Developing a Water Quality Standard for the Open Water of the Great Salt Lake

Back to the Basics.

Where are we and
where do we need to go?

Report to the Steering Committee
December 5, 2006

Four Grand Questions

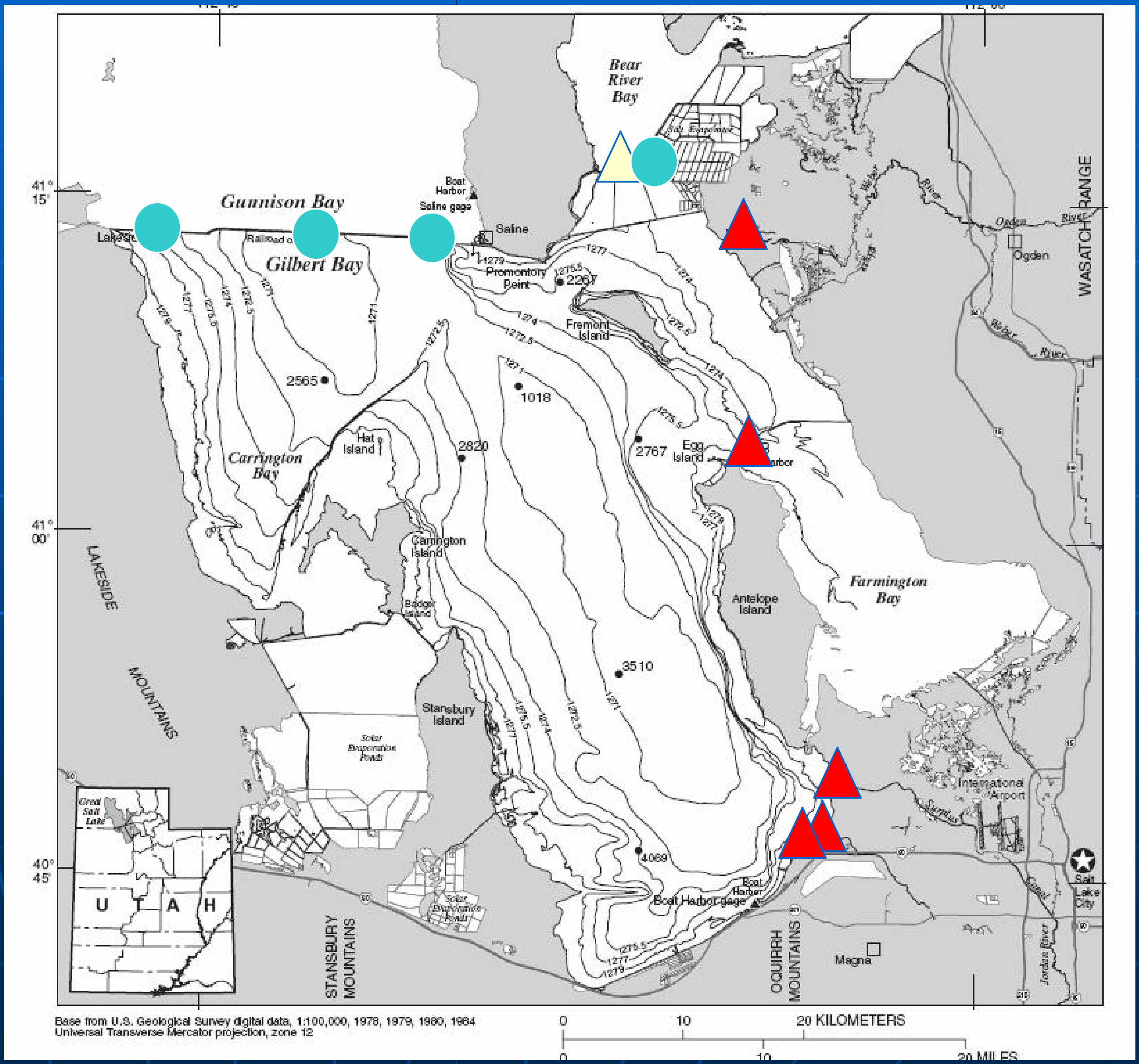
- What is the procedure utilized to develop a standard?
- What information do we have?
- Is that information adequate?
- If not, what more is needed?

GAGE SITE LOCATIONS

From Dave Naftz

Continuous gages

Intermittent gages/sample points



Preliminary Summary Selenium Loads
(g/day)

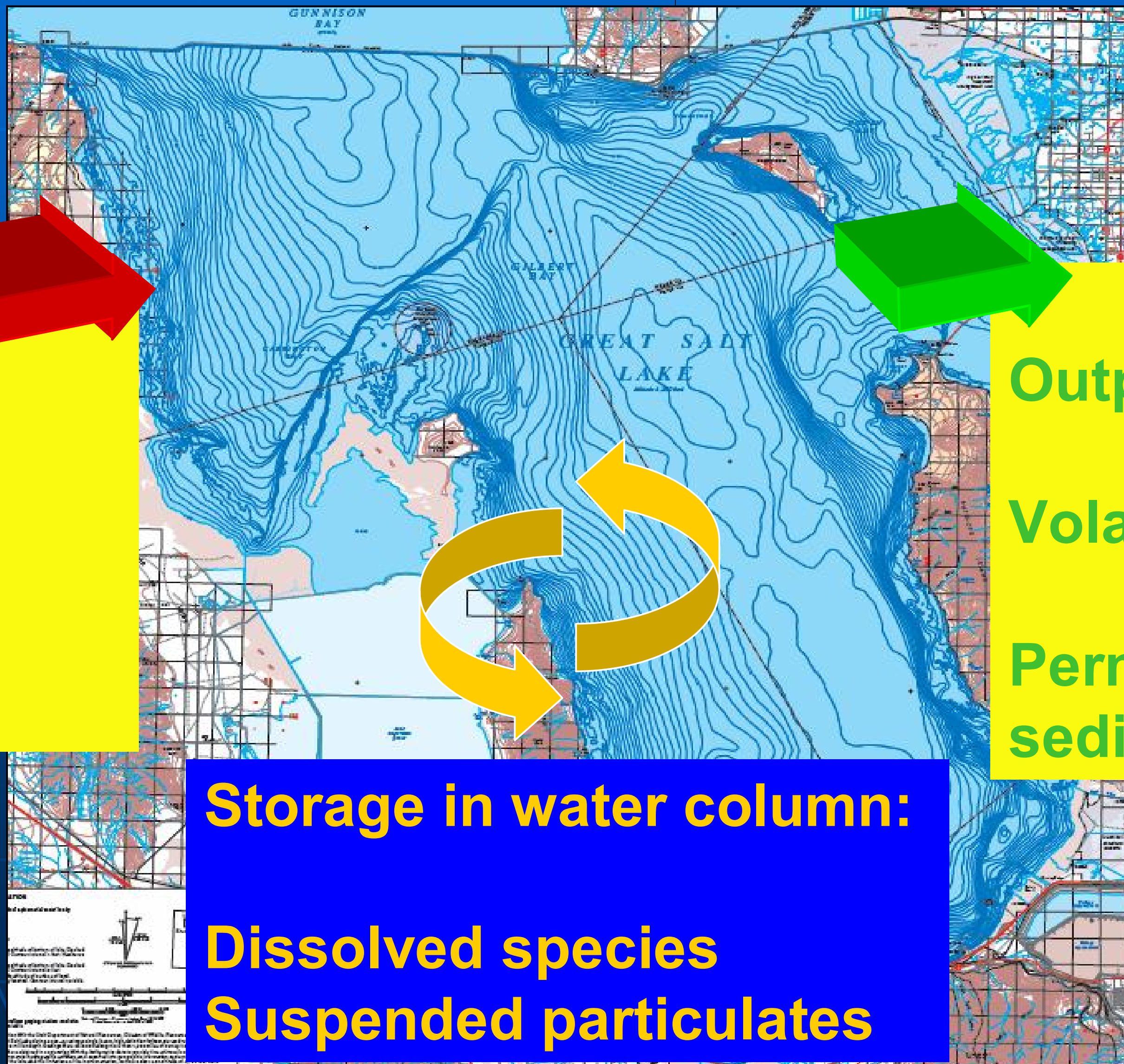
Bear River (2 Days in May)	1,966 to 3,177
Farmington Bay	42 to 570
Goggin Drain	48 to 2,717
KUCC Outfall	8 to 4,330
Lee Creek	106 to 417
Weber River	7 to 23
N. Arm (cumulative)	305

Total = 2,200 to 11,500 g/day

Question?

