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DEPARTMENT OF ENVIRONMENTAL SCIENCE AND POLICY
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Public Comment
Beneficial Uses and Mercury Objectives
Deadline: 2/17/17 12 noon

RECEIVED
2-17-17
SWRCB Clerk

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
PO Box 100, Sacramento, CA 95812-2000

State Board Members:

I am writing this letter as the author and lead of two studies relevant to the proposed action on Tribal Tradition Culture (CUL), Tribal Subsistence Fishing (T-SUB) and Subsistence Fishing (SUB) Beneficial Uses and Mercury Objectives. I have carried out two large survey-based studies of subsistence and tribe fishing and fish-use in California, both of which are referenced in the documentation for the proposed action and both of which are attached here. I also co-developed (with CDPH, RB, OEHHA, and others) the questionnaire and survey approach currently used throughout CA. I have carried out special studies of fishing, fish consumption, and threats to anglers from mercury in fish for CDPH, RB-5, and Sacramento County Regional Sanitation District. Finally, I have taught a core graduate class in survey protocols for the Human and Community Development program.

I would like to support the 3 Beneficial Use actions proposed with several caveats and conditions:

1) Traditional fish use has been suppressed so that contemporary use of 1 7-8 oz fish meal every 4-5 days is at least ½ to 1/3 of the traditional rates reported to me by elders in the tribes and as reported in the literature cited in the attached report on tribes' fish-use. The quantification of fish use is an appropriate part of establishing the beneficial use, but the rate used is low compared to rates just 1-2 generations in the past. This means that CA agencies should strive to use the higher traditional subsistence rates to set fish tissue contaminant standards and implementation actions for all waterways where tribes are maintaining a traditional reliance on fish.

2) We interviewed members of 40 tribes at the locations of 23 of CA's 146 state and federally-recognized tribes (attached report). Tribe members reported use of waterbodies across approximately 25% of California's land surface, with some minor overlap among tribes. This suggests that if all tribes were interviewed, most or all of the state's waterbodies would be used by members of a tribe. It would be appropriate to apply the tribe beneficial uses and associated standards and implementation actions to ALL waterbodies of the state, unless a reasonable finding can be made by dischargers/permittees, or others for non-use by tribes, for example of high-alpine lakes or agricultural canals with few fish. This is instead of putting the onus upon the tribes to prove their use of the waterbodies. A direct analogy relevant to previous SWRCB actions would be if individual recreational coastal water users in Southern California had to prove that they went surfing/swimming at a particular beach in order for the state's pathogenic bacteria standards to apply to that beach. This would be unreasonable and was not carried out for this largely white population. Another analogy from a sister agency would be if community residents adjacent to I-710 in Long Beach and Los Angeles had to prove that they breathed air contaminated by diesel truck exhaust before the Air Resources Board or AQMD would enact standards to protect them.

3) There is no good reason given for not providing a quantitative standard, target, or objective to meet the (non-tribal) subsistence (SUB) beneficial use. The rationale provided of there being wide variability in fish consumption also applies to tribal use, recreational use, and US household use of fish. This is an arbitrary basis for not setting a quantitative objective. There have been studies of fish use in the Bay Area (1999), Delta (2007-8), Clear Lake (early 2000s), Sierra Nevada reservoirs (2011), Los Angeles (late 1990s), and San Diego (2017). The 95^{th}% rate across these studies range from 32 g/day from the out-of-date Bay study, to 142 g/day (Delta study, Shilling et al., 2010). The range in rates is almost exactly the same as the range of variation across California tribes. The difference is that the latter were surveyed in the same year, whereas subsistence anglers have been surveyed across the last 16 years. If a narrative definition is used, then it MUST be accompanied by a commitment by the Board to support (fund) surveys across a range of communities that the Board finds sufficient to base a quantitative objective for fish tissue in order to protect this beneficial use. This commitment must be funded at a sufficient level and include a timeline for completion and updating of the beneficial use definition and accompanying water quality objective and fish tissue targets for contaminants.

4) The decision to not apply the beneficial uses in all waterways where they are relevant, regardless of the presence of a TMDL, is arbitrary. This is especially true for the Delta mercury TMDL where Regional Board 5 staff chose to ignore a study (attached) of fish consumption by, primarily, non-white communities. This means that the rate should be applied as new information for that TMDL as it is apparently new to the RB staff. In addition, at least two tribes fish in the upper Delta, which means that the 2 tribal beneficial uses should apply there, regardless of the approved TMDL. They can be used as new information to adapt the TMDL to current conditions.

5) The T-SUB beneficial use has been described as not being designed to protect fish or their habitat. In the case of every other beneficial use, the target of the beneficial use is protection of the use of water to meet the physical, biological and/or chemical conditions required to provide or protect the use, within the regulatory capacity of the SWRCB. For example, MUN protects drinking water so that it can be used by people. EST targets protection of water to support estuarine ecosystems, including protection of organisms and their habitat. REC-1 involves setting standards for pathogens and other contaminants that could harm humans when ingested while they recreate. It makes no sense that for the two beneficial uses that protect aquatic habitat and organism use by tribes would not actually be used to protect the actual features – fish and their habitat. This selective use of Board authority to provide limited protections for tribes does not seem to be based in science, legal consideration, or other rationale.

6) The implementation plan focuses on municipal and industrial dischargers to provide material reduction in mercury inputs to waterways while side-stepping the much more serious problem of elemental and oxidized mercury inputs from abandoned mines and downstream reservoirs and riparian zones, as well as the methylation environment exacerbated by agricultural discharge. Because no agency in the state is stepping forward to take programmatic responsibility for abandoned mines (including the DOC, which recently stepped back from this role), there is no path forward for reducing this greatest of inputs. The Board's "deep-pockets" approach toward dischargers unnecessarily limits the regulatory authority and other capacities of the Board and ignores possibly innovative approaches. For example, dischargers have previously discussed off-setting programs as a way to use their funds to reduce much greater amounts of mercury to waterways than they are discharging. If a discharger is faced with a $10 million retrofit to reduce mercury discharge by 1 kg/year to meet standards, it is entirely possible that a much greater reduction of inputs to the same waterway could be achieved for half the money. It seems possible to create a program where permits

to discharge require that dischargers contribute to a pooled fund that reduces mercury inputs to the same waterway (e.g., lower Sacramento River, Napa River, Cache Creek) by at least a 10-fold factor. This program could be designed based on existing and newly-collected information about discharge from abandoned mines and waterways, spatially-explicit decision-support tools, modeled/estimated BAFs, load tracking, and known/anticipated discharge rates from permitted entities. It could be accompanied by compliance monitoring and conditional permits. A process like this could be proposed within the implementation of these objectives and informal discussion with some of the involved parties suggests that it could be supportable assuming certain conditions are met for each of the important stakeholders.

Please email or call me with any questions.

Sincerely,

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Contaminated fish consumption in California's Central Valley Delta ☆

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ABSTRACT

Extensive mercury contamination and angler selection of the most contaminated fish species coincide in California's Central Valley. This has led to a policy conundrum: how to balance the economic and cultural impact of advising subsistence anglers to eat less fish with the economic cost of reducing the mercury concentrations in fish? State agencies with regulatory and other jurisdictional authority lack sufficient data and have no consistent approach to this problem. The present study focused on a critical and contentious region in California's Central Valley (the Sacramento–San Joaquin Rivers Delta) where mercury concentrations in fish and subsistence fishing rates are both high. Anglers and community members were surveyed for their fish preferences, rates of consumption, the ways that they receive health information, and basic demographic information. The rates of fish consumption for certain ethnicities were higher than the rates used by state agencies for planning pollution remediation. A broad range of ethnic groups were involved in catching and eating fish. The majority of anglers reported catching fish in order to feed to their families, including children and women of child-bearing age. There were varied preferences for receiving health information and no correlation between knowledge of fish contamination and rates of consumption. Calculated rates of mercury intake by subsistence anglers were well above the EPA reference dose. The findings here support a comprehensive policy strategy of involvement of the diverse communities in decision-making about education and clean-up and an official recognition of subsistence fishers in the region.

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1. Introduction

The present study provides critical data to support decision-making to reduce fish contamination, involve diverse stakeholder communities, and encourage safer fishing and eating patterns in California's Delta. The US Department of the Interior estimates that 10% of Californians engage in sport and subsistence fishing (USDI et al., 2003), many of whom fish in the watersheds of the Sacramento–San Joaquin Rivers Delta and San Francisco Bay. Subsistence fishing in areas with fish contamination creates the need for immediate policy initiatives, both to educate anglers about contamination and to speed the rate of remediation of the contamination. In California, fish contamination from mercury, polychlorinated biphenyls (PCBs), and other chemicals threatens fish consumption as a part of the daily diet. There has never been an economic evaluation of the cost of reducing fish contamination in California, though it is popularly thought to be high. Because of this perceived high cost of remediation, public agencies in California have proposed reducing fish consumption to reduce risk and exposure. There are actually several policy strategies that are available: (1) clean up environmental contamination in accordance with the Clean Water Act and California'a Porter-Cologne Act, (2) educate subsistence anglers about fish contamination, allowing them some choice, and (3) the combination of (1) and (2), developing pollution remediation plans that comprehensively deal with clean-up, new discharges, angler education, and inclusion of impacted communities. Currently, there is insufficient knowledge of fish consumption practices in California's Delta to make an informed choice among policy options.

California's growth was based initially on a gold-mining boom. Mercury mined in the Coast Ranges was used in the Coast and interior ranges to improve gold recovery (Alpers and Hunerlach, 2000). The watersheds of the Central Valley contain thousands of legacy mercury and gold mining features. Mercury also originates from natural geothermal activity, soil, atmospheric deposition,

Abbreviations: ANOVA, analysis of variance; CDFG, California Department of Fish and Game; CVRWQCB, Central Valley Regional Water Quality Control Board; FFQ, Food Frequency Questionnaire; PCBs, polychlorinated biphenyls; SAAC, Southeast Asian Assistance Center; SFEI, San Francisco Estuary Institute; TMDL, total maximum daily load; USDA, US Department of Agriculture; USEPA, US Environmental Protection Agency

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industrial and domestic waste-water, and unknown sources. Inorganic mercury enters the food chain primarily through bacteria-mediated mercury methylation (reviewed in Benoit et al., 2003) and bio-accumulates in organisms of higher trophic levels (Clarkson, 2002; Gilmour et al., 1998; May et al., 2000). Predatory fish (e.g., striped bass) tend to have the highest tissue concentrations of mercury (Wiener et al., 2003) and are favored by anglers.

Subsistence fishing is prevalent throughout the world, but tends not to be viewed as a behavior characteristic of urban communities. Urban California contains broad ethnic diversity, including many recently arrived immigrants who appear to have retained the cultural and economic practice of subsistence fishing. There is very high ethnic and language diversity in the Delta region of the Central Valley. Recently arrived Hmong, Cambodian, Vietnamese, Russian, and Mexican populations are common in Central Valley urban areas (Fujimoto, 1998). Many of these diverse communities relied on fishing as a cultural and economic practice in their countries of origin and have brought that practice with them. In addition, the social structure and accepted pathways of communication are quite different from the host culture (Fujimoto, 1998). This can make effective communication for education and/or decision-making particularly challenging—a problem that is poorly addressed in California state policy. There are also many California-born anglers and fish consumers in the Delta region who subsistence fish.

The Central Valley Regional Water Quality Control Board (hereafter the Regional Board) has developed a draft total maximum daily load (TMDL) for methyl-mercury in the Delta because of impairment to fish consumed by humans and wildlife (Central Valley Regional Water Quality Control Board, 2008). Because the consumption of fish by wildlife and humans is legally protected in these waters as a beneficial use under the Clean Water Act, legally, the state must develop a plan to resolve this impairment, which by strict definition means reducing mercury concentrations in fish. The Clean Water Act requires the development of TMDLs as science and policy guides for reducing particular types of waterway pollution. In the presence of subsistence fishing this is particularly challenging, because protecting their use would require potentially greater political and financial investments.

We used a food frequency questionnaire to study fish consumption patterns. Survey respondents were asked for a 30-day recall of fish intake from local waters and commercial sources. The vast majority of comparable studies using FFQs have reported accurate findings using this approach among a wide range of nationalities and ethnicities (Villegas et al., 2007; Quandt et al., 2007; Sullivan et al., 2006; Kuster et al., 2006; McNaughton et al., 2005). In cases where the FFQ has been less accurate, it tended to under-estimate actual consumption (Hudson et al., 2006; Lee et al., 2002). Anglers and community members were interviewed in English or the respondents' native language. A statistical description of fish consumption patterns is presented for the North Delta region of the Central Valley over 3 years (2005–2008), including information about individual fish species and ethnic communities. This information, combined with existing information about fish tissue concentrations of mercury is used as the basis for an exposure analysis. Findings are presented showing the diverse mechanisms through which anglers receive health related information. Finally, actual mercury exposure is compared to assumptions made in current policy-development for mercury remediation.

2. Methods

2.1. Study area

The study area comprised the North, South, and West Delta regions of the Central Valley, stretching from the cities of Sacramento and Stockton to the city of Fairfield (Fig. 1). The waterways included the Sacramento River (the largest in California), the Port of Sacramento Shipping Channel, Montezuma Slough, and the San Joaquin River. Specific sites for surveying along the Sacramento River were: Garcia Bend City Park, Freeport, Clarksburg, and Port of Sacramento shipping channel. These sites were chosen as sites likely to be popular with anglers after an expert review of CDFG creel survey data by river mile and pre-surveying site visits (Fig. 1). These areas were also chosen because fish tissue concentrations of mercury are high in the vicinity of the sites (within 10 river miles).

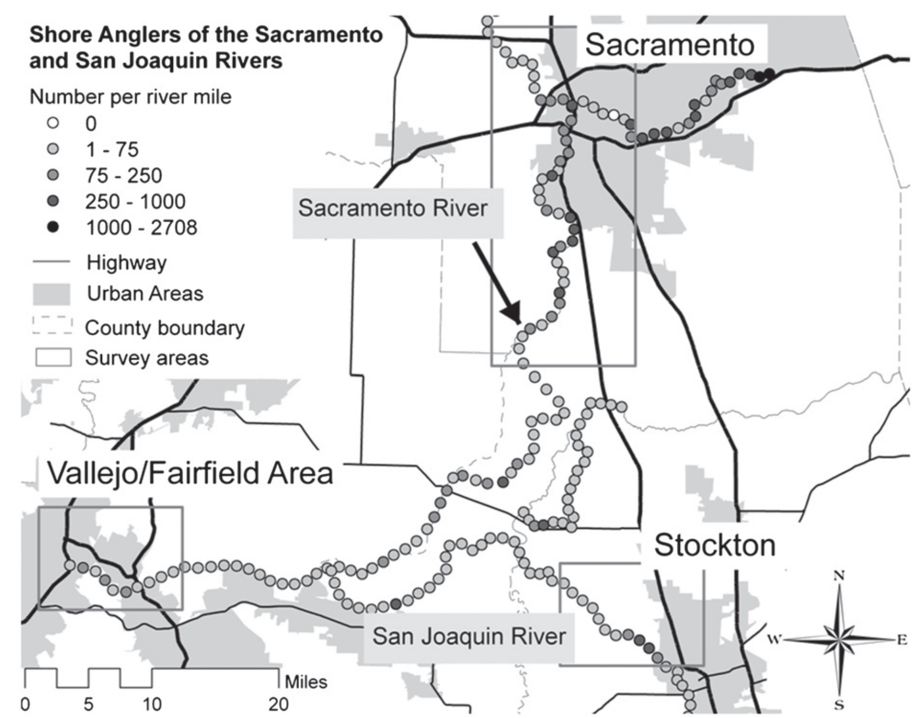

Fig. 1. Annual angling intensity in study area. Data from the California Department of Fish and Game creel survey program, 2000. Angler surveying areas for the present study.

2.2. Survey instrument, sample, and protocol

The survey instrument was designed to cover target fish species, fish consumption rates, health communication, and household demographics. It was designed in 2003 and 2004 in collaboration with the California Department of Public Health and the California Office of Environmental Health Hazard Assessment and is nearly identical to the instrument used in the recently published study of women attending clinics in Stockton, CA (Silver et al., 2007). There were 17 questions and the questionnaire took about 10 min to administer. Answers were recorded on the questionnaire, coded, and transferred to a computer spreadsheet. Fish filet models were used representing 3 different cooked weights of fish filet (1.5, 4.5, and 7.5 oz) in order to allow estimates of actual fish consumption rates.

Anglers were chosen for interviews as they were encountered along the river-bank by surveyors. All or the vast majority of anglers were interviewed as they were encountered, reducing bias in selection of the sampled population. However, the angler interviews were only conducted in English, which resulted in a failure to interview about 5% of those approached. 373 shore anglers were interviewed during biweekly to monthly site visits between September 2005 and June 2008. All days of the week were represented roughly equally in sampling; sampling was conducted primarily in the early morning and late afternoon when anglers were more likely to be present. In July and August, surveyors went into the field, but very few anglers were encountered when surveyors were present, which may be related to anglers fishing at different times of day, or night, during these hotter months. Encounters were initiated by the surveyor approaching the anglers and beginning a conversation about fishing. Anyone reporting that they had been previously interviewed was not interviewed again. On the vast majority of sampling days, all anglers observed fishing were interviewed. Community members were chosen for interviews based on prior knowledge of Southeast Asian Assistance Center (SAAC) staff that an extended family member fished, but without specific knowledge of how often they fished or ate fish. All such people identified by the SAAC staff were interviewed. SAAC staff live in the communities they serve and have access to households because of community familiarity with the organization. 137 community members were interviewed between December 2006 and June 2008.

Subjects were told that the survey was about fishing activity along the river and was being conducted to better understand what kinds of fish people were catching and eating. They were not told in advance that the survey was related to concerns about fish contamination.

2.3. Spatial and creel survey data

Fish contamination data up to 2006 were obtained from the California Regional Board, covering almost 30 years of measurements of mercury in various fish species, and from the San Francisco Estuary Institute (SFEI) for 2005–2007. Mean mercury concentrations (parts per million or micrograms/gram) were calculated for each target species using values for legal-sized or edible fish at or near the angler survey sites. In the case of striped bass, this corresponded to lengths >18 in, for sturgeon this corresponded to lengths >48 in and for all other fish species lengths >12 in, except sunfish, bluegill, and crappie where lengths >6 in were used.

Creel survey data covering 1999–2001 (the most recent and comprehensive available) were obtained from the California Department of Fish and Game in computer spreadsheets and in written reports to the US Fish and Wildlife Service. The survey covered fishing effort, types and numbers of fish caught, and location of fishing. The creel survey data were attributed to river mile points along the Sacramento River using ArcView 3.2 (Fig. 1). The river mile points were manually measured using ArcView 3.2 along the center-line of the river using geo-referenced digital photographs. These data were used to choose sites for surveying and to compare fishing activity of the surveyed population in this study with the creel survey population.

2.4. Survey data analysis

Fish consumption rates (g/day) were calculated for each individual based on 30-day recall of how much and how often individual types of fish (e.g., catfish) were eaten. Anglers were grouped by major race/ethnicity (e.g., Hispanic) according to Census Bureau classification. Minor ethnicity (e.g., Lao) was also recorded when the survey respondent provided sufficient information for the classification. Rates of mercury intake were calculated for individuals based on individual consumption rates determined through surveying for specific fish types and the regional mean mercury concentrations for those fish types, which is based on fresh weight. Because the cooked weight of fish, represented by the fish filet models used in surveying, is about 75% of the fresh weight, the calculated rates of mercury intake here are a conservative estimate of actual rates. Mean and 95th percentile fish and mercury consumption rates were calculated for all interviewees and median rates calculated for all recent consumers. Data were organized in MS Excel and all statistical analysis was done using the commercial software SPSS 16.0. Trends analysis was performed using the Seasonal Kendall test software developed by the US Geological Survey (Hirsch et al., 1982; Hirsch and Slack, 1984; Helsel et al., 2006).

3. Results

3.1. Context: fish contamination and angling intensity

Concentrations of mercury in commonly eaten fish were calculated using a combination of the Regional Board and SFEI datasets (Table 1). Fish sizes ranged from >6 in (bluegill) to >48 (sturgeon) and mean wet tissue concentrations ranged from 0.052 ppm (shad) to 0.772 ppm (largemouth bass) wet tissue weight.

