

South River Fish Tissue Update

October 21, 2003

Sampling Stations Prior to 2001

STATION	STAT_ID	Location
1	1BSTH026.12	Waynesboro City Park above Rife Loth Dam
3	1BSTH025.10	Waynesboro City Park north of DuPont footbridg
5	1BSTH020.44	Dooms, VA near Rt. 611 bridge (above dam)
6	1BSTH014.60	Crimora, VA near Rt. 612 bridge
7	1BSTH004.21	Grottoes, VA near Grand Caverns bridge
8	1BNTH004.10	Near Rt. 668 bridge below confluence with Midl R
9	1BSSF100.10	Lynwood, VA near Rt. 708 bridge
10	1BSSF078.24	Shenandoah, VA (boat ramp above dam)
16	1BSSF062.97	Newport Landing south of Alma, VA on Rt. 340
11	1BSSF054.20	Hamberg, VA near Rt. 211 bridge
17	1BSSF037.60	Fosters Landing near Rt. 664 bridge
12	1BSSF020.70	Bentonville Landing at Gooney Run
18	1BSSF010.18	Karo Landing at Gooney Run
15	1BSHN022.63	Berryville, VA near Rt. 7 bridge

New Stations

STATION STAT_ID Location

2001

21 1BSTH022.75 South River Hopeman Parkway, Waynesboro

22 1BSHN047.98 Rt. 624 bridge-downstream of Warren Pwr Dam

23 1BSHN038.48 Rt. I7/50 bridge

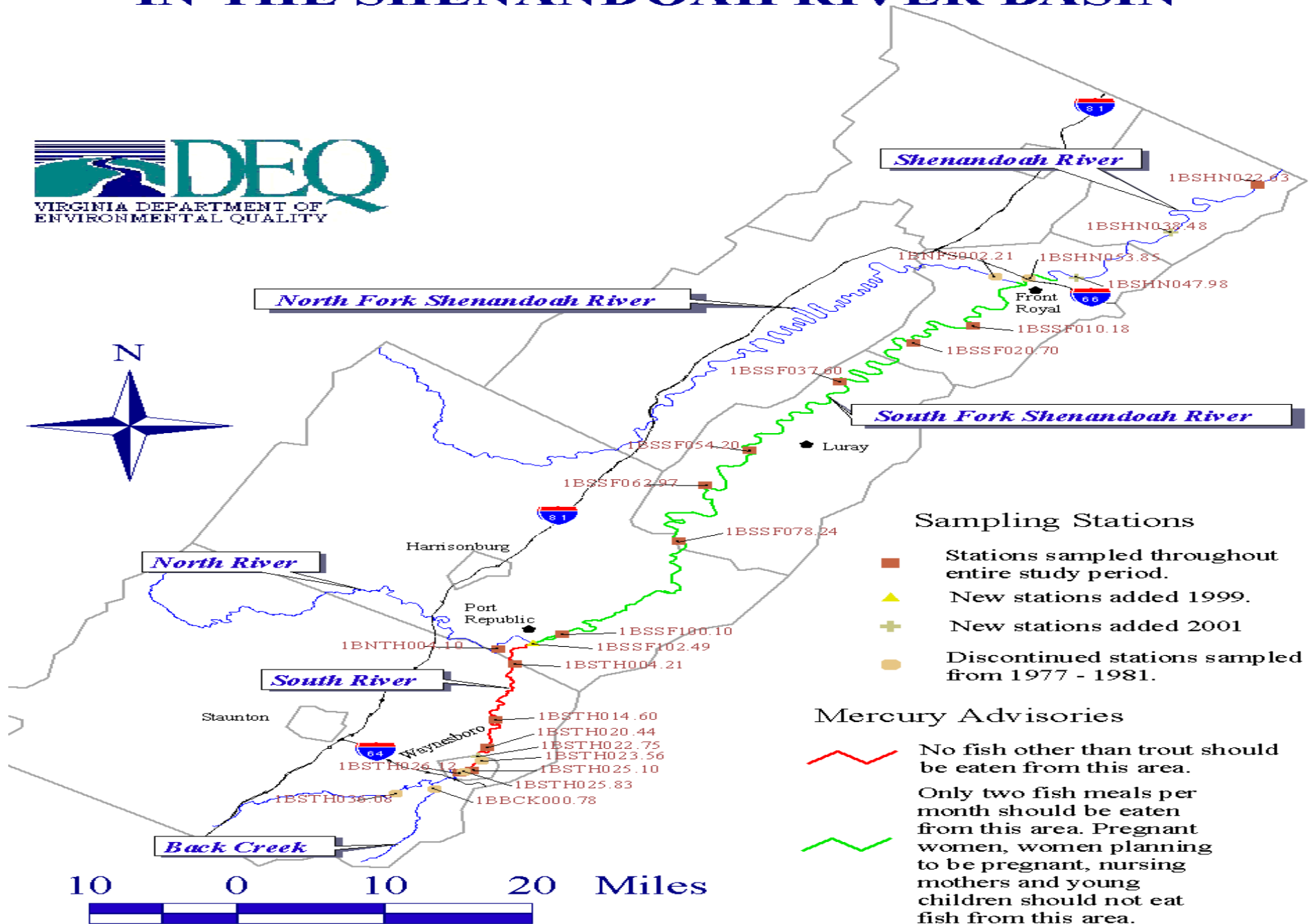
2002

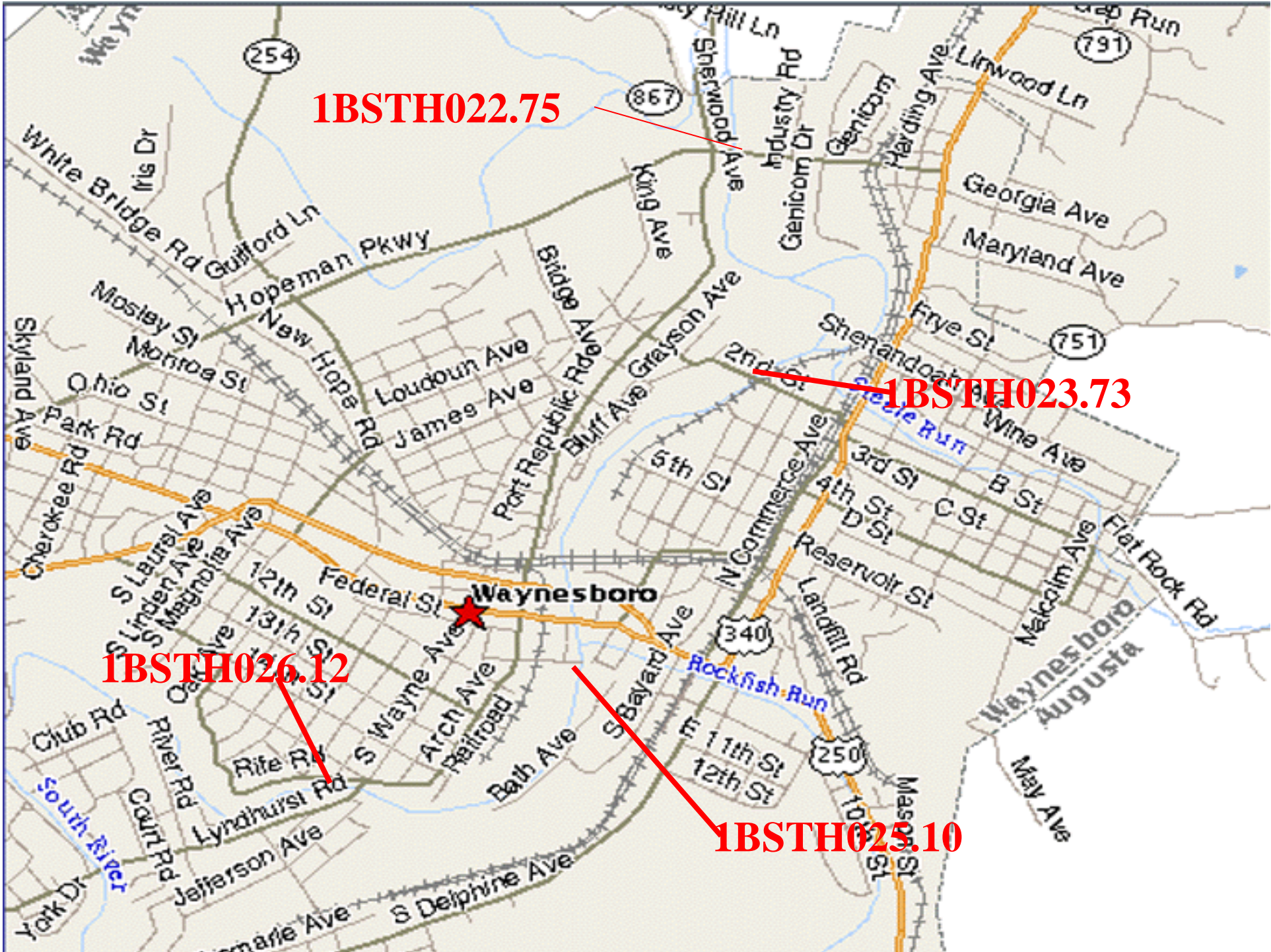
24 1BSTH023.73 South River 2nd Street, Waynesboro

25 1BSSF063.17 SF Shenandoah Newport Landing

26 1BSSF003.50 SF Shenandoah Luray Ave Launch - Front Royal

MERCURY FISH ADVISORIES IN THE SHENANDOAH RIVER BASIN





1BSTH022.75

1BSTH023.73

1BSTH026.12

1BSTH025.10

Statistical Methods

- **Analysis of covariance (ANCOVA) of $\log(\text{Hg})$ on $\log(\text{length})$ was used**
 - **intercept adjusted for station and year**
 - **slope adjusted for station and year**
 - **insufficient data to adjust for station*year interaction**
 - **separate model fit to each species**

Statistical Methods

- **ANCOVA removes the effect of size from the Hg measurements, so as not to bias the results due to the effects of different sized fish being sampled in different years or at different stations.**

Statistical Methods

- **For tests of differences or trends in Hg levels over time, data from years 1977-1983 were combined to provide baseline**
 - **sparse data in early years.**
 - **Not all years were observed at all stations.**
- **ANOCOVA model retained all years separately.**

Trends Over Time: All Bass

- At several stations (5, 6, 7, 12, 15, 17) total Hg levels are still higher than at baseline.
- In all statistically significant cases, 2002 values are lower than in recent past.
- Trends since 1996 are all decreasing.

LOG(Total Hg) in Bass
ESTIMATED CHANGE

PARM		EST	P_T		
Station	1 96-02TRN	-0.303	0.0301	*	-
Station	3 96-02TRN	-0.103	0.0235	*	-
Station	5 02-77/83	0.169	0.0001	*	+
Station	6 02-77/83	0.122	0.0001	*	+
Station	7 02-77/83	0.053	0.0022	*	+
Station	7 02-99	-0.069	0.0082	*	-
Station	7 02-96	-0.070	0.0355	*	-
Station	8 02-78/83	-0.084	0.0028	*	-
Station	8 02-96	-0.174	0.0002	*	-
Station	9 02-77/83	-0.034	0.0001	*	-
Station	9 02-96	-0.063	0.0198	*	-
Station	10 02-96	-0.051	0.0116	*	-
Station	11 02-99	-0.043	0.0207	*	-
Station	11 02-96	-0.078	0.0001	*	-
Station	12 02-77/83	0.063	0.0001	*	+
Station	12 02-96	-0.133	0.0004	*	-
Station	15 02-77/83	0.124	0.0001	*	+
Station	17 02-80/83	0.067	0.0004	*	+
Station	17 02-96	-0.052	0.0774	*	-

- is decrease

+ is increase

LOG(Total Hg) in All Bass
TESTS FOR TREND 1994-2002

STATN	STAT_ID	JTSTD	P2_JT	SIGNIF
1	1BSTH026.12	-1.152	0.25	
3	1BSTH025.10	-0.527	0.60	
5	1BSTH020.44	0.503	0.61	
6	1BSTH014.60	-0.623	0.53	
7	1BSTH004.21	-3.145	0.00	**
8	1BNTH004.10	-1.541	0.12	
9	1BSSF100.10	-4.270	0.00	**
10	1BSSF078.24	-3.922	0.00	**
11	1BSSF054.20	-1.497	0.13	-is decrease
12	1BSSF020.70	-0.316	0.75	+is increase
15	1BSHN022.63	-2.013	0.04	**
16	1BSSF062.97	+2.241	0.03	**
17	1BSSF037.60	-3.123	0.00	**
18	1BSSF010.18	-1.273	0.20	
21	1BSTH022.75	-0.387	0.70	
23	1BSHN038.48	0.438	0.66	

