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PREHISTORIC SALMON FISHING IN THE NORTHERN GREAT BASIN: ECOLOGICAL DYNAMICS, TRADE-OFFS, AND FORAGING STRATEGIES

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INTRODUCTION

Since the publication of Julian Steward’s (1938) Basin-Plateau Aboriginal Sociopolitical Groups, anthropologists’ discussions of Southern Idaho hunter-gatherers have largely emphasized anadromous fish exploitation (e.g., Liljeblad 1957:33-39; Murphy and Murphy 1960:319-322, 1986). Specifically, summer and fall runs of Chinook salmon (Oncorhynchus tshawytscha) are seen to form the critical subsistence base for Northern Shoshone and Bannock groups overwintering along the Snake River (e.g., Liljeblad 1957:33-34; Meatte 1990:17; Pavesic 1978: passim; Pavesic and Meatte 1980:19-23). However, the view that salmon fishing and storage provided the only subsistence focus worthy of discussion is based on a narrow reading of how the Middle Snake River was used by historic period groups. Ethnographic and ethnohistoric documents clearly point out that different groups pursuing different subsistence strategies occasionally moved into the area, and that there is greater variability in the behavior of Snake River groups than frequently is acknowledged. Delimiting the scope and cause of this variability is central to understanding how conditions in the past affected tactics of resource use.

From both Steward’s and Jack Harris’s (1940) work we know that a variety of people who were not members of Snake River groups moved into the region on an irregular basis to exploit salmon (Steward 1938:166). These groups used a variety of strategies to exploit the Snake River salmon runs. Both Grouse Creek Shoshone from Utah and Tosawi or White Knife Shoshone from northern Nevada occasionally migrated to the Snake River to harvest and consume fish below Shoshone Falls, the upper limit of the runs [see Figure 1] (Harris 1940:46; Steward 1938:162, 175; Steward 1943:268-269). Also, mounted Shoshone and Bannock from the Fort Hall area moved to Southwestern Idaho to procure and dry fish before transporting these stores back to Eastern Idaho for winter use (Steward 1938:200, 203, 205). Two general points can be made here. Snake River Shoshone (sensu Steward 1938, 1941) were not the only groups to forage along the Middle Snake River below Shoshone Falls. These other groups pursued different exploitation strategies, with mounted Fort Hall groups fishing almost exclusively for storage and transport, while Grouse Creek and White Knife Shoshone rarely stored or transported fish (Harris 1940:46; Steward 1938: 162,175, 200, 203, 205; 1943:268-269).
Figure 1. Map showing the location of Middle Snake River ethnographic groups. The upper limit of migrating salmon is at Shoshone Falls.

Among the Snake River groups documented by Steward (1938:165-172), there is greater variability in the tactics of salmon use than usually is acknowledged by most researchers. As Steward (ibid.:165) says, “fishing was their principle subsistence,” and families “preferred to move any foods collected to the vicinity of the river so as to be near cached salmon.” This salmon-dominated perspective has come to influence the picture of native subsistence so much so that among contemporary researchers salmon fishing is the main criterion for distinguishing southern Idaho groups from Shoshonean peoples elsewhere in the Basin (e.g., Murphy and Murphy 1986:284; cf. Meatte 1990:71-72). This critical definitional quality is central to the most frequently invoked ethnographic analogue. Pavesic and Meatte offer its most bold rendition, saying that “within the Snake River canyon, the mechanism forcing population shifts and determining village size were the anadromous fish runs, the highest yielding protein resource available” (Pavesic and Meatte 1980:21). While the importance of salmon cannot be discounted, other information makes it abundantly clear that other resources formed important components of the diet.

Steward (1938:167) writes that both fishing and seed and root collecting were critical subsistence areas. He goes on saying that “seasonal activities of all (families) were similar, varying only as one family or another wandered to a place of abundant roots, seeds, or fish, and remained there instead of returning to the Snake River for the winter” (ibid. [emphasis added]). What Steward is driving at is that local conditions play crucial roles in determining tactics of resource exploitation. This leads to variation as to which resources are stored for winter use. Steward talks about overwintering by using “dried salmon, insects, and roots” (ibid.) and discusses spring steelhead trout (Salmo gairdneri) use by groups who had stayed near “their caches of dried roots” (ibid.). Most important among these roots was camas (Camassia quamash). Because camas was available for longer harvest periods, was easily stored, and survived for longer periods, it has been argued to provide higher returns than salmon (Plew 1983, 1990, 1992; cf. Statham 1975, 1982).

What is clear from this brief review of observations on historic period subsistence is that 1.) different groups employed different strategies in using the Middle Snake River and 2.) tactical responses by resident Snake River groups were driven by contingencies of resource encounters. Basically these statements merely acknowledge that critical parameters which figure into most foraging models coming from evolutionary ecology (e.g. Krebs and Davies 1991; Smith and Winterhalder 1992; Stephens and Krebs 1986; Winterhalder and Smith 1981) also
played a role in Southern Idaho. Rather than accept the universal "utility" or "virtue" of exploiting salmon as evidenced in the quote from Pavesic and Meaitte (1980:21) above, we follow Schalk's (1977) lead in noting that fish runs vary in their productivity and distribution in both time and space. This variation impacts how and when alternative resources will be used.

Within an optimality approach, prey items are added to the diet, providing that harvesting on encounter will not produce lower returns than would be the case if the predator continued searching (Stephens and Krebs 1986:17-24). Decision making within the prey algorithm yields three important outcomes: 1.) prey items are either always or never taken on encounter (the zero-one rule); 2.) prey are ranked by their profitability and are added to the diet in the order of their ranking; and 3.) the inclusion of a resource depends on its profitability and the characteristics of other higher-ranked items (ibid.:24). This means that we cannot merely appeal to one really "good" resource and expect the world of the forager to revolve around it. We must understand something about variation in profitability of a variety of resources.

