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EPA

FEASIBILITY REPORT ON ENVIRONMENTAL INDICATORS FOR SURFACE WATER PROGRAMS

EXECUTIVE SUMMARY

CONTENTS

ACKNOWLEDGEMENTS

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ACRONYMS

BIOS	A component of STORET which stores biological data
BMAN	Benthic Macroinvertebrate Ambient Network
BOD	Biochemical Oxygen Demand
BSC	Biological Stream Classification system
CWA	Clean Water Act
DDT	Dichloro-Diphenyl-Trichloro-ethane
DMR	Discharge Monitoring Report
EDS	Effluent Data Statistics
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
EPT	total number of Ephemeroptera, Plecoptera and Trichoptera in a sample
FDA	Food and Drug Administration
FWS	Fish and Wildlife Service
GAO	Government Accounting Office
GIS	Geographic Information System
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
IWB	Index of Well-Being
MBI	Macroinvertebrate Biotic Index
NASQAN	National Stream Quality Monitoring Network
NAWQA	National Water Quality Assessment program
NCBP	National Contaminant Biomonitoring Program
NCC	National Computer Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSSP	National Shellfish Sanitation Program
NST	National Status and Trends program
OPPE	Office of Policy, Planning and Evaluation
ORD	Office of Research and Development
OW	Office of Water
OWRS	Office of Water Regulations and Standards
PAHs	Polycyclic Aromatic Hydrocarbons
PC	Personal Computer

ACRONYMS (Continued)

PCBs	Polychlorinated Biphenyls
PCS	Permit Compliance System database
PIBI	Potential Index of Biotic Integrity
POTW	Publicly Owned Wastewater Treatment plants
RTI	Research Triangle Institute
SIC	Standard Industrial Classification
STORET	STOrage and RETrieval (EPA's computerized water data base)
STPs	Sewage Treatment Plants
TBS	Temple, Barker & Sloane, Inc.
TOC	Total Organic Carbon
TOXNET	TOXicology data NETwork
TRI	Toxic Release Inventory
TSI	Trophic Status Index
TSS	Total Suspended Solids
USGS	United States Geological Survey
WBS	Waterbody System
WQI	Water Quality Index

I. INTRODUCTION

This executive summary presents the results of a study on the feasibility of six measures identified as potential environmental indicators of the quality of the nation's surface waters. The complete feasibility report is available from the Environmental Results Branch, EPA Headquarters (phone FTS/(202) 382-4900). It provides more background information about the project, discusses each indicator in more detail, and contains additional graphical presentations of the indicators.

The feasibility analysis is the second portion of a three-phase project jointly managed by the Office of Water Regulations and Standards (OWRS) and the Office of Policy, Planning and Evaluation (OPPE) at EPA. The first phase consisted of identifying and describing a series of potential indicators for freshwater, estuarine and coastal environmental quality, and holding a workshop of federal and State personnel to review, revise and narrow down the candidate indicator list. Three reports were completed in Phase One: Resource Document for the Workshop on Environmental Indicators for the Surface Water Program (March 28-29, 1989), Workshop on Environmental Indicators for the Surface Water Program (March 28-29, 1989), and Results: Workshop on Environmental Indicators for the Surface Water Program (July 1989). In the second phase, contractors and EPA personnel assessed the feasibility of reporting on the set of indicators selected at the workshop. These were selected as most meaningful and practical for one or more of the following purposes: status and trend reporting; overall water program evaluation, and evaluation of the effectiveness of individual program components (e.g., point source regulation, or toxic chemical controls). The present report addresses questions relating to data availability, the degree to which the proposed measures meet the criteria of a "good" indicator, and which of the possible "uses", described further below, is met by the measure. In the third phase of the project, EPA and State personnel will develop options and recommendations for specific applications of the indicators by States, Regions, or EPA Headquarters.

The use of environmental indicators is becoming an increasingly important evaluation tool for federal and State environmental programs (Figure I-1). Carefully chosen indicators of surface water quality can help answer two fundamental questions:

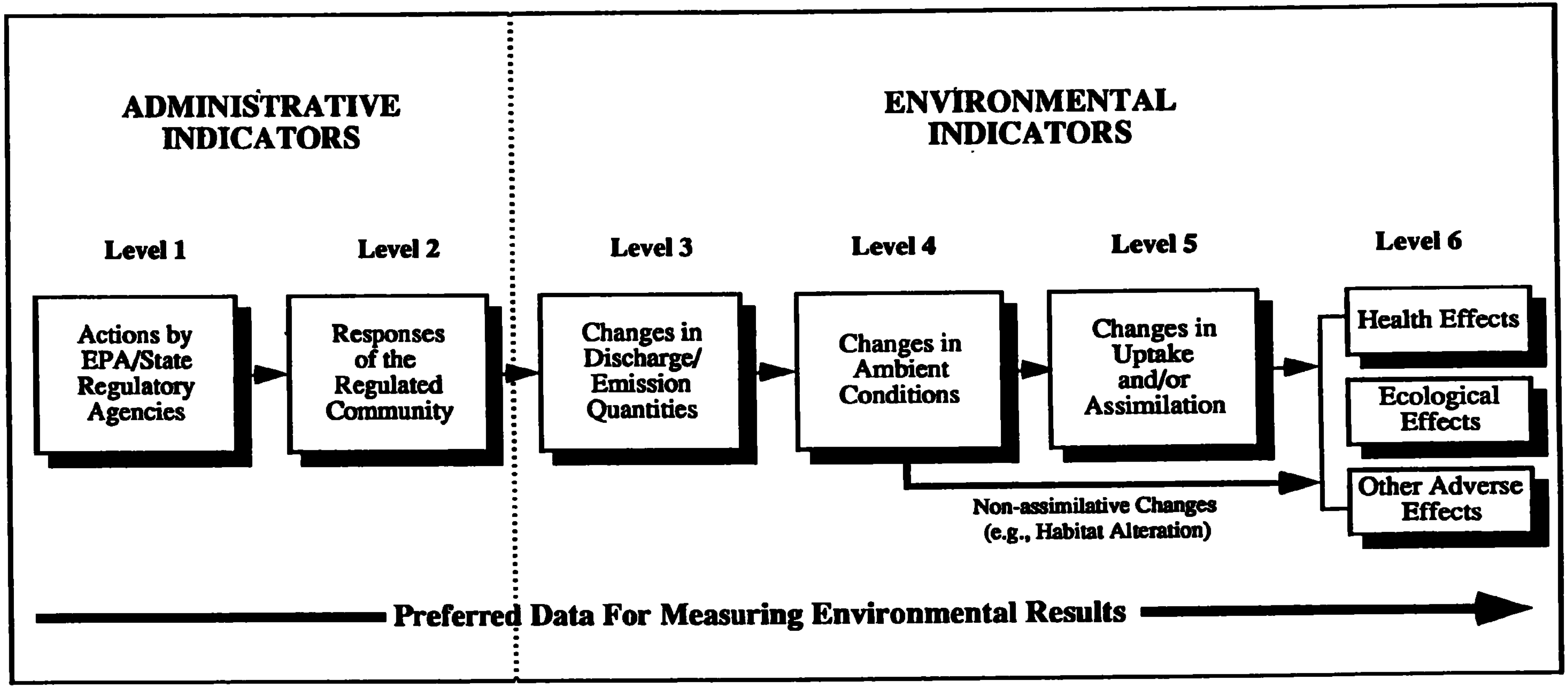
- What is the quality of surface waters, and
- How are we doing in our efforts to improve it?

Environmental managers at EPA and elsewhere can use indicators for several specific purposes related to these general questions, including:

- Identifying trends over time and space;
- Evaluating program effectiveness;
- Targeting resources to areas with greatest environmental impact;
- Targeting resources to areas of potential or developing problems; and
- Communicating results to the public and legislators.

Figure I-1

Continuum of Indicators



The six environmental indicators analyzed in this report are:

- designated use support and attainment of "fishable/swimmable" goals
- shellfish harvest area classifications
- trophic status of lakes
- toxics in fish and shellfish
- biological community measures and
- pollutant loading from point sources.

The following six chapters are devoted to each of these indicators. Strengths, weaknesses and possible improvements for each indicator are contained at the beginning of each chapter and summarized at the end of the report. Evaluation criteria used in the feasibility analysis included data availability, data consistency/comparability, spatial and temporal representativeness of data, utility in trend assessment, relationship to ultimate impact, scientific defensibility, sensitivity to change, relationship to risk, cost of data collection and analysis, relationship to existing programs and presentation value. Selected graphical examples from the full report are included in each chapter to demonstrate the presentation value of each indicator. Conclusions and recommendations from the study are listed at the end of the report.

II. DESIGNATED USE SUPPORT AND ATTAINMENT OF "FISHABLE/SWIMMABLE" GOALS

SUMMARY

Description of the Indicator

This indicator uses information provided by the States to EPA on the status of their waterbodies. The information, included in reports required under section 305(b) of the Clean Water Act (CWA), describes to what degree individual waterbodies are meeting their designated uses. State and local governments assign designated uses to waterbodies and determine the criteria by which they will be evaluated as part of their water quality standards.

States also report to EPA on the extent to which their waters meet the "fishable and swimmable" goals of the CWA. This differs from designated use support in the types of information each State considers adequate to allow a determination (e.g. monitored versus professional judgement).

Possible Applications

The State data are currently used in the development of a national assessment of water quality. This is the States' and EPA's primary vehicle for informing Congress of the state of the nation's waters. At the March 1989 workshop on developing surface water indicators, the workgroup on status and trends recommended that "designated use support" be used as a "high visibility" indicator to generate attention and solicit questions about the underlying results.

Strengths	National data collection and reporting system is already in place and used by all States (Recently Computerized). "Fishable/Swimmable" reporting provides information on goals of primary interest to the public and is easily understood by general public.
Weaknesses	Since State reporting is inconsistent and not standardized, measures cannot be used to evaluate trends. Within a State, inconsistencies exist from one reporting cycle to the next.
Possible Improvements	Increase use of the Waterbody System to allow EPA to aggregate results; Increase use of reach numbers or other geographic identifiers to facilitate trend assessments; Increase systematic ambient monitoring by States (e.g. returning to certain subsets of waters regularly to establish trends).

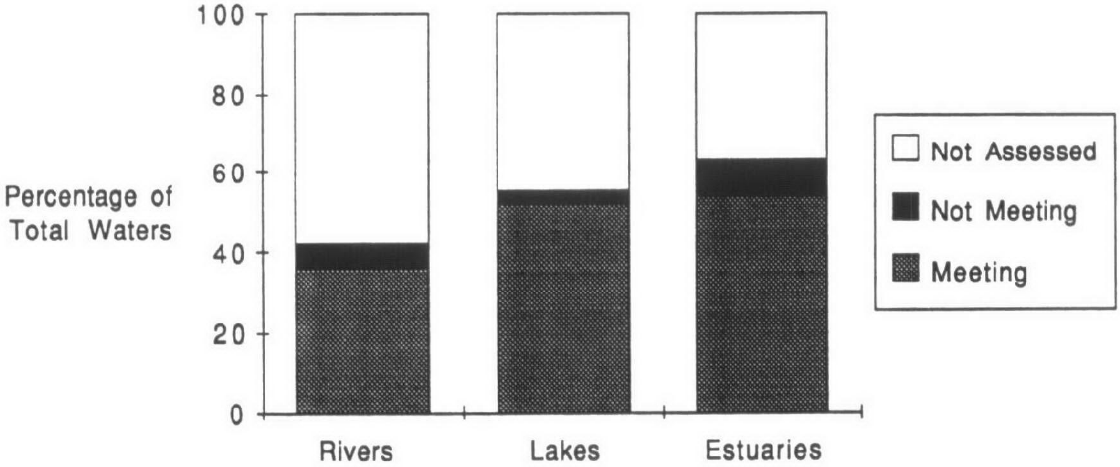
EVALUATION CRITERIA

Data availability	**Good**-States currently collect information on a biennial basis and report it to EPA through the 305(b)reports.
Data consistency/comparability	**Poor**-No consistent basis for monitoring sampling design from State to State and water quality standards vary.
Spatial representativeness	**Fair/Poor**-Although the same waters are not assessed from one cycle to the next, the identified bodies are representative of those types of waters within a State.
Temporal representativeness	**Fair/Poor**-It is primarily based on physical-chemical data which are transient.
Utility in trend assessment	**Poor**-Since the same waters are not assessed from one cycle to the next, it is impossible to determine trends. Waterbodies can be reported as evaluated, meaning the data from the last cycle is sometimes just repeated in the next report.
Relation to ultimate impact	**Good**-For Fishable/Swimmable since the degree to which these goals are met is the ultimate impact. **Fair**-For designated use since the exact impact of the chemical/physical data are not known; Better if biological community data are included in the use attainment determination.
Scientific defensibility	**Fair/Poor**-Methodologies vary from State to State, therefore, the degree to which designated use and fishable/swimmable determinations are defensible as true measures of water quality is also variable.
Sensitivity to change	**Poor**-Categories are too broad to detect incremental changes.
Relationship to risk	**Fair/Poor**-The relationship is tenuous for both ecological and human health risks. The link from chemical/physical to actual environmental damage is ill-defined. Changes in fishable/swimmable do relate to potential human health risk, but the connection with designated use is less strong.
Cost to collect and analyze data	**Low**-States already engaged in data collection; Improved collecting/reporting would require incremental cost increases.

