FINAL SECOND FIVE-YEAR REVIEW COMMENT RESPONSE FOR THE HUDSON RIVER PCBS SUPERFUND SITE

Prepared by

U.S. Environmental Protection Agency
Region 2

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FIVE-YEAR REVIEW COMMENT RESPONSE FOR HUDSON RIVER PCBs SITE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

A1016	Aroclor 1016
A1221	Aroclor 1221
A1242	Aroclor 1242
A1254	Aroclor 1254
ADD	Average Daily Dose
ARAR	Applicable or Relevant and Appropriate Requirement
AT	Albany-Troy
ATSDR	Agency for Toxic Substances and Disease Registry
BERA	Baseline Ecological Risk Assessment
BMP	Baseline Monitoring Program or best management practice
BSAF	Biota Sediment Accumulation Factor
BW	body weight
CAG	Community Advisory Group
CAM	Corrective Action Memo
CCC	Criteria Continuous Concentration
CCE	Cornell Cooperative Extension
CDC	Centers for Disease Control and Prevention
CDF	cumulative distribution function
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIP	Community Involvement Plan
cm	centimeter
COC	chemical of concern
COPC	chemical of potential concern
CS	Catskill
CSF	Cancer Slope Factor
CSM	Conceptual Site Model

CT	central tendency
CTE	Central Tendency Exposure (Exposed)
CU	Certification Unit; dredging target area within which performance metrics were applied
DAD	Dredge Area Delineation
DDS	Downstream Deposition Study
DDT	dichlorodiphenyltrichloroethane
DEC	see NYSDEC
DoC	depth of contamination
DOH	see NYSDOH
DQO	Data Quality Objective(s)
dw	dry weight
EDI	equal discharge increment
EPA	see USEPA
EPC	Exposure Point Concentration(s)
EPS	Engineering Performance Standards
ERRD	EPA Region 2's Emergency and Remedial Response Division
ERT	Environmental Response Team
FCA	Fish Consumption Advisory(ies)
FIR	food ingestion rate
FS	Feasibility Study
FISHRAND	mechanistic, time-varying, fish tissue contaminant bioaccumulation model
ft	foot (or feet)
FWQC	Federal Water Quality Criteria
FWS	Fish and Wildlife Service
FYR	Five-Year Review (unless otherwise indicated, the Second Five-Year Review report initially released as "Proposed" in June 2017)
g/cm^3	grams per cubic centimeter
g/day	gram per day
g/m^2	gram per square meter

GAC	granular activated carbon
GC/ECD	Gas Chromatography/ Electron Capture Detection method
GCL	geosynthetic clay liner
GE	General Electric Company
HDC	high-density core
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HQ-OSRTI	EPA Headquarters' Office of Superfund Remediation and Technology Innovation
HUDTOX	Upper Hudson River Toxic Chemical Model; a mechanistic, numerical chemical fate and transport model for water and sediment
IARC	International Agency for Research on Cancer
IC	Institutional Control(s)
IRIS	Integrated Risk Information System
kg	kilogram
Kg/day or kg/d	kilogram per day
Kg/month	kilogram per month
Kg/yr	kilograms per year
Km	kilometers
K_{ow}	octanol/water partition coefficient
L/day	liters per day
Lb	Pound
LCL	Lower Confidence Limit
LHR	Lower Hudson River
LOAEL	Lowest Observed Adverse Effect Level
LPCB	lipid normalized PCBs
M1668	EPA high-resolution gas chromatography / mass spectrometry (HRGC/HRMS) congener-based PCB analysis method; version 1668c of the method (M1668c) has been used primarily since 2016
M8082	EPA gas chromatography (GC) Aroclor-based PCB analysis method

MADIS	Multiple Aliquot Depth Integrated Sampler
MCA	Monte Carlo Analysis
MCL	maximum contaminant level
mGBM	modified Green Bay Method; gas chromatography / electron capture detector (GC/ECD) congener-based PCB analysis method adapted by GE for the Hudson River from one originally developed for the Great Lakes
mg/kg	milligram per kilogram
mg/kg-ww	milligram per kilogram wet weight
MNA	Monitored Natural Attenuation
MNA1	baseline MNA scenario
MNA2	"updated" MNA scenario used in Field et al (2016)
MNR	Monitored Natural Recovery
MPA	Mass Per Unit Area; typically expressed as grams per square meter (g/m^2)
MPUV	mass per unit volume
NAPL	non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Northumberland Dam
ng/L	nanogram per Liter
ng/m^3	nanograms per cubic meter
NHANES	National Health and Nutrition Examination Survey
NIST	National Institutes of Standards and Technology
NLOM	non-lipid organic matter
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NYC	New York City
NYS	New York State
NYSCC	New York State Canals Corporation
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health

NYSDOT	New York State Department of Transportation
O&M	Operations and Maintenance
OM&M	Operations, Maintenance, and Monitoring
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit; an officially designated portion of a CERCLA site for investigation and remediation purposes
PAH	polycyclic aromatic hydrocarbon
PCB	Polychlorinated Biphenyl
PCRDMP	Post-Construction Remnant Deposit Monitoring Plan
PE	Performance Evaluation
PKSD	Pumpkinseed
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRA	probabilistic analysis
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PSCP	Performance Standards Compliance Plan
PWS	public water supplies
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QoLPS	Quality of Life Performance Standard
RA	Remedial Action
RAM	Remedial Action Monitoring
RAMP	Remedial Action Monitoring Program
RAWP	Remedial Action Work Plan
RAO	Remedial Action Objective
REM 3/10/Select	Removal Criteria by respective River Sections as stated in the ROD
RfC	Reference Concentration
RfD	Reference Dose

RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RM	River Mile
RME	Reasonable Maximum Exposure (Exposed)
ROD	Record of Decision
RPM	Remedial Project Manager
RS	River Section
SAV	Submerged Aquatic Vegetation
SEDC	Supplemental Engineering Data Collection
Site	Hudson River PCBs Superfund Site
SMR	standardized mortality ratio
SOP	Standard Operating Procedure
SOW	statement of work
SRM	Standard Reference Material
SSAP	Sediment Sampling and Analysis Program
TBC	To Be Considered; criteria explored as potentially germane to remedial decision-making in parallel with ARARs
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TID or TD	Thompson Island Dam
TIP	Thompson Island Pool
TOC	Total Organic Carbon
TPCB	Total PCB
$TPCB_{Aroclor}$	PCB compounds measured as Aroclors
$TPCB_{HE}$	PCB compounds measured as homolog equivalents
Tri+ PCBs	PCBs containing three or more chlorines
TRV	toxicity reference values
TSCA	Toxic Substances and Control Act
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
UE	Unrestricted Exposure

µg/L	microgram per liter
µg/m^3	micrograms per cubic meter
UHR	Upper Hudson River
USEPA	United States Environmental Protection Agency
USGS	Unites States Geological Survey
UU	Unlimited Use
WCS	Waste Control Specialists, LLC
WIR	water ingestion rates
WQ	Water Quality
ww	wet weight

I. INTRODUCTION

1.1 The Second Hudson River PCBs Superfund Site Five Year Review

The purpose of the Second Five-Year Review (FYR) for the Hudson River PCBs Superfund Site is to determine if the Superfund cleanup remedy is working as intended and is protective of human health and the environment. Superfund law requires that five-year reviews be performed when a cleanup action leaves some hazardous substances on a site at levels that do not allow for unlimited use and unrestricted exposure. These reviews are required every five years from the start of construction of the cleanup action.

The second Hudson River PCBs Superfund Site FYR was led by United States Environmental Protection Agency (EPA) Project Director, Gary Klawinski, and EPA Office of Superfund Remediation and Technology Innovation (OSRTI) - Environmental Response Team (ERT) manager Marc S. Greenberg, Ph.D. Participants also included other EPA staff within EPA Region 2's Emergency and Remedial Response Division (ERRD) and EPA Headquarters' Office of Superfund Remediation and Technology Innovation (HQ-OSRTI) as appropriate.

EPA's Comprehensive Five-Year Review Guidance states that, for complex projects, a multidisciplinary five-year review team of experts may be needed to adequately review the protectiveness of the remedy. This five-year review included a rigorous and unprecedented stakeholder and community engagement process. Because of the complexity of the Hudson River Polychlorinated Biphenyls (PCBs) Operable Unit (OU) 2 remediation, EPA assembled a FYR team that included representatives of state agencies, federal agencies, natural resource trustees, Community Advisory Group members, and EPA subject matter experts. The team provided input on remedy implementation and performance based on information that includes environmental data and document review. Team members regularly and actively participated in meetings throughout the review period.

Three public workshops were held during the FYR to provide information about the review and the review process to the public. EPA also accepted public comments on the proposed FYR report. Written correspondence was received during the FYR from the public, multiple State and Federal agencies, environmental groups, and elected officials.

1.2 FYR Public Outreach and Engagement

Throughout the five-year review process, EPA provided various opportunities for public participation. Before the initiation of the formal public comment period for the second FYR, the public was notified of and invited to participate in the five-year review process via press releases, public workshops, the Hudson River Listserv and EPA's Hudson River PCBs Superfund site webpage: www.epa.gov/hudson. Additionally, EPA provided updates on the FYR process and report to stakeholders represented by the project Community Advisory Group (CAG). These meetings were and are open to the public. As mentioned in Section 1.1, three public workshops were also held at varying locations in the project area during the five-year review process to discuss the purpose of the review and the timeline, and to provide status updates and an opportunity for members of the public to provide input and ask questions.

Although EPA does not typically seek public comment on a FYR report, EPA initiated a formal public comment period in concert with the release of the proposed FYR report on June 1, 2017. The comment period was originally set to end on June 30, 2017. Shortly after the release, on June 8, 2017, EPA extended the public comment period until September 1, 2017 in response to requests from several stakeholders.

During the public comment period, as mentioned above EPA hosted three public information meetings, in Upper Hudson River and Lower Hudson River communities, and in New York City. EPA discussed the purpose, scope and findings of the five-year review and answered questions from the public during those meetings:

- Lower River: June 28, 2017 6 p.m. – 8 p.m. at the Poughkeepsie Grand Hotel in Poughkeepsie, New York
- Upper River: July 19, 2017 6 p.m. – 8 p.m. at the Saratoga Hilton in Saratoga, New York
- New York City: August 9, 2017 6 p.m. – 8 p.m. John Jay College of Criminal Justice in New York City, New York

EPA reviewed and considered all written comments provided during the public information meetings, as well as written comments received during the public comment period. By the close of the comment period, EPA had received 1,968 discrete submissions of comments. Of the 1,968 submissions, 51 were from government (state and federal) agencies, other organizations and businesses/corporations. 529 were unique submittals from individuals and 1,388 were additional letters based on templates provided by organizations. An index listing the names of commenters is attached to this report as Appendix A.

1.3 FYR Comment Review and Response

All comments submitted to EPA during the public comment period were carefully considered. To ensure a complete and comprehensive evaluation and response to the FYR comments, all comment documents were reviewed and catalogued within a database system. To manage the comments, each comment letter was divided into segments that each captured a unique theme or topic with respect to the FYR process or report. Each of the segments was also assigned representative keywords (or key phrases) and entered into an electronic database for sorting and processing. The segments were organized for content and then assigned to review by subject matter experts (SME). All unique segments were identified and were individually adopted as a "master comment," or were consolidated with other similarly themed segments (addressing similar issues) into a single master comment. EPA prepared a response for each master comment.

A quality assurance program was implemented to verify that the full body of segments were reviewed and categorized appropriately. All segments identified to be within the scope of the FYR report and/or process were consolidated into master comments. The quality assurance program was also used to verify that these topics were accurately represented in the master comments and the responses are technically complete. EPA received some comments and opinions that were outside the scope of the FYR report and process. These comments have been summarized briefly in Section 2 and, as appropriate, are not addressed as part of the master comments and responses.

Responses were informed by and drawn from:

- material presented in the second FYR report
- previous project reports and other literature
- the experience of other remedial projects and individuals
- EPA policy
- technical analyses that were performed specifically to address comments or questions raised during the public comment period.

For ease of review and understanding, the comments and responses were grouped into 6 categories:

- Data Collection
- Modeling Analysis
- Assessment
- Remedy
- Protectiveness Determination
- FYR Process and Public Outreach and Engagement

These categories were selected to reflect the logical progression of the FYR process from data collection to determination. Some master comments and responses pertain to two or more of these categories. As an example, a comment pertaining to the evaluation of water samples, could apply to both data collection (how that sample was collected and why) and assessment (how that information was used to inform the FYR report). EPA placed the comments and responses into the category where the comment and response are most focused and has provided content and references to other categories as appropriate.

Table 1, below, provides a list of the master comments as organized into the categories, and indicates which categories apply to the comment.

Table 1 FYR Master Comment Response List

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
1	**Additional data are required to understand the effectiveness of the remedy**	3.1 Data Collection	X		X	X	X	
2	Adjust data treatment techniques for Aroclor data	3.3 Assessment			X			
3	Assess risks of PCBs based on changes in consumption	3.3 Assessment			X			
4	Assess risks of PCBs in air	3.3 Assessment			X			
5	Consider the risks to Environmental Justice communities	3.6 FYR Process			X			X
6	Consumption survey required to assess new populations eating fish	3.1 Data Collection	X				X	
7	Despite institutional controls people are still eating fish	3.1 Data Collection	X				X	
8	EPA did not investigate the potential for links to autism in the first five-year review.	3.3 Assessment			X			
9	EPA models of recovery in fish, sediment, and water are overestimated and should be revisited	3.2 Modeling Analysis		X				
10	EPA must address whether the targets for improvements in water quality have or will be met	3.4 Remedy				X		
11	EPA must calculate the risks of dioxin contamination (or dioxin-like congeners)	3.3 Assessment			X			
12	EPA must consider protection of natural resources as fish consumption advisories do	3.5 Protectiveness				X	X	

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
	not protect environmental receptors							
13	EPA must include a site-wide protectiveness statement in accordance with the guidance	3.5 Protectiveness				X	X	
14	EPA must reinstate suspended solids monitoring at Waterford to improve evaluation of PCB load to the Lower Hudson River	3.1 Data Collection	X		X			
15	EPA should update its models to reflect information obtained during dredging	3.2 Modeling Analysis		X				
16	EPA should finalize the study done on black bass	3.3 Assessment	X		X			
17	EPA should ensure that there is adequate outreach to the diverse communities in the Lower Hudson River	3.6 FYR Process						X
18	EPA should look for updated information on the toxicity of PCBs	3.3 Assessment			X			
19	EPA should qualify the 2016 spring and fall data properly according to the impacts expected by the dredging	3.3 Assessment			X			
20	EPA should recalculate human health risks	3.3 Assessment	X		X			
21	EPA should require GE to conduct an RI/FS of the Lower Hudson River	3.3 Assessment			X			
22	EPA should track the attainment of the interim fish tissue targets of 0.4 mg/kg and 0.2 mg/kg PCB as it	3.4 Remedy				X		

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
	assesses the success of the remedy.							
23	EPA should review all the data when developing the Five-Year Review report in accordance with the guidance	3.6 FYR Process			X	X		X
24	EPA should indicate the current state of testing and analysis of human health impacts for users of the river	3.3 Assessment			X			
25	EPA should update the Community Involvement Plan	3.6 FYR Process						X
26	Conceptual site model - relationship of sediment, water, fish	3.2 Modeling Analysis		X				
27	EPA's model prediction that the Upper Hudson River PCB load to the Lower Hudson River is the primary factor for recovery of Lower Hudson River fish is proven incorrect by this Five-Year Review	3.2 Modeling Analysis		X				
28	EPA will not reach the target levels as anticipated in the ROD	3.3 Assessment			X	X		
29	EPA's analysis of fish data is flawed	3.3 Assessment			X			
30	EPA's analysis of water PCB trends must consider changes in both loading conditions and comparisons of monitoring data to model	3.3 Assessment	X		X	X		

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
	predictions when developing and interpreting trends							
31	EPA's species-weighted-average approach to estimating fish recovery rates should be updated based on the current population's diet. EPA must modify its homologue correction and use of data in developing temporal trends.	3.1 Data Collection	X		X		X	
32	"Will be protective" is not an appropriate determination for the Hudson River PCBs Site. "Will be protective" is only appropriate when a remedy is still "under construction."	3.5 Protectiveness					X	
33	Habitat reconstruction did not achieve the project objectives	3.4 Remedy				X	X	
34	Water quality improvements from dredging tend to decrease with distance downriver from dredging	3.2 Modeling		X				
35	Incorporate Hudson River Reference Material in future fish analyses	3.3 Assessment	X		X			
36	Increase the use of congener PCB analysis and decrease use of Aroclor analysis	3.3 Assessment			X			
37	Institutional controls should not be a part of the remedy	3.5 Protectiveness					X	
38	EPA should compare data to ROD forecast regardless of implementation	3.4 Remedy			X	X	X	

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
39	Public Involvement in the Five-Year Review Process	3.6 FYR Process						X
40	The larger-than-expected mass of PCBs and higher surface sediment PCB concentrations remaining in the sediment following remediation will extend the recovery of the river	3.3 Assessment			X	X		
41	Reassess air risks	3.3 Assessment			X			
42	The comprehensive sediment sampling data from the SSAP should be treated as the baseline for evaluating recovery of PCB-contaminated cohesive sediment in non-dredged areas	3.4 Remedy	X	X	X	X		
43	Resolve diverging views of data with other agencies	3.3 Assessment			X		X	
44	NOAA's models demonstrate that the EPA ROD models are flawed and should be updated to correctly reflect the role of sediment concentrations in evaluating protectiveness of the remedy	3.2 Modeling Analysis		X			X	
45	The remedy is not protective	3.5 Protectiveness	X		X	X	X	
46	Use of the non-standard protocol (without rib-in vs. rib-out) impacts how the data can be used	3.3 Assessment			X			
47	By leaving more PCBs than anticipated in portions of the Upper Hudson River, the	3.4 Remedy			X	X		

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
	remedy as implemented may not achieve the targeted reductions in water and fish PCB concentrations in the timeframes anticipated by EPA							
48	The Lower Hudson River (LHR) fish recovery is not responding as expected	3.4 Remedy				X		
49	EPA's use of the data on fish body burdens to estimate the rates of recovery is highly subjective. EPA's analysis of trends does not support their conclusions about the rate of decline during the period 1995-2008	3.3 Assessment	X	X	X			
50	The impact of dredging on fish tissue PCB concentrations has passed and concentrations have now reached equilibrium. Future declines in concentration will be very gradual and prolong the time to achieve ROD targets	3.3 Assessment			X	X	X	
51	Changes in fish sampling locations result in data that is not suitable for long term PCB temporal trend analysis	3.3 Assessment	X		X	X		
52	Adequacy of the OM&M sediment sampling program, especially with respect to development of post-dredging baseline information	3.4 Remedy	X			X	X	

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
53	Surface PCB Concentration of the Non-Dredge Areas in RS1 has not declined	3.3 Assessment			X	X		
54	There is no basis in the record for the estimate of mass discharged to the river by GE from the capacitor plants in Hudson Falls and Fort Edward (1.3 million pounds)	3.1 Data Collection	X		X			
55	EPA needs to update the conceptual site model (CSM) and recalibrate and update HUDTOX and FISHRAND models in order to properly understand the impacts of the dredging on the resultant fish concentrations	3.2 Modeling Analysis		X			X	
56	Sediment concentrations remaining in the river are higher than anticipated and sediment concentration rate of decline is overestimated	3.3 Assessment		X	X	X		
57	Analysis of sediment PCB data outside the dredge areas miscalculated the concentration and mass located in these areas	3.3 Assessment	X		X			
58	EPA recognized that more PCBs were present in the Upper Hudson River sediments than originally estimated in the 2002 ROD but did not alter remedial activities to account for this knowledge	3.4 Remedy		X	X	X		

Comment Number	Comment Title	Response Found in Section	Topics Covered by Comment Response					
			Data Collection	Modeling Analysis	Assessment	Remedy	Protectiveness	FYR Process and Public Engagement
59	Hudson River PCB concentrations will not reach the target levels anticipated in the ROD and EPA is claiming a short-term impact to the fish from recent dredging when such impacts should be negligible	3.5 Protectiveness					X	
60	Data incompatibilities Lead to Errors in Interpretations	3.3 Assessment	X		X			
61	Significant PCB deposits left behind are in excess of other cleanup projects	3.1 Data Collection	X		X			

II. COMMENTS OUTSIDE SCOPE OF FYR

EPA received many comments on the FYR, with some being identified as outside the scope of the FYR. General descriptions of these comments are provided below.

- Some commenters noted that General Electric (GE) should not have been allowed to contaminate the river.
- Commenters wrote about past final decisions made by EPA on the project.
- Some commented about the Hudson River floodplain (including the Old Champlain Canal). The floodplain project is a separate operable unit and is not part of the upper river remedy or this FYR.
- Comments were received on the participation of other federal or state agencies in the remedy review. Those comments are best addressed by those agencies.
- Some commenters asked EPA to give New York State lead agency status for the project, while others discussed the disagreement on data interpretations between agencies, and others wrote about the impact of the five-year review on the trustees' NRDA claims.
- Comments were received on other environmental issues that impact the Lower Hudson River, such as transport of oil and gas on the river and the proposed closing of the Indian Point nuclear facility.
- Some comments were received on other unrelated project reports written by EPA.
- Some comments were received on Operation, Maintenance, and Monitoring (OM&M) work plans. Those comments will be considered by EPA as those plans are developed and finalized. Responses have been provided for comments pertaining to the data collected as part of the OM&M program during the FYR period.
- Some comments discussed the timing of the certification of completion of the remedial action under the 2006 consent decree with GE with respect to the timing of the completion of the five-year review. The determination of protectiveness as part of this FYR is independent of the certification of completion of the remedial action.

III. MASTER COMMENTS AND RESPONSES

This section contains the 61 master comments and responses. Note that some comments and responses may also be applicable to other categories, as identified in Table 1 of this document.

3.1 Data Collection

This section includes comments and responses concerning what data was collected (e.g., fish, water, and sediment), how it was collected, and the need for additional data collection and consideration.

3.1.1 Comment 1: Additional data are required to understand the effectiveness of the remedy

Comment

Commenters raised concerns regarding whether the existing data are sufficient to determine if fish will recover in the timeframes laid out in the ROD. Commenters requested that EPA require additional studies and data collection within the Upper and Lower Hudson to provide the evidence needed to determine future fish PCB concentrations and the subsequent risks to human health. A more robust fish and sediment sampling program than that proposed by EPA was recommended, with a focus on sample size and segmentation, and increased spatial resolution. Commenters point out that the prior sampling program focused on determining PCB concentrations in fish by river section but sampling each river pool would be more effective in determining accurate contamination concentrations, because resident fish integrate their exposure within smaller areas compared to larger river sections.

One commenter suggested that the post-remedial fish PCB concentrations are expected to be higher than EPA anticipated at the time of remedy selection. The commenter further questioned whether the deviation from the forecast trends were due to the higher-than-expected post-remedy absolute sediment concentrations or the less-than-targeted relative reduction in sediment concentration.

A commenter indicated that the lesser degree of improvement in surface sediment PCB concentrations should be reflected in less improvement in fish PCB concentrations. The commenter said that since surface sediment concentrations in RS 3 only improved by 4 percent based on the dredging, then PCB levels in fish in RS 3 should only immediately improve ~ 4 percent as a direct result of the dredging, and fish in the Lower River, where no sediment remediation was done, should show little additional improvement as a result of the remedy.

One commenter urged EPA to expressly include at least the following benchmarks as a way to measure the success or failure of the remedy to protect human health and the environment both in subsequent FYRs and as more data becomes available each year:

1. Species-weighted fish fillet Upper Hudson average PCB concentrations must be at or below 0.4 mg/kg within five years of the completion of dredging (by 2020);
2. Species-weighted fish fillet Upper Hudson average PCB concentrations must be at or below 0.2 mg/kg within sixteen years of the completion of dredging (by 2031);
3. Largemouth bass, whole body PCB concentrations must be within EPA's recalculated forecast range of 0.2 mg/kg to 0.07 mg/kg for RS 1, 2, and 3 within 23 years of the completion of dredging (by 2038); and
4. Species-weighted fish fillet average PCB concentrations in RS 1 must be at or below 0.05 mg/kg within 43 years of the completion of dredging (by 2058).

Response

EPA asserts that the existing data, representing limited post-dredging monitoring, are not sufficient to assess the rate of post-dredging recovery. While the 2016 OM&M data characterize the fish body burdens in the first year post-dredging, these fish may still be impacted by dredging activities. Many of the sport fish included in the 2016 data set were obtained as part of the spring sampling event (the normal time for their collection). These data represent adult fish, typically several years old. Thus, the measured PCB levels in the spring 2016 fish were likely still influenced by the dredging activities of 2015 and earlier, and therefore, are not exclusively part of the post-dredging condition. The ROD anticipated at least a one-year equilibrium period of the system in response to remedial activities. Sampling data from another remediated PCB site shows that this equilibration period could be as many as 3 to 5 years following intrusive activities (AECOM, 2012). During the equilibration period, PCB concentrations in fish and the water column can exhibit wide variation with little trend. After this equilibration period, the system is expected then to follow a more predictable natural recovery. To determine how many years of data will be needed to accurately identify post-dredging recovery rate and inform the OM&M sampling program design, EPA performed statistical power calculations using the fish body burden data from 1998 to 2008, part of the MNA period that preceded the remediation. These calculations indicate that approximately eight or more years of data will be required to accurately identify and confirm the post-remedy rate of decline for each species in each river section.

Commenters suggested that EPA focus its future monitoring on a reach-by-reach basis rather than for the whole river or by river section. While the ROD addresses the river on a section basis, EPA agrees that there is value in also assessing reaches (pools) within the river. EPA notes that the extensive surface sediment data sets collected by EPA/GE and NYSDEC do not indicate the continued presence of "toxic hotspots." Nonetheless, EPA will include the reach consideration in the continued assessment of the recovery of the river. All reaches will be monitored as part of the surface sediment sampling program, thus also providing recovery information on a reach basis. Depending on data availability and the degree of similarity of PCB concentrations, reaches may be grouped as part of long-term trend analysis. Periodic reach-specific fish monitoring will also be done as appropriate to confirm fish recovery is consistently occurring throughout the Upper Hudson. Additionally, EPA will coordinate with NYSDEC and NYSDOH regarding location-specific sampling modifications, as necessary to inform decisions regarding adjusting fishing restrictions and advisories.

Individual fish species will respond to contaminant exposures in different ways depending on their foraging strategies and life histories. It is important to note that any individual fish (and, more broadly, any individual fish species) will achieve target levels at different times given: 1) variability in actual exposures; 2) highly localized exposures; 3) the importance of sediment *vs*. water exposure pathways, which can vary over time due to prey availability and natural variability in exposure conditions; 4) variability in lipid content of fish and prey items; and 5) variability in consumption of specific prey items and PCB concentrations in prey. Thus, while EPA will continue to monitor the declines in fish PCB levels relative to the ROD's interim targets and the remediation goals for fish fillet, the post-dredging model projections included in the ROD are not precise dates that must be met in order for the remedy to be successful.

Remedy protectiveness was evaluated in the ROD by comparing predicted fish tissue concentration trajectories over time under different remedial alternatives. As noted in the ROD, different target levels will be achieved at different times depending on the species and river section (or river pool given species-specific foraging strategies and life histories). Evaluation of post-dredging fish concentration trajectories is the best method for assessing recovery over time due to uncertainty associated with long-term model predictions.

Regarding the amount of PCBs left behind and the reduction in surface sediment concentrations, EPA notes in Table A4-5 of Appendix 4 of the FYR report that the removal activity alone achieved substantially better reduction in surface PCB levels in RS 1, the targeted level in RS 3, and somewhat less than expected reduction in RS 2. However, incorporating the surface sediment data collected in 2016, the table shows greater reductions in all three river sections. It is likely that the combination of the remedy itself, natural attenuation since the 2002 to 2005 sampling, and additional attenuation since the remedy was important in achieving this reduction. These observations are further supported and refined by the more extensive sampling conducted by NYSDEC; see EPA's April 2019 Technical Memorandum entitled "Technical Memorandum Evaluation of 2016 EPA/GE and 2017 NYSDEC Surface Sediment Data" (www.epa.gov/hudson). Given that the average surface sediment concentrations were estimated to decline more than 80 percent in all three river sections (based on comparison of the 2002 to 2005 SSAP and the 2016 OM&M sediment sampling datasets), EPA does not agree that an update to the Conceptual Site Model (CSM) is needed. EPA will continue to monitor sediment concentrations closely.

EPA will continue to monitor PCB levels in fish and assess the corresponding declines in fish tissue concentrations over time. EPA disagrees with a commenter's certainty that fish tissue concentrations will be higher than what was anticipated in the ROD because the absolute concentrations in the sediments were higher than expected. As documented in Appendix 4 of the FYR report and further supported by the 2017 NYSDEC sediment survey, the sediment data would suggest a substantial improvement in fish exposure to PCBs and, therefore, fish body burdens are expected to decline.

As stated in the FYR report, it is EPA's assessment that fish tissue concentrations will decline in response to the relative decline in surface sediment concentrations and the ensuing reduction in water column concentrations and fish exposure. Absolute sediment concentrations do not dictate specific PCB levels in fish, since factors such as organic carbon and sediment type influence the bioavailability of the PCBs to fish. As documented in the FYR report, the surface sediments have declined substantially since the 2002 to 2005 SSAP, in both dredged and non-dredged areas, yielding reductions of 80 to 96 percent, depending on river section. Fish concentrations are expected to decline similarly in future years.

In addition to the direct evidence on the recovery of the sediments themselves and the implications for fish body burden declines in response, levels of PCBs in the water column are also expected to continue their declines in response to the sediment improvements as well as the upstream source control remedy implemented near the former Hudson Falls plant. The water column remains an important means of exposure for fish. These reductions in PCB concentrations in sediment and water are expected to lead to concomitant reductions in fish tissue concentrations. While EPA has

estimated these improvements through extensive modeling, additional long-term monitoring data must be obtained before the success of the remedy can be more fully assessed.

Lastly, as discussed elsewhere in these responses, EPA is currently evaluating the sampling and monitoring needs for the Lower Hudson.

3.1.2 Comment 6: Consumption survey required to assess new populations eating fish

Comment

Commenters question the effectiveness of NYSDOH's fish consumption advisories (FCAs) noting that the public is still consuming fish from the Hudson River despite the advisories. Commenters indicated that PCB concentrations currently found in fish continue to result in exposures to both human and ecological receptors which are above EPA's acceptable risk range. Numerous comments noted that comprehensive studies of FCA compliance or effectiveness have not been performed in over 20 years. Some commenters were encouraged that EPA requested the assistance of NYSDOH in evaluating the performance of the existing FCAs and the efficacy of the state's outreach program. Some comments were concerned with environmental justice impacts, noting that communities of color, low-income communities, and immigrants catch and eat fish from the Lower Hudson River. Many comments requested that, since fish consumption patterns have changed since the 1990s, when the last risk assessment was conducted, a detailed scientific, broad-based fish consumption survey be conducted to quantify current and potential human exposure for all contaminated river reaches in order to determine whether the advisories are sufficiently protective over the short and long-term. If the survey finds that consumption patterns have changed, the commenters request a review of risk assessment calculations to determine if updates are needed. Additionally, comments request that EPA consider and evaluate the localized effects of human exposure in more contaminated areas of the River.

Response

It is not possible or expected that the fish will recover immediately after the conclusion of dredging. Rather, as EPA made clear in the 2002 ROD, such recovery will take many years. As is the case at other contaminated sediment sites where the risk from fish consumption guides remedial decisions. Natural attenuation is a necessary component of the remedy for the Hudson River PCB Superfund Site. As a result, FCAs and/or fishing restrictions are a necessary component of the remedy.

In the development of the ROD, various consumption surveys were taken into consideration when identifying consumption patterns and quantities for the risk assessment. The 1991 New York Angler survey (Connelly et. al., 1992) was used in the development of the exposure assessments and in identifying species consumed. The *Connelly* survey was selected because the climate and characteristics of the New York water bodies in that study were more likely to represent Hudson River anglers than non-New York surveys. This survey was used in the development of the exposure assessment and identification of species consumed. While it is understood that consumption patterns will not remain the same over time, EPA was able to assess the need to update the risk calculations based on the information currently in hand. Further, an update to the

consumption survey is not expected to increase the efficacy of the risk calculations because risks are determined on an individual basis and the consumption rates as well as the species mix remain appropriate and representative.

EPA reviewed the assumptions that were used as input to the risk assessment as part of this FYR, including those associated with consumption. Further consideration of specific populations of fish as a food source from the river does not affect the risk calculations. It does, however, highlight an opportunity for additional/updated outreach efforts to inform the public about the advisories.

The FYR includes discussion of efforts New York State has taken to improve the effectiveness of the advisories; Appendix 13 of the FYR report details New York State's efforts which include more signage posting, updated graphics and informative materials, and the performance of angler convenience surveys to target and expand its outreach. Given the iterative and ongoing nature of outreach and recent NYSDOH efforts to enhance and focus efforts, the institutional controls (fishing restriction and fish consumption advisories) appear to be functioning as expected. EPA will continue to work closely with the NYSDEC and the NYSDOH to improve their fish advisory outreach program. EPA strongly encourages the public to carefully review and adhere to the advisories set by New York State.

3.1.3 Comment 7: Despite institutional controls people are still eating fish

Comment

Commenters questioned the effectiveness of NYSDOH's fish consumption advisories (FCAs), noting that the public is still consuming fish from the Hudson River despite the advisories. Commenters also indicated that various fish consumption convenience surveys taken over the last few years indicate that fish are being consumed.

Response

EPA recognizes that some anglers do not comply with or may not be aware of the NYSDOH Hudson River Fish advisories and NYSDEC fishing restrictions. EPA agrees that it is important to continue and coordinate efforts with NYSDOH on its Outreach Program in an effort to optimize awareness by the public. The Outreach Project includes ongoing efforts designed to more effectively reach a broader and more diverse population of those who potentially catch and consume fish from the Hudson River.

As discussed in Section 2.4 and Appendix 13 of the FYR report, Institutional Controls (IC) are an integral part of Superfund site management, investigation, remediation, and post-remediation monitoring. ICs have been effectively implemented by EPA and other government agencies at contaminated sites for decades. As discussed in the 2002 ROD, site-specific ICs, including continuation of fish consumption advisories and fishing restrictions, were anticipated to be implemented as long-term control measures along with active remediation and a long-term monitoring program. These site-specific ICs were designed to prevent or limit exposure to PCBs through consumption of contaminated fish. EPA also acknowledged in the 2002 ROD that consumption advisories are not fully effective by themselves in that they rely on voluntary

compliance in order to prevent or limit fish consumption. For this reason, they were implemented as part of a broader remedy.

The 2002 ROD indicated that fishing restrictions and consumption advisories will remain in place until the relevant remediation goals were met. EPA will not consider the OU2 remedy to be complete until the MNA component also has been completed and project objectives are achieved, including the fish consumption goal of 0.05 mg/kg PCBs in species-weighted fish fillet. As was the case during the Baseline Monitoring Program (BMP) and Remedial Action Monitoring Program (RAMP), EPA anticipates continued support and close coordination with New York State to optimize the ongoing effectiveness of the consumption advisories and fishing restrictions during the ongoing MNA phase of the Project.

As discussed in FYR report, EPA is encouraged by the post-dredging fish (see Appendix 3), water (see Appendix 1), and sediment data (see Appendix 4), however given the limited amount of post-dredge data a protectiveness determination cannot be made at this time. EPA also understands that it is not possible for fish tissue PCB levels to recover immediately after the conclusion of dredging – that recovery will take many years. As such, EPA will continue to monitor post-dredging (natural recovery) results collected under OM&M, work with New York State to continually improve IC effectiveness, and evaluate remedy protectiveness by comparing future observations to expectations outlined in the ROD (which include various RAOs including fish targets and goals). Therefore, as the river continues to recover, it is important for Hudson River-area residents who fish to carefully review and adhere to the regulations and advisories set by New York State.

3.1.4 Comment 14: EPA must reinstate suspended solids monitoring at Waterford to improve evaluation of PCB load to the Lower Hudson River

Comment

Commenters suggested that the Hudson River Foundation recommendation to reinstate USGS suspended sediment sampling at Waterford, along with additional high flow sampling, is needed because higher than anticipated PCB mass remains in River Sections 2 and 3 after the completion of dredging and because the current post-dredging data are insufficient to characterize the PCB loading to the Lower Hudson River (LHR) that is associated with this remaining PCB mass. Commenters noted that the updated HUDTOX model still underestimated measured 2004 to 2008 PCB loads by 8 to 41 percent during that pre-dredging period, so an improved data-based characterization of the observed PCB loads to the Lower Hudson is important for evaluating the effectiveness of EPA's implemented remedy.

Response

EPA agrees that the collection of additional suspended sediment data near Waterford would be helpful to further characterize loads to the Lower River. TSS analysis has been done on all water samples collected during the remedial action. Long term monitoring is expected to continue to include TSS analysis. This monitoring provides comparable results to the historical data collected

by USGS near Waterford. Therefore, the current sampling program is sufficient to characterize the PCB loading to the LHR.

EPA has and will continue to collect weekly water column data from Waterford to assess load to the LHR. In addition to this weekly monitoring, high flow sampling will continue to be conducted. This monitoring may help assess the effectiveness of the remedy with respect to impacts on the LHR and the post remedy variability associated with high flow loads. EPA agrees this high flow monitoring is important and that PCB mass transported downstream during these events can be significant compared to the yearly load totals. The impact from high flow events is one contributing factor to the differences in observed *vs*. predicted loads during the 2004 to 2008 MNA period.

EPA will evaluate if an empirical relationship between suspended solids transport and PCB loads can be derived from such post dredging monitoring including under high flow conditions. Ongoing monitoring will continue to provide PCB loading information downstream of Waterford and its effect on conditions in the LHR.

The reduction in the average surface sediment PCB concentration in RS 2 was lower than expected by the ROD based on the SSAP data. As indicated in the FYR report, achievement of the various remedial goals for RS 2 may lag those anticipated by the ROD by several years. However, based on surface sediment data collected in 2016 and 2017,[1] the inherent uncertainties in the model forecasts, the long periods already anticipated to achieve the remedial goals in the Upper Hudson and the better-than-anticipated improvements in RS 1 and RS 3, this delay in RS 2 is not deemed a significant concern at this time.

3.1.5 Comment 31: EPA's species-weighted-average approach to estimating fish recovery rates should be updated based on the current population's diet. EPA must modify its homologue correction and use of data in developing temporal trends

Comment

EPA examined fish body burden decline on both an individual and a composite basis. However, the composite basis only took into consideration three sportfish species (largemouth bass, yellow perch, and brown bullhead). EPA noted that the pre-dredging PCB concentration decay rate for the composite was 8 percent per year, consistent with its modeling analyses. EPA's choice of these three sport fish species was intended to represent a typical fisherman's creel, based on studies done during the 1990s. It is unclear whether these proportions are still representative of the exposed population's diet, especially in light of population demographic changes. Different groups within the population may consume different species or use different preparation techniques than the EPA analyses assume. How will EPA address this possibility?

In an effort to test the effect of data transformation into homologue equivalent measurements on the estimated decay rate, EPA calculated average decay rates by species and river section and plotted these on a river-mile basis for both $TPCB_{HE}$ and $TPCB_{Aroclor}$. However, about 50 percent

[1] See Appendix 4 of the FYR report and EPA's April 2019 Technical Memorandum entitled "Technical Memorandum Evaluation of 2016 EPA/GE and 2017 NYSDEC Surface Sediment Data" (www.epa.gov/hudson).

of the samples used in the $TPCB_{HE}$ trend analyses were eliminated for this step by selecting only those species-river section combinations with at least 100 samples and 8+ years of data. This elimination procedure censors out a large portion of the data and the effect of this has not been statistically evaluated.

Response

EPA's use of three species to create a composite fisherman's creel for evaluating both risk and remedy success represents a conservative approach, ensuring that estimates of exposure are based on average conditions and not on a single species whose PCB concentrations might be high or low relative to the risk-based thresholds. EPA agrees that the selection of fish consumed by local populations can vary spatially and over time. EPA recognized this in the ROD, with different species sets used in the Lower and Upper Hudson. Although the project uses a generic fisherman's creel, EPA will look at all available data when evaluating the project. Additionally, NYSDOH sets the fish advisories in NYS, and these advisories are specific to individual species and not based on the fisherman's creel. EPA recognizes this and will require GE to collect additional fish species as appropriate in the future to help inform NYSDOH on its advisories. EPA collects data on more species than are included in the creel composite, recognizing the need to consider other species. EPA modeled seven different species in the ROD and examined a total of eight different species in the FYR. The analysis in the FYR determined the decay rates for each species at each station. The decay rates for each species included in the composite form the upper and lower boundaries of the rate that can be derived from a specific creel composite.

Regarding the calculation of decay rates throughout the Hudson as measured by both $TPCB_{HE}$ and $TPCB_{Aroclor}$, EPA's data presentations in the FYR report were intended to show that essentially all permutations of the data revealed the same or similar relationships over time and across distance. The commenter's assertion that half of the data were excluded did not take note that this was a reference to the second of several figures prepared in support of EPA's FYR report. In Figure A3-16A, of Appendix 3 of the FYR report, nearly all of the long-term data were used in both the $TPCB_{HE}$ and $TPCB_{Aroclor}$ plots. In Figure A3-16B of Appendix 3 of the FYR report, EPA selected only those fish trends with the most extensive records in an effort to eliminate less robust records (with fewer measurements and over shorter periods of time), where the less robust trends might confound the overall interpretation of trend with river mile. These data were eliminated from both $TPCB_{HE}$ and $TPCB_{Aroclor}$ plots shown in Figure A3-16B of Appendix 3 of the FYR report, so there is no difference in the amount of data used in either plot. The point of these analyses is to show that the data describe the same trend, regardless of the length of time or the amount of data available for individual species. That is, that the relatively rapid rates of decline in Upper Hudson fish body burdens decline with distance downstream in the Lower Hudson. The exclusion of data generated without ribs, which reduces the numbers of samples available for several species, does not change the observed trend (see Figure A3-16C of Appendix 3 of the FYR report). There is no need to conduct more rigorous statistical analysis to test the effect of the screening procedures since all three approaches yield the same overall trend with distance downstream.

3.1.6 Comment 54: There is no basis in the record for the estimate of mass discharged to the river by GE from the capacitor plants in Hudson Falls and Fort Edward (1.3 million pounds)

Comment

A commenter has concluded that there is no basis in the record for the estimate of the PCB mass discharged to the river by GE from the capacitor plants in Hudson Falls and Fort Edward (1.3 million pounds) as presented in the FYR report. The commenter stated that the estimate is uncertain, and believes that it is inaccurate and inappropriate to continue to cite this estimate. The actual mass discharged to the river is unknown, and may be much more than 1.3 million pounds (650 tons).

Response

The estimate of 1.3 million pounds was originally published by Professor John Sanders of Columbia University in a peer-reviewed journal (Sanders, 1989; page 16). According to the report, the estimate is based on historical use records of PCBs at the GE capacitor facilities between 1957 and 1975. The report stated that less than one percent of the PCB mass used during manufacturing at these facilities (estimated at 133,100,000 pounds) was discharged into the Upper Hudson River (*i.e.,* about 1,331,000 pounds). Nonetheless, EPA acknowledges the possibility that the value may underestimate PCB release from the GE facilities, and should not be interpreted as an upper bound estimate.

3.1.7 Comment 61: Significant PCB deposits left behind are in excess of other cleanup projects

Comment

Commenter stated that the remedy left behind significant deposits of PCB-bearing sediments throughout the Upper Hudson that were not identified for removal by the ROD criteria. Those deposits are in excess of standards used in other PCB cleanup projects and leave the river subject to additional cleanup costs when other residential or public projects are attempted.

Response

EPA does not agree with the premise of this statement; the standards used in other PCB cleanup projects are not relevant to the Upper Hudson River for two primary reasons.

First, EPA's 2002 ROD made the explicit decision to target Tri+ PCB and not Total PCBs, since the Tri+ PCB fraction represented the main exposure to humans who consume fish and fish-eating birds/mammals. The lighter PCB fraction does not significantly accumulate in fish tissue and thus poses minimal risk. Therefore, the premise that the Hudson sediment contamination should be addressed based on a Total PCB criterion is not supported.

Second, the ROD explicitly specified removal criteria for surface sediment concentrations and sediment inventory of Tri+ PCBs based upon a comparison of mathematically simulated remedial alternatives. The selected remedial alternative provided a good balance between the degree of reduction and the required extent of disruption to the river. The ROD recognized that active remediation to the levels suggested by the commenter would have required bank-to-bank dredging for the entire length of the Upper Hudson at much greater cost and disruption to the environment and surrounding communities, but without correspondingly greater improvements. Rather than require such an extensive remedy, EPA included a MNA[2] component in the remedy as outlined in the ROD. It was, and still is, EPA's contention that the Upper Hudson will attain Tri+ PCB levels of approximately 0.25 mg/kg or less Tri+ PCB in the surface sediment as a result of the dredging and natural recovery. EPA's ultimate remedial goal for the sediments is to achieve Tri+ PCB levels at the surface that result in the anticipated reduction in fish.

3.2 Modeling Analysis

This section includes comments and responses concerning spatial scale, the relationship of fish, sediment, and water data, and the assumptions on how the river is going to recover. Modeling analysis includes justification of the models and assumptions used to assess the Remedial Action Objectives (RAOs). EPA has completed additional technical analysis supporting comment responses related to NOAA's emulation model. This analysis is included as Appendix C of this document.

3.2.1 Comment 9: EPA models of recovery in fish, sediment, and water are overestimated and should be revisited

Comment

Commenters indicated that the MNA recovery rates estimated by EPA for the MNA period prior to dredging overestimate the rate of recovery, referring to NOAA's analyses and emulation of EPA's ROD models (and subsequent application of those analyses and emulation with assumed adjustments for decay and sediment PCB concentrations) to support that conclusion. Commenters also indicated that based on NOAA estimates the remedy is not protective and further state that post-dredging PCB concentrations in fish should be used to determine remedy effectiveness/protectiveness as outlined in the ROD, rather than EPA relying on percent reduction of PCBs in sediment and uncertain PCB decay rates. One commenter also stated that post-remedy concentrations are driven by both the recovery rate and initial (post-dredging) concentrations. In contrast, another commenter finds a lack of scientific credibility in the effort conducted by NOAA to emulate, update, and forecast with the EPA ROD models (HUDTOX and FISHRAND) using SSAP sediment monitoring in 2002-2005.

Response

EPA conducted an extensive independent review of NOAA's manuscript entitled *Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation* (Field, et al., 2016),

[2] The term MNA used in the 2002 ROD was consistent with then-current usage; subsequently EPA's 2005 Sediment Remediation Guidance established Monitored Natural Recovery (MNR) as the consensus term of art for sediment sites. The two terms are synonymous in the current context.

which uses model emulation to predict lengthy delays in fish recovery times relative to forecasts made with EPA's models. EPA's detailed responses regarding NOAA's emulation model are contained in EPA's white paper[3] and in Appendix C of this document, and summarized here.

NOAA developed an "emulation" of EPA's models and subsequently "updated" the surface sediment PCB concentrations to forecast fish tissue concentrations in a predictive scenario known as MNA2 in their manuscript. This MNA2 model emulation is not valid because it ignores the underlying mechanisms of the model and that the model was developed using actual water, fish and sediment data. If the sediment concentrations were different than those used in the model (as the MNA2 model emulation suggests) then the relationships between fish, water and sediment would also need to be adjusted. Simply changing a variable such as sediment PCB concentration without recalibrating the underlying model to maintain consistency with the calibration data produces results that are flawed. EPA's evaluation of the NOAA manuscript shows that the MNA2 predictions are biased high for water column PCBs and fish tissue PCBs. This bias is the main reason for NOAA's prediction of extended times to reach RAO targets. Appendix C of this document provides additional supporting information and shows that most of the change in time to recover claimed by NOAA is due to this upward bias caused by a failure to recalibrate. No model-data comparisons are presented in the NOAA paper to support their water column PCB predictions or wet-weight fish tissue predictions, even though extensive data on both have been collected since the ROD. Also, NOAA did not consider all the available sediment data sets in their analysis.

In contrast, the EPA models that supported the ROD successfully reproduced data from 1977-1998, were peer-reviewed as part of the Superfund process and continued to match trends in water and fish data through the extended 1998-2008 period of pre-dredging monitored natural recovery reasonably well, as shown in the FYR report (Appendices 1 and 3).

Commenters indicated that post-dredging PCB concentrations in fish should be used to determine remedy effectiveness/protectiveness as outlined in the ROD, rather than EPA relying on percent reduction of PCBs in sediment and uncertain PCB decay rates. EPA agrees that fish tissue concentrations and their recovery rates are the primary metric to be used when assessing the effectiveness of the remedy. However, EPA must also use all available data when evaluating the remedy effectiveness, including water, sediment, fish and any analysis of those data including percent reduction. It is also important to consider that, for this five-year review period, limited post-dredging fish data are available and these data are likely still impacted by dredging project activities (including habitat reconstruction activity in 2016). Lastly, up to eight or more years of post-dredging data are expected to be necessary to assess with statistical confidence when fish tissue concentrations will achieve the goals set in the ROD.

EPA remains committed to collecting post-dredging data under the OM&M program to improve its understanding of PCB concentration trends in fish, sediment and water over time.

[3] See: White Paper: Responses to NOAA Manuscript Entitled: "Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation" (Field, Kern and Rosman, 2015) (EPA, 2016)

3.2.2 Comment 15:EPA should update its models to reflect information obtained during dredging

Comment

Commenters indicated that the conceptual site model (CSM) should be updated as part of the ongoing management of the remedial program for this site, now in the monitored natural recovery phase. The commenter asserts that data collected during dredging indicates a fundamental change in the relative contribution of water-borne to sediment-borne PCB contamination to fish body burdens. The commenter believes that the relatively limited increases in fish PCB body burdens during dredging in response to the much larger increases in water column concentrations must indicate that fish body burdens are controlled primarily by sediment with little water column input. The commenter also indicated that the appropriate spatial scale (*i.e.,* pool-by-pool, rather than averaged over multiple pools) should be used in the design of sediment, water, and fish sampling to be undertaken to better understand the performance of the remedy.

Response

Two years of post-dredging data are not sufficient to assess the post-remediation recovery. EPA anticipates that it will take up to eight or more years of fish tissue data to identify trends with a reasonable degree of scientific certainty. EPA does not believe that a fundamental change to the CSM is needed. The main mechanisms for PCB transport, degradation, resuspension and fish uptake in the CSM are still operative, although now driven by lower concentrations overall. While EPA agrees that fish tissue body burdens did not increase as much as water column concentrations during dredging, EPA does not believe those data are sufficient to invalidate the relative contributions estimated in the ROD models. In particular, HUDTOX and FISHRAND models are based on many years of calibration data, and forecasted trends and concentrations in fish body burdens were well matched to those observed during the pre-dredging MNA period from 1998 to 2008. Thus, the models' mathematical representation of site conditions appears to be sound. Moreover, although the models were used to roughly approximate dredging conditions, the models were not designed to capture the highly variable and transient conditions associated with dredging. EPA therefore does not consider the models' ability to represent the dredging period (including the post-dredging equilibration period) to provide a test of the models' reliability. Thus, EPA does not agree that the evidence requires a fundamental revision of EPA's models to change the relative roles of sediment and water exposure to fish body burdens.

Commenters suggested that EPA focus its future monitoring on a reach-by-reach basis rather than for the whole river or by river section. While the ROD's expectations are based on the river section scale, EPA agrees that there is value in assessing reaches within the river, river sections, and the whole river. EPA has and will continue to evaluate the river at these different scales. All reaches will be monitored as part of the surface sediment sampling program, thus providing recovery information on a reach basis. Depending on data availability and the degree of similarity of PCB concentrations, reaches may be grouped as part of long-term trend analysis. Periodic reach-specific fish monitoring will also be done as appropriate to confirm fish recovery is consistently occurring throughout the Upper Hudson. Additionally, EPA will coordinate with NYSDEC and NYSDOH

regarding location-specific sampling modifications as necessary to inform evaluations of ongoing recovery and decisions regarding adjusting fishing restrictions and fish consumption advisories.

3.2.3 Comment 26: Conceptual site model - relationship of sediment, water, fish

Comment

Commenters noted that fish tissue concentrations are closely tied to localized remedial activity and sediment contamination in the Upper Hudson River (UHR). Specifically, commenters asserted that UHR fish are not likely to travel between pools due to dams and locks and are exposed only to the sediments of the pool in which they live and that data collected during the Remedial Action Monitoring Program (RAMP) indicate that the local sediments play a larger role in influencing fish PCB concentrations than was thought at the time of remedy selection. As a result, commenters indicated that the scale of project management needs to change from river section to reach and the assumed relationships between sediment, water, and fish, under which cleanup levels were developed, need to be re-evaluated and re-quantified.

Response

EPA agrees that fish tissue concentrations are linked to sediment concentrations but does not agree that the relationship between sediment, water, and fish tissue PCB concentrations was not understood at the time of remedy selection. The HUDTOX and FISHRAND models were calibrated, verified, and applied to the UHR to support EPA decision-making. The application of the calibrated models to the UHR allowed direct comparisons of predicted water, sediment, and fish tissue concentrations across proposed remedial alternatives. The FISHRAND model assumed localized exposures on a reach-by-reach basis by relying on underlying sediment and water exposure concentrations developed using the HUDTOX model at these localized scales. The strength of the combined model framework lies in its ability to compare predicted concentration trajectories over time using a consistent set of assumptions. The models successfully underwent peer review in 2000.

The 2002 ROD reflects that relationships between key model components (sediment, water, and fish) were well understood and contributed to EPA's designation of REM 3/10/Select as the Selected Remedy. Consistent with the scale at which FISHRAND was calibrated and applied, fish data collected during the Baseline Monitoring Program (BMP, 2004-2008), *i.e*., prior to the RAMP (2009-2015), involved collecting multiple samples for each target species from multiple locations within reaches. The sampling locations adopted for the BMP were based on, and represented an expansion of, the number of long-term NYSDEC stations sampled for pre-dredge studies (Sloan, *et al*. 2002) in UHR reaches 8 through 5. The sampling approach developed for the BMP and carried forward as the RAMP reflected the BMP goals and DQOs. Specifically, the BMP (fish) goal was to "provide data on PCB levels in fish and water to allow the evaluation of long-term recovery trends" and the fish sampling DQO was to "establish baseline PCB levels in UHR resident sport fish and resident forage fish to allow for documentation of the changes in PCB concentration that result from remediation." As stated in BMP QAPP Section B.1.2.3, a specific objective of the fish sampling program was to provide "a reasonable estimate of reach average fish

PCB concentrations." Thus, the FISHRAND model and the BMP and RAMP fish data collection approaches were each designed to evaluate fish tissue concentrations on a reach basis.

As discussed in Appendix 1 of the FYR report for the water column, Appendix 3 for fish, and Appendix 4 for sediment, the model has performed within the range of expectations when compared to observed data prior to dredging. In 2016, concentrations for individual species ranged from 0.4 to 1.7 mg/kg depending on the species and location. Yellow perch, for example, had already achieved the 0.4 mg/kg interim target at several locations. The 2016 species-weighted average is about 1 mg/kg in all three river sections. These values are comparable to the model results for the first year post-dredging as shown in Figure A3-19 of Appendix 3 of the FYR report. Comments regarding potential challenges encountered in fish monitoring program implementation are further addressed in Appendix 3 and Appendix 8 of the FYR report. There is no basis for concern about the applicability of the CSM or model forecasts. The system underwent a "reset" following dredging activities and established a new "baseline" from which post-dredging, or MNA, trends will be evaluated. Accordingly, evaluating data-based trends into the future starting with this new baseline will require additional data over multiple annual cycles to provide statistically meaningful estimates of progress toward meeting the interim targets and final goal.

The ROD evaluated potential remedial alternatives at the river-section scale. Data collected in support of remedy selection and modeling were calibrated, verified, and applied at the reach scale. Results were then compiled as needed to the river-section scale as appropriate. EPA recognizes that in some reaches minimal data were collected. EPA and GE are currently discussing fish and sediment data collection scopes of work under the OM&M program, and have collected initial baseline post-dredging sediment, water, and fish samples. Data collection for all three media will continue under OM&M. Ongoing discussions include additional fish data collection in reaches 1 through 4 (see Figure 2 of the FYR report), in part for the purpose of informing NYSDOH fish consumption advisories and NYSDEC fishing restrictions. It is important to note that reaches 1 to 4 were not included in baseline fish monitoring because it was expected that the reach 5 would conservatively represent those reaches. Reaches 1 to 4 have significant sections of bedrock bottom and in most areas have lower sediment concentrations than the upstream reaches. Therefore, fish in those reaches will likely be lower in concentration than upstream reaches, including reach 5.

As the water, sediment, and fish recover from dredging and the project transitions from the remedial to the OM&M phase, the emphasis will be on comparing observed fish tissue levels to ROD targets and RAOs rather than comparison to model forecasts. Therefore, it is unnecessary to reevaluate and re-quantify the relationships between sediment, water, and fish PCB compartments at this time. EPA will continue to monitor post-dredging (natural recovery) results collected under OM&M and evaluate remedy protectiveness (as part of FYRs) by comparing future data to project RAOs (including the fish targets and goal).

3.2.4 Comment 27: EPA's model prediction that the Upper Hudson River PCB load to the Lower Hudson River is the primary factor for recovery of Lower Hudson River fish is proven incorrect by this Five-Year Review

Comment

Commenters noted that post-dredging impacts on water column Tri+ PCBs (PCBs containing three or more chlorines) in the Lower Hudson River average four times higher than predicted by the 2002 ROD models and that additional years of MNA will be required before PCB levels are acceptable in water, sediment and fish because the EPA ROD model of the Lower Hudson River failed to properly reflect the cyclic nature of sediment transport resuspension and deposition.
These commenters also argued that there are not enough data/evidence to support the assumption that PCB loading from the Upper Hudson to Lower Hudson River plays a major role in Lower Hudson River recovery because the FYR itself indicates that PCB loading from the Upper Hudson River to Lower Hudson River is not a primary factor considering the slow recovery of Lower Hudson River fish. The comments cite multiple studies and references (Thomann et al. 1989, Farley et al. 1999, USEPA 2000a, Hydroqual 2007, Rodenburg and Ralston 2017) that suggest, based on high-resolution core sampling, the primary source of PCBs to the Lower Hudson River is the result of past and continued loading of PCBs originating from the Hudson Falls and Fort Edward plant sites and sediments within the Upper Hudson River. Therefore, the commenters recommend that a more in-depth analysis of Upper Hudson River effects on the Lower Hudson River is needed.

Response

The Farley model that was used to extend EPA forecasts to the Lower Hudson River included sediment settling and burial, resuspension, and diffusive exchange as processes contributing to the complexity of PCB transport, as did EPA's model of the upper river. In contrast to development of EPA's Upper Hudson River model, the water column data available for calibration of the Farley model were very limited, and that model was not calibrated to water column data. As shown in FYR report Appendix 1, Farley model water column forecasts for Albany through 2008, which were driven primarily by EPA's HUDTOX Tri+ PCB forecasts for Troy Dam, the downstream boundary of the Upper Hudson River, were accurate, but Farley model water column Tri+ PCB forecasts for Poughkeepsie were systematically low, reflecting limitations in the Farley model calibration. EPA agrees that past loadings of PCBs from the Upper Hudson River have been a major source of PCBs to the lower river, including periods of uncontrolled historical release to the Upper Hudson River and subsequent periods of declining loads. EPA has evaluated the extent to which loadings from the Upper Hudson River currently contribute to Lower Hudson River concentrations, and as discussed in Appendix 1 of the FYR report, the evidence from the dredging period indicate that the water-column PCB response was greatly attenuated between Albany and Poughkeepsie, and that local sources, including legacy deposits, likely account for elevated Poughkeepsie water-column PCB concentrations. EPA agrees that it is important to collect additional data/information about other sources and PCB fate and transport in the Lower Hudson River. EPA is moving forward with supplemental studies of the Lower River.

3.2.5 Comment 34: Water quality improvements from dredging tend to decrease with distance downriver from dredging

Comment

Commenters suggested that available post-dredging data show that the improvement in water column PCB concentrations diminishes downstream of Thompson Island Dam (TID) and that it is unclear whether ROD targets for PCB mass transport reductions will be achieved because of data limitations and the complicating influence of year to year variations in flow.

Response

EPA agrees that annual variations in flow complicate PCB load evaluation and that trends over brief time frames may not well represent long-term water quality improvements. EPA also agrees that improvements to water quality decrease the farther one moves downstream from the dredging. However, Appendix 1 of the FYR report shows that overall post-dredging reductions in surface water PCB concentration were substantial at Waterford compared to the pre-dredging levels, as well as at the other Upper Hudson River (UHR) locations. As the river continues to recover, EPA (as part of OM&M) will continue to track water column PCB concentration and loading trends downstream of the dredging (including to the Lower River).

3.2.6 Comment 44: NOAA's models demonstrate that the EPA ROD models are flawed and should be updated to correctly reflect the role of sediment concentrations in evaluating protectiveness of the remedy

Comment

Commenters cited NOAA's model emulation (Field, et al., 2016), including its update substituting SSAP data for HUDTOX-simulated sediment concentrations, as a basis for determining that EPA's models are no longer valid. One commenter asserted that EPA's models assume that only sediments control fish exposures in RS 1 and 2, and that only the water column controls fish exposures in RS 3. The commenter argued that local sediments control exposures everywhere. Another commenter called for use of an updated model to assess the effect of post-dredging surface sediment concentrations on the protectiveness of the remedy.

Response

EPA conducted an extensive review of NOAA's manuscript entitled *Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation* (Field, et al., 2016). EPA's detailed responses regarding NOAA's emulation model are contained in EPA's white paper[4] and in Appendix C of this document, and summarized in Master Comment 9 (see Section 3.2.1). As discussed in the response to Master Comment 9 (see Section 3.2.1) and as detailed in Appendix C of this document, the NOAA updated model emulation produced biased water column and fish tissue simulations by failing to recalibrate after altering sediment concentrations.

[4] See: White Paper: Responses to NOAA Manuscript Entitled: "Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation" (Field, Kern and Rosman, 2015) (EPA, 2016)

Contrary to the commenter's assertion, FISHRAND does, in fact, assume that sediments are a critical element of PCB exposure for all fish in all River Sections, and simulates fish body burdens as functions of local sediment exposures, taking into account local habitat and ranges and recognizing dams as pool boundaries. In addition to sediment exposures, water column exposures also matter in FISHRAND, consistent with the science on fish PCB uptake, and varying by species according to their degree of benthic or pelagic exposure within the food web.

As shown in the FYR, EPA's models performed well in simulating water column concentrations and fish tissue concentrations through 2008, just prior to dredging, and EPA does not see a need at this time to develop an updated model. EPA notes that its models simulated water column and fish tissue concentrations for 2004 to 2008 much more accurately than the NOAA emulation model update cited by multiple commenters.

3.2.7 Comment 55: EPA needs to update the conceptual site model (CSM) and recalibrate and update HUDTOX and FISHRAND models in order to properly understand the impacts of the dredging on the resultant fish concentrations

Comment

Commenters stated that with fifteen years of data collected in the Upper Hudson River since the ROD was issued, and the realization that more PCB mass was present than originally estimated in the 2002 ROD, EPA needs to update the conceptual site model (CSM) and gather the data necessary to determine if the amount of remedial work identified in the ROD will achieve the targeted reductions in human health and environmental risk. EPA also needs to update the agency's understanding of how the PCBs remaining in Hudson River sediments impact the water column and fish in the river.

Commenters also stated that EPA must update, restructure and recalibrate the mathematical models developed for the Site to properly take into account what has been learned since the ROD was issued. These commenters asserted that EPA has never provided a valid scientific reason for not updating its modeling and flawed predictions. The commenters also stated that, currently, EPA is relying on overly optimistic model projections regarding the anticipated rate of natural recovery in the river by underestimating the impacts of local sediments on fish and thus underestimating the benefit of active remediation.

Response

Based on EPA's understanding of site conditions for the Upper Hudson River, the CSM appropriately represents the interactions among PCBs in the sediment, water column and aquatic organisms, and an update to the CSM is not warranted at this time. As presented in the 2002 ROD, the CSM for the Upper Hudson River describes the source-to-receptor succession in simple terms and identifies the major contamination sources, contaminant release mechanisms, secondary sources, and pathways and receptors of concern (EPA, 2002). Data collected subsequent to the release of the 2002 ROD have not altered EPA's understanding of how contaminant sources, release mechanisms and pathways of contaminants impact receptors of concern, and no data have

been collected that would necessitate a substantive update to the CSM as presented in the 2002 ROD. More specifically, the identification of additional PCB mass in the Upper Hudson did not require an alteration to the CSM, as PCBs in the sediment were accounted for in the original CSM presented in the 2002 ROD. However, EPA continually reviews new data as they are collected and will continue to assess whether updates to the CSM are necessary.

The HUDTOX and FISHRAND models were developed in a manner consistent with the CSM and the spatial scales needed to inform the 2002 ROD, including linking fish tissue concentrations at each sampling station to local sediment exposures. These models were also subject to a rigorous peer review by a panel of international experts (ERG, 2000). After extensive document review and a series of public meetings, the peer review panel determined that the models were acceptable and adequately reproduced historical data. Model-data comparisons presented in Appendices 1 and 3 to the FYR reportdemonstrate that the models successfully represent the water column and fish data collected during the 11-year MNA period from 1998 through 2008. Concerns over sediment data do not indicate the need for the EPA models (HUDTOX and FISHRAND) to be modified because their ability to accurately predict fish and water concentrations over the MNA period demonstrates they were not overly optimistic in predicting future conditions and that they had value as decision tools to inform the ROD at the time that it was issued in 2002.

Now that dredging activities have been completed, the development of empirical, data-based trends for the recovery of fish tissue and water column concentrations will provide the strongest evidence of whether the remedy is functioning as intended, rather than reliance on model-based predictions of trends in PCB concentration. While model-based predictions were necessary before the remedy was implemented, the project is entering a phase where the river bottom and PCB inventory have been extensively modified, and where the data itself will determine rates of recovery. It is unlikely that additional modeling work done at this time would add significant value in predicting long-term recovery. It should also be noted that the time needed to develop an updated suite of models, including necessary data collection, would be quite long. Updated models would need to be initiated to represent post-dredging conditions and then calibrated to a dataset adequate to support forecasting long-term trends. Accounting for potential model peer review, this process would likely take many years, at the end of which EPA would likely have collected sufficient post-dredging data to determine empirically-based MNA trends for PCBs in water, surficial sediments and fish within an acceptable range of uncertainty.

3.3 Assessment

This section includes comments and responses on PCB Aroclor considerations, risk assumptions, other EPA reports, fish data assessment, Lower Hudson River assessment as applicable, and other similar comments. Most of the master comments and responses fall within this category. As requested, EPA has finalized the Black Bass fillet tissue with and without ribs study. This study is included as Appendix D of this document.

3.3.1 Comment 2: Adjust data treatment techniques for Aroclor data

Comment

Some comments recommended that the impact of using a single correction factor to adjust multiple years of fish PCB data on the uncertainty of the temporal PCB trend analysis should be assessed. They also commented to confirm that TPCBs in fish from mGBM are comparable to TPCBs from M1668. The "homologue" adjustment of NYSDEC and GE fish data in the FYR uses a single factor based on a geometric mean of the ratio of Aroclor PCBs to mGBM TPCBs. In the case of the NYSDEC data, the adjustment factor from 1999-2000 is applied to all subsequent years without any data to document applicability. The NYSDEC adjustment factor applies the factor from wet weight analysis to the lipid-normalized concentrations, instead of more appropriately using the factor from lipid-normalized analyses, which are substantially different for some years. Also, for the 1997 NYSDEC fish data, the FYR relies on a model-estimated factor from Butcher et al. (1998), ignoring the data from the split-sample approach used for subsequent years. Using a single factor ignores the uncertainty/variability of the relationship for different subgroups (e.g., species, location, year) and may not represent the pattern in the underlying data. Some commenters also stated that the transformation from Aroclor to TPCB homologue-equivalent introduced a very large degree of uncertainty on the transformed data and therefore the fish tissue recovery rate of 8 percent is uncertain. Another commenter stated that EPA's conclusion that transforming the data from Aroclor based to homologue equivalent measurements had virtually no effect on fish tissue trends was based on an analysis that excluded about 50 percent of the total data.

Response

There are multiple assertions made in this comment, each of which is addressed below.

EPA's application of adjustment factors for Aroclor-based data is predicated on the theory that homologue- and congener-based methods (*e.g.,* capillary column-based methods, including GE's mGBM and EPA's M1668) provide more accurate estimates of the true PCB concentration, since these methods attempt to quantify the congeners themselves. Therefore, when matched pair data were available,[5] EPA developed relationships between Aroclor-based results and those of the homologue- and congener-based methods so as to adjust the Aroclor-based results to a consistent homologue-equivalent basis. This is discussed extensively in Appendix 5 of the FYR report. EPA uses the most applicable matched pair data to derive the appropriate correction factor for a dataset. EPA's primary estimates of the decay rates in fish tissue concentration are based on these homologue equivalent values. EPA recognizes that these transformations introduce variation and uncertainty, much of which can be difficult to quantify directly.

Because of the difficulties in assessing the magnitudes of the various individual uncertainties involved (*e.g.,* the use of a single conversion factor over multiple years of data), EPA did not assess the individual sources of uncertainty. Rather, EPA examined the overall level of uncertainty introduced by the transformation process. To assess the sensitivity of the decay rate estimates to EPA's homologue-equivalent-based approach, EPA repeated the entire analysis of decay rates

[5] Matched pair data refers to samples where both an Aroclor-based and a homologue- or congener-based method was run on the same sample, providing two TPCB concentration values for the same sample.

using the Aroclor-based fish tissue PCB concentrations as originally reported, thereby avoiding the uncertainties introduced by the transformations. In both approaches, the amount of data available for the calculations was the same (*i.e.,* there was no reduction in the amount of data used for the calculations by the homologue-equivalent-based approach, contrary to the assertion by the commenter.) These results are presented in Appendix 3 of the FYR report. In particular, Figures A3-16A through C directly contrast the rates obtained for fish tissue across the Hudson by both homologue-equivalent and Aroclor-based calculations. By using the Aroclor-based data as reported, the second set of diagrams in each figure avoid any uncertainties introduced by the transformation process.

To further reduce the uncertainty in the rate of decline evaluation, EPA relied on the integration of multiple fish species at each station, even testing the sensitivity of the results across larger and smaller data sets (compare Figure A3-16A to Figure A3-16B). EPA's analysis indicate that the Aroclor-based rates of decline are much the same as the homologue-equivalent-based rates. This conclusion was the same whether derived from all applicable fish tissue samples (Figure A3-16A) or when derived by the subset limited to species with large numbers of samples and more extensive temporal coverage (Figure A3-16B). Thus, the basis for the commenter's assessment that EPA's conclusion was derived from only 50 percent of the total data is unknown and cannot be replicated by EPA. By conducting this sensitivity analysis, EPA demonstrated that the concerns raised by the commenter, such as the use of a single adjustment factor for the post-1999 NYSDEC data, do not affect EPA's conclusions, since the decline rates show similar magnitude and spatial relationships along the river, with and without adjustment.

EPA's analysis also shows that the lipid-based decay rates are consistently slower than wet weight-based estimates. For both Aroclor and homologue-equivalent bases, lipid-based decay rates average between 5 and 10 percent per year in the Upper Hudson. These rates consistently reduce to much slower decay rates with distance downstream in the Lower Hudson by either PCB measurement basis. Thus, EPA's main conclusions about the rates of decline in fish tissue PCB levels over time are not sensitive to the treatment of the PCB data and are derived from all applicable fish tissue samples.

One concern raised by a reviewer is that EPA applied the adjustment factor from 1999-2000 NYCDEC fish data to all subsequent years. It should be noted that matched pairs are not available for NYSDEC data post-2000. Thus, there are no additional data from which to develop these factors. Since NYSDEC used the same laboratory from 1999 through 2011 and the reported Aroclor compositions are relatively similar during this period, the continued use of the 1999-2000 adjustment factor for the post-2000 period is the best approach based on available data. As explained above, EPA's sensitivity analysis concludes that this data treatment approach does not impact its conclusions regarding the magnitude or the spatial variation of the fish decay rates.

Regarding the use of lipid-normalized PCB adjustment factors *vs.* wet-weight PCB adjustment factors, EPA also does not agree with the comment's assertion. The available matched pair fish tissue data for Aroclor-based and the homologue-equivalent analyses are not consistently matched with lipid analyses. In some years (1995, 1999 and 2000), independent lipid analyses are available for both the Aroclor-based and the homologue-equivalent-based analyses, making lipid-normalized correction factors possible. In other years (1997 and 1998), lipid analysis is only

available for the Aroclor-based analysis, eliminating the possibility of a lipid-normalized correction factor between methods. For this reason, EPA approached this issue by developing correction factors based only on the reported PCB data, which could be done consistently for all years of data. As discussed previously in this response, EPA has compared the trends derived from the homologue-equivalent data and those from the raw Aroclor data, on both a wet-weight basis and a lipid-normalized basis. The comparison indicates that the average decay rates on a wet-weight basis and the average decay rates on a lipid-normalized basis are not changed by the use of homologue-equivalent data *vs.* the use of the original unmodified Aroclor data. These analyses suggest that the spatial variation and mean values for the decay rates are not sensitive to the data adjustment approaches.

The correction factor for the 1997 NYSDEC fish data was derived by regression analysis[6] using the matched pair data collected in 1997 (Butcher et al., 1998). Applying the correction factor from subsequent years to the 1997 data will introduce more uncertainty due to the differences in Aroclor and homologue analytical procedures applied by the different laboratories. These differences are the reason EPA developed the sampling year-analytical laboratory-specific equations shown in Table A5-20 in Appendix 5 of the FYR report.

Regarding the possible variations in these factors due to species differences, EPA examined the possible effect of various subgroups in its analysis, as presented in Figures A5-11 and A5-15 of Appendix 5 of the FYR report. These figures present the matched pair data on a species basis. It is evident from the figures, as concluded in the appendix, that there is no discernable difference in the relationship between the matched pairs of analytical results that can be explained by species differences.

EPA does agree with the commenter's underlying assertion that it is important to establish an accurate basis for PCB measurements in fish for the current and future monitoring efforts. However, it is not necessary to establish the accuracy of the mGBM or its comparability to M1668 in this regard. Specifically, since the mGBM is no longer available, it will not be used in future fish tissue monitoring. More importantly, the remediation changed in-river conditions significantly. Thus, trends prior to dredging, which reflect pre-dredge conditions, do not impact considerations going forward. Rather, it is the improvement in post-dredging conditions that will be monitored and form the basis for any future consideration regarding river recovery. To provide an accurate basis for long-term monitoring beginning in 2016-2017, EPA will be conducting analyses of fish tissue by both Aroclor-based (M8082) and congener-based (specifically M1668) methods as part of the ongoing fish monitoring program. Similar to the sediment monitoring program, samples will be homogenized and then split for analyses by the two methods. Also similar to the sediment program, GE's laboratory will be required to run reference standards to confirm analytical accuracy and provide a benchmark for future monitoring work.

[6] It is noted that Butcher *et al*., 1998 did not include these relationships in their paper.

3.3.2 Comment 3: Assess risks of PCBs based on changes in consumption

Comment

Commenters state that since the risk assessment work was completed in the mid to late 1990s, it appears that there has been a change in the species mix among sport fish in the Hudson River. Walleye are now more prevalent than during the 1990s and are now commonly found throughout the Lower Hudson and in the southern portion of the Upper Hudson. As a sought-after food fish, walleye may represent a portion of the overall take of fish for human consumption, particularly in the Lower Hudson. Available data indicate that the PCB concentrations in walleye are 1.5 to 2 times higher than in bass, another commonly sought after game fish, which was the species used in EPA's risk assessment. EPA needs to update the current understanding of risks posed by fish consumption given the change in fish species available for consumption. Surveys of people taking fish from the Hudson would help inform this issue. A comment stated EPA should consider crab consumption by both humans and other species (birds, fish) in the analysis of human health risks. Commenters additionally stated that the FYR failed to carefully examine the magnitude or extent of existing and previously ignored exposure pathways, such as the prevalence of the consumption of Hudson River fish.

Response

The Revised HHRA completed in 2000 included Walleye as a consumed species. As stated in the HHRA, the six species from the Connelly et al. (1992) survey that are potentially caught and eaten in the Upper Hudson River (bass, walleye, bullhead, carp, eel, and perch), were grouped in order to develop the fish ingestion weights from which the weighted concentration term was developed. Carp and eel, which are bottom feeders, were grouped with brown bullhead as Group 1. Walleye, which is similar to bass based on its large size and piscivorous diet, was grouped with the bass as Group 2. Group 3 is perch, for which yellow perch modeled concentrations were used. Using this approach, the concentrations of PCBs in fish species that were not modeled (i.e., carp and eel, walleye and some bass) were approximated based on the two species consumed that were modeled (brown bullhead and largemouth bass), so that consumption of the non-modeled species could be included in the species weighted exposure point concentrations (EPCs) which are the concentrations of PCBs in a given environmental medium at the point of human contact. Table 3-4 in the HHRA summarizes species-group intake percentages by summing the frequency percentage of the individual species in each group.

The point estimate EPCs in fish were derived using the species ingestion fractions shown in Table 3-4 multiplied by the PCB concentrations in each of the three modeled fish species. Thus, the point estimate of the weighted EPC is:

$$EPC = EPC_{Group1} \times 0.44 + EPC_{Group2} \times 0.47 + EPC_{Group3} \times 0.09$$

The fish species used to evaluate the EPCs in the HHRA are representative of the species to which people may be exposed at the Site, and that it is not necessary to perform risk calculations for additional species. EPA did not calculate risks and hazards from exposure to crabs in the Hudson River since crab data was not collected at the time of the RI/FS and considering that crabs are only

found in the New York Bay. In the 1996 and 1991-1992 Hudson Angler Surveys (NYSDOH, 1999b; Barclay, 1993), the NYSDOH conducted a creel survey of Hudson River anglers in 1996 (NYSDOH, 1999b). The Surveys found that Blue crabs were caught only south of Catskill, not in the Upper Hudson River (NYSDOH, 1999b). In addition, work conducted by EPA at another Superfund Site in the Newark Bay Complex found that crab consumption was lower than for fish consumption. For example fish ingestion rates for the Adult in the Hudson River was 31.9 g/day while the Crab Ingestion Rate for the Newark Bay Complex is 20.9 g/day. The Newark Bay Complex analysis looked at both fish and crab consumption finding the risks from fish consumption for the adult was 3 x 10-4 and 7 x 10-5 for crabs. The non-cancer Hazard for fish consumption was an HQ = 24 for fish consumption and the HQ was 5 for the crab consumption. EPA found that typically individuals consume either crab or fish so these values are not combined. In the case that an individual consumes both crab and fish the ingestion rate for each species is less than those who consume only fish or crab.

The NYSDOH has issued advisories which prohibit consumption of fish from the Upper Hudson River and recommend strict limitations on consumption of fish from the Lower Hudson River. EPA is working with NYSDOH to continue to improve the outreach efforts to inform anglers about the importance of following the advisories and regulations. While the studies show that fish consumption is occurring, EPA calculates risks from PCB exposure to the reasonably maximally exposed individual. Additional information about the number of people who consume fish therefore does not directly affect the risk calculations. Consistent with USEPA's Superfund guidance, this risk assessment does not estimate the number of anglers that consume their catch or the number of women of child-bearing age exposed through consumption of fish because CERCLA requires consideration of risk to an individual with a reasonable maximum exposure. It would be difficult to identify the number of anglers who are consuming fish in part because of the presence of fishing bans and fish consumption advisories and because of the potential for underreporting and the threat of fines for anglers keeping fish from the Upper Hudson River. It is also not possible to project with any certainty the number of potential anglers within various stretches of the river who would consume fish if there were no health advisories in the Upper Hudson River.

EPA included a detailed explanation of the calculations performed for human health and ecological risks in Appendix 11 of the FYR report. The calculations include an evaluation of the toxicity of PCBs, the assumed ingestion rate of PCBs from a number of pathways including from eating the fish, and described the Monte Carlo analysis from the original risk assessment. The appendix also describes the exposure assumption for eating fish based on the angler surveys used in the risk assessment.

3.3.3 Comment 4: Assess risks of PCBs in air

Comment

Commenters state that EPA's risk analysis should consider aerosolized PCBs and their cancer and non-cancer risks. Exposure to aerosolized PCBs has been shown to increase risk of cancer, hypertension, heart disease, and diabetes. Commenters further state that recent science indicates that exposure to PCBs through inhalation is a more significant risk than previously believed. The

risk characterization of the ROD and the intention of the RAOs are primarily intended to control unacceptable PCB exposures through consumption of contaminated food (i.e. fish). However, since 2002, the scientific community has documented that exposures to PCBs can occur through contaminated water, direct skin contact, or breathing contaminated air. A comment also stated that PCB contamination has migrated south to threaten New York City.

Response

EPA evaluated in the HHRA potential exposures to residents and recreators from exposure to PCBs in the Hudson River through a range of exposure pathways. The HHRA found that PCBs that volatilize from the river water may be inhaled by both recreators and residents living near the river and that the risks were *de minimus (*U.S. EPA, 2000), i.e., they were significantly lower than the unacceptable cancer risks and non-cancer health hazards from ingestion of fish. In addition, EPA conducted extensive sampling of PCBs in air during the dredging, as discussed further in the FYR report. A discussion of the air data during dredging is provided in Appendix 6 of the FYR report, along with information regarding the derivation of the toxicity values used in the risk assessment for air exposures.

At the current time, EPA's Integrated Risk Information System (IRIS) program is updating the Chemical Assessment for PCB non-cancer toxicity. A component of this assessment will be an evaluation of the existing scientific studies e.g., animal and human epidemiological studies, to determine if an inhalation toxicity value can be derived. The evaluation will include systematic review, evaluation of dose-response based on report exposures, public comment, and external peer-review consistent with the IRIS process.

This on-going reassessment of non-cancer health effects of PCBs included an October 2014 meeting of independent experts to provide input on the science underlying the development of IRIS reassessment. The experts discussed key science topics related to the non-cancer toxicity of PCBs including inhalation. IRIS is currently evaluating the extensive database of non-cancer toxicity information including inhalation studies.

Upon completion of this evaluation, the IRIS program will continue with the various steps in the IRIS process including internal Agency review, intra-agency review, external peer-review with a response to comments and updates to the report, and finally release of the document. Any updates to the IRIS chemical file for non-cancer PCBs will be evaluated as part of answering FYR - Question B (are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?).

EPA evaluated exposures to volatilized PCBs in the 2000 HHRA and found the risks were significantly lower than the unacceptable risks and hazards from ingestion of fish. EPA is currently evaluating available studies on PCB exposures through inhalation as part of the IRIS reassessment for non-cancer health effects. The IRIS assessment will include evaluation of the dose-response and exposures to determine whether existing toxicity values need to be updated. EPA provided copies of the studies identified by commenters to the IRIS staff for consideration during the current reassessment of non-cancer PCB toxicity. EPA will re-evaluate the impacts of this reassessment in future FYRs when the IRIS assessment is completed.

Regarding areas of the Lower River, the objective of the HHRA for the mid-Hudson river was to quantitatively evaluate current and potential cancer risks and non-cancer health hazards from river water, sediment, and fish in the Mid-Hudson River. This HHRA provides estimates of risks both to the Reasonable Maximum Exposure (RME) individual, or high-end risk (>90th to 99th percentiles), and to the Average Exposed Individual, or central tendency cancer risks and non-cancer health hazards (50th percentile). Since the Phase 1 Risk Assessment, USEPA has conducted extensive modeling efforts in order to forecast PCB concentration trends in environmental media in the Mid-Hudson River region (USEPA, 2000a; 2000f; 2000g). The results from these model forecasts were incorporated into this Phase 2 assessment. EPA also plans additional data collection and supplemental studies of the Lower River which will further inform our understanding of the extent of PCB contamination in that portion of the river.

3.3.4 Comment 8: EPA did not investigate the potential for links to autism in the first five-year review

Comment

CoA1016mmenters state that the EPA did not investigate potential links between PCB exposure and autism within the numerous Hudson River communities. They indicated that given the high and increasing prevalence of autism and its seriousness and apparent linkage to environmental agents that may include maternal exposure to PCBs during pregnancy, that the project success should be evaluated with this consideration.

Response

EPA's response to Question B in the FYR report evaluated whether existing data would change the overall outcome of the HHRA. The data evaluated included peer-reviewed documents on exposure assessment and plans for updating the Integrated Risk Information System database (IRIS). As explained in the FYR report, updates to the exposure assumptions in the ROD do not change the conclusions of the HHRA or the protectiveness of the remedy. EPA is re-evaluating the non-cancer toxicity information and any updates will be evaluated in the next FYR.

One commenter states that there is an "emerging link between PCBs and possible causation of autism." The commenter also states that EPA has "neither addressed this issue substantively, nor alluded to it." EPA disagrees with the commenter's suggestion that EPA did not address potential links between autism and PCBs. The response to Question B in the FYR highlights the upcoming updates to the non-cancer toxicity values, it is expected that these updates will include consideration of autism.

The following text provides additional information on this topic and EPA's approach to evaluating the toxicity of PCBs.

- EPA relies on the IRIS as the primary source of toxicity information in the Superfund program to evaluate cancer risks and non-cancer toxicity. The IRIS program represents that Agency's consensus toxicity information database for over 500 chemicals.

- Currently, the IRIS program has non-cancer Reference Doses (RfDs) for Aroclors 1016 and 1254 (A1016 and A1254) and a cancer assessment, including a Weight of Evidence that PCBs are a probable human carcinogen, for total PCBs. Information on IRIS is available at www.epa.gov/iris.
- The response to Question B in the FYR discusses the on-going reassessment of non-cancer toxicity for PCBs by toxicologists in EPA's IRIS program. The IRIS reassessment is evaluating thousands of studies on PCB toxicity using the Systematic Review process. The systemic review process will evaluate a large number of health endpoints that include autism, based on the available literature.
- The information from the systemic review will be used by the IRIS program to evaluate dose-responses for a number of diseases. Based on the evaluation, IRIS will determine if there is adequate information to update the current oral RfD or develop a new inhalation Reference Concentration (RfC).

This on-going assessment process is discussed on the IRIS webpage (www.epa.gov/iris) which includes documentation of the March 2014 draft literature searches and associated search strategies, evidence tables, and exposure response arrays for PCBs as a means to obtain input from stakeholders and the public. The literature search strategy, which describes the processes for identifying scientific literature, contains the studies that EPA considered and selected to include in the evidence tables. The preliminary evidence tables and exposure-response arrays present the key study data in a standardized format. The evidence tables summarize the available critical scientific literature. The exposure-response figures provide a graphical representation of the responses at different levels of exposure for each study in the evidence table.

EPA also held a meeting of scientific experts in the field of PCB toxicity on June 17-18, 2015 to discuss information on PCB toxicity (see https://www.epa.gov/iris/iris-public-meeting-jun-2015). As the process progresses, EPA will make information available on the webpage www.epa.gov/iris.

EPA's response to Question B in the five-year review acknowledges these efforts by the IRIS process and indicates that once the IRIS process is completed, EPA will re-evaluate the non-cancer toxicity risks at the Site with new reference dose numbers that are applicable. At this point in time, it is premature to prejudge the outcome of the assessment and the study and health endpoint that will be selected. Any changes to the toxicity values will also be evaluated in future Five Year Reviews based on the completion of the IRIS reassessment for non-cancer toxicity.

3.3.5 Comment 11: EPA must calculate the risks of dioxin contamination (or dioxin-like congeners)

Comment

EPA did not address dioxin or heavy metal contamination within the Hudson River. EPA should calculate these risks and until then, the Hudson River cannot be considered remediated.

Response

The commenter raised concerns regarding the evaluation of dioxins at the site. As part of the Revised HHRA EPA 2000), EPA evaluated cancer risks from exposure to dioxin-like PCBs following the guidance provided in the 1996 PCB Cancer Reassessment. The assessment of dioxin-like PCBs did not find an enhancement of risk associated with the dioxin-like PCBs. EPA as part of this FYR, evaluated the new toxicity information for dioxins using the approach in the 1996 PCB Cancer Reassessment and did not find enhancement of risk from dioxin-like PCBs. The results of this analysis did not change the conclusions from the HHRA.

In addition, the HHRA describes the process used to identify the chemicals of potential concern for the site and indicated that dioxins and other chemicals were not included as contaminants-of-concern because fish collected by NYSDEC found those other chemicals to be present either at very low levels or below detection limits. As discussed in the Revised HHRA:

A typical baseline Superfund risk assessment includes an evaluation of those chemicals at a contaminated site that pose a potential health concern, or chemicals of potential concern (COPCs). In the HHRA, PCBs were identified as the COPCs and later as chemicals of concern (COC), because the HHRA was being conducted as part of EPA's Reassessment of its 1984 interim No Action decision for the PCB-contaminated sediments in the Upper Hudson River, and because PCBs in fish tissues were detected at greater concentrations than other contaminants. As discussed in the Revised Baseline Modeling Report, in addition to monitoring for PCBs, fish collected by NYSDEC at the site were analyzed for total dichlorodiphenyltrichloroethane (DDT), total chlordane, total endrin, total endosulfan, dieldrin, aldrin, mirex, total heptachlor, total hexachlorobenzene, toxaphene, methoxychlor, individual polycyclic aromatic hydrocarbons (PAHs), cadmium, mercury, dioxins, and dibenzofurans. These compounds were found to be present at relatively low levels or below detection limits (Sloan, 1999), confirming that PCBs are the primary COCs in the Hudson River. Consequently, no screening of COPCs was performed during the Revised HHRA for this assessment.

<u>Contamination in the Lower Hudson</u>

The commenter states that there is a need to consider exposures from PCBs in the Lower Hudson River. The HHRA for the Mid-Hudson River (included in the HHRA) quantifies both carcinogenic and non-carcinogenic health effects from exposure to PCBs following EPA risk assessment policies and guidance. The Mid-Hudson was identified as the area between the Federal Dam in Troy, New York (River Mile 153.5) going south to the salt-water front at approximately River Mile 64. Both current and future cancer risks and non-cancer health hazards to young children, adolescents, and adults were evaluated based on the assumption of no remediation or institutional controls, in accordance with the National Contingency Plan, 40 CFR Part 300. The HHRA for the Mid-Hudson found the Reasonable Maximum Exposure (RME) cancer risks and non-cancer health hazards from ingestion of fish in the Mid-Hudson are about one-half the cancer risks and non-cancer Hazard Indices determined for ingestion of fish in the Upper Hudson.

