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Fish consumption and advisory awareness among low-income women in California's Sacramento–San Joaquin Delta☆

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Abstract

Fishing is a culturally important activity to the ethnically diverse population living in California's Sacramento–San Joaquin Delta. Due to runoff from abandoned gold mines, certain Delta fish are contaminated with methylmercury, a neurodevelopmental toxin. A state health advisory recommends limited consumption of certain Delta fish, to be followed in conjunction with a federal advisory for commercial and sport fish. We conducted a survey of low-income women at a Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic, to characterize commercial and sport fish consumption patterns and advisory awareness. Ninety-five percent of women consumed commercial fish. Thirty-two percent consumed sport fish; this proportion was much higher in Hmong (86%) and Cambodian (75%) women. Ninety-nine percent of sport fish consumers also consumed commercial fish. The overall fish consumption rate among consumers was 27.9 g/day (geometric mean, past 30 days, cooked portion); commercial and sport fish consumption rates were 26.3 and 10.5 g/day, respectively. We found ethnic differences in overall fish consumption rates, which were highest in African Americans (41.2 g/day) and Asians (35.6 g/day), particularly Vietnamese and Cambodians. Pregnant women ate less fish overall than other women (16.8 vs. 30.0 g/day, $p = 0.0001$), as did women who demonstrated specific advisory awareness (23.3 vs. 30.3 g/day, $p = 0.02$). Twenty-nine percent of all women exceeded federal fish consumption advisory limits. These results highlight the need for culturally and linguistically appropriate interventions that address both commercial and sport fish consumption.

Keywords: Fish; Advisory; Methylmercury; Women; California

1. Introduction

The health benefits of consuming fish are well documented. Fish are a source of omega-3 fatty acids and can protect against cardiovascular disease (Kris-Etherton et al., 2002; Mozaffarian and Rimm, 2006), improve cognitive development in children (Daniels et al., 2004), and slow cognitive decline in the elderly (Morris et al., 2005). However, methylmercury and other chemical contaminants found in some fish can counteract these benefits. Methylmercury can impair neurological development; high levels are toxic to children and adults (NAS, 2000). Even at low levels of exposure, methylmercury from maternal fish consumption has been associated with subtle neurotoxicity in children (NAS, 2000). Nationwide, it is estimated that six percent of women of childbearing age have blood methylmercury levels of potential health concern (MMWR, 2004). Fish consumption is believed to be the primary source of exposure to methylmercury.

Fish consumption advisories recommend the types and amounts of fish that can be eaten to keep exposure to

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mercury and other contaminants within levels considered to be safe. These advisories are more restrictive for sensitive populations, i.e., women of childbearing age, pregnant and breastfeeding women, and children. For these groups, the US Food and Drug Administration and US Environmental Protection Agency (FDA and EPA, 2004) recommend complete avoidance of certain types of high-mercury fish (shark, swordfish, king mackerel, and tilefish) and limited consumption of other commercial fish (12 oz/week, or 48.6 g/day, for most fish) and sport-caught fish (6 oz/week, or 24.3 g/day, unless a local advisory exists). Local advisories may be more or less restrictive.

Nationally representative surveys have been done to characterize US fish consumption and mercury body burden, but do not adequately characterize populations that consume large amounts of fish (MMWR, 2004; Schober et al., 2003). In California, there is limited evidence that some populations eat large quantities of fish and have elevated mercury levels. High fish consumption and blood mercury levels were reported in men, women, and children from one San Francisco medical practice (Hightower and Moore, 2003) and among a small Native American population living next to an abandoned mercury mine (Harnly et al., 1997).

Throughout the US, the available evidence suggests that non-white populations have high fish consumption (Anderson et al., 2004; Burger et al., 1999; Hightower et al., 2006; SCCWRP and MBC, 1994; SFEI, 2001; West et al., 1993) and high body burdens of mercury (particularly Asians, Pacific Islanders, and Native Americans (Hightower et al., 2006; Knobeloch et al., 2005)), and that non-whites and low-income populations have low advisory awareness (Anderson et al., 2004; Burger et al., 1999; Imm et al., 2005; SFEI, 2001). While regional angler studies have measured sport fish consumption and advisory awareness in ethnically diverse populations, few women are usually included in these studies, since anglers are predominantly male. However, fish consumption patterns of women and young children are of interest, since they are particularly sensitive to mercury's neurotoxic effects. One small study of women at a Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic in East Harlem, New York (Bienenfeld et al., 2003), found that 11% of fish consumers ate sport fish, despite an advisory recommending that women of childbearing age and children not eat any fish from local waters. Of these sport fish consumers, 55% were aware of the advisory. Although several clinic-based studies have described fish consumption by pregnant women (Daniels et al., 2004; Oken et al., 2003; Oken et al., 2005), these did not examine ethnically diverse or low-income populations, nor did they measure sport fish consumption or advisory awareness.

