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April 10, 2020

Sent via email to: paula.wilson@deq.idaho.gov
Docket: 58-0102-1801
Human Health Water Quality Criteria for Arsenic

Ms. Paula Wilson
Idaho Department of Environmental Quality
1410 N. Hilton, Boise, ID 83706

Dear Ms. Wilson:

The Department of Environmental Quality (Department) is conducting a negotiated rulemaking to revise the arsenic human health water quality criteria. The J.R. Simplot Company (Simplot) has participated in past meetings on this rulemaking and retained Arcadis U.S. Inc. (Arcadis) to review and analyze technical information that have been gathered during this rulemaking.

The Department has undertaken a very robust program to characterize arsenic, including inorganic arsenic concentrations, in fish tissues and surface waters. The data gathered by the Department is very important so that the arsenic human health water quality criteria for Idaho reflects Idaho's natural environment.

Arcadis has reviewed the data gathered by the Department. Their analysis of the data is provided in the attached report. As this report shows, the existing data set (which is extensive) indicates that the inorganic arsenic concentration in fish tissue is independent of the total arsenic concentration in surface water. A similar non relationship exists with the inorganic arsenic concentration in surface water. The attached report does provide some thoughts for the Department to consider in the upcoming field system.

As to how this data should be utilized in the development of a "new" human health arsenic water quality criteria, the lack of a definitive relationship suggests that the ingestion of just water (no ingestion of fish tissues) might be the best technical approach to establish a human health arsenic water quality criteria.

We appreciate the ability to provide this analysis and input to the Department. Please contact me at (208) 780-7365 or the Arcadis staff if you have any questions.

Sincerely,

Alan L. Prouty
Vice President, Environmental & Regulatory Affairs

Attachment

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A. LaBeau	IACI
B. Davenport	IMA
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TECHNICAL MEMO

To:

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Copies:

None

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From:

Paul Anderson
Emily Morrison

Date:

April 10, 2020

Arcadis Project No.:

30039729

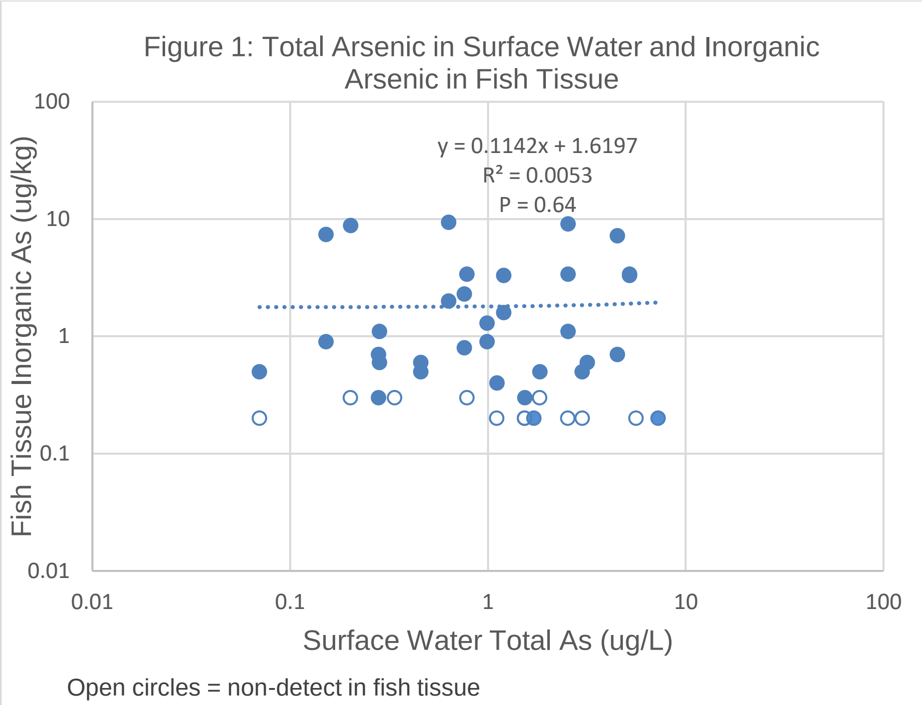
Subject:

IDEQ 2019 Preliminary Monitoring Findings

This technical memorandum provides an initial evaluation of the results of the Idaho Department of Environmental Quality (IDEQ) 2019 arsenic paired fish tissue and surface water sampling program summarized in 2019 Arsenic Accumulation in Fish Tissue Preliminary Monitoring Results dated March 2020 (IDEQ 2020) and how the results might be used to establish a bioaccumulation factor (BAF) for arsenic in Idaho surface waters.

