

From: [David Mayfield](#)
To: [ECY RE Fish Consumption](#)
Subject: Statewide Fish Surveys
Date: Thursday, November 10, 2011 6:06:18 AM
Attachments: [Mayfield et al. 2007-Fish.pdf](#)

Did WA DOE consider providing estimates for the general population as well as high-end consumers. Several relevant surveys have been conducted which should be incorporated into your assessment. In addition, EPA just released it's revised Exposure Factors Handbook which should be cross-referenced here.

Please see:

Results of a human used survey for shoreline areas of lake union, lake Washington, and lake sammammish

<http://your.kingcounty.gov/dnrp/library/2006/kcr1967.pdf>

Survey of fish consumption patterns of King County (Washington)
recreational anglers (attached)

Exposure Factors Handbook 2011 Edition (Final)

<http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252>

Thank you for your consideration.

David Mayfield, MS, DABT | Toxicologist
206-267-2919 | dmayfield@gradientcorp.com

Gradient | 600 Stewart Street | Seattle WA, 98101 | 206-267-2920 | www.gradientcorp.com

This message contains information which may be confidential or privileged. Unless you are the addressee (or authorized to receive for the addressee), you may not use, copy, or disclose to anyone this message or any information contained in the message. If you have received this message in error, please advise the sender by reply e-mail, and delete all copies of this message and its attachment(s).

Survey of fish consumption patterns of King County (Washington) recreational anglers

DAVID B. MAYFIELD^a, SUE ROBINSON^a AND JIM SIMMONDS^b

^a*Parametrix Inc., Bellevue, Washington, USA*

^b*King County Department of Natural Resources and Parks, Seattle, Washington, USA*

Three fish consumption surveys were conducted in King County, WA during 1997–2003. These surveys were conducted to support environmental analyses of proposed capital improvement projects planned by the King County Department of Natural Resources and Parks. Personal interviews were conducted at marine, estuarine, and freshwater locations throughout King County. Over 1300 anglers participated in the survey and provided consumption information. A majority of the respondents from the surveys (30–71%) were Caucasian, while the remaining respondents comprised various ethnic groups. The mean consumption rates for consumers of marine fish, shellfish, and freshwater fish were 53, 25, and 10 g/day, respectively. Results indicate that the consumption patterns of marine anglers from King County have remained consistent since the mid-1980s. The consumption distribution for marine anglers suggests that some respondents may consume fish as a large portion of their diet. The consumption habits of freshwater anglers are comparable to those of other recreational anglers throughout the United States. The survey results provide distributions of marine and freshwater fish consumption suitable for risk assessments conducted for anglers residing in King County, WA.

Journal of Exposure Science and Environmental Epidemiology (2007) 17, 604–612; doi:10.1038/sj.jes.7500559; published online 28 February 2007

Keywords: *risk assessment, exposure assessment, fish consumption*

Introduction

Governmental agencies must continually develop environmentally safe capital improvement projects to sustain the infrastructure of growing urban areas. Common projects can include the expansion of roads and utility services (e.g., water, sewer, and electricity) or construction of new public use areas. In addition to providing improved services, regulatory agencies must consider the consequences of proposed land use plans on public health as part of required environmental studies. This may include an assessment of public health risks from physical, chemical, or biological alterations in the environment (i.e., through the risk assessment process).

The King County Department of Natural Resources and Parks, Wastewater Treatment Division has engaged in a number capital improvement projects over the past decade. During the planning and design phases of its projects, the Department of Natural Resources and Parks conducted a number of surveys of public use areas to gather information

on the recreational patterns of King County residents. The surveys were designed to establish patterns of exposure for use in site-specific risk assessments. In addition to describing recreational patterns of exposure (data not presented herein), the surveys examined the potential for exposure to contaminants through consumption of locally caught fish and shellfish. While there is available information on national fish consumption patterns, the United States Environmental Protection Agency (US EPA) recommends the use of site-specific consumption information over default assumptions based on national studies (US EPA, 1999, 2000, 2002).

Several fish consumption studies have been conducted in Washington State (Pierce et al., 1981; Landolt et al., 1985, 1987; McCallum, 1985; CRITFC, 1994; Toy et al., 1996; WA DOH, 1997, 2001; Suquamish Tribe, 2000; Sechena et al., 2003). However, studies that focused on the general population of marine anglers were conducted over 15 years ago (Pierce et al., 1981; Landolt et al., 1985, 1987; McCallum, 1985). Surveys of freshwater anglers in Washington state were conducted at locations outside of the project area (i.e., King County, WA, USA) (CRITFC, 1994; WA DOH, 1997, 2001). More recent studies have focused only on populations with high (i.e., subsistence) consumption patterns (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000; Sechena et al., 2003). Thus, the purpose of the surveys conducted by the Department of Natural Resources and

1. Address all correspondence to: DB Mayfield, Parametrix Inc., 411 108th Ave NE, Suite 1800, Bellevue, Washington 98004, USA.

Tel.: +1-425-458-6200. Fax: +1-425-458-6363.

