macroinvertebrate methods originally published in the document, "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents," Environmental Monitoring Series, U.S. EPA, 1973, EPA-670/4-73-001, and was developed in the Aquatic Biology Branch, Environmental Monitoring Systems Laboratory -- Cincinnati to provide biomonitoring programs with current methods for assessing point and non-point sources of impacts, status and trends water quality monitoring.
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U.S. EPA. 1990. *Volunteer Water Monitoring: A Guide For State Managers.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. pp. 78. EPA 440/4-90-010. (NTIS: PB93-202596).

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, volunteer monitoring**

Abstract

This guide for State regional, and Federal program managers was developed to provide an overview of the use of citizen volunteers in environmental monitoring. Its basic premise is that a well organized, properly maintained volunteer monitoring program can yield credible water quality data that will be useful to the State. To help State program managers launch and manage such a program, this document discusses how to plan and organize projects, how to involve the media, and how to prepare quality assurance plant that will ensure that the data of known quality are produced. In addition, data management considerations and approached to data analysis are discussed, as well as costs and funding issues. Examples drawn from successful existing programs are provided throughout this document.

This guide begins by providing an overview of existing volunteer monitoring efforts and outlines how to plan a program that will produce high quality data. It then discusses steps in implementing a program, from launching a pilot to maintaining volunteer interest. Considerable focus is directed to providing credible, quality-controlled information and analyzing and presenting data provided by volunteers. This guides goes on to discuss costs and funding issues. The appendix describes five successful State-managed or sponsored programs. For further information on additional volunteer monitoring programs refer to the *National Directory of Citizen Volunteer Environmental Monitoring Programs* (U.S. EPA, 1990).

This document does not provide detailed information on specific monitoring methods that might apply to a volunteer effort.
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- Kentucky Water Watch Volunteer Stream Sampling Project
- New York Citizen Statewide Lake Assessment Program
- Ohio Scenic River Volunteer Monitoring Program
- Chesapeake Bay Citizen Monitoring Program

U.S. EPA. 1991. ***Biological Criteria: Guide to Technical Literature.*** **U.S. Environmental Protection Agency, Office of Water, Washington, DC. pp. 128. EPA-440/5-91-004. (NTIS: PB92-231489).**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, population/community, QA/QC, data analysis**

Abstract

This document is intended to serve as a general technical reference source for publications pertinent to the development of biological criteria. The references listed herein discuss methods and procedures appropriate to the development of biocriteria in streams and rivers, lakes and reservoirs, estuaries and near-coastal areas, and wetlands. It is intended to summarize the references, and provide general information on manpower requirements to implement methods for developing biocriteria.

Each entry in the reference catalog is presented in a standard format. In addition to the basic reference, each entry provides information on the procedure objective, suitability of the entry for the four major water types, advantages and disadvantages of the procedure, level of education needed to perform the procedure, field team size, collection time required, sample processing time, and data analysis time. Each reference is further categorized regarding its applicability to the major subdivisions of habitat assessment, population structure, community structure, population and community interaction, data analysis, and interpretive assessment. Finally, each reference is categorized according to its applicability to community groups of macrophytes, periphyton, phytoplankton, zooplankton, macroinvertebrates, fish, and other vertebrates.

Four appendices contain lists of reference numbers, cross-referenced to an alphabetical list by author, is provided for each of the four major water types, including estuarine and near-coastal waters. References within each appendix are further divided under the major subsections and community groups described above.

Fifty-two of the 210 references are listed as being applicable to estuarine and near-coastal environments. *[extracted from document]*

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APPENDIX E: REFERENCE CATALOG ENTRIES

U.S. EPA. 1991. *Methods for Aquatic Toxicity Identification Evaluations, Phase I Toxicity Characterization Procedures, 2nd ed.* U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Duluth, MN. EPA/600/6-91/003. (NTIS: PB92-100072).

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, toxicity/bioassay, sampling**

Abstract

This Phase I document is the first of a three phase series of documents that provide methods to characterize and identify the cause of toxicity in effluents. The first phase of the series, Phase I, characterized the physical/chemical nature of the acute and chronic toxicant(s), thereby simplifying the analytical work needed to identify the toxicant(s). Phase II provides guidance to identify the suspect toxicants, and the last phase, Phase III provides methods to confirm that the suspect toxicants are indeed the cause of toxicity. These recent TIE documents have been produced or revised to include chronic toxicity recommendations and additional information or experiences we have gained since the original methods were printed.

The manual describes procedures for characterizing the physical/chemical nature of toxicants in acutely toxic effluent samples, with applications to other types of samples such as receiving water samples, sediment pore water or elutriate samples, and hazardous wastes. The presence and the potency of the toxicants in the samples are detected by performing various manipulations on the sample and by using aquatic organisms to track the changes in the toxicity. This toxicity tracking step is the basis of the toxicity identification evaluation (TIE). The final step is to separate the toxicants from the other constituents in the sample in order to simplify the analytical process. Many toxicants must be concentrated for analysis.

Since the first document was developed, additional options or new procedures have been developed. For example, additional options are provided in the EDTA and sodium thiosulfate addition tests, and in the graduated pH test. Also a discussion has been added for testing the effluent sample over time (weekly) to measure the rate of decay of toxicity which is used to detect the presence of degradable substances, particularly chlorine or surfactants. Guidance for characterizing whether a toxicant(s) removed by aeration is sublatable is described, and techniques for characterizing filterable toxicity and a discussion of C_{18} solid phase extraction elutable toxicity has been added. Use of multiple manipulations is discussed and example interpretations of the results of the Phase I manipulations are provided.

Additional manuals describe the methods used to specifically identify the toxicants (*Methods for Aquatic Toxicity Identification Evaluations, Phase II Toxicity Identification Procedures for Samples Exhibiting Acute and Chronic Toxicity*) and to confirm whether or not the suspected toxicant(s) is the actual toxicant(s) (*Methods for Aquatic Toxicity Identification Evaluations, Phase III Toxicity Confirmation Procedures for Samples Exhibiting Acute and Chronic Toxicity*).
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U.S. EPA. 1991. ***Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, 4th ed.*** **Edited by C. I. Weber. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Cincinnati, OH. EPA-600/4-90-027.**

Note: This document was revised and republished in 1993 under the same title and with Report No. EPA-600/4-90-027F. (NTIS: P394-114733).

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, sampling, toxicity/bioassays, QA/QC, data analysis/management**

Abstract

This manual describes methods for measuring the acute toxicity of effluent to freshwater, estuarine, and marine macroinvertebrates and fish. The methods include:

- single and multiple concentration static non-renewal
- static-renewal
- flow-through toxicity tests for effluents and receiving waters

The acute toxicity tests described are for use in the National Pollutant Discharge Elimination System (NPDES) Permits Program to identify effluents and receiving waters containing toxic materials in acutely toxic concentrations. The methods included in this annual are referenced in Table IA, 40 CFR Part 136 regulations and, therefore, constitute approved methods for acute toxicity tests. They are also suitable for determining the toxicity of specific compounds contained in discharges. The tests may be conducted in a central laboratory or on-site, by the regulatory agency or the permittee.

Data can also be used to predict potential acute and chronic toxicity in the receiving water, based on the LC50 and appropriate dilution, application, and persistence factors. The tests are performed as a part of self-monitoring permit requirements, compliance biomonitoring inspections, toxics sampling inspections, and special investigations.

Modifications of these tests are also used in toxicity reduction evaluations and toxicity identification evaluations to identify the toxic components of an effluent, to aid in the development and implementation of toxicity reduction plans, and to compare and control the effectiveness of various treatment technologies for a given type of industry, irrespective of the receiving water.

Also included are guidelines on laboratory safety; quality assurance; facilities and equipment; test species selection and handling; dilution water; effluent and receiving water sample collection, preservation, shipping, and holding; test conditions; toxicity test data analysis; report preparation; organism culturing; and dilutor and mobile laboratory construction.
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Daphnids, *Daphnia pulex* and *D. magna*
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Rainbow Trout, *Oncorhynchus mykiss* and Brook Trout, *Salvelinus fontinalis*
Sheepshead Minnow, *Cyprinodon variegatus*
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U.S. EPA. 1991. ***Methods for the Determination of Metals in Environmental Samples.*** **U.S. Environmental Protection Agency, Environmental Monitoring System Laboratory, Office of Research and Development, Cincinnati, OH. EPA 600-4-91-010. (NTIS: PB91-231498).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, metals, tissue analysis, sampling, QA/QC**

Abstract

Thirteen analytical methods covering 35 analytes which may be present in a variety of environmental sample types are described in detail. Three of these methods are sample preparation procedures that require a separate determinate step found in other methods in this manual or elsewhere. These methods involve a wide range of analytical instrumentation including inductively coupled plasma (ICP)/atomic emission spectroscopy (AES), ICP/mass spectroscopy (MS), atomic absorption (AA) spectroscopy, ion chromatography (IC), and high performance liquid chromatography (HPLC). Application of these techniques to a diverse group of sample types is a somewhat unique feature of this manual. Sample types include waters ranging from drinking water to marine water as well as industrial and municipal wastewater, groundwater, and landfill leachate. Also included are methods that will accommodate biological tissues, sediments, and soils.

The methods in this manual are not intended to be specific for any single EPA regulation, compliance monitoring program, or specific study. In the past, manuals have been developed and published that respond to specific regulations, such as the Safe Drinking Water Act (SDWA) or to special studies such as the Environmental Monitoring and Assessment Program (EMAP) Near Coastal Demonstration Project. These methods are, however, available for incorporation into several regulatory programs due to their applicability to such diverse sample types. The ICP/AES, ICP/MS, and AA methods have been or will be approved for use in the drinking water and the permit programs. The methods applicable for use in marine and estuary waters will be available for use in the Agency's National Estuary Program and subsequent EMAP studies that may involve the determination of toxic metals in the water column.

The quality assurance sections are uniform and contain minimum requirements for operating a reliable monitoring program: initial demonstration of performance, routine analyses of reagent blanks, analyses of fortified reagent blanks and fortified matrix samples, and analyses of quality control (QC) samples. Other QC practices are recommended and may be adopted to meet the particular needs of monitoring programs e.g., analyses of field reagent blanks, instrument control samples, and performance evaluation samples.

The names of authors of the methods are provided to assist users in obtaining direct telephone support when required.
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Determination of Mercury in Tissues by Cold Vapor Atomic Absorption Spectrometry 245.6

U.S. EPA. 1991. ***A Project Manager's Guide to Requesting and Evaluating Chemical Analyses.*** **U.S. Environmental Protection Agency, Region 10, Puget Sound Estuary Program, Seattle, WA. EPA 910/9-90-24. (NTIS: PB92-132794).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, QA/QC, data analysis**

Abstract

The purpose of this manual is to help less-experienced project managers from governmental agencies, industry, and environmental groups in requesting appropriate chemical analyses and in making an informed evaluation of the results. Many project managers are not chemists, but most may need to plan for, request, discuss, or evaluate chemical analyses. Even after the results have been received and interpreted, many managers must still defend the project data or critical decisions made by themselves or staff. This manual is designed to guide the nonchemist. Strategies are presented throughout the manual for choosing options ranging from simple to more complex plans, requirements, analyses, or evaluations. When applicable, the relative cost consequence of these options, ranging from inexpensive to more expensive, is also described.

