Chapter 5, Part 2

Net Economic Value of Recreational Fishing on the Sacramento River in 1980,
by John Loomis and Sabrina Ise, Environmental Studies, University of California, Davis

This portion of Chapter 5 uses the travel cost method to estimate a demand equation for recreational fishing on the Sacramento River from Shasta Dam to the city of Sacramento. This demand equation is then applied to simulate the loss in recreational salmon fishing benefits on the Sacramento River, Delta and San Francisco Bay due to drought and global warming scenarios detailed in earlier chapters. The fish losses used in the TCM demand equation are developed using the salmon model described earlier in this chapter.

TRAVEL COST METHOD

The travel cost model estimates the benefits of a recreational resource by using the observed market behavior of users. The basic assumption of the model is that the number of trips taken to a site will decrease as distance traveled increases, since the farther the distance, the larger are direct out-of-pocket and time costs of travel. The calculation of benefits involves a two-step procedure. First, either an individual or per capita demand curve is estimated. The second step is to use the statistical coefficients from the first stage demand curve to derive the site or resource demand curve. The area under the site or resource demand curve can then be calculated and provides a measure of the consumer surplus benefits (Walsh, 1986:217-18). Consumer surplus is defined as the amount a user would be willing to pay for the resource rather than forgo it, net of any actual costs and the opportunity cost of time (Walsh, 45). Consumer surplus benefits are specific to each resource.

The travel cost method is recommended for use by federal agencies when valuing recreation in benefit-cost studies (U.S. Department of Interior, 1986; U.S. Water Resources Council, 1983). The different type of TCM demand models, comparison of time series and cross section TCM's and assumptions can be found in Ward and Loomis (1986) and Loomis and Cooper (1990).

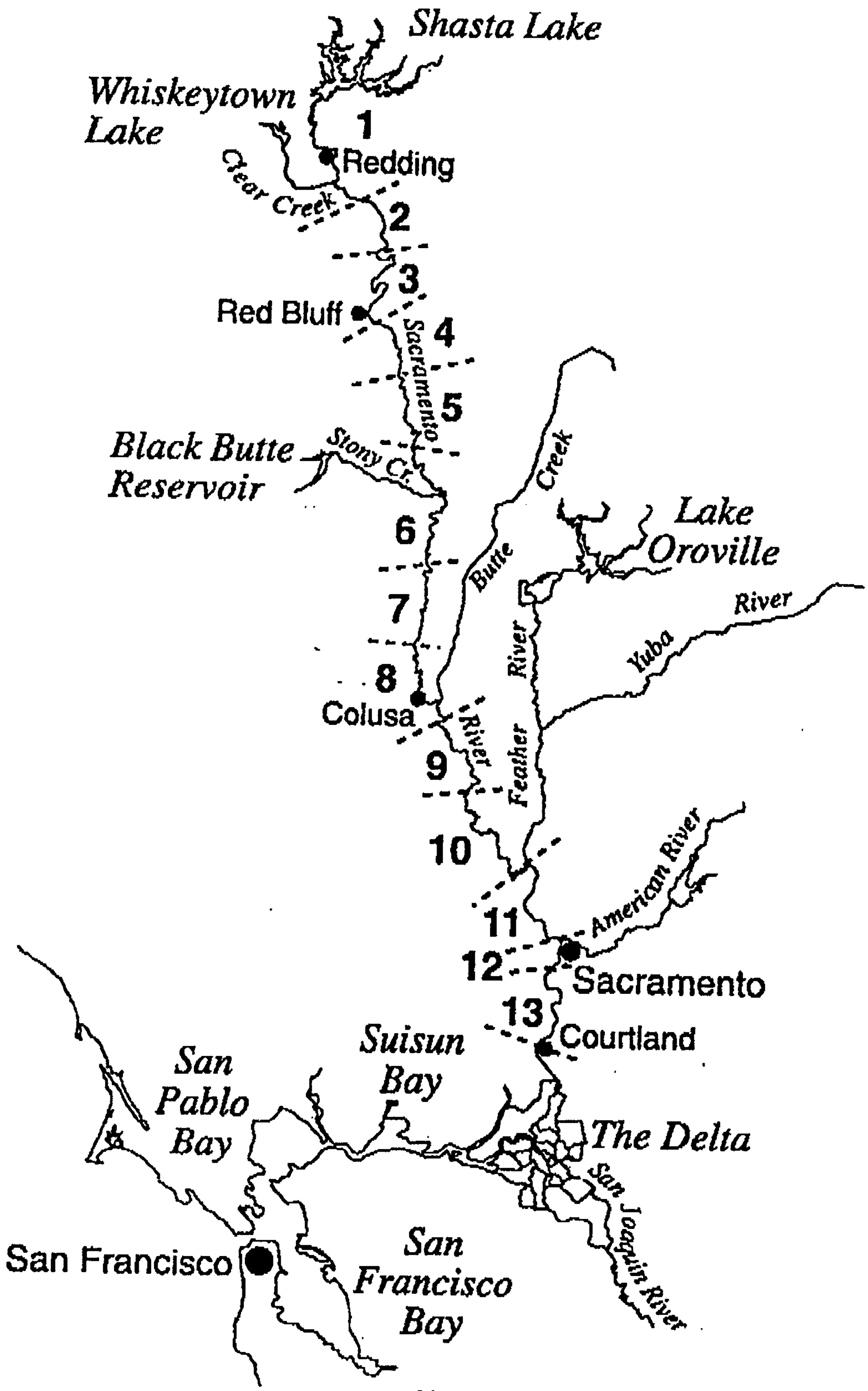
The per capita, or zonal, approach is preferred when users take only a few trips per year or the number of observations for each individual are limited (Walsh, 218). Given our secondary data which did not record annual trips per respondent, about the only model which can be estimated is the zonal TCM.

