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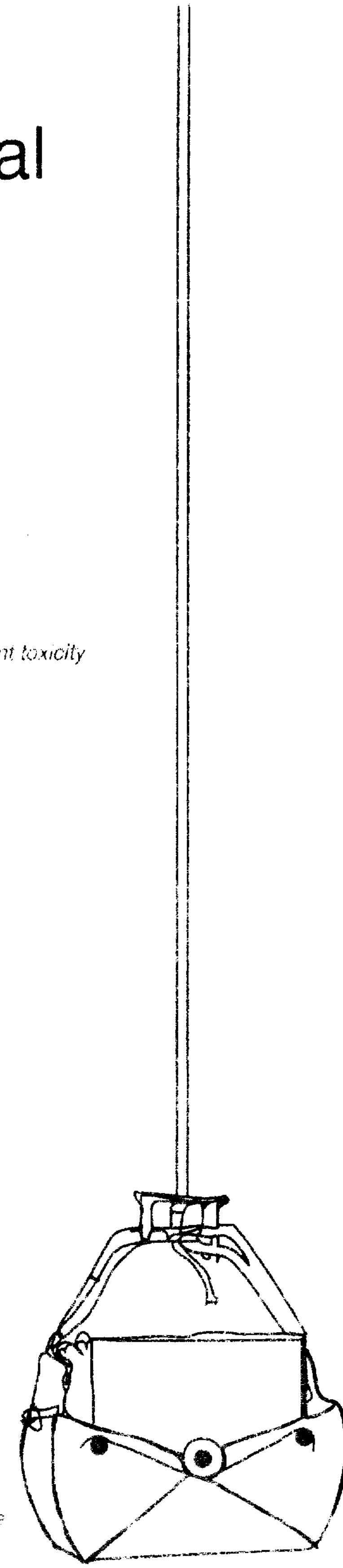
September 1993

EPA

R-EMAP

Regional Environmental Monitoring and Assessment Program



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R-EMAP

REGIONAL ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM

U.S. Environmental Protection Agency
Office Of Research And Development
Office Of Science, Planning And Regulatory Evaluation
Center For Environmental Research Information
Cincinnati, OH 45268

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CONTENTS

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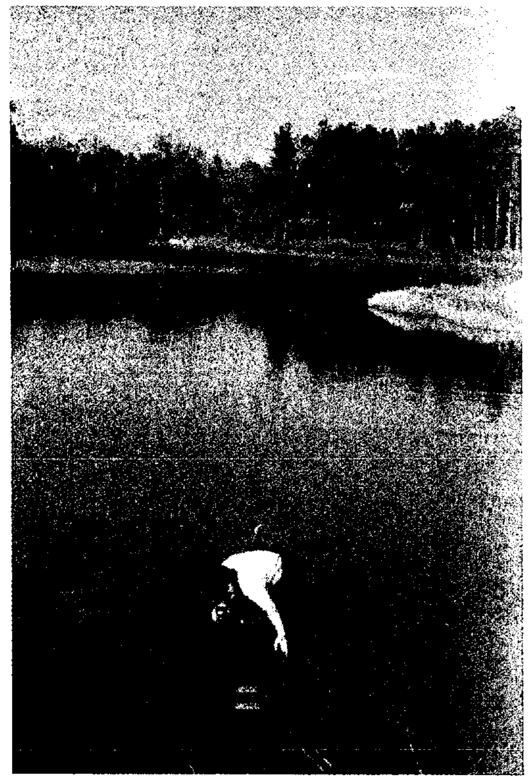
INTRODUCTION

The Environmental Monitoring and Assessment Program (EMAP) is an innovative, long-term research, monitoring, and assessment program designed to measure the current and changing condition of the nation's ecological resources. EMAP represents a new direction for the U.S. Environmental Protection Agency (EPA). Responding to the EPA Science Advisory Board's 1988 recommendation to monitor ecological status and trends, EPA initiated EMAP to help provide answers to questions such as:

- *What is the current geographic extent of ecological resources?*
- *What resources are degrading or improving, where, and at what rate?*
- *Are affected resources responding as predicted to changing control and regulatory programs?*



EMAP is assessing the condition of the nation's ecological resources–surface waters, estuaries, wetlands, agroecosystems, arid ecosystems, forests, the Great Lakes, and landscapes.

The ultimate goal of the program is to provide decision makers with sound ecological data to improve environmental risk management decisions.

This publication describes the Regional Environmental Monitoring and Assessment Program (R-EMAP), a new partnership among EMAP, EPA's Regional offices, other federal agencies, and states. R-EMAP adapts EMAP's broad-scale approach to produce ecological assessments at regional, state, and local scales. The introduction

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

below briefly describes the overall EMAP approach, including its innovative statistical sampling design and use of ecological **indicators**. Following this EMAP overview are descriptions of the R-EMAP projects currently under way and in the planning stages.

THE EMAP APPROACH

EMAP is "a new way of doing business." It addresses the larger scale, longer term environmental problems occurring at regional and national scales. Instead of taking the traditional single-chemical or single-site approach to environmental assessment, EMAP adopts a comprehensive, multimedia perspective of the environment to answer questions about overall ecological condition. EMAP has been designed to serve ultimately as "America's Ecological Report Card."

Surface water

CAROL DREW

It has four strategic objectives:

- *To estimate the current status, trends, and changes in selected indicators of the condition of the nation's ecological resources on a regional basis with known statistical confidence.*
- *To estimate the geographic coverage and extent of the nation's ecological resources with known statistical confidence.*
- *To seek associations between selected indicators of natural and anthropogenic stresses and indicators of the condition of ecological resources.*
- *To provide annual statistical summaries and periodic assessments of the nation's ecological resources.*

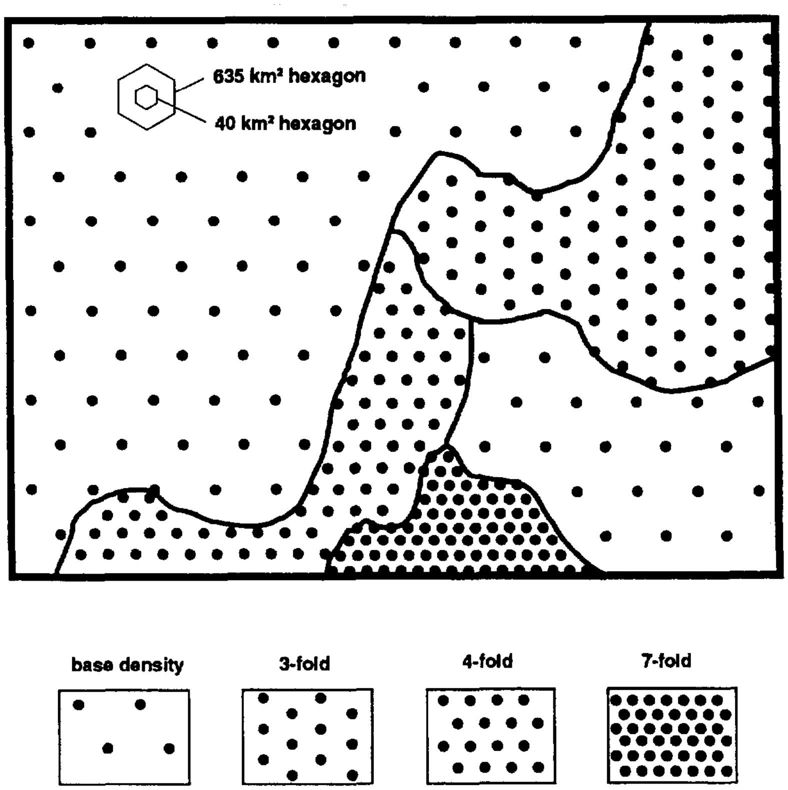
While EMAP is a multiagency effort, it is the scientific foundation for EPA's risk-based approach to protecting ecological resources. The Agency's goal is to focus resources on those problems that pose the greatest risks to the environment. To identify high-risk problems, it is important to understand the magnitude and extent of degraded resources. Once identified, high-risk problems can receive priority for intensive investigation of probable causes, followed by risk reduction through such methods as regulatory controls and joint efforts with resource management agencies. The success of these risk reduction methods is then measured and evaluated. EMAP's role in this strategy is to help identify high-risk environmental problems and to measure the cumulative effectiveness of environmental protection efforts.

EMAP Sampling Design

EMAP uses a statistical sampling design with three major components: the EMAP grid, a two-tier sampling approach, and a rotating sampling schedule. EMAP uses a systematic grid covering the coterminous United States, Alaska, Hawaii, and the Caribbean. The uniform spatial coverage provided by a grid ensures that each ecological resource is sampled in proportion to its geographical presence across the country. The EMAP grid consists of a set of points which, if connected, would form a series of adjacent equilateral triangles (Figure 1). The base density of the grid is one grid point per 635 square kilometers (km^2) (a linear point-to-point distance of 27 km), resulting in 12,600 grid points in the coterminous United States. The grid's placement is determined by a formal **randomization** to ensure strict adherence to requirements for **probability sampling**. The base density can be easily intensified for subregional studies (such as R-EMAP projects).

Figure 1

EMAP SAMPLING GRID, *with enhancements to increase grid density*



EMAP obtains a **probability**-based sample of an ecological resource in two stages: a Tier 1 sample followed by a Tier 2 sample. The Tier 1 sample is based on the EMAP base grid density shown in Figure 1. EMAP scientists use the Tier 1 sample, in conjunction with other information, to estimate resource extent and distribution (number of lakes, total area of lakes, acreage of forest, etc.) and to select the Tier 2 sample. In Tier 2, EMAP uses samples based on hexagonal areas centered at the grid points, each having an area of 40 km^2 (see Figure 1). The Tier 2 sample allows scientists to obtain detailed data on indicators of resource condition.

Estuary

The EMAP sampling schedule is designed to meet two objectives: assessing the status of a resource by sampling as much of the resource as possible at a given time, while detecting trends by repeated sampling at the same locations at regular time intervals. EMAP rotates through a 4-year sequence: During the first year, one quarter of the total grid points are Tier 1 points and potential Tier 2 points for that year; during the next year, sites designated as "second-year" are available for sampling, and so on. In this manner, all grid points are covered during a 4-year period. A second monitoring cycle begins in the fifth year by revisiting the first-year sites.

Ecological Indicators

EMAP combines its statistical sampling strategy with indicators of the condition of ecological resources. Traditionally, monitoring programs have measured pollutants in the environment to determine good or poor ecological condition. EMAP takes a different approach: It examines the condition of plant and animal communities through biological and ecological indicators. This approach recognizes that ecological resources are affected by multiple **stressors** in all environmental media (water, air, and soil), and these stressors can produce cumulative effects on entire populations and communities. EMAP measures two types of ecological indicators:


DAN O'NEAL U.S. FISH AND WILDLIFE SERVICE

Wetlands

- *Condition indicators, which are characteristics of the environment that provide quantitative estimates of the state of ecological resources and that are important to society. Examples include tree crown density and the number of species and individuals in fish communities.*
- *Stressor indicators, which are characteristics of the environment that are suspected to elicit a change in the state of ecological resources. They include both natural and human-induced stressors. Examples include acid deposition rates and ambient pollutant concentrations.*

EMAP scientists then determine whether statistical associations exist between indicators of ecosystem condition and indicators of natural and anthropogenic stress, including stressors. Through these correlation studies, scientists can formulate **hypotheses** about potential causes of change for further study.


STEVE DELANEY

Agroecosystem

Ecological Resource Groups

EMAP has established resource monitoring groups that are assessing the condition of eight ecological resources in the United States:

COURTESY OF UNIVERSITY OF CALIFORNIA NATURAL RESERVE SYSTEM

Arid Ecosystem

Agroecosystems

Dynamic associations of crops, pastures, livestock, other flora and fauna, soils, water, and the atmosphere.

Arid Ecosystems

Terrestrial systems characterized by a climate regime where annual precipitation ranges from less than 5 to 60 centimeters, **evapotranspiration** *exceeds precipitation, and air temperatures range from -40° to 50°C. The vegetation is dominated by woody perennials, succulents, and drought-resistant trees.*

Estuaries

Regions of interaction between rivers and nearshore ocean waters, where tidal action and river flow mix fresh and salt water. Examples include bays, mouths of rivers, salt marshes, and lagoons.

Forests

Lands with at least 10 percent of their surface area stocked by trees of any size, or formerly having had such trees as cover and not currently built up or developed for agricultural use.

The Great Lakes

The resource that encompasses Lakes Superior, Huron, Michigan, Erie, and Ontario, including river mouths up to the maximum extent of influence.

Surface Waters

The inland surface waters consisting of all the nation's lakes (other than the Great Lakes), rivers, and streams.

Wetlands

Areas saturated by surface or ground water with vegetation adapted for life under those soil conditions. Examples are swamps, bogs, fens, marshes, and estuaries.

Landscapes

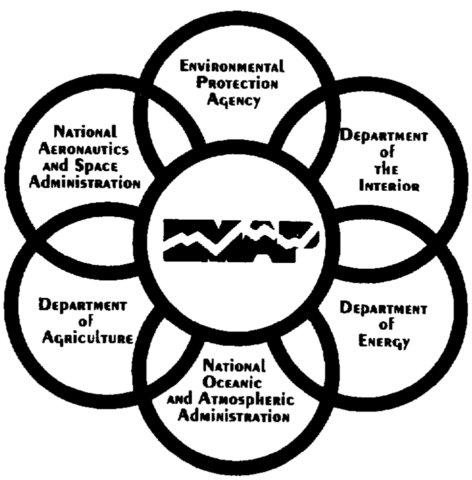
Areas where interacting **ecosystems** *are grouped and repeated in similar form.*

Each resource group uses compatible sampling designs, indicators, methods, and information management approaches to facilitate integrated assessments of ecological condition. Ecological assessments produced by the program identify the magnitude and extent of problems, indicating areas that need more intensive research and monitoring. In addition, EMAP data will be integrated with data from other research and monitoring programs, as appropriate.

Forest

Collaborative Activities

An ambitious effort such as EMAP requires the participation of the nation's best scientists. To date, collaboration has been established among 12 federal agencies, 28 states, and 50 universities. In addition to contributing to EMAP activities, many of these groups are also conducting more in-depth studies using EMAP's statistical and ecological approach. Because enhanced diagnostic monitoring generally takes place on a more refined geographic scale than that of EMAP, other federal agencies, states, and EPA Regions will play lead roles in following EMAP research with intensive site studies.



INTERAGENCY COOPERATION

REGIONAL ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM

R-EMAP was initiated to test the applicability of the EMAP approach to answer questions about ecological conditions at regional and local scales. Using EMAP's statistical design and indicator concepts, R-EMAP conducts projects at smaller geographic scales and in shorter time frames than the national EMAP program.

The objectives of R-EMAP are to:

- *Evaluate and improve EMAP concepts for state and local use.*
- *Assess the applicability of EMAP indicators at differing spatial scales.*
- *Demonstrate the utility of EMAP for resolving issues of importance to EPA Regions and states.*

REGIONAL EMAP

R-EMAP proposals are submitted to EMAP by the EPA Regional offices and undergo a competitive peer-review process before being approved for funding. This publication describes seven projects that were selected for funding in Fiscal Year 1993:

Great Lakes (Lake Superior)

Region I:
Fish Tissue Contamination in the State of Maine

Region II:
Characterizing Sediment Quality in the New York/New Jersey Harbor System

Region III:
Surface Water Quality Indicators in the Central Appalachian Ridges and Valleys Ecoregion

Region VI:
Toxics Characterization of Selected Texas Estuaries

Region VII:
Measuring the Health of Fisheries

Region IX:
Assessing Aquatic Ecosystems in a Highly Modified, Agriculturally Influenced Environment: California's Central Valley

Region X:
Biological Assessment of Wadable Streams in the Coast Range Ecoregion and the Yakima River Basin

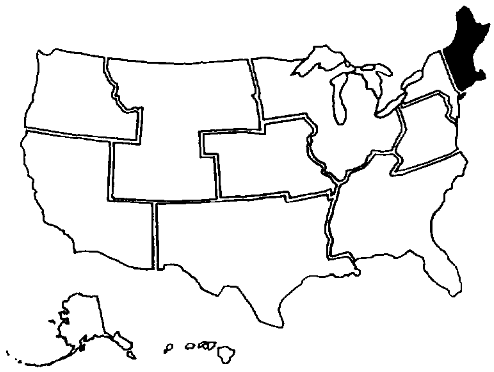
Each of these descriptions discusses the problem addressed by the project, activities, schedule, technical approach, and a contact for additional information.

Three additional R-EMAP projects, currently in the planning stages, are also described:

Region IV:
Ecological Risk Assessment of Mercury Contamination in the Everglades Ecosystem

Region V:
Developing an EMAP Signature for a Rare and Imperiled Ecosystem, Assessing Corn Belt Rivers and Streams, and Assessing Harbors and Embayments in a Great Lakes Area of Concern

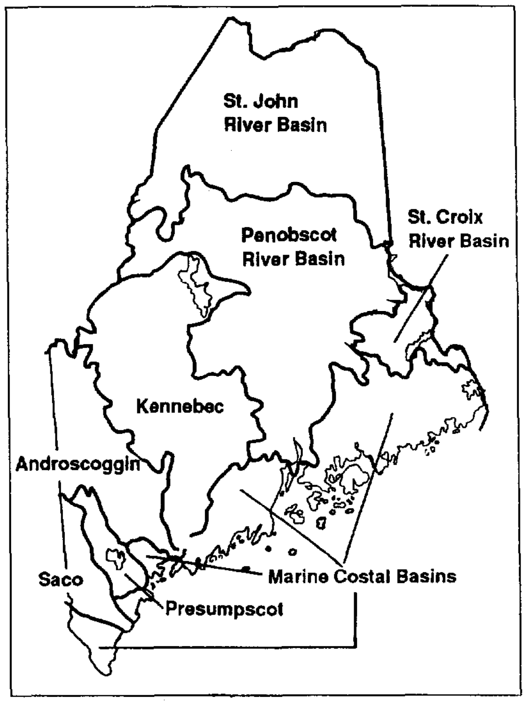
Region VIII:
Assessing Water Resources in the Mineralized Area of the Southern Rocky Mountains Ecoregion



REGION I

FISH TISSUE CONTAMINATION IN THE STATE OF MAINE

EPA and the state of Maine are concerned that Maine's **fishery** resources might be at risk from toxic chemicals in the environment. High mercury and organic contaminant levels have been found in fish collected from some of the state's pristine, remote lakes. Fish-eating birds and other animals higher in the food chain, as well as humans, might also be at risk. Significant levels of mercury, chlorinated organic compounds, and polychlorinated biphenyls (PCBs) have been found in Maine bald eagles. Maine's bald eagle **population** is recovering at a substantially slower pace than elsewhere in the nation.



STUDY AREA

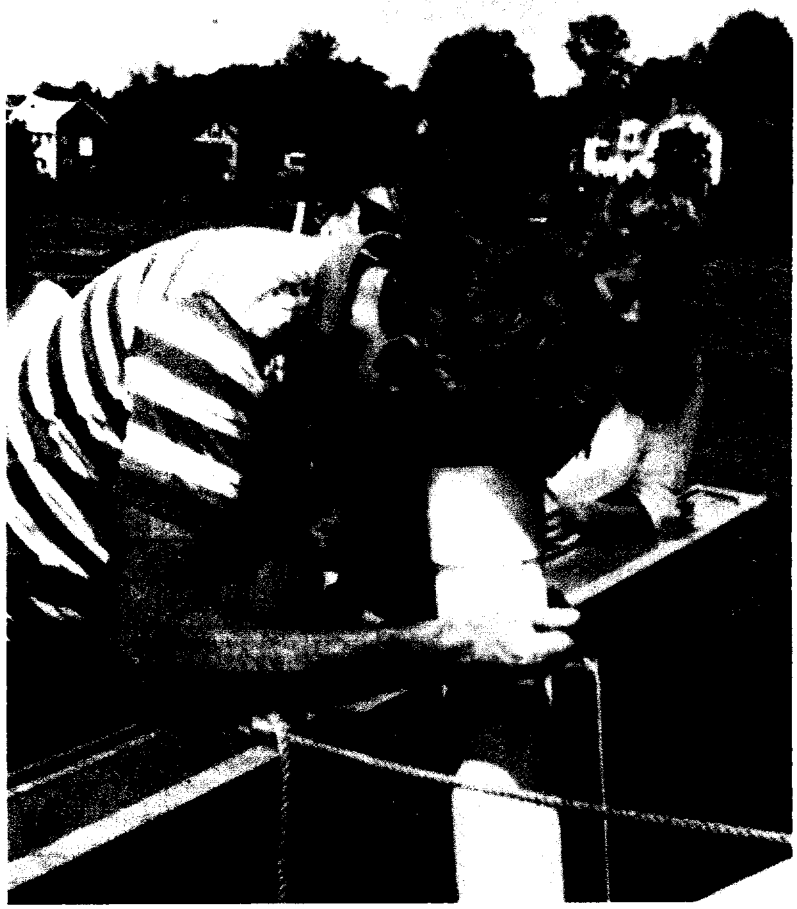
High levels of mercury and organic contaminants have been found in fish collected from some of Maine's remote, pristine lakes.

Good data to confirm these concerns, however, are lacking. The Region I R-EMAP project, the Maine Fish Tissue Contamination Project, will use fish tissue analysis to estimate the levels of contamination in fish populations and the risks that these levels pose to humans and wildlife. The study will also allow investigators to identify the contaminant levels and risks associated with factors such as species, lake type, geographic region, land use, and air transport regions and to project this analysis across the entire population of Maine lakes. This will help environmental and fishery managers focus their resource protection efforts on the areas at greatest risk.

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

The study will address the following questions:

- *What is the current status of fish tissue contamination by certain chemicals in the state of Maine?*
- *What do the concentrations of fish tissue contaminants imply about ecological risk (related to food chain* **biomagnification***) and human health risk (related to fish consumption)?*
- *What percentage and number of Maine lakes are contaminated, with what chemicals, and to what extent?*
- *What are the distribution patterns of fish tissue contamination? How is fish tissue contamination associated with possible* **stressors** *related to geography, population density, bedrock geology, and air flow patterns?*
- *What are the processes and patterns that determine the sensitivity of different lake types to contamination (such as water chemistry,* **sediment** *chemistry,* **hydrology***, and* **trophic state***)?*



A state field worker uses a viewscope to take Secchi disk measurements to determine water clarity in a study lake.

A multidisciplinary team, including personnel from EPA Region I, EPA's Office of Research and Development, the Maine Department of Environmental Protection, and the Maine Department of Inland Fisheries and Wildlife, will manage and implement the Maine Fish Tissue Contamination Project. Representatives from EPA's Environmental Research Laboratories in Duluth, Minnesota, and Corvallis, Oregon, and the U.S. Fish and Wildlife Service will provide technical guidance. The Maine Health and Environmental Testing Laboratory and the University of Maine (Orono) will perform sample processing and analysis. The EPA Region I Environmental Services Division will provide **quality assurance/quality control** support.

ACTIVITIES

Using the EMAP statistical design, the project will sample approximately 150 Maine lakes for fish tissue contaminants. Fish tissue will be analyzed for mercury, cadmium, lead, PCBs, and selected pesticides. In addition, lake sediments will be analyzed for metals, and **water column** measurements will be made for certain water quality parameters and trophic status indicators. The investigators will use the sediment and water column data to aid in the interpretation of fish tissue data. Where possible, investigators will also determine the air flow patterns, geology, lake conditions, and other factors that might influence the geographical distribution of fish tissue contamination statewide. Table 1-1 presents the milestones and schedule for the Maine Fish Tissue Contamination Project.

The expected benefits of these activities include:

- *Baseline data to evaluate the status of Maine fishery resources, to assess trends, and to identify potential actions to protect those resources.*
- *Demonstration of how the EMAP design can address issues in targeted geographic areas at the state and subregional levels.*
- *Input to a national data base for stressors of concern, such as mercury, PCBs, and pesticides.*
- *Information for use by other programs, such as monitoring Maine eagles for chemical contamination.*

Table 1-1

MILESTONES AND SCHEDULE	1992	1993	1994	1995
Initiate development of data management system	September			
Finalize statistical design—EMAP		February		
Draft quality assurance project plan (including sampling and analysis standard operating procedures and logistics)		February		
Conduct preliminary sampling run for fish tissue analysis		March		
Make final lake selection		April		
Initiate sampling/analysis		May		
Complete sampling		October		
Complete analyses		December		
Complete quality assurance/quality control			February	
Complete summary report			May	
Initiate Year 2 sampling/analysis (as needed)			May	
Draft assessment report (Year 1)			September	
Complete report				March

Table 1-2

ORDER OF PRIORITY FOR FISH COLLECTION

Group	Species	Scientific name	Size
COLD WATER (Top Trophic Level Predatory)	Lake trout	*Salvelinus namaycush*	16-20 inches
	Burbot	*Lota lota*	14-20 inches
	Landlocked salmon	*Salmo salar*	14-18 inches
	Brown trout	*Salmo trutta*	12-18 inches
	Brook trout	*Salvelinus fontinalis*	8-14 inches
WARM WATER (Top Trophic Level Predatory)	Chain pickerel	*Esox niger*	14-18 inches
	Smallmouth bass	*Micropterus dolomieui*	12-16 inches
	Largemouth bass	*Micropterus salmoides*	12-16 inches
	Yellow perch	*Perca flavescens*	8-12 inches
	White perch	*Morone americana*	8-12 inches
OMNIVOROUS (Feeding at Secondary Trophic Level)	White sucker	*Catostomus commersoni*	14-18 inches
	Brown bullhead	*Ictalurus nebulosus*	10-14 inches

TECHNICAL APPROACH

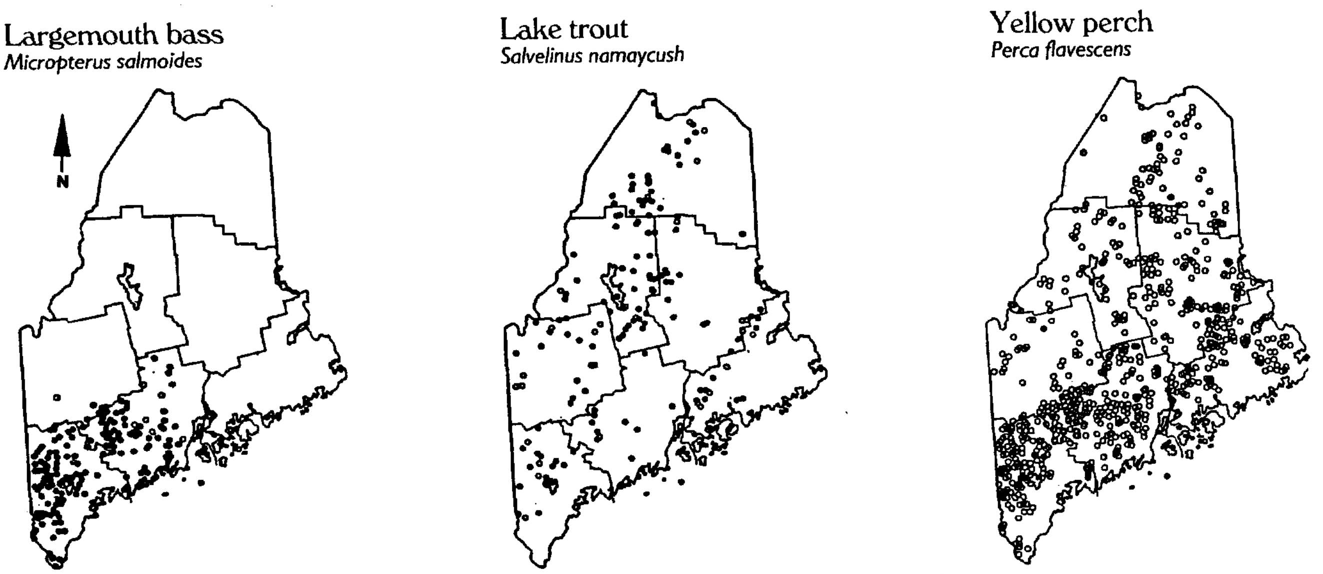
Lake Selection

EPA's Office of Research and Development Laboratory in Corvallis, Oregon, will select approximately 150 study lakes using EMAP's **probability** design. These lakes will be selected from among the 1,800 lakes that have been surveyed and found to have significant fisheries. The lake selection process will ensure that small, medium-sized, and large lakes have an equal probability of being included. This is important because large lakes (greater than 500 hectares) and medium-sized lakes (50 to 500 hectares) comprise about 65 percent of the total population and significantly more than that in surface area.

Using a **geographic information system (GIS)** and existing data, the investigators will classify the study lakes according to geography, geology, land use, human population densities, air flow patterns, and lake conditions. This information, together with the fish tissue data, will assist in the identification of geographic areas at risk.

Figure 1-1

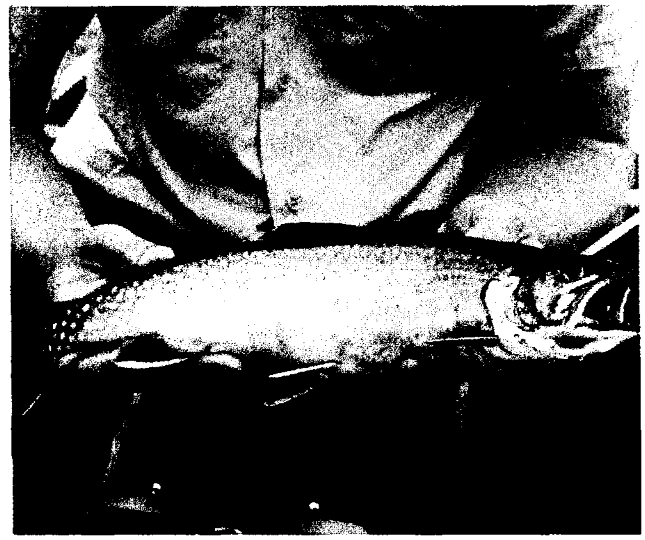
HISTORIC SPECIES DISTRIBUTION IN LAKES - *The R-EMAP project will provide updated information on species distribution.*



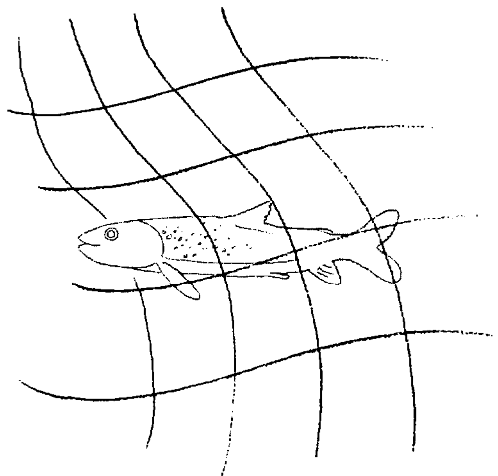
All dots indicate the presence of the species. Blackened dots indicate principal fisheries.

