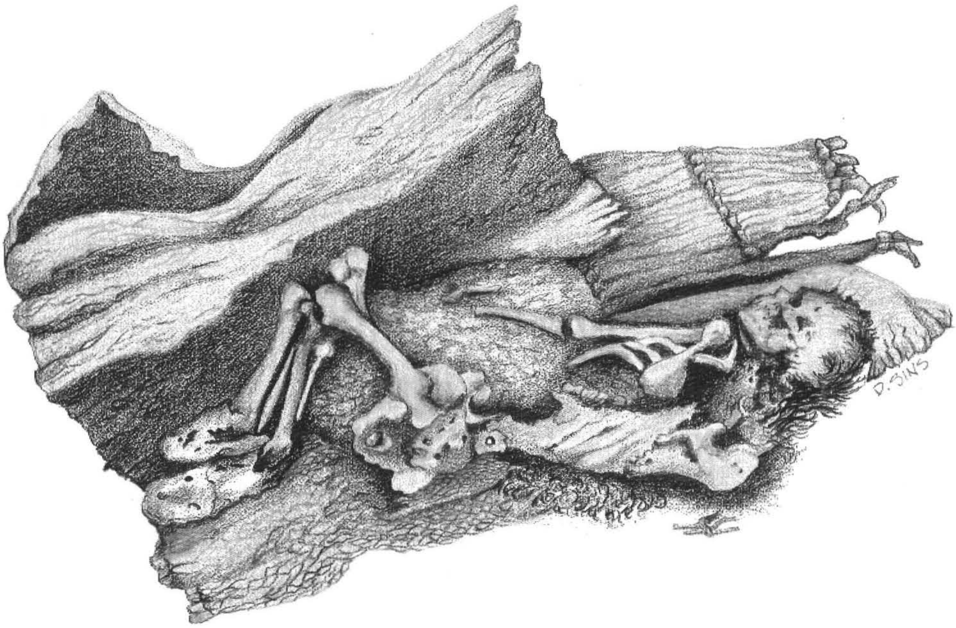
Nevada
Historical Society Quarterly



SPRING 1997

NEVADA HISTORICAL SOCIETY QUARTERLY

The *Nevada Historical Society Quarterly* solicits contributions of scholarly or popular interest dealing with the following subjects: the general (e.g., the political, social, economic, constitutional) or the natural history of Nevada and the Great Basin; the literature, languages, anthropology, and archaeology of these areas; reprints of historic documents; reviews and essays concerning the historical literature of Nevada, the Great Basin, and the West.

Prospective authors should send their work to The Editor, *Nevada Historical Society Quarterly*, 1650 N. Virginia St., Reno, Nevada 89503. Papers should be typed double-spaced and sent in duplicate. All manuscripts, whether articles, edited documents, or essays, should conform to the most recent edition of the University of Chicago Press *Manual of Style*. Footnotes should be typed double-spaced on separate pages and numbered consecutively. Correspondence concerning articles and essays is welcomed, and should be addressed to The Editor.

The *Nevada Historical Society Quarterly* (ISSN 0047-9462) is published quarterly by the Nevada Historical Society. The *Quarterly* is sent to all members of the Society. Membership dues are: Student, $15; Senior Citizen without *Quarterly*, $15; Regular, $25; Family, $35; Sustaining, $50; Contributing, $100; Departmental Fellow, $250; Patron, $500; Benefactor, $1,000. Membership applications and dues should be sent to the Director, Nevada Historical Society, 1650 N. Virginia St., Reno, NV 89503. Periodicals postage paid at Reno, Nevada and at additional mailing offices. POSTMASTER: Send address changes to *Nevada Historical Society Quarterly*, 1650 N. Virginia St., Reno, Nevada 89503.

FISH REMAINS FROM THE SPIRIT CAVE PALEOFECAL MATERIAL

9,400 Year Old Evidence for Great Basin Utilization of Small Fishes

B. Sunday Eiselt

INTRODUCTION

Paleofecal Studies

The analysis of human paleofecal material[1] is an exercise in dietary reconstruction rarely available to most researchers interested in human subsistence patterns. It provides direct evidence of the types of plants and animals eaten by people in the past, and reveals the interaction of humans with their environments through the accidental or purposeful ingestion of seasonal pollen, trace minerals, insects, and other chemicals. Paleofecal research also leads to the assessment of the physiological health of past individuals through the analysis of parasites, bacteria, and viruses. It should be noted, however, that paleofecal analysis provides an understanding of these conditions of past human lives at the individual level only. As such, this type of research should be articulated with paleoethnobiological studies of nonfecal archaeological deposits and paleoenvironmental reconstructions.

The analysis of human paleofecal material has a history beginning in the late 1800s. Harshberger (1896), commenting on the potential value of paleofecal analysis, was the first to suggest that seeds and bone found in prehistoric feces

Special thanks go to Gary Vinyard, professor of Biology and Ichthyology, University of Nevada, Reno for assisting in the identification of fish otoliths and eye lenses, and Dr. Peter Wigand for providing laboratory space at the Desert Research Institute Paleobotany Laboratory. This paper has benefited greatly from the constructive commentary of Catherine Fowler, Don Fowler, Gary Haynes, Peter Wigand and Stephanie Livingston.

could offer clues to ancient diet. According to Reinhard and Bryant (1992), paleofecal analysis has gone through three historical phases. The first began in 1829, when the term *coprolite* was coined and ended in the 1960s with the standardization of analytical techniques by E. O. Callen.[2] Callen, being almost single-handedly responsible for the next phase, extending from the 1960s till his death in 1970, brought about the standardization of techniques and initiated specialized studies of pollen, parasites, and macrofossils. It was during this time that widespread interest in the analysis of human fecal matter began. From the 1970s to the present, paleofecal studies are characterized by a refinement in techniques and broader applications of analysis to archaeological questions (Reinhard and Bryant 1992:246). Today, researchers continue to push the boundaries of fecal analysis by extracting and analyzing levels of testosterone and estradiol in modern and prehistoric feces in order to address issues of prehistoric diet related to biological sex (Sobolik *et al.* 1996).

There are several advantages and limitations to paleofecal research related to preservation and the individual nature of the data recovered. Gasser's (1982) work showed that many fragile items susceptible to decomposition in an open site are better preserved in fecal material simply because of the context of preservation. Miksecek (1987) conversely showed that differences between paleofecal contents and bulk sample data may also relate to increased difficulty in identifying damaged food fragments that have passed through a human digestive tract. Miksecek (1987) also showed the necessity of analyzing fecal and bulk samples in tandem since many items not ingested will become discarded as the result of food preparation and consumption. The combined sets of data are more effective when contrasted, revealing additional aspects of prehistoric diet not readily apparent when each is analyzed separately.

