

Drinking Water Fluoridation and Salmon*

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Abstract

Drinking water supplies have been fluoridated world-wide for more than 60 years because of broadly demonstrated public health benefits. Opponents of potable water fluoridation support their position by offering an article by David M. Damkaer and Douglas B. Dey of the National Marine Fisheries Service (NMFS) published in the *North American Journal of Fisheries Management* in 1989. This is apparently the only available publication that purports to link environmental impacts with fluoride levels less than 1 part per million (ppm; or milligrams per liter, mg/l).

It is very easy to read Damkaer and Dey's report and conclude that fluoride levels as low as 0.2 ppm in river water were shown to cause harm to adult salmon. However, this is not an accurate reflection of what they wrote.

I will lead you through the details of what they wrote so you can see that they could not explain their observations and they did not conclude that low levels of fluoride in the river is harmful to salmon, directly or indirectly. As a matter of fact, they write that they cannot explain the behavioral patterns they (and others) observed, nor could they demonstrate any negative impacts on fecundity, reproductive success, or survival because they did not look at those aspects of the salmon's life history.

1 The Reason for The Study

David M. Damkaer and Douglas B. Dey were biologists in the Puget Sound research center of the National Marine Fisheries Service (NMFS, now also called NOAA Fisheries). For reasons not explained in their publication, they undertook a study of adult salmon behaviors in the vicinity of the John Day Dam on the Columbia River. The stated reason was to investigate the effects of high fluoride levels from an adjacent aluminum plant on the fish. To understand the article in the *North American Journal of Fisheries Management*¹, we need to look

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¹Damkaer, D.M. and D.B. Dey. 1989. Evidence for Fluoride Effects on Salmon Passage at John Day Dam, Columbia River, 1982–1986. *North American Journal of Fisheries Management* 9:154–162.

closely at the language used, and the relationships among different sections of the article. Damkaer and Dey ask a lot of questions about salmon behavior in the vicinity of the John Day Dam, but they answer none.

The left-side column on page 154 (the first page of the article) is a history of observations (theirs and others) that returning adult chinook salmon spent more time in the tailrace² below the John Day Dam before moving upriver than they did at Bonneville, The Dalles, or McNary Dams. At the bottom of that column they write,

“The delay of nearly 1 week at John Day Dam appeared to contribute to increased mortality and may have affected the spawning success of migrating adult salmonids.”

But, nothing in the rest of the paper describes any research they did to measure salmon mortality or spawning success, so we do not know if the time the fish spent below the dam had any effect at all (negative or positive) on these two aspects of chinook population dynamics in the Columbia River in the 1980s. The authors did not cite any research at all to substantiate their speculation.

At the top of the right-side column on this first page the authors start to look at alternative theories of why the fish spent more time below this one dam, without assuming any particular effects on individual fish or the entire population. In other words, they started to focus on finding an explanation of what they and others had observed. The second paragraph in this column begins,

“The lack of response by migrating salmonids to flow alterations below the dam focused attention on the possibility that something in the water might be causing fish to avoid the north fishway and delay their passage. If behavior-altering pollutants were present at even very low concentrations, migrating adult salmonids might sense and respond to them.”

These are important observations, and they go on to cite numerous research studies that demonstrate that adult salmon do, indeed, have acute olfactory perception; for example, the fish can smell the extremely subtle differences in ocean and fresh waters that allow them to return to their natal streams from the deep ocean and far from the mouth of the Columbia River. However, after making this valid point about low concentrations of chemicals being responsible for the population dynamics observed below the John Day Dam, they begin the third paragraph (at the end of page 154) by writing,

“In 1982, preliminary studies of the distributions of many pollutants near John Day Dam suggested that the fish-passage delays might be related to contaminants discharged at an aluminum smelter

²The area of the river immediately below the turbine outlets where water velocity is much higher than in the rest of the river.

outfall on the north shore of the Columbia River about 1.6 km upstream from John Day Dam. High concentrations of fluoride in the vicinity of John Day Dam prompted us to focus sampling efforts on this contaminant.”

