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4 Ecofacts – Plant and Animal Analyses

4.1 Introduction

Wet sites, due to reduced oxygen, provide excellent preservation of both plant and animal remains. Due to the clear importance of Sunken Village as an acorn leaching and processing location – largely because of the aquifer streaming through this approximately 100–125 m of intertidal beach – the focus in Section 4 is on the leaching pits and acorn remains.

First we begin with a look at identifying the actual plant materials and fuels used at this site, requiring both visual observations of the plant remains and also cellular analysis of the wood, fibers and charcoal. Many of the perishable artifacts are introduced in this section while identifying their wood and fiber construction materials.

Second we report the abundant acorns and acorn leaching pit features, so numerous at Sunken Village.

Third, seed retrieval is explored, comparing the results of flotation techniques and fine wet screening.

And finally, the faunal analysis reflects the use of these animal resources in a secondary position, and probably to support the group while managing the acorn leaching pits from this site. The obvious contrast here to other Northwest Coast and Columbia River sites is the reduced focus on fisheries from this location.

4.2 Cellular Analysis of Artifact Plant Material and Charcoal

By Kathleen L. Hawes

4.2.1 Wood and Fiber Identification in Northwest Coast Wet Sites

The procedure of identifying wood and fiber materials by microscopic cellular analysis on the Northwest Coast of North America was pioneered in the 1970's by Dr. Janet Friedman, while conducting her research on the wealth of wooden artifacts from the Ozette Village wet site, Olympic Peninsula, Washington state, USA. Using information developed for the lumber industry, Dr. Friedman created a database of samples derived from the ethnobotany of the Ozette area, using this database for the basis of comparisons (Friedman 1978, 2005). The Ozette village had been partially covered by a landslide approximately 300 years ago, preserving normally perishable artifacts under anaerobic conditions, as well as plant materials such as sword fern, moss, berry seeds, and plant leaves (Gill 2005). The rich wood and fiber artifacts included basketry, wedges, fishing hooks, boxes, whale harpoons, ropes and cordage, arrow shafts as well as whole plank houses and furniture. The unique nature of Ozette and other wet sites on the Northwest Coast of North America has allowed plant material culture to be preserved and identified, adding a refreshing new understanding of the predominant ancient material culture and resources used by these ancient Peoples. The cellular identification of ancient plant material culture is complementary to information found in ethnobotanies, identifying traditional plant materials. Visual identification can be done on some plant materials, such as those made of western red-cedar (*Thuja plicata* Donn), which has a distinctive appearance; many times however features are obscured by silt and clay, long exposure to waterlogged conditions, and erosion.

4.2.2 Methods of Cellular Analysis

Cellular analysis of archaeological wood involves taking samples from three sections of a piece of wood (tangential, radial and cross-section), placing them on glass slides, and viewing these with a compound microscope. Differences between hardwoods and softwoods can be quickly identified by this method, and unique characteristics between softwoods can be observed in the rays, tracheids, and pit features (for more details about preparing the samples see Hawes in Croes *et al*. 2006, 2007a).

To identify plant material used in basketry and cordage, cellular analysis is used to determine if the material is woody tissue such as root or bough material; herbaceous dicot fibers; or monocot stem tissue.

4.2.3 Sunken Village Artifacts

Test excavations of the Sunken Village site in 2006 and 2007 yielded approximately 8600 artifacts (items that are the result of human activity, including abundant wood chips, split wood, charcoal, and basketry waste elements), of which approximately 80% were wood and fiber items. As examples, the wood and fiber artifacts recovered and examined by cellular analysis here include (a) an 'acorn' basket, (b) two wooden wedges, (c) branches lining an acorn leaching pit, (d) two *in situ* wooden stakes, (e) a carved wooden blade, (f) checker weave matting, and (g) a diamond-plaited soft bag.

4.2.3.1 The Acorn Basket

A beautiful basket, identified by master Warm Springs basket weaver Pat Gold as an acorn collecting basket, was recovered in 2006 in Transect V, Pit R (see Frontispiece and Ness *et al*., below).This basket is well-preserved with intact base and sides, carefully cross-warp twined. Ethnography of basketry of the Lower Chinook area includes references to spruce root (Ray 1938, 132–133; Silverstein 1990), hazelnut boughs mentioned by Bud Lane (personal communication, July 2006), and cedar bark and root (Pat Gold, personal communications, 2006; Gunther 1973, 19).

Cellular analysis was performed on a fragment of basketry debris, which was

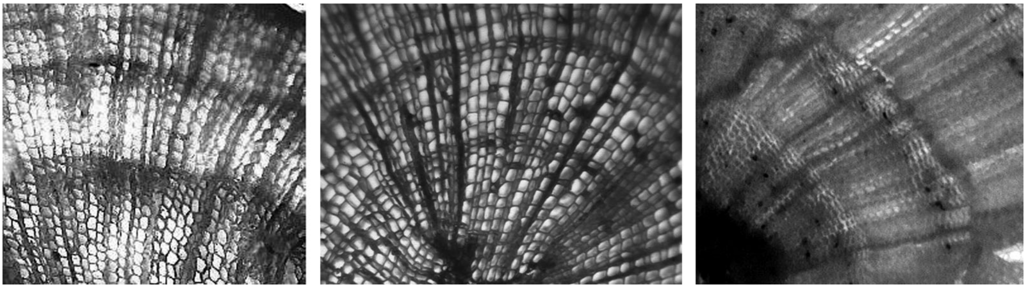

*Figure 4.1. (Left and center)Example of cross-section of acorn basket warp and a comparison of a modern example of a cross-section of Western red cedar (*Thuja plicata*) root. These both contrast to red cedar bough cross-sections (Right).*

identified as softwood, eliminating hazelnut (*Corylus spp)*, a hardwood. Samples were taken of modern western red cedar roots and boughs, and Sitka spruce (*Picea sitchensis* [Bong.] Carr) roots. Microscopic examination positively identified the sample as conifer, with further comparison between the cedar and spruce roots showing characteristics that match cedar roots. Red cedar root samples, even taken from different areas show a similarity in the pith, with a star pattern seen in the cross section; whereas the Sitka spruce root cross section shows an elliptical pattern. A cross-section analysis between red cedar roots and boughs shows differences in the cellular structure, with that of red cedar roots having larger cells and extremely narrow (1–2 cells thick) or absent growth rings. A cross-section view of red cedar bough shows a denser cellular structure, with a wider transition between earlywood and latewood growth. Cellular analysis of a cross section of the artifact basket matches that of western red cedar root (Figure 4.1).

4.2.3.2 Wooden Wedges

Two wooden wedges were excavated from the Sunken Village site in 2006. A full wedge from Transect VI, Test Unit 1, Trench 7 is complete with collar (Figure 4.2), and shows much use through pounding of the proximal end (Figure 4.3), and the point broken off at the distal end. A smaller wedge, discovered in Transect IV, Pit D, was broken lengthwise and lacks a collar; but also reveals adzing. Wedges of this type have been used for millennia, with wedges of similar types found in wet sites around the Pacific Northwest and spanning from (a) 9,450 years BP with a wooden wedge excavated from the Kilgii Gwaay site on the Queen Charlotte Islands (Fedje and Mathewes 2005) to (b) 31 wedges from the Hoko River site on the Olympic Peninsula from approximately 3,000 BP (Croes 1995), and (c) over 1,100 wedges recovered from Ozette dating to approximately 300 years BP (Gleeson 2005). Wooden wedges of this type are also included in the ethnography of the Lower Chinook/Cowlitz area (Gunther 1973; Stewart 1984). Wedges were used for splitting cedar planks, splitting out canoes, and for splitting firewood. The ethnobotany of this area indicates the most common woods used for wedges were crabapple (*Pyrus diversifolia*) (Ray 1938, 136; Gunther

Figure 4.2. Wooden wedge recovered – note fine adze faceting on body.

Figure 4.3 Wooden wedge, close up of rope collar to keep wedge from splitting while pounding – note the heavy wear from driving.

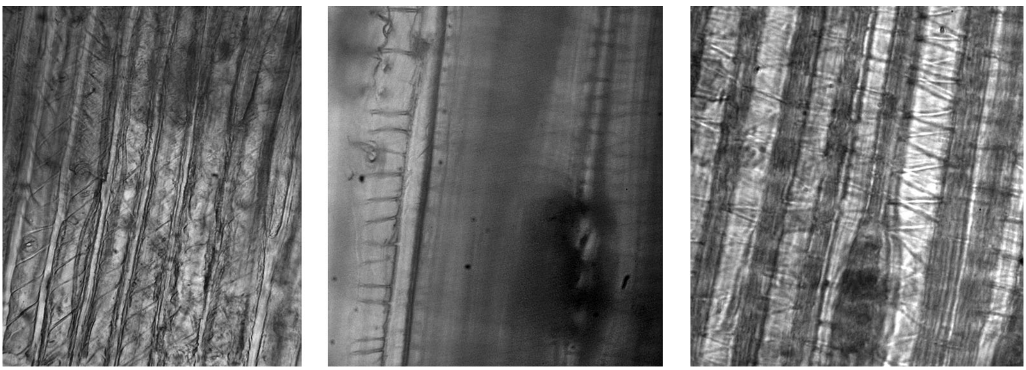

*Figure 4.4. Tangential section views of the wooden wedges from (left) Transect VI TU-1 Trench 7 and (center) Transect IV Pit D, showing the spiral thickening in the longitudal tracheids, a diagnostic feature of Pacific yew (*Taxus brevifolia*). (Right) identical example of modern Pacific yew.*

1973, 38; Silverstein 1990, 539), Pacific yew (*Taxus brevifolia* Nutt.) (Gunther 1973, 16), and western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) (Silverstein 1990, 539).

