

Statistical Analysis of South River Fish Tissue Data

October 8-9, 2002

STATION	Mile	STAT_ID	Location
1	-0.7	1BSTH026.12	Waynesboro City Park above Rife Loth Dam
3	0	1BSTH025.10	Waynesboro City Park north of DuPont footbrdg
5	5.4	1BSTH020.44	Dooms, VA near Rt. 611 bridge (above dam)
6	10.5	<i>1BSTH014.60</i>	<i>Crimora, VA near Rt. 612 bridge</i>
7	20.7	<i>1BSTH004.21</i>	<i>Grottoes, VA near Grand Caverns bridge</i>
8	-4.1	<i>1BNTH004.10</i>	<i>Near Rt. 668 bridge below confluence with Middle River</i>
9	27.9	1BSSF100.10	Lynwood, VA near Rt. 708 bridge
10	49.7	1BSSF078.24	Shenandoah, VA (boat ramp above dam)
11	65	1BSSF054.20	Hamberg, VA near Rt. 211 bridge
12	77.5	<i>1BSSF020.70</i>	<i>Bentonville Landing at Gooney Run</i>
15	93	<i>1BSHN022.63</i>	<i>Berryville, VA near Rt. 7 bridge</i>
16	108.7	<i>1BSSF062.97</i>	<i>Newport Landing south of Alma, VA on Rt. 340</i>
17	115.8	1BSSF037.60	Fosters Landing near Rt. 664 bridge
18	160	1BSSF010.18	Karo Landing at Gooney Run
20	25.3	1BSSF102.49	Port Republ below confluence of North and South River
21	2.4	<i>1BSTH022.75</i>	<i>Waynesboro near Hopeman Pkwy. bridge</i>
22	135	<i>1BSHN047.98</i>	<i>Rt. 624 bridge-downstream of Warren Power Dam</i>
23	144.5	<i>1BSHN038.48</i>	<i>Rt. I7/50 bridge</i>

Comparisons across Time

- 1999, 2001 to baseline
- 2001 to 1994, 1996, 1999
- 1999 to 1996, 1994
- Linear contrast 1994-2001
- Trend 1994-most recent
- Trend 1996-most recent
 - Last two affected by number of observations
 - first four determined by means

Statistical Methods : Fish

- A strong linear relationship (i.e., slope) exists between $\log(\text{Hg})$ & $\log(\text{length})$ but varies
 - across years
 - across stations
 - across species

Statistical Methods : Fish

- 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

Interpretation of next set of slides

- The statistics, including that described as EST or JTSTD are statistically adjusted values
- Only the sign (+/-) and p-value are informative.
- The magnitudes reported have no obvious value.
- Plots and means show importance

LOG(Total Hg) in Smallmouth Bass: ESTIMATED CHANGE BASELINE TO 2001

PARM		EST	SE	T	P_T
Station	3 01-83	0.012	0.176	0.40	0.6905
Station	3 Trn 94-01	0.543	0.686	1.15	0.2493
Station	3 01-94	0.093	0.217	1.98	0.0483
Station	3 01-96	-0.050	0.218	-1.05	0.2944
Station	3 01-99	0.040	0.149	1.79	0.0737
Station	5 99-79/83	0.259	0.260	3.85	0.0001
Station	7 99-77/83	0.113	0.140	5.75	0.0001
Station	7 99-94	0.000	0.034	0.06	0.9487
Station	8 99-78/83	-0.091	0.156	-3.73	0.0002
Station	8 99-94	0.000	0.031	0.05	0.9641
Station	9 99-77/83	-0.031	0.123	-2.04	0.0421
Station	9 99-94	0.001	0.060	0.31	0.7592
Station	9 99-96	-0.002	0.044	-1.04	0.2995

LOG(Total Hg) in Smallmouth Bass: ESTIMATED CHANGE BASELINE TO 2001

PARM	EST	SE	T	P_T
Station 10 99-77/82	-0.036	0.136	-1.97	0.0488
Station 10 99-96	-0.005	0.072	-0.93	0.3507
Station 12 99-77/83	0.092	0.118	6.65	0.0001
Station 12 99-94	0.002	0.029	2.60	0.0095
Station 12 99-96	-0.002	0.031	-2.18	0.0292
Station 15 99-77/83	0.117	0.125	7.54	0.0001
Station 15 01-77/83	0.106	0.103	9.96	0.0001
Station 15 01-99	0.000	0.024	0.62	0.5387
Station 15 01-96	-0.000	0.027	-0.52	0.6033
Station 17 99-80/83	0.088	0.127	5.43	0.0001
Station 17 99-94	0.014	0.088	1.81	0.0709
Station 17 99-96	-0.002	0.054	-0.61	0.5428
Station 18 99-80/83	0.063	0.150	2.81	0.0051
Station 18 99-96	-0.002	0.057	-0.71	0.4783

LOG(Total Hg) in Smallmouth Bass

TESTS FOR TREND OVER ENTIRE TIME IN ADJUSTED LOG(TOT_HG)

STATION	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	-0.10486	0.91649	
3	1BSTH025.10	0.89666	0.36990	
5	1BSTH020.44	3.76166	0.00017	**
6	1BSTH014.60	3.62170	0.00029	**
7	1BSTH004.21	4.82471	0.00000	**
8	1BNTH004.10	-3.66371	0.00025	**
9	1BSSF100.10	-1.96067	0.04992	**
10	1BSSF078.24	-3.17238	0.00151	**
11	1BSSF054.20	3.09566	0.00196	**
12	1BSSF020.70	3.89020	0.00010	**
15	1BSHN022.63	4.37975	0.00001	**
16	1BSSF062.97	-0.35400	0.72334	
17	1BSSF037.60	4.98741	0.00000	**
18	1BSSF010.18	2.58620	0.00970	**

LOG(Total Hg) in Smallmouth Bass

TESTS FOR TREND FROM 1994 ADJUSTED LOG(TOT_HG)

STATION	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	-0.71005	0.47768	
3	1BSTH025.10	0.49957	0.61738	
6	1BSTH014.60	1.27279	0.20309	
7	1BSTH004.21	-1.27279	0.20309	
8	1BNTH004.10	-0.89815	0.36911	
9	1BSSF100.10	-1.00466	0.31506	
10	1BSSF078.24	-1.58114	0.11385	
11	1BSSF054.20	-2.32702	0.01996	**
12	1BSSF020.70	1.11691	0.26403	
15	1BSHN022.63	-1.22559	0.22035	
16	1BSSF062.97	-0.21138	0.83259	
17	1BSSF037.60	-0.65350	0.51343	
18	1BSSF010.18	-2.22131	0.02633	**

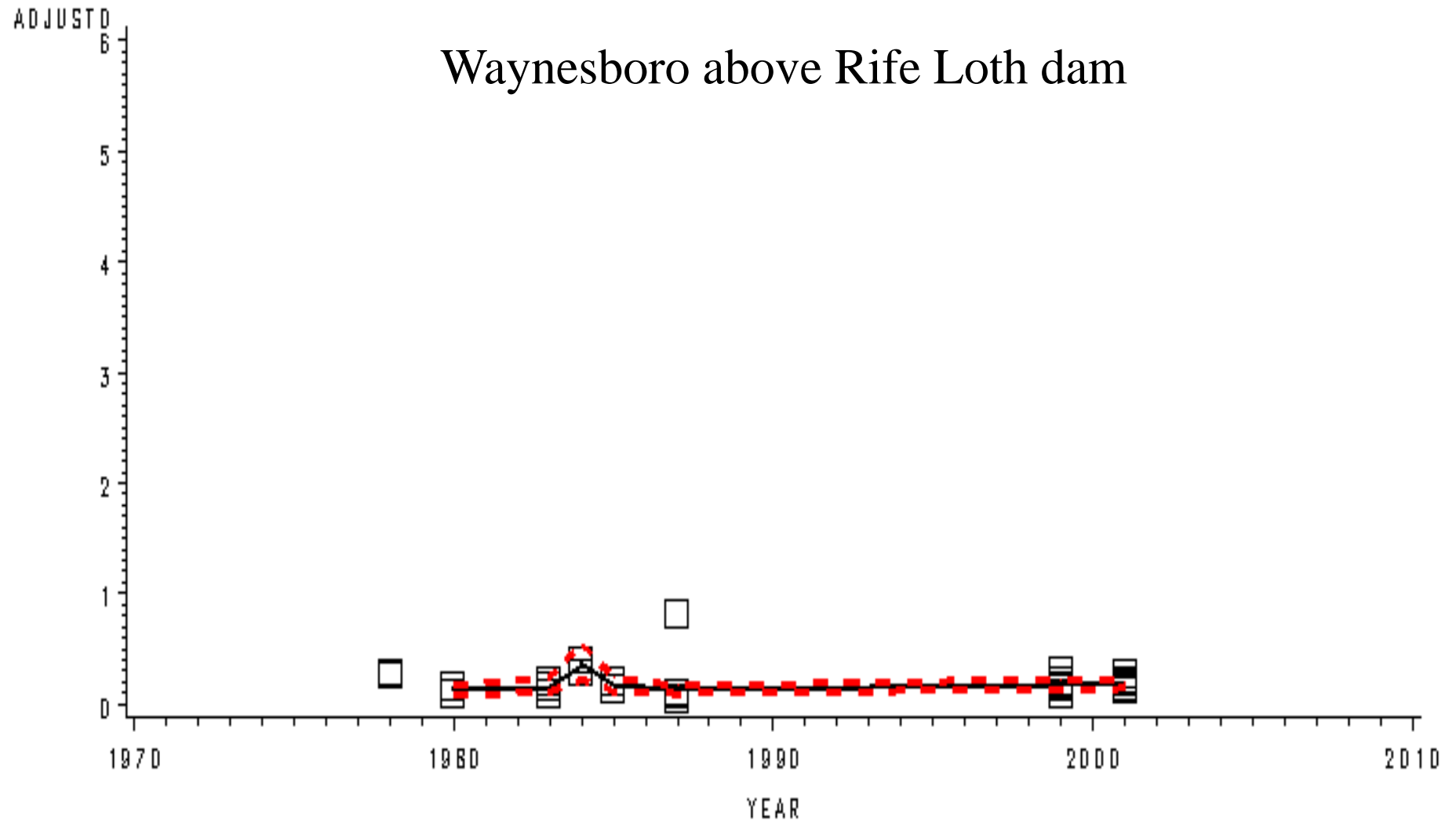
LOG(Total Hg) in Smallmouth Bass

TESTS FOR TREND FROM 1996 ADJUSTED LOG(TOT_HG)

STATION	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	-0.71005	0.47768	
3	1BSTH025.10	-0.46667	0.64074	
9	1BSSF100.10	-1.71868	0.08567	
10	1BSSF078.24	-1.58114	0.11385	
11	1BSSF054.20	-2.32702	0.01996	**
12	1BSSF020.70	-3.06186	0.00220	**
15	1BSHN022.63	-1.22559	0.22035	
16	1BSSF062.97	-1.98208	0.04747	**
17	1BSSF037.60	-2.31016	0.02088	**
18	1BSSF010.18	-2.22131	0.02633	**

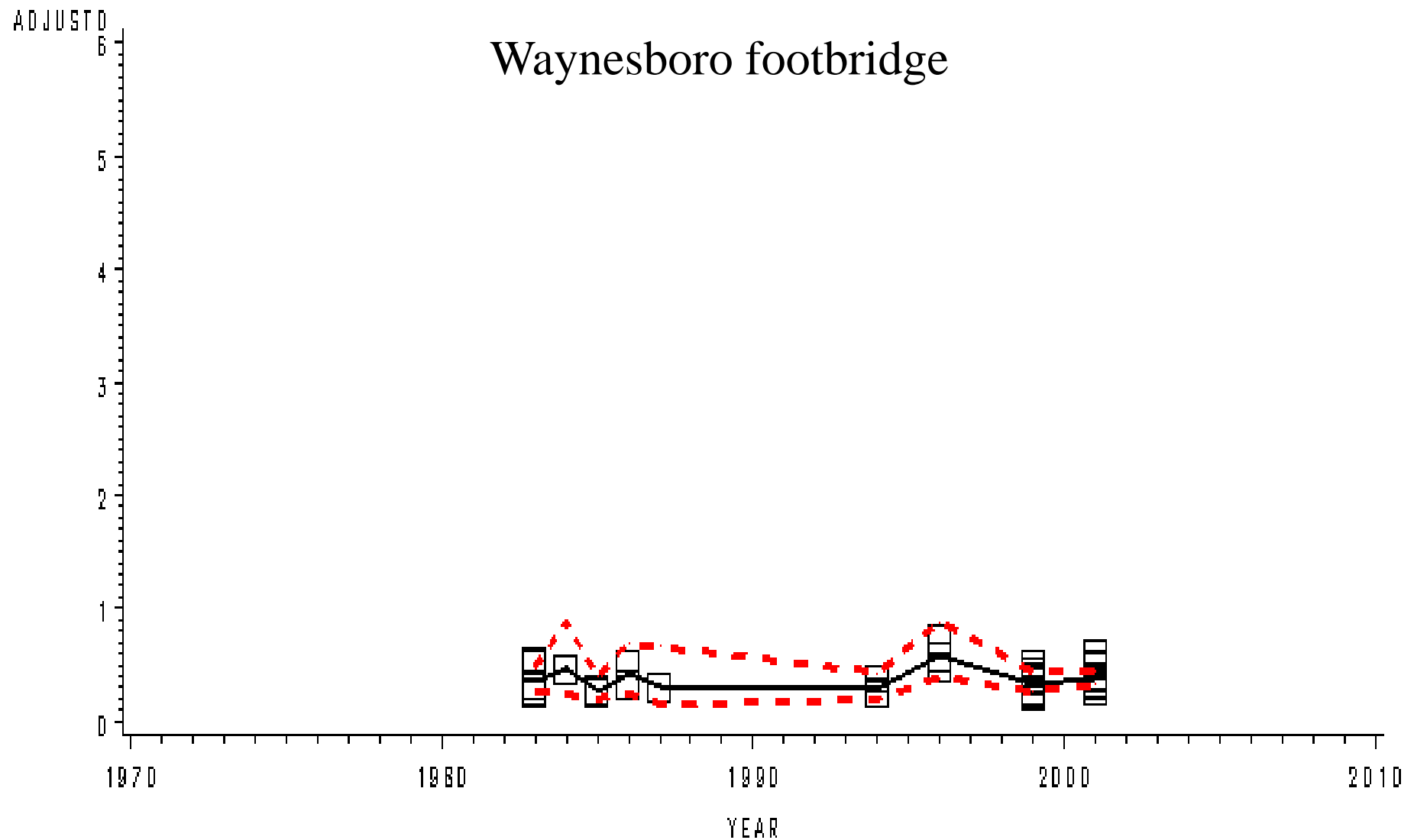
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION*YEAR LOGLEN STATION+LOGLEN YEAR+LOGLEN
FULL DATA SET
STATION=1 Stat_ID=185THD26.12



