Selenium Concentrations in Pariette Wetlands and the Hazard Posed to Aquatic Birds and Fish

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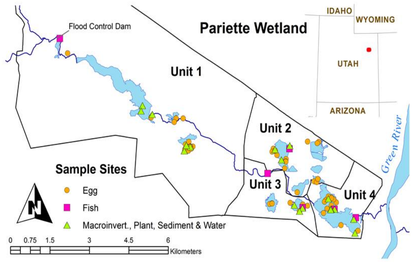
BACKGROUND

The Pariette Wetlands located in the Uintah Basin of northeastern Utah, is the largest US Bureau of Land Management (BLM) wetland development in Utah. The wetlands contain diverse vegetation and wildlife in an arid climate. In the late 1980s, elevated Se concentrations in the wetlands were determined to pose a moderate to high hazard to wetland birds. Since then, numerous mitigation efforts and changes in land management practices have been implemented. Continued monitoring efforts indicate that at times concentrations of selenium (Se) exceed the total maximum daily loads developed to meet the US EPA's water quality planning and management regulations (40CFR 130).



The objective of the study was to estimate the hazard posed by Se in the wetlands to aquatic-dependent birds and fish using the Lemly approach, which is based on the Se concentrations in five ecosystem components: bird eggs, fish, benthic macroinvertebrates, sediment and water.

MATERIALS AND METHODS

Water, sediment, benthic macro-invertebrates, fish and bird eggs were sampled in triplicate at 3 sites within 6 ponds, distributed along 4 units in the 24 wetland pond complex, from May-July 2014

Water
- Filtered through a 0.45 µm filter
- Persulfate digestion
- Total Se determined by HGAAS

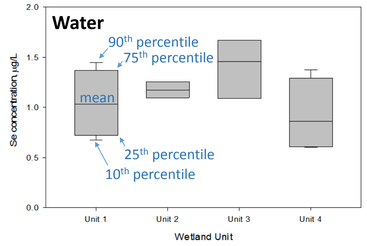
Sediments
- Cored from 0-2 and 2-5 cm depths
- $HNO_3/HClO_4$ digestion
- Total Se determined by HGAAS

Benthic macroinvertebrates
- Isolated from 0-5 cm sediment layer or captured with light traps.
- $HNO_3/HClO_4$ digestion
- Total Se determined by HGAAS

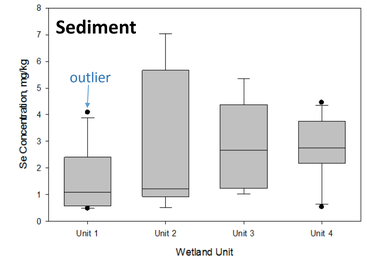
Fish
- Captured using seine traps
- 37 total samples, 4 species
- Total Se analyzed at Texas A&M's Trace Element Research Laboratory (TERL)

Bird eggs
- One egg sampled per nest (54 eggs total among 15 bird species)
- Total Se analyzed by TERL

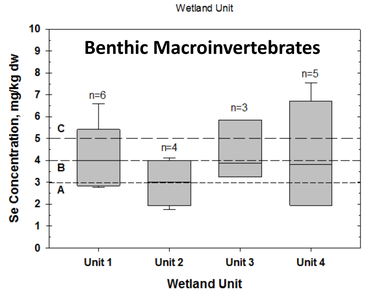
TOTAL SELENIUM IN ECOSYSTEM COMPONENTS



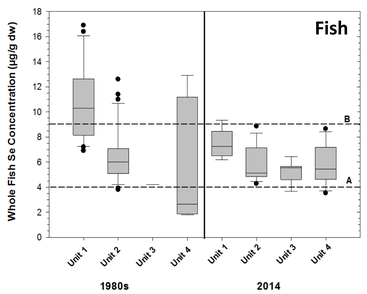
- Se concentrations in water sampled in June 2014 were below the Utah State Water Quality Standard for wildlife (4.6 µg/L) in all four wetland units.
- Water is part of the planktonic food chain and also directly ingested.



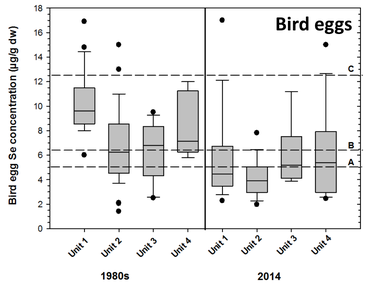
- Mean Se concentrations in the 0-5 cm depth sediments ranged from 1–2.5 mg/kg dw, predicting a minimal to low Se toxicity hazard to fish and birds through the benthic food chain.
- Se was heterogeneously distributed in the sediments. Se concentrations > 4 mg/kg indicate a high toxicity hazard.