Fish Species

The Maine Fish Tissue Contamination Project will target fish species for collection based on their trophic level. That is, for any given water body, the primary objective will be to collect both the top **predator** species in the system and a widely distributed **omnivore**. Because of the difficulty of collecting sufficient numbers of common species in all the study lakes, the project has developed a list of species to be collected in order of preference (Table 1-2), based on their distribution, trophic status, and desirability as game fish. (Figure 1-1 shows the distribution of fish in Maine lakes.) Because cold water and warm water lakes support different species, fish collections will be ordered according to trophic level for both types of lake. The project has also specified target fish sizes (length) in order to obtain specimens of comparable age.

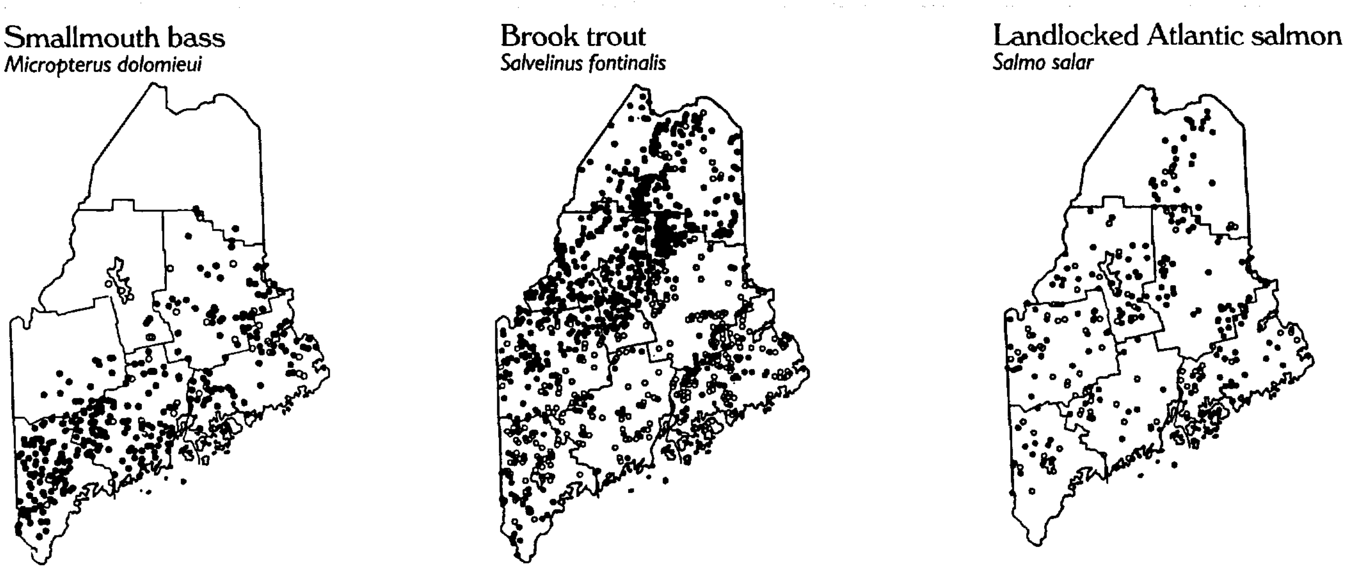


Scales of this brook trout are measured to determine the age of the fish specimen.



Field Program

The Maine Fish Tissue Contamination Project's field program consists of fish collecting, sediment sampling, and water quality sampling. Field activities will be conducted from May 1993 to mid-October 1993. If needed, a second field sampling season will begin in May 1994. The field sampling is a cooperative effort by the Maine Department of Inland Fisheries and Wildlife, the Maine Department of Environmental Protection, and EPA Region I. Field sampling is organized according to the seven fishery districts in Maine, with resident district biologists responsible for coordinating fish collections in each of the study lakes within their districts.



All dots indicate the presence of the species. Blackened dots indicate principal fisheries.

To collect fish specimens from Maine lakes, field crews will use gill nets (shown) and other equipment.

To collect the fish specimens, field crews will use experimental gill nets and other equipment, as needed, to obtain 10 of the targeted predator species and 5 omnivores from each of the selected lakes. The age of each specimen will be determined by measuring scales or fin rays, depending on the species.

Bottom sediment samples will be collected from the deepest hole in each of the study lakes. Sediment analysis will help the investigators interpret the fish results and establish associations with other factors such as geology, hydrology, and air transport patterns.

To assess the water quality in each lake, the field crew will measure water temperature, dissolved oxygen, and conductivity at 1-meter intervals over the deepest hole in the lake; then sediment samples will be collected at that location. A Secchi disk will be used to measure water clarity. To characterize the water chemistry in each lake, the crew will determine alkalinity and pH in the field and return water samples to the laboratory for additional analyses.

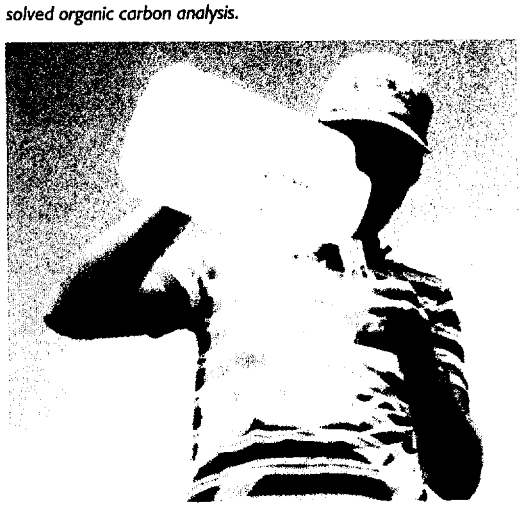
Laboratory Analyses

Fish Tissue Analyses Because fish tissue contamination has both ecological and human health implications, two types of fish tissue analyses will be performed: whole body fish analysis for metals and organic chemicals, and fish fillet (muscle) analysis for mercury only. (Mercury tends to concentrate more in the fillet, the part of the fish consumed by humans.)

For whole body analysis of predator and omnivore species, five fish of the same species will be ground up, combined, and homogenized. This tissue will be analyzed for the following substances:

- *Metals (mercury, cadmium, and lead).*
- *Chlorinated organic compounds/pesticides (total PCBs, aldrin, alpha-BHC, delta-BHC, gamma-BHC, chlordane, DDD4,4', dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, and toxaphene).*
- ***Lipids** and percent moisture.*

To characterize the water chemistry in each lake, the field crew will return water samples to the laboratory. Here a field worker pours water into a beaker for dissolved organic carbon analysis.



For fish fillet analysis (for predators only), fillets from five fish of the same species will be ground up, combined, and homogenized. The tissue will be analyzed for mercury and percent moisture.

Sediment Analyses The laboratory will conduct a chemical analysis on a homogenous mix of the sediment samples collected from each lake. Samples will be analyzed for metals (mercury, cadmium, and lead), total organic carbon, sediment grain size, and percent moisture.

Water Quality Analyses Water samples collected from three depths from each of the lakes will be analyzed for total phosphorus, dissolved organic carbon, **anions**, and **cations.**

Sediment samples will be collected from each of the study lakes. In this photo a field worker dumps sediment deposits from an Ekman dredge into a pan for testing.

A field worker prepares a probe to collect lake water quality data.

FOR MORE INFORMATION, CONTACT:

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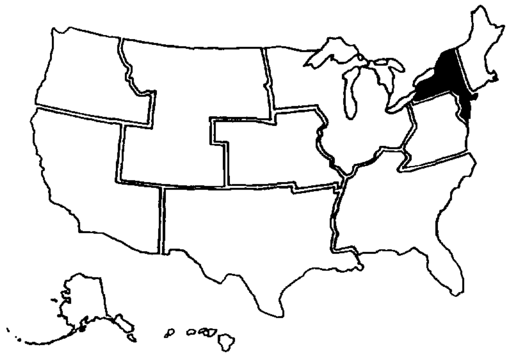
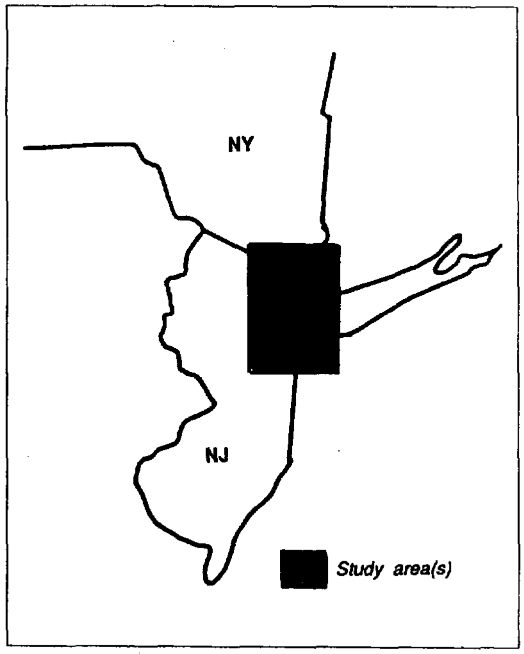


REGION II

CHARACTERIZING SEDIMENT QUALITY IN THE NEW YORK/ NEW JERSEY HARBOR SYSTEM

The New York/New Jersey (NY/NJ) Harbor system is an important economic, recreational, and aesthetic resource, supporting many **habitats** and species of fish, shellfish, and migrating birds. Existing data suggest that a number of areas in the NY/NJ Harbor **estuary** are highly contaminated with metals and organic chemicals.

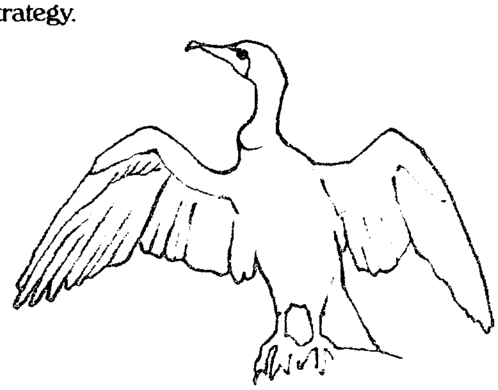


STUDY AREA

Some of the consequences of this contamination have included:

- *A moratorium on commercial fishing for striped bass due to elevated levels of polychlorinated biphenyls (PCBs) in these fish.*
- *Advisories against consumption of blue claw crabs from parts of the harbor because of unacceptable levels of PCBs and dioxin in crab tissue.*
- *Risk to nesting birds due to hydrocarbons entering the harbor system from oil spills.*

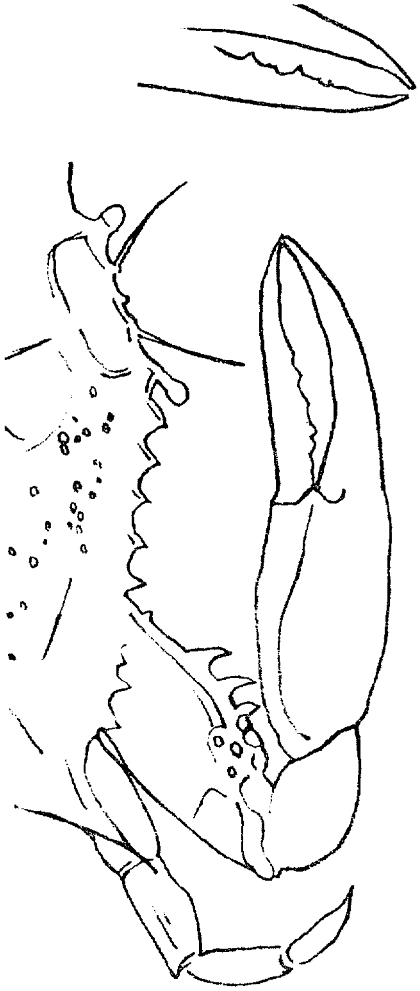
Because of these problems, EPA Region II and the NY/NJ Harbor Estuary Program have placed a high priority on developing a **sediment** management strategy. The existing data, however, are insufficient for developing this strategy.



The Region II R-EMAP project will provide the needed information by addressing the following questions:

- ? *What are the extent and magnitude of sediment degradation in the NY/NJ Harbor system?*
- ? *Is the degree of degradation similar throughout the system, or is it more severe or widespread in particular sub-basins or areas?*
- ? *Can the degradation be associated with particular contaminants or physical characteristics of the sediment?*

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.



This study is an intensified version of the EMAP-Estuaries (EMAP-E) sampling effort in the Virginian Province, an area covering the mid-Atlantic coastal states from Cape Cod, Massachusetts, to Cape Henry, Virginia. The study will demonstrate the usefulness of EMAP-like data for regional and subregional environmental management. It will also be a case study for evaluating EPA's strategy of integrating risk-based monitoring, assessment, and management programs. The project will provide critical information to help resource managers and the Harbor Estuary Program develop a contaminant management strategy. By providing baseline data against which to measure trends in sediment conditions, the project will also produce a means for evaluating the effectiveness of management strategies that are eventually implemented. In addition, it will bring together the many groups responsible for managing the NY/NJ Harbor system in an integrated, harborwide monitoring effort.

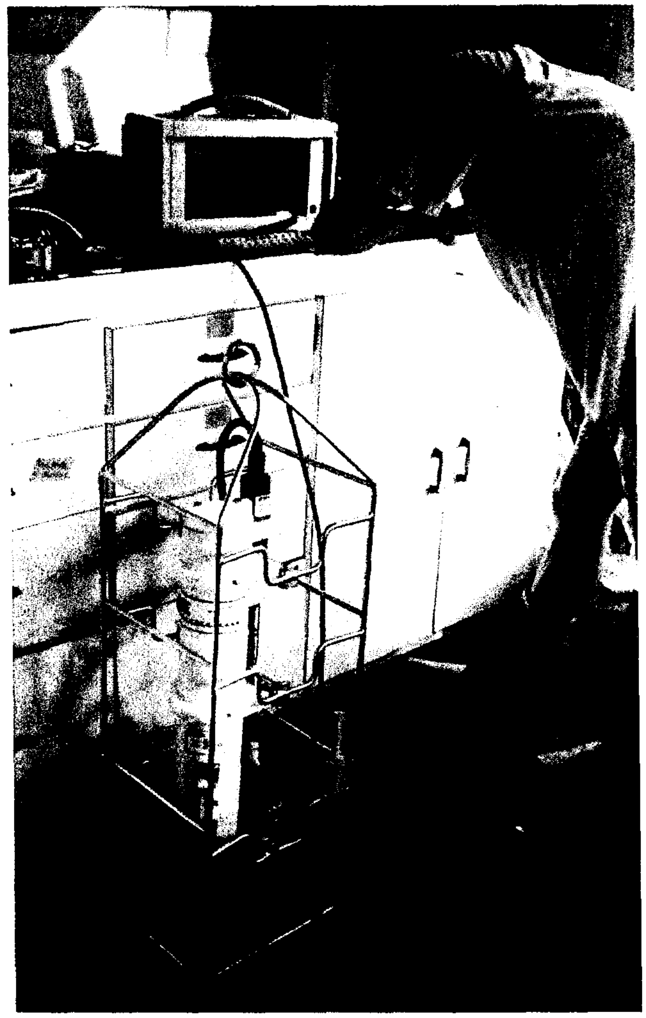
The project design is a cooperative effort by scientists from EPA Region II; EPA's Office of Research and Development; the NY/NJ Harbor Estuary Program; resource management agencies from New York City and the states of New York, New Jersey, and Connecticut; the National Marine Fisheries Service; the National Oceanic and Atmospheric Administration's (NOAA's) Status and Trends Program; and Rutgers University. In addition, several individuals from EPA's Environmental Research Laboratory in Narragansett, Rhode Island, who participated in EMAP monitoring in the Virginian Province, will assist in the project.

ACTIVITIES

To assess sediment condition, researchers will obtain water and sediment samples from each of the six sub-basins in the NY/NJ Harbor system (Figure 2-1). Sampling will be performed in the summer because pollution stress is highest then and because this sampling period ensures comparability with EMAP-E data. Half of the stations in all basins will be sampled the first year and the remainder in the second year to minimize variability between sampling years.

The investigators will conduct biological analyses of the sediment samples to determine the health of the **benthos** in the six sub-basins. Chemical analyses will indicate the presence of various types of pollutants. The investigators will then determine whether biological impairment or risks to benthic life are associated with particular contaminants or physical characteristics of sediment. Finally, the researchers will use the data obtained on benthic communities to produce an **index** of environmental quality for the NY/NJ Harbor system that is useful for environmental managers.

Table 2-1 shows the milestones and schedule for the Region II R-EMAP program.



A field worker obtains a water column profile for dissolved oxygen, temperature, salinity, pH, and oxidation-reduction potential

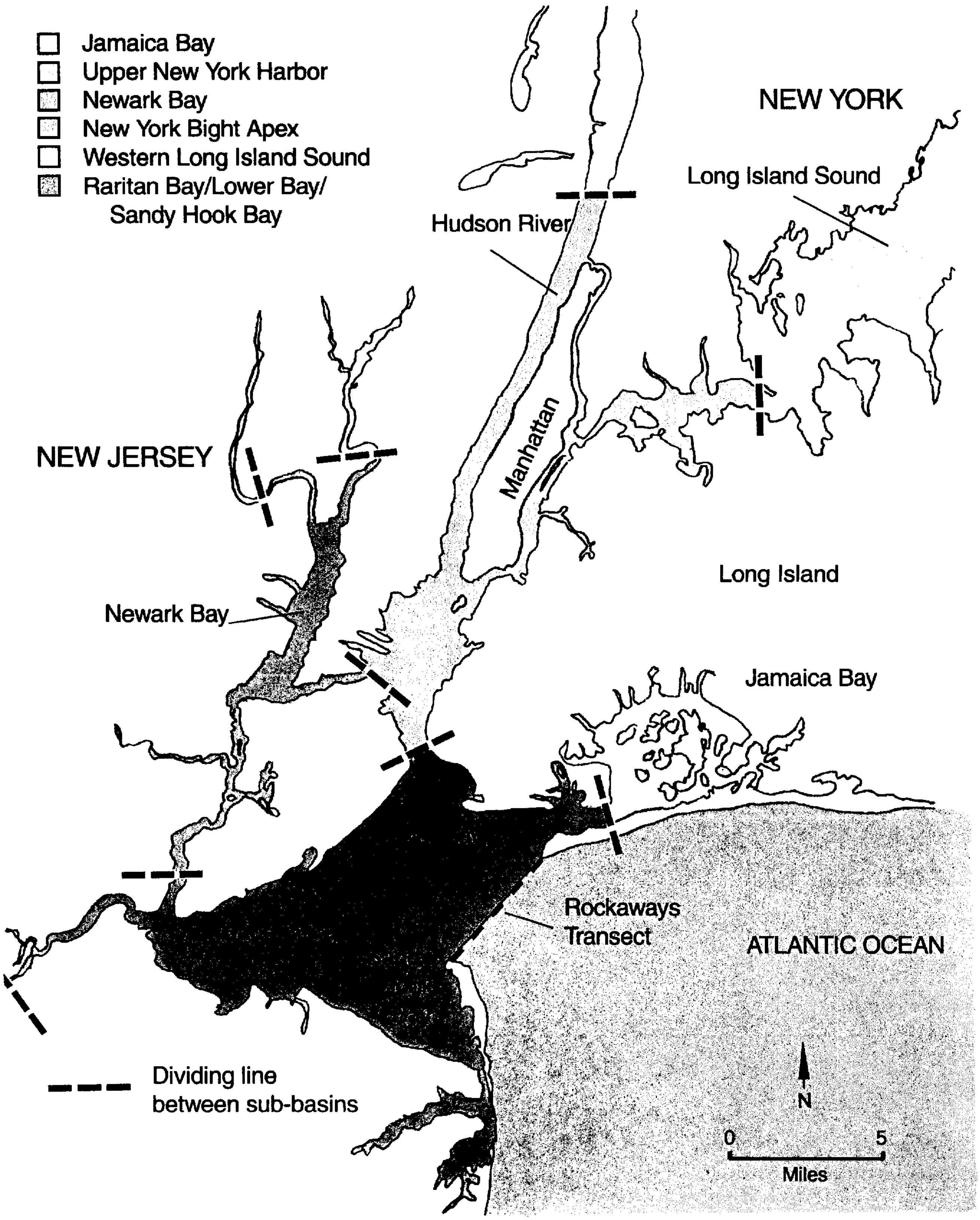
Table 2-1

MILESTONES AND SCHEDULE

	1993	1994	1995
Hold design workshop	February		
Complete workshop summary	March		
Year 1 field work	July - September		
Year 1 laboratory work	July through	March	
Year 1 data analysis		March - June	
Complete data summary		June	
Year 2 field work		July - September	
Year 2 data analysis		July through	March
Complete final report			July

Figure 2-1

MAP OF THE STUDY AREA SHOWING EACH OF THE SUB-BASINS



TECHNICAL APPROACH

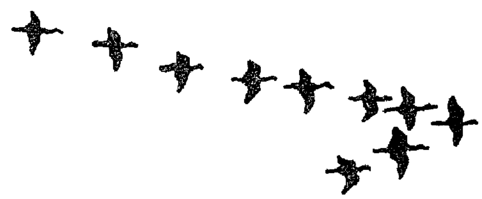
The Region II R-EMAP project has three objectives:

1. *To estimate the percentage of area in each of the six sub-basins in the NY/NJ Harbor system in which the benthic environment is "degraded," "not evidently degraded," or "marginal."*

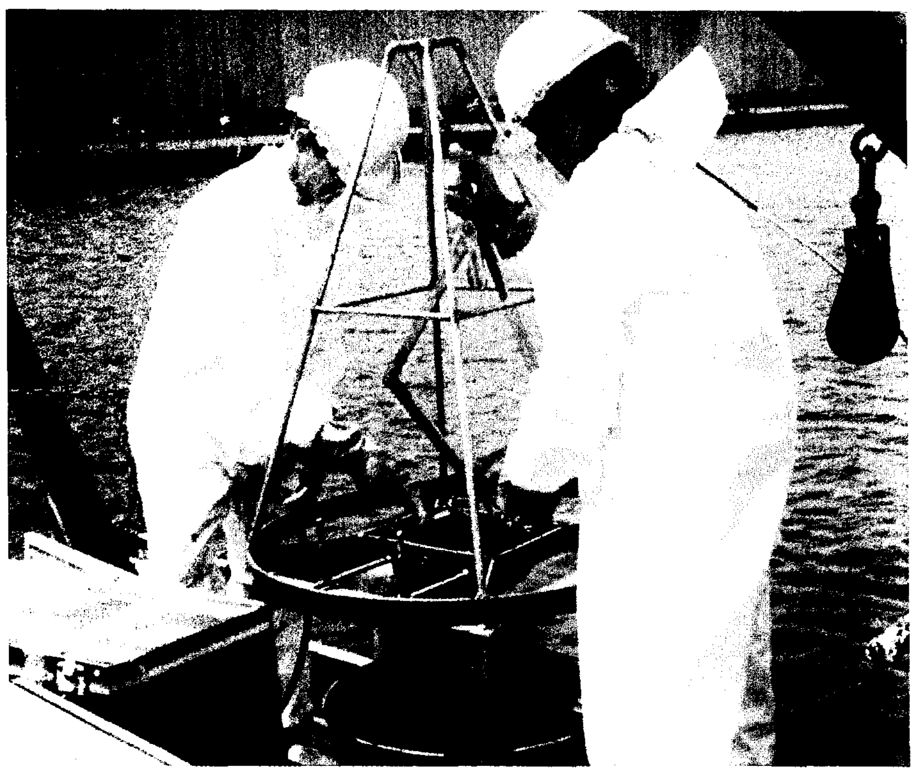
2. *To identify statistical associations between particular chemical contaminants and degraded benthos or toxic sediments.*

3. *To develop and validate an index of environmental quality for the NY/NJ Harbor system based on the condition of* ***benthic macroinvertebrate assemblages.***

Objectives 1 and 2: Characterize the Condition of the Benthos and Investigate Links Between Contamination and Benthic Condition



The study will obtain data on the extent and distribution of three indicators of sediment condition: benthic macroinvertebrate assemblages, sediment toxicity, and the concentrations of sediment contaminants. The study will use a **probability**-based sampling design similar to that of EMAP. The six sub-basins of the NY/NJ Harbor system (Figures 2-2 through 2-7) will be the six strata. Each sub-basin is affected by a separate watershed.



Field workers use a grab sampler to collect sediments for biological and chemical analyses.

Table 2-2

ANALYTICAL MEASUREMENTS FOR SEDIMENT SAMPLES

Polyaromatic hydrocarbons (PAHs)

DDT and its metabolites

Chlorinated pesticides other than DDT

Major and trace elements

18 PCB congeners

Organotins

Total organic carbon

Ammonia

Twenty-eight sampling stations have been selected in each sub-basin. Stations in all sub-basins except Newark Bay were selected by enhancing the EMAP base grid and placing sampling sites randomly in the resulting hexagons. The Newark Bay design is compatible with that of the other sub-basins but differs slightly to allow incorporation of NOAA data from that sub-basin. Figures 2-2 through 2-7 show the sites from which the 28 sampling stations for each sub-basin were selected.

To obtain the samples, the field crew will use the water column and sediment sampling procedures used in the EMAP-E program. To meet the first objective of the study, the investigators will evaluate the condition of the benthos using measurements of benthic macroinvertebrate species composition, abundance, and **biomass**. To meet the second objective, researchers will test for sediment toxicity and concentrations of sediment contaminants (Table 2-2).

Areas in the sub-basins will be classified as degraded, not evidently degraded, and marginal by comparing the data to critical ("threshold") values determined for each indicator (such as 80 percent survival of organisms in sediment toxicity tests). The researchers will also use statistical methods to evaluate whether the presence of contaminants is linked to the conditions observed in the biological sampling. This analysis will help researchers identify which contaminants are of greatest ecological significance. It will also help distinguish between contaminated areas that are clearly harmful to the ecosystem and those that pose a limited risk to aquatic life (for example, where chemicals are tightly bound to the sediment and are therefore "biologically unavailable" to organisms). Such information is important for developing effective contaminant management strategies: In areas where contaminants are biologically unavailable, it might be possible to leave sediments in place and implement pollution prevention to avoid further degradation. Remediation may be needed, however, in areas where contaminants are toxic and biologically available.

Figure 2-2

JAMAICA BAY

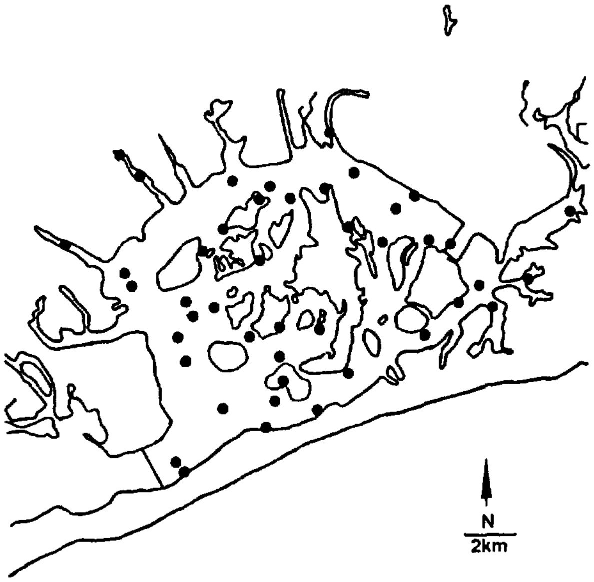


Figure 2-3

UPPER NEW YORK HARBOR

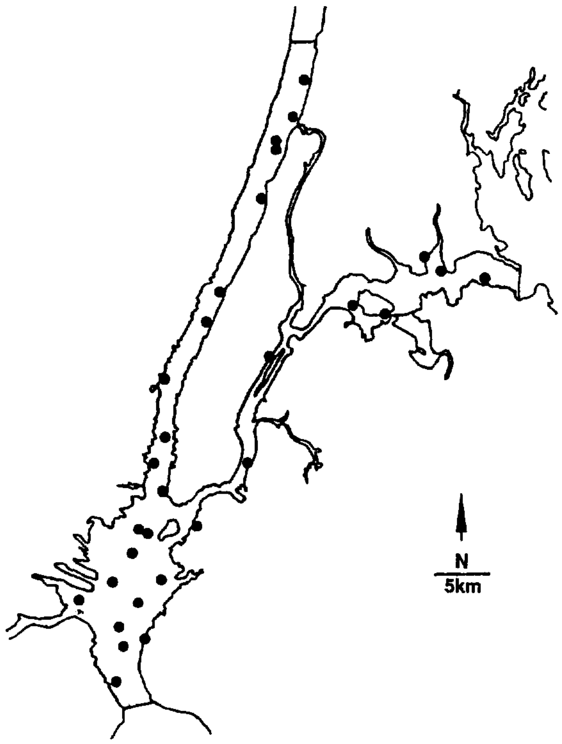


Figure 2-4

NEWARK BAY

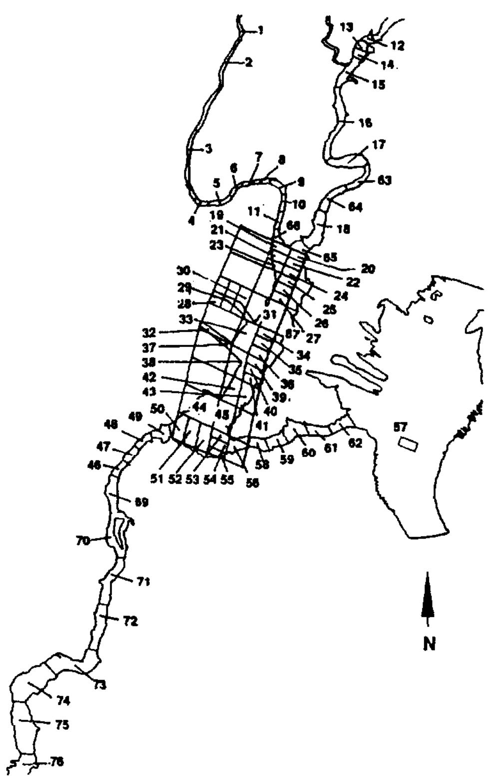


Figure 2-5

NEW YORK BIGHT APEX

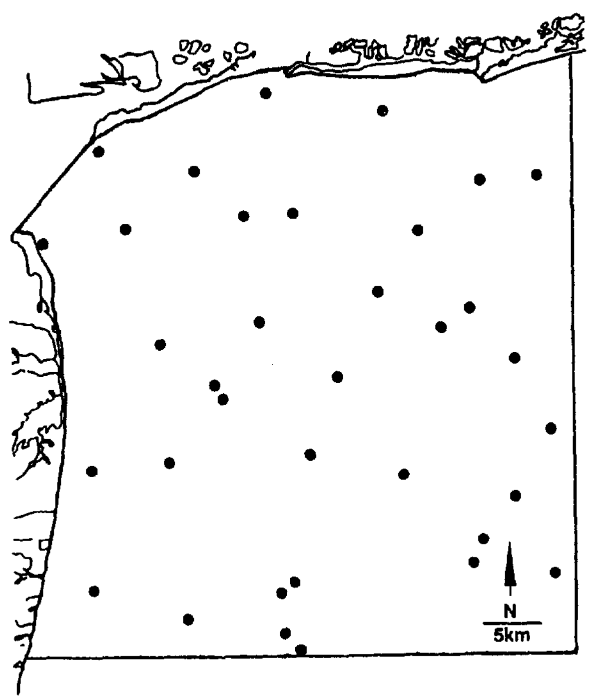


Figure 2-6

WESTERN LONG ISLAND SOUND

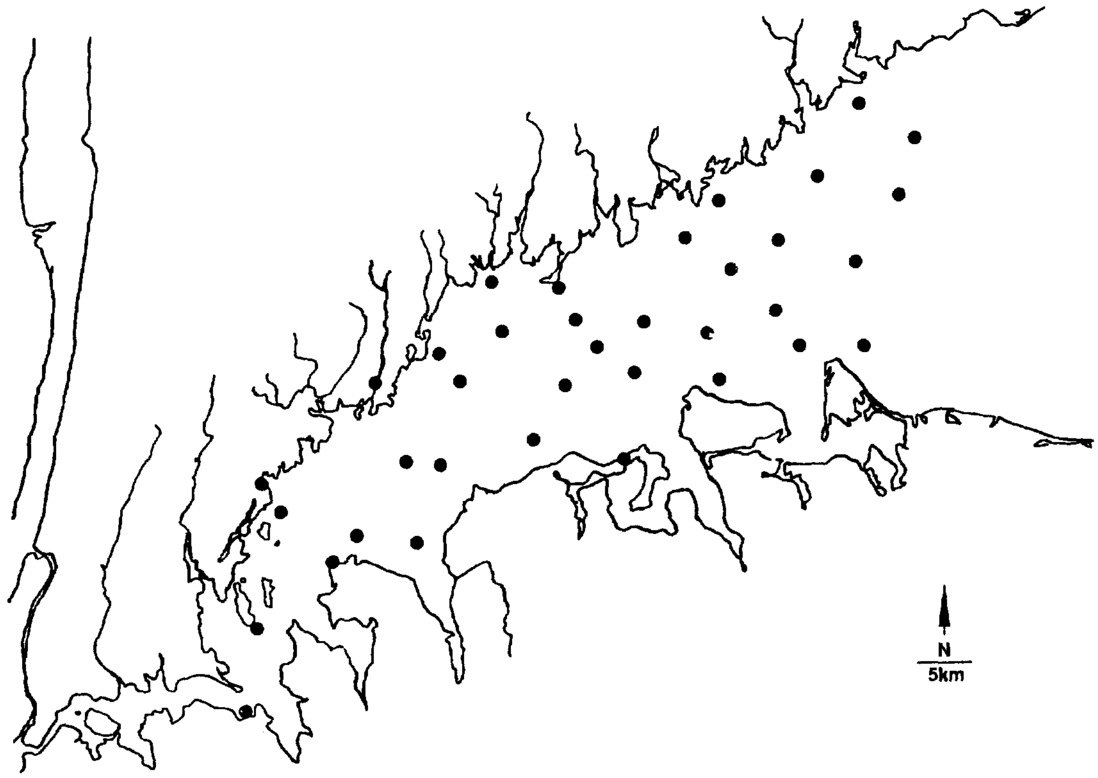
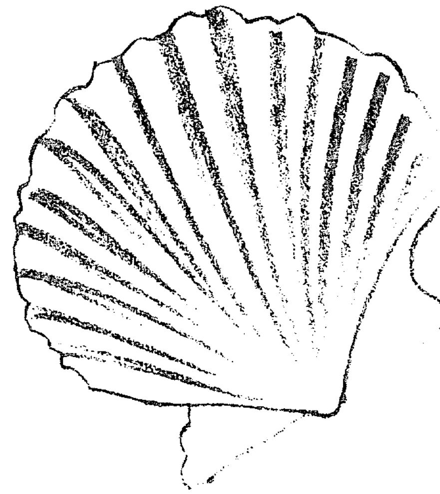