Examination of samples taken from the artifact wedges indicates a conifer species, which eliminates crabapple, a diffuse-porous hardwood. The samples also showed spiral thickening in the tracheids in both tangential and radial views. Pacific yew and Douglas-fir have characteristic spiral thickening in the tracheids, shown in tangential view; however the spiral thickening in Douglas-fir is closer together and at a very short angle. The spiral thickening in Pacific yew has a steeper angle. Douglas-fir also commonly has longitudal and tangential resin canals, which is lacking in Pacific yew. Western hemlock was also analyzed but lacked the characteristic spiral thickening in the tracheids. The angle of spiral thickening in the tracheids, lack of resin canals and modern wood sample comparison identifies both wedges as Pacific yew (Figure 4.4). The collar of the full wedge also indicates a conifer species, with characteristics of red cedar root or bough. In this case, the diameter of the wood used for the collar would indicate the wood as red cedar bough; and a microscopic comparison between cedar root and bough show the cellular structure to most closely resemble red cedar bough (see Figure 4.1).

4.2.3.3 Acorn Leaching Pit Lining Material

Plant lining material was removed from Transect IV Pit G including small twigs (less than 1cm diameter) lining the pit feature, found with needles still attached and identifiable as a conifer species. This feature also contained acorns, and was used for leaching and storage of acorns (Figure 4.5; Mathews 2006, below). The needles were short, generally between ½ and ¾ an inch in length, in double ranked rows along the branchlets, and detached very easily leaving small woody pegs. Several larger branches (1–1.5 cm diameter) were collected from Transect VI, Pit P for use in C-14 dating, and also were used for cellular analysis. Ethnographic information on the lining of these pit features is lacking, so comparisons were made among species of conifers which fit these observations, with the most likely being western hemlock, Grand fir (*Abies grandis* [Dougl.] Lindl.), and Pacific yew; all of which have needle attachments resulting in double ranked rows along the branchlets. Viewed with a dissecting microscope the attachment of the needles to the twigs, needle size and shape, and the alternating alignment of the branches identified the plant material as western hemlock. Examined with higher magnification, the cellular structure also was identifiable as western hemlock.

4.2.3.4 Wooden Stake Features

34 stake features were identified in 2006 within Transects III–VII, most near or within the pit features (usually the south side of the pit as a re-location marker; see example Figure 4.5); two were excavated for analysis and identification in 2006. Stake A, Transect V (7.3 cm diameter) still has bark covering the area which had been beneath the surface of the beach. The bark is smooth with resin blisters visible, a characteristic of young noble fir (*Abies*) species (Pojar and MacKinnon 1994). Stake A from Transect VI is smaller (5.7 cm diameter) and has no bark remaining. Both have adzing on the distal ends.

Cellular analysis of Stake A T-V revealed the absence of resin canals in both cross-and tangential section views. Ray parenchyma cells contained dark reddish contents, with

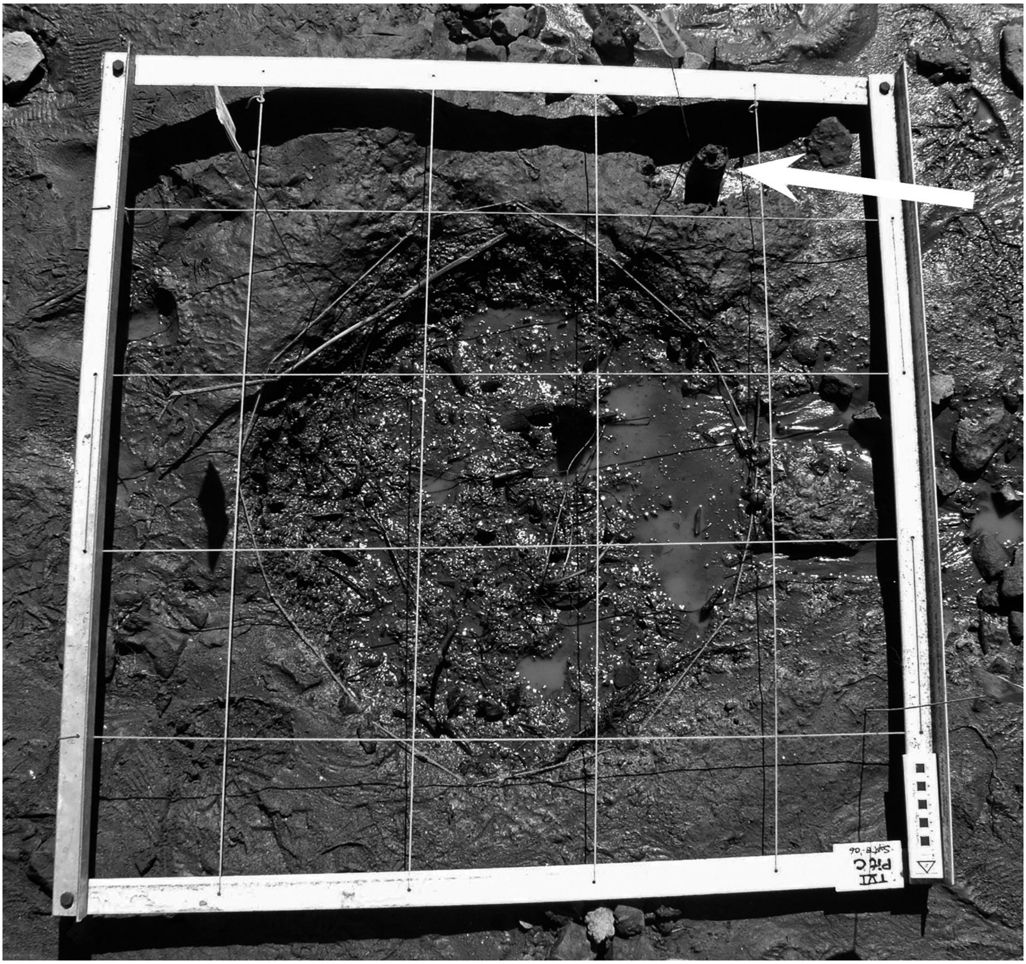

Figure 4.5. Example of acorn leaching pit (Transect VI, Pit C) with branch lining and a wooden stake at the south end of the pit (arrow).

the end walls nodular, and cross-field pitting small and taxodioid. These characteristics, as well as the visual identification of the bark, identify this stake as noble fir (*Abies procera*).

A sample from Stake A, Transect VI revealed resin canals in both cross-and tangential section views. The latewood cells are thickwalled, with a gradual transition from earlywood. The longitudal tracheids contain 1 row of bordered pits, with no spiral thickening apparent in the tangential section view; a radial section view shows cross-field pitting small and piceoid, and non-dentate ray tracheids. These features identify the smaller stake as spruce, most likely Sitka spruce (*Picea sitchensis*). This tree is more commonly found in the coastal areas.

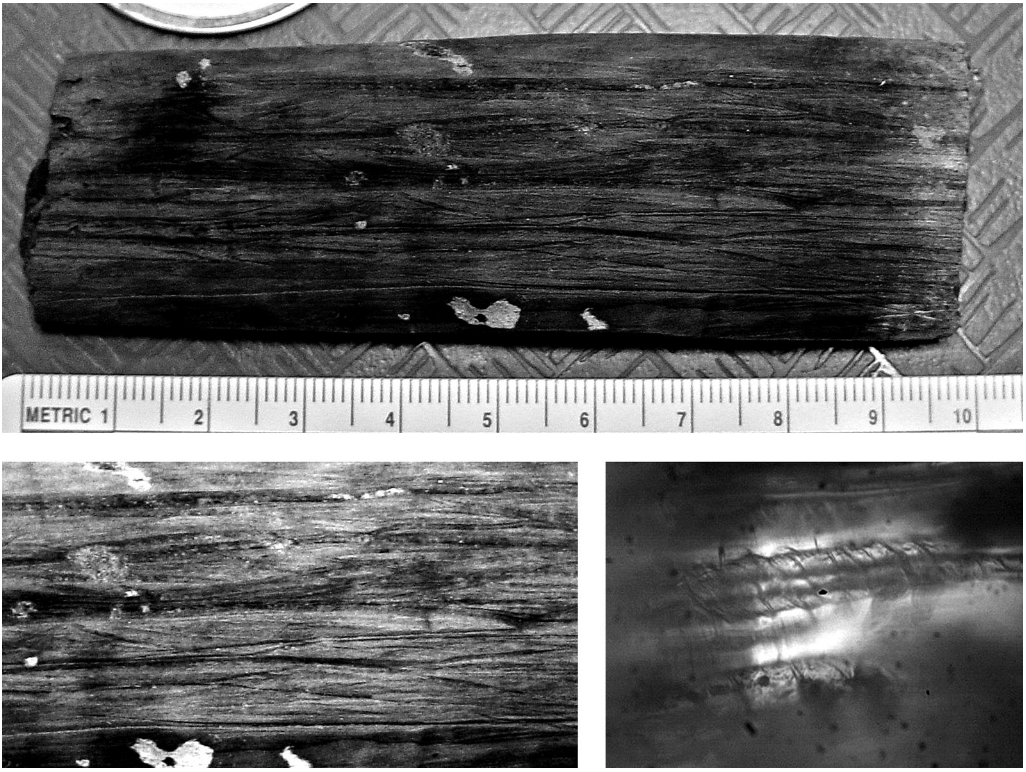

Figure 4.6. (Top) carved wooden blade fragment; (Bottom Left) close up view of incising on wooden blade; (Bottom Right) spiral thickening in tracheids identifying artifact as Pacific yew.

