GREAT BASIN FISHERFOLK

OPTIMAL DIET BREADTH MODELING OF THE TRUCKEE RIVER

PREHISTORIC SUBSISTENCE FISHERY

Susan G. Lindstrom
P.O. Box 3324
Truckee, CA 96160

ABSTRACT

Throughout the Holocene in the Truckee River region, large numbers of fish were profitably available and were economically cost effective to exploit. However, recognition of the actual subsistence significance of the fishery has been misinterpreted and underestimated through biases in the archaeological record, gaps in ethnographic and ethnohistoric documentation, and through the conventional characterization of fisheries procurement systems as one-dimensional and low ranking. This paper gives support for the modeling of fisheries resources in the Truckee River region, as a potentially complex and multi-dimensional procurement system which encompasses a spectrum of high to low ranking fish resources.

INTRODUCTION

Fish were likely a major component of the diet of prehistoric groups who inhabited both the upper and lower watershed of the Truckee River, an area of the western Great Basin encompassing Lakes Tahoe and Pyramid and their respective tributary lakes and streams. Here, native fish have been a productive and nutritious resource through time. Favorable fish habitats and large numbers of fish have thrived within the Truckee River Drainage Basin throughout the Holocene. This is supported by historic accounts which portrayed the fantastic size and abundance of the now-vanished native fishery. Yet, apart from a restricted area around Pyramid Lake (Tuohy 1990; Tuohy and Clark 1979) and one locale in the lower Truckee Meadows (Zeier and Elston 1986), the archaeological record is nearly silent on prehistoric fishing within the Truckee River watershed. Uneven ethnographic reporting has further served to downplay the relative importance of fish. A research problem, therefore, is presented in the mismatch between the biological, archaeological, and historical data and in ascertaining why such a favorable resource appears to have been underused by prehistoric populations.

In order to render some explanation for the apparent underuse of the Truckee River fishery, optimal foraging theory and optimal diet breadth modeling were employed as a source of beginning assumptions and hypotheses in the research designed to determine the nature of this prehistoric subsistence fishery. Left with a somewhat misleading ethnographic and ethnohistoric record on aboriginal fishing and faced with a void in archaeological remains associated with fish procurement, optimal diet breadth models offered some of the few remaining tangible avenues from which to base predictions regarding the subsistence character of ancient peoples within the Truckee River region.

FIGURING BENEFITS AND COSTS

Benefits

The subsistence Truckee River fishery was modeled according to the return rates and resource ranks which were computed for 9 native Lahontan fish species. The benefits side of the cost-benefit equation was framed in terms of fish caloric content, fish size and abundance, and fish availability.

Caloric Content. Proximate composition analyses were conducted by the author for different sets of Truckee River fish populations over a period of 2 consecutive years. Minerals analyses were performed by the University of California at Davis Nutrition Department. Both studies confirmed that Truckee River native fish are a highly nutritious food resource. Results show an overall caloric content per 100 grams edible sample ranging from 814 to 1430 calories. The whitefish and tui chub fillets are noteworthy for being generally highest in calories, protein, and fat. Protein content is similar for most of the other fillet samples, with fish eggs being highest. Cui-ui are twice as fat as cutthroat trout. "Minnow-sized" fish, to include tiny tui chub, mountain sucker, Lahontan redside, speckled dace, and Paiute sculpin, were analyzed whole and found to be high in protein, and fat, and highest in minerals.

Size and Abundance. The size and abundance of a resource also has bearing upon the benefits side of the cost/benefit equation, although abundance does not determine the rank of a resource. Historic and modern fish biomass data were consulted in order to arrive at some estimate of the abundance and size of pristine Truckee River fish. Period accounts, which portray the fantastic size and abundance of a now-vanished fishery, serve to underscore the huge discrepancy between profuse historic fish populations and rather scanty modern ones.

Historic catch records tend to bear out the incredible media reports. For example, a 42-pound cui-ui taken at Pyramid Lake is the largest cui-ui on record, although ones weighing over 6 pounds are now considered big. Historically, the largest specimens of cutthroat trout, including the world record of 41 pounds and the unofficial record of over 60 pounds, came from Lakes Pyramid and Tahoe, where 10-pounders were common and 20-

pound fish were not rare.