Figure 2-7

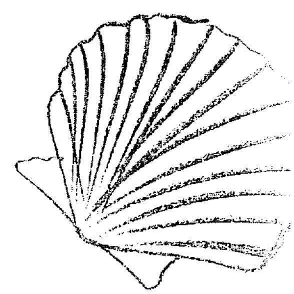
LOWER NEW YORK HARBOR/RARITAN BAY/SANDY HOOK BAY

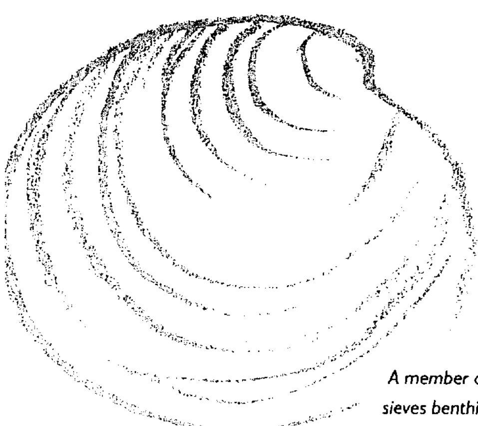
Objective 3:
Develop an Index of Environmental Quality for the NY/NJ Harbor System



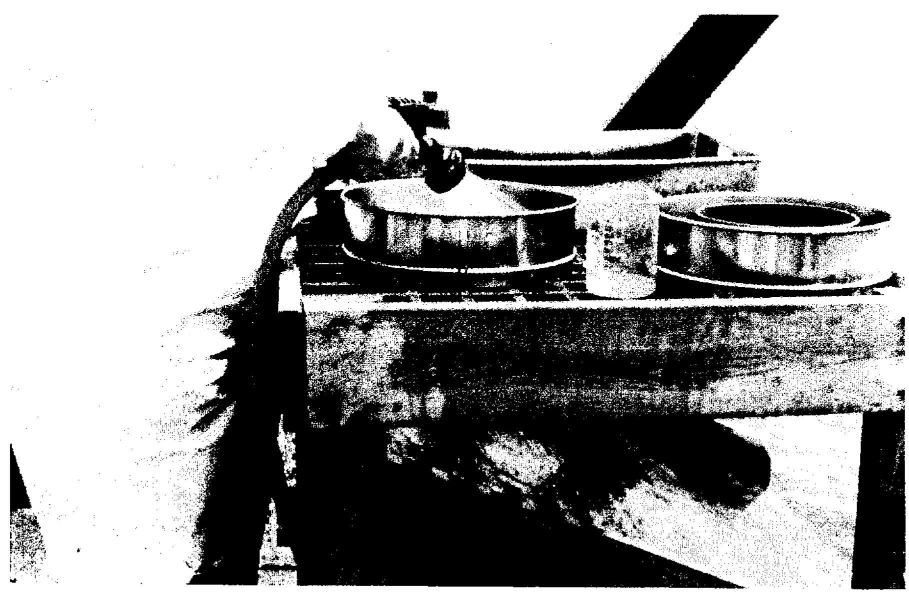
The third objective is to develop an index that allows environmental managers to classify sites based on the degree to which they have been stressed by contamination. The index will be based on properties of benthic macroinvertebrate assemblages. The investigators will begin with EMAP-E's index and calibrate it to the conditions within the NY/NJ Harbor system. The result will be an index scaled from 0 to 10 that allows environmental managers to recognize the degree of degradation that has occurred at a site without having to examine and interpret a more complex data base.

To accomplish this objective, between 20 and 30 index development sites (in addition to the 28 sites in each sub-basin) will be chosen to represent the regional range of conditions, including salinity, concentration of sediment contaminants, organic enrichment, sediment grain size, and dissolved oxygen concentration. The sites will be chosen based on existing data and professional judgment. Once data from these sites have been collected, the EMAP-E list of measures for differentiating between nondegraded reference sites and degraded sites (measures of biodiversity, community condition, individual health, **trophic** groups, and species composition) will be applied to the index development sites. This list of differentiating measures will be expanded based on experience with measures useful in site-specific evaluations of the NY/NJ Harbor system.





A member of the field crew sieves benthic macroinvertebrate samples. Samples will be analyzed for species composition, abundance, and biomass.



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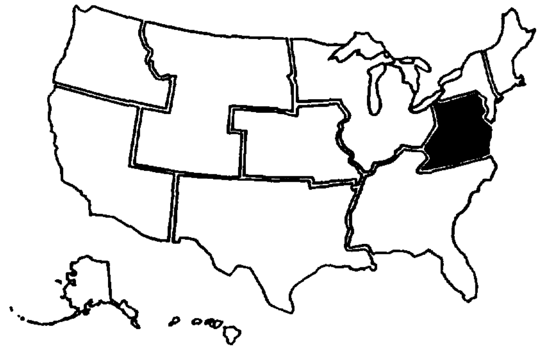
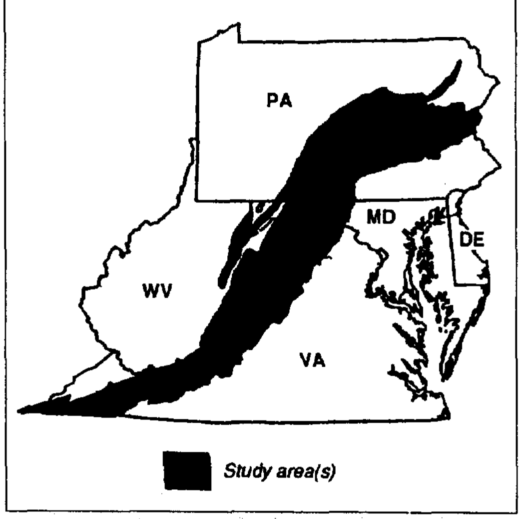


REGION III

SURFACE WATER QUALITY INDICATORS FOR THE CENTRAL APPALACHIAN RIDGES AND VALLEYS ECOREGION

Streams in the mid-Atlantic Highlands, an area that includes the Central Appalachians, the Central Appalachian Ridges and Valleys, and the Blue Ridge Mountains **Ecoregions**, are subject to heavy environmental stresses. Over a century of coal mining, deforestation, and urbanization have caused erosion, silting, and acid drainage in streams. This area also receives the highest rates of acid deposition in the United States. It is estimated that 12 percent of forested upland mid-Appalachian streams are acidic. More than half of all **stream reaches** are sensitive to acid deposition and may be subject to low pH episodes that are harmful to **biota**. The extent to which stream resources are affected by urbanization and **nonpoint source pollution** is unknown.



STUDY AREA

The Region III R-EMAP project focuses on the Central Appalachian Ridges and Valleys Ecoregion, which is affected by agriculture, some mining activity, urban nonpoint source pollution, and acid deposition.

The project goals are to:

- *Establish a baseline for assessing biological impairment of streams.*
- *Evaluate EMAP* ***indicators*** *for use in resource management in the Ridges and Valleys Ecoregion.*
- *Develop a comprehensive,* ***probability-*** *based assessment of streams in the Ridges and Valleys.*
- *Promote Regional and state cooperation.*

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

The Region III R-EMAP project is part of the mid-Atlantic Highlands Assessment (MAHA). MAHA combines a number of complex state, Regional, and national environmental monitoring designs, including those of the EMAP mid-Atlantic streams monitoring project and the Temporally Integrated Monitoring of Ecosystems (TIME) project, an EPA program to measure water quality in acid-sensitive environments. When fully developed, MAHA will provide a suite of environmental assessment tools to integrate land cover information, other measures of human-caused environmental stress, and the biological assessment of stream and fish communities and agricultural and forest ecosystems.

Region III R-EMAP field teams will include EPA biologists and biologists from the states of Pennsylvania, Maryland, Virginia, and West Virginia. Experts from universities in Region III will participate in data analysis and overall assessment of the project. The U.S. Fish and Wildlife Service was a cooperating agency in the initial field investigation, and other federal agencies are expected to participate in the future.

A field team uses electrofishing equipment to collect fish samples.

Table 3-1

MILESTONES AND SCHEDULE

	1992	1993	1994	1995
Select sites	Sept. - Oct.	Sept. - Oct.		
Set methods	Sept. - March	Sept. - March		
Field sampling		Spring/Fall	Spring/Fall	
Sample processing and analysis		Fall/Winter	Fall/Winter	
Integration and assessment			June through	December

ACTIVITIES

The investigators will select and sample 100 sites in the Central Appalachian Ridges and Valleys Ecoregion. The sampling will include water quality, fish, **benthic macroinvertebrates**, and **habitat** quality. The response of indicators to environmental stresses will be tested at 10 additional sites selected for the presence of stresses (such as agricultural nonpoint sources, **point sources**, habitat disturbance, and acid deposition).

Field workers process samples. Region III R-EMAP sampling will include benthic macroinvertebrates, habitat quality, fish, and water quality.

Investigators will also sample **reference sites** chosen to represent the least impaired conditions in the subecoregions. This sampling will require that the researchers refine and calibrate stream bioassessment methods and protocols for use in this ecoregion. The states currently sample invertebrates with a variety of gear and protocols. A comprehensive set of ecological protocols will be used in this project. The investigators will assess the methods used in this project and develop recommended standard methods for future use.

The data from all sites will be analyzed to produce an assessment of streams in the ecoregion and to perform a regional analysis of associations between stream conditions and environmental **stressors.** Table 3-1 lists the project milestones and schedule; Table 3-2 shows the tools and products to be developed.

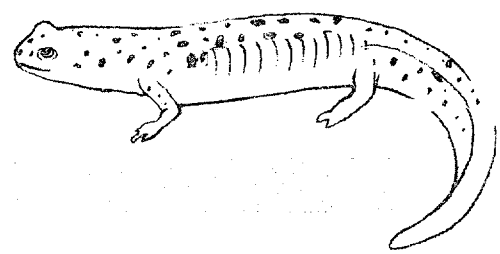


Table 3-2

PRODUCTS	BENEFITS
A set of consistent biological indicators and methods that have been tested and evaluated for use in stream bioassessment in the Ridges and Valleys Ecoregion.	Improved knowledge of the geographic limits of environmental effects.
Definition of ecoregion-specific reference conditions for use in state and Regional monitoring and assessment.	Recommended for implementation of biological water quality criteria; needed for assessing the status of streams in the ecoregion.
An integrated biological assessment of streams in the Ridges and Valleys. This assessment will estimate the magnitude and extent of different environmental problems and determine linkages between problems and biological effects on a regional scale.	Improved understanding of the significance and application of ecoregion boundaries for environmental management.
Data and assessments that will form a baseline for analyzing trends; unified monitoring plan for state and Regional agencies.	Uniform assessments, reduced costs, and increased coverage.

TECHNICAL APPROACH

The project is designed to answer the following questions:

? *What are the biological* ***reference conditions*** *for the Central Appalachian Ridges and Valleys Ecoregion?*

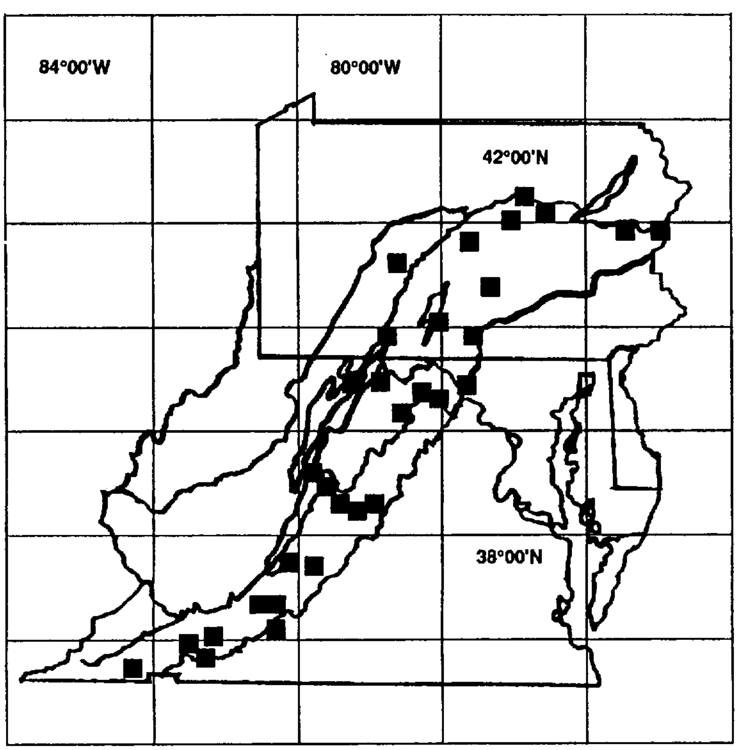
To develop ecoregional reference conditions, investigators will obtain regional data based on sampling of reference sites, using stream bioassessment methods developed for application in this ecoregion.

? *Do biological communities differ among subregions?*

Ecoregions and subregions are based on soils, geology, geomorphology, and vegetation. The investigators will determine whether biota differ among subregions having similar stream conditions. (If biota are similar, data analysis would be more powerful if data from similar subregions are lumped together.)

Figure 3-1

31 REFERENCE SITES



? *What is the status of mid-Atlantic Highlands streams biota?*

Determining the current status of stream resources will provide the baseline for assessing the effectiveness of ***best management practices (BMPs)*** *for pollution sources.*

? *What relationships can be established between biological impairment and possible causes of impairment?*

The project will not test causal relationships directly but will identify associations between impaired conditions and causal factors, such as acid deposition, acid mine drainage, nonpoint sources, and point sources. This information will help resource managers decide which problem is most important to address (for example, would it be most effective to mitigate acid mine drainage, to lobby for stricter regional controls on SO_2 emissions, or to educate the agricultural sector to use BMPs?). It will also identify critical areas for protection and restoration efforts.

? *Can trends be observed in the chemistry of mid-Atlantic Highlands streams since the National Surface Water Survey in 1986?*

Together with the TIME and EMAP projects, the Region III R-EMAP project will provide data for assessing trends in stream acidification from deposition. The project will develop information on biological integrity and acid-base chemistry at the same sites.

? *How can the EMAP approach be used to help restore and manage stream resources on a regional scale?*

The Region III project will attempt to integrate ecoregion-based assessments with state monitoring programs, using the EMAP design approach.

Selecting Reference Sites

Thirty-one sites (Figure 3-1) considered the least affected by environmental stresses represent the baseline against which to compare the test sites. State biologists will select reference streams based on their knowledge of site conditions, mapped information, and field visits.

Sampling Design

The investigators will use **probability**-based sampling design to select 44 R-EMAP test sites (Figure 3-2). The study will use a sevenfold magnification of the EMAP grid. Additional test sites will be used from the EMAP mid-Atlantic streams monitoring project and the TIME project.

Field workers take stream flow and habitat assessment measurements.

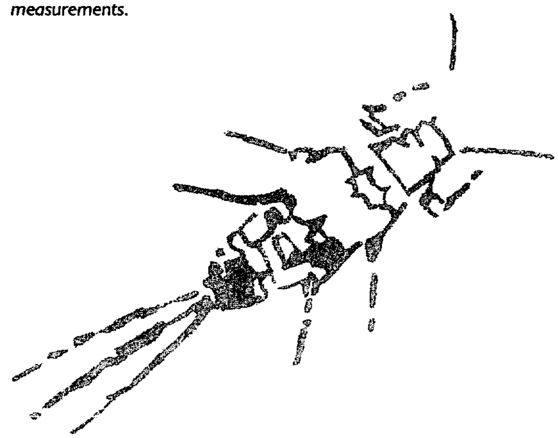
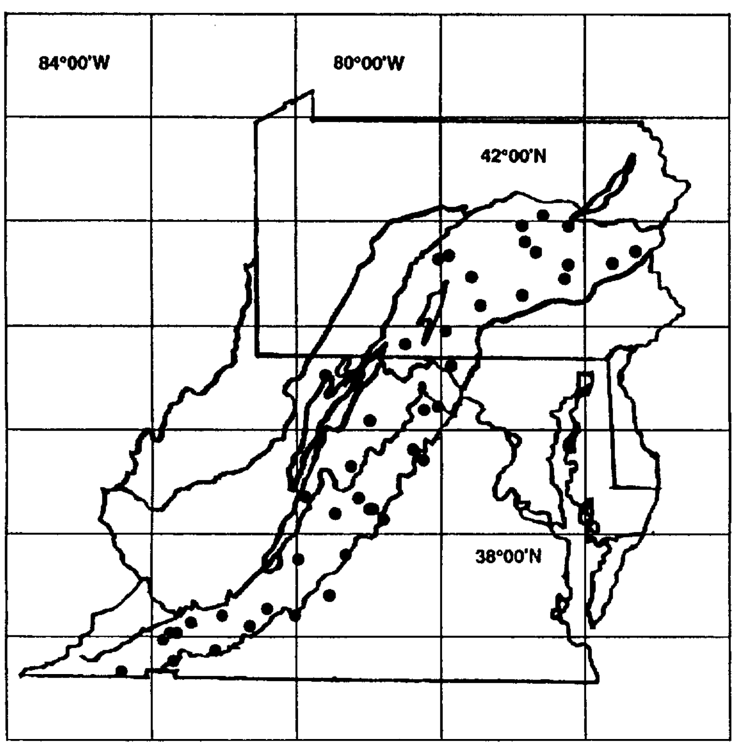


Figure 3-2

44 R-EMAP TEST SITES - *Sites from EMAP and TIME will also be used.*



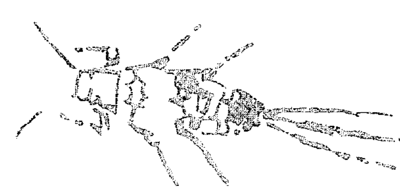


Table 3-3

WATER QUALITY PARAMETERS TO BE MEASURED

Temperature	Dissolved oxygen
Conductivity	Acid neutralizing capacity
pH	Sulfate
Iron	Magnesium
Calcium	Aluminum species
Total suspended solids	Total dissolved solids
Total organic carbon	Nitrite and nitrate
Phosphate	Total nitrogen
Total phosphorus	Chloride

Table 3-4

HABITAT ASSESSMENT VARIABLES

PRIMARY-INSTREAM HABITAT	
	Instream Cover (fish habitat)
	Benthic Substrate
	Embeddedness
	Velocity/Depth Combination
SECONDARY-CHANNEL MORPHOLOGY	
	Channel Alteration
	Bottom Scouring and Deposition
	Riffle/Pool, Run/Bend Ratio
	Channel Flow Status
TERTIARY-RIPARIAN AND BANK STRUCTURE	
	Bank Stability
	Bank Vegetation Protection
	Grazing/Disruptive Pressure
	Riparian Vegetation Zone Width

Indicators

Fish and macroinvertebrate communities will be collected as indicators of the response of ecological resources to habitat and exposure variables. Response measurements include species composition, abundance, and biomass. Investigators will assess the water quality parameters shown in Table 3-3 and will assess the habitat quality variables listed in Table 3-4. Finally, information will be obtained about industrial or other point source discharges, watershed land uses, human population density, fish stocking, urban development in the watersheds, barriers, and logging or other recent disturbances.

Integrated Bioassessment

The sampling results will allow investigators to characterize and measure reference conditions for each subregion. The status of stream quality will be assessed by comparing the data collected from reference sites, impaired sites, and probability sites. Investigators will analyze associations among biological indicators, habitat quality, water quality, and external stressor information.

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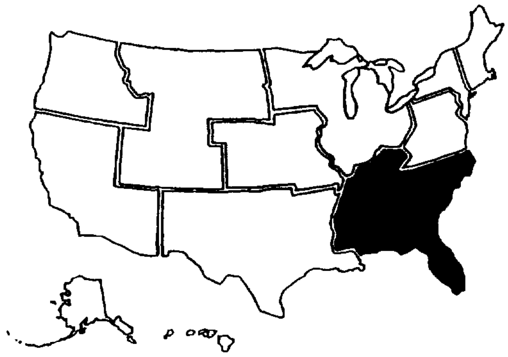
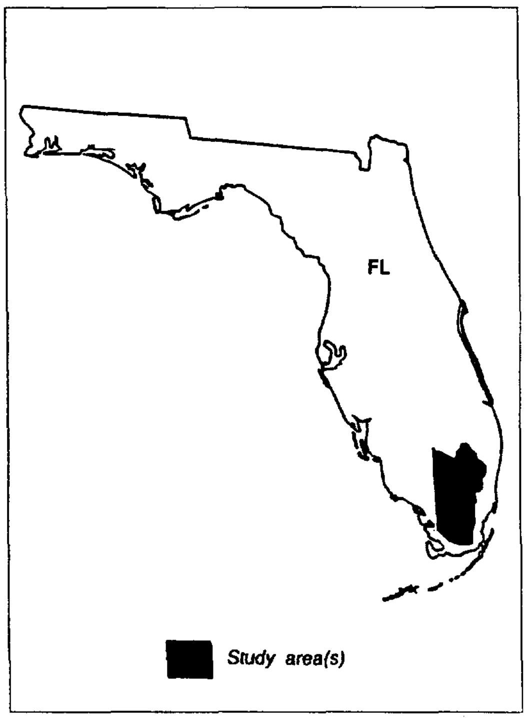


REGION IV

ECOLOGICAL RISK ASSESSMENT OF MERCURY CONTAMINATION IN THE EVERGLADES ECOSYSTEM

Since 1989, mercury has been found in elevated concentrations in various **biota** of the Florida Everglades, including fish, the Florida panther, raccoons, wading birds, and alligators. The state of Florida has issued a fish consumption advisory due to mercury contamination, banning or restricting the consumption of largemouth bass and other freshwater fish from 2 million acres encompassing the Everglades and Big Cypress National Preserve (Figure 4-1). Mercury contamination in Florida, although highest in the Everglades, also occurs in largemouth bass in many other lakes and streams across the state. Mercury in its most toxic form, methyl mercury, accumulates in aquatic life, and may pose increased risks to consumers at the top of the food chain (birds, mammals, and humans).



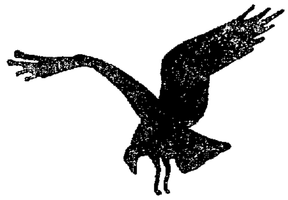
STUDY AREA

DANIEL SCHEIDT

Everglades wading birds, such as this Great White Heron, have been shown to have elevated mercury concentrations.

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

Scientists currently know little about the sources, extent, transport, transformation, and pathways of mercury in South Florida **ecosystems**. Possible mercury sources in South Florida include natural mineral and peat deposits, atmospheric deposition (global and regional), fossil fuel fired electrical generating plants, municipal waste incinerators, medical laboratories, paint, and agricultural operations. None of these individual sources, however, appears adequate to explain the vast area apparently contaminated.



The proposed Region IV R-EMAP study will identify and coordinate research, monitoring, and regulatory efforts to address this issue, using EPA's **ecological risk assessment** framework. The study will focus on the Everglades ecosystem, composed of the largest deposit of near-neutral peat in the world, encompassing a region about 40 miles wide by 100 miles long south of Lake Okeechobee to Florida Bay (Figure 4-2). The study area includes the Everglades Agricultural Area (EAA), three Water Conservation Areas (WCAs) including the Loxahatchee National Wildlife Refuge (WCA-1), Big Cypress National Preserve, Everglades National Park (ENP), and other areas drained for urban and agricultural development, resulting in massive hydrologic modifications.