Creel survey data collected by the California Department of Fish and Game (CDFG) indicate that the primary target fish species for all anglers, regardless of ethnicity, in the Northern region of the Central Valley Delta were striped bass, salmon, shad, and catfish (Murphy et al., 1999, 2000; Schroyer et al., 2001). This is similar to the targeted species in the present study (Table 2), with inter-ethnic differences in fish preferences. For all commonly caught fish there were mercury concentration data available in the study region (Table 1).

Table 1
Mercury concentrations of commonly eaten fish in the Northern Delta region, in size ranges sought by anglers.

Fish species (common name)	*N*	Mercury concentration		Length (in)	Location
		(Mean ppm)	SD		
Shad	19	0.052	0.023	> 15	AR, Delta
Bluegill	10	0.208	0.125	> 6	SR, SRSC
Carp	30	0.309	0.197	> 15	SR
Catfish	44	0.424	0.251	> 12	SR, Delta
Crappie	5	0.309	0.104	> 8	SR, Delta
Chinook Salmon	25	0.09	0.03	> 26	AR, FR, SR
Largemouth Bass	63	0.774	0.324	> 12	AR, SR
Sacramento Pike Minnow	42	0.763	0.525	> 12	AR, SR
Split-tail	1	0.37		16	SR
Sacramento Sucker	38	0.22	0.117	> 12	AR, SR
Rainbow Trout/Steelhead	12	0.061	0.014	> 18	AR, SR
Striped Bass	47	0.545	0.318	> 18	AR, Delta, SR
Sturgeon	11	0.271	0.241	> 48	SR
Sunfish	14	0.182	0.097	> 8	SR

AR=American River, FR=Feather River, SR=Lower Sacramento River. Data from the Central Valley Regional Water Quality Control Board database and San Francisco Estuary Institute reports online (http://www.sfei.org).

Table 2
Ethnicity-specific targeting of fish species. Shown are the fish species most commonly eaten and the fish species eaten in largest quantity. Ranks determined from survey for all respondents.

Ethnicity	Target	
	1st choice Frequency/amount	2nd choice Frequency/amount
African-American	SB/SB	CF/CF
SE-Asian	SB/SB	CF/CF
Lao	CF/SB	SB/SF
Hmong	SB/SB	CF/Stur
Asian/Pacific Islander	SB/SB	CF/CF
Hispanic	SB/SB	CF/CF
Native American	CF/LMB	CF/KS
White	SF/SB	SB/Stur
Russian	Carp/Carp	CF/CF

Carp=carp, CF=catfish, SF=sunfish, KS=Chinook salmon, LMB=largemouth bass, SB=striped bass, Stur=sturgeon.

In 2001, CDFG reported about 22,000 directly counted anglers at a survey rate of about one in every 4 days for all months of the year, but on different tributary rivers to the Delta (Schroyer et al., 2001). About 80% of those counted were fishing on the Sacramento River between the Feather River and the San Francisco Bay and other tributary rivers to the Delta. In 2001, of the approximately 1.2 million licensed anglers in California, 191,000 of them lived in 5 counties encompassing the Delta (Sacramento, San Joaquin, Solano, Yolo, and Contra Costa; data from the CDFG License Bureau). One interpretation of the 10-fold difference between the number of anglers counted by CDFG and the number of licensed anglers is that anglers fish about one of every 10 days on regional rivers. This is similar to the rate of fishing among anglers (one of every 4.5 days) and community members (one of every 10 days) in the present study.

3.2. *Rates of fish consumption*

Consumption rates for locally caught fish and commercially acquired fish were calculated for all respondents (Fig. 3 and Table 3). There was no significant relationship between day of the week when surveying occurred and ethnic group type, or fish consumption rate. Rates found for Southeast Asian community members were not significantly different from rates found for Southeast Asian anglers, but for other ethnic groups, community member consumption rates and angler consumption rates were significantly different. Because of this, most data analyzes on these two datasets were done separately. Consumption rates for anglers as a whole varied throughout the year, with peaks during the Fall, when both striped bass and salmon are returning to rivers to spawn (Fig. 3), and fishing activity is the highest (Fig. 2). There was no significant trend (P=0.78) in consumption of locally caught fish across the 3-year study period (2005–2008), when trend was corrected for seasonality using the Seasonal Kendall test (Hirsch et al., 1982; Hirsch and Slack, 1984; Helsel et al., 2006). The arithmetic mean and median consumption rates of *locally caught* fish were 27.4 and 17.0 g/day, respectively, for anglers—which are higher than and similar to the USEPA standard fish consumption rate of 17.5 g/day. Both the arithmetic mean and median consumption rates were used in the present study because they provide different types of information about behavior (Sechena et al., 2003). The mean and median rates of consumption of all fish (locally caught and commercial) were 40.6 and 24.1 g/day, higher than the combination of USEPA's average rate for fish consumption (17.5 g/day) and the USDA's average food intake rate for commercial fish (12.5 g/day). The corresponding mean fish consumption rates from the community member survey were 55.2 g/day (locally caught fish, median rate=21.3 g/day) and 63.4 g/day (total fish, median rate=28.4 g/day), with both types of rates being higher than the corresponding rates for anglers in the field ($P<0.05$, t-test), primarily because the majority of community members surveyed were Southeast Asians. Among the major ethnic groups, Southeast Asians ate the most locally caught fish, followed by African-Americans and Hispanics. However, there was no statistically significant difference in rates among the major ethnicities ($P>0.05$, ANOVA). Of the ethnic sub-groups, the Lao respondents had the highest mean total fish consumption rate (65.2 g/day) and locally caught fish consumption rate (57.6 g/day). Their rate of local fish consumption was significantly higher than the mean rate for all non-Lao anglers ($P<0.05$, t-test).

Women interviewed in community settings ate significantly more locally caught (54.1 g/day) and total (66.4 g/day) fish than male anglers (26.4 and 39.3 g/day; $P<0.05$, t-test) and identical amounts of commercially obtained fish. There was no statistically significant difference between male and female angler consumption rates ($P>0.05$, Table 3). There were no significant differences in consumption rates among age groups (Table 3). Rates of consumption for locally caught and total fish were significantly higher ($P<0.05$, t-test) for anglers from households with children, or from households with women of child-bearing age, than anglers from households without children or women of child-bearing age.

To represent the majority of the fish-consuming population, we also calculated the 95th percentile rates for locally caught, and total fish consumption and the corresponding mercury intake rates. By definition, 95% of fish consumers consume at or below the 95th percentile rate. These rates were compared to the rates used by the Regional Board for its Total Maximum Daily Load (TMDL) for methyl-mercury in the Delta region under different mercury load-setting "scenarios" corresponding to different assumed fish consumption rates (Central Valley Regional Water Quality Control Board, 2008). The scenarios were based on a range of consumption rates and were 17.5 g/day (scenarios A and C), 32 g/day (scenarios B and D), and 142 g/day (scenario E). All ethnicities and sub-ethnicities with sufficient "N" to calculate 95th percentile rates (exceptions=Russian and Native American) had locally caught and total fish intake rates greater than Regional Board scenarios A–D (Table 3). African-American, Lao, Vietnamese, Asian/Pacific Islander, and Hispanic anglers had 95th percentile rates greater than Regional Board scenario E (Table 3), which was the highest rate used by the Regional Board.

3.3. *Balancing locally caught and commercial sources of fish*

An important issue in understanding the economic and dietary decisions that subsistence fishing communities make when fish are contaminated, is the balance between buying and catching edible fish. Anglers and community members often consumed fish that they or someone they knew had caught as well as fish that they bought at markets or restaurants. For all ethnic groups and both genders combined, there was an inverse relationship between consumption rates of commercially acquired fish and locally caught fish (Fig. 4). There was a significant relationship between the frequency that anglers fished and the amounts of locally caught fish that they ate ($P<0.05$, Chi-square test).

3.4. *Rates of mercury consumption*

The combination of species-specific consumption rates and species-specific mercury concentrations was used to calculate the

Table 3
Mean and 95th percentile fish and mercury intake rates for different groups.

	N	Local fish intake		Local fish Hg intake		Total fish intake		Total fish Hg intake	
		Mean (g/d)	95th percentile (g/d)	Mean (μg Hg/d)	95th percentile (μg Hg/d)	Mean (g/d)	95th percentile (g/d)	Mean (μg Hg/d)	95th percentile (μg Hg/d)
Ethnicity									
African-American	32	31.2 [21.3]	242.3	15.7 [9.0]	127.8	48.3 [21.3]	252.0	20.8 [7.7]	130.6
Southeast Asian	152	32.3 [17.0]	129.4	14.0 [7.0]	62.8	42.8 [24.1]	180.2	17.1 [9.5]	74.7
Hmong	67	17.8 [14.9]	89.6	6.9 [6.2]	33.6	22.3 [19.1]	89.6	8.3 [8.3]	37.7
Lao	30	57.6 [21.3]	310.4	26.5 [10.5]	161.4	65.2 [24.1]	317.5	28.8 [9.5]	163.5
Vietnamese	33	27.1 [21.7]	152.4	11.9 [5.0]	77.4 [36.1]	55.4	249.3 [12.0]	20.4	105.9
Asian/Pacific Islander	38	23.8 [15.6]	148.3	9.8 [4.8]	40.4	46.1 [35.0]	156.4	16.5 [9.2]	49.5
Hispanic	45	25.8 [19.1]	155.9	10.8 [7.8]	48.1	36.3 [14.2]	169.5	13.9 [6.7]	54.1
Native American	6	6.5	ND	2.3	ND	69.9 [108.4]	ND	20.8 [33.3]	ND
White	57	23.6 [21.3]	138.9	8.8 [6.7]	43.8	34.7 [28.4]	139.2	12.1 [7.5]	46.8
Russian	17	23.7 [17.7]	ND	7.8 [5.6]	ND	36.1 [35.5]	ND	11.5 [9.6]	ND
All Anglers	373	27.4 [19.7]	126.6	11.4 [6.7]	51.5	40.6 [26.1]	147.3	15.4 [8.1]	56.6
Southeast Asian[a]	286	40.8 [17.0]	128.5	17.6 [7.3]	58.0	50.3 [25.5]	144.5	18.7 [7.9]	70.2
Hmong[a]	130	21.3 [14.9]	102.1	8.1 [4.6]	38.7	26.5 [17.0]	119.7	9.7 [4.5]	42.9
Lao[a]	54	47.2 [17.0]	265.8	20.4 [6.7]	117.8 [28.4]	54.4	267.0 [10.8]	22.6	118.8
Demographic Group									
Age									
18–34	143	32.0 [24.6]	138.9	13.0 [8.9]	55.6	44.9 [25.2]	151.5	16.8 [8.5]	66.7
35–49	130	22.7 [14.2]	120.5	9.8 [6.9]	51.2	36.8 [24]	143.9	14.0 [7.7]	57.5
> 49	87	30.6 [17.0]	207.0	12.8 [5.4]	92.3	44.3 [24.1]	217.2	17.0 [8.4]	95.4
Gender									
F	35	38.2 [22.5]	226.8	15.9 [8.4]	94.7	53.9 [24.6]	263.1	20.6 [8.2]	105.4
M	336	26.4 [19.5]	129.3	11.0 [6.5]	54.3	39.3 [26.1]	146.6	14.9 [8.1]	56.9
Household contains									
Woman 18–49 y-o	217	33.0 [21.2]	142.2	14.1 [7.3]	59.5	46.6 [7.3]	158.1	18.2 [8.8]	71.8
Children	174	35.1	142.8 [22.2]	15.4	61.2 [7.8]	49.2	171.9 [27.1]	19.6	78.3 [9.3]
Awareness									
0	172	24.7 [18.2]	121.6	10.4 [6.6]	51.9	35.5 [23.0]	143.5	13.7 [7.5]	56.6
1	44	42.8 [28.0]	361.1	19.5 [12.3]	187.5	52.9 [28.5]	361.1	22.5 [10.7]	187.5
2	115	28.4 [21.3]	139.6	11.0 [6.3]	61.2	45.8 [28.0]	151.7	16.2	63.3
3	35	12.2 [13.8]	62.4	5.1 [4.0]	32.1 [20.8]	28.1	95.6[6.0]	9.9	35.9
4	7	57.1 [36.1]	ND	24.3 [7.6]	ND	65.0 [39.0]	ND	26.7 [8.9]	ND

ND stands for "not determined" because of insufficient data. All data shown are for angler surveying, except for the data indicated as from combined angler and community surveys.
In the "mean" columns, the first value for a group is the arithmetic mean for all interviewees, the second value below it in "[ ]" is the median for recent consumers.

[a] Rates from combined angler and community surveys.

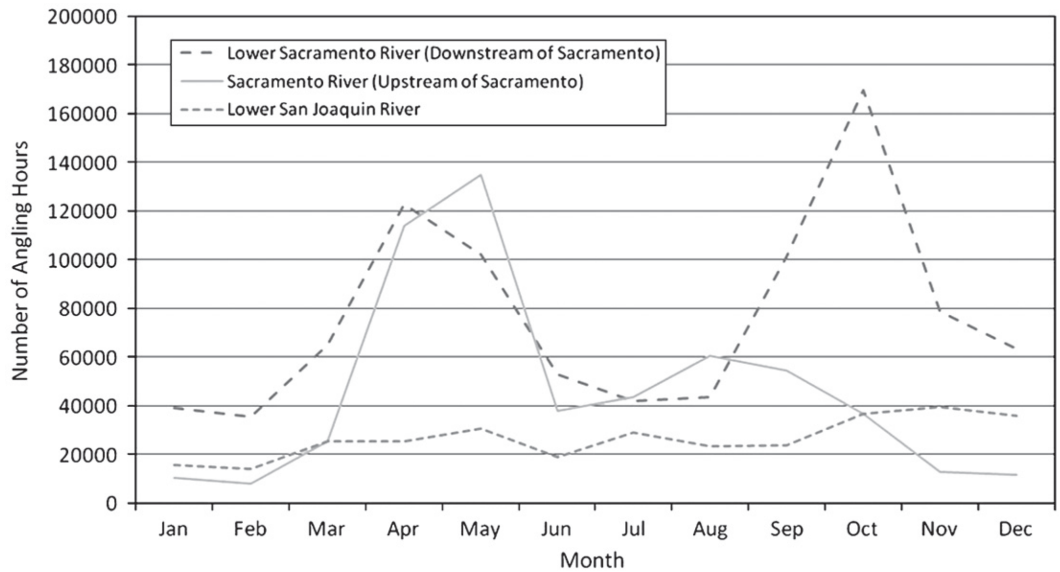

Fig. 2. Fishing intensity as angling hours varying by season and location on the Sacramento River and San Joaquin River. Data from the California Department of Fish and Game creel survey program, 2000.

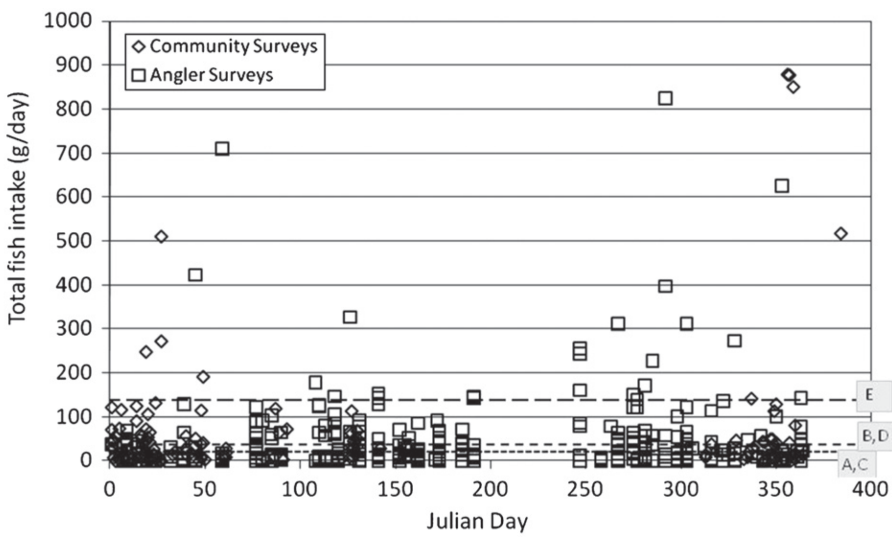

Fig. 3. Total fish consumption rates over the year (Julian Day 1=January 1). Each symbol represents an individual interviewee. The lines at the bottom represent the scenarios for fish consumption rates used by the Central Valley Regional Water Quality Control Board's TMDL for methyl-mercury in the Delta. A, C=17.5 g/day; B, D=32 g/day; E=142 g/day of fish consumed.

mercury intake rates of each surveyed angler and community member (Table 3, Fig. 5). Predictably, higher rates of mercury intake corresponded to higher rates of fish consumption because the types of fish consumed are similar across the range of consumption (Fig. 5), with the notable exception of two anglers (circled) who selectively consumed trout and salmon, which have low mercury concentrations in this region. Mean rates of mercury intake for individual ethnicities were compared to the USEPA reference dose (0.1 micrograms mercury/kg-body-weight/day) and to the grand mean of all intake rates. Approximately 5% of anglers had a mercury intake rate at least 10 times higher than the USEPA reference dose, the mercury intake rate 1/10 of the rate associated with measurable health impacts. The reference dose (7 micrograms/individual/day) was calculated using an average adult body-weight of 70 kg (Finley et al., 1994; USEPA, 1997). The mean total mercury intake rate for the whole sampled population is significantly greater than the USEPA reference dose ($P < 0.05$, *t*-test). Similarly, the mean mercury intake rates for Southeast Asian, Vietnamese, Lao, and Asian/Pacific Islander were all significantly higher than the USEPA reference dose ($P < 0.05$). For African-American, Lao, and Vietnamese anglers, 95th percentile local fish mercury intake rates were higher than 10 times the USEPA reference dose, and for these groups, as well as Southeast Asian anglers as a whole, the 95th percentile rates of mercury intake from total fish consumption were greater than 10 times the USEPA reference dose. Among ethnic groups, Lao and Vietnamese had mean mercury intake rates that were significantly higher than the grand mean rate for all anglers ($P < 0.05$).

Anglers from households with children had mercury intake rates that were significantly higher ($P < 0.05$) than the USEPA reference dose and higher than households without children

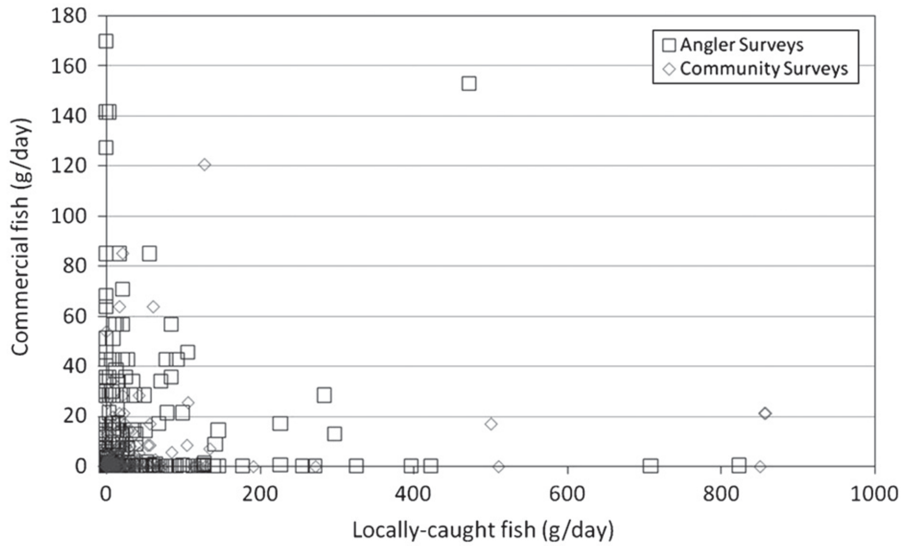

Fig. 4. Relationship between consumption rates for locally caught and commercially acquired fish.