Schalk (1977) has taken a large step toward documenting the ecological parameters which affect profitability of anadromous fish resources and how profitability varies by strategy of use. Schalk's specific environmental parameters — latitude, distance upstream from the mouth, and variation in discharge rate — are causal variables in that variation in their values directly affects the abundance and distribution, or structure, of the anadromous fish population. Understanding the significance of these variables lets us assess their implications for the historic period fishery in Southern Idaho.

Schalk (1977:214-218) divides his study of Pacific anadromous fish runs into three latitudinal groups, south of 45° north, between 45° and 60° north, and north of 60° north. The mouth of the Columbia-Snake system is situated near the southern margin of the central latitudinal group at slightly over 46° north, but the Snake in Southern Idaho is south of this by a substantial margin, falling between 42.5° and 43.5° north. This means that the Snake in Southern Idaho will exhibit qualities of both systems. In reviewing the southern, below 45° north fisheries, Schalk (ibid.:216) notes that the warmer environment presents two difficulties for anadromy. Because stream water temperatures are higher, short spawning seasons are found generally during the winter, and anadromous species face greater competition from non-anadromous fish, some of which are known to be exploited by ethnographic groups. Steward (1938:43) notes the native use of cutthroat trout (Salmo clarki) and whitefish (Prosopium williamsoni) and recognizes the presence of a number of other species, including black or blue sucker (Pantosteus jordani), yellow or large-scale sucker (Catostomus macrocheilus), chiselmouth (Acrocheilus alutaceus), Columbia chub (Mylocheilus caurinus), and northern squawfish (Ptychocheilus oregonensis). He also notes that "fish could be taken through the ice" (ibid.:168), when largely non-anadromous species were available. So we can say, to some degree, non-anadromous fish were used.

As his second major causal variable, Schalk (1977:218-220) considers distance upstream from the river's mouth. The locations of three winter camps identified by Steward (1938:165-166) and the three identified by Murphy and Murphy (1960:322) are all over 1,200 kilometers from the mouth of the Columbia River. This means that migrating fish had to cover this long distance. Since no food is consumed during
the run, body fat losses of 78-96% and protein losses of 31-61% and possibly even more are noted among spawning salmon (Idler and Clemens 1959; Plew 1983:62-63, Table 4). Steward (1938:43) says that “(s) spawning activities leave them emaciated and covered with sores,” and in the fall “most are dead or gone.” As has been pointed out, these well-traveled fish are substantially less desirable than those found near the coast (Plew 1983, 1990). This is because as the nutritional quality of the fish diminishes, so do returns from harvesting, resulting in a lower ranking within the prey algorithm. This nutritional fact also means that the farther one goes upstream, the more fish will be required to meet the needs of the same number of individuals.

Distance from the mouth plays another important role; it determines the duration of the run (Schalk 1977:224, 230). The farther one moves upstream, the fewer the number of species encountered since the habitat is less stable in terms of runoff (ibid.:219-220). This also acts to depress the number of fish encountered, reflecting the decrease in the amount of spawning area which lies upstream (Baumhoff 1963:170; Schalk 1977:223-224). Being far upstream also results in runs which are shorter and shorter in terms of their duration (Schalk 1977:241-242).

The last parameter discussed by Schalk (1977) is the consistency in the volume of water discharged by the river. Since this is largely a function of the size of the drainage basin, Schalk (ibid.:218-220) notes that rivers with larger discharge volumes show less interannual variation, leading to habitat stability. The Snake River is the largest contributor to the Columbia’s discharge and, in this way, can be seen to provide a stable spawning habitat. Now that the specific values for these parameters have been identified for Southern Idaho, we can compare these ideas to the limited information that we have regarding fish runs.

Since dams were constructed on the Columbia-Snake system beginning in the earliest part of the twentieth century, we have little quantitative information on the structure of Middle Snake River fish runs. The one exception is found in the work of Barton Evermann (1896), who records information on Liberty Millet’s fishery below Upper Salmon Falls, which is at the heart of the area inhabited by Snake River groups (Figure 1). During 1894, Evermann requested that two men harvest and weigh the daily catch at this location. These men used a small boat and a 91.2 m long seine which was 4.3 m deep in the center and stretched to a depth of 3 m at the wings in order to harvest a spawning bed 4.3-6.1 m below the water surface and 98.8 m long (ibid.:265). Figure 2 shows the weight of salmon caught between October 2 and November 1, 1894, spanning the duration of the fall chinook run. Though the daily harvesting time and, hence, work effort was not controlled, some clear run characteristics still can be seen. Most obvious is the temporal compression of the run, with the days that produced catches over 200 kg falling into the two- to two-and-one-half-week-long period between October 14 and 29. This would be anticipated within Schalk’s (1977) framework, given the latitudinal placement, distance from mouth, and discharge characteristics of the stream. Basically, we can see that these factors combine to produce only a short period of availability. This has important implications for how this resource could be used.

