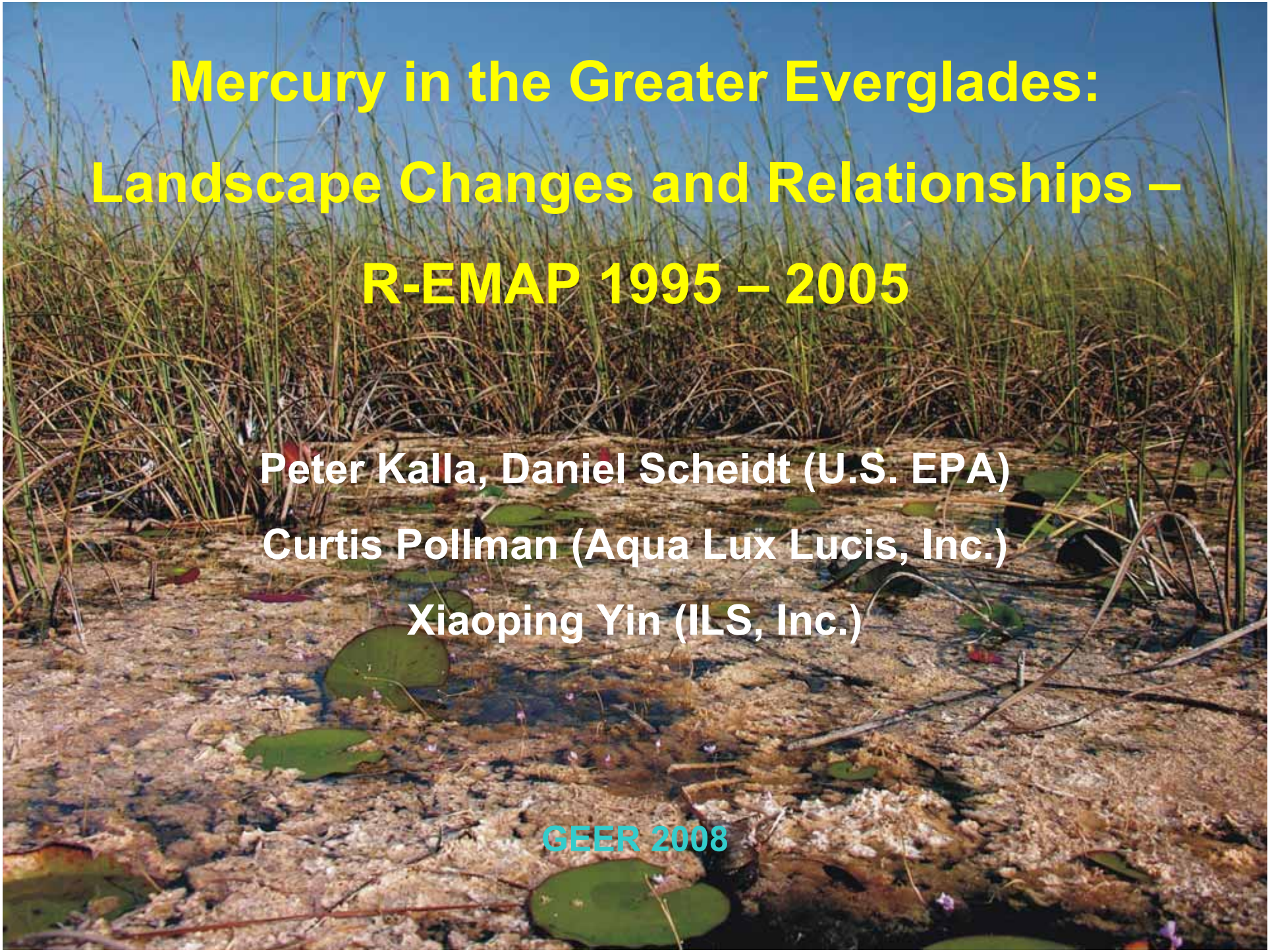


Mercury in the Greater Everglades: Landscape Changes and Relationships – R-EMAP 1995 – 2005

Peter Kalla, Daniel Scheidt (U.S. EPA)

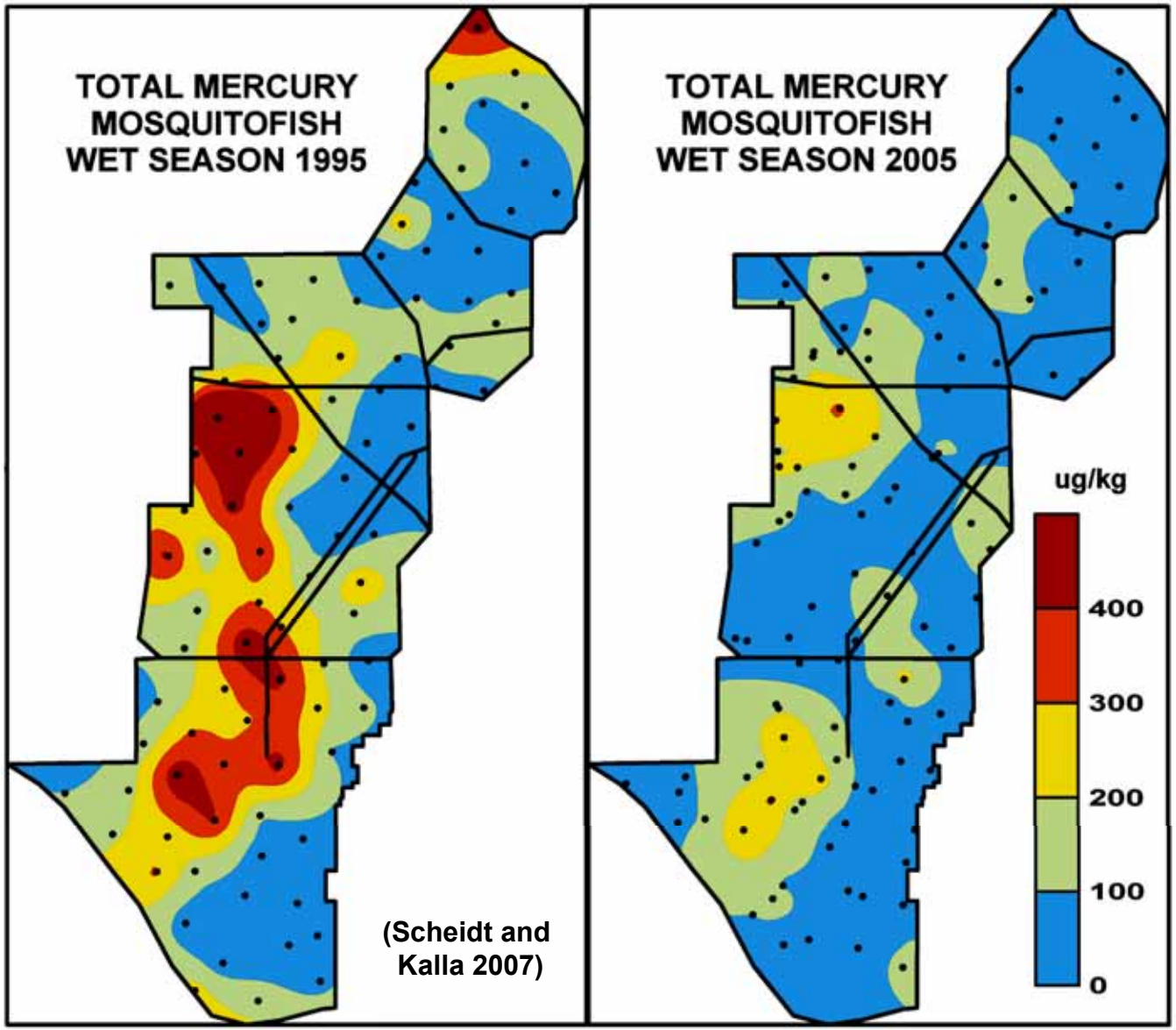
Curtis Pollman (Aqua Lux Lucis, Inc.)

Xiaoping Yin (ILS, Inc.)

GEER 2008

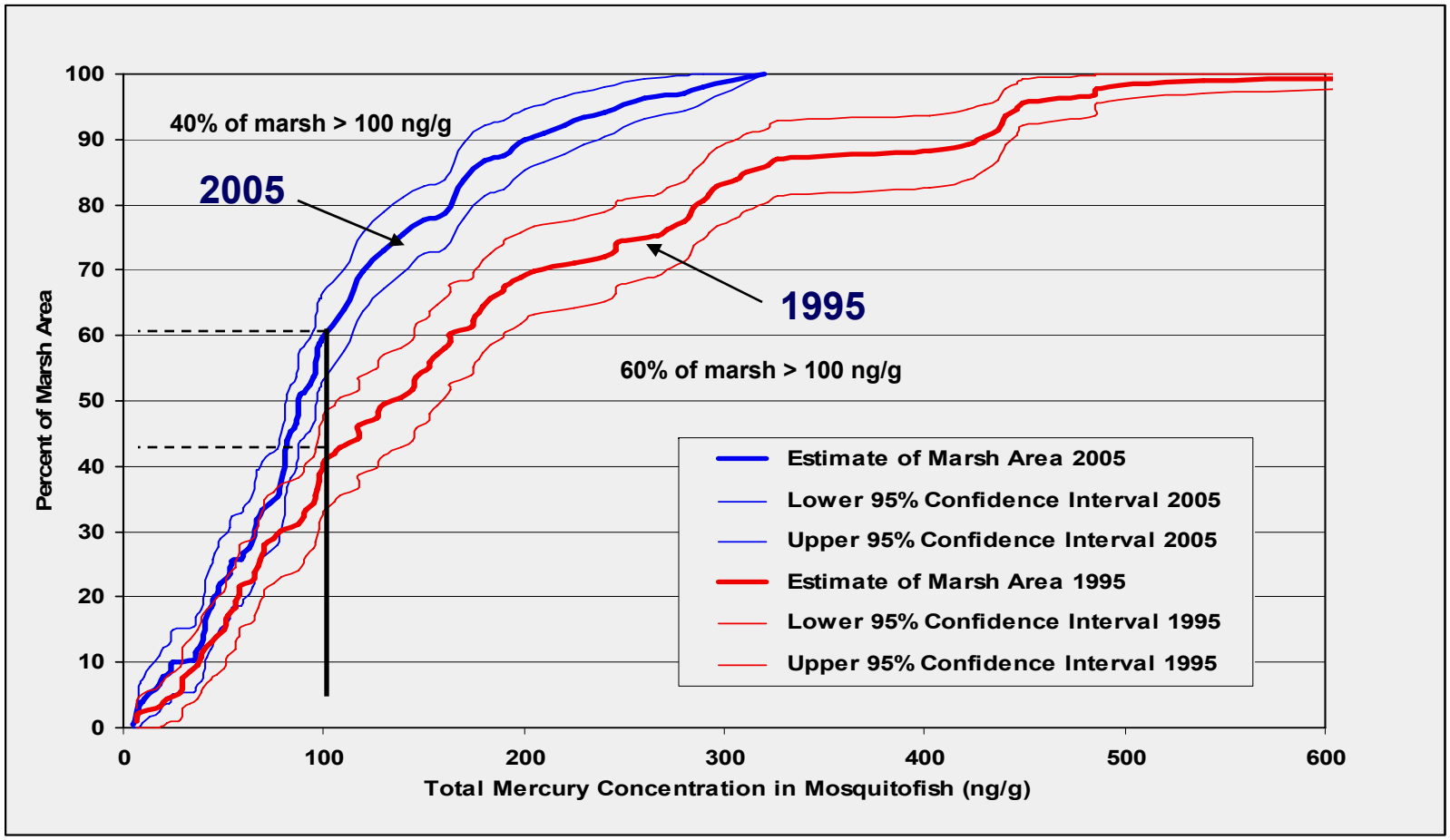
Mosquitofish Mercury, 1995 & 2005

Wet Season



Mosquitofish Mercury, 1995 & 2005

Wet Season



Mercury in Largemouth Bass 1988 - 2006

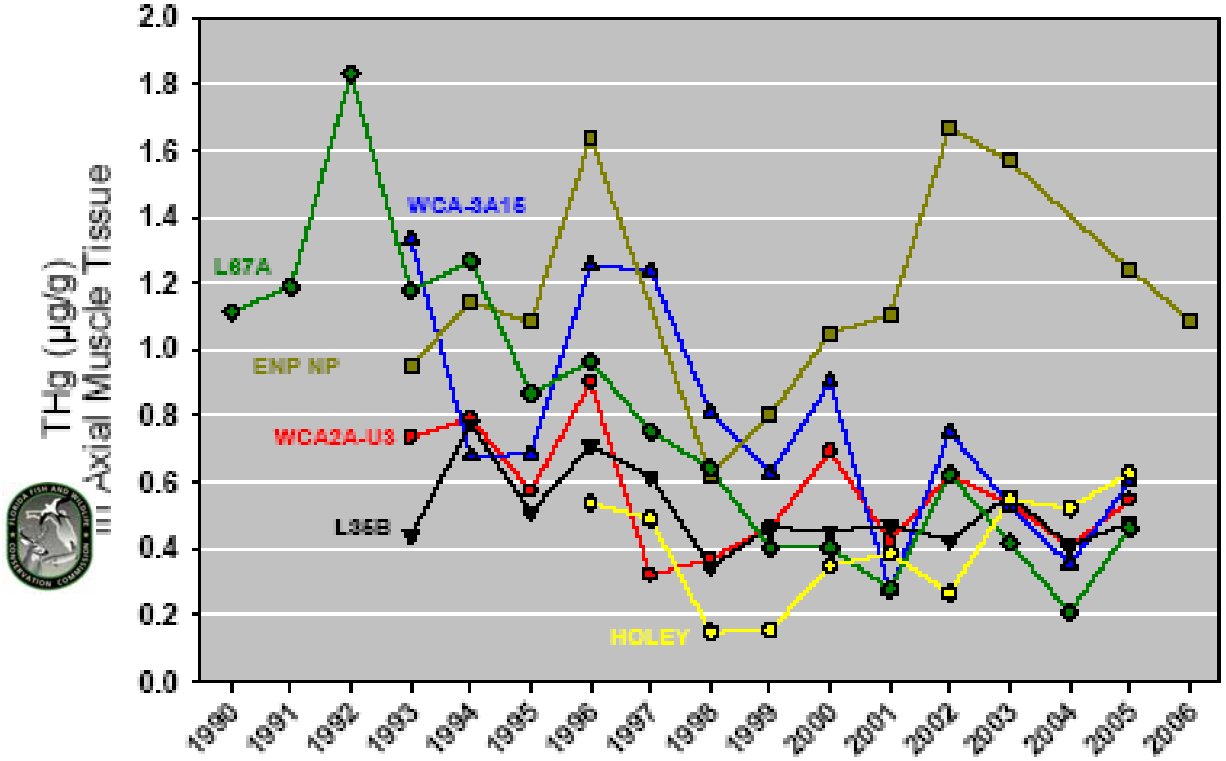
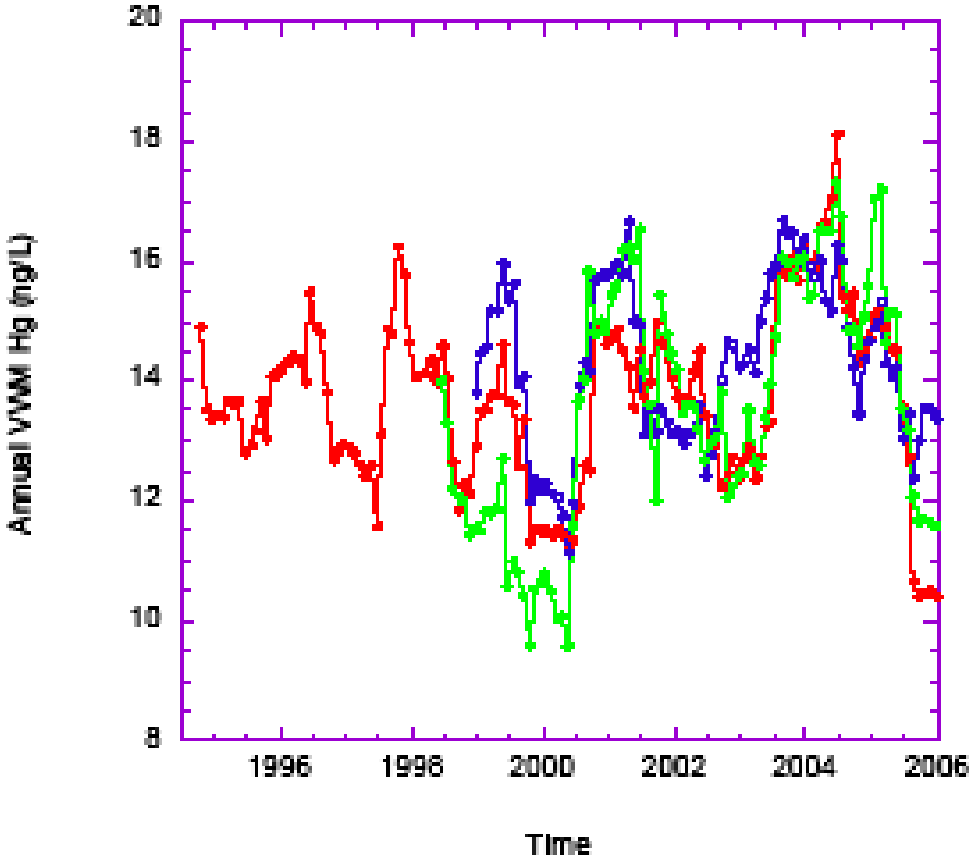


Figure 3B-9. Time series of geometric mean mercury concentrations for largemouth bass (age 1-2 cohort) for five Everglades sites. Sites L-35B and L-67A are canal sites in WCA-2 and WCA-3, respectively and sites U3 and 3A-15 represent interior marsh sites located in WCA-2A and 3A, respectively. The ENP NP site is located in the ENP (North Prong Creek) in the Shark River Slough and Site HOLEY is located in the canal within Holey Land WMA.