DATA COLLECTION AND METHODOLOGY

In 1980, the California Department of Water Resources conducted a survey of 3,066 anglers along the Sacramento River as part of an overall survey on recreational use

Sacramento River Sportfishing Areas

Figure 5.16



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of the river. For each of the 13 river segments defined in the survey, data on the number of anglers surveyed, by county of origin, was obtained. Map 5.16 shows the river segments in the survey. In estimating the first stage demand curve, the variable trips was equivalent to the number of anglers surveyed. In order to estimate trips per capita, however, destination sites and origin zones first had to be defined. Destination sites were chosen to correspond to the river segments as defined in the survey with two exceptions. The first exception was segments 12 and 13, which were excluded for the purposes of the statistical analyses since they were originally classified as part of the Delta (not the Sacramento River) in the salmon model. Fishing demand and benefits are included from these areas in the impact analyses through inclusion of the Delta as a recreational fishing site. The second exception was required by linking of salmon model fish catch statistics to our demand equation. The salmon model had only one extreme northern river section which essentially combined survey river sections 1 and 2 together. In addition, because of lack of public access to sections 5, 7, and 9, Department of Water Resources grouped visitation to these sections with the section having public access. As shown below this means that sections 4 and 5 are necessarily grouped together and sections 7, 8, and 9 are grouped together. The river sections estimated in the TCM demand model as sites are as follows:

Site	Segments
Anderson	1 and 2
Red Bluff	3
Tehama	4 and 5
Hamilton City	6
Colusa	7, 8, and 9
Knights Landing	10 and 11.

The second step in setting up the travel cost model was delineation of origin zones. Each of the zones was defined as either a single county or a group of counties, depending on proximity to the sites and county population. Generally, counties closest to the sites and those in the northernmost part of the state were not grouped together. As with the destination zones, specific sites within the origin zones had to be established in order to measure distance. In most cases, the largest city was chosen as the origin site, but location within the zone was also considered. Thirty-six zones were established which encompassed all but three California counties. These three, Mono, Inyo, and Alpine, were not included due to their low population levels and their geographical isolation on the eastern side of the Sierras.