Two basic tactics of salmon use are encountered in the Southern Idaho literature and were discussed above — immediate consumption or storage for winter use. In situations in which the temporal availability of fish is short, as is the case on the Middle Snake, groups must work quickly in order to harvest and process enough fish to last the winter (Schalk 1977:231-238). This requires having an organized, internally differentiated labor force and the necessary processing,
drying, and storage facilities in place and ready when the run begins (ibid.; O’Leary 1985). It is for this reason that when fishing for storage in Southwestern Idaho, “fishing directors” coordinated the actions of larger groups, supervising weir construction and catch distribution (Steward 1938:169). Thus we can see that there is a direct relationship between the structure of runs and the techniques used to exploit them. Schalk summarizes his findings for fisheries between 45 and 60° north latitude, including the Columbia and Snake drainage:

Dependence on anadromous fish might be rather limited prior to the adoption of storage, and the shift would be quite abrupt and systemic in nature. In the absence of storage, the degree of dependence on anadromous fish would be determined primarily by duration of availability. The duration of fish runs decreases northward, upstream, and as river size decreases, and related to these trends, decreased dependence on anadromous fish might be anticipated. Implementation of a storage strategy would be increasingly difficult along these same gradients. Specialization of anadromous fish requires increasing more efficient cultural systems as the storage process becomes more difficult. Because accessible productivity, stability in year-to-year production, and duration of availability all decrease in an upstream direction, it is anticipated that groups will tend to exhibit more generalized adaptations as distance upstream increases [emphasis added] (Schalk 1977:241-242).

In optimality terms this means that processing short-duration runs for storage requires some large investments of labor, increasing the prey item’s handling costs and reducing overall returns. As one moves farther upstream, consistency of runs in terms of productivity and timing become more highly variable, making the storage of
anadromous fish a more uncertain option (sensu Clark 1990; Smith and Boyd 1990; Kaplan and Hill 1992). Because of variation in the structure and productivity of the runs, we imagine that the degree to which runs were used was largely determined within the context of the distribution and abundance of other resources. This is exactly the type of information which is used to make predictions using the prey algorithm. Unfortunately, though we have extremely limited information on the distributional properties of fish, we have even less reliable information on the historic density and distribution of large mammals in the area.

Steward (1938:167) paints a rather bleak picture of large mammal procurement, saying that the "(h)unting of large animals was rarely undertaken and involved no communal effort." We do know that a variety of species were present in the past, including mule deer (Odocoileus hemionus) which tends to aggregate along canyon streams, such as the Snake River (Larrison and Johnson 1981:122). Steward (ibid.) says that deer were taken south of the river on game trails, but played a less significant role than either fish or roots. With regard to the latter, recent research into the nutritional parameters and handling costs of camas demonstrate that this root compares quite favorably with salmon, resulting in a higher rank within the prey algorithm (Plew 1990, 1992).

What emerges from this review of subsistence is an appreciation of the variability which existed in the past as well as the variation anticipated within contemporary foraging models. Using this information it is clear that there was no singular focus in historic Northern Shoshone and Bannock subsistence which rationally can be projected into the past. This poses a gigantic problem for most Idaho archaeologists who rely on the "normative" model of overwintering on dried salmon as their main interpretive device (e.g., Meatte 1990; Pavesic 1978; Pavesic and Meatte 1980). If we propose to learn anything by studying the past, we have to get beyond simply accommodating the archaeological record to such assertions of "knowledge." In order to research how the Snake River was used in the past, we have to exploit our prior knowledge about what determines local ecological situations and how people varied in their responses to these conditions.

The remainder of this paper focuses on developing an understanding of how prehistoric group organizational dynamics varied within the ecological milieu outlined above. The basic theme is the determination of how technology was used to extract resources in a variety of local settings. An intersite comparison of faunal and tool data is argued to provide insights into how economic groups were organized.

**MIDDLE RANGE THEORETICAL BACKGROUND**

Working from ethnographic materials, Binford (1977, 1979, 1980, 1982, 1990) has defined a number of relationships between different types of economic organization, strategies of resource use, and technology. He defines a continuum of economic organization - from foragers, who move residences from patch to patch, to collectors, who assemble task groups for the exploitation of specific resource targets (Binford 1980). At the most basic of levels, two other observational realms go hand-in-hand with the forager-collector continuum. First is site richness. With the formation of specialized task groups, a wider variety of sites is produced (Binford 1980, 1982). This is because specialized task groups may consist of a wider variety of individual groupings. Further, many steps may be involved in the bulk procurement of resources, as is the case with salmon fishing for storage (e.g., O'Leary 1985). Bulk procurement can produce greater investments
in specialized monitoring posts, processing areas, storage facilities, etc. The second observational realm is in tool technology. When gearing up for bulk procurement, groups frequently make heavy investments in a specialized, highly transported technology (Binford 1977, 1979). The payoff for higher technological investments is its specific suitability to the task at hand.

Patterns associated with foragers are contrasted with those of collectors. Since the forager strategy is dominated by switching patches, the technology is geared toward utility in a variety of tasks. Often tools are expediently produced to deal with the exigencies of resource encounters. Whereas specialized groups are common among collectors, the basic organizational building-block of foragers centers on the family or reproductive unit.

Binford's research points out that there are a number of interrelationships between the scale of organization and the strategies and tactics of resource procurement. Basically, at the forager end of the continuum, we see more direct feeding and less dependence on storage. Tools also are multifunctional, being produced to accomplish a wide variety of tasks, and these items often are produced in an expedient manner, with all stages of reduction occurring at one or a few sites. With this background knowledge in hand, we can proceed with the analysis of the Middle Snake data.

**INTERSITE SPATIAL ANALYSIS**

Seven Late Archaic archaeological sites form the core of the intersite comparisons presented here (Figure 3). These sites are located within a few hundred meters of the Snake River, along a ca. 40-kilometer-long span between modern-day Glenns Ferry and Hagerman, Idaho. These deposits yielded calibrated radiocarbon dates between ca. A.D. 900 and A.D. 1800 (Figure 4; Table 1), making them the most recent deposits known in this area. Since the relationships defined below span this approximately 1,000-year-long period, consistency in patterning is seen to reflect the stability of food procurement tactics over this period of time.

One of the localities, the Bliss site (10-GG-1), contains three temporally and spatially discrete areas of use (Figure 3 in Plew [1981]). These are treated as three different deposits, and, following Plew (1981), are labeled by Area indicator, from earliest to latest, Bliss A, Bliss B, and Bliss A1.