However, previous to this statement they neither established that high fluoride concentrations effect adult salmon populations (by citing published research on the topic or their own quantitative data) nor did they eliminate very low concentrations of any other chemical as a reason for the observed behaviors of salmon at the dam. It would be reasonable to ask how they justified focusing on fluoride and ignoring everything else. This is a very important point that they bring up later in their article.

The authors conclude their introduction by telling us that,

“the purpose of this paper is to document changes in the migratory behavior of adult salmonids at John Day Dam in relation to fluoride concentrations and to present data from behavioral bioassays that demonstrate the effects of fluoride on migrating adult salmon.”

The critical question is: *did they document that fluoride concentrations in the water affected the behavior of adult salmon in the Columbia River or in the laboratory?* Let us look carefully at their methods.

2 Fishway³ Preference by Adult Salmon

Figure 1 on page 155 shows the location of sampling stations in the Columbia and John Day Rivers. Initially, both physical (temperature, dissolved oxygen, pH, and conductivity) and chemical (fluoride and turbidity).⁴ It is important to note that,

“[B]eginning in 1983, water samples for fluoride and turbidity analyses were collected daily from the north and south fishways at John Day Dam, April-October.”

These water samples came from within the fishways themselves, not the numbered stations shown in their Figure 1. They also took water quality samples below the John Day (stations 14-16), The Dalles, and Bonneville Dams.

To understand the meaning of the fishway water quality samples, turn to page 159 and read toward the end of the first paragraph on the left-side column,

“Also, fluoride, turbidity, and water temperature measurements in the fishways *did not indicate a relationship* with passage preference.”
[Emphasis added.]

³The ladders on each end of the dam that allow adult salmonids to swim upriver past the dam.

⁴This is a rather unusual categorization. Dissolved oxygen, pH (acidity/alkalinity) and conductivity are chemical components of the water, and turbidity (the results of suspended particles, dissolved particles, and color) is generally considered to be a physical attribute.

So, Damkaer and Dey concluded that they could not demonstrate that fluoride levels influenced the salmon's choice of fishway, although that appeared to be an issue of serious concern and the reason that they conducted flume (artificial stream channel) studies in their Puget Sound laboratory. Therefore, the low sample size in the laboratory studies, and the lack of a clear preference in those results⁵, tells us that even the high fluoride levels at the north side of the Columbia River did not influence the choice of fishway by for passing the John Day Dam by returning adult salmon.

3 Delays in Migrating Past the Dam

Since the water in the fishways shows no effect on the fishes' behavior, the authors attempt to reduce the importance of the fishway preference factor, which we remember they stated as the driving force of the study⁶. Instead, they tell us on page 159, left-side column just above "behavior experiments" that,

"Whether or not the various factors monitored at the dam actually influence the salmonids' choice of fishway is only a part of the question; passage delay, not the choice of fishway, has been the problem at John Day Dam."

What Damkaer and Dey wrote about the effects of fluoride on *passage time* at the John Day Dam is as contradictory and unsupportive of their assumptions as what they wrote about the effects of fluorides on *fishway preference*. For example, the first sentence of the abstract (on page 154) begins:

"There is evidence that fluoride from an aluminum plant near John Day Dam had a *significant negative effect* on passage time and survival of adult Pacific salmon. . . ." [Emphasis added.]

As noted earlier in this critique, the NMFS authors acknowledge that even very low concentrations of chemicals can affect the migratory behavior of salmon, but they focused on only the comparatively high concentrations of fluoride and several other physical and chemical characteristics of the river's water. Reading their methods section (pages 155-156), we find nothing that addresses the time spent before passing the dam, influences on adult survival prior to arrival at their spawning grounds, decreased reproductive success, or any other component of salmon behavior.

They did not find any difference in water chemistry in the north or south fishway and they did not measure any component of adult fecundity or survival. So, what do they tell us about the time spent below the dam?

⁵Page 159, right-side column and the paragraph just above Discussion, states that the coho salmon showed no preference for a fluoride level of 0.2 mg/l. There is also no reason to believe it is an effect threshold in the Columbia River, either, for any species of salmon.