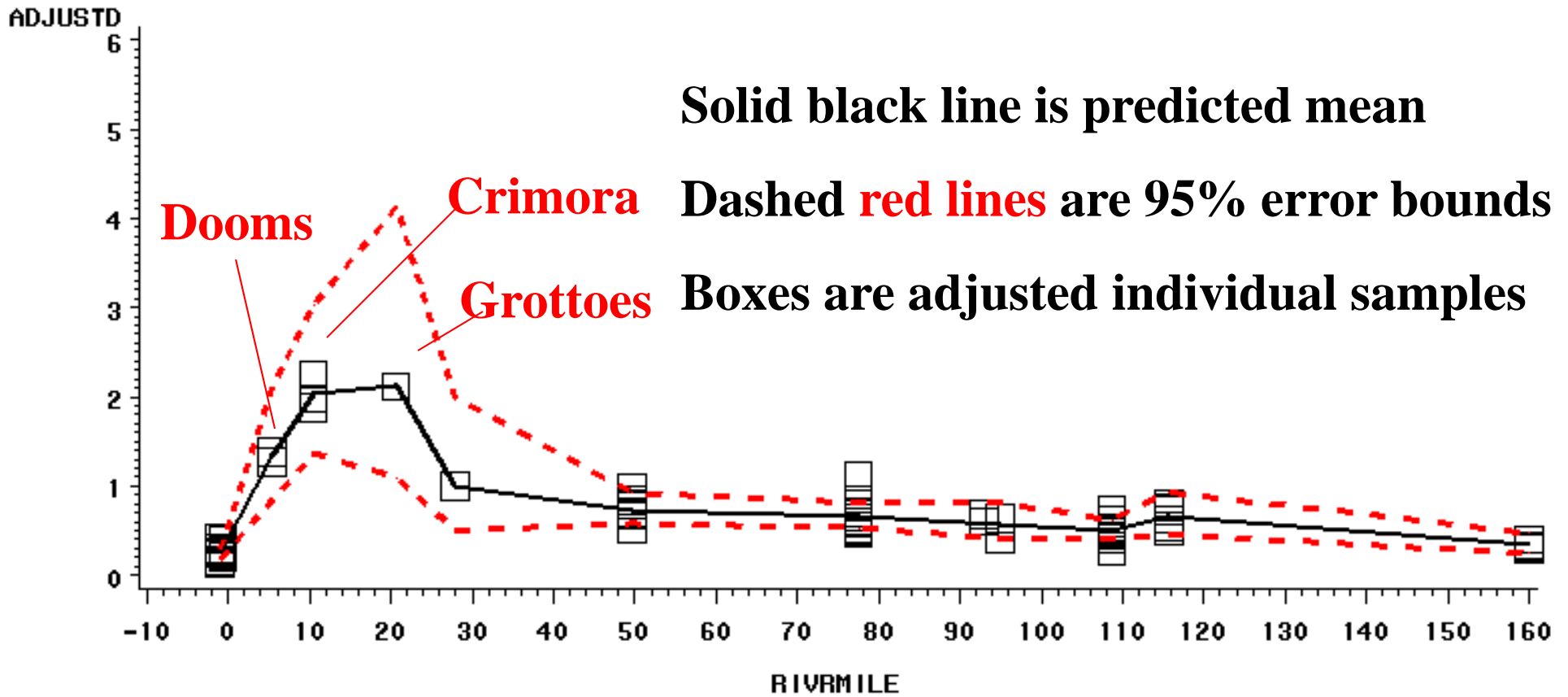
LOG(Total Hg) in All Bass

TESTS FOR TREND 1996-2002

STATN	STAT_ID	JTSTD	P2_JT	SIGNIF	
1	1BSTH026.12	-1.416	0.16		
3	1BSTH025.10	-1.603	0.11		
5	1BSTH020.44	-0.748	0.45		
6	1BSTH014.60	-2.031	0.04	**	
7	1BSTH004.21	-2.961	0.00	**	
8	1BNTH004.10	-2.788	0.01	**	
9	1BSSF100.10	-4.137	0.00	**	
10	1BSSF078.24	-4.883	0.00	**	-is decrease
11	1BSSF054.20	-5.524	0.00	**	
12	1BSSF020.70	-3.833	0.00	**	
15	1BSHN022.63	-2.013	0.04	**	
16	1BSSF062.97	-2.734	0.01	**	
17	1BSSF037.60	-4.317	0.00	**	
18	1BSSF010.18	-2.727	0.01	**	
21	1BSTH022.75	-0.387	0.70		
23	1BSHN038.48	0.438	0.66		

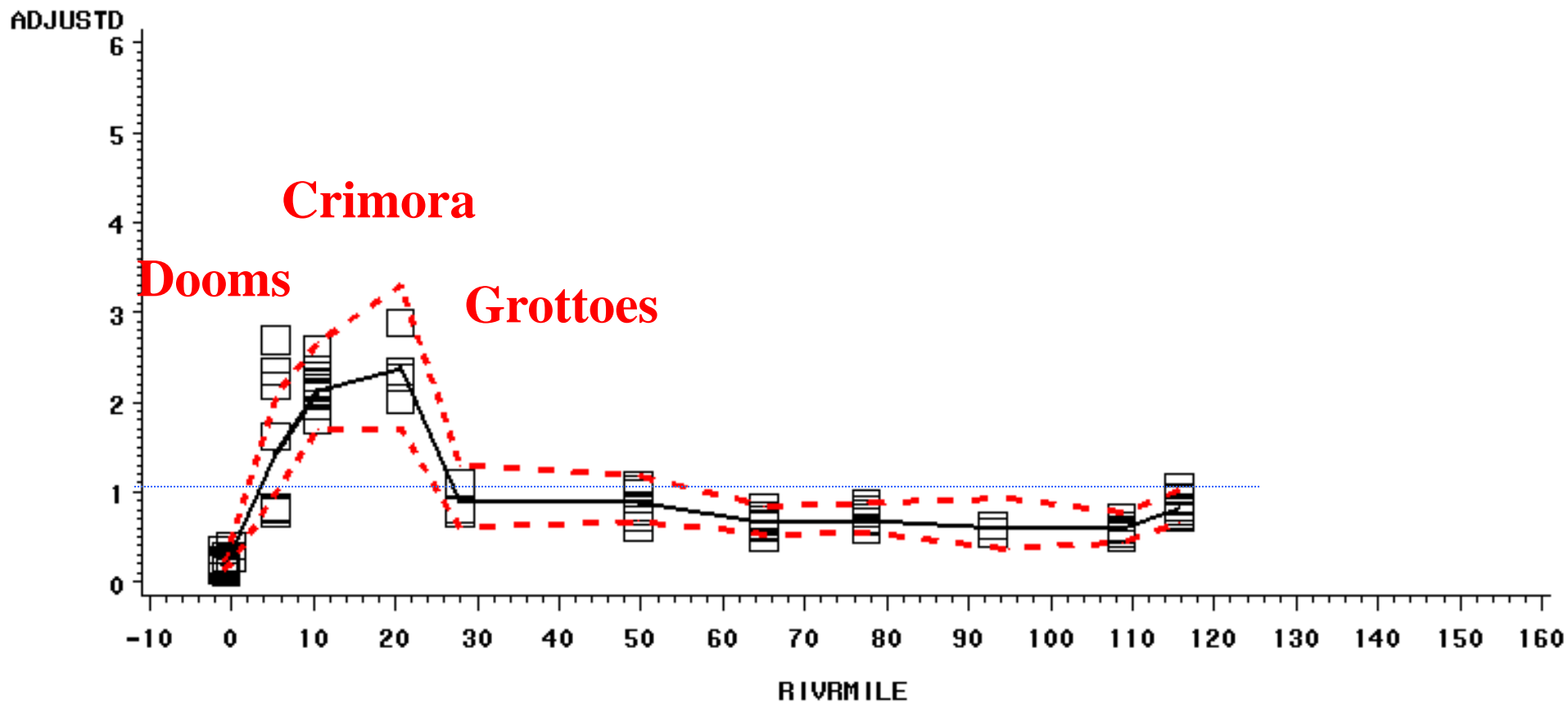
Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION!YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1992



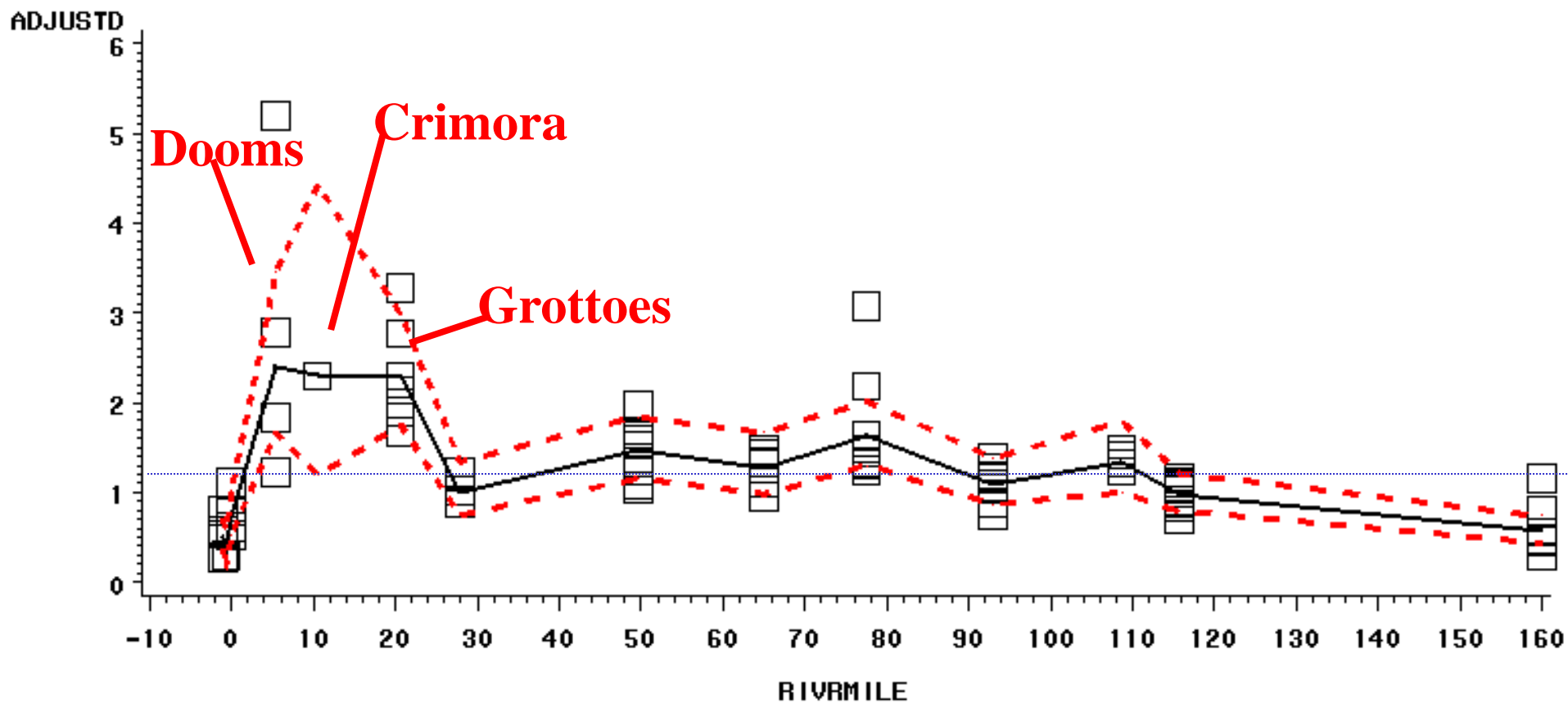
Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION!YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1994



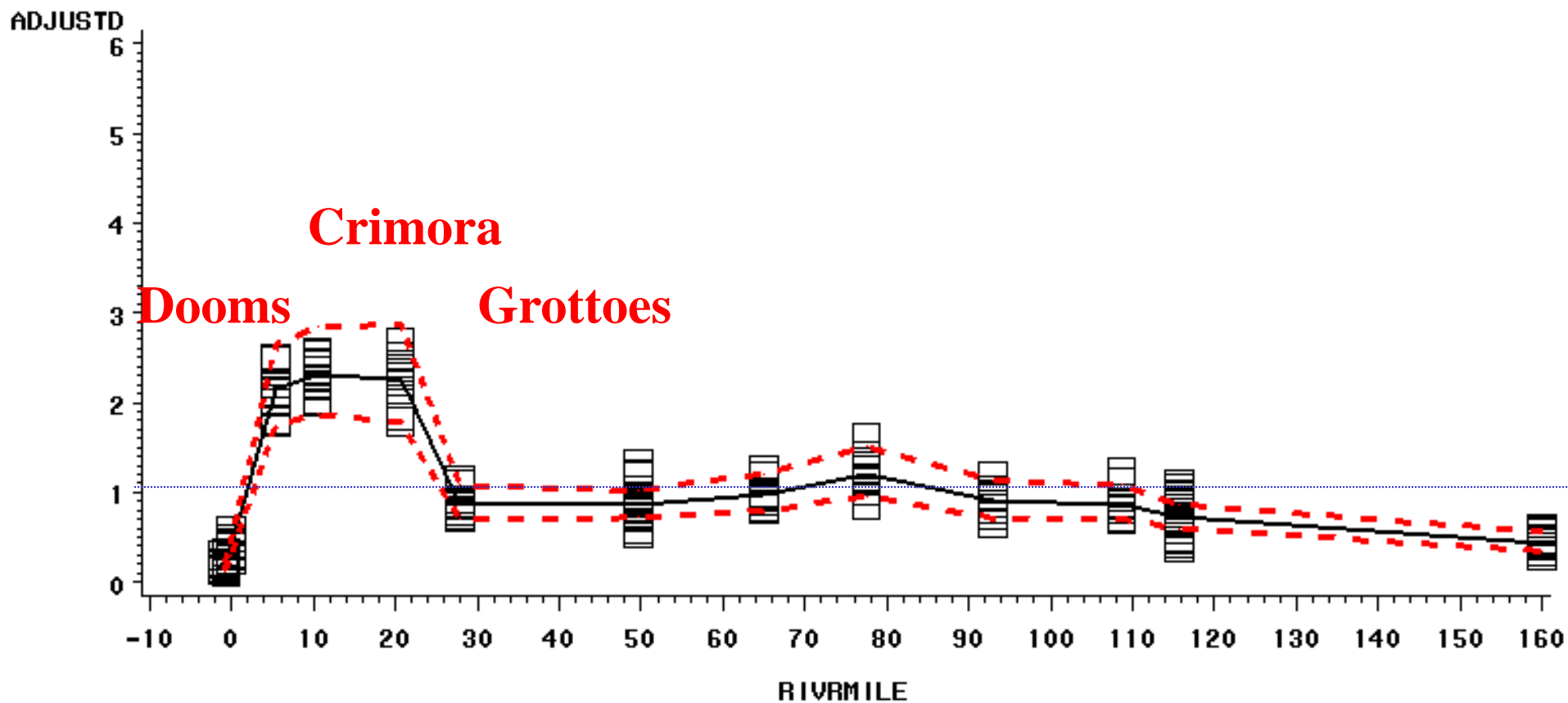
Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1996