The manual is not intended to take the place of technical experts, whose advice may be needed at times to assist with problems specific to each analytical effort. However, by using the detailed information and checklists provided in this manual, and by seeking the advice of a chemist or experienced quality assurance specialist where needed, project managers should be better able to make analytical requests and to evaluate the general quality of results received from chemical laboratories. For example, the preliminary evaluation of results provides guidance on determining when results are likely to be clearly acceptable, clearly unacceptable, or will require a more detailed review by a specialist. This preliminary evaluation is made using six major criteria for data completeness and laboratory performance, including analytical accuracy and sensitivity. Response measures are described for common deficiencies in analyses to provide both a better sense of what can be done easily by the manager and what questions should be asked of the laboratory or a specialist, if needed.
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U.S. EPA. 1991. ***Volunteer Lake Monitoring: A Methods Manual.*** **Prepared by J. Simpson for U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Assessment and Watershed Protection Division, Washington, DC. pp. 129. EPA 440/4-91-002. (NTIS: PB92-218411).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, sampling, turbidity, pH, temperature, dissolved oxygen, pathogenic organisms, population/community**

Abstract

The EPA has developed this manual to present specific information on volunteer lake water quality monitoring methods. It is tended both for the organizers of the volunteer program, and for the volunteer who will be actually sampling lake conditions. Its emphasis is on identifying appropriate parameters to monitor and setting out specific steps for each selected monitoring method. Careful quality assurance/ quality control procedures are advocated throughout this manual to ensure that the data collected by volunteers are useful to States and other agencies.

This manual begins by summarizing the steps necessary to plan and manage a volunteer monitoring program, including setting general goals, identifying the uses and users of collected data, and establishing sound quality assurance procedures. Rather than addressing every parameter and method that might be monitored by the citizen volunteer, this manual concentrates special attention on three of the most common lake pollution problems: increased algal growth, increased growth of rooted aquatic plants; and lowered or fluctuating levels of dissolved oxygen. All three are common symptoms of human-induced eutrophication. Other lake conditions that can be monitored by volunteers are also briefly discussed including sedimentation, turbidity, lake acidification, and bacteriological condition.

Although this manual is written specifically for volunteer monitoring of lakes, all the general principles of organization and most of the specific methods can be applied to estuarine water bodies as well. *[extracted from document]*

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U.S. EPA. 1992. *Consumption Surveys for Fish and Shellfish. A Review and Analysis of Survey Methods.* U.S. Environmental Protection Agency, Office of Water and Office of Science and Technology, Washington, DC. EPA 822/R-92-001. (NTIS: PB92-231539).

Media in which methods can be used: ☐ Water ☐ Sediment ☑ Biota

Keywords: **Biological characterization, sampling, QA/QC, data management**

Abstract

Although several studies have demonstrated that fish and shellfish consumption rates differ both regionally and within specific subpopulations, most States do not have available sufficient data to calculate local consumption rates or to identify special populations at risk. Examples of these special populations are recreational and subsistence anglers and members of their households -- in particular, women of child-bearing age, children, and the elderly -- who frequently consume fish obtained from contaminated sites. This report was designed as a critical assessment of fish tissue consumption rate survey approaches and methods and their applicability for estimating consumption rates in recreational and subsistence fish populations. Additional information is provided to assist Federal and State agencies in developing appropriate surveys to answer questions and resolve issues related to the fish consumption rates of special populations.

Five approaches to obtaining fish consumption data were reviewed:

- recalled information collected by telephone
- recalled information collected by in-person (face-to-face) interviews
- recalled information requested on self-administered mailed questionnaires
- diaries maintained by anglers
- on-site creel censuses

Five elements common to all surveys have been identified, and specific methodological details are provided to help solve problems that may be encountered when undertaking a fish consumption survey.

- Survey design must address the purpose for which the survey is to be conducted, the resources available for carrying it out, including time and funding available, and the approach to be used.

- Survey participants should be identified from a pool of subsistence or recreational anglers, and the method by which the sample is selected may vary depending on the approach that will be used to collect the data and how the data will be analyzed.

- The information to be collected should examine sociodemographic factors that may influence fish consumption rates, as well as those factors that are needed to calculate fish consumption rates, minimizing the number of assumptions that could compromise results. The survey length and complexity should be carefully considered in order to elicit maximum cooperation from respondents.

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- Appropriate quality assurance procedures need to be developed before beginning the survey, and quality control must be carefully monitored during the survey to ensure the validity of the data *before* statistical analyses are conducted.

- Data processing procedures and statistical analyses should be performed to provide the desired information and correlations.

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APPENDIX: SUMMARY OF SURVEY METHODS INFORMATION

U.S. EPA. 1992. *Environmental Monitoring Methods Index, Version 1.0.* U.S. Environmental Protection Agency, Environmental Monitoring Management Council, Washington, DC. pp. 112 + three software diskettes. (NTIS: PB92-503093).

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, dissolved oxygen, pH, inorganics, organics, pesticides, PAHs, PCBs**

Abstract

The Environmental Monitoring Methods Index (EMMI) is a computerized database listing environmentally significant analytes that are monitored by EPA, methods for analyte analysis, and the regulatory lists on which analytes appear. This database is designed to aid environmental program managers and others who must develop lists of analytes for study, identify appropriate analytical methods for a particular analyte and matrix, and locate primary sources to assist in making new environmental policies.

The present version covers updates in the Code of Federal Regulations and Federal Register through June 1991. EMMI encompasses a total of 2,607 analytes, 49 lists, and 1,167 methods, and includes a database cross-reference with 5,740 analytes. Chemical Abstract Service (CAS) registry numbers are used to unambiguously identify analytes and to cross-reference other databases.

This database contains detailed information on analytes from environmentally significant lists, methods and apparatuses used to identify those analytes, source documents containing information referenced in EMMI, organizations that promulgate the lists and methods, and vendors of analytical standards. Where possible. Descriptions have been simplified to render EMMI accessible to individuals with a basic understanding of analytical chemistry or environmental science.

Information available on regulated pollutants, analytical methods, and regulatory and monitoring lists includes:

- the CAS number, names, and synonyms of each regulated pollutant
- 50 regulatory and office based lists associated with CAA, CERCLA, CWA, EPCRA, HSWA, CRA, SARA, SDWA, and other legislation
- laws, EPA regulations, and legal decisions
- summaries of 926 analytical methods used to identify and quantify the pollutant
- detection limits for analytical methods appropriate for air, water, soil, and sludge matrices
- manufacturers of analytical standards
- regulatory limits
- 42 government offices and contacts responsible for related lists and analytical methods

This abstract was excerpted from:

W.A. Telliard, EPA's Environmental Monitoring Methods Index: Linking Environmentally Significant Analytes, Methods, and Lists. *Environmental Science & Technology*, January, 1993, pp. 39-41.

Contact: (703) 519-1222

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APPARATUS	(apparatus used in methods)
DOCUMENTS	(interesting documents relating to lists and vendors)
LAWS	(laws relating to lists and references to other pertinent laws)
VENDORS	(vendors of standards as listed for each analyte)

U.S. EPA. 1992. ***Field Operations and Safety Manual: EMAP-Estuaries 1992 Virginian Province.*** **Preliminary Draft. U. S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Narraganesett, RI. pp. 210. EPA/600/x92/xxx.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, sampling, QA/QC, dissolbed oxygen, salinity, temperature**

Abstract

The Environmental Monitoring and Assessment Program (EMAP) is a nationwide program initiated by the Environmental Protection Agency (EPA) in 1990. The purpose of this program is to monitor annually the condition of all the Nation's major ecosystems. As a component of the Near-Coastal (EMAP-NC) Program, annual sampling will be conducted in the Virginian Province (Cape Cod, MA to Cape Henry, VA).

The purpose of this document is to provide detailed instructions on all field sampling methods. Two versions of this document are available: the unabridged brainy version and an abbreviated version for use in the field. This version contains only the pertinent information needed to successfully complete sampling activities.

Procedures described in the manual include the collection of temperature, salinity, dissolved oxygen, pH, transmissivity, fluorescence, and photosynthetically activated radiation using electronic instrumentation. Sediment and water sampling and fish trawl protocols are listed also. Sample storage, packaging, and shipping are addressed, as are instructions for field filtrations for dissolved oxygen.

This manual describes, in detail, all field collection methods, including Quality Assurance (QA) and safety. It is designed to serve as a guide for field personnel and to be carried on the boats at all times. An effort has been made to anticipate problems and questions that may arise, and to include information on resolving them. All methods, as described in this manual are standard operating procedures, and are to be adhered to by all field personnel. As [if] methods change, an updated version of the pertinent section[s] will be prepared and incorporated into this manual.
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U.S. EPA. 1992. *Methods for the Determination of Chemical Substances in Marine and Estuarine Environmental Samples.* U.S. Environmental Protection Agency, Environmental System Laboratory, Office of Research and Development, Cincinnati, OH. EPA 600/R-92/121. (NTIS: PB93-182913).

Media in which methods can be used: ☑ Water ☑ Sediment ☐ Biota

Keywords: Water quality, sediment quality, metals, inorganics, organics, nutrients, chlorophyll, sampling, QA/QC

Abstract

This manual contains seven methods for determination of nutrients, metals, and chlorophyll. Methods 353.4, revision 1.2, and 365.5, revision 1.3, for the measurement of nitrite + nitrate and orthophosphate, respectively, appeared in the 1991 interim manual. Since then they have undergone multilaboratory validation studies. Method 365.5 performed well in the study and multilaboratory data are presented in the revision of the method that appears here. The performance of Methods.353.2 in the study indicated the cadmium reduction column chemistry and maintenance require further investigation. The method has been retained in this manual so that further testing can continue using a standardized method description.

Method 440.0 for measurement of total particulate carbon and nitrogen is based upon a well established combustion technique. Procedures for partioning the organic and inorganic fractions of carbon are also presented. A multilaboratory study is in progress, and the results will be included in a subsequent revision of the method.

The three metals methods represent current state-of-the-science in metals measurements. Two of the methods are graphite furnace atomic adsorption techniques and the third uses inductively coupled plasma mass spectrometry. Single laboratory performance data are included in the methods. Although few laboratories currently have the instrumentation capabilities to perform all of these methods, it is extremely important to present them in order to stimulate the development of laboratory capability before multilaboratory studies can be conducted.

Method 445.0 is for the determination of chlorophyll-*a* and the pheopigments using fluorescence detection. This method was evaluated using two natural water samples of primarily green and blue-green algae.