Mercury in Wet Deposition, 1995-2005



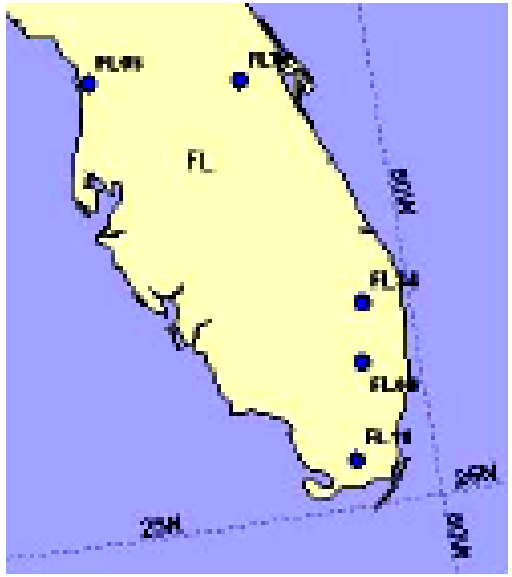
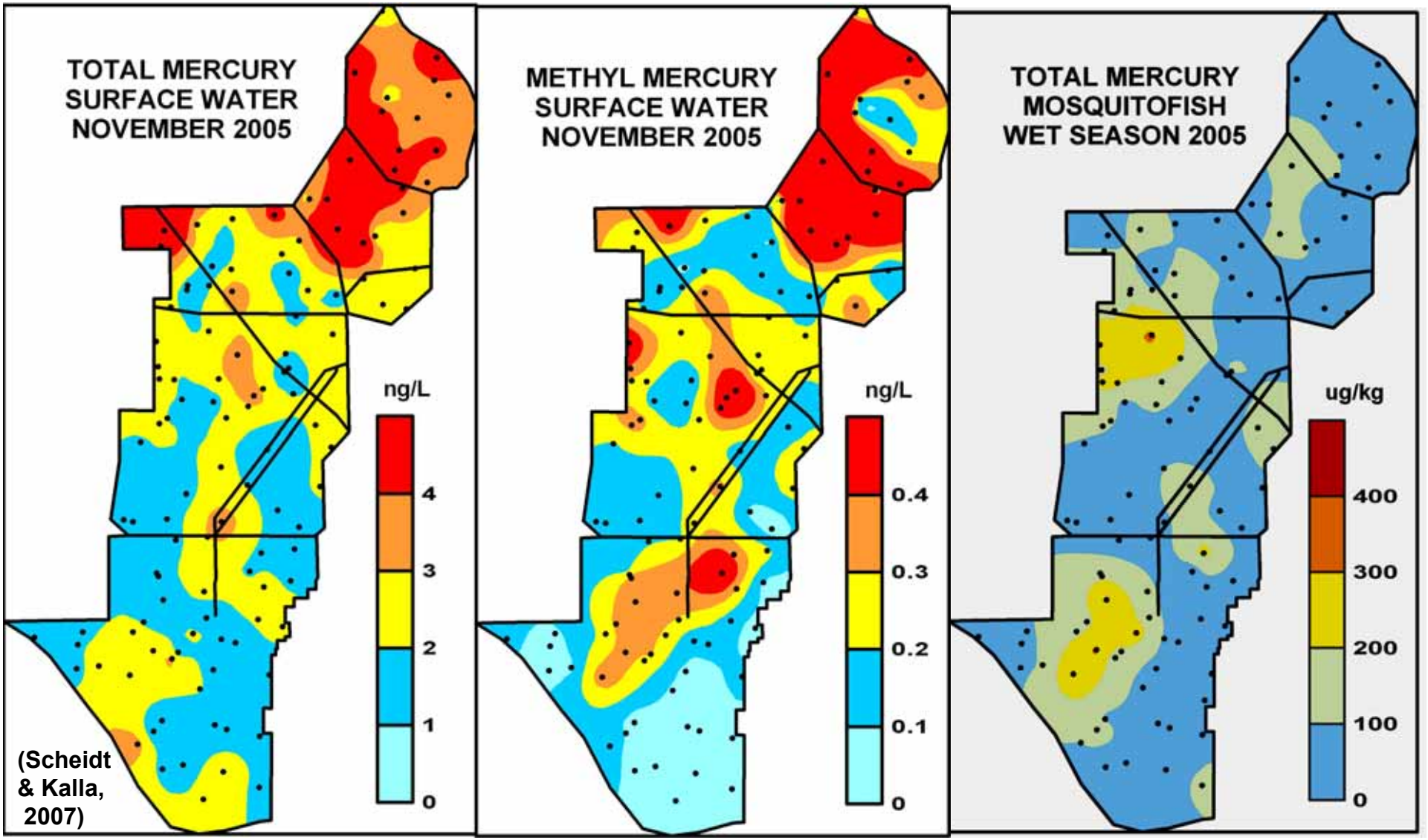


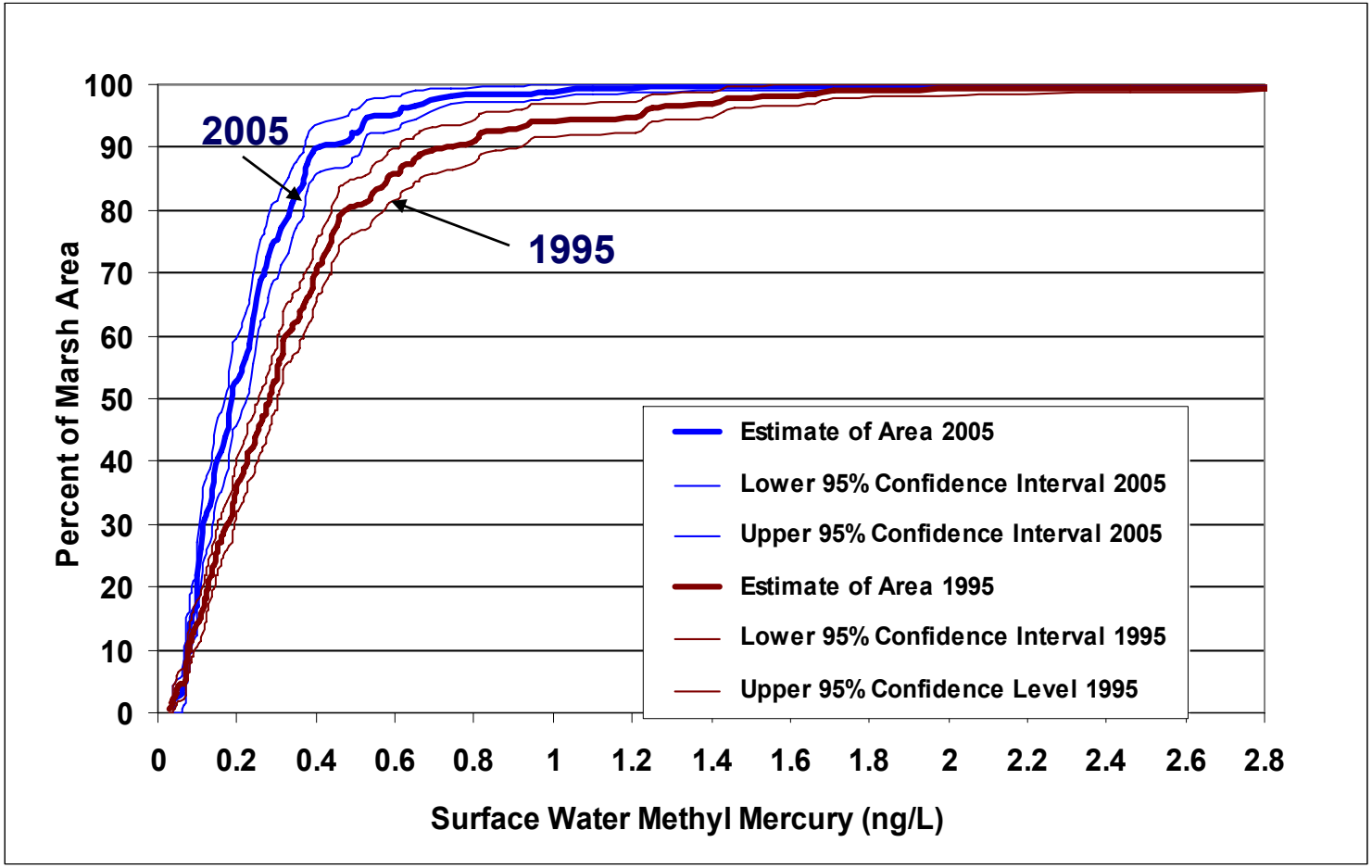
Figure 3B-15. Running annual volume-weighted mean concentration of mercury in wet deposition in south Florida, 1995 through 2005. Fluxes are calculated monthly based on the current and previous 11 months of data. Red closed circles are FL11, blue open circles are FL04, and green closed diamonds are FL34.