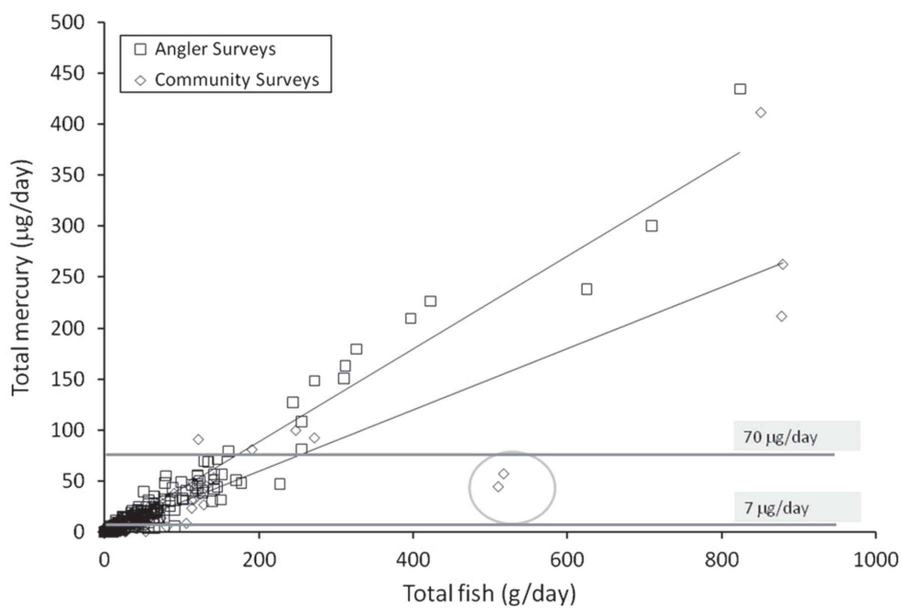

Fig. 5. Calculated mercury intake rates per interviewee compared to total fish consumption rate. The lines corresponding to 7 and 70 μg/day are the USEPA mercury reference dose for adults and ten times the dose, respectively. The circled pair of symbols represent surveyed community members who were consuming large amounts of low-mercury fish (salmon and trout). The upper line represents the least-squares regression fit for the angler survey results and the lower line, the corresponding fit for the community survey results.

(Table 3). Anglers from households with women of child-bearing age had higher rates of mercury intake than anglers from households without women of child-bearing age, but with only marginal significance ($0.05 < P < 0.10$).

The fish filet models used in surveying represented cooked fish, which has about 75% the mass and volume of fresh fish. Mercury concentrations are calculated and used here for fresh fish. Therefore, the mercury intake rates calculated here represent a conservative estimate of actual rates, where actual rates could be 1.33 times higher than those reported.

3.5. Awareness of fish contamination

Respondents were asked about their awareness of warnings about fish contamination and their responses coded according to accuracy and completeness of the response (range=0, no awareness, to 4, high awareness and accurate recall, Table 4). Angler awareness (Table 5) was highest among White respondents (mean=1.9), followed by Native Americans (mean=1.6), and African-Americans (mean=1.4). Awareness was also highest in middle-aged respondents (compared to other age groups) and higher in men than women. There was significantly lower ($P < 0.05$, t-test) awareness of warnings about fish consumption among Southeast Asians interviewed in community settings than for Southeast Asian anglers interviewed while fishing.

Awareness was compared to fish consumption and various demographic parameters (Table 3). Anglers that were more aware of warnings about fish contamination did not have statistically different rates of fish consumption or corresponding mercury intake than anglers with low awareness ($P > 0.05$, t-test). Awareness in households with children present (mean=0.97) was significantly ($P<0.05$, ANOVA) lower than in households without children (mean=1.2). There was no significant difference in awareness correlated to the presence or absence of a woman of child-bearing age in the household.

3.6. Pathways for communication of health information

Because state and local governments are considering informational campaigns about fish contamination and in some places have started them, we tested the fishing populations for awareness of this issue. Among African-Americans, Hispanics, Native Americans, and Russians, a sign at a fishing location was the main source of information about fish contamination (Table 5). Among Southeast Asians, Asian/Pacific Islanders, and Whites, television was the main source of information (Table 5). Secondary sources of information included friends and family and community clinics (Table 5). When sources of warnings about eating fish were compared among ethnicities, Asian, Southeast Asian, and White groups reported warnings from different sources than all other groups ($P<0.05$, Chi-square test). Similar results were found when trusted sources of health information were compared among groups. Asian, Southeast Asian, Hmong, and White groups reported trusting different sources for health information than all other groups ($P<0.05$, Chi-square test). There were no differences among age groups for trusted sources of health information. Males and females both recalled warnings primarily from television, but women also relied on friends and family as an important source.

The primary trusted source of health information for African-American, Southeast Asian, Asian/Pacific Islander, Hispanic, and White populations was health providers (Table 5). For Native Americans, family and friends were the primary source of health information (Table 5). Secondary sources for all groups included family and friends, television, radio, newspaper/magazines, and community centers (Table 5). For all age groups and genders, the primary source of health information was from medical providers. Secondary sources included family and friends and television.

Table 4
Coded awareness of health warnings about eating fish.

Code	Categories of responses
0	No awareness of health warnings
1	Report awareness of pollution, toxicity, some non-specified problem with fish
2	Awareness of one of the following: mercury contamination, OR specific contaminated fish species, OR specific recommended amounts of fish per time period, OR warnings about children and pregnant women fish consumption
3	Awareness of two of the issues in (2)
4	Accurate recall of mercury contamination, specific fish, frequency of consumption (1 meal/month), and warnings about children and pregnant women consumption

4. Discussion

This study shows that anglers in the Sacramento/San Joaquin Rivers Delta may be exposed to mercury in amounts well above the USEPA reference dose. This exposure is in part because the consumption rates of locally caught fish (primarily) are relatively high (compared to the USEPA average value), including being higher than the rates used by state agency staff to develop pollution control plans. In addition, the exposure is concentrated in non-white, primarily immigrant populations, though many ethnicities are affected. Rates of fish consumption vary seasonally, based primarily on fish availability, affecting the accuracy of mercury intake calculations from short-term studies.

4.1. Consumption rates compared to other studies

The fish consumption rates in the present study vary to some degree by ethnicity. This has been found to be true for a comparable study in a nearby area (Silver et al., 2007) and other areas. Fish consumption rates for certain ethnicities in the Delta region are similar to the rates found for Asian American and Asian Pacific Islanders in Washington (117.2 g/day; Sechena et al., 2003), for Yakama Nation members (58.7 g/day; Columbia River

Table 5
Mean awareness, sources of warnings about fish consumption, and trusted sources of health information for different groups of anglers.

Ethnicity	*N*	Awareness Mean (0=none, 4=high)	Source of warning 1st, 2nd choice	Trusted health sources 1st, 2nd choice
African-American	32	1.4	3, 4	1, 3
Southeast Asian	152	0.40	1, 4	1, 3
Hmong	67	0.58	1, 4	1, 3
Lao	30	0.67	1, 3	1, 5/10
Vietnamese	33	1.1	1, 4	1, 4
Asian/Pacific Islander	38	1.2	1, 4	1, 4
Hispanic	45	1.0	3, 1	1, 4
Native American	5	1.6	3, 4	3
White	57	1.9	1, 3	1, 3
Russian	17	0.8	3, 7	4, 7
All Anglers	373	1.1	1, 3	1, 3
Age				
18–34	83	0.9	4, 1/3	1, 4
35–49	82	1	1, 8	1, 4
>49	54	0.6	8, 1	1, 3
Gender				
F	23	0.6	1, 4	1, 3
M	198	0.9	1, 8	1, 3
Household				
With woman 18–49	142	1.13	1, 3	1, 3
With children	116	0.97	1, 3	1, 3

For warning sources: 1=television, 3=sign at fishing location, 4=friend or family, 7=community clinic, 8=other. For trusted sources of health information: 1=health care provider, 3=family or friend, 4=television, 5=radio, 7=newspaper or magazine, 10=community center.

Inter-Tribal Fish Commission, 1994), New Jersey adults (50.2 g/day; Stern et al., 1996), and the 99th percentile consumption rates found in national surveys (USEPA, 2001). The rates presented here are the first measured for local angling populations in the Delta.

The mean consumption rates observed for certain ethnic groups of Delta anglers (Table 3) are several times higher than the default consumption rate (17.5 g/day) the USEPA recommended for public agency planning, based on the 90th percentile rate from USDA nation-wide consumption surveys (USEPA, 2001). This consumption rate was used by the USEPA to set the target methyl-mercury concentration for fish tissue at 0.3 mg/kg fish tissue. The rates found here are also several times higher than the mean daily consumption rate (4.58 g/day) for the general US population (USEPA, 2002). These USEPA rates of consumption and the consumption rate calculated for San Francisco Bay anglers (95th percentile rate=32 g/day), are used by the Regional Board to set target fish tissue concentrations for the Delta through the TMDL process (Central Valley Regional Water Quality Control Board, 2008; described in more detail below). In all cases, the average and 95th percentile rates used in proposed pollution regulation are less than mean local fish consumption rates we found for Lao and the combined Southeast Asian fish consumers (Table 3). The consumption rates of locally caught fish that sometimes have multiple contaminants, especially near urban areas and near the San Francisco Bay, indicate that many fish consumers in the Delta have exposure levels of immediate public health concern.

4.2. *Mercury intake*

Few studies have calculated mercury intake from subsistence fishing using local measurements of mercury concentrations in fish (Stern et al., 1996). Other studies have compared fish consumption rates with mercury body load (e.g., blood; Cole et al., 2004). Our study provides the first accurate estimates of mercury intake for various populations eating multiple species of locally caught fish in California's Central Valley Delta, which can be compared in future studies to measured mercury body loads. These intake rates indicate that most fish consumers may be taking in greater than the USEPA maximum of 0.1 micrograms/kg-body-weight/day. About 5% of consumers are consuming more than 10 times the maximum recommended dose. This number could be higher by 1.33-fold because the rate of mercury intake was conservatively calculated (see Section 2). Certain ethnic groups are on average consuming several times greater than the USEPA reference dose. Ethnic group-specific 95th percentile rates for fish and mercury intake are higher than the highest rates used by the Regional Board for pollution control planning (Central Valley Regional Water Quality Control Board, 2008) and near to or greater than 10 times the USEPA reference dose. All of these findings pose complex, but straightforward policy questions about who should be protected and to what degree.

4.3. *Policy issues*

4.3.1. *Disproportionate health impacts of mercury intake*

The USEPA has determined that a dose of 0.1 microgram/kg body-weight/day of mercury is the maximum that children and women of child-bearing age should consume to protect fetal and child brain development (USEPA, 2004). This reference dose is approximately one tenth the intake rate that has been found to result in measurable health effects in various studies. For a 70 kg (154 lb) person (average adult body-weight), the rate would be 7 micrograms of mercury/day. Stern et al. (1996) calculated the mean rate of mercury intake for New Jersey adults, based on fish consumption rates (mean=50.2 g/day), as 7.5 micrograms of mercury/day.

In the present study, the rates of mercury intake were calculated for all respondents (Fig. 4) and are shown in Table 3 by ethnicity, gender, and age group. For none of the groups were calculated mean mercury intake rates from fish consumption less than the reference dose. The Lao respondents had the highest mean mercury intake rate (28.8 micrograms/day), 4 times higher than the reference dose. The vast majority of this mercury intake was from locally caught fish (26.5 micrograms/day). Of the different ethnic groupings, only Lao had mean mercury intake rates that were significantly higher than the reference dose (t-test, $P<0.05$).

4.3.2. *Impacts of state regulatory response*

In their interpretation of the Clean Water Act, the state has developed a draft TMDL for methyl-mercury in edible fish (Central Valley Regional Water Quality Control Board, 2008). The implementation is intended to be a combination of reduction of methyl-mercury in sediments and water column through waste-load allocations and changes in fish-eating behavior in at-risk human populations. The first phase of implementation includes developing education and outreach programs directed at communities eating fish from the Delta. The draft Delta TMDL states: "*Beneficial use protection in the case of mercury pollution, therefore, must be accomplished by a combination of cleanup and education. Education is a needed part of a TMDL implementation plan until effects of all mercury reduction efforts are reflected in fish tissue levels*." State agencies recognize this as a critical part of their overall strategy. For example, a New Jersey study found that a reduction in fish consumption rates was correlated with exposure to state warnings and advisories (Burger, 2008). This is intended to be the short-term "risk-reduction" program paralleling mercury controls, in order to protect human health until fish tissue targets (for mercury) are achieved. One danger of this approach is that TMDL attainment for humans may be achieved through changing human behavior (reducing fish consumption), rather than controlling mercury in the system. However, our study found no relationship between knowledge of fish contamination and fish consumption rates.

For subsistence fishing populations, simply trying to encourage less fish consumption may be infeasible and if successful, may pose heavy cultural and economic burdens on the population. In the case of the Delta methyl-mercury TMDL, if in a future TMDL amendment, fish consumption rates have dropped because of effective communication by agencies, then fish tissue target concentrations could be raised higher than they would have to be now to protect high-intake fish consumers. Because correcting impairment is the purpose of TMDLs under the Clean Water Act, it remains to be seen whether or not risk-reduction through fish consumption reduction can be legally defended as a TMDL implementation strategy. State responsibility also extends to protecting piscivorous birds and mammals. Fish tissue targets that take into account this responsibility may end up remaining relatively protective of high-intake human consumers as well.

4.4. *Effectively protecting beneficial uses*

A critical issue at the interface between state pollution policy and science is the method used to determine actionable risk. In this study and in most similar studies, the mean fish consumption rate is calculated to indicate the relative risk faced by consumers of contaminated fish. In many studies, the 90th or 95th percentile rates are also calculated as a way to track high-intake consumers. Consideration of 95th percentile rates of mercury intake is more protective of most of the population than measures of central tendency, is likely to lead to the most protective public policy, and is the strategy chosen by the Regional Board. The high 95th percentile mercury intake rates calculated for African-American, Southeast Asian, Lao, and Vietnamese put these groups at risk of measurable health effects from mercury consumption. Any policy response and pollution remediation plan (such as a Total Maximum Daily Load under the Clean Water Act) developed to deal with mercury contamination of edible fish in the Delta should include consideration of the 95th percentile rates.

In the staff report accompanying the TMDL and testimony to the Regional Board itself (Shilling, personal observation; CVRWQCB, 2008) staff suggest that the low fish tissue targets ($\sim$0.05 ppm) corresponding to the higher "subsistence" rates (142 g/day) are not realistic and instead suggest targets that are more attainable. In contrast to this assertion, current concentrations of mercury in American shad, rainbow trout, and other species in the Delta and tributary rivers are comparable to 0.05 ppm (Table 1 and unpublished data from the Regional Board). The more attainable targets suggested by the Regional Board (0.24–0.29 ppm; CVRWQCB, 2008) correspond to estimated fish consumption rates of 17.5–32 g/day, which are relatively low compared to fish consumption rates found for certain ethnicities in the present study. Because the estimated consumption rates used as the basis for TMDL standards do not account for high rates of fish consumption among certain groups, the TMDL is unlikely to be protective of beneficial uses and therefore may not be compliant with the Clean Water Act or California's Porter-Cologne Act.

4.5. Fish consumption patterns for health benefits

Balancing fish consumption for health benefits with concerns about contamination requires consideration of type and size of fish, frequency of consumption, and amount consumed. Species-specific contaminant concentrations, means that rates of contaminant intake can depend as much on total fish intake as on the pattern of fish species consumption. However, by changing patterns of consumption, it is possible to retain the value of eating fish from a health point-of-view, while avoiding the neuorological harm from mercury intake (Oken et al., 2005). In this case, consuming fish with lower mercury concentrations (smaller and/or low trophic level) can result in net health benefits (e.g., see Fig. 5). Because it is unlikely that many anglers and communities will stop or reduce fish consumption, patterns of consumption could be addressed. People could contribute to their exposure-reduction by eating fish in the palette of preferred types that are low in contaminants, by catching them from places known to have lower contaminant concentrations, and/or by focusing more on smaller fish that have lower concentrations of bioaccumulative toxins. Because anglers surveyed in this study showed willingness to eat fish species with low concentrations of mercury (e.g., salmon, shad, trout), it is possible that in general, changes in eating patterns are possible. However, ethnic-specific preferences for different species may pose a barrier to this type of change.

4.6. Community responsibility

In other areas where fish contamination has been approached from a public health perspective, the success of changing consumers' behavior has been variable. Based upon our findings, the learning process for this behavioral change is unlikely to originate directly from state agencies; rather trusted community sources (community organizations, family and friends, health providers) and certain mass media are likely to be more effective. This suggests that well-advertized community-based programs that develop and implement policies related to fish consumption behavior will be the most successful model. In the present study, there were inter-ethnic group differences in both the source of recalled warnings about fish consumption and for trusted sources of health information. A single cookie-cutter approach to communication of risk information may not be appropriate for the highly diverse angling communities of California's Central Valley Delta region. An approach that is more likely to reflect the needs and communication pathways of these diverse communities is one originating from the communities themselves and possibly initiated by trusted community organizations and community health providers (Shilling et al., 2008). In a recent study, Castello et al. (2008) provided evidence that the involvement of fishers in fishery management can result in significant improvements in fish populations and fishery quotas. A similar approach to fish contamination where impacted subsistence fishers were involved in solution-building would be a significant improvement over the current approach.

4.7. Environmental justice

The California Bay-Delta Authority has been the entity responsible for coordinating understanding of environmental problems in the Bay-Delta and coordinating and leading responses to these problems. This body has been criticized for its lack of inclusion of environmental justice practices (Shilling et al., 2009), lack of public input, and lack of clear connections between science and policy (Little Hoover Commission, 2005). Fish contamination is very much an environmental justice issue in the Bay-Delta and the Central Valley in general because of disproportionate impacts to the ethnically diverse fish consumers and the lack of involvement of these impacted consumers in decision-making. Community organizations that the authors have collaborated with have expressed interest and have active involvement in decision-making around attainment of target concentrations of mercury in fish. As will probably be the case for effective communication and community education about fish contamination, an effective strategy for attainment of mercury standards would be one that included the knowledge and activities of groups representing the impacted communities.

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California Tribes Fish-Use

Final Report

California tribes have used fish for ceremony, diet, and as a part of culture for far longer than California has existed. Because of concern expressed by members of California tribes, the State Water Resources Control Board and the US Environmental Protection Agency supported the collection of information about the current and traditional use of fish by members of tribes across the state, to inform draft water regulations. We found that tribes use fish in similar patterns (fish types and source-waters) as they did traditionally, but not in terms of amounts. Tribes used 29 freshwater/anadromous fin-fish species, 23 marine fin-fish species, and 18 other invertebrate, and plant species and groups of species. Current 95^{th} percentile rates of consumption of caught-fish varied by tribe and ranged between 30 g/day (Chumash) and 240 g/day (Pit River). The rate of fish use (frequency and consumption rate) was suppressed for many tribes, compared to traditional rates, which most tribes attributed primarily to water quantity and quality issues. This report describes the surveying approach and findings about tribes' use of fish.

July, 2014

California Tribes Fish-Use: Final Report

A Report for the State Water Resources Control Board and the US Environmental Protection Agency

Agreement # 11-146-250 between SWRCB and UC Davis

By

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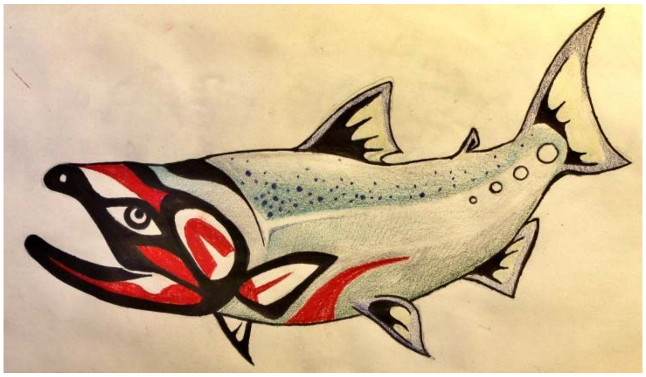

Contents

Summary

Tribes have been concerned that water quality and other water-related decisions tend to lack consideration of tribes' use of water and fish. The State Water Resources Control Board and the USEPA provided funding to collaborate with tribes in discovering what the patterns of fish use were historically and are currently. UC Davis researchers worked with partner tribes to establish an appropriate approach to interviewing tribe members about fish use. Members of 40 CA tribes and tribe groups were surveyed directly at 24 locations and staff from 10 tribes were surveyed online using standard questionnaires. Traditional uses of fish were assessed using literature review and surveying of tribe members and staff. Contemporary uses were assessed using tribe member interviews. We found that tribes use fish in similar patterns (fish types and source-waters) as they did traditionally, but not in terms of amounts. Tribes used 26 freshwater/anadromous fin-fish species, 23 marine fin-fish species, and 18 other invertebrate, and plant species and groups of species. The single most commonly caught and/or eaten fish species group among all tribes was "salmon", which could include chinook or coho salmon. 95th percentile rates of consumption of caught-fish varied by tribe and ranged between 30 g/day (Chumash) and 240 g/day (Pit River). The rate of fish use (frequency and consumption rate) was suppressed for many tribes, compared to traditional rates, which most tribes attributed primarily to water quantity and quality issues.

