Wetland Management and Agricultural Organic Matter Reduction to Decrease Methylmercury Loads from the Cosumnes River Preserve (CRP) (Parts 1 and 2)

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Presentation outline

1. Introduction to the Cosumnes River Preserve (CRP)
2. Discuss scientific challenges and approaches
3. Evaluate foundational work on proposed management practices
4. Describe current CRP study design
5. Describe observations of proposed management practices to date


Cosumnes River Preserve
Protecting and Restoring Central Valley Wetlands and Valley Oak Forests
A Conservation Partnership

Our Goal….

To permanently protect, restore, and manage native habitats and agricultural lands for native species, with special emphasis on migratory waterfowl and waterbirds and threatened and endangered species.

Sandhill Crane Foraging Habitat Use

•Greaters: Corn 33%, Rice 28%, Pasture 10%, Savannah 9%, Fallow 8%, Wetland 6%, Wheat 3%, Sudan 2%

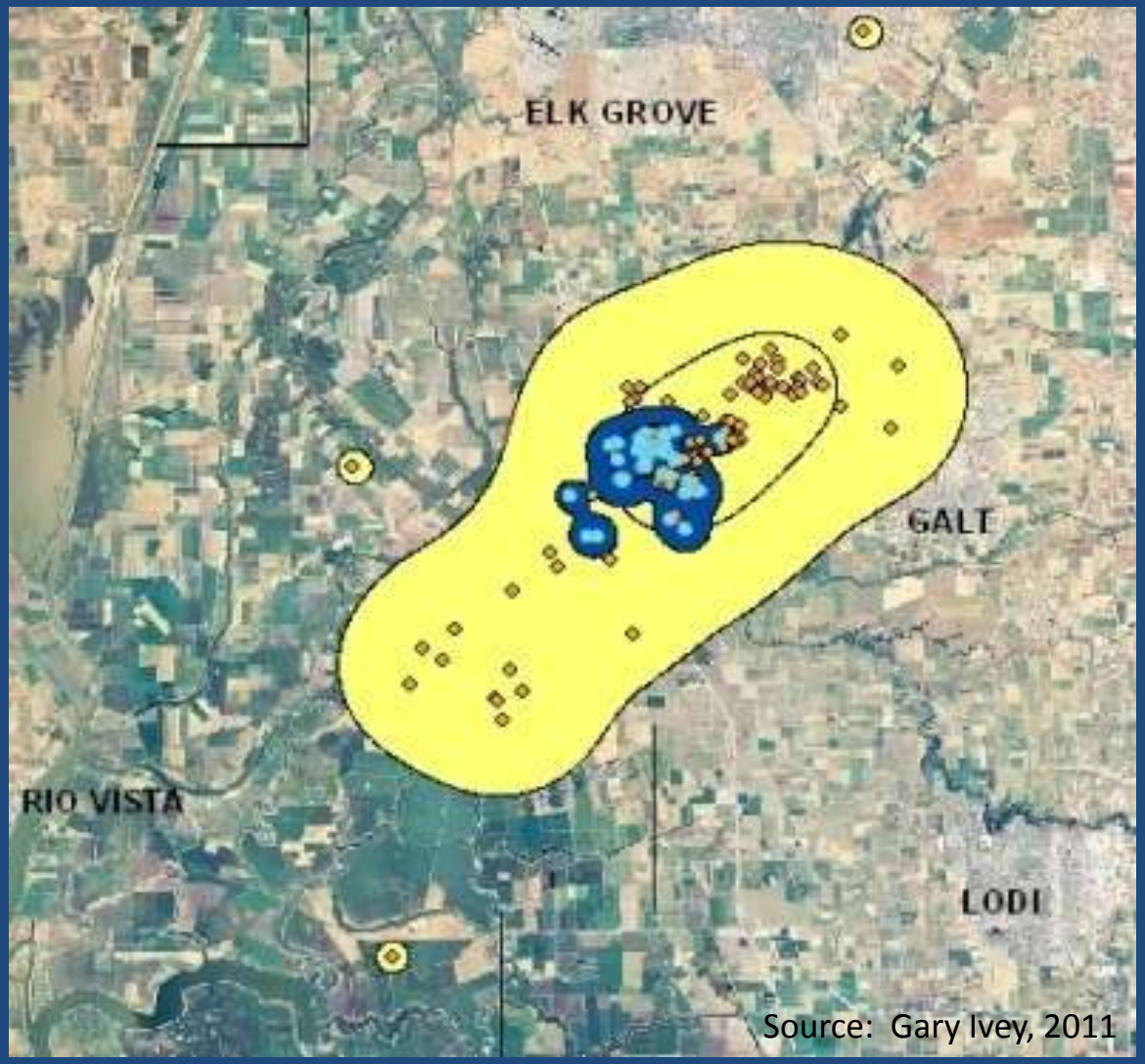
•Lessers: Corn 53%, Alfalfa 15%, Pasture 10%, Rice 8%, Wheat 5%, Savannah 4%, Wetlands 2%, Fallow 2%, Levees 1%