In California, the Sacramento–San Joaquin Delta is home to an ethnically diverse population that includes immigrants and refugees from Southeast Asia, Central and South America, and Eastern Europe. Fishing is a culturally important activity in many of these communities. However, certain fish in the Delta are contaminated with mercury due to runoff from abandoned gold mines. An advisory issued by state authorities recommends consumption limits of 6 oz/month (or 5.7 g/day) for certain fish from the Delta and San Francisco Bay due to mercury and PCB contamination (OEHHA, 1994).

We conducted a survey of ethnically diverse, low-income women in the Delta. The goals of the survey were to determine rates of fish consumption from all sources, evaluate the relative contributions of sport and commercial fish to overall fish consumption, and ascertain participants' awareness of fish consumption advisories.

2. Materials and methods

We conducted a survey in October 2004 at the Delta Health Care WIC clinic in Stockton, California, one of the largest cities in the Delta region. This clinic serves ethnically diverse low-income women (within 185% of federal poverty guidelines) who are pregnant or breastfeeding, and families with children under age five. The clinic setting afforded an opportunity to provide education about fish consumption after the survey, and to develop and evaluate educational strategies based on survey results.

One month before the survey, staff posted flyers in multiple languages throughout the clinic. The flyers mentioned a survey involving fish eating habits, but did not divulge the purpose of the study, and emphasized the participation incentive (a ten dollar gift card for a popular store). During the week-long survey, WIC staff asked all eligible women visiting the clinic whether they wanted to participate. All women enrolled in WIC were eligible to participate, as were mothers and female guardians of children enrolled. Men and "alternates" (persons authorized to pick up vouchers for a friend or family member) were not eligible to participate.

To increase participation among respondents with limited English literacy, we administered on-site personal interviews, assisted by multilingual WIC staff (fluent in English, Spanish, Vietnamese, Khmer, Tagalog, and Hmong). At the end of the survey, interviewers delivered a tailored health education message to participants based on their fish consumption practices.

2.1. Fish consumption

We determined fish consumption separately for commercial and sport fish. Interviewers asked participants to name or to identify from photographs fish species that they had ever consumed. Participants could list up to 14 types of commercial fish or shellfish (referred to in this report as "commercial fish"), and 14 types of sport-caught fish or shellfish ("sport fish"). For fish eaten in the last 30 days, we also asked respondents about consumption frequency, portion size, and source of the fish. To assist respondents with recall of portion size, interviewers showed fish fillet "portion models" corresponding to 1.5, 3.0, 4.5, 6.0, and 7.5 oz cooked weight, along with a 6-oz can of tuna. We asked respondents to choose among the individual portion models to estimate their intake for each reported fish type.

2.2. Consumption above advisory limits

We compared participants' fish intake to limits recommended by federal and local advisories for women of childbearing age (for this analysis, we excluded six study participants above age 49). Generally, these advisories include several options, with the intention that only one option should be followed during any given time period. For example, during a week when one eats 6 oz of sport fish, no commercial fish should be eaten. Similarly, during a week when one eats 12 oz of commercial fish, no sport fish should be eaten. However, if one eats 3 oz of sport fish in a given week, it is difficult to determine how much additional commercial fish can be eaten to maintain safe exposure levels during that week. While such calculations may be impractical for the general public, we attempted to evaluate whether a woman's combined intake of sport and commercial fish exceeded joint FDA/EPA advisory limits. Since this advisory allows women to eat twice as much commercial fish (12 oz) as sport fish (6 oz) in a week, we halved each woman's commercial intake and added it to her sport intake. If this combined amount exceeded 6 oz/week, or if the woman ever ate shark, swordfish, tilefish, or king mackerel, she was considered to have exceeded the joint FDA/EPA advisory limit.

We did not evaluate consumption above state or county advisory limits for specific water bodies, due to the variety and complicated nature of local advisories in the water bodies where study participants may have obtained sport fish. For example, several local advisories only apply to fish above a certain length, and we did not expect study participants to know the length of fish caught by a friend or family member.

2.3. Advisory awareness

To assess advisory awareness, interviewers asked, "Are you aware of any health warnings about eating fish or shellfish for women of childbearing age?" Women who answered yes were coded as having "general awareness." We asked women with "general awareness" to describe the health warnings, and coded women who mentioned health-protective behaviors consistent with federal or local fish advisories for women of childbearing age as having "specific awareness." Thus, women with "specific awareness" are a subgroup of women with "general awareness." No distinction was made between sport and commercial advisories. Responses about shellfish toxins or raw fish, or general statements such as "fish is good for you," were coded as having "general" but not "specific" awareness.