Regarding recovery, fecal matter may be difficult to distinguish during excavations. Decomposed fecal pieces may appear merely as clusters of organic material, and can be destroyed or missed while digging. If they are recovered decomposed, their identity as fecal matter is ambiguous. Research documenting the characteristics and structure of fecal organic assemblages therefore should be pursued in a continued effort to separate fecal (individual) from non-fecal (aggregate) data. Finally, fecal data, because it represents individual meals consumed in specific seasons, may provide insights into the seasonality of past human behavior. Storage of foods gathered in one season and ingested in another can be a source of interpretative error, but determining the harvest season of ingested foods is possible and can be helpful for economic analyses relating to seasonal exploitation of resources.

Fish Bones and Fecal Matter in the Great Basin.

The interaction of humans with wetland environments in the high desert of the Great Basin has been a topic of some interest in regional anthropological research for many years. Loud and Harrington (1929) first suggested the importance of marshes to the people represented by the Lovelock Culture. Later work (Heizer and Kreiger 1956; Heizer and Napton 1970) served to raise general questions about the utilization of prehistoric Great Basin marsh resources in relation to Jennings's (1957; 1964) desert culture concept. Bedwell's (1973) western pluvial lakes tradition (WPLT) hypothesis likewise implies that early Great Basin cultures focused on lacustrine and grassland resources. This in turn suggests we should find faunal evidence supporting marsh and grassland exploitation in early archaeological contexts.

Fish remains have been reported from several central and western Great Basin archaeological sites including Hidden, Lovelock, and Falcon Hill caves, the Stillwater Marsh in western Nevada, and the Karlo Site in California (Follett 1967, 1970, 1974, 1977, 1980; Greenspan 1988; Raymond and Sobel 1990). One way, therefore, to assess the contribution of wetland resources to prehistoric diets is through the analysis of fish bones from these and other such sites. Fish bones found in paleofecal material, in particular, can offer direct evidence of aquatic resource utilization in the past.

These anthropologically oriented questions regarding lacustrine resource utilization have led to new and innovative research projects attempting to find ways of distinguishing cultural from natural fish bone assemblages in the Great Basin (Butler 1996; Greenspan and Raymond 1996) and elsewhere (Stewart and Gifford-Gonzalez 1994; Butler 1993; Wim Van Neer and Muniz 1992; Stewart 1991). Although these studies have been effective at finding differences between natural and cultural assemblages, considerably less attention has been given to documenting the range of variation within and between different types of culturally produced collections. In this article, fish remains found in paleofecal material from Spirit Cave, western Nevada, and those recovered from the Peninsula Site, an open-air archaeological site in Warner Valley, southeastern Oregon, will be compared in order to document the range of variability in fish assemblage structure possibly attributable to different paleoenvironments, capture strategies, and taphonomic histories. The Spirit Cave paleofecal materials represent direct evidence of the effects that human procurement and consumption have on fish bone during processing and digestion. The open-air archaeological site has been interpreted as representing cultural discard patterns related to fish processing, but not ingestion (Eiselt, in preparation).

A comparative collection of fishes captured from a stream in Murrer's Meadow, northeastern California, provides the basis for making taxonomic identifications and allows for the assessment of the relative live sizes of the fishes represented in the archaeological materials. It also enables an estimate of the hydrological environment from which the archaeological specimens were procured. With the Murrer's Meadow fishes, an attempt was made to replicate indigenous mass-capture strategies in order to understand species selection and economic issues.

MATERIALS

Spirit Cave

Six boli recovered from the abdominal cavity of the Spirit Cave mummy were processed for fish bone prior to extraction of pollen (see Wigand, this issue). An additional two samples, taken from sediments above the interred individual, were inspected using a 10-micron dissecting scope, but no bones were observed. Bone from the fecal matter was separated as light fraction organic material during the rendering and cleaning of the boli prior to pollen extraction. This material was further rinsed, dried, then screened through 24-, 42-, and 60-mesh U.S.A. standard sieve brass screens for identification. The contents of the 24-mesh screens were identified, and the remaining finer screen contents were scanned for identifiable elements. Two of the six samples from the 24-mesh screen contained high amounts of bone. Because of time constraints only 50 percent of each of these was analyzed. The 24-mesh screen contents for the remaining four samples were identified completely. Identifications were made with the aid of a 10-micron dissecting scope. Taxon, element, side, burning, and degree of fragmentation (represented as a percentage of the whole) were noted during analysis.

Of 697 elements identified to taxon from all six boli of the paleofecal material, 640 or 91.82 percent of the assemblage was identified to indeterminate cyprinidae, 3.73 percent of the assemblage to tui-chub, 0.43 percent to an indeterminate redside/dace category, and 4.01 percent of the assemblage was identified as suckers (Table 1, Appendix 1). All of the Spirit Cave fish elements are extremely small, which reduces the ability to distinguish between larger and smaller minnows, thereby increasing the indeterminant cyprinid count.

TABLE 1

Spirit Cave Paleofecal Material, Number of Identified Specimens

Taxon	Count	Percentage
Cyprinidae		
Gila sp.	26	3.73
cf. *Rhinichthys/Richardsonius* sp.	3	0.43
Indeterminant	640	91.82
Catostomidae		
Catostomus sp.	28	4.01
Total NISP	697	100

In addition to the fish bone specimens, fish eye lenses, otoliths, and possible animal fibers also were noted. These specimens are not included in the Number of

Identified Specimens (NISP) count because they cannot be referred to at the family level, but are mentioned here because they clearly represent ingested fishes. Fish eye lenses are characterized by their density and hardness, spherical shape, amber color, and translucence when light is passed through them from below. A slight pucker can occur on the surface possibly related to digestive or post-depositional effects on the lenses, and these were noted on the paleofecal specimens. The upper left quadrant of Figure 1 shows an example of a fish lens.

FIGURE 1. Spirit Cave fish bone. Fish eye lens is present in upper left quadrant, Scale bar = 1 cm intervals

Twenty-one otoliths were identified. Otoliths are characteristically flat, disc-shaped calcium-carbonate nodules with visible ridges in the shape of rings. Possible animal fibers were also present in the fecal matter (see Appendix 1), the identification of which was made by a visual comparison with modern sinew samples.

The Peninsula Site

Results of the paleofecal analysis were compared to 4,442 identified fish bone elements recovered from the Peninsula Site (35LK2579), an open-air village site in southeastern Oregon, for the purposes of addressing questions of differential bone survivorship, species selection, and paleohydrological interpretations. The Peninsula Site is located along the eastern shore of Hart Lake in Warner Valley, southeastern Oregon (Figure 2).