The numbering of methods was correlated with previous EMSL-Cincinnati methods whenever possible. The metals methods are 200 series, the nutrients nitrite + nitrate and orthophosphate are 300 series, and the particulate carbon and nitrogen, and chlorophyll methods are 400 series.
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U.S. EPA. 1992. ***Monitoring Guidance for the National Estuary Program, Final.*** **U.S. Environmental Protection Agency, Office of Water, Office of Wetlands. Washington, DC. EPA 842 B-92-004).**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, currents, depth, grain size, salinity, turbidity, temperature, sampling, QA/QC, nutrients, metals, dissolved oxygen, oxygen demand, chlorophyll, PAHs, PCBs, organics, toxicity/bioassays, population/community, bioaccumulation, pathogenic organisms**

Abstract

This document provides guidance on how to design, implement, and evaluate a monitoring program. The document also describes the essential data required to evaluate environmental risks and trends within an estuarine environment. It is also intended to provide a technical basis for discussions on the development of monitoring program objectives, the selection of monitoring program components, and the allocation of sampling efforts. The intended audience consists of members of National Estuary Programs' Management Committees, and Advisory Committees, program coordinators, and scientific staff. The document may also be useful to other coastal and marine resource managers with monitoring responsibilities.

Five steps are developed for this approach to monitoring design:

- develop monitoring objectives and performance criteria
- establish testable hypotheses and select statistical methods
- select analytical methods and alternative sampling designs
- evaluate expected monitoring study performance
- implement monitoring study and data analysis

Existing sampling and analytical methods available for monitoring estuarine water quality, sediment quality, biological resources, and human health risk are presented. This methods section is intended to provide a summary of available information and to address the most important issues associated with the design and implementation of the monitoring program. Issues common to all monitoring methods include quality assurance/quality control, statistical design, and data use and limitation considerations.

The integration of existing monitoring efforts into the estuary monitoring program is discussed, as well as coordination with existing federal agency status and trends programs, such as EPA's Ecosystem Monitoring and Assessment Program (EMAP), NOAA's National Status and Trends Program, and the U.S. Geological Survey's National Water Quality Assessment Program. Emphasis is placed on the importance of using standardized protocols within each estuary, and in developing performance-based criteria to evaluate the comparability of analytical methods.

Two case studies from existing estuarine monitoring programs are presented. These examples (from Puget Sound and Chesapeake Bay) demonstrate the process of developing a strategy and the use of statistical methods to evaluate the monitoring plan before and after implementation.
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[same section headings as above]

Bioaccumulation
[same section headings as above]

Bacterial and Viral Pathogens
[same section headings as above]

U.S. EPA. 1992. ***Recommended Analytical Techniques and Quality Assurance/Quality Control Guidelines for the Measurement of Organic and Inorganic Analytes in Marine Sediment and Tissue Samples. Draft.*** **U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Narragansett, RI.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, QA/QC, tissue analyses, inorganics, metals, organics, pesticides, PAHs, PCBs**

Abstract

This document is intended to provide guidance on the analysis of organic and inorganic analytes in marine sediments and tissues. Its purpose is to suggest analytical methods for measuring contaminants in the low parts-per-billion concentration range. The analytical techniques contained herein are those employed by the U.S. EPA Environmental Research Laboratory in Narragansett, RI for the analysis of marine environmental samples. They are intended, however, to serve only as examples and are not being suggested as EPA standard methods. These methods have been successfully employed on marine samples to achieve these detection limits. Included with the analytical methods are quality assurance/quality control (QA/QC) guidelines. The overall objective of the document is therefore to ensure that data produced under these guidelines will be of the highest quality, have detection limits necessary for trace level marine samples, and be comparable to data produced by other laboratories employing similar methods.

No procedures have been officially approved by the regulatory agencies for low-level (i.e., low parts-per-billion) analysis of organic and inorganic contaminants in estuarine sediments and tissue samples. This document includes methods that have been used at ERL-N in work related to the EMAP Program and are similar to those that have been used for NOAA's National Status and Trends Program. The EMAP and NS&T programs have chosen not to specifically require that particular analytical methods always be followed, but rather that a performance based program be followed, in which participating laboratories demonstrate proficiency through the regular analysis of Standard or Certified Reference Materials (SRMs or CRMs) or similar types of accuracy-based materials.
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U.S. EPA. 1992. *Sediment Classification Methods Compendium.* U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA 823-R-92-006. (NTIS: PB93-115186).

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, toxicity/bioassays, sampling, QA/QC, population/community**

Abstract

This document is a compendium of 12 scientifically valid and accepted methods that can be used to assess sediment quality and predict ecological impacts. Although the methods described in this document are not suitable for meeting specific tests, criteria, and procedures required by certain regulations (e.g., risk assessment under the Comprehensive Environmental Response, Compensation, and Liability Act), they provide useful measures or predictors of overall ecological impacts in an area. The 12 methods were selected based on their utility for assessing whether and to what extend sediments are "contaminated" or have the potential to pose a threat to the environment. Each has been applied at various levels in the decision-making process in different types of environments (e.g., freshwater, marine) as described.

The information provided for each method includes the following:

- how each method is currently used or could be used
- a detailed description of the method, including types of data, equipment, and sampling procedures needed
- the applicability of the method to the protection of wildlife and humans
- the utility of the method to produce numeric sediment quality criteria
- the method's applicability to making different types of sediment management decisions
- the method's advantages, limitations, costs, level of acceptance, and accuracy
- the degree to which the method is actually being used now
- how well it is validated
- its potential uses

An extensive list of references and the names, addresses, and telephone numbers for the authors of each description are provided. Although a detailed description of each method is provided, consultation of these references and/or additional follow-up with the authors is recommended before applying any of the methods.
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U.S. EPA. 1992. *Standard Operating Procedures and Field Methods Used for Conducting Ecological Risk Assessment Case Studies.* Prepared for Naval Command, Control and Ocean Surveillance Center, RDT&E Division, San Diego, CA, by U.S. Environmental Protection Agency, Environmental Research Laboratory, Narragansett, RI. Technical Document 2296. pp. 416 + appendices.

Media in which methods can be used: ☑ Water ☑ Sediment ☑ Biota

Keywords: Water quality, sediment quality, biological characterization, sampling, QA/QC, grain size, total solids, pH, organics, inorganics, pesticides, nutrients, metals, PCBs, organotin, toxicity/bioassays, bioaccumulation, pathogenic organisms, tissue analysis, population/community, chlorophyll

Abstract

The emphasis on determining the ecological impacts of hazardous substances on coastal and estuarine ecosystems requires the use of appropriate methods and procedures to obtain accurate and comparable data. The methods and procedures presented in this document have been field-tested during research and monitoring activities performed to support ecological risk assessment case studies. The case studies were developed as part of an interagency Memorandum of Agreement between the U.S. Navy Naval Command, Control and Ocean Surveillance Center (NCCOSC) Research, Development, Test, and Evaluation Division (NRaD), San Diego, CA, and the U.S. Environmental Protection Agency (EPA) Environmental Research Laboratory Narragansett (ERL-N), Narragansett, RI. The case studies included a marine ecological risk assessment pilot study for Naval Construction Battalion Center, Davisville, RI, and an estuarine ecological risk assessment for Naval Shipyard Portsmouth, Kittery, ME.

The methods and standard operating procedures (SOPs) documented in this report were prepared by investigators at ERL-N, University of New Hampshire Jackson Estuarine Laboratory (UNH, JEL), and the Marine Environmental Support Office (MESO) of NCCOSC NRaD who were involved in particular aspects of the case studies. The methods were applied within an ecological risk assessment framework to evaluate their applicability to characterize ecological risk. This document has been prepared to fully document the procedures used in the case studies and to assist in the development of suitable techniques capable of achieving the objectives of ecological monitoring and assessment activities. As more information is developed, these procedures will provide a basis for improving and expanding the capabilities needed to accurately assess ecological risk.

This document has been organized into three sections. Section 1 consists of SOPs for general laboratory and field methods, and chemistry methods. General laboratory and field methods includes procedures for collecting and preparing samples, measuring sediments and water column attributes, culturing test organisms, and conducting bioassays. The chemistry methods provides procedures for the analysis of trace levels contaminants (subparts per billion range for some organic compounds and subparts per million range for metals) suitable for a wide range of environmental assessment activities. Specific SOPs are provided for sample collection and storage, preparation for organic and trace metal analysis, analysis of samples by a variety of instrumentation, and instrument maintenance. Procedures for generic activities, such as sampling plan development and data management, currently are not incorporated in this manual.

Section 2 provides procedures used for sampling and analysis of estuarine habitats. Section 3, documents procedures for sampling and analysis of ultratrace levels of organotin compounds in seawater, sediment, and tissue samples. Appendix A provides results of organotin analysis optimization techniques to obtain

subpart per trillion detection levels in seawater and part per billion detection levels in tissues and sediments. Appendix B contains a detailed description of analytical procedures for extracting organotin compounds from soft tissues of marine organisms. A complete guidance document for conducting field and laboratory quality assurance and quality control (QA/QC) protocols, criteria, and corrective action for the Estuarine Ecological Risk Assessment for Naval Shipyard Portsmouth is included in Appendix C.

This SOP manual will be maintained as a "living document." Individual descriptions will be updated in a continuous fashion as advances in scientific understanding of biological, chemical, and physical processes are incorporated into assessment procedures. Major procedural changes that potentially invalidate previous SOP approaches will be noted where appropriate. Additionally, new SOPs will be incorporated into the manual as they are finalized. Updated versions of specific SOPs may be obtained by contacting the Technical Information Manager of the developing laboratory. The contact person for each of these SOPs was responsible for developing or applying the method to the project, and has developed a QA/QC protocol, available upon request. The contact person is also available to answer specific questions regarding the SOPs.
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U.S. EPA. 1992. ***Synthesis of Methods to Predict Bioaccumulation of Sediment Pollutants.*** **Research Report. U.S. Environmental Protection Agency, Bioaccumulation/Stratozone Team, Pacific Ecosystems Branch, Environmental Research Laboratory, Newport, OR.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Sediment quality, bioaccumulation, sampling, data analysis, QA/QC**

Abstract

This document is designed to be an aid in choosing the most appropriate test or model for assessing or predicting bioaccumulation of sediment-associated pollutants. With one exception, the methods are limited to bedded (whole) rather than resuspended sediments. The techniques are evaluated solely in terms of uptake by sediment-dwelling (i.e., infaunal) invertebrates rather than by epifaunal invertebrates (e.g., mussels, oysters) or fish. Although focused on marine and estuarine organisms, the techniques should be generally applicable to freshwater environments.

A questionnaire section directs the reader to sections which describe a specific direct measurement technique (laboratory test or field survey) or model that best fits the available data and goals of the project. These sections introduce the model or direct measurement method, describe its use and limitations, identify the sampling requirements for the direct methods, and direct the reader to references where the technique is described in greater detail.

For bioaccumulation models, two toxicokinetic (bioenergetics based and a first-order kinetic) and two equilibrium partition models (bioaccumulation factor and equilibrium partitioning or AF) are discussed. Where possible, tables of model input parameters and reference values are provided.

For direct measurements of bioaccumulation, several laboratory tests are presented as well as the alternative of assessing bioaccumulation from field collected organisms. The laboratory tests described range from a simple 28-day exposure to tests which use time-series sampling during uptake and depuration phases to determine input parameters for the first-order kinetic model. An appendix is provided which contains information that is generic to any laboratory bioaccumulation test, such as species selection and exposure systems.

