Eastern Research Group, Inc.

April 5, 2000

Dear Reviewers:

The following is a recap of what was presented at the Informational Meeting for the Peer Review of Hudson River PCBs Ecological & Human Health Risk Assessment. This meeting took place March 22 and 23, 2000 at the Sheraton Saratoga Springs in Saratoga Springs, NY.

Please refer to the enclosed agenda, which specifies the presentations and their corresponding numbered packet.

You will also find two videos that were taken at the briefing. There is an error on the labels on the videos. The videos correspond with the following dates:

Tape #1: Currently labeled 03/24; is actually 03/22; Day 1
Tape #2: Correctly labeled; 03/23/00

If you have any questions or concerns, please do not hesitate to contact any of us here at ERG.

Thank you.

Sincerely,

Melanie Russo

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Communications

Data, Information, and Knowledge Management

Economic and Statistical Support

Emissions Inventory and Exposure Assessment

Engineering

Environmental Health

Environmental Management Systems

Environmental Measurements

Occupational Health and Safety

Regulatory Support

Community Environmental Planning

EPA United States Environmental Protection Agency Region 2

Informational Meeting for the Peer Review of Hudson River PCBs Ecological & Human Health Risk Assessment

Sheraton Saratoga Springs
Saratoga Springs, New York
March 22-23, 2000

Agenda

Meeting Facilitator: Jan Connery, Eastern Research Group, Inc.

WEDNESDAY, MARCH 22, 2000

8:00AM	**Registration/Check-in**	
8:30AM	**Welcome Remarks** *Jan Connery, Eastern Research Group, Inc.*	
8:45AM	**Presentation on Site Background** *Alison Hess, U.S. Environmental Protection Agency*	**SLIDE PACKET #1**
10:00AM	BREAK	
10:15AM	**Presentation on Findings from Previous Reports** *Alison Hess, U.S. Environmental Protection Agency*	**SLIDE PACKET #1**
11:00 AM	**Adjourn for Site Tour**	
11:30AM	**Board Bus for Site Tour**	
12:00AM	LUNCH (on own, bus will stop at local restaurant)	
5:00PM	**End of Site Tour/Return to Hotel**	

THURSDAY, MARCH 23, 2000

8:30AM	**Presentations on Ecological Risk Assessment** *Ed Garvey, TAMS Consultants, Inc.*	**SLIDE PACKET #2**
	Helen Chernoff, TAMS Consultants, Inc. *Katherine von Stackelberg, Menzie-Cura & Associates, Inc.*	**SLIDE PACKET #3**
10:30AM	BREAK	
10:45AM	**Review the Charge to Reviewers on the Ecological Risk Assessment** *Damien Hughes, U.S. Environmental Protection Agency*	

(over)

11:45AM LUNCH (on own)

THURSDAY, MARCH 23, 2000 (CONTINUED)

1:00PM **Presentations on Human Health Risk Assessment**
Marian Olsen, U.S. Environmental Protection Agency
David Merrill, Gradient Corp. SLIDE PACKET #4

3:00PM BREAK

3:15PM **Review the Charge to Reviewers on the Human Health Risk Assessment**
Damien Hughes, U.S. Environmental Protection Agency

4:15PM Adjourn

Hudson River PCBs Site Reassessment

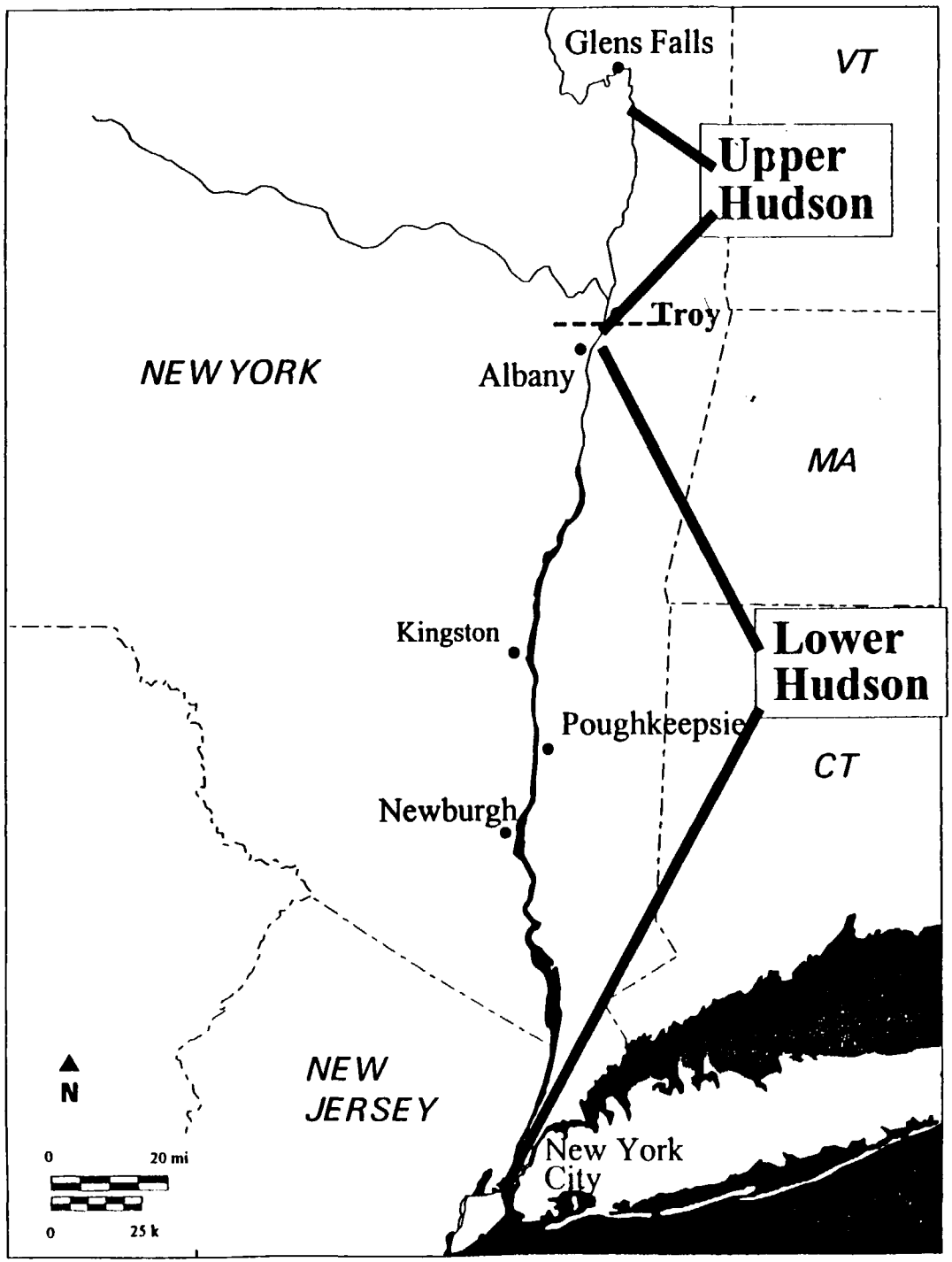
Risk Assessment Peer Review

March 22, 2000

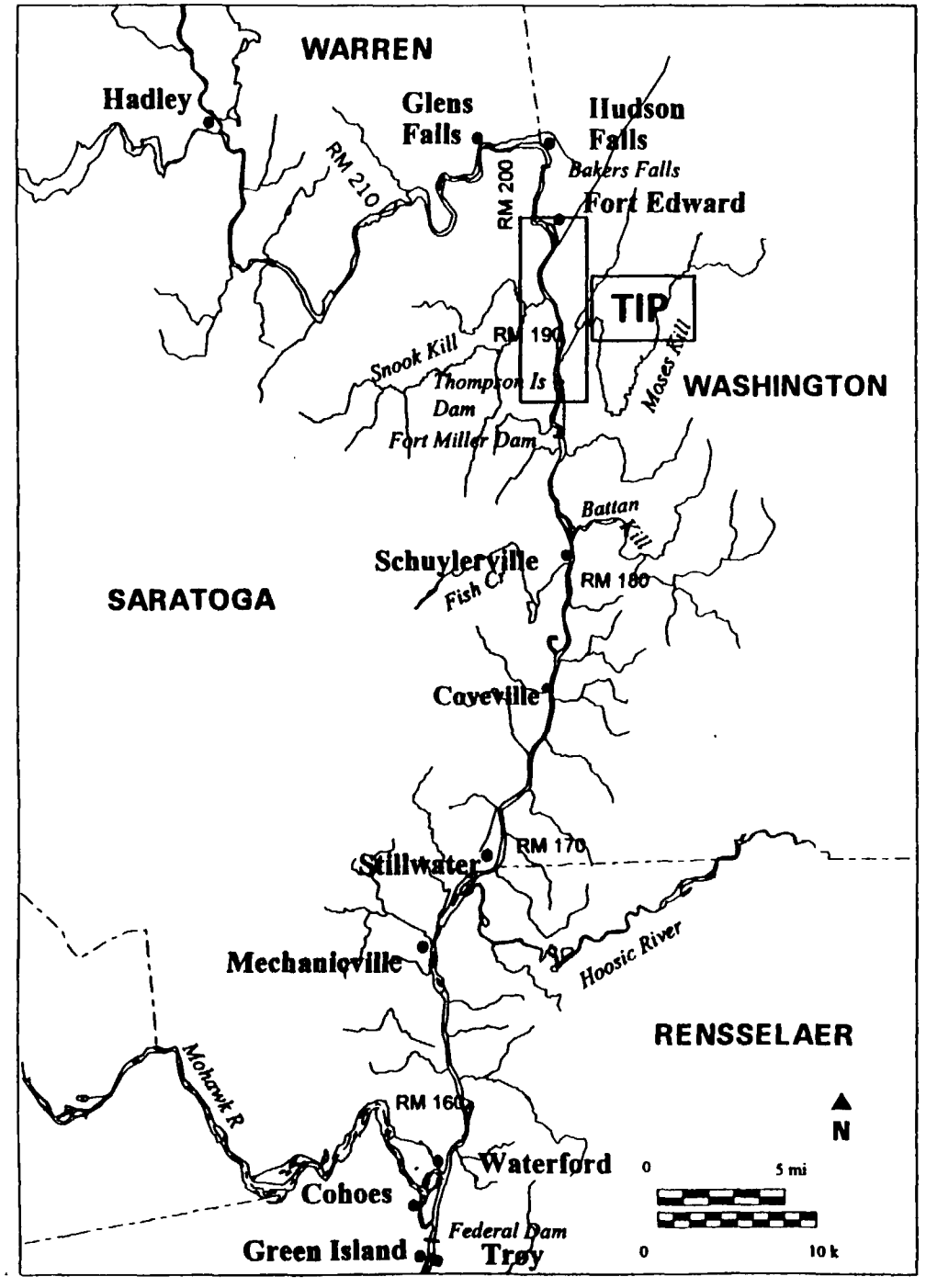
Alison A. Hess, CPG
USEPA - Region 2

Hudson River PCBs Site Reassessment

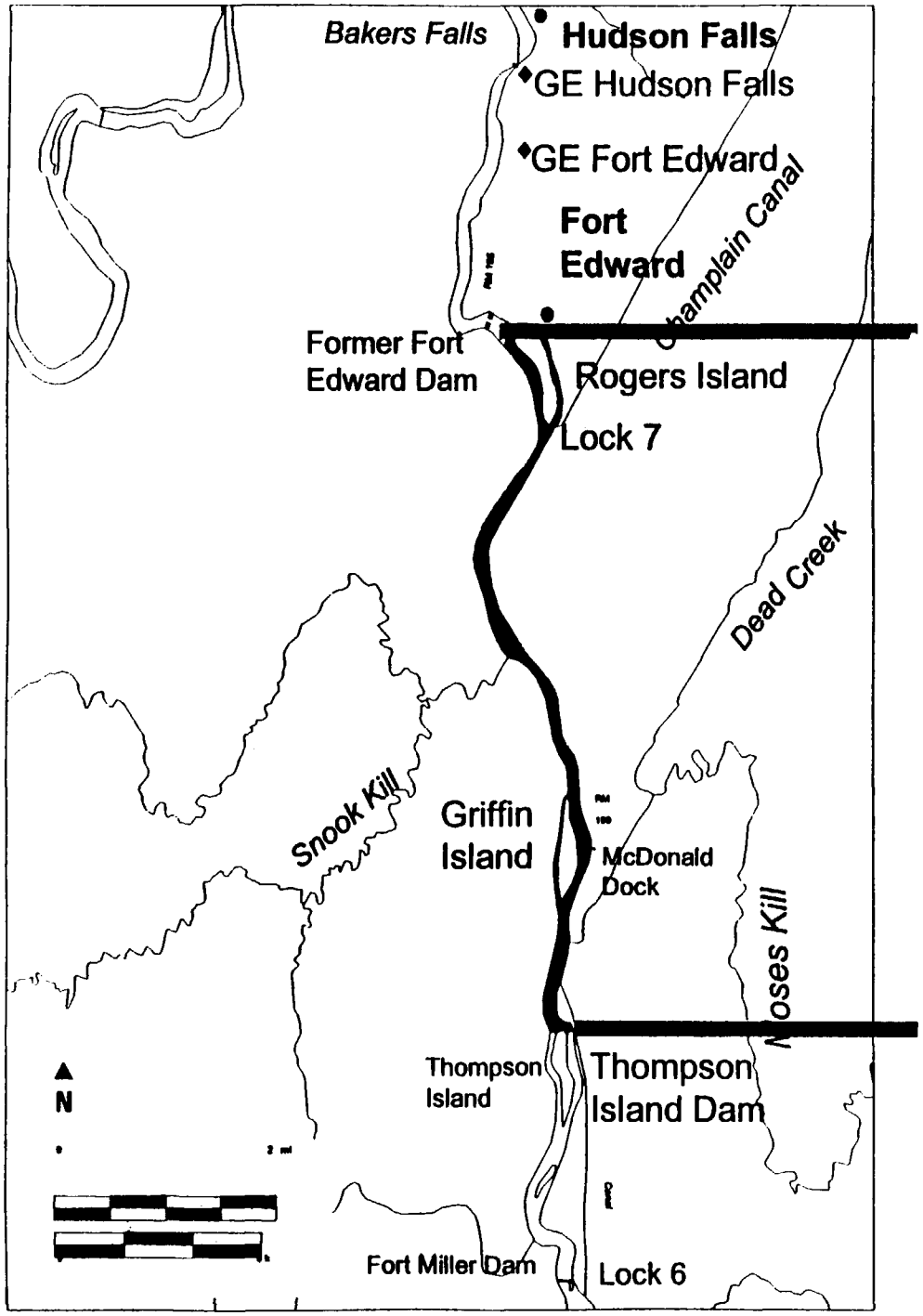
- Site Background
- Findings from Previous Reports
- Feasibility Study



Upper and Lower Hudson River

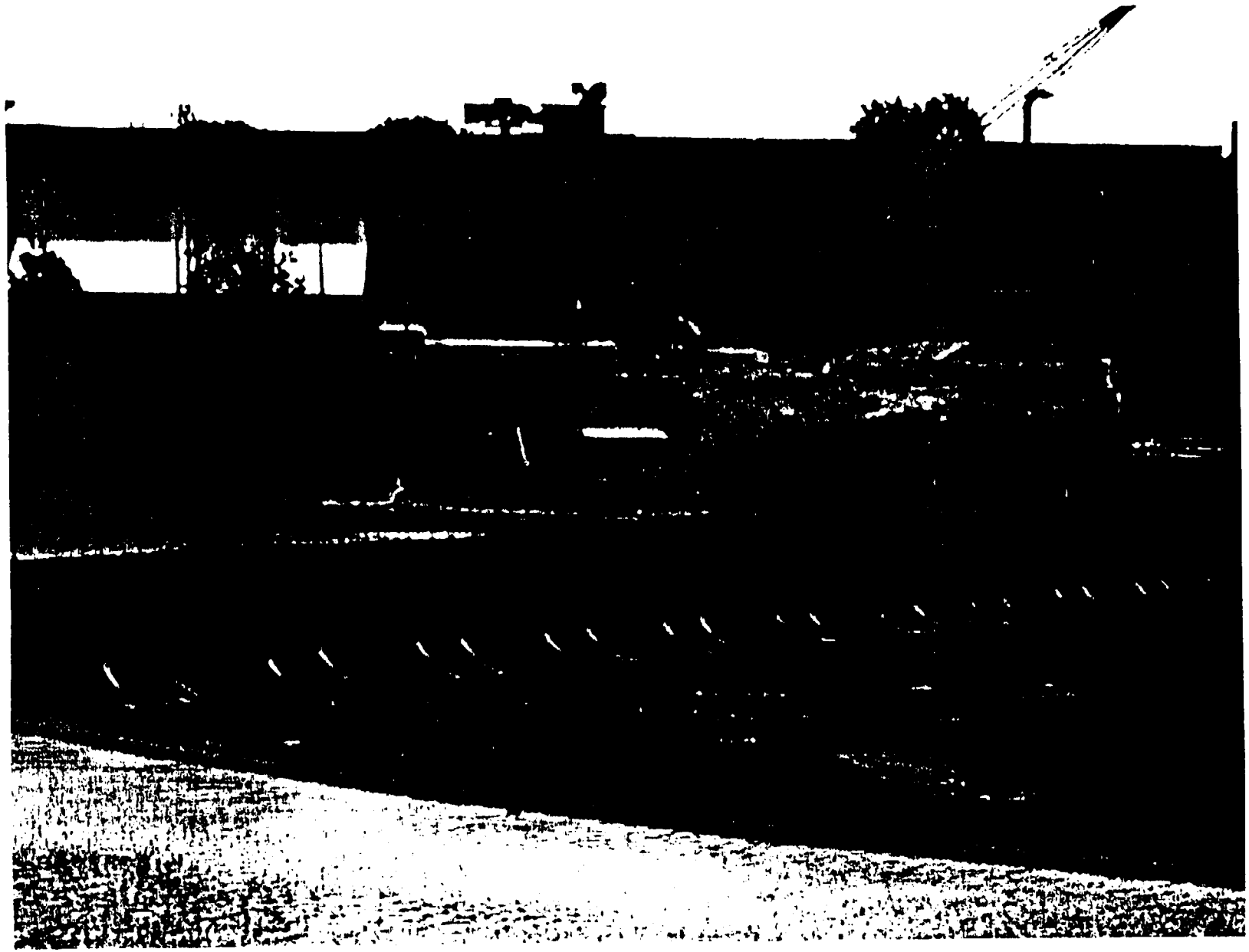


Upper Hudson River



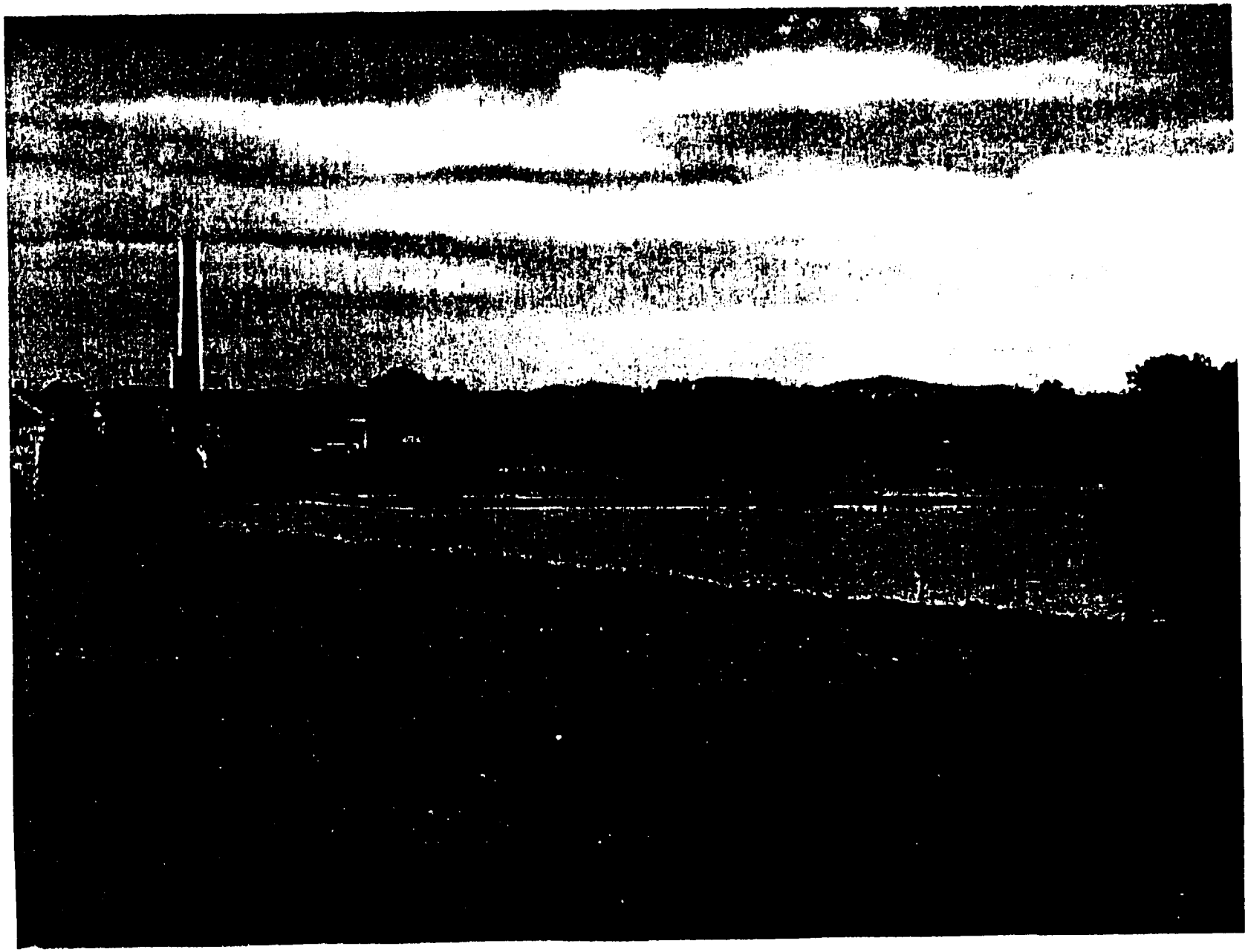
Thompson Island Pool

GE Hudson Falls Plant Site - Bakers Falls Dam

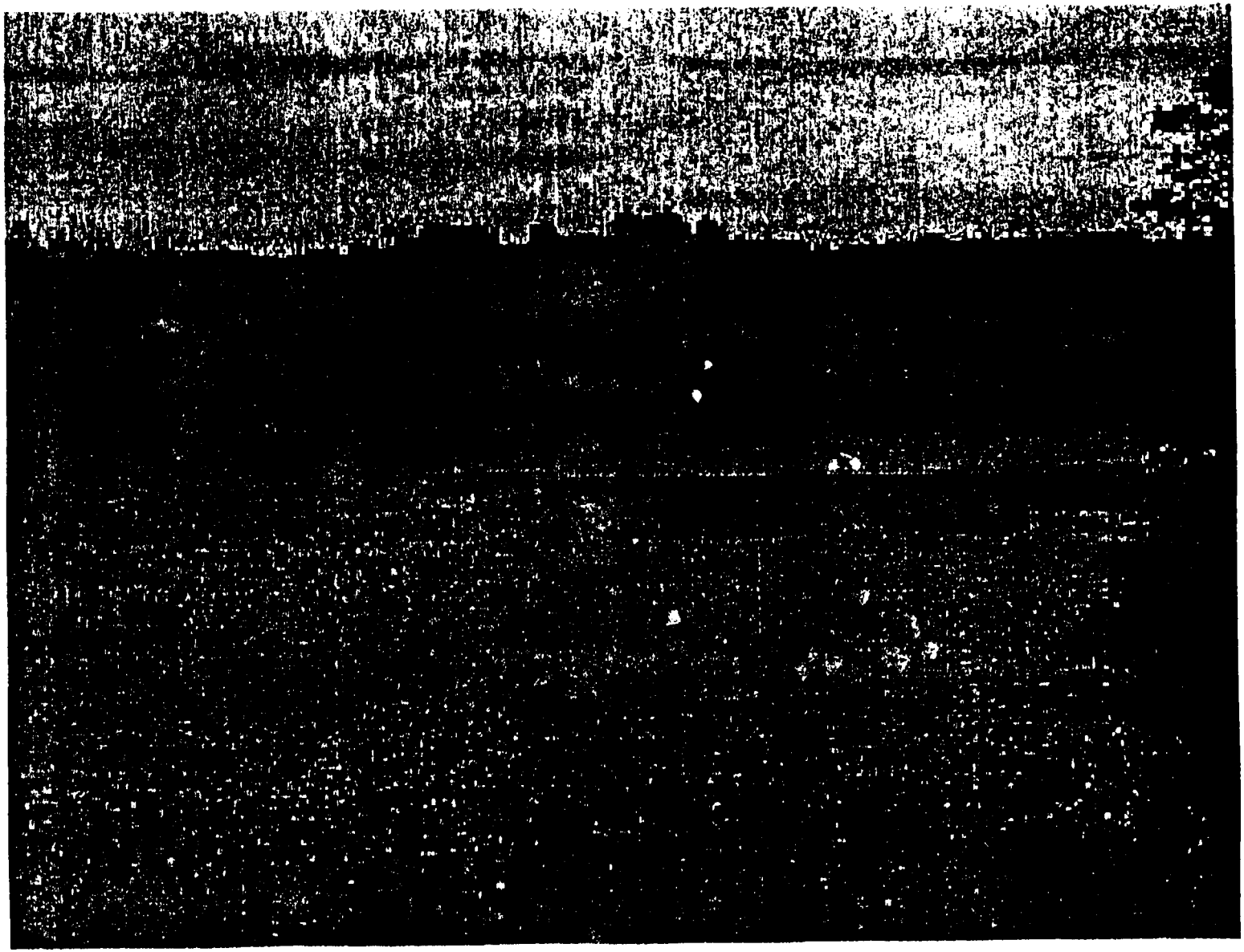


Upper Hudson River - Looking Upstream from Fort Edward

Remnant Deposit 5 and Location of Former Ft. Edward Dam



Upper Hudson River -Thompson Island Pool



Upper Hudson River /Champlain Canal

Hudson River PCBs Site Timeline

1947 -1976 GE used PCBs in manufacturing capacitors

1973 Ft. Edward Dam removed

1976 Fishing ban and consumption advisories

1980 Clean Water Act - Section 116

1983 Site proposed for Superfund NPL

1984 Record of Decision

Hudson River PCBs Site
1984 Record of Decision

- Cap Remnant Deposits
- Treatability Study for Waterford
- Interim "No-Action" for
  PCB-contaminated sediments

Decision to Conduct the Reassessment

- Re-opener in 1984 ROD
- Requested by NYSDEC
- EPA requirement for 5-Year Reviews

Reassessment Announced
December 1989

Purpose of the Reassessment

To evaluate whether any action is required to address the PCB-contaminated sediments in the Upper Hudson River in order to be protective of human health and the environment.

Principal Reassessment Questions

1. When will PCB levels in fish meet human health and ecological risk criteria under continued No Action?

2. Can remedies other than No Action significantly shorten the time required to achieve acceptable risk levels?

3. Could a flood scour sediments, exposing and redistributing buried contamination?

Hudson River PCBs Site Reassessment

1989 Decision to conduct the Reassessment

1990 Reassessment Scope of Work issued

1991 Remnant Deposit capping completed
Event at GE Hudson Falls Plant Site

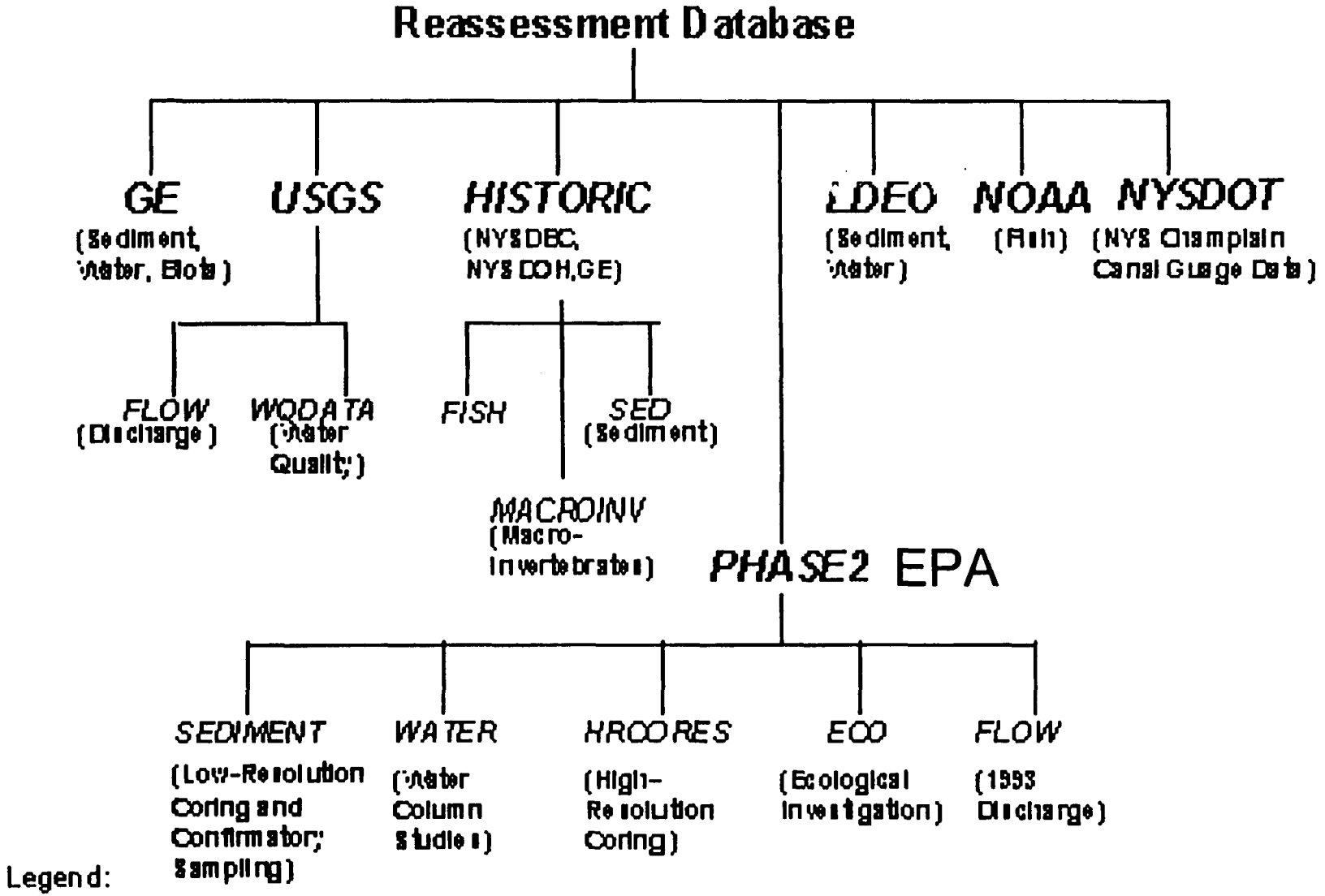
1992 - 1994 EPA Phase 2 sampling and analysis

1995 Data validation

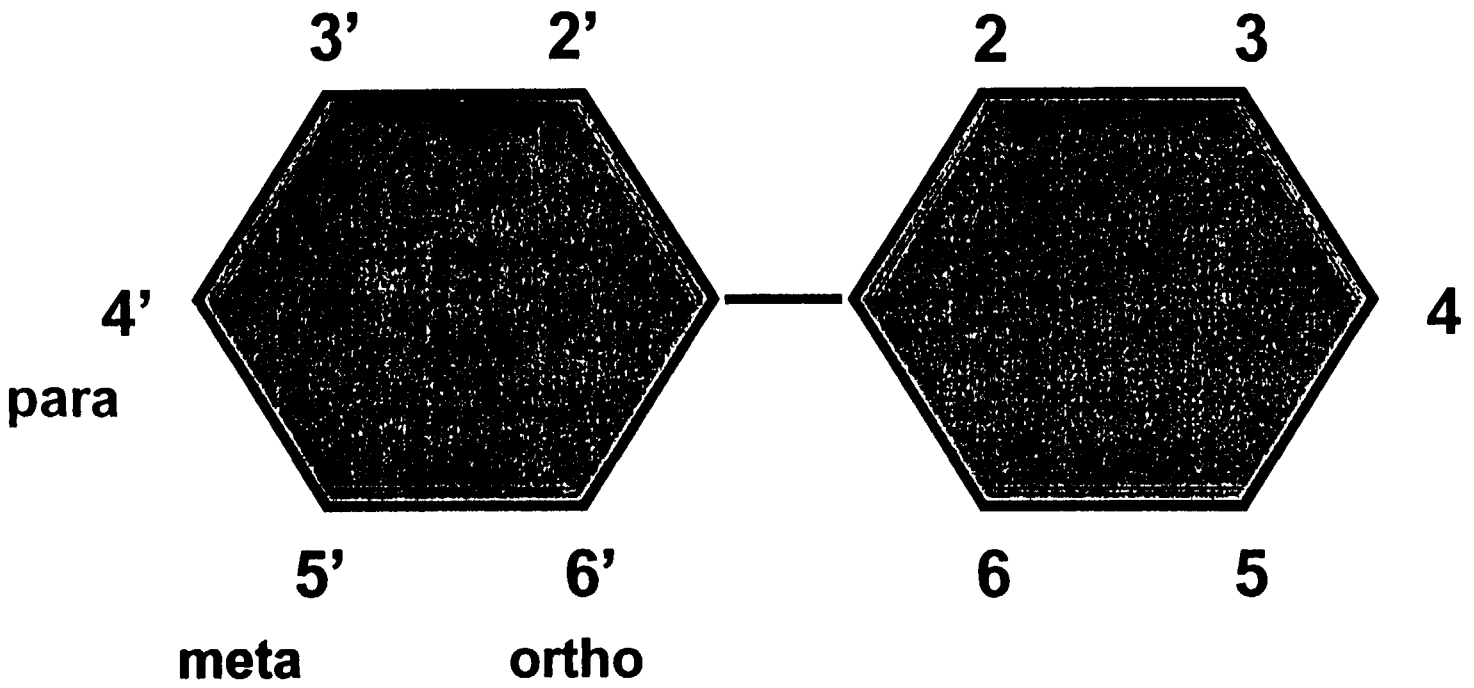
1996 - 2000 Release of Phase 2 Reports

Hudson River PCBs Reassessment Reports

Phase 1 Report	Aug 1991
Phase 2 Reports (Remedial Investigation)	
1. Database Report	Nov 1995
2. Preliminary Model Calibration Report	Oct 1996
3. Data Evaluation and Interpretation Report	Feb 1997
3A. Low Resolution Sediment Coring Report	July 1998
4. Baseline Modeling Report	May 1999
5. Ecological Risk Assessment	Aug 1999
6. Human Health Risk Assessment	Aug 1999
Phase 3 Report (Feasibility Study)	Dec 2000


Reassessment Database
GE
(Sediment, Water, Biota)
USGS
HISTORIC
(NYSDEC, NYSDOH,GE)
LDEO
(Sediment, Water)
NOAA
(Fish)
NYSDOT
(NYS Champlain Canal Gauge Data)
FLOW
(Discharge)
WQDATA
(Water Quality)
FISH
SED
(Sediment)
MACROINV
(Macro-Invertebrates)
PHASE2 EPA
SEDIMENT
(Low-Resolution Coring and Confirmatory Sampling)
WATER
(Water Column Studies)
HRCORES
(High-Resolution Coring)
ECO
(Ecological Investigation)
FLOW
(1993 Discharge)
Legend:
USGS - Main Directory
WQDATA - Subdirectory
(NYSDEC, NYSDOH,GE) - directory contents description

Polychlorinated Biphenyl



209 congeners

Tri+ PCBs

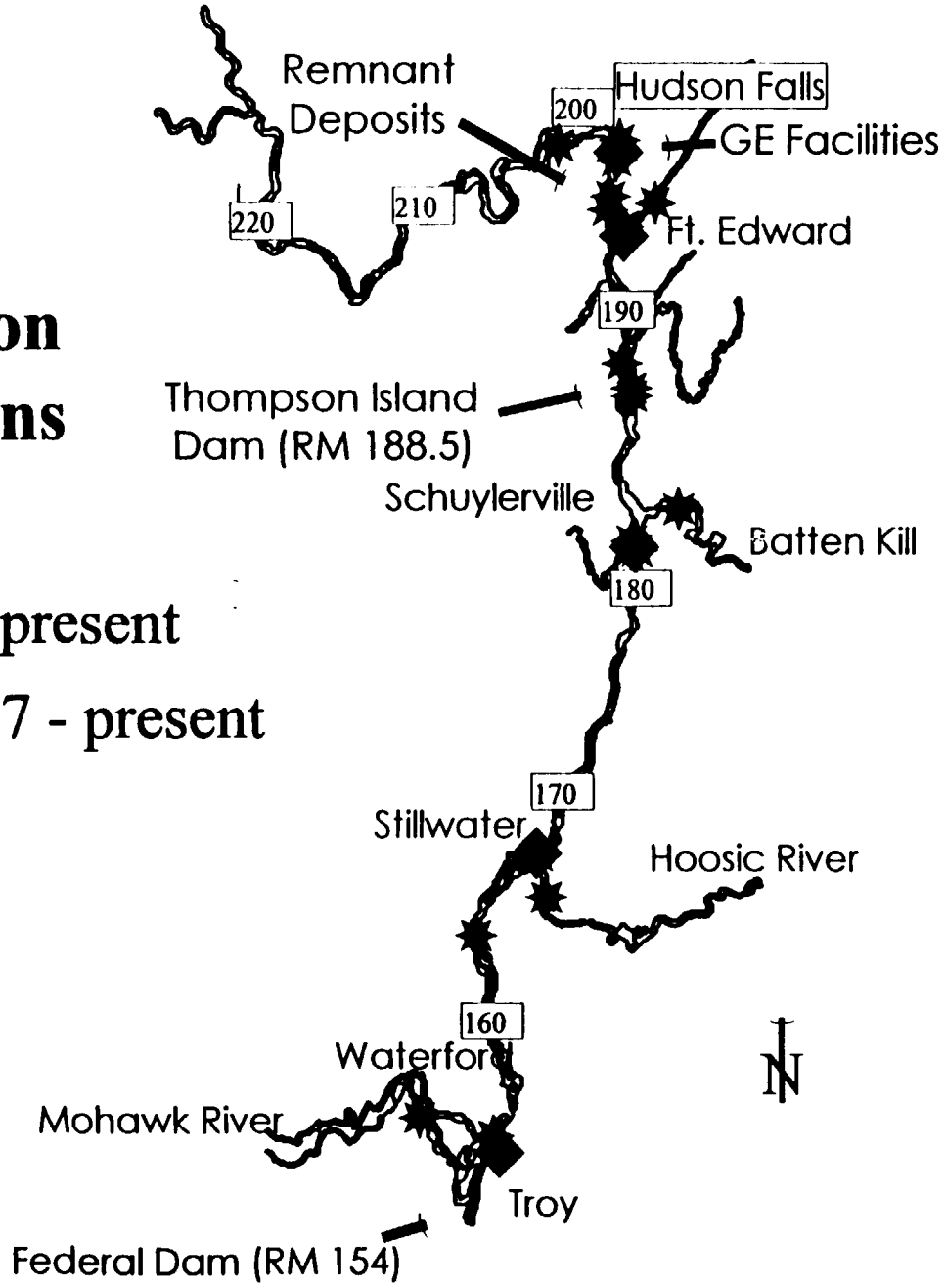
- Sum of congeners with three or more chlorines per molecule
- Provides a consistent basis for the comparison of various analytical techniques for the entire historic record

EPA Phase 2 Sampling Programs

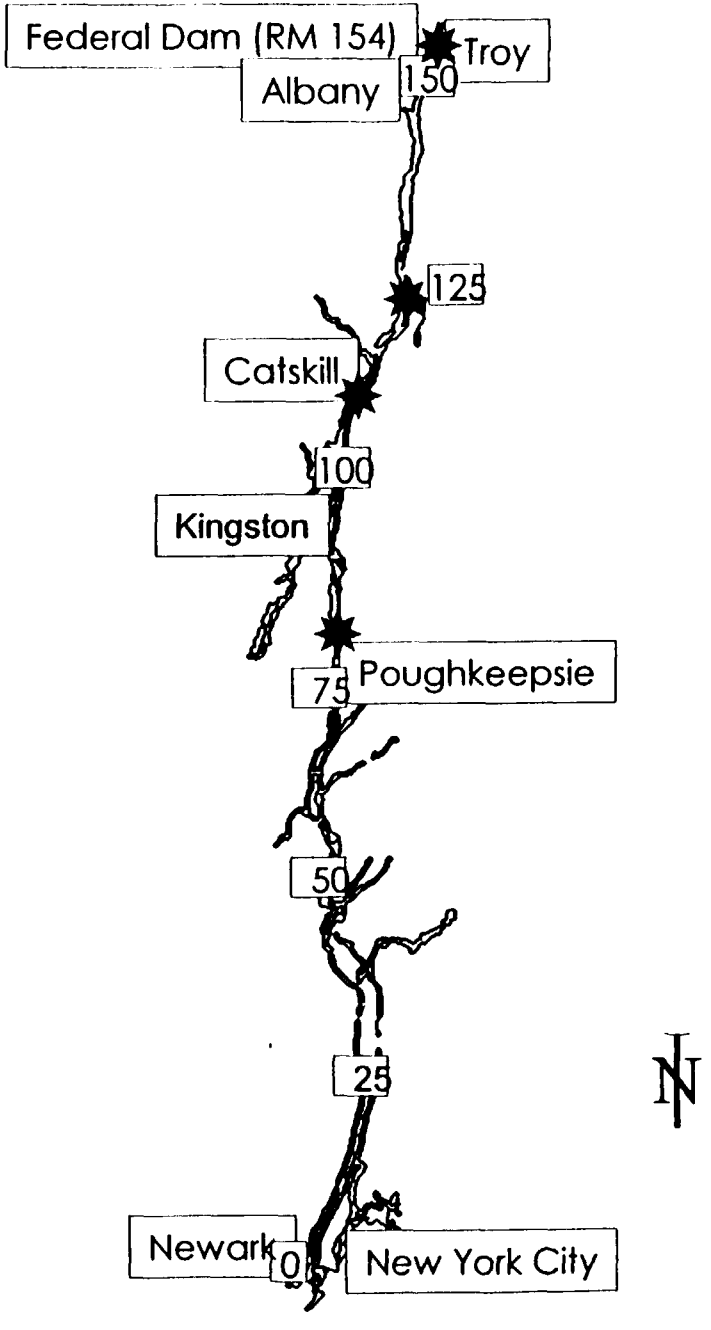
- Water-Column Sampling
- Sediment Sampling
- Geophysical Investigation
- Ecological Investigations

Upper Hudson Water Stations

- ✸ EPA 1993
- ✸ GE 1991 - present
- ◆ USGS 1977 - present



Lower Hudson Water Stations EPA (1993)



High Resolution Sediment Investigation

- High resolution sediment cores were obtained from 28 locations from the Upper and Lower Hudson

