South River Site Conceptual Model

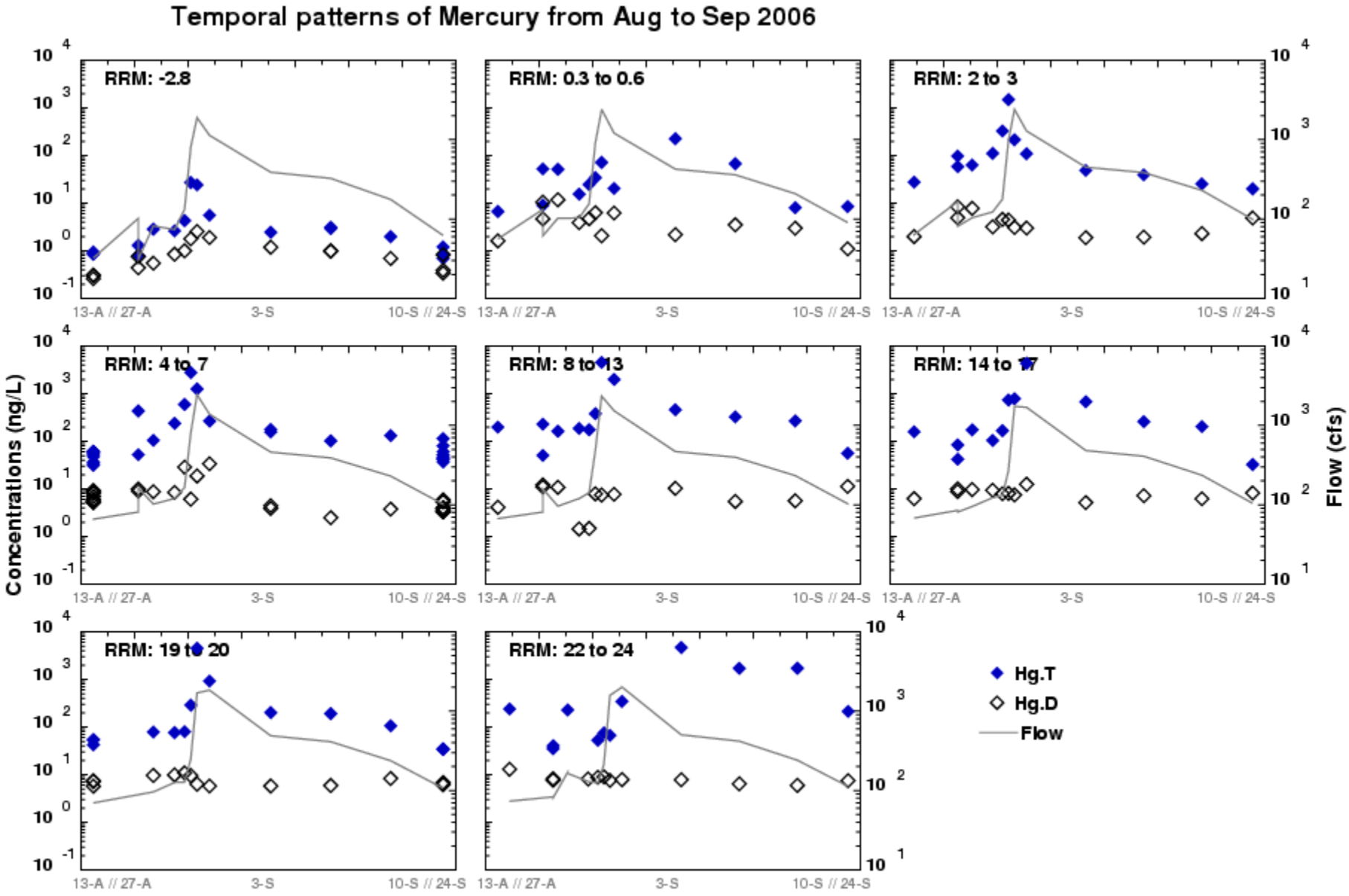
SRST

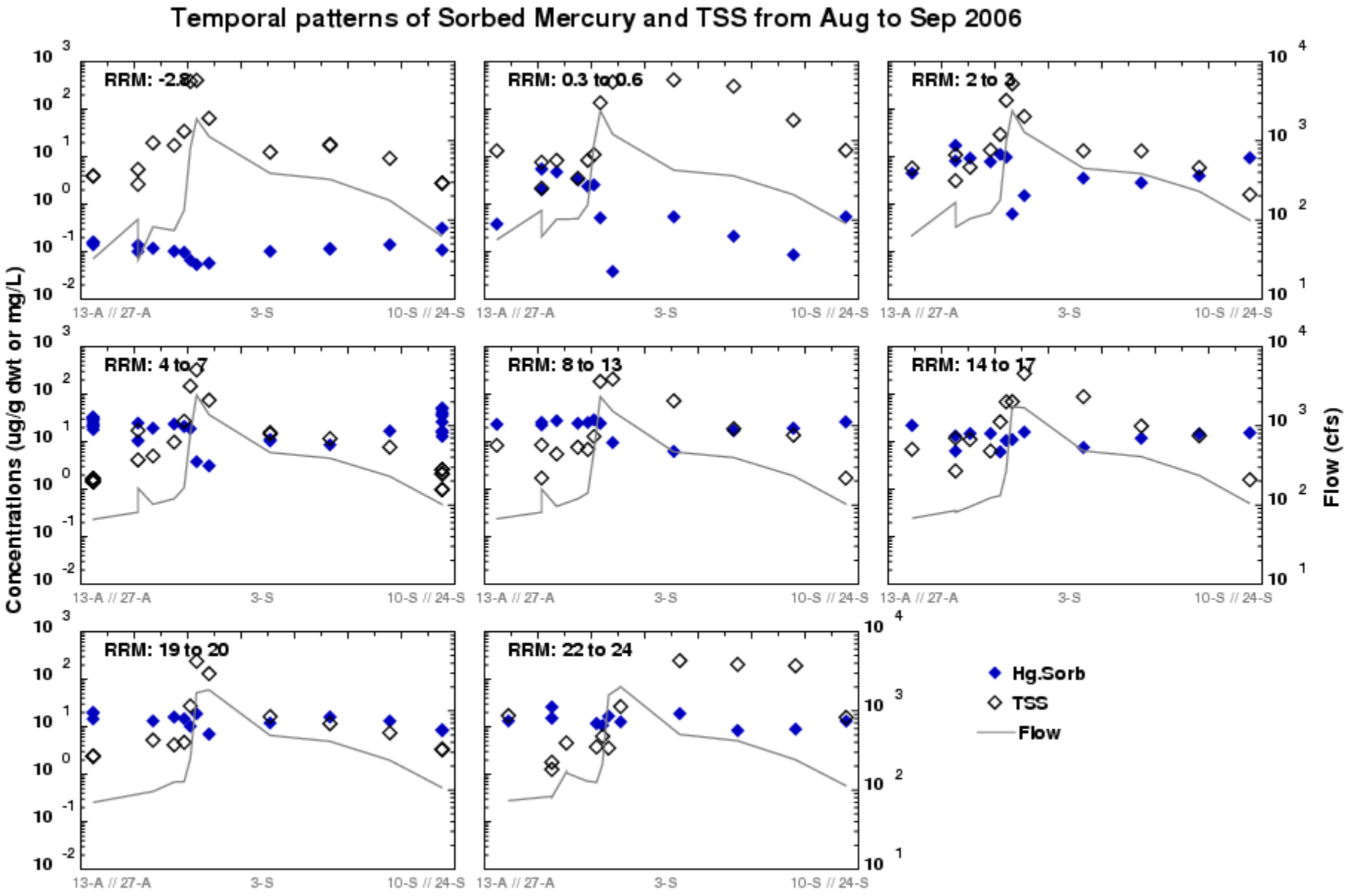
HydroQual

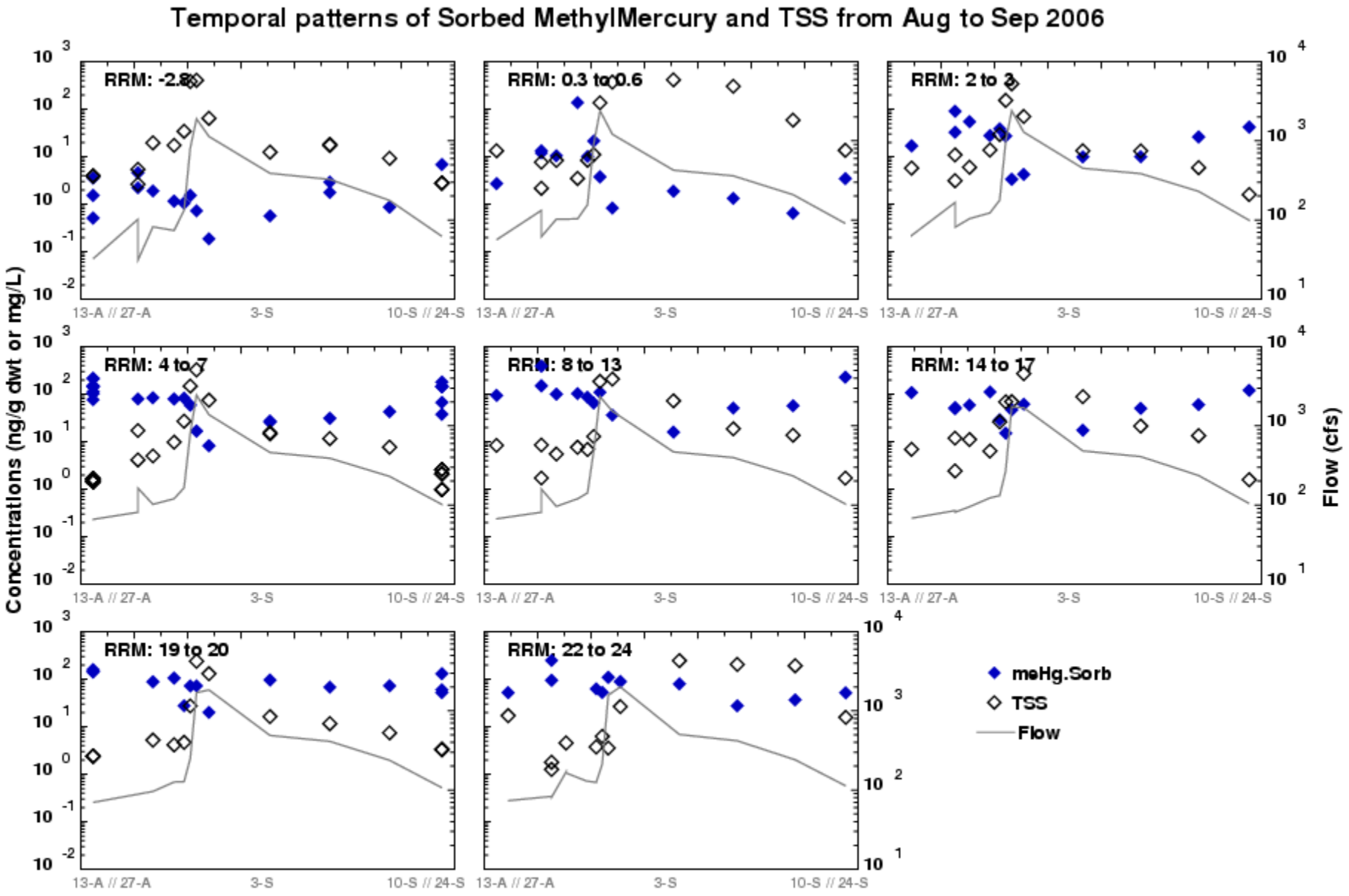
April 17, 2007

Outline

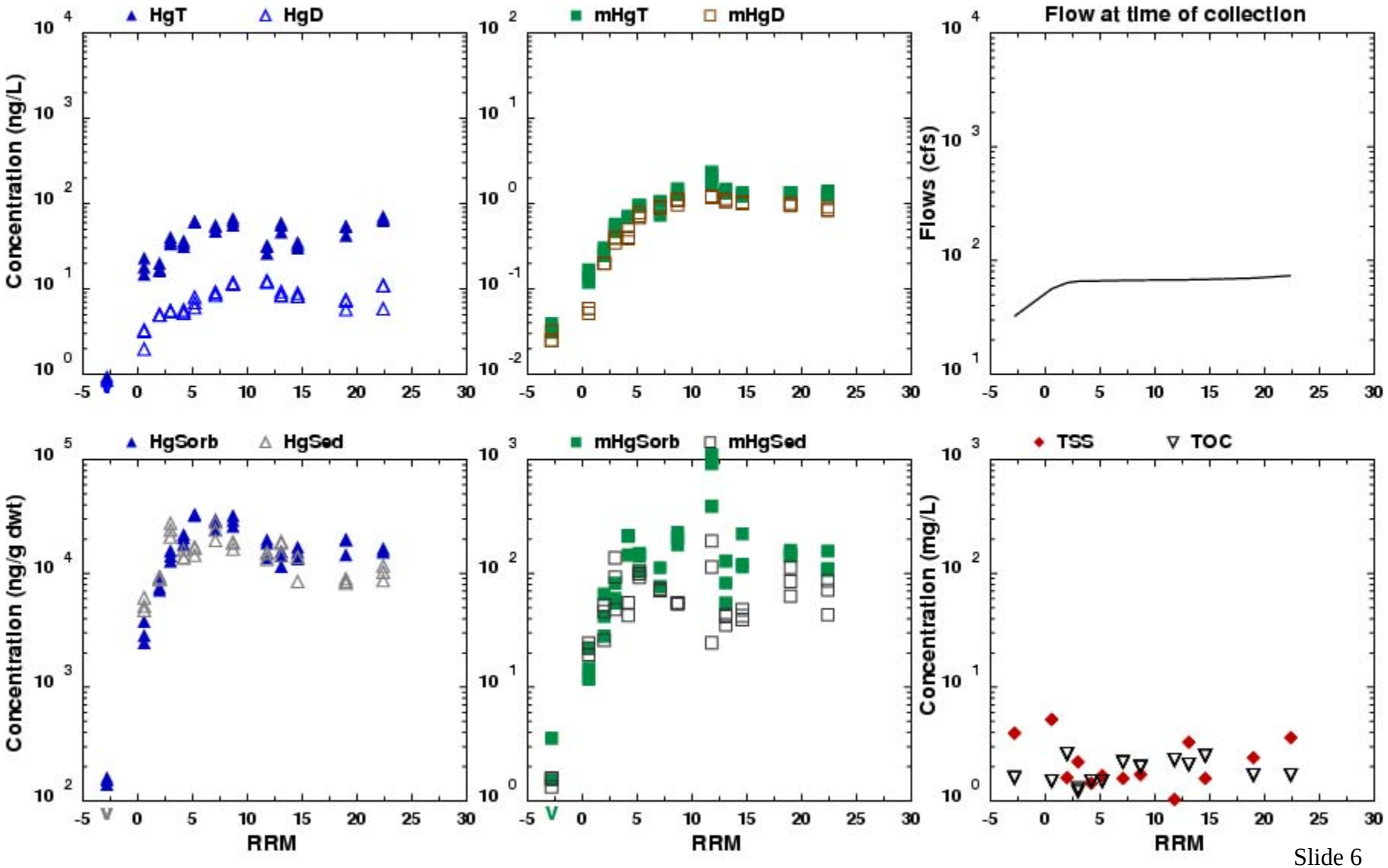
- Data analysis and loading calculations of monthly monitoring data and storm events
  - Time-variable estimates of flow necessary to understand storm events
- Temporal plots
  - Evaluation of seasonal patterns
- Fish-Hg
  - Statistics and bioaccumulation calculations