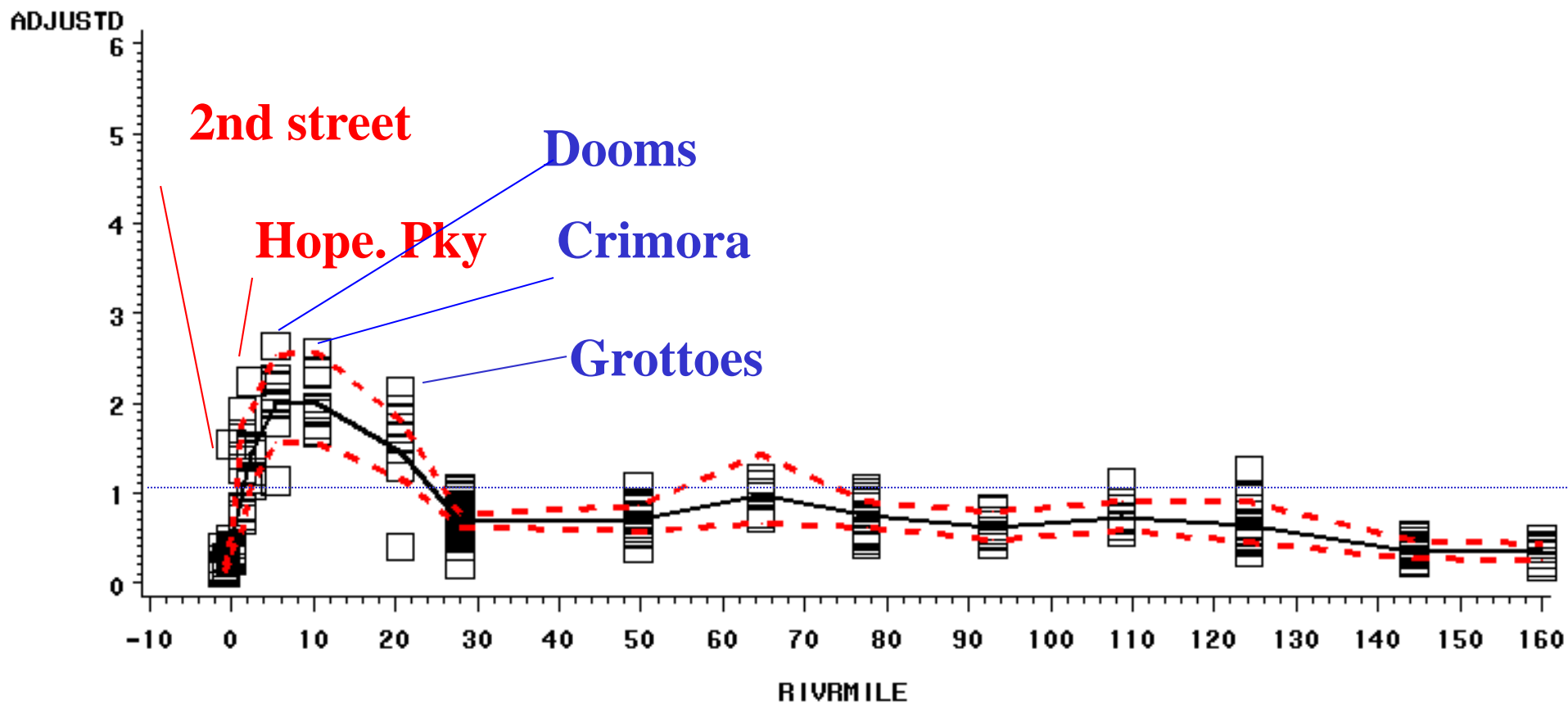
Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION!YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1999



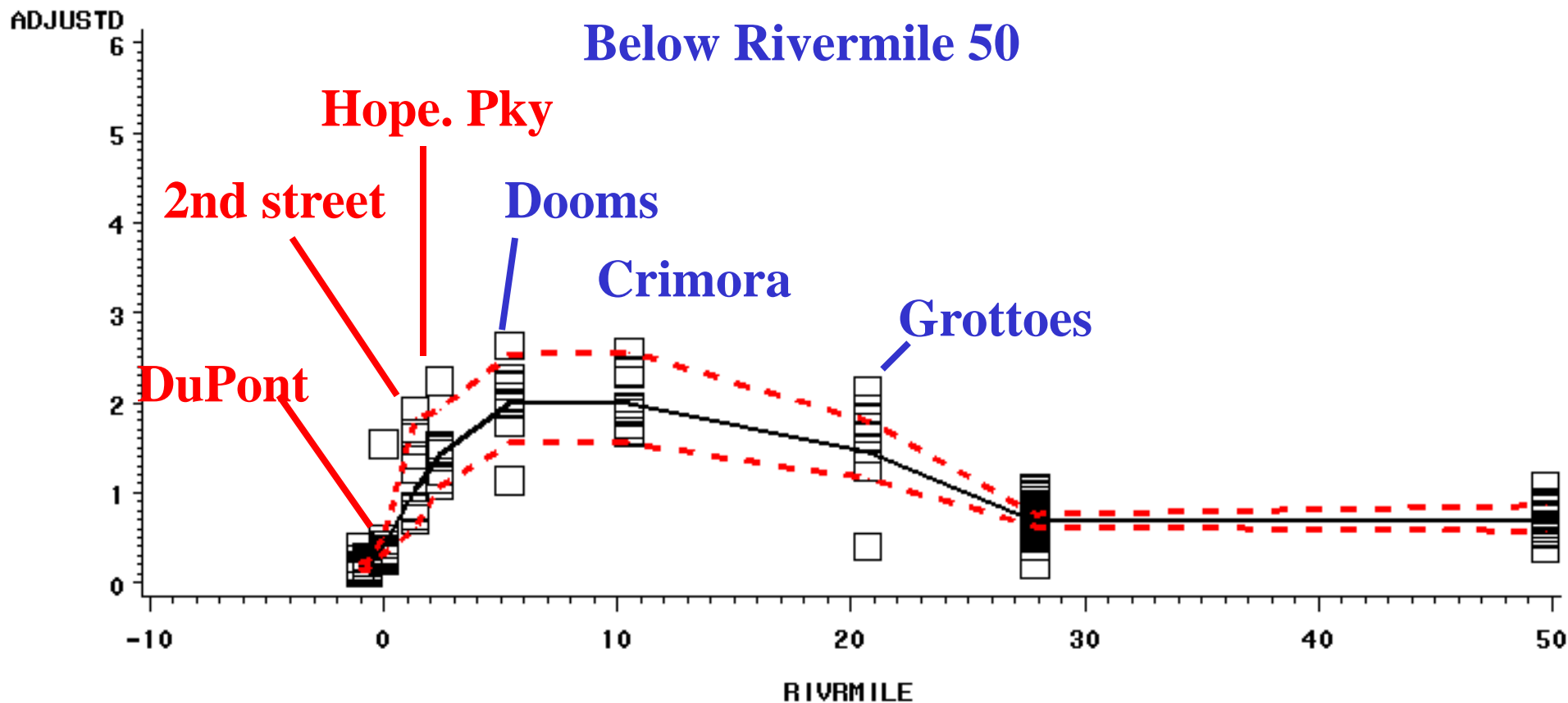
Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=2002



Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION!YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=2002



2002 Results: Bass

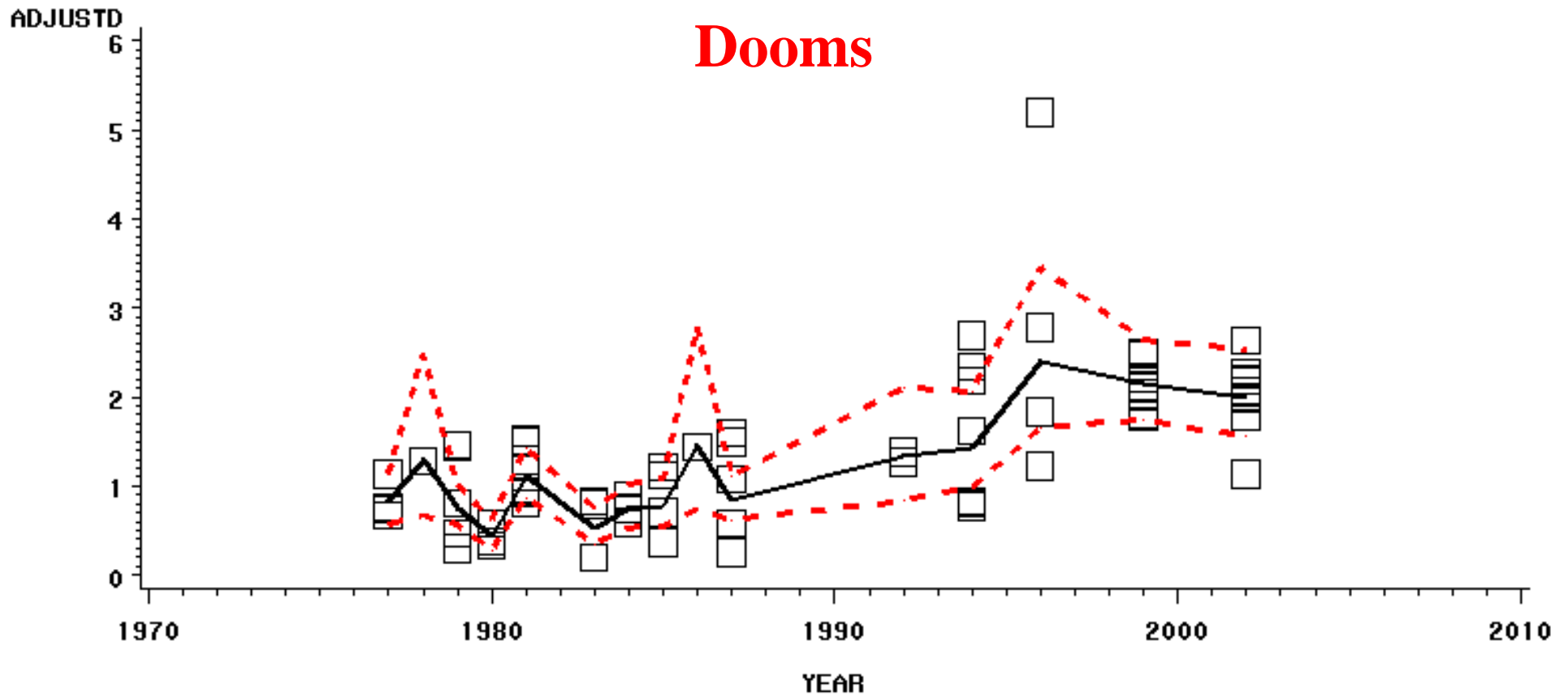
RIVRMILE	STAT_ID	STATION	NUM	ADJSTDMN	SDADJSTD
-1	1BNTH004.10	8	9	0.18867	0.09068
-0.7	1BSTH026.12	1	9	0.18205	0.05781
0	1BSTH025.10	3	9	0.48172	0.40299
1.37	1BSTH023.73	24	9	1.12554	0.45667
2.4	1BSTH022.75	21	9	1.46425	0.33347
5.4	1BSTH020.44	5	9	2.02762	0.40919
10.5	1BSTH014.60	6	9	2.01537	0.32177
20.7	1BSTH004.21	7	9	1.56063	0.49933
27.9	1BSSF100.10	9	51	0.70944	0.16701
49.7	1BSSF078.24	10	18	0.71732	0.15946
64.62	1BSSF063.17	25	9	0.97838	0.14969
77.5	1BSSF054.20	11	18	0.77293	0.20202
93	1BSSF037.60	17	9	0.62259	0.13027
108.7	1BSSF020.70	12	9	0.73932	0.17325
124.29	1BSSF003.50	26	18	0.67142	0.24176
144.5	1BSHN038.48	23	18	0.36080	0.08792
160	1BSHN022.63	15	9	0.34785	0.09541