2.4. Statistical methods

We used SAS versions 8.2 and 9.1 for all analyses (SAS Institute Inc., Cary, NC). We examined rates of commercial, sport, and overall (the sum of commercial and sport) fish consumption over the 30 days prior to the administration of the survey. These outcomes were not normally distributed; therefore, we present fish consumption rates in terms of geometric means (GM), expressed in cooked grams/day (g/day). In addition, we used a natural log transformation of the fish consumption rates for linear regression analyses, using PROC GLM, to determine whether these varied by ethnicity, age, education, pregnancy, breastfeeding status, and advisory awareness. We also performed multivariate linear regression analyses, adjusting for all variables significant in unadjusted analyses. All possible interaction terms between these variables were investigated; since none were statistically significant, none were included in the final model. Although no variables were significant predictors of sport fish consumption in unadjusted analysis, for comparison purposes, the adjusted models presented for overall and commercial fish are also presented for sport fish.

Multivariate results are presented as percent changes, calculated as $e^{\beta}-1$. A percent change of 0 indicates no change; >0 an increase, and <0 a decrease. We calculated a partial R^2 for each term in the model by dividing the sum of squares for that term by the total sum of squares. We used the least significant difference measure of uncertainty (Andrews et al., 1980) to display graphically whether ethnic variation in fish consumption was statistically significant.

We performed a χ^2 test to evaluate whether other measures of respondents' fish consumption (consumption among household members and fish portion sizes) varied by ethnicity. We conducted adjusted and unadjusted logistic regression to determine whether: (i) consumption above the joint FDA/EPA advisory limit varied by ethnicity, age, education, pregnancy, breastfeeding status, and advisory awareness; and (ii) women with "general" and "specific" advisory awareness varied in ethnicity, age, education, pregnancy, and breastfeeding status, compared to women without such awareness.

We asked participants to select their ethnicity from a printed list. In order to increase sample sizes for ethnic groups with small numbers in this survey, we assigned mixed-ethnicity women ($n = 41$) into the category of the least-represented ethnic group with which they identified for analysis. Thus, we categorized a woman who described herself as both white and Native American as Native American, since just three women self-identified as Native American only.

The major ethnic groups represented were white, African American, Hispanic, and Asian. Other ethnic groups and Asian subpopulations each represented five percent or less of the study population, but we obtained sufficient sample sizes for an examination of Cambodian, Vietnamese, Hmong, Filipina, and Native American groups. We combined Lao ($n = 4$), Chinese ($n = 4$), Indian ($n = 1$), Pakistani ($n = 1$), Pacific Islander (PI, $n = 6$), and unknown Asian ($n = 1$) respondents into an "Other Asian/PI" group ($n = 17$). The remaining participants were Arab or Persian ($n = 4$); due to the extremely small sample size, their results are not given in any analysis by ethnicity. One woman who was missing ethnicity data was not included in analyses by ethnicity.

3. Results

3.1. Statistics

All ethnicity analyses presented here categorized mixed-ethnicity individuals to the least represented ethnicity. We ran ethnicity analyses with this categorization, as well as without (categorizing mixed-ethnicity individuals into a separate "mixed" category), and results were similar in both analyses (data not shown).

3.2. Study population

During the study period, 2159 men and women visited the WIC clinic. Of these, 500 eligible women agreed to participate in the survey. Most women (477, or 95%) reported ever eating commercial fish, and 158 women (32%) reported ever eating sport fish. The commercial fish consumption analysis included 457 women (91%) who reported eating commercial fish in the last 30 days. The sport fish consumption analysis included 80 women (16%) who reported eating sport fish in the last 30 days. Since all but one of the sport fish consumers also consumed commercial fish, there were 458 women in the overall fish consumption analysis.

Demographic characteristics of the study population are shown in Table 1. The ethnicity distribution of the study population was similar to the ethnicity distribution for the population served by Delta Health Care WIC as a whole (Grunsky J, pers. comm.). The majority of study participants (90%) were between the ages of 18 and 39, and more than half had completed high school, obtained a General Equivalency Diploma, or continued education beyond that level. Almost all women (98%) lived in the city of Stockton.

3.3. Fish consumption

Table 2 shows results of unadjusted analysis of fish consumption by demographic group. Ethnicity (white, African American, Hispanic, Asian, or Native American)

Table 1
Demographic characteristics of study population, and characteristics by advisory awareness, *n* (%)