4.2.3.5 Carved Wooden Blade Section

A section of a carved wooden blade was recovered from Transect III, Pit A; and originally identified as a possible rib bone (Figure 4.6). This section is 9.9 cm long, with a lenticular shape in cross section, and reveals fine incised lines on one side. The wood is very hard, which explains the original misidentification as bone. Cellular analysis revealed this artifact carved from Pacific yew.

4.2.3.6 Woven Checker Matting

Several fragments of checker weave were recovered from Transects III, V, and VI. These were visually identified as Western red cedar bark, which has a characteristic appearance (Figure 4.7). Microscopic examination and comparison of modern cedar bark samples confirm the identification of cedar bark.

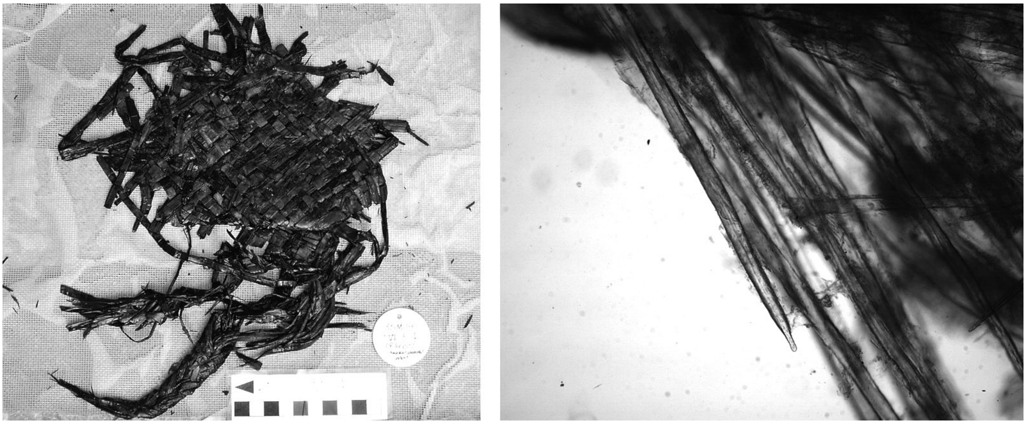

Figure 4.7. (left)Western red cedar bark checker-weave basketry (Transect VI, Pit D). (right) Sample of modern cedar bark.

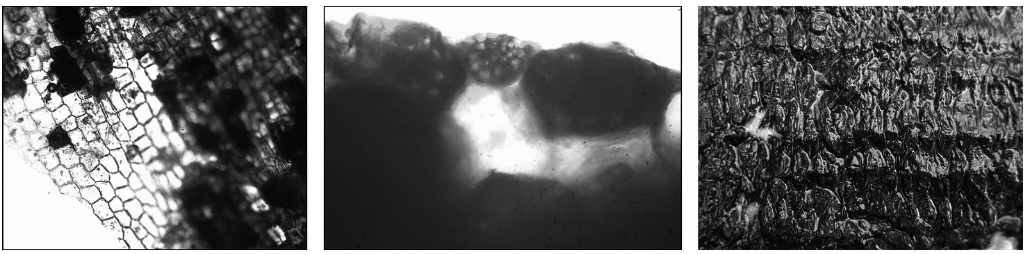

Figure 4.8. Tangential section view (left) and cross-section view (center) of soft weave fragment. (Right) Close-up of soft diamond plaiting weave.

4.2.3.7 Diamond-Plaited Soft Bag

The diamond-plaited soft weave fragment recovered from Transect VI, Pit G is a very unique specimen (Figure 4.8) (See Ness, below). Initial analysis indicated that the weave was not likely constructed from Western red cedar bark, and this was confirmed microscopically. The surface is very worn and impregnated with silt, which interferes with microscopic examination. A cross section view revealed characteristics of monocot fibers, with vascular bundles and epidermal cells visible. Cells with tannins were observed in the tangential view, which are characteristic of *Scirpus* species. Comparisons were made between modern samples of tule (*Scirpus acutus)* and sweetgrass (*Scirpus americanus)*, with similarities between both species observed. Cell arrangement was also difficult due to crushing of the plant material, but size differences between vascular bundles and schlerenchyma cells appear to be similar to sweetgrass.

4.2.4 Charcoal

4.2.4.1 Introduction

Charcoal is one of the most common plant material recovered archaeologically, yet it often remains unanalyzed. Defined as the charred remains of a plant's woody structures, predominately from trees and shrubs, charcoal is frequently used for radiocarbon dating; but can also provide evidence of selection and use of wood at a site, and of ancient vegetation and environment (Smart and Hoffman 1988).

The use of particular wood types as fuel can depend on physical characteristics, such as heat content and quantity of smoke produced during burning. The form of wood is also considered in choosing firewood. Fuelwood collectors today generally prefer fallen trees and dead branchwood; this affects the taxa selected, as some trees are more likely to drop their branches than others (Smart and Hoffman 1988). Cultural values can affect the choice of wood for fuel. In a Straits Salish story of the Saanich People, arbutus (*Arbutus menziesii*) was the tree used by the survivors of the Great Flood (a tradition common to almost all Northwest Coast Peoples) to anchor their canoes to the top of Mount Newton. To this day, the Saanich People do not burn arbutus in their stoves, because of the important service this tree provided long ago (Pojar and McKinnon 2004).

Charcoal from Sunken Village had been used in radiocarbon dating of the site, and currently is being examined microscopically to identify the types of wood that have used for possible cultural fires. The results of this cellular analysis has been compared to the stratigraphic sampling and profiling of cultural layers in Test Unit 4, to correlate these charcoal samples to specific *in situ* vegetal mats that were laid down at different times on this river point bar beach deposit (see Punke, above, Figures 3.13, 3.15).

4.2.4.2 Methods of cellular analysis

The same methods are used to identify charcoal larger than a thumbnail as for wood analysis, using the same planes of orientation (see above); however, due to its brittle nature charcoal is broken into the proper orientations rather than cut. Charcoal has reflective surfaces, which means a standard microscope using direct light sources generally creates too much contrast to view cells, so a metallurgical microscope is used to produce imaging of cellular structure (Figure 4.9). This has a light source that is transmitted directly down onto the sample through the objectives, and then retransmitted from the sample back through the objectives, eliminating reflection (Lepofsky 2007).

4.2.4.3 Test Unit 4 Charcoal Cellular Analysis

Over 1700 pieces of charcoal were recovered from Test Unit 4, which was excavated to the 50 cm level in 2006. A 5% sample (n=85) was taken from each 10 cm arbitrary level and examined microscopically. This method was used for the sake of time, with further research planned to complete the appropriate sample size for taxa diversity. In this preliminary study, the majority of charcoal was identified as *Quercus* species, most likely Oregon white oak, also commonly know as Garry oak (*Quercus garryana,* the only native

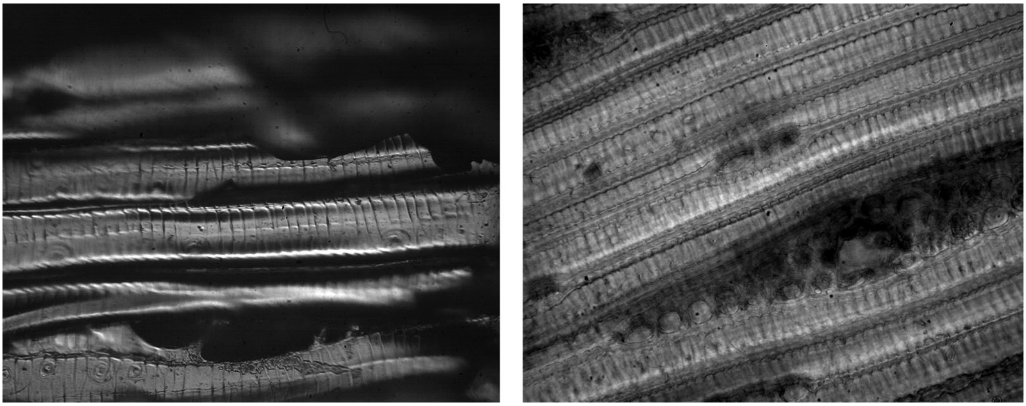

*Figure 4.9. Example of cellular structure of Douglas-fir (*Pseudotsuga menziesii*) identified in archaeological charcoal from 35MU4 (Left) compared with the cellular structure of archaeological uncharred wood (Right),both revealing spiral thickening and resin canals.*