EVALUATION CRITERIA

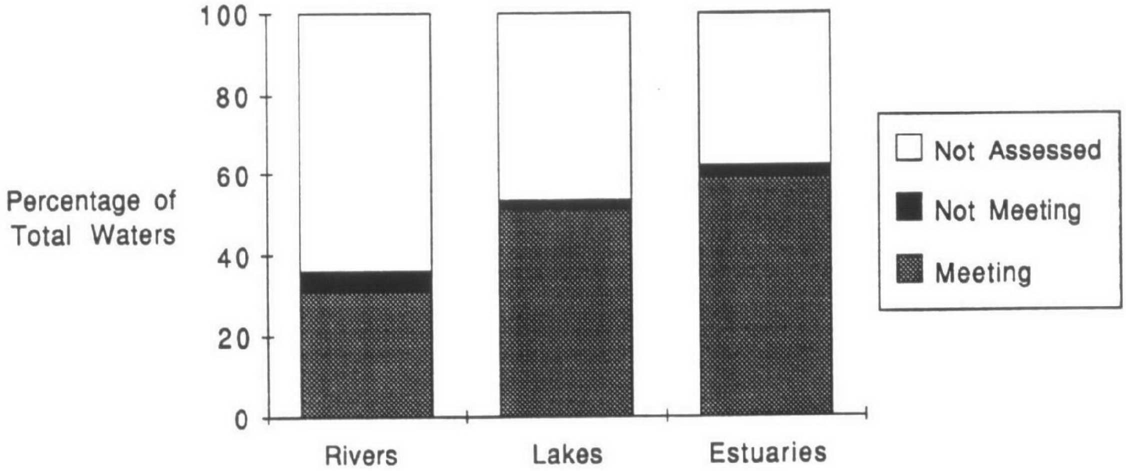
Relationship to existing programs	**Good**-Required as part of 305(b) CWA requirements.
Presentation value	**Good**-Fairly easily understood by the general public; Can be presented using maps and graphs.

Figure II-1
Nationwide Summary of CWA Fishable Goal 1988



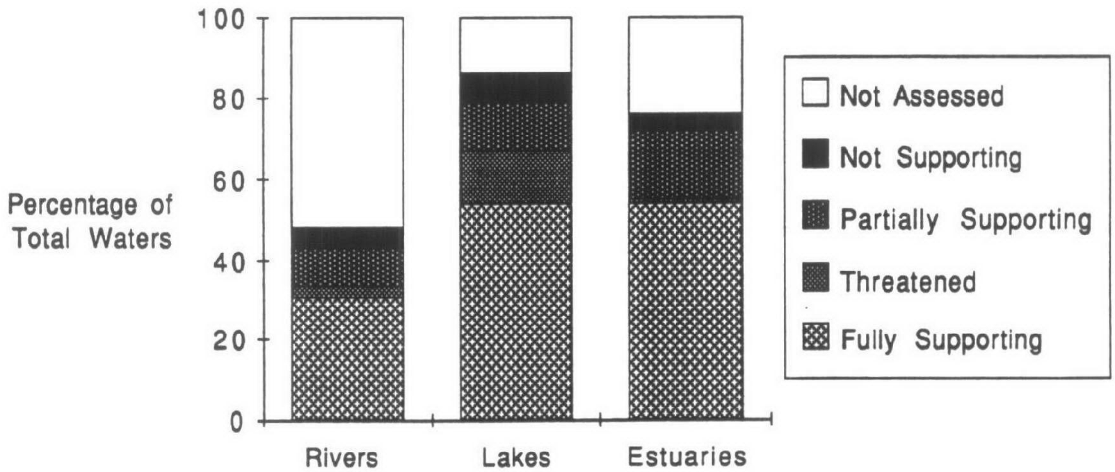
Source: 1988 305(b) Reports

Figure II-2
Nationwide Summary of CWA Swimmable Goal 1988



Source: 1988 305(b) Reports

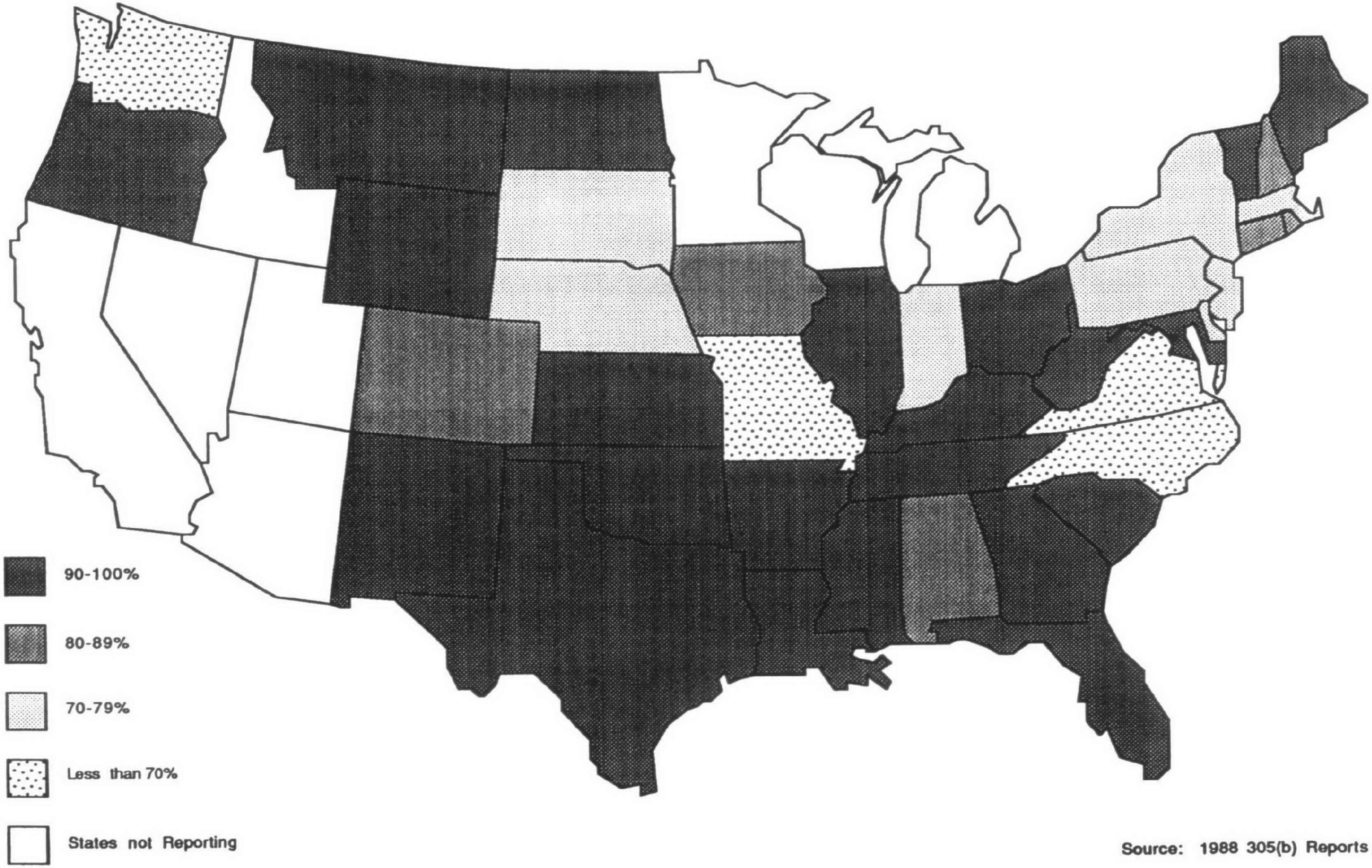
Figure II-3
Nationwide Designated Use Support 1988



Source: 1988 305(b) Reports

Figure II-5

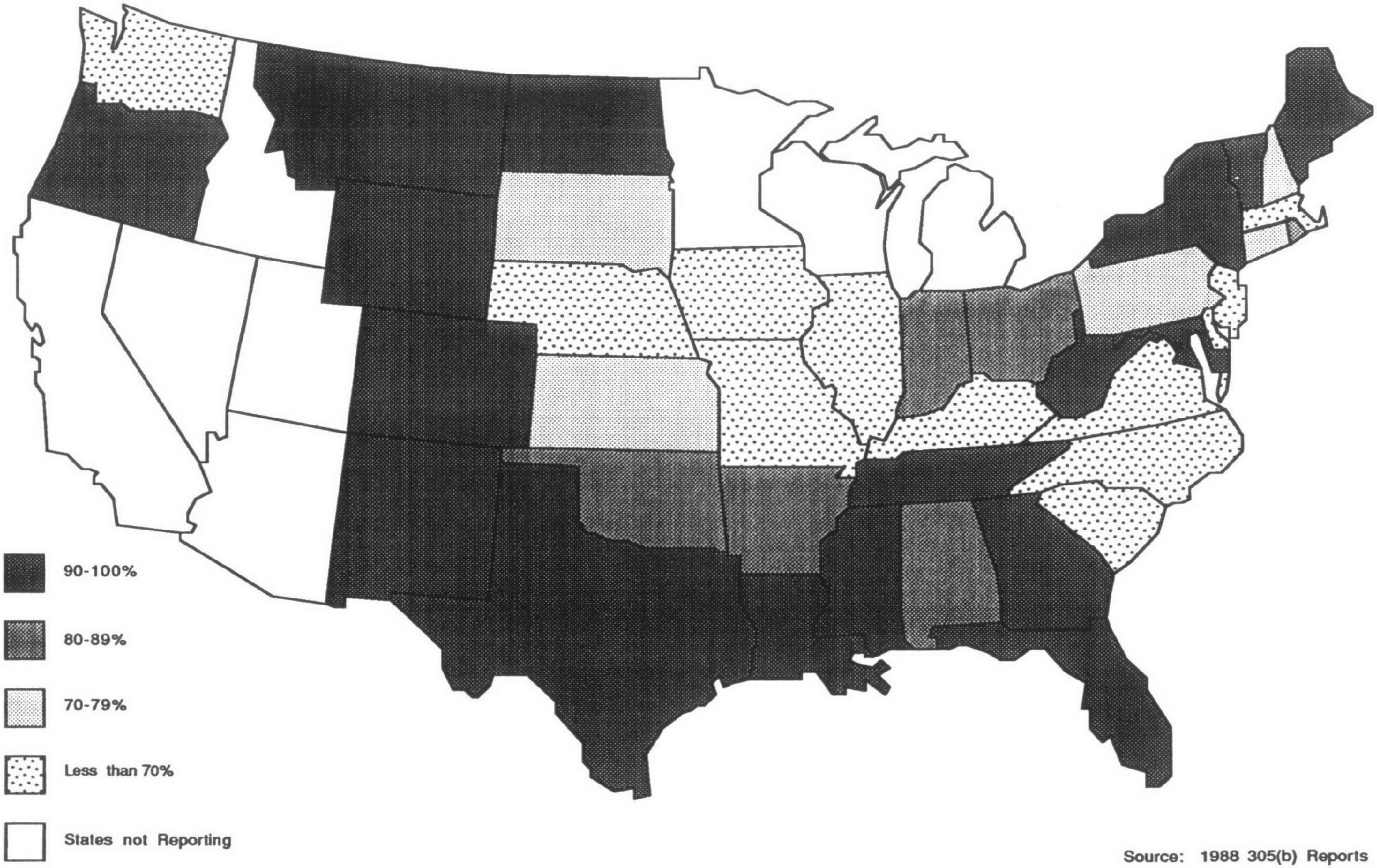
Percentage of Assessed River Miles Per State Meeting CWA Fishable Goal in 1988



Source: 1988 305(b) Reports

Figure II-6

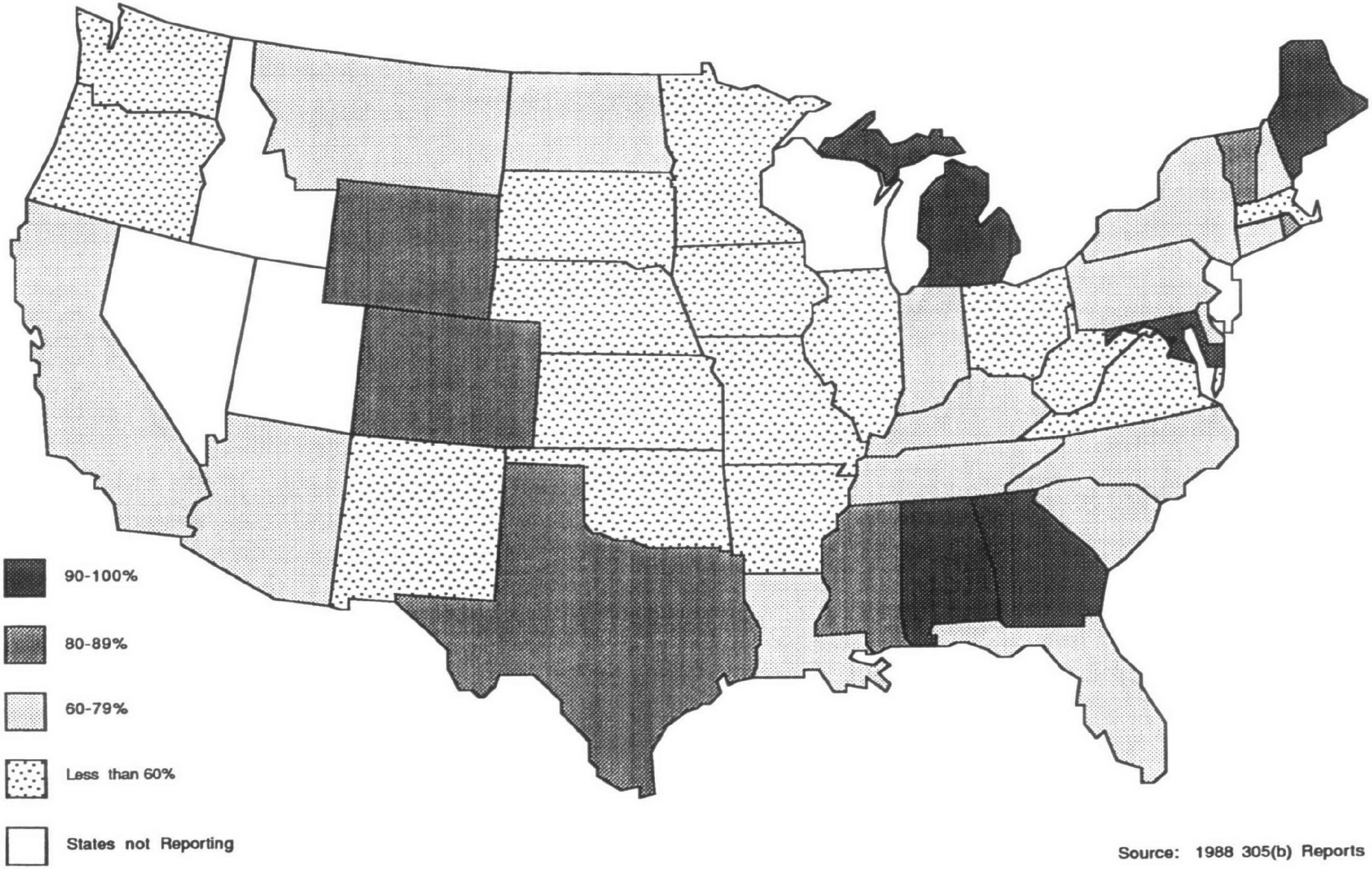
Percentage of Assessed River Miles Per State Meeting CWA Swimmable Goal in 1988



