CONSUMPTION OF FRESHWATER FISH BY MAINE ANGLERS

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ABSTRACT

In deriving a water quality standard that is protective of human health, it is essential that realistic estimates of exposure be used. For lipid-soluble chemicals like 2,3,7,8-tetrachlorodibenzo-p-dioxin, the most important potential route of human exposure is through direct ingestion of fish. Historically, it has been stated that recreational anglers incur the greatest potential for exposure due to their presumed high levels of fish consumption. However, a number of site-specific factors including species preference, availability, access, length of fishing season, and cultural heritage can greatly influence rates of freshwater fish consumption within a single region of the United States. It is inappropriate to generalize by applying a fish consumption estimate from one region of the country to another region for the purpose of deriving state-specific water quality regulations as there is a potential to severely overestimate or underestimate actual rates of consumption. To avoid this deficiency, a statewide mail survey was undertaken to characterize current rates of freshwater fish consumption by Maine's resident recreational anglers. Results of the survey indicate that consumption of freshwater fish is considerably lower in Maine than has been reported for other regions of the country. Findings of the study confirm that state- or region-specific estimates of fish consumption should be developed for use in establishing water quality regulations that are based on the protection of human health.

KEY WORDS

2,3,7,8-TCDD, dioxin, fish consumption, water quality

INTRODUCTION

In recent years, a number of states have derived ambient water quality standards for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) using EPA's (1984) default value of 6.5 g/day for fish consumption. This value, used by the EPA (1984) in developing its Ambient Water Quality Criteria for TCDD, is a national per capita fish consumption rate which includes all commercially-harvested and recreationally-caught freshwater and estuarine fish and shellfish (EPA 1989a). While this consumption rate may be reasonable for certain regions of the country where TCDD affects commercial freshwater and estuarine fisheries from which fish are harvested for distribution to the general population, it is not an appropriate rate for states in which there are no commercial fisheries on impacted inland waters.

In the state of Maine, TCDD has only been detected in fish tissues collected from certain non-estuarine reaches of a few warmwater rivers in the state. Because Maine has no commercial fisheries on the rivers, potentially impacted fish are not available to the general population, but rather, are only available to anglers who fish these waters and those individuals who share in their harvest. Because this was the only population potentially impacted by fish from these rivers, it was believed that a region or state-specific estimate of consumption of freshwater fish from rivers should be used a the basis for a water quality standard for TCDD in Maine

Published studies that specifically investigate or estimate freshwater fish consumption in Maine are nonexistent. The fish consumption data that are available in the scientific literature are based on national surveys or are specific to other regions of the country (Rupp et al., 1980; Humphrey, 1978; Parsons et al., 1991; Puffer et al., 1981; Pierce et al., 1981; Javitz, 1980; Honstead et al., 1971.). Many surveys make no distinction between the consumption of commercially-harvested and recreationally-harvested fish (Javitz, 1980; EPA, 1989a). The most frequently used estimates of fish consumption are of limited use for estimating freshwater fish consumption from Maine rivers because they are either based on marine studies (Puffer et al., 1981; Pierce et al., 1981) or include a

combination of both saltwater and freshwater species and do not consider the sources of the fish consumed in the diet (Javitz, 1980; EPA, 1989a). Furthermore, the use of freshwater fish consumption studies from one region of the U.S. may overestimate or underestimate the consumption of freshwater fish in another region of the country as differences in preferred species, availability, access, length of fishing season and cultural heritage can greatly influence freshwater fish consumption in a particular region.

Due to lack of relevant data pertaining to consumption of freshwater species from rivers in Maine or the northeastern United States, a statewide mail survey of licensed resident anglers was undertaken. The purpose of this study was to characterize the rates of freshwater fish consumption by Maine's resident anglers. This study was modeled after earlier surveys conducted on behalf of the Maine Department of Inland Fisheries and Wildlife (IFW) (Boyle et al., 1989). These IFW surveys assessed angler effort. The present investigation was designed to determine what amount and proportion of the fish catch harvested from Maine's inland waters is consumed daily by licensed anglers.