These observations on the Truckee River fishery were primarily recorded between the 1870s and the 1920s, during a time when the age structure of the species was affected by dam construction, which tended to concentrate and impound migrating fish. As a result, numbers of old and large adults increased relative to smaller juveniles. Eventually native fish populations were decimated by commercial overfishing, pollution, obstruction of spawning runs, and by the introduction of non-native species. By 1929 neither cutthroat trout nor cui-ui could migrate up the Truckee River. By 1938 the Tahoe and Pyramid strains of cutthroat trout were extinct and the cui-ui was an endangered species.

Size estimates were derived from these historic observations and were averaged with modern fish biomass data collected by fisheries biologists in order to arrive at an estimate of total and edible fish weights. Fish were pooled into size categories (large, medium, small, and minnow-sized), ranging from large cutthroat, at 5 to 10 pounds, down to minnow-sized weighing less than an ounce. Two separate weights were assigned for some species in order to account for their variable size differences due to age class and habitat.

Fish Availability. The Truckee River fishery can be characterized as sufficiently stable and predictable to have allowed for considerable year-to-year regularity in its use. Fowler and Bath (1981) and Janetski (1983) have earlier discussed the relative stability of fish populations in the few large deep lakes in the Great Basin. The Truckee River sustained a favorable fish habitat throughout the Holocene, even during times when fisheries elsewhere dwindled or were ruined under climatic stress. The Truckee River joins 2 great lakes, Lakes Tahoe and Pyramid, the only lakes within the Lahontan system that did not dry up during the Holocene. Fish were available all year but were especially plentiful during their spawning cycles, collectively lasting over a period of at least 9 months (La Rivers 1962; Moyle 1976; Snyder 1917). Massive tui chub inshore migrations and congregations of large schools of Lahontan redsides along shallow shorelines are reported in Lakes Tahoe and Pyramid. Both Lahontan cutthroat trout (primarily winter and early spring spawners) and cui-ui (which spawned in the spring) are reported to have ascended the Truckee River in large densely packed schools. More importantly, fish such as the large cutthroat trout and mountain whitefish spawned during the late fall, winter and early spring, when terrestrial resources were least productive. As such, human procurement scheduling conflicts with other valuable terrestrial resources may have been minimal.

<u>Costs</u>

Costs, or energy outputs, were figured according to the time expended to procure and process these fish using traditional methods. A variety of traditional fishing practices were categorized according to individual capture techniques (including spear/harpoon and hook-and-line) and mass capture techniques (including gill net; bag, dip, or lift net; basket trap; multiple hook-and-line; and basket scoop). The type, size, and application of a particular item of fishing gear was determined from ethnohistoric and ethnographic accounts (Bath 1978:51; Curtis 1926; Follett 1982; Fowler 1986, 1989:33; Fowler and Bath 1981; Kroeber and Barrett 1960; Loud and Harrington 1929; Lowie 1939; Speth 1969; Wheeler 1980:26). The kind and amount of fish taken with a particular fishing technique during an isolated fishing episode was also deduced from the anthropological literature. An estimate of pursuit and processing times were obtained by averaging several diverse data sets to include: (1) recorded historic and modern catch rates; (2) personal observations of field studies conducted by fish-and-game personnel; (3) interviews with commercial fish processors; and (4) results of time-motion experimental studies conducted by other archaeologists (Chang 1987, 1988; Helm 1972; Raven 1990; Raymond and Sobel 1990). Costs were also formulated for manufacturing and maintaining fishing gear. Task-specific time estimates for manufacturing and maintaining were derived from contemporary craftspeople skilled in replicating aboriginal fishing gear. These rates were supplemented by time estimates occasionally presented in the anthropological literature. These manufacturing and maintenance costs were not incorporated into the overall return rates. Return rates developed by others have not been adjusted for these costs, and an effort was made to make these data comparable.

Pursuit Costs. Procurement costs incurred by a typical gill netting episode during spawning serve as an example to illustrate how procurement costs for other fishing methods were developed. Procurement tasks for unattended gill net fishing include setting the net (by wading, swimming, or watercraft), pulling the net out of the water, and picking the fish out of the net. Averaging the available data, it was determined that it takes about 5 minutes to set and pull out a net and anywhere from ½ to 1½ minutes to remove each fish, depending upon its size.

Processing Costs. Processing times were averaged from information derived from more casual-paced aboriginal fish camps on the one hand (Chang 1987; 1988:155), and times obtained from modern commercial fish processors on the other. For example, large and medium-sized fish, consumed immediately, require a processing time of 2 minutes per fish. This includes 1 minute per fish for cleaning and filleting and 1 minute per fish (prorated time) to set up for cleaning and to maintain a clean working area. Additional costs for fish preservation by drying is estimated to be a total of about 3 minutes per fish. This includes prorated times of 1 minute allotted per fish to assemble a make-shift rack, 1 minute to tend each fish for the duration of the drying period, and 1 minute to pack each fish for storage. The processing costs for small and minnow-sized fish destined for immediate consumption (i.e., whole), are negligible.