Source: 1988 305(b) Reports

Figure II-7

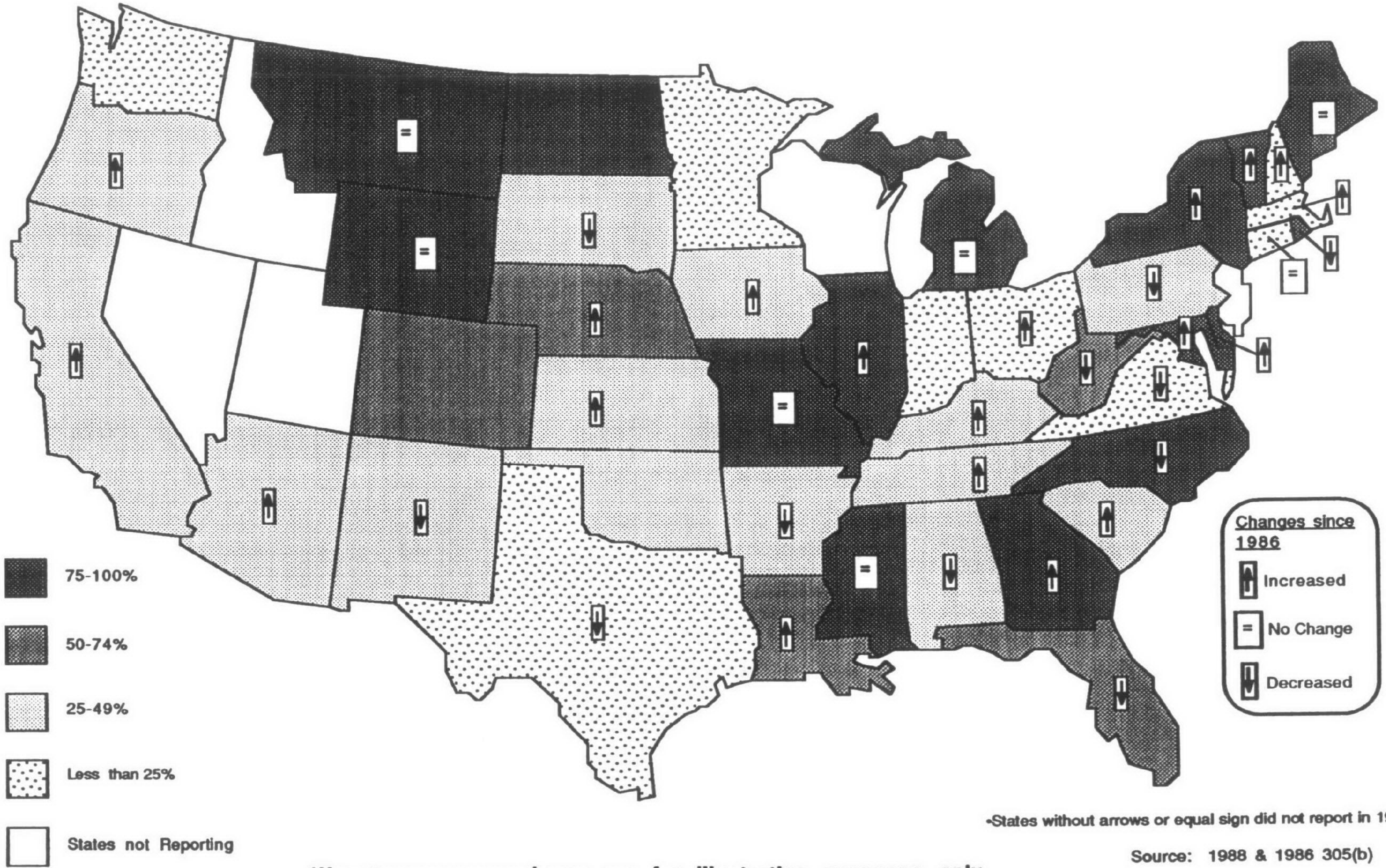
Percentage of Assessed River Miles Per State Fully Supporting Designated Use in 1988



Source: 1988 305(b) Reports

Figure II-8

Percentage of Total River Miles Assessed Per State in 1988*



•States without arrows or equal sign did not report in 1986

*Year-to-year comparisons are for illustrative purposes only.

Source: 1988 & 1986 305(b) Reports

III. SHELLFISH HARVEST AREA CLASSIFICATIONS

SUMMARY

Description of the Indicator

The indicator identifies potential contamination of coastal waters by investigating the degree to which State governments close off or limit access to shellfish harvesting areas. The State agencies classify different areas based on water quality monitoring (not shellfish tissue monitoring). The resulting information constitutes one of the nations largest consistently collected water quality data bases. States report this information to NOAA as part of the National Shellfish Sanitation Program (NSSP), which provides well-defined guidelines to the States. States do, however, vary in their interpretation of the guidelines. This measure is one of five indicators chosen by NOAA in its state of the marine environment report.

Possible Applications

Shellfish harvest areas are the most commonly monitored feature of coastal waters and data are readily available. On both a nationwide and regional level, data provide a good indication of the general status of marine waters and, with continued improvements, can be used to assess trends.

Strengths	Data collection has been consistent for over 20 years on a nationwide basis using National Shellfish Sanitation Program (NSSP) guidelines. National standards developed by FDA are used by all States. Indicator is easily understood by public and policy makers.
Weaknesses	Variations in State to State decision-making on classifications limit nation-wide comparisons somewhat; Reclassifications are not always due to water quality changes, but in past have reflected changes in areas monitored; Only fecal coliform levels are monitored (which are not bacteria of concern, but are indicators of pathogens); The indicator is not well reported for open coastal (as opposed to estuarine) waters.
Possible Improvements	Greater consistencies in classifications would allow for nationwide comparisons; Correlating with other data, such as sediment and shellfish tissue contamination would provide a more complete indicator of surface water quality.

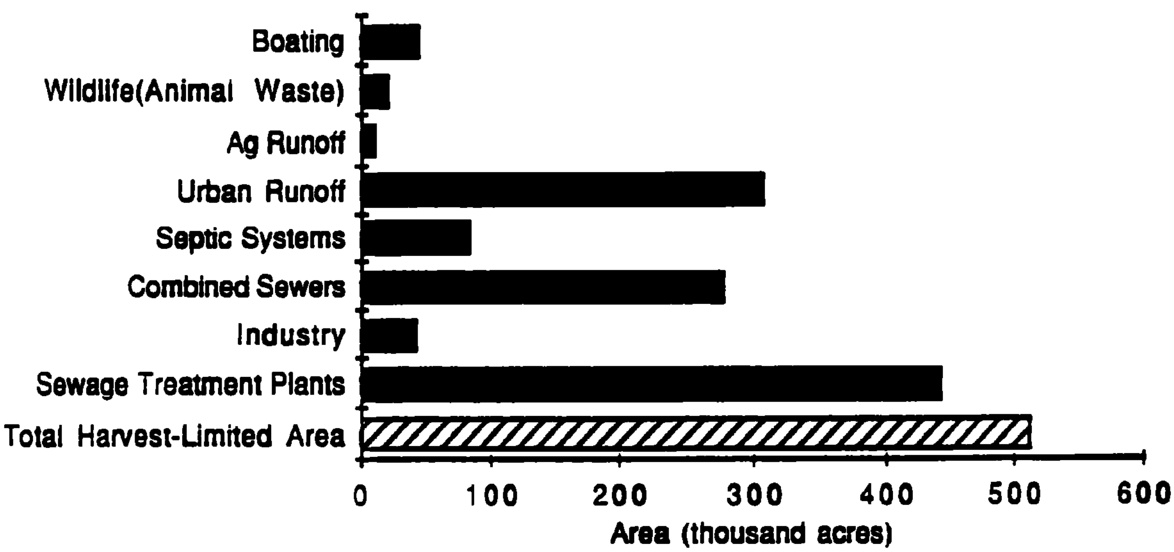
EVALUATION CRITERIA

Data availability	**Good**-NOAA publishes the National Shellfish Register covering all continental coastal States approximately every five years. Some States include shellfish information in their 305(b) Reports.
Data consistency/comparability	**Fair**-Even with inconsistencies in classifications the data are consistently presented. NOAA personnel visit States and take into account State-to-State differences to standardize the data for the national report. Physical and administrative differences limit comparability of different regions (East Coast-West Coast).
Spatial representativeness	**Good**-The majority of estuarine areas are classified as shellfish growing waters (approximately 95% of East Coast estuarine areas), and are consequently covered by the indicator. (Open coastal waters are not very well represented.)
Temporal representativeness	**Good**-Most stations sample at a minimum of 5 times annually (conditional classifications more often), therefore, seasonal variation is taken into account. Reasonably consistent data sets exist for most areas since the 1970's.
Utility in trend assessment	**Fair**-Data are available to assess trends, however, not all changes in classification are the result of water quality changes. NOAA does distinguish changes which are the result of water quality from those due to changes in areas monitored for Northeast, Mid-Atlantic, and West Coast. These data will allow for trend assessments.
Relation to ultimate impact	**Fair**-Relationship between shellfish harvest area classification and ultimate impact is limited because only fecal coliform levels are monitored. Coliform levels do not relate directly to human health impacts, rather they are an indicator of the possible presence of pathogens.
Related factors	**Important**-To have a more useful indicator, the ancillary data on pollutant sources should be used. (NOAA began collecting these data in the mid-1980's.)

EVALUATION CRITERIA

Scientific defensibility	**Fair**-Not all classifications are the results of monitoring; Coliform levels are only an indicator of pathogens; Quality of sampling varies among states.
Sensitivity to change	**Good**-Can get immediate reading of change in coliform levels.
Relationship to risk	**Fair**-Difficult to relate coliform levels directly to health risk, but indirect qualitative relationship definitely exists; Monitoring primarily coliform levels excludes factors other than sewage pollutants related to risk; Not relevant to ecological risk.
Cost to collect and analyze data	**Moderate**-State monitoring programs vary in size and cost though reporting to NOAA is well established and consistent; Due to high cost, States only monitor fecal coliform levels, monitoring actual pathogens would be prohibitively expensive.
Relationship to existing programs	**Good**-NOAA's National Shellfish Register presents shellfish harvest area classifications and assesses status, trends and pollution sources. States use classifications to assess designated use support, and to target sewage treatment plant and combined sewer overflow upgrade activities.
Presentation value	**Good**-Shellfish harvest area classifications are understandable to government decisionmakers and the public. Status and trends can be easily presented on graphs and charts.

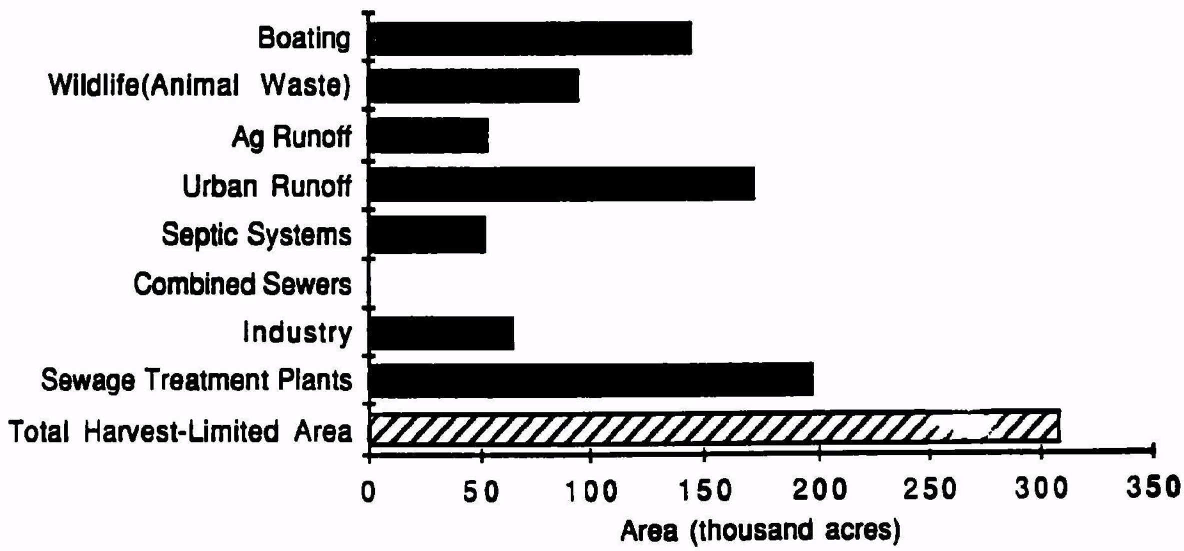
Figure III-1
Shellfish Harvest Area Affected by Pollution Sources
Northeast Region (1988)



Note: •Total harvest-limited area includes: Conditional, Restricted and Prohibited waters.
•Multiple pollution sources are often identified for a single harvest-limited area, therefore the sum of the area affected by sources in an estuary is usually greater than the amount of harvest-limited area.

