Great Salt Lake Water Quality Studies

Selenium Program Update

February 22, 2008

CH2MHILL /CWECS

Agenda

1. **Program Update**
   - Program Objective
   - Status of Investigations
   - Status of Model
   - What is next?
2. **Protection Levels**
3. **Implementation**

Program Objective

Define a site-specific, numeric water quality standard for selenium (Se) that prevents impairment of the beneficial uses of the open waters of the Great Salt Lake

Program Questions

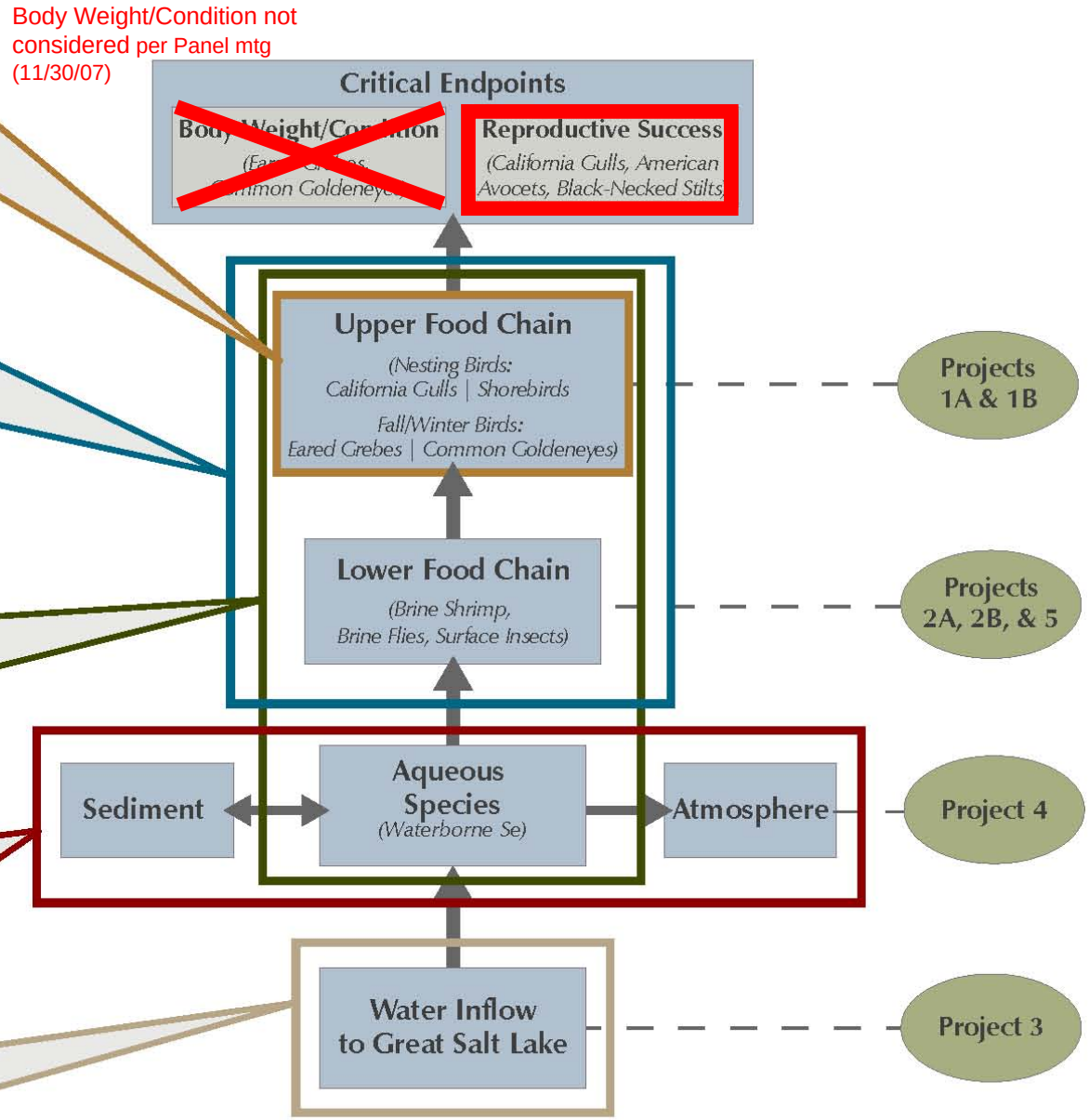
1. Are significant ecological effects occurring in aquatic wildlife (i.e., the "Upper Food Chain" box)? If so, to which ones and at which locations? What are the associated selenium concentrations in tissues (including bird blood, liver, and eggs)?

2. What is the relative importance (based on selenium concentrations and their availability) of various food-chain exposure pathways for aquatic wildlife (i.e., linkage of "Lower Food Chain" to "Upper Food Chain" as highlighted in the blue box)?

3. What are the transfer factors that describe relationships between selenium concentrations in the water column, in bird diets, and the concentrations found in bird eggs (i.e., stepping down to the "Aquatic Species" of waterborne selenium highlighted in the green box)?

4. What are the most important processes that affect the partitioning, cycling, and release of selenium in the Great Salt Lake open waters (i.e., transport and fate of selenium in the ecosystem?

