Basin Plan Amendment for the Development of Methylmercury Total Maximum Daily Load for the Lower American River and Lake Natoma

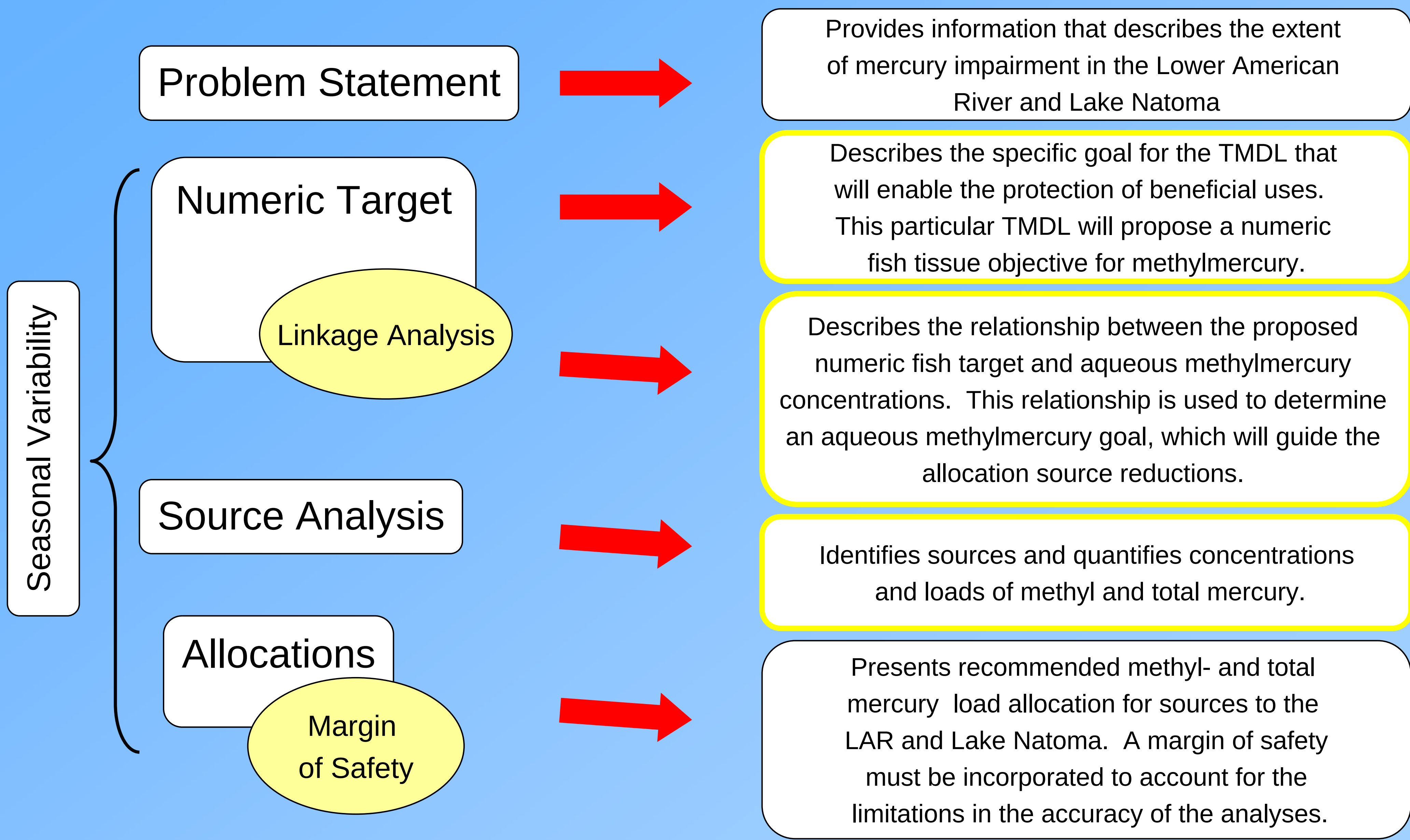
Stakeholder Meeting

August 12, 2010

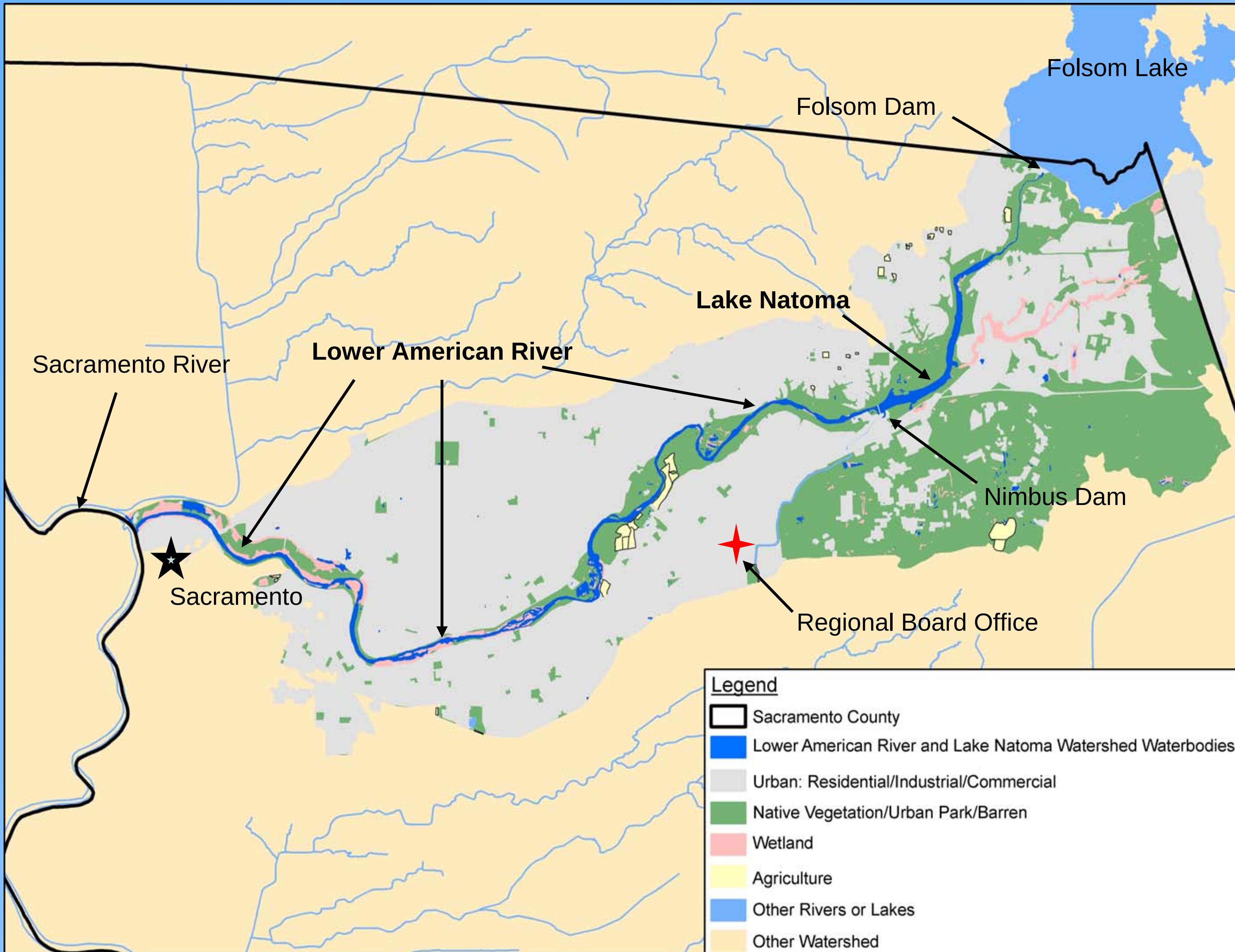
Overview

- Brief Review of the Mercury Problem in the Lower American River and Lake Natoma
- Sources of Inorganic Mercury
- Sources of Methylmercury
- Numeric Targets
- Linkage Analysis
- Next Steps

TMDL Elements