	Participants (column %)		General awareness (row%)		Specific awareness (row%)	
Total	500		224	(45%)	156	(31%)
Ethnicity						
White	70	(14%)	54	(77%)	39	(56%)
African American	59	(12%)	29	(49%)	19	(32%)
Hispanic	262	(52%)	97	(37%)	66	(25%)
Asian	93	(19%)	38	(41%)	27	(29%)
Cambodian	20	(4%)	8	(40%)	7	(35%)
Vietnamese	12	(2%)	2	(17%)	2	(17%)
Hmong	21	(4%)	4	(19%)	2	(10%)
Filipina	23	(5%)	14	(61%)	10	(43%)
Other Asian/PI	17	(3%)	10	(59%)	6	(35%)
Native American	11	(2%)	4	(36%)	4	(36%)
Arab/Persian	4	(1%)				
*p-value**				<0.0001		0.0003
Age						
⩽17	12	(2%)	4	(33%)	4	(33%)
18–24	160	(32%)	67	(42%)	49	(31%)
25–29	130	(26%)	66	(51%)	49	(38%)
30–39	158	(32%)	69	(44%)	41	(26%)
40–49	34	(7%)	13	(38%)	10	(29%)
50+	6	(1%)	5	(83%)	3	(50%)
p-value for trend				0.53		0.60
Education						
<9th grade	74	(15%)	17	(23%)	11	(15%)
Some high school	99	(20%)	34	(34%)	24	(24%)
High school graduate or equivalency	131	(26%)	55	(42%)	34	(26%)
Some college or technical school	122	(24%)	74	(61%)	54	(44%)
College/technical school graduate or more	73	(15%)	44	(60%)	33	(45%)
p-value for trend				<0.0001		<0.0001
Pregnant	66	(13%)	27	(41%)	23	(35%)
Non-pregnant	434	(87%)	197	(45%)	133	(31%)
p-value				0.49		0.49
Breastfeeding	105	(21%)	54	(51%)	40	(38%)
Non-breastfeeding	395	(79%)	170	(43%)	116	(29%)
p-value				0.12		0.09

*Five group comparison (White, African American, Hispanic, Asian, and Native American).

was a significant predictor of overall and commercial fish consumption ($p = 0.004$ and 0.03, respectively). Vietnamese, other Asian/PI, and African American participants had the highest intakes, and white and Native American participants the lowest. African American and Asian women had statistically significantly higher overall consumption than Hispanic women (Fig. 1), but only African American women had statistically significantly higher commercial fish consumption than Hispanic women (Fig. 2(a); Hispanic is used as a reference category because it is the largest group). Increasing age was also a significant predictor of increased overall and commercial fish consumption, while education was not (Table 2). Pregnant women had significantly lower overall and commercial fish consumption than non-pregnant women. Women with general advisory awareness did not consume less fish than women without. However, women with specific advisory awareness had lower overall and commercial fish consumption than women without (Table 2). When the data were stratified by ethnic group, this effect was most pronounced in Asian and African American women (data not shown).

No variables were significant predictors of sport fish consumption, perhaps due to the small sample size ($n = 80$); however, some trends are noteworthy. Asian and African American women had the highest sport fish consumption (Table 2). Although no groups varied significantly from the Hispanic reference group (Fig. 2(b)), Asian women overall had significantly higher consumption than white women ($p = 0.04$). As with commercial fish consumption, women with specific advisory awareness had lower sport fish consumption than women without; this difference was not statistically significant (Table 2). In contrast to the finding that pregnant women had decreased commercial fish

Table 2
Predictors of fish consumption in last 30 days (geometric mean (GM) cooked g/day), unadjusted. Analysis limited to fish consumers only

	Overall		Commercial		Sport	
	N	GM	*N*	GM	*N*	GM
Total	458	27.9	457	26.3	80	10.5
By ethnicity						
White	60	22.8	60	22.1	8	4.8
African American	52	41.2	51	40.4	7	14.2
Hispanic	241	24.8	241	24.4	17	9.3
Asian	89	35.6	89	29.0	42	12.4
Cambodian	20	36.4	20	24.4	12	19.0
Vietnamese	12	71.4	12	62.5	6	7.6
Hmong	18	27.6	18	22.9	10	9.9
Filipina	23	24.5	23	21.5	7	8.9
Other Asian/PI	16	46.7	16	40.6	7	17.2
Native American	11	21.9	11	20.5	4	11.8
*p-value**		0.004		0.03		0.3
By age						
<17	12	26.6	12	21.1	5	13.9
18–24	142	23.4	141	22.3	22	8.9
25–29	119	30.0	119	28.0	18	13.4
30–39	145	29.2	145	27.8	25	13.2
40–49	34	35.5	34	33.7	9	5.6
50+	6	40.0	6	39.6	1	1.4
p-value for trend		0.03		0.01		0.2
By education						
<9th grade	68	22.8	68	21.9	12	5.8
Some high school	89	30.0	89	28.1	16	12.8
High school graduate or equivalency	118	27.1	118	25.1	20	15.8
Some college or technical school	115	30.0	114	28.8	23	7.7
College/technical school graduate or more	67	28.4	67	26.8	9	15.1
p-value for trend		0.3		0.3		0.2
By pregnancy status						
Pregnant	58	16.8	58	16.1	6	12.8
Non-pregnant	400	30.0	399	28.3	74	10.4
p-value		0.0001		0.0002		0.9
By breastfeeding						
Breastfeeding	96	31.1	96	29.9	11	10.2
Non-breastfeeding	362	27.1	361	25.5	69	10.6
p-value		0.3		0.2		0.6
By advisory awareness						
General awareness	207	27.2	207	25.5	34	10.1
No general awareness	251	28.5	250	27.1	46	10.9
p-value		0.6		0.5		0.8
Specific awareness	146	23.3	146	22.0	21	9.7
No specific awareness	312	30.3	311	28.6	59	10.8
p-value		0.02		0.01		0.7