METHODS

Survey design and implementation

A statewide mail survey was developed with the assistance of HBRS in Madison, Wisconsin, resource economists at the University of Maine, and fisheries biologists with IFW. A pretest of the survey was conducted in order to evaluate whether respondents had difficulty in understanding or responding to any of the survey questions. Based on responses gathered in telephone interviews in the pretest and a review of the returned pretest surveys, final revisions to the survey were made.

The sample population consisted of Maine residents holding a valid Maine fishing license in 1989. A total of 2,500 surveys were mailed to Maine resident anglers whose names were randomly selected from the 1989 license files of IFW. Because IFW license files for 1990 were incomplete at the time that the sample was selected, names were randomly selected from the complete 1989 IFW files of resident fishing licenses. As open water fishing season for most Maine waters closes September 30, surveys were mailed in mid-October of 1990. Postcards were sent one week later, thanking those who had already returned the survey, and asking those who had not yet returned the survey to do so. On November 7, 1990, a follow-up survey packet was mailed to 1,111 anglers who had not yet responded, and the recipients were asked to complete and return the survey by December 3, 1990.

Data Analysis

A numerical coding scheme was used to record responses to each question in the mail survey. Each returned survey was translated to numeric values and edited, and the numeric values were then entered into a data base using the SPSS/PC (V3.1) + Data Entry II Program (SPSS, 1989). To verify that all data were entered correctly, each completed survey was entered twice and the results compared. Response frequencies were constructed for each survey question as a final check for data entry accuracy.

Anglers were asked to report the number of each species of fish caught during the 1989-1990 ice fishing season and 1990 open water season. For those fish caught during open water season, anglers were asked to report and differentiate between fish obtained from standing waters (lakes and ponds) and those obtained from flowing waters (rivers and streams). Of the total fish caught, anglers were asked to estimate the total number of fish and the average length of each fish that was eventually consumed. In addition to those fish caught by the responding angler, the respondents were also asked to describe the number, species and average length of each consumed fish which was obtained from other members of the respondent's household and from individuals outside of the household.

For analytical purposes, the population of interest was defined as all respondents who fished in either the 1989-1990 ice fishing or 1990 open water fishing seasons, and all respondents who did not fish in either season, but consumed Maine freshwater fish caught by either another member of the respondent's household or by someone outside the respondent's household. Respondents were also asked to report the number of other freshwater fish consumer living in the respondent's household.

The ice fishing season may include the end of one calendar year and the beginning of the next calendar year. As it was believed that ice fishermen would likely recall the season as a whole rather than just

that portion occurring in 1990, anglers were asked about the entire 1989-1990 ice fishing season. It was assumed that the frequency and success of ice fishing trips in the late Fall and early Winter of 1989 would be representative of trips to be taken in the late Fall and early Winter of 1990. Therefore, to avoid duplication, anglers were not asked to estimate ice fishing trips planned for the late Fall of 1990.

Because some Maine waters are open for limited fishing until October 31, respondents were asked whether they planned to make any additional open water fishing trips between the date of completion of the survey and the end of October, a period of no more than two weeks. If they did plan future trips, they were asked to indicate how many future trips were planned.

Each respondent was asked to report how many fishing trips had been made to ice fishing, standing water, and flowing water locations during the season. The total number of reported trips was calculated for each angler, as was the ratio of trips to flowing waters to trips to standing waters and ice fishing locations. Future consumption from all waters and from flowing waters was estimated by assuming that consumption from future trips would be directly proportional to reported consumption from completed trips.

Estimating Fish Consumption Rates

The total mass of freshwater fish consumed by each respondent's household was estimated from the respondent-provided information on quantity and average length of each consumed fish species. For example, the equation used to estimate the mass of freshwater fish consumed from ice fishing sources is presented below:

$$IMC_i = QI_i \times 10^{\{C_i + n_i \log (LI_i \times f)\}} \times EP_i$$

where:

IMC_i	=	Total mass of freshwater fish species i consumed by angler and household from Maine ice fishing sources (g)
QI_i	=	Quantity of fish species i consumed from Maine ice fishing sources;
C_i	=	Constant in length/mass relationship for species i (log g)
n_i	=	Slope in length/mass relationship for species i (log g/log mm)
LI_i	=	Average length of consumed freshwater fishspecies i from Maine ice fishing sources (in)
f	=	conversion factor (25.4 mm/in)
EP_i	=	Fraction of whole fish mass that is edible for species i (g consumed/g whole fish)