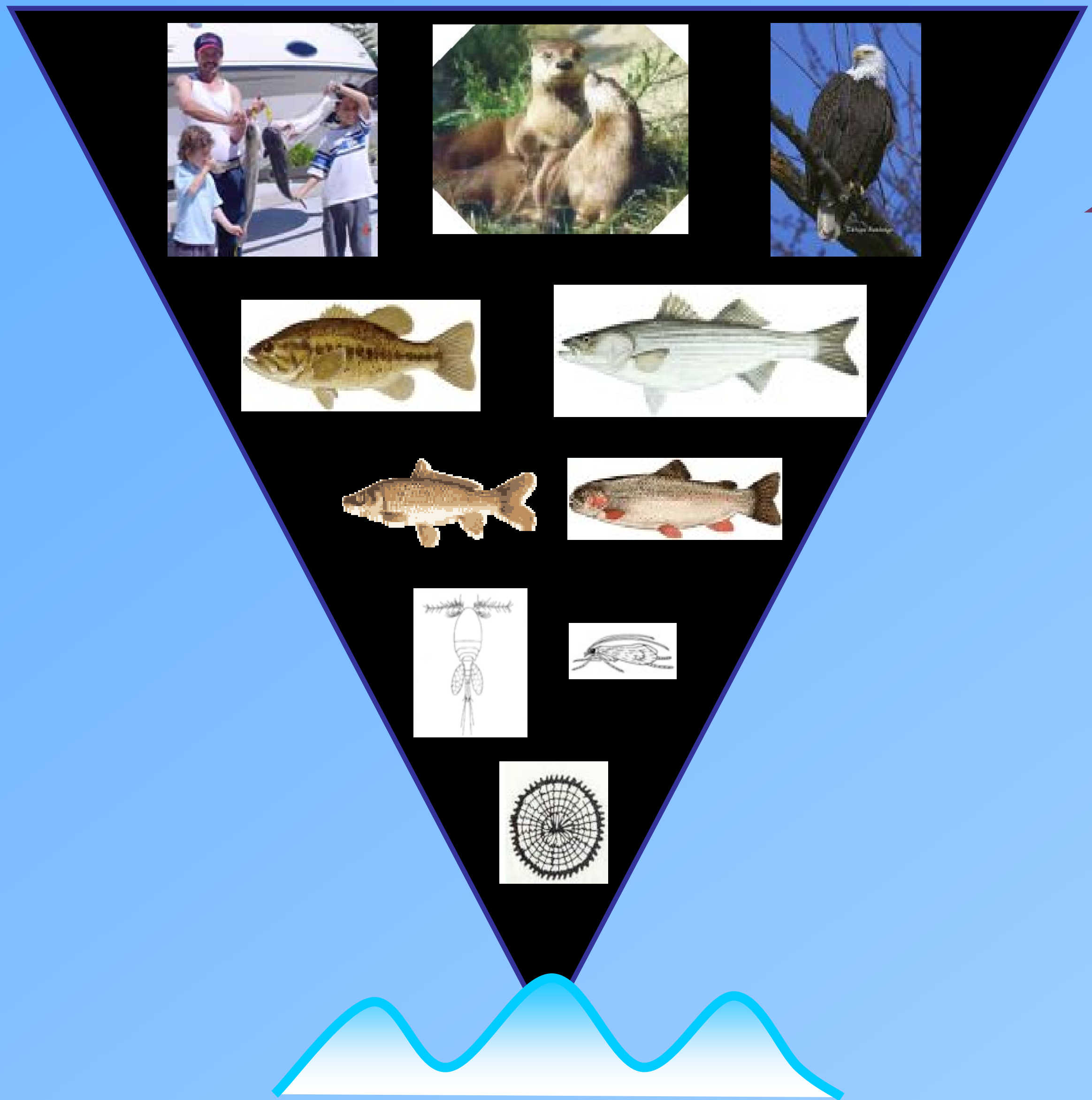
Scope of the Project



Why is Mercury a Problem?

- Mercury is a toxicant that impairs the nervous, reproductive, and immune systems in humans and wildlife.
- Mercury can have lethal and sub-lethal effects.
- Offspring can be exposed to mercury during embryonic development.
- Methylmercury (MeHg) is one of the most toxic forms because it is more readily absorbed and excreted more slowly.
- Exposure is mainly through the consumption of fish.