Background

California Tribes have been fishing and eating fish for far longer than California has existed. Although practices, fishing areas, fished species, and amounts of fish eaten may have changed over time, the cultural and dietary importance of fish has not. Anglo-American anthropologists have estimated that for certain California tribes, fish consumption was at least one pound per day, which for certain coastal tribes may have been mostly salmon (Hewes, 1973; Hewes, 1942 and Hewes 1947, cited in Swezey and Heizer, 1977). This rate is similar to other reported rates in Northern California, for example, Harper and Harris (2008) report that a review of the literature reveals that Columbia River Tribes consumed about a pound of fish per day (620 gpd) before contact with Europeans led to suppression of fish populations and fish consumption.

The Karuk tribe and academic collaborators have studied their own fish use practices and health consequences of fish use (Karuk Tribe, 2004; Reed and Norgaard, 2005). They have demonstrated that the loss of salmon led to a decline in fish consumption by tribe members, and this was linked to health declines, including an increase in an incidence in diabetes, heart disease and hypertension. Because of the direct linkage between dam construction blocking salmon runs, which led to cultural, diet, and health problems for the Karuk, a case could be established that the dams should be removed.

Suppression of fish use and consumption is an important concept in the regulation of water management and problems related to development and extraction activities. Because many of these activities are permitted by state and federal agencies, there is an opportunity to reverse the harm being caused to a use of aquatic systems, once it has been identified. Harper and Harris (2008) make the case that although fish consumption by Columbia River Tribes has been suppressed, a subset of the Tribes' members still practice original subsistence rates and that the subsistence practice should form the basis for regulatory and other means of protecting a recovered use of fish.

Aquatic organism use by California Tribes has been previously studied primarily by analyzing shell and bone fragments in middens associated with traditionally-settled areas, both before and after European colonization. Studies by Gobalet et al. (1990a, 1990b, 1992, 2004) demonstrated that tribes used at least 76 species and groups of species of marine and freshwater fish throughout California. Since colonization and displacement of tribes from most of their traditionally-fished areas, the pattern (fish targeted), geographic distribution, and rate of fish use may have changed.

Policy Framework

Water and aquatic ecosystems are protected by a number of different state and federal laws, such as the state and federal Clean Water Acts. Fish populations are further protected from endangerment and extinction by the state and federal Endangered Species Acts. Fish use by members of the public is protected as a beneficial use (when applicable) under the Clean Water Act, as a recreational use by the Fish and Game code and administratively protected on most public lands. Fish use by tribes is further protected for certain tribes with treaty rights, but not for most tribes. There is an increasingly-recognized gap between the traditional practices of many tribes to use fish for various reasons and the protection of these practices in state and federal law.

Previous studies of fish use by specific California tribes (e.g., Reed and Norgaard, 2005) and the current study suggest that new, or reformation of existing policies are needed that protect the various ways that fish use is important to tribes. These ways include health, sovereignty, culture, environment, economy, and moral/legal. Responsive policies from state and federal agencies will explicitly take these ways of use into account. Being responsive could mean developing new policies, such as SWRCB's proposed beneficial use designation for cultural and traditional use. It could also mean articulating the various ways that fish use is important in new state and federal statutes. Finally, it could mean identifying and protecting these uses in re-negotiated or new treaties between the US and tribes, or in new agreements between California and tribes.

A key component of water policy in California is the development of water quality criteria based upon standard fish consumption rates. These criteria are usually related to fish contamination (e.g., by mercury) and vary inversely with fish consumption rates. The USEPA recommends using a 90th percentile rate of consumption to protect the general population and a 99th percentile rate to protect anglers who consume their catch (USEPA, 2000). In California, both the San Francisco Bay Regional Water Quality Control Board (SFRWQCB, 2006) and the Central Valley Water Quality Control Board (CVRWQCB, 2010) have used the 95th percentile rate of consumption from regional studies to protect fish consumers. Subsistence fishing was considered in one alternative (Alternative 5) of the Delta methylmercury TMDL (CVRWQCB, 2010) as follows: "*Some people are subsistence consumers; because of tradition or need, these people have high consumption rates of locally caught fish, represented by a rate of 142.4 g/day (four to five fish meals per week). This rate is the 99th percentile consumption rate identified in a national food intake survey and recommended by USEPA for subsistence anglers and their families… Therefore, Alternative 5 is protective of (a) people who eat a very high amount of TL4 fish specie*s." (CVRWQCB, 2010). These various sources of guidance and policy findings support the use of a 95th or 99th percentile rate of consumption by tribes as the basis for local and regional water quality criteria, fish tissue criteria, and other water policies promulgated by the state to protect tribes' use of fish.

Methods

The sections below describe how partnerships were developed with tribes, how interviews were conducted, literature retrieval and analysis, and methods of statistical analysis.

Project Locations and Times

There were two primary types of locations where interviews were conducted: 1) tribal offices and 2) tribal or inter-tribal events. The tribes and event locations were distributed widely across California (Figure 1). Interviews were conducted between 1 and 3 times for each tribe between May/2013 and June/2014 (Table 1).

Figure 1. **Tribe and interview locations in California.**

Table 1 **Tribe locations and identities (in parentheses) and month when interviewing was carried out.**

Partner Tribes/Locations	Interview Months
Upper Lake Rancheria (Habematolel Band Pomo)	5,7/2013
North Coast Campout (Inter-Tribal)	6/2013
Bridgeport Indian Colony (Paiute)	6/2013
Big Valley Rancheria (Big Valley Band Pomo)	7/2013
Sugar Bowl Rancheria (Scotts Valley Band Pomo)	7,11,12/2013
Stewarts Point Rancheria (Kashia Band Pomo)	8/2013
Buena Vista Rancheria (Me-Wuk)	8/2013

Blue Lake Rancheria (Wiyot & Yurok)	8/2013
Round Valley Rancheria (Yuki, Pit, Pomo, Nomlacki, Concow, Wailaki)	9/2013
Bear River Rancheria (Mattole & Wiyot)	9/2013
Fort Bidwell Reservation (Northern Paiute)	9/2013
Big Pine Indian Reservation (Paiute)	10/2013
Wiyot Tribe Reservation (Wiyot)	11/2013
Bishop Reservation (Paiute)	12/2013
Death Valley (Timbisha Shoshone)	12/2013
Mechoopda Indian Tribe of Chico Rancheria (Maidu)	3/2014
North Fork Rancheria (Mono)	4/2014
Big Sandy Rancheria (Mono/Monache)	4/2014
Grindstone Indian Rancheria (Wintun-Wailaki)	4/2014
Manchester/Pt. Arena (Pomo)	4/2014
Santa Ynez Rancheria (Chumash)	5/2014
Chemehuevi Reservation (Chemehuevi)	5/2014
Fort Mojave (Mohave)	5/2014
Pit River (Achomawi & Atsugewi)	6/2014

Collaboration with Tribes

The project was inspired by tribes expressing the need for the state and federal agencies to use information about tribes' use of fish in setting water quality standards and thresholds. Tribes were also consulted about appropriate techniques to use to approach tribes and individual tribe members, appropriate questions to ask individuals, and the types of information that would be important to collect. This consultation led to the development and refinement of the questionnaires and the methods used in the field. Tribes suggested collecting information about historical uses of fish, traditional and customary uses of fish, contemporary uses of fish, and threats and causes of fish use reduction (if any).

Contact with Tribes

All 146 federally-recognized and state-recognized tribes and one tribe that has neither recognition (Winnemem-Wintu) were contacted twice by email and letter-mail to solicit their participation in the project. About two-dozen tribes responded by email, phone, or in-person at meetings that they would be interested in further discussion and possible participation. Of these, 12 participated and the remainder changed their position about participating. After learning about the project in various ways (e.g., word-of-mouth), another 12 tribes wanted to participate.

Various reasons were given for not wanting to participate in the project. One major concern was that the federal and state governments and the University of California had all violated trust in various ways in the past and that regulatory, trust, and land management agencies were inconsistent in their consideration of tribes' needs, interests, and indigenous rights and uses of land and water. It is important to consider non-participation in this project NOT as lack of interest in fish use, but rather some combination of lack of time/resources to participate, political resistance to governmental intrusion, and knowledge of past failure of government to act to protect tribal interests.

Interview instruments

Two questionnaires were used to interview tribe members in the field, one focused on traditional uses and threats to uses (Appendix 1) and the other focused on contemporary uses and threats to use (Appendix 2). The traditional use questionnaire included questions about tribe's traditional fishing dependence, fishing areas, and traditionally-used fish. The questionnaire also included questions about past rates of consumption of traditionally-used fish and whether and why current fish use might have been impaired compared to traditional patterns. The contemporary use questionnaire included questions based on 30-day recall about the frequency of fishing and consumption of particular locally-caught and store-bought fish species. It also included questions about reasons that fish use may be less than desired or anticipated, as well as basic household and demographic information.

Tribes were also surveyed using an online instrument focused on tribes' traditional and customary use of fish (Appendix 3). The questionnaire contained questions focused on whether tribes used and still use fish, the types of fish used, the frequency tribes traditionally ate fish, and the barriers to fish use. Tribe staff were contacted via email and provided a link to the survey. This online questionnaire was used to reach additional tribes that were not involved in the two field surveys.

Field interviews

Field interviews were carried out in two primary ways: 1) working with tribes to organize tribe members on certain days when UC Davis staff could come and interview them and 2) working with tribes to find out how to engage in specific tribe events where interviewing tribe members was feasible. This approach is different from the method that an epidemiological study might use of randomly sampling a population, based on tribe rolls, and conducting in-person or phone interviews. The demographic mix (income, age, and gender) that resulted from our approach led us to believe that we had incidentally interviewed a random subset of each tribe. To encourage tribe members to come on certain days to be interviewed, staff would announce to the tribe members via email list-serves, newsletter announcements, and posted fliers (on notice boards) that interviews were going to take place. All tribe members were invited and no attempt was made to target anglers and users of fish specifically. Tribe cultural and community events were assumed to attract a cross-section of each tribe. People were approached opportunistically at these events, or sometimes people approached the interviewers at the UC Davis project booth.

Literature review

Available literature about tribes' fish use was searched from tribal and academic library resources. Several kinds of information were retrieved from these sources: 1) narrative descriptions of traditionally-fished areas, 2) narrative or quantitative description of rates of fish use and consumption, 3) narrative description of fish species used, and 4) descriptions of and threats to and changes in fish use. This information was important in understanding what fish tribes had traditionally relied upon and is important context for reports of current fish use.

Data management

Data from the questionnaires were entered into Excel spreadsheets by the field interview staff and the project lead. Photocopies of the questionnaires were kept by the field staff until safe delivery of the originals to UC Davis, then destroyed. Original questionnaire forms were kept in a locked file cabinet inside a locked office at UC Davis. Data entered into Excel spreadsheets were kept in password-protected computers. Incomplete questionnaire responses were retained as blanks in the spreadsheet. Any questions about individual responses were resolved by discussions between the field staff and the project lead. All tribes were informed that they had the right to refuse sharing of the data after it had been collected. No tribe used this right.

Coding of interview responses

Narrative responses to questions were recorded as either one of the existing possible answers to questions, or as a new type of answer to the question. One of the questions referred to why a certain fish that had been eaten in the past was not consumed in the last 30 days. Answers were grouped by type of response, for example many respondents to this example questions said that they had not been fishing for the fish, or it was out of season. These types of answers were grouped as response types. If too few people responded with particular answer-types, then these more individual responses were retained, but not coded and therefore lumped together.

Mapping waterways for fishing

Tribe members were asked to list waterways where they had traditionally/historically caught fish and waterways where fish originated that they had consumed in the last 30 days. This list of waterway names was used to select hydrologic unit code-10 (HUC-10) watersheds from a standard USGS HUC map using ArcGIS 10. The HUC-10 scale was chosen because it was the smallest HUC scale that captured full waterways, such as specific creeks. For each tribe, 2 maps were created: 1) core traditionally-fished watersheds (identified by 2 or more respondents), and 3) watersheds where currently-consumed fish were obtained.

Statistical Analyses

State regulatory processes typically use the 95th percentile rate of fish consumption to calculate target contaminant concentrations that will protect most users (CVRWQCB, 2008). In order to represent as many native fish-users as possible, we calculated 95th and 99th percentile fish use rates. The mean use rate was not calculated or reported, because it has no meaning in policies intended to be protective of most or all users. The measures examined included frequency of fish consumption, fish portion sizes and fish consumption rates.

Frequency of traditional fish consumption was reported in one of 6 categories (>1 meal/day, 1/day, 2-3/week, 1/week, 1/month, <1/month). Frequency of contemporary consumption was reported as # meals in last 30 days and for comparison with traditional frequencies was converted to the frequency categories used for the traditional interviews. Traditional and contemporary frequency distributions among all tribe respondents were tested for significant differences using a Chi-test R (a statistical package; R Core Team, 2013) for two independent sample frequency distributions.

Traditional fish consumption rates were calculated by multiplying individually-reported frequencies of consumption by an estimated portion size of fin-fish. Meal portion sizes were estimated using the average and 95^{th} % portion size from the contemporary survey. The assumption of a similar portion size in the past and current consumption could be questionable, it was a conservative approach considering the lack of data on fish meal portion size from the past. The average consumption rate obtained was then multiplied by the traditional frequency numbers to get estimates of traditional consumption rates (grams per day).The comparison of traditional and contemporary fish consumption rates was carried out using the Wilcoxon-Mann-Whitney test, which is a suitable non-parametric test for two independent samples for which the dependent variable is not normally-distributed.

Fish consumption rate comparisons were also tested at more specific levels: at the tribe level and the regional level. For tribe comparisons, only those with samples sizes of 10 or more respondents were used. The regional level comparisons have been based on the Water Board region classification for California.

Results

Traditionally Fished Watersheds

Tribes traditionally used most or all streams in their national territories. This traditional use has been reduced in most cases to a set of streams and watersheds that are still used, or were used by recent generations (Figure 3). When present, ancillary areas were often at least as large as the core areas. In some cases, nearby tribes fished the same watersheds.

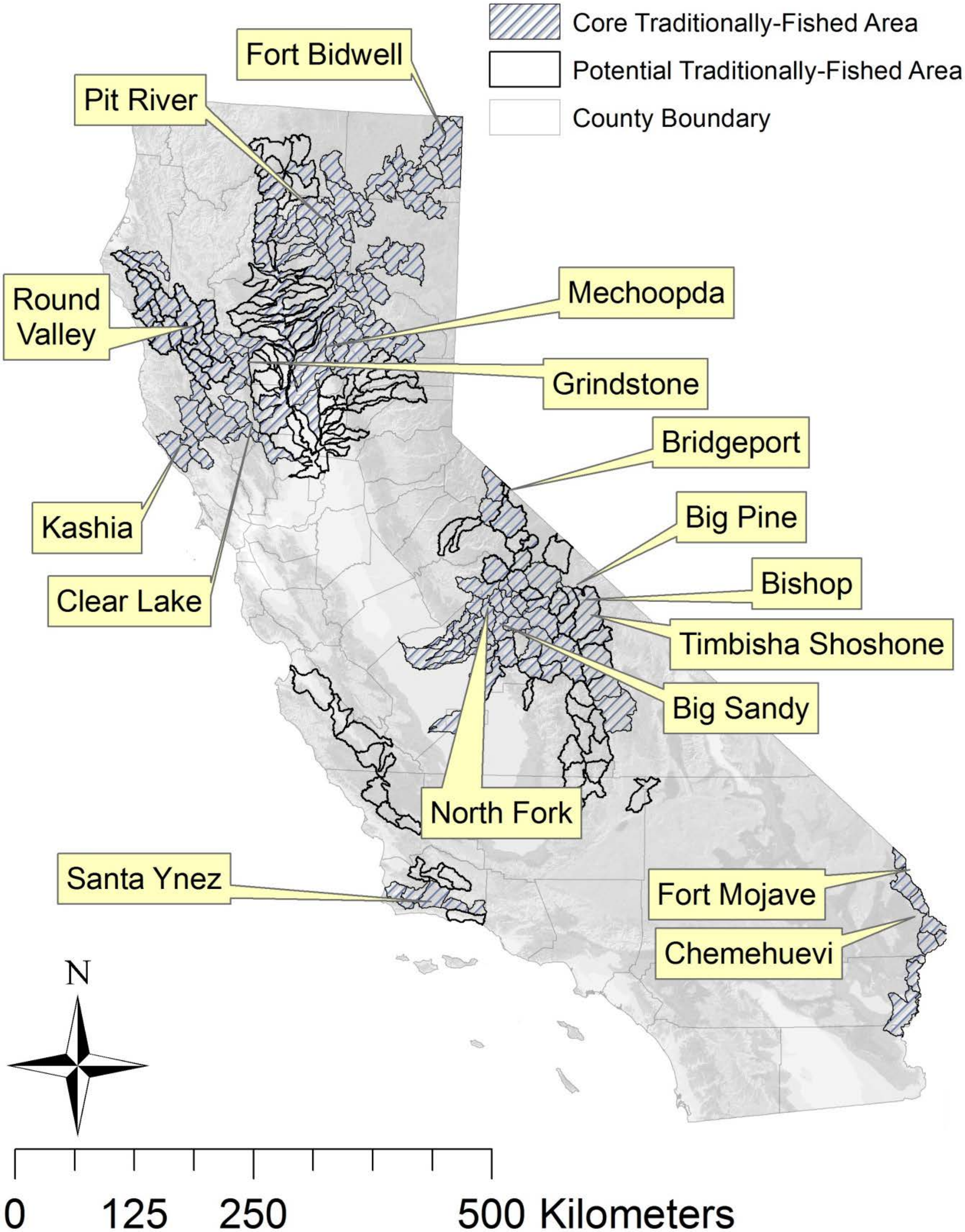

Figure 3. Traditionally-fished watersheds (hydrologic unit code HUC-10). Areas with darker color represent areas where fishing areas of more than one tribe overlapped.

Traditional Reliance of California Tribes on marine, estuarine, and freshwater aquatic organisms

California tribes have longed relied on bony and cartilaginous (e.g., sharks) fish. Much of this reliance has been recorded by the tribes by themselves and by archaeologists who have investigated midden piles at pre- and post-contact village sites (Table 2).

Table 2. Fish species relied upon historically/traditionally by California tribes.