E-mail: dmayfield@parametrix.com

Received 22 May 2006; accepted 15 December 2006; published online 28 February 2007

Parks was to update existing information on the consumption patterns of the general population of marine anglers in King County. Freshwater anglers in King County have not been examined in any previous investigation; thus, the results presented here define consumption rates for a population that has not been adequately described.

This paper details the results from three recreational fish consumption surveys conducted in King County during 1997–2003. Information on the patterns of anglers interviewed at marine, estuarine, and freshwater locations are summarized. These include fishing frequency, species caught, and consumption preferences. Distributions of consumption rates of fish and shellfish are quantified in grams per day for each of the surveys. Finally, the results are compared to other local and national consumption surveys.

Methods

Three consumption surveys were conducted over varying years and locations throughout King County, Washington (Figure 1). The first survey was conducted during a 10-week period from June 1997 to August 1997. The locations of this survey included marine and estuarine public parks and boat launches throughout Elliott Bay and the Duwamish River (Figure 1). The Duwamish River is an estuary that discharges into Elliott Bay and is subject to marine tidal influences. Anglers from this section of the Duwamish River primarily caught marine species; thus, these locations are treated as marine locations rather than freshwater. The results of this survey were reported previously by Simmonds et al. (1998); however, a detailed analysis of fish and shellfish consumption rates was not performed in this report. Thus, the methods and results presented herein provide a more detailed re-analysis of the original data. The second survey (North King County) was conducted over 1-year from March 2001 to March 2002. This survey focused on marine locations throughout North King County and Snohomish County. The third survey was conducted at freshwater locations around Lake Sammamish, Lake Washington, and Lake Union from June 2002 to May 2003. The North King County and King County Lakes surveys were each coupled with an additional survey that focused on sand and water contact activities (data not presented). The personal interview design and survey questionnaires were developed in accordance with US EPA guidance for conducting fish consumption surveys (US EPA, 1992, 1998).

Survey Design and Surveyor Training

The survey design and surveyor training was consistent between the three surveys with minor differences. The Elliott Bay and Duwamish River surveys were performed over 10 weeks on Saturdays and Sundays and 10 (randomly selected)

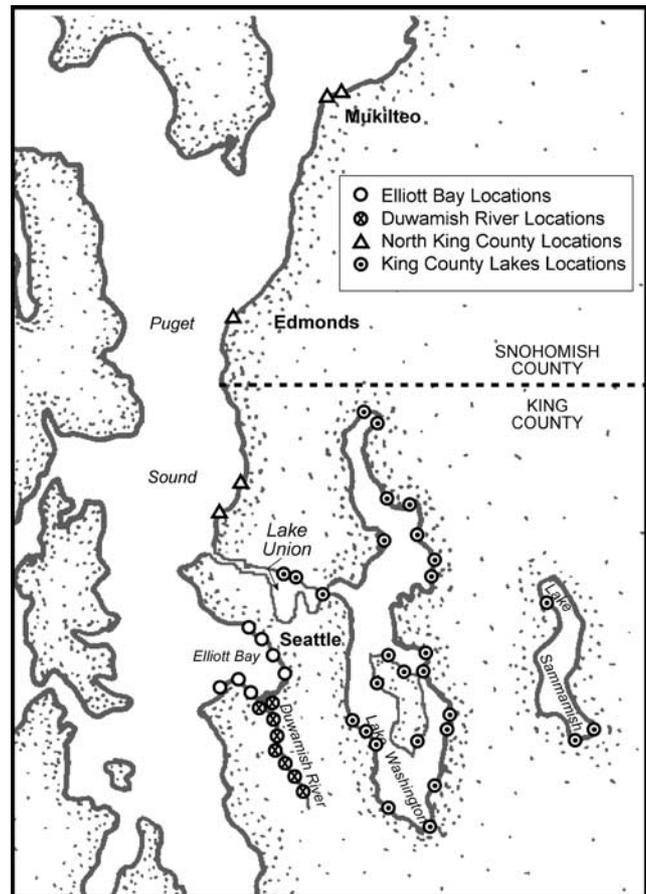


Figure 1. Survey locations.

weekdays. Locations were visited randomly between the hours of 0500–2200 hours. The locations of the survey included public parks and popular fishing areas throughout the project area. Each location was visited at least twice a day (a.m. and p.m.).

The North King County and King County Lakes surveys followed a stratified random design and were conducted over a period of 1 year. The locations of the surveys included marine and freshwater public parks and boat launches throughout King County and part of Snohomish County, WA, USA. Locations were visited randomly during open hours, typically between 0700 to 2000. The locations were visited on both weekdays and weekends throughout the year. Surveyors attempted to interview as many anglers and recreational users as possible within a 1-h site visit. The interview process typically required 5–10 min to complete. Before the start of all surveys, the surveyors were trained on how to fill out the forms and how to approach potential respondents. To avoid introducing bias, the surveyors wore no identifying caps or badges and did not mention any of the intended capital improvement projects planned throughout King County.