Materials from both Assemblage 1 and 2 at the Crutchfield site (10-GG-191, Murphey and Crutchfield 1985) have been combined here. The reason for this is twofold: both assemblages produced similar C-14 dates (Figure 4; Table 1). More importantly, however, both assemblages largely were
Three Island Crossing (TX-5723)
Blitz Area A (RL-1500)
Blitz Area B (RL-1502)
Three Island Crossing (TX-5722)
Crutchfield Assemblage 2 (T-12209)
Three Island Crossing (TX-5724)
Blitz Area B (RL-1500)
Crutchfield Assemblage 1 (T-12223)
Blitz Area B (RL-1502)
Blitz Area A1 (RL-1508)
Blitz Area A1 (TX-7462)
Blitz Area A1 (TX-7464)

Figure 4. Calibrated radiocarbon date ranges for Middle Snake River sites.

located within a few centimeters of one another in the same soil horizon (Zone IV of Murphey and Crutchfield [1985:13-15, Fig. 4]). Of the 24 excavation units which yielded Assemblage 1 or 2 faunal materials, only two overlapped, producing materials assigned to both Assemblage 1 and 2. Thus, when the faunal remains are plotted back onto the site map (Murphey and Crutchfield 1985: Fig. 5), a patchwork appears, with Assemblage 1 materials in one square and Assemblage 2 items in the next one and then back again. In some cases, horizontal transects from unit to unit reveal bewildering patterns with materials assigned to the different assemblages alternating back and forth. At best the vertical distinction between the two assemblages is sketchy. For this reason, both are combined here.

Three remaining sites are included, Clover Creek (10-EL-22 [Plew and Gould 1990]), Three Island Crossing (10-EL-294 [Plew and Gould 1994]), and the Hagerman Fish Hatchery site (10-GG-176 [Daughtery and Welch 1985; Landis and Lothson 1983; Lothson and Virga 1981; Pavesic and Meatte 1980]). Neither the Hagerman site nor Clover Creek indicate that the site dates to the A.D. 1000-1200 period (Plew and Gould 1990: Table 1).

To determine the economic focus at these different sites, frequencies of faunal materials were assessed (Table 2). In some cases only summary values are available, presenting an analytical problem. As an example, at both Three Island Crossing (Plew and Gould 1994) and Clover Creek (Plew and Gould 1990) only total numbers of individual specimens (NISPs) of animal bone are given. At both Hagerman and Crutchfield, only the presence of mussels is noted; no counts are given (Lothson and Virga 1981; Murphey and Crutchfield 1985; Pavesic and Meatte 1980). In order to assess economic differences and similarities between sites, distances were established by using a frequency-based metric, phi-square (see Equation 1). This

\[ D_{a,b} = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X}_i)^2}{n_j}} \]

Where \( D_{a,b} \) is the distance between two groups \( a \) and \( b \), \( X_i \) is observed value, and \( \bar{X}_i \) is the value expected under the null of independence.

Equation 1.
Table 1

Calibrated radiocarbon samples from Middle Snake River archaeological sites

<table>
<thead>
<tr>
<th>SITE</th>
<th>Sample Provenance</th>
<th>Lab Number</th>
<th>C-14 Age (Years BP)</th>
<th>Calibrated Date Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss Area A1 (10-GG-1)</td>
<td>S 41.94-42.06/W 28.54-73, 114-122 cm bpd</td>
<td>TX-7464</td>
<td>250 ± 50</td>
<td>1641-1672, 1780-1799, 1945-1953</td>
</tr>
<tr>
<td></td>
<td>S 40.20/W 29.94, 95 cm bpd</td>
<td>TX-7465</td>
<td>290 ± 50</td>
<td>1523-1578, 1626-1660</td>
</tr>
<tr>
<td>Bliss Area B (10-GG-1)</td>
<td>Trench 5, No Elevation Data</td>
<td>RL-1503</td>
<td>500 ± 100</td>
<td>1329-1347, 1392-1480</td>
</tr>
<tr>
<td></td>
<td>Trench 5, No Elevation Data</td>
<td>RL-1505</td>
<td>630 ± 90</td>
<td>1285-1413</td>
</tr>
<tr>
<td></td>
<td>Trench 5, No Elevation Data</td>
<td>RL-1502</td>
<td>900 ± 140</td>
<td>999-1014, 1015-1279</td>
</tr>
<tr>
<td>Crutchfield (10-GG-191)</td>
<td>Assemblage 1, Pit 900, Feature C2, 21 cm</td>
<td>I-12623</td>
<td>620 ± 80</td>
<td>1289-1413</td>
</tr>
<tr>
<td></td>
<td>Assemblage 2, Pit 1A, Feature E2, 8 cm</td>
<td>I-12203</td>
<td>700 ± 80</td>
<td>1262-1327, 1351-1364, 1365-1390</td>
</tr>
<tr>
<td>Bliss Area A (10-GG-1)</td>
<td>N 0-1/E 48-50, No Elevation Data</td>
<td>RL-1500</td>
<td>1140 ± 120</td>
<td>774-1020</td>
</tr>
<tr>
<td>Three Island Crossing (10-EL-294)</td>
<td>N 28-29/E 20-21, Feature 4, Unknown Elevation</td>
<td>TX-5724</td>
<td>580 ± 180</td>
<td>1278-1455, 1456-1479</td>
</tr>
<tr>
<td></td>
<td>N 29/E 17, 45-47 cm bpd</td>
<td>TX-5722</td>
<td>970 ± 60</td>
<td>1000-1012, 1016-1157</td>
</tr>
<tr>
<td></td>
<td>N 17-19/E 19-20, Feature 5, 30 cm bpd</td>
<td>TX-5723</td>
<td>970 ± 330</td>
<td>690-752, 760-1316, 1370-1386</td>
</tr>
</tbody>
</table>

metric was chosen since we wanted distances to reflect proportional differences rather than simple variation in sample size. The distance matrix (Table 3) is based on the two classes of information available from all of the sites, the total NISPs of animal bones and fish bones from Table 2.

