Idaho Fish Consumption Rate and Human Health Water Quality Criteria—Discussion Paper #1

Fish Consumers and Nonconsumers

State of Idaho
Department of Environmental Quality
Surface Water Program
1410 North Hilton
Boise, Idaho 83706

October 2013

Printed on recycled paper, DEQ October 2013,
PID WQST, CA 82136. Costs associated with this
publication are available from the State of Idaho
Department of Environmental Quality in accordance
with Section 60-202, Idaho Code.

Introduction

Any population will have a range of fish consumption habits among its people, including nonconsumers. These nonconsumers, if their fish consumption is truly zero, will have no risk from exposure to any contaminants that may be in the fish nor will they accrue any of the benefits a fish diet can confer (Rheinberger and Hammitt 2012). As such, nonconsumers are sometimes excluded when calculating a regulatory fish consumption rate used to derive criteria intended to protect human health. Such an exclusion requires accurate identification of both consumers and nonconsumers if it is to be soundly justified. These issues are discussed below.

Who are nonconsumers?

On the surface, this is an easy question to answer: they are people who eat no fish—absolutely none, zero—during their lifetime. A few such people may exist. However, considering the many types of fish and shellfish and various ways they can be prepared and consumed—ranging from a whole smoked fish or canned sardine down to Caesar salad dressing or fish sauce used as a minor component of something else—some would say a true nonconsumer is rare or nonexistent.

Determining nonconsumers is largely a measurement problem. How well can we determine very low rates of fish consumption? Is there some level close to zero we are comfortable calling zero, even though we know it is really not? And what does such trimming of the full distribution of consumption rates (i.e., excluding those with an *estimated* fish consumption rate of zero) do to our statistics and quantification of risk? How are nonconsumers of fish factored into our calculation of cancer rate statistics?

How do we know who are consumers and who are not?

All survey data are self-reported and thus subject to the respondents' ability to remember, an issue known as recall bias (Ebert et al. 1994; EPA 1999). Recall bias is very much dependent on the nature of the question asked, how far back someone is asked to remember, and the detail to be recalled. A person may remember eating fish last month but not the date. Similarly, people may remember significant meals but forget a tuna canapé grabbed from an hors d'oeuvre tray at a party. People may be fairly confident they ate some fish in the last year but not remember what kind or how much, despite offering their best estimate. These self-reporting issues are well known and must be accounted for or at least acknowledged in behavioral surveys.

Recall bias aside, two basic methods are available to determine someone's fish consumption rate. One is to ask how often the person eats fish or shellfish and how much is usually eaten at a meal. Two numbers result—a frequency of meals and a typical meal size. The product is a person's fish consumption rate and is commonly expressed in grams per day but can be expressed in any other units desired, such as pounds per year.

With this approach, if the recall period is long enough, say a year, a survey is likely to capture infrequent consumers of fish (i.e., only those who said they ate no fish in a year, a very low frequency, would be seen as nonconsumers). However, the estimated consumption rate for the individual may be inaccurate, due to problems in quantifying a typical meal. Someone may forget small or trivial meals and thus underestimate frequency, or a person may get the frequency right but base a typical portion on memorable larger meals (e.g., where fish was the main course).

If the recall period is long enough, this estimate may represent a person's long-term average consumption rate or usual intake rate. This rate is not necessarily what a person may eat on any given day. For most people, particularly infrequent or episodic fish consumers, the variation from day to day will be considerable and confounds efforts to accurately estimate a full distribution of usual intake rates (Tran et al. 2013).

A second way to estimate fish consumption rates is to employ short-term dietary recall (e.g., what did a person eat yesterday or the day before). This approach generally results in more certain recall and thus better meal size, type, and preparation information. However, this approach assumes that consumption on the day (or few days) chosen for interviewing represents a person's typical consumption, when it may not. This assumption particularly breaks down when food items are only episodically consumed, as fish often is. Because daily consumption of fish for periodic consumers is sporadic, these people are more likely to be identified as nonconsumers. Infrequent consumers are especially unlikely to have eaten any fish recently. Thus, they are surveyed with zero fish consumption even though their actual rate of consumption is higher. With short-term recall, surveyors can gather better quantified, more reliable information for the day, but the tradeoff is increased uncertainty about how well that day represents usual intake—for the individual and the population.

Under-accounting of consumption by infrequent fish consumers can be corrected (Haubrock et al. 2011; Keogh and White 2011; Tooze et al. 2006). The National Cancer Institute method for correction uses measures of variation from day to day (by person) estimated from variation in repeat surveys. This method requires interviewing the same person on different days. Other methods use a separate question on frequency of consumption to augment the short-term recall data.