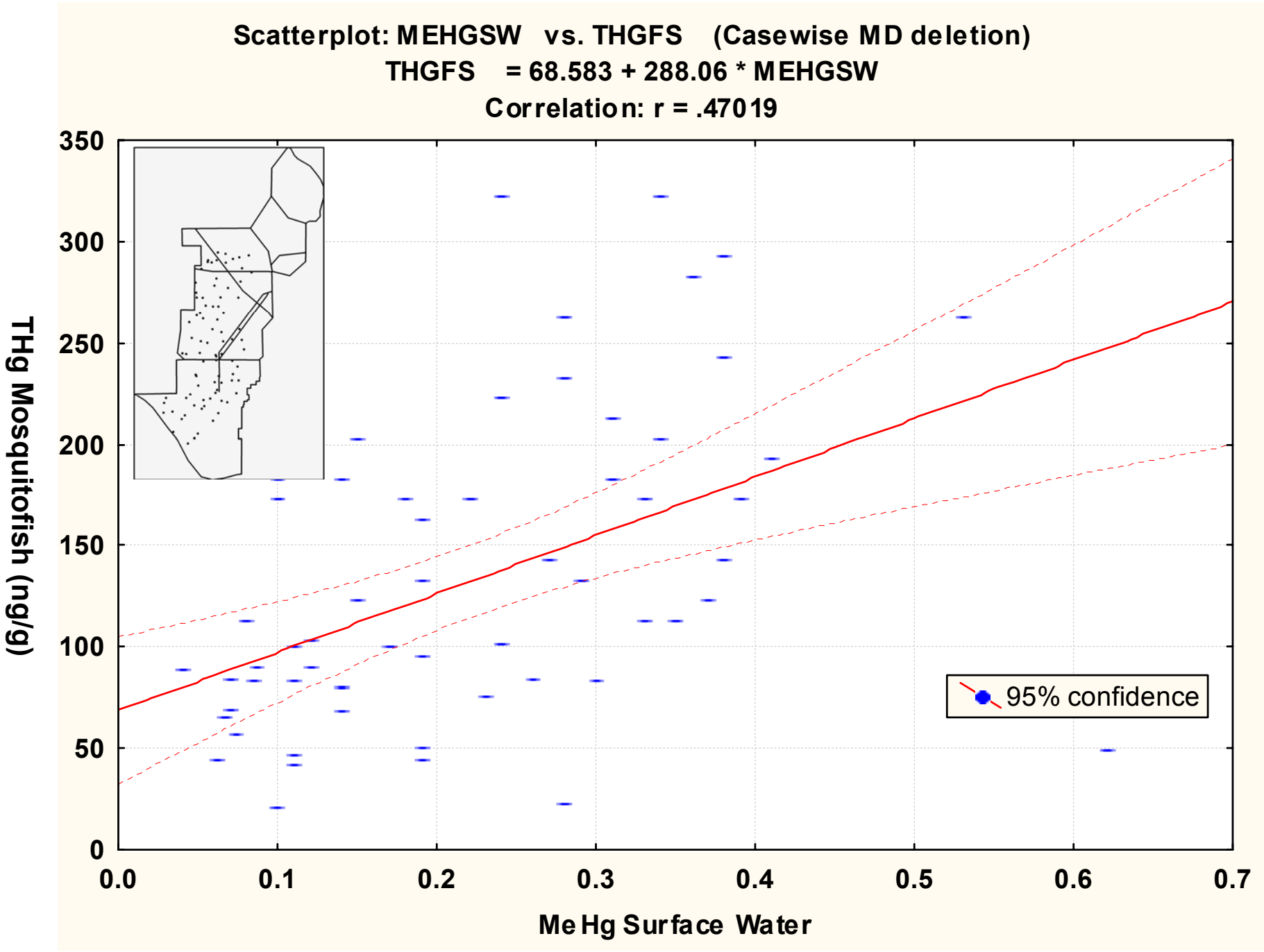
Mercury, Wet Season 2005



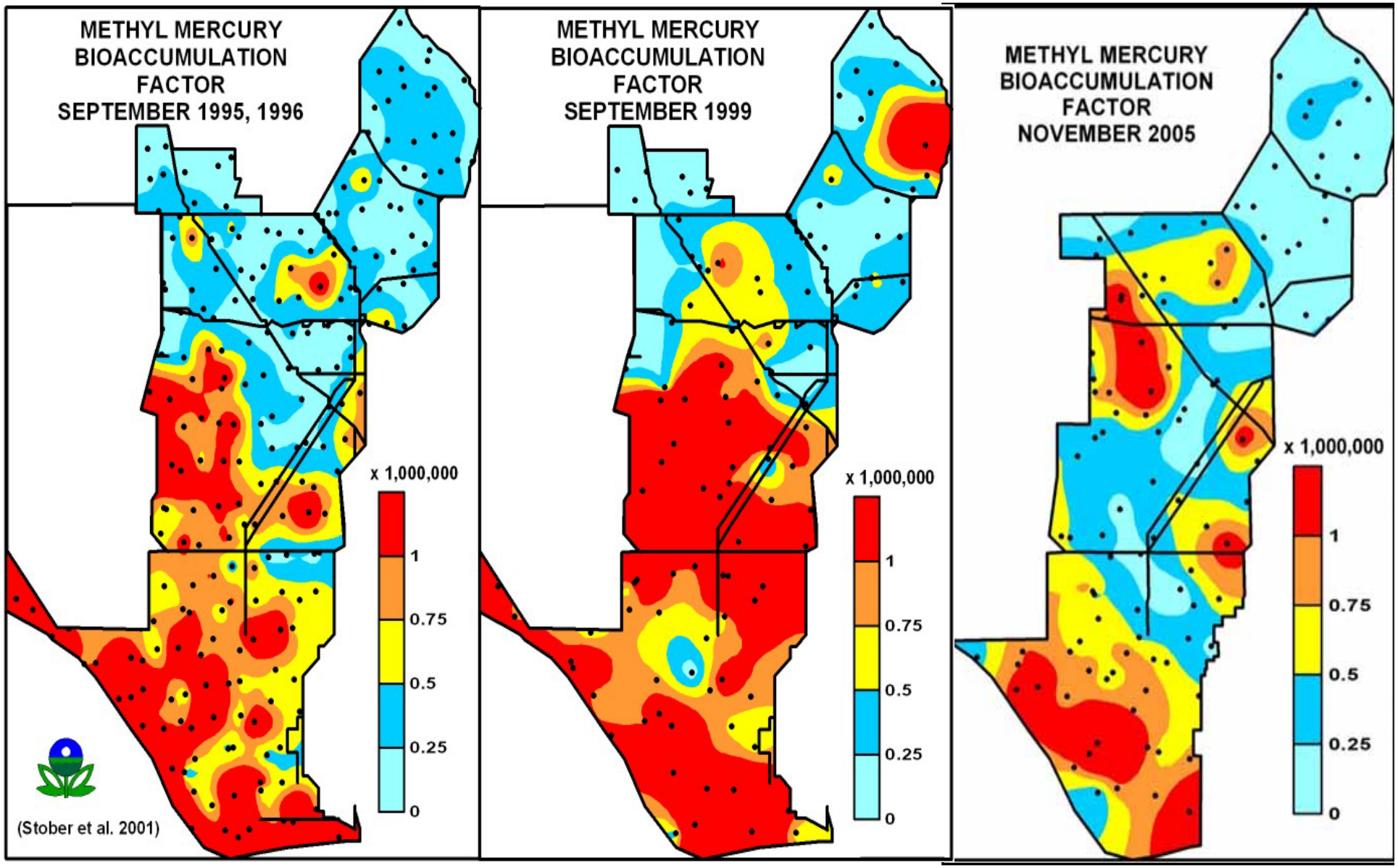
Water Methyl Mercury, 1995 & 2005

Wet Season

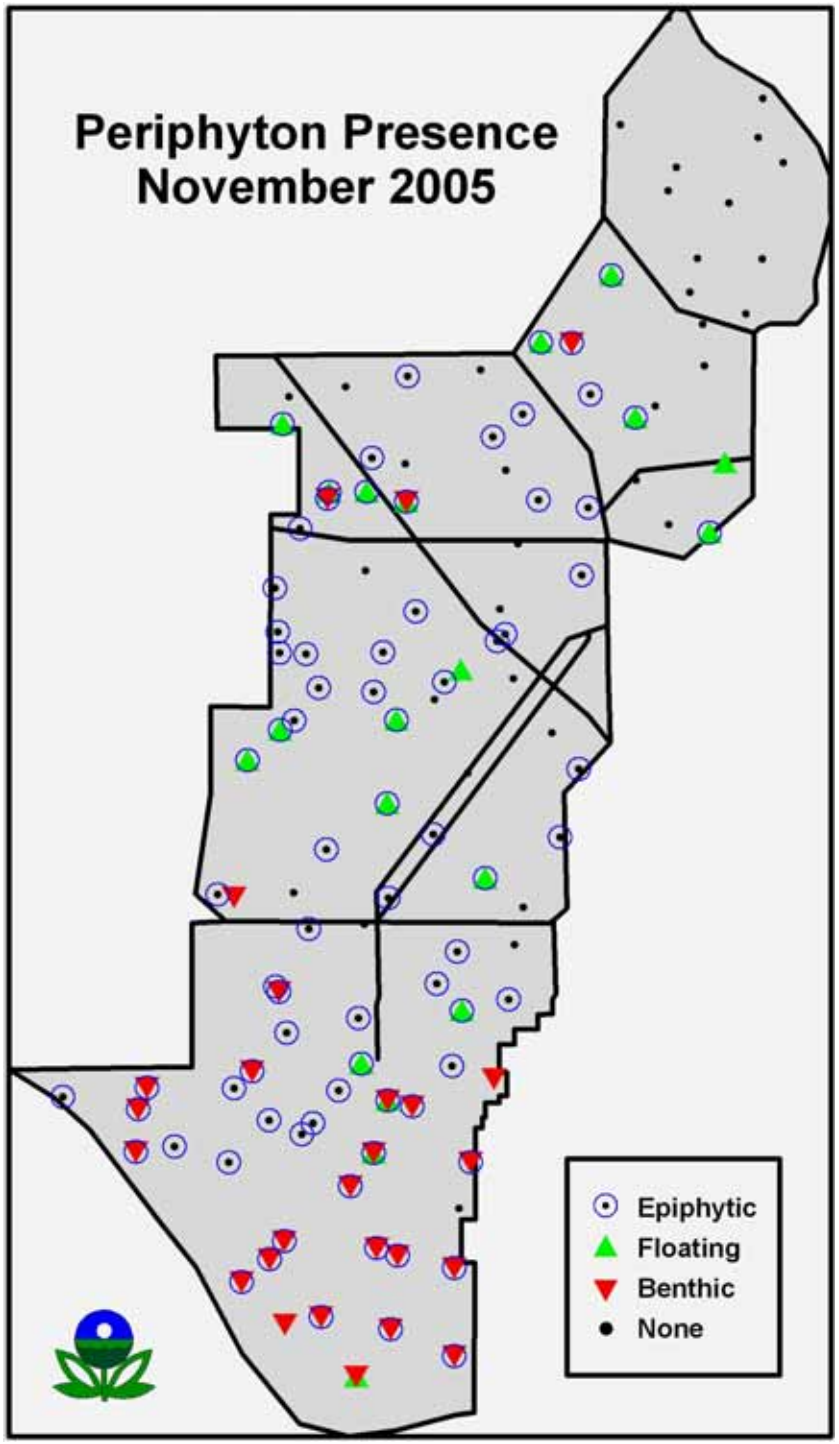


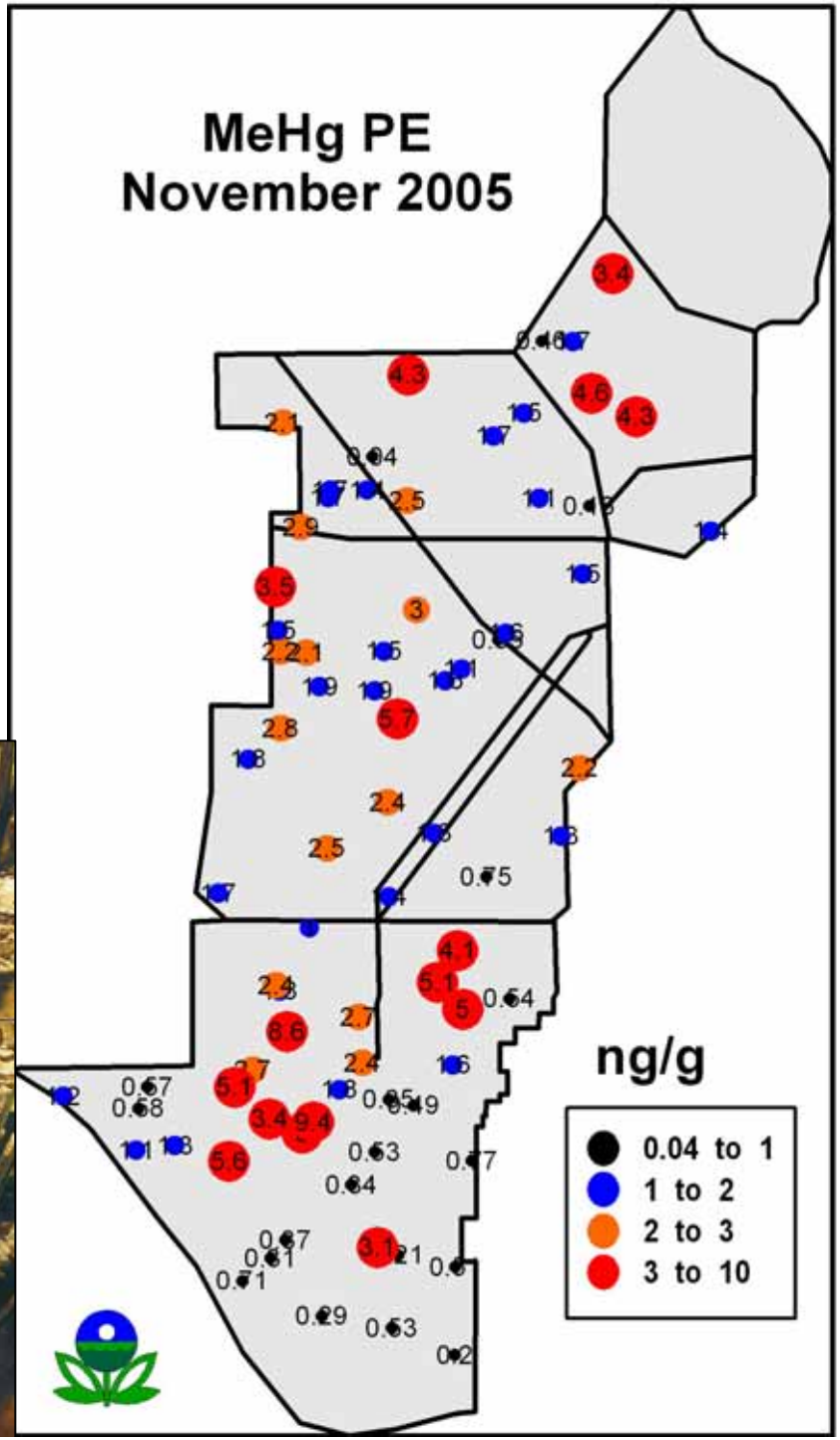

Scatterplot: MEHGSW vs. THGFS (Casewise MD deletion)
THGFS = 68.583 + 288.06 * MEHGSW
Correlation: r = .47019
THg Mosquitofish (ng/g)
MeHg Surface Water
95% confidence
0
50
100
150
200
250
300
350
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

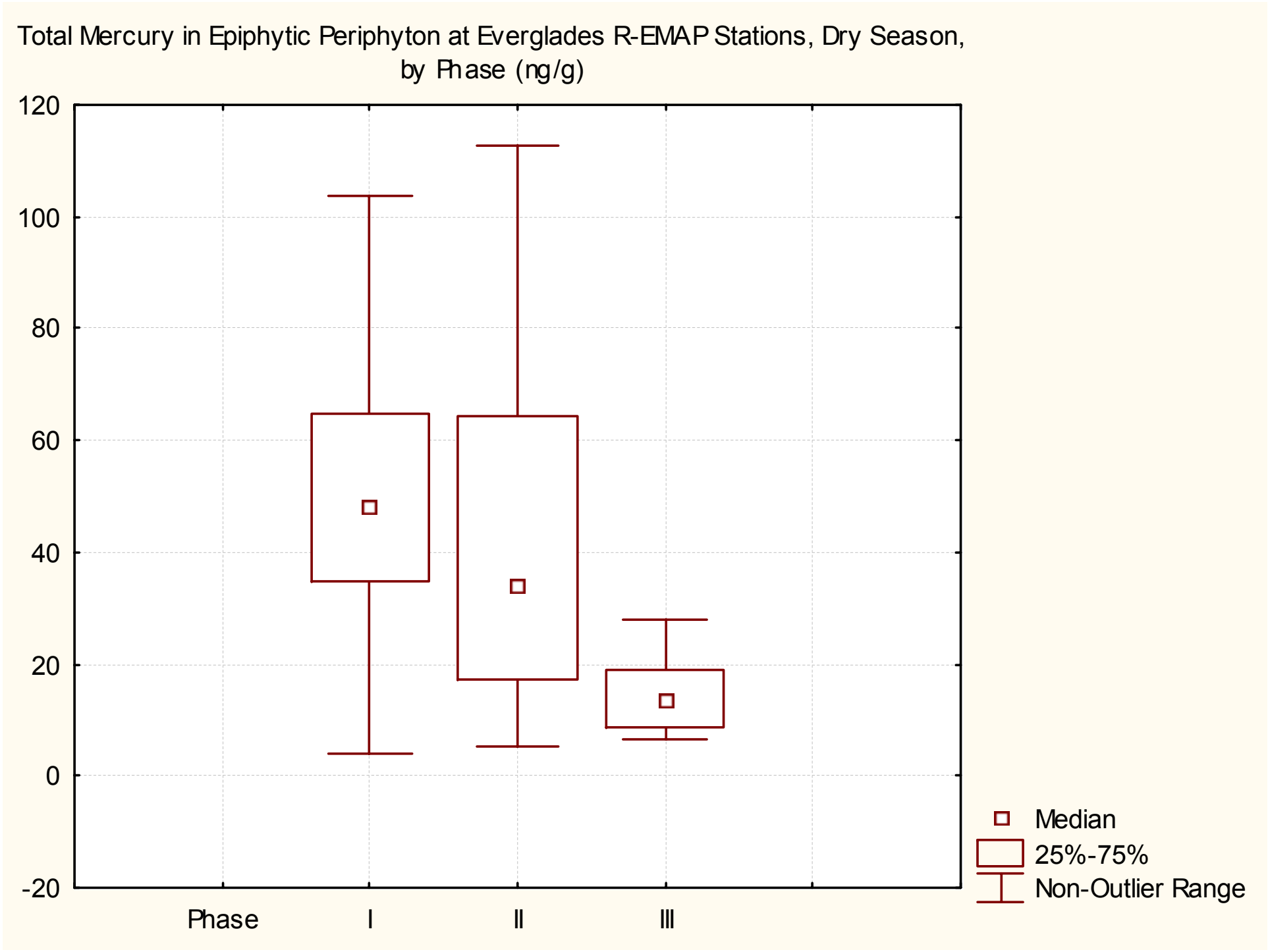
Changes in Bio-magnification of Mercury Over Time

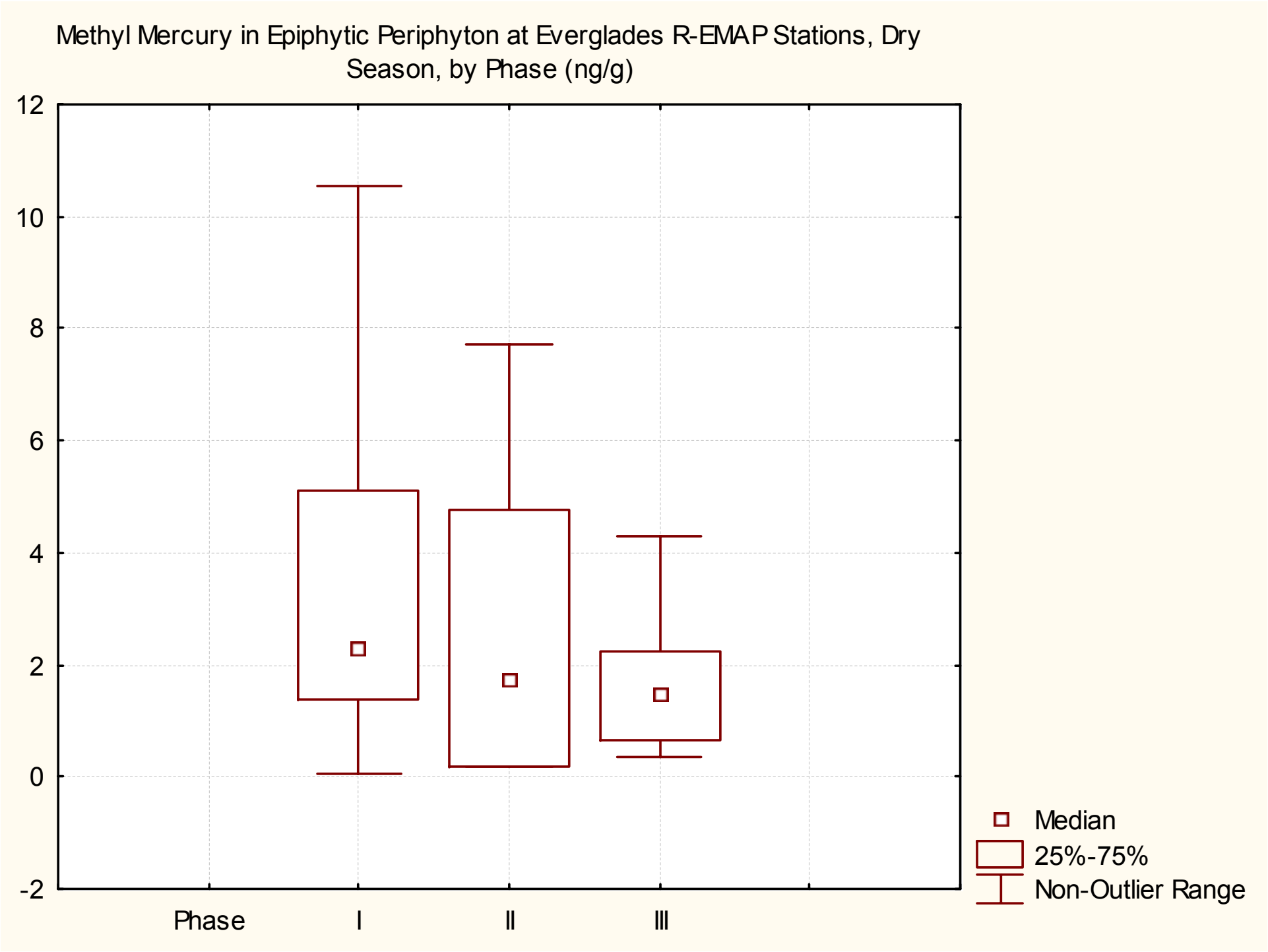


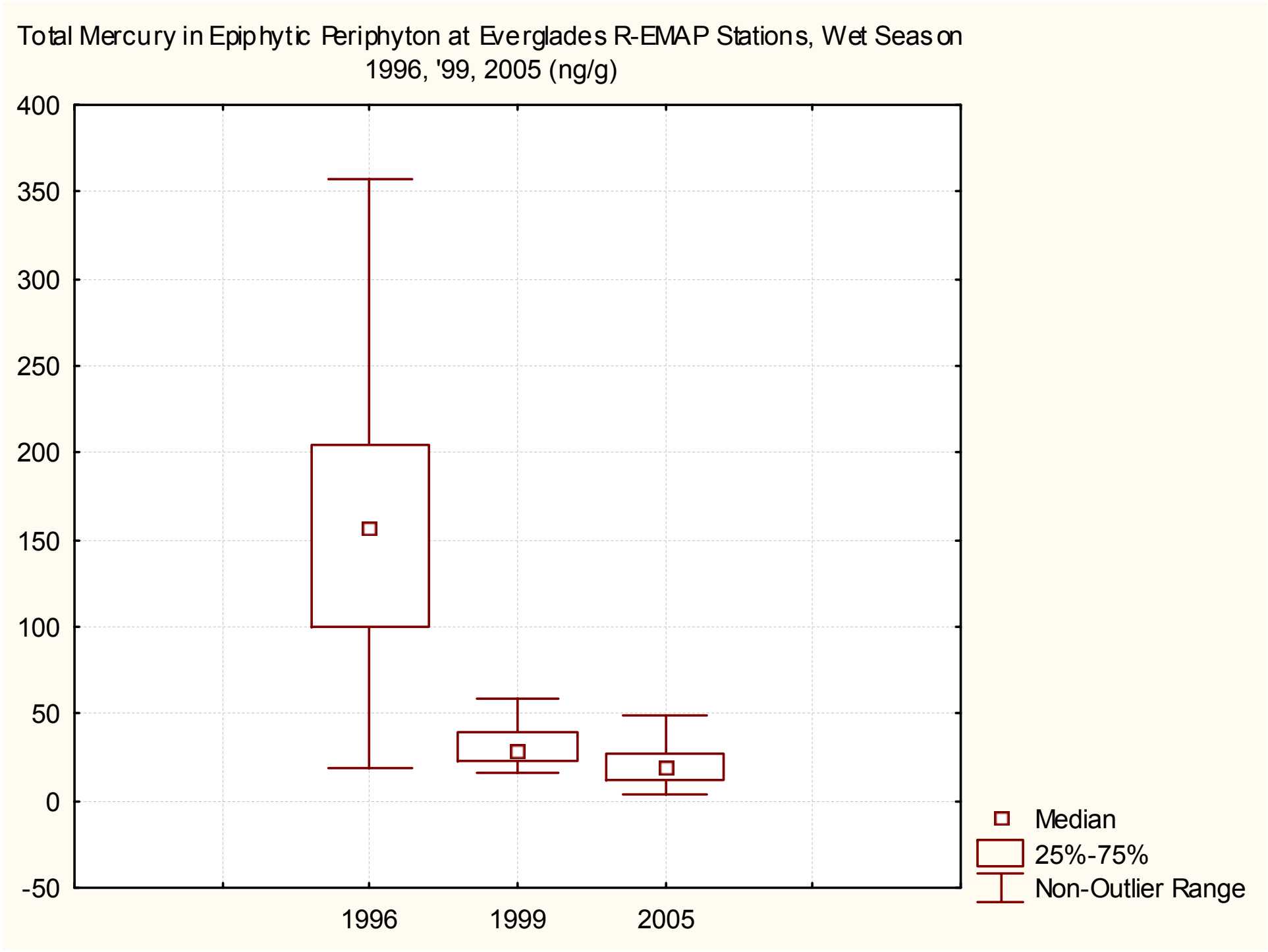
	THgFish	BAFMeHg
THGSW		-0.4217
MeHgSW	*0.4702*	-0.7801
BAFTHG	0.9133	0.7763
BAFMeHG	0.6477	
MeHgPE	**0.678**	
MeHgPF		-0.9391
MeHgPSM	0.583	
TCSD		*-0.3345*
FDOCPW		-0.4917
DOCSW		-0.646
AFDWSD		*-0.3661*
BDSD		0.4271
COND		-0.2614
CLSW		-0.4659
SO4SW		-0.4697
SO4PW		-0.538
H2SPW		-0.6261
depth		*-0.5278*
APASW	0.5054	0.5299
CHLASW		-0.2581
TPSW	-0.3804	-0.4656
TPFC	-0.5834	
TPSD1		-0.3185