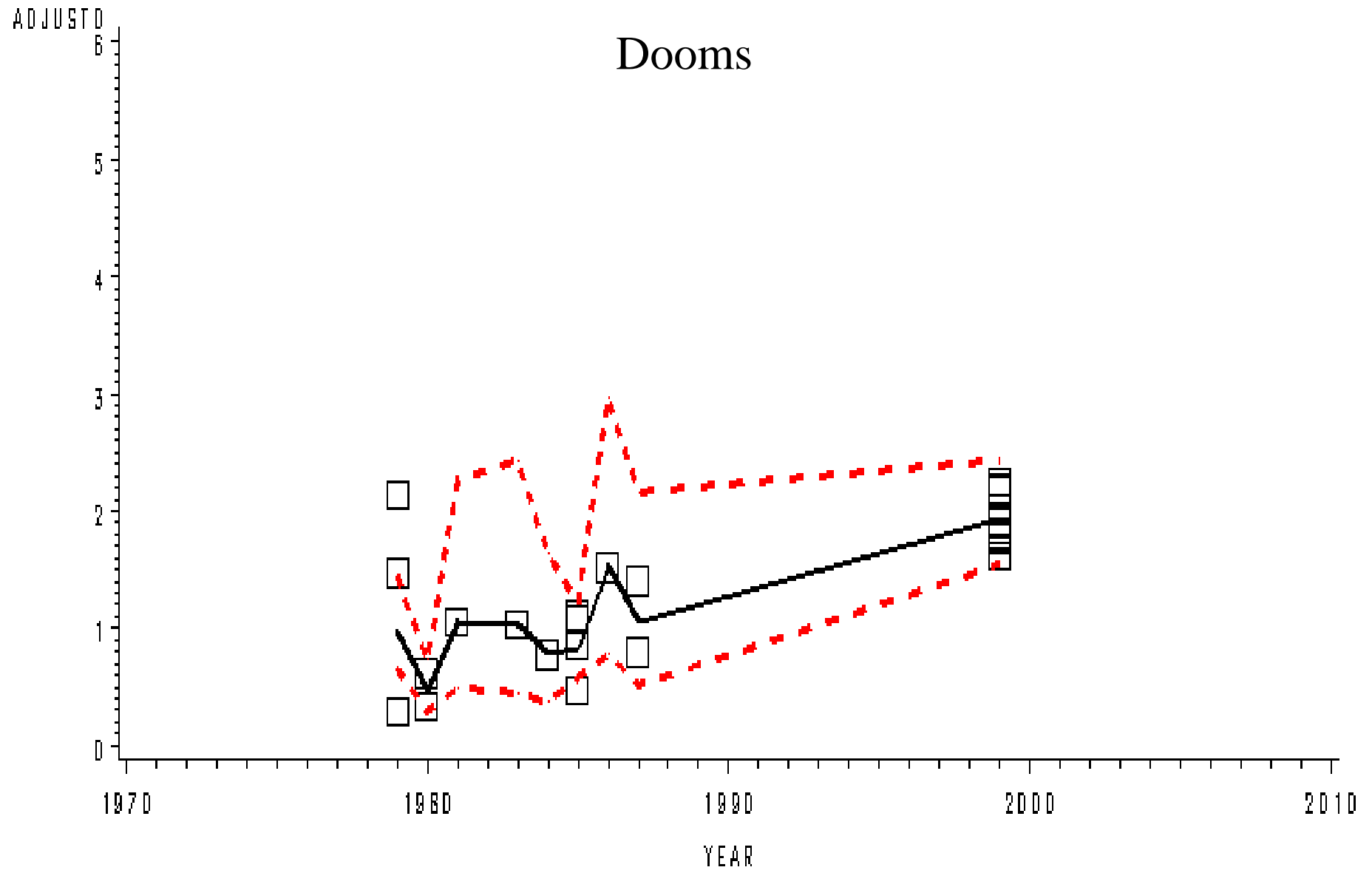
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION*YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=3 Stat_ID=18STHD25.10



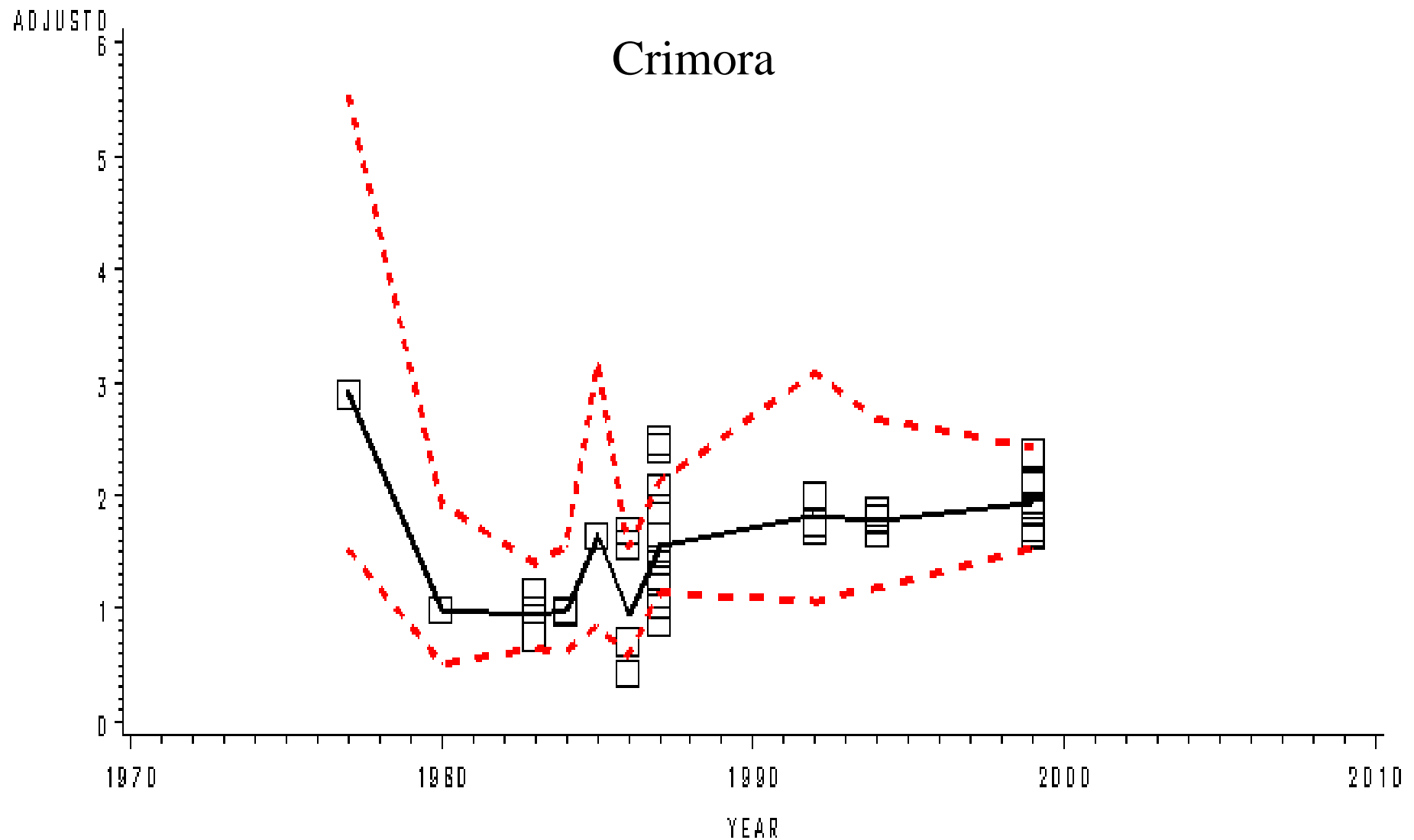
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION;YEAR LOGLEN STATION+LOGLEN YEAR+LOGLEN
FULL DATA SET
STATION=5 Stat_ID=185THD20.44



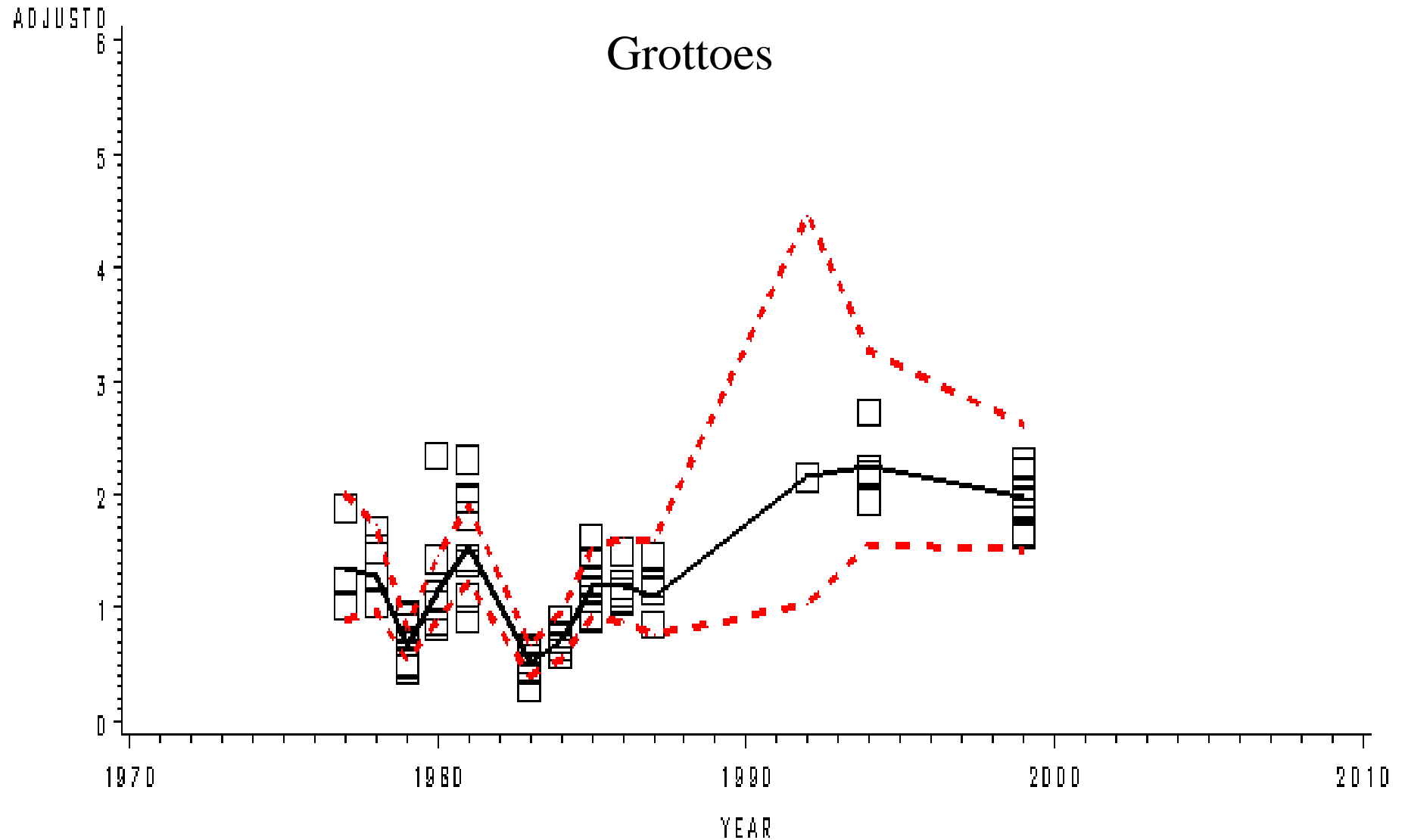
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=6 Stat_ID=18STHD14.6D