This report in no way supersedes or takes the place of any guidance or requirements set forth in any regulatory document by any agency.
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U.S. EPA. 1993. ***Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis.*** **U.S. Environmental Protection Agency, Office of Science and Technology, Office of Water, Washington, DC. EPA 823-R-93-002. (NTIS: PB93-237899).**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, sampling, QA/QC, metals, pesticides, PAHs, PCBs, inorganics, organics, tissue analysis, data analysis/management**

Abstract

This manual is intended to describe what the EPA Office of Water believes to be scientifically sound methods for sample collection, chemical analyses, and statistical analyses of fish and shellfish tissue contaminant data for use in fish contaminant monitoring programs that have as their objective the protection of public health.

The purpose of this manual is to provide overall guidance to States on methods for sampling and analyzing contaminants in fish and shellfish tissue that will promote consistency in the data States use to determine the need for fish consumption advisories. **This manual provides guidance only and does not constitute a regulatory requirement for the States.**

This technical guidance manual is intended for use as a handbook by the State and local agencies that are responsible for sampling and analyzing fish and shellfish tissue. Adherence to this guidance will enhance the comparability of fish and shellfish contaminant data, especially in interstate waters, and thus provide more standardized information of fish contamination problems.

This manual is the first in a series of four documents to be prepared by the EPA Office of Water as part of a Federal Assistance Plan to help States standardize fish consumption advisories. The remaining three documents will provide guidance on risk assessment, risk management, and risk communication.

This sampling and analysis manual is not intended to be an exhaustive guide to all aspects of sampling, statistical design, development of risk-based screening values, laboratory analyses, and QA/QC considerations for fish and shellfish contaminant monitoring programs. Key references are provided that detail various aspects of these topics. In addition, States may obtain a list of related documents relevant to fish and shellfish contamination monitoring by accessing the EPA Nonpoint Source Bulletin Board System (NPS BBS). The phone number of the BBS is (301) 589-0205.

Monitoring Strategy: Section 2 outlines the recommended strategy for State fish and shellfish contaminant monitoring programs. This strategy is designed to (1) routinely screen waterbodies to identify those locations where chemical contaminants in edible portions of fish and shellfish exceed human health screening values and (2) sample more intensively those waterbodies where exceedances of these SVs have been found in order to assess the magnitude and the geographic extent of the contamination.

Target Species: Section 3 discusses the purpose of using target species and criteria for selection of target species for both screening and intensive studies. Lists of recommended target species are provided for inland freshwaters, Great Lakes waters, and seven distinct estuarine and coastal marine regions of the United States.

Target Analytes: Section 4 presents a list of recommended target analytes to be considered for inclusion in screening studies and discuss criteria used in selecting these analytes.

Screening Values: Section 5 describes the EPA risk-based procedure for calculating screening values for target analytes.

Field Procedures: Section 6 recommends field procedures to be followed from the time fish or shellfish samples are collected until they are delivered to the laboratory for processing and analysis. Guidance is provided on site selection and sample collection procedures; the guidance addresses material and equipment requirements, time of sampling, size of animals to be collected, sample type, and number of samples. Sample identification, handling, preservation, shipping, and storage procedures are also described.

Laboratory Procedures: Section 7 described recommended laboratory procedures for sample handling including: sample measurements, sample processing procedures, and sample preservation and storage procedures. Section 8 presents recommended laboratory procedures for sample analyses, including cost-effective analytical methods and associated QC procedures, and information of sources of certified reference materials and Federal agencies currently conducting interlaboratory comparison programs.

Data Analysis and Reporting: Section 9 includes procedures for data analysis to determine the need for additional monitoring and risk assessment and for data reporting. This section also described the National Fish Tissue Data Repository (NFTDR), a national database of fish and shellfish contamination monitoring data.
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U.S. EPA. 1993. ***Laboratory Methods Manual - Estuaries. Environmental Monitoring and Assessment Program.*** **U. S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Cincinnati, OH. pp. 289. EPA/600/4-91/024.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, toxicity/bioassays, inorganics, metals, tissue analysis, organics, grain size, total solids, population/community, pesticides, PAHs, PCBs, organotin, total organic carbon**

Abstract

This EMAP program is designed to monitor a defined set of parameters (i.e., indicators of estuarine and coastal environmental quality) on a regional scale, over a period of decades, using standardized field sampling and laboratory methods with a probability-based sampling design. A defined set of parameters that serve as indicators of environmental quality are addressed. Categories of indicators identified and sampled are as follows:

- **Response indicators** - Measurements that quantify the integrated response of ecological resources to individual or multiple stressors. Included are benthic species composition, abundance and biomass; gross pathology of fish; fish species composition and abundance; relative abundance of large burrowing bivalves; and histopathology of fish.

- **Exposure indicators** - Physical, chemical, and biological measurements that quantify pollutant exposure, habitat degradation, or other causes of degraded ecological condition. Included are sediment contaminant concentration; sediment toxicity; contaminants in fish flesh; contaminants in large bivalves; and continuous and point measurements of dissolved oxygen concentration.

- **Habitat indicators** - Physical, chemical, and biological measurements that provide basic information about the natural environmental setting. Included are sediment characteristics: water salinity, temperature pH, depth, and clarity; chlorophyll-a fluorescence and the amount of photosynthetically active radiation (PAR) in the water column.

Recommended protocols for those indicator parameters that are measured in the laboratory are presented in this document. These include methods of laboratory analyses of selected inorganic and organic parameters, tissue analyses, sediment toxicity testing methods, sediment composition, and grain size determinations. Histopathological procedures and macrobenthic community assessment protocols are also discussed. Protocols for indicator parameters collected or measured in the field are contained in EMAP-NC Field Operations Manuals (Macauley, 1991; Strobel and Schimmel, 1991).
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U.S. EPA. 1993. ***Methods for Aquatic Toxicity Identification Evaluations, Phase II Toxicity Identification Procedures for Samples Exhibiting Acute and Chronic Toxicity.*** **U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Duluth, MN. EPA/600/R-92/080. (NTIS: PB94-114907).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, organics, metals, toxicity**

Abstract

This document is one in a series of guidance documents intended to assist dischargers and their consultants in conducting acute or chronic aquatic toxicity identification evaluations (TIEs). TIEs might be required by state or federal agencies resulting from an enforcement action or as a condition of a National Pollutant Discharge Elimination System (NPDES) permit. The TIE approach is applicable to effluents, ambient waters, sediment pore waters or elutriates, and hazardous waste leachates. The methods described in this document will also help to determine the adequacy of effluent TIEs when they are conducted as part of a toxicity reduction evaluation (TRE).

This Phase II document is the second of a three phase series of documents that provide methods to characterize and identify the cause of toxicity in effluents. The first phase of the series, Phase I, characterized the physical/chemical nature of the acute and chronic toxicant(s), thereby simplifying the analytical work needed to identify the toxicant(s). Phase II provides guidance to identify the suspect toxicants, and the last phase, Phase III provides methods to confirm that the suspect toxicants are indeed the cause of toxicity. These recent TIE documents have been produced or revised to include chronic toxicity recommendations and additional information or experiences we have gained since the original methods were printed.

This Phase II document provides identification schemes for non-polar organic chemicals, ammonia, metals, chlorine, and surfactants that cause either acute or chronic toxicity. The document is still incomplete in that it does not provide methods to identify all toxicants, such as polar organic compounds. This Phase II manual also incorporates chronic and acute toxicity identification techniques into one document.

While the TIE approach was originally developed for effluents, the methods and techniques directly apply to other types of aqueous samples, such as ambient waters, sediment pore waters, sediment elutriates, and hazardous waste leachates. These methods are not mandatory protocols but should be used as general guidance for conducting TIEs.

The sections of both Phase I documents which address health and safety, quality assurance/quality control (QA/QC), facilities and equipment, dilution water, testing, sampling, and parts of the introduction are applicable to Phase II. These sections, however, are not repeated in their entirety in this document. *[copied from document]*

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U.S. EPA. 1993. ***Methods for Aquatic Toxicity Identification Evaluations, Phase III Toxicity Confirmation Procedures for Samples Exhibiting Acute and Chronic Toxicity.*** **U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Duluth, MN. EPA/600/R-92/081. (NTIS: PB84-123833).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, toxicity/bioassays, QA/QC**

Abstract

This Phase III document is the last in a series of guidance documents intended to aid discharges and their consultants in conducting aquatic organism toxicity identification evaluations (TIEs). TIEs might be required by state or federal agencies as the result of an enforcement action or as a condition of a National Pollutant Discharge Elimination System (NPDES) permit. These documents should aid individuals in overseeing and determining the adequacy of effluent TIEs as a part of toxicity reduction evaluations (TREs).

In this confirmation document, guidance is included when the treatability approach is taken. Use of the treatability approach required confirmation as much as or more than the toxicant identification approach (Phase II). The reader is encouraged to use both the acute Phase I characterization and the chronic Phase I characterization documents for details of quality assurance/quality control (QA/QC), health and safety, facilities and equipment, dilution water, sampling, and testing. The TIE methods are written as general guidance rather than rigid protocols for conducting TIEs and these methods should be applicable to other aqueous samples, such as ambient waters, sediment elutriate or pore waters, and leachates.

In 1989, the guidance document for acutely toxic effluents entitled *Methods for Aquatic Toxicity Identification Evaluations: Phase III Toxicity Confirmation Procedures* was published. This new Phase III manual and its companion documents are intended to provide guidance to aid dischargers in confirming the cause of toxicity in industrial and municipal effluents. The toxicity identification evaluation (TIE) starts with a characterization of the effluent toxicity using aquatic organisms to tract toxicity; this step is followed by identifying a suspect toxicant(s) and then confirming the suspect toxicant as the cause of toxicity.

This Phase III confirmation document provides greater detail and more insight into the procedures described in the acute Phase III confirmation document. Procedures to confirm that all toxicants have been correctly identified are given and specific changes for methods applicable to chronic toxicity are included. A difficult aspect of confirmation occurs when toxicants are not additive, and therefore the effects of effluent matrix affecting the toxicants are discussed. The same basic techniques (correlation, symptoms, relative species sensitivity, spiking, and mass balance) are still used to confirm toxicants and case examples are provided to illustrate some of the Phase III procedures.
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U.S. EPA. 1993. ***Methods for the Determination of Inorganic Substances in Environmental Samples.*** **U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Cincinnati, OH. EPA/600/R-93/100. (NTIS: PB94-120821).**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☐ **Biota**

Keywords: **Water quality, sampling, turbidity, inorganics, nutrients, oxygen demand, data analysis**

Abstract

This manual contains ten updated and revised automated, semi-automated or methods amenable to automation for the determination of a variety of inorganic substances in water and wastewater.

These methods include and address, in an expanded form, information concerning safety, quality control, pollution prevention, and waste management. Methods were selected which minimize the amount of hazardous reagents required and maximize sample throughput to allow expanded quality control.

Automated methods are included for nitrate-nitrate, phosphorus, and sulfate. Semi-automated methods cover cyanide, ammonia, total kjeldahl nitrogen (TKN), chemical oxygen demand (COD), and generic phenolics. Methods amenable to automation include turbidity and inorganic anions by ion chromatography.
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U.S. EPA. 1993. (In press.) ***QA/QC Document for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations Phase 1 - Chemical Evaluations.*** **U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Standards & Applied Science Division (WH-585), Washington, DC.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, QA/QC, sampling, data analysis/management, tissue analysis**

Abstract

This document provides programmatic and technical guidance on quality assurance and quality control (QA/QC) issues related to evaluations of impacts associated with the discharge of dredged materials into inland and ocean waters. This QA/QC document serves as a companion manual to the *Ocean Testing Manual* and the *Inland Testing Manual*, both developed jointly by EPA and USACE.

