

# **Evaluation of Angler Fish Consumption After a Health Advisory on Lake Hartwell, Georgia and South Carolina**

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*Abstract:* A roving creel survey was conducted on Lake Hartwell, Georgia and South Carolina, in 1992 to evaluate spatial and temporal differences in anglers' awareness of a fish consumption advisory and their fish consumption habits. A higher percentage of Georgia residents were interviewed in areas of Lake Hartwell that included large proportions of the Georgia shoreline. The frequencies of anglers that ate fish they caught from Lake Hartwell and percentages of anglers not aware of the current health advisory were generally higher in these areas. Mean per capita fish consumption estimates were higher in spring and summer than in winter and fall. Within season comparisons of mean per capita estimates among lake strata indicated consumption rates were higher in areas of Lake Hartwell closer in proximity to Georgia and in one particular area encompassed by South Carolina. Anglers consumed an estimated 0.23 kg of fish per month in 1992 lake-wide. Georgia anglers appeared unaware of the current health advisory. Most anglers continued to consume fish they caught from Lake Hartwell.

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High Levels of polychlorinated biphenyls (PCBs) were detected in the flesh of fishes collected from Lake Hartwell, Georgia and South Carolina, in 1976 by the South Carolina Department of Health and Environmental Control (SCDHEC) and the United States Environmental Protection Agency (EPA). Sangamo Weston, Inc., of Pickens, South Carolina, had discharged PCBs from their wastewater treatment plant into Town Creek, a tributary of Twelve Mile Creek (Gaymon 1982), from the mid-1950s until halted in fall 1977 by SCDHEC and the EPA.

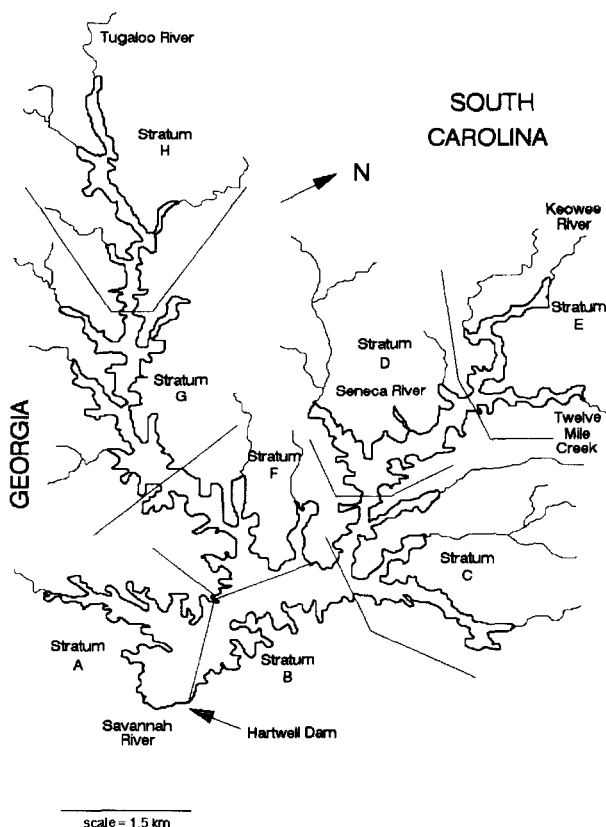
In fall 1976, SCDHEC and the EPA issued a public health advisory warning the public not to eat fish taken from the Seneca River arm of Lake Hartwell (north of S.C. Hwy. 24 bridge). Twelve Mile Creek flows directly into the Seneca River that comprises the majority of the South Carolina portion of Lake Hartwell. An ad-

ditional advisory in 1985 warned the public not to eat individual fish >1.4 kgs taken from throughout Lake Hartwell. The advisory modification resulted from a decrease in the safe consumptive tolerance level of PCBs from 5 ppm to 2 ppm by the United States Food and Drug Administration (FDA) (Gaymon 1988).