With short-term recall surveys, the issue of missing infrequent consumers of fish lessens for a population of people with more frequent fish consumption, simply because fewer people are likely to be encountered who say they ate no fish recently. The effect of misidentifying infrequent consumers as nonconsumers on the statistical distribution of fish consumption rates also lessens when most people in the population are identified as fish consumers.

A preponderance of fish consumers is expected for populations whose cultures are intimately tied to fish resources, such as northwest Indian tribes or certain minorities, such as Asians and Pacific Islanders. Idahoans in general may also have a high fish consumption rate.

What do we already know about Idaho fish consumers?

The Behavioral Risk Factor Surveillance System (BRFSS) survey conducted in 2012 indicates that a high proportion of Idahoans are fish eaters (Vannoy, personal communication, September 2013). Over 5,000 people in Idaho were surveyed and asked two questions about their fish consumption habits: (1) how often do you eat fish and (2) how often do you eat fish that has been caught in Idaho waters? Including consumption from any source versus only consumption from Idaho waters makes a big difference in the fraction of those people labeled nonconsumers.

The Idaho Department of Health and Welfare analyzed the BRFSS data by looking at respondents who reported a consumption frequency of at least once per month and at least once a year. On a monthly basis 78% of Idahoans ate fish from any source, but only 17.1% ate fish from Idaho. On an annual basis the frequencies rise to 91% for any fish and 57% for Idaho fish.

The rates for any fish are likely even higher because question 1 excluded shellfish. Thus, someone who ate only shrimp or clam chowder, for example, would have been among the 9% of Idahoans identified as nonconsumers, in a year. All things considered, it appears the vast majority of Idahoans are fish consumers. If we consider that human health criteria are to reflect a lifetime exposure of 70 years, it becomes even more apparent that everyone, or nearly everyone, is likely a fish consumer. With few or no true nonconsumers of fish in Idaho, there is little or no difference in basing statistics on everyone or just known consumers.

How does misclassification affect calculated statistics?

Consumption frequency is a big part of determining an individual's usual intake (long-term average consumption rate); thus, infrequent fish consumers are more likely to have a lower rate (Subar et al. 2006). Because infrequent/low consumers on many days eat no fish, they are prone to be identified, mistakenly so, as nonconsumers, particularly in short-term recall surveys. The effect of this misclassification depends on the consumption rate of those misclassified, how many are misclassified, decisions on data trimming, and what statistics are chosen to represent the population.

To illustrate how the effect of misclassification interacts with decisions on trimming and choice of statistic, two hypothetical fish consumption distributions are presented below. Distribution 1 represents the true, full knowledge distribution and includes 10% of the population as nonconsumers. Distribution 2 is the same as the first except that an additional 15% of the population, because of survey limitations or measurement error, is mistakenly identified as nonconsumers. The trimmed data represent the results when only consumers (i.e., those with a fish consumption rate greater than 0 are included in the analysis.

Table 1. Hypothetical comparison of fish consumption rates, usual intake, in grams per day.

	Distribution 1 (True)	
	Entire Population	Trimmed
Median	17.5	23.0
Mean	47.515	52.8
90th Percentile	127.8	136.6

	Distribution 2 (15% Misidentified Nonconsumers)	
	Entire Population	Trimmed
Median	17.5	39.0
Mean	47.480	63.3
90th Percentile	127.8	158.8

Misidentifying some low consumers as nonconsumers only slightly drags down the calculated mean consumption rate for the whole population (47.515 to 47.480). However, it increases the calculated mean consumption rate significantly when data are trimmed to exclude nonconsumers. This difference is likely because the consumption rates were low for misidentified nonconsumers, a very realistic possibility.

Current US Environmental Protection Agency (EPA) guidance does not recommend using the mean in criteria calculations but instead a more conservative upper percentile. In the example distributions above, excluding some low consumers because they are misidentified as nonconsumers makes no difference at all in the whole population 90th percentile. That's good. However, it does make a rather large difference in the trimmed 90th percentile (136.6 versus 158.8). This difference is because an upper percentile, such as the 90th, shifts further to the right (to high consumption values) in what remains of the distribution when the left tail (low values) is trimmed.

