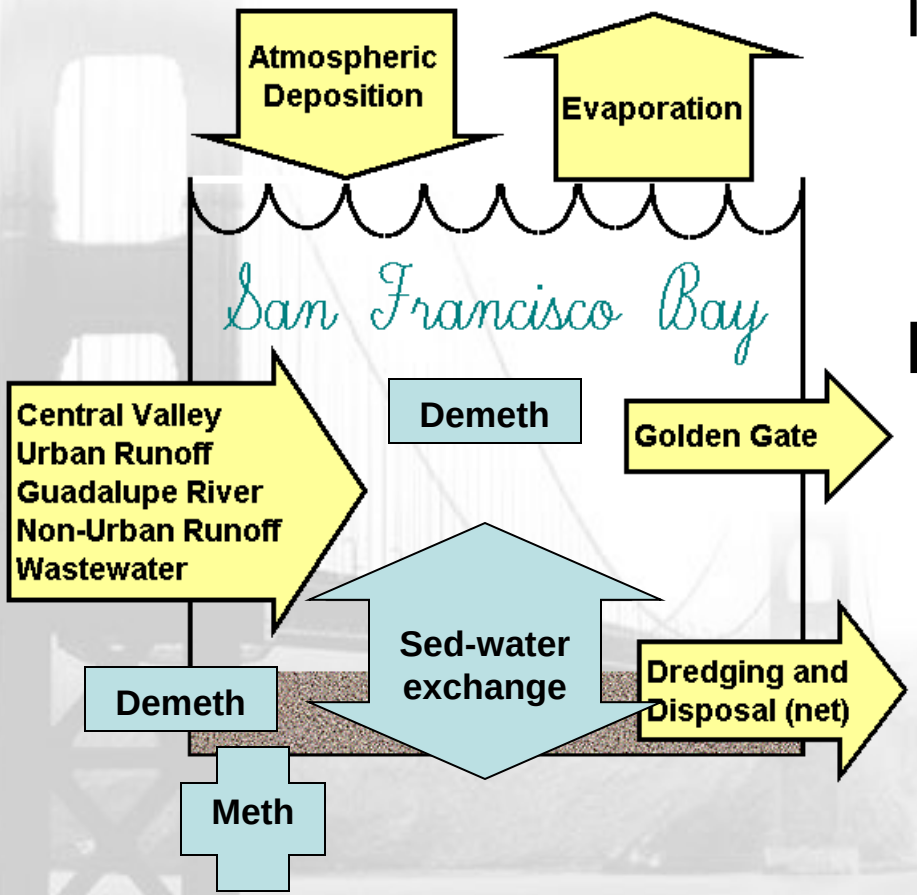
A Methyl Mercury Mass Budget for SF Bay:
Implications for Wetland Restoration?

Donald Yee, San Francisco Estuary Institute

Management Qs & Hypotheses

- MQ2:What are the local vs. regional environmental impacts due to restoration projects?
- Hypothesis2: Methylmercury from tidal wetland restorations is a minor part of the total pool of methylmercury (therefore a minor factor to Bay-wide mercury impairment).
- Hypothesis3: We do not expect to be able to measure the regional impacts to the Bay's food web from tidal wetland restoration projects

Methyl Mercury Mass Budget Model



Need to track MeHg

- MeHg <1% of totHg
- Poor MeHg:totHg correlation

Differences from Hg 1 Box Model

- Methylation & demethylation
- Potentially rapid response (days-months vs decades)

WWMMMBD?

What Would A Methyl Mercury Mass Budget Do?

- Synthesize - do Bay data make sense given…
  - Loading, production, degradation, sed-water exchange, and other processes?
- Quantitative conceptual model of MeHg
  - ID key factors for MeHg fate
- Feasibility/needs of refined model(s)
  - E.g. temporal & spatial detail
- What it won't/can't do
  - Identify local "hot" spot impacts (regional only)
  - Predict long term fate (no Hg linkage)

External Loads (Imports to Bay)

+ Direct atmospheric (wet) deposition 0.1 g/d
  - Area x literature rain MeHg x local rainfall
+ Delta (Mallard Island) discharge 9.8 g/d
  - Flow x concentration (Region 5 MeHg TMDL)
+ Local watersheds 4.9 g/d
  - RMP measured watersheds (extrapolated)
+ Wetlands (mid range estimate) 2.0 g/d
  - Volume x (incoming - outgoing) concentrations
+ POTWs (16 largest, ~95% discharge) 0.8 g/d
  - Flow x concentration

= 17.6 g/d total

Hypothesis2: Is 10% minor?