*Five group comparison (White, African American, Hispanic, Asian, and Native American).

consumption, pregnant women had slightly higher sport fish consumption than non-pregnant women; this difference was not statistically significant (Table 2). All of the pregnant sport fish consumers were non-white, and four out of six were Asian.

Multivariate analysis results (Table 3) were similar to the unadjusted results. Adjusted models for overall and commercial fish consumption were statistically significant ($p<0.0001$). Compared to Hispanic women, African American women ate 71% more fish from all sources ($p=0.001$), and Vietnamese women ate 156% more ($p=0.003$). With each increasing year of age, overall fish consumption increased by 1% ($p=0.08$). Pregnant women ate 40% less overall fish than non-pregnant women ($p=0.001$), and women with specific advisory awareness ate 20% less overall fish than women without ($p=0.04$). However, these models did not explain much of the variability in consumption rates ($R^2=0.10$ for both models). The partial R^2 in these models was highest for the ethnicity term but remained low for all terms ($R^2\leqslant 0.05$), further indicating that most of the variability in consumption rates has not been explained by the variables investigated here.

The proportion of women who reported ever consuming sport fish varied by ethnicity, with Asians, Native Americans, whites, and all Asian subpopulations more likely to report this than Hispanic women (Table 4). Very high proportions of Hmong and Cambodian women reported ever consuming sport fish (86% and 75%, respectively).

Most women (76%) reported that children (under age 18) in their households ate commercial fish. Nineteen percent of participants reported that children in their households ate sport fish; this proportion differed significantly by ethnicity (χ^2 $p<0.0001$), with the highest proportions in Hmong (71%) and Cambodian (45%) families, and the lowest proportion in Hispanic families (9%).

The mean portion size was about 5 oz (5.3 oz (151 g) for commercial fish, 5.5 oz (154 g) for sport fish). Portion size varied significantly by ethnicity for commercial fish ($p<0.0001$), with Vietnamese and African American women having the largest mean portion sizes (7.5 oz (212 g) and 6.4 oz (180 g), respectively) and Hmong women the smallest (3.4 oz, or 97 g). Portion size varied by ethnicity for sport fish as well, although the difference was not statistically significant ($p=0.09$). Mean sport fish portion size was largest among the four Native American women (9.6 oz, or 271 g), and African American women (6.9 oz, or 194 g); Hmong women had the smallest portion size of 4.3 oz (121 g).

The most common sport fish species that women reported ever consuming were catfish (43% of 158 ever sport fish consumers), striped bass (38%), salmon (25%), bluegill/perch (21%), crawdad/crayfish (18%), crab (17%), and trout (17%). The most common commercial fish ever consumed were shrimp/prawns (86% out of 477 ever commercial fish consumers); canned tuna (79%); fish sticks, burgers, and fillets (64%); crab, lobster, and crayfish (53%); salmon (44%); and tilapia (34%).

3.4. Consumption above advisory limits

Fourteen women of childbearing age (3%) reported ever eating shark or swordfish; six of these consumed

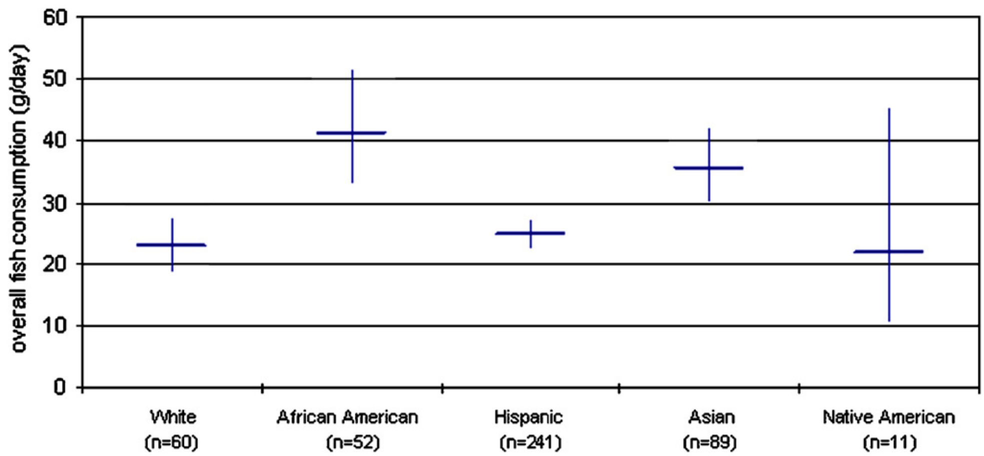

Fig. 1. Overall fish consumption rate (g/day; geometric mean (GM) and least significant difference), by ethnicity, among fish consumers only, $n = 458$. Error bars that do not overlap indicate a statistically significant difference at $\alpha = 0.05$.

