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DIVISION OF
WATER QUALITY

August 17, 2008

Mr. Walt Baker, Director
Utah Division of Water Quality
Salt Lake City, UT

Dear Mr. Baker;

I would like to comment on the proposed water quality standard for selenium in Gilbert Bay of the Great Salt Lake. As you know, I have been involved in collecting some of the data on selenium in the water and in the brine fly community on the lake bottom, as well as studies on mercury and nutrient contamination in the lake.

1. **The Great Salt Lake Ecosystem is highly polluted and some components are impaired.** Mercury concentrations in the lake are the highest reported in the country and three species of birds are on a consumption advisory for this contaminant. Eutrophication is Farmington Bay is the worst of any water body in Utah and the bay has mercury and other heavy metal contamination much in excess of those in Gilbert Bay. We have not been good stewards of this ecosystem, but recent efforts such as the endeavor to establish a selenium standard for the lake are evidence that we are now recognizing the value of the lake.

2. **The existing data suggest that selenium concentrations in Gilbert Bay are already potentially high enough to cause deleterious effects on birds (Figure 1), and thus the standard adopted should be set very cautiously.**

   a. Recently published data by Vest et al. (2008) showed that selenium concentrations in livers of goldeneye ducks increased steadily during their residence while feeding on brine flies (ca. 70% of prey, J. Vest, personal communication). When they arrive at the lake in October or November the ducks have concentrations near 2 μg Se/g, but by March and April 19% of the birds sampled had concentrations <u>greater than 10 μg/g.</u> Eared grebes may behave similarly: In September they had mean liver concentrations of 9-10 ug Se/g and this had increased to 22 μg Se/g in November for individuals collected at Stansbury Island (Conover 2007, Appendix 1).

   b. Health-related problems have been shown to occur in mallard ducks at concentration greater than 5 μg/g (Hoffman 2002) or 10 μg/g (Heinz 1996). Fairbrother et al. (1994) found that American avocets had hatching malformations, decreased size at hatch and possible impaired immune function at concentrations of 4.8 μg Se/g in the Tulare Basin of California.

   c. <u>If</u> goldeneye or grebes behave physiologically like mallards then we already have nearly an effective concentration that could harm approximately 20% of the goldeneye (EC_{20}) utilizing

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Gilbert Bay. Unfortunately, we do not have physiological data for goldeneye or grebes, nor for that matter, for most of the birds that utilize the lake.

d. Many members of the Water Quality Steering Committee recommended that the numeric standard for selenium in bird eggs should be 12.5 mg/kg. This represents approximately a 4.5-fold increase in the concentrations that would be allowed.

   (1) - If concentrations increased equally in the food web leading to goldeneyes, Vest et al's (2008) data indicate that 86% of these birds would reach tissue concentrations exceeding 10 μg/g, and 50% would exceed 24 μg Se/g, a concentration that has been shown to cause a variety of problems in birds (Figure 1). Mean November concentrations in grebes could reach 100 μg Se/g, (assuming linearity in the relationships).

3. **The lack of physiological and ecological data on the organisms in Gilbert Bay argues for a cautious approach in setting standards.**

   a. We do not know the physiological response of most of the birds that utilize the lake. Mallard ducks may be a reasonably sensitive species, but we do not know if they are more sensitive than all the birds that utilize the lake. What are the sensitivities of snowy plovers or Wilson's phalaropes–we don't know.

   b. The food web in the lake, and particularly that of the birds is poorly known, so modeling efforts to predict concentrations in the birds are tenuous.

      i. In the recent study of selenium concentrations sample sizes of birds for diet analyzes were extremely small:

         (1) American avocets, N = 15
         (2) Black-necked stilts, N = 5
         (3) California gulls, N = 24
         (4) Eared grebes, N = 60

   Sample sizes of several hundreds of birds spaced through time and around the lake will be necessary to understand their diets.

      ii. Diets of other birds are not known or very poorly described. For example, the diet of eared grebes that extensively utilize the lake have not been systematically studied, despite frequent statements that brine shrimp are their sole food source at the lake. In contrast to that assumption, grebes collected at the lake for a physiological study were found to eat primarily water boatmen (Jennifer Gafney, MS thesis, San Diego State Univ.), while those collected by Conover (2008) ate primarily brine shrimp but also some brine flies.

      iii. These comments are not meant as criticisms–it is difficult to collect ecological data, budgets and time are limited, and funded studies on pollution in the lake have only recently been initiated. Data from my own study of brine flies was similarly limited by small sample sizes. My point is that we need to know a lot more about the lake before we can make accurate predictions of how increasing concentrations of any toxicant will influence birds, brine shrimp or other species.