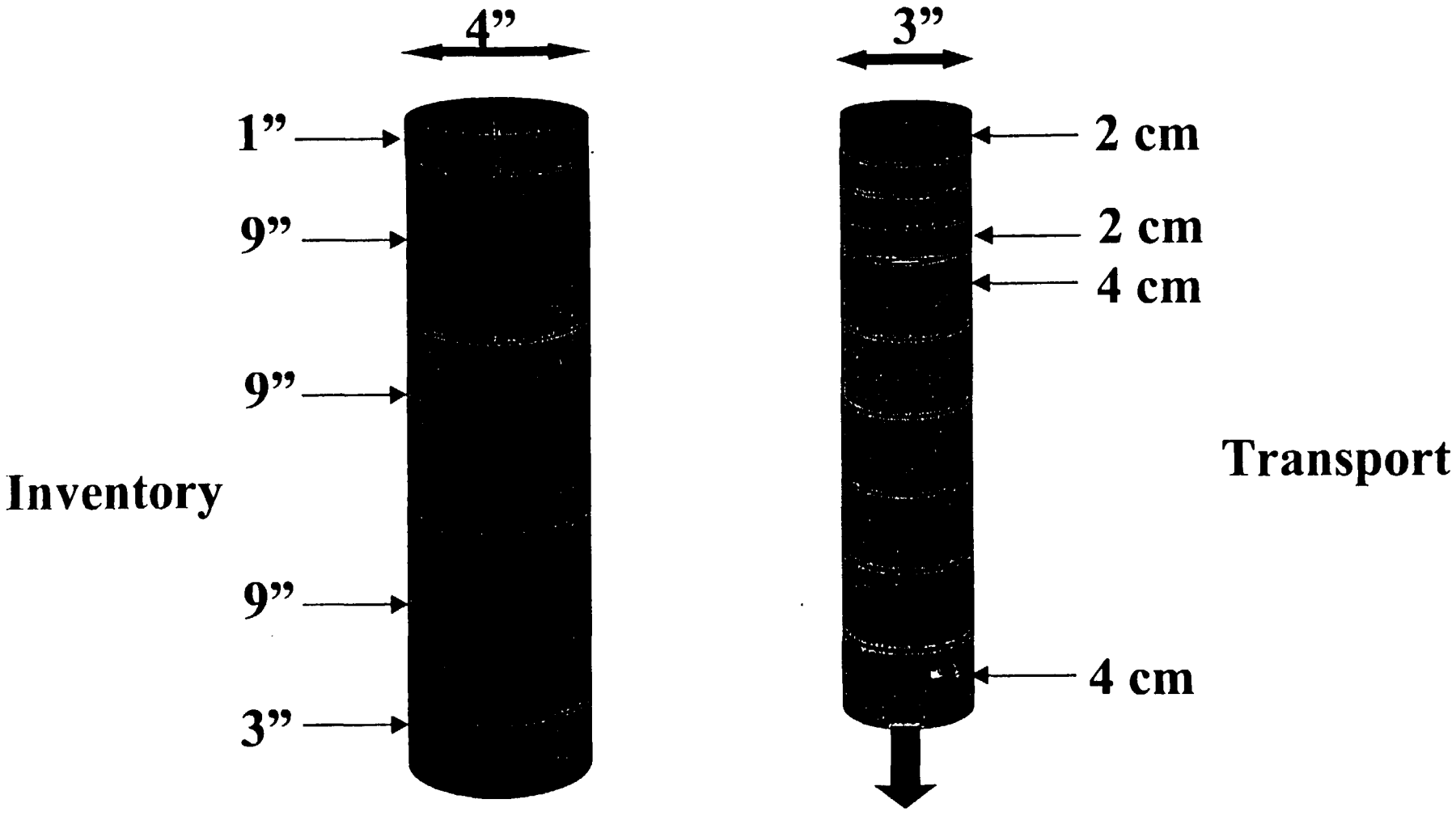
- Sediment cores were sliced into thin layers to examine historical PCB transport as recorded by the sediments

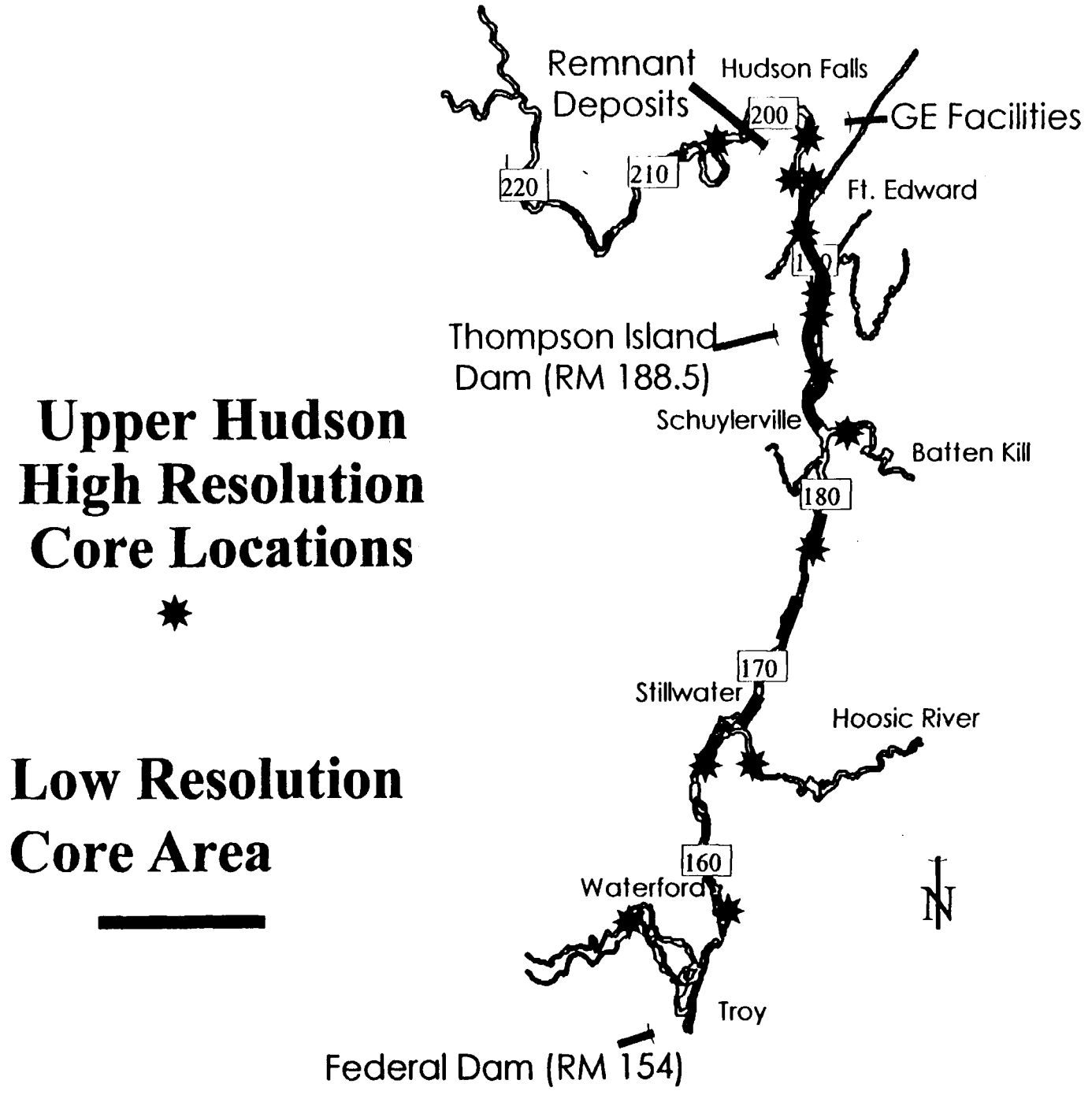
Low Resolution Sediment Coring Program

- Obtain new sediment PCB inventories to compare with 1984 estimates at selected locations in the TI Pool.

- Refine PCB mass estimates at selected hot spots below the TI Dam to compare with 1976 estimates.

Low Resolution v. High Resolution




Upper Hudson
High Resolution
Core Locations
Low Resolution
Core Area
Remnant
Deposits
Hudson Falls
GE Facilities
200
210
220
Ft. Edward
Thompson Island
Dam (RM 188.5)
Schuylerville
Batten Kill
180
170
Stillwater
Hoosic River
160
Waterford
Troy
Federal Dam (RM 154)
N

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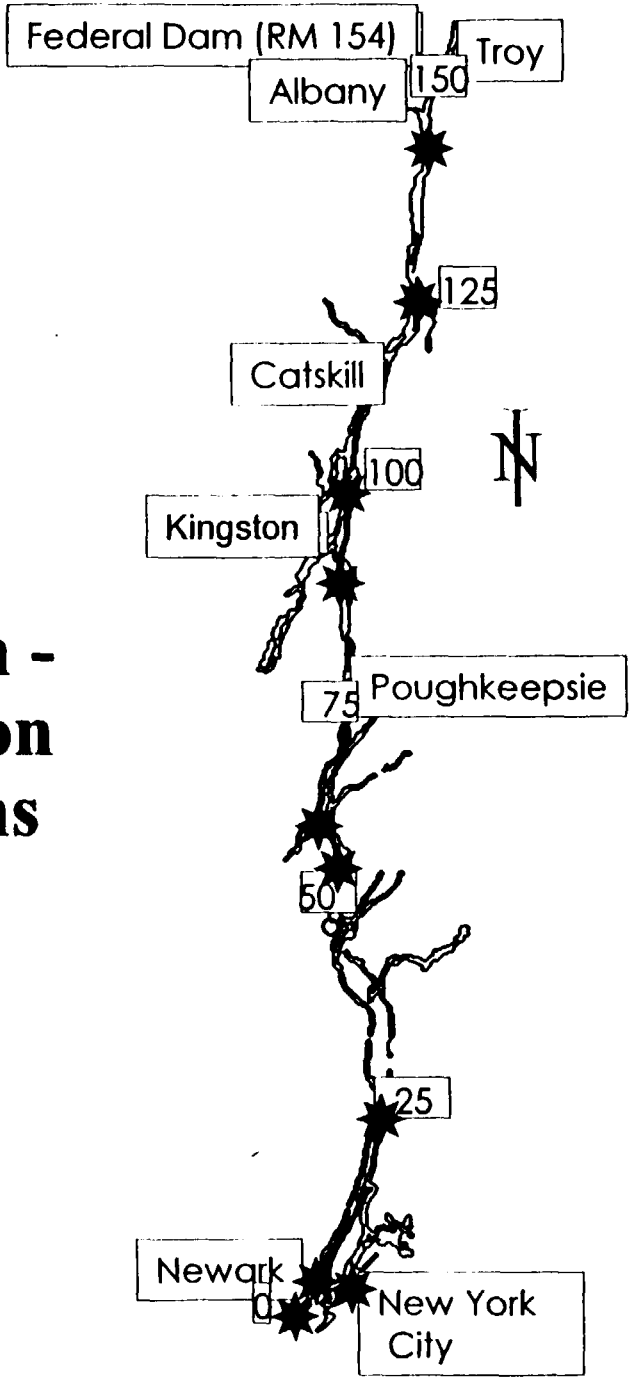
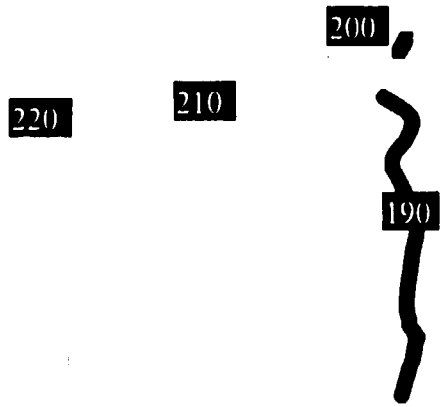
Lower Hudson - High Resolution Core Locations



Geophysical Investigation

- Acoustic signals provide information on sediment texture, bathymetry and layering
  - Side-scan sonar images provide "photographs" of the river bottom

- Confirmatory samples provide confirmation of the sediment classes identified via acoustic signals

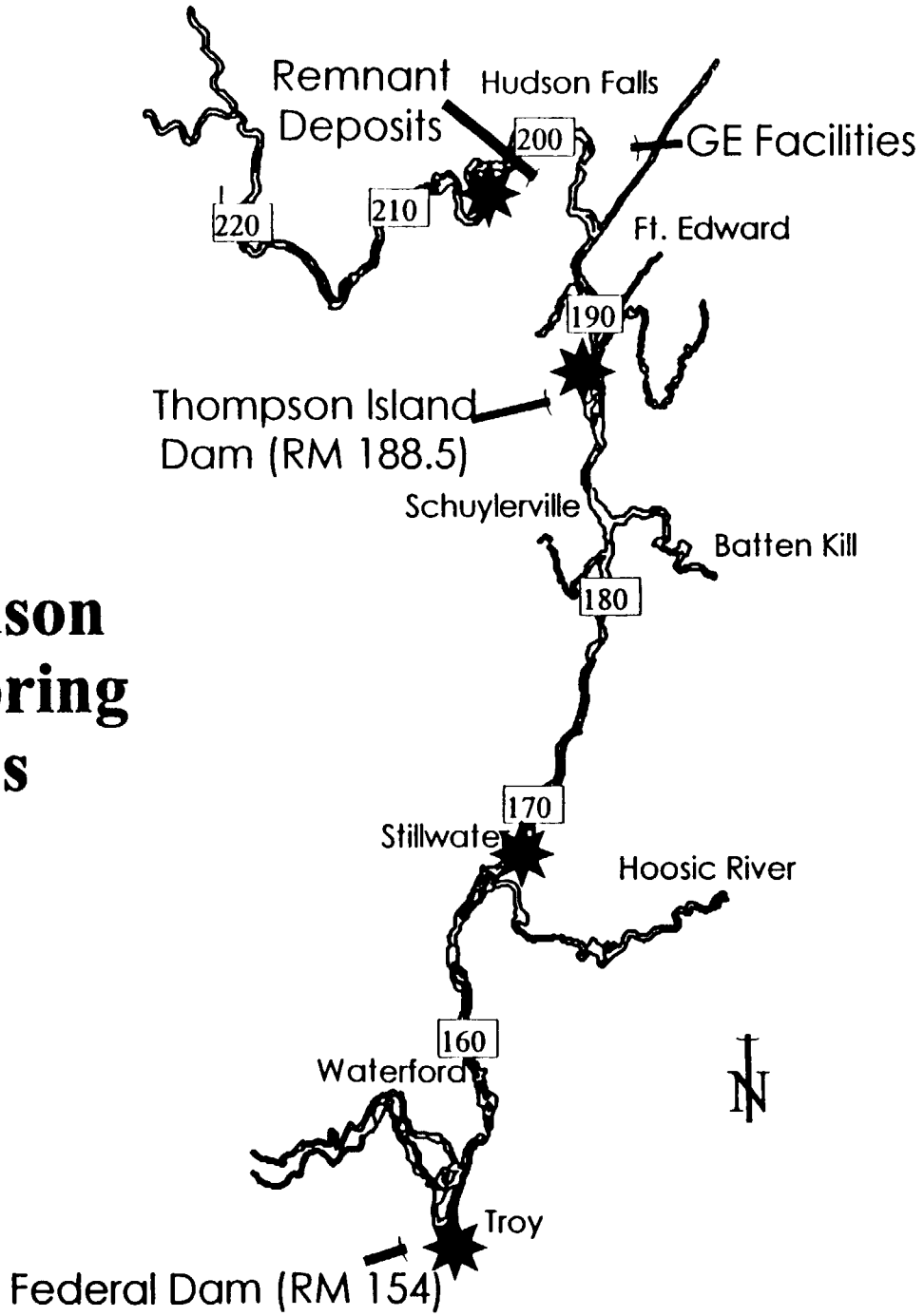


Geophysical Survey Area

Ecological Investigations

- EPA Phase 2 (1993)
  - Sediment sampling
  - Benthic invertebrates
  - Fish
- NYSDEC Fish Monitoring
- NOAA/NYSDEC Fish (1993 and 1995)
- USF&W Tree Swallow Study
- NYSDOH Multiplate Sampling

Upper Hudson Fish Monitoring Locations



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Summary

Upper Hudson River

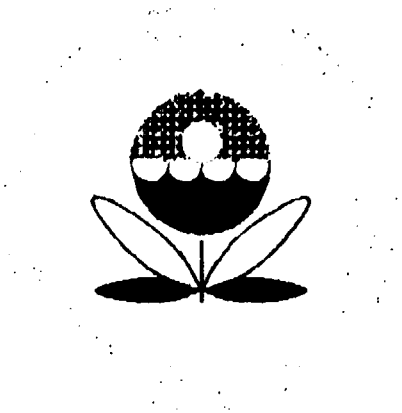
Thompson Island Pool	Reaches Below TI Dam
– Upper 6 miles	– Lower 34 miles
– 1 dam	– 6 dams
– 40% of PCB mass	– 60% of PCB mass
– Higher sediment concentrations	– Lower sediment concentrations

Lower Hudson River

153 miles, no dams, tidal, large PCB mass inventory at low concentrations

Hudson River PCBs Reassessment

Findings from Previous Reports



Geochemistry

Data Evaluation and Interpretation Report (DEIR)
Low Resolution Sediment Coring Report (LRC)

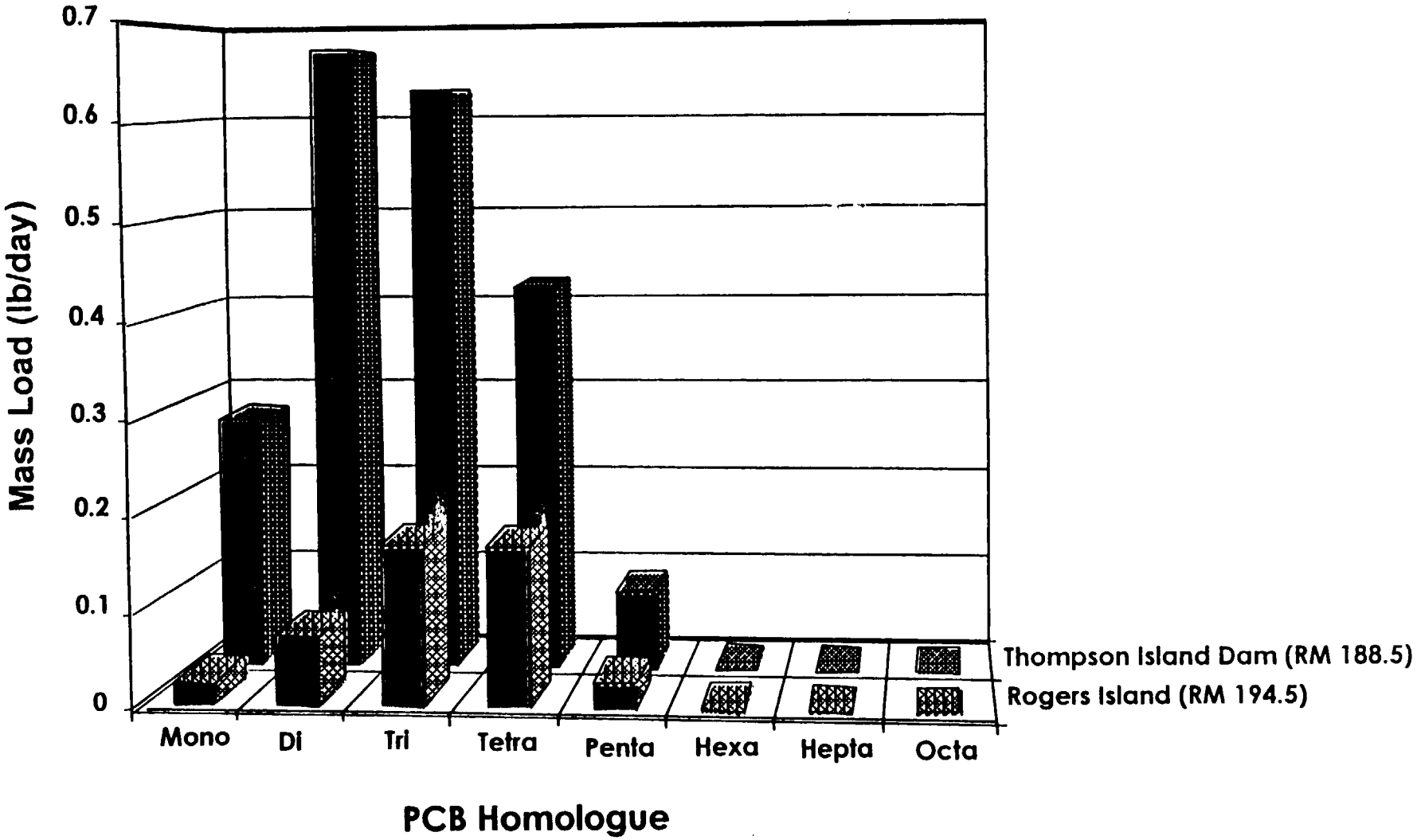
- water-column transport
- dechlorination
- burial
- sediment inventory

Water-Column Transport

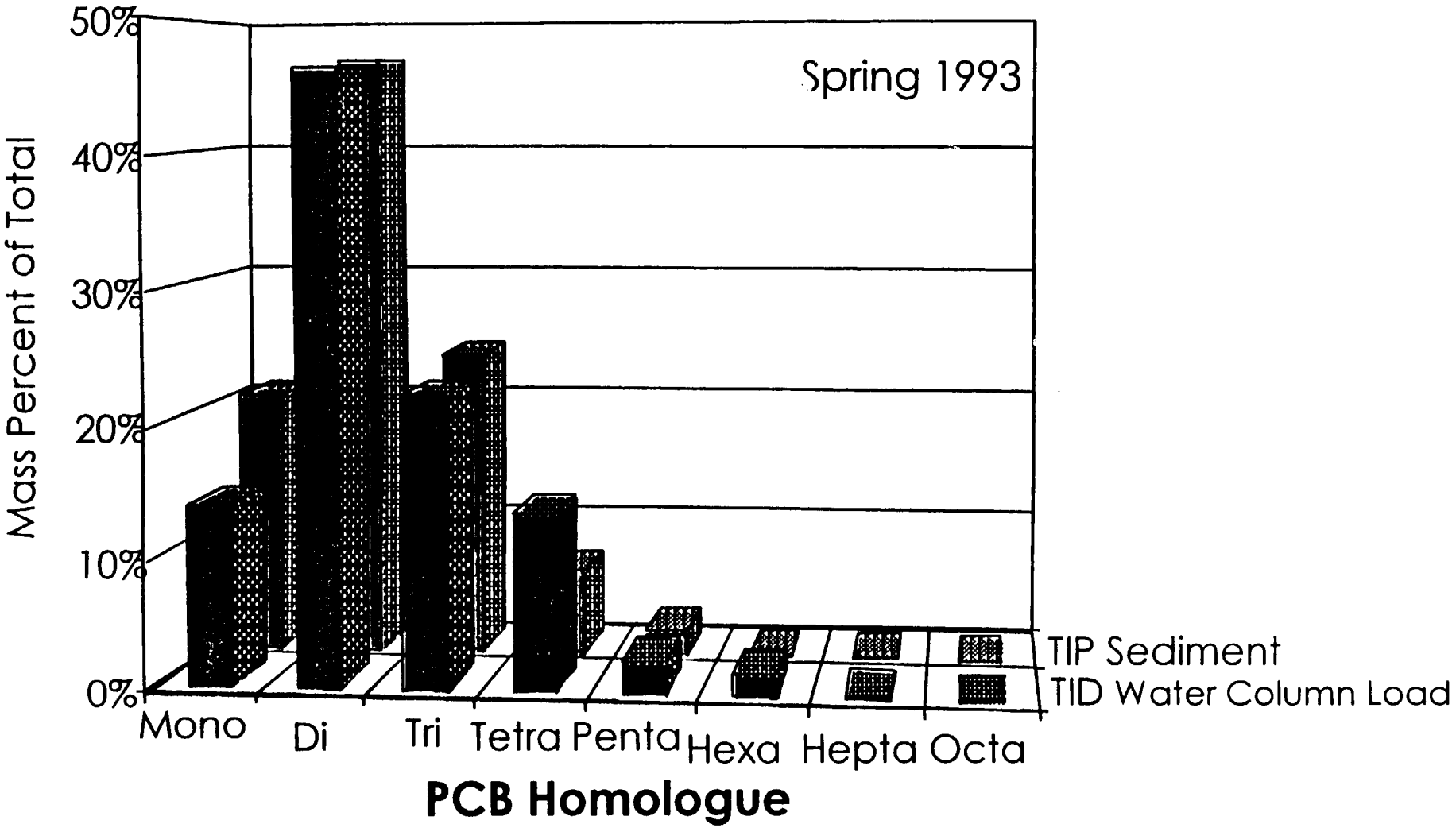
- The increased PCB load across the Thompson Island Pool (TIP) has a readily identifiable homologue pattern which originates from the sediments within the pool.

- The Thompson Island Pool load dominates the water-column load in the freshwater Hudson during low-flow conditions (10 months of the year).

The Thompson Island Pool sediments are a major source of PCBs to the freshwater Hudson.



Phase 2 Mean Summer Water Column PCB Loads (1993)

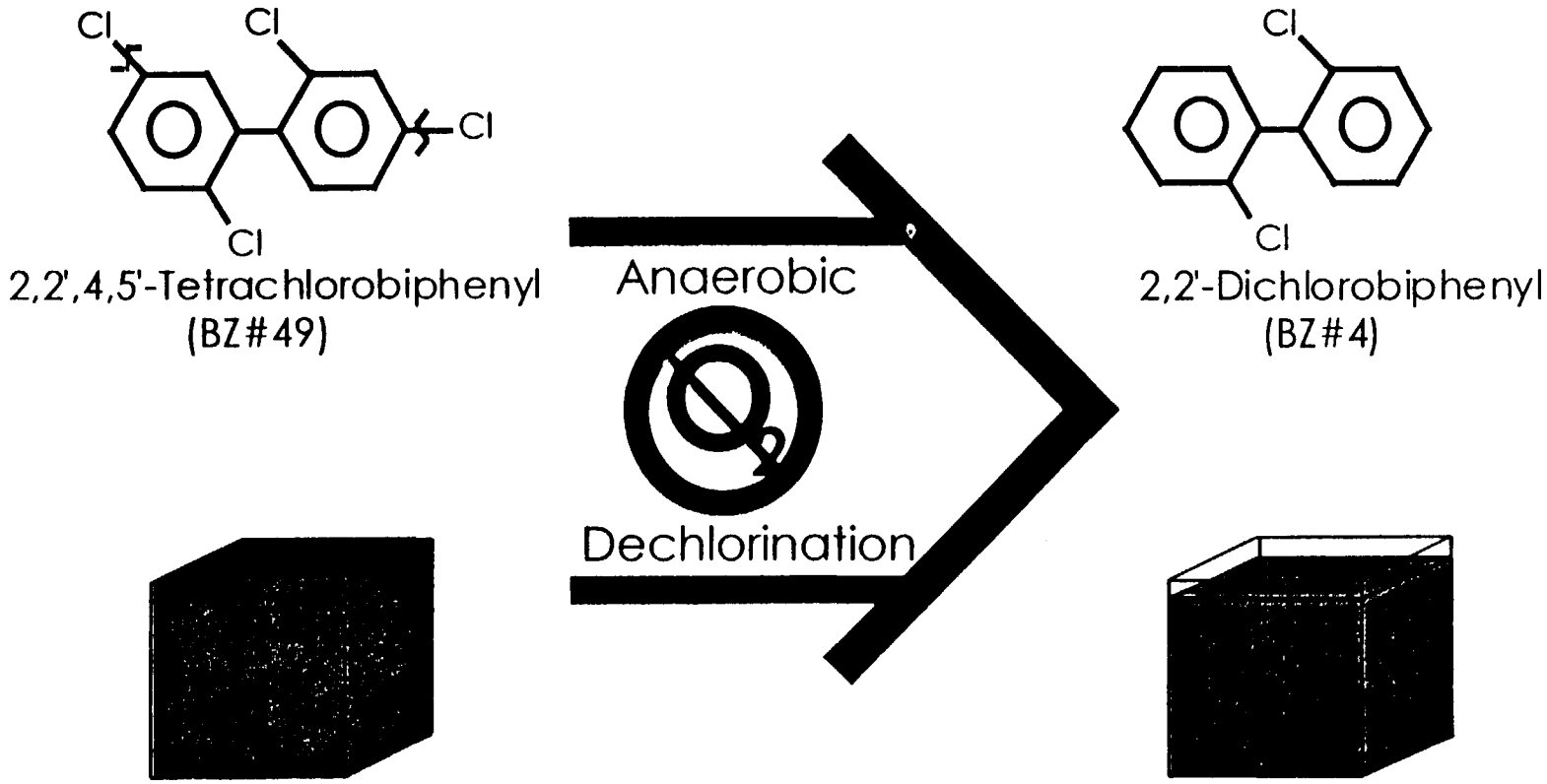


The PCB load from the Thompson Island Pool originates from the sediments within the Pool.

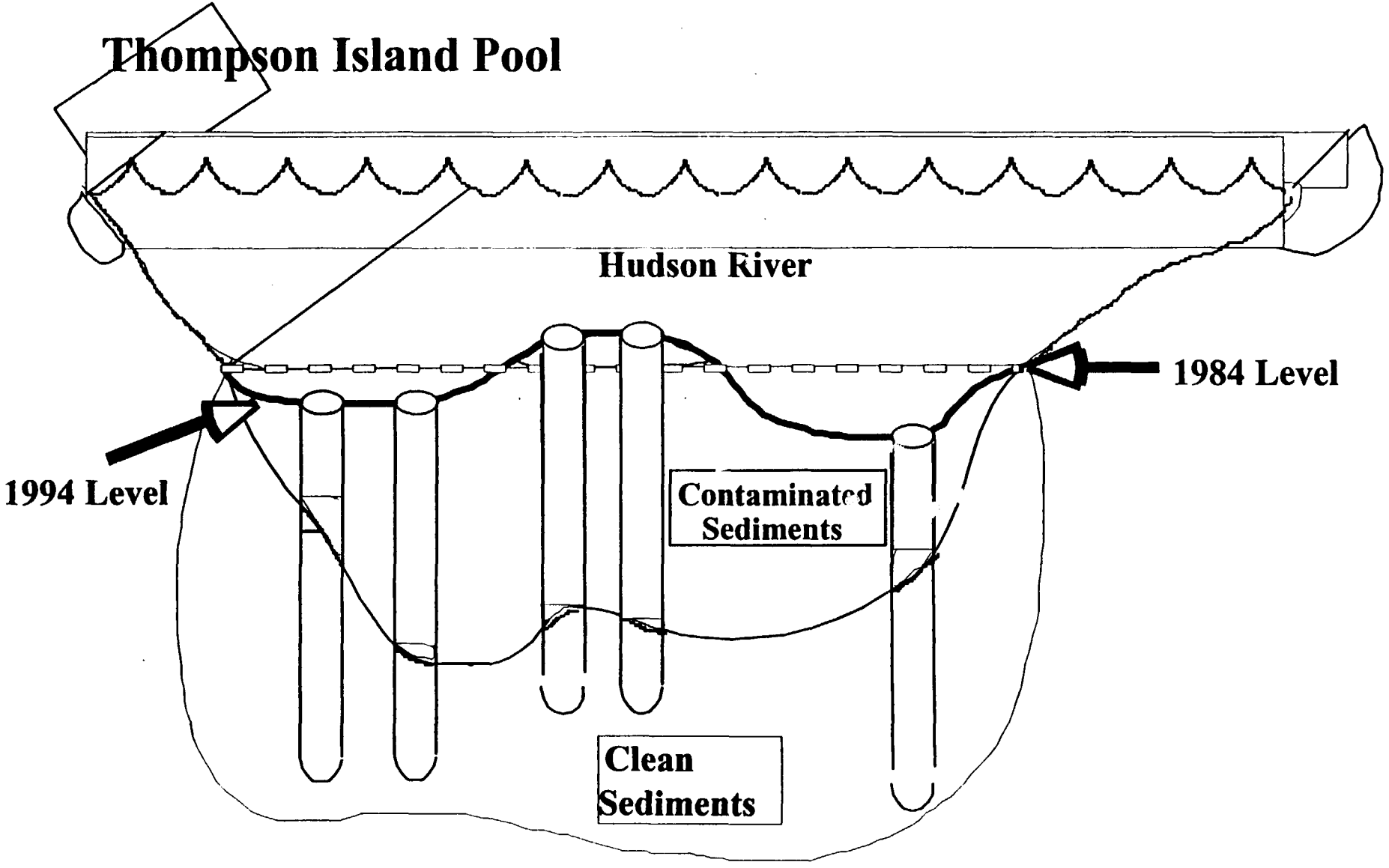
Dechlorination

- The extent of dechlorination is limited in the sediments, resulting in probably less than 10 percent mass loss from the original concentrations.
- Extent of dechlorination controlled by concentration, not time.
- Dechlorination occurs relatively quickly (several years), then rate becomes negligible.
- Even with "extensive" dechlorination, fish are still bioaccumulating Aroclor 1248-like PCBs (with 3, 4 and 5 chlorine atoms).

Sediment inventories will not be naturally "remediated" via dechlorination.


Cl
Cl
Cl
Cl
2,2',4,5'-Tetrachlorobiphenyl
(BZ#49)
Anaerobic
Dechlorination
Cl
Cl
2,2'-Dichlorobiphenyl
(BZ#4)
Mass Before
Dechlorination
Mass After
Dechlorination

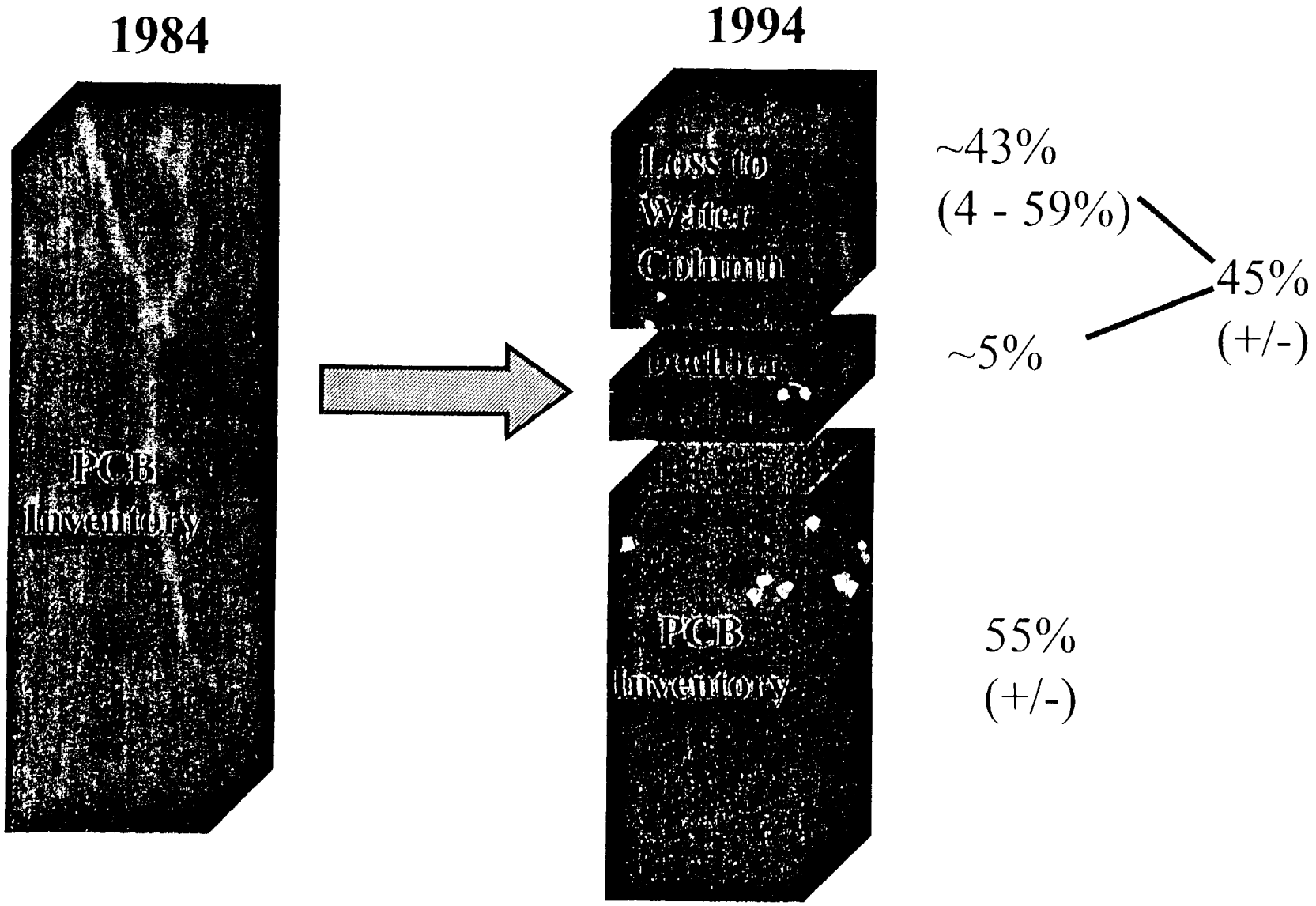
Thompson Island Pool



Sediment Inventory of PCBs

- From 1984 to 1994, there has been a statistically significant loss of PCB inventory (between 4 and 59 percent) from highly-contaminated sediments in the Thompson Island Pool (>10 g/m^2).

PCBs in the most highly contaminated areas are being redistributed within the river.


1984
1994
PCB
Inventory
Loss to
Water
Column
PCB
Inventory
~43%
(4 - 59%)
~5%
45%
(+/-)
55%
(+/-)

Modeling Findings

- Revised Baseline Modeling Report (January 2000)
    - Supercedes Baseline Modeling Report (May 1999)
- Responsiveness Summary to Baseline Modeling Report issued February 2000
- Peer Review underway--to be completed March 28

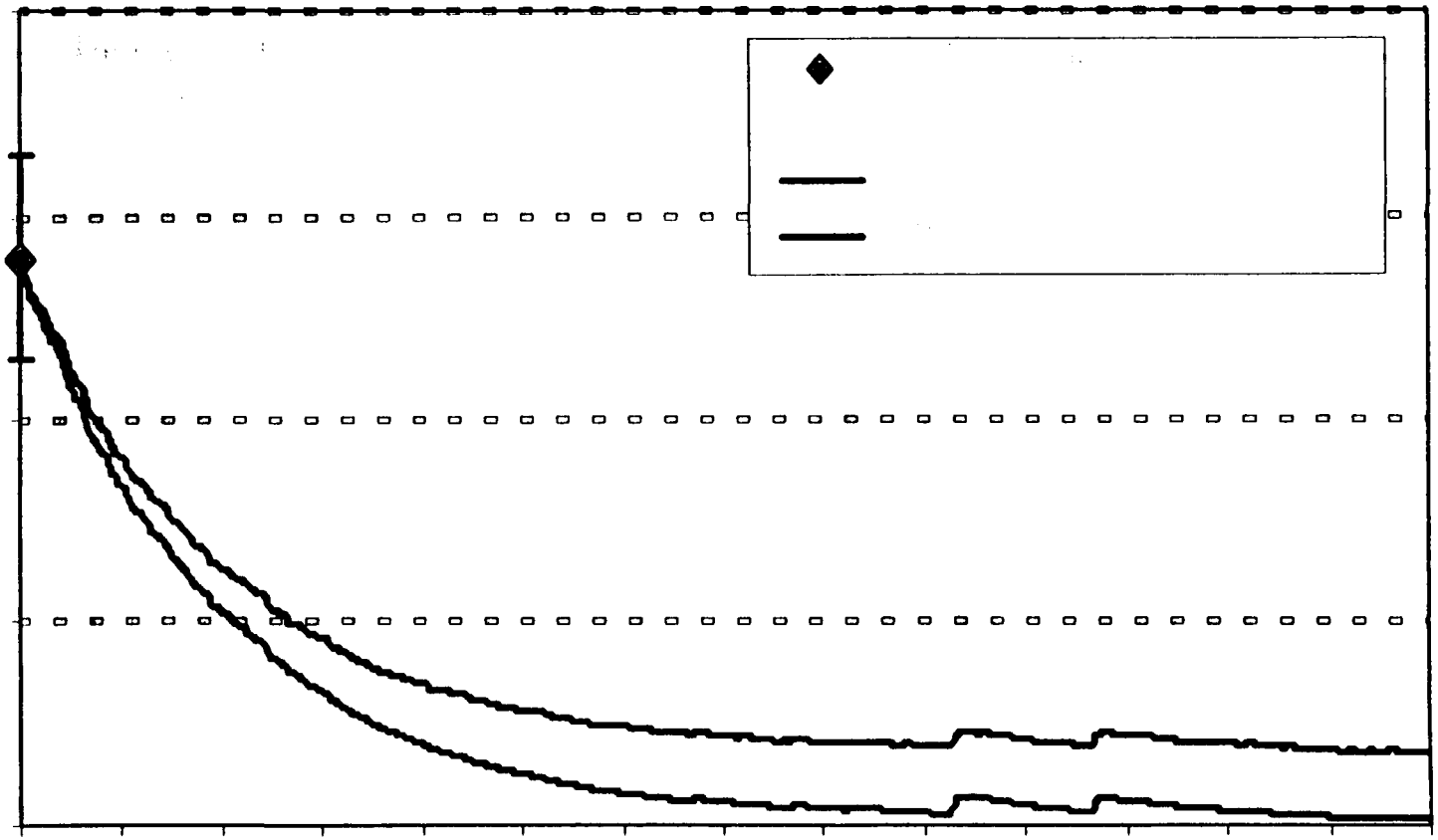
Modeling - Source Contribution

For the first two to three decades of the model forecast, depending on location, the in-place PCB (Tri+) reservoir in the sediments and sediment-water transfer processes control responses of surface sediment concentrations.

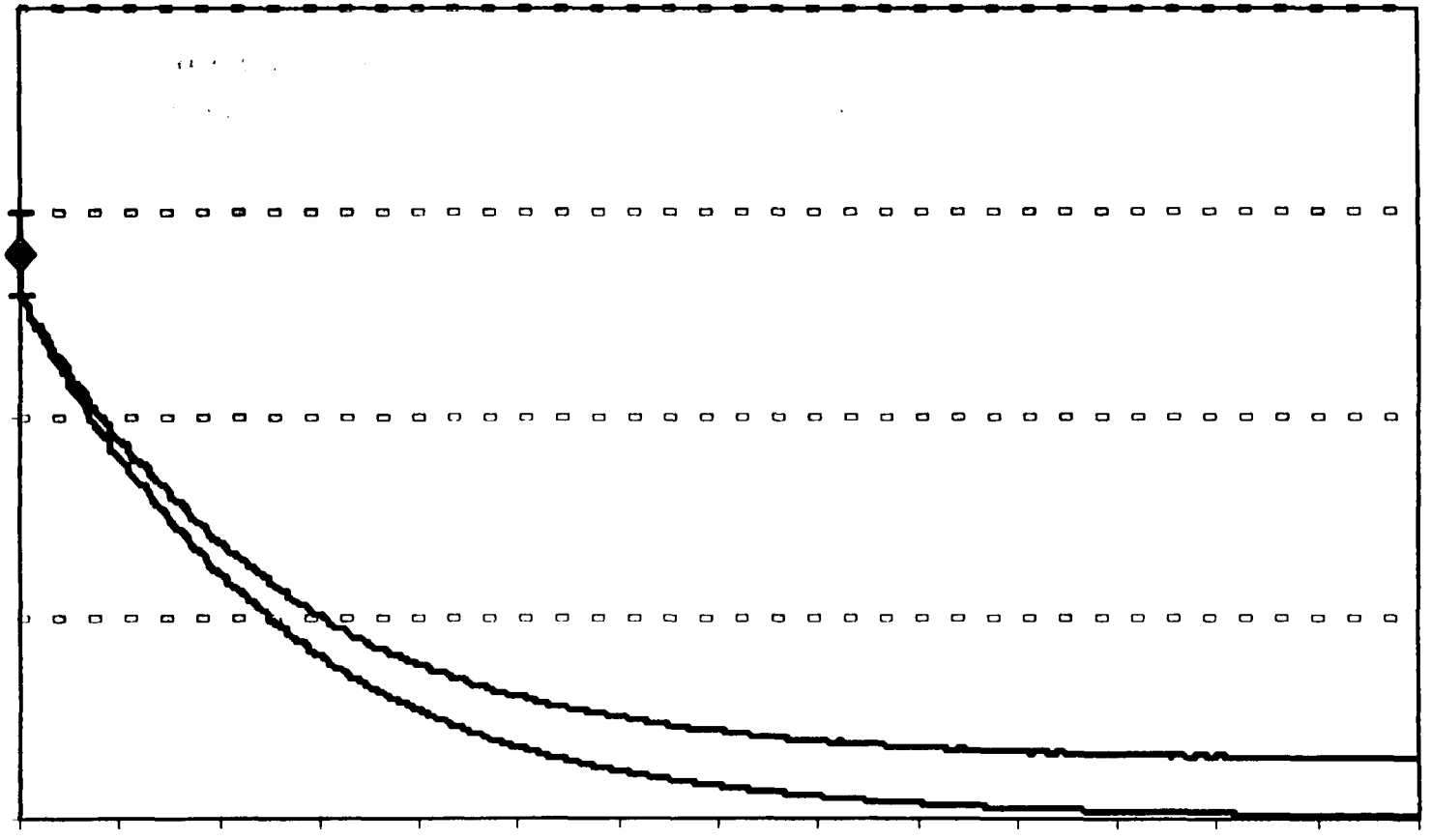
PCB (Tri+) loads from upstream of the model boundary at Fort Edward (*e.g.*, GE Hudson Falls Plant site) control the long-term responses of PCB (Tri+) concentrations in the water column and surface sediments, and accordingly, body burdens in fish.