MMHg Bioaccumulates…



Top Predators

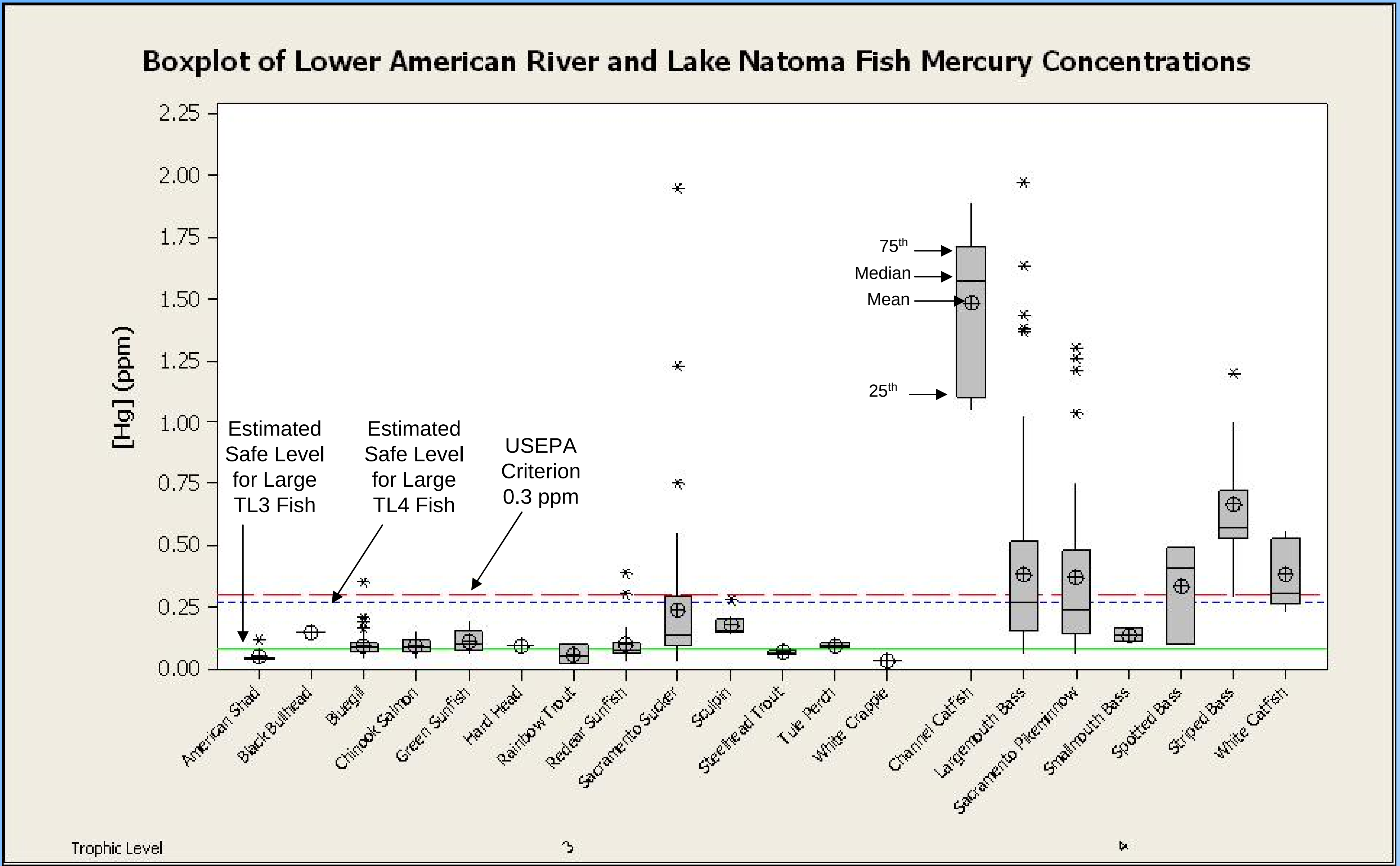
Trophic Level 4
bass, catfish
pikeminnow

Trophic Level 3
bluegill, carp,
silverside, sucker

Trophic Level 2
juvenile fish,
zooplankton

Trophic Level 1
diatoms, algae

Extent of Impairment



Summary of Non-Anadromous Fish Mercury Concentrations Collected from the Lower American River and Lake Natoma During 2000-2008

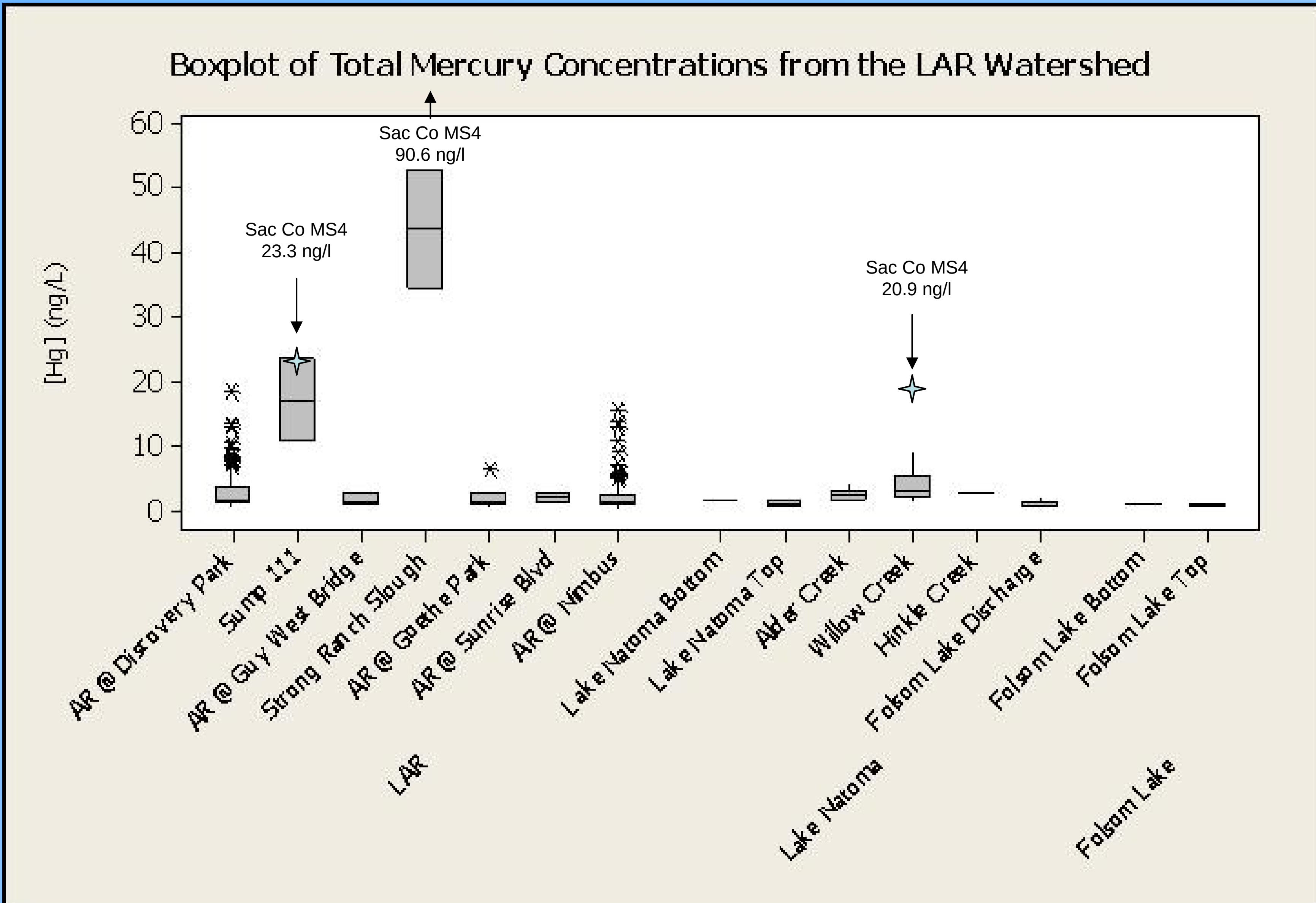
Trophic Level	Species	Sample Number	Mean [Hg] (ppm)	Median	Standard Deviation	Minimum	Maximum
Trophic Level 3	Black Bullhead	1	0.145	0.145	--	0.145	0.145
	Bluegill	114	0.091	0.083	0.041	0.041	0.353
	Green Sunfish	5	0.109	0.098	0.052	0.061	0.196
	Hard Head	1	0.088	0.088	--	0.088	0.088
	Rainbow Trout	2	0.059	0.059	0.054	0.020	0.097
	Redear Sunfish	32	0.095	0.074	0.073	0.028	0.388
	Sacramento Sucker	56	0.210	0.124	0.301	0.029	1.951
	Sculpin	8	0.174	0.153	0.049	0.141	0.281
	Tule Perch	4	0.092	0.092	0.009	0.081	0.103
	White Crappie	3	0.031	0.031	0.001	0.030	0.031
Trophic Level 4	Channel Catfish	11	1.482	1.576	0.289	1.049	1.887
	Largemouth Bass	139	0.381	0.262	0.333	0.058	1.976
	Sacramento Pikeminnow	30	0.322	0.191	0.324	0.062	1.260
	Smallmouth Bass	2	0.135	0.135	0.040	0.107	0.163
	Spotted Bass	3	0.330	0.407	0.207	0.096	0.488
	White Catfish	6	0.357	0.294	0.142	0.223	0.560