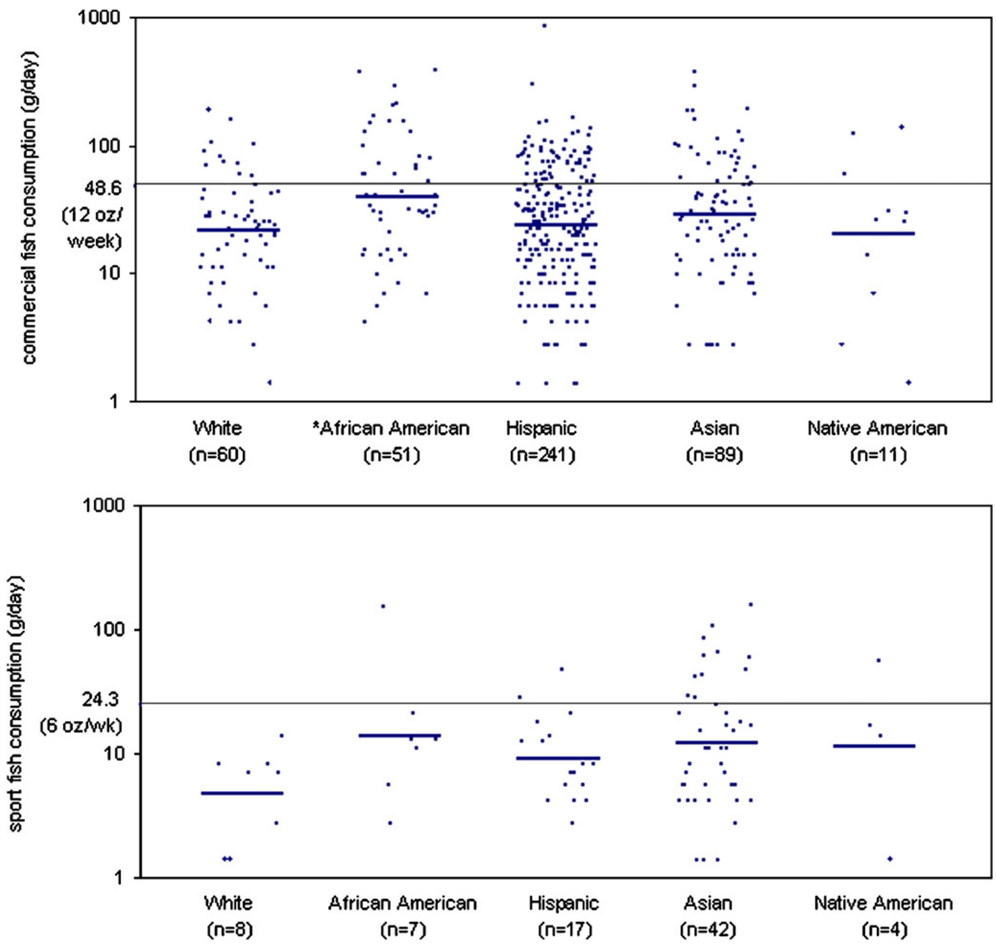

Fig. 2. (a) Commercial ($n = 457$) and (b) sport ($n = 80$) fish consumption for each fish consumer (g/day), and geometric mean, by ethnicity. Starred ethnicities have GM consumption statistically significantly different than that of Hispanic women. Horizontal lines represent FDA/EPA advisory limits of 12 oz of commercial fish, and 6 oz of sport fish, per week.

sport-caught shark and one consumed sport-caught swordfish. No women in this survey reported consumption of tilefish or king mackerel (which are not commonly available in California). One-quarter of women ($n = 122$) consumed more than 12 oz of commercial fish per week, and 16 women (3%) consumed more than 6 oz of sport fish per week. Ten women (2%) consumed fish from the Delta or San Francisco Bay at levels above those recommended

Table 3
Predictors of fish consumption in last 30 days, adjusted for all other variables in model. Analysis limited to fish consumers only