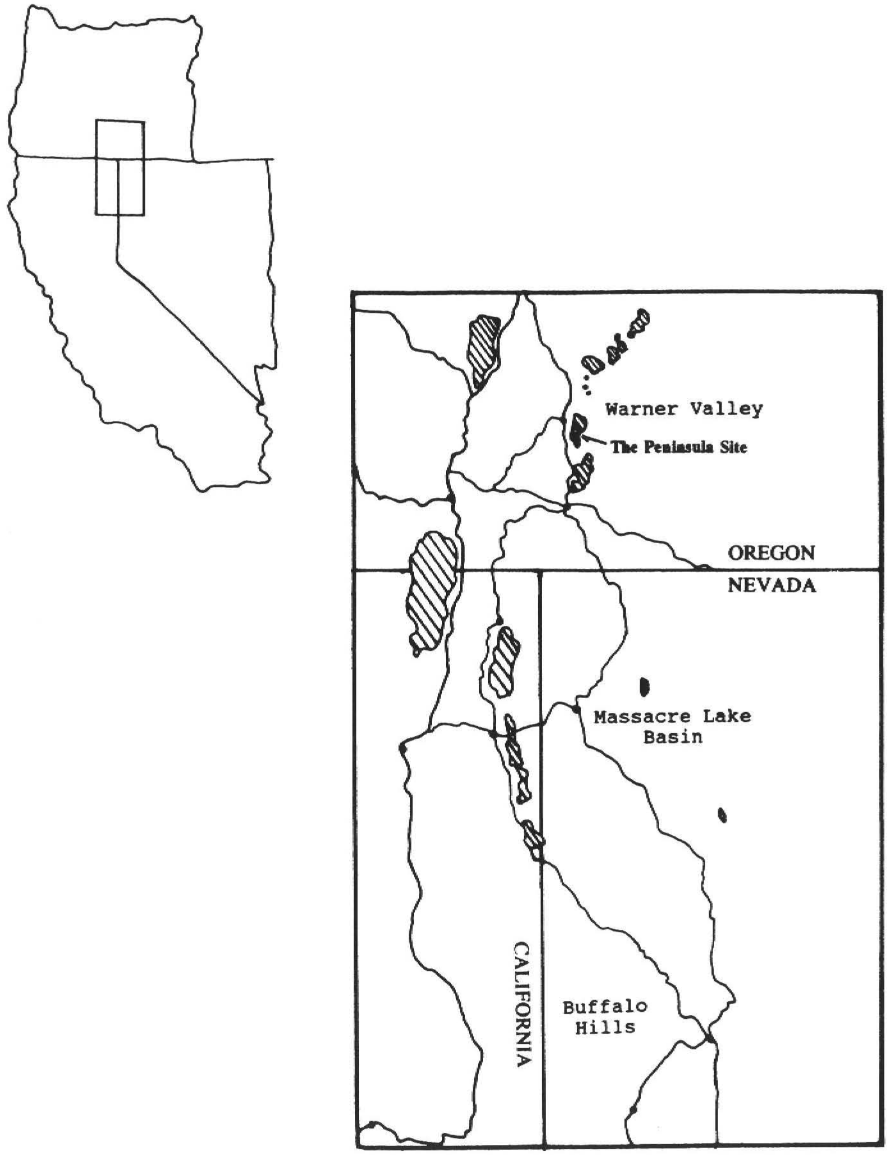


FIGURE 2. The Peninsula Site, Warner Valley southeastern Oregon

The site is interpreted as having been a Late Archaic, possible winter village site dating to between 700 and 400 B.P. This interpretation is based on a valley-bottom location, the presence of numerous and large depression features, and associated domestic debris including evidence of intense and prolonged occupation. Artifacts found on the site include Rosespring, Desert Side Notch, and Elko projectile points; groundstone mortars, metates, and manos; possible net sinkers;

tabular basalt knives; stone balls; bone beads and pendants; and basketry (Young 1993).

Several depressions located at the site were excavated by the University of Nevada, Reno, in cooperation with the Lakeview District Bureau of Land Management for several sessions during the summers of 1990, 1995, and 1996. One depression contained a well-preserved burned structure in which earthen covering, matting layers, wood structure elements, and domestic debris were recovered *in situ*. Spatial patterning of objects recovered from the floor reveal activity areas related to lithic production, fish processing or consumption, hide working, and bone ornament production (Eiselt, in preparation). To achieve this level of spatial integrity, the structure was probably buried rapidly after abandonment and burning.

The Peninsula Site fish elements were recovered from cultural fill above depression floors, on depression floors, and in trash midden deposits associated with depressions. These fish bones are interpreted as culturally derived and not natural accumulations based on the integrity and type of the context in which they were found (Moore 1995). Burned elements were present, and these were located on the depression floor that was overlain by the burned structure (Figure 3). Other burned elements were found in artifact-rich middens located adjacent to depressions. The Peninsula Site fish bone material is therefore thought to be the result of indigenous discard patterns.

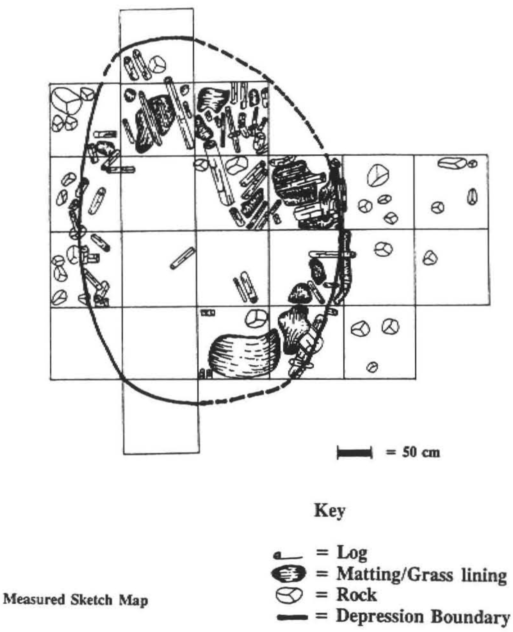


FIGURE 3. Depression Feature 304. Pit house feature showing structure element arrangement and plan view definition

Recovery of fish bone from the Peninsula Site was achieved using 1/8-inch mesh screen. Block soil samples were collected in the field and these were processed using 60- mesh (.250 mm) dry screening techniques and a Lux magnifying lamp in the laboratory. The use of this smaller mesh did not produce appreciably better recovery rates for identifiable fish bone, although more unidentifiable small bone fragments were collected.