For each fish species, the mass of each fish was estimated from the lengths reported by each angler using a standard length to mass relationship expressed as a linear regression based on logarithms (Nielsen and Johnson, 1983; Cone, 1989):

$$\log (W) = C + n \text{ Log } (L)$$

The parameters C and n are species-specific constants. The exact value of n is dependent on the shape of the fish; however, it usually approximates 3 (Nielsen and Johnson, 1983). The exact value of each parameter is affected by several variables including season, the type of waterbody in which the fish resides, the sex, age and sexual maturity of the fish. Because these parameters can vary widely, the relationship for a particular species in a given river, lake, or stream is most precisely determined by site-specific sampling and measurement.

For several species, constants relating length to mass were taken from logarithmic regression equations specific to the state of Maine. These constants were obtained from IFW and were derived from length and mass measurements compiled over several years from numerous Maine rivers and lakes. For those species for which Maine-specific equations were not available, the most appropriate relationship was selected from those reported in the available literature (Carlander, 1969; 1977).

Using the length-mass relationship yields the mass of the whole fish based on its length. Because not all of the fish is edible, it was necessary to characterize the relationship between the mass of a whole fish, and that portion considered to be edible. The EPA (1989b) recommends that 30 percent be used to estimate the edible portion of finfish. Specific studies were undertaken to determine the edible portion of smallmouth bass and landlocked salmon in Maine (Ebert, 1991a). In these Maine studies, the edible portion was defined as being synonymous with fillet size. Although it is recognized that a number of fish species may not be

filleted, overall the use of fillet data is a reasonable estimator for the edible portion of the fish.

For smallmouth bass collected from two Maine rivers, the mean edible portion was approximately 30 percent of the whole fish mass (Ebert, 1991a). Landlocked salmon demonstrated a mean edible portion of 37 percent (Ebert, 1991a). Based on recommendations by EPA (1989b) and the results of the Maine-specific studies (Ebert, 1991a), conservative edible portions of 40 percent for landlocked salmon and Atlantic salmon and 30 percent for all other species except smelt were selected to estimate consumable mass. For smelt, a higher edible portion estimate of 78 percent was used. Selection of this higher multiplier was based on the knowledge that some smelt consumers eat all but the head of the fish, while others do not eat the viscera or the head. Data on the relative weight of head and viscera, as recorded during the analyses of landlocked salmon edible portion (Ebert, 1991b), were used to estimate the edible portion for smelt.

The freshwater fish mass consumed from Maine ice fishing sources by the angler and his or her household was then calculated as the sum of IMC_i over the fifteen species. Analogous equations were developed for calculating consumption from lakes and ponds, rivers and streams, other household sources, and non-household sources, based on reported quantities and lengths of fish consumed from each of these sources.

For those 88 respondents indicating that future fishing trips were planned, the freshwater fish consumption rate from these future trips was estimated on the plausible assumption that consumption of fish from future trips would be proportional to consumption from trips already completed and reported.

The average daily freshwater fish reported consumption rate from all Maine sources for individual members of a respondent's household was computed by summing the source-specific and computed future mass of fish consumed and then dividing by household size, using the following equation:

$$FCA = (IMCT + SMCT + FMCT + HMCT + OMCT + MCF) \times 1/HS \times 1/T$$

where:

FCA	=	Freshwater fish consumption from all Maine sources (g/person-day)
IMCT	=	Total mass of freshwater fish consumed from Maine ice fishing sources (g)
SMCT	=	Total mass of freshwater fish consumed from Maine standing water sources (g)
FMCT	=	Total mass of freshwater fish consumed from Maine flowing water sources (g)
HMCT	=	Total mass of freshwater fish consumed from other household sources (g)
OMCT	=	Total mass of freshwater fish consumed from other non-household Maine sources (g)
MCF	=	Total mass of freshwater fish estimated to be consumed from future fishing trips (g)
HS	=	Number of persons in angler's household reported to consume freshwater fish (persons)
T	=	Time over which fish was consumed (365 days)

Household size was calculated as the number of persons in the angler's household who were reported to eat the freshwater fish caught. The mass of fish consumed per household member was then divided by 365 days to yield an annualized per-person per-day fish consumption estimate.