As indicated in the FYR report, EPA agrees that is important to collect additional data and conduct supplemental studies to better understand the PCB contamination in the Lower Hudson River, which includes the Mid-Hudson.

3.3.6 Comment 16: EPA should finalize the study done on black bass

Comment

Two commenters recommended that EPA finalize the 2014 black bass DEC standard fillet vs rib-out study, so it can potentially be peer reviewed and the paper can then be cited in documents by the Natural Resource Damage Trustees.

Response

EPA determined that fish collected and processed between 2007 and 2013 by GE did not have the ribcage included as part of the fillet as required by project documents. In response to this deviation from the QAPP, EPA required that GE perform a special study that would facilitate evaluation of whether or not inclusion of the rib cage (ribs) had a significant impact on fish tissue PCB concentrations and lipid levels. Black bass (smallmouth bass and largemouth bass) were the focus of the 2014 study because they are large enough to produce fillets of sufficient size for comparison, were generally considered to be representative of other species and are collected from monitoring stations in the Upper and Lower Hudson River.

EPA completed its evaluation of GE's 2014 special study on black bass and provided the report as Appendix D of this document. The preliminary results of the analyses were shared with commenters, project stakeholders, and the Hudson River Community Advisory Group in October 2015. EPA's analyses found that on a wet-weight basis, the difference between fillets prepared with and without ribs was variable and could be greater than a factor of two. For lipid normalized data, the difference between the two fillet approaches averages less than 20 percent. As a result, EPA determined that comparison of lipid normalized results from fillets prepared with and without ribs could be conducted, but that results should be evaluated cautiously. It should be noted that the period of data collection when the rib was not included (2007 to 2013) was just prior to and during dredging activities. Fish tissue PCB concentrations observed during dredging were impacted by dredging-related PCB resuspension and are not useful for establishing post-dredging fish recovery trends. No significant project decisions were made or altered based on fish data from the years when the ribcage was not included in the fillet samples. Also, no adjustments to fish advisories or regulations were made by New York State based on those data.

3.3.7 Comment 18: EPA should look for updated information on the toxicity of PCBs

Comment

Commenters state that EPA has failed to acknowledge any new information related to exposure assumptions or toxicity data that could impact the human health risk assessment, siting that recent science indicates that PCBs are more toxic than previously thought. Commenters note concern that EPA is still classifying PCBs as probable human carcinogens (in the Integrated Risk Information System [IRIS] listing) with a cancer weight-of-evidence classification B2, whereas the International Agency for Research on Cancer, of the World Health Organization, has now listed PCBs as a known human carcinogen.

In addition, dioxin-like PCBs can now be evaluated via EPA's listing of non-cancer endpoints for dioxin via the reference dose in EPA's IRIS as well as several additional toxicological endpoints which have been updated in terms of health effects. All of this information adds to the growing body of research which demonstrates that PCBs are more toxic to humans than previously believed when the human health risk assessment was being developed for the ROD. As a result, the FYR report needs to address the greater toxicity as a change in assumptions and new information that was not available at the time the ROD was developed.

Commenters also indicated that there is not sufficient data available to evaluate if the cleanup levels in the ROD are still valid; to determine if the exposure pathways used in the risk assessments are still valid (due to changes in fish species distribution, and in population demographics among human fish consumers); and to determine if the toxicity assumptions are still valid, as EPA has not yet completed the anticipated update to the IRIS database for PCBs.

Commenters noted that PCBs pose a significant risk to public health including cancer, cardiovascular disease, and cognitive and development disorders in children while some also noted that the link from PCBs to health impacts has not been proven. When considering remedies to address PCB contamination in the Hudson, the EPA determined that cancer and non-cancer health risks were well above the acceptable risk range for people who ate fish from both the Upper and Lower Hudson. The Superfund cleanup remedy was intended to address the risks, and the FYR is intended to ensure the risks have been adequately addressed.

Response

Commenters stated that PCBs pose a significant risk to public health. EPA uses risk assessment to inform decisions under CERCLA, commonly referred to as the Superfund law. The goal of the risk assessment is not to predict specific diseases but rather to assess risks to support risk management decisions. The risk assessment provides a methodology for evaluating current and future risks under specific exposure assumptions for different age ranges (e.g., young child through adult) and different activities (e.g., outdoor workers, construction workers, recreational users, and residents). Both human health and ecological risk assessments were developed for the Hudson River. The documents were externally peer-reviewed and were updated to reflect the comments from the peer-reviewers before the final HHRA was issued in November 2000. The HHRA was a component of the decision to take remedial action at the site. Currently, EPA does not plan to conduct additional risk assessments as discussed in the response to the FYR Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Still Valid? At the next FYR and subsequent FYRs, EPA will review updates to toxicity values and exposure assumptions to determine the need to update the risk assessment.

EPA conducts evaluations of the toxicity of chemicals, such as PCBs, through IRIS. The webpage www.epa.gov/iris provides IRIS assessments for carcinogenicity (for total PCBs) and non-cancer toxicity (Aroclors 1016 and 1254 [A1016 and A1254]). The IRIS process involves the evaluation of a large number of studies of the toxicity of the chemical including evaluation of the chemicals potential to cause cancer and non-cancer health effects.

At the current time, EPA is re-evaluating the non-cancer toxicity of PCBs following the IRIS process outlined in the graphic below. The update includes an evaluation of the available published scientific literature, development of dose-response information where data is adequate, and the development of toxicity values. When the process is completed, any updates to the non-cancer toxicity values will be evaluated in the next FYR in Question B.

In 2000, EPA conducted an HHRA to support the decision to take action at the Site. The HHRA found that the cancer risks exceeded the risk range of 1×10^{-4} to 1×10^{-6} (risk of one in ten thousand to one in a million) established under the NCP. The HHRA also found that the non-cancer hazards exceeded the goal of protection of a Hazard Quotient (HQ) or a Hazard Index (HI) = 1. Fish consumption was the risk driver; other exposure pathways posed risks within the risk range and below a HI = 1.

EPA is working with NYSDOH to inform anglers fishing in the Hudson River of the NYSDOH Fish Consumption Advisories. EPA will continue these efforts and share fish sampling results with NYSDOH and NYSDEC to inform the on-going need to maintain or modify the fish consumption advisories. (See Appendices 3 and 11).

Future FYRs will review the on-going NYSDOH outreach program for the fish consumption advisories and the concentrations of PCBs in fish necessary to inform the fish advisories.

Commenters noted that the link from PCBs to health impacts has not been proven. EPA studied the effects of PCBs on humans, including evaluation of cancer and non-cancer health effects. IRIS provides the Agency's consensus database for toxicity information used in assessments of risks and hazards at Superfund sites. The IRIS assessments for PCBs classify PCBs as a probable human carcinogen based on limited human evidence and adequate animal evidence. The IRIS document summary of the cancer hazards to humans is described below.

- A cohort study by Bertazzi et al. (1987) analyzed cancer mortality among workers at a capacitor manufacturing plant in Italy. PCB mixtures with 54%, then 42% chlorine were used through 1980. The cohort included 2,100 workers (544 males and 1556 females) employed at least 1 week. At the end of follow-up in 1982, there were 64 deaths reported, 26 from cancer. In males, a statistically significant increase in death from gastrointestinal tract cancer was reported, compared with national and local rates (6 observed, 1.7 expected using national rates, standardized mortality ratio [SMR]=346, confidence interval [CI]=141-721; 2.2 expected using local rates, SMR=274, CI=112-572). In females, a statistically significant excess risk of death from hematologic cancer was reported, compared with local, but not national, rates (4 observed, 1.1 expected, SMR=377, CI=115- 877). Analyses by exposure duration, latency, and year of first exposure revealed no trend; however, the numbers are small.
- A cohort study by Brown (1987) analyzed cancer mortality among workers at two capacitor manufacturing plants in New York and Massachusetts. At both plants, the Aroclor mixture being used changed twice, from 1254 to 1242 to 1016. The cohort included 2,588 workers (1,270 males and 1,318 females) employed at least 3 months in areas of the plants considered to have potential for heavy exposure to PCBs. At the end of follow-up in 1982, there were 295 deaths reported, 62 from cancer. Compared with

national rates, a statistically significant increase in death from cancer of the liver, gall bladder, and biliary tract was reported (5 observed, 1.9 expected, SMR=263, $p<0.05$). Four of these five occurred among females employed at the Massachusetts plant. Analyses by time since first employment or length of employment revealed no trend; however, the numbers are small.

- A cohort study by Sinks et al. (1992) analyzed cancer mortality among workers at a capacitor manufacturing plant in Indiana. A1242, then A1016, had been used. The cohort included 3,588 workers (2,742 white males and 846 white females) employed at least 1 day. At the end of follow-up in 1986, there were 192 deaths reported, 54 from cancer. Workers were classified into five exposure zones based on distance from the impregnation ovens. Compared with national rates, a statistically significant excess risk of death from skin cancer was reported (8 observed, 2.0 expected, SMR=410, CI=180-800); all were malignant melanomas. A proportional hazards analysis revealed no pattern of association with exposure zone; however, the numbers are small, looked for an association between occupational PCB exposure and cancer mortality. Because of small sample sizes, brief follow-up periods, and confounding exposures to other potential carcinogens, these studies are inconclusive.
- Accidental ingestion: Serious adverse health effects, including liver cancer and skin disorders, have been observed in humans who consumed rice oil contaminated with PCBs in the "Yusho" incident in Japan or the "Yu-Cheng" incident in Taiwan. These effects have been attributed, at least in part, to heating of the PCBs and rice oil, causing formation of chlorinated dibenzofurans, which have the same mode of action as some PCB congeners (Safe, 1994).

Since the IRIS assessment was finalized, there have been additional studies of worker exposures to PCBs published in the scientific literature, documenting the risks.

Some commenters noted that the change in designation by the International Agency for Research on Cancer (IARC) as a “known carcinogen” is justification for new calculations on risk, with some commenters stating that this should be considered “new information”. EPA is re-evaluating the non-cancer toxicity from exposure to PCBs. The toxicity values in the original HHRA have not changed and these values are listed in the IRIS chemical files available on the database. Upon completion of the reassessment, EPA will evaluate the impacts of the reassessment in a future FYR.

The Reassessment of PCB non-cancer toxicity is a multi-level evaluation involving a number of steps listed below including internal review and external peer-review. In addition, the toxicity of PCBs for non-cancer health effects includes thousands of studies that will be reviewed using Systematic Review by the IRIS program. As such, it is anticipated that the review process and development of the next toxicity value will take significant time to complete. The progress on developing this toxicity value will be evaluated in future FYRs (see figure 18-1 below).

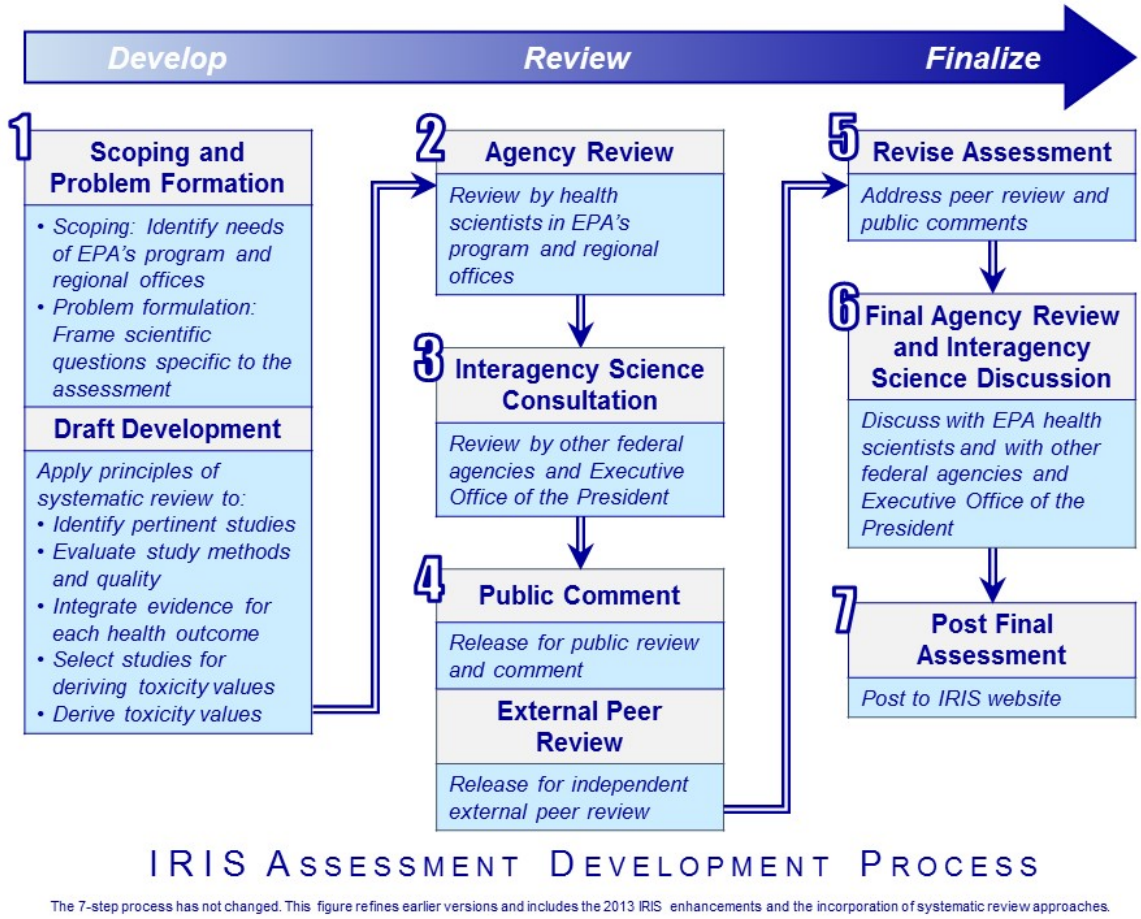


Figure 18-1 IRIS Assessment Development Process

There is no new toxicity information that would change the calculated cancer risks and non-cancer hazards. As such, updates to the calculated risks/hazards are not necessary. EPA will monitor the progress of the updates to the IRIS non-cancer toxicity assessment for PCBs.

The FYR guidance calls for updating the risk assessment if new information is available that will change the results of the human health risk assessment. The cancer risks and non-cancer hazards are representative of the exposures to the Reasonably Maximally Exposed (RME) individual. The information identified in the comment does not provide specific information and references to peer-reviewed studies necessary to evaluate if there are any changes in the exposure assumptions that would change the conclusions of the HHRA. As discussed in previous responses, EPA evaluated risks/hazards from exposure to Walleye as part of the HHRA.

The Superfund program relies on IRIS and the 2011 Exposure Factors Handbook and Superfund Standard Default Exposure Assumptions. IRIS provides the Agency's consensus toxicity database for use in assessing cancer risks and non-cancer toxicity. Another component of the risk assessment is the exposure assessment that evaluates the routes of exposure for various receptors (e.g., resident, recreator, outdoor worker, construction worker, etc.) and age groups. The combined information on exposure and toxicity are used to calculate risks. At the current time, IRIS is updating the non-cancer toxicity values for PCBs including evaluation of inhalation toxicity.

Based on the extensive number of studies on PCB toxicity in the scientific literature this review will include a number of scientists at EPA with expertise in this area. In addition, the draft document will go through internal Agency review, public comment, and external peer-review before the final document is available for application in HHRAs. The development of the exposure assessment for this FYR relied on information from EPA's 2011 Exposure Factors Handbook that is updated on an on-going basis, and the Superfund Standard Default Exposure Assumptions. Both documents were evaluated in responding to Question B to determine if any new information in the published scientific literature would require changes in the 2000 Hudson River Risk Assessment and its conclusions. This review did not identify any new information that would require updating of the HHRA.

3.3.8 Comment 19: EPA should qualify the 2016 spring and fall data properly according to the impacts expected by the dredging

Comment

The 2016 spring sport fish in the Upper Hudson (black bass, bullhead, perch) should be assessed as being impacted by the dredging work which ended in 2015, as the trend in fish PCB data indicates that the spring fish represent the previous years' conditions. The fall 2016 forage fish, however, should indicate the first year of post-dredging conditions, as they went through an entire growth season in 2016 without dredging impacts.

Response

The spring 2016 sport fish are the first fish collected after completion of the dredging activities. Nonetheless, EPA agrees that the spring sport fish obtained in 2016 likely included fish that were exposed to dredging impacts. Those collected in the fall are further removed from direct dredging activities, although in both cases it is not fully known to what degree the fish were exposed to dredging-related conditions prior to when they were caught. EPA agrees the fall 2016 pumpkinseed and forage fish, including young-of-the-year fish, represent the first sampling and analysis of fish that were not directly exposed to conditions during dredging (assuming those fish were born after dredging completed). However, both spring and fall 2016 data sets may have been influenced by dredging-related impacts. While the spring fish, which are largely adults, were present in the river during dredging, the young-of-the-year fish from the fall of 2016 could still have been exposed to dredging-related disturbances, such as transport of unconsolidated surface sediments that remained after dredging, or from sediment disturbances related to habitat replacement and reconstruction activities, which continued throughout 2016. EPA maintains that further monitoring of fish levels will be important to assess post-dredging recovery. This condition supports the need and importance of fish monitoring for the foreseeable future.

With limited fish, water, and sediment data post-dredging, it is unclear exactly what riverine conditions the 2016 data represent. EPA considers 2016 to be a transitional year within a re-equilibration period for the system, which was anticipated by the ROD. The comment serves to further emphasize the need for additional data before trends in recovery of water, sediment and fish can be further evaluated.

3.3.9 Comment 20: EPA should recalculate human health risks

Comment

Commenters state that the EPA should recalculate risks to specific populations -- specifically, populations in New York City, and communities along the Hudson River that may still face the same health threats as they did prior to dredging. Commenters indicate that EPA should determine if the changes in fish species availability for consumption, and changes in community population demographics, result in a significant change to the risk assessment inputs and results.

Commenters state that the EPA should recalculate the risks to human health based on the fact that two or more times more contamination than previously estimated was found in the Hudson River. Specifically, the EPA should consider the links between PCB exposure and impacts to the health of children, and whether the dredging project should be extended to remediate remaining PCBs. EPA should be conservative, not only in protecting the scientific knowledge base, but in protecting public health.

Response

The externally peer reviewed revised HHRA describes the risk assessment process and how it was applied to the Hudson River. The report is available at: https://www3.epa.gov/hudson/revisedhhra-text.pdf. The goal of the risk assessment is to determine the need to take action at the Superfund site. The FYR considered a broad range of data, including any changes in toxicity or exposure information that may impact the protectiveness determination.

EPA's response to Question B in the FYR evaluated whether existing data would change the overall outcome of the Revised HHRA. The data evaluated included peer-reviewed documents on exposure assessment and plans for updating the Integrated Risk Information System (IRIS) database, discussed below. As explained in the FYR report, updates to the exposure assumptions in the ROD do not change the conclusions of the HHRA or the protectiveness of the remedy. EPA is re-evaluating the non-cancer toxicity information for PCBs and any updates will be evaluated in the next FYR.

The following is additional information regarding EPA's approach to evaluating the toxicity of PCBs:

- EPA relies on IRIS as the primary source of toxicity information in the Superfund program to evaluate cancer risks and non-cancer toxicity. The IRIS program represents the Agency's consensus toxicity information database for over 500 chemicals.
- Currently, the IRIS program has non-cancer Reference Doses (RfDs) for Aroclors 1016 and 1254 (A1016 and A1254) and a cancer assessment, including a Weight of Evidence that total PCBs are a probable human carcinogen. Information on IRIS is available at www.epa.gov/iris.

- The response to Question B in the FYR discusses the ongoing reassessment of non-cancer toxicity for PCBs by toxicologists in EPA's IRIS program. The reassessment will evaluate thousands of studies on PCB toxicity using the systematic review process, which will evaluate a large number of published studies on the effects of PCBs. The report "Scoping and Problem Formulation for the Toxicological Review of Polychlorinated Biphenyls (PCBs): Effects Other Than Cancer" (EPA/635/R-14/198) provides a preliminary survey of the literature conducted in 2015. A preliminary list of broad health effect categories in which effects were observed and for which there may be enough data to further evaluate specific health endpoints includes: cardiovascular, dermal and ocular, developmental effects on growth and maturation, endocrine, gastrointestinal, hematological, hepatic, immunological, metabolic, neurological, and reproductive effects. As the reassessment moves forward this evaluation of the literature may be updated to incorporate newer studies

  This information from the systematic review will be used by the IRIS program to evaluate dose-responses for a number of diseases. Based on the evaluation, IRIS will determine if there is adequate information to update the current oral RfD or develop a new inhalation Reference Concentration (RfC).

The ongoing assessment process is discussed on the IRIS webpage (www.epa.gov/iris), including documentation of the March 2014 draft literature searches and associated search strategies, evidence tables, and exposure response arrays for PCBs as a means to obtain input from stakeholders and the public prior to developing the draft IRIS assessments for PCBs. The literature search strategy, which describes the processes for identifying scientific literature, contains the studies that EPA considered and selected to include in the evidence tables. The preliminary evidence tables and exposure-response arrays present the key study data in a standardized format. The evidence tables summarize the available critical scientific literature. The exposure-response figures provide a graphical representation of the responses at different levels of exposure for each study in the evidence table. EPA also held a meeting of scientific experts in the field of PCB toxicity on June 17-18, 2015 to discuss information on PCB toxicity (see https://www.epa.gov/iris/iris-public-meeting-jun-2015). As the process progresses, EPA will make information available on the webpage www.epa.gov/iris. The FYR, Question B, acknowledges these efforts by the IRIS process indicating that EPA will re-evaluate the non-cancer toxicity information as part of the reassessment for non-cancer that is anticipated to include updates to the oral RfD. It is premature to prejudge the outcome of the assessment and the study and health endpoints that will be selected. Any changes to the toxicity values will be evaluated in future FYRs based on the completion of the IRIS reassessment for non-cancer toxicity.

3.3.10 Comment 21: EPA should require GE to conduct an RI/FS of the Lower Hudson River

Comment

A number of commenters asserted that EPA should require GE to complete a RI/FS of the Lower Hudson River (LHR). The commenters cited the significant magnitude and long duration of GE's PCB releases as evidence that there is a significant need to investigate contamination to the Lower

Hudson. Commenters asserted that while other PCB sources do exist in the Lower Hudson, EPA has stated in public meetings that GE was the primary contributor. Commenters stated that the remedy has had little to no beneficial impact on the Lower Hudson to date. This is demonstrated by decay rates of PCB concentrations in fish tissue that are not statistically different from zero. Additionally, a number of government agencies have published findings that substantial PCB contamination remains within the river, necessitating study and remediation.

Commenters also indicated a study of the LHR must include a historical study, establishing the extent and elevation of the river throughout its course prior to and during the PCB dumping, as well as the evolution of the navigational channel within the Lower River. This historical study will reveal areas that are not currently part of the Hudson River and were not included in the initial risk assessment and monitoring, such as deposits behind dykes and above the current high tide line.

Other commenters expressed concern with waterways/access points to the River besides the main river channel. Specifically, individuals who own marinas in the LHR have to pay a large cost to dredge out their marinas due to contaminated sediment. Some commenters suggested that GE should pay for this type of cleanup. It was stated that these marinas in the LHR, which cannot dispose of contaminated dredge spoils economically, will be impacted for a much longer timeframe than indicated in the FYR report.

Response

As stated in the FYR report, data collected from the LHR indicate that the LHR is not recovering as quickly as the Upper Hudson River (UHR). This suggests that the declining PCB concentrations in the water of the UHR may have less of an impact downstream of the project area than anticipated. EPA agrees that much of the PCB contamination of sediments in the Lower Hudson originated from GE releases from the Upper Hudson. As part of the remedial investigation that led up to the OU2 ROD, EPA collected a series of high-resolution cores in both the Upper and Lower Hudson. The analysis of these cores demonstrated that at the time of the coring study (1992), Lower Hudson sediment PCB patterns and, therefore PCB inventory, could be attributed to Upper Hudson GE releases as far south as RM 50. Below RM 50 there were other notable sources of PCBs to the river. It should also be noted that there are other known ongoing and historic PCB releases from several PCB contaminated sites above RM 50 in the LHR. The furthest upstream source is near Albany. Understanding and resolution of all of these sources of PCBs creates challenges and uncertainty for fish recovery in the LHR. EPA has met with NYSDEC and discussed other sources the state is aware of. To better understand how PCBs in the UHR affect water, sediment and fish recovery in the LHR, more information/data will need to be collected. EPA has informed the public that it is important to collect additional data and conduct supplemental studies in order to better understand the PCB contamination in the LHR. The specific obligations of GE and any other parties with respect to the Lower Hudson will be defined as that process proceeds.

EPA expects that the supplemental studies of the LHR will start in 2019 and will take several years to complete. These studies will supplement information collected during EPA's investigation of the LHR in the 1990s, the routine monitoring of LHR fish and water by GE under EPA oversight since 2004, and the periodic monitoring of LHR fish by New York State. The supplement studies

will inform the need for a RI/FS. Such an RI/FS, if undertaken, would likely be extensive and complex and could take a number of years. It is too early in the process to determine if a cleanup is needed in the LHR. Based on the studies completed, EPA would decide whether remedial work is called for; such a decision would be made after an opportunity for public review and comment.

EPA will continue to work closely with NYSDEC, the Hudson River Natural Resources Trustees (NYSDEC, FWS, NOAA) and other stakeholders to determine what additional supplemental studies are necessary to further evaluate how the LHR and UHR are linked and how sediment contamination in the Lower River will affect water column, sediment and fish tissue PCB recovery over time. PCB loads from the Upper Hudson to the Lower Hudson are expected to continue to decrease and natural attenuation recovery will continue for the entire Hudson River system.

3.3.11 Comment 24: EPA should indicate the current state of testing and analysis of human health impacts for users of the river

Comment

Commenters state that the EPA should test people for the presence of PCBs who work, live, or play on or near the Hudson River. Testing should be conducted over a period of years (decades). All test results and associated reports should be made available to the public.

Response

The CERCLA (i.e. the Superfund law), does not provide authority for EPA to conduct human studies such as evaluation of blood PCB levels in populations. The Superfund law established the ATSDR which conducts such population studies at specific sites where ATSDR determines a need for such an analysis. ATSDR has not determined that population testing for PCBs is needed at the site.

Other federal Agencies such as the CDC also conduct ongoing research on blood PCBs levels across the U.S. population through the National Health and Nutrition Examination Survey (NHANES) (https://wwwn.cdc.gov/Nchs/Nhanes/2009-2010/PCBPOL_F.htm). State agencies may also conduct such studies, through grants from the National Institute of Environmental Health Sciences, EPA, or National Institute of Health.

EPA's evaluation of current and future risks supporting the decision to take action and the remedial goals for PCBs in fish were based on the peer-reviewed HHRAs, which are available at https://www3.epa.gov/hudson/reports.htm. EPA uses risk assessment as a tool to evaluate the likelihood and degree of chemical exposure and the possible adverse health effects associated with such exposure. The basic steps of the Superfund HHRA process are the following: 1) Data Collection and Analysis to determine the nature and extent of chemical contamination in environmental media, such as sediment, water, and fish; 2) Exposure Assessment, which is an identification of possible exposed populations and an estimation of human chemical intake through exposure routes such as ingestion, inhalation, or skin contact; 3) Toxicity Assessment, which is an evaluation of chemical toxicity including cancer and non-cancer health effects from exposure to

chemicals; and 4) Risk Characterization, which describes the likelihood and degree of chemical exposure at a site and the possible adverse health effects associated with such exposure.

A component of the HHRA is the evaluation of the toxicity of the chemical. EPA's Integrated Risk Information System (IRIS), a consensus database of toxicity information used to support decisions at Superfund sites, and across the Agency, provides information on both cancer and non-cancer toxicity information. A component of the assessment is studies in animals exposed under laboratory conditions to PCBs, including information on the blood PCB levels in the animal used in the studies (e.g., two year cancer bioassays in rats) for the cancer assessment and Rhesus monkeys for the non-cancer toxicity assessment. Both studies showed direct linkages between the blood PCB levels and health effects. The IRIS chemical files for PCBs (cancer assessment) and Aroclor 1016 (A1016) and Aroclor 1254 (A1254) are available at: https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=294, https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=462, and https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=389, respectively.

3.3.12 Comment 28: EPA will not reach the target levels as anticipated in the ROD

Comment

Several reviewers commented on the time for fish tissue concentration to reach anticipated levels specified in the ROD. The ROD states that the time to reach target PCB concentrations in fish was a primary factor in the comparison of remedial alternatives. Comments state that EPA predicted that the dredging remedy would result in rapid reductions in PCB levels in fish so that might allow for fish consumption restrictions to be relaxed in five to ten years, as opposed to many decades as is now predicted. Commenters also believe that the recovery rate of fish tissue is lower than the 8 percent presented in the FYR report. Given the recovery rates anticipated and derived from the data and the recent 2016 fish tissue data, several have commented that it will take several additional decades for ROD targets to be achieved.

Response

The first year of post-dredging data (2016) provides the baseline for the post-dredging monitoring period, and additional data and time are required after the remediation to assess when fish tissue concentrations will achieve the goals set in the ROD. The ROD anticipated at least a year of equilibration in the system in response to remedial activities. Another site, as discussed below, has taken several years to reach post-dredging equilibrium. It is expected that after the post-dredging equilibration period, the system will then follow natural recovery trends. An accurate determination of the time to reach specific ROD targets and goals requires information on the equilibrated PCB concentration following dredging. EPA therefore disagrees with commenters who used the 2016 PCB fish tissue as the post-dredging equilibration concentration and applied various recovery rates to determine the time frame to reach certain fish tissue targets.

Post-dredging equilibration over several years has also been observed in other remedial sites. For example, as described in Section 2.7 of Appendix 8 of the FYR report, at Cumberland Bay (Lake Champlain, New York), fish tissue PCB levels were observed to require several years to recover

in the wake of a removal action (NYSDEC 2012). At the Cumberland Bay (Wilcox Dock) Site, the Wilcox Dock remediation was implemented by NYSDEC in 1999 and 2000, and fish tissue concentrations for two species, including rock bass and yellow perch, indicated that several post-dredging years passed before concentrations began to stabilize. Following stabilization, fish tissue concentrations recovered at a rate of about 25 percent per year.[7] While there is limited pre-dredging data available for the Wilcox Dock Site, it is likely that the pre-dredging recovery rate must have been significantly lower than the estimated post-dredging recovery rate. Overall, these observations suggest that some time is required for remedial sites to undergo equilibration before it is reasonable to expect the ultimate post-dredging trend to decline towards remedial goals and target PCB levels.

The observed pre-dredge Hudson River MNA recovery rate in fish was approximately 8 percent per year. The post-remedial recovery rate is expected to incorporate a significant adjustment to the new post-dredge river conditions followed by the period of continued MNA. Although the recovery was forecast by the HUDTOX and FISHRAND models, there are few examples of remedial actions at the magnitude of the Hudson River project where sufficient time has passed since remediation to develop a robust understanding of how sediment contaminant concentrations recover after such an action. Because of uncertainty in the post-remedial recovery rate, it is difficult to make definitive predictions of the time to reach specific recovery goals. The remedy was designed and constructed with the expectation that both interim targets and ultimate risk-based goals would be reached over a period of time. The interim targets, in particular, provide useful milestones to help assess the actual rate of recovery relative to expectations. As the long-term monitoring data are amassed, the understanding of remedial effectiveness will be refined. With this refinement, EPA will be able to determine whether additional data collection and investigation are needed.

EPA recognizes that because individual fish species will respond to contaminant exposures in different ways depending on their foraging strategies and life histories, the ROD utilized a calculated "average" or "composite" fish to represent the variety of fish likely to be consumed by anglers. It is important to note that any individual fish (and any individual fish species more broadly) will achieve "target levels" at different times given a number of factors including: 1) variability in actual exposures; 2) highly localized exposures; 3) the importance of sediment *vs.* water exposure pathways, which can vary over time due to prey availability; 4) uncertainty and variability in lipid content of fish and prey items; 5) uncertainty and variability in consumption of specific prey items and PCB concentrations in those prey; and 6) measurement uncertainty (including allowing for differences in sampling programs and analytical methods).

It is important to note that the Hudson River is a large, diverse and dynamic natural system and it is unrealistic to expect that an average, species-weighted concentration (measured in mg/kg wet weight) will be achieved consistently within a precise time-frame. The variability inherent in large, dynamic systems such as the Hudson River may well lead to a situation in which an average concentration (based on data) for any specific species and sampling location might achieve a target

[7] From Figures A8-5.1 and A8-5.2in Appendix 8 of the FYR report, fish PCB concentrations in Cumberland Bay declined from 4-5 mg/kg in 2005 to about 1 mg/kg in 2009, corresponding to an average rate of decline of about 25 percent per year.

threshold in a given year, but again rise just above it the following year due to any one of the processes listed above, particularly when averaging across species and sampling locations.

Based on 2016 fish tissue monitoring data (presented in Figure A3-19 in Appendix 3 of the FYR report), fish tissue concentrations for individual species range from 0.4 to 1.7 mg/kg depending on the species and location. Even though the system has not equilibrated, yellow perch, for example, has already achieved the 0.4 mg/kg interim target at several locations. The Upper Hudson species-river section-weighted average based on 2016 data is about 1 mg/kg, this value is comparable to the model results from the first year post dredging (2010) , as shown in Figure A3-19 of Appendix 3 to the FYR report.

The HUDTOX and FISHRAND models were calibrated, verified and applied to the Upper Hudson River, and designed to support decision-making by allowing direct comparisons of predicted water, sediment, and fish tissue concentrations across proposed remedial alternatives. The strength of the models lies in their ability to compare predicted concentration trajectories in sediment, water, and fish over time based on a consistent set of assumptions. Absolute model predictions are likely to differ from actual observations due to the same six factors noted above. In addition, differences in environmental conditions (*e.g.*, flow rates, upstream boundary conditions, *etc.*) also contribute to potential differences between predicted versus modeled tissue concentrations, particularly given that the models were primarily designed to predict relative tissue concentrations across remedial alternatives rather than absolute concentrations over time. Nonetheless, model-data comparisons, as presented in Appendix 3 of the FYR report for the pre-dredging MNA period, show that the model performed well, and continues to perform well based on 2016 data (Figure A3-19). The pre-dredge data comparisons in this FYR were not intended to be a predictor of future recovery trends as some commenters indicated. Those analyses simply indicate that the modeling tools used for EPA decision-making performed well, thereby supporting decisions made in the ROD.

In conclusion, the Upper Hudson River system underwent a "reset" with dredging, which established a new baseline from which post-dredging MNA trends must be evaluated. Accordingly, evaluating data-based trends into the future starting with this new baseline will require additional data over multiple annual cycles to provide statistically meaningful estimates of progress toward meeting the interim targets and remedial goals. EPA estimates that as many as eight or more years of fish data will be needed to confidently determine recovery trends.

3.3.13 Comment 29: EPA's analysis of fish data is flawed

Comment

A commenter indicated that EPA compares observations of fish tissue concentrations using median values against the fish tissue concentration goals listed in the ROD, which are based on average concentrations. Additionally, EPA compares average individual fish PCB concentrations against the remedial goals although achievement of the goals will be evaluated based on species-composite averages across river sections and the entire Upper Hudson. Such comparisons to individual species at individual locations are not particularly meaningful when comparing to the metrics EPA chose in the ROD. EPA should compare fish data using the same consistent basis of measurement

(*i.e.,* average to average). However, comparisons at specific locations are very important in understanding trends in site media over time, and the commenter encouraged EPA to gather fish, sediment, and water data on a pool-by-pool basis rather than river section basis.

Response

EPA agrees that clarity is needed when comparing various metrics concerning PCB contamination. In Section 5.1.1.3 and Appendix 3 of the FYR report, EPA compares median PCB concentrations observed in 2016 fish with the interim target levels for fish tissue. EPA agrees that it is the average value that ultimately determines achievement of an interim target or a remedial goal. Nonetheless, the observation that a median value has fallen below a target or goal indicates that an important milestone has been reached. Specifically, this indicates that more than half the fish caught showed tissue concentrations less than the target or goal.

EPA does not agree that comparisons of individual species to the target levels or remedial goals are meaningless. Since the species composite consists of a weighted average of individual species, it is important to identify which species may be contributing to an exceedance of a goal or target, if that is observed. EPA recognizes that a species composite target or goal can only be met when individual species begin to meet that level.

EPA agrees that data collected on a pool-by-pool basis is useful in interpreting the recovery of the system. For this purpose, EPA has analyzed data collected at the pool-by pool (i.e., reach) scale and will continue to do so. EPA recognizes that there is limited fish data from Reaches 1 through 4 (*i.e.,* the lower half of RS 3) and that additional fish collection from these reaches is necessary. The 2019 fish sampling program will include fish collected from each of these reaches. Note that while EPA will continue to evaluate the data on a reach basis, the success of the remedy is assessed primarily on a river section basis.

3.3.14 Comment 30: EPA's analysis of water PCB trends must consider changes in both loading conditions and comparisons of monitoring data to model predictions when developing and interpreting trends

Comment

Commenters stated that the GE facility source control assumption reflected in the upstream boundary condition for EPA's model (HUDTOX) MNA forecasts (*i.e.,* PCBs containing three or more chlorines [Tri+ PCBs] decreasing from 0.16 kg/day to 0.0256 kg/day starting in 2005) is a significant factor resulting in high model-based decay rates presented in Table A1-7 of Appendix 1 of the FYR report, as opposed to natural recovery processes unrelated to source control.

Additionally, commenters stated that EPA did not account for the effects of the Allen Mill gate structure and bedrock seeps of PCB oil prior to GE's completion of upstream source control measures when interpreting data-based estimates of water column PCB declines presented in the FYR report. Commenters also suggested that major changes in water column PCB sampling locations and methods were not accounted for and that these changes make determination of temporal changes in water column PCBs unreliable. Citing these reasons, the commenters

recommended that the post-source control period from 2005 to 2008 be used as a baseline when calculating both data and model (HUDTOX)-based MNA decay rates for water column PCB concentrations.

Another commenter suggested that the Farley model's under-prediction of Lower Hudson River water column PCB concentrations during the pre-dredging period was a result of the Farley model only being calibrated to sediment and fish data. The commenter suggested that an increase in observed Tri+ PCB concentrations between Albany and Poughkeepsie that is not reflected in TPCB water column data indicates the presence of a local PCB source, but that 2016 PCB concentrations at Poughkeepsie were lower than Baseline Monitoring Program (BMP) observations and, therefore, still show a response to dredging.

Response

EPA does not concur with commenters' suggestions that 2005 to 2008 is an appropriate time frame over which to characterize water column PCB decay rates under MNA from data or from HUDTOX simulations, because variability in annual flows dominates the temporal decline in water column PCB decline over such a short period. This flow dominance produces trend estimates that are highly uncertain and have no applicability to longer periods that are relevant to assessing MNA performance as an aspect of the remedy.

The assumed trend in upstream boundary loads in the ROD MNA forecast simulations reflected control of the Hudson Falls and Fort Edward GE plant sites as external sources to the river. To better understand the influence of upstream source controls on MNA simulations, EPA has conducted an alternate diagnostic HUDTOX MNA forecast using the lower of the two-constant upstream boundary PCB loads assumed in the ROD (0.0256 kg/day), and starting this load in 2000 instead of 2005. This alternate diagnostic forecast controls for variability in the upstream boundary loads and also negates the potential influence of the data-based 1997-1999 upstream boundary conditions as well as the 1991 Allen Mill gate failure.

Table A1-7 of Appendix 1 of the FYR report presented simulated decay rates, 1995 to 2008, in the ROD MNA forecast and the updated MNA forecast incorporating actual flows. Table A1-7 is reproduced below, and Table A1-7a presents the alternative simulations that assume a constant upstream boundary load starting in 2000, and computing decay rates for the period 2000 to 2008.

Table A1-7 (as presented in Appendix 1 of the FYR report): Average Annual Water Column Tri+ PCB ROD and Updated MNA Forecasts for 1998-2008. Augmented by Pre-MNA Calibration Results for 1995-1998

	Year	ROD MNA (step-down upstream PCB load)				MNA Update (step-down upstream PCB load)			
		TI Dam	Schuyler-ville	Stillwater	Waterford	TI Dam	Schuyler-ville	Stillwater	Waterford
PRE-ROD	1995	55.8	63.1	50.4	42.7	55.8	63.1	50.4	42.7
	1996	30.2	38.3	37.0	34.3	30.2	38.3	37.0	34.3
	1997	29.0	35.9	36.6	34.7	29.0	35.9	36.6	34.7
MNA FORECAST	1998	38.3	44.2	38.7	35.8	38.2	43.6	41.4	39.4
	1999	32.7	38.4	34.2	29.8	34.0	39.2	40.0	35.0
	2000	24.7	29.0	26.5	25.0	24.8	29.6	28.0	25.7
	2001	25.1	30.4	26.6	24.6	32.8	35.8	33.1	29.9
	2002	27.6	30.3	23.7	21.1	27.8	30.5	28.0	24.7
	2003	26.6	28.8	23.0	19.9	23.0	26.0	23.6	21.4
	2004	29.3	31.0	23.7	19.7	20.9	23.1	21.0	18.7
	2005	13.5	17.0	15.5	14.6	12.0	15.5	16.0	15.6
	2006	11.6	14.9	13.5	12.4	8.8	12.2	13.0	12.5
	2007	12.1	15.3	13.2	12.1	13.0	15.2	14.7	13.1
	2008	13.8	15.9	12.3	10.4	10.0	12.0	15.7	12.9
1995 - 2008	Decay Rate	9.7%	9.6%	10.4%	10.6%	11.7%	11.4%	9.9%	10.0%

Table A1-7a Average Annual Water Column Tri+ PCB ROD and Updated MNA Forecasts for 1998-2008. Augmented by Pre-MNA Calibration Results for 1995-1998, Assuming Constant Upstream Boundary PCB Loadings, 2000-2008

	Year	ROD MNA (constant upstream PCB load)				MNA Update (constant upstream PCB load)			
		TI Dam	Schuyler-ville	Stillwater	Waterford	TI Dam	Schuyler-ville	Stillwater	Waterford
PRE-ROD	1995	55.8	63.1	50.4	42.7	55.8	63.1	50.4	42.7
	1996	30.2	38.3	37.0	34.3	30.2	38.3	37.0	34.3
	1997	29.0	35.9	36.6	34.7	29.0	35.9	36.6	34.7
MNA FORECAST	1998	38.3	44.2	38.7	35.8	38.2	43.6	41.4	39.4
	1999	32.7	38.4	34.2	29.8	34.0	39.2	40.0	35.0
	2000	15.4	20.8	21.6	21.8	15.6	21.5	22.8	22.3
	2001	16.0	22.4	21.6	21.3	19.3	24.3	25.4	24.7
	2002	16.3	20.5	18.0	17.2	16.0	20.1	20.9	20.0
	2003	14.9	18.6	16.7	15.6	13.2	17.2	17.4	17.0
	2004	16.4	19.7	16.7	15.0	11.4	14.5	14.8	14.1
	2005	13.1	16.3	14.2	13.2	11.7	15.0	14.9	14.3
	2006	11.3	14.4	12.6	11.4	8.6	11.7	12.3	11.6
	2007	11.8	14.8	12.4	11.1	12.7	14.7	13.9	12.3
	2008	13.5	15.4	11.6	9.6	9.8	11.6	15.2	12.3
2000 - 2008	Decay Rate	3.8%	5.5%	8.4%	10.3%	7.5%	8.7%	7.7%	9.5%

The right panel of Table A1-7a presents the alternative MNA Update forecast, holding upstream loadings constant starting in 2000, and computing decay rates starting in that year. The decay rates from this alternate HUDTOX MNA forecast ranged from 7.5 percent to 9.5 percent per year and are lower at each station than the corresponding rates presented in Table A1-7, but are generally consistent with the MNA-based rates of water column PCB decline reported. Note that these rates of decline apply to the 2000 to 2008 period and are expected to become smaller over time, as PCB attenuation in the Upper Hudson River becomes increasingly controlled by upstream and other sources rather than by PCB mass transfer from the sediment bed.

The HUDTOX-simulated 1995 to 2008 water column PCB trends presented in Table A1-7 are representative of actual observed conditions over that period. EPA does not assert that post-remedy attenuation rates will match those trends, only that continued declines are anticipated. Post-remedy MNA trends can, and will, be addressed through the OM&M program that is an integral part of the ongoing MNA component of the remedy.

Table A1-7a also shows an alternative version of the ROD MNA forecast, which used synthetic future flows assumed at the time of the ROD, and holding upstream loads constant starting in 2000. As with the alternative MNA update, the assumption of constant loads and the shift to the 2000 to 2008 timeframe reduces the estimated recovery rates, in this case to a range of 3.8 percent to 10.3 percent for the four stations.

With respect to FISHRAND predicted trends, some portion of the 1995 to 2008 predicted recovery simulated by that model would similarly be due to source control assumptions because the HUDTOX simulations provided exposures for FISHRAND in the Upper Hudson River and PCB loads for the Lower Hudson River.

Using data only from Rogers Island, a commenter concluded that the impact of the Allen Mill gate failure continued well past 1995 (for Waterford and Stillwater) and 1997 (for Thompson Island Dam [TID] and Schuylerville), rendering them inappropriate starting years for MNA trend analysis. In order to assess the impact of the Allen Mill Gate failure on PCB loads to the Upper Hudson River, EPA reviewed Tri+ PCB concentration data and estimated loads at Fort Edward/Rogers Island and Thompson Island Pool (TIP) between the period of 1991 (when the gate failure occurred) and 2008 (the last year of the BMP). Figure 30-1 (below) plots the Tri+ PCB concentration (ng/L) for samples collected at Fort Edward/Rogers Island and TIP between 1991 and 2008. Figure 30-1 indicates that for the years 1991-1992, during and immediately after the Allen Mill gate failure, concentrations were the highest at both stations and the stations exhibited similar concentrations. By 1993, peak summertime concentrations at both stations had decreased by a factor of almost 10 and concentrations at Fort Edward/Rogers Island had typically fallen below concentrations at TIP. By the beginning of 1996, concentrations at Fort Edward/Rogers Island were almost a factor of 10 lower than in TIP, and concentrations at Fort Edward/Rogers Island remained consistently lower than TIP throughout the year. Note also that beginning in 1996 the number of samples collected at Fort Edward/Rogers Island that were below the analytical detection limit began to increase, while the vast majority of samples collected at TIP were still above the detection limit. Between 1996 and 2003 (the last year of pre-BMP data), concentrations at Fort Edward/Rogers Island were consistently lower than in TIP throughout the year and were dominated by non-detect results. Starting in 2004, samples at both stations were collected as part of the BMP. The analytical method used to quantify PCB data during the BMP included a lower detection limit, such that all samples contained detectable concentrations of PCBs. The comparison of Tri+ PCB concentrations and the number of non-detect samples at the two stations indicates that beginning in 1996, concentrations at TIP were driven more by localized sources of PCBs (*e.g.*, release of PCBs from sediments and PCB-contaminated in-river debris) than by upstream sources such as the Allen Mill gate failure.

Figure 30-2 (below) plots the monthly average Tri+ PCB load (kg/month) at Fort Edward/Rogers Island and TID between 1991 and 2008. The monthly Tri+ PCB load at each site was calculated

by averaging the measured Tri+ PCB concentration by month including only days where measurements occurred at both stations and multiplying the average daily concentration by the number of days in the month. As with the concentration plots, the highest loads occurred between 1991 and 1992. However, the load calculations indicate that by 1993 to 1994 the loads at both stations had substantially declined, and that by 1995 to 1996 the loads at TIP were substantially higher than Fort Edward/Rogers Island. As the loads at TIP were substantially greater than at Fort Edward/Rogers Island by approximately 1996, this provides further evidence that upstream sources of PCB load (including PCB releases from the Allen Mill gate failure) no longer contributed a substantial loading of PCBs into the upstream boundary of the Site (*i.e.*, Ft. Edward/Rogers Island), and that loads measured at TIP could largely be attributed to localized sources present between Fort Edward/Rogers Island and TIP. Thus, declines in water column PCB loads beginning in 1996 can be largely attributed to natural attenuation/natural recovery of the Site, as opposed to reduction in upstream inputs of PCBs. In conclusion, it is EPA's position that starting the MNA period in 1996 is justified and appropriate.

With respect to water column monitoring, EPA recognized that changes in the location and method of sample collection between various datasets could impact the ability to analyze long-term changes in water column PCB concentrations. Therefore, pilot studies were initiated at TID and Schuylerville that involved concurrent sample collection at both the pre-BMP (*i.e.*, Post-Construction Remnant Deposit Monitoring Plan (PCRDMP) monitoring program) and BMP stations to assess whether the change in station location and method of collection produced a bias in PCB water column concentration. At the Schuylerville station, concurrent samples were collected between June 2004 and May of 2006. At TID, concurrent samples were collected between June 2004 and August 2008. These studies were summarized in documents reviewed by EPA prior to allowing the station location and method collection to be altered (Corrective Action Memo (CAM) 6 (GE 2006) and CAM 14 (GE 2008)). Results of these pilot studies indicated that alteration of the sample collection location and/or method of collection at the long-term monitoring stations did not produce a significant bias in the water column PCB concentration. As such, it is EPA's position that it is appropriate to use multiple datasets to calculate long-term trends in water column PCB concentrations at these stations. Unlike the Thompson Island Dam and Schuylerville monitoring stations, the Stillwater and Waterford monitoring stations were not monitored during the PCRDMP monitoring program. The trend analysis included in Appendix 1 of the FYR report did not include data at the Stillwater monitoring station between 1998 and 2004 (the beginning of the BMP) and between 2001 and 2004 for the Waterford monitoring station. Prior to 2001 (for Waterford) and 1998 (for Stillwater), USGS-collected water column PCB data were used. While a comprehensive comparison of datasets could not be carried out for the Stillwater and Waterford monitoring stations, sample collection methodology used by the USGS was similar to methods used during the PCRDMP monitoring program at TID and Schuylerville. Further, sample collection at all four sites during the BMP period was based on a common approach (*i.e.*, all used a multiple aliquot depth integrated sampler (MADIS)). Thus, results from TID and Schuylerville provide evidence that sampling differences between the USGS and BMP datasets do not produce a significant bias in reported water column PCB concentrations.

EPA recognizes that the analytical methods used by the USGS differed from the methods used during the BMP period, including the USGS method having a higher detection limit (11 ng/L). However, of the 61 USGS samples included in the trend analysis at Stillwater station from 1995

through 1997, only 8 samples were identified as non-detect for Tri+ PCBs, and the PCB concentrations for these samples were set at 5 ng/L, approximately one-half the detection limit of the method. Similarly, only 8 out of 68 USGS samples collected at Waterford station from 1995 through 1997 were identified as non-detect for Tri+ PCBs, and these samples were also assigned a concentration of 5 ng/L. Beginning in 1999, USGS updated their method for measuring PCBs. However, issues related to the new USGS method produced PCB concentrations that were biased high between 1999 and 2000. By 2001, the issues related to the updated methodology were resolved and USGS data from 2001 were included in the trend analysis at the Waterford station. The updated USGS methodology had a lower detection limit than the previous method and was able to detect concentrations below 11 ng/L. In conclusion, while EPA recognizes that sampling and analytical methods did change during the time period used in the trend analysis at the four long-term monitoring stations, these differences were deemed not to cause significant bias in the water column PCB concentration so that it is appropriate to combine datasets.

EPA acknowledges that concentrations shown in FYR report Appendix 1 Figure A1-3b show generally higher concentrations at Poughkeepsie than at Albany. Data reviewed for the FYR did not reveal an explanation for the difference in concentrations between these two locations. EPA does not agree that the decline in concentrations at Poughkeepsie between the BMP and 2016 necessarily shows a response to dredging. The decline over this time period could reflect an ongoing decay in concentrations due to processes in the Lower Hudson River, a response to dredging, or a combination. In particular, the absence of increases in water column concentrations at Poughkeepsie as a response to dredging suggests that the lower concentrations in 2016 do not reflect a response to the decrease in water column loads from the Upper Hudson at the end of the dredging period. EPA will continue to carefully evaluate data collected from the Lower River including from Poughkeepsie and Albany as part of future supplemental studies.

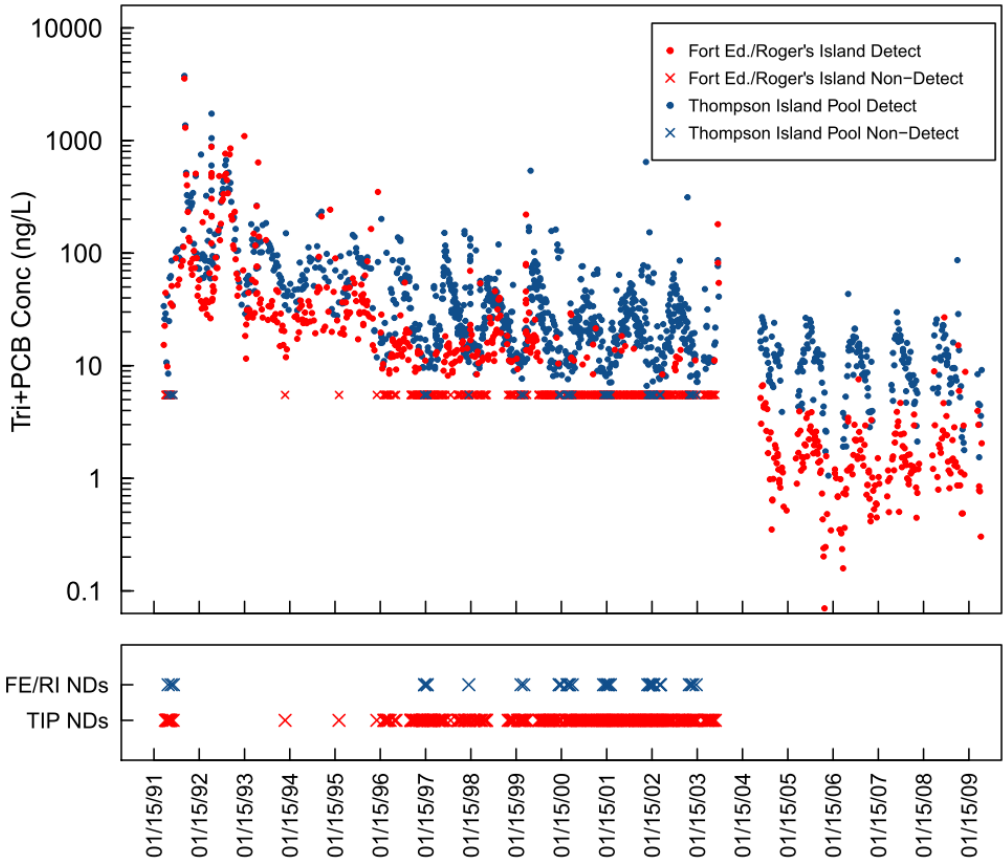


Figure 30-1 Measured concentrations at Ft. Edward/Rogers Island and Thompson Island Dam (TID) between 1991 and 2008. Top panel shows samples with and without Tri+ PCB detections. Non-detect samples are assigned a concentration of 5.5 ng/L, which is one-half the detection limit. Bottom panel indicates when non-detect samples were collected. Note the Allen Mill gate failure occurred in 1991 to 1992 and the Baseline Monitoring Program (BMP) began in 2004.

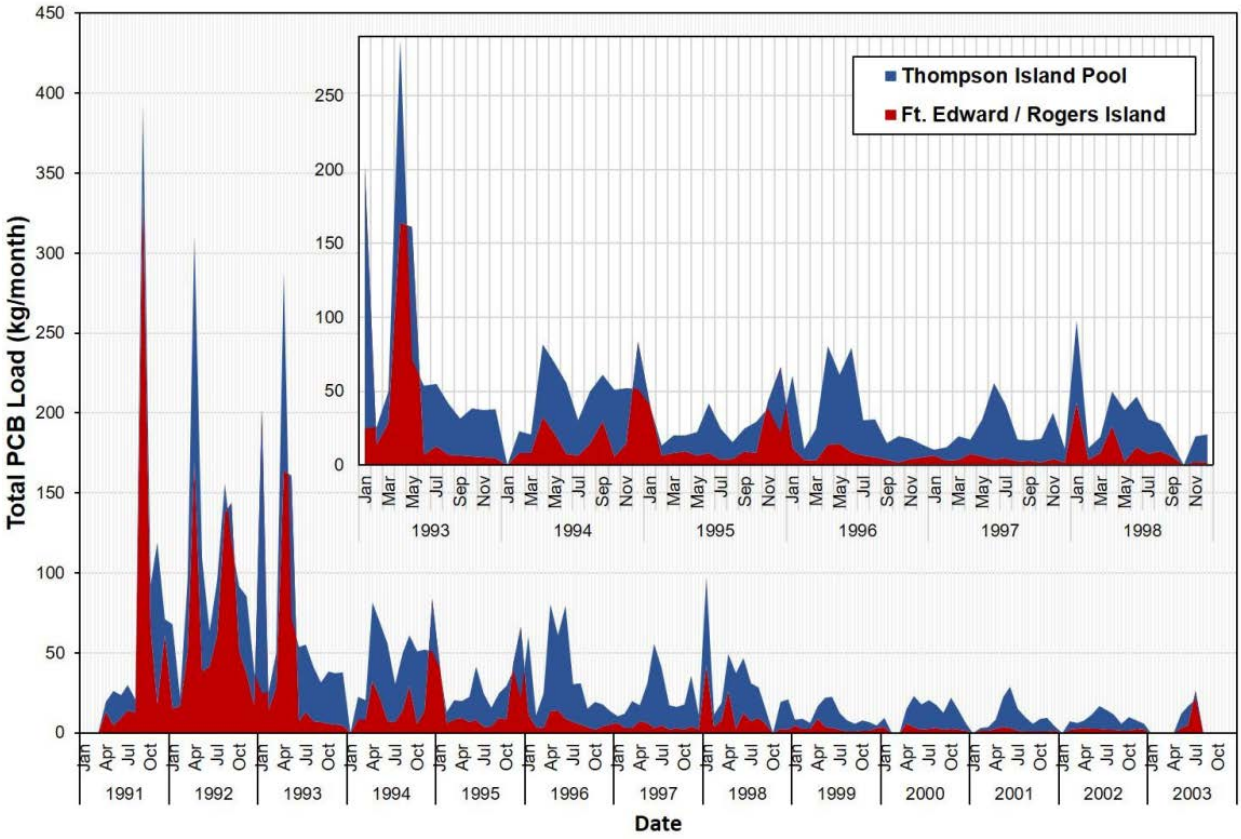


Figure 30-2 Monthly average Tri+ PCB load at Ft. Edward/Rogers Island and Thompson Island Dam (TID) between 1991 and 2008. Note the Allen Mill gate failure occurred in 1991 to 1992 and the Baseline Monitoring Program (BMP) began in 2004.

3.3.15 Comment 35: Incorporate Hudson River Reference Material in future fish analyses

Comment

Commenters requested the incorporation of Hudson River Reference Material in future fish analyses.

Response

EPA agrees that some form of performance evaluation (PE) material should be incorporated into future fish analyses under OM&M. Currently, EPA is evaluating the use of multiple potential materials, including National Institutes of Standards and Technology (NIST) Standard Reference Material (SRM) 1946 (Lake Superior Lake Trout) and NIST SRM 1947 (Lake Michigan Lake Trout). EPA understands that NYSDEC has used SRM 1947 along with Hudson River Reference Material for QA in its fish analyses. EPA is currently discussing with GE the future use of PE and reference materials as part of laboratory QA approaches for both fish tissue (NIST SRMs 1946 and 1947) and sediment (*e.g.*, NIST SRM 1944) samples.

3.3.16 Comment 36: Increase the use of congener PCB analysis and decrease use of Aroclor analysis

Comment

Underestimation of Total and Tri+ PCBs in sediment based on EPA Method 8082 (M8082) relative to recent EPA Method 1668 (M1668) split-sample analysis is not addressed in the FYR report. The 2016 split-sample analysis for sediment suggests that both the Aroclor and modified Green Bay Method (mGBM) PCB analyses may significantly underestimate the Total PCB concentration as compared to full congener analysis (M1668).

The analytical method for measuring the PCBs in the samples is outdated and must be updated. The 2016 Sediment Work Plan indicates that PCBs will be measured via M8082 (modified via the Green Bay procedure) and EPA indicates that 4% of the samples will also use M1668 to measure PCBs. Given the greater accuracy of M1668, the justification for relying on the older and less accurate M8082 is unclear. As EPA moves away from using M8082, and adopts M1668, there will be a problem unless a much larger percentage of samples use both methods to establish a rigorous conversion basis. For these reasons, EPA should increase the number of samples analyzed by both methods in every reach of the river. This will ensure enough data are available for substantive and statistically significant comparisons between the methods to facilitate accurate conversion before EPA switches to only M1668 for OM&M sediment samples in the future. A commenter questioned whether the exposure assumptions, toxicity, data, cleanup levels, and remedial actions objectives used at the time of the remedy selection are still valid, stating that the variability of testing methods has tainted the results to date.

Response

EPA agrees with the comment concerning the importance of comparability between the two analytical methods. It is EPA's intention to establish a representative, precise and accurate estimate of PCB concentrations in the sediments, water and fish as part of the baseline monitoring program. Each of these attributes is addressed by different aspects of the OM&M program. However, the issue raised in this comment concerns accuracy most directly. That is, how can EPA be sure that the concentrations for sediments obtained in 2016 and 2017 are accurate while using M8082, an Aroclor-based method which approximates the Total PCB concentration as the sum of the reported Aroclors? Accuracy is particularly important for long-term monitoring. Analytical variation through time (essentially a "drift" in the report values) must be minimized so that changes observed in reported average concentrations over time can be attributed to real changes in the river over time, and not to variations in the analytical methods. Maintaining accuracy helps to reduce the uncertainty in the long-term monitoring data.

To this end, EPA began an initial program in 2016 to compare M8082 results with those obtained by M1668. The 2016 program consisted of the analysis of a limited number of samples by both methods. However, due to the sequencing of sample splits during collection, as well as differences in the processing of the samples at the respective laboratories, resolution of the differences between M8082 and M1668 results is challenging since the data are confounded by these additional technical considerations. While it is expected that M1668 is more precise given its direct

quantitation of individual PCB congeners, this does not mean that the M8082 results are inaccurate. Historically, EPA has recognized differences between M8082 and other analytical methods and addressed these differences by means of an adjustment factor to reconcile the differences (*e.g.,* EPA 1997; Butcher *et al* 1998; EPA 2017). In some instances, the M8082 results fall below the second method results, whereas in other instances, the M8082 results exceed the second method results. Recently, EPA has also evaluated sediment data matched pairs of M8082 and M1668 analyses collected by NYSDEC in 2017 to better determine the relationship between results associated with two methods.

As a result of this concern, and in recognition of the need to maintain both accuracy and precision throughout the OM&M program, EPA has undertaken a more rigorous approach in 2017 to compare the two methods. Specifically, EPA has required GE to standardize its collection and processing of surface sediment samples in a more rigorous fashion, based on the lessons learned from 2016. The sample processing steps used by GE to produce samples for both M8082 and M1668 analysis have been revised to use standard techniques for removal of larger particles (*i.e.,* sieving), as well as to incorporate standardized procedures for sample homogenization. In this manner, differences in the absolute values obtained by the two methods can be reconciled with a known and acceptable level of uncertainty. That is, this approach will quantify the precision between the two methods.

In addition, EPA is also requiring the use of reference materials by both the GE and EPA labs. These standards will include both NIST and other reference materials that are designed for long-term stability, so that future sampling programs will also be referenced to the same known standards. In this manner, the EPA's approach will establish accuracy for the 2016-2017 program while also tying future sediment monitoring to the same reference values. Finally, based on the findings of the methods study using 2016 and 2017 samples as well as the results of the NYSDEC work described below, EPA will identify a frequency of analysis by M1668 for future sampling programs to confirm and maintain comparability over time.

As discussed briefly above, EPA has also evaluated the recently available 2017 NYSDEC sediment dataset of matched pairs of M8082 and M1668 analyses. The 2017 NYSDEC dataset contains 117 matched pair samples, obtained as part of NYSDEC's 2017 Upper Hudson surface sediment investigation. The analysis of these matched pair samples found that both Total PCB and Tri+ PCB concentrations derived from M1668 measurements were higher than those obtained by M8082. Based on the analyses, Total PCB by M1668 was approximately 55 percent higher than the sum of Aroclors based on M8082. Similarly, Tri+ PCBs by M1668 was approximately 44 percent higher than those predicted from Aroclor data (M8082) using GE's equation [Tri+ = 0.13*A1221 +0.89*(A1242+A1254)]. These differences between M8082 and M1668 are not as large as those suggested by the GE 2016 samples, which may be the result of consistent split sample preparation between the two methods. EPA will continue to evaluate the difference between two methods once more data are available.

The exposure assumptions, toxicity, data, cleanup levels, and remedial actions objectives used at the time of the remedy selection were based on Aroclor data from M8082. If M1668 had been used in the time of the remedy selection, it is likely that the cleanup levels would have been adjusted as appropriate. Thus, the continuous use of M8082 for the analysis of fish, water and sediment is

required to maintain long tern internal consistency and compatibility with the remedial objectives. For environmental media (fish, water and sediment), EPA developed and applied its own congener-based dual column Gas Chromatography/ Electron Capture Detection (GC/ECD) method throughout the RI/FS process to provide accurate estimates of PCB levels, which was used in conjunction with M8082, providing some of the best data available anywhere at the time. PCB analytical methods have continued to evolve, and EPA is applying them as appropriate. Notably, the EPA and the NYSDEC relied and continue to rely on M8082 for fish characterization, although confirmation via more sophisticated methods is also being developed.

It is important to note that EPA has not simply relied on the various methods themselves to provide accurate and precise results. Throughout the remedial design sampling (SSAP), GE was required to run performance evaluation (PE) samples (essentially laboratory-certified samples of known concentration) to demonstrate accuracy in their analyses. Similarly, EPA required PE samples be included in the post-dredging residual sampling program conducted by GE. Thus, while there remain analytical accuracy and precision challenges to be considered for the 2016 data and for subsequent OM&M monitoring, EPA has required GE to monitor the accuracy of its results throughout the remedial design and remediation periods. In this regard, EPA is confident it has based its decisions on reliable data throughout the study and remediation of the Upper Hudson River.

3.3.17 Comment 40: The larger-than-expected mass of PCBs and higher surface sediment PCB concentrations remaining in the sediment following remediation will extend the recovery of the river

Comment

Commenters stated that actual PCB sediment concentrations should be the primary measure of remedy success as defined by the ROD rather than decay rates or percent reduction. The commenters assert that the success of the remedy does not depend on the percentage or amount of PCBs removed, but the magnitude and spatial extent of PCBs left behind, which greatly exceeded expectations in the 2002 ROD, and that the FYR incorrectly emphasizes the percent reduction in PCB mass in the river. Using actual values of the residual PCB concentrations rather than percentages, commenters state that the remedy as implemented does not conform to the 2002 ROD expectations or meet remediation goals judged necessary to achieve protection of human health and the environment in RS 2 and RS 3.

Commenters also stated that EPA compared PCB residual concentrations with the “less stringent interim expectations” described in the 2012 FYR without any justification of why this is correct. Furthermore, commenters indicate that there are insufficient post-remedial data available to evaluate if the remedy is functioning as intended by the decision documents, and that the FYR should acknowledge that the highly contaminated areas adjacent to the dredged areas identified during remedial design as part of the SSAP have not been re-sampled sufficiently to determine post-dredging PCB concentrations, percent reduction, or decay rates.

Response

EPA acknowledges that the pre-design SSAP sediment samples collected from 2002 to 2005 contained PCBs at concentrations that were higher than ROD-based modeled concentrations. The practical significance of this apparent difference was carefully and extensively considered by EPA. It was determined that the change in fish tissue concentrations could be predicted without re-calibrating the model to account for the higher sediment concentrations identified in the SSAP. This is because the change in fish tissue concentrations is known to be proportional to the change in sediment concentrations irrespective of the absolute sediment concentrations prior to implementation of the remedy.

The remedy was developed by considering the proportional change in fish tissue PCB concentrations that was required to meet risk-based thresholds over a period of time. Even if the actual surface sediment PCB concentrations are different from those that were expected at the time of the ROD, reducing the absolute PCB surface sediment concentrations by the same percentage as anticipated by the ROD is expected to achieve the same percentage reduction of fish PCB concentrations projected in the ROD. This analysis is explained below.

The physical premise underlying sediment to fish accumulation is that fish tissue PCBs are approximately proportional to sediment concentrations to which water and prey items are exposed. This is expressed mathematically as:

$$PCB_{fish} = k \times PCB_{sed}$$

where, *k* is defined as the fish to sediment accumulation factor, which is a relative constant value for a specific species from a specific portion of the site that have similar ecological and chemical conditions (Burkhard, 2009).

With this assumption of proportionality, the ratio of post-dredging to pre-dredging fish tissue PCB concentration can be related to sediment concentrations as follows:

$$\frac{PCB_{fish-post}}{PCB_{fish-pre}} = \frac{k \times PCB_{sed-post}}{k \times PCB_{sed-pre}} = \frac{PCB_{sed-post}}{PCB_{sed-pre}}$$

This formulation indicates that the desired proportional change in fish tissue concentrations can be obtained via an equal proportional change in surface sediment concentrations. Therefore, it is only necessary to achieve the proportional change in sediment concentrations, as opposed to achieving some absolute sediment concentration.

Remedy Outcome Compared to Anticipated Percent Reduction in 2012 FYR

As described above, the use of proportional change in PCB concentration in sediment as an indicator of proportional change in fish tissue concentrations is consistent with the conceptual site model and physics underlying the development of the ROD targets. Appendix 4 of the FYR report acknowledges that estimates of proportional change in sediment concentration could be uncertain due to differences in sampling designs and sediment collection equipment in 2002-2005 and 2016. EPA specifically referred to these changes as "apparent" change, identifying that they embodied

actual change due to the remedy, actual change due to natural recovery, and potential artifacts of differing sampling methods. In an effort to understand and fully explore these issues, EPA also developed a hind-cast method for estimating changes in concentration that helped to reduce these effects. See Section 5 of Appendix 4 of the FYR report for details.

As presented in Table A4-5 of Appendix 4 of the FYR report, based on comparison of the 2002 to 2005 SSAP dataset and the 2016 OM&M sediment sampling dataset, the percentage declines in average Tri+ PCB (PCBs containing three or more chlorines) concentrations in surface sediments (0-2 inch interval) as a result of dredging and MNA were 96, 88 and 80 percent in RS 1, RS 2 and RS 3, respectively. These reductions exceed estimates presented in the 2012 FYR (87, 36, and 5 percent reductions as a result of dredging in RS 1, RS 2 and RS 3, respectively) and the 2002 ROD (79, 64 and 4 percent reductions as a result of dredging alone, in RS 1, RS 2 and RS 3, respectively). Thus, the actual percentage reductions achieved by dredging and MNA are substantially greater than those anticipated by the ROD or the 2012 FYR.

Residual Concentrations at the Edges of Certification Units

Surface sediment data (0-2 inch) from the 2016 OM&M program were used to evaluate whether there are any "highly contaminated areas adjacent to the dredged areas." The OM&M sediment sampling program is based on a probability-based sample selection procedure that supports unbiased estimation of mean PCB concentrations per river section. The sample selection process is spatially balanced and includes samples from edges of certification units in proportion to the size of these areas. This sampling procedure is referred to as a self-weighting design because any underlying stratification of the population is represented proportionally to stratum size. For example, if CU edges represent 10 percent of a given river section, then approximately 10 percent of samples will be from these areas. This approach provides the data necessary for unbiased estimates of river-section averages which are expected to be proportional to fish tissue concentrations averaged over the same river section. These data are appropriate and unbiased for judging the average effect of the remedy at the river section scale.

Figures 40-1a, 1b and 1c below show how the surface sediment Tri+ PCB concentrations in non-dredged areas vary with distance from the closest dredged area boundary. The figures also include a weighted average line, which represents a running average through the data as a function of distance from the dredging boundary. The weighted curves for the areas outside dredging boundaries show no significant positive increase in surface sediment Tri+ PCB concentrations from dredging boundary out to the maximum distance values on the plot (150 ft in RS 1 and 300 ft in RS 2 and RS 3). These plots indicate that sediments close to the dredging boundaries are not particularly more contaminated than those located far away. Furthermore, the concentrations of Tri+ PCB in surface sediments are generally low. The average surface sediment concentration of Tri+ PCB in non-dredged areas from the 2016 OM&M program was 1.7 mg/kg, 1.5 mg/kg and 0.8 mg/kg in RS 1, RS 2 and RS 3, respectively. When comparing the individual sample results to their respective dredging criteria (i.e., 10 mg/kg for RS 1, 30 mg/kg for RS 2 and RS 3), only one sample (out of 215 samples) exceeded the criteria. If the most stringent RS 1 criterion was applied to the entire Upper River, there were only two exceedances. Future OM&M sampling will provide more data to determine the post-dredging percent reduction rate[8].

[8] The 2017 NYSDEC surface sediment sampling program further confirmed that the surface sediment concentrations outside the dredging boundary are generally low. The average surface sediment concentration of Tri+ PCB in non-

EPA acknowledges that the effect of the remedy may vary by reach. EPA has and will continue to evaluate the remedy on smaller spatial scales, including by river reach (*i.e.*, stretches of the river that are separated by dams or locks), for future assessment of the recovery of the river. As an example, EPA's evaluation of the combined 2016 EPA/GE and 2017 NYSDEC sediment data presented in the EPA's April 2019 "Technical Memorandum Evaluation of 2016 EPA/GE and 2017 NYSDEC Surface Sediment Data" (www.epa.gov/hudson) indicates that there are three very localized areas where PCB levels are statistically elevated compared with surrounding areas. EPA and NYSDEC will undertake analyses to jointly define "Areas of Interest" to be tracked in greater detail (e.g., with increased local sampling density) in the future.

dredged areas from the 2017 sediment survey was 2 mg/kg, 3 mg/kg and 0.76 mg/kg in RS 1, RS 2 and RS 3, respectively. When using the combined 2016 OM&M and 2017 NYSDEC surface sediment datasets, there are only 4 sample locations out of 1,304 (or 0.3 percent) where Tri+ PCB concentrations exceed their respective criteria in recoverable sediments across both dredged and non-dredged areas (3 in RS 1 and 1 in RS 2). Further, there are only 8 locations (in RS 2 and RS 3 combined, or 0.74 percent of 1,078 locations) where Tri+ PCB concentrations exceed the lower RS 1 removal criterion of 10 mg/kg. Overall, if the RS 1 criterion were applied to the entire Upper River (which is not what the ROD required, but what some have suggested), just 11 sample locations (3 in RS 1, 2 in RS 2 and 6 in RS 3, or 0.84 percent overall) exceed that most stringent threshold.

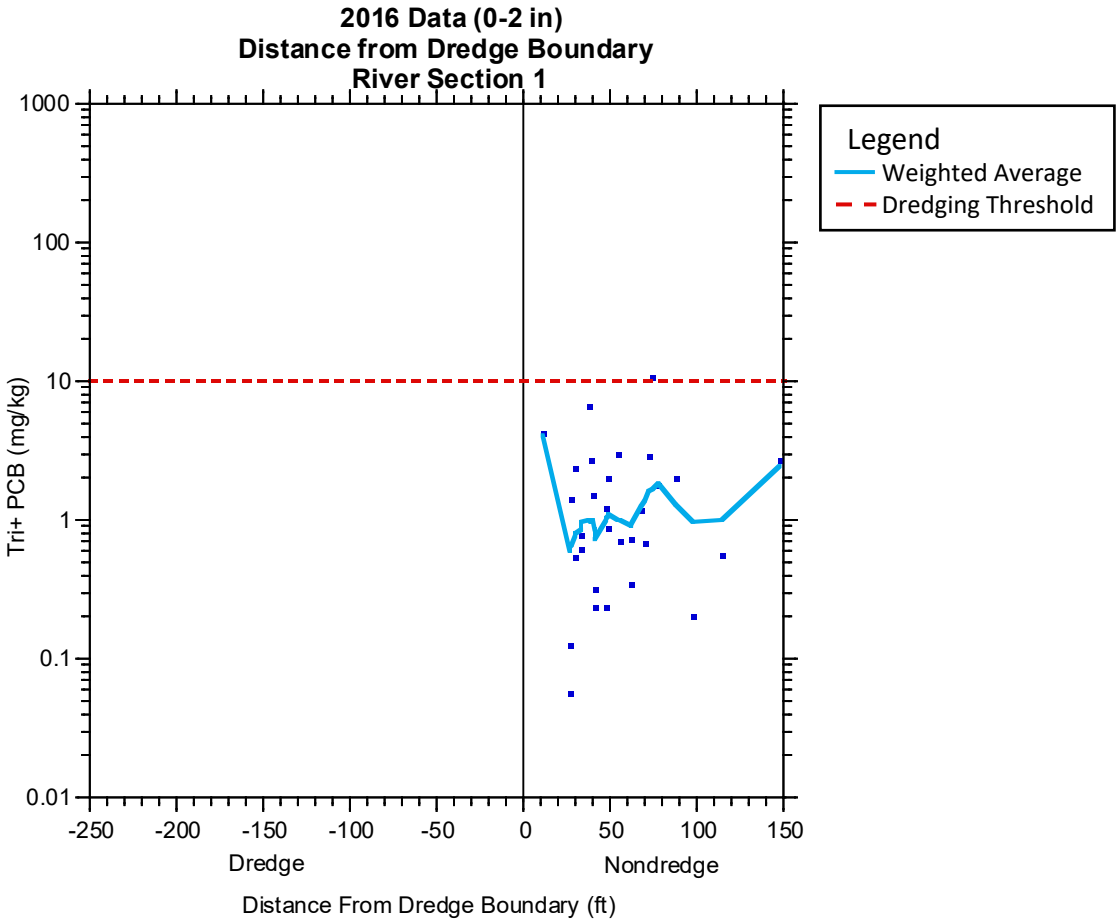


Figure 40-1a Variability in surface sediment Tri+ PCB concentrations with distance from dredging boundary in RS 1. Samples were collected under the 2016 OM&M program. Samples with distance greater than 150 ft are not shown.

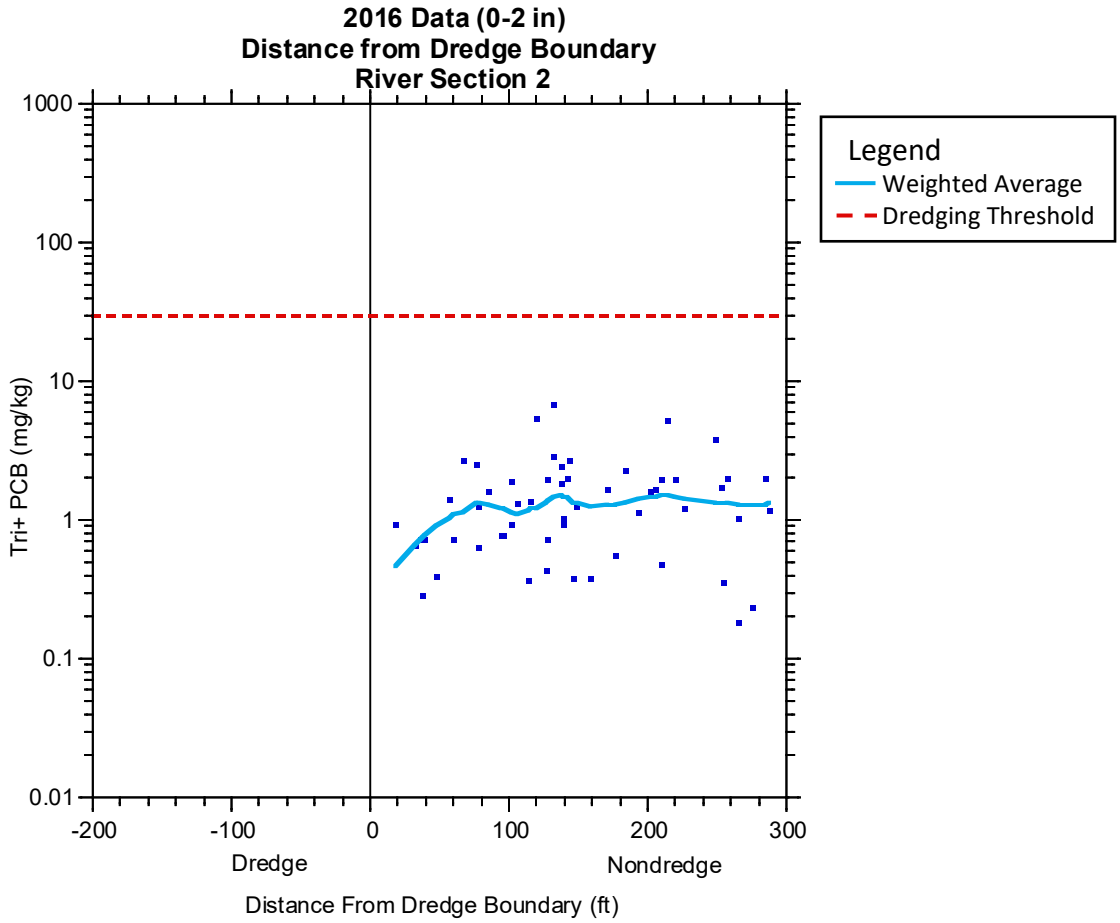


Figure 40-1b Variability in surface sediment Tri+ PCB concentrations with distance from dredging boundary in RS 2. Samples were collected under the 2016 OM&M program. Samples with distance greater than 300 ft are not shown.

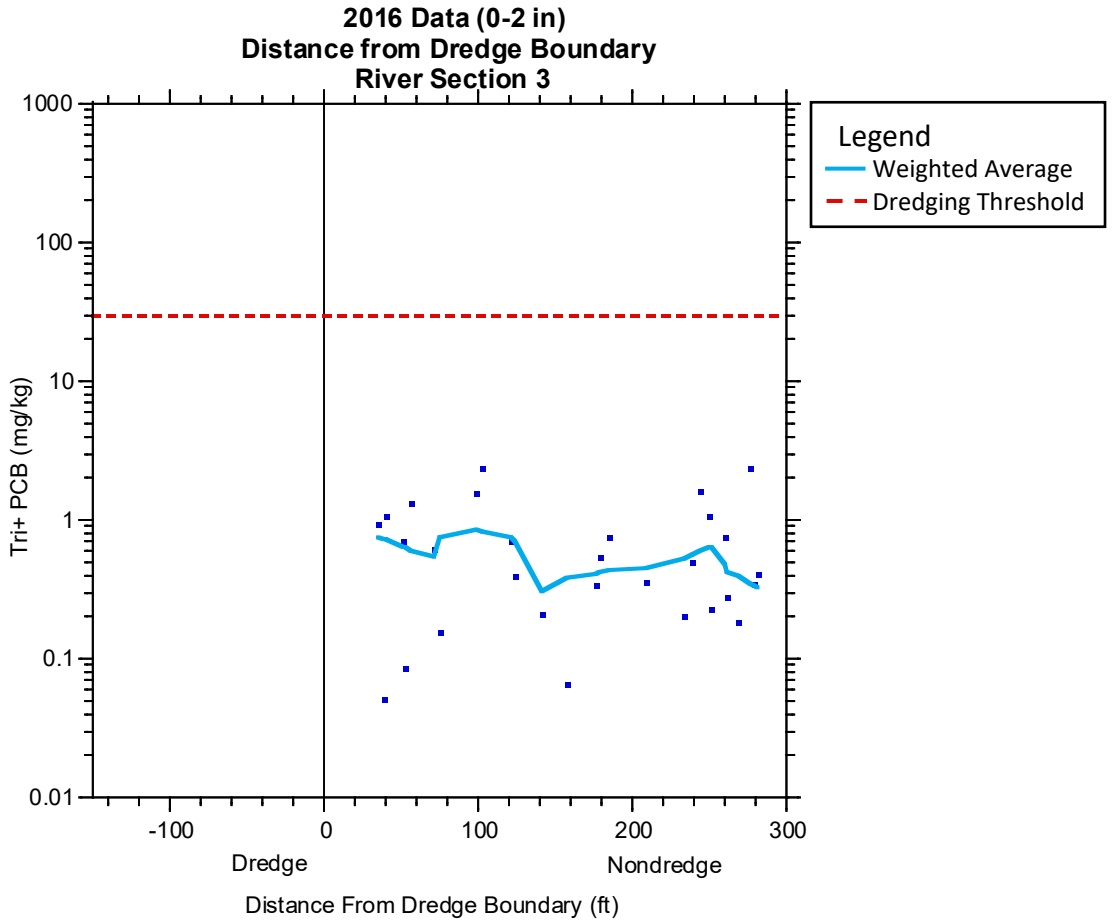


Figure 40-1c Variability in surface sediment Tri+ PCB concentrations with distance from dredging boundary in RS 3. Samples were collected under the 2016 OM&M program. Samples with distance greater than 300 ft are not shown.

3.3.18 Comment 41: Reassess air risks

Comment

Commenters state that PCBs from the Hudson River will volatilize and be inhaled, and these air-borne PCBs become a significant exposure to anyone living or spending significant time near the river. They say that people who live along the Hudson River have a significantly increased risk of hospitalization for heart disease and diabetes, which is because of their proximity to PCBs from the Hudson River or sediment that volatilize and pollute the atmosphere near the river. This exposure is not voluntary for anyone living near the river. Commenters noted that simply living near a PCB contaminated site poses a risk of exposure and to disease. The very large amounts of PCBs that GE now plans to leave behind greatly exacerbate this problem. EPA should verify that the air route of exposure is not a significant route of exposure requiring remedial action, particularly in the Lower Hudson.

Response

The HHRA evaluated a number of exposure pathways including air exposures. The results of this analysis indicated that the cancer risks from inhalation of PCBs in air were 1 x 10^{-6} based on modeling of air concentrations. These risks are at the lower bound of EPA's generally acceptable cancer risk range for exposures at Superfund sites, and 100 times lower than the upper bound of the risk range of 10^{-4} (one in ten thousand). In addition, the inhalation risks are significantly lower than all other pathways, including ingestion of fish.

Prior to and during the remediation, air data was collected in areas around the dredging (both upwind and downwind) and in the areas near the river. This data was collected by multiple agencies over a period of years from 2005 to 2015. This data was analyzed in Appendix 6 of the FYR report. The data indicate that PCB air concentrations before the dredging (GE and NYSDEC data) and during dredging (GE data) are both below estimates in the HHRA. Also, estimates of post-dredging PCB air data indicate that concentrations are lower than those estimated in the HHRA. As PCB concentrations in water are likely to decrease over time due to monitored natural attenuation, it is expected that the PCB emissions from the river will also continue to decrease over time based on the mass of PCBs removed from the River.

3.3.19 Comment 43: Resolve diverging views of data with other agencies

Comment

Commenters stated that EPA should reconcile divergent views on the timing required to meet the goals of the cleanup and on the protectiveness determination by taking credible data and analyses from studies conducted by other federal and state agencies into consideration, notably NOAA and the NYSDEC.

Response

EPA has considered the data and input from the other agencies. EPA believes that reconciliation of diverging government agency views about cleanup and protectiveness determinations has been complicated by the NOAA emulation model (Field, et al., 2016) which attempts to "update" the surface sediment PCB concentrations to forecast fish tissue concentrations. Simply changing a variable, such as sediment concentrations, as NOAA did, without recalibrating the underlying model to maintain consistency with the calibration data, produces results that are flawed. EPA's detailed responses regarding NOAA's emulation model are contained in EPA's white paper[9] and in Appendix C of this document, and summarized in MasterComment 9 (see Section 3.2.1).

Additionally, EPA believes other agencies may have misinterpreted the significance of the SSAP data with regard to the projected fish PCB recovery rates as discussed in the responses to Master Comments 47 (see Section 3.5.5) and 58 (see Section 3.4.9). EPA will continue to take into consideration other federal and state agencies' views regarding the ongoing OM&M phase of the

[9] See: White Paper: Responses to NOAA Manuscript Entitled: "Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation" (Field, Kern and Rosman, 2015) (EPA, 2016)

remedy. EPA has extensively evaluated surface sediment data collected by NYSDEC in the summer of 2017 and has prepared a detailed technical memorandum, which is being published concurrently with the Final Second FYR (see: Technical Memorandum Evaluation of 2016 EPA/GE and 2017 NYSDEC Surface Sediment Data, April 2019, [www.epa.gov/hudson]). Notable findings of that evaluation are that: (1) the 2017 NYSDEC data and the 2016 EPA/GE data collected outside dredged areas yielded similar estimates for surface sediment PCB concentrations; (2) the remedy significantly reduced PCB concentrations in dredged areas and there has not been substantive recontamination of those dredged areas; and (3) no hot spots (*i.e.*, areas exceeding the ROD removal criteria) were identified.[10] EPA and NYSDEC have agreed that additional data are needed to determine if the remedy is effective and if any additional remedial work would be necessary or beneficial. EPA will continue to consider information and data provided by NYSDEC and other agencies and use those data as appropriate to inform future evaluations of the progress of the remedy.

3.3.20 Comment 46: Use of the non-standard protocol (without rib-in vs. rib-out) impacts how the data can be used

Comment

Comments from multiple reviewers focused on the findings of EPA's preliminary evaluation of the differences in PCB concentrations between black bass fillets with and without rib cages included in the sample. Reviewers pointed out that EPA found differences in PCB concentrations in fish tissue samples on both wet-weight and on a per-lipid basis which could influence interpretation of these data generated by GE's contracted analytical laboratory from 2007 through 2013. Some reviewers noted that actual wet weight concentrations in fish tissue samples could be on the order of two times higher than measurements without ribs would suggest, which could influence NYSDOH fish consumption advisories. Several reviewers expressed that combining these samples with historical samples that included the rib cage and surrounding tissue could bias estimates of natural recovery rates, bio-accumulation rates and wet weight concentrations needed to inform fish consumption advisories.

Reviewers pointed out that efforts to correct fish tissue PCB concentrations could be unreliable due to high variability in the ratios of with-rib to without-rib PCB concentrations for individual pairs. Reviewers also identified that the EPA study was restricted to black bass species and suggested that EPA should embark on a similar study of other species comprising important components of the monitoring program. It was suggested that these additional studies should be aimed at understanding root causes of sample variability. The primary concerns focused on potential inability to: 1) accurately estimate temporal trends in PCB concentrations, 2) make fair comparisons to modeled predictions, and 3) forecast future concentrations and the time to reach remedial objectives.