Survey Instrument

A survey questionnaire was designed for each of the three surveys to gather information on fishing frequency and consumption preferences. The two-page questionnaire included questions for respondent demographics, fishing location preferences, fishing frequency, consumption rates, preferred species, and preferred cooking methods. Specifically, the forms included questions to record the age, sex, and ethnicity of the respondents. Frequency-specific questions sought information on the typical number of hours and number of days spent at survey locations. In addition, questions designed to estimate the frequency (days/year) of visiting King County specific locations were included. Consumption-specific questions included noting the type of fish typically collected (fish or shellfish), the intended use of catch (e.g., consume, catch, and release), and cooking preferences (e.g., grilled, boiled, broiled). In addition, it was noted if the respondent's family included children, approximate age of the children, and whether they also consume the respondent's catch. Finally, surveyors were instructed to weigh (with a hand held scale) any fish or shellfish that had been caught during the time of the interview. Respondents typically did not have a catch to weigh or refused to have their catch weighed. Thus, limited data on actual harvested weights was obtained from these surveys.

Calculation of Consumption

In order to compare the results from surveyed marine sites to previous studies conducted in or near King County, the method for calculation of fish and shellfish consumption (i.e., the harvest method) was adopted (Puffer et al., 1981; Landolt et al., 1985, 1987; US EPA, 1988). This method provides estimates of consumption by combining information on fishing frequency and the weight of fish caught during the time of the interview. The equation for fish and shellfish consumption is:

$$\text{consumption rate (g/day)} = (\text{FF} \times \text{W} \times \text{CF}) / (\text{NF} \times \text{AT})$$

where FF is the frequency of fishing (days/year); W the total weight of catch (grams/catch); CF the cleaning factor (0.3 for all fish, 0.49 for all shellfish); NF the number in family consuming catch; and AT the averaging time (365 days/year).

The frequency of fishing for the Elliott Bay, Duwamish River, and North King County surveys was based upon the respondents estimated number of days spent fishing per year. Due to the limited number of fish actually measured during the time of the interviews, a mean value for total weight was used in the consumption equation. The uncleaned mean (median) weights for fish and shellfish caught by anglers interviewed at Elliott Bay were 1574 (680) and 1053 (500) g/catch, respectively. The uncleaned mean (median) weights for fish and shellfish caught by anglers interviewed at Duwamish River sites were 544 (327) and 821 (612) g/catch,

respectively. The mean (median) weights for fish and shellfish caught by anglers interviewed in North King County were 1035 (454) and 683 (454) g/catch, respectively. Use of the mean weights provided consumption rate estimates comparable to those estimated from other surveys using this methodology (Puffer et al., 1981; Landolt et al., 1985, 1987; US EPA, 1988). The cleaning factors were the same as those used by Landolt et al. (1985, 1987). The number of consumers in the family was either one for individuals or the number in the family reported by the respondent. The North King County survey did not query for the number of consumers in the family; thus, an average value for family size of 2.5 was used for this parameter, which is an average derived from other studies of recreational fish consumption (Puffer et al., 1981; West et al., 1989; US EPA, 1999).

The consumption rate for the King County Lakes survey was conducted by an alternative calculation method. During this survey, the respondent was presented with visual representations of fish fillets of varying meal sizes (6, 8, 10, and 12 ounce fillets). The respondent was asked to estimate their typical meal size from the visual aid and how often they had consumed fish they caught from the lakes in the previous month. Surveyors also asked the respondent to provide the same information for any children (i.e., <18 years) who also consumed their catch. Thus, an estimate of fish consumption could be estimated for both adults and children. The calculation method relies on the estimated meal size based on the visual aid combined with the number of self-caught fish meals the respondent recalled eating in the past month. This method has been used successfully in a number of consumption surveys (West et al., 1989, 1993; Meredith and Malvestuto, 1996; Scheaffer et al., 1999; Williams et al., 2000). The equation to estimate the consumption rate is:

$$\text{consumption rate (g/day)} = (\text{MF} \times \text{MS} \times \text{CF}) / \text{AT}$$

where MF is the meal frequency of self-caught fish (meals/month); MS the meal size (ounces); CF the conversion factor (28.35 g/ounce); and AT the averaging time (30 days/month).

Data Analysis

The completed survey forms were coded and entered into an electronic database (Microsoft Excel[®]2000) to allow for data analysis. Each of the data sets was analyzed independently; however, an additional analysis of consumption rates using combined data from both the Elliott Bay/Duwamish River and North King County Surveys was also undertaken. The arithmetic mean, standard deviation, standard error, and percentiles were calculated and are presented in tables throughout this article. In some cases, data were not recorded (i.e., due to surveyor error) or was not provided by the respondents; therefore, the sample sizes may vary in the tables provided in the following sections.