Source: NOAA

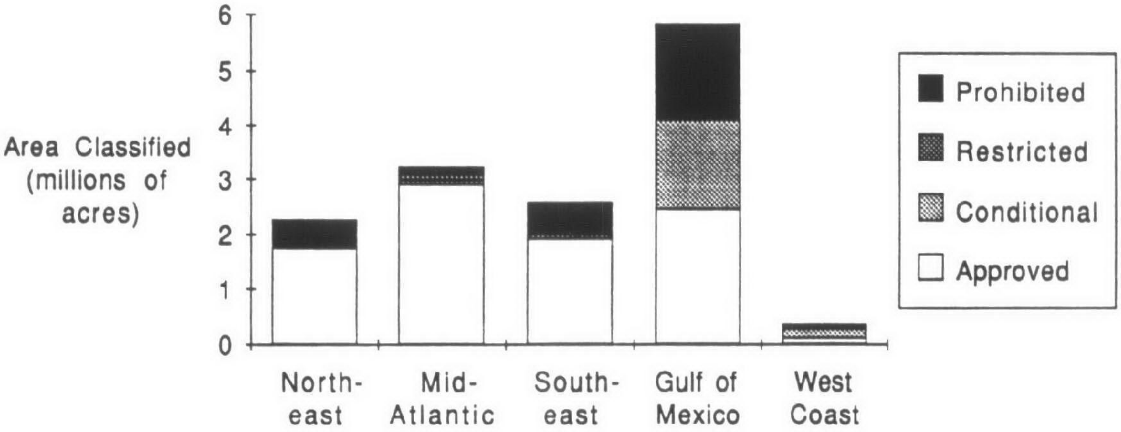
Figure III-2
Shellfish Harvest Area Affected by Pollution Sources
Mid-Atlantic Region (1988)



Note: •Total harvest-limited area includes: Conditional, Restricted and Prohibited waters.
•Multiple pollution sources are often identified for a single harvest-limited area, therefore the sum of the area affected by sources in an estuary is usually greater than the amount of harvest-limited area.

Source: NOAA

Figure III-6
1985 National Shellfish Harvest Area Classifications
(Subdivided by Regions)



Source: 1985 NOAA Data

IV. TROPHIC STATUS OF LAKES

SUMMARY

Description of the Indicator

Trophic status is the most commonly used measure of status and trends lake water quality. Eutrophication is a process by which a waterbody becomes rich in dissolved nutrients, filled with detritus, and seasonally deficient in dissolved oxygen to the extent that aquatic life is impaired. Eutrophication can result from the slow, natural aging of a lake or can be accelerated by excessive enrichment of nutrients (primarily phosphorus) from pollution sources such as fertilizer, sewage and detergents. States report the trophic status of publicly owned lakes in their 305(b) reports and some States report into the Waterbody System (WBS). States vary in their methods of determining trophic status with the majority using Carlson's Trophic Status Index (TSI). As a result of the different reporting methods, EPA must slightly modify the data of some States to achieve a nationwide comparison of trophic status.

Possible Applications

Eutrophication data provide a measure of the quality of lakes and support State program managers in targeting specific monitoring or enforcement activities. The rapid eutrophication of a lake signals a pollution problem and can serve as a warning system.

Although inconsistencies and data gaps in monitoring and reporting limit nationwide evaluations, the indicator does present some useful qualitative information regarding the nation's lake water quality.

Strengths

Reporting the trophic status of publicly owned lakes is required by Clean Water Act (CWA) 314(a); Provides a scientifically defensible measure of the ecological health of lakes.

Weaknesses

Regional geographic and hydrologic differences in lakes may limit national comparisons. A eutrophic condition does not necessarily mean that a lake does not support its designated use(s). The number of lakes evaluated by trophic status fluctuates, making trend analysis difficult. Seasonal fluctuations in trophic status are not always taken into account.

Possible Improvements

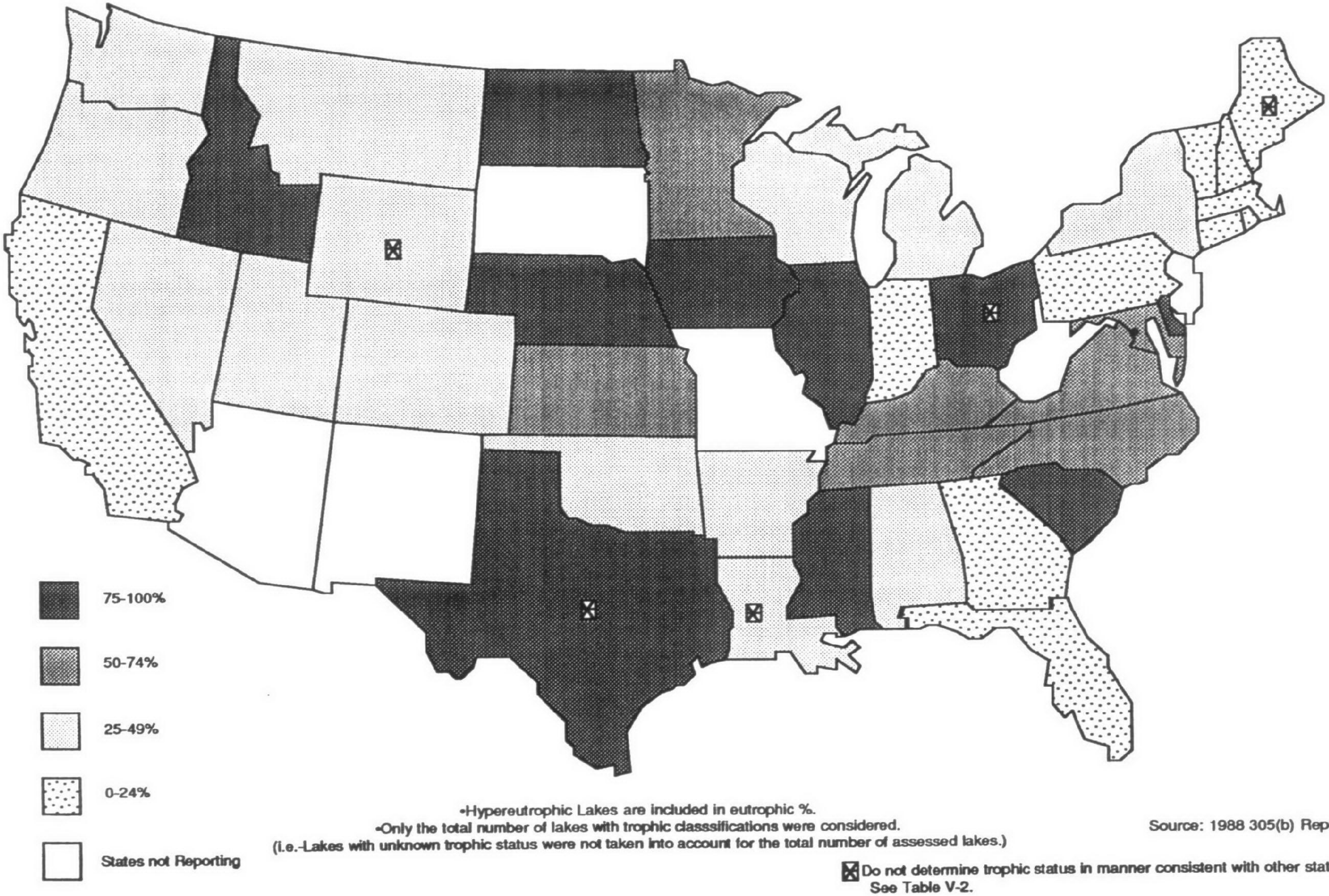
Establish a baseline number of lakes to determine trends; Record seasonal fluctuations; Report both number of lakes and lake acres.

EVALUATION CRITERIA

Data availability	**Good/Fair**-Reported in 305(b) reports, Clean Lakes List and in the Waterbody System (WBS). Currently six States put trophic data in the WBS, although the number is expected to increase in the future. EPA can compare results from States using different methods.
Data consistency/comparability	**Good/Fair**-The majority of States use Carlson's TSI. Others use methods suited to individual needs. Some States only report trophic status by number of lakes and not acreage.
Spatial representativeness	**Fair**-States only assess a portion of their total lakes.
Temporal representativeness	**Fair**-There is no consistent accounting for temporal fluctuations.
Utility in trend assessment	**Fair**-The number and frequency of lakes monitored and assessed is not consistent enough to assess trends. If a baseline number of lakes assessed were established then utility in trend assessment would be good.
Scientific defensibility	**Good**-Carlson's TSI is a scientifically defensible measure. Other methods such as professional judgements may be not entirely consistent, but are often technically sound in their own right. They are not necessarily less valid for purposes of the indicator program.
Sensitivity to change	**Good**-TSI in particular has a range of 1 to 100 and can show incremental changes.
Relationship to risk	**Good**-For ecological risk rapid eutrophication is strongly related. This indicator is not directly relevant to human health risks.
Cost to collect and analyze data	**Low**-Monitoring and analysis systems are already in place and budgeted at the State level, and the measurements are relatively inexpensive compared to other water quality measures (e.g. toxics).
Relationship to existing programs	**Good**-Trophic status is reported in 305(b) reports, Clean Lakes classification report, and used in State management programs.
Presentation value	**Good/Fair**-Eutrophication is not as easily understood by the public as other indicators but can be explained. Presentations can consist of national maps, accepting comparability of varying State results.

Figure IV-3

Percentage of Assessed Lakes Per State Classified as Eutrophic (1988)



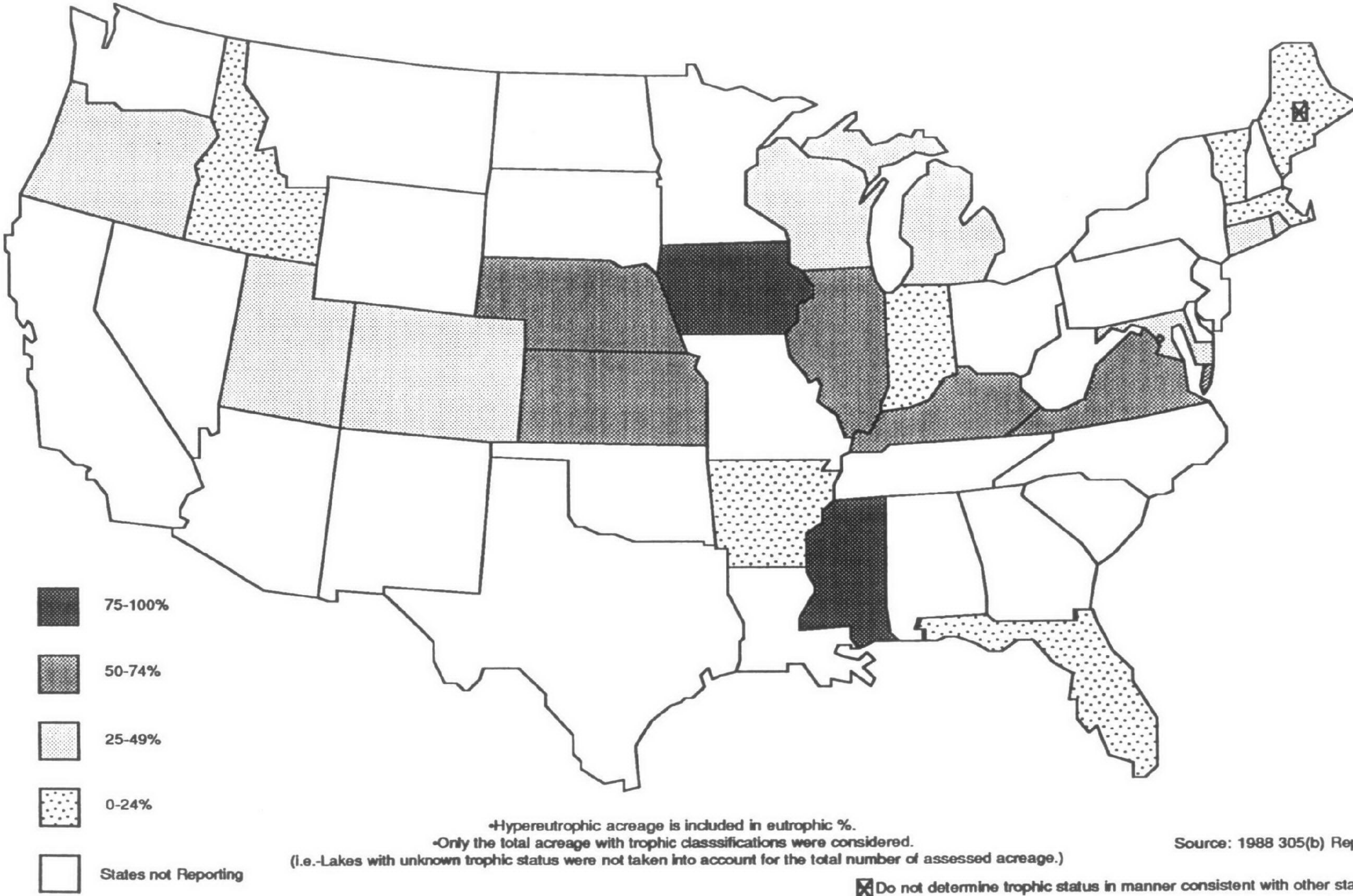
•Hypereutrophic Lakes are included in eutrophic %.
•Only the total number of lakes with trophic classsifications were considered.
(i.e.-Lakes with unknown trophic status were not taken into account for the total number of assessed lakes.)

☒ Do not determine trophic status in manner consistent with other states; See Table V-2.

Source: 1988 305(b) Reports

Figure IV-4

Percentage of Assessed Lake Acreage Per State Classified as Eutrophic (1988)



•Hypereutrophic acreage is included in eutrophic %.
•Only the total acreage with trophic classsifications were considered.
(I.e.-Lakes with unknown trophic status were not taken into account for the total number of assessed acreage.)