- What is the relationship between selenium loading and the concentration of Se in the food chain and lake water?
- After Dave has “fine tuned” the loadings, what then?

Se Flux in the S. Arm



Inputs:

Rivers & streams

Outputs:

Volatilization

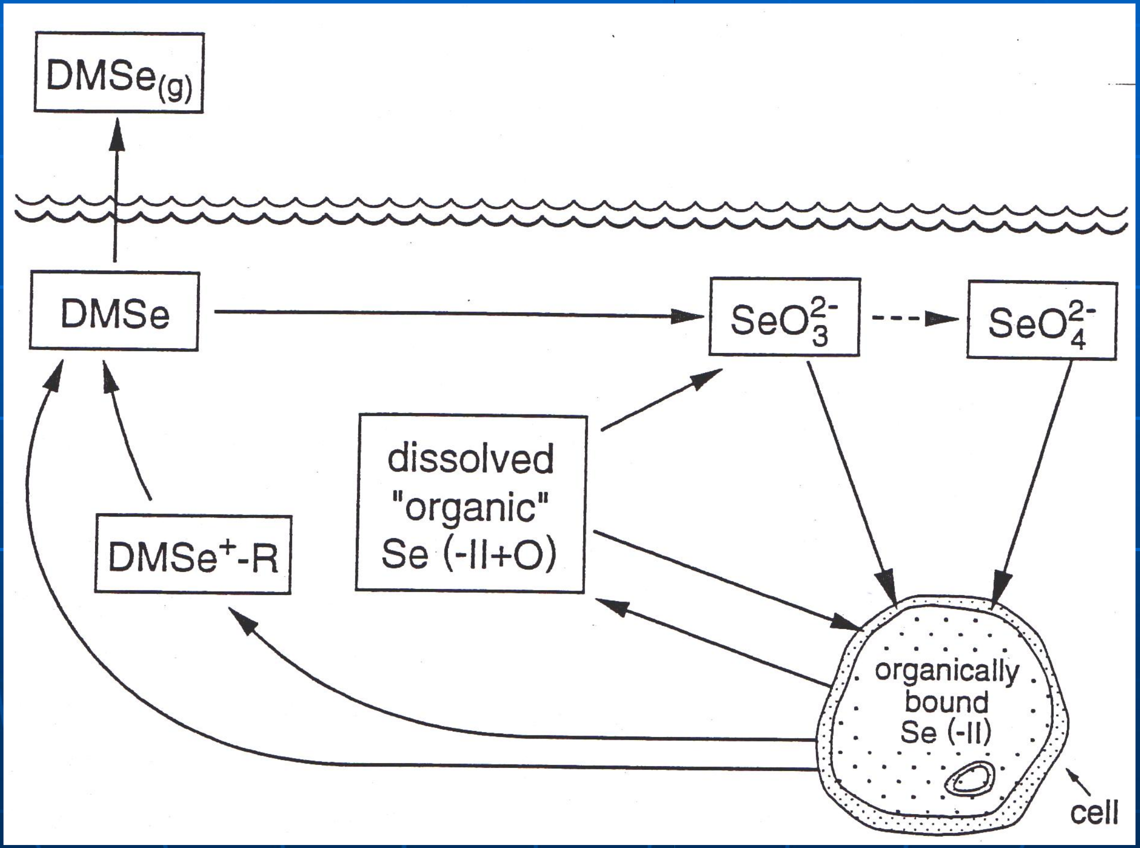
Permanent sedimentation

Storage in water column:

Dissolved species
Suspended particulates

Volatilization of Se

Biotransformation of Se



(Cooke and Bruland, 1987)

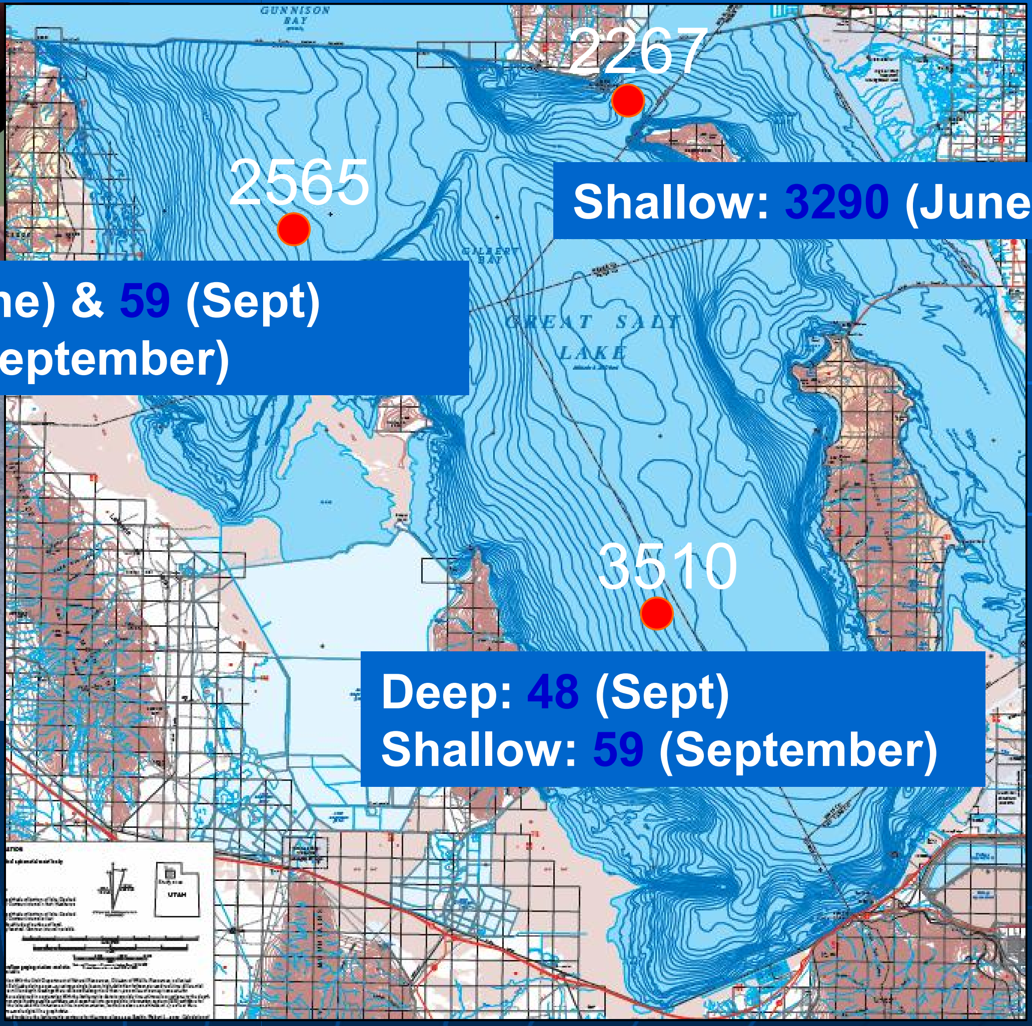
Example fluxes

Residence time (d)	Volatile Se (Kg/yr)	Removed/total
10	237	1/21
1	2,372	1/2
0.1	23,725	4.7

Until we know what resident time is, the amount of volatilization is still in question.

Downward Sedimentation

Downward sediment flux mg/cm²/yr



Shallow: 3290 (June)

Deep: 322 (June) & 59 (Sept)
Shallow: 18 (September)

Deep: 48 (Sept)
Shallow: 59 (September)