Figure 4-1

LARGEMOUTH BASS MERCURY TISSUE CONCENTRATIONS IN FLORIDA, 1989 TO 1993

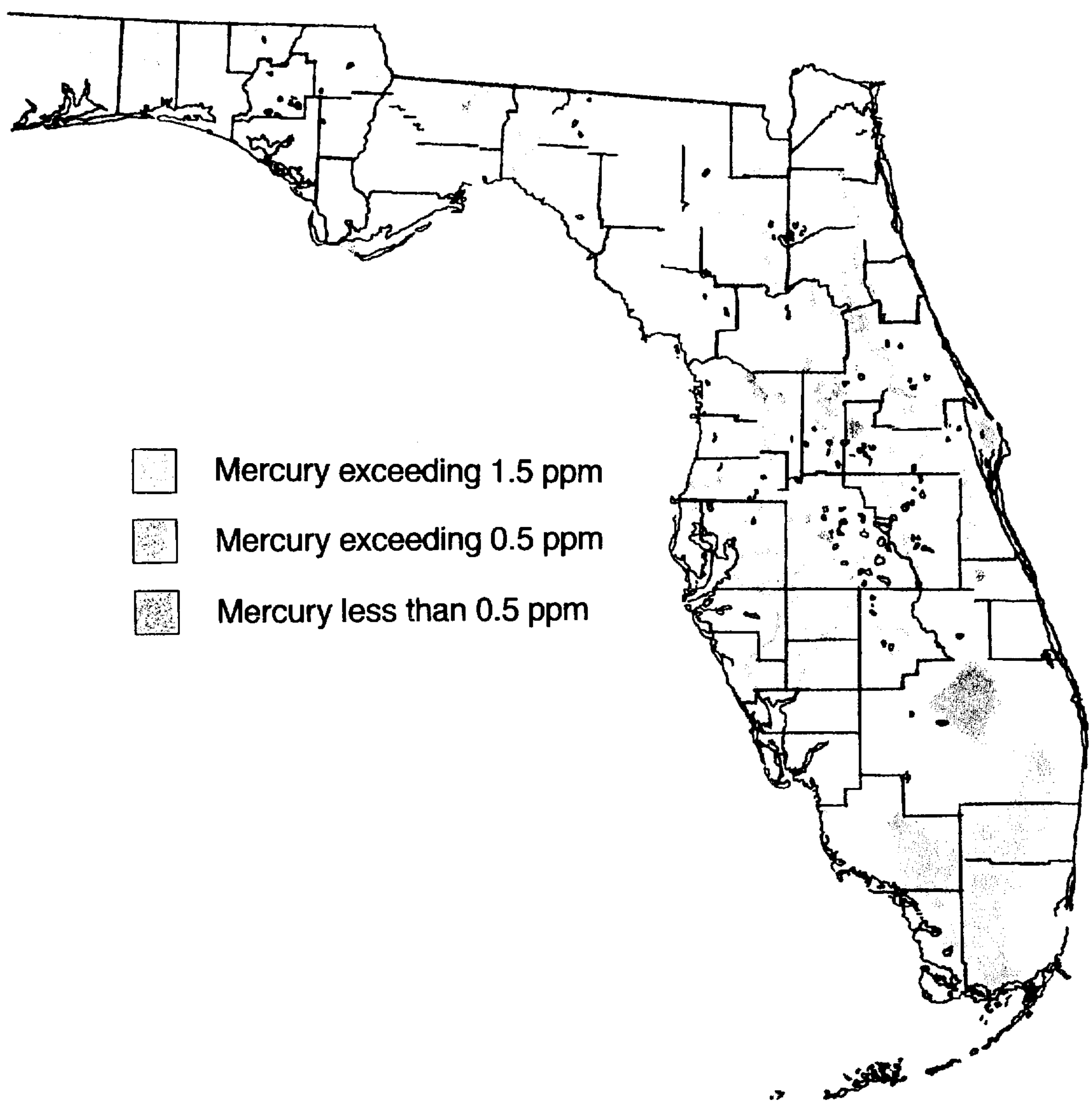
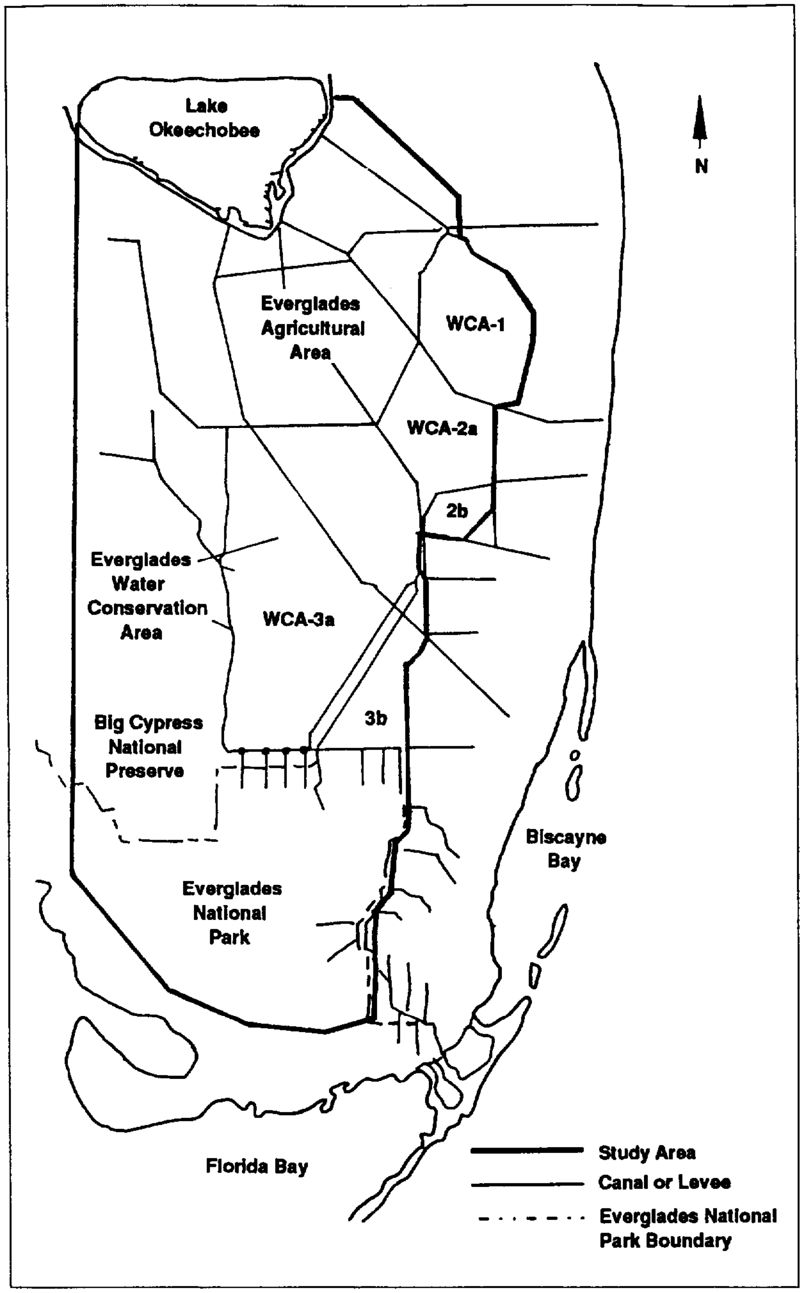


Figure 4-2

DETAIL OF STUDY AREA

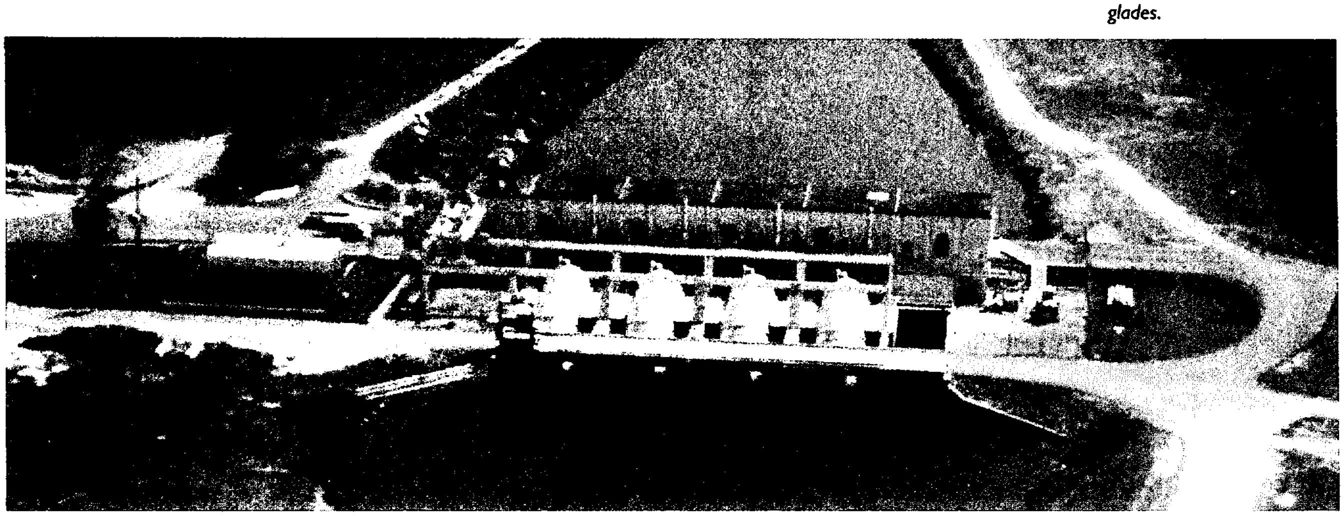


Seven policy-relevant questions have been identified to guide the development of this complex research and monitoring effort:

- *What is the magnitude of the problem? What are the current levels of mercury contamination in various species? What ecological resources of interest are being adversely affected by mercury?*
- *What is the extent of the mercury problem? What is the geographic distribution of the problem? Is it **habitat**-specific?*
- *Is the problem getting worse, getting better, or staying the same?*
- *What factors are associated with, or contribute to, methyl mercury accumulation in sensitive resources?*
- *What are the contributions and importance of mercury from different sources?*
- *What are the risks to different ecological systems and species from mercury contamination?*
- *What management alternatives are available to ameliorate or eliminate the mercury contamination problem?*

Structures such as this massive pump move water from the Everglades Agricultural Area southward to the Everglades.

DANIEL SCHEIDT

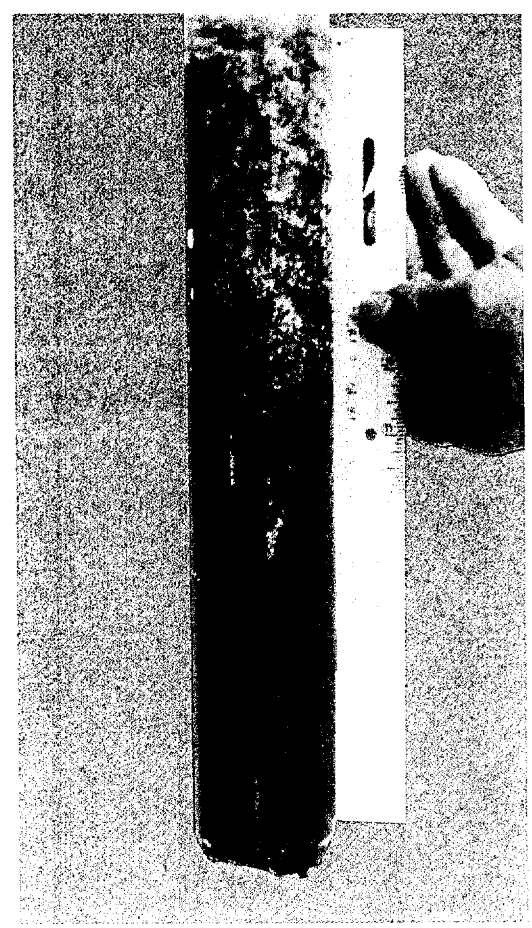


SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Drainage water being pumped from a sugarcane field in the 1,000-square mile Everglades Agricultural Area.

The proposed Region IV R-EMAP project will focus on the first four questions above and will initiate an ecological risk assessment process. The project will integrate and coordinate the efforts of various state and federal agencies, including EPA's Office of Research and Development and Region IV Environmental Services Division; Florida's Department of Environmental Protection, Freshwater Game and Fish Commission, Department of Health and Rehabilitative Services, and South Florida Water Management District; the U.S. Army Corps of Engineers; the U.S. Geological Survey; and industry representatives. Dr. Ron Jones of the Southeastern Environmental Research Program at Florida International University is cooperating closely with both the Everglades National Park and Region IV on this R-EMAP project.

Soil core from Water Conservation Area 3A, showing periphyton overlaying peat. A critical aspect of the Everglades mercury study is quantifying the mercury pool in these soils and understanding mercury cycling processes.



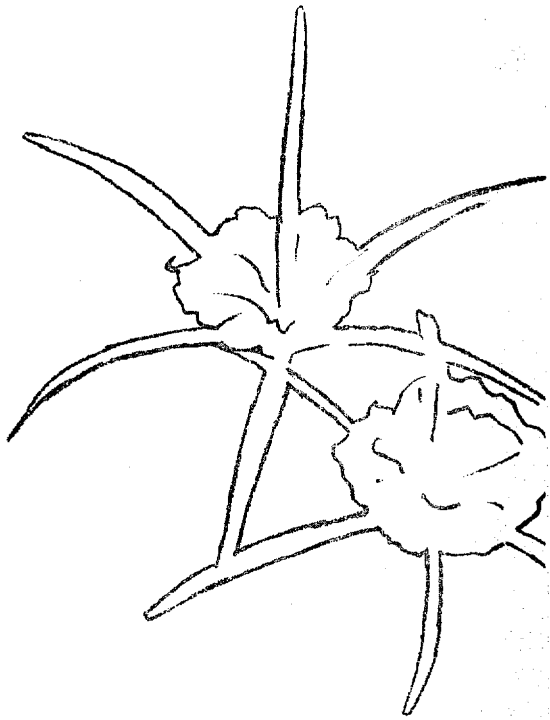
DANIEL SCHEIDT

Critical path analysis is an important component of the study. Top predators, such as the alligator with which the Everglades are so closely identified, recently have been shown to have elevated mercury concentrations.

DANIEL SCHEIDT

Cycling of Mercury in the Everglades Ecosystem

Significant quantities of mercury cycle through the air, water and solid phases of the global environment. Mercury cycling through the atmosphere is estimated at 6 billion grams per year. Within this global background, certain regional areas may have higher atmospheric background concentrations due to nearby urban or industrial activity. In South Florida, the operation of solid waste incinerators and fossil fuel power plants has increased since 1940. It is possible, therefore, that regional atmospheric mercury might also have increased over this time period. Figure 4-3 depicts atmospheric deposition of mercury from urban sources into the Everglades. Figure 4-4 shows a conceptual model of the biogeochemical cycling of mercury in the Everglades ecosystem.



Important components of the mercury cycle include:

- *Sequestering of mercury*

  Because the abundant organic matter in wetlands sequesters mercury, Everglades soils contain a substantial mercury pool even without continuing atmospheric deposition. These soils are a suspected source of the mercury contaminating fish in associated waters. The subsidence (loss of surface elevation) of peat and muck in the Everglades Agricultural Area over the years may have resulted in the concentration of mercury at the soil surface, facilitating methylation, transport of mercury downstream, and/or evaporation of mercury.

- *Mercury methylation*

  Inorganic mercury is converted to methyl mercury primarily through the actions of microorganisms. Sulfur-reducing bacteria have been implicated in mercury methylation. Methylation greatly increases the toxicity of mercury, its ability to be ***bioaccumulated,*** *and its mobility in the environment.*

- *Eutrophication*

  One of the most noticeable changes in the Everglades ecosystem in recent years is ***eutrophication.*** *Phosphate enrichment in Everglades soils has triggered microbial consumption of organic matter, resulting in anaerobic conditions and a change from* ***oligotrophic*** *to eutrophic ecosystems in some areas. Under eutrophic conditions, inorganic mercury may be converted to methyl mercury and bioaccumulated in the food chain.*

- *Surface flow of water*

  This may be an important transport mechanism that moves sediment, phosphorus, and inorganic and organic mercury off the Everglades Agricultural Area via canals to the downstream Water Conservation Areas and toward Everglades National Park. An average of 200 tons of phosphorus flow from the 700,000-acre agricultural basin into downstream habitats each year, resulting in systemic changes in wetland flora and fauna.

- *Evasion (soil degassing)*

  Evasion from South Florida wetland habitats, other land uses, and open waters is a component of the mercury cycle that has not yet been quantified.

- *Aquatic and terrestrial bioaccumulation pathways*

  Critical path analyses for the top terrestrial and aquatic ***predators*** *(birds, reptiles, and mammals) in several habitat types are an important part of an ecological risk assessment for mercury contamination in the Everglades ecosystem.*

Figure 4-3

ATMOSPHERIC DEPOSITION OF MERCURY FROM URBAN SOURCES INTO THE EVERGLADES

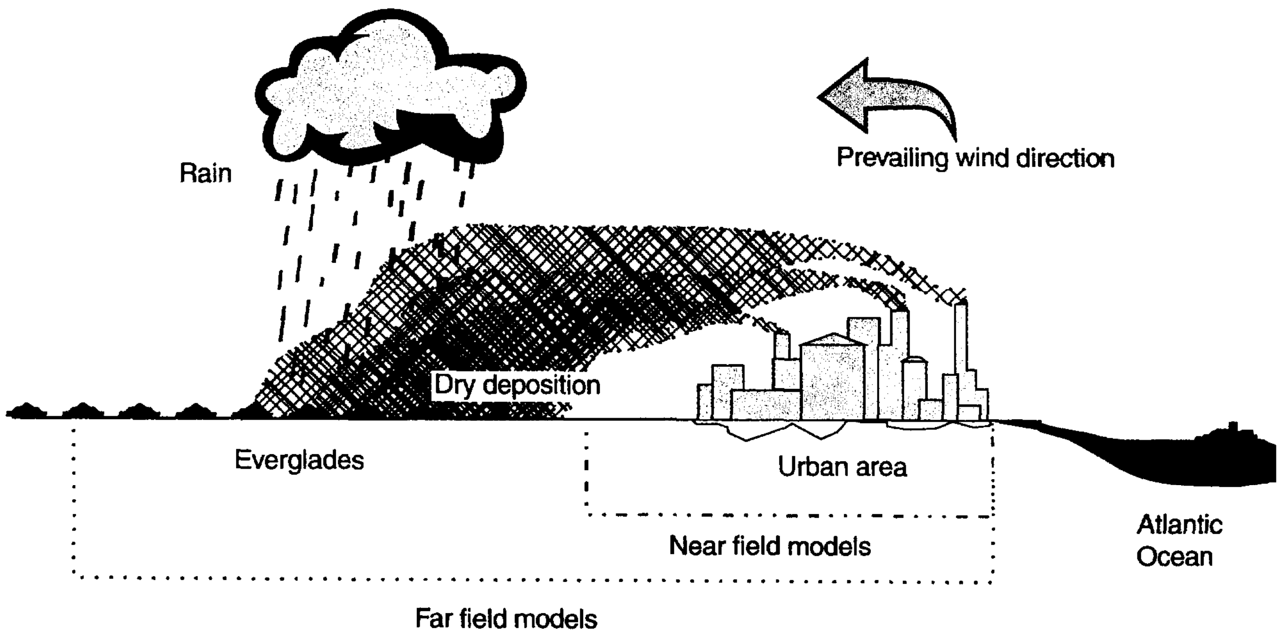
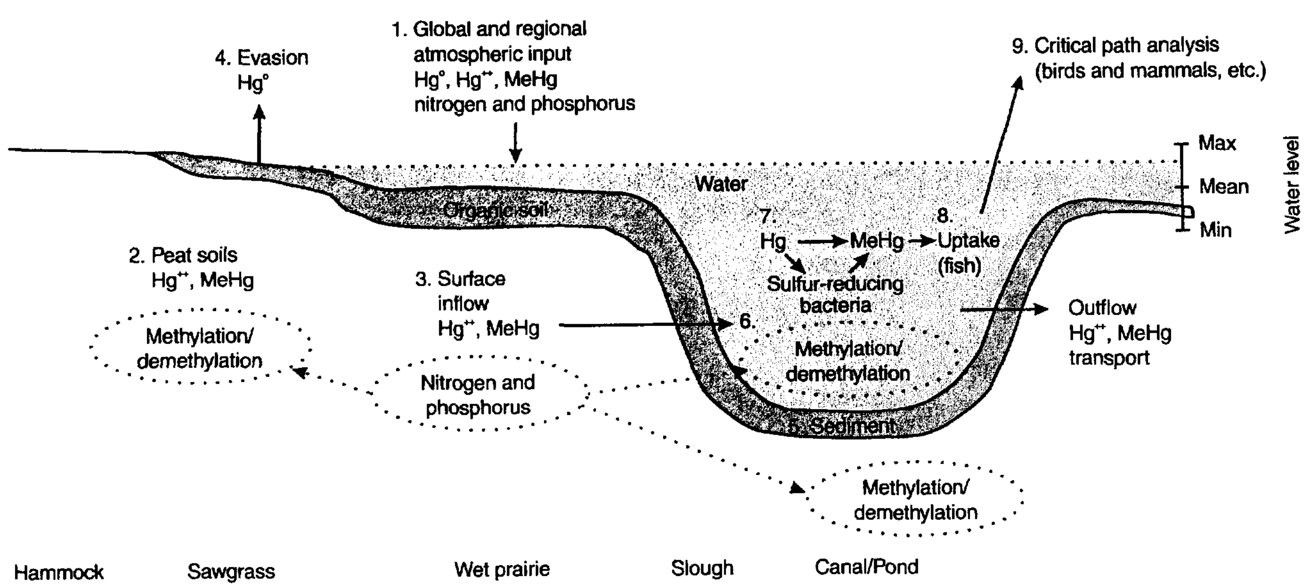


Figure 4-4

CONCEPTUAL MODEL OF BIOGEOCHEMICAL CYCLING OF MERCURY IN THE EVERGLADES ECOSYSTEM



ACTIVITIES

The Region IV R-EMAP study is designed to answer questions that focus on the extent, magnitude, and trends of the mercury problem, as well as to provide information for the initial phase of the ecological risk assessment process. All the activities are part of a larger interagency effort to study mercury contamination in the Everglades. Habitat types that will be sampled include canals, ponds, sloughs, wet prairies, sawgrass marsh, and hammocks/tree islands. Canal sampling is scheduled to begin in September 1993, with other tasks to follow in fall and winter 1993-94.

Water, soil, **sediment**, and biota will be sampled using the EMAP sampling strategy. Regional air monitoring is being conducted by the Florida Atmospheric Mercury Study, supported by Florida Power and Light, Electric Power Research Institute, Florida Department of Environmental Protection, and EPA Region IV. In addition, the Region IV Environmental Services Division is initiating studies of the sources, fate, and transport of mercury emissions. Data from these studies will be integrated into the Region IV R-EMAP study. Finally, the Region IV R-EMAP study and other projects are jointly developing analytical capabilities to allow researchers to measure mercury at the parts per trillion level in water and air.

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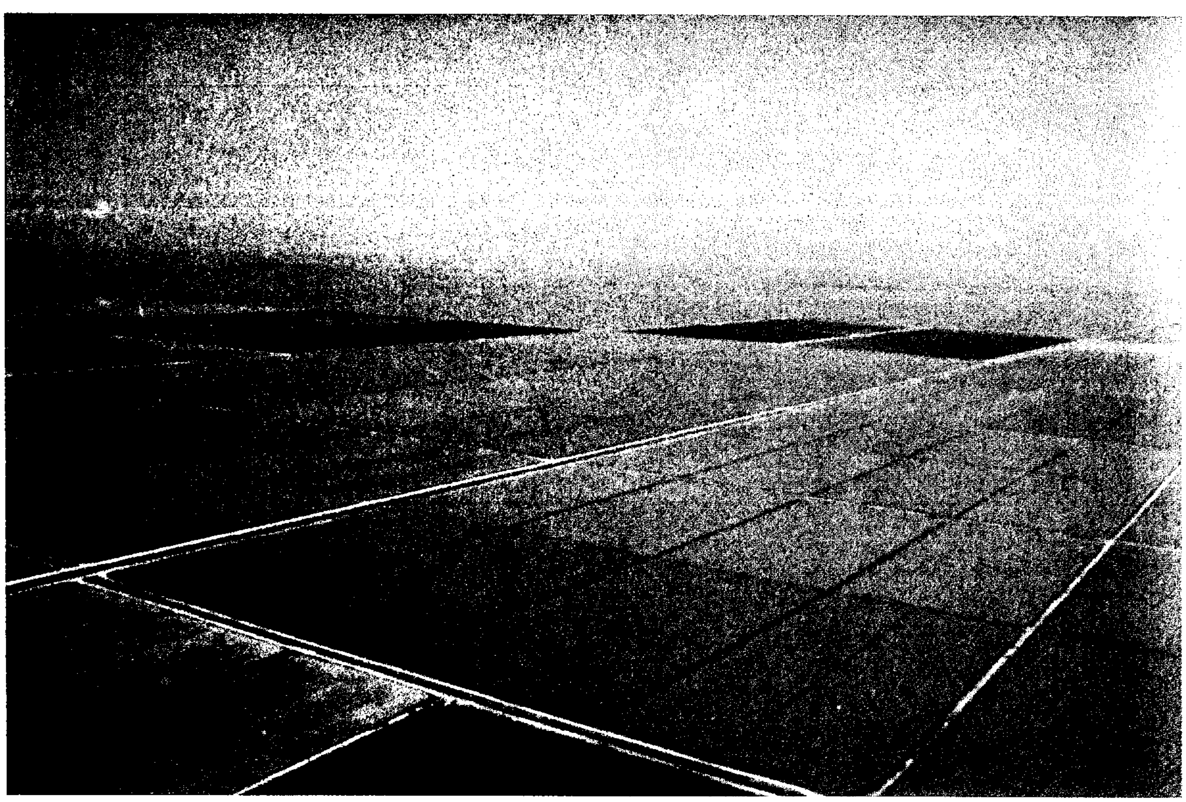

The Everglades Agricultural Area (EAA) encompasses 700,000 acres of former Everglades wetlands. Each year an average of 800,000 acre-feet of drainage water containing 200 tons of phosphorus is pumped from the EAA southward into the Everglades. The mass of mercury contained in this enriched water is currently unknown.

TECHNICAL APPROACH

The Region IV R-EMAP study will test a number of **hypotheses** regarding mercury contamination in the Everglades ecosystem. These include the following:

- *Mercury concentrations are significantly increased by human-induced (global and local) releases to the air and subsequent wet/dry deposition to the Everglades ecosystem.*
- *The Everglades Agricultural Area is loading the downstream Water Conservation Areas and the Everglades National Park with mercury and/or methyl mercury.*
- *Eutrophication of the Everglades is resulting in conditions conducive to the methylation of mercury of geologic origin in peat soils.*

The Region IV R-EMAP results and findings will provide a basis for defining an ecological risk assessment of the impact of mercury on the entire system, as well as on selected rare and endangered species. This assessment will help researchers determine the factors and processes to be incorporated into a mathematical model of the mercury cycle in the Everglades ecosystem.

Sampling Site Selection and Indicators

Region IV R-EMAP scientists will use a random, **probability**-based sampling strategy, based on the EMAP approach. The strategy will be designed to be integrated with the assessment strategy of the South Florida Geographic Initiative, a Region IV program to address crucial environmental issues in South Florida. The sampling grid is a seven-fold enhancement of the EMAP base grid, resulting in points distributed across the entire 4,000-square-mile study area. The distance between the individual points with the full grid density is about 4 km, with a hexagon area of about 13 km^2 around each grid point. Grid points in the Everglades Agricultural Area, Water Conservation Areas, and Everglades National Park have an equal probability of inclusion. The intensity of sampling will be decreased in the areas outside this primary study area.

Table 4-1 summarizes the indicators to be measured during the Region IV study.

Everglades marsh sampling stations can be accessed by airboat during the wet season. Boats equipped with electroshocking equipment, such as this National Park Service boat, are used to collect fish for mercury analyses.

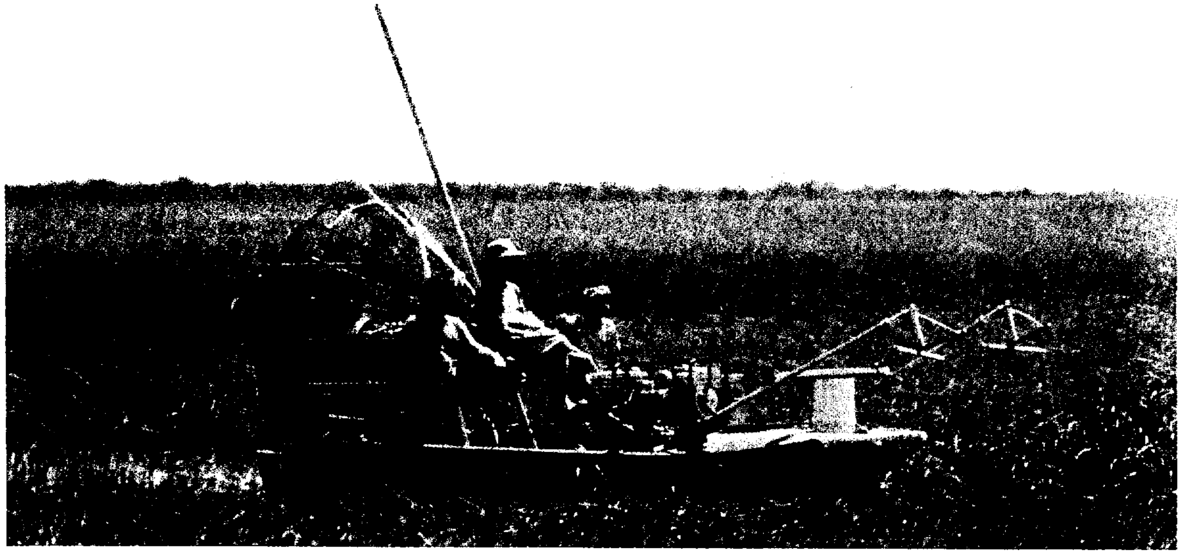

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Table 4-1

MEASUREMENT PARAMETERS

		Conventional Parameters	Hg
CANALS (50 RANDOMLY SELECTED SITES)			
	Water	Temperature, turbidity, conductivity, dissolved oxygen (DO), pH, dissolved organic carbon (DOC), total phosphorus (TP), SO_4, total suspended solids (TSS)	Total mercury (T), methyl mercury (MeHg)
	Sediment	% mineral content, TP, pH, redox potential (Eh)	T, MeHg
	Biota	Gambusia (a fish), length (L) and width (W)	T
CANAL STRUCTURES (7 SITES: BI-WEEKLY TIME SERIES FOR ONE YEAR)			
	Water	Temperature, turbidity, conductivity, DO, pH, DOC, TP, SO_4, TSS	T, MeHg
TRANSECTS (4 TRANSECTS–70 SITES)			
	Water	Temperature, turbidity, conductivity, DO, pH, DOC, TP, SO_4, TSS	T, MeHg
	Soil (3 depths)	Bulk density, % mineral content, TP, pH, Eh	T, MeHg
	Biota	Gambusia, L, W	T
MARSH GRID (179 RANDOMLY SELECTED SITES)			
	Water	Temperature, turbidity, conductivity, pH, DOC, TP, SO_4, alkaline phosphatase, TSS	T, MeHg
	Soil (3 depths)	Bulk density, % mineral content, TP, pH, Eh	T, MeHg
	Biota	Gambusia, L, W	T

Samples will be taken in the following order of priority:

- *Randomly selected canal samples (Figure 4-5).*

  Samples based on the enhanced base grid will be taken systematically at 50 sites in a north-to-south sequence over a one-week period. These sites will be accessed by helicopter or boat. This sequence will be carried out twice each year during the wet (May-October) and dry (November-April) seasons. After four cycles, sampling at the initial set of 50 stations will be repeated. This sampling will allow researchers to gain an initial spatial understanding of total mercury and methyl mercury in water, sediment, and biota.

- *Water monitoring at seven canal structures (Figure 4-6).*

  The South Florida Water Management District will carry out this sampling at bi-weekly intervals for one year. Four of the canal structures to be sampled are the main discharge points for water from the Everglades Agricultural Area. The other three canal structures, located at progressive intervals down the canal system toward Everglades National Park, will help the researchers determine whether a spatial gradient exists.

- *Sampling at 70 sites in four marsh transects (straight lines with fixed sampling points) (Figure 4-6).*

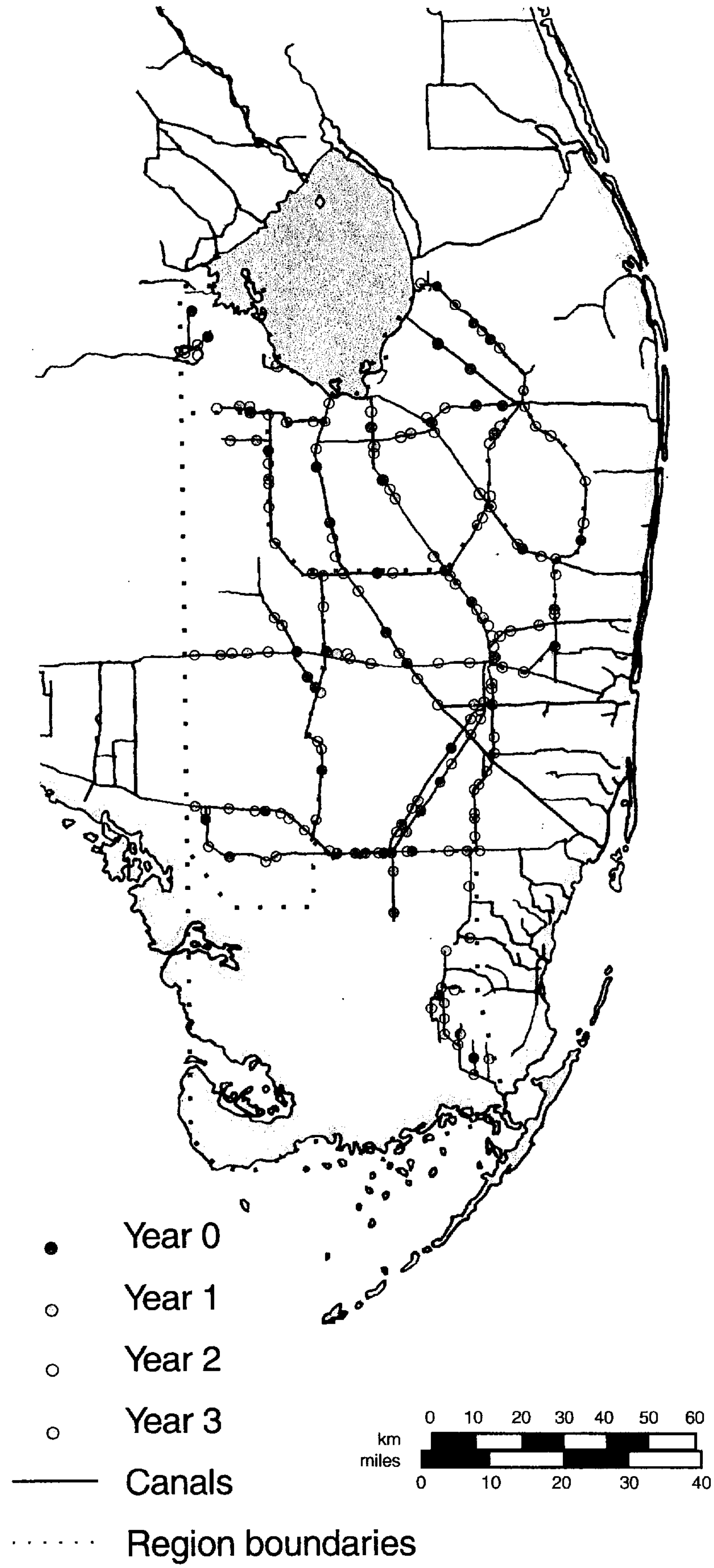
  These transects are located across known nutrient gradients. Water, soil, and biota will be sampled to test the eutrophication hypothesis. Depending on the strength of the relationship of total phosphate to methyl mercury, this effort will be used to evaluate the design and practicality of the marsh grid sampling effort.