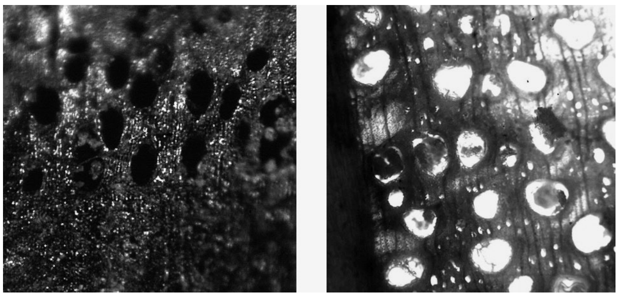

*Figure 4.10. Archaeological sample of Oregon white oak (*Quercus garryana*) charcoal (Left) and modern uncharred sample from Sauvie Island (Right).*

oak in this region), which grows in abundance on Sauvie Island; with Douglas-fir the second most common species found (*Pseudotsuga menziesii*) (Figure 4.10, Table 4.1).

A litho-stratigraphic analysis of Test Unit (TU) 4 is defined by Dr. Punke with seven stratigraphic units (SU 1–7) analyzed (See Table 3.2, and Figure 3.9). A preliminary analysis of collected charcoal fragments (larger than a thumbnail) collected will be related to these SUs in order to explore areas of potential and concentrated cultural activity (Table 4.2).

The majority of charcoal fragments recovered were from the 20–30 cm level, which corresponds to Stratigraphic Unit 4 (SU-4) contained many fragments of wood up to ~3 cm in length (see Appendix F. Table 1. Website: http//www.library.spscc.ctc.edu/crm/JWA9.pdf); the matrix contains approximately 15% organic matter and humified organics; thin layers (~1 cm) of iron oxide stained sands (dark yellowish brown 10YR4/4) and iron reduced sands (grayish brown 10YR5/2) throughout; and shellfish fragments.

LEVELS (cm)	***Quercus garryana***	***Alnus rubra***	***Pseudotsuga menziesii***	***Thuja plicata***	***Prunus spp***	***Acer spp***	***Salix spp***
0–10	1		2				
10–20	12	4	2	1	1	1	
20–30	19	8	6		5	2	
30–40	4	3	5		1		1
40–50	3		3		1		
TOTALS	39	15	18	1	8	3	1

Table 4.1. Wood species identified in charcoal by TU-4 levels.

Stratigraphic Unit	**Corresponding Level**	**Total charcoal fragments**	**5% samples analyzed**
1	0–10 cm	56	3
2	10–20 cm	418	21
4	20–30 cm	808	40
3, 5	30–40 cm	287	14
6, 7	40–50 cm	142	7

Table 4.2. Number of charcoal fragments per stratigraphic Units in Test Unit (TU) 4.

The second highest number of charcoal fragments was found in SU-2 (10–20 cm), which had a very low organic content (see Punke, Table 3.2, above).

287 charcoal fragments were recovered from the 30–40 cm level, which included SU-3 and 5. SU-3 contained an organic content of~50%, with plentiful wood fragments up to 3.0 cm in length (see Appendix F, Table 1, Website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf); whereas SU-5 had markedly less organic content. SU-6, 7 were from the 40–50 cm level, with 142 fragments of charcoal. SU-6 had a very low organic content; SU-7 however had a high proportion of humified organics and wood debris (~90%) (see Punke, Table 3.2, above).

4.2.5. Summary and Conclusions

The results of cellular analysis of artifacts and pit features made of wood, fiber and charcoal confirm many ethnobotanical and traditional uses of wood products of this area. Continuing research is also being done on the woodchips, split wood, and wooden wedge fragments recovered in 2006 and 2007 from the Sunken Village site to help identify materials used in woodworking (see below). With further excavation of the Sunken Village site and analysis of wood and fiber plant material, a greater knowledge and understanding of the technology of ancient Native People of Sauvie Island can be used to add to the history of this area. Continued archaeological research should be considered for this site, as more artifacts are likely to be found. In Test Unit 4, Transect VI, excavation was halted at the 50 cm level, and from 2007 coring clearly vegetal mat horizons continue for at least another 3 m.

The preliminary results of analysis of the charcoal in the TU-4 stratigraphic units reveals an abundance of Oregon white oak as fuel wood in the assemblage. Oaks form the genus *Quercus* of the beech family, Fagaceae. Oregon white oak (*Q. garryana*) is a member of the white oak subgenera, producing acorns that were processed in over 100 acorn leaching pits recorded at the site, carefully lined with western hemlock boughs and still containing acorns. This species of oak is seldom self-pruning; therefore it is possible that branches were being deliberately removed, either primarily as firewood, to access acorns, or to encourage acorn growth by pruning unnecessary limbs that compete for nutrients. Further research is planned to complete the appropriate sample size for taxa diversity.

4.3 Acorns and the Acorn-Leaching Pits

By Bethany Mathews

4.3.1 Introduction

During limited excavation in 2006 and mapping in 2007 approximately 100 pit features were recorded in a 125–meter section of the Multnomah Channel slough on Sauvie Island (see Figures 3.2–3.3). At the surface and after clearing a layer of silt, these remnant features contained wood, lithic, bone, and botanical artifacts, of which only acorns and hemlock branches and twigs (with needles) are found in every pit feature and are believed to be the liner and primary contents of these leaching pits. Charcoal is also found in all of these features, but because charcoal is found throughout the site it cannot be exclusively associated with the features, though ash would have served a practical purpose in acorn tannin leaching. Beyond examining the surface of the pits at 35MU4, one pit feature (Pit P, Transect VI) was excavated in 2006 so that a profile could be studied (see Punke, above). These acorns and pit features on Sauvie Island are evidence of a plant resource that has been previously underestimated in its importance to the ancient Northwest Coast of North America.

4.3.2 Defining the Sunken Village Site Acorn-Leaching Pits

The approximately one hundred pits recorded at 35MU4 were identified on the surface, sometimes because of the presence of acorns, but the more obvious marker of the leaching pits at the surface is a circle of branches protruding from the beach (Figures 4.11 and 4.12). Fire-cracked rock, found throughout the surface of the slough, tends to settle on pit depressions and was also used as an indicator, though circular formations of fire-cracked rock proved to be misleading at times. Associated with the pits were over forty wooden stakes, which may have served as markers for the pits on the beach surface. These stakes may have marked groups of pits, either for identification on the slough after silting, or for ownership purposes (see Figures 4.5 and 4.11).

Figure 4.11. (left) Branches protruding from edges of an acorn-leaching pit (right) A well-preserved wooden stake, possibly a marker stake for an acorn-leaching pit.

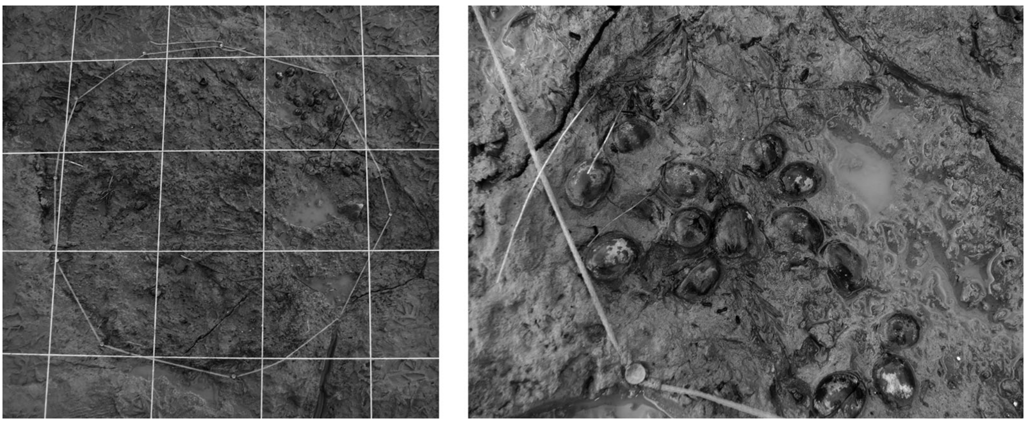

Figure 4.12. (left) Example of acorn leaching pit surface (Pit A, Transect IV); (right) acorns from upper right corner of the pit). Also notice hemlock needles showing as liner.