•Cranes selected newly flooded habitats, regardless of type

• With the exception of the organic rice, cranes avoided feeding in fields subjected to prolonged flooding

Source: Gary Ivey, 2011

Sandhill Crane Home Range



Problem

- CRP is considered a “hot spot” for mercury contamination
  - OEHHA consumption advisory
  - Delta MeHg TMDL listed CRP as focus area
- CRP goals may not align with Hg concerns
  - Wetland restoration may increase Hg methylation
  - Wildlife recruitment may increase Hg exposure
- Cosumnes R. identified as an area of concern for MeHg
  - Based on summer fish measurements
  - 2-4 mos/yr, no flow upstream of CRP!!
    - CRP contributes contaminants only through tidal mixing of Delta and Mokelumne River water during dry season
- What can land managers do?

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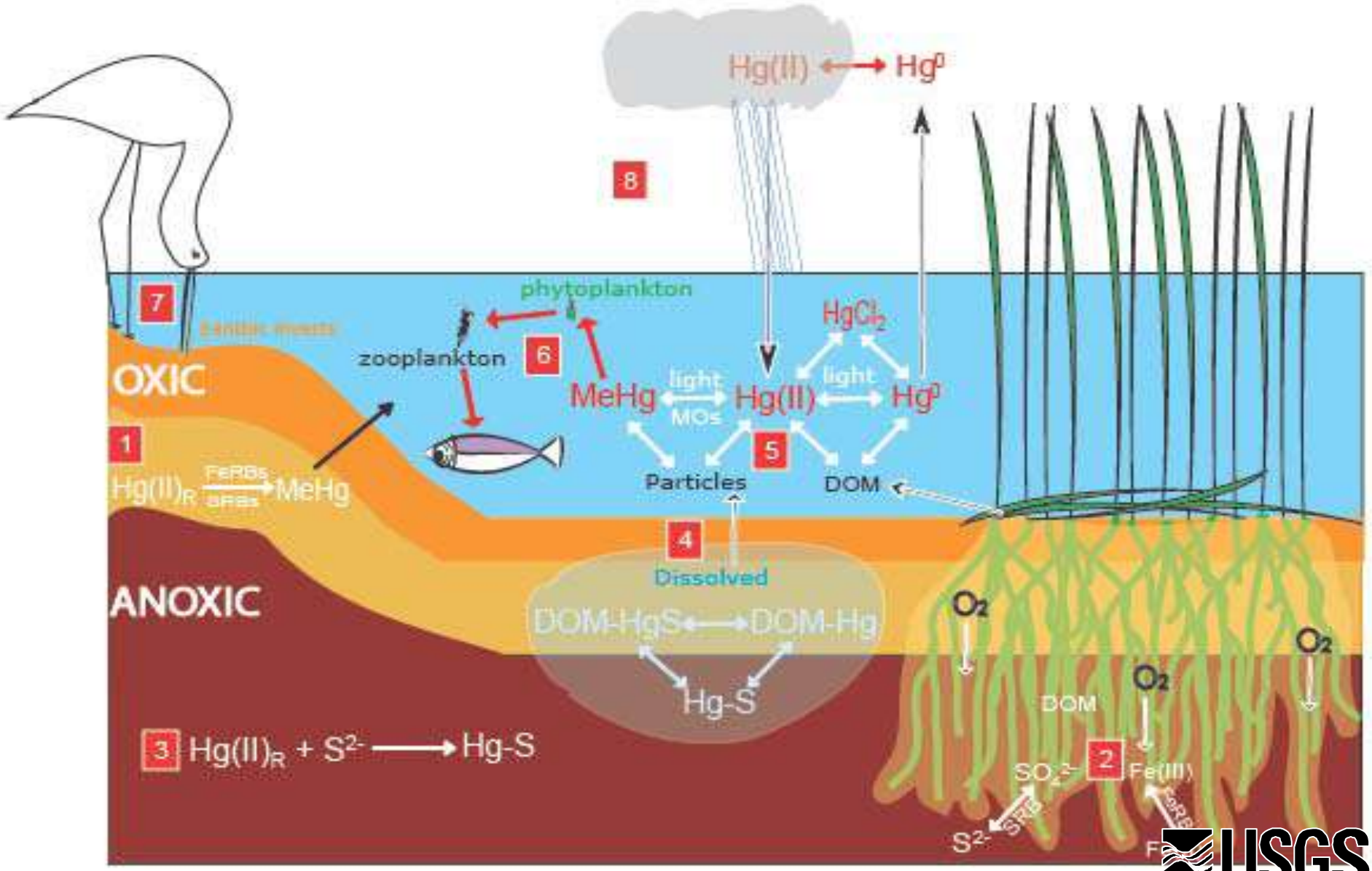
Hg-MeHg transformations