- *Marsh grid sampling (179 randomly selected sites).*

  The initial cycle of the marsh sampling is shown in Figure 4-7a; Figure 4-7b shows the density after four cycles. Water, soil, and biota will be sampled, when available, at each site. Soil will be sampled at depths of 0 to 5 cm (surface), 20 to 25 cm (middle), and 40 to 45 cm (maximum depth). The maximum depth was deposited approximately 100 years ago. Other information, such as the habitat type in which each station is located and the depth of water present, will be recorded as each site is sampled.

Figure 4-5

CANAL SAMPLING LOCATIONS



Analytical Methods

To determine the sources and fluxes of mercury in the Everglades ecosystem, the investigators will need to accurately measure mercury at ultra trace levels (parts per trillion) in air, water, sediment, soil, and fish tissue. To accomplish this, researchers will use a technique called automated cold vapor atomic fluorescence spectrometry.

The study will employ "clean" sampling protocols for air and water to prevent contamination of the samples during the collection, transport, and storage phases. "Clean" protocols for laboratory analysis of total and methyl mercury in air, water, soil/sediment and tissue are also being developed by related projects.

Figure 4-7a

SAMPLING SITES FOR INITIAL CYCLE OF MARSH SAMPLING

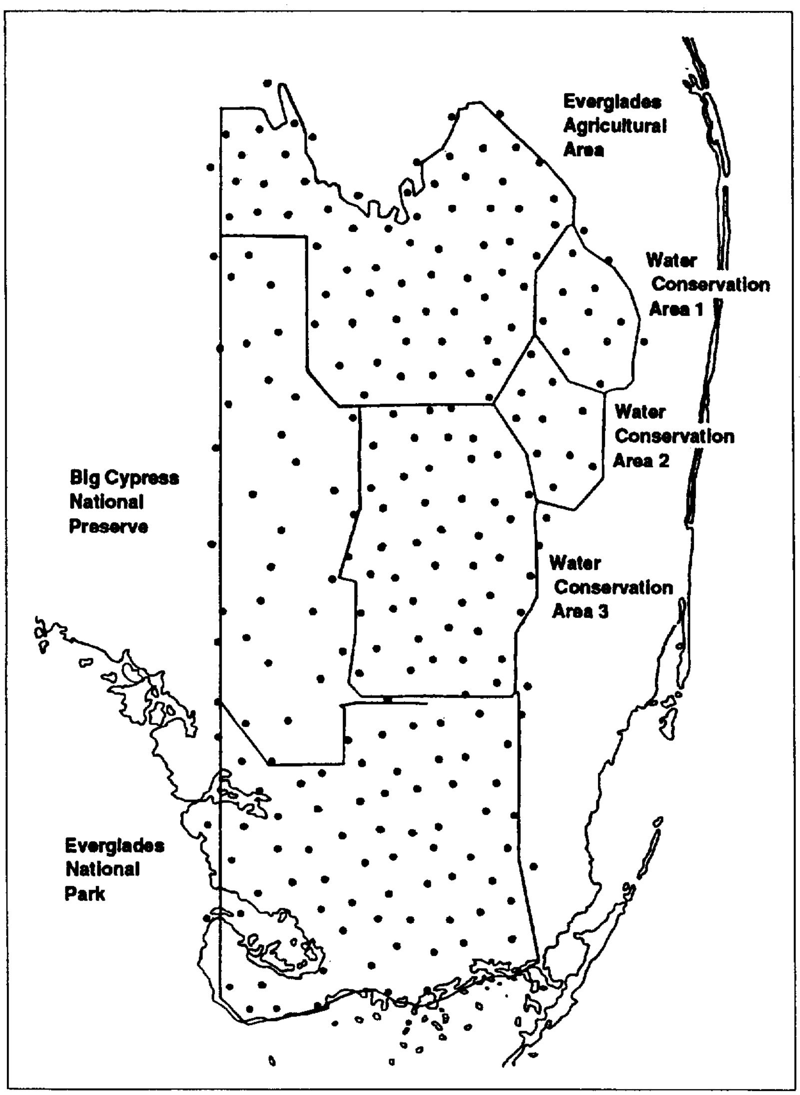


Figure 4-6

CANAL STRUCTURE AND TRANSECT SAMPLING SITES

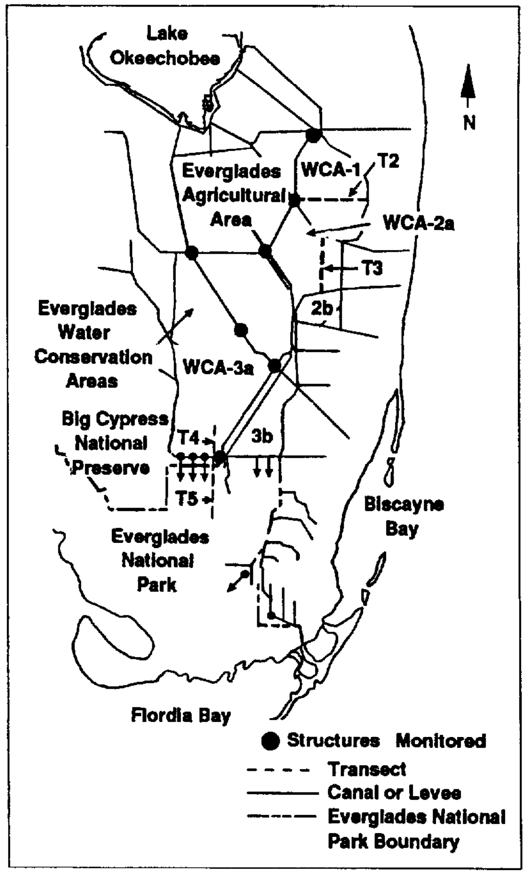
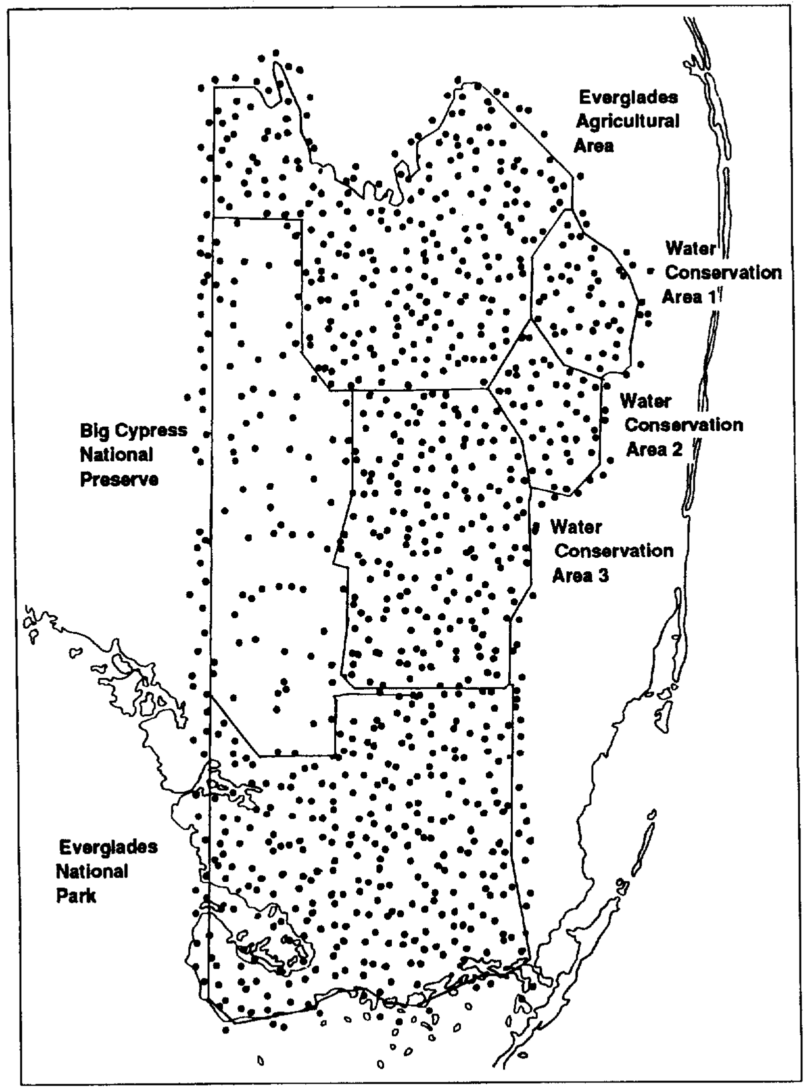


Figure 4-7b

MARSH SAMPLING DENSITY AFTER FOUR SAMPLING CYCLES



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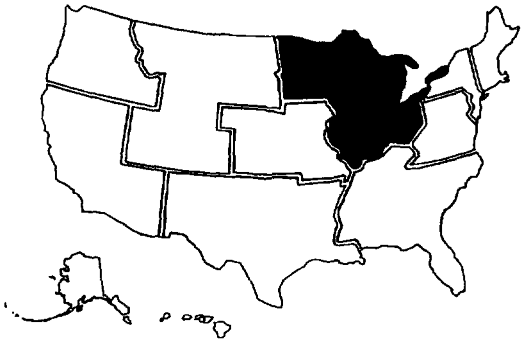
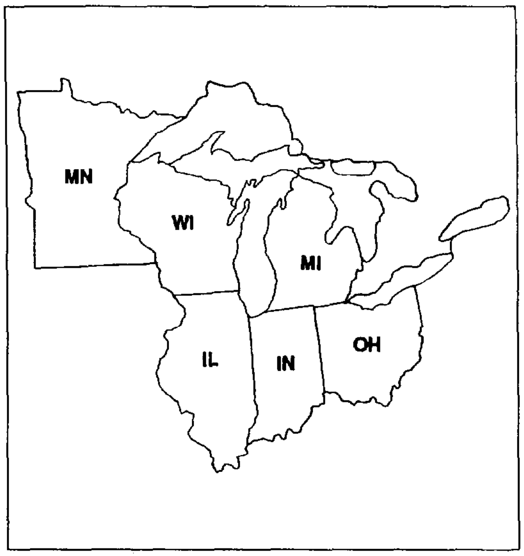


REGION V

THREE PROPOSALS FOR MONITORING AND ASSESSING ECOLOGICAL RESOURCES

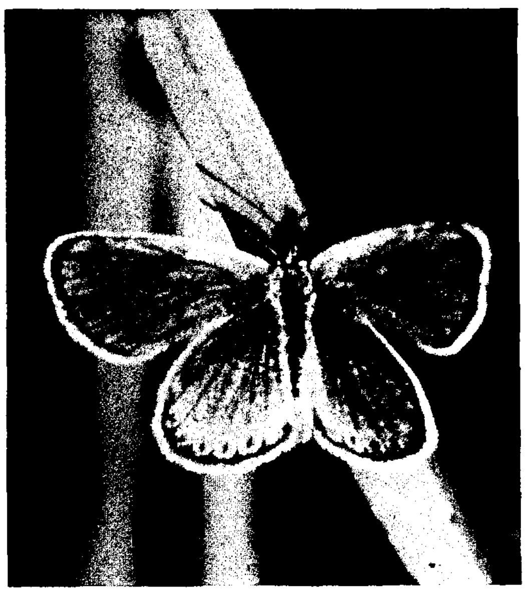
Region V is developing three proposals for consideration as R-EMAP projects. Following evaluation by the Region's R-EMAP Technical Steering Committee, one or more of these proposals will be submitted to EPA's Office of Research and Development for funding.



STUDY AREA

Developing an EMAP Signature for a Rare and Imperiled Ecosystem

This proposed project will establish a protocol ("signature") for identifying, monitoring, and assessing the rare and imperiled Oak Savanna and Woodland **Ecosystem**. This terrestrial ecosystem ranges from the Great Lakes Basin to the Gulf Coast. Because of economic development and exploitation, it is estimated that less than 0.01 percent of this ecosystem remains.



The Karner Blue Butterfly, an endangered species that inhabits the Oak Savanna and Woodland Ecosystem.

The approach proposed for this project involves obtaining data through **remote sensing** to characterize ecological resources in the ecosystem. These data will be important for efforts to preserve and restore the ecosystem and to promote biological diversity. It will also help efforts to protect the Karner Blue Butterfly, an endangered species that inhabits this woodland ecosystem.

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

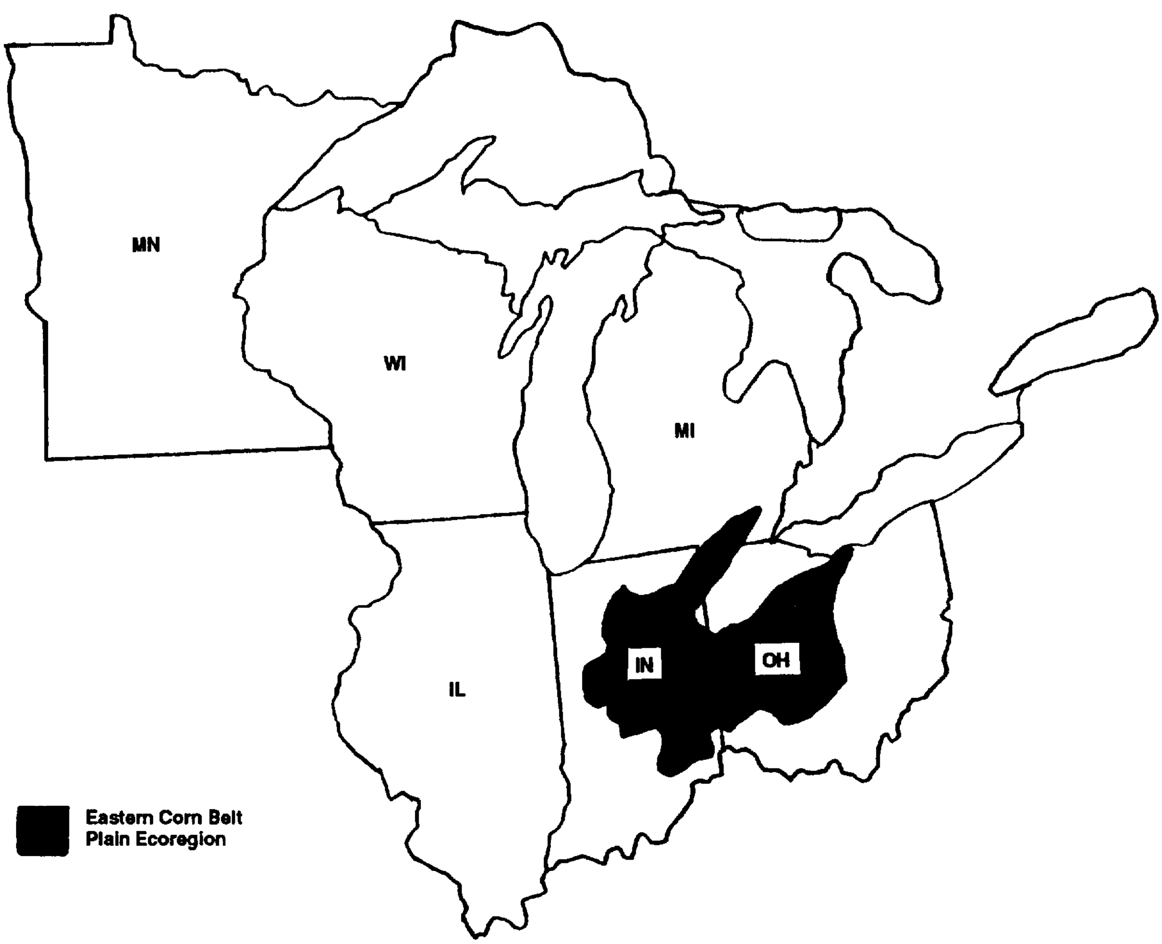
The rare and imperiled Oak Savanna and Woodland Ecosystem

Assessing Corn Belt Rivers and Streams

This proposed project will evaluate the use of the EMAP sampling design for establishing **reference conditions**, evaluating stream status, and developing **biocriteria** in the Eastern Corn Belt Plain **Ecoregion** (Figure 5-1), which stretches across the states of Michigan, Ohio, and Indiana. The study will also compare the EMAP grid design with an intensive design being developed by the state of Ohio. Testing the EMAP design for biocriteria development will assist the states in developing reference conditions and may help them develop status and trends reports required under the Clean Water Act at a significant cost savings.

Figure 5-1

THE EASTERN CORN BELT PLAIN ECOREGION

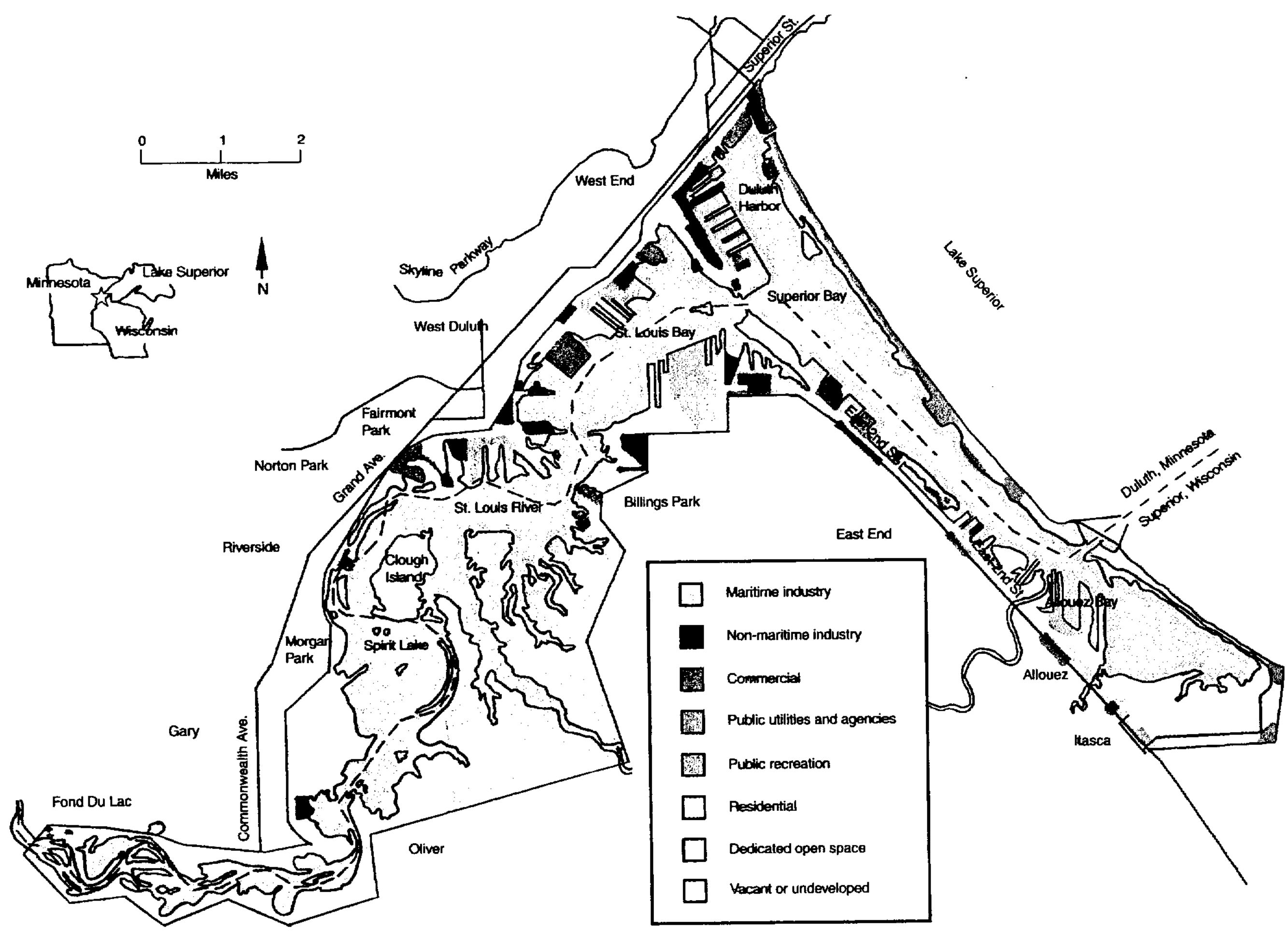


Assessing Harbors and Embayments in a Great Lakes Area of Concern

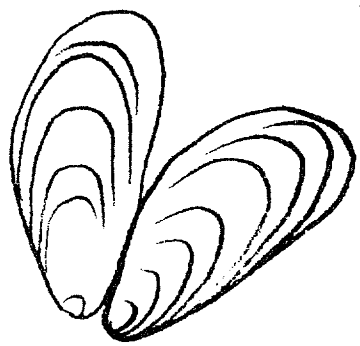
This proposed project will establish a monitoring framework that can be used by all states in the Region to meet monitoring requirements under the Clean Water Act. A total of 43 Areas of Concern (AOCs) in the Region have been found to have impairments posing ecological and human health risks. The areas most affected are the harbors and embayments of major tributaries entering the Great Lakes.

Figure 5-2

DULUTH - SUPERIOR HARBOR, *including St. Louis Bay*



This project will address the St. Louis Bay AOC (Figure 5-2), because it is typical of other harbors and embayments that are AOCs. The St. Louis River Drainage Basin covers approximately 4,900 square miles in the states of Minnesota and Wisconsin. The proposed approach involves the use of the EMAP **probability**-based sampling frame (perhaps in combination with another sampling frame to accommodate distinct **physiographical** sections of the study area) on a subregional scale. The project will follow the sampling and collection protocols of the EMAP-Surface Waters and the EMAP-Great Lakes Resource Groups. Indicators will be selected that address the most frequently impaired uses for all 43 AOCs in the Region.



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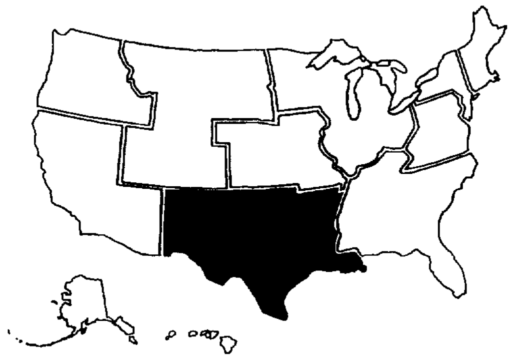
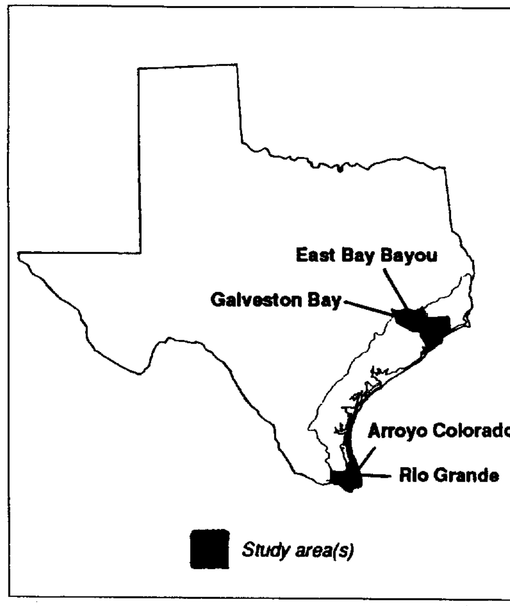


REGION VI

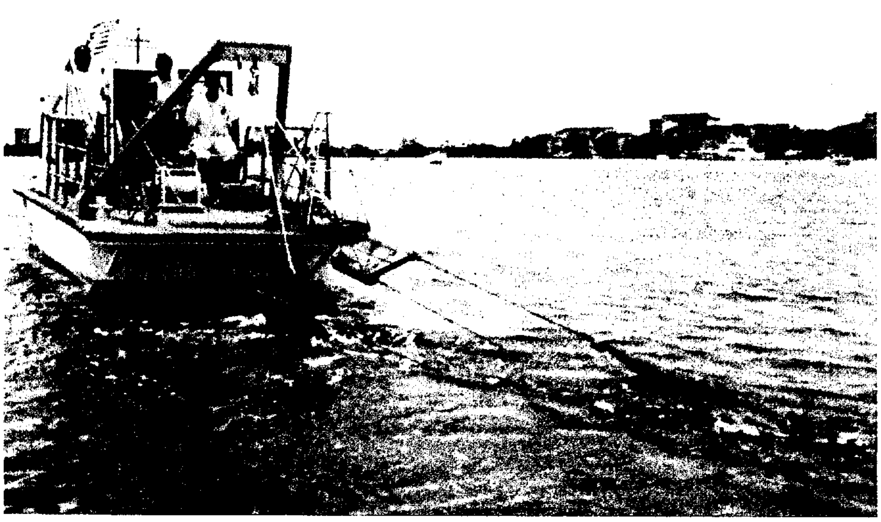
TOXICS CHARACTERIZATION OF SELECTED TEXAS ESTUARIES

Since 1991, a full-scale EMAP study has been under way in the Louisianian Province, encompassing the Gulf Coast from northern Florida through Texas. This study, known as EMAP-**Estuaries** or EMAP-E, has generated concerns about contaminants in fish and **sediments** in several estuaries along the Texas coast. The Region VI R-EMAP project, R-EMAP-TX, is using the EMAP sampling design to address waterbody-specific questions arising from the 1991 EMAP-E study. R-EMAP-TX is focusing on potential problems in several estuarine systems: contaminated sediments in the Galveston Bay estuary, biological impairment (fish pathology and sediment toxicity) in the East Bay Bayou of Galveston Bay, and contamination in tidal reaches of the Arroyo Colorado River and the Rio Grande River.



STUDY AREA

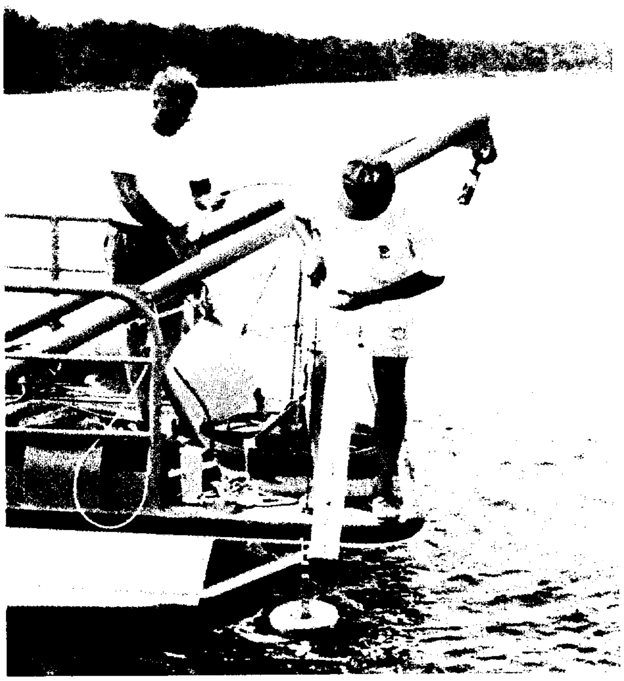
R-EMAP-TX collects fish samples to obtain data on fish pathology and fish tissue contamination.



The goals of R-EMAP-TX are to:

- *Collect additional data to characterize the extent and severity of potential waterbody-specific problems identified by EMAP-E.*
- *Obtain the scientific information that environmental managers need to identify toxic pollutants of most importance in specific geographic areas.*
- *Evaluate the usefulness of coupling the EMAP regional approach as a screening tool with the R-EMAP approach of obtaining refined measurements in specific waterbodies.*
- *Design and implement procedures that link an EMAP and a R-EMAP project and that maximize data comparability between the projects.*
- *Test whether the EMAP approach (statistical design and indicators) is appropriate for addressing waterbody-specific questions.*

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.



Field workers use an electronic probe to measure dissolved oxygen and other water quality parameters.

Planning for R-EMAP-TX is provided by an interagency team representing the Environmental Services and Water Quality Management Divisions of Region VI, the Texas Water Commission, and EPA's Office of Research and Development (ORD). To ensure that the data from R-EMAP-TX are comparable to the data from EMAP-E, R-EMAP-TX is employing the EMAP-E protocols, personnel, equipment, and laboratories. Texas A&M University in College Station, Texas, will conduct the field activities. The laboratories for R-EMAP-TX are the EPA/ORD Environmental Research Laboratory in Gulf Breeze, Florida; the Gulf Coast Research Laboratory in Biloxi, Mississippi; and Texas A&M University.

ACTIVITIES

Table 6-1 presents the milestones and schedule for R-EMAP-TX. The activities of R-EMAP-TX in each of the four study areas are described below.

Table 6-1

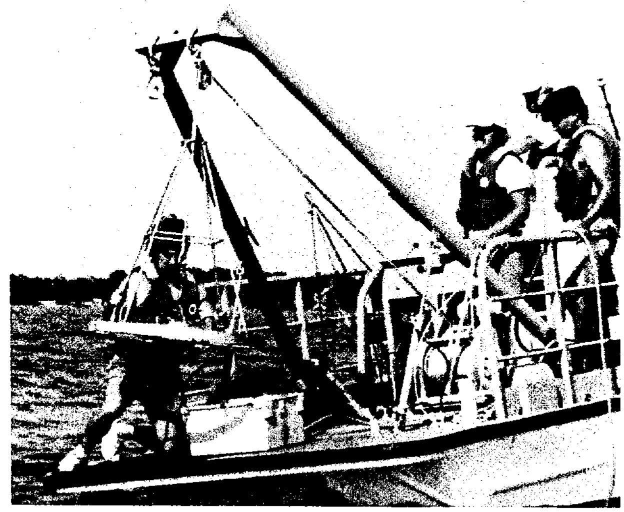
MILESTONES AND SCHEDULE

	1993	1994
Quality assurance project plan completed	March	
All funding/personnel/equipment in place	June	
Field crew trained	July	
All sampling activities conducted	September	
Field activity report completed	October	
Sample processing/analysis completed		March
Data audited and transmitted to state and Region		April
Data entered into state data base		May
Draft report completed		June
Final report completed		August

Galveston Bay Sediments

The results of the 1991 EMAP-E study found tributyltin (TBT), a substance highly toxic to aquatic life, in 11 of 12 EMAP sediment samples collected from Galveston Bay and its associated tributaries and embayments. Five of the samples had concentrations higher than 5 parts per billion (ppb). In contrast, only 13.3 percent of the 183 sites sampled in the Louisianian Province taken in that year's EMAP study had TBT sediment levels higher than 1 ppb.