Upstream loads control the long-term rate of recovery in the river.

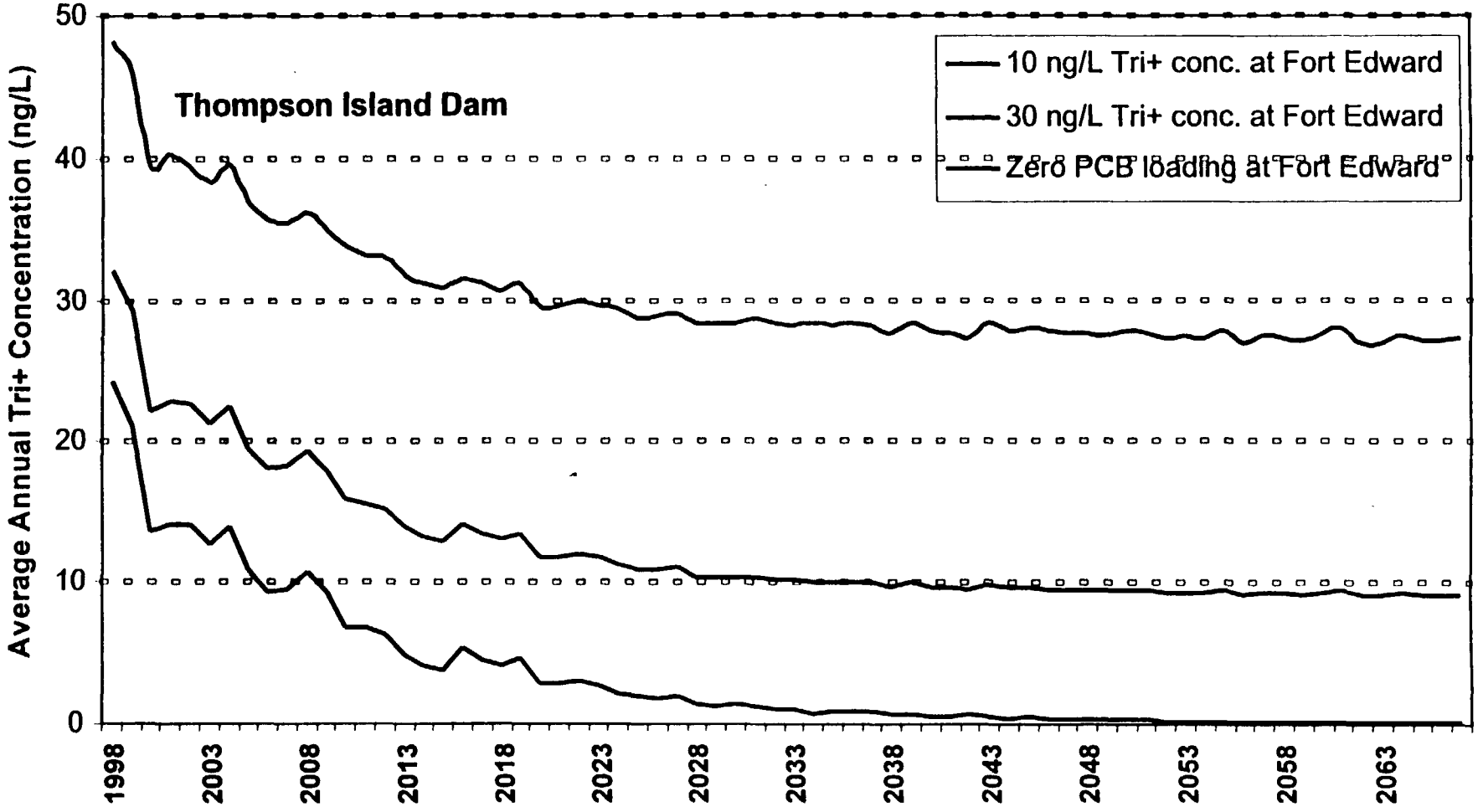
Forecast Surface Sediment Tri+ Concentrations for Thompson Island Pool (Cohesive)



Forecast Surface Sediment Tri+ Concentrations for Thompson Island Pool (non-cohesive)



Forecast Annual Average Water-Column Tri+ Concentrations at Thompson Island Dam



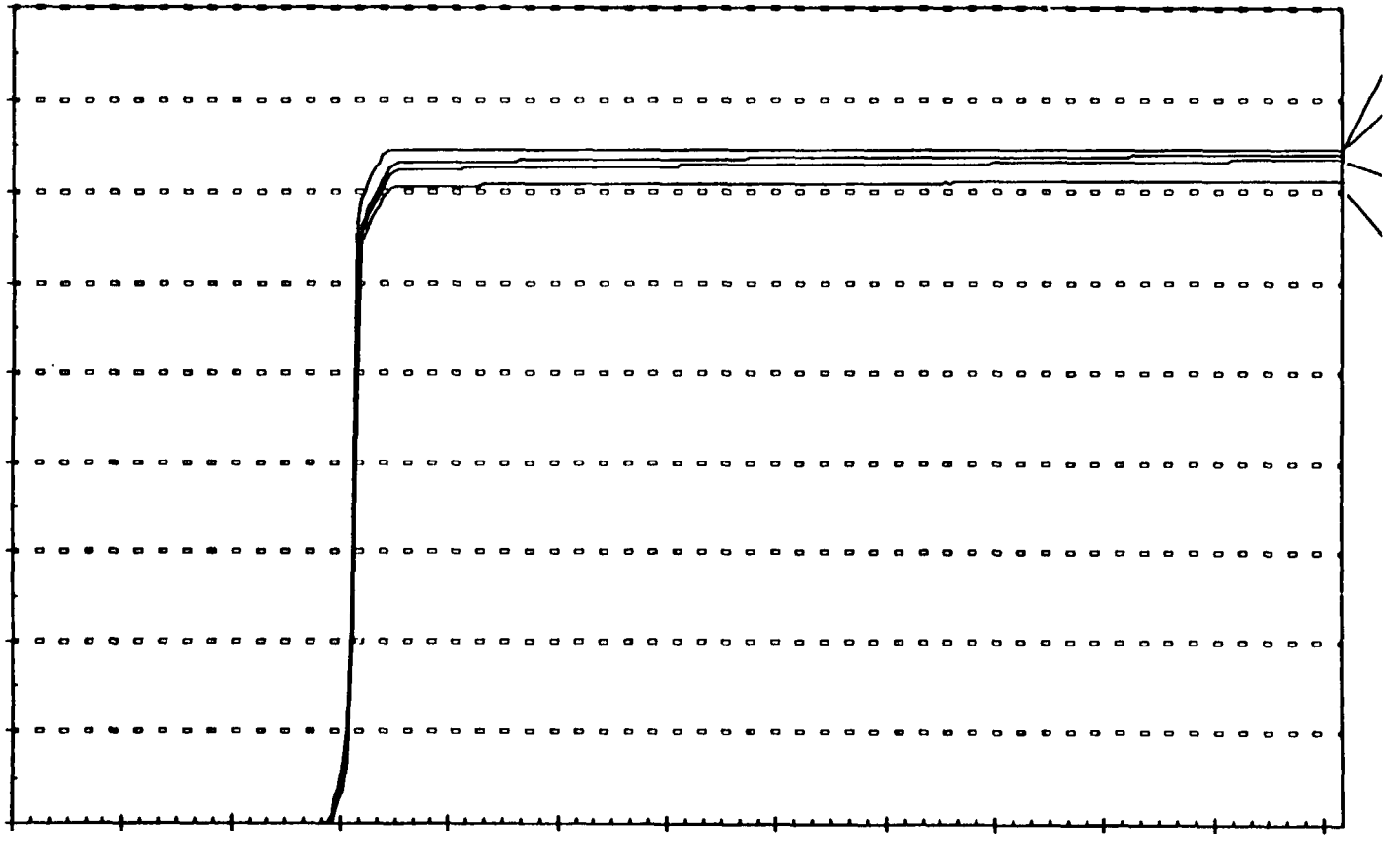
Modeling - Major Floods

A 100-year flood would not yield substantial impacts on the PCB levels in the Upper Hudson River.

- 60 lbs of PCBs lost from Thompson Island Pool
- Impact of flood on water-column PCB levels is minimal after one year.

100-year flood scenario not a critical factor.

Cumulative Net Increase in Tri+ Mass Loading Due to 100-Year Peak Flow, Relative to No Action



Modeling - Burial (Sequestering)

Thompson Island Pool: net deposition of sediment, but losses of PCBs from the sediment

- From 1984 - 1994, the model estimated that ~2000 kg of PCBs (Tri+) were lost from the Thompson Island Pool sediments, while at the same time ~2 cm of net sediment deposition occurred across the pool.

Burial does not isolate PCBs in the sediments.

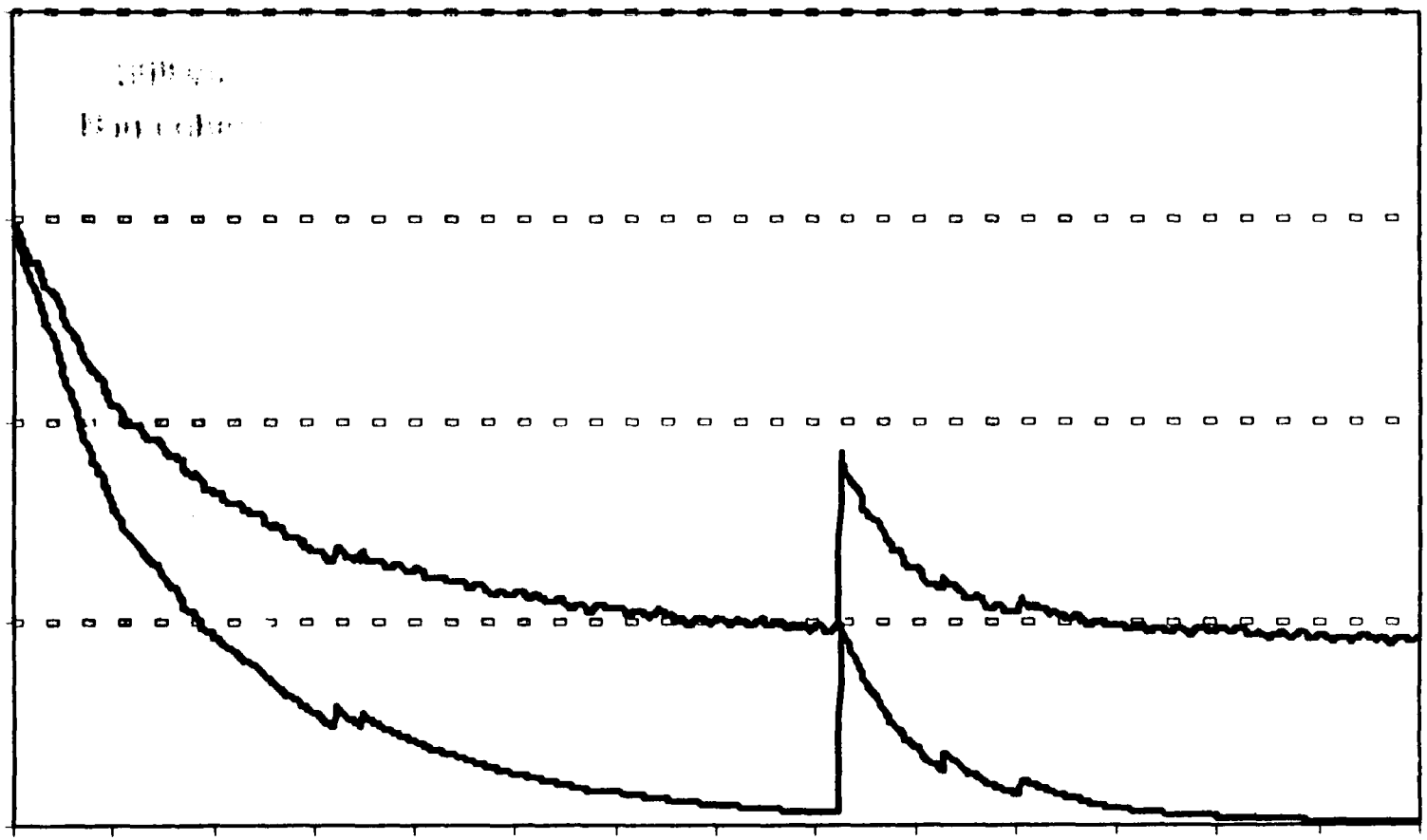
Modeling - Sediment Erosion

Forecasts show that relatively small annual erosion rates eventually, over an extended length of time, expose PCB concentrations in localized areas that were previously at depth.

- The occurrence, magnitude and timing of these computed increases are dependent on forecast assumptions.
- It is reasonable to assume that localized erosion occurs within the river, but at scales smaller than the spatial scale of the model. Therefore, the model may not accurately reflect the areal extent of such erosion or its timing.

Localized erosion can occur even if the river reach is net depositional

Forecast Surface Sediment Tri+ Concentrations for Stillwater Reach



Modeling - Uncertainty

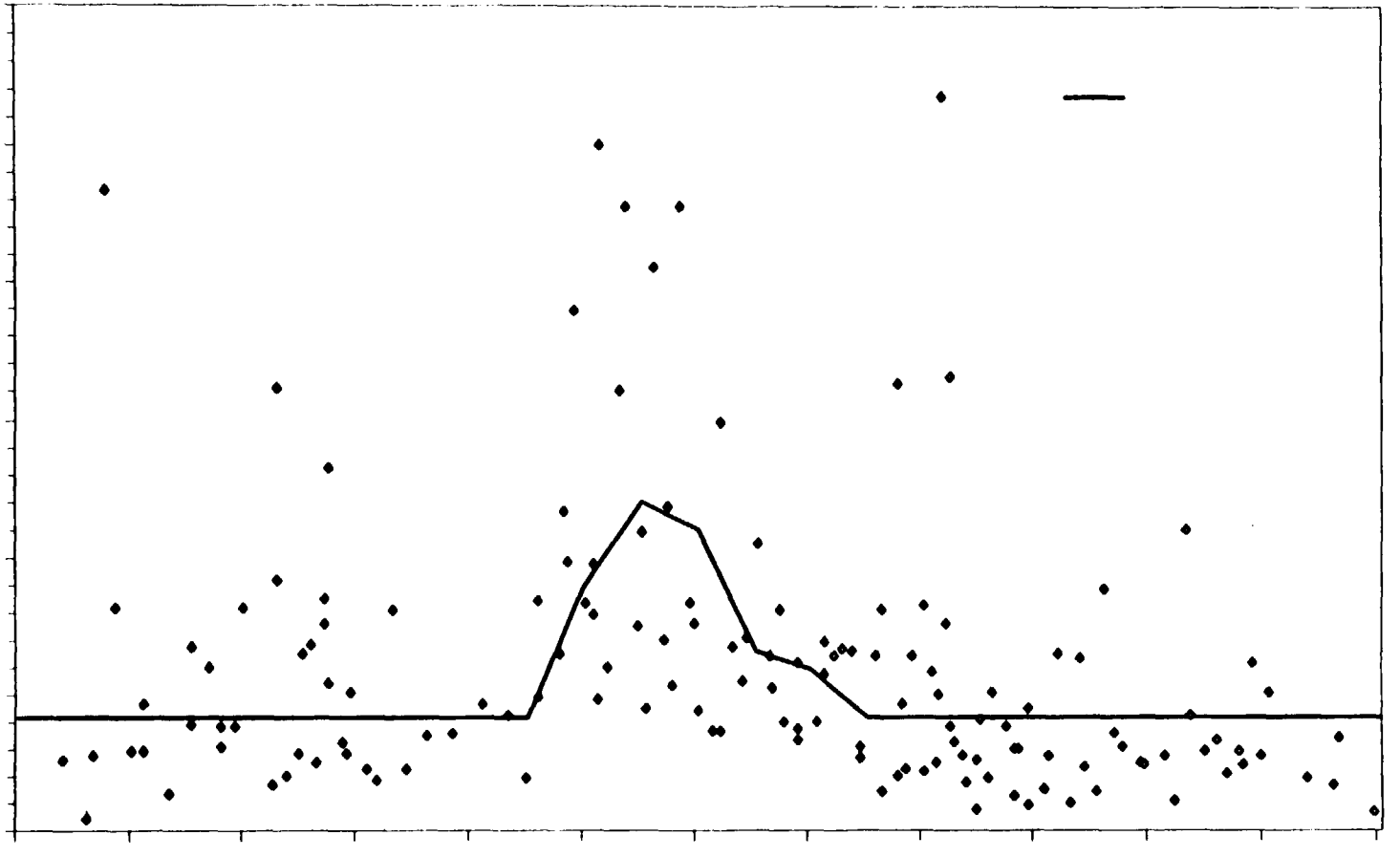
There is a substantial contribution of PCBs from the sediment that is not dependent on the flow of the river.

- The mechanism for non-flow dependent transfer is not fully understood and had to be estimated empirically.

- The empirical PCB sediment-water transfer is approximately 50 percent of the PCB loading to the water column in the Thompson Island Pool.

Sediment-water exchange of PCBs is not fully understood.

Data Based Sediment-Water Mass Transfer Rate in Thompson Island Pool, 1993-1997



Modeling - Forecasts of Fish Tissue Concentrations

- Small differences in target levels can make decadal changes in the time it takes to reach target levels
- Appropriate target levels will be identified in the Feasibility Study

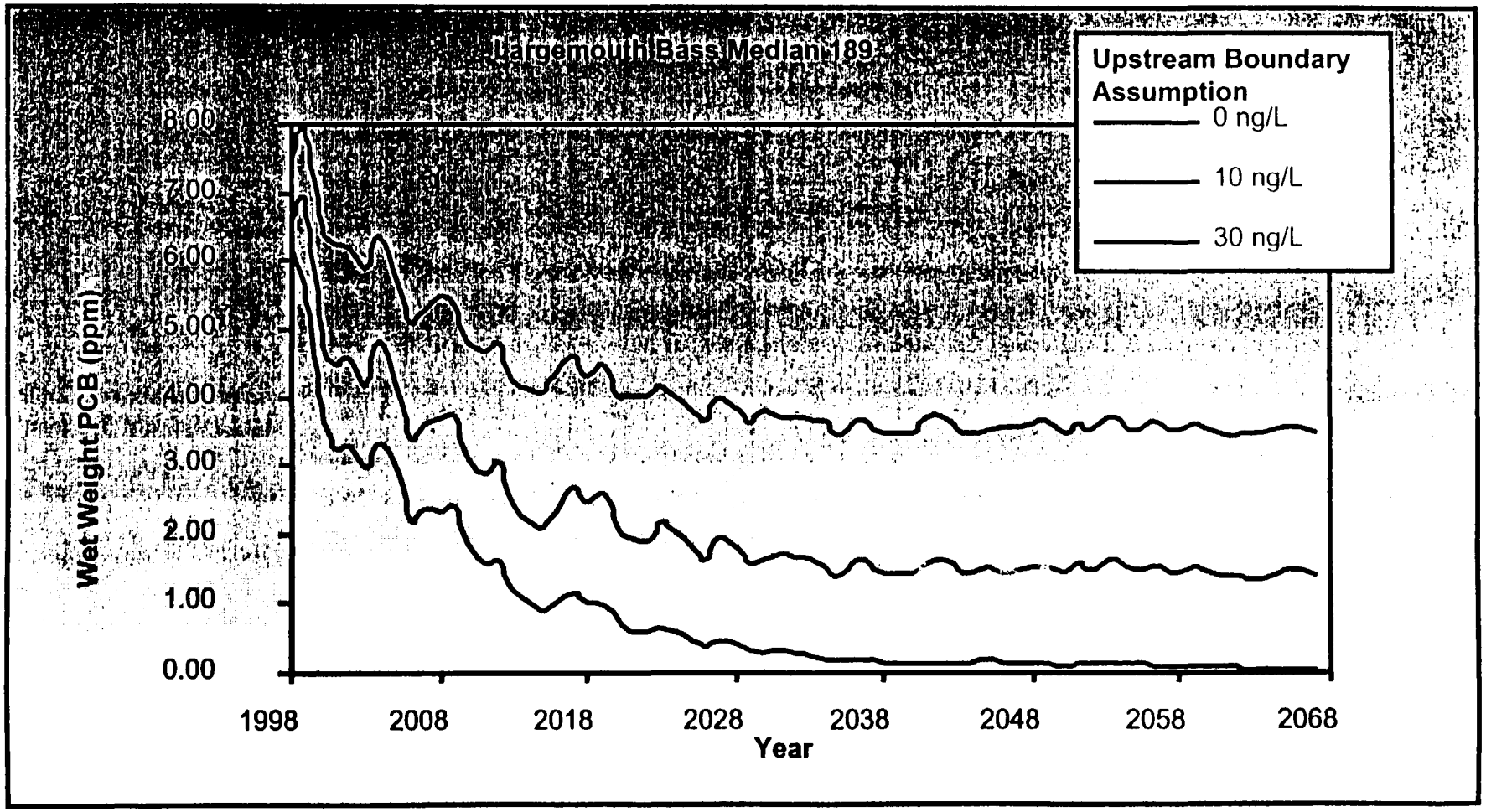
Time to reach target level is dependent on target level selected.

Relative Importance of Sediment and Water

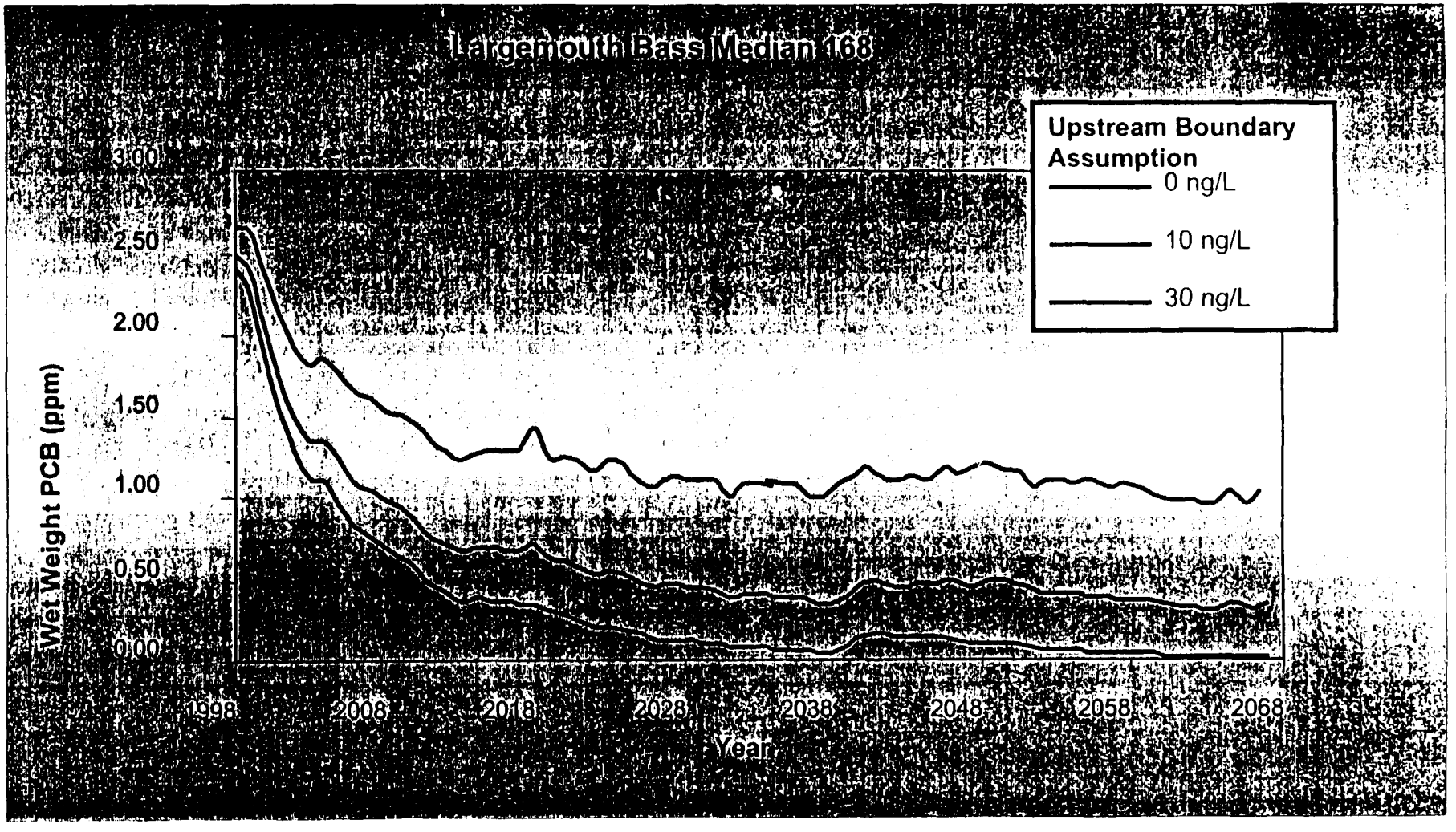
	Brown Bullhead	Largemouth Bass	Pumpkinseed
Elasticities			
Dissolved Water (ng/l)	0.05	0.27	0.77
Sediment (mg/kg)	0.95	0.73	0.23

(Coefficients obtained using average-based steady-state model results in linear regression)

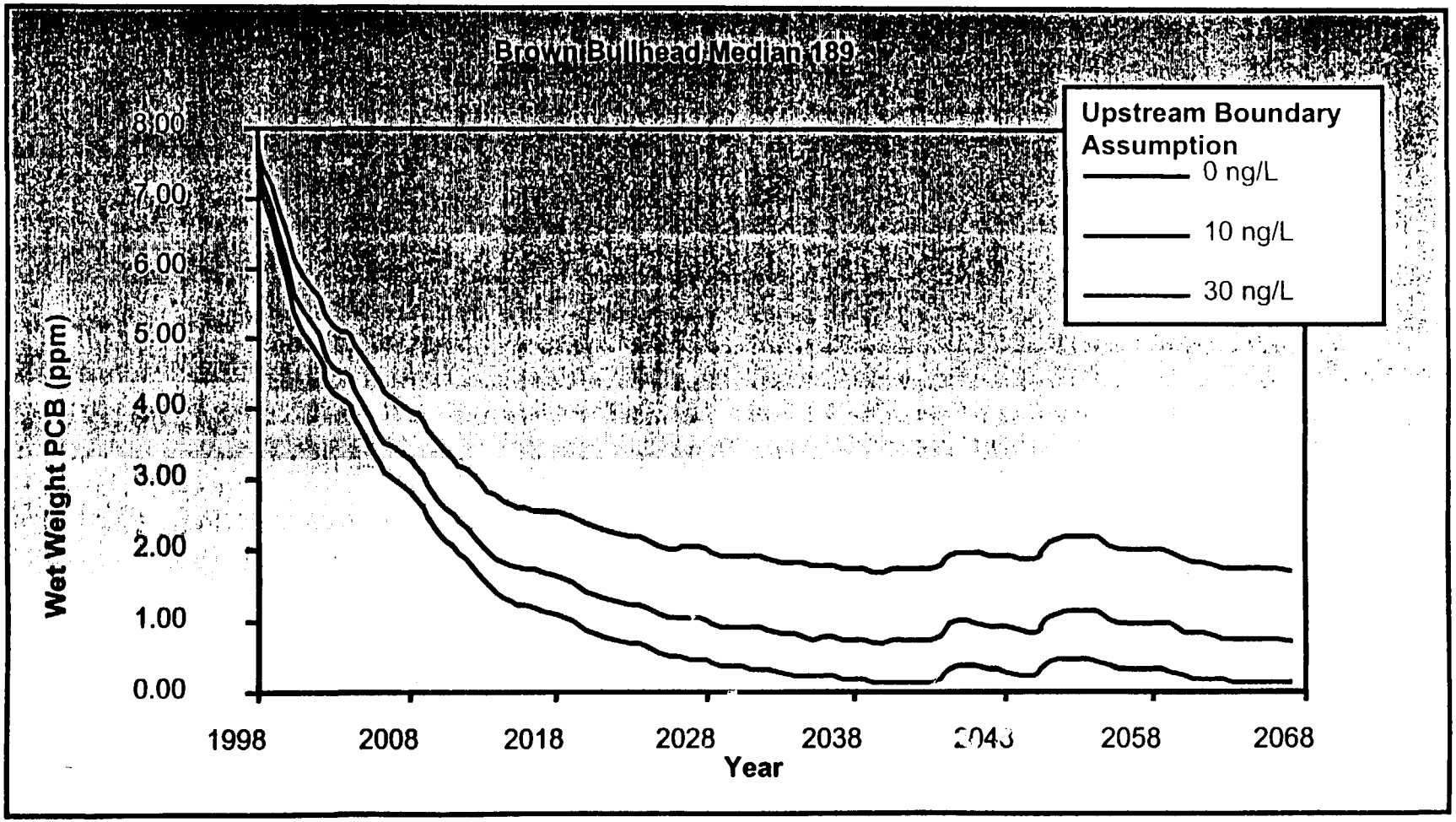
FISHRAND Forecasts 1998 - 2067 for RM 189 (TIP)



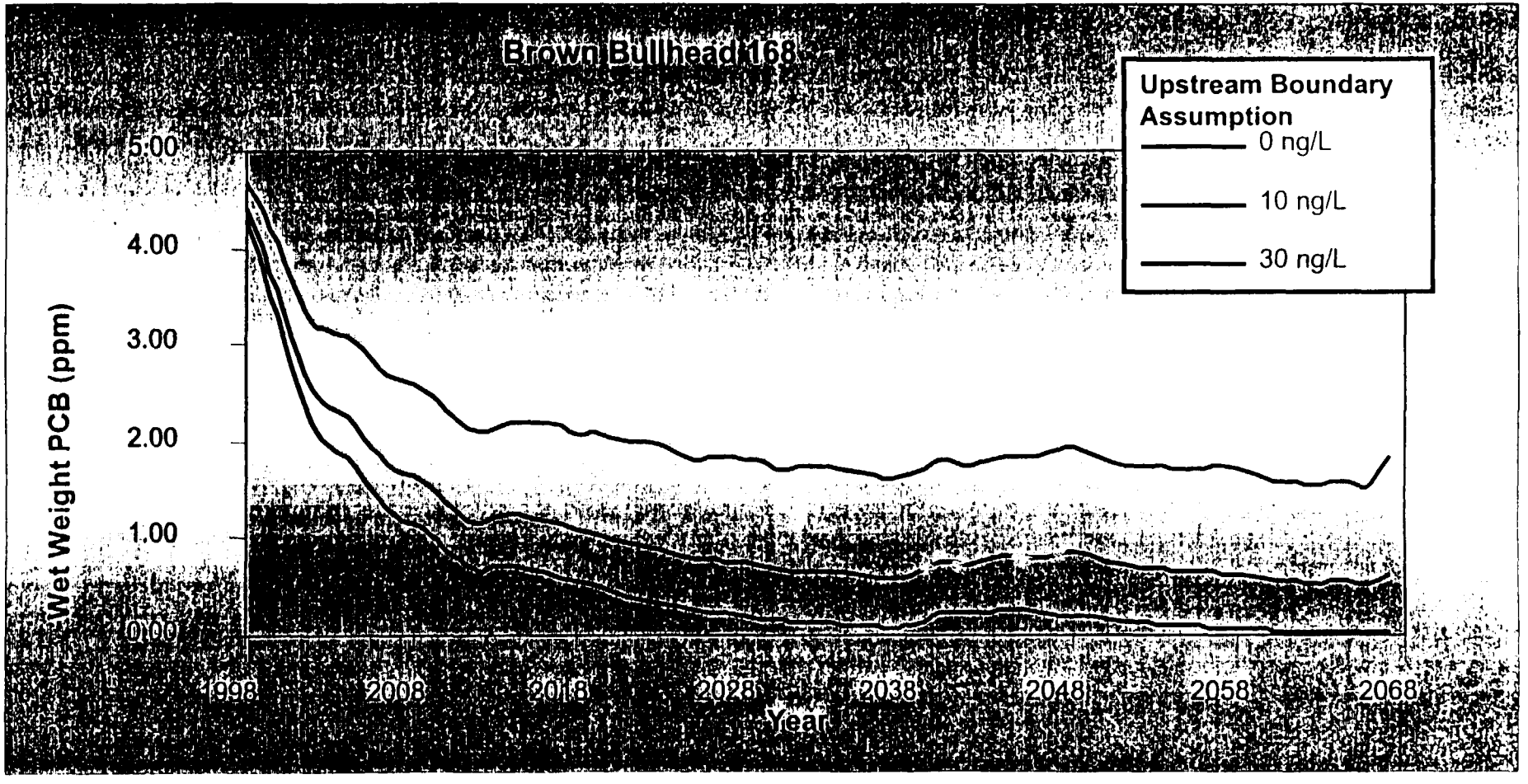
FISHRAND Forecasts 1998 - 2067 for RM 168 (Stillwater)



FISHRAND Forecasts 1998 - 2067 for RM 189 (TIP)



FISHRAND Forecasts 1998 - 2067 for RM 168 (Stillwater)



Summary of Findings

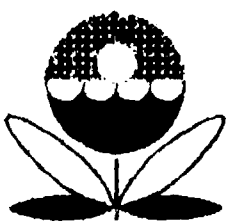
- TIP sediment is the major source of PCBs to the water column
- Dechlorination is not sufficient
- Burial does not isolate PCBs in sediment
- If unabated, PCB loads from upstream of the Thompson Island Pool control the long-term response of the system

Hudson River PCBs Reassessment

Human Health Risk Assessment

Upper Hudson - August 1999

Mid-Hudson - December 1999

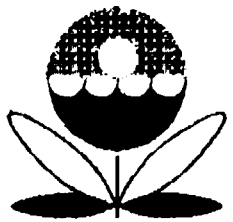


Hudson River PCBs Reassessment

Ecological Risk Assessment

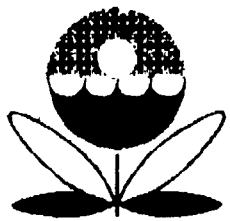
Upper Hudson - August 1999

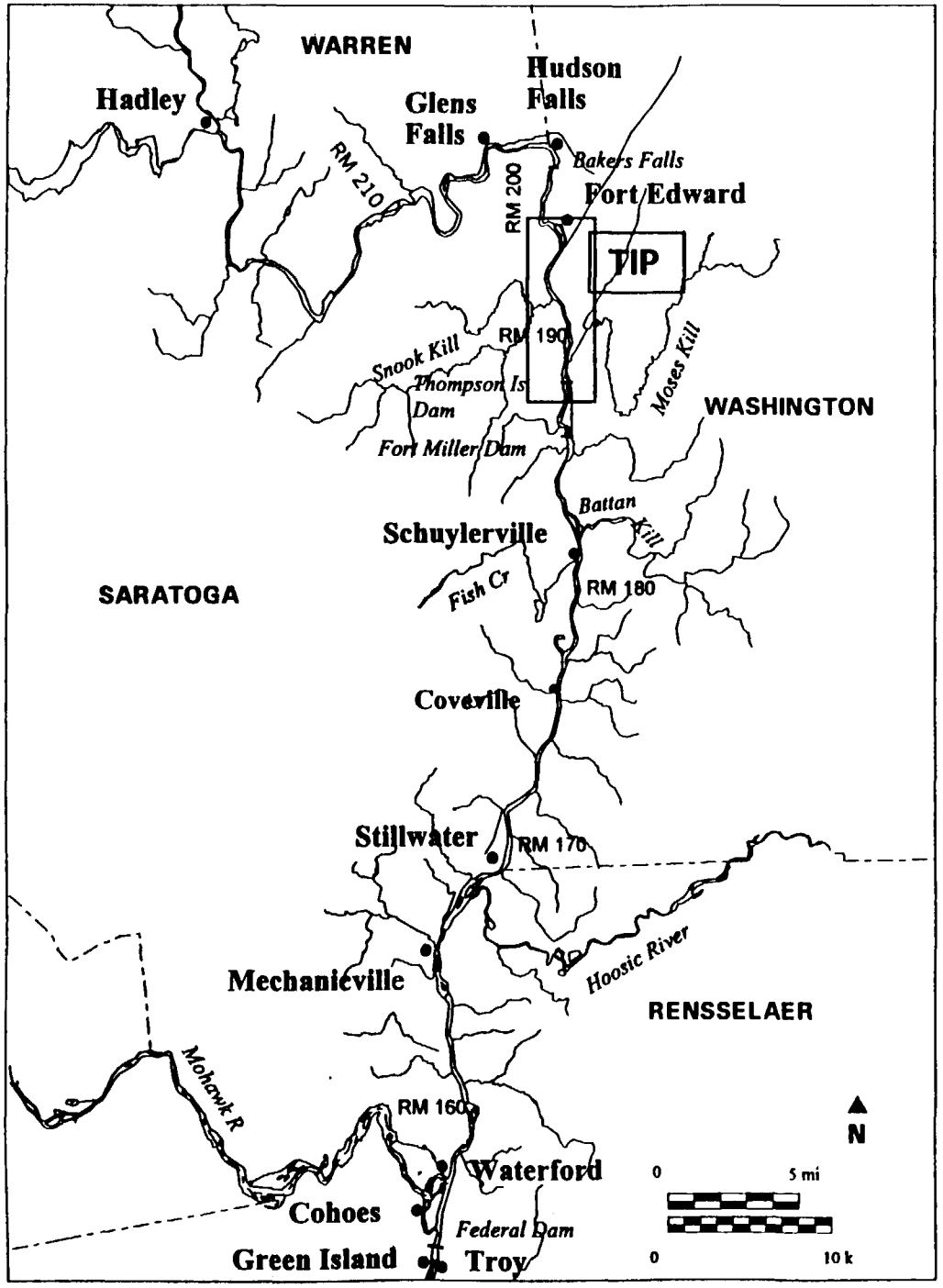
Lower Hudson Future - December 1999



Hudson River PCBs Reassessment

Phase 3 Report - Feasibility Study





Purpose of FS

Evaluate options to address the PCB-contaminated sediments in the Upper Hudson River to protect human health and the environment.

- **SOW 9/98**
- **Resp Sum 4/99**

Remedial Action Objectives

Developed as part of Feasibility Study

Specify:

- Contaminants (PCBs) and media of interest
- Exposure pathways (*e.g.*, consumption of fish)
- Preliminary remediation goals (*e.g.*, target conc. in fish)

Permits a range of alternatives to be developed

General Response Actions

- No-action
- Monitored natural attenuation
- Containment (capping)
- *In-situ* treatment
- Dredging (+/- treatment) and disposal

No-Action

- required by law
- provides basis for comparison of alternatives
- establishes baseline condition

No need for remediation
Monitoring is allowed

Monitored Natural Attenuation

- baseline condition presents risk or exceeds applicable standards
- expect to achieve remediation goals in reasonable time frame compared to active alternatives
- may include institutional controls
- may be used in conjunction with other alternatives

No active remediation
Monitoring is necessary

NCP Nine Criteria

Threshold Factors
1) Overall Protection of Human Health and Environment
2) Compliance with Other Environmental Laws

Primary Balancing Factors
3) Long-term Effectiveness and Permanence
4) Reduction of Toxicity, Mobility or Volume
5) Short-term Effectiveness
6) Implementability
7) Cost

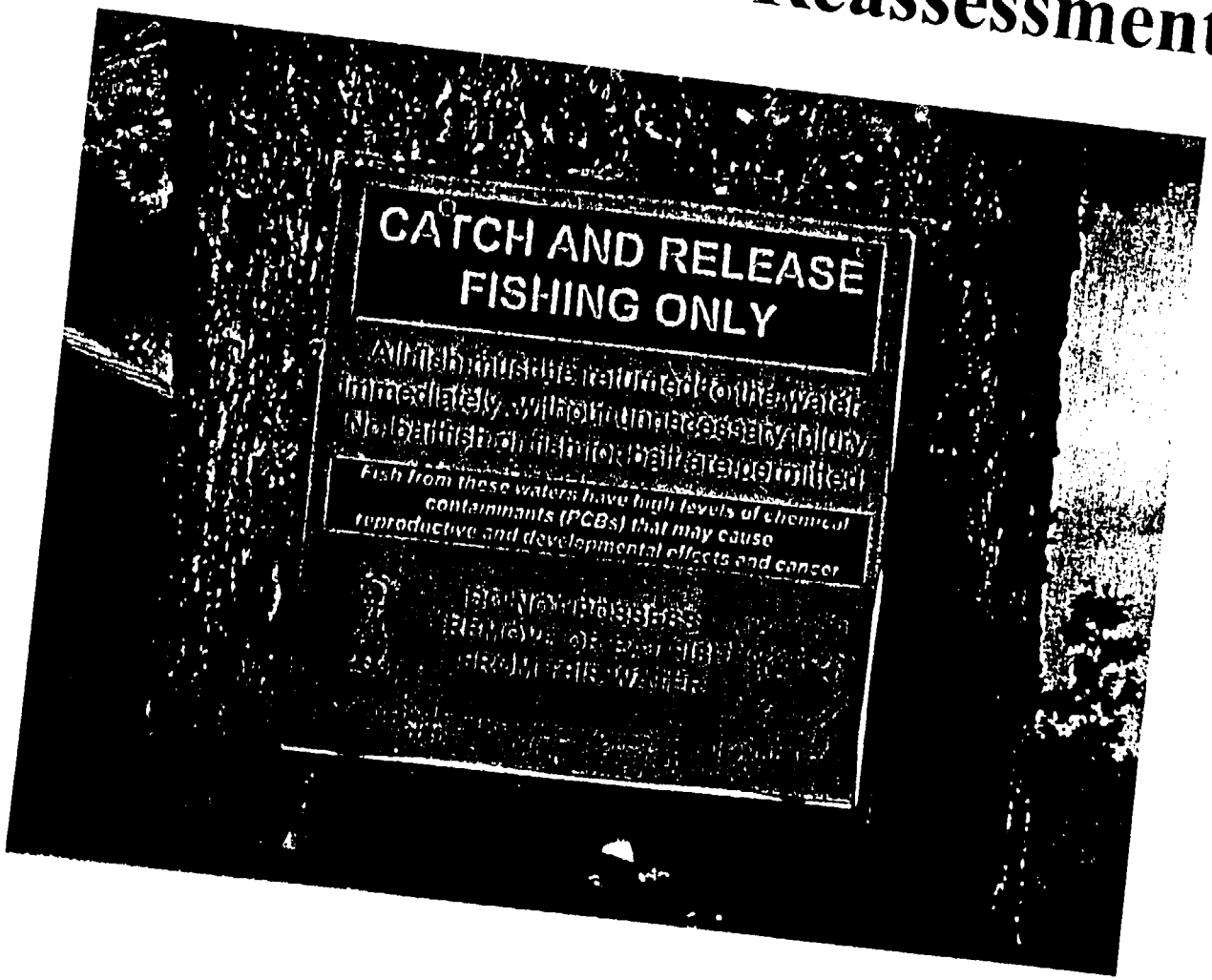
Modifying Criteria
8) State Acceptance
9) Community Acceptance

Proposed Plan - Record of Decision

- Proposed Plan identifies preferred alternative
  - Public comment (assess community acceptance)

- Record of Decision
  - Responsiveness Summary

Hudson River PCBs Reassessment



www.epa.gov/hudson

2

Examination of Exposure Pathways Based on Congener Patterns

Relationships Among Fish Body Burdens and Exposure Media

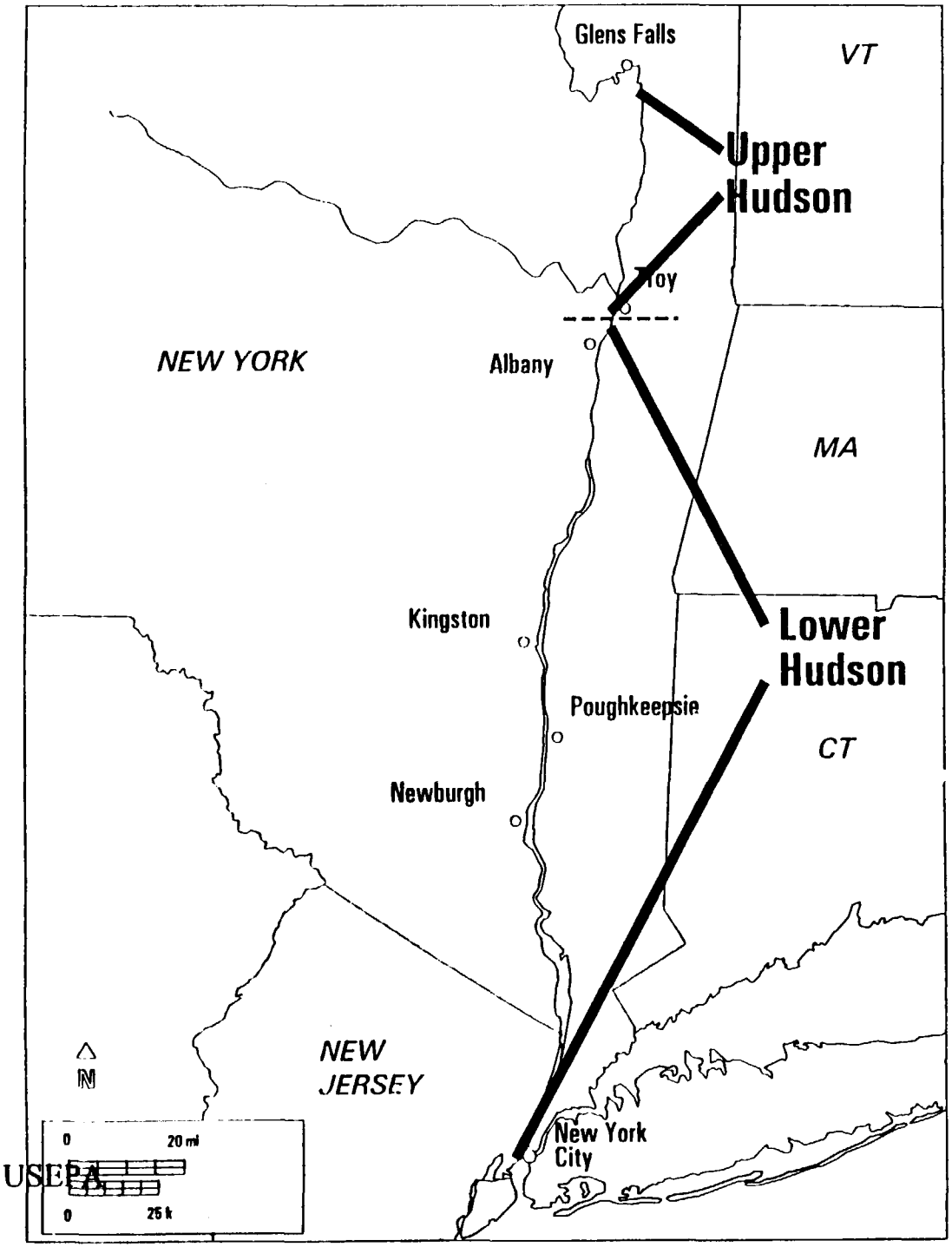
Edward A. Garvey, Ph.D.