2002 Observations at Rivermile 0

STAT_ID	RMILE	LENGTH	WEIGHT	OBS_TOTHG	ADJUSTD
1BSTH025.10	0	19.4	94	0.26	0.32713
1BSTH025.10	0	20.4	129	0.32	0.36997
1BSTH025.10	0	21.2	126	0.28	0.30586
1BSTH025.10	0	22.0	173	0.27	0.27491
1BSTH025.10	0	23.0	150	1.63	1.54002
1BSTH025.10	0	24.6	192	0.50	0.42475
1BSTH025.10	0	25.2	205	0.32	0.26099
1BSTH025.10	0	26.2	266	0.63	0.48113
1BSTH025.10	0	28.2	275	0.52	0.35072

Adjusted and Predicted Total Hg in Bass

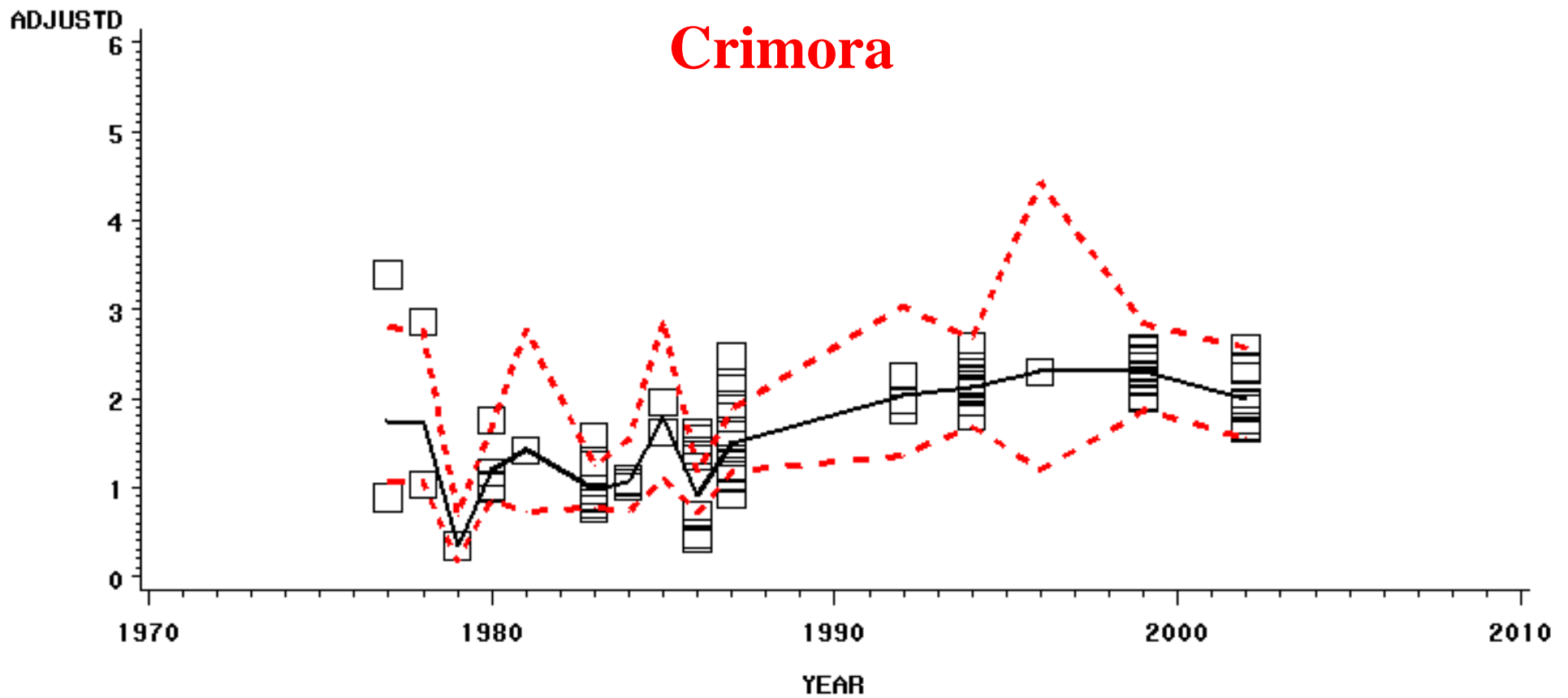
MODEL: LOGTHG=STATION!YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=5 Stat_ID=1BSTH020.44



Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=6 Stat_ID=1BSTH014.60

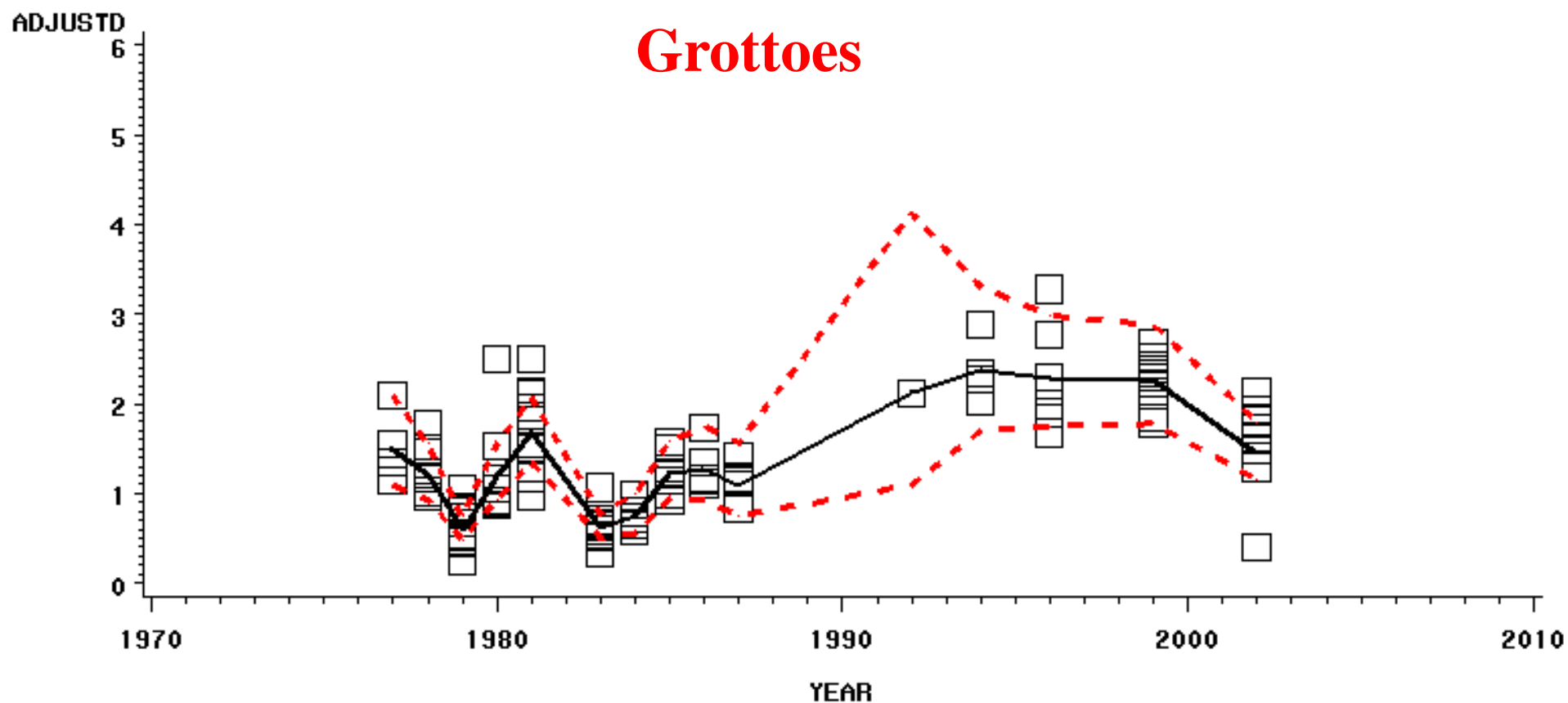
Crimora



Adjusted and Predicted Total Hg in Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=7 Stat_ID=1BSTH004.21

Grottoes



Smallmouth Bass Results

- **Results for small mouth bass are very little different from those for all bass (smallmouth + largemouth).**
- **A few charts will demonstrate this**

Trends over Time: Smallmouth

- At several stations (5, 7, 8, 9, 12, 15, 17) total Hg levels are still higher than at baseline.
- In all statistically significant cases, 2002 values are lower than in recent past.
- Trends since 1996 are all decreasing.

LOG(Total Hg) in Smallmouth Bass
Estimated Change

	PARM	STN_EST	SE	P_T	
Station	5 02-79/83	0.965	0.288	0.00	*+
Station	7 02-77/83	0.383	0.132	0.00	*+
Station	7 02-99	-0.420	0.157	0.01	*-
Station	7 02-94	-0.409	0.202	0.04	*-
Station	8 02-78/83	-0.475	0.170	0.01	*-
Station	9 02-77/83	-0.454	0.074	0.00	*-
Station	12 02-77/83	0.506	0.122	0.00	*+
Station	12 02-96	-0.692	0.188	0.00	*-
Station	15 02-77/83	0.870	0.133	0.00	*+
Station	17 02-80/83	0.481	0.133	0.00	*+

- is decrease

+ is increase

LOG(Total Hg) in Smallmouth Bass
TESTS FOR TREND 1996 - 2002

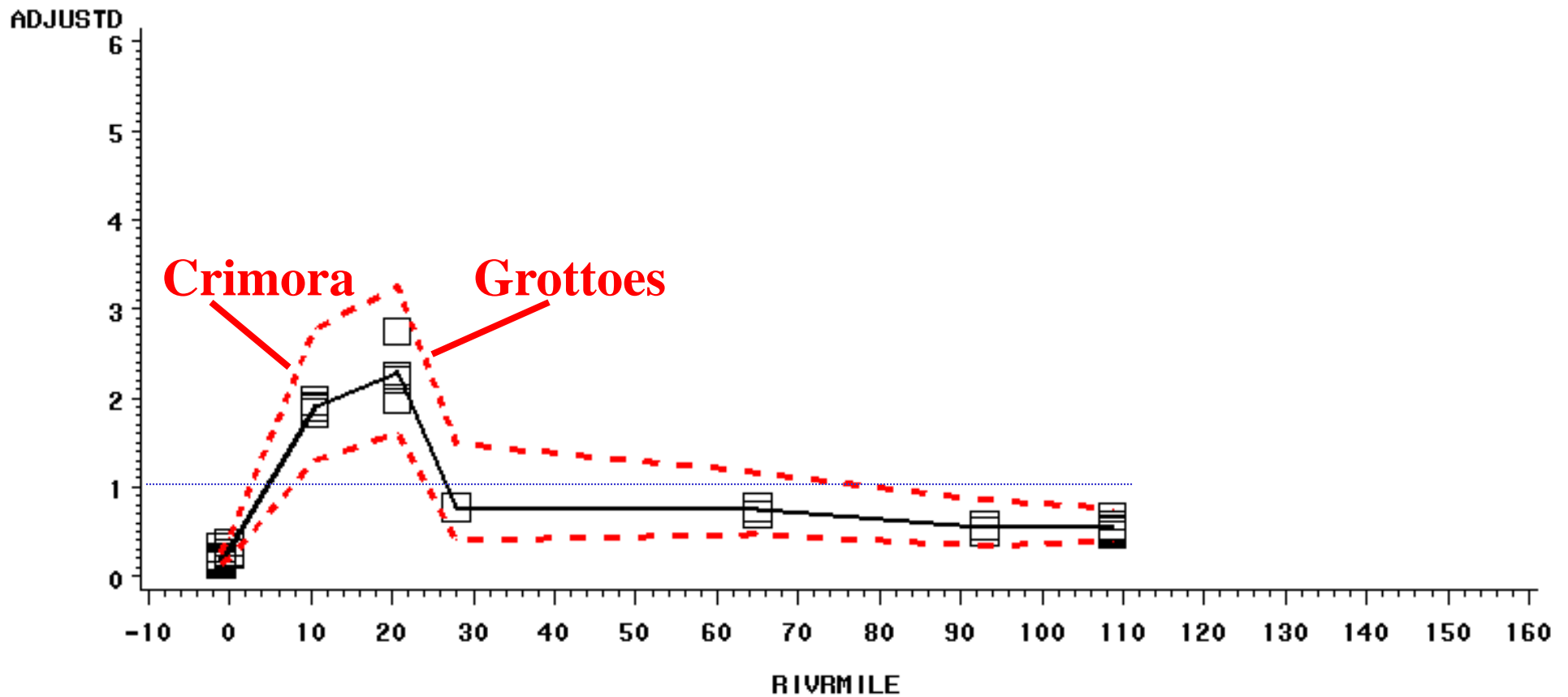
STATN	STAT_ID	JTSTD	P2_JT	SIGNIF
1	1BSTH026.12	-1.21277	0.23	
3	1BSTH025.10	-0.34121	0.73	
5	1BSTH020.44	-1.38804	0.17	
6	1BSTH014.60	-1.32350	0.19	
7	1BSTH004.21	-3.56770	0.00	* - is decrease
8	1BNTH004.10	-1.36941	0.17	+ is increase
9	1BSSF100.10	-3.47869	0.00	*
10	1BSSF078.24	-1.80986	0.07	
11	1BSSF054.20	-4.15493	0.00	*
12	1BSSF020.70	-0.61495	0.54	
15	1BSHN022.63	-2.20912	0.03	*
16	1BSSF062.97	+0.21138	0.83	
17	1BSSF037.60	-3.12356	0.00	*
18	1BSSF010.18	-1.77705	0.08	