4.3.3 Acorns

Acorns are the most abundant botanical artifact associated with the pit features, and were identified as those of *Quercus garryana*, commonly called Oregon white oak (Young and Young 1992, 290; Figure 4.12). For comparison, some contemporary acorns were collected from trees growing on Sauvie Island, which were identified by leaf as the Oregon white, also known as Garry oak (*Quercus garryana*) (Pojar and MacKinnon 1994, 50). Girth measurements of a few large trees about a mile from the site estimate that the oak population has been there for at least 700 years (personal observation). The Oregon white oak is the dominant oak type in the Pacific Northwest oak woodlands north of San Francisco, California, USA along the coast of the northwestern United States and British Columbia, Canada (Agee 1993, 352). A small sample of acorn shells from the leaching pits on Sauvie Island was sent to Dr. Yang at Simon Fraser University for DNA testing. Researchers in the archaeology department at Simon Fraser will use these samples in a study on genetic similarities of *Quercus garryana*, which may have migrated north to the Fraser River in British Columbia through human transport (Dana Lepofsky, personal communication, 2008).

Acorns at Sunken Village were found complete, or in fragmented parts of the shell, nut, and occasionally cap. Though a large percent of the acorns were only found in fragments (73%), the fragments generally represent all parts of the acorn with the exception of the cap. Many acorns are whole (with the nut inside the shell) which means they were being left in these pits on the beach for later use instead of immediate consumption, unlike the numerous hazelnut fragments (see Mathews, below). Acorn caps, with three exceptions, were not found in the pits. Although they would have preserved as well or better than the thinner acorn shell in the archaeological record, acorns with caps attached probably would not have been collected, as these would be infested and are known to fall from the tree not because of ripeness but from insect movement.

A small portion of the acorn fragments are found completely charred, while most fragments and whole acorns show some mottled marks that appear to be the result of heat, but might also result in part from the leaching process. Heating could have killed any insects that might further infest the store. It might have aided in the removal of tannins and flavoring of the nuts. Experiments have shown that cracking or splitting the shells would speed up the leaching process considerably (personal observation), and this could have been accomplished through heating. Though removing tannins is not necessary when eating acorns in small servings, unleached acorns are unpleasantly bitter and consuming too much tannin can make a person ill. Heating would also prevent the acorns from germinating during the storage period as white oaks have a very quick germination period (Stein 1990, 657).

While being prepared for conservation in the South Puget Sound Community College laboratory, the acorns were measured for length, width and thickness so that a minimum number of individuals might later be determined (example in Appendix D:212, website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf). These measurements were used to find the average acorn size, which was used to estimate how many acorns might have been stored in the pits at 35MU4.

4.3.4 Western Hemlock

Twigs protruding from the ground often mark a pit in a circular pattern on the surface, and the pits were lined from the sides to the base of the pit. Many of the twigs and branches, especially those at lower, less disturbed levels, still have their needles attached. Branches lining the bottom of Pit P (Transect VI) were radiocarbon dated at 1760 to 1880 CE (130 ± 60 BP) (Figure 4.13; and see Figure 3.4). The intact needles made it possible to identify the species, but wood cells identification confirmed the species was western

Figure 4.13. (left) In situ hemlock branches and needles near base of a pit, after silt cap has been washed away. Acorns and hazelnuts can be seen in this photo. (right) Base of north half of Pit P with hemlock bough lining exposed. The lining was C14 dated to 1760 to 1880 CE (130 ± 60 BP), indicating the last time this acorn leaching pit was used.

hemlock (*Tsuga heterophylla*) (Hawes 2007, above), which grows along the coastal areas of Oregon, Washington and British Columbia (Pojar and MacKinnon 1994, 30). Looking at modern western hemlock, it seems likely that this type of branch was selected over other conifers because of its thick coverage. Western hemlock boughs are flat and full, making very good cover while still allowing water to pass through easily, where other native branch types might require several layers to separate the acorns from the surrounding matrix. This would have been necessary for removal of the acorns from the pits, making the process less labor-intense for removal and cleaning after leaching. Hemlock was also considered an edible plant by many tribes of the Pacific Northwest, which might have led to it being chosen over other conifers (Moerman 2002, 571).

4.3.5 Charcoal

Charcoal is found throughout the site and at every level of excavation in pit features. Over 5000 thumbnail-sized or larger pieces were collected from 35MU4, with 2500 coming from the half-excavated Pit P. Though the charcoal could be remnants of cooking or wood burning done at or near the site, ash and charcoal are frequently used in leaching processes in California (Gifford 1936, 301). Ash is used to speed up the active leaching process, and adding ash and charcoal to the pits would ensure that the acorns were sweetened by the time they needed to be removed from the pits.

4.3.6 Pit Construction

Pits generally take on a circular shape at the surface, with diameters smaller than a meter. While only a few pits were tested, the depth of a well-preserved pit (Pit P, Transect VI) was 55 centimeters below the modern surface. Many pits were badly eroded with only a few centimeters of depth remaining. The acorn-leaching pits are concentrated in a 125–meter section of the slough (within Transects III–VI, Figures 3.2–3.4c), where aquifers under the natural levee would have moved water through the buried acorns (see Figure 6.7). The rising water of the Multnomah Channel would have covered the sealed pits after harvest in the fall until early spring (Diedrich 2007a, and Figures 2.4 and 2.5). This compares well with ethnographic reports of acorns leaching for several months after harvest.

4.3.7 Pacific Northwest Balanophagy

Oregon white oaks grow along the west coast from northeastern Vancouver Island in Canada, down to San Francisco, California, and extends at its eastern-most point to the Warm Springs area in Oregon (Peter and Harrington 2002, 189). Balanophagy, 'the eating of acorns', is rarely mentioned in ethnographic and historic accounts of the Northwest, and is even more rarely mentioned in archaeological site reports in the region. However, California is well-known for its acorn-dependent cultures. The typical process of preparing acorns in California, as followed by the Miwok/Pauite tradition in Yosemite, involves gathering, drying, shelling, winnowing, and pounding the acorns into flour, followed by actively leaching the acorn flour with water to remove tannins, sweetening the acorn flour (Ortiz 1991). Acorn flour was then frequently prepared as cakes, breads and porridges (Moerman 2002, 461). Though southern California leaching methods are always described as an active process, passive leaching has been recorded in northern California, where the white oak is the dominant oak type. For instance, the Wintu of northwest California leached acorns in swampy grounds through the winter, then removed them in the spring and prepared them by boiling or roasting. Paiute also buried acorns in mud in the fall to 'ripen' (Moerman 2002, 459). A passive leaching pit site north of San Francisco, dated to between 3370 and 4450 BP, suggests that passive leaching was a technique used in central California before active leaching techniques were widely adopted around 3000 years ago (Eric Wohlgemuth, personal communication 2008).

In the Pacific Northwest the methods of preparation range from eating the nut raw or roasted as the hazelnut is eaten, to various methods of leaching and preparing. Klallam ate acorns with no preparation (Gunther 1973, 28). The Snohomish and Suquamish (possibly Duwamish) set up camp on the Nisqually valley from August to October to gather acorns and berries, as did people from as far away as the Strait of Juan de Fuca (Norton 1979, 187). The Nisqually and Coastal Salish ate unleached preparations of acorn, while the Chehalis (Moerman 2002, 461) and Cowlitz are known to have used passive leaching methods to sweeten their acorns (Gunther 1973, 28). Erna Gunther recorded that Squaxin roasted acorns on hot rocks before consuming them (Gunther 1973, 28). Acorn shell fragments have been found at Qwu?wes (45TN240), a Squaxin archaeological site on Mud Bay near Olympia, in quantities that greatly outnumber hazelnuts, which are frequently mentioned in ethnographic information for the region (Bethany Mathews, personal observations 2007).

Further south, Lewis and Clark recorded people on the Columbia eating acorns raw and roasted. These people, who were probably the Wishram, said they acquired the acorns from people living near the falls (DeVoto 1997, 259). Acorns were used as a trade item by the mid-Chinook tribes, and the Wascopam of The Dalles are known to have baked acorns in the earth with hot rocks, and then leached them in pits dug near water through the winter. In the spring women were seen on a stream bank, removing acorns from the water. Their acorns were eaten with dried or pounded salmon (Aguilar 2005, 77–78).

In 1847 Paul Kane, an artist and explorer, recorded acorns being prepared as a delicacy by Chinook, in a way that was "a peculiarly characteristic trait of the Chinook Indian... confined solely to this tribe." According to Kane the preparation, called 'Chinook olives' by European explorers, was made by digging a hole in the ground close to the entrance of a home, filling it with a bushel of acorns, then covering the hole with grass and dirt, and depositing urine in the hole for four to five months. Kane writes that the Chinook considered these acorns "the greatest of all delicacies" (Harper 1971, 94). From discussions with California archaeologist Wendy Pierce, who is familiar with passive acorn leaching in California, it is believed that this would not have been a very effective way to leach tannins (personal communication 2006). If urine was used to process acorns, it is possible it was not the full method of preparation by the Chinook.