Periphyton Presence
November 2005
Epiphytic
Floating
Benthic
None

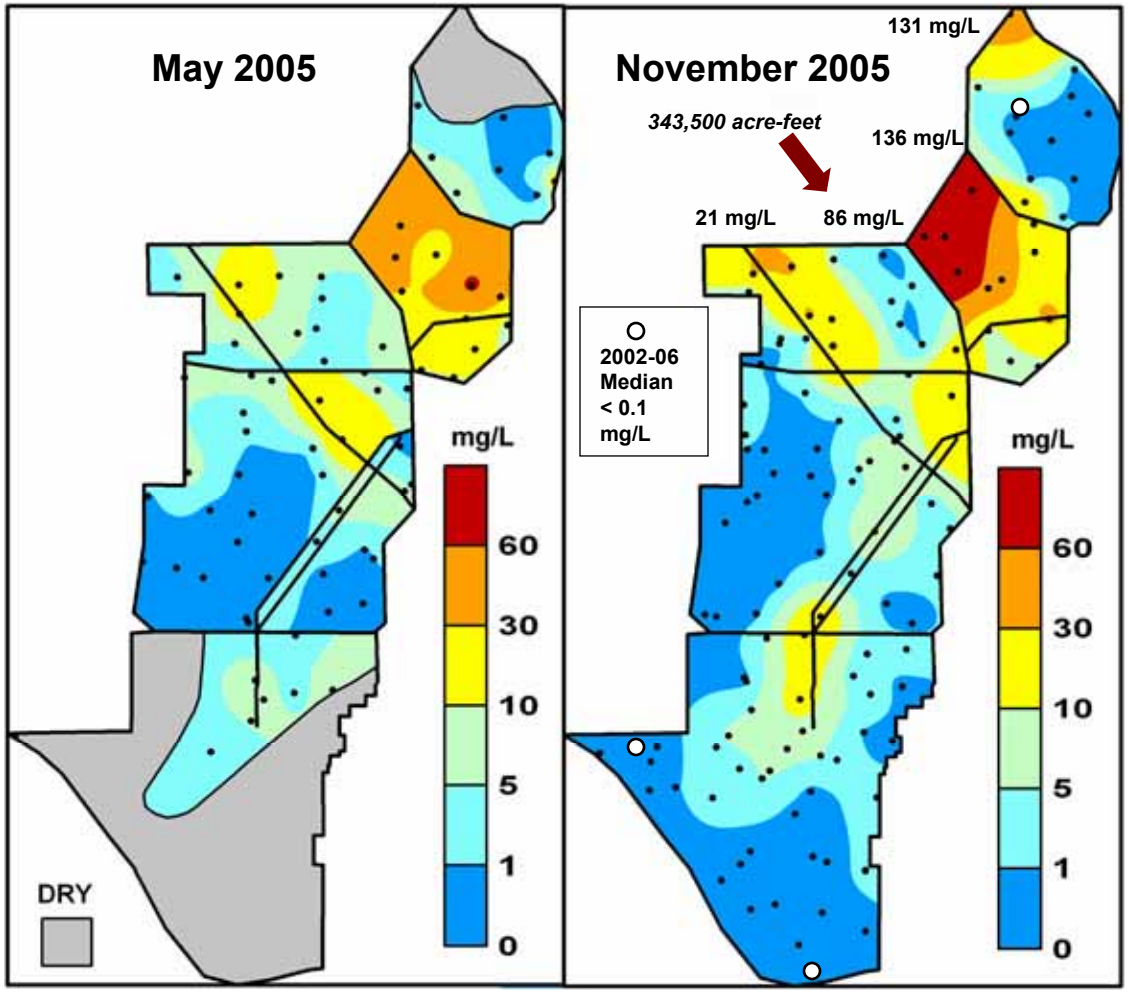

MeHg PE
November 2005
ng/g
0.04 to 1
1 to 2
2 to 3
3 to 10


Total Mercury in Epiphytic Periphyton at Everglades R-EMAP Stations, Dry Season, by Phase (ng/g)
120
100
80
60
40
20
0
-20
Phase
I
II
III
Median
25%-75%
Non-Outlier Range

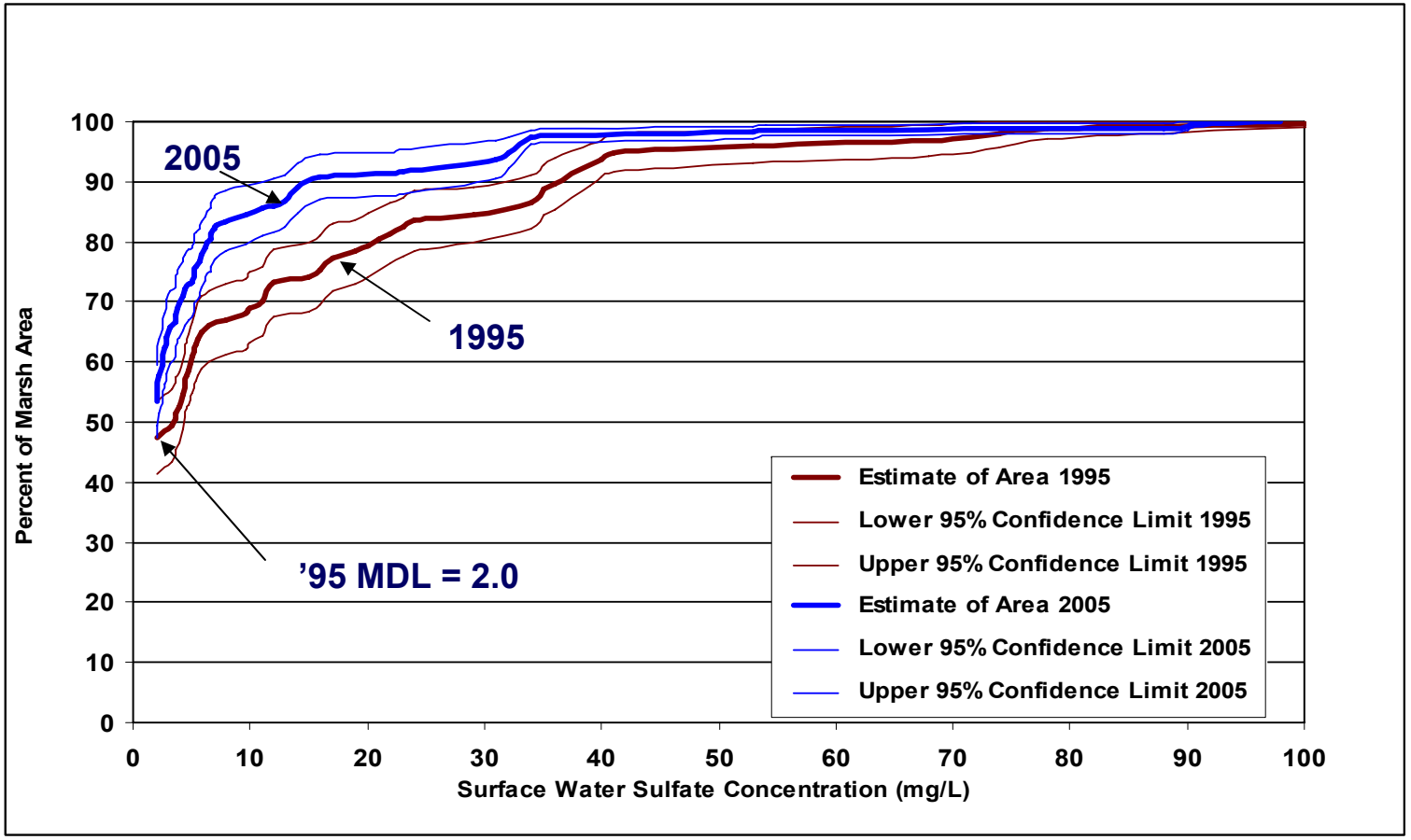

Methyl Mercury in Epiphytic Periphyton at Everglades R-EMAP Stations, Dry Season, by Phase (ng/g)
12
10
8
6
4
2
0
-2
Phase
I
II
III
Median
25%-75%
Non-Outlier Range

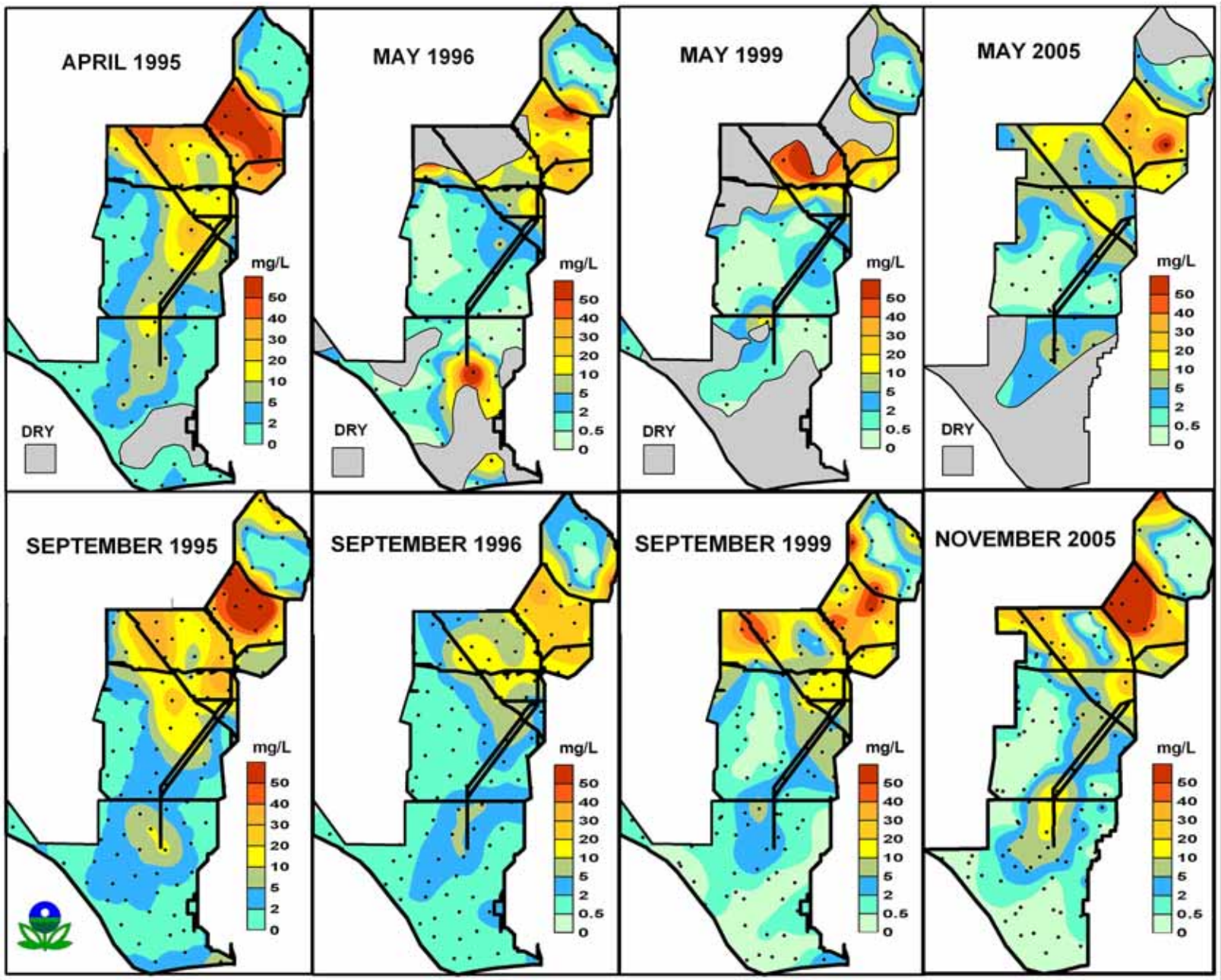

Total Mercury in Epiphytic Periphyton at Everglades R-EMAP Stations, Wet Season 1996, '99, 2005 (ng/g)
400
350
300
250
200
150
100
50
0
-50
1996
1999
2005
Median
25%-75%
Non-Outlier Range

Surface Water Sulfate 2005

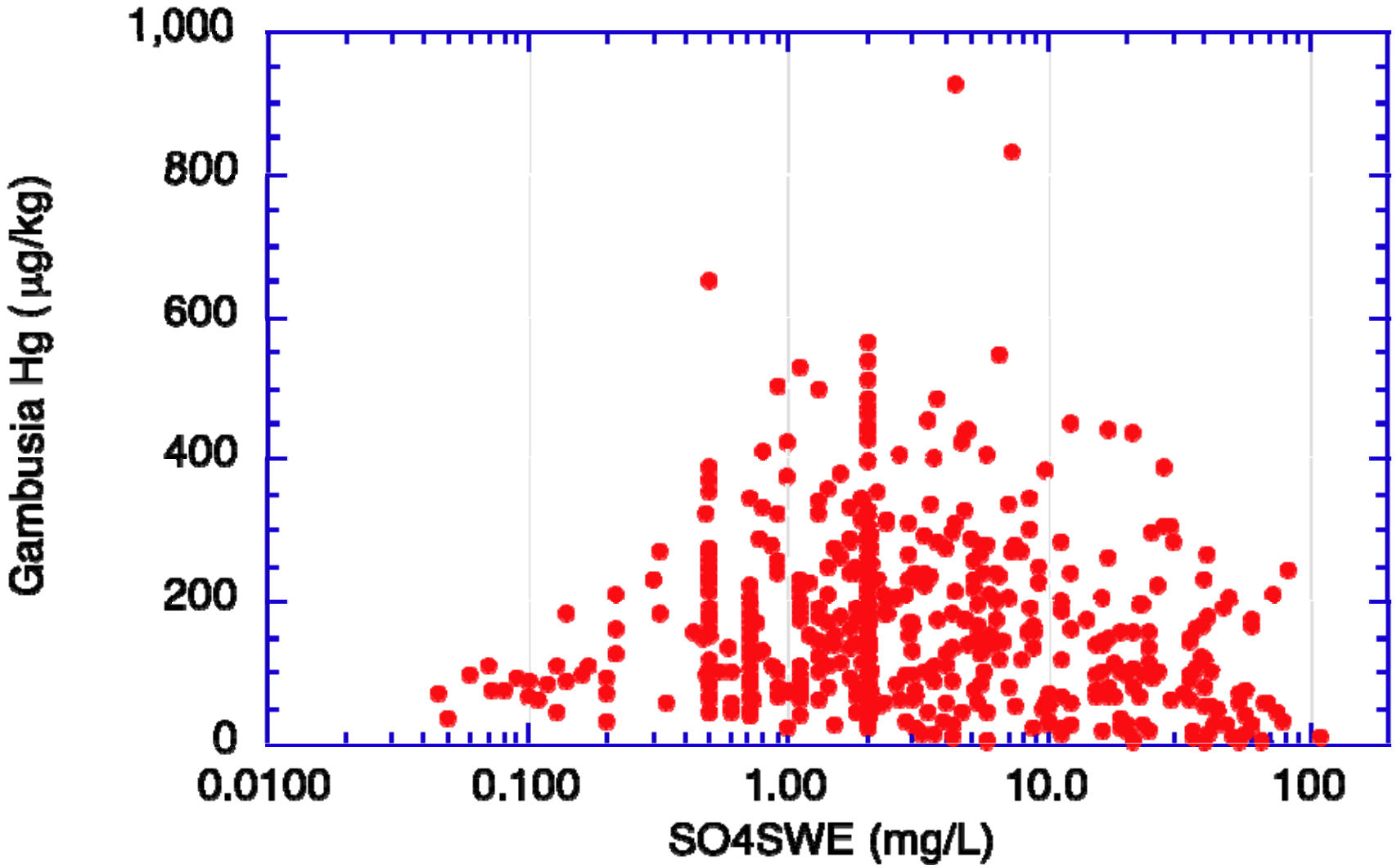


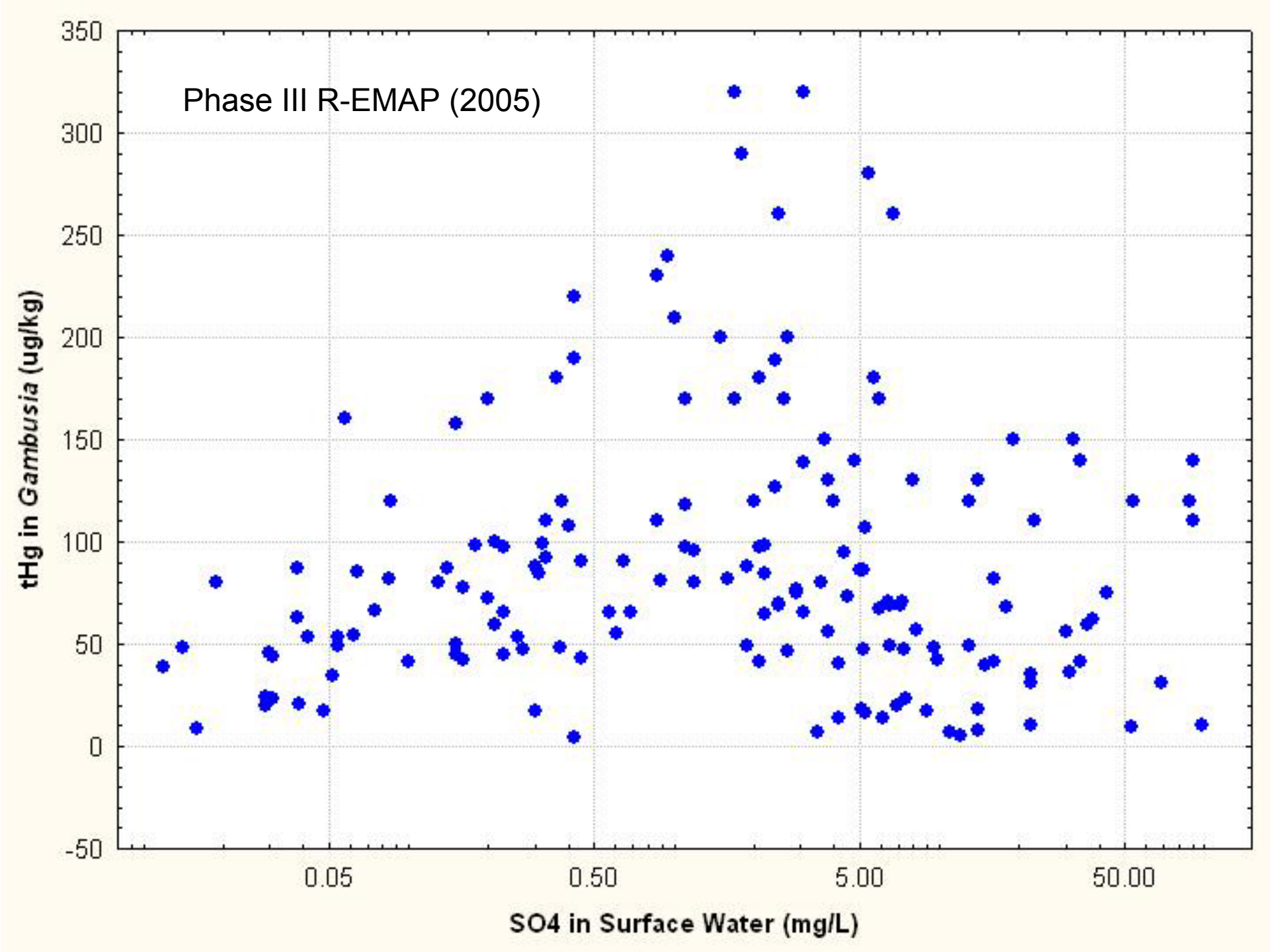
Surface Water Sulfate, 1995 & 2005
Wet Season