Estimates of freshwater fish consumption from flowing water only were computed using a similar method. Future consumption attributable to flowing waters was estimated by multiplying the future consumption estimated for all sources by the ratio of the number of fishing trips reported for flowing waters to the total number of fishing trips reported. The portion of consumption from other household and non-household sources attributable to flowing waters was estimated based on the ratio of reported consumption from flowing water to reported consumption from ice fishing, standing water, and flowing water combined.

RESULTS

A total of 1,612 surveys were completed and returned. Of these, 1,369 reported having fished during the 1989-90 ice fishing season or the 1990

open water season, or having consumed Maine freshwater fish caught during the 1989-1990 season. A total of 1,251 respondents reported having fished during either the ice fishing season or the open water season or both. Of the 599 individuals who indicated that they had gone ice fishing, 508 (85 percent) reported having caught fish. Of the 1,127 individuals who went open water fishing, 1,053 reported having fished in ponds or lakes and 745 reported having fished in streams and rivers. A total of 976 individuals (87 percent) reported having caught fish on at least one open water fishing trip during the 1990 season. While 352 respondents did not fish in either season, 109 of these did consume freshwater fish from other Maine sources. These 109 respondents, with the 1,251 who fished in 1989-90, made up the 1,369 anglers defined as the population of interest.

Due to the large sample size, statistical analysis was conducted without assuming a distributional model. Table 1 presents the median (50th percentile), 66th, 75th, 90th, and 95th percentiles which were calculated by rank to summarize fish consumption rates.

Consumption of fish caught in all types of waterbodies including lakes, ponds, streams and rivers, is designated as "All Waters" whereas consumption of fish from flowing waters only is designated as "Rivers and Streams". Within the "All Waters" category, there are two subgroups identified: "All Anglers", representing the total respondent population of interest and their households, including non-consumers; and "Consuming Anglers", representing fish-consuming angler households only. In addition to the "All Anglers" and "Consuming Anglers" designations within the "Rivers and Streams" category, a third subgroup was identified. This group, designated as "River Anglers" includes survey respondents (consumers and non-consumers) who indicated that they fished on rivers or streams at least once during the 1990 open water season, or who consumed fish attributable to rivers and streams.

The median consumption rate for All Anglers from All Waters was 1.1 g/day while the 75th percentile for this group was 4.2 g/day and the 95th percentile was 21 g/day. Median consumption for Consuming Anglers was 2.0 g/day with a 75th percentile of 5.8 g/day and a 95th percentile of 26 g/day. For flowing waters only, the median consumption rate for all anglers, consuming and not consuming, was 0 g/day with a 75th percentile of 0.37 g/day and a 95th percentile of 4.4 g/day. For all River Anglers (including consumers and non-consumers), the median consumption rate was 0 g/day with a 75th percentile of 0.81 g/day and a 95th percentile of 5.7 g/day. For Consuming Anglers only, the median consumption rate was 0.99 g/day with a 75th percentile of 2.5 g/day and a 95th percentile of 12 g/day.

DISCUSSION

The EPA has stated that "whenever possible, data on local consumption patterns should be collected or obtained from a current database" (EPA, 1989b). This survey was undertaken in an effort to provide information on the freshwater fish consumption habits of Maine anglers. The results of this study provide the most accurate and only known characterization of freshwater fish consumption habits by Maine's anglers.

A significant finding of this survey is that many anglers do not consume any freshwater fish. Twenty-three percent of all anglers surveyed reported that they consumed no freshwater fish caught in 1990. Fifty-five percent of the river anglers surveyed reported that they ate no freshwater fish during the 1990 season.

In this statewide mail survey, the median consumption rate for all anglers and for river anglers on flowing waters, including non-consumers, was 0 g/day while the median for consuming anglers on flowing waters was 0.99 g/day. For all waterbody types, the median for all anglers was 1.1 g/day and the median for consuming anglers only was 2.0 g/day.

