Message

From: Pierce, Maggie [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=65DA64C7613743968F3703922AE72743-PIERCE, MAGGIE]
Sent: 11/4/2020 9:52:55 PM
To: Wirick, Holiday [wirick.holiday@epa.gov]
Subject: RE: Conclusions from NDDEQ's selenium investigations

Thanks for both of these! I'll check them out.

From: Wirick, Holiday <wirick.holiday@epa.gov>
Sent: Wednesday, November 4, 2020 2:51 PM
To: Pierce, Maggie <Pierce.Maggie@epa.gov>
Subject: Conclusions from NDDEQ's selenium investigations

Hi Maggie, per my message, here are North Dakota's selenium investigation conclusions.

From: Wax, Peter N. <pwax@nd.gov>
Sent: Tuesday, October 20, 2020 11:12 AM
To: Wirick, Holiday <wirick.holiday@epa.gov>
Subject: selenium

Here you go.

Conclusions of Selenium Investigations
1) North Dakota Aquatic Life is fully supporting based on selenium concentrations in flesh. a. The highest concentration reported was less than half (4.53 mg/kg/dw) the recommended criteria for fish muscle (11.3 mg/kg/dw). The state recognizes that skin on fillets is not the same as muscle, however, the department determined that double the concentration is a significant safety factor which is protective of our fish populations.

2) Bioaccumulation was not identified.
3) Correlations between water and fish flesh concentrations of selenium are poorly correlated and statistically insignificant.
4) North Dakota study design is deficient: a. Lower detection for selenium concentrations in water not sensitive enough.
b. Muscle sample had skin attached.
c. No stream fish flesh data.
d. Fish species are a minor representation of total taxa.
e. No whole fish data included.
f. No ovary or egg data included.

5) Current data is needed.
6) It is prudent to adopt egg/ovary, whole body, and as a measure of safety muscle selenium criteria for the protection of aquatic life.
7) It is prudent to restart selenium fish flesh investigations.

Selenium: Adding selenium fish flesh to Table 1. Criteria is applied in a hierarchy process beginning with Egg-Ovary of 15.1 mg/kg, Whole Body of 8.5 mg/kg and Muscle of 11.1 mg/kg as dry weight to reflect the CWA Section 304(a) Recommended criteria for the Protection of Aquatic Life.

The EPA recommendations translates the fish flesh data into water concentrations criteria for lentic (lakes) and lotic (streams). The department has determined the translation from flesh concentrations of selenium to water is not appropriate for the state and does not propose changing the water concentration criteria for lakes and streams.

Not implementing a change in the water concentration criteria for selenium took into account the following rationale: (1) Aquatic life is protected using Egg-Ovary, Whole Body and Muscle criteria, (2) North Dakota selenium concentrations in fish flesh are less than half the proposed criteria, (3) biological accumulation of selenium in flesh is not occurring, and (4) comparisons of water column to fish flesh selenium concentrations show no statistically significant relationship.

Selenium concentrations in 529 fish tissue samples collected from North Dakota lakes were less than half the Clean Water Act, section 403(a) recommended criteria for fish muscle in lentic systems of 11.3 mg/kg/dw. Selenium concentrations in 529 fish fillet samples ranged from 0.056 mg/kg/dw to 4.53 mg/kg/dw. The results provide reasonable confidence that continuation of research into an appropriate state specific concentration for water (Lentic and Lotic) will not place the beneficial use Aquatic Life as risk.

Ancillary decision-making processes includes: (1) Maintaining credibility with the citizens of North Dakota and the regulated community, (2) historical difficulties in amending criteria once it has been adopted, and (3) a lack of known dischargers/generators of selenium in the state.

In short, the reasoning for adopting the EPA recommended fish flesh criteria for selenium: Based on the departments review, the Egg-Ovary accurately identifies impairment to aquatic life (fish) and that there is a clear linkage to Whole Body and Muscle.

In short, the Reasoning for not adopting of the EPA lentic and lotic water concentration selenium criterion: (1) North Dakota lake and fish flesh (skin on fillet) data does not support a linkage between water column selenium concentrations or accumulation of selenium in fish flesh, (2) the linkage between water quality concentrations, ingestion, and biological accumulations and expression is complex and not explained by greater concentrations in the water, and (3) fish in North Dakota are not in jeopardy from high selenium concentrations in muscle.

