General Electric Company
Albany, New York

ANALYSIS OF HUDSON RIVER PCB SOURCES BASED ON INTERPRETATION OF DATA

Prepared for the NYSDEC/USEPA Meeting
October 16, 1997

HydroQual, Inc.

Overall Conclusions

1) Natural recovery that occurred historically in the Hudson River was slowed or reversed beginning sometime in the late-1980s due to releases to the river from the vicinity of the GE Hudsons Falls Plant.

2) Remedial actions at the Hudsons Falls Plant site have nearly eliminated this source.

3) The residual sediment source is derived from surface sediments in the TIP and in downstream reaches.

4) Surface sediments throughout the river bottom contribute PCBs such that so-called hot spots are not the dominant source.

5) Old dechlorinated sediments and sediments buried more than a few centimeters do not contribute significant PCBs to the water column or the fish.

6) The magnitude of the TIP sediment source has been overestimated due to a sampling bias at the Thompson Island Dam station.

7) The reductions in PCB loading to the river have resulted in an significant reductions in fish PCB levels.

8) Because the PCB loading has been reduced to levels significantly below those of the late-1980s, it is anticipated that fish levels will continue to decline below the levels of the late-1980s

9) Downstream sources contribute significantly to sediment and fish PCBs at minimum at locations below river mile 100 and dominate in the metropolitan area.

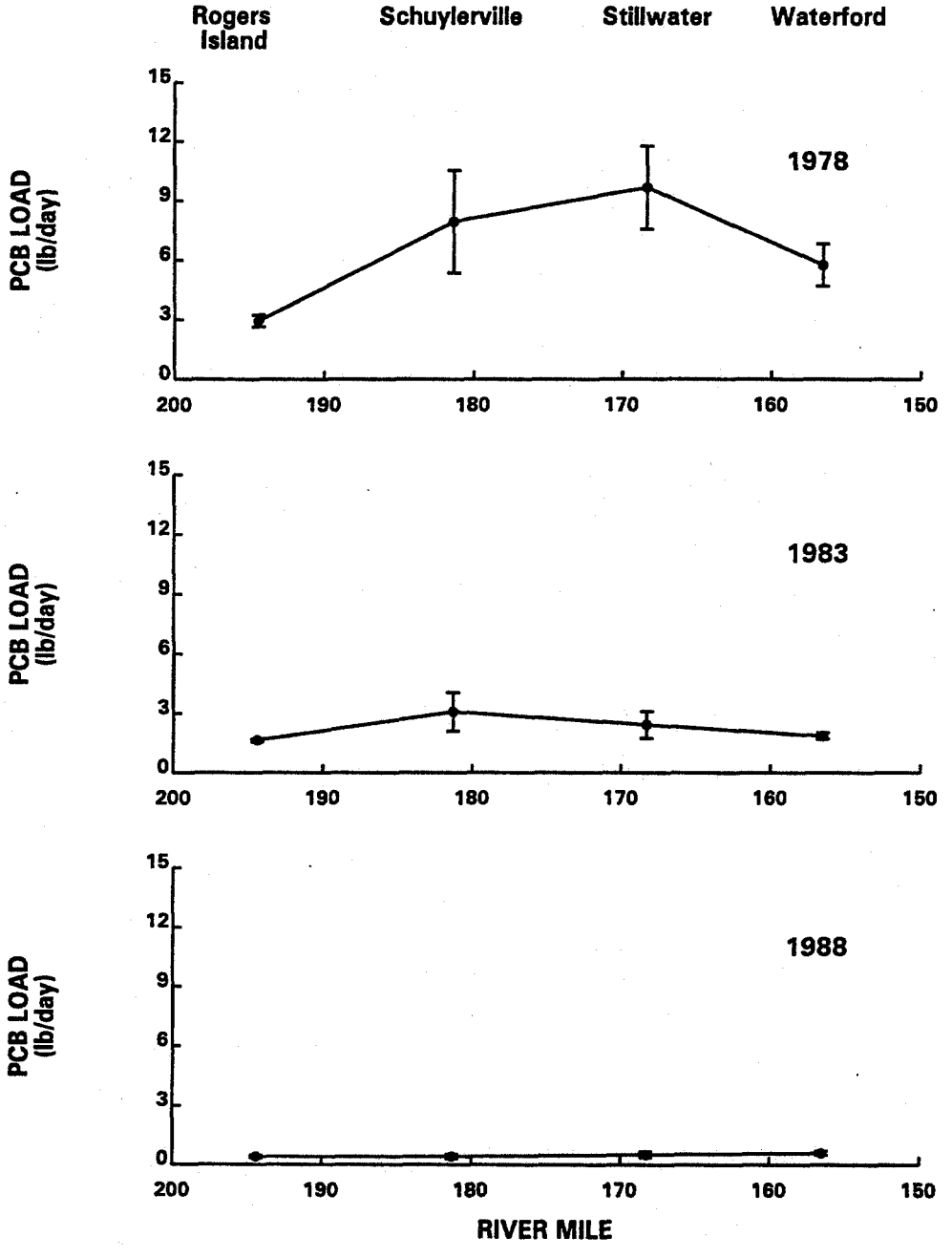
The Upper Hudson River has demonstrated natural recovery capability, as evidenced by declines in PCB levels from the late 1970s to the late 1980s

Supporting Data:

1) Spatial profiles of summer low flow average PCB loading show differing patterns through time (Figure 1). As an example of late 1970s conditions, the 1978 data show an increase from about 3 lb/d at Rogers Island to about 10 lb/d at Stillwater. By 1983 the load had declined such that about 1.5 l/b passed Rogers Island and the maximum downstream was about 3 lb/d. Declines continued such that by 1988 the loading was about 0.5 lb/d at all of the locations in the River.

2) Comparison of the temporal profiles at Fort Edward (Rogers Island) and Schuylerville (Figure 2), shows that the apparent contribution from sediments declined significantly through time. In the late 1970s, the sediments were the dominant source. By the mid- to late 1980s sources upstream of Fort Edward dominated.

SPATIAL PROFILES OF SUMMER AVERAGE* UPPER HUDSON RIVER WATER COLUMN PCB LOADINGS



* June-August at flows < 5000 cfs

FIGURE 1

The recovery slowed in the late 1980s and perhaps reversed due to PCB releases to the river from upstream of Fort Edward (i.e., the upstream source)

Supporting Data:

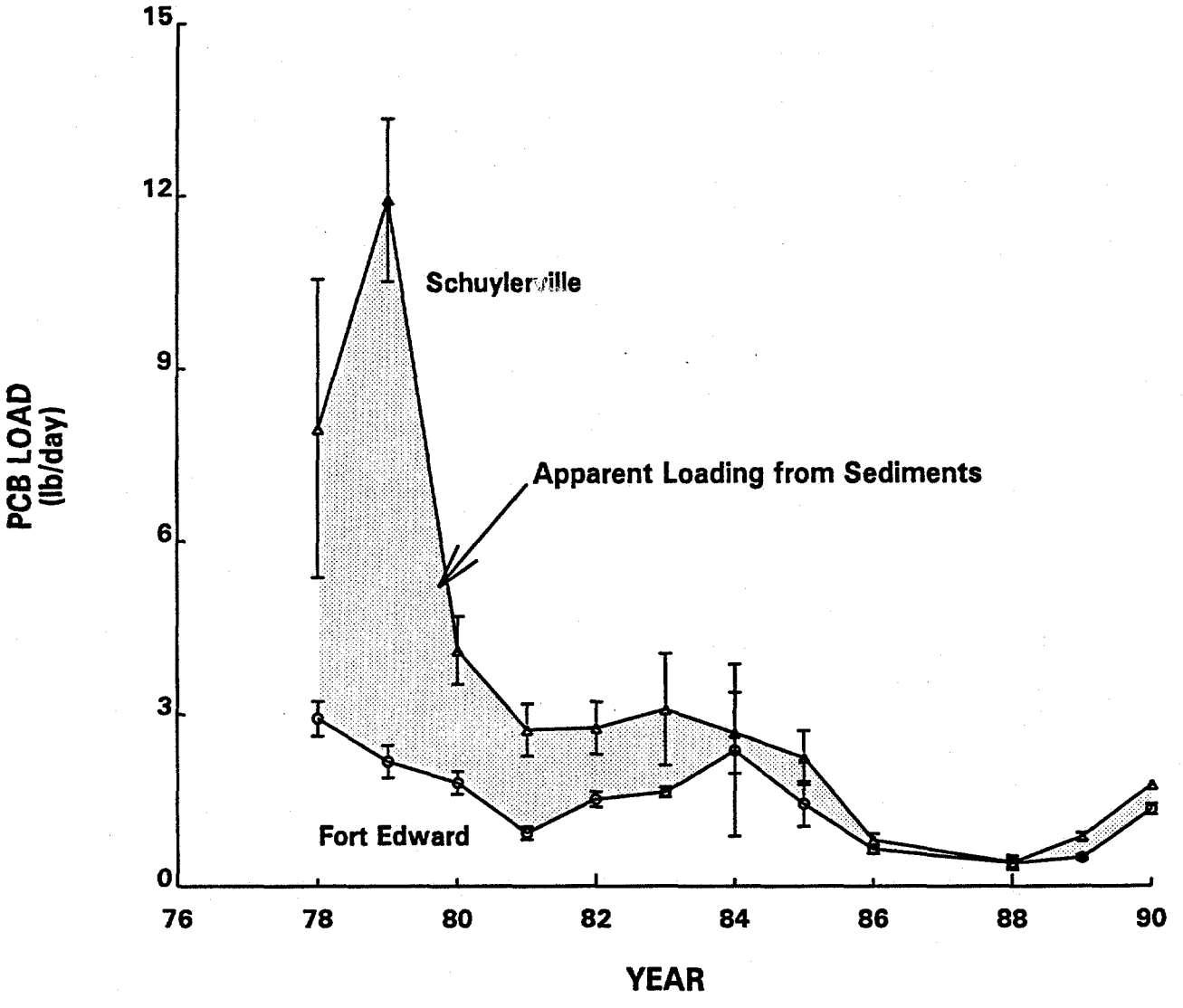
1) High resolution sediment cores collected as part of the EPA Phase 2 study show evidence of active PCB releases beginning sometime in the 1980s. Breaks are seen in the rate of PCB decline between the buried peak and the sediment surface (Figure 3). The breaks indicate a reduction in natural recovery rate due to PCB loading to the water column. The timing of the breaks is difficult to assess due to variations in deposition rate and mixing within the cores. It is likely that the peak concentrations were deposited between 1973 and 1976. The breaks occur at horizons that were probably deposited 10 - 15 years after the peak.

2) PCB concentrations in largemouth bass and pumpkinseed collected from Thompson Island Pool do not exhibit a consistent decline through the 1980s, and may have increased between 1988 and 1990 (Figure 4).

3) Summer low flow average PCB concentrations at stations downstream of Rogers Island increased between 1988 and 1991 (Figure 5). *Note that a portion of the increase may be due to differences in PCB measurement techniques.*

4) The apparent loading from sediments increased in 1991 (Figure 6).

TEMPORAL TREND OF SUMMER AVERAGE LOW FLOW[1] PCB LOADING PASSING FT. EDWARD & SCHUYLERVILLE



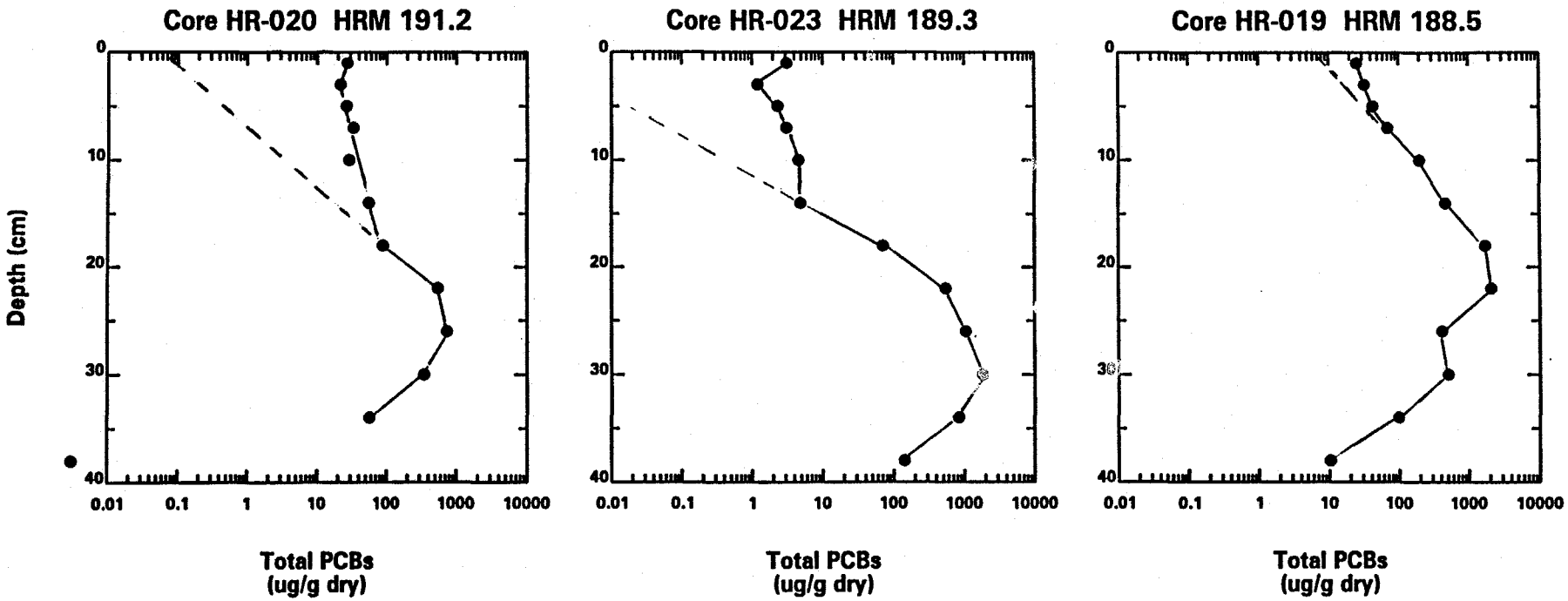
[1] June-August at flows < 5000 cfs

mean +/- one standard error

FIGURE 2

Mon Oct 13, 1997 14:25:29

O/PLOTS/sedload.sed sedload.gdp



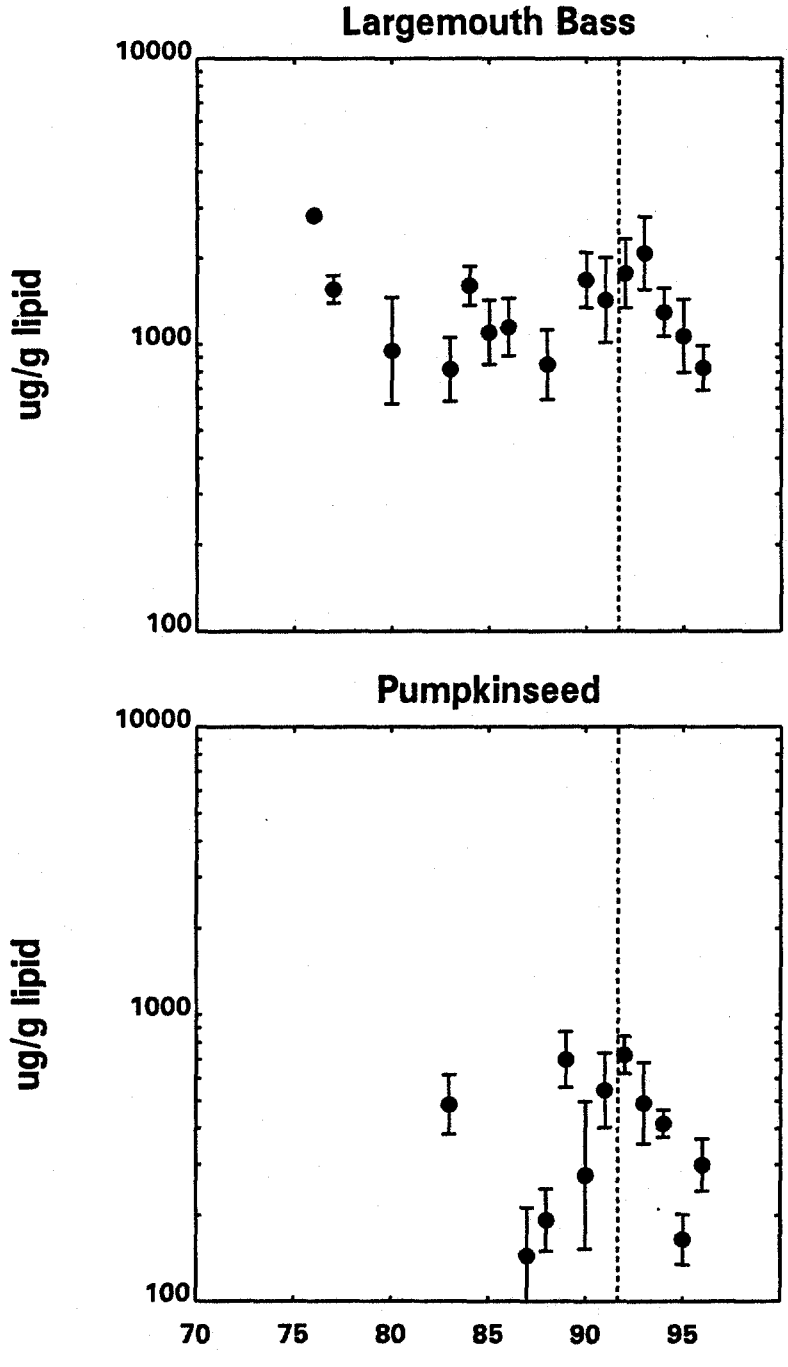
USEPA Phase II High Resolution Sediment Core Data