Region	Tribe(s)	Marine, estuarine, freshwater	Fish Species/Groups	Top 5 (Marine, estuarine, freshwater)
North Coast (Karuk Tribe, 2009)	Karuk	All	Salmon, steelhead, sturgeon, trout, lamprey, suckers	*(list not prioritized) Salmon, steelhead, lamprey, sturgeon, trout, suckers
San Pablo Bay (Gobalet, 1990a)	Ohlone	Marine	Shark, rays, skates, herring, sardine, anchovy, midshipman, smelt, white seabass, surfperch, shiner perch, seaperch, pile perch, monkeyface prickleback, rockfish, sanddab	Sturgeon, sardine/herring, salmon, bat ray, topsmelt/jacksmelt
		Estuarine	Sturgeon, threadfin shad, salmon, striped bass, surfperch, gobies, longjaw mudsucker, sculpin, flounder	
		Freshwater	Minnows, splittail, hitch, hardhead, Sacramento sucker	
Delta, Cache Ck (Gobalet, 1990b)	Ohlone, Pomo, Patwin	Estuarine	Sturgeon, salmon, delta smelt,	
		Freshwater	Carp/minnow, thicktail chub, hitch, California roach, hardhead, Sacramento blackfish, splittail, Sacramento pikeminnow, speckled dace, Sacramento sucker, threespine stickleback, prickly sculpin, perch	Carp/minnow, perch, Sacramento sucker, salmon/steelhead, thicktail chub
South Bay, Central Coast (Gobalet, 1992)	Coastanoan	Marine	Shark, ray, longjaw mudsucker, anchovy, rockfish, pile perch, cabezon, rock prickleback, silverside, topsmelt, jacksmelt, herring/shad/sardine	Silverside, carp/minnow, Sacramento perch, Sacramento sucker, sturgeon
		Estuarine	Sturgeon, steelhead, salmon	

		Freshwater	Sacramento perch, Sacramento sucker, carp/minnow, thicktail chub, hitch, hardhead, Sacramento blackfish, splittail, Sacramento pike minnow	
	Chumash	Marine	Shark, ray, skate, herring/sardine, anchovy, jacksmelt, white sea bass, white croaker, corbina, black croaker, drum/hardheads, senorita, sheephead, kelp bass, sea bass/grouper, skipjack tuna, bonito, mackerel, albacore, yellowtail, barracuda, shiner perch, rubberlip seaperch, pile perch, surfperch, opaleye, lingcod, rockfish, halibut, flatfish	herring/sardine, shark, anchovy, ray, senorita
		Estuarine	Steelhead	
		Freshwater	Arroyo chub	
Sacramento Valley watershed (Gobalet et al., 2004)	Maidu, Wintu, Nomlacki, Wailaki, Pomo, Me-Wuk		Sturgeon, thicktail chub, hitch, California roach, hardhead, Sacramento blackfish, splittail, Sacramento pike minnow, speckled dace, Sacramento sucker, steelhead, chinook salmon, delta smelt, longfin smelt, threespine stickleback, sculpin, Sacramento perch, tule perch	Sacramento perch, Sacramento sucker, thicktail chub, Oncorynchus spp., Sacamento blackfish
San Joaquin Valley watershed	Mono, Yokuts	Freshwater	Sturgeon, thicktail chub, hitch, hardhead, Sacramento blackfish, splittail, Sacramento pikeminnow, Sacramento sucker, Chinook salmon, Sacramento perch, tule perch	Sacramento perch, Sacramento sucker, Sacramento blackfish, hitch, tule perch
		Marine	Shark, ray, yellowtail, barracuda	
Central Coast (near SB)	Chumash	Marine	Shark, smoothhound, skate, guitarfish, ray, herring/shad/sardine, anchovy, midshipmen, northern clingfish, silverside, rockfish, lingcod, sculpin, sea bass, yellowtail, jack mackerel, drum/croaker/hardhead, white sea bass, white croaker, queenfish, opaleye, shiner perch, perches, pile perch, barracuda, senorita, sheephead, kelpfish, longjaw mudsucker, bonito, chub mackerel, swordfish, flatfish, ocean sunfish	
		Freshwater	Steelhead, threespine stickleback	

Fish Historically Present in Traditionally-Fished Watersheds

Freshwater fish historically present in waterways fished traditionally by tribes were derived from the PISCES database (http://pisces.ucdavis.edu). According to this database, the number of species historically available in traditionally-fished areas varied between 2 (Fort Bidwell Paiute) and 12 (Mechoopda) species. This range is likely a function of the size of the area, the fish species diversity of the bioregion within which the tribe fishes, and the thoroughness of surveys of fish presence.

Tribe/Region	Fish Species
Bishop Paiute	Owens sucker, Owens speckled dace, Long Valley speckled dace, Kern River rainbow trout, Central California roach, Sacramento pikeminnow,
Bridgeport Paiute	Mountain sucker, Lahontan redside, Lahontan speckled dace, Lahontan cutthroat trout, mountain whitefish
Big Pine Paiute	Owens sucker, Owens speckled dace, Long Valley speckled dace
North Fork	Central California roach, hardhead, Sacramento pikeminnow, Sacramento hitch, Sacramento perch, Sacramento tule perch
Grindstone	Sacramento hitch, hardhead, Sacramento pikeminnow, Pacific lamprey, Chinook salmon, Central California roach, Central Coast coho salmon
Mechoopda	Hardhead, Sacramento pikeminnow, Pacific lamprey, Chinook salmon, Central California roach, Sacramento perch, Sacramento tule perch, Sacramento hitch, riffle sculpin, Lahontan redside, Lahontan speckled dace, mountain sucker
Fort Bidwell Paiute	Pacific lamprey, Northern (Pit) roach,
Clear Lake Pomo	Sacramento perch, Sacramento hitch, hardhead, Sacramento pikeminnow, Sacramento tule perch, Pacific lamprey, Chinook salmon, Central California roach, Central Coast coho salmon, coastal cutthroat trout
Kashia Pomo	Pacific lamprey, coastal cutthroat trout, Central Coast coho salmon, Sacramento pikeminnow, hardhead

Traditional Pattern of Fish Use

Traditional fish use among tribes varies geographically, based on a combination of local fish availability and trade with other tribes. We found that tribes used a wide range of aquatic species and organism types (Table 3). Salmon was reported as traditionally-used by all tribes except Timbisha Shoshone (Table 3). There was a tendency for the number of types of aquatic organism to increase based on the number of people interviewed (Figure 2), suggesting that it would be useful in the future to interview at least 20 to 30 people per tribe about traditionally-used organisms.

Table 3. Aquatic species and species groups historically used by tribe-members interviewed.

Tribe	Aquatic spp. (#)	Aquatic species (types)
Me-Wuk (1)	5	Striped bass, catfish, clams, mussels, salmon
Nomlacki (12)	20	Catfish, sucker, pike, salmon, steelhead, Sacramento pike minnow, hitch, surf-fish, black bass, trout, perch, carp, bluegill, crayfish, mussels, clams, abalone, seaweed, kelp, tule
Maidu (10)	17	Bluegill, bass, carp, catfish, trout, eel, salmon, perch, rainbow trout, pike, sturgeon, steelhead, crayfish, clams, mussels, tule, seaweed
Paiute (35)	17	Tui chub, speckled dace, sucker, pupfish, rainbow trout, salmon, catfish, Lahontan cutthroat, brook trout, brown trout, perch, brine fly larvae, freshwater clams, snails, watercress, tule
Timbisha Shoshone (9)	8	Brook trout, golden trout, rainbow trout, brown trout, carp, bass, catfish, pupfish
Mojave (4)	14	Trout, striped bass, catfish, humpback catfish, carp, bullhead, steelhead, rainbow trout, bluegill, sturgeon, black bass, bonytail chub, minnows, crayfish
Washoe (2)	3	Trout, salmon, catfish
Mono (13)	16	Rainbow trout, brown trout, salmon, steelhead, black bass, perch, sucker, bluegill, eel, carp, minnows, crayfish, mussels, clams, water cress, cattails
Chemehuevi (24)	15	Black bass, catfish, striped bass, bonytail chub, razorback sucker, humpback chub, bluegill, red-ear sunfish, Colorado humpback chub, Sacramento pike minnow, trout, carp, crappie, crayfish, clams
Pit River (13)	17	Salmon, trout, sucker, red-band trout, steelhead, catfish, sturgeon, eel, black bass, bluegill, perch, crab, crayfish, mussels, clams, water cress, water lily
Wiyot (1)	2	Salmon, sturgeon
Wailaki (2)	6	Salmon, trout, surf fish, crab, mussel, seaweed
Pomo (56)	27	Catfish, carp, bluegill, crappie, blackfish, perch, sucker, cod, shark, tuna, surf fish, salmon, trout, cabezon, rockfish, bullhead, crab, crayfish, barnacles, mussels, abalone, snails, sea urchins, sea anemone, kelp, seaweed, tule

Pomo/Wailaki (5)	16	Catfish, surf fish, salmon, blackfish, night fish, cod, abalone, hitch, bass, carp, bluegill, perch, eel, crab, mussels, seaweed
Chumash (7)	30	Salmon, trout, black bass, catfish, rockfish, steelhead, swordfish, sailfish, shark, sardine, tuna, halibut, perch, sea bass, surf-fish, mackerel, smelt, eel, crayfish, lobster/crab, abalone, snails, oyster, mussels, clams, urchin, cattails, seaweed, kelp

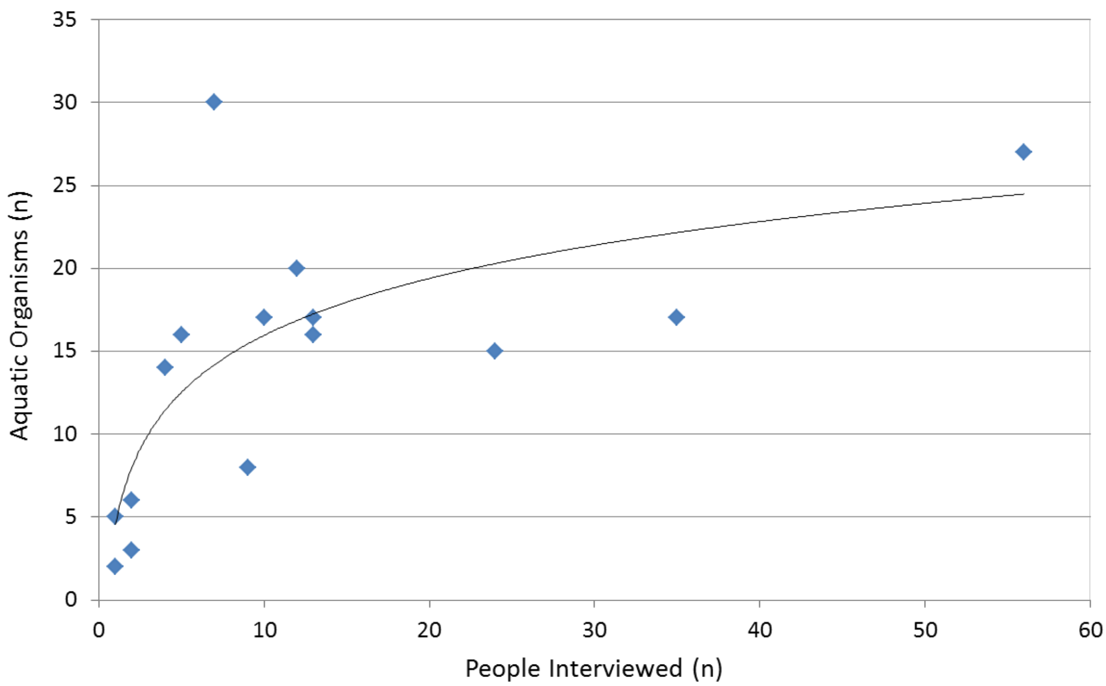

Figure 2. **Comparison of number of aquatic organisms reported used by a tribe and the number of people interviewed. The log curve fit better than a linear regression (based on R).**

The patterns of traditional fish use by tribes in different regions varied considerably (Table 4). Fish species used in certain regions were not used in others, most likely because of lack of availability. For commonly-used species and species groups (e.g., trout and black bass), the proportions varied among regions. The overall effect was that patterns varied among tribes and among regions.

Table 4. Fish species and groups historically used by tribe-members within each Region. Black bass includes both largemouth and smallmouth bass.

	Water Board Region				
Species	**Central Coast**	**Central Valley**	**Lahontan**	**North Coast**	**Total**
Black bass	11.1	8.3	6.7	7.9	6.4
Black crappie	0.0	3.1	0.5	0.0	1.9
Blackfish	0.0	0.3	0.0	0.0	0.2
Bluegill	0.0	6.7	4.6	1.6	5.4
Brook trout	0.0	0.3	3.1	0.0	1.1
Brown trout	0.0	0.6	10.3	0.0	3.5
Bullhead	0.0	0.3	0.0	6.4	0.8
Carp	0.0	5.3	6.2	1.6	5.1
Catfish	11.1	16.1	15.9	9.5	15.3
Chi/Hitch	0.0	8.0	0.0	6.4	5.3
Chub	0.0	0.0	4.1	0.0	1.3
Cutthroat trout	0.0	0.0	4.1	0.0	1.3
Golden trout	0.0	0.0	3.1	0.0	1.0
Lahontan dace	0.0	0.0	0.5	0.0	0.2
Minnow	0.0	0.3	0.5	0.0	0.3
Native trout	0.0	0.6	0.0	0.0	0.3
Perch	0.0	9.1	0.5	3.2	5.7
Pike	0.0	1.9	0.0	0.0	1.1
Pupfish	0.0	0.0	5.1	0.0	1.6
Quiee	0.0	0.0	0.5	0.0	0.2
Rainbow trout	0.0	1.7	11.8	0.0	4.6
Salmon	33.3	12.7	4.1	31.8	12.3
Shad	0.0	0.3	0.0	0.0	0.2
Shapal	0.0	0.3	0.0	0.0	0.2
Speckled dace	0.0	0.0	1.5	0.0	0.5
Sacramento pike minnow	0.0	0.3	2.1	0.0	0.8
Steelhead	11.1	4.2	0.5	12.7	4.0
Sturgeon	0.0	2.2	0.5	3.2	1.8
Sucker	0.0	6.7	4.1	0.0	5.1
Trout	33.3	11.1	9.7	15.9	11.5

Traditional Rates of Fish Use

Most respondents to traditional-practices surveying (64%) reported eating fish every day, or more than once a day when they were young (Figure 4). About 90% of respondents ate fish more frequently than once per week.

Rates of fish consumption (of any fish species) were calculated for each respondent to the traditional survey (rate = meal size X frequency). For an average meal size of 7.9 oz, 95^{th} % rates were up to 222.9 g/day for Maidu, Paiute, Pomo, Wailaki, and Yurok tribe members. For a 95^{th} % meal size of 17.5 oz, rates were up to 496.1 g/day for Maidu, Paiute, Pomo, Wailaki, and Yurok tribe members.

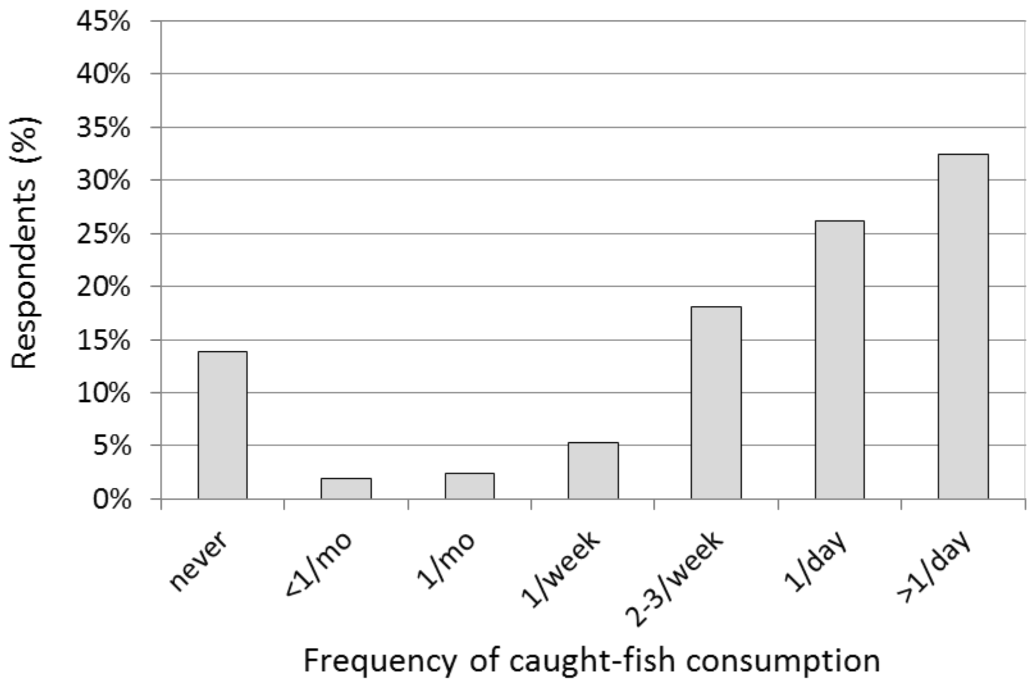

Figure 4. **Traditional frequencies of fish consumption.**

The vast majority of respondents reported that fishing and eating fish was culturally and traditionally important to tribes and an important part of tribe members' diet (Figure 5). Conversely, the majority reported that these traditional practices were not maintained now.

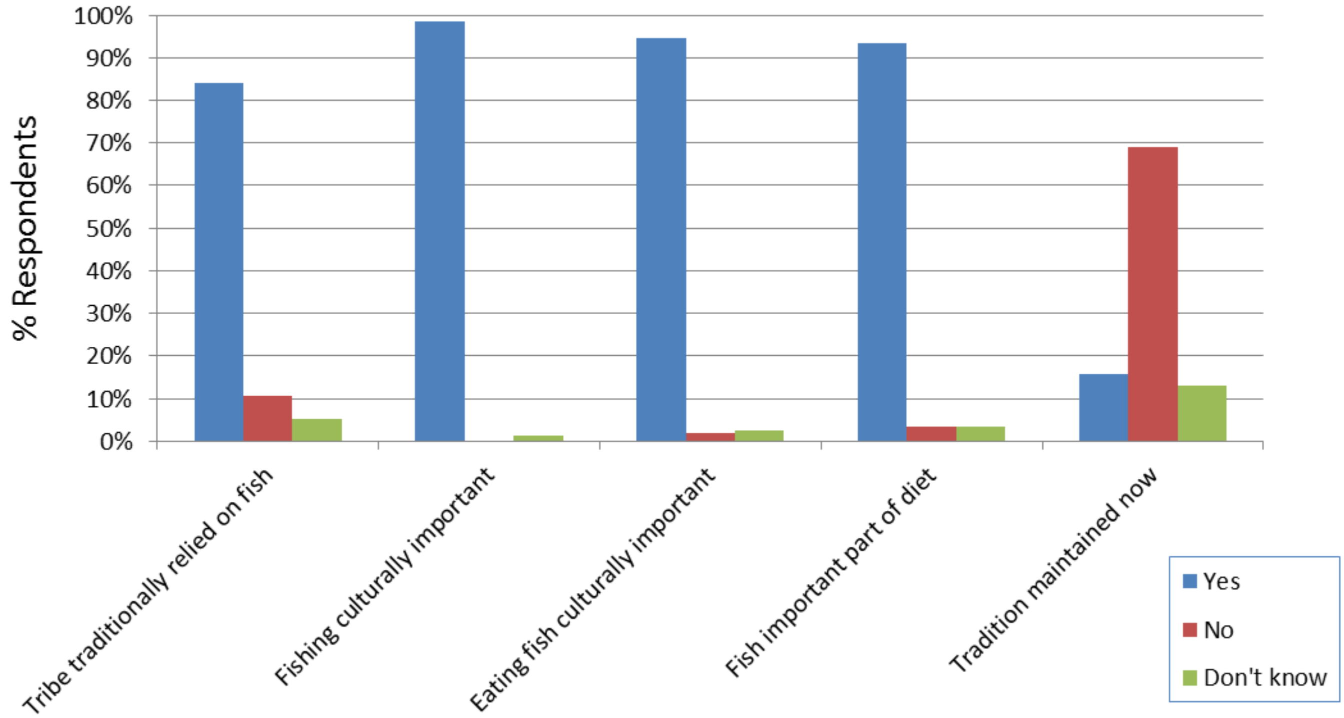

Figure 5. **Fish use traditions and maintenance of traditions today.**

Contemporary Places for Catching Fish

Where there were sufficient respondents, watersheds were identified from which tribe members had obtained fish in the last 30 days (Figure 6). In most cases, fished areas were adjacent to the tribes' Rancherias or Reservations. Most tribes had received salmon from the lower Klamath River watershed and many had caught fish from the ocean and coastal areas.