R-EMAP-TX will attempt to confirm these preliminary findings and further document the extent of contamination and the severity of effects on aquatic life resulting from contamination by TBT and other pollutants.



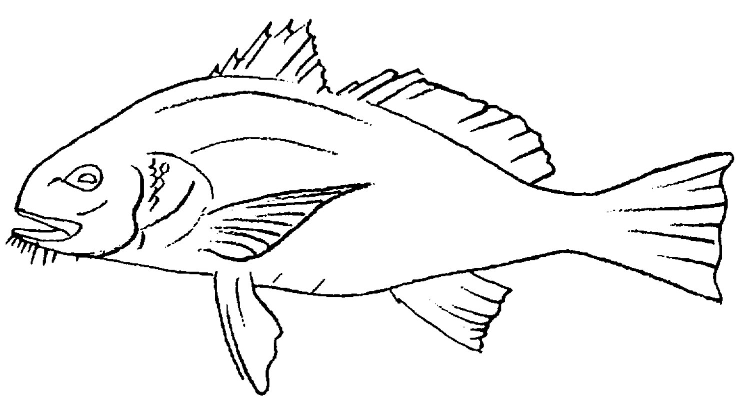
Members of the field crew use a grab sampler to collect sediment samples.

Further sampling in Galveston Bay will be conducted to determine:

- *The extent of sediment in the Galveston Bay estuary with TBT concentrations exceeding 1 ppb and 5 ppb.*
- *Whether high concentrations of TBT and other contaminants in sediment are correlated with degraded fauna conditions.*
- *How TBT concentrations in the **water column** are related to TBT concentrations in the underlying sediment.*

Biological Impairment in the East Bay Bayou of Galveston Bay

In the 1991 EMAP-E study, the East Bay Bayou, a small tidal river of Galveston Bay, exhibited a high fish pathology rate (45 percent for Atlantic croaker and 65 percent for sand seatrout). The background pathology rate for the whole Louisianian Province was less than 1 percent. In addition, the toxicity tests of the sediment from this area showed significantly high mortality rates for **benthic** invertebrates.



R-EMAP-TX will conduct more intensive sampling in the East Bay Bayou to determine:

- *Whether there is, in fact, a significant difference between the fish pathology rate found in the East Bay Bayou and that found across the Louisianian Province.*
- *Which specific areas in the East Bay Bayou have the highest fish pathology rates.*
- *What the contaminant levels are in fish and sediment in the East Bay Bayou.*
- *Whether the sediments in the East Bay Bayou are toxic to sediment organisms in laboratory tests.*
- *Whether the sites with the highest contaminant levels correspond to the sites where the greatest biological impairment is found.*

Toxic Contamination in Tidal Reaches of the Arroyo Colorado River

Measurements taken during the 1991 EMAP-E study from one site in the tidal portion of the Arroyo Colorado River showed high fish tissue concentrations of agriculture-related contaminants, particularly toxaphene. R-EMAP-TX will take additional measurements to determine whether the results from the one site are indicative of conditions throughout the tidal portion of the river. This part of R-EMAP-TX will focus on the levels of chlorinated hydrocarbons in fish tissue, chemical and toxicity tests of sediments, and benthic community analyses.

Toxic Contamination in Tidal Reaches of the Rio Grande River

R-EMAP-TX is also sampling the tidal reaches of the Rio Grande, another major tributary in southern Texas. During the EMAP-E survey, investigators were not able to sample the Rio Grande. To determine whether or not the Rio Grande has problems similar to those in the Arroyo Colorado, R-EMAP-TX is performing the same tests in the Rio Grande as in the Arroyo Colorado. In addition, R-EMAP-TX will take water column samples to complement a separate toxics study being conducted by EPA and Texas on the nontidal reaches of the Rio Grande.

TECHNICAL APPROACH

R-EMAP-TX is designed to obtain unbiased statistical estimates of the ecological condition of the four estuarine systems under study. R-EMAP-TX will collect field samples during August and September 1993 to coincide with the field sampling season used by EMAP-E. Sampling is limited to a time period in which environmental stress is expected to be most severe. A second sampling season is planned for September 1994. This will allow investigators to further assess problems confirmed by the 1993 sampling, to expand sampling to additional estuaries, and to address any unusual climatic conditions (such as hurricanes or high freshwater runoff) that could bias the results during a single sampling season.

Sampling Design

The areas to be sampled by R-EMAP-TX are Galveston Bay and its adjacent embayments and tributaries, with the exception of the Houston Ship Channel; the East Bay Bayou; the Arroyo Colorado River from the mouth to Port Harlingen, TX; and the estuarine portion of the Rio Grande from the mouth to a point 5 kilometers inland. To obtain data that provide unbiased estimates of the status of these estuaries, R-EMAP-TX is randomly selecting sample sites using an extension of the EMAP-E sampling design.

In Galveston Bay, sample site selection is based on a randomly placed hexagonal grid. The sampling scale for this project calls for a grid of 31 hexagons of 70 square kilometers each (four times the density of the sampling conducted in the 1991 EMAP-E survey). Sampling sites are chosen randomly within each hexagon. Figure 6-1 shows the sampling sites for the Galveston Bay estuary.

For the three small tidal rivers–the East Bay Bayou, the Arroyo Colorado, and the Rio Grande–a systematic linear grid is used to select sampling sites. The linear grid defines the spine of the rivers, starting at the mouth and extending upstream to designated points. Sampling segments are placed every 2.5 km along the spine (four times the density used in the 1991 EMAP-E project). Sampling sites are chosen randomly within each segment. The sampling design results in 6 segments in the East Bay Bayou (Figure 6-1), 10 in the Arroyo Colorado (Figure 6-2), and 3 in the Rio Grande (Figure 6-2).

A sorting tray is used to process sediment samples in the field.

Indicators

R-EMAP-TX is measuring the following indicators to assess the environmental status of the estuaries under study:

- *Fish pathology*
- *Species richness in benthic communities*
- *Levels of contaminants in fish tissue*
- *Levels of TBT and other contaminants in sediments*
- *Sediment toxicity*

Figure 6-1

GALVESTON BAY AND EAST BAY BAYOU SAMPLING SITES

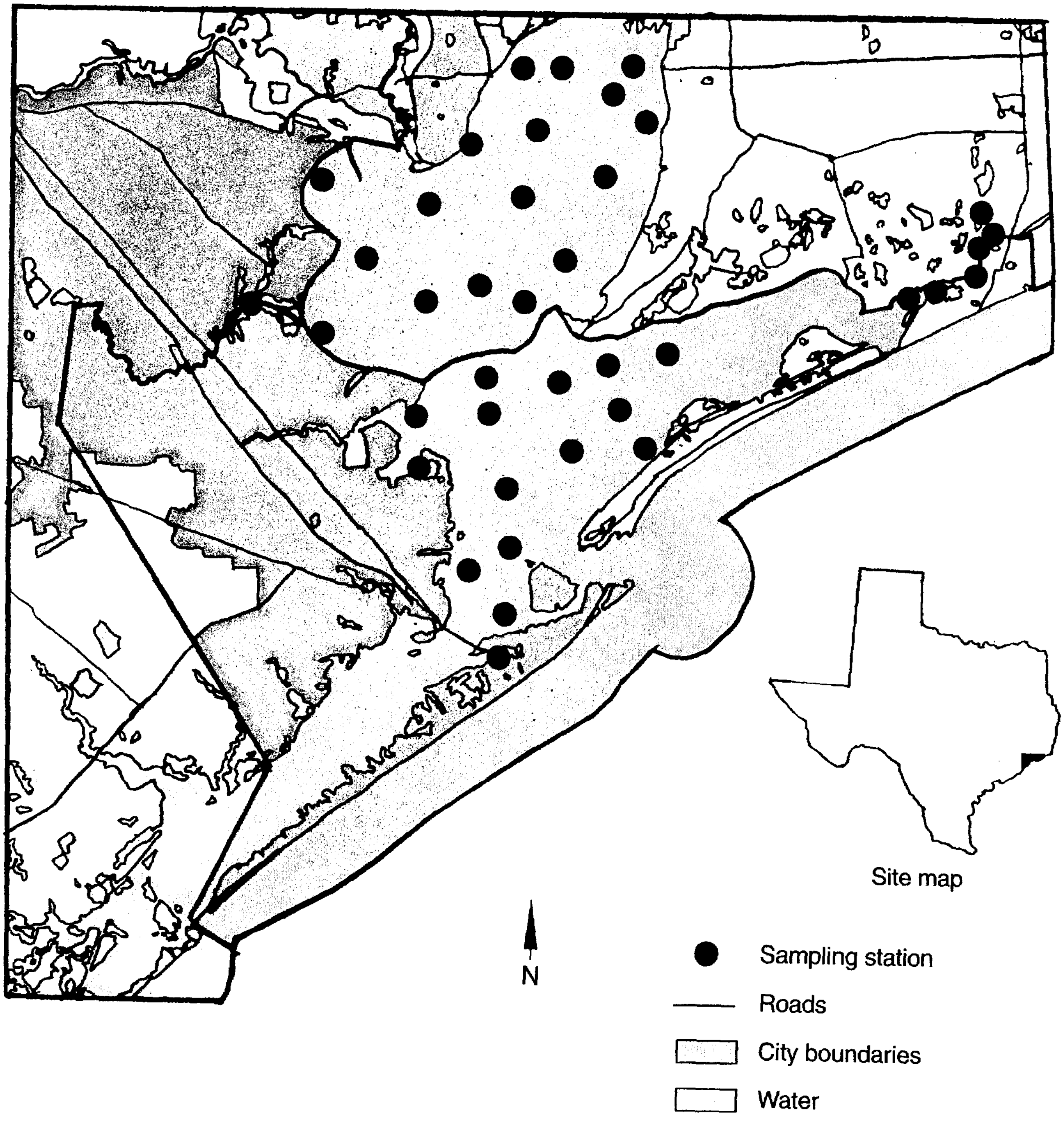
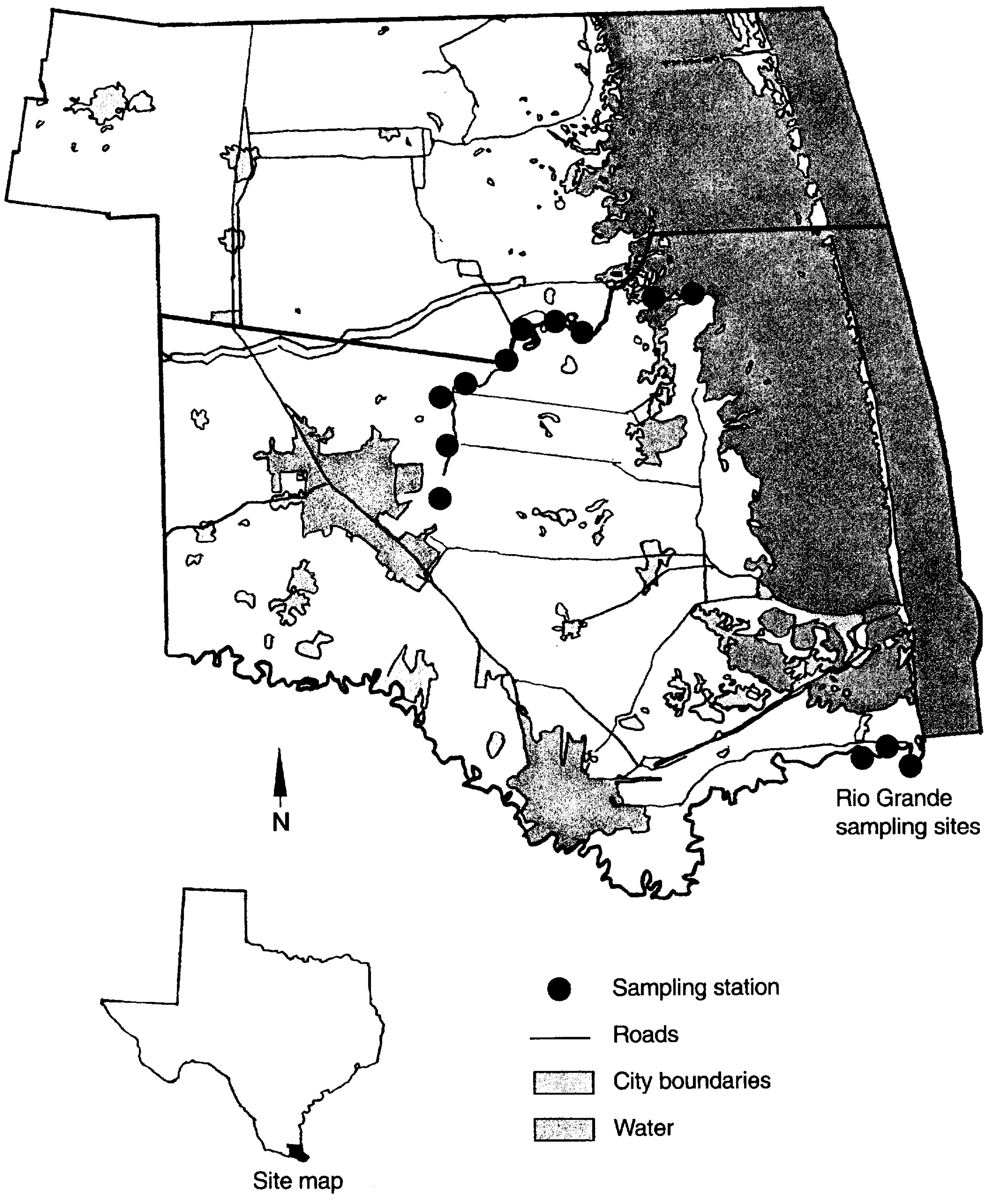


Figure 6-2

ARROYO COLORADO AND RIO GRANDE SAMPLING SITES



Hypothesis Testing

To address questions of concern to environmental managers, R-EMAP-TX will test several **hypotheses**. Some of the questions to be addressed and hypotheses to be tested are listed below.

East Bay Bayou

Questions of Interest:

- *What is the frequency of pathologies in the East Bay Bayou?*
- *What are some of the potential sources for these observed pathologies?*

Hypotheses:

- *The incidence rate of pathologies observed at the East Bay Bayou does not differ from the rates found across the Louisianian Province.*
- *The incidence rate of pathologies observed at specific East Bay Bayou sites does not differ from the rate of pathologies found overall in the East Bay Bayou.*

  (If the high rates of pathology found by EMAP-E are confirmed, managers will need to consider follow-up investigations of potential sources. The R-EMAP-TX results will help managers focus on areas where biological impairment is greatest.)

Tidal Reaches of the Arroyo Colorado and Rio Grande Rivers

Question of Interest:

- *Are the anoxia (lack of oxygen) and high concentrations of agriculture-related contaminants found by EMAP-E in the Arroyo Colorado of deep south Texas indicative of conditions throughout the tidal portion of the river? Do similar contamination problems exist in the tidal reaches of the Rio Grande River?*

Hypothesis:

- *Tissue levels of chlorinated hydrocarbons in the tidal rivers of south Texas do not exceed human health criteria.*

  (If this hypothesis is rejected, further studies of the potential sources, fate, and transport of agriculture-related contaminants in these rivers would be warranted. The Texas Department of Health would also be advised to consider fish advisories or fish bans in these areas.)

Galveston Bay Sediments

Questions of Interest:

- *What is the extent and distribution of high TBT levels in Galveston Bay sediments?*
- *Do TBT concentrations in the sediments correspond to the condition of the bottom fauna?*

Hypotheses:

- *Less than 20 percent of Galveston Bay sediments contain greater than 1 ppb TBT.*
- *Less than 20 percent of Galveston Bay sediments contain greater than 5 ppb TBT.*

  (If either of these hypotheses is rejected, environmental managers will be alerted to the need for additional controls on TBT releases to Galveston Bay.)

- *There is no positive association between species richness and concentrations of TBT and other contaminants found in Galveston Bay sediments.*

  (If this hypothesis is rejected, precautions regarding TBT use and/or further studies on the biological effects of TBT and other contaminants would be warranted.)

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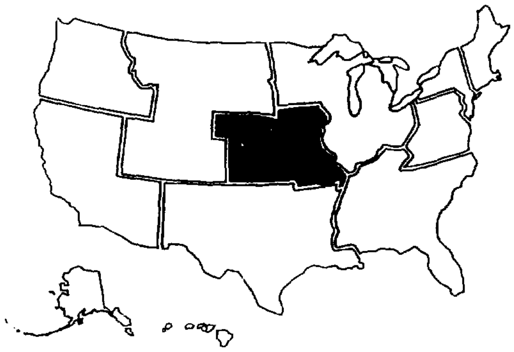


REGION VII

MEASURING THE HEALTH OF FISHERIES

Region VII is concerned that concentrations of contaminants in fish tissue may be impairing the quality of Region VII **fisheries.** The purpose of the Region VII R-EMAP study is to determine the health of the fisheries in the Region and to establish baseline data and methods that could be used to assess long-term trends in fishery health throughout the Region.

STUDY AREA

The Region VII R-EMAP project will address the following questions:

- *What is the current fish community structure (biological integrity), and does it indicate poor or good fishery health?*
- *Are the fish diseased, parasitized, or deformed? If so, to what extent?*
- *Do the fish contain toxic substances? If so, to what extent?*
- *Are the water and sediment polluted? If so, to what extent?*
- *What are the distribution and extent of the sport and commercial fishes?*
- *What is the condition of Region VII fishery habitats?*

The answers to these questions may be helpful to the states in Region VII in developing **biocriteria.**

The Region VII study is a collaborative effort between EPA's Office of Research and Development, the Region VII Environmental Services Division (ESD), and the states of Missouri, Kansas, and Nebraska.

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

ACTIVITIES To assess the status of fisheries in Region VII, researchers will obtain water, **sediment,** and fish samples and will assess **habitat** quality from randomly selected lakes, ponds, and streams in the four-state Region. The samples will be taken from July through September 1994. The investigators will perform statistical analyses on the data obtained from each sampling site. They will use these analyses to formulate conclusions related to fishery health, such as "Twenty percent of the streams in Region VII have an Index of Biological Integrity (IBI) score greater than 45."

Table 7-1 presents a schedule of milestones and deliverables for the Region VII R-EMAP program.

Water sample collection along the Wood River near Grand Island, Nebraska.

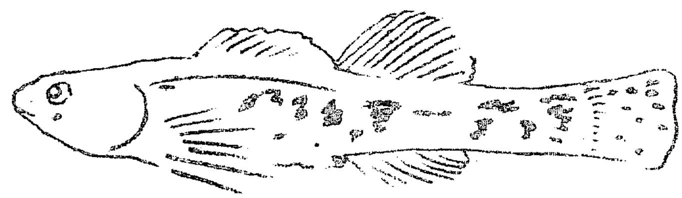


Table 7-1

MILESTONES AND SCHEDULE

	1993	1994	1995
Develop Cooperative Agreements (CAs) with states or work contracts with contractors	February - May		
Submit CAs and/or contracts	June		
Contracts approved; begin site reconnaissance process	September		
Equipment purchased, field crews organized	December		
Conduct training session for all sampling team leaders and finish site reconnaissance process		May	
Data collection		July - September	
Data reporting		October - December	
Draft report issued			April
Draft report reviewed by states, ORD, and others			May
Final report issued			September

TECHNICAL APPROACH

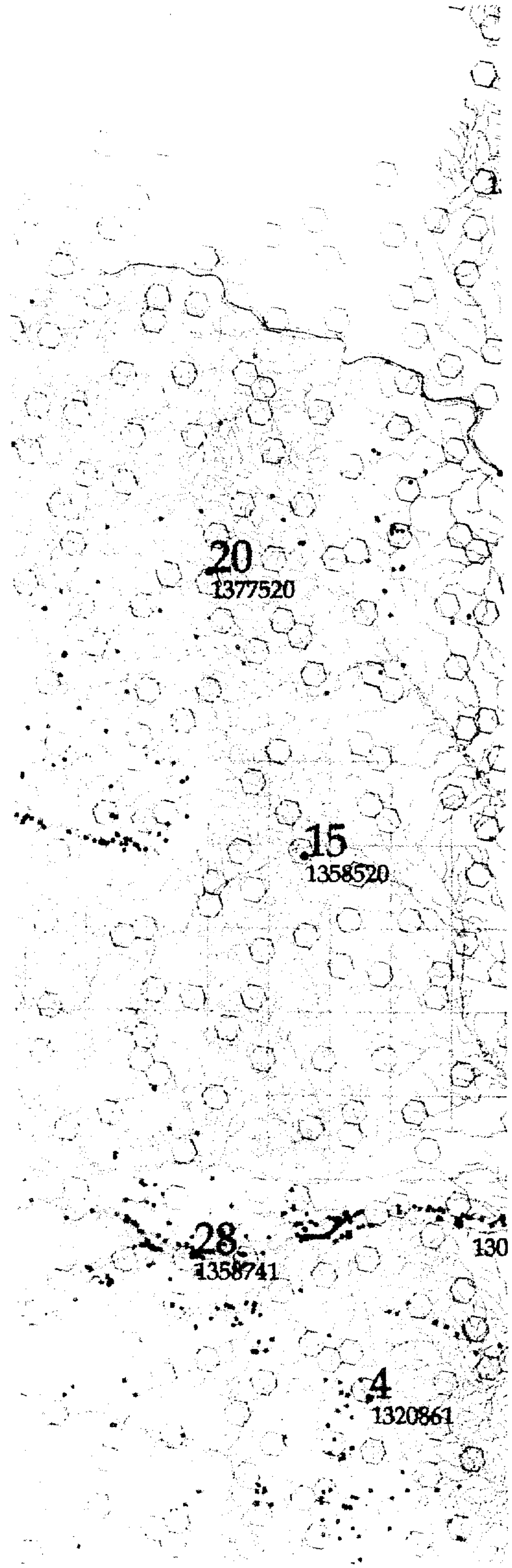
Statistical Design and Sampling Site Selection

To determine the sample sites, investigators will randomly select 120 hexagons, 40 square kilometers each, from the 1,100 EMAP hexagons in Region VII. An additional 15 sites will be selected by the three states participating in the study. These 15 sites can be used to evaluate known or suspected water quality or habitat problems, measure **reference conditions** in **ecoregions,** or serve as additional random sampling sites.

Once all the randomly selected hexagons have been identified, all waterbodies identified in EPA's River Reach File Version 3 (RF3) data base will be included as part of the random sample **population.** From this population, the investigators will randomly choose sampling sites. Because ponds are believed to be an important fishery resource in the Region, at least 25 percent of the sampling sites will be located at ponds.

The randomly selected waterbodies will be screened for legal and logistical accessibility. For streams, investigators will determine sample sites of between 150 and 300 meters based on characteristics of **fluvial geomorphology.** For lakes and ponds, in general, 10 sampling stations will be established at evenly spaced intervals around the perimeter of the lake or pond.

In addition to the randomly selected sites and the 15 sites selected by the states, another 12 sites will be used to study reference conditions in the ecoregions (such as forested land in Missouri and rangeland in Nebraska). To determine the natural variability of biological communities, both in time and in space, each state will designate two ecological **reference sites** (one lake/pond and one stream site). Each site will be duplicate-sampled in July and duplicate-sampled again in September. (Duplicate sampling involves bisecting each sampling site and sampling the fish community in each subarea.) Determining the variability of the biological data will be important for long-term monitoring because it will allow researchers to recognize both natural and human-induced changes and perhaps distinguish one from the other.



Section of map showing R-EMAP stream and lake sample locations. Numbered dots indicate selected sample locations.

Indicators

The Region VII R-EMAP project will measure several indicators to assess the health of fisheries:

- *The biological integrity of the fish community. For streams, the investigators will obtain Index of Biological Integrity (IBI) scores using the* ***metrics*** *in Table 7-2. The metrics for lakes and ponds, as well as the exact scoring criteria, will be determined later in the study.*
- *The presence, number, and sizes of fishes of game, sport, or commercial value.*
- *The percentage of individual fish that are free of external anomalies (disease, deformities, and parasites). The field workers will check specimens for the anomalies listed in Table 7-3.*
- *The degree of water, sediment, and fish tissue contamination from pesticides and metals (Table 7-4).*
- *General water quality parameters related to nutrient levels and sediment loading in streams and* ***eutrophic*** *conditions in lakes and ponds (Table 7-5).*
- *Habitat quality. The field crew will assess habitat quality at a sampling site based on the parameters listed in Table 7-6.*

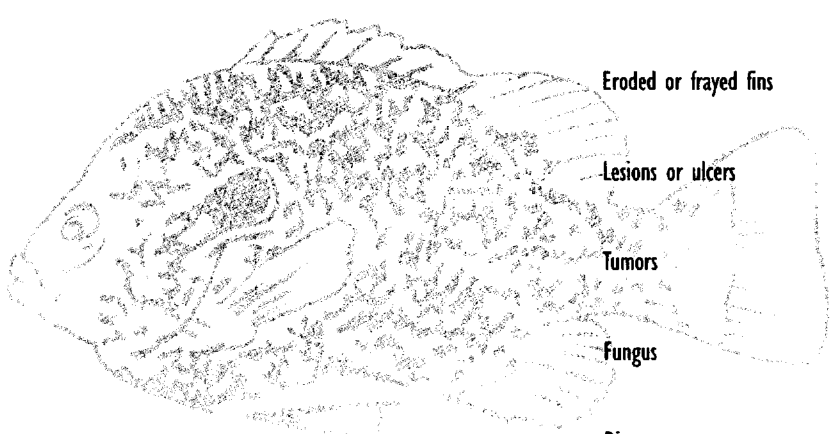


Table 7-2

METRICS FOR BIOLOGICAL INTEGRITY IN STREAMS

CATEGORY	METRIC
Species richness and composition	Total number of fish species
	Number and identity of darter species
	Number and identity of sunfish species
	Number and identity of sucker species
	Number and identity of intolerant species
	Proportion of individuals as green sunfish, carp, bullheads, and goldfish
Trophic composition	Proportion of individuals as omnivores
	Proportion of individuals as insectivorous cyprinids
	Proportion of individuals as piscivores (top carnivores)
Fish abundance and condition	Number of individuals in sample
	Proportion of individuals with anomalies

Table 7-3

EXTERNAL FISH ANOMALIES

Deformities	Can affect the head, spinal vertebrae, fins, stomach shape, scales, operculum, and eyes. Deformities include pugheadness, barbel and jaw deformities, and clubtail.
Eroded or frayed fins	Includes necrosis at the base of the caudal fin (peduncle disease) and erosions of the preopercle and operculum.
Lesions or ulcers	Appear as open sores, exposed tissue, or prominent bloody areas.
Tumors	Result from proliferative cellular growth; tissue is firm and not easily broken.
Fungus	Appears on the body or eyes as a white, cottony growth and usually attacks an injured or open area of the fish.
Disease	Any readily apparent diseases, such as "pop-eye," "Ich," columnaris, gas bubble disease, or blindness in either eye.
Parasites (heavy)	Includes leeches, anchor worm, spinyhead worm, and copepods. Parasites can cause soft, tumor-like masses and heavy black spot infestations.

Table 7-4

FISH TISSUE (T), WATER (W), AND SEDIMENT (S) ANALYSES

	T	W	S
PESTICIDES			
Chlordane	•	•	•
cis-Chlordane	•		•
trans-Chlordane	•		•
cis-Nonachlor	•		•
trans-Nonachlor	•		•
Oxychlordane	•		•
Propachlor		•	•
Heptachlor	•		•
Heptachlor epoxide	•		•
Aldrin	•		•
Dieldrin	•		•
p,p'-DDE	•		•
Metolachlor		•	•
Trifluralin		•	•
Atrazine		•	•
Alachlor		•	•
Cyanazine		•	•
Endrin	•		•
PCBs	•		•
Hexachlorobenzene	•		•
alpha-HCH (Lindane)	•		•

	T	W	S
PESTICIDES			
beta-HCH	•		•
gamma-HCH	•		•
p,p-DDT	•		•
p,p-DDE	•		•
Chlorpyrifos	•	•	•
Diazinon	•	•	•
Disulfoton	•	•	•
METALS			
Silver		•	•
Barium	•	•	•
Nickel		•	•
Selenium	•	•	•
Chromium	•	•	•
Lead	•	•	•
Zinc	•	•	•
Arsenic	•	•	•
Cadmium	•	•	•
Copper		•	•
Mercury (total)	•	•	•
OTHERS			
Total organic carbon			•

Table 7-5

GENERAL WATER QUALITY PARAMETERS

Total phosphorus

Total suspended solids

Turbidity

Dissolved oxygen

Temperature

pH

Ammonia

Nitrite-nitrate-nitrogen

Total organic carbon

Chemical oxygen demand

Conductivity

Table 7-6

HABITAT QUALITY PARAMETERS

STREAMS AND RIVERS	LAKES
Bottom substrate type and quality	Bank stability
Embeddedness	Bank vegetative stability
Channel alteration and morphology	Substrate
Bottom scouring and deposition	Percentage of emergent vegetation (areal coverage)
Pool/glide and riffle/run quality	Land use in basin (human influences)
Bank stability	Size
Bank vegetative stability	Maximum depth
Instream cover and riparian corridor condition	Fish
Stream velocity	Littoral habitat
Stream flow	
Surrounding land use	
Gradient	

Sample Collection

Fish will be collected from each sampling site using **electrofishing** and **seining** techniques. The field crew will identify and count large fish of specified sizes and species and will examine 30 specimens from each sampling site for the presence of external anomalies. Small fish will be preserved and sent to a laboratory for counting and identification. If fish of sport or commercial value are present, one species or family of species will be composited into a sample for fish tissue analysis. Water and sediment samples will be collected according to Region VII standard operating procedures for this sampling.