Temporal patterns of Mercury from Aug to Sep 2006
RRM: -2.8
RRM: 0.3 to 0.6
RRM: 2 to 3
RRM: 4 to 7
RRM: 8 to 13
RRM: 14 to 17
RRM: 19 to 20
RRM: 22 to 24
13-A // 27-A
3-S
10-S // 24-S
Concentrations (ng/L)
Flow (cfs)
Hg.T
Hg.D
Flow

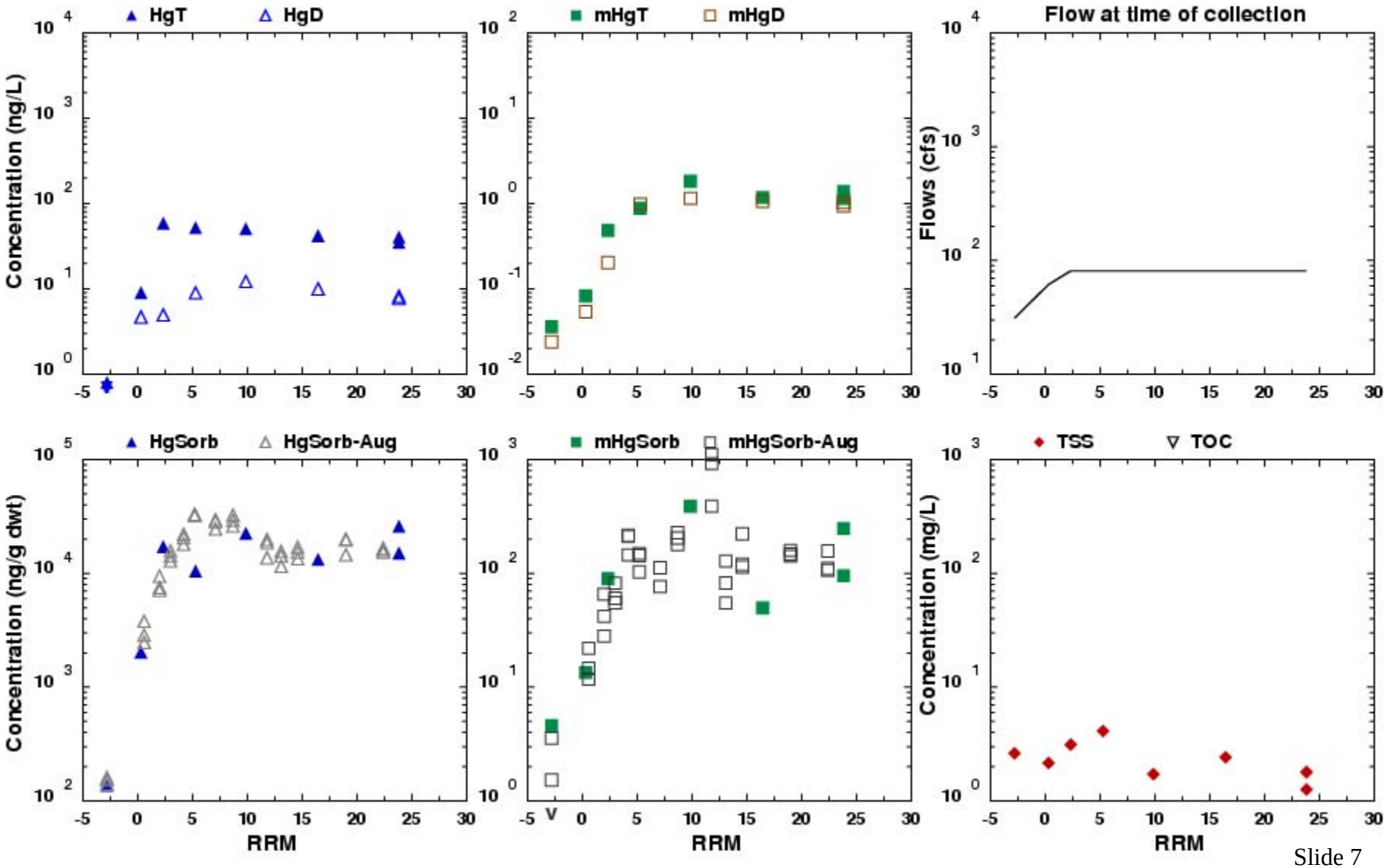

Temporal patterns of Sorbed Mercury and TSS from Aug to Sep 2006
RRM: -2.8
RRM: 0.3 to 0.6
RRM: 2 to 3
RRM: 4 to 7
RRM: 8 to 13
RRM: 14 to 17
RRM: 19 to 20
RRM: 22 to 24
13-A // 27-A
3-S
10-S // 24-S
Concentrations (ug/g dwt or mg/L)
Flow (cfs)
Hg.Sorb
TSS
Flow


Temporal patterns of Sorbed MethylMercury and TSS from Aug to Sep 2006
RRM: -2.8
RRM: 0.3 to 0.6
RRM: 2 to 3
RRM: 4 to 7
RRM: 8 to 13
RRM: 14 to 17
RRM: 19 to 20
RRM: 22 to 24
13-A // 27-A
3-S
10-S // 24-S
Concentrations (ng/g dwt or mg/L)
Flow (cfs)
meHg.Sorb
TSS
Flow

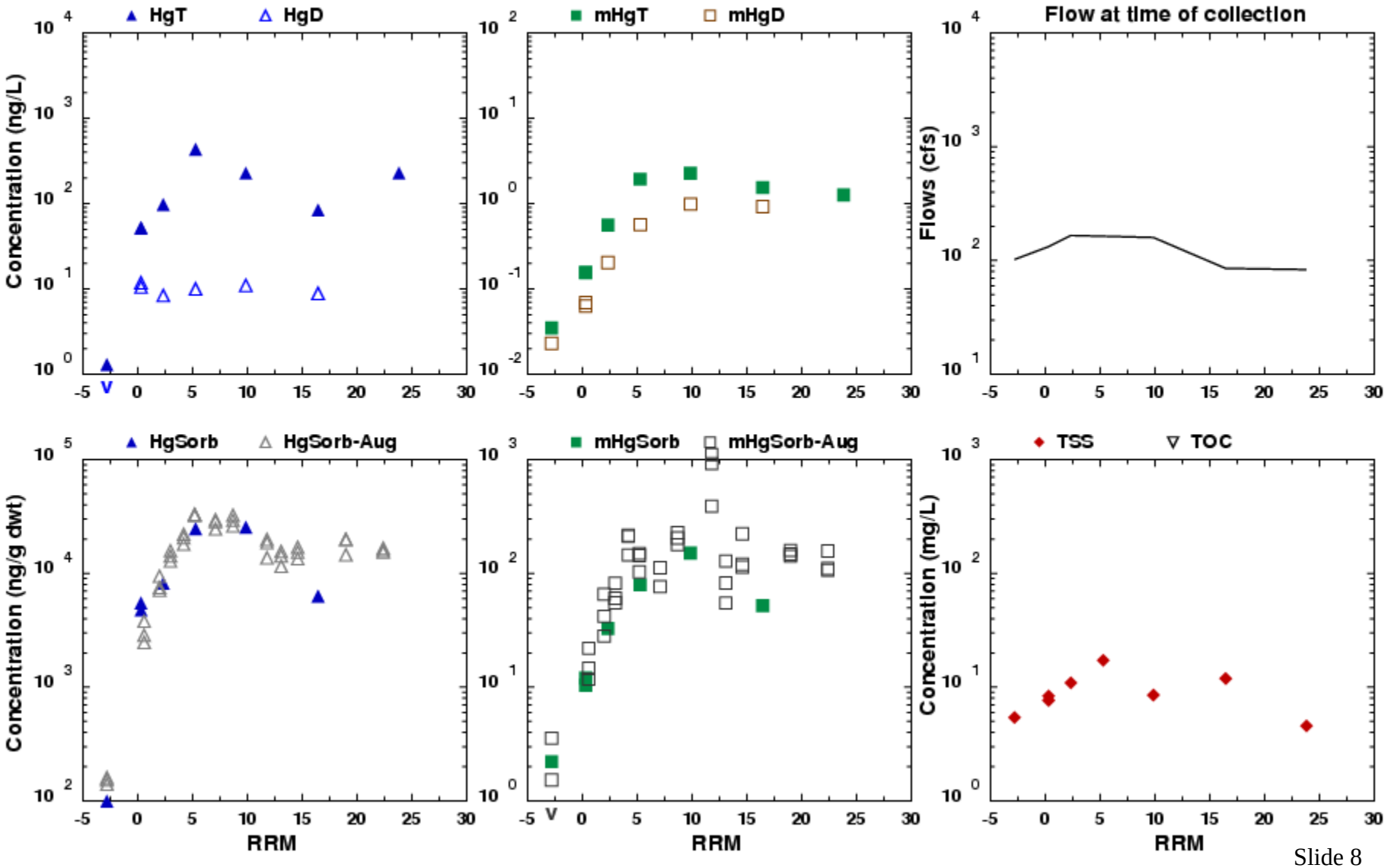
Monthly monitoring data: August 2006



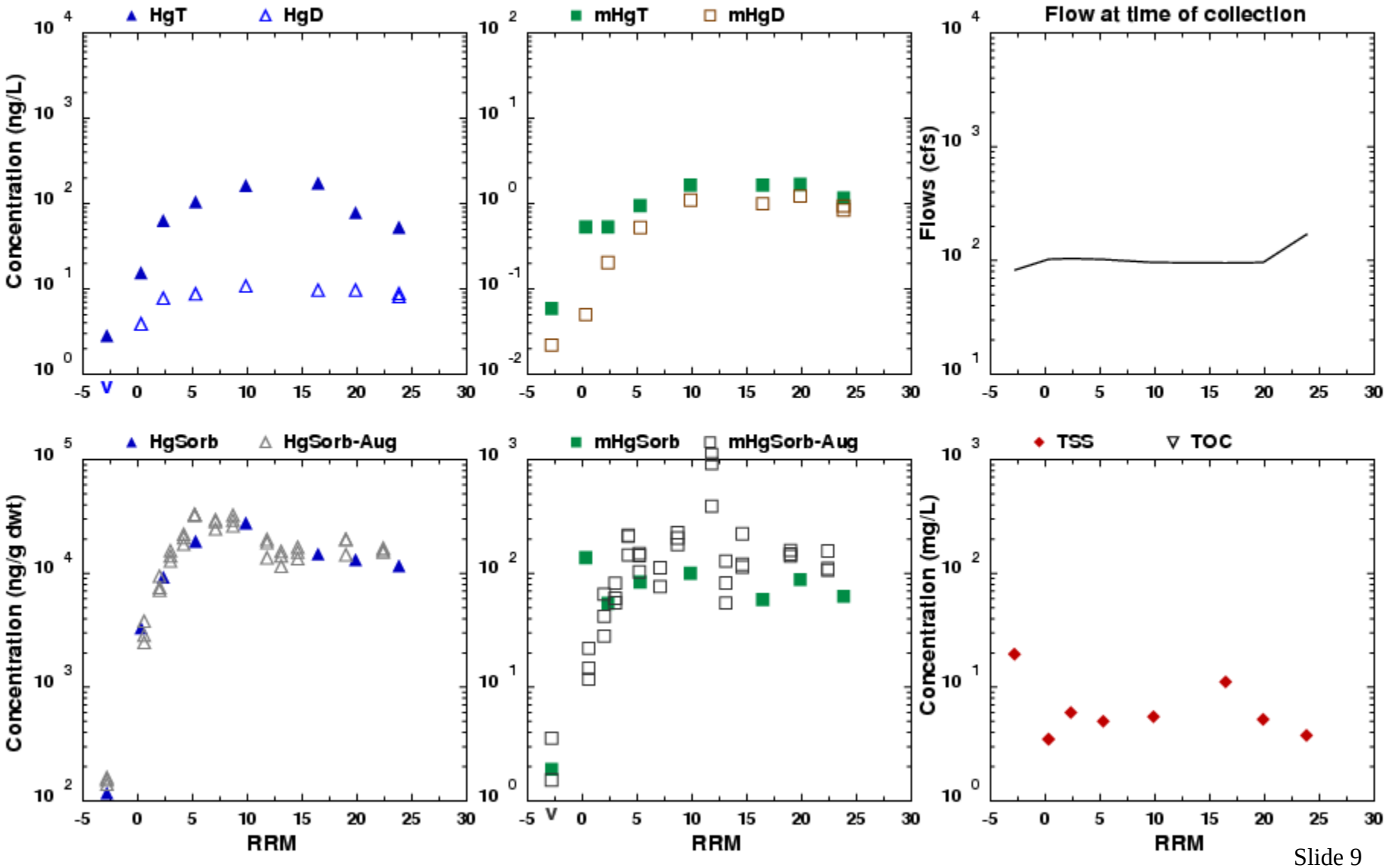
August-September 2006 storm event data: t1 (0-3 hrs)