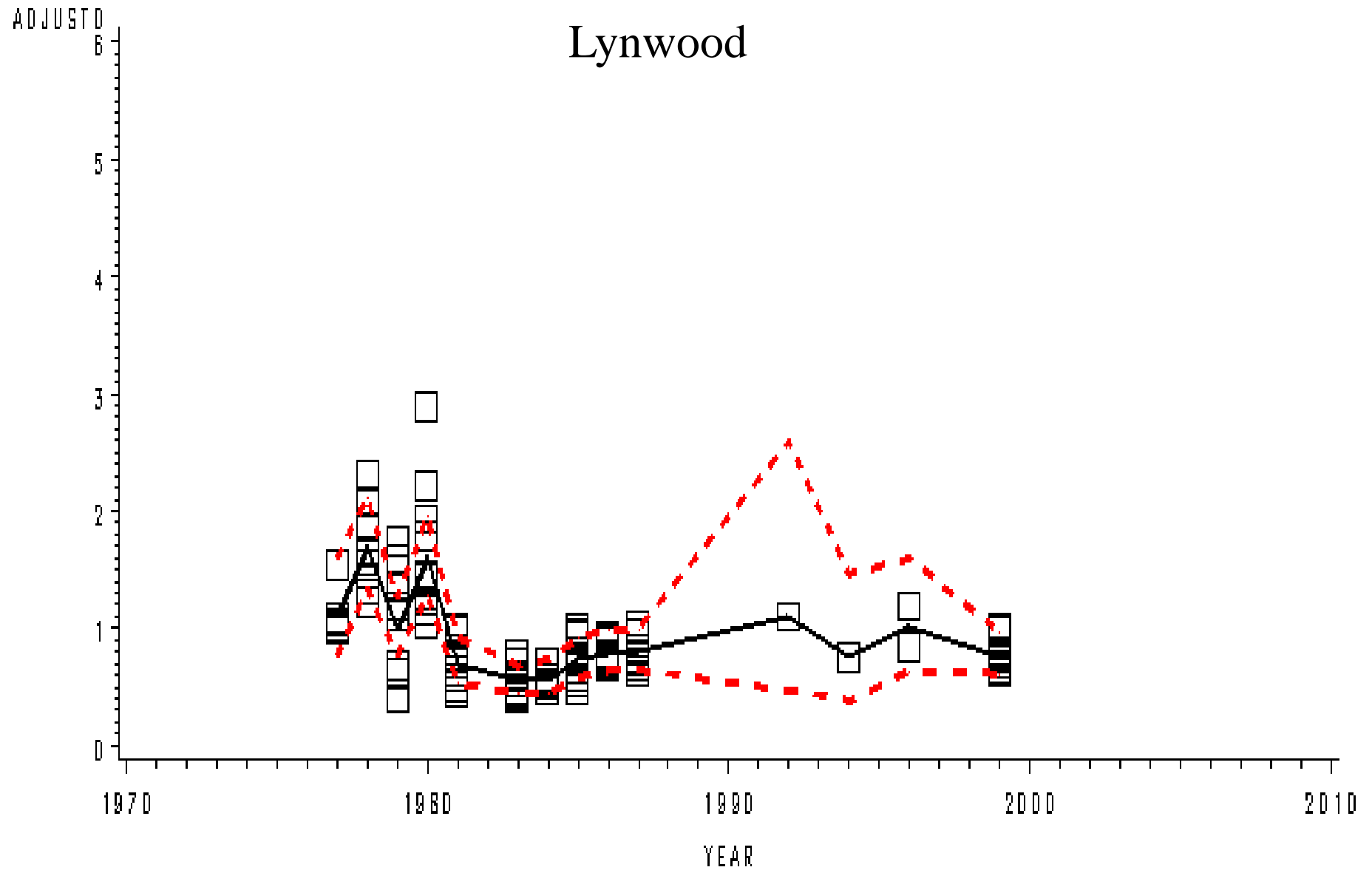
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=7 Set_ID=185THDD4.21



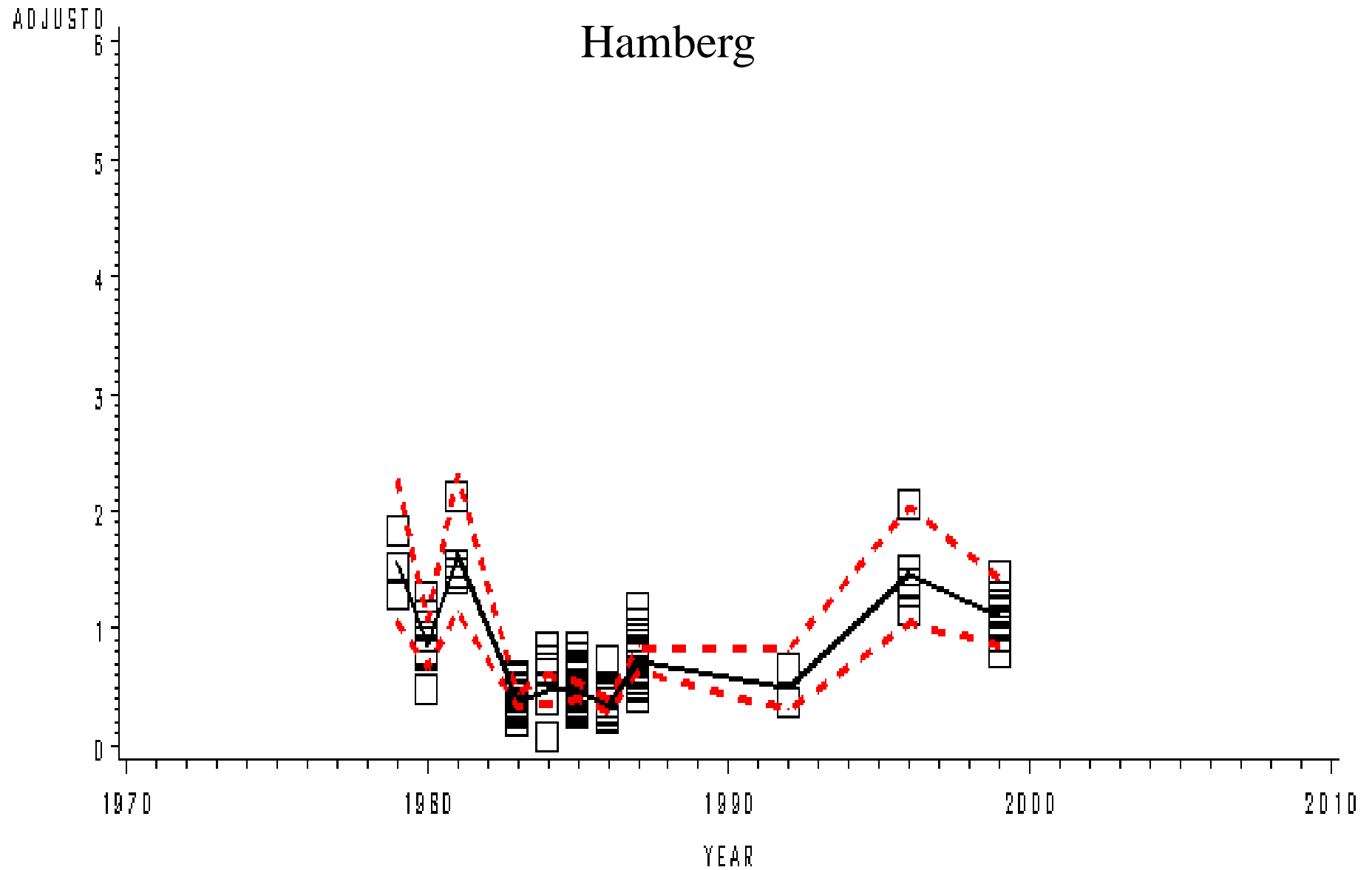
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION;YEAR LOGLEN STATION+LOGLEN YEAR+LOGLEN
FULL DATA SET
STATION=0 Stat_ID=1855F100.10



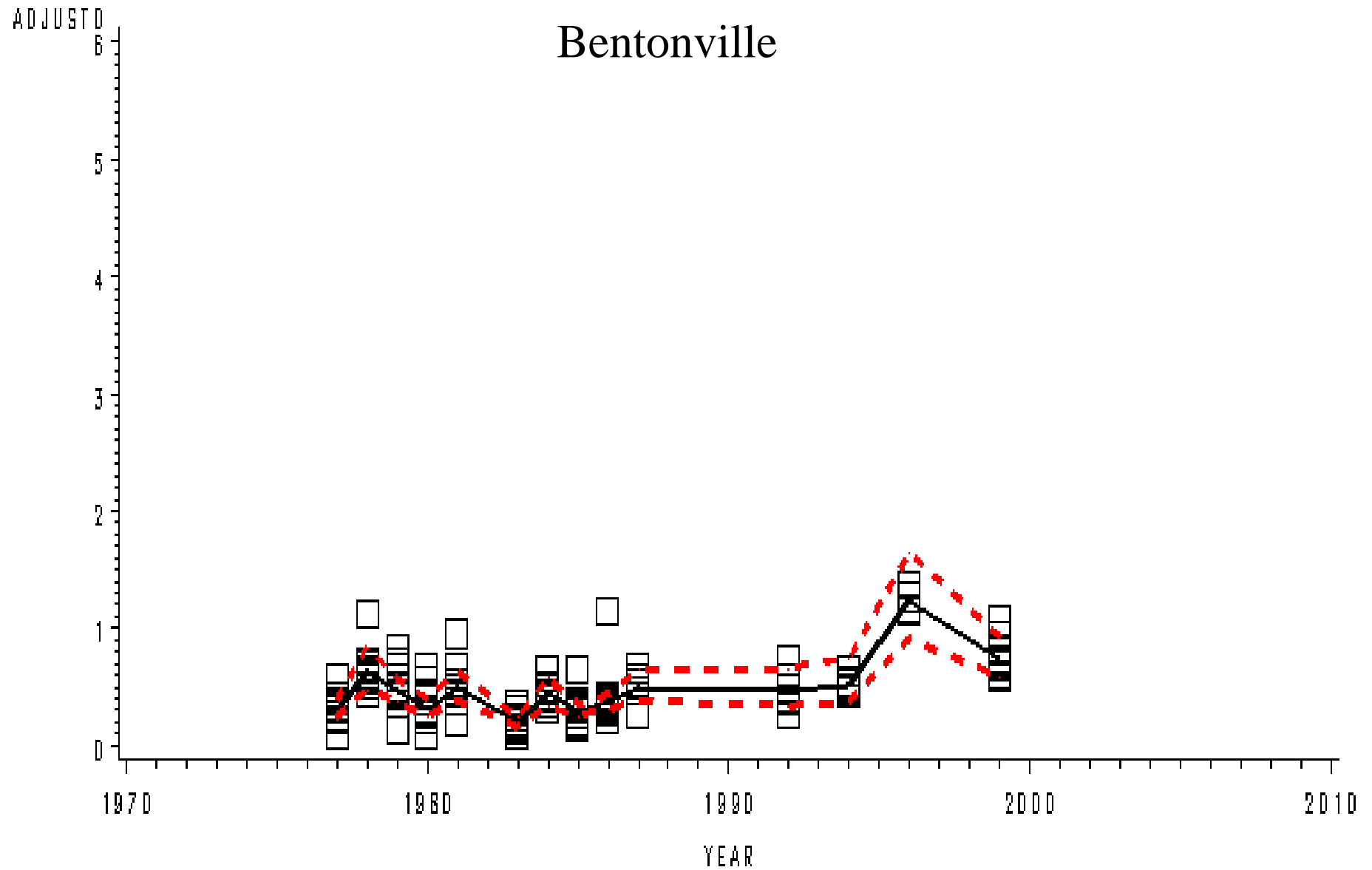
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION;YEAR LDGLEN STATION+LDGLEN YEAR+LDGLEN
FULL DATA SET
STATION=11 Stat_ID=1855F054.20



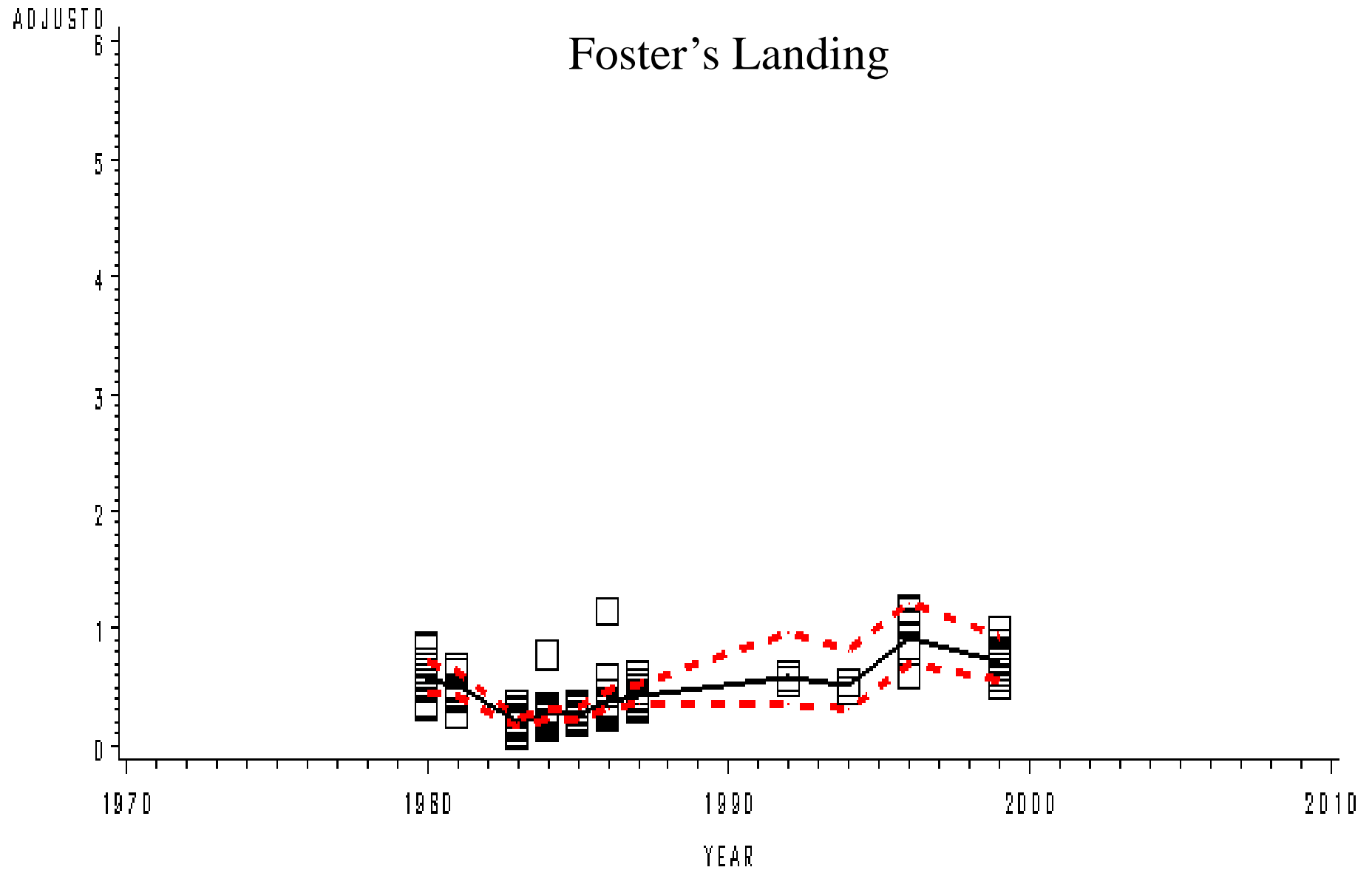
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION;YEAR LOGLEN STATION+LOGLEN YEAR+LOGLEN
FULL DATA SET
STATION=12 Stat_ID=1855F020.70