Several reviewers expressed a desire for EPA and or GE to conduct additional comparative studies looking at differences between standard fillet and without-rib processing protocols. One reviewer pointed out that understanding the effects of the change in protocol was necessary for trustees to

[10] Of the nearly 1,900 sediment locations occupied and sampled by NYSDEC and GE, there were only four sampling results at scattered locations that exceeded the ROD surface sediment removal criteria.

quantify injuries as part of the natural resource damage assessment. Finally, several reviewers stated that this study was necessary to understand the anticipated time for fish tissue PCBs to reach remedial goals.

Response

Based on information provided by New York State, EPA's understanding is that between 2007 and 2013 GE's contract laboratory did not follow the NYSDEC standard fillet approach by not including the rib cage material in the analyzed fish fillets. The 2004 BMP QAPP indicated that, "All fish will be prepared for contaminant analyses following collection according to the SOP for Annual Fish Sampling (Appendix 21; adapted from NYSDEC procedures)." The NYSDEC standard fillet approach and Appendix 21 of the 2004 BMP QAPP require inclusion of the rib-bones and belly flap with the fillet that is removed from the fish and subsequently analyzed for PCBs and lipids. In 2013, GE indicated to EPA that "the ribcage was not included with the fillet in either the BMP or the Remedial Action Monitoring Program (RAMP) for samples collected since 2007." In response, EPA requested that GE perform a special study that would facilitate evaluation of whether or not inclusion of the rib cage (ribs) had a significant impact on fish tissue PCB concentrations and lipid levels. Black bass (small mouth bass and largemouth bass) were the focus of the resulting 2014 study because they are large enough to produce fillets of sufficient size for comparison, are processed with skin on, and are collected from RAMP stations on the Upper Hudson River (UHR) and Lower Hudson River (LHR).

The 2014 study indicated that on a wet weight basis, the difference between fillets prepared with ribs *vs.* without ribs was variable and could be greater than a factor of two. For lipid-normalized data, the difference between the two fillet approaches averages less than 20 percent. As a result, EPA determined that the difference in fillet methods does not affect lipid-normalized fillet trend data. However, EPA recognizes that the results of the 2014 special study found differences in PCB concentrations in fish tissue samples with and without ribs on both wet-weight and per-lipid bases, which could influence interpretation of project data. However, the majority of the data influenced by the change in fillet protocol were collected prior to, or during remediation, and currently collected (post-dredging) data are not routinely compared to that period. There are also PCB data for samples processed as whole-body for pumpkinseed and forage fish from the UHR and LHR and for samples processed following the NYSDEC standard fillet method from LHR stations during the BMP and RAMP that span the period in question. Whole body processed fish are not affected by the change in fillet protocol. In addition, post-dredging filleted fish samples are being processed in a manner that is consistent with NYSDEC filleting protocols. EPA has been conducting robust oversight of fillet protocol for post-dredging fish. Post-remedial evaluations of fillet data will focus on how PCB concentrations relate to the interim targets (i.e., 0.4, 0.2 mg/kg) and project goals (e.g., 0.05 mg/kg PCBs), and the time required to reach those targets and goals.

The Natural Resource Trustees requested that the study entitled "Special Study of Black Bass Fillet Tissue With and Without Ribs" be finalized as part of the FYR. The special study is not directly part of the FYR but the findings have been considered in the process of reviewing and presenting the data in the FYR report. The study which was conducted in 2014 has been finalized and provided to the public and trustees as requested (Louis Berger & Kern, 2019; see Appendix D of this document).

EPA agrees that the change in processing methodology is an important issue and that temporal evaluations involving standard fillet and non-standard fillet data may be biased (low) due to variations in sample preparation methods. Because this issue has been discovered and corrected for current and future monitoring efforts, EPA disagrees with reviewers with respect to the value of additional study of other species. EPA acknowledges suggestions that the disposition of sample preparation should be accounted for when estimating past natural recovery rates.

As part of the five-year review, EPA conducted exhaustive evaluations, considering alternative ways to handle varying fish tissue lipid levels, standard fillet vs rib-out methods, and variable starting and ending dates in efforts to identify the most robust methods for estimating PCB recovery rates in fish tissues. These efforts are reflected in the variety of methods reported in Appendix 3 of the FYR report. EPA anticipates further evaluation of PCB and lipid levels in fish tissue in efforts to develop the most effective approaches for the design of OM&M plans for the Hudson River remedy. Temporal variation in lipid concentrations in fish tissue is not unique to the Hudson River, but has also been observed in monitoring data from both the Fox River and Kalamazoo River Superfund sites. Although the causes are not well understood, there is general agreement that empirical estimates of PCB trends should adjust statistically for these temporal trends in lipid content.

Pre-dredging recovery rates estimated from various media and analysis methods and time intervals are generally consistent with the approximately 8 percent recovery rate projected by EPA with the HUDTOX model in the upper river. Although some estimated rates are lower than the expected 8 percent, other estimates exceed the 8 percent expectation and no estimates are sufficiently definitive to suggest that future trends in fish PCB recovery will fall below the recovery rates anticipated in the ROD.

As reviewers have pointed out, because of the large change in the Upper Hudson in-river environment as a result of the remedy, pre-dredging natural recovery rates may or may not be predictive of future rates, particularly as tissue PCB levels approach regional background levels when recovery rates are expected to decline. Nonetheless, no other empirical data are available for estimating recovery rates at this time. Through development of Appendix 3 of the FYR report, EPA found that recovery rate estimates were sensitive to how lipid content was handled either as a variable in multiple regression or as a normalizing factor. It was noted that in many species-by-location combinations, lipid content varied substantially through time; it was also found through examination of paired lipid measurements that there was some measurement error in lipid content.

Understanding that lipid normalization has strong parallels to regression methods and is therefore subject to similar sensitivities, EPA plans to further evaluate: 1) how temporal trends in lipid content may influence reliability of PCB trend estimates, 2) if temporal trends in lipid content may vary by species or tissue type, and 3) whether diagnostics can be developed to identify situations for which PCB trend estimates are most likely to be accurate.

As stated previously, EPA disagrees with the need for additional retrospective studies of differences in PCB measurements associated with the change in processing protocols because remaining technical questions related to fish tissue PCB concentrations are prospective and do not

require linkages to pre-dredging monitoring data. Resources would be better allocated toward prospective evaluations that will improve future data quality to provide more reliable estimates of key metrics in the OM&M period. Post-remedial evaluation of fillet data will focus on how PCB concentrations relate to the interim fish targets and remediation goal (i.e., 0.4, 0.2 and 0.05 mg/kg PCBs) and the time required to meet those milestones. Comparisons with pre-dredging tissue levels are not useful for these evaluations.

One could argue that better understanding of pre-dredging recovery rates would inform understanding of times to recovery, but this requires the assumption that pre- and post-remedial rates will be similar. While this may be true, the only way to test that hypothesis is to estimate post-dredge rates from data and compare them. However, once post-dredging rates can be estimated for comparison, there would no longer be a need to apply the pre-dredging rates.

At this time, EPA's focus is on understanding current tissue PCB concentrations, post-dredging natural recovery rates and the time necessary to reach remedial objectives. For these prospective objectives, the utility of a paired comparison of the effects of the protocol deviation would be of little value because:

1. The non-standard fillet data will not really influence future decisions on the protectiveness of the remedy. These decisions will be based on standard fillet data collected post-dredging.
2. The rib-out data span a relatively short portion (2007 to 2008) of the overall baseline monitoring period (to), and therefore, do not have substantial influence considering the extent of the NYSDEC baseline data (back to 1997 and earlier). In addition, NYSDEC collected some samples processed according to the protocol during the 2007 to 2008 period, so we could identify large discrepancies if they occurred.
3. The special study conducted by GE and EPA shows that when the non-standard fillet data are used with lipid normalization, the data can be combined with standard fillet data for determining trends, but that results should be interpreted judiciously.
4. Samples analyzed without ribs were mostly obtained from the UHR during dredging. A correction to the "true" value for the dredging period is largely academic since we cannot hope to recreate the actual exposure conditions during dredging due to their highly transient nature. As a result, there is very limited application to model improvement or even Biota-Sediment Accumulation Factor (BSAF) refinement to be gained from such a correction.
5. There are uncertainties associated with the differences between Aroclor-based, historical capillary column (homologue-equivalent)-based, and congener-specific isotope dilution-based analytical methods. EPA is working on procedures to minimize and understand any differences between laboratories and methods as part of the OM&M program. However, accounting for these uncertainties, by implementing a fillet-processing driven correction, would yield highly uncertain values of little technical value, particularly with respect to fish data from the remedial action period (2009 to 2015).

3.3.21 Comment 49: EPA's use of the data on fish body burdens to estimate the rates of recovery is highly subjective. EPA's analysis of trends does not support their conclusions about the rate of decline during the period 1995-2008

Comment

A number of comments were provided regarding the use of fish tissue PCB concentrations as a means to calculate the rate of decline and support the viability of EPA's original modeling analysis. These comments include:

a) The fish data show shorter term variations that yield very different decay rates than what EPA calculated for the entire 1995 to 2008 period, thus EPA's choice of period is arbitrary. In general, other selected averaging intervals yielded slower rates than those obtained by EPA.

b) The rates of recovery across the individual species-location pairs vary drastically. The use of an average rate is deceptive in supporting EPA's protectiveness statement for the Site, because those fish populations with slow recovery rates or slightly increasing trends have half-lives several decades longer than the 8 years suggested by the 8 percent rate. These populations will continue to be an exposure risk for human health beyond the timeframe suggested by the FYR. The use of average recovery rates does not consider the variability in individual recovery rates by species.

c) Exclusion of the fillet samples generated without ribs from 2007 to 2008 yields dramatically slower decay rates for Hudson River fish. If inclusion of the fillet samples generated without ribs produced a trend line truly representative of fish tissue MNA recovery, then the rate of recovery would not be consistently slower across species and River Sections once those data are removed.

d) Fish tissue concentration decay rates are extremely variable such that the 8 percent average decay rate is a highly uncertain, biased high, and oversimplified representation of this variation. EPA's claimed 8 percent rate of recovery exaggerates the estimate of the rate of natural recovery in the Hudson River. At present, it cannot be concluded from any of the analyses performed that rates of recovery are on track with the ROD model output. The data does not support EPA's conclusion that the goals of the ROD will be achieved.

e) EPA overestimated the average rate of decline for adult sport fish in the Upper Hudson River (UHR).

f) Pumpkinseed (PKSD) samples did not show the variation in rate estimates since they were not subject to sample processing differences with respect to inclusion or exclusion of the rib cages.

Response

In the FYR report, EPA's examination of the historical record from 1995 to 2008 was intended to characterize fish body burden trends when external inputs to the river were largely controlled and significantly reduced relative to previous periods. The period 1998 to 2008 (a subset of the 1995 to 2008 period) also represents a forecast period for EPA's models (HUDTOX and FISHRAND),

thereby a means to test their accuracy by comparing the forecasts with observations. For the models to generally agree with the data over such a long period of time, they would need to represent the internal exchanges of PCBs between fish, sediment and water in a manner that reflected actual conditions and the rates at which those exchanges took place. From these comparisons, EPA could examine how well the models represented the actual environmental conditions and processes that occur in the river, as the water flows downstream from Ft. Edward. The agreement between model and data, if it could be demonstrated, would justify EPA's use of the models as decision tools to evaluate the relative benefits of several remedial scenarios. In addition, EPA's goal in this FYR was not to establish the decay rate for MNA for future conditions for the river. EPA does not expect the decay rates observed during 1995 to 2008 to fully represent post-remedy recovery rates. EPA disagrees with the commenter's assertion that the models overestimated the rates of recovery during the MNA period. As shown in the multiple figures in Appendix 3 of the FYR report and as discussed further below, there is good agreement between model forecasts and the data during the MNA period. Thus, the results justify EPA's use of the models as decision tools to evaluate the relative benefits of several remedial scenarios. As to future conditions, reliable estimates of the actual post-remedy recovery rates are best derived from post-dredging data.

EPA has characterized UHR decay rates with a single average based on the results of several monitoring stations, each of which yielded similar average decay rates across species. However, EPA did not characterize the rates in the Lower Hudson River (LHR) in this manner. EPA has already indicated that LHR decay rates below Albany are not strongly linked to UHR conditions since the rates of change are slower there and decline with distance downstream of Albany. Thus, the decay rates in this region are not well-represented by a single LHR recovery rate average (and EPA does not calculate one). EPA notes this observation is not fully consistent with EPA's original model expectations. This was an important finding concerning the LHR, as discussed elsewhere in the FYR.

The observation that decay rates vary by species and location across the Hudson but yield similar averages in the UHR speaks to the robust nature of the fish monitoring program and EPA's approach in analyzing the data. Local conditions ultimately control fish body burdens but these conditions can vary widely even within a single river reach. Thus, EPA's approach, by considering the larger data sets for individual fish at each station, effectively averages across the various local conditions at each station. As shown in Appendix 3 of the FYR report, the model forecasts agree well with many fish species across the UHR, although not all species in all instances. EPA's use of an average rate of decline integrates across the various sources of uncertainty and incorporates the fish species/river mile pairs that did not match well. Nonetheless, if EPA's analyses were as uncertain as maintained by the commenters, it is highly unlikely that each UHR section would yield approximately the same average rate of decline. The examination of many fish at each station yields a robust basis on which to determine the average decay rates.

As noted above, fish body burdens of PCB are determined by local conditions. However, these local conditions can be significantly impacted by external variables such as river flow, water temperature, and nutrient loads, which impact fish growth, fish feeding preferences, food availability and other factors. Thus, short-term variations in the fish tissue concentrations are anticipated. EPA agrees that the estimated decay rates for shorter time periods would be very

different than, for example, the nine percent decay rate for the 1995 to 2008 period based on lipid-normalized concentrations for largemouth bass in RS 1, with some slower periods and some faster periods than those estimated by EPA. For example, if only the last nine years are considered (the period 2000 to 2008), the decay rate more than doubles to 19 percent per year for largemouth bass lipid-normalized concentrations in this river section. Figures 49-1a and 49-1e further demonstrate the range of the actual decay rates based on varying time windows, specifically the decay rates for 3, 5, 8, 9 and 10-year intervals for lipid-normalized PCB concentrations for five different fish in RS 1 based on the 1998 to 2008 data. (See Appendix B of this document for further explanation of these figures). From the figures it is evident that short-term rates can vary substantially (more than 600 percent) from the long-term rates. The results also indicate that the variability of the decay rate decreases as the length of the window approaches the period of available data.

EPA also conducted a power analysis to determine the ability to detect a 5 percent or an 8 percent annualized decline over 8 years and 4 years. The analysis was based on lipid-normalized data for largemouth bass and PKSD at RS 1-TD 5 station (RM 189). The sample size was assumed to be 15 to 20 samples per year. A power of 0.8 means that there is 80 percent probability to detect a true trend. The results (Table 49-1) indicate that with 8 years of monitoring data, the probability to detect an 8 percent annualized decline is 99 percent for PKSD and 90 percent for largemouth bass. If the annualized rate is 5 percent, the probability to detect the trend is reduced to 85 percent for PKSD and 53 percent for largemouth mass. When the analysis is conducted over a 4-year period, the probability to detect a 5 percent or 8 percent decline for either species is less than 50 percent. A power of 0.8 or greater is the required power to identify a true trend. The analysis supports the premise that a trend derived from short-term interval is highly uncertain, and that at least 8 years of monitoring data are needed to detect an 8 percent annualized decline. Additional years of data may be required if the rate is slower than 8 percent. Therefore, in order to examine long-term recovery rates, it is important to examine the longest possible record available, so that these shorter-term fluctuations are averaged out. Thus, the numerical model simulated conditions from 1977/1978 to the present while also forecasting future conditions; the overall goal of such a long simulation period was to capture the long-term average trends in PCB concentrations in the various media. In this regard, the EPA's choice to examine 1995 to 2008 was not arbitrary, but rather designed to examine the longest period where external loads to the UHR were relatively small and well-defined. The observation that fish tissue concentrations increase and decrease over short periods of time does not detract from the model's ability to capture the long-term trends across the entire UHR for the 1995 to 2008 period.

Further to this point, EPA is not basing its evaluation on the observations of the MNA rate itself prior to dredging. This period simply provided the EPA the opportunity to test the models' accuracy while waiting for actual measurements of post-dredging conditions to become available. EPA's evaluation indicated the following:

- The remedy removed more PCB mass than anticipated;
- The remedy reduced surface concentrations better than anticipated in RS 1, as expected in RS 3 and only somewhat less than planned in RS 2 [post-dredging sampling indicates that surface concentrations in all three sections have declined even further than originally targeted by remediation since completion of the remedy];

- The models on which the EPA based its decision were able to forecast UHR conditions accurately over a lengthy period (1998 to 2008), and thus, they should be useful indicators of the anticipated degree of recovery post-dredging; and
- PCB levels in fish continued to decline during the period 1998 to 2008, and have returned to levels at or below 2008 conditions in most areas of the river as of 2016.

With regard to individual species decay rates, EPA has pointedly displayed the relationships between model forecasts and available data for all of the main monitoring stations throughout the Hudson, on both wet weight and lipid-normalized bases (see Figures A3-2 to A3-15 of Appendix 3 of the FYR report). In presenting these data and model forecasts together, EPA has shown where the model and data agree and where they do not. EPA does not agree with the assertion that the observed rates of recovery during 1998 to 2008 are not in agreement with those predicted by the model for the UHR and Albany area.

In Figures A3-16A to A3-16C, EPA shows the individual decay rates for all species with sufficient data to support a decay rate estimate. The variability among species and across stations is directly shown and considered in these figures. It is clear from these figures that the averages are good representations of the estimated decay rates. More to the point, although these graphs depict pre-dredging conditions, and confirm the accuracy of the model forecasts of MNA, the graphs do not show post-dredging behavior. For that, EPA is awaiting data to be collected in the coming years. While the model and data comparisons during the pre-dredging period confirm that the model's use in analysis and decision-making in the feasibility study and the ROD is justified, the data-based rates of recovery observed prior to dredging are not a basis to estimate post-remedy recovery rates. Furthermore, although the models did forecast post-remedy rates of recovery, reliable estimates of the actual post-remedy recovery rates are best derived from post-dredging data.

The commenters also raise the concern that the departure from the standard fish sample processing protocol (*i.e.,* without ribs) has so impacted the 2007 to 2008 data that no data generated without ribs should be considered. As EPA shows in Figure A3-16C, exclusion of the data generated without ribs does add variance to the estimates of decay rates but still leads to the same major conclusions; that is, that lipid-normalized decay rates are about eight percent per year in the UHR, and that these rates decline with distance downstream in the LHR below Albany. However, the assertion that the data generated without ribs are invalid is simply incorrect. As discussed in Appendix 3 of the FYR report and detailed in Appendix D of this document, EPA directed GE to complete a special study of black bass fillet tissue with and without ribs. The results of the analysis show that data generated without ribs were largely comparable to those generated with ribs on a lipid-normalized basis, with a difference of less than 20 percent. Thus, it is appropriate to include the data generated without ribs in the lipid-normalized data trend analysis.

EPA further explored the commenter's assertion that UHR fish body burden decay rates decrease markedly if the 2007 and 2008 data generated without ribs are excluded. EPA agrees that these rates do decrease without the additional 2 years of data, but this change is not due to the data generated without ribs. Rather, it is the result of the particularly low PCB concentrations in fish tissue in most species for years 2007 and 2008. EPA notes that the exclusion of the 2007 and 2008 data generated without ribs has a significant impact on the decay rate for some species such as largemouth bass in RS 1, roughly about a sixty percent reduction in rate. However, for a similar

species, specifically smallmouth bass, the decay rate was actually increased by excluding the 2007 to 2008 data generated without ribs, by about 35 percent (indicating faster recovery). This suggests that the exclusion of the rib during sample processing does not always yield a less contaminated sample.

EPA further explored this possibility by examining the change in decay rate for PKSD, a species analyzed on a whole-body basis, and not subject to the rib processing issue. Lipid-normalized PKSD PCB data are plotted in the attached figure (Figure 49-2), replicating the PKSD graphs from Figures A3-9A and A3-10A in Appendix 3 of the FYR report. In both instances, the original regression line and equation are shown based on a fit to the data from 1995 to 2008. The decay rates are the same for both RS 1 and RS 2, as it turns out, -4.9 percent per year. Also shown on each graph is an additional regression, fit to the data from 1995 to 2006, excluding the 2007 and 2008 data. This parallels the analysis done by the commenter for species processed on a fillet basis, excluding those samples processed without rib cages. For PKSD, the decay rate in RS 1 drops from -4.9 percent per year to -0.8 percent per year by excluding those two years of data. In RS 2, the data actually show a positive trend, changing from to -4.9 percent per year to +0.8 percent per year by excluding those two years of data. These changes yield an 80 to 115 percent decline in the decay rate simply by arbitrarily excluding the last two years of data. This analysis shows that PKSD show a similar change in decay rate if the last two years of data are excluded as that seen for fillet-based species trends when the rib-excluded samples (from 2007 and 2008) are omitted from the analysis. This result is contrary to the assertion by the commenter who ascribes the change in trend to the effect of the rib-excluded samples. Rather, EPA's analysis indicates that the reduction in decay rate calculated by the commenter is largely due to the omission of the data for 2007 and 2008.

While EPA agrees that the exclusion of the rib cage from fillet samples does result in lower PCB levels on a wet weight basis, this observation regarding lipid-normalized PCB levels in PKSD sample indicates the observation of slower decay rates with the exclusion of 2007 and 2008 data for all sample types is more likely related to the exclusion of these years of data. On this basis, the exclusion of the last two years of data is not justified. The relatively small effect of rib removal on lipid-normalized concentrations (estimated to be less than 20 percent) does not justify the exclusion of the 2007 and 2008 data from the trend analysis. As EPA has already noted, the goal of EPA's analysis is to estimate the long-term rate of decline over the period 1995 to 2008 as compared with the model-estimated rate of decline for the same period. This analysis shows that the 2007 to 2008 data should be a part of that analysis.

Lastly, EPA agrees with the commenter that there are not enough data available since the completion of dredging and related project activities in 2015 to determine if the remedy will be protective within the time frame anticipated by the ROD. While sediment and water both have sufficient data to identify the reductions due to dredging, EPA estimates that as many as eight or more years of post-dredging fish tissue data are needed to establish a statistically relevant trend for fish.

Table 49-1 Power to detect 8 percent or 5 percent annualized change with monitoring data for 4 years and 8 years

Years of Monitoring Data	True Rate of Decline (%/year)	Species	Power	5th Percentile Estimate (%/year)	95th Percentile Estimate (%/year)
4	- 5%	Pumpkinseed	0.20	-12%	2%
		Largemouth Bass	0.13	-15%	4%
	- 8%	Pumpkinseed	0.46	-14%	0%
		Largemouth Bass	0.28	-18%	1%
8	- 5%	Pumpkinseed	0.85	-8%	-2%
		Largemouth Bass	0.53	-9%	-1%
	- 8%	Pumpkinseed	0.99	-10%	-5%
		Largemouth Bass	0.90	-12%	-4%

Notes:

- Analysis was performed based on lipid-normalized Tri+ PCB concentrations in largemouth bass and pumpkinseed at RS1-TD5 station (RM 189).
- The sample size was set at 17 per year. Similar results were obtained when sample size varied from 15 to 20.
- A power of 0.8 means that there is 80% probability to detect a declining trend that is there. A power of 0.8 or higher is the desired power for trend analysis.
- Positive value for the 95th percentile indicates a reasonable probability for incorrectly detecting a positive trend when the true trend is negative.

3.3.22 Comment 50: The impact of dredging on fish tissue PCB concentrations has passed and concentrations have now reached equilibrium. Future declines in concentration will be very gradual and prolong the time to achieve ROD targets

Comment

Commenters asserted that fish tissue in all river sections experienced a transient increase in PCB concentration in the one to two years following dredging upstream and then a subsequent stepdown in concentration. They stated that the data do not support EPA's contention that fish tissue concentrations are still being significantly impacted by the dredging activity. Commenters argued that fish tissue concentrations have returned to pre-dredging concentrations and have reached equilibrium concentrations, with additional declines in fish tissue PCB concentrations occurring only gradually, over a very long time. Commenters stated EPA is now left with fish tissue concentrations that are more elevated than expected at the time of the 2002 ROD and it is very unlikely that these concentrations will decline at the rate EPA predicted.

Response

EPA agrees with commenters that fish tissue at many stations experienced short-term and transient increases in PCB concentrations during proximal dredging or dredging-related activities. In addition, barge traffic around previously dredged areas may have had an impact on equilibration of conditions. However, EPA disagrees that it can be concluded that fish tissue PCB concentrations have now reached a post-dredging equilibrium. For many species, (*e.g.*, brown bullhead and black bass at Thompson Island Pool [TIP], pumpkinseed [PKSD] and yellow perch at Stillwater, and

other species discussed in Appendix 8 of the FYR report), concentrations are only now returning to pre-dredging conditions and 2016 data exhibit continuing downward trends in fish tissue concentrations following the most recent upstream dredging activities. With only one year of post-dredging fish tissue data collected, there currently isn't enough data to conclude that post-dredging equilibrium has or has not been established; additional data collection over a number of years will be required to fully establish the trajectories of the fish tissue concentration recovery and conclude when equilibrium has been reached.

A review of data at the Cumberland Bay – Wilcox Dock Superfund Site (Lake Champlain) where remedial dredging was completed in 2000 may provide context on approximately how long it may take to establish equilibrium concentrations. Appendix 8 of the FYR report, Figure A8-5.1 and A8-5.2 show yearly wet weight TPCB concentrations in fish tissue of rock bass and yellow perch, respectively, collected at that site. In both cases, PCB concentrations continued to decline for at least 8 years following dredging activities. In the case of yellow perch, concentrations returned to pre-dredging concentrations following dredging activities and remained there for upwards of 5 years before declining to PCB concentrations that were significantly below pre-dredging concentrations. Thus, based on pre- and post-dredging data collected at the Cumberland Bay – Wilcox Dock Site, 7 to 9 years may be required to develop a complete picture of rates of decline of fish tissue concentrations.

Therefore, it is important that additional data over multiple annual cycles (likely 8 years or more) be collected to more fully understand how fish are responding to dredging and provide statistically meaningful estimates of progress toward meeting the interim targets and final goals. While EPA finds the 2016 fish data results encouraging, one year of data does not suggest trends and cannot not be used to conclude that fish tissue concentrations have reached an equilibrium. EPA will continue to monitor post-dredging (natural recovery) results collected under OM&M and to evaluate remedy protectiveness through the FYR process which includes comparing future observations to the ROD targets and remedial goals.

3.3.23 Comment 51: Changes in fish sampling locations result in data that is not suitable for long term PCB temporal trend analysis

Comment

Several commenters noted that fish PCB tissue concentration data exhibit variability across the Upper Lower River (ULR) and Lower Hudson River (LHR) and through time, specifically when viewed from the perspective of pre-dredge compared to post-dredge. Reviewers asserted that some of the observed variability may be attributed to changes in the locations from which some fish species were collected, while others suggested that the observations warrant further investigation, with commenters mentioning pumpkinseed (PKSD) in particular. A commenter further suggested that EPA only "use only lipid-normalized data to evaluate temporal trends and for comparison to food web model projections use wet weight values adjusted to the standard lipid content for each fish species used in the modeling."

Furthermore, commenters concluded that the decay rates in the UHR were generally low when only using the long-term monitoring species (or species groups) and stations established by

NYSDEC and when restricting the size range and time of year to be consistent with NYSDEC monitoring. Specifically, their analysis shows that "only black bass and yellow perch from the Thompson Island Pool monitoring station show PCB decay rates greater than 8 percent. Bullhead and pumpkinseed from that same location have PCB decay rates of less than 5 percent and 0 percent, respectively. At the other UHR long-term monitoring locations in the Stillwater Pool, all species had PCB decay rates less than 5 percent."

In addition, a commenter stated that the MNA period for fish should begin in 1997 rather than 1995, which is consistent with prior practice (*i.e.,* use consistent data).

Response

EPA agrees that there is considerable variability in long-term fish tissue data trends (see Appendices 3 and 5 of the FYR report), even when data associated with non-NYSDEC fillet processing protocols are excluded from the analyses. EPA also agrees that the affected lipid data (i.e. using lipid-normalized data) should be included in temporal trends analyses. The 2002 ROD anticipated that fish tissue data would continue to exhibit variability by species and across time and stations, both during dredging and following the conclusion of dredging (See Appendix 8 of the FYR report).

EPA does not agree that changes in sampling locations over time make fish tissue data unreliable or inappropriate for assessing temporal trends. As described in the 2004 BMP QAPP (Section B1.2 "Upper Hudson Fish Monitoring"), the locations, sampling frequency, target numbers and species for the Baseline Monitoring Program (BMP) and Remedial Action Monitoring Program (RAMP) were based on NYSDEC long-term monitoring approaches and represented species associated with a range of sediments and human and ecological uses. As indicated in the NYSDEC 2005 Report on PCBs in the Hudson River, "With the adoption of the Baseline Monitoring Program (BMP), as part of the PCB Remediation effort, GE took over a portion of the fish monitoring beginning in 2004, but they have adopted the basic DEC plan for the Upper River" (Sloan *et al* 2005). These long-term data, in conjunction with data generated during the BMP, were intended to be used in spatial and temporal trends analyses of PCB concentrations in UHR fish and are still used, in concert with RAMP and post-dredging data, for this purpose. The 2004 BMP QAPP (along with the Phase 1 and Phase 2 RAMP QAPPs) indicates that "reasonable attempts will be made to maintain sample location integrity throughout the program," but in the event that fish cannot be collected at each location in every year, at least two locations within each pool or reach and two locations within each river section (*e.g.*, stations ND-1, ND-2, ND-3 and ND-5 in the Northumberland pools in RS 2, consisting of Reaches 7 and 6) would be sampled. Note that the number of fish stations within Reaches 8 through 5 increased under the BMP and these stations represent the current (RAMP) collection stations. EPA, GE, and NYSDEC are discussing potential fish sampling stations in Reaches 4 through 1 under the OM&M program.

An examination of the locations of the fish stations actually sampled each year at the UHR and Albany-Troy monitoring locations indicates that, during both the BMP and RAMP periods, the location of fish collected during the spring and fall sampling windows changed over time. These changes were sometimes necessary to collect target species each year in the vicinity (plus or minus approximately one river mile) of a historical station (*e.g.*, Station TD-1 2004 to 2016), loss of

habitat (*e.g.*, the abandonment of Station ND-4 in Reach 6 in 2004/2005), or a combination of habitat loss and operational considerations (*e.g.*, the transition from the south Albany turning basin at RM 143 to transects along the east and west shores of the Hudson River between RM 145 and 147 between 2004 and 2013). Figure 51-1 presents the change of fish stations over time in RS 1 and RS 3. Note that long-term monitoring was not conducted by NYSDEC in RS 2. Because the sampling of fish is performed along a transect and the actual sampling location depends on the availability of fish, the NYSDEC "stations" historically occupied represent relatively large areas (usually within a mile radius) generally centered on the designated station location (as described below consistent with the 2004 BMP QAPP). In consideration of this, GE BMP locations that are within a 1-mile radius of the assigned "NYSDEC stations" can be considered as equivalent to the NYSDEC stations. These equivalent locations are marked within the red rectangle boxes in Figure 51-1. These figures show that brown bullhead, largemouth bass, PKSD, and yellow perch were all consistently monitored at the "NYSDEC stations" from 1995 to 2008.

As described in the 2004 BMP QAPP (Table B-3) and subsequent RAMP QAPP, the intent of the selected post-2003 stations was (and is) to sample from available habitats "approximately evenly distributed (depending on habitat availability) within the pool [or pools]" for the purpose of "establish[ing] a baseline for comparison to construction and post-construction conditions." Also, as discussed in the BMP Data Summary Reports, changes in sampling locations were made in consultation with NYSDEC and EPA field oversight. For these reasons, EPA does not agree that changes in sampling locations over time significantly impact EPA's ability to use these data in long-term trend analyses. Of particular note, an insistence on limiting data to a single "station" effectively limits the temporal coverage of the data, reducing the ability to detect long-term trends in the data.

To illustrate EPA's perspective, EPA evaluated the impact of station inclusion on the decay rates of brown bullhead, large-mouth bass, PKSD, and yellow perch in RS 1. Specifically, EPA compared the rates that were derived from samples at the established NYSDEC station (RM 189), within a 1-mile radius of the NYSDEC station (RM 188.5-190), and from all RS 1 locations (RM 189-194). The decay rates were calculated on a lipid-normalized concentration basis using samples collected between 1997 and 2008. Note that based on the reduction of PCB loads originating above OU2, MNA began sometime between 1995 and 1996. On this basis, 1995 was used as starting year for the MNA period in the FYR report. However, to address the commenter's concern that MNA did not begin until 1997, the decay rate analysis presented in this response begins in 1997. EPA obtains the same or similar decay rates whether the analysis begins in 1995 or 1997.

As shown in Table 51-1, for three of the four species, the rates are not impacted by the stations included when the restriction on the location does not impact the available length of time (number of years) for deriving the trend. For brown bullhead, large-mouth bass and yellow perch, their rates of decline based on data within a 1-mile radius of the NYSDEC station (RM 188.5-190) were similar to the rates obtained using all RS 1 stations. This is attributed to the similar temporal coverage of the data (*i.e.,* 1997 to 2008) available for both data sets. In contrast, the rates for these species were much slower when only using the single NYSDEC station (RM 189) because they were derived from a shorter time period, (*i.e.,* 1997 to 2005). By restricting the samples to the NYSDEC station, the number of years for the trend analysis is significantly reduced and the downward trend observed across the entire period being examined here (1997 to 2008) is not

strongly evident from 1997 to 2005. Conversely, all stations from 2004 to 2008 exhibit a strong downward trend. From these observations, as illustrated in detail in Appendix 3 of the FYR report, it is likely that all stations exhibit both slow and rapid periods of decline, providing further support for the longer-term rate calculation applied by EPA to minimize the effect of short-term trends.

PKSD does not show the same behavior as the other species. Its rate of decline based on data within a 1-mile radius of the NYSDEC station (RM 188.5-190) was lower than that obtained using all RS 1 stations. However, when looking at the most recent data (2004 to 2008), the rate of decline of PKSD is high and is comparable to the other species. This is further illustrated in Figures 51-2a and 51-2b, which present lipid-normalized PCB concentrations for largemouth bass and PKSD in RS 1. Note that a single station covers the period up to about 2003 for PKSD and to 2005 for largemouth bass, with subsequent conditions documented at other locations within the same river section. Note that all stations post-2003 indicate a downward trend. Additionally, within a given year, the variability of PCB levels across stations is comparable to the variation within a single station, indicating that most stations are tracking similar conditions. These observations support the combination of multiple stations within a river section in the calculation of rates of decline. These results suggest that it is not the sampling location, but the temporal span of the data that primarily impacts the calculated rate of decline. Longer-term trends provide the best estimates of the actual rate of fish tissue recovery.

A commenter also mentioned that the high rate of decline for PKSD at the Albany/Troy location was highly unreliable because of the change in sampling location. The conclusion was made based on the commenter's findings that "at the Albany/Troy location all species except pumpkinseed had PCB decay rates of 4% or less" and "the decay rate of pumpkinseed was low at other locations in the Lower Hudson River (LHR) (Catskill and Poughkeepsie)". EPA does not agree with the commenter's assertion that at the Albany/Troy location all species except PKSD had PCB decay rates of 4 percent or less. EPA's analysis, based on lipid-normalized data, shows that the decay rates of smallmouth bass, largemouth bass, brown bullhead, yellow perch, PKSD, spottail shiner and striped bass were all greater than 8 percent for this river section (Table A3-3 of Appendix 3 in the FYR report). Considering that PKSD is known to show high site fidelity compared to largemouth bass, smallmouth bass and bullhead, the similar decay rate of these species implies that the change of locations is not the cause of the high decay rate of PKSD observed in this river section. The lipid-normalized PCB concentrations for PKSD at the Albany/Troy location are shown in Figure 51-3. This figure shows that PKSD PCB levels are declining no matter which time interval or monitoring location is selected. The period prior to 2004 is characterized by a rate of decline of -7 percent per year while the period 2004 to 2008 is characterized by a rate of -20 percent per year. The overall rate of decline for 1997 to 2008 is -17 percent per year. EPA notes that in Table A3-3 of FYR report Appendix 3, EPA obtains a rate of -13 percent per year, based on a slightly long period, 1995 to 2008.

The lower rates of decline for PKSD observed at other locations in the LHR as claimed by the reviewer do not support the conclusion that "the high decay rate of pumpkinseed at the Albany/Troy location is highly unreliable". This is because the rate of decline across all species is shown to decrease with distance downstream *(i.e.,* downstream locations recover more slowly than the upstream locations under MNA). The spatial pattern of decay rates is illustrated in Figure A3-16 of Appendix 3 of the FYR report.

EPA agrees that based on one year (2016) of post-dredging data, differences between BMP and post-dredge PCB fish tissue levels can be observed at the river section and station scale. However, such variability was anticipated by the ROD as "short-term temporary impacts" to aquatic species and habitats resulting from dredging. As discussed in Appendix 8 of the FYR report, some of this variability may be due to the proximity of dredging and dredging-related activities to fish habitat and fish sampling stations. Other differences between pre- and post-dredging fish tissue concentrations could be attributed to stresses resulting from habitat changes, variations in lipid levels and changes in other uncharacterized environmental conditions.

A commenter accurately noted that RS 1 "post-dredging TPCB concentrations in pumpkinseed and small forage fish were three to six times lower than observed pre-dredging levels…[while]…further downstream, the results are mixed." However, RS 1 (including PKSD and forage species) fish tissue concentrations started out at higher pre-dredging concentrations than either the Albany-Troy or LHR Stations (See Appendix 3 of the FYR report, Figures A3-2 through A3-5). And, prior to dredging, target fish species in RS 1-3 and RM 152 at Albany-Troy also exhibited similar average recovery rates (Appendix 3 of the FYR report, Figure A3-16). In contrast, stations below RM 152 started out at lower pre-dredge fish tissue levels and exhibited recovery rates prior to dredging that were slower than or even positive (meaning increasing over time) when compared with those observed at UHR stations or at RM 152. In fact, striped bass, yellow perch, and white perch at LHR stations below RM 90 (NYSDEC data) have exhibited tissue PCB concentrations approaching the 0.4 mg/kg target level since the BMP. PCB levels in Lower Hudson fish below RM 140 are primarily governed by local sediment conditions and are not closely linked to conditions in the Upper Hudson, nor the Upper Hudson PCB loads to the Lower Hudson. Large reductions in fish tissue levels are anticipated for the Upper Hudson fish in response to the remedy, while less change is expected in response in Lower Hudson fish.

The extent of variability in fish tissue concentrations observed at the various fish sampling stations during the BMP and RAMP is neither inconsistent with levels anticipated in the ROD nor unexpected considering the range of species observed and the distance over which they were collected for the project. For the reasons listed above, while EPA acknowledges the variability in results across fish monitoring stations, it does not agree that variation among species and locations requires additional investigation at this time in the Upper Hudson. Given the lack of correlation between Upper Hudson and Lower Hudson fish tissue responses, EPA has identified the LHR as an area requiring further investigation.

Regarding the use of lipid-normalization, EPA does not agree that field-collected wet-weight data should be adjusted to (modeled) lipid values such as those reflected in pre-dredging forecasts from the ROD. For the ROD forecasts, lipid values were assigned using random values from a tri-modal distribution of lipid concentrations based on historical data. As a result, forecast lipid values reflect a potential range from within an estimated population. This approach was used because it was understood that because species' lipid values vary over time, it was not possible to predict lipid levels precisely into the future, but an accurate estimate was still required to construct forecasts. In contrast to modeled lipids, field-collected fish data reflect the actual (observed) lipid content of harvested sample species and at the level of an individual fish. Additionally, EPA notes that while lipid levels and PCB levels in fish tissue are correlated, the relationship between the two

parameters is not always linear. That is, for two fish of the same species, age and size with comparable PCB exposure but one with twice the lipid content, the fish with the higher lipid level will not necessarily have twice the PCB level. As a result, the utility of adjusting observed (individual fish) lipid contents to reflect a population-level model distribution is not clear.

A commenter raised the concern that the rate of decline for PCB levels in fish tissue was slower than expected when only using the long-term monitoring species (or species groups) and stations established by NYSDEC and when restricting the size range and time of year to be consistent with NYSDEC monitoring. Without these restrictions, EPA's analysis using lipid-normalized data shows a much higher decay rate than the commenter noted. In the UHR, only brown bullhead in RS 2 and RS 3 shows a decay rate less than 5 percent (See Table A3-3 of Appendix 3 in the FYR report). The low rates of decline reported by the commenter are the result of a specific sample selection process. The commenter limited his/her selection to tissue samples exclusively from NYSDEC-established stations, within a certain specimen size range and a specific time of year from 1997 to 2006, thereby eliminating any of the GE data. As discussed above, the restriction to NYSDEC-established stations basically excludes samples collected after 2004 and also restricts data to a single station. Therefore, the commenter's analysis does not reflect long-term (temporal) trends or fish tissues representative of the reach-scale. EPA further evaluated the impact of specimen size on the rate of decline. The analysis indicates that the exclusion of fish samples that do not meet the NYSDEC monitoring size criteria do not substantively affect the overall rates of decline. It was noted that only a small fraction of samples do not meet NYSDEC's selection criteria for brown bullhead (0.3 percent with length less than 175 mm), largemouth bass (3.6 percent with length less than 250 mm), and yellow perch (9.3 percent with length less than 150 mm). However, for PKSD, about 25 percent of samples do not meet NYSDEC's selection criteria. In Figure 51-4, EPA presents the trends of PKSD in RS 3 to show that removal of data points by length is inconsequential for the rate of decline. The restriction to the time of year also does not impact the rate of decline as fish samples were largely collected from the same season from 1997 to 2008. As an example, Figure 51-5 compares the trend of yellow perch at Albany/Troy using only spring samples against that using all samples. The rate of decline for the spring samples is 9.7 percent per year, which is similar to 10.4 percent per year derived from all samples.

The commenter also excluded the tissue samples from 2007 to 2008 in the trend analysis because the samples were analyzed using a non-NYSDEC-standard fillet approach by not including the rib cage material in the fillet harvested for analyses. GE has conducted a specific study to evaluate whether or not inclusion of the rib cage (ribs) had a significant impact on fish tissue PCB concentrations and lipid levels. For lipid-normalized data, the difference between the two fillet approaches averages less than 20 percent (see Section 3.3 in Appendix 3 of the FYR report). EPA also conducted a sensitivity analysis to compare the fish recovery rates from data generated with and without ribs (compare Figure A3-16A with Figure A3-16C in Appendix 3 of the FYR report). The results of this sensitivity analysis indicate a similar distribution of the estimated rates of decline, with or without the non-NYSDEC standard fillet data. Therefore, EPA's conclusion on the rates of decline and their distributions across the Hudson River, on a lipid-normalized basis, is consistent regardless of whether the non-NYSDEC-standard fillet data are used or not.

The low rates of decline reported by the commenter are mainly attributable to the restriction to the "NYSDEC station" which excludes the samples after 2004 and does not reflect the long-term

trend. EPA's goal is to derive trends that represent the entire species population in a wider area, such as those on River Section basis, and over as long a period as possible so as best to capture the long-term trends. The trend figures provided in Appendix 3 of the FYR report (Figures A3-9 through A3-11) clearly show a consistent downward trend of tissue PCB concentrations for various species in three river sections. These figures also suggest that the rates of decline on average are consistent throughout the UHR and RM 152.

Table 51-1 Impact of Sampling Locations on Temporal Fish Tissue Trends in RS 1

The decay rates were derived from lipid normalized Tri+ PCB data from 1997 to 2008

Species	RM 189 to RM 189.4			RM 188.5 to RM 190			All Locations		
	Count	Rate of Decline (%/yr)	Actual years of data available	Count	Rate of Decline (%/yr)	Actual years of data available	Count	Rate of Decline (%/yr)	Actual years of data available
Brown Bullhead	139	-3%	1997-2005	166	-6%	1997-2008	260	-8%	1997-2008
Large-mouth Bass	165	-3%	1997-2005	195	-11%	1997-2008	214	-11%	1997-2008
Pumpkinseed	104	5.4%	1997-2003(1)	156	-3%	1997-2008	262	-6%	1997-2008
Yellow Perch	152	-8%	1997-2005	182	-13%	1997-2008	316	-14%	1997-2008

Note: (1) Pumpkinseed: one sample from 2004 and one sample from 2005 were excluded from the analysis since the data are too limited for these years.

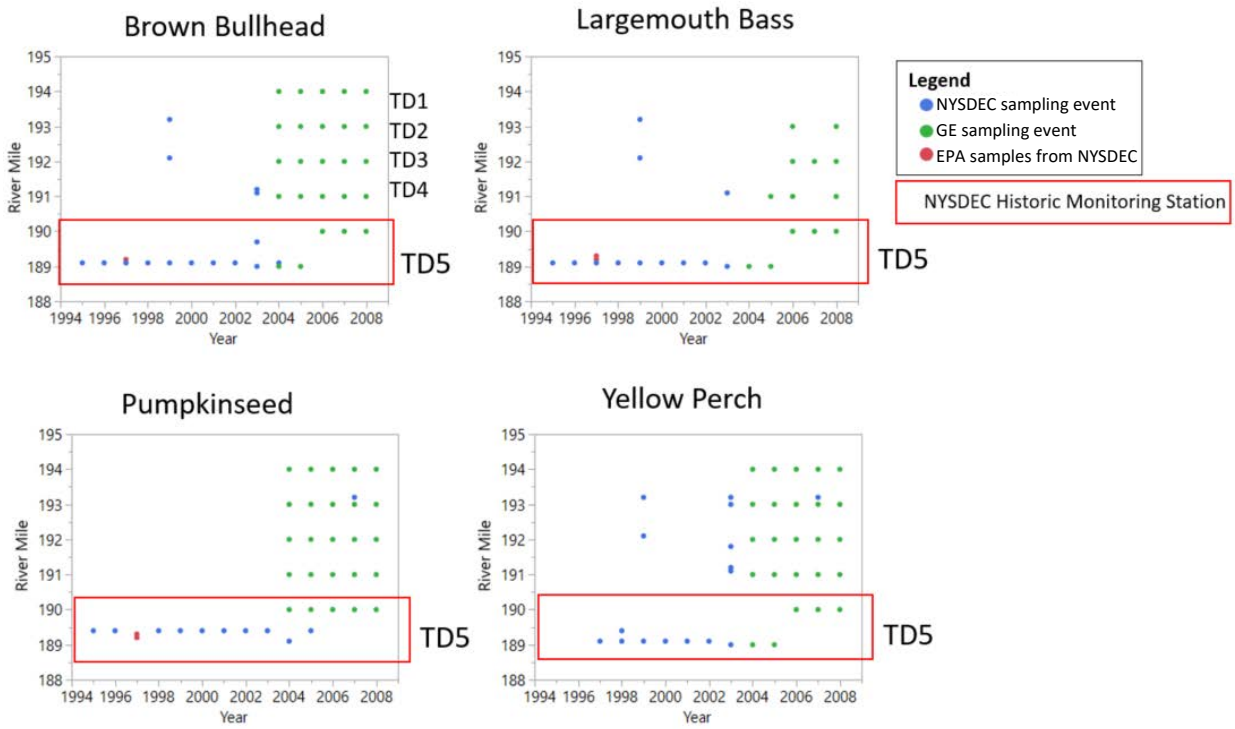


Figure 51-1a Fish sampling stations in River Section 1

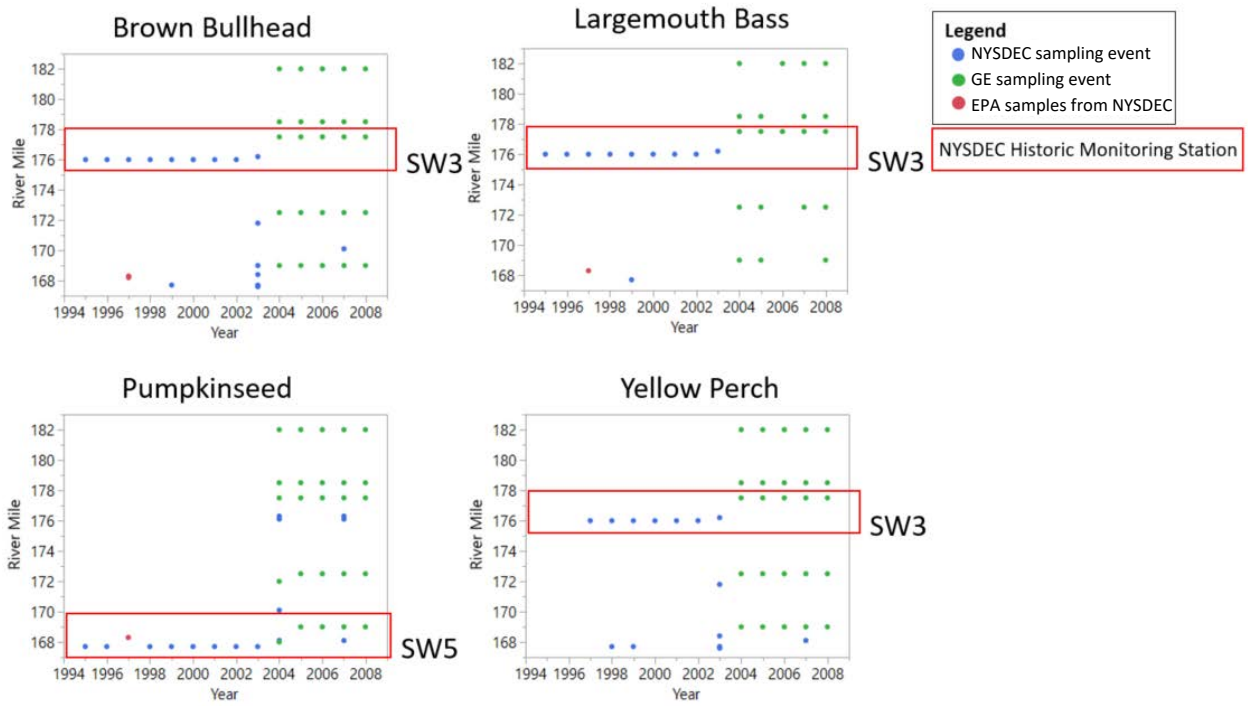


Figure 51-1b Fish sampling stations in River Section 3

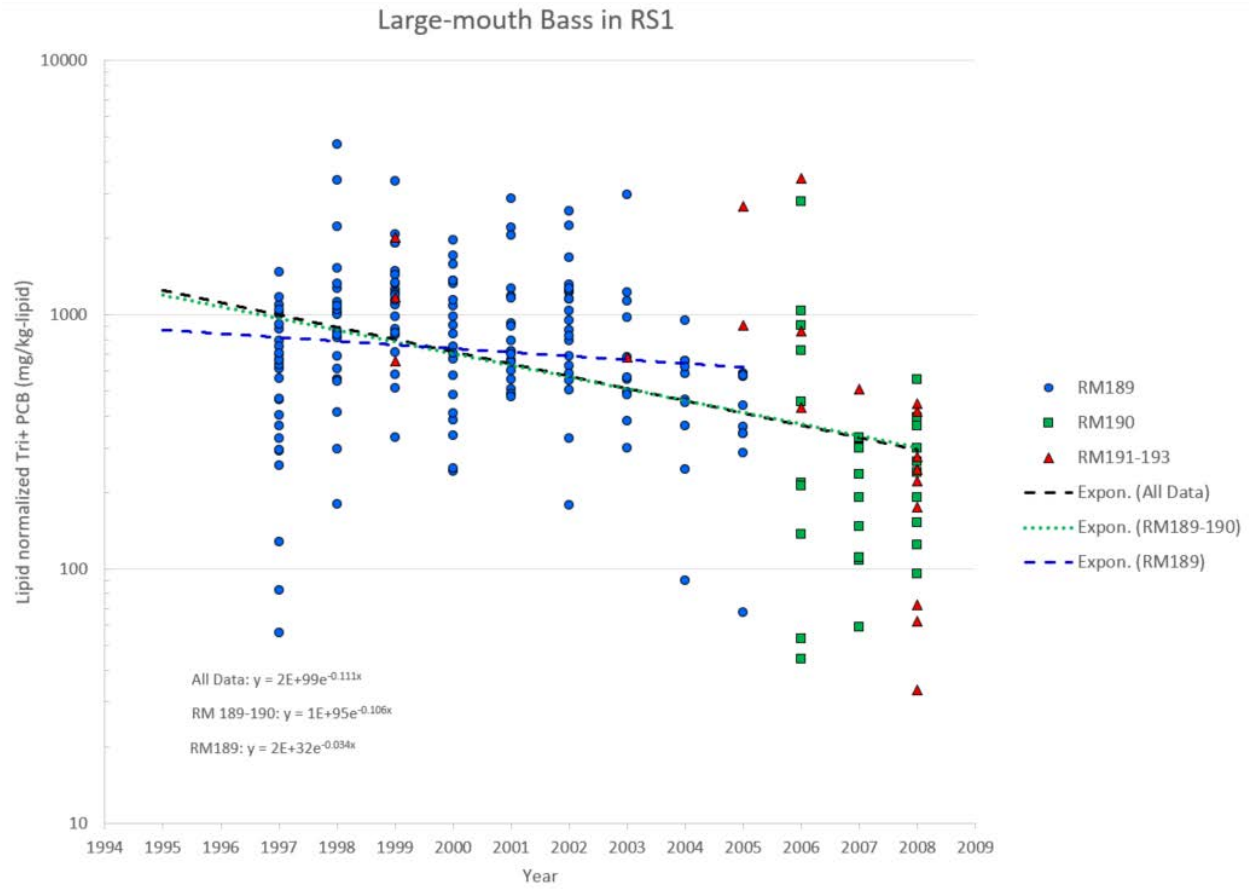


Figure 51-2a Variation of rates of decline in fish tissue concentration with station inclusion for largemouth bass at River Section 1

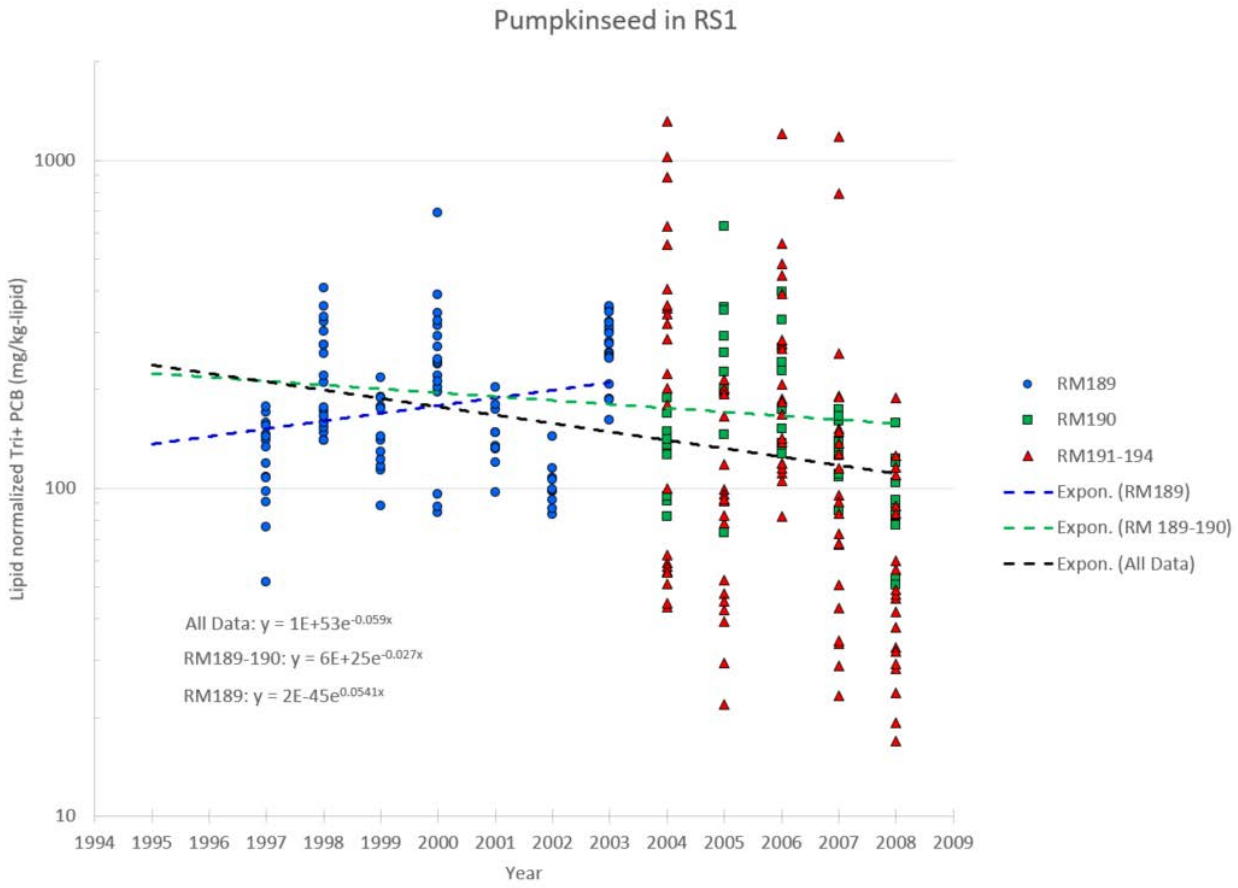


Figure 51-2b Variation of rates of decline in fish tissue concentration with station inclusion for pumpkinseed at River Section 1

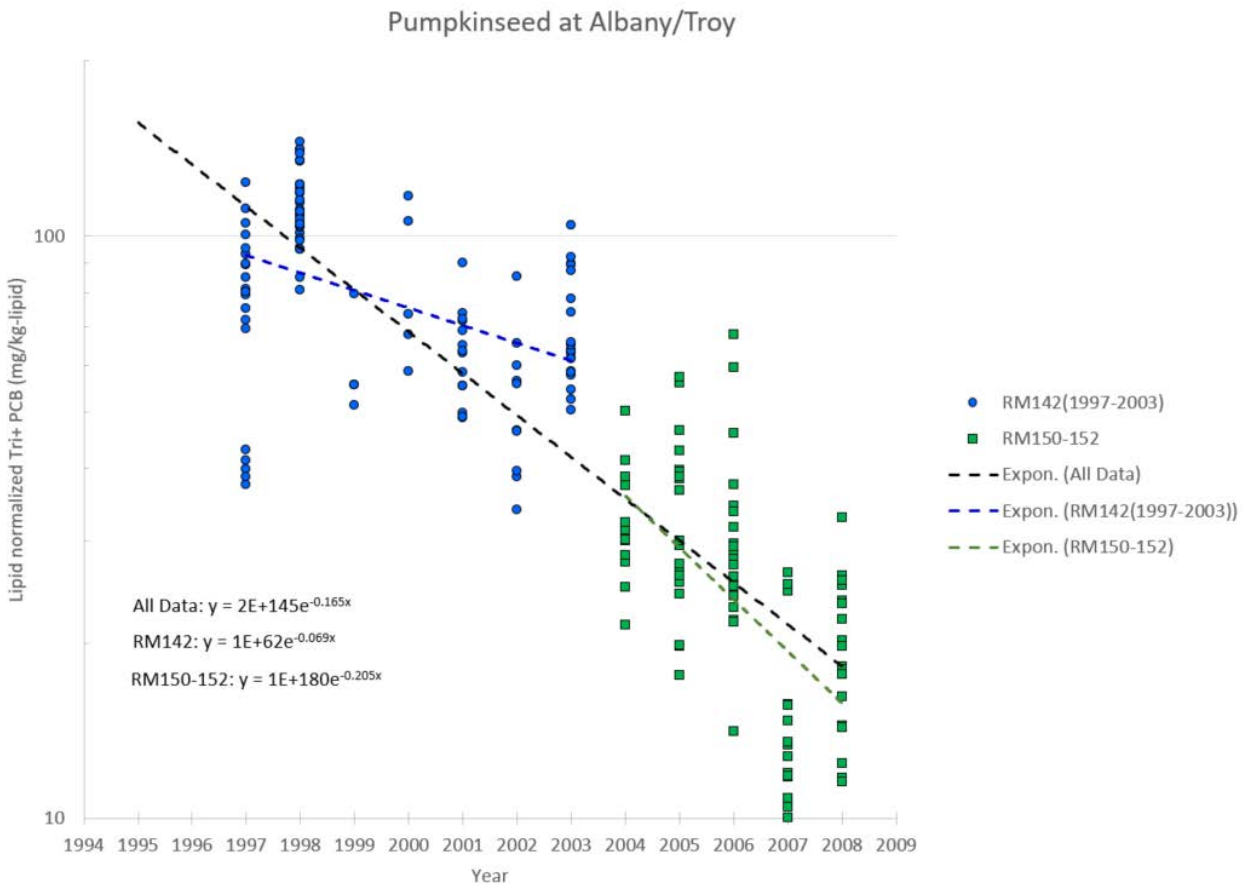


Figure 51-3 Variation of rates of decline in fish tissue concentration with station inclusion for pumpkinseed at Albany/Troy

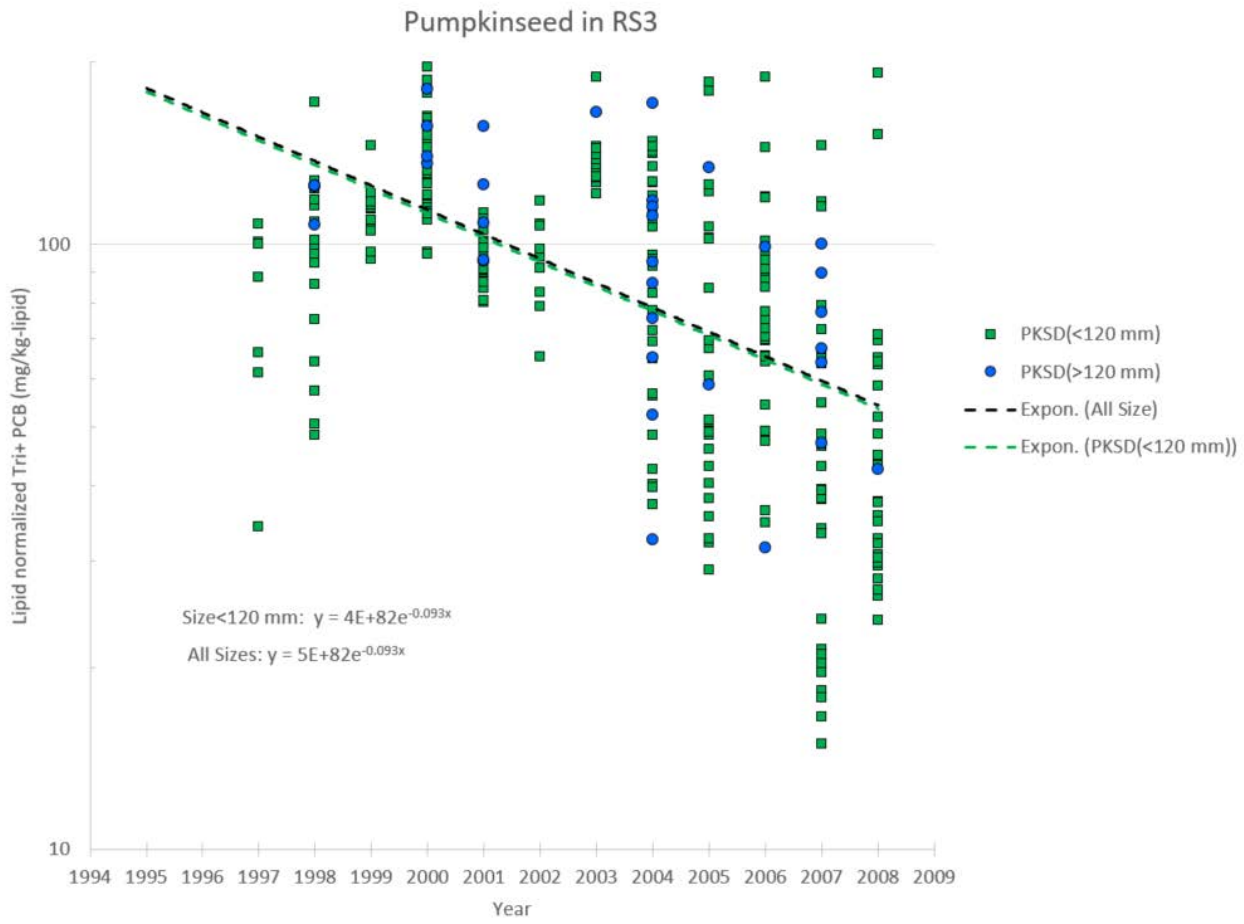


Figure 51-4 Variation of rates of decline in fish tissue concentration with restriction on species length for pumpkinseed at River Section 3

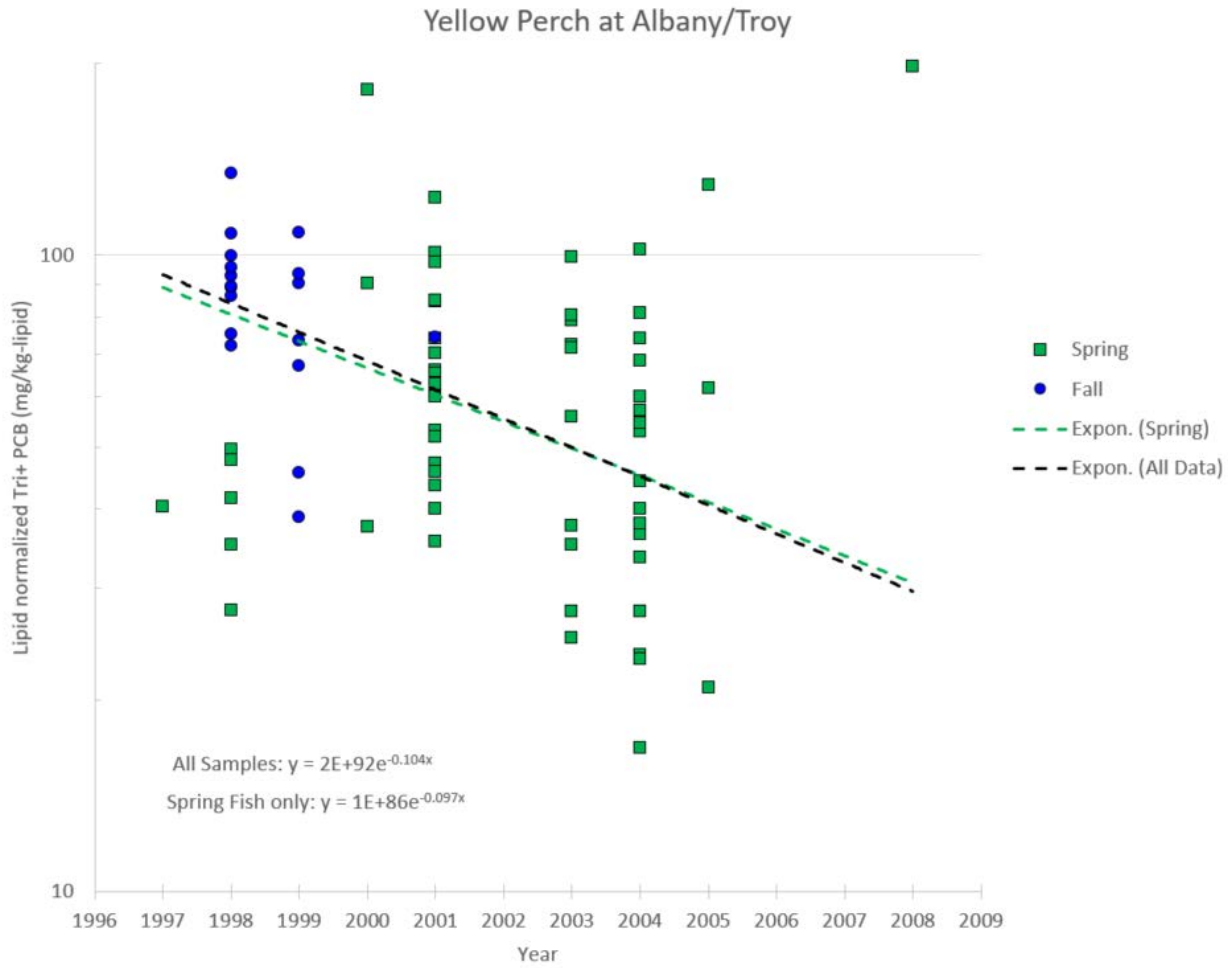


Figure 51-5 Variation of rates of decline in fish tissue concentration with restriction on season – Yellow Perch at Albany/Troy

3.3.24 Comment 53: Surface PCB Concentration of the Non-Dredge Areas in RS1 has not declined

Comment

A commenter stated that when the SSAP dataset is separated into dredged and non-dredged area sample sets, cumulative distribution plots show lesser degrees of improvement in non-dredged areas than the improvement shown by plotting all SSAP samples. Non-dredged areas in RS 1 show very little or no improvement.

Response

EPA disagrees with the commenter's conclusion that non-dredged areas in RS 1 show very little or no improvement, because the commenter's analysis was based on comparison of incompatible data. The commenter compared the 2016 OM&M data surface sediment data representing the 0-2 inch interval, to the 2002 to 2005 SSAP sediment data representing sediment intervals from 0-12 inches. In general, deeper sediments outside of the dredged areas tend to be less contaminated, so

juxtaposition of the two differing sampling intervals does not provide a comparison of equivalent metrics.

EPA has repeated the analysis by directly comparing the 0-2 inch SSAP data to the 2016 OM&M data in RS 1, using a cumulative distribution function (CDF) plot shown in the Figure 53-1 below, and the results show that there is significant improvement in the non-dredged areas. The y-value on the CDF plot is interpreted as the proportion of population or probability with value less than the corresponding x-value. For an environmental dataset, the y-values can be considered as percentiles of a dataset. Figure 53-1 compares the distributions of concentrations (represented by cumulative probability or percentiles) between 2002 to 2005 SSAP samples and 2016 OM&M samples. At any given percentile (y-value), the concentration (x-value) from the 2002 to 2005 SSAP dataset is always greater than that from the 2016 OM&M samples. The data indicate that spatially comparable concentrations in non-dredged areas of RS 1 have declined between the 2002-2005 period and 2016, with a median (50^{th} percentile) value decreased from 5.4 mg/kg to 2.3 mg/kg. The geometric mean has decreased from 4.3 mg/kg to 1.7 mg/kg, representing a two and a half-fold decrease in TPCB concentration. The arithmetic mean has decreased from 8.4 mg/kg to 4.1 mg/kg. These results clearly indicate a reduction in TPCB concentration in RS 1 surficial sediments within the past thirteen years. Based on the geometric mean results, over the course of thirteen years, there has been a yearly 7 percent decrease in the concentration of TPCBs in the 0-2 inch interval of the non-dredged areas.

Unlike RS 1, which was extensively sampled outside the dredged areas, RS 2 and RS 3 cannot be effectively compared using the method applied by the commenter. The RS 2 and RS 3 sample locations in the 2003 data set are focused primarily on the areas surrounding the CUs and do not provide a spatially representative sample of the non-dredged river areas.

Using the side-scan sonar surveys of sediment texture across all three river sections, EPA integrated TPCB concentrations based on cohesive and non-cohesive sediment textures to estimate the change in TPCB concentration in each river section. This more rigorous assessment of the data can be found in Appendix 4, Table A4-5 of the FYR report. The table shows the area-weighted average concentration in RS 1 has decreased from 4.15 mg/kg to 1.7 mg/kg. This is equivalent to the two and a half-fold reduction in TPCB concentration seen in the geometric mean.

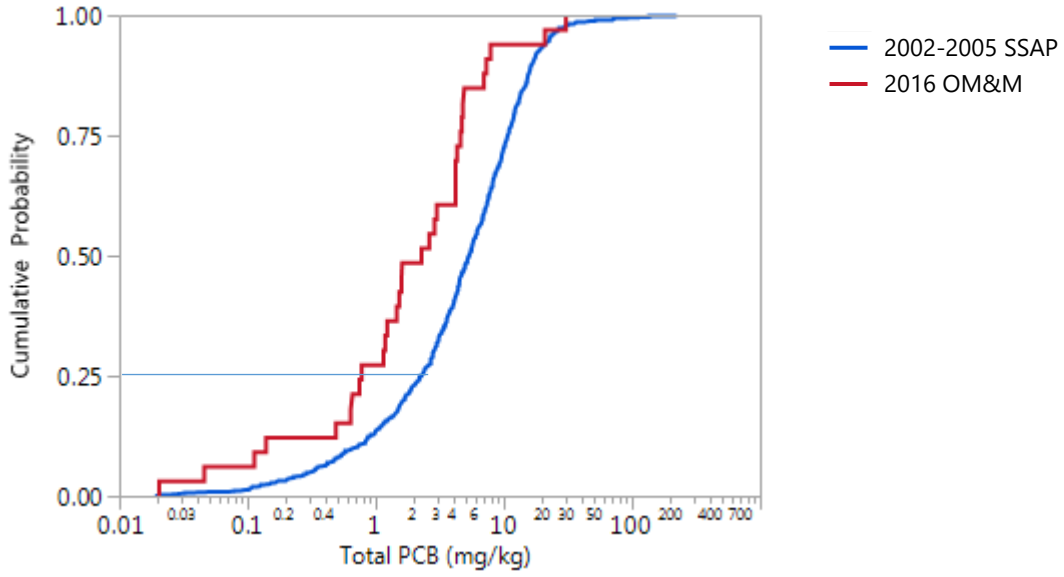


Figure 53-1 Cumulative Distribution Function (CDF) Plot for 0-2 inch Sediment Samples for RS 1 In Non-dredged Areas

3.3.25 Comment 56: Sediment concentrations remaining in the river are higher than anticipated and sediment concentration rate of decline is overestimated

Comment

Commenters state that data collected after 2002 show higher levels of surface sediment contamination than anticipated in portions of RS 2 and 3 that were not targeted for dredging and that estimated post-dredging surface PCBs are ~5X higher than expected in RS 2 and RS 3 and ~3X higher than expected in RS 1. Commenters argue this increases the uncertainty as to whether all remedial action objectives, including target PCB levels in fish, will be fully achieved. Commenters also state that the ROD expected that the target cleanup levels for RS 2 and RS 3 would result in those river sections having post-dredging surface sediment PCB concentrations comparable to those in RS 1.

Commenters indicated that it was an error to try to anticipate or estimate the rate of post-dredging recovery in surface sediment concentrations based upon the rate of improvement before the remedy, as there has been fundamental changes in the system due to source control before dredging and sediment removal/backfilling as part of the dredging.

Commenters indicate surface sediment TPCB concentrations show a general improvement between SSAP (2002 to 2005) and OM&M (2016) datasets. However, when the SSAP dataset is separated into dredging and non-dredging area sample sets, lesser degrees of improvement in non-dredging areas are indicated, with non-dredging areas in RS 1 showing very little or no improvement.

Several commenters stated that other studies indisputably show PCB concentrations in river sediment are two to three times higher than estimated at the time the cleanup remedy was selected and draw conclusions that additional work in the upper Hudson is essential.

Response

EPA acknowledges that sediment PCB data from the 2003 pre-design sampling program had higher concentrations than average concentrations observed in the previous sampling program in 1998 and that the average concentrations were higher than modeled predictions. EPA is also aware that these results inject a certain level of uncertainty into the remedial process, but it is important to note that a very large percentage of the surface area in RS 1 was remediated and the change in surface concentrations in dredged and un-dredged areas combined for RS 1 and RS 3 met expectations. The change in surface concentrations in RS 2 was less than expected. EPA continues to monitor all three river sections, including any areas that have higher than expected surface concentrations. Relative change as opposed to absolute concentrations is the primary consideration related to predicted change in PCB concentrations in biota. This relationship is fully embedded in the basic physics and site conceptual model regarding the Hudson River and other contaminated sediment sites nationally. EPA also recognizes that the time for PCBs in fish tissue to reach target concentrations is a function of both the absolute post-dredging concentrations and the natural recovery rate. However, because the negative short-term effects of the remedy may remain in effect for some period of time, it will take some time for the near-term post-dredging PCB concentrations in fish tissue to stabilize.

3.3.26 Comment 57: Analysis of sediment PCB data outside the dredge areas miscalculated the concentration and mass located in these areas

Comment

Commenters indicated EPA has not yet made a quantitative assessment of the PCB mass remaining in non-dredged areas as compared to previous estimates presented in the 2002 ROD. Commenters stated this assessment was important in understanding long-term performance of the remedy. Commenters presented reservations regarding how estimates of the mass of PCBs in non-dredged areas of the Upper Hudson River were calculated. Specifically, commenters took issue with the methodology used to estimate the mass in "unclassified" areas of RS 3, how core MPA values were aggregated spatially to derive an areal estimate of MPA for each River Section or each sediment type within RS 3, and the overall estimate of mass remaining. An alternative estimate of the mass remaining outside the dredged areas was presented by GE.

Response

In consideration of the comments and alternative estimate received, EPA developed a modified method for estimating the mass of PCBs in the “unclassified” sediment of RS 3, which utilizes the cores collected in the “unclassified” sediment and improves upon the original methodology presented in the FYR report.

EPA compared its methodology for estimating mass outside dredged areas with GE's methodology, and has identified two important factors that result in a substantive difference between GE's and EPA's estimates. Depending on whether a core recovery correction is applied to sediment core data, EPA's estimates of total PCB inventory remaining can be between approximately 10 percent and 50 percent more than GE's estimates (*i.e.,* 50 percent more when the core recovery correction is applied, 10 percent more when it is not). The issue of including or omitting recovery correction of core segment lengths highlights some of the uncertainty in estimating the mass of PCBs remaining in the Upper Hudson River. Second, the use of different spatial aggregation techniques for MPA values also introduces some uncertainty and results in differences between estimates of mass remaining. EPA's analysis indicated that the remaining 10 percent difference between EPA's and GE's estimates (*i.e.,* when a core recovery correction is not applied to EPA's estimate) largely arose from the differences in spatial aggregation. It may not be possible to definitively conclude that one spatial aggregation method is preferable to another. Thus, the Final FYR has been revised from the Proposed FYR to present the likely range of PCB inventory remaining. Based on EPA's analysis, 40,000 kg of PCB inventory is likely a best estimate while 60,000 kg of PCB inventory is likely an upper bound estimate on PCB inventory remaining in the Upper Hudson River.

3.3.27 Comment 60: Data incompatibilities Lead to Errors in Interpretations

Comment

Various commenters identified several challenges with data, including conflation of natural recovery and source control efforts prior to about 1995, variation in sampling equipment and analytical methods, changes in sample preparation and handling techniques for fish, and temporal changes in lipid content that may be conflated with temporal changes in PCBs in several species and location combinations. One commenter argued that EPA is making a fundamental error - assuming that all of the changes in sediment PCB concentrations are the result of natural recovery. The commenter also pointed out that without taking the impact of source control into account, all of EPA's estimates of rates of natural recovery represent overestimations and upper bounds; recovery rates could be no higher, but the recovery due to natural processes are very likely much less. Another commenter reinforced this idea stating that the MNA period includes major source control. It was also noted that the rate of post-remedial recovery could not be estimated from the recovery rate estimated prior to the remedy. One commenter further suggested that the natural recovery rate prior to the remedy is known to be 1.3 percent in sediment based apparently on a partial reading of Field et al. (2016). Other commenters suggested that apparently larger amounts of PCB mass in the river than anticipated will necessarily delay fish tissue concentrations reaching targets within time frames anticipated in the ROD.

Response

EPA agrees that the variety of historical sediment PCB data present challenges for developing empirically-based estimates of natural recovery rates prior to and after completion of active remediation in the Upper Hudson River. Many of the challenges identified by commenters were also pointed out by EPA in the FYR report and its appendices. In particular, EPA went to great lengths to analyze data in multiple ways to reduce adverse effects of several of the factors

identified by commenters, and also discussed uncertainties in the recovery rate estimates presented. Some of the challenges are further discussed below; however, it is important to emphasize that these challenges are not unique to the Hudson River. In, fact some may be the inadvertent, but inevitable, consequence of the development of data quality objectives at different stages of the remedial investigation process. In the early phases of an investigation, analytical methods are selected and sampling programs are largely designed to identify worst case situations with limited data collection. These efforts are largely forensic and are not designed for comparison with future data sets to understand mechanisms of recovery. As sites evolve from forensics to site characterization and feasibility analysis, objectives evolve and existing data are invariably added to in efforts to fill spatial and temporal gaps. As risk evaluations evolve, some early actions for source control are initiated, and investigatory data begins to be replaced with more representative sampling efforts as time progresses toward remedial design. At this point in time the need for understanding of current and future recovery rates increases and mechanistic models and empirical evaluations are embarked upon. Unfortunately, when interest turns to understanding recovery rates, the available data have been developed for a variety of differing objectives presenting the kinds of difficulties identified by commenters and discussed at length by EPA.

The commenter's statement that the recovery rate in Upper Hudson River sediment was 1.3 percent during the MNA period appears to be a reference to Field, et al. (2016), who reported such a rate. EPA disagrees with the reviewer that the recovery rate is known. In the FYR report, EPA discusses several issues that complicate efforts to reliably estimate recovery rates including differing spatial layouts of samples and sediment collection equipment. Field et al. also pointed out that lack of unbiased estimates of mean surface PCB concentration at multiple points in time limited potential to reliably estimate the natural recovery rate. This is consistent with how EPA has discussed empirical estimates of the recovery rate in sediment, which support the conclusion that further monitoring is needed to understand post-dredging recovery rates and expected time for contaminated media to reach targets. It should also be noted that this issue is not unique to the Hudson River PCBs Superfund site. At many sites nationally, sampling efforts are focused more on characterization of nature and extent of contamination in sediment as opposed to estimation of recovery rates. Generally, monitoring of fish tissue and water are relied upon more heavily for understanding recovery rates.

The anticipated recovery rate in fish water and sediment was expected to be approximately 8 percent per year, although little is known about post-dredging recovery rates because the scale of the remedial action is nearly unique. There are few examples of remedial actions of the magnitude of the Hudson River project where sufficient time has passed since remediation to develop a robust understanding of how sediment contaminant concentrations recover after such an action. Because the post-dredging recovery is not fully understood, it is difficult to make definitive predictions of the time to reach specific recovery goals. To rectify this, the remedy was designed and constructed with the understanding that the ultimate risk-based goals would be reached over a period of time and that, after completion of the dredging, remedy effectiveness (i.e., risk reduction) would be evaluated through long term monitoring. Through long term monitoring, additional data will be generated which will allow rigorous estimation of recovery rates and, as these data are developed, understanding of remedial effectiveness will be refined. With this refinement, EPA will be able to determine if and when additional investigation may be needed.

EPA undertook an in-depth evaluation to understand recovery rates based on fish, water and sediment data prior to implementation of the remedy. With these rigorous efforts to account for the factors identified by commenters, recovery rate estimates generally span a relatively wide range of values, but the anticipated rate of 8 percent per year is within the range of uncertainties of these estimates. EPA disagrees with commenters' assertion that existing data are adequate to conclude that the remedy has failed and believes that it would be premature to change course with the level of uncertainty around post-remedial recovery rates. EPA agrees with the commenter's suggestions that monitoring methods and operating procedures need to be decided and standardized throughout the monitoring period in order to minimize the uncertainties that have complicated estimating rates in the pre-remedial period.

Regarding unanticipated amounts of PCB mass in the dredge areas, it cannot be assumed that additional PCB mass is necessarily an indicator of higher exposures for biota in the post-dredging period. Generally fish tissue concentrations are proportional to surface sediment PCB concentrations as opposed to PCB mass as the reviewer suggests. EPA disagrees with the commenter because the dredging portion of the remedy achieved the approximate percentage reductions in average surface sediment PCB concentrations, the primary driver of percentage change in water and tissue PCBs.

3.4 Remedy

This section includes comments and responses on topics such as requests for more dredging, modifications to the remedy, attainment of the targets and goals, and the time for recovery of the river.

3.4.1 Comment 10: EPA must address whether the targets for improvements in water quality have or will be met

Comment

One commenter states that available post-dredging data show that the improvement in water column PCB concentrations diminishes downstream of Thompson Island Dam (TID) and that, because of limited data, it is unclear whether the ROD targets for PCB mass transport reductions will be achieved within anticipated timeframes. Another commenter indicated that the 2016 water column PCB data and EPA's estimated 10 percent per year recovery rate suggest that the freshwater aquatic life criterion of 14 ng/L will be met sooner than originally estimated by EPA.

Response

Appendix 1 of the FYR report states that EPA expects the water quality criterion for aquatic life to be met consistently within several decades. Given the short time period since the end of dredging, there is limited water column data available to determine water column concentration trends at this time. Also, the effects from future flows and upstream loads provide some uncertainty in terms of future water column concentrations. Therefore, it is not possible to project an expected date of compliance with this criterion with a high degree of precision using currently available post-dredging trends. Uncertainty in the time to meet the aquatic life standard will be reduced by the continuing collection of post-dredging water column data to support the development of post-

dredging water column decay rate estimates. It is worth noting that during 2016 water column concentrations were generally below the 14 ng/L threshold. However, meeting this criterion is also challenging due to higher water column concentrations during high flow events in the river.

EPA will continue to evaluate post dredging PCB transport reductions from the upper to the lower river. This evaluation will include consideration of PCB transport during high flow events in the river. There have been minimal high flow events since dredging ended, so additional data collection is needed to inform estimation of the impact of these events on future PCB loading trends.

3.4.2 Comment 22: EPA should track the attainment of the interim fish tissue targets of 0.4 mg/kg and 0.2 mg/kg PCB as it assesses the success of the remedy

Comment

EPA appears to be abandoning the ROD's interim remedial targets for fish PCB concentrations that formed the basis for justifying the dredging remedy, and in doing so is arbitrarily ignoring critical questions A & B in its own FYR guidance. In the FYR report, EPA is now stating that the remedy will not be protective until the ultimate remedial goal of 0.05 parts per million PCB in fish is reached. EPA should take the actions necessary to ensure that the remedy rapidly achieves the interim targets identified in the ROD – specifically, achieving the first interim target (0.4 mg/kg PCB in average fish concentrations) within five years after dredging, and the second interim target (0.2 mg/kg) in sixteen years.

Response

Remedy protectiveness was evaluated in the ROD by comparing predicted fish tissue concentration trajectories over time under different remedial alternatives. As noted in the ROD, different target levels will be achieved at different times depending on the species and river section (or river pool) given species-specific foraging strategies and life histories. Interim target levels and the final remedial goal were developed for the ROD and continue to be evaluated, as mentioned in the FYR report and its appendices. The first interim target level (0.4 mg/kg) has been achieved in about 30 percent of the long-term Lower Hudson species-location combinations (the species collected at a particular monitoring stations *e.g.,* black bass collected at Catskill), based on the average $TPCB_{HE}$ levels from 2009 to 2016 (Table 22-1a Summary column). In addition, average $TPCB_{HE}$ levels in yellow perch in the Lower Hudson were near or below the 0.2 mg/kg interim target from 2009 to 2016 and, with a $TPCB_{HE}$ of 0.053 mg/kg, essentially achieved the 0.05 mg/kg remediation goal in the Albany area in 2016 (Table 22-1a). In the Upper Hudson, primarily in RS 3, average $TPCB_{HE}$ levels in yellow perch were near or below the 0.4 mg/kg threshold in 2016 (Table 22-2a). Concentrations for other species are farther away from the interim targets, as noted in Tables 22-1a and 22-2a attached to this response. The above results are based on $TPCB_{HE}$ concentrations. The $TPCB_{Aroclor}$ results are essentially the same and are provided in Tables 22-1b and 22-2b.

EPA did not focus its FYR on attainment of the interim target levels. As noted in the FYR report (Section 5.1), the post-dredging data are too limited to confirm attainment, and too little time has

elapsed since the dredging was completed. EPA anticipates that as many as eight or more years of post-dredging fish tissue data will be needed to establish statistically relevant rates of decline in post-dredging fish tissue PCB levels. Therefore, the FYR primarily focused on the documented achievements of the remedy, such as PCB mass removed, reduction in surface sediment concentration and control of the PCB loads to the Lower Hudson. Given that the FYR occurred so close to the completion of dredging, it is not yet possible to accurately assess the long-term improvements in fish tissue.

In the ROD, EPA stated that the remediation goal for protection of human health with regard to fish consumption was attainment of 0.05 mg/kg in fish fillet (species-weighted average concentration) throughout the Hudson, but primarily in fish of the Upper Hudson. As indicated in the ROD, the interim target levels of 0.4 and 0.2 mg/kg are not remediation goals but interim targets to be achieved along the way to the final remediation goal, the achievement of which could be used by the State as a basis to reevaluate the fish advisories and potentially relax some fishing restrictions. It is true that modeling conducted by EPA and discussed in the ROD projected that the 0.4 and 0.2 mg/kg interim targets would be achieved within 5 and 16 years, respectively. However, actual conditions during dredging did not, and were not expected to, match up in every way with conditions as understood when the ROD modeling was conducted. Therefore, direct comparisons of observed fish tissue concentrations to ROD forecasts need to be carefully considered. It should also be noted that dredging started later than the model considered. Also short-term and localized increases and subsequent decreases in fish tissue PCB concentrations were anticipated in the FS and ROD (and observed between 2009 and 2016) were not directly reflected in the long-term fish tissue forecasts presented in support of remedy selection. For these reasons, direct comparisons of observed data to ROD forecasts need to be done carefully with the various factors taken into consideration.

EPA will continue to use the interim targets to track progress toward the remediation goal. At this time, EPA does not have sufficient data to determine if the interim targets will be achieved within EPA's expectations. As stated above, as EPA obtains more years of fish data, the Agency will be better able to assess progress toward the interim targets and the final remediation goal.