5. What are the sources of waterborne selenium entering Great Salt Lake, and what is the relative significance of each of the various sources?



Status of Investigations

Status of Investigations

- **Project 1 – Birds**
  - Reports complete, awaiting final comments from Panel
- **Project 2A – Benthic Zone**
  - Report complete, found on website
- **Project 2B – Pelagic Zone**
  - Awaiting draft report, data nearly complete

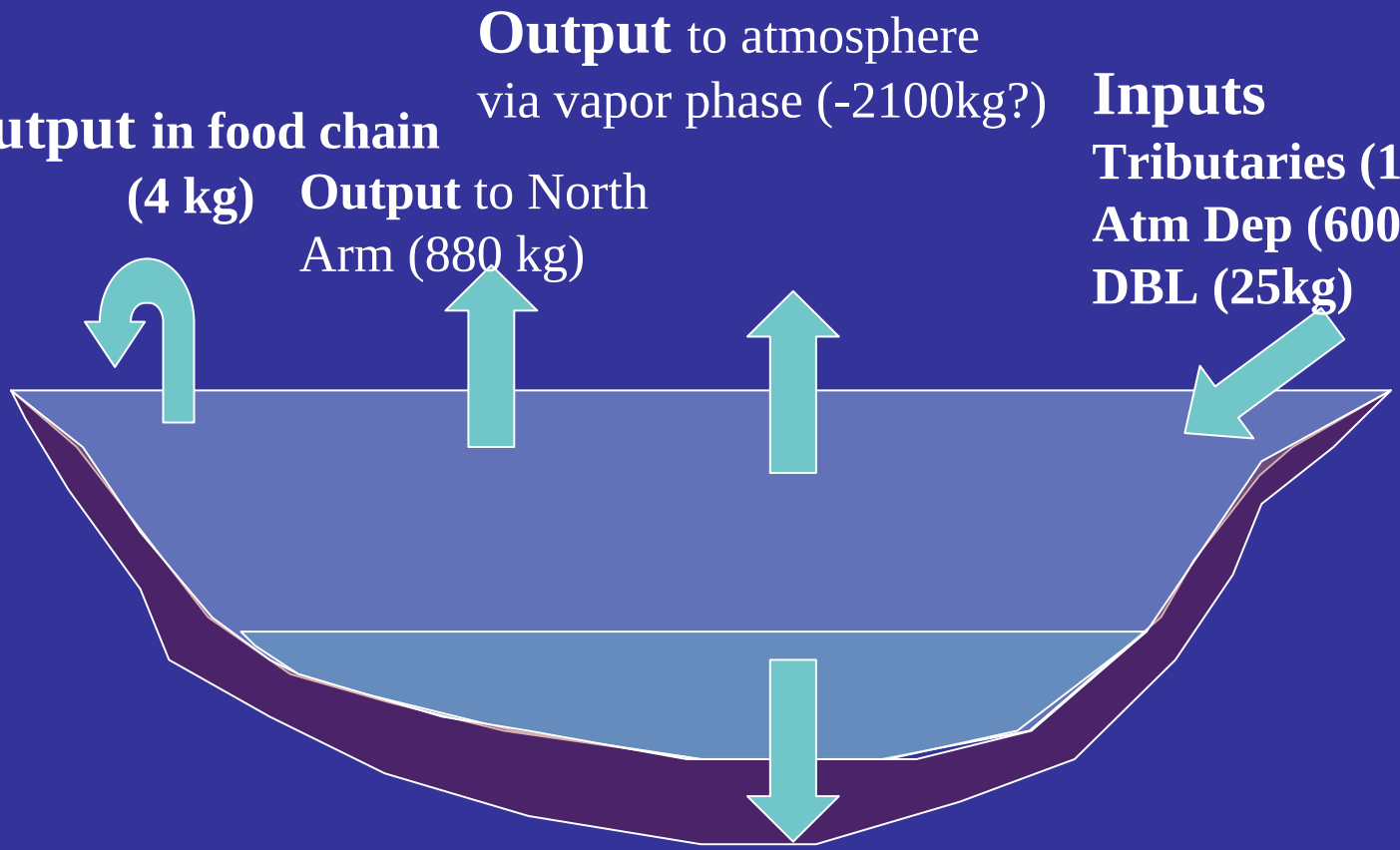
Status of Investigations

- **Project 3 – Se Loads**
  - Report complete, awaiting final comments from Panel
- **Project 5 – Brine Shrimp Kinetics**
  - Report complete
  - Awaiting final comments from Panel
  - Final experiment to be completed
    - *Look at brine shrimp uptake directly from water at lower concentrations*

Status of Investigations

- **Project 4 – Se Flux**
  - Panel had requested additional analyses
    - *Update volatilization estimates*
    - *Make salt corrections to sediment concentrations, update sediment flux*
    - *Look into atmospheric deposition*
    - *What happens if deep brine layer shrinks?*
  - Draft report update submitted, in review

Mass Balance



Mass Balance

- **Observations**
  - Mass balance generally balances
  - Work remains to be done to refine:
    - *Potential missing load of Se*
    - *Loads from North Arm GSL*
    - *Loads from Weber River*
    - *Atmospheric deposition*
  - Water Se concentrations may have increased slightly during study period; perhaps just part of normal cycle

When are you going to see the reports!?!?