- Both TL3 and TL4 fish exhibit statistically significant relationships between length and mercury concentration.
- No significant increases or decreases were found over time, when adjusted for length.
- No significant differences were found between LAR and Lake Natoma fish mercury concentrations, when adjusted for length.
- No significant differences were found within trophic level species mean mercury concentrations, when adjusted for length.

Sources of Inorganic and Methyl- Mercury

- THg Concentration Data
- MeHg Concentration Data
- THg Loads
- MeHg Loads

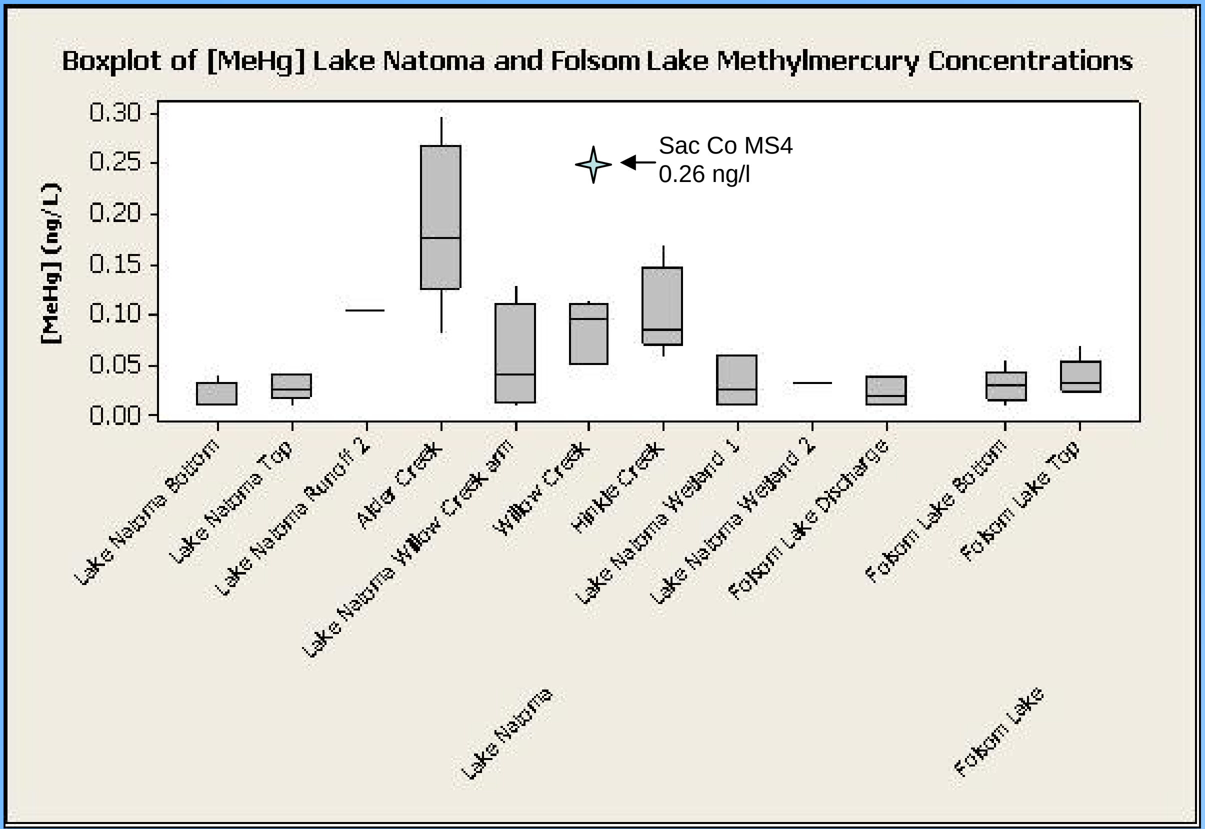
Total Mercury Concentrations



Total Mercury Concentrations

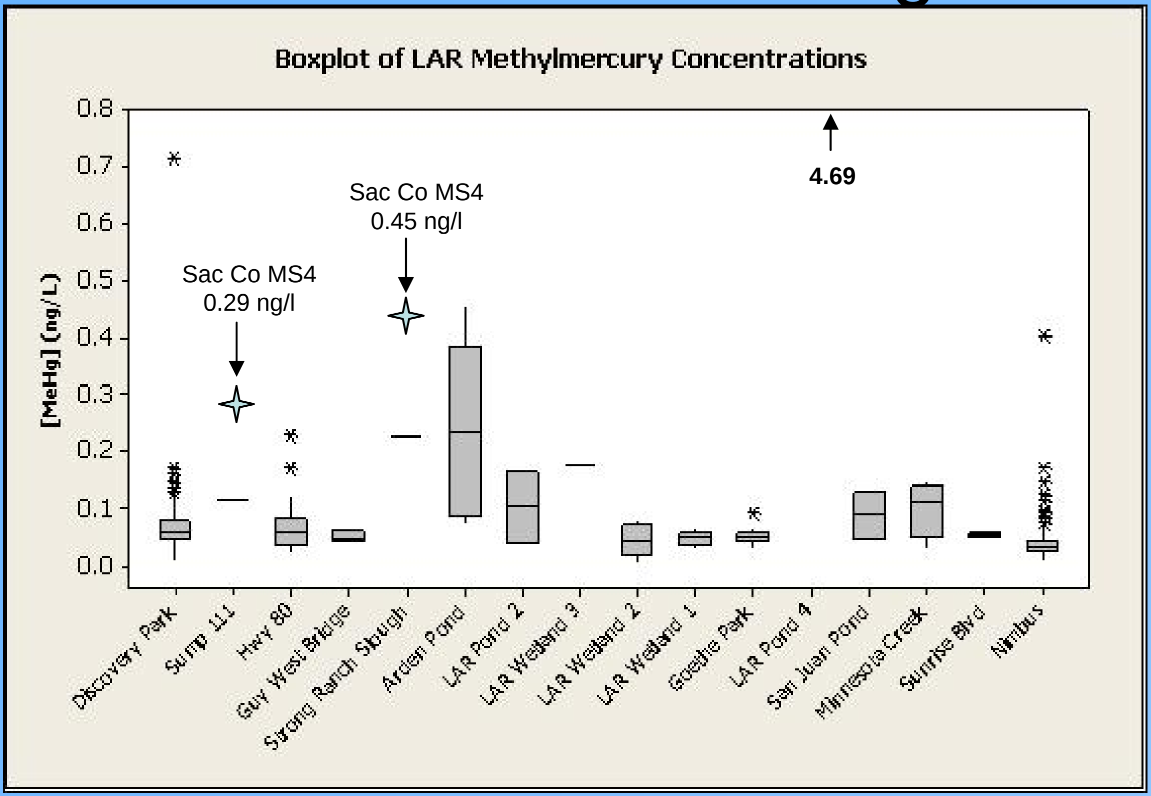
Station Name	n	Mean	Minimum	Median	Maximum
AR @ Discovery Park	240	2.60	0.46	1.71	18.51
Sump 111	**2**	**17.14**	**10.68**	**17.14**	**23.6**
AR @ Guy West Bridge	3	1.60	0.99	1.13	2.67
Strong Ranch Slough	**2**	**43.55**	**34.3**	**43.55**	**52.8**
AR @ Goethe Park	8	2.12	0.57	1.46	6.23
AR @ Sunrise Blvd	2	1.96	1.25	1.955	2.66
AR @ Nimbus	199	2.09	0.083	1.33	15.4