Results

Demographics

Over 2400 individuals were approached during the shoreline surveys. A total of 152, 807, 228, and 212 unique individuals agreed to be interviewed at the Duwamish River, Elliott Bay, North King County, and King County Lakes locations (Table 1), respectively. The response rate of non-repeat contacts ranged from 48–93%. The results presented in the following sections and tables represent information from unique (i.e., non-repeat) respondents. Respondents were predominantly male (84–88%) and greater than 15 years of age (>80%). The age of respondents was recorded differently between the surveys (Table 1). The Duwamish River/Elliott Bay surveys asked the respondents to choose an age category rather than report their specific age. The ethnic background of respondents also varied by survey location; however, the majority of the respondents were either Caucasian (30–71%) or Asian and Pacific Islander (12–43%).

Fishing Preferences

The descriptive statistics for frequency of fishing at all four survey areas are presented in Table 2. Respondents' visitation

rates varied throughout the different survey locations. The mean (median) fishing frequency ranged from 16 to 54 (4–28) days/year. Anglers in King County primarily sought to catch fin-fish (Table 3). Respondents at marine and estuarine locations intended to catch only fish (77–89%), while some respondents intended to catch only shellfish (3–17%) (i.e., crabs, shrimp, and mollusks). Most anglers at freshwater locations only intended to catch fish (99%), while a few respondents (<2%) indicated that they intended to catch crayfish.

The species actually caught and identified during the interviews was limited and varied by survey location (Table 4). The species caught at Duwamish River locations by most anglers and in the largest quantities included herring and crabs. The species caught with the highest frequency at marine locations (Elliot Bay and North King County) included sea perch, sole, salmon, crabs, and shrimp. Other species infrequently caught by anglers at estuarine or marine locations during the survey included flounder, rockfish, sculpin, and lingcod. At freshwater locations, the largest quantities of fish caught included perch, trout, salmon, bass, and bullhead. No crayfish were identified during the surveys.

Table 1. Respondent demographics.

Category	Duwamish River	Elliott Bay	North King County	King County Lakes
Water body type	Estuarine	Marine	Marine	Freshwater
Year(s) of study	1997	1997	2001–2002	2002–2003
Interview attempts	250	1697	245	260
Agree (non-repeat contact) ^a	152 (61%)	807 (48%)	228 (93%)	212 (82%)
Agree (repeat contact)	8 (3%)	124 (7%)	4 (2%)	4 (2%)
Disagree (non-repeat contact)	59 (24%)	165 (10%)	2 (<1%)	36 (14%)
Disagree (repeat contact)	31 (12%)	598 (35%)	11 (5%)	8 (3%)
Missing data	0 (0%)	3 (<1%)	0 (0%)	0 (0%)
<i>Gender^a</i>				
Male	127 (84%)	706 (88%)	193 (85%)	186 (88%)
Female	13 (8%)	68 (8%)	34 (15%)	24 (11%)
Missing data	12 (8%)	33 (4%)	1 (<1%)	2 (<1%)
<i>Age^a</i>				
≤15 years old	14 (9%)	52 (6%)	—	—
>15 years old	134 (88)	750 (93%)	—	—
≤18 years old	—	—	35 (15%)	30 (14%)
>18 years old	—	—	191 (84%)	175 (83%)
Missing data	4 (<3%)	5 (<1%)	2 (<1%)	7 (3%)
<i>Ethnicity^a</i>				
Caucasian	46 (30%)	374 (46%)	133 (58%)	150 (71%)
African American	17 (11%)	85 (11%)	8 (4%)	16 (8%)
Asian & Pacific islander	65 (43%)	246 (30%)	56 (25%)	25 (12%)
Hispanic/Latino	6 (4%)	31 (4%)	13 (6%)	7 (3%)
Native American	3 (2%)	27 (3%)	9 (4%)	1 (<1%)
Multiracial	—	—	5 (2%)	4 (2%)
Other	4 (3%)	22 (3%)	3 (1%)	2 (<1%)
Missing data	11 (7%)	22 (3%)	1 (<1%)	7 (3%)

^aNumber of respondents for gender, age, and ethnicity categories is based upon non-repeat contact interviews.

Table 2. Summary statistics for fishing frequency (number of days/year).

Location	N	Mean	SD	SE	Percentiles				
					5%	25%	50%	75%	95%
Duwamish River	149	16	30	2	1	1	4	16	94
Elliott Bay	796	36	65	2	1	2	10	40	156
North King County	198	54	71	5	1	11	28	63	240
King County Lakes	204	19	39	3	1	3	7	14	74

Table 3. Type of catch sought by anglers.

Location	N	% catch type		
		Fish (%)	Shellfish (%)	Both (%)
Duwamish River	152	80	8	12
Elliott Bay	807	89	3	6
North King County	228	77	17	5
King County Lakes	212	99	<2	0

Table 4. Species caught and kept by anglers.