3 General Scientific Approaches

1. Biosentinels

Pros: shows integrated effects, strong statistical power, easy conceptual linkage to ecosystem effects

Cons: cannot explain processes, response relies on assumed tight cause-effect relationship

3 General Scientific Approaches

2. Loads assessments

Pros: easy linkage to TMDL, identification of external source pipeline

Cons: cannot explain processes; hydrology is often complex, difficult to measure (uncertainty high) and expensive; high temporal variability requires high sample frequency, $$

3 General Scientific Approaches

3. Process studies

Pros: provide understanding of both source and production, are widely transferable, feed engineering solutions

Cons: expensive, slow to develop, application not always clear or direct

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TMDLs and BMPs

What information is needed?	Why?
• Source of MeHg – Hg(II) source (substrate) – Methylation rate	• Can we control or reverse this? • Do we need source control or process control?
• Transport processes – Particulate or dissolved? – Temporal trends?	• Can we stop it? Bury it? Trap it? Limit biotic exposure through temporal disconnect?
• Losses in the system – Transformations – Physical loss	• Can we exploit this to our favor?

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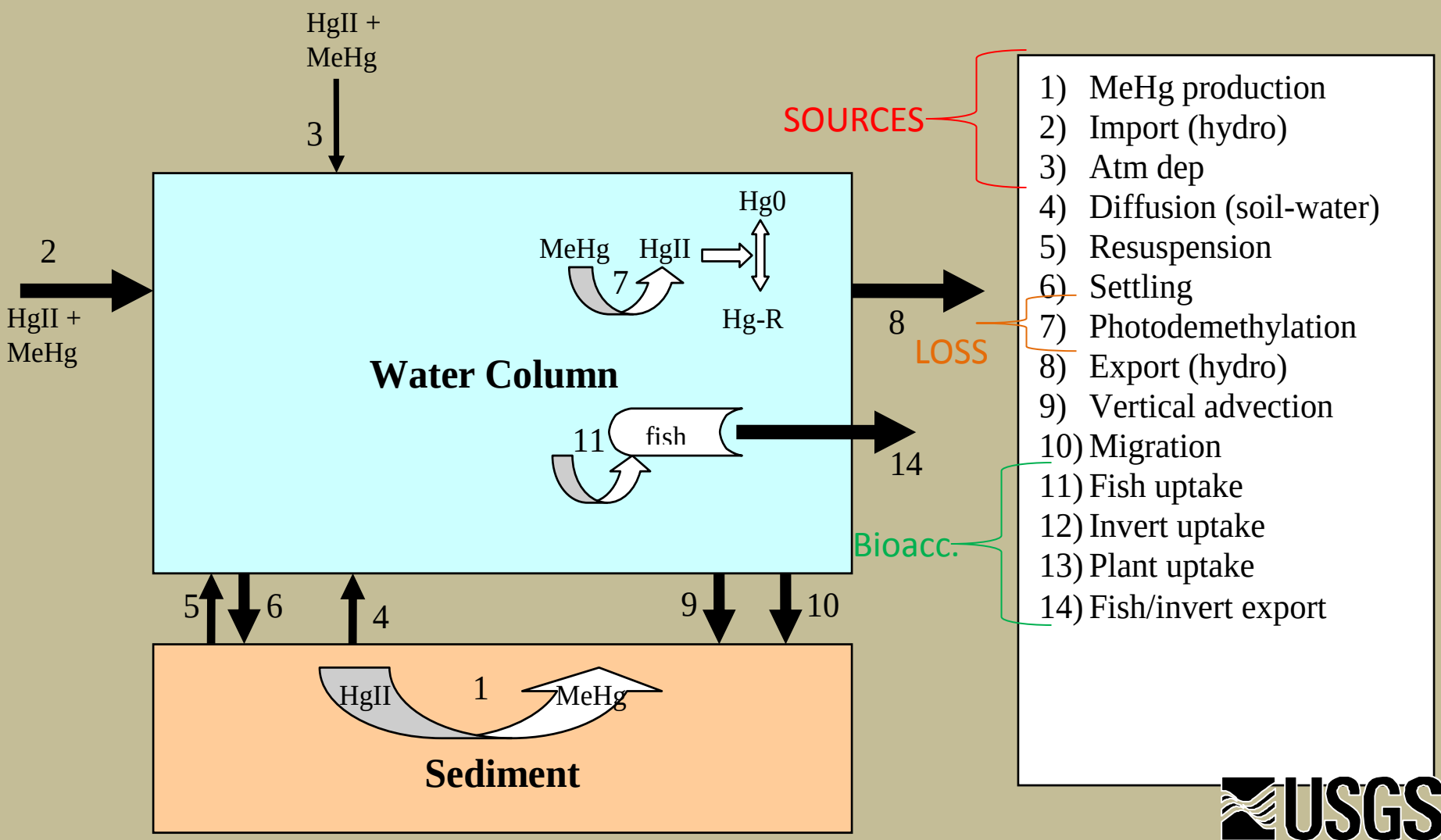
Simplified box model



Yolo Bypass Wildlife Area

- Comprehensive study 2006-2008 – all approaches
  - Measured 7 of 14 components in box model
  - indirect info on another 4

Proposed management actions to control MeHg

1. Minimize wet-dry cycles