^{210}Pb rate = 22 mg/cm²/yr

Permanent Sedimentation

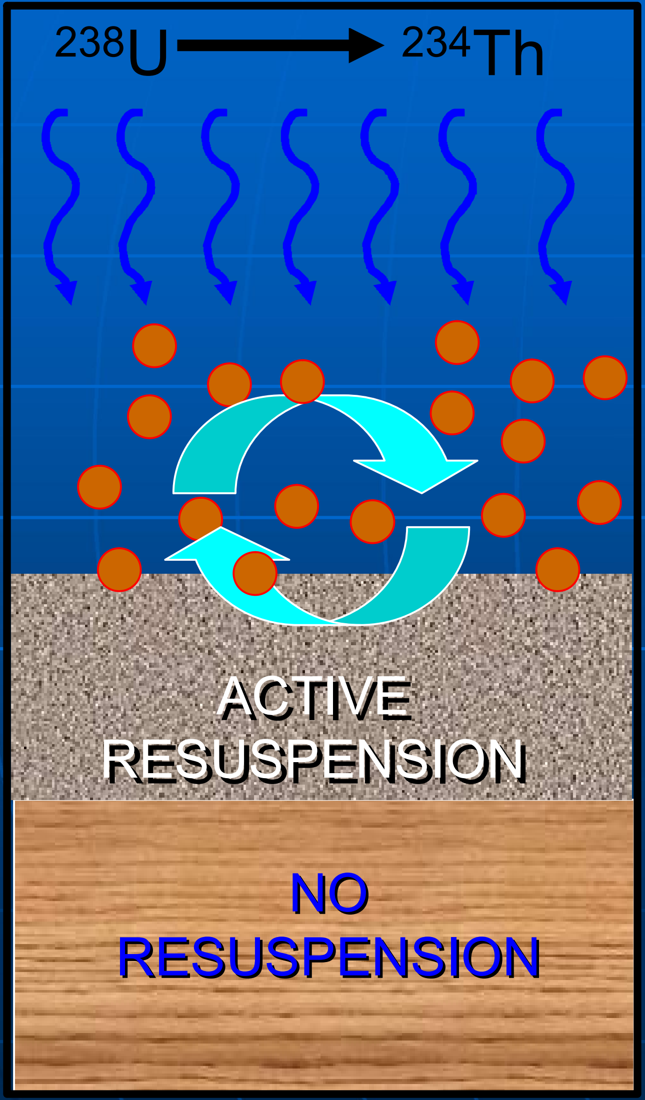
Selenium sedimentation rate:

Waiting for Se concentrations from cores (LET and UU labs)

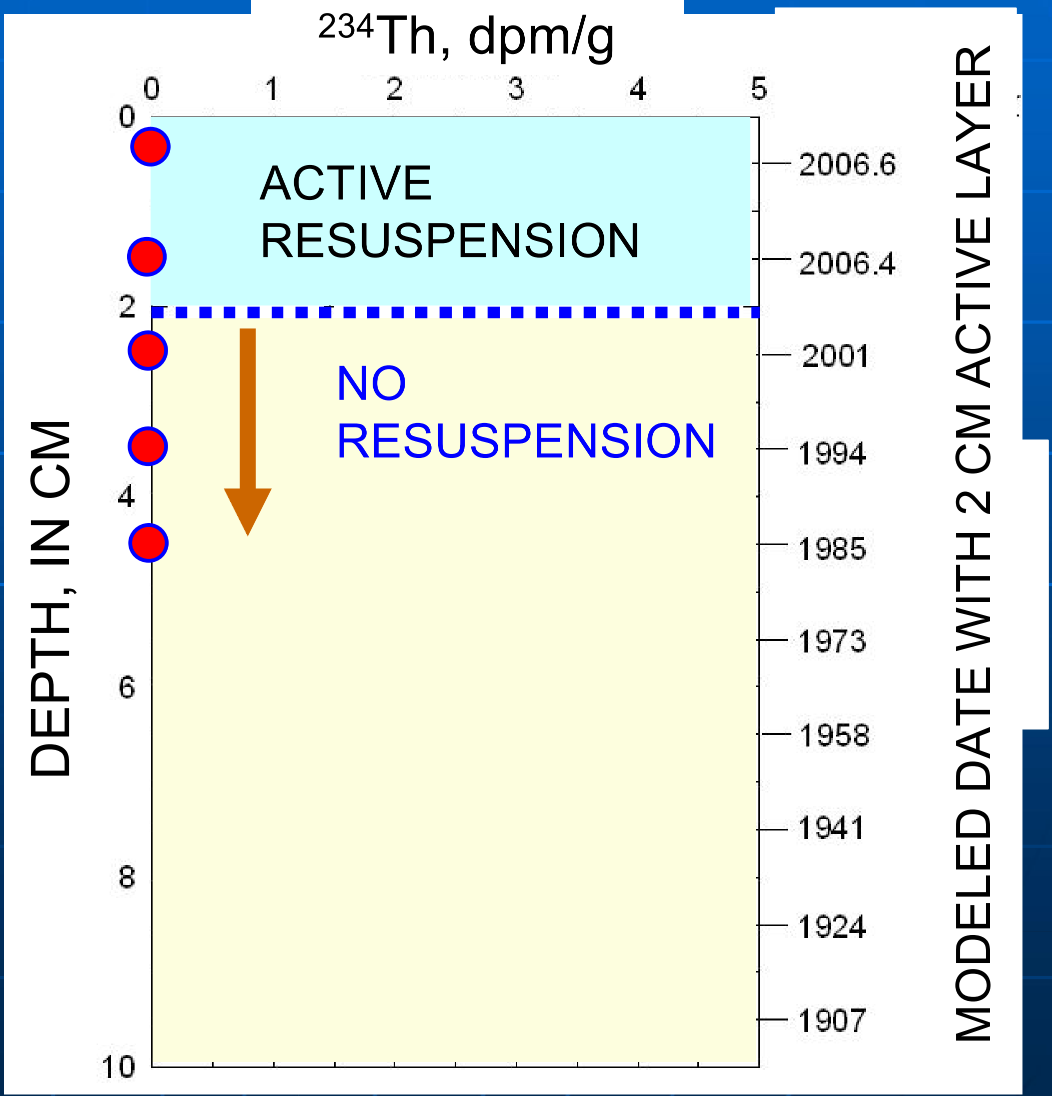
Questions?

- Do the available data show that the concentration of Se is increasing in the more recent sediments?
- What are the reflux components?
  - Deposition
  - Resuspension

Sediment Re-suspension



^{234}Th half life = 24 days



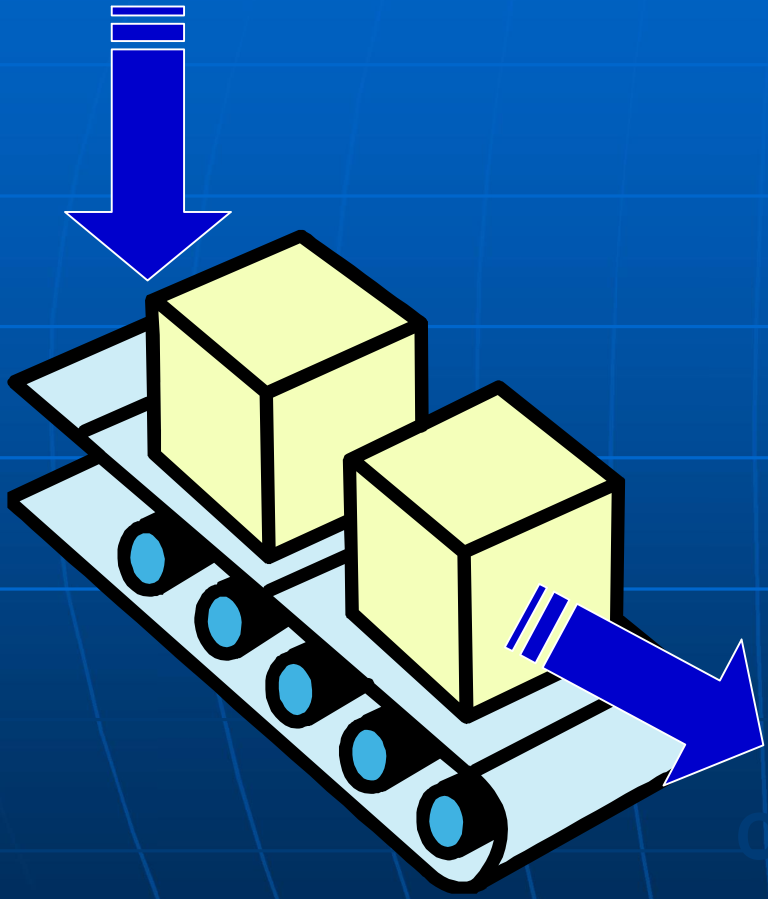
Mixing & Re-solubilization

Mechanisms

- Wind Induced Surface Wave
- Seiche or Internal Wave
- Langmuir Circulations
- Thermal Mixing

Deep Brine Transport of Se

Vertical Se Flux



CH_3Hg

< Production   Distribution   Consumers   Other contaminants >

Questions?