Species	Duwamish river		Elliott Bay		North King County		King County Lakes	
	(N) Anglers	(N) Caught	(N) Anglers	(N) Caught	(N) Anglers	(N) Caught	(N) Anglers	(N) Caught
<i>Anadromous Fish</i>								
Salmon	0	0	11	11	2	2	9	30
Trout	0	0	0	0	0	0	16	31
<i>Marine Fish</i>								
Flounder	5	6	3	4	2	2	0	0
Gunnel fish (eel)	1	1	0	0	0	0	0	0
Herring	5	38	0	0	0	0	0	0
Lingcod	0	0	1	1	0	0	0	0
Rockfish	0	0	6	6	1	1	0	0
Sculpin	4	5	4	4	0	0	0	0
Sea perch	2	9	13	155	4	12	0	0
Sole	6	9	5	13	1	1	0	0
<i>Freshwater Fish</i>								
Bass	0	0	0	0	0	0	5	16
Bluegill	0	0	0	0	0	0	3	3
Bullhead	0	0	0	0	0	0	1	12
Yellow perch	0	0	0	0	0	0	14	75
<i>Shellfish</i>								
Clams	0	0	1	25	0	0	0	0
Crabs	15	52	17	60	12	22	0	0
Moonsnail	1	1	0	0	0	0	0	0
Shrimp	0	0	7	124	5	14	0	0

Consumption Preferences

The primary goal of the King County surveys was to describe consumption patterns of recreational anglers. A series of questions was asked during the interview to describe angler

consumption preferences. Anglers planned on using their catch in a variety of ways (Table 5). A majority of the anglers reported consuming their catch either individually (20–66%) or with others (35–57%). If anglers reported sharing their

catch with other people, they were asked if this included young children (<10 years old). The percent sharing with young children was 27%, 32%, 49%, and 46% from the Duwamish River, Elliott Bay, North King County, and King County Lakes, respectively. Other frequently described uses included: giving catch away (5–26%), using catch as bait (2–20%), or performing catch and release (9–64%).

The anglers who indicated that they would consume their catch were also asked what parts of the fish they typically consume (Table 6), and which cooking methods they typically utilize. Anglers from all locations primarily reported eating only the fillet or muscle of the fin-fish they collected (>88%), while a smaller portion reported consuming other portions of the fish (5–12%). Respondents consuming shellfish primarily reported eating only the meat of these species (>99%). Cooking techniques may alter contaminant concentrations (Morgan et al., 1997; Moya et al., 1998), thus it is important to understand the preparation methods of the survey respondents. The survey results identified that respondents preferred cooking their catch by baking, frying, grilling, boiling, or steaming. No respondents reported eating their catch raw or uncooked.

Consumption rates of King County anglers are presented in Table 7 for reported consumption of marine fish, shellfish, and freshwater fish. The consumption rates are reported by

area, and represent combined data across all freshwater locations or all marine locations. The (lower) Duwamish River anglers were included in the marine and shellfish consumption rates (i.e., rather than the freshwater consumption rates), because their measured catch — by virtue of proximity to Elliott Bay — included only marine species (Table 4). The mean (median) consumption rate for marine fish and shellfish was 53 (21) and 25 (11) g/day, respectively. The highest consumption rates were observed for Elliott Bay (mean = 63 g/day) anglers followed by North King County (32 g/day) and Duwamish River anglers (8 g/day). The mean (median) consumption rate from all freshwater locations was 10(0) and 7(0) g/day for respondents and their children, respectively. Although many respondents reported consuming fish from King County lakes, many had not consumed any fish in the previous month. Therefore, the median consumption rate was found to be 0 g/day.

Ethnic differences were examined for all marine locations and all freshwater locations, separately. The mean marine fish consumption rates were 73, 60, 50, 43, and 35 g/day for Native American, Caucasian, Asian and Pacific Islander, African American, and Hispanic/Latino respondents, respectively. The mean shellfish consumption rates were 40, 38, 20, 19, and 2 g/day for Native American, African American, Asian and Pacific Islander, Caucasian, and Hispanic/Latino respondents,

Table 5. Angler's intended use of catch.

	Duwamish river (N = 35 ^a) (%)	Elliott bay (N = 76 ^a) (%)	North king county (N = 133) (%)	King county lakes (N = 212) (%)
<i>% of Respondents Who^b</i>				
Consume catch individually	20	21	62	66
Consume with others (family)	51	57	35	56
Give away	6	5	9	26
Sell	0	0	0	1
Use as bait	20	12	2	6
Catch and release	9	11	15	64
Other ^c	11	4	0	3

^aSample size is smaller than other tables since only anglers with a successful catch were asked this question.

^bRespondents may have indicated more than one intended use, therefore, total percent may exceed 100.

^cThe category for "Other" included any response that varied from the available questionnaire categories (e.g., "store for later use").

Table 6. Parts of fin-fish consumed.

Location	N	% portion consumed		
		Fillet without skin (%)	Fillet with skin (%)	Other parts (head, organs) (%)
Duwamish River	17 ^a	59	29	12
Elliott Bay	35 ^a	60	31	9
North King County	87	89	N/A ^b	10
King County Lakes	139	94	1	5

^aSample size is smaller than other tables since only anglers with a successful catch were asked this question.

^bThis survey did not differentiate eating fillet with or without skin.

N/A, not applicable.

Table 7. Consumption rates (g/day) for recreational anglers.