Source: 1988 305(b) Reports

☒ Do not determine trophic status in manner consistent with other states; See Table V-2.

V. TOXICS IN FISH AND SHELLFISH

SUMMARY

Description of the Indicator

This proposed indicator measures the accumulation of pesticides and other toxic chemicals in fish and macroinvertebrate tissue. Currently, several Federal Agencies including the Fish and Wildlife Service (FWS), the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA), as well as many State Agencies collect these data. States commonly use the information to help develop fish consumption advisories. FWS and NOAA studies are ongoing and can provide status and trend information on a regional level. The State programs vary in the type of animals tested, the amount and quality of the testing done, the chemicals that are analyzed and the way the results are used. To use on a national level the State data will require better data storage and accessibility. FWS and NOAA data are typically for whole-fish or liver samples, and thus indicative of ecological risks but not human health risks. EPA and State data are often for edible tissue fillets, and thus can be used to estimate potential risks to human consumers.

Possible Applications

The FWS and NOAA data can be used directly to support regional status and trend identification for river and marine systems. EPA will have to decide how it wants to use the State data in a regional or national assessment program. The Agency might be able to develop trend data for selected States and sites if it were to ask States to provide data from locations that are part of ambient monitoring systems.

Strengths

The accumulation of toxicants in fish and shellfish tissue can provide an indication of the general quality of the water resource, at least with regard to specific chemicals and the implications of their presence. Some nationally consistent data sets exist. Many States collect tissue contamination data. There is a lot of interest among the general public, especially with regard to any human health risks associated with toxic contamination of fish and shellfish.

Weaknesses

The actual ecological implications of fish and shellfish contamination are a subject of controversy. There is a lot of variability among States in the chemicals tested for and in the quality of the analysis. State data are hard to retrieve if they are put into STORET.

Possible Improvements

Increase in the use by States of BIOS as central repository for storage and retrieval of data; Have States include more information in their 305(b) reports; Greater coordination among various federal agencies (FWS, NOAA and EPA) in site selection and identification of chemicals to be tested; Possible extension of EPA Bioaccumulation Study.

EVALUATION CRITERIA

Data availability	**Good**-For FWS and NOAA data; Available in periodic reports and from computerized databases; Also, data should be readily available from EPA's bioaccumulation study. **Fair**-State data are maintained on State databases which may or may not be automated. Some States put data into STORET, but retrieval of information from that system is difficult.
Data consistency/comparability	**Good**-For EPA Bioaccumulation Study and FWS and NOAA studies, consistent analytical methods are used throughout the country. Although different fish species are, by necessity, used in different regions, the differing samples can be used for comparison purposes. **Fair/Poor**-States have a lot of variability in the type of chemicals tested for, species tested, and the quality of the analysis.
Spatial representativeness	**Good**-FWS sites were chosen to provide national information on status and trends. Benthic surveillance and mussel watch sites are located near urbanized areas so as to be representative of the general areas in which they are located. **Fair**-Bioaccumulation study; Some sites were randomly chosen, others were located in undisturbed areas, areas of important fisheries and at problem areas. Each type of site could be representative of similar sites around the country. **Variable**-State information is better in States with ambient monitoring networks.
Temporal representativeness	**Good**-The presence of contaminants in fish and shellfish tissue is more temporally consistent than measuring for the chemicals in the water column, since they are less transient. In the National Contaminant Biomonitoring program (NCBP), sampling always occurs in the fall to increase temporal comparability and similarly bivalves are always tested in the fall in NOAA's status and trends program. **Variable**-The State testing results vary not only between States but may also change within a State from one year to the next, affecting temporal comparability.

EVALUATION CRITERIA

Utility in trend assessment

Good/Fair-The FWS study is designed specifically to measure trends for specific contaminants in fish tissue. NOAA data will also support trends as monitoring continues into the future. The state data that is done at fixed monitoring stations would be useful for trend monitoring. However, a lot of monitoring is done for "special studies" and would not support the development of trends.

Scientific defensibility

Good-FWS and NOAA studies use well-defined and accepted study protocols as does the EPA Bioaccumulation study. State activities are much more variable.

Sensitivity to change

Fair-However, the utility of this measure to detect changes in the toxic load would depend to a great extent on the species involved and their tendency to accumulate particular chemicals. The FWS study demonstrated the decline in the use of certain pesticides. The pesticides were still being found long after their use was discontinued, which is important in demonstrating continued impact, but shows that natural response lags will slow down the ability to demonstrate environmental results. Non-linear relationships of loads to ambient concentrations in tissues mean that modest incremental changes in pollutant inputs will not always be distinguishable from tissue monitoring.

Relationship to risk

Fair-For bivalves and where fish fillets are analyzed the measure provides information relevant to human health risks. The measure is directly related to ecological risk. However, quantitative information on the actual environmental impacts of the accumulated toxicants is usually not available.

Cost to collect and analyze data

Moderate/High-Costs for tissue toxicity tests and their evaluation can be high. Accordingly, studies such as EPA's Bioaccumulation study may not be repeated.

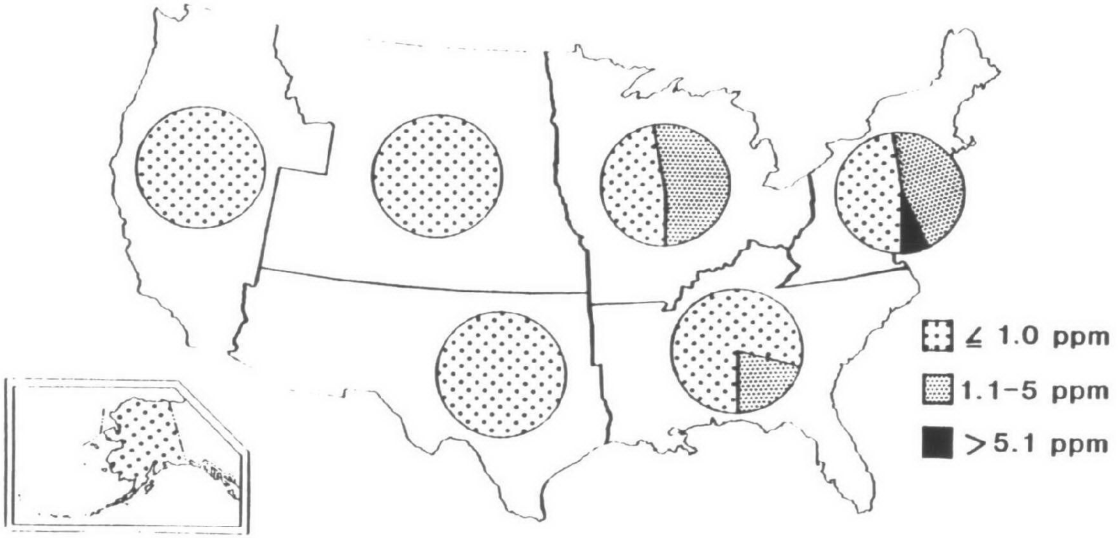
Relationship to existing programs

Good-Several Federal Agencies are already doing testing as are States in conjunction with FDA. States can report findings in the 305(b) reports.

Presentation value

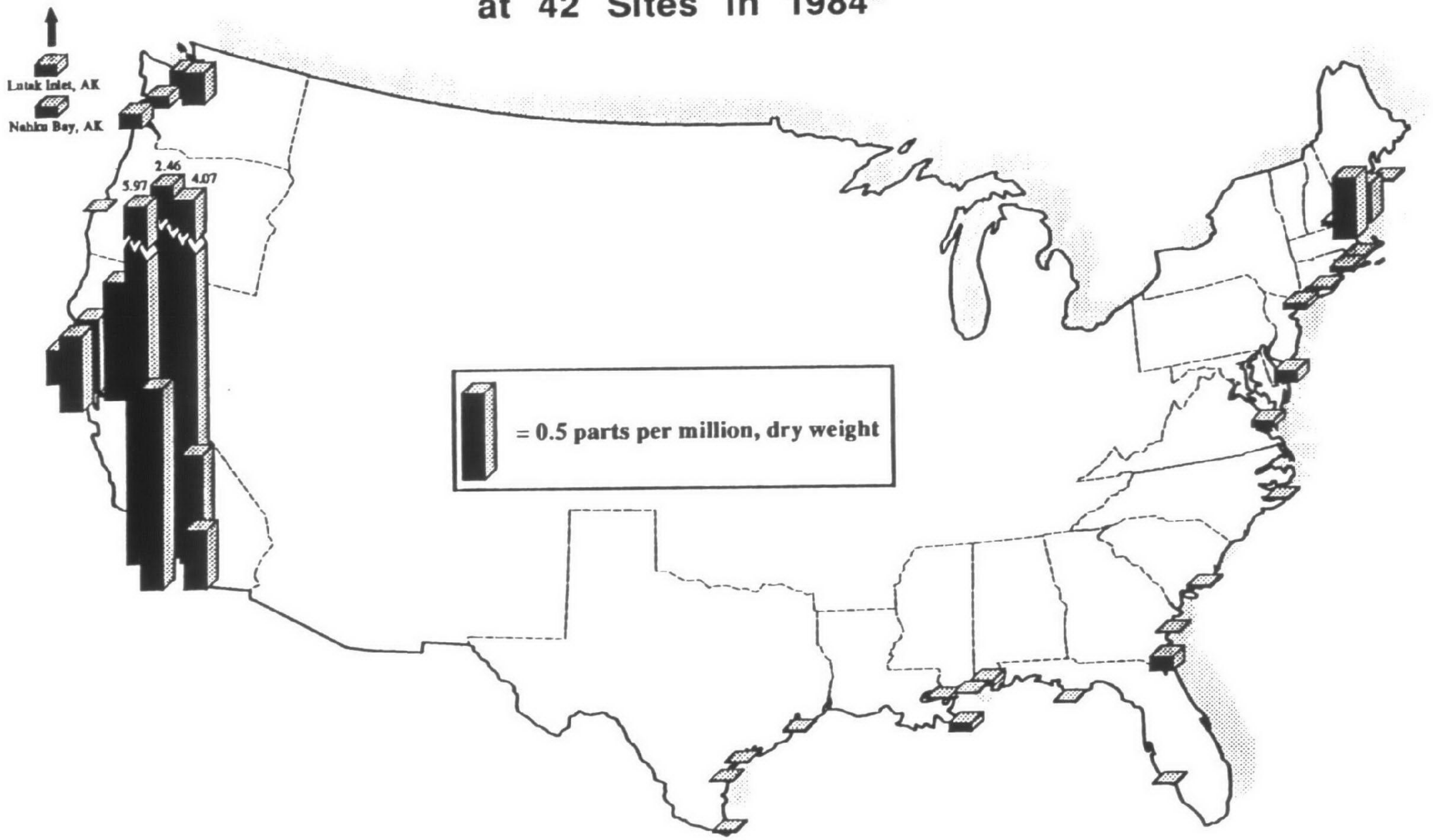
Good/Fair-The information is understood by the public and can in certain instances be well displayed on maps. However, given the wide range of variables in different studies, it is difficult to get a "nationwide" view from State studies.

Figure V-1
National Contaminant Biomonitoring Program (NCBP)-PCB Residues in Freshwater Fish (1980-81)



Source: FWS

Figure V-3
Total DDT in Livers of Estuarine Fish Composites Collected at 42 Sites in 1984*



*Computed from original data for the 1984 NOAA Status and Trends Program.

Source: NOAA: A Historical Assessment Report 1988

VI. MEASURES OF BIOLOGICAL COMMUNITY STRUCTURE

SUMMARY

Description of the Indicator

The basic indicator is the health of the biological communities of water body segments, as measured by monitoring and abundance of species expected to inhabit that type of water (and in some cases, of species considered to be sensitive to polluted conditions). States use a variety of biological community measures, with the Index of Biotic Integrity (based on counts of fish species), other fish community indices, and several types of macrobenthic invertebrate indices being the most common.

To use this indicator at the national level, we will attempt to combine data on the health of biological communities in all monitored water bodies according to their qualitative rankings according to the various indices used for bioassessments. That is, we will use only the information on whether the biological community of a given segment was considered to be in excellent, good, fair, or poor condition, considering all segments with the same qualitative ranking as equivalent for the national evaluation. This approach was recommended by several State and regional biologists in the workgroup on program effectiveness evaluation at the March 1989 Surface Water Indicators Workshop, and was then voted one of the most highly rated potential national indicators by the workgroup as a whole.

Possible Applications

Because the specific types of biological monitoring (i.e., which types of animals or plants are counted) vary from State to State, only very qualitative reporting will be justified at the national level. Such qualitative information could be useful for Federal planning and targeting. It will not support site-to-site comparisons. However, the Agency believes that if spatial data availability issues can be worked out, this indicator may support comparisons of broad-scale trends in biological conditions among geographic regions, States, watersheds, etc.

At the State level, where consistent methods of monitoring and analysis can be assured, sophisticated analyses of biological community data are already being done. Such analyses can be used to support impact assessments for specific pollution sources, or to assess the results of pollution control upgrades at particular facilities.

Strengths

This indicator is the most direct measure possible of support of a Clean Water Act (CWA) goal, because maintaining biological integrity is one of the legislative mandates. The information is scientifically defensible, and also makes sense to the public and decision makers. Availability of data to assess the status of waters nationwide is moderately good, with data available for some waters in almost all States, provided that a decision is made to consider the various types of biological community measures as comparable to one another in a broad, qualitative sense.

Weaknesses

The variety of approaches to assessing biological community integrity means that no single approach will likely ever be embraced by all States. This means that only rough, qualitative comparisons of conditions from place to place will ever be likely using this approach. Also, biological monitoring is now often done in special studies rather than as part of ambient network monitoring, so that there are relatively few locations where temporal trends can be assessed.