LOG(Total Hg) in Smallmouth Bass
TESTS FOR TREND 1996 - 2002

STATN	STAT_ID	JTSTD	P2_JT	SIGNIF
1	1BSTH026.12	-1.21277	0.23	
3	1BSTH025.10	-1.25989	0.21	
5	1BSTH020.44	-1.38804	0.17	
6	1BSTH014.60	-2.20454	0.03	* - is decrease
7	1BSTH004.21	-3.26599	0.00	* + is decrease
8	1BNTH004.10	-0.92717	0.35	
9	1BSSF100.10	-3.45425	0.00	*
10	1BSSF078.24	-1.80986	0.07	
11	1BSSF054.20	-4.15493	0.00	*
12	1BSSF020.70	-3.88687	0.00	*
15	1BSHN022.63	-2.20912	0.03	*
16	1BSSF062.97	-1.55735	0.12	
17	1BSSF037.60	-4.22884	0.00	*
18	1BSSF010.18	-1.77705	0.08	
22	1BSHN038.48	+1.22565	0.22	

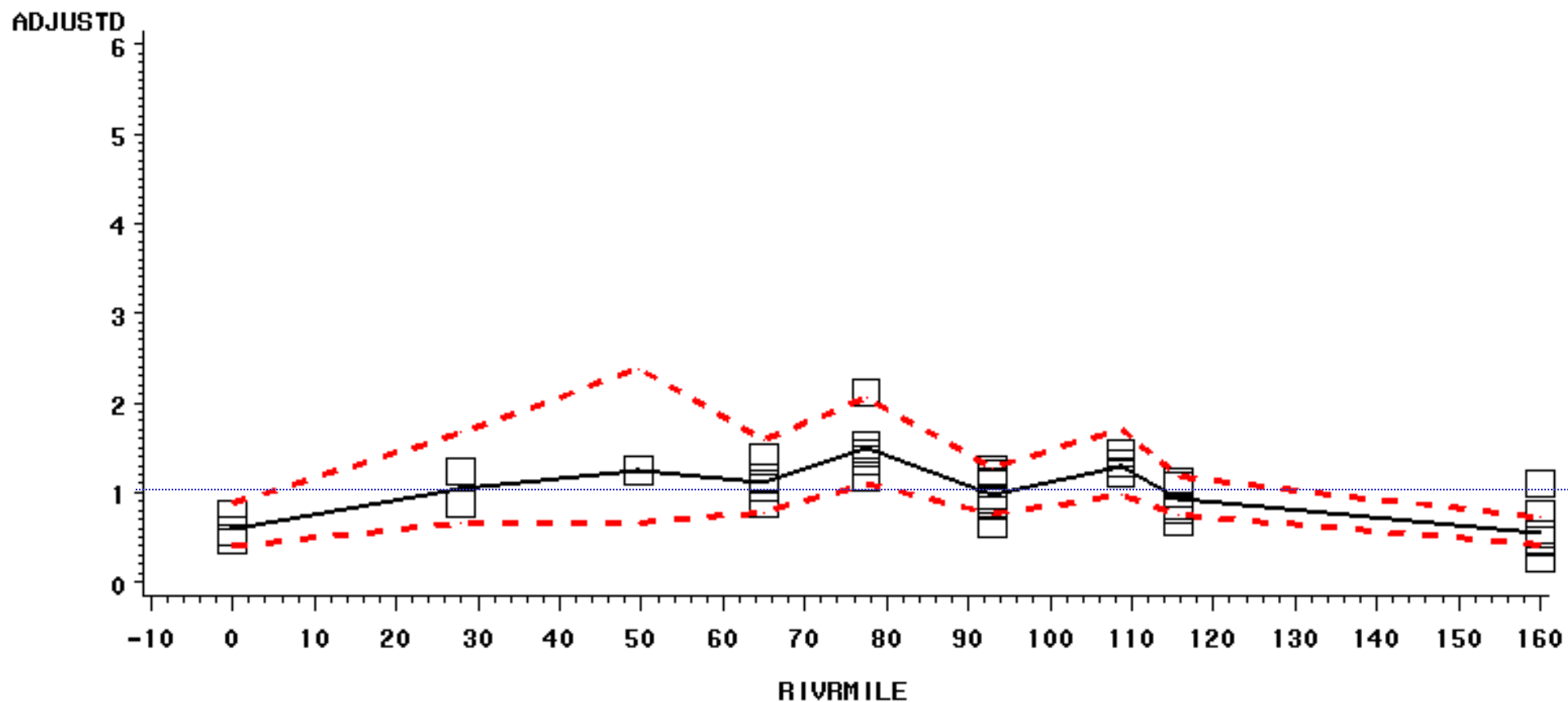
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1994



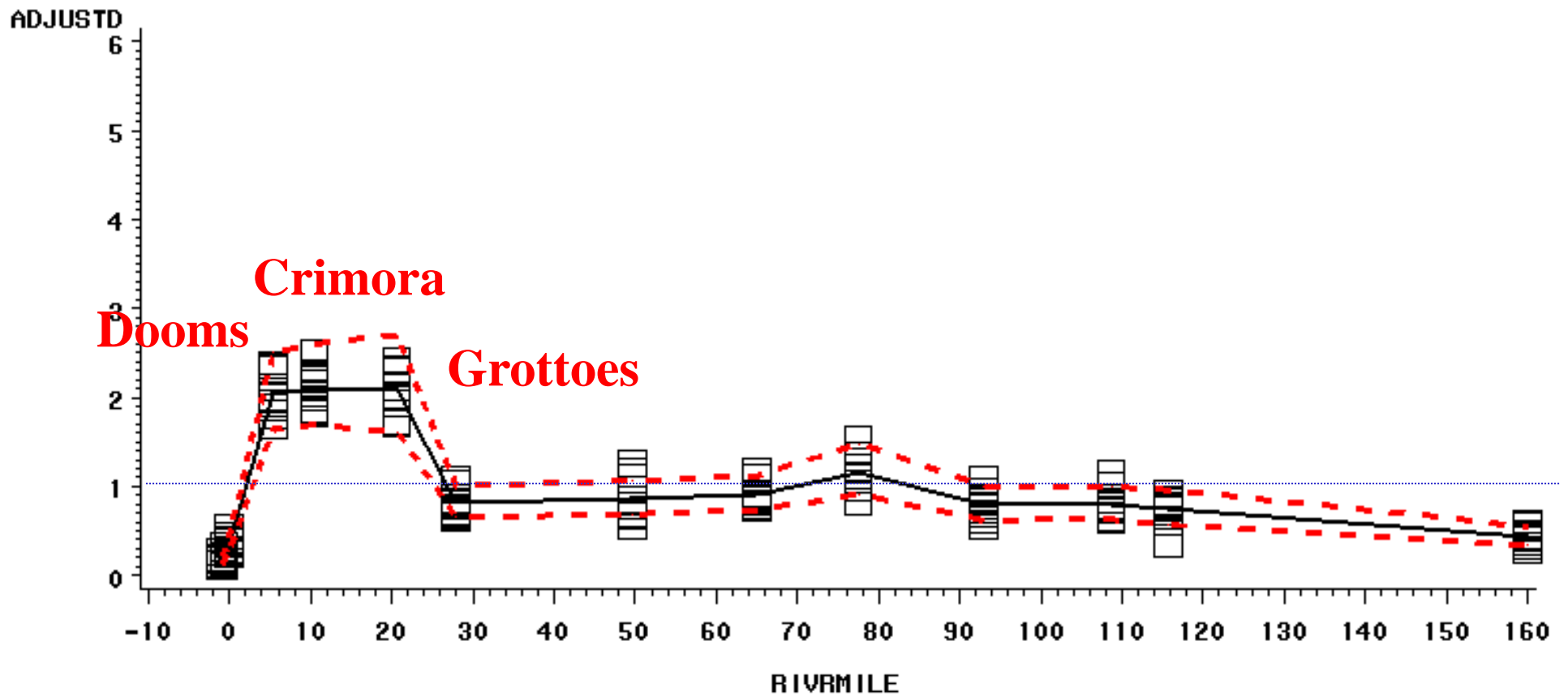
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1996



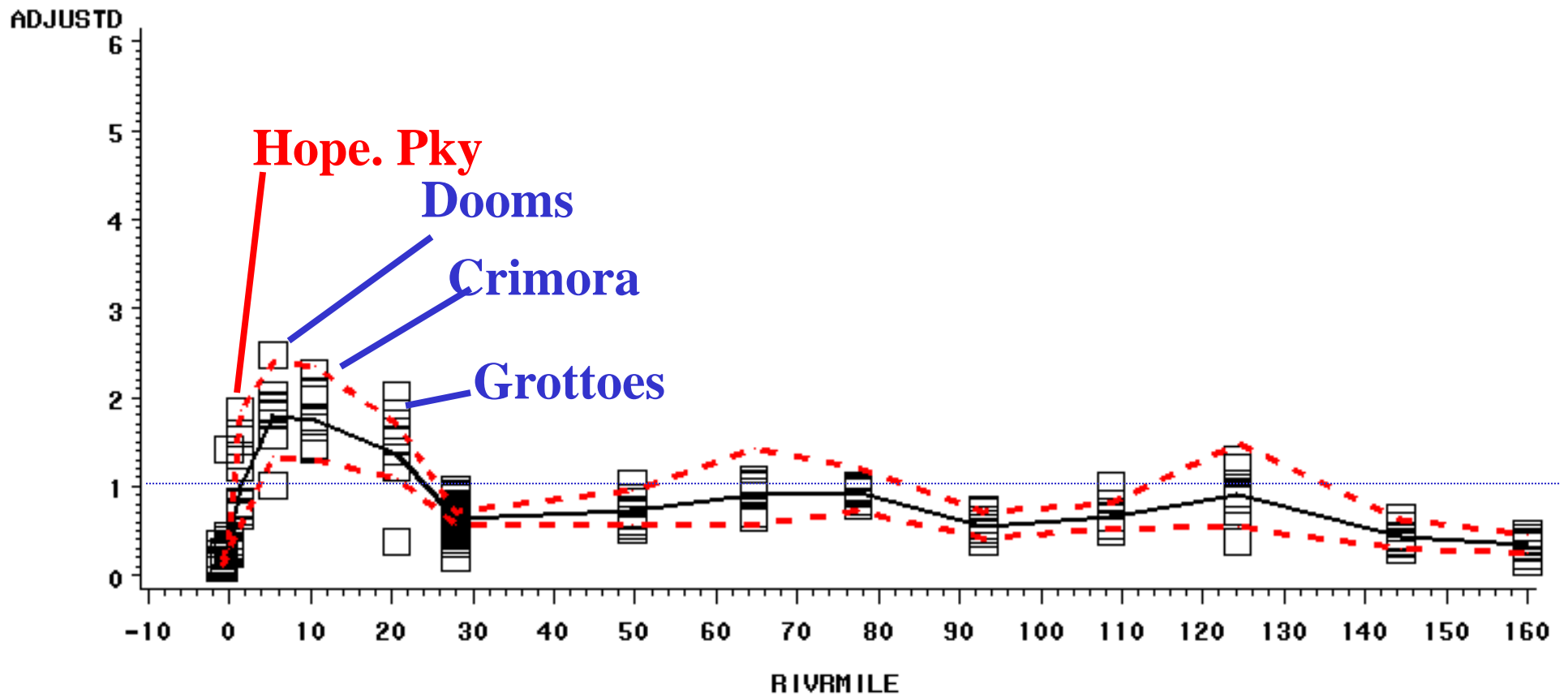
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1999



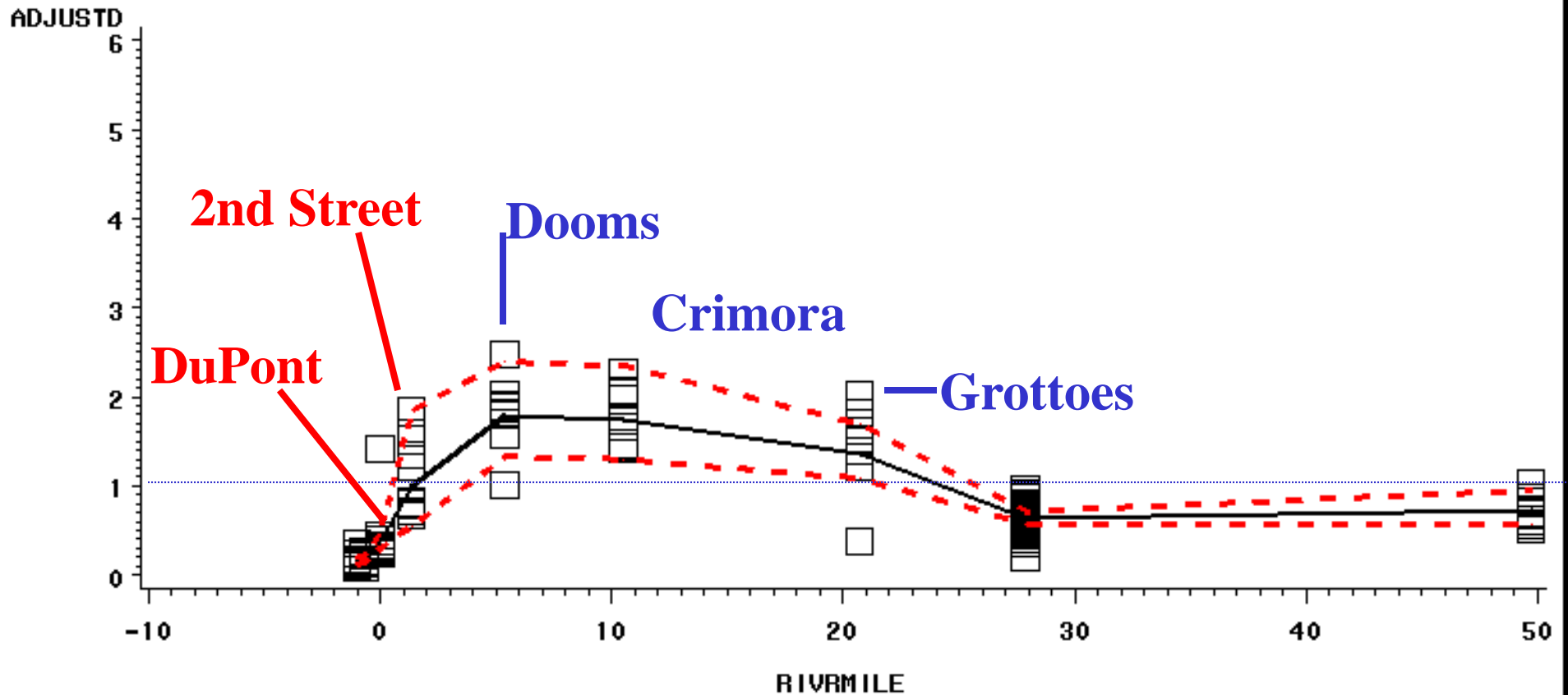
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=2002



Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=2002



2002 Results: Smallmouth

RIVRMILE	STAT_ID	STATION	NUM	ADJMN	STD
-1	1BNTH004.10	8	9	0.173	0.08
-0.7	1BSTH026.12	1	9	0.171	0.05
0	1BSTH025.10	3	9	0.444	0.37
1.37	1BSTH023.73	24	9	1.077	0.44
5.4	1BSTH020.44	5	9	1.825	0.39
10.5	1BSTH014.60	6	9	1.767	0.31
20.7	1BSTH004.21	7	9	1.468	0.47
27.9	1BSSF100.10	9	51	0.660	0.16
49.7	1BSSF078.24	10	9	0.742	0.16
64.62	1BSSF063.17	25	9	0.909	0.13
77.5	1BSSF054.20	11	9	0.930	0.07
93	1BSSF037.60	17	9	0.557	0.12
108.7	1BSSF020.70	12	9	0.666	0.15
124.29	1BSSF003.50	26	9	0.946	0.28
144.5	1BSHN038.48	23	9	0.435	0.10
160	1BSHN022.63	15	9	0.354	0.10

Sunfish Results

- Sunfish present a similar set of conclusions.

Trends over Time: Sunfish

- At several stations (5, 8, 12, 15) total Hg levels are still higher than at baseline.
- Statistically significant 2002 values are lower than in recent past, except for:
 - **1BSTH026.12 (Station 1, control) and 1BSSF020.70 (Bentonville Landing at Gooney Run) 2002 increased over 1994**
- Trends since 1996 are decreasing, except for:
 - **Non-significant increase at 1BSSF010.18 (Karo Landing at Gooney Run)**

LOG(Total Hg) in Sunfish
ESTIMATED CHANGE BASELINE TO 2002

	PARM	STD_EST	SE	P_T	
Station	1 02-94	0.553	0.185	0.00	*+
Station	1 02-96	-0.812	0.189	0.00	*
Station	3 02-96	-0.927	0.184	0.00	*
Station	5 02-77/83	0.913	0.144	0.00	*+
Station	5 02-96	-0.490	0.184	0.01	*
Station	5 02-99	-0.402	0.185	0.03	*
Station	6 02-96	-0.540	0.184	0.00	*
Station	6 02-99	-0.361	0.184	0.05	*
Station	7 02-94	-0.530	0.195	0.01	*
Station	7 02-96	-0.491	0.212	0.02	*
Station	7 02-99	-0.419	0.185	0.02	*
Station	8 02-77/83	-0.647	0.150	0.00	*
Station	8 02-96	-0.364	0.186	0.05	*

LOG(Total Hg) in Sunfish
ESTIMATED CHANGE BASELINE TO 2002

	PARM	STD_EST	SE	P_T	
Station	9 02-96	-0.640	0.186	0.00	*
Station	10 02-94	-0.447	0.184	0.02	*
Station	10 02-96	-0.402	0.185	0.03	*
Station	11 02-96	-0.594	0.184	0.00	*
Station	11 02-99	-0.640	0.184	0.00	*
Station	12 02-77/83	0.819	0.147	0.00	*+
Station	12 02-94	0.567	0.185	0.00	*+
Station	15 02-77/83	0.297	0.147	0.04	*+
Station	17 02-99	-0.756	0.185	0.00	*

Adjusted LOG(Total Hg) in Sunfish
 TESTS FOR TREND 1994 - 2002

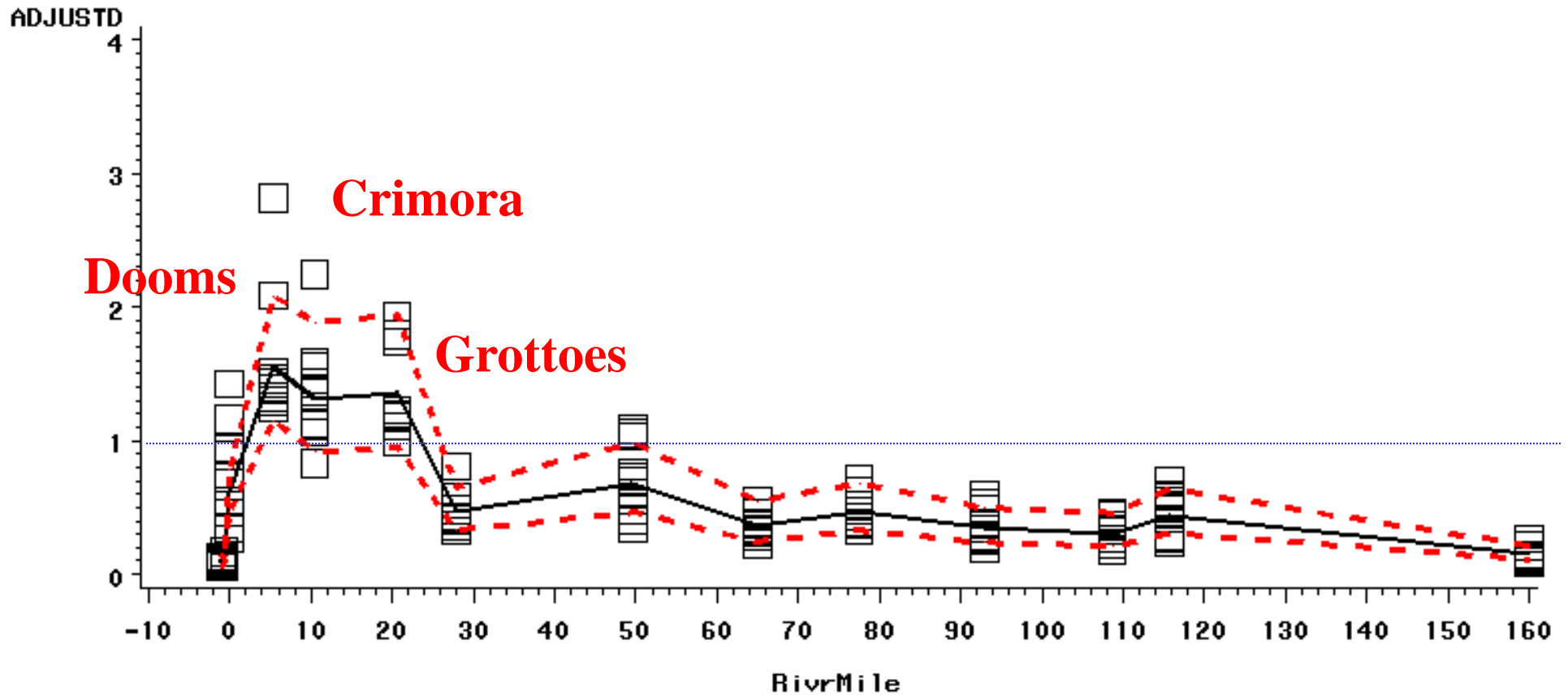
STATN	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	+1.58009	0.11409	
3	1BSTH025.10	-0.68000	0.49650	
5	1BSTH020.44	-2.25588	0.02408	*
6	1BSTH014.60	-1.87990	0.06012	
7	1BSTH004.21	-3.02806	0.00246	*
8	1BNTH004.10	-3.08323	0.00205	*
9	1BSSF100.10	-1.67958	0.09304	
10	1BSSF078.24	-3.50915	0.00045	*
11	1BSSF054.20	-1.83675	0.06625	
12	1BSSF020.70	+0.87729	0.38033	
15	1BSHN022.63	-1.92549	0.05417	
16	1BSSF062.97	+1.06466	0.28703	
17	1BSSF037.60	+0.20052	0.84107	
18	1BSSF010.18	+2.77571	0.00551	*+

Adjusted LOG(Total Hg) in Sunfish
TESTS FOR TREND 1996 - 2002

STATN	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	-3.31133	0.00	**
3	1BSTH025.10	-2.93939	0.00	**
5	1BSTH020.44	-4.64000	0.00	**
6	1BSTH014.60	-4.84000	0.00	**
7	1BSTH004.21	-3.21207	0.00	**
8	1BNTH004.10	-4.64064	0.00	**
9	1BSSF100.10	-4.48124	0.00	**
10	1BSSF078.24	-4.16000	0.00	**
11	1BSSF054.20	-4.68000	0.00	**
12	1BSSF020.70	-3.72000	0.00	**
15	1BSHN022.63	-2.64000	0.01	**
16	1BSSF062.97	-2.11660	0.03	**
17	1BSSF037.60	-3.00000	0.00	**
18	1BSSF010.18	+1.20949	0.23	

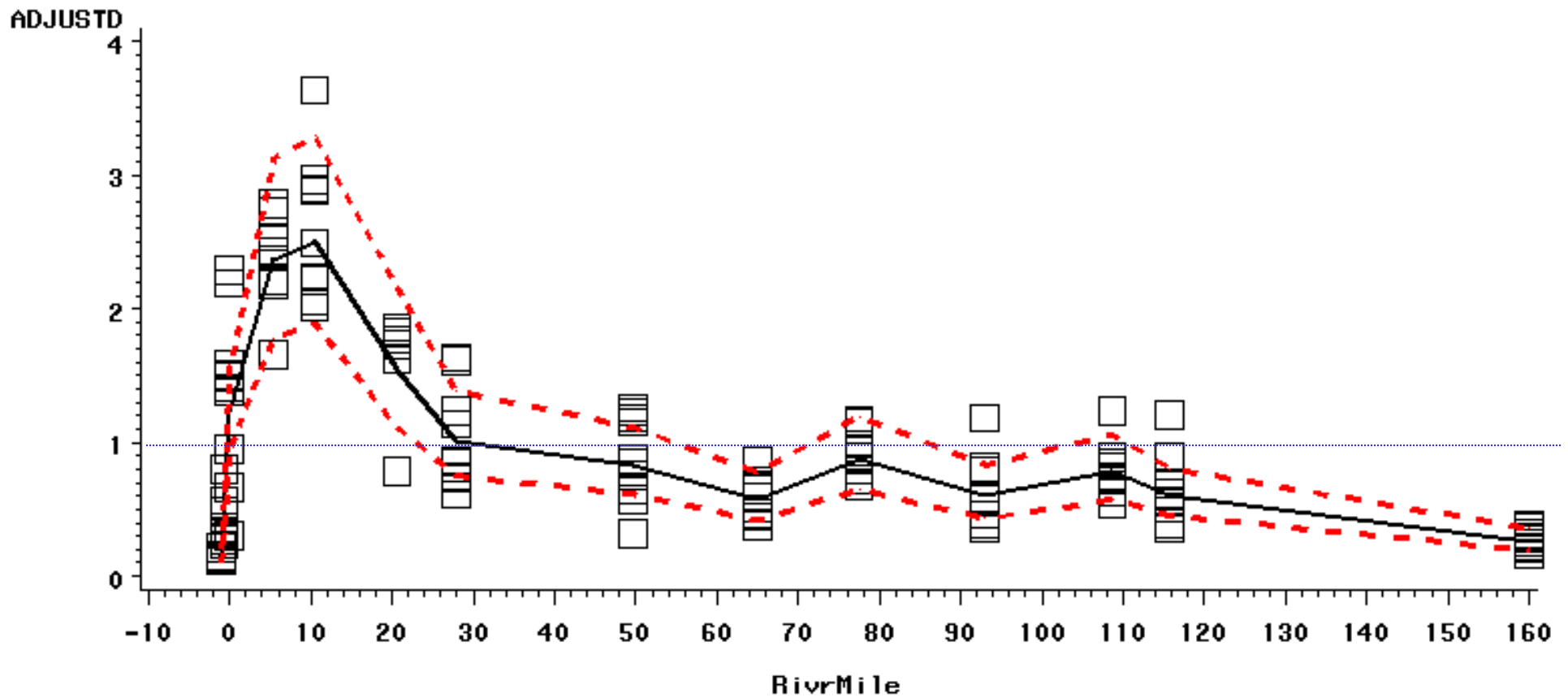
Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1994