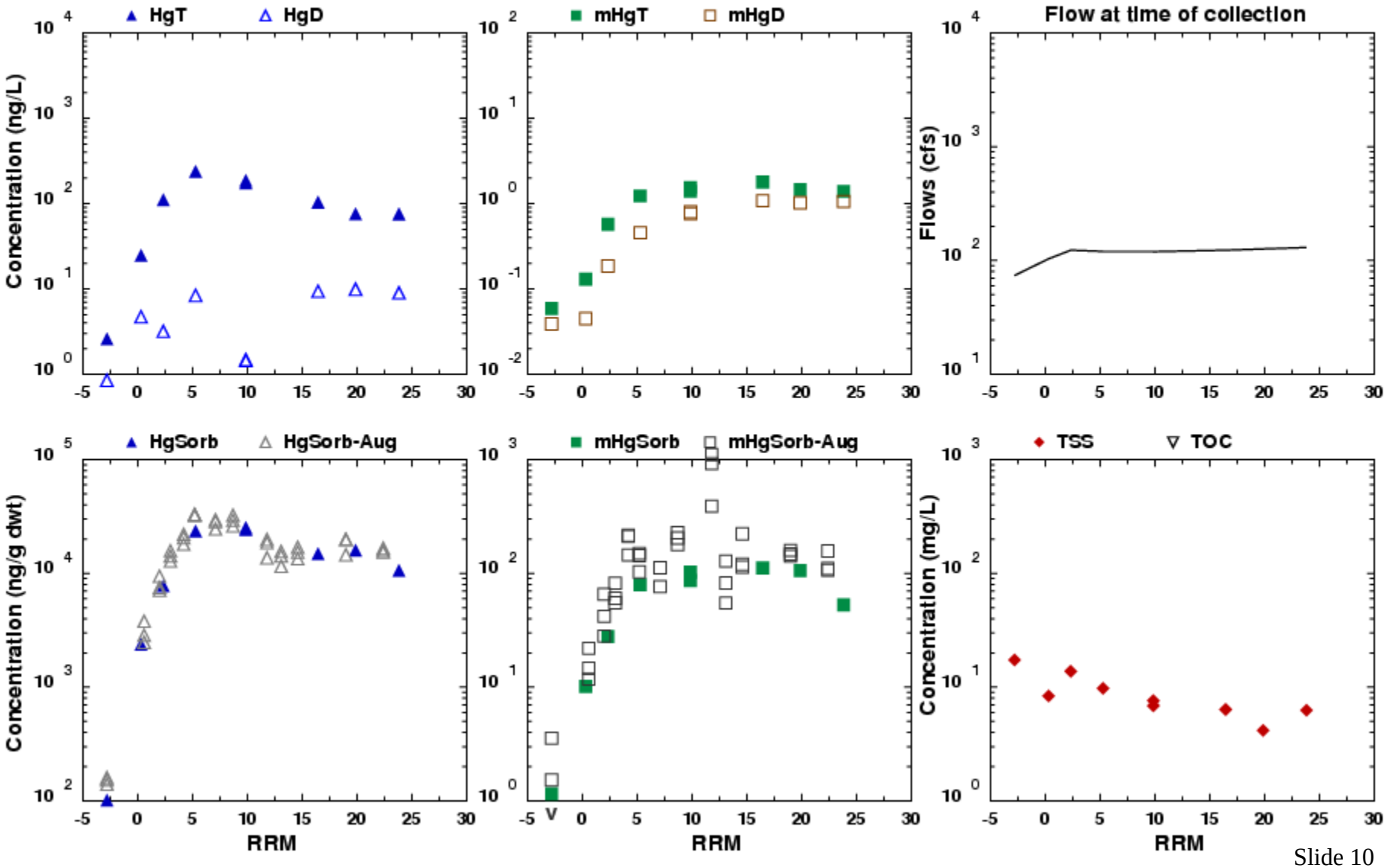
August-September 2006 storm event data: t2 (15-17 hrs)



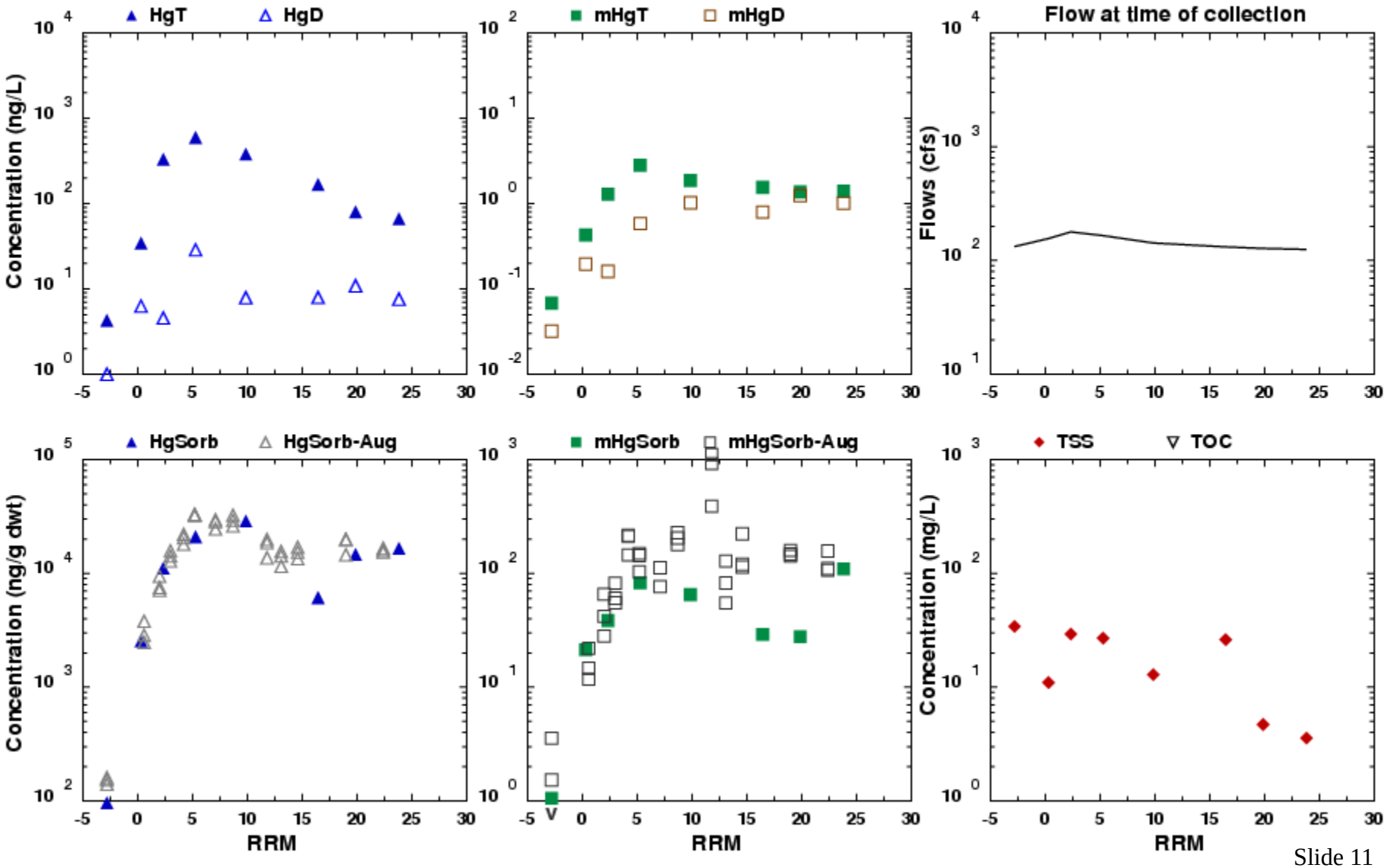
August-September 2006 storm event data: t3 (25-30 hrs)



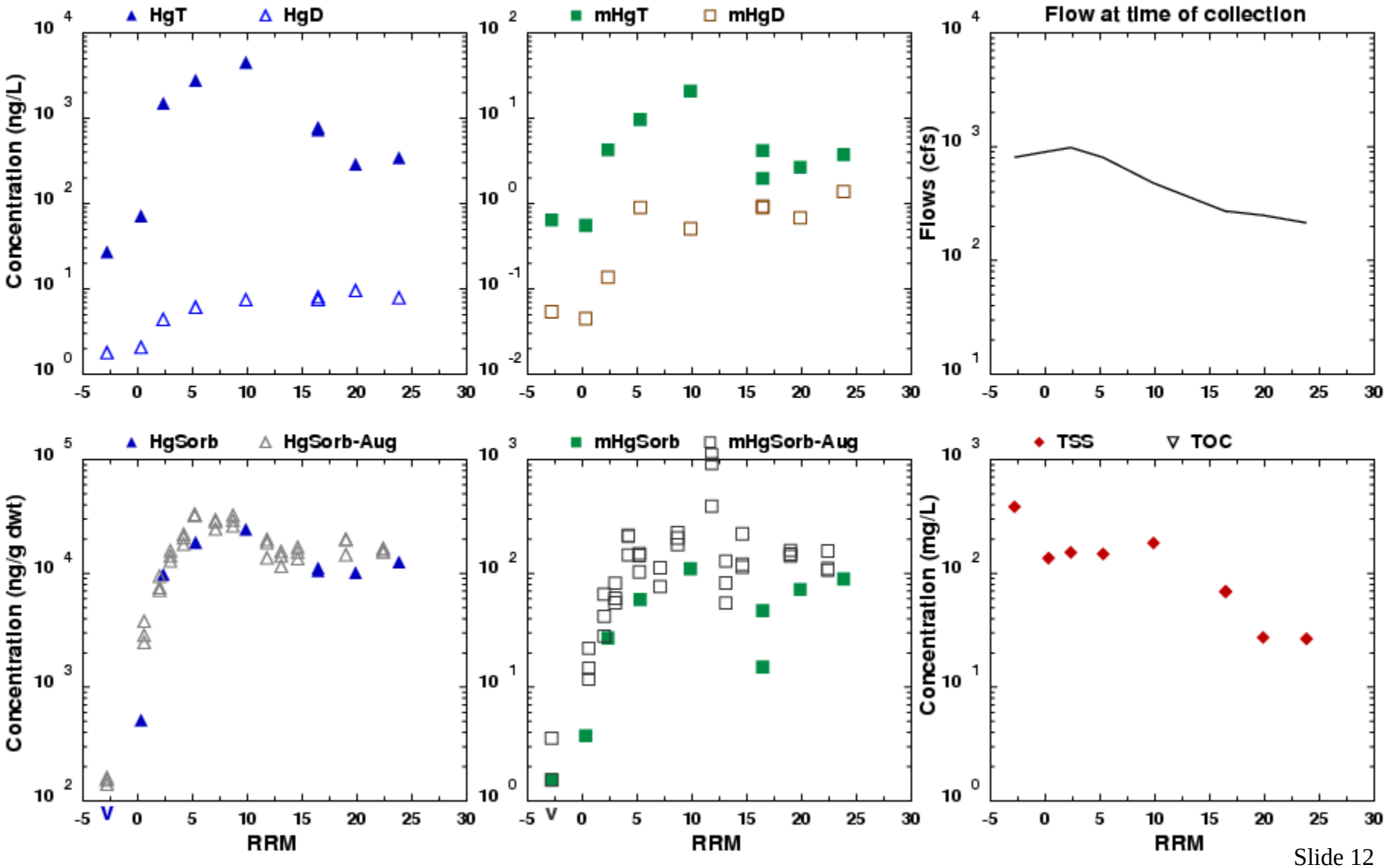
August-September 2006 storm event data: t4 (44-47 hrs)



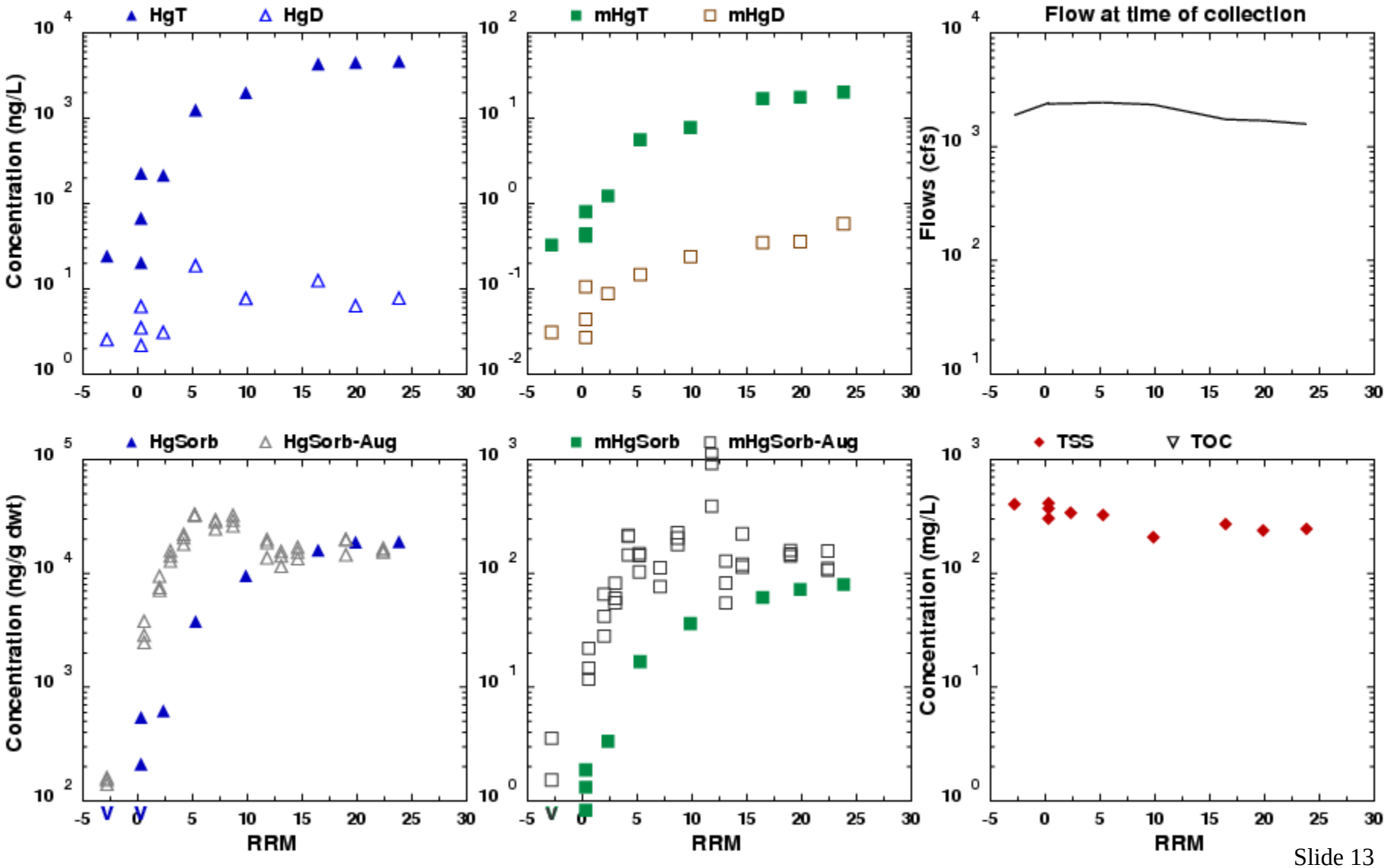
August-September 2006 storm event data: t5 (52-55 hrs)