Last updated: 2/20/2008

Project No.	Project Description	Principal Investigator	Report Name	Date of Last Submittal from PI	Date Submitted to Panel	Panel Comments Requested By:	Report Status								Comments
							Initial Draft Submitted	CH2M HILL Review	Final Draft Submitted	CH2M HILL Review	Submitted to Panel for Review	Comments Received from Panel	Report Finalized	Report Approved for Publication	
1A	Shorebirds	John Cavitt	Concentration and Effects of Selenium on Shorebirds at Great Salt Lake, Utah 2006	10/4/07	11/1/07	1/24/08	X	X	X	X	X	X			Waiting for final comments
1A	Shorebirds	John Cavitt	Selenium and Mercury Concentrations in Breeding Female American Avocets at Ogden Bay, Great Salt Lake, Utah, 2007	11/26/07	12/3/07	1/24/08	X	X	X	X	X	X			Waiting for final comments
1B	Gulls & Overwintering Birds	Mike Conover	Concentration and Effects of Selenium in California Gulls Breeding on Great Salt Lake, Utah 2006/2007 data	9/24/07	11/1/07	1/24/08	X	X	X	X	X	X			Waiting for final comments
1B	Gulls & Overwintering Birds	Mike Conover	Concentrations of Selenium in Eared Grebes from the Great Salt Lake, Utah	10/20/07	11/1/07	1/24/08	X	X	X	X	X	X			Waiting for final comments
1B	Gulls & Overwintering Birds	Mike Conover	Concentrations of Selenium and Mercury in Common Goldeneyes from the Great Salt Lake, Utah	10/20/07	11/1/07	1/24/08	X	X	X	X	X	X			Waiting for final comments
2A	Benthic Food Web	Wayne Wurtsbau	Preliminary Analyses of Selenium Bioaccumulation in Benthic Food Webs of the Great Salt Lake, Utah	10/15/07	11/1/07	Complete	X	X	X	X	X	X	X	X	Last submittal from PI included 2007 sediment data.
2B	Pelagic Food Web	Brad Marden	Synoptic Survey of the Pelagic Zone: Selenium in Water, Seston and Artemia, 2006/2007	7/25/07		1/30/08	X	X							
3	Selenium Loads	Dave Naftz	Estimation of Selenium Loads Entering the South Arm of Great Salt Lake, Utah	11/23/07	12/3/07	3/14/08	X	X	X	X	X				
4	Selenium Flux	Bill Johnson	Estimate of Selenium Removal Fluxes from the South Arm of Great Salt Lake, Utah	11/1/07	11/9/07	3/14/08	X	X	X	X	X				Expecting an updated report with DBL contributions & corrected sediment data.
5	Brine Shrimp Kinetics	Martin Grosell	Brine Shrimp Kinetics Study, Project 5	11/30/07	12/3/07	1/30/08	X	X	X	X	X	X			Waiting for final experiment
	Synthesis Report	CH2M HILL	Draft Report - Selenium Program, GSL WQ Studies	11/1/07	11/1/07	1/30/08					X				Last priority