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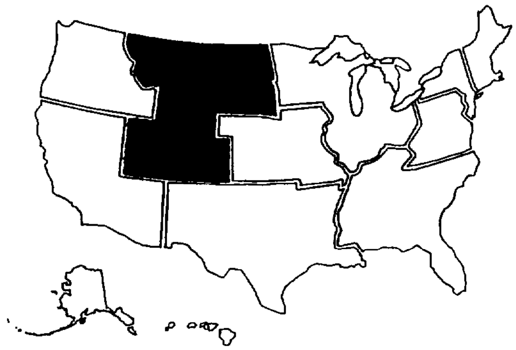
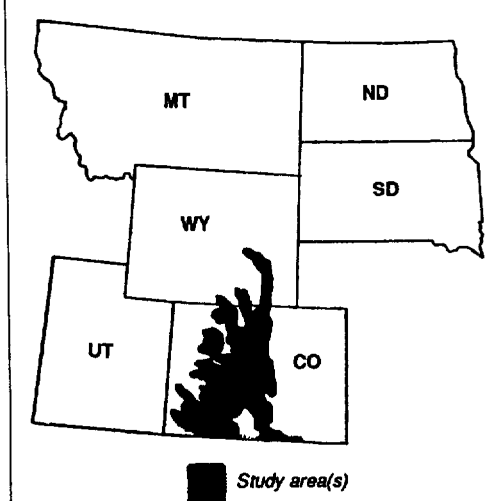


REGION VIII

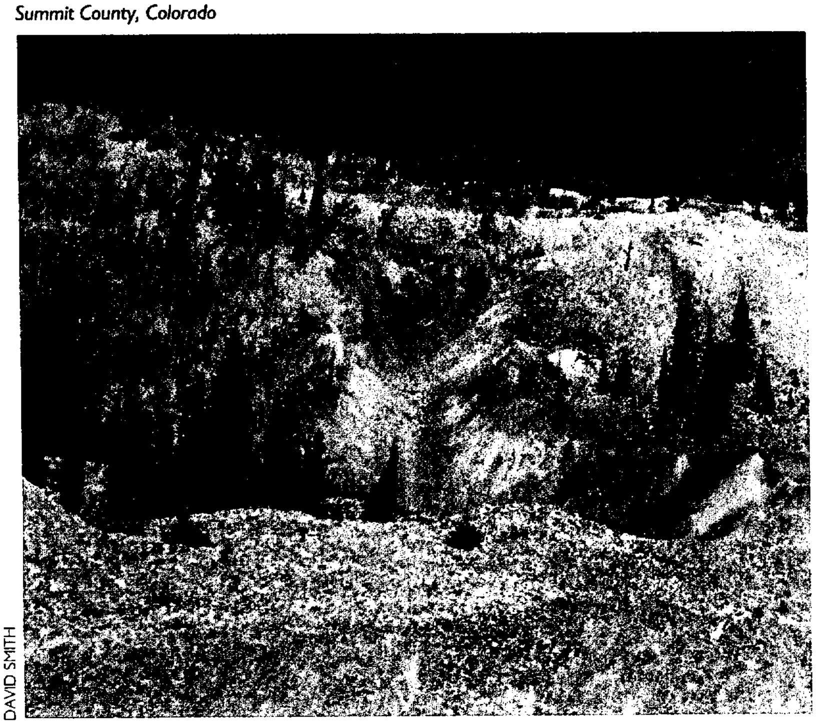
ASSESSING WATER RESOURCES IN THE MINERALIZED AREA OF THE SOUTHERN ROCKY MOUNTAINS ECOREGION

Region VIII is concerned that the release of toxic metals from abandoned mines and mills into the environment could cause widespread destruction of aquatic resources. The proposed Region VIII R-EMAP project will focus on **headwater** streams in mineralized areas (areas that have been subjected to extensive mining activity) in the Southern Rocky Mountains **Ecoregion.**



STUDY AREA

Mine tailings in French Gulch, Summit County, Colorado



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The project will address the following questions:

- *What is the current condition of biological communities in headwater streams in the ecoregion, and what proportion of affected streams can be linked to high metals loadings?*
- *What biological indicators are suitable for detecting the impact of metals in headwater streams?*
- *What constitutes a* ***reference condition*** *against which to judge the status of streams in mineralized areas of the Rocky Mountains?*
- *Can the EMAP scale be appropriately adjusted to target and analyze problems in this ecoregion?*

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

Region VIII is working to establish partnerships with state and federal agencies and the academic community to conduct this R-EMAP project.

ACTIVITIES

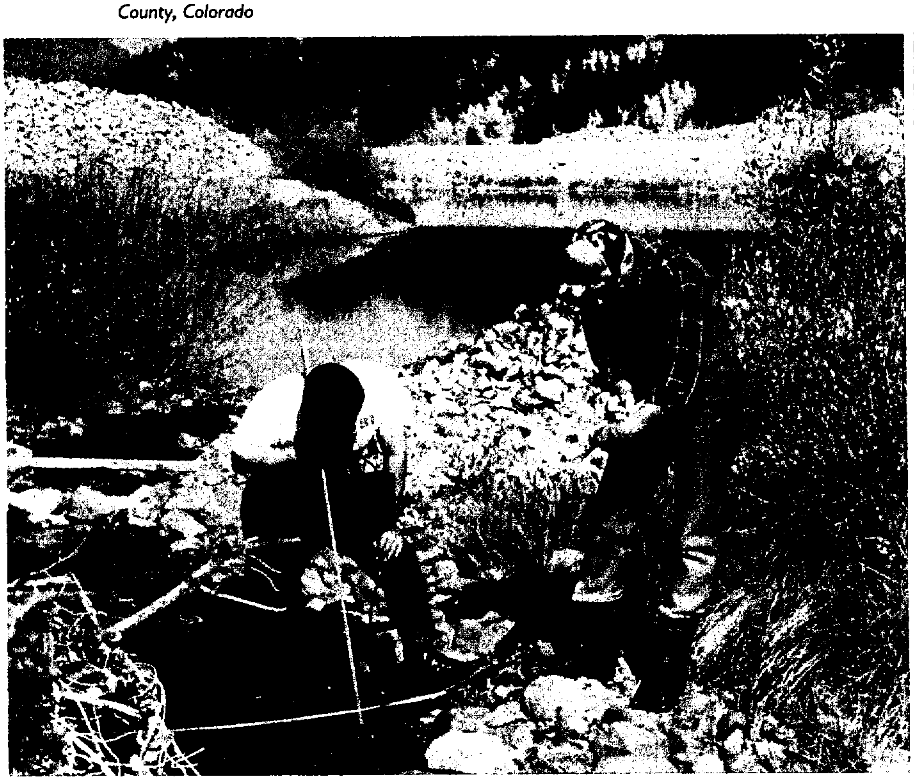
Investigators will conduct pilot work on indicators in 1993; the full project, including sampling of biological, chemical, and physical parameters in selected headwater streams, will be conducted in 1994 and 1995.

TECHNICAL APPROACH

The population of interest will be streams within the Southern Rocky Mountains Ecoregion, with sampling limited to mineralized areas. During the initial selection process, streams will be **stratified** according to stream size. After sampling takes place, an analysis of stream flow and stream **morphology** may help investigators refine the stratification of streams into meaningful groups for statistical analysis of the data.

A minimum of 50 sites will be sampled during 1994 and 1995. This total includes three types of sites:

Taking stream flow measurements, French Gulch, Summit County, Colorado



DAVID SMITH

- ***Reference sites***

  These sites will be selected in consultation with state government and federal land management agency staff.

- *"Test" sites*

  To distinguish minimally affected or unaffected sites from affected sites, it is important to collect measurements from sites with known impacts—that is, streams with high metals loadings. Investigators will select several test site locations within the study area representing different ecological conditions.

- **Probability** sites

  These sites will be selected using EMAP's systematically arranged grid design, combined with a probability-based selection process. The investigators will use the EMAP-Surface Waters method for selecting ***probability samples.***

The 1993 **pilot study** will consist of sampling at approximately 15 sites in the Southern Rocky Mountains Ecoregion.

The goals of the pilot study are to:

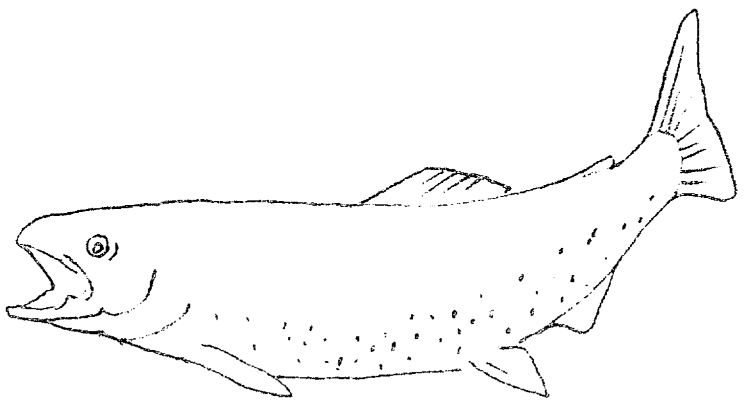
- *Field-test sampling protocols and logistical constraints (including sampling in remote areas).*
- *Evaluate the ability of different protocols to differentiate between test sites and reference sites.*
- *Obtain a preliminary indication of the range of variation associated with biological communities in two major basins in the ecoregion.*

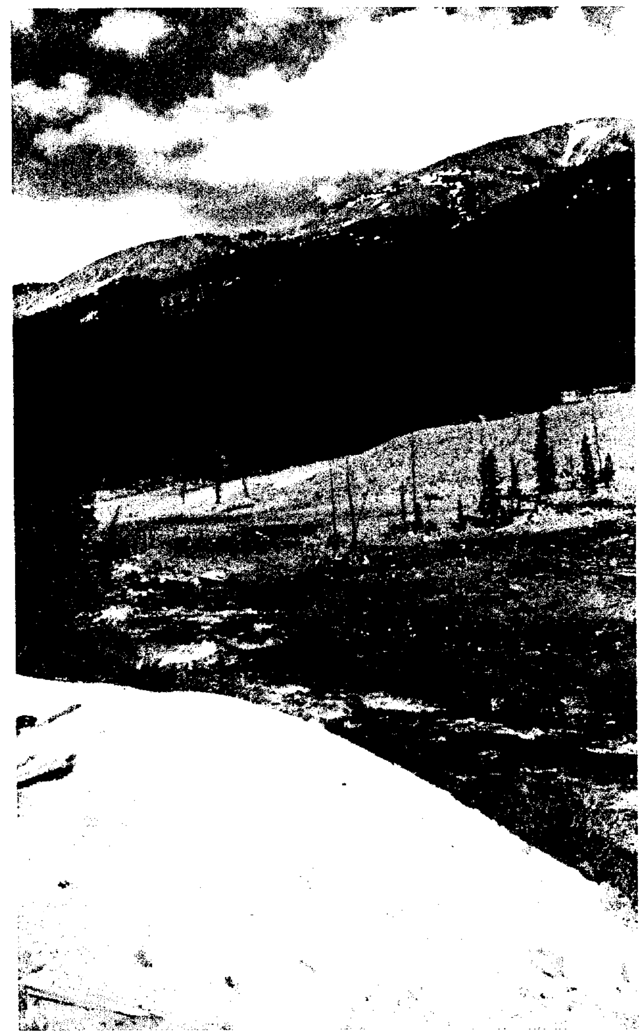
For the pilot study, sampling is planned in two basins: the Arkansas River and the Eagle River in Colorado. Sites for the pilot study will be selected based on stream characteristics (not probability sampling). A mix of reference sites and test sites will be identified in each basin.

Indicators

Investigators will field-test the indicators shown in Table 8-1 during the 1993 pilot work. After review of the 1993 pilot data, Region VIII scientists will decide whether to use this full suite of parameters during project implementation in 1994 and 1995.

Sampling protocols will be based on the written protocols developed for the joint EMAP 1993 Surface Waters and Region III R-EMAP Project, modified for Rocky Mountain headwater streams.





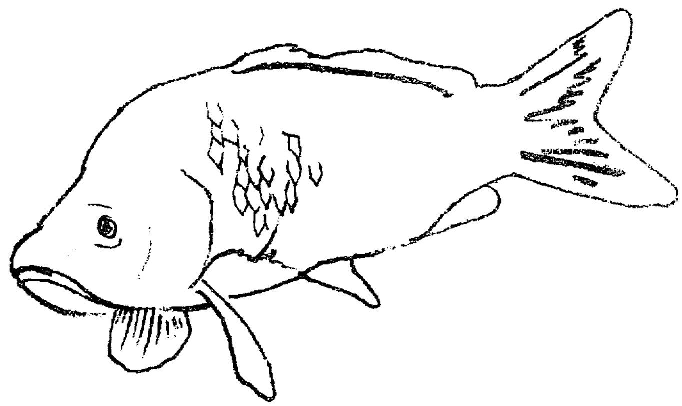
Mine dump and tailings pile along Chalk Creek, Chaffee County, Colorado

Table 8-1

PROPOSED ENVIRONMENTAL INDICATORS

Fish community structure and abundance
Macroinvertebrate community structure and abundance
Periphyton community structure and abundance
Benthic metabolism
Sediment toxicity
Quantitative physical habitat measures
"Rapid" habitat measures
General water quality parameters
Metals: water column concentrations
Metals: sediment concentrations

Sampling period The sampling period will be limited to a maximum of 45 days to ensure that the samples can be considered to come from a single population. Sampling will take place in August and September to take into account both biological and logistical considerations:



- *Headwater streams are accessible during these months.*
- *Lower stream flows will minimize dilution of metals to help ensure that high concentrations will be sampled. Lower flows will also maximize the effectiveness of* ***electroshocking.***
- *Macroinvertebrate populations should be large enough to facilitate identification.*
- *August and September will be an appropriate time for measuring physical habitat characteristics of the stream and* ***riparian*** *zones.*

Data analysis and reporting The investigators will evaluate several methods for data analysis and reporting, including **multivariate** statistics and **multimetric** measures. The methods selected must be able to effectively distinguish between reference sites and test sites. **Geographic information system (GIS)** technology will be used for data analysis and presentation.

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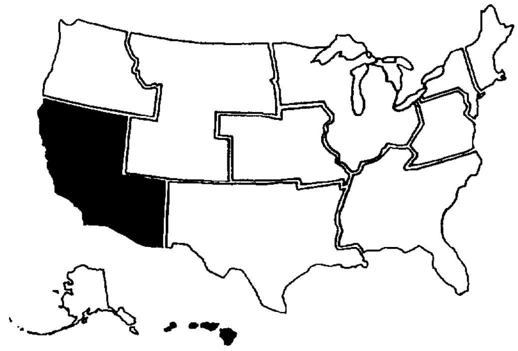
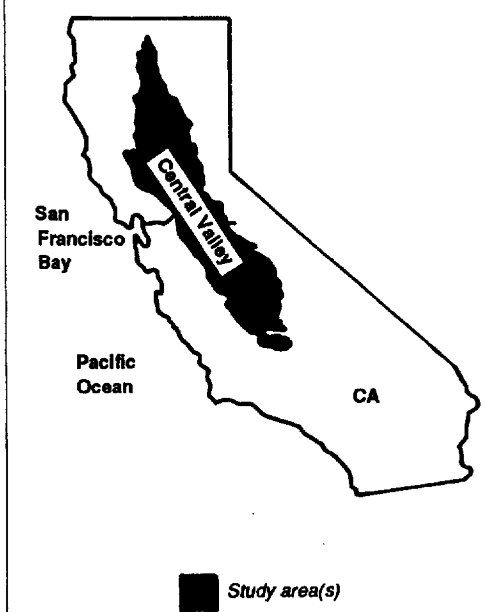


REGION IX

Assessing Aquatic Ecosystems In A Highly Modified, Agriculturally Influenced Environment: California's Central Valley

California's Central Valley, which comprises more than 48,000 miles of surface water and 16 percent of the land area of California, is one of the nation's most productive agricultural areas. EPA and the state of California are concerned, however, that agricultural practices might be jeopardizing the health of wildlife and the quality of aquatic ecosystems throughout the Central Valley. The Central Valley contains ecologically critical and highly impaired **habitat** for both aquatic and terrestrial resources. As a result of pesticide runoff, resident fish populations such as striped bass, chinook salmon, and delta smelt have experienced sharp declines in the last decade, and some are now listed as threatened or endangered species. Many wildlife deaths and deformities have been linked to selenium that is dissolved from soil by irrigation and enters surface water. In addition, many bird populations are in a steep decline due to the lack of high-quality wintering habitat.



STUDY AREA

Previous studies focusing on the Sierra foothill streams and the San Francisco Bay Delta have indicated that human-related activities, such as contamination by agricultural wastes, have contributed to the decline in environmental conditions for aquatic life. However, the aquatic biological communities in the waters of the Central Valley have not been comprehensively evaluated. The Region IX R-EMAP project seeks to assess the current condition of aquatic resources in the Central Valley, focusing on constructed agricultural drains (ditches) and natural waterbodies affected by agricultural management practices. The geographic target area of the project is the whole watershed of the Sacramento-San Joaquin Valley, approximately 24,000 square miles.

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

The objectives of the Region IX R-EMAP study are to:

- *Assess the current **biotic** condition of surface waterbodies in the Central Valley.*
- *Establish baseline conditions for different waterbody types in the Central Valley.*
- *Correlate R-EMAP data with other data collected by the California Regional Water Quality Control Board (such as biotoxicity monitoring).*
- *Modify existing **indices** to allow better assessment of the current biotic condition of surface waters in the Central Valley.*
- *Demonstrate to the Region and states the usefulness of EMAP indicators and sampling design for various environmental programs.*
- *Use the results of the study to develop scientifically supported environmental quality standards to measure the health of ecosystems.*
- *Assist other states and Regions with the development of meaningful, realistic water quality standards for agricultural drains.*

JOE VAN OS, THE IMAGE BANK

Fish populations such as the chinook salmon have experienced sharp declines in the last decade as a result of pesticide runoff.

The Region IX R-EMAP project will be jointly managed by staff from the EPA Region IX Environmental Services Branch and Water Management Division. California's Department of Fish and Game will be responsible for most of the data collection and taxonomic work.

ACTIVITIES

The Region IX R-EMAP project will assess the biotic integrity of agriculture-dominated waterbodies in the Central Valley. Some drains are thought to provide extremely important habitat, supporting **biota** where the original habitat has been highly modified or destroyed. Even before the concentrations of agricultural chemicals reach toxic levels, sensitive species may disappear and native biotic diversity may decrease. To assess the health of aquatic communities, the Region IX R-EMAP project will categorize these waterbodies based on:

- *Certain physical features, such as mileage, stream order, and waterbody type.*
- *Habitat condition, using physical indicators and basic water chemistry indicators.*
- *Biological indices of fish and **macroinvertebrate assemblages.***

This will allow the investigators to assess the overall health of the resources and the biological condition of each waterbody. Depending on the results, the sampled waterbodies may be re-categorized according to additional critical features.

To accomplish the project objectives, the investigators will undertake the following activities:

- *Conduct biological and chemical sampling and field assessment of the physical integrity of drains, sloughs (marshy areas), streams, and wetlands in the Sacramento/San Joaquin Valley.*

- *Design baseline biological monitoring to provide information on the biological health of the waters, including species diversity and* ***populations*** *of macroinvertebrates. Water and* ***sediment*** *chemistry monitoring will provide baseline data and identify the magnitude of the problem for chemicals of concern.*

- *Identify waters potentially at risk from current or future water diversions by assessing streams, rivers, sloughs, and wetlands impaired by lack of instream flows.*

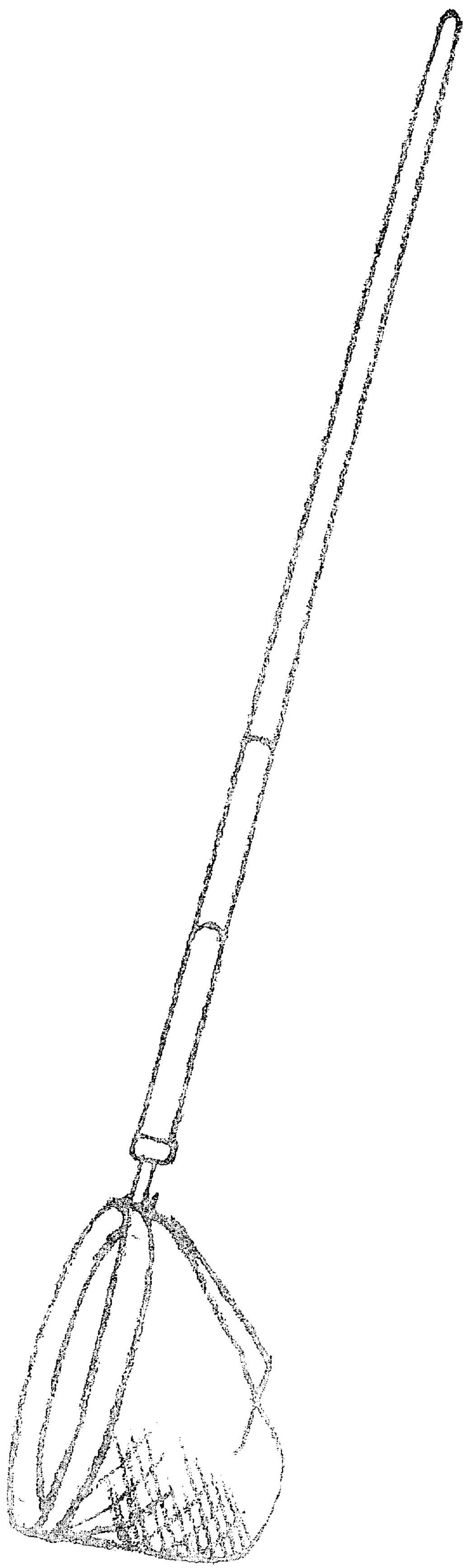
- *Make the data generated through these activities available to other interested agencies.*

Table 9-1 shows the schedule and milestones for the Region IX R-EMAP project.

Table 9-1

MILESTONES AND SCHEDULE

	1992	1993	1994
Complete planning	Oct. - Dec.		
Implement the hexagon frame		January	
Classify and select waterbodies		Feb. - March	
Pilot/logistics/site access		April - June	
Train field crew		June	
Conduct field sampling activities		July - Sept.	
Complete assessment of data		Oct. -Nov.	
Complete interim report		December	
Complete field activity report			January
Select waterbodies for Year 2			February
Conduct field sampling activities			March - May
Complete assessment of data			June - Aug.
Begin field activity report			August
Complete final report			September



TECHNICAL APPROACH

Sampling Design

The Region IX R-EMAP project will focus exclusively on California's Central Valley. The monitoring network will be established by overlaying the national EMAP 12,600 40-km^2 hexagon frame over the California Central Valley. Figure 9-1 illustrates this for an example watershed, the Middle San Joaquin. (Agricultural drains are shown as dotted lines.)

The investigators will then randomly select sampling sites within the hexagons for field monitoring. These sites will be selected to represent all classes of waterbodies highly affected by agricultural land use. During the first year, the investigators will select and sample approximately 80 sites in the Sacramento-San Joaquin Valley. An additional 10 to 20 sites will be selected and sampled to reflect representative agricultural waters throughout the Valley. At each site, measurements will include fish and macroinvertebrate collections, physical habitat assessments, and basic water chemistry analyses. (Macroinvertebrates will be collected using a standard D-frame dip net; fish will be collected using **electrofishing** equipment.)

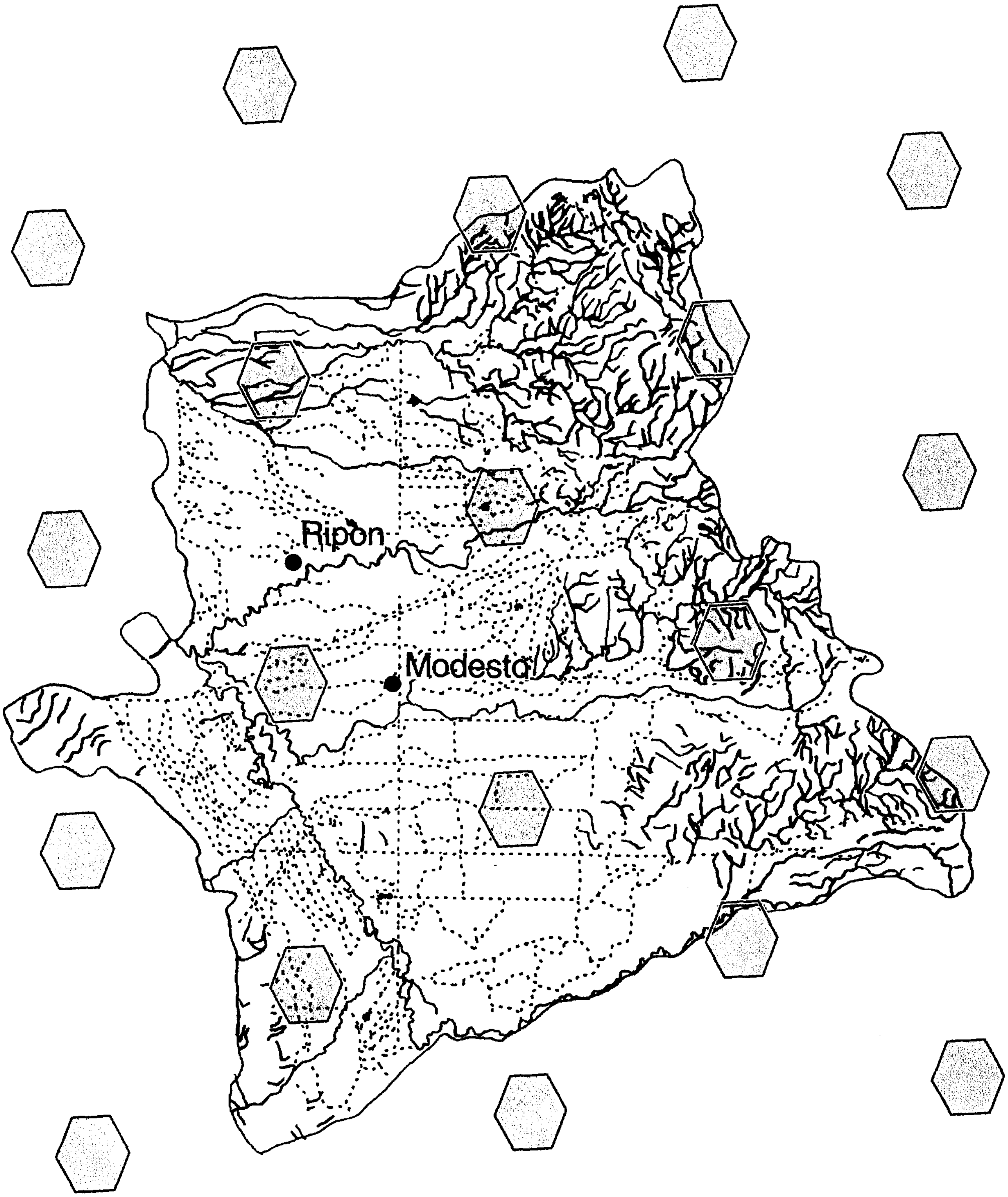
In the project's second year, the field crew will revisit the same sites, one-half during the same index (sampling) period and one-half during a different index period. The researchers will evaluate how the measurements vary between seasons and how the target communities vary between the two sampling years.

Indicators

The Region IX R-EMAP project will use fish and macroinvertebrate assemblages as indicators of response to environmental **stressors.** The study will assess these organisms (number, species, length and weight, and presence of external abnormalities) to determine if they have been affected by chemical, physical, or biological changes in their habitats. The response indicators used in this study will not directly identify the causes of problems originating from certain land-use practices. Rather, they will allow investigators to determine associations between measured indicators and potential stressors. Subsequent studies could investigate further to determine the probable causes of impacts such as contamination from agricultural pesticides, habitat alterations, and nutrient loadings.

Figure 9-1

MONITORING NETWORK FOR THE MIDDLE SAN JOAQUIN



Two nationally recognized indices of biotic integrity, the Rapid Bioassessment Protocol and the Index of Biotic Integrity, were developed using very different streams and communities than those in the Central Valley. This project will determine what modifications to these indices are needed to accurately assess the current condition of aquatic biota in the Central Valley.

The study will use the habitat parameters listed in Table 9-2 (for nontidal coastal plain streams) and Table 9-3 (for reaches where **glides** and pools are prevalent). Water chemistry indicators will include temperature, dissolved oxygen, pH, conductivity, turbidity, and flow.

Agricultural practices might be jeopardizing the health of wildlife and the quality of aquatic ecosystems in California's Central Valley.

STATE OF CALIFORNIA, DEPT. OF WATER RESOURCES

Table 9-2

HABITAT PARAMETERS FOR NONTIDAL COASTAL PLAIN STREAM ASSESSMENT

GENERAL CHARACTERISTICS	
	Channel modification
INSTREAM MEASUREMENTS	
	Instream habitat
	Pool variety
STREAMBANK MEASUREMENTS	
	Bank stability
	Bank vegetative type
	Dominant vegetation
RIPARIAN ZONE MEASUREMENTS	
	Shading
	Riparian vegetative zone width

Table 9-3

HABITAT PARAMETERS FOR REACHES WHERE GLIDES AND POOLS ARE PREVALENT

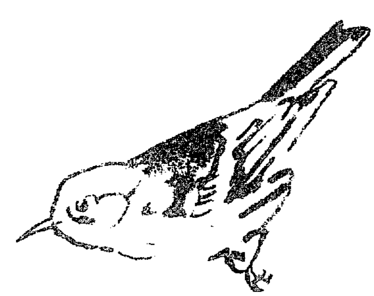
- Bottom substrate/instream cover
- Pool substrate characterization
- Pool variability
- Canopy cover (shading)
- Channel alteration
- Deposition
- Channel sinuosity
- Lower bank channel capacity
- Upper bank stability
- Bank vegetative protection
- Grazing or other disruptive pressure
- Streamside cover
- Riparian vegetative zone width (least buffered side)

Hypotheses

The Region IX R-EMAP project will test the following **hypotheses**:

- *Biotic integrity indices based on fish and macroinvertebrate assemblage data can distinguish satisfactory from unsatisfactory conditions of aquatic ecosystems in the Central Valley.*
- *The current conditions of aquatic biota in the Central Valley, as measured by these biotic indices, show little variation among the waterbodies sampled.*
- ***Multivariate** analysis of the data will delineate subregional groupings of the selected waterbodies.*
- *Biotic conditions, as measured by biotic indices, will differ significantly between agricultural drainage ditches and supply canals.*
- *Conditions of the fish and macroinvertebrates differ according to the following factors:*
  - *Whether the waterbody dries up after the irrigation season.*
  - *Whether the waterbody is an agricultural return ditch or supply canal.*
  - *Whether the water source is in the Sacramento-San Joaquin River Valley delta or the Sierra Nevada mountains.*

The results of this study will help states with irrigated agriculture to assess their agriculture-dominated waterbodies and develop meaningful, realistic water quality standards for agricultural drains. The study will also help meet the need for scientifically supported environmental quality standards to measure the health of these ecosystems.