Possible Improvements

More consistent monitoring in space and time, i.e., establishing more monitoring network locations that will be monitored repeatedly over time would allow trend assessments for a larger portion of the nation's waters than is currently possible.

EVALUATION CRITERIA

Data availability

Fair - Most States use biological community monitoring for at least a few critical water bodies, or for special one-time studies. A number of States have incorporated such monitoring into ambient monitoring networks, and additional States may do so in the future. The proportion of most States' assessed water bodies in which biological community monitoring is done is currently quite low. However, the positive response of most States to recent recommendations by State and federal agencies concerning the benefits of biological monitoring indicates that biomonitoring will probably be carried out for larger portions of many States' surface waters in coming years.

Data consistency/comparability

Fair - A variety of biological community measures are commonly used, which differ greatly in the type of organisms whose abundance is assessed, and in the complexity of procedures for combining data on various species' abundance. Some measures are formulated into sophisticated mathematical indices to take into account habitat features and other environmental factors (e.g., IBI based on ecoregions) while others are relatively simple weighted sums of a few key species. The great differences in the types of measures used means that data from State to State, and sometimes within States, will not support sophisticated ecological comparisons among sites or regions. This indicator development project is investigating whether biomonitoring experts concur with the sense of the March 1989 Surface Water Indicator Development Workshop that the biological community indices commonly used for water quality assessments are sufficiently comparable to be aggregated for qualitative national status and trend analyses.

Ability to estimate

Poor - The utility of biological community monitoring derives from its direct nature. One is monitoring the feature of the environment that water quality regulations seek to protect, so that one cannot be fooled into falsely believing the ecological protection goal of the CWA has been met, as can occur when physical and chemical measures are used. Attempting to infer what biological conditions are from non-biological measures would thus be contrary to the basic reason that biological community measures are desirable in the first place.

Spatial representativeness

Fair - Biological community assessments are done in most States, but often in only a small portion of the assessed waters. The major challenge in using these assessments to evaluate national status and trends will be working out spatial data availability issues. It will be necessary to identify segments where monitoring could be expected to be representative of the segment as a whole, rather than of

EVALUATION CRITERIA

small, high impact areas subject to intensive study (such as a point source discharge monitoring study).

While this issue of spatial representativeness is not a trivial one, biological community measures in fact present less of a problem than the chemical measures on which State use-support assessments are traditionally based. This is because biological communities tend to integrate water quality conditions over space and time.

<u>Temporal representativeness</u>

Good - Biological community health is more temporally consistent in a given location than water quality itself is, because water column conditions are transient while organisms remain.

<u>Utility in trend assessment</u>

Fair - Biological community monitoring is sometimes part of State monitoring networks designed for trend assessment, in which case monitoring is repeated at fixed locations over time. But other biomonitoring data are from one-time studies that do not support temporal trend assessments, and so would have to be excluded from a national assessment intended to look systematically at spatial and temporal trends.

<u>Relation to ultimate impact</u>

Good - Damage to biological communities is one of the ultimate impacts the CWA seeks to prevent. In relation to the "fishable goal", if the particular measure used assesses organisms other than fish (e.g., a benthic community index), then the measure is still a very good indirect indicator of impacts on fish, due to food web relationships.

<u>Related factors/ Ancillary information</u>

Important - Data on habitat and water body type are necessary to properly interpret biological community data, because the types of organisms composing a healthy community vary according to substrate, depth, flow, climate, etc.

<u>Scientific defensibility</u>

Good - Most biological community measures currently used by States have been developed, reviewed, and refined by academic and government scientists and are very sound technically. The concept of considering different measures or indices as qualitatively equivalent for national assessment purposes is tentatively considered sound by a selection of federal and State biologists, but requires testing and further expert evaluation.

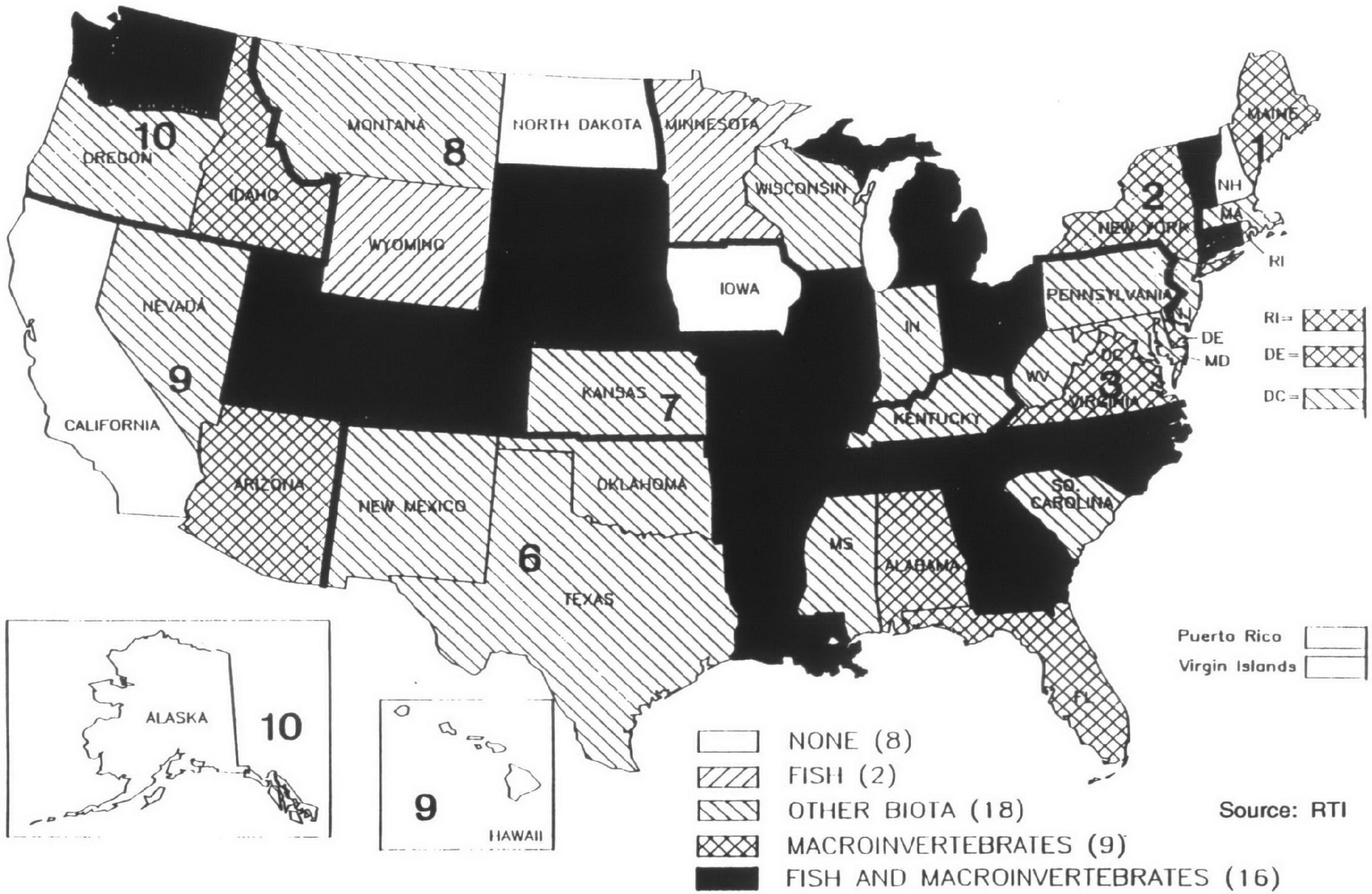
<u>Sensitivity to change</u>

Good - Some particularly pollution-sensitive organisms are typically included in each biological community index, so that the biological community monitoring is an excellent method to identify pollution impacts when they first become ecologically significant.

EVALUATION CRITERIA

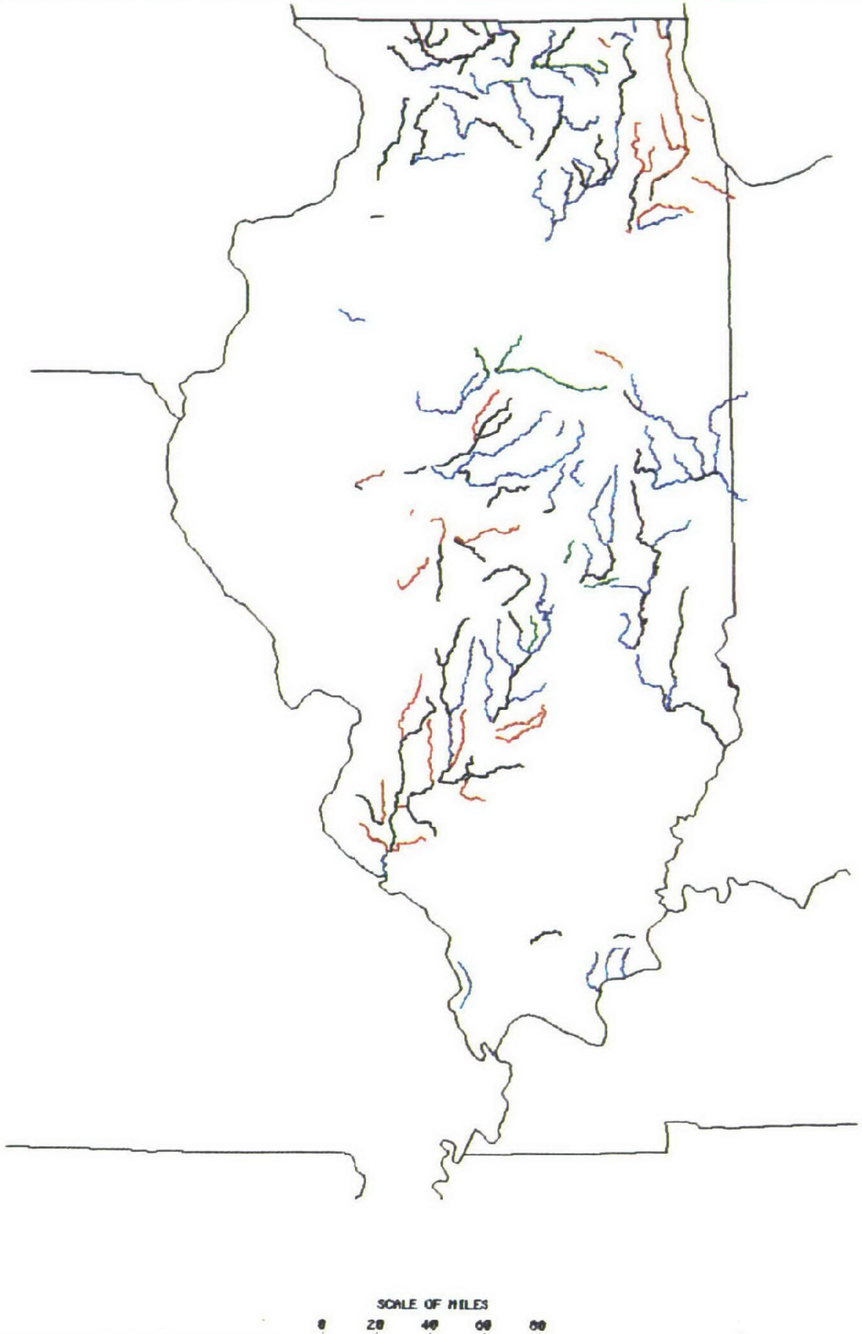
Relationship to risk	**Good** - Degradation of biological community structure is a direct measure of ecological impact.
Cost to collect and analyze data	**Moderate** - Biological monitoring can be more expensive than basic chemical monitoring for conventional pollutants, but it is often less expensive than toxic chemical monitoring as presently done, and is much less expensive than full-blown monitoring for all toxics of potential concern.
Relationship to existing programs	**Good** - States and EPA already have made provision for reporting and analyzing biological community data as part of the process for assessing use support and preparing 305(b) reports. Guidance on how to incorporate biological community parameters more explicitly into State standards will be refined by EPA in the next few years.
Presentation value	**Good** - The concept of balanced biological communities is well understood by decision makers and the public.