/power2/geco0310/DATA/PHASE2/HRCORES/PLOTS/TEMPFILES/ptotfig.gdp

Thu Jun 12, 1997 17:20:59

312577

FIGURE 3



All sizes
All seasons
All tissues
Males & Females
Mean +/- two standard *errors* of the mean

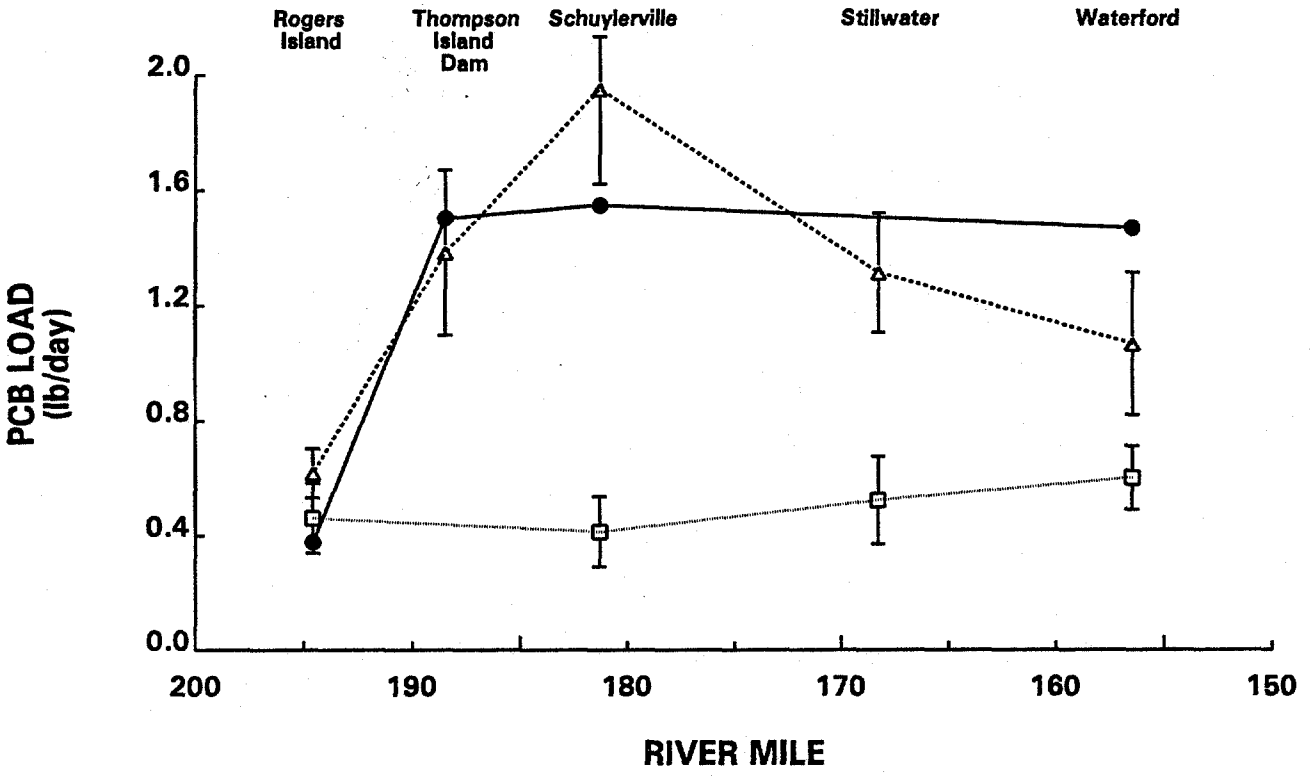
Temporal patterns in tPCB Concentrations in Thompson Island Pool

Wed Oct 15, 1997 12:17:18

/power2/geco0510/OLD_STRUC/geco0330/DATA/[illegible]

FIGURE 4

UPPER HUDSON RIVER
SPATIAL PROFILE OF SUMMER LOW FLOW PCB LOADING IN 1988, 1991, & 1993



Legend:

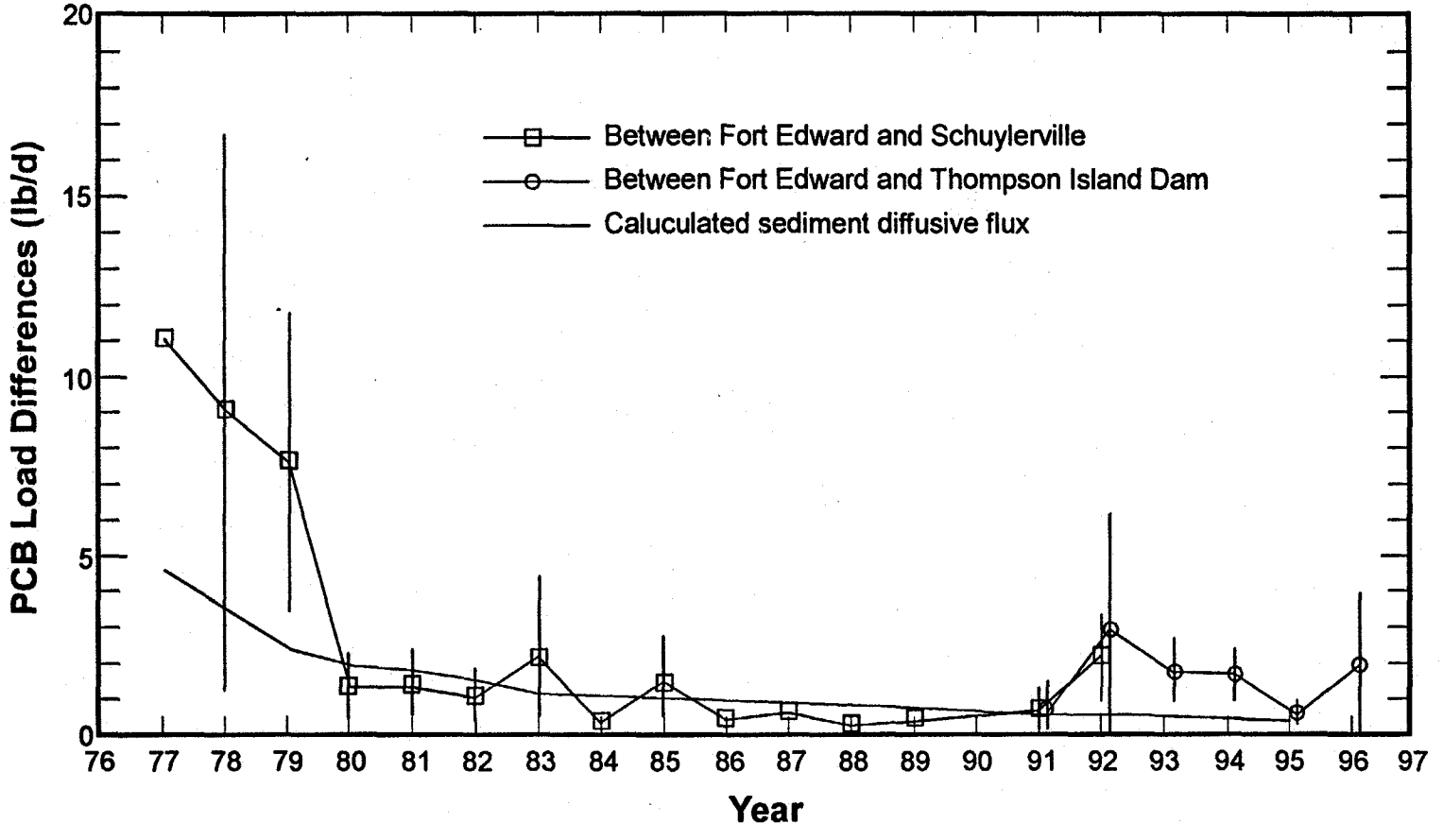
- 1993 EPA Transect 6
- 1991 OBG Jun-Aug, Flow < 5000 cfs
- 1988 USGS Jun-Aug, Flow < 5000 cfs

FIGURE 5

Tue Oct 14, 1997 13:49:54

tran6.sed tran691.gdp

PCB LOADING INCREASE WITHIN THE UPPER HUDSON RIVER



312580

FIGURE 6

However, the apparent loading from TIP sediments has been overestimated. A sampling bias at the Thompson Island Dam station has resulted in overestimation of the PCB flux passing the Dam.

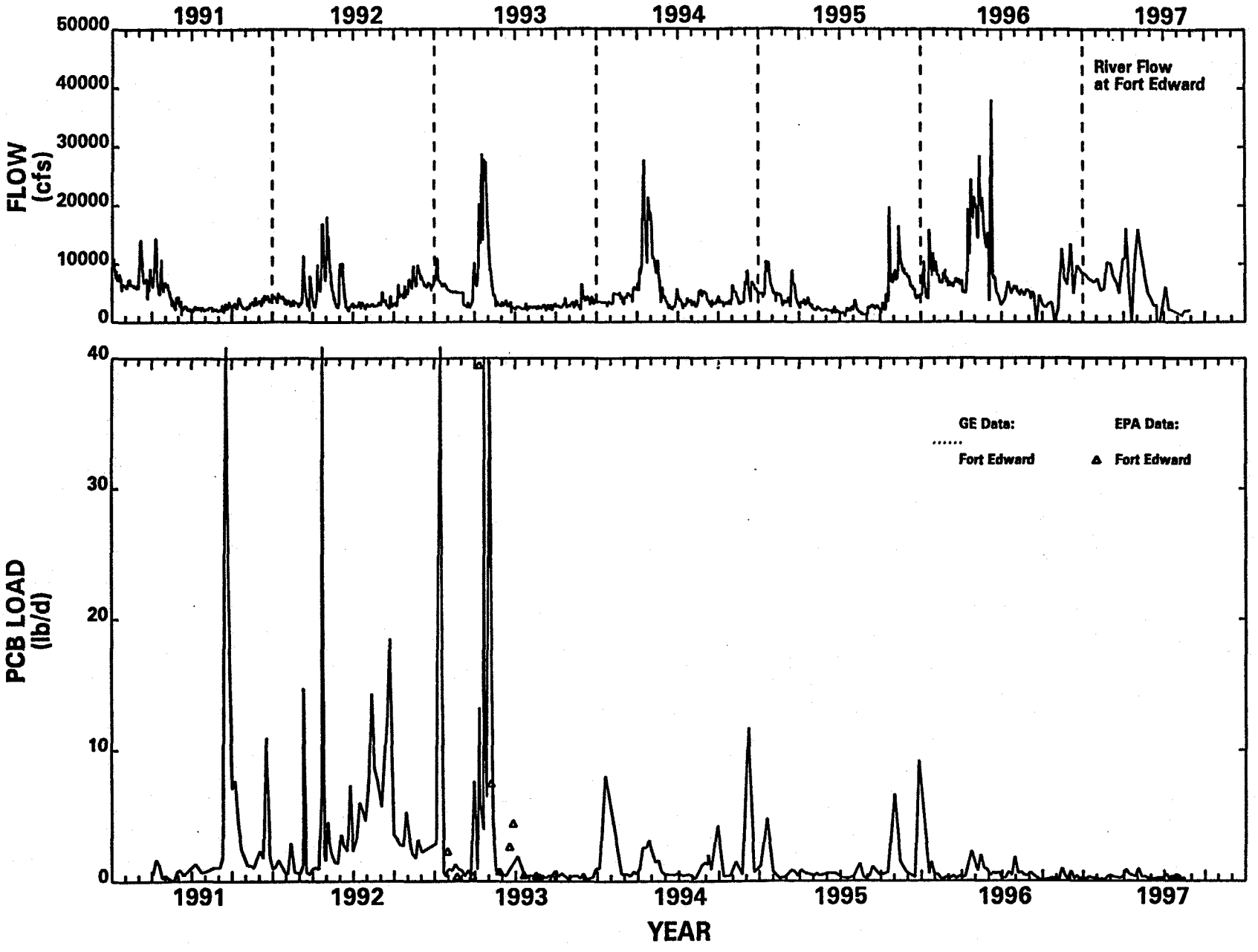
Supporting Data:

See "Results of the General Electric 1996-97 Thompson Island Pool Research Program"

Remedial efforts have nearly eliminated the upstream source

Supporting Data:

1) The PCB loading entering Thompson Island Pool (as measured at Rogers Island) has declined significantly since the substantial releases that occurred between September, 1991 and April 1993 (Figure 7). The current loading is about 0.2 lb/d.