4. **A standard that allows a large increase in selenium (e.g. the proposed 12.5 μg/g, or 4.5-fold increase) is not necessary for economic reasons, and given our uncertain understanding of toxicological responses in the lake, unwise.** A two-fold increase in concentrations would allow for

substantial increases in point and non-point discharges and still provide far more protection for organisms than the proposed 4.5-fold increase.

5. **The proposed egg tissue concentration of 12.5 μg/g thought to provide an EC_{10} is based on an inappropriate control, and would cause higher mortalities than indicated.**

   a. With selenium and some other constituents that are necessary for birds in low concentrations, using a control group fed diets with no selenium would have caused mortalities. The work of Beckon et al. (2004) explicitly dealt with this behavior with regards to selenium toxicity to mallards. In the data set they used, the highest proportion of eggs that hatched occurred at about 3 ug Se/g, and hence it would be appropriate to use that value as the "control" with which to compare toxic effects of higher concentrations. An analysis of their data yields an EC_{10} egg concentration of 8 μg Se/g. This "hormetic effect" was not incorporated into the majority recommendation, but it should have been.

6. **The numeric standard that is adopted should be an integer value.**

   a. Values used in some of the recommendations are unrealistically precise (e.g. 12.5, 5.15 μg/g). None of the studies at the Great Salt Lake nor physiological studies that have been utilized were sufficiently precise to justify reporting such precision. For example, in the mallard analysis by Ohlendorf (2003) he was 95% confident that the effective concentration (EC_{10}) was between 6.4 and 16.5 μg/g. Given that high degree of uncertainty, there is no justification to adopt a standard with concentrations given in tenths or hundredths.

   b. *More importantly, reporting these unjustified levels of precision may mislead the public (and perhaps ourselves) into thinking that we have an excellent idea of the toxicology of the organisms in the lake–we do not!* There are protocols for reporting significant digits (http://en.wikipedia.org/ wiki/Significant_figures) and they should be followed in the adoption of a standard.

7. **The studies to date have focused entirely on Gilbert Bay and consequently the resulting standard adopted should only be applicable to that portion of the lake.**

   a. This limitation was explicit in early meetings of the working group when it was decided to focus research efforts on this limited portion of the lake. Because salinities vary from <1 to nearly 30% in the other bays, we cannot extrapolate models such as those constructed by Theresa Presser for Gilbert Bay to the remainder of the lake.

   b. Among other factors that could confound these models is that the bioaccumulation rate of selenium may well be different at different salinities (Brix et al. 2004). In Bear River Bay and the southern portion of Farmington Bay fish can be abundant at low salinities and they are fed upon by pelicans and terns. These parts of the food web have not been studied so we should not adopt a standard developed for Gilbert Bay and apply it to the entire lake. The playas around Gunnison Bay are another example of a completely unstudied system with respect to selenium, and the very high salinities in that zone may appreciably modify how selenium behaves in the ecosystem.

   c. An explicit example of the spatial variability in the lake comes from within Gilbert Bay itself. Conover (2008) found selenium levels in grebe livers of 7.3 ± 0.6 μg/g at Antelope Island, but a very high level of 21.7 ± 4.0 μg/g two weeks latter at Stansbury Island.

8. **The data argue that an egg selenium concentration of 6-8 µg/g would protect most of the birds utilizing Gilbert Bay and still allow for considerable discharges into the lake.**

   a. The re-analysis of mallard hatching success by Beckon et al. (2008) for mallards suggest an EC_{10} of 8 µg/g.

   b. The lower 95% confidence interval of the original egg mortality analysis by Ohlendorf (2002) was 6 µg/g.

Thank you for considering these comments.