Equipment Manufacturing and Maintenance Costs. Although these costs are difficult to quantify, they are very important, and future cost-benefit analyses should attempt to incorporate them into the resource return rates. Manufacturing costs are usually one-time costs; once they have been incurred, a fishing implement can service multiple fishing (and non-fishing) procurement episodes over a period of years. Routine maintenance, especially for netted gear (cleaning, drying, mending), is ongoing. Figuring these costs is further complicated as they are often incurred by individuals who can no longer participate in more rigorous subsistence activities; these individuals pool their labor to manufacture and maintain an item which can then be loaned or "rented" to others in return for other subsistence favors.

Again, gill netting serves as a representative example for the computation of other equipment manufacturing cost estimates. The dimensions of regional ethnographic and archaeological gill net specimens are variably described. Accordingly, an average gill net size of 100 feet long by 4 1/2 feet wide, with a cordage diameter of 1/16 inch and mesh sizes of 1/2 inch, 1 inch, 1 1/2 inches, 2 inches, and 4 inches was selected. The total cordage required to make 1 gill net of these dimensions can literally be measured in miles. A gill net made with 4-inch mesh requires 3,343 feet of cordage. The same net made with 1/2-inch mesh requires 34,634 feet, or over 6 1/2 miles of cordage! The former larger mesh net takes a total of about 213 hours to manufacture, where the latter smaller mesh net takes 2,220 hours, over 10 times the labor involvement to make the same sized net. Working an average of 6 hours a day, the former net takes 1 person about 36 days to complete, the latter takes 370 days to finish. These figures do not include the time and materials required to manufacture gill net accessories, such as floats, spreading sticks and net weights.

RESULTS

Fish Procurement Models

Twenty-five distinct fish procurement models were developed, into which the critical variables of environment, fish biology, and aboriginal fishing techniques were incorporated. The generation of so many different fish return rates was not intended to overcomplicate the picture beyond what the highly interpretive archaeological record can handle. To have formulated a single model with a single return rate for fish, would have been misleading and greatly oversimplified the situation.

The models were streamlined by combining the many potential variables, and a separate resource return rate was developed for each size class of fish, according to a specific capture technique and whether or not the fish was spawning. In addition, resource rankings were divided into 2 distinct sets, 1 for fish consumed fresh and another including processing costs for drying and storage. The fish resource return rates obtained in this study are generally compatible with those established by Evans (1990), Raven (1990), and Raymond and Sobel (1990).

Resource Return Rates

According to these results, spawning fish always produce higher return rates. When processing costs for drying and storage are considered, ranks tend to be structured by fish size, with largest fish ranking highest and minnow-sized fish ranking lowest. When processing costs for storage are not included, the efficiency of the capture technique is the dominant factor affecting resource rank, superseding the influence of fish size. In this latter case, mass capture techniques for spawning fish are most efficient, with spawning small fish taken by basket scoop ranking highest. Basket traps and gill nets for spawning fish rank next highest. The capture of spawning fish with bag, dip, or lift nets rank next. These are followed in rank by multiple hook-and-line, gill netting, and spearing/harpooning nonspawning fish.

These data were then incorporated into existing resource rankings for Great Basin terrestrial plants and animals, as developed by Fowler and Walter (1987), Madsen and Kirkman (1988), and Simms (1984). Fish ranked high on the subsistence list, assuming the top positions under some conditions. When processing costs for drying for storage are not included in resource rankings (Table 1), small fish taken by mass capture with a basket scoop, whether spawning or not, surprisingly rank first out of a total of 58 ranking positions, with a return rate of 600,000 cals/hr. This is well above the second-ranked grasshoppers at 273,000 cals/hr. Fish then assume the third through eleventh positions at 126,000 to 40,000 cals/hr. Big game resources enter the subsistence system at ranks 12 and 13 at 31,000 cals/hr, unexpectedly far down the list. Lower positions are filled by fish, smaller mammals, and ducks, with plants comprising the bulk of the remaining list down to 91 cals/hr.