Lake Natoma Bottom	1	1.64	1.64	1.64	1.64
Lake Natoma Top	5	0.99	0.476	0.876	1.63
Alder Creek	**5**	**2.40**	**1.48**	**2.273**	**3.681**
Willow Creek	**6**	**3.82**	**1.83**	**3.02**	**9.03**
Hinkle Creek	1	2.71	2.712	2.712	2.712
Folsom Lake Discharge	6	0.95	0.49	0.716	1.9
Folsom Lake Bottom	1	0.83	0.83	0.83	0.83
Folsom Lake Top	3	0.77	0.504	0.839	0.966

Lake Natoma MeHg Concentrations



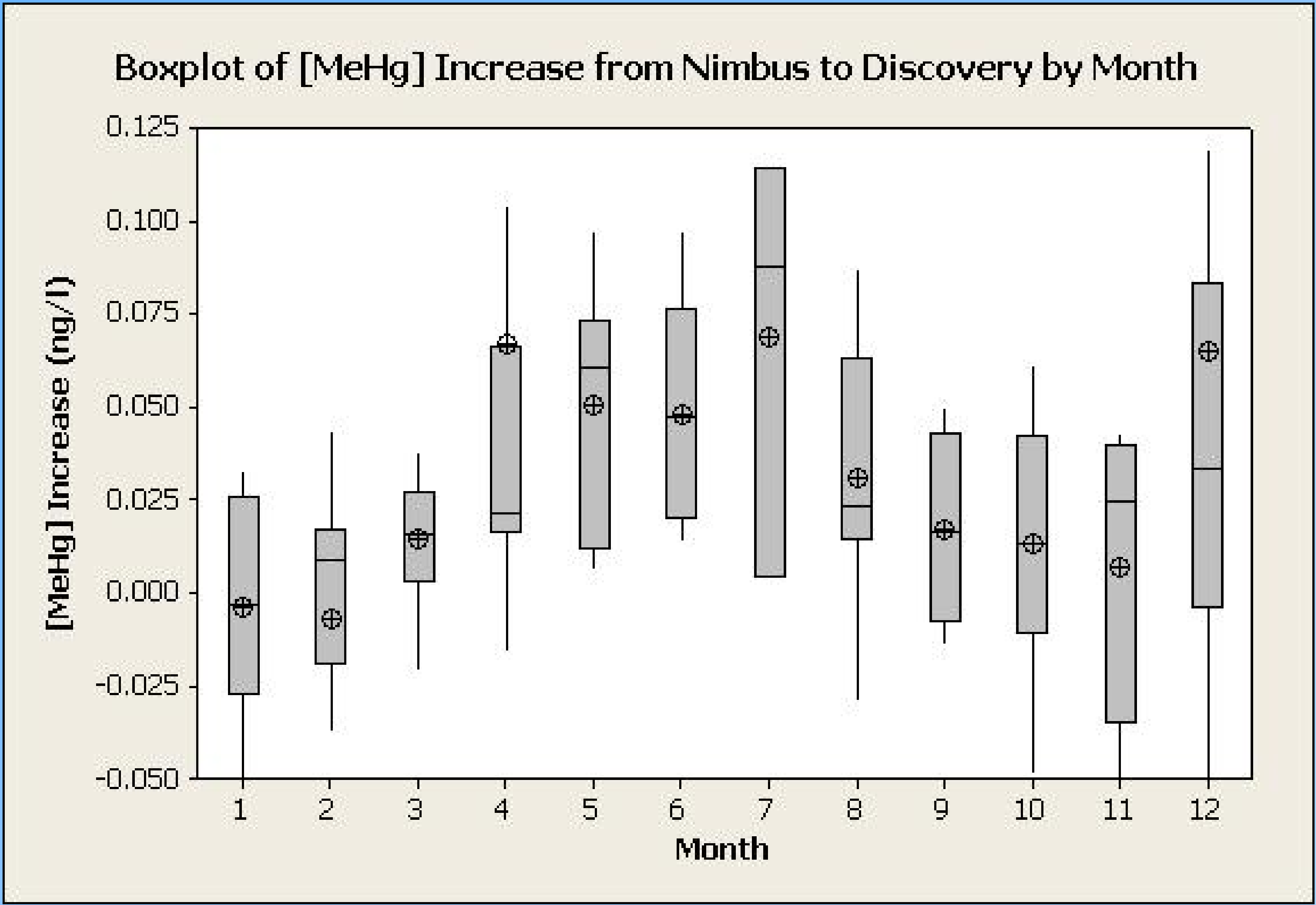
Station Name	n	Mean	Minimum	Median	Maximum
AR @ Nimbus	103	0.045	0.0096	0.033	0.406
Lake Natoma Bottom	6	0.018	0.01	0.01	0.04
Lake Natoma Top	6	0.028	0.01	0.0265	0.042
Lake Natoma Runoff 2	1	0.104	0.104	0.104	0.104
Alder Creek	**5**	**0.192**	**0.082**	**0.177**	**0.294**
Lake Natoma Willow Creek Arm	4	0.056	0.01	0.042	0.128
Willow Creek	**6**	**0.086**	**0.049**	**0.097**	**0.113**
Hinkle Creek	**5**	**0.104**	**0.058**	**0.086**	**0.167**
Lake Natoma Wetland 1	5	0.033	0.01	0.026	0.061
Lake Natoma Wetland 2	1	0.033	0.033	0.033	0.033
Folsom Lake Discharge	6	0.023	0.01	0.02	0.04
Folsom Lake Bottom	5	0.029	0.01	0.03	0.055
Folsom Lake Top	5	0.038	0.024	0.032	0.0695