Location	N	Mean	SD	SE	Percentiles		
					50%	90%	95%
<i>Marine fish consumption</i>							
Duwamish River ^a	50	8	13	2	2	23	42
Elliott Bay	377	63	91	5	31	145	221
North King County	67	32	40	5	17	85	102
(All locations)	494	53	83	4	21	121	181
<i>Shellfish consumption</i>							
Duwamish River	16	20	33	8	4	77	123
Elliott Bay	49	28	33	5	14	74	119
North King County	31	22	33	6	12	62	132
(All locations)	96	25	33	3	11	60	119
<i>Freshwater fish consumption</i>							
King County Lakes (all respondents)	128	10	24	2	0	23	42
King County Lakes (children of respondents)	81	7	20	2	0	17	29

^aThe Duwamish River is tidally influenced by Elliott Bay and anglers exclusively caught marine species, therefore data for these locations were considered to represent marine conditions.

respectively. The mean freshwater fish consumption rates were 26, 13, 8, 6 g/day for African American, Asian and Pacific Islander, Caucasian, and Hispanic respondents, respectively. Statistical analyses of these consumption rates were not performed due to the low sample sizes of various ethnic groups.

Discussion

The results of this study provide pertinent information on the consumption patterns of anglers consuming fish and/or shellfish caught from water resources in King County, WA, USA. Information from the three surveys was utilized by the King County Department of Natural Resources and Parks in their exposure modeling for required environmental analyses of capital improvement projects. In addition, the Washington Department of Health used the results from the King County Lakes survey to set a consumption advisory for Lake Washington (WA DOH, 2004). Further, the results supplement previously existing consumption information and provide new data for freshwater fish consumption.

The patterns of marine anglers reported from the King County surveys are comparable to those previously reported for anglers in and around King County. Marine angler patterns reported here are similar and do not appear to have changed from studies conducted in the mid-1980s (Pierce et al., 1981; Landolt et al., 1985, 1987; McCallum, 1985). The frequency of fishing trips was widely variable in current and previous studies with an average of one fishing trip per week (Landolt et al., 1985, 1987). Anglers in all Puget Sound studies primarily sought fin-fish, while a smaller proportion intended to catch shellfish. Similar species were also caught

and kept by all Puget Sound anglers, including salmon, perch, and crab. However, previous surveys were able to collect more information on the number and types of species collected during the fishing trips (Pierce et al., 1981; Landolt et al., 1985, 1987; McCallum, 1985).

The consumption preferences and rates of marine anglers have remained consistent with previous investigations (Pierce et al., 1981; Landolt et al., 1985, 1987; McCallum, 1985). Anglers from all surveys primarily reported consuming the fillet of fish collected in King County, while a smaller proportion reported consuming other parts of the fish. Similarly, marine anglers from all studies chose to consume their fish cooked, while only a small proportion of all anglers (<5%) consumed their catch raw.

The consumption rates from previous marine surveys conducted in and around Puget Sound were re-analyzed by the US EPA (1988). Estimates of mean (median) marine fish consumption ranged from 39 to 61 (1.9–26) g/day (Table 8). Estimates of the 95th percentile of marine fish consumption from these surveys ranged from 24 to 246 g/day (US EPA, 1988). The fin-fish consumption estimates (i.e., mean, median, and 95th percentile) from the current investigation of marine locations (53, 21, and 181 g/day) fall within each of these ranges. Therefore, consumption rates of marine fish in King County do not appear to have changed over the past 20 years. Consumption rates of King County recreational anglers are higher than those reported by the US EPA (1999) for the general US population (Table 8). This is not surprising since a large portion of the US population may not fish as often as recreational anglers interviewed in this study. King County angler consumption rates were either comparable or less than the consumption rates from surveys

Table 8. Comparison of Consumption Rate Studies (g/day).

Location	Mean	Median	Upper percentile	Reference
<i>Marine fish</i>				
King County Recreational Anglers	53	21	181 (95th)	Current study
Puget Sound Recreational Anglers	39–61	1.9–26	24–246 (95th)	McCallum (1985), Landolt et al. (1985, 1987), Pierce et al. (1981), US EPA (1988)
King County Asian & Pacific Islanders (all finfish)	51	32	102 (90th)	Sechena et al. (2003)
Puget Sound Native American Anglers	81	50	200 (90th)	Suquamish Tribe (2000)
General US population	42	17	174 (95th)	Toy et al. (1996)
	14	—	63 (95th)	US EPA (1999)
<i>Shellfish</i>				
King County Recreational Anglers	25	11	119 (95th)	Current study
King County Asian & Pacific Islanders	54	31	107 (90th)	Sechena et al. (2003)
Puget Sound Native American Anglers	133	63	363 (90th)	Suquamish Tribe (2000)
	19	13	104 (95th)	Toy et al. (1996)
<i>Freshwater fish</i>				
King County Recreational Anglers				
Adults	10	0	42 (95th)	Current study
Children	7	0	29 (95th)	
Lake Roosevelt, WA Recreational Anglers	26 ^a	—	64 (90th) ^a	WA DOH (1997)
Columbia River tribes				
Adults	59	41	170 (95th)	CRITFC (1994)
Children	20	12	73 (96th)	
Recreational Anglers US (AL, CT, IN, MN, MI, WI, Lake Ontario)				Connelly et al. (1996), Ebert et al. (1993), 1996; Fiore et al. (1989), Meredith and Malvestuto (1996), Scheaffer et al. (1999), West et al. (1989, 1993), Williams et al. (2000)
Adults	2–30	—	12–61 (95th)	
Children	5–8	—	—	
US EPA default consumption rate	17.5	—	142.4	US EPA, 2000

