RMP
Mercury Strategy Team
2026

Meeting #2

June 2, 2026

Zoom Stuff

This meeting is being recorded and AI-transcribed

Item 1: Introductions and Meeting Goals

1.	**Introductions, Meeting Goals, Agenda Review** Major goals for the meeting: 1. Discuss progress and timeline on WDM 2. Discuss progress and timeline on in-Bay recovery trajectory model 3. Discuss progress and timeline on Mercury Synthesis Materials: None	9:00 Jay Davis
2.	**Discussion: WDM Update** Update on progress to date and timeline for completion. Materials: Slides presented at the meeting **Desired Outcomes:** Informed group and feedback provided.	9:05 Matt Heberger, Pedro Avellaneda
3.	**Discussion: In-Bay Recovery Trajectory Modeling Update** Update on progress to date and timeline for completion. Materials: Slides presented at the meeting **Desired Outcomes:** Informed group and feedback provided.	9:25 Kara Scheu, Sam McWilliams, Craig Jones
4.	**Discussion: Mercury Synthesis Update (Part 1)** Update on progress to date and timeline for completion: Jay's sections. Materials: Slides presented at the meeting **Desired Outcomes:** Informed group and feedback provided.	10:10 Jay Davis

5.	**Discussion: Mercury Synthesis Update (Part 2)** Update on progress to date and timeline for completion: Don's sections. Materials: Slides presented at the meeting **Desired Outcomes:** Informed group and feedback provided.	10:40 Don Yee
6.	**Discussion: Mercury Synthesis Update (Part 3)** Update on progress to date and timeline for completion: Lester's sections. Materials: Slides presented at the meeting **Desired Outcomes:** Informed group and feedback provided.	11:15 Lester McKee
7.	**Review Next Steps and Action Items and Adjourn**	11:50 Jay and Group

Item 2
Discussion: WDM Update

WDM Hg Timeline (updated)

- Sediment model finalized: May 29
- … Mercury model development & report writing occurring in parallel
- Mercury results available: June 30
- Send draft report for review: July 24
- Comments received: Aug 7
- Final revisions and release final report: Aug 14

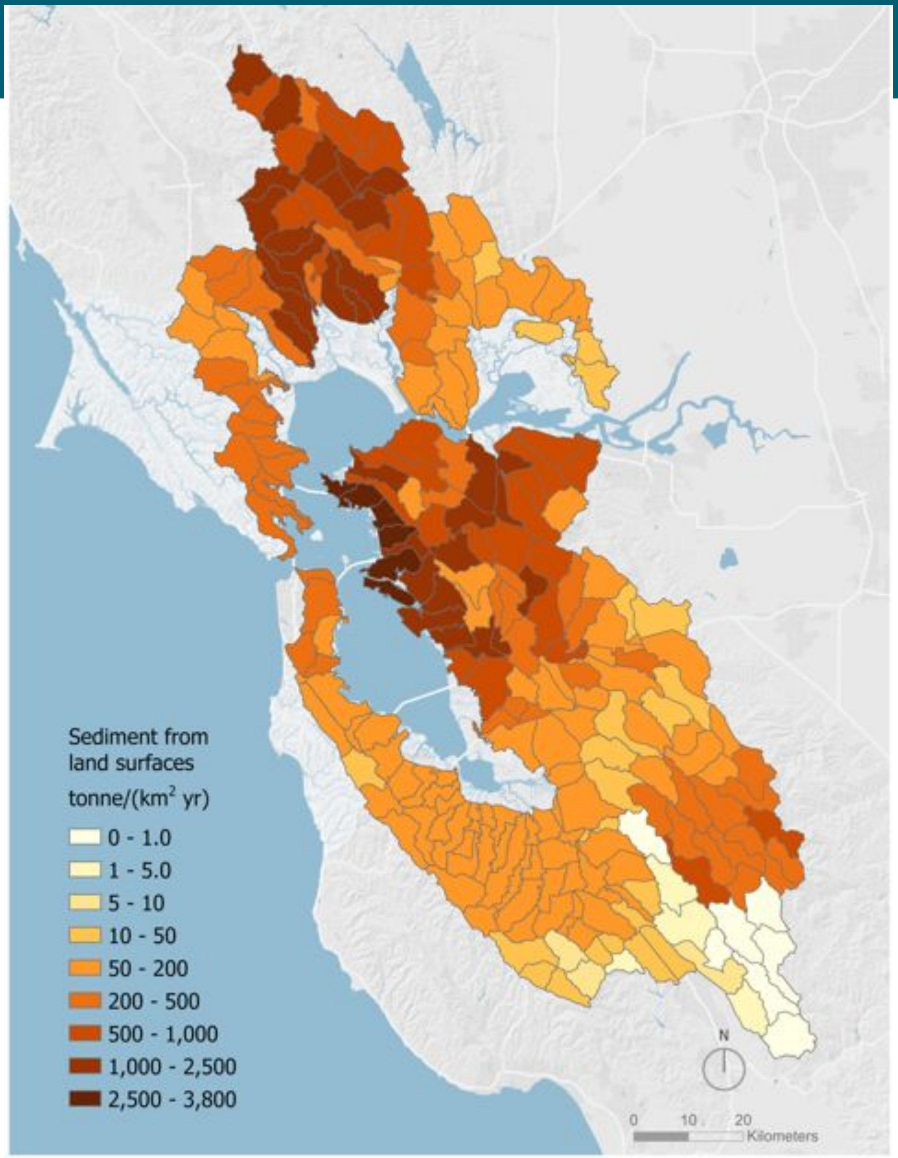
WDM Hg Update

- Longer update given at the May 14 Sources, Pathways, and Loadings Workgroup meeting (slides here)
- Major overhaul of the model to make it more realistic and defensible:
  - updated input data (precipitation and evaporation)
  - recalibrated hydrology (flow simulation)
  - recalibrated sediment, focusing on three critical fixes identified in our April 10, 2025 memo
- Model web page: https://mghydro.com/pages/wdm/

Three main recommendations:

1

Fix erosion and sediment washoff from land surfaces, which show unusual patterns that are inconsistent with our understanding of watershed processes.



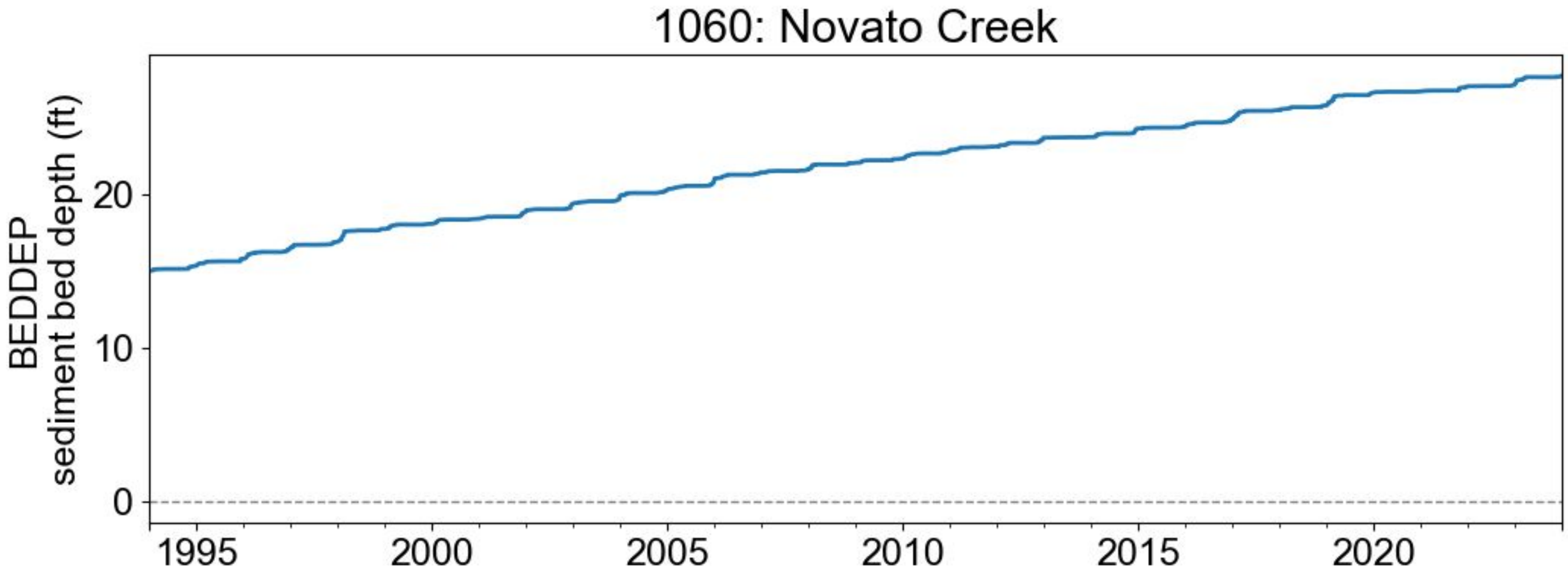
What did we change?

- Reviewed and changed key sediment parameters (land and in-stream) based on Basins Technical Note 8
- Parameters remained consistent across the region
- Targeted typical sediment yields for land uses (based on literature, local reports, and journal articles)

Three main recommendations:

2

Balance sediment scour and deposition in channels, which is out of balance in over 80% of reaches.



What did we change?

- Defined new critical bed shear stresses for silt and clay
- Reviewed and changed reach slope across the domain
- Removed several F-tables that were causing unusual flow velocities (>20 ft/s) in several model reaches
- Defined sediment fractions as follows: 12% sand, 38% silt, 50% clay (USGS data).

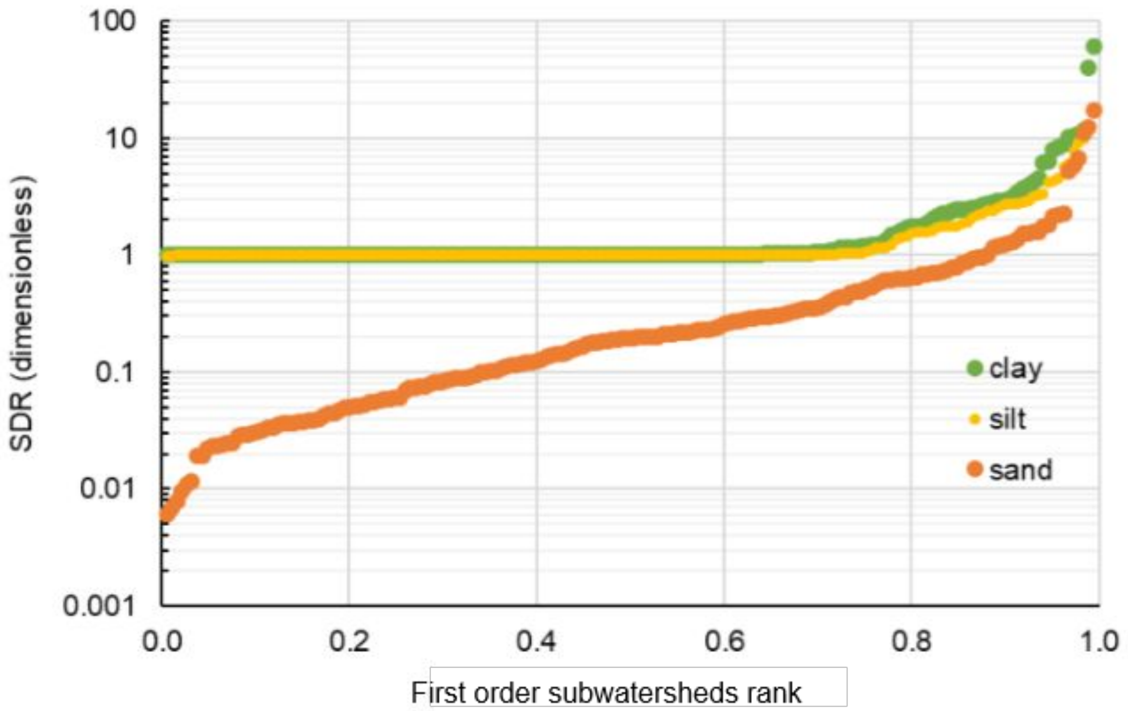
Three main recommendations:

3

Verify sediment delivery ratios (SDR) for all 3 classes (sand, silt, clay)

Average SDR > 1 not possible.

Implication: majority of the sediment in flow is coming from the reservoir of channel bed sediment and NOT the land surfaces in the watershed

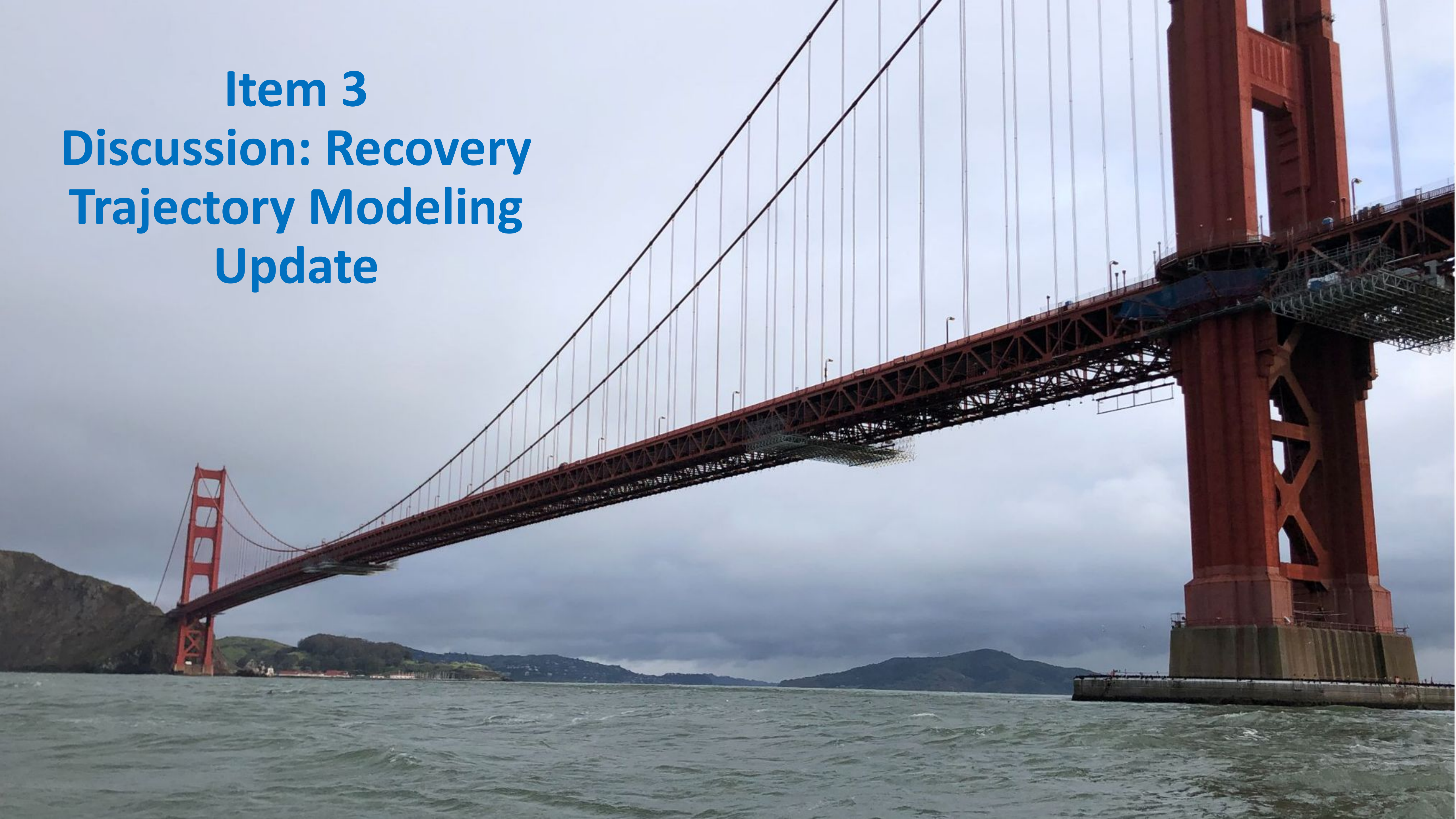


$$SDR = \frac{sediment\ leaving\ an\ outlet}{sediment\ from\ watershed\ land}$$

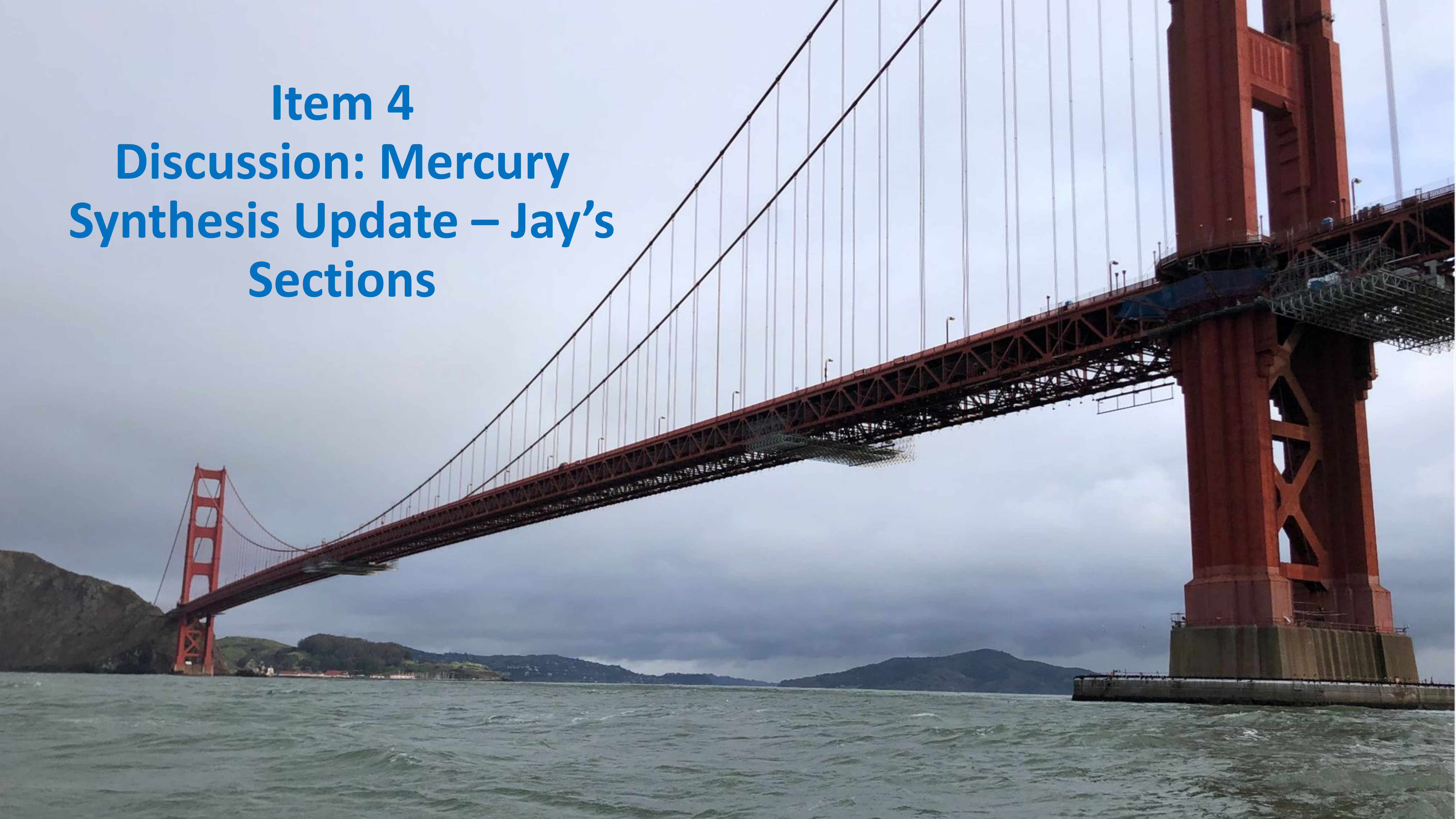
What did we change?

- All of the changes above affected sediment delivery rations
- Checked sediment deposition in reservoirs

Item 3
Discussion: Recovery Trajectory Modeling Update



Item 4
Discussion: Mercury Synthesis Update – Jay's Sections



Surface and Suspended Sediment Status and Trends

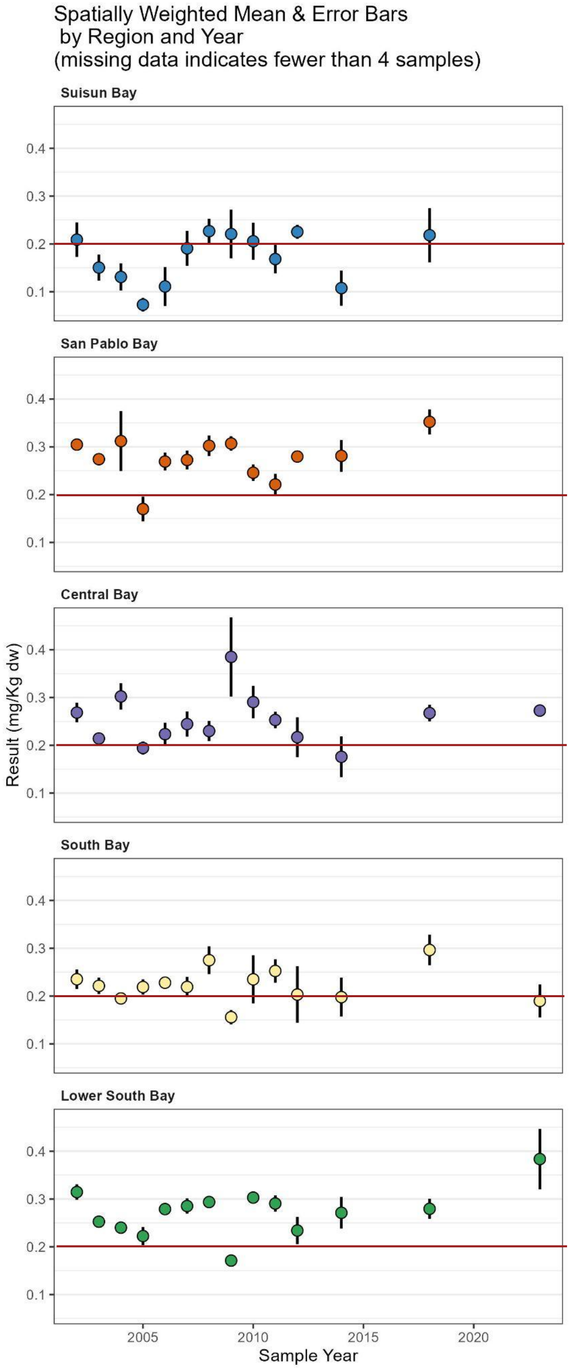
- Who: Jay (surface), Don (suspended), some Data Services (DS) support
- Literature - not applicable
- Datasets
  - RMP sediment and water data
- Notes
  - include new data for 2023 archived samples
  - include brief summary of margins data

WB Guidance

- Compile any new data (i.e., archived Bay sediment samples special study). **Are there any updated status and observed trends? Can we show any progress?**
- Evaluate data in terms of time and space **(subembayment)**
- The bed sediment data are probably less variable and likely a better indicator for changes, but the suspended sediment target is what is in the TMDL so must be evaluated. Work with the WB if there are issues that arise involving the difference between dissolved and total mercury used in the calculation.

2023 Sediment Data

- *World premiere!*
- Didn't sample North Bay in 2023 due to focus on CECs
- No trends - no progress
- High value in LSB in 2023: 0.61 (others were 0.26, 0.32, 0.35)
- 5-year cycle is going to make it impossible to detect a trend (show progress) in a career - buyer's remorse?
- Power analysis recommended



Mean

0.17

0.27

0.25

0.22

0.27

Biota Status and Trends

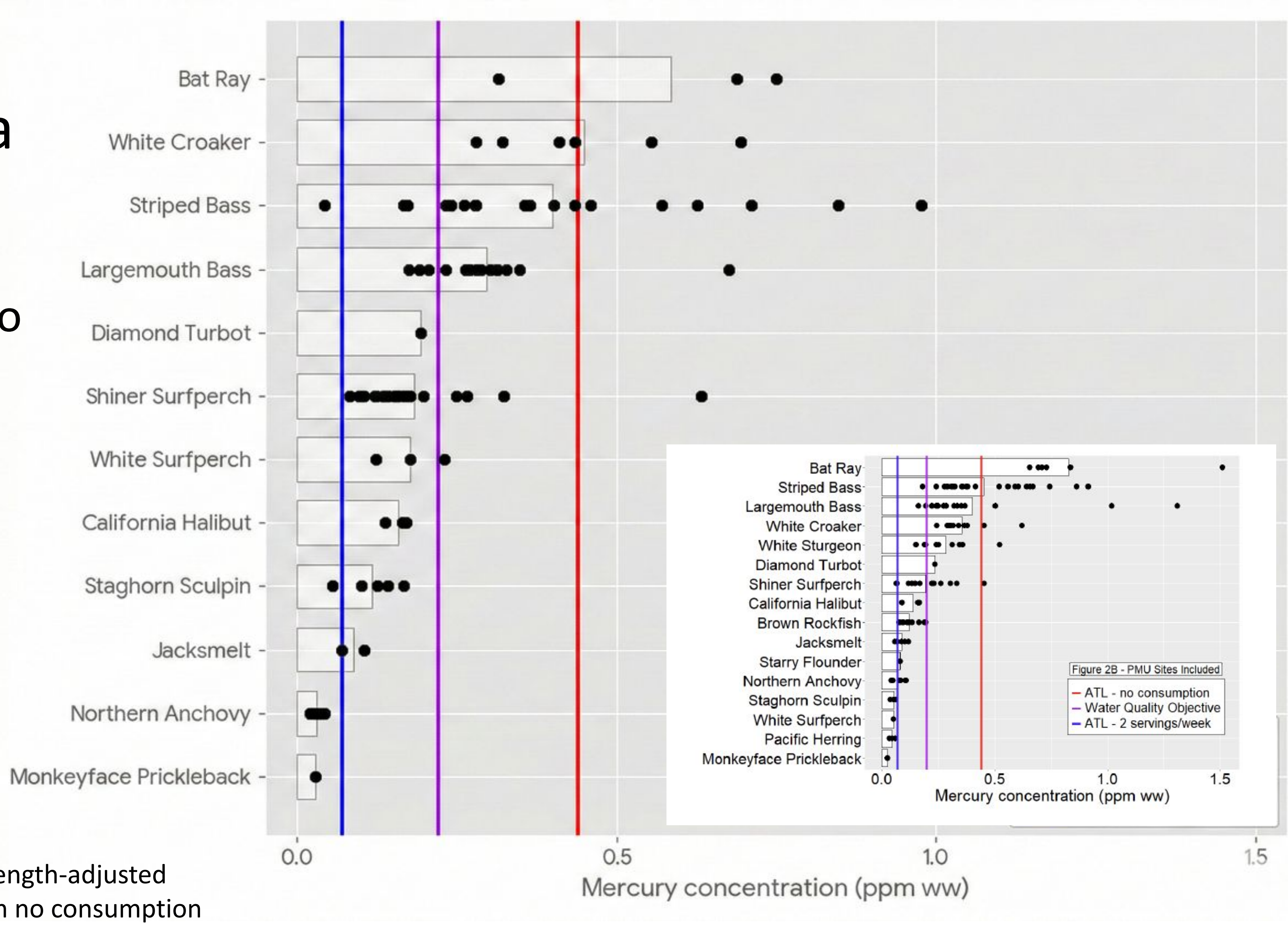
- Who: Jay, some Data Services (DS) support
- Literature - quick check for data not already included below
- Datasets
  - RMP: sport fish, bird eggs
  - North Bay Biosentinels, WB Wetland permit study: wetland biosentinel fish
  - South Bay Salt Ponds
- Notes
  - good to address topic of restored wetlands as a potential source of MeHg (separate Synthesis section on this?)
  - include 2024 sport fish and bird egg data

WB Guidance

Compile any new data and qualitatively evaluate trends. Biota data may not show much change at the Bay-wide scale (e.g., striped bass), but there could be some **evidence in some types of biota (bird eggs or prey fish) when looking at smaller spatial scales**. This slow rate of Bay-wide change in biota concentrations highlights the significance of the Hg reservoir in SF Bay sediments and supports rationale for time extension of TMDL.