2. Minimize flows out of rice fields (esp wet harvest)
3. Minimize residue organic materials that promote production
4. Recycle water, use less “clean” irrigation source
5. Promote photodemethylation

CRP study objective

Implement modifications to land use practices across several dominant wetland types to reduce methylmercury production and discharge to the Sacramento-San Joaquin Delta.

- compare 3 rice residue managements
- compare 3 wetland flooding schedules

… test potential management practices (MPs) with respect to Hg methylation and MeHg exposure to biota (and loads, at least semi-quantitatively)

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Rice fields

Evaluate 3 organic matter (rice stubble) management practices

1. Harvest and Chop (RHC)

   Standard management,

   leave residue on surface

2. Chop and Disk (RCD)

   Incorporate residue into soil strata

3. Swath and Bale (RSB)

   Remove all surface residue

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Managed wetlands

Evaluate 3 water management schemes

1. **Fall flood seasonal wetland**

   Flood in fall and drain in late summer (1x/yr)

2. **Spring flood seasonal wetland**

   Flood and drain according to rice schedule (2x/yr)

3. **Permanent wetland**

   Perennially flooded (0x/yr)

Approach

Biosentinel approach

...with some evaluation of processes and loads (as funding permits)

- Using YWA comprehensive study results to guide management practice (MP) selection
- Need to verify that MPs are working as planned for OM reduction and methylation
  - Windham-Myers add-on study
- Need confirmation of transport processes