Status of the Model

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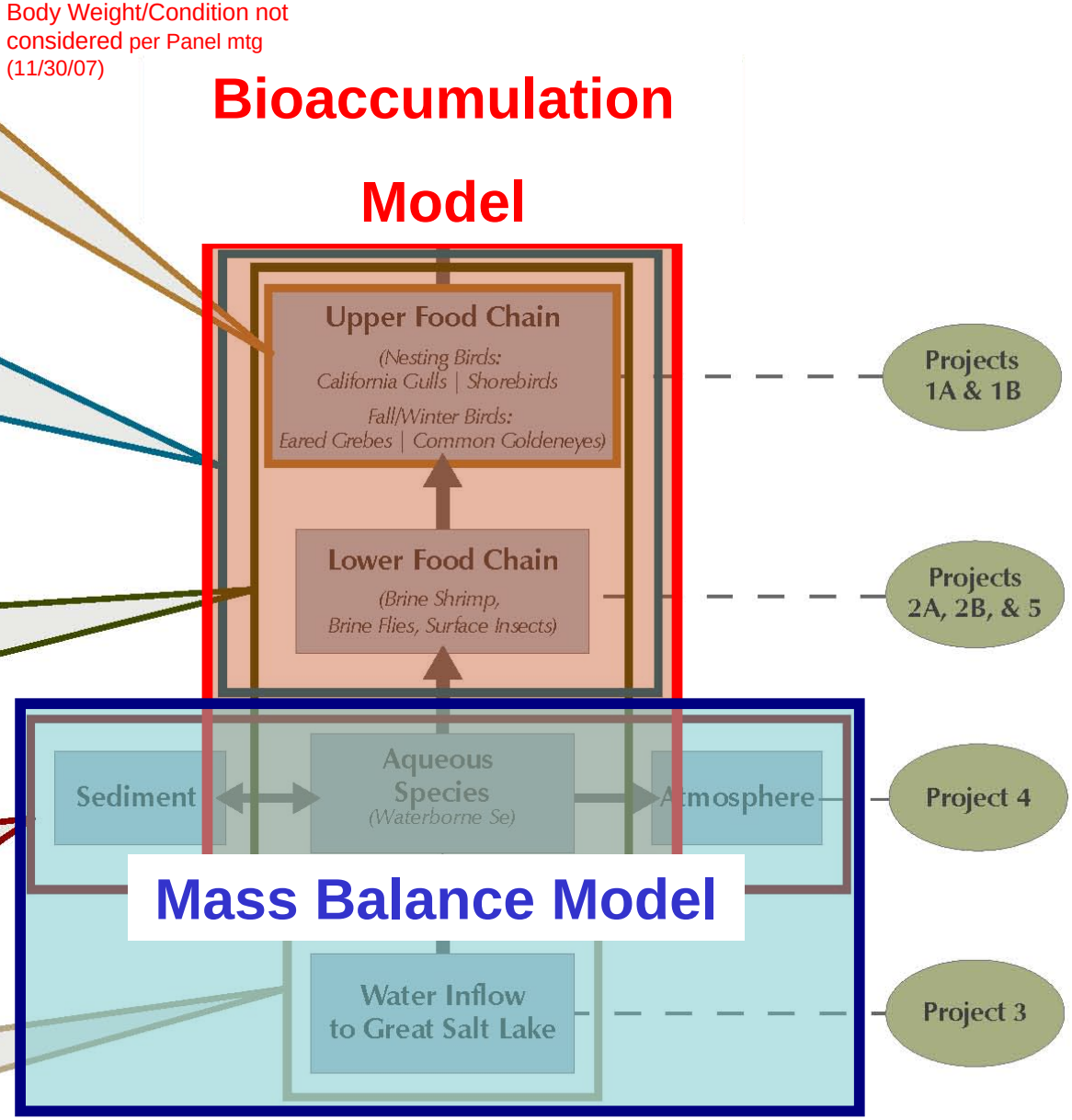
Body Weight/Condition not considered per Panel mtg (11/30/07)



Question No. 1

1a. Have any adverse effects been observed in the reproductive endpoints in aquatic wildlife due to Se that were investigated as part of this program?

1b. Have any adverse effects been observed in non-reproductive endpoints in aquatic wildlife due to Se that were investigated as part of this program?

Answer to Question No. 1a

- **No hatchability or teratogenesis effects were observed for gulls, avocets, and stilts.**
  - 133 eggs sampled
  - We did observe one egg with a Se concentration of 9.2 ppm at the KUCC outfall that is above the lower 95% confidence limit (6.4 ppm) of the EC_{10} for egg hatchability.

Answer to Question No. 1b

- **A determination cannot be made at this time due to confounding variables and insufficient data, however elevated concentrations of Se and Hg were observed in bird blood and livers.**
  - This may indicate that some of these birds are using Se to detoxify Hg.

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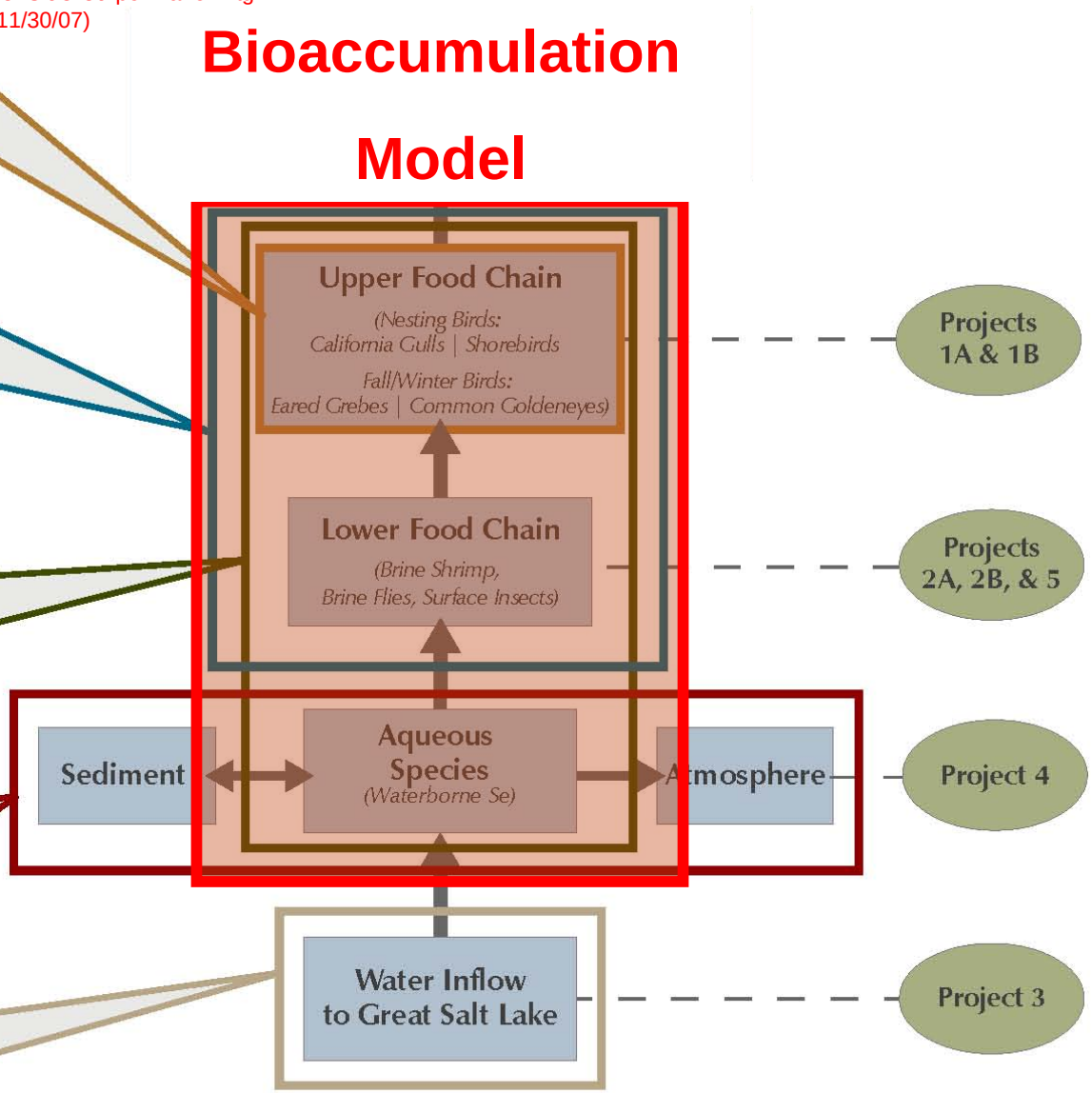