Wetland Load Estimate Accuracy?

- From Bay on tides
  - 160 km^2 wetlands, 30 cm water, 0.1 ng/L, 25% in particulate MeHg left behind (-2 g/day)
- To Bay on tides,
  - HAAF estimate of 0.8% of daily wetland MeHg production exported (+4 g/day)
  - Petaluma ebb-flood (0.05 ng/L) difference (+6 g/day)
- How far off before it matters?
- Are other factors more important?

Other Processes Modeled

- Internal load – MeHg production
- Biouptake
- Volatilization
- Outflow (through Golden Gate)
- Burial
- Degradation
- Sed/water exchange

Base Case Run

- Mass (inventory) vs daily flux/degrade/produce
- Water Mass
  - Net sediment to water exchange, ext load = Degradation>, GG outflow, >> bio-uptake,volatilization
- Total (Water+Sediment)
  - Production ~balances degradation >> all other processes

* Flux box measurement similar: ~.014 kg/d (Choe et al)

Mass in Water	0.236	kg
Ext. Load	0.018	kg/d
Sed to Water*	0.021	kg/d
Water Degrade	0.024	kg/d
GG Outflow	0.014	kg/d
Bio-uptake	<0.001	kg/d
Volatilize	<0.001	kg/d
Mass in Sediment	30.8	kg
Methylate	1.82	kg/d
Sed Degrade	1.79	kg/d
Sed to Water	0.021	kg/d
Burial	0.007	kg/d

Parameter Sensitivity

Scenario	Mass S	Mass W
Base Case	*30.8 kg*	*0.236 kg*
Load /3	30.7	0.191
Load x3	31.0	0.370
WaterDegrade /3	30.9	0.317
WaterDegrade x3	30.6	0.134
SedDegrade /3	88.8	0.556
SedDegrade x3	10.4	0.123
Methylate /3	10.3	0.123
Methylate x3	92.0	0.574

WDMMMBD?

What Did Methyl Mercury Mass Budget Do?

- Did Bay data make sense?
  - Base case near starting state- near “right” Baywide?
  - Non-unique solution (e.g. offsetting errors?)
- Feasibility/needs of refined model(s)
  - 1 box driven by steady state/equilibrium
  - Basis for more detailed models?
    - Much higher data needs
- Key factors affecting MeHg fate
  - Water loads will have small effect (Hypothesis3)
    - 20x Wetland exports = 3x total loads = Bay water MeHg +50%
  - More sensitive to de/methylation rates

Management Strategy - Dr. Evil

Acquire $1 Million

Option A- Control Methylation:

- Sterilize (thermonuclear device)

Option B- Control Demethylation:

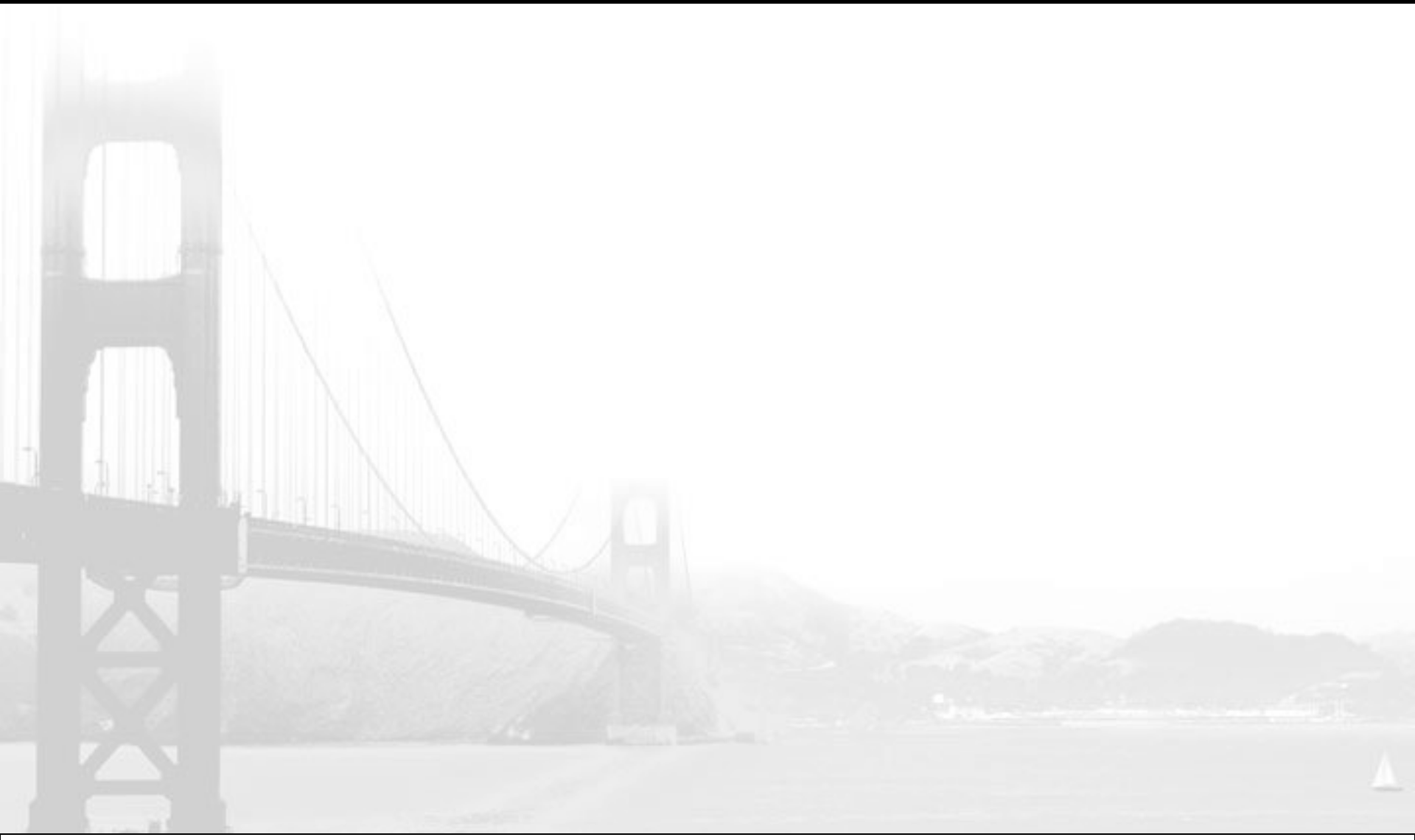
- Equip sharks w/ UV lasers to photodemethylate

Management Strategy - Reality

- Baywide mass balance insensitive, but…
- Specific sites may be more affected (YMMMBMV)
  - Wetland loads larger % of budget
  - Special biota of concern (food web entry)

- Restoration may be better than status quo
  - Monitor & model management effectiveness "adaptive management"
  - *IF* locations found where critical pathways (e.g. de/methylation) need to/may be acted on
    - *THEN* act (e.g.holding ponds, aeration, project redesign, etc)

(Unfortunately likely > $1 million)



Internal Load- MeHg Production

- Function of multiple factors-
  - Would need complex C & S & Hg model
- Next best- lab incubation production rates?
  - Marvin-DiPasquale et al anaerobic incubations
- Assume portion of sediment layer methylates
  - Methylating zone in fraction (30%) of sediment

Loss Processes

- Bio-uptake = “export” from Bay 0.13 g/d
  - Small fish biomass (CDFG) x concentration (RMP)

1-Box Model Losses

- Volatilization
  - Air/water partitioning (Lindqvist & Rodhe 1985)
- Outflow (through Golden Gate)
  - Tidal mixing (Connolly), assume ocean MeHg ~0
- Burial
  - Fuller sedimentation 0.88cm/yr (~9% of mixed layer)

Modeled Internal Processes

- Degradation
  - Sediment: Marvin-DiPasquale demethylation rates = 0.083/d (decay)
    - Assume demethylating zone (70% of mixed layer)
  - Water: Krabbenhoft Petaluma water half life~7 days (0.10/d decay)
- Benthic flux
  - In daily resuspension & de/sorption

Large uncertainties some parameters

- Some have small ~no effect