After both origin and destination sites had been established, roundtrip distance calculations were made. The computer software package, PCUSA, was used to calculate these distances. Given the latitude and longitude of each origin and destination, PCUSA calculates the one-way distance between the two locations. A comparison between the computer-generated distances and those measured on a standard California road map, however, indicated that PCUSA consistently underestimated the distance by an average factor of 1.15. This factor was exactly consistent with the average circuity factor reported in Hellerstein et al. (USFS, 1988). Therefore, to obtain accurate roundtrip distances, each one-way distance reported by PCUSA was multiplied by 1.15 and then doubled. Roundtrip distances were then converted into 1990-91 dollars per trip based on per mile travel costs. These consisted of costs for gasoline and oil, routine maintenance, wear on tires, and for the opportunity cost of travel time. Data for the first three expenses were reported by the American Automobile Association as 1991 costs per mile for a midsize 4-door sedan (Amer. Auto. Assoc., 1991:4-5). These costs of 0.098 cents per mile for car operation were then divided among the average of 2.75 anglers per car (Sorg et al., 1985). Following the recommendations of the U.S. Water Resources Council (1979, 1983), the opportunity cost of time was measured as half the average hourly wage rate (of $12.97) in California for 1990 (calculated from data in Fay, 1991:270). From this hourly cost, a per mile cost was estimated based on the assumption that average speed during a trip was 40 miles per hour.

Population data for each origin zone was required in order to calculate trips per capita. County populations and per capita income in 1980 were obtained from California Statistical Abstract 1985. For those zones which included more than one county, a population-weighted average of per capita income over all counties in the zone was used. Trips per capita from each county to river segment was calculated by dividing the number of sampled anglers from county i visiting river segment j by the population of county i. This yields a visitation rate that adjusts for the different populations of each county.

Lastly, baseline data on fish catch for each site was taken from estimated catch figures of all species as reported in the Sacramento River Recreation Survey 1980 (SRRS). In the SRRS, fish catch of both shore and boat anglers for each of the 11 different reaches of the river was reported. Each of these reaches was assigned to one of the travel cost model's six sites. The fish catch for each of the six sites was then computed as the sum of the catch for all reaches assigned to that site. While ideally the fish catch variable would reflect just salmon since that is what is being modeled in the stream flow biology model, the available angler visitation data relates to fishing for all species including, but not limited to salmon.

RESULTS

We first briefly present an overview of survey results and then the details on the travel cost method demand equation. As is required by the TCM nearly 90% of the visitors to the Sacramento River considered it to be their primary destination. About three-fourths of the visitors came from the eight counties along or adjacent to the river. Day users averaged about 3.5 hours and campers averaged 3.8 days. About 60% of the anglers used a boat. In the upper cold water reaches of the river, catch was dominated by rainbow trout. As one progresses further south along the river the water warms and catfish and striped bass become the common fish caught. Unfortunately for our study, salmon represent only about 5% of the overall fish catch, although it may represent more than this in terms of angler effort.

TCM Results

The per capita demand curve for trips was estimated by standard OLS techniques on a sample of 216 observations. The results of the final regression equation are presented below.

The demand for trips to the Sacramento River was assumed to be dependent on the distance to the site, the number of fish caught, and income. A plot of distance ordered residuals demonstrated visitation behavior was consistent with a linear in the logs transformation. The per capita regression equation is:

$$\underset{}{TRIPSij/POPi} = \underset{-(1.71)^{**}}{-17.529} - \underset{(-11.80)^{*}}{2.169\ \ln(DISTij)} + \underset{(1.54)}{.328\ \ln(FISHj)} + \underset{(1.30)}{1.428\ln(INCi)}$$

(t-values in parentheses)
$R^2 = .41 \quad n = 216$
$F = 49.25^{*}$

* significant at .01 level ** significant at .10 level

where:

TRIPSij/POPi	=	angler trips from county i to river section j
DISTij	=	round-trip distance from county i to section j
FISHj	=	total number of fish caught at river section j
INCi	=	per capita income in county or origin zone i

As expected, the equation shows that trips per capita are negatively correlated with distance and positively correlated with both the number of fish caught and per capita income.

The model is statistically significant at the 1% level, as determined by an overall F test. Approximately 41% of the variation in trips per capita is explained by the independent variables. All the signs of the parameters agree with *a priori* expectations. The coefficient for distance is significant at the 1% level. The coefficients for fish catch and income, however, are not significant at the 10% level, but would be considered significant at the 20% level. While this is below conventional levels we feel it is best to avoid a type II error, (saying fish catch is not statistically significant) when we have found fish catch to be significant in every other TCM demand equation we have estimated (see Loomis, 1988, for examples of Oregon and Washington salmon and steelhead; see Loomis and Cooper, 1990, for example for trout fishing in northern California). Thus we

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would rather risk the possibility of saying it is significant when it is not. As discussed later in this section, the less than perfect data may make determination of statistical significance difficult. Of course the marginal significance of the fish catch coefficient implies a wide variance around our estimate of the change in recreational fishing benefits with changes in fish catch. This should be kept in mind when reviewing the results.