Bioaccumulation Model

- **End goal is to:**
  - Allow user to change water concentration and/or input values to evaluate critical endpoints, and
  - Allow user to change bird and egg diet limits and look at associated water concentration; back-calculate water concentration
- **Thus, Panel will be able to provide recommendations relating level of protection to a water concentration**

Bioaccumulation Model

Selenium Cycling in the Open Waters of the Great Salt Lake

All numbers or figures in **blue TEXT** or with blue background may be changed by user. Cells with black text are formulaic and may not be changed.

Water Column Concentration (µg Se/L)

Water column concentrations have been observed to vary historically between 0.40 and 0.86 µg Se/l

Please specify the water column concentration to estimate diet / egg conc. **0.40**

Solve for the water concentration that yields:

Diet Limits	Solve for Shorebird	Solve for Gull
Egg Limits	Solve for Shorebird	Solve for Gull

Use these buttons to display detailed calculation modules and other information:

Displays detailed worksheets of inputs for Estimated Mass Balance scenario

SHOW MB Inputs | HIDE MB Inputs

Displays measured and modeled water column and biota tissue concentrations

SHOW Abiotic Model | HIDE Abiotic Model

Displays assumed actual and modeled diet and tissue concentrations (including blood, liver, and egg) for Shorebirds and Gulls

SHOW Bird Model | HIDE Bird Model

Resulting Tissue Concentrations of Diet Options (µg Se/g dw)

Choose brine shrimp model: (•) Grosell Model ( ) GSL Regression

Please specify concentrations of diet options for each species

Diet Options	Concentration	Shorebird	Gull
Brine shrimp	1.22	0%	100%
Brine shrimp cysts	1.29	0%	0%
Brine fly	1.25	100%	0%
Corixid	0.95	0%	0%
Midge	1.34	0%	0%
Total Before Sediment		**100%**	**100%**
Sediment	0.37	5%	0%
Total Onsite Diet Concentration		**1.27**	**1.22**

Please specify offsite diet ratio and concentration

Offsite	1.90	0%	0%

Limits and Modeled Diet Concentrations for Each Species (µg Se/g dw)

	Shorebird	Gull
Limits for Diet Concentration	2.00	4.90
Modeled Diet Concentration	**1.27**	**1.22**

Resulting Egg Concentrations and Indices for Each Species (µg Se/g dw)

Please specify limits and which model to use to estimate Egg Concentration

(•) Shorebird Model ( ) Mallard Model

	Shorebird	Gull
Limits for Egg Concentration	12.50	12.50
Modeled egg concentrations	1.85	3.73

Bioaccumulation Model
(water to diet)

- **Looked at simple transfer factors and regressions for water to various food items**
- **Looked at two models for water to brine shrimp:**
  - Martin Grosell model (laboratory derived)
  - GSL regression model (derived from field data)

Bioaccumulation Model

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Bioaccumulation Model
(water to diet)

- **Action items**
  - Finalize GSL regression model for brine shrimp
  - Add a third “generalized” regression model for brine shrimp
  - Link brine fly concentrations to brine shrimp
  - Adjust layout of user interface
  - Panel finalized scenarios for final runs
    - *Assume no off-site diet items*
    - *Gull diet – 100% brine shrimp*
    - *Shorebird diet – 100% brine flies*

Bioaccumulation Model

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Bioaccumulation Model
(diet to egg)

- **Looked at simple transfer factors and regressions for diet to egg**
- **Looked at three regressions for diet to egg:**
  - Gull model
  - Mallard model
  - Shorebird model