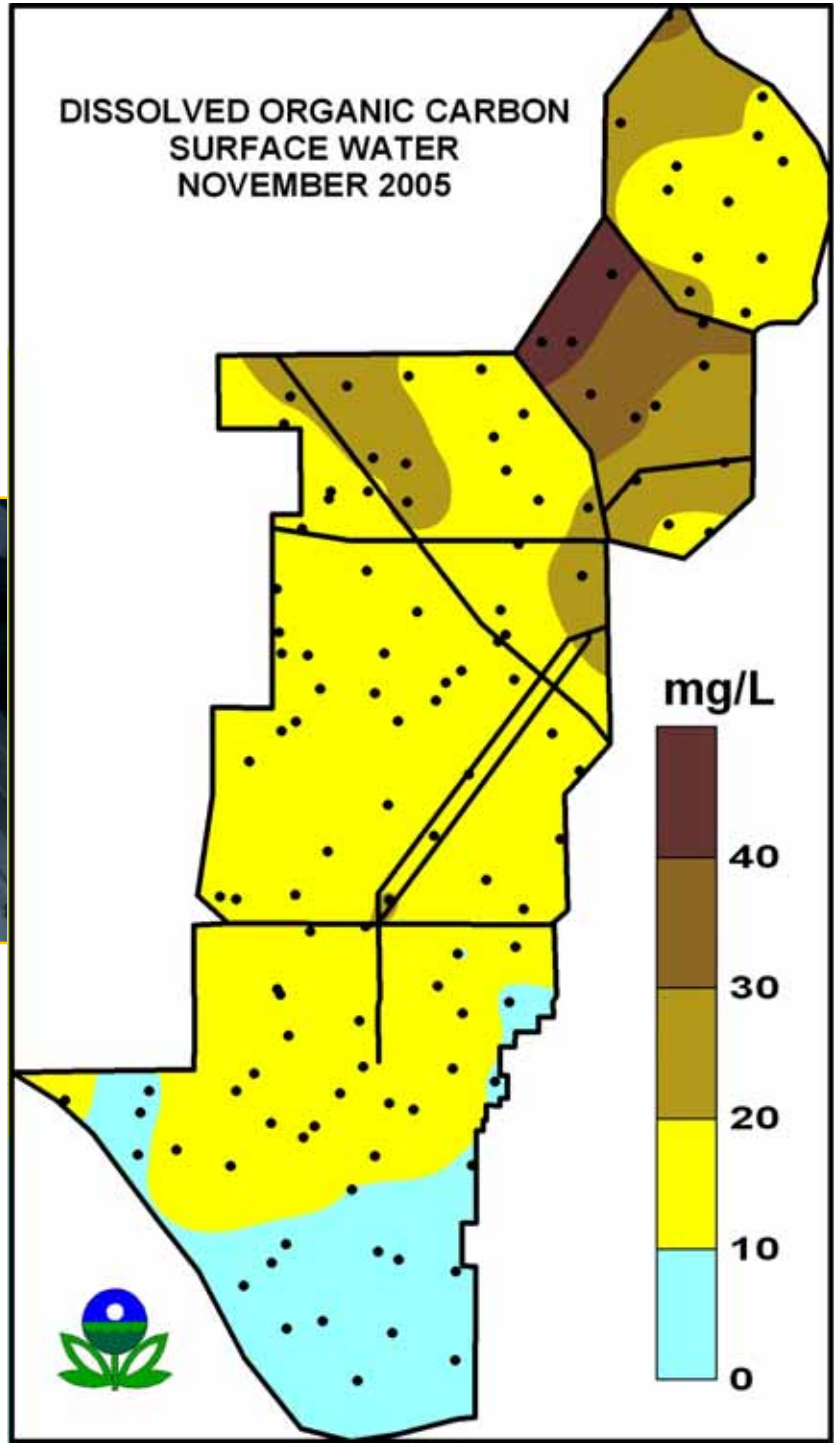

APRIL 1995
MAY 1996
MAY 1999
MAY 2005
SEPTEMBER 1995
SEPTEMBER 1996
SEPTEMBER 1999
NOVEMBER 2005
DRY
mg/L
50
40
30
20
10
5
2
0.5
0

Mosquitofish Mercury Is Non-linearly Related to Surface Water Sulfate

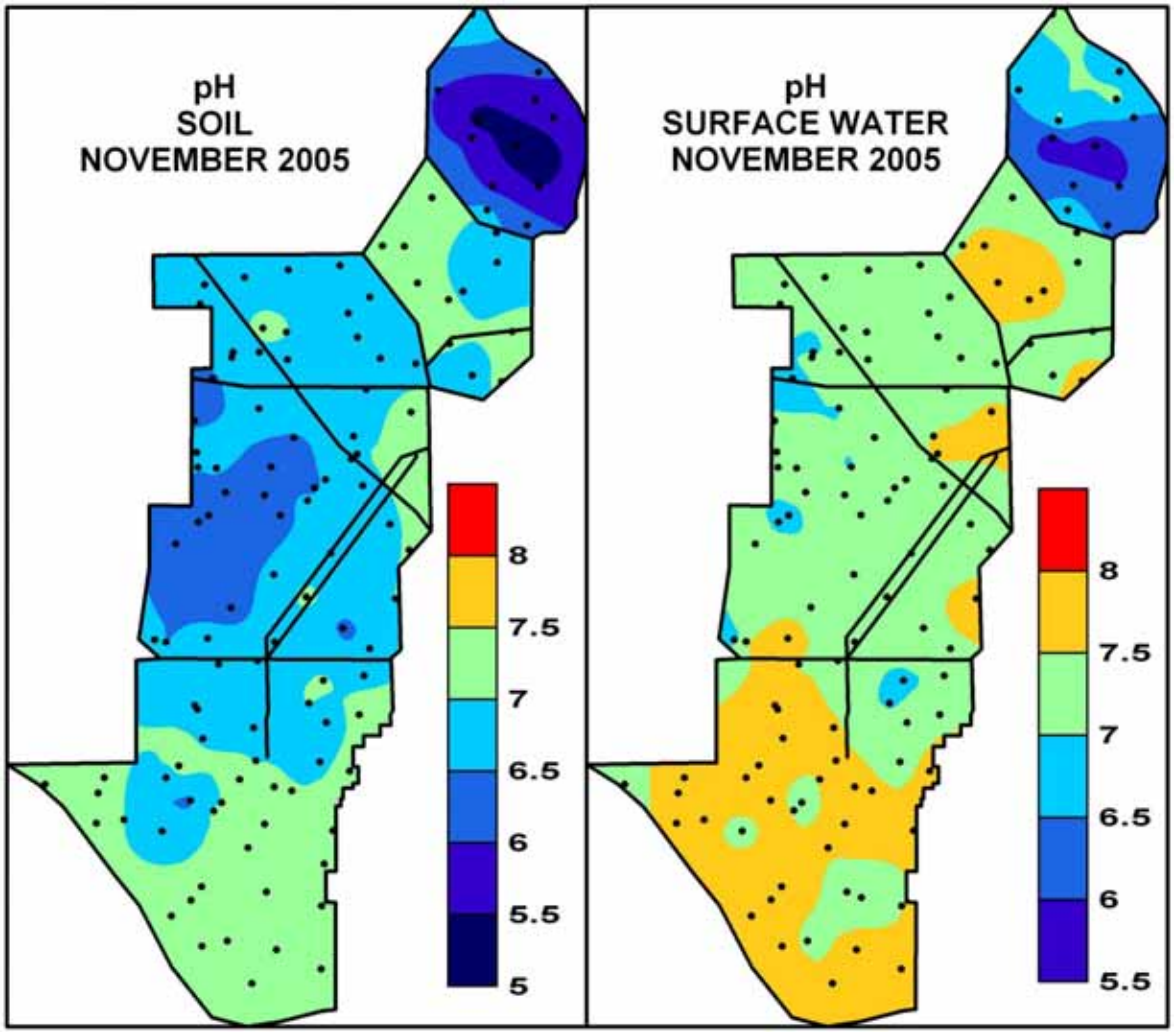



Phase III R-EMAP (2005)
tHg in Gambusia (ug/kg)
350
300
250
200
150
100
50
0
-50
0.05
0.50
5.00
50.00
SO4 in Surface Water (mg/L)