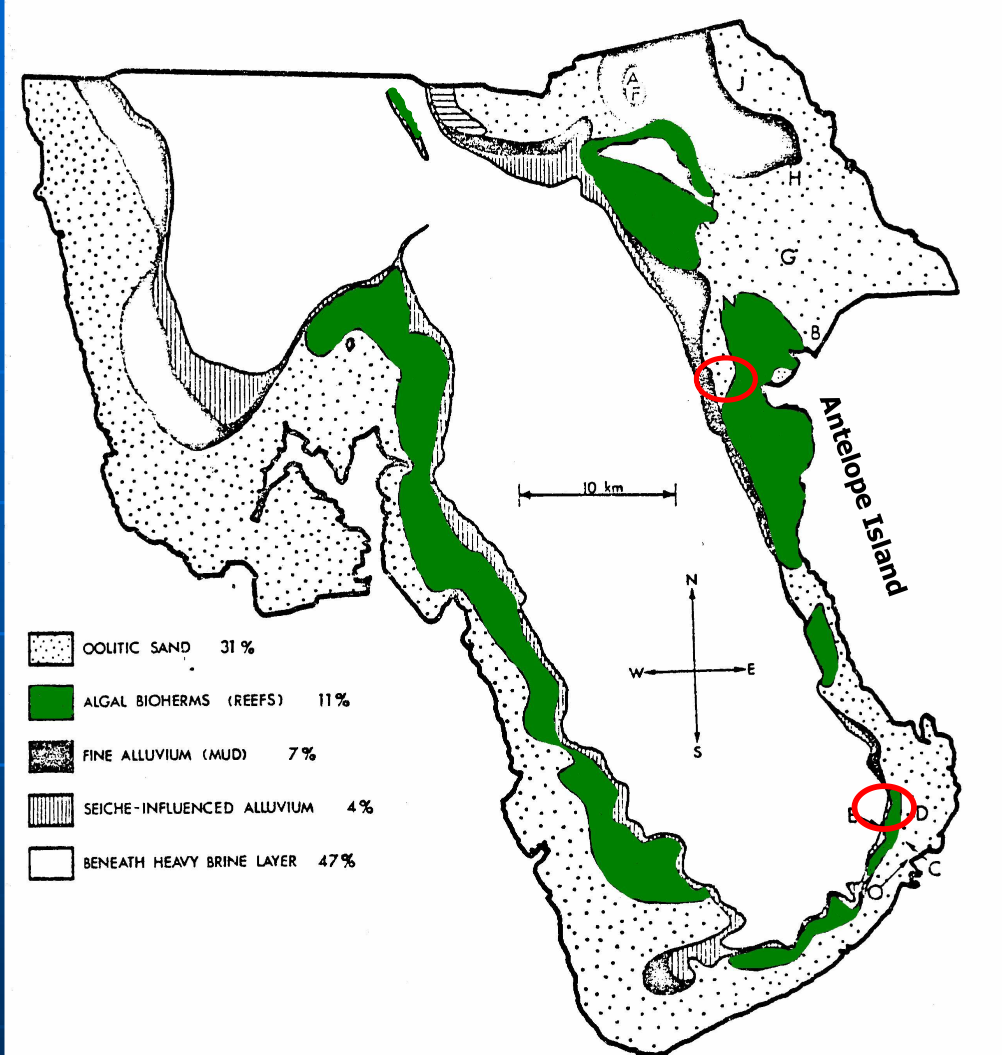
- What is the ultimate fate of Selenium and is it in equilibrium?
  - Deposition to sediment
  - Volatilization to the atmosphere
  - Amount into the biota
  - Amount in the water column

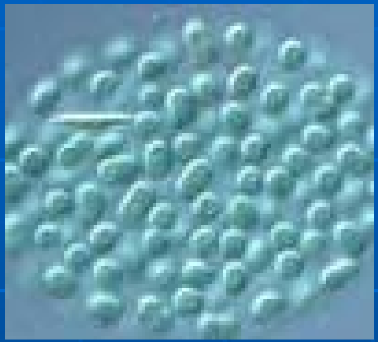

Wayne Wurtsbaugh
Utah State University
November 29, 2006
DWQ Selenium Science Panel

Stromatolites

Dominant hard substrate for periphyton, brine fly larvae & pupae

Distribution in Gilbert Bay





Aphanothece sp.
(cyanobacteria)

Food Web Importance:
Principal Brine Fly Habitat

Ephydra cinerea

Conclusions

- **Selenium concentrations are low in:**
  - **Overlying water (0.4 µg/L)**
  - **Periphyton (1.7 µg/g)**
  - **All life stages of brine flies (1.5 µg/g)**
- **There was no biomagnification within the short benthic food web**

Evaluating Selenium Accumulation by Great Salt Lake Brine Shrimp (*Artemia franciscana*)