312583

Figure 7

/power2/geco0510/ANALYSIS/WATER/OBG/TEMPORAL/2p2.gdp
DATE: Mon Sep 22 TIME: 17:58:22

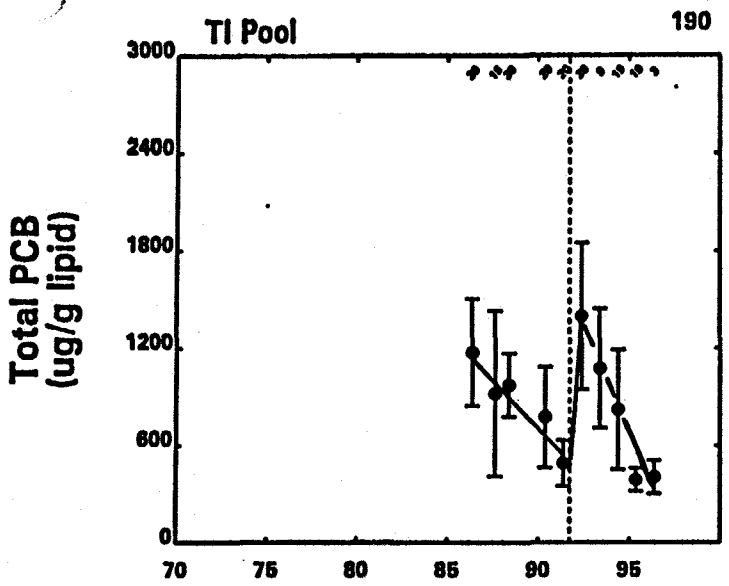
Datafiles -- fetl_avgs.bin,FTEDWD.PRN,recent.det

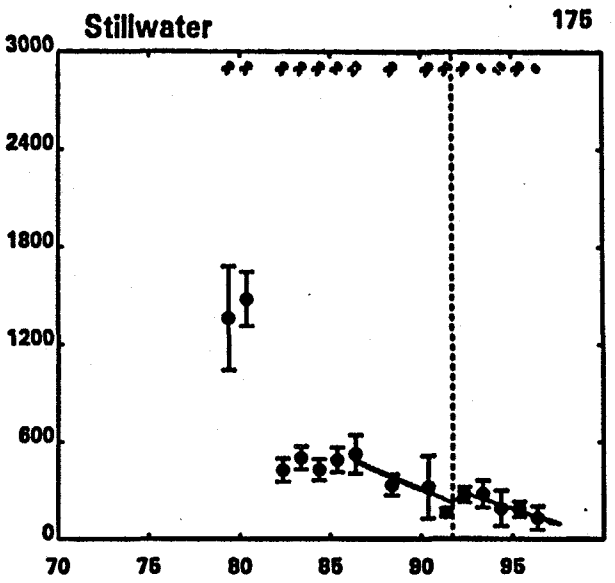
Natural recovery appears to have resumed

Supporting Data:

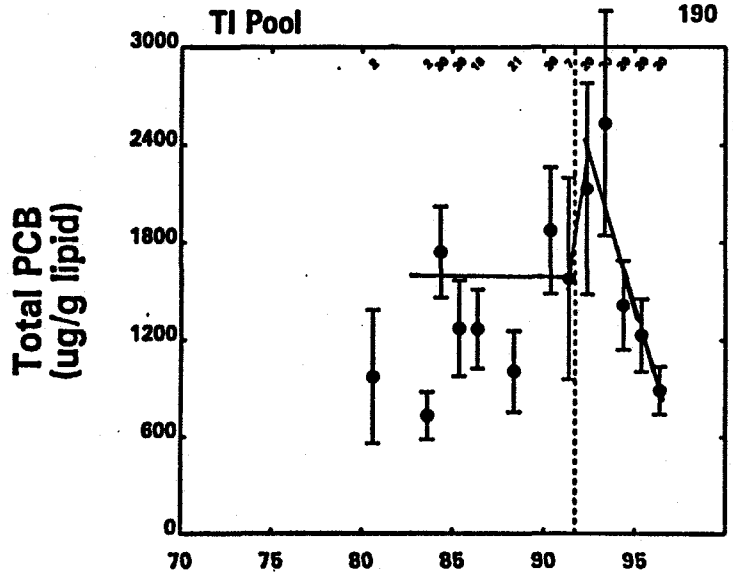
1) PCB levels in fish have shown a consistent decline since 1992 (Figure 8). A decline of about a factor of two occurred between 1993 and 1996. The 1996 levels are near or at historic lows.

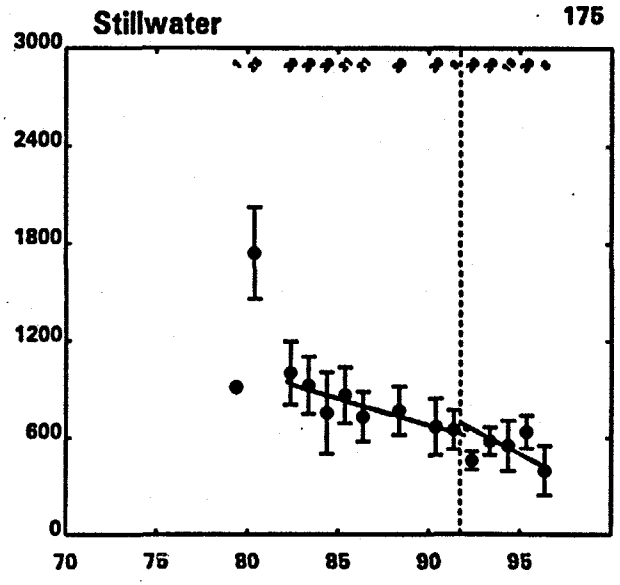
Brown Bi ead





Largemouth Bass





All sizes
Apr - Sep
All tissues (see database notes)
Males & Females
Mean +/- 2 std errors

Vertical line at Sept 17, 1991
Values are plotted approximately at the midpoint of each season
Number of observations are indicated at the bottom of each panel

312585

FIGURE 8

Temporal patterns in Total PCB Concentration

The residual sediment source is derived from surface sediments that have been deposited over the entire river bottom; not just from so called "hot spots" and not from old dechlorinated sediments

Supporting Data:

1) PCB concentrations in the main channel of the river gradually increase as water traverses the Thompson Island Pool (Figures 9 and 10).

2) Organic carbon normalized PCB concentrations in coarse sediments are as high as those in the fine sediments characteristic of hot spots (Figure 11). *Note that fluxes and bioaccumulation are controlled by the organic carbon normalized concentration, not the dry weight normalized concentration.*

3) The PCB composition in the water column indicates that the PCBs are derived from the pore water of undechlorinated sediments (Figure 12) that are typically found at the sediment surface.

HUDSON RIVER PROJECT
1996 Time of Travel Survey

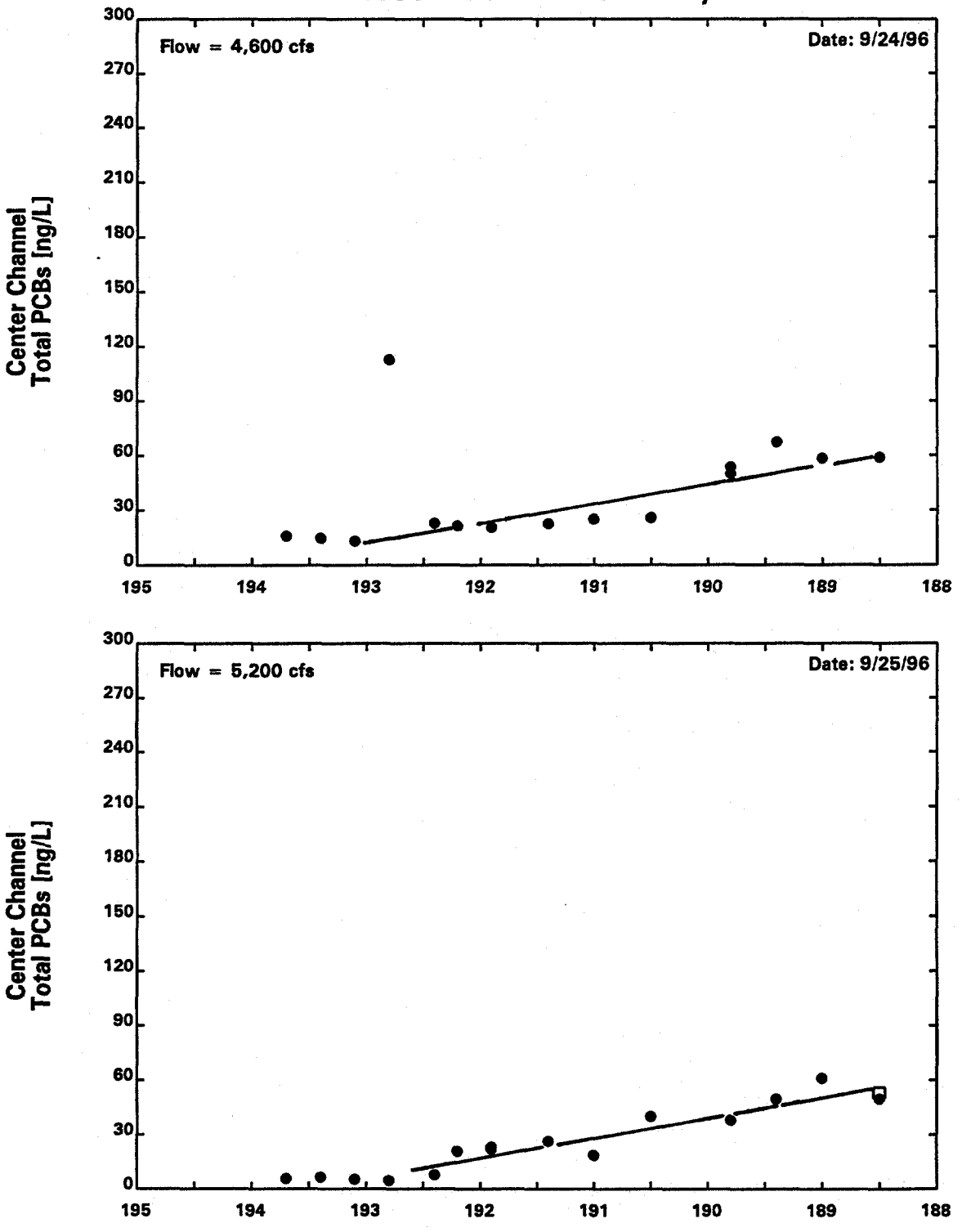


FIGURE 9

HUDSON RIVER PROJECT
1997 Time of Travel Survey

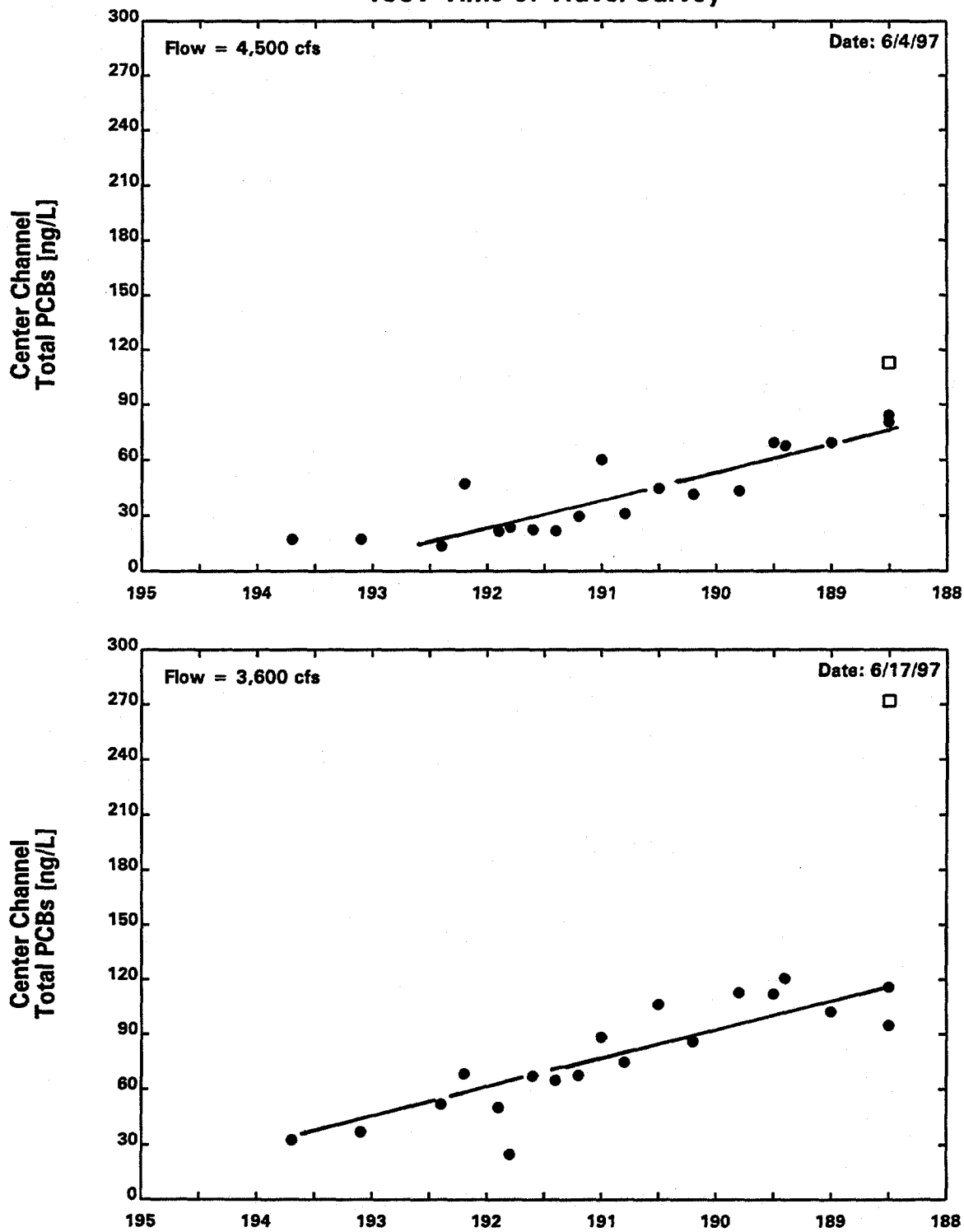
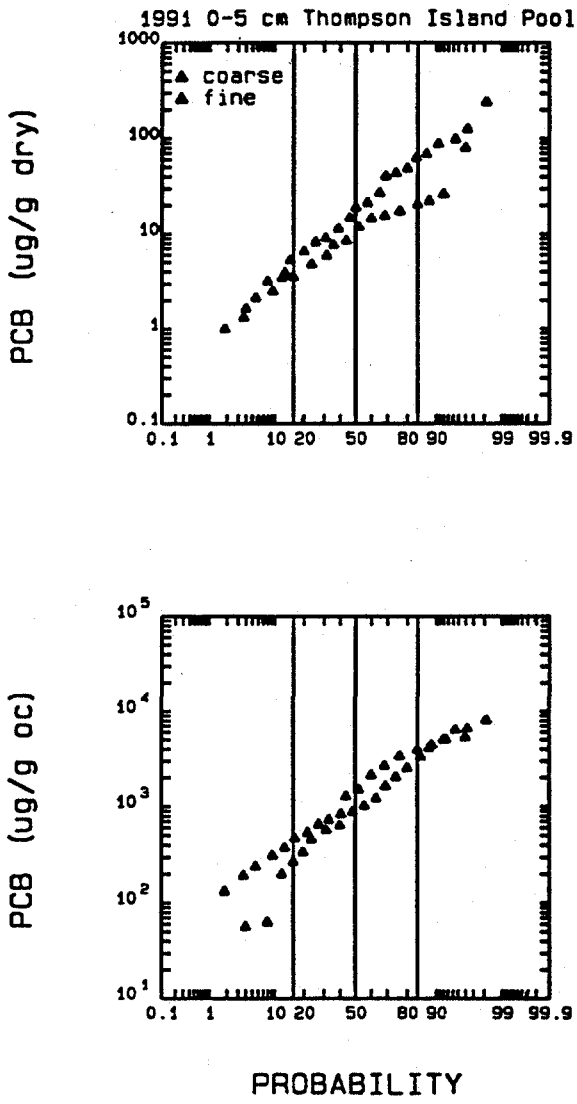
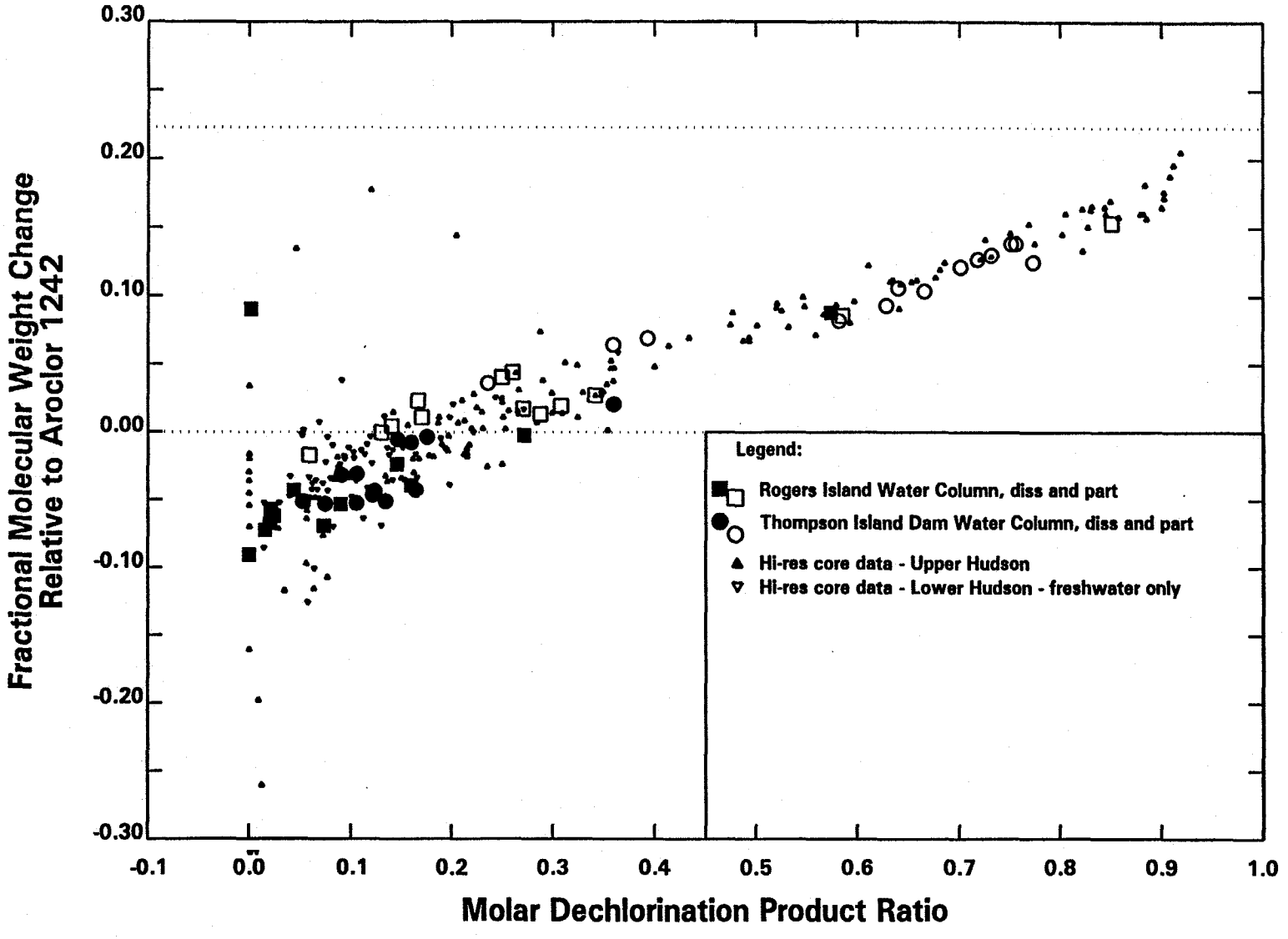