Table 22-1a
Comparison of Lower Hudson PCB Concentrations in Fish With Interim Targets and Remedial Goals
Total PCB - Homologue Equivalent Basis

		2009-2015			Post-dredging 2016			Summary*	
RM	Species	No. of samples	Average (mg/kg-ww)	Median (mg/kg-ww)	No. of samples	Average (mg/kg-ww)	Median (mg/kg-ww)	Average (mg/kg-ww)	Median (mg/kg-ww)
152	Pumpkinseed	125	0.8	0.8	20	0.5	0.4		
	Smallmouth Bass	**26**	**1.8**	**2.1**	**19**	**1.4**	**1.5**		
	Spottail Shiner	46	1.0	0.8	9	0.2	0.3		
	Striped Bass	**279**	**2.0**	**1.4**	**20**	**0.3**	**0.2**		
	White Perch	**26**	**0.9**	**0.9**	**12**	**1.2**	**1.1**		
	Yellow Perch	**14**	**0.3**	**0.2**	**8**	**0.05**	**0.03**		
	White Catfish	**6**	**2.5**	**1.9**					
	Channel Catfish	**134**	**2.7**	**2.6**	**20**	**2.0**	**1.9**		
113	**Brown Bullhead**	**84**	**0.3**	**0.3**	**19**	**0.4**	**0.4**		
	Largemouth Bass	**14**	**0.9**	**0.7**					
	Pumpkinseed	49	0.6	0.6					
	Smallmouth Bass	**64**	**0.7**	**0.6**					
	Striped Bass	**145**	**0.5**	**0.3**	**20**	**0.61**	**0.71**		
	White Perch	**30**	**0.6**	**0.5**					
	Yellow Perch	**30**	**0.3**	**0.2**					
	Channel Catfish	**20**	**2.5**	**1.7**					
90	**Brown Bullhead**	**22**	**0.6**	**0.5**					
	Largemouth Bass	**5**	**0.3**	**0.3**					
	Pumpkinseed	39	1.1	1.0					
	Smallmouth Bass	**15**	**0.3**	**0.3**					
	Striped Bass	**124**	**0.6**	**0.4**					
	White Perch	**20**	**1.2**	**1.0**					
	Yellow Perch	**20**	**0.2**	**0.2**					
	Channel Catfish	**25**	**3.0**	**2.2**					
50	**Striped Bass**	**123**	**0.5**	**0.4**					
	No. of RM-species pairs		25	25		9	9	25	25
	Between 0.4 and 0.2 mg/kg-ww		6	9		3	2	7	8
	Between 0.2 and 0.05 mg/kg-ww		0	0		1	1	1	1
	Below 0.05 mg/kg-ww		0	0		0	1	0	1

Notes:
Value less than 0.4 mg/kg interim target but greater than 0.2 mg/kg interim target
Value less than 0.2 mg/kg interim target but greater than 0.05 mg/kg remedial goal
Value less than 0.05 mg/kg remedial goal
Sportfish shown in **bold.**
* Column integrates the most recent data for each RM-species pair.
White catfish and channel catfish were not presented in the Appendix 3.

Table 22-1b
Comparison of Lower Hudson PCB Concentrations in Fish With Interim Targets and Remedial Goals
Total PCB - Aroclor Basis

		2009-2015			Post-dredging 2016			Summary*	
RM	Species	No. of samples	Average (mg/kg-ww)	Median (mg/kg-ww)	No. of samples	Average (mg/kg-ww)	Median (mg/kg-ww)	Average (mg/kg-ww)	Median (mg/kg-ww)
152	Pumpkinseed	125	1.0	1.0	20	0.5	0.5		
	Smallmouth Bass	**26**	**2.3**	**2.6**	**19**	**1.7**	**1.7**		
	Spottail Shiner	46	1.3	1.1	9	0.3	0.3		
	Striped Bass	**279**	**1.8**	**1.3**	**20**	**0.3**	**0.2**		
	White Perch	**26**	**1.2**	**1.1**	**12**	**1.5**	**1.3**		
	Yellow Perch	**14**	**0.4**	**0.3**	**8**	**0.1**	**0.0**		
	White Catfish	**6**	**3.1**	**2.4**					
	Channel Catfish	**134**	**3.4**	**3.3**	**20**	**2.3**	**2.2**		
113	**Brown Bullhead**	**84**	**0.3**	**0.3**	**19**	**0.4**	**0.4**		
	Largemouth Bass	14	**1.0**	**0.7**					
	Pumpkinseed	49	0.5	0.5					
	Smallmouth Bass	**64**	**0.7**	**0.6**					
	Striped Bass	**145**	**0.4**	**0.3**	**20**	**0.7**	**0.8**		
	White Perch	**30**	**0.5**	**0.4**					
	Yellow Perch	**30**	**0.3**	**0.2**					
	Channel Catfish	**20**	**2.1**	**1.5**					
90	**Brown Bullhead**	**22**	**0.5**	**0.4**					
	Largemouth Bass	**5**	**0.3**	**0.2**					
	Pumpkinseed	39	0.9	0.9					
	Smallmouth Bass	**15**	**0.3**	**0.3**					
	Striped Bass	**124**	**0.5**	**0.3**					
	White Perch	**20**	**1.0**	**0.8**					
	Yellow Perch	**20**	**0.2**	**0.2**					
	Channel Catfish	**25**	**2.6**	**1.9**					
50	**Striped Bass**	**123**	**0.5**	**0.3**					
	No. of RM-species pairs		25	25		9	9	25	25
	Between 0.4 and 0.2 mg/kg-ww		5	8		2	2	5	7
	Between 0.2 and 0.05 mg/kg-ww		1	2		1	0	2	2
	Below 0.05 mg/kg-ww		0	0		0	1	0	1

Notes:
Value less than 0.4 mg/kg interim target but greater than 0.2 mg/kg interim target
Value less than 0.2 mg/kg interim target but greater than 0.05 mg/kg remedial goal
Value less than 0.05 mg/kg remedial goal
Sportfish shown in **bold.**
* Column integrates the most recent data for each RM-species pair.
White catfish and channel catfish were not presented in the Appendix 3.

Table 22-2a
Comparison of Upper Hudson PCB Concentrations in Fish With Interim Targets and Remedial Goals
Total PCB - Homologue Equivalent Basis

Area	Species	Post-dredging 2016 No. of samples	Post-dredging 2016 Average (mg/kg-ww)	Post-dredging 2016 Median (mg/kg-ww)
RS1	**Brown Bullhead**	**30**	**1.4**	**0.9**
	Largemouth Bass	**16**	**1.0**	**0.5**
	Pumpkinseed	30	1.0	0.8
	Smallmouth Bass	**14**	**1.7**	**1.0**
	Spottail Shiner	7	1.2	1.0
	Yellow Perch	**30**	**0.4**	**0.3**
RS2	**Brown Bullhead**	**24**	**1.7**	**1.6**
	Largemouth Bass	**10**	**0.6**	**0.6**
	Pumpkinseed	25	2.6	2.0
	Smallmouth Bass	**15**	**2.5**	**2.2**
	Spottail Shiner	5	3.1	3.3
	Yellow Perch	**25**	**0.5**	**0.4**
RS3	**Brown Bullhead**	**29**	**1.0**	**0.9**
	Largemouth Bass	**26**	**1.2**	**1.0**
	Pumpkinseed	30	1.0	1.0
	Smallmouth Bass	**4**	**2.0**	**1.7**
	Spottail Shiner	5	2.4	2.4
	Yellow Perch	**30**	**0.3**	**0.3**
	No. of Area-Species pairs		18	18
	Between 0.4 and 0.2 mg/kg-ww		1	2
	Between 0.2 and 0.05 mg/kg-ww		0	0
	Below 0.05 mg/kg-ww		0	0

Notes:

Value less than 0.4 mg/kg interim target but greater than 0.2 mg/kg interim target

Value less than 0.2 mg/kg interim target but greater than 0.05 mg/kg remedial goal

Value less than 0.05 mg/kg remedial goal

Sportfish shown in **bold.**

3.4.3 Comment 33: Habitat reconstruction did not achieve the project objectives.

Comment

Several commenters, including the NYSDEC, indicated that EPA has not required GE to perform enough habitat reconstruction to allow for the work to achieve the habitat reconstruction goals. Comments state that habitat reconstruction has not resulted in repopulation of species within the parameters that the ROD anticipated. Other commenters stated that habitat reconstruction work is not relevant to the protectiveness determination in the FYR.

Response

The success of the habitat reconstruction work is relevant to Question A of the FYR (i.e., whether the remedy is functioning as intended by the ROD). The backfill and cap materials play dual roles in isolating residual contamination (and therefore reducing exposures of fish to PCBs) and as an integral habitat reconstruction component. The 2002 ROD indicates that the habitat reconstruction program was anticipated to include the following dimensions:

- Backfill of dredged areas with approximately one foot of clean material to isolate residual PCB contamination and to expedite habitat recovery, where appropriate;
- Various measures to address the anticipated short-term impacts to floodplains, wetlands, and SAV communities (including minimizing impacts to wetlands, controlling resuspension, stabilizing shorelines, and reconstructing habitats impacted by implementation in an adaptive management context); and
- Monitoring the restoration of aquatic vegetation until benchmark followed by success criteria have been achieved.

Remedial activities were anticipated to result in short-term temporary impacts to aquatic and wildlife habitat of the Upper Hudson River (UHR). As discussed in Appendix A to the ROD (Statement of Findings on Floodplains and Wetlands) implementation was anticipated to "remove considerably more material from the river bottom than it [would] place as fill." For these reasons and where appropriate, habitat replacement/backfilling measures were implemented, and monitoring programs have been established to verify the attainment of the habitat replacement objectives.

As discussed in Section 5.1.1.2.3 (Habitat Reconstruction) of the FYR report, and consistent with the 2002 ROD, project habitat reconstruction activities began and were implemented in an adaptive management framework to replace SAV communities, wetlands, and to stabilize river bank habitat and shorelines. These activities have included:

- Backfilling of dredged areas with approximately 1.4 million cubic yards of backfill and cap materials, including approximately 1 foot of clean backfill material to isolate residual PCB contamination and support re-establishment of designated habitats;

- The installation of approximately 1.5 million individual riverine fringing wetland and SAV plants (of which approximately 65 percent were locally harvested) and approximately 1,700 pounds of seed mixes over approximately 29 acres of wetland and 39 acres of submerged aquatic habitat reconstruction areas to help expedite habitat recovery;
- The installation of approximately 13.5 miles of various shoreline stabilization measures; and
- A monitoring program to facilitate implementation of habitat reconstruction and shoreline stabilization during and following construction.

EPA does not agree that habitat reconstruction is not achieving project objectives. While remediation goals specific to vegetation replacement requirements may not have been detailed in the ROD, the placement of fill and backfill materials to isolate residual contamination and/or serve as an attenuating layer (including layers to prevent bioturbation or inhibit other disturbance to cap materials and to serve as a clean habitat for the benthic organism repopulation) was anticipated and discussed. Such measures were designed, adapted to accommodate river bottom and operation considerations, and implemented during construction. Where appropriate during the remedial action, backfill and caps (including habitat backfill and caps topped with additional backfill layers) were installed in accordance with project requirements and to performance standards. Details regarding specific backfill and cap installations or habitat reconstruction areas can be found in the CU Form 2 and Form 3 packages that were submitted by GE and reviewed by EPA. Monitoring of these caps, backfill surfaces, and shorelines continues under the OM&M program.

Furthermore, EPA disagrees with other reviewers who commented that habitat reconstruction has not resulted in repopulation of species within the parameters that the ROD anticipated. As discussed in the ROD, habitat reconstruction to reduce impacts to wetlands and SAV communities was designed and implemented to reflect pre-dredge and existing wetland and submerged aquatic vegetation communities. Specifically, and as outlined in the 2003 Habitat Delineation and Assessment Work Plan, the primary goal of the habitat reconstruction program is to replace the functions of the habitats of the UHR to within the range of functions found in similar physical settings in the UHR. Plant species installed as live plants and seed mixes were based on extensive pre-dredge vegetation monitoring data collected between 2003 and 2008. Monitoring of reconstructed habitats, as described in the Phase 1 and Phase 2 Adaptive Management Plans and annual Operation, Maintenance, and Monitoring Plans and implemented through the OM&M program is on-going and is currently in the benchmark monitoring phase. This benchmark phase of monitoring includes evaluating individual reconstruction areas using quantitative but non-destructive (not harvesting) measures. The purpose of benchmark monitoring is to help areas get on trajectory to success by measuring their progress and evaluating the need for potential response actions. Benchmark monitoring can last for up to 6 or more years. Response activities such as replanting, reseeding, removal of loose coir fabric, and invasive species control have been implemented in past years and are also planned for 2019.

The next phase of habitat monitoring is the Success Criteria phase in which reconstructed SAV and wetlands are grouped by reach or an alternate spatial scale. These groups of reconstructed SAV and wetlands are then assessed using quantitative comparisons to reference areas to

determine if the habitat reconstruction areas have been successfully re-established. This Success Criteria phase of monitoring is anticipated to last for approximately another 2 to 5 years beyond the benchmark phase. Because reconstruction areas are grouped together for this phase of the evaluation, many individual areas may be under observation for an extended period of time (7 to 10 years). The initial habitat reconstruction effort has resulted in the installation of the species and quantities called for in the designs and in the areas dredged. Habitat survey results regarding species composition and overall coverage are encouraging. However, it is too early in the monitoring process to determine whether or not the overall project habitat reconstruction goals have been met. Monitoring and adaptive management will continue under the OM&M program. EPA will continue to coordinate with NYSDEC regarding restoration activities.

3.4.4 Comment 38: EPA should compare data to ROD forecast regardless of implementation

Comment

Commenters stated that EPA has rejected attempts to compare post-dredging data to 2002 ROD forecasts because of the operational changes during dredging.

Response

EPA does not reject such comparisons and has made explicit comparisons in Appendix 1 and Appendix 3 of the FYR report between ROD expectations based on EPA's models and post-dredging data for water-column and fish tissue PCBs. EPA does cite differences between anticipated and actual dredging operations in interpreting those comparisons: fish-tissue data from the period immediately after dredging reflect a transition from conditions experienced during dredging, which differed from anticipated conditions as described in Appendix 8 of the FYR report. Model-data comparisons for fish tissue are presented in Appendix 3 of the FYR report (Figure A3-19). Figure A3-19 shows a comparison between species-weighted model results (Model Mean) for the selected remedy for the year 2010 (projected in the ROD to be the first post-dredging year) and observed monitoring data for the actual first post-dredging year (2016) (Data Mean). These results show that the model-anticipated concentrations in the first year post-dredging are similar to those observed. As stated in Appendix 3 of the FYR report, ongoing post-dredging monitoring over as many as eight or more years is needed to draw a scientifically reliable conclusion. Nonetheless, these early data are encouraging and, when compared to model predictions, indicate that the model has performed as expected.

3.4.5 Comment 42: The comprehensive sediment sampling data from the SSAP should be treated as the baseline for evaluating recovery of PCB-contaminated cohesive sediment in non-dredged areas

Comment

A number of comments were provided regarding the comparison of various surface sediment datasets in Appendix 4 of the FYR report. Specifically, commenters stated that comparing the 2002 to 2005 SSAP data with the 2011 to 2013 Downstream Deposition Study (DDS) and 2016

OM&M dataset was not appropriate, as the DDS sampling did not target highly contaminated areas and thus, had very limited data collected from the highly contaminated cohesive sediments surrounding the dredge areas, and DDS sampling only sampled the top 2 inches and not the top 12 inches of surface sediment used to define dredge areas. Commenters also stated that the surface sediment PCB concentrations for cohesive sediment in RS 2 and RS 3 estimated from the DDS sediment survey and 2016 sediment monitoring survey should be considered to be biased low. Further, commenters did not agree with how surface sediment texture was classified in RS 3. A commenter stated that the predictive model used to classify sediment texture in 2016 OM&M samples in RS 3 incorrectly categorized cohesive sediments. They commented that of the cohesive sediments in RS 3 that were identified by the model, only approximately 1/3 of samples contained at least 25 percent fine-grained sediments and more than 20 percent of the samples were described by field samplers as "coarse" or "rock". Finally, they commented that the congener-based M1668 produced significantly higher PCB concentrations than Aroclor-based PCB analysis method (M8082).

Response

EPA disagrees with the commenter's assertion that the SSAP dataset should not be compared to the DDS sampling program. First, the evaluation carried out in Appendix 4 of the FYR report with SSAP and DDS (and OM&M) samples only included the 0 to 2-inch sample depth interval, to avoid comparing PCB concentrations at different depths. Second, while the DDS program did not specifically target highly contaminated cohesive sediments surrounding dredging target areas, in RS 2 the median PCB concentration of the SSAP samples targeted for re-occupation by the DDS cores was significantly higher than the overall median PCB concentration of the SSAP samples. In RS 3, the median PCB concentration of the SSAP locations targeted for re-occupation by the DDS samples was not statistically different than the median PCB concentration of all SSAP cores collected within RS 3. Thus, the commenter's claim that DDS samples did not target highly contaminated areas, and thus are not comparable to SSAP samples, is unfounded.

The 2016 OM&M sampling program was designed in an unbiased fashion in order to detect long-term changes in surface sediment concentrations. Unlike the SSAP sampling program, the OM&M does not target specific areas, such as locations in close vicinity to dredging target areas. EPA acknowledges that the biased nature[11] of the SSAP program, particularly in RS 3 where a large number of samples were located in the vicinity of dredged areas, versus the unbiased design of the OM&M sampling program, creates a challenge when comparing PCB concentrations between the two datasets. However, the OM&M program is specifically designed to alleviate issues that arose when attempting to compare historical sediment datasets collected within the Upper Hudson River. Thus, in the future, the OM&M data will provide a comprehensive, "apples to apples" dataset that will allow EPA to detect changes in surface sediment concentrations through time.

EPA disagrees that the 2011 to 2013 DDS estimates of RS 2 and RS 3 surface sediment PCB concentrations in cohesive sediments are biased low. In RS 2 outside the dredged area, the 95% lower confidence limit (LCL) of SSAP locations targeted for DDS re-occupation was greater than

[11] EPA notes that the sampling design bias was purposefully implemented by GE under EPA's direction to identify and delineate areas of contaminated sediment. As such the SSAP sampling design was not intended to provide average sediment concentrations, as was the 2016 sampling program.

the 95% upper confidence limit (UCL) for the full set of RS 2 SSAP locations (Field, Kern, Rosman, 2016, Figure 13). This indicates that, in fact, the targeted SSAP locations for DDS were representative of relatively high SSAP concentrations. As such, it would be expected that resampling of the targeted SSAP locations during the DDS program would produce lower PCB concentrations as a result of the Central Tendency Theorem (commonly referred to as "regression to the mean," or median in the case of a log-normally distributed dataset). However, the median of the DDS locations did not simply regress back toward the median of the entire SSAP data set, Rather, the DDS locations exhibited a 95% UCL that was lower than the 95% LCL for the entire population of SSAP cores in RS 2. This indicates that the median of the DDS locations was less than the median of the corresponding targeted SSAP locations (as would be expected), but, more to the point, that the median PCB concentration of the DDS locations was significantly lower than the median of the entire SSAP core dataset in RS 2. This clearly indicates that cohesive surface sediment outside CUs exhibited improved conditions (*i.e.*, reduction in PCB concentration) between collection of the SSAP and DDS data.

In RS 3 outside the dredged area, the 95% UCL and LCL of PCB concentrations of the SSAP locations that were targeted for re-occupation by DDS cores bracketed the 95% UCL and LCL of PCB concentrations of all SSAP locations in RS 3, indicating that the targeted SSAP locations were representative of the distribution of all SSAP locations in RS 3, implying a fair comparison between the datasets (Field, Kern, Rosman, 2016, Figure 14). As with RS 2, the observation that the 95% UCL of the DDS cores was lower than the 95% LCL of both the targeted SSAP locations and all SSAP locations in RS 3 indicates that RS 3 cohesive surface sediments outside CUs also exhibited improved conditions (*i.e.*, reductions in PCB concentrations) between the times of collection of the SSAP and DDS data.

Thus, EPA's analysis indicates that PCB concentrations of DDS samples collected in RS 2 and RS 3 should not be considered biased low. Instead, the lower median PCB concentration of DDS samples compared with both the re-occupied SSAP cores and all SSAP cores in RS 2 and RS 3 indicates recovery of surface sediment.

With regard to classification of sediment type in RS 3 based on a predictive model, as was done for Appendix 4 of the FYR report, we disagree that the use of the model adds uncertainty to the classification of sediment texture. EPA was not able to reproduce the commenter's results regarding the performance of the predictive model in RS 3. In RS 3, EPA identified 21 samples from the 2016 OM&M surface sediment sampling program that were identified as cohesive by the model. Of these 21 surface samples, 16 (73 percent) had greater than or equal to 25 percent fines (defined as the sum of percent fine clay and percent fine silt). EPA's percentage (73 percent) is substantially larger than the value of "about 1/3," as presented in the comment. Similarly, the commenter asserted that more than 20 percent of the cohesive sediments identified by the model were described by field samplers as "coarse" or "rock." EPA did not identify any cohesive sediment samples collected in RS 3 during the 2016 OM&M sampling program that were described by field samplers as "coarse" or "rock." Furthermore, during the 2016 OM&M sampling program, a steel probing rod was extensively used by samplers to assess sediment texture prior to sample collection. Sediment probing is a standard, acceptable technique that involves physically penetrating the river bottom with a metal rod to assess the sediment texture. Of the 21 samples identified as cohesive in RS 3, 19 were classified as "fine grained," while the remaining two

samples were classified as "transitional." Thus, EPA's analysis of the predictive model used in RS 3 indicates that it performed well when classifying sediment as either cohesive or non-cohesive, and there is no indication that the model increased the uncertainty in sediment classification.

Finally, EPA is currently investigating differences between sediment PCB concentrations using M1668 and M8082. EPA has evaluated the difference in PCB concentrations from the two methods using the matched pairs of sediment samples analyzed by both methods in the 2017 NYSDEC sediment dataset. As the commenter indicated, the comparison indicates that Total PCB concentrations derived from M1668 measurements are approximately 55 percent higher than those derived from M8082. Similarly, the Tri+ PCB concentrations from the sum of congeners (M1668) are approximately 44 percent greater than those predicted from Aroclor data (M8082) using GE's equation [Tri+ = 0.13*A1221 +0.89*(A1242+A1254)].[12] M1668 provides a more robust basis than M8082 and modified Green Bay Method (mGBM) to determine both Total PCB and Tri+ PCB concentrations. However, the spatially extensive records of sediment PCB concentrations collected as part of the Remedial Design (SSAP data) were based on M8082. Therefore, to track changes in surface sediment concentrations relative to the SSAP data, sediment samples will continue to be analyzed via M8082. To provide an accurate basis for long-term monitoring and future evaluations regarding river recovery, EPA will be conducting analyses of sediment by both M8082 and specifically M1668 as part of the ongoing monitoring program. The laboratory will also be required to run reference standards to confirm analytical accuracy and provide a benchmark for future monitoring work.

3.4.6 Comment 47: By leaving more PCBs than anticipated in portions of the Upper Hudson River, the remedy as implemented may not achieve the targeted reductions in water and fish PCB concentrations in the timeframes anticipated by EPA

Comment

Commenters indicated that the dredging left behind high levels of PCB contamination in the sediment and that the remaining PCB inventory was larger than originally estimated in the 2002 ROD with the result that fish will recover at a slower rate than originally estimated. Concern was expressed that without additional removal of "toxic hotspots" in the Upper Hudson River, there will be a substantial delay in the recovery of the resource and a delay in reaching remedial action objectives. Commenters also stated that the selected remedy as applied in RS 2 and RS 3 left behind substantial PCB mass in the vicinity of dredged areas, creating a "donut" of PCB inventory around dredged areas.

Response

The following important information is provided to address commenters concerns: 1) how are fish exposed to PCBs in the Upper Hudson River; 2) distinguish between surface sediment PCB concentrations (measured in mg/kg) and PCB inventory in the sediment (measured in kg of PCBs in river sediments or in g/m^2 of river bottom), and 3) distinguish between the absolute amount of PCBs removed (measured in kg of PCBs removed from the river) and relative amount of PCBs

[12] GE's equation (and similar forms of the equation) have been used to estimate Tri+ PCB concentrations from the M8082 (Aroclor-based) results throughout the SSAP and DDS sampling programs.

removed (measured as a percentage of total PCBs in the river sediment). As explained below, it is the PCBs in the surface sediments and water column of the Upper Hudson River that directly drive the PCB concentrations found in fish tissue, and it is these PCB sources - and not the total PCB inventory remaining - that are the best indicators of fish exposure to PCBs.

In the Upper Hudson River, the PCBs in fish tissue are driven by PCBs in the water column (both dissolved PCBs and PCBs bound to suspended solids) and PCBs in the upper few inches of the sediment bed. It is these two compartments of PCBs that directly affect long-term trends in fish tissue PCB concentrations. In the 2002 ROD, these two PCB compartments were forecast using the HUDTOX model, and were also used as inputs to the FISHRAND model, which produced projections of PCB concentrations in fish tissue into the future. Analyses presented in Appendices 1 and 3 of the FYR report indicate that water column and fish tissue concentrations declined at similar rates during the baseline monitoring period (1995 to 2008).[13] Long-term measurements of surface sediment data also indicate declining PCB concentrations. Post-dredging data collected in 2016 show further decline, although data will need to be collected over more OM&M program cycles to establish long-term trends. The similarity in rates of decline between the three different media (fish tissue, water and surface sediment) highlight the close linkage between them and support the use of water and surface sediment measurements as direct indicators of the reduction in fish exposure to PCBs over time.

In the Upper Hudson River, the surface sediment PCB concentration, for purposes of long-term monitoring and direct fish exposure, is defined as the concentration of PCBs in the upper 2 inches of the sediment, closest to the sediment-water interface. PCB inventory refers to the mass of PCBs throughout the sediment bed and does not distinguish between PCBs in the surface sediment or PCBs greater than 2 inches below the sediment-water interface. Thus, the inventory of PCBs in the Upper Hudson River includes PCBs in the surface layer that fish are regularly exposed to as well as PCBs that have little interaction with fish (*i.e.,* PCBs that are below the surface sediment layer). Because of the limited access to the deeper layers, it is not appropriate to link rates of decline in fish tissue PCB concentrations with PCB inventory. PCB inventory does not directly characterize the concentrations of PCBs to which fish are exposed. In particular, tracking PCB inventory through time does not account for reductions in surface sediment concentrations due to burial by cleaner sediments produced upstream of the Site. In this instance, while PCB concentrations in the surface sediments would decline, there would be little impact on the undisturbed PCB inventory at depth.

Instead, as discussed above, surface sediment concentrations and water column concentrations should be the direct metrics used to assess the degree of PCB exposure to fish. For surface sediment concentrations, the recent 2016 OM&M data show that the overall percent reductions (remediation plus natural recovery) of PCBs containing three or more chlorines (Tri+ PCBs) concentrations were estimated to be 96 percent, 88 percent and 80 percent for RS 1, RS 2 and RS 3, respectively. These percentage reductions are greater than were anticipated by the ROD. The data also indicate that post-dredging average surface sediment concentrations of Tri+ PCBs are near or below 1 mg/kg (see Tables A4-5 and A4-6 in Appendix 4 of the FYR report).[14] Since the

[13] Similar rates of decline are observed for later starting dates, *e.g.,* 1996 to 2008 or 1998 to 2008.

[14] The average concentration and level of reduction obtained from the 2016 EPA/GE data were also confirmed by the 2017 NYSDEC surface sediment survey.

surface sediment concentration is a direct driver of fish tissue concentration, the above evidence (*i.e.,* the large relative reduction in surface sediment PCB concentration as well as the current low surface sediment concentration) suggests that it is likely that fish will also show a corresponding decline in the near future.

EPA recognized that the PCB inventory may impact fish tissue PCB levels indirectly by supplying PCBs to the surface sediment and water column PCB concentrations through sediment resuspension during high flow events (*i.e.,* flows in excess of 15,000 cfs), and set removal criteria for sediment PCB inventory as well as for surface concentration. However, predictions from the HUDTOX model indicated that the very high flow conditions associated with a 100-year peak flow event would remove, on average, less than a 1-cm layer of sediment. The results from model simulation are supported by the measurements taken during the spring 2011 high flow event when actual flow rates exceeded the 100-year peak flow conditions used in the HUDTOX model simulations. Data collected during and after the 2011 event did not find evidence of widespread scour and transport of highly-contaminated PCB-bearing sediment within the Site.

When assessing the success of the remedy with regard to the removal of PCB inventory from the Upper Hudson River, it is important to base the assessment on a comparison of 2002 ROD estimates of the amount of PCB inventory that would be removed relative to the amount of PCB inventory that EPA estimated in the ROD was present (measured as a percent reduction in PCB inventory) *vs.* the actual percent reduction in PCB inventory as a result of dredging. The reason for basing the effectiveness of PCB removal in part on the percent reduction in PCB inventory is that any changes to the estimate of absolute inventory present prior to dredging (*e.g.,* as a result of sampling challenges and characterization of PCB concentrations in the sediment subsequent to the release of the 2002 ROD) do not change the relative reductions in fish exposure that are needed to achieve the remedial objectives for fish tissue.

In the 2002 ROD, the specific goals for the relative reduction in PCB inventory, measured as a percentage of total PCBs in the river sediment in each river section prior to dredging, were: 80 percent of PCB mass removed in RS 1; 86 percent of PCB mass removed in RS 2; and 28 percent of PCB removed in RS 3.[15] As presented in Appendix 2 (Table A2-6b) of the FYR report, the targeted percent reduction in PCB inventory was exceeded in RS 1 and RS 3, but not for RS 2 (the 2002 ROD stated 86 percent of PCBs were to be removed, but calculations in Appendix 2 indicate that approximately 82 percent of PCB inventory was removed). However, the overall target reduction for the Upper Hudson of 65 percent was exceeded by the actual removal, which achieved 76 percent. Given that PCB inventory is not the direct driver of fish tissue concentration and given the overall reduction of 76 percent of the Upper Hudson inventory, it is unlikely that the additional 4 percent of the original inventory remaining in RS 2 will substantively impact the rate of recovery in the river section. RS 2 will be regularly monitored under OM&M to quantify the actual rate of recovery.

With regard to the assertion that the selected remedy left behind contaminated sediment around dredged areas, EPA analyzed the 2002-2005 SSAP and 2016 GE/2017 NYSDEC sediment data in

[15] From EPA, 2002. Responsiveness Summary to the Hudson River PCBs Site Record of Decision, Table 363334-1. These percentages for inventory reduction should not be confused with anticipated reductions for surface sediment and fish tissue, discussed elsewhere in these responses.

each river section to investigate whether "donuts" (rings) of elevated PCB inventory or surface sediment concentrations were left around dredged areas. In the remedial design, EPA specifically looked at two criteria for determining whether a location needed to be dredged: 1) a maximum top 12-inch interval Tri+ PCB concentration in excess of the dredging criteria of 10 mg/kg, 30 mg/kg and 30 mg/kg Tri+ PCB for RS 1, RS 2 and RS 3 respectively, and 2) a Tri+ PCB MPA value in excess of 3 g/m^2, 10 g/m^2 and 10 g/m^2 for RS 1, RS 2 and RS3 respectively. As part of applying these criteria, an adjustment was made where selected areas were allowed to remain undisturbed when the PCB inventory was buried below 12 inches or more of low-concentration sediments (less than 1 mg/kg).

EPA explored this concern by examining the variation of concentrations of Tri+ PCB in surface sediment (0-2 inch) as a function of distance from the sampling location to the nearest dredged area boundaries. The results were represented in Figures 47-1a, 2a, and 3a for samples from the SSAP program, and in Figures 47-1b, 2b, and 3b for samples from the 2016 GE and 2017 NYSDEC programs, respectively. Figure 47-4 illustrates how the distances were assigned to each location using the 2016 and 2017 surface sediment data as an example.

In each of the figures, a blue line has been added, which represents a weighted least square fit to the data. This line approximates the variation of the median of the data with distance from the dredged area boundary. The curves were fit separately for the data inside the dredging boundary and outside the dredging boundary. Hence the curves do not meet at the boundary itself (0 on the horizontal axis). In reviewing these curves, it is apparent that there is little variation in the surface sediment concentration as a function of distance from the dredged area boundary. That is, the median concentration as approximated by the weighted curve is nearly flat in both halves of each figure.

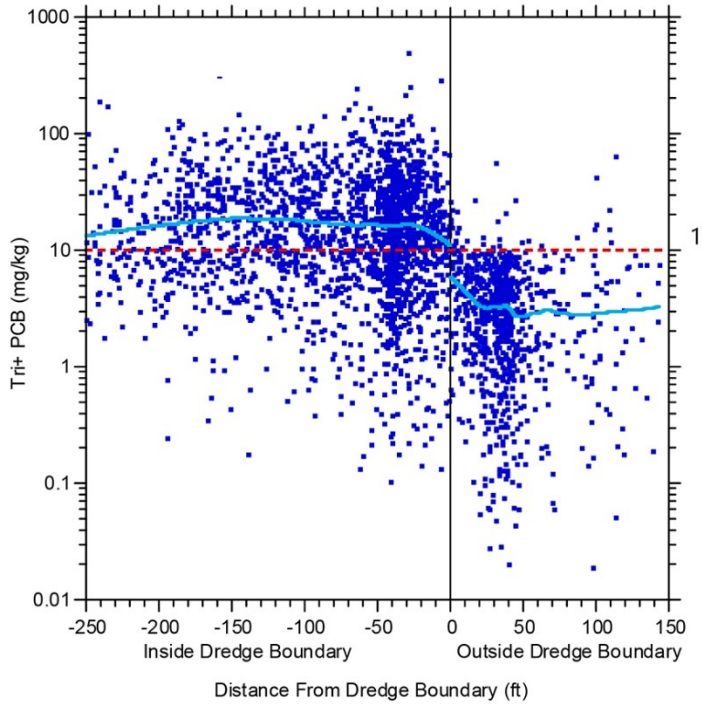
EPA further examined the variations of PCB inventory as a function of distance from the sampling location to the nearest dredged area boundaries. The PCB inventory was represented by the maximum Tri+ PCB concentration in the top 12 inches of sediment[16] and MPA data from the SSAP program. Figures 47-5, 47-6 and 47-7 show the results for maximum Tri+ PCB concentration, and Figures 47-8, 47-9 and 47-10 show the results for MPA data. These figures also display the threshold for removal for each river section as described above.

The figures illustrate that for cores outside dredged areas in all three river sections, a very limited number of points were above the threshold for removal, confirming the successful selection of locations according to the criteria. Nearly all above-threshold locations, as well as a large number of below-threshold locations were included in the dredged areas. GE was not required to "chase" isolated cores above the threshold, as this would likely have caused more sediment disturbance (a negative impact on the river ecosystem) with little positive gain from the removal of the isolated contaminated sediments. The orange dots shown in Figure 47-10 represent spatially isolated locations that met the "Select" criterion of an inventory greater than 10 g/m^2 underlying a minimum of 12 inches of surface sediment less than 1 mg/kg Total PCB, which were permitted to remain according to the ROD criteria.

[16] As defined in the 2007 Dredge Area Delineation (DAD) Report (GE, 2007)

The weighted curves on these figures (blue lines) indicate that there is little variation in the PCB inventory from the dredging boundary out to the maximum distance values on the plot (150 ft in RS 1 and 300 ft in RS 2 and RS 3), indicating little gradient. These plots indicate that sediments close to the dredging boundaries are not particularly more contaminated than those located further away. Thus, these graphs indicate that finer-grained sediments close to the dredging boundaries are similar in average concentration to finer-grained sediments elsewhere in the river section, and a "donut" feature of high concentrations immediately proximate to the dredging boundaries as argued by the commenter is not apparent. Fine-grained sediments have similar Tri+ PCB MPA value and maximum top 12-inch interval Tri+ PCB concentrations throughout each river section.

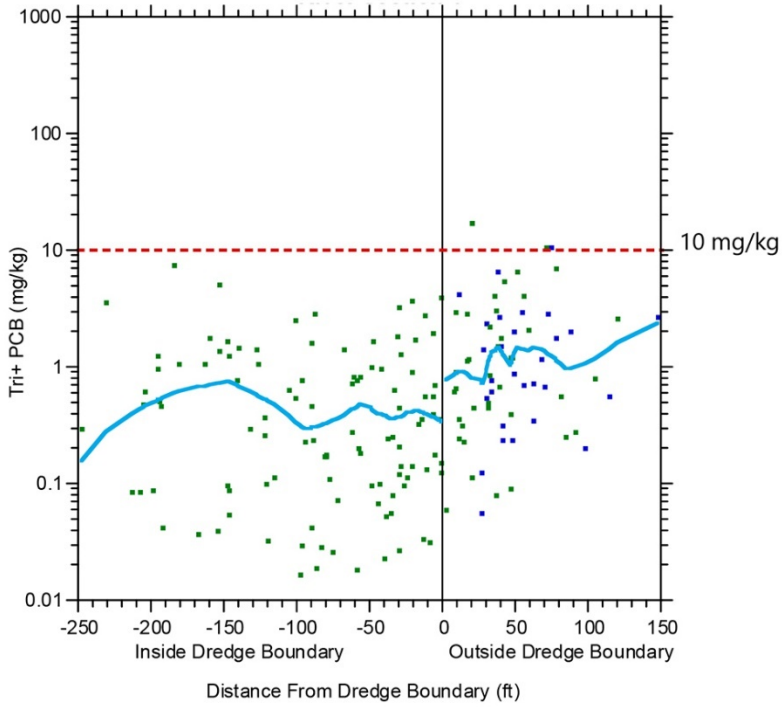
In conclusion, the dredging activities achieved their stated goals in the 2002 ROD, when evaluated using an appropriate metric (the amount of PCBs removed relative to the total amount of PCBs present in the Upper Hudson River sediment prior to dredging). Further, the remaining PCB inventory in sediments of the Upper Hudson River is not an appropriate metric to project future rates of decline in fish tissue PCB concentrations, as PCB inventory does not quantify the amount of PCBs that fish are exposed to, largely by failing to account for sediment burial. Instead, surface sediment concentrations and water column concentrations provide more informative measures of the amount of PCBs that fish are exposed to. These concentrations along with fish tissue concentrations should form a basis for assessing rates of decline in fish tissue concentrations moving forward (and ultimately the success of the remedial activities). Lastly, concerns that high levels of contamination are found in the immediate vicinity of dredged areas is not borne out by the SSAP data or by the 2016 OM&M and 2017 NYSDEC surface sediment data. (See also the Response to Master Comment 40 (see Section 3.3.17), regarding the absence of "hot spots" post-dredging.)



SSAP Surface Sediment Tri+ PCB Concentrations *vs.* Distance from Dredging Boundary
River Section 1
2002-2005 (0-2 in. Samples)

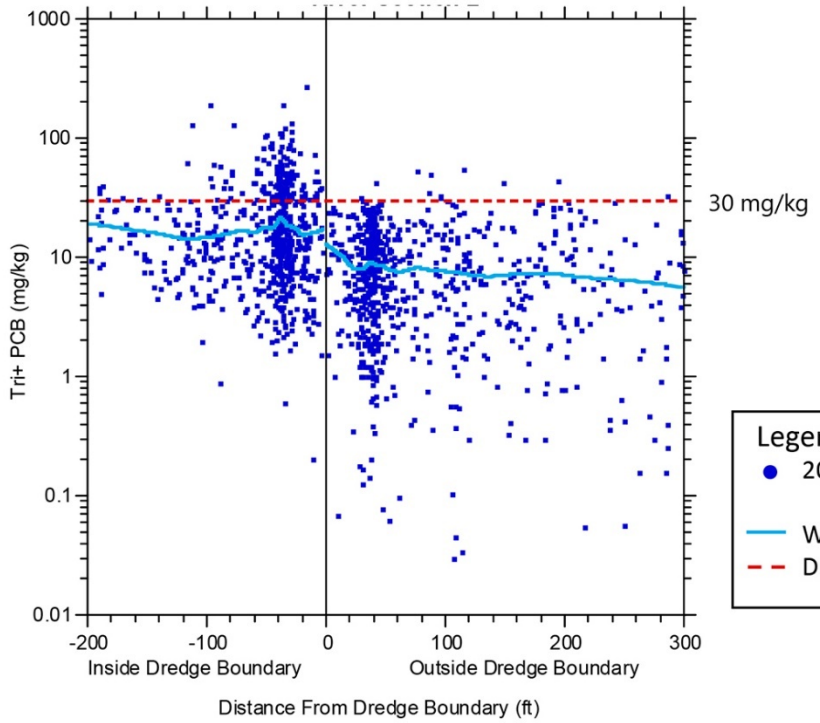
Figure 47-1a

April 2019



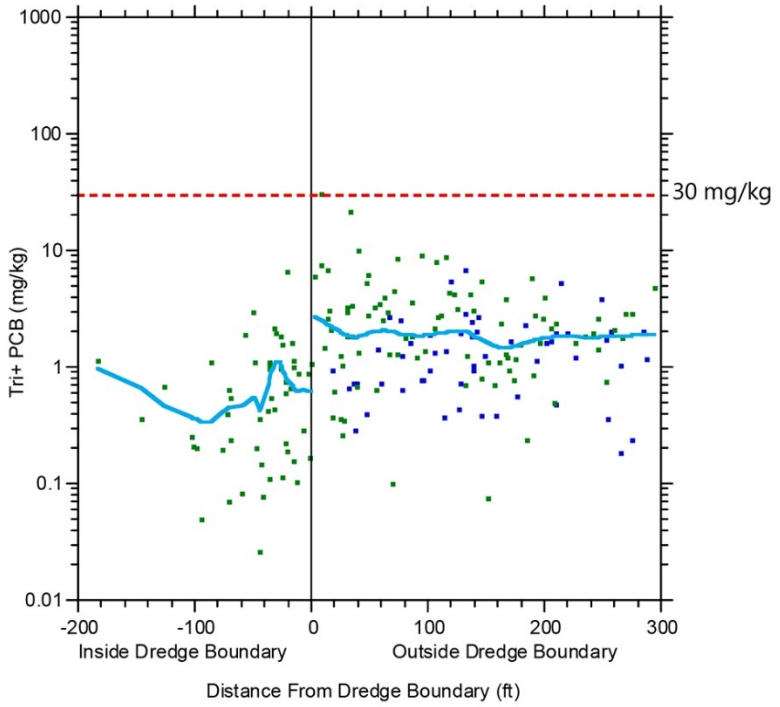
OM&M Surface Sediment Tri+ PCB Concentrations *vs.* Distance from Dredging Boundary
River Section 1
2016-2017 (0-2 in. Samples)

Figure 47-1b
April 2019



SSAP Surface Sediment Tri+ PCB Concentrations *vs.* Distance from Dredging Boundary
River Section 2
2002-2005 (0-2 in. Samples)

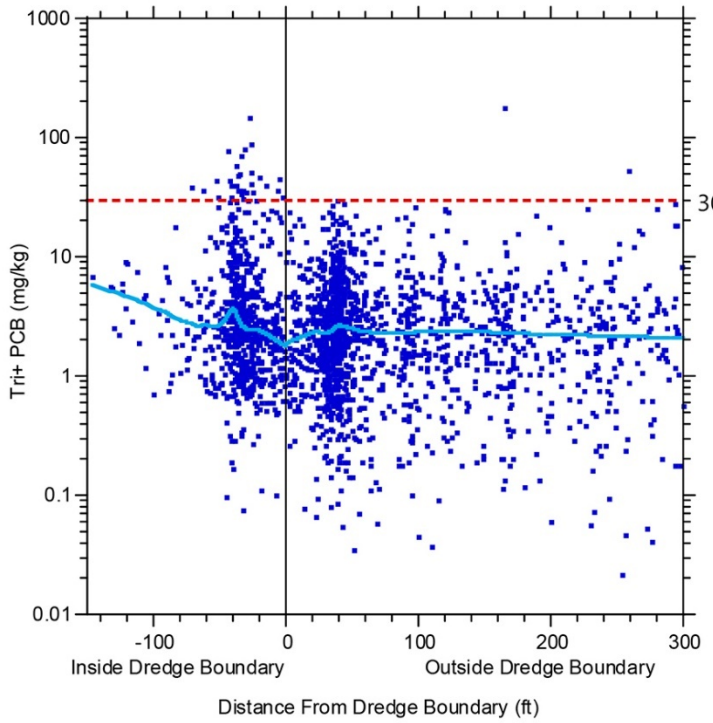
Figure 47-2a
April 2019



OM&M Surface Sediment Tri+ PCB Concentrations *vs.* Distance from Dredging Boundary
River Section 2
2016-2017 (0-2 in. Samples)

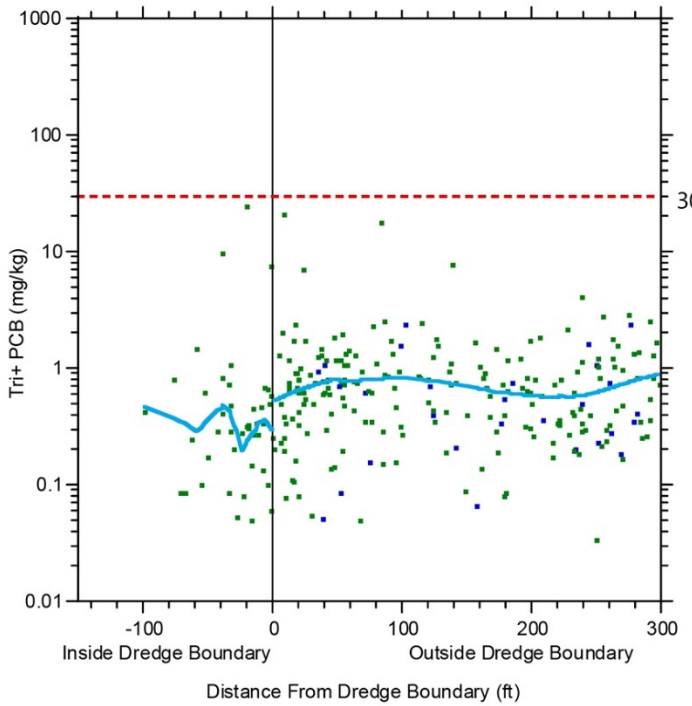
Figure 47-2b

April 2019



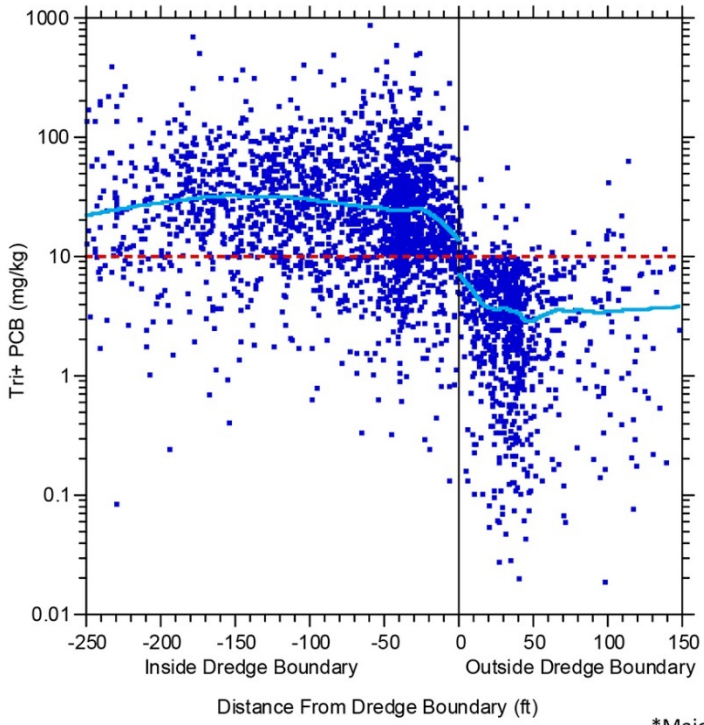
SSAP Surface Sediment Tri+ PCB Concentrations *vs.* Distance from Dredging Boundary
River Section 3
2002-2005 (0-2 in. Samples)

Figure 47-3a
April 2019



OM&M Surface Sediment Tri+ PCB Concentrations *vs.* Distance from Dredging Boundary
River Section 3
2016-2017 (0-2 in. Samples)

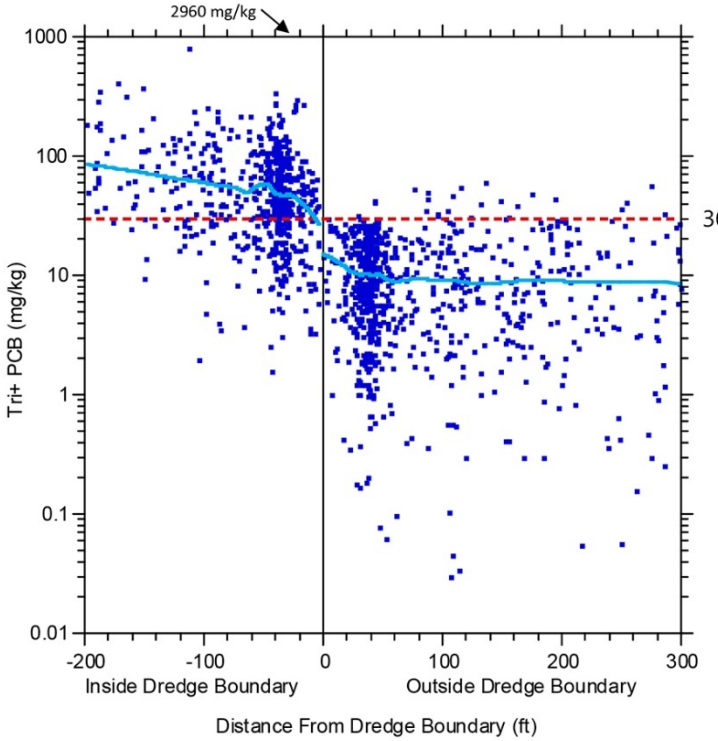
Figure 47-3b
April 2019



*Majority of points from the SSAP data set were from 2002 to 2005, a small portion of the points were obtained in 2007 as a part of the SEDC sampling program.

SSAP Maximum Sediment Tri+ PCB Concentration *vs.* Distance from Dredging Boundary
River Section 1
2002-2005 (Maximum value in 0-12 in. interval)

Figure 47-5
April 2019

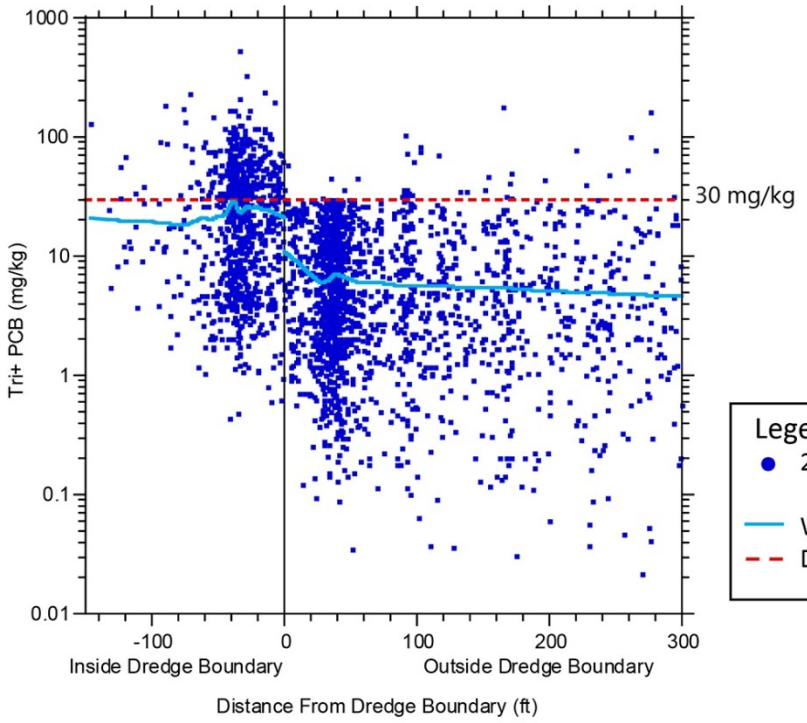


*Majority of points from the SSAP data set were from 2002 to 2005, a small portion of the points were obtained in 2007 as a part of the SEDC sampling program.

SSAP Maximum Sediment Tri+ PCB Concentration *vs.* Distance from Dredging Boundary
River Section 2
2002-2005 (Maximum value in 0-12 in. interval)

Figure 47-6

April 2019

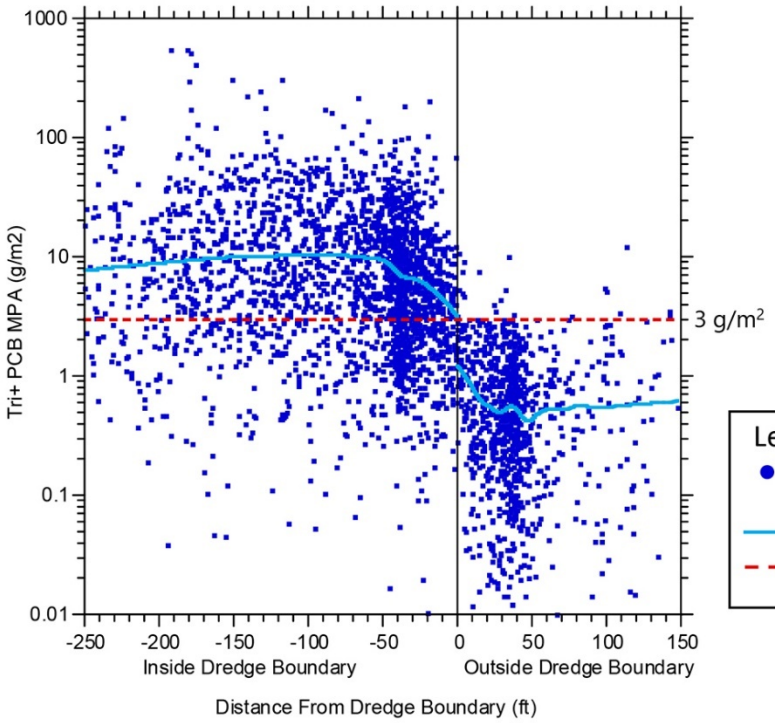


*Majority of points from the SSAP data set were from 2002 to 2005, a small portion of the points were obtained in 2007 as a part of the SEDC sampling program.

SSAP Maximum Sediment Tri+ PCB Concentration *vs.* Distance from Dredging Boundary
River Section 3
2002-2005 (Maximum value in 0-12 in. interval)

Figure 47-7

April 2019

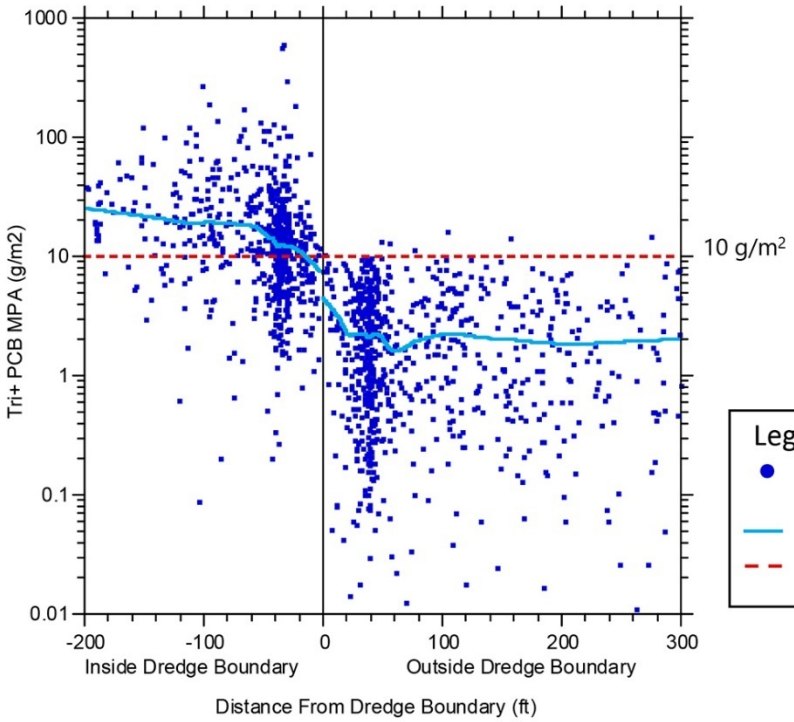


*Majority of points from the SSAP data set were from 2002 to 2005, a small portion of the points were obtained in 2007 as a part of the SEDC sampling program.

SSAP Tri+ PCB MPA *vs.* Distance from Dredging Boundary
River Section 1
2002-2005

Figure 47-8

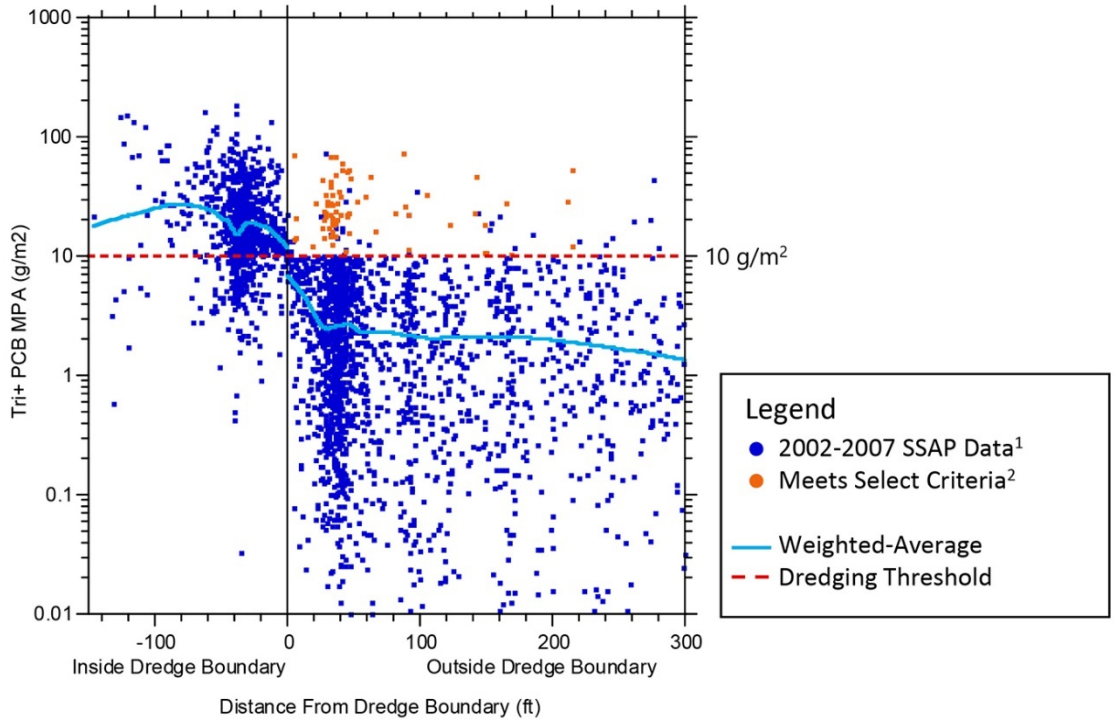
April 2019



*Majority of points from the SSAP data set were from 2002 to 2005, a small portion of the points were obtained in 2007 as a part of the SEDC sampling program.

SSAP Tri+ PCB MPA *vs.* Distance from Dredging Boundary
River Section 2
2002-2005

Figure 47-9
April 2019



1. Majority of points from the SSAP data set were from 2002 to 2005, a small portion of the points were obtained in 2007 as a part of the SEDC sampling program.
2. The orange dots shown present spatially isolated locations that met the "Select" criterion of an inventory greater than 10 g/m^2 underlying a minimum of 12 inches of surface sediment less than 1 mg/kg Total PCB, which were permitted to remain according to the ROD criteria.

Hudson River PCBs Superfund Site	SSAP Tri+ PCB MPA *vs.* Distance from Dredging Boundary River Section 3 2002-2005	Figure 47-10 April 2019

3.4.7 Comment 48: The Lower Hudson River (LHR) fish recovery is not responding as expected

Comment

Commenters raised a number of related issues concerning the rate of fish recovery in the LHR, and EPA's conclusion that fish PCB levels in LHR fish are not strongly linked to Upper Hudson River (UHR) loads and conditions. There were seven major points that are outlined and addressed below.

1. A commenter stated that the FYR appears to disregard prior conclusions and modeling results in the ROD (USEPA, 2002) that the UHR PCB load to the LHR is the primary factor in the recovery of LHR fish. The FYR report cites slower recovery of LHR fish as evidence that the UHR does not play an important role in the LHR and speculates about "other sources." Based on high-resolution core sampling data and modeling (Thomann et al. 1989, Farley et al. 1999, USEPA 2000a, Hydroqual 2007, Rodenburg and Ralston 2017), the primary source of PCBs to the LHR is the result of past and continued loading of PCBs originating from the Hudson Falls and Fort Edward plant sites and sediments within the UHR.
2. A commenter stated that the FYR Report indicates that the remedial work in the UHR will have little or no beneficial impact in the LHR. The commenter notes that this is in contrast to the ROD assumption that PCB loading from UHR to the LHR plays a major role in recovery of the LHR. EPA appears to have rejected this major ROD assumption with little technical basis provided in the FYR.
3. A commenter stated that the remedy in the UHR is not likely to have a significant impact on fish in the LHR and says that EPA should not state that PCB sources other than GE's discharges in the UHR are controlling LHR fish PCB concentrations unless the agency has data to support such a conclusion.
4. A commenter stated that the identification of both fish tissue and sediments in the LHR with significantly elevated PCB concentrations suggests that the remedial work in the UHR is less likely to achieve the targeted reductions in PCB concentrations in the estuarine portion of the river than anticipated by EPA in the ROD.
5. A commenter noted that the increase in water column PCB concentration due to dredging was not reflected in a commensurate impact on the fish in the Hudson River, and that, typically, only those fish in the immediate vicinity of the dredging work, or immediately downstream, showed a significant reaction to the dredging. This indicated to the commenter that the local sediments are much more important in controlling fish PCB concentrations than impacts from upstream sources, which in the Hudson River primarily means upstream sediments. This is most important for the LHR, where the fish showed little to no response to the dredging work upstream, so that it can no longer be expected that the remedial program in the UHR will result in significant improvement in fish PCB concentrations south of Albany.
6. It is stated by a commenter that PCB levels in the 160-mile portion of the LHR have not benefited much, if at all, from upriver dredging, and that contamination in fish at

Poughkeepsie remains as high as it was before the dredging project. Below the Troy Dam all the way to New York City, EPA's own studies show PCB concentrations in fish haven't declined as expected as a result of the upriver dredging.

7. A commenter stated that EPA should recognize that there is much more work to be accomplished to address the human health and ecological risk posed by the disposal of PCBs in the Hudson River. EPA should do the work necessary to ensure that the remedy in the UHR is protective, and to implement a full investigation and remedial program in the LHR south of Troy.

Response

EPA recognized many of the concerns raised by the commenters, noting in the FYR report that fish body burden decay rates declined with distance downstream of Albany, and that fish tissue concentrations below RM 113 in the LHR did not respond to the increased loads at Waterford during dredging. These observations, along with others listed below, are sufficient to support EPA's assertion that PCB concentrations in LHR fish are not strongly linked to current loads originating from the UHR. Specifically, while fish in the UHR and LHR fish at RM 152 (Albany/Troy), clearly responded to the increased water column loads and concentrations due to dredging, below RM 152 fish tissue levels increased little, if at all, during dredging. Water column concentrations at Poughkeepsie (RM 90) also did not respond to dredging as was observed upstream, and instead gradually decreased slightly during the dredging period. In addition, water column concentrations at Poughkeepsie during 2004-2008 were slightly higher than those observed at Albany (See Figure A1-2 of Appendix 1 of the FYR report), a condition that is incompatible with LHR conditions caused by UHR loadings alone. These multiple lines of evidence indicate that LHR conditions, at least those at RM 113 and downstream, are not strongly linked to current PCB loads and conditions of the UHR.

It is important to distinguish between past (pre-dredging and dredging) and current (post-dredging) loadings from the UHR to the LHR. While the link between UHR loadings and LHR impacts has reduced over time, GE sources in the UHR have been the primary source of PCBs in the LHR. EPA notes that further studies are needed to better understand the extent of PCB contamination in the sediments of the LHR. As discussed below, EPA is relying on the investigative sediment work for the LHR that was conducted prior to the ROD

EPA agrees with the commenter's assertion that the weakness of the current link does not necessarily mean that external downstream loads to the LHR have suddenly grown to greater importance. Rather, it is most likely that an extensive inventory of PCB contamination in the sediments of the LHR is primarily responsible for LHR PCB levels in both fish and water. This inventory is derived primarily from historical GE discharges and UHR loads to the LHR. As noted by the commenter, the magnitude of the historical GE loads was examined as part of the investigations that led to the ROD, primarily using dated sediment cores, and more recent work continues to support the ROD conclusions in this regard. While LHR external sources may have increased in relative importance, EPA believes that the majority of the LHR PCB inventory (and by inference, the majority of PCB exposure) can be attributed to GE-related PCBs originating from the UHR, extending to approximately RM 50 or further downstream. EPA is currently evaluating what additional studies need to be completed for the LHR.

The ROD states as follows with regard to the impacts of UHR remediation on the LHR:

> *…the reduced PCB load over the Federal Dam projected by the selected remedy will ultimately result in reduced concentrations of PCBs in fish, sediment and water. This in turn will result in reduced risks to humans and ecological receptors living in and near the Lower Hudson River from PCB contamination originating in the Upper Hudson River.* (EPA, 2002; p. 2)

While this statement is still true, the strength of the link between Upper and LHR PCB levels has diminished since the collection of data which formed the basis for the 2002 ROD. Reduced loads at Waterford translate to reduced fish body burdens in the LHR, but the reduction may now be relatively minor likely due to the current dominance of LHR legacy sediment contamination in exposure.

The FYR recognized the variation in decay rates in fish tissue along the LHR. However, EPA does not agree with the assertion that increases in UHR fish levels were constrained to the areas in the immediate vicinity of the dredging. While the effects may have been greatest in these locations, all UHR fish monitoring stations downstream of dredging showed some increases. EPA agrees with the commenter's assertion that PCB levels in fish did not respond proportionately to the increase in water column concentrations (*e.g.,* compare the relative rise in water column concentrations in Figure A1-1 of Appendix 1 of the FYR report with Figures A3-2 to A3-5 of Appendix 3 of the FYR report, which could reflect the roles played by sediments in fish exposure, as well as the localized increases in dissolved water column PCB that were observed in near field monitoring. However, even fish in the LHR at RM 152 and RM 113 were affected by the increased loads to the LHR, as evidenced by the change in slope, or actual increase in body burden, for most fish at these stations during the dredging period. See Figures A3-5 and A3-6 in Appendix 3 of the FYR report for the trends in absolute body burden. Lipid-normalized trends show less of an impact, particularly at RM 113 but still are suggestive of a weak dredging-related impact for some species. See Figures A3-12 and A3-13 of Appendix 3 of the FYR report.

Downstream of RM 113, the data do not suggest a dredging-related impact. This gradual attenuation with distance in dredging-related increases in fish tissue PCB concentrations parallels the decline in PCB level decay rates in fish. Because LHR fish body burdens are declining more slowly than UHR fish body burdens and are less responsive to UHR dredging-related loads, it can be concluded that the factors driving LHR fish body burdens are not now strongly linked to those driving UHR fish body burdens. As noted by the commenter and stated in the FYR, given the lack of strong correlation, these lines of evidence indicate that further remediation of the UHR would be unlikely to result in substantial improvements in LHR fish PCB levels, particularly for areas downstream of Albany.

This conclusion does not mean, however, that all dredging-related benefits to the LHR have been realized. As also discussed for the UHR, EPA anticipates it will take several years before the improvements directly resulting from the dredging are evident in the UHR, and this also applies to locations in the upper portion of the LHR that clearly responded to UHR loadings, including Albany/Troy (RM 152). EPA has determined that at least 8 years of monitoring data on PCB

levels in fish, water, and sediment are needed before the magnitude of the dredging-related improvements can be determined.

EPA does not agree with the commenter's assertion that all areas of the LHR were declining more slowly than anticipated prior to dredging. As shown in Appendix 3 of the FYR report, Figures A3-5 to A3-6, body burdens at RM 152 and RM 113 were declining from 1997 to 2008 at rates comparable to those predicted by the ROD. Note the close agreement in line slope as well as absolute magnitude for the actual observations (dashed blue line) with the model forecasts (red and purple lines) for most fish species at each of these stations. Lipid-normalized results show similar agreement at the RM 152 station (see Figure A3-12) but less agreement at RM 113 (see Figure A3-13). The greatest deviations between anticipated recovery and actual observations in fish occur for the RM 90 and RM 50 stations (see Figures A3-7, A3-8, A3-13 and A3-14). In these instances, the fish levels are clearly declining more slowly than anticipated by the ROD. As mentioned previously, EPA is evaluating the needed monitoring requirements and additional study needs for the LHR in order to understand the observed trends.

Despite the much more gradual decline evident in the most-downstream LHR fish tissue levels, EPA notes that LHR fish tissue levels are approaching, and in some cases have fallen below, the interim remedial target levels. In examining these data, EPA has developed Tables 22-1a and 22-1b, which present mean and median PCB concentrations in fish tissue for long-term fish monitoring stations in the LHR, based on homologue-equivalent $TPCB_{HE}$ and $TPCB_{Aroclor}$ results, respectively. In each table, data are provided for two periods, 2009 to 2015, representing mean and median fish tissue concentrations in the LHR during the dredging period, and for 2016, representing the first year of post-dredging data. Note that 2016 data are not available for all species and stations. Additionally, data available for RM 50 are limited to a single species for the post-2009 period. While data from a single year post-dredging cannot provide an estimate of the long-term decay rate, the table does note which species have achieved one or more of the interim targets or final remedial goals.

For 2016, mean and median concentrations for yellow perch, spot tail shiner and striped bass at RM 152 all fall below the interim target of 0.4 mg/kg-ww (*i.e.,* on a wet weight basis), using either measurement basis (*i.e.*, $TPCB_{HE}$ or $TPCB_{Aroclor}$). This represents three of the seven species with long-term data studied at this station. Below RM 152, 2016 fish data are sparse but dredging period data are available for many species and locations. At RM 113, mean fish tissue concentrations for two species, brown bullhead and yellow perch, were at or just below the interim remedial target of 0.4 mg/kg-ww during the dredging period, using either measurement basis. At RM 90, three species fell below the interim target of 0.4 mg/kg-ww during 2009-2015. Median concentrations fell below the interim value of 0.4 mg/kg-ww for even more species. Note that by definition, when median concentrations fall below a threshold, this indicates that more than half of the observations fall below this threshold. Overall, based on the most recent data available (see the last column in each table), about thirty percent of the species-station pairs (*e.g.,* yellow perch at RM 152) fell below the first interim remedial target of 0.4 mg/kg-ww using either measurement basis. Forty percent of the median values (10 of 25 pairs) fell below this target as well. In the case of yellow perch, all three stations with data were near or below the second interim remedial target of 0.2 mg/kg-ww. These observations do not mean that the fish consumption advisories can be modified

for yellow perch or any other species because that is a decision for the State of New York. Nevertheless, these data do indicate that some recovery is occurring in the LHR.

3.4.8 Comment 52: Adequacy of the OM&M sediment sampling program, especially with respect to development of post-dredging baseline information

Comment

Sediment
Commenters stated that the current surface sediment OM&M sampling program is not adequate to provide an appropriate baseline conditions of post-dredging concentration. Available surface sediment data are not sufficient to evaluate the percent reductions in surface sediment concentrations that are achieved by the remedy. The data collected pursuant to the 2016 work plan for the FYR are not in compliance with the 2010 decision documents and are inadequate to track effectiveness and protectiveness of the remedy and therefore, cannot appropriately be used in the FYR. The Downstream Depositional Study (DDS) does not provide post-remediation baseline concentrations and is not suitable for evaluating sediment recovery rates.

Commenters asserted that an estimate of the rate of change developed over a 10-year interval and on a River Section basis is not sufficient to evaluate the performance of the remedy in a time frame commensurate with the remedial targets. EPA should direct that an increased number of samples be collected such that there is a statistical power to determine sediment concentration trends in 5 rather than 10 years. Sediment sampling should be performed on pool-by-pool basis, and should occur at smaller time intervals (i.e., more frequently). EPA should reveal the fundamental basis for the sample design analysis. EPA should develop a robust and data-driven monitoring program for surface sediment.

A commenter recommended using the existing framework of the SSAP (80-foot sampling grid) to quantify the concentrations in each reach (pool). Transects also should extend beyond the SSAP sampling area to extend coverage to the entire area of each reach, including previously unsampled areas as well as remediated CUs. EPA should use probability-based statistical design for selection of sample locations within dredged and non-dredged areas. Sample size should be determined using variability of existing data to quantify temporal decay rates with adequate precision. A commenter recommends that an additional 1,800 sediment samples be collected in each sampling event.

Fish
A commenter stated that it should not be necessary to wait eight years to determine the rate of decline for fish PCB concentrations. EPA needs to perform a statistical power analysis to determine the number of fish samples to collect.

Overall
Commenters requested that EPA increase the number of sediment and fish tissue samples to the scale and frequency necessary to optimize the remedy through further remedial work as necessary to achieve the targeted fish PCB reductions identified in the ROD. EPA should ensure the

collection of sufficient water, sediment, and fish data to fully assess whether the remedy will meet the targets in the ROD, starting with the initial target of 0.4 ppm PCBs in fish by 2020.

If the targets are not likely to be met, EPA must direct that sufficient additional remedial work be done. To date, EPA's persistent refusal to collect and analyze a full array of data has run counter to EPA's original commitment to clean up the site. EPA has thus far refused to do so, and as a result NYSDEC has begun gathering the needed sediment data starting in summer 2017.

Response

The commenters request EPA to increase the number of sediment and fish tissue samples to the scale and frequency that they believe is necessary to achieve the targeted fish PCB reductions identified in the ROD. Inherent in the comments is an underlying inference that available sampling results indicate that the recovery of sediment and fish is known to be on a trajectory that will miss the targets stated in the ROD. However, EPA's analysis conducted for the FYR report shows that prior to dredging, the actual rates of decline in surface sediment and fish tissue PCB concentrations in the Upper Hudson River remained within reasonable bounds of uncertainty as compared to those anticipated at the time of the ROD, and therefore EPA does not have reason to believe that the targets identified in the ROD will not be met within the general timeframes identified. Although pre-dredging data does not provide reason to believe the targets will be missed, EPA recognizes it does not at this time have sufficient data to determine the post-dredging rates of decline and therefore cannot determine if the ROD targets will be achieved within the expectations of the ROD. If further sampling data indicate that remedial goals are unlikely to be met within the timeframes contemplated by the ROD, EPA will evaluate whether further action should be taken. Further action could include additional sampling and analysis.

The current OM&M sampling program was statistically designed to estimate the spatial average within each of three river sections with relative error of 50 percent in RS 1, 40 percent in RS 2 and 25 percent in RS 3. To meet this objective, the 2010 OM&M Scope of Work (USEPA, 2010) estimated that 350 sample locations from the non-dredged areas and a minimum of 50 locations from backfilled areas in each river section would have to be sampled during each sampling event. With this design, it was anticipated that in each river section a 5 percent annualized decline over 10 years would be detectable with at least 80 percent power. However, the estimate of the number of samples relies on the variance of available data. Using estimates of variance developed from results for surface sediment samples collected during the 2011-2013 DDS program, EPA subsequently reduced the number of samples required to 226 in non-dredged areas. It should be noted that although EPA's sampling design is on a river section basis, the sampling locations were selected independently within dredged and non-dredged areas and were allocated proportionally to the size of each stratum within each designated river-mile segment. This stratified random sampling design yields samples that are spatially balanced along the entire length of the Upper Hudson River in proportion to the area to be sampled. Therefore, this sampling approach provides data for each river reach. EPA will continue to update the number of samples required for future OM&M sampling events as new data become available. Based on EPA's power analysis, the frequency and scale of data collection established were appropriate for meeting EPA's DQOs based on the ROD requirements. EPA's monitoring program is also consistent with or exceeds the

level of post-remedial monitoring effort at other Superfund sediment sites, including the Fox River, Wisconsin (USEPA and WNDR, 2009) and Portland Harbor, Oregon Superfund Sites.

NYSDEC asserted that EPA's OM&M sediment sampling plan was not sufficiently rigorous to determine whether the remedy was performing in a manner needed to reach the fish tissue concentration targets outlined in the ROD. As a result, NYSDEC undertook a more intensive sediment program in 2017 with DQOs established to detect an 8 percent annual change in total PCBs in surface sediment over a 5-year timeframe with statistical power of 80 percent for each of eight river reaches. The results of NYSDEC's surface sediment sampling program became available in early 2018, a few months after the end of the public comment period established by EPA for the FYR. In consideration of concerns raised by commenters, and in collaboration with NYSDEC, EPA undertook an extensive technical review of the results from the approximately 1,200 sediment samples collected by NYSDEC in 2017, together with the sediment samples taken by EPA/GE under the OM&M sampling program in 2016. EPA has documented the findings in a technical memorandum (Louis Berger & Kern Statistical Services, 2019), which is available on EPA's Hudson River web page (https://www3.epa.gov/hudson/).

EPA's evaluation shows that the 2017 NYSDEC samples yielded comparable results to the 2016 EPA/GE OM&M samples regarding the mean concentrations on both the river reach and river section basis. Both datasets (individually and collectively) suggest that the remedy achieved the required percent reductions in surface sediment concentrations.[17] The surface sediment concentrations in non-dredged areas in 2016/2017 were at or below concentrations forecast by the empirical trends derived from historical data. The data also show that the rate of decline in surface sediment concentrations from non-dredged areas in RS 1 are consistent with ROD model forecasts (8 percent), with a best estimate rate of 6 percent per year. The combined 2016 EPA/GE OM&M and 2017 NYSDEC data will be used as the baseline conditions of post-dredging concentration.[18] Estimates of recovery rates will be based on comparison of these baseline concentrations with future rounds of sediment data collected within the OM&M program. Despite the larger number of samples collected by NYSDEC in 2017 compared to the samples collected by EPA/GE in 2016, the similar results from these two datasets suggest that the scale of data collection under EPA's OM&M program is appropriate to meet the requirements of the ROD and the 2010 Statement of Work. Prior to the next round of sampling, EPA will evaluate the number of samples needed to confirm that sufficient samples will be collected to allow for a meaningful evalution on both a river reach and river section basis.

With respect to commenters' assertions that sampling frequency should be increased so that the rate of decline could be evaluated in 5 years rather than 10 years, and that sediment sampling should be performed on pool-by-pool basis. EPA agrees that sampling and evaluation of sediment

[17] On an area-weighted average concentration basis, the 2016 OM&M data show that the overall percent reductions (remediation plus natural recovery) of Tri+ PCB were estimated to be 96 percent, 88 percent and 80 percent for RS 1, RS 2 and RS 3, respectively (see Table A4-5 in Appendix 4 of the FYR report). When using the combined 2016 OM&M and 2017 NYSDEC datasets, the overall percent reductions were 93 percent, 89 percent and 87 percent for RS 1, RS 2 and RS 3, respectively (compare Table A4-5 in Appendix 4 of the FYR report and Table 3.2-1 in EPA's technical memorandum [Louis Berger & Kern Statistical Services, 2019] These percentage reductions are substantially greater than what were anticipated by the ROD.

[18] EPA agrees that the DDS program was not designed to evaluate the average concentrations in a specified area and should not be relied on as the only basis for evaluating sediment recovery rates.

data by river reach and river section are both useful. EPA proposes to add the reach consideration to the future assessment of the recovery of the river. However, EPA reasoned that large areas of undiscovered contamination that would cause one reach to be markedly higher than others in the same river section would not have been missed by the remedial design sampling. Therefore, it was, and is, reasonable to design the sampling program on a river section basis. This is further supported by the agreement between the 2016 EPA/GE and 2017 NYSDEC data as discussed above, even though GE's sampling program consisted of significantly fewer samples than NYSDEC's. EPA also believes that a 5-year window is too short to detect a recovery rate of 5 percent with acceptable statistical power. Commenters appear to underappreciate the data requirements necessary to accurately estimate first order recovery rates from empirical data. For a given population of PCB data, the precision of recovery rate estimates varies with the sample size, the frequency of monitoring, the duration of the monitoring program, and the variability of the sample data. Of these parameters, the precision of the recovery estimates is the most sensitive to the duration of the monitoring period, followed by the number of samples collected in the first and last monitoring time step. Although counterintuitive, increasing the frequency of monitoring has much less influence on the accuracy and power of the monitoring program. EPA's program optimizes these design parameters recognizing that little is to be gained by frequent monitoring over a short period of time relative to a 10-year program that will estimate recovery rates much more accurately. Based on EPA analyses, statistical power to detect recovery rates in this 3 to 10 percent range would be dramatically reduced by restricting attention to a 5–year period, and increased temporal monitoring frequency would not mitigate the problem.

EPA agrees that the OM&M program should be used to optimize next steps in evaluating the Upper Hudson River remedy. EPA agrees that the post-dredging fish and sediment data results available for this FYR are inconclusive indicators of remedy "protectiveness." More monitoring is needed. EPA will continue to review fish tissue data from semi-annual sampling, and fish will in the future be collected from additional sampling locations beyond those that have been used for many years. EPA will also carefully consider each round of sediment data collected within the OM&M program and consider a range of adaptive responses as those data become available.

3.4.9 Comment 58: EPA recognized that more PCBs were present in the Upper Hudson River sediments than originally estimated in the 2002 ROD but did not alter remedial activities to account for this knowledge

Comment

Several commenters concluded that a change was needed but not made in the remedial strategy for PCBs. Specifically, the commenters noted that the remedial design investigation identified substantially more PCBs in the sediments of the Hudson than originally anticipated in the ROD. Commenters indicated that EPA has not provided a satisfactory scientific rationale for not expanding the remedial work to take into account the increase in PCB mass that was identified prior to dredging activities. As a result, commenters state that there will be more PCB mass left behind than originally anticipated.

Commenters were concerned that PCB-contaminated sediment in the shallow portions of the river was missed during dredging, and these areas are where exposure to children and wildlife occur. It

is the commenters' understanding that the floodplain project will extend only to the edge of the water, not into the shallows. Thus, these contaminated areas will be left for future generations. Commenters state that two to three times as much PCBs remain in the river as originally expected, and without additional removal, a "series of Superfund-caliber sites will be left behind" in the Hudson River.

Response

EPA agrees that more PCBs were identified and dredged than originally anticipated but disagrees with the contention that an adjustment was needed in the remedial design to address the additional PCB inventory. The 2002 ROD estimates of PCB inventory in sediments of the Upper Hudson River were based on data collected prior to the publication of the ROD, including sediment data from various sampling programs conducted between 1977 and 1998. These datasets were collected for different purposes using different sampling methodologies but were the best sediment PCB data available at the time of the 2002 ROD. Additional information on the differences between sediment sampling programs is described in more detail in the 2002 Responsiveness Summary for the ROD (EPA, 2002) and EPA's white paper[19] (EPA, 2016).

Subsequent to the release of the 2002 ROD, from 2002 to 2005 an extensive sediment coring program (SSAP) collected data at a higher resolution both spatially and vertically than the pre-ROD sampling. The purpose of the SSAP sampling was to refine the areal and vertical extent of dredging within the Upper Hudson River as part of the Remedial Design (GE, 2002; GE, 2007). The higher spatial and vertical resolution of the SSAP dataset identified more PCB inventory and higher surface concentrations than originally anticipated in the ROD. However, the purpose of the sediment removal program in the ROD was to reduce surface sediment concentrations and sediment inventory so as to reduce fish tissue concentrations. In other words, the primary goal was not to reach a pre-determined sediment concentration or PCB mass, but rather to achieve a sufficient reduction in sediment concentrations to yield a proportional reduction in fish tissue concentration (see also Master Comment 40 [see Section 3.3.17], regarding the relationship between surface sediment concentration and fish tissues concentrations).

The 2002 ROD design was based on ultimately reducing fish concentrations in the Upper Hudson by approximately 99 percent or more, basically by reducing their exposure to contaminated surface sediments by 79 percent in RS 1, 64 percent in RS 2, and by 4 percent in RS 3 via dredging[20] and allowing natural attenuation to achieve the further reduction in exposure (additional information regarding calculation of these reduction percentages is provided in Table 1 of Appendix A of the 2012 FYR report (EPA, 2012)). As can be seen in these numbers, the majority of the reduction in RS 1 and RS 2 was expected to be achieved by dredging. If the SSAP data (which was not available at the time of the ROD) are taken into account, the anticipated levels of reduction via dredging alone based on the ROD criteria (3/10/Select) were 87 percent, 36 percent, and 5 percent,

[19] See: White Paper: Responses to NOAA Manuscript Entitled: "Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation" (Field, Kern and Rosman, 2015) (EPA, 2016)

[20] Note that for an initial average concentration of 10 mg/kg, the planned 79 percent reduction would yield 2.1 mg/kg after dredging. Similarly, a 64 percent reduction yields 3.6 mg/kg and a 4 percent reduction yields 9.5 mg/kg. In a parallel manner, the achieved reductions based only on SSAP data would yield 1.3 mg/kg for a 87 percent reduction, 6.3 mg/kg for a 37 percent reduction and 9.5 mg/kg for a 5 percent reduction.

respectively, for the three river sections (EPA, 2012). EPA did not adjust the ROD criteria after the SSAP data became available since it was anticipated that the thresholds set by the ROD would, when accounting for the SSAP dataset, result in greater proportional reductions in surface sediment concentrations than estimated in the ROD for RS 1 while RS 3 would achieve the planned proportional reduction. Only in RS 2 the remedial action appears not to achieve the proportional reduction when accounting for the SSAP dataset. However, as discussed in more detail below, when more recent and more representative data from 2016 are examined for RS 2, it is apparent that this section also achieved a reduction similar to that anticipated by the ROD.[21]

As part of the FYR report, EPA compared the SSAP data with the 2016 surface samples and the CU backfill sampling results to estimate the overall change in surface sediment concentrations. This comparison accounts for both the active remedy (*i.e.*, dredging) and natural recovery. On an area-weighted average basis, the overall percent reductions (the active remedy plus natural recovery) in surface sediment concentration (0-2 inch interval) of Tri+ PCB were estimated to be 96 percent, 88 percent and 80 percent for RS 1, RS 2 and RS 3, respectively. These percentage reductions are substantially greater than anticipated in the ROD for the active remedy alone, *i.e.,* 79, 64, and 4 percent for RS 1, RS 2 and RS 3, respectively. The calculations also indicate that post-dredging average surface sediment concentrations of Tri+ PCBs are near or below 1 mg/kg. Additional details on the calculation of these reductions can be found in Tables A4-5 and A4-6 and accompanying text in Appendix 4 of the FYR report (EPA, 2017). By implementing the active remedy as specified in the ROD and accounting for natural recovery, EPA achieved a better than planned reduction in surface sediment Tri+ PCB concentrations in all river sections based on the 2016 sampling data.

It should be noted that the discussion above is predicated on the representativeness of the SSAP data for the non-dredged areas. That is, the percentage reductions estimated above assume that the SSAP data obtained for the non-dredged areas can be used to accurately estimate the average PCB concentrations in all non-dredged areas. In RS 1, the SSAP data can probably be considered representative since the sampling grid extended across the entire river section, and few areas were left un-sampled. However, in RS 2 and RS 3, the non-dredged area sampling was focused on the areas closest to the dredging zones to establish the boundary between areas for removal and those that could be left in place. As such, it is likely that these data are not representative of the entirety of non-dredged areas. This systematic bias in the SSAP data for RS 2 and RS 3 was appropriate, given the goals of the program, but EPA's use of the SSAP data to estimate inventory remaining and average surface concentration in non-dredged areas has yielded values that are almost certainly biased high in RS 2 and RS 3.

This observation on the bias in the SSAP data is supported by the more recent surveys of surface sediment concentrations outside the dredging prisms. For both the Downstream Deposition Study (DDS) program directed by EPA in 2011 to 2013 and for the 2016 non-dredged area study designed by EPA with a statistically unbiased sampling layout, the surface concentrations of PCBs in non-dredged areas are substantially lower than those would be suggested by the SSAP data, even after allowing for natural recovery. As shown in Table A4-5 in Appendix 4 of the FYR report, current estimates of Tri+ PCB concentrations in all non-dredged areas in all three river sections

[21] Levels of reduction greater than 87 percent, 36 percent, and 5 percent for RS 1, RS 2 and RS 3, respectively, were also confirmed by the 2017 NYSDEC surface sediment survey.

are less than 2 mg/kg. These values should be contrasted with EPA's estimates of pre-dredging PCB concentrations in non-dredged areas (Pre-dredging SSAP Survey column in Table A4-5) also shown in the table. Given the statistically rigorous unbiased sampling design used in 2016, these results either suggest a very rapid rate of recovery in non-dredged areas (the rate would be equivalent to a 2.5-year half-life) or, more likely, that the earlier data sampling design was biased and did not provide an accurate estimate of the average PCB concentration or, most likely, some combination of the two factors. In any case, the most recent data indicate that surface concentrations of Tri+ PCB in non-dredged areas are less than 2 mg/kg in all river sections, and that after combining these data on an area-weighted basis with the low concentrations of the dredged areas, overall average concentrations are not statistically different from 1 mg/kg on a river section basis.[22]

In conclusion, based on the 2016 EPA/GE and 2017 NYSDEC data, surface sediment concentrations of Tri+ PCB are between 80 and 95 percent lower than those observed in the SSAP survey. While the decrease is undoubtedly due to some combination of active remediation, natural recovery, and artifacts of sampling design, the most recent data clearly show low average surface sediment concentrations throughout the Upper Hudson.

The risk assessment completed as part of EPA's investigation of the Upper Hudson identified fish consumption as the major pathway of exposure yielding risks to human health. No cleanup criteria were developed for sediments based on direct human exposure since this pathway does not yield unacceptable risks to humans. However, in the investigation of shoreline areas during the RI and the remedial design, the shoreline and shallow areas were extensively sampled, identifying those areas that exceeded EPA's removal thresholds. These areas were not missed but, if they were not dredged, they were either demonstrated to be low in PCB level or likely to be low based on indirect lines of evidence (sediment texture), or the shoreline area was too unstable to permit remediation. Based on measured PCB levels, swimming in the Upper Hudson River does not pose an unacceptable risk to human health. Hence, no further remediation is needed in the Upper Hudson River to reduce exposure via in-river activities such as swimming and wading. As part of the floodplain comprehensive study, EPA is investigating shoreline/floodplain areas up to the edge of the water at normal river elevation. Additionally, areas of human use along the shoreline that become exposed as water levels recede are being investigated.

3.5 Protectiveness Determination

This section includes comments and responses with respect to whether the determination is consistent with the EPA FYR guidance and policy, RAOs, and considerations related to institutional controls. Since the proposed Second Five-Year Review was issued in 2017, EPA has completed additional technical analysis supporting comment responses related to the deferral protectiveness statement discussed in this section (See Appendix B of this document).

[22] The current surface sediment concentration in non-dredged area was confirmed by the 2017 NYSDEC surface sediment survey

3.5.1 Comment 12: EPA must consider protection of natural resources as fish consumption advisories do not protect environmental receptors

Comment

Commenters noted that fish consumption advisories (FCAs), which address human consumption of impacted wildlife, do not protect all environmental receptors such as fish, birds, small mammals, and benthic organisms that could be exposed to PCBs left behind by the remedy. Commenters indicated that EPA, as the environmental agency charged with implementing the remedy and ensuring its protectiveness to human health and the environment, should quantify the impacts to these receptors in the Second Five-Year Review.