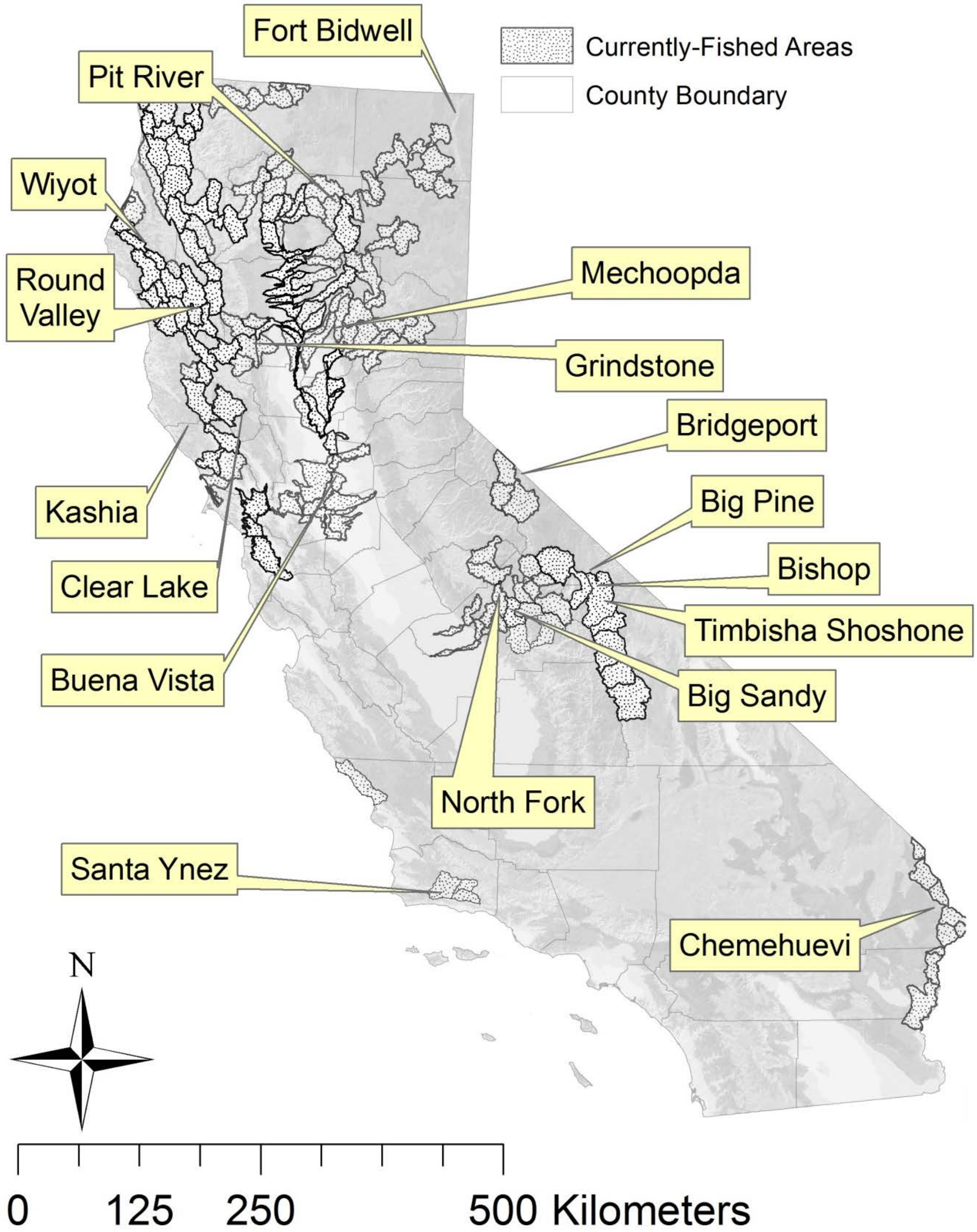

Figure 6. **Currently-fished watersheds (hydrologic unit code HUC-10). Areas with darker color outlines represent areas where fishing areas of more than one tribe overlapped.**

As was the case with the use of different types of aquatic organism, the number of places reported as being sources of fish increased based on the number of people interviewed (Figure 7), suggesting that it would be useful in the future to interview at least 30 people per tribe about places fished.

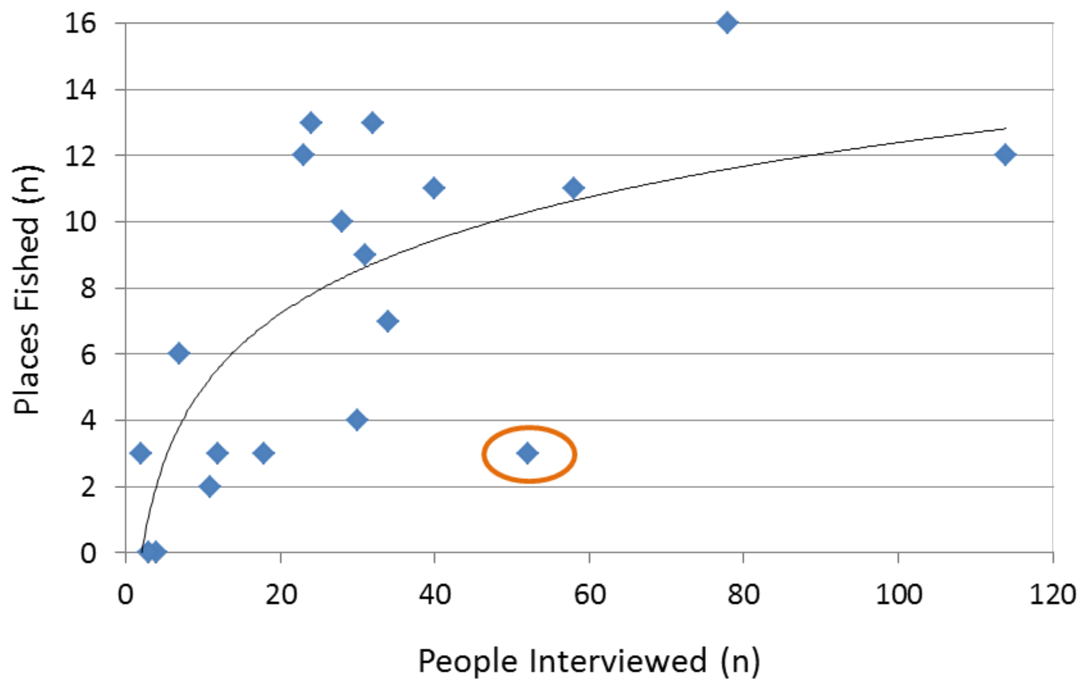

Figure 7. Relationship between # of people interviewed and number of places from which fish was caught and eaten. The log curve fit better than a linear regression (based on R). The circled point represents a desert tribe where 3 large places were cited as sources of fish.

Contemporary Pattern of Fish Use

Contemporary fish use among tribes varies geographically, based upon local native and non-native fish availability. We found that tribes used a wide range of aquatic species and organism types (Table 5). Salmon was reported as currently-used by all tribes and for most tribes was among the top 3 fish species/groups used (Table 5). For most tribes, current fish use was similar to historical use by the same tribe, where similarity was indicated by dividing the number of fish that are currently used that were used historically, divided by the total number historically used. As was the case with traditional use, there was a tendency for the number of types of aquatic organism to increase based on the number of people interviewed (Figure 8), suggesting that it would be useful in the future to interview at least 30 people per tribe about currently-used organisms.

Table 5. Aquatic species and species groups used by each tribe interviewed. The number of people from each tribe is indicated in parentheses following the tribe name. Similarity was calculated as the number of currently-fished species/groups divided by the number traditionally-fished (underlined, cf. Table 3).

Tribe/Location	Aquatic species /species groups	Similarity (%)
Me-Wuk (37)	<u>Salmon</u>, trout, sturgeon, <u>catfish</u>, <u>striped bass</u>, <u>bivalves</u>, lobster/crab, crayfish, halibut, abalone, carp, sunfish/bluegill, perch, largemouth bass, snapper, cod, rockfish, lamprey/ eel, crappie, smelt, shrimp, squid, steelhead, American shad	100
Nomlacki (31)	<u>Catfish</u>, <u>salmon</u>, <u>trout</u>, <u>abalone</u>, lobster/crab, <u>seaweed</u>, <u>bivalves</u>, striped bass, <u>largemouth bass</u>, shrimp, <u>sunfish/bluegill</u>, <u>carp</u>, <u>surf-fish</u>, <u>perch</u>, sturgeon, <u>kelp</u>, <u>Sacramento pikeminnow</u>, lamprey/ eel, shark, <u>sucker</u>, crappie, <u>hitch</u>, <u>steelhead</u>, halibut, squid	80
Mono (6)	<u>Salmon</u>, <u>trout</u>, striped bass, <u>largemouth bass</u>, catfish, <u>bivalves</u>, smallmouth bass, <u>sunfish/bluegill</u>, <u>sucker</u>, lobster/crab, <u>watercress</u>	47
Maidu (32)	<u>Salmon</u>, <u>trout</u>, <u>catfish</u>, lobster/crab, <u>largemouth bass</u>, striped bass, <u>crayfish</u>, abalone, shrimp, <u>bivalves</u>, <u>seaweed</u>, <u>sunfish/bluegill</u>, <u>sturgeon</u>, <u>carp</u>, halibut, cod, tuna, <u>perch</u>, <u>lamprey/ eel</u>, rockfish, <u>Sacramento pikeminnow</u>, crappie, surf-fish, <u>smallmouth bass</u>, hitch, snapper, lingcod, tilapia, seabass, shark	47
Paiute (Bishop, 17)	<u>Trout</u>, <u>salmon</u>, <u>catfish</u>, crayfish, <u>bivalves</u>, largemouth bass, <u>water cress</u>, sunfish/bluegill, lobster/crab, <u>brine fly larvae</u>, carp, tule, striped bass, codfish, abalone, tuna, rockfish, <u>perch</u>, frog, sturgeon, lingcod, tilapia, haddock, algae, cattails	50
Paiute (Big Pine, 24)	<u>Salmon</u>, <u>trout</u>, crayfish, <u>catfish</u>, lobster/crab, <u>bivalves</u>, shrimp, largemouth bass, carp, sunfish/bluegill, striped bass, triggerfish, swordfish, mahi mahi,	29
Paiute (Bridgeport, 18)	<u>Salmon</u>, <u>trout</u>, <u>catfish</u>, crayfish, striped bass, largemouth bass, sunfish/bluegill, cui cui, <u>tui chub,</u> <u>bivalves</u>, sturgeon, smallmouth bass, <u>perch</u>, carp, <u>pupfish</u>, mountain whitefish, <u>sucker</u>, lobster/crab, abalone	57
Northern Paiute (Fort Bidwell, 11)	<u>Salmon</u>, <u>trout</u>, <u>catfish</u>, crayfish, lobster/crab, <u>bivalves</u>, abalone, largemouth bass, sturgeon, shrimp, <u>cutthroat trout</u>, striped bass, walleye, snapper, squid, scallop	36
Timbisha	<u>Trout</u>, <u>catfish</u>, salmon, crayfish, <u>largemouth bass</u>, lobster/crab, bivalves,	80

Shoshone (14)	sunfish/bluegill, striped bass, carp, watercress, shrimp, tuna, halibut, squid, shark, perch, crappie, rooster fish, cod, abalone, brine shrimp larvae, snail	
Washoe (6)	Salmon, trout, catfish, smelt, abalone, striped bass, largemouth bass, smallmouth bass, perch, sunfish/bluegill, sturgeon, steelhead, bivalves, crayfish	100
Chemehuevi (46)	Striped bass, catfish, largemouth bass, salmon, trout, sunfish/bluegill, crayfish, bivalves, lobster/crab, carp, abalone, tuna, smallmouth bass, sturgeon, shark, swordfish, tilapia, perch, halibut, sea bass, cod, orange roughy, squid, seaweed	60
Mojave (5)	Catfish, trout, striped bass, largemouth bass, salmon, crayfish, smallmouth bass, sunfish/bluegill, sturgeon, carp, steelhead, tuna, tilapia, bivalves, lobster/crab	64
Pit River (27)	Salmon, trout, catfish, bivalves, lobster/crab, sturgeon, largemouth bass, crayfish, abalone, striped bass, squid, seaweed, sunfish/bluegill, sucker, lamprey/ eel, smallmouth bass, shrimp, carp, tule, watercress, perch, cabezon, cod, split-tail, Sacramento pike minnow, halibut, lingcod, snapper, tuna, surf-fish, rockfish	88
Wiyot (32)	Salmon, lobster/crab, trout, bivalves, sturgeon, lamprey/eel, abalone, surf perch, smelt, cod, catfish, rockfish, largemouth bass, halibut, sunfish/bluegill, steelhead, striped bass, night fish, perch, cabezon, snapper, crayfish, carp, tuna, sand dabs,	100
Hoopa (Blue Lake/Bear River 4)	Salmon, sturgeon, trout, steelhead, lamprey/eel, lobster/crab, bivalves, abalone, crayfish	ND
Karuk (Bear River, 3)	Salmon, sturgeon, trout, lamprey/eel, snapper, ling-cod, halibut, lobster/crab, bivalves, abalone, crayfish, seaweed, catfish, striped bass, largemouth bass, perch, steelhead, smelt, rockfish, surf fish, cod, tuna, flounder, ray, squid, snail	ND
Pomo (Clear Lake, 164)	Salmon, catfish, trout, abalone, lobster/crab, bivalves, largemouth bass, hitch, crayfish, striped bass, carp, seaweed, sturgeon, perch, surf-fish, smelt, crappie, lamprey/eel, halibut, shrimp, squid, tilapia, tuna, snapper, kelp, snail, blackfish, sea slug, rockfish, American shad	63
Pomo (Kashia, 23)	Salmon, abalone, bivalves, trout, seaweed, lobster/crab, striped bass, largemouth bass, surf-fish, crayfish, sunfish/bluegill, catfish, bullhead, snail, tilapia, carp, sturgeon, split tail, perch, cabezon, kelp, rock cod, rock fish	63
Pomo-Wailaki (12)	Split-tail, carp, lobster/crab, seaweed, striped bass, salmon, kelp, largemouth bass, smallmouth bass, trout, Sacramento pike minnow, abalone, cod, catfish, sunfish/bluegill, blackfish, bivalves, crayfish, smelt, sea anemone	69
Wailaki (16)	Salmon, trout, catfish, abalone, lobster/crab, striped bass, smelt, carp, crayfish, largemouth bass, split-tail, sturgeon, bivalves, seaweed, sunfish/bluegill, steelhead, cabezon, cod, halibut, shrimp, kelp	83
Round Valley (35)	Salmon, trout, abalone, smelt, striped bass, catfish, lobster/crab, steelhead, sturgeon, bivalves, crayfish, largemouth bass, sunfish/bluegill,	ND

	lamprey/eel, cod, snapper, carp, seaweed, tuna, hitch, nightfish, rockfish, surf-fish, crappie, halibut, squid	
Yurok (15)	Salmon, sturgeon, trout, lobster/crab, cod, steelhead, lamprey/eel, bivalves, surf-fish, abalone, halibut, striped bass, largemouth bass, catfish, sunfish/bluegill, rockfish, crayfish, perch, carp, smelt, tuna, crappie, Sacramento pike minnow, nightfish, walleye, snapper, seaweed	ND
Chumash (12)	Trout, salmon, catfish, crayfish, largemouth bass, lobster/crab, halibut, bivalves, sunfish/bluegill, sturgeon, striped bass, abalone, shrimp, snapper, perch, carp, smelt, rockfish, cabezon, tuna, flounder, lingcod, snail	71

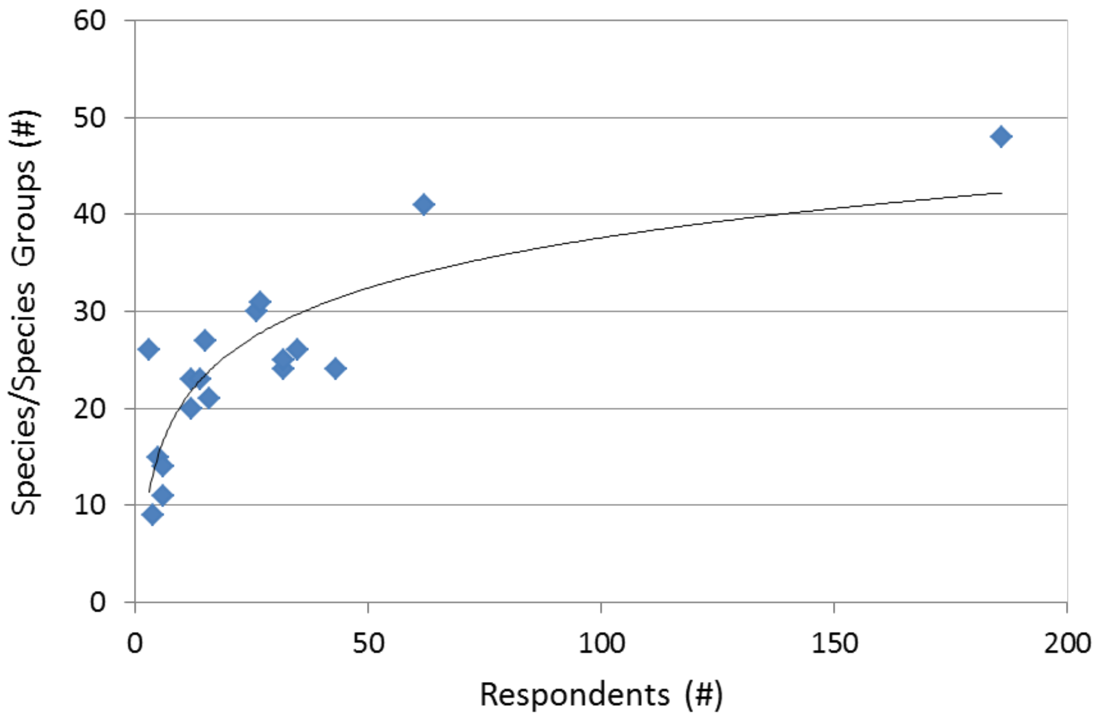

Figure 8. **Relationship between # of people interviewed and number of aquatic organisms species and species groups caught and eaten. The log curve fit better than a linear regression (based on R).**

Tribe and Region Standard Rates of Fish Consumption

Where there was sufficient information, the contemporary frequency of fish use was compared to the frequency of traditional fish use. For all tribes as a group, there was a significant difference ($P<0.001$) between contemporary and traditional frequencies of using fish. This is reflected in the distributions of frequencies (Figure 9), with contemporary frequencies of eating fish skewed toward low frequencies (never to once per month) and traditional frequencies skewed toward high frequencies (once per day).

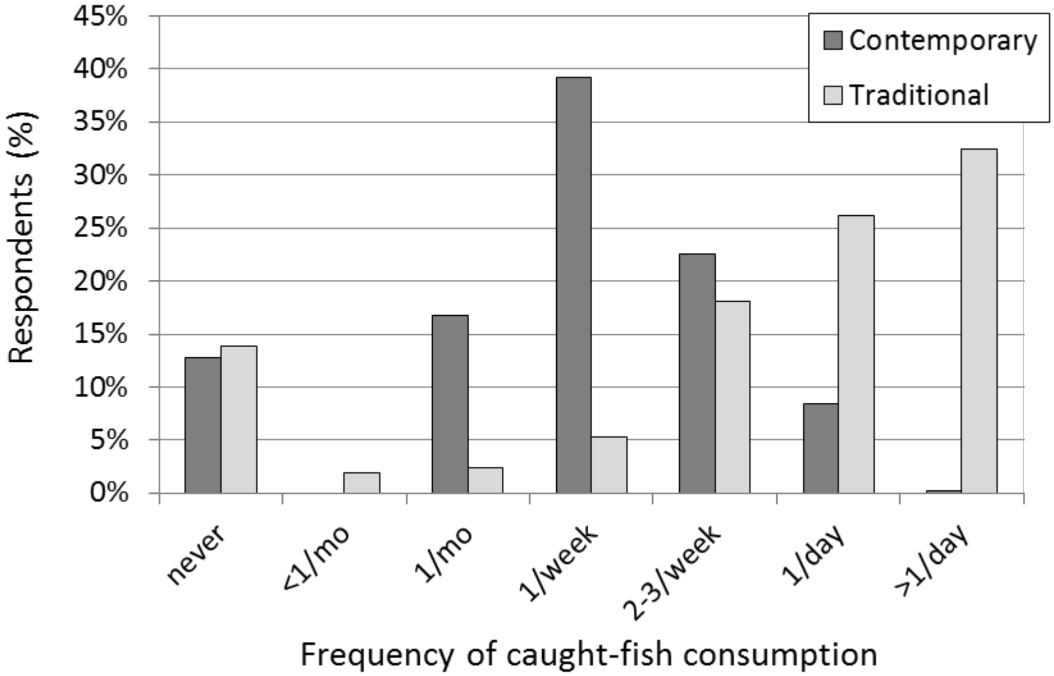

Figure 9. Comparison of contemporary and traditional frequencies of fish use

Tribe-specific rates of fish use were calculated for individual species, groups of species, for all caught finfish, and for all aquatic organism use. Of particular interest for state water policy formulation is the rate of use of caught-fish (all finfish retrieved from state waters). The 95th percentile rate of contemporary caught-fish consumption for all tribes as a group was 141.8 g/day (Table 6). This rate was significantly different from the traditional rate, which was estimated as frequency per individual times average portion size from contemporary consumption. The estimated 95th percentile traditional consumption rate was at least 222.9 g/day (one 7.88 oz average portion size per day) for all tribes interviewed.

Table 6. Contemporary rates of fish and other aquatic organism consumption for all interviewed tribe members.