Science Advisory Board

November 29, 2006

Dr. Marjorie Brooks

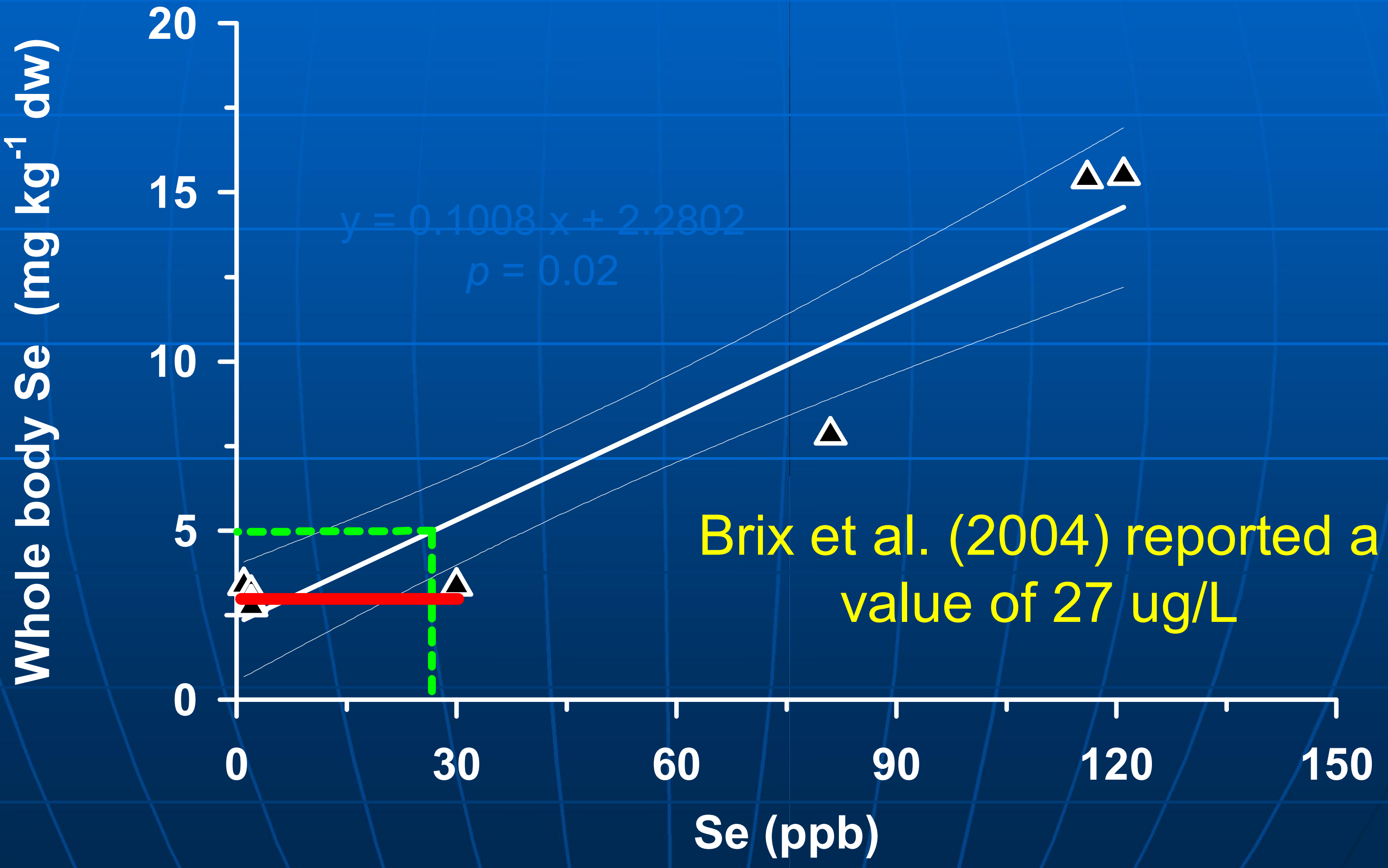
University of Wyoming

and

University of California

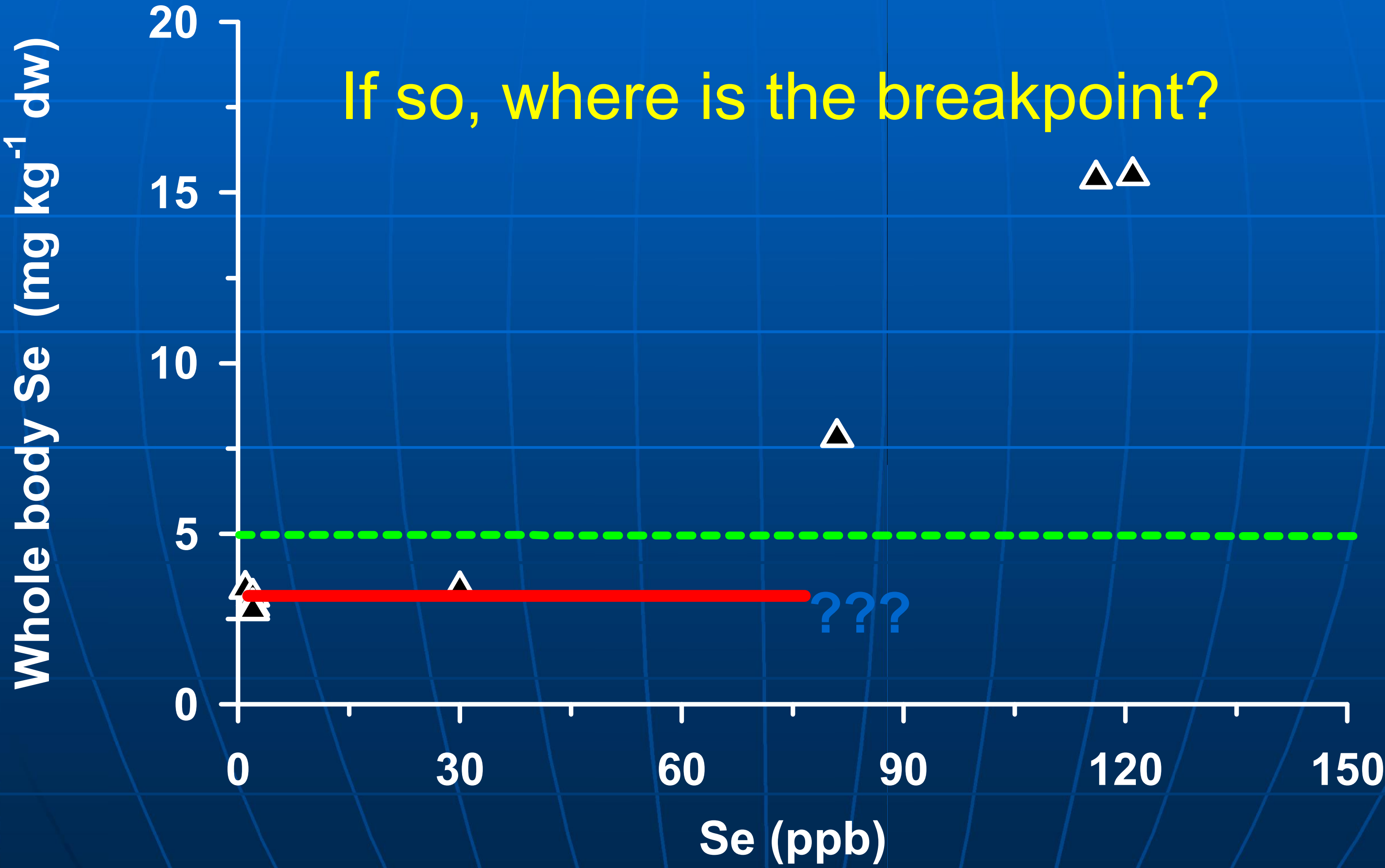
NCEAS

The Issue:
If we assume 5 mg/Kg (dwt) in the diet of birds is protective, what is the associated water selenium concentration?

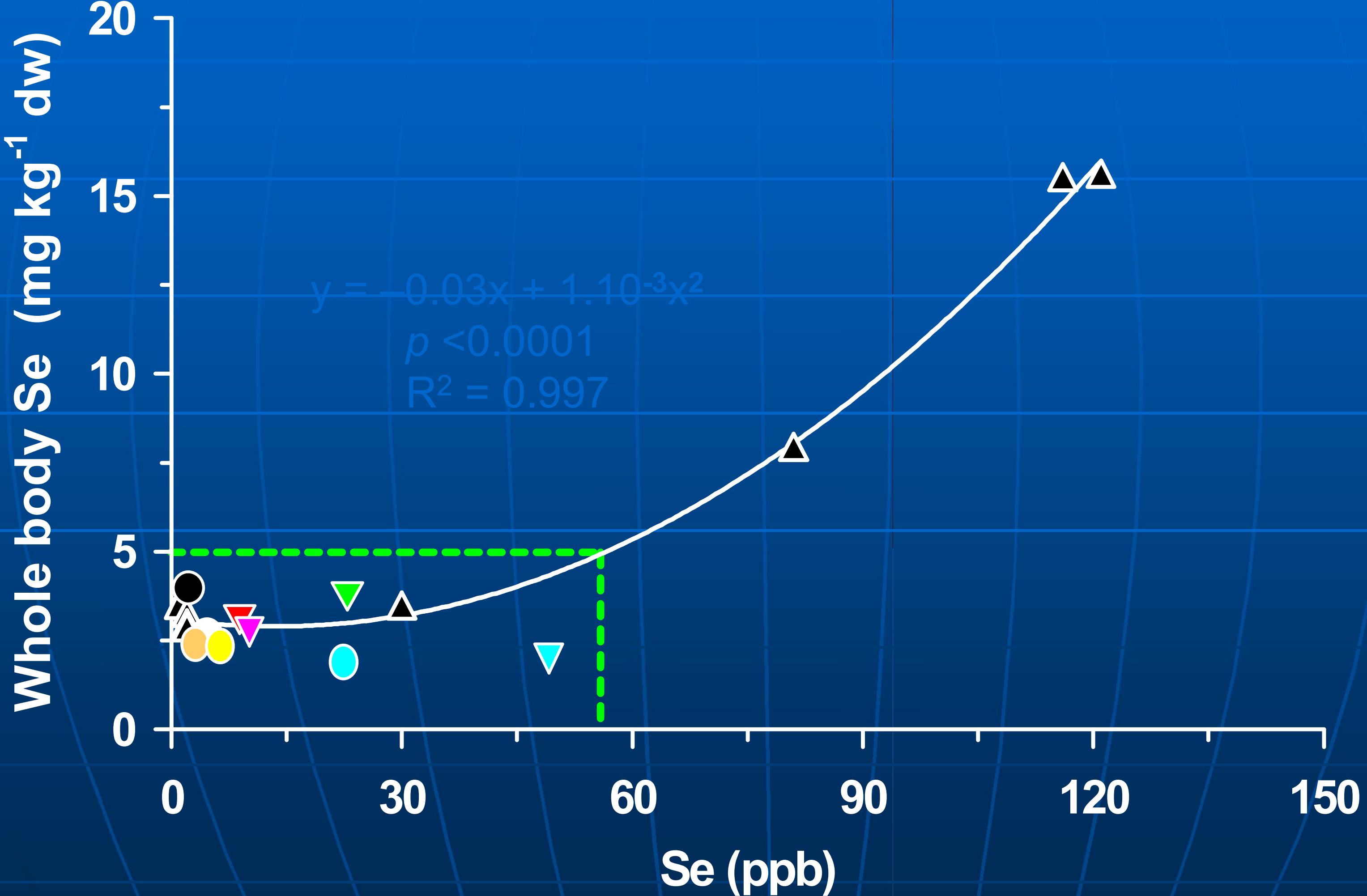


Brix et al. (2004) reported a value of 27 ug/L

The Issue:
Are the shrimp regulating selenium accumulation?



These data may indicate that accumulation is below the dietary criterion of 5 mg/kg dwt, consistent with a non-linear fit of the Brix et al (2004) data.



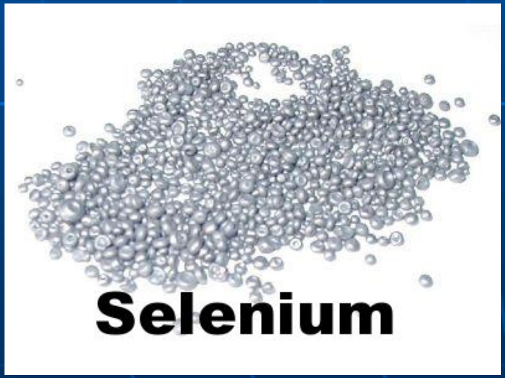
Summary

- For Se concentrations $\leq$ 27 ppb Se, shrimp tissue accumulations were always less than a bird dietary threshold of 5 mg / kg dwt
- Brine shrimp exposures to Se in water and algae are not related to exposure concentration in the range of 1-11 ug/L
- Conclusion:
  - Shrimp may regulate bioaccumulation or selenium uptake may be kinetically controlled.
  - SeO_3 is taken up more rapidly than Se04 both in algae and in brine shrimp.