Response

The RAO established the ROD for protection of ecological receptors is to "reduce the risks to ecological receptors by reducing the concentration of PCBs in fish," since consumption of fish contaminated with PCBs remains the primary route of exposure for most upper trophic level wildlife species. The results of the Baseline Ecological Risk Assessment (BERA) supported EPA's decision that remedial action was necessary to reduce unacceptable risks to ecological receptors.

The FYR report contains a summary of the BERA conducted for the ROD and, consistent with Question B of the FYR process, an evaluation of ecological risk exposure assumptions and toxicity values (see Section 5.2.3.2 Ecological Toxicity and Appendix 11 of the FYR report). Based on current information available in the scientific literature, EPA concluded that updates to ecological exposure assumptions and refinement of the toxicity values do not affect the protectiveness determination of the selected remedy with respect to ecological receptors.

The risk-based goal for the ecological exposure pathway is a range from 0.3 to 0.03 mg/kg PCBs in fish (largemouth bass, whole body) and for consumption of fish by the river otter. This ecological goal is considered protective of all the ecological receptors evaluated because it was developed for the river otter, determined to be at greatest risk from PCBs at the Site. In addition, a range from 0.7 to 0.07 mg/kg PCBs in spottail shiner (whole fish) was developed for the mink, which is a species known to be sensitive to PCBs. Other species, such as the bald eagle, were considered but are at less risk than the river otter.

The dredging remedy has reduced PCB inventory in the sediment, thereby reducing exposures to wildlife. More data will need to be collected before a determination can be made as to the longer-term effect the dredging has had on reducing fish tissue concentrations relative to the risk ranges given above. The number of years needed to reach a conclusion will be based in part on the variability of the data. However, EPA anticipates that it will take as many as eight or more years post-dredging fish tissue data to identify trends with a reasonable degree of scientific certainty.

3.5.2 Comment 13: EPA must include a site-wide protectiveness statement in accordance with the guidance

Comment

Commenters indicated that EPA must make a site-wide protectiveness determination since remedial construction is complete at the Hudson River Superfund Site. The protectiveness determination should generally be the same protectiveness determination as the one for the least protective OU at the site. In addition, because the OU2 remedy here includes the use of institutional controls by way of the NYSDOH fish consumption advisories, EPA must also evaluate the current and long-term effectiveness of the fish consumption advisories and include relevant information about the advisories as part of the protectiveness determination.

Commenters also indicated that EPA admits that the cleanup is not protective of human health and the environment in the Lower Hudson River (LHR) by omitting a protectiveness determination for the 150-mile stretch below the Federal Dam. In the First FYR, EPA issued a site-wide protectiveness determination for the entire 197-mile Superfund site. However, the Proposed Second FYR did not contain a site-wide determination. While EPA claims that the cleanup "will be protective" in the Upper Hudson River (UHR), EPA makes no determination about the cleanup for the 150-mile stretch of the Hudson River below the Federal Dam. Omitting a protectiveness determination for this portion of the Site is concerning and has caused confusion among the people who live, work, and play along the LHR.

Response

EPA developed the protectiveness statements for OU1 and OU2 using the Agency's comprehensive five-year review guidance and supplemental memoranda on the use of protectiveness statements. EPA considered adding a site-wide protectiveness statement, as in the 2012 FYR report. However, in accordance with the guidance EPA did not include a site-wide statement in this FYR because the Agency is still at the RI/FS stage regarding OU4 (Upper Hudson River Floodplain) and is just beginning to conduct supplemental studies of the LHR.

As per the guidance, a site-wide protectiveness statement is typically issued when a site that has multiple operable units (OUs) and has reached construction completion. The guidance discourages issuing a site-wide statement prior to this because all remedies at the site may not have been selected and constructed. Therefore, to minimize any confusion and in accordance with the guidance, EPA chose not to issue a site-wide statement in this FYR.

Limited data collection from the LHR indicates that recovery rates are slower than in the UHR and may no longer be strongly associated with PCB loading from the UHR. The rate of decline of fish tissue PCB concentrations generally decreases with distance downstream. As a result, there is a decrease in the correlation between fish PCB concentrations in the UHR and LHR with distance downstream. This indicates that PCB sources in the UHR have less of an impact on LHR fish than on fish in the UHR. PCB removal by dredging in the UHR has reduced PCB transport to the LHR. This beneficial reduction, along with continued natural recovery, is expected to continue to reduce PCBs in the LHR.

Water column PCB concentrations at Albany/Troy were consistent with modeling predictions during the MNA period and, as expected, increased during the dredging. By contrast, results at Poughkeepsie were generally higher than model predictions and were not impacted by the dredging, indicating that the strength of the relationship between UHR and LHR water column concentrations weakens with distance downstream. It should be noted that there are other sources of PCBs in the LHR, including legacy sediment contamination and possible local sources. Although the local sources have been less significant than the GE sources of PCBs originating in the UHR, both these LHR sources and legacy sediment contamination should continue to be further investigated.

EPA agrees that it is important to carry out supplemental studies of the LHR and will begin that work in 2019. These studies will supplement information collected during the Reassessment process in the 1990s that led to the 2002 Record of Decision, along with the results of periodic monitoring of LHR fish and water by GE under EPA oversight since 2004, and periodic monitoring of LHR fish by New York State. The supplemental studies will also help inform the need for a remedial investigation and feasibility study. It is too early in the process to determine if a cleanup is needed in the LHR.

Regarding the effectiveness of the fish consumption advisories, the State of New York has in place fishing restrictions and advisories against consumption of fish to control human exposure pathways that could result in unacceptable risks. EPA acknowledged in the ROD that the consumption advisories are not fully effective in that they rely on voluntary compliance in order to prevent or limit fish consumption. EPA will continue to work with New York State to ensure the ongoing maximum effectiveness of the advisories. See FYR report Section 2.4.2 (Institutional Controls for OU2) and Appendix 13 for additional details regarding the fish consumption advisories.

3.5.3 Comment 32: "Will be protective" is not an appropriate determination for the Hudson River PCBs Site. "Will be protective" is only appropriate when a remedy is still "under construction."

Comment

Commenters state that for the purposes of developing a protectiveness statement, construction of the remedial action is complete. According to the Protectiveness Determination Guidance, a "will be protective" determination is only appropriate when remedial construction activities are ongoing, but the remedy is anticipated to be protective upon completion and no remedy implementation or performance issues have been identified. Therefore, "will be protective" is not an available option for the OU2 remedy because construction of the remedy is complete. The physical (dredging) and engineering components of the remedial action were completed in 2015 and 2016, respectively.

Response

A protectiveness determination of "will be protective" is an appropriate option for remedies at which construction activities are ongoing. Construction was not complete at the end of the time for the FYR (December 2016). A brief discussion of this point is included below. However, because there is limited post-dredging data available and EPA has determined that as many as 8 or more years of fish tissue data are necessary to establish statistically reliable trends, EPA has differed making a protectiveness determination at this time. Additional supporting technical information regarding EPA's deferral determination is included in Appendix B of this document.

EPA appropriately considered data and information collected through December 2016 for the Second FYR and evaluated OU2 protectiveness as of the end of that year. Data and other information obtained after December 2016 will be considered in the next FYR for OU2.

Although demobilization of the sediment processing facility was largely completed in December 2016, certain demobilization activities, including removal of filter presses and subsequent sampling in the filter press building, were not completed until April 2017. EPA project staff also coordinated with EPA Headquarters FYR staff on interpretation of EPA's five-year review guidance and it was agreed that construction was not complete at the end of 2016[23].

3.5.4 Comment 37: Institutional controls should not be a part of the remedy

Comment

One reviewer commented that EPA should take note of the effectiveness of institutional controls (ICs) as stated in the ROD and indicated that understanding that fish advisories rely on voluntary compliance and therefore are not completely effective in preventing fish consumption is a primary basis for the need, identified in the ROD, for rapid reductions in human health risk in the years immediately following remediation.

Response

ICs are an integral part of Superfund site management, investigation, remediation, and post-remediation monitoring. Specifically, ICs are non-engineered measures such as administrative and legal controls that help minimize the potential for human exposure to contamination and/or protect the integrity of the remedy. ICs are routinely employed at remedial sites and are routinely used by EPA and other government agencies at Superfund sites. As discussed in the 2002 ROD, ICs, including continuation of fish consumption advisories and fishing restrictions, were anticipated to be implemented as long-term control measures, along with active remediation and a long-term monitoring program. These controls are designed to prevent or limit exposure to PCBs through consumption of contaminated fish. Hudson River ICs and their role in the overall remediation approach are discussed in Section 2.4 and Appendix 13 of the FYR report.

[23] EPA guidance included: (Comprehensive Five-Year Review Guidance (OSWER 9355.7-03B-P) and Memorandum: Clarifying the Use of Protectiveness Statements for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews (OSWER 9200.2-111).

ICs are an important component of the remedy for the Hudson River project and EPA continues to work closely with NYS to implement them. EPA understands that while ICs rely on voluntary human compliance and are not by themselves protective of the environment, the remedy is significantly more protective with the outreach conducted and information disseminated through the ICs than without it. Because ICs are not "stand alone" remedial components, EPA selected from a range of remedial alternatives and selected the alternative Removal Criteria by respective River Sections as stated in the ROD (REM 3/10/Select), which includes upstream source control, fish consumption advisories/fishing restrictions, and long-term monitoring of post-construction natural attenuation. EPA anticipates that ICs will need to remain in place for the foreseeable future as the long-term monitoring component of the remedy continues.

3.5.5 Comment 45: The remedy is not protective

Comment

Commenters have asserted that current site human health and ecological risk levels are in excess of EPA's acceptable range, that the remedy is thus not protective, and that EPA's protectiveness statements contradict the fundamental goals of the 2002 ROD. These assertions are based on comparisons of available post-dredging fish data to the modeling projections contained in the ROD regarding the estimated time of achievement of the interim fish target of 0.4 mg/kg of PCBs in the species-weighted Upper Hudson River (UHR) average (Table 11-2 of the ROD). Based on these assertions, commenters conclude that the remedy is not protective and should indicate to the agency that further active remediation is necessary.

Response

EPA is deferring its determination of protectiveness because there is not enough data available since the completion of dredging and related project activities in 2015 to evaluate whether the remedy is functioning as intended as described in the ROD and the underlying FS. The following are several key relevant points from the FYR:

- The dredging portion of the remedy was implemented as designed and within expectations described in the ROD;
- Prior to dredging, MNA was occurring at rates of decline that are generally in agreement with the modeling done for the ROD;
- Early post-dredging results are within expectations of the modeling analyses presented in the FS and ROD;
- Fish, sediment and water data are not sufficient to evaluate post-dredging trends and likely reflect continued impacts from dredging operations [as noted in the ROD (e.g., pp. 68-69), EPA's expectation was that following dredging, the river system would require at least a year or more to equilibrate to post-dredging conditions and exposures];
- The 2002 ROD exposure assumptions are still valid and appropriate for the Site;
- No other information has come to light that could call into question the protectiveness of the remedy; and

- EPA continues to work with New York State to control human exposure pathways that could result in unacceptable risks from the consumption of fish.

EPA recognizes the remedy for OU2 is not yet protective of human health and the environment. However, as the ROD makes clear, the remedy includes an extensive post-dredging period of natural recovery (termed "monitored natural attenuation," or MNA, in the ROD). EPA will continue to monitor the progress of MNA in the OM&M phase of the remedy for the foreseeable future.

EPA agrees that, in general, fish tissue concentrations are currently above the ROD's interim fish target concentration of 0.4 mg/kg. However, EPA does not agree that fish tissue concentrations are significantly different from model projections. For the 2002 ROD, remedy protectiveness was evaluated by comparing predicted fish tissue concentration trajectories over time under different remedial alternatives. The HUDTOX and FISHRAND models were calibrated, verified and applied for the UHR and designed to support decision-making by allowing direct comparisons of predicted water, sediment, and fish tissue concentrations across proposed remedial alternatives. The strength of the models lies in their ability to predict concentration trajectories in sediment, water, and fish over time for multiple scenarios representing remedial alternatives which could then be compared based on a consistent set of assumptions. However, model predictions were likely to differ from actual observations due to: 1) variability in actual exposures; 2) highly localized exposures; 3) the importance of sediment *vs*. water exposure pathways, which can vary over time due to prey availability and natural variability in exposure conditions; 4) uncertainty and variability in lipid content of fish and prey items; 5) uncertainty and variability in consumption of specific prey items and PCB concentrations in prey; and 6) measurement uncertainty (including allowing for differences in sampling programs and analytical methods).

In addition, model forecasting involves population-level assumptions regarding key components such as lipid content and average exposure. However, post-dredging data collection involves collection, processing and analyses of data regarding individual fish. Individual fish and species will respond to contaminant exposures in different ways depending on their foraging strategies and life histories. As a result, individual fish (and any individual fish species, more broadly) will achieve "target levels" at different times and may not completely match "absolute" model forecasts because of varying (real) exposures, diet/available prey, uncertainty in lipids contents based on diet and available prey, and potential data collection and measurement uncertainty.

Differences between assumptions underlying remedy design and actual implementation are discussed in Appendix 8 of the FYR report. Although there were differences in the implementation compared to the underlying assumptions in the analyses presented in the ROD, in general the implementation was not significantly different than those underlying assumptions. In addition to uncertainty resulting from differences in design and implementation, the modeling analysis presented in the ROD assumed a post-dredging "equilibration" period depending on remedy-specific implementation and construction schedule assumptions that would not (as anticipated) be tested until design details were worked out. Furthermore, even if implementation had exactly matched design, some uncertainty was always expected related to water, sediment, and fish in terms of observed (actual) data exactly matching forecasts. For example, differences in environmental conditions (*e.g.*, flow rates, upstream boundary conditions) may contribute to

potential differences between forecasts and observed (actual) fish tissue concentrations, particularly given that the models were designed primarily to predict relative tissue concentration trajectories across remedial alternatives rather than absolute concentrations over time.

The FYR report presents comparisons in Appendix 1 for the water column, Appendix 3 for fish, and Appendix 4 for sediment. Appendix 3 demonstrates that for the pre-dredging MNA period the model performed well and continues to perform well based on 2016 data (Figure A3-19). This figure shows that the mean fish tissue PCB concentrations in 2016 for individual species range from 0.3 to 1.7 mg/kg depending on the species and location. Yellow perch, for example, has already achieved the 0.4 mg/kg interim target at several locations. The species-river section-weighted average based on 2016 data is 1.0 mg/kg, which compares well to model predictions as shown in Figure A3-19. Early post-dredging results therefore are consistent with modeling analyses and expectations presented in the FS and ROD and do not suggest that there are flaws in the model forecasts. Fish PCB data will continue to be collected and evaluated to determine whether subsequent observation cycles demonstrate consistency with ROD-anticipated trends.

EPA acknowledges there are some challenges with certain aspects of data collection and analyses. Specifically, it has been challenging to reconcile the surface sediment data from the 2002 to 2005 SSAP dataset with trends based on the 1977, 1991, and 1998 datasets to which HUDTOX was calibrated. Appendix 4 of the FYR report addresses these challenges EPA has also received comments regarding potential challenges to fish monitoring program implementation. These are addressed in Appendix 3 and Appendix 8 of the FYR report and in responses to Master Comments 51 (see Section 3.3.23 regarding changes in fish monitoring locations), and 46 (see Section 3.3.20 regarding changes in sample processing procedures). Based on the available information, at this time there is no reason to question underlying model assumptions or to evaluate the significance of post-dredging fish tissue results from the perspective of time to attain target levels.

Additional data will be required to evaluate the long-term trend. Power calculations conducted to support the OM&M sampling program design indicate that as many as eight or more years of data will be required to evaluate fish tissue trends in a statistically significant and robust manner. The UHR underwent a "reset" with the implementation of dredging, and post-dredging data will establish a new "baseline" from which trends must now be evaluated. Post-dredging fish tissue data reported in the FYR pertain to a single year and were collected in a ROD-anticipated "year of equilibration." Accordingly, evaluating data-based trends into the future, starting with this new baseline, will require additional data over multiple annual cycles to provide statistically meaningful estimates of progress toward meeting the interim and final targets. EPA finds the 2016 fish data results encouraging, but one or two year of data does not establish a "trend" (toward or away from target levels) and a single year of post-dredging data is not sufficient to conclude that the remedy is not protective or that further active remediation is warranted. As such, EPA will continue to monitor post-dredging (natural recovery) results collected under OM&M and to evaluate remedy protectiveness by comparing future observations to ROD targets and remedial action objectives.

3.5.6 Comment 59: Hudson River PCB concentrations will not reach the target levels anticipated in the ROD and EPA is claiming a short-term impact to the fish from recent dredging when such impacts should be negligible

Comment

Commenters asserted that PCB concentrations in the river will not reach the target levels anticipated in the ROD and that EPA is claiming a short-term impact to the fish from changes in the dredging and construction schedule when in fact the impact should be negligible. Work in RS 1 in the last year of dredging should not have had a significant effect on fish tissue concentrations observed during fall 2015 or in 2016. The impact of the dredging work on the fish clearly shows that the increase in water column PCB concentration did not have a commensurate impact on the fish in the Hudson River. Typically, only those fish in the immediate vicinity of the dredging work, or immediately downstream, showed a significant reaction to the dredging.

Response

Although post-dredging MNA recovery rates are not impacted by the construction schedule, it is not reasonable to assume that construction activities during dredging could have been predicted exactly as anticipated in the ROD. Direct comparisons between ROD calendar year forecasts and observed fish tissue concentrations are not necessarily “apples-to-apples” comparisons. Additionally, while short-term and localized increases and subsequent rapid decreases in fish tissue PCB concentrations were anticipated in the FS and ROD, and were observed between 2009 and 2016, they were not directly reflected in the long-term fish tissue forecasts presented in support of remedy selection. For these reasons, direct comparisons of observed data to ROD forecasts during dredging are not appropriate.

Individual fish species respond to contaminant exposures in different ways depending on their foraging strategies and life histories. It is important to note that any individual fish (and any individual fish species more broadly) will achieve "target levels" at different times given: 1) variability in actual exposures; 2) highly localized exposures; 3) the importance of sediment *vs.* water exposure pathways, which can vary over time due to prey availability and natural variability in exposure conditions; 4) uncertainty and variability in lipid content of fish and prey items; 5) uncertainty and variability in consumption of specific prey items and PCB concentrations in prey; and 6) measurement uncertainty (including allowing for differences in sampling programs and analytical methods). As a result, while the ROD anticipated perturbations to post-dredging fish tissue recoveries, the full range of specific impacts and the timing of such delays on each fish species or population could not reasonably have been predicted.

EPA agrees that fish tissue PCB concentrations may be influenced by dredging and related support work but does not agree that “only those fish in the immediate vicinity of the dredging work, or immediately downstream, showed a significant reaction to the dredging." Data show (Figures A8-4.1 through A8-4.12 of Appendix 8 of the FYR report) that fish tissue concentrations may or may not have varied significantly (statistically) from Baseline Monitoring Period (BMP) levels. However, species at most stations exhibited elevated tissue concentrations as dredging approached a sampling location, or in the year of dredging or after dredging, that were significantly

(statistically) different from either station BMP levels or levels observed in the years immediately preceding dredging.

Specifically, fish collected in both spring and fall, including black bass, yellow perch, and pumpkinseed (PKSD), as anticipated by the ROD, exhibited localized and transient increases in response to dredging at 4 out of 5 Thompson Island Pool (TIP) fish stations during remediation. Figures A8-4.1 through A8-4.4 of Appendix 8 of the FYR report, also suggest that fish tissue PCB concentrations for all species continue to drop from the elevated levels observed during dredging (which concluded in 2015) and do not appear to have leveled off or stabilized yet (data through 2016). This observation is consistent with results from another remedial site, the NYSDEC Cumberland Bay Site in Lake Champlain. As discussed in Appendix 8 of the FYR report, while limited pre-dredging data are available for the Cumberland Bay Site, Figures A8-5.1 and A8-5.2 indicate that for both fall-collected species (*i.e.*, rock bass and yellow perch), several post-dredging years passed before fish tissue PCB levels began to stabilize.

This pattern is also observed for other species at stations located in RS 2 and RS 3 during dredging despite differences in the duration of dredging immediately upstream (other than RS 1/Reach 8) of or within a reach. Upper Hudson River (UHR) fish tissue levels not returning to BMP or pre-dredging levels immediately after dredging may be a product of dredging and support vessel traffic following dredging but is certainly associated with the approach and implementation of local (*i.e.*: at the scale of the reach or station) dredging. As indicated in Tables A8-5 and A8-6, of Appendix 8 of the FYR report, dredging platforms were accompanied by a fleet of support vessels and sediment barges that also had to transit upstream reaches (*e.g.*, moving dredged materials to the processing facility) for several years after sediment removal at a given location. As a result, the end of dredging and backfill operations in a CU may not have resulted in the immediate end of project activities (and consequent environmental disturbances, such as near-shore wave action) in the vicinity of individual fish data collection stations or within a reach or river section.

Overall, the data in hand are consistent with ROD expectations regarding localized and transient increases in fish tissue concentrations. In addition, available data do not conclusively indicate that fish tissue concentrations have leveled off or stabilized since dredging concluded. In fact, fish PCB tissue concentration data collected during and since dredging suggest a general downward trend for several species at multiple sampling stations from within all three river sections. This pattern is reasonable to expect given that dredging within reaches or sections ended in different years, but vessel traffic in these reaches may not have. Upper Hudson fish tissue levels not immediately (or by the spring or fall of 2015 or 2016) returning to BMP or pre-dredging levels may be a product of site-specific dredging and support activities. However, and as is suggested by the NYSDEC Cumberland Bay data, it may also reflect that sediments and fish tissue levels simply require time to stabilize from short-term, transient impacts associated with active remediation. Appendix 8 of the FYR report (See Figure A8-5.2) indicates that while downward trends in fish tissue PCB concentrations can be observed in the first few years after dredging, it will take as many as 8 or more years of data collection before trends in the data can be determined with statistical confidence. Taken together, these observations suggest that while recent UHR results are generally consistent with the ROD's expectations, post-dredging data may still be exhibiting "localized and transient" impacts; and that it is still too early to determine the full extent

of dredging impacts on local fish tissue concentrations (*i.e.,* more data collection cycles are needed).

3.6 FYR Process and Public Engagement

This section includes comments and responses on the FYR process, the FYR team formation, public engagement, the Community Involvement Plan (CIP), and interactions between EPA and the trustees and other stakeholders.

3.6.1 Comment 5: Consider the risks to Environmental Justice communities

Comment

Commenters noted that the original HHRA did not consider newer subpopulations of anglers, such as minority or immigrant populations, who rely on subsistence fishing, use different species of fish, and consume small forage fish in different ways. Additionally, commenters noted that more people are relying on fish for subsistence than when the ROD was issued, pointing to significant changes in demographics and fish consumption patterns on the Hudson River, particularly in the Lower Hudson. Commenters also noted that EPA's Community Involvement Plan's (CIP) goal with regard to environmental justice is to increase awareness and information about the project, especially in communities that may not know how to access information or that may not have many opportunities or methods to do so and that the EPA should consider developing specific strategies for reaching out to underrepresented communities, as it has done in other locations. As such, commenters requested that the risk assessment be revisited to take into account all consumption patterns in order to accurately capture human health risks. They requested that this information be included in the FYR. Commenters further requested that EPA should ensure that the communities that are most interested in using the Hudson for subsistence fishing are adequately informed and have a meaningful opportunity to participate in the public comment process for the FYR report.

Response

Under CERCLA, cancer risks and non-cancer hazards were evaluated based on potential exposures to the Reasonably Maximally Exposed (RME) individual. RME is defined as the maximum exposure that is reasonably expected to occur in the Upper Hudson River under baseline conditions (*i.e*., assuming no remediation and no other measures to control exposure, such as fishing advisories and restrictions) and is not a worst-case exposure scenario. The risk assessment considers exposures currently and in the future. As described below, the HHRA describes the process used to evaluate exposures in the Hudson River including evaluation of consumption of fish by subsistence anglers. Based on the available information EPA considers the original ingestion rate representative of the RME individual.

Fish Ingestion Rate. The fish ingestion rate used in the HHRA was based upon an estimate of the long term average consumption of self-caught fish in the angler population, expressed as an annualized daily average rate in units of grams of fish per day (g/day).

The HHRA evaluated a number of fish consumption survey studies as described in the assessment. Based on this assessment, EPA selected the fish ingestion rate based upon a survey of over 1,000 New York anglers (Connelly *et al.*, 1992) who caught and consumed fish. For the adult exposure, the Central Tendency Exposed (CTE) fish ingestion rate (for the average exposed individual) is the 50_{th} percentile of the empirical distribution (4.0 g/day) and the RME ingestion rate is the 90_{th} percentile (31.9 g/day). For a one-half pound serving, these ingestion rates represent approximately 6.4 and 51 fish meals per year, respectively. The process used to develop these ingestion rates are outlined in the HHRA and externally peer-reviewed.

Subsistence Subpopulations. Subpopulations of highly exposed or less exposed anglers have not been explicitly characterized, but instead are assumed to be represented in the fish ingestion rate distribution. For example, the 99_{th} percentile fish ingestion rate from the 1991 New York Angler survey is 393 meals per year, or more than one fish meal per day. Furthermore, even those responses claiming a consumption rate of up to 1,000 meals per year were included from the 1991 New York Angler survey. Although it is possible that there are subsistence or highly exposed individuals who do not obtain fishing licenses, and therefore would not have been captured in the 1991 New York Angler survey or included in the generated distribution of ingestion rates, there are no known, distinct subpopulations that may be highly exposed in the Upper Hudson River area.

Review of the limited literature on subsistence or highly exposed angler populations supports the assumption that these subpopulations are likely to be adequately represented in the total distribution of fish ingestion rates developed for Upper Hudson River anglers. As presented in a thesis by Wendt entitled "Low Income Families' Fish Consumption of Freshwater Fish Caught From New York State Waters," low-income families in 12 counties throughout New York, including Albany and Rensselaer counties were interviewed (Wendt, 1986). Wendt reported that between 9% and 49% of the low-income families in each county ate freshwater fish from New York State waters. Wendt then conducted a more in-depth survey of low-income families in Wayne County, New York, bordering Lake Ontario and determined fish consumption rates. The average consumption rate was 17.5 meals per year, or 10.9 g/day. In comparison, the arithmetic average consumption rate from the distribution selected to represent Upper Hudson River anglers is 27.8 meals per year, or 17.3 g/day.

Some commenters indicated that EPA should take additional steps to ensure that there is sufficient outreach to the diverse communities in the Lower Hudson River, including low-income communities, communities of color, and subsistence fishing communities.

Based on public input received when the cleanup decision was made, the EPA committed to developing a comprehensive public involvement program to be employed throughout the design and construction phases of the project. As a commenter accurately noted, according to the EPA's 2009 CIP, EPA's community involvement efforts over the last several years have largely focused on the upriver communities. This is the area where dredging took place and where the impacts and effects of the dredging were most directly felt. Environmental justice considerations not only recognize the burden of industrial pollution from historical practices, but the potential impacts of cleanups themselves.

While the dredging component of the cleanup remedy is now complete, the EPA remains committed to keeping the public informed about future work, including the long-term monitoring that will be conducted to track the recovery of the river over time, and any efforts that are initiated in the future to collect additional information/data in the Lower Hudson River. The EPA will continue to coordinate with New York State and the site's CAG, which includes Lower Hudson River interest groups, to evaluate outreach needs.

Several commenters also stressed the importance of continued and ongoing outreach to subsistence fishing communities in the Lower Hudson River to ensure that they are adequately informed about the PCB contamination in the river and the existing New York State fish consumption advisories. NYSDOH has primary responsibility for educating and informing people who fish in the Hudson River about the current New York State restrictions and advisories. As discussed in Appendix 13 of the FYR report, pursuant to the Consent Decree between GE and EPA, GE has contributed $4 million to Health Research, Inc., of Rensselaer, New York, in order to support the State's implementation of appropriate fish consumption advisories and fishing restrictions. The NYSDOH has a Hudson River Fish Advisory Outreach program which specifically targets its communication to high-risk populations, such as women, children and low-income citizens and works to develop specific strategies for reaching out to underrepresented communities in both the upper and Lower Hudson River.

The Hudson River Fish Advisory Outreach Project uses various outreach strategies that include distribution of written and electronic materials, partnerships, and a presence at community events and public venues to achieve its objectives. NYSDOH fish advisory outreach work has been conducted in partnership with other state and local agencies. NYSDOH has established partnerships with commercial fishermen, recreational anglers, boating community representatives, environmental justice advocates, immigrant rights advocates, local health officials, environmental conservation officials, parks and recreations officials, health care provider representatives, community group leaders, and food pantry and community food networks.

To improve its outreach, NYSDOH has also been making educational materials more accessible to lower-literacy and non-English speaking individuals. NYSDOH is also working with partners, such as the Latinos Unidos of the Hudson Valley, the U.S. Committee for Refugees and Immigrants, and the Chinese America Planning Council, to learn about different cultures and communities to more effectively communicate information to a more diverse audience via both existing and new venues. These efforts include making presentations to faith-based groups and establishing "youth ambassadors" to help communicate health advice to their communities. The addition of part-time project staff who attend public outreach events and possess Spanish and Chinese language skills also enables the project to reach a broader audience more effectively.

The EPA will continue to coordinate closely with NYSDEC and NYSDOH on the implementation of the outreach program.

3.6.2 Comment 17: EPA should ensure that there is adequate outreach to the diverse communities in the Lower Hudson River

Comment

Commenters state that EPA's community involvement goals include providing understandable information to the public, ensuring that the public has a meaningful opportunity to engage with EPA, and helping the public understand the Superfund decision-making process. Commenters questioned the number of EPA's community involvement activities in the downriver communities. Commenters provided examples of outreach in the Upper Hudson communities that Lower Hudson residents do not benefit from such as EPA's enhanced physical presence in the Upper Hudson through field offices, public meetings, community events, and media appearances. Commenters question whether EPA has made specific efforts to ensure that its outreach materials, like fact sheets, technical documents, and e-mails, are widely available to various audiences.

Some commenters indicated that EPA should take additional steps to ensure that there is sufficient outreach to the diverse communities in the Lower Hudson River, including low-income communities, communities of color, and subsistence fishing communities.

Response

Based on public input received when the remedy was selected for OU2, EPA committed to developing a comprehensive public involvement program to be used throughout the design and construction phases of the project (which included the dredging work). As a commenter accurately noted, according to the EPA's 2009 Community Involvement Plan (CIP), EPA's community involvement efforts over the last several years have largely focused on the upriver communities. This is the area where dredging took place and where the impacts and effects of the dredging were most directly felt. Environmental justice considerations not only recognize the burden of industrial pollution from historical practices, but the potential impacts of cleanups themselves.

While the dredging component of the OU2 remedy is now complete, EPA remains committed to keeping the public informed about future work, including the long-term monitoring that will be conducted to track the recovery of the river over time, and efforts that are initiated in the future to collect additional information/data in the Lower Hudson River. EPA will continue to coordinate with New York State and the site's CAG, which includes Lower Hudson River interest groups, to evaluate outreach needs. EPA expects that the supplemental studies of the Lower Hudson River will start in 2019 and will take several years to complete.

The primary risk to people from Hudson River PCBs is the consumption of PCB-contaminated fish. As natural recovery of the river continues, human exposure to PCB-contaminated fish will continue to be controlled through fishing restrictions and fish consumption advisories issued by New York State. As discussed in Appendix 13 of the FYR report, NYSDOH has a Hudson River Fish Advisory Outreach Program, which specifically targets its communication to high-risk populations, such as women, children, and low-income citizens and works to developed specific strategies for reaching out to potentially underrepresented or informed communities in both the Upper and Lower Hudson River. Informing people about the New York State fishing restrictions

and advisories is primarily the responsibility of NYSDOH. EPA continues to coordinate with NYSDOH to ensure that the state's fish advisory information is integrated into project informational materials, discussed during public meetings and presented on the EPA's project webpage. Updates on the status and progress of the NYSDOH's Hudson River Fish Advisory Outreach Program are also presented to the site's CAG periodically.

Pursuant to the Consent Decree between GE and EPA, GE has contributed $4 million to Health Research, Inc., of Rensselaer, New York, in order to support the State's implementation of appropriate fish consumption advisories and fishing restrictions. Much of the outreach conducted as part of the Hudson River Fish Advisory Outreach Program focuses on informing the community about the risks from high PCB concentrations in fish, strategies to reduce exposure to PCBs during fish consumption, and the recommended frequency of consumption of Hudson River fish. NYSDOH staff who conduct outreach also provide advice to anglers on alternate waters near the Hudson River that are safer in terms of fish consumption.

The Hudson River Fish Advisory Outreach Program uses various outreach strategies that include distribution of written and electronic materials, partnerships, and a presence at community events and public venues to achieve its objectives. NYSDOH fish advisory outreach work has been conducted in partnership with other state and local agencies.

EPA understands the challenges faced by NYSDOH regarding informing the public about fish consumption and the importance of the Outreach Program to reducing human exposure to contaminated fish. EPA will continue to coordinate with NYSDEC and NYSDOH on the implementation of the outreach program and to identify potential additional and/or more effective outreach techniques into the future.

3.6.3 Comment 23: EPA should review all the data when developing the Five-Year Review report in accordance with the guidance

Comment

Commenters state that EPA should follow its own guidance and include credible data and analyses that are independently verified and peer reviewed, including those conducted by NYS and federal agencies, in its FYR. They state it is imperative that the FYR process be conducted in the most expeditious manner possible, and that the study include a comprehensive, independent, and objective analysis of all available data, including the NOAA analysis, and an opportunity for full participation by the NYSDEC, NYSDOH, the federal natural resource trustees, and other interested stakeholders.

Commenters claim that EPA's draft FYR report of the Site lacks clear metrics to evaluate the success or failure of the cleanup, and without clear metrics, the public is left in the dark as to how EPA compared current conditions with the 2002 ROD expectations to reach its conclusion that the remedy will be protective. Therefore, EPA should identify and list the criteria that it used to evaluate the performance of the remedy in the FYR, as well as the criteria that the agency will use for subsequent reviews. This should lead to a fair consideration of all relevant targets, not a selective view of only the targets that are being met.

Response

EPA's 2002 remedy selection for the Upper Hudson River (UHR) explicitly relied on two separate elements: first, the very extensive dredging project, covering almost 500 acres and involving removal of a large volume of PCB-contaminated sediment; and second, natural recovery with extensive monitoring, predicted to take more than five decades.

The ROD also identifies objectives for the cleanup, including the reduction in fish tissue PCB concentrations, because the main threat to people's health (and the health of other animals) from PCB contamination in the Hudson River is through fish consumption. EPA's overarching approach was to significantly improve the rate of fish recovery by removing sediment (with limited capping) so that the river could recover quicker than by natural recovery alone.

Computerized models were used to compare dredging options and estimate how long it would take under each option to achieve the interim fish recovery targets and the long-term remediation goal. The model runs extended for 55 years after the end of dredging. No dredging alternative, even the most aggressive, was predicted to achieve EPA's goal for fish recovery (0.05 mg/kg of PCBs in fish) within this time period, in the UHR as a whole. The EPA therefore laid out two interim targets for the cleanup remedy. The first of these (0.4 mg/kg in fish) would allow people to consume one fish meal every two months. The second (0.2 mg/kg) would allow people to consume one fish meal every month.

EPA will measure success for the UHR dredging remedy by comparing the goals set in the ROD with data gathered through an extensive program of water, sediment and fish monitoring. Fish are collected twice each year, in spring and fall, from a specified series of locations throughout the UHR and Lower Hudson River (LHR). Water quality data are collected weekly or monthly depending on location. Sediment data will be collected every five years. It will take up to eight or more years of fish tissue data to identify trends with a reasonable degree of scientific certainty. EPA will continue to carry out FYRs into the future, which will consider all data including the new data gathered since the previous review.

As mentioned above, EPA has and plans to collect an extensive amount of fish, water quality and sediment data from the Hudson River. This FYR considered all available project data (e.g., fish, water, sediment, air) through 2016. Data collected in 2016 reflects conditions less than a year after completion of dredging and are still influenced by dredging-related impacts. EPA has considered in the FYR the analysis provided by other agencies including NOAA and NYSDEC. Members of these agencies were on the FYR review team and contributed to the meetings held to discuss the project and progress of the FYR. EPA has evaluated the NOAA analyses mentioned by the commenters and presented its findings at a FYR team meeting. EPA response to the NOAA analysis is in EPA's White Paper titled *Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation* -March 2016 (https://www3.epa.gov/hudson/pdf/EPA%20White%20Paper%20-%20Responses%20to%20NOAA%20Manuscript.pdf), and further supplemented in Appendix C of this document. EPA concluded that NOAA's claim that fish tissue concentrations will not meet remedial goals until many decades longer than anticipated by EPA's

model forecasts is not supported by the data. NOAA's analysis did not reflect the breadth of project sediment and fish data. NOAA also did not complete an appropriate emulation model calibration.

EPA established the metrics to be used in the FYR at the beginning of the process and presented them to the FYR team. During early FYR team meetings, team members asked specific questions about the data to be used and approach for evaluation. EPA with its technical experts discussed the data and approach to be used for the FYR. Following the issuance of the draft FYR report, EPA held a follow up meeting with the FYR team where the data and analysis were further explained and discussed. At each team meeting, EPA allowed time for full discussion of questions and concerns of team members. The criteria being used in assessing the data are based on the EPA guidance on conducting FYRs and are presented in Section 5 of the FYR report.

EPA disagrees that the FYR lacks clear metrics against which to evaluate the effectiveness of the remedy. The remedial action objectives, remedial goals and fish PCB target concentrations all serve as metrics for evaluating the remedy, and the FYR includes discussion of the available data in relation to those metrics. Data collected to date (primarily fish tissue data) may still be impacted by dredging related activities and more data is needed. However, actual conditions during dredging did not and were not expected to match up in every way with conditions as understood when the ROD modeling was conducted. Therefore, direct comparisons of observed fish tissue concentrations to ROD forecasts need to be carefully considered. It should also be noted that dredging started later than the model considered. Also short-term and localized increases and subsequent decreases in fish tissue PCB concentrations were anticipated in the FS and ROD (and observed between 2009 and 2016) were not directly reflected in the long-term fish tissue forecasts presented in support of remedy selection. For these reasons, direct comparisons of observed data to ROD forecasts need to be done carefully with the various factors taken into consideration.

In the Final FYR report EPA is deferring a final protectiveness determination because it has determined that there are not yet sufficient years of post-dredging data available on which to support making a protectiveness determination.

3.6.4 Comment 25: EPA should update the Community Involvement Plan

Comment

Commenters state that EPA is not performing adequate outreach to communities along the Hudson River. While EPA has a Community Involvement Plan (CIP), it has not been updated since 2009 and was intended to guide activities through the completion of dredging. Now that dredging is complete, EPA should revise the CIP to better address the ongoing risks associated with PCB contamination that will continue for decades along the entire Hudson River Superfund Site.

Response

As commenters accurately noted, the most recent update to the CIP for the in-river dredging portion of the cleanup was in 2009 and was intended to guide activities through the completion of dredging. Under the Superfund program, the CIP lays out the approach and rationale for community involvement efforts and activities throughout the Superfund cleanup process and is

typically prepared early in that process. The original CIP for the Hudson River PCBs Superfund Site was developed in 2003, during the design portion of the cleanup, and was subsequently updated in 2009, prior to the start of dredging. EPA is currently in the process of preparing the CIP for the Upper Hudson River (UHR) floodplain component of the Superfund site, for which GE currently is performing a remedial investigation under an administrative consent order with EPA. While CIPs are not developed specifically for Five-Year Reviews (FYR), or to guide post-cleanup outreach efforts, the CIP is a valuable resource when planning community involvement activities during the FYR and for continued community engagement after cleanups are completed.

Based on public input received when the cleanup decision was made, EPA committed to developing a comprehensive public involvement program to be employed throughout the design and construction phases of the project. While the dredging component of the cleanup remedy is now complete, EPA remains committed to keeping the public informed about future work, including the long-term monitoring that will be conducted to track the recovery of the river over time and any efforts that are initiated in the future to collect additional data in the Lower Hudson River (LHR). Information will be available on the Hudson River PCBs site webpage and EPA will continue to develop fact sheets and news releases related to elements of the work that are of greatest interest to the community. EPA also plans to continue to participate in meetings of the site's CAG, as requested, to provide project updates. CAG meetings are open to the public.

Some commenters noted that although the dredging has ended, information should continue to be provided and available to all Hudson River communities, and particularly down river subsistence fishing communities, regarding the risks associated with PCB contamination in the Hudson River. The NYSDOH has primary responsibility for informing people about current New York State fishing advisories. More information about New York State's Hudson River Fish Advisory Outreach Project is discussed in Appendix 13 of the FYR. EPA will continue to coordinate closely with New York State on the Hudson River Project including matters related to the fishing restrictions and advisories.

3.6.5 Comment 39: Public Involvement in the Five-Year Review Process

Comment

Commenters had various concerns pertaining to stakeholder and public involvement in the FYR process. Commenters requested a defined scope for FYR team members to provide input on topics such as identifying objectives, a timetable for completing tasks, a scoping process that solicits input from agencies and the public, and criteria for transparency in the process. A request to extend the public comment period was also provided along with a request for EPA to respond to any comments received in writing.

In addition, commenters were concerned that EPA only held two public information meetings along the entire "197-mile stretch of the Hudson River Superfund Site, neither of which are located in or near New York City." Commenters stated that the EPA should hold a public information meeting in NYC regarding the Proposed Second Five-Year Review Report for the Hudson River Superfund Site. Commenters also said that it is crucial that the local community, including those

along the Lower Hudson River, have the opportunity to hear directly from the EPA on this proposed report and to have their own voices be heard.

Commenters also stated that EPA is conducting vastly more extensive community outreach at similar Superfund sites. Commenters provided the following example: EPA Region 10 has held more than eighty community outreach and engagement activities since 2012 regarding the Portland Harbor Superfund Site, which is also contaminated with PCBs. There, EPA identified strategies for reaching out to underrepresented communities in the region, had translators present at meetings, and attended cultural events to promote greater community engagement.

Response

While the five-year review was underway, the EPA consistently indicated the Agency's commitment to a transparent and inclusive five-year review process. While not required by law, or the usual Superfund procedures, the EPA took the nearly unprecedented step of offering an opportunity for the public to comment on the draft five-year review report.

Per the EPA guidance on conducting five-year reviews, EPA is expected to obtain input on the review from multiple groups and agencies, including state-level agencies, community groups, and other federal partners. For the Second Five-Year Review, EPA established a team that included representatives from state and federal agencies, the Hudson River Natural Resource Trustees, and representatives from the site's Community Advisory Group. The scope for the team members was established at the first team meeting and team member responsibilities were identified and discussed. Over the course of the review period, the five-year review team met 13 times to discuss data and other relevant project information. In these meetings, EPA presented data being used in the analyses for the five-year review and explained EPA's understanding of the data to date. EPA also dedicated multiple meetings to receive input from team members on the analysis of the data, the concerns and questions on the analyses being conducted, clarification on the protectiveness determination, and to discuss the draft report with team members to assist in their development of comments. EPA has shared all the data and, to the extent possible, the technical assessment documents and related materials that were part of its decision-making on this five-year review.

In addition, EPA held workshops, open to the public, to discuss important aspects of the review process and to discuss EPA's progress on the analyses conducted to date. EPA also reported to the community advisory group at multiple meetings throughout the review process to update the group as well.

The Proposed Five-Year Review report, including all the technical appendices, and a brief fact sheet were made publicly available on the Hudson River PCBs site webpage (www.epa.gov/hudson) along with information about how to submit written comments during the public comment period.

On June 1, 2017, EPA issued the Proposed Second Five-Year Review Report and initiated a 30-day public comment period. The public comment period was subsequently extended as requested by the public to 90 days and concluded on September 1, 2017. Three public information meetings were held at various locations in the project area during the comment period. One of the public

meetings was held in NYC as requested by the public. Approximately 2,000 comments were received from the public, as well as State and Federal agencies, environmental groups, and elected officials. All comments received were carefully considered in development of the Final Second Five-Year Review Report.

IV. REFERENCES

Barclay, B. 1993. "Hudson River Angler Survey." Hudson River Sloop Clearwater, Inc. Poughkeepsie, New York.

Bertazzi, PA, L. Riboldi, A. Pesatori, L. Radice, and C. Zocchetti. 1987. "Cancer mortality of capacitor manufacturing workers." In Am J Ind Med. 1987;11(2):165–76.

Brown, DP. 1987. "Mortality of workers exposed to polychlorinated biphenyls–an update". In Arch Environ Health. 1987;42(6):333–9.

Burkhard, L. 2009. Estimation of Biota Sediment Accumulation Factor (BSAF) from Paired Observations of Chemical Concentrations in Biota and Sediment. U.S. Environmental Protection Agency, Ecological Risk Assessment Support Center, Cincinnati, OH. EPA/600/R-06/047.

Butcher, J.B., T.D. Gauthier, and E.A. Garvey, 1998. Use of Historical PCB Aroclor Measurements: Hudson River Fish Data. In *Environmental Toxicology and Chemistry*, Vol. 16, No. 8, pp. 1618-1623.

Connelly, N.A., B.A. Knuth, and C.A. Bisogni. 1992. Effect of the Health Advisory changes on Fishing Habits and Fish Consumption in New York Sport Fisheries. September. Cornell University: Ithaca, NY.

Eastern Research Group, Inc. 2000. Report on the Peer Review of the Hudson River PCBs Human Health Risk Assessment. Prepared for U.S. Environmental Protection Agency, Region II. September, 2000. Final Report.

Eastern Research Group, Inc.. 2000. Report on the Peer Review of the Revised Baseline Modeling Report for the Hudson River PCBs Superfund Site. Final. Prepared for U.S. Environmental Protection Agency, Region II, Emergency and Remedial Response Division. EPA Contract No. 68-W6-0022, Work Assignment No. 4-12, May 10.

EPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February 1997.

EPA. 2000a. Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS Volume 2D. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra Tech, Inc. January 2000, http://www.epa.gov/hudson/reports.htm (Last accessed: 02/10/2015)

EPA. 2000b. *Phase 2 Report Further Site Characterization and Analysis Volume 2F - Revised Human Health Risk Assessment Hudson River PCBs Reassessment RI/FS - Upper Hudson River and Mid-Hudson River*. Vol. 2F. November 2000.

EPA. 2000c. *Phase 2 Report – Review Copy Further Site Characterization and Analysis Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS,* Volume 2D/ Book 1 of 4, Fate and Transport Models. Prepared for EPA and USACE by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. January 2000.

EPA. 2000d. *Hudson River PCBs Reassessment RI/FS Phase 3 Report: Feasibility Study*. *Book 1 of 6: Report Text, Book 2 of 6: Figures and Tables, Book 5 of 6: Appendix D through Appendix H.* Prepared by TAMS Consultants, Inc., for EPA and USACE, December 2000.

EPA. 2001. *Comprehensive Five-Year Review Guidance*. EPA 540-R-01-007. OSWER No. 9355.7-03B-P.

EPA. 2002a. *Record of Decision for the Hudson River PCBs Superfund Site. U.S. Environmental Protection Agency.* February 2002.

EPA. 2002b. Responsiveness Summary Hudson River PCBs Site Record of Decision. January 2002. Prepared for EPA Region 2 and USACE Kansas City District by TAMS Consultants, Inc.

EPA. 2010. Attachment E to Statement of Work, Operations, Maintenance and Monitoring Scope for Phase 2 of the Remedial Action. December 2010.

EPA. 2012a. First Five-Year Review Report for Hudson River PCBs Superfund Site. June 1, 2012.

EPA. 2012b. *Memorandum: Clarifying the Use of Protectiveness Statements for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews* (OSWER 9200.2-111). From James E. Woolfort, Director, Office of Superfund Remediation and Technology Innovation and Reggie Cheatham, Director, Federal Facilities Restoration and Reuse Office, to National Superfund Program Officers, Region 1-10. September 13, 2012. https://semspub.epa.gov/work/HQ/174829.pdf

EPA. 2014. Scoping and Problem Formulation for the Identification of Potential Health Hazards for the Integrated Risk Information System (IRIS) Toxicological Review of Ethylbenzene [CASRN 100-41-4]. https://nepis.epa.gov/Exe/ZyNET.exe/P100L2BO.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2011+Thru+2015&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C11thru15%5CTxt%5C00000013%5CP100L2BO.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

EPA. 2016a. Responses to NOAA Manuscript Entitled: "Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation" (Field, Kern, Rosman, 2015). https://www3.epa.gov/hudson/pdf/EPA%20White%20Paper%20-%20Responses%20to%20NOAA%20Manuscript.pdf.

EPA. 2017a. PCB Data Collection and Analyses with Sediment Grain Size Distribution: Results of Analyses of Sediment Samples Collected During EPA Oversight of General Electric Contractors Performing 2016 Surface Sediment Data Collection. Data Collected Fall 2016 and Analyzed January 2017. Prepared by Axys Analytical Services and Louis Berger for USEPA (Filename: 2017-01-30 FINAL Hudson HRFO 20-16 - Master Database [validated].xlsx). January 31, 2017.

EPA. 2017b. Proposed Second Five-Year Review Report for Hudson River PCBs Superfund Site. May 31, 2017.

EPA. 2019a. Technical Memorandum – Evaluation of 2016 EPA/GE and 2017 NYSDEC Surface Sediment Data, Hudson River PCBs Superfund Site. Prepared for USEPA Region 2 and USACE Kansas City District by Louis Berger, U.S., Inc. and Kern Statistical Services. January 2019. (https://www3.epa.gov/hudson/).

EPA. 2019b. Special Study of Black Bass Fillet Tissue With and Without Ribs. Prepared for USEPA Region 2 and USACE, Kansas City District by Louis Berger, U.S., Inc. and Kern Statistical Services, Inc. January 2019. (https://www3.epa.gov/hudson/).

EPA and Wisconsin Department of Natural Resources (WDNR). 2009. Lower Fox River Remedial Design Percent Design Report for 2010 and Beyond Remedial Actions. Volume 2 of 2. Appendix I: Long-Term Monitoring Plan, November 2009.

Farley, K. J., R. V. Thomann, T. F. I. Cooney, D. R. Damiani and J. R. Wands. 1999. An Integrated Model of Organic Chemical Fate and Bioaccumulation in the Hudson River Estuary. Riverdale, NY, Report to The Hudson River Foundation: 170.

Field, L.J., J.W. Kern, and L.B. Rosman. 2016. "Re-visiting projections of PCBs in Lower Hudson River fish using model emulation." *Science of Total Environment* 557-558 (2016) pp. 489-501. (http://dx.doi.org/10.1016/j.scitotenv.2016.02.072).

GE. 2002. *Design Support Sediment Sampling and Analysis Program, Field Sampling Plan*. Prepared for General Electric Company by Quantitative Environmental Analysis, LLC. (QEA). April 2002.

GE. 2006. Corrective Action Memorandum (CAM) No. 6 – Modification to the Daily Far-Field Monitoring Schedule. Memorandum from John Roche, Anchor QEA, to Bob Gibson, General Electric. August 12, 2013.

GE. 2007. Hudson River PCBs Site Phase 2 Dredge Area Delineation Report. Prepared for General Electric Company by QEA, LLC. December 17, 2007.

GE. 2008. CAM No. 14 – Hudson River Phase 2 Remedial Action Monitoring Program – Analytical Procedures for Water Samples Collecting at Beginning of 2017 through Start of OM&M. Memorandum from Meg Michell, Environmental Standards, Inc., to Bob Gibson, General Electric. May 17, 2017.

GE. 2011. Hudson River PCB's Site 2011 Remedial Action Monitoring Quality Assurance Project Plan (RAMQAPP). Prepared by Anchor QEA (Glens Falls, NY) in Conjunction with Environmental Standards, Inc. (Valley Forge, PA). Appendix 3.8-4 (SOP for the Tissue Reduction/Grinding for Whole Body and Filleted Fish, August 2011).

Huber, P.J. 1973. Robust Regression: Asymptotics, Conjectures and Monte Carlo. Annals of Statistics, 1, 799-821. http://dx.doi.org/10.1214/aos/1176342503

Huber, P. J. 1981. Robust Statistics. John Wiley and Sons, New York.
Hudson River Phase 2 Remedial Action Monitoring Program – Analytical Procedures for Water Samples Collecting at Beginning of 2017 through Start of OM&M. Memorandum from Meg Michell, Environmental Standards, Inc., to Bob Gibson, General Electric. May 17, 2017.

HydroquaL. 2007. A Model for the Evaluation and Management of Contaminants of Concern in Water, Sediment, and Biota in the NY/NJ Harbor Estuary, Contaminant Fate & Transport & Bioaccumulatoin Sub-models, July 2007 http://carpweb.org/modeling/Modeling_reports?CFTB.pdf

Lenth, R. V. 2009. Java Applets for Power and Sample Size [Computer software]. Retrieved January 29, 2014, from http://www.stat.uiowa.edu/~rlenth/Power.
Lilliefors, H. W. "On the Kolmogorov-Smirnov test for normality with mean and variance unknown." Journal of the American Statistical Association. Vol. 62, 1967, pp. 399–402.

Neter, J., Kutner, M. H., Nachtsheim, C. J., and Wasserman, W., 1996. Applied Linear Statistical Models, 4thEdition, Richard D. Irwin, Inc., Burr Ridge, Illinois. NYSDEC 2005. Of Time, PCB's and the Fish of the Hudson River. NY State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources. Albany, NY, July 2005, Appendix 1 (Fish Collection, Sample Preparation, and Analytical Procedures, page 259).

NYSDEC. 2012. *Cumberland Bay Sludge Bed – Wilcox Dock Site # 5-10-017 Removal and Disposal Project Pre-to Post-Dredging Monitoring (Volumes I of II and II of II) Ten Year Review.* Prepared by AECOM, Latham, NY. June 2012.

NYSDOH. 2000. 1996 Survey of Hudson River Anglers – Hudson Falls to Tappan Zee Bridge at Tarrytown, New York. Final Report, February 10, 2000.

Rodenburg, L.A. and D.K. Ralston. 2017 Historical sources of polychlorinated biphenyls to the sediment of the New York/New Jersey Harbor.

Safe. S.H. 1994. “Polychlorinated Biphenyls (PCBs) Environmental Impact, Biochemical and Toxic Responses, and Implications for Risk Assessment”. Critical Reviews in Toxicology, 24, 87-149. http://dx.doi.org/10.3109/10408449409049308

Sanders, J.E. 1989. PCB-pollution problem in the Upper Hudson River: From environmental disaster to environmental gridlock.' *Northeastern Env. Sci.* 8(1): 1-86.

Sinks, T., G. Steele, AB Smith, K. Watkins, RA Shults. 1992. “Mortality among workers exposed to polychlorinated biphenyls.” In American Journal of Epidemiology. 1992;136(4):389–98.

Sloan, R.J., M.W. Kane and L.C. Skinner. 2002. 1999 as a Special Spatial Year for PCBs in Hudson River Fish. Bureau of Habitat, Division of Fish, Wildlife and Marine Resources, New York State Department of Environmental Conservation, Albany, New York. 111 p.

Sloan, Ron. 1999. Briefing on 1997 Striped Bass PCB Results. Memorandum from Ron Sloan to James Colquhoun. February 11, 1999. https://semspub.epa.gov/work/02/68407.pdf

Sloan et al. 2005. “Of Time, PCBs and the Hudson River.” Ronald J. Sloan, Michael W. Kane, and Lawrence C. Skinner. Bureau of Habitat, Division of Fish, Wildlife and Marine Resources, NYSDEC, Albany, New York. July 2005.

Thomann, R. F., J. A. Mueller, R. P. Winfield and C. R. Huang. 1989. Mathematical model on the long-term behavior of PCBs in the Hudson River Estuary. New York, NY, Hudson River Foundation.

Wendt, M.E. 1986. Low Income Families’ Consumption of Freshwater Fish Caught From New York State Waters. Thesis, Cornell University. August.

White, H. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity". Econometrica. 48 (4): 817–838

Final Second Five-Year Review Comment Response for the Hudson River PCBs Superfund Site

APPENDIX A
LIST OF COMMENTERS (INDEX)

Government, Agencies, Organizations and Businesses/Corporations

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
EPA Index Number	**Agency/Organization**	**First Name**	**Last Name**	**Division**	**Title/Role**	**Date submitted**
Federal and State Government						
1	United States Senate	Kirsten	Gillibrand		United States Senator	6/7/2017
2	United States Senate	Charles	Schumer		United States Senator	7/18/2017
		Kristen	Gillibrand		United States Senator	
3	New York State Assembly	Didi	Barrett	106th District	Assemblymember	8/28/2017
4	New York State Assembly	Didi	Barrett	106th District	Assemblymember	6/28/2017
5	New York State Assembly	Ellen	Jaffee	97th District	Assemblymember	6/7/2017
6	New York State Senate	David	Carlucci	38th District	State Senator	8/30/2017
		Terrance	Murphy	40th District	State Senator	
		Martin J.	Golden	22nd District	State Senator	
		Marisol	Alcantara	31st District	State Senator	
		Jesse	Hamilton	20th District	State Senator	
7	New York State Senate	Brad	Hoylman	27th District	State Senator	8/9/2017
8	New York State Senate	Liz	Krueger	28th District	State Senator	7/19/2017
		Carrie	Woerner	113th District	Assemblymember	
		Joseph P.	Addabbo, Jr.	15th District	State Senator	
		Jamaal	Bailey	36th District	State Senator	
		Brian	Benjamin	30th District	State Senator	
		John E.	Brooks	8th District	State Senator	
		Leroy	Comrie	14th District	State Senator	
		Martin Malavé	Dilan	18th District	State Senator	
		George	Latimer	37th District	State Senator	
		Kevin S.	Parke	21st District	State Senator	
		José	Peralta	13th District	State Senator	
		Gustavo	Rivera	33rd District	State Senator	
		James	Sanders, Jr.	10th District	State Senator	

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		José M.	Serrano	29th District	State Senator	
		Thomas J.	Abinanti	92nd District	Assemblymember	
		Didi	Barrett	106th District	Assemblymember	
		Kevin A.	Cahill	103rd District	Assemblymember	
		Jeffrey	Dinowitz	81st District	Assemblymember	
		Anthony	D'Urso	16th District	Assemblymember	
		Patricia	Fahy	109th District	Assemblymember	
		Sandra R.	Galef	95th District	Assemblymember	
		Deborah J.	Glick	66th District	Assemblymember	
		Richard N.	Gottfried	75th District	Assemblymember	
		Pamela J.	Hunter	128th District	Assemblymember	
		Ellen	Jaffee	97th District	Assemblymember	
		Brian P.	Kavanagh	74th District	Assemblymember	
		William	Magee	121st District	Assemblymember	
		Shelley	Mayer	90th District	Assemblymember	
		John T.	McDonald, III	108th District	Assemblymember	
		Yuh-Line	Niou	65th District	Assemblymember	
		Daniel	O'Donnell	69th District	Assemblymember	
		J. Gary	Pretlow	89th District	Assemblymember	
		Linda B.	Rosenthal	67th District	Assemblymember	
		Nily	Rozic	25th District	Assemblymember	
		Rebecca A	Seawright	76th District	Assemblymember	
		Jo Anne	Simon	52nd District	Assemblymember	
		Dan	Stec	114th District	Assemblymember	
		Fred W.	Thiele	1st District	Assemblymember	
		Mary Beth	Walsh	112th District	Assemblymember	
		Jaime R.	Williams	59th District	Assemblymember	

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		Kenneth P.	Sebrowski	96th District	Assemblymember	
9	New York State Senate	José	Peralta	13th District	State Senator	8/31/2017
Agencies						
10	National Oceanic and Atmospheric Administration	Thomas	Brosnan		Hudson River Case Manager	9/1/2017
11	National Oceanic and Atmospheric Administration	Jay	Field			9/1/2017
		Lisa	Rosman			
12	New York State Bridge Authority	Joseph	Ruggiero		Executive Director	6/28/2017
13	New York State Department of Environmental Conservation	Kevin	Farrar			9/1/2017
14	New York State Department of Environmental Conservation	Basil	Seggos		Commissioner	6/7/2017
15	New York State Department of Environmental Conservation	Basil	Seggos		Commissioner	8/30/2017
16	New York State Office of the Attorney General	Maureen	Leary		Assistant Attorney General	9/1/2017
		James	Wood		Assistant Attorney General	
		Brittany	Haner		Assistant Attorney General	
		John D.	Davis		Environmental Scientist	

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
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Local Government						
17	Albany County	Daniel	McCoy		County Executive	9/1/2017
	Rockland County	Edwin J.	Day		County Executive	
	Dutchess County	Marcus J.	Molinaro		County Executive	
	Ulster County	Michael P.	Hein		County Executive	
	Orange County	Steven M.	Neuhaus		County Executive	
	Westchester County	Robert P.	Astorino		County Executive	
18	Columbia County Environmental Management Council	Edwin	Simonsen		Chair	8/31/2017
19	Dutchess County	Marcus	Molinaro		Dutchess County Executive	6/28/2017
20	Dutchess County Regional Chamber of Commerce	Frank	Castella Jr.		President and CEO	8/16/2017
21	Kingston Conservation Advisory Council	Julie	Noble		Chair	8/31/2017
		Elizabeth	Broad			
		Lorraine	Farina			
		Emilie	Hauser			
		Lynn	Johnson			
		Kevin	McEvoy			
		Casey	Schwarz			
22	Town of Saratoga	Thomas N.	Wood III		Supervisor	8/21/2017
23	Town of Saugerties	Greg	Helsmoortel		Supervisor	8/29/2017

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
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24	Town of Stuyvesant Town Board	Melissa	Naegeli		Town Clerk	8/10/2017
		Ed	Scott		Councilman	
		Tom	Burrall		Councilman	
		Brian	Chittenden		Councilman	
		Kelley	Williams		Councilwoman	
		Ron	Knott		Supervisor	
25	Ulster County Environmental Management Council	Dave	Haldeman		Chair	8/31/2017
26	Village of Schuylerville	Dan	Carpenter		Mayor	9/1/2017
27	Village of Schuylerville	Dan	Carpenter		Mayor	9/1/2017
28	Westchester County	Robert	Astorino		County Executive	8/28/2017
Organizations						
29	Catskill Mountainkeeper	Kathleen	Nolan		Senior Research Director	9/1/2017
30	The Chamber of Southern Saratoga County **Signatories include organizations and businesses*					9/1/2017
	Mechanicville-Stillwater Chamber of Commerce	Barbara A.	Corsale		President	
	NYS Building and Construction Trades Council	James	Cahill		President	
	Dutchess County Regional Chamber of Commerce	Frank M.	Castella, Jr.		President & CEO	
	R. L. Baxter Building Corporation	Robert	Baxter		Owner	

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	Schuylerville Area Chamber of Commerce	Marla	Hodge		President	
	McDonald's REAAL, Inc.	Roger E.	Grout		President	
	The Chamber of Southern Saratoga	Pete	Bardunias		President & CEO	
	Elyse Harney Real Estate	Elyse D.	Harney		Principal Broker/Owner	
	Local Union 21	Ron	Diaz		Business Agent	
	Plumbers and Steamfitters HVACR	Thomas	Carey		Business Agent	
	Walkway Over the Hudson	Elizabeth	Waldstein-Hart		Executive Director	
	Poughkeepsie Alliance	Paul	Calogerakis		Chairman	
	Hudson Development Corporation	Sheena	Salvino		Executive Director	
	American Towns	Ted	Buerger		Chairman	
	Dutchess Community College	Pamela	Edington, Ed.D		President	
	The Business of Your Business	Wiley	Harrison		Owner	
	Rbeach & Bartolo Realtors	Victor	Mendolia		Associate Real Estate Broker	
	Finance& Corporate Development Omnicom Group	John	Hamilton		Vice President	
	Bryant Rabbino LLP	Kim	Taylor		Of Counsel	
	Saugerties Lighthouse	Patrick	Landewe		Keeper	
	Bonura Hospitality Group	Joe	Bonura		Principal	
	IKOR - Life Care Management Solutions	James	Sullivan		President & Managing Director	
	Consigli Construction, NY	Gregory	Burns		President	

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
EPA Index Number	**Agency/Organization**	**First Name**	**Last Name**	**Division**	**Title/Role**	**Date submitted**
	Meyer Contracting Corporation	Christian W.	Meyer		President	
	Putnam Market	Catherine	Hamilton		President	
	Obercreek Farm LLC	Alex	Reese		Owner	
	Ugly Rooster Café	Ariel	Pagan		Owner	
	Northshire Bookstore	Chris	Morrow		Co-Owner	
	Five Porch Farms	Dan	Lundtquist		Owner	
	Healthy Living	Eli	Lesser-Goldsmith		Co-owner and General Manager	
	H H Hill Realty Services, Inc.	Harry	Hill		Principal Broker	
	National Resources, Inc.	Joseph	Cotter		CEO	
	Green Conscience Home & Garden	Karen	Totino		Licensed Real Estate Salesperson	
	Peak Magazine	Kellie	McGuire		Owner	
	Hudson River Cruises	Kevin	Buckel		General Manager	
	Spath Counseling Services	Kevin	Spath		Owner	
	Landscape Architects, P.C.	Kim	Mathews, RLA, FASLA		Principal	
	Kit Burke-Smith Jewelry	Kit	Burke-Smith		Owner	
	Storm King Adventure Tour	Kris	Seiz		Owner	
	Mohawk Maiden Cruises, LLC	Mara Hodge &	Maria Saavedra		Owners	
	Dutchess Tourism Inc.	Mary Kay	Verba		President & CEO	
	Bellefield Development Partners, LLC	Michael	Oates		Managing Partner	
	Fusion Lab, Inc.	Alon	Koppel		Partner	
	Jeffrey Russell Werner, LLC	Jeffrey Russel	Werner, Esq		Attorney	

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EPA Index Number	**Agency/Organization**	**First Name**	**Last Name**	**Division**	**Title/Role**	**Date submitted**
	Spatial Dynamics	Jaime	McMillian		Founder	
	Arts Center on Hudson	Jaime	McMillian		Founder	
	Growler and Grill	Mike	Fitzgerald		Owner	
	Saratoga Apple, Inc.	Nathan	Darrow		Owner	
	Gardening Angels	Peggy	Fusco		Owner	
	Alisson Spears AIA	Alison	Spears			
		Chip	Lowenson			
		Daniel	Kramer			
	Mary W. Harriman Foundation	David H.	Mortimer		President	
	David Redden, LLC.	David	Redden		Director	
	Deco Works Ltd.	Evan Mason and	Garrard Beeney		Principals	
		Gary	Glynn			
		Hoke	Slaughter			
		Jay	Saunders			
		James	Goodfellow			
		Julia	Widowson			
		Kristin	Flood			
		Leigh	Seippel			
	United Catalyst, LLC.	Marjorie Hart	Acting CEO			
	Land Trust Alliance	Michael P.	Dowling		Immediate Past Chair	
	Dillion, Ready & Co, Inc.	Ned	Whitney		Retired Managing Director	
		Richard	Klapper			
	Pierpoint Capital	Richard	Krupp		Managing Partner	

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
EPA Index Number	**Agency/Organization**	**First Name**	**Last Name**	**Division**	**Title/Role**	**Date submitted**
	Debevoise & Plimpton LLP	Sara A. Q.	Fitts			
31	Hudson River Fishermen's Association	Gil	Hawkins		Vice President	6/15/2017
32	Riverkeeper, Inc.	Jeremy	Cherson		Campaign Advocacy Coordinator	7/7/17
33	Riverkeeper, Inc.	Jeremy	Cherson		Campaign Advocacy Coordinator	7/19/17
34	Riverkeeper, Inc.	Richard	Webster, Esq			6/5/2017
	Hudson Fishermen's Association	Gil	Hawkins			
	Natural Resources Defense Council	Daniel	Raichel, Esq			
	Scenic Hudson, Inc.	Althea	Mullarkey			
	Hudson River Sloop Clearwater, Inc.	Manna Jo	Greene			
35	Riverkeeper, Inc.	Richard	Webster		Legal Director	6/16/2017
36	Saratoga Unites Environmental Action Committee	Julie	Wash			8/31/2017
37	Scenic Hudson, Inc.	Hayley	Carlock		Director of Environmental Advocacy	9/1/2017
	Hudson River Fishermen's Association	Gil	Hawkins			
	Riverkeeper, Inc.	Richard	Webster, Esq			
	Hudson River Sloop Clearwater, Inc.	Manna Jo	Green			
	Sierra Club, Atlantic Chapter	Roger	Downs			

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
EPA Index Number	**Agency/Organization**	**First Name**	**Last Name**	**Division**	**Title/Role**	**Date submitted**
	Natural Resources Defense Council	Mark	Izeman			
38	Scenic Hudson, Inc.	Hayley	Carlock		Director of Environmental Advocacy	9/1/2017
	Hudson River Fishermen's Association	Gil	Hawkins			
	Riverkeeper, Inc.	Richard	Webster, Esq			
	Hudson River Sloop Clearwater, Inc.	Manna Jo	Green			
	Sierra Club, Atlantic Chapter	Roger	Downs			
	Natural Resources Defense Council	Mark	Izeman			
39	Society of Saint Ursula	Kathleen	Donnelly			8/15/2017
40	The Historic Hudson - Hoosic Rivers Partnership	Tom	Richardson		Partnership Chairperson	8/31/2017
41	Walkway Over the Hudson	Elizabeth	Waldstein-Hart		Executive Director	8/31/2017
42	Hudson River Sloop Clearwater, Inc. Petition * Petition with 503 signatures					8/22/2017
43	Hudson River Sloop Clearwater, Inc. Petition *Petition with 150 signatures					8/28/2017

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Government, Agencies, Organizations and Businesses/Corporations						
EPA Index Number	**Agency/Organization**	**First Name**	**Last Name**	**Division**	**Title/Role**	**Date submitted**
Businesses/Corporations						
44	Bonura Hospitality Group	Joseph	Bonura Jr.		Owner	8/1/2017
45	ecoSPEARS	Ian	Doromal		Vice President	9/1/2017
46	General Electric	John	Haggard	Global Remediation; Global Operations, Environmental, Health & Safety	Leader	9/1/2017
47	Hudson Development Corporation	Sheena	Salvino		Executive Director	8/31/2017
48	Mohawk Maiden Cruises	Marla	Hodge		Master Captain, Owner	8/30/2017
49	Seaweed Yacht Club; Hudson River Boat & Yacht Club Association	Janice	Anderson		Commodore; Director	8/28/2017
50	The Business of your Business	Wiley	Harrison		Owner	8/7/2017
51	United Campus Holdings Company, LLC	Wayne	Senecal		President and CEO Emeritus	7/19/2017