Component	Min (g/day)	Max (g/day)	95th % (g/day)	99th % (g/day)
Salmon	0	382.7	72.6	179.9
All caught fish	0	623.7	141.8	240.2
Bought fish	0	255.1	60.8	152.1

Other aquatic organisms	0	402.6	27.7	96.8
Total fish	0	623.7	181.9	333.2
Total aquatic organisms	0	708.7	200.0	400.0

Importance of Salmon

Salmon was reported as being currently consumed by almost every tribe member interviewed, regardless of tribe and was the most common single type of fish consumed by tribes individually and collectively (Tables 6 & 7). North Coast tribes generally consumed more salmon and a larger proportion of caught fish as salmon than interior tribes (Central Valley, mountains, and desert). This pattern held when tribes' fish uses were grouped by Water Board Region: Lahontan, Central Valley, North Coast, and Central Coast (Table 8).

Table 7. Proportion of consumed caught-fish composed of salmon for each tribe.

Tribe Name (n)	Salmon (95^{th} % g/day)	Caught fish (95^{th} % g/day)	Total fish (95^{th} % g/day)	% Caught = Salmon
Me-Wuk (32)	22.4	57.2	99.7	39
Maidu (26)	69.1	133.6	183	52
Pit River (17)	196.2	240.4	277.3	82
Paiute (52)	28.3	59.5	81.5	48
Northern Paiute (11)	37.6	63.1	99.9	60
Timbisha Shoshone (14)	39.8	104	257.8	38
Mono (6)	29.8	42.2	52.1	70
Chemehuevi (43)	0	110.3	178.6	0
Pomo (183)	28.3	59.2	101.8	48
Pomo-Wailaki (12)	28.9	34.8	59.2	83
Wailaki (16)	19.8	81.5	85.8	24
Round Valley Tribes (35)	57.8	70.3	81.6	74
Wiyot (30)	132.5	139.1	144.2	95
Yurok (15)	115.1	170.2	170.2	68
Chumash (12)	8.2	29.8	55.4	28
Total	72.6	141.8	181.9	51

Table 8. Proportion of caught fish composed of salmon within each region.

Water Board Region (n)	Salmon (95th % g/day)	Caught fish (95th % g/day), (99th% g/day)	Total fish (95th % g/day) , (99th% g/day)	% Caught = Salmon
Central Valley (288)	42.5	83.1, 203.8	125.1, 264.3	51
Lahontan (135)	20.4	71.9, 126.1	122.6, 206.8	28
North Coast (107)	119.1	162.2, 374.1	180.3, 374.8	74
Central Coast (12)	8.2	29.8, 47.9	55.4, 56.8	27

Barriers to Traditional Fish Use

Tribe members were asked why traditional fishing and fish use practices were not maintained. Responses ranged widely, but centered around two main themes – aquatic ecosystem conditions and being able to fish. Degraded stream/water conditions and the loss of fish populations were the most commonly cited barriers to traditional fish use, followed by regulatory and access restrictions (Table 9).

Table 9. Reasons traditional and contemporary fish use practices were not maintained for all tribes as a group (traditional, n=152 respondents; contemporary, n=394 respondents).

Reasons Traditions Not Maintained	% Traditional Respondents	% Contemporary Respondents
Aquatic ecosystem condition		
Fish declines	45%	24%
Concerns about water/fish quality	42%	11%
Streams dried up	37%	16%
Fish locally extinct	16%	ND
Land/water development	10%	ND
Ability to fish		
Regulation/limits/restrictions	18%	18%

Access to traditional fishing areas	15%	15%
License not affordable	10%	5%
Racism/hostility toward tribe members	2%	0.3%

Relationship Between Fish Use and Income

Like all populations of people, there is variation in income within California tribes. The largest income class among respondents (36% of respondents) had an individual annual income in the range $18,000 to $50,000. This is similar to the distribution of income in 2012 among people in the US, where 25% of people interviewed by the US Census Bureau reported an individual annual income between $17,500 and $50,000 (Source: U.S. Census Bureau, Current Population Survey, 2013 Annual Social and Economic Supplement. http://www.census.gov/hhes/www/income/data/incpovhlth/2012/dtables.html, accessed 7/18/2014). Amounts of salmon, caught fish, bought fish, and total fish varied among income classes. For most income classes, caught fish dominated the fish diet, while for the >$100,000 income class, caught and bought fish were eaten in similar proportions. In the >$100,000 income class, the vast majority of fish consumed was salmon, whereas for other income classes, was closer to half of total caught fish consumed. One explanation for the zig-zag pattern in consumption across income classes is that there may be multiple patterns occurring simultaneously. One possibility is that very low income people have less ability to afford fishing equipment, transportation to fishing sites, and time to go fishing, resulting in less fishing. There may be a threshold when more fish can be acquired through fishing (i.e., >$18,000) and higher thresholds where fish can be bought more readily, possibly replacing caught fish. Finally, greater income may also affect peoples' ability to travel to catch salmon, which are only available in a few places in the state.

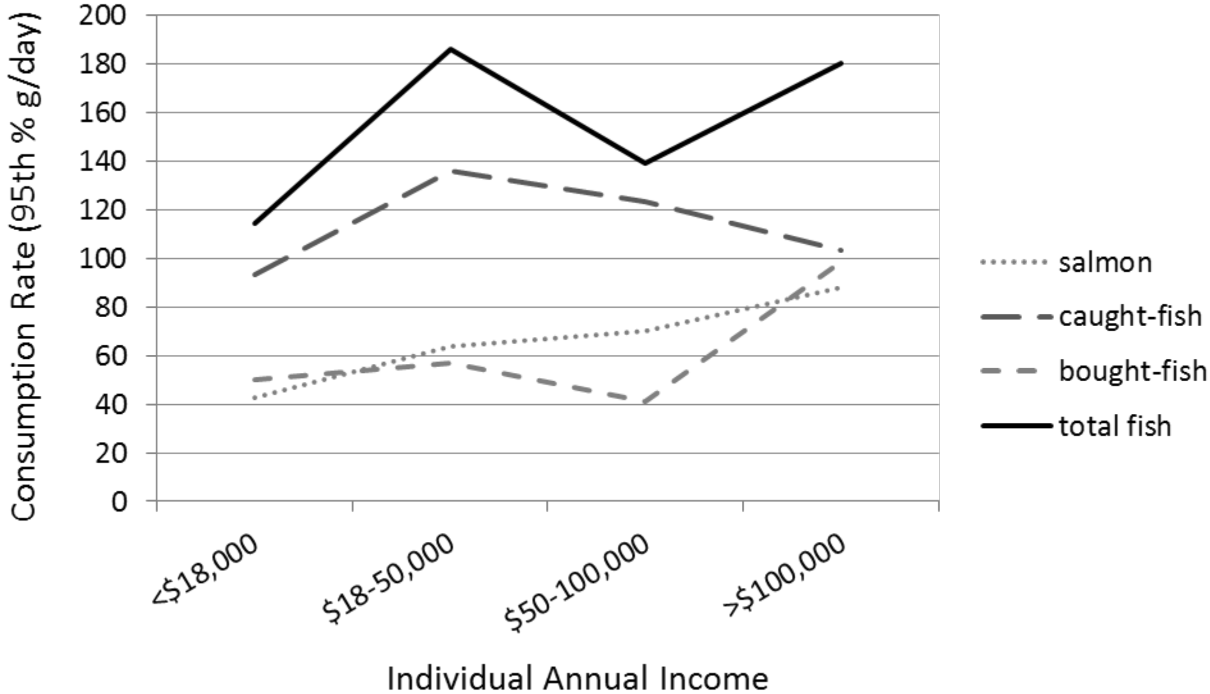

Figure 9. **Comparison of patterns of fish-use and individual annual income.**

Maintenance of Traditional Practices

Three standards were used for maintenance of traditional fish use by tribes: 1) maintenance of fishing locations, 2) maintenance of fish species range, and 3) maintenance of fish consumption. Comparison of currently-fished areas with traditionally-fished areas revealed that traditional fishing is maintained in most places (Figure 9). Although access was described as a problem (Table 8), tribe members reported that they were able to fish most historically-fished waterways. Similarly, although certain fish species and species groups may have gone locally-extinct or endangered, most tribes reported currently using most species/groups that they traditionally-used (Table 5).

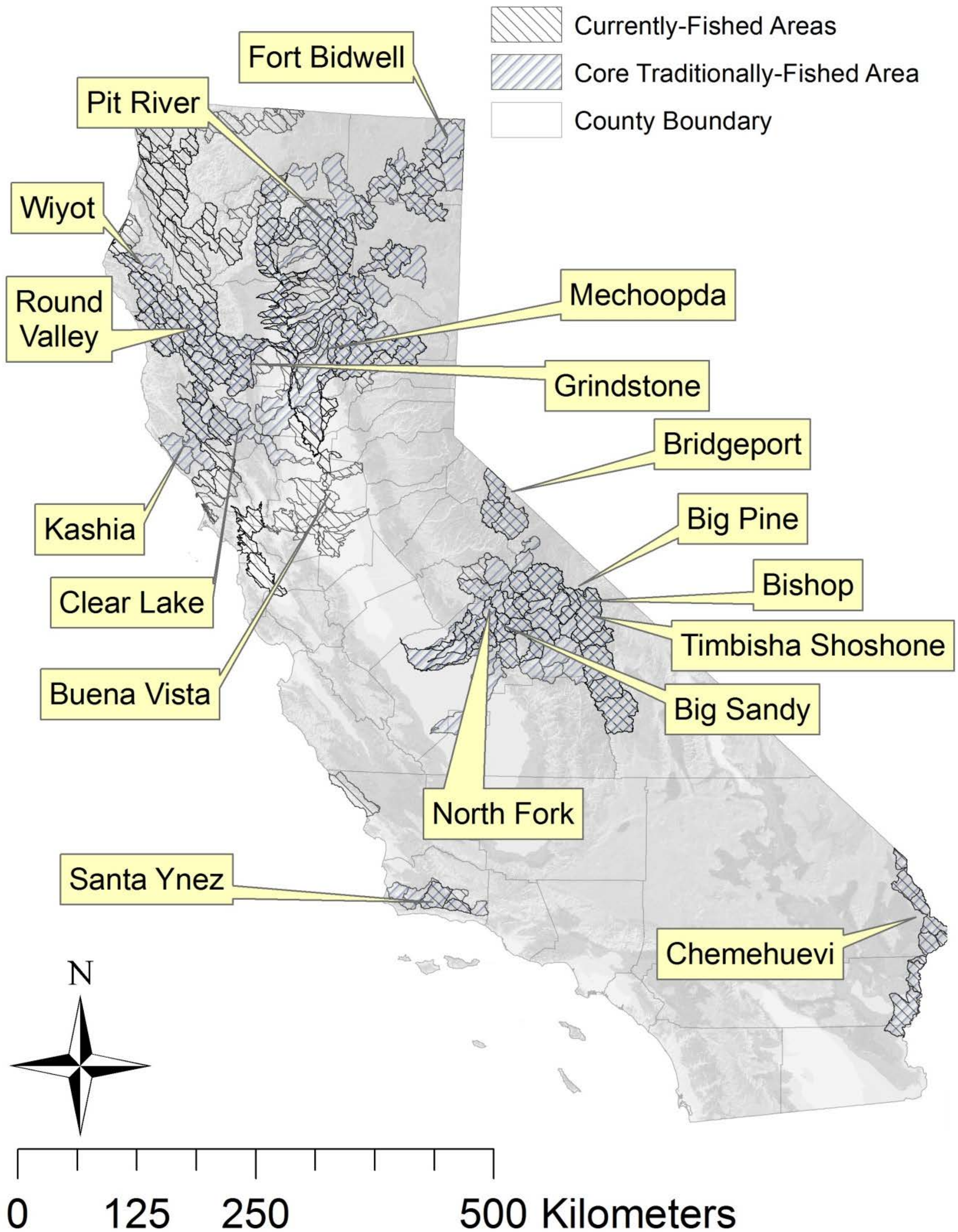

Figure 9. Comparison of currently-fished and traditionally-fished areas (HUC-10 watersheds). Doubly-hatched ("criss-cross" pattern) watersheds were both historically fished and were recently-fished.

Tribe Staff Perspective

Tribe staff were contacted by email and asked various questions about traditional and contemporary fish use. In general their responses were similar to the responses of individual tribe members (see Appendix 4 for more detail). The vast majority of tribe staff responses were consistent with these statements and ideas: fish use was and still is important to tribes for cultural, subsistence, and other reasons; tribe members historically ate fish once per day or more often; aquatic ecosystem conditions and ability to fish (e.g., regulations and access) are barriers to fish use; and tribe members do not eat as much fish as they used to. Tribe staff also expressed the opinion that future projects of this type that rely on interviews of tribe members be conducted and/or led by tribes themselves.

Discussion and Conclusion

Members of California Tribes use fish in similar patterns compared to traditional and historical uses, but sometimes at suppressed rates. The rates of fish consumptions for tribe members are among the highest recorded in California and for many regions are likely to be the highest and therefore the most policy-relevant. Although there are many exogenous barriers to fish use, such as reduced flows from excessive water withdrawals and water quality issues, tribes still practice the main patterns of fish use in terms of broad use of aquatic organisms and wide geographic spread of waterways used. Protection of tribes' use of fish will require target fish tissue concentrations of contaminants to be near background, recovery of fish populations through recovery of aquatic systems/flows, and recognition of accessibility issues that tribes face.

Widespread and Broad Tribe Use of Aquatic Ecosystems and Organisms

The watershed area fished by individual tribes increased with the number of tribe members interviewed and for all regions represented a significant proportion of the total watershed area. Based on the area included after interviewing members of only 10 tribes about historically fished areas and members of 24 tribes about currently fished areas, it is likely that if all tribes were interviewed, the majority of California's waterways and watersheds could be considered traditionally and culturally used by tribes.

Tribe members reported traditional and contemporary use 26 freshwater/anadromous fin-fish species, 23 marine fin-fish species, and 18 other invertebrate, and plant species and groups of species. The more people interviewed per tribe, the longer the list of organisms reported as being used, suggesting that the lists are incomplete. Even with potentially incomplete reporting, about half of the fin-fish reported as being used were fish that had been found during archaeological investigations of middens. The other half of fish reported used was primarily composed of non-native fish that had been introduced since the mid-1800s (e.g., catfish in 1874; Dill and Cordone, 1997).

Importance of Salmon Within and Among Regions

Yoshiyama (1999) provides one of the most exhaustive reviews of the use of salmon by California tribes, particularly in the Central Valley. By his estimate, based on citations, there may have been ~160,000 indigenous people living in the Central Valley and foothills (Cook, 1978; in Yoshiyama, 1999), equaling a density of ~3 people per square mile. Hewes (1947, 1978; in Yoshiyama, 1999) estimated that the per capita consumption rate of salmon among tribes was up to 1 pound (453 g) per day. This rate was likely just part of overall fish consumption, as suggested by archeological investigation suggesting tribes' use of a broad range of fish species (e.g., Gobalet et al., 2004).

Within the primary salmon-bearing areas of the Klamath, Sacramento and San Joaquin Rivers and tributaries, access to salmon runs was the object of some conflict, negotiated fishing rights, and trade of the resulting fish products (reviewed in Yoshiyama, 1999). Tribes from the desert east of the Sierra Nevada may have traditionally crossed the range to catch salmon in the Spring (Jackson and Spence, 1970; in Yoshiyama, 1999), suggesting that salmon was important historically to California desert tribes in the same way that tribes report its importance today.

Because so many salmon runs are listed as threatened or endangered or at risk of becoming so, it is challenging for most native people to practice using what may have been the most important fish to them collectively. The reasons that salmon populations are reduced in California rivers varies among regions, ranging from water quality issues (all rivers), to physical barriers (dams, most rivers), to insufficient flows due to withdrawal for agricultural and urban uses (most rivers). The cause of salmon declines is one of the most well-studied of the ecological impacts of Euro-American settlement of the West. Although the reasons vary for salmon declines, the regulatory (for agencies) and statutory (for the legislature) authority exists to solve most of the problems salmon, and by extension tribes, face for recovery to healthy populations that could support restored traditional use. The current problem with salmon recovery is usually not lack of knowledge, but rather lack of political will to act to protect salmon and their traditional use.

Tribe and Region Standard Rates of Fish Consumption

The USEPA (USEPA, 2000), San Francisco Bay Regional Water Quality Control Board (SFBWQCB, 2006), and Central Valley Water Quality Control Board (CVRWQCB, 2010) have all supported the use of the 95^{th} or 99^{th} percentile rates of fish consumption to develop water quality criteria and fish tissue criteria that are protective of people catching and eating fish from local waterbodies. These recommendations and actual use of these standards were made without conditioning based on the impact these criteria might have on those responsible for implementing or meeting these criteria, which is consistent with the use of the Clean Water Act as protective of beneficial uses and users without condition.

The standard rates are reported here as 95^{th} percentile rates for individual tribes and for regions. The tribe specific rates presented here are useful in setting water quality criteria and fish tissue criteria at both the local waterbody scale and the region scale. Because tribes reported the waterbodies/HUC-10 watersheds that they had traditionally fished and the waterbodies/HUC-10 watersheds from which they had derived fish in the last 30 days, these criteria can be used at the HUC-10 or more general scale. In order to develop criteria useful at the regional scale, tribes' collective use of fish can be used for all waterbodies in a region, unless absence of use by tribes can be demonstrated.

Suppression, Maintenance and Recovery of Traditional Fish Use

Compared to estimates from archaeological investigations and recall of elder tribe members, use of fish has been suppressed compared to historical rates. The daily use of fish reported by elders for only a couple of generations ago suggests that the suppression has been most severe in recent years. Elder and younger tribe members observed that fish availability, flows, and water quality may all be barriers to catching and eating fish at historical rates. The preponderance of evidence points toward regulated and restorable environmental conditions as being the primary barriers to recovery of traditional uses by tribes. For most tribes, there are individual and groups of tribe members who consume fish at rates similar to historical rates of fish use. This maintenance of traditional fish use points to the possibility that fish use could be recovered for the majority of tribe members, as has been described for Columbia River tribes (Harper and Harris, 2008).

Recoverable rates of fish use should be established based on tribe or regional standards, based on quantification of "traditional, cultural and subsistence use" of fish based on tribe members' reporting of historical activities. This has been done here for several tribes, but could be expanded to include more tribes who potentially made greater use of fish than those who were interviewed.

Barriers to Traditional and Contemporary Fish Use by California Tribes

Almost half of tribe members interviewed reported declines in fish populations as the primary barrier to maintenance or recovery of traditional rates of fish use. Approximately a third of tribe members reported water flows and quality as critical issues, which is highly correlated with fish declines. Lower proportions reported logistical problems with fish access, ranging from physical access to traditional fishing locations to state regulations and limits and cost of fishing.

Similar patterns were seen for barriers to contemporary fish use. Approximately ¼ of respondents reported declines in fish populations as the primary barrier to being able to use fish. Fewer, but sizable proportions of respondents reported water flows, water quality, regulations/limits, access to fishing sites, and costs as barriers.

The state policy nexus with these barriers to both traditional and contemporary fish use includes many state regulatory frameworks and permitting systems for water use and discharge of pollutants. If tribal traditional, customary, and subsistence use is regarded as a "beneficial use" under the Clean Water Act, then restoration of the use will require recovery of the flows and water quality that will permit healthy and less-contaminated fish populations to return and be used by tribes.

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Appendix 1. Traditional Fish Use Questionnaire

Survey #	Card #

California Tribes, Traditional Fishing and Fish Use Survey

Date: ___________ Interviewer name: _______________ Time start: _____:_____ am pm
end: _____:_____ am pm

Location of Interview:
Tribe:

Hello. My name is ________. Because of concerns expressed by California tribes about fish and fishing, I am conducting a survey for the University of California Davis. We want to learn about the fishing practices and uses of fish by people in your tribe. This will help the tribe and the state set water quality standards to protect your ability to safely eat fish. At the same time, we want to protect your privacy, so I will not be asking your name or collecting personal information. This survey will take about 15 minutes and we are giving this gift to people who participate. Do you agree to let me interview you about your tribe's traditional fishing practices and use of fish?

1a. ☐ **Y agree, proceed**
☐ N (do not proceed)

1b. [IF INDIVIDUAL DOES NOT WANT TO BE SURVEYED] Please note any known reason that they declined:	**1c. [IF NO] Record observed gender:**
☐ No time ☐ Language barrier ☐ Appeared threatened/uncooperative ☐ Other:___________ ☐ Unknown	☐ Male ☐ Female

2. Have you ever been interviewed before about fishing or eating fish
☐ Y (fishing __ eating fish ___) Who?
☐ N (proceed)

3. Did your tribe traditionally rely on fish as a source of food in the past?
☐ Y
☐ N
☐ Don't know/refused

4. Were subsistence practices such as fishing protected under treaties signed by the tribe?
☐ Y
☐ N
☐ Don't know/refused

5. What major creeks, rivers, lakes, or other water-bodies were traditionally fished by your tribe (possibly use map as aid)?