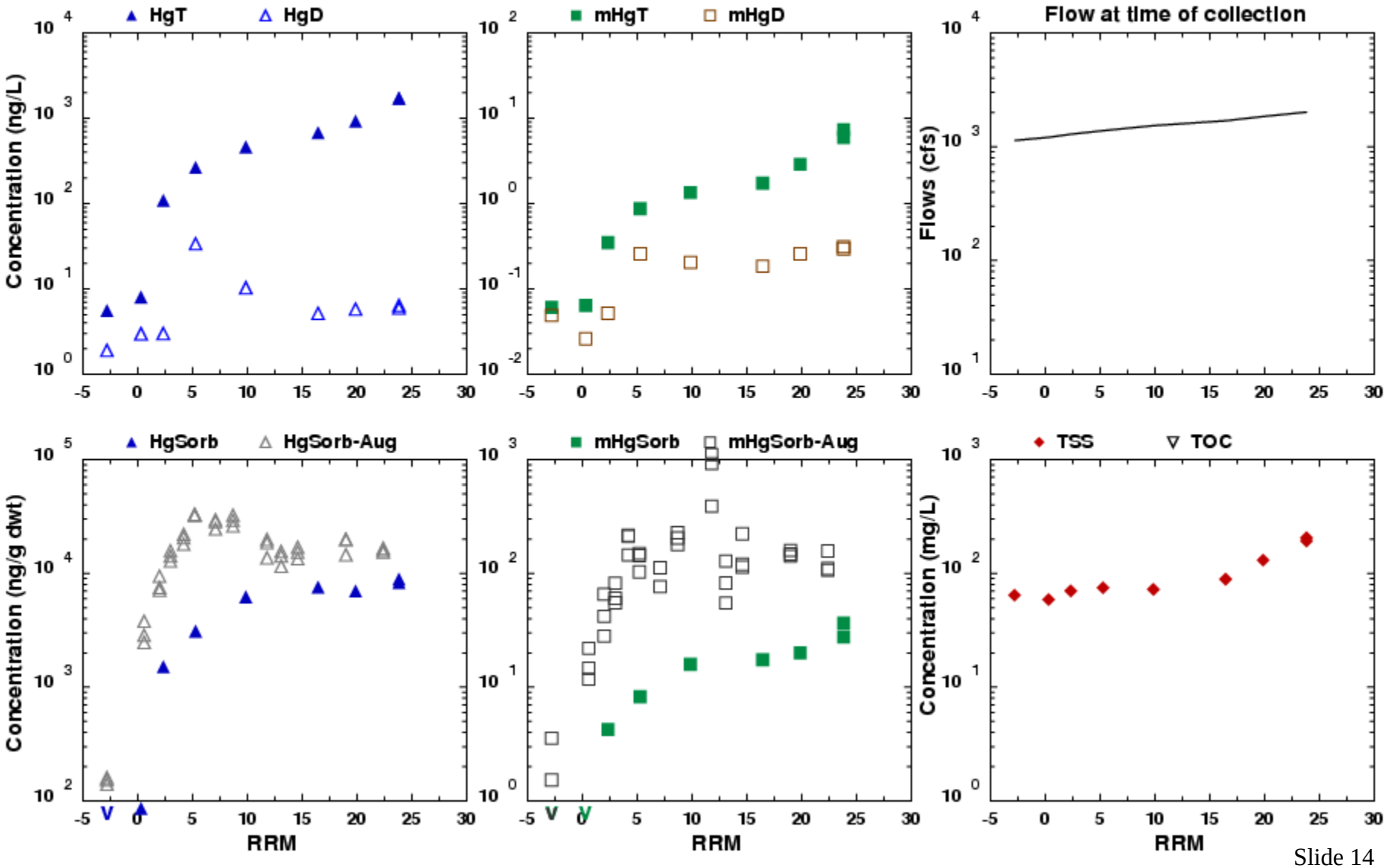
August-September 2006 storm event data: t6 (56-60 hrs)



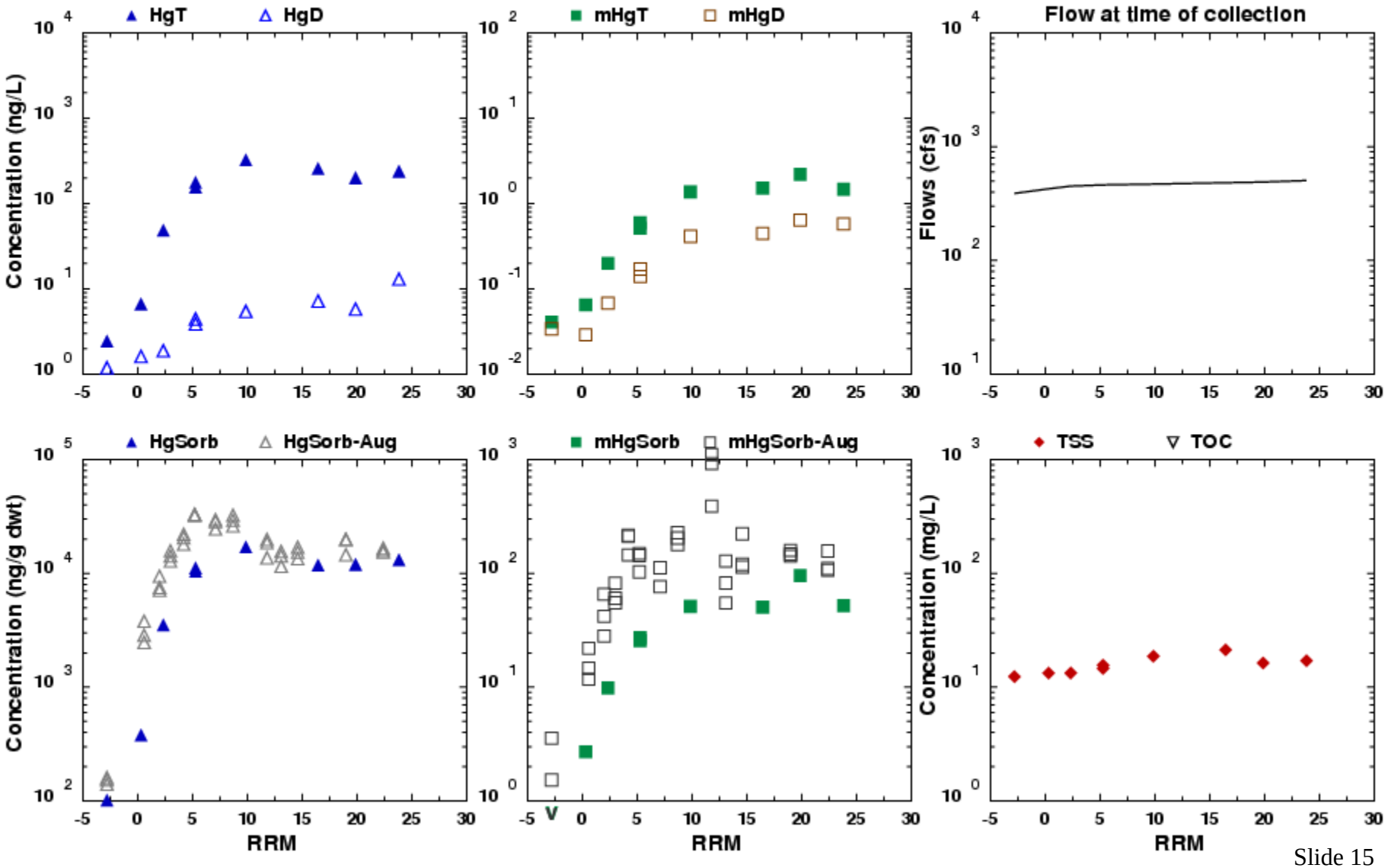
August-September 2006 storm event data: t7 (64 hrs)



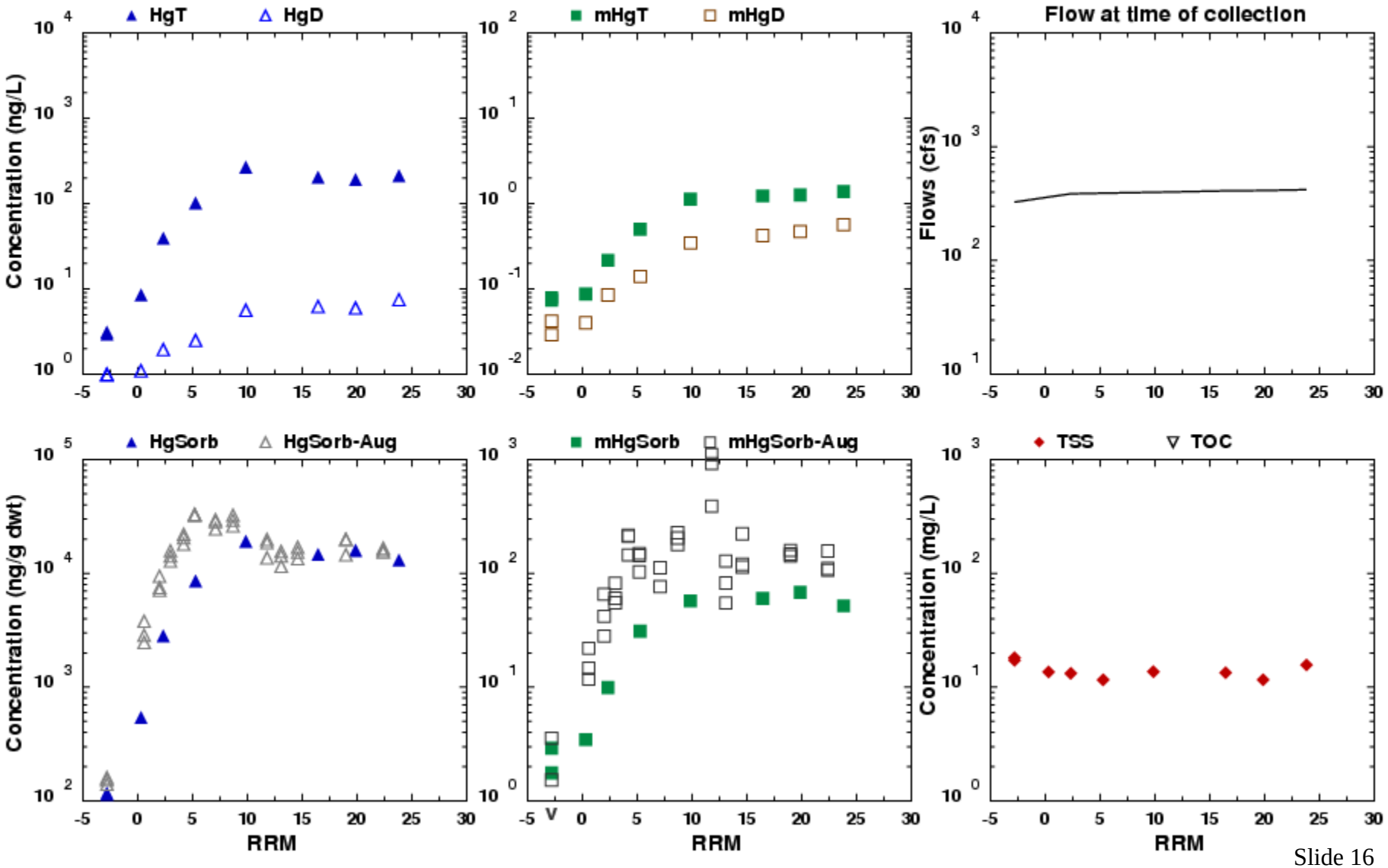
August-September 2006 storm event data: t8 (75 hrs)



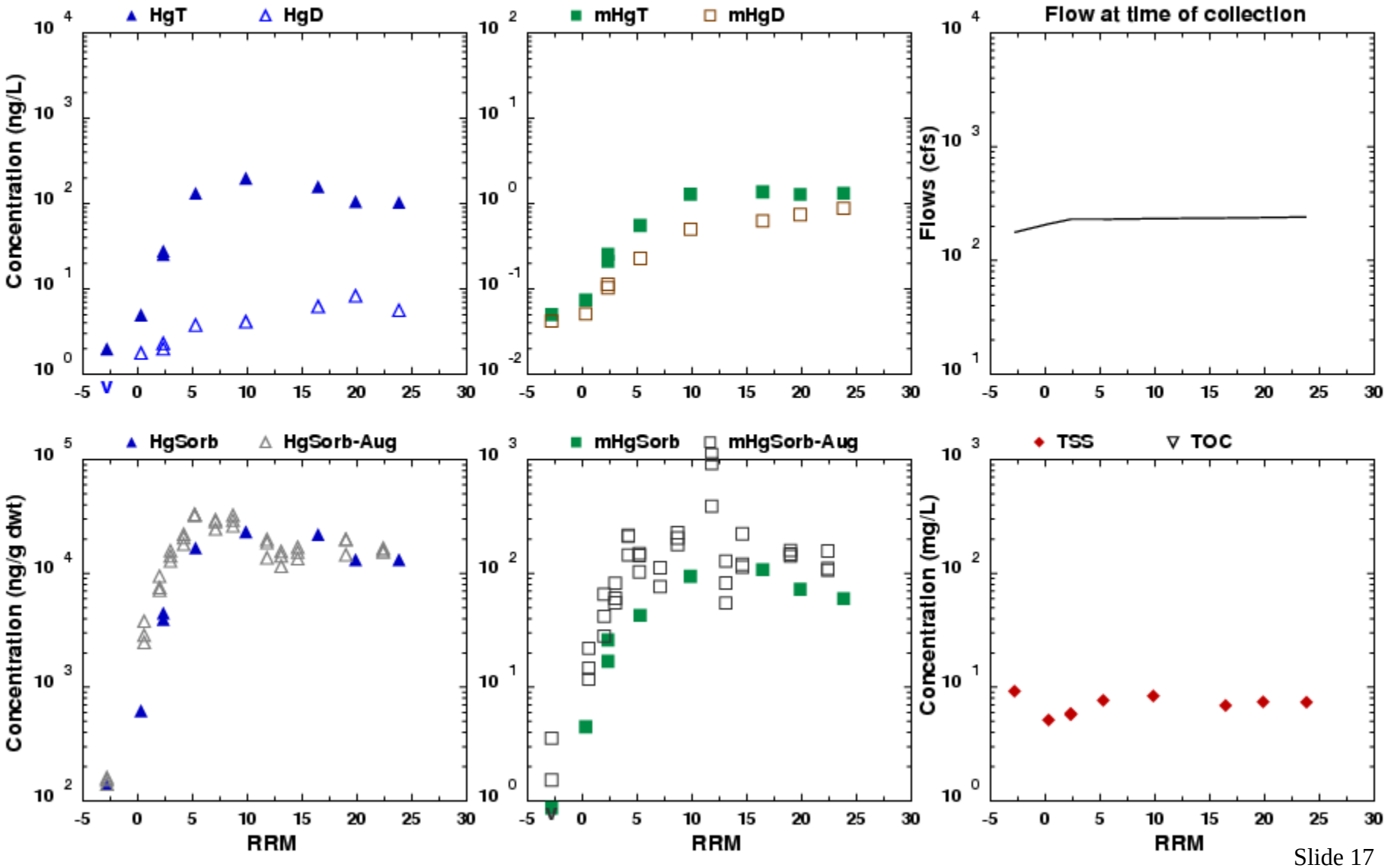
August-September 2006 storm event data: t9 (122 hrs)