The purpose of this document is

- to provide guidance on the development of quality assurance project plans for ensuring the reliability of data gathered to evaluate dredged material proposed for discharge under the Clean Water Act and the Marine Protection, Research, and Sanctuaries Act

- to outline procedures to be followed when sampling and analyzing sediments, water, and tissue

- to provide recommended target detection limits (TDLs) for chemicals of concern

This Phase 1 document pertains largely to physical and chemical evaluations. Phase 2 of the QA/QC guidance, pertaining to biological evaluations, will be published in 1995.
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U.S. EPA. 1993. *Volunteer Estuary Monitoring: A Methods Manual.* U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. EPA 842-B-93-004.

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, biological characterization, dissolved oxygen, nutrients, chlorophyll, population community, pathogenic organisms, sampling, QA/QC, volunteer monitoring**

Abstract

This manual compiles methodologies and techniques used in volunteer monitoring programs for estuarine waters. The manual describes specific techniques that managers can use to enhance existing programs or to launch a new volunteer monitoring program.

The focus of the manual is the identification of those water quality parameters that are most important in determining an estuary's water quality. The significance of each parameter and specific methods to monitor it are then detailed in a step-by-step fashion. Proper quality assurance and quality control are stressed to ensure that the data are useful to state agencies and other users.

Chapter 1 summarizes the process of planning and managing a volunteer monitoring program. Chapter 2 follows with a discussion of the particular problems that afflict the nation's estuaries. Chapter 3 describes those parameters that paint a broad-brush picture of an estuary's fundamental nature and outlines how to measure them. Chapters 4 through 7 take a detailed look at the most important parameters used in describing the water quality of an estuary: dissolved oxygen, nutrients and phytoplankton, submerged aquatic vegetation, and bacteria. Chapter 8 discusses the monitoring of marine debris, organizing a beach cleanup program, and collecting shellfish for toxic substance, bacteria, or paralytic shellfish poisoning analysis. Chapter 9 discusses the reasons for training volunteers and the steps necessary to ensure complete and interesting training sessions. Chapter 10 concludes the manual with a discussion of different data presentation techniques and the importance of credible data.

At the end of each chapter, references and materials from existing volunteer monitoring estuary programs are listed. These references should prove a valuable source of detailed information to anyone interested in establishing a new volunteer program or a background resource to those with already established programs.
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U.S. EPA. 1994. ***CWA Section 403: Procedural and Monitoring Guidance.*** **U.S. Environmental Protection Agency, Office of Water; Office of Wetlands, Oceans, and Watersheds, Ocean and Coastal Protection Division, Washington, DC. EPA 842-B-94-003.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, currents, depth, grain size, salinity, turbidity, temperature, sampling, QA/QC, nutrients, metals, dissolved oxygen, chlorophyll, PAHs, PCBs, organics, population/community, bioaccumulation, pathogenic organisms**

Abstract

The Clean Water Act (CWA, or the Act), Public Law 95-217, was enacted in 1972. The Act is the single most important and comprehensive piece of legislation dealing with the environmental quality of the Nation's waters, covering both marine and freshwater systems.

Section 402 of the CWA established the National Pollutant Discharge Elimination System (NPDES). This section of the Act requires that any direct discharger of pollutants to the surface waters of the United States obtain an NPDES permit before the discharge can take place. To obtain a NPDES permit, a discharger must demonstrate compliance with all applicable requirements of the Act. In the case of discharges to the territorial sea, the contiguous zone, or the ocean, these requirements include Section 403 of the Clean Water Act, which sets forth criteria to prevent unreasonable degradation of the marine environment and authorized imposition of any additional effluent limitations, including zero discharge, necessary to protect the receiving waters to attain the objectives of the Clean Water Act.

This document is designed to provide the EPA Regions and NPDES-authorized States with a framework for the decision-making process for Clean Waters Act Section 403 evaluations and to provide guidance on the type and level of monitoring that should be required as part of permit issuance under the "no irreparable harm" provisions of Section 403. (Generally, ambient monitoring is not required if a determination of "no unreasonable degradation" is made.) The decision-making aspects of the program, such as determination of information requirements and sufficiency of information, determination of no unreasonable degradation, and the decision to issue/reissue or deny a permit, are described. Options for monitoring under the basis of no irreparable harm, including criteria for evaluating perceived potential impact and establishing monitoring requirements to assess actual impacts, are discussed. Finally, summaries of monitoring methods for evaluating the following parameters are provided:

- **physical characteristics,** such as temperature, salinity, density, depth, turbidity, and current velocity and direction, to characterize the water column, to verify hydrodynamic models, and to indicate spatial and temporal variations
- **water chemistry** to evaluate the quality of receiving waters
- **sediment chemistry** to determine pollutant levels in sediments
- **sediment grain size** to describe spatial and temporal changes in the benthic community
- **benthic community structure** to detect and describe spatial and temporal changes in community structure and function

- **fish and shellfish pathobiology** to provide information regarding damage or alteration to organ systems of fish and shellfish

- **fish and shellfish populations** to detect and describe spatial and temporal changes in the abundance, structure, and function of fish and shellfish communities

- **plankton characteristics** including biomass, productivity, and community structure and function, to identify the dominant species, detect short- and long-term spatial and temporal trends, and examine the relationship between water quality conditions and community characteristics

- **habitat identification** to determine whether pollutant-related damage will cause long-lasting harm to sensitive marine habitats

- **bioaccumulation** to provide the link between pollutant exposure and effects

- **pathogens** to assess water conditions in the vicinity of discharges and surrounding areas and to assess relative pathogen contributions from permitted effluent discharges

- **effluent** characterization to predict biological impacts of an effluent prior to discharge

- **mesocosms and microcosms** to assess ecological impacts from marine discharges

Each method section contains an explanation of why the measurement of the parameter of concern might be included as part of a 403 monitoring program, and a discussion of monitoring design considerations, analytical methods, statistical design considerations, the use of data generated, and quality assurance/quality control considerations.
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APPENDIX B OCEAN DISCHARGE CRITERIA

U.S. EPA. 1994. ***Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume II: Risk Assessment and Fish Consumption Limits.*** **U.S. Environmental Protection Agency, Office of Science and Technology, Office of Water, Washington, DC. EPA 823-B-94-004.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, QA/QC, metals, pesticides, PCBs, inorganics, organics, tissue analysis, data analysis/management**

Abstract

The purpose of this document is to provide guidance to States and Native American Tribes on the development of fish consumption limits for chemically contaminated noncommercial freshwater and estuarine fish.

The objective of Volume II is to provide guidance on the development of risk-based meal consumption limits for 23 high-priority chemical fish contaminants (target analytes). The target analytes addressed in this guidance series were selected as particularly significant fish contaminants by EPA's Office of Water, based on their occurrence in fish, their potential for bioaccumulation, and their toxicity to humans. The criteria for their selection are discussed in Volume I of this series. In addition to a presentation of consumption limits, Volume II contains a discussion of risk assessment methods used to derive the consumption limits, as well as a discussion of methods to modify these limits to reflect local conditions. Additional sources of information are listed for those seeking a more detailed discussion of risk assessment methods.

The resultant guidance should help improve the comparability of the methods that underlie fish consumption advisory programs. This manual provides guidance only and does not constitute a regulatory requirement of the States.

This manual is the second in a four volume set of documents prepared by the EPA Office of Water. *Volume I: Fish Sampling and Analysis*, was released in September 1993. *Volume III: Risk Management* and *Volume IV: Risk Communication*, are scheduled for publication during late 1994 or early 1995. All four of these documents are begin developed in a cooperative fashion with Native American Tribes and State, Federal, and Local Government Agencies.

Copies of this document may be obtained by writing to the U.S. Environmental Protection Agency, Fish Contamination Section (4305), 401 M Street S.W., Washington, D.C. 20460.
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U.S. EPA. 1994. ***Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods.*** **U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. EPA 600/R-94/025.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Sediment quality, toxicity/bioassay, QA/QC, sampling**

Abstract

This manual describes a laboratory method for determining the short-term toxicity of contaminated whole-sediments using marine and estuarine amphipod crustaceans. Test sediments may be collected from estuarine or marine environments or spiked with compounds in the laboratory. A single test method is outlined that may be used with any of four amphipod species, including *Ampelisca abdita*, *Eohaustorius estuarius*, *Leptocheirus plumulosus*, and *Rhepoxynius abronius*. The toxicity test is conducted for 10 days in 1 L glass chambers containing 175 mL of sediment and 800 mL of overlying water. Overlying water is not renewed, and test organisms are not fed during the toxicity tests. Temperature and salinity of overlying water, and choice of negative control and reference sediments, are species-specific. The endpoint in the toxicity test is survival, and reburial of surviving amphipods is an additional measurement that can be used as an endpoint.
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U.S. EPA. 1994. ***Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates.*** **U.S. Environmental Protection Agency, Office of Research and Development, Duluth, MN. EPA 600/R-94/024.**

Media in which methods can be used: ☐ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Sediment quality, bioaccumulation, toxicity/bioassay, QA/QC, sampling**

Abstract

Procedures are described for testing freshwater organisms in the laboratory to evaluate the toxicity or bioaccumulation of contaminants associated with whole sediments. Sediments may be collected from the field or spiked with compounds in the laboratory. Toxicity methods are outlined for two organisms, the amphipod *Hyalella azteca* and the midge *Chironomus tentans*. The toxicity tests are conducted for 10 days in 300-mL chambers containing 100 mL of sediment and 175 mL of overlying water. Overlying water is renewed daily, and the test organisms are fed during the toxicity tests. The endpoint of the toxicity test with *H. azteca* is survival and the endpoints in the *C. tentans* are survival and growth. Procedures are described primarily for testing freshwater sediments: however, estuarine sediments (up to 15 ppt salinity) can also be tested with *H. azteca.*

Guidance for conducting 28-day bioaccumulation tests with the oligochaete *Lumbriculus variegatus* is provided in the manual. Overlying water is renewed daily and test organisms are not fed during bioaccumulation tests. Methods are also described for determining bioaccumulation kinetics of different classes of compounds during 28-day exposures with *L. variegatus.*
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U.S. EPA. 1994. ***National Directory of Volunteer Environmental Monitoring Programs. 4th ed.*** **U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC. pp. 551. EPA 841-B-94-001.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☑ **Biota**

Keywords: **Water quality, sediment quality, biological characterization, volunteer monitoring**

Abstract

Volunteer environmental monitoring programs are being established at an increasing rate during the past 5 years. This fourth edition of the National Directory includes 517 programs in 45 states. These programs are making substantial contributions to scientific research, resource management, and local advocacy.