FIGURE 10



DATE: Wed Feb 8 TIME: 14:20:07
/power2/geco0310/DATA/SEDIMENT/PLOTS/ecnorm.gps

FIGURE 11



312590

FIGURE 12

Molar Dechlorination Product Ratio and Fractional Change in Molecular Weight

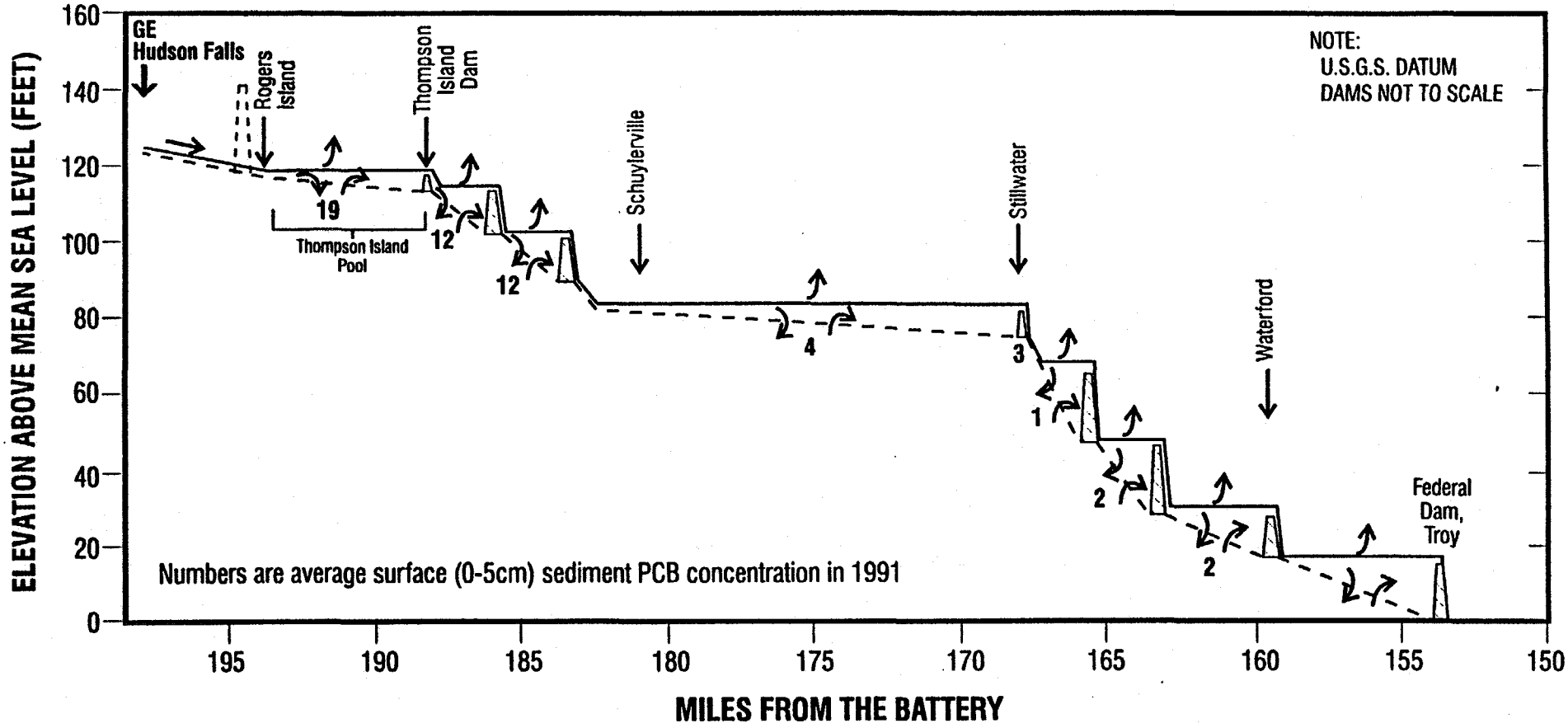
Wed Oct 15, 1997 12:23:25 /power2/geco0510/OLD_STRUC/geco0310/DATA/DECHLOR/LINE [line1]unk]

Surface sediments from above and below the TID contribute PCBs to the water column

Supporting Data:

1) Surface sediments in the two reaches immediately below the TIP have PCB levels comparable to those in the TIP (Figure 13).

2) Using unbiased data, the PCB loading increases between the Thompson Island Dam and Schuylerville (Figure 14).



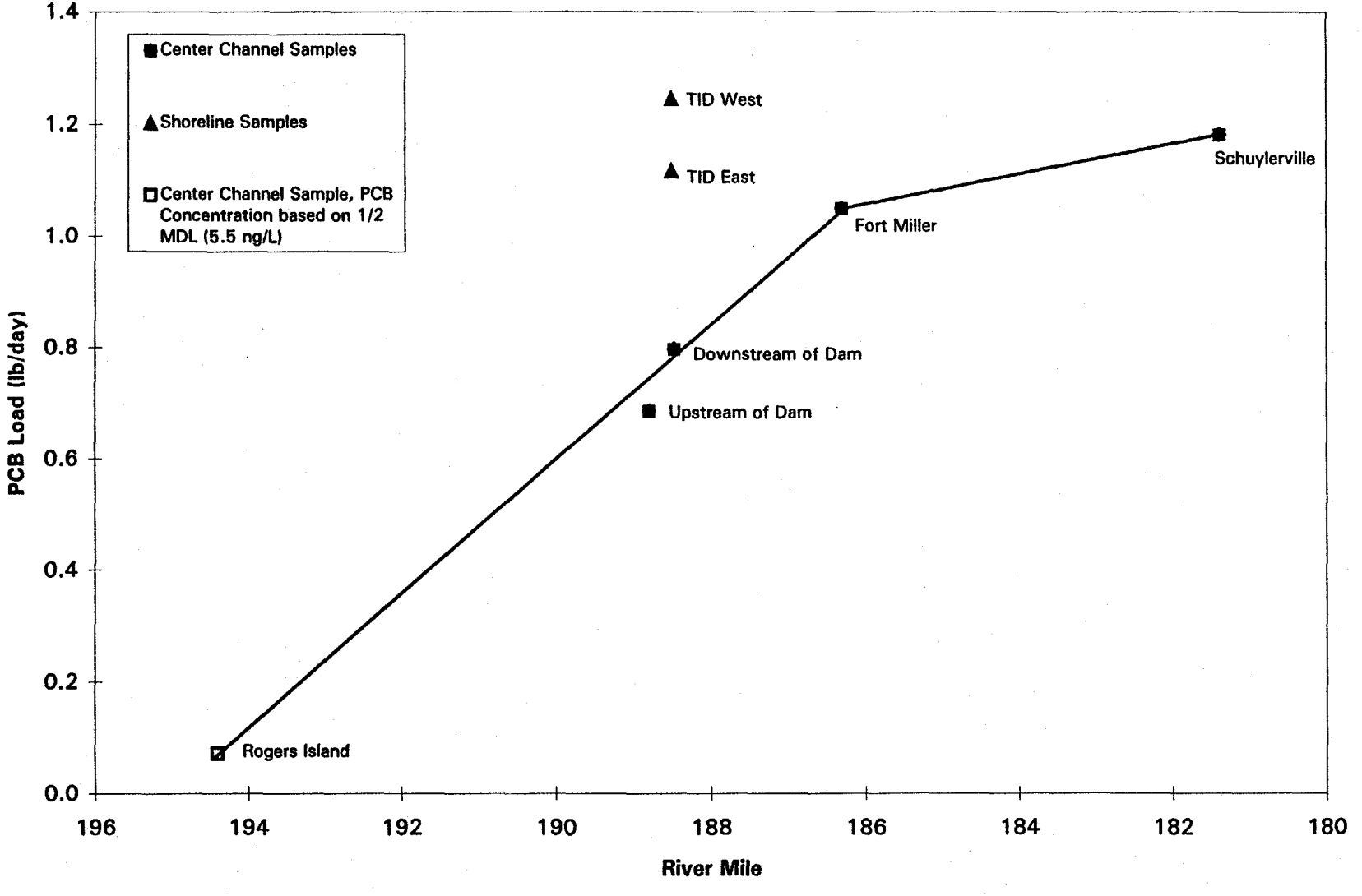
UPPER HUDSON RIVER
WATER SURFACE PROFILE
(FORT EDWARD TO FEDERAL LOCK)

312592

FIGURE 13

GENERAL ELECTRIC COMPANY - Hudson River Project

Spatial Profile of PCB Loading During 8/13/97 Sampling Event



312593

FIGURE 14

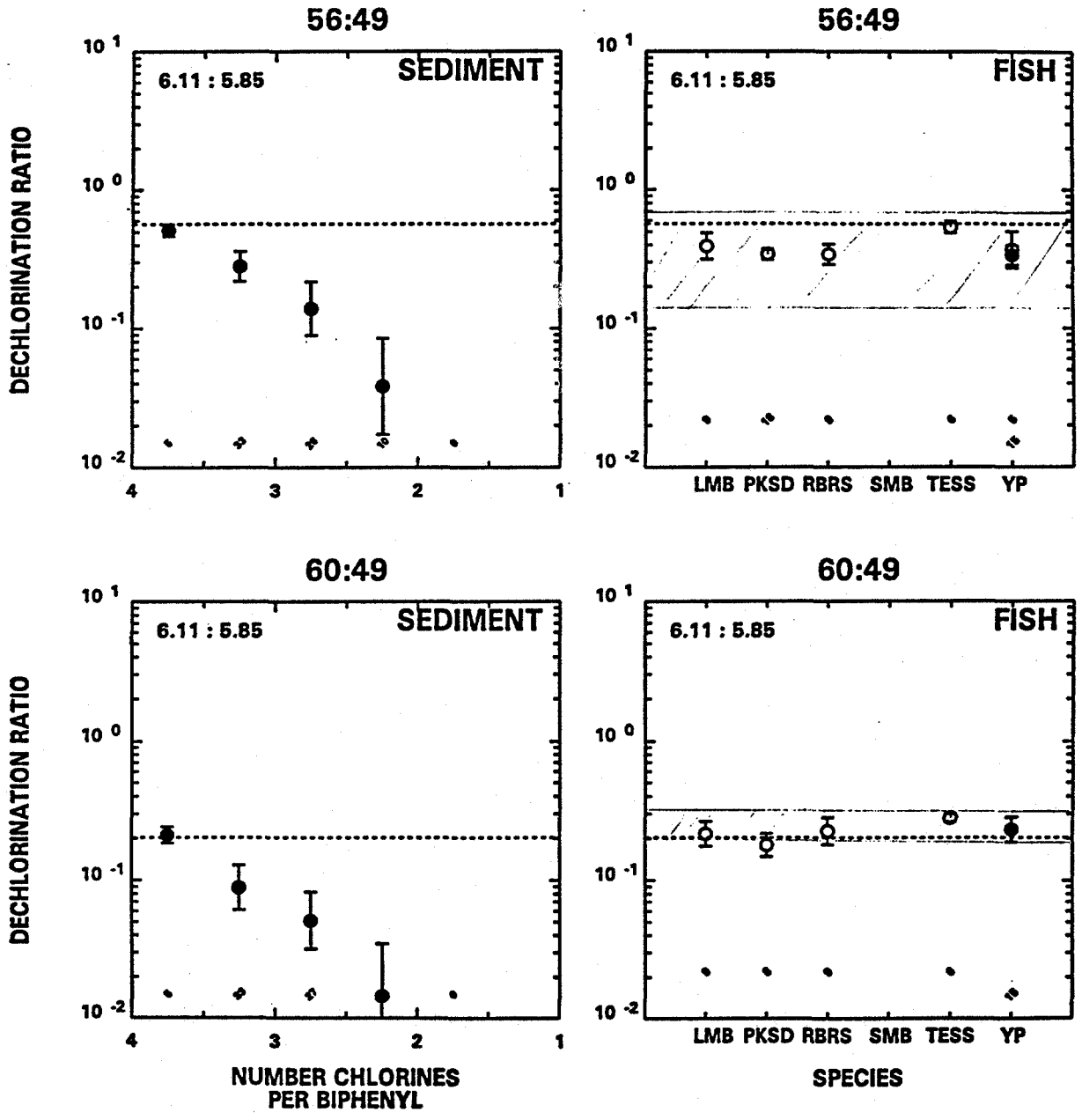
tip18cload.xls - aug 97 spatial plot Chart 1
10/15/97 - 4:12 PM

