Idaho Fish Consumption Rate and Human Health Water Quality Criteria—Discussion Paper #4

Market (All) or Local Fish

State of Idaho
Department of Environmental Quality

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Introduction

Water quality criteria for human health are established to protect people from undue risk associated with various chemicals. Because people are exposed to chemicals from multiple routes, water quality criteria depend on more than just the overall exposure of a person receives from drinking water. These criteria also incorporate exposure to chemicals from eating fish that live in the water.

This paper explores the issue of using a fish consumption rate reflective of all fish (market) consumed by the population or one that reflects only fish caught in Idaho waters (local fish). Consuming fish from Idaho's lakes, reservoirs, rivers and streams should not pose an undue health risk for Idaho citizens. To that end, human health criteria are established to avoid such risks. Water quality criteria established by the state are meant to regulate waters within the state and prevent excess accumulation of potentially harmful chemicals in fish tissue. The policy decision identified here is the appropriateness of selecting a fish consumption rate based on all fish consumed or only those consumed from Idaho waters.

The Idaho Department of Environmental Quality (DEQ) is currently gathering information on fish consumption in Idaho. DEQ, with help from the rulemaking committee, designed a survey that identifies the source of fish consumed so that data may be analyzed to ascertain both the overall fish consumption as well as consumption of fish from Idaho waters. The survey was designed in this way to allow for calculation of a fish consumption rate based on the outcome of these policy discussions. The Idaho fish consumption survey is also designed to implement a National Cancer Institute (NCI) methodology to determine the intra-person variability for eating fish

Philosophically speaking the question here is whether water quality criteria are to protect people from exposure to harmful contaminants regardless of the route of exposure or if the criteria are to protect people from only the route of exposure specific to Idaho waters, knowing that Idaho's water quality criteria can only be used to reduce contaminants in discharge to Idaho waters. For example, as a fish consumer, you may eat fish from a wide variety of sources; therefore, you are already exposed to certain contaminants based on that fish consumption. If you want to eat that beautiful rainbow trout you caught last weekend, should the water quality that trout has been living in be protected at a level that accounts for only the amount of Idaho fish you eat or all fish you eat?

Principles for Risk Management Decisions

The United States Environmental Protection Agency's (EPA's) Risk Characterization Policy and Guidance (EPA 1995) provides some fundamental principles to consider when making risk management decisions such as the one described in this paper. These principles include the following:

- Transparency—Risk management decisions should be identified separately from the science used to guide them. These decisions should be clearly articulated along with the assumptions used.

- Consistency—Risk management decisions should be consistent but may need to recognize the unique characteristics of specific situations.
- Context—Characterization of risk should include a discussion of how a specific risk compares with similar risks.
- Communication—Risk management decisions should include exchanging information with an interactive process among individuals, groups, and institutions.
- Summary—A description should be provided of the overall strengths and limitations of the assessment and conclusions.

These guiding principles help ensure that risk management decisions are made in a manner that provides clarity, transparency, reasonableness, and consistency. The following discussion will use these principles when considering the use of market versus local fish in determining the overall fish consumption rate for Idaho.

How Fish Consumption Rate Impacts Water Quality Criteria

Water quality criteria for human health protection are inversely proportional to the rate of fish consumption. Higher fish consumption rates mean lower water quality criteria if all other variables remain the same. Conversely, lower fish consumption results in higher criteria. When evaluating what types of fish to include in the fish consumption rate, it is important to decide not just what fish consumption rate to choose, but to identify why that rate is being selected.

Fish consumption rate is not the only factor affecting the calculation of water quality criteria for human health. Other issues are closely tied into these calculations. This means that policy decisions should be made with the whole picture in mind. To that end, a discussion of the impacts of choosing market vs. local fish depends on other factors such as bioaccumulation, relative source contributions, and level of acceptable risk. This paper will touch briefly on bioaccumulation and relative source contributions while a future discussion paper will focus on level of acceptable risk.