6. What kinds of fish did you traditionally catch and eat?
[List fish by common name, clarify and/or use visual aid if uncertain]

____

____

____

7. How much of each kind of fish did you traditionally eat?

____

____

____

____

____

1 > one meal a day
2 1 meal per day
3 2-3 meal per week
4 1 meal per week
5 1 meal per month
6 less often than 1/month

8. Was fishing a culturally important activity in the past?
- ☐ Y
- ☐ N
- ☐ Don't know/refused

9. Was eating fish an important part of culture in the past?
- ☐ Y
- ☐ N
- ☐ Don't know/refused

10. Was eating fish an important part of the diet in the past?
- ☐ Y
- ☐ N
- ☐ Don't know/refused

11. Is this tradition maintained now?
- ☐ Y
- ☐ N
- ☐ Don't know/refused

12. If not, why not?

☐ Fish declines ☐ Fish locally extinct ☐ Streams dried up
☐ Concern about water/fish quality ☐ Don't know/refused

☐ Other: ____

Appendix 2. Contemporary Fish Use Questionnaire

Survey # Card #

California Tribes, Contemporary Fishing and Fish Use Survey

Date: ___________ **Interviewer name:** _______________ **Time start:** _____:_____ **am** **pm**
end: _____:_____ **am** **pm**

Location of Interview:

Hello. My name is ________. Because of concerns of California Tribes about fish, I am conducting a survey for the University of California Davis. We want to learn about the fishing practices and uses of fish by people in your tribe. This will help the tribe and the state set water quality standards to protect your ability to safely eat fish. At the same time, we want to protect your privacy, so I will not be asking your name or collecting personal information. We are not concerned with licenses or size limits. This survey will take about 15 minutes and we are giving this gift to people who participate. Do you agree to let me interview you about fishing and using fish?

1a. ☐ **Y agree, proceed**
☐ N (do not proceed)

1b. [IF INDIVIDUAL DOES NOT WANT TO BE SURVEYED] Please note any known reason that they declined:

- ☐ No time
- ☐ Language barrier
- ☐ Appeared threatened/uncooperative
- ☐ Other:_____________
- ☐ Unknown

1c. [IF NO] Record observed gender:

☐ Male ☐ Female

2. Have you ever been interviewed before about fishing or eating fish
☐ Y (fishing __ eating fish ___) Who?
☐ N (proceed)

3. Do you fish? ☐ Yes ☐ No

If interviewed while fishing

4. What are you trying to catch today?___________________________

4b. Are you going to eat the fish you catch today?

- ☐ Yes
- ☐ No
- ☐ Don't know/Not Sure
- ☐ Refused

[If yes] Are you going to feed it to your family? ☐ Yes ☐ No

If interviewed in office/home

4c. [IF NO] What do you usually do with the fish you catch?

- ☐ Eat it myself
- ☐ Give it to others to eat
- ☐ Catch and release it
- ☐ Other: _________________
- ☐ Refused

4d. [IF NO] Do you ever eat fish that you or someone you know catches?

- ☐ Yes
- ☐ No [IF NO, SKIP TO **Q7a**]
- ☐ Don't know/Not Sure [SKIP TO **Q7a**]
- ☐ Refused [SKIP TO **Q7a**]

5. About how many times did you go fishing in the last 30 days?

_____________**[ENTER NUMBER] per** ☐ week ☐ month ☐ other_______ ☐ Don't know ☐ Refused

6a. **Do you eat [*NAME OF FISH]* that you or someone you know catches?** *Ask about specific fish listed below, as well as any others not named. Fresh, smoked, canned, etc.* *Do this question first down the column, then come back and do fish by fish for b-d.*	**6b.** **How many times did you eat *[NAME OF FISH]* in the LAST 30 DAYS?** **>once per day possible** *If zero, skip to next row.*	**6c. If check box in 6a and 6b = 0, ask why have not eaten in last 30 days**	**6d.** **How much *[NAME OF FISH]* did you eat in one meal?** *SHOW PICTURE OF FISH PIECES. Circle letter and write number of UNCOOKED models per meal.* *Only ask for types eaten in the* ***last 30 days.*** **A – Small** **C – Medium** **E – Large**	**6e.** **Where was the *[NAME OF FISH]* caught?** *Only ask for types eaten in the* ***last 30 days.*** *WRITE RESPONSE AND ENTER CODE* 1= Local river 2= Local reservoirs, ponds, or lakes 3 = Coastline, beach 4= Oceans or seas 5= Other (write response) 6= Location of survey
☐ Catfish			A B C D E (Circle) ____ # of pieces/meal	
☐ Striped Bass			A B C D E (Circle) ____ # of pieces/meal	
☐ Largemouth bass			A B C D E (Circle) ____ # of pieces/meal	
☐ Sunfish/bluegill			A B C D E (Circle) ____ # of pieces/meal	
☐ Salmon			A B C D E (Circle) ____ # of pieces/meal	
☐ Carp			A B C D E (Circle) ____ # of pieces/meal l	
☐ Sturgeon			A B C D E (Circle) ____ # of pieces/meal	
☐ Trout/Rainbow			A B C D E (Circle) ____ # of pieces/meal	
☐ Other__________			A B C D E (Circle) ____ # of pieces/meal	
☐ Other__________			A B C D E (Circle) ____ # of pieces/meal	
☐ Other__________			A B C D E (Circle) ____ # of pieces/meal	
☐ Other__________			A B C D E (Circle) ____ # of pieces/meal	

	Do you eat [*NAME OF SHELLFISH]* that you or someone you know catches?			
☐ Clams/mussels/ oysters			____ # /meal	
☐ Crawdads/crayfish			____ # of crayfish/meal	
☐ Abalone			____# or amount/meal	
☐ Crab			____ # or amount/meal	
☐ Other			____ # or amount/meal	

7a. In the last 30 days, have you eaten fish that came from stores, markets, restaurants, or cafeterias? (examples, tuna, fish sticks)

☐ Yes →
☐ No
☐ Don't know/ Not Sure
☐ Refused

[GO TO Q8a]

7b. In the last 30 days, how many times did you eat fish that comes from stores, markets, restaurants, or cafeterias?

[SHOW PICTURES]. Circle letter and write number of pieces per meal]

A B C D E (Circle)

________ times in last 30 days

____ #of pieces/meal

What kind of fish was it? ____________________________

8. Are you able to eat as much fish now as in the past?

☐ **Yes**
☐ **No**
☐ **Don't know/ Not Sure**
☐ **Refused**

9. What are the main things that affect how much fish you can catch?

____

____

10. Are there times of year when you eat more fish? When is that and what kinds of fish

____

11. What are the main things that affect how much fish you can eat?

____

____

HOUSEHOLD & DEMOGRAPHIC INFORMATION

12. In the past year, have any children under 18 in your household eaten fish that you or someone you know caught?

☐ Yes
☐ No
☐ Don't know/ Not Sure
☐ Refused

13. In the past year, have any women between ages 18 and 49 in your household eaten fish that you or someone you know caught?

☐ Yes
☐ No
☐ Don't know/ Not Sure
☐ Refused

14. In the past year, have any women expecting a child or who have a baby in your household eaten fish that you or someone you know caught?

☐ Yes
☐ No
☐ Don't know/ Not Sure
☐ Refused

15. If you don't mind, could you tell me how best to describe your tribal affiliation and ethnicity:

16. If you don't mind me asking, what is your age: [READ CHOICES. CHECK APPROPRIATE BOX.]

1 ☐ Under 18?
2 ☐ between 18 and 34?
3 ☐ between 35 and 49?
4 ☐ over 49?
5 ☐ Refused

17. What city, town or zip code do you live in? _______

18. [RECORD APPARENT GENDER]

☐ male
☐ female

19. I am going to show you a list with some income levels on it, please pick the category that best describes your annual household income from all sources.

☐ Less than $18,000
☐ $18,000 to less than $50,000
☐ $50,000 to less than $100,000
☐ $100,000 or more
☐ Don't know / Not sure
☐ Refused

Appendix 3. Online Surveying Questionnaire

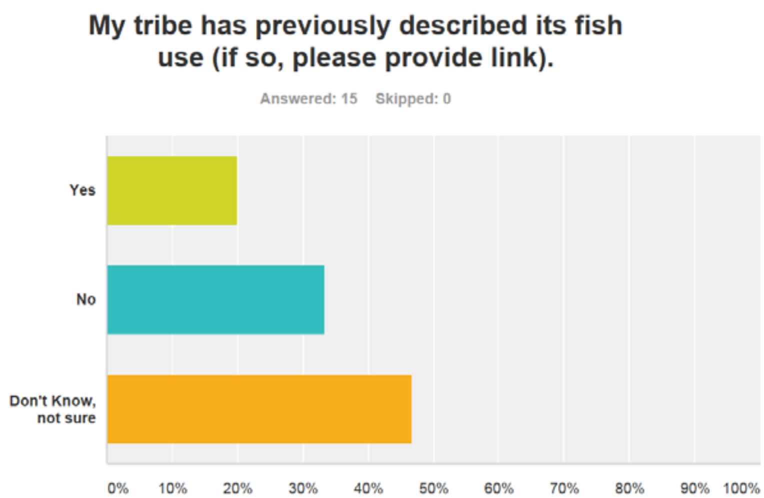
Online Surveying Questionnaire

1. What is your tribe?
2. My tribe has previously described its fish use (if so, please provide link).
3. Would you consider fish important to your tribe for cultural, subsistence, or other reasons?
4. Historically, were fish important to your tribe for cultural, subsistence, or other reasons?
5. What types of fish did your tribe rely on in the past? (Please write in order of importance)
6. What types of fish does your tribe rely on now? (Please write in order of importance)
7. How often did tribe members eat fish in the past?
8. What are the primary impacts or barriers to your tribe's fish use?
9. Do tribe members eat as much fish as they would traditionally?
10. In the future, studies of tribes' fish use should be conducted by...?

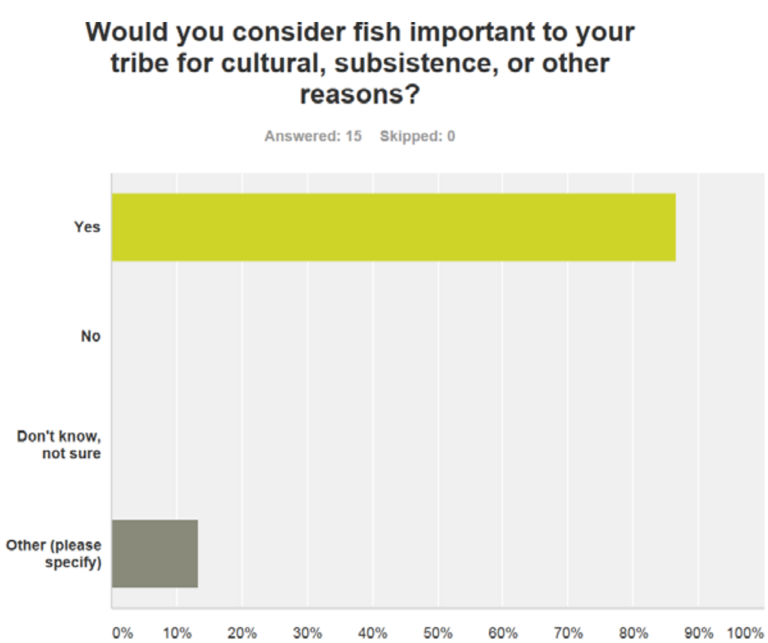
Appendix 4. Tribe Staff Responses to Survey

Question 1. Tribe staff responding: Wilton Rancheria, Karuk, Wintu, Round Valley Tribes, Big Valley Band of Pomo, Noyo River, Bear River Band of Rohnerville Rancheria, North Fork Rancheria of Mono Indians, Pala Band of Mission Indians, Mechoopda Indian Tribe

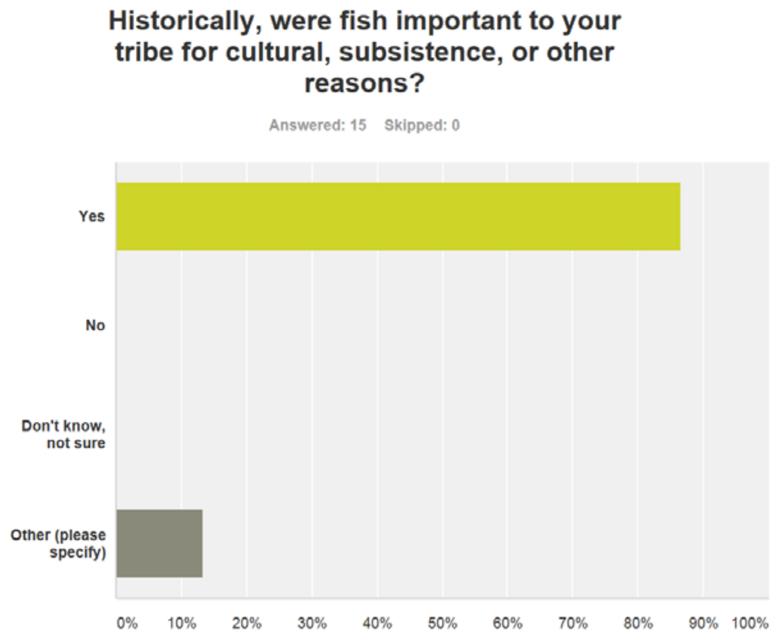
Question 2.



Question 3.



Question 4.

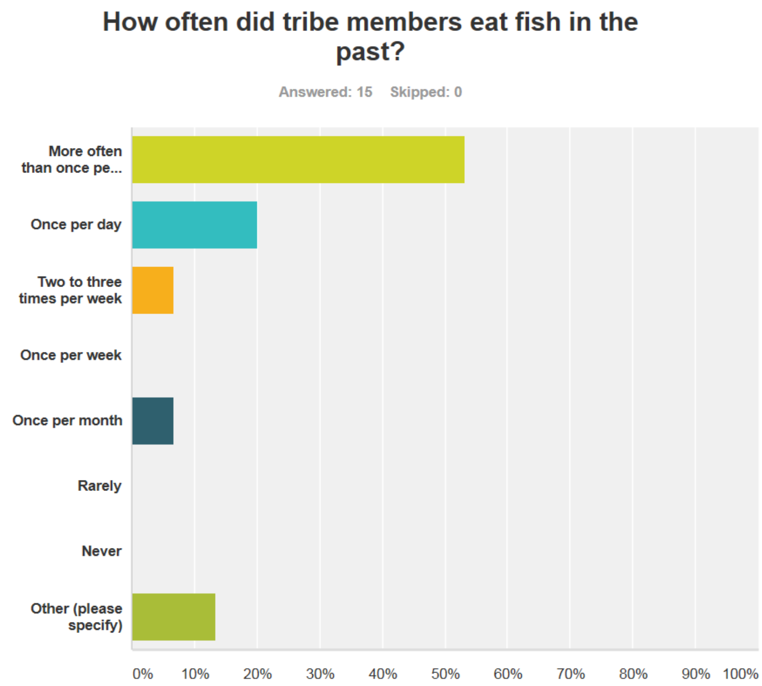


Questions 5 & 6.

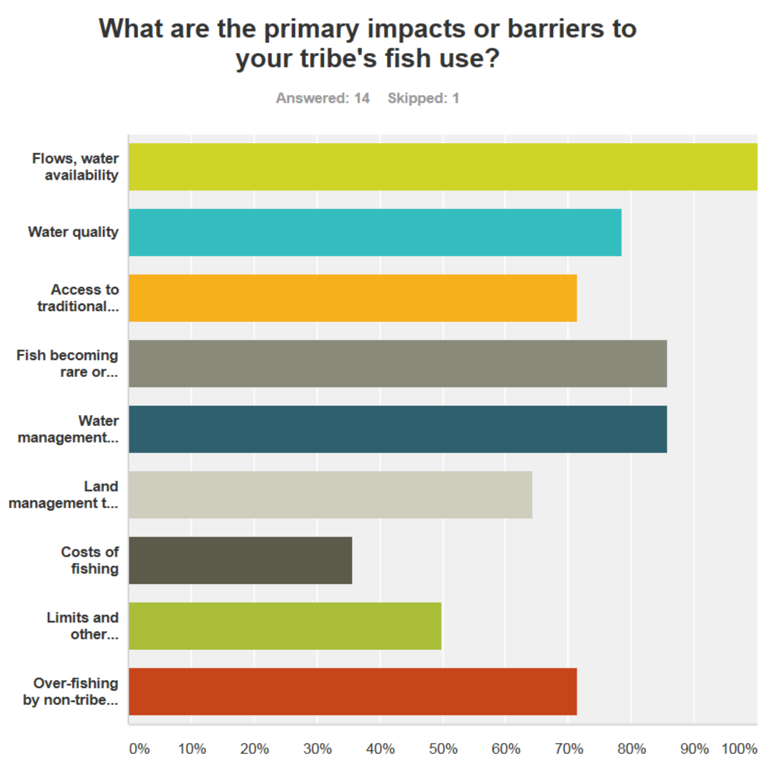
What types of fish did your tribe rely on in the past? (Please write in order of importance) What types of fish does your tribe rely on now? (Please write in order of importance)

Tribe	Past Fish Species/Groups	Current Fish Species/Groups
Wilton Rancheria (Me-Wuk)	Chinook salmon, sturgeon, fresh water eel	Chinook salmon
Karuk (2)	Chinook and coho salmon, sturgeon, eel	Chinook, eel
Wintu	Salmon, trout, sturgeon, eel	Salmon
Round Valley Indian Tribes (5)	Salmon, steelhead, trout, eel	Salmon, steelhead, trout
Big Valley Band of Pomo Indians	Sha (blackfish), hitch, ah-ah-sha (yellow catfish), sha-pal (sim. steelhead), dee-tah (sim. crappie), sun perch, bluegill, trout, black bass, catfish, clams	Store-bought fish, catfish and crappie from lake, clams and crayfish from lake, hitch from creeks, gifted salmon
Noyo River	Salmon, perch, surf fish & all other types of fish from the ocean	Salmon, surf fish, cod, cabazon, & anything else we can catch
Bear River Band of Rohnerville Rancheria	Salmon, lamprey/eel, steelhead, trout	Salmon, lamprey/eel
North Fork Rancheria of Mono Indians	Salmon	Trout
Pala Band of Mission Indians	Trout, bass, ocean shore fish	none
Mechoopda Indian Tribe	"Its not the type of fish, but what is in season and what is needed."	"It is up to the Tribe and the season of fish that are available."

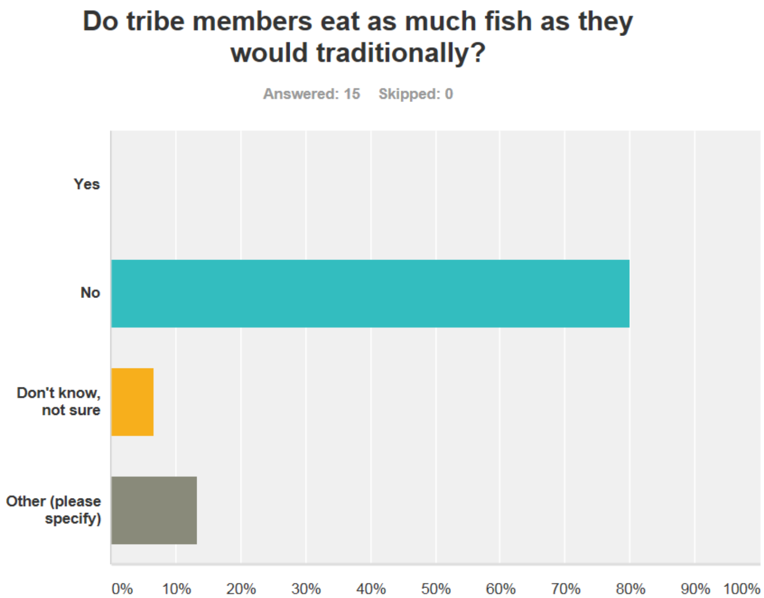
Question 7.



Question 8.



Question 9.



Question 10. In the future, studies of tribes' fish use should be conducted by...?

Type of Entity	Percent of responses
Tribes	40%
State agencies	0
Federal agencies	0
Academia	0
Non-governmental organizations	6.7%
Private consultants	0
Combination of above	53%