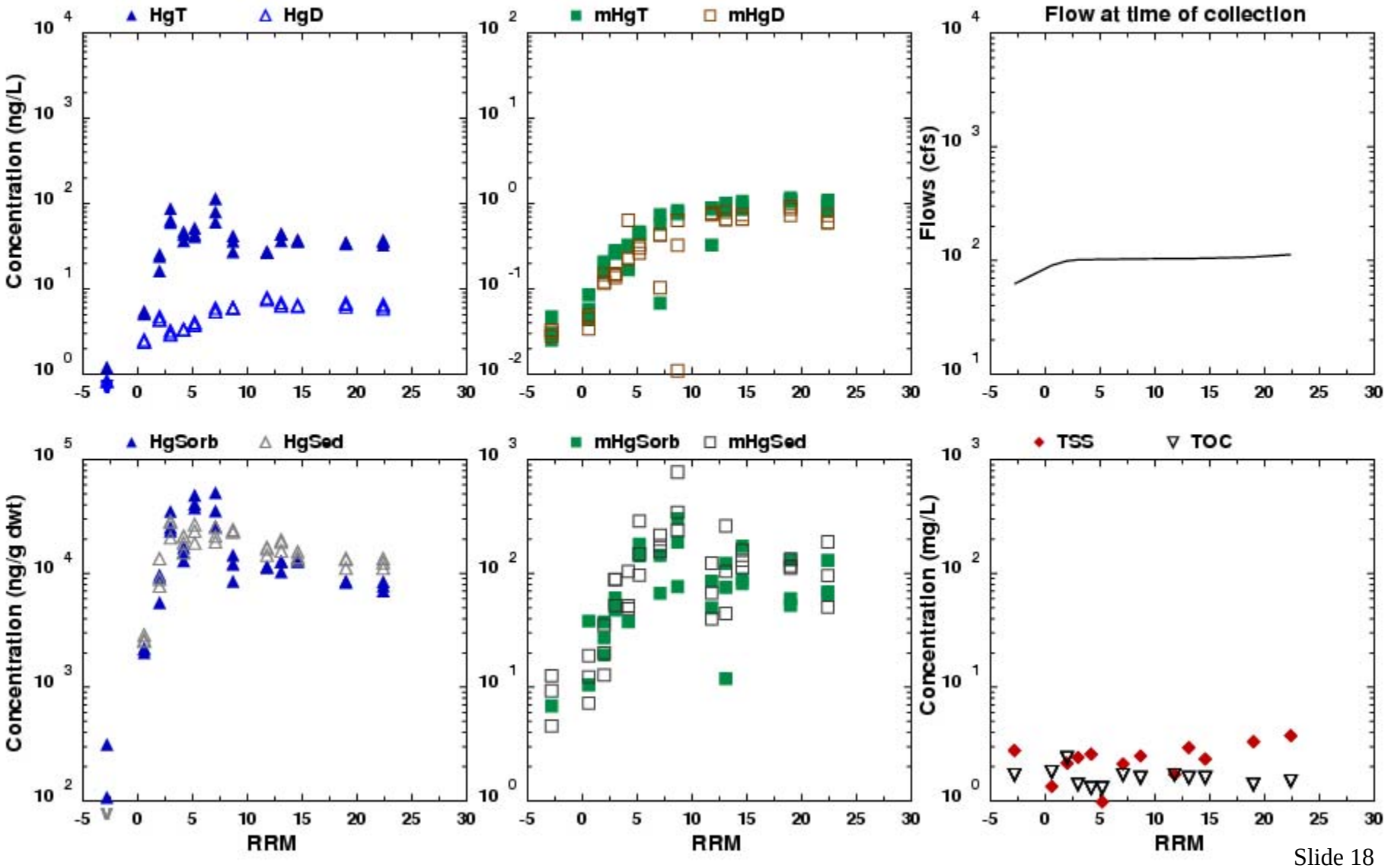
August-September 2006 storm event data: t10 (170 hrs)



August-September 2006 storm event data: t11 (218 hrs)

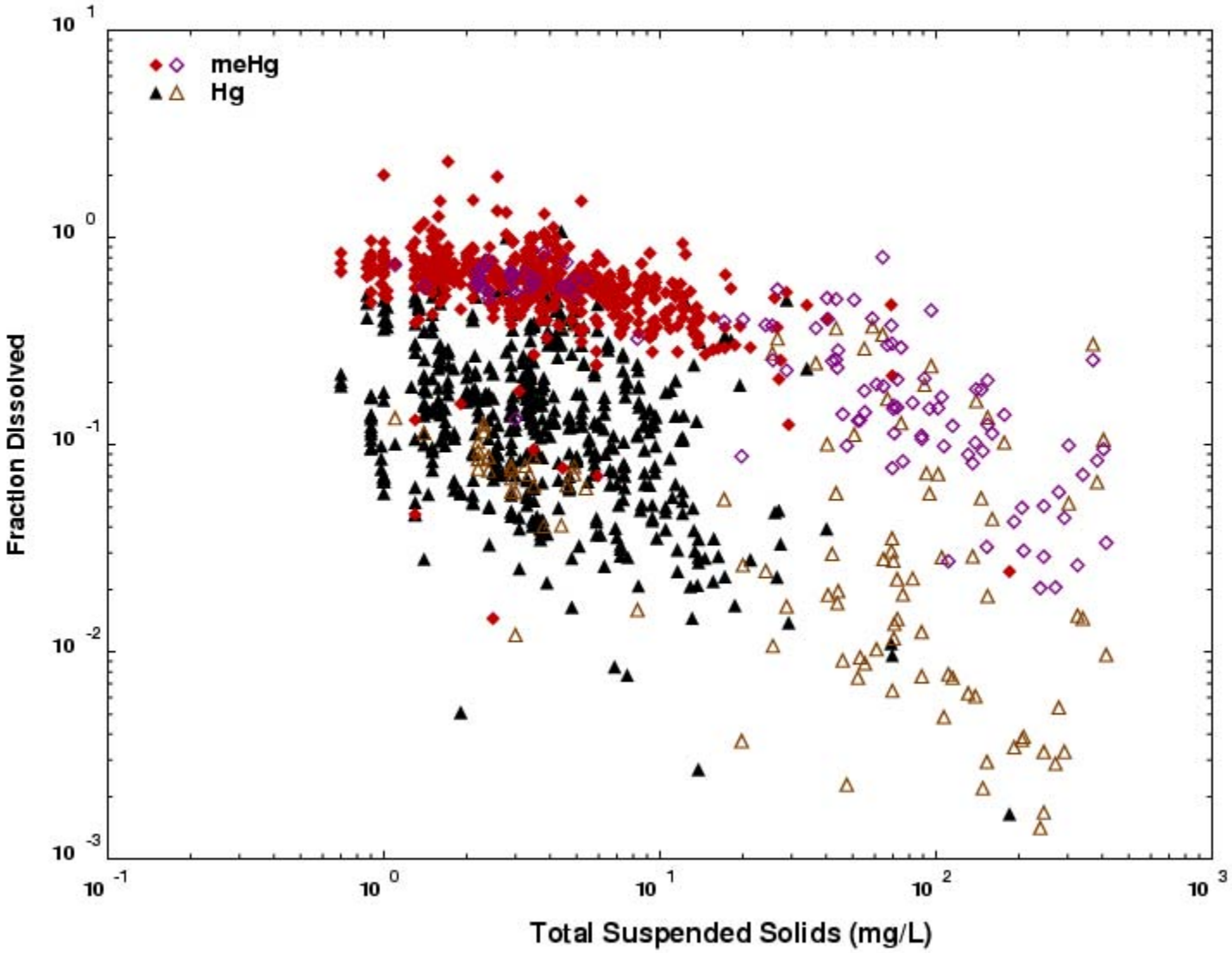


Monthly monitoring data: September 2006



All storms and monthly monitoring data: Fraction of dissolved Hg, meHg vs TSS

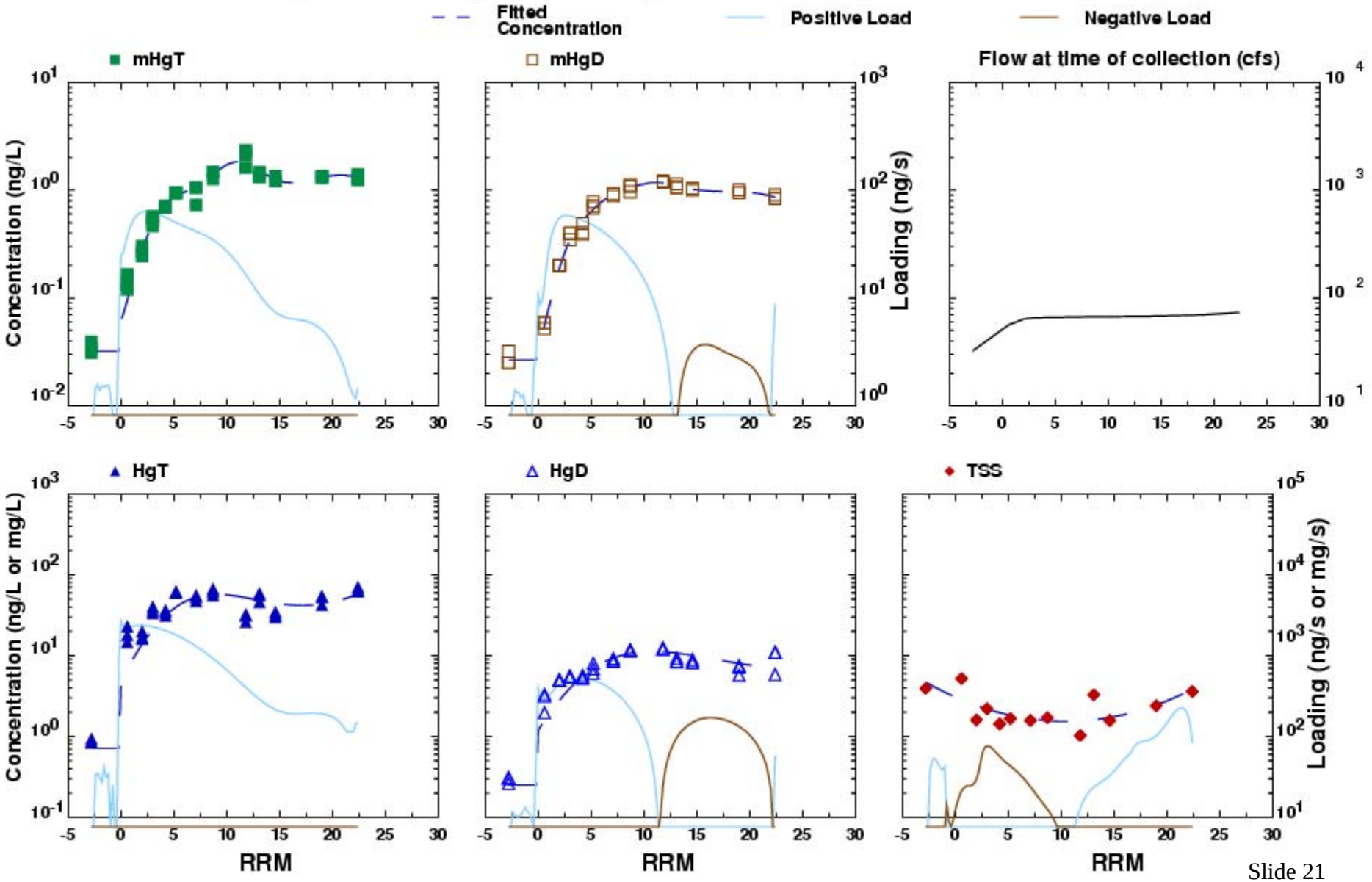
Hollow Symbols are at High Flow (>500 cfs)