Cancer Effects (Linear)

The equation used to develop human health water quality criteria combines chemical toxicity values developed by EPA with conservative exposure parameters to calculate concentrations of chemicals in surface water associated with a given level of risk. This equation is provided below as an example of how the choice of a fish consumption rate impacts the overall assumptions within the criteria calculation.

$$WQC = RSD * \frac{BW}{DI + (\boldsymbol{FI} * BAF)}$$

where

WQC = Water quality criterion (mg/L)

RSD = Risk Specific Dose (mg/kg-day) calculated as risk factor (10^{-5} to 10^{-7})/ slope factor

BW = Human Body Weight (kg, 70 for average adult)

DI = Drinking Water Intake (L/day, 2 for average adult)

FI = Fish Intake (kg/day)

BAF = Bioaccumulation Factor (L/kg)

Fish Intake

EPA recommends a default fish intake rate of 17.5 grams/day (g/day) to protect the general population of fish consumers. This value represents the 90th percentile of the 1994 to 1996 data from the United States Department of Agriculture CSFII survey (USDA 2000). It represents uncooked weight of freshwater and estuarine finfish and shellfish only. EPA also recommends this value as a default intake rate for recreational fishers, along with a value of 142.4 g/day for subsistence fishers. These national recommendations for fish consumption rates were based on consumption of freshwater and estuarine fish only; they did not include marine species.

EPA has urged states and tribes to develop criteria to protect highly exposed population groups and to use local, state, or regional data over default fish intake values as more representative of their target population. A four preference hierarchy is recommended: (1) use of local data, (2) use of data reflecting similar geography/population groups; (3) use of data from national surveys; and (4) use of EPA's default intake rates. The main rationale for the present fish consumption rate survey effort is to collect state data to better understand fish consumption rates in Idaho.

If the fish consumption rate is based only on Idaho specific fish, we intentionally focus on only Idaho fish and shellfish routes of exposure. While this may seem like the most practical route (we can only regulate what goes on in Idaho, not out in the ocean), it also means that we are not accurately estimating the overall risk to the population if there is any consumption of fish from other sources. The overall risk to Idaho citizens would be underestimated. If the fish consumption rate is based on all fish consumed, regardless of source, we are protecting the population at a known and acceptable risk level while knowing that there may be a significant portion of the exposure from outside sources that we do not regulate or monitor.

Consider the following hypothetical fish consumers. John is a regular fish eater, 3–4 times per week. He consumes mainly fish from the market: cod, halibut, and tilapia. His overall fish consumption rate is 64.8 g/day. However, his consumption rate of Idaho fish approximates 0. Paul is an avid fisherman and typically fishes every weekend, bringing home trout, catfish, bluegill, and crappie. His fish consumption rate is also 64.8 g/day, but it is all Idaho fish. If the fish consumption rate is determined by overall fish consumption, in both cases the rate would be 64.8 g/day. If the fish consumption rate is only determined by consumption of Idaho fish, the mean fish consumption rate for these two individuals is then 32.4 g/day.

If we hold all the other parameters associated with calculating the criteria (linear cancer risk) the same, the criterion for a carcinogen increases 1.6 times. The response in criteria values is not exactly twofold because it also depends on the bioaccumulation factor (i.e., uptake, storage, and accumulation of organic and inorganic contaminants by organisms from their environment). If there is a high bioaccumulation factor (3,000), the change in criteria values approaches 2. Low bioaccumulation (100) means a smaller change between the two calculated criteria.

Returning to protection, if the fish consumption rate is based on all fish consumed, John and Paul are protected at the same risk level. If the fish consumption rate is specific only to Idaho fish, the two are no longer protected at the same rate. Paul's associated risk with eating Idaho fish is greater than John's. If we look at the two different consumption rates and the level of protection for each of our two hypothetical fish consumers, we see that the cancer risk for Paul, who eats 64.8 g/day of Idaho fish, increases from 1×10^{-6} to 1.62×10^{-6} when using the criteria established by selecting only Idaho fish consumption, holding all other assumptions the same. This simplistic view illustrates that changing the basis for the fish consumption rate can impact the relative risk and level of protection. Figure 1 provides a graphical depiction of the issue.