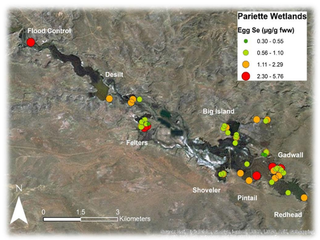
- [Se] < A: Minimal hazard in diet items for birds
- [Se] < B: Low probability for reproductive impairment in aquatic food-chain items
- [Se] > C: High hazard of reproductive impairment in sensitive species



- A = Lower threshold for mortality of juveniles and reproductive failure
- B = EC_{10} in parent fish associated with larval mortality and edema in offspring

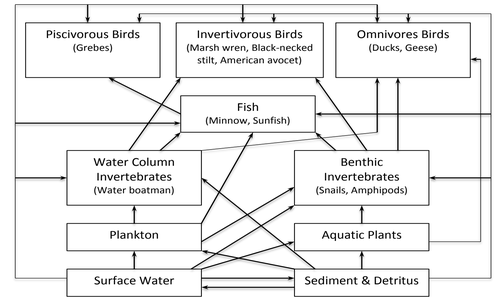


- A = Level that exceeds the normal range of bird egg Se concentration
- B = Level that approaches reproductive impairment
- C = Elevated probability for reduced egg hatchability in sensitive and moderately sensitive species



- Distribution of Se hazard in bird eggs along the Pariette Wetland complex
- 0.30–0.55 µg/g fww: minimal hazard
- 0.56–1.10 µg/g fww: upper end of minimal hazard to lower end of low hazard
- 1.11–2.29 µg/g fww: low hazard
- 2.30–5.76 µg/g fww: moderate hazard

PARIETTE WETLANDS FOOD-WEB



Se inputs to the wetland
- Irrigation return water
- Groundwater
- Run off

Se outputs from the wetland
- Outlet into the Green River
- Evapotranspiration
- Seepage
- Volatilization

SELENIUM HAZARD SCORES

Site and environmental component	[Se] Range	Se concentration Geometric mean µg/g dw or µg/L	Hazard Rank by Component	Hazard Score	Hazard Rank
Unit 1					
Water	0.1-1.6	0.31	None	1	
Sediments	0.4-3.9	1.2	Minimal	2	
Invertebrates	2.7-6.5	4	Moderate	4	
Fish eggs	20.4-30.8	24.3	High	5	
Bird eggs	2.7-17	4.7	Minimal	2	
			Total	**14**	**Moderate**
Unit 2					
Water	0.83-1.12	0.97	None	1	
Sediments	0.1-3.7	0.83	None	1	
Invertebrates	1.8-4.1	2.8	Minimal	2	
Fish eggs	14.0-29.2	18.9	Moderate	4	
Bird eggs	2.0-7.7	3.8	Minimal	2	
			Total	**10**	**Low**
Unit 3					
Water	0.16-0.82	0.4	None	1	
Sediments	0.1-7.7	0.82	None	1	
Invertebrates	3.2-5.9	4.1	Moderate	4	
Fish eggs	12.1-21.2	17.2	Moderate	4	
Bird eggs	3.9-11.2	5.7	Low	3	
			Total	**13**	**Moderate**
Unit 4					
Water	1.14-2.24	1.56	Minimal	2	
Sediments	0.4-4.2	2	Low	3	
Invertebrates	1.9-7.5	3.6	Low	3	
Fish eggs	11.6-24.8	18.1	Moderate	4	
Bird eggs	2.8-15	5.3	Low	3	
			Total	**15**	**Moderate**

- Component scores: 5=high to 1=no identifiable hazard.
- Se concentrations in fish eggs are estimated as:
  $[Se]_{fish\ eggs} = [Se]_{fish\ whole\text{-}body} \times 3.3$
- Final hazard score is the sum of the component scores: 16-25=high, 12-15=moderate, 9-11=low, 6-8=minimal, and ≤ 5=no hazard (Lemly AD, 1997, *Environ Manag* 21:343-358; Lemly AD, 2002, *Ecotox & Environ Safety* 52:123-127)

CONCLUSIONS

- The final Se hazard scores suggest low to moderate Se hazards to birds and fish in the Pariette Wetlands
- The Se hazard to fish and birds occupying Pariette Wetlands has decreased since the late 1980s.

This research was sponsored by a grant from the Utah Division of Water Quality