Of the 7,784 fish bones recovered from the Peninsula Site, 4,442 were identifiable to element and 1,850 were identifiable to taxon. In the Peninsula Site assemblage, cyprinid bones were large enough to discount the possibility of confusing tui-chub with dace or redsides, but dental formulas from Peninsula Site pharyngeals were checked in the case of smaller specimens. Of the total assemblage 5,934 (76.2 percent) specimens were identified to an indeterminant fish category, 1,493 (19.1 percent) were identified as tui-chub (*Gila* sp.), and 357 (4.5 percent) were identified as sucker (*Catostomus* sp.) (Table 2).

TABLE 2

Peninsula Site Fish Material, Number of Identified Specimens

Taxon	Count	Percentage
Unidentifiable Fish	5934	76.2
Cyprinidae		
Gila sp.	1493	19.1
cf. *Rhinichthys/Richardsonius* sp.	0	0.0
Catostomidae		
Catostomus sp.	357	4.5
Total NISP	7784	100

Murrer's Meadow Fishes

Fish captured from Willow Creek near Eagle Lake, Lassen County, California were used during the zooarchaeological analysis of the Spirit Cave material as a comparative collection to make distinctions between tui-chub (*Gila* sp.), sucker (*Catostomus* sp.), redsides (*Richardsonius* sp.), and speckled dace (*Rhinichthys* sp.). The collection was also used to assess relative sizes of fossil specimens recovered from the Spirit Cave boli. Murrer's Meadow is located approximately 100 miles northwest of Spirit Cave at an elevation of 5,000 feet. Studies conducted by Moyle *et al.* (1991:268) show that Willow Creek is characterized by high conductivity, high water hardness, and total alkalinity. Summer water temperatures range near 21 degrees Celsius. Fish were collected from Willow Creek as it flows through Murrer's Meadow to Susan River. Although the area sits near a major transition zone between Great Basin, Cascade Range and Sierra Nevada biomes, Willow Creek contains the same fish species as commonly found throughout the Great Basin (Table 3).

At extremely small size ranges, tui-chub, redsides, and dace can be separated only by using the dental formula from the pharyngeal bone. Dace and redside have two rows of teeth resulting in a 2442 or 1441 dental formula, tui-chub have only one row. Although these cyprinids are difficult to distinguish, suckers are easily separated using distinctive morphological characteristics of elements related to their movements, habitat, and feeding preferences. Suckers are bottom-dwelling fishes that forage from rocks and floor debris. Sucker bone morphology can be characterized as dense, curvate, and extremely rugulate, serving to increase bone tensile strength. In addition, since suckers are bottom feeders, their mouths are positioned more ventrally on the fish head. This causes distinctive osteological features in the bones related to feeding. Sucker pharyngeals likewise reflect their trophic status since teeth are rake-like, acting as sieves to catch vegetal debris. In contrast, minnows feed in the water column primarily on drift consisting of invertebrates and zooplankton. Pharyngeals of these taxa contain graduated and curvate teeth ending in sharp points used for processing hard-bodied food materials. Cyprinid mouthparts are also positioned more forward on the fish head as the result of their foraging strategies. Cyprinid elements are more gracile presumably since they are not bottom dwelling fish.

TABLE 3

Species Composition Murrer's Meadow
Data taken from Moyle *et al.* (1991:269)

Taxon	N	Average Standard Length (cm)
Lahontan Redside *Richardsonius egregius*	50	5.9
Speckled Dace *Rhinichthys osculus*	*55*	*3.8*
Tui-Chub *Gila bicolor*	*18*	*5.7*
Tahoe Sucker *Catostomus tahoensis*	*24*	*7.0*
Rainbow Trout *Oncorhynchus mykiss*	*0*	*0*
Paiute Sculpin *Cottus beldingi*	*21*	*5.1*

Specimens collected from Murrer's Meadow were also used to estimate the approximate size of the fish found in the paleofecal material. Exact measurement of elements was not possible given their small size, but Figure 4 shows the pharyngeal of a captured Speckled Dace measuring 3.2 cm live length (on the left) as compared to several of the paleofecal pharyngeals considered to be typical for the Spirit Cave assemblage.

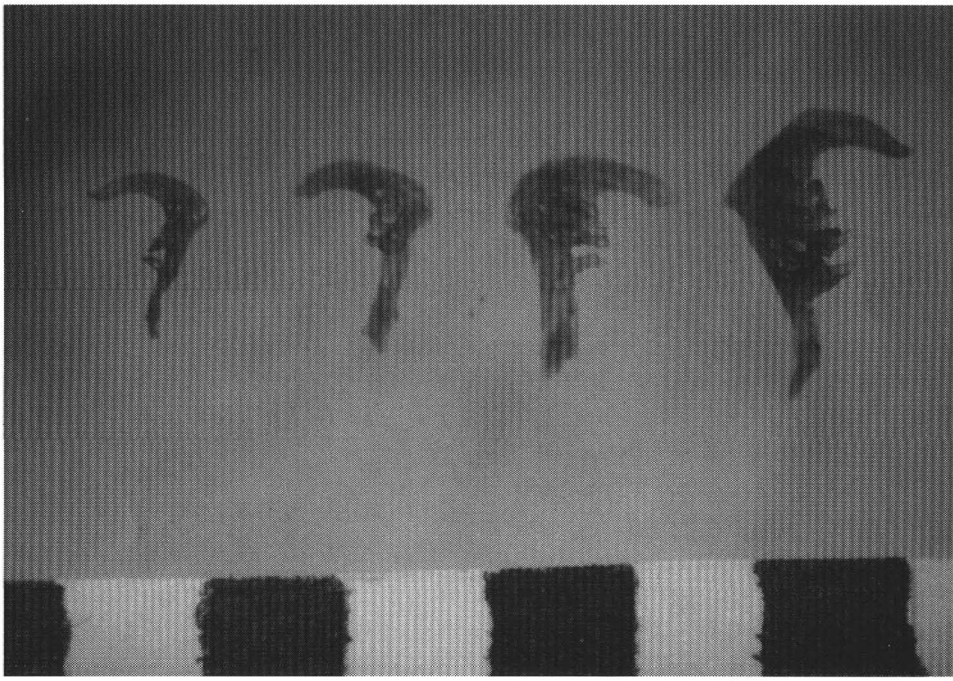


FIGURE 4. Comparison of Murrer's Meadow fish pharyngeal (on the left) to several from the Spirit Cave assemblage, (modern specimen measures 3.7 cm live length)

METHODS

Habitat Preferences

Habitat preferences of the taxa represented in the Spirit Cave and Peninsula Site assemblages are inferred from published descriptions (Moyle *et al.* 1991; Sigler and Sigler 1987; Moyle 1976), and from comparative specimens from the Murrer's Meadow collection. Relative sizes of fish found in the archaeological material were determined loosely by visual inspection. As such, comparisons of size are made by rough estimate. Future research will include the quantification of live captured fish sizes and specific element measurements to obtain more accurate results. Most of the Spirit Cave specimens represent fish sizes in the range of 3-7 cm live length.