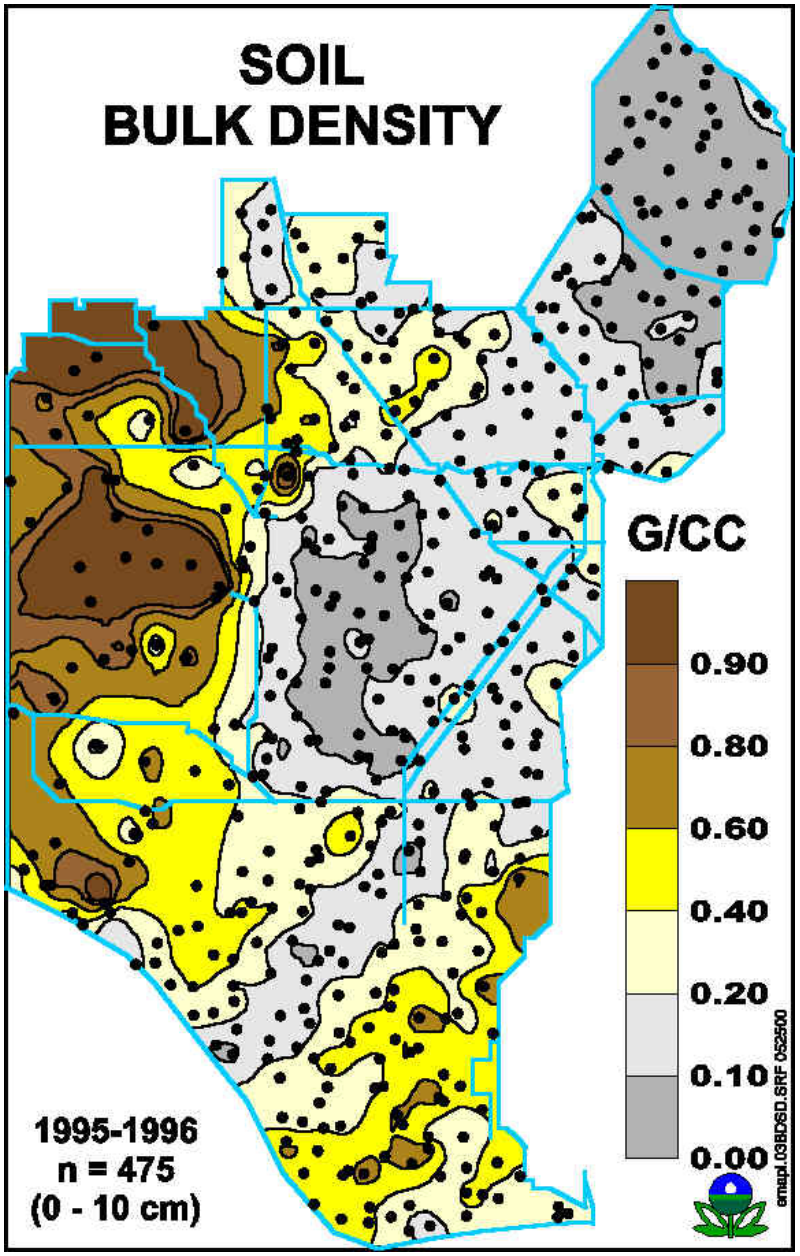
Organic Carbon



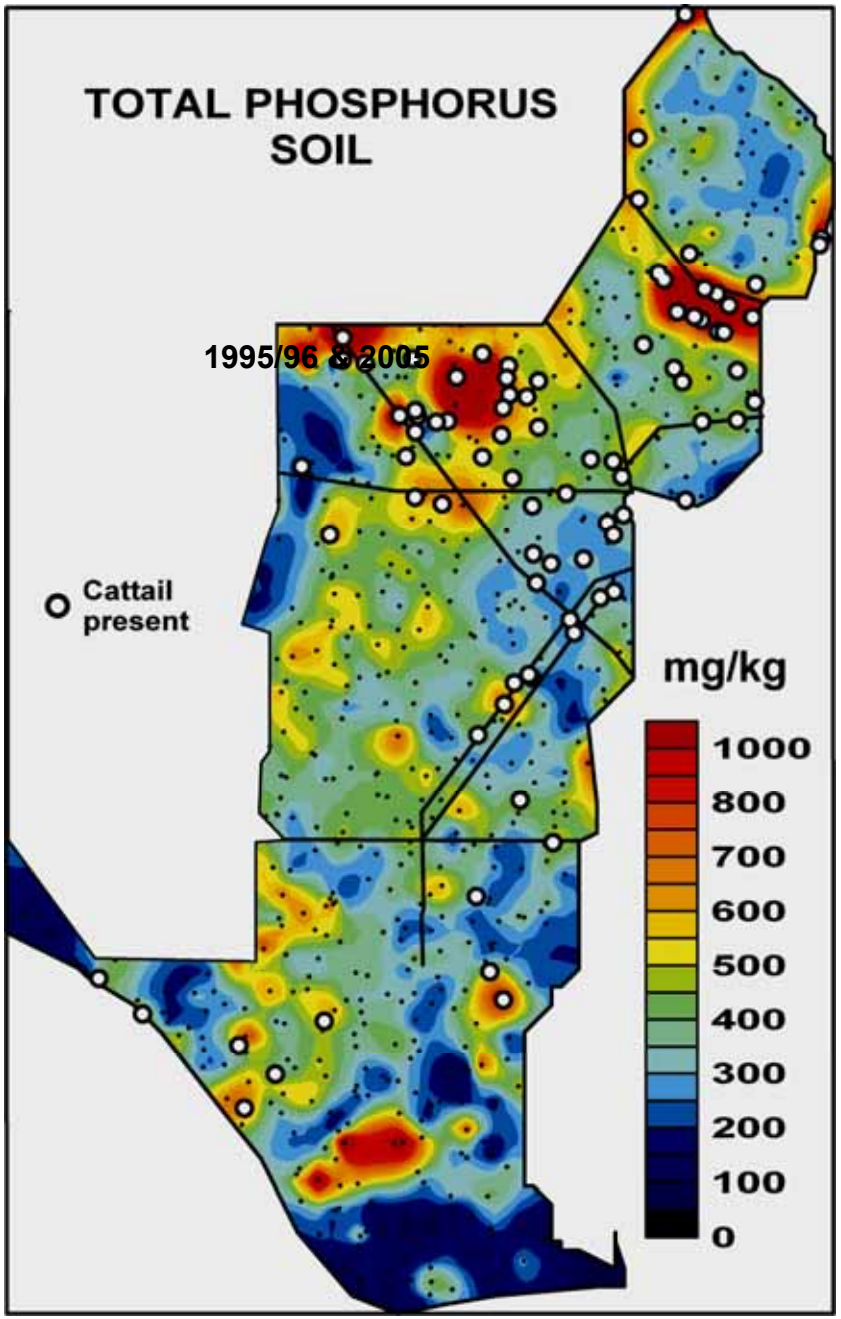
pH


pH
SOIL
NOVEMBER 2005
8
7.5
7
6.5
6
5.5
5
pH
SURFACE WATER
NOVEMBER 2005
8
7.5
7
6.5
6
5.5

Bulk Density



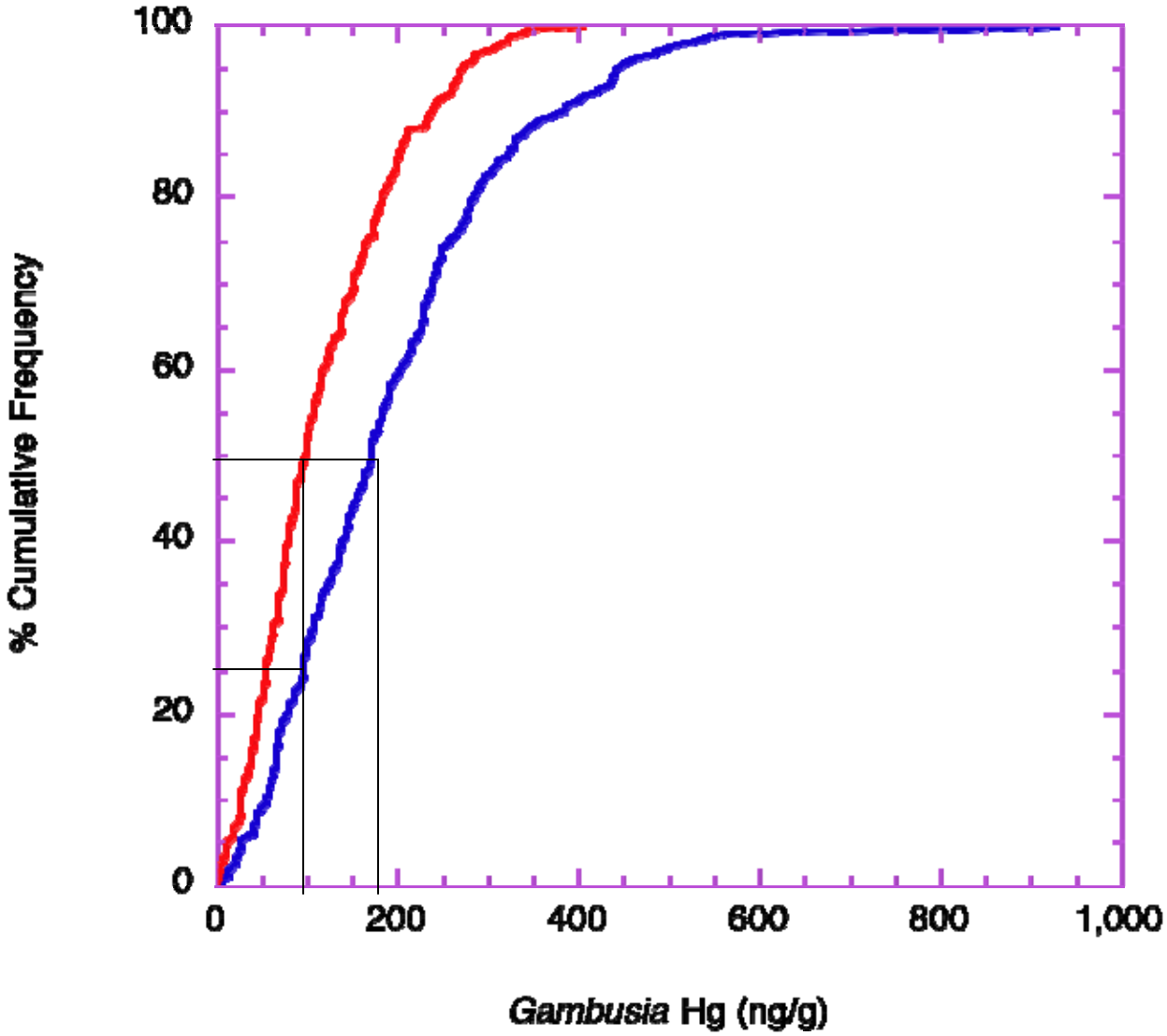
Total Phosphorus in Soil

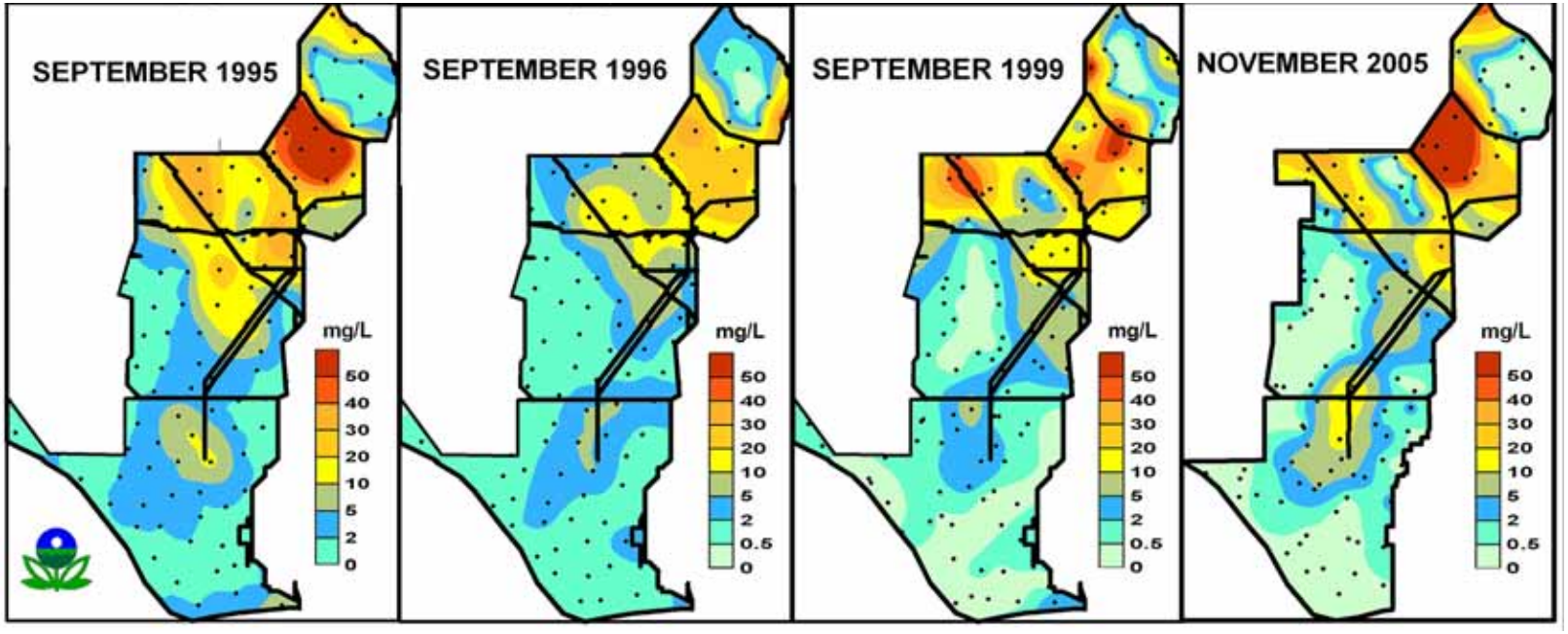


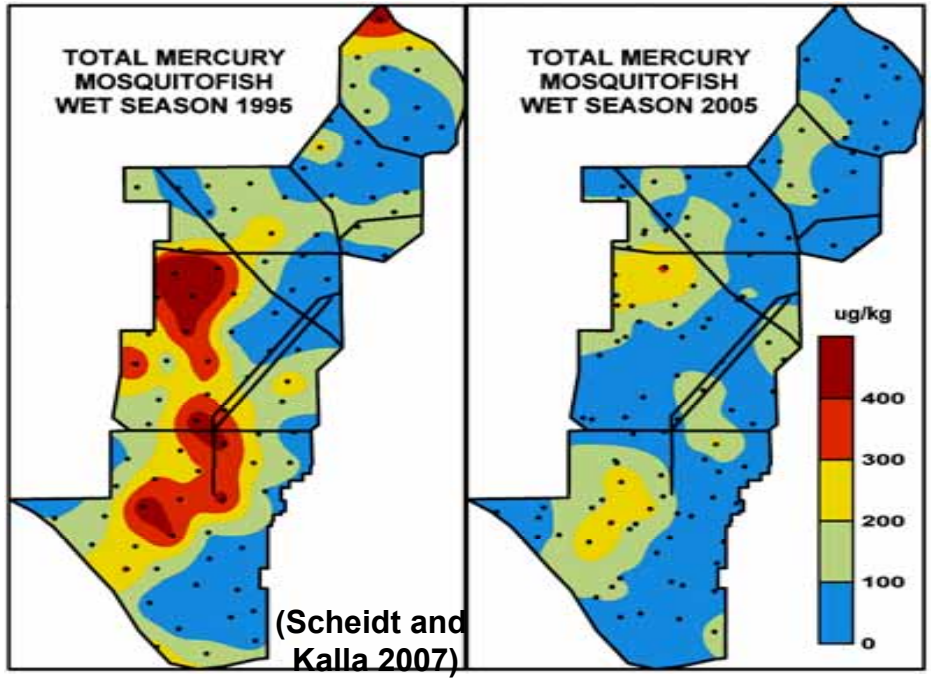
Optimal Abiotic Conditions for Elevated Mercury in Mosquitofish

- Surface water SO4: 0.5 – 40 mg/L
- Bulk density: 0.07 – 0.6 g/cm^3
- Soil TP: 100 – 800 mg/kg
- Surface water DOC: 8.0 – 35 mg/L TOC
- Surface water pH: 6.6 < pH < 8.0

Intersected Optimal Ranges of Surface Water Sulfate, pH, and TOC, and Soil TP and Bulk Density Elevates Mosquitofish Mercury Concentration

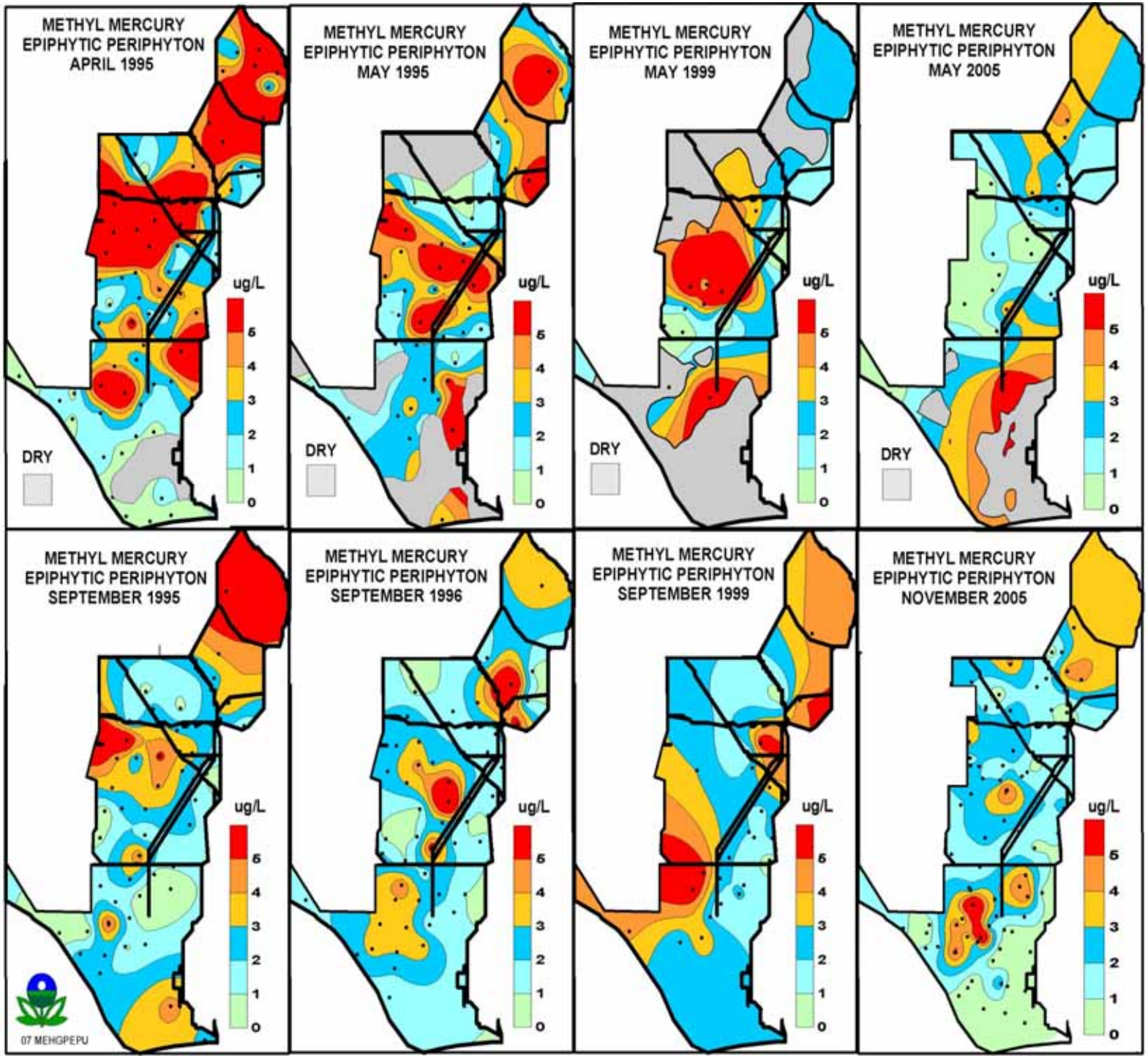


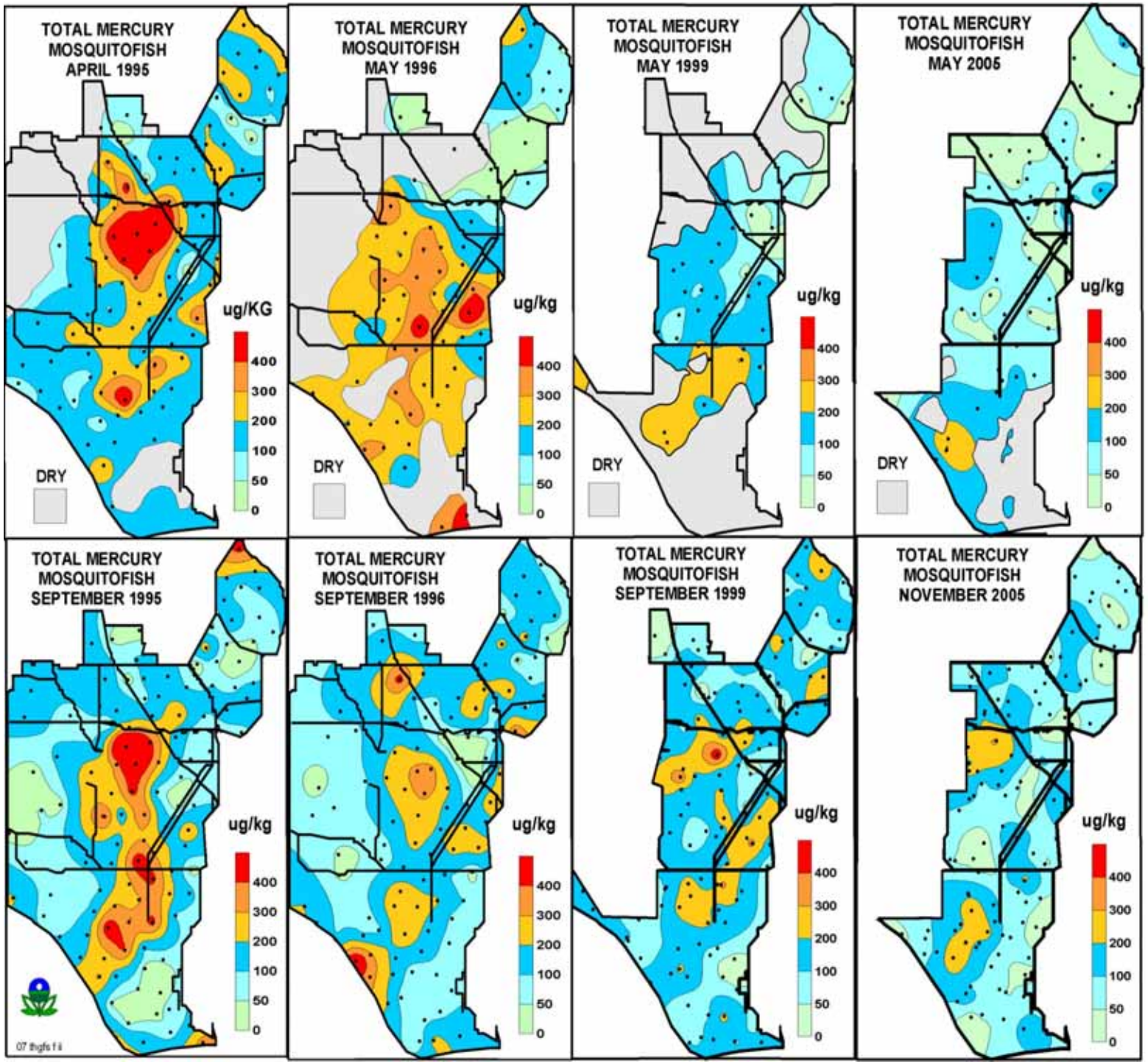


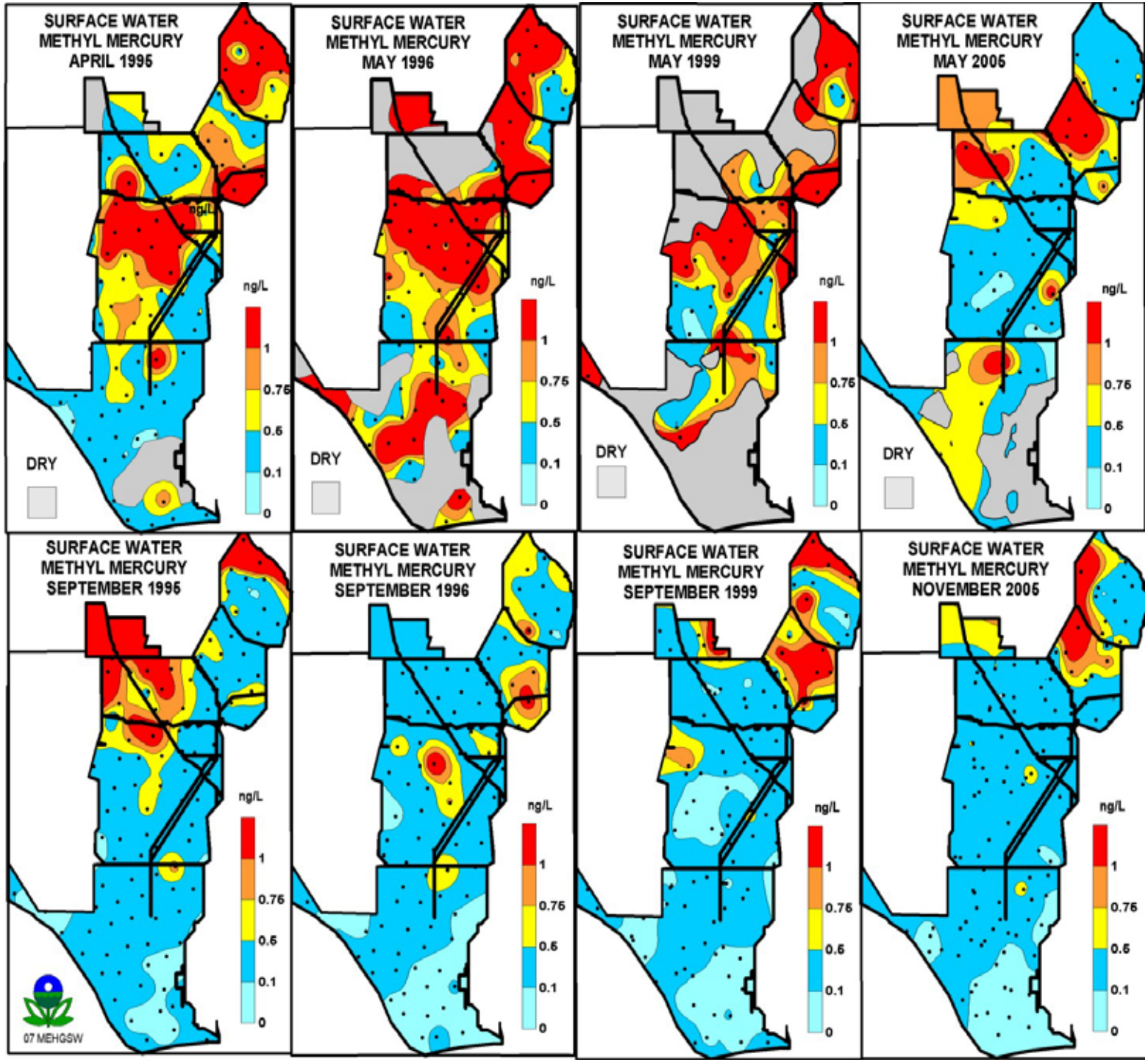


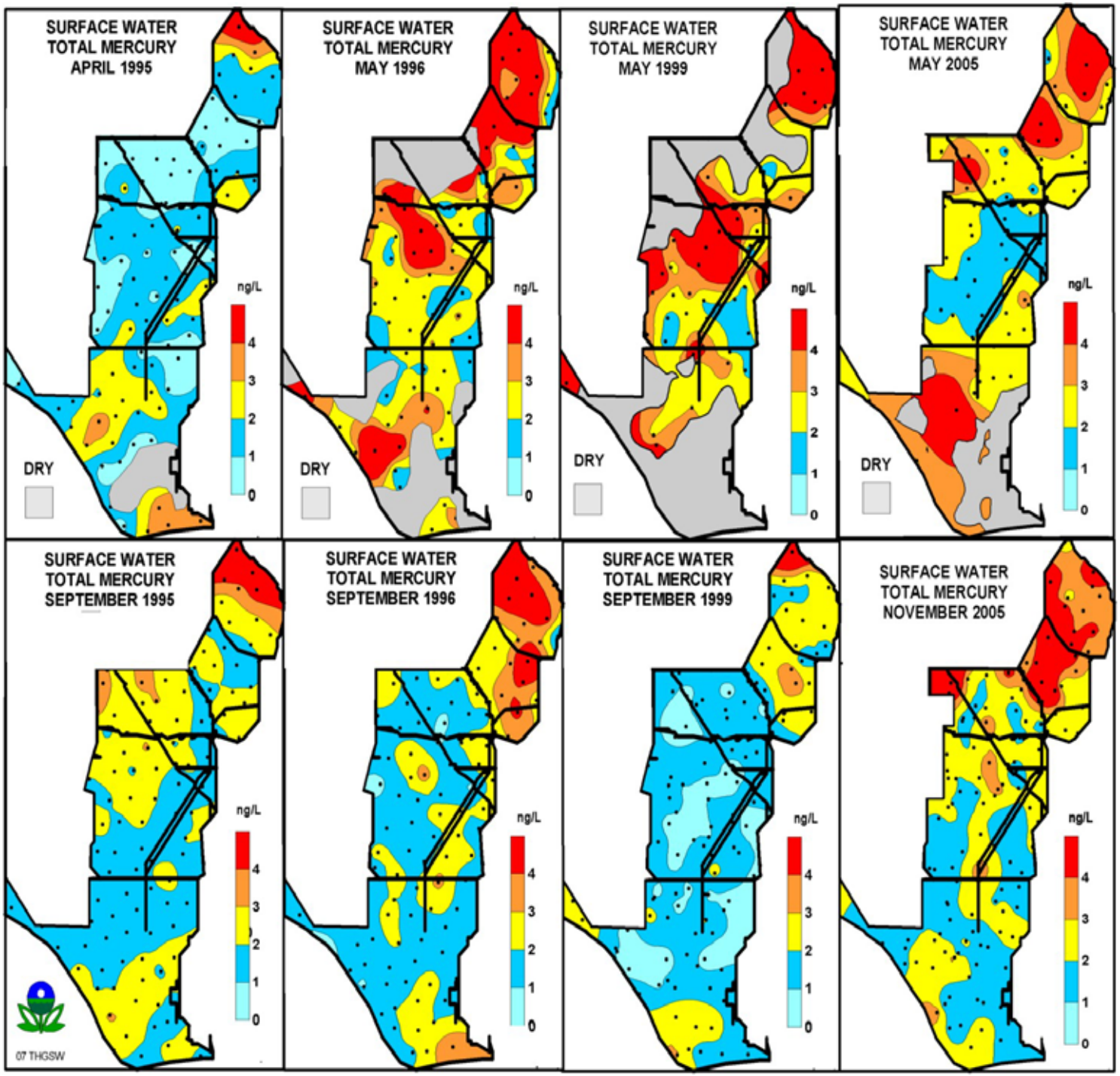
(Scheidt and Kalla 2007)