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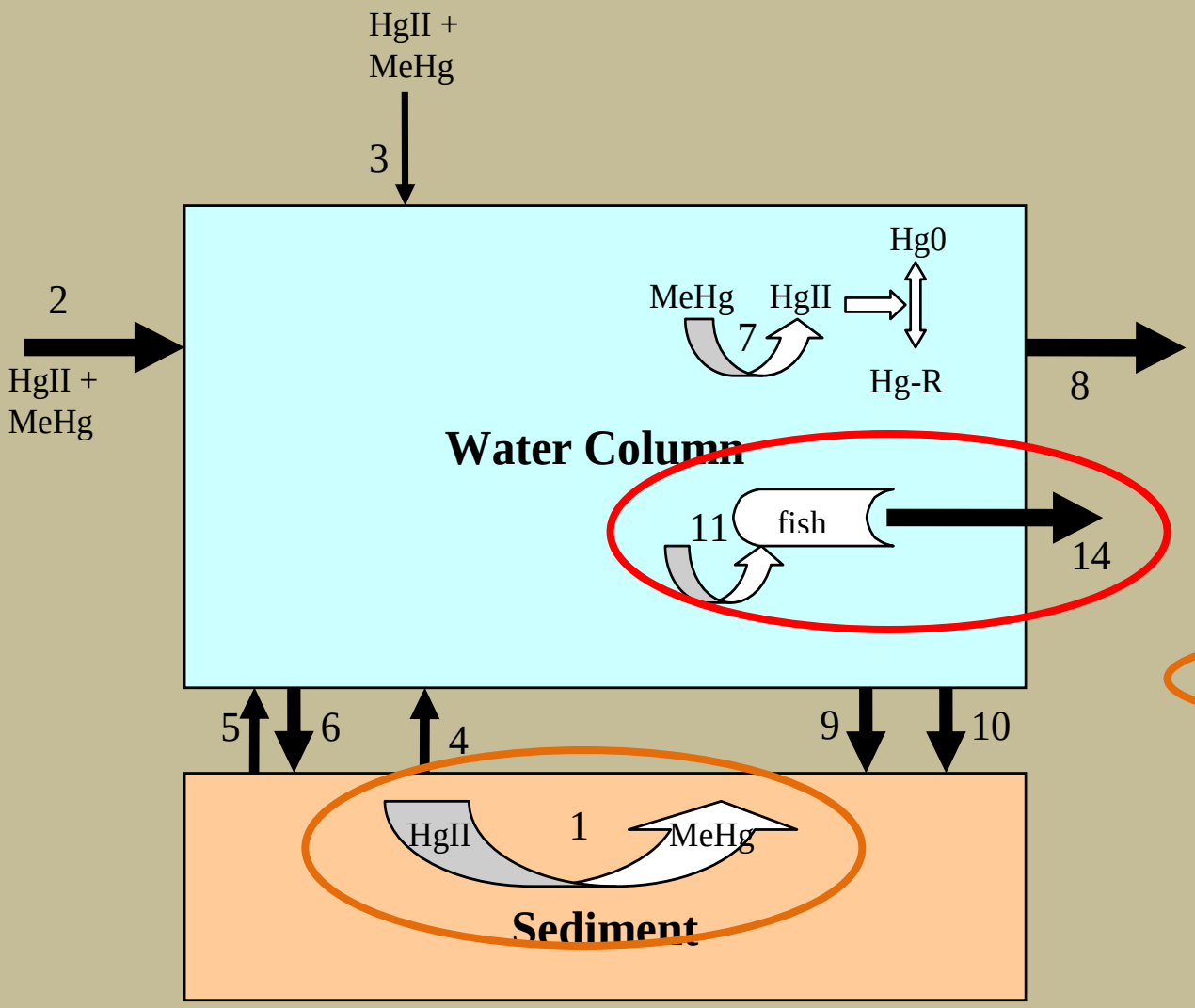
Study Measurements: MeHg source and bioaccumulation



1) MeHg production
2) Import (hydro)
3) Atm dep
4) Diffusion (soil-water)
5) Resuspension
6) Settling
7) Photodemethylation
8) Export (hydro)
9) Vertical advection
10) Migration
11) Fish uptake
12) Invert uptake
13) Plant uptake
14) Fish/invert export