Continuation of selenium criteria evaluation for adoption or development of state specific water quality criteria with include restarting the state's fish flesh monitoring program. The restart will include a study design that will identify the relationship between water column concentration of selenium and fish flesh in North Dakota lakes and streams.

Selenium Detail: EPA finalized and published updated criterion for selenium per the CWA section 304(a) in 2016. The 2016 version reflects the latest scientific knowledge, which indicates that selenium toxicity to aquatic life is primarily based on organisms consuming selenium contaminated food rather than exposer to selenium in water (EPA 822-R-16-006, June 2018). The final criterion is expressed both in terms of fish tissue concentration (egg/ovary, whole body, muscle) and water concentration (lentic, lotic). North Dakota agrees with EPA's finding on fish tissue and proposes to amend the state's Standards of Quality for Waters of the State for fish flesh. North Dakota has determined there is enough contradictory results in the state specific data to question the recommended water concentration (lentic and lotic) and proposes to continue with development of state specific criterion and not risk writing an inappropriate standard for North Dakota.

The decision to not adopt the recommended water lentic and lotic water concentration is data driven. The decision involves researching current concentration in fish flesh, bioaccumulation and the relationship between selenium concentrations in 529 fish tissue samples to average lake water concentrations of selenium. The fish flesh samples come from 31 discrete lakes. The majority come from Lake Darling, Lake Tewaukon, Lake Ilo, Lake Oahe, Lake Sakakawea, and Devils Lake with 132, 81, 59, 59, 45 and 24 fish samples, respectively. There were 15 species of fish sampled. Species most commonly represented in the data are northern pike, walleye, yellow perch, and channel catfish dominating the date at 186, 183, 44, and 26, respectively. The department looked at the levels of selenium in fish flesh, the bioaccumulation by species in lakes and the relationship between the concentration of selenium in fish tissue flesh and selenium concentrations in the water.

Fish Flesh Concentrations: Selenium concentrations in 529 fish fillet (skin on) samples ranged from 0.056 to 4.53 mg/kg/dw. The median concentration is 1.36 mg/kg/dw, the average is 1.408 mg/kg/dw and the standard deviation was 0.847. No fish were above the 304(a) recommended concentration for muscle of 11.3 mg/kg/dw.

Biological Accumulation: Bioaccumulation of selenium was not found. Length of fish was used as an age indictor in individual waters for the bioaccumulation investigations (Table 1). Biological accumulation was assumed if selenium concentrations increased with length.

Thirteen comparisons of selenium flesh concentration and length were completed. The relationship between species length and flesh concentration were weakly correlated, randomly distributed and as or more likely to produce a downward trend in selenium concentrations as the species of fish grew as an increase (Figures 1 & 2) (Table 1).

Table 1. Results of selenium bioaccumulation investigation.

Lake	Species	N	R^2	P-Value	Trend
Lake Darling	Walleye	67	0.089	0.014	Increasing
Lake Darling	Northern Pike	37	0.030	0.304	Decreasing
Lake Darling	Yellow Perch	25	0.003	0.782	Decreasing
Devils Lake	Walleye	12	0.245	0.102	Decreasing
Lake Oahe	Channel Catfish	14	0.000	0.977	Increasing
Lake Sakakawea	Walleye	17	0.398	0.007	Decreasing
Lake Sakakawea	Northern Pike	6	0.199	0.503	Decreasing
Lake Sakakawea	Channel Catfish	12	0.018	0.679	Increasing
Lake Tewaukon	Walleye	36	0.027	0.335	Decreasing
Lake Tewaukon	Northern Pike	33	0.124	0.044	Decreasing
Lake Ilo	Northern Pike	51	0.003	0.711	Decreasing
Sprague Lake	Walleye	29	0.039	0.304	Increasing
Sprague Lake	Northern Pike	42	0.014	0.463	Decreasing