Figure VI-2
Communities Sampled in River Biosurveys (1989)



Source: RTI

Figure VI-3
Illinois Streams Evaluated Using Index of Biotic Integrity (IBI) (1989)



Note: This is a color map: If Report is photocopied, use black and white map on next page for distribution. Color maps are available from the Environmental Results Branch, U.S. EPA (Phone (FTS/202) 382-4900)

ENVIRONMENTAL PROTECTION AGENCY

STORET SYSTEM

ILLINOIS REACHES
BIO-COMMUNITY DATA
NOVEMBER 14 1989
"IBI2.PRN"

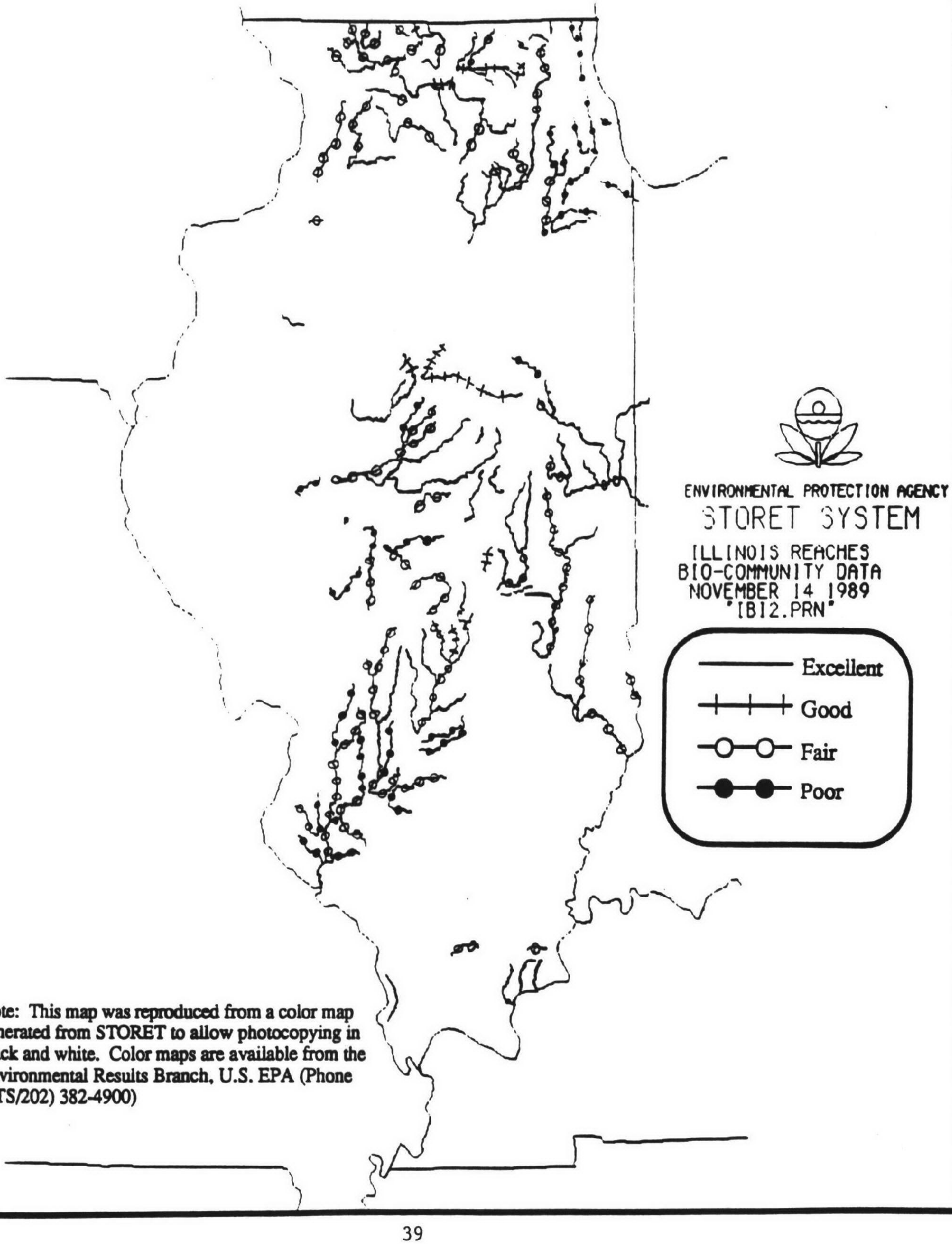
****

- 4=EXCELLENT
- 3=GOOD
- 1=FAIR
- 2=POOR

****

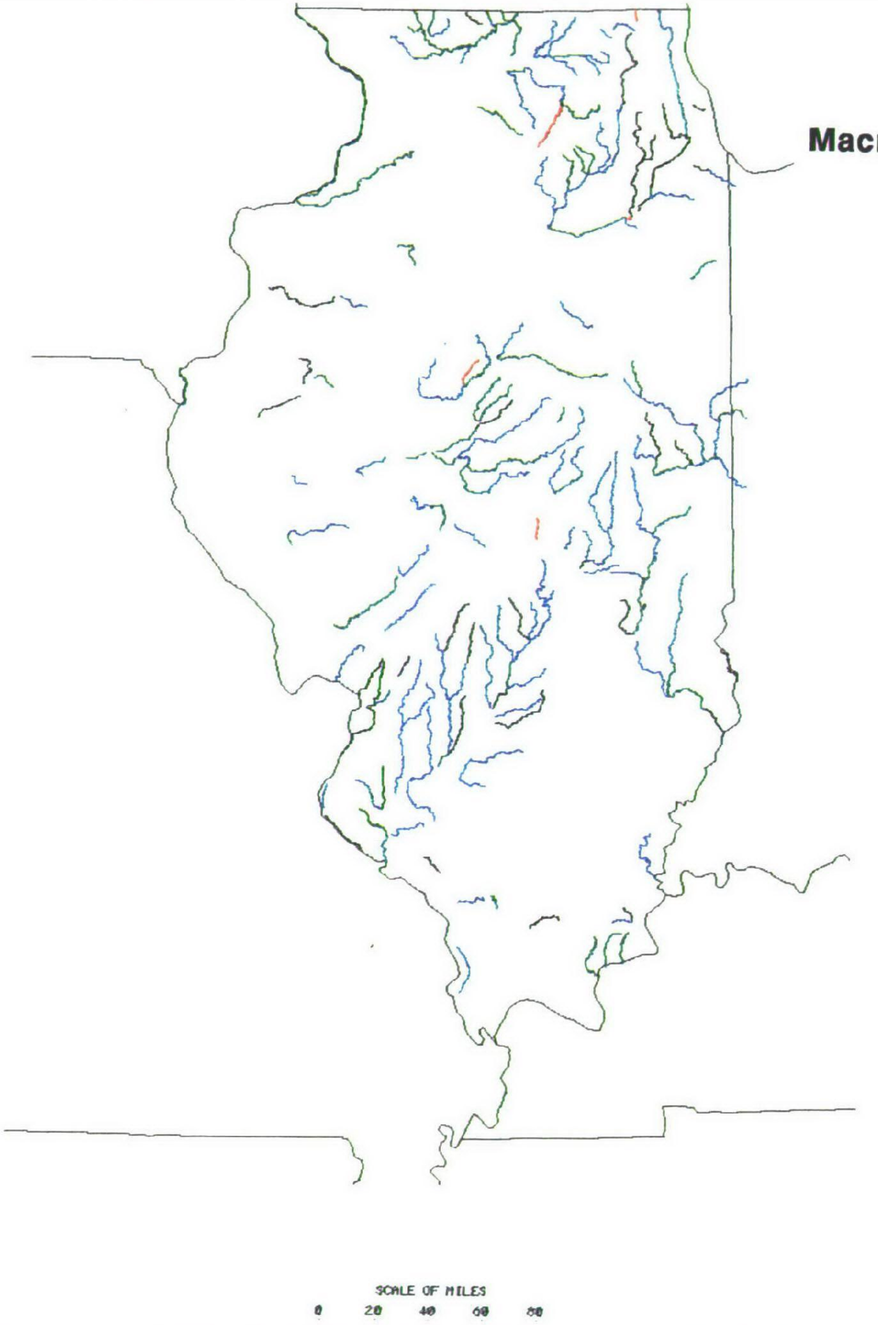
PROJECTION - ALBERS EQUAL AREA
SCALE 1:1048312

Figure VI-4
Illinois Streams Evaluated Using
Index of Biotic Integrity (IBI) (1989)



Note: This map was reproduced from a color map generated from STORET to allow photocopying in black and white. Color maps are available from the Environmental Results Branch, U.S. EPA (Phone (FTS/202) 382-4900)

Figure VI-5
Illinois Streams Evaluated Using Macroinvertebrate Biotic Index (MBI) (1989)



Note: This is a color map: If Report is photocopied, use black and white map on next page for distribution. Color maps are available from the Environmental Results Branch, U.S. EPA (Phone (FTS/202) 382-4900)

ENVIRONMENTAL PROTECTION AGENCY

STORET SYSTEM

ILLINOIS REACHES
BIO-COMMUNITY DATA
NOVEMBER 14 1989
"MBI2.PRN"

****

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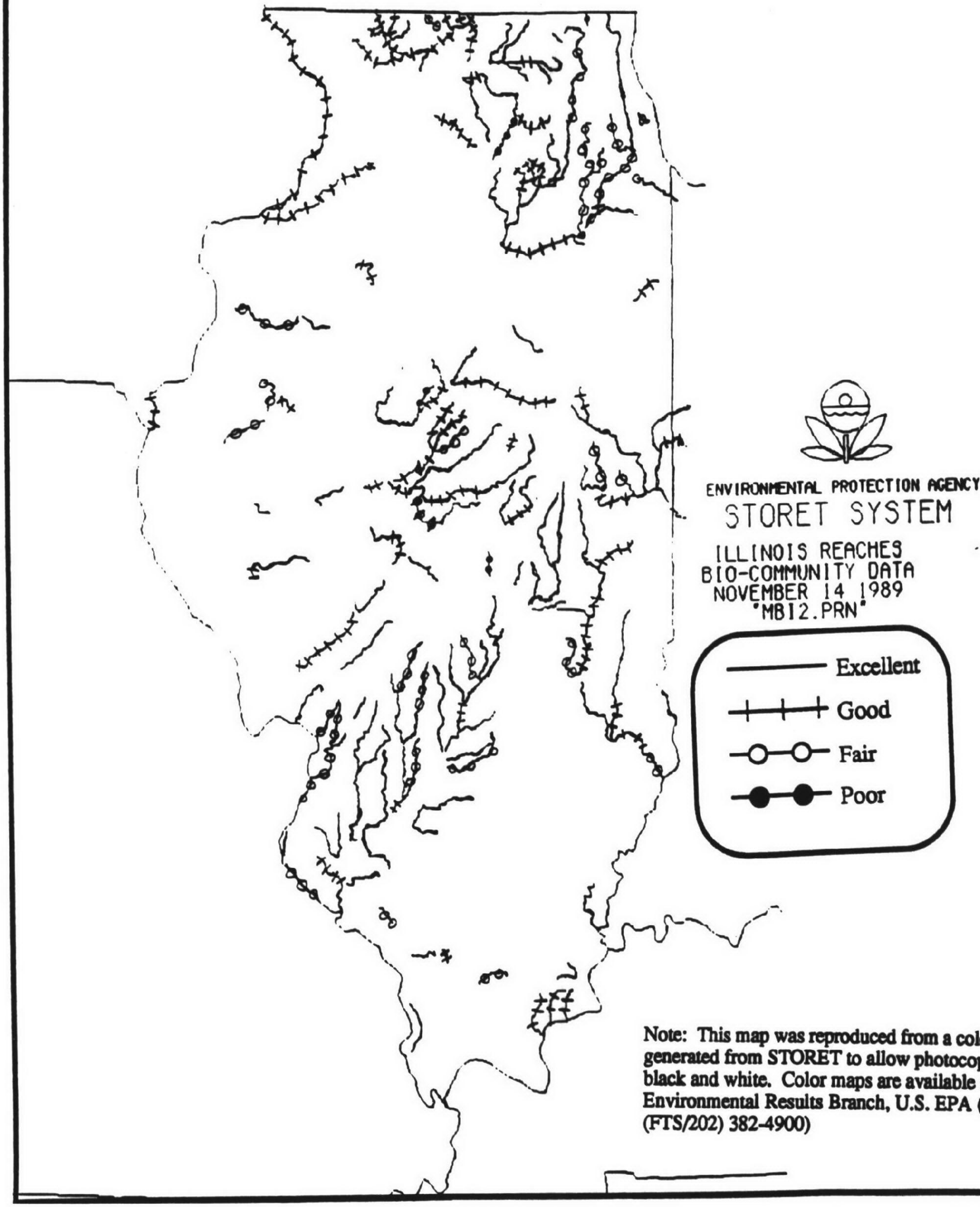
****

PROJECTION - ALBERS EQUAL AREA
SCALE 1:1048312

Figure VI-6
Illinois Streams Evaluated Using Macroinvertebrate Biotic Index (MBI) (1989)



Note: This map was reproduced from a color map generated from STORET to allow photocopying in black and white. Color maps are available from the Environmental Results Branch, U.S. EPA (Phone (FTS/202) 382-4900)

VII. LOADING ESTIMATES FROM POINT SOURCES

SUMMARY

Description of the Indicator

This indicator shows the location, magnitude, type and timing of pollutant discharges into receiving surface waters. Although loading estimates do not directly reflect the quality of the water resource, they are a useful measure of the pollutant stress placed on the system and provide an indication of the effectiveness of regulatory programs in controlling pollutant discharges.

Possible Applications

Pollutant loading estimates can be used for evaluating progress made in some point source control programs, and targeting future point source regulation and enforcement activities. If time series of loads are available, trends in discharges can be depicted and correlated with changes in treatment technologies, land use management practices, service areas and production levels. Pollutant loading estimates are often the primary measures for evaluating enforcement programs.

Strengths

Data collection and reporting system is in place in all States. The data are spatially and temporally fairly consistent, with good correlation between pollutant loadings and water quality. Indicator is easily understood by public and policy makers and is closely tied to a major regulatory program.

Weaknesses

Availability and quality of data is limited, especially for toxic compounds. Current data management system (Permit Compliance System (PCS)) cannot be used reliably to compute loads. Additional data collection requirements are costly.

Possible Improvements

Require permitted facilities to report seasonal and annual loads; Modify PCS to allow computation of loads.

EVALUATION CRITERIA

Data availability	**Fair** - Discharge Monitoring Reports (DMR) data for majors are reported to PCS for all States, with varying levels of participation and quality control. Greatest amount of monitored data is available for wastewater volume, and conventional pollutants, with much less data available for metals and toxic organics. Availability and quality of data for minors is variable, but is generally much poorer than for majors.
Data consistency/comparability	**Good** - Analysis methods are generally standardized for permitted pollutants. Therefore, comparison of estimates among States or regions is reasonable.
Ability to estimate	**Fair** - All load estimates are approximations. When monitored data do not exist or are suspect, engineering estimates can be substituted, with substantial reduction in credibility.
Spatial representativeness	**Good** - Because all major point sources are included in PCS, data for majors is spatially representative. Data is less reliable for minors.
Temporal representativeness	**Good** - For major point sources, pollutant loadings are monitored on a daily, weekly or monthly basis. Therefore, monitoring data are reasonably representative of temporal variation. Monitoring for minors can be less frequent and therefore less representative.
Utility in trend assessment	**Fair** - It is impossible to assess trends on an individual facility basis where time series data exist. However, national trend assessment is difficult because PCS has not been fully supported in the past. With proposed improvements to the system, and better participation by States, capability to assess trends will improve in the future.
Relation to ultimate impact	**Fair** - Loading estimates do not directly relate to ultimate water quality impacts. However, correlations have been observed between load reductions and improvements in biological community structure and other measures of water quality.
Related factors	**Important** - For useful interpretation of loading trends, it is critical to collect ancillary data characterizing levels of industrial production, changes in treatment processes, increases in service areas, etc.
Scientific defensibility	**Good** - Load reductions have been correlated to improvements in water quality.