Sincerely,

Wayne Wurtsbaugh
Professor

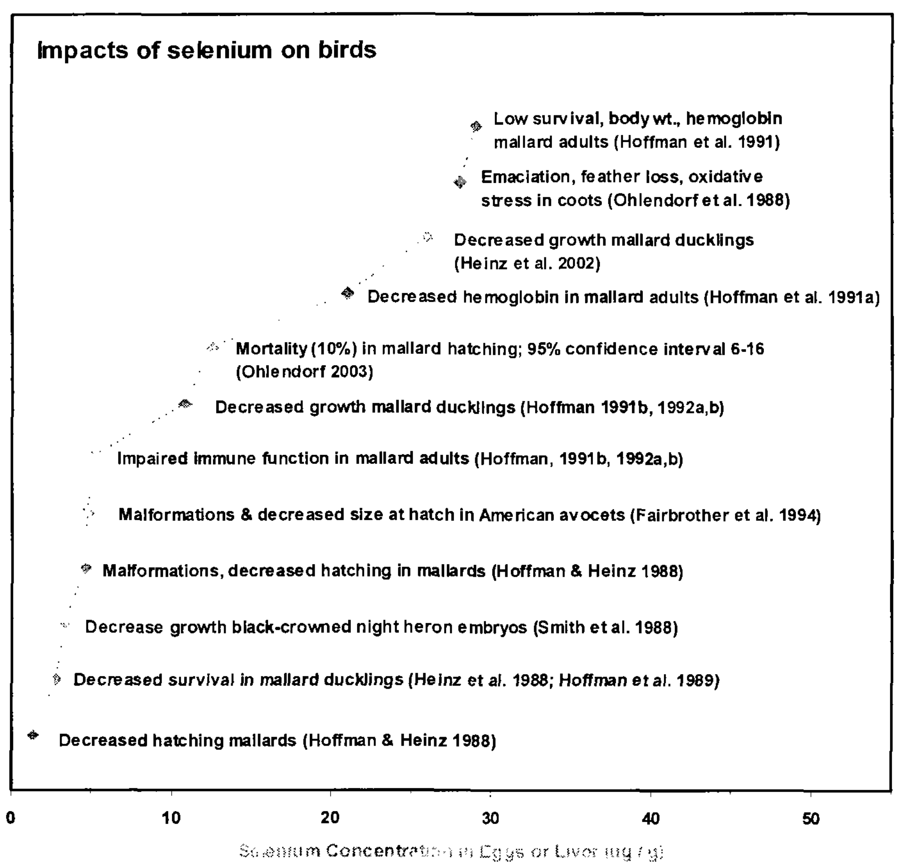

Figure 2. Physiological and lethal impacts of selenium on birds. Derived primarily from the review of Hoffman (2002).

References

Beckon, W.N., C. Parkins, A. Maximovich, and A.V. Beckon. 2008. A general approach to modeling biphasic relationships. Environmental Science and Technology 42:1308-1314.

Brix, K. V., D. K. DeForest, et al. (2004). Derivation of a chronic site-specific water quality standard for selenium in the Great Salt Lake, Utah, USA. Environmental Toxicology and Chemistry 23: 606-612.

Conover, M., J. Luft and C. Perschon. 2008. Concentrations of Selenium in Eared Grebes from the Great Salt Lake, Utah. Final Report. In CH2MHill (ed.) Final Report: Development of a selenium standard for the open waters of the Great Salt Lake. Prepared for the Utah Department of Environmental Quality, Division of Water Quality. <http://www.deq.utah.gov/Issues/GSL_WQSC/docs/GLS_Selenium_Standards/index.htm>. Accessed 2008, 30 July.

Fairbrother, A., M. Fix, T. O'Hara and C.A. Ribic. 1994. Impairment of growth and immune function of avocet chicks from sites with elevated selenium, arsenic, and boron. J. Wildlife Diseases 30:222-233.

Heinz, G.H. 1996. Selenium in birds. In Beyer, W.N., G.H. Heinz & A.W. Redmon-Norwood (eds.) Environmental contaminants in wildlife: Interpreting tissue concentrations. CRC Press, Boca Raton, FL, pp 447–458.

Hoffman DJ (2002) Role of selenium toxicity and oxidative stress in aquatic birds. Aquat Toxicol 57:11–26

Ohlendorf, H.M., 2003. Ecotoxicology of selenium. In: Hoffman, D.J., Rattner, B.A., Burton, G.A. and Cairns, J., Editors, 2003. Handbook of Ecotoxicology, Lewis Publishers, Boca Raton, FL, pp. 465–500.

Ohlendorf, H. 2007. Final technical memorandum. Threshold Values for Selenium in Great Salt Lake. Presented to Utah Division of Water Quality, Salt Lake City, Utah.

Vest, J.L., M.R. Conover. C. Perschon, J. Luft & J.O. Hall. 2008. Trace element concentrations in wintering waterfowl from the Great Salt Lake, Utah. Achieves Environmental Contamination and Toxicology. DOI 10.1007/s00244-008-9184-8