Fish are exposed to undechlorinated PCBs characteristic of the water column and the surface (0-2 cm) sediments

Supporting Evidence:

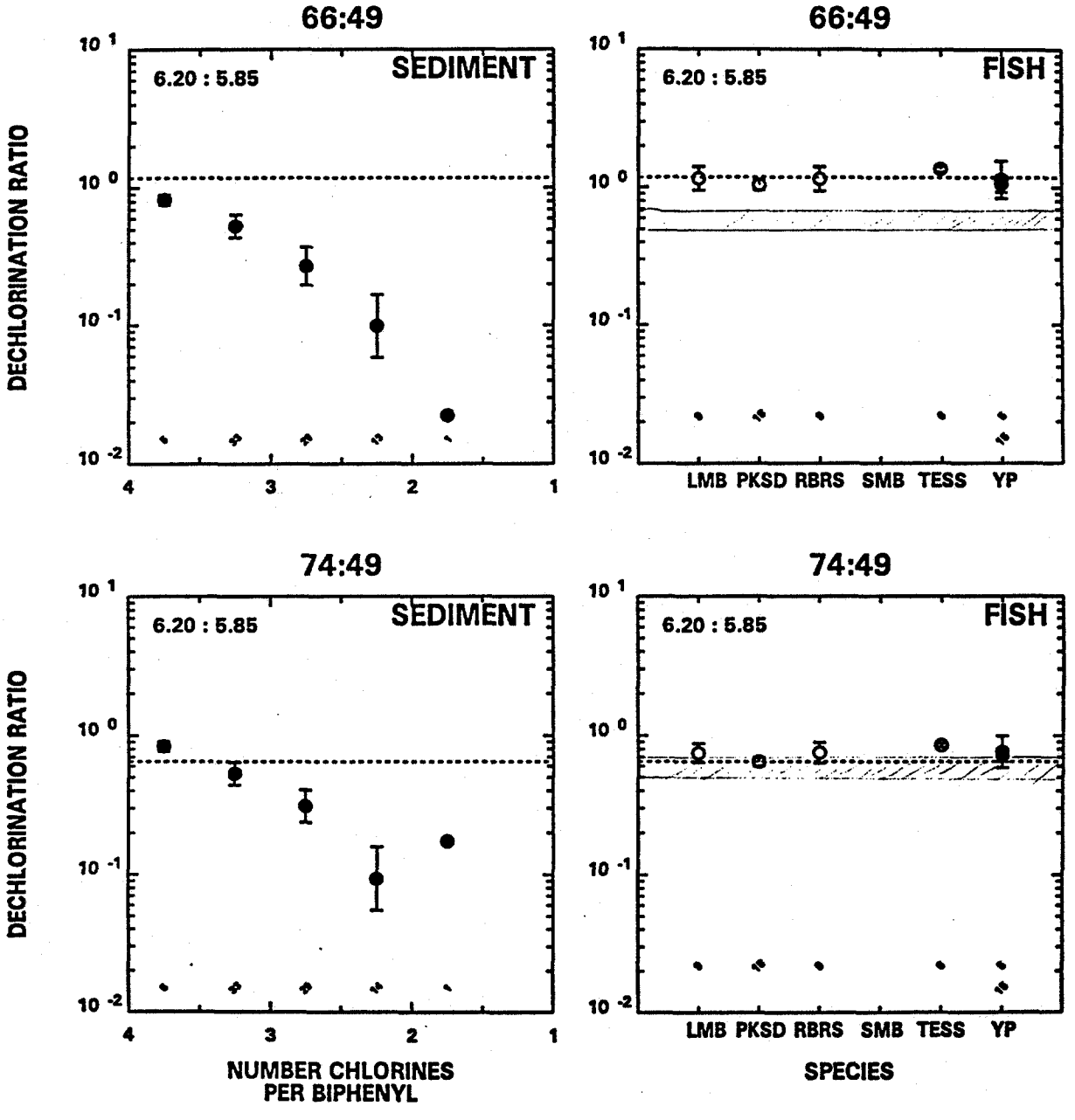
1) The ratio between two congeners with similar bioaccumulation potential, but differing susceptibility to dechlorination provides a marker of PCB source. Evidence from sediments indicates that such ratios change as PCBs are dechlorinated (left panels in Figures 15 and 16). The ratios in all species of Upper River fish analyzed by NOAA and EPA are similar to those found in undechlorinated sediments (right panels in Figures 15 and 16) and in Aroclor 1242 (dashed line in the figures).

2) Calculations of PCB homolog specific bioaccumulation indicate that the homolog pattern in fish is consistent with exposure to surface sediments (0 - 2 cm) (left panel in Figures 17-19) and inconsistent with exposure to 0-5 cm sediments (center panel) or with fully dechlorinated sediments (right panel).



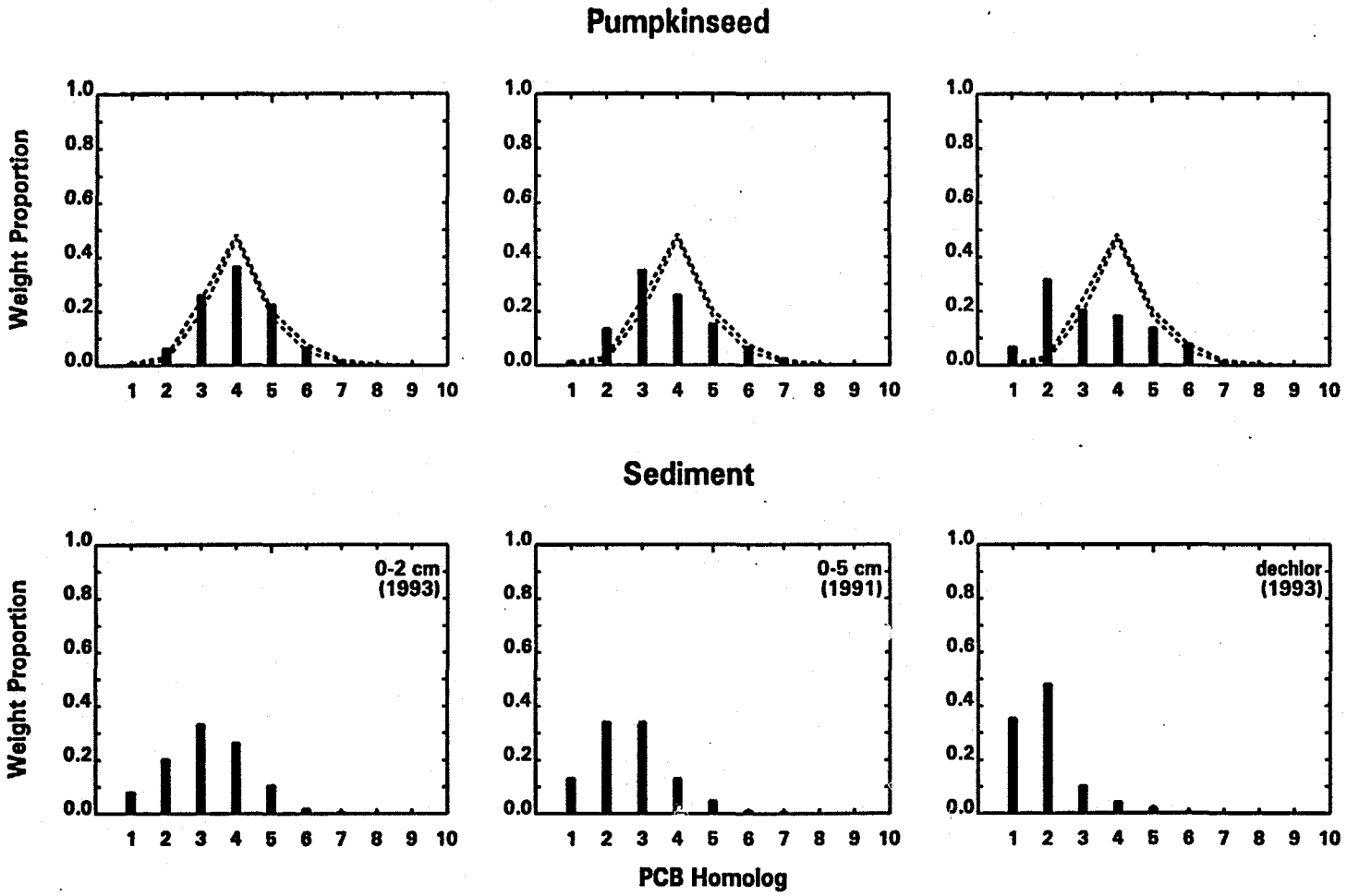
PCB Congener Dechlorination Ratios in Upper Hudson River (RM> = 153)
Geometric Mean +/- 2 Standard Errors
Sediment: USEPA Phase II High Resolution Cores 0-40 cm (0.5 CL/BP bins)
Fish: ○ NOAA
● USEPA Phase II
Horizontal Dashed Line Represents Ratio in Aroclor 1242

FIGURE 15



PCB Congener Dechlorination Ratios in Upper Hudson River (RM> = 153)
Geometric Mean +/- 2 Standard Errors
Sediment: USEPA Phase II High Resolution Cores 0-40 cm (0.5 CL/BP bins)
Fish: ○ NOAA
● USEPA Phase II
Horizontal Dashed Line Represents Ratio in Aroclor 1242

FIGURE 16



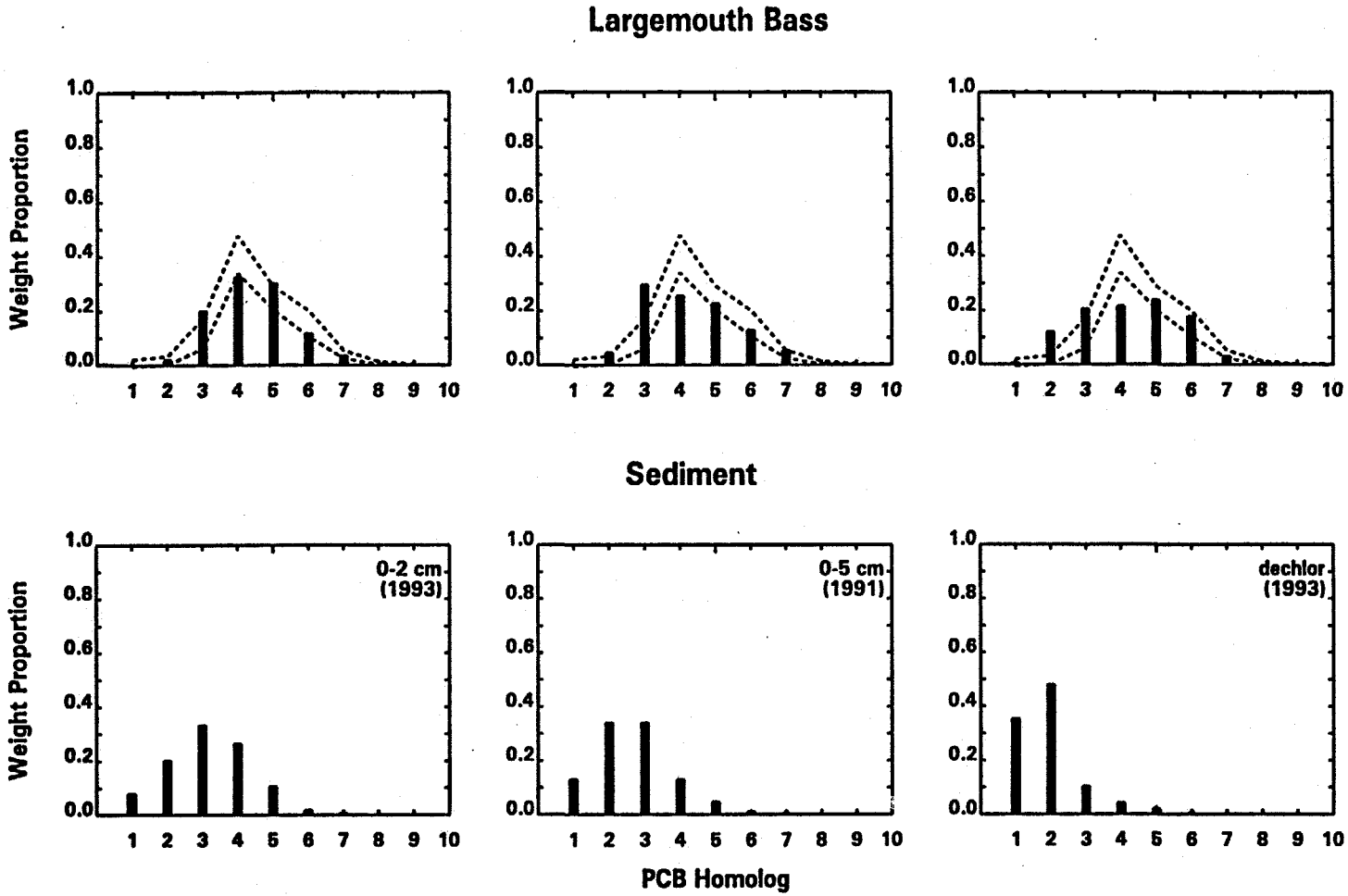
STEADY STATE FOOD WEB MODEL
PUMPKINSEED IN THOMPSON ISLAND POOL

Tue Aug 26, 1997 15:08:27

Data: after 1989
dashed lines: TI Pool pumpkinseed, +/- 2 std errs
Model: Age 3 Pumpkinseed

