

# Toxic Contamination in the Hudson: A Tale of Two Rivers

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Port Authority of New York and New Jersey  
New Jersey Department of Transportation

# *Lessons Learned*

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1. Consider field monitoring and modeling simultaneously.
2. Take advantage of multiple contaminants (or homologs or congeners) in understanding contaminant behavior and in calibrating models.
3. Be prepared for slow response times for sediment contaminants.
4. Measure (and develop appropriate methods for estimating) sediment, organic carbon, nutrient and contaminant sources.
5. Don't overlook the complexities of bioaccumulation.
6. Don't oversell the benefits of your remedy.



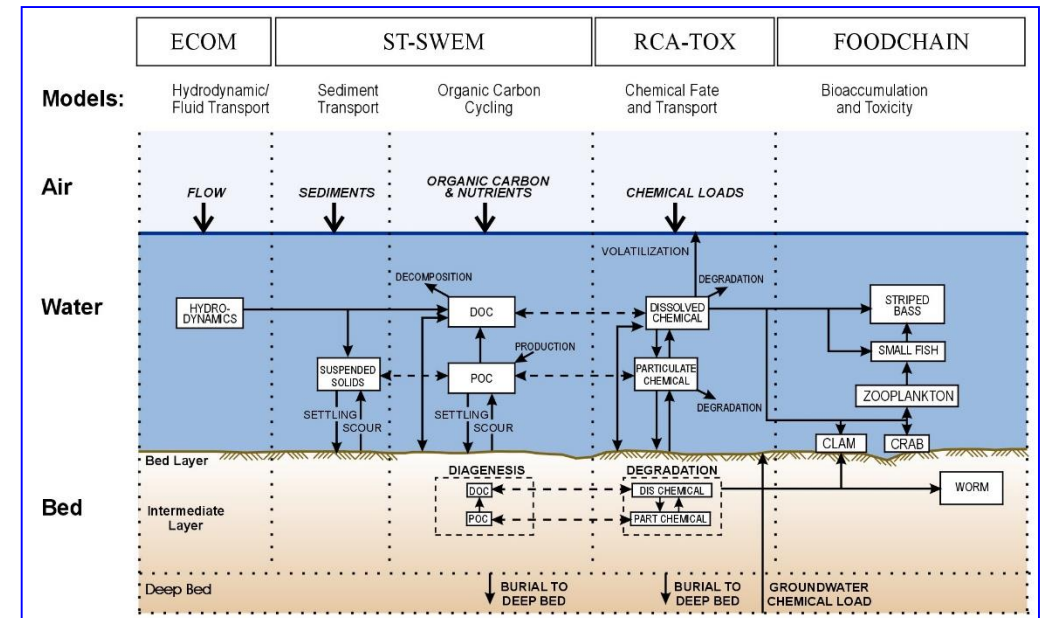
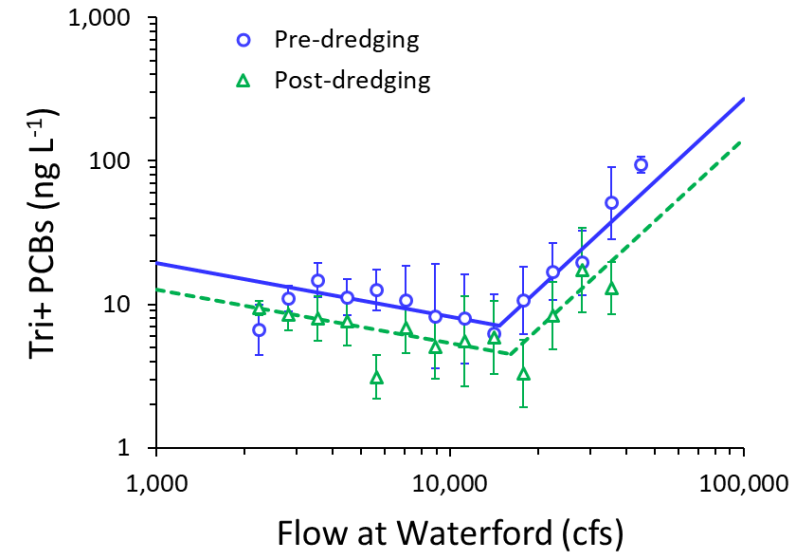
7. Don't lose sight of your ultimate objective (to provide scientific support for management decisions).



# Field data ↔ Modeling

Simple and complex models have played an important role in:

- Advancing our understanding of contaminant behavior
- Designing field collection programs
- Filling in data gaps
- Forecasting future conditions



# Evaluation of the Upper Hudson Dredging Program

## Timeline

1949-77

1984

1989

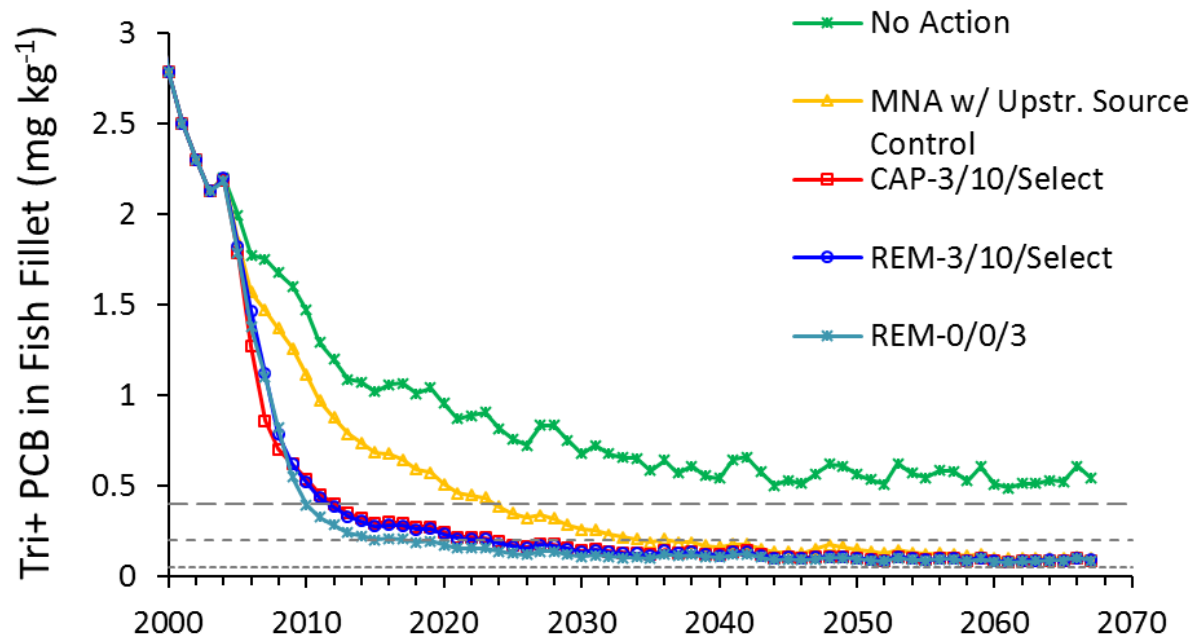
2002

2009

2010

2011-15

2016



EPA 2002 Record of Decision (ROD)

Model Projections: PCBs in Fish Fillets

“River-Length”, Whole Body Average PCB Concentration

Note: dredging assumed to occur from 2004 through 2009.

Report (June 2017) is available at:

<http://www.hudsonriver.org/>

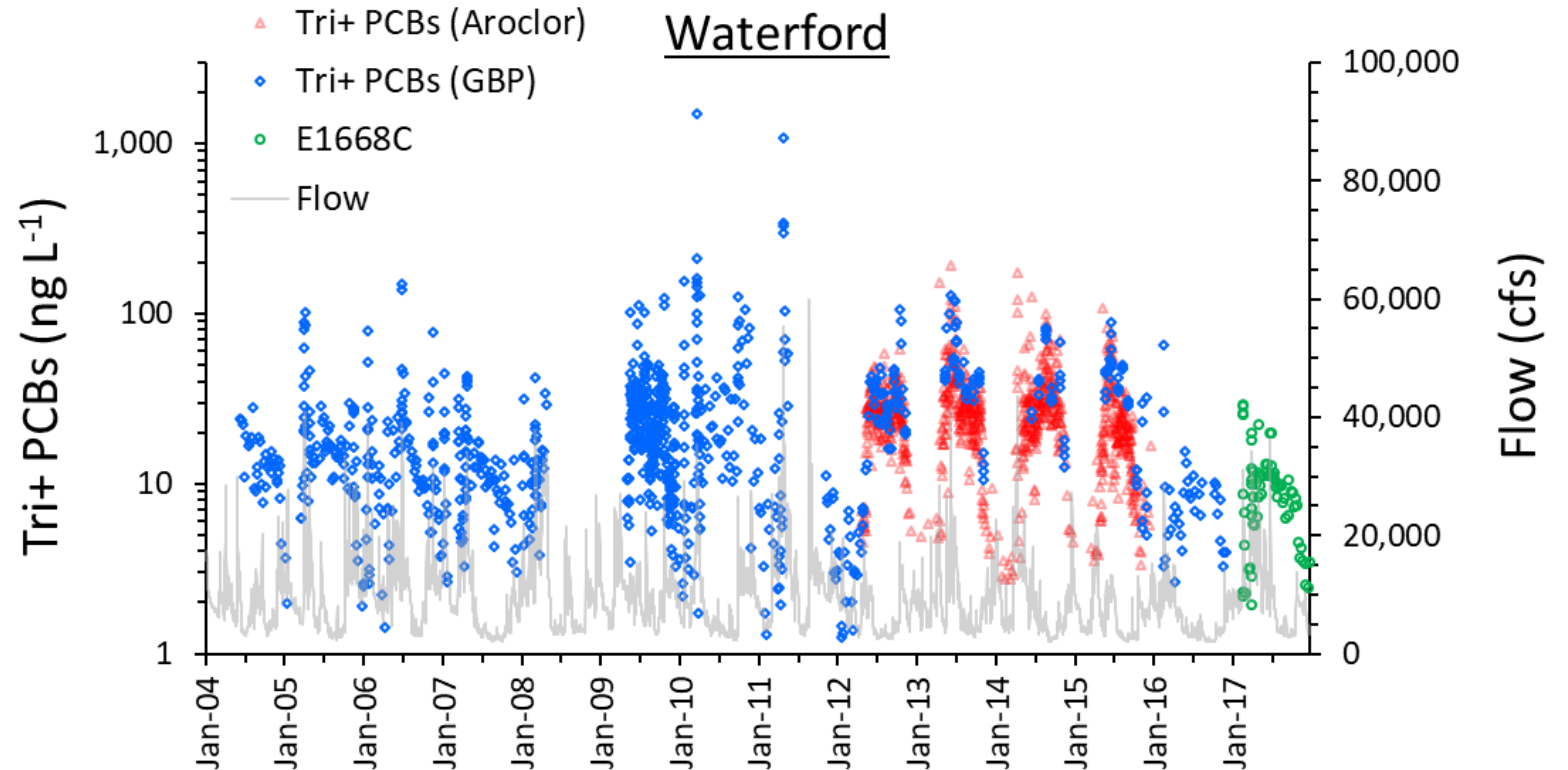


# Dredging Program: Upper Hudson

## ROD and EPS Targets

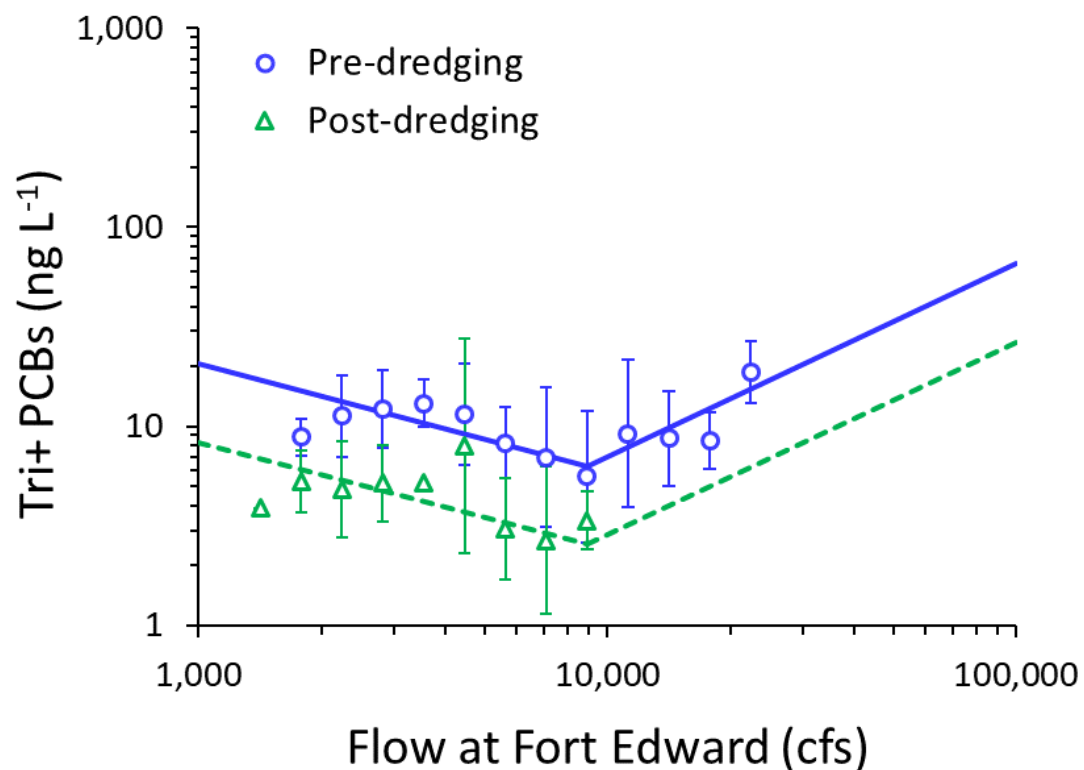
The dredging program met mass removal target of 2.65 MCY of PCB-contaminated sediment.

Tri+ PCB release passed Waterford was less than 1% of total PCB removed.