All of the mistaken nonconsumers in this hypothetical example were low consumers. It is possible, though unlikely, that some could actually have a higher consumption rate and still be misidentified. If this were the case, the mean would show less of a difference than in this example. However, the effect on the 90th percentile (or above) would be the same as long as all the misidentified consumers had a fish consumption rate below the 90th percentile of the true distribution.

In summary, the effect of misidentifying low consumers as nonconsumers is significant for a trimmed distribution. The effect on upper percentiles is greater than the effect on the mean.

How has EPA handled the question of including nonconsumers in these statistics?

EPA based its national recommended fish consumption rates in 2000 and again in 2002 on the whole population, not just consumers, perhaps because the agency recognized the limitations of the consumption studies used to identify consumers and how that might bias statistics in a trimmed distribution (EPA 2000, 2002). EPA may have also based rates on the entire population because marine fish and shellfish were excluded in the chosen rate, making it more likely some fish consumers would be misidentified.

Recommendations

The Idaho Department of Environmental Quality recommends assuming that all Idahoans are likely consumers of some fish and shellfish in their lifetime and that statistics be based on the entire population.

With this assumption, the misclassification of some infrequent consumers of fish as nonconsumers will result in their fish consumption rate being counted as zero when it is not. These excess zeros will have little to no effect on whole population statistics, as seen in the example distributions.

On the other hand, if a regulatory fish consumption rate is based on just fish consumers (i.e., the trimmed dataset), then steps must be taken in survey execution and analysis—such as employing the National Cancer Institute method—to ensure that consumers and nonconsumers are accurately identified. This care is necessary because of the large bias potentially introduced through misidentification.

If only fish consumers are used, this will add a measure of conservatism—greater protection for the whole population—to the extent that a real difference in fish consumption rates exists (i.e., since trimmed data result in higher consumption rates).

References Cited

Ebert, E.S., P.S. Price, and R.E. Keenan. 1994. "Selection of Fish Consumption Estimates for Use in the Regulatory Process." *Journal of Exposure Analysis and Environmental Epidemiology* 4(3):373–393.

EPA (US Environmental Protection Agency). 1999. *Guidance for Conducting Fish and Wildlife Consumption Surveys*. Washington, DC: EPA, Office of Water. EPA 823-B-98-007.

EPA (US Environmental Protection Agency). 2000. *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)*. Washington, DC: EPA, Office of Water. EPA-822-B-00-004.

EPA (US Environmental Protection Agency). 2002. *Estimated Per Capita Fish Consumption in the United States*. Washington, DC: EPA. EPA-821- C- 02-003. 262 pp.

Haubrock, J., U. Nöthlings, J. Volatier, A. Dekkers, M. Ocké, U. Hartig, A. Illner, S. Knüppel, L.F. Andersen and H. Boeing. 2011. Estimating Usual Food Intake Distributions by Using the Multiple Source Method in the EPIC-Potsdam Calibration Study. *The Journal of Nutrition* 141:914–920.

Keogh, R.H. and I.R. White. 2011. Allowing for Never and Episodic Consumers when Correcting for Error in Food Record Measurements of Dietary Intake. *Biostatistics* 12(4):624–636.

Rheinberger, C.M. and J.K. Hammitt. 2012. "Risk Tradeoffs in Fish Consumption: A Public Health Perspective." *Environmental Science and Technology* 46(22):12337–12346.

Subar, A.F., K.W. Dodd, P.M. Guenther, V. Kipnis, D. Midthune, M. McDowell, J.A. Tooze, L.S. Freedman, and S.M. Krebs-Smith. 2006. The Food Propensity Questionnaire: Concept, Development, and Validation for Use as a Covariate in a Model to Estimate Usual Food Intake. *Journal of the American Dietetic Association* 106:1556–1563.

Tooze, J.A., D. Midthune, K.W. Dodd, L.S. Freedman, S.M. Krebs-Smith, A.F. Subar, P.M. Guenther, R.J. Carroll, and V. Kipnis. 2006. A New Statistical Method for Estimating the Usual Intake of Episodically Consumed Foods with Application to their Distribution. *Journal of the American Dietetic Association* 106(10):1575–1587.

Tran, N.L., L.M. Barraj, X. Bi, L.C. Schuda, and J. Moya. 2013. "Estimated Long-Term Fish and Shellfish Intake—National Health and Nutrition Examination Survey. *Journal of Exposure Science and Environmental Epidemiology* 23:128–136.

Vannoy, J. 2013. Personal communication. E-mail form Jim Vannoy, Idaho Department of Health and Welfare, dated September 19, 2013, to Don Essig, Idaho Department of Environmental Quality.