USEPA

TAMS/MCA

Outline of Presentation

- Sampling Program
- Examination of Homologue Patterns in Biota
- Comparison Among Stations and Species
- Initial Principal Components Analysis
- Selected Congener Ratios
- Summary

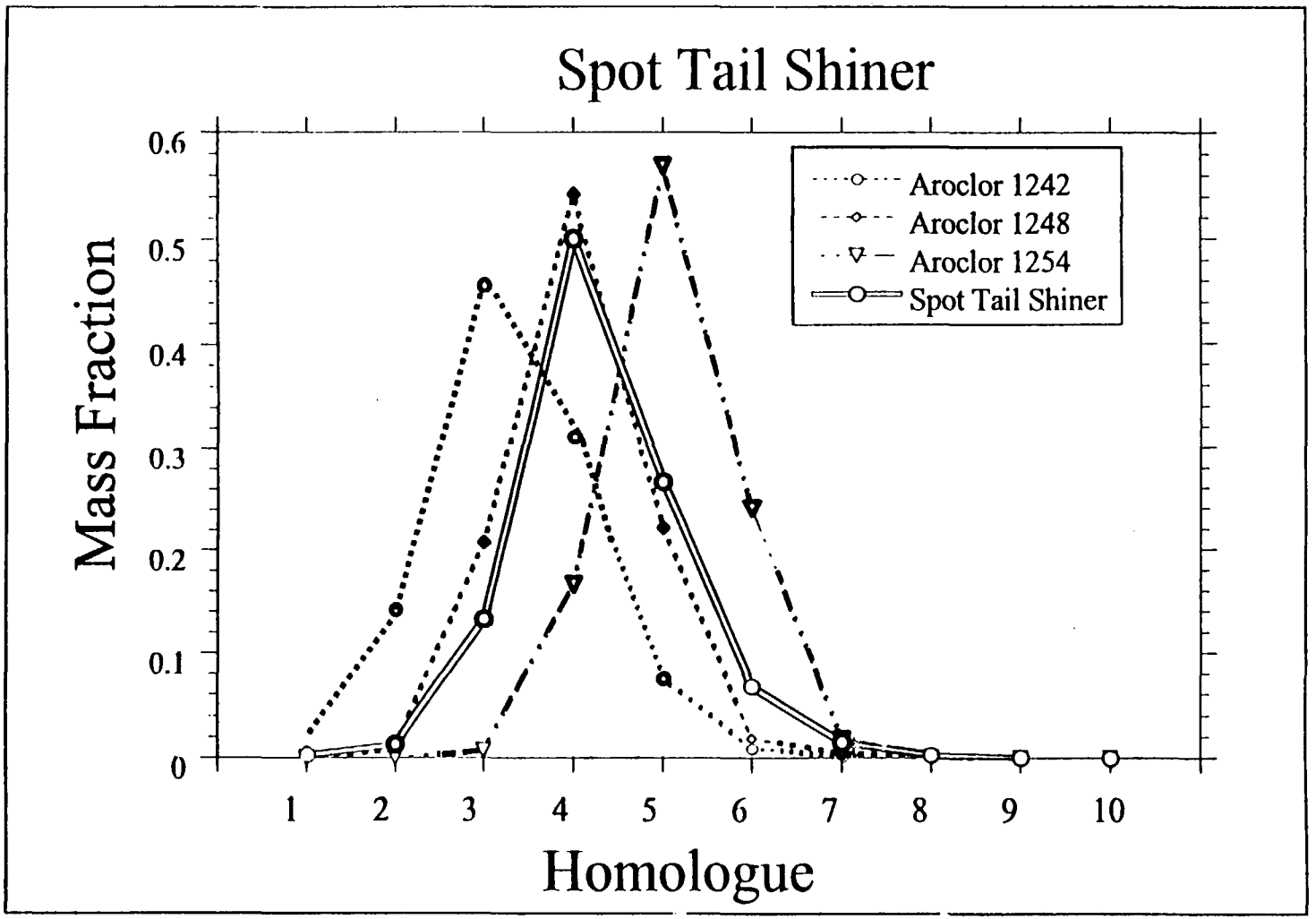


Scope of Ecological Risk Assessment

308607

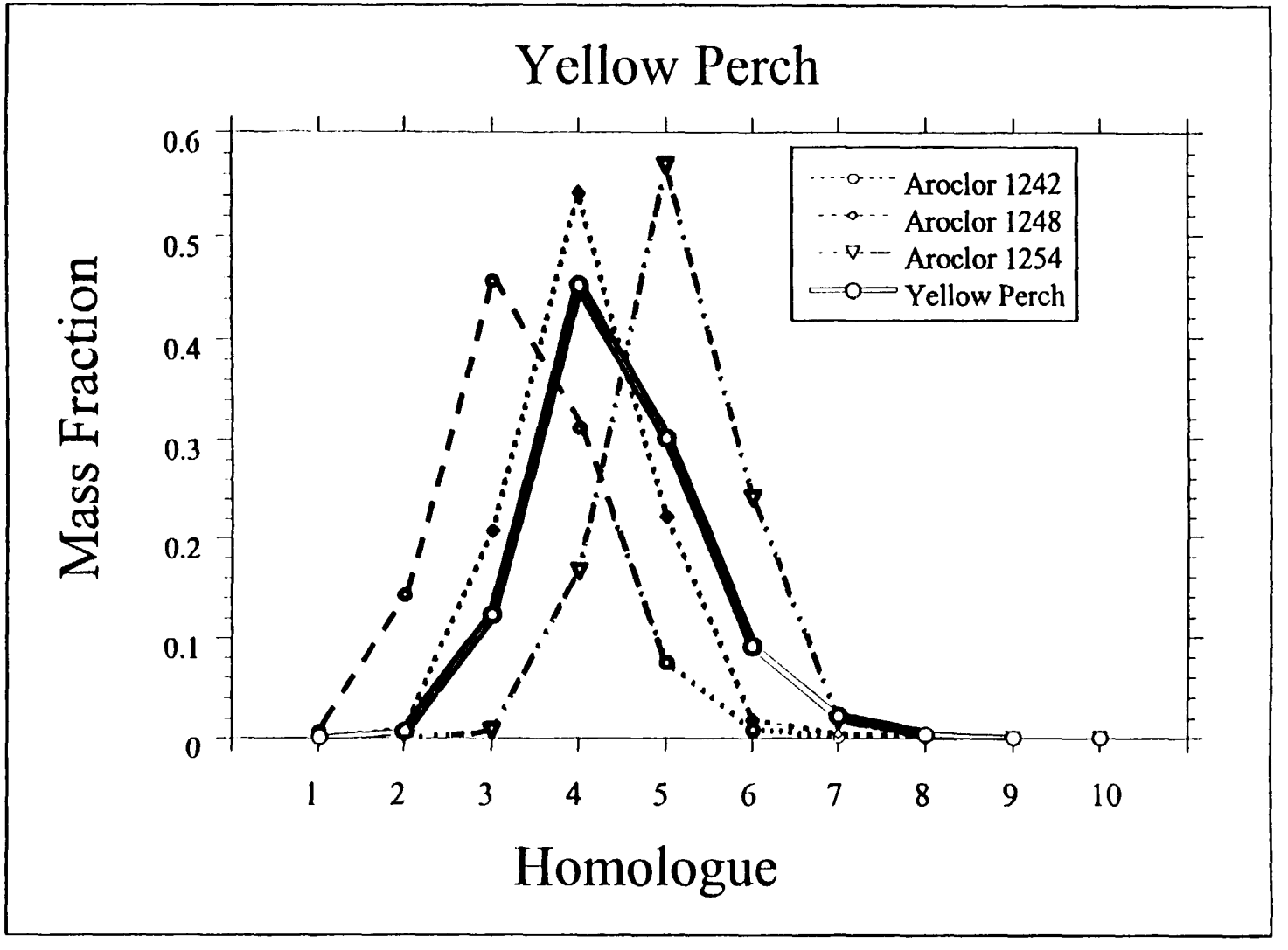
Ecological Sampling Program

- 19 ecological sampling stations throughout Hudson
- Co-located samples
  - Sediments (0-5 cm)
  - Benthic Invertebrates
  - Fish
- Coincident water column sampling (Aug & Sept 93)
- High resolution cores
  - Spanning 200 river miles
- Low resolution cores
  - RM 194 to 168 only



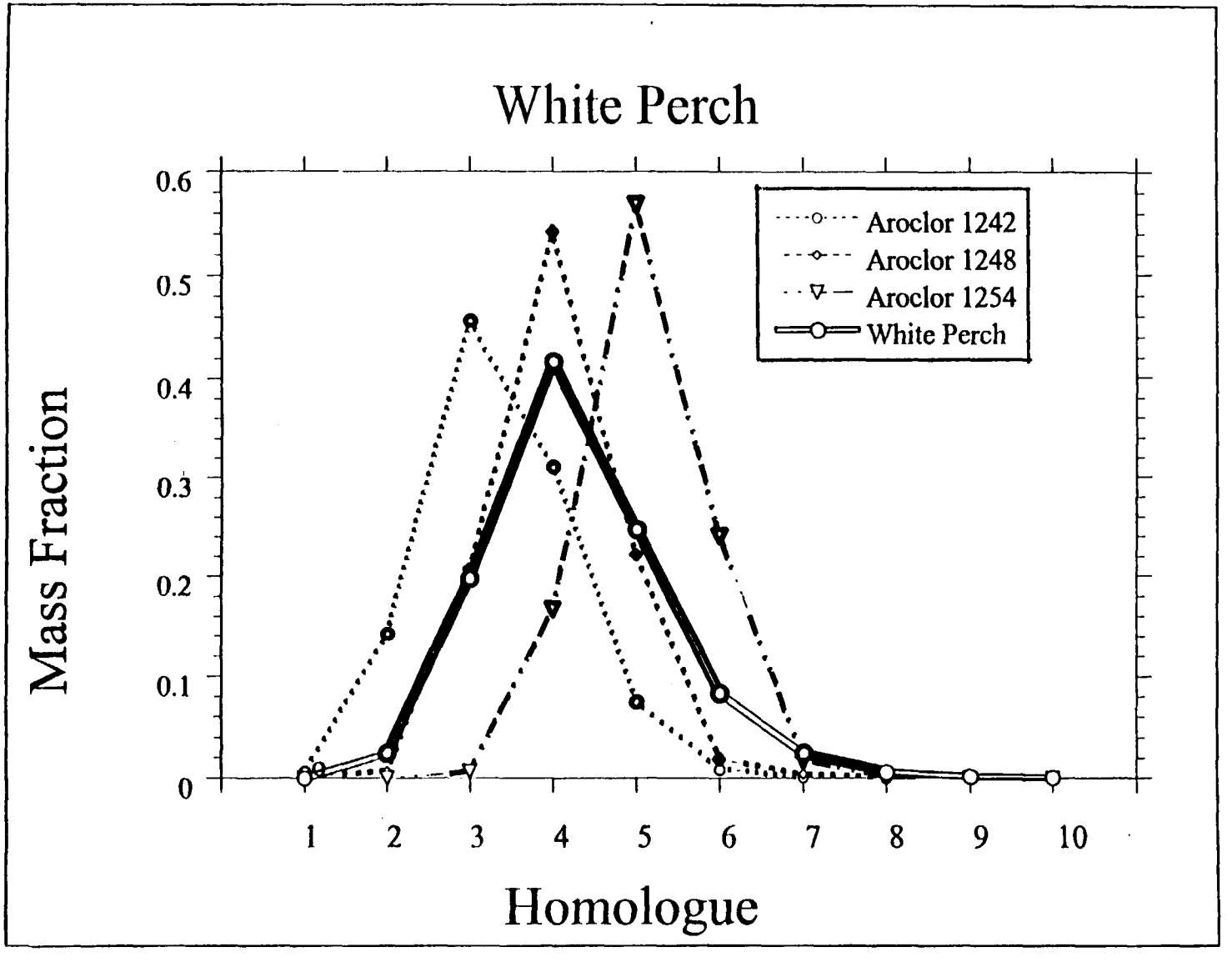
A Comparison of Homologue Patterns in Aroclors and Fish

USEPA RM 195 to 175 TAMS/MCA



A Comparison of Homologue Patterns in Aroclors and Fish RM 175 to 156

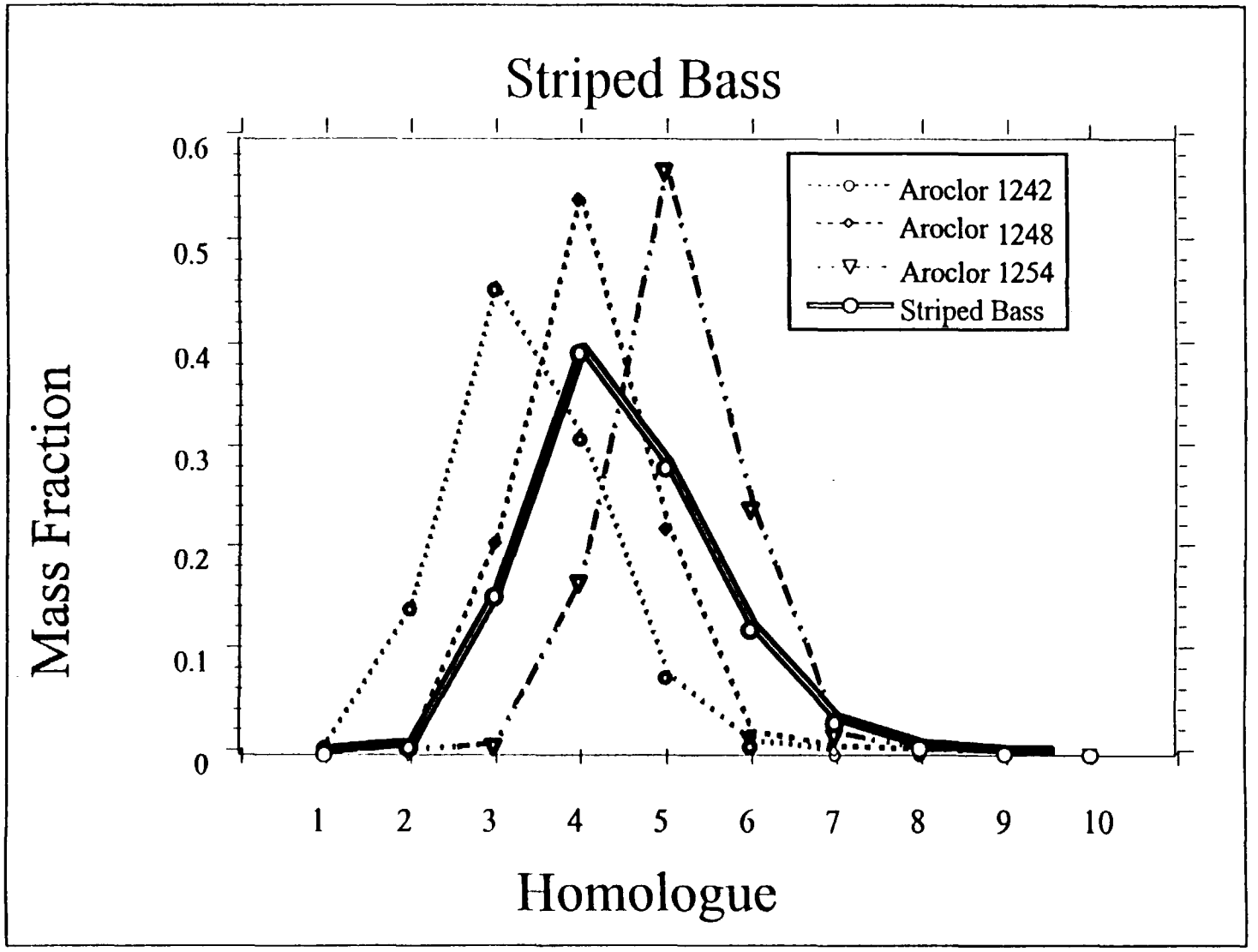
USEPA TAMS/MCA



A Comparison of Homologue Patterns in Aroclors and Fish
RM 156 to 100

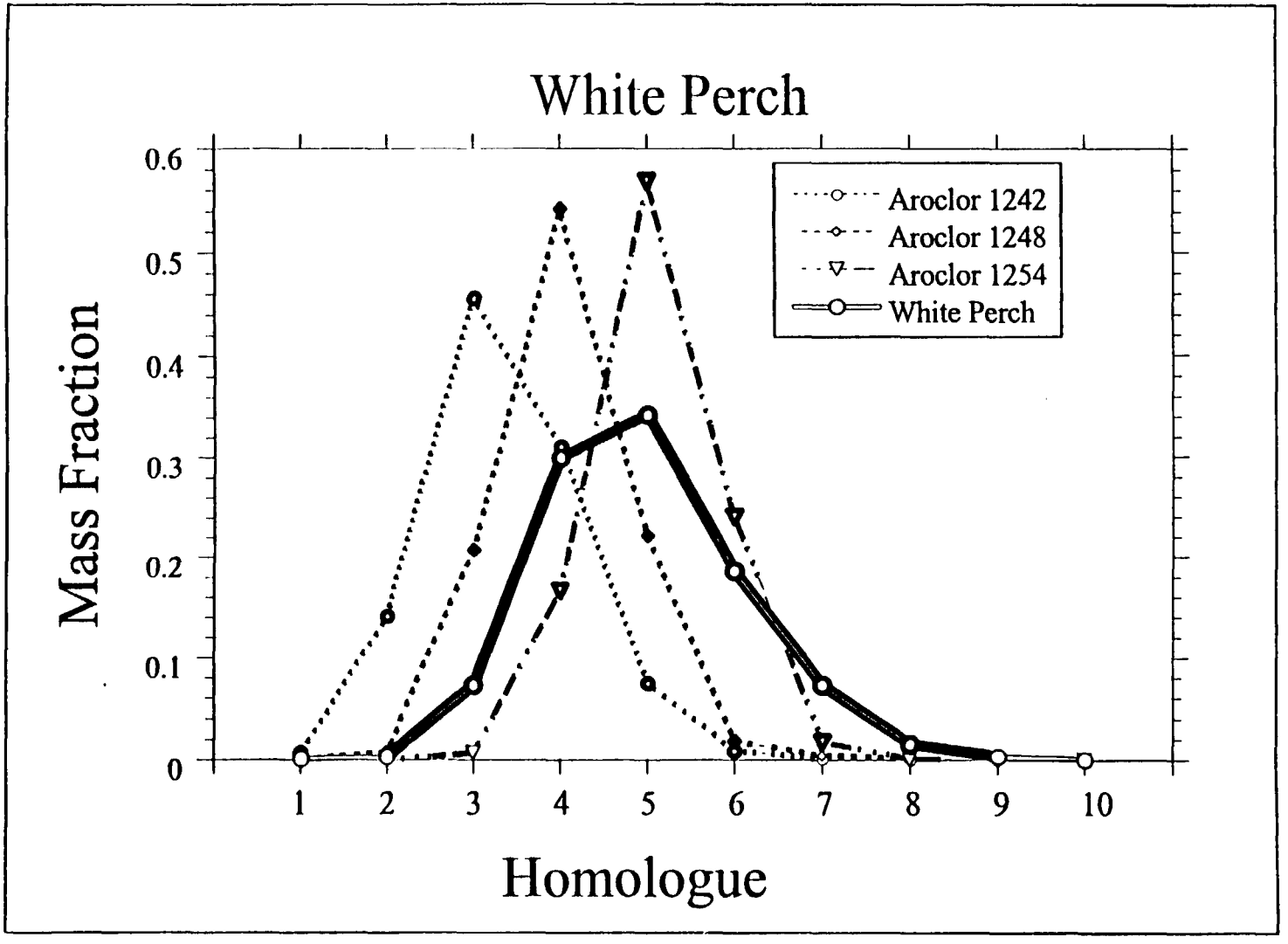
USEPA

TAMS/MCA



A Comparison of Homologue Patterns in Aroclors and Fish

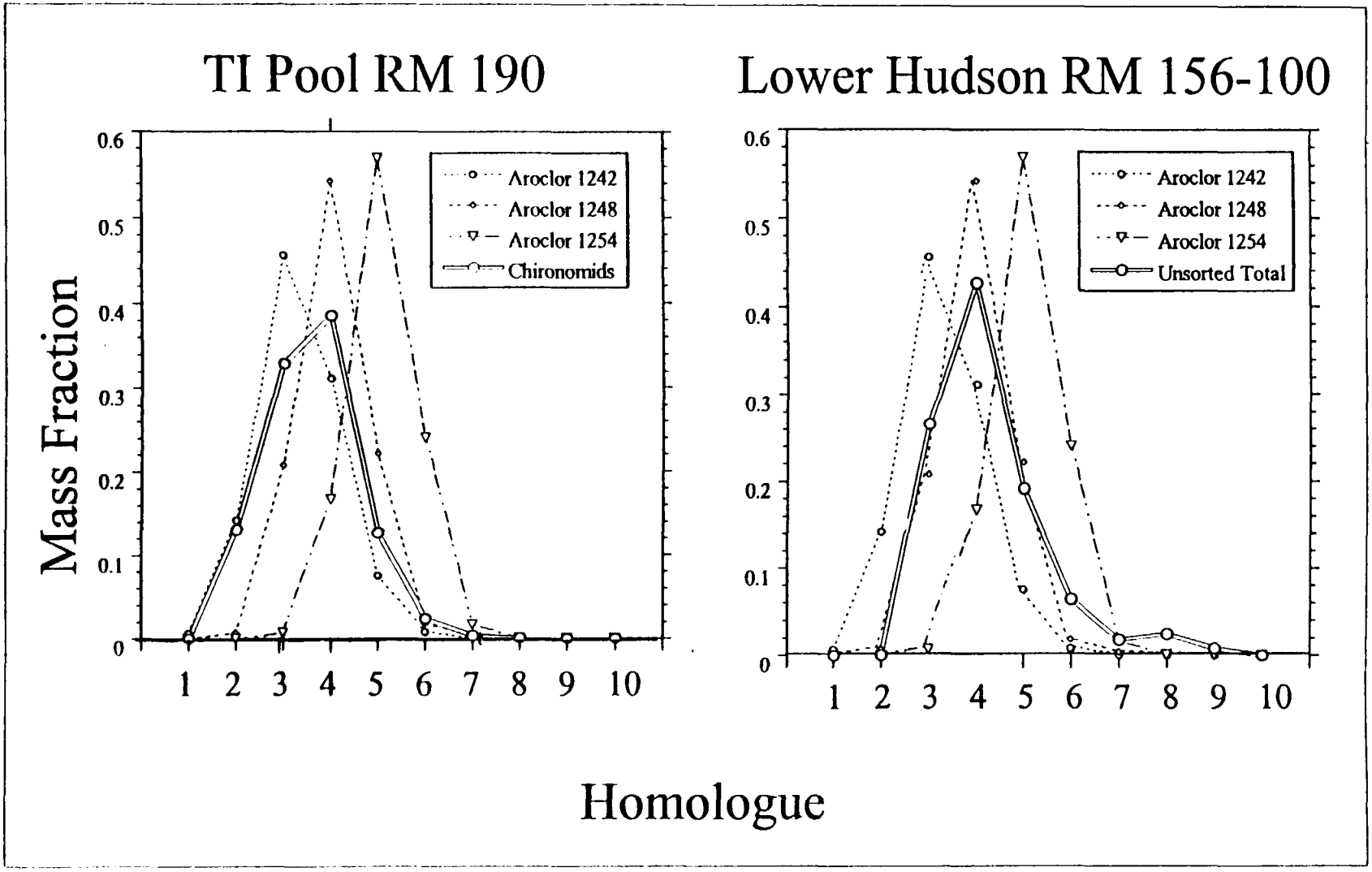
USEPA RM 100 to 60 TAMS/MCA



A Comparison of Homologue Patterns in Aroclors and Fish
RM 60 to 0

USEPA

TAMS/MCA

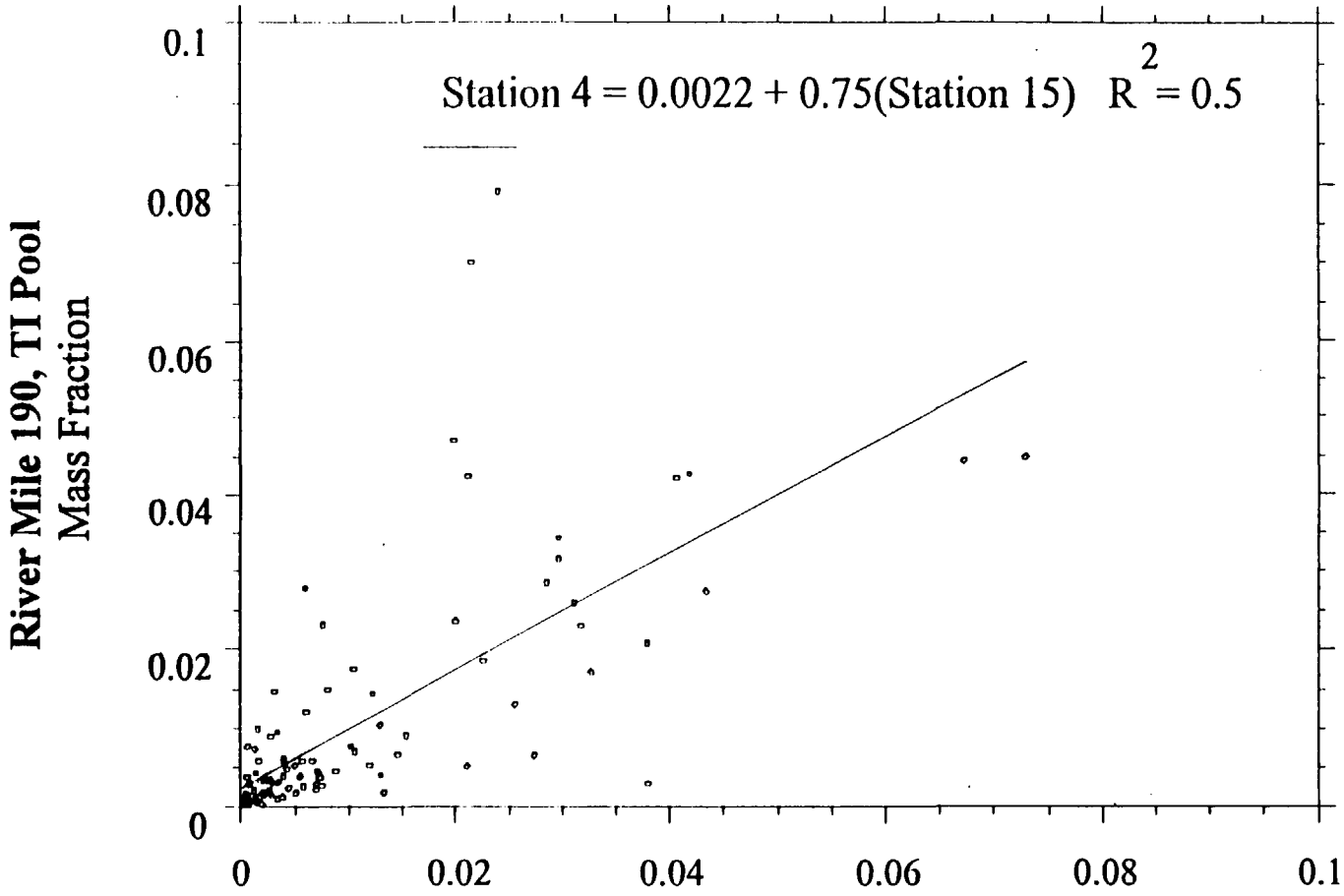


A Comparison of Homologue Patterns in Aroclors and Invertebrates

USEPA

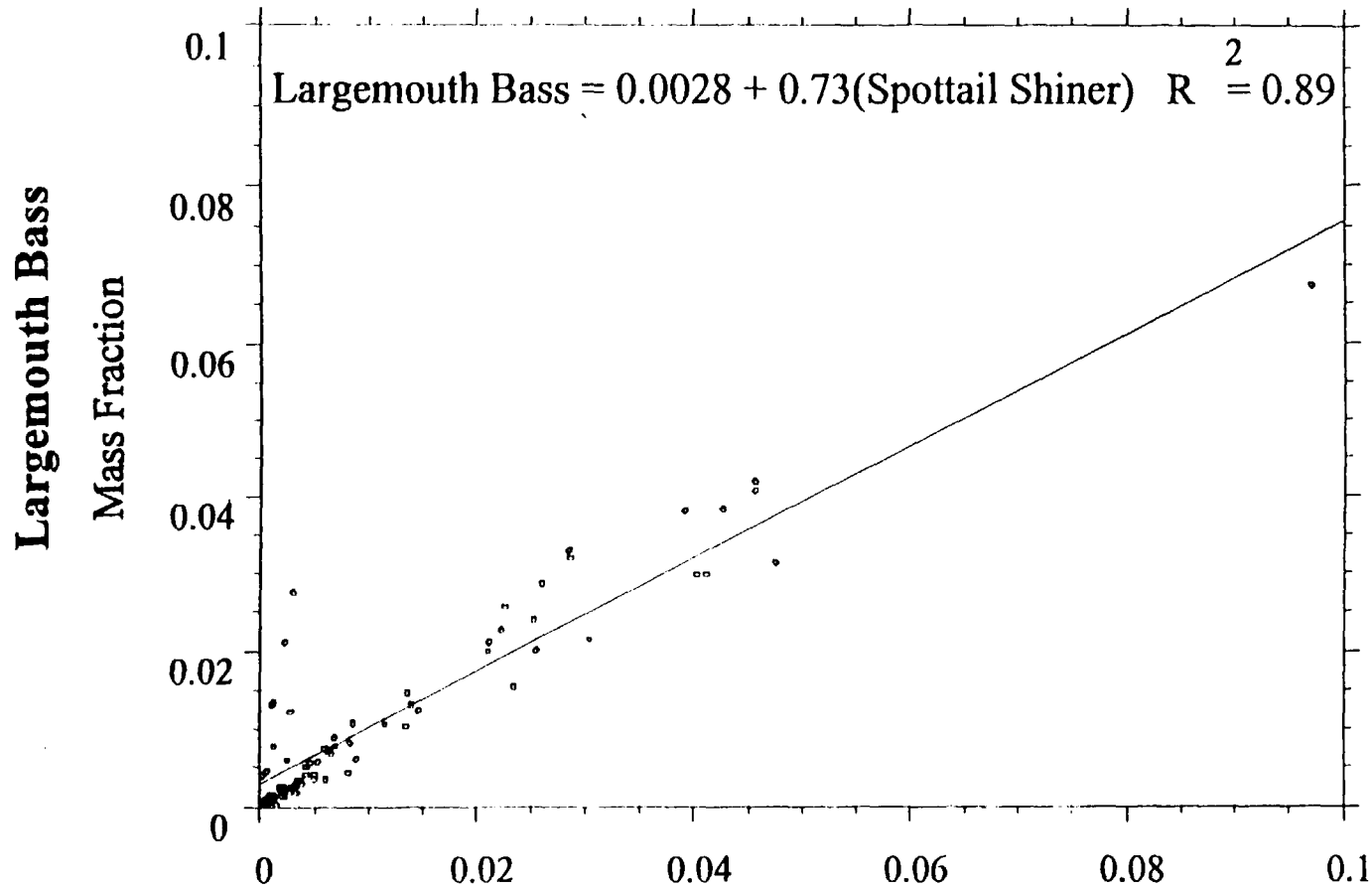
TAMS/MCA

Largemouth Bass



Comparisons of Congener Mass Fraction Between Stations

River Mile 89.4, Freshwater Lower Hudson



Comparisons of Congener Mass Fraction Between Species

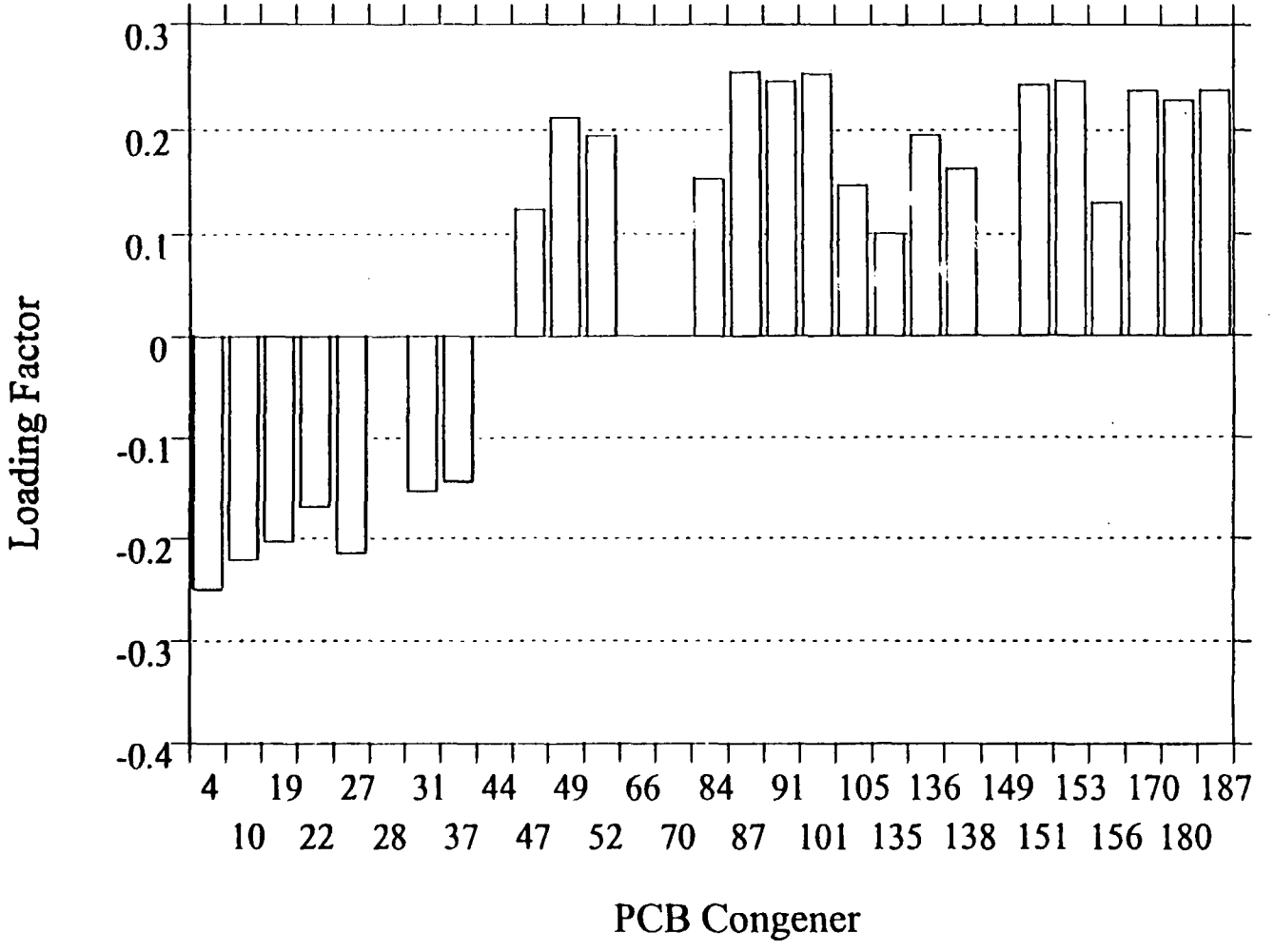
Homologue Patterns

- Patterns show dominance by tetrachloro homologue in the freshwater Hudson
- Patterns resemble Aroclor 1248
- Pattern below salt front shows impact of NYC metro sources

Principal Components Analyses

- Three separate analyses performed
- Initial (primary) analysis based on 29 congeners selected via optimization
- Analysis shows ability to separate data by media and location
- Principal components are easily interpreted from geochemical perspective

