CALORIES AND CONSTRUCTION: ECOLOGY OF EXTRACTION STRATEGIES ON THE LOWER KLAMATH RIVER

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Salmon fishing has been crucial along the Klamath River for millennia, but causes for patterning and variation are not well understood. Why do net fishing and spearing occur in some times and places while larger-scale extraction strategies emerge in others? This study compares strategies in terms of caloric investment and return to better understand why the fish dam strategy developed when and where it did, and why it was not continued farther upriver once it emerged. It also discusses the effects that such centralized collection strategies might have had on other aspects of sociopolitical complexity.

Alfred L. Kroeber, T.T. Waterman and Arnold R. Pilling, arguably the three most important 20th century ethnographers of traditional Yurok culture in northwestern California, described Yurok subsistence as being especially reliant on seasonal harvests of anadromous fish, particularly king and silver salmon, and steelhead trout (e.g., Pilling 1978; Waterman and Kroeber 1937). These anadromous fish made spawning migrations in huge numbers up the Klamath River each year between mid-August and mid-October.

The Yurok strategy involved the construction of several temporary wooden barriers or dams across the Klamath River. When these dams were erected, they prevented the migrating fish from being able to swim farther upriver. The fish could then be caught in great numbers. Organized labor teams involving workers from many surrounding villages would share in the collection of logs, construction of the dams, catching of the fish, gathering of firewood, butchering of the fish, smoking and packing the fish carcasses, disposing of the debris, and feeding the labor crews. After ten days, the dam would be torn down, allowing most of the annual spawning run to proceed upriver. Project leaders would divide up the preserved fish among the workers, who then could carry the fish to their homes and use it as a primary food staple for the following year.

This remarkable adaptive strategy has understandably drawn much attention from anthropologists. As is usually the case, however, such attention does not necessarily lead to consideration of other questions and issues. What, for example, made this strategy viable for the Yurok, but not their upstream neighbors, the Hupa and Karok, who shared the adjacent parts of the river system and also relied on fishing for the same fish populations? What implications did this strategy have for the development of the institutionalization of power and authority, as happened with some other fishing-intensive cultures of California, such as the Chumash? How did these strategies manifest themselves in what we can see in the archaeological record?

A CALORIC MODEL

One way this set of questions might be approached is in relation to a kind of cost and benefit analysis. The strategy of fish dam construction has significant costs compared with the sort of individual fishing done by upstream peoples, and by the Yurok themselves at other times of year. It also yields significant harvests. Are there points at which the investment stops yielding returns that justify the expenditures? If so, the adoption or lack of adoption of a fish dam strategy could be understood as a rational decision, especially when knowledge of the strategy was widespread regionally.

According to Arnold R. Pilling (personal communication and Pilling 1978), the Kepel fish dam on the lower Klamath River, about ten miles downstream from the mouth of the Trinity River, was among the largest and most important of all Yurok temporary fish dams (also see Waterman and Kroeber 1937). When summer was progressing, a “big man” from the community at Kepel would begin to recruit work teams from eight, ten or more surrounding settlements. Actual work would take place as the end

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of summer approached. Two to three hundred men and women would begin gathering at the village of Kepel. Some work teams would begin to range up into the hills to chop down saplings and bring them to the riverbank. Others would collect masses of dried brush and wood for smoking fires. Others would cut flexible plant material to use as ropes. Others would build smoking racks. When construction day arrived, work crews would wade into the river to build a porous barrier across the channel. Curved fence lines were built below the dam to serve as channel traps or weirs. By then, anadromous fish (particularly silver and king salmon and steelhead trout) would have already begun their spawning runs upriver.

Reportedly the construction of the dam took ten days (Waterman and Kroeber 1937:52). When the dam was completed, the migrating fish would be blocked from progressing upriver. They would circle around below the dam, often getting caught in the spirals of fences, which made them especially easy to net and spear for harvesting. Then the fish would be brought ashore by the tens of thousands to be butchered, smoked and divided. Because the anadromous fish migration extended over 8-10 weeks, having the dam up for ten days meant that only a fraction of the fish population was harvested, and others could progress farther upstream for other communities to catch.