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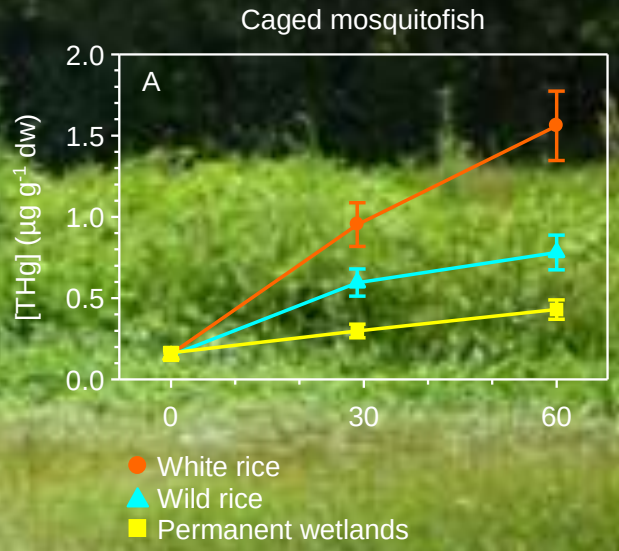
1. Caged fish sampling

Purpose:

1) **Integrated exposure biosentinels**
2) **Compare treatment and habitat effects on Hg bioaccumulation**

Methods:

- **1 cage at both the inlet and outlet of each field/wetland**
- **30 tagged fish per cage**
  - **individual growth and Hg bioaccumulation**
- **30-60 day exposure period**



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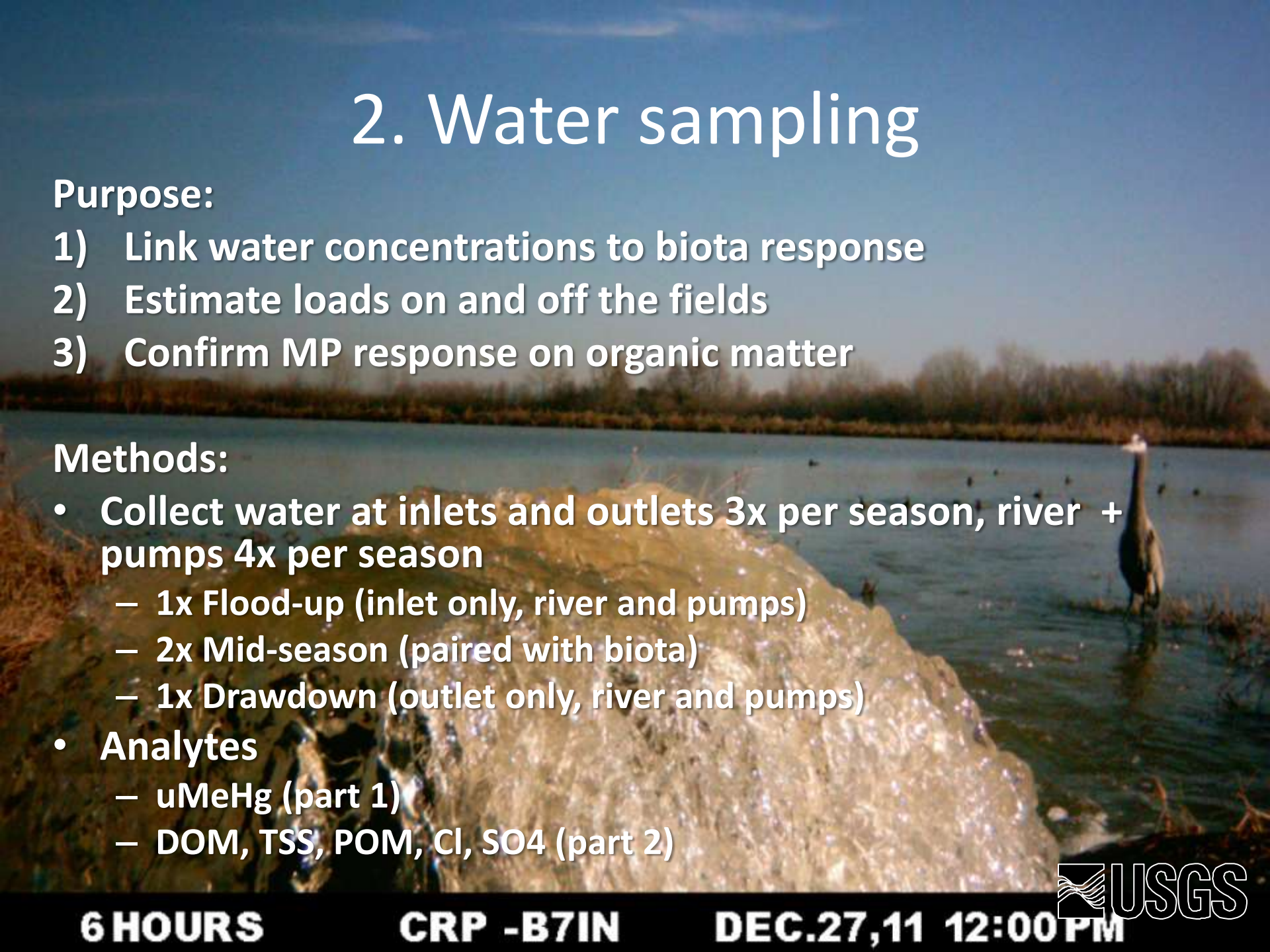
2. Water sampling