It is important to note that because the fish consumption rates are positively skewed rather than symmetrically distributed, the arithmetic mean is not the most appropriate descriptive measure of the center of the distribution. The median, or 50th percentile, is a more physically relevant central tendency measure for a skewed dataset as 50 percent of consumption rate estimates lie above the median and 50 percent fall below the median. Thus, the median values provide the most representative consumption rate estimate for each of the angler populations.

It is likely that these fish consumption rates may be overestimated due to survey biases. Chase and

Harada (1984) have reported that participants responding to self-report surveys tend to over-report their actual participation in recreational activities. Similar results were reported by Soldat (1970) in his survey of Columbia River anglers. In a study done for the U.S. Fish and Wildlife Service Westat, Inc. (1989) reported that a one-year recall period produced "substantial overestimates" of fishing statistics. Westat, Inc. (1989) stated that factors that can affect reporting include the length of the recall period, the frequency of the fishing trips, interest in or importance of the activity to the individual, and the perceived social desirability of the activity. Similar biases have been reported in other studies of recreational activities (Ghosh, 1978; Chase & Godbey, 1983).

The results of this survey indicate that the consumption of freshwater fish by Maine's anglers is low. The consumption rate estimates for the median consumers in each of the angler groups were well below the EPA's (1984) recommended per capita estimate of 6.5 g/day. In fact, the EPA's estimate represents the 96th percentile of consumption for all river anglers and the 92nd percentile of consuming river anglers. Results of this study indicate that rates of consumption of freshwater fish from Maine's rivers are considerably lower than those from Maine's lakes and ponds or from rivers in other regions of the country.

Table 1. Analysis of Fish Consumption Rates

	All Waters[a]		Rivers and Streams[b]		
	All Anglers[c]	Consuming Anglers[d]	All Anglers[c]	River Anglers[e]	Consuming Anglers[d]
N of Cases	1,369	1,053	1,369	745	464
Median (50th percentile)[f,g]	1.1	2.0	0	0.28	0.99
66th percentile [f,g]	2.6	4.0	0	0.85	1.8
75th percentile [f,g]	4.2	5.8	0.37	1.4	2.5
Arithmetic Mean [f]	5.0	6.4	1.2	2.3	3.7
Percentile at the Mean [g]	79	77	85	83	81
90th percentile [f,g]	11	13	2.1	4.2	6.1
95th percentile [f,g]	21	26	4.4	6.7	12
Percentile at 6.5 g/day [g,h]	83	77	97	95	92

a. "All Waters" based on fish obtained from all lakes, ponds, streams and rivers in Maine, from other household sources and from other non-household sources.
b. "Rivers and Streams" based on fish caught only from rivers and streams in Maine.
c. "All Anglers" includes survey respondents (consumers and non-consumers) who fished during the 1989-1990 ice fishing or 1990 open water seasons as well as those anglers who did not fish but reported consuming freshwater fish caught from Maine sources during those seasons.
d. "Consuming Anglers" refers to only those anglers who consumed freshwater fish obtained from Maine sources during the 1989-1990 ice fishing or 1990 open water fishing season.
e. "River Anglers" is a subset of "All Anglers." "River Anglers" includes survey respondents (consumers and non-consumers) who indicated that they fished on rivers or streams during the 1990 open water season.
f. Fish consumption rates are expressed in g/person-day and are the average consumption per day by freshwater fish consumers in the household. Fish consumption rates under "All Waters" are based on reported consumption from all Maine sources, and estimated consumption during 1990 after the survey was completed. Rates summarized under "Rivers and Streams" are based on reported consumption from rivers and streams, estimated consumption during 1990 after the survey was completed, and estimated consumption from other household and non-household sources attributable to rivers and streams.
g. Calculated by rank without any assumption of statistical distribution.
h. Fish consumption rate recommended by EPA (1984) for use in establishing ambient water quality standard

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Session 31. Poster Session

The following papers (Session 31) have been reviewed by the Technical Program Committee of the TAPPI Environmental Division and approved for publication based on two criteria: (1) the ideas appear to be new and (2) the papers present technical information rather than a commercial.