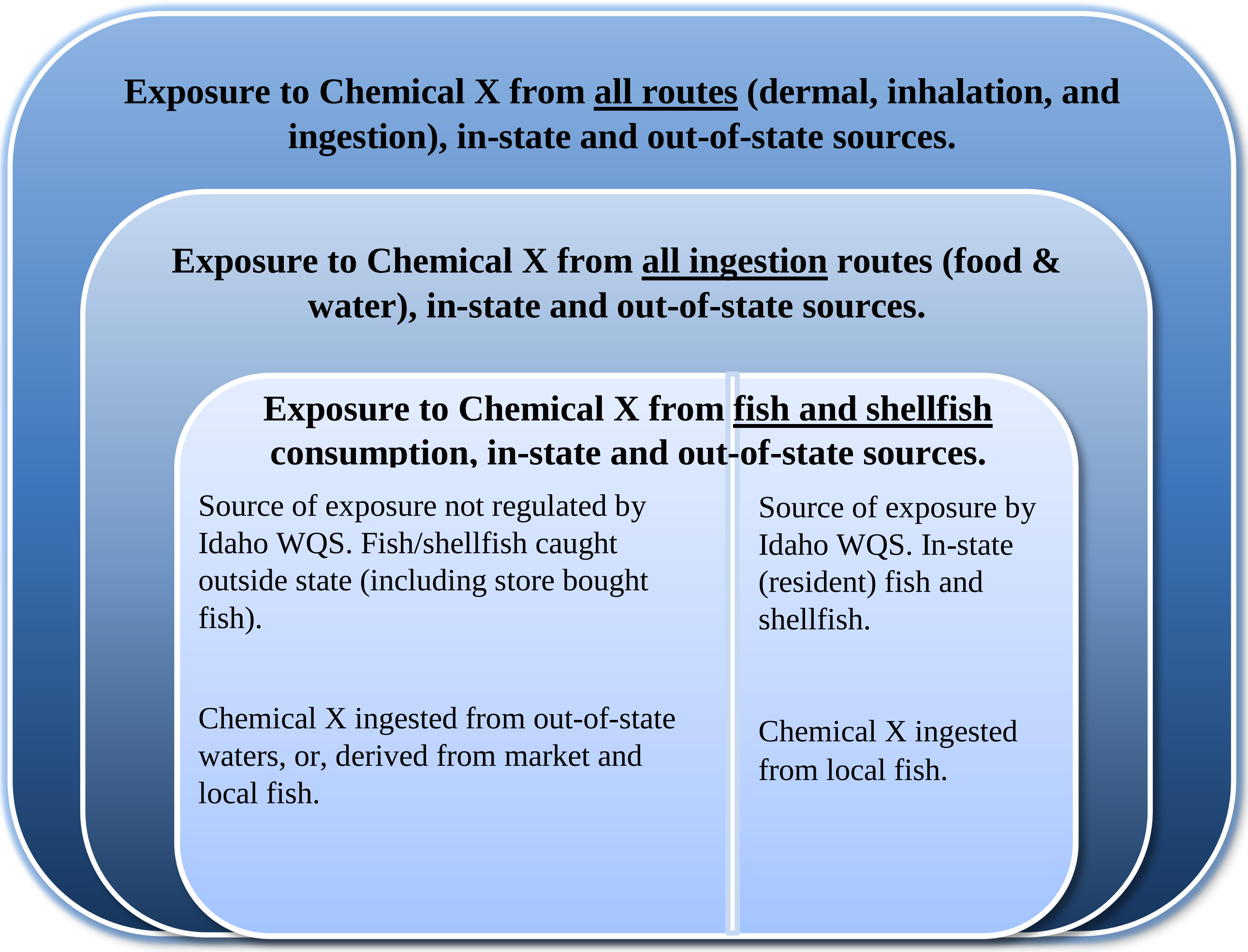

Figure 1. Relative exposure to pollutant X from all routes, all ingestion routes, and fish consumption routes (adapted from WaDOE 2014).

The figure shows the overall exposure to a given chemical from all possible routes of exposure such as air, food, water, and skin absorption (outer box); the amount of exposure to the given chemical from all sources in food and water (middle box); and the amount of exposure to the given chemical from consumed fish and shellfish (inner box). The exposure from consumption of fish and shellfish is divided into exposure from all sources of fish and only Idaho sources of fish.

Although Idaho water quality standards only control the level of chemical exposure in Idaho, the overall protection of human health depends upon all routes of exposure.

Other Factors Impacting Water Quality Criteria Derivation

The previous issue paper regarding probabilistic criteria development discussed some of the factors that go into calculating human health criteria, specifically body weight and drinking water intake. The following two sections describe and define some of the remaining components, chiefly bioaccumulation and relative source contribution. Both of these components impact the final calculation of criteria and therefore should be considered in the discussion of fish consumption rates.