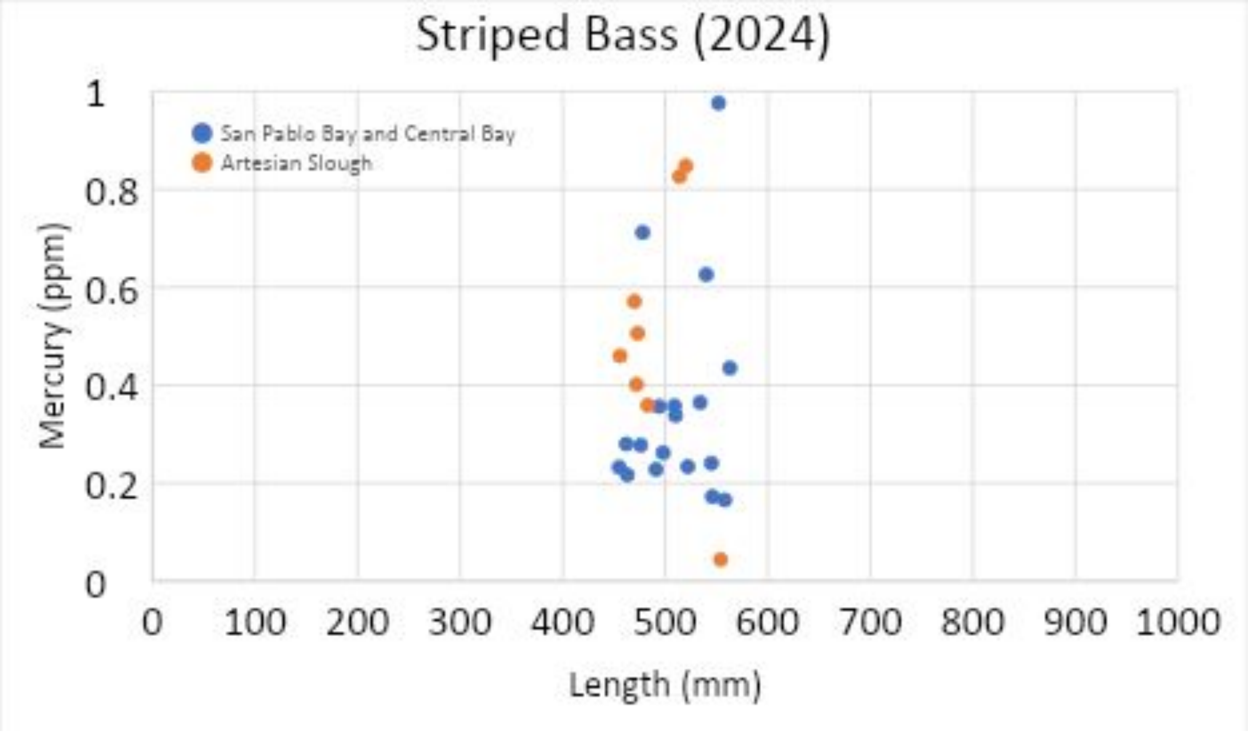
2024 Sport Fish Data

- Generally very similar to 2019 (thumbnail)



Notes

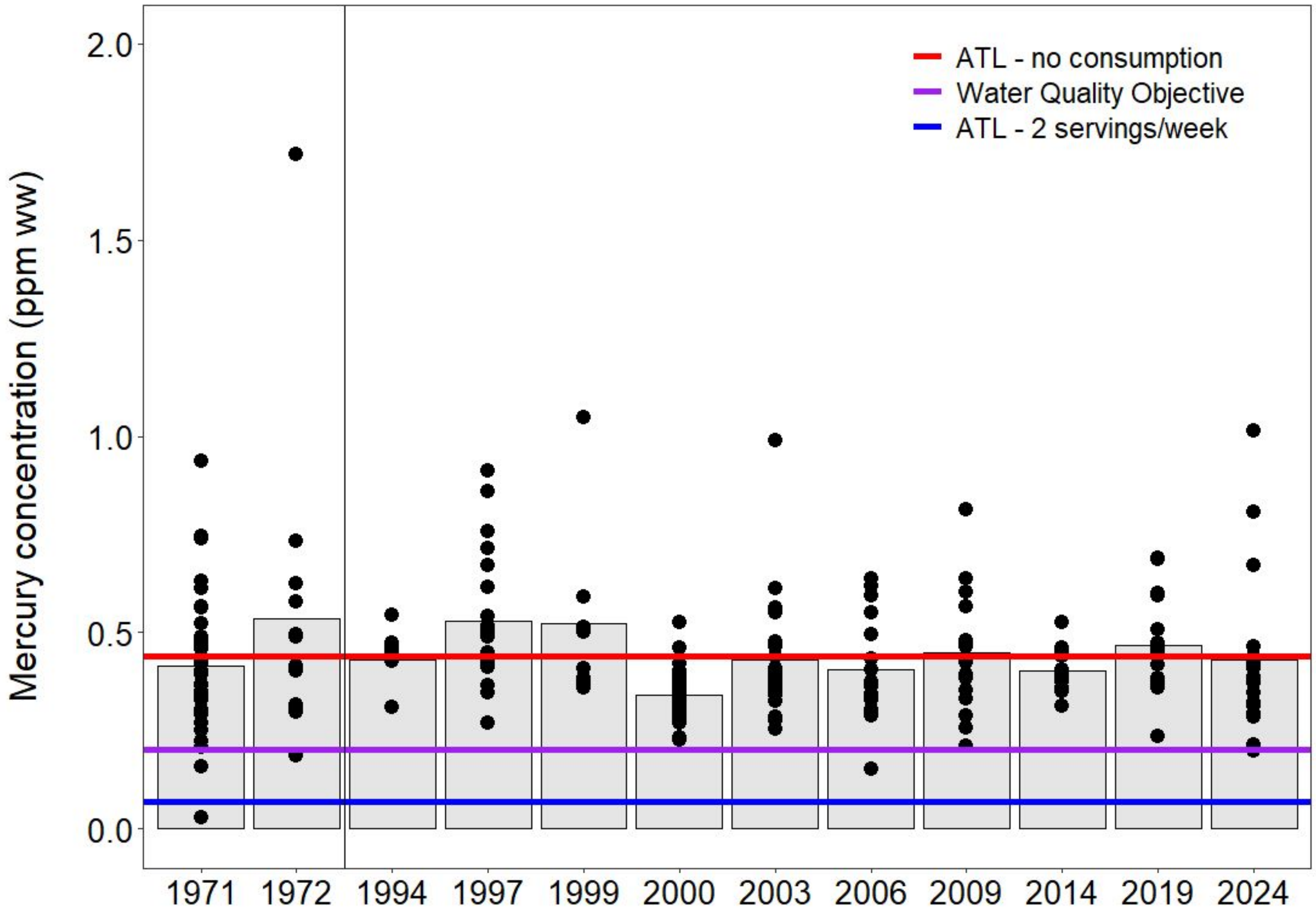
- striped bass and largemouth bass **not** length-adjusted
- striped bass mean still around 0.44 ppm no consumption ATL (for the sensitive population)



Notes

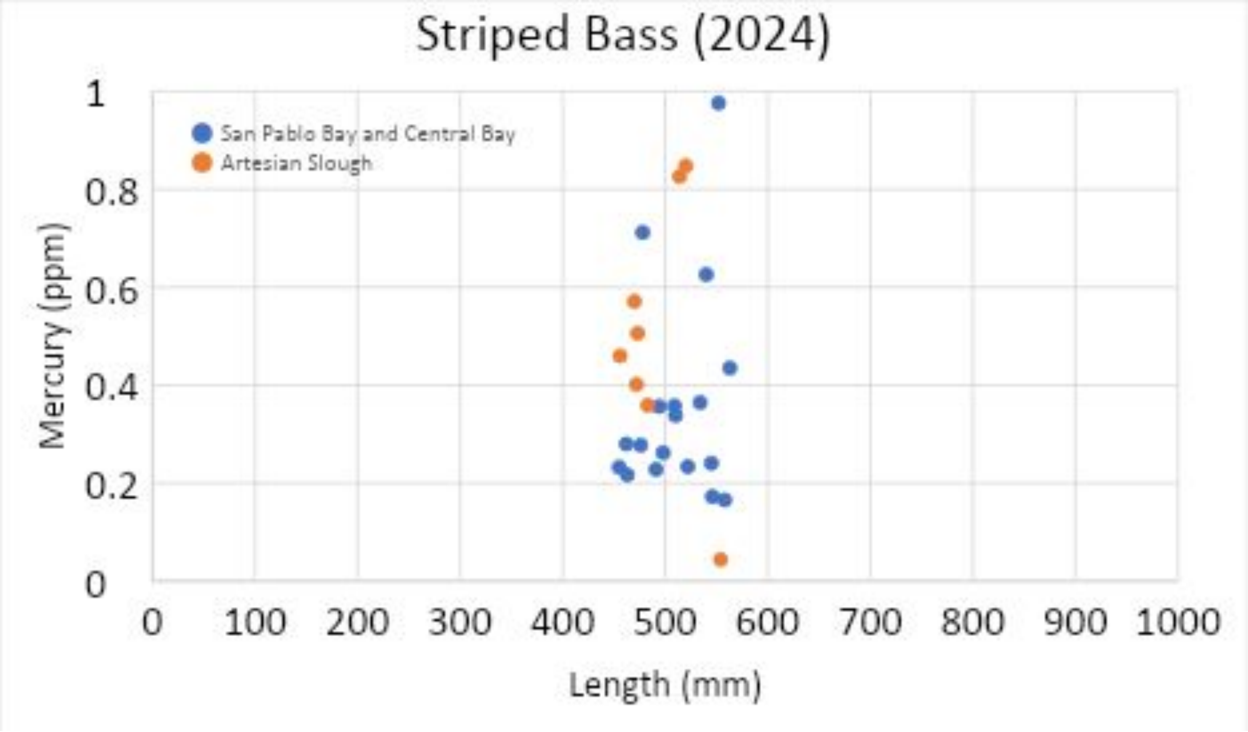
- As in 2019, we got a limited size range of striped bass in 2024 - not a good basis for regression - will have to get creative again using past data
- Bass from Artesian Slough were again higher than bass from the rest of the Bay
- We'll aim for a wider size range in 2029 - will be hard to get larger fish though - ***may*** want to reconsider the 60 cm size for length-adjustment

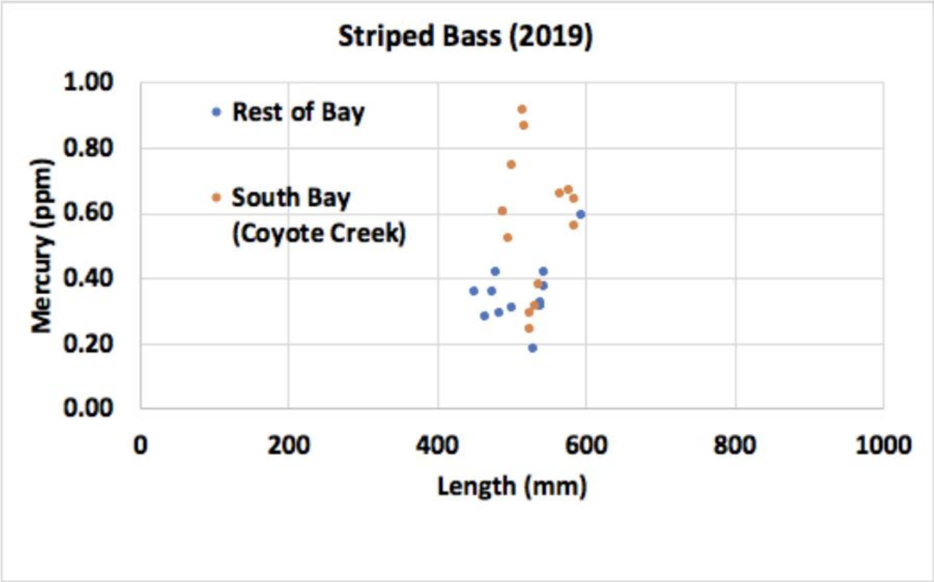
Striped Bass Time Series



Notes

- This graph is based on 60 cm length-adjusted data. Pre-2019 years recalculated using regressions with un-transformed Hg. Used the same length-Hg regression equation used in 2019, based on the 2014-2019 data.





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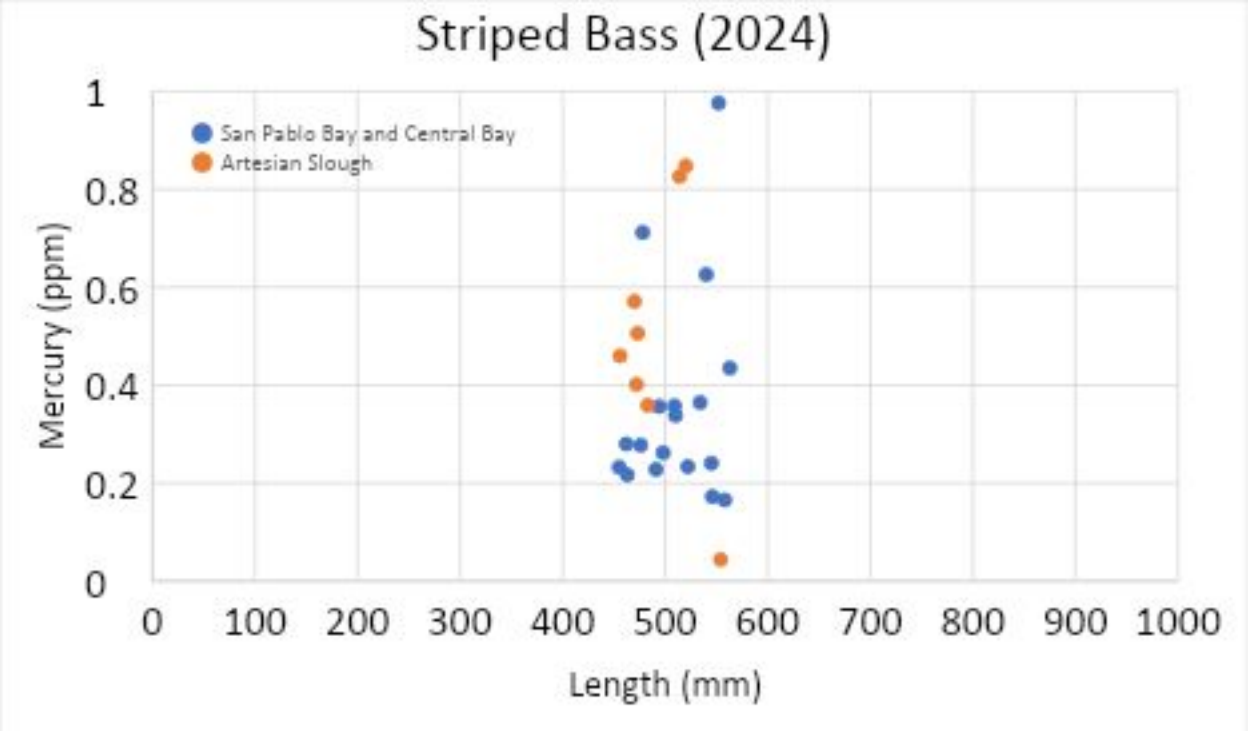
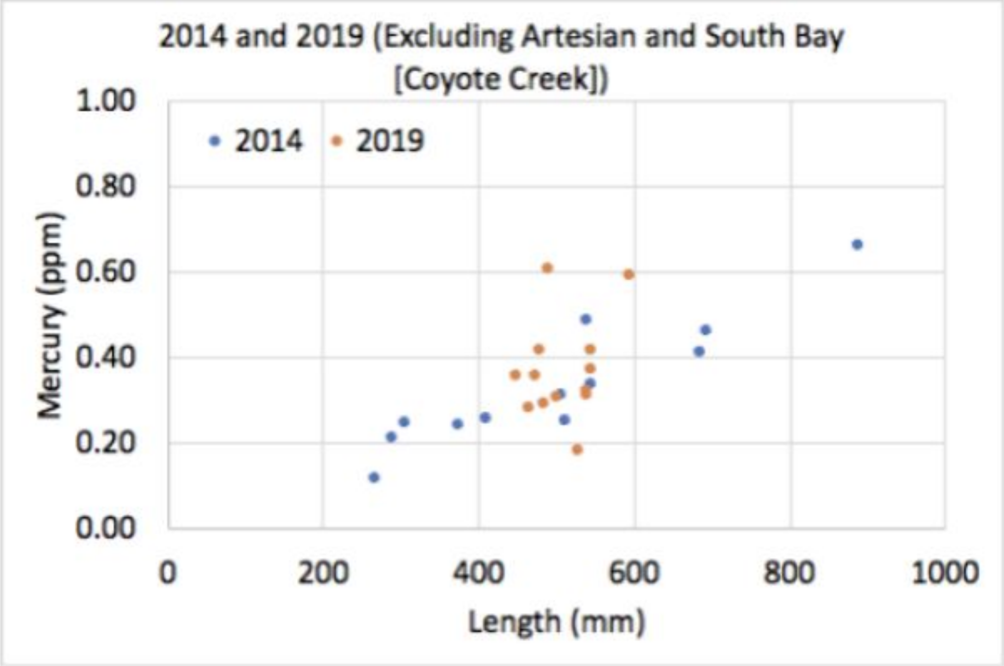
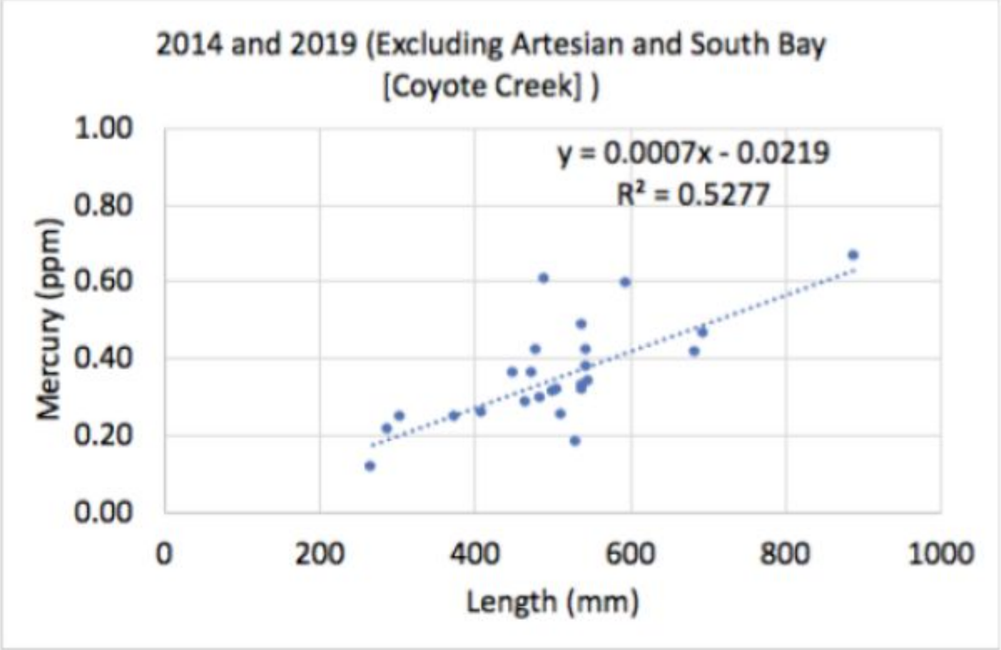
Notes

- 2019 data were very similar

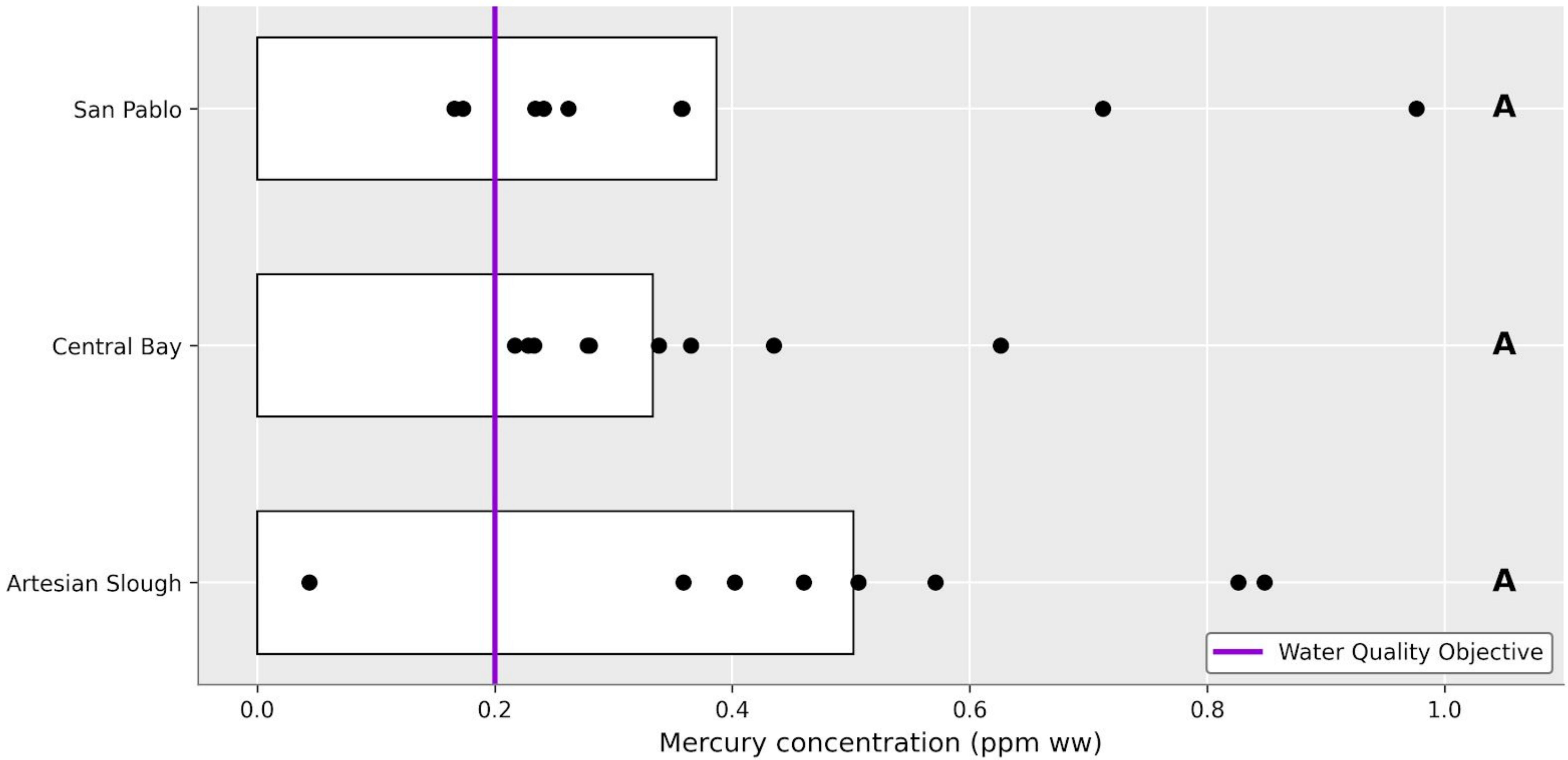






Notes

- In 2019 we used a combination of the 2019 data and 2014 data, excluding the South Bay bass (because they were higher) - will do something similar for 2024

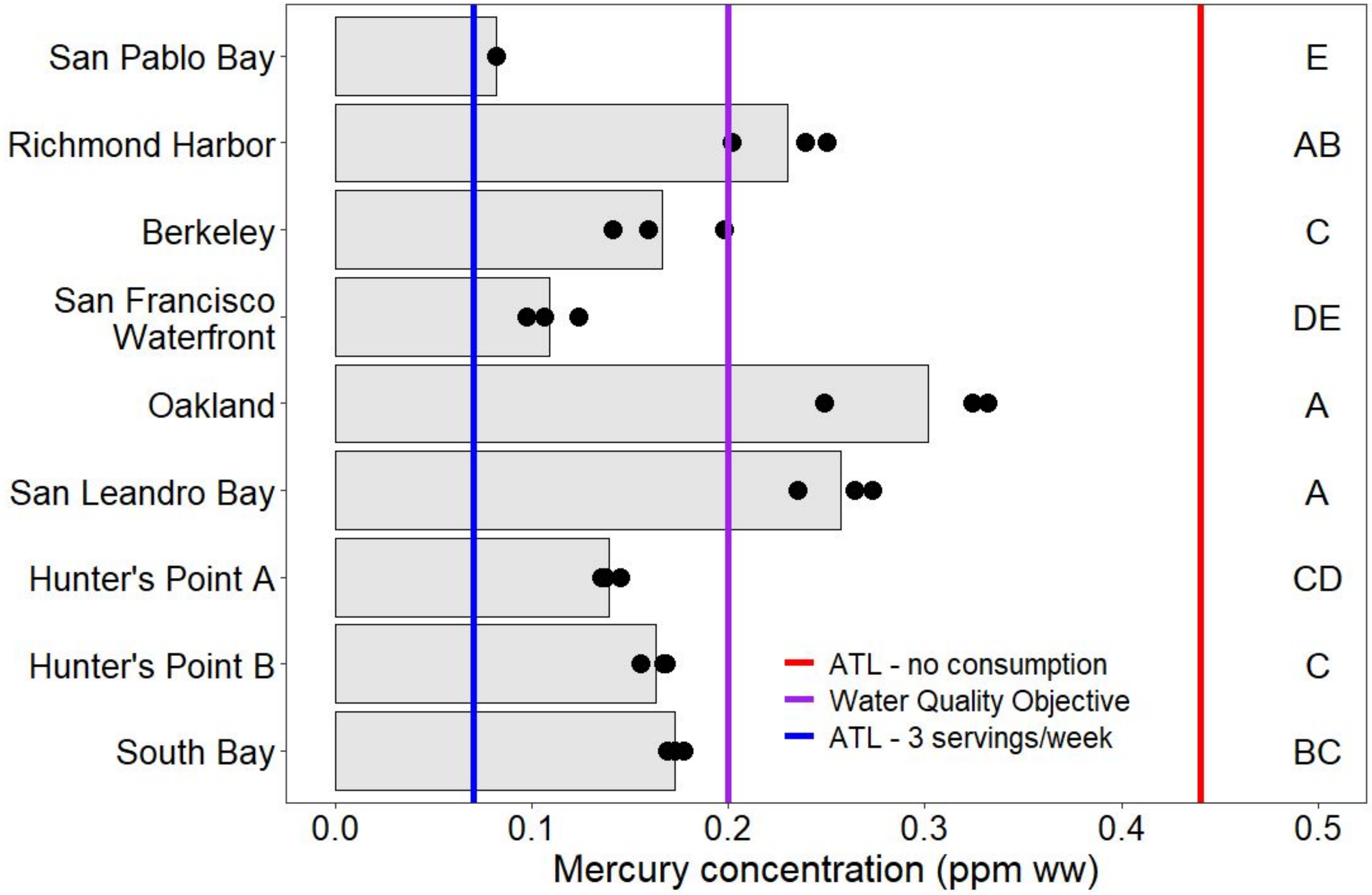


Notes

- Artesian Slough bass versus other areas - higher but not statistically significant

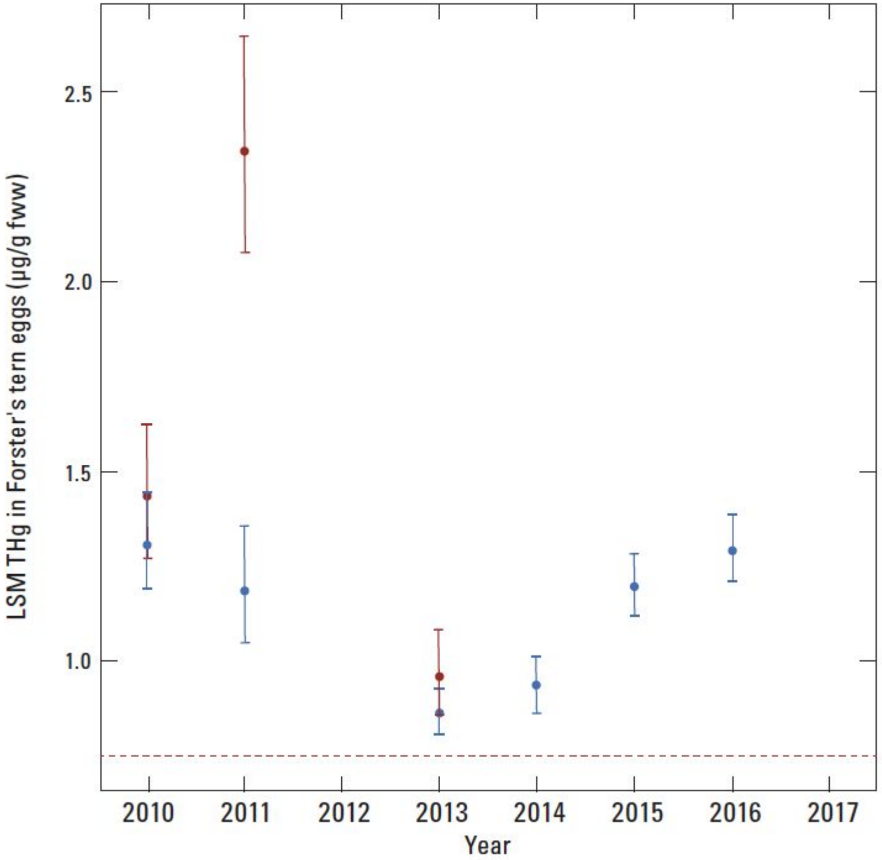
2024 Shiner Surfperch

- *World premiere!*
- Shiner a great spatial indicator
- There is significant variation at smaller spatial scales



Biota: Wetland Monitoring

- South Bay Salt Pond Restoration Project
- Significant dataset
- Substantial risk to birds
- Short-term, but not long-term, increases due to restoration



EXPLANATION

Site type

A8-complex

Reference ponds

Figure 9. Graph showing model-averaged geometric least squares mean (LSM) total mercury (THg) concentrations in Forster's tern eggs (n = 522) within the A8-complex and at reference ponds during 2010–17. The red dashed line indicates the avian toxicity benchmark for Forster's terns (0.75 microgram per gram in fresh wet weight [µg/g fww; Eagles-Smith and others, 2009, Ackerman and others, 2016a]). The response variable for these models was log-transformed egg total mercury concentration. Year, treatment (A8-complex vs reference pond), and nest initiation date were included as covariates as well as two-way interactions among the variables, and site was included as a random effect in all models. Depending on the year, reference ponds consisted of A2W, A1, AB2, AB1, New Chicago marsh, Charleston Slough, N1, and (or) SF2. Error bars represent the standard error.