From the Wasco and Chinook also come the stories of Little Raccoon and his grandmother. This story about a greedy young raccoon describes five pits of acorns being stored by his grandmother for the winter. In the Chinook version of the story, grandmother stores her acorns in swampy ground, which suggests that passive leaching methods were used by the Chinook. Little Raccoon is tired of eating wapato, jerky and dried fish-eyes, so he sneaks acorns from the acorn pits, and in both versions of the story proceeds to get himself into one life-altering predicament after the next. (Hunn 1990, 186–187, Ray 1938, 148–151). This story of Little Raccoon and the acorns not only adds strength to ethnographic reports on acorn use by the Chinook and surrounding tribes, but implies that acorns were an important and desirable winter food.

The memory of passive leaching is alive in northwest tribes today. The Siletz of western Oregon call acorns that are leached in stream banks for several months to a year 'tus-xa', and acorns are still gathered, stored and eaten by people living there (Bud Lane, personal communications 2007). Observations of passive leaching methods in the Northwest at contact and ethnographic descriptions are fairly wide-spread, though rare. Future understanding of the extent and antiquity of these passive leaching features might explain whether there was a migration of the idea through the northwest to California or vice versa, where the same species of oak is found.

4.3.8 Population Estimate

An estimate of the possible human population supported by the acorn-leaching pits on Sauvie Island was made by determining the size of the individual pits, how many

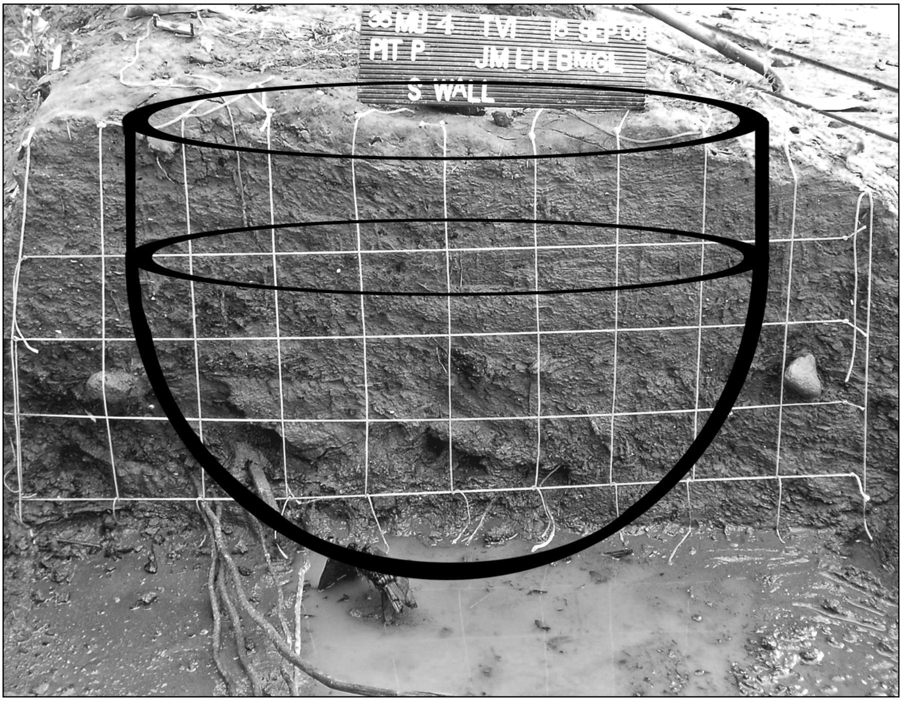

Figure 4.14. The volume of the leaching pits was calculated using Pit P in Transect VI as a model (grid 10 cm sq). Note the hemlock bough lining near base and rocks to either side of outer edges, which help to define the pit boundaries.

acorns they might store, and how many people could be fed by the estimated total of acorns present. Estimates were then compared to historical statistics on populations living near the site of the leaching pits, and to California ethnographic information on populations that relied on acorns as a staple food.

4.3.9 Acorn-Leaching Pit Volume

The volume of the leaching pits was calculated using Pit P in Transect VI as a model (see Figure 3.4c for location). Pit P was a well-preserved pit and is probably representative of the size of the ancient leaching pits (Figures 4.13 and 4.14). This feature was first measured at the surface, and then a one meter by one-half meter unit was excavated so that a profile of the pit could be seen. The general shape of the pit can be described as a half-sphere at the bottom, with a cylinder extending the pit to the surface (Figure 4.14). A formula for the volume of this shape was created by adding these shapes together. The formula for the volume of a cylinder and half sphere is $V = r^2h + \frac{2}{3} r^3$ (based on volume formulas in Percy and Waites 1997, 107, 409).

The surface of Pit P was 84 cm at the widest, and 71 cm at the narrowest area of the pit, which is closely comparable to the average recorded pit surface of an oval that measures 82 cm by 72 cm. For the purpose of making a conservative estimate, the narrowest diameter of 71 cm was used to calculate the volume of Pit P. Though the cap of the pit has probably eroded to some degree, the bottom of the feature is marked by hemlock boughs lining the pit at 55 cm below surface. This means that the pit originally extended at least 19.5 cm above the half sphere shape. Plugging these numbers into the volume formulas for the pit shape, the total volume of Pit P is found to be about 170,900 cm^3.

4.3.10 Ancient Quercus garryana *Acorn Volume*

Similarly, the general shape of the average acorn found at 35MU4 is that of a divided sphere joined by a cylinder of the same diameter (see acorn examples, Figure 4.12). The formula for this volume is $V= r^2h + 4/3\ r^3$ based on volume formulas in Percy and Waites (1997, 107, 409). The average size of acorns leaching at Sauvie Island was found by measuring the length and width of excavated whole acorns. Sixty examples were used to find the average size, which at present is believed to be 2.218 cm long, and 1.610 cm wide. Like the pit volume calculations, these numbers were used in the volume formula and the volume of the average acorn is believed to be about 3.423 cm^3.

4.3.11 Acorns per Acorn-Leaching Pit

To estimate how many acorns each pit is capable of holding, the pit volume is divided by the volume of the average acorn. An estimate of volume displacement had to be made to account for the space being displaced by the rounded acorns. Using one liter of Oregon white oak acorns, displacement was found to be about forty percent. The volume occupied by the acorns when pits were full would be about 102,540 cm^3, meaning that nearly 30,000 average acorns could fit into each pit. The displacement calculation also showed that 120 acorns fit into a one liter container, meaning that about 20,500 might fit into a pit. The rest of the calculations will use 25,000 as an average of the two.

4.3.12 Acorn Totals at 35MU4

Using the estimate of 25,000 acorns per pit, and a minimum of 100 pits, there may have been approximately 2,500,000 acorns being processed at the site every winter, if these pits were filled annually. Aside from the uncertainty of consistency of original pit sizes and the possibility of ash or other fill, the biggest potential problem with this figure may be that pits seem to overlap in places and may not have all been used contemporaneously. However, as far as possible at present, these estimates are conservative. Further research may result in identifying more leaching pits, so it is reasonable to assume that these one hundred or more pits might have been used at the same time.

Large crops are produced once every three years on the Oregon white oak, followed by a year of moderate production, and a year of crop failure before the bumper crop year returns (Peter and Harrington 2002, 198). One study showed that Oregon white oaks in the Willamette Valley can produce up to 1737 kilograms of acorns per hectare (Stein 1990, 657). The average mature acorn from *Q. garryana* weighs 5.35 grams (Young 1992, 292) meaning that about 325,000 acorns can be collected from a hectare of Oregon white oak grove in the Willamette Valley south of Sauvie Island, which means that less than eight hectares of oak would have to be collected from to fill these pits during bumper years.

If the acorns were collected during a moderate production year, it seems likely that the trees needed to fill the leaching pits would be available, given the proximity of oaks today. During a crop failure year though, it could be that few pits were utilized on the Multnomah slough.

4.3.13 Acorn Nutrition

To calculate the amount of calories these acorn-filled pits could provide a population, the calories per acorn were multiplied by the possible total amount of acorns. Though data has not been located for the calories per acorn, other important nutritional values are comparable to the acorns from *Q. lobata*, another white oak, which grow in regions of California with *Q. garryana. Quercus lobata* contains 4.44 calories per gram. (Bainbridge 1986, 2; Basgall 1987, 25). Based on data in Young 1992, the average mature acorn from *Q. garryana* weighs 5.35 grams. Though I have not located data for the calories per acorn, other important nutritional values are comparable to the acorns from *Q. lobata,* another white oak, which grow in regions of California with *Q. garryana. Quercus lobata* contains 4.44 calories per gram. (Bainbridge 1986, 2; Basgall 1987, 25). Using the estimate of 4.44 calories per gram, each *Q. garryana* acorn contains about 23.75 calories when consumed raw. If the site has 2.5 million acorns leaching for use every year, these leaching pits on Sauvie Island could provide over 59 million calories to the group or groups who owned them. About seventy percent of the Oregon white oak acorn's nutrition is in the form of carbohydrates (Bainbridge 1986, 2), which people in the area might have had a great need for it in the winter months when the acorns might have been retrieved from pits after leaching for as much as a year. I suspect that the use of acorns was overshadowed by the importance of wapato in the area for general subsistence, and acorns may have been more important as a delicacy trade commodity produced by the owners of this acorn leaching station (Darby 2005; see also Section 6.3 below).