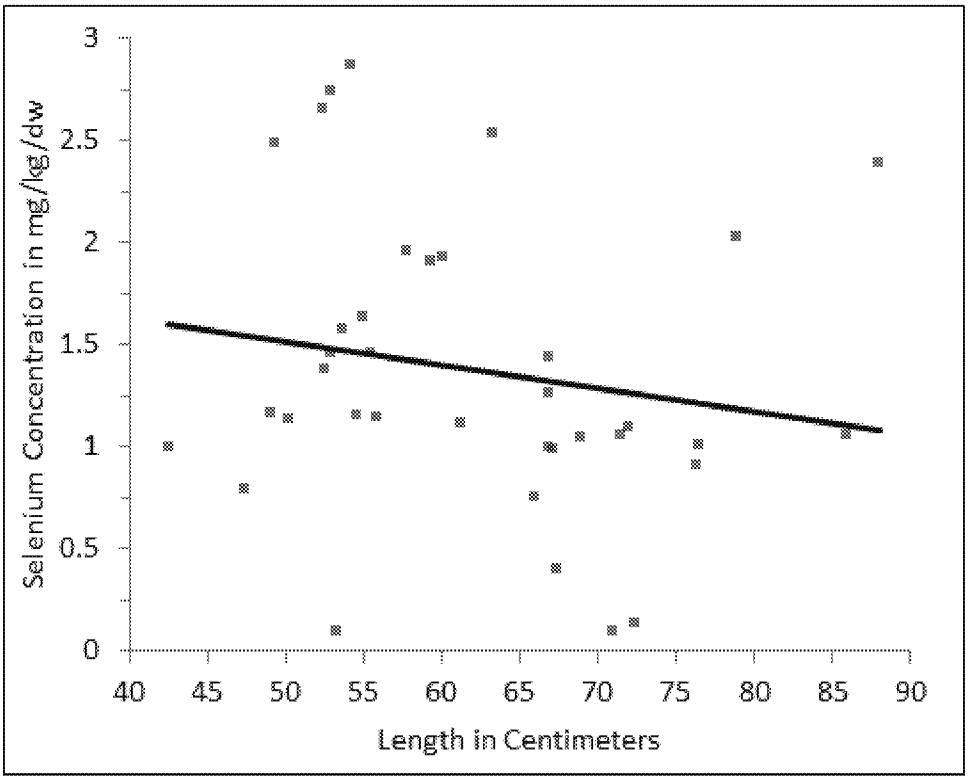


Figure 1. Lake Darling Se in Northern Pike/Length. R-Square of 0.030.

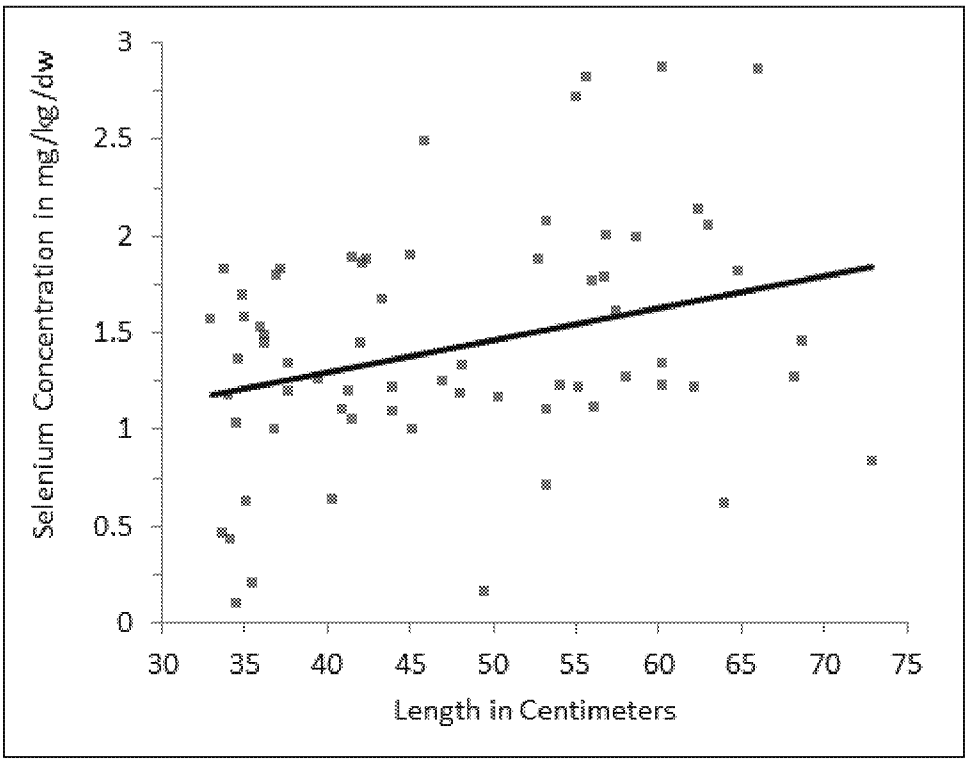
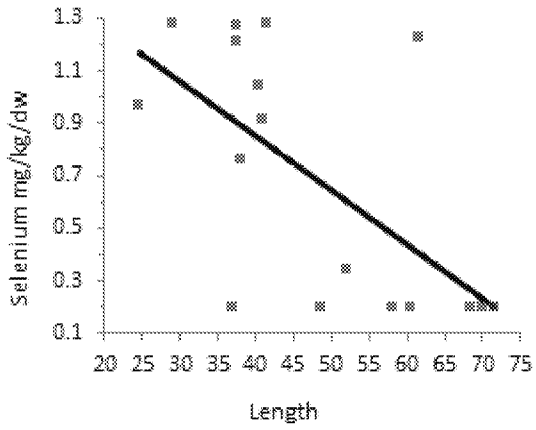