Notes

- Forster's Tern eggs
- Spike in 2011 was due to reconfiguration in the pond A8 complex but it was short-lived

Notes

- Forster’s tern eggs in South Bay as a whole
- Spikes in 2006, 2011, and 2015-2017
- 2006 - coincident with some of the initial restoration actions at the island ponds (ponds A19–21
- 2011 - after the breaching of pond A6 and the construction and initial opening of the A8 tidal control structure
- 2015-2017 - followed the 3-gate condition to 5-gate condition transition in the operation of the A8-TCS (September 2014) and encompassed the extreme flow event during January–February 2017
- no monitoring after 2017

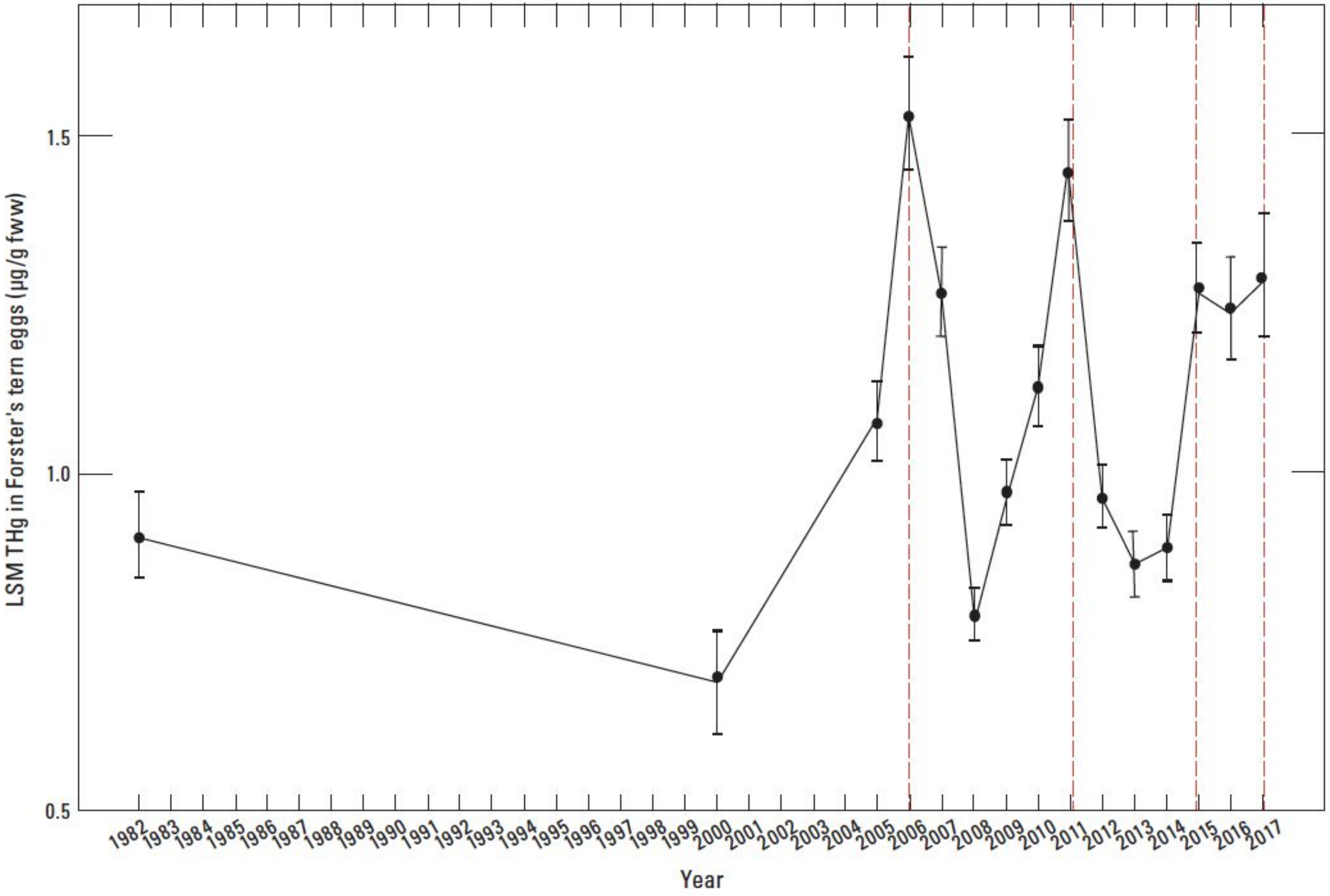


Figure 11. Graph showing long-term trend in total mercury (THg) concentrations in Forster’s tern eggs collected from southern San Francisco Bay during 1982–2017. The time series also includes historical reference values in 1982 for Bair Island (n=10 eggs) by Ohlendorf and others (1988) and in 2000 for 4 sites (n=21 eggs) by Schwarzbach and Adelsbach (2003). Values from 2005–2017 are least squares means (LSM) in micrograms per gram in fresh wet weight [µg/g fww] accounting for site as a random effect (model results in table 1). Error bars represent the standard error. The red dashed lines highlight peaks in years prior to (2006) and during (2011 and 2015–17) the South Bay Salt Pond Restoration Project Phase 1 period of study (2010–2017).

Notes

- Prey fish data from slough sites - focus on more complete silverside series on top
- Spike in 2011 like the tern eggs - in Alviso Slough only and linked to management actions
- No spike in 2015-16 - unlike the tern eggs
- Spike in late 2016 thought to be related to earlier transition to the 5 gate condition
- Back to baseline in 2018

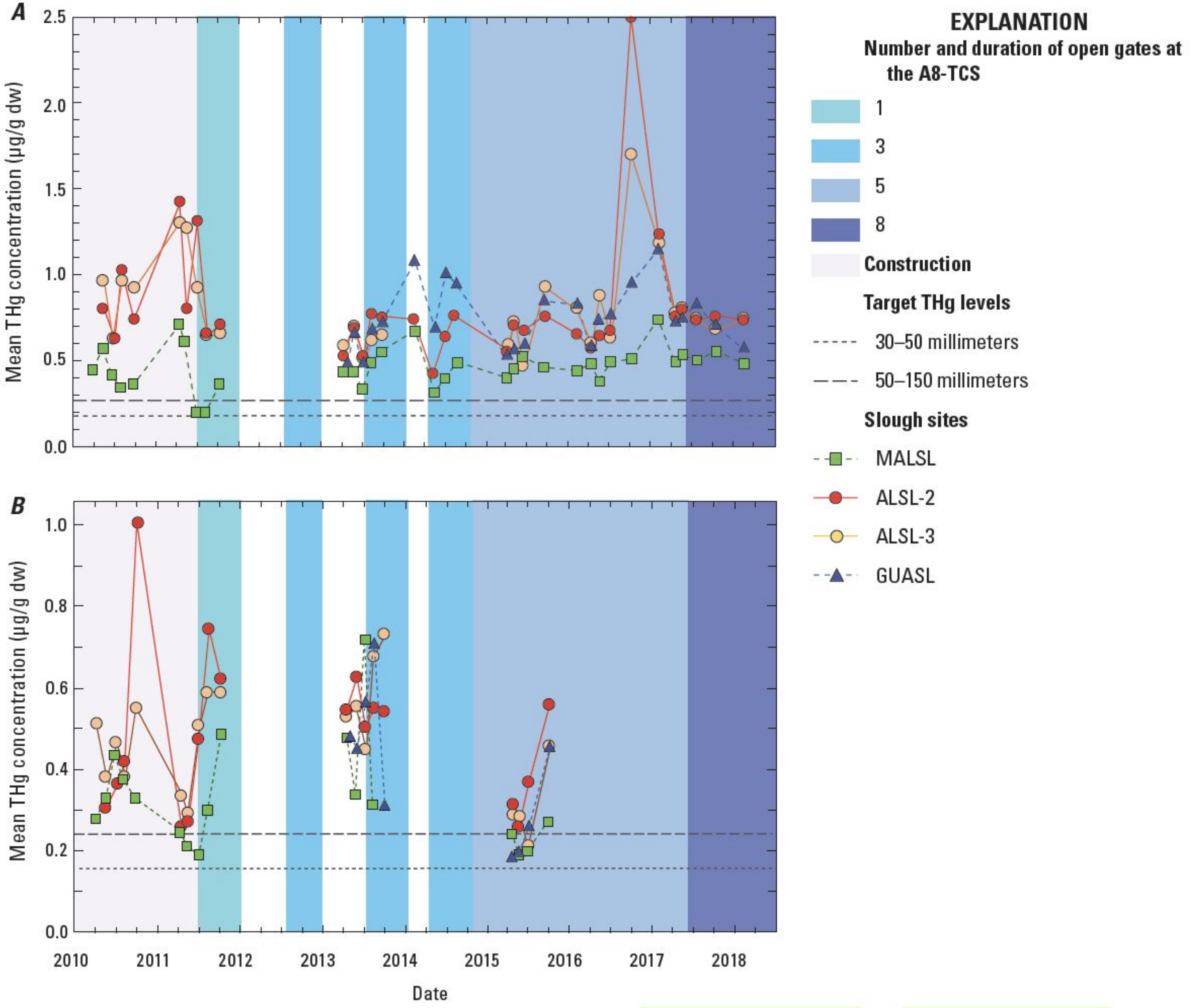
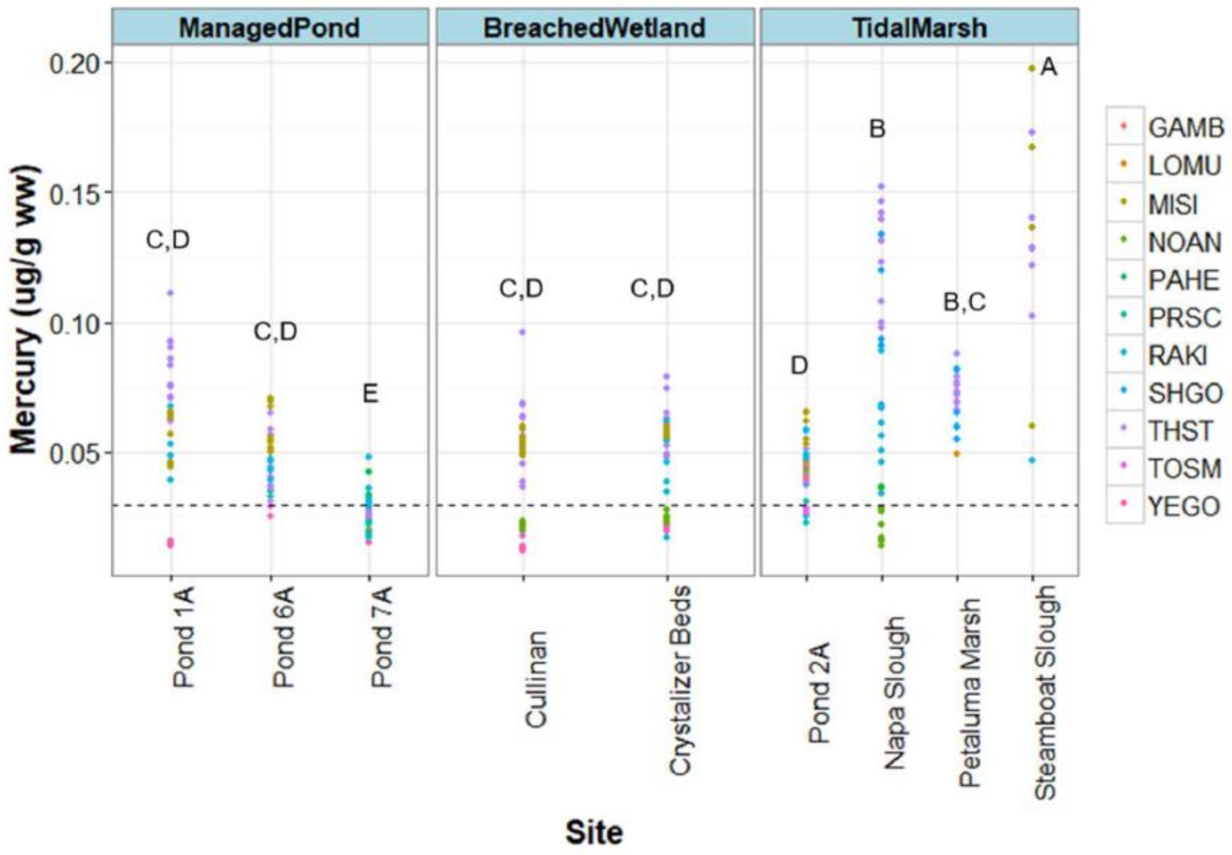


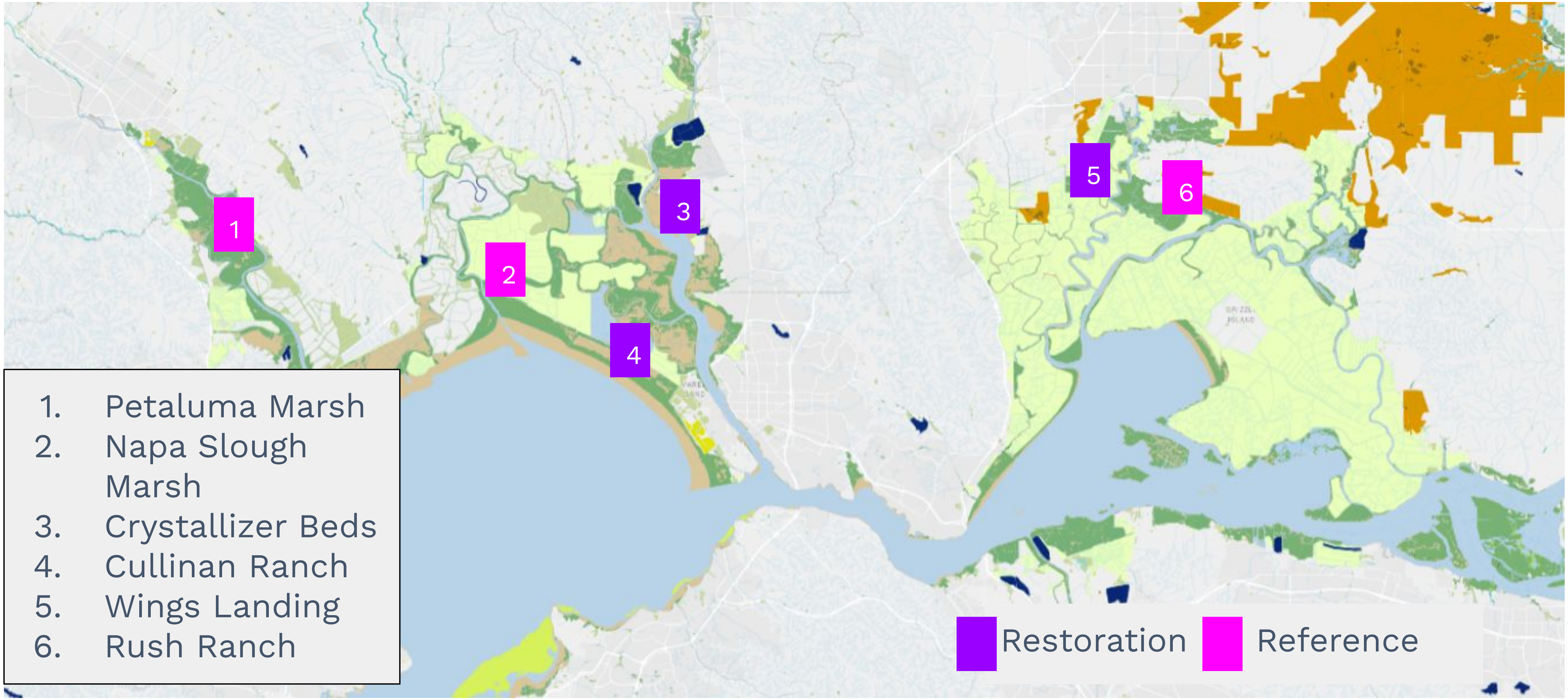
Figure 15. Graphs showing mean total mercury (THg) concentrations of Mississippi silverside (*A*) and three-spine stickleback (*B*), by slough site, for the years 2010–18 and 2010–16, respectively. Each Mississippi silverside data point (*A*) represents the mean of 6 composite samples of 8 fish each; 48 fish total, whereas each three-spine stickleback data point (*B*) represents the mean of 10–15 individually analyzed fish (homogenized whole body). Target THg levels (horizontal dashed lines) for 30–50 millimeters and 50–150 millimeters fish are in dry weight equivalents of 0.03 and 0.05 microgram per gram (µg/g) wet weight regulatory targets, respectively. Year labels are centered on January 1 of each year. THg concentrations are given in micrograms per gram dry weight (µg/g dw). Locations of samples shown on figure 3. Nonshaded background represents duration when all gates are closed.

- North Bay Biosentinels Project
- Robinson et al. (2018)



Monitoring was conducted in 2016 and 2017. The results were consistent with findings from an earlier phase of the project (2012-2014) that showed methylmercury concentrations in restoration sites could pose a risk to fish and piscivorous wildlife, but levels within restored areas were no higher than at reference sites. Concentrations varied by site, species, and year.

Sites sampled



Samples collected

2022:

- 156 samples
- MISI, TOSM, YEGO were the most common species
- YEGO was collected at all sites
- Challenging to get target species, possibly due to drought conditions

2024

- 127 samples
- MISI and THST were the most common species, collected at all sites
- Collected less common juvenile STBA and SPLT

Samples collected

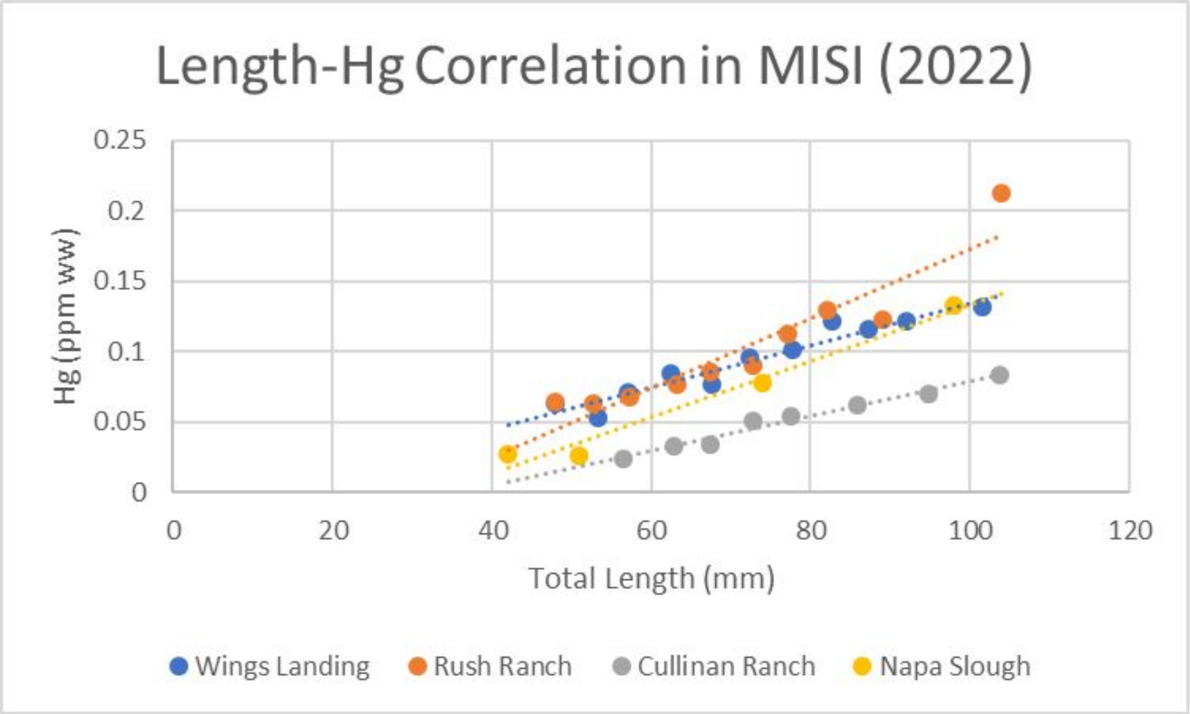
2022

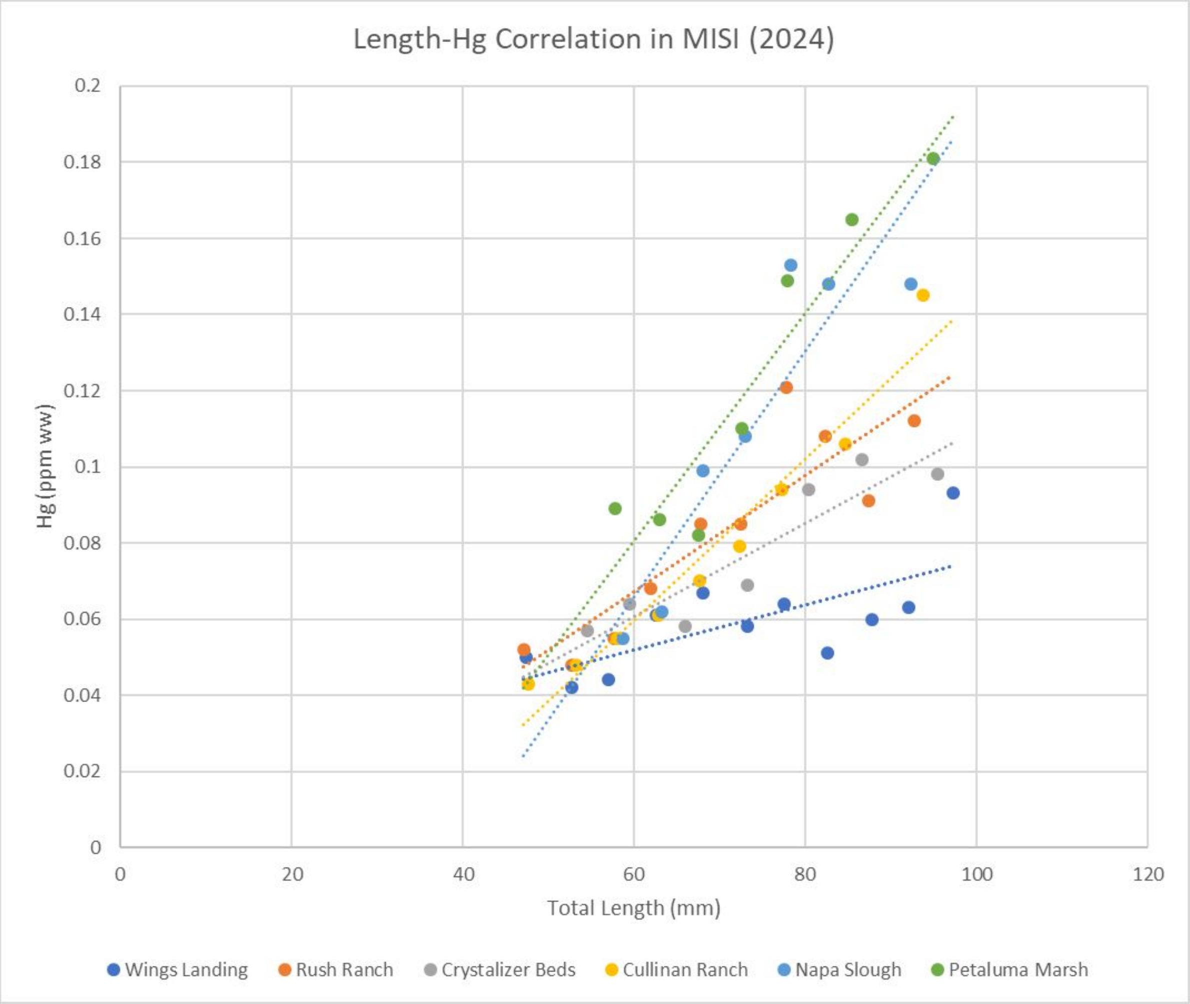
	Crystallizer Beds	Cullinan Ranch	Napa Slough Marsh	Petaluma Marsh	Rush Ranch	Wings Landing	**Grand Total**
Arrow Goby (ARGO)	4	4	2	2			**12**
Mississippi Silverside (MISI)		8	5		10	11	**34**
Prickly Sculpin (PRSC)					2	1	**3**
Rainwater Killifish (RAKI)		1	3	3			**7**
Shimofuri Goby (SHGO)			4	2	1	1	**8**
Palaemon Shrimp (SHRMP)		3	4	3	5	5	**20**
Staghorn Sculpin (STSC)	3						**3**
Three-spined Stickleback (THST)		3		6	6	4	**19**
Topsmelt (TOSM)	8	8	6	7			**29**
Yellowfin Goby (YEGO)	4	4	4	3	3	3	**21**
Grand Total	**19**	**31**	**28**	**26**	**27**	**25**	**156**

2024

	Crystallizer Beds	Cullinan Ranch	Napa Slough Marsh	Petaluma Marsh	Rush Ranch	Wings Landing	**Grand Total**
Mississippi Silverside (MISI)	7	9	7	7	10	11	**51**
Rainwater Killifish (RAKI)			3	4			**7**
Yellowfin Goby (YEGO)	4	3	4		3		**14**
Three-spined Stickleback (THST)	1	4	6	5	5	5	**26**
Topsmelt (TOSM)	4		2	3			**9**
Juvenile Topsmelt (jTOSM)	4	3		3			**10**
Juvenile Striped Bass (jSTBA)		3					**3**
Juvenile Splittail (jSPLIT)	4	3					**7**
Grand Total	**24**	**25**	**22**	**22**	**18**	**16**	**127**