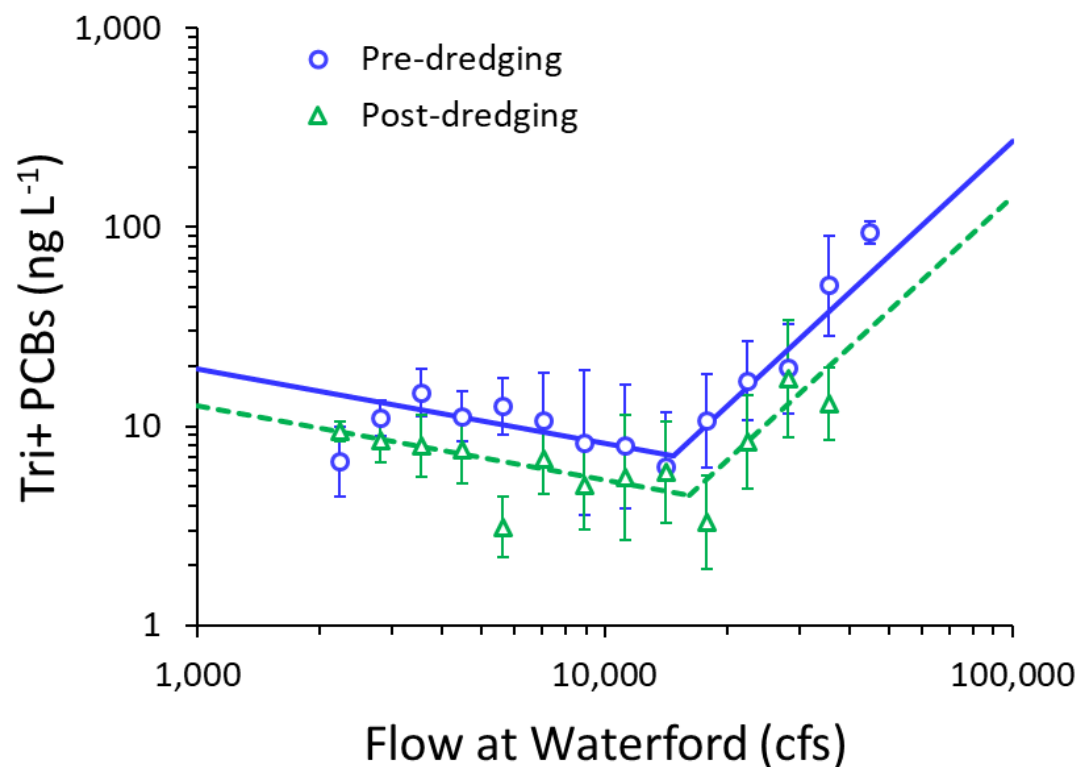


# Evaluating the Effects of Flow on Tri+ PCBs

## Thompson Island Dam

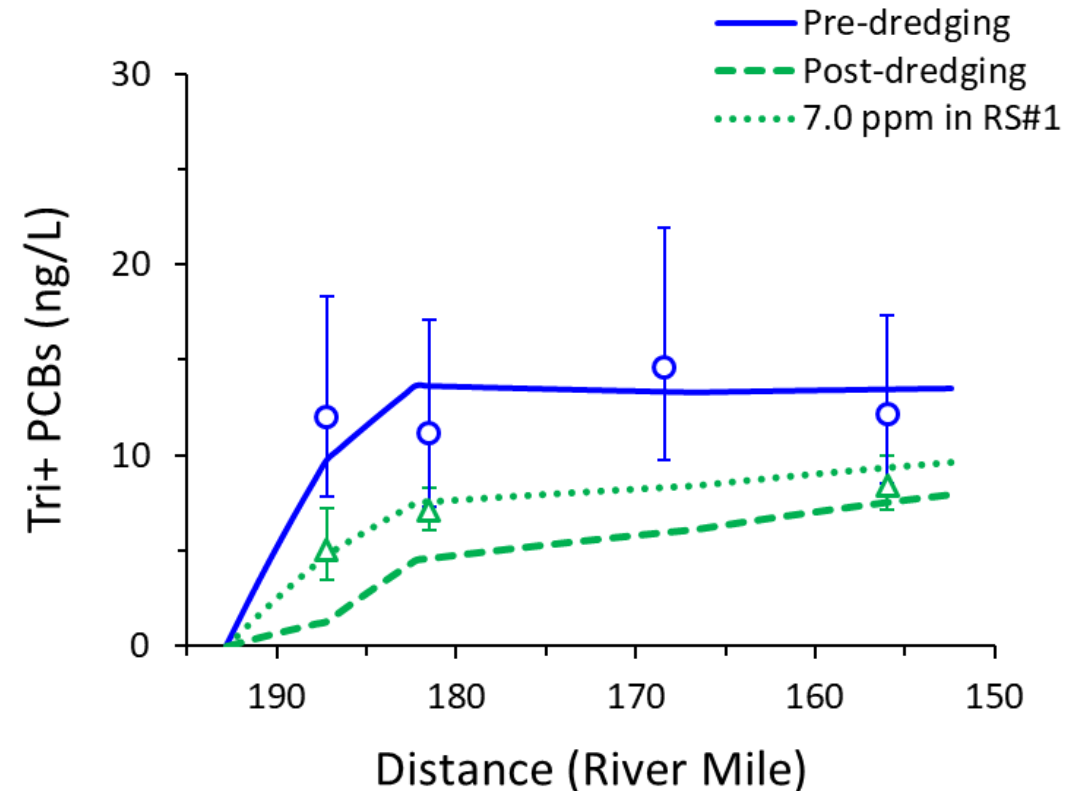
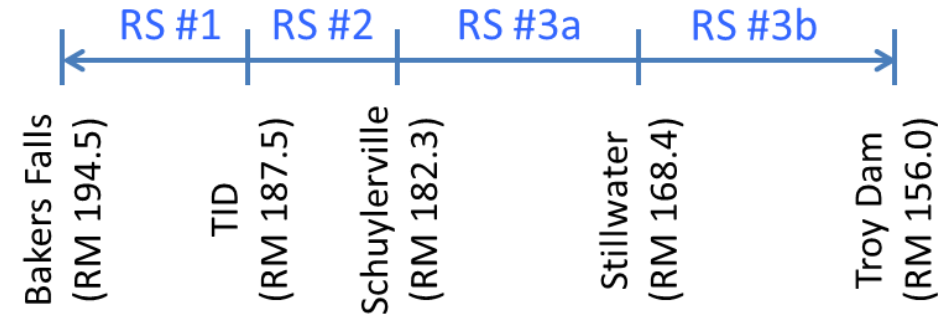
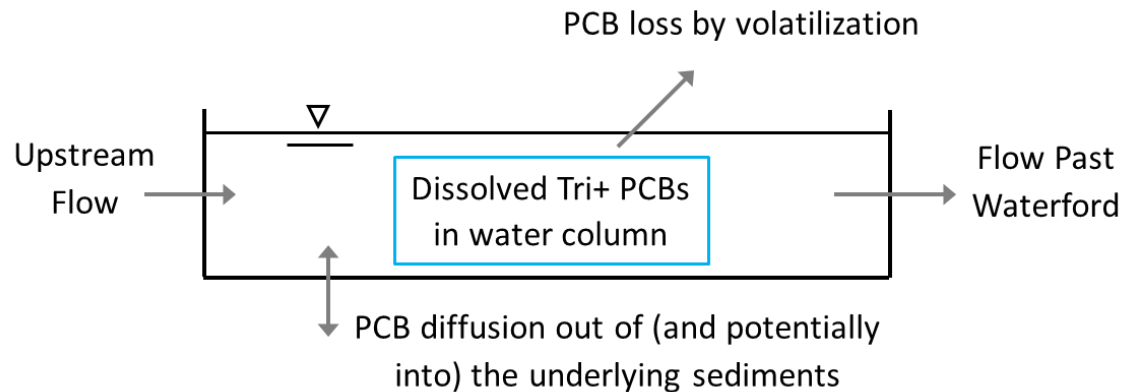


## Waterford



# Linking Expected Sediment Reductions and Water Column Responses

A simple, summer-time (low-flow) model was used to examine observed and expected Tri+ PCB responses in the water column.



# PCBs in Upper Hudson Fish

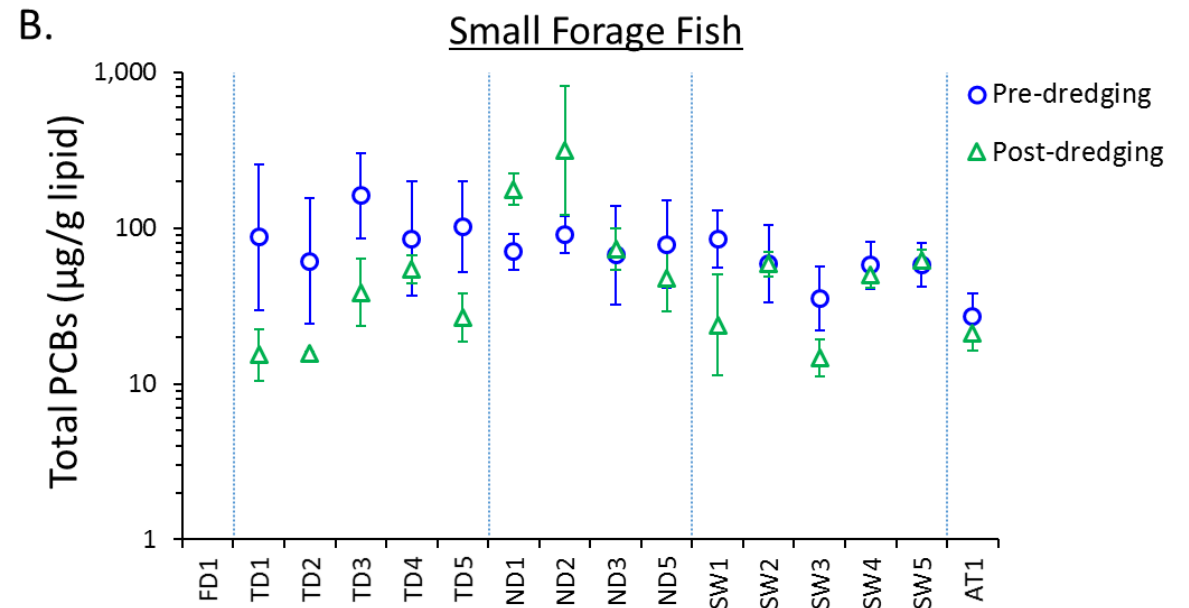
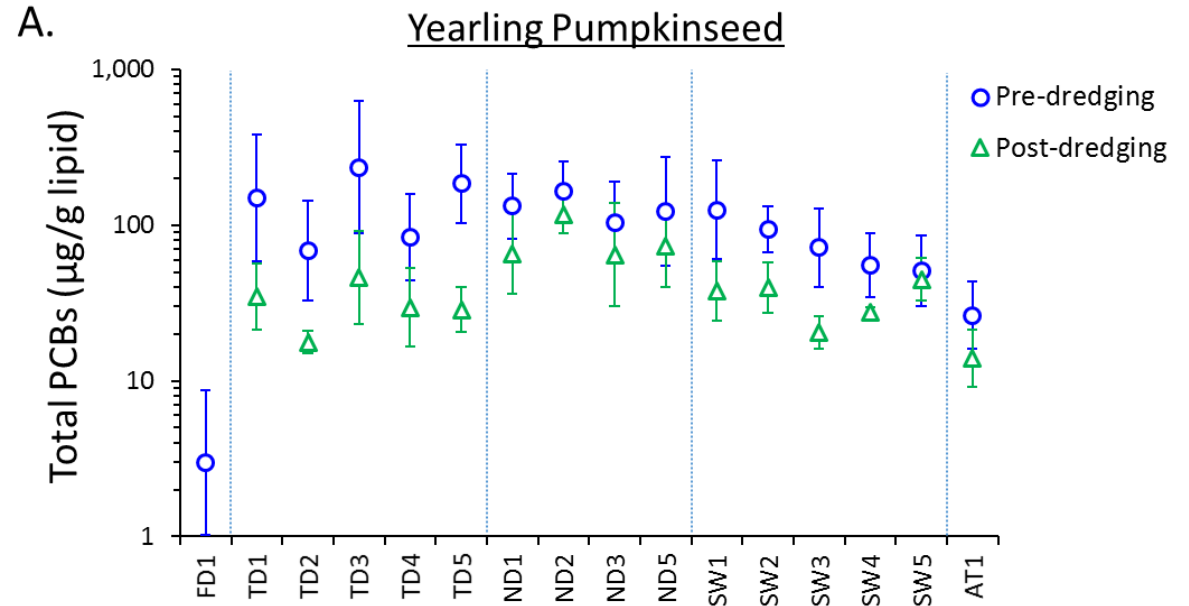
Lipid-normalized conc. of PCBs in:

(A) Yearling pumpkinseed

(B) Small forage fish

The dredging program was effective in reducing PCB concentrations in fish in Thompson Island Pool.