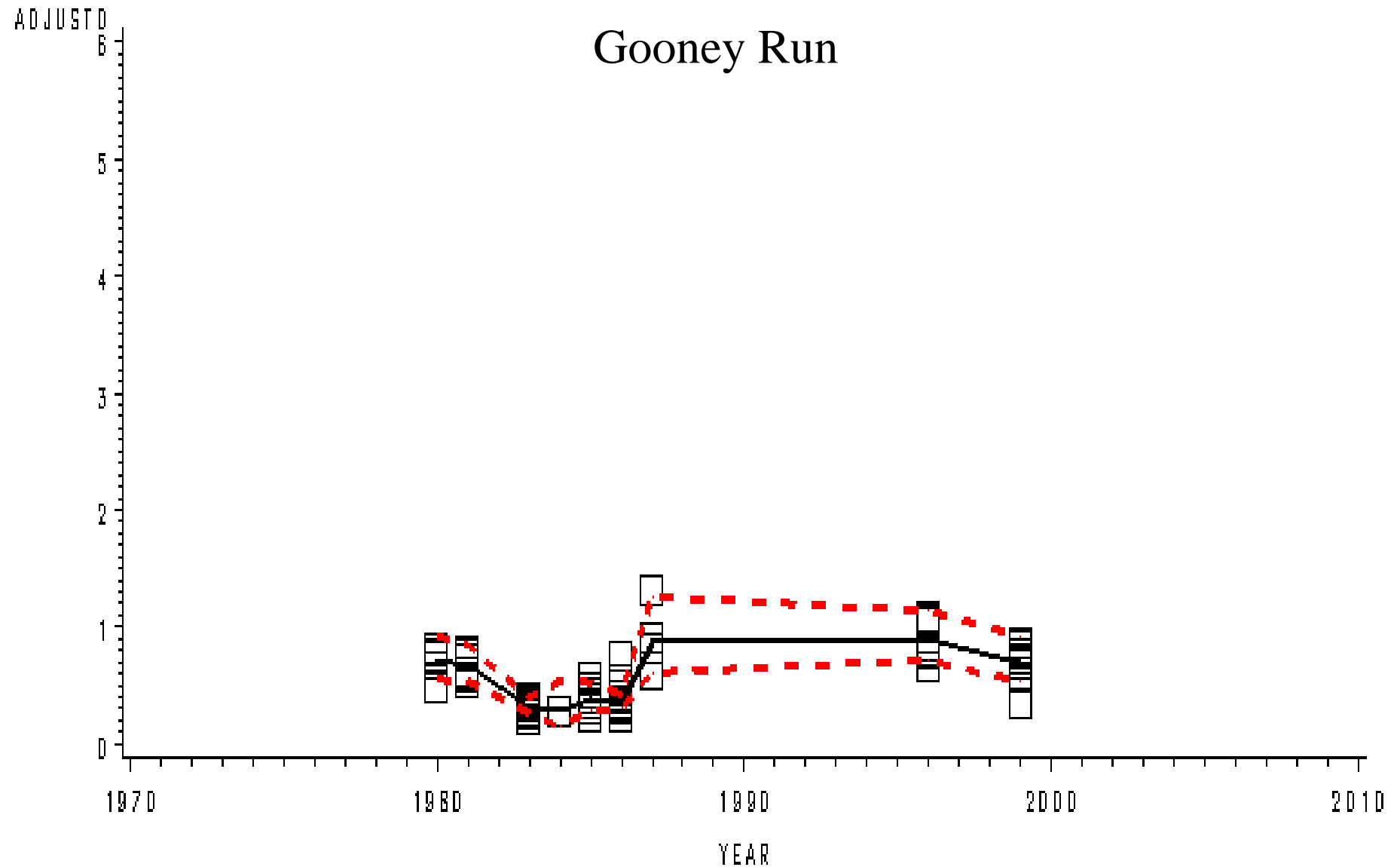
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LGTHG=STATION;YEAR LGLEN STATION+LGLEN YEAR+LGLEN
FULL DATA SET
STATION=17 Stat_ID=1855F037.60



Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION;YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=18 Stat_ID=1855FD1D.18

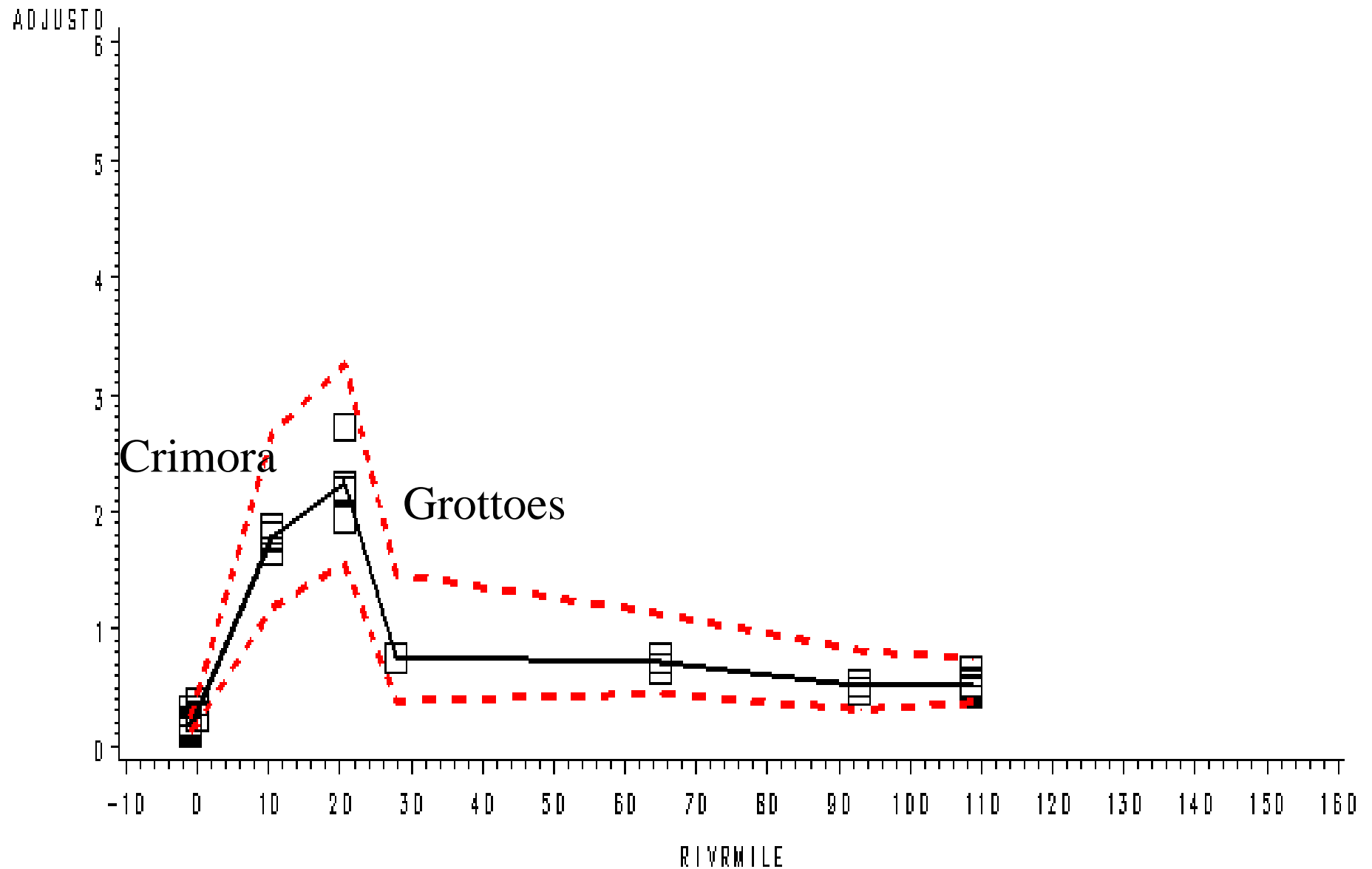


Total Hg by Rivermile

- **The next few plots show the total Hg levels in smallmouth bass tissues along a 160 mile stretch of the South River, beginning in 1994.**

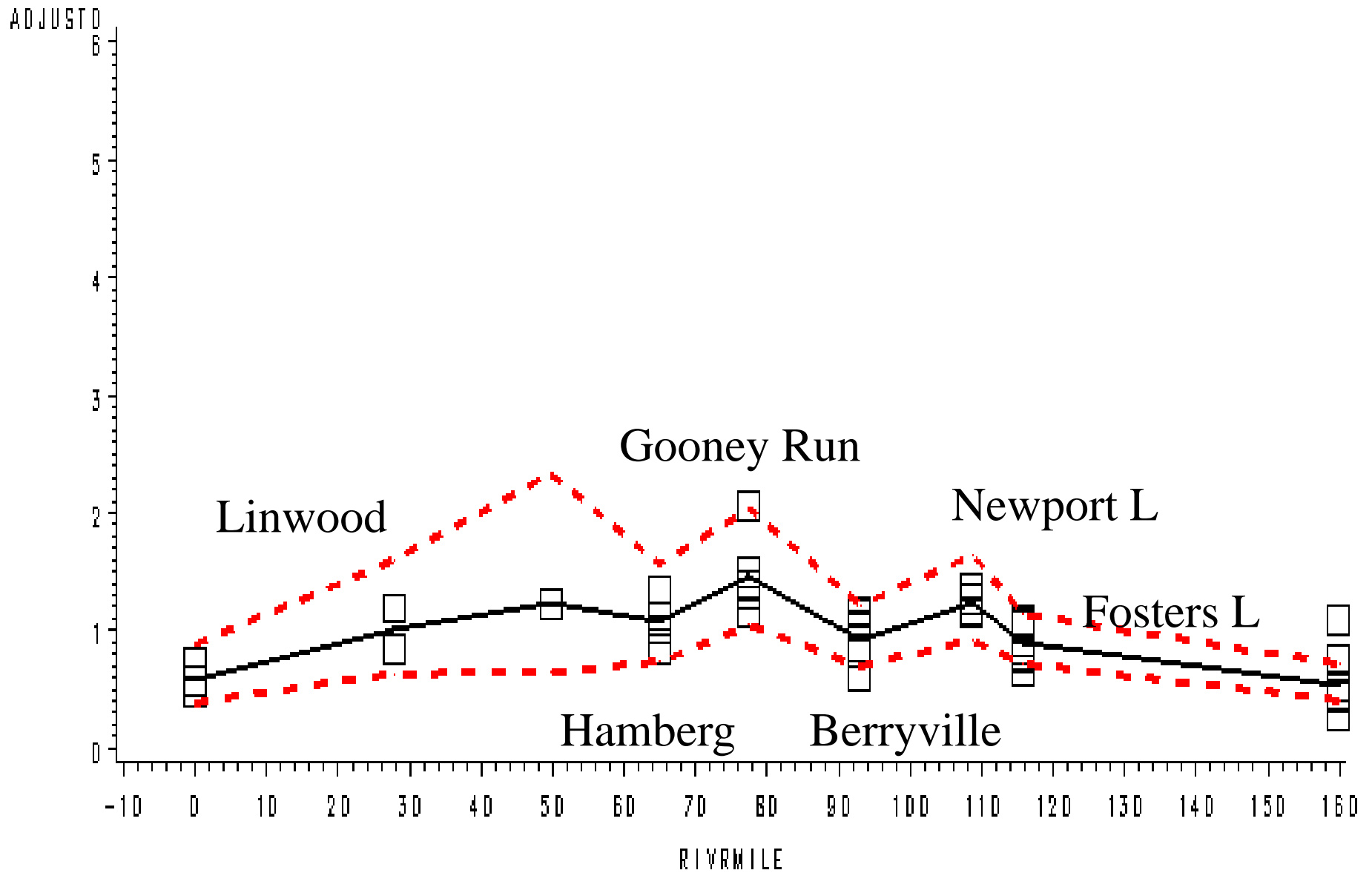
Adjusted and Predicted Total Hg in Smallmouth Bass