312597

FIGURE 17



STEADY STATE FOOD WEB MODEL
LARGEMOUTH BASS IN THOMPSON ISLAND POOL

Tue Aug 26, 1997 15:08:16

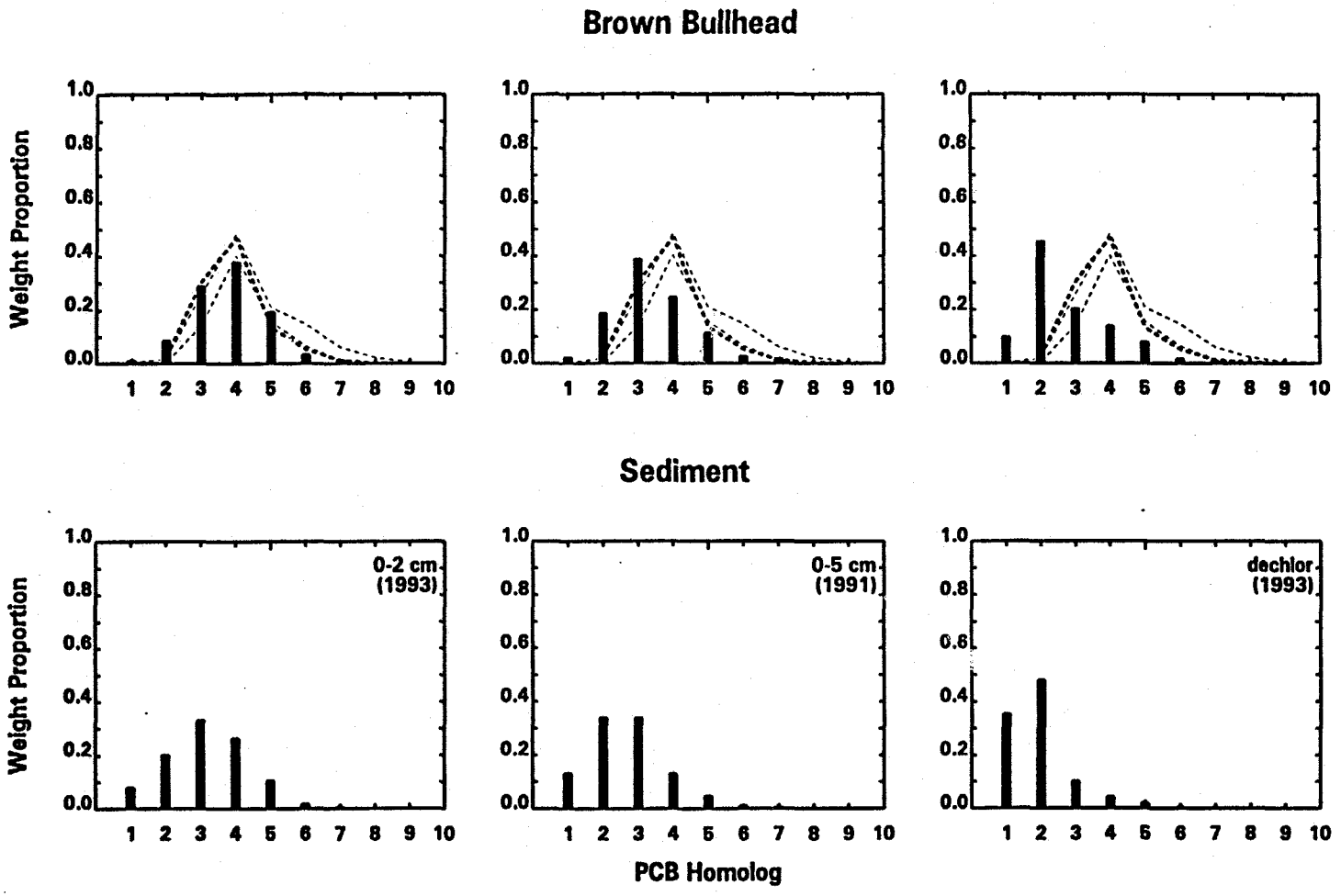
Data: after 1989

dashed lines: TI Pool largemouth and smallmouth bass, +/- 2 std errs

Model: Age 5 Largemouth Bass

312598

FIGURE 18



STEADY STATE FOOD WEB MODEL
BROWN BULLHEAD IN THOMPSON ISLAND POOL

Data: after 1989
light dashed lines: Upper HR, +/-2 std errs
heavy dashed lines: TI Pool
Model: Age 3 Brown Bullhead

312599

FIGURE 19

The lower river PCB problem is not dominated by the Upper River PCB source

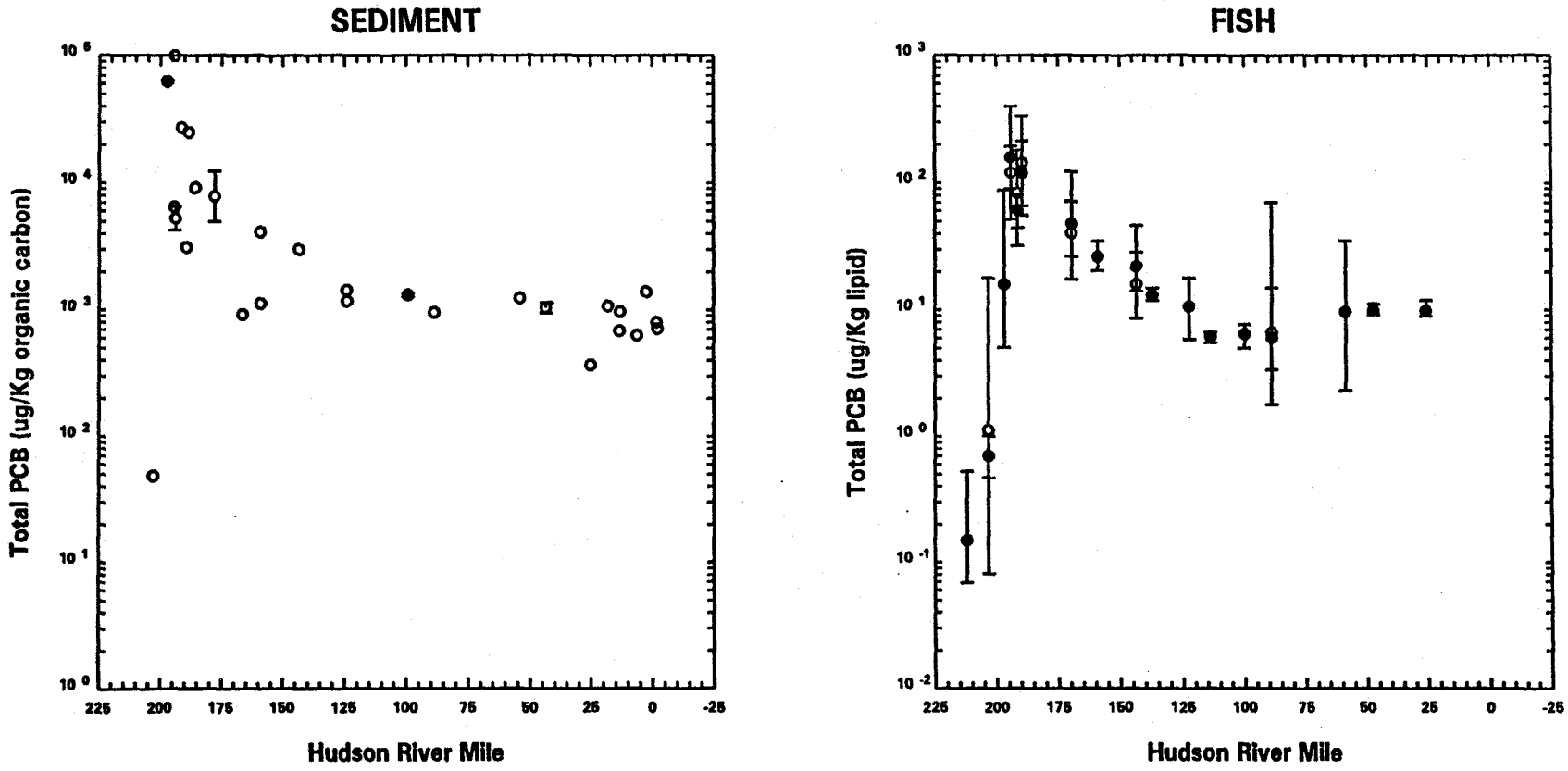
Supporting Evidence:

1) Sediment and fish PCB concentrations decline from Thompson Island Dam to about river mile 100. Between river mile 100 and NY Harbor the pattern varies depending on the manner in which PCBs are aggregated:

   a) Total PCB levels are approximately constant or rise slightly (Figure 20)

   b) The homologs exhibit a shift in pattern with level of chlorination (Figures 21-30). Monochloro- and Dichloro-PCBs continue to decline. Trichloro-and Tetrachloro-PCBs are approximately constant. An increase is seen with the higher chlorinated homologs, becoming more pronounced with the level of chlorination.

   Levels attributable to an upstream source **must** decline with distance downstream due to dilution with additional fresh water and salt water and due to losses resulting from volatilization and deposition. Thus, the pattern seen for monochloro- and dichloro-PCB may be indicative of the behavior of an upstream source. The patterns seen for Total PCB and the higher homologs indicate that downstream sources become increasingly important with distance below river mile 100 and dominant in the metropolitan region.



312601

Total PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

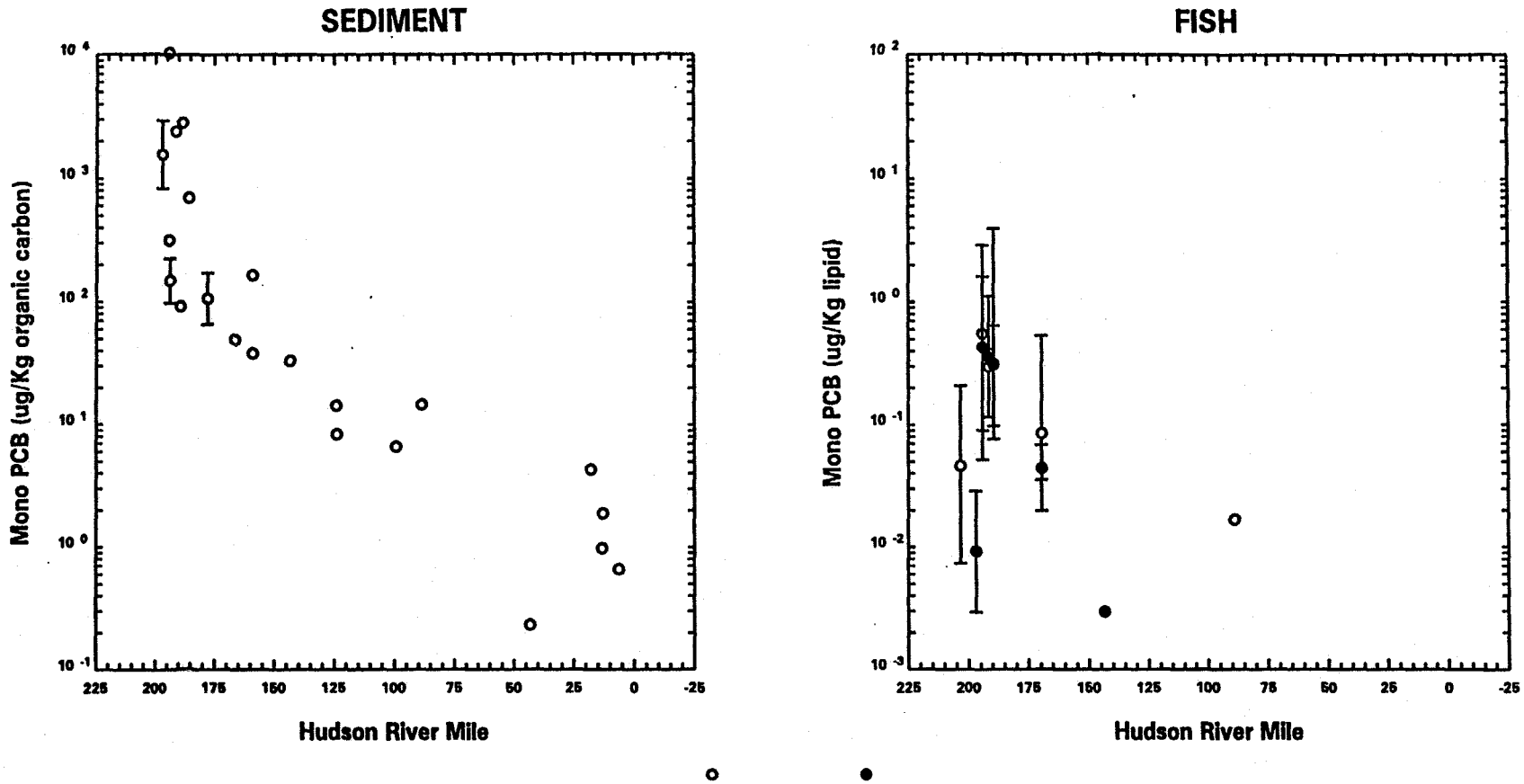
All Fish except Striped Bass and White Perch

Total PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

FIGURE 20

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



312602

Mono PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

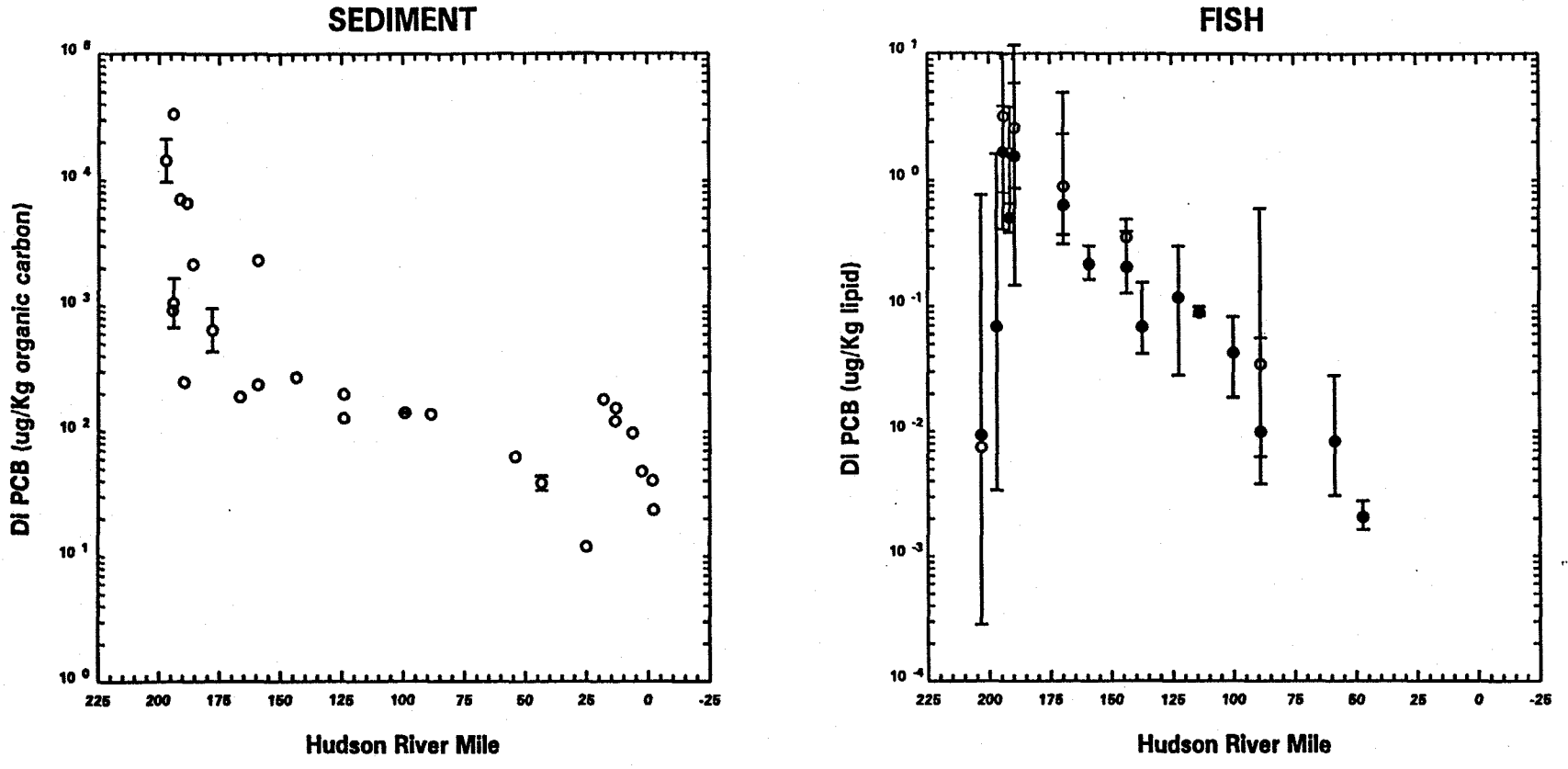
All Fish except Striped Bass and White Perch