Post-dredging PCB conc. in fish downstream of TIP showed mixed results.



## *Has the Upper Hudson dredging program been effective?*

- Yes/No?? based on PCB mass removal, meeting EPS targets and 2016-17 Upper Hudson water column and pelagic fish monitoring ....
- but the site is still in the very early stages of 40+ years of MNR.

## *Should modifications be made to the monitoring program?*

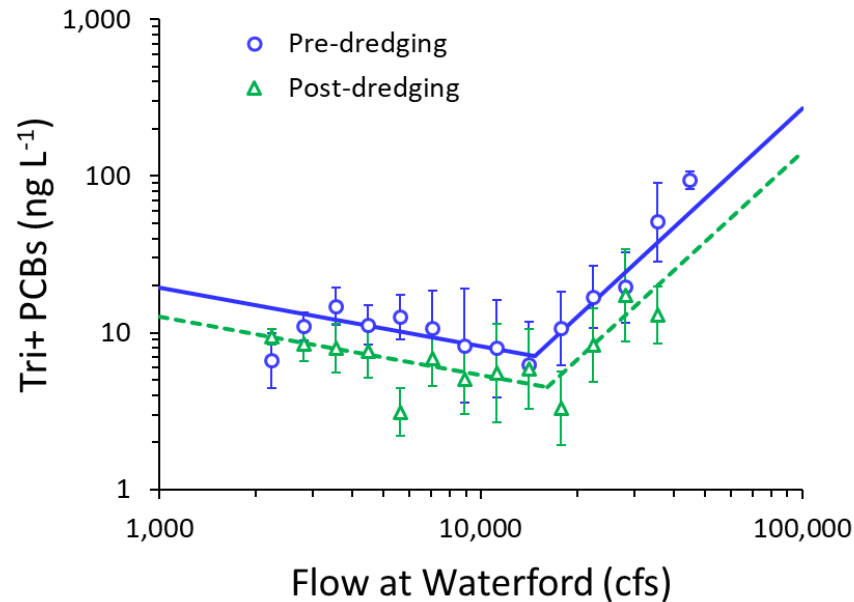
- The monitoring program should be designed to detect trends (i.e., slow declines).
- Use high resolution analytical methods (e.g., EPA Method 1668) for water column, sediment and fish samples.
- Collect additional sediment and sediment core data.
- Continue to collect supporting information (e.g., the USGS suspended sediment monitoring program).
- Test and refine data analysis and modeling tools.



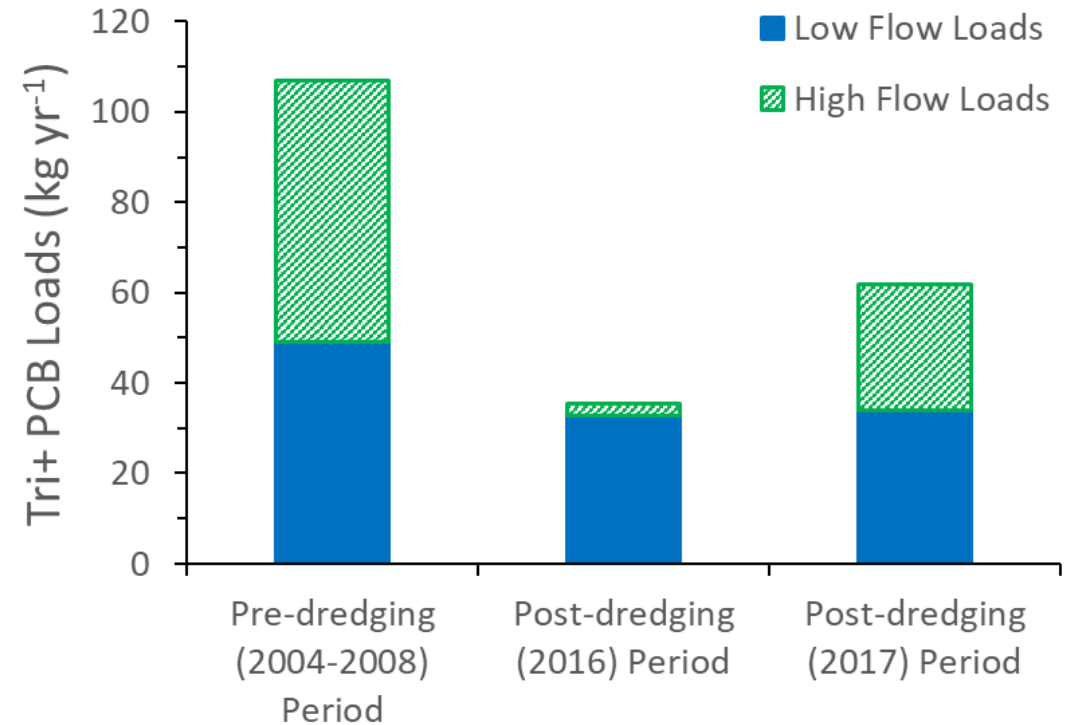
*How will the Upper Hudson dredging program and other Superfund remedial actions affect the Lower Hudson and NY-NJ Harbor?*

# Effect of Dredging on PCB Loads to the Lower Hudson

Tri+ PCB loads passed Waterford were determined from USGS stream flows and PCB-flow regressions.



## Estimation of Tri+ PCB Loads Passed Waterford



However, no clear trends were observed for PCB concentrations in Lower Hudson water or fish measurements.

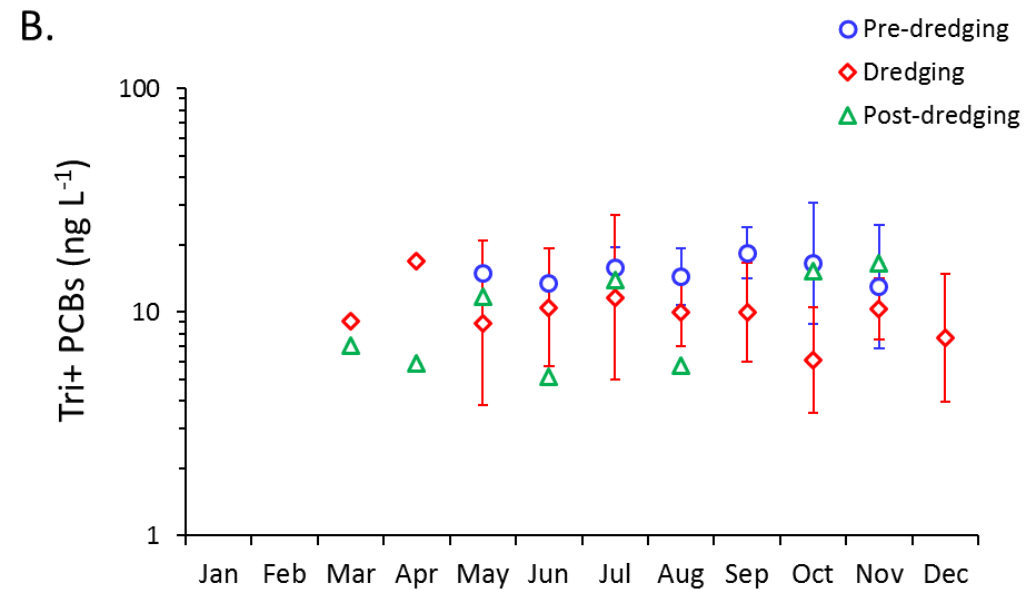
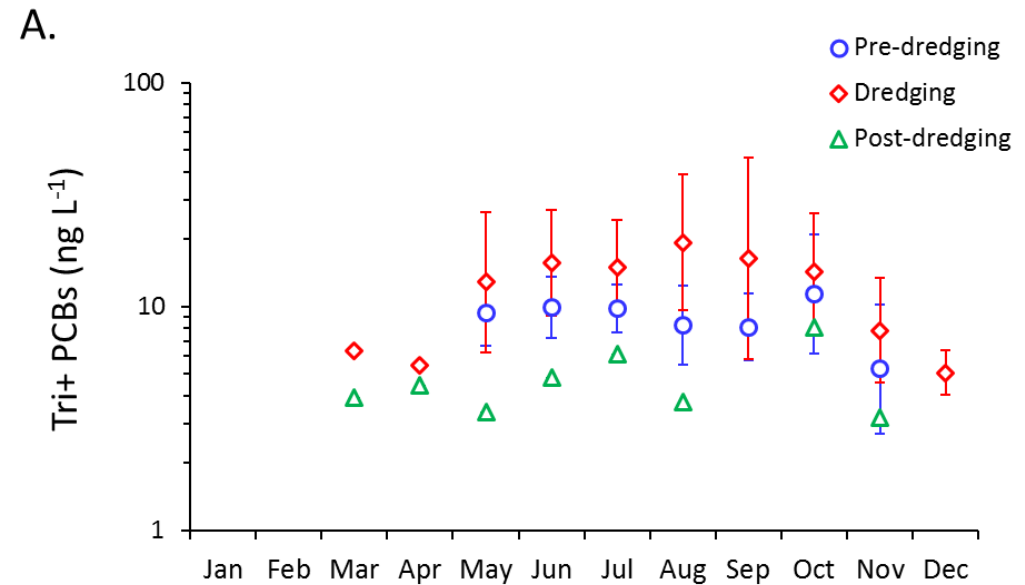
# PCBs in Lower Hudson: Water

Tri+ PCB water column  
concentrations in the Lower Hudson:

(A) Albany (RM 145)

(B) Poughkeepsie (RM 75)

Water column and fish in the Lower Hudson below Albany are showing slow responses to the Upper Hudson dredging program due to the complexities of tidal resuspension and sediment transport in the Lower Hudson.