	Overall		Commercial		Sport	
N	457		456		79	
Model p-value	<0.0001		<0.0001		0.5	
Model R^2	0.10		0.10		0.15	
	% change	p-value	% change	p-value	% change	p-value
Ethnicity (compared to Hispanic)						
White	3%	0.87	2%	0.91	−46%	0.20
African American	71%	0.001	71%	0.001	44%	0.48
Hispanic		reference		reference		reference
Asian						
Cambodian	47%	0.12	0%	0.99	99%	0.11
Vietnamese	156%	0.003	128%	0.01	−11%	0.82
Hmong	16%	0.58	−3%	0.92	−12%	0.80
Filipina	4%	0.88	−7%	0.73	−12%	0.81
Other Asian/PI	86%	0.02	64%	0.07	86%	0.23
Native American	−11%	0.72	−15%	0.60	43%	0.58
Age (per year of age)	1%	0.08	1%	0.07	−2%	0.31
Pregnant (vs. not pregnant)	−40%	0.001	−40%	0.001	31%	0.60
Specific advisory awareness (vs. no specific awareness)	−20%	0.04	−21%	0.04	−6%	0.86

β coefficients have been back-transformed and are expressed as percent changes (e^{β}–1) of fish consumption.

Table 4
Percent of participants from each ethnicity who reported ever having consumed sport fish or (among women of childbearing age only) having consumed any fish at levels exceeding the joint FDA/EPA advisory limit in the last 30 days

	Total	Ever consume sport fish			Women ⩽50	Consumption above joint FDA/EPA advisory limit		
	N	N	(Row %)	p-value	N	N	(Row %)	p-value
Total	500	158	(32%)		494	142	(29%)	
White	70	21	(30%)	0.05	67	13	(19%)	0.39
African American	59	15	(25%)	0.27	58	21	(36%)	0.07
Hispanic	262	49	(19%)	Reference	261	64	(25%)	Reference
Asian	93	64	(69%)	<0.0001	92	39	(42%)	0.001
Cambodian	20	15	(75%)	<0.0001	20	13	(65%)	<0.0001
Vietnamese	12	7	(58%)	0.001	12	8	(67%)	0.001
Hmong	21	18	(86%)	<0.0001	21	5	(24%)	0.94
Filipina	23	13	(57%)	<0.0001	22	5	(23%)	0.85
Other Asian/PI	17	11	(65%)	<0.0001	17	8	(47%)	0.04
Native American	11	6	(55%)	0.01	11	3	(27%)	0.84

by the state advisory (without taking into account recommendations based on fish length; data not shown).

More than one-quarter of women (29%) exceeded the joint FDA/EPA advisory limit via a combination of sport and commercial fish consumption (Table 4; these data do not take any local advisories into account). Compared to Hispanic women, this proportion was significantly higher among Vietnamese, Cambodian, and Other Asian/PI women, as well as among Asian women as a whole, and somewhat higher among African American women.

In the multivariate model, pregnant women were 2.2 times more likely to consume fish within the joint FDA/EPA advisory limit (95% confidence interval 1.1, 4.6) than non-pregnant women, adjusting for ethnicity, age, education, breastfeeding status, and specific advisory awareness. Of these, ethnicity was the only other significant predictor of fish consumption within the joint FDA/EPA advisory limit ($p = 0.02$). Results were very similar for a multivariate model that included general, rather than specific, advisory awareness.

3.5. Advisory awareness

Almost half of study participants (45%) had general advisory awareness. A subset of these (31% of study participants) had specific advisory awareness (Table 1). Ethnicity (white, African American, Hispanic, Asian, or Native American) was a significant predictor of both general and specific awareness. A majority (56%) of white women had specific awareness, compared to only 10% of Hmong and 17% of Vietnamese women.

In the multivariate model, ethnicity and education were both significant predictors of general and specific advisory awareness ($p<0.01$), after adjusting for age, pregnancy, and breastfeeding status (none of which was statistically significant). With each additional year of education, women were 1.2 times as likely to have general advisory awareness (95% confidence interval 1.1, 1.2) and 1.1 times as likely to have specific advisory awareness (95% confidence interval 1.1, 1.2).

The most common sources of advisory awareness were television (15%), friends or family members (9%), health care providers (6%), WIC (6%), and newspaper/magazine (6%). Women were most likely to trust information received from WIC (65%) and health care providers (45%).

4. Discussion

Increased fish consumption among Asian and African American anglers (SFEI, 2001) and non-angling Asian women (Hightower et al., 2006; Knobeloch et al., 2005) compared to other ethnic groups has been noted elsewhere. However, to our knowledge, this is the first study to quantify higher fish consumption in non-angling, low-income Asian and African American women compared to other ethnic groups, and to compare consumption rates among different Southeast Asian subgroups. Furthermore, we were able to distinguish the contributions of sport and commercial fish to overall fish consumption. This revealed a high rate of commercial fish consumption in African American women, in addition to the expected high rate of sport fish consumption. Similarly, while higher advisory awareness among whites compared to non-white groups has been reported previously (Anderson et al., 2004; Imm et al., 2005; SFEI, 2001), awareness among non-angling, low-income women has not previously been well characterized. Our findings suggest that fish contamination may have disproportionate impacts on low-income, non-white groups in the Delta.