IDEQ is to be commended for undertaking a comprehensive state-wide sampling program to better understand the relationship between concentrations of arsenic in surface water and concentrations of arsenic in fish tissue, the results of which can be used to inform development of a BAF for use in establishing water quality criteria (WQC) for arsenic in Idaho waters. The 2019 dataset is exceptionally robust and, to Arcadis' knowledge, represents a one-of-a-kind study given the large number of sampling locations and their geographic coverage. We focused our review on the interpretation of the 2019 results and not the sampling approach and methods as those were consistent with the approach and methods presented and discussed at previous rulemaking meetings.

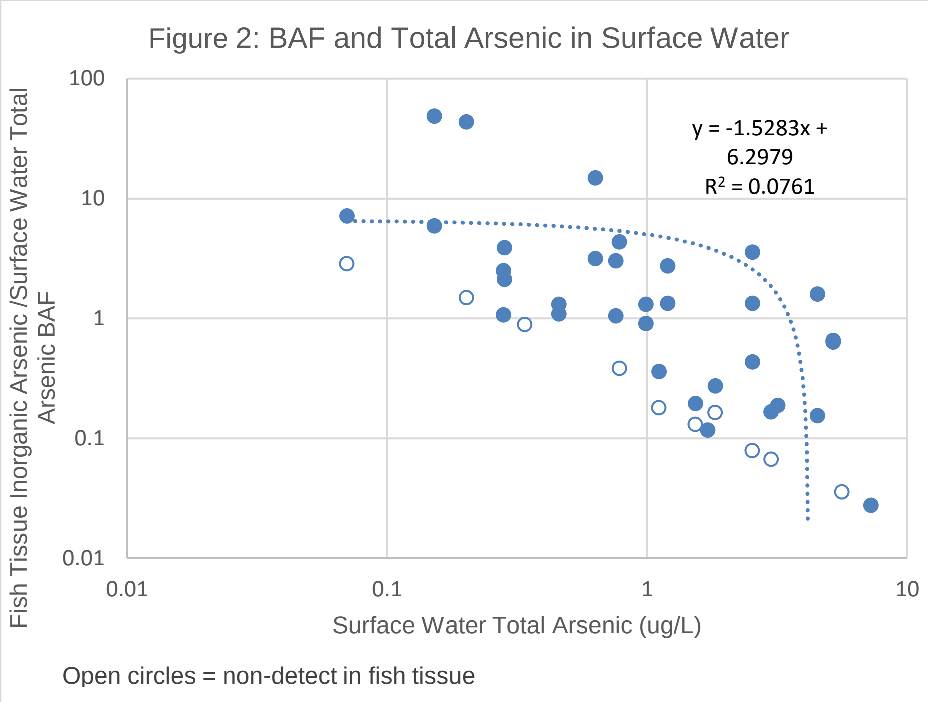
Arcadis' confirmed the key finding presented by IDEQ (2020). Namely that that the concentration of inorganic arsenic (iAs) in fish tissue is not related to the concentration of iAs in surface water. We also confirmed that a relationship does not exist between total arsenic (tAs) in fish tissue and tAs in surface water (results not shown). More importantly, because our understanding is that the state-wide arsenic WQC that IDEQ is developing will be for tAs in surface water, Arcadis evaluated the relationship between iAs in fish tissue (the form of arsenic in fish tissue that is assumed to be toxic) and tAs in surface water. A direct relationship between iAs in fish tissue and tAs in surface water was also absent (Figure 1).



The absence of a direct relationship between the concentration of arsenic in water and fish tissue is a key finding. It indicates that the concept of a single state-wide BAF is not applicable to arsenic in Idaho surface waters. While it is true that a BAF can be calculated for every paired fish tissue and surface water sample (as summarized in Table 3 of IDEQ 2020) the large range of those iAs BAFs from 0.02 to 97 L/kg (nearly 5,000-fold)[1] reinforces that a meaningful relationship between the concentration of arsenic in water and fish tissue is absent.