# *Can previous and current studies of the Lower Hudson explain the apparent disconnect between the Upper and Lower Hudson?*

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## Contaminants of Concern

PCBs

Dioxins

Furans

PAHs

Pesticides

Hg

Methyl-Hg

Cd

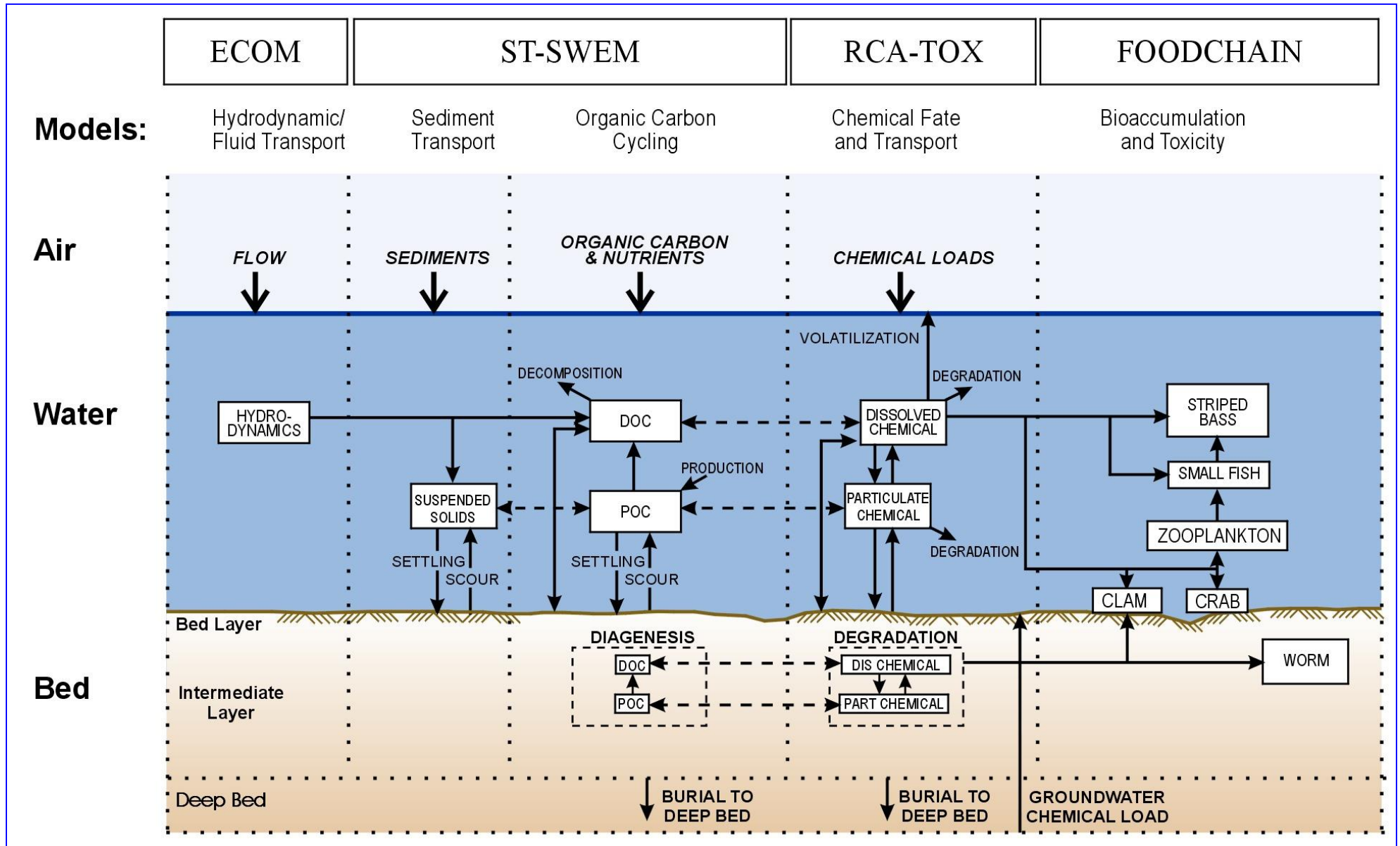
## Contamination Assessment Reduction Project (1999-2005)

CARP was a large field sampling and mass balance modeling study of toxic contaminants in the Lower Hudson and NY-NJ Harbor to:

- Evaluate the long-term fate of toxic contaminants in harbor sediment and biota.
- Provide input for the long-term management of dredged material.



# CARP Modeling Framework

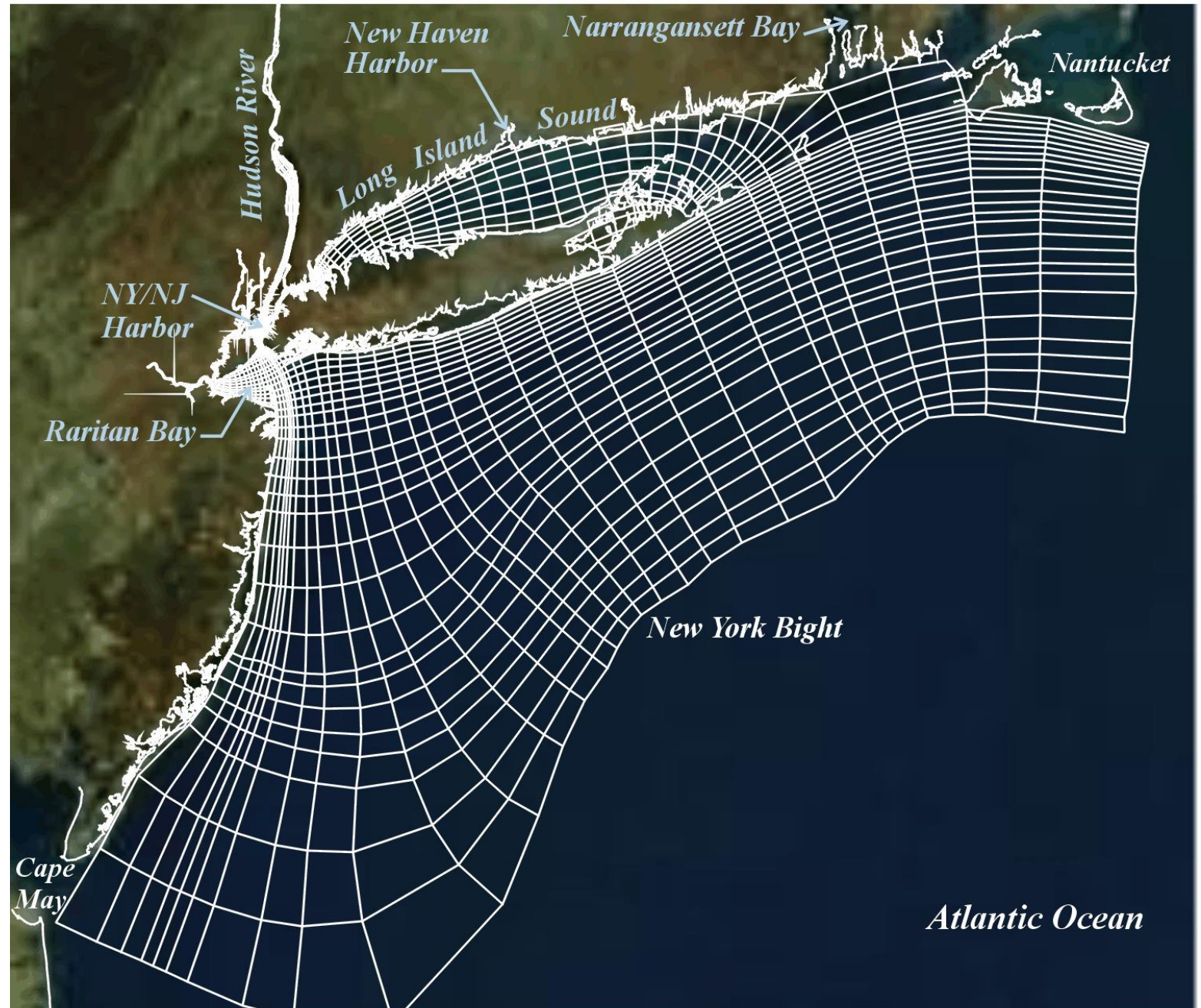


## *CARP Model Grid*

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Spatial extent from the  
head of tide to the  
continental shelf break

