ESTIMATING EXPOSURES TO DIOXIN-LIKE COMPOUNDS FOR SUBSISTENCE ANGLERS IN NORTH AMERICA

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1. Introduction

In conducting human health risk assessments of exposure to dioxins, furans, PCBs, or other persistent organic compounds, some of the highest levels of exposure are believed to be attained through the ingestion of contaminated fish. Typically it has been assumed that recreational anglers have the highest potential for exposure to these compounds because they may have access to large amounts of fish from an impacted location. Fish consumption rates ranging from less than one to more than 180 g/day[1-7] have been used to estimate exposures via this pathway.

Historically, however, there has been concern that there may be a subpopulation of anglers who consume greater amounts of self-caught fish than the general recreational angler population, due to their reliance on fishing as a major or sole source of dietary protein for their families[3,8-11]. In an attempt to be protective of these hypothetical individuals, USEPA[12] has recommended that a fish consumption rate of 180 g/day, equivalent to total substitution of fish for all meat and poultry in the typical American diet, be used to evaluate potential subsistence anglers.

The definition of a subsistence population has traditionally been extremely ambiguous. In North America, Native American populations that have subsistence and treaty rights to certain fisheries[13] and Arctic Inuits who, because of tradition and their remote location, rely heavily on native foods obtained from the sea[14-15], appear to be high consumers. Beyond these fairly well-defined and well-characterized populations, the definition of a subsistence angler is less clear. While the term "subsistence" implies that there is an economic basis for the behavior, the issue of concern from a risk assessment point of view is whether there are any subpopulations that consume fish at higher rates than the distribution of rates for the general recreational angler population.

In order for an individual to consume at high rates, that person must have access to large amounts of the fish and must have either a need or preference to consume locally caught fish in large quantities. There are several ways in which such a population might be defined including:

1) low income individuals who must rely on fish for their dietary needs,
2) native peoples who have cultural traditions of consuming large quantities of fish,
3) commercial anglers who have ready access to large amounts of fish, and
4) recreational anglers who have a strong preference for fish instead of meat or poultry.

The fish consumption habits of the above four subpopulations in North America, compared with the distributions of consumption rates for the general recreational angler population, are discussed below.

2. Income Level

It appears that low income, in and of itself, may not lead to high levels of fish consumption. The fish consumption survey literature indicates that there are no significant differences in fish consumption rates among different income groups[1,4,7,11,16-18]. Wendt[19] studied the fish consumption habits of low income families living in New York State to determine how much freshwater fish they consumed from New York State waters. Based on the reported range of meals and an assumed meal size of 1/2 lb (227 g), it can be estimated that these individuals consumed at a mean rate of 11 g/day and a maximum

rate of 60 g/day. This mean is consistent with the means reported in surveys of New York's recreational anglers[5-6] and other recreational anglers in the northeastern U.S.[1,20], while the maximum rate is lower. Thus, while this pattern may not hold true for other geographic areas, based on these data it does not appear that low income populations living near a waterbody of interest necessarily have higher rates of fish consumption than the population of recreational anglers living in that area.

3. Ethnic background

There are data indicating that certain localized North American ethnic subpopulations may have higher rates of consumption than the general angler population. Studies of native peoples in the Pacific Northwest of the U.S. and Canada indicate that they rely more heavily on fish as a staple of their diets than does the general population[13,15,21-24]. Rates ranging as high as 1,000 g/day have been reported for these people. These differences are generally attributable to the continuation of traditional practices, access to substantial amounts of fish, and, in some cases, lack of availability of market-based foods.

It appears that when individuals from these same ethnic populations reside in a more heterogeneous and economically developed area, these differences diminish[21]. While mean consumption rates reported for native peoples living in closer proximity to economically developed areas were higher than the mean values reported for the general recreational populations[11,23,25-27], their maximum rates were similar. Other comparisons of fish consumption by ethnic background have reported no significant differences among consumption rates for those groups[1,17,28].

There is some indication that certain ethnic populations in North America may consume more fish than the general angler population. It is important to note, however, that while their mean rates of ingestion may be higher than the general angler population, their maximum rates of consumption do not exceed maximum values reported for the recreational angler population, except for those groups that are socially isolated from other ethnic groups and promote traditional ceremonial and dietary practices.