Additionally, BAFs (calculated as the iAs fish tissue concentration divided by the tAs surface water concentration for each individual paired sample) tend to decrease with increasing surface water concentration (Figure 2) though the relationship is not statistically significant[2]. Such a trend is expected given the lack of a relationship between fish tissue and surface water concentrations; because fish tissue concentrations are essentially identical across the entire range of surface water concentrations, dividing a constant range of tissue concentrations by an increasing surface water concentration results in lower BAFs at higher surface water concentrations. Thus, the existing data set (which is extensive) indicates that the iAs concentration in fish tissue is independent of the tAs concentration in surface water.

[1] Inorganic arsenic in fish tissue to tAs in surface water BAFs range from 0.03 to 49 L/kg, about 1,700-fold (results not shown).
[2] A similar, but not statistically significant, trend of decreasing BAF with increasing iAs concentration in surface water also observed (results not shown).



Arcadis also investigated whether a relationship exists between arsenic in fish tissue and arsenic in water for individual species (Table 1). None of the relationships were statistically significant and no consistent trends were apparent. Tissue concentrations increase with increasing concentrations for some species and decrease for other species. Notably, in trout species, the concentration of iAs in tissue tended to decrease with increasing iAs or tAs concentration in water.

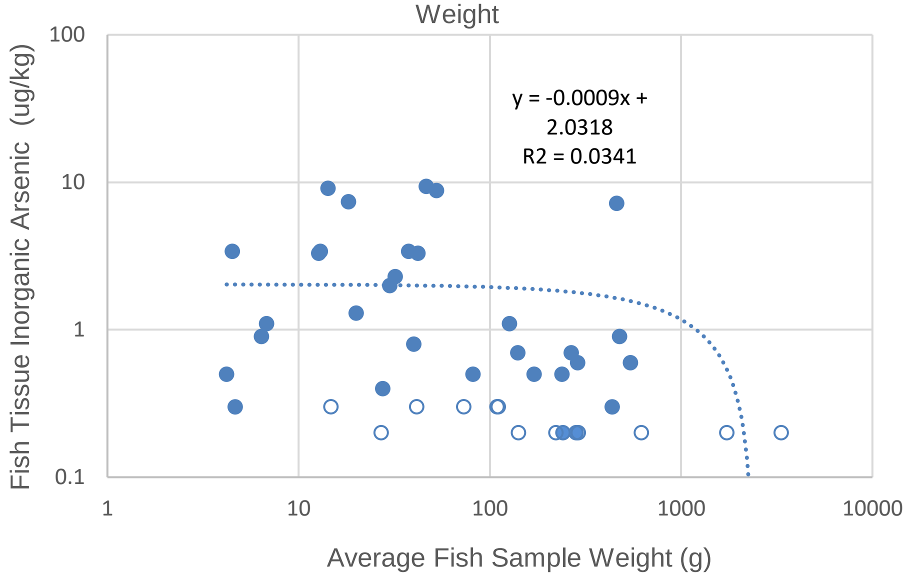
Table 1. Summary of Surface Water to Fish Tissue Regression Results of Individual Species

Species	Sample Size	Regression Equation	R^2	p
Tissue iAs to Water tAs				
Brown Trout	5	iAs(ug/kg) = -0.08(tAs(ug/L)) + 0.65	0.48	0.2
Cutthroat Trout	9	iAs(ug/kg) = -0.01(tAs(ug/L)) + 1.82	0.00	0.99
Northern Pikeminnow	5	iAs(ug/kg) = 0.02(tAs(ug/L)) + 0.39	0.01	0.88
Rainbow Trout	6	iAs(ug/kg) = -0.81(tAs(ug/L)) + 4.59	0.12	0.26
Sculpin sp.	7	iAs(ug/kg) = 0.81(tAs(ug/L)) + 1.62	0.25	0.26
Tissue tAs to Water tAs				
Brown Trout	5	tAs(ug/kg) = 4.97(tAs(ug/L)) + 42.2	0.08	0.64
Cutthroat Trout	9	tAs(ug/kg) = 66.7(tAs(ug/L)) + 47.4	0.28	0.14
Northern Pikeminnow	5	tAs(ug/kg) = 0.66(tAs(ug/L)) + 20.6	0.001	0.96
Rainbow Trout	6	tAs(ug/kg) = 21.3(tAs(ug/L)) + 79.3	0.33	0.23
Sculpin sp.	7	tAs(ug/kg) = 6.81(tAs(ug/L)) + 53.3	0.06	0.59
Tissue iAs to Water iAs				
Brown Trout	5	iAs(ug/kg) = -0.06(iAs(ug/L)) + 0.56	0.31	0.33
Cutthroat Trout	9	iAs(ug/kg) = 0.26(iAs(ug/L)) + 1.63	0.006	0.85
Northern Pikeminnow	5	iAs(ug/kg) = 0.06(iAs(ug/L)) + 0.35	0.06	0.7
Rainbow Trout	6	iAs(ug/kg) = -0.88(iAs(ug/L)) + 4.60	0.13	0.49
Sculpin sp.	7	iAs(ug/kg) = 1.18(iAs(ug/L)) + 1.26	0.36	0.15