When processing costs for drying fish for storage are included (Table 2), a different subsistence pattern emerges. The profuse harvest of grasshoppers tops the list (again, at 273,000 cals/hr), with large spawning fish taken by the most efficient capture assuming the next 6 top positions (84,000 to 50,000 cals/hr). Large game take the eighth and ninth ranks (again at 31,000 cals/hr). Fish are then interspersed further down the list with small mammals, ducks, insects, and plants. With processing costs included, minnow-sized fish now fall near the bottom of the list (under 300 cals/hr).

That the mass capture of large spawning fish would rank high was anticipated at the outset of this study. However, it was unexpected that spawning smaller fish would have such high return

Table 1. Summary of ranked importance of food types in the prehistoric diet in the Truckee River Drainage Basin according to diet breadth modeling.[1]

RANK	RESOURCE	CAPTURE TECHNIQUE
1	small fish	mass capture
2	grasshopper	mass capture
3- 8	large fish	mass capture and/or spawn
9-11	small fish	mass capture
12-13	big game	-
14-15	medium fish	mass capture
16	minnow-size fish	mass capture
17-18	medium fish	mass capture
19-20	small fish	mass capture
21-22	medium fish	mass capture and/or spawn
23-25	small mammal	-
26	cattail pollen	-
27	small mammal	-
28	large fish	individual capture/non-spawn
29	small mammal	-
30	duck	-
31,33-34	minnow-sized fish	mass capture
32	Pandora moth larvae	mass capture
35	seed	-
36	acorn	-
37	pinyon pine nut	-
38	root	-
39-40	seed	-
41	medium fish	individual capture/non-spawn
42-43	seed	-
44	minnow-sized fish	mass capture
45-46	seed	-
54-55	root	-
56-58	seed	-

[1] Resource rates do not include fish processing times for drying for storage.

rates. Taken in spawn by mass capture and immediately consumed whole, small fish constitute the optimal food choice, as modeled for the aboriginal forager living in the Truckee River region.

It is important to emphasize here that neither these resource rankings, nor those developed by others, incorporate the more elusive but consequential costs of equipment manufacturing and maintenance, search time, and transport time, nor the range of individual variability in handling costs. All of these costs are very important, and future cost-benefit analyses should attempt to incorporate them into resource return rates. The processing costs for drying terrestrial meat products for storage or the costs for grinding and cooking nuts and seeds for

Table 2. Summary of ranked importance of food types in the prehistoric diet in the Truckee River Drainage Basin according to diet breadth modeling.[1]

RANK	RESOURCE	CAPTURE TECHNIQUE
1	grasshopper	mass capture
2- 7	large fish	mass capture and/or spawn
8- 9	large game	-
10-14	medium fish	mass capture and/or spawn
15	small mammal	-
16	medium fish	individual capture in spawn
17-18	small mammal	-
19	cattail pollen	-
20	small fish	mass capture
21	small mammal	-
22-26	small fish	mass capture and/or spawn
27	large fish	individual capture/nonspawn
28	small mammal	-
29	duck	-
30	Pandora moth larvae	mass capture
31	medium fish	individual capture/nonspawn
32	acorn	-
33	seed	-
34	pinyon pine nut	-
35	root	-
36-45	seed	-
46	minnow-sized fish	mass capture
47	seed	-
48-50	minnow-sized fish	mass capture
51	seed	-
52	minnow-sized fish	mass capture
53	seed	-
54-55	root	-
56-58	seed	-

[1]Resource rates include fish processing times for drying for storage.

consumption are not included in these figures. This may slightly lower the resource rankings for land animals and especially deflate plant rankings. The costs for incorporating processing costs for drying for storage are incorporated into the fish return rates presented in Table 2, but they do not include the relatively small processing time required for cooking. The large difference between processing times required for seed foods versus fish is underscored by one of Willard Z. Park's Northern Paiute respondents: "If seeds had to be ground, a meal was not eaten upon arising, but food was ready about 10 or 11 o'clock in the morning...It took several hours of grinding before the meal was ready...If only fish was to be eaten, it could be quickly roasted over a fire" (Fowler 1989:11).

Note that some of the extremely high fish return rates reflect fishing during peak spawning periods. Simms (1984:90) earlier suspected that fish were fairly high ranked in some situations, such as spawning seasons, although at the time he had no data on handling times. Certainly, these resource return rates can be adjusted downwards. Nevertheless, even if fish return rates are reduced by an order of magnitude, fish still maintain their relatively high rank within the overall subsistence system.