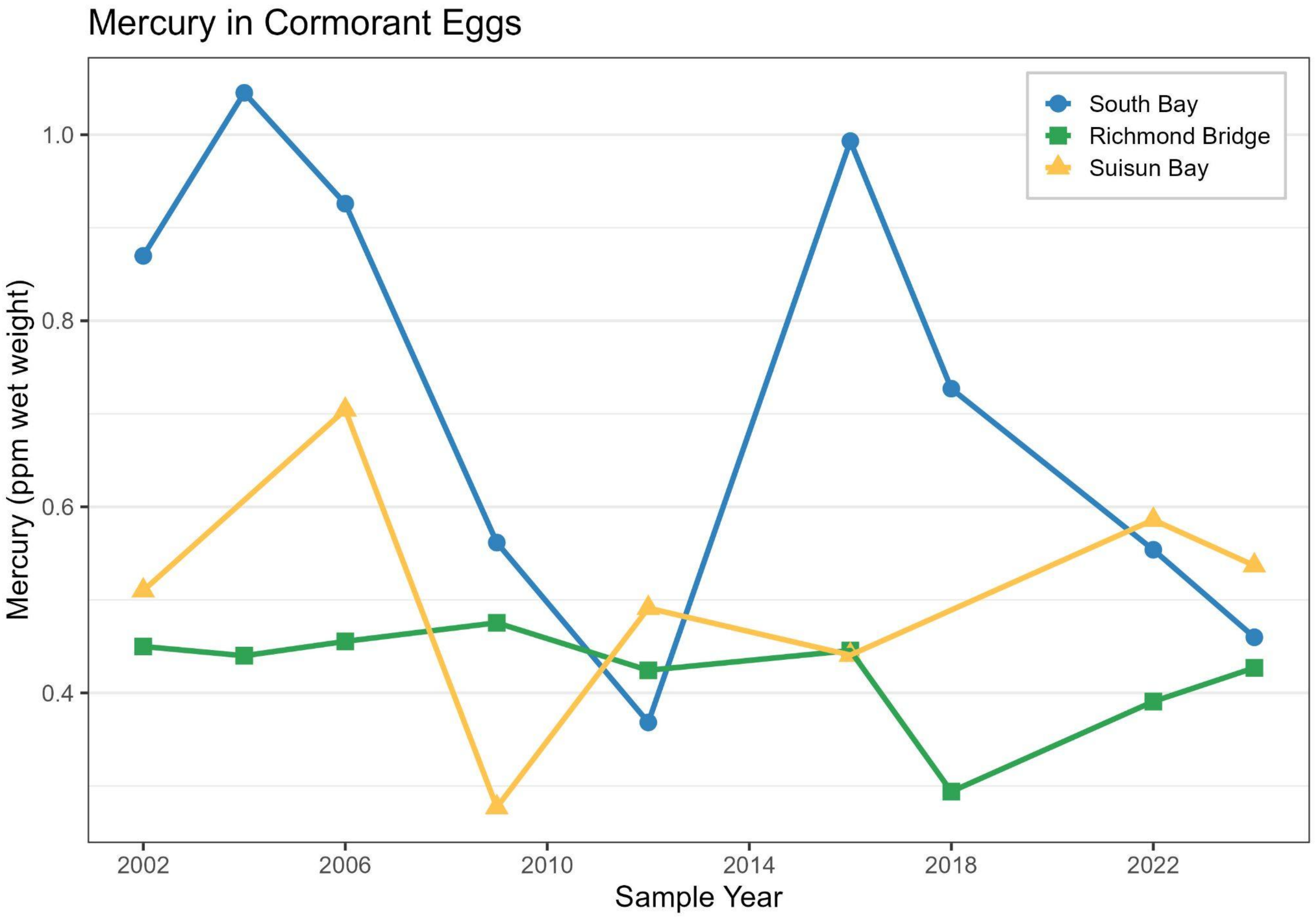
MISI Length-Hg Standardization





2022 and 2024 Bird Egg Data

- *World premiere!*
- No Suisun eggs in 2018
- South Bay highly variable - timing seems to match Forster's Terns
- No trends evident



Notes
- xx

Notes

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- Spikes in 2006, 2011, and 2015-2017
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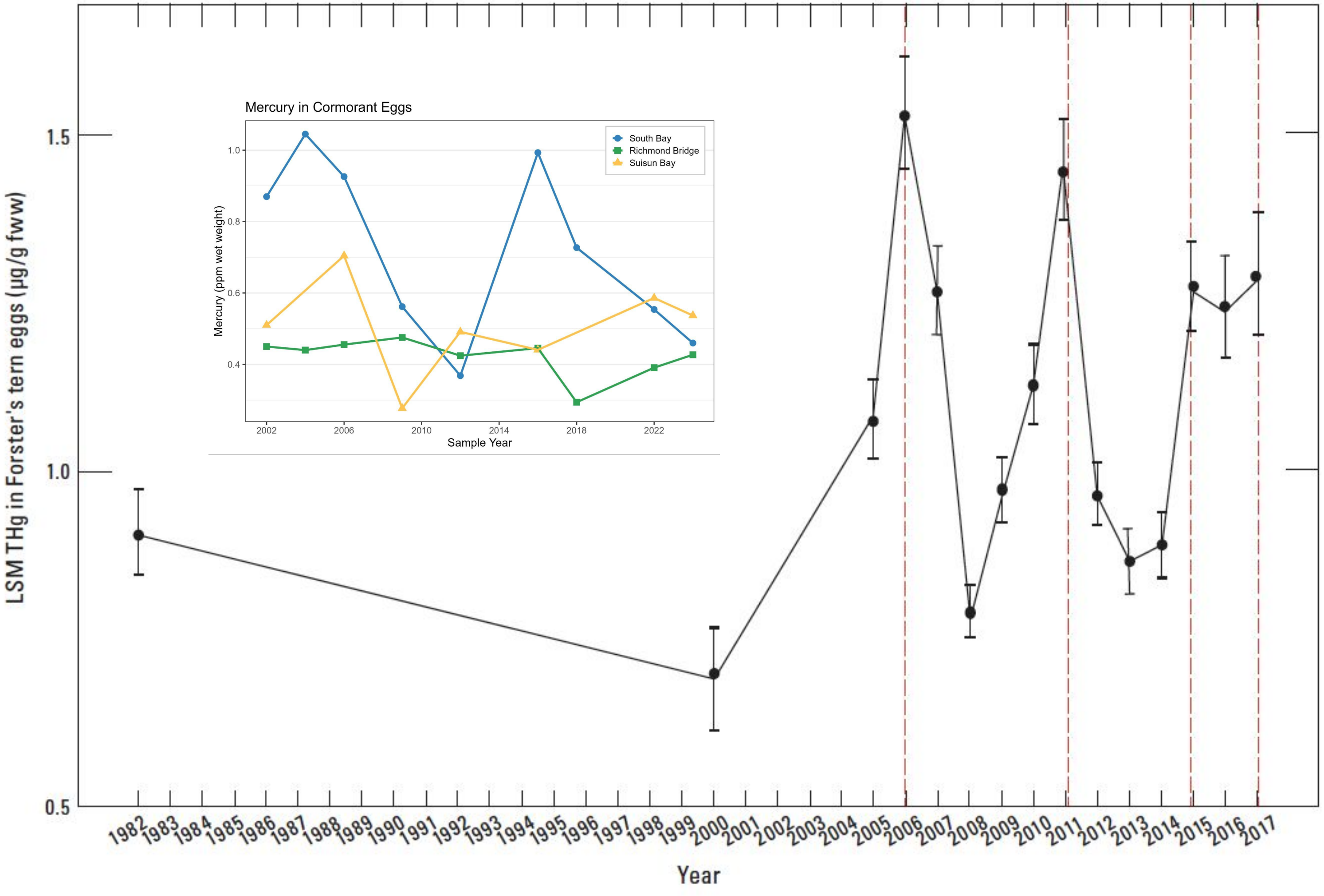

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Wastewater Inputs

- Who: WB (James Parrish), Jay write
- Literature - NA
- Datasets
  - NPDES data
- Notes
  - haven’t contacted James yet

WB Guidance

This is one of the Water Board’s strongest datasets because this is reported on a regular basis and the Water Board provides annual reports to the Board. This is potentially already done.

Last update provided at the July 9, 2025 Board Meeting (July 2025 Executive Officer's Report, page 3) included the 2024 municipal and industrial Hg loads.

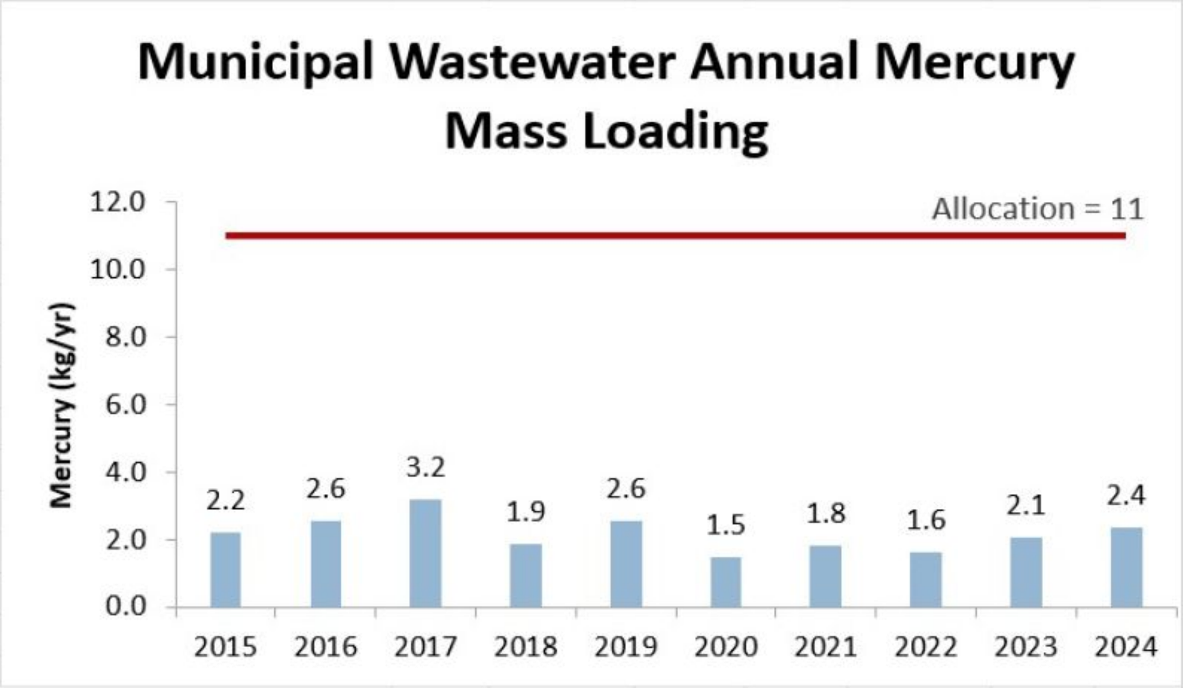


Figure 1: Municipal Mercury Mass Loads

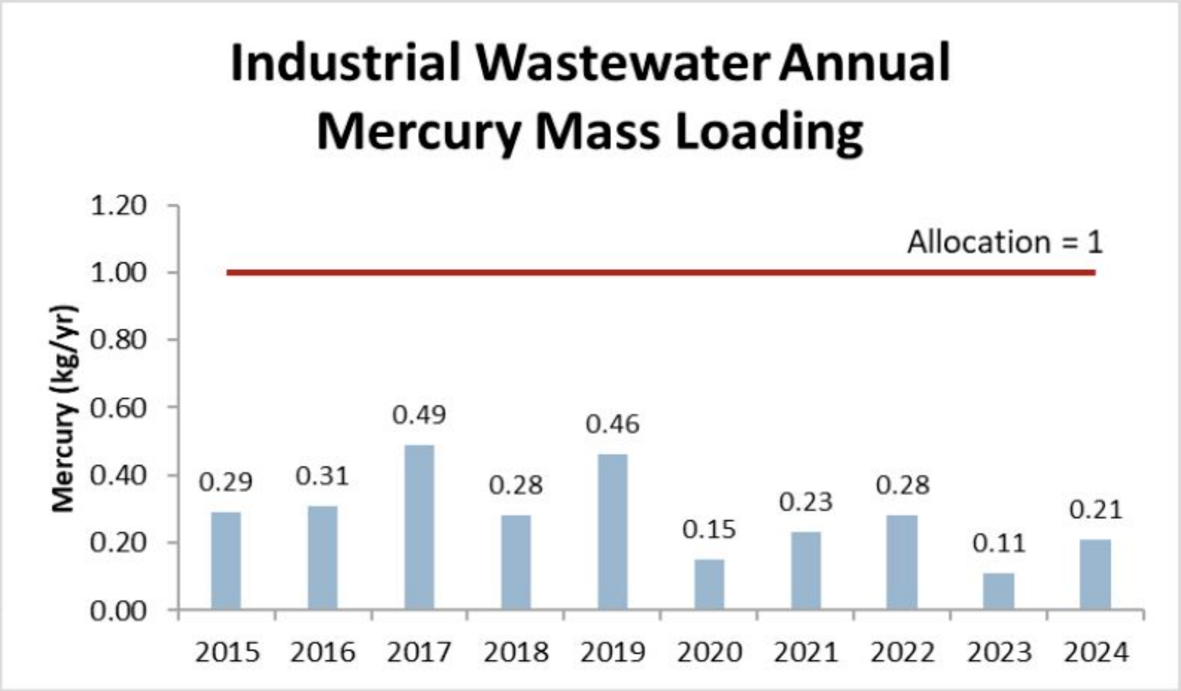
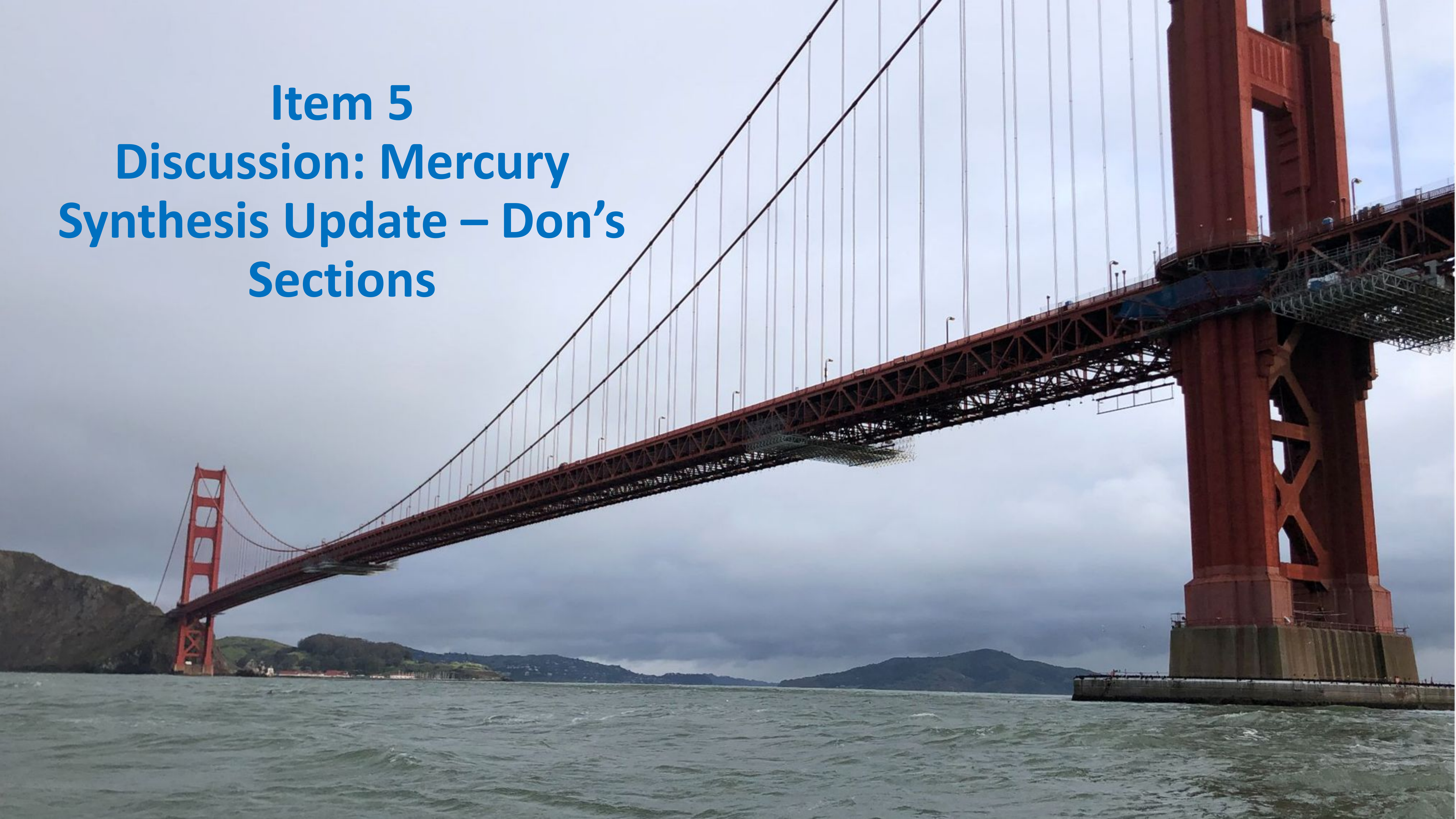


Figure 2: Industrial Mercury Mass Loads

Item 5
Discussion: Mercury Synthesis Update – Don's Sections



Atmospheric Mercury

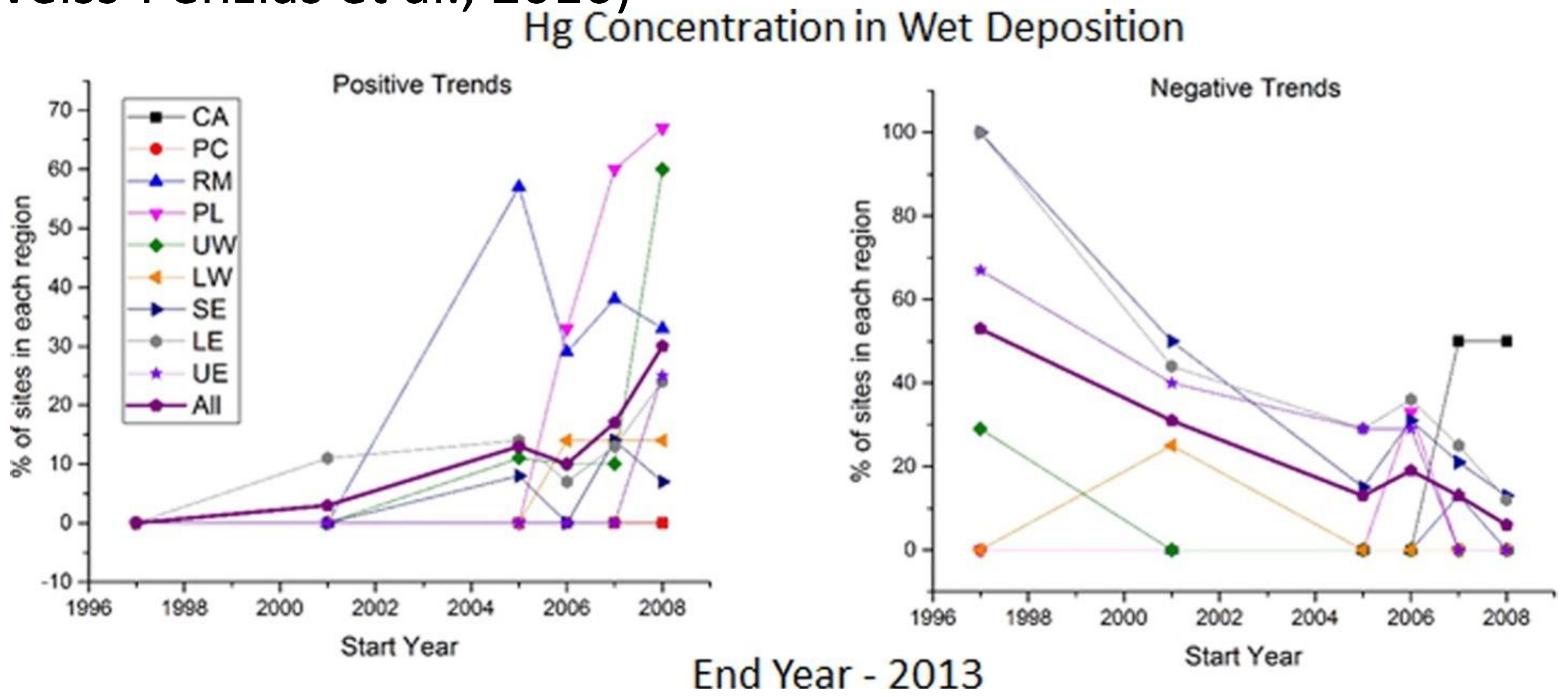
MERCURY LOADS TO THE BAY (kg/year)

PATHWAY	TMDL ALLOCATION	TMDL LOAD ESTIMATE	LATEST LOAD ESTIMATE	COMMENTS
POTWs	20	20	2.9	SFBRWQCB (2012)
Industry			0.4	SFBRWQCB (2012)
Urban Stormwater	82	160	120	McKee et al. (2015)
Central Valley	330	440	190	David et al. (2015)
Atmospheric Deposition	7	27.2	–	New estimate not available
Bed Erosion	220	460	–	New estimate not available
Guadalupe River	2	92	90	McKee et al. (2015)
Non-urban Stormwater	25	25	–	New estimate not available
Sediment Dredging and Disposal	0	Net loss	–	New estimate not available

USA-CAN Atmospheric Hg - Up or Down

- USA emissions down (esp. east coast) but global increase (Weiss-Penzias et al., 2016)

https://doi.org/10.1016/j.scitotenv.2016.01.061



UNEP Global Mercury Assessment 2018

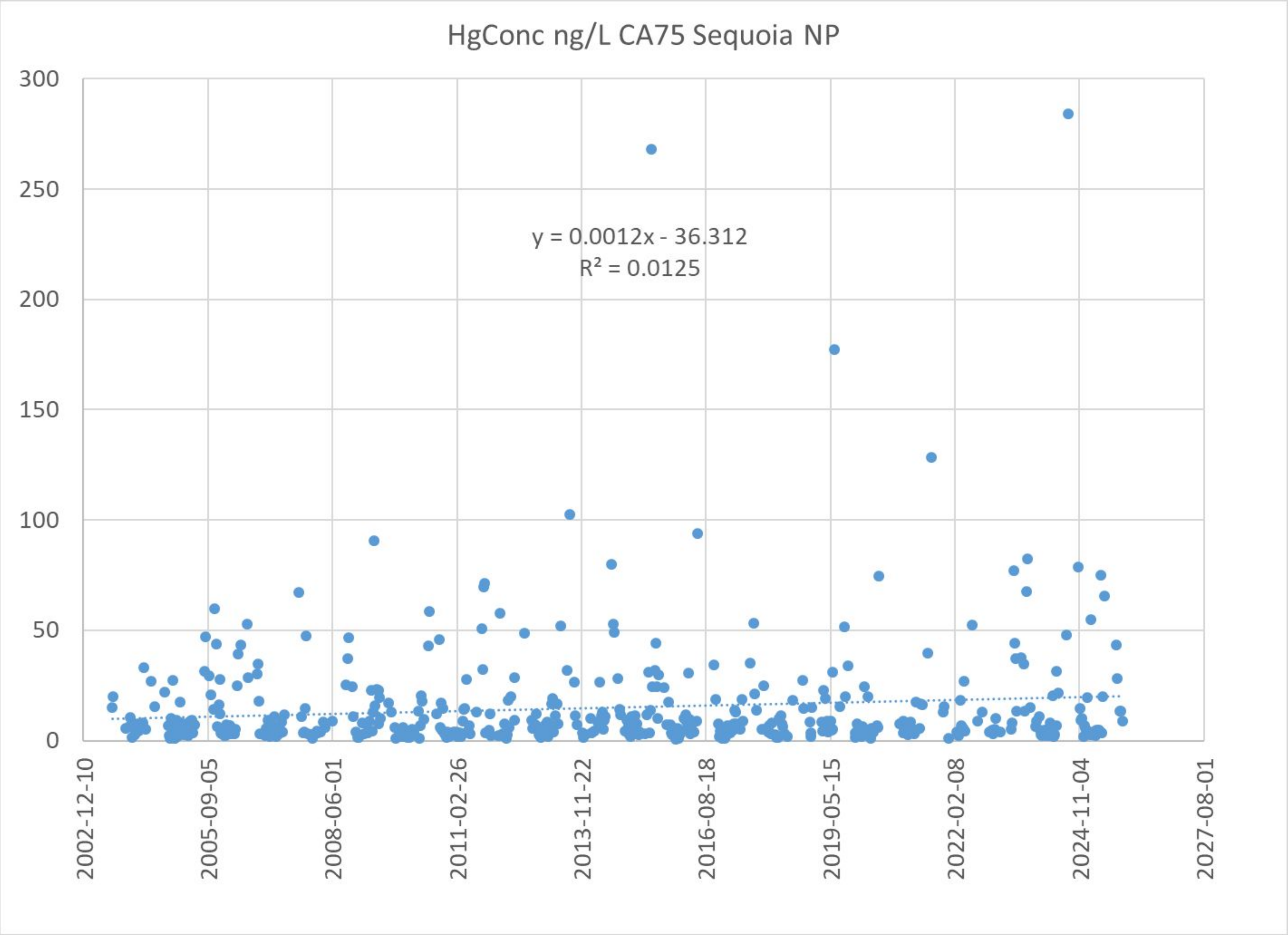
KEY FINDING 2

Estimated global anthropogenic emissions of mercury to the atmosphere for 2015 are approximately 20% higher than they were in updated estimates for 2010.

Continuing action to reduce emissions has resulted in modest decreases in emissions in North America and the European Union. Increased economic activity, notably in Asia, and the use and disposal of mercury-added products appears to have more than offset any efforts to reduce mercury emissions.

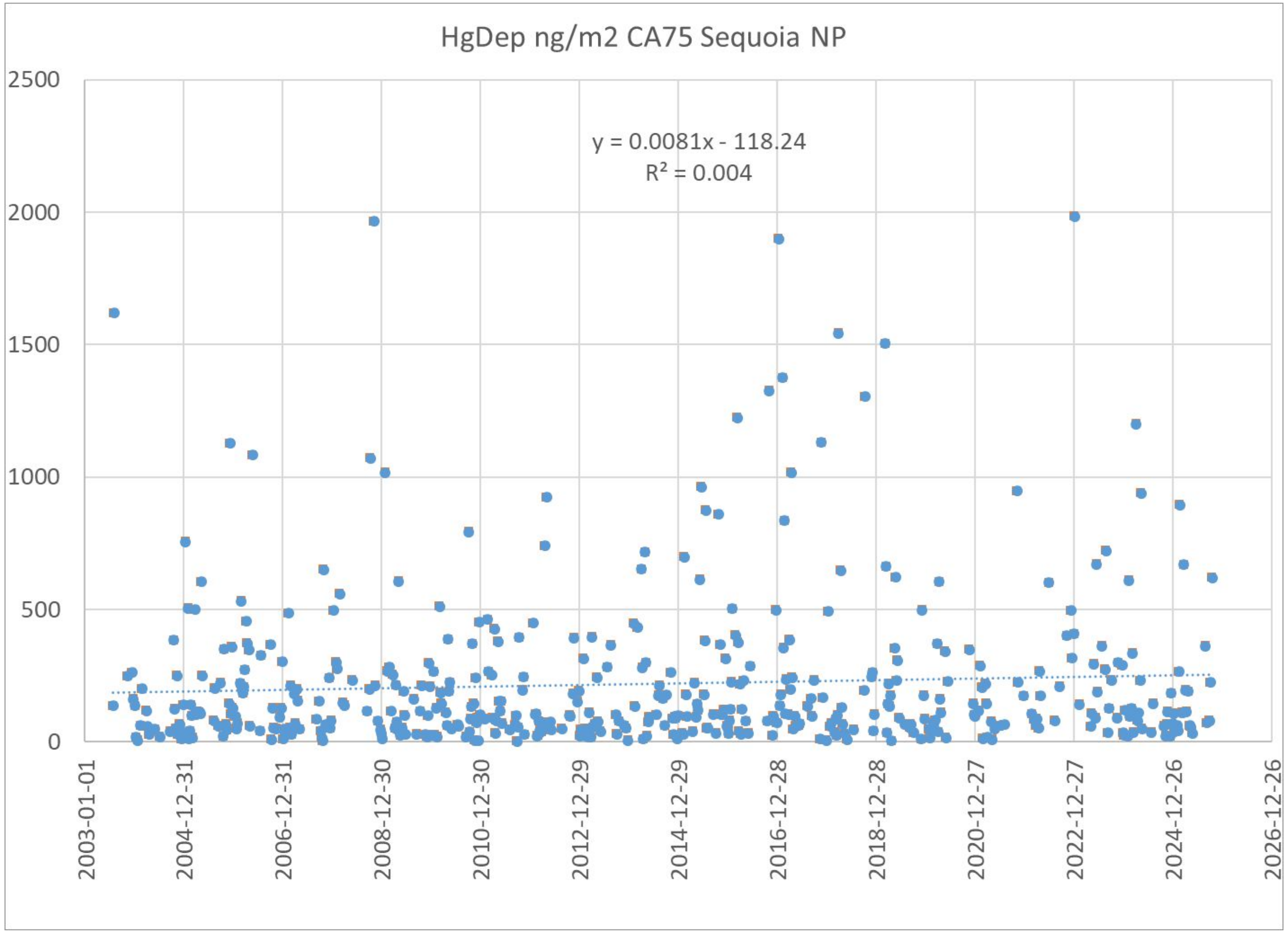
CA MDN site

no trend in Hg concentration in rainfall



CA MDN site

no trend in weekly Hg deposition in rainfall



Local Point Sources Reduced

Lehigh (Cupertino) cement plant closed permanently

Not upwind of Bay in prevailing winds, direct dep impact small

North Bay refineries converted (~50% regional capacity loss)

Rodeo, Martinez/Avon converted to biofuels

Benicia converted to import terminal

Closure/Conversion Airdep Impacts

- South Bay Cement Plant
  - ~0 on direct deposition (Bay was not downwind)
-
- North Bay refineries
  - 50% upper bound (only if local sources 100% of deposition)
  - 50% of the difference between North Bay (21 µg·m2/yr) and Central Bay (18 µg·m2/yr) sites in RMP 2000 study = 7% change in N Bay

- Overall impact -3%
- Hg evaporation/evasion (water to air) still dominates

Air Dep Takeaway

- Atmospheric deposition was a small portion of Bay budget
- Anthropogenic emissions flat or slightly rising, up to +20%/decade
  - natural emissions ~⅔ of global total, so ~0.7%/yr rise in Hg_{conc}
- Blum group isotope work showed food web Hg ~ sediment
  - (total inventory) isotope signature (water column/ air dep Hg not preferentially taken up)
- Atmospheric deposition not a controllable knob, but still a small portion of Bay budget
  - continued long term global increase could be problematic

Sediment Mixed Layer

Fuller et al 1999

Uniform ^{210}Pb top 25cm, 33cm mixed zone, 9cm half gaussian σ

Leahy 1976

Tracer in dredged material disposal, to 30cm+ in 2-6 months

Bay RMP cruises

Redox transition zone (brown -> gray) usually ~7-9cm depth (rarely <5 or >11)

Some benthos burrow to ~20cm (N. succinea, , Macoma petalum)

Sediment Mixing Takeaway

No major shifts in benthic community over ~5 years, but already ~75% invasive species (H. Jimenez et al., 2019) https://doi.org/10.1016/j.ecss.2019.106324

Absent major shifts in benthic community composition, hydrodynamics, or sediment supply, sediment mixing processes are likely to change little in the long term.