Purpose:

1) Link water concentrations to biota response
2) Estimate loads on and off the fields
3) Confirm MP response on organic matter

Methods:

- Collect water at inlets and outlets 3x per season, river + pumps 4x per season
  - 1x Flood-up (inlet only, river and pumps)
  - 2x Mid-season (paired with biota)
  - 1x Drawdown (outlet only, river and pumps)
- Analytes
  - uMeHg (part 1)
  - DOM, TSS, POM, Cl, SO4 (part 2)



3. Soil/plant sampling

Purpose:

1) Confirm effect of MPs (OM and MeHg prod)
2) Measure plant uptake (seed source to birds)

Methods:

- Measure plant and soil metrics corresponding with MP treatments that allow interpretation of key mechanisms by which Hg(II)-methylation, MeHg bioaccumulation and export are influenced by field management
- Analytes:
  - Pore water OM, MeHg
  - Plant and residue OM metrics
  - Soil Hg speciation, OM
  - Seed Hg and MeHg

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Data analyses/stat approach

- Generalized Linear Model (GLM) to test for effects of rice management and inlets vs outlets while controlling for the influence of fish growth.

- Similar approach for seasonal vs permanent wetlands – and rice fields vs seasonal wetlands with similar water management

- Integrate soil-water-biota with repeated measures ANOVAs or non-parametric direct comparisons where appropriate to assess variability among responses

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Expected Benefits

- Confirm/reject proposed MPs for MeHg in CRP
  - Powerful statistical assessment of MPs' integrated effects on both MeHg uptake (part 1) and production (part 2)
  - If response is clear and strong, will lay foundation for feasible MeHg reduction MPs
- Compare effectiveness of water MPs to residue MPs
- Confirmation of proposed MPs from YWA study shows transferability across different systems
  - Rejection of MPs indicates a missing dominant variable in our understanding

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Limitations

- Caged fish approach does not reflect Hg availability to wildlife
- Statistical design focuses on an expected response
  - If response is null, mixed or unexpected there is little explanatory power as to why
    - No information as to why the MP did not transfer to this situation - would feed the greater knowledge base and improve future MP development
- Loads assessment will be semi-quantitative, at best
  - No Hydrology component
  - No understanding of transport processes
    - particulate vs dissolved vectors
  - Leaves large gap of understanding between source and uptake in box model (many processes)