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



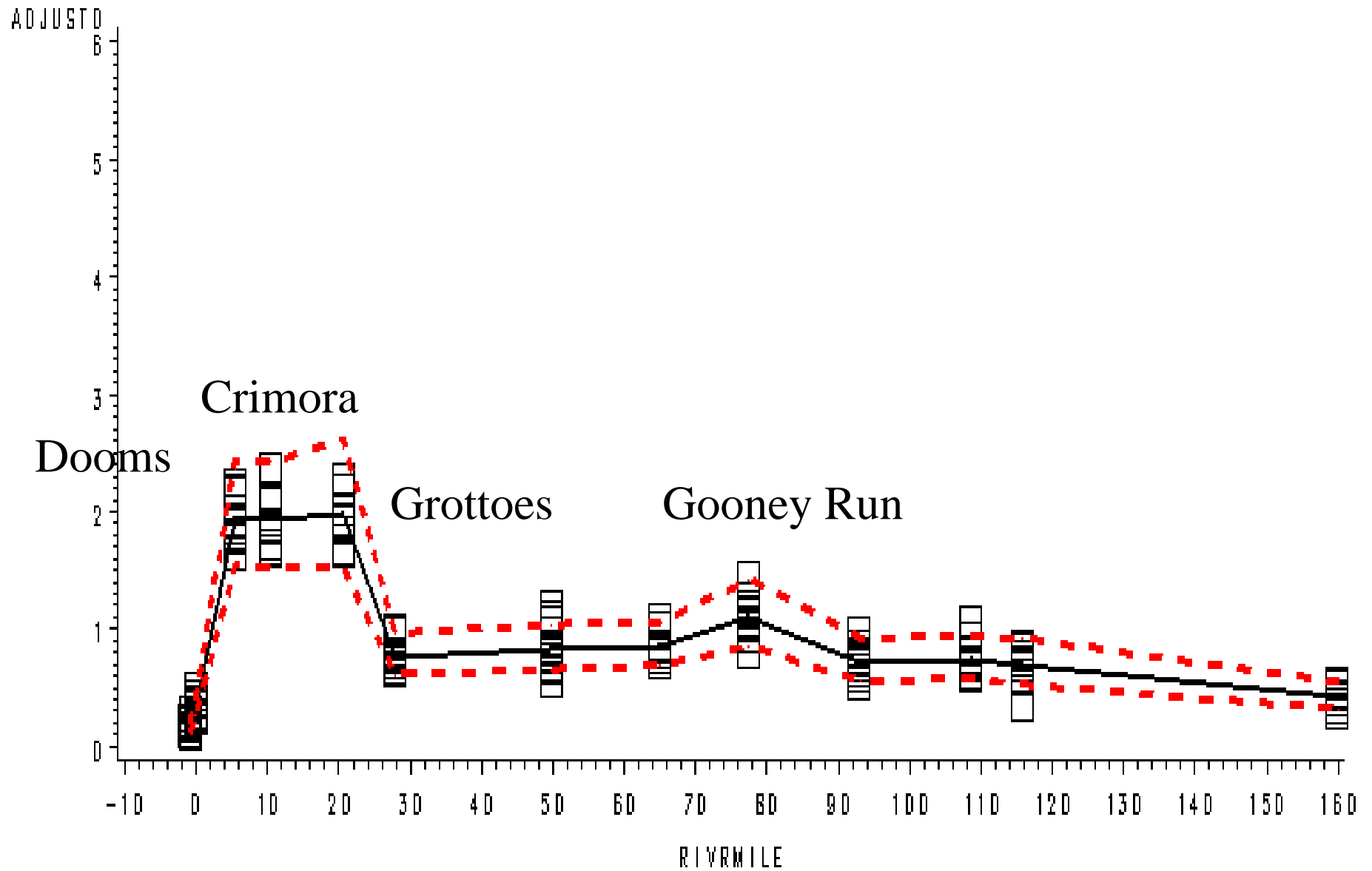
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LOGTHG=STATION*YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
YEAR=1986



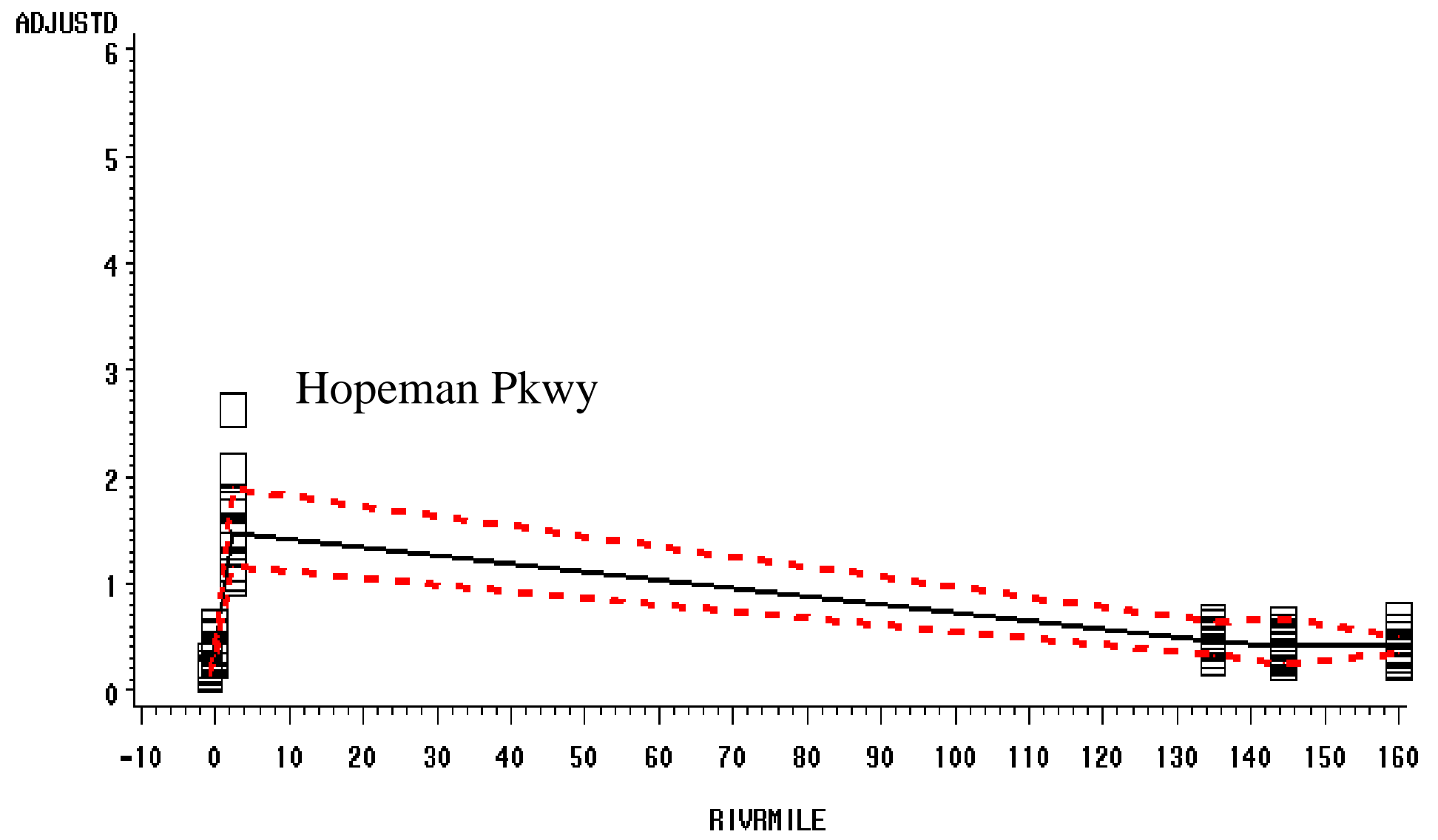
Adjusted and Predicted Total Hg in Smallmouth Bass

MODEL: LGTHG=STATION;YEAR LGLEN STATION+LGLEN YEAR+LGLEN
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=2001



Conclusions for Smallmouth

- 2001 data shows elevated Hg levels at Hopeman Parkway
- The three previously identified sites (Dooms, Crimora, Grottoes) show high levels in 1994, 1999 (no sample in 1996, 2001)
- 1996 had significantly higher levels for many sites

SUNFISH

- **7 species of sunfish, including redbreast, having similar characteristics were combined for analysis.**

Adjusted Mean Total Hg (X 100) in SUNFISH by Station and Year

STATION/YEAR

	77	78	79	80	81	83	84	85	86	87	92	94	96	99
1	26	32	27	18	10	11	17	14	19	13	18	08	38	
3	64	39	42	30	35	20	39	21	50	51	74	60	122	
5	46	131	70	33	73	22	62	71	96	55	85	154	237	175
6	126	177	91	93	94	52	71	75	119	74	126	131	251	154
7	90	101	31	75	91	54	67	81	114	77	102	135	154	120
8	21	28	13	16	20	09	13	13	13	07	16	10	15	08
9	73	113	36	69	50	23	39	43	51	59	72	46	102	47
10	41	66	31	32	49	24	47	49	54	51	53	68	83	54
11	47	70	41	46	69	30	32	47	42	47	49	47	88	65
12	51	23	27	18	38	17	28	30	37	42	37	31	78	51
15	11	33	12	12	07	08	05	07	06	02	24	15	26	10
16				76	46	24	34	48	35	43	60	36	57	42
17				31	66	16	25	30	45	33	51	34	60	68
18				35	39	16	20	45	25	123	42	44	60	70

LOG(Total Hg) in Sunfish

ESTIMATED CHANGE BASELINE (AVG OVER 1979-83) TO 2001

PARM	EST	SE	T	P_T
Station 1 96-77/83	0.113	0.145	5.35	0.0001
Station 1 96-94	0.010	0.037	7.33	0.0001
Station 3 96-77/83	0.177	0.152	7.66	0.0001
Station 3 96-94	0.003	0.030	3.50	0.0005
Station 5 99-77/83	0.182	0.138	9.52	0.0001
Station 5 99-94	0.001	0.030	0.84	0.4015
Station 5 99-96	-0.000	0.030	-0.48	0.6305
Station 6 99-77/83	0.085	0.137	4.52	0.0001
Station 6 99-94	0.001	0.030	1.38	0.1687
Station 6 99-96	-0.001	0.030	-0.99	0.3225
Station 7 99-77/83	0.093	0.138	4.88	0.0001
Station 7 99-94	-0.001	0.032	-0.58	0.5599
Station 7 99-96	-0.000	0.035	-0.35	0.7281
Station 8 99-77/83	-0.059	0.149	-2.63	0.0085
Station 9 94-77/82	-0.026	0.141	-1.30	0.1921
Station 9 99-94	0.000	0.036	0.27	0.7907
Station 9 99-96	-0.004	0.037	-2.80	0.0051

LOG(Total Hg) in Sunfish					
ESTIMATED CHANGE BASELINE (AVG OVER 1979-83) TO 2001					
PARM		EST	SE	T	P_T
Station 10	99-77/83	0.077	0.143	3.80	0.0001
Station 10	99-94	-0.001	0.030	-0.73	0.4642
Station 10	99-96	-0.000	0.030	-0.48	0.6334
Station 11	99-77/83	0.067	0.137	3.57	0.0004
Station 11	99-94	0.002	0.031	2.13	0.0334
Station 11	99-96	0.000	0.030	0.25	0.8020
Station 12	99-77/83	0.131	0.143	6.43	0.0001
Station 12	99-94	0.003	0.030	3.68	0.0002
Station 12	99-96	0.000	0.030	0.11	0.9157
Station 15	99-77/83	0.091	0.195	2.39	0.0171
Station 15	99-94	0.001	0.037	0.68	0.4982
Station 15	99-96	-0.001	0.034	-0.78	0.4368
Station 17	99-80/83	0.157	0.152	6.82	0.0001
Station 17	99-94	0.017	0.060	4.79	0.0001
Station 17	99-96	0.011	0.060	3.14	0.0017
Station 18	99-80/83	0.165	0.147	7.60	0.0001
Station 18	99-94	0.011	0.060	3.14	0.0017
Station 18	99-96	0.009	0.060	2.60	0.0093

LOG(Total Hg) in Sunfish

TESTS FOR TREND OVER TIME IN ADJUSTED LOG(TOT_HG)

STATION	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	-0.0090	0.99283	
3	1BSTH025.10	5.3393	0.00000	**
5	1BSTH020.44	8.4365	0.00000	**
6	1BSTH014.60	9.5965	0.00000	**
7	1BSTH004.21	6.7543	0.00000	**
8	1BNTH004.10	-2.9799	0.00288	**
9	1BSSF100.10	2.4994	0.01244	**
10	1BSSF078.24	5.4779	0.00000	**
11	1BSSF054.20	11.1595	0.00000	**
12	1BSSF020.70	5.7264	0.00000	**
15	1BSHN022.63	1.1495	0.25035	
16	1BSSF062.97	1.1467	0.25150	
17	1BSSF037.60	4.6682	0.00000	**
18	1BSSF010.18	6.0089	0.00000	**

LOG(Total Hg) in Sunfish

TESTS FOR TREND FROM 1994 ADJUSTED LOG(TOT_HG)

STATION	STAT_ID	_JTSTD_	P2_JT	SIGNIF
1	1BSTH026.12	3.67423	0.00024	**
3	1BSTH025.10	2.57016	0.01017	**
5	1BSTH020.44	0.68442	0.49371	
6	1BSTH014.60	0.57035	0.56844	
7	1BSTH004.21	-0.53325	0.59386	
8	1BNTH004.10	-0.95070	0.34175	
9	1BSSF100.10	0.11408	0.90917	
10	1BSSF078.24	-1.36884	0.17105	
11	1BSSF054.20	1.56000	0.11876	
12	1BSSF020.70	1.93920	0.05248	
15	1BSHN022.63	-2.15194	0.03140	**
16	1BSSF062.97	1.02663	0.30459	
17	1BSSF037.60	3.61223	0.00030	**
18	1BSSF010.18	2.54757	0.01085	**

LOG(Total Hg) in Sunfish

TESTS FOR TREND FROM 1996 ADJUSTED LOG(TOT_HG)