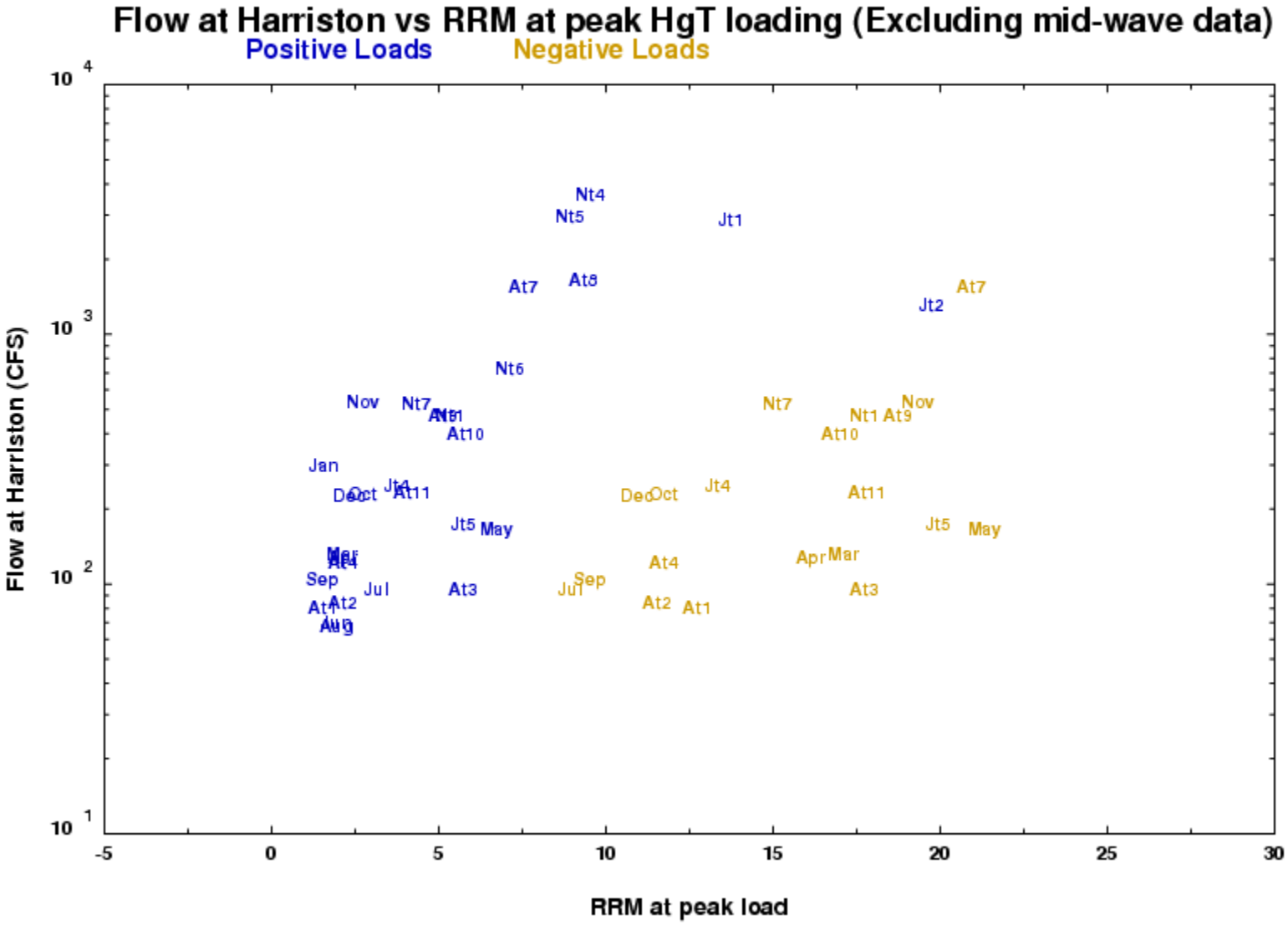


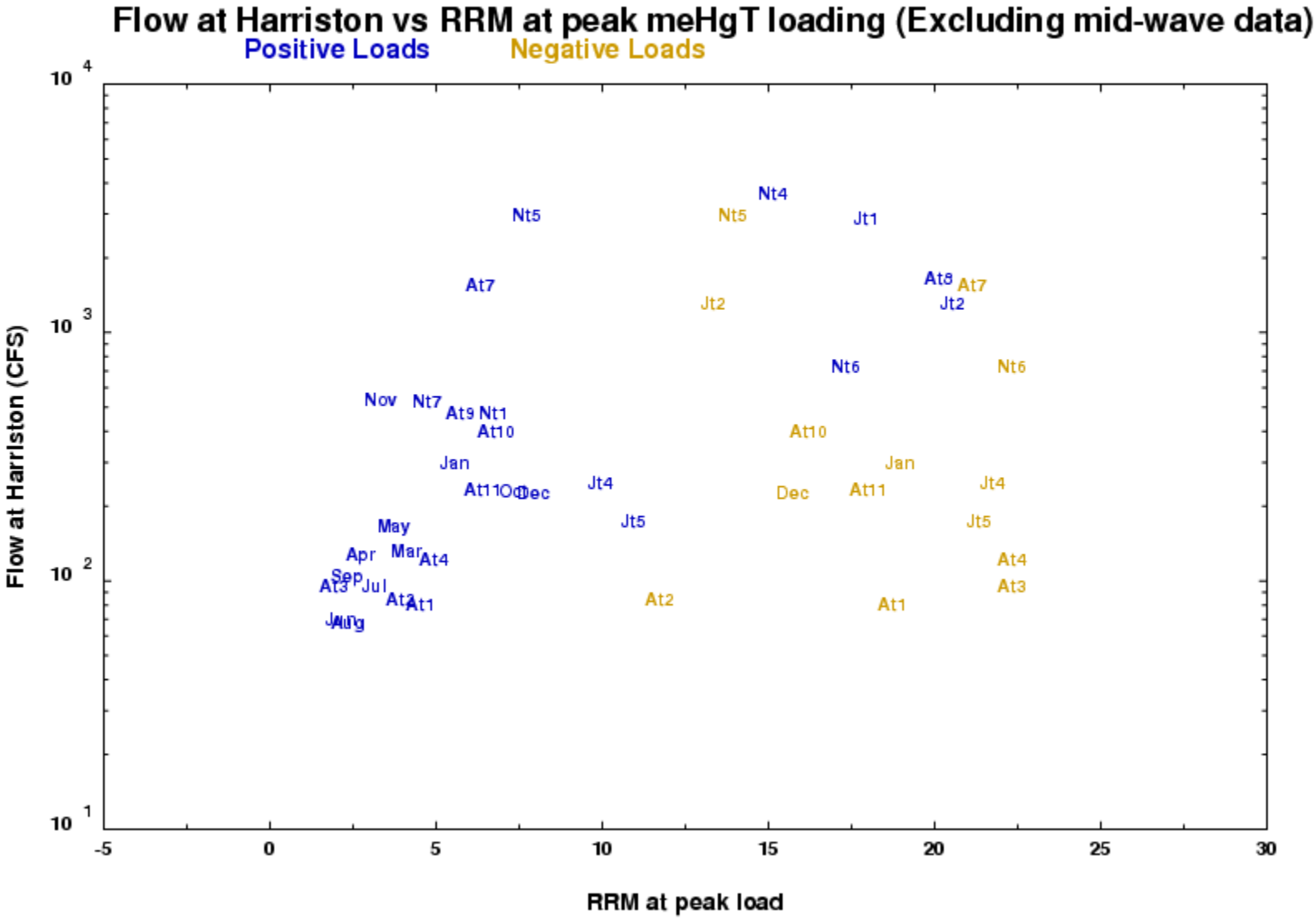
Data Analysis

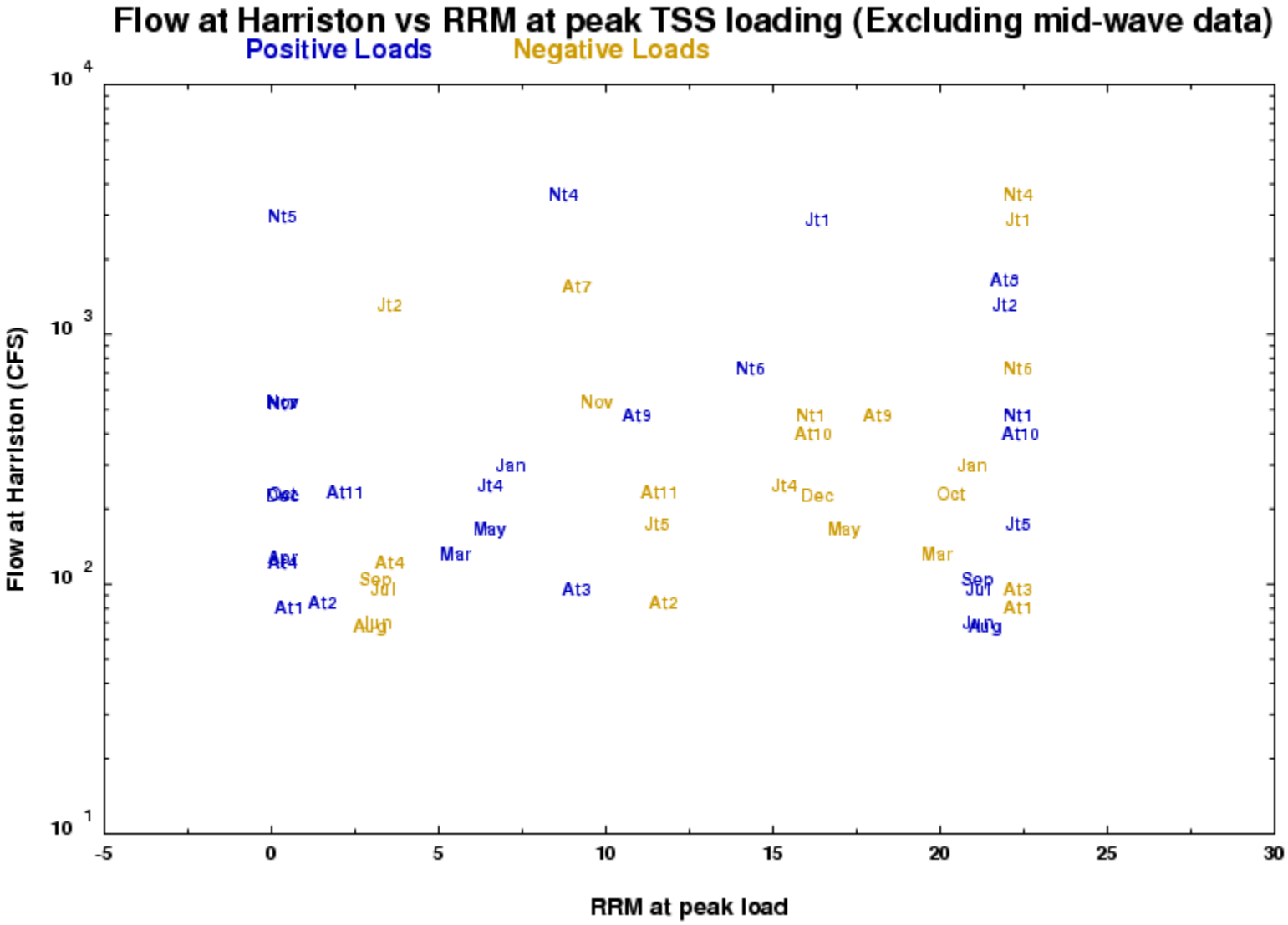
- Observations
  - Data reflect passage of storm's wave
  - Positive relationship between Flow and TSS
- Conclusions
  - Initial dilution of particulate Hg
  - Increasing TSS scrubs out dissolved material

Monthly monitoring data: August 2006



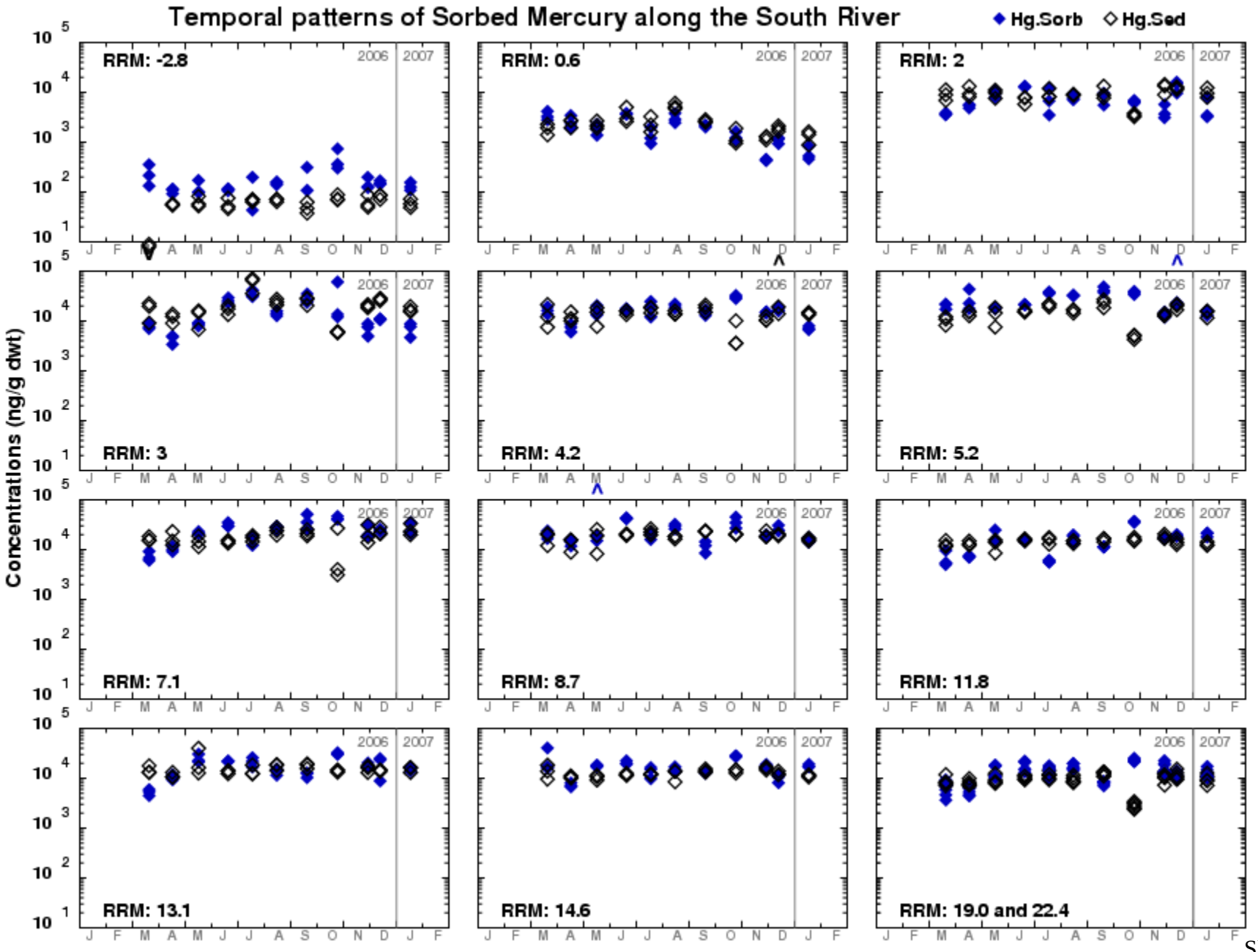

Flow at Harriston vs RRM at peak HgT loading (Excluding mid-wave data)
Positive Loads
Negative Loads
Flow at Harriston (CFS)
RRM at peak load
10 4
10 3
10 2
10 1
-5
0
5
10
15
20
25
30
Nt4
Nt5
Jt1
At7
At8
Jt2
At7
Nt6
Nov
Nt7
Nt7
Nt1
At9
Nov
At10
At10
Jan
Oct
Jt4
At11
Oct
Jt4
At11
Jt5
May
Jt5
May
Mar
Apr
Mar
At4
Sep
Jul
At3
Sep
Jul
At3
At2
At2
At1
At1
Aug