Prior baseline mixed depth ~15cm reasonable.

Suspended & Bed Sediment Linkage

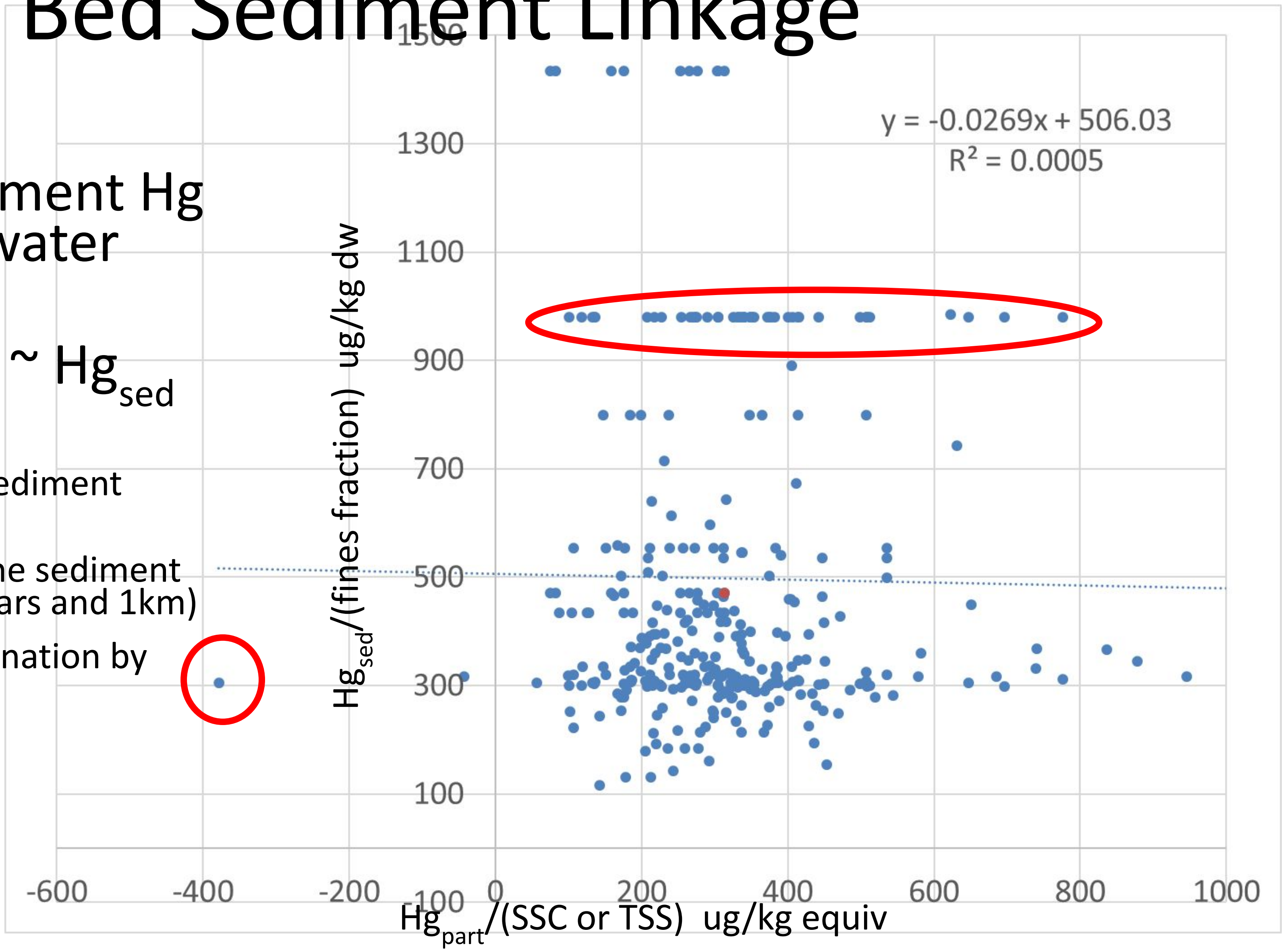
Hypothesis: Bed sediment Hg highly correlated to water particulate Hg

$$(Hg_{tot} - Hg_{diss})/SSC \sim Hg_{sed}$$

Pair water results with nearest sediment sample, fines normalized

Some water samples had only one sediment sample nearby (N=1, within 5 years and 1km)

Analytical RPDs 10-20%, determination by difference very noisy)



Suspended & Bed Sediment Linkage

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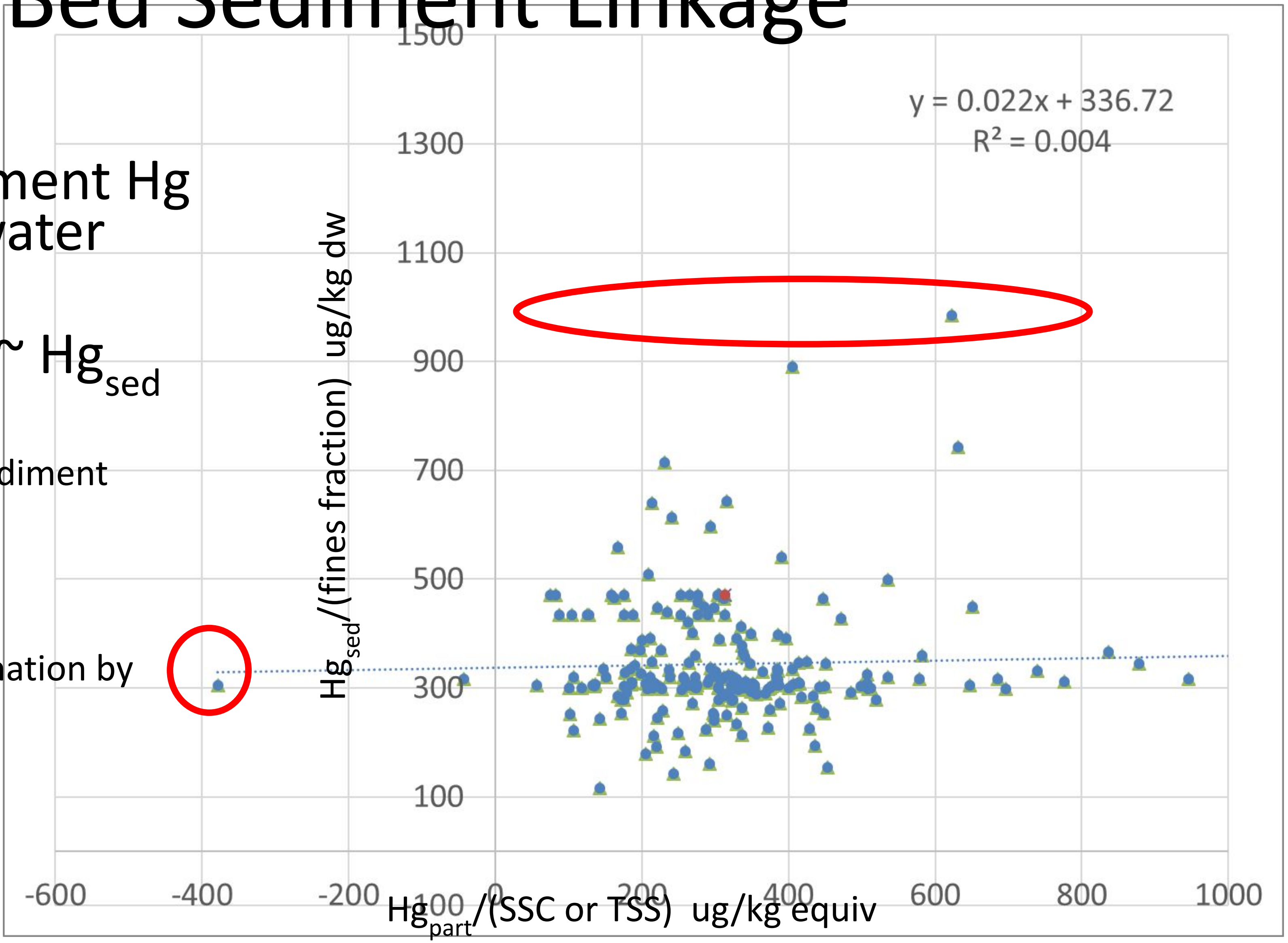
$(Hg_{tot} - Hg_{diss})/SSC \sim Hg_{sed}$

Pair water results with nearest sediment sample, fines normalized

N=1 sets removed

Analytical RPDs 10-20%, determination by difference very noisy)



Suspended & Bed Sediment Linkage

Hypothesis: Bed sediment Hg highly correlated to water partic

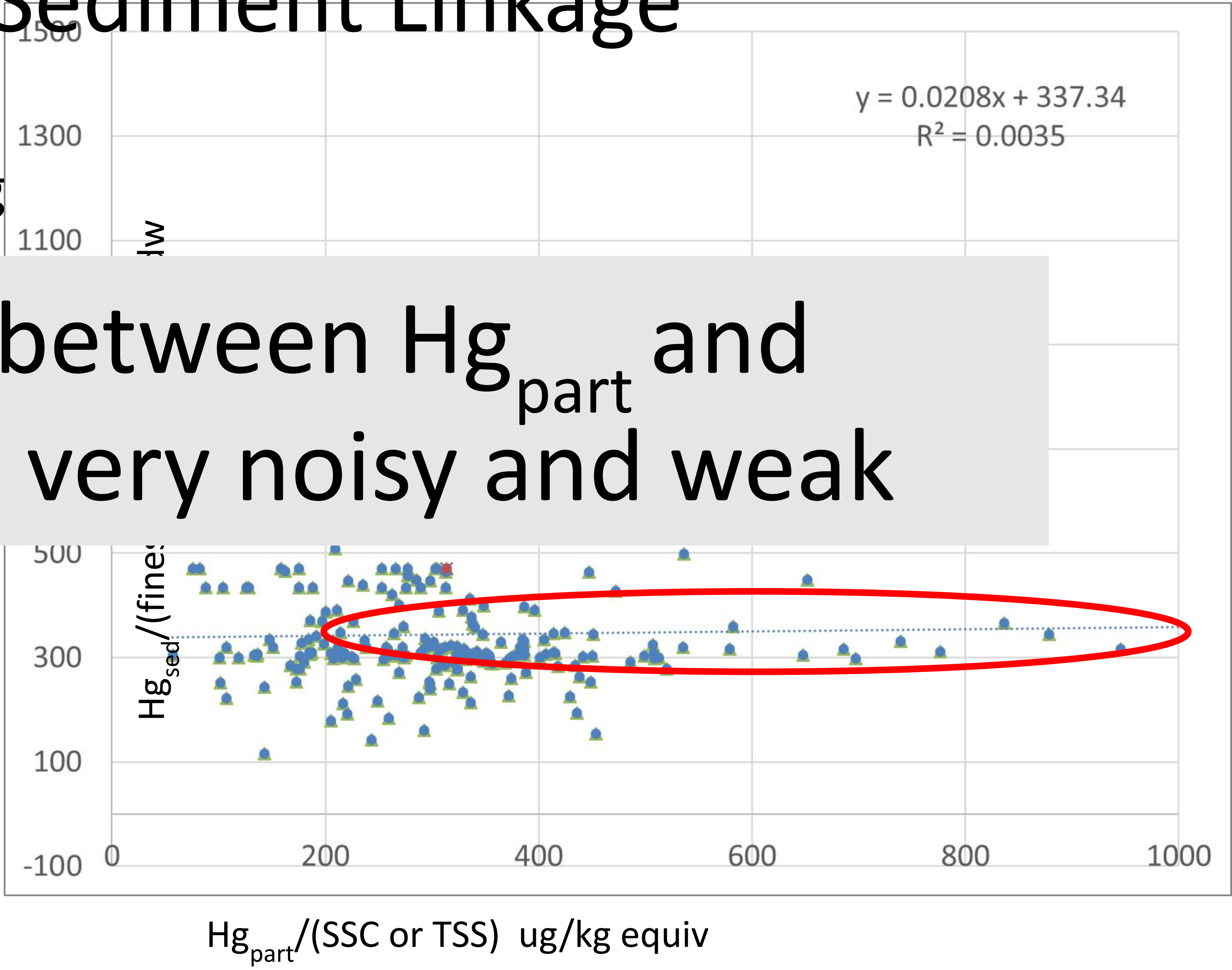
(Hg

Pair wate sample, fi

N=1 sets removed

<0 sets removed

LSB & BA20 have many Hg/SSC sharing averaged sediment for many water samples



Relationship between Hg_{part} and Hg_{sed} nearby very noisy and weak

Suspended & Bed Sediment Takeaway

Conceptually, resuspended bed sediment has to be part of water column SSC

- In summer, few other plausible sources

Individual Water particulate Hg not highly correlated with sediment Hg

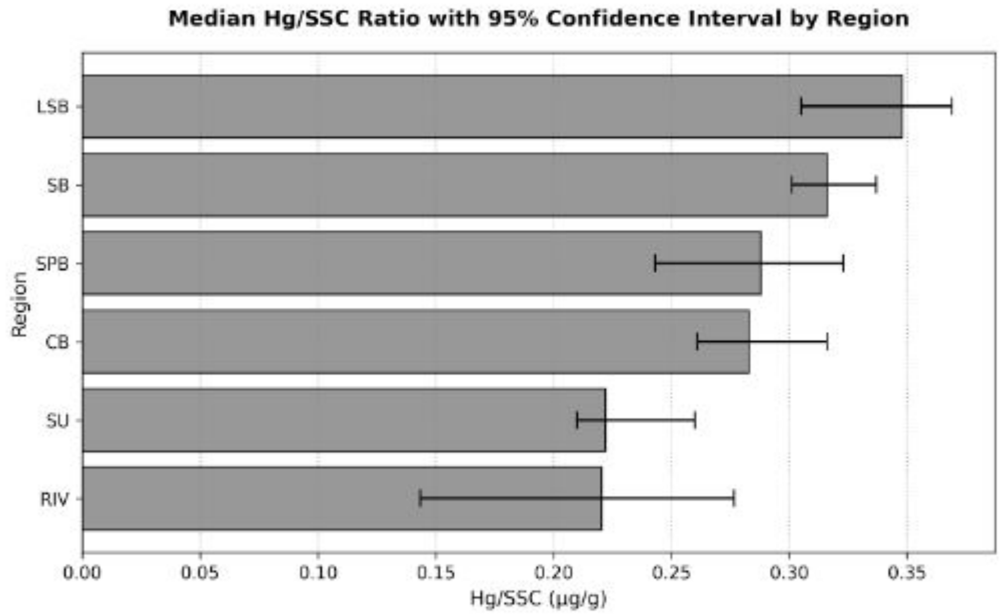
- Noise of deriving Hg_{part} by difference
- SSC & TSS on a separate subsample
- Measurement uncertainty stacked
- Temporal & spatial separation of water & sediment samples

Suspended Sediment Hg

- Segment scale evaluation
  - Drop particulate Hg<0
  - Drop SSC <4mg/L (results near MDL highly variable)
- Median & 95% CI by bootstrap (10k)

  LSB & SB > SU & Riv

  CB & SPB no diff from upper or lower groups



Sediment medians SPB > LSB > CB > SB > SU > RIV

Still not *that* tightly linked (only SU & RIV lower in common)

Suspended Sediment Hg Trends?

Linear regression by year Hg/SSC

Region	Count (n)	Slope (µg/g per year)	% change per year	Intercept	Fit (R2)	P-value
LSB (Lower South Bay)	53	-11.4E-3	-3%	23.26	78.0E-3	0.04
SB (South Bay)	61	-9.0E-3	-3%	18.38	43.0E-3	0.11
CB (Central Bay)	44	-5.4E-3	-2%	11.12	15.0E-3	0.43
SU (Suisun Bay)	33	4.0E-3	2%	-7.77	19.0E-3	0.44
SPB (San Pablo Bay)	29	6.5E-3	3%	-12.81	42.0E-3	0.29
RIV (Rivers)	20	8.9E-3	3%	-17.60	135.0E-3	0.11

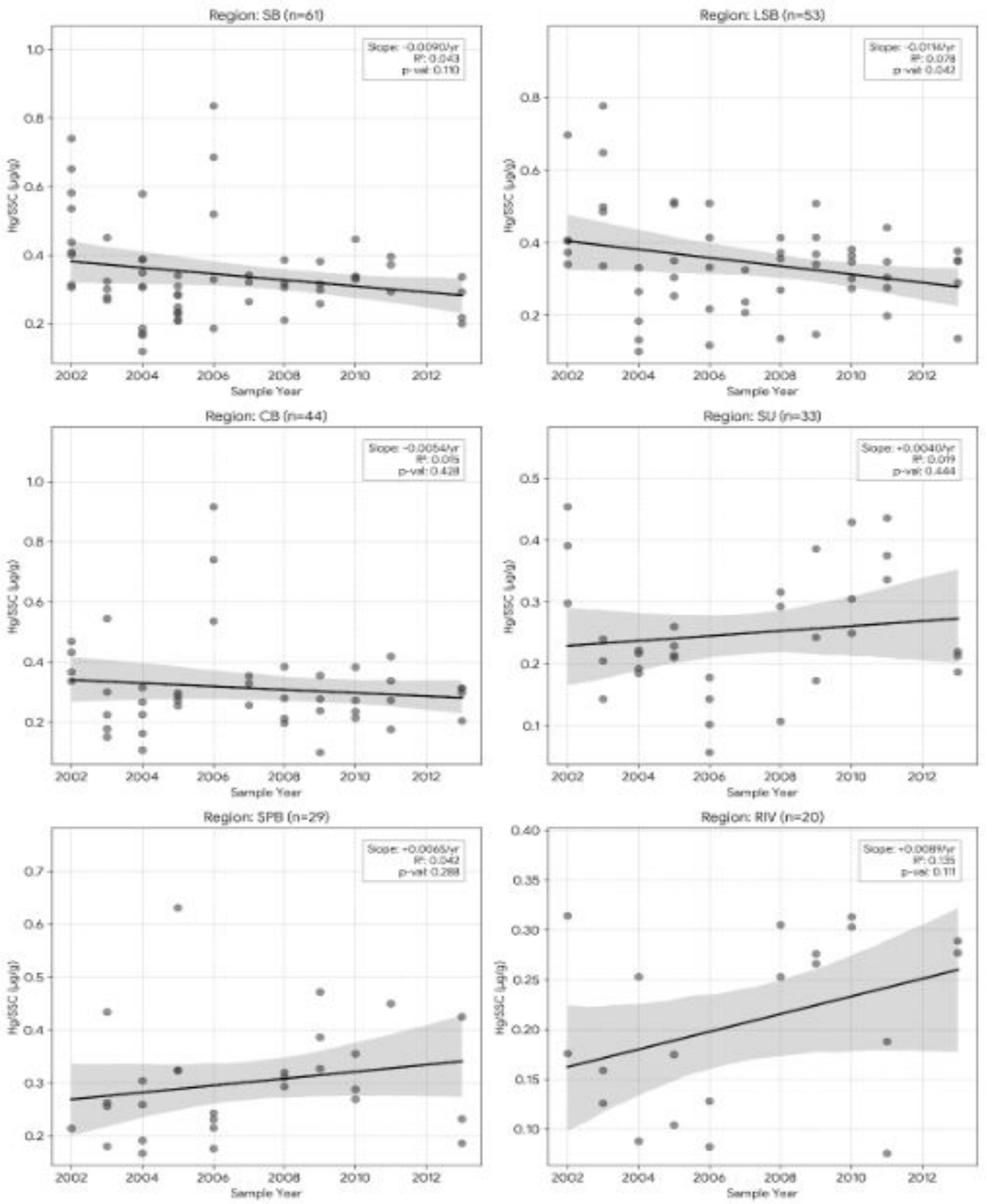
Hg/SSC Trends?

LSB - significant decline (most signal, and most local management activity)?

SB - needs more time/change but hints expected decline

Rivers - needs more time/change, hints a rise?

SU, SPB - no trend (+3% slope)



Bed Erosion Inputs

Historical Hg loads pre 1970s were higher than post CWA

For bed erosion to be a substantial contributor

1. Historical concentrations much higher
2. Depositional through ~1980
3. Erosional going forward
4. Major portion of Bay sediment area/budget

#2&3 somewhat incompatible absent major shifts in sediment supply, hydrodynamic /wave energy

Rare Depositional Locations

- USGS (1990) cores
  - 90+ sites collected
  - 2 reported in detail
- Polluted max subsurface

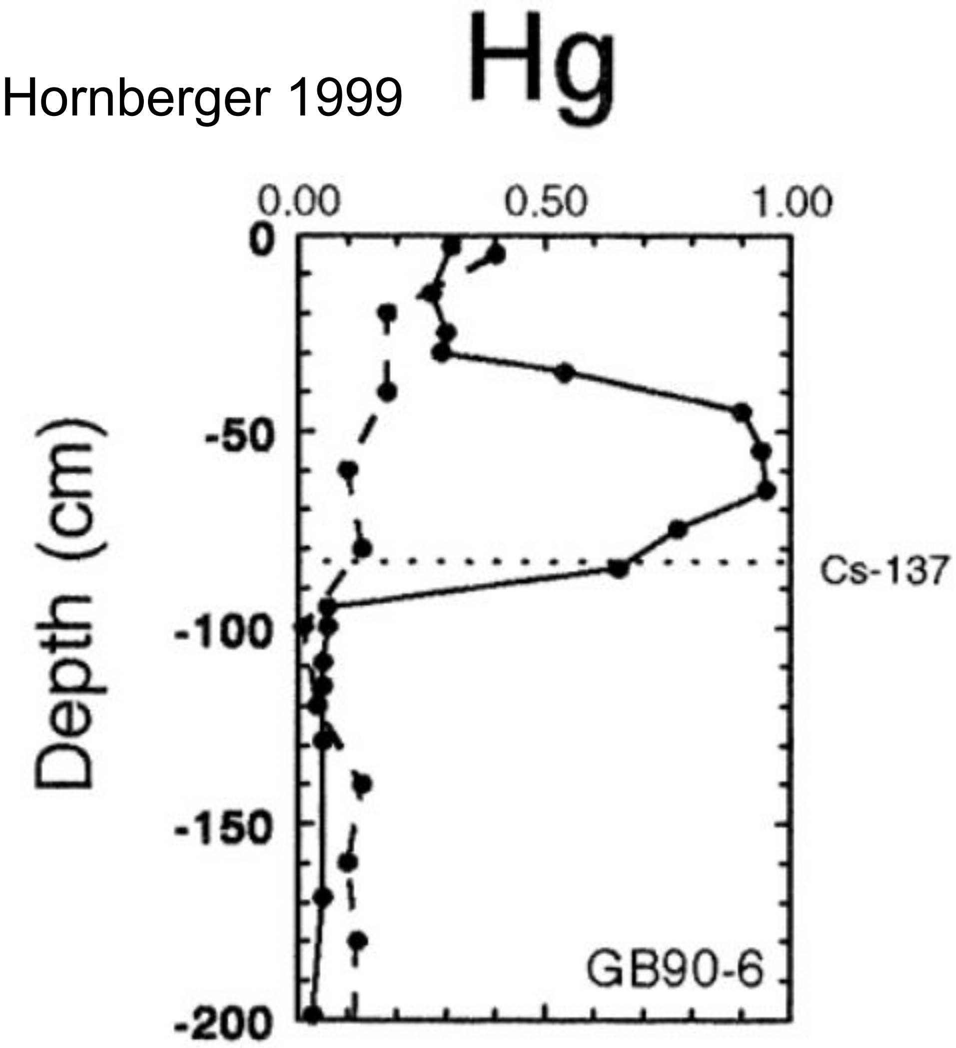
SFEI (2005) cores

Subtidal cores 0 for 11 with subsurface Hg max

Himson et al., 2023, 1 of 19 cores

Subsurface Hg max, but “continuous deposition since 1858 CE, based on bathymetric survey data

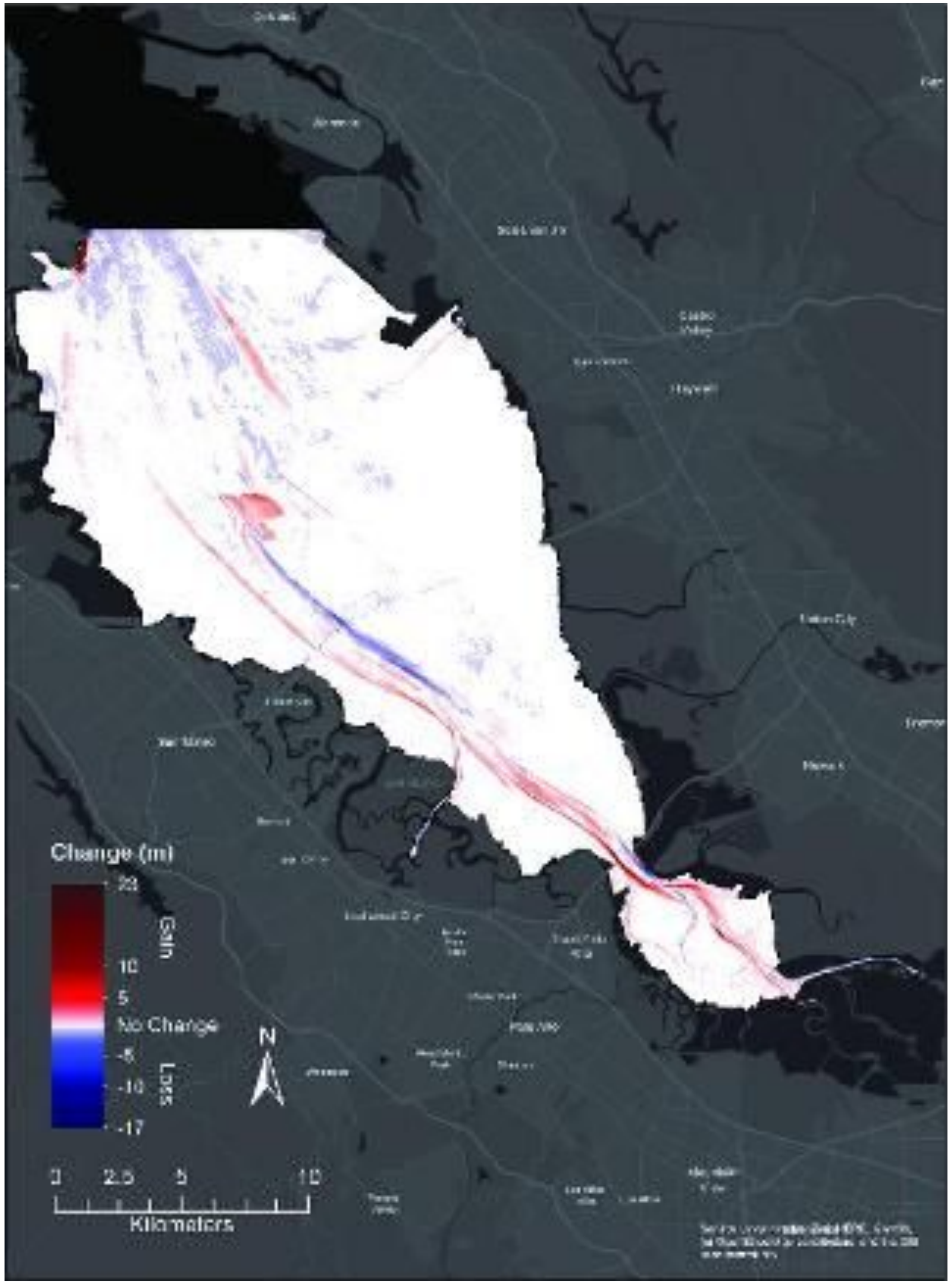
Hornberger 1999



Bed Erosion Inputs

Fregoso, T.A., Jaffe, B.E., and Foxgrover, A.C., 2024, Bathymetric change analysis in San Francisco Bay, California, from 1971 to 2020: U.S. Geological Survey data release, https://doi.org/10.5066/P1332UUW