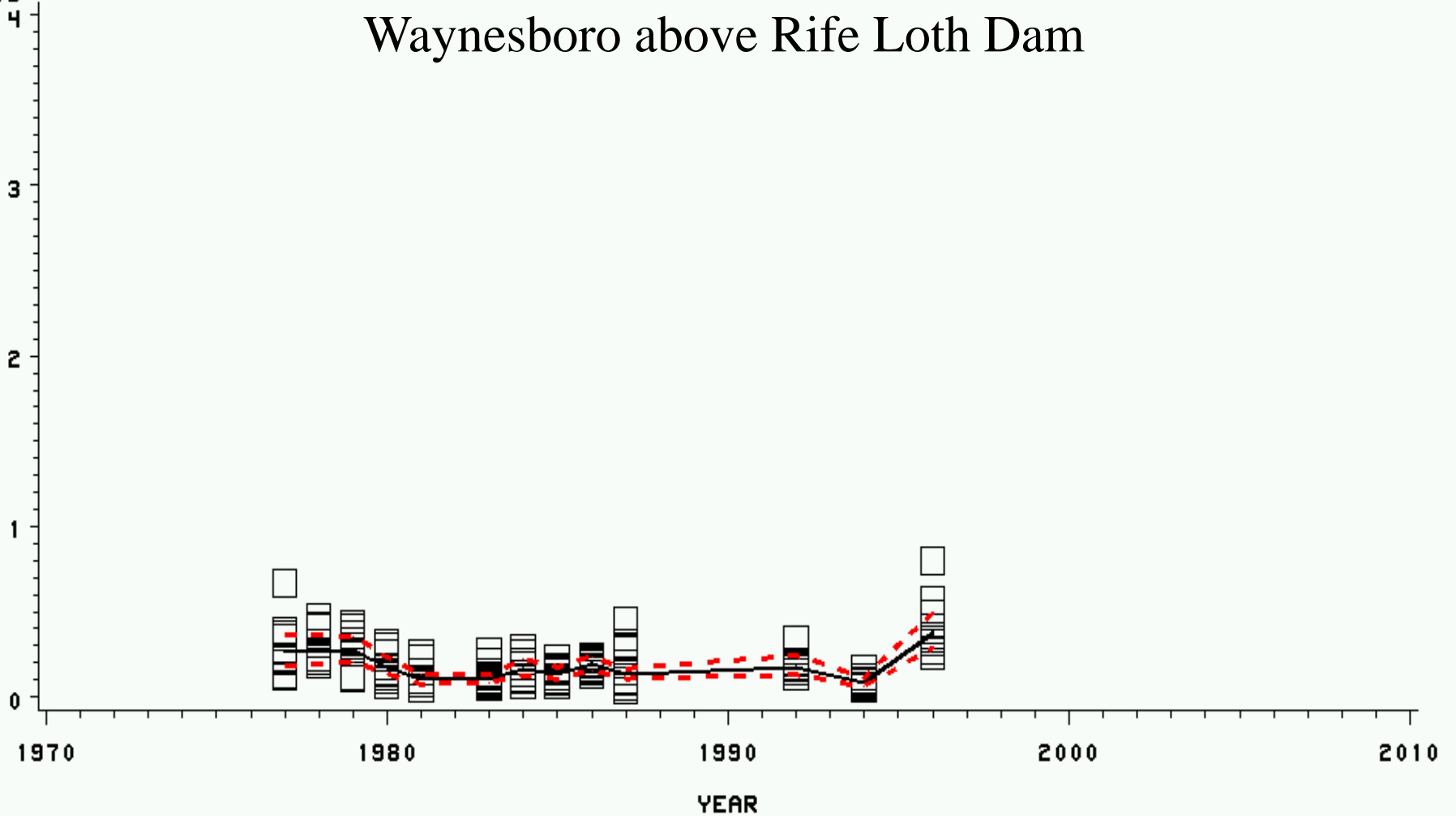
STATION	STAT_ID	_JTSTD_	P2_JT	SIGNIF
5	1BSTH020.44	-2.79694	0.00516	**
6	1BSTH014.60	-3.62846	0.00029	**
7	1BSTH004.21	-1.30158	0.19306	
8	1BNTH004.10	-3.78107	0.00016	**
9	1BSSF100.10	-3.78107	0.00016	**
10	1BSSF078.24	-2.49457	0.01261	**
11	1BSSF054.20	-2.26779	0.02334	**
12	1BSSF020.70	-3.47727	0.00051	**
15	1BSHN022.63	-3.77964	0.00016	**
16	1BSSF062.97	-2.19219	0.02837	**
17	1BSSF037.60	0.90711	0.36435	
18	1BSSF010.18	0.83152	0.40568	

Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=1 Stat_ID=1BSTH026.12

ADJUSTD

Waynesboro above Rife Loth Dam

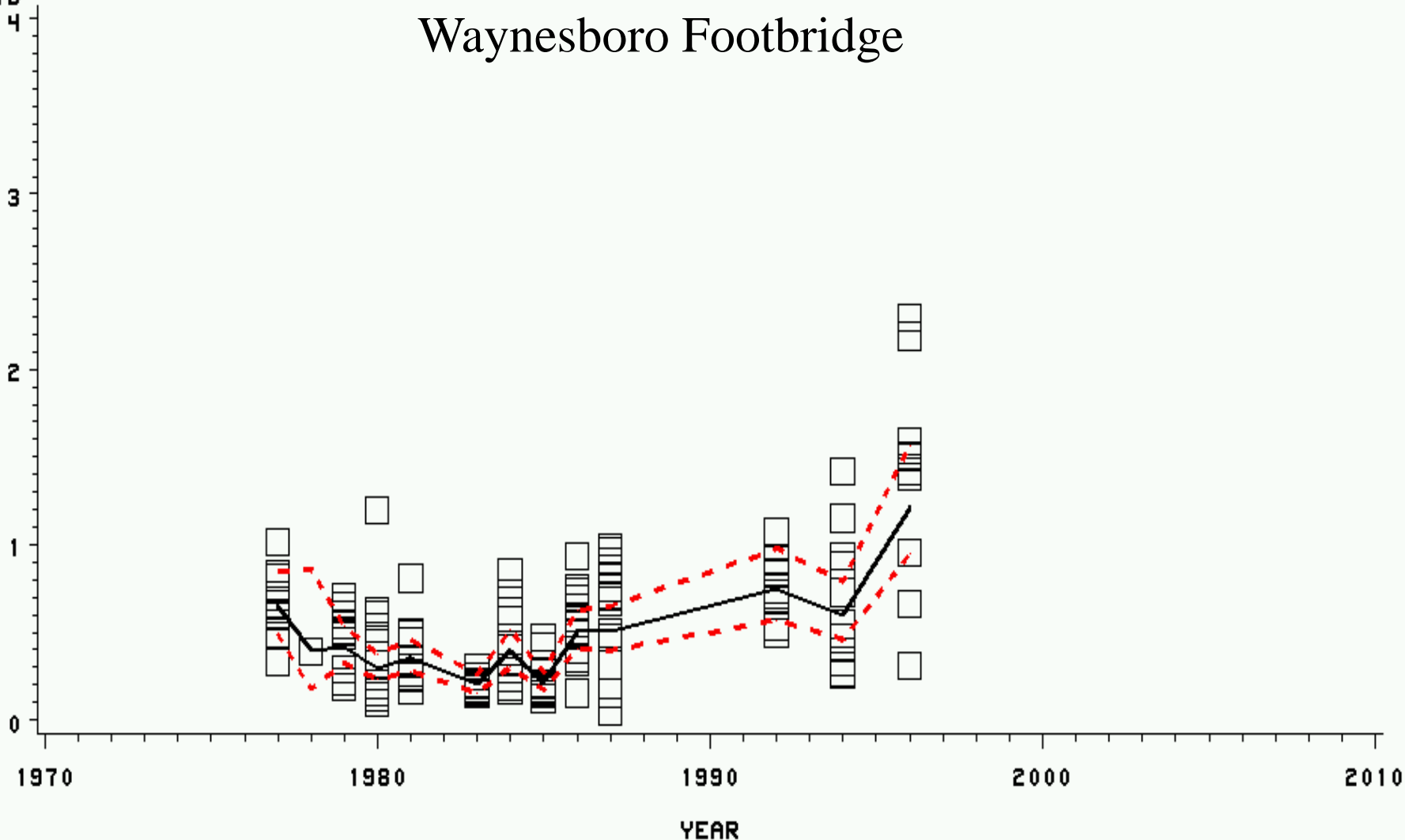


Adjusted and Predicted Total Hg in SUNFISH

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

ADJUSTD

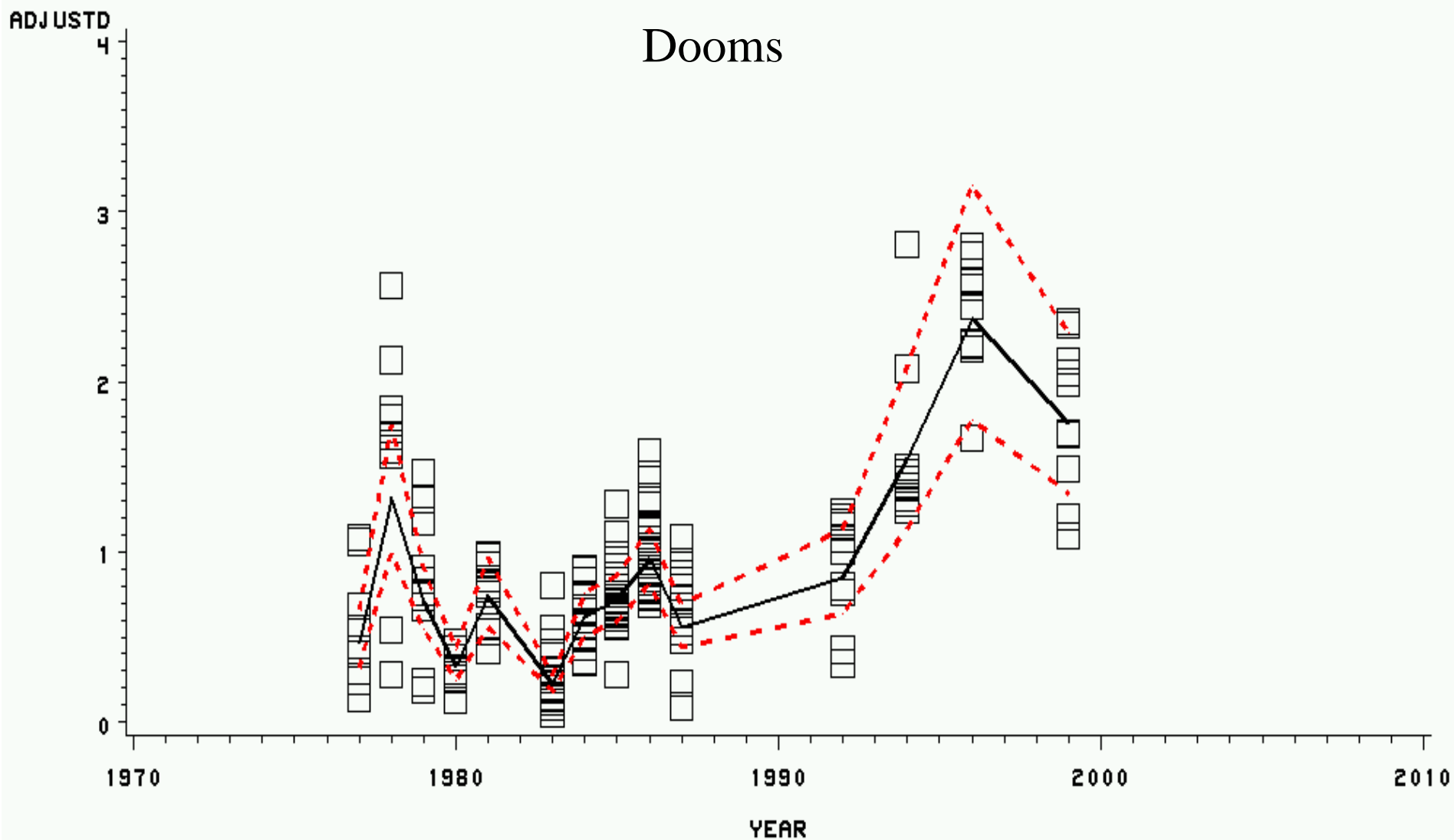
Waynesboro Footbridge



Adjusted and Predicted Total Hg in SUNFISH

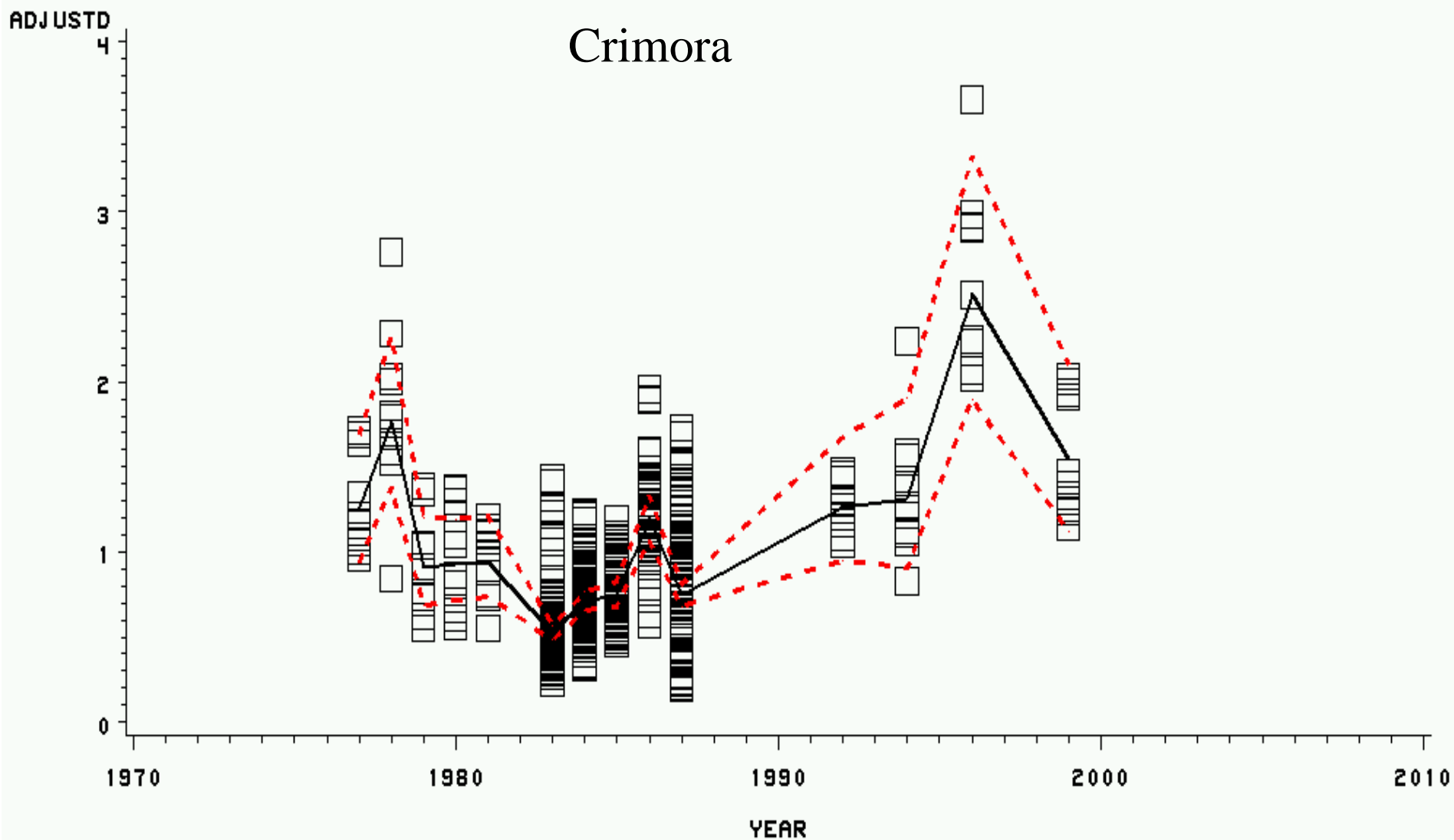
MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=5 Stat_ID=1BSTH020.44