Little variation was seen in the sizes of these bones. The Peninsula Site specimens represent fish sizes ranging from 10-30 cm live length, with more variation in bone sizes occurring in this assemblage.

Specific taxa present in the Spirit Cave material and the relatively small size of the elements identified suggest a shallow, moderately swift moving water environment possibly connected to a larger benthic system, at least intermittently (Sigler and Sigler 1987). Redsides and dace inhabit cool flowing streams, with rocky substrates primarily, but they also occur in large and small lakes, warm permanent and intermittent streams and outflows of desert springs (Moyle 1976). Tui-chub are found in most water regimes in the Great Basin, as are suckers. Based on this, a shallow water habitat may have existed around, or very near Spirit Cave (Figure 5).

FIGURE 5. Carson Lake, Nevada. This photograph may be a fair representation of the water habitat surrounding Spirit Cave 9,400 B.P.

The modern habitat preferences of the taxa found at the Peninsula Site and the larger size of the elements identified suggest the presence of a moderately large body of water with associated shorelines, some of which may have contained moderate marsh development (Sigler and Sigler 1987). Further evidence of a well-developed marsh at the time of site occupation is found in the house remains.

House matting from the large depression was constructed from large Poacea (grass) and Cyperaceae (sedge) type stem fragments, both of which are common marshland plants.

Taphonomy

Fish specimens from both Spirit Cave and the Peninsula Site samples also provide evidence of taphonomic trajectories that led to their preservation, recovery and thereby to the cultural behavior of the people who are responsible for the sites. In addition, decomposed fecal matter can be missed during excavation. Documenting the structure of fish assemblages that have passed through a human digestive tract provides a potential avenue for identifying fecal contents in the absence of well-formed boli.

Paleofecal contents represent discrete units in which post-burial depositional processes have minimally affected the original material, but subtractive forces may include mechanical damage due to mastication and gastrointestinal acids. These processes produce distinctive damage patterns on fish bone including pitting, warping, and fragmentation (Butler 1996). Crazing of the enamel on the pharyngeal teeth may also provide further evidence of digestive processing (Smith 1985). It was therefore expected that the paleofecal material from the Spirit Cave boli would contain more of the smaller bones, with warpage and breakage the result of mastication or digestion. Although charred fish bones were commonly encountered in the open-air archaeological assemblage, only three burned fish elements were noted in the Spirit Cave materials.

Taphonomically, the Peninsula Site fish assemblage should have experienced a different origin and history than that of the Spirit Cave material. The Spirit Cave samples contain ingested bone consumed at a specific point in time. The Peninsula Site assemblage represents an aggregate of behaviors resulting from human discard patterns. Expected subtractive forces in the Peninsula assemblage therefore include processing techniques spread over a period of time, trampling, diagenesis, and burning. Warpage and breakage, due to these processes, should be present. It was also expected that the recovery of small cranial bones from the open-air assemblage would be additionally reduced due to screen size.

To facilitate the Spirit Cave and Peninsula Site comparison, the numbers of identified specimens were tallied by element. Elements were then grouped according to fish-body regions recognized by ichthyologists (Wheeler and Jones 1989). These include the hyoid, neurocranium, branchiocranium, vertebral, and appendicular regions. An "other" category includes fin rays and ossified cartilage pieces. Rib counts were not included as part of this analysis due to problems estimating the number of identifiable specimens using extremely fragmented bone (Thomas and Mayer 1983). Frequency counts for each grouped set of elements were then transformed into percentages of the whole assemblage.

In the paleofecal material, 5.9 percent of the assemblage comes from the appendicular region, 16 percent from the hyoid region, 43.8 percent from the vertebral, 11.87 percent from the neurocranium, and 20 percent from the branchiocranium region (Figure 6).

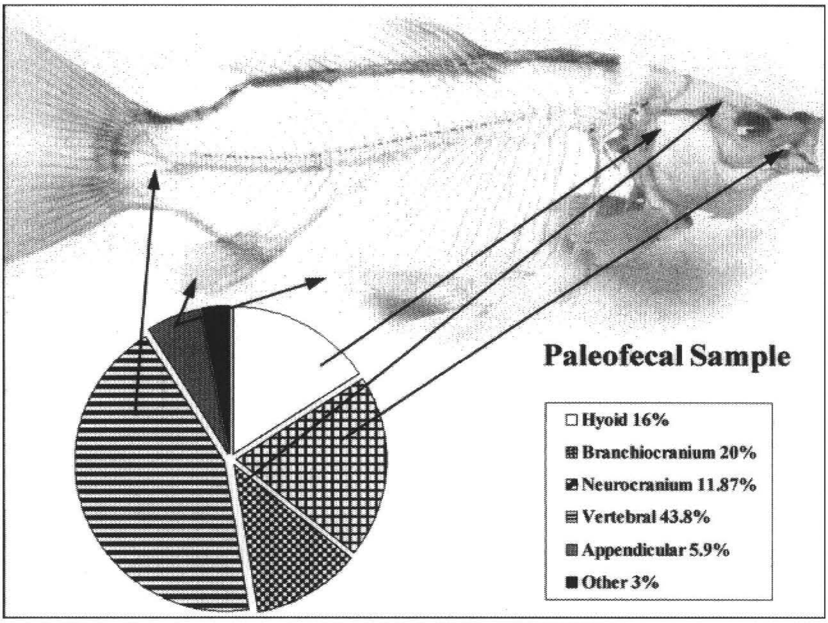


FIGURE 6. Bone survivorship percentage, Spirit Cave

This grouping shows that the percentages of mouth and vertebral bones are higher for the total assemblage. External, protruding bones such as those from the hyoid and neurocranium regions make up less of the assemblage. The positions of these bones externally on the fish body may make them more susceptible to the processes of digestion (including mastication and the action of gastrointestinal acids) that mechanically and chemically render bone unidentifiable. Internal bones may be better protected from these processes because of their shape, bone density, and tensile strength.

Only three burned fish elements were noted in the Spirit Cave material--one dentary, one rib, and one unidentifiable bone. The two identifiable burned bones are found externally in the fish skeleton, and if roasted, these external elements should be easily charred. Given the small number of charred bones, however, roasting was probably minimally applied to the Spirit Cave material. Instead, the small fishes may have been boiled or eaten raw.

In the 4,442 specimens identified to element in the Peninsula Site, 26.9 percent came from the appendicular region, 22 percent from the hyoid region, 17.2 percent from the vertebral region, 14.8 percent from the neurocranium, and 16 percent from the branchiocranium (Figure 7). The Peninsula Site yielded slightly more of the large, flat facial bones of the hyoid region, as well as more appendicular (fin girdle) bones when compared to the Spirit Cave material (applying Spearman's rank correlation coefficient shows a slight negative correlation of .3 with an associated probablility of .9, alpha = .05). These hyoid and appendicular areas include most of the external, or protruding bones of the fish.