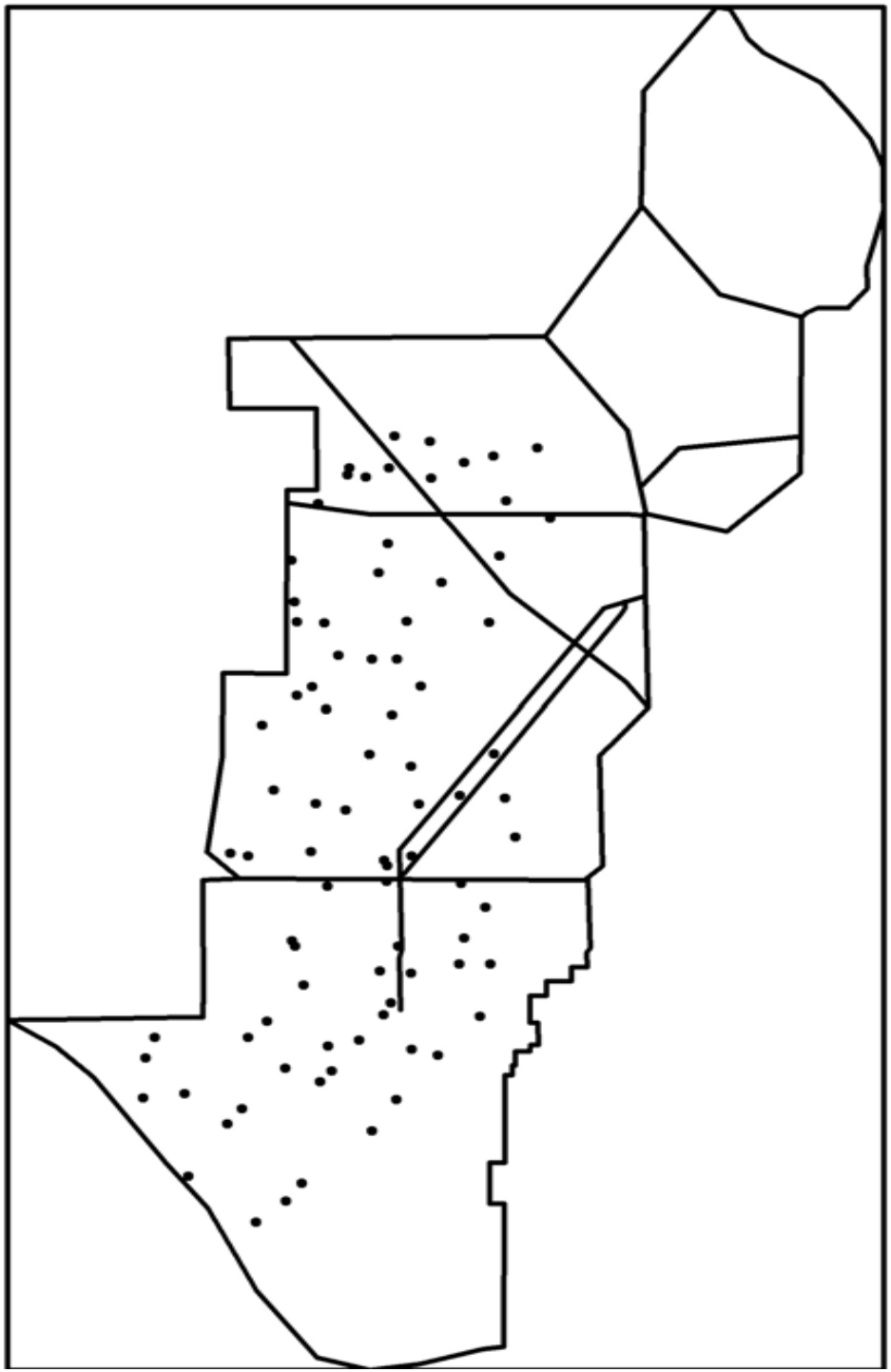
	THgFish	BAFMeHg	DOCPW	DOCSW	SO4SW	SO4PW	H2SPW	APASW	TPSW	TPFC	TPSD1
THGSW		-.4217	.5056	*.6480*	*.4309*	.3099	*.5060*		*.8789*		
MeHgSW	*.4702*	-.7801	.5537	.5953	.6503	.5602	.6080		*.6794*		*.6254*
THGSD			.4260	-.5775			.3328				.6015
MeHgSD			*.6319*	*.2455*				-.4300			.6454
BAFTHG	.9133	.7763	-.3001	-.4168		-.3821	-.3583	.5669	-.4360	-.5610	
BAFMeHG	.6477		-.4917	-.6460	-.4697	-.5380	-.6261	.5299	-.4656		-.3185
THGPE			*.8108*				*.8798*				.3259
MeHgPE	.6780										
THGPB			.8143	.6083			.6822				
MeHgPB			.6922	.5417	*.8719*						.5736
MeHgPF		-.9391									
THGPSM			.3773				.5607	*.4411*			.3047
MeHgPSM	.5830		.3668	*.4004*	*.3901*			*.4686*			.5646
THGFC			.5523							.6254	
MeHgFC			*.6405*			.5834				.7130	.6174
TCSD		*-.3345*		.5324			.4027				.6343
FDOCPW		-.4917		.7755	.6056	*.5968*	.7254	-.4550			.5034
DOCSW		-.6460	.7755		*.8438*	*.6201*	.7943	-.3749	*.5551*		.4744
AFDWSD		*-.3661*	.6219	.6003	.3079		.4803			.4594	.7599
BDSD		.4271	-.5586	-.5614			-.4359			-.4249	-.6795
COND		-.2614	*.3361*	*.8550*	*.8373*	*.6292*	.6701				*.3217*
CLSW		-.4659	.4310	*.8542*	.7917	.7439	.7887	-.3400	*.3274*		*.3512*
SO4SW		-.4697	.6056	*.8438*		.7914	*.7697*	-.2821			.2611
SO4PW		-.5380	*.5968*	*.6201*	.7914		.8057	-.4751			.2592
H2SPW		-.6261	.7254	.7943	*.7697*	.8057		-.3814			.2598
PWEh				*-.3335*	*-.3700*		*-.3863*				
depth		*-.5278*	.5307	.6004	.4204		.6664				.3047
APASW	.5054	.5299	-.4550	-.3749	-.2821	-.4751	-.3814		-.5349	*-.6617*	-.6426
CHLASW		-.2581			-.3814	-.3832		.6531	.3359		
TPSW	-.3804	-.4656		*.5551*				-.5349		*.4588*	*.6470*
TPFC	-.5834							*-.6617*	*.4588*		*.7649*
TPSD1		-.3185	.5034	.4744	.2611	.2592	.2598	-.6426	*.6470*	*.7649*	

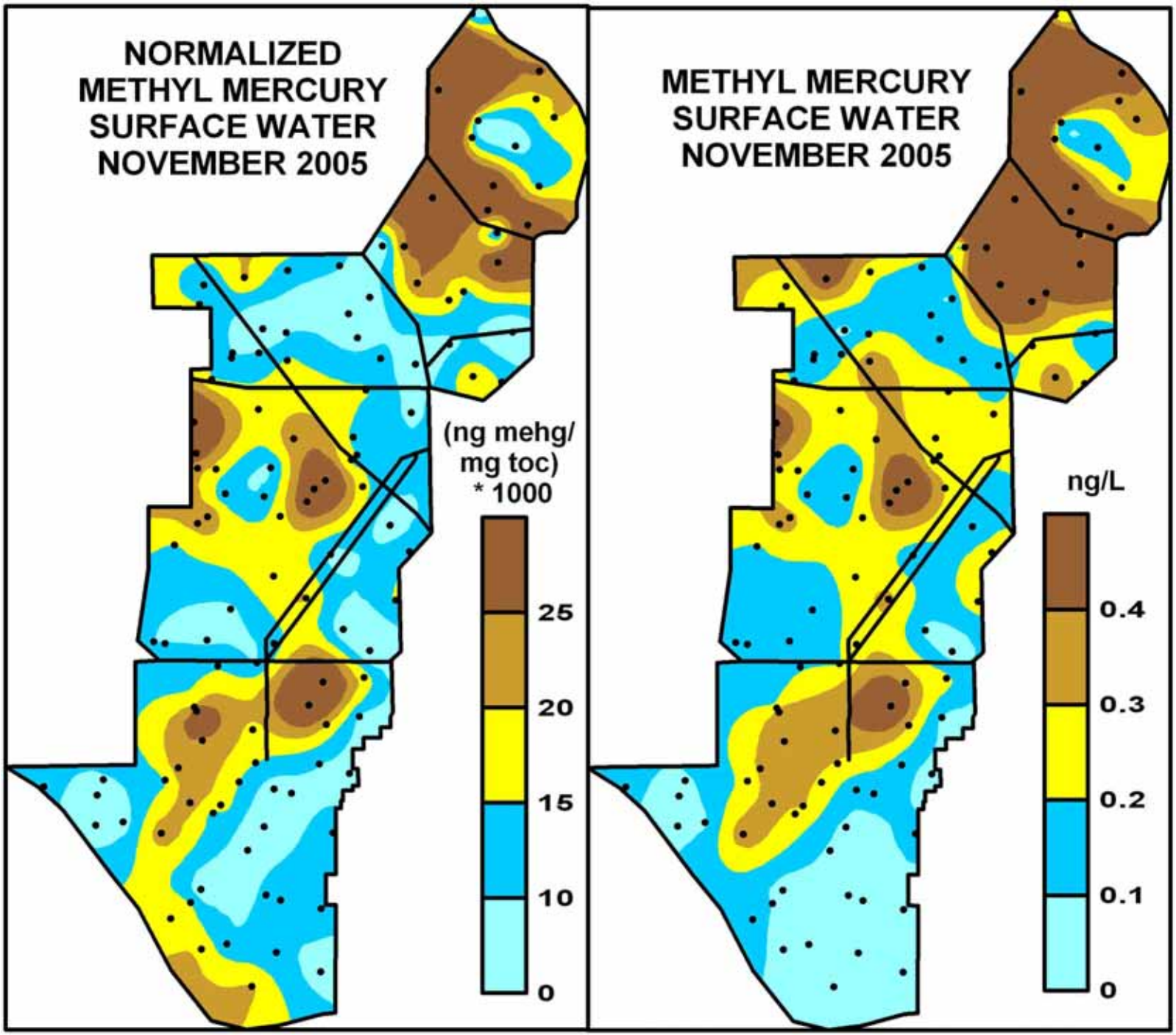

METHYL MERCURY
EPIPHYTIC PERIPHYTON
APRIL 1995
METHYL MERCURY
EPIPHYTIC PERIPHYTON
MAY 1995
METHYL MERCURY
EPIPHYTIC PERIPHYTON
MAY 1999
METHYL MERCURY
EPIPHYTIC PERIPHYTON
MAY 2005
METHYL MERCURY
EPIPHYTIC PERIPHYTON
SEPTEMBER 1995
METHYL MERCURY
EPIPHYTIC PERIPHYTON
SEPTEMBER 1996
METHYL MERCURY
EPIPHYTIC PERIPHYTON
SEPTEMBER 1999
METHYL MERCURY
EPIPHYTIC PERIPHYTON
NOVEMBER 2005
DRY
ug/L
6
5
4
3
2
1
0
07 MEHGPEPU

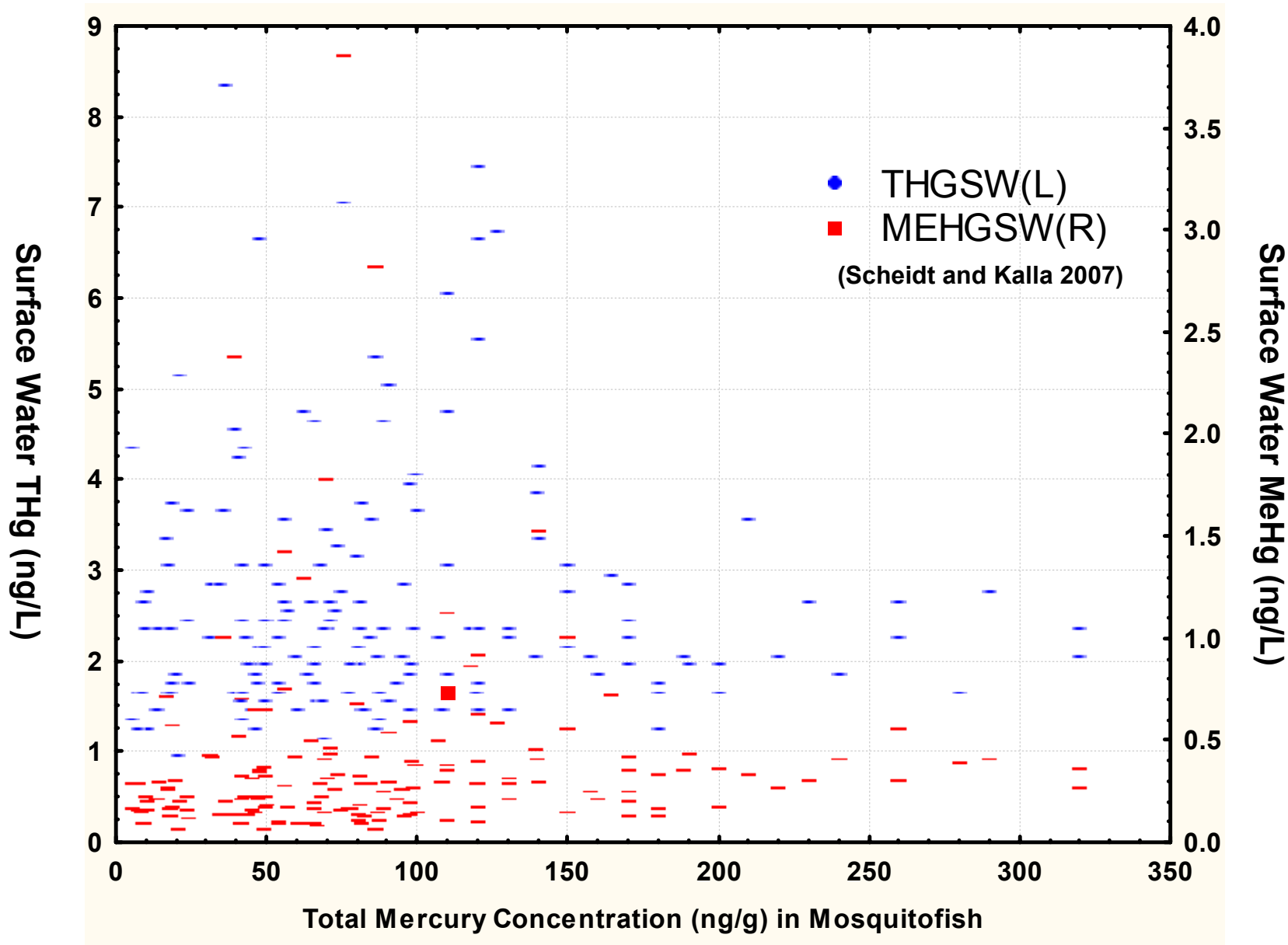

TOTAL MERCURY
MOSQUITOFISH
APRIL 1995
ug/KG
400
300
200
100
50
0
DRY
TOTAL MERCURY
MOSQUITOFISH
MAY 1996
ug/kg
400
300
200
100
50
0
DRY
TOTAL MERCURY
MOSQUITOFISH
MAY 1999
ug/kg
400
300
200
100
50
0
DRY
TOTAL MERCURY
MOSQUITOFISH
MAY 2005
ug/kg
400
300
200
100
50
0
DRY
TOTAL MERCURY
MOSQUITOFISH
SEPTEMBER 1995
ug/kg
400
300
200
100
50
0
TOTAL MERCURY
MOSQUITOFISH
SEPTEMBER 1996
ug/kg
400
300
200
100
50
0
TOTAL MERCURY
MOSQUITOFISH
SEPTEMBER 1999
ug/kg
400
300
200
100
50
0
TOTAL MERCURY
MOSQUITOFISH
NOVEMBER 2005
ug/kg
400
300
200
100
50
0