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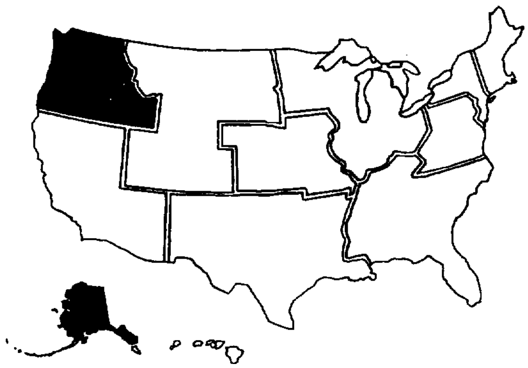
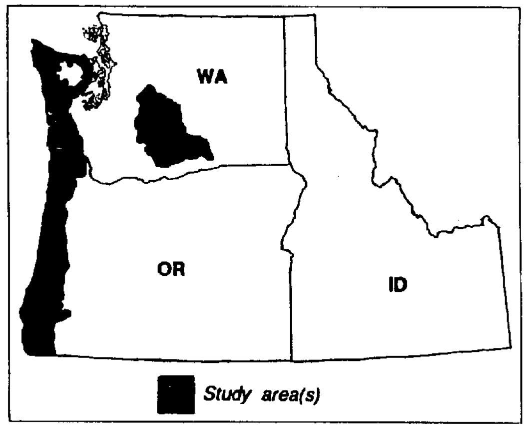


REGION X

BIOLOGICAL ASSESSMENT OF WADABLE STREAMS IN THE COAST RANGE ECOREGION AND THE YAKIMA RIVER BASIN

Many rivers and streams in the Pacific Northwest cannot support beneficial uses, such as salmonid spawning and cold water **biota**, because of **siltation** and other forms of pollution. The problems observed in these streams include elevated temperatures, high fecal coliform and nutrient levels, and altered **habitat** and stream flow. The primary causes of these problems are **nonpoint source pollution** and physical disturbances to **riparian** vegetation and stream banks from adjacent agricultural, forestry, and grazing land uses. The Region X R-EMAP project will characterize the extent and severity of these environmental disturbances to the streams in two areas of the Region: the Coast Range **Ecoregion** and the Yakima River Basin.



STUDY AREA

In 1990, Region X established the Biological Assessment Workgroup, consisting of representatives from EPA Headquarters, Region X, and the Office of Research and Development; the U.S. Forest Service; the U.S. Geological Survey; the U.S. Bureau of Land Management; the U.S. Department of Agriculture, Soil Conservation Service; the U.S. Fish and Wildlife Service; the states of Washington, Oregon, and Idaho; and several universities in the Region. The Workgroup was convened to address the identification and monitoring of water resource problems in the Region.

Words defined in the glossary (page 75) are in bold type the first time they appear in this section.

As part of this effort, the states identified their top geographic priorities for future biological assessments of stream **ecosystems**. Among these priorities were the Coast Range Ecoregion and the Yakima River Basin (Columbia Basin Ecoregion). The Coast Range represents a forested ecosystem, while the Yakima River Basin is in an area used for agriculture, grazing, and forest harvest. These two ecosystems are the focus of the Region X R-EMAP project.

Oregon Department of Environmental Quality conducting macroinvertebrate sampling.

The goals of the Region X project are to:

- *Evaluate the usefulness of applying EMAP indicators and sampling design to Regional and statewide water and other environmental programs.*
- *Assist states in building consistent and accurate programs for biological assessments of stream ecosystems.*
- *Provide the states and Regions with tools for evaluating the success of nonpoint source programs, particularly those addressing agriculture, forestry, and grazing.*
- *Assist the states in developing biological criteria for water quality programs.*

The questions to be addressed regarding the condition of the Coast Range Ecoregion and the Yakima River Basin include:

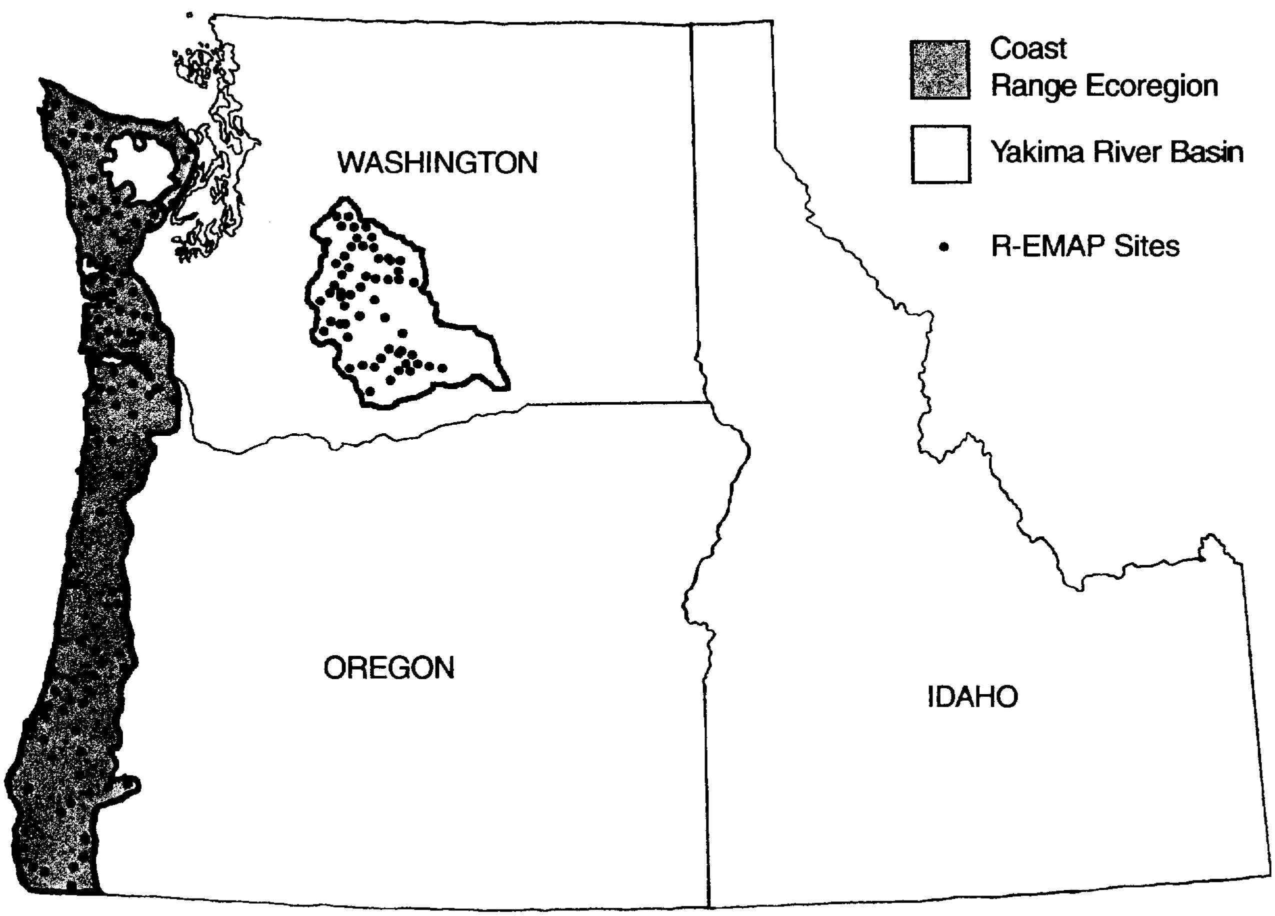
- *What is the status of randomly selected small wadable streams (streams in which sampling can be performed by wading into the water) in the Coast Range Ecoregion and the Yakima River Basin?*
- *How does the status of these randomly selected streams compare to that of* ***reference sites,*** *selected to represent the least affected stream condition?*
- *Is there a direct association between the status of the streams in the study area and the surrounding land uses and land cover?*

The answers to these questions will help the Region and the states focus on priority watersheds and evaluate the effectiveness of programs addressing nonpoint source pollution and habitat alteration (such as **best management practices**, public education, and restoration).

The Region X R-EMAP project is a joint effort by the Region X Environmental Services Division, EPA's Office of Research and Development, the Washington Department of Ecology, and the Oregon Department of Environmental Quality.

Figure 10-1

PROPOSED SAMPLING SITES



ACTIVITIES

To conduct biological assessments of wadable streams, the Region X project will sample randomly selected streams in the Coast Range Ecoregion and the Yakima River Basin. Field measurements will be taken to characterize **macroinvertebrate** and fish **assemblages**, physical habitat, and physical and chemical water parameters. Sampling will take place from July to October in both 1994 and 1995.

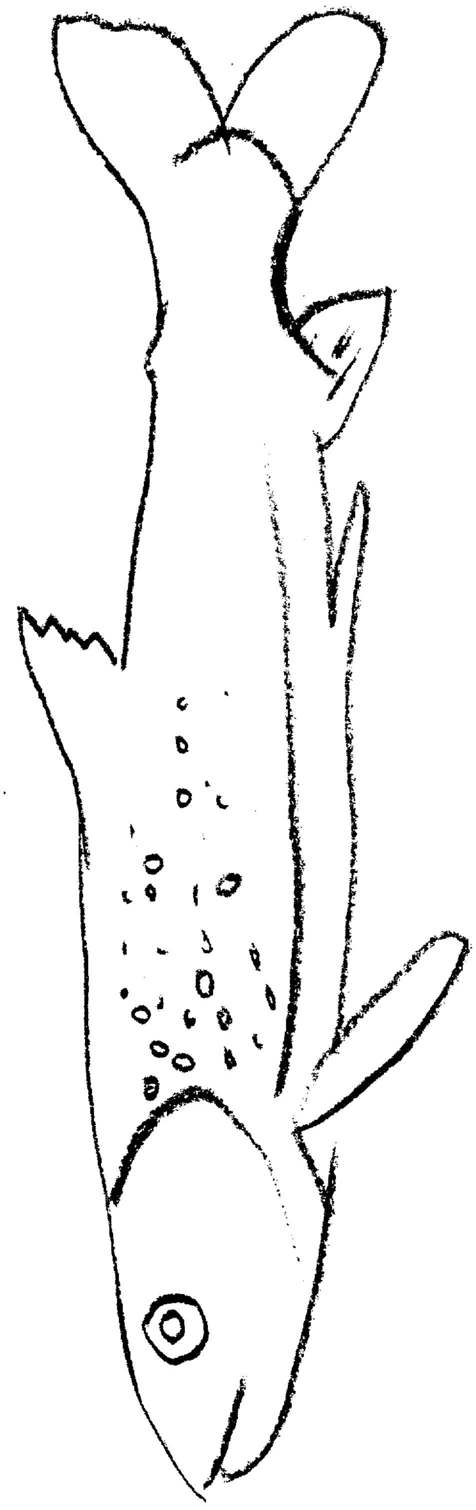
Table 10-1 lists the project milestones and schedule.

Table 10-1

MILESTONES AND SCHEDULE	1993	1994	1995	1996
Quality assurance/quality control plan	April			
Site selection using EMAP grid	June			
Cooperative agreements final	August			
Compile existing landscape information	September			
Region X Environmental Services Division (ESD) pilot to ensure state method comparability	October			
Region X ESD pilot data compilation and reporting	December			
Site reconnaissance and access approvals	December			
Method refinement and adjustment after pilot		March		
Year 1 chemical, physical, and biological sampling		October		
Method refinement and adjustment after Year 1			February	
Year 2 site selection using EMAP grid			March	
Year 1 data compilation and reporting			May	
Year 1 interim report to EPA from states			May	
Site reconnaissance and access approvals			June	
Year 1 final report			September	
Year 2 chemical, physical, and biological sampling			October	
Year 2 data compilation and reporting				February
Year 2 interim report to EPA from states				May
Final report of entire project				August

TECHNICAL APPROACH

To randomly select sampling sites, Region X will use the EMAP-Surface Waters protocols developed for the EMAP mid-Appalachian pilot study. In the first year of the project, the Washington Department of Ecology will sample approximately 20 randomly selected streams in the Yakima River Basin (Figure 10-1). In addition, at least 60 streams in the Coast Range Ecoregion will be randomly selected and sampled by the Oregon Department of Environmental Quality and the Washington Department of Ecology. Any additional sampling sites will be chosen based on the needs of state and Regional management. All the streams sampled will be small wadable streams. The same sampling strategy will be followed in the second year of the project.

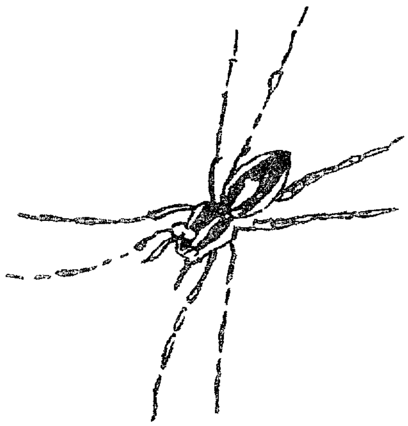


Macroinvertebrate Assemblages

To collect representative samples of macroinvertebrates from the study streams, the field crew will randomly select four 0.18-square-meter (2-square-foot) areas at each **riffle** site. The field crew will take four "kick samples" at these locations by disturbing a 30- to 60-centimeter area of the stream bottom with the feet and collecting the sample with a D-frame, fine-mesh net. They will then combine the four samples to compose a single macroinvertebrate sample for each riffle site. The laboratory will identify, count, and measure the macroinvertebrates present in each sample. The investigators will consider refinements to the macroinvertebrate sampling method, based on the results of the EMAP Surface Water Pilot Study conducted in Oregon in summer 1993.

Fish Assemblages

The field crew will collect fish using **electrofishing equipment**. The fish will be identified, counted, and measured, and then returned to the stream. Field measurements will be taken in a randomly selected portion of the stream, a minimum of 100 meters to a maximum of 300 meters in length, depending on stream size.



Physical Habitat

At each site, field workers will measure 11 parameters pertaining to the physical habitat of the stream (Table 10-2). An additional parameter, successional stage (type of plant communities present), will be measured at forested sites. Both a qualitative and a quantitative approach will be used to assess the parameters. The quantitative measurements allow the investigators to compare the habitat quality across the sampling sites. The qualitative information provides supplemental information useful for characterizing the sites. The investigators will consider additions to or refinements of the existing habitat parameters based on the outcome of the EMAP Surface Water Pilot Study conducted in Oregon.

Table 10-2

PARAMETERS AND MEASUREMENT APPROACHES FOR ASSESSING PHYSICAL HABITAT

Parameter	Explanation	Qualitative Approach	Quantitative Approach
Channel shape and landmarks	Physical layout and characteristics of the stream	•	
Vegetative patterns	Type and density of the surrounding vegetation	•	
Flow direction	Direction of stream flow	•	
Riffles and pools	Occurrence and characteristics of riffles and pools	•	
Residual pool depth	Depth and characteristics of residual pools. Pool depth can be affected by surrounding land uses and will be measured as an indicator of fish habitat	•	•
Macroinvertebrate sampling areas	Depth and characteristics of the macroinvertebrate sampling areas	•	
Large woody debris	Amount, size, and characteristics of the large woody debris (single logs, log jams, stumps, root wads, and beaver dams) along the stream bank at the seasonal high water level	•	•
Erosion and deposition	Severity and characteristics of erosion and deposition areas	•	
Canopy closure	Sky area containing vegetation	•	
Substrate embeddedness	Measure of how deep boulders and cobbles are embedded into the fine sediment of the stream bottom		•
Solar energy input	Direct stream insolation	•	

Physical and Chemical Water Quality Parameters

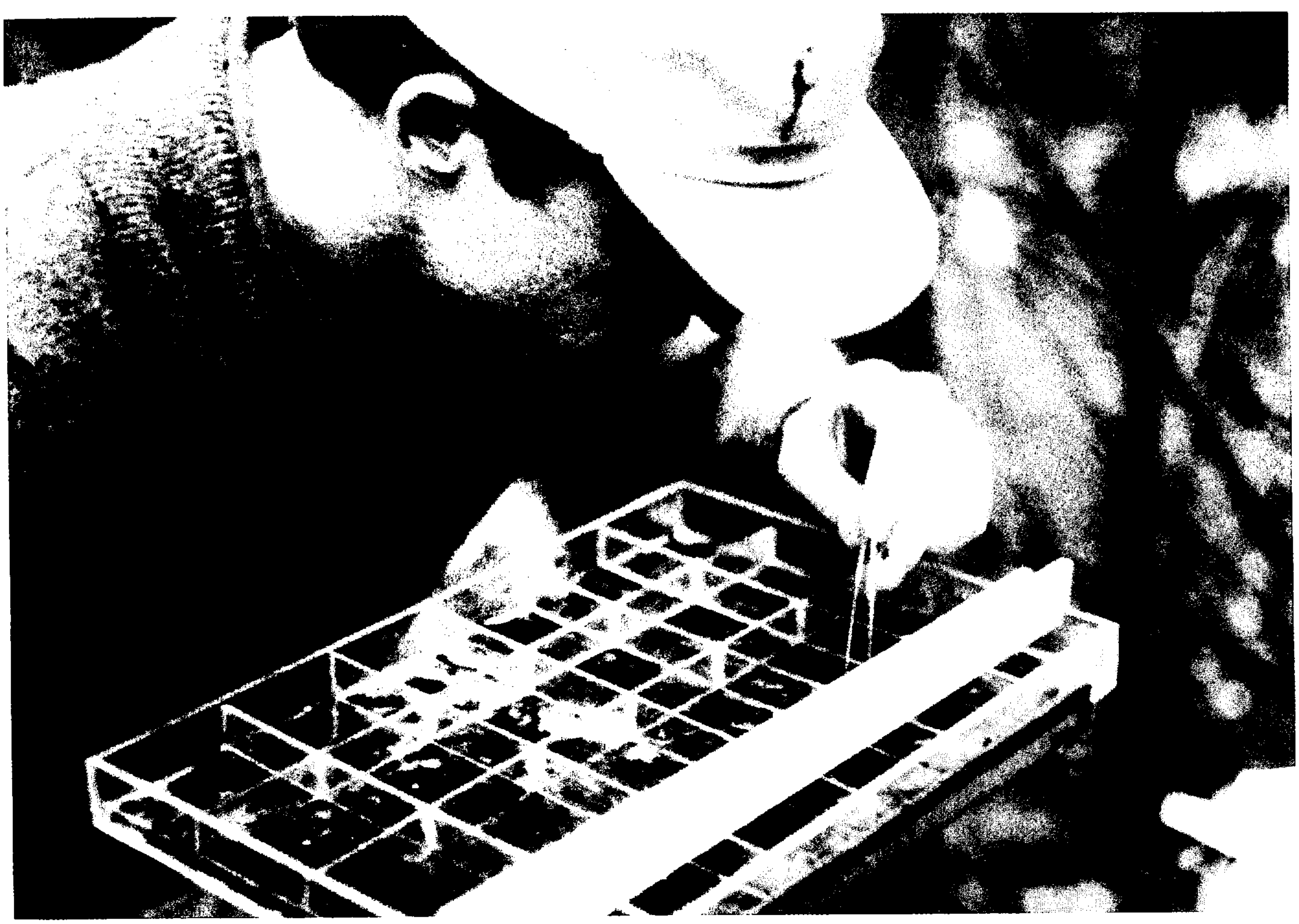
For each sampling area, several physical and chemical water quality parameters (listed in Table 10-3) will be measured. The field crew will record data on conductivity, pH, temperature, dissolved oxygen, high water mark, stream flow, and stream gradient. Each state laboratory will analyze the remaining parameters. The states will use comparable sampling and analysis protocols and **quality assurance/quality control** procedures to ensure consistency.

Table 10-3

WATER QUALITY PARAMETERS TO BE MEASURED

Temperature
Dissolved oxygen
Conductivity
pH
High water mark
Stream flow
Stream gradient
Alkalinity (as $CaCO_3$)
Ammonia (as nitrogen)
Biochemical oxygen demand
Orthophosphate (as phosphorus)
Nitrate and nitrite (as nitrogen)
Total suspended solids
Turbidity

Oregon Department of Environmental Quality staff subsampling macroinvertebrates.



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GLOSSARY

Anion An ion (atom or group of atoms) with a negative electrical charge, such as nitrate or chlorine.

Assemblage A group of organisms sharing a microhabitat.

Benthic/Benthos Relating to or occurring in or on the bottom layer of a body of water.

Benthic macroinvertebrates Organisms such as marine worms, sea cucumbers, crustaceans, clams, and roundworms; commonly used as **indicators** due to their direct interaction with **sediments** and their sensitivity to organic enrichment and chemical contamination.

Best management practices (BMPs) A management activity or engineered structure, or combination of these, that eliminates or reduces an adverse environmental effect of a pollutant. Examples of BMPs include minimal pesticide application, careful monitoring of hazardous material storage, and erosion and sedimentation controls.

Bias In statistics, the systematic error or persistent distortion of a measurement process which deprives the result of representativeness (that is, the expected sample measurement is different than the sample's true value).

Bioassay A laboratory or field test in which living organisms are used to detect the presence of or test the effect of a particular substance, factor, or condition.

Bioaccumulation Increased concentration of a substance in living organisms as they take in contaminated air, water, or food; the concentration increases because the substance is very slowly metabolized or excreted.

Biocriteria Threshold levels or guidelines that describe the desired biological integrity of aquatic communities of surface waters.

Biomagnification The process by which certain pollutants become increasingly concentrated in living organisms as the pollutants are passed up the food chain.

Biomarker — Biochemical, physiological, or histological (relating to the microscopic structure of tissues) **indicators** of either exposure to or effects of xenobiotic chemicals (chemicals that do not occur naturally in the environment) at the organism or suborganismal level.

Biomass — All of the living material in a given area; often refers to vegetation.

Biota — The animal and plant life of a given region.

Biotic — Of or pertaining to living organisms.

Cation — An ion (atom or group of atoms) with a positive electrical charge, such as sodium or calcium.

Conductivity — Ability to carry heat or electricity.

Correlation — A valid statistical association between two variables; correlation does not in itself imply a causal relationship.

Cyprinid — Any of the carp family or a related family.

Ecological risk assessment — A process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of one or more **stressors.**

Ecoregions — Regions of relative homogeneity in ecological systems or in relationships between organisms and their environment. Scientists have divided the United States into 78 ecoregions by interpreting regional patterns in land-surface form, soil, potential natural vegetation, and land use.

Ecosystem — The interacting system of a biological community and its non-living environmental surroundings.

Electrofishing (electroshocking) — A fish collection method that uses a device to stun fish with an electric current.

Embeddedness — The degree to which boulders, rubble, or gravel are surrounded by fine **sediment**. Indicates the suitability of the stream **substrate** as **habitat** for **benthic macroinvertebrates** and for fish spawning and egg incubation.

Estuary — A region of interaction between a river and nearshore ocean waters, where tidal action and river flow mix fresh and salt water. Such areas include bays, mouths of rivers, salt marshes, and lagoons. These brackish water **ecosystems** shelter and feed marine life, birds, and wildlife.

Eutrophication — A condition in which an overload of microbial activity causes depleted-oxygen conditions.

Evapotranspiration — The loss of water from soil both by evaporation and by loss of water vapor from plants growing in the soil.

Fishery — A permanent body of water with sufficient volume or flow characteristics to sustain a group of fish on a perennial basis.

Fluvial geomorphology — The shape and topographic features of rivers and streams.

Geographic information systems (GIS) — A collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display geographically referenced data.

Glide — A calm stretch of shallow, smoothly flowing water.

Habitat — The place where a **population** (e.g., human, animal, plant, microorganism) lives and its surroundings, both living and non-living.

Headwater — The upper tributary of a river or stream.

Hydrology — The study of surface and subsurface water.

Hypothesis — A proposition set forth as an explanation for the occurrence of some specified group of phenomena. In hypothesis testing, the statement is either proven or disproven by new evidence gathered in a study.

Index (Indices) — A mathematical aggregation of **indicators** or **metrics**.

Index period — The period of the year when measurement of an **indicator** yields meaningful information.

Indicator — A characteristic of the environment, either **biotic** or abiotic, that can provide quantitative information on the condition of ecological resources.

Insolation	The radiation from the sun received by a surface.
Intolerant species	A species that is sensitive to pollution.
Lipids	Any of the group of organic compounds consisting of the fats and other substances with similar properties.
Littoral	Of or pertaining to a shore.
Metrics	Numerical values that represent species composition or other quantitative community parameters.
Macroinvertebrates	See **benthic macroinvertebrates.**
Morphology	Form and structure.
Multimedia	Pertaining to more than one environmental medium (air, soil, water).
Multimetric	Pertaining to more than one **metric**.
Multivariate	In statistics, having more than one variable.
Necrosis	Death or decay of tissue.
Nonpoint source pollution	Contamination that is diffuse and does not have a single point of origin or is not introduced into the environment from a specific outlet. Pollutants are generally carried off the land by stormwater runoff. Nonpoint sources can include agriculture, forestry, mining, urban sources, construction, dams and channels, land disposal, and saltwater intrusion.
Oligotrophic	Low in nutrients and microbial activity.
Omnivore	An organism that feeds relatively equally on plants and animals.
Operculum	The bony covering protecting the gills of fishes.
Periphyton	Organisms that live attached to underwater surfaces.
Physiographical	Pertaining to physical geography.

Pilot study A research activity that requires field work to meet a stated quality objective. Pilot studies do not provide preliminary estimation of resource condition, but are used to evaluate **indicators**, sampling strategy, methods, and logistics.

Piscivores Organisms (such as many aquatic birds) that feed or subsist on fish.

Point source A stationary location or fixed facility from which pollutants are discharged or emitted; any single identifiable source of pollution, such as a pipe or smokestack.

Population In statistics and sampling design, the total universe addressed in a sampling effort (e.g., all lakes of a certain size within the study area); an assemblage of units of a particular resource or any subset of extensive resources about which inferences are desired or made. In biology, a group of interbreeding organisms occupying a particular space.

Predator A species that preys on other species, usually for food.

Preopercle The foremost **opercular** bone.

Probability The likelihood of occurrence of a specific event. EMAP uses probability-based sampling of explicitly defined ecological resource **populations**. This enables resources to be sampled in proportion to their occurrence, providing, with known confidence, statistical estimates of status, extent, changes, and trends.

Probability sample A sample chosen in such a manner that the probabilities of including the selected units in the sample are known, and all entities that make up a target **population** have an equal probability of selection.

Quality assurance/quality control (QA/QC) A system of procedures, checks, audits, and corrective actions to ensure that all research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of known and highest achievable quality.

Randomization The process of imposing an element of chance on the selection of a sample.

Reference condition The set of attributes of ecological resources that assist in identifying where a portion of the resource **population** is located along a continuum from the worst possible condition to the best possible condition, given the prevailing topography, soil, geology, potential vegetation, and general land use of the region.

Reference site One of a **population** of benchmark or control sampling locations that, taken collectively, represent an **ecoregion** or other large biogeographic area; the sites, as a whole, represent the best ecological conditions that can be reasonably attained, given the prevailing topography, soil, geology, potential vegetation, and general land use of the region.

Regression In statistics, techniques that describe the relationship between two or more sets of measurements and use data from one or more sets to predict, or estimate, another set of data.

Remote sensing The collection and interpretation of information about an object without physical contact with the object (for example, satellite imaging and aerial photography).

Riffle A section of stream channel characterized at low flow by fast, shallow flow.

Riparian Situated on the banks of a river.

Sediment Solid particles that settle to the bottom of a body of water.

Seining Using a large net to catch fish; the net is buoyed along the top and weighted along the bottom so as to float perpendicularly.

Siltation The process by which earthen materials composed of fine particles become suspended in or deposited by water.

Stratification The division of a target **population** into subsets or strata which are internally more homogeneous with respect to the characteristic to be studied than the population as a whole.

Stream reach The straight course of a stream between two bends.

Stressor Any physical, chemical, or biological entity that can induce an adverse response.

Substrate — Underlying material; in a river or stream, substrate materials may include rock, gravel, tree roots, and submerged or emergent vegetation.

Trophic state/level — Classification of taxa within a community that is based on feeding relationships (if aquatic and terrestrial green plants constitute the first trophic level, the herbivores feeding on them constitute the second trophic level).

Water column — The depth of water in any waterbody measured from the surface to the bottom **sediments**.

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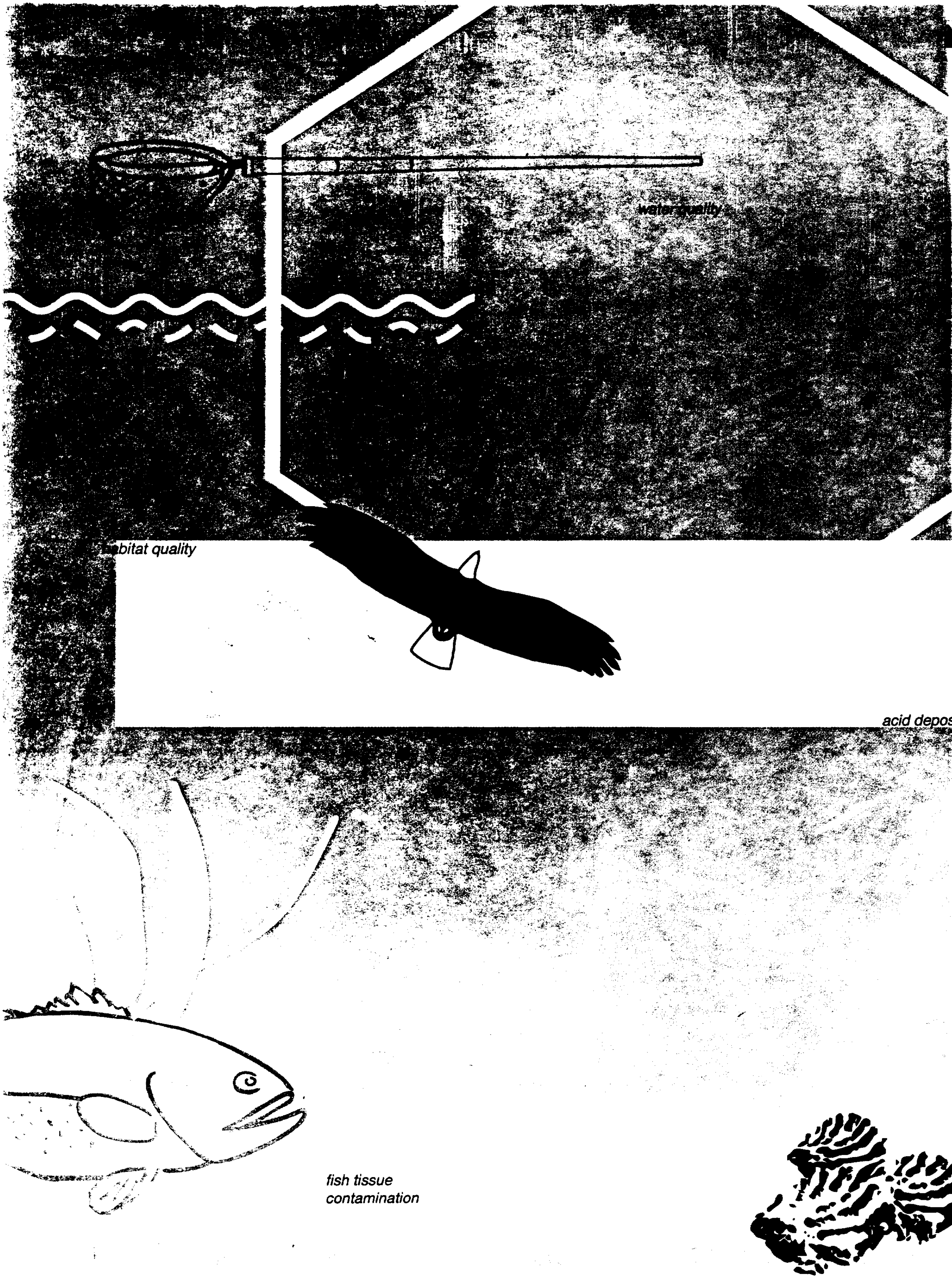
water quality
abitat quality
acid depos
fish tissue
contamination