⁶Page 159, left-side column, just above Methods: "The purpose of this paper is to document changes in the migratory behavior of adult salmonids at John Day Dam ... that demonstrate the effects of fluoride on migrating adult salmon."

Before looking for this information in their article, consider the fact that the John Day Dam is the only one of the four lower Columbia River dams that has a major tributary—a salmon-bearing tributary—immediately upriver from the dam.

During the period 1971–1982, an annual average of more than 5,400 adult chinook salmon returned to spawn in the John Day River and its tributaries. This large number of fish wait for the proper cues (odor, photoperiod, water flow velocity, water temperature) before moving past the dam, into the John Day River, and making their way to their spawning sites. Because Damkaer and Dey did not consider any factor other than fluoride concentration in the water we do not know if the preference shown by the adult chinook salmon for the south fishway was related to John Day River water that entered the mainstem Columbia River but flowed past the dam closer to the south bank than to the north bank. If most of these fish were headed to the John Day River then they would naturally prefer the south bank of the river, and would use the south fishway to swim upriver past the dam.

We do not know, so there is no reason to attribute Damkaer and Dey’s conclusions to their assumption that fluoride concentration avoidance caused the observed distribution patterns. They address this point in the first paragraph of their Results section (page 156) where they write,

“Of considerable interest, however, were indications that the generally warmer (and, therefore, less oxygen-rich) and more turbid John Day River influenced the Columbia River near John Day Dam. *Physical data corroborated photographic evidence that the John Day River could influence returning salmonids as they approach John Day Dam.*”
[Emphasis added.]

In a single sentence the authors provide a valid explanation for the delay in moving upriver, past the John Day Dam. They continue that paragraph by writing,

“Dates, times, locations, depths of measurements of river water in the John Day Dam region for 1982–1985 are available in tabulated form in ...”

and they cite four of their earlier reports conducted under contract to the Army Corps of Engineers.

4 Reported Results

When they discuss fish passage results (page 158, right-side column) they note the number of adult salmon expected to reach McNary Dam, but they do not account for the average of 5,400 fish who left the main stem Columbia River for the John Day River system and would not reach the McNary Dam under any circumstances. They suggest a reason for the delays and fishway preference on

page 159 (left-side column, first full paragraph) by noting the strong preference in spring and summer with less-strong preference in the autumn. This can be explained by the different “runs” of chinook (and other salmonids) where adults return at different time periods during the year.

Damkaer and Dey’s discussion of their results (beginning on page 159) says that they *could not find a reason* for either the fishway preference or delays in moving up past the dam. They showed in the results section that it was not the fluoride concentrations from the aluminum plant, yet their second discussion paragraph tells us there was “empirical and theoretical evidence” of its influence. However, everything they wrote up to this paragraph provides no support for that statement.

They note, correctly, that fluoride levels greater than 1 mg/l may have sub-lethal or lethal effects on salmon. It all depends on the hardness of the water and other factors. Fluoride concentrations in the Columbia River at the aluminum plant and below (as far as Bonneville Dam) exceeded the level generally accepted as therapeutic when added to drinking water supplies, that is 1.0 ppm. Extrapolating the effects on salmon of fluoridated drinking water that has been treated to lower residual fluoride levels before being discharged to a receiving river with much higher levels measured in the river, or with those same much higher levels in the completely different environment of a flume in the Seattle area using Puget Sound water is not good science because the results are not directly comparable.

5 Conclusion

The Damkaer and Dey study suffers from major internal inconsistencies. Their *a priori* assumption that the observed distribution of chinook salmon, and their residence time below the John Day Dam, were due solely to the fluoride levels associated with discharge of the north bank’s aluminum plant did not hold up in their data. They recognized the influence of the John Day River on fish behavior but did not explore that as a causative mechanism explaining the observed behaviors of chinook salmon around the dam. This one paper is not a foundation to support the contention that fluoridated drinking water has any negative environmental impacts.