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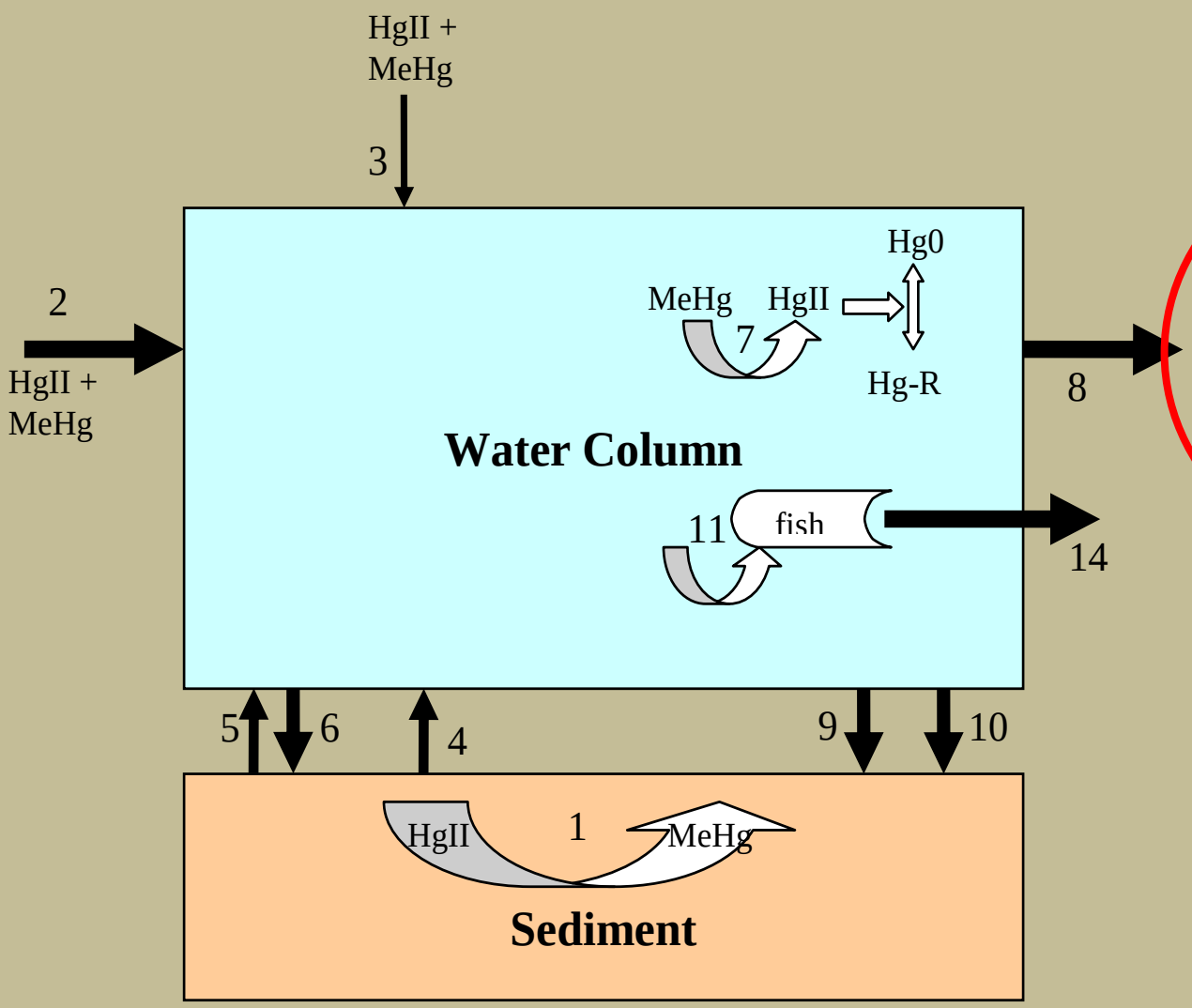
Study Unknowns



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The Reality of “Best” Management Practices

- Feasibility of Implementation (*e.g.,* swathing, baling, *etc.*)
- Feasibility of Implementation (*e.g.,* seasonal flooding)
- Increased algae, weeds, and shrimp in organic rice
- Increased vegetation in wetland ponds by holding water longer
- Decreased productivity (*e.g.,* invertebrate production?)
- Decreased bird usage of ponds and rice fields (still an unknown)
- Increased pumping, machinery, and labor costs
- Overall increase in wetland and rice program costs for negligible MeHg reduction results (still an unknown)


QUESTIONS?
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