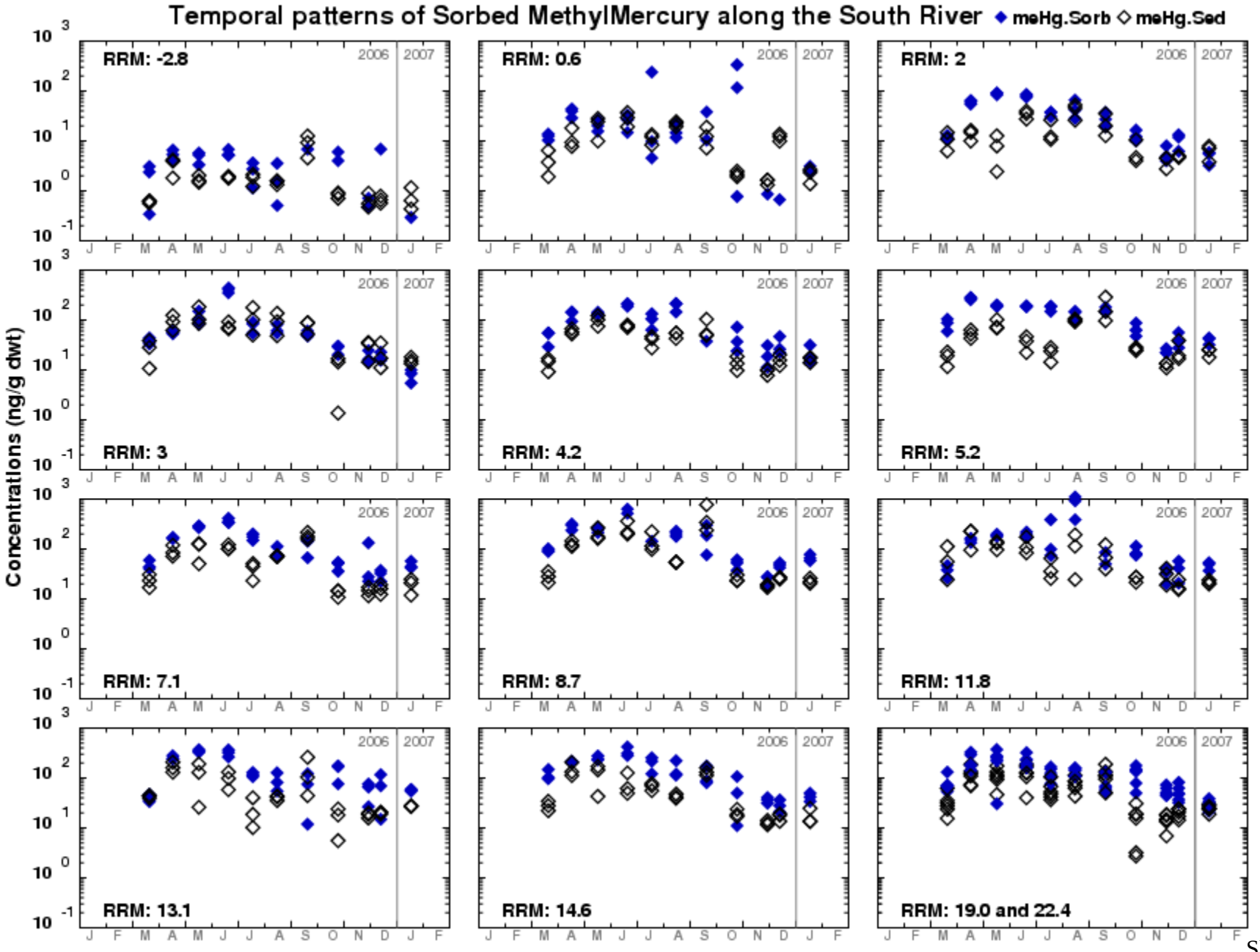

Flow at Harriston vs RRM at peak meHgT loading (Excluding mid-wave data)
Positive Loads
Negative Loads
Flow at Harriston (CFS)
RRM at peak load
10 4
10 3
10 2
10 1
-5
0
5
10
15
20
25
30
Nt4
Nt5
Nt5
Jt1
At7
At8
At7
Jt2
Jt2
Nt6
Nt6
Nov
Nt7
At9
Nt1
At10
At10
Jan
Jan
At11
Oct
Dec
Jt4
Dec
At11
Jt4
May
Jt5
Jt5
Apr
Mar
At4
At4
Sep
At3
Jul
At3
At2
At1
At2
At1
Jun
Aug

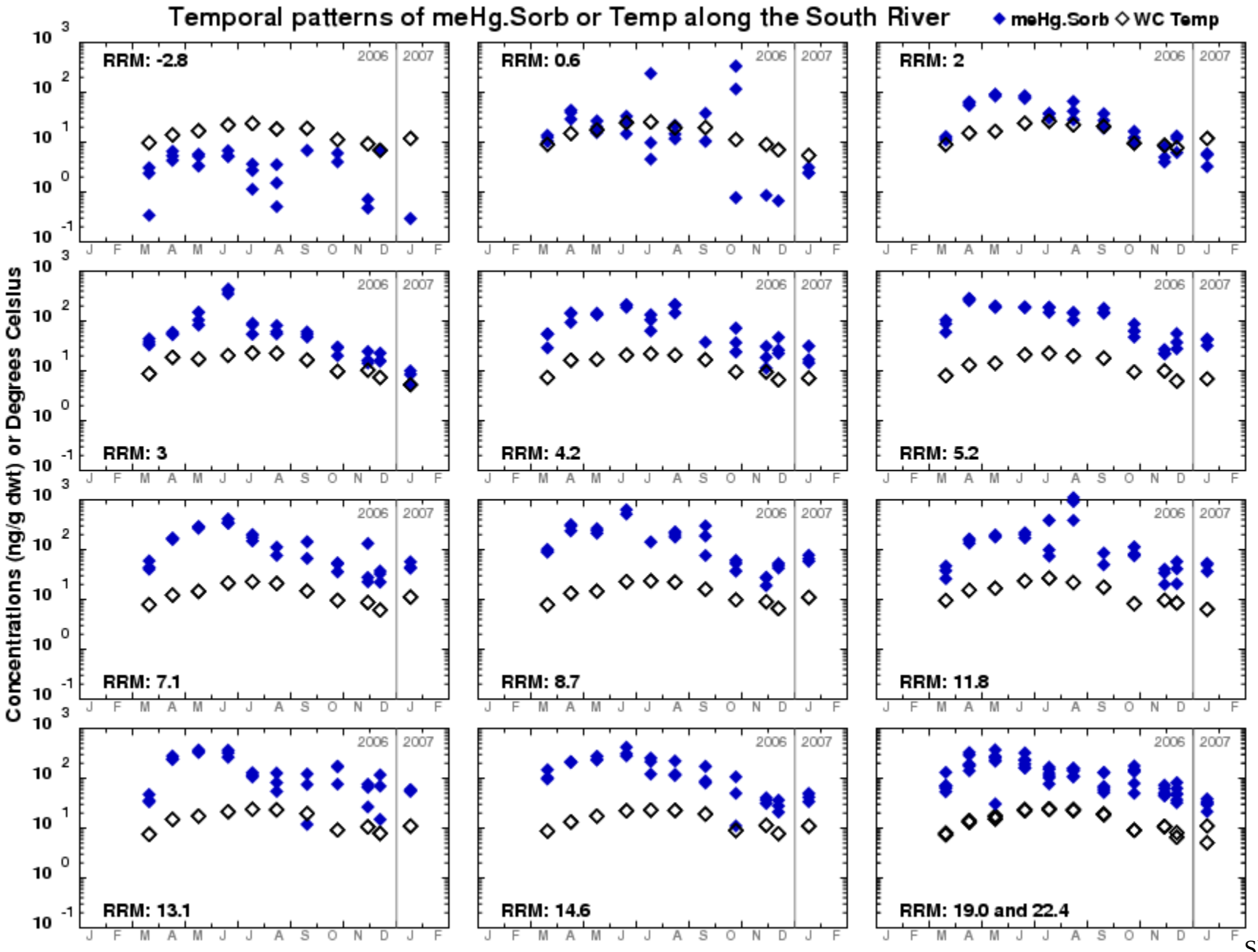

Flow at Harriston vs RRM at peak TSS loading (Excluding mid-wave data)
Positive Loads
Negative Loads
Flow at Harriston (CFS)
RRM at peak load
10 4
10 3
10 2
10 1
-5
0
5
10
15
20
25
30
Nt4
Nt5
Jt1
Nt4
Jt1
At7
At8
Jt2
Jt2
Nt6
Nt6
Nov
Nov
At9
Nt1
At9
Nt1
At10
At10
Jan
Jan
Jt4
At11
At11
Jt4
Dec
Oct
May
Jt5
Jt5
May
Mar
Mar
At4
Sep
Jul
At3
At3
At1
At2
At2
At1
Aug

Incremental loading analysis

- Observations:
  - Location of peak Hg, meHg load migrates downstream as flows increase
- Conclusions
  - Suitable tool for steady state situations, at high or low flow
    - Need fate and transport calculation to assess movement of large masses of solids and Hg during passage of storm waves
  - Relationship between location of peak Hg, meHg loads and flow (at Harriston)
    - A potential tool for estimating the location (and magnitude) of Hg, meHg loads during steady state situations
    - TSS is introduced all along the River
  - Possibly related to stream stage and location of inundated side-channels or islands

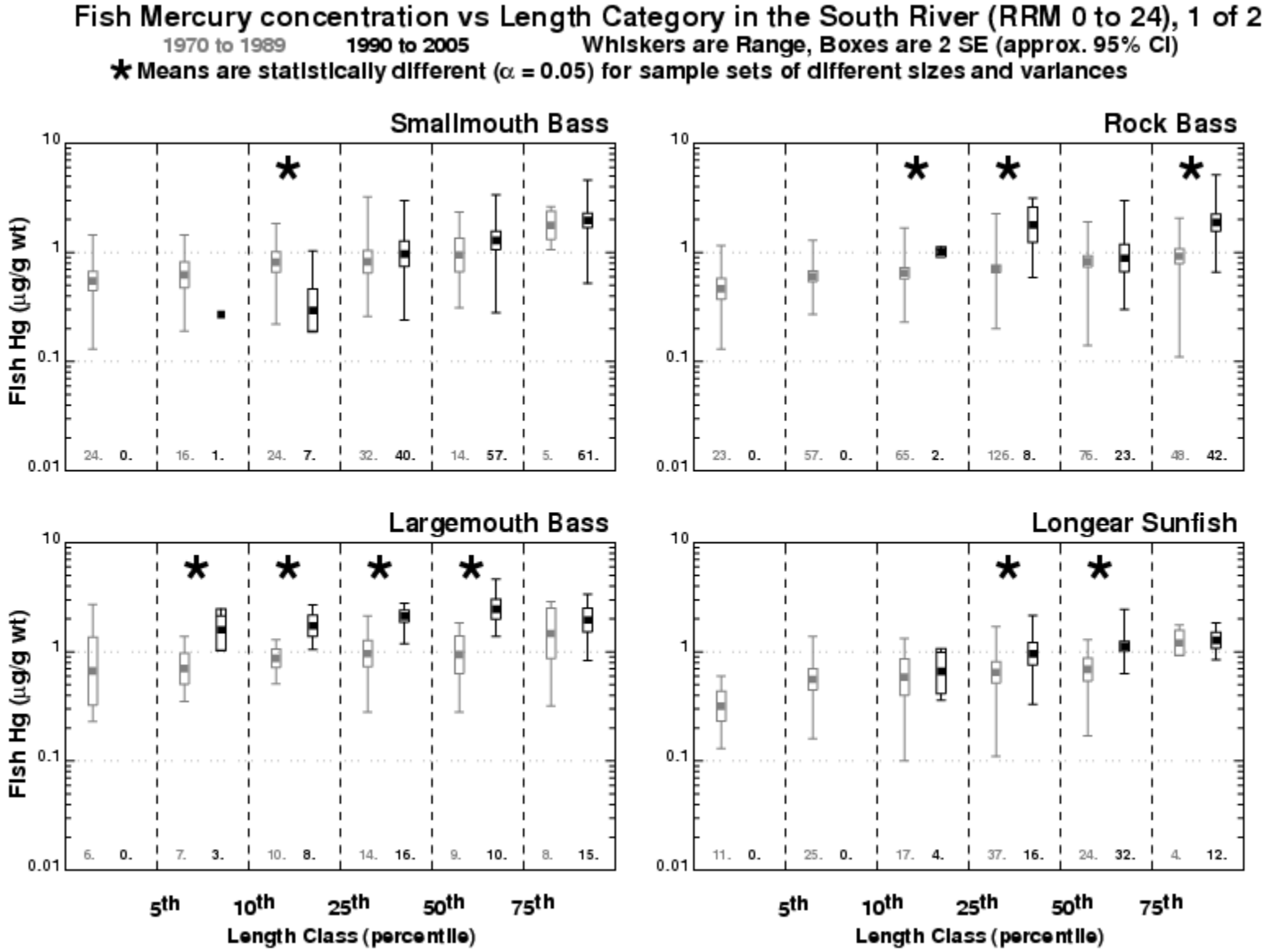

Temporal patterns of Sorbed Mercury along the South River
Hg.Sorb
Hg.Sed
Concentrations (ng/g dwt)
RRM: -2.8
RRM: 0.6
RRM: 2
RRM: 3
RRM: 4.2
RRM: 5.2
RRM: 7.1
RRM: 8.7
RRM: 11.8
RRM: 13.1
RRM: 14.6
RRM: 19.0 and 22.4
2006
2007
J F M A M J J A S O N D J F


Temporal patterns of Sorbed MethylMercury along the South River
meHg.Sorb
meHg.Sed
Concentrations (ng/g dwt)
RRM: -2.8
RRM: 0.6
RRM: 2
RRM: 3
RRM: 4.2
RRM: 5.2
RRM: 7.1
RRM: 8.7
RRM: 11.8
RRM: 13.1
RRM: 14.6
RRM: 19.0 and 22.4
2006
2007
J F M A M J J A S O N D J F


Temporal patterns of meHg.Sorb or Temp along the South River
meHg.Sorb
WC Temp
Concentrations (ng/g dwt) or Degrees Celsius
RRM: -2.8
RRM: 0.6
RRM: 2
RRM: 3
RRM: 4.2
RRM: 5.2
RRM: 7.1
RRM: 8.7
RRM: 11.8
RRM: 13.1
RRM: 14.6
RRM: 19.0 and 22.4
2006
2007
J F M A M J J A S O N D J F