This edition contains the results of nationwide survey questionnaire, mailed to subscribers of EPA's *The Volunteer Monitor.* Data reported included details on the uses the collected environmental data, the organizations that use the data, the number and environment type of stations monitored, monitoring frequency, physical, chemical, biological, and other parameters. The data also contains contact names, addresses, and telephone number of the volunteer program coordinators.
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U.S. EPA and U.S. Army Corps of Engineers. 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal Testing Manual.* U.S. Environmental Protection Agency, Office of Water and Department of the Army, U.S. Army Corps of Engineers, Washington, DC. pp. 288. EPA-503/8-91/001.

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, QA/QC, grain size, total solids, toxicity/bioassays, metals, organics, inorganics, total organic carbon, PAHs, PCBs, pesticides, tissue analysis, bioaccumulation, data analysis/management**

Abstract

This manual, commonly referred to as the "Green Book", is an update of *Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters* (EPA/USACE, 1977). The manual contains technical guidance for determining the suitability of dredged material for ocean disposal through chemical, physical, and biological evaluations. The technical guidance is intended for use by dredging applicant, laboratory scientists, and regulators in evaluating dredged-material compliance with the United States Ocean Dumping Regulations.

Integral to the manual is a tiered-testing procedure for evaluating compliance with the limiting permissible concentration (LPC) as defined by the ocean-dumping regulations. The procedure comprises four levels (tiers) of increasing investigative intensity that generate information to assist in making ocean-disposal decisions.

This manual provides a balance between technical state-of-the-art and routinely implementable guidance for using the evaluative procedures specified in the regulations. Guidance is included on the appropriate uses and limitations of the various procedures and on sound interpretation of the results. This manual contains summaries and discussions of the procedures for ecological evaluation of dredged material required by the regulations, tests to implement them, definitions, sample-collection and preservation procedures, evaluative procedures, calculations, interpretative guidance, and supporting references required for the evaluation of dredged material discharge applications in accordance with the regulations. Even so, this manual cannot stand alone. It is imperative that the supporting references be consulted for detailed or more comprehensive guidance whenever indicated. The technical procedures in this manual are designed only for dredged material.

This manual is organized into three parts and two appendices. Part I, General Considerations, presents the purpose and background of the manual and summarizes the Federal regulations that are relevant to dredged material evaluations. Part II, Evaluation of Potential Environmental Impact, presents guidance on the testing and evaluation of dredged material that is proposed for ocean disposal. Sections 4.0 through 7.0 of Part II describe the components of the four tiers in the tiered-testing procedure. Part III, Data Generation, presents guidance on sampling, physical and chemical analysis, biological-effects evaluation, statistical methods, and quality assurance. Appendix A is a reprint of the ocean dumping regulations (40 CFR 220-228) and Appendix B provides technical guidance for using the numerical models to calculate initial mixing.
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U.S. EPA and U.S. Army Corps of Engineers. 1994. ***Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (Draft): Inland Testing Manual.*** **U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC and Department of the Army, U.S. Army Corps of Engineers, Washington, DC. EPA-823-B-94-002.**

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, sampling, QA/QC, grain size, total solids, toxicity/bioassays, pathogenic organisms, bioaccumulation, data analysis/management**

Abstract

The USACE and EPA have statutory and regulatory responsibilities with regard to the management of dredged material discharge activities in inland and near coastal waters. The USACE is responsible for regulating non-Federal dredging and dredged material discharge activities through a permit program, and for conducting Federal dredging and discharge activities in conjunction with its Civil Works Program. EPA is responsible for establishing, in conjunction with the USACE, guidelines pertaining to the evaluation of these activities, and performing oversight actions.

This manual, commonly referred to as the *Inland Testing Manual,* represents a major effort by the USACE and EPA to establish procedures applicable to the evaluation of potential contaminant-related environmental impacts associated with the discharge of dredged material in waters regulated under Section 404 of the Clean Water Act (inland waters, near coastal waters, and surrounding environs) through chemical, physical, and biological evaluations. This manual is consistent, to the maximum extent practicable, with the procedures established for ocean waters (i.e., the *Green Book,* entitled *Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Manual EPA/USACE, 1991*). This manual replaces the May 1976 proposed testing protocol, *Ecological Evaluation of Proposed Discharge of Dredged or Fill Material into Navigable Waters.*

The technical guidance in this manual is intended for use by USACE and EPA personnel, state regulatory personnel, as well as dredging permit applicants and others (e.g., scientists, managers, and other involved or concerned individuals). Key changes to the 1976 testing protocol include a tiered approach, accommodation for sediment quality standards, 28-day bioaccumulation testing, comparison of benthic test results with those of the reference sediment, improved statistics, improved model applications, and new test organisms. Because this manual is national in scope, the guidance provided is generic and may need to be modified in certain instances. Permit applicants and others are strongly encouraged to consult with their appropriate Regional and District experts for additional guidance.
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U.S. FDA. 1990. ***National Shellfish Sanitation Program Manual of Operations Part 1 Sanitation of Shellfish Growing Areas 1990 Revision.*** **U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Center for Food Safety and Applied Nutrition, Division of Cooperative Programs, Shellfish Sanitation Branch, Washington, DC. pp. 136.**

Media in which methods can be used: ☑ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Water quality, biological characterization, sampling, tissue analysis, pathogenic organisms, toxicity, QA/QC**

Abstract

This manual was developed from a cooperative effort between the U.S. Food and Drug Administration and the Interstate Shellfish Sanitation Conference. This first of two volumes is prepared as a guide for preparing State laws and regulations relating to sanitary control of shellfish growing area classification, laboratory procedures, shellfish relay operations, growing area patrol operations, and marine biotoxins.

A section on laboratory procedures provides National Shellfish Sanitation Program laboratories with information on: (1) analytical methods and quality assurance procedures associated with the examination of seawater and shellfish; (2) references and information necessary for conducting bacteriological, toxicological, chemical, and physical tests; and (3) guidance for development and implementation of quality assurance procedures. Adherence to the procedures set out in this section will provide the uniformity necessary to provide reliable laboratory results upon which public health issues can be made in determining whether shellfish are suitable for human consumption.
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U.S. Geological Survey. 1987. ***Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples.*** **In** ***Techniques of Water-Resources Investigations of the United States Geological Survey.*** **Edited by L.J. Britton and P. E. Greeson. U.S. Department of the Interior, Geological Survey, Denver, CO. pp. 375.**

Media in which methods can be used: ☐ **Water** ☐ **Sediment** ☑ **Biota**

Keywords: **Biological characterization, pathogenic organisms, population/community, sampling**

Abstract

The series of chapters on techniques describes methods used by the U.S. Geological Survey for planning and conducting water-resources investigations. The material is arranged under major subject heading called books and is further subdivided into section and chapters. Book 5 is on laboratory analysis. Section A is on water. The unit of publication, the chapter, is limited to a narrow field of subject matter.

Chapter A4 contains methods used by the U.S. Geological Survey to collect, preserve, and analyze water to determine its biological and microbiological properties. Part 1 consists of detailed descriptions of more than 45 individual methods, including those for bacteria, phytoplankton, zooplankton, seston, periphyton, macrophytes, benthic invertebrates, fish and other vertebrates, cellular contents, productivity, and bioassays. Each method is summarized, and the applications, interferences, apparatus, reagents, analyses, calculations, reporting of results, precisions, and references are given. Part 2 consists of a glossary. Part 3 is a list of taxonomic references.
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U.S. Geological Survey. 1989. *Methods for Determination of Inorganic Substances in Water and Fluvial Sediments. 3rd ed.* In *Techniques of Water-Resources Investigations of the United States Geological Survey.* Edited by M.J. Fishman and L.C. Friedman. U.S. Department of the Interior, Geological Survey, Denver, CO. pp. 642.

Media in which methods can be used: ☑ **Water** ☑ **Sediment** ☐ **Biota**

Keywords: **Water quality, sediment quality, QA/QC, sampling, metals, inorganics, oxygen demand, turbidity, nutrients**

Abstract

A series of manuals on techniques describes methods used by the Geological Survey for planning and conducting water-resources investigations. The material is arranged under major subject headings called books and is further subdivided into sections and chapters. Book 5 is on laboratory analyses, Section A is on water. The unit of publication, the chapter, is limited to a narrow field of subject matter.

Chapter A1 of the laboratory manual contains methods used by the Geological Survey to analyze samples of water, suspended sediments, and bottom material for their content of inorganic constituents. Included are methods for determining dissolved, total recoverable, and total concentrations of constituents in water-suspended sediment samples, and recoverable and total constituents in samples of bottom material. Essential definitions are included in the introduction to the manual, along with a brief discussion of the use of significant figures in calculating and reporting analytical results. Quality control in the water-analysis laboratory is discussed, including accuracy and precision of analyses, the use of standard reference water samples, and the operation of an effective quality assurance program. Methods for sample preparation and pretreatment are given also.

The analytical methods are arranged according to the analytical technique employed for the determination: atomic absorption spectrometric, calculation, colorimetric, electrometric, gravimetric, and titrimetric methods. More than 200 methods are given for the determination of 69 different inorganic constituents and physical properties of water, suspended sediment, and bottom material, and many of the methods given are identical except for the preparation step, which varies with the particular type of sample that is taken for analysis. Included in the manual are many automated methods, particularly the colorimetric methods that make use of the Technicon AutoAnalyzer system to automate the determination from sample introduction to final concentration readout.

A brief discussion of the principles of the analytical technique involved and its particular application to water analysis proceeds each group of analytical methods. For each method given, the general topics covered are application, principle of the method, interferences, apparatus and reagents required, a detailed description of the analytical procedure, reporting results, units and significant figures, and analytical precision data, when available.
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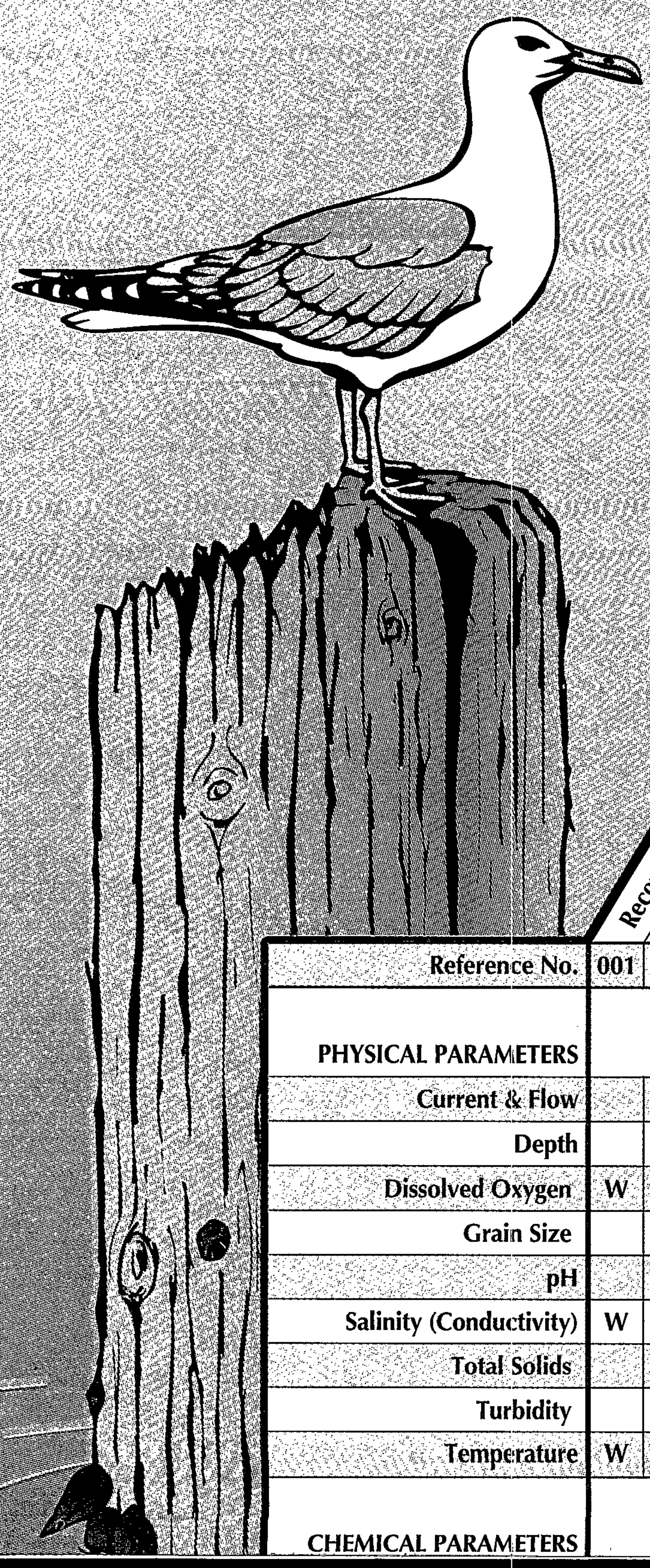