16,000 water column  
and  
16,000 sediment cells



# *CARP Monitoring Program*

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Field measurements to support model development:

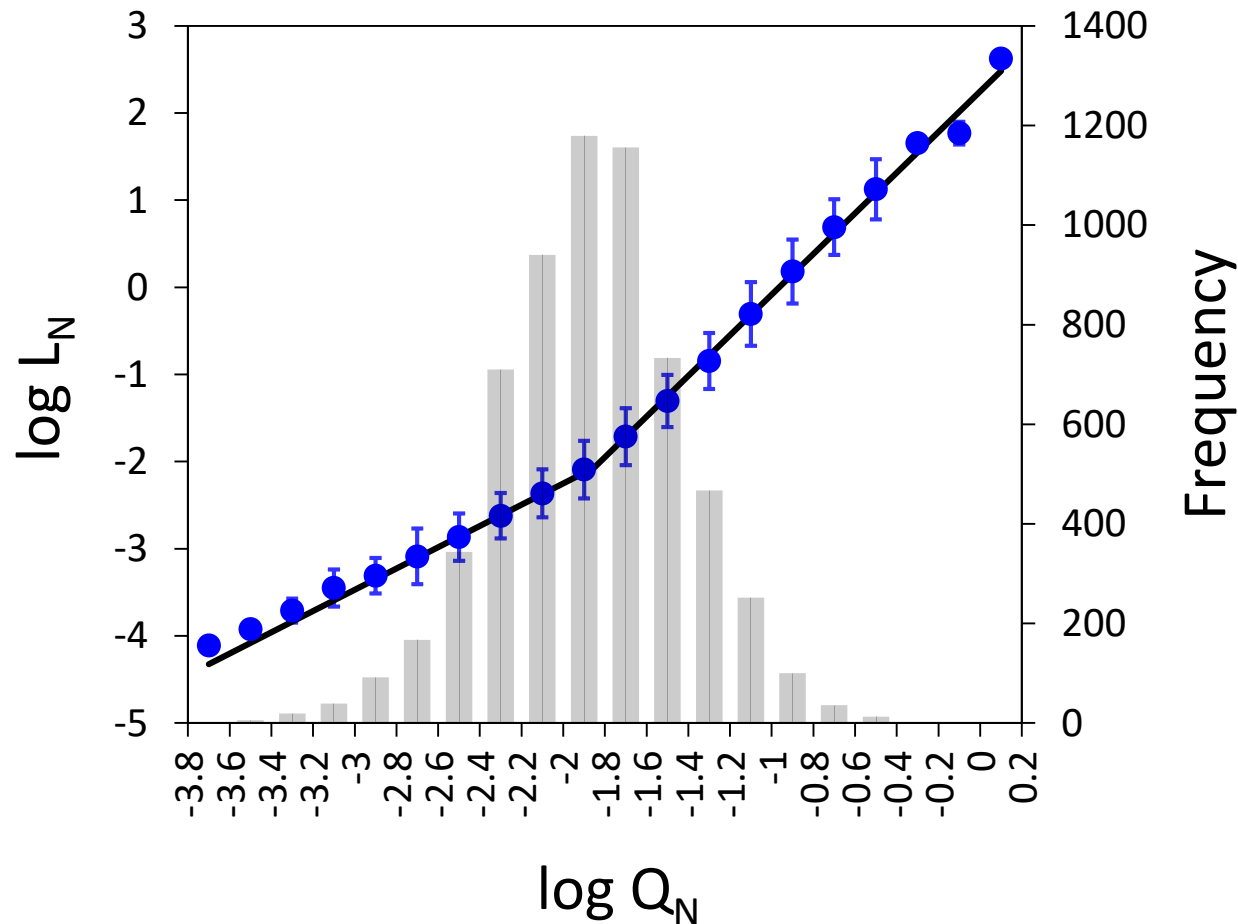
- Tidal stage, currents and salinity
- suspended sediment, sediment bed characteristics
- organic carbon, algae, nutrient concentrations
- contaminant concentrations in water, sediment and biota

In addition, we need field measurements and appropriate methods for estimating sediment, organic carbon, nutrient and contaminant sources.

## CARP Source Characterization

- 34 Tributaries
- 99 STPs
- > 700 CSOs
- > 1,000 SWOs
- Atmosphere
- 6 Landfills
- In-Place Contaminants (Sediment Initial Conditions)
- Plus Sediment, Organic Carbon and Nutrient Loads

# Example: Estimating Suspended Sediment Loads

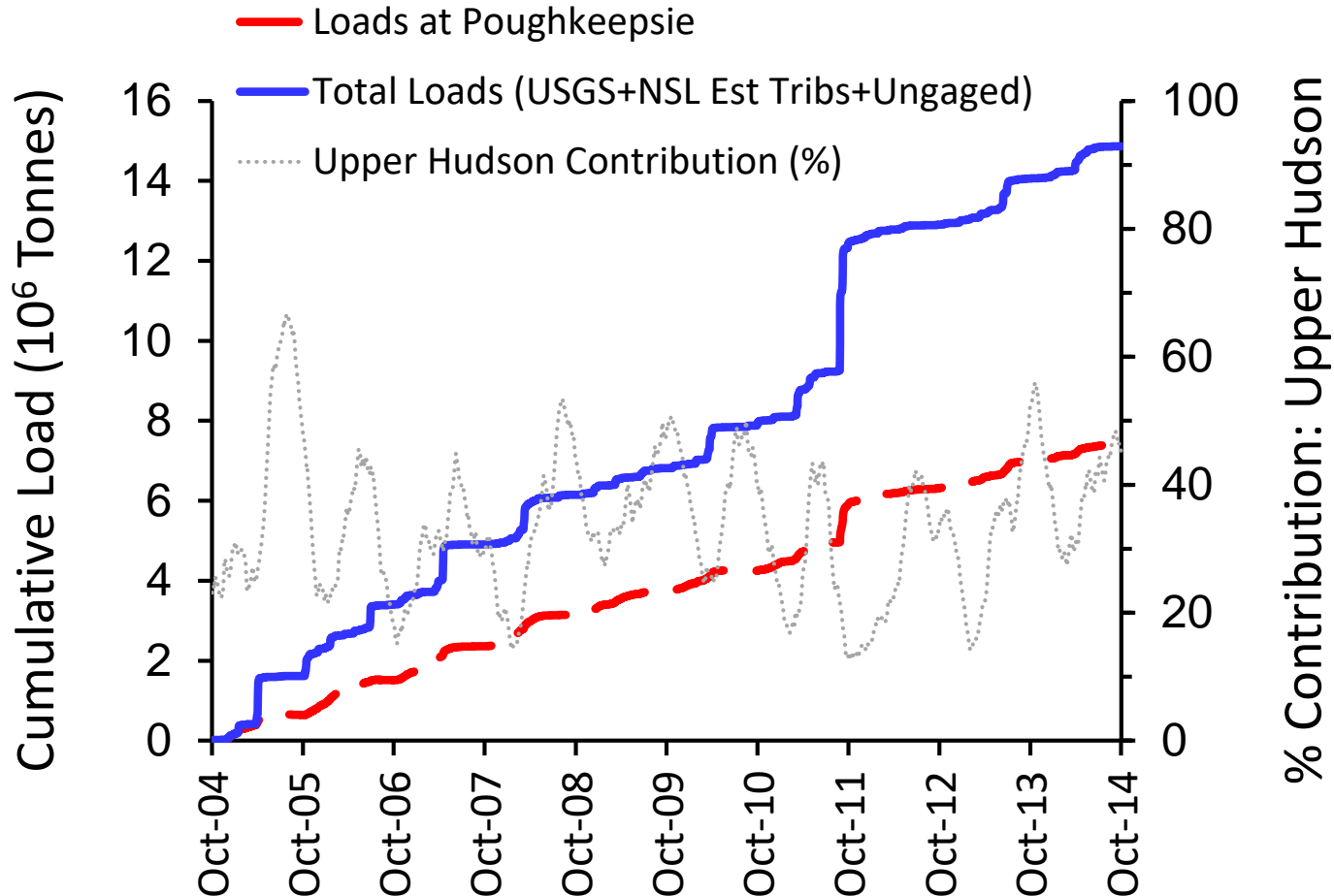


Generalized regressions for suspended sediment loads were developed using the modified NSL method and data from NYS USGS suspended sediment monitoring program (da Luz et al., in prep.)