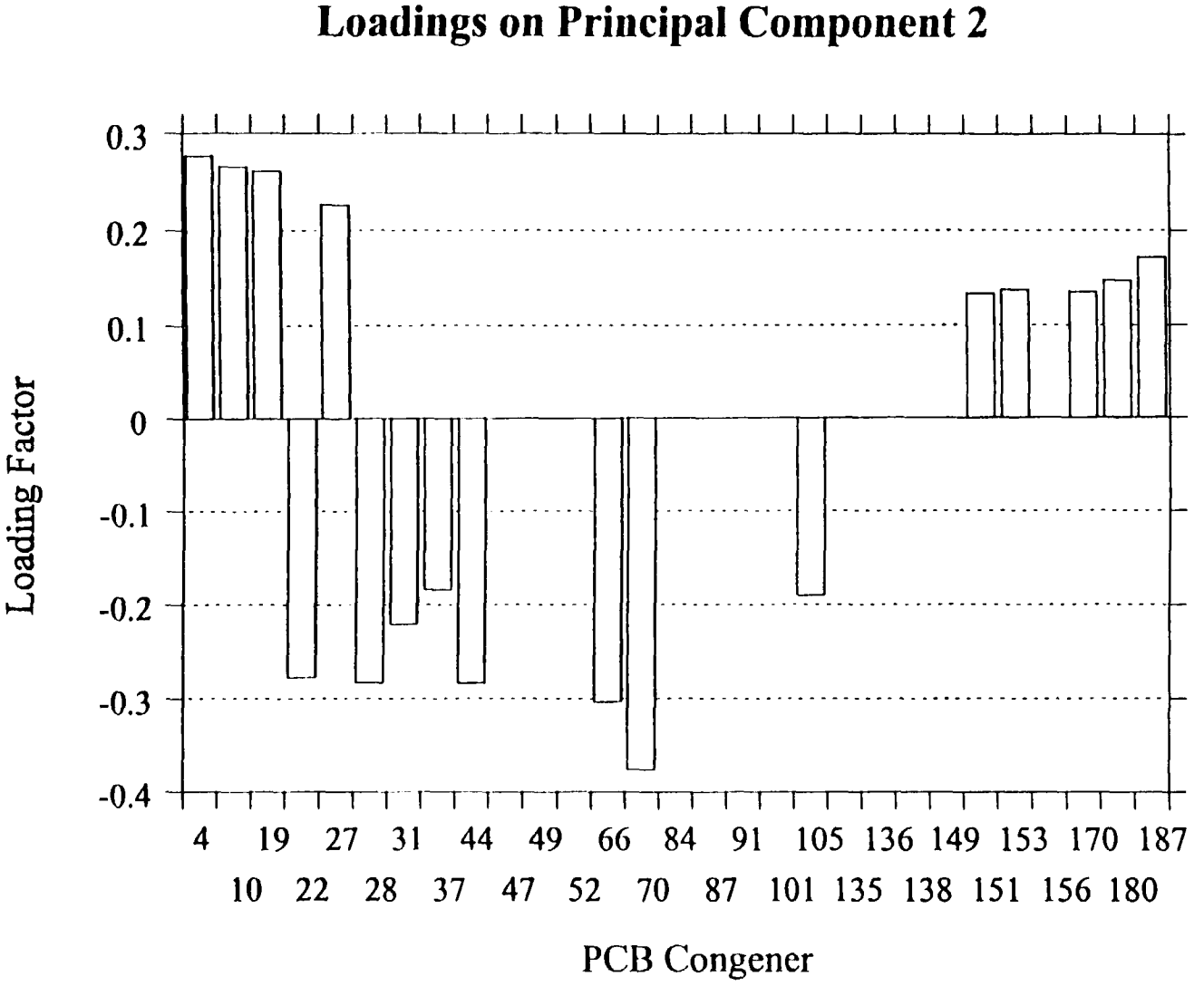
Loadings on Principal Component 1



Congener Loadings for Principal Components 1

1993 USEPA and NOAA Data for Sediments, Water, Fish and Benthic Invertebrates

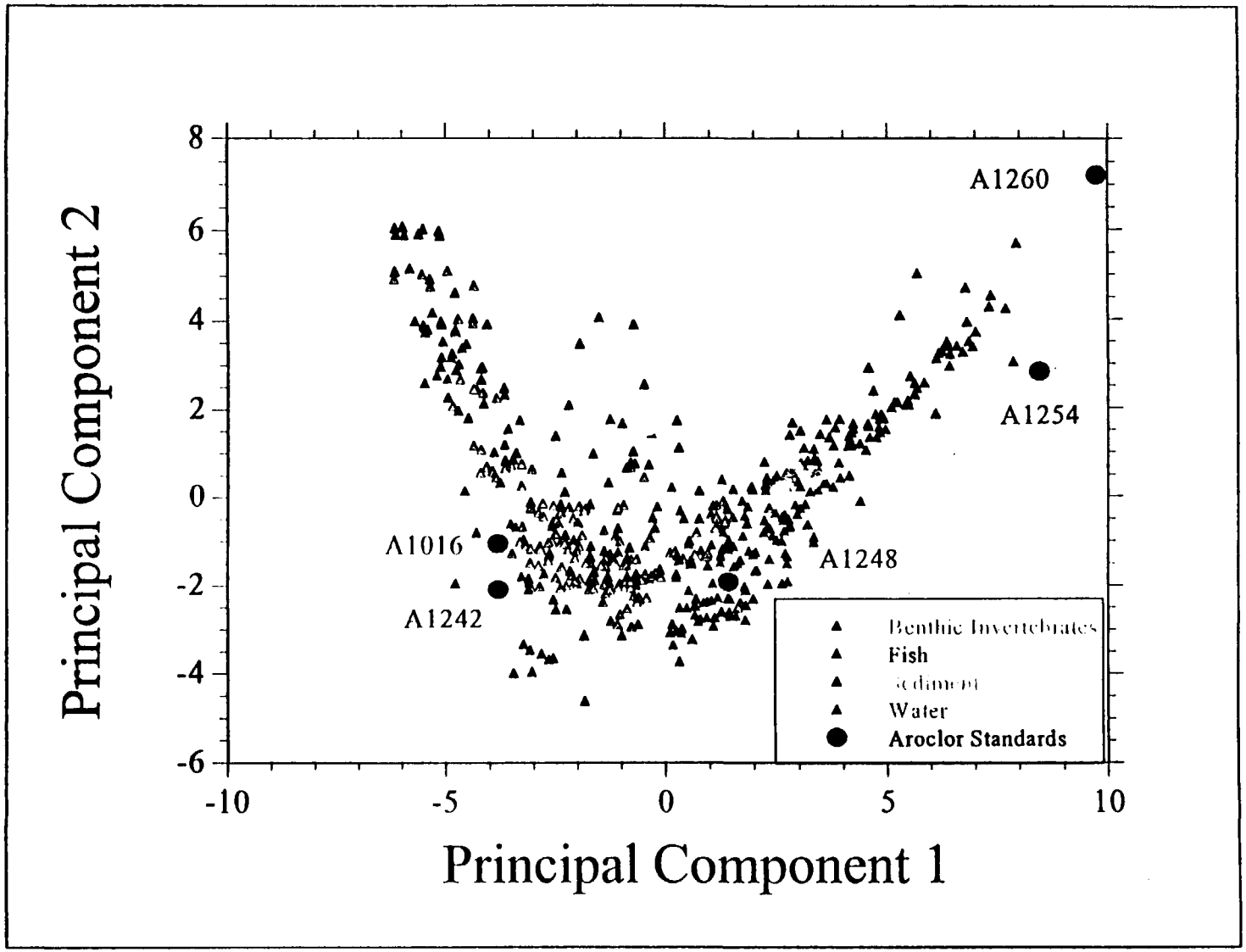
USEPA TAMS/MCA



Congener Loadings for Principal Components 2

1993 USEPA and NOAA Data for Sediments, Water, Fish and Benthic Invertebrates

USEPA TAMS/MCA

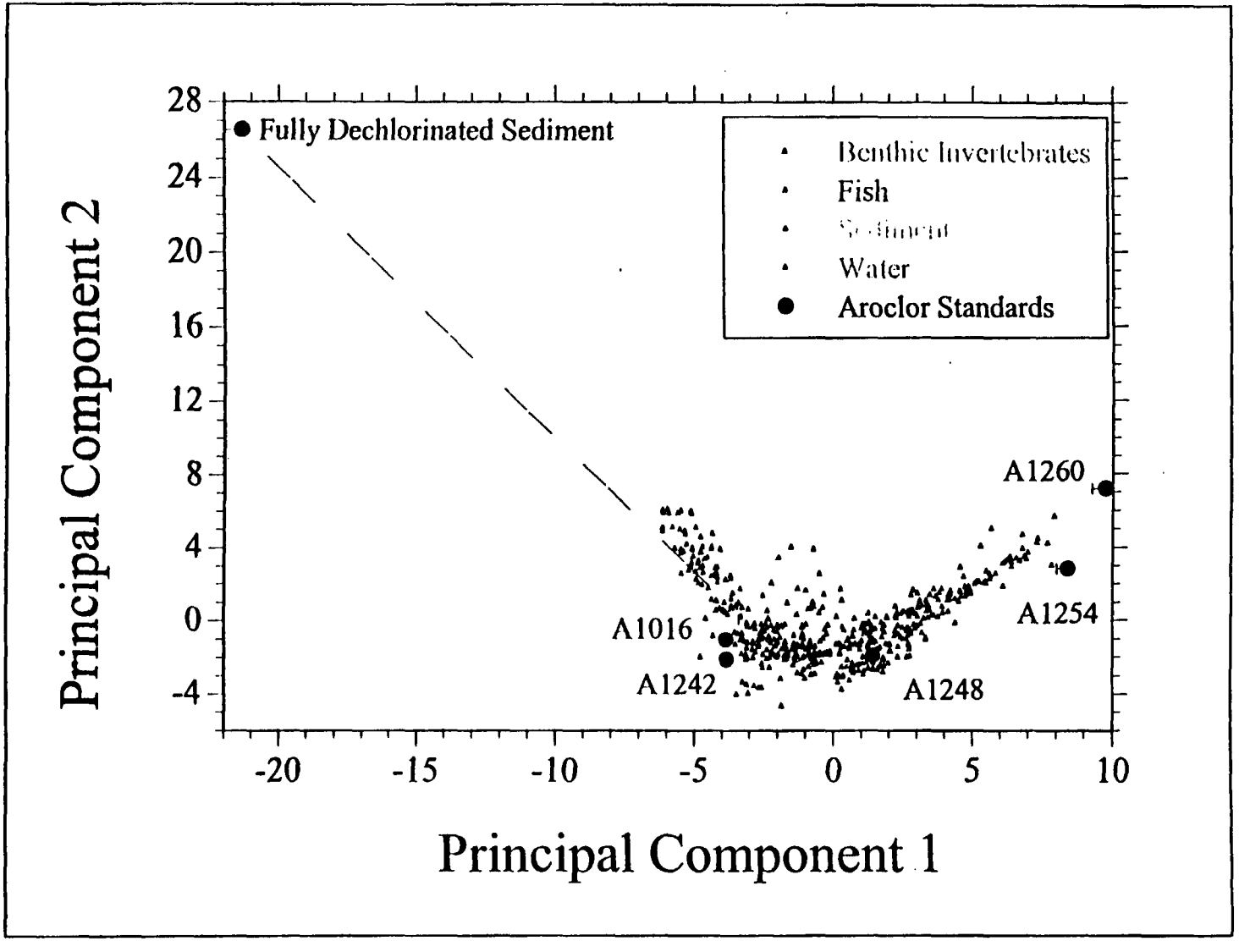


Principal Component Results for Phase 2 Samples

Relationship Among Mainstem Hudson Samples

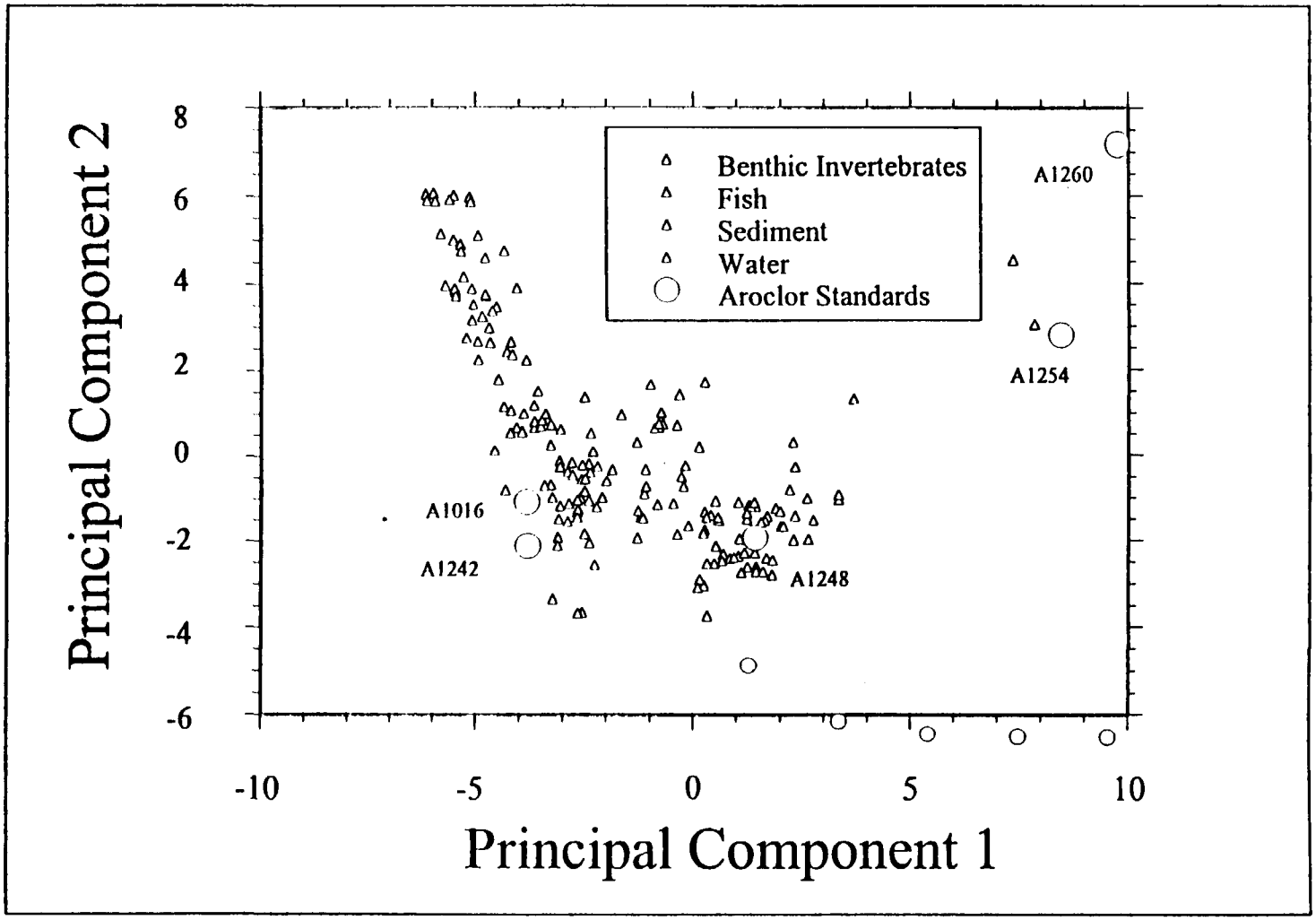
USEPA

TAMS/MCA



Principal Component Results for Phase2 Sample

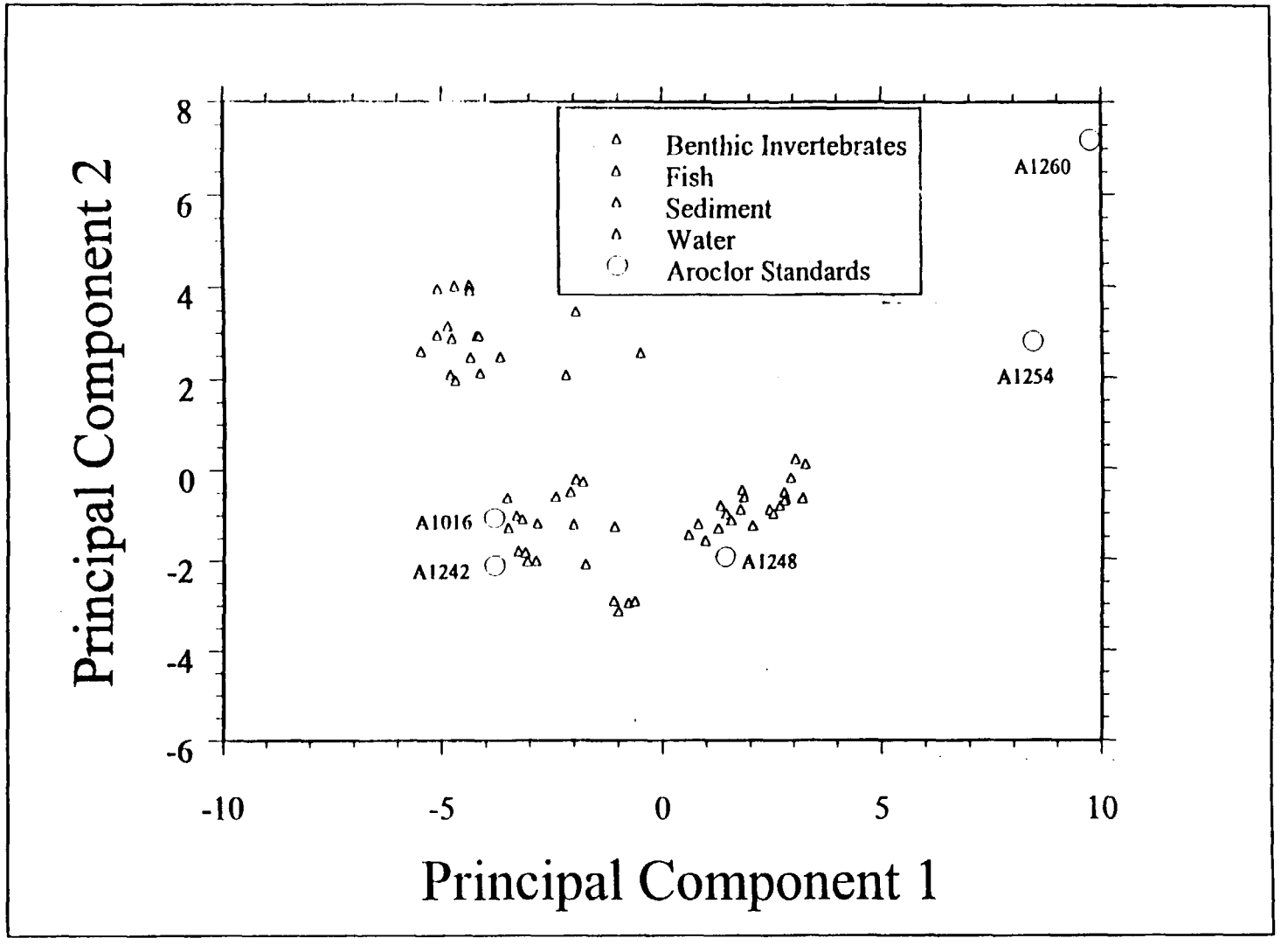
USEPA Fully Dechlorinated Sediment *vs.* Mainstem Samples TAMS/MCA



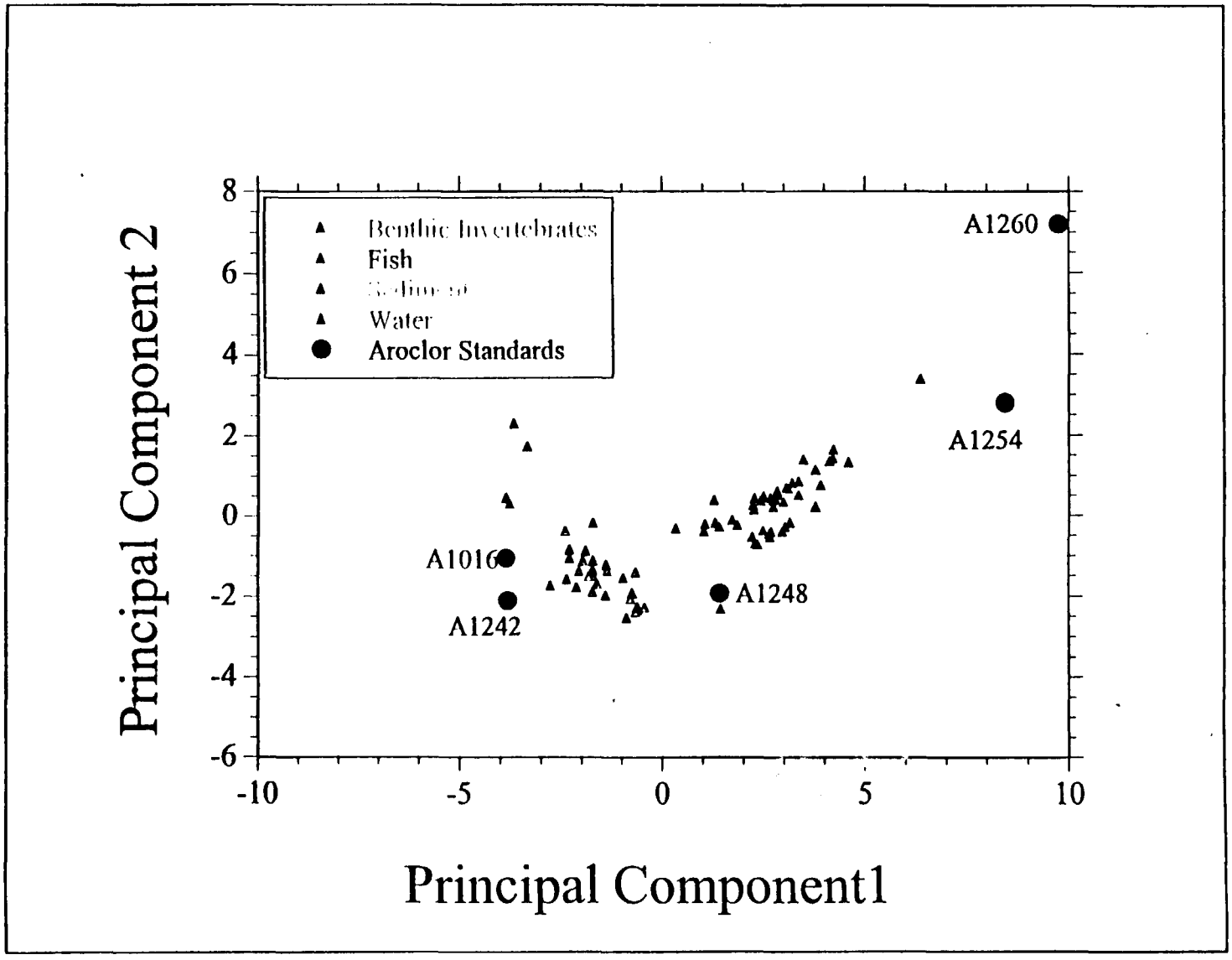
Principal Component Results for Hudson River Media
RM 195 to 175

USEPA

TAMS/MCA



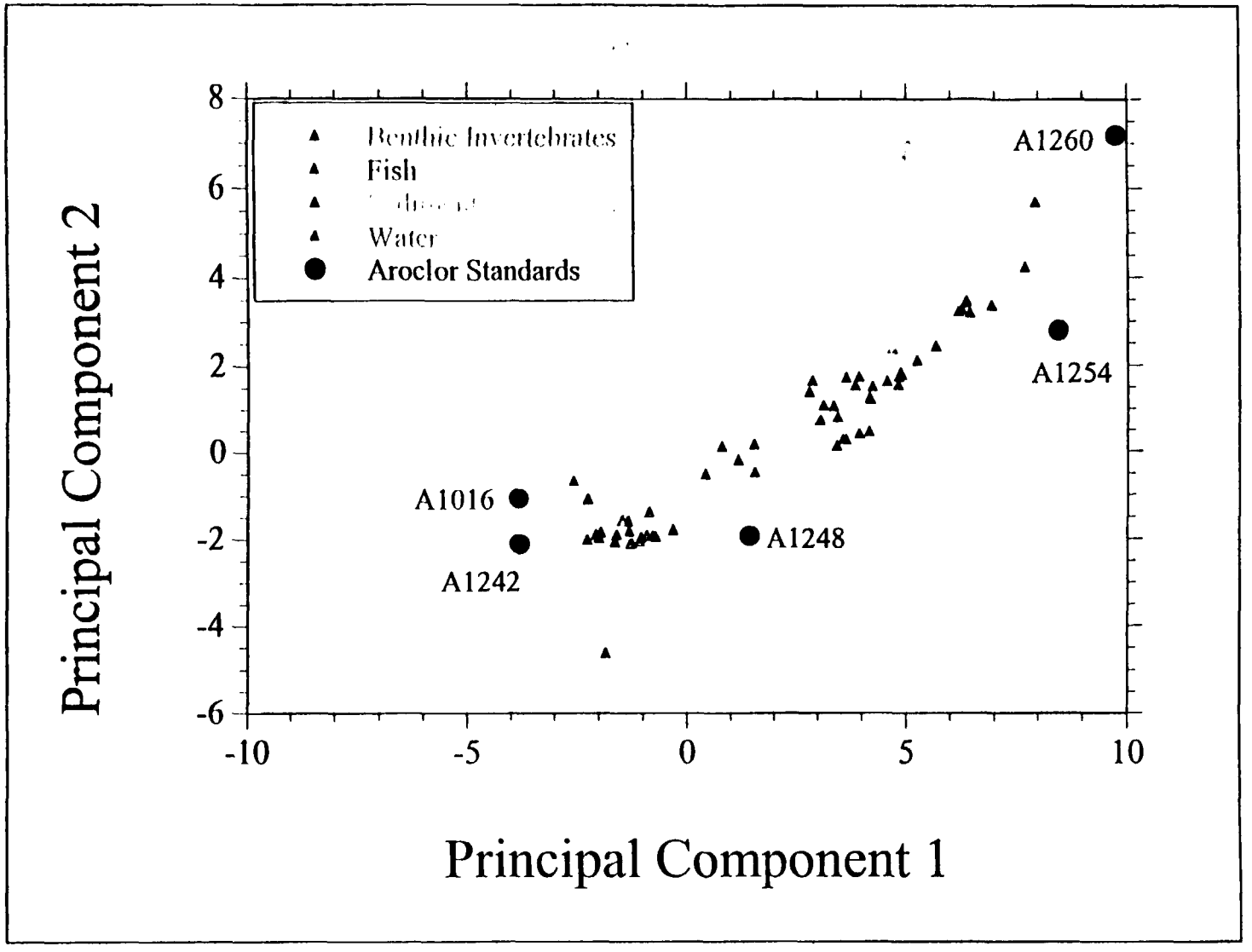
Principal Component Results for Hudson River Media RM 175 to 156



Principal Component Results for Hudson River Media
RM 156 to 100

USEPA

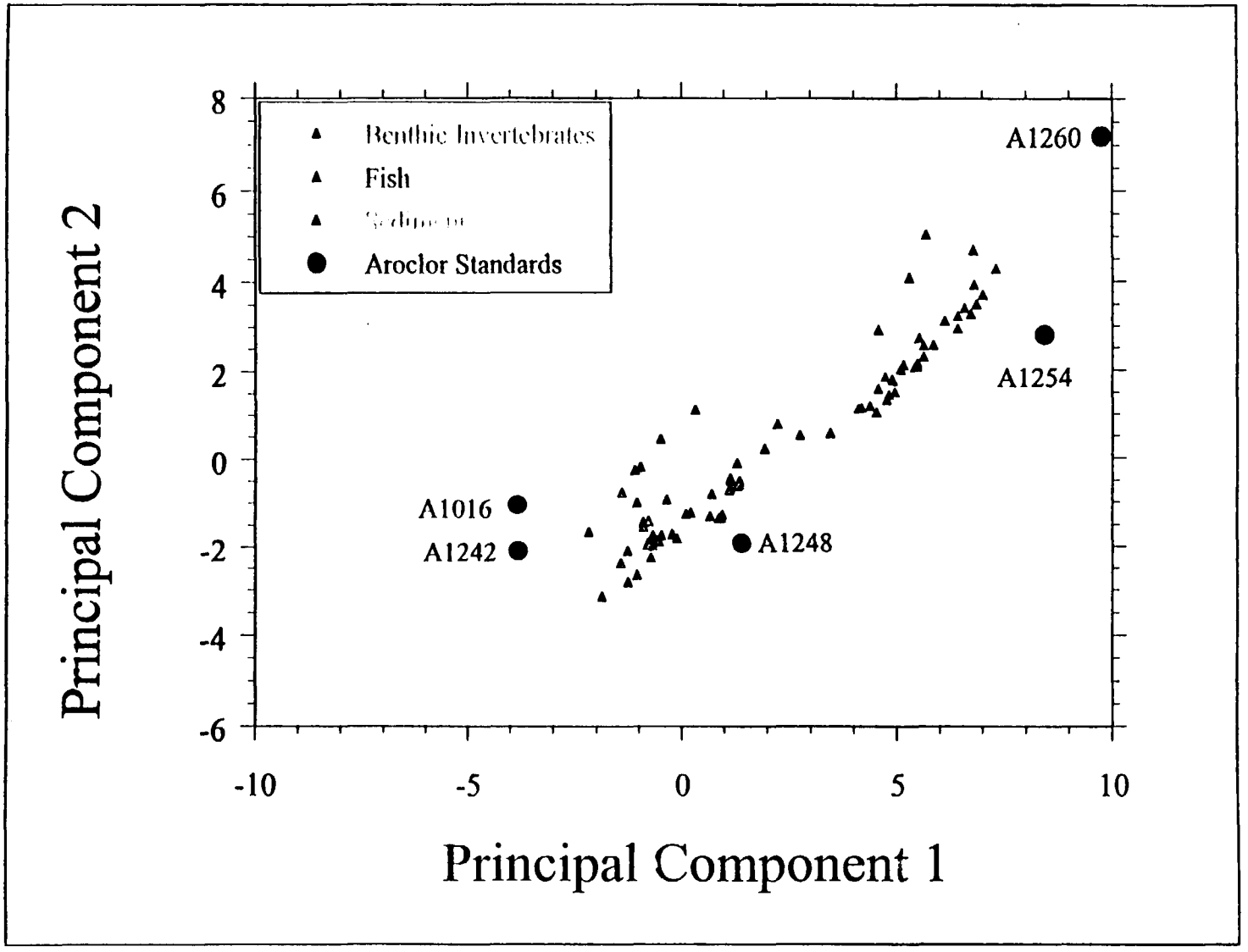
TAMS/MCA



Principal Component Results for Hudson River Media
RM 100 to 60

USEPA

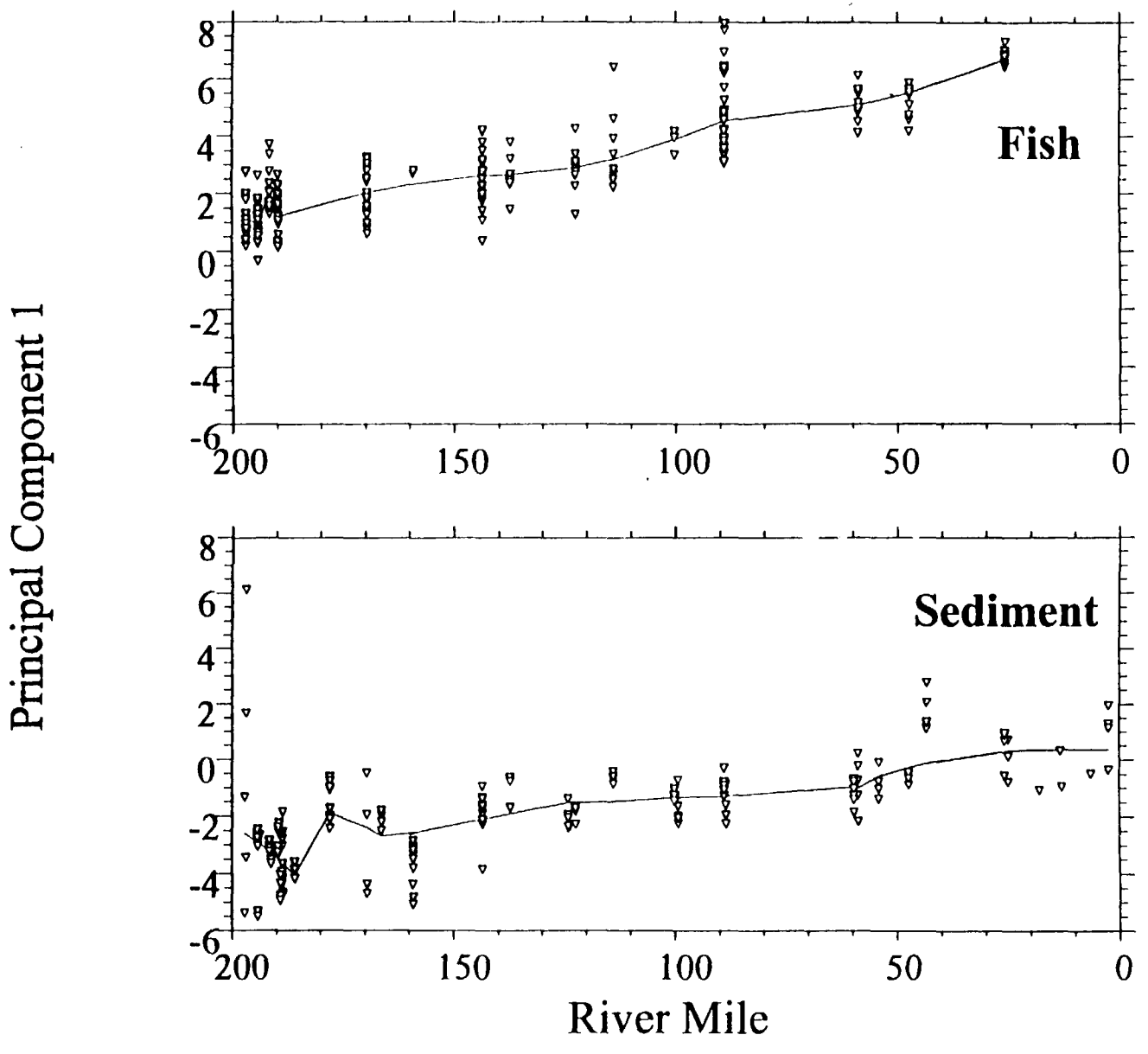
TAMS/MCA



Principal Component Results for Hudson River Media
RM 60 to 0

USEPA

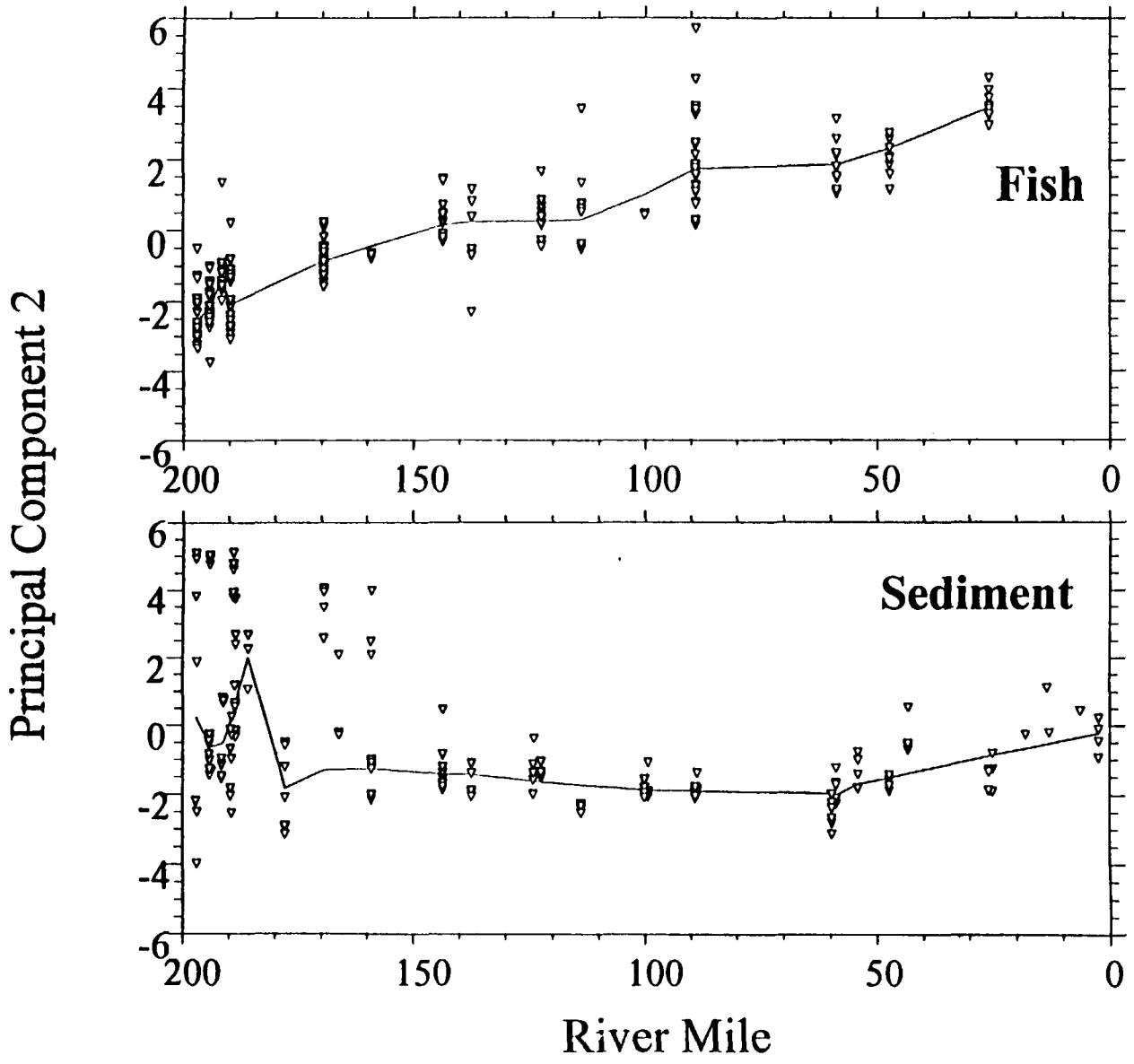
TAMS/MCA



Variation of Principal Component 1 with River Mile in Fish and Sediment

USEPA

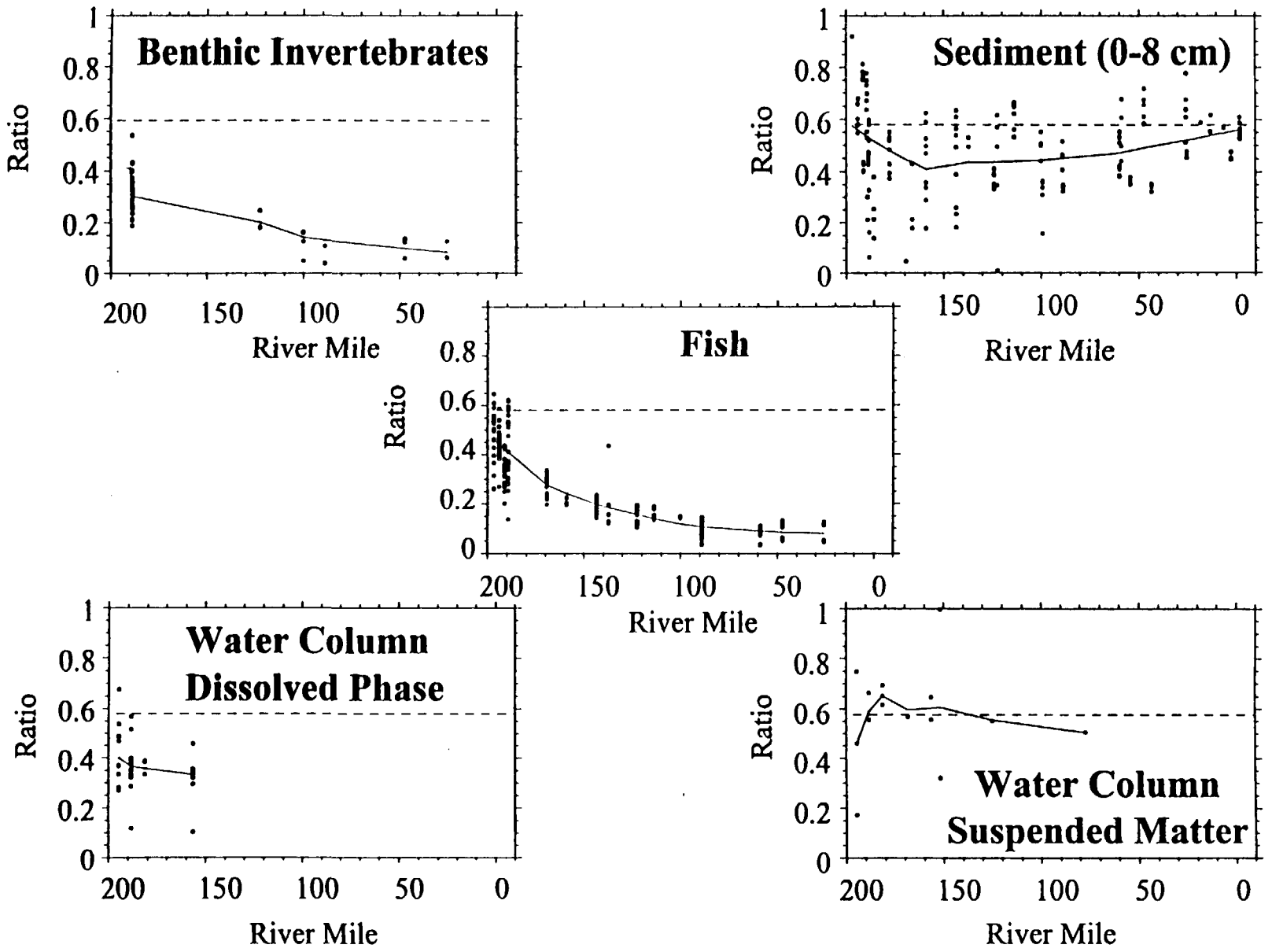
TAMS/MCA



Variation of Principal Component 2 with River Mile in Fish and Sediment

Examination of Congener Ratios

- Several congener ratios have been proposed as tracers for PCB sources
- Four separate congener ratios were examined in the ERA
- Ratio variations in fish do not follow those in exposure media

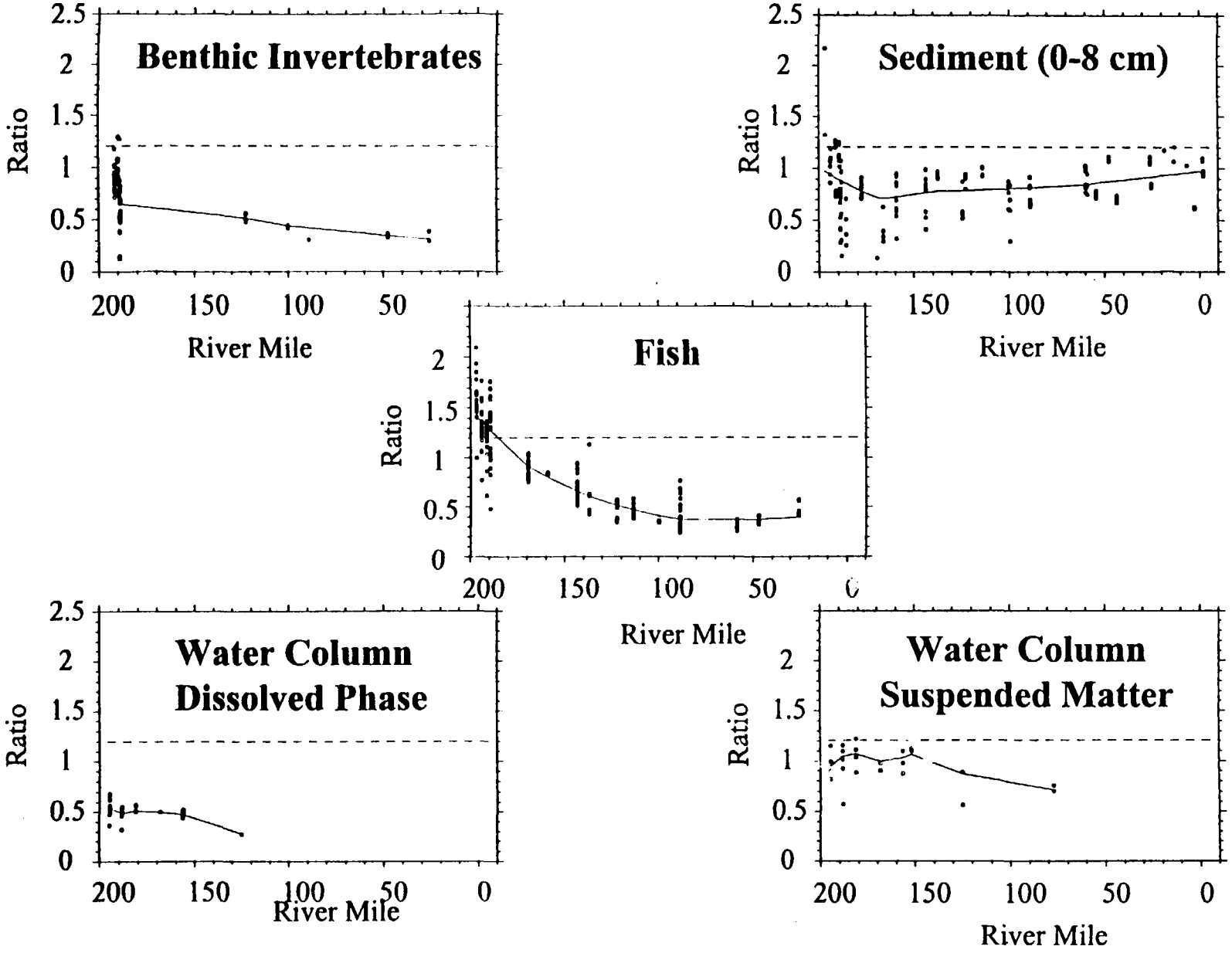


A Comparison of Congener Ratio 56/49 for 1993 Hudson River Samples

1993 USEPA and NOAA Data

USEPA

TAMS/MCA



A Comparison of Congener Ratio 66/49 for 1993 Hudson River Samples

USEPA

1993 USEPA and NOAA Data

TAMS/MCA

Summary

- Fish body burdens most closely resemble Aroclor 1248 in molecular weight although they are clearly derived from other Aroclors.
- Body burdens for benthic invertebrates are heavier than the sediments to which they are exposed but lighter than the fish that prey on them.
- Fish patterns were more similar within stations than within species, indicating control by local conditions and not trophic level.
- Fish congener patterns gradually shift to heavier congeners downstream of the GE facilities.

Summary (continued)

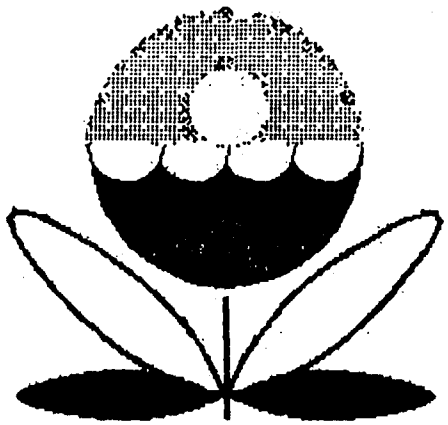
- Individual congener ratios do **not** permit the tracing of fish body burdens to their sources. This may be due to alteration of the congener mixture by metabolic processes within the fish themselves.
- PCBs in fish do not reflect the congener patterns of the exposure concentrations. Rather, it would appear that processes internal to the fish serve to shift the original pattern toward a more chlorinated mixture.

Hudson River Ecological Risk Assessment

Helen Chernoff, TAMS Consultants, Inc.