A roving creel survey was initiated on Lake Hartwell by the South Carolina Wildlife and Marine Resources Department (SCWMRD) to assess anglers' fish consumption rates, fish consumption habits, and awareness of the current health advisory. Differences among seasons and lake strata were evaluated. This study was funded by the EPA as part of the biological investigations required for Remedial Investigation/Feasibility Study at the Sangamo Weston, Inc./Twelve Mile Creek/Lake Hartwell PCB Contamination Superfund Site Operable Unit Two.

## Methods

Lake Hartwell is a 22,633-ha reservoir with a mean depth of 14 m and a shoreline length of 1,550 km on the Savannah River (Fig. 1) bordering Georgia



**Figure 1.** Geographical strata surveyed during the 1992 Lake Hartwell roving creel survey.

and South Carolina. The reservoir is maintained by the U. S. Army Corps of Engineers for hydroelectric power and recreation. Major tributaries are the Tugaloo River, the Seneca River, and the Keowee River. Lake Hartwell is considered borderline oligotrophic-mesotrophic (Joe Carroll pers. commun.).

A roving creel survey with nonuniform probabilities and a stratified random sampling design (Malvestuto et. al 1978) was designed in consultation with Fishery Information Management Systems, Inc. (FIMS) in Auburn, Alabama. Probabilities assigned to the Lake Hartwell creel survey parameters were based on review of historic creel data.

The sample period (Jan–Dec 1992) was divided into 4 time blocks: winter (Jan–Mar), spring (Apr–Jun), summer (Jul–Sep), and fall (Oct–Dec). Thirty-two surveys were conducted in each block for a total of 128 sample days.

Lake Hartwell was divided into 8 geographical strata (Fig. 1) which were sampled 4 times within each block. Dates, sampling times, and strata were randomly selected for each time block. Time consisted of 3 4-hour periods: 1) AM (0600–1000 hours), 2) noon (1000–1400 hours) and 3) PM (1400–1800 hours). Each time period was assigned a probability of 0.3333. Fifty percent of the sample days were weekdays and 50% were weekend days.

Surveys were conducted within each stratum by making either a right or left circuit, selected randomly. An “instantaneous count” was made around a full circuit of the sample area with as many interviews conducted as possible while completing the circuit. When possible, fish in the anglers’ creels were measured (TL in cm) to obtain length-frequency data for later conversion to weights (kg) using species-specific length-weight regression equations developed by SCWMRD.

Per capita fish consumption estimates were calculated based on fish measured in anglers’ creels, the dress-out percentage (40%), the number of people who ate meals of fish, and the frequency of meals eaten of fish from Lake Hartwell in 1 month. Mean monthly per capita fish consumption estimates were calculated for each block. An annual mean monthly per capita fish consumption estimate by block was calculated by weighting the seasonal estimates by the percentage of angler effort that occurred in a particular block. Estimates of per capita fish consumption were also calculated for each geographical stratum by block and annual estimates were calculated by weighting the strata estimates by the percentage of angler effort that occurred during a particular block and stratum.

Data were compiled and analyzed with SAS software (SAS 1988). Creel programs designed by FIMS were employed to expand daily creel data to block estimates of per capita fish consumption. Associated relative standard errors (RSE) were calculated where possible. A *t*-test was used to detect significant differences in per capita fish consumption estimates between blocks and strata. A *z*-test was used to test for significant differences between resident and nonresident angling frequencies within and between strata. A *z*-test was also used to test for significant differences between the frequencies of anglers interviewed in each stratum that ate fish from Lake Hartwell and between the frequencies of anglers interviewed in each stratum unaware of the health advisory. Differences were considered significant at  $P < 0.05$ .

## Results

### Anglers

Anglers interviewed in areas of Lake Hartwell that were in closer proximity to Georgia than South Carolina were generally nonresident anglers. A significantly higher percentage of nonresident anglers were interviewed in strata A, G, and H while significantly higher percentages of South Carolina residents were interviewed in strata D, E, and F (Fig. 1, Table 1). Block comparisons indicated that in stratum A for spring and summer, significantly more nonresident anglers were interviewed (70% and 37%) than resident anglers (35% and 4%). In stratum D in the fall, significantly more resident anglers were interviewed (74%) than nonresident anglers (31%); however, comparisons within blocks between remaining strata were similar.