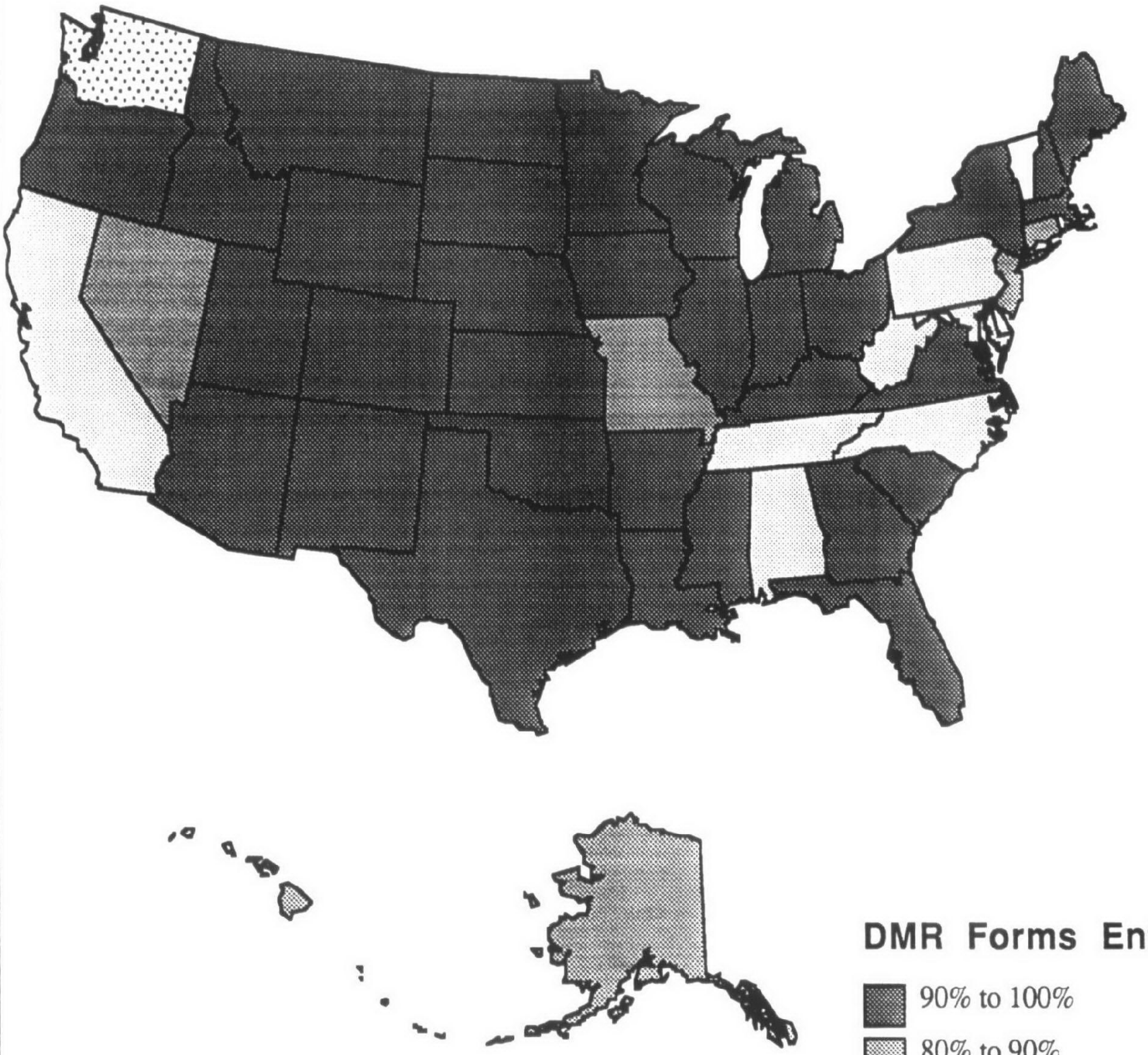
EVALUATION CRITERIA

Sensitivity to change	**Good** - Loads generally directly reflect changes in industrial production levels, improvements or failures in treatment, etc.
Relationship to risk	**Poor** - It is difficult to directly relate loads to risk. Monitoring data to support loading estimates for toxic compounds of greatest concern frequently are not available.
Cost to collect and analyze data	**Moderate** - Because self-monitoring and compliance monitoring systems for the National Pollutant Discharge Elimination System (NPDES) are already in place, monitoring and analysis costs are already budgeted by facilities and States. Increased toxics monitoring is expensive. PCS would have to be modified to allow computation of loadings.
Relationship to existing programs	**Good** - DMR reporting is well established, supported and continually being improved. There is a clear connection between load estimates and effectiveness of point source control programs.
Presentation value	**Good** - Concept of pollutant loadings is generally accepted and understandable to government decisionmakers and public. Status and trends can be graphically portrayed on charts and maps.

Figure VII-1
Availability of PCS Data for Making Point Source Loading Estimates

Percent of DMR Forms from Major Facilities Entered into PCS

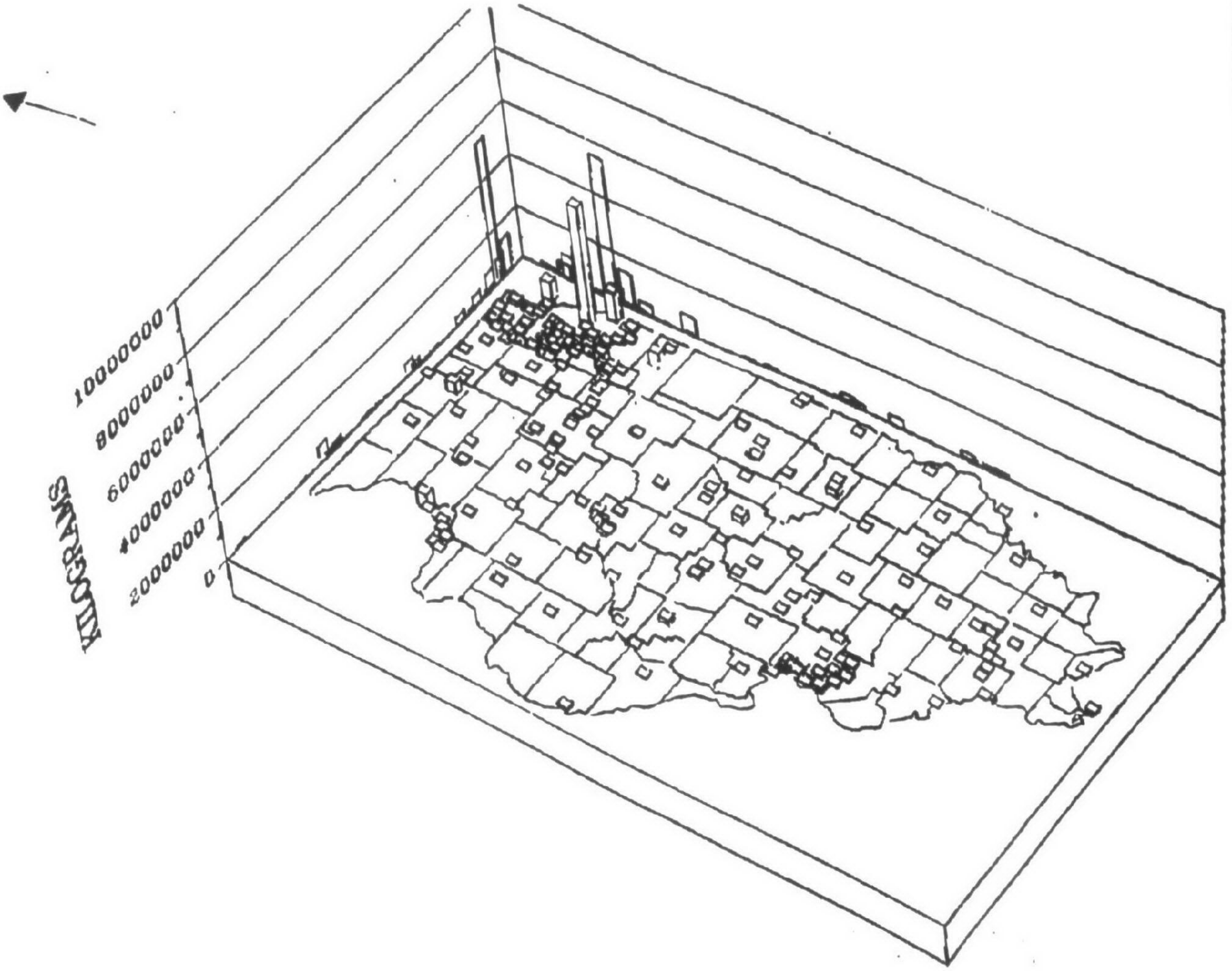
(4th Quarter of FY 1989)



Source: Office of Water Enforcement Support Branch

Note: data for U.S. Territories not shown

Figure VII-3
PCS Example - Three-Dimensional Map Displaying Total Suspended Solids (TSS) Loadings Across Illinois (1988)



VIII. SUMMARY CHARACTERISTICS OF PROPOSED INDICATORS

Indicators	Strengths	Weaknesses	Possible Improvements
Designated Use and Attainment of "Fishable/ Swimmable" Evaluation Goals	•Data collection system already in place •Computerized framework •Low cost to maintain and improve •Of primary interest to majority of public •Easily Understood	•At present, can not be used to evaluate trends •Inconsistencies and lack of standardization •Inconsistent within state from one reporting cycle to the next	•More consistency in definitions of use •Increase in use of reach number or other geo-referenced data element •Increase in the use of WBS
Shellfish Harvest Area Classifications	•Data collected for over 20 years •Data collection has been fairly consistent •Easily understood by general public	•Variations in state-to-state interpretation of classifications •Reclassifications for reasons not related to water quality changes	•Greater consistency in classifications •Correlating with other monitoring data (such as NOAA's Mussel Watch data)
Trophic Status of Lakes	•Data collection system already in place •Report required by CWA 314(a) •Scientifically defensible methods •Computerized framework	•Regional differences limit national comparisions •The number of lakes evaluated fluctuates •Lakes are monitored too infrequently to derive trends	•Establish baseline in order to be able to evaluate trends •Report seasonal fluctuations •In 305(b), report both number of lakes and lake acreage
Toxics in Fish and Shellfish USFWS NCBP	•L-T collection system in place •Trends established •Computurized data collection •Of major interest to FWS	•Only for rivers and streams •Limited number of chemicals tested •Actual ecological implications of fish and shellfish contamination are a subject of controversy	•Plan to expand to estuaries •Looking to include new toxicants •May include USGS sites and perhaps NOAA's Mussel Watch sites
NOAA NS&T Benthic Surveillance	•Consistent nationwide sampling •Good trend analysis •Have ancillary information on sediments at sites and fish abnormalities •Spatial and Temporally representative	•Different fish at different locations •Not useful for human health considerations •Not point source specific	•Coordinate data collection with other sources •Develop centralized database •Develop protocols on monitoring to increase comparablity with other sources data
NOAA NS&T Mussel Watch	•Consistent nationwide sampling •Can correlate info with sediment data •Spatial and Temporally representative	•Not point source specific	•Same as above
EPA National Bioaccumulation Study	•Located around known and suspected sources •Can draw conclusions on impacts •Can develop information on bioaccumulation	•One time only study •No trends •Not spatially or temporally rep.	•Repeat study to assess programs in place around sources and to further examine bioaccumulation •Identify sites to be re-tested as part of nationwide trend study
Tissue Residue Data Collected by States	•Being done at state level •Used in some use assessment •Related to health advisories	•Varies from state to state in species, location, chemicals, purpose and amount of testing •No data storage with easy retrieval	•Change in 305(b) to provide summarized results •Use Bios data system •Develop agreements on monitoring protocols to increase comparability
Biological Community Measures	•Fish integrate impacts over whole stream •Bivalves are excellent indicator of environmental stress •Heightened interest in states and regions •Community data is necessary complement to physical/chemical testing •Different states can use systems that are appropriate to their conditions	•Relatively limited amount of biomonitoring being carried on as part of water quality analyses •Resource constraints •No centralized database	•Increase guidance to state in terms of how to do community analyses and what to do with the information •Make identification of community analyses part of the 305(b) reports
Pollutant Loading Estimates from Point Sources	•Data collection and reporting in place •Spatially and temporally representative •Good correlation between pollutant loadings levels and water quality	•Limitations on availability and quality of data •Little data available for toxic compounds •Current data management system (PCS) can not compute loads •Additional data collection would be costly	•Require permitted facilities to report seasonal and annual loads •Modify PCS to allow computation of loads

IX. CONCLUSIONS AND RECOMMENDATIONS

1. The shellfish harvest area classification data available from the National Oceanic and Atmospheric Administration (NOAA) could be incorporated into an EPA indicator reporting process in the near term.

2. It would be most efficient and logical for the Office of Water (OW) to use the State 305(b) reports as the primary vehicle through which it develops data on indicators.

3. The consistent use of the Waterbody System and individual reach numbers by the States should be encouraged.

4. In the long-term, there are some additional monitoring and coordination activities that the Agency, other Federal Agencies, and the States should consider to develop more meaningful indicators.

5. EPA should actively encourage State programs designed to implement measures of biological community well-being.

6. If it is desired that indicator data be used for national trend assessment, the Office of Water (OW) and State water quality Agencies might reconsider a monitoring strategy in which each State returns to a subset of fixed monitoring stations on regular intervals to permit trend reporting on a few indicators.