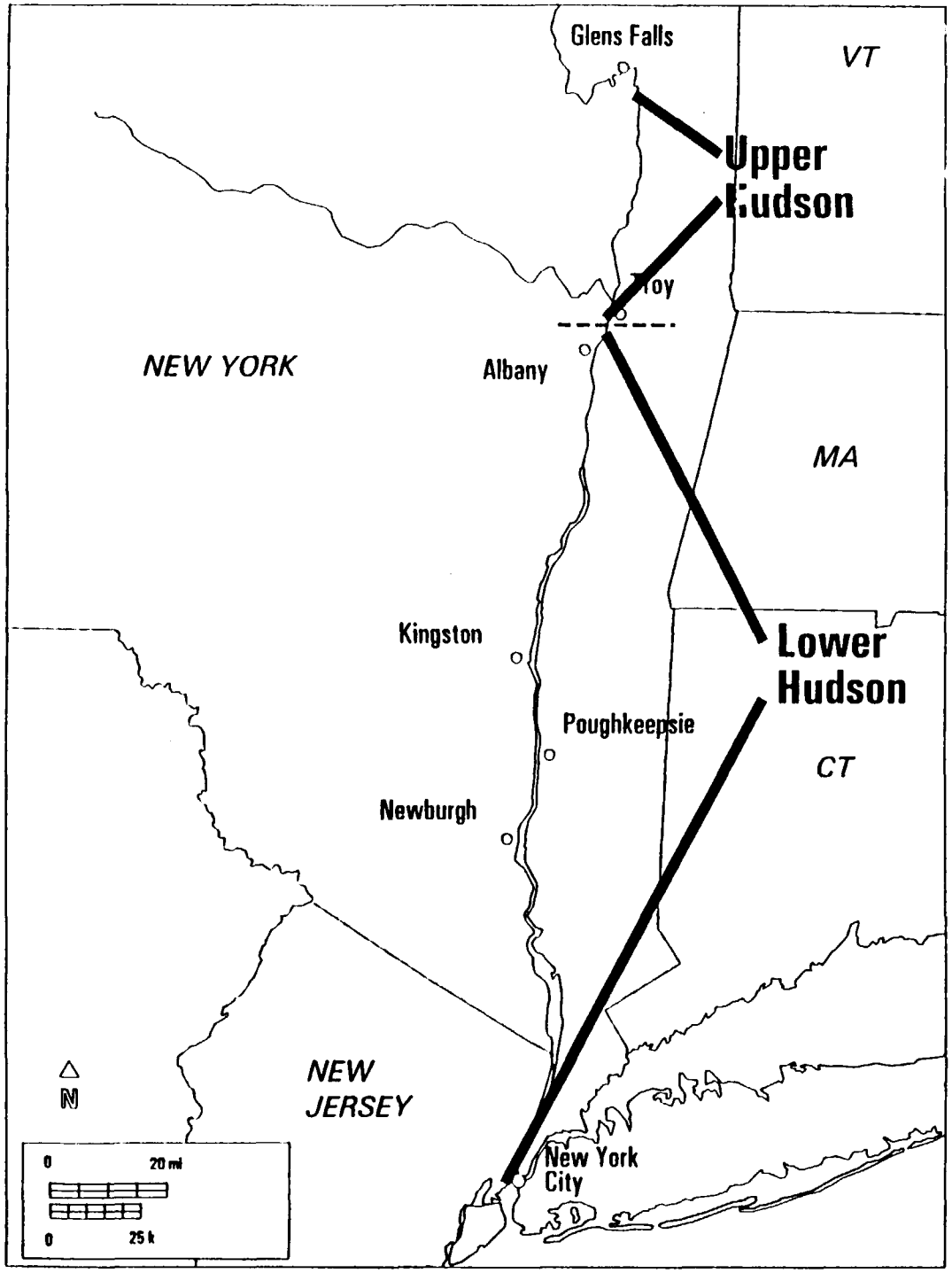
Katherine von Stackelberg, Menzie-Cura & Associates, Inc.

March 23, 2000



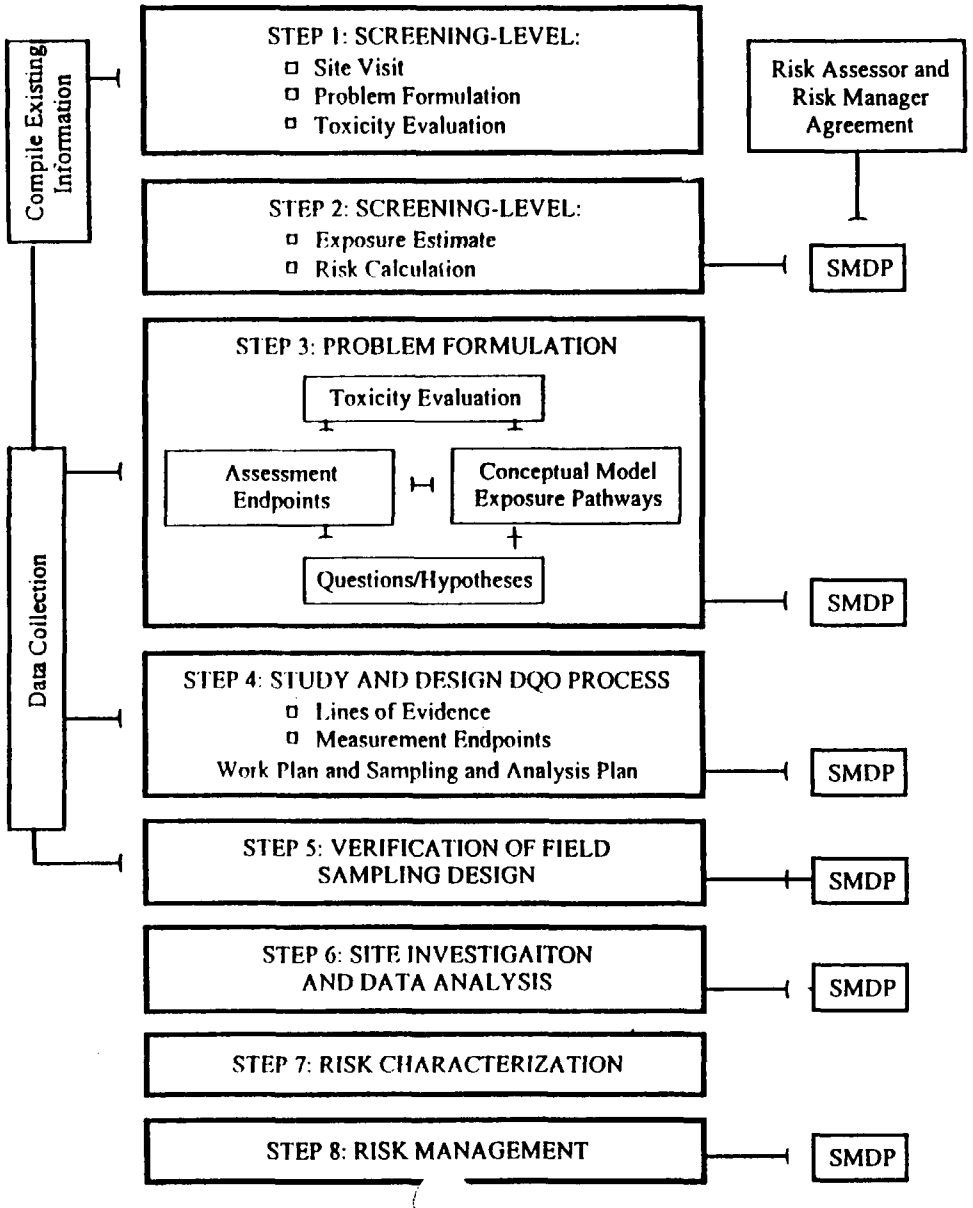
Overview of Presentation

- Walk through steps of ecological risk assessment process
  - USEPA, ERAGS, 1997
- Conclusions of baseline ecological risk assessment
  - August, 1999 report
  - March, 2000 Responsiveness Summary



Scope of Ecological Risk Assessment

Eight-Step Ecological Risk Assessment Process for Superfund



Ecological Risk Assessment Process

- Problem Formulation
- Analysis
  - Characterization of Exposure
  - Characterization of Ecological Effects
- Risk Characterization
  - Uncertainty Analysis

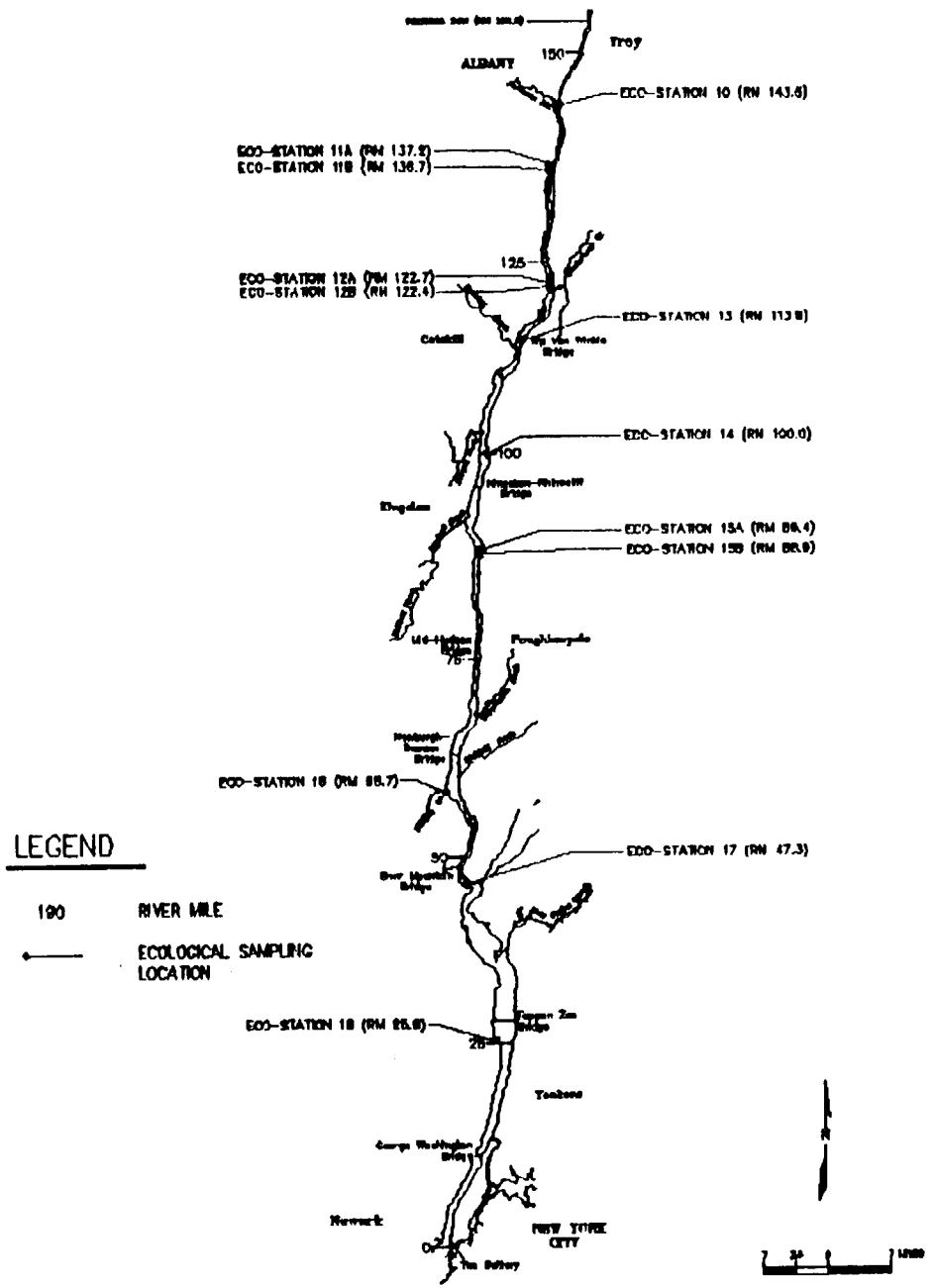
Problem Formulation

- Site Characterization
- Contaminant of Concern (PCBs)
- Conceptual Model
  - Exposure pathways
- Assessment Endpoints
- Measurement Endpoints
- Receptors of Concern

Site Characterization

- Upper Hudson River
  - Current (field sampling program: 1993)
  - Future (1993 - 2018)
- Lower Hudson River
  - Current (field sampling program: 1993)

Upper Hudson River Ecological Sampling Locations



Contaminant of Concern: PCBs

- Total PCBs as Tri+
  - Concordance with historical Aroclors
  - Tri+ roughly equivalent to total in fish
- Dioxin equivalents (12)
  - Van den Berg et al., 1998 (WHO)
  - Data quality issues (BZ#81, BZ#126)
  - USFWS samples
  - Phase 2 data

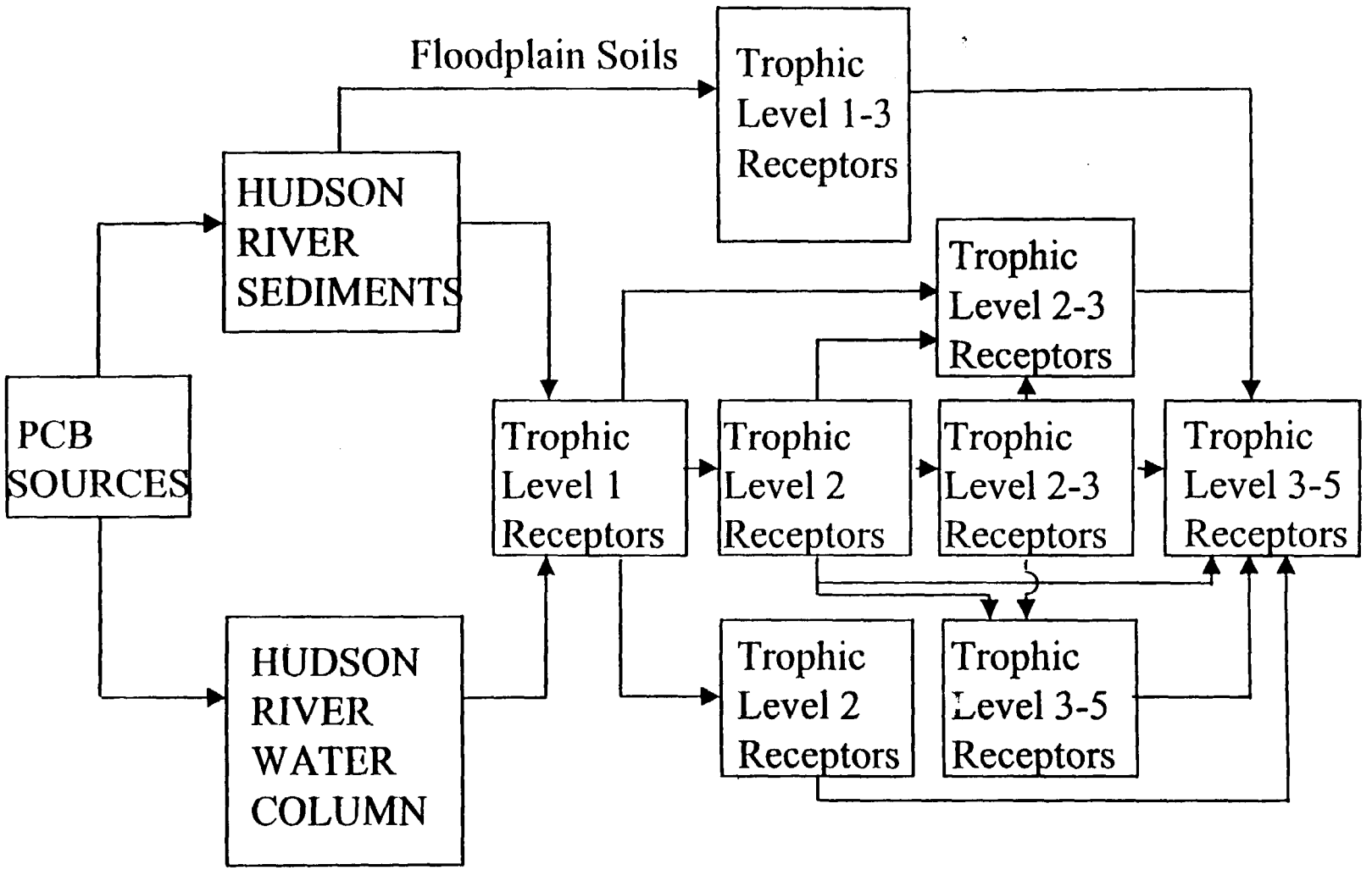
Average Proportion of Fish-Based TEQ Congeners

	BZ#77	BZ#81	BZ#105	BZ#118	BZ#126
Upper River Mean	0.28		0.06	0.11	0.52
Lower River Mean	0.05		0.02	0.05	0.85
Whole River Mean	0.15		0.03	0.07	0.71
Egg Mean	0.32	0.11	0.04	0.07	0.40
Chick Mean	0.38	0.13	0.04	0.08	0.33
Odonate Mean	0.34	0.05	0.03	0.05	0.49
Insect Mean	0.34	0.11	0.04	0.05	0.42

Conceptual Model

- Exposure Pathways
  - Aquatic exposure pathways
  - Terrestrial (nearshore) exposure pathways
- Ecosystems of the Hudson River

Conceptual Model Diagram



Exposure Pathways

- How receptors come into contact with PCBs:
  - Ingestion of water
  - Ingestion of food (e.g., fish, insects)
  - Incidental ingestion of sediment
- Expressed as:
  - Dietary dose (mammal, bird)
  - Egg concentration (bird, fish)
  - Body burden (fish)

Ecosystems of the Hudson River

- Upper Hudson River
  - Non-tidal freshwater - above Federal Dam (RM 153)
- Lower Hudson River
  - Tidal freshwater - Federal Dam to Newburgh (RM 153 to RM 60)
  - Estuarine - Newburgh to Manhattan (RM 60 to RM 0)
  - Marine - New York Harbor and beyond

Assessment Endpoints

- Explicit expression of the environmental value that is to be protected
- Based on:
  - Mechanisms of toxicity
  - Receptor groups that are sensitive or highly exposed to PCBs
  - Potentially complete exposure pathways

Assessment Endpoints

- Benthic community as source of prey
- Protection and maintenance (survival, growth, and reproduction) of populations of:
  - local fish (forage, omnivorous, and piscivorous)
  - local birds (insectivorous, waterfowl, and piscivorous)
  - local wildlife (insectivorous, omnivorous, piscivorous)
- Protection of threatened and endangered species
- Protection of significant habitats

Measurement Endpoints

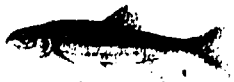
- Actual measurements used to evaluate ecological risk (lines of evidence)
  - Benthic community indices
  - Measured and modeled:
    - PCB body burdens in fish (wet weight, lipid-normalized)
    - PCB dietary doses to wildlife
    - PCB concentrations in bird eggs
    - PCB concentrations in sediment and surface water
  - Water Quality Criteria and Sediment Guidelines
  - Field observations

Receptors of Concern

- Representative of wildlife species using Hudson River
- Represent different trophic levels, feeding strategies, habitat preferences
- Receptors include:
  - macroinvertebrate communities
  - fish
  - birds
  - mammals

Ecological Receptors of Potential Concern in the Hudson River

Fish



Spottail Shiner

Pumpkinseed

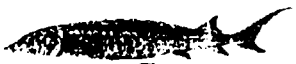
Brown Bullhead

White Perch

Yellow Perch

Largemouth Bass

Striped Bass



Shortnose Sturgeon

Birds

Tree Swallow

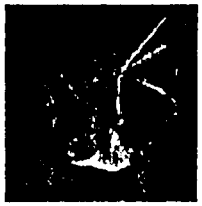
Mallard

Belted Kingfisher

Great Blue Heron

Bald Eagle

Mammals



Little Brown Bat

Raccoon

Mink

River Otter

308653

NYS and Federal Threatened and Endangered Species

- Invertebrates - Karner blue butterfly
- Fish - shortnose sturgeon
- Herpetofauna -northern cricket frog, bog turtle, Blanding's turtle, timber rattlesnake
- Birds - peregrine falcon, bald eagle, osprey, northern harrier, red-shouldered hawk
- Mammals - Indiana bat, eastern woodrat

Significant Habitats

- 34 Sites Designated as Significant Coastal Fish and Wildlife Habitats
- 5 Additional Sites Containing Important Plant and Animal Communities
- 4 Sites Comprise the Hudson River National Estuarine Research Reserve

Exposure Assessment

- Sediment and water concentrations
  - measured: 1993 USEPA dataset
  - modeled: HUDTOX model
- Phytoplankton (mallard)
  - dissolved water * K_{ow} * lipid
- Invertebrate and fish
  - measured: 1993 USEPA dataset
  - modeled: FISHRAND model

Exposure Models

- Avian receptors
  - dietary dose
    - 1993 data
    - HUDTOX, FISHRAND models
  - egg concentration (biomagnification factor)
- Mammalian receptors
  - dietary dose
    - 1993 data
    - HUDTOX, FISHRAND models

Upper Hudson River Sediment & Water Modeling

- HUDTOX model
  - Tri+ as exposure for fish
  - Total PCB for:
    - comparison to water quality criteria
    - comparison to sediment guidelines
    - incidental sediment ingestion
    - water ingestion

The FISHRAND Model

- Phytoplankton
  - dissolved water * K_{ow} * lipid
- Benthic invertebrates
  - BSAF
- Fish species
  - Gobas modeling framework
  - Revised Baseline Modeling Report

Exposure Parameters

- Site-specific data if possible
- US EPA Wildlife Exposure Factors Handbook
- Peer-reviewed literature

Sample Receptor Parameters

EXPOSURE PARAMETERS FOR BALD EAGLE

	Exposure Parameters	
Sex (M/F)	Female	Male
Age (Adult/Juvenile)	Adult, Breeding	
Male/Female Body Weight (kg)	5.10	3.20
Total Daily Dietary Ingestion (kg/day wet wt.)	0.65	0.46
Total Daily Dietary Ingestion (kg/day dry wt.)	-	-
General Dietary Characterization	Opportunistic Piscivore	
Percent Diet Composition (% wet wt.)		
Fish (Total Component)	100%	
Aquatic Invertebrates (Total Component)	0%	
Non-river Related Diet Sources	0%	
Water Consumption Rate (L/day)	0.175	0.129
Percent Incidental Sediment Ingestion in Diet	0.00%	

Ecological Effects

- PCBs shown to exhibit chronic toxicity
  - Reproductive
  - Developmental
  - Neurological
  - Immunological
  - Biochemical
- Focus on effects with most direct relevance to population

Effects Assessment

- Toxicity Reference Values (TRVs)
  - Laboratory studies
    - No observed adverse effect levels (NOAELS)
    - Lowest observed adverse effect levels (LOAELS)
  - Field studies
    - No observed adverse effect levels (NOAELS)
- Uncertainty factor approach
  - Great Lakes
  - Oak Ridge National Laboratories

Procedure to Select TRVs

- Done individually for each receptor
- Compile laboratory studies
  - same family: no uncertainty factor
- Compile field studies
  - only used for NOAEL due to co-occurrence of other contaminants
- At most, factor of 10 uncertainty
  - subchronic to chronic (avian)
  - interspecies (fish, mammal)

Risk Characterization

- Integrates the exposure and effects assessments
- Discussion of uncertainty
- Present risk results

Toxicity Quotient (TQ)

- Comparison of measured and/or modeled doses or concentrations in the receptors of concern to the toxicity reference values
- Toxicity quotients equal to or greater than one (TQ>1) typically considered to indicate potential risk to ecological receptors

Weight of Evidence

- Weight of evidence approach
  - Multiple measurement endpoints evaluated for each assessment endpoint
  - Each measurement endpoint is a line of evidence

Risks to local benthic invertebrate communities were examined using three lines of evidence:

- 1) examination of benthic community structure;
- 2) comparison of measured and modeled water column concentrations of PCBs to criteria; and
- 3) comparisons of measured and modeled sediment concentrations to guidelines.

Risks to local fish populations were examined using five lines of evidence:

- 1) comparison of measured and modeled total PCB fish body burdens to TRVs;
- 2) comparison of measured and modeled TEQ fish body burdens to TRVs;
- 3) comparison of measured and modeled water column concentrations of PCBs to criteria;
- 4) comparisons of measured and modeled sediment concentrations to guidelines; and
- 5) field-based observations.

Risks to local bird populations were examined using six lines of evidence:

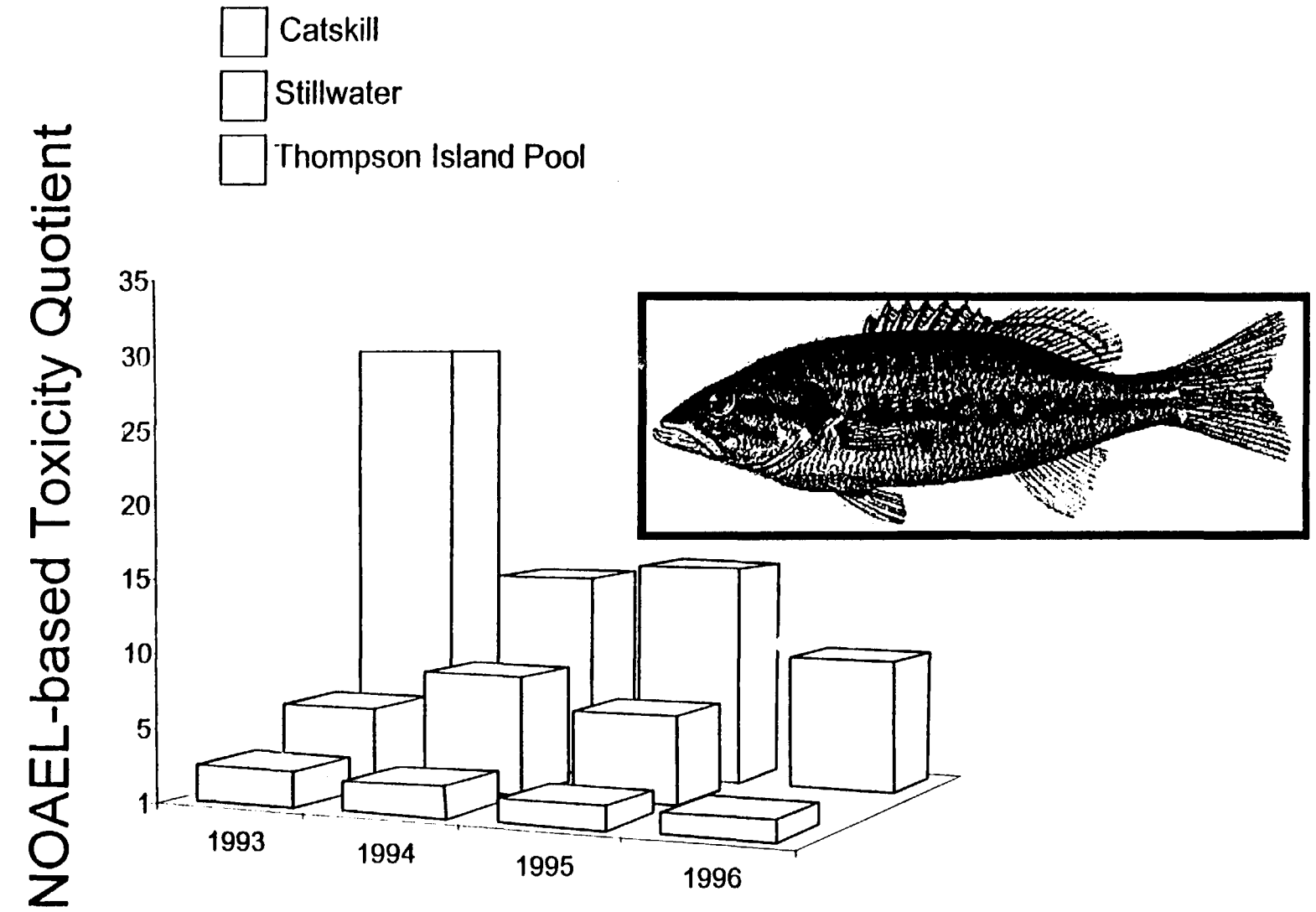
- 1) comparison of measured and modeled total PCB dietary doses to TRVs;
- 2) comparison of measured and modeled TEQ dietary doses to TRVs;
- 3) comparison of measured and modeled total PCB egg concentrations to TRVs;
- 4) comparison of modeled and modeled TEQ egg concentrations to TRVs;
- 5) comparison of measured and modeled water column concentrations of PCBs to criteria; and
- 6) field-based observations.

Risks to local mammal populations were examined using four lines of evidence:

- 1) comparison of measured and modeled total PCB dietary doses to TRVs;
- 2) comparison of measured and modeled TEQ dietary doses to TRVs;
- 3) comparison of measured and modeled water column concentrations of PCBs to criteria; and
- 4) field-based observations.

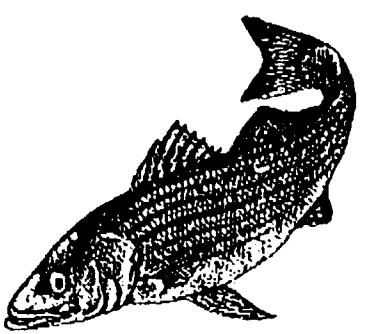
Risks to significant habitats were examined using two lines of evidence:

- 1) comparison of measured and modeled water column concentrations of PCBs to criteria; and
- 2) comparisons of measured and modeled sediment concentrations to guidelines.

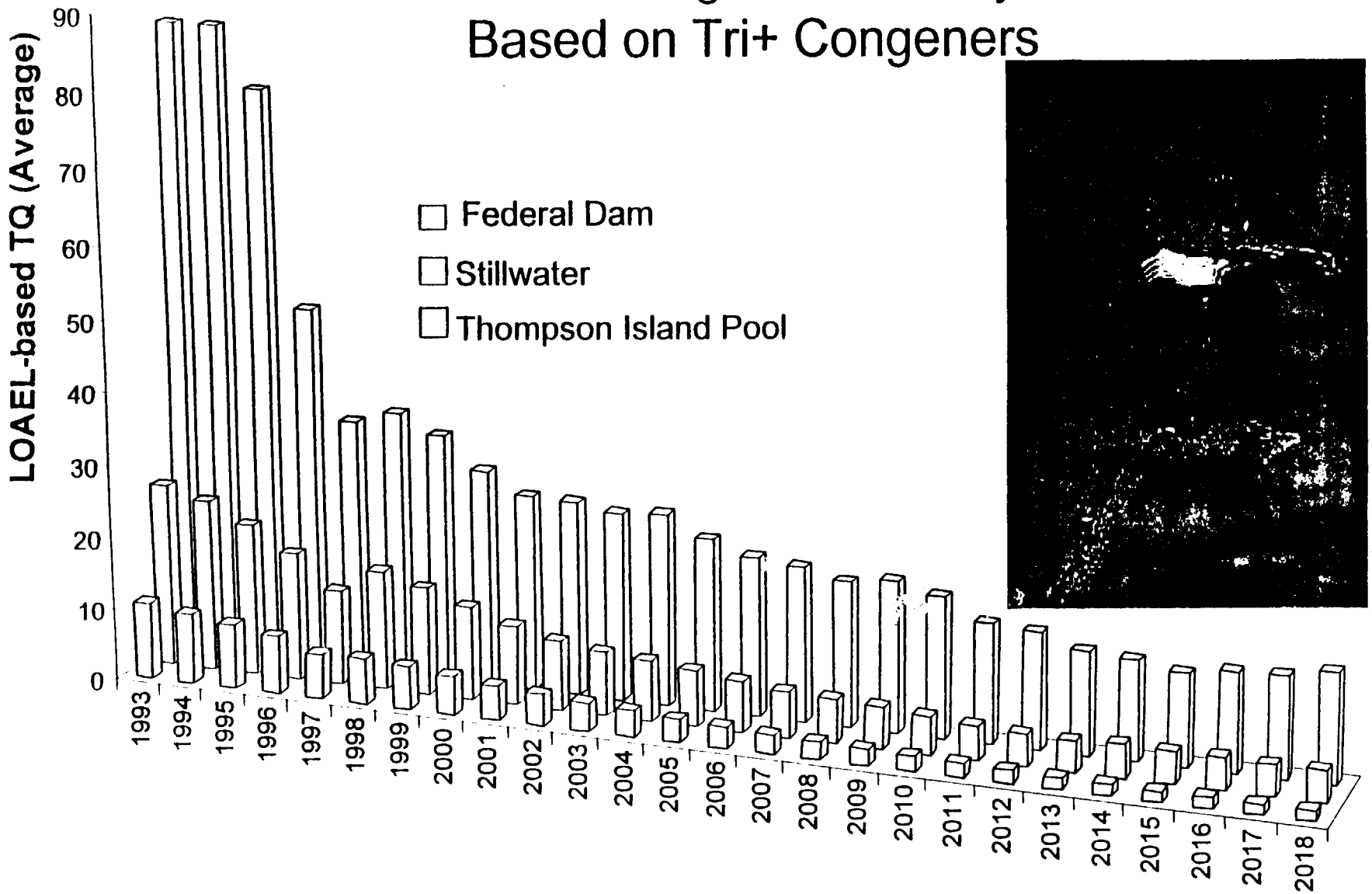


Largemouth Bass Risk Based on TEQs

Striped Bass Toxicity Quotients



Belted Kingfisher Dietary Risk Based on Tri+ Congeners



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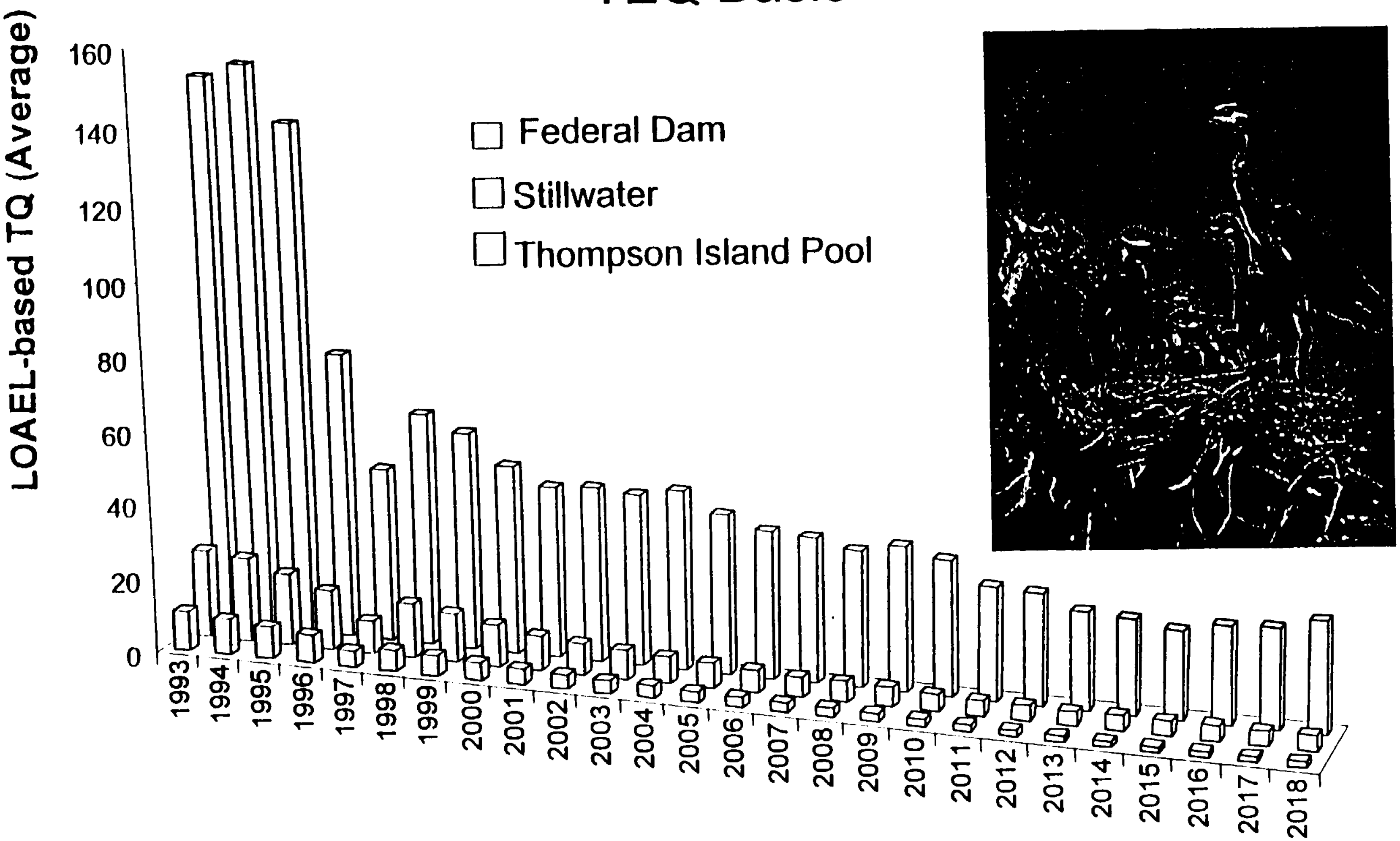
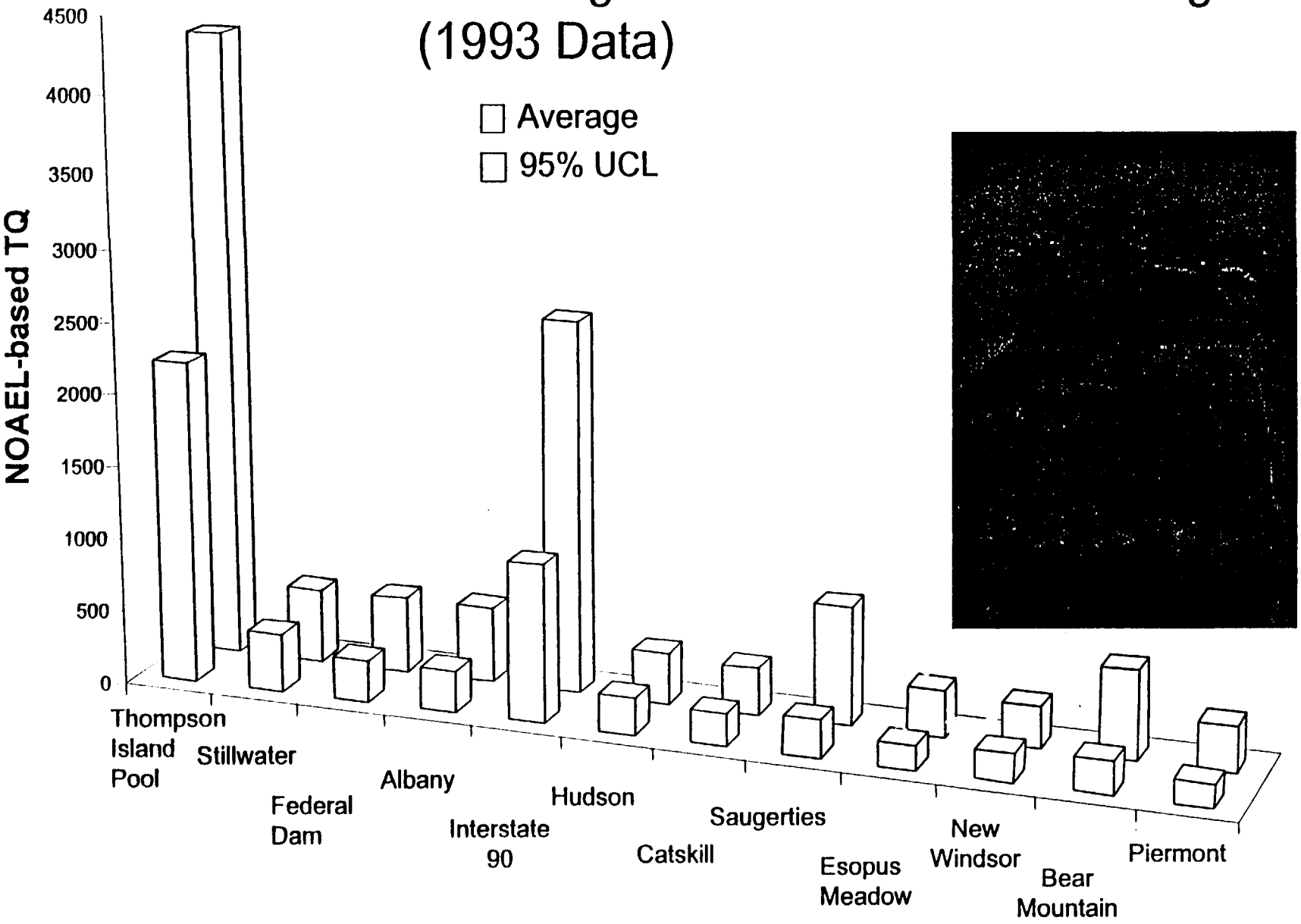
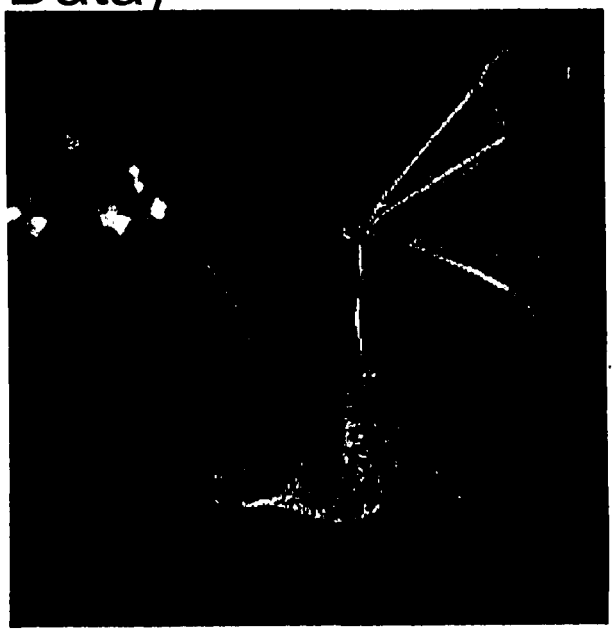
Great Blue Heron Egg Risk on a TEQ Basis



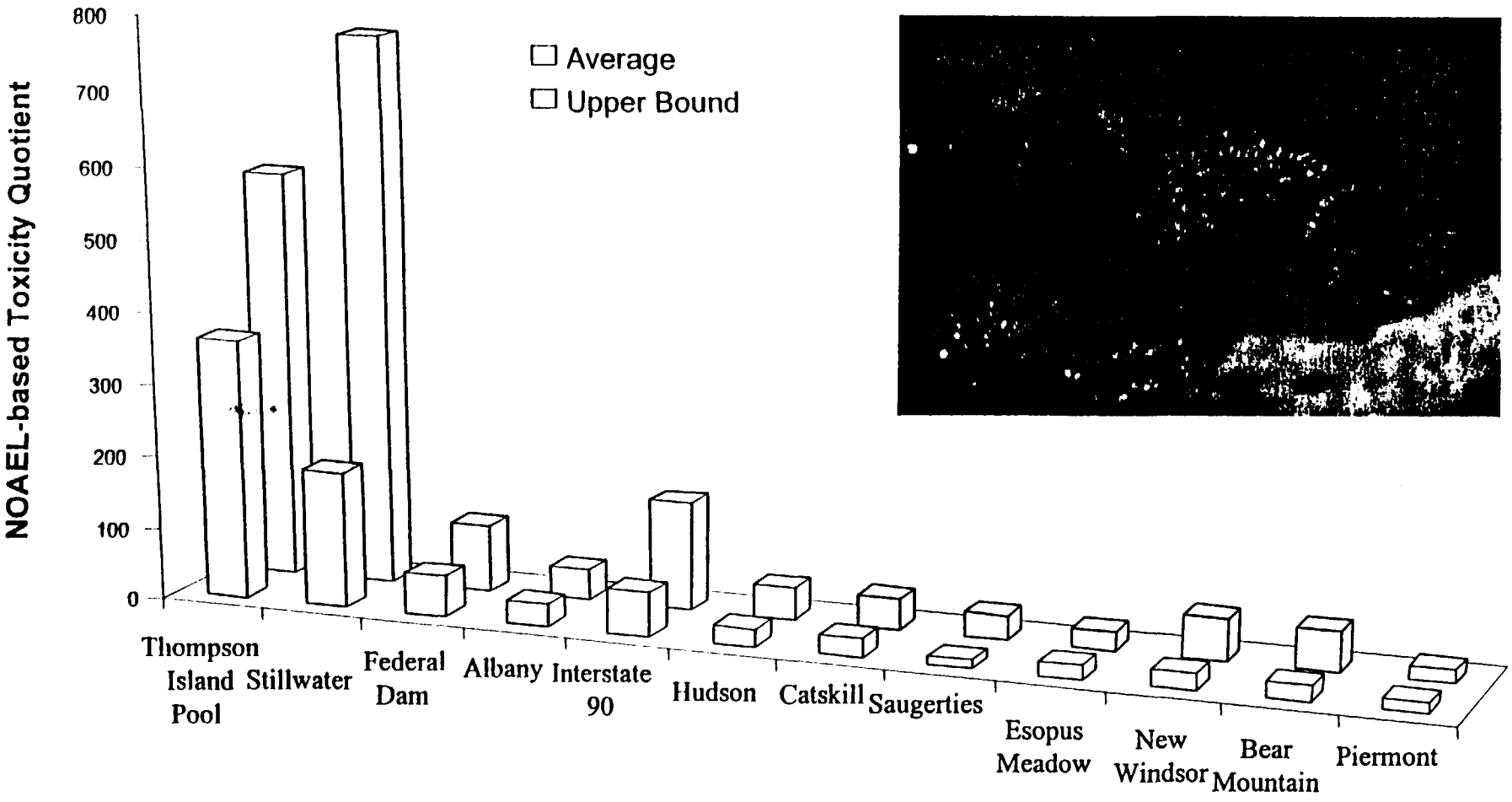
Bald Eagle Risk Based on Tri+ Congeners (1993 Data)