Bioaccumulation Model

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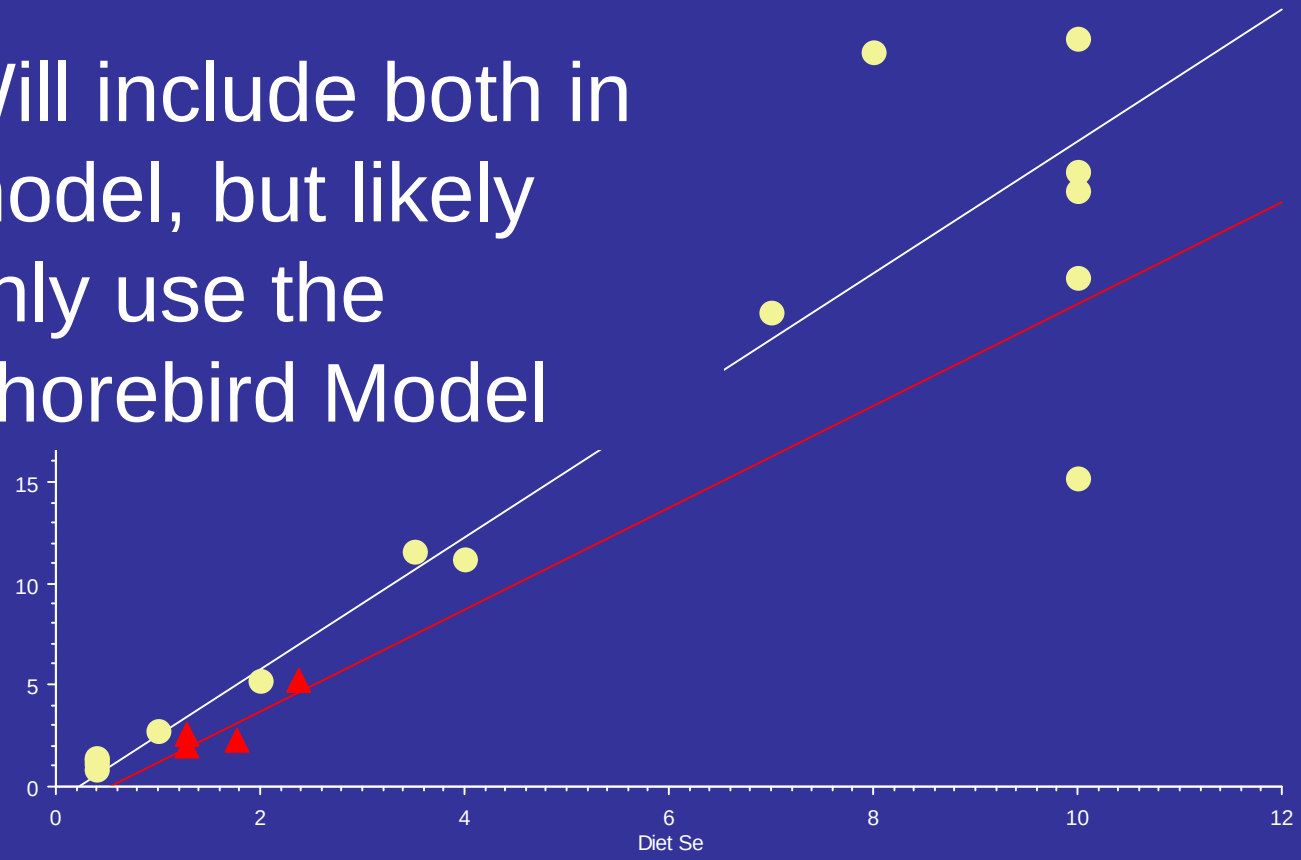
Bioaccumulation Model
(diet to egg)

- Gull model – not used, no relationship observed between diet and egg
- Mallard model – different species, not site-specific, but conservative
- Shorebird model – uses site-specific data

Bird models

Conclusion:

Will include both in model, but likely only use the Shorebird Model



Egg Se = -1.342 + 2.519 * Diet Se; R^2 = 0.785 (Shorebird)
Egg Se = -0.743 + 3.262 * Diet Se; R^2 = 0.875 (Mallard)

Bioaccumulation Model
(water to diet)

- **Action items**
  - Review additional historical shorebird data from the GSL
  - Finalize Shorebird Model

Illustrating Results - Diet

Modeled Reduction in Egg Hatchability

As a Function of Water Column, Diet, and Egg Selenium Concentration

Mallard Egg Hatchability as a Function of Selenium Concentration*

Choose Species to Analyze: (●) Shorebird ( ) Gull

Water, Sediment, and Tissue Concentrations

Water Concentration (µg Se/L)	**0.40**
Sediment Concentration (µg Se/g dw)	0.37
Diet Concentration (µg Se/g dw)	1.27
Egg Concentration (µg Se/g dw)	1.85

Estimated Range of Reduction in Egg Hatchability

Choose EC Curve to Display: (●) DIET ( ) EGG

As a Function of Diet Concentration	
Lower Bound %	< 1%
Max. Likelihood %	***< 1%***
Upper Bound %	< 1%