EXPLAINING THE MISMATCH BETWEEN EXPECTED ABORIGINAL FISH USE AS MODELED AND AS OBSERVED ETHNOGRAPHICALLY AND ARCHAEOLOGICALLY

There are several reasons to suspect that recognition of the actual subsistence significance of the Truckee River fishery has been misinterpreted and underestimated, namely taphonomic factors affecting the archaeological record and gaps in ethnographic reporting.

Taphonomy

Fragile fish remains are poorly preserved and perishable fishing gear is prone to decomposition, especially in the acidic soils of the upper Truckee River watershed. Furthermore, earlier archaeological recovery techniques were inadequate and only recently augmented by methods explicitly aimed at recovering fish remains and distinguishing between cultural and noncultural accumulations (Greenspan 1985). In addition, fish remains often go undetected due to aboriginal fish processing techniques which are generally conducted away from the living site. Furthermore, non-diagnostic fishing-related artifacts can be easily misinterpreted and new insights into ancient fishing tools are needed.

Ethnography

A second reason for the apparent underuse of the Truckee River fishery is due to gaps in the ethnographic and ethnohistoric record, which tend to promote an inattention to the native use of the hydric environment. In general, researchers in the Great Basin tend to perceive the aboriginal inhabitants as being hunters/gatherers or seed-eaters, not fisherfolk. Fishing practices among the Pyramid Lake Paiute were primarily documented by Willard Z. Parks, but observations were made at a time when cutthroat trout and cui-ui were becoming endangered or extinct. Ethnohistoric and ethnographic observations on Washoe fishing is especially meager. For either aboriginal group, the data do not reflect the relatively high rank of fish that the models predict.

Yet ethnographic data do hint at a greater level of technological specialization and social complexity for Washoe and Pyramid Lake Paiute groups, compared to many of their surrounding neighbors (Bath 1978). Relative semisedentism and higher population densities, private ownership of fishing spots and gear, communal labor in fishing pursuits, and the presence of fishing cliques and fishing captains are also reported (especially for the Pyramid Lake Paiute). Despite these facts, these people have been characterized as technologically and culturally deficient, partially based upon their inability to store a large supply of fish for the winter (Downs 1966:16-17; Steward 1955:106). That prehistoric populations in the Truckee River region possessed all the necessary preservation technology for the long-term storage of fish (if they so opted) is demonstrated by the large local and visiting populations which assembled to partake of the cui-ui runs to dry for future consumption. Without considering the biological structure of the fisheries resource, and using the fish spawning episodes and corresponding storage strategies of groups in the Pacific Northwest as a standard, some researchers have incorrectly generalized that the amount of fish preserved and stored for future use is a measure of the relative importance of fish in the food economy. Similar generalizations imply that groups that do not store are necessarily mobile (Thomas 1985; Binford 1980:12). These assertions may not apply to aboriginal groups in the Truckee River watershed. Relying upon a stable fishery with relatively long periods of availability, there may have been no need to implement a formal storage strategy in order to sustain more sedentary lives with relatively larger and more complex social systems (Schalk 1977).

Fish are further downplayed in the contemporary archaeological literature and stereotyped as a resource of "second resort". Arguments contend that intensive fishing is undertaken only during periods of climatic and/or population stress that force people to use previously ignored resources of lower rank. Thereby, fish are lumped together with other low ranking foods such as plants, water fowl, and invertebrates (Bettinger and Baumhoff 1982; Binford 1968; Dansie 1987; Elston 1982; Flannery 1969; Zeier and Elston 1986). Rather, a contrasting image can be inferred from the diet breadth models presented here. Instead, these data indicate that aboriginal fishing in the Truckee River region is best characterized as a complex procurement system, wherein fish are ranked variably in the diet. Under some circumstances, fish can rank even above large game as the highest ranking food, being one of the first items added to the diet and one of the last items dropped from it. Fish cannot be considered under one rubric as "low ranking". Rather, future reconstructions of prehistoric lifeways should make way for fish to assume a variety of subsistence roles.

NOTES

This paper stems from my dissertation research on the Truckee River prehistoric subsistence fishery in which the formulation of cost-benefit data are thoroughly presented. Similarly, within the short space of this paper, a general description of optimal foraging theory was withheld. Note that a discussion of its principles and applications has been presented most thoroughly and eloquently by Bettinger (1980) and Simms

(1984, 1985a, 1985b, 1987, 1988), and that the general concepts of diet breadth modeling have been applied to the Truckee River fishery in like manner.

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