Individuals

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
Unique Submittals			
52	Patricia	Aakre	7/24/17
53	Emm	Ache	8/30/17
54	Claudia	Ackerman	8/21/17
55	Jeff	Adams	9/1/17
56	Sam	Adels	8/14/17
57	Deborah	Adler	8/21/17
58	Joanna	Albertson	8/28/17
59	Tomara	Aldrich	9/1/17
60	Elizabeth	Allee	6/5/17
61	Richard	Allen	8/21/17
62	Suzanne	Allen	8/21/17
63	Roland	Alley	8/21/17
64	Thomas	Amisson	8/28/17
65	Mary	Andrews	9/1/17
66	Anonymous	Anonymous	7/25/17
67	Anonymous	Anonymous	8/21/17
68	Emi	Araki	8/29/17
69	Patricia	Arcuri	8/21/17
70	Al	Arioli	8/21/17
71	Dwight	Arthur	6/6/17
72	Tom	Artin	7/24/17
73	Judith	Asphar	8/24/17
74	Doris	Bachmann	9/1/17
75	Talya	Baharal-Gnida	8/21/17
76	Patrick	Bailey	8/21/17
77	Eric	Baker	8/21/17
78	Marni	Bakst	8/21/17
79	Kathryn	Barry	7/7/17
80	Scott	Basal	8/21/17
81	Susan	Basu	9/1/17
82	Bill	Bates	8/10/17
83	Cari	Bates	8/21/17
84	Alex	Beauchamp	8/29/17
85	Laurel	Becker	8/28/17
86	Andrew	Bell	8/29/17
87	Ros	Bell	8/21/17
88	Sandra	Bensalah	8/21/17
89	Lisa	Berry	8/21/17
90	Ryan	Blum	8/29/17
91	Cora	Bodkin	8/4/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
92	Betty	Boomer	7/26/17
93	Jon	Bowermaster	8/29/17
94	Danielle	Brecker	8/28/17
95	Nancy	Breen	8/21/17
96	Claire	Briguglio	8/9/17
97	Kristin	Brown	8/21/17
98	Helene	Browning	9/1/17
99	Ronda	Brunsting	7/28/17
100	John	Buckley	8/31/17
101	Tom	Buckner	6/16/17
102	Tom	Buckner	8/21/17
103	David	Budd	8/31/17
104	Ted	Buerger	8/25/17
105	Jack	Burke	7/28/17
106	Linda	Burke	8/21/17
107	Sanford	Bush	8/31/17
108	Brenda	Campbell	8/21/17
109	Alyssa	Carbone	8/21/17
110	Valerie	Carlisle	7/5/17
111	Arthur	Carlucci	8/29/17
112	Miani	Carnevale	8/29/17
113	Jeremy	Carpenter	8/21/17
114	Jay	Cartagena	9/1/17
115	Brian	Caserto	8/21/17
116	Thomas	Cathcart	8/21/17
117	Dana	Chaifetz	5/30/17
118	Gwendolyn	Chambers	8/2/17
119	Martha	Cheo	6/17/17
120	Jeremy	Cherson	8/2/17
121	Jean	Chung	8/30/17
122	C.D.	Clark	7/19/17
123	Lawrence	Clarke	8/21/17
124	Blythe	Clark-McKitrick	8/31/17
125	Stephen	Cluskey	6/5/17
126	Nora	Cofresi	8/25/17
127	Nancy	Colas	8/29/17
128	Jon	Cole	8/25/17
129	Kelly	Collins	7/28/17
130	Daniel	Convissor	8/25/17
131	Jennifer	Convissor	8/28/17
132	James	Corcoran	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
133	Isabel	Cotarelo	8/21/17
134	Kyle	Cottier	8/29/17
135	Linda	Coupart	7/9/17
136	Michael and Reva	Cowan	9/1/17
137	Caroline	Craig	8/29/17
138	Patrick	Cunningham	7/28/17
139	Lawrence	Curtin	8/22/17
140	Nancy	Cutler	8/29/17
141	Caroline	Cutroneo	6/6/17
142	Peter	Cutul	9/1/17
143	Tara	D'Andrea	8/29/17
144	Roya	Darling	8/21/17
145	D	Darvie	7/28/17
146	George	Dashnaw	8/30/17
147	Eileen	de Munck	9/1/17
148	Margaret	Dean	8/21/17
149	Susan	Deane-Miller	8/21/17
150	Eva	Deitch	8/29/17
151	Darin	DeKoskie	6/28/17
152	Victoria	Delgado	7/25/17
153	OA	Dell	8/21/17
154	Alex	DeRosa	6/21/17
155	Jim	Desmond	8/24/17
156	Yvonne	Devlin	8/21/17
157	Frank & Joan	DiChiaro	8/22/17
158	Joanna	Dickey	9/1/17
159	Rita	Dixit-Bubiak	7/28/17
160	Jennifer	Dobson	8/22/17
161	Ron	Dombroski	6/10/17
162	Judy	Dong	9/1/17
163	Elke	D'Onofrio	9/1/17
164	Colleen	Dougherty	8/30/17
165	Ryan	Doyle	8/29/17
166	Jacquelyn	Drechsler	9/1/17
167	Jill	Dunay	8/21/17
168	Jake	Dunn	8/21/17
169	Rebecca	Dwyer	8/28/17
170	Jeff	Economy	8/30/17
171	Seth	Edelman	8/21/17
172	Jane	Ehrlich	8/29/17
173	Sarita	Eisenstark	8/21/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
174	Wallace	Elton	9/1/17
175	Katherine	Enberg	8/21/17
176	Cory	Ethridge	8/10/17
177	Mary	Evans	8/30/17
178	Russell	Faller	6/21/17
179	Russell	Faller	6/27/17
180	Russell	Faller	8/29/17
181	Armanda	Famiglietti	6/4/17
182	Peter	Farrell	8/21/17
183	Nina	Faver	8/21/17
184	Nancy	Felcetto	8/29/17
185	Roy	Felcetto	8/29/17
186	Deborah	Felder	8/29/17
187	Ricardo	Fernandez	8/22/17
188	Linda	Fernberg	8/25/17
189	Elvira	Ferrario	8/16/17
190	Mary	Fetherolf	8/21/17
191	Joe	Finan	8/30/17
192	Margaret	Finch	8/29/17
193	Rebecca	Finnell	8/30/17
194	John	Fisher	8/21/17
195	Lynn	Flanagan	7/19/17
196	Peter	Flanagan	9/1/17
197	Kristin	Flood	8/19/17
198	Patricia	Flood	8/21/17
199	Craig	Fogel	8/29/17
200	Bob, Marie	Foster	8/28/17
201	Marion	Foster	7/29/17
202	Tiffani	Francisco	8/29/17
203	Marcus	Frank	9/1/17
204	Florence Joan	Freeman	8/21/17
205	Linda; Chester	Freeman	8/18/17
206	Kate	Frizzell	8/25/17
207	Sharon	Gagne	8/21/17
208	Gail	Galitzine	8/29/17
209	Nancy	Gardner	8/21/17
210	Linda	Geary	8/21/17
211	Sheila	Geist	8/29/17
212	Sheila	Geist	8/30/17
213	Linda	Gerena	8/22/17
214	Ira	Gershenhorn	8/9/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
215	Jacquelyn	Gier	7/25/17
216	Steve	Gilman	6/2/17
217	Mary	Goddard	8/23/17
218	Nadine	Godwin	8/30/17
219	Steve	Gold	8/29/17
220	Patricia	Goldberg	8/22/17
221	Allan	Goldhammer	8/21/17
222	Freya	Goldstein	8/21/17
223	Karen	Goodman	6/6/17
224	Leslie	Gordon	7/25/17
225	Cindy	Gould	8/29/17
226	Nicole	Graf-Javery	8/23/17
227	Meryl	Greenblatt	8/22/17
228	Hannah	Greene	8/28/17
229	Rosalie	Griffith	8/22/17
230	Joan	Grishman	8/21/17
231	Daley	Gruen	8/29/17
232	Carol	Grunkemeyer	7/6/17
233	Robert	Grunkemeyer	7/6/17
234	Christine	Guarino	8/21/17
235	Michael	Gunderson	9/1/17
236	Mary	Gunter	8/21/17
237	Anne	Hager	8/28/17
238	Nancy	Hager	8/29/17
239	Christine	Hague	8/16/17
240	Emily	Hague	8/29/17
241	Paul	Hague	8/16/17
242	Brandon	Hakulin	8/21/17
243	Karen	Hall	8/21/17
244	Rhonni	Hallman	8/21/17
245	Mary	Hammett Stevenson	8/17/17
246	Martin	Hangarter	8/26/17
247	Terence	Hannigan	7/21/17
248	Beth	Hanson	8/31/17
249	Marc	Happet	9/1/17
250	Anne	Heaney	8/7/17
251	Anne	Heaney Johnson	8/17/17
252	Patricia	Heller	8/21/17
253	Irene	Herz	8/22/17
254	Jonathan	Herzog	9/1/17
255	Deborah	Highley	8/21/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
256	Annie	Hillay	7/25/17
257	Barbara	Hobens	8/21/17
258	Dana	Hoey	8/21/17
259	Miriam	Hoffman	8/4/17
260	Karin	Holloway	8/21/17
261	Timothy	Holmes	8/29/17
262	Wendy	Holtzman	8/18/17
263	Arlene	Holzman	7/19/17
264	Patrick	Hono	8/21/17
265	Joseph	Hope Jr.	8/21/17
266	Robin	Horowitz	8/29/17
267	Pat	Hughes	8/21/17
268	Carole	Hunt	8/22/17
269	David	Hupert	8/29/17
270	Ryan	Jafri	8/21/17
271	Ed	Jahn	8/26/17
272	Lee	Jamison	8/29/17
273	Lois	Janove	6/6/17
274	Susan	Johnson	8/22/17
275	Abigail	Jones	8/30/17
276	Justin	Jordak	8/21/17
277	Ellen	Jouret-Epstein	5/30/17
278	Christopher	Joy	9/1/17
279	Peter	Jung	8/4/17
280	Elissa	Jury	8/30/17
281	F. Michael	Kadish	7/11/17
282	Gloria	Kadish	8/7/17
283	Robert	Kalman	8/21/17
284	Sara	Kaminker	6/6/17
285	Carole	Kane	8/20/17
286	Edith	Kantrowitz	8/29/17
287	Edith	Kantrowitz	8/31/17
288	Nancy	Kaplan	8/29/17
289	Michelle	Karell	5/30/17
290	George	Katopis	8/21/17
291	Deb Peck	Kelleher	9/1/17
292	William	Kelleher	7/10/17
293	Laird	Kelly	8/16/17
294	Quinn	Kelly	8/21/17
295	Marci	Kenneda	8/24/17
296	John	King	8/21/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
297	Laurence	Kirby	8/21/17
298	Rachel	Kish	8/22/17
299	Cary	Kittner	8/21/17
300	Caroline	Klapproth	8/21/17
301	Amy	Kletter	8/29/17
302	Vladimir	Klimenko	8/30/17
303	Pete	Klosterman	8/29/17
304	J.	Knott	7/20/17
305	Wayne	Kocher	8/8/17
306	Susan	Koff	7/6/17
307	Laura	Kohlmann	8/22/17
308	Phil	Kovacs	8/21/17
309	Patricia	Kram	9/1/17
310	Pamela	Krimsky	8/28/17
311	Thomas	Kryzak	8/29/17
312	Peggy	Kurtz	8/22/17
313	A. Norman	Kvam	8/21/17
314	Marc	Lallanilla	8/31/17
315	Frank	Lancellotti	8/31/17
316	Barbara	Landa	7/25/17
317	Sasha	Langesfeld	7/25/17
318	Julie	Lappano	8/28/17
319	Michael	Laser	8/23/17
320	Judy	Lass	8/29/17
321	J. Eva	Lau	9/1/17
322	Robin	Laurita	8/22/17
323	Margaret	Leather	9/1/17
324	Patti	Lenseth	8/2/17
325	Jean	Leo	9/1/17
326	Esther	Light	9/1/17
327	David	Limburg	8/21/17
328	Hedvig	Lockwood	8/21/17
329	Elizabeth	LoGiudice	8/21/17
330	Skyler	Long	8/21/17
331	Albert and Doris	Lowenfels	8/29/17
332	Barbara	Lubell	8/21/17
333	David	Macaluso	8/25/17
334	Andrew	MacInnes	8/31/17
335	Edward	Mack	8/21/17
336	Cathy	Mackey	8/22/17
337	Molly	MacQueen	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
338	Sarah	MacWright	8/21/17
339	Kevin	Magee	8/21/17
340	Tom	Mahoney	8/30/17
341	Tom	Mahoney	8/30/17
342	Barry	Maisel	7/17/17
343	Pamela	Malcolm	8/21/17
344	Lucy	Manning	7/21/17
345	Mickey	Marcella	6/9/17
346	Jeffrey	Marino	8/31/17
347	Jeffrey	Marino	9/1/17
348	Kate	Marriott	8/21/17
349	Daniel	Marshall III	8/21/17
350	Matthew	Martini	8/29/17
351	Kara	Masciangelo	8/22/17
352	Kara	Masciangelo	8/22/17
353	Kara	Masciangelo	8/29/17
354	Kara	Masciangelo	8/30/17
355	Janice	Mastromarchi	8/31/17
356	David	Mathis	8/28/17
357	Debra	Mathis	8/29/17
358	Anne	McCabe	8/21/17
359	Christa	McCauley	8/21/17
360	Nora	McDowell	9/1/17
361	Willis	McEckron	6/14/17
362	Susan	McGrath	8/21/17
363	Virginia	McGreevy	7/31/17
364	Grant	McKeown	8/30/17
365	Merry	McLoryd	9/1/17
366	Jaime	McMillan	8/29/17
367	Patrick	McMullan	8/29/17
368	Christopher	McNally	8/24/17
369	David	McNally	8/21/17
370	Kathryn	McNamara	8/22/17
371	Francis	Metelski	8/21/17
372	Julie	Metz	8/21/17
373	Carol	Meyer	8/21/17
374	Robert	Michaels	8/30/17
375	Checko	Miller	8/21/17
376	Checko	Miller	9/1/17
377	Patricia	Miller	8/21/17
378	Scott	Miller	7/17/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
379	Katharine	Millonzi	8/29/17
380	Giles	Mitchell	8/25/17
381	Deidre	Moderacki	8/29/17
382	Julian	Moll-Rocek	7/25/17
383	Carol	Monteleoni	7/26/17
384	Philip and Carol	Monteleoni	7/26/17
385	Kimberly	Mooers	8/31/17
386	Kimberly	Mooers	8/31/17
387	Sol	Mora	7/26/17
388	Teresa	Morelle	8/18/17
389	David	Mortimer	8/28/17
390	Eric	Munson	8/21/17
391	Maria	Muro	8/29/17
392	Jay	Murphy	8/31/17
393	Sean	Murray	8/31/17
394	Judy Gelman	Myers	8/16/17
395	Ani	Nappa	8/21/17
396	Jonathan	Nedbor	9/1/17
397	Patrick	Nelson	9/1/17
398	Mike	Newman	7/6/17
399	Grace	Nichols	8/21/17
400	Bob	Nirkind	8/25/17
401	William	Nixon	8/31/17
402	Jean	Noack	8/29/17
403	Wendy	Nodop	8/21/17
404	Erika	Nonken	8/29/17
405	Brian	Nowitski	8/29/17
406	Alexis	O'Brien	8/29/17
407	Kathryn	O'Brien	8/21/17
408	Annemarie	O'Connor	8/22/17
409	MaryAnna	O'Donnell	8/21/17
410	Rick	Oestrike	7/6/17
411	Margot	Olavarria	8/24/17
412	Victoria	Oltarsh	8/22/17
413	Victoria	Oltarsh	8/29/17
414	Kathryn	Ornstein	8/29/17
415	Eric	Ortner	8/22/17
416	Lauree	Ostrofsky	9/1/17
417	Margaret	Othrow	6/9/17
418	Carl	Otto	8/29/17
419	Craig D.	Palmer	8/25/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
420	John	Palmer	8/21/17
421	Julie	Parisi	8/21/17
422	Greg	Patch	8/21/17
423	Barbara	Paterson	8/21/17
424	Joy	Pell	9/1/17
425	Valerie	Percy	8/22/17
426	Katherine	Perino	8/29/17
427	Robert	Perretti	5/30/17
428	Robert	Perretti	8/16/17
429	Robert	Perretti	8/16/17
430	Allison	Philpott	6/14/17
431	Kate	Phipps	8/29/17
432	Steven	Plotnick	7/13/17
433	Philip	Podmore	9/1/17
434	Rhonda	Pomerantz	8/22/17
435	Gail	Porter	5/30/17
436	Nicole	Porto	8/29/17
437	Sarah	Posner	8/29/17
438	Beth	Propper	8/29/17
439	Teri	Ptacek	9/1/17
440	Carmen	Pujols	6/27/17
441	Carmen	Pujols	6/28/17
442	Merrilyn	Pulver-Moulthrop	8/31/17
443	Patrick	Purcell	8/21/17
444	Ann	Quota	8/30/17
445	B	R	6/5/17
446	Amparo	Rally	8/30/17
447	Donald	Rally	8/30/17
448	Dorrit	Ram	8/16/17
449	Michael	Reed	7/25/17
450	James	Renner	8/31/17
451	Ryan	Reutershan	9/1/17
452	Heidi	Reyes	8/15/17
453	Michelle	Riddell	8/21/17
454	Michael	Riggio	8/29/17
455	Dennis	Riley	8/22/17
456	Andres	Rivera	8/29/17
457	David and Mary	Roberts	8/26/17
458	Timothy	Roberts	8/26/17
459	Clinton	Robinson	8/29/17
460	Matthew	Robinson	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
461	Jennifer	Roeder	8/29/17
462	Jessica	Roman	8/29/17
463	Christine	Root	9/1/17
464	Edith	Root	8/21/17
465	Bruce	Rosen	8/25/17
466	Martha	Roth	8/29/17
467	Matt	Rowan	7/20/17
468	Ann	Royston	9/1/17
469	Leah	Rubenstein	8/21/17
470	Franz	Safford	8/30/17
471	Donald	Sagar	9/1/17
472	Patricia	Santiago	8/21/17
473	Jeffrey	Scales	8/29/17
474	Lisa	Scerbo	8/31/17
475	Karin	Scheele	7/25/17
476	Marilyn	Schiller	7/24/17
477	Marian	Schoettle	8/22/17
478	Roni	Schotter	8/30/17
479	Penny	Schoutn	8/21/17
480	Greg	Schultz	7/25/17
481	Phillip	Schwartz	8/21/17
482	Annie	Scibienski	8/21/17
483	Nancy	Sconza	8/21/17
484	Pat	Sexton	8/21/17
485	Eric	Shelfin	8/22/17
486	Laurel	Shute	8/31/17
487	Laurel	Shute	9/1/17
488	Claire	Siegel	7/28/17
489	Bena	Silber	9/1/17
490	Sherrill	Silver	7/26/17
491	Donna	Simms	8/21/17
492	Marianne	Siniopkin	8/25/17
493	Joanne	Sinovoi	8/29/17
494	Donald	Smith	8/22/17
495	Mark	Smith	8/21/17
496	Marie	Snyder	7/25/17
497	Sara	Sogut	8/21/17
498	Sara	Sogut	8/29/17
499	Jessica	Soloman	6/2/17
500	Leola	Specht	8/7/17
501	Leola	Specht	8/10/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
502	Paula	Speer	8/21/17
503	Judith	Stahl	8/31/17
504	Colin	Stair	8/29/17
505	Judy	Stanley	8/21/17
506	Alex	Stavis	8/21/17
507	Alex	Stavis	8/21/17
508	Maxina	Stearn	8/9/17
509	Stephanie	Stefanski	8/29/17
510	Joe	Stefko	8/16/17
511	Evelyn	Stein	8/29/17
512	Barbara	Stemke	6/28/17
513	Fred	Stern	9/1/17
514	Marylou	Stern	8/22/17
515	Eric	Stiller	8/25/17
516	Julia	Stokes	8/31/17
517	Barbara	Sugin	8/29/17
518	Leonard	Sugin	8/29/17
519	Eileen	Sullivan	6/18/17
520	James	Sullivan	8/29/17
521	Marilyn	Sullivan	8/21/17
522	Christian	Sweningson	8/29/17
523	Nava	Tabak	8/30/17
524	Linda	Tafapolsky	8/21/17
525	Constance	Taft	8/21/17
526	Silvana	Tagliaferri	7/2/17
527	Jeff	Tanenbaum	8/9/17
528	Maria-Luisa	Tasayco	8/29/17
529	Annabel	Taylor	8/29/17
530	Marie	Taylor	9/1/17
531	Jaden	Thompson	7/25/17
532	Jack	Thorpe	8/21/17
533	Judith	Timke	7/26/17
534	Sarah	Todd	7/27/17
535	Nancy	Torchia	9/1/17
536	Vito	Trasmonte	9/1/17
537	Diane	Trieste	8/30/17
538	Barbara	Ungar	8/25/17
539	Michael	Vagnetti	8/25/17
540	Peter	Van Aken	8/21/17
541	Mark	Varian	8/29/17
542	Jessica	Vaughan	8/22/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
543	Jason	Velez	8/22/17
544	Harry	Vincent	8/25/17
545	Connie	Vixon	8/29/17
546	Tico	Vogtt	8/21/17
547	Leslie	Von Pless	8/23/17
548	Dorothy	Wadsworth	8/21/17
549	Jennifer	Walford	8/25/17
550	Alison	Waller	7/21/17
551	Emily	Waller	7/27/17
552	Bella	Wang	8/28/17
553	Kathleen	Wanser	8/29/17
554	Laura	Ward	8/22/17
555	Robyn	Waters	8/29/17
556	Noah	Watts	7/25/17
557	Russell	Wege	7/25/17
558	Laura	Weiland	7/25/17
559	Gerald	Wein	9/1/17
560	Mark	Weinstein	8/21/17
561	Harvey	Weiss	9/1/17
562	Tierney	Weymueller	8/21/17
563	Cindy	Wian	8/28/17
564	Jared	Widjeskog	8/21/17
565	Trisha	Wild	8/23/17
566	Courtney M.	Williams	8/25/17
567	Jason	Williams	8/21/17
568	Autumn	Williams-Wussow	8/21/17
569	Geniene	Wilson	8/21/17
570	Sally	Wilson	7/19/17
571	Sarah	Wilson	7/20/17
572	Tania	Wolf	8/30/17
573	Bill	Wolfsthal	8/31/17
574	Doug	Wygal	8/29/17
575	Elizabeth	Yalkut	6/12/17
576	Erin	Yarrobino	8/23/17
577	Kathleen	Young	8/21/17
578	Brook	Zelcer	8/30/17
579	John	Zimmerman	7/20/17
580	Juliette		7/25/17
Form Letters			
581	Patricia	Aakre	8/25/17
582	Betty	AbajianSeaman	8/21/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
583	Gabriel	Abate	8/29/17
584	August	Abel	8/19/17
585	Katherine	Abel	8/29/17
586	Steven	Abel	8/25/17
587	Olya	Abezgauz	8/21/17
588	Olya	Abezguaz	8/22/17
589	Doug	Abramson	8/21/17
590	Mary	Abrey	8/22/17
591	Bobbie	Adams	8/29/17
592	Sean	Adams	8/18/17
593	Jana	Adler	8/26/17
594	Joan	Agro	8/24/17
595	Grace	Aiello	8/29/17
596	Sonja	Aiken	8/22/17
597	Pascal	Akesson	8/29/17
598	Donald	Albrecht	8/30/17
599	Diane	Alden	8/24/17
600	Rick	Alfandre	8/21/17
601	Jill	Alibrandi	8/26/17
602	Gail	Allan	8/29/17
603	Jeannette	Allan	8/24/17
604	David	Allen	8/30/17
605	Kendra	Allenby	9/1/17
606	Ivanya	Alpert	8/29/17
607	Steven	Altarescu	9/1/17
608	Karen	Ambrosetti	8/21/17
609	Martin	Amsel	8/24/17
610	Amy	Anderson	8/29/17
611	Emily	Anderson	8/30/17
612	Katherine	Anderson	8/29/17
613	Tracy	Anderson	8/29/17
614	Nancy	Andreassi	8/29/17
615	Audrey	Ang	8/28/17
616	Paul	Annetts	8/24/17
617	Lisa	Arbisser	9/1/17
618	Mercedes	Armillas	8/29/17
619	Lindsey	Arnell	8/30/17
620	K	Arnone	8/7/17
621	Barbara	Aronowitz	8/24/17
622	Eric	Arroyo	8/29/17
623	Karen	Asher	8/21/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
624	Jude	Asphar	8/29/17
625	Bianca	Assim-Kon	8/18/17
626	Alexis	Audette	8/24/17
627	Carol	Auer	8/22/17
628	Melisa	Auf der Maur	8/31/17
629	Brian	Austin	8/29/17
630	Sharon	AvRutick	8/22/17
631	S	B	8/24/17
632	Katherine	Babiak	8/30/17
633	Jesse	Bachir	8/29/17
634	Frances	Backofen	8/21/17
635	Marta	Baez	8/29/17
636	Cari	Bailey	8/21/17
637	Melissa	Bailey	8/22/17
638	Jeffrey	Bains	8/29/17
639	P	Baker	8/16/17
640	Candace	Balmer	8/30/17
641	Janice	Banks	8/29/17
642	Peter	Bannon	8/29/17
643	Daniel	Barclay	8/29/17
644	Alan	Bare	8/24/17
645	John	Barone	8/21/17
646	Enzo	Barrios	8/30/17
647	Marina	Barry	8/29/17
648	Carolyn	Bartholomew	8/24/17
649	Olga	Bartnicki	8/29/17
650	Cat	Basciano	8/16/17
651	Mark	Bastian	9/1/17
652	William	Battaglia	8/30/17
653	Pamela	Battle	8/30/17
654	Deborah	Bauer	8/30/17
655	Joan-Marie	Bauman	8/24/17
656	Deborah	Baumann	8/29/17
657	John	Bauza	8/21/17
658	Susan	Baxter	8/24/17
659	Bonnie	Bayardi	8/25/17
660	Linda	Beach	8/24/17
661	Carol	Bean	8/22/17
662	Elisabeth	Bechmann	8/29/17
663	Juan	Bedoya	8/22/17
664	Stephan	Beffre	8/26/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
665	Bertram	Beissel	8/29/17
666	Stephen	Bellomo	8/30/17
667	David	Bennett	8/29/17
668	Frances	Berger	8/22/17
669	Stephanie	Berger	9/1/17
670	Deborah	Bergman	8/28/17
671	Jill	Berliner	8/7/17
672	Janice	Bernard	8/29/17
673	Jean	Bernard	8/22/17
674	Bonnie	Bernstein	8/29/17
675	Lesley	Bernstein	8/22/17
676	Lisa	Berrol	8/22/17
677	Lisa	Berry	8/30/17
678	Joseph	Bertolozzi	8/22/17
679	Karyn	Bevet	8/22/17
680	Bob	Bickford	9/1/17
681	Annie	Bien	8/18/17
682	Alex	Billig	8/21/17
683	Gene	Binder	8/21/17
684	Janet	Binion	8/21/17
685	Janet	Binion	8/29/17
686	Richard	Binkele	8/22/17
687	Beth	Birnbaum	8/24/17
688	Jacqueline	Birnbaum	8/7/17
689	Maureen	Black	8/25/17
690	Sandy	Black-McDonough	8/29/17
691	Jeremiah	Blatz	8/25/17
692	Ashley	Blazer	8/29/17
693	Brandon	Block	8/17/17
694	Corliss	Block	8/25/17
695	Josephine	Bloodgood	8/21/17
696	Donald	Bluestone	9/1/17
697	Richard	Bodane	8/24/17
698	Dwight	Bodycott	8/18/17
699	Pauline	Boehm	8/10/17
700	Hollis	Bogdanffy	8/21/17
701	Gusti	Bogok	8/19/17
702	David	Bogoslaw	8/29/17
703	Gabrielle	Bordwin	8/29/17
704	Jim	Botta	8/24/17
705	Garrison	Botts	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
706	KJ	Bowen	8/30/17
707	Grace	Bowne	8/24/17
708	Mary Alice	Boyle	8/22/17
709	Mary Alice	Boyle	8/22/17
710	Diane E.	Bradley	8/25/17
711	Kathleen	Brady	8/30/17
712	Ira	Brandenburg	8/23/17
713	Peter	Brandt	8/7/17
714	Nancy	Breen	8/22/17
715	Sophie	Breitbart	8/22/17
716	Lise	Brenner	8/29/17
717	Patricia	Brescia-Cantine	8/29/17
718	Frank	Brice	8/21/17
719	John	Brinkman	8/24/17
720	Anna	Bristow	8/30/17
721	Undine	Brod	8/30/17
722	Kathleen	Brodbeck	9/1/17
723	Marinus	Broekman	8/24/17
724	Alan	Brown	8/29/17
725	Babette	Brown	8/7/17
726	Denise	Brown	8/29/17
727	Janelle	Brown	8/25/17
728	Elizabeth	Bruen	8/22/17
729	Deborah	Brunner	8/22/17
730	Nancy	Bruno	8/29/17
731	Jan	Buchalter	8/8/17
732	Anne Marie	Bucher	8/24/17
733	Joseph	Buchheit	8/11/17
734	Teresa	Buchholz	8/29/17
735	Karin	Bucklin	8/29/17
736	Catherine	Budd	8/22/17
737	Katie	Bull	8/29/17
738	Diane	Burke	8/29/17
739	Sue	Burke	8/22/17
740	Kit	Burke-Smith	8/22/17
741	Margaret	Burton	8/31/17
742	Elena	Busani	8/24/17
743	Edward	Butler	8/29/17
744	Susan	Butterfass	8/22/17
745	Joyce	Byrne	8/21/17
746	Suzanne	Cachon	8/30/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
747	Peter	Callaway	8/29/17
748	R	Cammisa	8/25/17
749	Dac	Campbell	8/30/17
750	Patti	Candelari	8/29/17
751	Irwin	Cantos	8/22/17
752	Michelle	Capuano	8/22/17
753	Patricia	Cardello	8/30/17
754	Patricia	Cardoso	8/24/17
755	Rachel	Careau	9/1/17
756	Elisa	Caref	8/21/17
757	Kathy	Carey	9/1/17
758	Patsy	Carl	8/30/17
759	Nancy	Carmichael	8/22/17
760	Christy	Carosella	8/29/17
761	Katelyn	Carroll	8/22/17
762	Matthew	Carroll	8/21/17
763	Teri-Ann	Carryl	8/30/17
764	Matthew	Carson	8/22/17
765	Carmen	Casado	8/30/17
766	Jose Chicaiza	Casado	8/30/17
767	Lynn	Cascio	8/29/17
768	Allan	Casement	8/29/17
769	Leslie	Cassidy	8/29/17
770	Elizabeth	Castaldo	8/29/17
771	Dorinda	Cataldo	8/24/17
772	Armanda	Catenaro	8/25/17
773	Mikki	Chalker	8/24/17
774	Michael	Chameides	9/1/17
775	Henry	Charles	8/29/17
776	Phylicia	Chartier	8/3/17
777	Lisa	Chason	8/31/17
778	Myrel	Chernick	8/30/17
779	Elaine	Cherry	8/30/17
780	Russell	Chiappa	8/29/17
781	Evelyn	Chiarito	8/29/17
782	Evonne	Cho	8/22/17
783	Kelly	Choi	8/30/17
784	Doris	Chorny	8/31/17
785	Peggy	Christian	8/30/17
786	Bob	Christianson	8/24/17
787	Stephanie	Christoff	8/20/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
788	Lauren	Ciborski	8/31/17
789	Monique	Clague	8/29/17
790	Lawrence	Clarke	8/29/17
791	Meryl	Classen	8/29/17
792	Anne Katherine	Cleary	8/22/17
793	Susan	Clelland	8/29/17
794	Geralyn	Clemens	8/31/17
795	Jesse	Clinton	8/29/17
796	Joseph	Cloidt	8/29/17
797	Laura-Christina	Cobb	8/17/17
798	Claudia	Cockerill	8/22/17
799	Florence	Cohen	8/29/17
800	Wendi	Cohen	8/29/17
801	Herbert	Coles	8/29/17
802	Bonnie	Collins	8/25/17
803	Thomas	Comiskey	8/7/17
804	David	Condon	8/29/17
805	Patricia	Connolly	8/24/17
806	Douglas	Cooke	8/29/17
807	James	Cooper	8/29/17
808	Adam	Cooperstock	8/24/17
809	Ryan	Coraldi	8/22/17
810	Marion	Corbin	8/22/17
811	Marion	Corbin	8/22/17
812	Marion	Corbin	8/29/17
813	Phyllis	Corcacas	8/29/17
814	Jared	Cornelia	8/29/17
815	Sean	Cortright	8/22/17
816	Victoria	Costello	8/22/17
817	Fiona	Cousins	8/17/17
818	Sherrill	Cox	8/25/17
819	Susan	Cox	8/7/17
820	Laurrie	Cozza	8/29/17
821	Marcelle	Crago	8/30/17
822	Joy	Cranker	8/22/17
823	Fran	Crilley	8/25/17
824	Al	Cruz	9/1/17
825	Helen	Cu	8/29/17
826	Ann Marie	Cunningham	8/29/17
827	Benjamin	Curran	8/23/17
828	Annalise	Curtin	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
829	Whitefeather	Curtiss	8/22/17
830	Caroline	Cutroneo	8/21/17
831	Clarissa	Cylich	8/21/17
832	Jane	Cyphers	8/16/17
833	Julie	Dahl	8/21/17
834	Marge	Dakouzlian	8/25/17
835	Jordan	Dale	8/30/17
836	Susan	Damato	8/19/17
837	Donna	Dangelo	8/22/17
838	Beth	Darlington	8/7/17
839	Kate	Darringo	8/18/17
840	Nina	David	8/24/17
841		Davis	8/28/17
842	Juanita	Dawson-Rhodes	8/29/17
843	Carol	De Angelo	8/24/17
844	C	de Ben	8/18/17
845	Noel	De La Cruz	8/25/17
846	Gerald	Dean	8/23/17
847	Nita	DeBono	8/19/17
848	Diane	DeChillo	9/1/17
849	Theresa	DeGraw	8/25/17
850	Julia	Dehn	9/1/17
851	Charles	Del Regno	8/23/17
852	Charlie	Del Regno	9/1/17
853	Arthur	Delaney	8/20/17
854	Robert	DeLay	8/30/17
855	Peter	DeLorenzo	8/29/17
856	Sheila	Dempsey	8/7/17
857	Laura	deNey	8/29/17
858	Daryl	Denning	8/24/17
859	Donna	Denny	8/30/17
860	Margaret	DeRose	8/30/17
861	Mark	Dery	8/21/17
862	Roberta	Desalle	8/29/17
863	Claudia	Devinney	8/7/17
864	Sterling	DeWeese	8/22/17
865	Harris	Diamant	9/1/17
866	Josh	Diamond	9/1/17
867	Rosalind	Dickinson	8/29/17
868	Tara	DiDonna	8/22/17
869	David	Dienes	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
870	James	DiMunno	8/18/17
871	Jacalyn	Dinhofer	8/29/17
872	NoÃ©	Dinnerstein	8/30/17
873	Doreen	Diorio	8/30/17
874	Vincent	DiTizio	8/30/17
875	Barbara	DiTommaso	8/19/17
876	James	Doherty	8/25/17
877	Adam	Dominiak	8/18/17
878	Ann	Donohue	8/29/17
879	Elaine	Donovan	8/7/17
880	Chris	Doolittle	8/22/17
881	David	Douglas	8/29/17
882	Susan	Downes	8/21/17
883	Taylor	Doyle	8/21/17
884	Muriel	Doyne	8/18/17
885	Christine	Drosky	8/22/17
886	Bette	Druck	8/16/17
887	Chris	Drumright	8/29/17
888	Brian	Duea	8/29/17
889	Diane	Duffus	8/25/17
890	Brian	Duffy	8/23/17
891	John	Dugan	8/22/17
892	John	Dugan	9/1/17
893	Timothy	Dunn	8/29/17
894	Bernadette	Duquette	8/22/17
895	Janet	Duran	8/30/17
896	Gregory	Durniak	8/29/17
897	Virginia	Dwyer	8/29/17
898	Emily	Eckart	8/21/17
899	Choral	Eddie	8/21/17
900	Alisa	Eilenberg	8/7/17
901	Esmee	Einerson	8/29/17
902	Josh	Eisenstark	8/24/17
903	Liz	Elkin	8/29/17
904	Jan	Emerson	8/29/17
905	Anne	Endler	8/7/17
906	Anna	Engdahl	8/29/17
907	D.	E-Platt	8/21/17
908	Lori	Epstein	9/1/17
909	Susan	Epstein	9/1/17
910	Alessia	Eramo	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
911	Jessica	Ettinger	8/30/17
912	Alicia	Everett	8/30/17
913	Jennifer	Fahey	8/25/17
914	Judy	Fairless	8/29/17
915	Eugene	Falik	8/12/17
916	Russell	Faller	8/8/17
917	Dan	Famer	8/21/17
918	Stacey	Farber	8/21/17
919	Raymond	Farrington	8/29/17
920	Tami Lin	Farrow	8/29/17
921	Mary	Fasano	8/22/17
922	Wendy	Fast	8/30/17
923	Mary Ann	Fastook	8/29/17
924	Pat	Faye	8/21/17
925	Kristina	Fedorov	8/25/17
926	Arnold	Feinsilber	8/30/17
927	Dianne	Felix	8/25/17
928	Ellen	Fenton	8/31/17
929	Roxanne	Ferber	8/25/17
930	Yvette	Fernandez	8/30/17
931	Andrew	Fetherolf	8/25/17
932	Ariel	Feuz	8/25/17
933	Jon	Fields	8/29/17
934	Francisco	Figueirido	8/30/17
935	Cristina	Fiorillo	8/29/17
936	Chrissy	Fischetti	8/22/17
937	Mel	Fish	8/22/17
938	Norman	Fisher	8/22/17
939	Kaitlin	Fitch	8/7/17
940	Julia	Fitzgerald	8/29/17
941	Mike	Fitzgerald	8/21/17
942	Barbara	Fitzhugh	8/31/17
943	Barbara	Fitzhugh	9/1/17
944	Ellen	Fleishman	8/24/17
945	Diana	Flood	8/22/17
946	Patricia	Flood	8/22/17
947	Patricia	Flood	8/25/17
948	Patricia	Flood	8/29/17
949	Patricia	Flood	8/29/17
950	Patricia	Flood	8/30/17
951	Bobbie	Flowers	8/24/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
952	Jillian	Flynn	8/17/17
953	Thomas	Folkl	8/25/17
954	J.R.	Fontaine-Serra	8/29/17
955	Maureen	Ford	8/29/17
956	Tanya	Foret	8/21/17
957	Janet	Forman	8/18/17
958	Laura	Forman	8/21/17
959	Devlin	Foster	8/30/17
960	Ian	Fountain	8/21/17
961	Ian	Fountain	9/1/17
962	Steven	Fowler	8/21/17
963	Andrea	Frank	8/29/17
964	Elaine	Frankle	8/30/17
965	Brian	Frederick	8/24/17
966	Misha	Fredericks	9/1/17
967	Heather	Free	8/6/17
968	Ava	Freeman	8/30/17
969	Ronald	Friedman	8/24/17
970	Justin	Fromm	8/16/17
971	L.	Fron	8/29/17
972	Romain	Fruge	8/28/17
973	Mark	Frusciante	8/22/17
974	Carrie	Fudge	8/30/17
975	Jane	Fuller	9/1/17
976	Roy	Fuller	8/24/17
977	Dorian	Fulvio	8/29/17
978	Lee	Furbeck	9/1/17
979	Victoria	Furio	8/29/17
980	Rob	Fursich	8/7/17
981	Deborah	Fusco, RMT	8/22/17
982	Maria	Gagliardi	8/30/17
983	Bernard	Galiley	8/29/17
984	Barbara	Galli	8/22/17
985	Dianne	Galliher	8/29/17
986	Angel	Garcia	8/18/17
987	Cari and Donald	Gardner	8/7/17
988	Joy	Garland	8/18/17
989	Ktie	Garton	8/29/17
990	Nathan	Gauthier	8/29/17
991	John	Gebhards	8/24/17
992	Sharon	Gelfand	8/22/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
993	Sharon	Gelfand	8/22/17
994	Michael	Gelfer	8/7/17
995	Derek	Gendvil	8/29/17
996	Donna	George	8/29/17
997	Thomas	George	8/29/17
998	Paul	Ghenoiu	8/22/17
999	Helen	Ghiradella	8/24/17
1000	Mary	Gianetto	8/22/17
1001	Mary	Gianetto	8/22/17
1002	Anthony	Giannantonio	8/22/17
1003	Laurette	Giardino	8/22/17
1004	Thomas	Giblin	8/18/17
1005	Ward	Giblin	8/18/17
1006	David	Gilbert	8/22/17
1007	Nina	Gimmel	8/30/17
1008	Mark	Ginsburg	8/30/17
1009	Clarice	Glandon	8/29/17
1010	Toni	Glikes	8/21/17
1011	Matthew	Glock	8/22/17
1012	Matthew	Glock	8/30/17
1013	Rise	Gluck	8/29/17
1014	Alexander	Goasdoue	8/7/17
1015	Susan	Goldfarb	8/21/17
1016	Allan	Goldstein	8/21/17
1017	Howard	Goldstein	8/29/17
1018	Mary	Goldstein	8/22/17
1019	Louise	Golub	8/29/17
1020	Ronaldo	Gonzalez	8/22/17
1021	Mike	Good	8/30/17
1022	Karine	Gordineer	8/25/17
1023	David	Gordon	8/27/17
1024	Emily	Gordon	8/28/17
1025	Nancy	Gordon	9/1/17
1026	Richard	Gordon	8/29/17
1027	Sarah	Gordon	8/30/17
1028	Cyd	Gorman	9/1/17
1029	Deborah	Gorman	8/29/17
1030	Mark	Gorsetman	8/19/17
1031	Laura	Grady	8/25/17
1032	Jacqueline	Grand Pre	8/30/17
1033	George	Graney	8/21/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1034	D	Green	8/31/17
1035	Jeff	Greenberg	8/29/17
1036	Karen	Greenspan	8/29/17
1037	Daria	Gregg	8/8/17
1038	Sophie	Greller	8/29/17
1039	Homer Ellis	Griffin	8/29/17
1040	Lucy	Grimes	8/29/17
1041	Tracy	Griswold	8/7/17
1042	Andrew	Grod	8/21/17
1043	John	Gromada	8/31/17
1044	Martin	Gromulat	8/7/17
1045	Sabina	Gross	8/18/17
1046	Yonni	Groza	8/23/17
1047	Gina	Guarino	8/22/17
1048	Richard	Guier	8/29/17
1049	James	Guilianelli	8/22/17
1050	James	Guilianelli	8/29/17
1051	Paula	Gullo	8/23/17
1052	Rachel	Gumina	8/24/17
1053	Karlene	Gunter	8/9/17
1054	Marina	Gutierrez	8/21/17
1055	Zinnia	Gutowski	8/29/17
1056	Dominique	ha	8/17/17
1057	Connie	Haack	8/21/17
1058	Jeffrey	Haas	8/23/17
1059	Renee	Hack	8/24/17
1060	Renee	Hack	8/30/17
1061	Heather	Haggerty	8/22/17
1062	Brandon	Hakulin	8/21/17
1063	Peter	Halewood	8/28/17
1064	Brett	Hall	8/22/17
1065	Margaret	Halliday	8/25/17
1066	Hagit	Halperin	8/29/17
1067	Jane	Halsey	8/29/17
1068	Colleen	Hamilton	8/18/17
1069	John	Hamilton	8/25/17
1070	Michele	Hamilton	9/1/17
1071	Sarah	Hamilton	8/7/17
1072	Susan	Hamilton	8/2/17
1073	Mary Lynn	Hanley	8/29/17
1074	Terence and Norma	Hannigan	8/22/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1075	Rosalie	Harman	8/16/17
1076	Elizabeth	Harrington	8/23/17
1077	Emmalia	Harrington	8/16/17
1078	Elaine	Hartel	8/29/17
1079	Joyce	Hartsfield	8/22/17
1080	Christine	Harvey	8/18/17
1081	David	Harvey	8/22/17
1082	Bjorn	Harvold	8/17/17
1083	Tracey	Hastings-Ward	9/1/17
1084	Martin	Hauser	8/30/17
1085	Jill	Hausman	8/29/17
1086	Kathy	Haverkamp	8/29/17
1087	Gerry	Hawkins	8/22/17
1088	Sheryl & Don	Haynie/Samuel	8/24/17
1089	Mary	Hays	8/28/17
1090	Chris	Hazynski	8/24/17
1091	William	Healey	8/7/17
1092	Thomas	Hearty	8/24/17
1093	Josh	Heffron	8/24/17
1094	Eli	Hegeman	8/19/17
1095	Adriana	Heguy	8/16/17
1096	Michael	Heimbinder	8/29/17
1097	Jenny	Heinz	8/24/17
1098	Mary	Heller	8/29/17
1099	Laurie	Henderson	8/22/17
1100	-	Hera	8/29/17
1101	Jan	Herndon	8/18/17
1102	Carol	Herring	9/1/17
1103	Marianne	Herrmann	8/22/17
1104	Nava	Herzog	8/25/17
1105	Brenda	Hewett	8/31/17
1106	Pat	Hickey	8/25/17
1107	Brian	Higbie	8/25/17
1108	Jeanne	Hobert	9/1/17
1109	Mark	Hockman	8/18/17
1110	Matthew	Hoff	9/1/17
1111	Deborah	Hoffman	8/25/17
1112	Randi	Hoffmann	8/29/17
1113	Paul	Hofheins	8/18/17
1114	Constance	Hoguet Neel	8/24/17
1115	Hussein	Hollan	8/25/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1116	Susan	Holland	9/1/17
1117	Tamsin	Hollo	8/22/17
1118	John	Holodak	8/29/17
1119	F	Holz	8/29/17
1120	J	Holz	8/29/17
1121	Teresa	Hommel	8/29/17
1122	Natalia	Hook	8/21/17
1123	Stephen	Hopkins	8/17/17
1124	Jennifer	Horowitz	8/19/17
1125	Lily	Hou	8/29/17
1126	Jennifer	Houston	9/1/17
1127	Paticia	Houston	8/24/17
1128	Claire	Howard	8/24/17
1129	Nina	Howes	8/21/17
1130	Vicki	Huber	8/29/17
1131	Christina	Hubrt	8/22/17
1132	Jerold	Huebner	8/23/17
1133	Marc	Humphrey	8/30/17
1134	Obie	Hunt	8/16/17
1135	Heather	Hurley	8/30/17
1136	June	Hurst	8/29/17
1137	Noelene	Hutchinson	8/25/17
1138	A	I	8/29/17
1139	Hatti	Iles	8/29/17
1140	Cora	Impenna	8/22/17
1141	Daniel	Incristo	8/3/17
1142	Margaret	Innerfoher	8/7/17
1143	Adam	Isler	8/29/17
1144	Susan	Italia	8/31/17
1145	Lisa	Izes	8/30/17
1146	Sandy	J	8/29/17
1147	B.L.	Jacobi	8/22/17
1148	Carol	Jagiello	8/29/17
1149	Chip	James	8/21/17
1150	Chip	James	8/30/17
1151	Jared	Jamesson	8/29/17
1152	Shahla	Jannetta	8/31/17
1153	Alan	Jasper	8/29/17
1154	Payont	Jatasanont	8/29/17
1155	Lynne	Jeanette	8/30/17
1156	Barbara	Jesrani	8/30/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1157	Angela	Johnsom	8/23/17
1158	Carla Rae	Johnson	8/28/17
1159	Kathy	Johnson	8/21/17
1160	Margaret	Johnson	9/1/17
1161	Theresa	Johnson	8/24/17
1162	David	Johnston	9/1/17
1163	Nathaniel	Johnston	8/22/17
1164	Blanche	Jones	8/22/17
1165	Marjorie	Jones	8/22/17
1166	Robert	Jones	8/19/17
1167	Walter	Jones	9/1/17
1168	Barbara	Joslyn	8/29/17
1169	Adrian	Juarez	8/30/17
1170	Carol	Jurczewski	8/29/17
1171	Elaine	Jurumbo	8/29/17
1172	Deedra	Kaake	8/22/17
1173	Marilyn	Kaggen	8/24/17
1174	Lyle	Kahn	8/29/17
1175	Sabrina	Kahn	8/12/17
1176	Paul	Kalka	9/1/17
1177	Jean	Kallina	8/22/17
1178	Edith	Kantrowitz	8/31/17
1179	Sandra	Kaplan	8/29/17
1180	Sylvia	Kaplan	8/29/17
1181	Joe	Karr	8/24/17
1182	Beth	Kashmann	8/25/17
1183	Sheri	Kastner	9/1/17
1184	Lora	Katen	8/29/17
1185	Nikki	Katsikas	8/28/17
1186	Alayne	Katz	8/30/17
1187	Stacy	Katz	8/21/17
1188	Annie	Katzman	8/29/17
1189	Andreas	Kaubish	8/7/17
1190	Alix	Keast	8/24/17
1191	John	Keiser	8/24/17
1192	Peter	Keiser	8/19/17
1193	Charles	Keller	8/24/17
1194	Matthew	Kelly	8/29/17
1195	Vincent	Kelly-Brownell	8/29/17
1196	Jane	Kendall	8/30/17
1197	Meredith	Kent-Berman	8/19/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1198	Maria	Keramari	8/22/17
1199	David	Kern	8/24/17
1200	Ethan	Kerr	8/23/17
1201	Lisa	Ketchum	8/25/17
1202	JK	Kibler	8/29/17
1203	Johanna	Kiernan	8/30/17
1204	Joh	Killen	8/22/17
1205	Kevin	Kilner	8/29/17
1206	Donald	Kimmel	8/25/17
1207	D.	King	9/1/17
1208	David	King	8/26/17
1209	Julie Parisi	Kirby	8/7/17
1210	Lori	Kirsch	9/1/17
1211	Leonard	Kirsch III	8/21/17
1212	Leonard	Kirsch III	8/22/17
1213	Leonard	Kirsch III	8/22/17
1214	Leonard	Kirsch III	8/25/17
1215	Leonard	Kirsch, III	9/1/17
1216	Sandra	Kissam	8/24/17
1217	Eresha	Kissoon-Fareed	8/22/17
1218	Timothy	Kleeger	8/30/17
1219	Amy	Kletter	8/29/17
1220	David	Klinke	8/7/17
1221	Ulrike	Klopfer	8/24/17
1222	Claudine	Klose	9/1/17
1223	Nina	Knanishu	8/19/17
1224	Brian	Knowles	8/31/17
1225	Michael	Kodransky	8/30/17
1226	Laura	Koestler	8/29/17
1227	Laura	Kohlmann	8/22/17
1228	Alon	Koppel	9/1/17
1229	Ray	Koretsky	8/30/17
1230	George	Kormendi	8/29/17
1231	Ellen	Korz	8/27/17
1232	Ellen	Kozak	8/30/17
1233	JAmes	Kozlik	8/22/17
1234	Lori	Krane	8/29/17
1235	Steven	Krauss	8/21/17
1236	Jennifer	Krawitz	8/11/17
1237	Pam	Kray Gallivan	8/18/17
1238	Elena	Krumova	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1239	Richard	Krupp	8/25/17
1240	Walter	Kuciej	8/29/17
1241	William	Kuehnling	8/18/17
1242	Elyse	Kunz	8/30/17
1243	Pat	Kush	8/24/17
1244	Toren	Kutnick	8/18/17
1245	Katie	Kynast	8/29/17
1246	John	Lacey	8/21/17
1247	Dimitri	Laddis	8/28/17
1248	Dennis	Ladner	8/31/17
1249	Annik	LaFarge	8/30/17
1250	Terri	Laidman	8/22/17
1251	Andrew	Laiosa	8/29/17
1252	Marion	Lakatos	8/29/17
1253	Catherine	Lala	8/22/17
1254	Katrina	Lalonde	8/22/17
1255	Tara	Lambert	8/28/17
1256	Wendy	Lambert	8/22/17
1257	William	Landau	8/22/17
1258	Hilary	Lander	8/22/17
1259	Michelle	Lange	8/30/17
1260	Norbert	Langer	8/29/17
1261	Hatti	Langsford	8/30/17
1262	Bianca	Lanza	8/30/17
1263	Bianca	Lanza	9/1/17
1264	Ricky	Lark	8/22/17
1265	Nancy	Larsen	8/22/17
1266	Carol	Latourette	9/1/17
1267	Lynn	Lauber	8/21/17
1268	Julianna	Lavin	9/1/17
1269	Linda	Lavin	8/22/17
1270	Susan	Lawrence	8/22/17
1271	Michael	Lebron	8/22/17
1272	Jo-Ann	Lechner	8/19/17
1273	Benjamin	Lee	8/29/17
1274	Deborah K.	Lee	8/29/17
1275	Diane	Lee	8/30/17
1276	Michel	Lee	8/29/17
1277	Steven	Lee	8/31/17
1278	Steven	Lee	9/1/17
1279	Arthur	Leibowitz	8/7/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1280	Hannah	Leider	8/29/17
1281	Doug	Leihbacher	8/22/17
1282	Jill	Lein	8/30/17
1283	B. R.	Lemonik	8/24/17
1284	Bernice	Lenahan	8/4/17
1285	Eileen	Lennon	8/21/17
1286	Wayne	Lensu	8/7/17
1287	Gale	Leonard	8/25/17
1288	Gerson	Lesser	8/29/17
1289	Kathleen	Letchford	8/29/17
1290	Rhonda	Levine	8/7/17
1291	Ellen	Levinson	8/21/17
1292	Jeffrey	Levitt	8/18/17
1293	David	Levy	8/21/17
1294	Erma	Lewis	8/29/17
1295	Erma	Lewis	8/29/17
1296	Mike	Lieber	8/22/17
1297	D. M.	Linkie	8/25/17
1298	Matthew	Liponis	8/31/17
1299	Danette	Lipten	8/22/17
1300	Jennifer	Lischak	8/25/17
1301	Jim	Littlefield	8/29/17
1302	Elaine	Livingston	8/24/17
1303	Patricia	Livingston	8/30/17
1304	Patricia	Livingston	9/1/17
1305	Rich	Locicero	8/22/17
1306	Diane	Lombardi	8/22/17
1307	Diane	Lombardi	8/22/17
1308	Catherine	Lombardo	8/30/17
1309	Robert	Long	8/22/17
1310	Scott	Longstreet	8/21/17
1311	Mary	Loomba	8/29/17
1312	Michael	Loos	8/29/17
1313	Nancy	Lopez	8/24/17
1314	Christopher	Lord	8/19/17
1315	Mark	Lotito	8/27/17
1316	Evan	Loughran	8/10/17
1317	Hilarie	Louis	8/24/17
1318	Joe	Lowenbraun	8/23/17
1319	Alison	Lucek	8/30/17
1320	Nicole	Luciani	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1321	Rachel	Lugo	8/23/17
1322	Brian	Luman	8/24/17
1323	Martin	Lupowitz	8/25/17
1324	Susan	Lupul	8/22/17
1325	Barbara	Lynch	8/24/17
1326	Lois	Lynn	8/18/17
1327	Clarinda	Mac Low	8/29/17
1328	Stephen	Mac Nish	8/29/17
1329	Marissa	Macagnone	8/22/17
1330	Michael	Macelhiney	8/29/17
1331	Christine	Maciel	8/22/17
1332	Robert	Mackey	8/29/17
1333	Michael	Madden	8/7/17
1334	Robert	Madorran	8/30/17
1335	Laraine	Mai	8/21/17
1336	Karyn	Maier	8/30/17
1337	Linda	Maldonado	8/24/17
1338	Matthew	Malina	8/29/17
1339	Kenneth	Malkin	8/21/17
1340	Athena	Malloy	8/18/17
1341	Mitch	Maloof	8/24/17
1342	Danielle	Maltby	8/22/17
1343	Lindsay	Mandel	8/28/17
1344	Michael	Mangino	8/22/17
1345	Alexandra	Manning	8/29/17
1346	Clint	Marallo	8/24/17
1347	Marlena	Marallo	8/2/17
1348	Jack David	Marcus	8/17/17
1349	Jack David	Marcus	8/22/17
1350	Kimberly	Marcus	8/29/17
1351	Karlene	Maresco	8/22/17
1352	Jordan	Margolis	8/23/17
1353	Kathy	Margulis	8/29/17
1354	Phillip	Marinelli	8/29/17
1355	Jane	Marinsky	8/21/17
1356	Darian	Mark	8/29/17
1357	Emily	Maroney	8/29/17
1358	Debbie	Marotta	8/22/17
1359	Jim	Marrinan	8/30/17
1360	Laurence	Martin	8/22/17
1361	Rea	Martin	8/30/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1362	Tina	Martin	8/29/17
1363	Isabel	Martins	8/18/17
1364	Joan	Martorano	8/22/17
1365	Toby	Marxuach-Gusciora	8/29/17
1366	Kara	Masciangelo	8/28/17
1367	Ben	Mastaitis	8/24/17
1368	Angela	Mastracchio	8/21/17
1369	Frances	Mastrota	8/7/17
1370	Dennis	Mathews	8/29/17
1371	Larissa	Matthews	8/18/17
1372	Elizabeth	Maucher	8/29/17
1373	Hope	Mauran	8/29/17
1374	Kurt	Mausert	8/21/17
1375	George Louis	Mayer	8/29/17
1376	Francis	Mayle	8/29/17
1377	Kathleen	Mazza	8/21/17
1378	Linda	McArdle	8/30/17
1379	Diane	McAteer	8/29/17
1380	Paul	McCarthy	8/28/17
1381	Richard	McCauley	8/24/17
1382	Flannery	McDermott	8/25/17
1383	John	McDonald	8/29/17
1384	Roland	McDonald	8/24/17
1385	Mary	McGeary	8/7/17
1386	Chris	Mcginn	8/29/17
1387	Emma	McGregor-Mento	8/16/17
1388	Steven	McIntyre	8/30/17
1389	Grant	McKeown	8/28/17
1390	Mary	Mckeown	8/22/17
1391	Alan	McKnight	8/7/17
1392	Brian	McLaughlin	8/29/17
1393	Kathleen	McLaughlin	8/24/17
1394	Elizabeth	McMahon	8/7/17
1395	Jennifer	McMorrow	8/25/17
1396	Jennifer	McMorrow	8/29/17
1397	Susan	McNamara	8/17/17
1398	William	McNamara	9/1/17
1399	Monica	McQuade	8/25/17
1400	Robert	McQuilkiin Jr.	8/22/17
1401	Joanna	Meakin	8/25/17
1402	Tatiana	Mejia	8/19/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1403	Dominic	Melita	8/29/17
1404	Donna	Menconeri	9/1/17
1405	Rik	Mercaldi	8/21/17
1406	Jonathan	Mernit	8/21/17
1407	Andrew	Meyer	8/22/17
1408	Laurie	Miccio	8/25/17
1409	Bonnie	Michaels	8/22/17
1410	Sharon	Michales	8/24/17
1411	Ragnar	Midtskogen	8/21/17
1412	Lyndsey	Milcarek	8/20/17
1413	Joanne	Miller	8/29/17
1414	John	Miller	8/5/17
1415	Jonathan	Miller	8/16/17
1416	Marjorie	Miller	8/24/17
1417	Matthew	Miller	8/22/17
1418	Alvin	Miller Jr	8/25/17
1419	Alvin	Miller Jr	8/30/17
1420	Alvin	Miller Jr	9/1/17
1421	Alvin	Miller Jr.	8/22/17
1422	Judy	Miller-Lyons	9/1/17
1423	Jackie	Mills	8/29/17
1424	Laura	Milsom	8/22/17
1425	Harut	Minasian	8/31/17
1426	Hayley	Mink	8/29/17
1427	Ellen	Miret	8/22/17
1428	Lily	Mleczko	8/29/17
1429	Alexis	Mohr	8/30/17
1430	Phyllis	Mollen	8/24/17
1431	Barbara	Moloney	8/21/17
1432	Barbara	Moloney	8/22/17
1433	Jesse	Monahan	8/21/17
1434	Joanne	Moncada	8/29/17
1435	Gail	Moore	8/29/17
1436	Robert	Moore	8/24/17
1437	Thomas	Moore	8/29/17
1438	Anne	Mor	8/22/17
1439	Sylvia	Morais	8/22/17
1440	Will	Morel	8/29/17
1441	Teresa	Morelle	8/18/17
1442	Dennis	Morley	8/29/17
1443	Lewis	Morrison	8/19/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1444	Janet	Moser	8/24/17
1445	Chelsea	Mozen	8/7/17
1446	Norine	Muhfeld	8/10/17
1447	James	Mulder	8/29/17
1448	Ellen	Mulkerin	8/22/17
1449	Mary	Mullaney	8/22/17
1450	Monuca	Mulligen	8/29/17
1451	Dory	Munder	8/30/17
1452	Laura	Munisteri	8/22/17
1453	Eric	Munkelt	8/30/17
1454	Eric	Munkelt	9/1/17
1455	Maki	Murakami	8/29/17
1456	Lizzie	Murchison	8/29/17
1457	Susan	Murphy	8/21/17
1458	Susan	Murphy	8/29/17
1459	Dara	Murray	8/29/17
1460	William	Murtha	8/29/17
1461	Michael	Musante	8/23/17
1462	Roger	Muzii	8/29/17
1463	Lindsey	Muzzio	8/29/17
1464	Carol	Myers	8/24/17
1465	Emma	Myers	8/31/17
1466	Laura	Myerson	8/24/17
1467	Sandra	Naidich	8/18/17
1468	S.	Nam	8/18/17
1469	Courtney	Nandagiri	8/24/17
1470	Jean	Naples	8/7/17
1471	P.	Naprstek	8/31/17
1472	Gretchen	Nau	8/22/17
1473	Rosemary	Neer	8/21/17
1474	Lisa	Neste	8/29/17
1475	Eric	Neuman	8/21/17
1476	Lynn	Neuman	8/29/17
1477	Ted	Neumann	9/1/17
1478	John	Neumeister	8/21/17
1479	John	Neumeister	9/1/17
1480	Bob	Nevelus	8/30/17
1481	Roxie	Newberry	8/30/17
1482	Antonella	Nielsen	8/29/17
1483	Anthony	Nigro	8/29/17
1484	Carla	Ninos	8/28/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1485	Sajendra	Nithiananthan	8/29/17
1486	Joseph	Nitzberg	9/1/17
1487	Mary	Noll	8/24/17
1488	Lauren	Noonan	8/21/17
1489	Terry	Nord	8/22/17
1490	Mary Ann	Nordheimer	8/29/17
1491	Ilana	Novick	8/29/17
1492	Laura	Nowack	8/28/17
1493	Natalie	Nussbaum	8/29/17
1494	Kathy	Oconnor	8/28/17
1495	Mary Beth	OConnor	8/29/17
1496	Patricia	Odell	8/29/17
1497	Cynthia	Ofer	8/29/17
1498	Kerry	O'Flynn	9/1/17
1499	Barb	OFriel	9/1/17
1500	Elizabeth	O'Hara	8/29/17
1501	William	O'Hearn	8/29/17
1502	Luis	Olavarria	9/1/17
1503	Margot	Olavarria	8/16/17
1504	Kevin	Oldham	8/19/17
1505	Joseph	Olejak	8/23/17
1506	Victoria	Oltarsh	8/25/17
1507	Carole	Osterink	8/30/17
1508	Linde	Ostro	8/25/17
1509	Joseph	O'Sullivan	8/21/17
1510	Tara	O'Sullivan	9/1/17
1511	Jane	Osuna	9/1/17
1512	Marge	Othrow	8/24/17
1513	Maxwell	Owen	8/30/17
1514	Michael	Owen	8/29/17
1515	Roseanne	Pacheco	8/22/17
1516	Linda	Pachter	8/29/17
1517	Sarah	Page	9/1/17
1518	Harela	Paglia	8/21/17
1519	Vic	Paglia	8/7/17
1520	Carol	Painter	8/21/17
1521	Laura	Pakaln	8/22/17
1522	Tami	Palacky	8/29/17
1523	Anne	Palagano	8/22/17
1524	Craig	Palmer	8/29/17
1525	Julie	Palmeri	8/22/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1526	Charlie	Pane	9/1/17
1527	Drew	Panko	8/24/17
1528	Laura	Pantazis	8/29/17
1529	John	Papandrea	8/24/17
1530	Joan	Paris	8/21/17
1531	Pat	Pascual	8/18/17
1532	Michael	Pastore	9/1/17
1533	Jacob	Patenaude	8/22/17
1534	Randolph	Patrick	9/1/17
1535	Ernest	Paviour	8/18/17
1536	Anrea	Payne	9/1/17
1537	Gail	Payne	8/24/17
1538	Jennifer	Paynter	8/21/17
1539	Barbara	Pearson	8/7/17
1540	Pippa	Pearthree	8/29/17
1541	Robert	Pease	8/21/17
1542	Mary	Peck	8/30/17
1543	Melanie	Pedicini	8/7/17
1544	Annadora	Pedro	8/22/17
1545	Susan	Pelosi	8/30/17
1546	Vickiana	Pena	8/28/17
1547	Eliane	Pereira	8/24/17
1548	Martha	Perlmutter	8/18/17
1549	Richard	Perras	8/18/17
1550	Robert	Perretti	8/7/17
1551	Tony	Perrottet	8/17/17
1552	Debbie	Peters	8/29/17
1553	Laura	Petit	8/22/17
1554	Joe	Pfister	8/18/17
1555	Gaelene	Phelps	8/29/17
1556	Gaelene	Phelps	9/1/17
1557	Trent	Philipp	8/24/17
1558	Brother Robert	Pierson OHC	8/22/17
1559	Jon	Pike	8/30/17
1560	Thomas	Pintagro	8/29/17
1561	Debra	Plishka	8/29/17
1562	Jane	Podell	8/22/17
1563	Albert	Poland	8/25/17
1564	Jack	Polonka	8/18/17
1565	Marian	Pompa	8/31/17
1566	Charles	Pompey	8/22/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1567	Tyler	Poniatowski	8/29/17
1568	Bernadette	Powis	8/29/17
1569	Diane	Praus	8/19/17
1570	Ralph	Preiss	8/21/17
1571	Spencer	Prevallet	8/13/17
1572	Elysee	Price	8/29/17
1573	Lou	Priem	8/19/17
1574	Richard	Procida	8/24/17
1575	Camala	Projansky	8/25/17
1576	Clifford	Provost	8/8/17
1577	Lise	Prown	8/24/17
1578	Nicholas	Prychodko	8/24/17
1579	David	Prystal	8/29/17
1580	Laurie	Puca	8/27/17
1581	Katy	Purtee	9/1/17
1582	Katheryn	Quick	8/21/17
1583	Diane	Quinn	8/21/17
1584	Edythe Ann	Quinn	8/29/17
1585	Mary	Quinn	8/29/17
1586	Joseph	Quirk	8/28/17
1587	Laura	Rabinow	8/23/17
1588	Tracy	Raczek	8/8/17
1589	Mary	Rader	8/31/17
1590	Joann	Ramos	8/7/17
1591	Hale	Randers-Pehrson	8/20/17
1592	Edward	Rashba	8/22/17
1593	Andrew	RatZin	9/1/17
1594	Marie	Rayho	8/30/17
1595	Jeff	Reagan	8/22/17
1596	Lobi	RedHaw	8/29/17
1597	Joyce	Reeves	8/29/17
1598	Lenore	Reeves	8/29/17
1599	Pam	Rehm	8/29/17
1600	Cynthia	Reichman	8/29/17
1601	Michael	Reichman	8/29/17
1602	Mary	Reilly	8/21/17
1603	John	Reimnitz	8/31/17
1604	Josephine	Reina	8/22/17
1605	Edward	Rengers	8/29/17
1606	Beth	Renner	8/29/17
1607	Beth	Renner	8/30/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1608	Beth	Rennig	8/30/17
1609	Athena	Resch	8/23/17
1610	Haleigh	Reutershan	8/22/17
1611	Cathy	Revis	8/7/17
1612	Cathy	Revis	8/22/17
1613	Annia	Reyes	8/23/17
1614	Adelaide	Reynolds	8/29/17
1615	Thomas	Reynolds	8/24/17
1616	Robert	Rice	8/16/17
1617	Frederich	Rich	8/25/17
1618	Amanda	Richards	8/24/17
1619	Kathleen	Richardson	8/7/17
1620	Diana	Riddle	8/29/17
1621	George	Riggs	8/24/17
1622	James	Riley	8/29/17
1623	Kelly	Riley	8/29/17
1624	Dianne	Rinaldi	8/31/17
1625	Melissa	Rinzler	8/29/17
1626	Diane	Rios	8/30/17
1627	Elaine	Risch	8/22/17
1628	Barbara	Riso	9/1/17
1629	Javier	Rivera	8/24/17
1630	Renee	Rizzo	8/18/17
1631	Krystal	Roach	8/27/17
1632	Chuck	Roberts	8/29/17
1633	Cynthia	Roberts	8/22/17
1634	Marcia	Robinson	8/18/17
1635	Robert	Robinson	8/30/17
1636	Iris	Rochkind	8/19/17
1637	Zachary	Rodgers	8/22/17
1638	Heriberto	Rodriguez	9/1/17
1639	Sylvia	Rodriguez	8/16/17
1640	Lily	Rodulfo	8/22/17
1641	Robert	Rogers	8/24/17
1642	Johanna	Rose	9/1/17
1643	Stephen	Rose	8/24/17
1644	Chris	Rosen	8/29/17
1645	Jenny	Rosenthal	8/23/17
1646	Robert	Rosenthal	8/18/17
1647	Suzie	Ross	8/21/17
1648	Timothy	Rosser	8/7/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1649	Janice	Rossi	8/24/17
1650	Jodie	Rossi	8/22/17
1651	Livia	Rossi	8/30/17
1652	Janice	Rost	8/29/17
1653	Janice Arlene	Rost	8/22/17
1654	Rochelle	Rothbaum	8/23/17
1655	Margery	Rothenberg	8/22/17
1656	Christina	Rousseau	8/29/17
1657	Wileen	Rowley	9/1/17
1658	Rebecca	Roy	8/30/17
1659	Jonathan	Rubin	8/19/17
1660	Paul	Rubin	8/16/17
1661	Karen	Rubino	8/29/17
1662	Helena	Rudd	8/16/17
1663	Rosalee	Ruediger	8/21/17
1664	Vincent	Rusch	8/29/17
1665	Mike, Pat	Ruscigno, Hilliard	8/31/17
1666	Paul	Russell	8/21/17
1667	Samantha	Russo	8/20/17
1668	Seth	Rutman	8/19/17
1669	Megan	Ryan	8/29/17
1670	Elaine	Sacco	9/1/17
1671	Marysa	Sacerdote	8/30/17
1672	Emma Lou	Sailors	8/24/17
1673	Diana	Salsberg	8/28/17
1674	Laurie	Salzberg	8/31/17
1675	Ahide	Sanchez	8/31/17
1676	Dominick	Santise	8/29/17
1677	Mary	Sari	8/29/17
1678	Carolyn	Sas	9/1/17
1679	Daniel	Savatteri	8/30/17
1680	Jason Douglas	Saville	8/22/17
1681	Marietta	Scaltrito	8/24/17
1682	Chris	Scanga	8/28/17
1683	Christopher	Scanga	9/1/17
1684	Kelley	Scanlon	8/24/17
1685	Martin	Schabu	8/20/17
1686	Wendy	Scheir	8/29/17
1687	Joan	Schildwachter	8/29/17
1688	Elaine	Schindler	8/21/17
1689	Pierre	Schlemel	8/24/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1690	Erica	Schmidt	8/29/17
1691	Naomi	Schmidt	8/30/17
1692	Chris	Schneebeli	8/29/17
1693	Shirley	Schue	8/29/17
1694	Marthe	Schulwolf	8/22/17
1695	Phillip	Schwartz	8/30/17
1696	Sybil	Schwartzbach	9/1/17
1697	Sabine	Schwarz	8/29/17
1698	Thomas	Scialo	8/7/17
1699	Carina	Scorcia	8/29/17
1700	Amanda	Scott	8/22/17
1701	P.	Scoville	8/7/17
1702	Margaret	Scripp	8/29/17
1703	Shelley	Seccombe	8/31/17
1704	Michael	Seckendorf	8/29/17
1705	Laura	Seitz	8/31/17
1706	Kim	Sellon	8/14/17
1707	Richard	Sena	8/29/17
1708	Yoshihiro	Sergel	8/29/17
1709	Donna	Serpentini	8/30/17
1710	Linda	Sewell	8/7/17
1711	Susan	Shaak	8/21/17
1712	Karen	Shalom	8/22/17
1713	Barbara	Shapiro (Raskopf)	8/29/17
1714	William	Sharfman	8/7/17
1715	William	Sharfman	8/25/17
1716	Janis	Sharkey	9/1/17
1717	Gary	Shaw	8/23/17
1718	Clare	Sheridan	8/21/17
1719	Ian	Sheridan	8/29/17
1720	Samantha	Sherry	8/28/17
1721	Kate	Sherwood	8/24/17
1722	Alice	Shields	8/7/17
1723	Susan	Shockett	8/23/17
1724	Beth	Shortsleeves	8/29/17
1725	Lisa	Shumate	8/19/17
1726	Elizabeth	Shundi	8/22/17
1727	Susan	Sie	8/30/17
1728	Ana	Sierra	8/18/17
1729	Ethan	Signer	8/18/17
1730	Jeffrey	Silman	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1731	Jill	Silverman	8/30/17
1732	Laura	Silverman	8/24/17
1733	Sasha	Silverstein	8/29/17
1734	Virginia	Simek	8/22/17
1735	Beatrice	Simmonds	8/3/17
1736	Eileen	Simon	8/22/17
1737	Norman	Sissman	8/29/17
1738	John	Skelly	8/23/17
1739	Caren	Skibell	8/29/17
1740	Darren	Skotnes	8/29/17
1741	Katherine	Slawinski	8/27/17
1742	Jessica	Smith	8/23/17
1743	Kevin	Smith	8/21/17
1744	Mary	Smith	8/7/17
1745	Melinda	Smith	8/20/17
1746	Vanessa	Smith	8/27/17
1747	Addie	Smock	8/7/17
1748	Virginia	Snider	8/29/17
1749	Elena	Snyder	9/1/17
1750	Sandy	Sobanski	8/24/17
1751	Gillian	Sobocinski	8/27/17
1752	Sabrina	Solomon	8/29/17
1753	David	Sorensen	8/7/17
1754	Nicolai	Soriano	9/1/17
1755	Cynthia	Soroka-Dunn	8/30/17
1756	Deniseadenise	Sossa	8/30/17
1757	Rebecca	Soule	8/29/17
1758	Trevor	Southlea	8/31/17
1759	Harvey	Spears	8/7/17
1760	Leola	Specht	8/7/17
1761	Elaine	Sperbeck	8/29/17
1762	Vanessa	Spiegel	8/30/17
1763	Barry	Spielvogel	8/24/17
1764	Abby	Spitzer	8/21/17
1765	Abby	Spitzer	8/28/17
1766	Stuart	Spolin	8/21/17
1767	Rebekkah	Sprague	8/30/17
1768	Ann	Sprayregan	8/29/17
1769	Judy	St. Hedley	8/24/17
1770	Jane	Stabile	8/21/17
1771	Shannon	Stagman	8/28/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1772	Anna	Stahlie	8/30/17
1773	Carol	Stamets	8/29/17
1774	Judyth	Stavans	8/30/17
1775	Alex	Stavis	8/16/17
1776	Jean	StClair	8/22/17
1777	Jean	StClair	8/22/17
1778	Fern	Stearney	8/22/17
1779	Doug	Steckler	8/19/17
1780	Deborah	Stedge	9/1/17
1781	Joanne	Steele	8/29/17
1782	Dylan	Stein	8/21/17
1783	Herbert	Stein	8/19/17
1784	Herbert	Stein	8/24/17
1785	Jane	Stein	8/24/17
1786	Lorenz	Steininger	8/29/17
1787	Richard	Stern	8/18/17
1788	Susan	Stevens	9/1/17
1789	Paige	Stevenson	8/22/17
1790	Heather	Stewart	8/28/17
1791	Michael	Stocker	8/7/17
1792	Jill	Stolt	8/22/17
1793	Claudia	Stoltman	9/1/17
1794	Marcia	Stone	8/29/17
1795	Peggy	Stork	8/22/17
1796	Laurie	Storm	8/29/17
1797	James	Strickler	8/23/17
1798	Caroline	Stupple	8/30/17
1799	Moraima	Suarez	8/29/17
1800	Josh	Subin	8/30/17
1801	Anna	Sullivan	8/21/17
1802	Terry	Sullivan	8/29/17
1803	Karen	Sussan	8/30/17
1804	Judith	Swallow	8/22/17
1805	Tami	Swartz	8/29/17
1806	Kathleen	Sweeney	8/28/17
1807	Leslie	Sweeney	8/29/17
1808	Glynis	Sweeny	9/1/17
1809	Alexandra	Sweeton	8/28/17
1810	Michael	Szeto	8/29/17
1811	Sandy	Tabin	8/30/17
1812	Susan	Tabor	8/31/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1813	Christen	Tallas	9/1/17
1814	Gail	Tauber	8/28/17
1815	Abigail	Taylor	8/30/17
1816	Jason	Taylor	9/1/17
1817	Nancy	Taylor	8/30/17
1818	Margaret	Teahan	8/7/17
1819	Gary	Telfer	8/21/17
1820	Michele	Temple	8/7/17
1821	Edith	Templeton	8/29/17
1822	Hannah	Tennant-Moore	8/21/17
1823	Lynne	Teplin	8/18/17
1824	Ron	Tergesen	8/29/17
1825	Rashida	Tewarson	8/22/17
1826	Deborah	Thackrey	8/22/17
1827	Robert	Thibault	8/24/17
1828	Irene	Thiel	8/24/17
1829	Tracy	Thomas	8/22/17
1830	Lorraine	Thompson	9/1/17
1831	James	Thoubboron III	8/25/17
1832	Robert	Tipp	8/30/17
1833	Jo	Toland	8/29/17
1834	Elizabeth	Tolliver	8/22/17
1835	Lynn	Tondrick	8/29/17
1836	Susan	Torres	8/18/17
1837	Joan	Traber	8/22/17
1838	Joanne	Trapanese	8/22/17
1839	Nancy	Traverse	8/22/17
1840	Thomas	Trengove	8/29/17
1841	Adam	Trese	8/30/17
1842	Mary	Troland	8/29/17
1843	Ryan	Trow	8/30/17
1844	Ann	Troxler	8/29/17
1845	Barbara	Trypaluk	8/29/17
1846	Ling	Tsou	8/16/17
1847	Ling	Tsou	8/21/17
1848	Leigh Ann	Tulleson	8/30/17
1849	Alexander	Turkenich	8/29/17
1850	Charity	Turner	8/22/17
1851	Deborah	Turner	8/30/17
1852	Sean A.	Twohig	8/29/17
1853	Francine	Tyler	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1854	Joel	Tyner	9/1/17
1855	Kathy	Upham	8/22/17
1856	Chris	Usami	8/20/17
1857	Nick	Vailakis	9/1/17
1858	Fernando	Valentin	8/14/17
1859	Matthew	Van Brocklin	8/21/17
1860	Brent	Van Dyke	8/30/17
1861	Marcsha	Vander Heyden	8/16/17
1862	Theresa	Vanyo	8/22/17
1863	Patrick	Varekamp	8/24/17
1864	Alexandra	Vargo	9/1/17
1865	Anna	Varney	8/20/17
1866	Joseph M	Varon	8/29/17
1867	Francisco J.	Velez	8/25/17
1868	Joanna	Venditto	8/21/17
1869	Maria	Venidis	8/18/17
1870	Robert	Veralli	8/24/17
1871	David	Verhoff	8/25/17
1872	David	Verhoff	8/28/17
1873	Margaret	Vernon	8/24/17
1874	Paolo	Vidali	8/19/17
1875	Nicole	Vidor	8/30/17
1876	Lauren	Vigna	8/29/17
1877	Harry	Vincent	8/22/17
1878	Richard	Vincent	9/1/17
1879	Jerald	Vinikoff	8/18/17
1880	Andy	Von Salis	8/18/17
1881	Helen	Vose	8/29/17
1882	Carla	Waldron	8/19/17
1883	Ruth	Walker	8/22/17
1884	Steven	Walker	8/29/17
1885	Robert	Waller	8/29/17
1886	Brad	Walrod	8/29/17
1887	Gerald	Walsh	8/18/17
1888	Ruth	Walter	8/21/17
1889	Wendy	Walters	8/24/17
1890	Jonathan	Wang	8/31/17
1891	Eddie	Ward	8/9/17
1892	Ken	Ward	8/19/17
1893	Marc	Ward	8/24/17
1894	Paula	Ward	8/30/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1895	Bob	Warren	8/22/17
1896	Carol	Warren	8/29/17
1897	Edward	Warren	8/21/17
1898	Dina	Wasserman	8/21/17
1899	Marc	Waters	8/19/17
1900	Eli	Watts	8/18/17
1901	Michael	Watts	9/1/17
1902	Noah	Watts	8/23/17
1903	Clifford	Weathers	8/23/17
1904	Esther	Weaver	8/24/17
1905	Melissa	Weaver	9/1/17
1906	Marie	Webster	8/25/17
1907	Marie	Webster	8/28/17
1908	Annie	Wei	8/30/17
1909	Carmen	Wei	8/18/17
1910	Penelope	Weinberg	8/22/17
1911	Adam	Weinert	8/22/17
1912	Adam	Weinert	8/22/17
1913	Florence	Weintraub	8/15/17
1914	Elaine	Weir	8/18/17
1915	Stana	Weisburd	8/30/17
1916	Marcia	Weiss	8/22/17
1917	Alicia	Weissman	8/21/17
1918	Shaye	Wel	8/21/17
1919	William	Welkowitz	8/29/17
1920	Heather	Wells	8/23/17
1921	Molly	Westbrook	8/30/17
1922	Patrick	Whalen	8/29/17
1923	Ian	Wheeler	8/29/17
1924	Mona	White	8/29/17
1925	Penny	White	8/24/17
1926	Edward B.	Whitney	8/25/17
1927	Wheelock	Whitney	8/25/17
1928	Teena	Wildman	8/29/17
1929	Kimberly	Wiley	8/24/17
1930	Michael	Wiley	8/31/17
1931	Seth	Wiley	8/30/17
1932	Andrea	Williams	8/29/17
1933	Andrew	Williams	8/24/17
1934	Suzanne	Williams	8/22/17
1935	Nathanel	Williams Jr.	8/29/17

Appendix A - List of Commenters on the Proposed Second Five-Year Review Report: Individuals			
EPA Index Number	**First Name**	**Last Name**	**Date Submitted**
1936	Thomas	Windberg	8/29/17
1937	Dana	Winkler	8/30/17
1938	Amy	Winter	8/24/17
1939	Marsha	Wiseltier	8/18/17
1940	Ron	Wish	8/24/17
1941	Frederick	Wishner	8/29/17
1942	Andrew and Kathleen	Wittenborn	8/29/17
1943	Ellen	Wolfe	8/7/17
1944	Peter	Wood	8/29/17
1945	Rick	Wood	8/29/17
1946	Veronica	Wood	8/29/17
1947	Sarah	Woodard	8/18/17
1948	Richard	Wright	8/22/17
1949	Richard	Wright	8/29/17
1950	Richard	Wrobel	8/21/17
1951	Yishin	Yang	9/1/17
1952	Donna	Yannazzone	8/22/17
1953	Emma	Young	8/21/17
1954	Jean	Young	8/29/17
1955	Kathy	Young	8/30/17
1956	Kristina	Younger	8/29/17
1957	J	Yuzawa	8/24/17
1958	Phyllis	Zahnd	8/7/17
1959	Susan	Zeiger	8/29/17
1960	Brook	Zelcer	9/1/17
1961	Janet	Zies	9/1/17
1962	Andrea	Zinn	8/29/17
1963	Pamela	Zino	8/30/17
1964	James	Zorn	8/22/17
1965	Carlo	Zucchi	8/29/17
1966	Cordelia	Zukerman	8/21/17
1967	Anonymous		8/18/17
1968	Anonymous		8/18/17

APPENDIX B

DEFERRAL STATEMENT - Supporting Technical Information

Final Second Five-Year Review Comment Response for the Hudson River PCBs Superfund Site

APPENDIX B

DEFERRAL STATEMENT - SUPPORTING TECHNICAL INFORMATION

Appendix B - Deferral Statement - Supporting Technical Information

Given the limited temporal coverage of post-dredging data currently available, EPA has decided to defer the Second Five-Year review (FYR) protectiveness determination at this time. Specifically, there are not enough data available since the completion of dredging in Fall 2015 for EPA to determine at this time whether the remedy was sufficiently successful in accelerating the reduction of human health and ecological risks to meet the remedial action objectives of the 2002 Record of Decision (ROD) for Operable Unit 2 (OU2) of the Site. The ROD anticipated a robust remedial action followed by "monitored natural attenuation" (MNA) to meet the remedial action objectives. To evaluate and estimate the remedy's long-term reduction of risk, EPA needs a number of years of post-dredging data that are not influenced by the dredging activities. While EPA and others have made extensive analyses of the rates of decline of PCBs in fish tissue during the period prior to dredging, the in-river conditions were extensively modified by the remedy, and these historical rates are therefore not expected to reflect future conditions.

EPA's decision to defer its determination of protectiveness for the Upper Hudson River (UHR) remedy recognizes the challenges in determining the post-dredging long-term rates of recovery for PCB levels in fish throughout the UHR so soon after completion of the dredging. The dredging portion of the remedy removed more than 70 percent of the PCB inventory, and more than 500 acres of river bottom were backfilled or capped, dramatically reducing PCB concentrations in the most contaminated areas. However, only two years of post-dredging fish data are available for review, and these data are still expected to be impacted by dredging-related sediment conditions and dredging-related disturbances[1] (as opposed to exposure to only post-dredging conditions) since fish concentrations in adult sportfish are known to reflect uptake over multiple years of exposure.

Fish body burdens of PCBs are the result of several processes involving PCB exposure through prey, water and sediment; PCB metabolism and depuration; environmental conditions that affect prey availability; lipid storage in fish; PCB levels in exposure media; and duration of exposure to PCBs. This last factor means that PCB body burdens in larger (older) fish, in particular, integrate across multiple years of exposure. Thus, adult sport fish (Bass, Bullhead and Perch) collected in the first and second year after dredging will have derived a portion of their body burdens from exposure during the period of dredging. While PCBs continue to decline in the water and sediment as a result of the dredging and associated capping and backfilling, as documented in the monitoring data, the rates of decline in fish tissue are confounded in the short-term by the processes mentioned above. Additionally, EPA believes it is likely that the dredging-related disturbances further increased the year-to-year variability in fish tissue concentrations, at least in the short-term, making identification of the overall rate of decline more difficult to discern at this time.

Evidence for the variable nature of fish tissue PCB levels in the Hudson River, and hence the importance of evaluating trends of decline over a longer period of time, can be observed in the fish monitoring data obtained prior to the remedy (1998 to 2008). This period represents the MNA period immediately following completion of EPA's modeling effort for the ROD which was characterized by a typical range of flow events and declining PCB transport from above Rogers Island. Despite the relatively consistent environmental conditions, the fish tissue data for PCBs fluctuates from year-to-year, with increases for short periods, to be followed by periods of more regular decline. An example is provided in Figure B-1 for brown bullhead in River Section (RS) 1. This figure illustrates the variation in annual mean PCB levels as described. Both wet weight and lipid-normalized concentrations are presented in the figure. Both

[1] These would include contaminated sediments exposed while dredging, increased water column concentrations due to dredging or habitat reconstruction activities, and temporary deposits of resuspended sediment, among others.

metrics show occasional substantive deviations (*e.g.,* year 2004) from the overall declining trend exhibited for the decade prior to dredging. This declining trend was evident at the time of the ROD, indicating that natural recovery was occurring; the remedy was selected to accelerate this trend.

EPA's statistical analyses of past fish tissue data, as discussed below, indicated that to accurately represent the actual rate of decline in fish tissue PCB levels, it is necessary to examine the annual record over extended periods of time that are generally eight or more years. As noted previously, only two years of post-dredging data (2016 and 2017) are available at this time. The importance of the longer perspective is further illustrated in Figures B-2 through B-4. Figures B-2 and B-3 show the observed rates of decline in lipid-normalized PCB concentrations in fish when calculated over successive 5-year windows (*e.g.,* 1998-2002, 1999-2003), as opposed to a longer 11-year integration of the data (*i.e.,* 1998-2008). As shown in these figures, the rates of decline based on the five-year windows vary substantially, often deviating far from the longer-term trend *(i.e.,* up to 3 times faster and as much as 10 times slower, even indicating net rates of increase in some instances). Note that the 11-year long-term rates reasonably agree across species (8 to 15 percent per year), suggesting that fish tissue concentrations decline across all five species at similar rates when viewed over longer periods.

To further support EPA's decision to defer a protectiveness determination for the remedy, EPA conducted two separate analyses. First, the 1998 to 2008 lipid-normalized concentrations of PCBs in five fish species from RS 1 were used to develop rates of decline over progressive time windows, specifically 3, 5, 8, 9 and 10-year intervals. The results are shown in a series of plots (Figures B-4a through B-4e). In each instance, the apparent rate of decline is calculated for each species for each time window (*e.g.,* 1998 to 2000, 1999 to 2001, etc. for 3-year windows; 1998 to 2002, 1999 to 2003, etc. for 5-year windows; and 1998 to 2005, 1999 to 2006, etc. for 8-year windows). These rates are then plotted against the length of the data window to illustrate the reduction in variability of the rate estimate as the window is extended. The number of calculable windows becomes small as the length of the window approaches the length of the data period (11 years). In each diagram, a set of empirical curves has been added to approximately bound the range of values.

It is evident for each species, that increasing the length of the data window (*i.e.,* the period of available data) greatly reduces the variability of the estimates, converging on the 11-year average. For all but the Pumpkinseed, the variability of the estimates for the 8-year window is within +/- 50 percent of the 11-year rate of decline, indicating that 8 years is likely the minimum period of data needed to assess the fish trends.

In the second analysis, EPA conducted a power analysis for the ability to detect a trend in fish tissue concentrations. The analysis, summarized in Master Comment 49, found that approximately of 8 years of data are needed to detect a declining trend of 8 percent per year with an 80 percent level of confidence. A longer period is needed if the rate is less than 8 percent per year.

The discussion above focuses on lipid-normalized data, since these data generally show less variation from year to year. A similar analysis based on wet weight data would yield similar or greater variation in year-to-year rates of decline, since the rates of decline of wet weight concentrations incorporate variations in lipid content as well as PCB exposure over time.

These results have important implications pertaining to drawing conclusions on the remedy. A determination of the remedy's protectiveness will need to rely heavily on the observed rate of decline of PCB levels in fish; however, this rate can easily be misrepresented or would at least be highly uncertain if a short-term assessment of the data formed its basis. Given the history of year-to-year variation in fish tissue levels during a relatively undisturbed period (1998 to 2008), there is a high likelihood that the

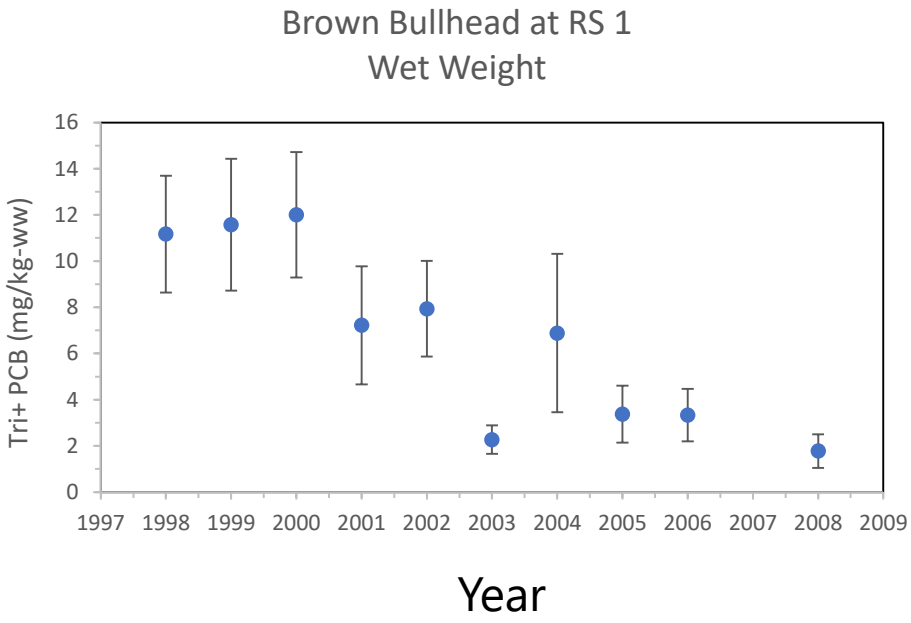
apparent rate of decline, influenced by dredging (and the accompanying disturbance to the system), as measured after only 3 to 5 years of data would not adequately represent the actual rate of decline. As is evident from Figures B-2, B-3 and B-4, the short-term estimates can both underestimate and overestimate the actual rate of decline.

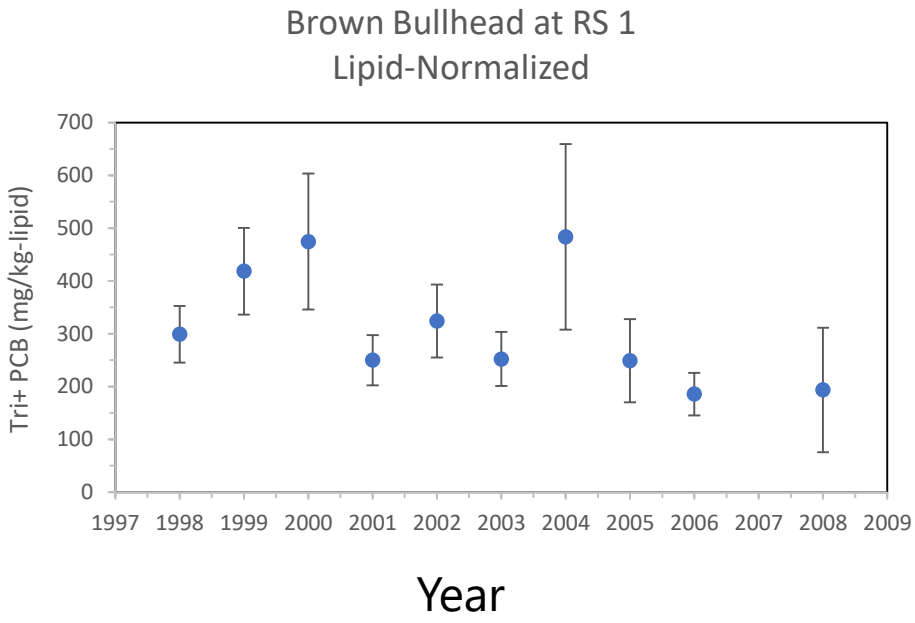
Although EPA does not believe it has sufficient post-dredging fish tissue data to support a protectiveness determination, the information available for sediments and water are not inconsistent with a remedy that will be protective. The dredging portion of the remedial action was implemented successfully and within the expectations described in the ROD, substantially reducing PCB inventory and surface sediment concentrations in the UHR. Source control actions at the former GE plant and the reductions in sediment PCBs from the dredging have also led to declines in surface water concentrations in the Upper Hudson. EPA is anticipating a similar reduction in PCB levels in fish in the early portion of the post-dredging MNA period, followed by continued but more gradual declines in fish tissue concentrations during the later post-dredging MNA period.

EPA carefully considered over 2,000 comments provided by the public on the Proposed Second FYR Report. Many of the comments focused on the rates of recovery in fish, sediment and water. By adjusting to deferring a protectiveness determination, EPA acknowledges that there are limitations and some uncertainty in the existing data. It is also important that EPA have more data before a protectiveness determination is made. Therefore, EPA has decided to defer its decision on the protectiveness of the remedy until the agency is able to obtain sufficiently reliable, longer term estimates of the rates of decline of PCB levels in fish tissue in the UHR.

EPA will not consider the OU2 remedy to be complete until the natural attenuation component also has been completed and the remedial action objectives are met.[2]

[2] Note: There is no inconsistency between this statement and EPA's decision to issue a Certification of Completion of the Remedial Action to GE under the 2006 Consent Decree. The term "Remedial Action" has a specific meaning in the Consent Decree. Importantly, the term does not include Operation, Maintenance and Monitoring (OM&M). While the post-dredging monitored natural attenuation period is a key explicit part of the remedy, it is part of the OM&M rather than the "Remedial Action" activities under the Consent Decree. In the Consent Decree, the term "Remedial Action" refers to the dredging itself and the associated construction work by GE (principally, the capping, backfilling, habitat reconstruction and later decommissioning of the sediment processing facility). GE remains responsible for carrying out all of the OM&M under the Consent Decree.





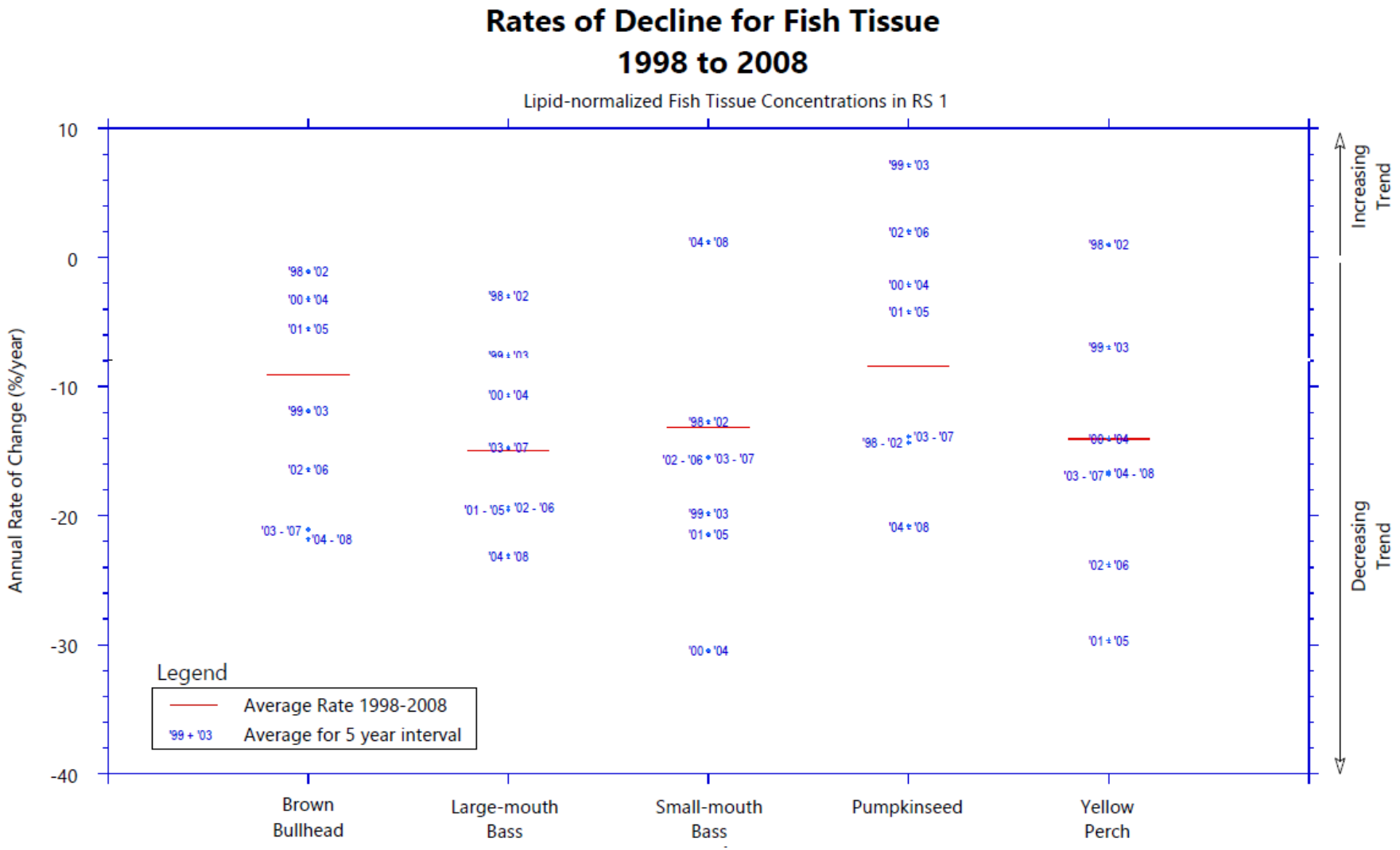
Notes:

- Data shown as annual mean and 95th percentile confidence interval on the mean.

Trend of Tri+ PCB Concentrations for Brown Bullhead in RS 1 wet weight and lipid-normalized basis

Figure B-1

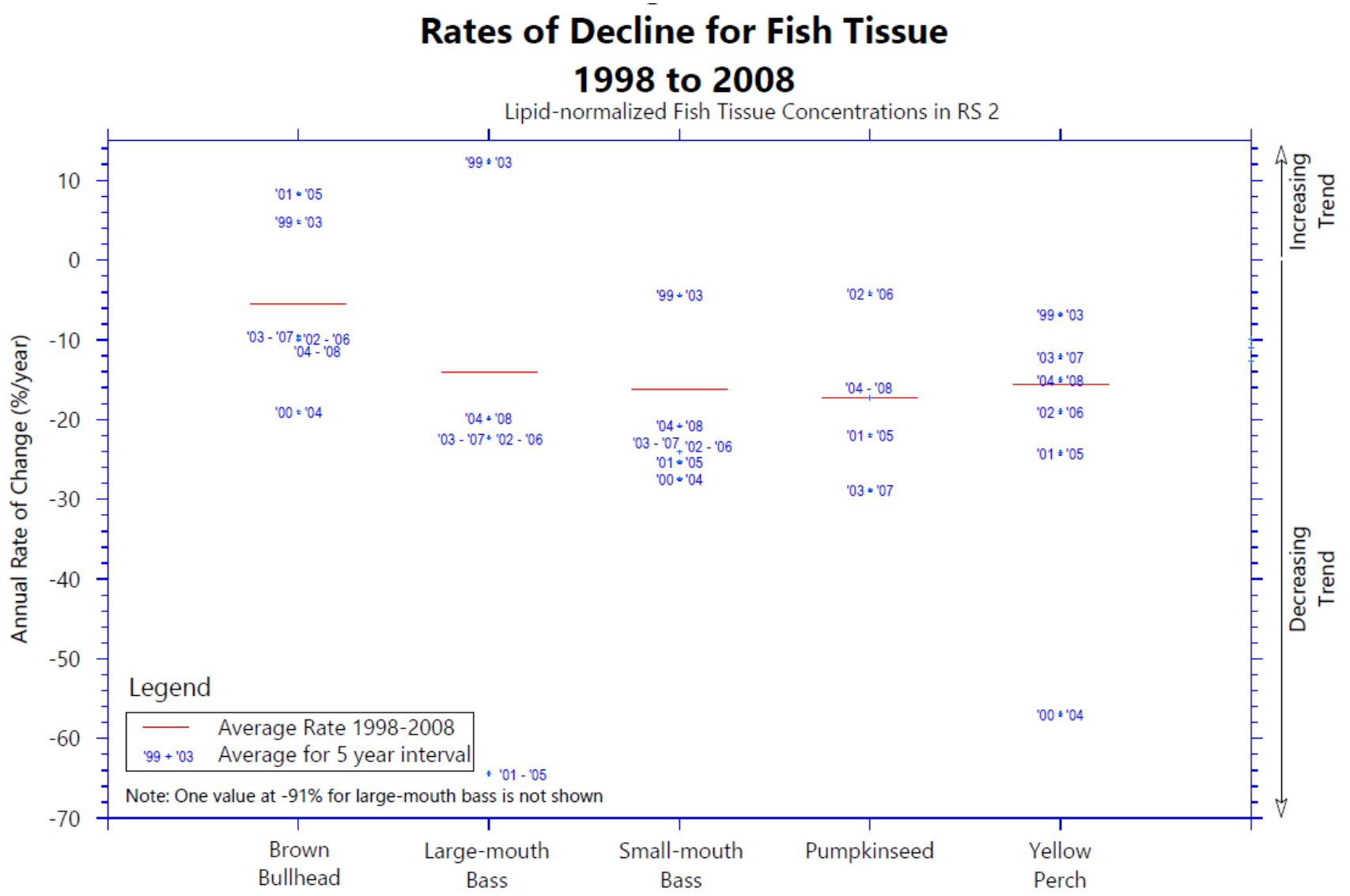
April 2019



Variation in Rate of Decline using 5-year Averaging Interval: Lipid-normalized Concentrations in RS 1

Figure B-2

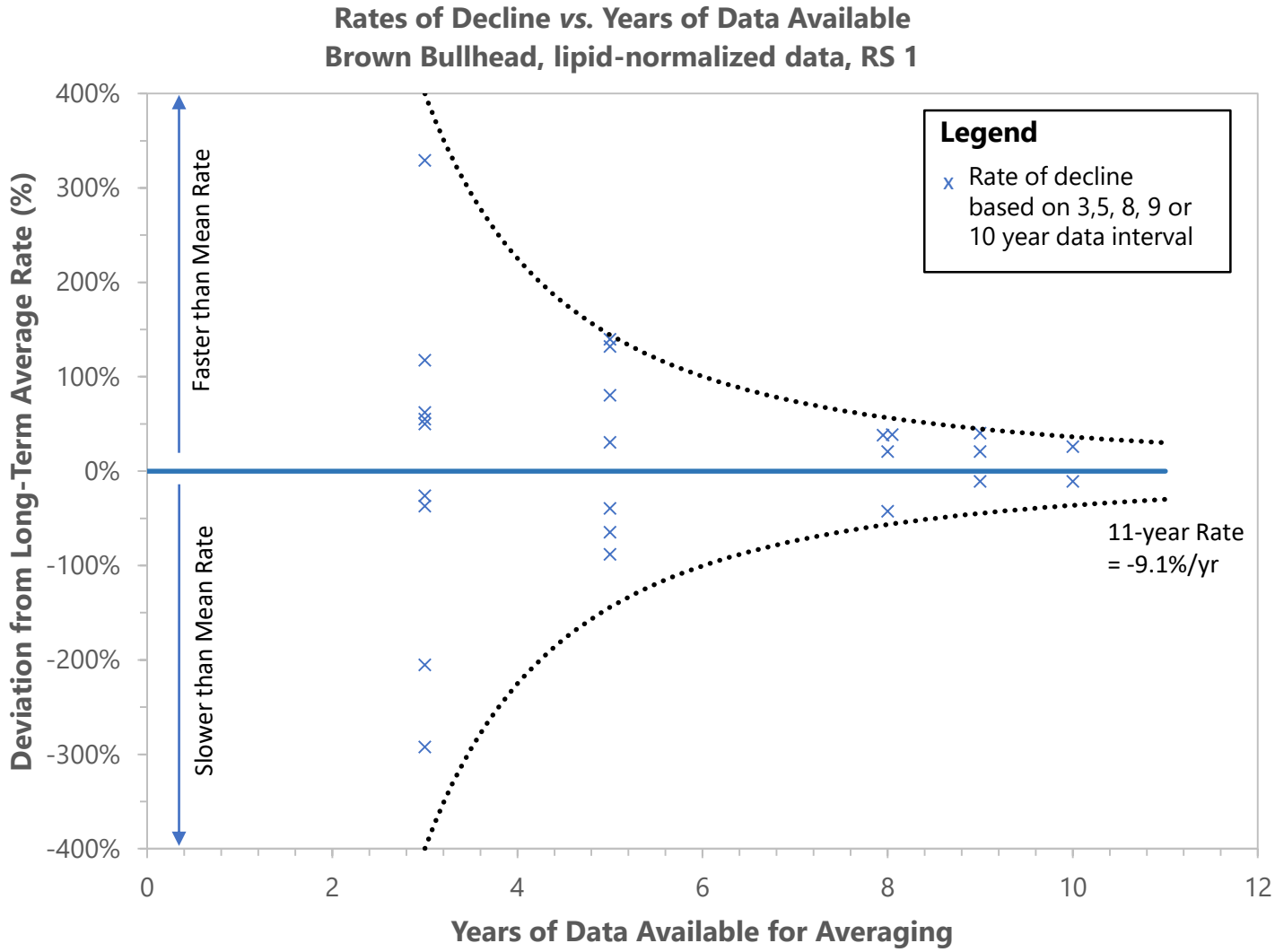
April 2019



Variation in Rate of Decline using 5-year Averaging Interval: Lipid-normalized Concentrations in RS 2

Figure B-3

April 2019



Notes:

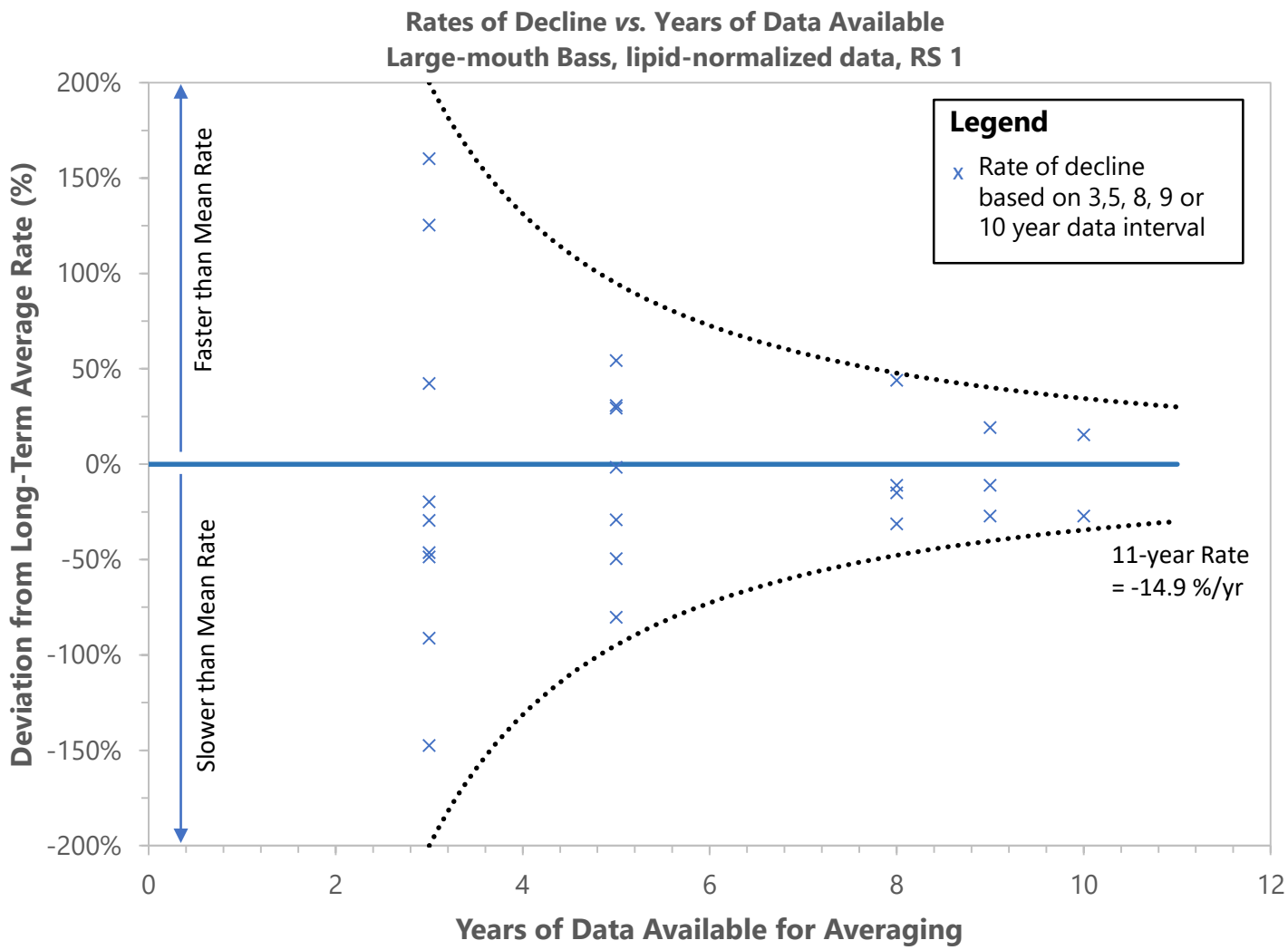
- Deviation from long-term average rate (y) was calculated as the relative change of the short-term average rate to the 11-year average rate.
- As an example, the symbols at the five-year interval on the X- axis represent the rates calculated for the following intervals: 1998 to 2002, 1999 to 2003, 2000 to 2004, 2001 to 2005, 2002 to 2006, 2003 to 2007 and 2004 to 2008, resulting in seven separate estimates of the decay rate, represented by the seven x's on the graph at 5 years.
- Dotted lines are empirical lines to show the approximate decline in variance with increasing number of years for averaging.
- Note that a positive deviation of 100% is equal to a decay rate that is twice as fast as the 11 year rate, whereas a negative deviation of 100% is equal to a decay rate of 0%/year (a flat line trend).
- The data used in this figure represents the 11-year period, 1998 to 2008.