LAR MeHg Concentrations



Station Name	n	Mean	Minimum	Median	Maximum
AR @ Discovery Park	122	0.071	0.01	0.0575	0.714
Sump 111	1	0.117	0.117	0.117	0.117
AR @ Hwy 80	19	0.073	0.025	0.0581	0.229
AR @ Guy West Bridge	3	0.051	0.044	0.0492	0.0609
Strong Ranch Slough	1	0.225	0.225	0.225	0.225
Arden Pond	**6**	**0.241**	**0.076**	**0.2325**	**0.454**
LAR Pond 2	2	0.104	0.042	0.1035	0.165
LAR Wetland 3	1	0.177	0.177	0.177	0.177
LAR Wetland 2	4	0.045	0.01	0.0435	0.081
LAR Wetland 1	5	0.049	0.035	0.053	0.065
AR @ Goethe Park	12	0.053	0.035	0.051	0.0928
LAR Pond 4	**1**	**4.690**	**4.69**	**4.69**	**4.69**
San Juan Pond	2	0.089	0.049	0.089	0.129
Minnesota Creek	4	0.101	0.035	0.111	0.146
AR @ Sunrise Blvd	2	0.054	0.0508	0.0539	0.057
AR @ Nimbus	103	0.045	0.0096	0.033	0.406

MeHg Increases By Month



Total Mercury Mass Balance

Source/Sink	THg Load (g/yr)	% of Sources to Lake Natoma	% of Sources to LAR
Folsom Dam	3135	36%	
Urban Runoff/Urban Tribs[a]	218	2%	
Sediment Flux[b]	91	1%	
Atmospheric Deposition (Direct and Indirect)[c]	28	0.3%	
Hatchery & Canal	-87	--	
Evasion[d]	-696	--	
Unknown Source to Lake Natoma	**5,333**	61%	
Nimbus Dam	**8,022**		63%
Urban Runoff[a]	2,003		16%
Sediment Flux[b]	252		2%
Atmospheric Deposition (Direct and Indirect)[c]	55		0.4%
Evasion[d]	-1915		--
NPDES Facilities[e]	974		8%
Unknown Source to LAR	**1399**		11%
American River @ Discovery Park	**10,790**		

[a]LWA, 2009. Sacramento Stormwater Quality Partnership, Additional Total Mercury and Methylmercury Analyses.

[b]Choe, 2004. Sediment Flux = 130 ng/m2/day

[c]Stephenson, 2008. Wet Deposition = 2.1 $ng/m^2/day$, Dry Deposition = 4.5 $ng/m^2/day$, multiplied by runoff coefficient.

[d]Stephenson, 2008. Evasion = 0.99 $ug/m^2/day$

[e]Bosworth, 2010. A Review of Methylmercury Discharges from NPDES Facilities in California's Central Valley.

Methylmercury Mass Balance

Source/Sink	MeHg Load (g/yr)	% of Sources to Lake Natoma	% of Sources to LAR
Folsom Dam	76.8	55%	
Urban Runoff/Urban Tribs[a]	2.4	2%	
Open Water Sediment Flux[b]	3.3	2%	
Atmospheric Deposition (Wet Deposition only)[c]	0.6	0.4%	
Hatchery & Canal	-2.5	--	
Instream Wetlands[d]	7.9	6%	
Upstream Wetlands[e]	13	9%	
Unknown Source to Lake Natoma	**36**	25%	
Nimbus Dam	**137**		62%
Urban Runoff[a]	21.6		10%
Open Water Sediment Flux[b]	9		4%
Atmospheric Deposition (Direct and Indirect)[c]	1		0.5%
Instream Wetlands[d]	23		10%
Upstream Wetlands[e]	12.8		6%
NPDES Facilities[f]	4.6		2%
Unknown Source to LAR	**12**		5%
American River @ Discovery Park	**221**		

[a]LWA, 2009. Sacramento Stormwater Quality Partnership, Additional Total Mercury and Methylmercury Analyses.

[b]Stephenson, 2008. Sediment Flux = 4.65 ng/m^2/day

[c]Stephenson, 2008. MeHg wet deposition = 3.4% THg wet deposition. No estimate of MeHg dry deposition.

[d]Wood, 2010. Delta wetland production rates: warm season = 40.6 ng/m^2/yr and cool season = 3.0 ng/m^2/yr. Wetland acreage located within 50 meters of mainstem water bodies.