Temporal Plots

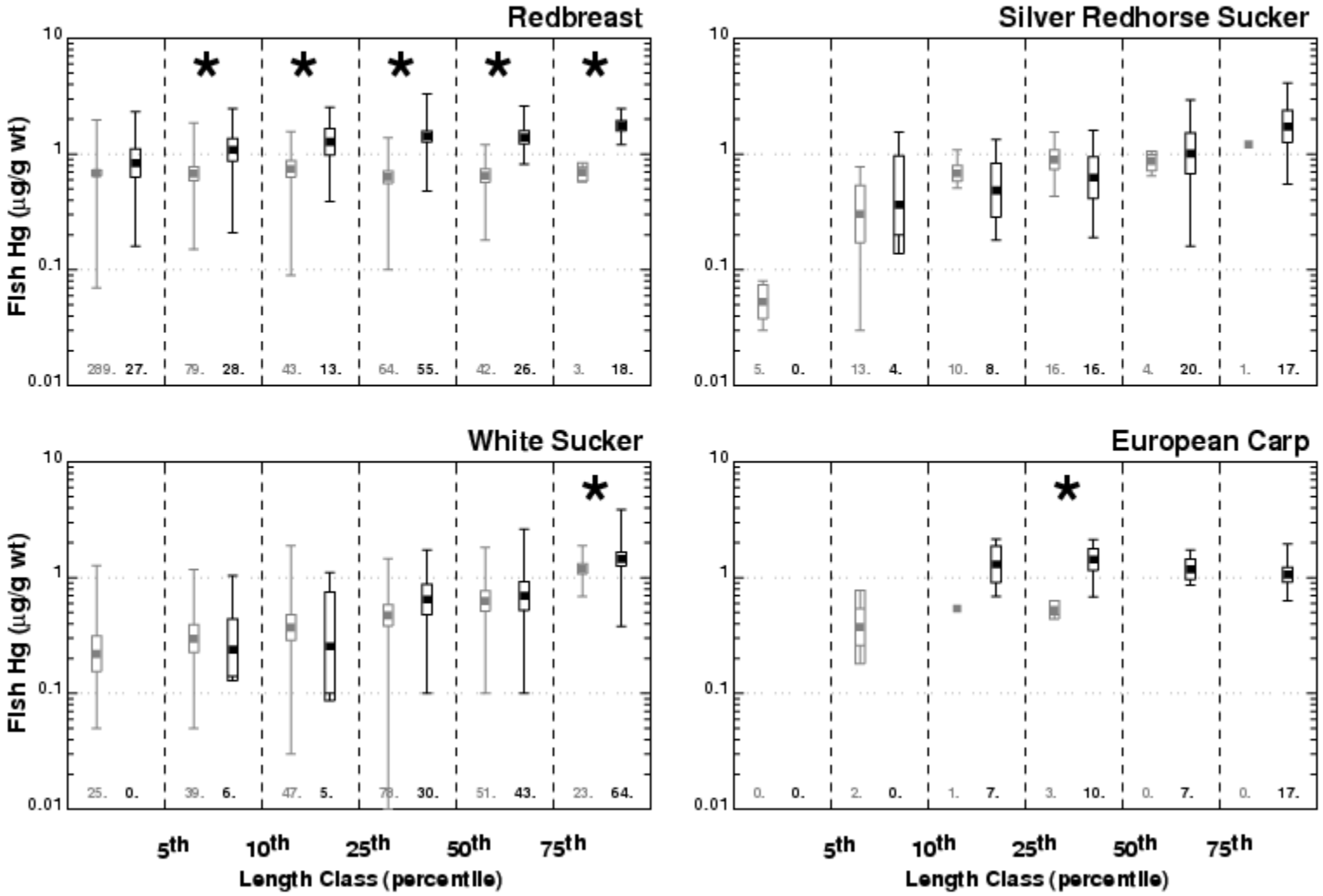
- Observations
  - Peak meHg.Part in April – June
  - Peak Temperature June-August
  - Enrichment of WC meHg.Sorb (but not Hg.Sorb)
- Conclusions
  - Temperature/season affects meHg production
  - Possible bioavailability affects on methylation
  - Possibly due to greater association of meHg with certain particle types that are more readily resuspended


Fish Mercury concentration vs Length Category in the South River (RRM 0 to 24), 1 of 2
1970 to 1989
1990 to 2005
Whiskers are Range, Boxes are 2 SE (approx. 95% CI)
* Means are statistically different (α = 0.05) for sample sets of different sizes and variances
Smallmouth Bass
Rock Bass
Largemouth Bass
Longear Sunfish
Fish Hg (µg/g wt)
10
1
0.1
0.01
24. 0.
16. 1.
24. 7.
32. 40.
14. 57.
5. 61.
23. 0.
57. 0.
65. 2.
126. 8.
76. 23.
48. 42.
6. 0.
7. 3.
10. 8.
14. 16.
9. 10.
8. 15.
11. 0.
25. 0.
17. 4.
37. 16.
24. 32.
4. 12.
5th
10th
25th
50th
75th
Length Class (percentile)

Fish Mercury concentration vs Length Category in the South River (RRM 0 to 24), 2 of 2

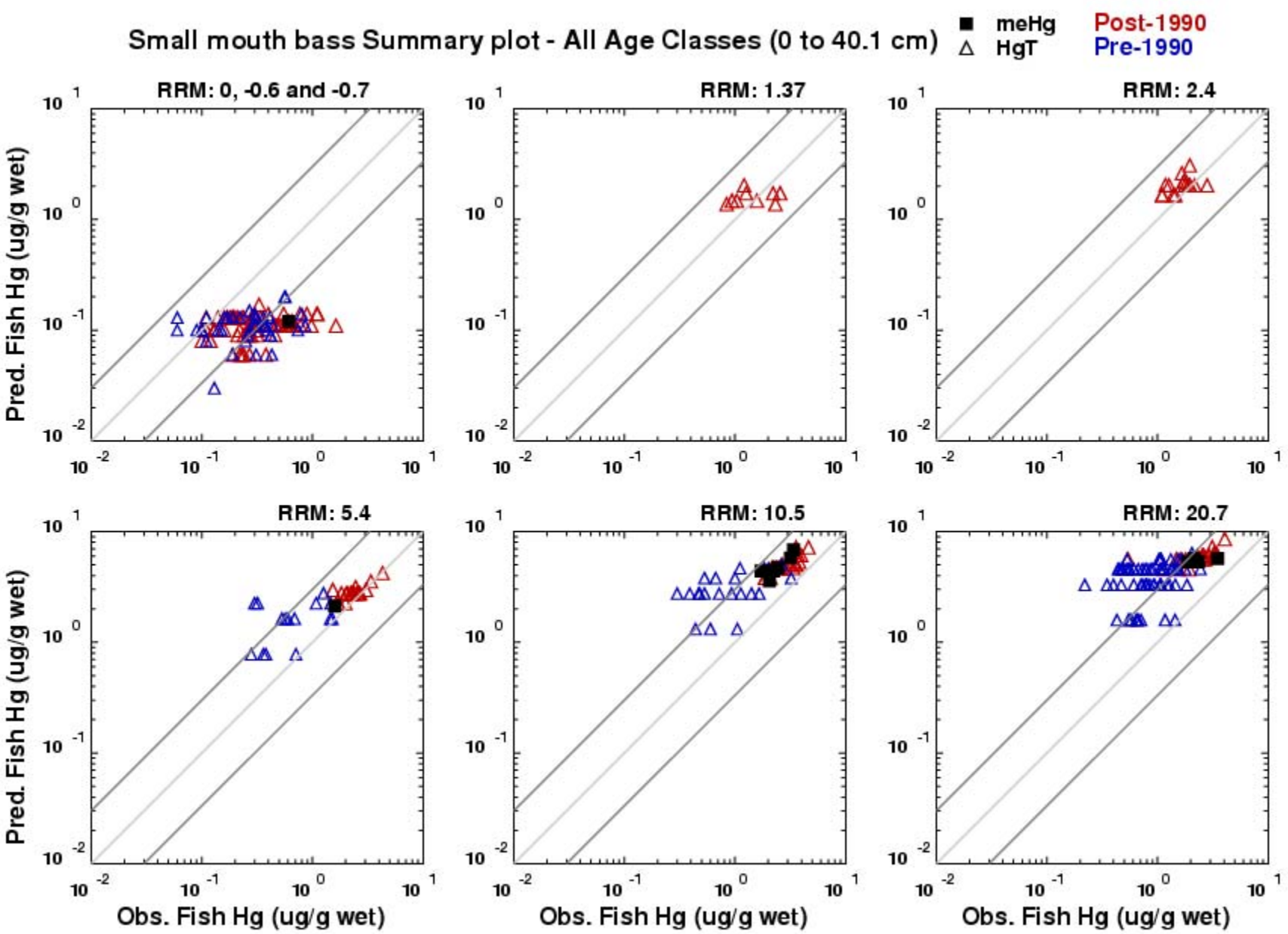
1970 to 1989 **1990 to 2005** **Whiskers are Range, Boxes are 2 SE (approx. 95% CI)**

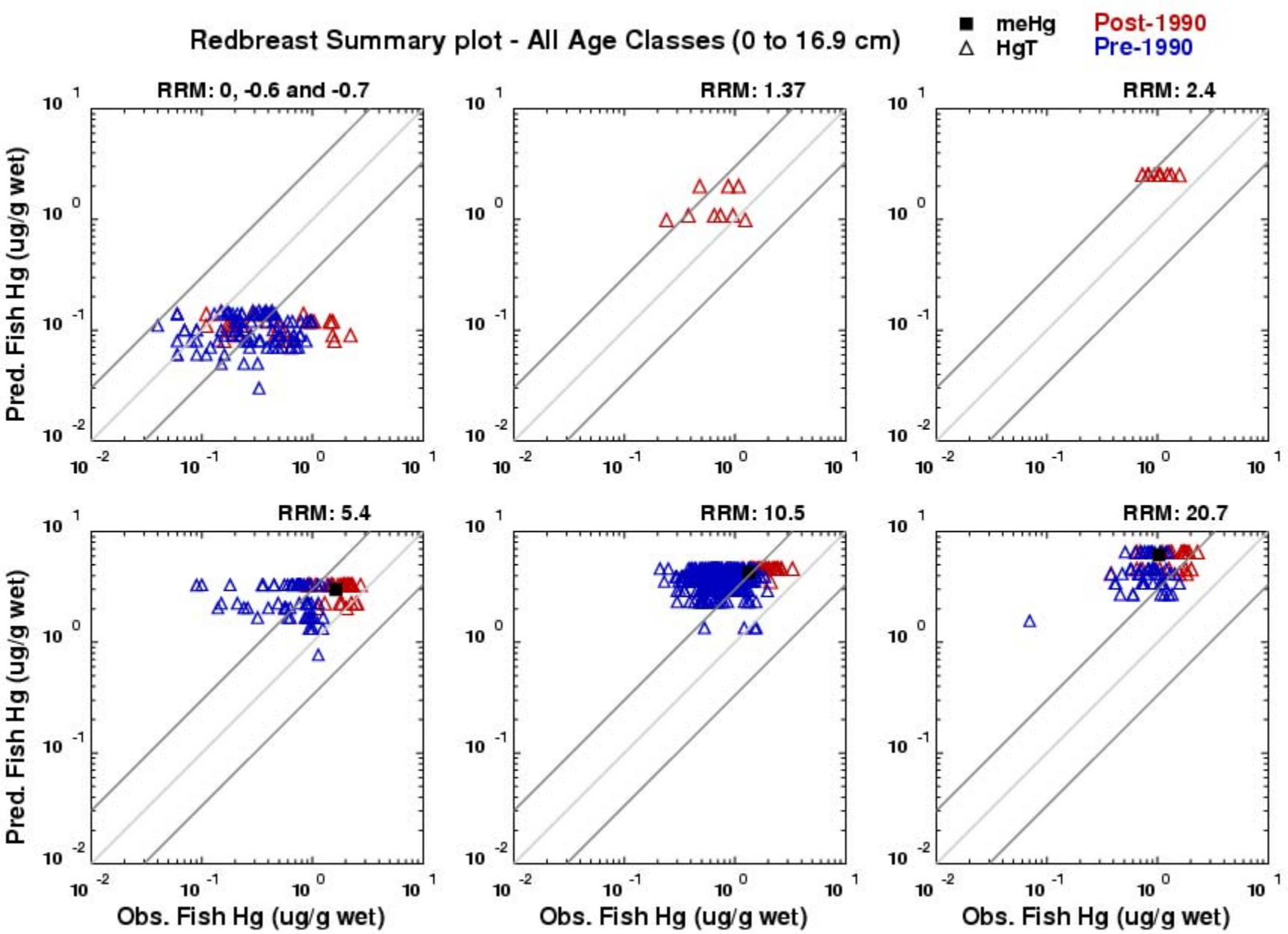
*** Means are statistically different (α = 0.05) for sample sets of different sizes and variances**



Fish Bioaccumulation Model

- Thomann-Farley model
  - Bioenergetics are generic for white perch
  - Assumed that bioenergetics have not changed over the last 30 years..
  - Fish-age based on length relationships in Murphy 2004
- Dietary structure and concentrations
  - Extended from Murphy 2004
  - Assimilation of dissolved and dietary Hg, meHg parameterized from Literature and CARP datasets


Small mouth bass Summary plot - All Age Classes (0 to 40.1 cm)
meHg
HgT
Post-1990
Pre-1990
RRM: 0, -0.6 and -0.7
RRM: 1.37
RRM: 2.4
RRM: 5.4
RRM: 10.5
RRM: 20.7
Pred. Fish Hg (ug/g wet)
Obs. Fish Hg (ug/g wet)


Redbreast Summary plot - All Age Classes (0 to 16.9 cm)
meHg
HgT
Post-1990
Pre-1990
RRM: 0, -0.6 and -0.7
RRM: 1.37
RRM: 2.4
RRM: 5.4
RRM: 10.5
RRM: 20.7
Pred. Fish Hg (ug/g wet)
Obs. Fish Hg (ug/g wet)

Fish Hg

- Observations:
  - Some more recent fish-Hg (>1990) measurements are much higher than historic fish-Hg (<1990)
  - Initial bioaccumulation calculations are in good agreement with well-characterized sites
- Conclusions
  - Much of the variability in fish-Hg can be explained by size and location of fish sample
  - Largemouth Bass and Redbreast seem to have more Hg in more recent years
    - Change in diet or habitat characteristics?
  - Calculated fish-Hg highly sensitive to prey-meHg content, very little from water column
    - Evaluation of recent prey and fish data can further constrain calculations

Other ongoing or future work

- Data analysis of additional biological data (fish and prey items)
  - Including extension of initial bioaccumulation calculations to assess long-term bioavailability patterns
- Assessment of Hg(II) speciation with standard models (WHAM6)
  - Impact on Hg bioavailability for methylation?
- Estimate mass of soil transported during low flow or storm events compared to geomorphology work

Scope of work

- Identify potential sources of mercury and methylmercury to the South River
  - Location and magnitude of loads migrates as function of flow
  - *In-situ m*ethylation likely occurring throughout River
    - Influenced by temperature, bioavailability, microbial respiration
- Identify important processes for migration and exposure pathways
  - Bioaccumulation calculation and fish data analysis
  - Storm waves resuspend (and transport?) large masses of solids
  - Enrichment in meHg.Part, different particle type?
- Identify data needs for further refinement of the CSM
  - Supporting evidence that soil erosion can be responsible for WC Hg in SR
  - Controls on methylation and bioaccumulation of Hg
- Recommend new or improved methodologies for collecting data to meet needs
  - Hg speciation and microbial respiration
  - Entry of Hg, meHg into base of foodchain
  - Stream stage and/or velocity measurements coincident with samples