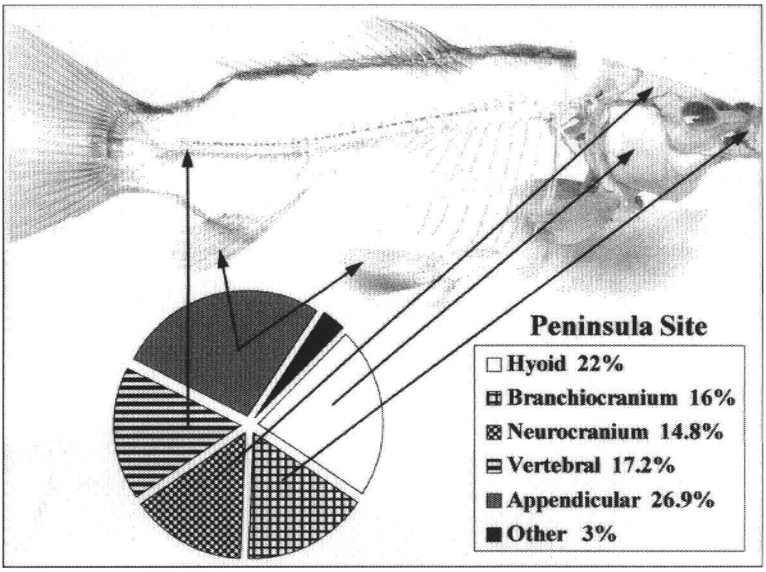


FIGURE 7. Bone survivorship percentages, the Peninsula Site

Fish bone derived from open-air and paleofecal samples experience different taphonomic histories related to their origins, preservtion, and recovery. Differential bone survivorship for the fecal material therefore includes a loss of identifiable external bones on the fish body possibly related to processes inherent in digestion. A more even recovery of fish body parts is seen with the open-air materials, but slightly fewer internal bones were identified.

Capture Strategies

Fish bone sizes varied between the two assemblages with larger elements coming from the open-air site. This difference is most likely the result of the hydrographic environments exploited (previously discussed) and capture strategies. Peninsula Site inhabitants probably exploited a larger benthic system with associated marshes, and the Spirit Cave individual probably drew from a smaller water system containing some moderately swift-moving currents. Likewise, the greater variety in fish sizes found at the Peninsula Site suggests these people used a variety of techniques to capture fish, but both sites show evidence of mass-capture strategies. This fishing strategy is noted ethnographically for several Great Basin groups (Fowler and Bath 1981; Fowler 1990, 1989; Evans 1990; Kelly 1932; Lindstrom 1992; Stewart 1941), and there also is indication that mass capture techniques may be more common than we think in the archaeological record (Greenspan and Raymond 1996; Raymond and Sobel 1990).

Variability in fish size is greater in the Peninsula Site assemblage than in the Spirit Cave materials. The majority of fishes represented at the Peninsula Site probably ranged from 10 to 15 centimeters in length, but approximately 20 percent of the assemblage contained larger fish ranging from 15 to 30 centimeters. This, in combination with the presence of possible net sinkers at the Peninsula Site, indicates that a variety of capture strategies were practiced there. Smaller fishes may have been captured using dipping or basketry trapping techniques, whereas larger fishes would have been more easily taken with net or spear technology. Most of the Spirit Cave specimens represent fish sizes ranging from 3 to 7 cm live length. There was less variability in fish element sizes, and the elements were consistently smaller. This indicates that they may have been mass-captured using finely woven basketry dip or net technology.

The fish captured from Murrer's Meadow were used to assess the effort needed to mass-capture small fishes using net and dip technology. To do this, a small dip net, constructed from a 6-by-4 foot nylon net with one-inch mesh, was strung between two 6-foot poles. Several solitary and paired-person techniques for capturing fish were attempted. These included team herding, single person dipping maneuvers, and a lie and wait strategy using a submerged net. All produced positive results. Within forty-five minutes of mock foraging, .562 kg, or eighty-two small fishes were recovered. The only limiting factor experienced was in selecting resource-rich pools.

The Murrer's Meadow fishing trip demonstrates that fish can be readily captured in a short period of time using dip technology. Diet breadth analyses such as those provided in foraging theory (Smith and Winterhalder 1992; Simms 1987) might initially predict that small minnows should not be taken by foragers because of low energetic returns, but when mass capture strategies and behavioral attributes of schooling populations are considered, net return rates probably do increase appreciably. Initial research by Raymond and Sobel (1990) and Lindstrom (1992) show dipping and netting to be very effective ways to acquire food with minimal effort (once a net is constructed), thereby increasing the economic ranking of small fish in the human diet at times when fish are schooling or otherwise concentrated.

Foraging technology and the division of labor is another source of variability attributable to cultural fish assemblages. As part of a recent analysis of Klamath basketry at the Phoebe Hearst Museum in Berkeley, Samuel Barrett's field notes on his turn-of-the-century ethnographic work with the Klamath Indians of central Oregon were reviewed for information related to fish mass capture practices. In these notes, Barrett refers to a twined, conical burden basket as a fish scoop used by women near the marshland tules where fish nets could not reach. Barrett's work shows that if the ethnographic record is used as a guide for archaeological research, the interpretation of small and large fish present in an archaeological assemblage should involve discussions of both prehistoric netting and dipping technologies. The two activities are, however, different strategies involving different costs and benefits for male and female foragers.

There also may be a relationship of fish size to capture strategy and technology not readily apparent in the archaeological record without more detailed work with fish bone (Ruth Greenspan, personal communication 1996). This type of relationship between size and capture or processing strategy could in fact account for some of the patterning in the Spirit Cave materials.

CONCLUSION

Comparing two culturally derived fish bone samples documents the range of variability in these collections that may be attributable to different paleoenvironments, capture strategies, and taphonomic histories. The Spirit Cave materials represent a set of discrete, well-preserved events involving an individual's final meals before death. The Peninsula Site assemblage represents an aggregation of activities relating to the consumption and disposal of fish remains through time. Although several studies have been conducted with the intent of finding ways to distinguish natural from cultural assemblages (Butler 1996, 1993; Greenspan and Raymond 1996, Stewart and Gifford-Gonzalez 1994; Wim Van Neer and Muniz 1992; Stewart 1991), considerably less attention has been given to documenting the range of variation between different types of culturally produced collections.