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Reference No.	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
PHYSICAL PARAMETERS																	
Current & Flow				W													
Depth																	
Dissolved Oxygen	W	W		W											W		
Grain Size				S							S						
pH		W		W	W										W		
Salinity (Conductivity)	W	W		W	W										W		
Total Solids		W			W						WS				W		
Turbidity		W		W	W										W		
Temperature	W	W													W		
CHEMICAL PARAMETERS																	

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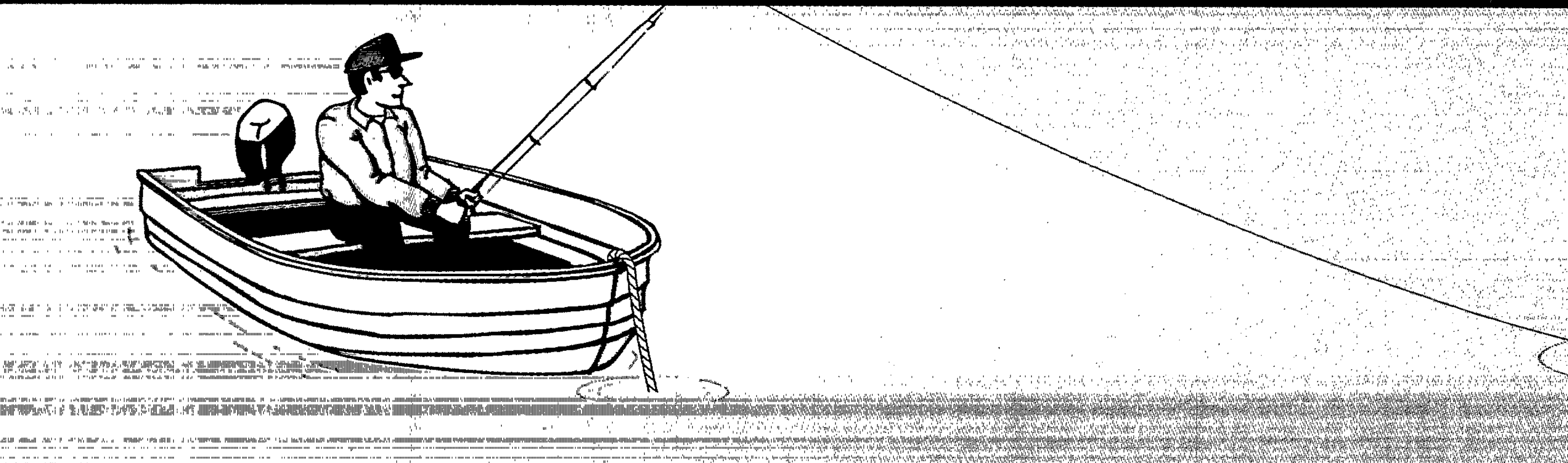

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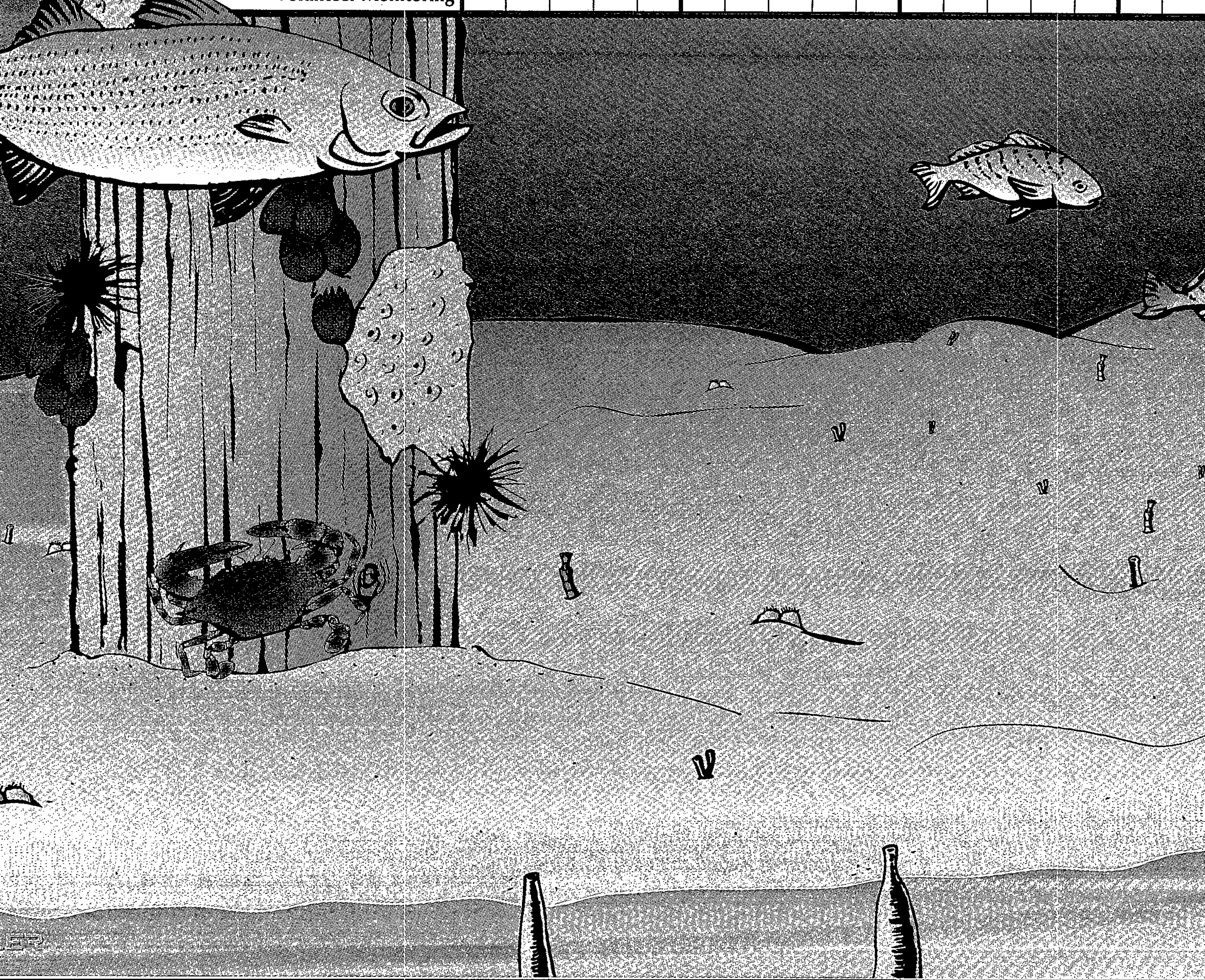
Metals		W			W									S	W		
Inorganic Constituents		W		WS	W										W		
Organic Constituents		W		WS	W										W		
Total Organic Carbon		W		WS							S				W		
Nutrients		W		WS							WS				W		
Oxygen Demand		W		WS							WS				W		
PAHs		W		WS	W									S	W		
PCBs		W		WS	W									S	W		
Pesticides		W		WS	W										W		
Organotins					W										W		
Radioactivity		W		WS	W										W		
BIOLOGICAL PARAMETERS																	
Bioaccumulation																	
Chlorophyll											WB						
Pathogenic Organisms	WB	WB		WS	W												
Population/Community											B						
Tissue Analysis			WSB														
Toxicity/Bioassays	WB	WB	WSB			WB								S			
RELATED TOPICS																	
Data Analysis/Management			WSB	WS	W		W	WSB	W	W		WS			W	W	
QA/QC			WSB	WS		WB	W	WSB			WSB	WS					
Sampling	WB	W	WSB	WS		B	W				WSB	WS	B				S
Volunteer Monitoring																	



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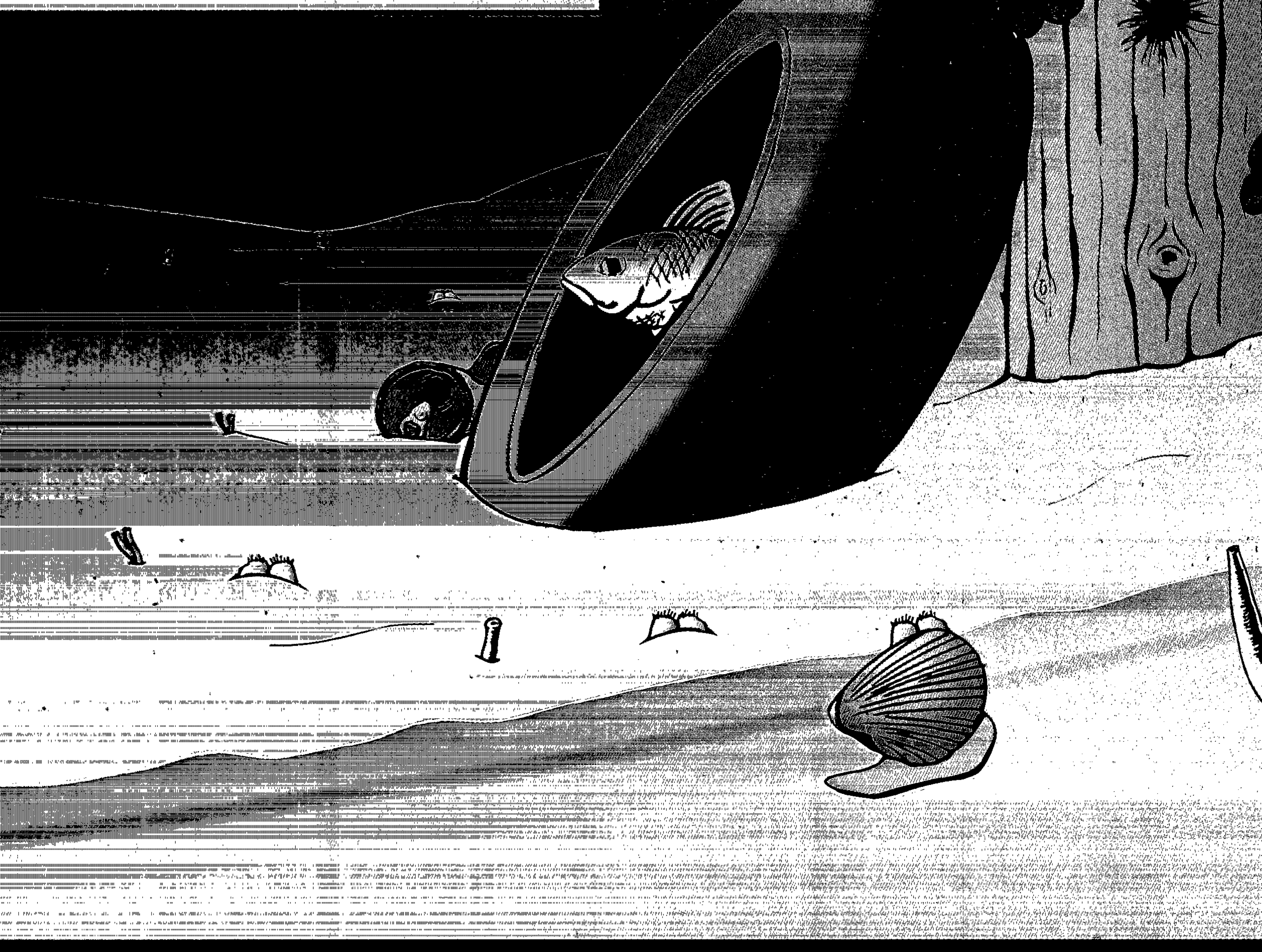
EGEND