4. Commercial Anglers

Individuals who have commercial fishing licenses have unlimited access to their marketable catch and could be assumed to consume more fish than the recreational angler population. Limited data on the fish consumption activities of freshwater commercial anglers, however, indicate that commercial anglers may not eat substantial amounts of the fish that they harvest, due to the fact that the sale of those fish is critical to their household income and their ability to pay for other foods and living expenses. For example, Hubert et al.[29] who studied commercial freshwater fishing activities in Upper East Tennessee during 1973 reported that, of a total of 94,079 kg of fish commercially harvested by 29 anglers, 2,665 kg were retained for personal use. If those fish were divided among the 29 anglers and their families and assumed to have edible portions of 30 percent[2], the resulting mean consumption rate is 25 g/day. This mean rate is very similar to mean rates reported for recreational anglers fishing large bodies of water[18,30]. Thus is appears that commercial freshwater anglers may not consume substantially more fish than recreational anglers fishing the same types of waterbodies.

5. Recreational Anglers

Fish consumption rates among recreational anglers are highly variable. While most recreational anglers appear to eat very little fish on an annual basis[1,5-7], there is a small fraction of the recreational population that eats large amounts of fish[1,30]. If there were common characteristics that distinguished these anglers from the general recreational population, it might be important to consider them a separate subpopulation for evaluation in risk assessment.

An analysis of the behavioral and demographic characteristics of the top ten percent of Maine freshwater anglers who consumed fish[1] indicated that the anglers with consumption rates at or above the 90th percentile of the fish consumption rate distribution identified in this study were not *distinguishable from other consumers by any factors other than their consumption rates.* An analysis of income levels, ages, and other demographics resulted in no common factors and indicated that these

high consumers represented a cross-section of the total angler population studied. As a result, aside from their high fish consumption rates, there was nothing to identify them as a cohesive, identifiable subpopulation needing to be evaluated separately.

6. Discussion

Based on available survey data and on a critical review of the relevant literature, it is clear that high level fish consumers in North America are a diverse group that can not easily be defined or identified by socioeconomic characteristics. With the exception of certain native peoples who have continued to promote their cultural dietary traditions, there are no characteristics that allow the risk assessor to identify the presence of a high fish consuming population. Rather, high level fish consumers are a diverse group of individuals who consume large amounts of fish for a number of economic, cultural, and preferential reasons.

The exception to this may be localized ethnic populations that have strong cultural ties and practices. In this situation, there may be promotion of traditional fish consuming behaviors for those cultures that have historically relied an the consumption of large amounts of fish to meet their dietary protein needs. If such a population is present, its consumption rate distribution may not be well represented by the consumption rate distributions reported for recreational anglers and should be carefully evaluated.

Unless such a population is known to exist in the area of interest, risks to the high-end exposed individuals within a given population can likely be adequately addressed by selecting an upper percentile value ($\geq$90th percentile) from the consumption distributions derived from surveys of recreational anglers. It is important to note, however, that while the range of values in those distributions may include values for the high end individuals, the skewness of the distributions may differ (i.e., the means may differ) so that the shape of the distribution for recreational anglers may not correspond to the distribution of consumption rates for certain segments of the population. In addition, the conclusions drawn from this analysis may not hold true for other geographic areas where ethnic backgrounds vary and there is less demographic diversity in the recreational angler population.

7. References

1) Ebert, E.S., N.W. Harrington, K.J. Boyle, J.W. Knight and R.E. Keenan (1993): Estimating consumption of freshwater fish among Maine anglers. N. Am. J. Fish. Mgt. 13:737-745.
2) USEPA (1989): Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish: A Guidance Manual. U.S. Environmental Protection Agency, Washington, D.C. EPA-503/8-89-002. September.
3) USEPA (1995): Exposure Factors Handbook - Review Draft. U.S. Environmental Protection Agency,Washington, DC. EPA/600/P-95/002A. June.
4) Connelly, N.A., T.L. Brown, and B.A. Knuth (1990): New York Statewide Angler Survey 1988. New York State Department of Environmental Conservation, Division of Fish and Wildlife, Albany, NY. April.
5) Connelly, N.A., B.A. Knuth and C.A. Bisogni (1992): Effects of the Health Advisory Changes on Fishing Habits and Fish Consumption in New York Sport Fisheries. Project No. R/FHD-2-PD. Cornell University, Ithaca, NY. September.
6) Connelly, N.A., B.A. Knuth, and T.L. Brown (1996): Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. North American Journal of Fisheries Management 16:90-101.
7) West, P.C., J.M. Fly, R. Marans and F. Larkin (1989): Michigan Sport Anglers Fish Consumption Survey. University of Michigan, School of Natural Resources, Ann Arbor, MI. Technical Report No. 1. May.
8) Abraham, K., L. Alder, H. Beck, W.Mathar, R. Palavinskas, U. Steuerwald, and P. Weihe (1995). Organochlroine compounds in human milk and pilot whale from Faroe Islands. 15th International Symposium on Chlorinated Dioxins and Related Compounds 26:63-67. Edmonton, Canada. August 21-25.
9) Becher, G., H.R. Johansen, J. Alexander, M.Løvvik, P.I. Gaarder, and W. Gdynia (1995). Consumption of crabs and body burden of PCDDs/PCDFs: A study of male crab consumers from a