In order to graphically depict structured differences in prey targets, that is, variation in harvested resources, the phi-square distance matrix was used to compute an average linkage clustering solution (Figure 5). Two major branches are revealed, one with three sites showing Three Island and Bliss A1 as being most similar and including at a somewhat greater distance Bliss B. This group on the left side of Figure 5 contains sites with low frequencies of animal bones relative to the number of fish remains (see Table 2). The other major branch contains four sites with high animal bone frequencies. Here, Clover Creek is the major outlier, and Hagerman and Crutchfield look most similar.
Table 2

Number of Individual Specimens (NISP) Recovered from Snake River Archaeological Excavations.7

<table>
<thead>
<tr>
<th>SITE</th>
<th>Animal</th>
<th>Shell</th>
<th>Fish</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss A</td>
<td>197</td>
<td>2</td>
<td>18</td>
<td>217</td>
</tr>
<tr>
<td>Bliss B</td>
<td>41</td>
<td>19</td>
<td>336</td>
<td>396</td>
</tr>
<tr>
<td>Bliss A1</td>
<td>46</td>
<td>31</td>
<td>124</td>
<td>201</td>
</tr>
<tr>
<td>Crutchfield</td>
<td>121</td>
<td>Present</td>
<td>7</td>
<td>128</td>
</tr>
<tr>
<td>Hagerman</td>
<td>18</td>
<td>Many</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Three Island</td>
<td>6,847</td>
<td>3,148</td>
<td>19,010</td>
<td>29,005</td>
</tr>
<tr>
<td>Clover Creek</td>
<td>23,285</td>
<td>228</td>
<td>22</td>
<td>23,535</td>
</tr>
</tbody>
</table>

In between these two, the Bliss A assemblage is included. In looking over the qualitative information in Table 2, the close linkage of Hagerman and Crutchfield makes good sense. These two are the only sites which, based on textual descriptions (Lothson and Virga 1981; Murphey and Crutchfield 1985; Pavesic and Mette 1980), are dominated by river mussel procurement, a resource not discussed in the ethnoarchaeological literature.

The clustering dendrogram showing difference in harvested prey is important; it can serve as a model by which tool frequencies can be assessed. We are interested in assessing the degree to which specialized technological components were used to pursue specific resources. In other words, we are interested in resource and technological specialization. An empirical evaluation of this comes from assessing the degree to which assemblages contain unique classes of items and then by evaluating the fit between the faunal information and the tool assemblages. The simplest, but most specific idea which can be advanced is one in which an isomorphic relationship between variation in harvested prey and variation in the

Table 3

Phi-Square Distance Matrix Based on Animal and Fish NISP.

<table>
<thead>
<tr>
<th>SITE</th>
<th>Bliss A</th>
<th>Bliss B</th>
<th>Bliss A1</th>
<th>Crutchfield</th>
<th>Hagerman</th>
<th>Three Island</th>
</tr>
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<tbody>
<tr>
<td>Bliss A</td>
<td>0</td>
<td>.7921</td>
<td>.6645</td>
<td>.0540</td>
<td>.0311</td>
<td>.1327</td>
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<tr>
<td>Bliss B</td>
<td></td>
<td>0</td>
<td>.2048</td>
<td>.7796</td>
<td>.5033</td>
<td>.0422</td>
</tr>
<tr>
<td>Bliss A1</td>
<td></td>
<td></td>
<td>0</td>
<td>.6729</td>
<td>.4300</td>
<td>.0011</td>
</tr>
<tr>
<td>Crutchfield</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>.0030</td>
<td>.1075</td>
</tr>
<tr>
<td>Hagerman</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.0419</td>
</tr>
<tr>
<td>Three Island</td>
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<td>0</td>
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exploitative technology occurs. This can be assessed by evaluating whether the structure discovered by analyzing the faunal differences holds for the technological data as well. The faunal diagram (Figure 5) is the set of structural information used in this test.

![Dendrogram of the average linkage clustering solution for the faunal data (not to scale).](image)

**Figure 5.** Dendrogram of the average linkage clustering solution for the faunal data (not to scale).

Fine-grained information on tool frequencies was readily available for all of the sites (Table 4). Virtually all recovered items can be classed into one of the twelve categories used here – projectile points, potsherds, groundstone, hammerstones, choppers, knives and bifaces together, scrapers, cores, modified flakes, abraders or shaft straighteners, perforators and drills, and miscellaneous fabricating or processing items. The last class reflects those items included in Winters’s (1969) functional classification which are not specified in the other categories. The only other items from these sites which are not included are non-utilitarian items – ornamental and ceremonial items, including beads, marine shells, pipe fragments, and red ochre (ibid.). Total numbers of items range between 208 at Bliss B to 1,580 at Bliss A1.

It is important to note that the classification used here is exhaustive with respect to items which arguably served economic functions. An inspection of Table 4 shows that out of 84 cells in the site-by-tool classification, only 10 cells contain zeros. This means that there is a **high degree of redundancy in the number of functional tool classes represented at each site**. Five of the sites yielded items which filled 10 of the 12 possible classes. The other two sites produced items in every class. This means that Middle Snake sites are quite even in the number of discrete classes of functional items recovered. That is, the **same functional and technological units are represented in virtually all of these sites**. There are no clearly differentiated specialized tools found at these sites, regardless of the fact that they vary widely in economic orientation, as evidenced in the faunal data. Further, we do know that specialized, task-specific equipment existed for prehistoric fishing at a location some 100 kilometers downstream (Pavesic et al. 1987; Schellbach 1967). The fact that **none** of these materials have been recovered from these seven sites, including one which yielded 19,010 fish remains (Three Island Crossing; see Table 2), strongly reflects the generalized nature of these assemblages.