Similar regressions were developed for contaminant loads from tributaries.

Regressions for west-side tributaries based on data from the Mohawk, Catskill and Rondout tributaries.

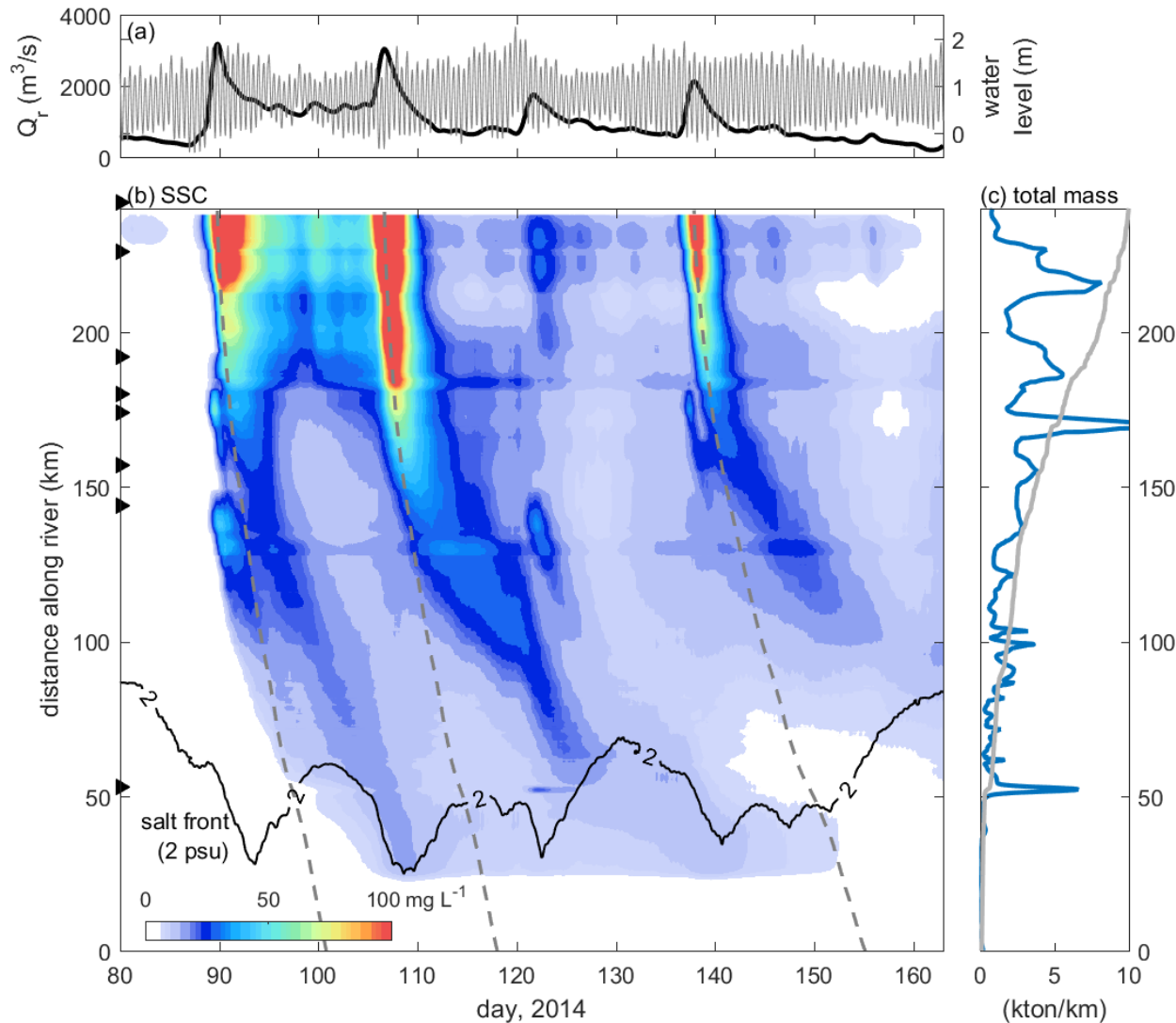
# Sediment Trapping: Tidal, Freshwater Hudson



Based on suspended sediment load estimates, approximately 35% of the sediment load to the Lower Hudson is from the Upper Hudson River.

A large fraction of sediment entering the tidal, freshwater Hudson is trapped above Poughkeepsie.

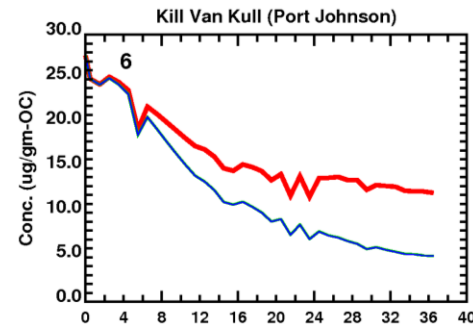
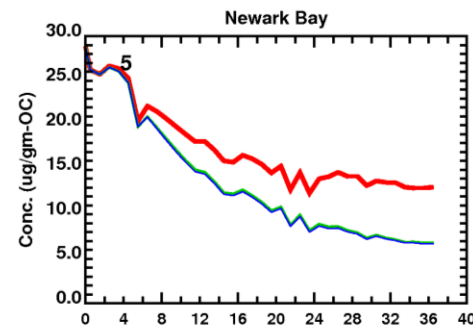
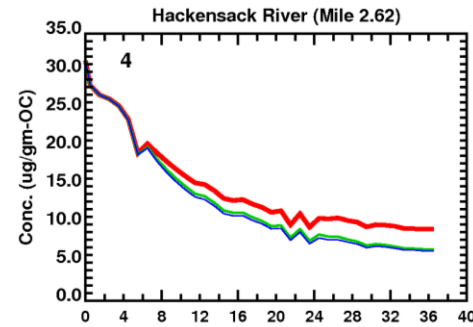
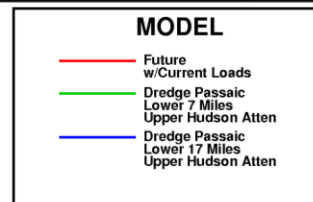
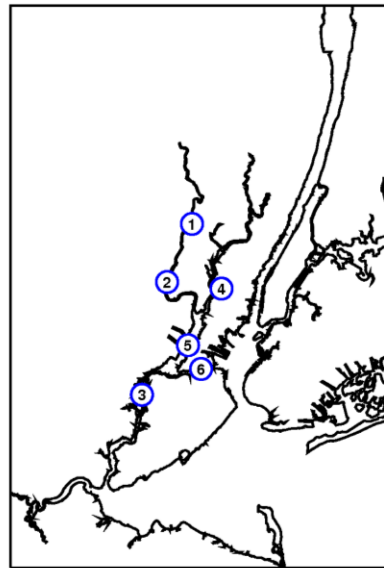
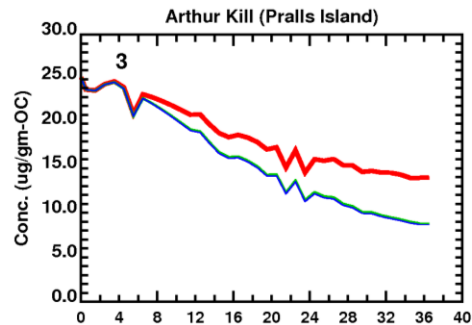
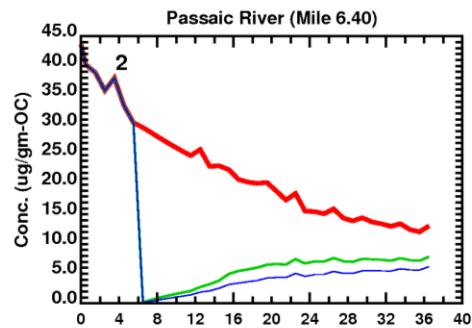
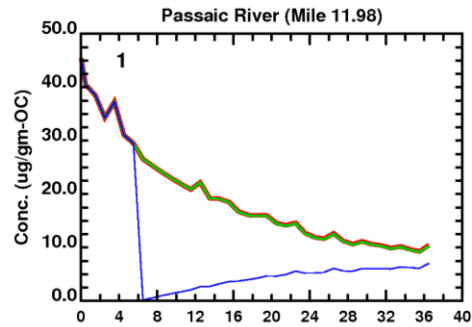
# Sediment Transport Modeling Results



Sediment transport modeling results confirm that tidal resuspension, estuarine circulation and seasonal movement of the salt wedge are effective in:

- Trapping sediment in the tidal freshwater and estuarine sections of the river.
- Mixing contaminated sediments over large distances
- Exposing both pelagic and benthic organisms to contaminants.