- Main areas of change near Central Bay, and adjacent to main channels



Bed Erosion Inputs

1956 to 1983

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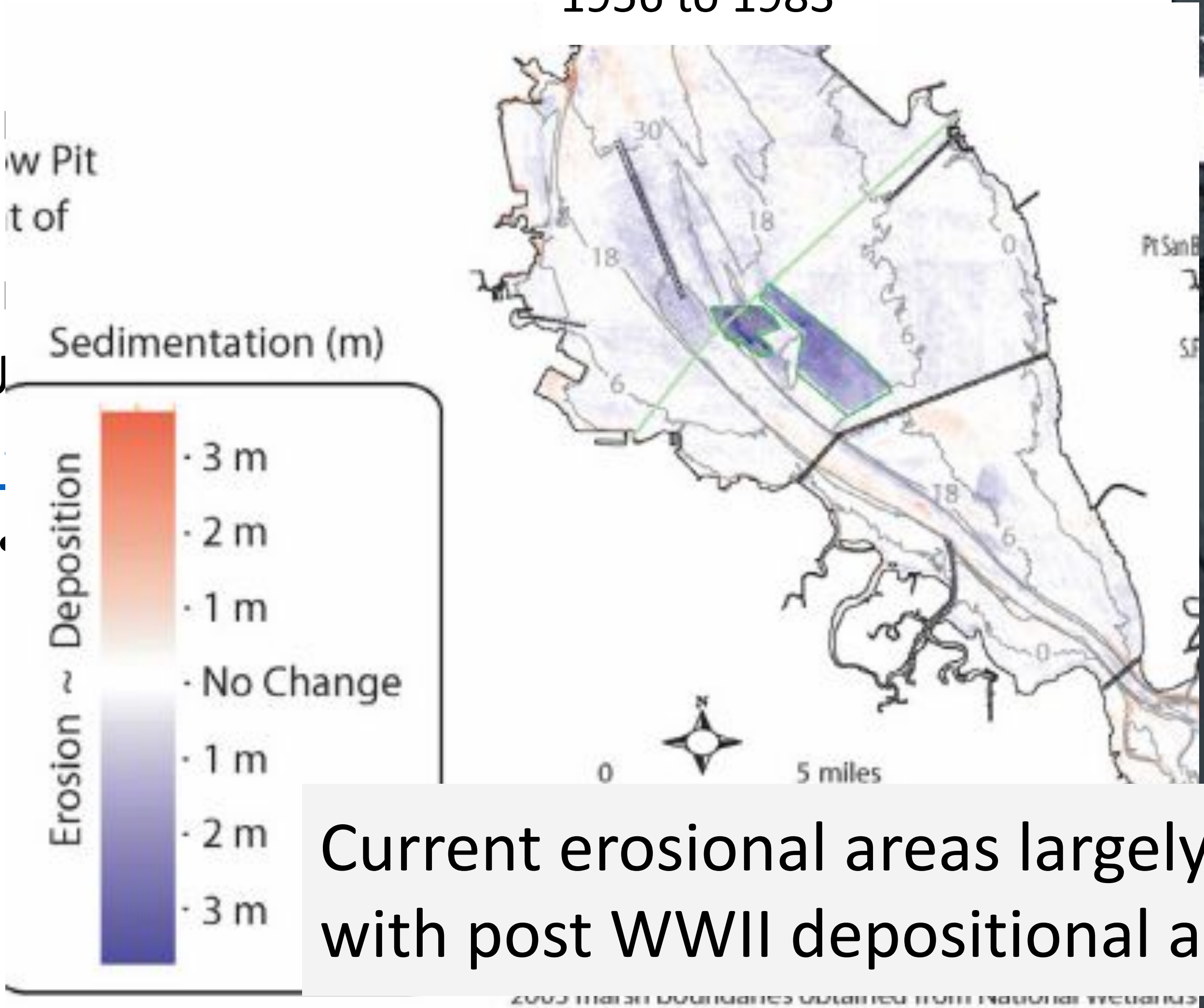
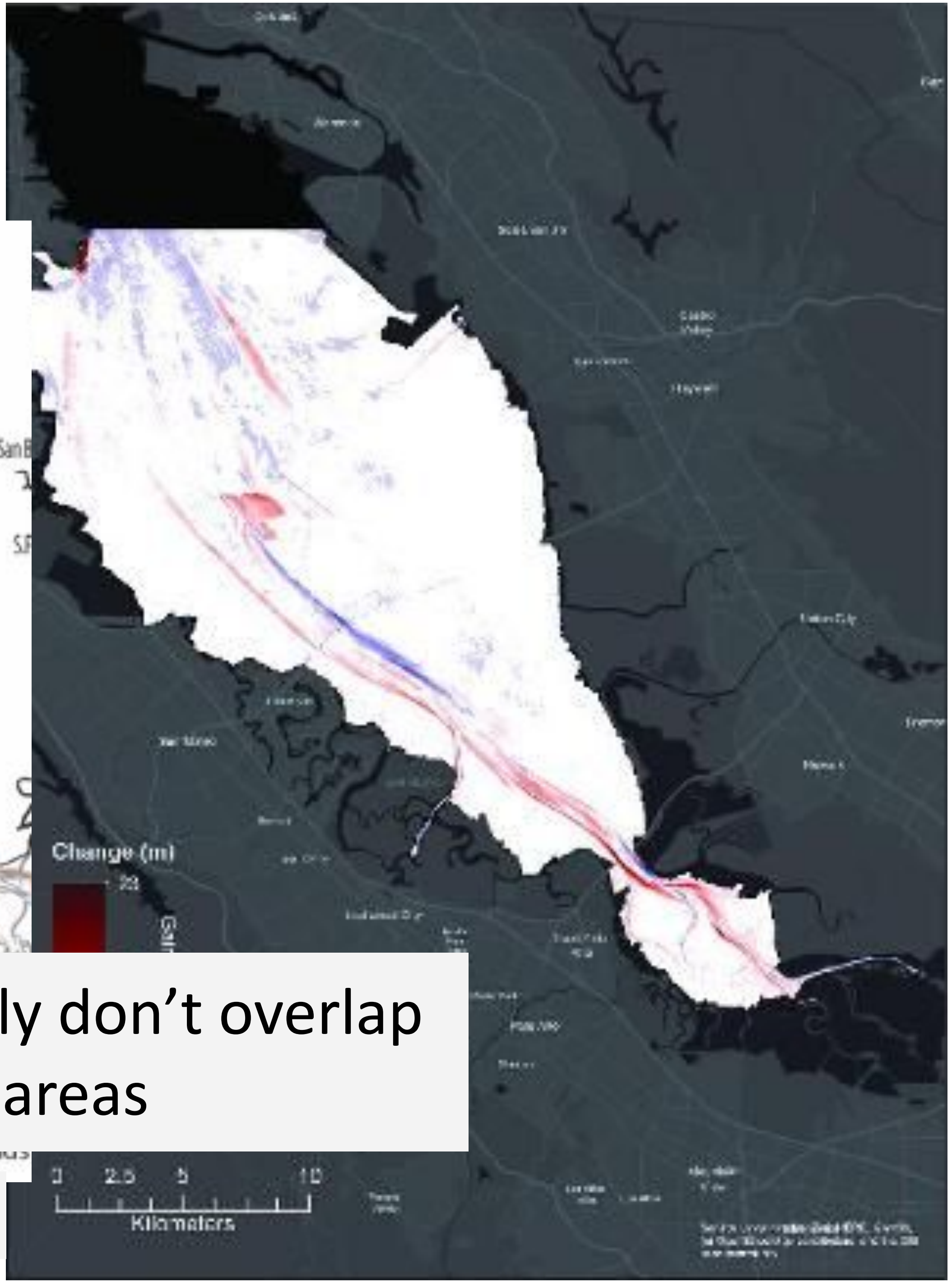




Current erosional areas largely don't overlap with post WWII depositional areas

https://pubs.usgs.gov/of/2006/1287/of2006-1287.pdf

Bed Erosion Takeaway

A major Hg input from bed erosion is highly unlikely

- Areas depositional during peak Hg period (WWII-1980) limited
- Areas recently erosional also <5% of Bay
- Overlap of the above even smaller
- Peak sediment Hg ~3x current ambient

Some areas might see erosion of historical deposits, but are probably localized and small in scope

Long term budget with flat profile, no change with erosion likely closer to reality on a regional scale

- Decision: Keep prior eroding deposit subsurface max assumption as (extreme) bounding scenario? Or drop entirely?

Bed Erosion Update

A major Hg input from bed erosion is highly unlikely

- Subsurface peak sediment Hg rare
- Decision: Keep prior eroding deposit assumption as (extreme) bounding scenario? Or drop entirely?

Some areas might see erosion of historical deposits, but are probably localized and small in scope

Where to get erosion rate

Sediment model?

Assume Jaffe et al last change extends into future?

Sediment Erosion/Deposition

Jaffe volume x median surface Hg

	Volume change 1983-2014 Mm3/yr	Sediment mass change Mt/yr	Mercury median mg/kg	Mercury kg/year into sed layer
Suisun	-28	-0.73	0.21	-150
San Pablo	-14	-0.35	0.27	-97
Central	16	0.42	0.24	101
South	-9	-0.23	0.23	-53

Dredging Removal

DMMO 2021 Annual Report

Year	In Bay Disposal	Reuse Upland	Ocean Disposal	Total Dredging
2017	1,219,727	883,475	922,594	3,025,796
2018	1,096,379	763,391	643,308	2,503,078
2019	643,835	1,709,984	246,188	2,600,007
2020	716,535	848,208	1,010,317	2,575,060
2021	1,046,278	420,289	770,964	2,237,531
5yr avg	944,551	925,069	718,674	2,588,294

Dredging Removal

Upland + Reuse + Ocean Disposal

- Average 1.6M cy per year (2017-2021)
- Subtidal dry bulk density ~30 lb/ft3 = 810 lb/cy
- Non-Bay disposal ~1.3e9 lb/year = 5.9e8 kg sediment
- Bay avg mercury ~0.25 mg/kg dw
- 1.47e8 mg of Hg in disposed sediment
- ~ 150 kg/year exported?

Validate with DMMO Hg testing data?

MERCURY LOADS TO THE BAY (kg/year)

PATHWAY	TMDL ALLOCATION	TMDL LOAD ESTIMATE	LATEST LOAD ESTIMATE	COMMENTS
POTWs	20	20	2.9	SFBRWQCB (2012)
Industry			0.4	SFBRWQCB (2012)
Urban Stormwater	82	160	120	McKee et al. (2015)
Central Valley	330	440	190	David et al. (2015)
Atmospheric Deposition	7	27.2	–	New estimate not available
Bed Erosion	220	460	–	New estimate not available
Guadalupe River	2	92	90	McKee et al. (2015)
Non-urban Stormwater	25	25	–	New estimate not available
Sediment Dredging and Disposal	0	Net loss	–	New estimate not available

Dredging Removal - DMMO Hg

Upland + Reuse + Ocean Disposal

Non-Bay disposal ~1.3e9 lb/yr = 5.9e8 kg sediment

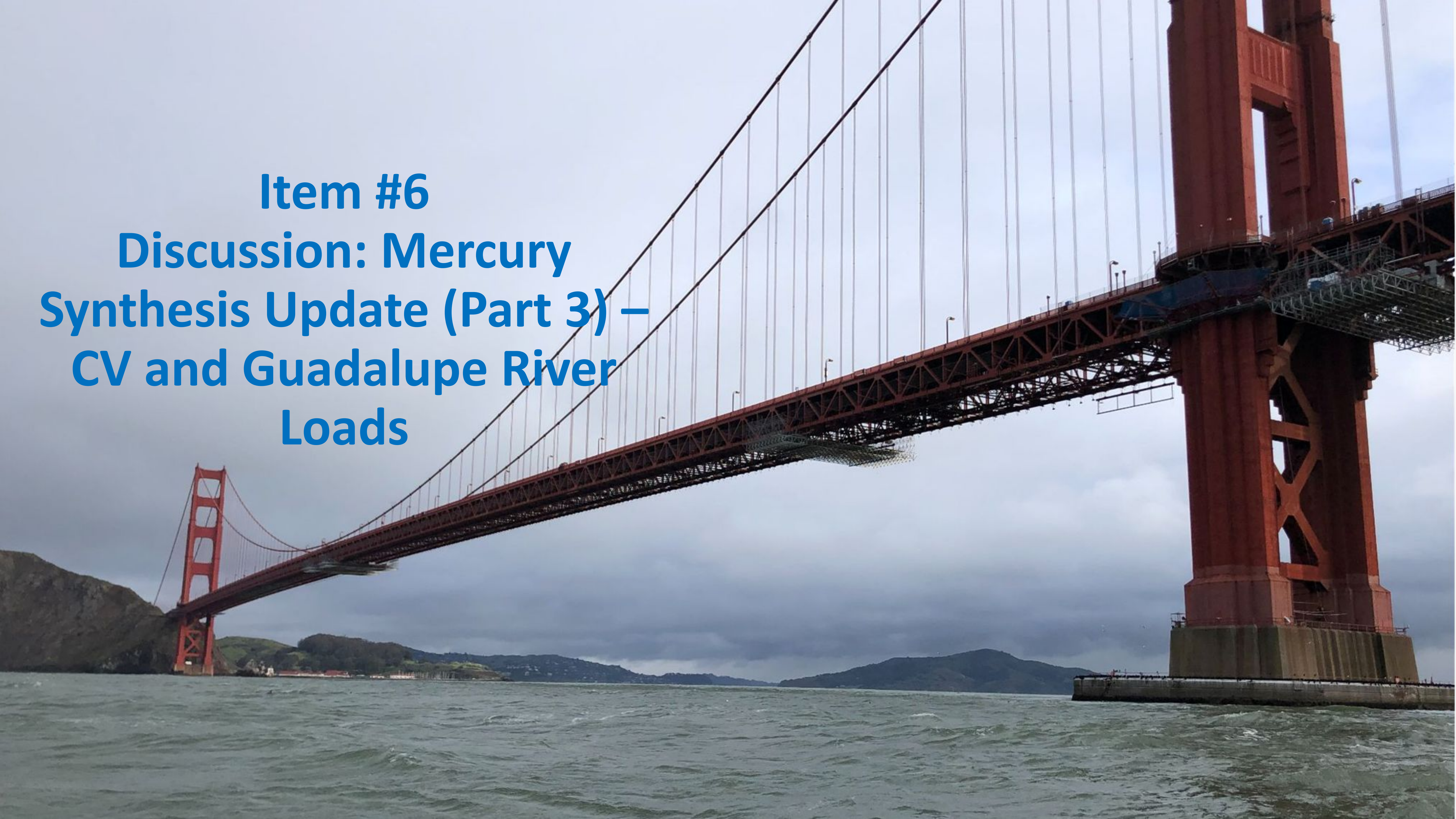
Bay avg Hg ~0.25 mg/kg dw

DMMO avg ~0.31 mg/kg dw

~180 kg/yr Hg exported

	Column Labels		
	Mercury		
Row Labels	Average of Hg	Min of Hg	Max of Hg
Central Bay	0.36	0.01	12.00
Reference	0.09	0.02	0.32
Rivers	0.27	0.02	1.10
San Pablo Bay	0.30	0.02	0.96
South Bay	0.39	0.01	1.59
Suisun Bay	0.18	0.01	1.57

Item #6
Discussion: Mercury Synthesis Update (Part 3) – CV and Guadalupe River Loads



Central Valley Hg Sources

Historic Mining Legacy

Total mercury production exceeded **100,000 metric tons** (1850–1981). Approximately **7,700 tons** were used specifically for gold recovery across 13,500 prospects.

Production Peak: 1870s

ATMOSPHERIC

Atmospheric Deposition

Mercury deposition from regional and global industrial sources affecting the entire 154,000 km² watershed area.

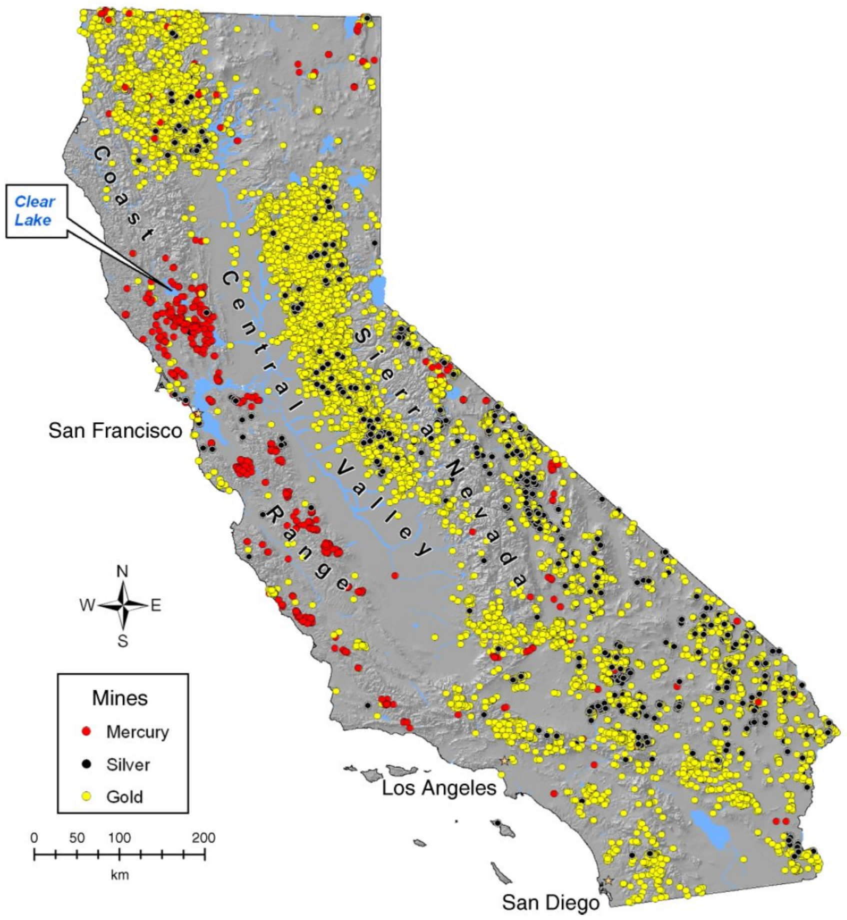
~ 3,600 kg Hg annually

URBAN CENTERS

Urban & Industrial Runoff

2020 Census: 6.2 million. Contamination from Central Valley urban centers. Estimated based on comparative data from the nine-county Bay Area.

~ 100 kg Hg / annually



Source: Alpers et al. (2005). USGS Fact Sheet 2005–3014; Wiener and Suchanek (2008): https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/06-1939.1

Historical Estimates of Total Mercury Loads

Summary of loads estimates passing through the Chips/Mallard Island cross-section into San Francisco Bay

CONCENTRATION STABILITY

7 – 11 ng/L
Consistent flow-weighted mean across authors (*excluding Davis et al.'s who concentrations were based on RMP status and trends (BG20/30 sampling in the 90s).

PARTICLE-BOUND HG

0.22 mg/kg
Consistent particle ratio across authors (**excluding Johnson and Looker who particle ratio was from Foe's monthly X2 sampling).

PRIMARY LOAD DRIVERS

Climatic Variation
Variance (190–710kg) driven by flow & sediment loads, not the Hg concentration or particle ratio used.

Author	Averaging Period	Delta Outflow (Mm^3)	Sediment (Mt)	Total Hg (kg)	FWMC (ng/L)	Ratio (mg/kg)
Davis et al. (2000)	WY 1993-1998	34,867	3.5	**710**	20*	0.20
Johnson & Looker (2003)	WY 1995-2000	38,101	1.6	**440**	-	0.28**
Louie et al. (2008)	WY 1984-2003	20,943	0.80	**198**	9	0.25
David et al. (2009)	WY 1995-2006	29,553	1.2	**260**	9	0.22
David et al. (2015)	Long-term Mean	24,474	0.83	**190**	8	0.23
OWWG (2020)	WY 1999-2006	22,038	1.047	**237**	11	0.23

Data Sources & Interpretive Techniques

6-Step Load Estimation Protocol refined by the RMP Sources, Pathways, and Loadings Workgroup (SPLWG) from 2002-2018:
(McKee et al., 2002; Leatherbarrow et al., 2005; McKee et al., 2006; David et al., 2009; McKee et al., 2013; David et al., 2015; Schoellhamer et al., 2018)

STEP 1 Sediment Data Pre-Processing

Established a time-continuous dataset for Suspended Sediment Concentration (SSC) using USGS 15-minute interval data at Mallard Island (WYs 1995–2023), averaged to a **daily scale**.

STEP 2 Daily Outflow Estimates

Extracted daily tidally averaged water discharge from the DWR Dayflow Model web portal, utilizing the most recent updated estimates as of **April 2026**.

STEP 3 Total Hg Concentration Estimation (Hg)

Calculated daily concentrations using equations derived from simple linear regression across three distinct flow and salinity classes (where y = ng/L, x = mg/L):

Flow > 4,200 m^3/s	$y = 0.22x + 4.31$	*Big floods; Yolo Bypass bypass*
Flow < 4,200 & EC < 2	$y = 0.11x + 3.08$	*Mainstem Sacramento/San Joaquin*
Flow < 4,200 & EC > 2	$y = 0.29x - 2.17$	*Low-flow/Estuarine bed sediment*

STEP 4 Daily Advective Load Estimation

Multiplied daily concentration data by daily flow volumes. Outputs converted to **metric tonnes** for suspended sediment and **kilograms (kg)** for total mercury.

STEP 5 Tidal / Dispersive Flux Correction

Adjusted advective loads for upstream dispersive flux using historical relationships. The flow-weighted **29-year mean adjustment was -18%**. Neglecting this workflow step would bias total load calculations up by 18% seaward.

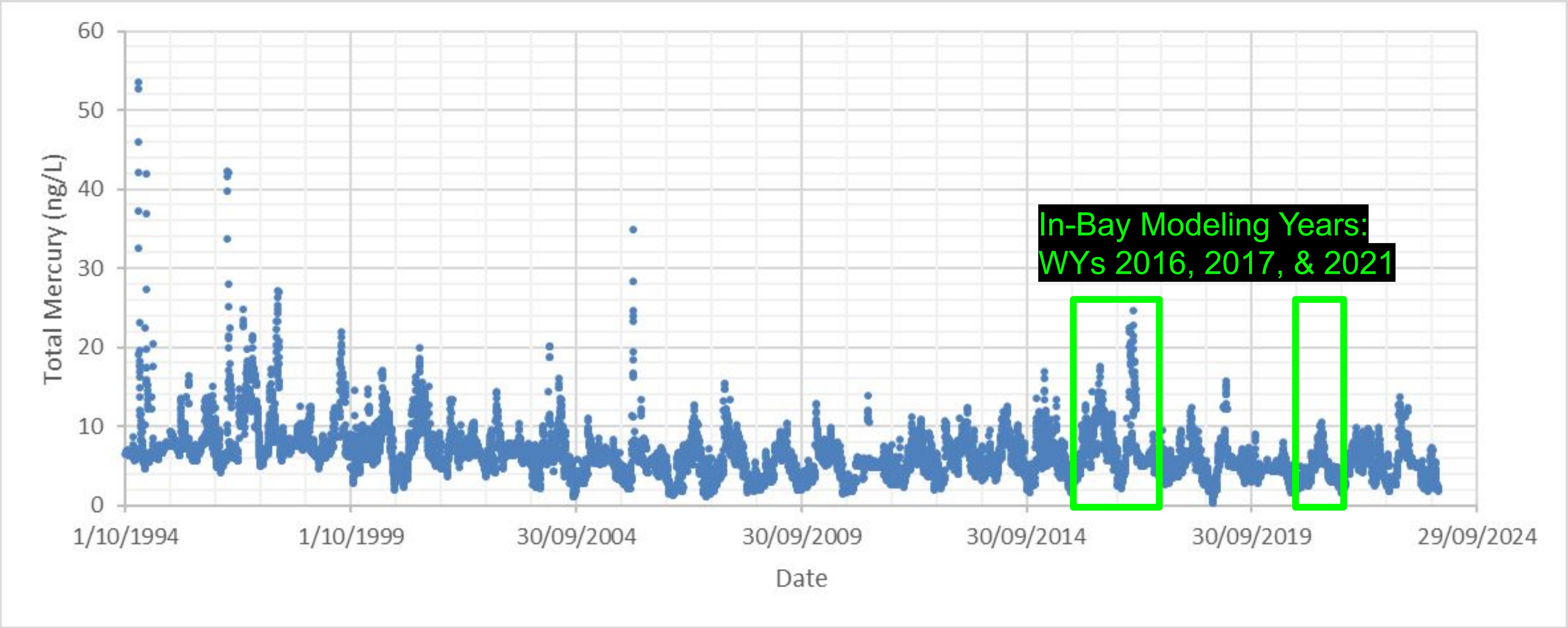
STEP 6 Load Summation & Error Propagation

Observational and regression errors were explicitly propagated using the root-sum-of-squares method to ensure natural climate variability is isolated from calculation uncertainties:

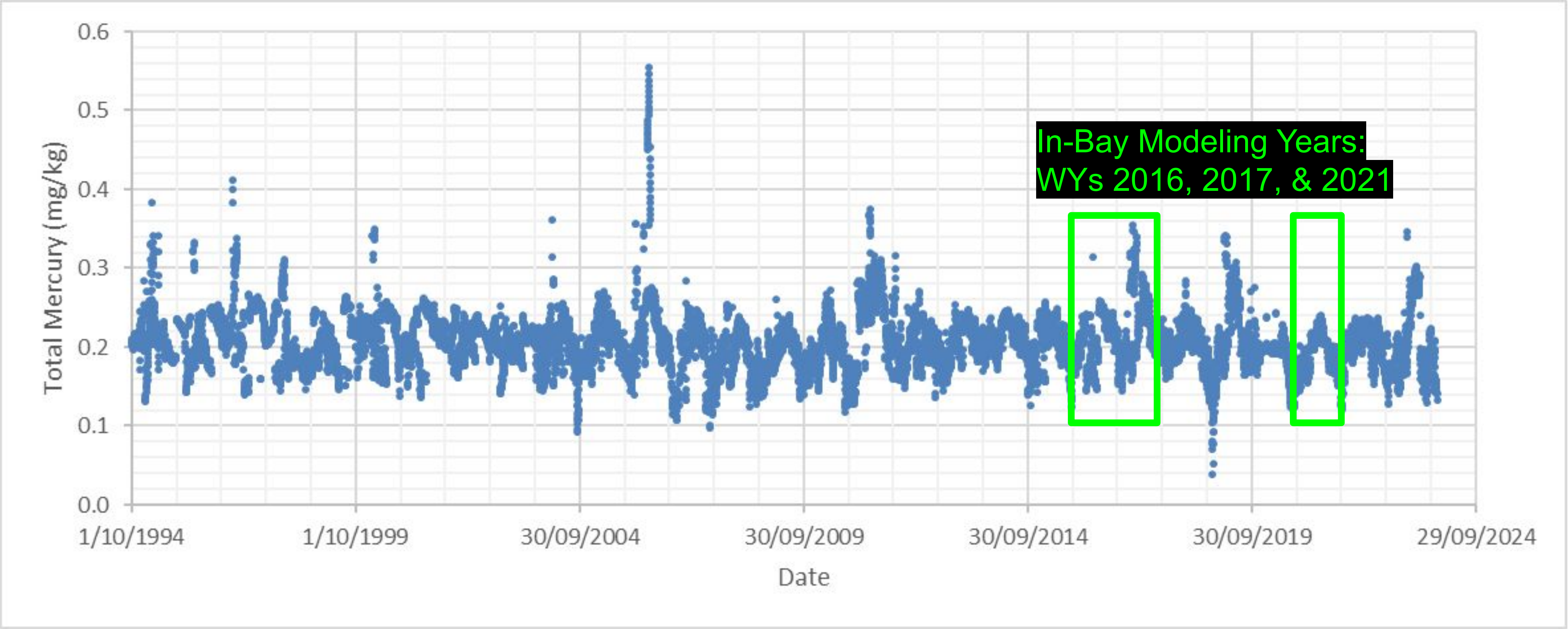
32%
Estimated Suspended Sediment Error

36%
Estimated Total Mercury Error

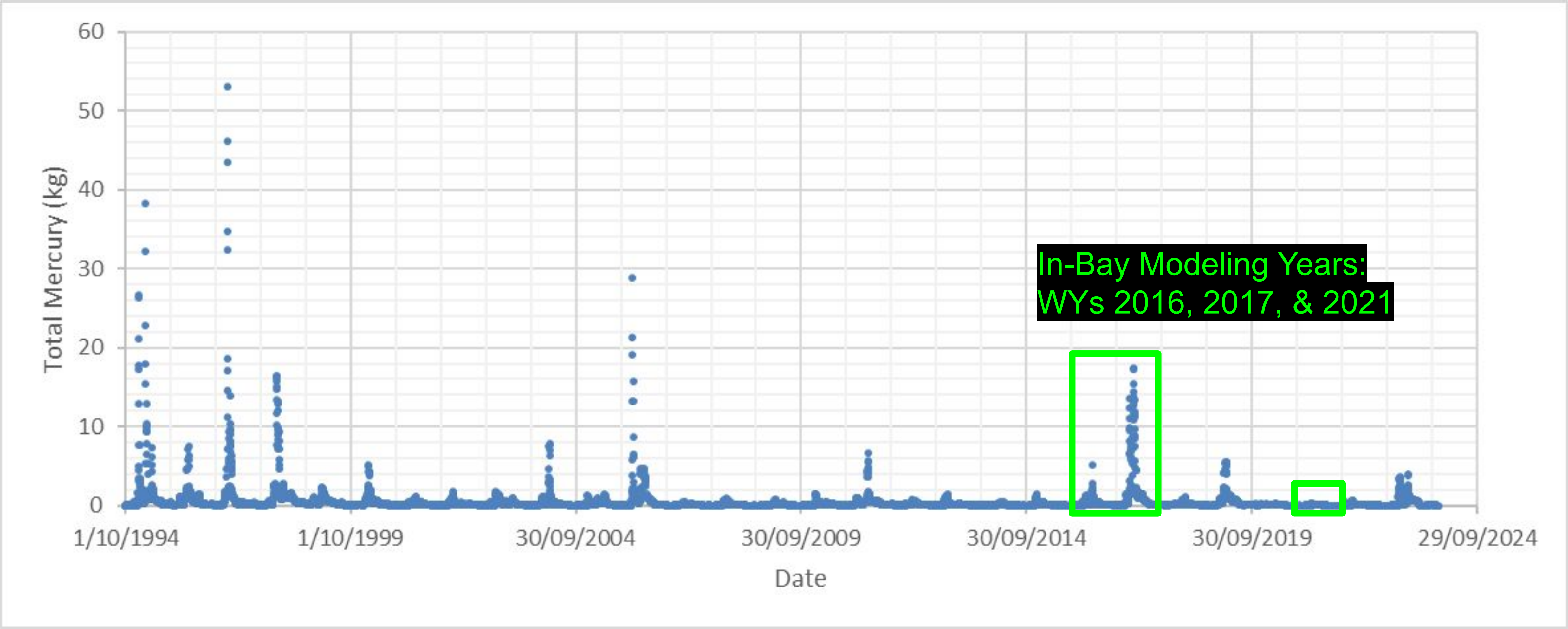
Sacramento River at Mallard Island: Modeled Concentrations



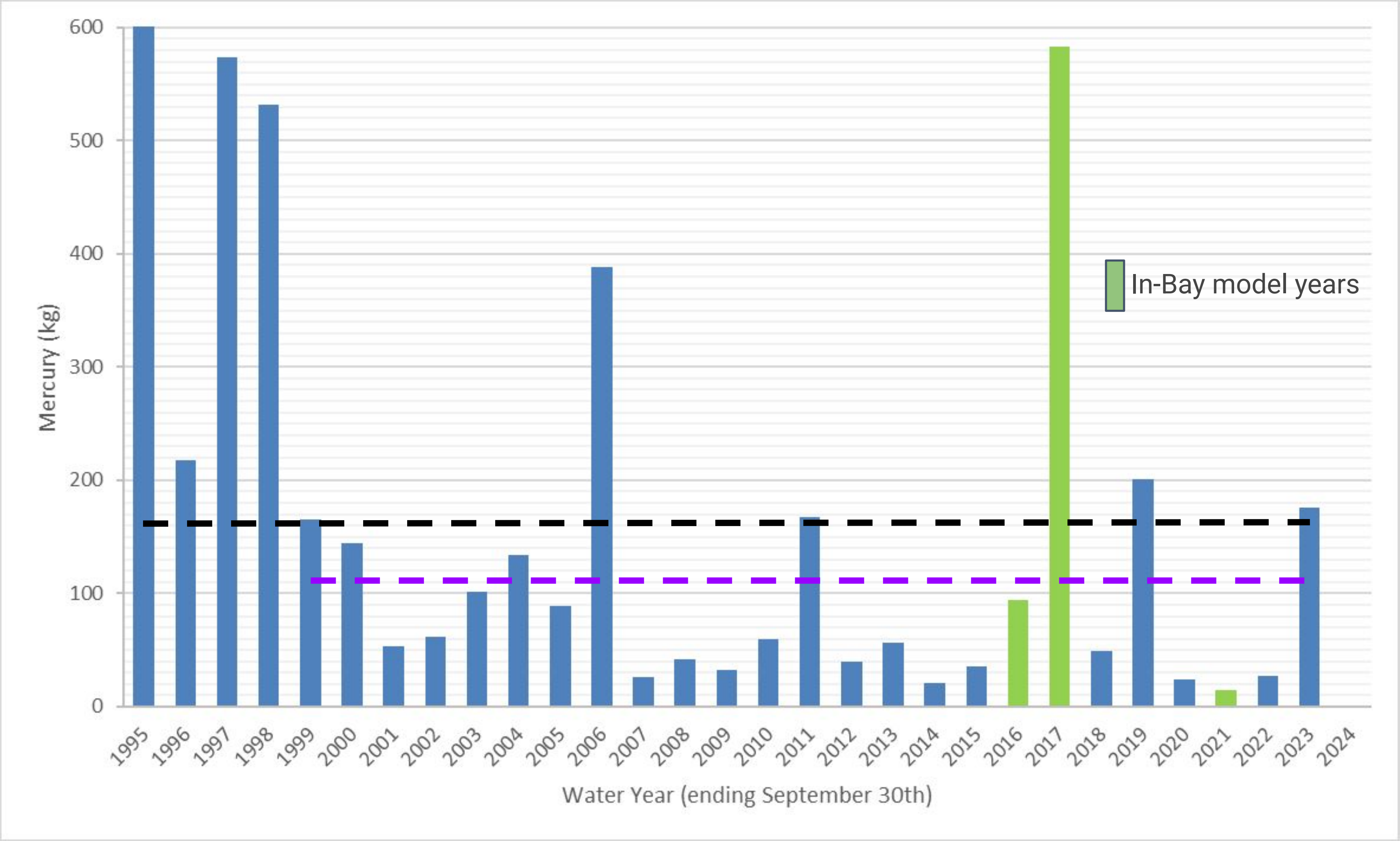
Sacramento River at Mallard Island: Modeled Particle Ratios



Sacramento River at Mallard Island: Modeled Daily Loads



Sacramento River at Mallard Island: Modeled Annual Loads



Loads variability (kg)

Range: 15 - 602

2016: 94
2017: 584
2021: 15

Summary Metrics

27-Yr Arithmetic Average
163 kg

Post-1999 Average
112 kg

Annual Mercury Loads & Long-Term Averages: Summary

HISTORICAL TMDL BASELINE

440 kg / year

TMDL LOAD ALLOCATION TARGET

330 kg / year

CONTEMPORARY BASELINE (WY 1999–2023)

112 ± 40 kg / year

Extreme Climatic Driving Forces

California's Mediterranean climate introduces large annual variance. Across the 29-year history, flow volume varied **12-fold**, suspended sediment sediment loads varied **30-fold**, and total mercury loads varied **39-fold** (15 to 584 kg).

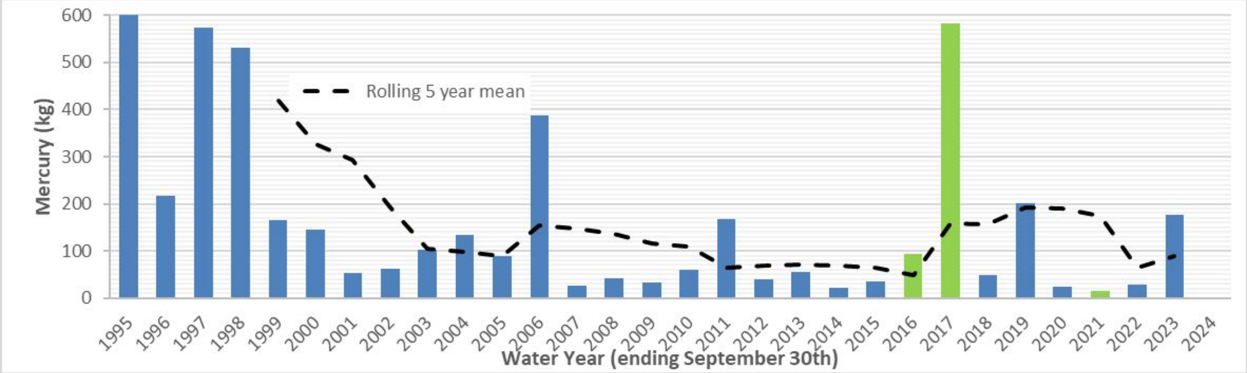
Explaining Shifting Benchmarks

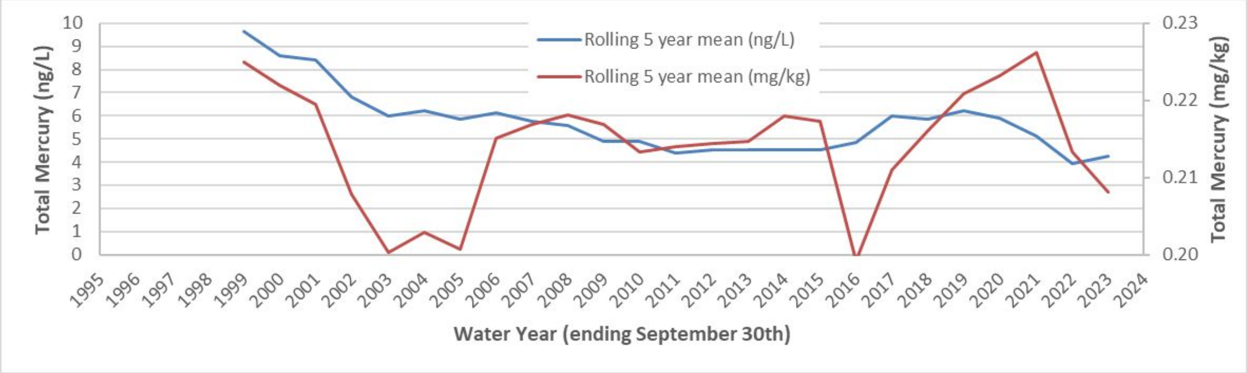
Early regulatory targets relied on significantly higher historical sediment loads from the exceptionally wet 1990s and particle ratios biased towards dry-weather sampling. Factoring in the modern, stabilized sediment regime and wet weather biased particle ratios drops the contemporary load down to ~140 kg.

HYDROLOGICAL & CONTAMINATION PROFILES

Parameter	25-Yr post 1998 Baseline	2021 (Dry)	2016 (Mod)	2017 (Wet)
Annual Flow Volume (Mm^3)	18,064	5,068	14,048	59,987
Mean Outflow Flow (cfs)	20,179	5,675	15,689	67,176
Mean Daily Sediment Load (t)	1,340	197	1,377	5,957
Mean Flow-Weighted Hg (ng/L)	6	x	7	10
Mean Daily Hg Flux (kg)	0.30	0.04	0.26	1.60

Sacramento River at Mallard Island:
5-year rolling means





Total Mercury 5-Yr Loads

Loads diminished from **418 kg** (90s) to **49 kg** during the 2012-2016 drought.

8.5-FOLD VARIATION

Water 5-Yr Concentrations

Relatively stable 5-year means ranging tightly between **4 to 10 ng/L**.

2.5-FOLD VARIATION

5-Yr Particle Ratios

Nearly static ratio (HgT:SSC) between **0.20 and 0.23 mg/kg**.

14% VARIATION

Primary Driver: The contrast between the highly variable loads and relatively static particle chemistry is consistent with the conclusion that **climate and total sediment volume** play a much larger role in annual Hg variation than shifting Hg chemistry.

Sacramento River at Mallard Island: Multi-Decadal Trend Analysis

Statistical synthesis of flow, suspended sediment, and total mercury trajectories over a 25-to-50-year horizon

Hydrological Flows

CYCLICAL / NO MONOTONIC TREND

- **No Monotonic Trends:** Multi-decadal non-parametric tests (25, 35, and 50-year spans) yield p-values well over 0.05. Hydrology is governed entirely by climate oscillations.
- **Climate Risk:** Projections for 2090 suggest warming will eliminate half of April snowpack, contributing to earlier winter flood peaks and severe spring/summer runoff declines.
- **Reservoir Buffering:** Modifying infrastructure operations handles a 1–9% flow alteration, easily absorbing current shifts.

Suspended Sediments

FLAT LOADS POST-1999

- **Stable Modern Loads:** Following the sudden 1999 step change, the period from WY 1999–2023 displays no statistically significant trend in overall sediment loads.
- **Concentration Decline:** Flow-weighted concentration shows a slight monotonic decline of 0.33 mg/L/year ($p < 0.05$), but load calculations remain steady.
- **Double Mass Verification:** Slopes show no significant breakpoint between eras ($p = 0.291$). The 2017 shift was an artifact of extreme weather, not a system shift.

Total Mercury (HgT)

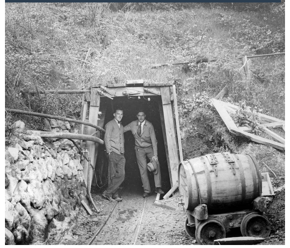
DIVERGENT WATER VS. PARTICLE TRENDS

- **Water-Column Decline:** Long-term summer/fall data displays a downward trajectory of −0.16 ng/L/year, approaching statistical significance ($p = 0.058$).
- **Particulate Concentration Rise:** Conversely, combined site metrics reveal a clean, statistically significant increase of +0.008 mg/kg/year ($p = 0.031$) on particles.
- **Biological Trapping:** The summer decline in water-column mercury is potentially driven by sediment trapping from expanding invasive aquatic vegetation.

System Summary: Multi-decadal baseline analysis shows that environmental load delivery remains tightly bound to **cyclical climate oscillations and physical sediment transport behavior**. Localized changes in raw mercury inputs play a negligible role relative to systemic hydrological forces.

Guadalupe River Hg sources

Senador mine ca. 1925



Historic Mining Legacy

Total mercury production: 40,000 metric t, 30% of North American Hg production and 6% of world production since 1850.

Production Peak: 1865 (1,600 metric t)
Mine closure: 1975

ATMOSPHERIC

Atmospheric Deposition

Mercury deposition from regional and global industrial sources at rates of 4.2 and 19 µg·m-2·yr-1 (Tsai and Hoenocke, 2001) affecting the entire 414 km² watershed area.

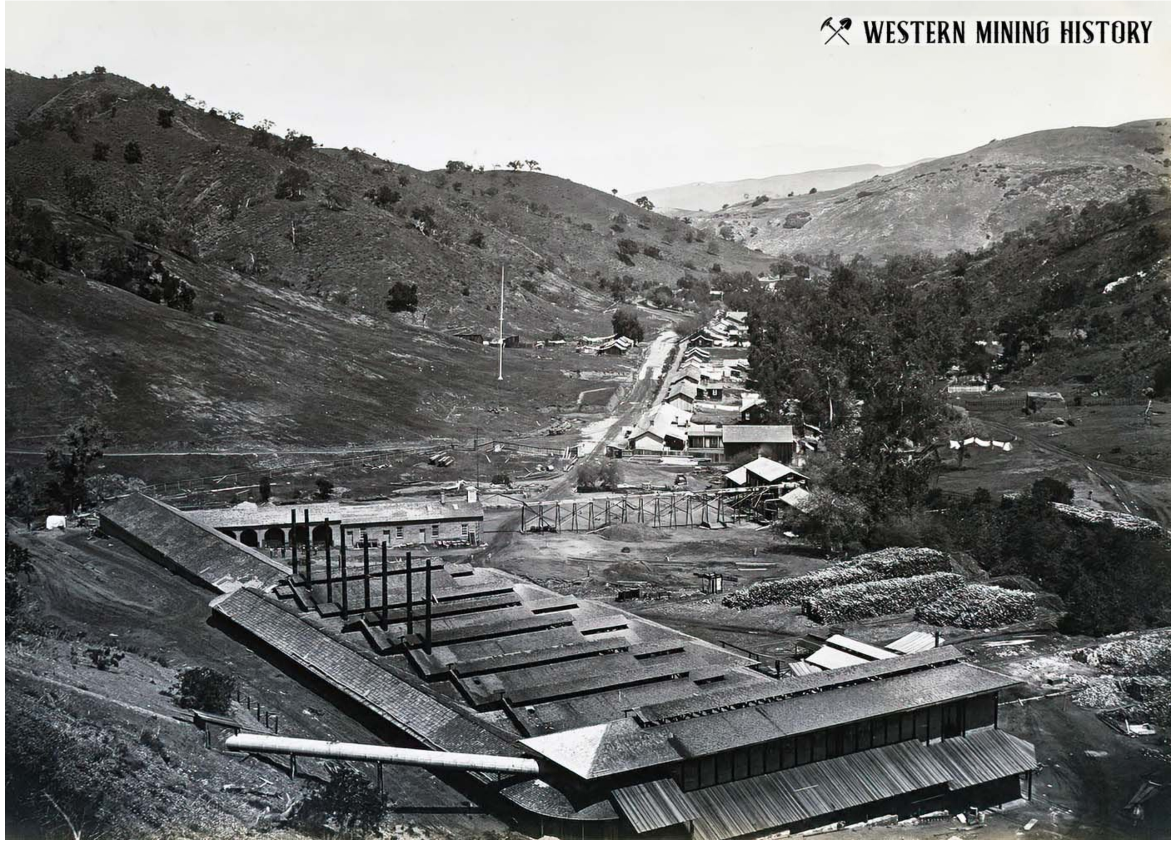
~ 10 kg Hg / annually

URBAN CENTERS

Urban & Industrial Runoff

Water Board working with consultants, SFEI, and stakeholders estimated the portion of Guadalupe runoff from the urban area

14 kg Hg / annually



Hacienda Smelting Yard at New Almaden

Historical Estimates of Total Mercury Loads

Author & Year	Methodology & Basis of Estimate	Total Hg (kg)	Range (kg)
AbuSaba & Tang (2000)	Sediment Hg (1-10 mg/kg) + Avg Annual Sediment Load	**497**	**320**
Leatherbarrow et al. (2002)	Flow-weighted mean concentration (RMP fixed time sampling)	**29**	—
Thomas et al. (2002)	Early season flood data (1–5 mg/kg) + Modeled loads	—	**4 - 30**
KLI and EOA (2002)	Median 25th/75th percentile Hg + Avg annual load	**5.4**	**2.9 - 12.7**
Looker & Johnson (2004)	Bedded sediment concentration (2.4 mg/kg) + Avg annual load	**92**	—
Austin et al. (2008)	Flood water sampling (WY 2004) + Monte Carlo simulation	**106.5**	**0 - 100**
McKee et al. (2006); SFEI (2007)	15-min SSC/flow + Climatic normalization (1977-2006)	**129**	**88 - 170**
Gilbreath et al. (2015)	POC monitoring (WY 2012–14) + Climatic normalization (1975–2014)	**90**	—
McKee et al. (2017)	POC monitoring + Climatic normalization (1981–2010)	**139**	—

Wide Variability
5.4 - 497 kg

Methodological Evolution
Conceptual models to spot sampling to comprehensive flood monitoring

Converging Consensus
90 – 139 kg

Data Sources & Interpretive Techniques

Literature Synthesis

- Compiled data from McKee et al. (2004, 2005, 2006, 2010, 2017a,b), Gilbreath (2015), Balance Hydrologics (2011), AECOM (2015), and Tetra Tech (2024).
- Accepted published loads for described wet seasons without exception.

Regression Modeling

- Dry season and unsampled years estimated via monthly flow vs. load regression.
- **Hg Release:** Triggered when rainfall intensity > 2 in / 6 hrs (Almaden Reservoir Gauge).
- **Non-Release:** Standard regression applied for all other months.

Long-term Integration

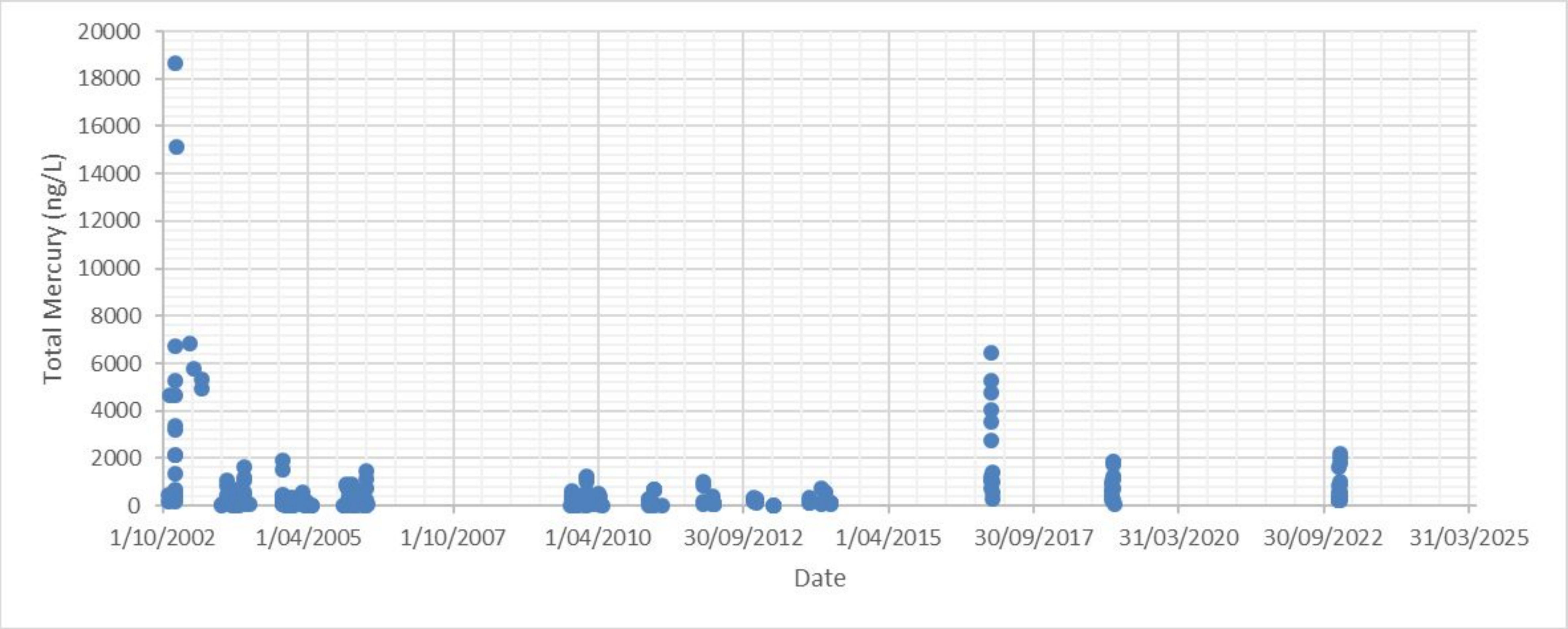
- 30-year climate period (1981–2020) analyzed for release conditions.
- Long-term average derived by integrating monthly estimates across the full representative record.

PRIMARY MONITORING INPUTS

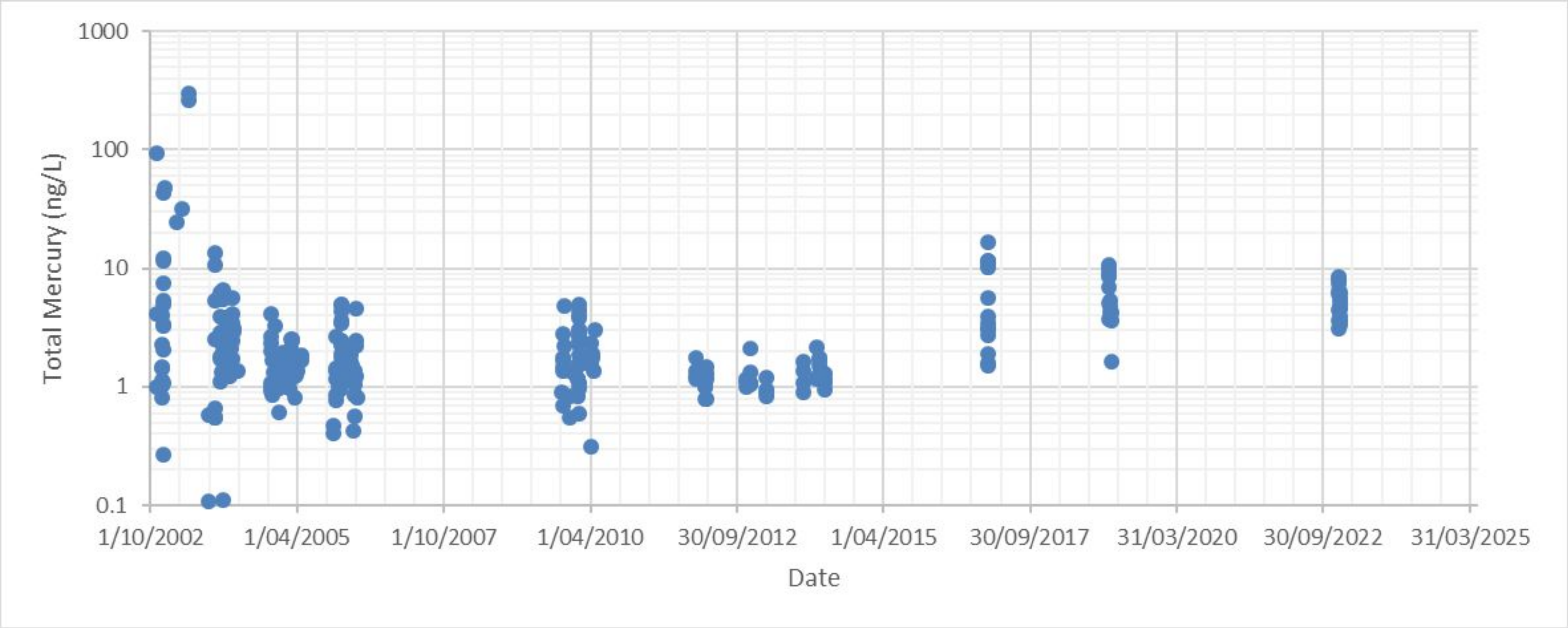
Flow Gauges: USGS Guadalupe River @ San Jose (11169000, 1981-2002) and @ Highway 101 (1116925, 2003-2020).

Climate Data: SCVWD Almaden Reservoir Rainfall Intensity Gauge.