It is clear that there is little difference between these sites in terms of the richness of functional items represented. It remains to be shown whether the variability in these assemblages is a direct function of economic pursuits. A straightforward notion stands behind the test of isomorphism between the faunal and tool data. The test is based on a technique pioneered in genetics (Long 1992). First, tool frequencies were converted into relative frequencies on a site-by-site basis; in turn, these values were transformed using an arcsine or angular transformation (see Equation 2) in order to spread out the tails of

\[
X_{ij} = \sin^{-1}\left(f_{ij}\right)^{\frac{1}{2}}
\]

*Where* \(f_{ij}\) *is the relative frequency of the jth item in the ith row.*

**Equation 2.**
Table 4

Frequencies of Tools Classes at Middle Snake River Sites

<table>
<thead>
<tr>
<th>SITE</th>
<th>Bliss A</th>
<th>Bliss B</th>
<th>Bliss A1</th>
<th>Crutchfield</th>
<th>Hagerman</th>
<th>Three Island</th>
<th>Clover Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projectiles</td>
<td>97</td>
<td>55</td>
<td>439</td>
<td>91</td>
<td>124</td>
<td>246</td>
<td>119</td>
</tr>
<tr>
<td>Pottery</td>
<td>219</td>
<td>84</td>
<td>797</td>
<td>66</td>
<td>64</td>
<td>935</td>
<td>310</td>
</tr>
<tr>
<td>Groundstone</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>57</td>
<td>84</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Hammerstones</td>
<td>1</td>
<td>4</td>
<td>43</td>
<td>25</td>
<td>3</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Choppers</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Knives/Bifaces</td>
<td>23</td>
<td>21</td>
<td>64</td>
<td>40</td>
<td>57</td>
<td>80</td>
<td>44</td>
</tr>
<tr>
<td>Scrapers</td>
<td>7</td>
<td>1</td>
<td>57</td>
<td>42</td>
<td>22</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>Cores</td>
<td>3</td>
<td>6</td>
<td>32</td>
<td>101</td>
<td>34</td>
<td>26</td>
<td>50</td>
</tr>
<tr>
<td>Modified Flakes</td>
<td>41</td>
<td>32</td>
<td>77</td>
<td>103</td>
<td>51</td>
<td>15</td>
<td>44</td>
</tr>
<tr>
<td>Abraders</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Perforators/Drills</td>
<td>8</td>
<td>2</td>
<td>29</td>
<td>21</td>
<td>9</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Miss. Fab./Processing</td>
<td>2</td>
<td>1</td>
<td>15</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5

Covariance Matrix of Arcsine Transformed Relative Frequencies of Tool Classes

<table>
<thead>
<tr>
<th>SITE</th>
<th>Bliss A</th>
<th>Bliss B</th>
<th>Bliss A1</th>
<th>Crutchfield</th>
<th>Hagerman</th>
<th>Three Island</th>
<th>Clover Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss A</td>
<td>.060665</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bliss B</td>
<td>.052771</td>
<td>.049721</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bliss A1</td>
<td>.052803</td>
<td>.045231</td>
<td>.049107</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crutchfield</td>
<td>.016617</td>
<td>.017933</td>
<td>.015404</td>
<td>.018371</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hagerman</td>
<td>.026771</td>
<td>.026412</td>
<td>.025435</td>
<td>.020960</td>
<td>.033610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Island</td>
<td>.062689</td>
<td>.052088</td>
<td>.057727</td>
<td>.016179</td>
<td>.027965</td>
<td>.073153</td>
<td></td>
</tr>
<tr>
<td>Clover Creek</td>
<td>.050495</td>
<td>.045051</td>
<td>.046582</td>
<td>.020041</td>
<td>.028189</td>
<td>.057019</td>
<td>.049899</td>
</tr>
</tbody>
</table>

75
the distributions and increase variances (Snedecor and Cochran 1989:289-290; Sokal and Rohlf 1981:427-428). Using these transformed relative frequencies, a Q-mode covariance matrix (see Equation 3) was computed for use in subsequent steps (Table 5).

\[
S_{jk} = \frac{\sum_{i=1}^{c} (X_{ij} - \bar{X}_j)(X_{ik} - \bar{X}_k)}{c - 1}
\]

Where \(S_{jk}\) is the covariance, \(c\) is the number of variables, \(X_{ij}\) is the observation for the \(i\)th row and \(j\)th column, and \(\bar{X}_j\) is the mean of the \(j\)th column.

Equation 3.

In order to assess the fit between the tool frequency-based covariance matrix and the tree structure discovered during the clustering of the faunal data, three steps are required (Long 1992). First is the specification of the null hypothesis (\(H_0\)). Figure 6 shows the same hierarchical structure as in the faunal clustering solution. In this diagram a single node marks where Clover Creek diverges from Hagerman, Crutchfield, and Bliss A, implying that Clover Creek is equally differentiated from the latter three sites. If the relationships between sites specified in the faunal clustering are manifest in the tool frequencies, the covariances between Clover Creek and these other three sites should be equal (\(H_{0.2}\) in Table 6). This is one of four sets of equations which form the specific hypothesis inherent in the hierarchical structure presented in Figure 6. The overall null hypothesis is specified in Table 6 (\(H_{0.2}-H_{0.4}\)). Within the structure-based hypothesis, the greatest number of terms result from the initial divergence at the top of the tree in Figure 6. This indicates that the covariances between fish-dominated assemblage frequencies (Three Island, Bliss A1, and Bliss B) and frequencies at animal or shellfish dominated sites (Crutchfield, Hagerman, Bliss A, and Clover Creek) are all equal (Table 6, \(H_{0.1}\)). The two remaining equations specify simple equalities. First is that the covariances between the most similar fish-dominated assemblages (Three Island and Bliss A1) and Bliss B are equal (Table 6, \(H_{0.4}\)). Second is that the covariances between the shellfish-dominated locales (Crutchfield and Hagerman) and Bliss A are equal (Table 6, \(H_{0.3}\)). These specific terms serve as constraints used in the next step.