As the regression equation is linear in the logs, interpretation of the values of the individual regression coefficients must be in terms of percentage, rather than absolute, changes. From the estimated demand equation above, the coefficient for distance indicates that a 1% increase in miles traveled reduces trips per capita by 2.16%. The influence of fish catch on trips per capita is not nearly as strong however; each additional 1% change in fish catch only causes trips per capita to increase by .33%. For every 1% increase in income, trips per capita increases by 1.42%.

CALCULATION OF BENEFITS

Using the estimated per capita demand equation, the number of trips per capita to each site for various added distances was computed by successively adding miles, in 20 mile increments, to the current distance for each zone, until trips per capita from all zones fell to near zero. At this point, the six site demand curves, i.e. trips as a function of price, were calculated simply by multiplying trips per capita for each zone by the zonal population, and summing trips across zones. The added distance variable was then converted into a price variable using a cost per mile of $0.197.

Before calculating total benefits, however, it was necessary to convert the predicted number of trips for the sample into predicted trips for the population. For each site, total angler days for the population was obtained by dividing the estimated total angler hours, as reported in the SRRS, by average trip length (SRRS, 1980). The sample expansion factor was then derived by dividing total angler days for the population by the predicted number of angler days for the sample, at zero-added distance. Computing the area under the site demand curves and multiplying by the angler day expansion factor resulted in total consumer surplus benefits of $6,272,365. This figure is just for fishing along the 11 sections of the Sacramento River and does not include any of the tributaries nor the Delta or San Francisco Bay. This figure also reflects catch statistics in 1980. The travel cost method demand equation estimated a total of 381,538 angler days across all 11 river sections under the 1980 fishing conditions. This angler day estimate from the TCM demand equation is about 14% above Department of Water Resources estimates for the same 11 sections. Dividing the 11 river section consumer surplus of $6.2 million by the estimated number of trips yields a consumer surplus benefit per trip of $16.44. This means each angler would pay $16.44 over and above his or her existing travel costs to be able to fish at the Sacramento River section of their choosing.

This average value per trip is somewhat lower than other estimates of fishing value in California. For example, Cooper and Loomis (1990) estimated a value of fishing on the Feather River (a tributary of the Sacramento) at between $22 and $24 per day from 1981 to 1985. However, when we apply the TCM equation estimated above to the Feather River, we obtain a consumer surplus per trip of $30.42, quite a bit above both the Cooper and Loomis (1990) and our average value of $16.44. The lower average value estimated in this report may be due to long distances many river segments are from the population centers and a limited number of access points.

Interface of Bioeconomic Travel Cost Method Demand Model with Salmon Model

The output of salmon model runs with alternative flows yielded estimates of total salmon populations. As explained earlier this was divided up between commercial and sport catch as well as escapement. The sport catch by river section was input as a variable in the travel cost method demand equation. Reductions in sport fish catch from drought or global warming shifted the TCM demand equation inward. Since benefits are defined as consumer's net willingness to pay or consumer surplus, the inward shift in the demand curve resulted in recreational fishing benefits falling accordingly. Note the fish catch variable in these simulations is just the river sport catch salmon under the baseline, 4 year drought and GFDL climate change and does not include any other species.

Since the salmon model river sections did not perfectly overlap with the Sacramento River Recreation study sections in all cases, sport fish catch was prorated across river sections or sections combined. The largest combination was the Lower Sacramento River which the salmon model defined as a 213 mile stretch from Princeton Ferry to the Golden Gate Bridge. This encompasses a large part of the Sacramento River, parts of the Delta and San Francisco Bay as well as being the stretches located next to very large human population centers. Not surprisingly, sport fishing on this section contributed a majority of the angler benefits.