Hudson River PCBs SUPERFUND SITE

Deviation from Long-Term Average Rate vs. Years of Data Available
Brown Bullhead, lipid-normalized data, RS 1

Figure B-4a

April 2019



Notes:

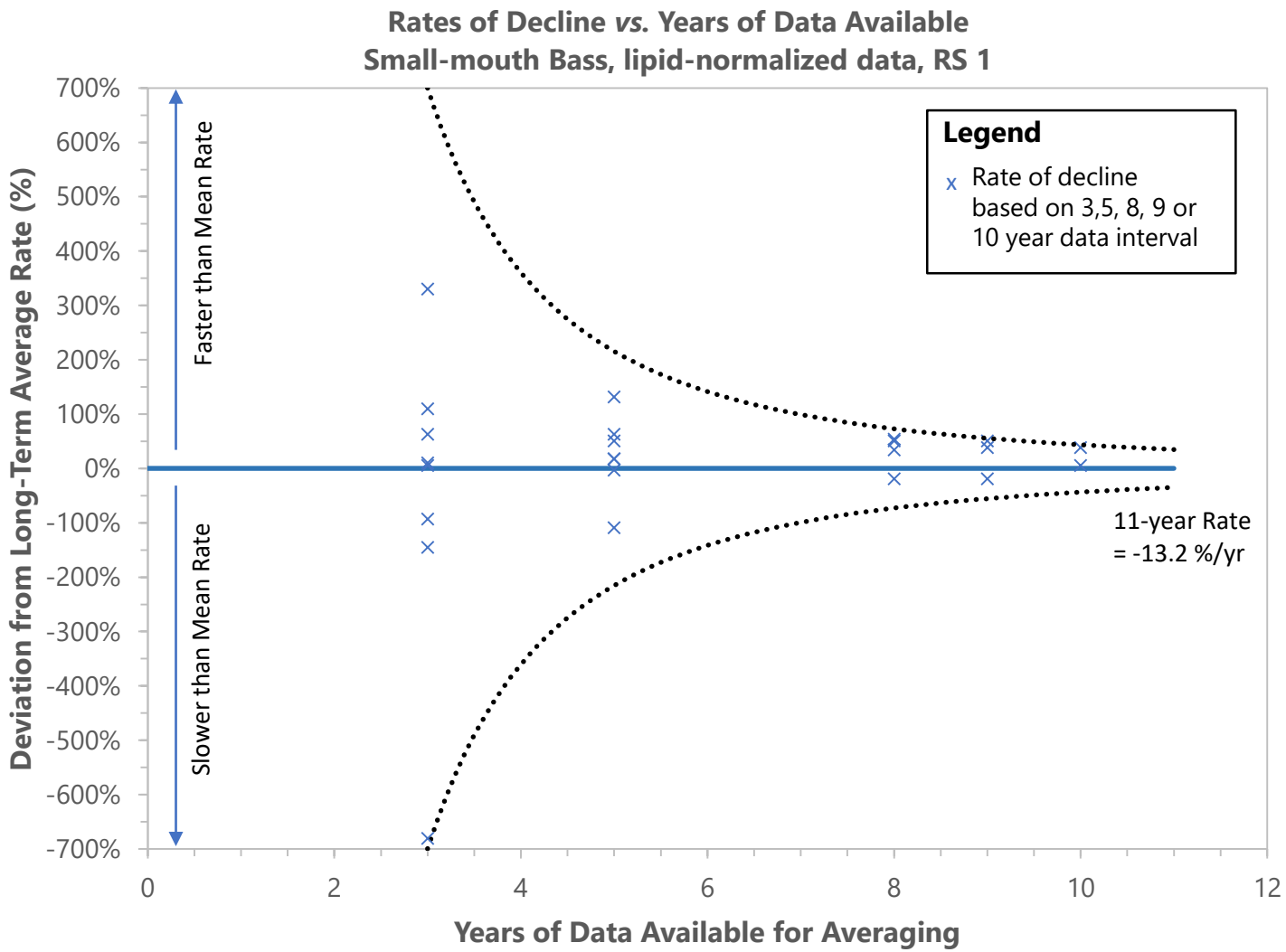
- Deviation from long-term average rate (y) was calculated as the relative change of the short-term average rate to the 11-year average rate.
- As an example, the symbols at the five-year interval on the X- axis represent the rates calculated for the following intervals: 1998 to 2002, 1999 to 2003, 2000 to 2004, 2001 to 2005, 2002 to 2006, 2003 to 2007 and 2004 to 2008, resulting in seven separate estimates of the decay rate, represented by the seven x's on the graph at 5 years.
- Dotted lines are empirical lines to show the approximate decline in variance with increasing number of years for averaging.
- Note that a positive deviation of 100% is equal to a decay rate that is twice as fast as the 11 year rate, whereas a negative deviation of 100% is equal to a decay rate of 0%/year (a flat line trend).
- The data used in this figure represents the 11-year period, 1998 to 2008.

Hudson River PCBs SUPERFUND SITE

Deviation from Long-Term Average Rate vs. Years of Data Available
Large-mouth bass, lipid-normalized data, RS 1

Figure B-4b

April 2019



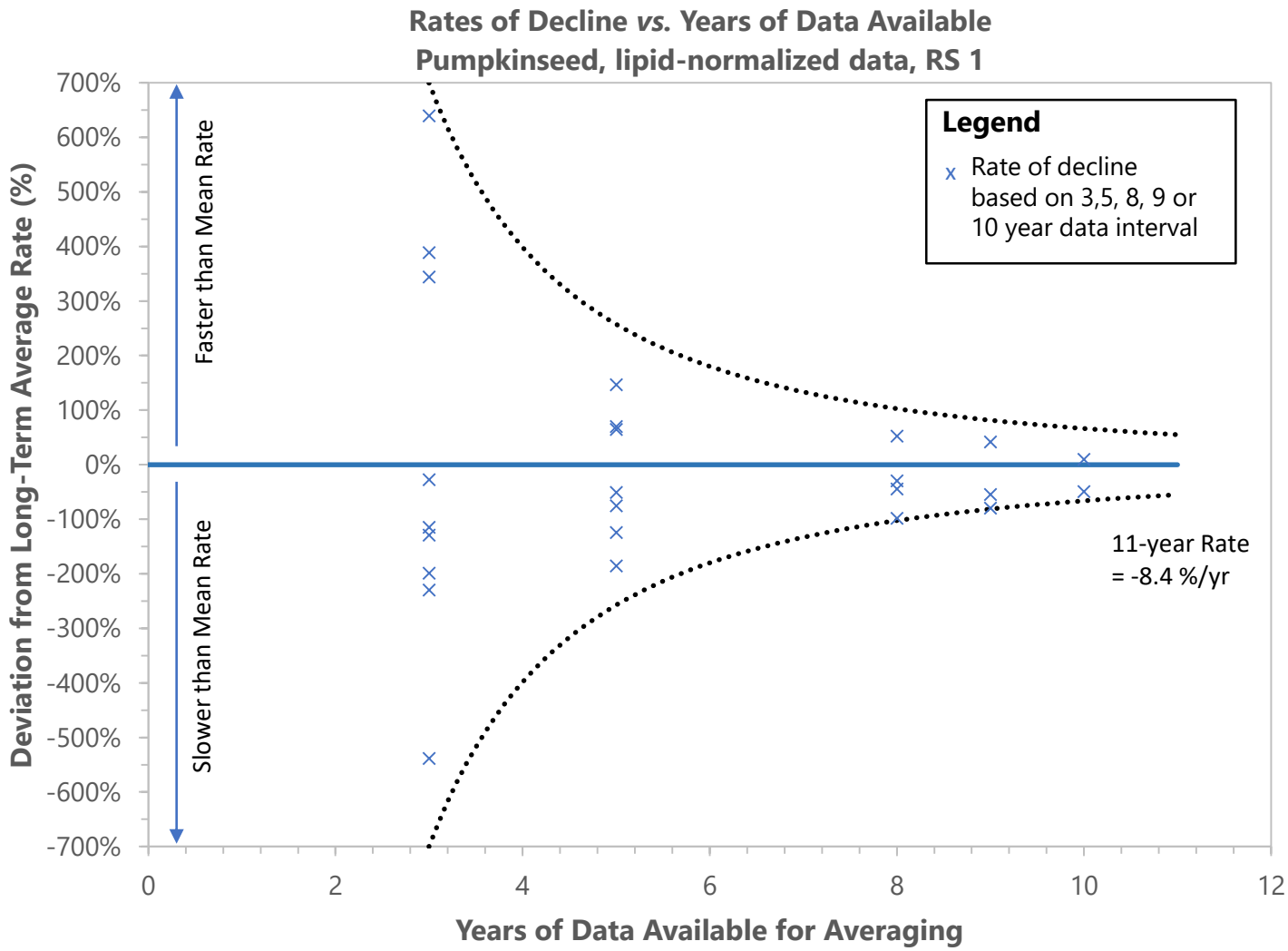
Notes:

- Deviation from long-term average rate (y) was calculated as the relative change of the short-term average rate to the 11-year average rate.
- As an example, the symbols at the five-year interval on the X- axis represent the rates calculated for the following intervals: 1998 to 2002, 1999 to 2003, 2000 to 2004, 2001 to 2005, 2002 to 2006, 2003 to 2007 and 2004 to 2008, resulting in seven separate estimates of the decay rate, represented by the seven x's on the graph at 5 years.
- Dotted lines are empirical lines to show the approximate decline in variance with increasing number of years for averaging.
- Note that a positive deviation of 100% is equal to a decay rate that is twice as fast as the 11 year rate, whereas a negative deviation of 100% is equal to a decay rate of 0%/year (a flat line trend).
- The data used in this figure represents the 11-year period, 1998 to 2008.

Deviation from Long-Term Average Rate vs. Years of Data Available
Small-mouth bass, lipid-normalized data, RS 1

Figure B-4c

April 2019



Notes:

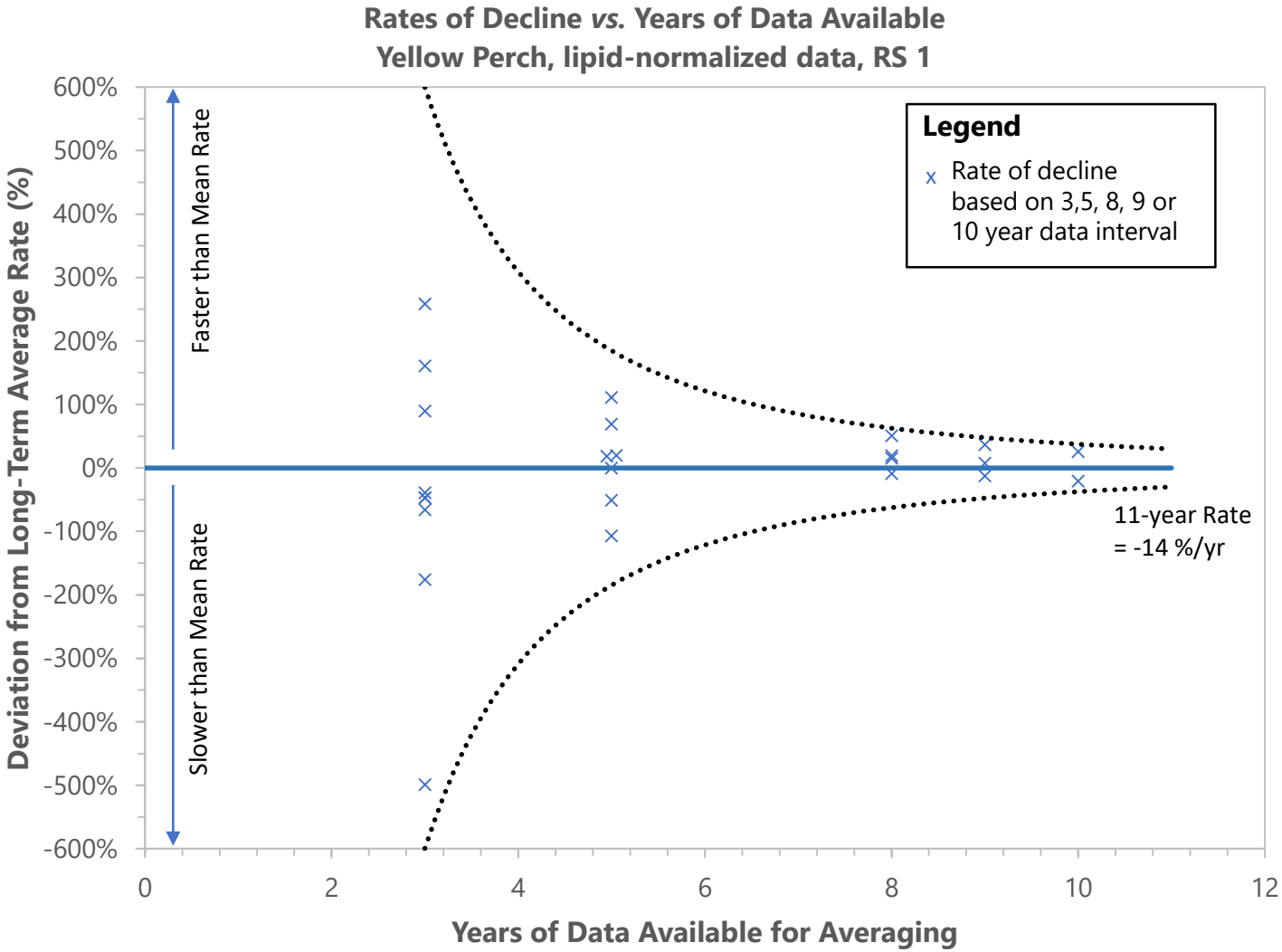
- Deviation from long-term average rate (y) was calculated as the relative change of the short-term average rate to the 11-year average rate.
- As an example, the symbols at the five-year interval on the X- axis represent the rates calculated for the following intervals: 1998 to 2002, 1999 to 2003, 2000 to 2004, 2001 to 2005, 2002 to 2006, 2003 to 2007 and 2004 to 2008, resulting in seven separate estimates of the decay rate, represented by the seven x's on the graph at 5 years.
- Dotted lines are empirical lines to show the approximate decline in variance with increasing number of years for averaging.
- Note that a positive deviation of 100% is equal to a decay rate that is twice as fast as the 11 year rate, whereas a negative deviation of 100% is equal to a decay rate of 0%/year (a flat line trend).
- The data used in this figure represents the 11-year period, 1998 to 2008.

Hudson River PCBs SUPERFUND SITE

Deviation from Long-Term Average Rate vs. Years of Data Available
Pumpkinseed, lipid-normalized data, RS 1

Figure B-4d

April 2019



Notes:

- Deviation from long-term average rate (y) was calculated as the relative change of the short-term average rate to the 11-year average rate.
- As an example, the symbols at the five-year interval on the X- axis represent the rates calculated for the following intervals: 1998 to 2002, 1999 to 2003, 2000 to 2004, 2001 to 2005, 2002 to 2006, 2003 to 2007 and 2004 to 2008, resulting in seven separate estimates of the decay rate, represented by the seven x's on the graph at 5 years.
- Dotted lines are empirical lines to show the approximate decline in variance with increasing number of years for averaging.
- Note that a positive deviation of 100% is equal to a decay rate that is twice as fast as the 11 year rate, whereas a negative deviation of 100% is equal to a decay rate of 0%/year (a flat line trend).
- The data used in this figure represents the 11-year period, 1998 to 2008.

Hudson River PCBs SUPERFUND SITE

Deviation from Long-Term Average Rate vs. Years of Data Available
Yellow Perch, lipid-normalized data, RS 1

Figure B-4e

April 2019

Final Second Five-Year Review Comment Response for the Hudson River PCBs Superfund Site

APPENDIX C

TECHNICAL MEMORANDUM

EVALUATION OF FIELD, KERN AND ROSMAN (2016)

Prepared by:

Louis Berger US, Inc.

&

LimnoTech

April 2019

Some comments on the draft Five-Year Review (FYR) report asserted that EPA's models of the Hudson River are no longer considered to be scientifically valid, citing as evidence a paper (Field, Kern, and Rosman 2016) senior authored by L. Jay Field, NOAA Office of Response and Restoration. In this paper, the authors developed a regression-based replica of EPA's models (an "emulation"), updated levels and trends in surface sediment concentrations (an "updated emulation scenario"), and predicted lengthy delays in Lower Hudson River (LHR) fish recovery times relative to forecasts made with EPA's models. EPA disagrees with the assertion that its models are not scientifically valid, and with the commenters' citation of the NOAA paper as the basis for the comments. Specifically, EPA has reviewed NOAA's use of an "updated emulation scenario" to estimate recovery times of LHR fish, as presented in Field et al., and finds it to be unreliable for the following reasons:

- The authors changed the value of a key input to their baseline emulation (surface sediment PCB concentration) without recalibrating its relationship to closely linked model outputs (water column and fish tissue PCB concentrations);
- This resulted in a substantial upward bias in their simulations of water column and fish tissue PCBs, which can be readily seen in comparisons of model to data; and
- That upward bias was the main factor accounting for the lengthy recovery times that they forecasted, as opposed to their additional assumption of a slower sediment recovery trend.

The NOAA baseline emulation is not a new model, but is an approximate replication of results from EPA's models, and consists of a set of simple statistical correlations between EPA's predictions of *Upper* Hudson River (UHR) sediment and water column PCBs and *Lower* Hudson River fish tissue PCBs. The statistical correlations that constitute NOAA's baseline emulation model are closely fit to EPA's Monitored Natural Attenuation (MNA) and Selected Remedy forecasts, as the authors discuss in their Appendix A[1]. In describing their "updated emulation scenario," however, they stated in their Abstract that their study "applied model emulation to evaluate the impact of updated sediment concentrations in the original mechanistic model projections of time to reach risk-based thresholds in fish in the LHR." This statement implies that the authors show the output that one would obtain by updating sediment concentrations in EPA's models, but that is not true: substituting updated sediment concentrations for baseline sediment inputs in NOAA's statistical emulation produces a shift in the outputs of the statistical equations away from the water and fish data to which the underlying models were calibrated, but without recalibrating. Without recalibration, the NOAA "updated emulation scenario" cannot be accepted as reliable and, in fact, its results are inconsistent with observed data. This failure to recalibrate should have been pointed out during the peer review process, and remedied before the paper was accepted for publication.

These points are briefly summarized below and demonstrated in more detail in the body of this Technical Memorandum.

[1] The outputs taken from the Selected Remedy simulation to fit the emulation equations were limited to the post-dredging period.

The EPA models (HUDTOX and FISHRAND) were calibrated to all of the historical datasets for water column, sediment and fish tissue PCB concentrations for 1977-1998, and then used to conduct 70-year forecast simulations for MNA for 1998-2067. Field et al. (2016) developed a baseline emulation of EPA's models using regression equations and "updated" the inputs to those regressions by modifying the inputs to their set of regressions. The particular "updated emulation scenario" that they say provides the best estimates of long-term recovery times for *Lower* Hudson River fish assumes a one-time increase in *Upper* Hudson River surface sediment concentration in 2003, based on the 2002 to 2005 Sediment Sampling and Analysis Program (SSAP) dataset (averaged to 2003), and also assumes a decrease (to 3 percent) in the assumed rate of recovery of sediment. The discussion of NOAA results that follows focuses on this "updated emulation scenario," but the overriding conceptual criticism of updating inputs to their baseline emulation without recalibration applies to each updated scenario presented in the paper.

With regard to surface sediment PCB concentrations, temporal trends are complicated by the fact that none of the past sediment sampling programs were designed and implemented in a manner which allows for a consistent analysis of temporal trends. Appendix 4 of the Second FYR addresses the complications and limitations in the long-term sediment data as part of the analysis of temporal trends in sediment PCB concentrations in the UHR.

NOAA's "updated emulation scenario" errs conceptually by re-assigning the values of a key model state variable (surface sediment PCB concentration) in 2003, after five years of the 70-year MNA forecast simulation, and re-starting the simulation at 2003 without re-calibrating the original underlying EPA models. This re-assignment interjects an artificial discontinuity in 2003 that fractures the connection between the original EPA model calibrations and the results of NOAA's "updated" projections from 2003 onward. Because the re-assignment of surface sediment PCB concentrations in 2003 represents substantial up-scaling (by factors of 2 to 6, depending on location), NOAA's "updated" projections for water column and fish tissue PCBs are biased substantially high relative to the observed fish tissue PCB data in 2003, when this upscaling factor is applied. This substantial upward bias in predicted wet weight fish tissue PCB concentration is the main reason that Field et al. (2016) predicted longer times to reach specific risk thresholds (such as 0.2 mg/kg wet weight) than the EPA models.

In contrast, the EPA models that supported the Record of Decision (ROD) for the Upper Hudson River Superfund Site successfully reproduced observed data for UHR water and fish PCB concentrations from 1977 to 1998, were successfully peer-reviewed as part of the Superfund process, and those models continued to closely match observed trends in UHR water and fish PCB concentration data through the extended 1998 to 2008 period of MNA, as shown in in Appendices 1 and 3 of the FYR. Field et al. (2016) did not present an "updated" emulation of UHR fish tissue PCB concentrations, so their paper does not offer an alternative to EPA's projections of UHR fish tissue recoveries; the paper is focused exclusively on *Lower* Hudson River fish recovery times.

EPA shares the concern about slower-than-expected fish tissue recoveries in the LHR that was expressed by some commenters. The decline in recovery rates with distance from the UHR was shown in Figure A-16B of Appendix 3 and discussed there. For the LHR, EPA employed HUDTOX to project PCB loadings from the UHR to the LHR. Those loadings were input to the

Farley Model, which projected LHR water and sediment PCB concentrations, and FISHRAND was then used to project LHR fish tissue concentrations. As shown in Appendix 3, EPA's models tended to under-predict fish tissue PCB concentrations at River Mile (RM) 90 (Kingston) and RM 50 (West Point) for the period 2004 to 2008, whether model and data are compared in wet weights or after lipid normalization, and also showed a faster rate of decline for this period than indicated by data. Note, however, that FISHRAND was not explicitly calibrated to LHR fish data; instead, the model as calibrated for the UHR was directly applied to the LHR.

Specification of inputs for sediment and water exposure concentrations is central to the application of the FISHRAND model. Insufficient historical LHR water column PCB data existed at the time of the ROD to support a calibration of Farley Model water column PCB predictions, and Appendix 1 shows that the Farley model under-predicted water column PCBs at Poughkeepsie (RM 75) for the period 2004-2008. Consequently, water column PCBs may have been under-predicted for earlier time periods as well, contributing to potential mismatches between predicted and observed fish tissue concentrations in the FISHRAND model. In addition, while PCB loadings from the UHR to the LHR are well characterized, their contribution to sediment and water exposure concentrations experienced by LHR fish are less well understood. EPA is committed to additional studies of fish tissue recovery trends in the LHR and the factors that affect those trends.

Notwithstanding EPA's concern about LHR fish tissue recovery rates, EPA does not accept NOAA's "updated emulation scenario" as a reliable predictive tool for the LHR because, and as shown below, the PCB exposure concentrations in this model are substantially biased and inconsistent with observed data.

The Updated Emulation Scenario is Not Calibrated and Does Not Match Observed Data

Field et al. (2016) relied on an "updated emulation scenario," which included up-scaled sediment concentrations in the UHR, to reach conclusions about time to meet fish tissue recovery targets in the LHR. Their baseline emulation model has a simplified structure that links key HUDTOX and FISHRAND outputs using regressions, without explicitly representing the complex interactions between sediment, water, and the food chain. They developed their baseline emulation model as follows:

- They first fitted an exponentially declining time trend to the simulated surface sediment PCB concentrations in EPA's ROD MNA forecast. The time series that they developed had a recovery rate (i.e. annual rate of decline) of about 8 percent per year;
- They then used that emulation of EPA's surface sediment forecast series as an independent variable, in regressions, to predict EPA's ROD MNA forecast values of water column PCBs.
- Finally, they used those emulated water column concentration forecasts for one *Upper* Hudson River location (Waterford) as an independent variable, in regressions, to predict EPA's ROD MNA forecasts of wet weight fish tissue PCBs at four *Lower* Hudson River locations.

This completed their baseline emulation model, a linearization which closely tracked the HUDTOX and FISHRAND MNA forecasts and, indeed, could not exist without these underlying mechanistic forecasts. The baseline emulation model links EPA's key outputs to each other using a statistical correlation, as opposed to a representation of the underlying physical, chemical, and biological processes. FISHRAND predicts median wet-weight concentrations in each year for each species and location, based on assumed *a priori* population distributions of percent lipid, and the NOAA emulation also predicts median wet weight concentrations for each species and location for each year, for the same assumed percent lipid distribution.

NOAA then developed their "updated emulation scenario" as follows:

- They altered the sediment forecast time series in 2003 by up-scaling sediment PCB concentrations by factors of 2 to 6 (depending on location) to match their own estimates, which were based on the 2002 to 2005 SSAP sediment data;
- They then projected their re-assigned sediment PCB concentrations forward from 2003 at a declining 3 percent per year rate of recovery, based on their fit to a trend relating their interpretation of 1991 and 2002 to 2005 data for sediment PCB concentrations;
- Finally, they plugged the "updated" sediment values into the regressions described above to produce "updated" predictions of water column and wet weight fish tissue PCB concentrations, thus completing their "updated emulation scenario." Their Table A.2 provides coefficients for the regressions relating sediment to water column PCB and their Table S-1 provides the coefficients for their equations that predict wet weight fish tissue concentrations.

The NOAA "updated emulation scenario" differs from their baseline emulation scenario in two important ways. First, sediment PCB concentrations in 2003 were up-scaled by factors of 2 to 6; and second, assumed recovery rates from 2003 forward were down-scaled from 8 percent to 3 percent per year. This "updated scenario" results in new predicted water column and fish tissue PCB concentration predictions throughout the entire system from 2003 onward, and shifting away from contemporaneous water and fish data that without a mechanistic basis or understanding.

Extensive water column and fish PCB data are available for multiple UHR and LHR monitoring stations for 2003 to 2008 to evaluate and test the accuracy of the NOAA "updated emulation scenario" and assess the effect of these assumptions on previously calibrated relationships. The NOAA authors presented no such tests for water column concentrations, or for the wet weight fish tissue concentrations predicted by their "updated scenario." These tests are presented in the next section of this Technical Memo in the form of comprehensive model-data comparisons for the outputs of the NOAA "updated emulation scenario," including four *Upper* Hudson River water column sampling locations and for the four fish species that NOAA simulated at three *Lower* Hudson River locations.

The schematics below illustrate the difference between EPA's mechanistic models and the NOAA emulation of those models, before and after "updating" inputs. Figure C-1 represents EPA's models. Multiple complex physical, chemical and biological processes that affect

sediment, water, and fish tissue PCBs in the Hudson River are represented and linked. PCBs in sediment and water, and their interactions, are represented in HUDTOX, and processes affecting fish tissue PCBs are represented in FISHRAND, which relies on predicted sediment and water column exposures at appropriate spatial and temporal scales. In the development of EPA's models, all simulations were constrained by the available sediment, water column, and fish tissue data for 1977 to 1998. Parameters governing the processes represented in HUDTOX and FISHRAND were calibrated to achieve consistency of historical simulations with data.

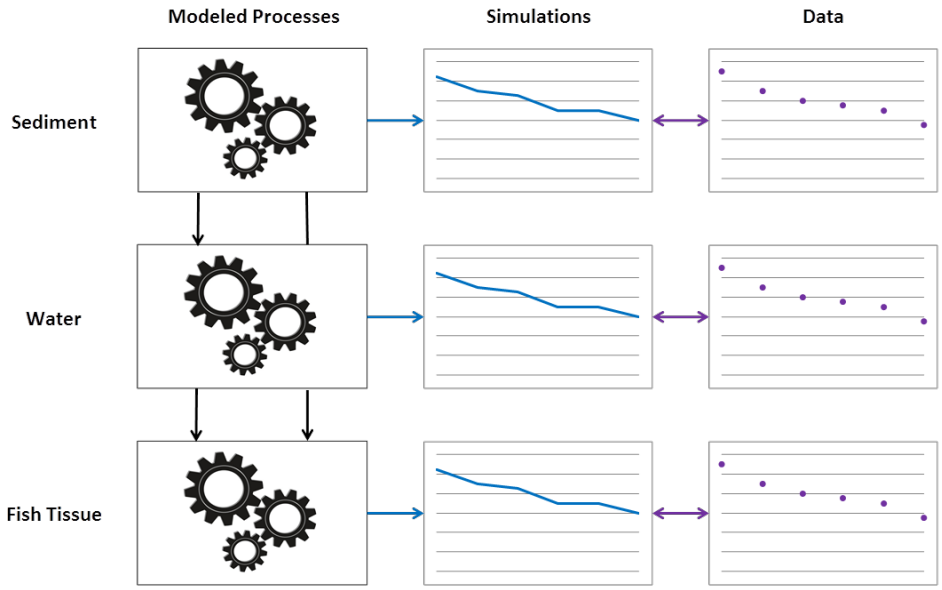


Figure C-1: Schematic of Linkages between EPA Model Representations of Sediment, Water, and Fish, and Sediment, Water, and Fish Data

Figure C-2 illustrates the structure of the baseline emulation model implemented by Field et al. They predicted HUDTOX UHR water column PCB forecast outputs using HUDTOX surface sediment PCB forecast outputs. Similarly, they predicted FISHRAND fish tissue PCB forecast outputs in the LHR using only HUDTOX water column predictions of PCB concentrations at Waterford. These predictions for water column and fish tissue PCBs were based on regression equations that do not attempt to represent important elements of the UHR conceptual site model. Unlike EPA's models, the NOAA model does not relate fish tissue concentration to sediment exposure, but uses only *Upper* Hudson River water column PCB concentration as a simplified predictor of *Lower* Hudson River fish PCB concentration. Further, the NOAA model does not represent home ranges or include seasonal fluctuations in predicting fish PCB exposure, as does EPA's FISHRAND model. The NOAA model only predicts fish tissue PCB levels for LHR stations beginning at RM 152 (Albany/Troy). It uses annual average water column PCB concentrations at Waterford as the driving exposure concentrations to predict fish tissue concentrations as far south as RM 50 (West Point). Thus, a water column station in the *Upper* Hudson River was used to represent *Lower* Hudson River fish exposures over a range of more than 100 miles.

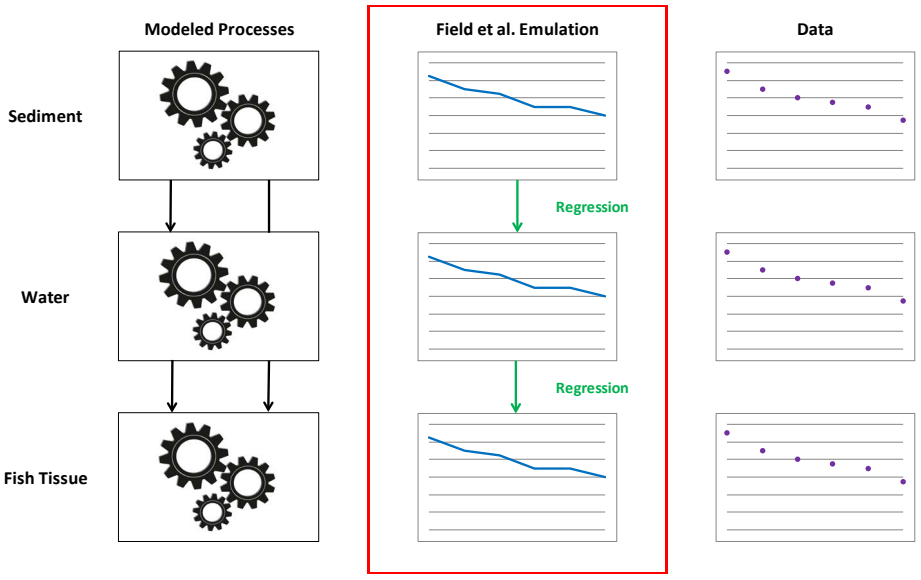


Figure C-2: Schematic of NOAA Baseline Emulation of EPA's MNA Model (MNA1)

The "update" that Field et al. (2016) introduced to their emulation model involved up-scaling UHR sediment PCB concentrations in 2003 by factors of 2 to 6 and down-scaling assumed UHR sediment recovery rates from 2003 onward. This is illustrated conceptually in Figure 3 which depicts an altered surface sediment PCB concentration time series in response to the insertion of a new surface sediment data point that was not part of the original HUDTOX calibration dataset.

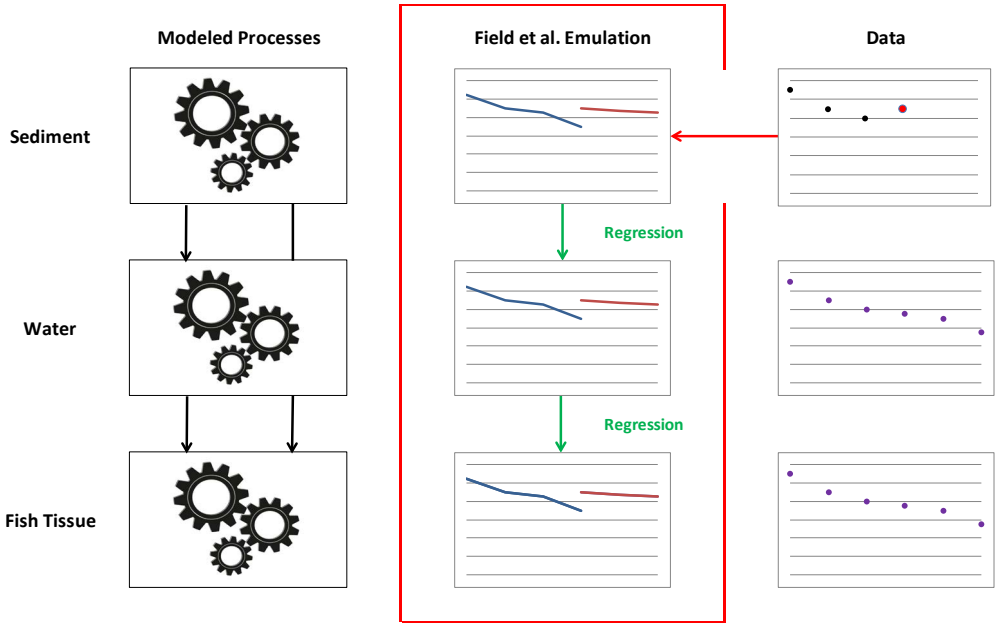


Figure C-3: Schematic of NOAA "Updated Emulation Scenario" of EPA's MNA Model (MNA2)

By "updating" their emulation model to scale all their predictions relative to the 2002 to 2005 SSAP dataset, Field et al. (2016) severed the connection that existed between their baseline emulation and the temporal trends in the calibration datasets for the original EPA models. The same would be true if the HUDTOX MNA forecast were interrupted in 2003 and its predicted sediment concentrations replaced by 2002 to 2005 averages. If this were done, HUDTOX would no longer be consistent with the prior sediment and water column data to which it was calibrated. As discussed below, not only does the NOAA "update" sever the connection with the calibration datasets for the original EPA models, it results in forecasts for water column and fish tissue PCBs that are biased substantially higher than the observed data.

The NOAA updated emulation scenario computes water column PCB concentrations that are biased substantially high, relative to observed data.

Field et al. (2016) used their regression equations to predict average annual values of the following:

- Water column PCB concentration in four HUDTOX model subsections in the UHR
  - Their equations predicted annual PCB loadings from sediment to the water column, assuming an "updated" sediment trend for each UHR subsection and fitting their equations to the HUDTOX water column forecast; and
- Wet weight fish tissue PCB concentrations for four fish species at four stations in the LHR below Federal Dam
  - Their equations predicted annual average LHR wet weight fish tissue PCB concentrations using emulated water column PCB concentrations at Waterford as their sole independent variable for each combination of species and LHR location. Thus, the NOAA emulation assumes that fish tissue concentrations in *Lower* Hudson River fish can be adequately predicted based on an *Upper* Hudson River water concentration.

EPA replicated the NOAA emulation model, using the documentation of regression equations and coefficients provided in Field et al. (2016). Initial 2003 sediment PCB conditions for the emulation were obtained from their Table 2, for both the baseline and "updated" MNA scenarios, which they denoted as MNA1 and MNA2. Model equations were obtained from their Appendix A, and inputs and coefficients from their Tables A.1 and A.2. EPA's replication of the NOAA procedures assumed an upstream source concentration for Tri+ PCB of 2 ng/L for every year.[2]

Comparisons between EPA's reconstruction of the NOAA "updated" MNA scenario (MNA2) with observed data show systematic upward bias for UHR water column Tri+ PCB concentrations. This is shown in Figure C-4 for the period 2003 to 2008. This interval begins with the first year of the MNA2 simulation and ends with 2008, the last year of MNA before dredging. Figure C-4 shows model-data comparisons for the four water column sampling

[2] This value was assumed because Field et al. (2016) wrote that their paper focuses on scenarios with upstream concentrations decaying to 2 ng/L by 2005, for consistency with recent monitoring data, and held constant at this value for the remainder of their long-term simulations. A sediment decay rate of 3 percent per year was also assumed in EPA's replication of MNA2.

locations in the MNA2 scenario from upstream to downstream: Thompson Island Dam (TID), Schuylerville, Stillwater, and Waterford.

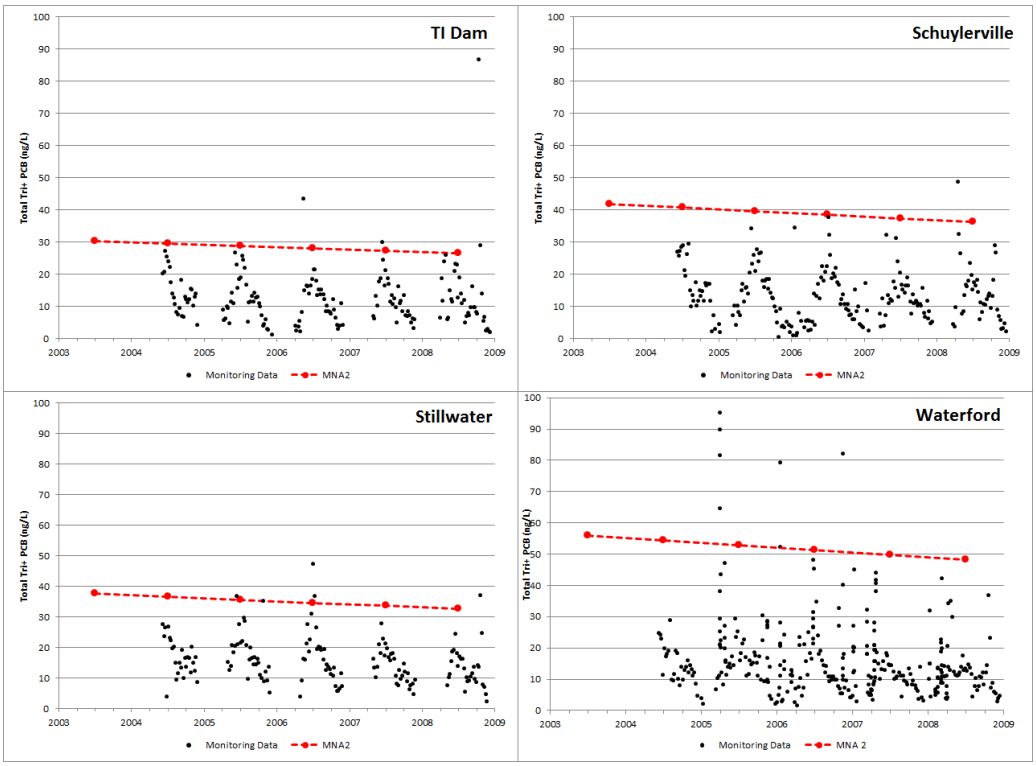


Figure C-4: Comparisons between NOAA "Updated Emulation Scenario" (MNA2) and 2004-2008 GE Data for Water Column PCBs at Four UHR Sampling Stations.

At TID, predicted Tri+ PCB concentrations in the MNA2 scenario exceed all but the most extreme values of 2004 to 2008 water column data, and the same is true for the Schuylerville and Waterford locations.[3] As is clear from Figure C-4, MNA2 scenario concentrations at Waterford are higher than at the other locations throughout the 2003-2008 period, and the simulated increase in water column concentration between Stillwater and Waterford is wholly inconsistent with site-specific data for these locations. MNA2 scenario concentrations at Waterford exceed those at Schuylerville by more than 15 ng/L in every year, and exceed observations in the other two reaches by even more. Accuracy of prediction at Waterford is critical to the NOAA "updated emulation scenario," because the computed MNA2 water column concentration at Waterford is the single independent variable that represents exposures for fish tissue PCB concentrations at all of the LHR locations in their model.

Predicted water column Tri+ PCB concentrations at Waterford in the MNA2 scenario are biased especially high, relative to the other three stations, for three reasons:

- NOAA "updated" 2003 surface sediment concentrations in each reach, and this inflated the water-column load gain (i.e., the upstream-to-downstream increase in water column

[3] Note that there are no water column data at these stations for 2003 to compare to the emulation predictions.

concentration) within each reach. These successive load gains are additive from TID to Schuylerville, to Stillwater, and to Waterford in their "updated emulation model;"

- The NOAA sediment update for the Waterford reach is also proportionally much greater (increasing by a factor of 6) than the adjustments that were applied for the other reaches (factors of 2 to 3); and
- The NOAA regression coefficient that they used to compute water column PCB load gain from their assumed surface sediment concentrations (reported as "Sed to water" in their Table A.2) is much greater for the Waterford reach than for the other three reaches.

The substantial bias of the MNA2 scenario for water column Tri+ PCB concentrations, in general and on a reach-by-reach basis, demonstrates the pitfalls of re-assigning surface sediment concentrations in a baseline emulation model and then re-starting the "updated" model without testing the results against observed data.

The NOAA updated emulation scenario also computes wet weight fish tissue PCB concentrations that are biased substantially higher than observed data.

The NOAA "updated emulation scenario" predicts wet weight fish tissue PCB concentrations, as does EPA's FISHRAND model, but while FISHRAND relies on sediment and water exposure concentrations at appropriate spatial and temporal scales, the NOAA "updated scenario" characterizes exposure to *Lower* Hudson River fish using only *Upper* Hudson River water column concentrations. Because water column Tri+ PCB concentrations in the "updated" MNA2 scenario show substantial upward bias, this same bias is propagated to the fish tissue concentrations in this scenario. All of the predicted fish tissue concentrations in MNA2, from Albany to West Point, are functions of the MNA2 scenario water column concentrations at Waterford, and all of the bias in the Waterford water column concentrations is transferred to fish tissue concentrations in the "updated emulation scenario" via its regression equations.

This bias is demonstrated below with time series plots that show comparisons between the NOAA "updated emulation scenario" and observed data for LHR fish tissue wet weight PCB concentrations for 2003 to 2008[4], for the species and locations in the MNA2 scenario, at RM 152 (Albany/Troy), RM 113 (Catskill), and RM 90 (Kingston). EPA has not constructed comparable model-data comparisons for RM 50 (West Point), because there were insufficient data for 2003 to 2008 at this location for an informative comparison.

Figure C-5 shows wet weight PCB concentration data for white perch, brown bullhead, largemouth bass, and yellow perch at RM 152 versus results from the MNA2 scenario. Each fish sample is shown as an individual data point. Although data for brown bullhead and largemouth

[4] Model data comparisons are provided for 2003 to 2008 because NOAA provided sediment updates for 2003 in its Table 1 to initialize a scenario, and did not provide a time series of upstream boundary conditions sufficient to produce a spreadsheet replication for the full historical period. The period 2003 to 2008 provides the best test of the "updated emulation scenario," because this is the period for which NOAA up-scaled sediment concentrations by the greatest amount. NOAA relied on sediment data from one of the calibration datasets (1991) in developing its "updated" sediment trend, so the fit to data of its "updated emulation scenario" should be more and more similar to the fit of the original calibration if extended backward from 2003 toward 1991.

bass are quite sparse for this period, in general the NOAA MNA2 scenario results are substantially higher than the data, with few data points serving as exceptions.

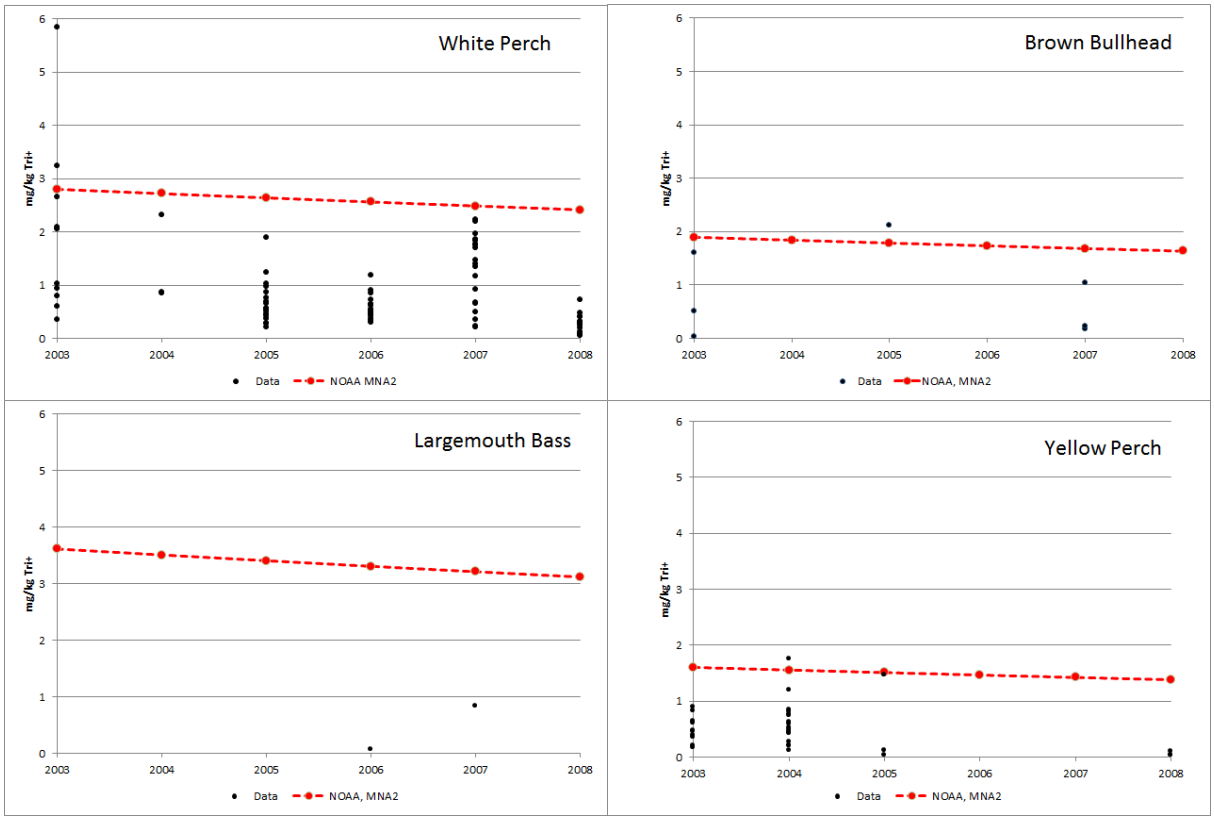


Figure C-5: Comparisons between NOAA "Updated Emulation Scenario" (MNA2) and Observed Wet Weight Fish Tissue PCBs at RM 152.

Figure C-6 shows wet weight PCB concentration data for white perch, brown bullhead, largemouth bass, and yellow perch at RM 113 versus results from the MNA2 scenario. Numerous observations are available for all four species at this location, and again, the NOAA MNA2 scenario results are, in general, substantially higher than the data, with few data points serving as exceptions.

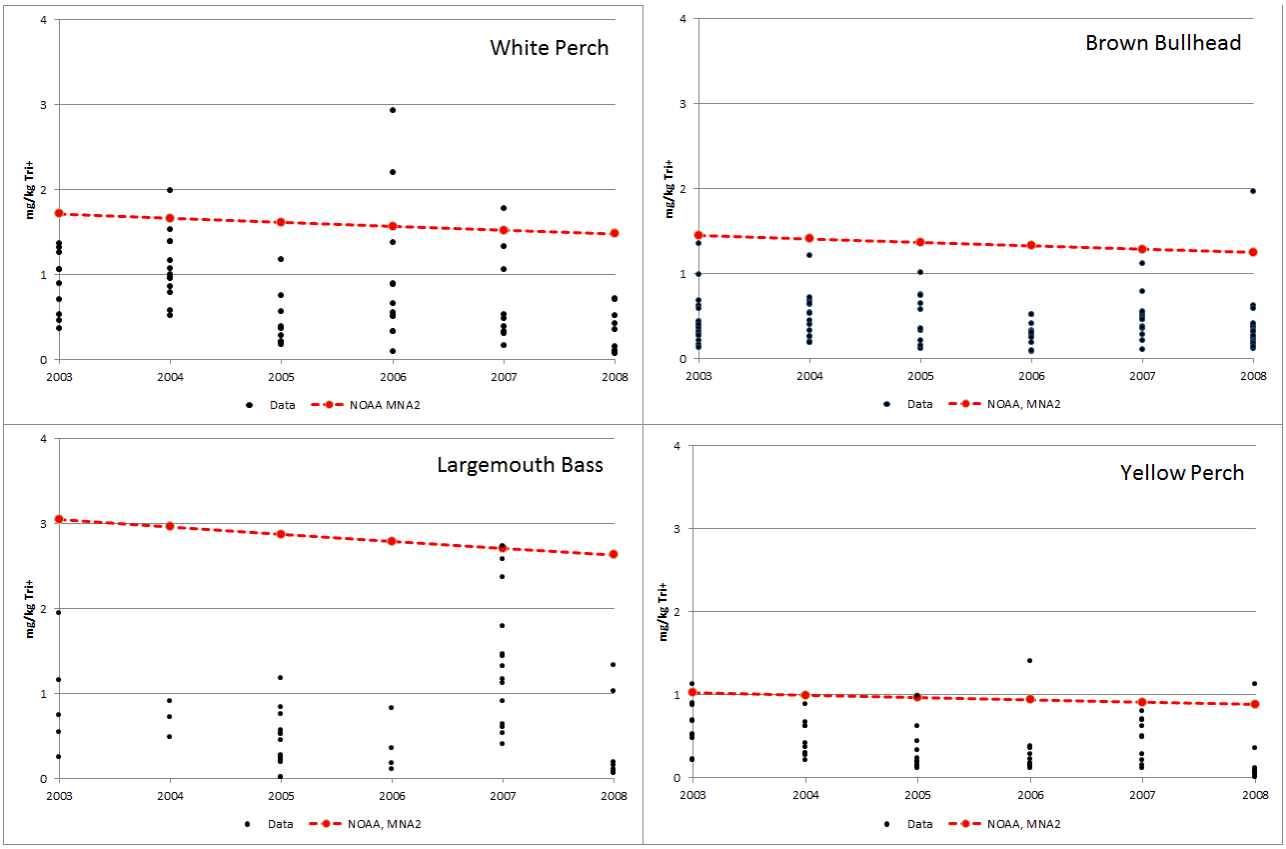


Figure C-6: Comparisons between NOAA "Updated Emulation Scenario" (MNA2) and Observed Wet Weight Fish Tissue PCBs at RM 113.

Figure C-7 shows wet weight PCB concentration data for white perch, brown bullhead, largemouth bass, and yellow perch at RM 90 versus results from the MNA2 scenario. At RM 90, as at RM 152 and RM 113, the NOAA MNA2 scenario results are generally higher than the data, although the deviations from data are smaller.

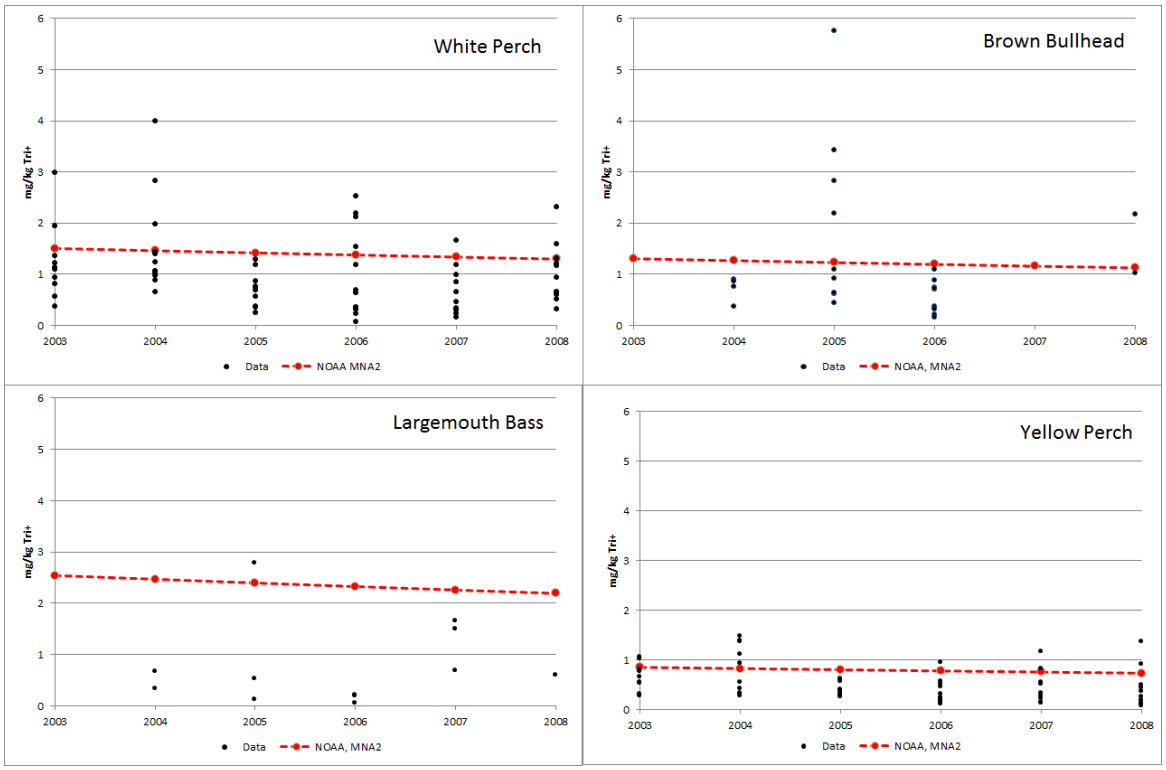


Figure C-7: Comparisons between NOAA "Updated Emulation Scenario" (MNA2) and Observed Wet Weight Fish Tissue PCBs at RM 90.

In their paper, the authors contend that their "updated emulation scenario" provides a better fit than EPA's models to LHR fish tissue PCB data, after those PCB data have been transformed to a common lipid content[5]. For example, while their "updated scenario" performs poorly in matching 2004 to 2008 white perch wet weight data at RM 152 (see Figure C-5), it appears to show a satisfactory fit to lipid-adjusted data (see their Figure 10). It is questionable whether a simple lipid normalization is an appropriate assumption at the very low lipid contents reported for many of these fish, as EPA more fully discusses in Appendix 3 of the FYR. Also using a simple lipid normalization, EPA estimated a 3 percent recovery rate for white perch at RM 152, so it is not surprising that NOAA shows in its Figure 10 a close overlay between their "updated scenario" (assuming 3 percent decay from 1991 sediment concentrations) and lipid-adjusted data for this species and location. In general, EPA agrees that lipid-normalization is a useful tool in estimating data-based rates of recovery, and has shown in Appendix 3 of the FYR that lipid normalization tends to reduce estimates of fish tissue recovery rates in both the UHR and the LHR, based on available historical data.[6] Moreover, lipid adjustment cannot offset the mismatch between predicted wet weight concentrations and data for the other species simulated in NOAA's "updated scenario:" adjusting 2003 to 2008 largemouth bass or yellow perch data to FISHRAND's assumed median lipid would actually shift the data downward, increasing the gap between the "updated scenario" and the data at each station. For brown bullhead, normalization

[5] They transform to the median value in FISHRAND's probabilistic distribution of lipid inputs.

[6] However, lipid normalization for the purpose of evaluating temporal trends is different from lipid adjustment for the purpose of comparing model predictions of wet weight tissue concentrations to observed data, as explained in Appendix 3.

of the 2003 to 2008 data using FISHRAND's median lipid value would cause an upward shift by a factor of about 2, which is not enough to match the NOAA "updated scenario" to data at RM 152 or 113. Thus, the model-data comparison at RM 152 that the authors show in their Figure 10 appears to be a special case, and is not in itself sufficient to confirm the accuracy of their method.

Regardless of the role of lipid adjustment in computing rates of recovery, the authors constructed their specific predictions of LHR wet weight fish tissue PCBs, and thus their predicted times to reach wet weight PCB targets in the LHR, based on their predicted water column exposure concentrations in the UHR at Waterford using their "updated emulation scenario." As shown above, these computed exposure concentrations are biased substantially high and are completely inconsistent with observed data. The authors also assumed that the water concentrations at this single location in the *Upper* Hudson River can be used to reliably predict *Lower* Hudson River fish concentrations over a range of more than 100 miles. Consequently, EPA does not accept the NOAA "updated emulation scenario" as an accurate or reliable tool to replace EPA's models in projecting LHR fish tissue concentrations.

NOAA's up-scaling of 2003 sediment PCB concentrations accounts for most of the difference between their predictions of recovery times and those in EPA's ROD. The down-scaling of their assumed sediment recovery rate has a much smaller effect on their predicted recovery times.

As discussed above, the Field et al. "updated emulation scenario" involved (i) up-scaling sediment PCB concentrations in 2003 by factors of 2 to 6 and (ii) down-scaling assumed sediment recovery rates from 2003 onward from 8 percent to 3 percent per year. As shown above, the "update" to 2003 surface sediment concentrations imparted substantial upward bias to the water column and fish tissue PCB concentrations in the "updated scenario" (MNA2). The additional downscaling of the trend in sediment concentrations also affects the subsequent rate of change in simulated water column and fish tissue concentrations, slowing the recovery rate of each via the emulation model regression equations. Of the two changes in the Field et al. (2016) "update," the up-scaling of sediment PCB concentrations in 2003 has the dominant effect on estimates of time to achieve ROD goals, with the down-scaling in recovery rate playing a more minor role.

This is shown in Figure C-8 below, which plots the Field et al. (2016) estimates of time to reach the 0.2 mg/kg Tri+ PCB (wet weight) human health risk threshold, by species and location, after remediation, from their supplemental Table S-3. They present the following three cases:

- Their baseline case (REM1), using their original emulation of EPA's ROD model and an 8 percent post-dredging sediment recovery rate;
- A variant of REM1 assuming 3 percent post-dredging decline in surface sediment concentrations, and
- The "updated emulation scenario" case (REM2), with up-scaled surface sediment concentrations in 2003, as in their MNA2 simulation, and a 3 percent post-dredging sediment recovery rate.

A comparison of the two variants of REM1 in Figure C-8 shows that the imposition of the 3 percent sediment recovery rate by itself has a relatively minor effect on times to recover. The largest predicted increase is for largemouth bass at RM 152, from two to 16 years. Scenario REM2 retains the 3 percent sediment recovery rate and adds the up-scaling of 2003 sediment concentrations. The results for REM2 in Figure C-8 show that imposition of up-scaled surface sediment concentrations lengthens the predicted time to recover by many decades for most species and locations. Thus, the long times to recover shown by Field et al. (2016) are due primarily to the up-scaling of sediment concentrations, which imparted an upward bias in predicted water column and wet weight fish tissue PCB concentrations, an issue that should have been addressed through recalibration.

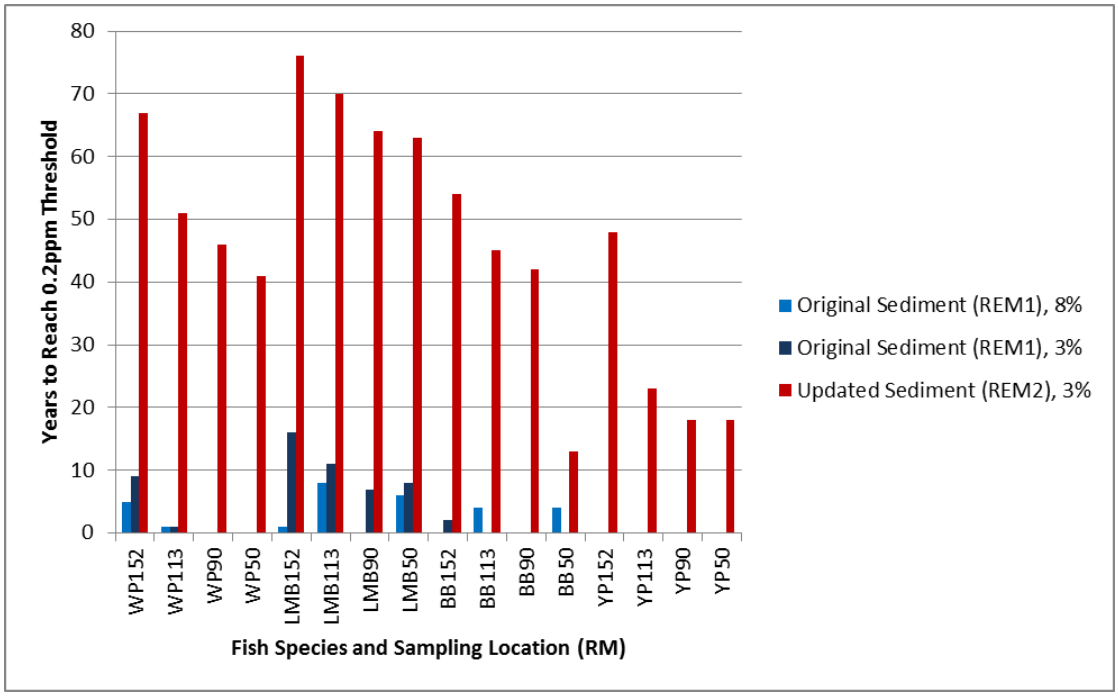


Figure C-8: Estimated Years to Reach 0.2 mg/kg Human Health Risk Threshold by Species and Location for Selected Scenarios (Source: Field et al. Supplemental Table S-3)

The original mechanistic models (HUDTOX-FISHRAND) used by EPA to inform the ROD for the UHR successfully reproduced the available historical data for 1977-1998 and remain scientifically valid management tools.

The mechanistic models HUDTOX and FISHRAND were constrained through calibration to UHR data for the period 1977 to 1998 (EPA, 2000a). Those long-term historical calibrations of HUDTOX and FISHRAND to all the available data provided the foundation for use of those models in conducting forecast simulations to estimate long-term responses to remedial alternatives in the RI/FS.

HUDTOX, the PCB transport and fate model, was calibrated to data for the following variables:

- Tri+ PCB surface sediment concentration trends;
- Solids burial rates;
- In-river solids and Tri+ PCB mass transport at high and low flows; and
- Solids and Tri+ PCB water column concentrations.

The historical calibration of HUDTOX was also tested through model-data comparisons for total PCBs and five individual congeners from 1991 to 1997.

FISHRAND, the mechanistic bioaccumulation model, was calibrated to data for five species of fish: largemouth bass, brown bullhead, yellow perch, spottail shiner and pumpkinseed using Bayesian updating. Model calibration was conducted for Tri+ PCB concentration in fish tissue on a wet weight basis by optimizing *a priori* input distributions for lipid (empirical) and Log of the octanol/water partition coefficient (K_{ow}) (congener-specific based on literature data) as discussed in greater detail in EPA (2000a).

HUDTOX and FISHRAND were subject to a rigorous peer review by a panel of international experts (Eastern Research Group, Inc, 2000). After extensive document review and a series of public meetings, the peer review panel determined that the models are acceptable and adequately reproduce historical data. The panel noted that the models do not reflect a fully mechanistic understanding of all chemical, physical, and biological processes, and expressed concern about increasing temporal uncertainty over time in the model forecasts**.** In its Response to Peer Review Comments, EPA acknowledged uncertainties in the models, but reiterated that the models provide a sufficient understanding of the system on which to base a decision for the site.

The original mechanistic HUDTOX-FISHRAND models, when extended to include the 1998-2008 pre-dredging period, continue to show good agreement with the observed data.

After the last round of sediment sampling used to test EPA's models, an eleven-year period of sampling and pre-remedial design followed, providing a test of the accuracy of the models in predicting water column and fish tissue PCB concentrations under conditions of monitored natural recovery. In Appendices 1 and 3 of the FYR, HUDTOX and FISHRAND forecasts were compared to monitoring data for that period (1998 to 2008), which ended with the commencement of remedial dredging. Appendix 1 shows a 1998 to 2008 HUDTOX simulation of water column PCBs, updated to include actual river flows, to be generally faithful to both seasonal and long-term trends in water column PCBs for the full period, including the intensive data collection period of 2004-2008. Appendix 3 shows that FISHRAND showed good agreement between data and predicted wet-weight and lipid-adjusted fish tissue concentrations for the UHR (where the model was calibrated) and RM 152 using the 1998-2008 HUDTOX simulations to provide PCB exposure concentrations.

References

Eastern Research Group, Inc. 2000. Report on the Peer Review of the Revised Baseline Modeling Report for the Hudson River PCBs Superfund Site. Final. Prepared for U.S. Environmental Protection Agency, Region II, Emergency and Remedial Response Division. EPA Contract No. 68-W6-0022, Work Assignment No. 4-12, May 10.

Field, L.J., J.W. Kern, and L.B. Rosman. 2016. "Re-visiting projections of PCBs in Lower Hudson River fish using model emulation." *Science of Total Environment* 557-558 (2016) pp. 489-501. (http://dx.doi.org/10.1016/j.scitotenv.2016.02.072).

EPA. 2000a. Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS Volume 2D. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra Tech, Inc. January 2000, http://www.epa.gov/hudson/reports.htm (Last accessed: 02/10/2015)

EPA. 2016a. Responses to NOAA Manuscript Entitled: "Re-Visiting Projections of PCBs in Lower Hudson River Fish Using Model Emulation" (Field, Kern, Rosman, 2016). https://www3.epa.gov/hudson/pdf/EPA%20White%20Paper%20-%20Responses%20to%20NOAA%20Manuscript.pdf.

Final Second Five-Year Review Comment Response for the Hudson River PCBs Superfund Site

APPENDIX D

SPECIAL STUDY – BLACK BASS FILLET TISSUE WITH AND WITHOUT RIBS

Prepared by

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April 2019

APPENDIX D
SPECIAL STUDY - BLACK BASS FILLET TISSUE WITH AND WITHOUT RIBS

1 Introduction and Background:

In 2004 GE began conducting analyses for PCB on fish samples collected as part of the Baseline Monitoring Program (BMP). Protocols established for and approved for use under the BMP Quality Assurance Project Plan (QAPP) included procedures used by NYSDEC for fish collection and sample preparation. Specifically, the 2004 BMP QAPP indicated that: "All fish will be prepared for contaminant analyses following collection according to the SOP for Annual Fish Sampling (Appendix 21; adapted from NYSDEC procedures)." Both the NYSDEC standard fillet approach and the standard operating procedure (SOP) detailed in BMP QAPP Appendix 21 involve inclusion of the rib-bones and belly flap with the fillet that is removed from the fish and subsequently analyzed for PCB's and lipids. EPA determined, based in part on information provided by NYSDEC oversight staff, that the adult sportfish fillets processed by GE from 2007 to 2013 did not include the ribcage as required. In response to this deviation from the approved project procedures, EPA required that GE perform a special study in 2014 evaluating the degree to which exclusion of the rib cage (ribs) impacted measurement of fish tissue PCB concentrations and lipid levels during the six years in question. Black bass (smallmouth bass and largemouth bass) were the focus of the special study because they are large enough to produce fillets of sufficient size for comparison and are collected from project monitoring stations in both the Upper and Lower Hudson River.

The primary objective of this special study was to evaluate the comparability of lipid-normalized PCBs in black bass fillets with and without ribs. This study compared Aroclor PCB ($TPCB_{Aroclor}$), lipid, and lipid normalized PCBs (LPCB) in black bass fillets processed with and without the ribs. Consistent processing of fillet samples for chemical analysis is important because organic chemicals such as PCBs are preferentially found within lipid rich tissues, such as those surrounding the gut and rib cage. Comparison of chemical concentrations in groups of samples derived from differing sample preparation procedures can result in systematic biases, which could influence their interpretation. In this study, the influence of differential processing of fillets with respect to inclusion of the ribs was investigated through a paired samples analysis comparing chemical parameters in left and right hand fillets from each fish.

2 Methods:

The difference between fillets with and without ribs was evaluated to determine if the two-sided 95 percent confidence interval contained zero (i.e., zero difference), and the half width is less than 20 percent of the mean [LPCB] (all samples). Aroclor PCB concentrations from the two processing methods were considered comparable within the margin of error and would be considered adequate for subsequent analysis and interpretation. If both of these conclusions could not be drawn, the data would be evaluated to determine the potential value of a larger sample sizes which would be generated in a subsequent year of study.

2.1 Hypothesis and Data Quality Objective

This study tests the null hypotheses that after adjustment for lipid content, the LPCB concentrations of samples with ribs are consistent with those without ribs. This hypothesis was predicated on an ability to achieve a detectable difference of 20 percent change in the concentrations of LPCB with 80 percent power ($\beta = 0.2$). The number of paired samples was determined under the assumption that LPCB concentrations would be compared using a paired Student's t-test at 5 percent level of significance ($\alpha = 0.05$) and that a 20 percent difference in mean LPCB concentration would be detected with 80 percent power. Sample data from black bass collected in 2013 were used to determine the minimum number of fillet pairs necessary to meet this Data Quality Objective (DQO) (**Table** 1). Power and sample size calculations were performed using methods for paired Student's T-tests (Lenth, 2009). The number of fish required to meet the special study objective of detecting a 20 percent change in LPCB at 80 percent power ($\beta = 0.2$) with 5 percent level of significance is n = 130.

Table 1. Lipid-Normalized PCBs in Hudson River Black Bass Fillets 2013.

STN	TISS	Sample fish per Station	Average [LPCB] (mg PCB/kg-Lipid)	Standard Deviation	Coefficient of Variation (percent)
AT1	SF	20	153	41	27
CS1	SF	20	68	26	39
FD1	SF	30	4	7	153
ND1	SF	5	781	140	18
ND2	SF	5	780	477	61
ND3	SF	5	468	178	38
ND5 (BMP)	SF	10 *	576	491	85
SW1	SF	5	525	226	43
SW2	SF	5	535	200	37
SW3 (BMP)	SF	10	584.	321	55
SW4	SF	5	261	105	40
SW5	SF	5	303	146	48
TD1	SF	5	377	205	54
TD2	SF	5	473	326	69
TD3	SF	5	1304	814	62
TD4	SF	5	1008	717	71
TD5 (BMP)	SF	10	450	219	49

* Note: At n=130 the sampling design for this special study calls for 5 more fish from within ND pool (RS2) to attain n=130 and make numbers for each RS equal.

2.2 Approach:

1) Fish collected under the Remedial Action Monitoring Program (RAMP) were used to supply sets of paired (left and right) black bass fillets.
2) The left and right fillets of each fish were processed in exactly the same way with the exception that the ribs were included (taken with) one fillet and excluded (not taken) from the other.
3) The method used to process fillets including ribs is the NYSDEC standard fillet method (Attachment, 1: Standard Operating Procedure (SOP) PrepLab3, dated 2011). The approach used to process fillets that do not include ribs is Appendix 3.8-4 of the 2011 Hudson River PCBs Site

RAMP Quality Assurance Project Plan (QAPP), Attachment 2: SOP for the Tissue Reduction/Grinding for Whole Body and Filleted Fish, August 2011).

4) In order to avoid bias and provide representative sample populations, equal numbers of left and right rib samples were processed from the fish collected within each River Section and from historical NYSDEC monitoring locations.
5) EPA provided robust oversight at the GE contractor laboratory throughout the study. NYSDEC also participated in observing the work.
6) The 130 required Black bass were collected from the usual RAMP fish sampling locations from RS 1 through RS 3 and the Albany-Troy (AT) and Catskill (CS) locations. An additional five fish were also collected from RS 2 yielding 130 paired fillets.
7) Data generated by the study, for both fillets, was prepared and analyzed consistently with the RAMP and current post-dredging program, including relevant QA/QC and laboratory controls using a modification of the EPA M8082A Aroclor Sum Method (Pace SOP S-NY-O-314-rev.00; Appendix A3-1 of Revised Attachment A to the Phase 2 RAMP QAPP).

2.3 Statistical Analysis Methods

Each fish resulted in a pair of PCB measurements and a pair of lipid measurements which were compared statistically. To test the null hypothesis of the study, the distribution of differences in paired LPCBs were evaluated relative to the mean difference in LPCB concentrations. To further examine the results of the special study, EPA also subjected the data to the following additional statistical evaluations:

1) robust regression between paired lipid-normalized PCBs,
2) robust regression between paired lipid content measurements,
3) robust regression between paired wet weight PCB measurements, and
4) average ratios of rib to without-rib wet weight PCB measurements.

Statistical methods for each analysis are described in the next sections.

2.3.1 Paired Differences

The distribution of differences in paired LPCBs were evaluated relative to the mean difference in LPCBs, μ_0, and the null hypothesis was:

$$H_0\colon\ |\mu_{Rib} - \mu_{No-Rib}| \geq 0.2 \times \mu_0$$

versus the alternative hypothesis:

$$H_a\colon |\mu_{Rib} - \mu_{No-Rib}| < 0.2 \times \mu_0.$$

The null hypothesis, or assumed condition, is that the difference between preparation methods is greater than 20 percent. Therefore, rejection of this null hypothesis at the 5 percent level of significance indicates that one can be 95 percent confident that the difference in preparation methods is less than 20 percent. This null hypothesis can be tested with the paired-samples Student's t-test, or equivalently by constructing a 95 percent interval for the mean difference in LPCBs and comparing the absolute value of the confidence limits with $0.2 \times \mu_0$. The null hypothesis is rejected when the upper and lower confidence limits are less in magnitude than $0.2 \times \mu_0$. Rejection of the null hypothesis indicates satisfaction of the data quality objective stated above.

2.3.2 Robust Regression

Traditional regression analyses based on least squares fitting (Neter et al., 1996) require the assumption that regression residuals are normally distributed with constant variance, across the range of the predictor variables. These assumptions were tested by fitting a least squares regression line and testing the residuals for normality with the Lilliefors test (Lilliefors, 1967), and for constant variance using the White test (White, 1980). When tests of either or both assumptions failed, then robust regression was used to estimate the relationships between rib and without-rib LPCB, PCB and lipid levels. The M-estimation procedure (Huber 1973) was used to fit the robust regression line to data using a bi-square weighting function (Huber, 1981). The idea behind robust regression is to minimize the influence of extremes by weighting samples close to the fitted line more heavily than those more distant from the line. In this way the influence of potential outliers is reduced without the need to remove them from the data set.

2.3.3 Average of Ratios

It is not uncommon for environmental scientists to work with ratios in efforts to explore bivariate relationships, although there are some disadvantages relative to regression analysis including: 1) ratios can be shown to be equivalent to a line through the origin which forces the relationship to be a direct proportionality; and 2) distributions of ratios tend to be highly right skewed and therefore estimates based on ratios tend to be highly uncertain. Despite these general concerns the mean ratio of without-rib to rib PCBs (wet-weight concentrations) was estimated for completeness and to acknowledge traditional use of ratios in environmental data analysis.

3 Results

3.1 Difference in Lipid-Normalized PCBs

The average of LPCBs in fillets with and without ribs were 439 mg PCBs/kg lipid and 473 mg PCBs/kg lipid respectively, and the overall average was 456 mg PCBs/kg lipid (Figure 1). The zone of compliance (for data quality) of 20 percent of the mean was (0.2 x μ_0) = 91 mg PCBs/kg lipid. The upper and lower confidence limits were -0.69 mg PCBs/kg lipid and 69 mg PCBs/kg lipid respectively showing that the average of differences between LPCBs in fillets with and without ribs was less than the 20 percent zone of compliance with 95 percent level of confidence.

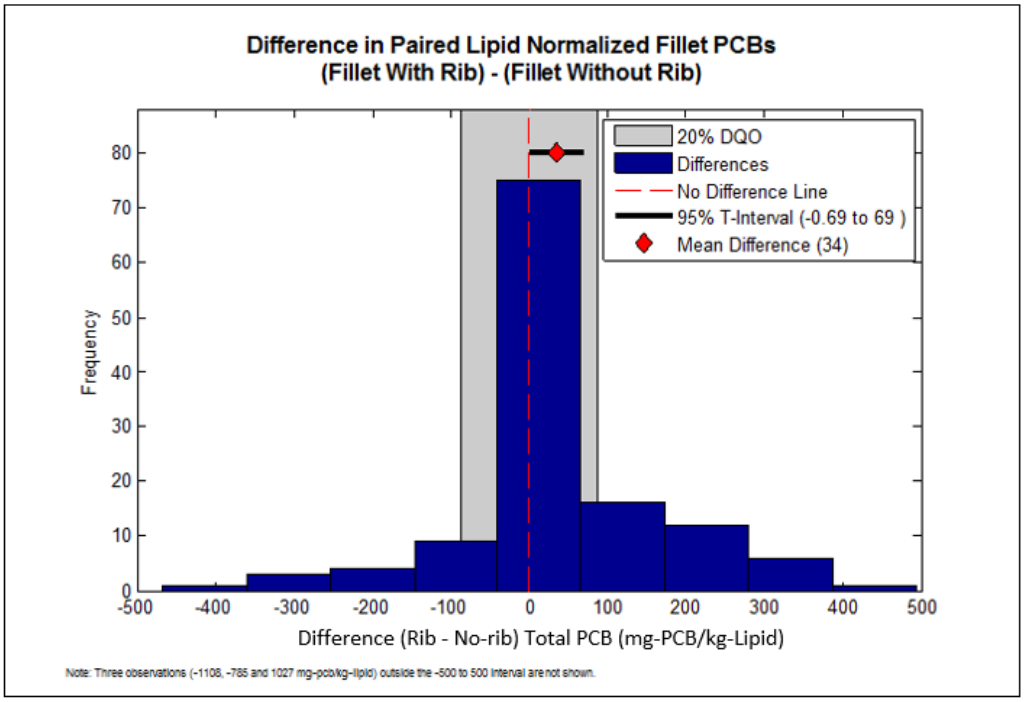


Figure 1. Differences in LPCBs with 20 percent zone of compliance for data quality (gray band) and 95 percent confidence interval for the mean difference between LPCBs in fillets with and without ribs.

This bias at approximately 8 percent with samples with ribs being higher is sufficiently small as to not present a major issue for data interpretation. Because the two-sided 95 percent confidence interval contains zero (i.e., zero difference), and the half width is less than 20 percent of the mean [LPCB], EPA determined that a second year of comparisons was not needed.

3.2 Robust Regression:

3.2.1 LPCB

The nature of the relationship between rib and without-rib LPCBs was investigated further through regression analysis. A traditional least squares line was first fit to the data and residuals were found to vary with concentration (White Test, $p<0.001$) and were non-normal (Lilliefors Test, $p<0.001$). To compensate for these deviations from standard regression assumptions, the data were subjected to a robust regression through the origin. The paired data and fitted line are plotted in Figure 2, and parameter estimates are provided in Table 2. This analysis confirms that LPCB in samples including the rib average were approximately 8 percent% (range of 6 percent to 10 percent) higher than those without the rib.

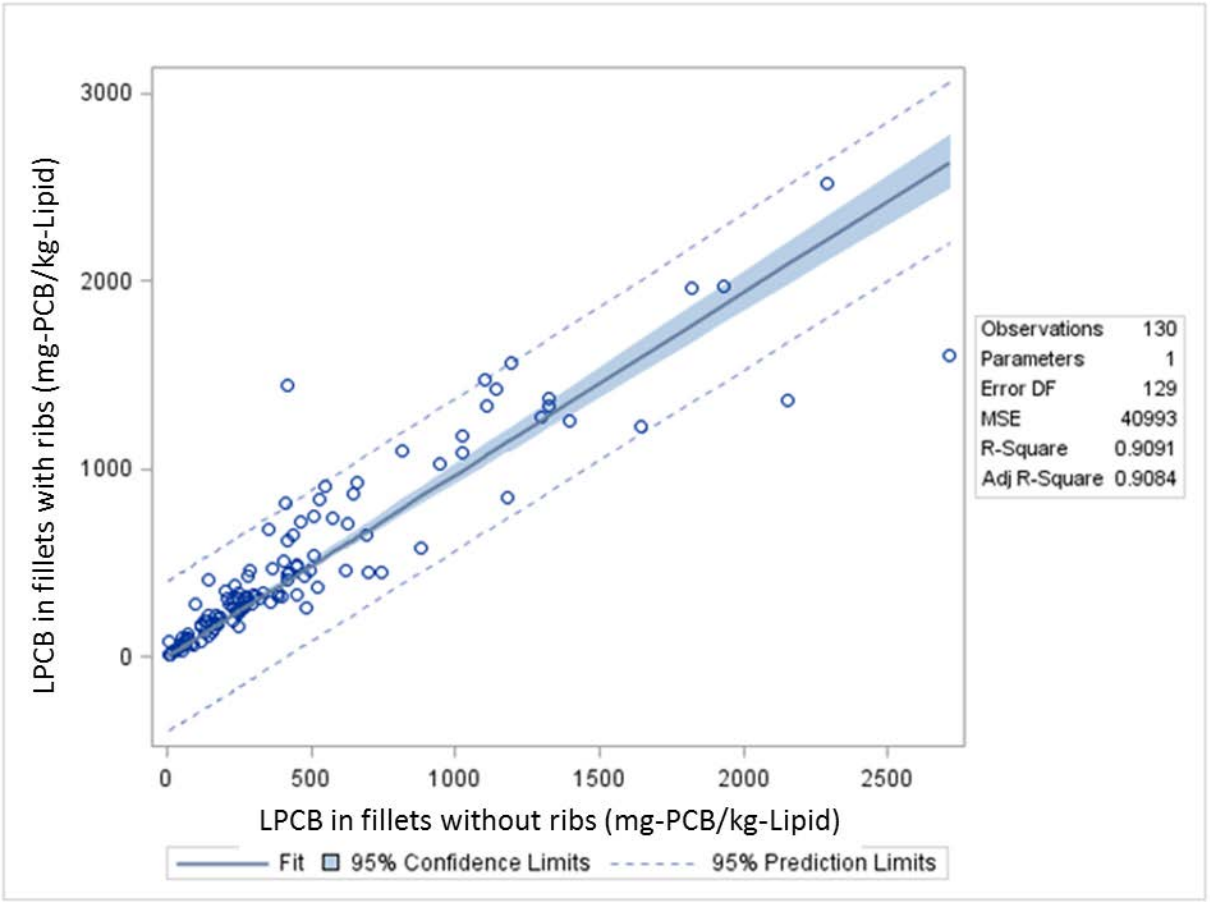


Figure 2. Fitted robust regression line for LPCB concentrations in black bass fillets with ribs vs. those without ribs, Hudson River, NY.

Table 2. Parameter estimates for robust regression between LPCB concentrations in black bass fillets with and without ribs, Upper Hudson River.

Parameter	DF	Estimate	Standard Error	95 Percent Confidence Limits		Chi-Square	Pr > ChiSq
LPCB	1	1.08	0.0109	1.06	1.10	9797.	<.0001
Scale	1	67					

3.2.2 Percent Lipid

Robust regression was used to estimate the relationship for percent lipid in fillets with and without ribs. The percent lipid in rib fillets was approximately 16 percent (CI: 10 percent, 22 percent) greater than in without-rib samples (Figure 3. Percent lipid in fillets with ribs vs. those without ribs with robust regression fit., Table 3).

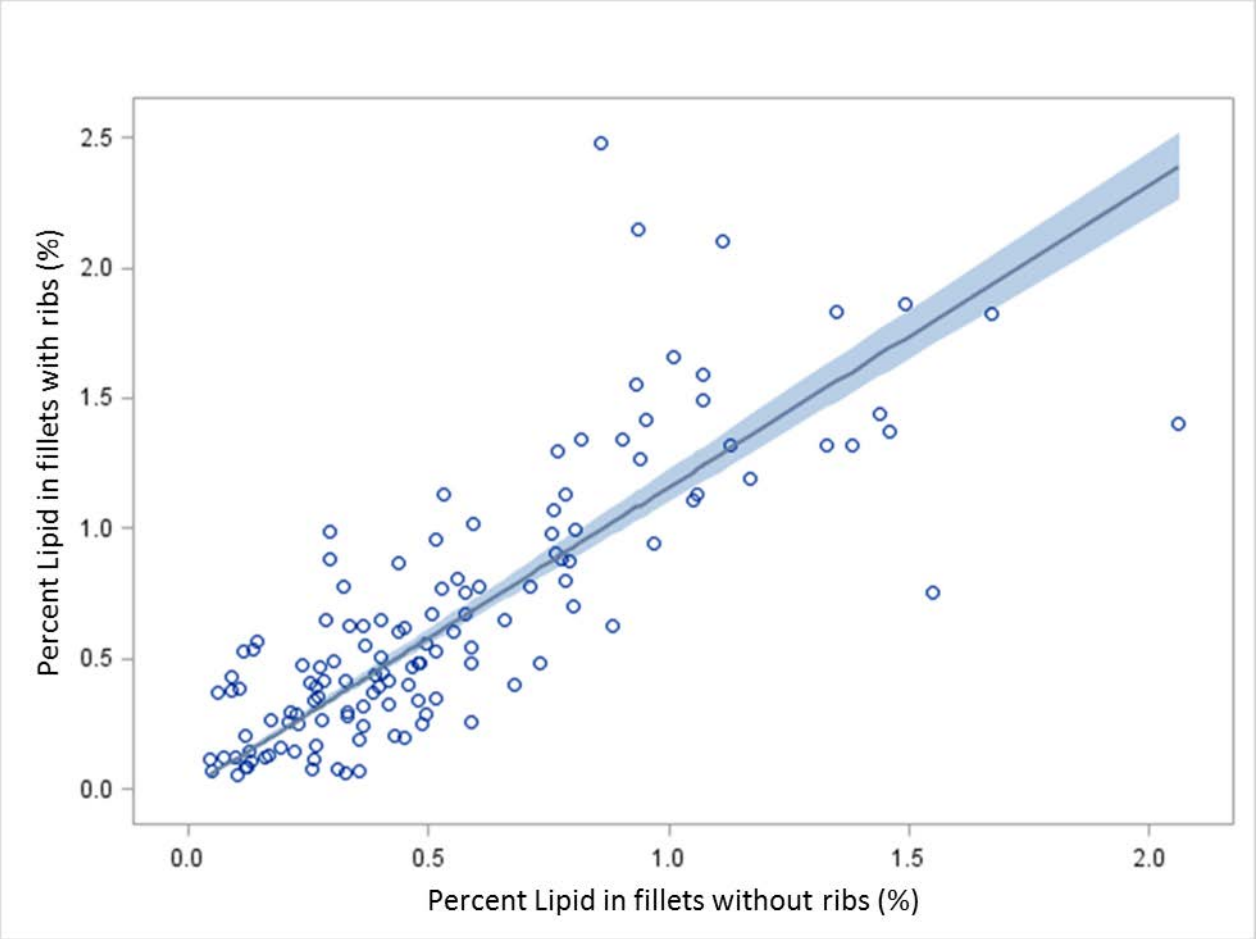


Figure 3. Percent lipid in fillets with ribs vs. those without ribs with robust regression fit.

Table 3. Parameter estimates for robust regression between percent lipid in black bass fillets with and without ribs, Upper Hudson River.