^aEstimated values based on number of meals per year (42 and 103), multiplied by an 8-ounce meal (227 g), divided by 365 days/year.

of Asian and Pacific Islanders and Native Americans (Table 8). These results suggest that this survey may have captured respondents that consume self-caught fish at rates comparable to known subsistence populations.

Estimates of shellfish consumption have not been previously described for recreational anglers in King County. Marine anglers from the present surveys were estimated to have shellfish consumption rates (mean, median, and 95th percentile) of 25, 11, and 119 g/day, respectively (Table 8). Mean and median shellfish consumption rates were generally lower than those from Asian and Pacific Islanders and Native American anglers (Table 8). Thus, a large portion of the interviewed King County recreational anglers appears to consume shellfish at a lesser rate than known subsistence populations.

Freshwater fish consumption has not been previously examined in King County. Adult freshwater anglers from the present surveys were estimated to have fin-fish consumption rates (mean, 95th percentile) of 10 and 42 g/day. Children's freshwater fin-fish consumption rates (mean, 95th percentile) were 7 and 29 g/day (Table 8). These rates are comparable to other Washington State or national recreational consumption

surveys, which ranged from 2 to 30 and 5 to 8 g/day, for adults and children, respectively (Table 8). Freshwater fish consumption rates from King County were lower than subsistence consumption rates reported from a survey of Native Americans (Table 8). The present consumption rates are also lower than the US EPA default consumption rate for recreational anglers (Table 8), suggesting that the use of the US EPA default consumption rate for King County freshwater anglers may result in overestimates of exposure.

Consumption surveys typically contain unavoidable sources of error (US EPA, 1998). For example, the questions on fishing or consumption frequency are subject to recall bias. The consumption rate equations for fish and shellfish consumption are primarily based on the frequency estimates, and thus may be over or under-estimated. In addition, creel surveys of this type may over-sample frequent anglers (Price et al., 1994) and may lead to over-estimation of the consumption rate for the general population. Finally, consumption rates were calculated based on several assumptions for the frequency, weight of catch or meal size, cleaning factor, and the number of people sharing their catch. These assumptions will lead to potential error or bias in the

estimated consumption rates. Thus, the uncertainties inherent in these surveys should be recognized when interpreting the results.

Conclusion

Three fish consumption surveys were conducted in King County, WA, USA during 1997–2003. These surveys were conducted to support environmental analyses of proposed capital improvement projects planned by the King County Department of Natural Resources and Parks. The results of the surveys provided updated information for marine angler consumption patterns and new information for freshwater anglers. Survey results suggest that King County seafood consumption patterns have remained stable since the mid-1980s. The surveyed populations were also found to have consumption rates that are comparable to other regional and national recreational anglers. These surveys provide estimates of marine fin-fish and shellfish and freshwater fin-fish consumption rates suitable for risk assessments considering the general population of anglers residing in Puget Sound, WA, USA.