Notes:
Non-detects were equal to the detection limit.

As part of collecting fish tissue samples, IDEQ field teams recorded the length and weight of fish comprising each tissue sample. For all species combined there was a very slight, not statistically significant, trend for iAs concentration in fish tissue to decline with increasing weight of fish comprising the sample (Figure 3). This trend was observed in cutthroat trout, rainbow trout, northern pikeminnow and sculpin sp., while an increasing trend was observed in brown trout (Table 2). None of the relationships within individual species were statistically significant.

Figure 3: Fish Tissue Inorganic As and Average Fish Sample Weight



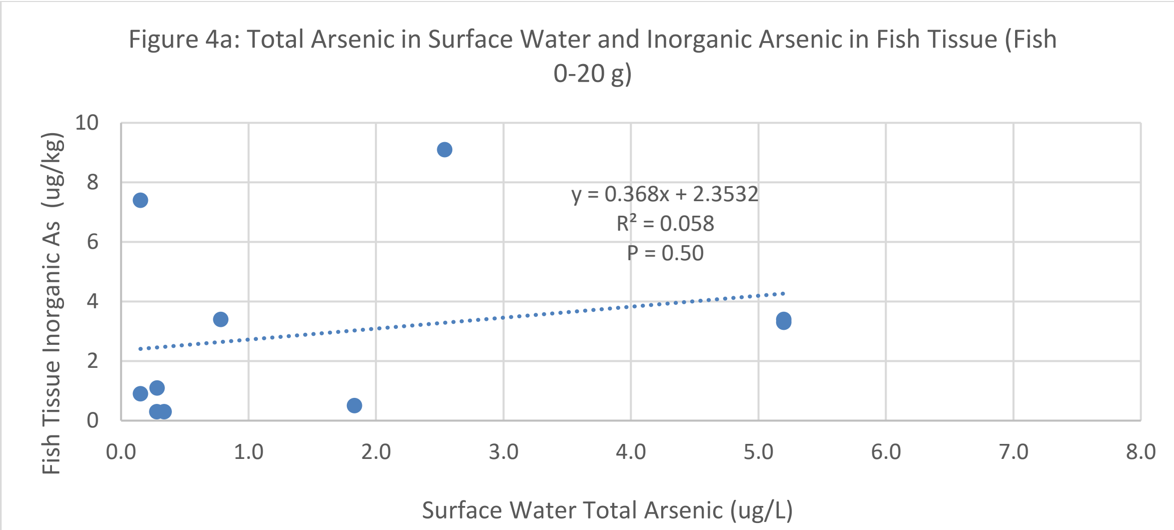
Open circles = non-detect in fish tissue

Table 2. Summary of Inorganic Fish Tissue Concentration Regressions by Species

Species	Sample Size	Regression Equation	R^2	p
Brown Trout	5	iAs(ug/kg) = -0.075(tAs(ug/L)) + 0.65	0.48	0.2
Cutthroat Trout	9	iAs(ug/kg) = -0.011(tAs(ug/L)) + 1.82	0.00	0.99
Northern Pikeminnow	5	iAs(ug/kg) = 0.022(tAs(ug/L)) + 0.39	0.008	0.88
Rainbow Trout	6	iAs(ug/kg) = -0.813(tAs(ug/L)) + 4.59	0.12	0.5
Sculpin sp.	7	iAs(ug/kg) = 0.805(tAs(ug/L)) + 1.62	0.24	0.26
All Fish Combined[a]	45	iAs(ug/kg) = 0.039 (tAs(ug/L)) + 1.72	0	0.86