SURFACE WATER
METHYL MERCURY
APRIL 1995
SURFACE WATER
METHYL MERCURY
MAY 1996
SURFACE WATER
METHYL MERCURY
MAY 1999
SURFACE WATER
METHYL MERCURY
MAY 2005
SURFACE WATER
METHYL MERCURY
SEPTEMBER 1995
SURFACE WATER
METHYL MERCURY
SEPTEMBER 1996
SURFACE WATER
METHYL MERCURY
SEPTEMBER 1999
SURFACE WATER
METHYL MERCURY
NOVEMBER 2005
DRY
ng/L
1
0.75
0.5
0.1
0
07 MEHGSW


SURFACE WATER
TOTAL MERCURY
APRIL 1995
DRY
ng/L
4
3
2
1
0
SURFACE WATER
TOTAL MERCURY
MAY 1996
DRY
ng/L
4
3
2
1
0
SURFACE WATER
TOTAL MERCURY
MAY 1999
DRY
ng/L
4
3
2
1
0
SURFACE WATER
TOTAL MERCURY
MAY 2005
DRY
ng/L
4
3
2
1
0
SURFACE WATER
TOTAL MERCURY
SEPTEMBER 1995
ng/L
4
3
2
1
0
07 THGSW
SURFACE WATER
TOTAL MERCURY
SEPTEMBER 1996
ng/L
4
3
2
1
0
SURFACE WATER
TOTAL MERCURY
SEPTEMBER 1999
ng/L
4
3
2
1
0
SURFACE WATER
TOTAL MERCURY
NOVEMBER 2005
ng/L
4
3
2
1
0

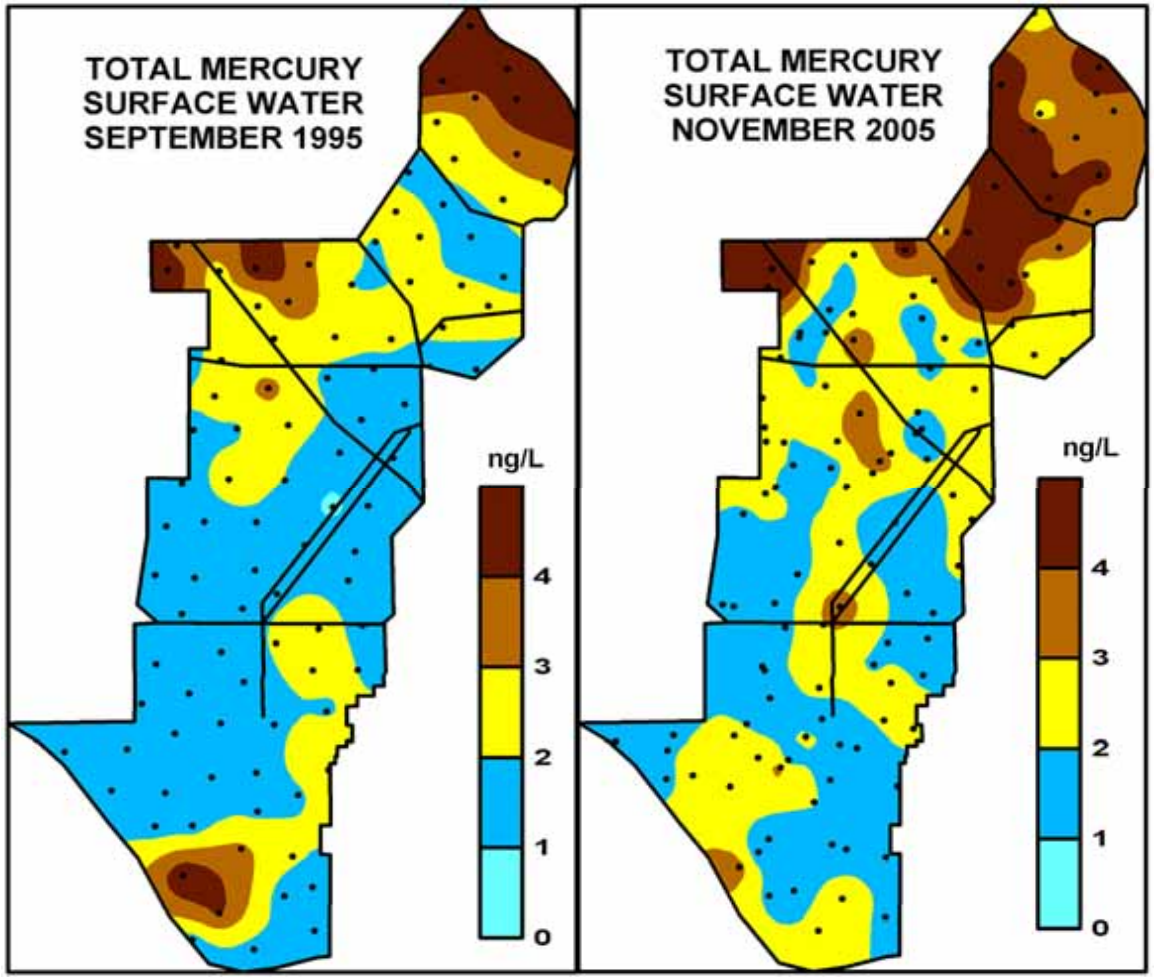



NORMALIZED
METHYL MERCURY
SURFACE WATER
NOVEMBER 2005
(ng mehg/
mg toc)
* 1000
25
20
15
10
0
METHYL MERCURY
SURFACE WATER
NOVEMBER 2005
ng/L
0.4
0.3
0.2
0.1
0


THGSW(L)
MEHGSW(R)
(Scheidt and Kalla 2007)
Surface Water THg (ng/L)
Surface Water MeHg (ng/L)
Total Mercury Concentration (ng/g) in Mosquitofish
0
1
2
3
4
5
6
7
8
9
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
50
100
150
200
250
300
350

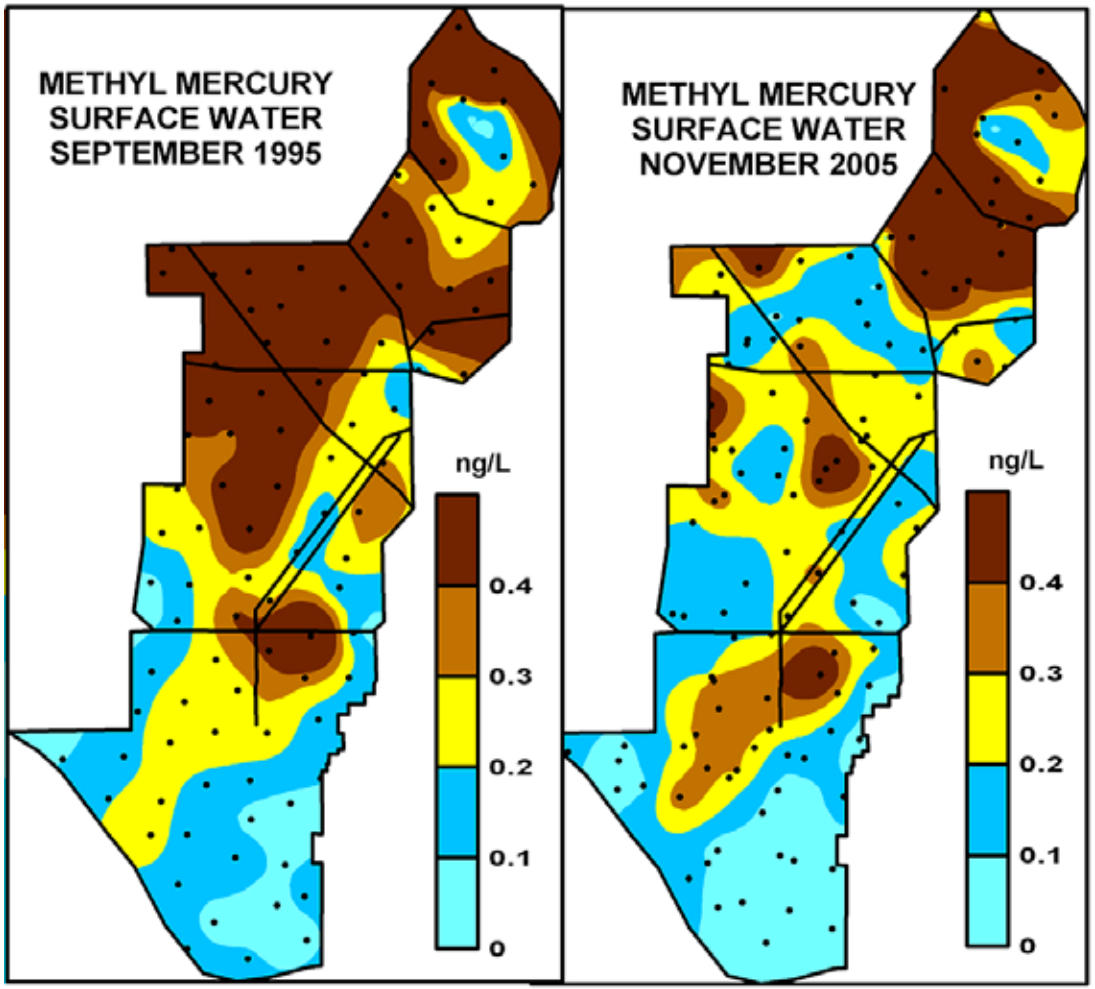
Water Total Mercury, 1995 & 2005

Wet Season



Water Methyl Mercury, 1995 & 2005

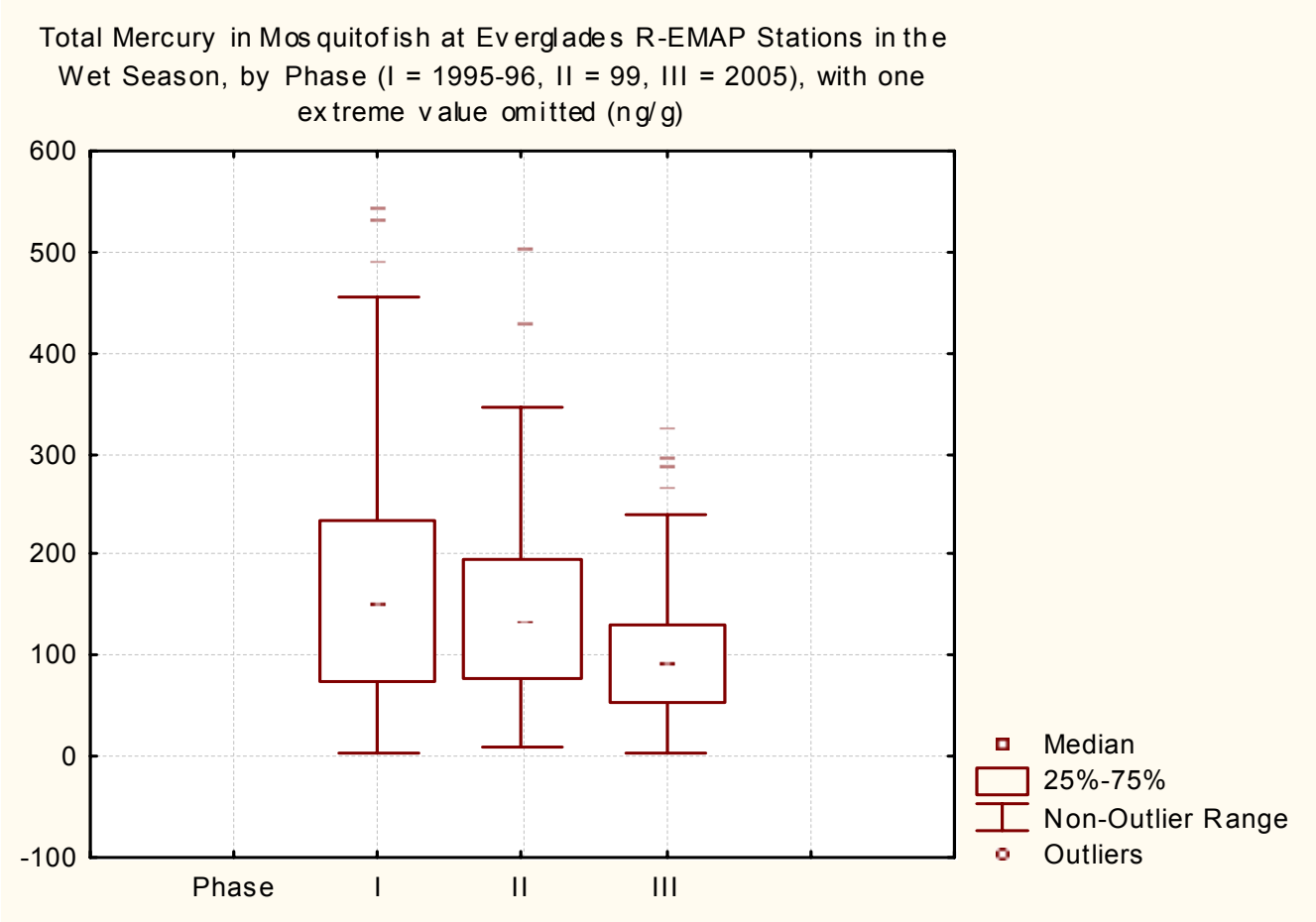
Wet Season



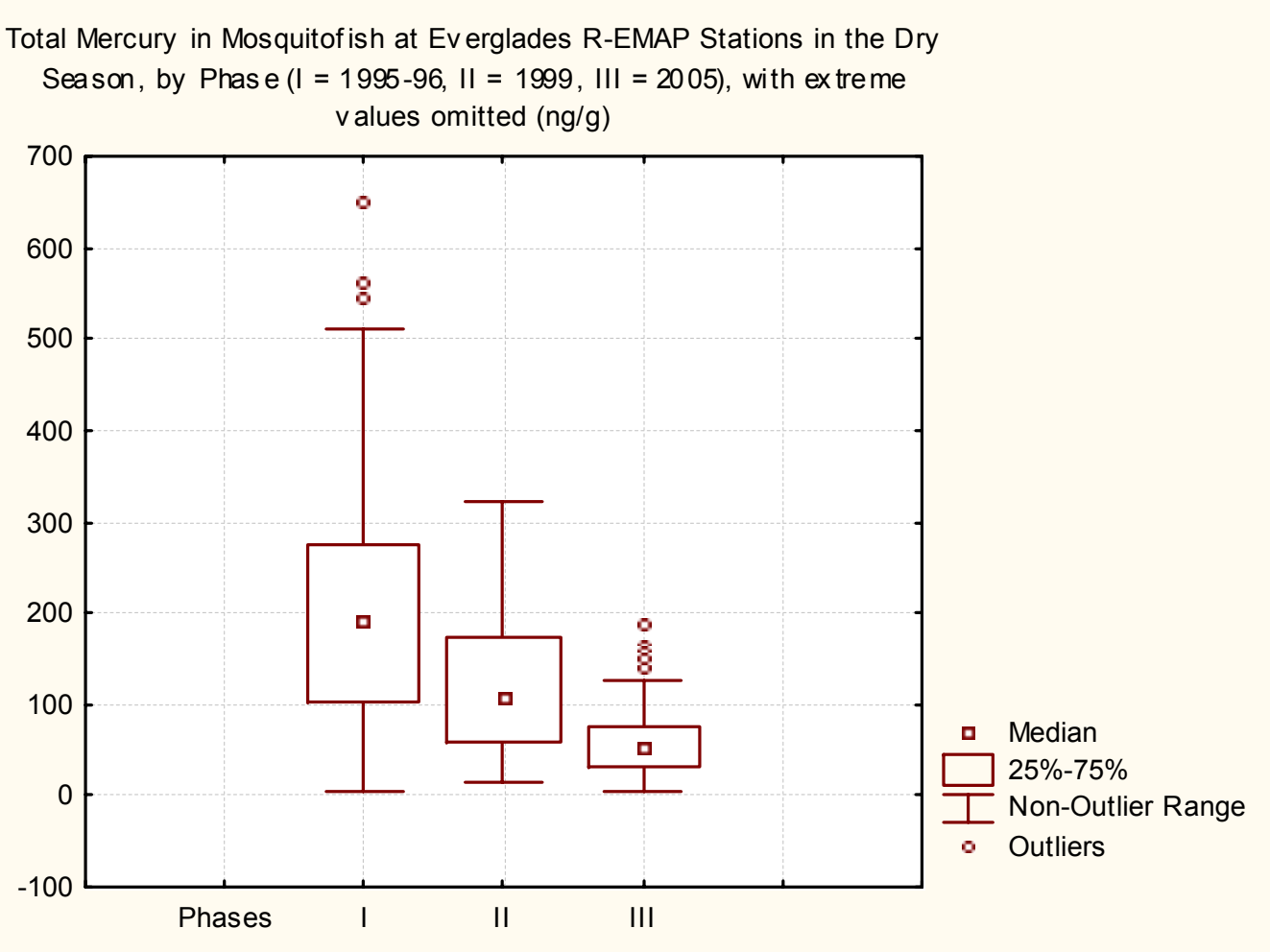
Slight drop 1995 to 1999

Slight increase 1999 to 2005

Mosquitofish Mercury 1995/96, 1999, 2005
Wet Season



Mosquitofish Mercury 1995/96, 1999, 2005
Dry Season



Program Findings
1995/96 -- 1999 -- 2005

- Mercury in fish and water:
  - Mosquitofish: pronounced drop
    - **142 ↘ 127 ↘ 87 ug/kg**
  - Surface water:
    - Less methyl mercury
      - 0.28 ↘ 0.19 ↗ 0.21ng/L
    - More total mercury
      - 1.86 → 1.90 ↗ 2.20 ng/L
    - Many values at or near MDL

Mercury in Periphyton
1995 - 2005

- Dry Season
  - **Methyl mercury declined**
    - In floating periphyton growth form
    - In benthic periphyton growth form
    - In epiphytic periphyton growth form

Conclusions & Synthesis

- Mercury in mosquitofish has declined.
  - by up to 133 ng/g in median values
- Mercury in some periphyton has declined.
  - tHg in core wet epiphytic (-126 ng/g)
- All other changes are very subtle.
  - Slightly (0.3 ng/L) more total mercury in water.
  - Slightly (0.08 ng/L) less methyl mercury in water.
- Mercury decline may be explained by changes in sulfate and organic carbon that are translated to fish via the food web.

Acknowledgements:

Yong Cai, Guangliang Liu

Len Scinto, Joe Boyer

Brenda LaSorsa

Tim Fitzpatrick

Danny Adams, Pam Betts

Mel Parsons, Phyllis Meyer

Jenny Richards