/ = Water S = Sediment B = Biota



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Field Operations & Safety Manual: EMAP-Estuaries 1992 V
Mtds for Determination of Chemical Substance
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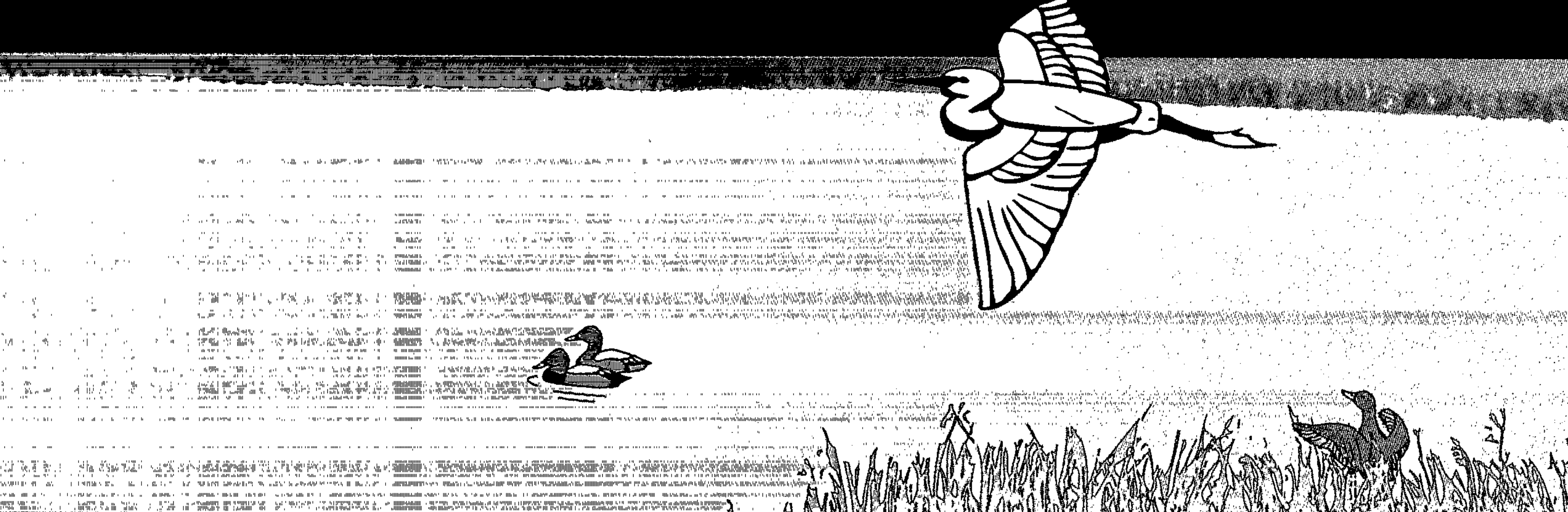
METHODS



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088	089	090	091	092	093	094	095	096	097	098	099	100	Reference No.
													PHYSICAL PARAMETERS
			W										Current & Flow
			W										Depth
		W	W										Dissolved Oxygen
			S					S	S				Grain Size
													pH
			W										Salinity (Conductivity)
								WS	W				Total Solids
W			W									W	Turbidity
			W										Temperature
													CHEMICAL PARAMETERS

S																W					WS		WS	WS	S		WS
S																					WS		WS	WS	S		WS
S										B	B										WS		WS	WS	S		WS
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		WSB	W						W						WS	W	WS							WSB		S	WSB
B	B	WSB	W		S				W			WB		B		W	WS	WS	WSB	B		WSB		WSB			WSB
B		WSB					W			B	B	WB		B		W	WS	WS	WSB	B		WSB	WS	WSB	S	S	WSB
B		WSB			S	W	W	WB		B	B	WB		B	WS	W	W		WB	B		WSB	WS	WSB		S	WSB
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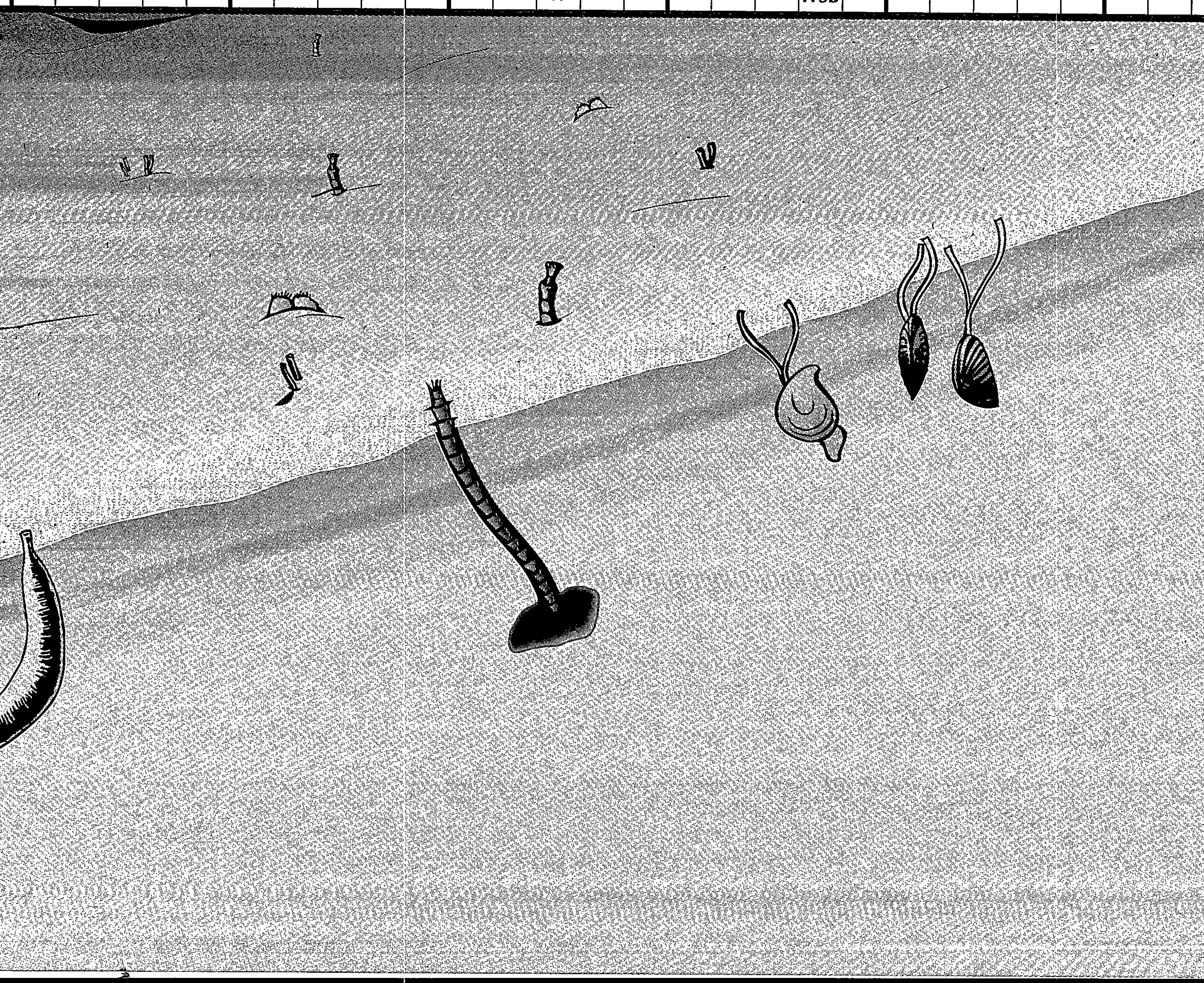

			WS	B				WS	WS			WS	Metals
W			WS	B				WS	WS			WS	Inorganic Constituents
			WS	B				WS	WS				Organic Constituents
			S					WS	WS				Total Organic Carbon
W		W	W									WS	Nutrients
W		W										WS	Oxygen Demand
			WS	B				WS	WS				PAHs
			WS	B				WS	WS				PCBs
			WS	B				WS	WS				Pesticides
													Organotins
													Radioactivity
													BIOLOGICAL PARAMETERS
			WSB			S		WS	WS				Bioaccumulation
		W	W										Chlorophyll
		WB	WSB							WB	B		Pathogenic Organisms
		B	WSB								B		Population/Community
	B		WSB	B				WS	W	B			Tissue Analysis
					S	S		WS	WS	B			Toxicity/Bioassays
													RELATED TOPICS
W	WS			B				WS	WS				Data Analysis/Management
	WS	WB	WSB	B	S	S		WS	WS	WB		WS	QA/QC
W	WS	WB	WSB		S	S		WS	WS	WB	B	WS	Sampling
		WB					WSB						Volunteer Monitoring

IARINE AND ESTUARINE MONITORING METHOD

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A comprehensive listing of references on the subjects of sample collection, analytical methods, quality assurance, and other pics related to water, sediment, and ological monitoring of estuarine and astal environments. This chart is distributed with the EPA publication *Bibliography of Methods for Marine and Estuarine Monitoring*. The informatio presented in this table represents a summary of the references described in the report. For each reference listed in this poster, a complete citation, keywords, an abstract, and the table of contents are included in the report.

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eans and Coastal Protection Division, U.S. Environmental Protection Agency, Washington, DC, 19