![Figure 6. Structural model for Snake River tool data. The circled node shows the point at which Clover Creek diverges from Crutchfield, Hagerman, and Bliss A. This relationship is specified as H0.2 in Table 6.](image)

The second step in evaluating the faunal-tool relationship requires the computation of a maximum-likelihood solution for a matrix which is constrained by the model structure. The estimate for the covariance matrix follows the approach developed by Anderson (1973). A total of 13 parameters are estimated in the iterated maximum-likelihood covariance matrix given in Table 7.

The final step comes in evaluating whether or not difference exists between the observed and expected matrices (given in Tables 5 and 7). Using a log-likelihood ratio statistic (see Equation 4; Long 1992), we fail to reject the null of the two matrices being equal, since there is no significant difference between the matrices \(T = 20.1708; \ df = 15; \ p = .165\). This means that the same structure discovered within the faunal clustering...
### Table 6

Hypothesis Derived from the Structural Model

<table>
<thead>
<tr>
<th>SITE</th>
<th>Bliss A</th>
<th>Bliss B</th>
<th>Bliss A1</th>
<th>Crutchfield</th>
<th>Hagerman</th>
<th>Three Island</th>
<th>Clover Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss A</td>
<td>$s_{21}$</td>
<td>$s_{22}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bliss B</td>
<td>$s_{12}$</td>
<td>$s_{22}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bliss A1</td>
<td>$s_{13}$</td>
<td>$s_{23}$</td>
<td>$s_{33}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crutchfield</td>
<td>$s_{14}$</td>
<td>$s_{24}$</td>
<td>$s_{34}$</td>
<td>$s_{44}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hagerman</td>
<td>$s_{15}$</td>
<td>$s_{25}$</td>
<td>$s_{35}$</td>
<td>$s_{45}$</td>
<td>$s_{55}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Island</td>
<td>$s_{16}$</td>
<td>$s_{26}$</td>
<td>$s_{36}$</td>
<td>$s_{46}$</td>
<td>$s_{56}$</td>
<td>$s_{66}$</td>
<td></td>
</tr>
<tr>
<td>Clover Creek</td>
<td>$s_{17}$</td>
<td>$s_{27}$</td>
<td>$s_{37}$</td>
<td>$s_{47}$</td>
<td>$s_{57}$</td>
<td>$s_{67}$</td>
<td>$s_{77}$</td>
</tr>
</tbody>
</table>

$H_{01}: s_{13} = s_{14} = s_{15} = s_{16} = s_{23} = s_{24} = s_{25} = s_{26} = s_{34} = s_{35} = s_{36} = s_{45} = s_{46} = s_{56} = s_{67}$

$H_{02}: s_{17} = s_{27} = s_{37} = s_{47} = s_{57} = s_{67}$

$H_{03}: s_{15} = s_{14} = s_{25} = s_{24}$

$H_{04}: s_{35} = s_{34}$

### Table 7

Maximum-Likelihood Covariance Matrix Constrained by the Faunal Structure

<table>
<thead>
<tr>
<th>SITE</th>
<th>Bliss A</th>
<th>Bliss B</th>
<th>Bliss A1</th>
<th>Crutchfield</th>
<th>Hagerman</th>
<th>Three Island</th>
<th>Clover Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bliss A</td>
<td>.046822</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bliss B</td>
<td>.038481</td>
<td>.047285</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bliss A1</td>
<td>.038481</td>
<td>.048006</td>
<td>.062749</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crutchfield</td>
<td>.033292</td>
<td>.038481</td>
<td>.038481</td>
<td>.050876</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hagerman</td>
<td>.033292</td>
<td>.038481</td>
<td>.038481</td>
<td>.052394</td>
<td>.063972</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Island</td>
<td>.038481</td>
<td>.048006</td>
<td>.061617</td>
<td>.038481</td>
<td>.038481</td>
<td>.067292</td>
<td></td>
</tr>
<tr>
<td>Clover Creek</td>
<td>.046055</td>
<td>.038481</td>
<td>.038481</td>
<td>.046055</td>
<td>.046055</td>
<td>.038481</td>
<td>.056034</td>
</tr>
</tbody>
</table>

**frequencies.** The same intersite relationships solution fits the variation observed in tool underlie both data sets, meaning that there is a one-to-one correspondence between the organizational behavior which created both sets of information. Given that there is uniformity in the richness of technological functions at these sites, we clearly see that similar tool elements are being used to harvest a wide variety of resources. This finding has
direct implications for understanding past human organizational dynamics.

\[
T = (n-1) \left( \frac{2c+1-2}{(c+1)} \right) \left( \frac{2n\Sigma_n - n\ln|\Sigma_n| + n\ln|\Sigma| - n - 1}{6(n-1)} \right)
\]

Where \( c \) is the number of variables, \( n \) is the number of cases, \( \Sigma_n \) is the observed covariance matrix, and \( \Sigma \) is the expected covariance matrix.

Equation 4.