Results - measured concentrations



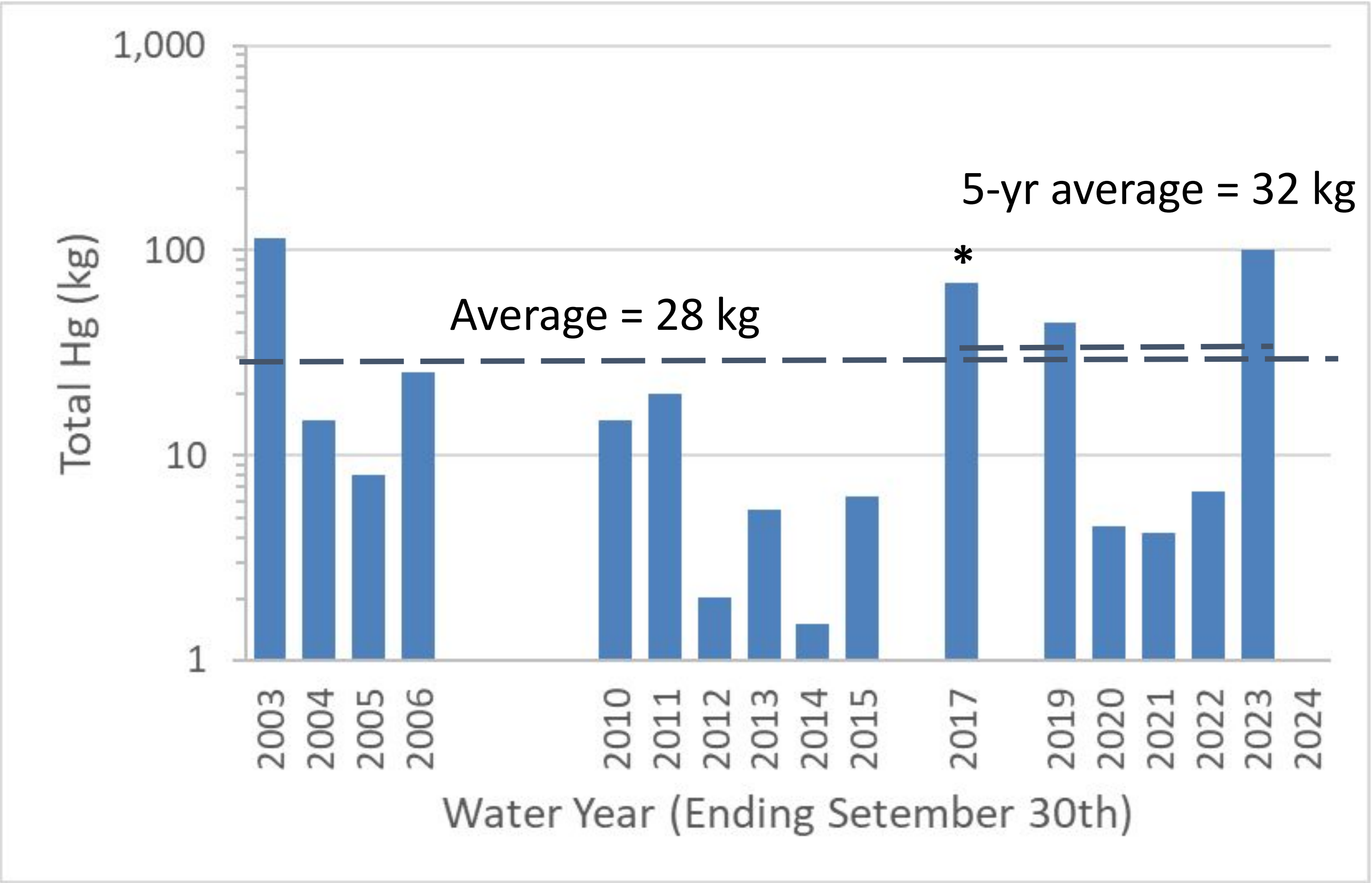
Results - measured particle ratios



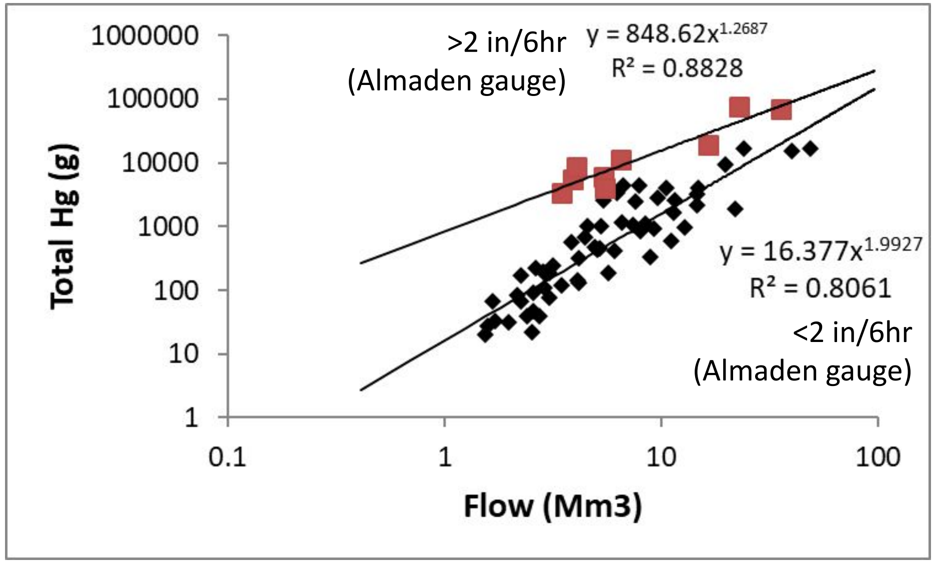
Results - measured wet season loads

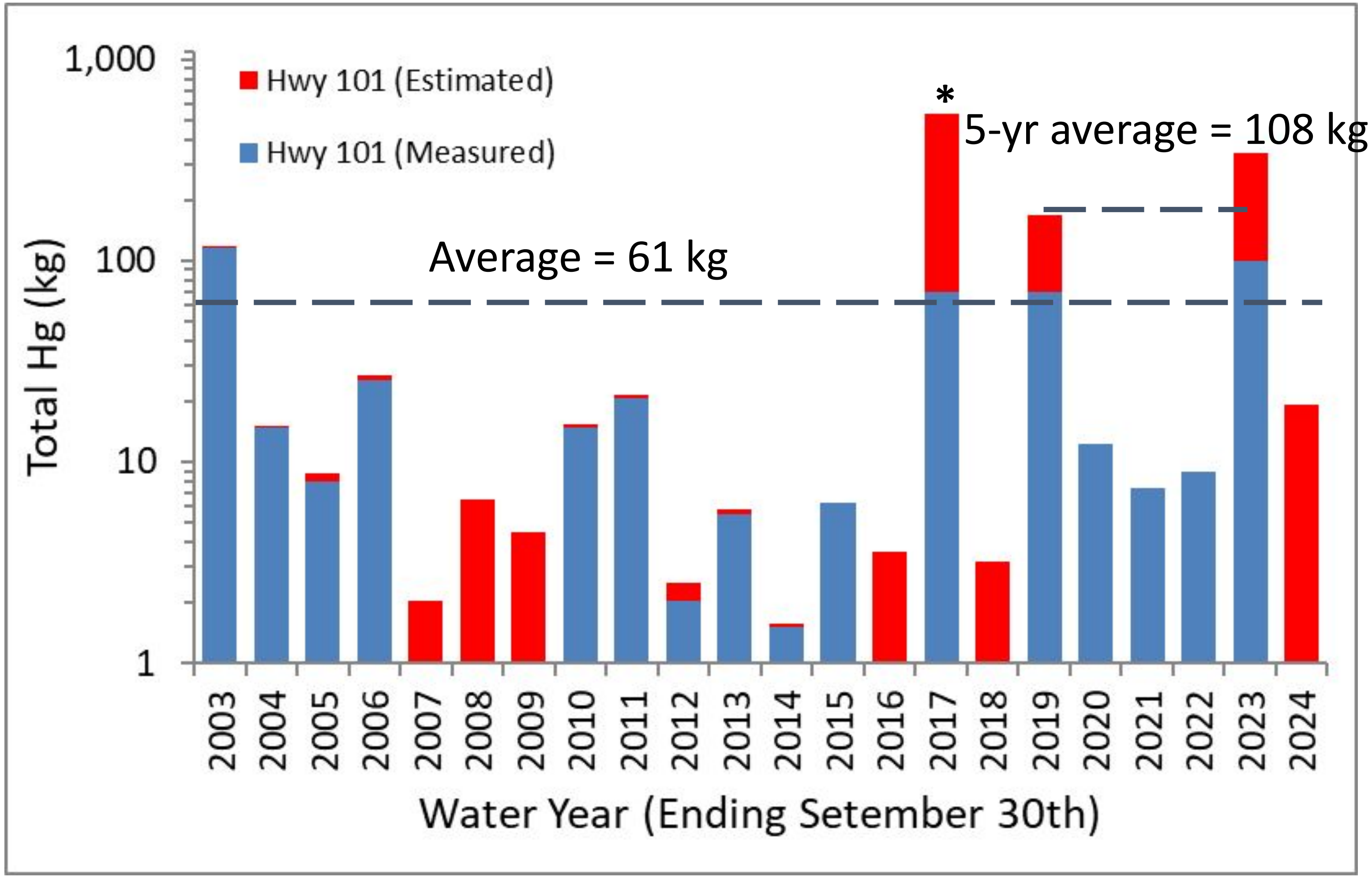
***Single storm**

Water Year	HgT (kg)	Information Source
2003	116	McKee et al. (2017a)
2004	14.8	McKee et al. (2017a)
2005	8.02	McKee et al. (2017a)
2006	25.6	McKee et al. (2017a)
2010	14.8	McKee et al. (2017a)
2011	20	Balance Hydrologics (2011)
2012	2.04	McKee et al. (2017a)
2013	5.48	McKee et al. (2017a)
2014	1.52	McKee et al. (2017a)
2015	6.3	AECOM (2015)
2017	70	McKee et al., 2017b)
2019	69.3	TetraTech (2024) Table 3-17.
2020	12.18	TetraTech (2024) Table 3-17.
2021	7.36	TetraTech (2024) Table 3-17.
2022	9	TetraTech (2024) Table 3-17.
2023	100.5	TetraTech (2024) Table 3-17.



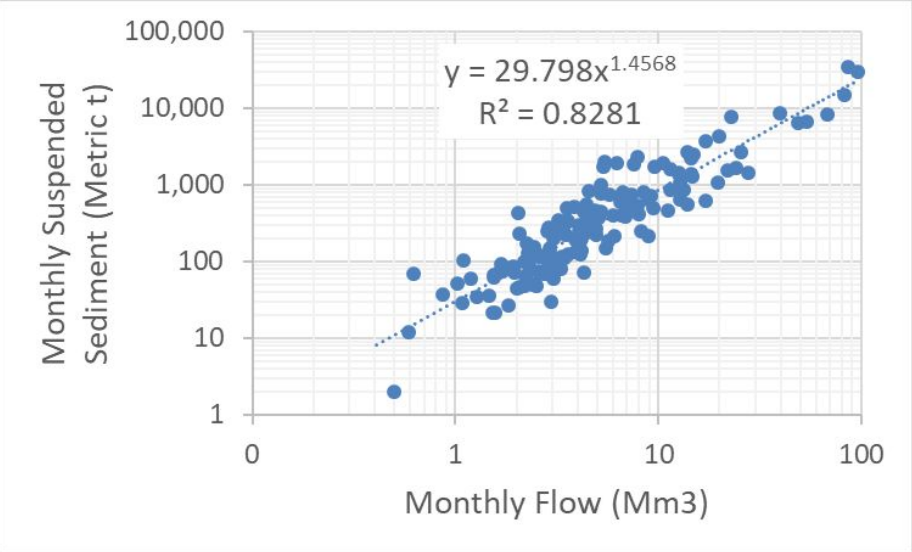
What are the estimated annual loads? (Flow-based method) (McKee et al., 2004, 2005, 2010, 2017)

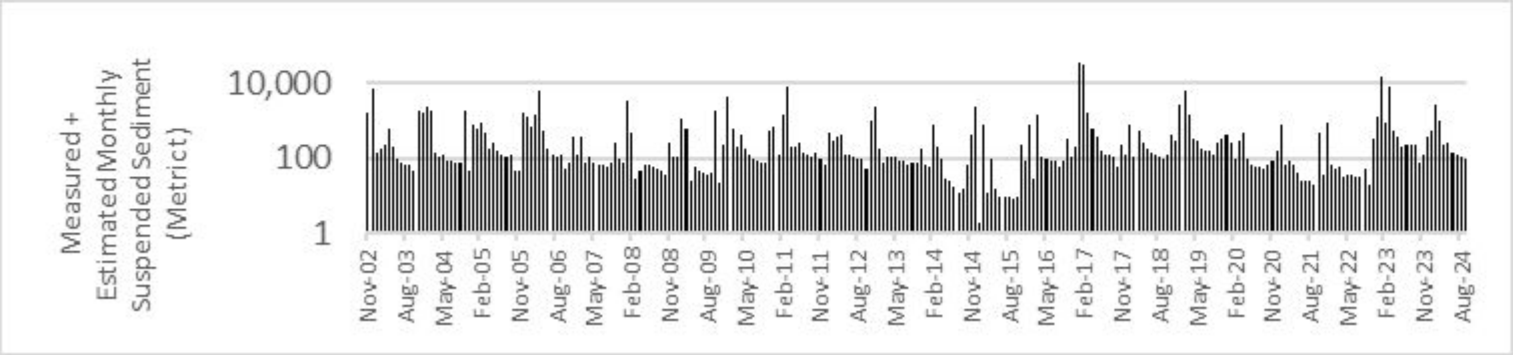


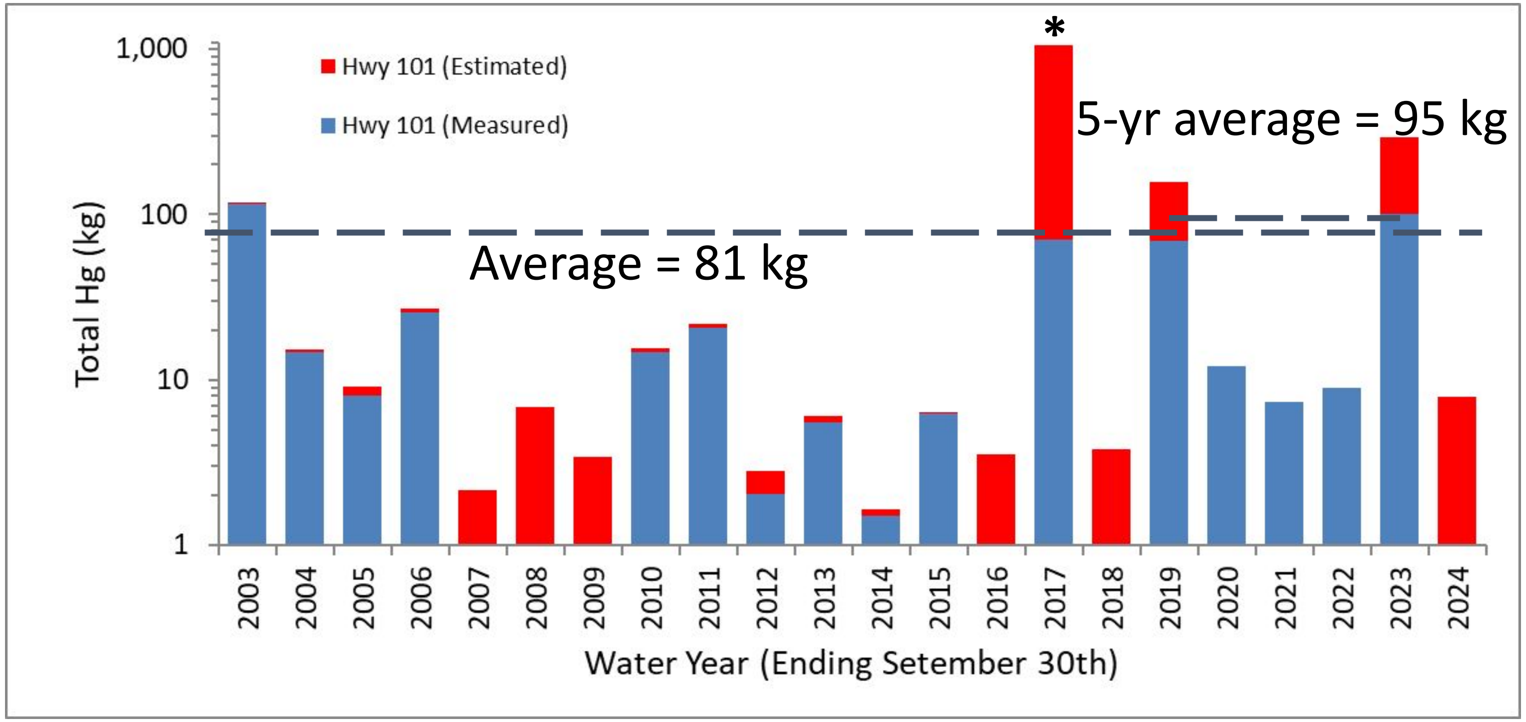


* Note this is ~ half of that published in the 2019 Pulse (1,072 kg). That is the nature of following a method that evolves as data evolves. It probably indicates that the method is not perfect. I suspect if I were to compute the loads in a variety of ways it would show a variety of results. The problem lies with the small data set - a few points can have a large influence on the evolving regression equations.

What are the estimated annual loads? (Sediment-based method)







So now the question becomes what particle ratios to use?

Option 1: Use only measured data (Still being compiled)
Option 2. Derive as Hg loads/sediment loads for all measured months/storms.

Graph on the left shows results for Option 2.
* This (1,061 kg) compared closely to what we published in 2019 Pulse (1,072 kg)

Annual Mercury Loads & Long-Term Averages: Summary

HISTORICAL TMDL BASELINE

92 kg / year

TMDL LOAD ALLOCATION TARGET

9.4 kg / year

CONTEMPORARY BASELINE (WY 2003–2024)

61-81 kg / year

Extreme Climatic Driving Forces

California's Mediterranean climate introduces large annual variance. Across the 22-year history, flow volume varied **12-fold**, suspended sediment sediment loads varied **48-fold**, and total mercury loads varied **344-fold** (7 to 343 kg).

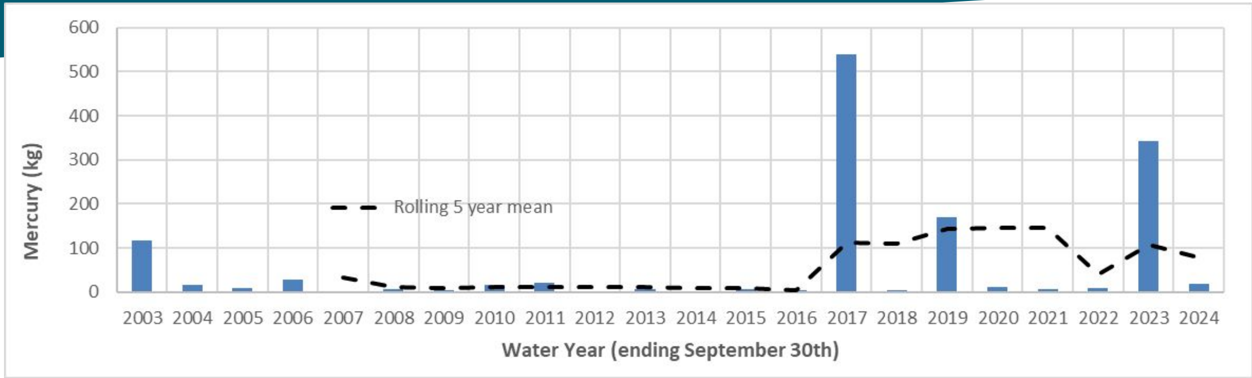
Explaining Shifting Benchmarks

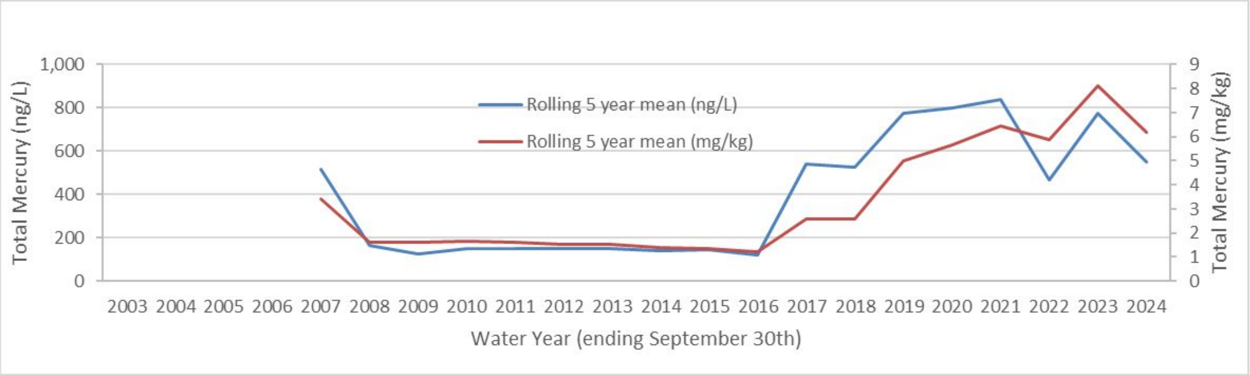
Early regulatory targets relied on less comprehensive monitoring data collected over just a few wet seasons. We now have a data set that spans 12 wet seasons and a sediment load data set that spans 22 set seasons. Methods have not changed. Refined loads estimated are purely a result of more data

HYDROLOGICAL & CONTAMINATION PROFILES

Parameter	22-Yr Baseline	2021 (Dry)	2016 (Mod)	2017 (Wet)
Annual Flow Volume (Mm^3)	72	24	37	249
Mean Daily Sediment Load (t)	9,405	1,423	3,106	68,581
Mean Flow-Weighted Hg (ng/L)	841	305	96	2,159
Mean Daily Hg Flux (kg)	0.17	0.02	0.01	1.5

Guadalupe River:
5-year rolling means





Total Mercury 5-Yr Loads

Loads ranged from **146 kg** (2017-21) to **4 kg** during the 2012-2016 drought.

37-FOLD VARIATION

Water 5-Yr Concentrations

More stable 5-year means ranging between **120 - 839 ng/L**.

7-FOLD VARIATION

5-Yr Particle Ratios

Similarly stable ratio (HgT:SSC) between **1.2 and 8.1 mg/kg**.

7-FOLD VARIATION

Primary Driver: Rainfall intensity in the historic mining district plays a much larger role in annual Hg variation than annual flow volume. High flow years like 2006, 2011 that had many small storms had relatively low loads.

Guadalupe River:
Multi-Decadal Trend Analysis

Statistical synthesis of flow, suspended sediment, and total mercury trajectories over a 25-to-100-year horizon

Hydrological Flows

MONOTONIC UPWARD TREND

- **FLOW Trends:** Multi-decadal non-parametric tests (93-year span) yield p-values <<0.05. FLOW IS INCREASING.
- **RAINFALL Trends:** Meteorologically, there is zero long-term upward or downward trend in how much rain falls on San Jose. The climate baseline is highly stable.
- **RUNOFF:RAINFALL Trends:** 1999-2023 (25-yr Positive trend p<0.05); 1974-2024 (50-yr positive trend); 1932-2024 (93-yr positive trend)

Suspended Sediments

NO TREND

- **Stable Loads:** Load appear to be control mainly by climate. Drier years yield lower loads; wetter year yield higher loads.
- **Stable Concentrations:** Flow-weighted concentration show no trends.
- **Double Mass Verification:** Slopes show no significant breakpoints. There was an uptick in 2017 due to the extreme weather, but not a system shift.

Total Mercury (HgT)

NO TREND

- **Water concentration:** No trend.
- **Particulate Concentration:** No trend although a slight hint at a slight increase (p=0.06.
- **Forcing:** Mercury transport in the Guadalupe River is entirely event-driven, the spikes in mercury concentration track the river's physical capacity to flush suspended sediment during high-flow winter storms (such as the massive surges seen in 2003 and 2017)

System Summary: Multi-decadal baseline analysis shows that environmental load delivery remains tightly bound to **cyclical climate oscillations and physical sediment transport behavior**. Localized changes in raw mercury inputs play a negligible role relative to systemic hydrological forces.

Future Load Reduction Hypotheses

Central Valley (CV)

SMALL CHANGE

~2% over 20 years (0.1%/yr)

Rationale: System has *massive storage capacity*. Legacy mining loads and modern atmospheric deposition are way larger than load outputs to the Bay. Mine cleanups and urban runoff management will yield localized improvements, but will have virtually no effect on concentrations or overall loads entering the Bay.

Guadalupe River

MEDIUM CHANGE

~10% over 20 years (~0.5%/yr)

Rationale: System has *moderate storage capacity*. 150 years past the historical mining peak when loads likely averaged several 1,000 kg/yr) attenuation has likely slowed down. Ongoing mine remediation can clear ~5 kg, and a projected 20% drop in urban loads yields another ~3 kg, cutting roughly 0.4 kg/yr.

Rest of Urban Runoff

LARGER CHANGE

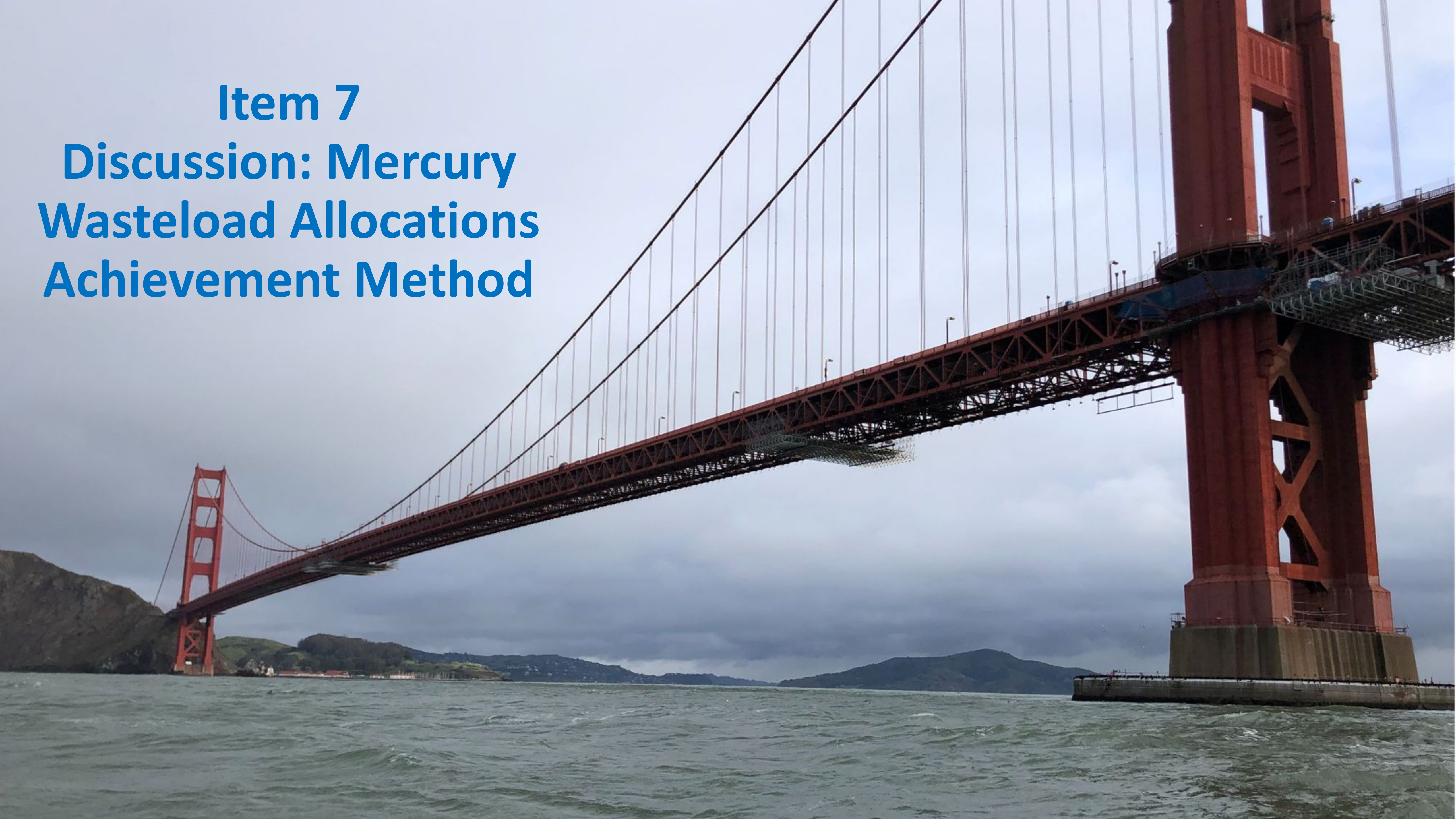
~20% over 20 years (1.0%/yr)

Rationale: System has *relatively small storage capacity*. Historical peak use and subsequent Hg bans are much more recent than legacy mining. Annual rainfall washoff steadily cleans un-stored sources, while industrial redevelopment, green infrastructure, recycling, and cleanups drive a ~1 kg/yr reduction.

Next Steps: Review & Cross-Reconciliation Required

These projections are early-stage working hypotheses. Unlike the other aspects of data syntheses, these concepts must be thoroughly cross-referenced and reconciled with input from **Jay, Don, Matt, and the Bay modeling team** before finalization.

Item 7
Discussion: Mercury Wasteload Allocations Achievement Method



Item 8
Next Steps

Next Steps

- Meet again after the drafts have been distributed - first week of August