The Spirit Cave materials contain the remains of tui-chub, speckled dace or Lahontan redsides, and suckers. This indicates that the water regime surrounding the cave 9,400 years ago included some moderately swift and some benthic water habitats. The small size of the fish captured also implies that they were taken in a shallow water system, possibly with basketry or very fine net-mesh dip techniques. The Peninsula Site fishes included only two taxa, the tui-chub and sucker. The relatively larger sizes of many of these elements indicates that the area surrounding the site 700 to 400 years ago contained a relatively large body of water, although streams and marshes were probably also present. The variability in fish sizes found at the Peninsula Site indicates that several capture strategies were possibly used to obtain fish. The percentages of sucker bones in the assemblages were essentially the same, and this could be related to similarities in water environments or exploitation strategies.

The Spirit Cave material contains a higher number of internal bones relative to the Peninsula Site assemblage, which includes more of the external flat bones of the facial and pectoral region. There may be some sampling bias related to recovery techniques between the two sites, but this is thought to be a minor factor in accounting for differences in bone survivorship. A possible interpretation for the patterning therefore involves considering processes of mastication and digestion which served to render external fish bone unidentifiable in the Spirit Cave assemblage.

One limitation of paleofecal research involves the individual nature of data obtained. Organic contents represent food items ingested in specific seasons, and some of these may in addition have been stored foods. Seasonally specific data are likewise difficult to articulate with research into general patterns of prehistoric subsistence economies, but the first step in overcoming these limitations is to specify the season in which resources may have been harvested. To this end, future research with the Spirit Cave materials might include investigating the season of fish mortality.

Twenty-one otoliths were identified from the Spirit Cave material. Since otoliths contain annular rings that are commonly used to determine the season of death for wildlife fishes, the Spirit Cave otoliths could be used to determine season of death (but not the season of ingestion) for the Spirit Cave fishes. Determining the season of death for the Spirit Cave otoliths requires a representative sample of modern specimens captured in each of the four seasons (minimal samples should be taken at first to avoid unnecessary killing of fish). If modern otoliths of this small size yield discernable seasonal rings, then the fossil specimens could be considered for analysis.

Another avenue for future research involves taking bone measurements of the Murrer's Meadow comparative collection in order to determine the live lengths of fishes from the archaeological material. It is expected that information such as live length and size will refine paleoenvironmental interpretations and enable the reconstruction of prehistoric subsistence technology related to fishing.

Taphonomic interpretations presented here are based on a comparison between two types of cultural assemblages that show differences in bone survivorship possibly related to human capture and processing strategies. External bones were under-represented, and internal bones were over-represented in the paleofecal material. Fecal fish bone sizes were also much smaller than those from the open-air archaeological specimens, indicating a fine net or basket dip technique for fish capture.

The paleofecal material may represent the terminal meals of an individual unable to process food normally due to a maxillary abscess, thereby making the fish assemblage anomalous, or the contents of the paleofecal specimens may be indicative of common resource exploitation practices during the early Holocene. Although more data are needed to address this problem, it can be argued, with the data at hand, that the people who used Spirit Cave 9,400 years ago probably did, based on the taxa and size ranges of fish found in the paleofecal material, exploit a marshland or meandering stream environment. Fish also were probably mass captured and eaten with little preparation.

NOTES

[1] During the first phase of paleofecal research, several contributions to the field came from the Great Basin. Loud and Harrington (1929) reported on the analysis of fecal remains found in Lovelock Cave, Nevada, where they revealed a prehistoric diet of various wild seeds and plant fibers for the inhabitants of that cave. In the 1950s Sperry and Fonner (Jennings 1957) completed the first study of paleofecal matter to include hair and feather analysis. In 1967, the Seventieth Report of the University of California Archaeological Survey contained six articles on various aspects of Lovelock, Humboldt, Hidden, and several other dry caves in Pershing County, Nevada (Heizer 1967). Cowen contributed to this volume which can be characterized as a pioneering interdisciplinary effort to incorporate several aspects of paleofecal research, including pathogen analysis, fish identification, and macrobotanical identification.

[2] The term *coprolite* was first coined by W. Buckland (1829) to refer to lithified dinosaur feces from paleontological contexts. More recently, the term has been used to refer to both lithified material and to human feces or mummy intestinal contents preserved by desiccation (Heizer and Napton 1969). Although this latter usage of the term is common in much of the literature today, for the purposes of this paper, desiccated human feces deposited in archaeological contexts will be referred to as *paleofecal matter* or *fecal matter* to distinguish it from lithified, non-human material (after Yarnell 1969).

BIBLIOGRAPHY

Bedwell, S. F.
1973 *Fort Rock Basin: Prehistory and Environment.* University of Oregon Books, Eugene.

Buckland, W.
1829 On the Discovery of Coprolites, or Fossil Feces, in the Lias at Lyme Regis, and in Other Formations. *Geological Society of London, Transactions Series* 2(3), part 1:223-236.

Butler, V.
1993 Natural Versus Cultural Salmonid Remains: Origin of the Dalles Roadcut Bones, Columbia River, Oregon, U.S.A. *Journal of Archaeological Science* 20:1-24.

1996 Tui Chub Taphonomy and the Importance of Marsh Resources in the Western Great Basin of North America. *Journal of Archaeological Research* .

Evans, N. H.
1990 Traditions of Sucker Exploitation in the Pit River System: An Ajumawi Example. *Journal of California and Great Basin Anthropology* 12(1):48-59.

Follett, W. I.

1967 *Fish Remains from Coprolites and Midden Deposits at Lovelock Cave, Churchill County, Nevada.* University of California Archaeological Survey Report 70. University of California, Berkeley.

1970 *Fish Remains from Human Coprolites and Midden Deposits Obtained During 1968 and 1969 at Lovelock Cave, Churchill County, Nevada.* University of California Archaeological Research Facility Contributions 10. University of California, Berkeley.

1974 *Fish Remains from Site NV-Wa-197, Winnemucca Lake, Nevada.* University of California Archaeological Research Facility Contributions 21. University of California, Berkeley.

1977 *Fish Remains from Thea Heye Cave, NV-Wa-385, Washoe County, Nevada.* University of California Archaeological Research Facility Contributions 35. University of California, Berkeley.

1980 Fish Remains from the Karlo Site (CA-Las-7), Lassen County, California. *Journal of California and Great Basin Anthropology* 2(1):114-122

Fowler, C. S.

1990 *Tule Technology: Northern Paiute Uses of Marsh Resources in Western Nevada.* Smithsonian Folklife Studies 6. Smithsonian Institution Press, Washington, D. C.

1989 Willard Z. Park's Ethnographic Notes on the Northern Paiute of Western Nevada 1933-1944. Vol.1. In *University of Utah Anthropological Papers,* edited by C. S. Fowler. Vol. 114. Salt Lake City.