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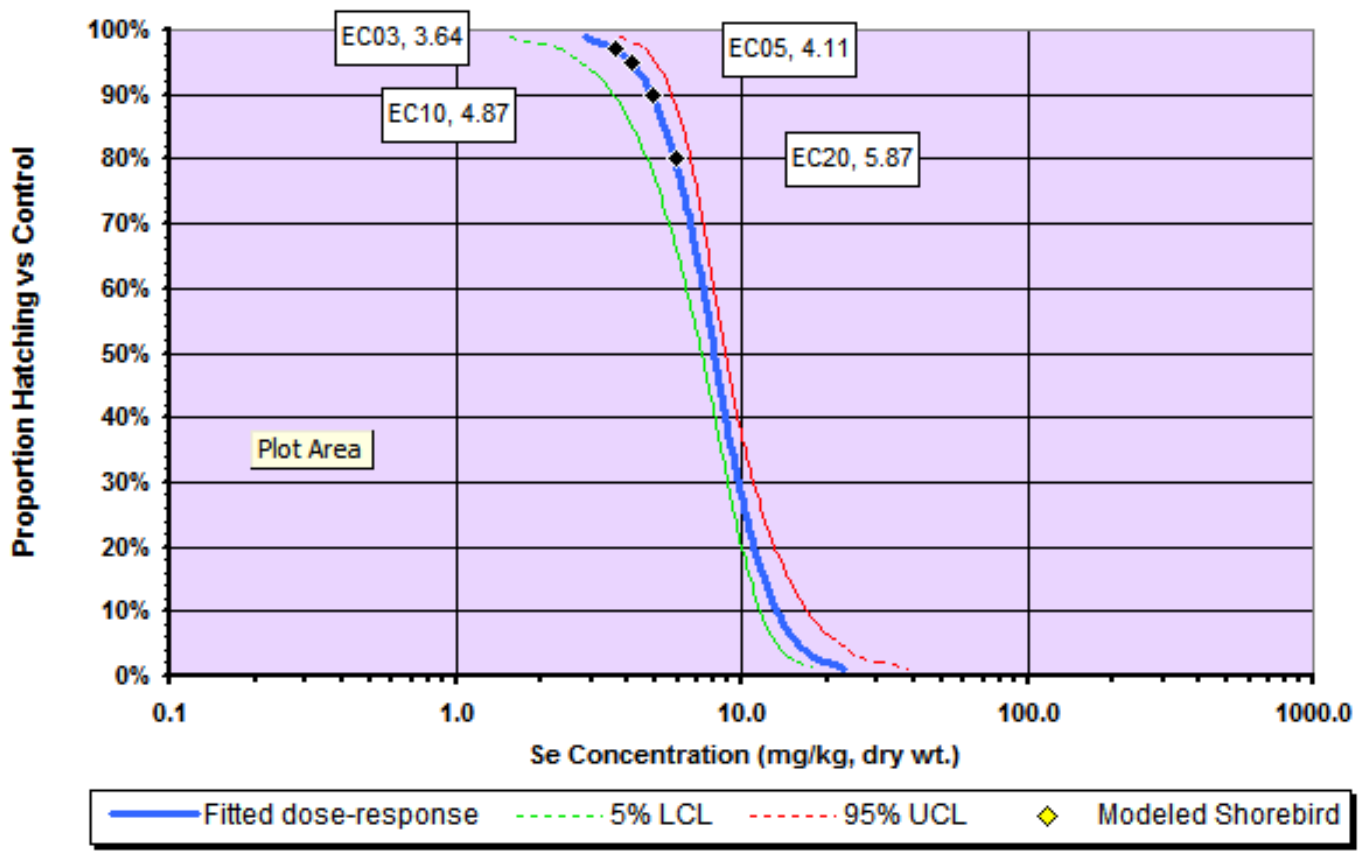