References

- Connelly N.A., Knuth B.A., and Brown T.L. Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. *N Am J Fish Manage* 1996; 16: 90–101.
- CRITFC (Columbia River Inter-Tribal Fish Commission). A fish consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs tribes of the Columbia River Basin. 1994 CRITFC Technical Report 94-3, Portland, OR.
- Ebert E.S., Harrington N.W., Boyle K.J., Knight J.W., and Keenan R.E. Estimating consumption of freshwater fish by Maine anglers. *N Am J Fish Manage* 1993; 13: 737–745.
- Ebert E.S., Su S.H., Barry T.J., Gray M.N., and Harrington N.W. Estimated rates of fish consumption by anglers participating in the Connecticut Housatonic River creel survey. *N Am J Fish Manage* 1996; 16: 81–89.
- Fiore B.J., Anderson H.A., Hanrahan L.P., Olsen L.J., and Sonzogni W.C. Sport fish consumption and body burden levels of chlorinated hydrocarbons: a study of Wisconsin anglers. *Arch Environ Health* 1989; 44: 82–88.
- Landolt M.L., Hafer F.R., Nevissi A., van Belle G., Van Ness K., and Rockwell C. Potential toxicant exposure among consumers of recreationally caught fish from urban embayments of Puget Sound. NOAA Technical Memorandum NOS OMA 23, Rockville, MD 1985, 104pp.
- Landolt M.L., Kalman D., Nevissi A., van Belle G., Van Ness K., and Hafer F. Potential toxicant exposure among consumers of recreationally caught fish from urban embayments of Puget Sound. Final Reports, NOAA Technical Memorandum NOS OMA 33, Rockville, MD 1987, 107pp.
- McCallum M. Seafood catch and consumption in urban bays of Puget Sound. Washington State Department of Social and Health Services, Division of Health, Olympia, WA 1985, 59pp.
- Meredith E.K., and Malvestuto S.P. Evaluation of two on-site survey methods for determining daily per capita freshwater fish consumption by anglers. *Am Fish Soc Symp* 1996; 16: 271–276.
- Morgan J.N., Berry M.R., and Graves R.L. Effects of commonly used cooking practices on total mercury concentration in fish and their impact on exposure assessments. *J Exp Anal Env Epidemiol* 1997; 7: 119–133.
- Moya J., Garrahan K.G., Poston T.M., and Durrell G.S. Effects of cooking on levels of PCBs in the filets of Winter Flounder. *Bull Environ Contam Toxicol* 1998; 60: 845–851.
- Pierce P.S., Noviello D.T., and Rogers S.H. Commencement Bay seafood consumption report. Preliminary Report. Tacoma-Pierce County Health Department, Tacoma, WA, 1981.
- Price P.S., Su S.H., and Gray M.N. The effect of sampling bias on estimates of angler consumption rates in creel surveys. *J Exp Anal Env Epidemiol* 1994; 4: 355–372.
- Puffer H.W., Azen S.P., Duda M.J., and Young D.R. Consumption rates of potentially hazardous marine fish caught in the metropolitan Los Angeles area. EPA Grant #R807 120010, 1981.
- Scheaffer A.L., O'Leary J.T., Williams R.L., and Mason D. Consumption of Indiana sport caught fish: mail survey of resident license holders. Department of Forestry and Natural Resources, Purdue University, Technical Report 99-D-HDFW-1, 1999.
- Sechena R., Liao S., Lorenzana R., Nakano C., Polissar N., and Fenske R. Asian American and Pacific Islander seafood consumption — a community based study in King County, Washington. *J Exp Anal Env Epidemiol* 2003; 13: 256–266.
- Simmonds J., Munger S., Strand J., Homan C., Robinson S., Toll J., Wisdom C., Seidel P., Greer H., and Shroy J. Results of a survey on seafood collection and consumption from the shores of the Duwamish River and Elliott Bay. Paper Presented at the Puget Sound Research Conference, Conference Proceedings, Seattle, WA, 1998; pp. 194–200.
- Suquamish Tribe. Fish consumption survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region. *The Suquamish Tribe*. Suquamish, WA, 2000.
- Toy K.A., Polissar N.L., Liao S., and Mittelstaedt G.D. A fish consumption survey of the Tulalip and Squaxin Island tribes of the Puget Sound region. In: *Tulalip Tribes*. Department of Environment, Marysville, WA, 1996.
- US EPA. Child-specific exposure factors handbook. EPA/600/P-00/002B. Interim Report, September Office of Research and Development, Washington, DC, 2002.
- US EPA. Consumption surveys for fish and shellfish: a review and analysis of survey methods. Office of Water, EPA-822-R-92-001, 1992.
- US EPA. Exposure factors handbook [CD-ROM], Office of Research and Development, Washington, DC, EPA/600/C-99/001, February 1999.
- US EPA. Guidance for conducting fish and wildlife consumption surveys. Office of Water, EPA-823-B-98-007 1998.
- US EPA. Health risk assessment of chemical contaminants in Puget sound seafood. Final report. Tetra Tech, Inc. TC-333-28 United States Environmental Protection Agency, Region 1.0, Seattle, WA, September 1988.
- US EPA. Methodology for deriving ambient water quality criteria for the protection of human health. Office of Water, Washington, DC, EPA/822/B-00/004, October 2000.
- WA DOH. Anglers who frequently fish lake Roosevelt, Washington Department of Health, Office of Environmental Health Assessment Services, Olympia, WA, 1997.
- WA DOH. Evaluation of contaminants in fish from Lake Washington, King County, Washington, Washington Department of Health. Division of Environmental Health, Olympia, WA, 2004.
- WA DOH. Lake Whatcom residential and angler fish consumption survey. Environmental Health Programs Washington Department of Health. Olympia, WA, 2001.
- West P.C., Fly J.M., Marans R., Larkin F., and Rosenblatt D. 1991–2 Michigan sport anglers fish consumption study. Technical Report No 6 May, Prepared by the University of Michigan. School of Natural Resources, Ann Arbor, MI 1993.
- West P.C., Fly M.J., Marans R., and Larkin F. Michigan sport anglers consumption survey. A report to the Michigan Toxic Substance Control Commission. Contract No. 87-20141, Michigan Department of Management and Budget 1989.
- Williams R.L., O'Leary J.T., Sheaffer A.L., and Mason D. An examination of fish consumption by Indiana recreational anglers: an on-site survey. Technical Report 99-D-HDFW-2, Department of Forestry and Natural Resources, Purdue University, 2000.