Dooms



Adjusted and Predicted Total Hg in SUNFISH

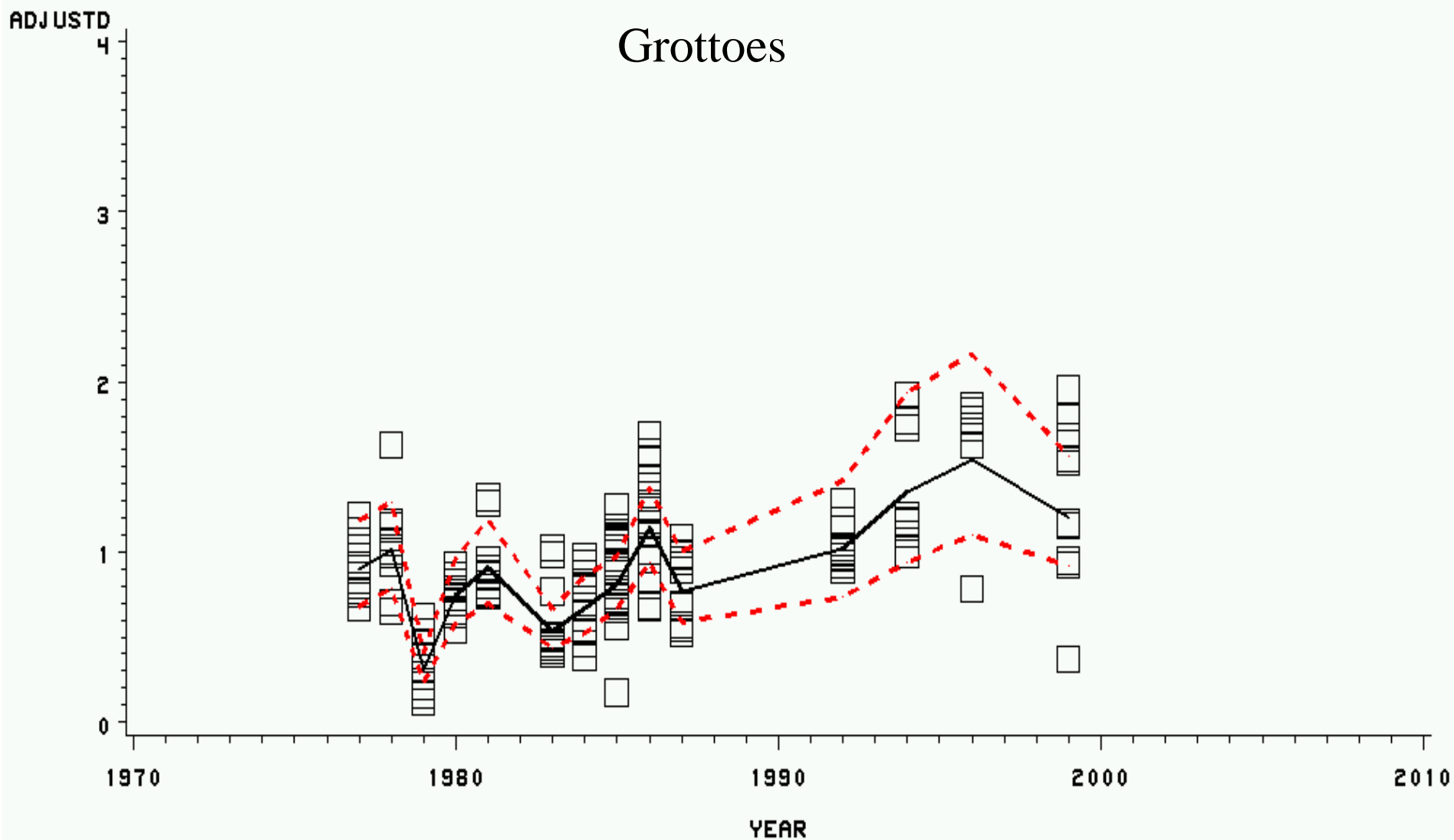
MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=6 Stat_ID=1BSTH014.60