Little Brown Bat Dietary Risk Based on Tri+ Congeners (1993 Data)



Mink Dietary Risk Based on Tri+ Congeners (1993 Data)



River Otter Risk Based on Tri+ Congeners

Field Studies

- Ongoing studies for mammals and birds
- Mammals
  - Trapping records
  - No organized surveys
- Avian
  - NYSDEC tagging program for eagles
  - USFWS
- Fish
  - Sampling for contaminants
  - Power plant abundance surveys

Uncertainty Analysis

- Exposure assessment
  - Conceptual model
  - Quantitative exposure parameters
  - PCB concentrations
- Effects assessment
  - Interspecies
  - Acute to chronic
- Magnitude of TQs

Conclusions of the Ecological Risk Assessment

- Toxicity quotients for upper trophic level birds and mammals exceed regulatory levels of concern
- PCBs may impair but not *prevent* reproduction

PCBs may adversely affect the survival, growth and reproduction of these animals

Conclusions of the Ecological Risk Assessment

- Toxicity quotients for birds and mammals consuming emergent aquatic insects and/or plants (bat, mallard, tree swallow) exceed regulatory levels of concern
- PCBs may impair but not *prevent* reproduction

PCBs may adversely affect the survival, growth and reproduction of these animals

Conclusions of the Ecological Risk Assessment

- Toxicity quotients for fish at the top of the food chain (such as largemouth bass, striped bass) exceed regulatory levels of concern
- PCBs may impair but not *prevent* reproduction and recruitment

PCBs may adversely affect fish survival, growth and reproduction

Conclusions of the Ecological Risk Assessment

- Threatened and endangered species, represented by the bald eagle and shortnose sturgeon, are at risk due to exposure to PCBs

Threatened and endangered species face reproductive risks from PCBs

Conclusions of the Ecological Risk Assessment

- PCB concentrations in water and sediments in the Hudson River generally exceed protective criteria and guidelines

Significant habitats and the animals that use them face risks from PCBs

Conclusions of the Ecological Risk Assessment

- Risks to fish and wildlife:
  - Greatest in the Upper Hudson River
  - Generally decrease moving down river
  - Greatest for top level predators
  - Under baseline conditions many species face considerable risk through the entire forecast period (modeled to 2018)

4

Upper Hudson River Human Health Risk Assessment

Hudson River PCBs Reassessment

MARIAN OLSEN - USEPA

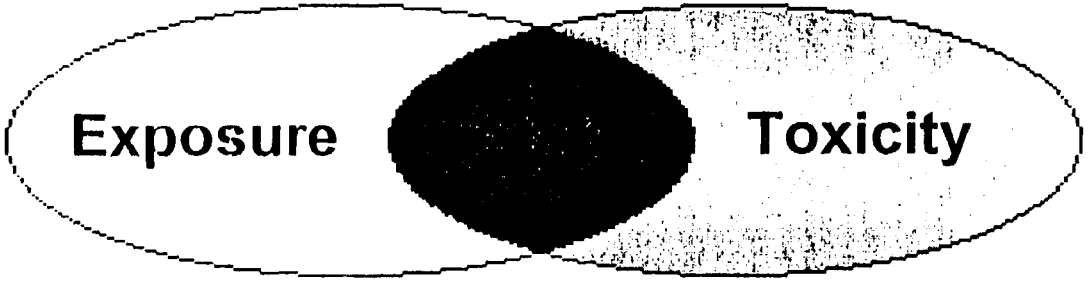
DAVE MERRILL - GRADIENT CORP

Peer Review Meeting March 23, 2000

Outline of Discussion

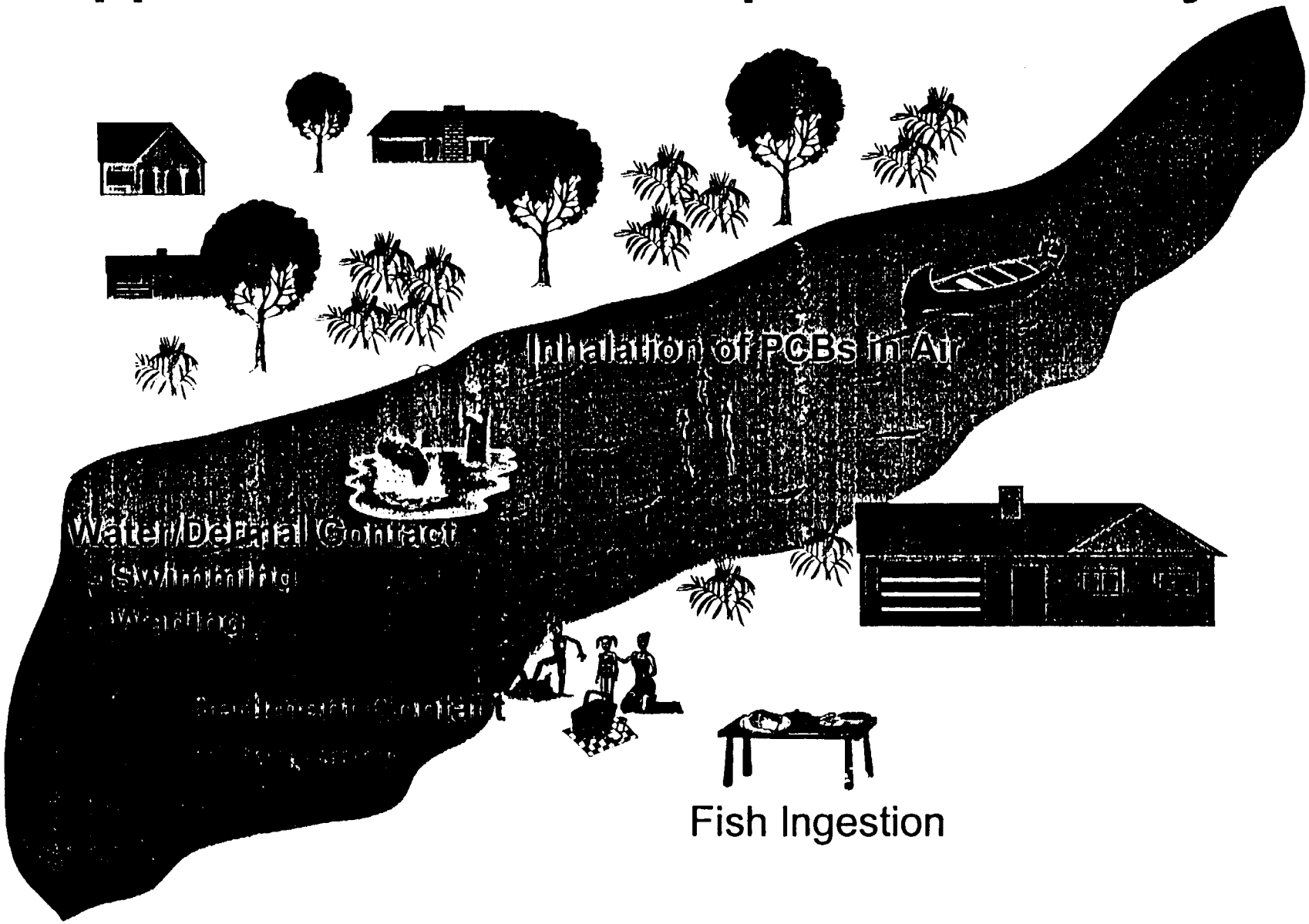
- **Summary of risk results (brief)**
- **PCB toxicity issues**
- **Exposure pathways**
  - fish, water, sediment, air
  - Project-specific exposure factors
- **Monte Carlo (probabilistic) approach**
  - Uncertainty/Sensitivity Analysis
- **Revised Upper-Hudson results based on revised BMR**

U.S. EPA Superfund Risk Assessment

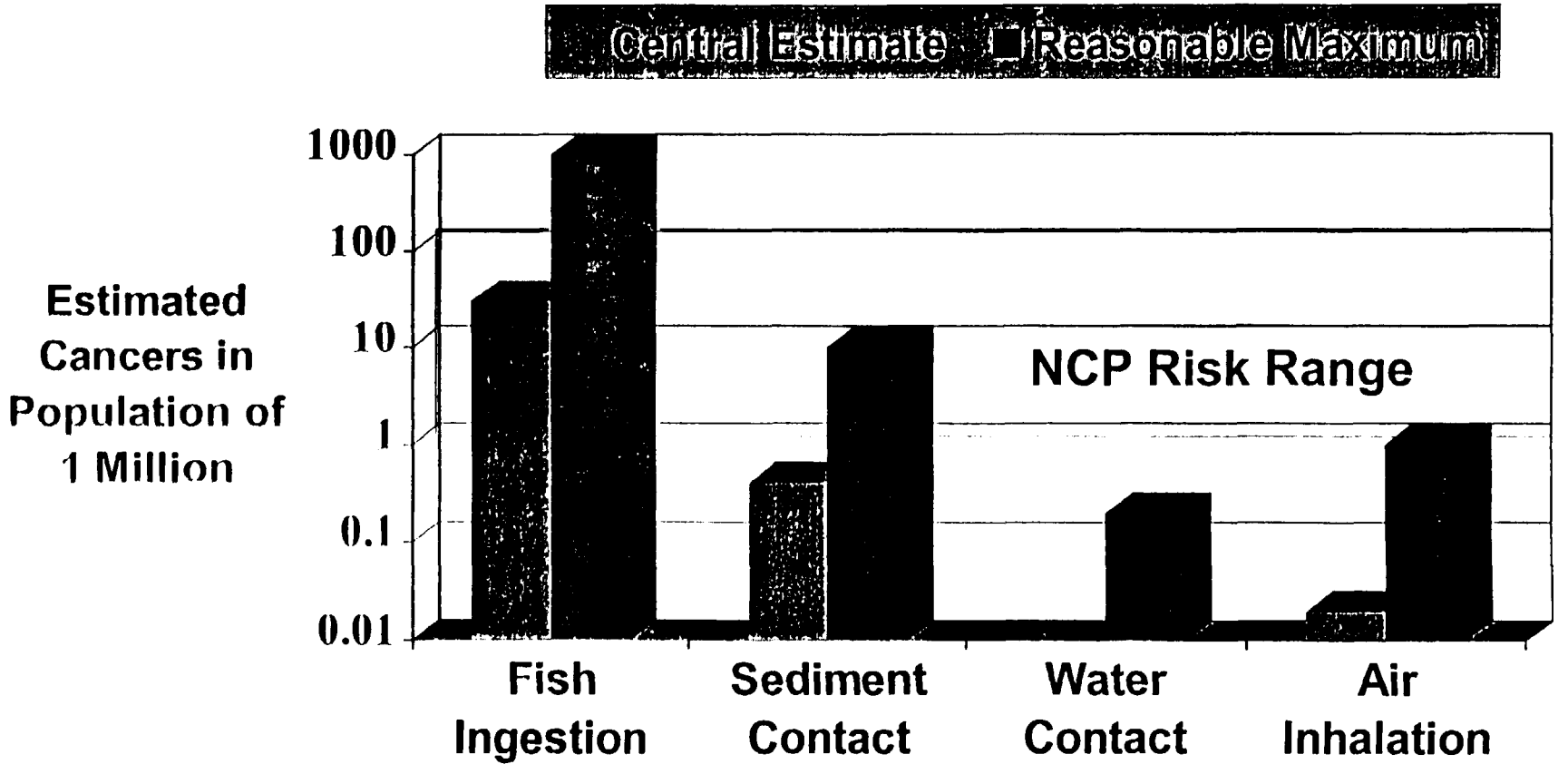


- Evaluated under current (baseline) and future conditions
- Baseline conditions evaluated in the absence of institutional or other controls
- Goal is health protection under reasonable maximum exposures

Upper Hudson River Exposure Pathways

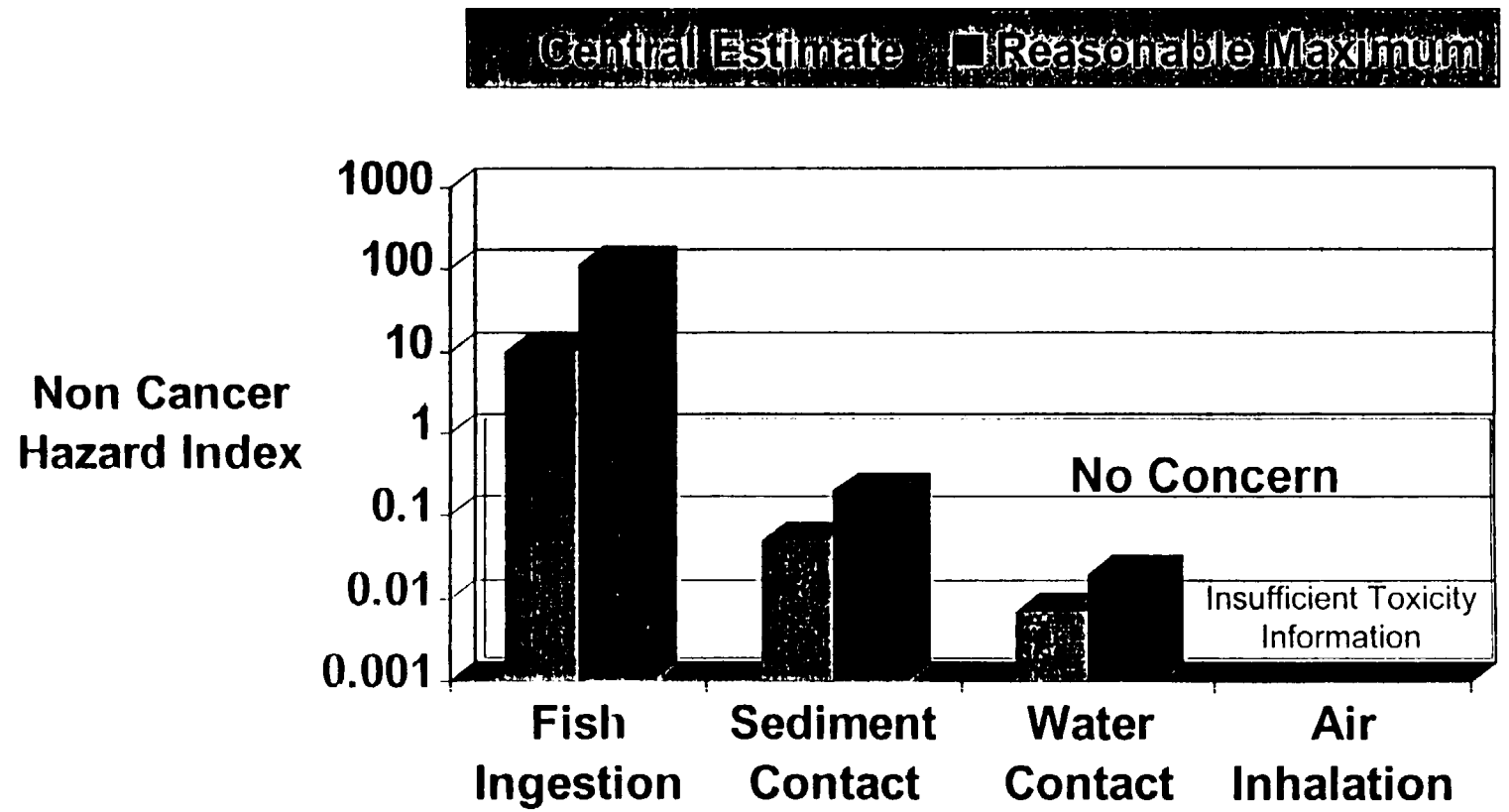


Cancer Risk Summary



August 1999 Report Values

Non-Cancer Hazard Index Summary

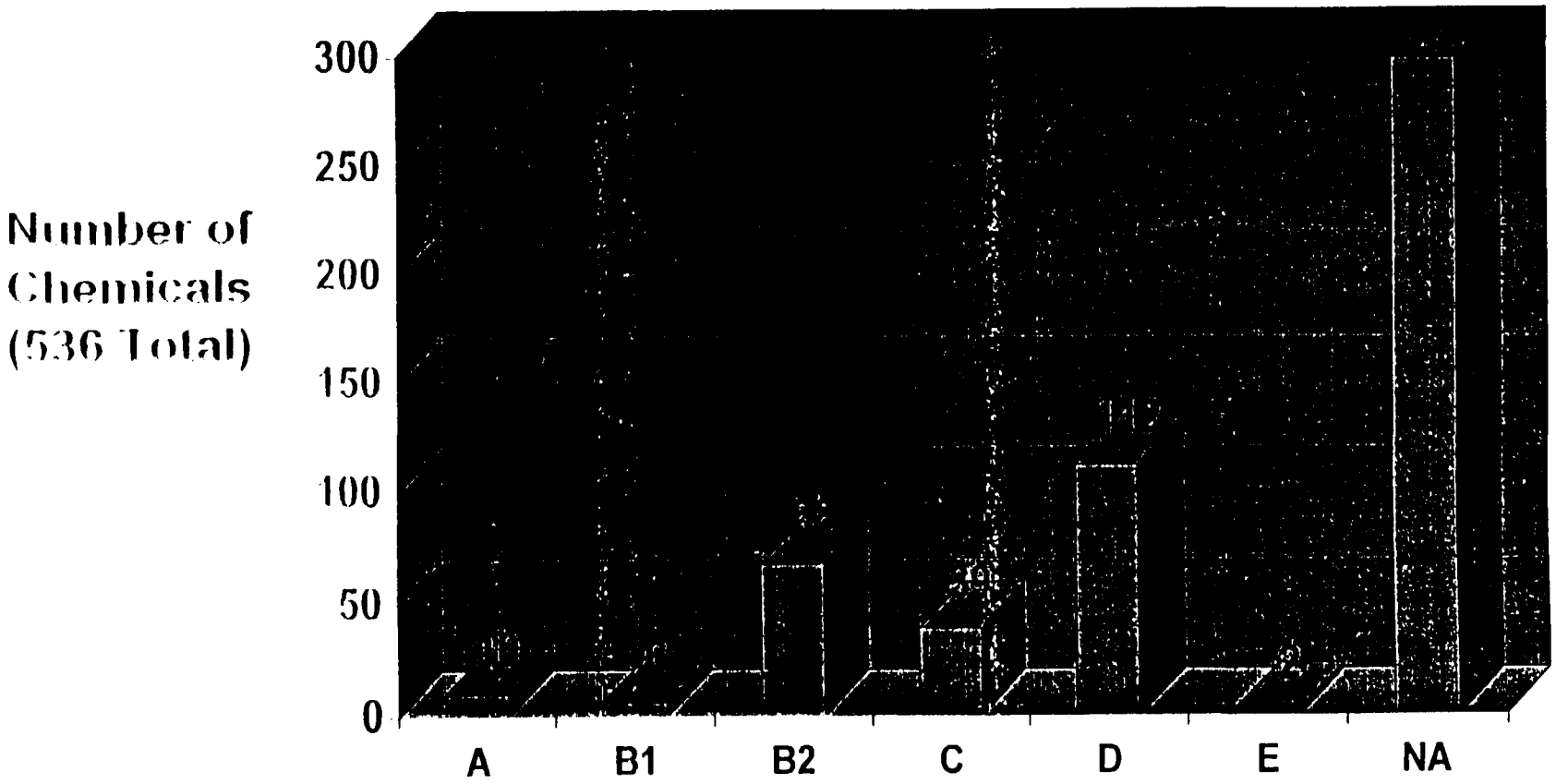


August 1999 Report Values

Process for Chemical Listing in IRIS

- Identify chemical in Federal Register listing
- EPA chemical manager develops toxicological file
- Draft chemical file reviewed by EPA
- File submitted for external review
- Internal (EPA) consensus review
- File is posted on IRIS

Carcinogens Classified in IRIS



Note: As of September 1999

Carcinogenicity of PCBs (IRIS)

- **Classified as probable human carcinogen**
  - Evidence from occupational studies is inadequate but suggestive
- **Sufficient evidence from animal laboratory studies**
  - Rats exposed to Aroclors 1260, 1254, 1242 and 1016 exhibited liver tumors (1996 study)
  - Males had increased numbers of thyroid tumors for all Aroclors
  - Commercial Arcolor mixtures cover range of congeners found in environment

Cancer Slope Factors for PCBs
CSF in mg/kg-day^{-1} (IRIS)

- **<u>High Risk & Persistence</u> (soil, sediment, fish)**
  - Upper-bound CSF = 2
  - Central Tendency CSF = 1
- **<u>Low Risk & Persistence</u> (air, water)**
  - Upper-bound CSF = 0.4
  - Central Tendency CSF = 0.3
- **<u>Lowest Risk & Persistence</u> (PCBs with $\leq$ 4 chlorines)**
  - Upper bound CSF= 0.07
  - Central tendency CSF = 0.04

Non-Cancer PCB Toxicity Factors (IRIS)

- Reference Dose (RfD): ***chemical intake likely to be without an appreciable risk of adverse effects to humans during a lifetime.***
- **RfD is based on feeding studies with rhesus monkeys**
- **Example adverse effects observed in animals:**
  - Reduced birthweight (1016)
  - immune system impairment (1254)
  - eye toxicity (1254)
- **PCBs have among the lowest reference doses (high toxicity) in IRIS**

IRIS Non-Cancer Toxicity Factors (RfDs) for PCBs

- **Aroclor 1254 - RfD = 2 x 10^{-5} mg/kg-day**
  - LOAEL based on various clinical & immunologic effects
- **Aroclor 1016 - RfD = 7 x 10^{-5} mg/kg-day**
  - NOAEL based on reduced birth weight

Averaging Time Considerations

- **Due to PCB concentrations decline over time, average concentration declines as averaging duration increases.**
- **Non-cancer**
  - RME concentration averaged over 7 years
  - 7-year period is based on definition of "chronic" exposure
  - Central tendency concentration averaged over ≈12 years
- **Cancer**
  - Averaged over RME (≈40 years) and central tendency (≈12 years) exposure durations

Risks to Children

- **Fish Ingestion**
  - Point Estimate
    - meal portion ≈ 1/3 of adult portion
    - RME cancer risk ≈ 1.2-fold lower than adult (revised values)
    - RME Hazard Index ≈ 2.3-fold greater than adult (revised values)
  - Monte Carlo
    - Simulated ages from ≥ 10 up to 70 years
    - No specific break-out of risks by age group
- **Sediment, Water & Air**
  - Included children, adolescents, and adults for all exposures

Revised results in Responsiveness Summary

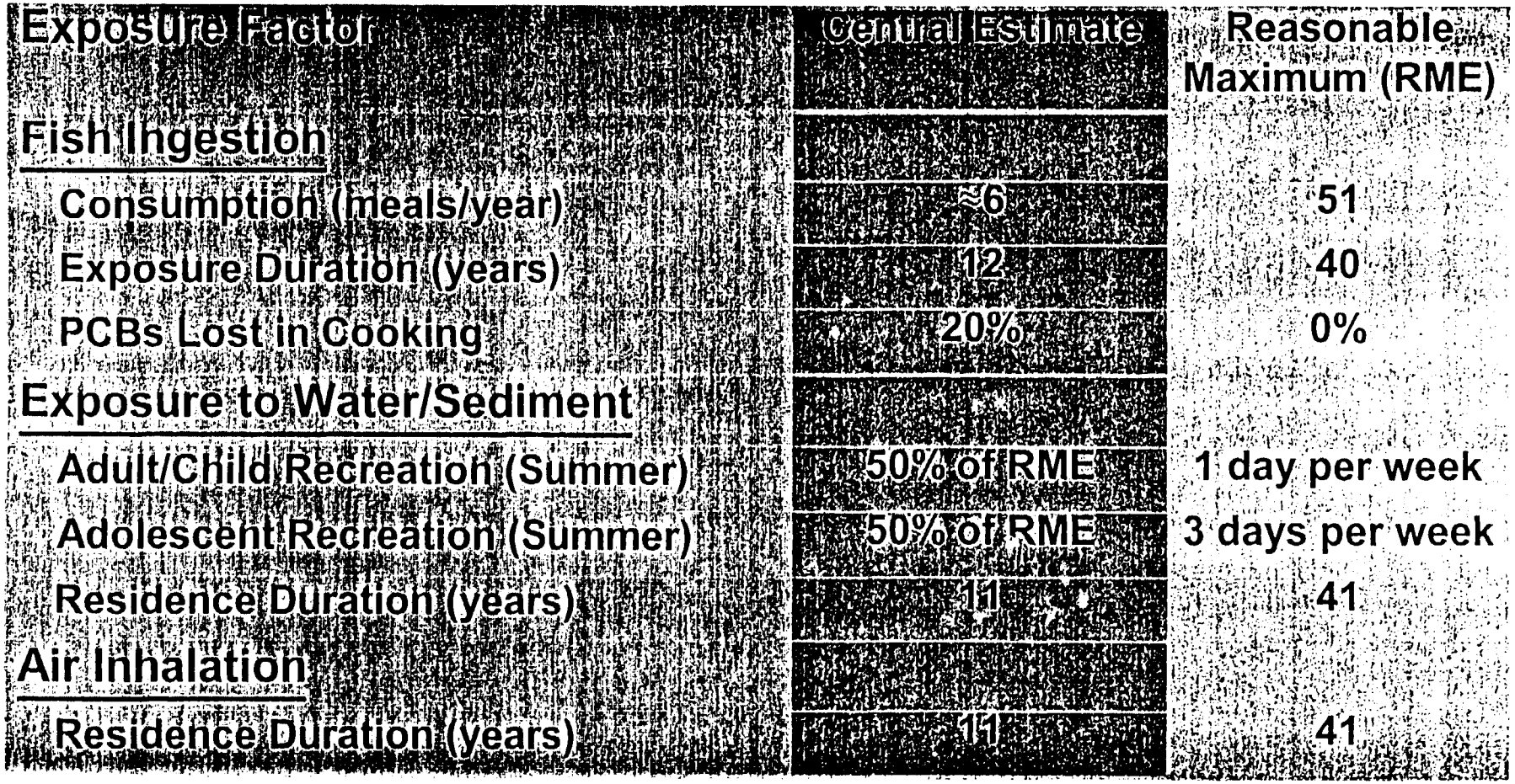
Exposure Pathways Evaluated

- **Fish Ingestion**
  - anglers who catch fish in Hudson in absence of advisories
- **Drinking water (*de minimis* -- Phase 1)**
- **Water (recreational contact)**
  - Dermal Contact
- **Sediment (recreational contact)**
  - Dermal contact
  - Ingestion
- **Air**
  - Recreators and residents along the river

Point Estimate & Probability Analyses

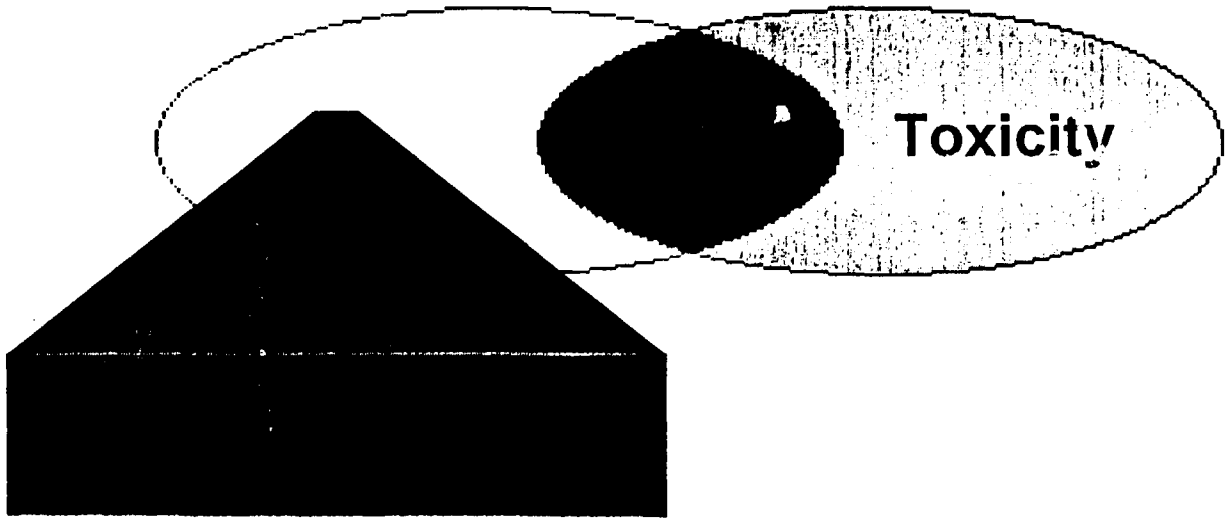
- **For all exposure pathways "point estimate" exposure and risk calculations were performed:**
  - Central Tendency estimate of average risk
  - Reasonable Maximum Exposure (RME) risk
- **Monte Carlo analysis performed for fish ingestion**

Summary of Important Exposure Factors



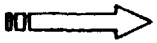
Exposure Factor	Central Estimate	Reasonable Maximum (RME)
Fish Ingestion		
Consumption (meals/year)	≈6	51
Exposure Duration (years)	12	40
PCBs Lost in Cooking	20%	0%
Exposure to Water/Sediment		
Adult/Child Recreation (Summer)	50% of RME	1 day per week
Adolescent Recreation (Summer)	50% of RME	3 days per week
Residence Duration (years)	11	41
Air Inhalation		
Residence Duration (years)	11	41

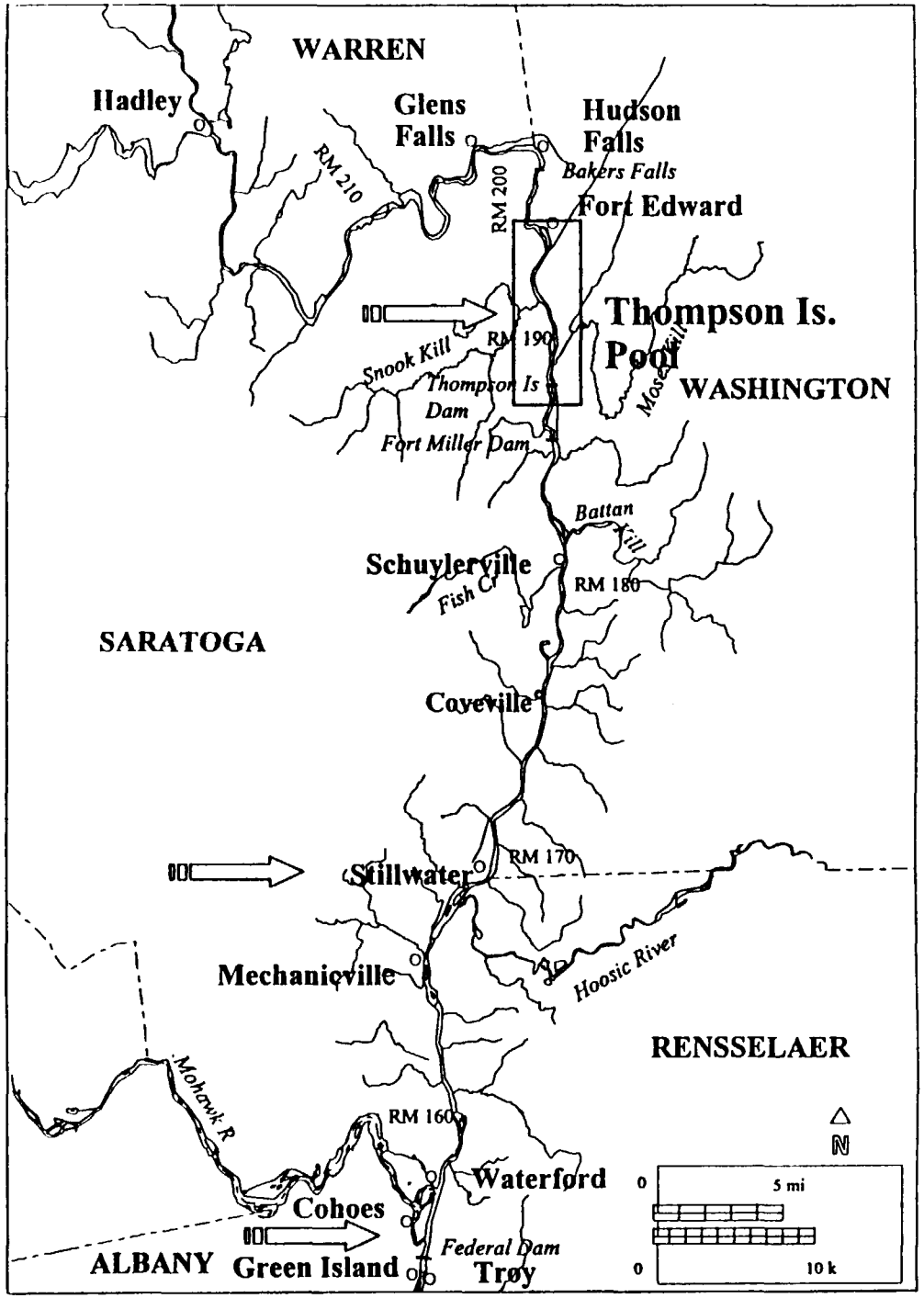
Discussion of Exposure Factors



Scope of Upper Hudson Human Health Risk Assessment

Locations of modeled PCB bioaccumulation in Fish



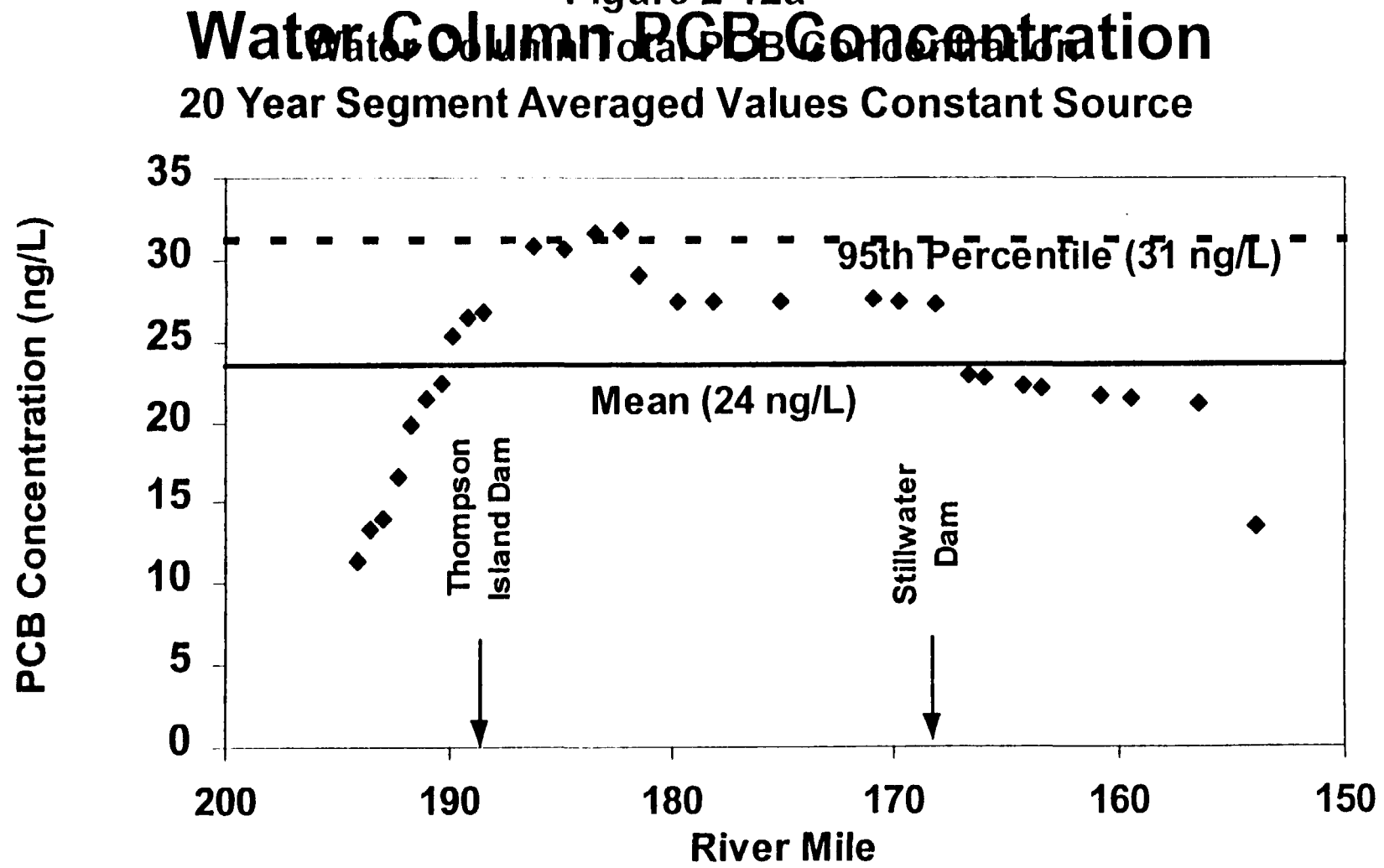


Exposure Point Concentrations (EPC)

- **Water & Sediment**
  - Baseline modeling report 20 year simulations (revised BMR 70 years)
- **Air (2 screening level estimation methods)**
  - Empirical transfer coefficient based on 1991 remnant monitoring and coincident river water monitoring
  - Mathematical diffusion & air dispersion modeling with field measured diffusion coefficients for Tri- and Tetra-CB
- **Fish**
  - Extrapolation of 20 year modeling results -- 3 species for 3 locations (revised BMR 70 years)

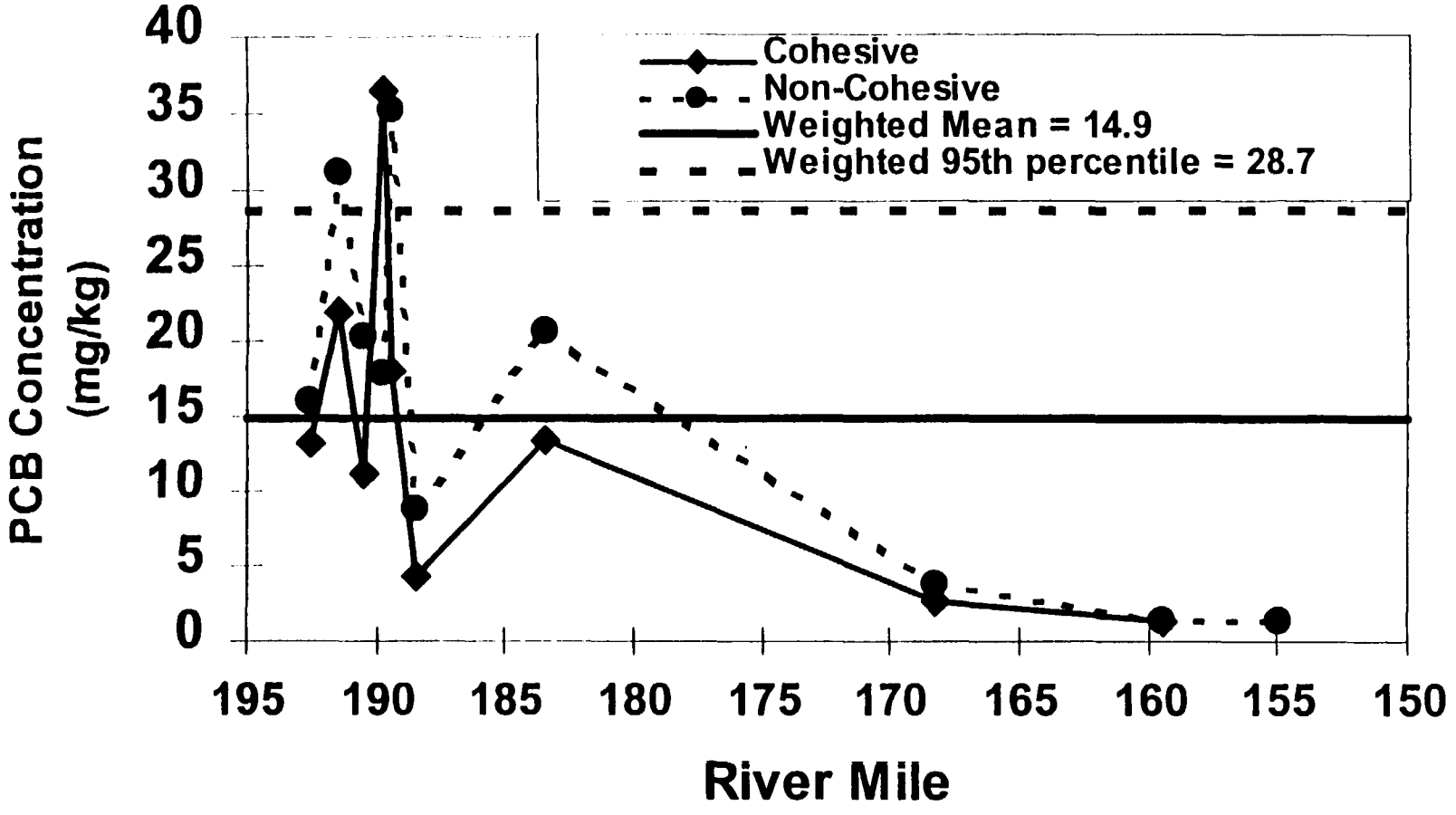
Figure 2-12a

Water Column PCB Concentration



August 1999 Report Example

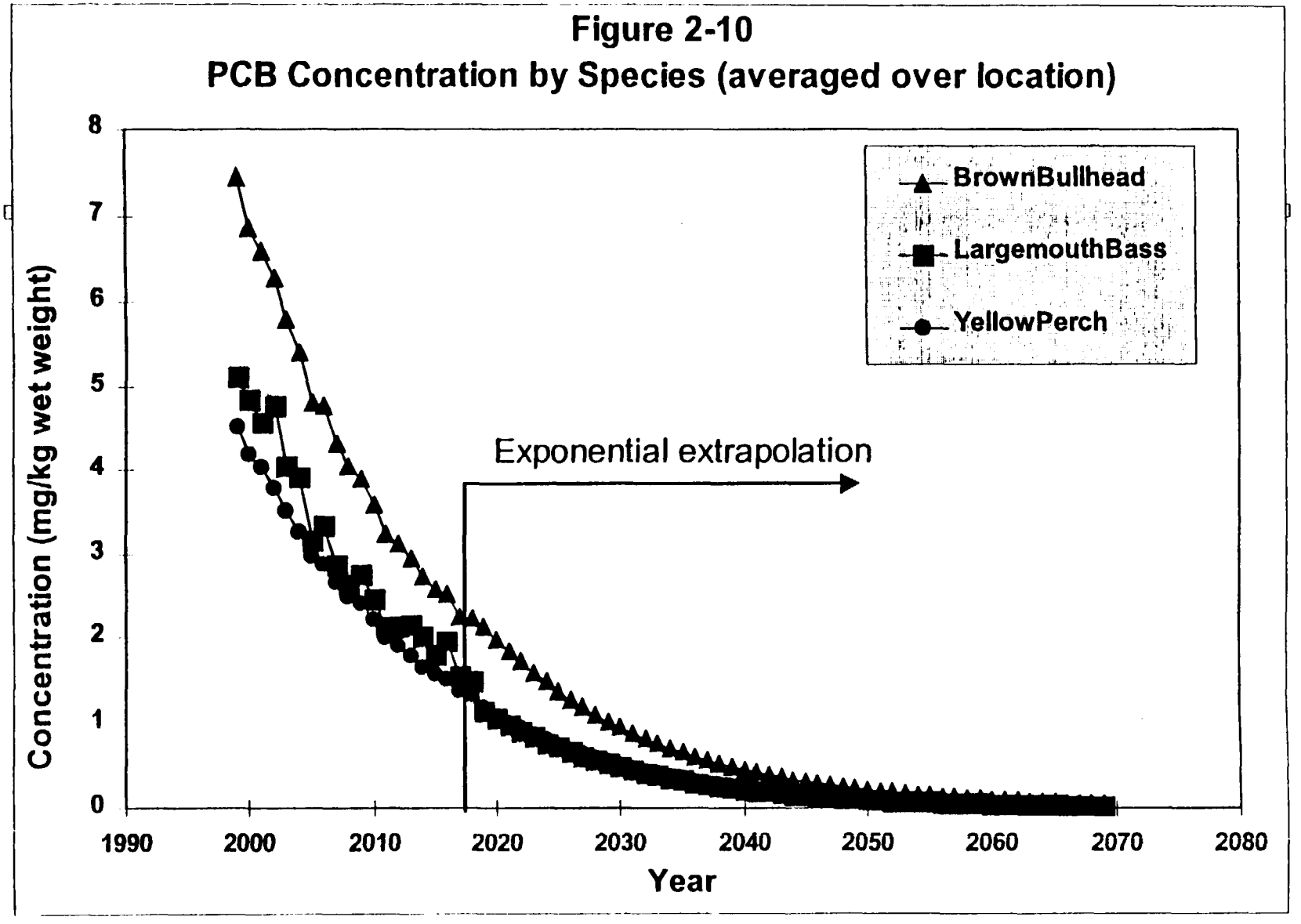
Figure 2-11b
Total PCB Concentration in Sediment (1999 - 2018)
20 Year Segment Averages -- Constant Source