A typical silver salmon weighs ten pounds, although some can reach 20 pounds or more. King salmon average 25 pounds, with some reaching 50 pounds or more. Typically, ¾ of the fish's body mass can be converted into edible meat. The Klamath River is estimated to have had fish runs of a million fish or more in all. As a side point, over 1 million salmon were caught on the Columbia River in 1941 (Moore and Moore 2003). The Columbia is a good deal larger than the Klamath, but devastation from construction of the Grand Coulee Dam had already beset the Columbia River salmon population by the time the 1941 harvest was made. The 1941 Columbia River catch could have yielded between 12 and 18 million pounds of edible meat.

According to the environmental analyst, Theodore Gresh, the spawning run on the Columbia River had the biomass of 500,000,000 pounds of fish during the 19th century (Moore and Moore 2003:46). Even if the Klamath's run were 1/10 of the volume of the Columbia's, and it should have been much larger than that, the Klamath would have brought 50,000,000 pounds of salmon meat upstream each year.

A harvest of 50,000 fish at Kepel is suggested as not excessive. Given Gresh's estimate above, if the Klamath had fish run body masses of at least 50,000,000 pounds, the running population would have numbered 2-3 million fish. A harvest of 50,000 fish would have had no serious impact on the survival of the species involved. Three or four dams could have been constructed without endangering the fish population.

For the sake of estimates, it will be assumed that the fish population harvested at Kepel was composed of about 2/3 silver salmon (*Oncorhynchus kisutch*) and 1/3 king salmon (*Oncorhynchus tschawytscha*). Steelhead trout were also significant but won't be calculated here. At these proportions, the annual harvest at Kepel might have yielded 300,000 pounds of edible king salmon meat and 250,000 pounds of silver salmon meat. According to Corinne Netzer, fresh salmon ranges between 800 and 900 calories per pound, depending on species. A harvest of this size, then, could yield between 44.0 and 49.5 million calories (Netzer 1994:528).

Considering that an active adult who burns 2000 calories per day only needs 730,000 calories for an entire year, this size fish harvest could provide 100 percent of the total calorie needs for 65-70 or more people. Healthy diets, however, require much more diversity, and salmon could at best provide only part of the diet. Calculating differently, the salmon harvest could potentially provide 300 calories per day for 400 or more people for an entire year. If a work crew from 8-12 villages contributed 200-300 people, the ten-day salmon harvest could provide much of the total year's protein needs for the whole population of all participating villages.

But what investment would be needed? A work crew averaging 250 people, would labor for about 3 weeks, including preparation and post-harvest tasks. If each averaged 2000 calories as a measure of labor, and they had to be fed to do the job, just conducting the harvest by dam-building would cost 10,500,000 calories. The cost is substantial to provide, but the yield would be 20 or more times the investment.

It is not just that salmon could be a major staple. Other cultures in the region fished for salmon, and used it as a major staple, but did their fishing individually with such tools as nets and spears. For the Yurok, the labor and management involved in putting up, operating and taking down a temporary fish dam was very substantial but the return more than justified it.

THE UNIQUENESS OF FISH DAMS

If the use of the fish dam strategy was so productive, however, why was this approach not followed by other cultures, both along the Klamath and in neighboring rivers where salmon runs also occurred? The upstream Karok, for example, are not recorded as having constructed fish dams (e.g., Bright 1978; Kroeber 1925; Kroeber and Barrett 1960), nor are the Hupa, who also lived upstream from the Yurok but on the lower Trinity River (e.g., Kroeber 1925; Kroeber and Barrett 1960; W. Wallace 1978). The same is the case for other river-dwelling groups in the region, such as the Tolowa, who occupied the lower Smith River (e.g., Gould 1976). The ecology of the salmon may provide part of the answer, but I think another important dimension can be found in calories—outlay compared with return.