[e]Wood, 2010. Delta wetland production rates: warm season = 40.6 ng/m2/yr and cool season = 3.0 ng/m2/yr. Wetland acreage located outside of 50 meters from mainstem water bodies.

[f]Bosworth, 2010. A Review of Methylmercury Discharges from NPDES Facilities in California's Central Valley.

Numeric Targets

- Numeric targets are the specific goals for the TMDL that will enable the protection of the beneficial uses of the LAR and Lake Natoma. The development of numeric targets involves the following elements:
  - Identification of the target media and the basis for using the selected target media to interpret or apply applicable water quality standards.
    - Target media examples: various biota, aqueous or sediment concentrations, etc.
  - Identification of target levels for the selected target media and the technical basis for the target levels.
  - Comparison of historical or existing conditions and desired future conditions for the target media selected for the TMDL.
- This TMDL will propose a numeric fish tissue objective for methylmercury.
  - Levels of methylmercury in fish tissue directly indicate whether beneficial uses are being met.

Development of the Numeric Target

- Key variables that are incorporated into the calculation of fish tissue targets are:
  - Acceptable daily dose level of methylmercury;
  - Body weight (bwt) of the consumer;
  - Trophic level or size of fish consumed; and
  - Rate of fish consumption.
- These components can be related using a basic equation (OEHHA, 2000; USEPA, 1995c):

$$\frac{\text{Safe daily intake * Consumer's body weight}}{\text{Consumption rate}} = \text{Acceptable level of mercury in fish tissue}$$

- Safe daily intake or reference doses, body weights, and consumption rates used are from recommendations from the USEPA, USFWS, and/or available literature.

Wildlife Fish Tissue Targets

Wildlife Exposure Parameters and Calculation Fish Tissue Targets										
Wildlife Species	Reference Dose (ug/kg b wt/day)	Body Weight (kg)	Total Food Ingestion Rate (g/day, wet wt)	Total Diet Safe Level	Fish Trophic Level 2/3, length 50-150 mm	Fish Trophic level 3, length >150 mm	Fish Trophic Level 4, length >150 mm	omnivorous birds	piscivorous birds	Trophic Level 2 aquatic prey includes fish, invertebrates, insects **
Mink	18	0.6	140	0.077	0.08					
River otter	18	6.7	1124	0.107	0.06		0.28			
Forster's tern	21	0.16	72	0.050	0.05					
Belted kingfisher	21	0.15	68	0.046	0.05					
Double-crested cormorant	21	1.74	390	0.094	0.09					
Common merganser	21	1.23	302	0.086		0.09				
Western grebe	21	1.19	296	0.084		0.08				
Bald eagle	21	5.25	566	0.195		0.11	0.29	0.19	1.36	0.019
Osprey	21	1.75	350	0.105		0.08	0.31			
Peregrine falcon	21	0.89	134	0.139		(0.17)		0.30	2.17	0.030

Examples:

Mink: 18 µg Hg/kg b wt/day * 0.6 kg b wt ÷ 140 g food/day = 0.077 µg Hg/g, or

Total Diet Safe Level: 0.077 ppm fish tissue from 50-150 mm TL2/3 fish.

Example (continued)

Wildlife Species	Reference Dose (ug/kg b wt/day)	Body Weight (kg)	Total Food Ingestion Rate (g/day, wet wt)	Total Diet Safe Level	Fish Trophic Level 2/3, length 50-150 mm	Fish Trophic level 3, length >150 mm	Fish Trophic Level 4, length >150 mm	omnivorous birds	piscivorous birds	Trophic Level 2 aquatic prey includes fish, invertebrates, insects **
River otter	18	6.7	1124	0.107	0.06		0.28			

River Otter: 18 µg Hg/kg b wt/day * 6.7 kg b wt ÷ 1124 g food/day = 0.107 µg Hg/g or 0.107 ppm fish tissue.

Since the otter eats from 2 different fish trophic levels and sizes, the total allowable mercury in its diet must be distributed to the fish sizes and trophic levels that it typically eats. The otter's diet consists of 80% from 50-150 mm TL2/3 fish and 20% from >150 mm TL4 fish.

TDSL = 80% * [TL2/3] + 20% * [TL4],

Where: [TL4] = [TL2/3] * ***FCM 4/3***

0.107 ppm = (0.80 * [TL2/3]) + (0.20 * [TL2/3] * ***4.5***)

Solving for [TL2/3]:

[TL2/3] = 0.06 ppm MeHg in 50-150 mm TL2/3 fish

[TL4] = 0.06 ppm * ***4.5*** = 0.28 ppm >150 mm TL4 fish

Trophic Level Food Group Translators

Calculated from LAR and Lake Natoma Fish Concentrations		
River Otter	FCM 4(150-500)/3(50-150)	4.5
Human	TLR 4/3 (150-500)	2.8
Osprey	TLR 4(200-450)/3(200-450)	3.8
Bald Eagle	TLR 4/3 >150	2.7
Calculated from National Averages or Literature		
Bald Eagle, peregrine falcon, human	FCM 3/2	5.7
Bald Eagle, peregrine falcon	FCM omnivorous bird	10
Bald Eagle, peregrine falcon	FCM piscivorous bird	12.5

Wildlife Fish Tissue Target Summary

Wildlife Exposure Parameters and Calculation Fish Tissue Targets										
Wildlife Species	Reference Dose (ug/kg b wt/day)	Body Weight (kg)	Total Food Ingestion Rate (g/day, wet wt)	Total Diet Safe Level	Fish Trophic Level 2/3, length 50-150 mm	Fish Trophic level 3, length >150 mm	Fish Trophic Level 4, length >150 mm	omnivorous birds	piscivorous birds	Trophic Level 2 aquatic prey includes fish, invertebrates, insects **
Mink	18	0.6	140	0.077	0.08					
River otter	18	6.7	1124	0.107	0.06		0.28			
Forster's tern	21	0.16	72	0.050	0.05					
Belted kingfisher	21	0.15	68	0.046	0.05					
Double-crested cormorant	21	1.74	390	0.094	0.09					
Common merganser	21	1.23	302	0.086		0.09				
Western grebe	21	1.19	296	0.084		0.08				
Bald eagle	21	5.25	566	0.195		0.11	0.29	0.19	1.36	0.019
Osprey	21	1.75	350	0.105		0.08	0.31			
Peregrine falcon	21	0.89	134	0.139		(0.17)		0.30	2.17	0.030

Recommended safe fish tissue levels in the Lower American River and Lake Natoma:

For small Trophic Level 3 fish (50- 150 mm) = 0.05 ppm

For large Trophic Level 3 fish (>150 mm) = 0.08 ppm

For large Trophic Level 4 fish (>150 mm) = 0.28 ppm

Fish Tissue Safe Levels to Protect Human Health

Scenarios	Body weight (kg)	Acceptable Daily LAR Fish MMHg Intake Level (ug/kg-day)	Total Consumption Rate of LAR Fish (g/day)	Safe MMHg Level in Total Diet of LAR Fish (ppm)	Distribution of Locally Caught Fish			Safe Concentrations of MMHg in Fish by TL (ppm, wet wt)		
					TL2	TL3	TL4	TL2	TL3	TL4
A.1	70	0.073	17.5	0.29	21.7%	45.7%	32.6%	0.04	0.21	0.58
A.2					---	50%	50%		0.15	0.43
A.3					---	---	100%			0.29
B.1	70	0.073	32	0.16	21.7%	45.7%	32.6%	0.02	0.11	0.32
B.2					---	50%	50%		0.08	0.24
B.3					---	---	100%			0.16
C.1	70	0.1	17.5	0.40	21.7%	45.7%	32.6%	0.05	0.28	0.80
C.2					---	50%	50%		0.21	0.59
C.3					---	---	100%			0.40
D.1	70	0.1	32	0.22	21.7%	45.7%	32.6%	0.03	0.16	0.44
D.2					---	50%	50%		0.12	0.32
D.3					---	---	100%			0.22
E.1	70	0.073	61	0.08	21.7%	45.7%	32.6%	0.01	0.06	0.17
E.2					---	50%	50%		0.04	0.12
E.3					---	---	100%			0.08
F.1	70	0.1	61	0.11	21.7%	45.7%	32.6%	0.01	0.08	0.23
F.2					---	50%	50%		0.06	0.17
F.3					---	---	100%			0.11
G.1	70	0.1	142.4	0.05	21.7%	45.7%	32.6%	0.01	0.03	0.10
G.2					---	50%	50%		0.03	0.07
G.3					---	---	100%			0.05

Allowable Human Consumption Rate Using Wildlife Safe Fish Levels

	Safe Concentrations of MMHg in Fish by TL (ppm, wet wt)			Distribution of Locally Caught Fish			Total Consumption Rate of LAR Fish (g/day)	Meals that Could Be Eaten per Week
	TL2	TL3	TL4	TL2	TL3	TL4		
Assuming consumption of commercial fish	0.05	0.08	0.28	21.7%	45.7%	32.6%	37	1.1
				---	50%	50%	28	0.9
					100%		64	2.0
				---	---	100%	18	0.6
Assuming no consumption of commercial fish				21.7%	45.7%	32.6%	51	1.6
				---	50%	50%	39	1.2
					100%		88	2.7
				---	---	100%	25	0.8

Linkage Analysis

How Do We Reduce Fish Levels?

Linkage Analysis

- The linkage analysis will describe the relationship between fish methylmercury concentrations and aqueous methylmercury concentrations.
- This relationship is used to determine an aqueous methylmercury goal, which will guide the allocation source reductions.
- The aqueous methylmercury goal will be derived from fish tissue concentrations using bioaccumulation factors (BAF)

Bioaccumulation Factor

Bioaccumulation Factor = [MeHg] Fish ÷ [MeHg] Water

Mean Fish Methylmercury Concentration Based BAFs					
	Mean Fish Concentrations		Mean Aqueous Concentration		
Fish Collection Location	TL3 [MeHg]	TL4 [MeHg]	Discovery Park [MeHg]	TL3 BAF	TL4 BAF
All Fish	0.124	0.385	0.0708	1.75E+06	5.44E+06
LAR Fish Only	0.127	0.336		1.79E+06	4.75E+06
Discovery Park Fish Only	0.158	0.412		2.23E+06	5.82E+06

Regression Based Fish Methylmercury Concentration Based BAFs					
	Mean Fish Concentrations		Mean Aqueous Concentration		
Fish Collection Location	250 mm TL3 [MeHg]	350 mm TL4 [MeHg]	Discovery Park [MeHg]	TL3 BAF	TL4 BAF
All Fish	0.128	0.465	0.0708	1.81E+06	6.57E+06
Discovery Park Fish Only	0.141	0.500		1.99E+06	7.06E+06

Safe Aqueous Concentrations and Necessary Reductions

Safe Aqueous [MeHg] = [MeHg] Fish ÷ BAF

Mean Fish Methylmercury Concentration Based Aqueous Goal						
Fish Collection Location	Estimated Aqueous Goal		MeHg Reductions		Aqueous Goal	Necessary Reductions
	TL3 [MeHg]	TL4 [MeHg]	TL3 [MeHg]	TL4 [MeHg]		
All Fish	0.046	0.051	35%	27%	0.046	35%
LAR Fish Only	0.045	0.059	37%	17%	0.045	37%
Discovery Park Fish	0.036	0.046	49%	34%	0.036	49%

Regression Based Fish Methylmercury Concentration Based Aqueous Goal						
Fish Collection Location	Estimated Aqueous Goal		MeHg Reductions		Aqueous Goal	Necessary Reductions
	TL3 [MeHg]	TL4 [MeHg]	TL3 [MeHg]	TL4 [MeHg]		
All Fish	0.044	0.043	38%	40%	0.043	40%
Discovery Park Fish	0.040	0.038	43%	46%	0.038	46%

Proposed Methylmercury Goals

Lower American River and Lake Natoma Numeric Fish Tissue Objectives and Allowable Human Consumption Estimated Using American River at Discovery Park Fish and Aqueous Methylmercury Data

	Safe Concentrations of MMHg in Fish by TL (ppm, wet wt)			Distribution of Locally Caught Fish			Total Consumption Rate of LAR Fish (g/day)	Meals that Could Be Eaten per Week
	TL2	TL3	TL4	TL2	TL3	TL4		
Assuming consumption of commercial fish	**0.05**	**0.08**	**0.27**	21.7%	45.7%	32.6%	38	1.2
				---	50%	50%	29	0.9
					100%		64	2.0
				---	---	100%	18	0.6
Assuming no consumption of commercial fish				21.7%	45.7%	32.6%	52	1.6
				---	50%	50%	40	1.2
					100%		88	2.7
				---	---	100%	25	0.8

Discovery Park Aqueous Goal and Necessary Reductions to Attain Fish Tissue

[MeHg] Goal	Necessary Reductions
0.038 ng/L	46%

Next Steps

- Tentative Meeting September 16, 2010
- Will Start to Discuss Load Allocations
- Will Start to Discuss Possible Implementation Actions

Please direct any comments or questions to:

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