Sixty-seven percent of anglers that frequented Lake Hartwell consumed fish they caught and 15% were unaware of the health advisory (Table 2). The frequency of anglers who ate fish from stratum A (80%) was significantly higher than the frequency of anglers that ate fish in stratum B (62%), stratum C (61%), stratum E (56%), and stratum F (63%), but was similar to strata D (70%), G (68%), and H (77%) (Table 2). Most comparisons of the frequency of anglers not aware of the health advisory between strata were similar. Three of the four strata that had the highest percentages of anglers who ate fish from Lake Hartwell (strata A, G, and H) also had the highest percentage of anglers unaware of the health advisory.

### Fish Consumption

The annual mean monthly per capita fish consumption estimate was 0.23 kg. Per capita fish consumption estimates were significantly higher in spring (0.31 kg, RSE = 34) and summer (0.38 kg, RSE = 46) than in winter (0.01 kg, RSE = 74) and fall (0.15 kg, RSE = 40). The winter per capita fish consumption estimate was significantly lower than spring, summer, and fall estimates.

Comparisons of mean monthly per capita fish consumption estimates among strata for each season indicated the highest consumption rates occurred in areas adjacent to Georgia (strata A, F, G, and H) and in stratum D, which is encompassed by South Carolina (Table 3). The highest consumption estimate in the spring occurred in stratum A (0.77 kg, RSE = 68) and strata F and G had the highest associated mean per capita consumption estimates during the summer (1.51 kg, RSE = 81 and 0.83 kg, RSE = 74). During the fall, strata A (0.38 kg, RSE = 90), B (0.20 kg, RSE = 100), D (0.24 kg, RSE = 76), and G (0.35 kg, RSE = 64) represented the 4 highest mean monthly per capita fish consumption estimates. Annual estimates of mean monthly per capita fish consumption for each stratum (weighted by angler effort) were higher than the annual estimate for the entire system in strata A, D, F, and H (Table 3).

## Discussion

A large percentage (85%) of the anglers contacted on Lake Hartwell in 1992 were aware of the health advisory concerning fish consumption. Connelly and Knuth (1993) surveyed a portion of the anglers from the Great Lakes states and found 83% were aware of health advisories in their respective states. Areas of

**Table 1.** Total number (*N*) and percentage (%) of South Carolina residents (SC) and nonresidents (other) contacted in each geographical stratum in winter (WIN), spring (SPR), summer (SUM), and fall (FALL) and for 1992 across all seasons (annual). The number of anglers contacted was weighted by the number of anglers in each fishing party. Percentages followed by asterisks were significantly different between residents and nonresidents ( $P < 0.05$ ). Comparisons of the percentages of Georgia residents contacted (GA anglers) and South Carolina residents (SC anglers) taken from annual percentages were made among the geographical strata. Percentages followed by the same letter within each angler category (GA anglers, SC anglers) were not significantly different ( $P > 0.05$ ). Z tests were used to test for differences in all percentage comparisons.

Stratum	Locale	WIN		SPR		SUM		FALL		Annual		GA anglers		SC anglers	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
A	SC	4	9	31	70*	2	4*	7	16	44	6*	53	73a	26	19b
	Other	0	0	35	35*	36	37*	27	28	98	22*				
B	SC	5	4	30	27	37	34	38	35	110	14	8	10b	62	80a
	Other	0	0	2	6	19	58	12	36	33	7				
C	SC	9	8	53	46	45	39	7	6	114	14	2	3b	59	88a
	Other	0	0	8	50	7	44	1	6	16	4				
D	SC	4	3	61	41	38	25	47	31*	150	19*	1	1b	80	88a
	Other	5	21	0	0	1	4	17	74*	23	5*				
E	SC	21	12	55	31	49	28	50	29	175	22*	2	2b	92	91a
	Other	2	12	5	29	4	24	6	35	17	4*				
F	SC	0	0	36	33	34	31	38	35	108	24*	16	19b	59	71a
	Other	0	0	5	10	19	40	24	50	48	11*				
G	SC	10	20	7	14	16	33	16	33	44	11*	71	72a	25	25a
	Other	24	17	52	37	42	30	21	15	139	30*				
H	SC	2	4	16	33	16	33	15	31	49	6*	47	63a	27	36b
	Other	14	17	26	32	20	25	21	26	81	18*				

**Table 2.** Total number (*N*) and the percentage (%) of anglers interviewed in each geographical stratum that ate fish from Lake Hartwell in 1992 and were not aware of the health advisory. *Z*-tests were used to compare percentages among strata within each angler category (anglers that ate fish and anglers unaware of the health advisory). Percentages followed by the same letter were not significantly different ( $P > 0.05$ ).