Figure 2. Lake Darling Se in Walleye/Length. R-Square of 0.089.

The investigation of bioaccumulation of selenium is inconclusive, but suggestive that selenium in flesh reduces as fish become larger. Of the 22 bioaccumulation investigations, 9 or 69% declined as fish became larger.

Only two of the relationships are significant. The two significant relationships (p=0.0066) and (p=0.044) are walleye in Lake Sakakawea and northern pike Lake Tewaukon, respectively. Both species experience steep declines in selenium concentrations as the fish become larger, which is the opposite of what would be expected if fish were accumulating selenium from the water column (Table 1) (Figures 3 & 4).



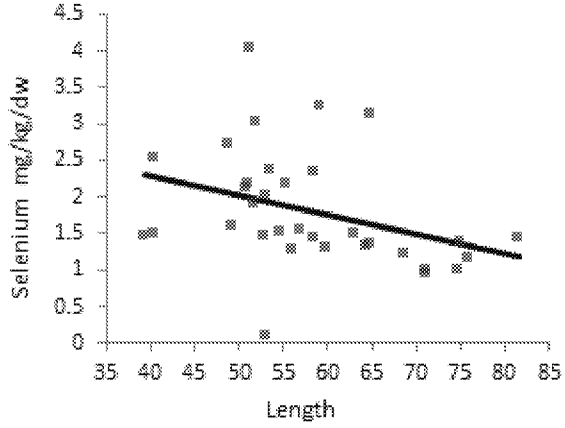


Figure 3. Walleye from Lake Sakakawea Selenium/Length.

Figure 4: Northern Pike from Lake Tewaukon Selenium/Length.

The analysis provides confidence that the fish of North Dakota do not have an abundance of selenium in their flesh and are not accumulating selenium. In retrospect, the results are not surprising as ingestion, not adsorption, is the mode of selenium accumulation (EPA 822-R-16-006, June 2018).

Selenium Fish Flesh and Water Concentration: Comparing the concentration of selenium in fish flesh to lake water concentrations is complicated. Of the 6,613 selenium lake samples 4,314 (65%) are less then detection and the lower detection limit was a moving target ranging from 1.0 to 10 µg/l. All fish flesh samples had reportable concentrations of selenium. To overcome the water quality challenges, multiple comparisons were run looking for significant results.

The preliminary investigations compared the average and maximum water selenium concentrations to fish flesh samples collected from matching water bodies. Result of the preliminary comparison using the average water concentrations are conflicting but significant (Table 2). Comparing the average selenium concentration in lake water to all fish samples shows an increasing trend while comparing the maximum water concentration to fish flesh had a decreasing trend (Figures 3 & 4), (Table 2).