Mono PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

FIGURE 21

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



Di PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

All Fish except Striped Bass and White Perch

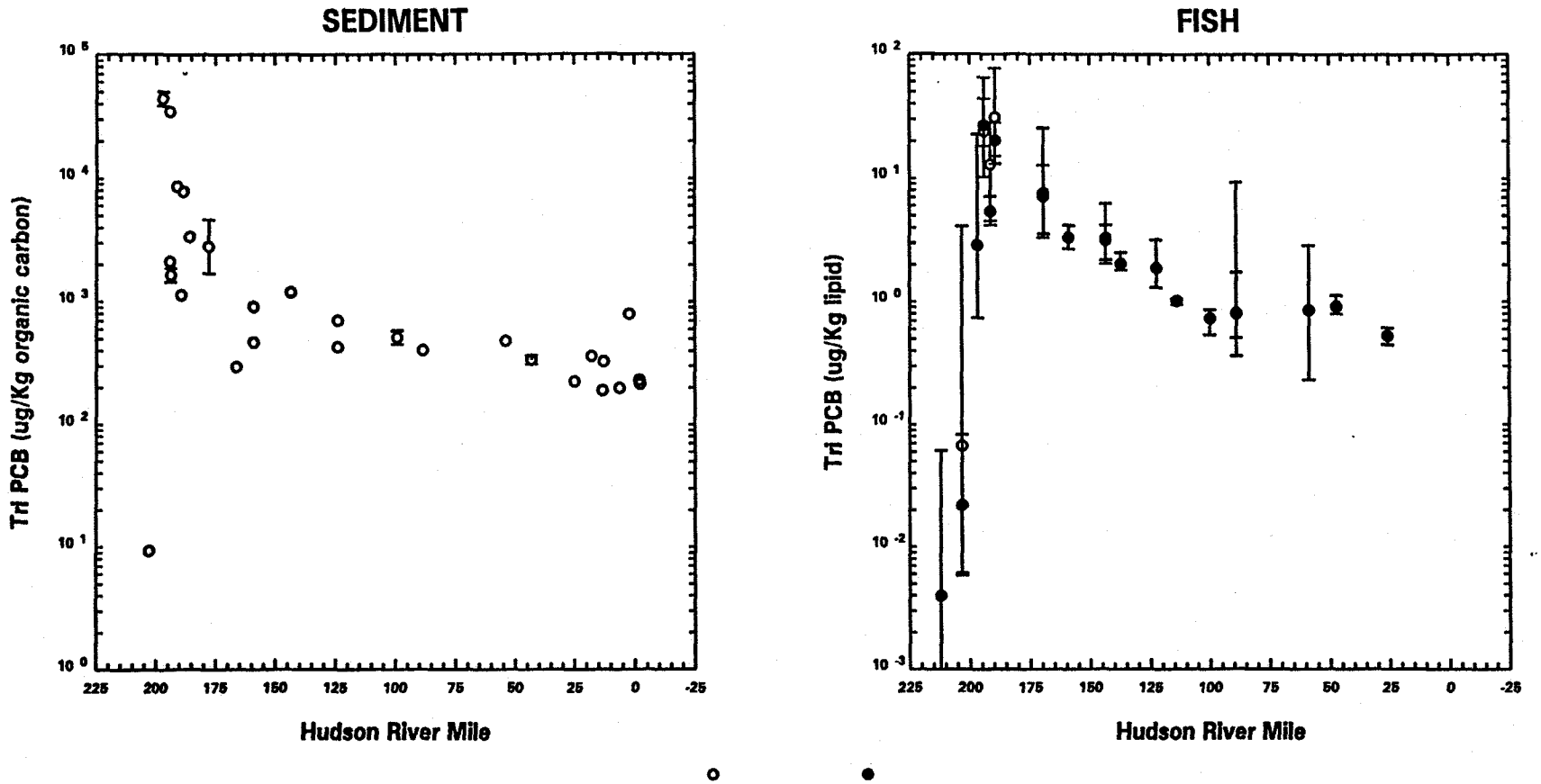
Di PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

312603

FIGURE 22

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



Tri PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

All Fish except Striped Bass and White Perch

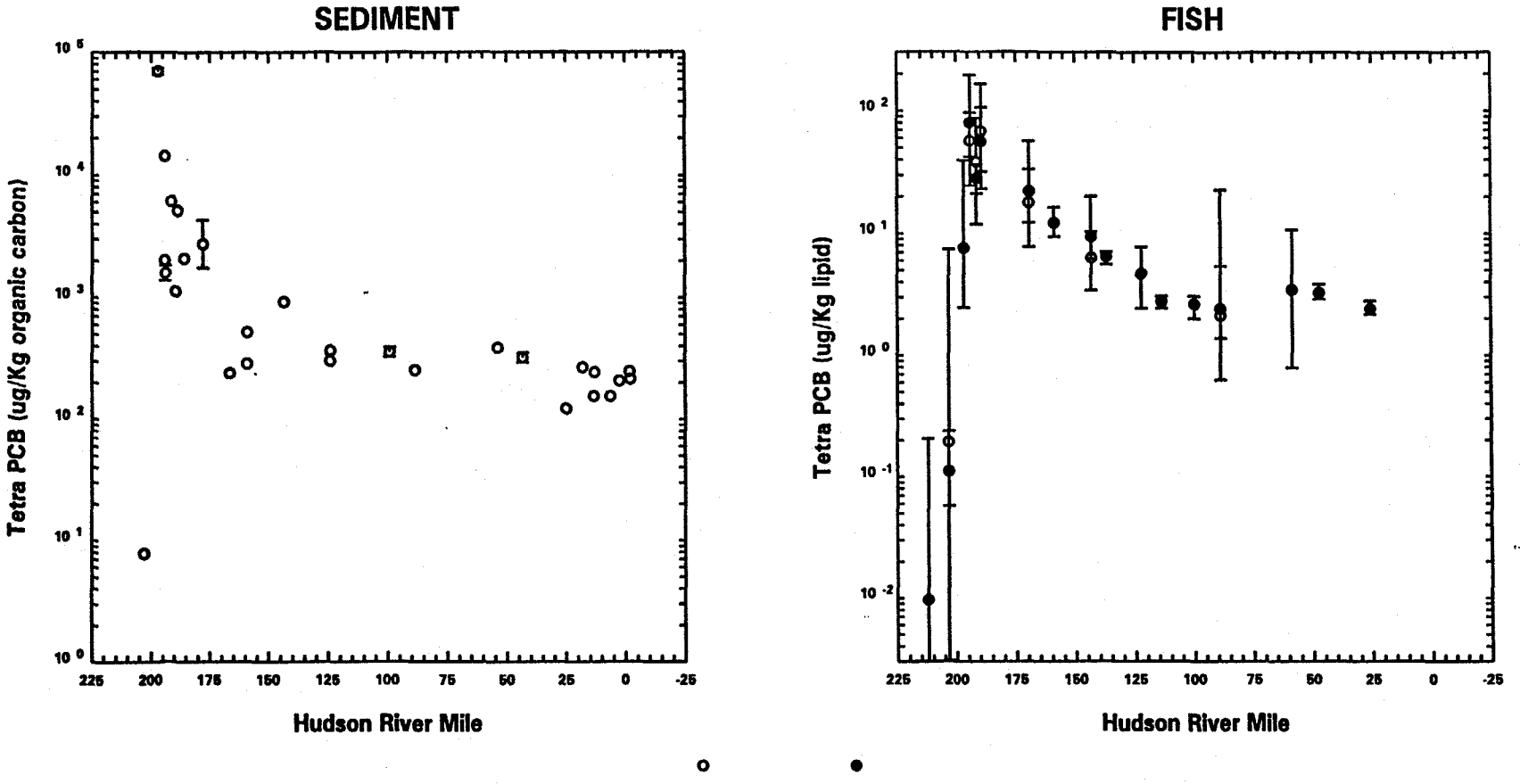
Tri PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

312604

FIGURE 23

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



312605

Tetra PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

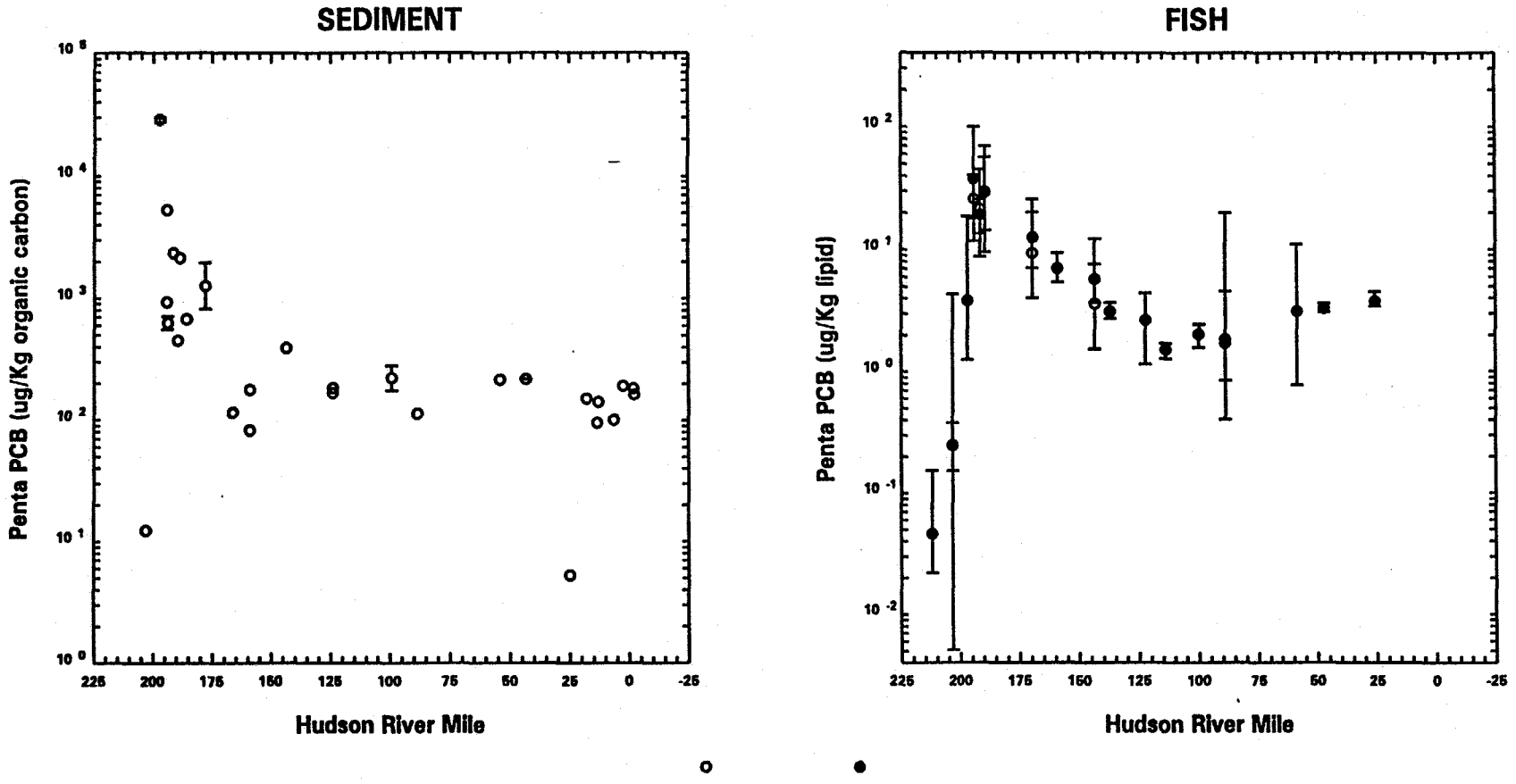
All Fish except Striped Bass and White Perch

Tetra PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

FIGURE 24

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



312606

Penta PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

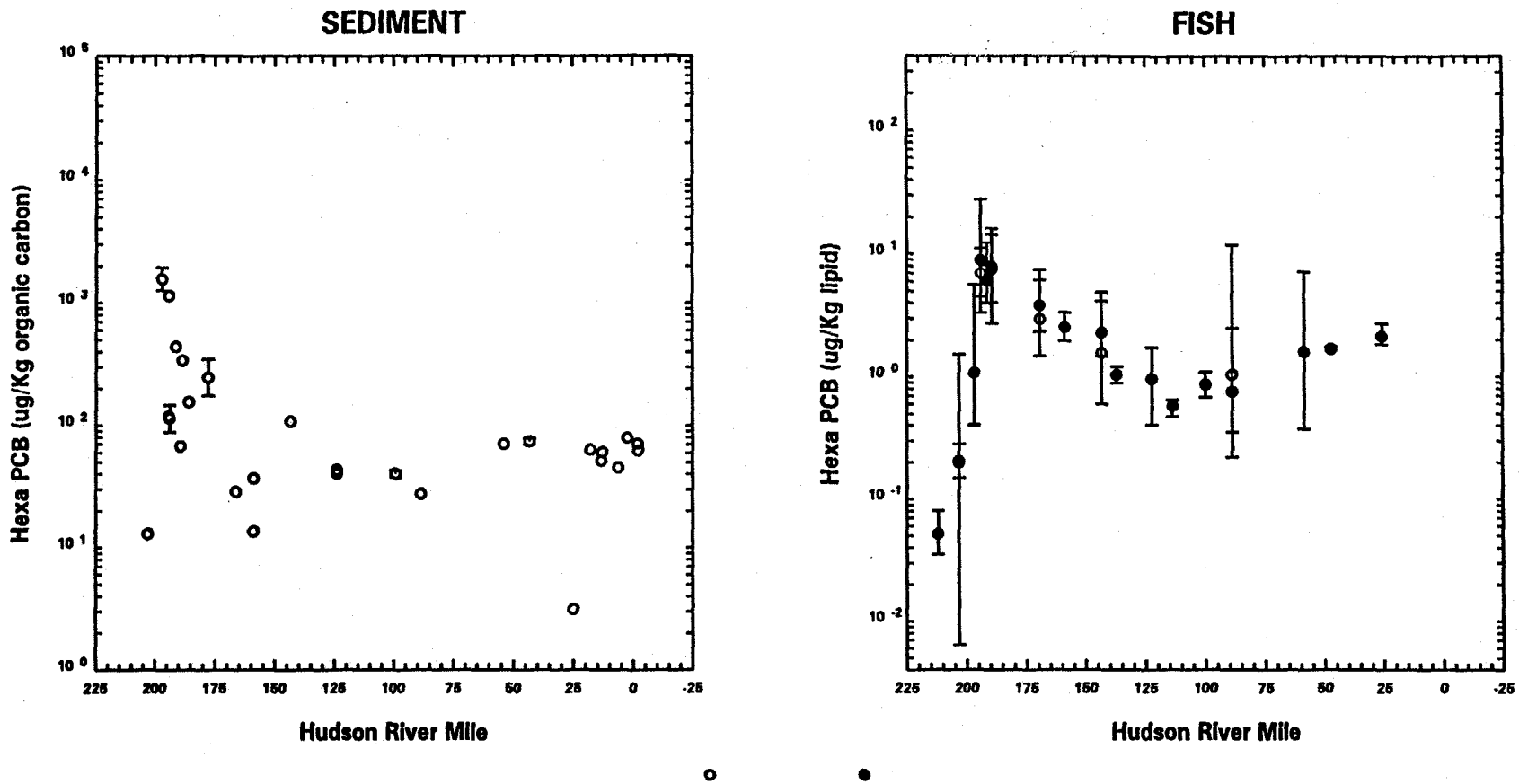
All Fish except Striped Bass and White Perch