Additional Recommended Study – Kinetic Uptake of Selenium Using Se75

- Dr. Martin Grosell, Univ. of Miami
- Three Components
  - Water to Algae
  - Algae to Brine Shrimp
  - Water to Brine Shrimp
  - Radioisotope (Se 75)
- Cost: ~$150,000

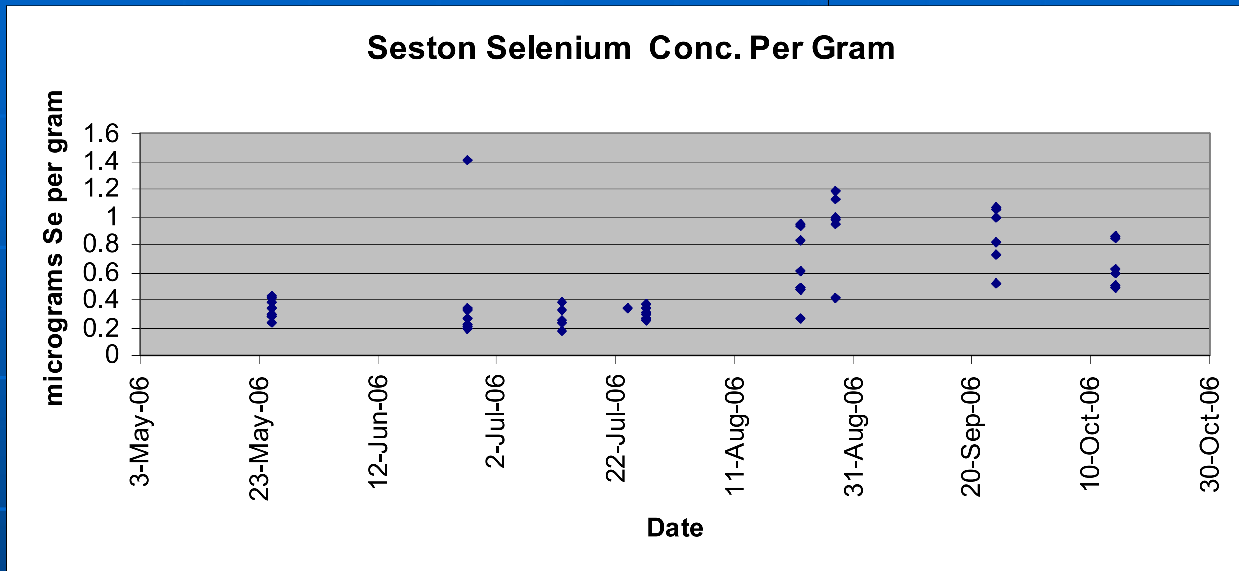
Great Salt Lake Selenium Studies Project 2B Synoptic Survey of Selenium in Water, Seston, and *Artemia* Biomass

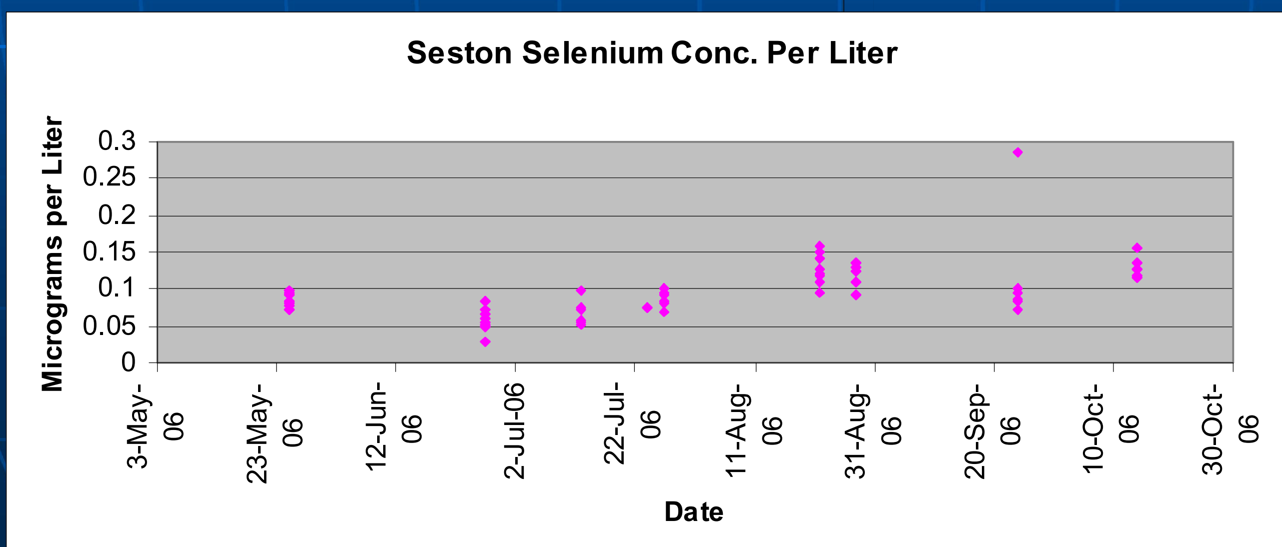


Brad Marden
Parliament Fisheries, LLC

PFC

SESTON (Water Column Particulates) SELENIUM





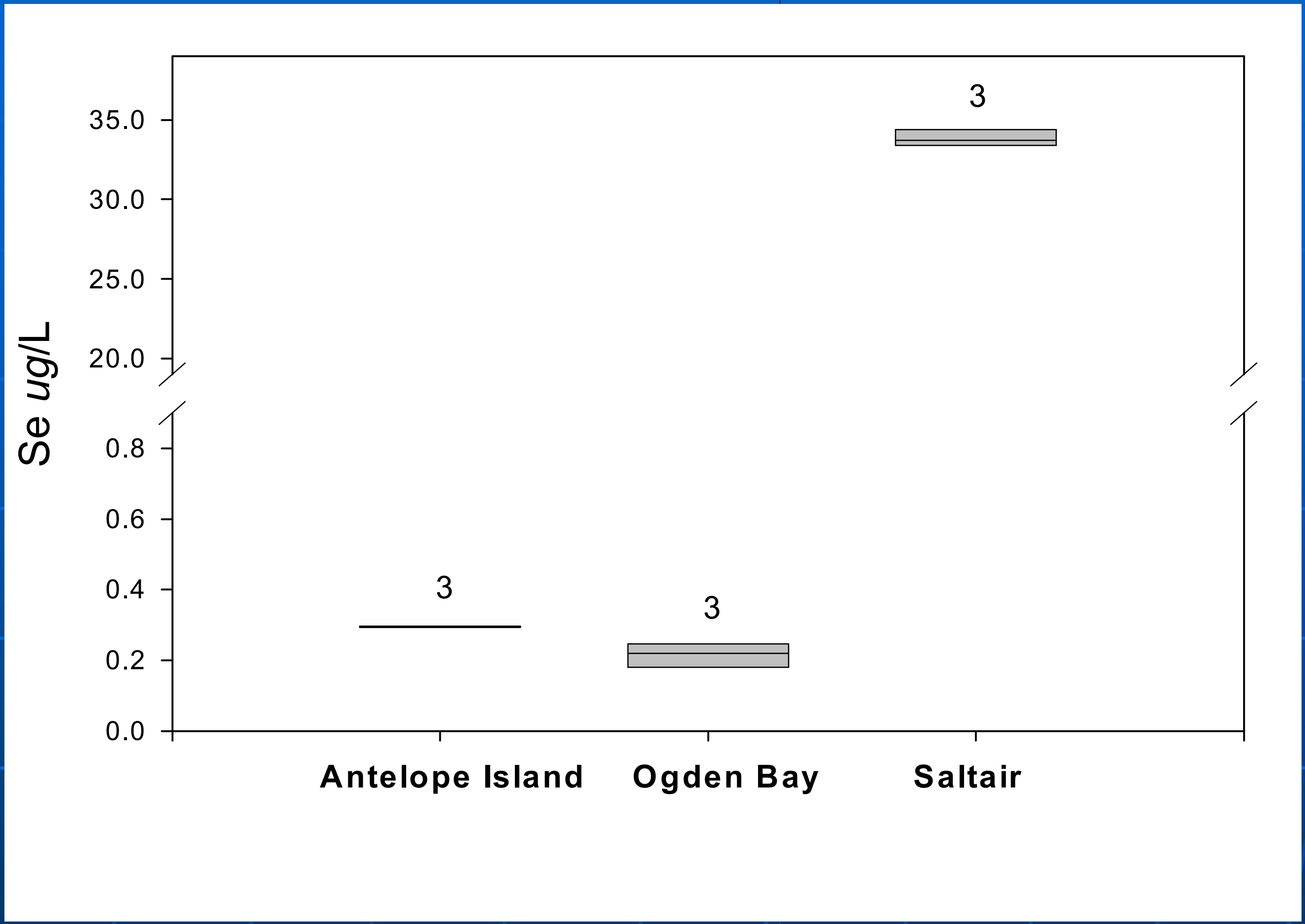
PFC

Concentration and Effects of Selenium in American Avocets and Black-necked Stilts

