FACT SHEET

Recommended Guidelines for a Water Quality Standard for Selenium in Great Salt Lake

The State of Utah formed a Science Panel in 2004 to study selenium (Se) in the open waters of Great Salt Lake (GSL). This fact sheet presents the Science Panel's recommended guidelines for a water quality standard for Se. A Steering Committee, comprised of various GSL stakeholders, will review the Science Panel's recommendations and define a site-specific, numeric water quality standard for Se that prevents impairment of the beneficial uses of the open waters of GSL.

Science Panel's Recommended Guidelines

It is the opinion of the Science Panel that a Se water quality standard that prevents impairment for aquatic wildlife of GSL lies within the following ranges:

- 3.6 to 5.7 mg Se/kg (mg/kg = parts per million) for bird diet items
- 6.4 to 16 mg Se/kg for bird eggs

The recommended guidelines are subject to the following qualifications and precautions:

- There is uncertainty in the guidelines, as reflected by the range of Se concentrations
- The guidelines would be applied by back-calculating from tissue concentrations to estimate a corresponding water concentration
- The Panel recognizes the need for conservatism in application of the guideline that will be recommended

What is the basis for this recommendation?

- **Why do the guidelines focus on birds?** Birds are likely the most sensitive to Se:
  - » The water quality standard will be developed to protect birds that feed primarily on open waters of GSL
  - » Exposure of birds to Se is mainly through their diet
- **How does Se affect birds?** The best-documented, most sensitive, and most readily monitored effect of Se on birds is reproductive success:
  - » Other endpoints such as body condition for migratory birds or adult mortality are important, but related Se concentrations are undetermined at this time
  - » Reproductive success is considered more sensitive than those other endpoints
- **How is the effect of Se on reproductive success studied?** Se concentration in eggs can be directly related to expected reproductive success (i.e., egg hatchability) through the use of field- or laboratory-derived relationships:
  - » Success is measured by egg hatchability (i.e., the number of eggs incubated full term that hatch vs. those that don't hatch)
  - » Field studies require extensive monitoring, eggs are sacrificed when sampled, and sampling of eggs is possible only during the nesting season (about a 2-month period)
  - » Laboratory studies describe the relationship between Se concentration in bird diet, eggs, and reproductive success
- **If collecting eggs is difficult, is there another way to link Se to reproductive success?** Field-collected food items can be used to represent the bird diet to estimate Se concentration in eggs and predict reproductive success:
  - » Samples of food items can be obtained throughout the year (though spring nesting season is most important)
  - » It is easier to obtain routine samples of food items than to sample eggs
- **What is the basis for linking Se in eggs and diet to reproductive success?** Laboratory studies provide the best available data for relating Se levels in bird diets or eggs to effects on reproductive success:
  - » Panel reviewed the literature for best data describing Se effects on egg hatchability
  - » Data set identified is from six laboratory studies of mallards fed a selenomethionine-augmented diet relating Se concentration in diet and eggs to egg hatchability
  - » Panel agreed to use values from Ohlendorf (2003)[1] to establish the range
- **Why use data for mallards, which do not nest on open waters of GSL?** Mallards as a species are more sensitive to Se than other species that commonly nest at GSL:
  - » Field studies show that birds that typically use saline, or salt water, non-marine habitats (e.g., avocets and snowy plover) seem to be less sensitive than closely related species typical of freshwater habitats (e.g., stilts and killdeer)[2]

» Mallards are a freshwater species; thus, using mallard data **builds conservatism**, or a safety factor, into any water quality standard

» The best available data set for Se effects on egg hatchability are for mallards

- **How do we link bird diet and egg concentrations to the water?** Research for the GSL Se Program included development of a model that characterizes the transfer of Se from water to the birds' diet and then to the birds' eggs:

  » Allows the development of a water concentration from specific diet and egg Se concentrations (by back-calculation)

How does the range of diet and egg selenium concentrations represent levels of protection?

The Science Panel has determined that selenium-related impairment for the open waters of GSL should be defined by hatching success of birds commonly nesting on the lake. Toxicological studies have shown that a 10% reduction (called an "EC_{10}") in egg hatchability of mallards occurs when the diet contains selenium concentrations between 3.6 and 5.7 mg/kg and selenium concentrations in eggs are between 6.4 and 16 mg/kg. This range of selenium concentrations in the diet and eggs and associated reductions in egg hatchability are shown in the table below. The statistical analysis indicates the greatest probability that a 10% hatchability reduction is associated with a 4.9 mg/kg diet and 12 mg/kg in the egg. There is only a very small chance that the low or high values in the ranges provided are the true concentration where a 10% effect occurs.

Diet Selenium (mg /kg)	Reduction in Hatchability	Egg Selenium (mg/kg)	Reduction in Hatchability
3.6	3%	6.4	2%
4.9	10%	12	10%
5.7	18%	16	21%

The Steering Committee will recommend to the Utah Water Quality Board the level of hatchability reduction that should be allowed before impairment is declared. The standard will be directly linked to that reduction.

What does the ECx mean?

- ECx is the effect concentration (in the diet or egg) at which X% of the eggs that are incubated to full term do not hatch because of Se exposure (i.e., 100 - X% of the eggs hatch successfully despite Se exposure of the hen)
- Each range of values (diet or egg) is determined from a toxicity (or exposure effects) curve established in the laboratory[1]
- The curve helps define the effect, in this case a certain percentage (X%) of eggs not hatching, for a given Se concentration
- When birds are exposed to the ECx in the diet, or concentrations reach the ECx in the eggs, up to an additional X% hatching failure may occur (there are other causes that also naturally contribute to hatching failure)
- The population significance of this failure depends on other losses (e.g., predation, flooding of nests, etc.)

What does the ECx NOT mean?

- It does NOT mean that X% of the overall bird population using GSL will die
- The ECx being used considers hatching success and does not apply to other endpoints, such as effects on the adult population:

  » Hatching success is a more sensitive endpoint than adult survival

What will the Science Panel provide to the Steering Committee?

- Recommended guidelines that relate tissue and water concentrations to a level of protection (ECx)
- Technical documentation of studies used to develop a model that relates Se in water to bird diet and then to bird eggs
- A palette of values relating tissue Se concentrations to water Se concentrations
- Recommendations for the water quality standard from each Science Panel member

References

1. Ohlendorf, H.M. 2003. Ecotoxicology of Selenium. Pages 465-500 in D.J. Hoffman et al., eds. *Handbook of Ecotoxicology*, Second Edition, Lewis Publishers, Boca Raton, FL.

2. U.S. Department of the Interior (USDI). 1998. *Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment*. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, Bureau of Indian Affairs, National Irrigation Water Quality Program Information Report 3.

For More Information, Contact:

William O. Moellmer, Ph.D.
Utah Department of Environmental Quality
Division of Water Quality
801-538-6329

JMS WB032008006SLC