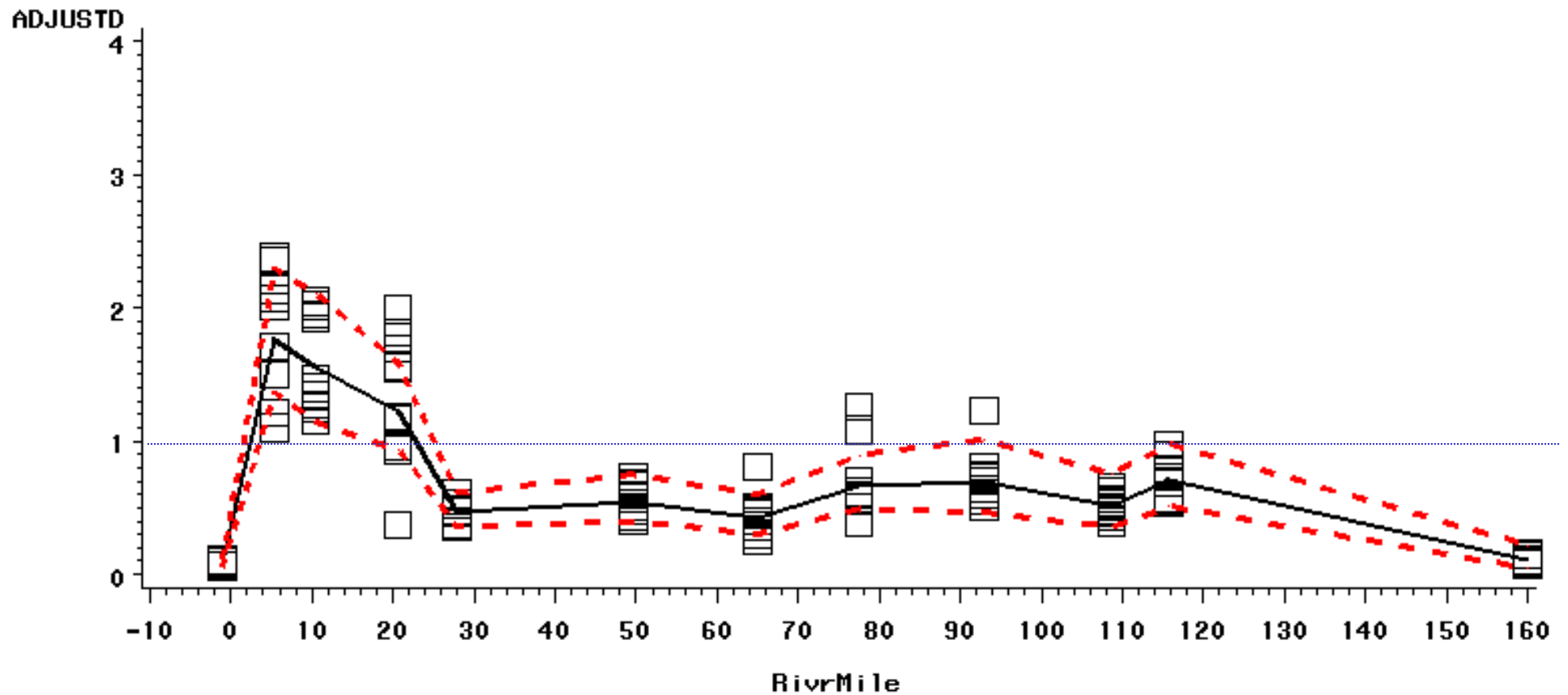
Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1996



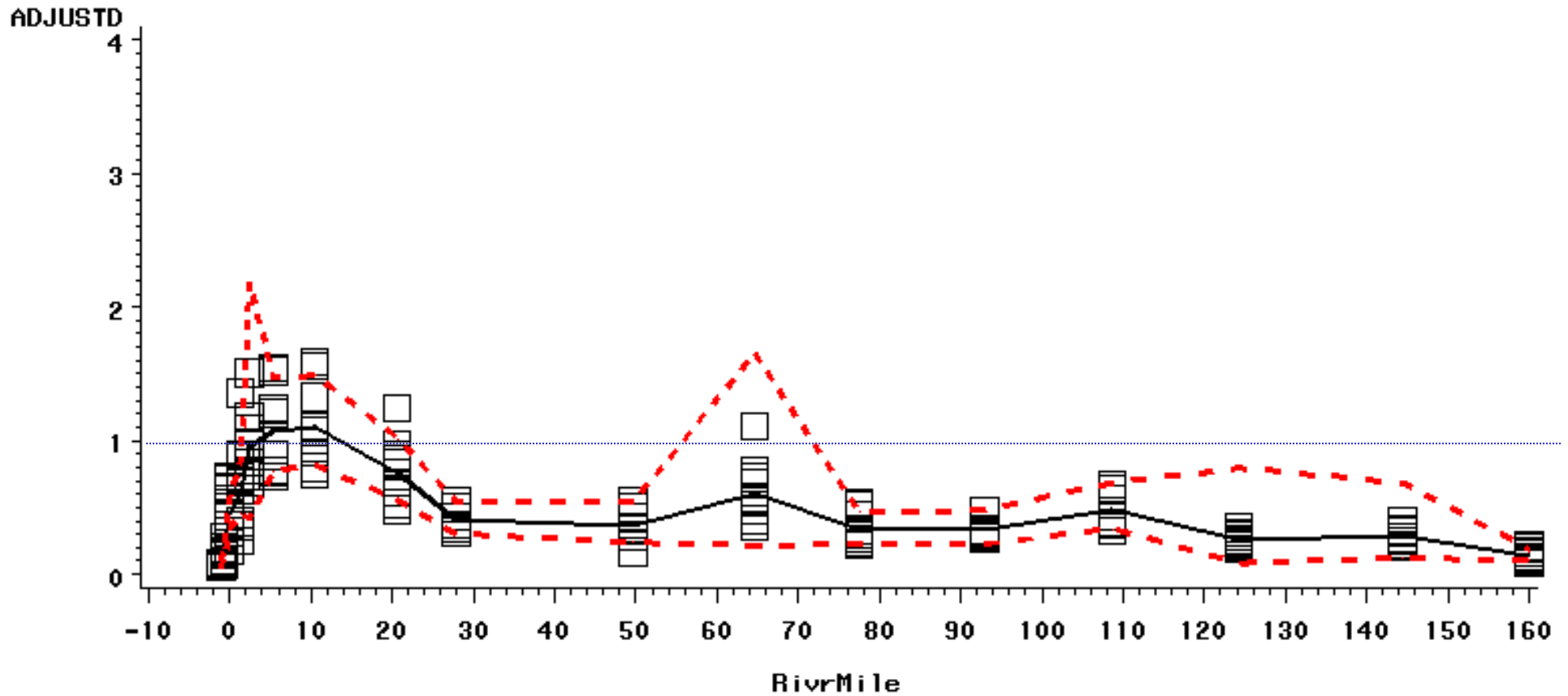
Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1999



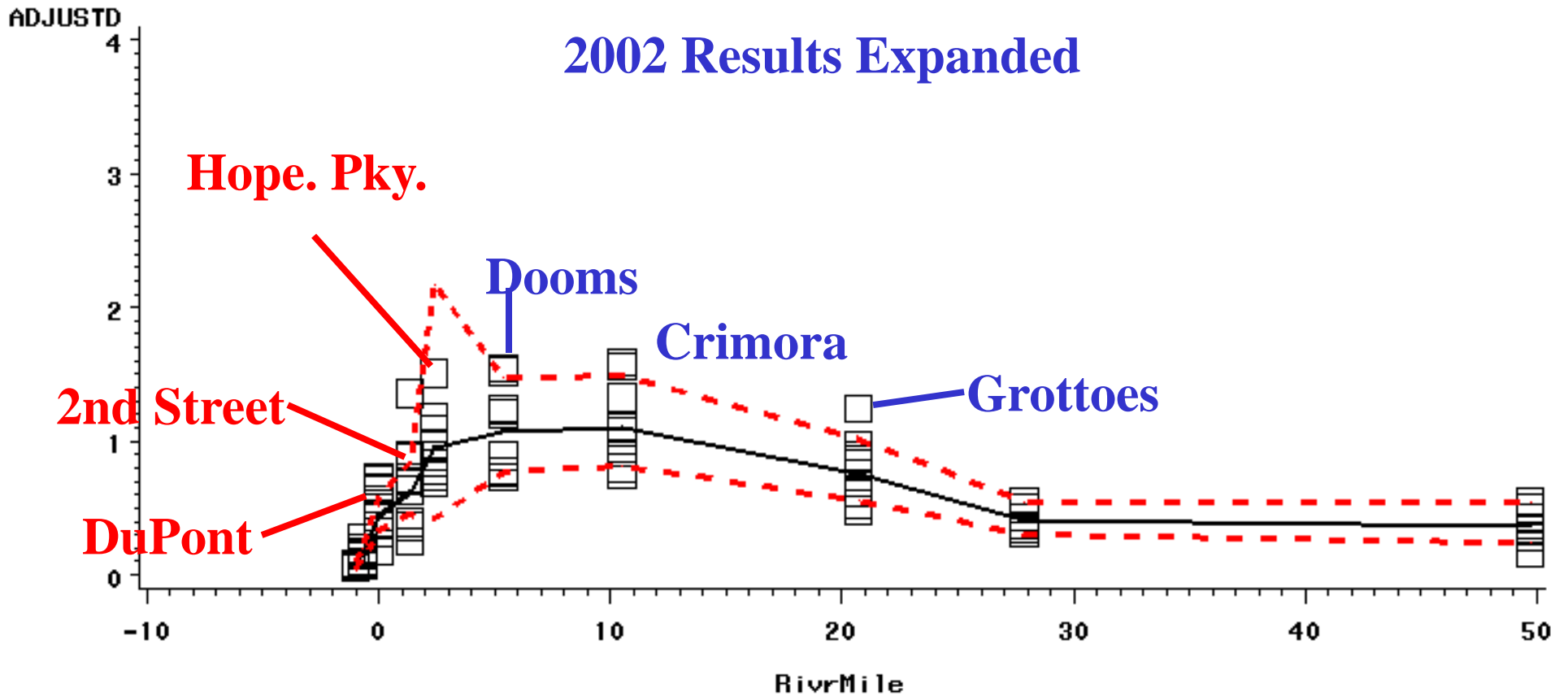
Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=2002



Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=2002



Sunfish 2002 Means

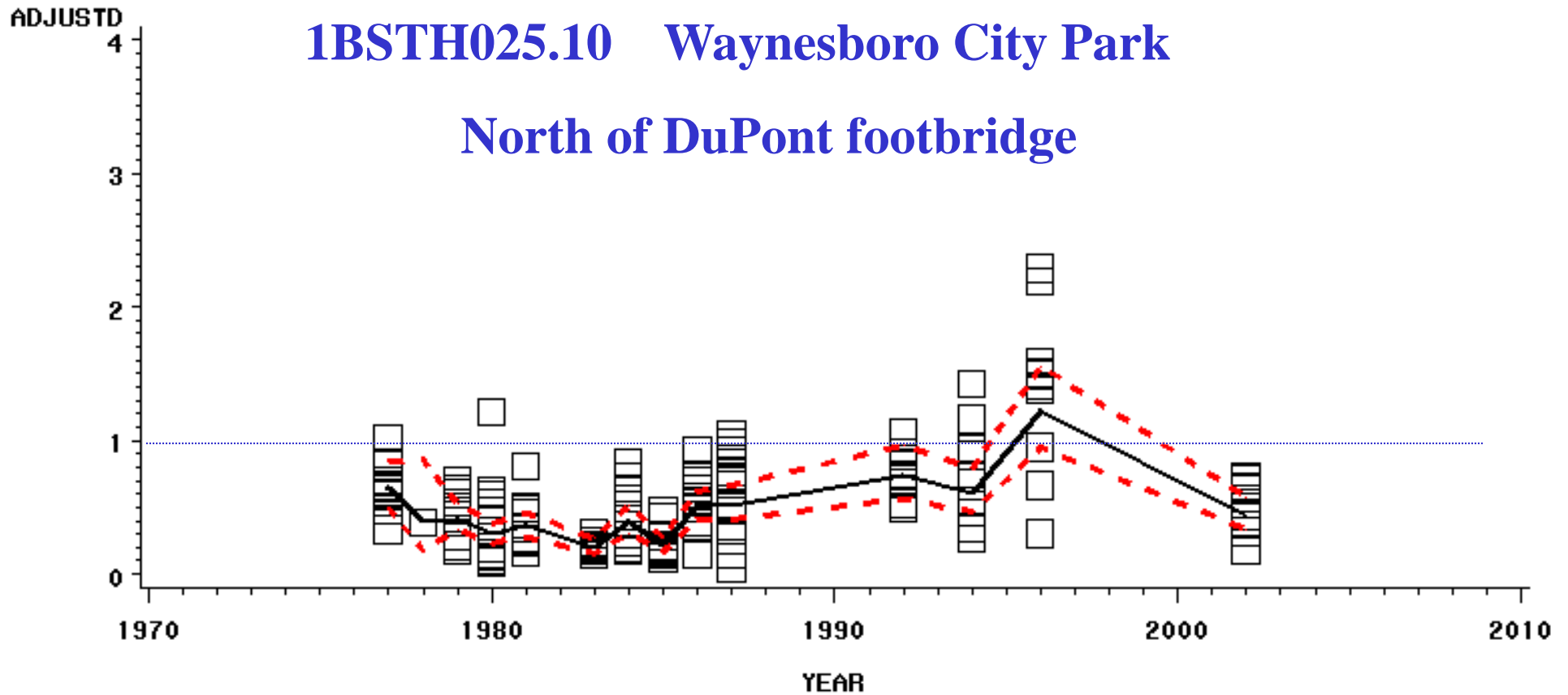
RMILE	STAT_ID	STATN	NUM	ADJSTDMN	SDADJSTD
-1	1BNTH004.10	8	9	0.07026	0.01292
-0.7	1BSTH026.12	1	9	0.15724	0.06222
0	1BSTH025.10	3	9	0.49381	0.21784
1.37	1BSTH023.73	24	9	0.69181	0.33884
2.4	1BSTH022.75	21	9	0.97892	0.25844
5.4	1BSTH020.44	5	9	1.10606	0.32038
10.5	1BSTH014.60	6	9	1.13873	0.30499
20.7	1BSTH004.21	7	9	0.78551	0.24499
27.9	1BSSF100.10	9	9	0.41369	0.08532
49.7	1BSSF078.24	10	9	0.37732	0.11687
64.62	1BSSF063.17	25	9	0.63021	0.22908
77.5	1BSSF054.20	11	9	0.34415	0.12516
93	1BSSF037.60	17	9	0.33097	0.05950
108.7	1BSSF020.70	12	9	0.49755	0.13280
24.29	1BSSF003.50	26	9	0.26031	0.04892
144.5	1BSHN038.48	23	9	0.30026	0.07033
160	1BSHN022.63	15	9	0.14455	0.04653

Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=3 Stat_ID=1BSTH025.10

1BSTH025.10 Waynesboro City Park

North of DuPont footbridge

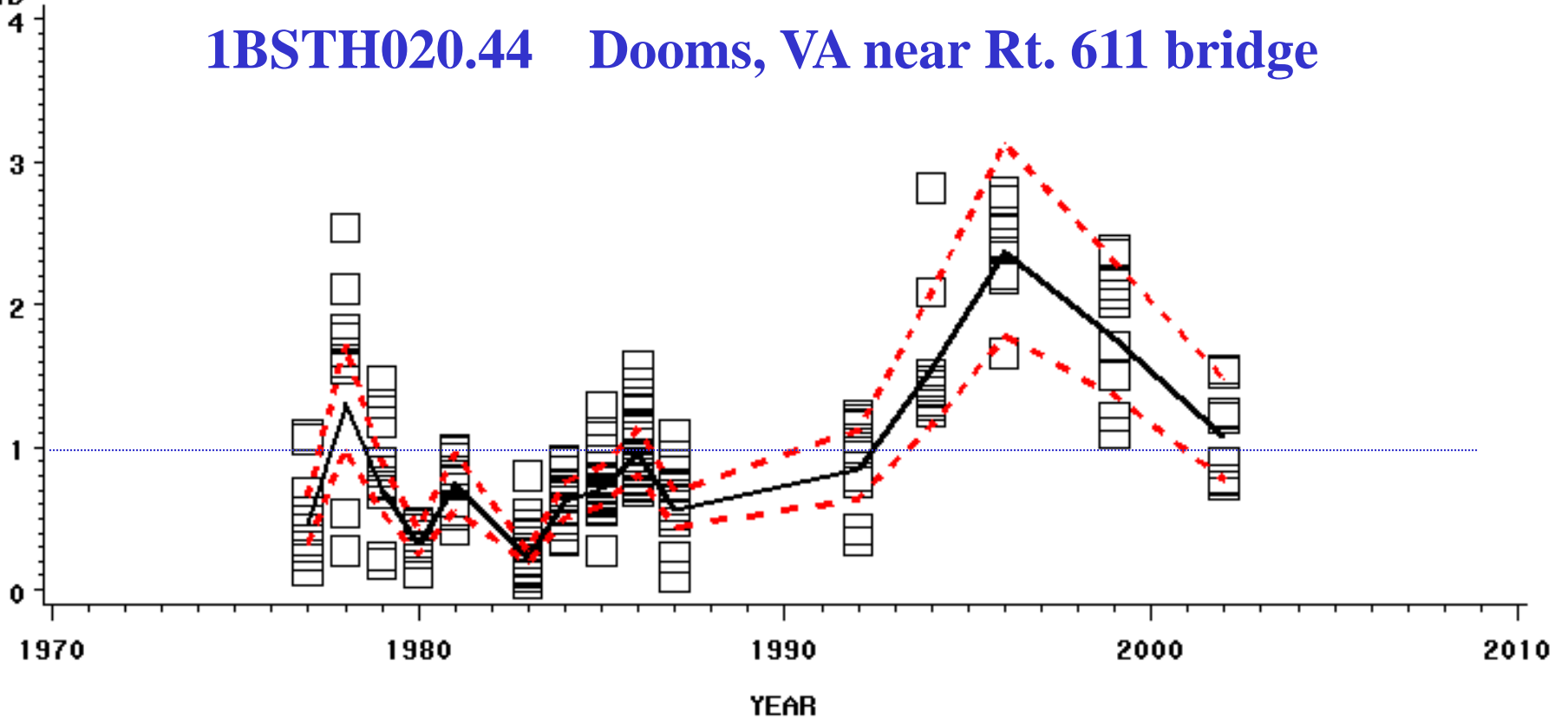


Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=5 Stat_ID=1BSTH020.44

ADJUSTD

1BSTH020.44 Dooms, VA near Rt. 611 bridge

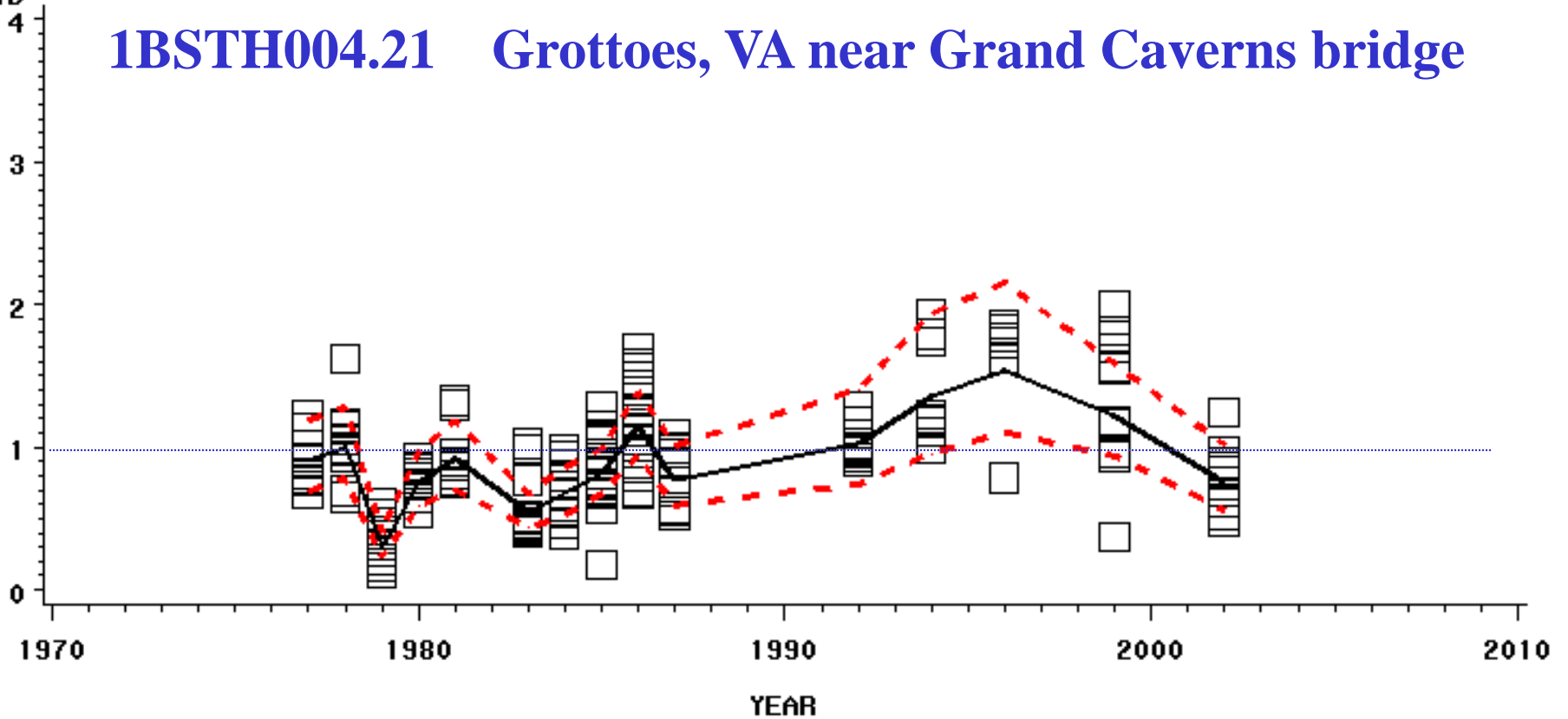


Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=7 Stat_ID=1BSTH004.21

ADJUSTD

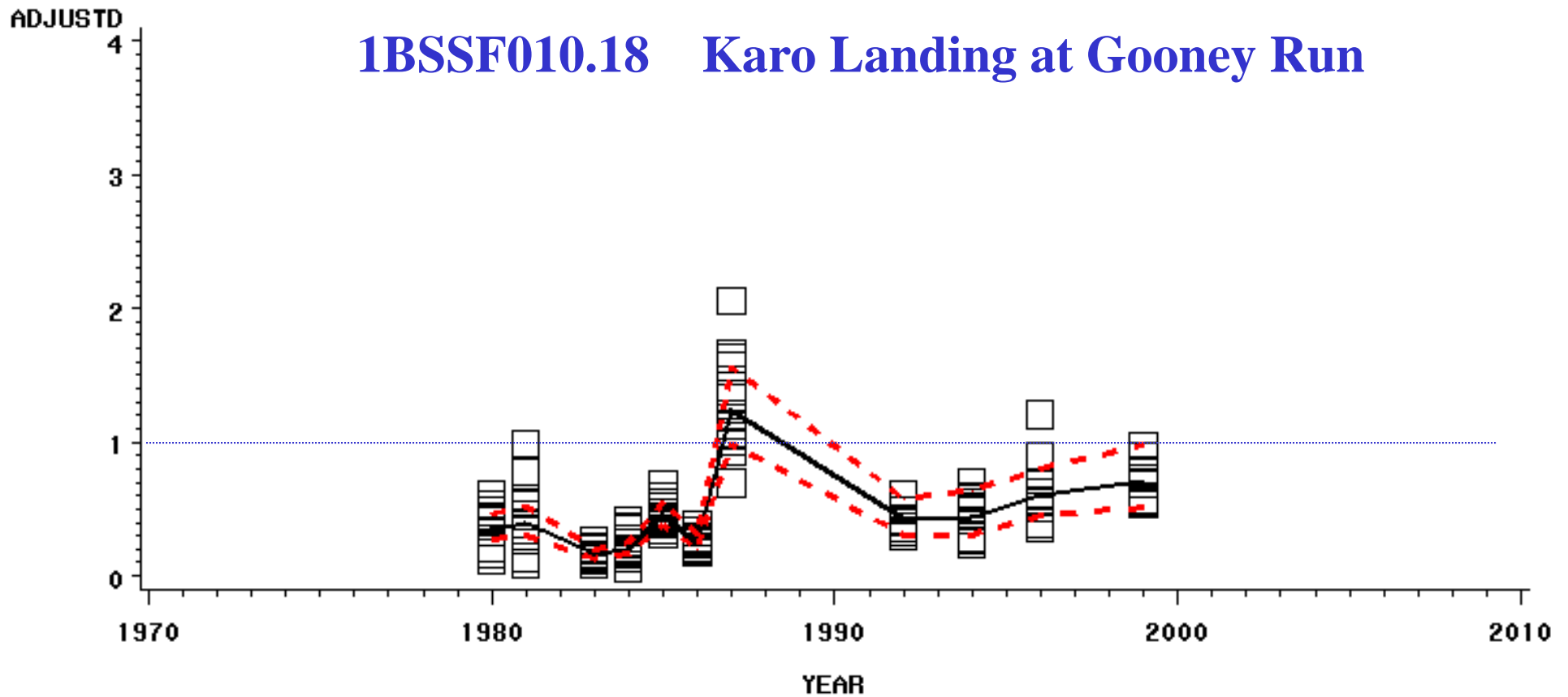
1BSTH004.21 Grottoes, VA near Grand Caverns bridge



Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION!YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=18 Stat_ID=1BSSF010.18

1BSSF010.18 Karo Landing at Gooney Run



Conclusions

- Total Hg levels continue to decrease from 1996 highs at every sampling station (except minor increase at Gooney Run),
 - Smallmouth, largemouth, sunfish
- Hg levels remain above baseline (77-83 avg) values at several stations
- Hg levels somewhat elevated at 2nd street, rise more at Hopeman Pky, continue to rise until Dooms or Crimora or Grottoes, then fall until Lynwood (1BSSF100.10), then flat.