Notes:
Non-detects were equal to the detection limit
[a] Includes species other than those listed in the table

Given that fish move and may be exposed to surface water and habitats beyond the reach from which surface water samples were collected, we evaluated whether a relationship between fish tissue and surface water may be more evident in smaller size classes of fish, under the assumption that smaller fish may have more limited movement than larger fish. None of the regressions within specific size classes were statistically significant though a trend of increasing iAs concentration in fish tissue with increase tAs concentration in surface water was more apparent in small sized fish (0-20g and 20-50g) than in larger size fish (50-200g, 200-500g and >500g) (Figures 4a-4e).



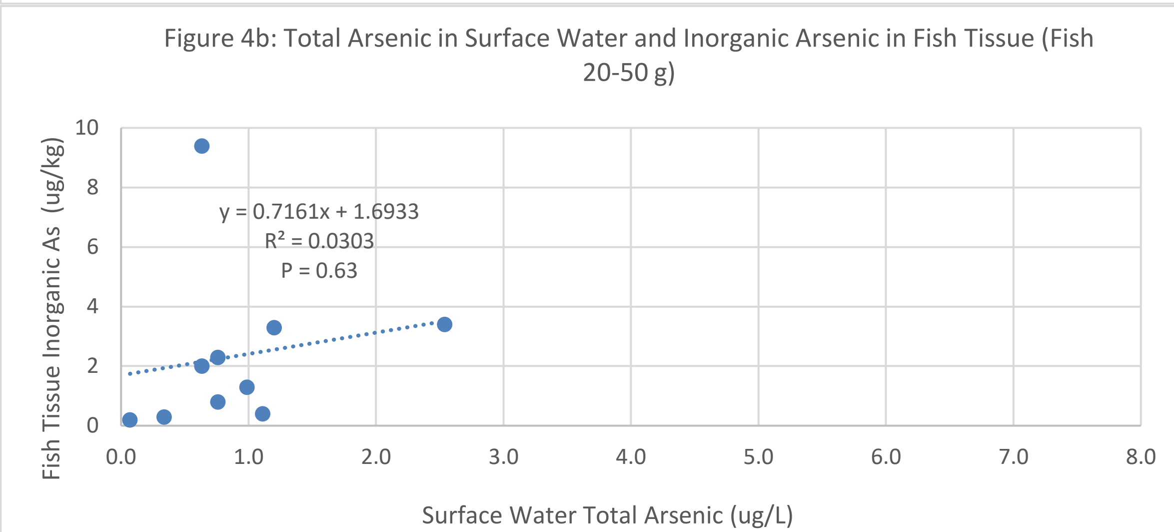


Figure 4c: Total Arsenic in Surface Water and Inorganic Arsenic in Fish Tissue (Fish 50-200 g)

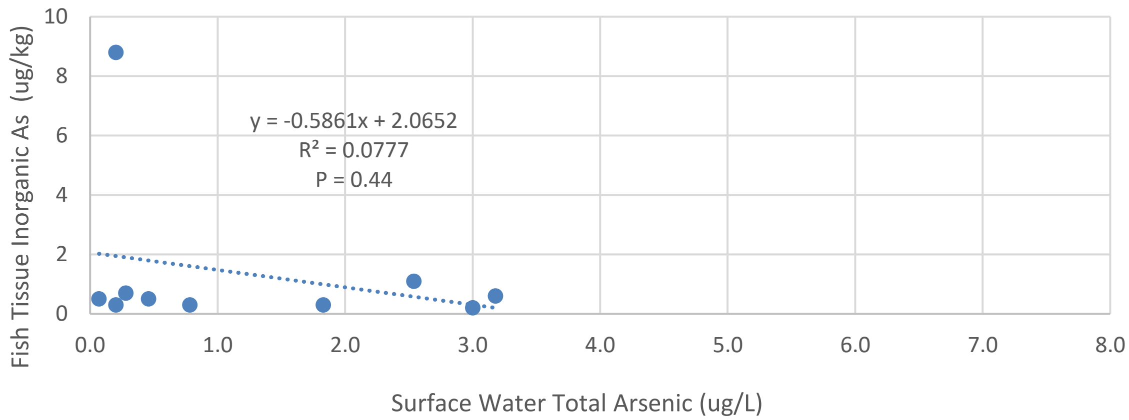


Figure 4d: Total Arsenic in Surface Water and Inorganic Arsenic in Fish Tissue (Fish 200-500 g)