polluted fjord area in Norway. 15th International Symposium on Chlorinated Dioxins and Related Compounds 26:39-43. Edmonton, Canada. August 21-25.
10) McCormack, C. and D. Cleverly (1990): Analysis of the potential populations at risk from the consumption of freshwater fish caught near paper mills. U.S. EPA. April 23.
11) West, P.C., J.M. Fly, F. Larkin, and R. Marans (1991): Minority anglers and toxic fish consumption: Evidence from a state-wide survey of Michigan. In: Proceedings of the Michigan conference on race and the incidence of environmental hazards (Bryan and Mohai, eds.).
12) USEPA (1989): Exposure Factors Handbook. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-89/043. July.
13) Columbia River Inter-Tribal Fish Commission (CRITFC) (1994): A fish consumption survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin. Technical Report 94-3. October.
14) Kinloch, D., H. Kuhnlein and D.C.G. Muir (1992): Inuit foods and diet: a preliminary assessment of benefits and risks. Sci. Tot. Environ. 122:247-278.
15) Coad, S. (1994): Consumption of Fish and Wildlife by Canadian Nature Peoples: A Quantitative Assessment from the Published and Unpublished Literature. Health and Welfare Canada.
16) Javitz, H. (1980): Seafood Consumption Data Analysis; Final Report. Prepared by Statistical Analysis Department, SRI International for U.S. Environmental Protection Agency, Washington, D.C. Contract No. 68-01-3887. September 24.
17) Anderson, A.C. and J.C. Rice (1993): Survey of fish and shellfish consumption by residents of the greater New Orleans area. Bull. Environ. Contam. Toxicol. 51:508-514.
18) Southern California Coastal Water Research Project (SCCWRP) and MBC Applied Environmental Sciences (1994): Santa Monica Bay Seafood Consumption Study. Santa Monica Bay Restoration Project, Monterey Park, CA. June
19) Wendt, M.E. (1986): Low income families' consumption of freshwater fish caught from New York State waters. Masters Thesis. Cornell University. August.
20) Ebert, E.S., S.H. Su, T.J. Barry, M.N. Gray, and N.W. Harrington (1996): Estimated Rates of fish consumption by anglers participating in the Connecticut Housatonic River creel survey. N. Am. J. Fish. Mngt. 16:81-89.
21) Wolfe, R.J. and R.J. Walker (1987): Subsistence economies in Alaska: Productivity, geography, and development impacts. Arctic Anthropology 24(2):56-81.
22) Dewailly, E., A. Nantel, J.P. Weber and F. Meyer (1989): High levels of PCBs in breast milk of Inuit women from arctic Quebec. Bull. Environ. Contam. Toxicol. 43:641-646.
23) NYSDOH (1993): Health Risk Assessment for the Akwesasne Mohawk Population from Exposure to Chemical Contaminants in Fish and Wildlife from the St. Lawrence River Drainage on Lands of the Mohawk Nation at Akwesasne and Near the General Motors Corporation Central Foundry Division at Massena, New York. New York State Department of Health, Bureau of Toxic Substance Assessment. October.
24) Richardson, G.M. and D.J. Currie (1993): Estimating fish consumption rates for Ontario Amerindians. J. Expos. Anal. Environ. Epi. 3(1):23-37.
25) Selikoff, I.J., E.C. Hammond, and S.M. Levin (1982): Environmental contaminants and the health of the people of the St. Regis Reserve. Vol. II.
26) Hutchison, R. and C.E. Kraft (1994): Hmong fishing activity and fish consumption. J. Great Lakes Res. 20(2):471-478.
27) Peterson, D.E., M.S. Kanarek, M.A. Kuykendall, J.M. Diedrich, H.A. Anderson, P.L. Remington and T.B. Sheffy (1994): Fish consumption patterns and blood mercury levels in Wisconsin Chippewa Indians. Arch. Environ. Health 49(1):53-58.
28) Landolt, M.L., F.R. Hafer, A. Nevissi, G. van Belle, K. Van Ness and C. Rockwell (1985): Potential Toxicant Exposure Among Consumers of Recreationally Caught Fish from Urban Embayments of Puget Sound. National Oceanic and Atmospheric Administration, Rockville, MD. Tech. Memo. NOS OMA 23. November.
29) Hubert, W.A., A.O. Smith, W.T. Morgan, W.P. Mitchell, and R.L. Warden (1975): Summary of Commercial Fisherman Surveys 1971-1974. Tennessee Valley Authority, Muscle Shoals, Alabama.
30) 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.