PREHISTORIC FORAGING ORGANIZATION

The quantitative analysis clearly indicates a direct relationship between the frequency of tools and the prey types represented. Both are seen to stem from the same organizational milieu. Though assemblage variation is determined by prey selection and encounters, tool kits contain the same functional components. Differential frequencies of the same functional elements are nearly the exclusive source of intersite variability. No specialized tools are noted, despite the fact that they are known to be used in the surrounding area. The behavioral domain under which these observations could be made is rather limited.

Groups creating sites would have to be similarly and consistently organized. This is because no unique, specialized sites are represented. If any were found, unique assemblage elements would have been found. As a result, the structural model would have failed since the hypothesized consistency in the covariance structure would have provided a poor fit. The failure to reject the structural model also implies something about the nature of tool production and discard relative to procurement.

Regardless of what resources were used, assemblages vary not in terms of unique elements, but in the greater production of certain generalized items found at most, if not all of the sites. Essentially the same set of items was used at Three Island Crossing in the harvesting of fish and at Clover Creek, where terrestrial animals dominate the recovered fauna (Table 2). Tool production appears to have been geared toward the expedient manufacture of generalized items on an encounter-to-encounter basis. In other words, what we see manifest in these Middle Snake archaeological assemblages is strong evidence for the direct feeding on resources. This is not the specialized production or processing associated with collectors (sensu Binford 1980), nor is it in any way consistent with patterns stemming from bulk production and storage of a short-duration resource such as salmon. Since there appears to be uniformity in the structural basis of assemblages, we argue that this indicates that an organizationally homogeneous unit was responsible for the production of these assemblages. Since direct feeding, a hallmark of foraging, is indicated, small-scale units, likely family reproductive units, are the sole elements of organization evidenced. Since this pattern spans the A.D. 800-1800 period, we believe that the foraging payoff for not intensively exploiting fish was relatively stable, though, obviously, this changed at some point in the recent past. After all, some historic groups did pursue this strategy. The question now becomes why that would occur, marking a point of excursion for future research.

This analysis provides us with a new way to address variability in both the prehistoric and historic periods. It is impossible to doubt that fishing and storage played important, but different roles in these two periods. We see the main benefit of this research as providing us with a new set of questions. Rather than choosing up sides in a pseudo-debate about who is using the right interpretation or who
cites the “correct” ethnographic analogy, we feel that we have successfully demonstrated
that human organization and tactics of resource use were somewhat different in the
past. Our findings are not dependent on projecting a normative model onto the
archaeological record. It is an approach which takes advantage of a number of ideas
which have some empirical mettle, such as the views put forth within behavioral ecology.
Because of the strength of the prior knowledge which we can bring to bear on the
problem, this analysis clearly identifies structural relationships which are necessarily
linked to specific patterns of economic organization. This research approach expands our frame into new, uncharted areas allowing us to explore ideas about what it is
that conditions variation in past and present human behavior, the primary goal of
anthropological inquiry.

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This paper has greatly benefited from discussions with Harold Hietala and Lewis R.
Binford at Southern Methodist University. Both encouraged the senior author in spite of some
extremely fuzzy initial ideas. Hal played devil’s advocate well, and his contribution has helped
clear up some rather murky ideas. Jeffrey C. Long at the National Institutes of Health and University
of New Mexico wrote the program which was used to calculate the maximum likelihood
covariance matrix as well as the log-likelihood ratio statistic which assesses the goodness of fit.
Jeff also wrote a clear set of instructions, providing all of the necessary references, which helped immeasurably. He introduced the senior author to the idea of a "test of teness" in the
Advanced Quantitative Methods in Biological Anthropology seminar at the University of New
Mexico. Many thanks are due.

Though the ideas expressed and evaluated here have evolved over the course of many years of
discussion and interaction with these individuals, the final responsibility for the ideas are our own.

ENDNOTES

1. Originally titled "Optimal Foraging Approaches to Prehistoric Salmon Fishing in the Northern
Great Basin: The Ecological Dynamics of Trade-Offs and Strategic Responses" and presented at
the 59th Annual Meeting of the Society for American Archaeology, Anaheim, Calif., April

2. The Bannock language is a dialect of Northern Paiute spoken by groups from the western margin
of Idaho and Southeastern Oregon on through Southeastern Idaho (Liljeblad 1957:20; Murphy
and Murphy 1986:284).

3. No data were collected during the four-day-long interval between October 6 and 10, the two-
day-long period between October 20 and 22, or the four days between October 27 and 31. Figure
2 shows the span of these intervals as dashed lines.

4. Sample data were drawn from a number of sources. The information on all the RL samples
from the Bliss site are reported in Plew (1981:157-159). The two Texas (TX) samples
from Bliss Area A1 are reported here for the first time. The Crutchfield site age estimates come
from Murphey and Crutchfield (1985:Table 1). the Three Island Crossing data are from Plew and
Gould (1994). The calibrated date ranges were obtained by the intercept method (Method A) of
Stuiver and Becker (1993) using the decadal data set. The ranges represent a 0.67 probability of
correct assignment.

5. As an example, the transect moving from unit
71 in the northwest to 7D in the southeast, yields
the following pattern: unit 71 contained
Assemblage 1 and 2 materials; next in line, 7G,
yielded Assemblage 1 remains only; the next unit,
7F, produced Assemblage 2 bones only; 7E
contained Assemblage 1 and 2 materials; and 7D
produced only Assemblage 1 materials (see
proveniency data in Murphey and Crutchfield
[1985]). This is a rather unusual horizontal
distribution for "discrete" stratigraphic layers
which are within a few centimeters of one
another.
6. This is simply the square root of the chi-square between two cases which has been divided by the total N.


8. The totals for Bliss A1 include items recovered during our 1991 and 1992 excavations at the site. However, the faunal remains from those years are only partially analyzed, so they are not included above.


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