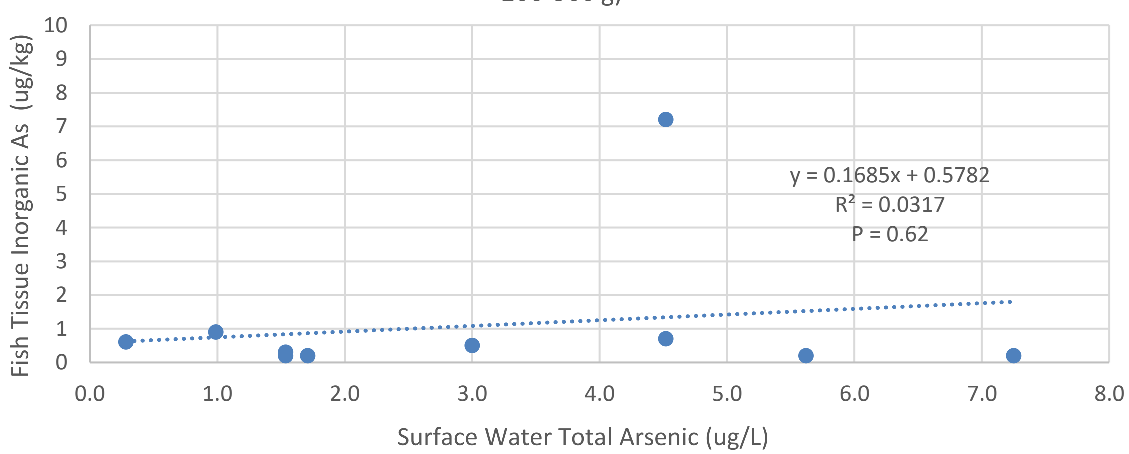
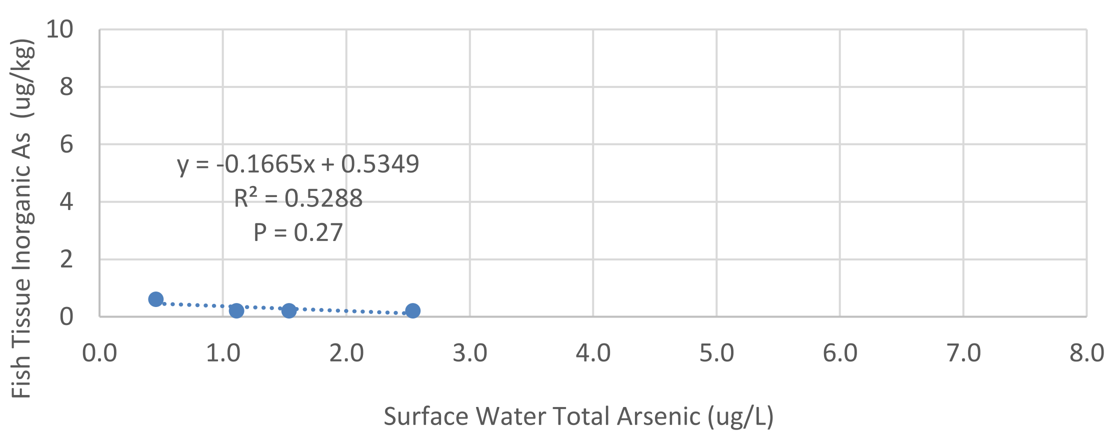


Figure 4e: Total Arsenic in Surface Water and Inorganic Arsenic in Fish Tissue (Fish >500 g)



Combined, these evaluations indicate that the concentration of iAs in fish tissue samples is independent of the concentration of arsenic in water and that the iAs concentrations measured in fish tissue collected in 2019 cannot be explained by, and are largely independent of, the various parameters measured by IDEQ during the 2019 field effort.