Fowler, C. S. and J. E. Bath

1981 Pyramid Lake Northern Paiute Fishing: The Ethnographic Record. *Journal of California and Great Basin Anthropology* 3(2):176-186.

Gasser, R. E.

1982 *The Specialists' Volume: Biocultural Analysis.* The Coronado Project Archaeological Investigation, No. 4. Museum of Northern Arizona Research Paper No. 23. Museum of Northern Arizona, Flagstaff.

Greenspan, R. L.
1996 Personal Communication.

1988 Fish Remains. In *Preliminary Investigations in Stillwater Marsh: Human Prehistory and Geoarchaeology*, Vol. 1, Cultural Resource Series Number 1 , edited by C. Raven and R. Elston, pp. 312-327U. U. S. Department of the Interior U.S. Fish and Wildlife Service Region 1, Portland, Oregon.

Greenspan, R. L. and A. W. Raymond
1996 Tui Chub Fishing at Harney Lake, Oregon. Paper presented at the Poster Session presented at the 25th Biennial Great Basin Anthropological Conference, Kings Beach, California.

Harshburger, J. W.
1896 The Purposes of Ethnobotany. *American Antiquity* 17:73-81.

Heizer, R. F.
1967 Papers on Great Basin Archaeology. *Reports of the University of California Archaeological Survey* No. 70. University of California Archaeological Research Facility, Department of Anthropology, Berkeley, California. April 1967.

Heizer, R. F., and A. D. Krieger
1956 The Archaeology of Humboldt Cave, Churchill County, Nevada. *University of California Publications in American Archaeology and Ethnology* 47(1). University of California Press, Berkeley.

Heizer, R. F. and L, K. Napton
1969 Biological and Cultural Evidence from Prehistoric Human Coprolites. *Science* 165:563-568.
1970 *Archaeology and the Prehistoric Great Basin Lacustrine Subsistence Regime as Seen from Lovelock Cave, Nevada*. Archaeological Research Facility Contributions 10. University of California, Berkeley.

Jennings, J. D.
1957 Danger Cave. *University of Utah Anthropological Papers* No. 27. University of Utah Press, Salt Lake City.

1964 The Desert West. In *Prehistoric Man in the New World*, pp. 149-174, edited by J. D. Jennings and E. Norbeck. University of Chicago Press.

Kelly, I.
1932 *Ethnography of the Surprise Valley Paiute.* University of California Publications in American Archaeology and Ethnology 31(1), Berkeley.

Lindstrom, S.
1992 *Great Basin Fisherfolk: Optimal Diet Breadth Modeling in the Truckee River Aboriginal Subsistence Fishery.* Ph. D. Dissertation, University of California.

Loud L. L. and M. R. Harrington
1929 *Lovelock Cave.* Publications in American Archaeology and Ethnology Vol. 25, No. 1. University of California, Berkeley.

Miksecek, C. H.
1987 Formation Processes of the Archaeobotanical Record. In *Advances in Archaeological Method and Theory*, Vol. 10, edited by M. B. Schiffer, pp. 211-247. Academic Press, New York.

Moore, M.
1995 *Analysis of Fauna from Sites in Warner Valley, Oregon.* M. A. Thesis, University of Nevada, Reno.

Moyle, P. B., T. Kennedy, D. Kuda, L. Martin, G. Grant
1991 Fishes of Bly Tunnel, Lassen County, California. *Great Basin Naturalist* 51(3):267-270.

1976 *Inland Fishes of California.* Berkeley. University of California Press, Berkeley, California.

Raymond, A. W. and E. Sobel
1990 The Use of Tui Chub as Food by Indians of the Western Great Basin. *Journal of California and Great Basin Anthropology* 12(1):2-18.

Reinhard K. J. and V. M. Bryant
1992 Coprolite Analysis: A Biological Perspective on Archaeology. In *Archaeological Method and Theory*, Volume 4 edited by M. B. Schiffer, pp. 245-288. The University of Arizona Press, Tucson and London.

Smith, E. A., B. Winterhalder (editors)
1992 *Evolutionary Ecology and Human Behavior.* Aldine de Gruyter, New York.

Sigler, W. F. and J. W. Sigler
1987 *Fishes of the Great Basin: A Natural History*. University of Nevada Press, Reno.

Simms, S. R.
1987 *Behavioral Ecology and Hunter-Gatherer Foraging: An Example from the Great Basin*. BAR International Series #381. Oxford, England.

Smith, G. R.
1985 Paleontology of Hidden Cave: Fish. In *The Archaeology of Hidden Cave, Nevada*, edited by D. H. Thomas, pp. 171-177. Anthropological Papers of the American Museum of Natural History. Vol. 61(1). American Museum of Natural History, New York City.

Sobolik, K. D., K. J. Gremillion, P. L. Whitten, and P. J. Watson
1996 Technical Note: Sex Determination of Prehistoric Human Paleofeces. *American Journal of Physical Anthropology* 101:283-290.

Stewart, K. M.
1991 Modern Fishbone Assemblages and Lake Turkana, Kenya: A Methodology to Aid in Recognition of Hominid Fish Utilization. *Journal of Archaeological Science* 18:579-603.

Stewart, K. M., and D. Gifford-Gonzalez
1994 An Ethnoarchaeological Contribution to Identifying Hominid Fish Processing Sites. *Journal of Archaeological Science* 21:237-248

Stewart, O. C.
1941 *Culture Element Distributions: XIV, Northern Paiute*. University of California Anthropological Records 4(3). University of California, Berkeley.

Thomas, D. H. and D. Mayer
1983 Behavioral Faunal Analysis of Selected Horizons. In *The Archaeology of Monitor Valley*, Vol 59:1, Anthropological Papers of the American Museum of Natural History, New York, edited by D. H. Thomas, pp. 353-390.

Van Neer, W. A., andA. M. Muniz
1992 "Fish Middens": Anthropogenic Accumulations of Fish Remains and Their Bearing on Archaeoichthyological Analysis. *Journal of Archaeological Science* 19:683-695.

Wheeler, A., and A. K. G. Jones
1989 *Fishes*. Cambridge Manuals in Archaeology. Cambridge University Press, Cambridge.

Yarnell, R. A.
1969 Contents of Human Paleofeces. In *The Prehistory of Salts Cave, Kentucky. Reports of Investigations* No. 16, edited by P. J. Watson, pp. 41-53. Illinois State Museum, Springfield.

Young, D. C.
1993 Section 2. Setting and Sites. In *Archaeological Investigations in Warner Valley, Oregon 1989-1992. An Interim Report* edited by D. D. Fowler, pp 3-32. University of Nevada, Reno, Department of Anthropology Technical Anthropology Reports 93-1.