These initial results are heavily influenced by just a few water bodies. To reduce the influence of select water bodies, selenium fish flesh concentrations are averaged by species and compared. The result from this analysis yielded weak relationships (R^2 of 0.006 and 0.001) with insignificant trend (p-values of 0.228 and 0.841). These results are heavily influenced by the large number of non-detections in water that were assigned a 1.0 µg/l.

Attempt to address the large number of non-detections, all non-detections were removed from the data set and the analysis rerun. This investigation yielded no substantial change from the results (Table 2).

Table 2. Results of selenium in water to selenium in flesh investigation

Water Quality	Fish Type	N	R^2	P-Value	Trend
Average	All	529	0.011	0.018	Increasing
Maximum	All	529	0.007	0.053	Decreasing
Average	Average by Species	76	0.006	0.228	Increasing
Maximum	Average by Species	76	0.001	0.841	Increasing
Average	Average by species[1]	45	0.010	0.509	Increasing
Maximum	Average by species[1]	45	0.001	0.872	Decreasing
Average	Bottom Feeder	19	0.001	0.936	Decreasing
Maximum	Bottom Feeder	19	0.001	0.917	Increasing
Average	Insectivore	27	0.074	0.169	Increasing
Maximum	Insectivore	27	0.001	0.906	Increasing
Average	Predator	30	0.004	0.745	Increasing
Maximum	Predator	30	0.019	0.466	Increasing

Less than the detection limit water quality results removed

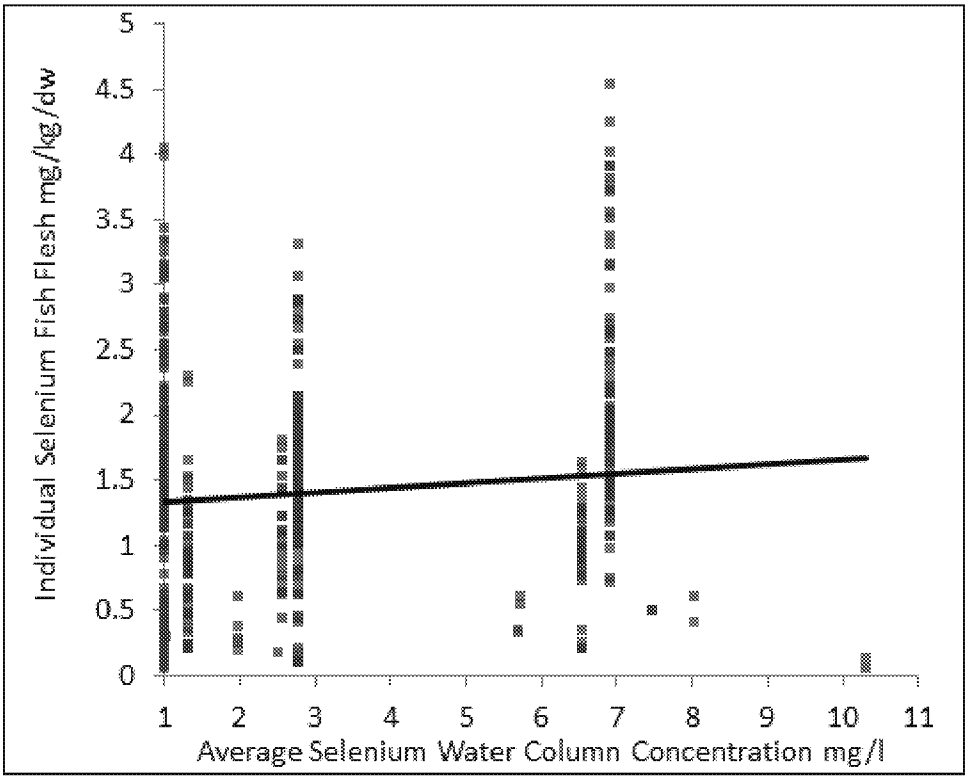


Figure 3. All 529 fish flesh samples compared to average water quality from lake of origin.