4.3.14 Possible Population

To understand how many people this calorie figure is capable of supporting, the Mono of California can be looked to as a model for a minimum population. The Mono provide an example of a group that depended on acorns as a staple throughout the year, which would represent the use of the food at its maximum. According to information in McCarthy 1993, the Mono consumed a preparation of acorns that required as many as 207 grams of whole raw acorns a day per person, the equivalent of about thirty-nine *Q. garryana* acorns a day. Consuming thirty-nine acorns a day for 365.25 days would mean that every individual would consume nearly 14,250 acorns annually. A society that had 2,500,000 acorns available, and depended on acorns as a staple food, would at minimum support 175 individuals. Though the people on and around Sauvie Island probably did not use acorns to the same extent as the California groups (and, again, it might have been a delicacy trade item as much as a staple at Sauvie Island), we can gain an understanding of how far this quantity of acorns might go. A group that had 2.5 million acorns available could support 175 individuals who consumed thirty-nine acorns a day for 365.25 days, the equivalent of the Mono staple preparation.

Since we can assume that acorns on Sauvie Island were not relied on for as great a portion of diet as they were in California, given their near absence in historical and ethnographic reports, the millions of acorns leaching on Sauvie Island could potentially support a larger population throughout the year. If acorns supplied only 500 calories to a person per day, the population supported might number over 300 individuals. If the acorns represent a smaller portion of the diet, as is suggested with the 'Chinook olives' idea of delicacy, the population estimate grows to such a large number that trade to other communities would have been likely, to make use of the acorns throughout the year.

It is interesting to compare these population estimates to the 1805/6 Lewis and Clark statistics for the area. Populations varied seasonally, increasing in the spring when more resources were available on the rivers than in the outlying areas. For the Multnomah Channel this meant that populations increased from 420 individuals in the fall of 1805, to 970 in the spring of 1806. Along the Lower Columbia River, Lewis and Clark statistics nearly doubled from 9800 in the fall, to 17840 in the spring (Boyd and Hajda 1987, 313). This seasonal population increase could coincide with the time when waters on the slough would have receded, and acorns might have been retrieved to support a population that was coming to the area for foods before spring produced abundant resources in their area.

4.3.15 Summary and Conclusions

Historic, ethnographic and archaeological information support the idea that acorns were commonly used as a source of food by people throughout what is now Oregon and Washington. If acorns were not a significant source of nutrition throughout the year, they were at least marginally important seasonally for many groups. Tribes traveling long distances, camping and trading for acorns demonstrate that this food source was worth the energy it required to obtain and prepare it. Further ethnographic and archaeological research, as well as future study of the acorn pits of 35MU4, may show that this valuable resource was used by many groups of the central and southern Northwest Coast.

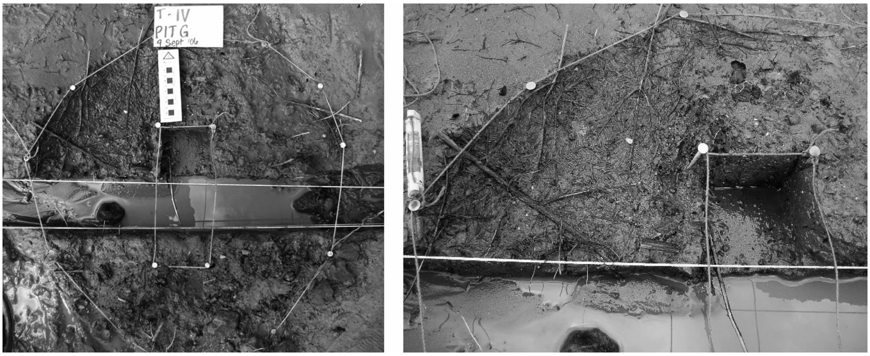

Figure 4.15. (left) Plan view of Acorn Pit G lined with western hemlock boughs, that has been sectioned by the 10 cm wide drainage trench from TU-3 . Acorns are visible lower right. (right) Close-up of same pit, showing location of 10 × 10 cm 100% sample removed for analysis. Acorns are visible upper right.

4.4 Seed Retrieval

4.4.1 Flotation vs Wet-sieving as Methods of Seed Retrieval

By Melanie Diedrich, James W. Goebel Jr., and Tressa Pagel

4.4.1.1 Introduction

As is found in most wet/waterlogged archaeology sites, the macro flora is well-preserved though often delicate. The usual processing involves careful wet-screening, cleaning and preservation in polyethylene glycol. Accepted flotation methods employed to isolate small seeds necessarily require drying the matrix more than once as well as agitation to disassociate the light-fraction material from the soil. Kidder has argued that rewetting dried carbonized plant remains can result in considerable damage or even the total destruction of delicate seeds (1997). Also, because the organic material has been waterlogged, some of it may not readily float. Therefore a comparison of flotation vs. fine wet-screening was determined to be necessary before full-scale lab work and analysis could proceed.

4.4.1.2 Methods and Materials

One hundred percent 10x10 cm soil column samples were taken from surface to bottom of five acorn-leaching pits (see example Figure 4.15), as well as one highly concentrated seed sample, possibly a corprolite, called a special soil sample (SSS) from 30–40 cm in TU4, Transect VI. AINW processed and screened material from the second (southern) ½ of Pit P, Transect VI. Lab procedures were written, combining methods from Nancy Stenholm (1994) and Sarah Walshaw (2004), adapting them to the size of the samples from this site. Experimental flotation and fine wet-screening began using 10 randomly chosen samples taken from four of the five acorn leaching pits and the special soil sample from TU4. From each of these ten, a 10% (by weight) sample was removed for flotation, and a 10% sample was removed for wet-screening.

The 10% flotation samples were dried on trays for two or three days. Screens for both procedures were made using fine tulle and even finer sheer fabric stretched over plastic embroidery hoops. These were stacked, coarser on top, for the light fraction A and B. The samples were placed in small buckets with milliliter markings, ⅔ full with water, and agitated. This procedure was repeated two or three times till flotation had ceased. Screens with finer sheer fabric were used individually for heavy fraction C and D. Heavy fraction C was agitated using one teaspoon of Calgon bath powder, which contains a defloculant, sodium hexametaphosphate, for a chemical separation of sediments. For heavy fraction D, the remanding sample was screened with a soft mist to remove clay and fine sand. The flotation fractions were again dried for one to two days then placed into containers.

The 10% wet-screening samples were poured over the stacked coarse and fine screens. A soft spray was used to carefully wash away clay and sand. The remaining material was then labeled, screens A and B. The wet-screened samples were slowly dried in closed containers.

Once the flotation and wet-screening process was finished, isolation of needles, seeds and small bones was accomplished using a dissecting microscope and tweezers. Counts were made of seeds for each 10%, totaled, and compared with the corresponding samples (Table 4.3, Figure 4.16). Identified seeds were separated and counted. The types and counts were then put into a spreadsheet for tabulation.

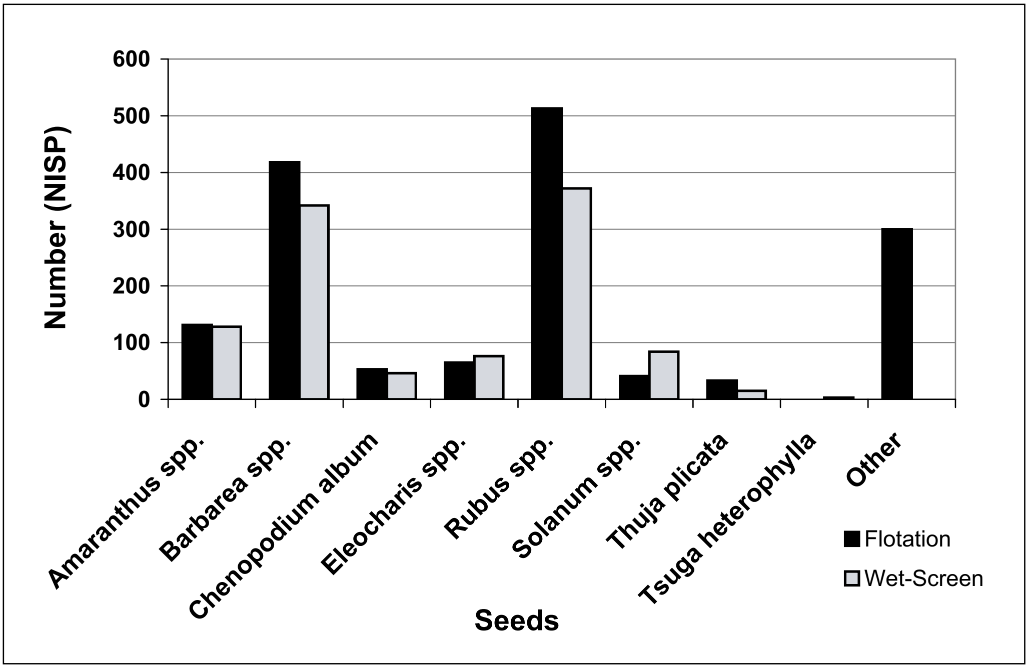

Figure 4.16. Comparing number of seeds (complete and fragments) found in flotation versus wet-screening.