From an ecological perspective, harvest yields had to be balanced against the potential destruction of the food source from over-harvesting. The use of three fish dams should have still allowed the salmon population to sustain itself, but the use of ten or fifteen dams might have led to diminishing fish populations if not to their eventual extermination. The downstream communities had first access to fish dam options, but the upstream populations could not simply imitate them and also retain their most important meat food source. At the same time, salmon disperse up creeks to spawn, so their population density declines the farther upstream they go. Thus the factor of investing great amounts of labor and energy to build fish dams would be increasingly counterproductive the farther upstream one was. (Boschung *et al.* 1983; D. Wallace 1983).

PERSPECTIVES ON SOCIOPOLITICAL COMPLEXITY

Based on this information, it is suggested that, in northwestern California, the construction of temporary fish dams to harvest salmon and steelhead trout in large quantities as a collector strategy was exclusively a feature of Yurok culture because only in the Yurok's environment was such a collection strategy energetically and ecologically viable. The recognition that the Yurok did engage in such large-scale, highly-organized collection activities raises another question, however. If the yield from downstream fish dam construction was so productive and relied so much on management and leadership, why did the Yurok not develop a structured political system with centralized authority and power? As reported by several ethnographers, they did not (e.g., Kroeber 1925; Kroeber and Barrett 1960; Pilling 1978; Waterman and Kroeber 1937). Why they did not poses a significant problem, because such systems did appear in some other parts of the West Coast where collective fish harvesting also took place.

As one example, the Chumash, along the Santa Barbara Channel, also relied on massive fish harvests and did develop political systems with complexities up to the level of chiefdoms in some cases (e.g., Grant 1978a, 1978b; Kroeber 1925). A number of cultures along the Northwest Coast, such as the Haida, the Nootka and the Kwakiutl, also relied heavily on collection strategies for maritime resources and also developed complex sociopolitical systems (e.g., Driver 1961; Oswalt and Neely 1999).

The Yurok show no evidence of having developed complex political authority systems, however, nor is there any evidence of it having occurred among other cultures in their region prehistorically. In the California literature, the understanding of the rise of complexity has been associated significantly with the emergence of food production (e.g., Bean and Lawton 1976), but that factor was clearly not relevant to the Yurok or the Chumash cases, nor to those of the Northwest Coast.

It can be suggested that the occurrence of the fish dam as an annual event may have some bearing on this question. The Yurok did not regularly practice the sort of ongoing activities for which community-level institutionalized leadership could have provided an adaptive advantage. Fish dam construction might be seen as an elaborate extension of the Great Basin rabbit drives, in which leaders served for the event but not beyond it (Oswalt and Neely 1999). With the Chumash, collective labor and management at the community level seems to have been a more regular, multidimensional and ongoing part of their lives. For example, the coastal and island Chumash regularly operated large, ocean-going canoes, which needed organized crews for building, maintaining and sailing. Ocean fishing by canoe in the Santa Barbara Channel took place over a substantial part of the year. In addition, frequent trips were made up and down the coast and between the islands and the mainland for such purposes as resource acquisition and trading. Some of these trips were made by individual crews, but many were made as collective community enterprises. The amount, variety and adaptive significance of collective activities on that scale appears to have been far smaller for the Yurok. If so, the selective advantage of evolving complex sociopolitical systems may not have emerged along the Klamath River as it did in Santa Barbara or the Northwest Coast.

California provides us with fascinating ranges of variation in sociopolitical complexity, so it may be one of the most productive places in the world for us to study just what forms of complexity tend to emerge under just what conditions. The case of the fish dam provides a particularly compelling borderline example. Such borderline cases may be particularly helpful in illuminating just what factors caused one culture to move to one side of the border while another culture remained on the other side. Even though the present analysis is based on some very generalized calculations, it may suggest directions for more focused analyses that can push the boundaries of our current understandings farther forward.

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