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

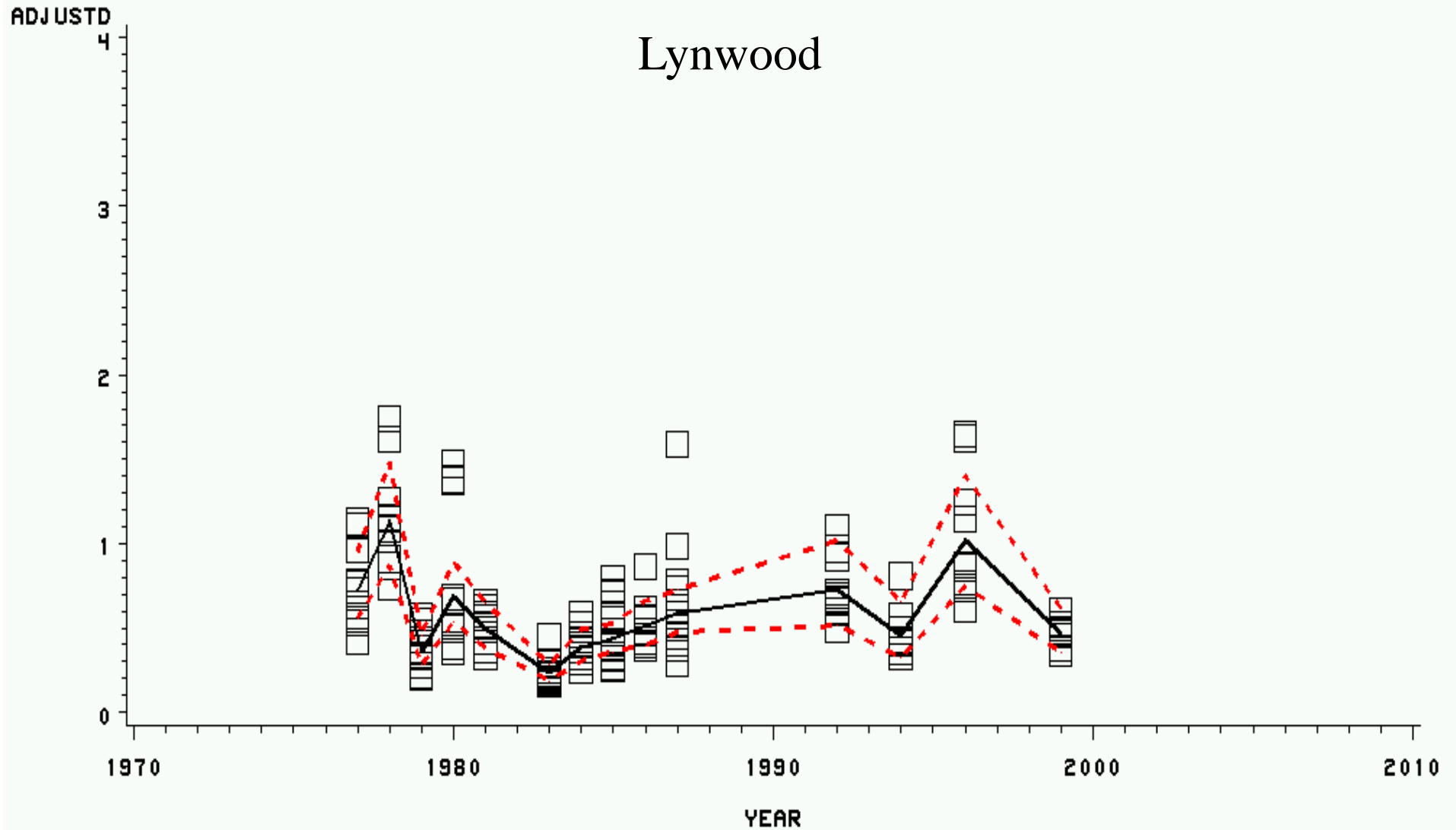
Grottoes



Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=9 Stat_ID=1BSSF100.10

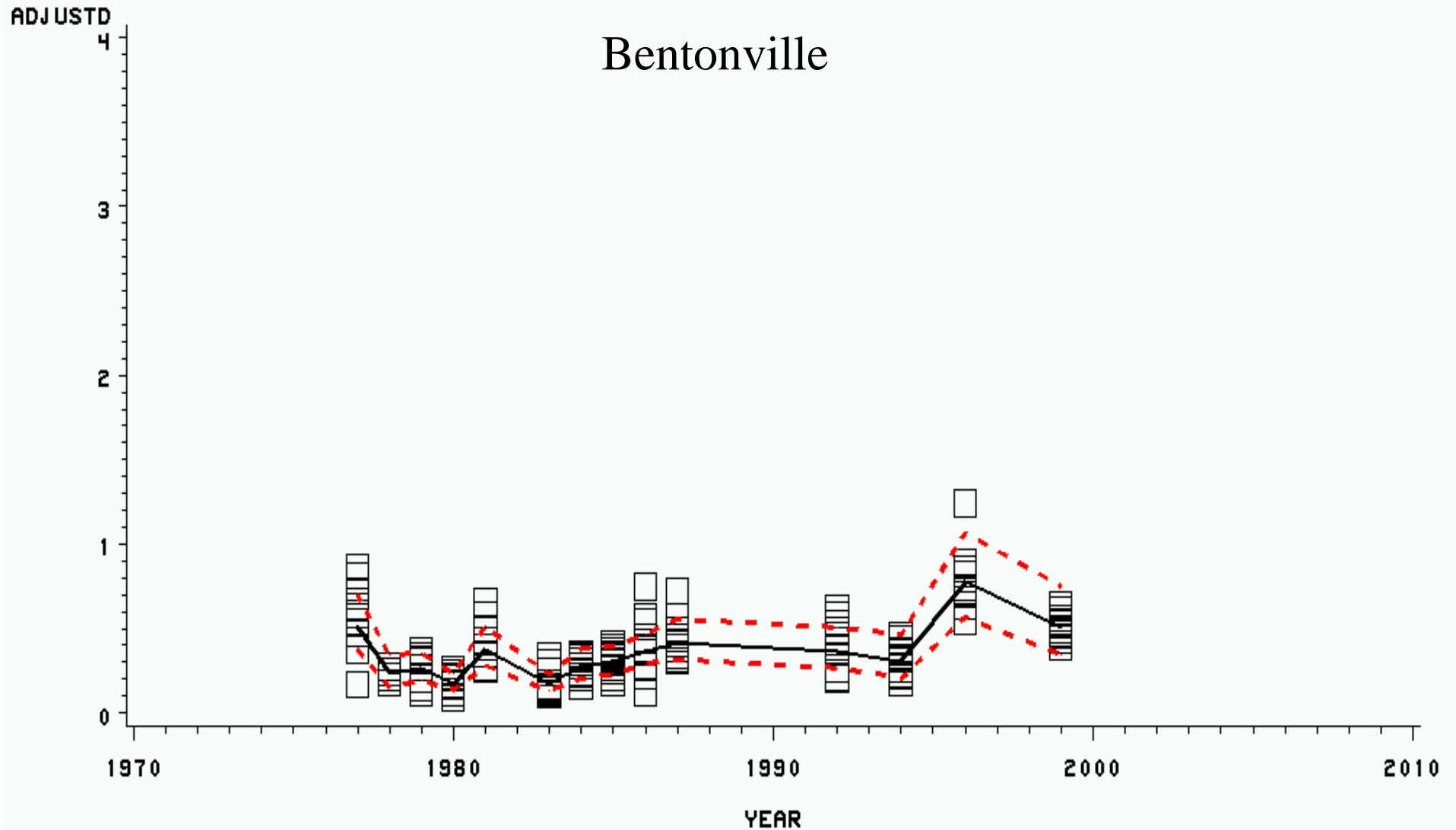
Lynwood



Adjusted and Predicted Total Hg in SUNFISH

MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=12 Stat_ID=1BSSF020.70

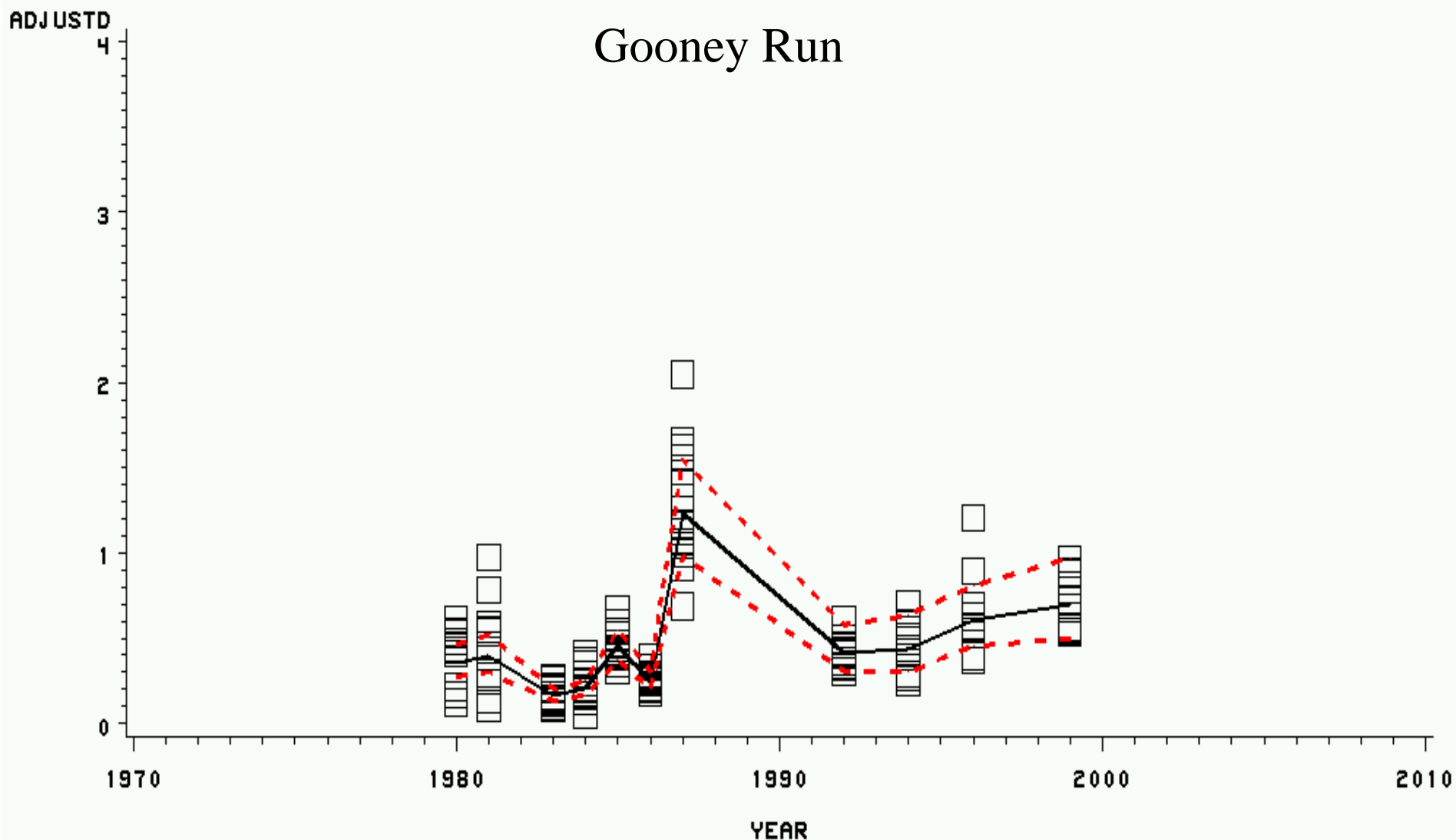
Bentonville



Adjusted and Predicted Total Hg in SUNFISH

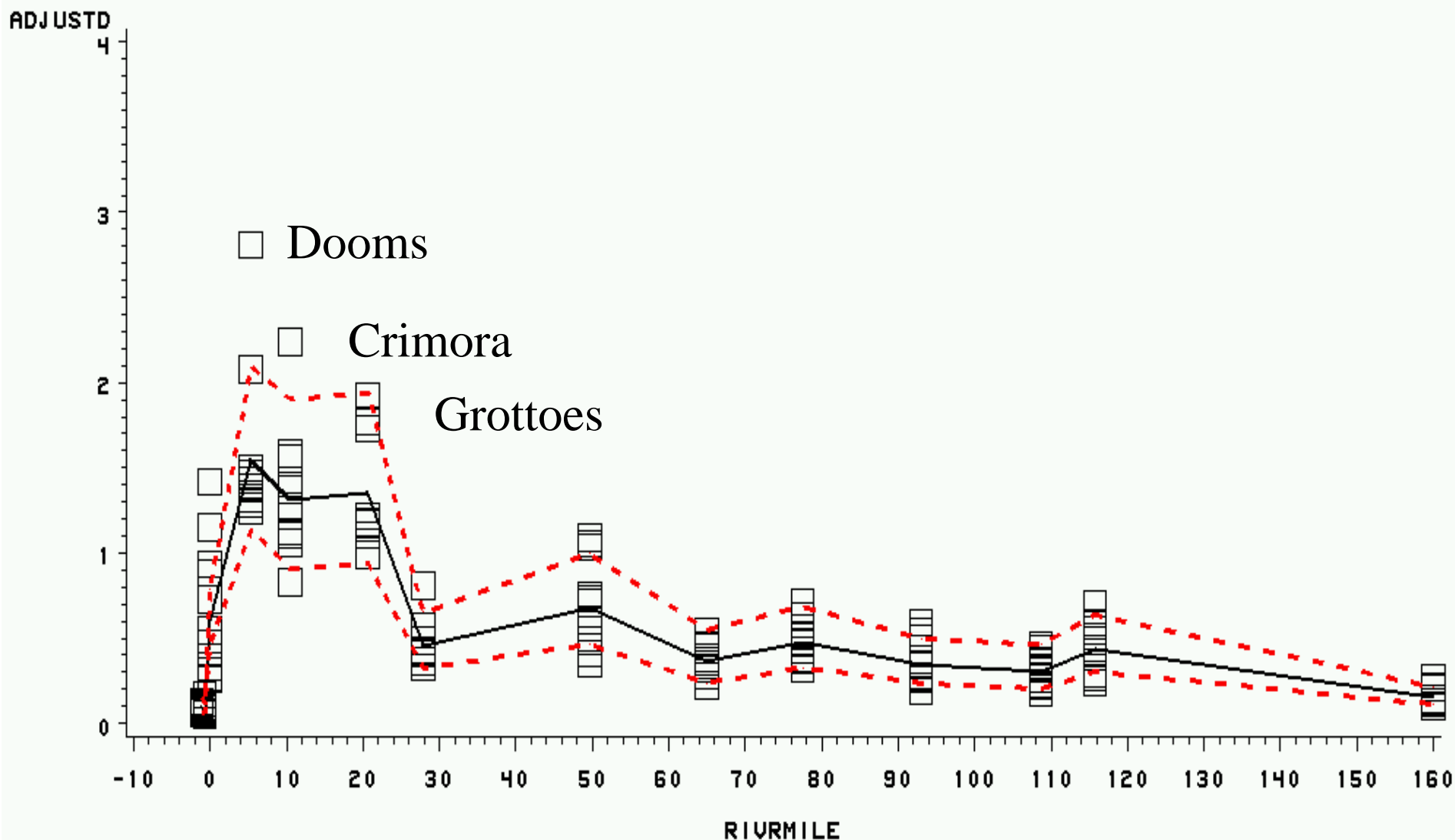
MODEL: LOGTHG=STATION|YEAR LOGLEN STATION*LOGLEN YEAR*LOGLEN
FULL DATA SET
STATION=18 Stat_ID=1BSSF010.18

Gooney Run



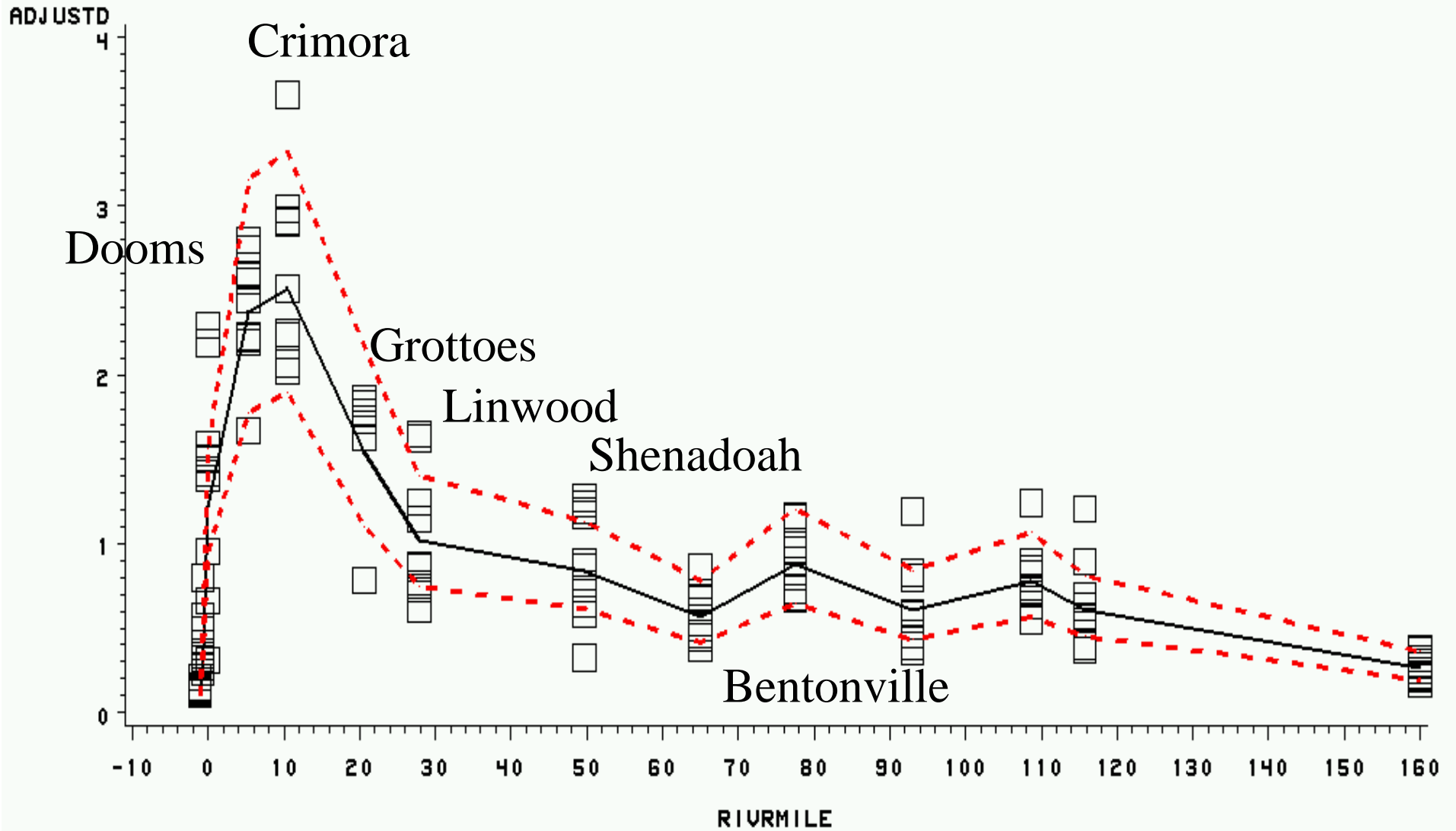
Adjusted and Predicted Total Hg in SUNFISH

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



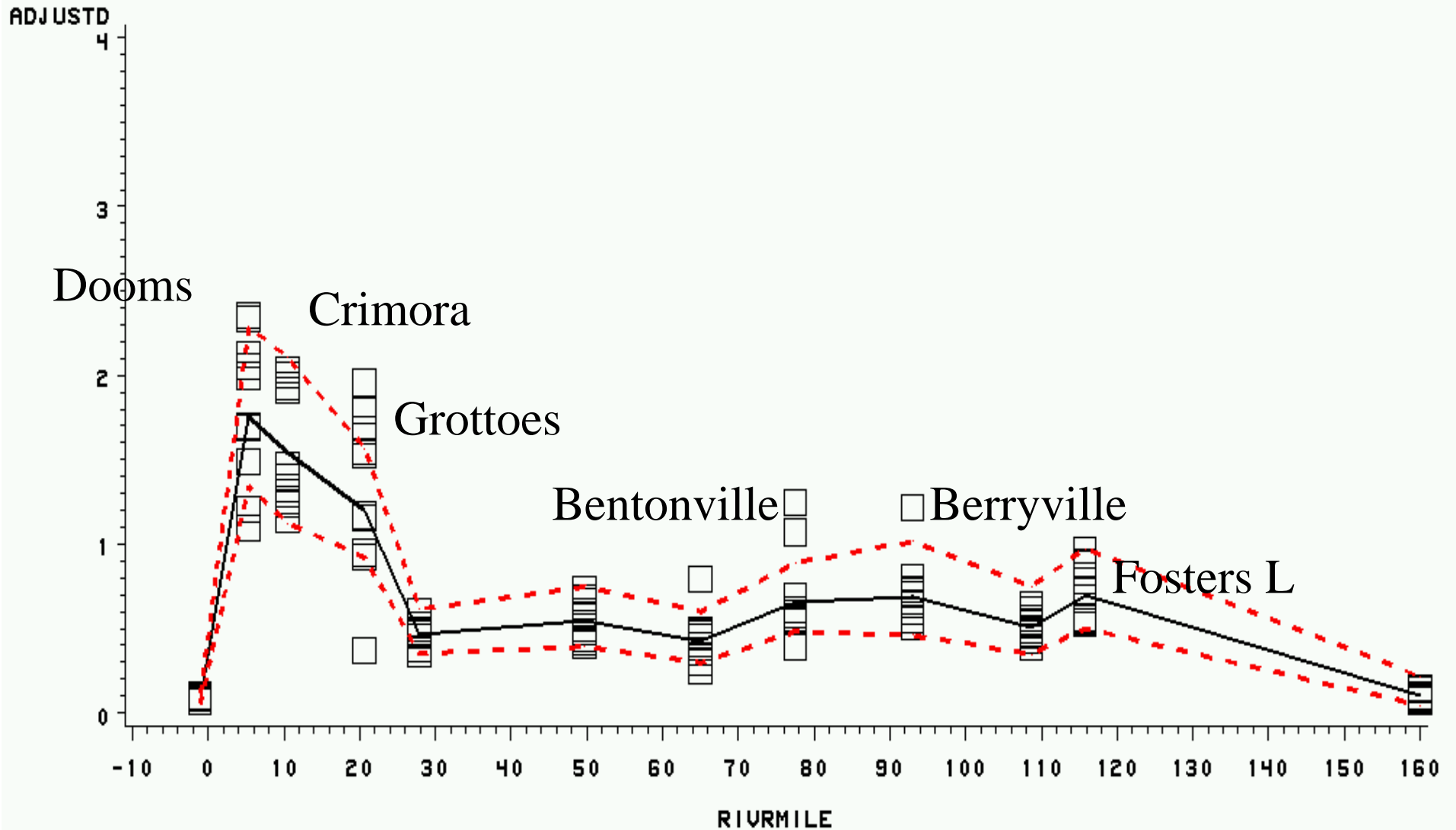
Adjusted and Predicted Total Hg in SUNFISH

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



Conclusions for Sunfish

- Dooms, Crimora, Grottoes show elevated Hg in 1996-1999
- 1996 had significantly higher levels for many sites