With regard to additional sampling in 2020, IDEQ (2020) lists four potential options. Which of those four options to undertake, or other option, would seem to depend upon the goal of the 2020 monitoring program. The 2019 sampling is very robust and indicates that a direct relationship between concentrations of arsenic in surface water and fish tissue is absent. Given the robustness of the 2019 sampling effort, it is not clear it needs to be repeated (i.e., the first of the listed options) unless the goal is to reinforce the likely absence of a relationship.

The second option is to target sites with more robust iAs water column data (IDEQ 2020). To the extent the arsenic concentration in surface water varies and is not well characterized by a one-time sample, collecting fish from the vicinity of the targeted monthly locations would help refine the concentration of arsenic in the water column. Review of the available 2019/2020 monthly monitoring data (posted on the Rulemaking Website on April 3, 2020) indicates that variation in water column concentration over the seven months of sampling (August 2019 through February 2020) is less than 2-fold at most sampling locations and is between 4- and 6-fold at only six of 40 locations. These results suggest that one-time surface water concentrations, like those collected as part of the 2019 paired surface water tissue sampling program, are likely to be reasonably representative of long-term concentrations at most sampling locations. Thus, it is not clear additional refinement of the water concentration will help explain the variation observed in fish concentrations. That said, we see no harm in collecting fish tissue samples at some of the monthly water column monitoring locations as it will help refine surface water concentrations, though IDEQ should not expect such refinement to greatly improve the relationship between arsenic concentration in fish tissue and surface water.

The third option is to target sampling locations with relatively high or low ambient iAs concentrations. Because ambient iAs concentrations in Idaho surface waters span a large range, it is not clear focusing on just the upper or lower end of that range will provide insight about tissue concentrations in the remaining waters. If a more focused approach to sampling is ultimately chosen, it will be important to collect data from the entire “cloud of 2019 points”, including the edges and corners, not just one portion of that “cloud”.

The fourth option is to collect individual fish rather than composites to better understand variability between fish species (IDEQ 2020). The fish tissue data collected in 2019 already provide strong indication that concentrations of iAs (and tAs) can be quite variable between species at a given sampling location and the duplicate results (Table 2 in IDEQ 2020) provide strong indication of substantial variability between individual fish within a species at a given sampling location. It is unclear how a finding of similar or greater variability between individual fish would be used when establishing a BAF for a WQC. Such data would seem to provide only further indication that the concentration of arsenic in fish tissue is independent of the arsenic concentration in water and that whatever factors determine the fish tissue concentration, the concentration in water plays a small, if any, part in that process.

An alternate goal of the 2020 sampling might be to collect information to help identify the causes of the large range of arsenic fish tissue concentrations observed in 2019. Such information would likely continue to include collection of paired fish tissue and water column samples but IDEQ might add collection of sediment and/or porewater samples, or of multiple species of different sizes at a single location to better understand if food web complexity is driving the observed differences between species and individuals, or perhaps, if sufficient mass can be collected, of components of the diet. Collecting other water quality and fish tissue parameters might also improve understanding of the causes of the iAs concentrations in fish tissue. For example, is there a parallel for arsenic to the role of organic carbon in sediments or lipid in fish when predicting fish tissue concentrations of non-ionized organic compounds. For organic compounds a relationship was typically evident from paired water and tissue samples; it was further refined using lipid and carbon data. The 2019 paired arsenic data are unique in the absence of any apparent relationship between tissue and surface water making it more difficult to identify which other parameters might need to be included in a sampling program.

With respect to selecting any (or several) of these 2020 monitoring options, the key question remains: how will IDEQ use the results when developing a WQC for arsenic? If the 2020 results reinforce the 2019 finding of no direct relationship between concentrations of arsenic in the water column and fish tissue, will a BAF and, therefore, fish consumption exposures, be excluded from the arsenic WQC? If the 2020 results confirm the 2019 findings, does this support continuing with the existing 10 micrograms per liter standard (which is based on consumption of water for drinking water purposes). If a BAF will continue to be included, what additional information is needed to inform selection of a state-wide BAF?

We are available to discuss the above results and other aspects of our initial review and evaluation at your convenience.

References

IDEQ 2020. 2019 Arsenic Accumulation in Fish Tissue. Preliminary Monitoring Results. 14 pp. March.