Stratum	Anglers that ate fish		Anglers unaware of health advisory	
	<i>N</i>	%	<i>N</i>	%
A	59	80a	21	28a
B	45	62b	8	11ab
C	41	61bc	12	18ab
D	62	70abc	2	2b
E	55	56bcd	6	6ab
F	51	63bcd	10	12ab
G	65	68abcd	24	25ab
H	57	77ab	18	24ab
Total	435	67	101	15

Lake Hartwell where predominantly Georgia anglers were contacted had the highest percentages of anglers that were unaware of the health advisory. Knuth (1990) indicated that successful implementation of consumption advisories will depend on how well the advisory reaches potential audiences. States' fishing regulations guides and posted warnings were the 2 most important sources of advisory information for Great Lake anglers (Connelly and Knuth 1993). Since the advisory on Lake Hartwell was implemented by SCDHEC, we suggest that PCB contamination of fish in Lake Hartwell may not be realized by Georgia anglers because no warning signs are posted at Georgia boat ramps.

The health advisory influenced few of the anglers contacted in 1992, and anglers continued to consume fish from all areas of Lake Hartwell. Thirty-six percent of anglers surveyed by Connelly and Knuth (1993) felt that Great Lakes fish did not pose a health problem. The same scenario may be the cause of the high percentage of anglers surveyed in this study that continue to consume the fish they catch from Lake Hartwell.

Mean per capita fish consumption estimates of anglers that frequented strata in close proximity to Georgia suggests that consumption may have been effected by the lack of health advisory signs at Georgia boat ramps. However, the relatively high mean per capita fish consumption estimate that occurred in stratum D (nearest the primary source of PCB contamination) where warning signs are present precludes this suggestion. The large percentage of anglers that continue to consume fish in this area of Lake Hartwell suggests that the health advisory has had little to no effect on fish consumption habits.

**Table 3.** Estimated mean monthly per capita fish consumption (PC) of fish (kg) from Lake Hartwell and associated relative standard errors (RSE) for each lake stratum during winter, spring, summer, and fall in 1992. The estimated mean monthly per capita fish consumption rate of anglers over the entire year within each stratum (annual) is an average of the seasonal estimates weighted by the amount of angler effort that occurred in a particular stratum during a particular season. Comparisons were made with *t*-tests for each season among strata. Estimates followed by the same letter were not significantly different ( $P > 0.05$ ).

Stratum	Winter		Spring		Summer		Fall		Annual
	PC	RSE	PC	RSE	PC	RSE	PC	RSE	
A	0	0	0.77a	68	0.20b	78	0.38a	90	0.26
B	0	0	0.03def	100	0.19b	68	0.20a	100	0.15
C	0	0	0.01e	100	0.07cd	54	0	0	0.03
D	0	0	0.54ab	67	0.03c	100	0.24a	76	0.28
E	0.12	74	0.32bcf	83	0.14bd	84	0.04b	100	0.14
F	0	0	0.03de	100	1.51a	81	0.03b	100	0.44
G	0	0	0.21cd	89	0.06cd	100	0.35a	64	0.18
H	0	0	0.55ac	81	0.83a	74	0	0	0.59

In conclusion, we suggest that a health advisory issued and posted concurrently by Georgia and South Carolina could affect fish consumption habits of nonresident anglers. Health advisory awareness of South Carolina anglers may be increased if fishing regulations guides included the health advisory information. Since most Lake Hartwell anglers continue to consume the fish they catch, evaluation of the degree of contamination of specific sportfish species may be necessary in order to revise the current health advisory.

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