John F. Cavitt
Weber State University

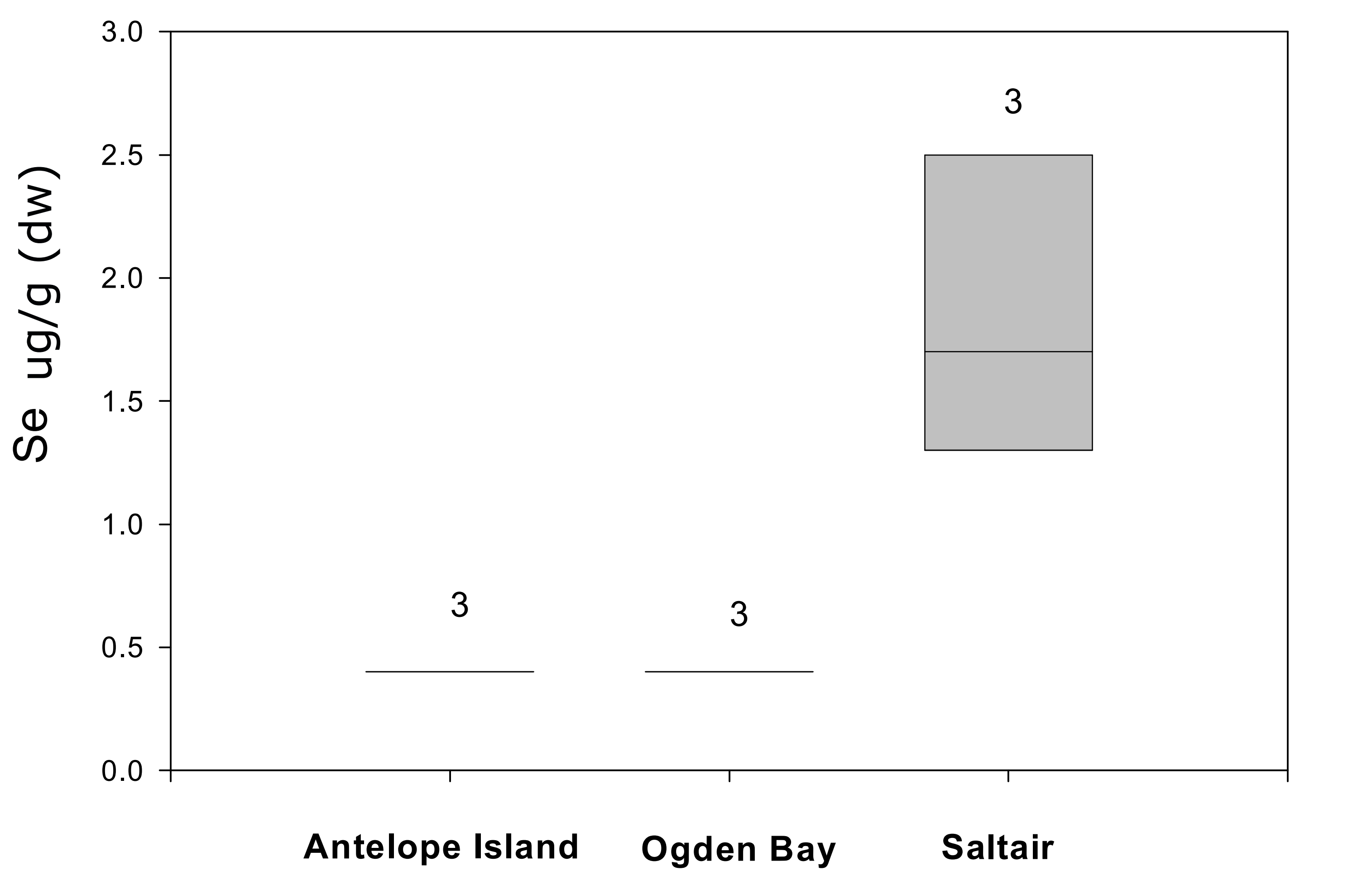
4 study sites located

- Ogden Bay
- Antelope Island, Bridger Bay
- Saltair
- West Carrington



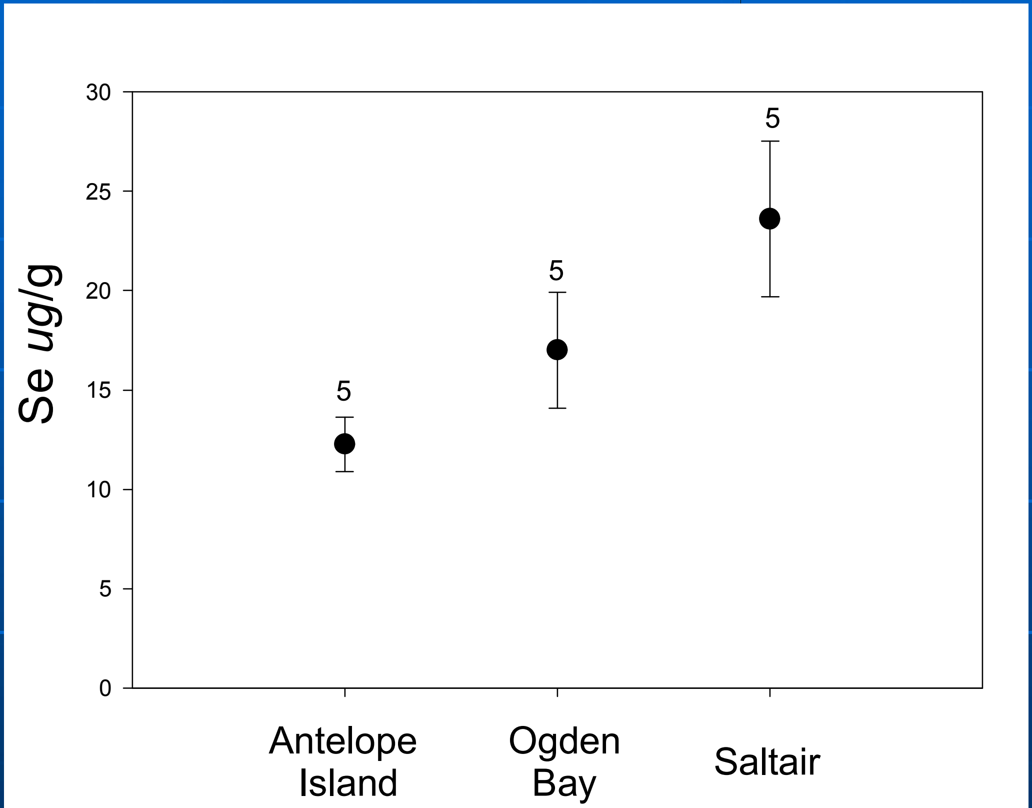
Median *Se* concentration from water samples at each foraging site

(H = 7.2, df = 2, P = 0.004)



Median *Se* concentration from sediment samples at each foraging site

(H = 7.7, df = 2, P = 0.07)