August 1999 Report Example

PCB Concentration in Fish

- **3 Modeled species -- bass, bullhead, perch**
- **Species consumption frequency reported in 1991 NY Angler survey for:**
  - bass, walleye, bullhead, carp, eel, perch (U. Hudson species)
  - salmon, trout, other (not typical U. Hudson)
- **Species ingestion fractions for 3 modeled species used as weighting factors for concentration term**
- **August 1999 Report extrapolated 20-year model forecast to cover up to 70 years exposure duration**
  - No extrapolation for revised BMR



August 1999 Report Example

Summary of PCB Concentration Term in Fish Used in Risk Calculations

- **Point estimate adopted average concentration over 3 model locations**
  - 40 year average = 2.2 mg/kg (1.4 mg/kg revised)
  - 12 year average = 4.4 mg/kg (2.4 mg/kg revised)
- **PCB concentration variability was addressed:**
  - Variations among species consumed
  - Variation in concentration between upstream and downstream locations (Monte Carlo sensitivity analysis)

Angler Population Exposure Duration

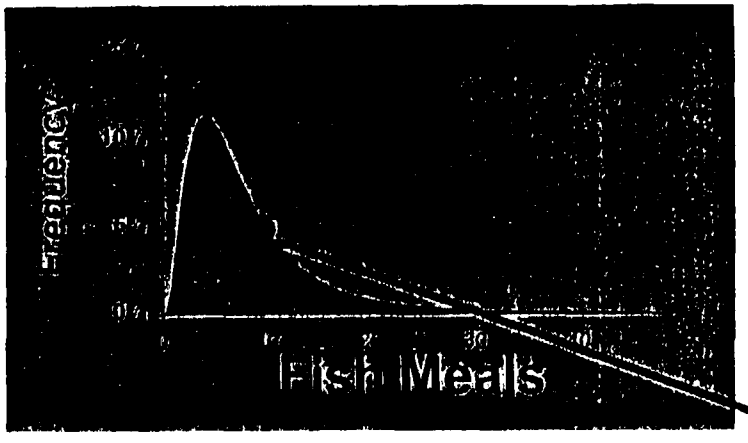
- **Exposure defined as the minimum of:**
  - Residence duration in 5 counties bordering Upper Hudson
  - Fishing duration
- **Residence duration estimated from 1990 Census data**
- **Fishing duration based on analysis of 1991 NY Angler Survey data**
- **Results:**
  - 50th percentile = 12 years
  - 95th percentile = 40 years

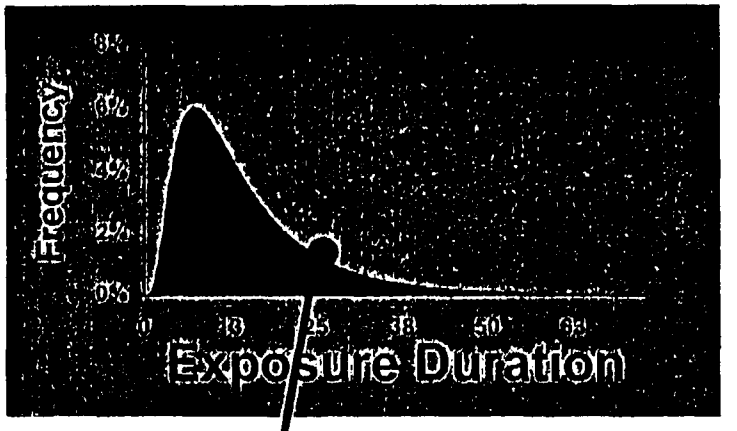
Variability/Uncertainty Analysis Evaluated Wide Range of Exposure Factors

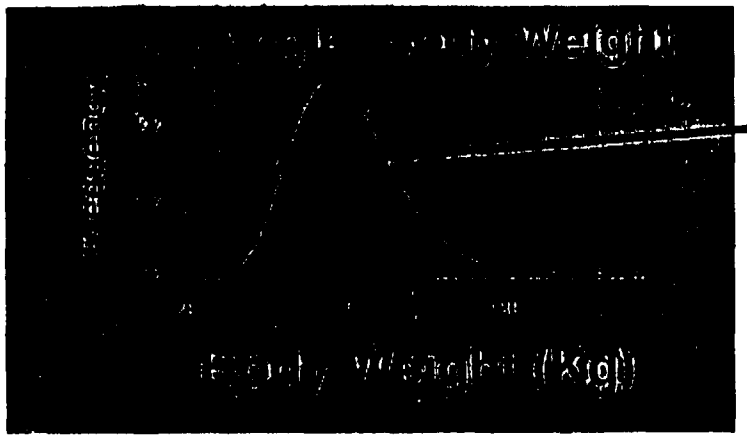
- **Point estimates**
  - Central tendency and reasonable maximum exposure (RME)
  - Intent is to assess exposures $\geq 90^{th}$ percentile
  - RME is combination of average and 90^{th} or 95^{th} percentile values for individual exposure factors

- **Probability methods (Monte Carlo Analyses)**
  - Developed distribution of fish consumption rates, species ingestion patterns, exposure duration
  - Sensitivity of input distributions and discrete estimates

Schematic of Monte Carlo Exposure to PCBs via Fish Consumption



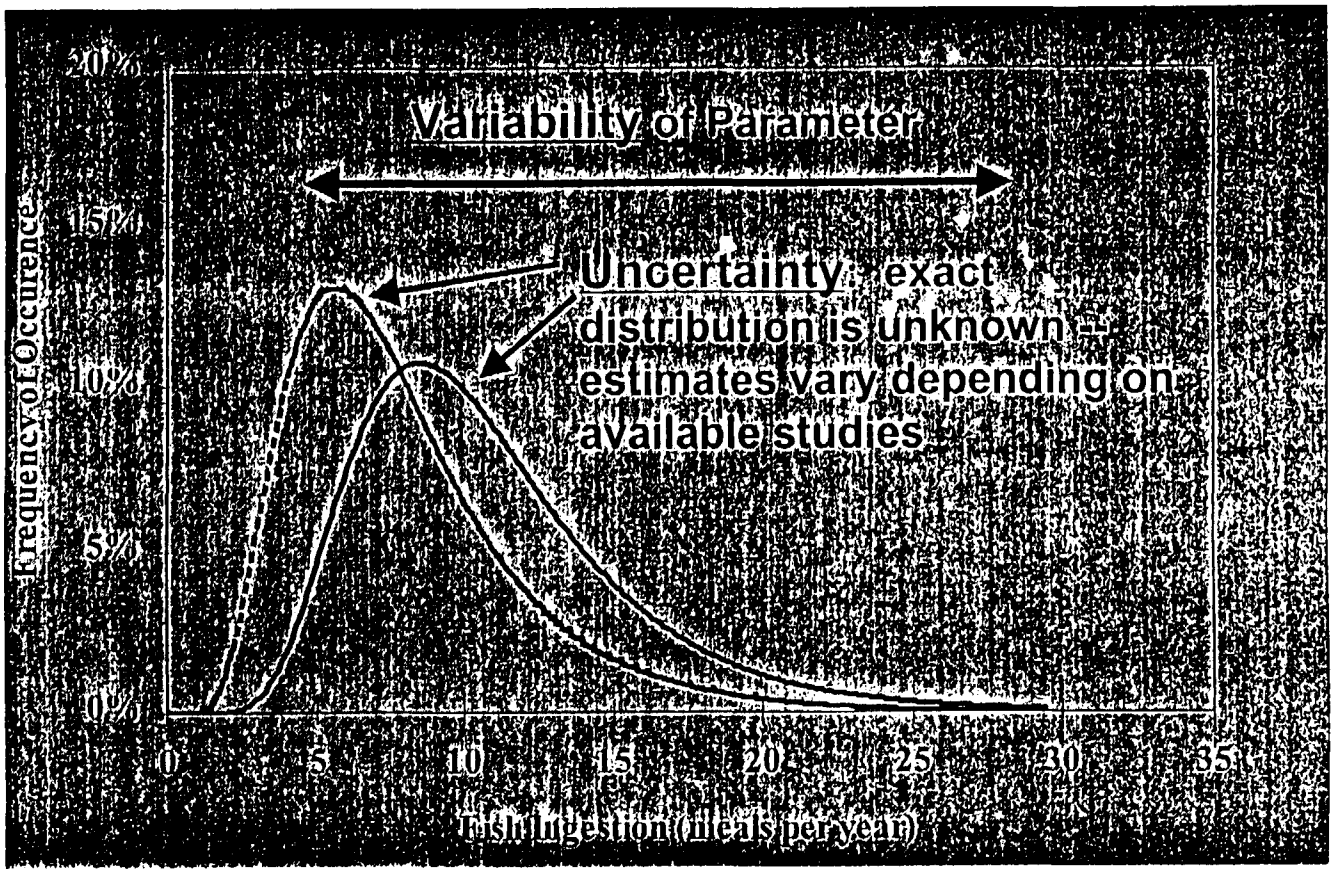




Sample Exposure Values From Possible Range

Calculate Risk
(10,000 Anglers x 72 combinations)

Exposure Factors Exhibit a Combination of Variability and Uncertainty



Full 2-D Monte Carlo Was Not Feasible

- Insufficient data to characterize probability distributions for uncertainty
- Sensitivity analysis performed as alternative to 2-D
- Examined uncertainty using a range of possible inputs (72 combinations)

Monte Carlo Analyses
10,000 Anglers x 72 Combinations

Exposure Factor	Base Case	Sensitivity Analysis
Fish Consumption	1991 NY Angler Survey	Maine Survey Michigan Survey L. Ontario Survey
Exposure Duration	Minimum of Fishing and Residence Duration	Residence Duration only
PCBs Lost in Cooking	20% (midpoint)	0% high end 40% low end
Fishing Location (concentration)	Average Thompson Is. Pool, Stillwater, Troy/Albany	Thompson Is. Pool (high) Troy/Albany (low)

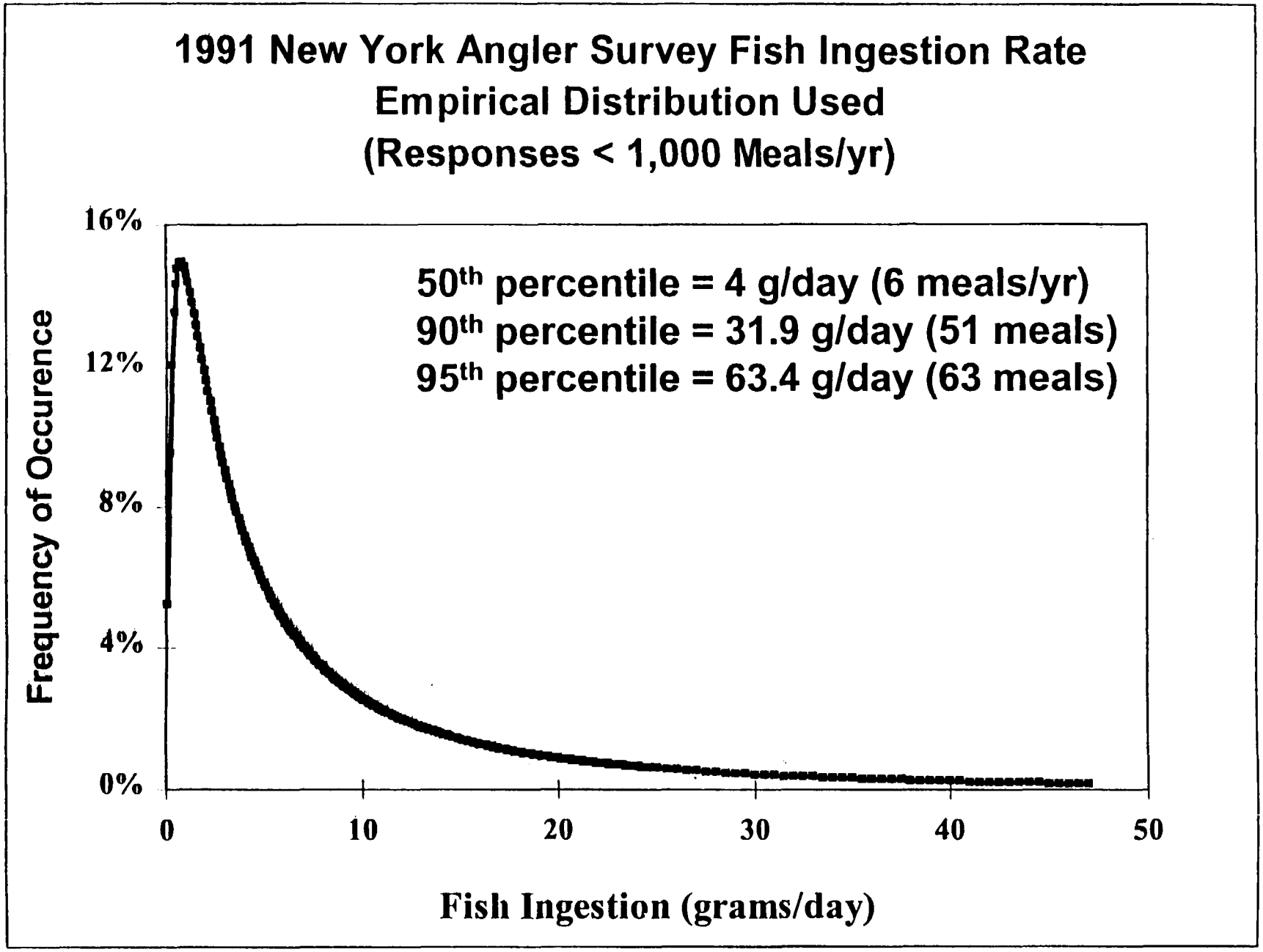
Angler Surveys Used for Sensitivity Analysis

- **1991 NY Angler Survey (Connelly et al., 1992)**
  - Mail survey of licensed anglers -- 1,030 responses
  - Reported water body, fish catch, consumption, species, distance traveled, awareness of advisories

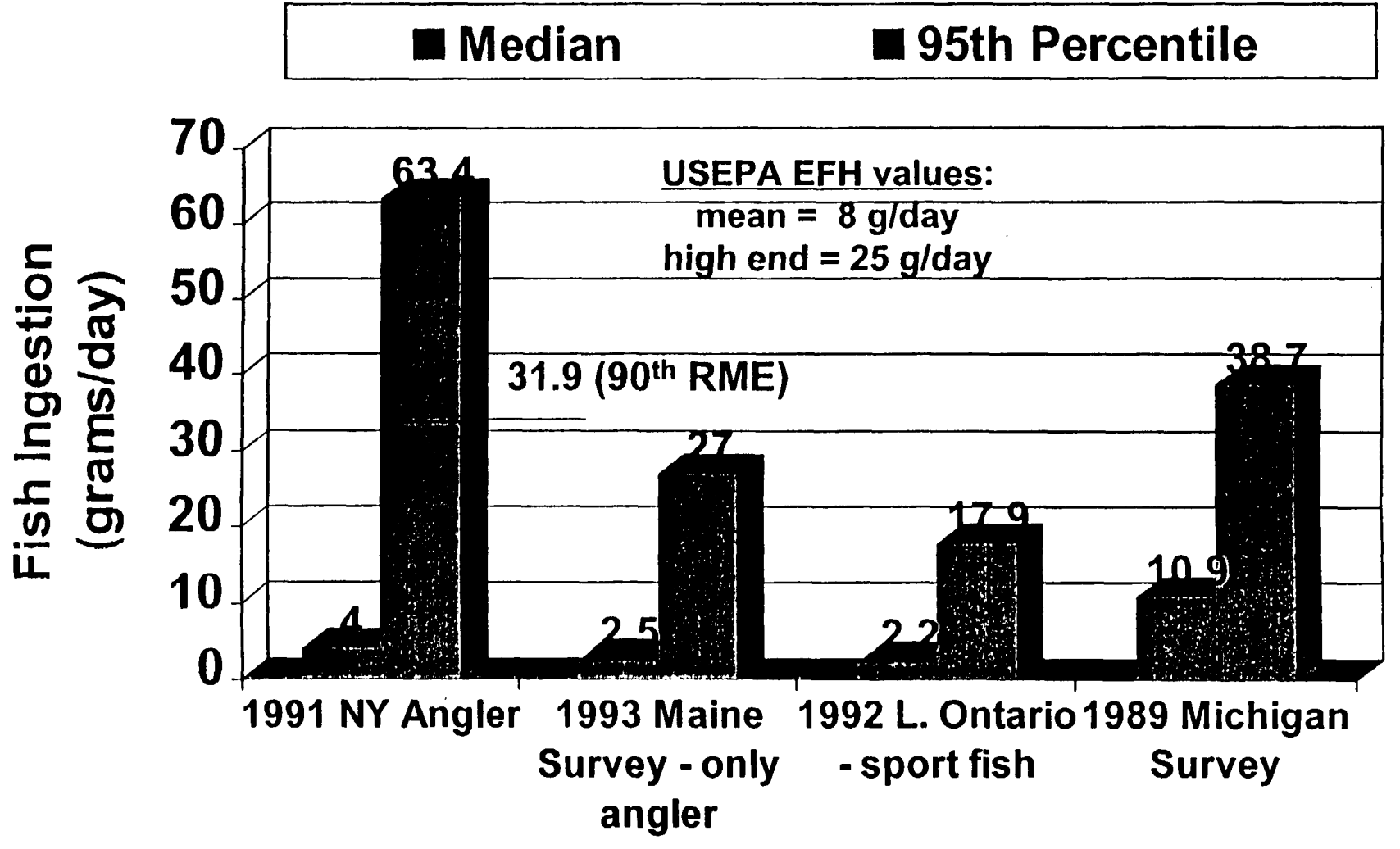
- **1992 L. Ontario Study (Connelly et al., 1996)**
  - 12-month diary survey -- 516 responses
  - respondents recorded fish consumption & fishing trips for a 1-year period

Angler Surveys Used (cont.)

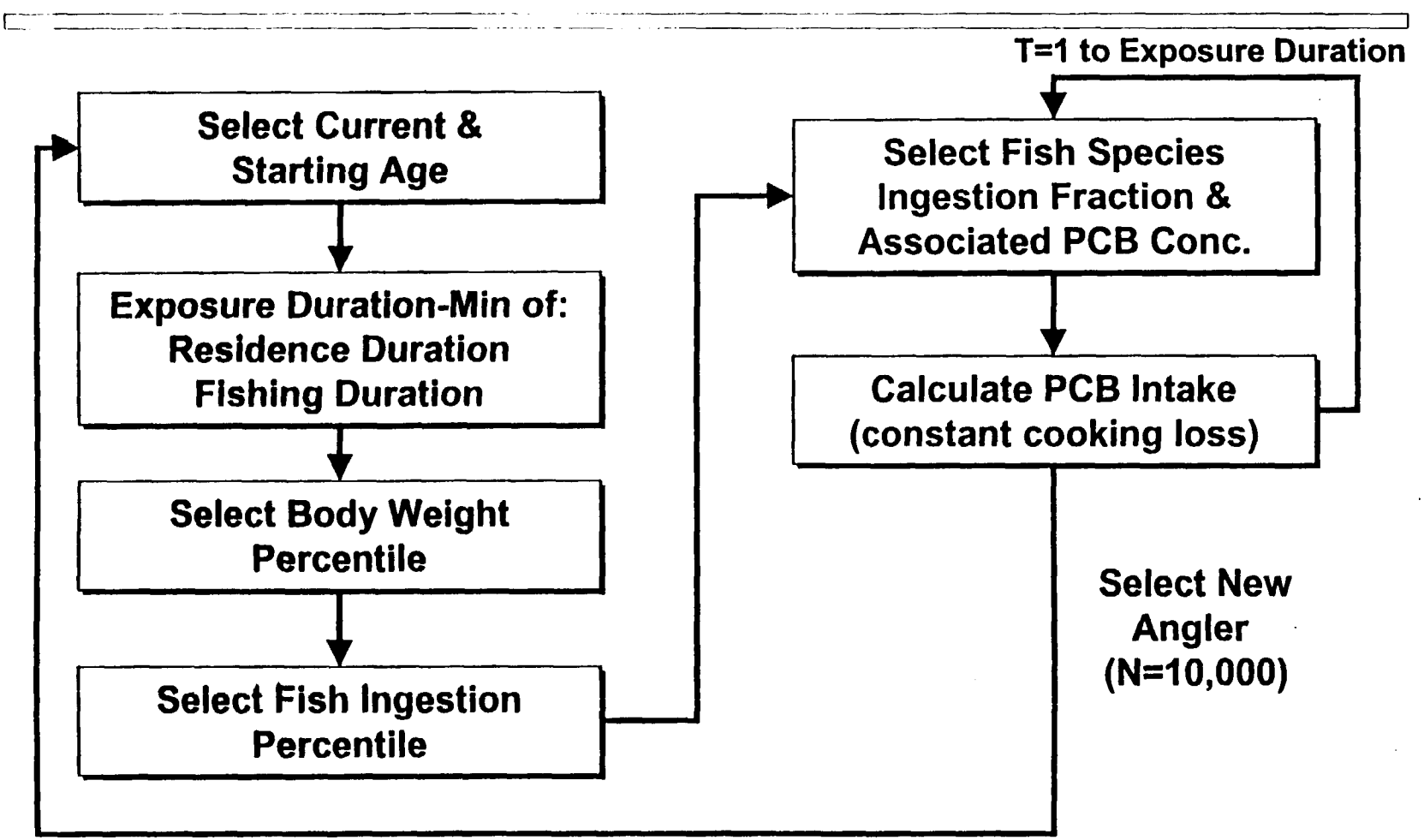
- **1993 Maine Angler (Ebert et al., 1993)**
  - Mail survey of licensed anglers
  - 1,612 returned surveys
  - Freshwater fish catch & consumption rates
- **1989 Michigan Sport Anglers (West et al., 1989)**
  - Mail survey of licensed anglers over 5 month period
  - 1,104 responses
  - Fish consumption (self-caught and other), serving size (8 oz. most typical)
- **Hudson-specific surveys considered but not adopted**


1991 New York Angler Survey Fish Ingestion Rate
Empirical Distribution Used
(Responses < 1,000 Meals/yr)
50th percentile = 4 g/day (6 meals/yr)
90th percentile = 31.9 g/day (51 meals)
95th percentile = 63.4 g/day (63 meals)
Frequency of Occurence
16%
12%
8%
4%
0%
0
10
20
30
40
50
Fish Ingestion (grams/day)

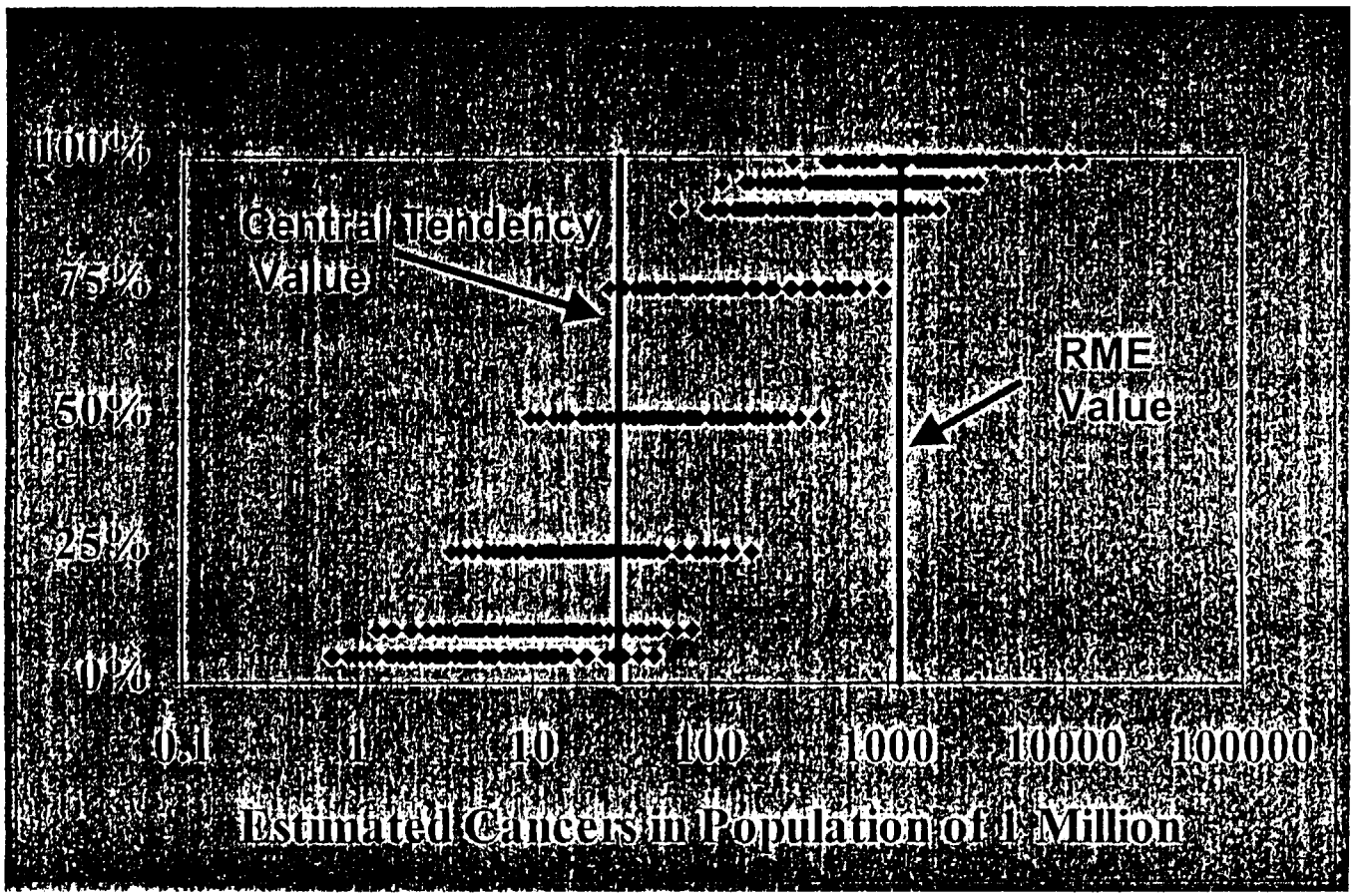
Comparison of Fish Ingestion Studies



Monte Carlo Simulation Approach

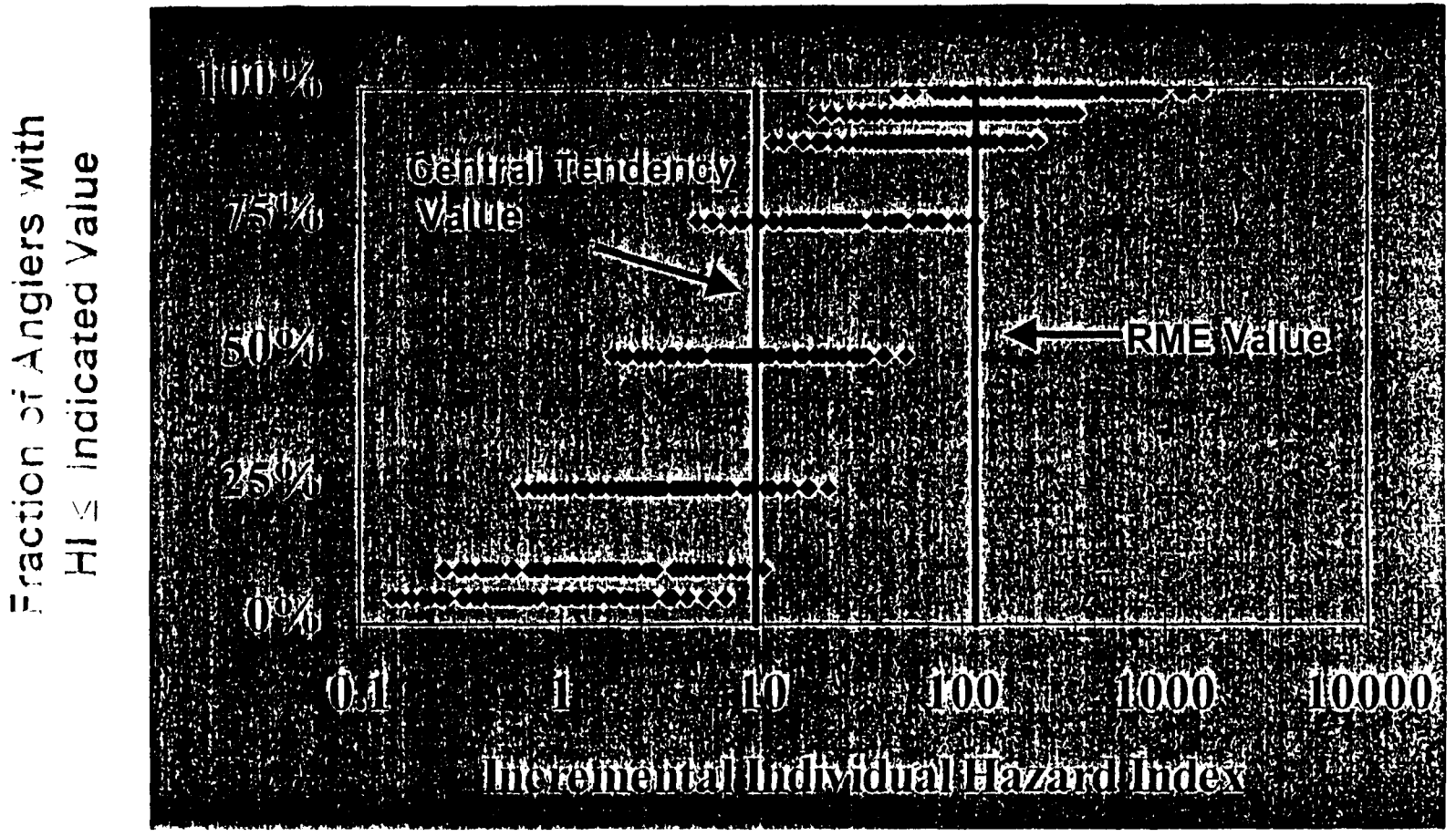


Range of Cancer Risk Estimates for Fish Ingestion



August 1999 Report Values

Range of Non-Cancer Hazard Index (HI) Estimates for Fish Ingestion

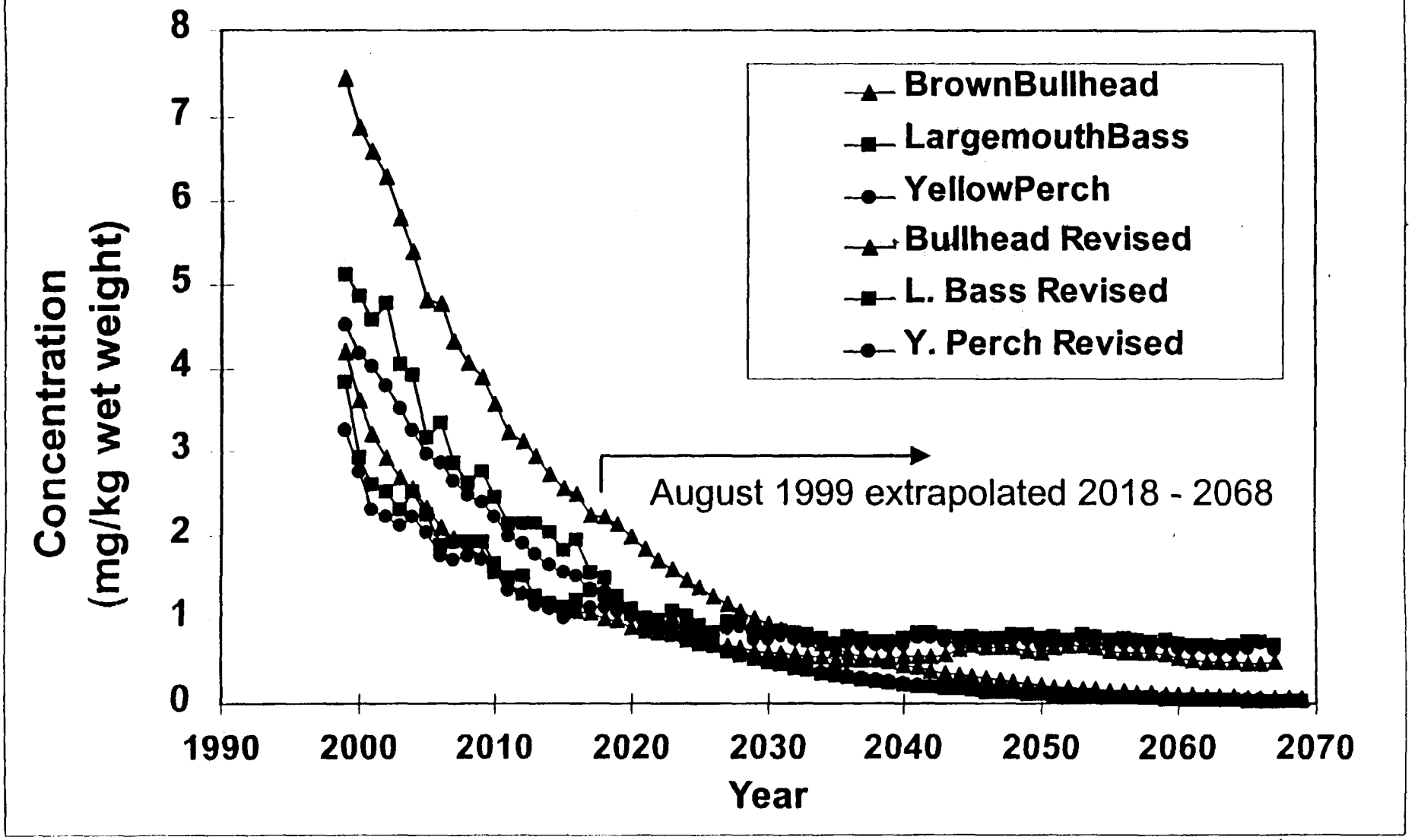


Augu 1999 Report Values

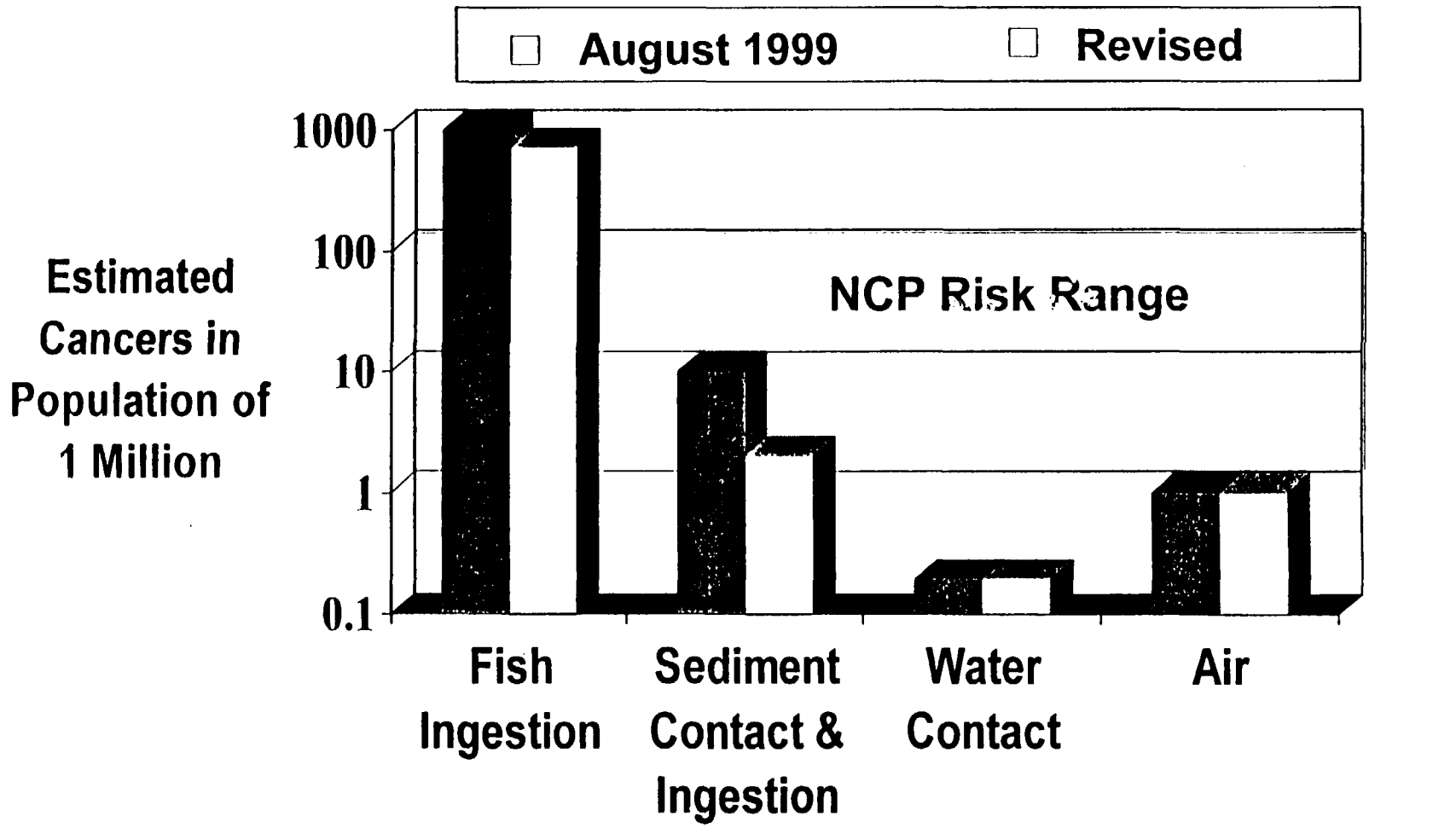
Impact of Revised BMR Results on August 1999 Upper Hudson Risk Assessment

- **Revised BMR forecast period = 70 years (vs. 20)**
- **Modeled average concentration in fish declined by ≈2-fold or less depending on species.**
- **Concentrations in water and sediment averaged over central tendency and RME exposure duration for child, adolescent, adult exposures (not limited to 20 year model period).**
- **Point estimate adult RME fish ingestion results:**
  - Cancer risks decline by approximately 30%
  - Non-cancer hazards decline by 44%

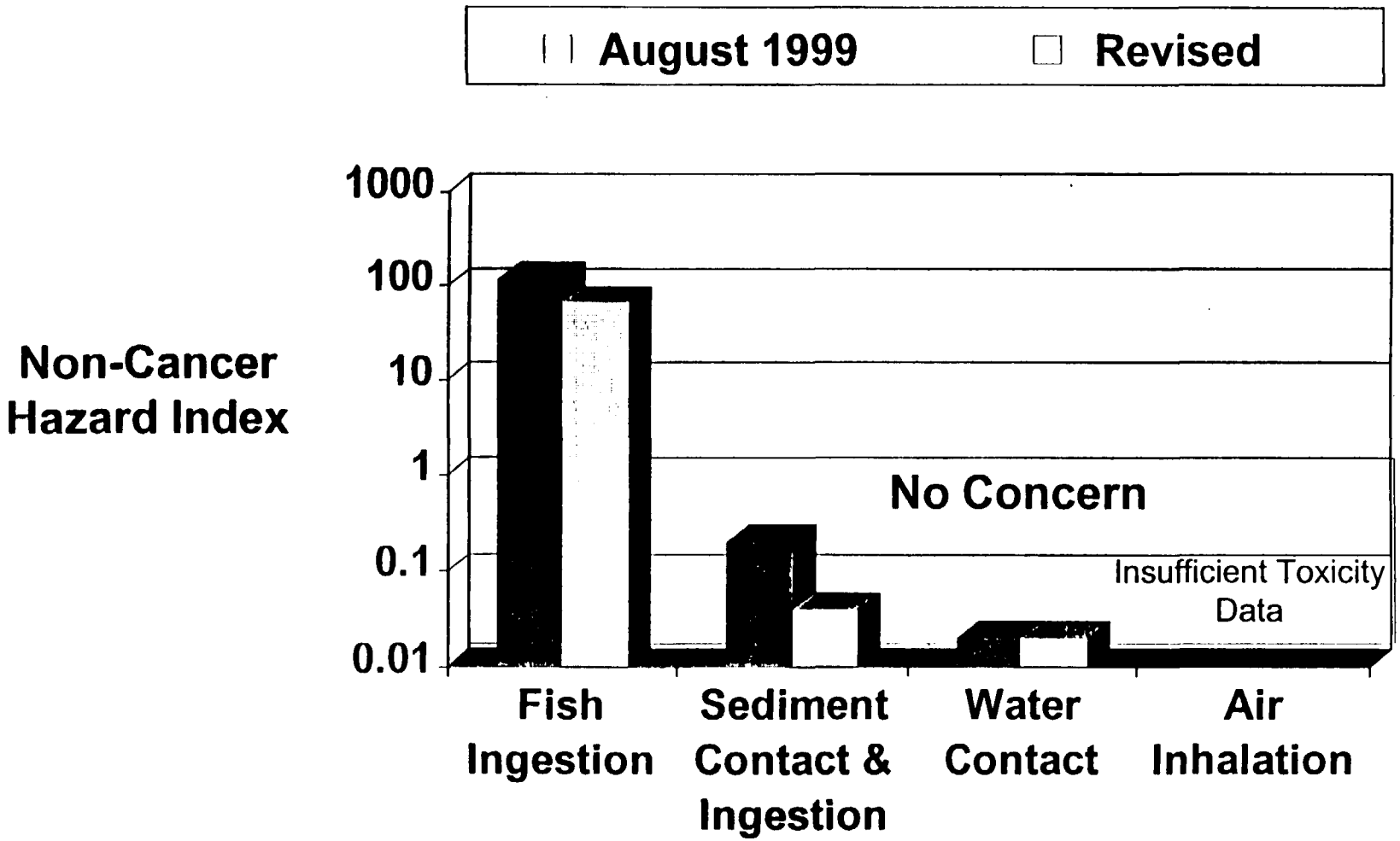
Comparison of August 1999 and Revised BMR Fish Modeling Results



Revised BMR Results -- Cancer RME



Revised BMR -- Non-Cancer RME



Summary

- **Fish ingestion RME cancer risks and non-cancer hazards exceed levels of USEPA concern**
- **Other exposure pathways are at or below levels of USEPA concern**
- **Revised BMR results do not significantly alter the risk assessment results**
- **Monte Carlo Analysis indicates RME fish ingestion:**
  - at or above 75th percentile for all combinations of exposure factor scenarios examined (cancer and non-cancer)