One strength of this survey is the use of physical models to estimate portion size. The wide variability in portion size reported here highlights the usefulness of this approach, compared to surveys that ask about meal frequency alone. However, as with all food frequency surveys, errors in recall may have occurred. Some individuals, particularly those who are overweight, may have underreported portion sizes (Willett, 1998). We did not collect data on women's body weight.

Few estimates of fish consumption among California women statewide are available. However, the proportions of women reporting fish consumption in this survey were higher than those reported among 179 California women interviewed as part of the Twelve State Study, a phone survey where 82% reported any fish or shellfish consumption, and 18% reported sport fish consumption, in the preceding 12 months (Anderson et al., 2004). Fish consumption in the WIC population was also higher than what we found among 2621 women of childbearing age who participated in another phone survey, the 2005 California Women's Health Survey (CWHS, 2006), where 81% reported eating commercial finfish and 17% reported eating sport finfish (not including commercial or sport-caught shellfish; manuscript in preparation). By comparison, in this survey, 94% of women reported eating commercial finfish and 30% reported eating sport finfish (not including commercial or sport-caught shellfish).

Fish consumption may be more common in the Delta than in California as a whole because the area contains many waterways and communities with strong cultural ties to fishing. Furthermore, fish may be an affordable source of protein for the low-income population described here. However, it is possible that the increased proportion of fish consumers represents a response bias, as the posted advertisements for the survey mentioned fish consumption. However, our impression was that the women were motivated primarily by the gift card incentive, and that those who declined to participate did so because of lack of time.

Since signs advertising the gift card incentive were posted a month before the survey, it is possible that women who otherwise would not have visited the clinic that specific week may have turned up to participate in the study. However, there is no reason to believe that such women would have had different fish consumption habits or advisory awareness than the underlying population served by the clinic.

This analysis did not demonstrate an association between fish consumption and educational attainment, although other studies have reported increased consumption and hair mercury levels with education (Anderson et al., 2004; Knobeloch et al., 2005; Schober et al., 2003; SFEI, 2001). Education in these studies may be a surrogate for income. For the WIC survey population, even though more than half had obtained at least a high school diploma or equivalent, all were low-income, and educational attainment may not correlate well with income. We did not collect data on income because the entire population, by definition, had incomes at or below 185% of the poverty line.

The variability seen in consumption rates has not been explained by the models presented here (as indicated by the fairly low R^2s). Low R^2s are not uncommon in social sciences research. The reasons why women eat the foods that they do are influenced by many factors and cannot fully be explained by demographic variables alone.

Results of this survey may not be generalizable to higher income populations. The sport fish consumption data presented here should be interpreted with caution, due to the small sample size obtained for many ethnic groups. We may have misclassified specific advisory awareness if some women knew the specifics of the advisory but did not mention them (no probing was done for this question). Some people may use different names for the same fish species. In this investigation, we received numerous reports of perch consumption from the Delta (perch is a class of saltwater fish not found in the Delta). Subsequent focus groups revealed that many Delta anglers refer to bluegill as perch, so we considered reports of perch from the Delta to mean bluegill. Our use of fish identification picture cards was intended to minimize such misclassification.

Our survey results showed that women with specific awareness of advisories consumed less commercial fish, and less fish from all sources, than women without specific awareness. This effect was not seen for women with general awareness. Although it is not a direct measure of behavior change, these findings suggest that knowledge of health advisories can influence behavior. The survey itself raised awareness of mercury contamination issues among WIC clients and staff. We assisted state WIC staff in developing a brochure entitled "Safety Tips about Fish" that is now used at WIC clinics statewide, and in August 2005, the Delta Health Care WIC clinic began incorporating education about fish contaminants into their standard protocol.

We found that 29% of all women surveyed reported fish consumption levels exceeding the federal advisory limit. The true number of women in this population exceeding advisory limits is undoubtedly even higher, since this estimate does not include any local advisories, many of which are much more restrictive than the default FDA/EPA advisory limit for sport fish. Evaluating whether individuals' fish consumption exceeds any local advisory limit in combination with the federal advisory limit is quite challenging; thus, it is unlikely that the public has a good grasp on how to interpret advisories correctly for fish obtained from different sources.

Clearer, integrated educational messages for the public are needed about mercury contamination of fish. In a region where primary source reduction may take decades, outreach and education are the only viable methods of immediate exposure reduction. Our results suggest that knowledge of health advisories can influence behavior, and that ethnic differences exist in advisory awareness and exposure. This underscores the need for culturally and linguistically appropriate interventions that integrate messages about both commercial and sport fish, balancing information on the risks of mercury and other chemicals with the benefits of fish consumption.

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