Parameter	DF	Estimate	Standard Error	95 Percent Confidence Limits		Chi-Square	Pr > ChiSq
Percent Lipid	1	1.16	0.03	1.10	1.22	1314	<.0001
Scale	1	0.22					

3.2.3 Wet Weight Total PCBs

A robust regression line was also fit to describe the relationship between rib and without-rib wet weight total PCBs in black bass fillets. Wet weight $TPCB_{Aroclor}$ in rib samples were approximately 16 percent (CI: 11 percent to 21 percent) higher than in without-rib samples (Figure 4 and Table 4) and there is substantially more variability in wet-weight concentrations reflecting differences in the amount of lipid in rib and without-rib samples.

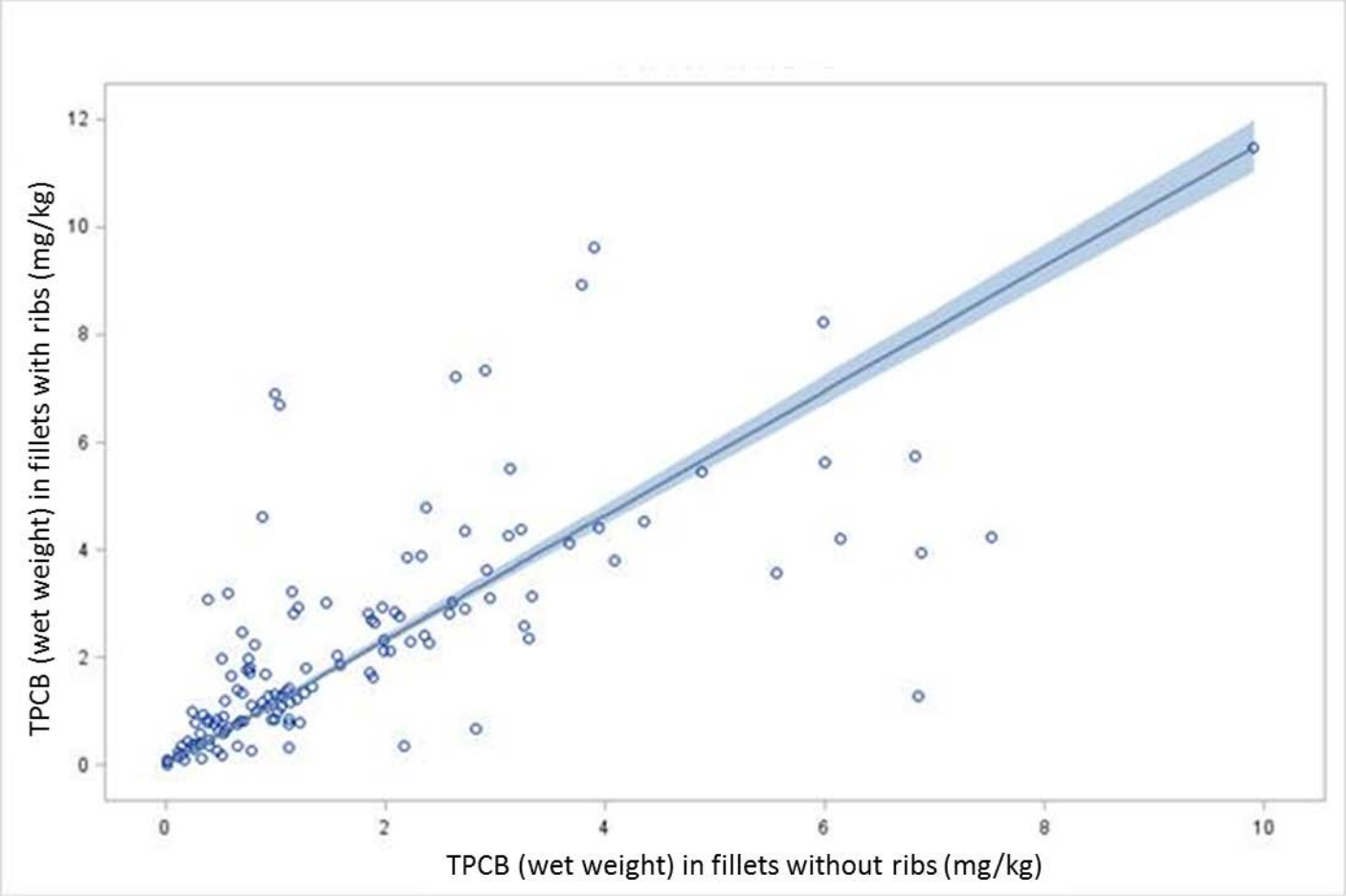


Figure 4. Wet weight total PCBs in fillets with ribs vs. those without ribs with robust regression fit.

Table 4. Parameter estimates for robust regression between wet weight total PCB in black bass fillets with and without ribs, Upper Hudson River.

Parameter	DF	Estimate	Standard Error	95% Confidence Limits		Chi-Square	Pr > ChiSq
TPCB	1	1.16	0.024	1.11	1.21	2315	<.0001
Scale	1	0.61					

3.3 Mean Ratios Wet Weight TPCB

The arithmetic averages of ratios of rib to without-rib wet weight $TPCB_{Aroclor}$ ranged from approximately 1.5 to 1.75 with 95% confidence intervals ranging from a high of 2.25 to below 1.25 (Figure 5). Average ratios were similar across all pools, suggesting that relationships are unrelated to specific environmental conditions, as opposed to differences in PCB content in muscle tissue as compared with that in and around the rib cage and belly flap. These estimated ratios are relatively imprecise, reflecting smaller sample sizes within pools, as well as high variation in the ratios themselves. Ratios of random variables for right skewed distributions are characteristically highly variable group comparisons based on averages of ratios are generally discouraged relative to other statistical approaches. These ratios were compiled here for comparison because statistical practitioners calculate such averages, however, we discourage their use.

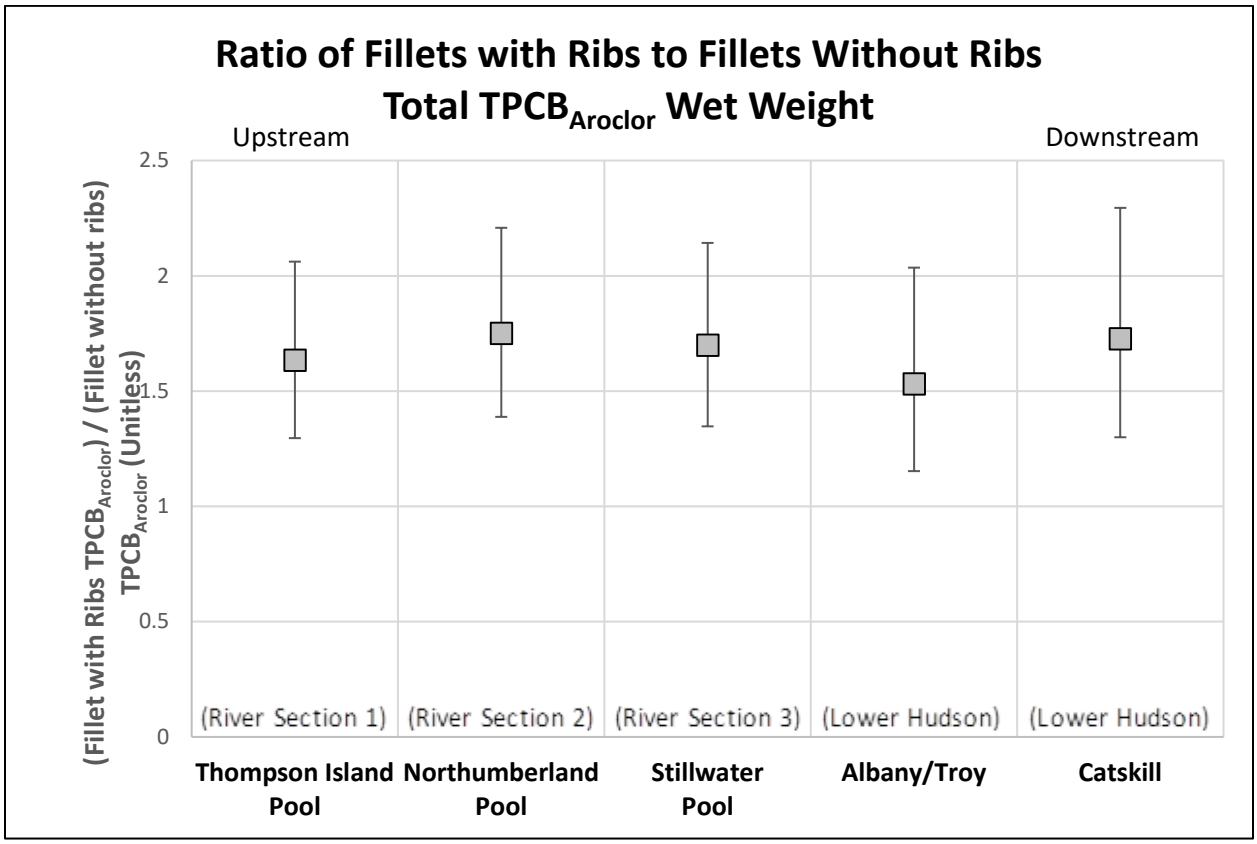


Figure 5. Average ratio of wet weight total PCBs in fillets with and without ribs by pool in the Upper Hudson River. Error bars represent approximate 95 percent confidence limits for the ratio.

4 Discussion

The primary objective of this special study was to evaluate the comparability of LPCBs in black bass fillets with and without ribs. The verification of such comparability, as shown through the statistical testing and analysis described above, is important because long-term fish tissue trends are based on LPCB

data recognizing that PCB concentrations generally co-vary with lipid content in fish tissue samples. LPCB tissue concentrations in this study were noticeably less variable than wet weight PCBs indicating that lipid normalization reduces bias between rib on and without rib PCB concentrations and improves power and precision of statistical analyses relative to analyses based on wet weight PCBs.

Some temporal comparisons of LPCB concentrations of interest may span periods when both fillets with and without ribs would be compared. This analysis indicates that rib and without-rib LPCB measurements are on average within the 20 percent zone of compliance for data quality with 95 percent level of confidence. This suggests that there is compatibility of the LPCB concentrations in rib and without-rib samples collected under the approved monitoring plans since 2004 but for transparency, the results from 2007 to 2013 should be identified as years where the fillet samples were prepared without the ribs.

Robust regression analysis suggests that differences in wet weight concentrations between rib and without-rib samples are substantially larger and more variable than lipid-normalized concentrations, suggesting that more care should be taken when interpreting temporal patterns in wet weight concentrations, or comparing wet weight PCB absolute thresholds where the data from years when without-rib fillets were analyzed (2007-2013) are included. The robust regressions can potentially be used to convert from rib to without-rib PCB concentrations to facilitate such careful evaluations of both wet weight and lipid-normalized PCB concentrations; although analyses based on combined data should be evaluated with and without conversions to understand the sensitivity of any particular analysis

EPA has determined that for the years in question, a 34 mg PCB/kg lipid difference (about 8 percent) would not appreciably effect data interpretation. It should be noted that the period of data collection when the rib was not included (2007 to 2013) was just prior to and during dredging activities. Fish data during dredging was impacted by dredging-related PCB resuspension. Therefore, fish monitoring data collected during that period would not be used to establish pre- or post-dredging fish recovery trends. No significant project decisions were made or altered based on fish data from those years; the data served its primary purpose to monitor changes during dredging and the results were within EPA's expectations. Also, no adjustments to fish advisories or regulations were made by New York State based on those data. Therefore, based on the results of the special study, EPA does not intend to complete any follow up studies associated with this matter. All post-dredging fish processing procedures have and will follow NYSDEC standard fish processing procedures as required by project documents. EPA will continue to oversee the fish processing at the laboratory as it monitors post-dredging recovery in fish.

5 References

General Electric Corporation 2011. Hudson River PCB's Site 2011 Remedial Action Monitoring Quality Assurance Project Plan (RAMQAPP). Prepared by Anchor QEA (Glens Falls, NY) in Conjunction with Environmental Standards, Inc. (Valley Forge, PA). Appendix 3.8-4 (SOP for the Tissue Reduction/Grinding for Whole Body and Filleted Fish, August 2011).

Huber, P. J. 1981. Robust Statistics. John Wiley and Sons, New York.

Huber, P.J. (1973) Robust Regression: Asymptotics, Conjectures and Monte Carlo. Annals of Statistics, 1, 799-821. http://dx.doi.org/10.1214/aos/1176342503

Lenth, R. V. (2009). Java Applets for Power and Sample Size [Computer software]. Retrieved January 29, 2014, from http://www.stat.uiowa.edu/~rlenth/Power.

Lilliefors, H. W. "On the Kolmogorov-Smirnov test for normality with mean and variance unknown." Journal of the American Statistical Association. Vol. 62, 1967, pp. 399–402.

Neter, J., Kutner, M. H., Nachtsheim, C. J., and Wasserman, W., 1996. Applied Linear Statistical Models, 4thEdition, Richard D. Irwin, Inc., Burr Ridge, Illinois. NYSDEC 2005. Of Time, PCB's and the Fish of the Hudson River. NY State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources. Albany, NY, July 2005, Appendix 1 (Fish Collection, Sample Preparation, and Analytical Procedures, page 259).

White, H. (1980). "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity". Econometrica. 48 (4): 817–838

Attachments to Appendix D

Attachment D-1: NYSDEC 2011. Prep Lab Standard Operating Procedure (SOP PrepLab3). NY State Department of Environmental Conservation (Hale Creek Field Station). 3/16/2011.

Attachment D-2: Anchor QEA 2011. Standard Operating Procedure: Tissue and Preparation & Homogenization for Biota and Plant Matrices. Appendix 3.8-4 SOP for the Tissue Reduction/Grinding for Whole Body and Filleted Fish (NE132_07) to the Hudson River PCBs Superfund Site Phase 2 Remedial Action Monitoring Program Quality Assurance Project Plan. Anchor QEA and Environmental Standards Inc. August 2011.

Attachment D-1

PREP LAB STANDARD OPERATING PROCEDURE
NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Hale Creek Field Station

Name of document: SOP – PrepLab3 (3-16-2011)
Revision date: 3/16/2011
Previous revision: Preplab2
Reasons for this revision:

- Delete references to dBase IV for entering data into databases.
- Add details regarding type of grinder used and instructions to mix the tissue and repeat the grinding step at least two more times and until the sample appears to be homogeneous.
- Add Section VI. - Minimizing sample contamination during sample preparation.
- Add reference, summary and background sections to the SOP.

Reference: *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, 3rd edition* (USEPA Office of Water, November 2000)

Summary: Samples are received at Hale Creek Field Station and dissected, ground and homogenized for future chemical analysis. In addition, samples for organochlorine analysis are freeze-dried to remove moisture.

Background:
New York State Department of Environmental Conservation conducts studies requiring chemical analysis on fish or other biological tissues. Routine monitoring and surveillance studies develop data on contaminants in fish for several reasons:

1. To identify sources of environmental contamination;
2. To identify the geographic extent of environmental contamination;
3. To identify temporal trends of contaminants in fish and wildlife;
4. To identify potential impacts to fish and their consumers; and
5. To provide information regarding human consumption advisories.

Chemical analyses of edible fish flesh have been determined to be the most appropriate analyses for satisfying all of these objectives. The following methodology has been developed in order to standardize the tissues under analysis and to adequately represent the contaminant levels of fish flesh. The portion of edible flesh analyzed will be referred to as the standard fillet unless otherwise noted. For some species, the procedure is modified as indicated below.

I. SAMPLE RECEIPT

A) All samples received by the lab are to be accompanied by a Collection Record and Continuity of Evidence form.
B) After comparison of samples received with the Collection Record, the Continuity of Evidence form is signed and dated.
C) The original forms are to be retained by the lab. Copies may be returned to the delivery person.
D) Depending upon sample type, the samples are to be stored locked in either the cooler or freezer.

II. SAMPLE LOG IN

A) All samples are assigned a unique serial Lab # which corresponds to a specific Tag # or ID # on the sample or sample container.
B) The Lab #s are to be indicated on the Continuity of Evidence form and the Collection Record.

C) From the Collection Record the Lab #, Tag #, Species, Location, Program, Length, Weight, Sex, and Age are entered into the computer Log file.

III. SAMPLE DISSECTION

A) Samples are removed from the freezer and allowed to partially thaw (large samples may be removed the previous night).

B) FISH: The portion of edible flesh analyzed will be referred to as the standard fillet unless otherwise noted. For some species, the procedure is modified as indicated below.

1) Standard Fillet

a) Remove scales from fish. Do not remove the skin.

b) Make a cut along the ventral midline of the fish from the vent to the base of the jaw.

c) Make a diagonal cut from the base of the cranium following just behind the gill to the ventral side just behind the pectoral fin.

d) Remove the flesh and ribcage from one-half of the fish by cutting from the cranium along the spine and dorsal rays to the caudal fin. The ribs should remain on the fillet.

e) Score the skin and homogenize the entire fillet.

2) Modifications to the Standard Fillet

a) Four modifications of the standard fillet procedure (see b,c,d,e) are designed to account for variations in fish size or known preferred preparation methods of the fish for human consumption.

b) Some fish are too small to fillet by the above procedure. Fish less than approximately 6 inches long and rainbow smelt are analyzed by cutting the head off from behind the pectoral fin and eviscerating the fish. Ensure that the belly flap is retained on the carcass to be analyzed.

c) Some species are generally eaten by skinning the fish. The skin from these species is also relatively difficult to homogenize in the sample. Hence, for the following list of species, the fish is first skinned prior to homogenization:

Brown Bullhead	White Catfish
Yellow Bullhead	Channel Catfish
Black Bullhead	Lake Sturgeon
Atlantic Sturgeon	

d) American eel are analyzed by removing the head, skin, and viscera; filleting is not attempted.

e) Forage fish and young-of-year fish are analyzed whole.

C) Wildlife/Other: Generally non-fish samples that are to be prepared have already been dissected. See supervisor for appropriate instructions.

D) All dissection tools are to be rinsed, washed with soap, rinsed, rinsed with DI water and dried between each sample dissection.

IV. HOMOGENIZATION

A) Thoroughly grind and homogenize fish fillets using a Waring commercial chopper/grinder model WCG75. Alternatively, a comparable food chopper, food processor, grinder, blender or homogenizer may be used.

B) Mix the tissue and repeat the grinding step at least two more times and until the sample appears to be homogeneous.

C) The homogenized sample is then subsampled into appropriate glass bottles. Generally 2-10 g is needed for metals analysis and 20g for organochlorine analysis. For the OC sample label and weigh an empty sample bottle. Add ca 20g of sample into the bottle and weigh again.

D) The bottles are capped and stored in the freezer.

E) All homogenization tools are to be rinsed, washed with soap, rinsed, rinsed with DI water and dried between each sample.

V. FREEZE DRYING

A) Generally samples for organochlorine analysis are freeze dried.

B) Make sure that the unit has been drained, all valves closed and the vacuum pump oil is clear and within the acceptable markings on the site vial.

C) Turn the refrigeration unit on. After the temperature OK light comes on (less than -40 C) turn the vacuum pump on. After the vacuum OK light comes on (less than 100 millitorr) the samples may be placed on the freeze dryer (make sure samples are frozen).

D) The samples are freeze dried ca 16 hours or until the samples reach a constant weight.

E) When freeze dried, the sample bottle is weighed again.

F) The sample is stored in the freezer until analysis is started.

VI. MINIMIZING SAMPLE CONTAMINATION DURING SAMPLE PREPARATION

A) Conduct all work in a clean environment, preferably a laboratory setting. All work surfaces, utensils and grinder work bowls and covers should be cleaned with soap and water, then rinsed with clean water, prior to working with samples, between each sample, and upon completion of sample preparation for the day. Alternatively, between samples aluminum foil may be placed on the work surface for the succeeding fish sample; discard foil after one use. DO NOT use aluminum foil if metals analyses are to be conducted on the sample.

B) Wear a clean laboratory coat for protection of clothing. Wear nitrile or latex gloves at all times while preparing samples. Clean gloves with soap and water between each sample, or discard gloves between samples and place new gloves on hands. If a glove is torn or punctured, immediately discard the glove and replace with a new glove. Discard gloves at the end of the day, or earlier if they become unsuitable for clean preparation of samples..

C) Rinse fish or other biological samples in clean water if soil, debris or other matter are evident on the exterior surfaces. Allow water to run off and dry exterior surface.

D) Following preparation of sample portions, place sample in clean containers of suitable size

for the sample. For example, place small samples in chemically clean glass jars, cover and label immediately. Jars should have PTFE-lined caps and be precleaned and certified to meet EPA standards for metals, pesticides and semi-volatiles. For large samples (e.g., a fish fillet), wrap in hexane-rinsed aluminum foil and label externally. Place foil wrapped sample in a labeled food-grade plastic bag for subsequent storage and transport. If hexane-rinsed aluminum foil is unavailable, and samples are not to be analyzed for phthalates, the excised sample may be placed in a food grade plastic bag, labeled externally and placed in frozen storage. DO NOT use aluminum foil if metals analyses are to be conducted on the sample.

Attachment D-2

APPENDIX 3.8-4
SOP FOR THE TISSUE REDUCTION/GRINDING FOR WHOLE BODY AND FILLETED FISH (NE132_07)

STANDARD OPERATING PROCEDURE

TISSUE AND PREPARATION & HOMOGENIZATION

FOR BIOTA AND PLANT MATRICES

Reference Methods: US EPA SW-846 Test Methods for Evaluating Solid Waste

LOCAL SOP NUMBER:	NE132_07
EFFECTIVE DATE:	03/29/2011
SUPERSEDES:	NE132_06
SOP TEMPLATE NUMBER:	SOT-ALL-Q-006-rev.03

APPROVALS

Dan Pfalzer
Assistant General Manager — Date: 03/29/2011

Christina L. Braidwood
Quality Manager — Date: 03/29/2011

PERIODIC REVIEW

SIGNATURES BELOW INDICATE NO CHANGES HAVE BEEN MADE SINCE PREVIOUS APPROVAL.

Signature	Title	Date
Signature	Title	Date
Signature	Title	Date

PACE ANALYTICAL SERVICES, INC
2190 TECHNOLOGY DRIVE
SCHENECTADY, NY 12308

(518) 346-4592

STANDARD OPERATING PROCEDURE

LABORATORY PROCEDURE NE132_07.DOC

REVISION 7 (03/29/11)

1.0 IDENTIFICATION OF TEST METHOD

1.1 Standard Operating Procedure for tissue preparation, processing and homogenization prior to extraction/digestion and analysis.

2.0 APPLICABLE MATRIX OR MATRICES

2.1 This method is applicable to the preparation and homogenization of animal and plant matrixes; including but not limited to: fish (whole body and fillets), mollusks (mussels, clams, etc.), crustaceans (lobster or shrimp, etc.), mammals (mice, mink, muskrat, shrew etc.), reptiles and amphibians (frogs or turtles, etc.), macro invertebrates (benthic worms, eels, insects and other biota), and vegetation (coastal and wetland grasses/plants).

3.0 DETECTION LIMIT

3.1 Not applicable

4.0 SCOPE AND APPLICATION

4.1 This method is intended to describe the preparation and homogenization procedures prior to the extraction, digestion and/or clean up of sample extracts. This procedure uses a variety of cutting, grinding and scaling equipment for size reduction, composting, and homogenization. Client and/or project may dictate additional specific requirements than stated below. Samples are best processed when partially frozen. Samples may be re-frozen after processing pending extraction or digestion.

5.0 SUMMARY OF TEST METHOD

5.1 Fish

5.1.1 Samples are weighed, measured, and gender determined if possible. The fish may be processed whole body or as fillets, and with the skin on or off. If fillets are to be removed and processed separately, this is generally done after the removal of the skin. If compositing is required, the identified samples for composite are filleted or skinned prior to homogenization. The carcass of the fish (after removal of the fillet) may be maintained for separate homogenization and analysis if requested.

5.2 Mollusks, crustaceans and other like invertebrates

5.2.1 Samples are measured and weighed prior to processing. Mollusks must be removed from their shells before processing. Due to the low weight of a single mollusk, crustacean, or invertebrate, these sample types are generally composited with others of the same species and/or sampling area prior to homogenization. Gender determination may need to be performed, i.e. lobsters. This is done prior to any processing and recorded. Additionally, lobsters are usually dissected, and the edible

meat (tail and claw) is removed for homogenization. Certain internal organs such as the hepatopancreas may need to be processed separately. If crabs are being processed, the legs, claws and body cavity are generally homogenized together.

5.3 Mammals

5.3.1 Mammals such as mink, mice, shrew or other rodents, must be prepared in a glove box or bio-hazard hood with the use of a HEPA biological respirator due to the potential health hazards associated with mammal tissue. All project specific sample preparation (weighing, skinning, compositing and homogenization) is performed in the glove box. Waste from the process must be treated with bleach before disposal. The outside surfaces of the sample containers must be disinfected before removal from the glove box.

5.4 Reptiles and Amphibians

5.4.1 Samples are generally processed as whole body samples. Depending upon the size, the specimen may need to be cut into small pieces and processed in part, then re-combined as a single sample. Due to the thickness of the skin of most reptiles, such as frogs, it is recommended that these be processed without the skin. If the skin must be processed, ensure that the grinder or processor blades are sharpened before use. The blades may need to be re-sharpened between every few samples as needed. Turtles must be removed from the shell prior to processing by digging out the head and legs, and as much of the body as feasible.

5.5 Macro invertebrates

5.5.1 Macro invertebrates such as worms, eels, insects or benthic biota are generally processed as whole body samples. Depending upon the size, the specimen may need to be cut into small pieces and processed in part, then recombined as a single sample. Due to the low weight of a single invertebrate, these sample types are generally composited with others of the same species and/or sampling area prior to homogenization.

5.6 Plants

5.6.1 Samples are rinsed prior to processing to remove soil, silt, small insects or other debris. Depending upon the size of the plant and the leaves, the sample may be processed mechanically, or may have to be cut into small pieces by hand. Plants can be processed either wet or dry, depending upon project specifications

6.0 DEFINITIONS

6.1 Abdomen- the posterior section of the body behind the thorax in an arthropod.

6.2 **Abductor-** to draw or spread away (as a limb or the fingers) from a position near or parallel the median axis of the body or from the axis of a limb.

6.3 **Arthropod-** any of a phylum (Arthropoda) of invertebrate animals (as insects, arachnids, and crustaceans) that have a segmented body and jointed appendages, a usually chitinous exoskeleton molted at intervals, and a dorsal anterior brain connected to a ventral chain of ganglia.

6.4 **Biota-** the flora or fauna of a region.

6.5 **Bivalve-** being or having a shell composed of two valves (shells).

6.6 **Caudal-** directed toward or situated in or near the tail or posterior part of the body.

6.7 **Carapace-** bony or chitinous case or shield covering the back or part of the back of an animal (as a turtle or crab).

6.8 **Composite-** combining the typical or essential characteristics of individuals making up a group.

6.9 **Crustacean-** any of a large class (Crustacea) of mostly aquatic mandibular arthropods that have a chitinous or calcareous and chitinous exoskeleton, a pair of often much modified appendages on each segment, and two pairs of antennae and that include the lobsters, shrimps, crabs, wood lice, water fleas, and barnacles.

6.10 **Digestate-** product of digesting.

6.11 **Fillet-** to cut, a boneless cut of fish.

6.12 **Head-** the upper or anterior division of the animal body that contains the brain, the chief sense organs, and the mouth.

6.13 **Hepatopancreas-** a glandular structure (as of a crustacean) that combines the digestive functions of the vertebrate liver and pancreas**.**

6.14 **Homogenize-** to reduce the particles of so that they are uniformly small and evenly distributed.

6.15 **Mantle-** a fold or lobe or pair of lobes of the body wall of a mollusk or brachiopod that in shell-bearing forms, lines the shell and bears shell-secreting glands.

6.16 **Pectoral muscle-** any of the muscles which connect the ventral walls of the chest with the bones of the upper arm and shoulder and of which there are two on each side of the human body.

6.17 **Swimmerets-** one of a series of small unspecialized appendages under the abdomen of many crustaceans that are best developed in some decapods (as a

lobster) and usually function in locomotion or reproduction

6.18 **Telson-** the terminal segment of the body of an arthropod or segmented worm.

6.19 **Thorax- 1)** the middle of the three chief divisions of the body of an insect also**,** the corresponding part of a crustacean or an arachnid. **2)** the part of the mammalian body between the neck and the abdomen also**,** its cavity in which the heart and lungs lie.

7.0 INTERFERENCES

7.1 Samples being tested for metals must be processed with a ceramic knife and/or ground with a plastic blade to prevent contamination from metals such as steel or tin.

7.2 Samples being tested for organics must be processed with metal, Teflon, PTFE and or glass utensils. The use of plastics may cause interferences with the analysis of samples.

8.0 SAFETY

8.1 The use of laboratory equipment and chemicals exposes the analyst to several potential hazards. Good laboratory techniques and safety practices shall be followed at all times. Approved PPE, which includes safety glasses, gloves, must be worn at all times in the lab. Lab coats are provided and may be worn. All Personal Protective Equipment (PPE) must be removed before leaving the laboratory area and before entering the employee lounge or eating area. Always wash your hands before leaving the laboratory.

8.2 All standards, reagents and solvents shall be handled under a hood using the proper PPE. All flammable solvents must be kept in the flammable storage cabinet, and returned to the cabinet immediately after use. When transporting chemicals, make sure to use a secure transporting devise and/or secondary outer container.

8.3 The chemist should have received in-house safety training and should know the location of first aid equipment and the emergency spill/clean-up equipment before handling any apparatus or equipment.

8.4 Extreme caution must be taken when using or handling knives, descalers, and grinders to homogenize the biota samples.

8.5 Re-useable cotton mesh glove liners may be worn under latex or PVC gloves as an additional measure when using sharp tools or knives, or when dealing with samples that have sharp teeth, spines, fins, or thorns. The mesh lining can help prevent piercing of the skin in case a tool or sample slips, during dissection or other preparation steps.

8.6 Polychlorinated biphenyls should be treated with extreme caution; as a class of chemical compounds they possess both toxic and suspected carcinogenic

properties.

8.7 All additional company safety practices shall be followed at all times as written in the Pace Analytical Chemical Hygiene Plan.

9.0 EQUIPMENT AND SUPPLIES

9.1 Cutting board-made of either glass or polyethylene.

9.2 Food processor with titanium cutting blade (small), or blender with stainless steel blades (large).

9.2.1 2- Retsch Grindomix (model GM200) with glass and or plastic mixing bowls

9.2.2 1-Kitchen Aid Little Ultra Power

9.2.3 1-Tor Rey (model M22) Large Food Processor

9.3 Knives: ceramic stainless steel, or titanium. (See Section 7.0 for interferences and/or contamination associated with different material knives and blades).

9.3.1 Gerber Stainless Steel Boning knives

9.3.2 Dexter Russel Chopping knives

9.3.3 Oneida Stainless Steel fillet knives

9.3.4 URI Eagle Ceramic Knife

9.4 Necropsy dissection kits

9.5 Analytical balance with precision to 0.01g.

9.6 Labconco multi-hazard glove box.

9.7 Advantage 200 LS Respirator Facepiece

9.8 Bench liner material (Lab Mat) and scissors.

9.9 Aluminum foil.

9.10 Plastic wrap or wax paper.

9.11 Titanium fork.

9.12 Teflon-coated spatula.

9.13 Teflon or stainless steel tweezers and dissection scissors.

9.14 PVC or Latex gloves.

9.15 Ruler.

9.16 Mallet.

9.17 Stainless steel or plastic strainer.

9.18 Salad spinner.

9.19 Pre-cleaned glass sample jars with Teflon or PTFE-lined caps.

9.20 Kim wipes.

9.21 Nylon bristled brushes for cleaning.

10.0 REAGENTS AND STANDARDS

10.1 **Deionized (DI) water**- Deionized (DI) water or reagent water is ASTM Type II laboratory reagent grade water or better (Type I).The Millpore NANO-pure system provides Type I water used in the metals laboratory for rinsing lab glass and plastic ware. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. If the purity of a reagent is in question, analyze for contamination.

10.2 **Hexane** - Pesticide grade

10.3 **Acetone** - HPLC grade

10.4 **Nitric acid 25%** - Add 250mL concentrated HNO3 to 400mL of reagent water and dilute to 1L in an appropriate flask. (See metals lab for this prepared solution).

10.5 **10% Bleach solution** - Add 100mL of commercial bleach to 500mL of reagent water and dilute to 1 liter in an appropriate beaker or flask**.**

10.6 **Alconox** - cleaning solution.

11.0 SAMPLE COLLECTION, PRESERVATION, SHIPMENT and STORAGE

11.1 Sample collection is not applicable to the Pace laboratory operation.

11.2 Please see the Pace SOP (NE227) that describes the responsibilities of sample custody including all proper documentation, verification, and tracking procedures following Chain of Custody (COC) protocols, sample receipt procedures, and Internal COC procedures for sample tracking include the use of sample tracking logbooks.

11.3 All samples should remain frozen at all times unless being tested. Fish usually arrive whole bodied or already filleted. Once received the sample must be ground and homogenized so that it may be analyzed. The homogenized fish tissue can be held for 6 to 12 months. The fish solvent extracts can be held for 3 months. Some

clients may request that the body and/or head of fish be saved once the fillets are cut out. Other biota material may have other specifications stated specifically for that project.

11.4 If samples are not shipped frozen, they will be stored in freezers at Pace Analytical upon arrival, and until processing. The samples must remain frozen and maintained at < -20˚C. Sample processing and extraction/digestion hold times are suspended by freezing the sample. Hold time monitoring is resumed when samples are removed from freezers for processing and then returned to freezers pending extraction or digestion. The organic hold time is 14 days from sample collection to extraction, and 40 days from extraction to analysis. The metals hold time is six months from sample collection to digestion and analysis. If mercury is to be determined, the hold time is 28 days from sample collection to digestion and analysis.

11.5 Tissue samples: As guidance, a minimum of 50 grams of sample must be collected for organic analyses, and 5 grams for metals analyses, in a glass jar with a Teflon or PTFE lined screw cap. The amount of sample needed, will depend upon the project management plan such as reporting limits and the need for MS/MSD and/or duplicate analyses. Extra sample must be collected, if possible, to allow the laboratory adequate sample volume in case of re-extract and reanalysis is needed. Large whole individual fillets or vegetation may be wrapped in plastic or aluminum foil depending upon the requested analyses. Large crustaceans, reptiles or amphibians may be individually packed in well-labeled Styrofoam coolers.

12.0 QUALITY CONTROL

12.1 Contamination Prevention

12.1.1 If the purity of a reagent is in question, analyze for contamination.

12.1.2 Blades for dissection may need to be re-sharpened between every few samples as needed.

12.1.3 Certain project specific sample preparation (weighing, skinning, compositing and homogenization) is performed in the glove box. Waste from the process must be treated with bleach before disposal. The outside surfaces of the sample containers being processed must be containerized, treated and disinfected before removal from the glove box.

12.2 The procedures described below are general cleaning and pre-processing procedures that are to be followed regardless of the type of tissue being processed. Samples are prioritized by the Laboratory Supervisor or Lab Manager based on hold time and client due date. All weights, measurements and other project required observations are recorded in LIMS.

12.2.1 Wash all utensils, sample processors (blades, blade post, cup and lid) and cutting boards with an Alconox solution and a sponge. Rinse thoroughly with tap water, then with DI water.

12.2.2 If the samples are going to be processed for organic analyses only, rinse

all washed utensils, processor parts and surfaces with hexane followed by rinsing with acetone.

12.2.3 If samples are going to be processed for metal analyses only, rinse all plastic and ceramic utensils with DI water and then Nitric acid 25% solution and then DI water again.

12.2.4 If requested by the client, the equipment or processing blank should be collected at this time by pouring DI water into and out of the processor, over the surfaces of the utensils and over the cutting board. The blank is collected in the appropriate container, at the project specification frequency, for the determinative analysis.

12.2.5 Gloves must be worn when handling tissue samples. Latex gloves may be worn. All gloves must be talc or dust free.

12.2.6 Tissue samples should be partially thawed before starting, to the point where it becomes possible to make an incision in, or cut through, the flesh. When samples are completely thawed they become soft and difficult to cut or fillet. NOTE: If whole bodies are not being processed, and the tissue is partially frozen during dissection, there is less of a chance of puncturing the gut cavity and any internal organs. Inadvertent puncture of the internal organs may contaminate the part(s) of the animal that have been selected for analysis. Also, internal organs may rupture during freezing. If this is observed during dissection, it must be noted in the processing records. Note any morphological abnormalities on the processing records.

12.3 Hold times: The homogenized fish tissue can be held for 6 to 12 months. The fish solvent extracts can be held for 3 months.

13.0 CALIBRATION AND STANDARDIZATION

13.1 Not Applicable

14.0 PROCEDURES

14.1 Fish Tissue Preparation:

14.1.1 Determine the wet weight for each individual fish using a calibrated balance and record in LIMS. The balance should be covered with aluminum foil if aluminum is not a metal of concern. If aluminum is a metal of concern and the sample will not be analyzed for organic compounds the balance should be covered with plastic wrap. If the sample is for both metal and organic compounds, wax paper may be used. Catch any excess fluid coming from the thawing specimen into the wax paper, foil or plastic wrap. All liquid from thawed whole fish must be kept as part of the sample. The technician must remember to zero the balance with the aluminum foil, plastic wrap, or wax paper on it before weighing the specimen. The foil, plastic wrap, or wax paper must be changed after each weighing.

14.1.2 Determine the length of each fish using a ruler, and record in LIMS. Some measurements may, or may not be, a part of the project specifications.

14.1.3 If gender identification is needed this must be done prior to the scaling and filleting processes.

14.1.4 Removal of Scales or Skin: If required by project specifications, the scales and/or skin of the fish will be removed prior to filleting.

14.1.5 Lay the fish on the cleaned, and/or lined, cutting board.

14.1.6 Scrape the fish from tail to head using the electric, automated descaler with ceramic claws to remove the scales. Note: If performing metals analysis, titanium or ceramic must be used.

14.1.7 Rinse the cutting board between fish with DI water and Alconox. If plastic, wax paper, or foil is used, change between fish.

14.1.8 Rinse the outside of the fish with DI water and pat dry with paper towel Place the fish on its side, on a clean cutting board, for filleting or skinning.

14.1.9 To skin the fish, loosen the skin behind the gill cover and pull the skin off toward the tail with a Catfish skinning tool, cutting lightly along the inside of the skin, Slowly separate the skin from the muscle tissue of the body or the fillet.

14.2 Filleting the Fish

14.2.1 Using fresh gloves and the specified knife, make a cut behind the entire length of the gill cover, making sure to cut through the skin, if still attached, flesh, and as close to the bone as possible. Note: If the fish samples are small, and it appears difficult to fillet, or if the amount of the fillet appears to be insufficient for the analysis, consult the Project Manager prior to filleting. In some cases it may be necessary to homogenize the whole body.

14.2.2 Make a cut across the base of the tail fin keeping as close to the caudal fin (tail) as possible. Continue cutting along the underbelly of the fish moving from the head to the tail.

14.2.3 Go back to the cut made at the beginning at the gill cover and slice down the entire length of the fish following along the backbone until reaching the cut previously made across the tail.

14.2.4 Remove the fillet from the fish. Be sure to include the belly flap in each fillet and do not remove the dark muscle tissue in the vicinity of the lateral line from the light muscle tissue that makes up the rest of the muscle tissue mass.

14.2.5 Remove any bones that may be left attached to the fillet. Repeat the fillet

steps for the second side of the specimen.

14.2.6 The general procedure recommended for filleting fish is illustrated in Apendix 1.

14.2.7 Note in the sample processing records in LIMS if the internal organs were ruptured during freezing or if inadvertent puncture of the internal organs occurred during the filleting process, rinse the fillet(s) tissue with DI water.

14.2.8 Cover the balance with the appropriate clean lining, and weigh the fillet(s). Record the fillet(s) weight(s) in the processing records.

14.2.9 If the fillet(s) and/or the carcass are to be homogenized immediately, proceed to Section 14.3. If not, rinse all fish parts with DI water and store in the appropriate container; see Section 9.0 for allowable materials. Note that it may be necessary to chop the fillet(s) or carcass into smaller pieces, with the appropriately cleaned knife, before storage, and before homogenization, so the entire sample will fit into the storage container or the homogenization vessel. If the samples will not be homogenized immediately, the samples must be placed back into the freezer, until homogenization.

14.3 Homogenization

14.3.1 Allow the fillet(s), carcass or whole body to partially thaw. Retain all fluids as part of the sample.

14.3.2 Homogenize whole fish bodies, carcasses, or fish fillets by placing them into the small or large food processor fitted with the appropriate blades. The sample may need to be cut into smaller pieces for processing. Process the sample until it appears to be fully and consistently homogenous. Continue to grind the sample until there are no chunks present in the homogenate. The homogenous nature of the sample is vitally important for reproducible results. Sample should be homogenized fully and thoroughly.

14.3.3 Individual homogenates may be processed further to prepare composite homogenates as required by project specifications. Composite homogenates must be prepared from equal weights of individual homogenates. All individual weights that make up one composite must be recorded, if required, or one composite weight may be recorded. If individual or composite homogenates were frozen prior to extraction/digestion, these homogenates must be thawed and re-homogenized by hand mixing prior to being extracted or digested.

14.3.4 Place the individual or composite homogenized samples into the appropriate glass jars to be frozen pending future extraction/digestion. If the samples will not be extracted/digested immediately, the samples must be returned to the freezer until extraction/digestion.

14.3.5 All utensils and equipment must be washed in between samples

according to the procedures described previously in Section 12.2.

14.4 Mollusk (Bivalves) Preparation (Mussels, Clams)

14.4.1 Wash all utensils, the cutting board, and surfaces as previously described in Section 12.2. Obtain samples from freezer.

14.4.2 If required by the project specifications, measure and record the length of the sample shell. Cover the balance with the proper material as described in Section 9.0, and weigh and record the sample weight in LIMS.

14.4.3 Wearing the proper gloves, place the sample on a clean, cutting board. Samples should be partially thawed. If the sample is frozen, it will be difficult to break open the shell. If the sample is excessively thawed, the internal tissue will become soupy and difficult to remove.

14.4.4 If preparing bivalve specimens, use the titanium knife to cut the abductor muscle by sliding the knife through the crevice where the two shells meet. Once the abductor muscle is cut the two shell pieces should come apart easily.

14.4.5 Carefully remove the top shell, and using the Teflon coated spatula, scoop out the internal tissue that is resting on the mantle.

14.4.6 Cover the balance with the proper material and weigh the amount of tissue obtained from the sample. Record the weight along with the information previously recorded on the processing records. The sample may now be stored pending homogenization in the appropriate jar.

14.4.7 Since the amount of tissue obtained from one bivalve is generally small, several specimens are frequently combined to make one sample. Utensils do not need to be rinsed between the individual samples that comprise one composite, but utensils must always be rinsed in between each composite sample.

14.4.8 After the tissue has been removed from all of the specimen shells for one composite or individual sample, place the tissue in the clean small processor with the titanium blade to be homogenized. Grind the sample until it appears to be fully and consistently homogenized and there are no large chunks.

14.4.9 If tissue is being processed for volatile organic carbon (VOC) analysis the homogenization must be done by hand.

14.4.10 Individual homogenates may be processed further to prepare composite homogenates as required by project specifications. Composite homogenates must be prepared from equal weights of individual homogenates. All individual weights that make up one composite must be recorded, if required, or one composite weight may be recorded. If individual or composite homogenates were frozen prior to extraction/digestion, these homogenates must be thawed and re-

homogenized by hand mixing prior to being extracted or digested.

14.4.11 Place the processed samples into the appropriate glass jars to be frozen for future extraction/digestion, and place back into the freezer.

14.4.12 All utensils and equipment must be washed in between samples according to the procedures described previously in Section 12.2.

14.5 Crustaceans (Lobsters, Crabs, Shrimp)

14.5.1 Wash all utensils, the cutting board, and surfaces as previously described in Section 12.2. Obtain samples from the freezer.

14.5.2 If project specifications require gender determination of lobsters, this must be done prior to dissecting. To determine the gender, hold the lobster by the thorax, and flip it over to examine the underneath abdomen, just below the legs and where the abdomen division begins, there is a first pair of swimmerets. The first pair of swimmerets is what is used to distinguish the lobster's gender. If the first pair is soft, has small hairs, and the swimmerets are crossed, it is female. On a male lobster, the first pair of swimmerets is hard and stiff, and generally do not touch.

14.5.3 If the hepatopancreas of the lobster samples is to be analyzed, the lobster samples must be received alive. If the samples are frozen prior to dissection, the hepatopancreas will burst upon thawing making it impossible to remove. To remove the hepatopancreas, the live lobster should be placed on a cleaned cutting board. Wearing the proper gloves, one analyst holds claws out in front of the lobster, while also holding down the lower abdomen and tail. The second analyst takes a titanium-coated knife, and places it on the grove in the outer shell, just behind the head region. Keeping the knife at an angle, the second analyst must push down and forward, to remove the head. Once the head is removed, the hepatopancreas can be seen lying just under the carapace and running the length of the thorax. The hepatopancreas is generally a greenish-yellow color, but there may be some variation. Using the Teflon coated spoon, scoop the hepatopancreas out gently trying not to break it into pieces. Cover the tray of the balance with the proper material, and weigh and record the weight of the hepatopancreas in the processing record, and place it into an appropriate sample jar for freezing and future extraction/digestion.

14.5.4 To remove the edible meat, remove the two claws from the body of the lobster at the joint. Place a piece of lab mat or paper towel over the claw and pound with a mallet. Once the shell is crushed, remove the meat, using the appropriately cleaned tweezers or other tool, making sure to get all the meat in the joints and arms. Cover the balance tray with the appropriate material and record the total tissue weight arms. Record this weight with the previously recorded information from the two claws and sample processing record.

14.5.5 Remove the abdomen and telson from the rest of the outer shell by pulling the lobster apart. Using the titanium coated knife, cut through the

center underside tissue of the lobster and laterally along the exoskeleton of the tail. Once the abdomen and tail have been cut open, separate the shell from the edible meat using cleaned utensils. Any eggs found in the female lobsters will have to be removed and discarded or sampled separately. Cover the balance tray with the appropriate material, and record the weight of the tissue obtained from the abdomen and telson on the processing record. The sample may now be stored pending homogenization in the appropriate jar.

14.5.6 If removing tissue from crabs, break off all legs and claws. Squeeze, pull, or pick all the tissue out of the legs and claws. Pull apart the outer shell. Scoop out the tissue using a Teflon coated spatula. Cover the balance tray with the appropriate material, and record the weight of the tissue obtained from the abdomen and telson on the processing record. The sample may now be stored pending homogenization in the appropriate jar.

14.6 Mammals (Mice, Mink, Muskrat, Shrew)

14.6.1 Wash all utensils, the cutting board, and surfaces as previously described in Section 12.2. Obtain samples from the freezer.

14.6.2 Place the first specimen partially thawed to be processed, and all equipment needed into the glove box/Bio-hood on a freshly laid out lab mat (Blue diaper).

14.6.3 Once all materials are in the glove box and set up for use, seal the transfer box and ensure the motor blower is on. Over tightening of the outer or inner door knobs is not necessary to achieve a good seal. Place your hands into the gloves attached to the glove ports and place Latex gloves over the glove port gloves for use. The outer Latex gloves will need to be changed in between each sample.

14.6.4 If the gender of the mouse or shrew needs to be determined, turn the animal over and note the length of the anus and the distance of the anus from the tail. If the anus is elongated in shape and does not touch the base of the tail, testicles and a large genital papilla are visible, and there are no nipples, the animal is male. If the anus is round in shape and almost touches the base of the tail and/or there are nipples (up to five sets), the animal is female. If the animal is very small, young or immature and a gender determination cannot be made, note that the gender is non determinable. Record the gender observations on the processing records.

14.7 Organ Dissection/Processing

14.7.1 If the mammal is being dissected for Brain, Liver, Kidney, Heart, Lung, or Adipose (Fat) tissue, each organ will need to be harvested.

14.7.2 Place the animal on its back with forceps. Pinch the skin at the base of anus and carefully make an incision at the tail end, and cut just below the skin along the abdomen and past the chest cavity. Cutting the skin flap

at the abdomen cavity carefully separate the adipose tissue from the muscle tissue. Below it should be a white/yellow material. Take this material out.

14.7.3 Identify each organ and remove them from the abdomen cavity.

14.7.4 Weigh and record the weight of the mammal organs and place into the appropriate container.

14.7.5 The rib cage will need to be cut with scissors. Once chest cavity is open, remove the heart and lungs.

14.7.6 Weigh and record the weight of the mammal organs and place into the appropriate container.

14.7.7 Since the amount of tissue obtained from one animal may be small, manually grinding of the organs may need to be done at the time of extraction.

14.7.8 Place the processed samples into the appropriate glass jars to be frozen for future extraction/digestion into the freezer.

14.7.9 Before removing any equipment all utensils and equipment must be washed with DI water and 10% bleach solution.

14.7.10 All disposable materials must be double bagged for disposal.

14.8 Whole Animal Processing:

14.8.1 If skinning of the mammal is required, carefully make an incision at the tail end and cut just below the skin along the back, from one hind leg to the other. Make another cut from one hind leg to one front leg and repeat the cut on the other side of the animal. Starting from the tail, lift the skin flap, and carefully separate the skin from the muscle tissue below. Pull the skin forward from the tail to the head to expose the back tissue of the animal. Repeat the procedure on the stomach side of the animal. Note: it may be very difficult to remove the skin from the legs, head, and tail. If some skin cannot be removed, note this on the processing records.

14.8.2 Weigh and record the weight of the mammal on the processing records. Depending upon the size of the mammal, it may need to be chopped into small pieces before being ground. Generally, mice and shrew can be quartered before homogenization if needed.

14.8.3 Put the whole body or chopped sample into the cup of the grinding unit. Turn the grinding unit on low speed and gradually increase the speed to homogenize the sample being careful to minimize any splatter or outside contamination. Homogenize until a uniform consistency is achieved.

14.8.4 Transfer the homogenized sample from the cup to the pre-labeled sample jar using the appropriate utensil. Clean the outside of the sample

jar with the 10% bleach soaked Kim wipe.

14.8.5 To clean the grinding unit in between samples, remove as much residual tissue on the blade as possible by operating the unit at low or medium speed, using DI water and 10% bleach. Rinse unit with DI water if metals are being done and/or hexane or acetone for organics.

14.8.6 Repeat steps 14.9.2 through 14.9.5 until the samples are complete.

14.8.7 Since the amount of tissue obtained from one mouse or shrew may be small, several specimens may be combined to make one sample, as required by project specifications. Utensils do not need to be rinsed between the individual samples that comprise one composite, but utensils must always be cleaned in between each composite sample.

14.8.8 If several specimens will be composited to make one sample, follow the applicable Sections of 14.9.2 through 14.9.5, for each of the specimens. The tissue obtained from each specimen may be weighed and recorded individually, then totaled for the composite weight. If only one composite weight is sufficient for the project specifications, weigh the entire composite and record that weight in LIMS.

14.8.9 Place the processed samples into the appropriate glass jars to be frozen for future extraction/digestion, placed back into the freezer.

14.8.10 Before removing any equipment all utensils and equipment must be washed with DI water and 10% bleach.

14.8.11 All disposable materials must be double bagged for disposal.

14.9 Reptiles and Amphibians (Frogs and Turtles)

14.9.1 Wash all utensils, the cutting board, and surfaces as previously described in Section 12.2. Obtain samples from the freezer

14.9.2 Wearing the proper gloves, place the turtle sample on the cleaned cutting board. The turtle should be partially thawed. If the turtle is frozen, it will be difficult to remove the muscle. If the sample is excessively thawed, the internal tissue will become soupy and difficult to remove.

14.9.3 Take all project required measurements. The distance between the anterior and posterior edge of a turtle carapace (top of shell) should be measured with a ruler and recorded on the processing records. If the entire mass of the turtle, including the shell, needs to be recorded, cover the balance with the proper material and weigh and record this weight in LIMS.

14.9.4 Since the bottom of shell and carapace are extremely dense and difficult to cut through with normal dissecting tools, the muscle tissue of the turtle must be removed by cutting the body of the turtle away from the shell. Insert a knife, made of the proper material, into the skin of the turtle, close to the shell on the lower half of the body. Slowly, cut along the

entire circumference of the shell. Repeat the procedure on the upper half of the body, on both sides of the shell.

14.9.5 With dissection scissors or a ceramic or titanium paring knife of the proper material, remove the skin from the hind limbs, tail, and fore limbs and neck. Remove any visible muscle tissue within the carapace. Most of this tissue will be found in the upper portion of the carapace around the pectoral area.

14.9.6 Using the appropriate utensils, remove the muscle tissue from the tail, neck, hind limbs, and fore limbs, including the feet, leaving bone and claws behind.

14.9.7 Cover the balance with the proper material and weigh the amount of tissue of the turtle sample. Record the weight along with the information previously recorded on the processing records. The sample may now be stored pending homogenization in the appropriate jar.

14.9.8 If processing frogs, allow the frogs to partially thaw, take the project specific measurements, and record them in LIMS. The number of frogs required to make up one sample, and the weight and length of the individual frogs, must be taken and recorded, if specified. In all cases, the skin must be removed from the frog prior to processing and chopped into smaller pieces, due to its thickness. It will then be added to the processor with the whole body of the frog, or it may be discarded depending upon the project specifications.

14.9.9 To skin the frog, make an incision, using the proper utensils, and cut into an area where there is an excess of skin, most likely around the neck. Slowly, pull the skin off of the frog using dissecting scissors, or a ceramic or titanium paring knife, as needed. Once skin is removed, chop it up into tiny pieces using the appropriate knife and set it aside to be processed with the whole frog body.

14.9.10 Cover the balance with the proper material and weigh the amount of tissue obtained from the frog samples if the tissue and the whole body will not be processed. Record the weight along with the information previously recorded on the processing records. The sample may now be stored pending homogenization in the appropriate jar.

14.9.11 Since the amount of tissue obtained from one small turtle or frog may be insignificant, several specimens may be combined to make up one sample. Utensils do not need to be rinsed between the individual samples that comprise one composite, but utensils must always be rinsed in between each composite sample.

14.9.12 If several specimens will be composited to make up one sample, the tissue obtained from each specimen may be weighed and recorded individually, then totaled for the composite weight. If only the composite weight is sufficient for the project specifications, weigh the entire composite and record that weight in LIMS.

14.9.13 After the tissue has been removed from all of the specimens, homogenize the muscle tissue, and skin if required, by placing it into the small or large food processor fitted with the appropriate blades. The sample may need to be cut into smaller pieces for processing. Grind the sample until it appears to be fully and consistently homogenous. Continue to grind the sample until there are no chunks present in the homogenate.

14.9.14 Individual homogenates may be processed further to prepare composite homogenates as required by project specifications. Composite homogenates must be prepared from equal weights of individual homogenates. All individual weights that make up one composite must be recorded, if required, or one composite weight may be recorded. If individual or composite homogenates were frozen prior to extraction/digestion, these homogenates must be thawed and re-homogenized by hand mixing prior to being extracted or digested.

14.9.15 Place the processed samples into the freezer to be frozen for future extraction/digestion.

14.9.16 All utensils and equipment must be washed in between samples according to the procedures described previously in Section 12.2.

14.10 Macro Invertebrates (Benthic Worms, Eels, Insects and other Biota)

14.10.1 Wash all utensils, the cutting board, and surfaces as previously described in Section 12.2. Obtain samples from the freezer.

14.10.2 Cover the balance tray with the appropriate material and record the weight of the invertebrate sample. Since the weight obtained from one invertebrate (benthic worm, insect, biota) may be small, several invertebrates may be combined to make one sample. In many cases, several invertebrates of the same species and sample location are delivered to the laboratory in one sample jar. Each specimen from this jar must be weighed, if requested, and composited to form one homogenized and unique sample. If only one composite weight is sufficient for the project specifications, weigh the entire composite and record that weight. Utensils do not need to be rinsed between the individual samples or specimens that comprise one composite, but utensils must always be rinsed between each composite sample.

14.10.3 Invertebrates such as eels must be chopped into smaller pieces before homogenization. This is generally due to the length of the specimen and the thickness of the skin.

14.10.4 Place the weighed specimen into the clean small processor with the titanium blade to be homogenized. Process the sample until it appears to be fully and consistently homogenized and there are no large chunks.

14.10.5 Individual homogenates may be processed further to prepare composite homogenates as required by project specifications. Composite homogenates must be prepared from equal weights of individual

homogenates. All individual weights that make up one composite must be recorded, if required, or one composite weight may be recorded. If individual or composite homogenates were frozen prior to extraction/digestion, these homogenates must be thawed and re-homogenized by hand mixing prior to being extracted or digested.

14.10.6 Place the processed samples into the appropriate glass jars to be frozen for future extraction/digestion, into the freezer.

14.10.7 All utensils and equipment must be washed in between samples according to the procedures described previously in Section 12.2.

14.11 Vegetation (Coastal and Wetland Grasses/Plants)

14.11.1 Wash all utensils, the cutting board, and surfaces as previously described in Section 12.2. Obtain samples from the freezer.

14.11.2 Wearing the appropriate gloves, plants must be rinsed with DI water to remove soil, silt, small insects, and other debris. Place the plants in a stainless steel or plastic strainer, depending on the determinative sample analysis, and rinse thoroughly with DI water. If analyzing the sample for both metals and organic compounds, rinse the plants carefully over a sink, being sure not to touch the sides of the sink with the plant sample.

14.11.3 Depending on the size and texture of the plants, some may be homogenized in the small food processor with the titanium blade. Samples such as long grass will have to be chopped into small pieces (approximately ½ inch) using titanium or ceramic knives. Leaves can generally be homogenized in the small food processor without pre-cutting.

14.11.4 Cover the balance tray with the appropriate material and record the weight of the plant sample. Since the weight obtained from one plant may be small, several plants may be combined to make one sample. Utensils do not need to be rinsed between the individual samples that comprise one composite, but utensils must always be rinsed in between each composite sample.

14.11.5 If several plants will be composited to make one sample, the weight of each specimen may be recorded individually, and then totaled for the composite weight. If only one composite weight is sufficient for the project specifications, weigh the entire composite and record that weight in LIMS.

14.11.6 After the plant weight for one composite or individual sample has been recorded, place the plant(s) in the clean small processor with the titanium blade to be homogenized, or place them onto the cleaned cutting board to be chopped. Grind or chop the plants until they appear to be fully homogenized.

14.11.7 Individual homogenates may be processed further to prepare composite homogenates as required by project specifications. Composite

homogenates must be prepared from equal weights of individual homogenates. If required, all individual weights that make up one composite must be recorded, otherwise one weight may be recorded for the composite. If individual or composite homogenates were frozen prior to extraction/digestion, these homogenates must be thawed and re-homogenized by hand mixing prior to being extracted or digested.

14.11.8 Place the homogenized plants back into the freezer to be frozen for future extraction/digestion.

14.11.9 All utensils and equipment must be washed between samples according to the procedures described previously in section 12.2.

15.0 CALCULATIONS

15.1 Not Applicable

16.0 METHOD PERFORMANCE

16.1 Not Applicable

17.0 POLLUTION PREVENTION

17.1 Refer to SOP Pace054 and Pace089 for instructions on the disposal of waste generated during the procedures previously mentioned.

18.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA FOR QUALITY CONTROL MEASURES

18.1 Not Applicable

19.0 CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

19.1 Not Applicable

20.0 CONTINGINCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

20.1 Not Applicable

21.0 WASTE MANAGEMENT

21.1 Refer to SOP Pace054 and Pace089 for instructions on the disposal of waste generated during the procedures previously mentioned.

22.0 REFERENCES

22.1 NELAP “Quality Systems” Manual, 2005.

22.2 U.S.EPA SW-846 "Test Methods for Evaluating Solid Waste; Volume 1B Laboratory Manual Physical/Chemical Methods", Office of Solid Waste and Emergency Response, Third Edition, Final Update III, December 1996.

22.3 EPA/6OOIR-961027, Guidance for the Preparation of Standard Operating Procedures (SOPS) for Quality Related Documents, 1996.

22.4 US EPA 823-R-95-007, "Guidance for Assessing Chemical Contaminated Data for Use in Fish Advisories", Volume 1: Fish Sampling and Analysis 2nd Edition, Office of Science and Technology, Office of Water, 1995.

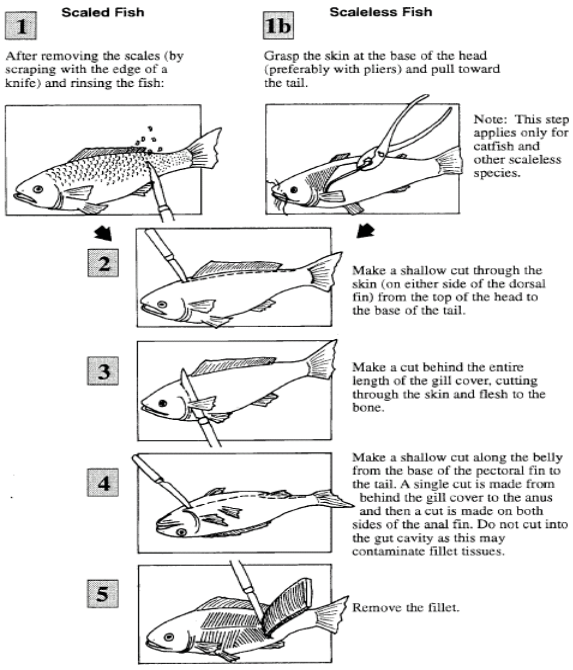
22.5 U.S. EPA, 1991d

23.0 ATTACHMENTS

23.1 Fish Filleting Diagram

23.2 Fish External & Internal Anatomy

Fish Filleting Diagram



23.2 FISH EXTERNAL/INTERNAL ANATOMY

EXTERNAL ANATOMY

1. Remove one fish from the storage tank, place in dissecting pan. Make sure fish is euthanized prior to any dissection.

2. Locate all fins (Figures 1a and 1b):
   Paired: pectoral (caudal to head, located ventrolaterally)
   pelvic (cranial to anus, located ventrolaterally)

   Single: dorsal (caudal to head on dorsal midline)
   adipose (caudal to dorsal fin on dorsal midline; salmonids)

   Anal: (Caudal to anus on ventral midline)

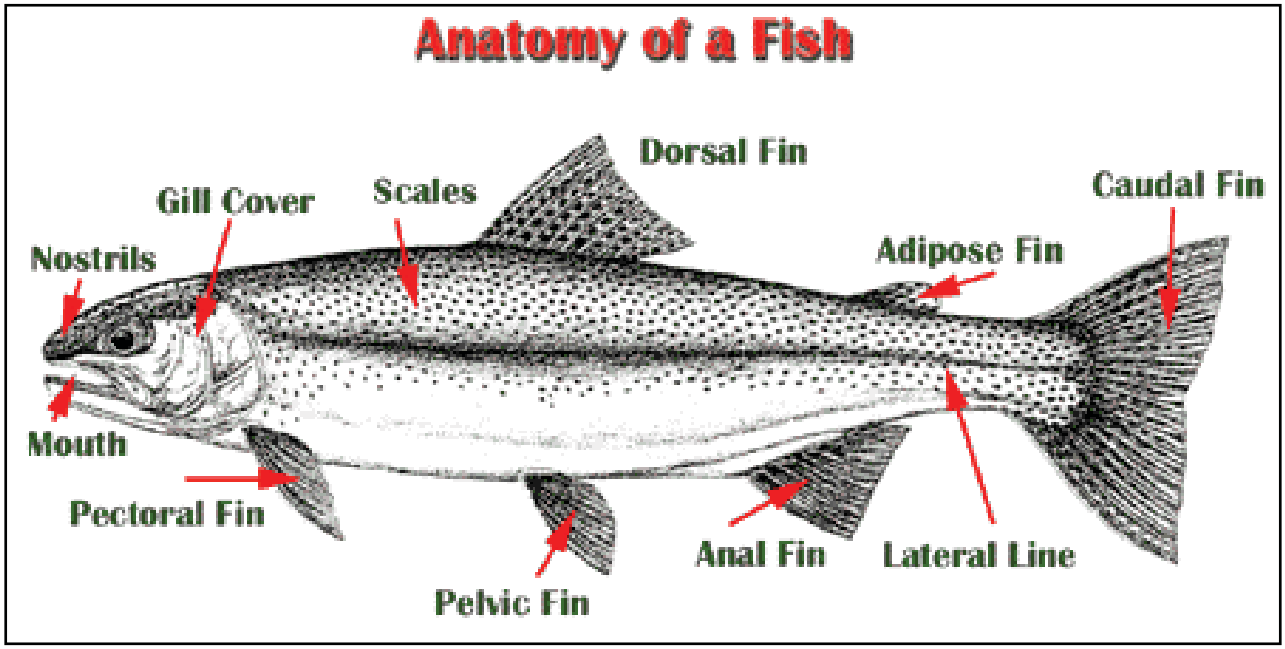


Figure 1a. Anatomy of a Fish (typical salmonid)

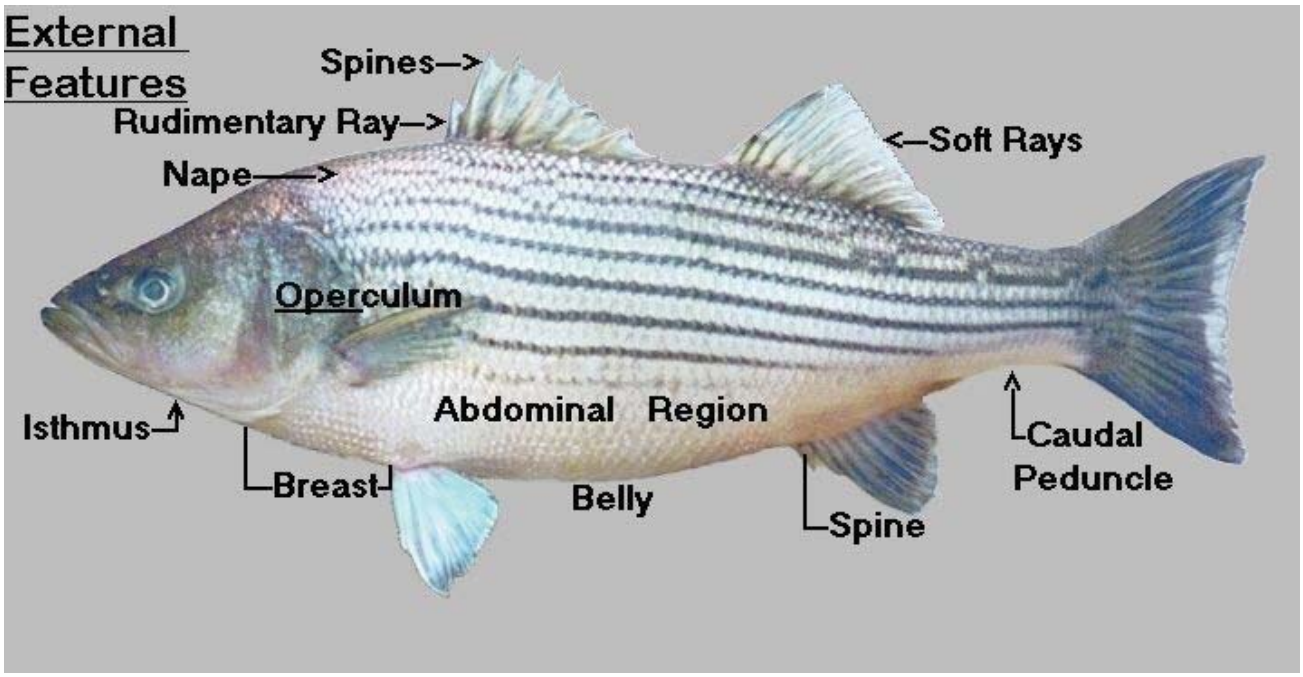


Figure 1b. External Anatomy of Striped Bass

3. Find the lateral line located laterally at mid-body running from head to tail. It arches dorsally over the operculum.

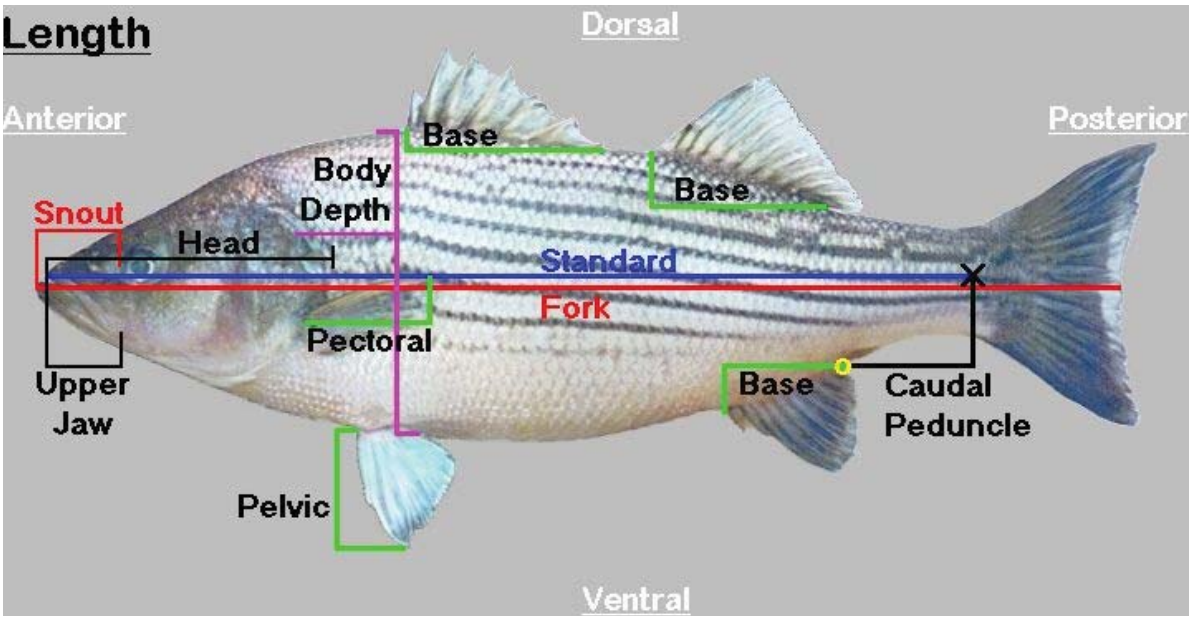


Figure 1c. Typical Measurements Locations

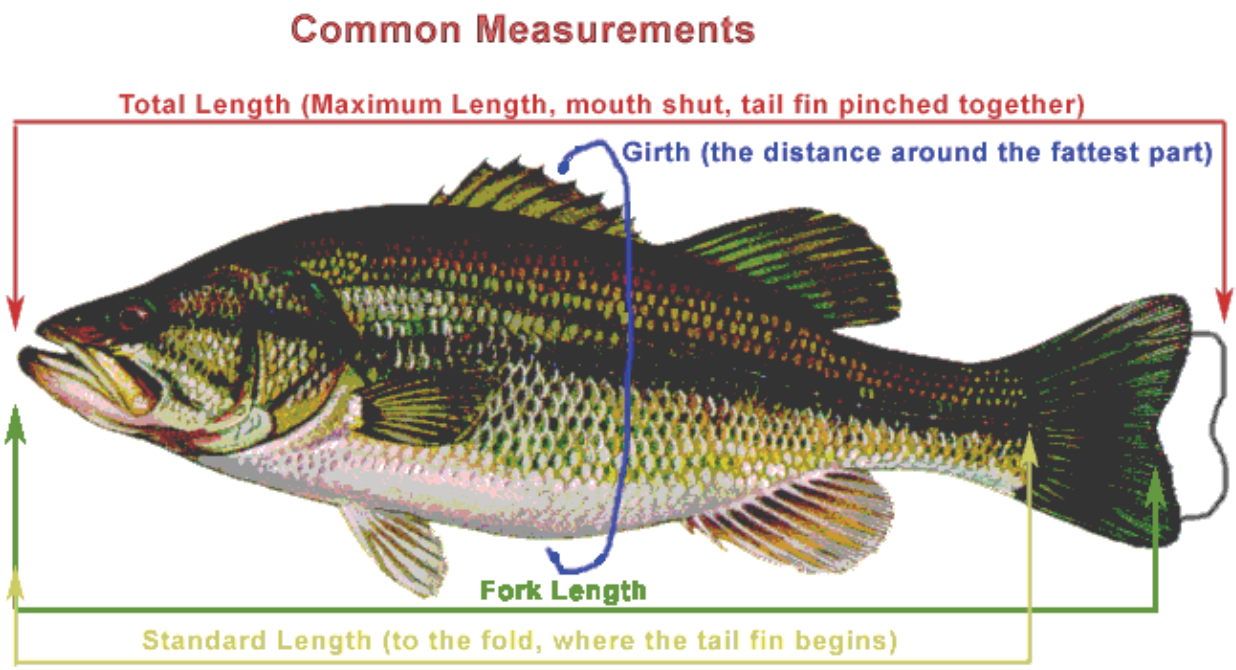
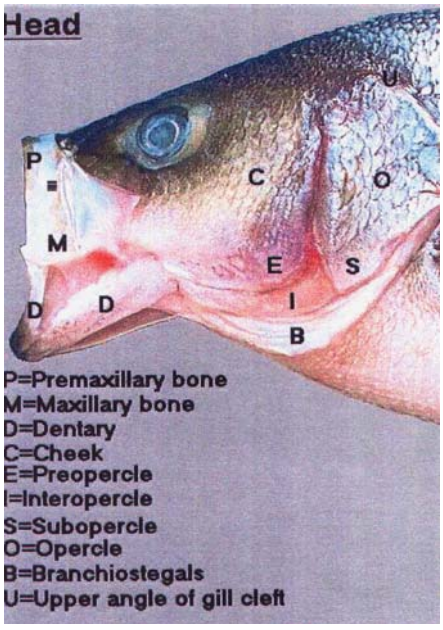
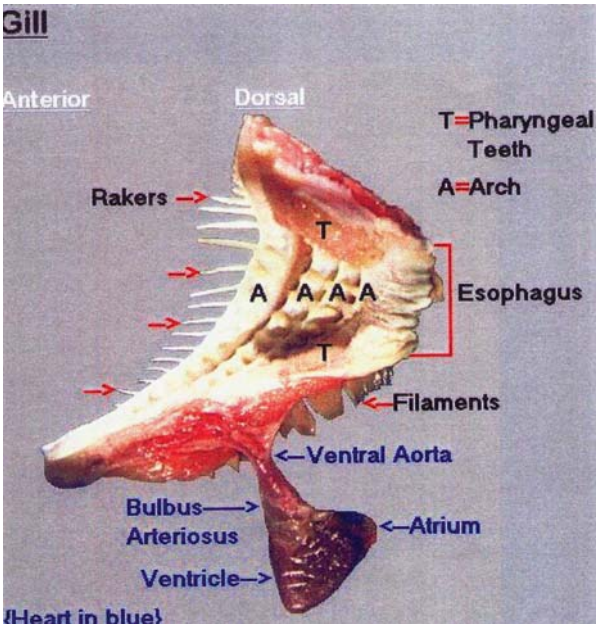


Figure 1d. Typical Measurements of Large Mouth Bass

4. The operculum covers the gills. Lift the opercular flap and identify the bony gill arches, cartilagenous gill filaments, and primary lamellae projecting off the gill filaments (Figures 1f, 1g)





5. Lay the fish on its right side with the head to your left. Open the body cavity with three cuts (Figure 1h). The first cut should originate just craniad to the anus and run cranial to a point ventral to the operculum. The second cut originates from the same point as the first and runs craniad along the dorsum of the body cavity to a point just dorsal to the operculum. The third cut connects the first two. All cuts should be made carefully with the blunt tip of the scissors in the body cavity while applying slight upward pressure to avoid damaging internal organs. Lift off the body wall.

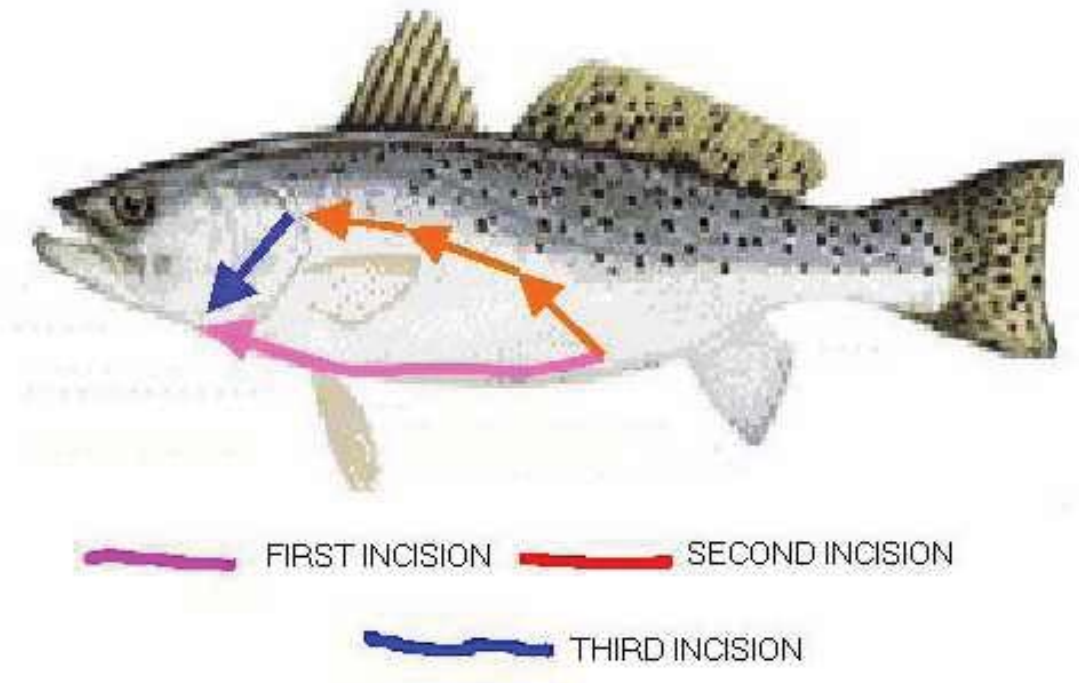
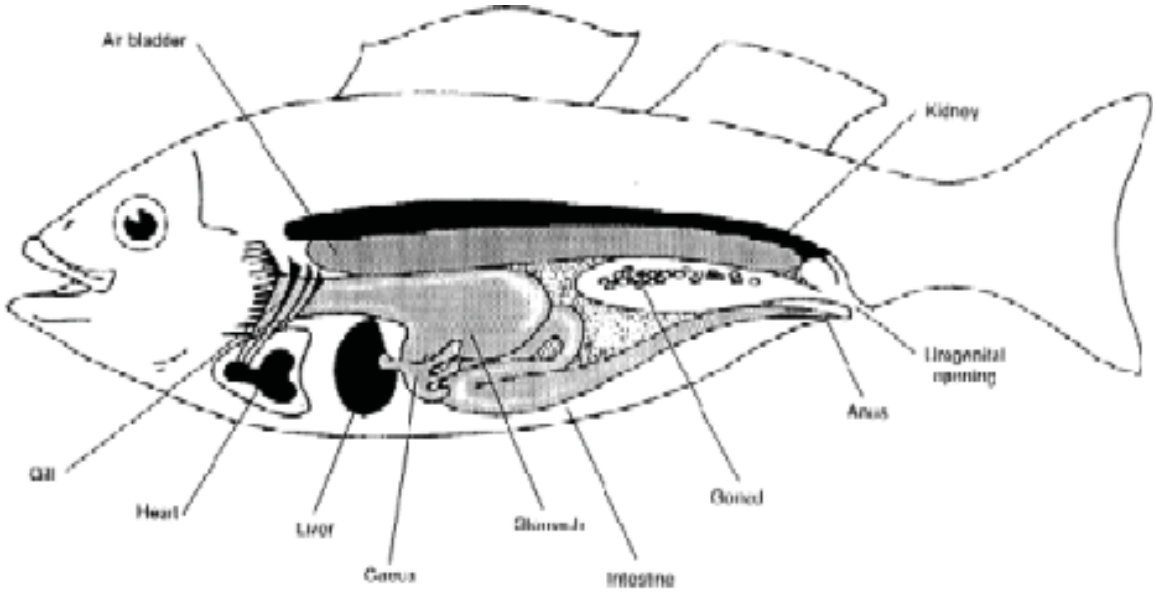
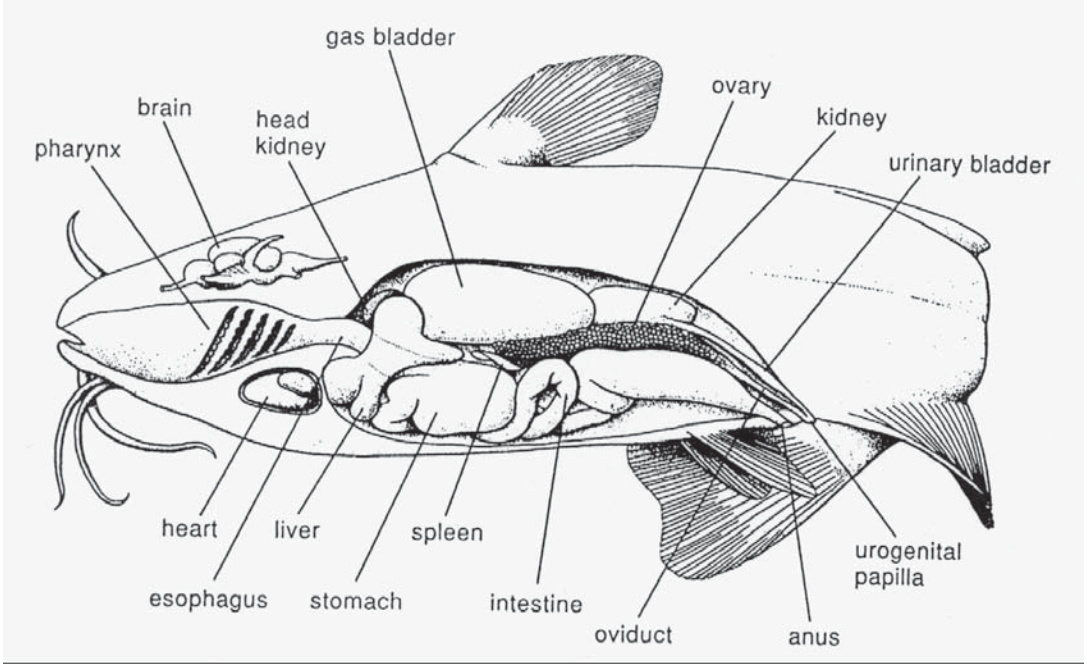


Figure 1h. Incisions to Expose Abdominal Cavity

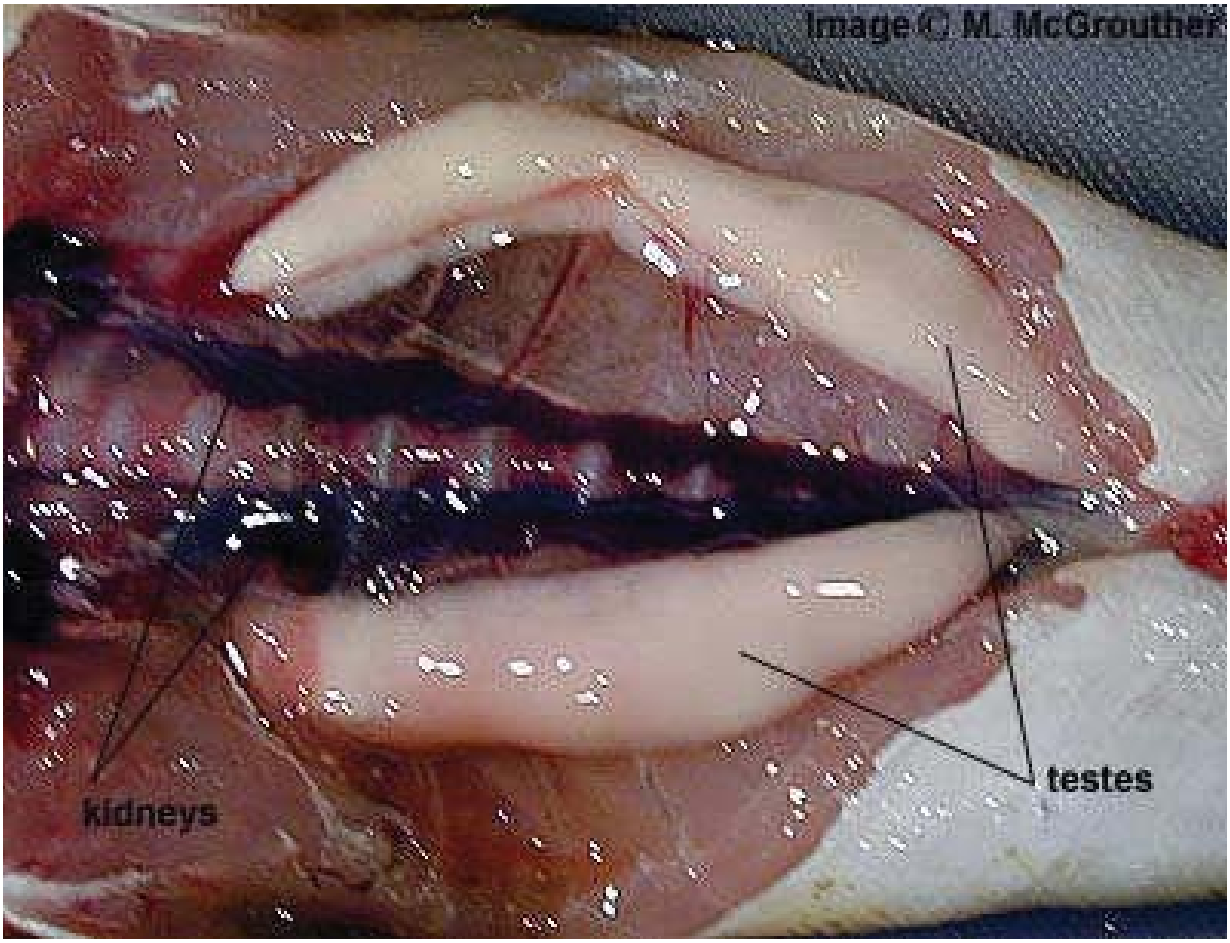
INTERNAL ANATOMY



Identify the gastrointestinal tract (Figures 1i-1,2). Pass a blunt probe through the oral cavity, pharynx, esophagus and into the stomach. Many fish species have pyloric cecae, which are blind sacs projecting from the aborad portion of the stomach. The stomach empties into the intestine, a long tubular structure supported by thin membranes called mesenteries. The intestine terminates at the anus. In fish the intestine is not divided into three distinct regions. The length and complexity of the intestine is directly proportional to the amount of plant matter consumed (herbivorous species have longer intestines). Open the stomach and intestines and note the normal texture and appearance of the lining, or mucosa. The intestinal mucosa will often exhibit lesions when enteric of systemic disease is present. The spleen is a small dark red organ attached to the mesenteries just caudal to the stomach. There may be more than one spleen. The main auxiliary digestive organs are the liver and pancreas. The liver is a large, tan, often leaf-shaped organ just caudal to the heart. The liver is a good site to see many lesions and is also a good site from which to isolate bacterial and viral pathogens. The location and size of the pancreas varies by species. The most common location is interspersed within the liver parenchyma. It may or may not be grossly visible. Cut the intestine near the anus, cut the esophagus and remove the gastrointestinal tract.



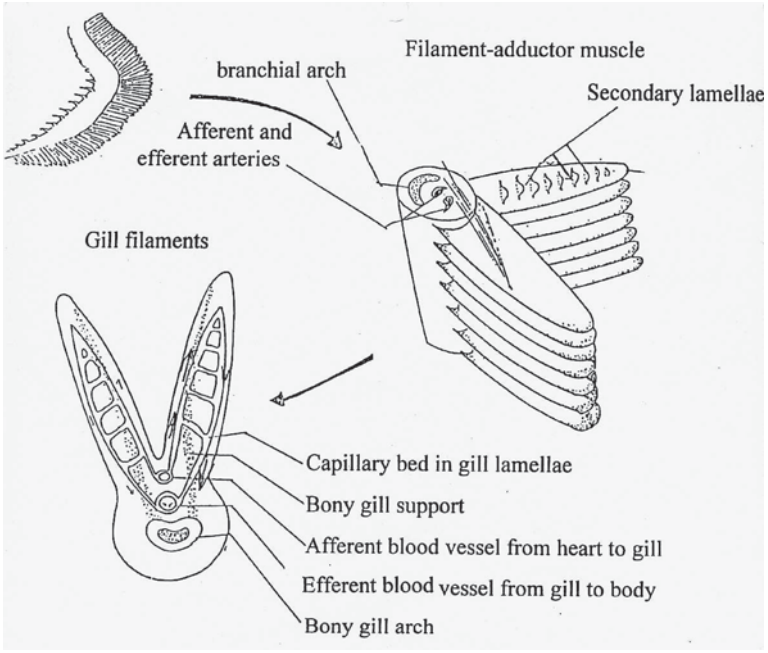
7. Locate the gonads, either ovaries or testes. Ovaries will appear as numerous spherical structures that may comprise up to 70% of body weight. Testes may comprise up to12% of body weight. In mature animals they will appear as a soft white organ suspended from the dorsal body wall. Also, if you don't see either of these organs, you might be working with an immature specimen. Note body length and compare to literature on the species/specimen you are working with.



The gonads and kidneys of an Eastern Blue-spotted Flathead. The gonads (testes) are the large, pale organs and the kidneys are the red tissue either side of the backbone.

8. Along the dorsum of the body cavity lies the swim bladder. It is a thick-walled white organ. Occasionally you may see hemorrhages in the swim bladder.

9. The kidneys also lie in the dorsum of the body cavity. The head kidney and trunk kidney are roughly divided by the swim bladder. In some species (e.g., salmonids) the kidneys are almost fused. The kidneys often exhibit lesions, and the trunk kidney is usually the preferred site for obtaining bacterial and viral cultures. In most fish we work with in this lab, the head kidney and trunk kidney appear fused.



10. The heart lies just caudal to the gills (return to previous figure, Figure 1i). The heart is enclosed in a thin-walled sac, the pericardium. Open the pericardium and examine the heart in situ. Blood returns from the body wall to the sinus venosus, a thin-walled chamber which empties into the atrium. The sinus venosus might be difficult to identify. The atrium pumps blood to the ventricle. The atrium lies cranial and dorsal to the ventricle. The ventricle is the main pump and largest part of the heart. Blood flows from the ventricle craniad to the bulbus arteriosus. The thick-walled elastic bulbus helps regulate blood pressure as blood leaves the heart. As the bulbus passes through the pericardium en route to the gills it becomes the ventral aorta.