Bioaccumulation Factor

Bioaccumulation is the uptake, storage, and accumulation of organic and inorganic contaminants by organisms from their environment. This accumulation occurs when an organism, in this case fish, absorb chemicals at rates greater than the chemical is flushed from the organism's system. This means that longer biological half-lives (how long it takes half of the concentration of the substance to leave the organism) of the chemical lead to increased risk of harm from consuming that organism, even if the concentration of the chemical in the water is low.

A bioaccumulation factor (BAF) is defined as representing the ratio (L/kg) of the concentration of a chemical in the tissue (mg/kg) of an aquatic organism to its concentration in the ambient water (mg/L) where the ratio does not change substantially over time, i.e., the ratio reflects bioaccumulation at or near steady state. Bioaccumulation of chemical constituents in fish is not identical across species or across chemicals. Some chemicals are lipid soluble and accumulate in the fatty tissue while others are protein soluble and accumulate in the muscle. National BAFs represent long-term average bioaccumulation of a pollutant in aquatic organisms commonly consumed by people. These BAFs also account for some major chemical, biological, and ecological attributes affecting bioaccumulation in water bodies across the United States and are developed separately for each trophic level to account for potential biomagnification of some chemicals in aquatic food webs.

Different fish consumption rates will have less impact for those chemicals with low BAFs. However, as BAFs increase, the overall impact on the exposure of humans to those chemicals from fish and shellfish consumption increases quickly. This would impact the overall risk to consuming fish and shellfish.

Relative Source Contribution

Relative source contribution (RSC) is a term that appears in the calculation of criteria for noncancer effects. This term is used to account for nonwater sources of exposure to noncarcinogens. The RSC is chemical specific and adjusts the criteria calculation to account for exposure to the chemical from other sources such as food (other than fish and shellfish) and inhalation. Criteria for carcinogens do not use an RSC because they are set at an incremental lifetime risk (1 in 10^6) posed by the chemical's presence in water (Louch et al. 2012).

The criteria calculation for these noncancer effects is based on a cumulative dose over time that would cause an observable effect. Since water quality criteria for human health only address exposure through drinking water and eating fish or shellfish (Figure 1), this correction factor is used to ensure that total exposure from all sources does not exceed the reference dose for lifetime exposure. The default value EPA recommends for RSC (where RSC has not been calculated) is 0.20. It is also recommended that the RSC not be established at greater than 0.80 to accommodate unknown exposures (EPA 2000).

EPA guidance suggests that not all risk from exposure should be apportioned to drinking water and fish consumption alone. Therefore, use of the relative source contribution default of 0.20 is recommended for those contaminants that do not have data already for calculating an RSC.

Selecting a fish consumption rate based solely on the consumption of Idaho fish suggests that this relative source contribution might need to be lower. The RSC term at 0.20 represents 20% of the lifetime exposure coming from the ingestion of fish, shellfish and water, and 80% is from other sources (e.g., inhalation, other dietary intakes). If the fish consumption rate selected reflects only consumption of Idaho fish, that leaves the exposure routes from other sources of fish unaccounted for if the RSC is not adjusted. This means that an RSC of 0.20 represents consumption of all fish, shellfish and water, and an RSC of less than 0.20 should be used if the fish consumption rate selected only reflects consumption of Idaho fish.

Conclusion

Including market fish in the calculation of a fish consumption rate is a policy decision. By including all sources of fish, the cancer risk factor and relative source contribution can be more accurately defined, and human health is protected on a broader scale. By excluding market sources of fish, the derived water quality criteria will be more specific to what Idaho water quality standards can regulate; however, this choice discounts the risk associated with consumption of fish from other sources.

The Idaho fish consumption survey is also designed to implement a National Cancer Institute (NCI) methodology to determine the intra-person variability for eating fish. This determination is made using repeat surveys where a respondent ate fish 24 hours prior to the survey both times. One drawback to selecting an Idaho fish-only consumption rate is that the number of repeat surveys where a respondent ate Idaho fish both times might not reach the overall goal of 50 repeats. Based on projected response rates, recall rates, and fish consumption percentages, it may not be possible, under the current budget constraints, to achieve the requisite number of repeats to apply the NCI methodology to consumption of only Idaho fish.

Since the Idaho survey will be collecting data on all types of fish consumed, it is possible that a comparison of Idaho fish consumed to overall fish consumption may be used to identify possible values of RSC. Current recommendations on RSC are a default value of 0.20, and a value no greater than 0.80.

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