Results of Impact Analysis Runs from Salmon Model

Tables 5.8 and 5.9 summarize the results from the two main scenarios. The first table reflects the four consecutive years of drought scenario. The annual average loss of recreational salmon fishing benefits is about $13 million, representing a 9% decrease in recreation benefits. The global warming scenario had annual losses of $35 million, representing a 23% loss in salmon angler benefits. This is a substantial reduction coming from just one source of impact. When this loss is added on to other ongoing adverse effects to salmon habitat from water diversions, loss of habitat, etc., the significance of this loss is magnified. Tables 5.8 and 5.9 present the river by river results and the sum of the differences.

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Table 5.8. Estimated recreational salmon fishing lost due to 4 years of consecutive drought.

Location	Baseline	4 year drought	Difference
American River	$1,251,307	$1,140,493	-$110,814
Sac River (ACID/Battle)	2,861,555	2,607,451	-254,104
Feather River	614,816	560,210	-54,606
Sac River (Tehama/Mill Cr)	3,431,114	3,126,440	-304,674
Sac River (Princeton, half Tehama, Ham City, and upper half Colusa)	3,215,411	2,925,023	-290,388
Sac River (Red Bluff Div. Dam)	258,573	235,601	-22,972
Lower Sac River (lower half Colusa, Knights Landing, Delta and SF Bay)	132,180,250	120,245,604	-11,934,646
Yuba River	5,665,392	5,162,311	-503,081
Average Annual Loss			**$13,475,285**
Percent Loss			**9%**

Table 5.9. Recreational salmon fishing lost due to a global climate change, GFDL new baseline and global warming scenario.

Location	GFDL Baseline	GFDL Climate Change	Difference
American River	$1,251,307	$994,287	-$287,020
Sac River (ACID/Battle)	2,861,555	2,204,416	-657,139
Feather River	614,816	473,809	-141,007
Sac River (Tehama/Mill Cr)	3,431,114	1,860,716	-1,570,398
Sac River (Princeton, half Tehama, Ham City, and upper half Colusa)	3,215,411	2,477,921	-737,490
Sac River (Red Bluff Div. Dam)	258,573	205,986	-59,321
Lower Sac River (lower half Colusa, Knights Landing, Delta and SF Bay)	132,180,250	101,866,000	-30,314,250
Yuba River	5,665,392	4,366,411	-1,298,981
Average Annual Loss			**$35,065,606**
Percent Loss			**23.46%**

Discussion of Results

While the average annual losses due to the drought and global warming are of the order of $13 and $35 million, respectively, the economic value of these two environmental effects are likely understatements of actual losses. One reason for the underestimate of economic value of salmon sport fishing loss relates to a limitation of this study: the only available fishing demand equation for the Sacramento River system is based on fishing for all species, including but not limited to salmon. A comparison of the size of our fish catch coefficient with salmon demand equations from Oregon and Washington (Loomis, 1988) indicates our angler response to catch coefficient is about half as large as found in Loomis (1988). Thus, the small reduction in angler visits associated with reductions in salmon populations may be due to using a generalized fishing demand equation which only partially reflects the desirability of fishing for salmon. In addition, the value per fishing trip reflects the average value for all types of fishing provided by the Sacramento River not the more highly prized sport salmon fishing trips. In addition, the change in benefits has a very wide confidence interval due to the imprecision in the estimation of the fish catch coefficient in the TCM demand equation.

Major Refinements Needed

First, it would be desirable to value sport salmon fishing using a demand equation reflecting just salmon fishing rather than an average of all fishing trips on the Sacramento River. Two options exist here. The preferred option is to collect recent data on salmon fishing trips via a survey of anglers. A possible alternative is to determine if the original angler survey forms or punch cards from the 1980 Department of Water Resources survey of anglers still exist. This data could then be input and analyzed. The California Department of Water Resources specialist (Ray Hinton) was unsure if the original raw data could be located in a readable form. Even if the data could be located the sub-sample of salmon fishing trips from the 1980 survey is quite small. Thus a new survey, reflecting today's condition would be appropriate. A new survey would also have the advantage of allowing for the possibility of more state-of-the-art demand modeling techniques being employed.

In addition, the general economic effects of environmental losses are understated because we are able to quantify fishery population losses for salmon only. Losses to other fish species sensitive to water temperature and river flow (such as steelhead and trout) could not be biologically modeled. Without estimates of the biological losses, an estimate of the economic losses is not possible. This is true for non-fishery resources likely to be affected by global warming as well.

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