Penta PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

FIGURE 25

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



312607

Hexa PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

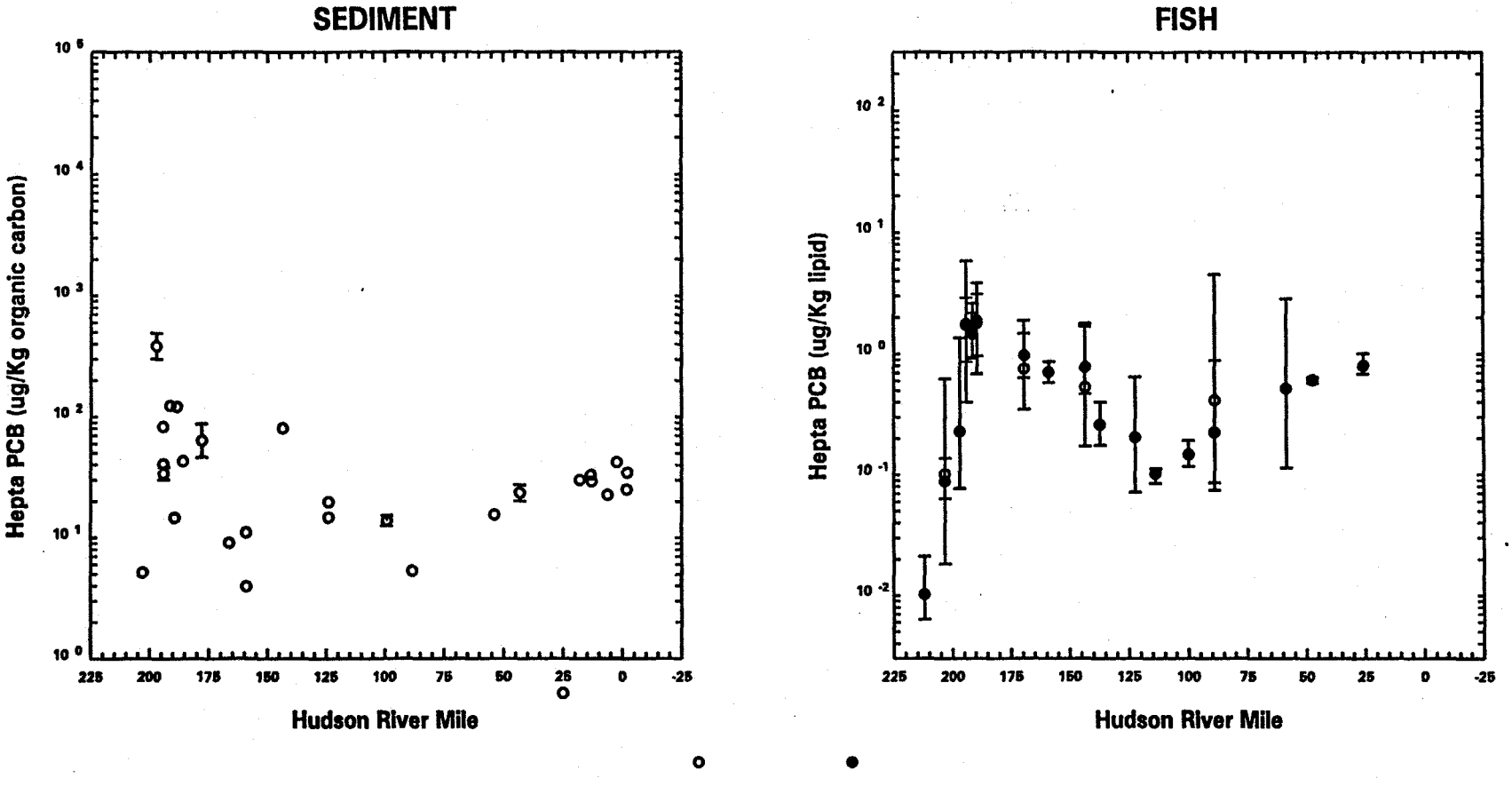
All Fish except Striped Bass and White Perch

Hexa PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

FIGURE 26

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



312608

Hepta PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

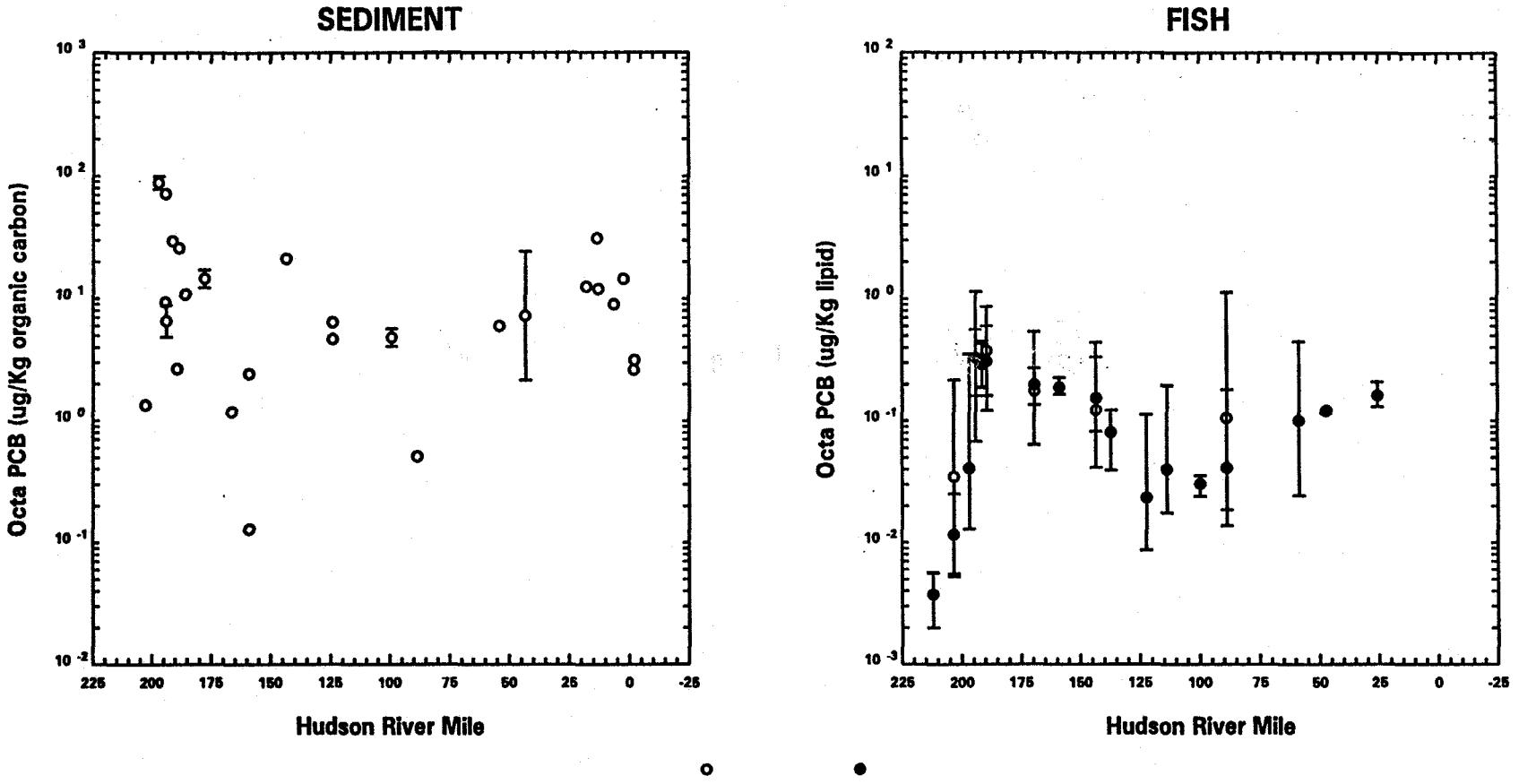
All Fish except Striped Bass and White Perch

Hepta PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

Figure 27

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



Octa PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

All Fish except Striped Bass and White Perch

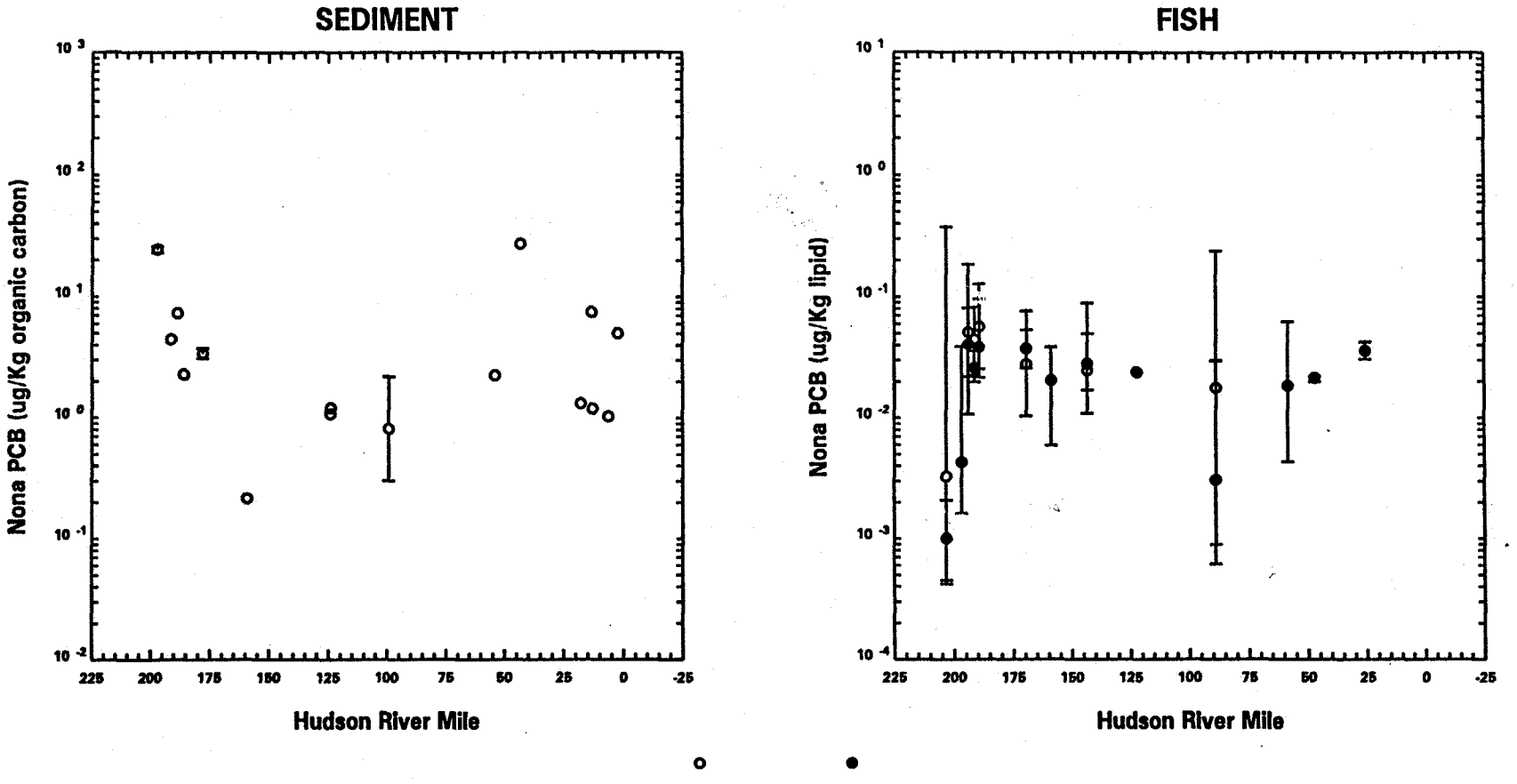
Octa PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

312609

Figure 28

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



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Nona PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

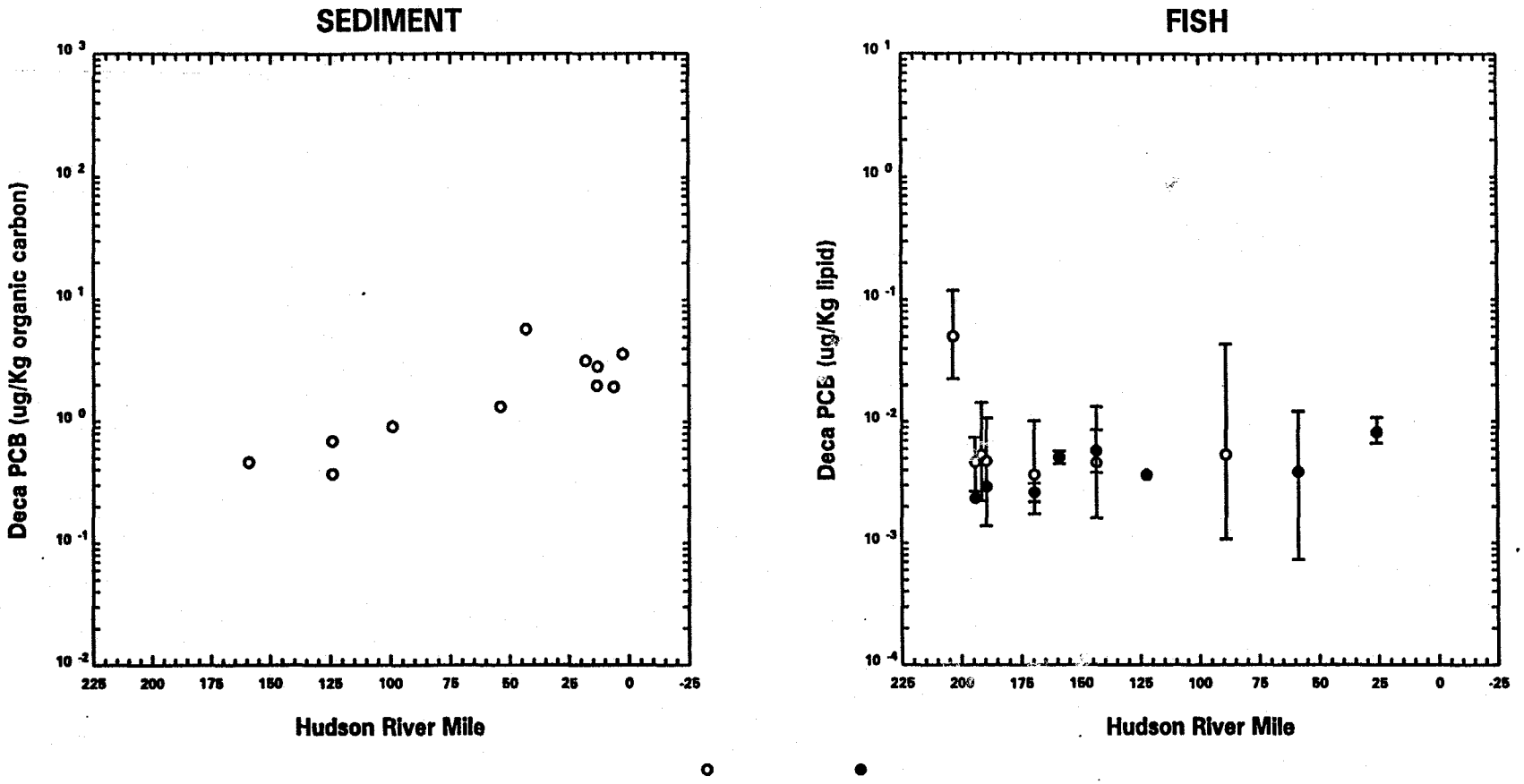
All Fish except Striped Bass and White Perch

Nona PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

FIGURE 29

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp



Deca PCB (Lipid Normalized) in Hudson River Fish -- NOAA and EPA Data 1993

All Fish except Striped Bass and White Perch

Deca PCB (Organic Carbon Normalized) in Hudson River 0-2 cm Sediment -- EPA Data 1992

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FIGURE 30

Wed Oct 15,1997 13:14:37

/power2/geco0510/ANALYSIS/MULTIMEDIA/HOM TOT/htbf1.sed htbf1.gdp