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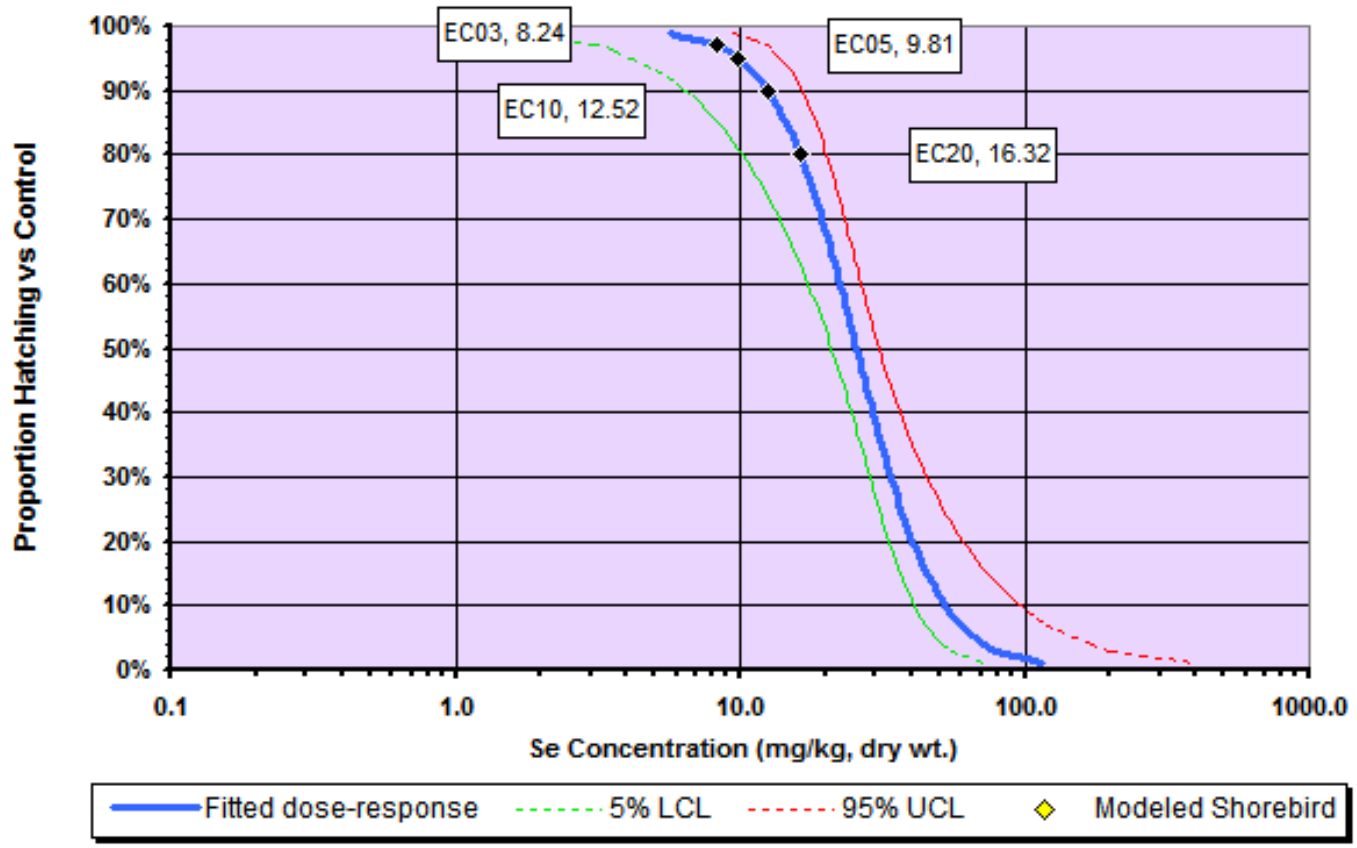

Mass Balance Model

Mass Balance Calculator

Sensitivity of Water Column Concentration to Changes in Mass Balance Assumptions

Attention:
Use the yellow boxes below and this column to examine how changes to estimated Input and Output selenium values might impact the mass balance of selenium within the lake.

Annual Mass Balance

	Estimated Values	Hypothetical Values
Water Column Selenium Inputs (kg)		
Tributaries	1,139	-
Atmospheric Deposition	596	-
Particle Dissolution & Sediment Remineralization	135	-
Deep Brine Layer Contribution	-	-
Shoreline Rewetting	10	-
Total kg	**1,881**	-
Water Column Selenium Outputs (kg)		
Loss to North Arm	880	-
Permanent Sediment Burial	248	-
Volatilization	750	-
Brineshrimp Cyst Harvest	4	-
Total kg	**1,882**	-
Lake Selenium Inputs Exceed Outputs by X kg:	**(1)**	-

Water Column Concentration

Predicted Water Concentration (Total µg Se/L)	**0.61**	**0.61**
Water Column Se Mass (kg)	5,878	5,878

Display detailed worksheets of inputs for Estimated Mass Balance scenario

SHOW MB Inputs | HIDE MB Inputs

Tributary Input (Kg)

Loading Source	2006-07	Dry Year	Wet Year	INPUT
Bear River	321	160	1,797	-
Farmington Bay	142	85	608	-
Goggin Drain	273	164	1,174	-
KUCC Outfall	296	296	961	-
Lee Creek	101	101	328	-
Weber River	53	32	337	-
Other	-	-	-	-
TOTAL Kg	1,185	838	5,207	-

Atmospheric Deposition Rate

	Dry Flux Rate kg/km2/yr	Wet Flux Rate kg/km2/yr	Input for Model
Ches Bay 1991	0.259	0.130	
Great Salt Lake	0.259	0.065	
Assumed Rate (dry + wet flux rate)		**0.324**	-

Volatilization Output (kg)

16th Percentile	Geomean	84th Percentile	User Input
245	1,890	14,553	-

Other Updates

- **New Technical Memorandum**
  - Explores hypothesis that Se/Hg interact to cause elevated Se in bird blood/livers
  - It appears that goldeneyes are using Se to detoxify Hg
- **PIs were approved to publish all material**
  - Panel still needs to review reports for projects 2B and 4
- **A fact sheet regarding recommended guidelines is being developed**

Questions?

- **March 14**
  - Data analysis/model complete
  - All review comments complete
- **March 28**
  - Panel to discuss/finalize model (conf call)
  - Distribute draft reports to steering committee
- **April 17 – conference call**
- **April 24**
  - Panel to circulate position papers within Panel
- **April 30, May 1**
  - Panel deliberates final recommendations
- **May 2**
  - Final recommendation to steering committee