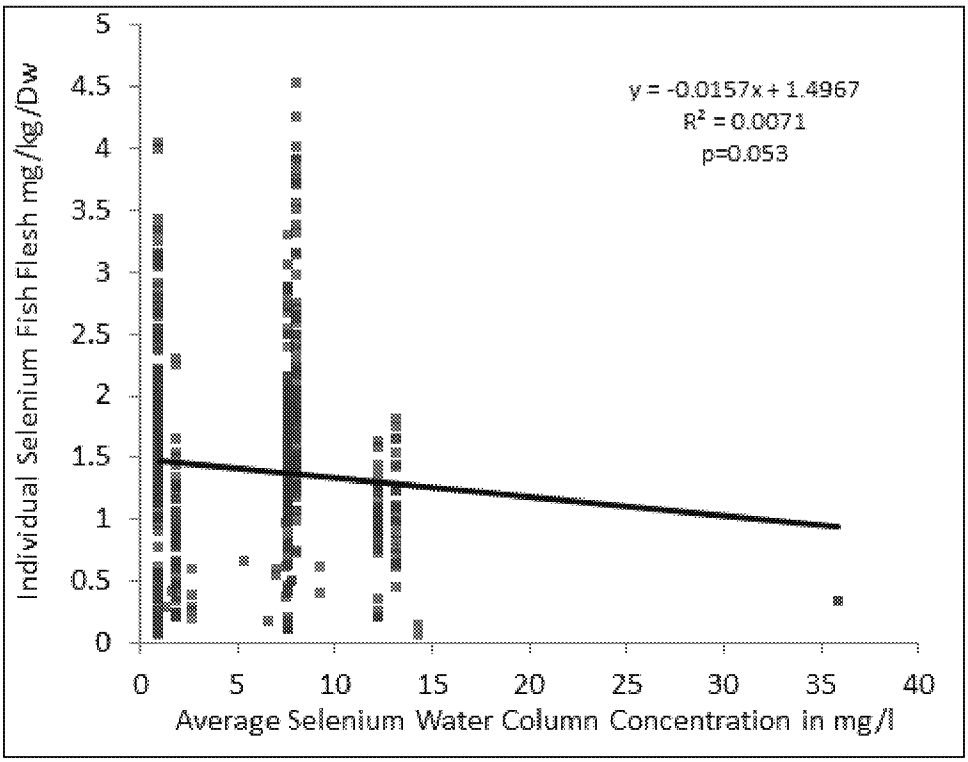


Figure 4. All 529 fish flesh samples compared to maximum water quality from lake of origin.

Comparing the average selenium concentration by species to the average and maximum water concentrations provided insignificant (p-value range of 0.228 – 0.906) and weakly correlated (R^2 values of 0.001 – 0.010) the comparisons which resulted in both increasing and decreasing trends in concentrations of flesh with increasing concentrations in the water body (Table 2).

Since selenium is accumulated through ingestion (EPA 822-R-16-006, June 2018) there might be a difference in uptake and accumulation of based on feeding type. To investigate that, the fish flesh data was subdivided into three groups based on feeding habits. The three feeding groups represented are: Bottom feeders, Insectivores, and Predators. Correlation analysis was run on all three groups using the average selenium concentrations of each fish species compared to the average and maximum water concentrations from the lake of origin. All results follow a similar path of being insignificant (p-value range of 0.169 – 0.936) and weakly correlated (R^2 values of 0.001 – 0.074) with 5 of the 6 comparisons trending towards an increase in flesh concentration with an increase in water concentrations (Table 2).

<u>Conclusions of Selenium Investigations</u>

1. North Dakota Aquatic Life is fully supporting based on selenium concentrations in flesh.

   a. The highest concentration reported was less than half (4.53 mg/kg/dw) the recommended criteria for fish muscle (11.3 mg/kg/dw). The state recognizes that skin on fillets is not the same as muscle, however, the department determined that double the concentration is a significant safety factor which is protective of our fish populations.
2. Bioaccumulation was not identified.
3. Correlations between water and fish flesh concentrations of selenium are poorly correlated and statistically insignificant.
4. North Dakota study design is deficient:

   a. Lower detection for selenium concentrations in water not sensitive enough.
   b. Muscle sample had skin attached.
   c. No stream fish flesh data.
   d. Fish species are a minor representation of total taxa.
   e. No whole fish data included.
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5. Current data is needed.
6. It is prudent to adopt egg/ovary, whole body, and as a measure of safety muscle selenium criteria for the protection of aquatic life.
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