# CARP: Fate and Transport Model Projections (starting in 2002)



Projection Run, Sediment, Time Series for Total PCB = 2\*(Di+Tetra+Hexa+Octa) (ug/gm-OC)

Current contaminant levels in sediments are largely associated with legacy contamination.

Contamination levels are expected to decrease very slowly in time.

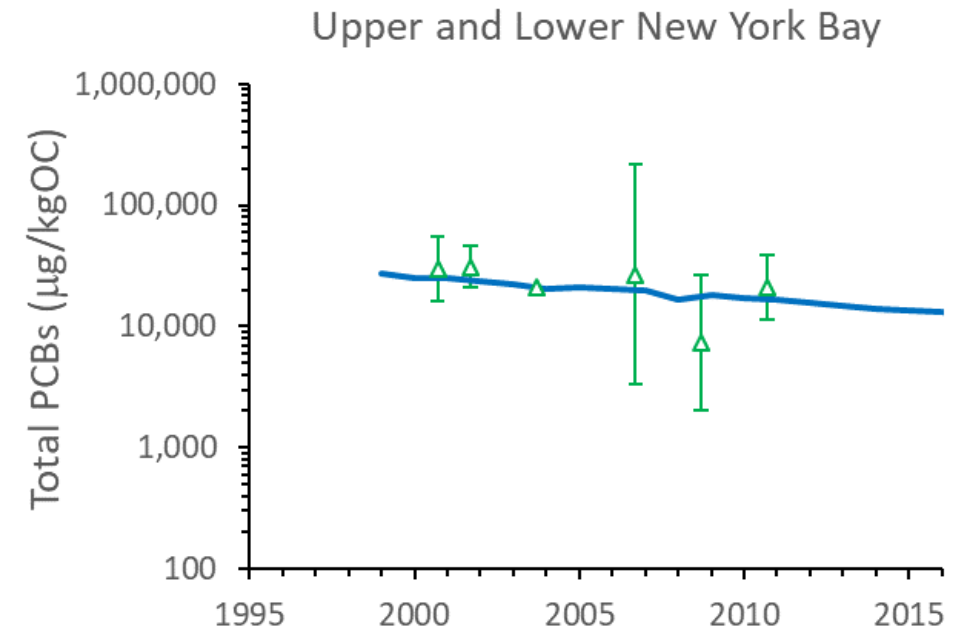
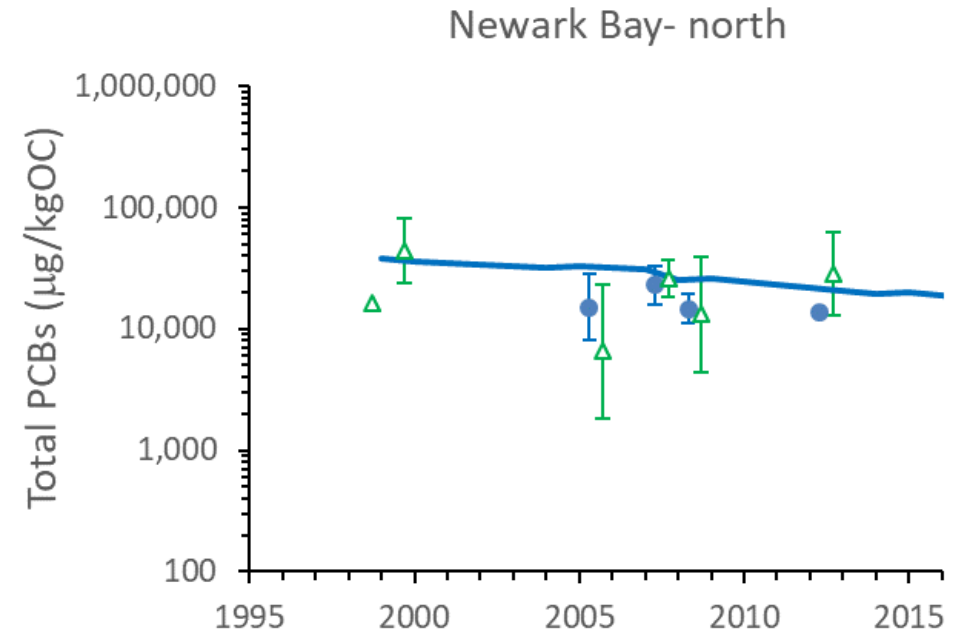
Superfund remedial actions are expected to further reduce contamination. Initial reductions will primarily be in areas closest to remedial actions.

# How reliable are the CARP model projections?

## CARP 2 Post-Audit

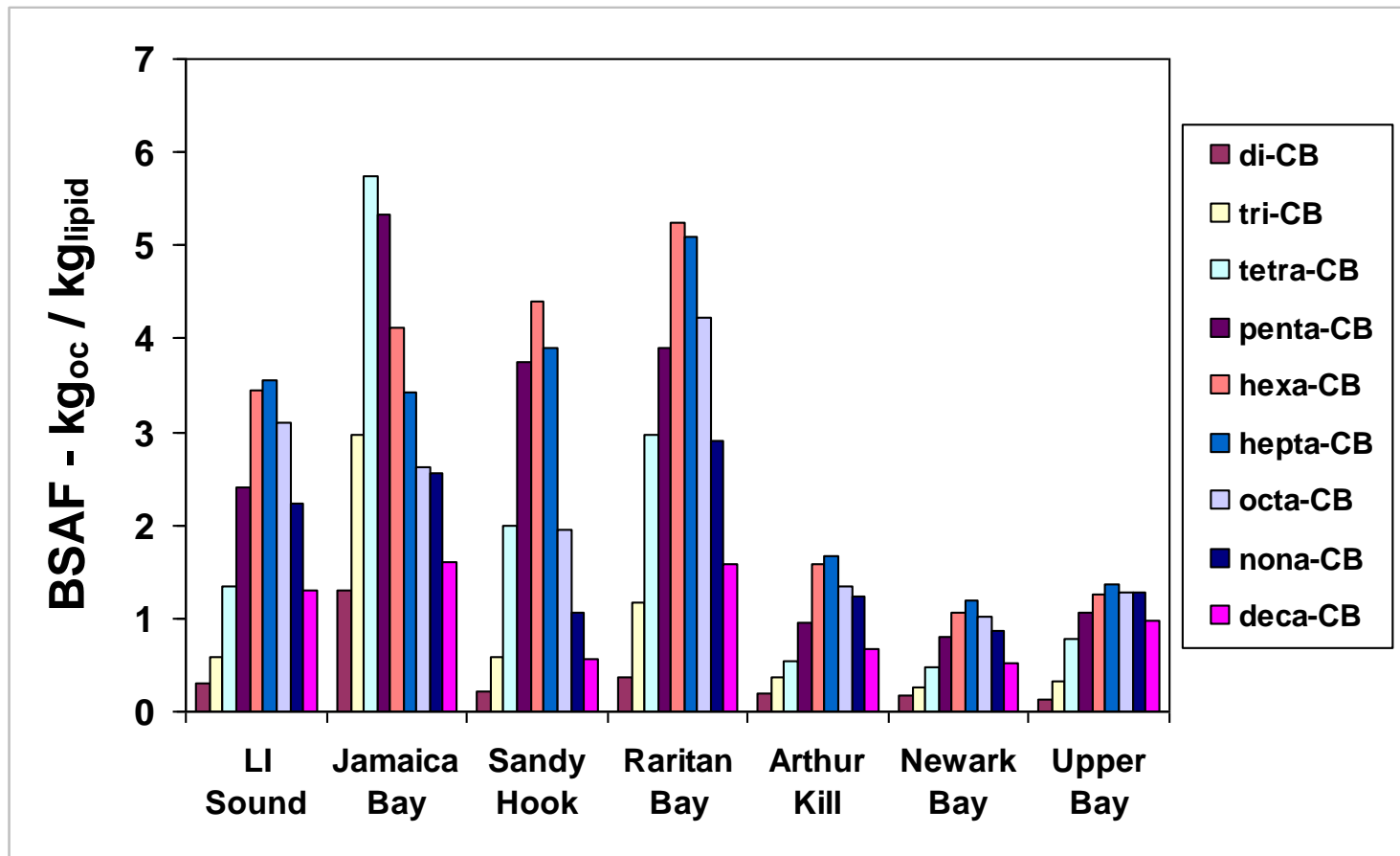
CARP model projections did a good job in describing the central tendency of the field observations, particularly for in-channel samples.

Remaining question: Will we ever be able to explain all the spatial variability in field observations?



# How reliable are static descriptors for bioaccumulation?

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BAFs, BSAFs, TMF, etc. appear to work reasonably well for slowly varying systems.

But we still don't understand bioaccumulation behavior (e.g., why do BSAFs vary with location in NY-NJ Harbor?).

## *When are dynamic bioaccumulation models required?*

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Dynamic bioaccumulation models are very useful in evaluating:

- Trophic transfer of contaminants in food webs.
- Time-variable responses.
- Effects of fish migration.
- Potential effects of remediation on bioaccumulation behavior.