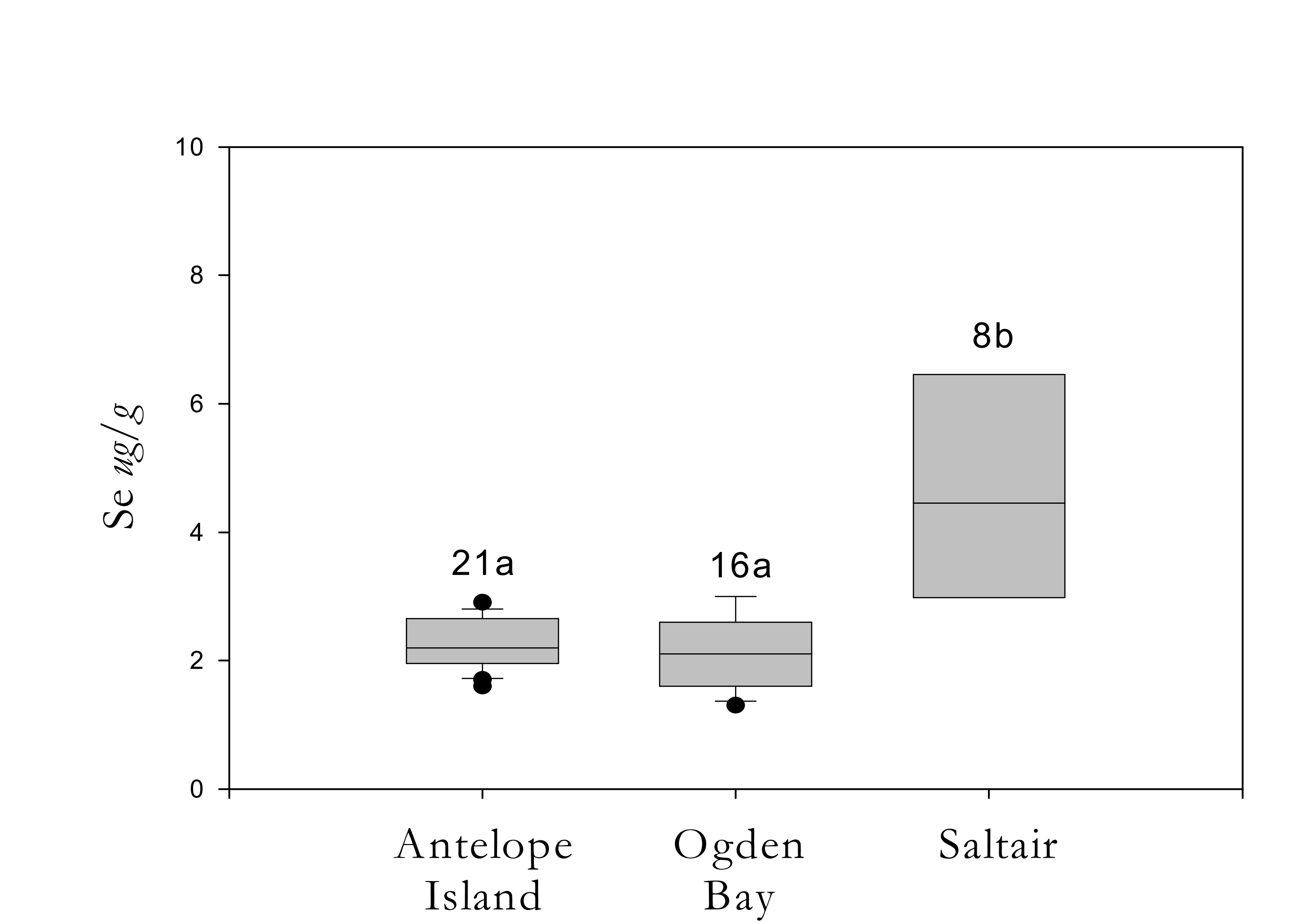
AMAV liver *Se* concentrations

($F_{2,14}$ = 3.79, P = 0.053)

Se concentration (*ug/g*) of macroinvertebrates sampled within foraging areas

Site	Brine Fly	Chiron.	Corixid
ANT	0.8 – 2.3 (1.56 ± 0.2)	-	2.5
OGB	0.97 - 3 (1.66 ± 0.7)	2.0	2.0 – 3.0
SALT	1.9 – 3.8 (2.7 ± 0.4)	-	2.1

Egg *Se* Concentration



H = 15.85, *df* = 2, *P* = 0.001

Productivity

Site	Spp.	Total Eggs Laid (# nests)	Clutch Size (n)	Hatchability (n)	Total Young Produced	# Young Leaving/Nest (n)
Antelope Island	AMAV	669 (196)	3.77 ± 0.05 (90)	0.94 ± 0.01 (86)	293	3.42 ± 0.08 (86)
Ogden Bay	AMAV	296 (90)	3.77 ± 0.08 (44)	0.97 ± 0.02 (40)	137	3.34 ± 0.10 (41)
	BNST	137 (39)	3.84 ± 0.09 (19)	1.0 ± 0 (18)	70	3.33 ± 0.10 (21)
Saltair	AMAV	32 (13)	4.0 ± 0 (2)	-	0	-

Dr. Cavitt Conclusions

- No deformities in any embryos or chicks.
- Hatchability in colonies normal
- Saltair colony eggs lost to flooding.
  - Literature values indicates there would be no problem in hatchability for the avocets.

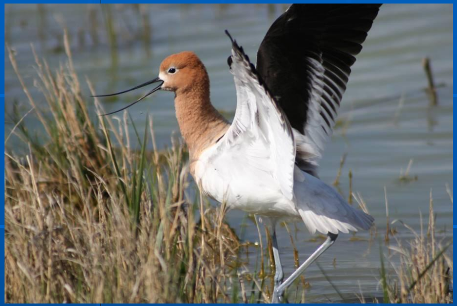
Dr. Conover Studies

- No deformities in gull chick embryos.
- No results of “out of the norm” for reproduction, etc.
- Concentrations in blood being further evaluated.

Simplified Conceptual Model
Se Flow

0.29
ug/L

1.56
[3.56 – 7.54]



(ppm)

2.26
[6.4 – 16.5]

Is the conceptual model" linear?

Critical Egg Concentration

Egg Concentrations				
mg/kg (dry wt.)	**Approach or Site**	**Effects**	**Species**	**Reference(s)**
12.5 CI (6.4 - 16.5)	Synthesis of lab data	Hatchability in mallards (10% effect level/95% confidence boundaries)	Mallard	Ohlendorf 2003
10	Synthesis of lab data	NOAEL	Mallard	Adams et al, 2003
12 - 16	Synthesis of lab data	EC10 for duckling mortality	Mallard	Adams et al, 2003
9	Synthesis of lab data	Impaired clutch viability (8.2% effects level)	Mallard	Lam and others, 2005
8.2 (or 7.3) (egg based on 73% moisture)	Field	16% depression in egg viability (***7.3 in paper***)	Spotted Sandpiper	Harding and others, 2005
6	Synthesis of field data	Threshold (3% effect level) of hatchability	Stilts	Skorupa, 1998a; Skorupa, 1999
5.1 (egg based on 78.4% moisture)	Field	15% depression in egg viability	American dipper	Harding and others, 2005

Critical Diet Concentration

Diet Concentrations

mg/kg	Approach or Site	Effects	Species	Reference(s)
4.87 (CI 3.56 - 5.74)	Synthesis of Lab Data	Hatchability in mallards (10% effect level/95% confidence boundaries)	Mallard	Ohlendorf 2003
5.1 (CI 3.5 - 6.2)	Synthesis of Lab Data	Mallard hatchability vs control as function of Se in diet	Mallard	Bill Adams suggestion
3.85 - 7.7 (diet based on 10% moisture)	Lab	Reduced hatching success in mallards (33% at 7.7ug/g); reduced growth and weight in hatchlings	Mallard	Stanley and others, 1996
7.7 (diet based on 10% moisture)	Lab	Reduction in number of surviving mallard ducklings produced per female	Mallard	Stanley and others, 1996
8.8 4.4/6.2 (diet based on 10% moisture)	Lab	8.8 - LOAEL, 4.4 - NOAEL, 6.2 - Geometric Mean Reduction (17%) in survival of mallard ducklings; mean decrease (43%) in number of 6-day-old ducklings	Mallard	Heinz and others, 1989
6	Lab	Adverse effect on body condition of male American Kestrels	American Kestrels	Yamamoto and Santolo, 2000
7.7 - 8.8 (diet based on 10% moisture)	Lab	Dietary threshold of teratogenic effects in mallards; above upper threshold, rate of deformity rises sharply	Mallard	Stanley and others, 1996
7.7 - 8.8 (diet based on 10% moisture)	Lab	Dietary threshold of mallard duckling mortality (parental exposure)	Mallard	Stanley and others, 1996

Four Grand Questions

- What is the procedure utilized to develop a standard?
- What information do we have?
- Is that information adequate?
- If not, what more is needed?

More Proposals

- More Sediment Flux Studies [Miami]
- Volatilization Flux to Atmosphere Study
- Additional brine shrimp/seston studies in spring 2007.
- CH2MHill – Model application and evaluation of relationships.

Next Science Panel Meeting

- The next Science Panel Meeting is schedules for Wednesday-Thursday, March 21-22, 2007.
- Members of the Science Panel have indicated they are willing to spend Friday March 23, 2007 in a joint meeting with the Steering Committee if the committee so desires.