Flotation Totals	**Pit A**	**Pit A**	**Pit B**	**Pit G**	**Pit G**	**Pit N**	**Pit N**	**Pit N**	**Pit N**	**SSS**	**totals**
	20–24cm	24–28cm	4–6cm	2–4cm	6–8cm	4–8cm	16–20cm	24–28cm	28–32cm	30–40cm	Flot
Amaranthus spp.	29	17	0	33	38	17	16	18	51	0	**219**
Barbarea spp.	77	34	1	3	16	34	57	25	91	133	**471**
Chenopodium album	15	12	0	0	5	6	12	4	10	0	**64**
Eleocharis spp.	25	14	6	0	3	5	1	7	11	1	**73**
Rubus spp.	18	20	0	2	5	4	5	13	23	434	**524**
Solanum spp.	4	2	0	0	2	6	9	11	14	1	**49**
Thuja plicata	0	0	0	0	0	0	0	29	4	0	**33**
Tsuga heterophylla	0	0	0	1	5	2	0	0	0	0	**8**
Other	1	6	0	0	2	0	4	1	9	279	**302**
SubTotals	169	105	7	39	76	74	104	108	213	848	**1743**
Wet-Screening Totals	**Pit A**	**Pit A**	**Pit B**	**Pit G**	**Pit G**	**Pit N**	**Pit N**	**Pit N**	**Pit N**	**SSS**	**totals**
	20–24cm	24–28cm	4–6cm	2–4cm	6–8cm	4–8cm	16–20cm	24–28cm	28–32cm	30–40cm	
Amaranthus spp.	15	15	0	20	30	6	19	33	46	0	**184**
Barbarea spp.	76	12	1	2	1	24	52	44	89	68	**369**
Chenopodium album	4	6	0	0	0	7	9	15	12	0	**53**
Eleocharis spp.	36	12	2	1	3	4	9	6	11	0	**84**
Rubus spp.	30	26	2	2	3	12	19	14	23	258	**389**
Solanum spp.	13	5	0	1	0	9	11	22	33	0	**94**
Thuja plicata	6	0	0	0	2	0	6	3	0	0	**17**
Tsuga heterophylla	1	0	0	6	5	0	2	0	0	0	**14**
Other	3		0	0	4	0	7	4	6	121	**145**
Sub Totals	184	76	5	32	48	62	134	141	220	447	**1349**

Table 4.3. Comparison of seed counts (complete and fragments) from flotation (top table) and wet-screening (lower table). Higher flotation count may be deceiving, see Results section below (4.4.1.3). SSS=special soil sample of concentrated seeds from TU4.

4.4.1.3 Results

Samples of the various seeds found were sent to the Washington State Department of Agriculture Seed Inspection Program Office in Yakima, Washington, for identification by Victor Shaul and Nancy Ashby. They identified *Amaranthus spp*. (pigweed), *Barbarea spp.* (American winter cress), *Chenopodium album* (lamb's quarters), *Eleocharis spp*. (spikerush), *Rubus spp*. (berries), and *Solanum spp*. (nightshade) (Table 4.3). Needles of *Tsuga heterophylla* (Western hemlock) and the leaf scales of *Thuja plicata* (Western red cedar) have also been isolated. The few small fish bones that have been isolated will be sent to Dr. Virginia Butler of Portland State University for identification when all of the seed and bone isolation is completed (see Butler, below, for current fine screened faunal remains identification).

The Flotation and wet-screening samples were then counted to do a comparison of the quantity and quality of the samples. Each of the flotation fractions were individually counted to compare and consider the effectiveness of the flotation process before they were subtotaled for each level, giving us an overall total of seeds collected during flotation. The flotation samples collected were 56% and wet-screened samples were 44% of the total seed count. The most prevalent types of seeds were the *Rubus spp.* seeds and the *Barbarea spp*. seeds. The flotation method yielded 524 and 471 respectively, and wet-screening yielded 389 *Rubus spp*. and 369 *Barbarea spp.* The highest concentration of seeds came from the Special Soil Sample, TU4, Transect VI, 30–40cm, from both flotation and wet-screening (Figure 4.16, Table 4.3).

Although it appears flotation resulted in a higher number of seeds recovered, the totals may be misleading. In fact, this process resulted in considerable damage to the seeds. While working under the dissecting microscope the fragile condition of the seeds could readily be seen. At times, the seeds were hard to find because each fraction had a coating of tiny mineral crystals left after the procedures. The plastic containers used to store the samples created static, which would cause the seeds and other light material to stick to the side of the dish. This made isolation difficult. Another problem that was observed during isolation was that the flotation sample seeds were dry and brittle. These seeds tended to fall apart when touched with the tweezers.

The wet-screened samples, on the other hand, were much easier to work with. Although there was more coarse sand to pick through, the seeds were cleaner, were firm, and held up better under the pressure applied by the tweezers when isolating the seeds. The wet-screened seeds continued to hold up better in storage, and the majority remained intact.

When the sample counts were totaled it became relevant to note that the seeds in the flotation samples were broken into many pieces. This could have ultimately skewed the final total in flotation's favor, and because these seeds are now broken, a recount is not possible. It is also relevant to note that for some species the difference between the flotation and wet-screening totals is minor, and in three cases the wet-sieving total is the greater.

After the totals were charted for both wet-screening and flotation a significant observation was made regarding the special soil sample (SSS) from TU4, Transect VI, 30–40 cm level. With the 20% sample used totaling only 13.6 grams it accounted for 1295 seeds, 42% of the experiments seed total. This compared with the 20% of all other matrix at 865.96 grams for a total of 1797, 58%. The high concentration of seeds found in this small sample may indicate a coprolite location (though source of the coprolite is indeterminate – could be human, but also dog, bear, raccoon, large bird, or from many other animals). Seeds found in the SSS for both flotation and wet-screening also support the conclusion of a coprolite. Within this matrix a total of 400 unidentified seeds have been found which appear to be burnt or partially digested; the *Rubus spp*. seeds also showed signs of having been burnt.

Four of the six seeds identified come from possible non-native origins. These four are *Barbarea spp*., *Chenopodium album*, *Eleocharis spp*, and *Rubus spp.* During the recent excavations at 35MU4 *Tsuga heterophylla* (western hemlock) boughs were taken from Pit P for carbon 14 dating (see Figures 3.4c and 4.13). The results placed the age of the hemlock at 130 ± 60 years, indicating the last time this acorn-leaching pit had probably been used was between 1760 and 1880 AD. We determined it would be reasonable for seeds found within the pits, most likely deposited with natural river sedimentation, to be post-contact seeds. Non-native seeds are therefore not unexpected.

While working with the dissecting microscopes during seed isolation a number of small black seeds were turning up that had the appearance of being tiny mollusks. The shells were thin and looked like they were attached by a hinge, with a shiny black periosticum-like exterior. Before we sent a sample of these seeds to Victor Shaul for identification, it was determined that a hydrochloric acid test should be preformed. If these were mollusks, the calcium carbonate would immediately dissolve in hydrochloric acid. A sample of 1M HCL was obtained from the South Puget Sound Community College biology laboratory, and three of the small seed/mollusks were isolated from the Pit N, 24–28cm. Under the dissecting scope a drop of hydrochloric acid was added; a probe was used to override surface tension on the seed. No fizzing or dissolving occurred. The only reaction was that after two minutes the black seeds shell began to turn a light brown, allowing us to conclude this was indeed a seed, not a mollusk. After a sample was sent to Victor Shaul the seeds were identified as *Amaranthus spp*. (pigweed).

4.4.1.4 Discussion and Conclusion

Due to the unknown sediment change from the dams and deforestation, the age of the macro-flora and fauna could not be determined. Further research will involve more soil samples taken from deeper levels. However, we were able to determine through a carbon 14 date of 130±60 calibrated years BP, taken from hemlock boughs lining acorn leaching Pit P (see Figure 3.4c) that it is chronologically possible for non-native species to be present within the fill of the pits.

The purpose of this experiment was to determine by comparison if flotation or wet-screening would be a better choice for wet-site material. Using the 10% samples from the 100% soil column samples, flotation and wet-screening procedures were carried out. Once the seeds were identified and counted we found that the flotation procedure offered a higher quantity of seeds, but this may not be an accurate reflection of recovery success because the seeds from flotation were in poor condition, and fragments were counted as well as whole seeds. The quality of the wet-screened samples was much better, with more whole seeds. Moreover, the seeds were easier to work with, and they continue to hold their condition in storage.

It appears from the research that has thus far been completed that a quantitative evaluation is problematic due to seed breakage. The qualitative evidence, however, indicates that fine wet-screening yields a good number of seeds in good condition, and this will be the preferred method of seed extraction in the future.

4.4.2 Flotation and Screening Samples from 2007 Cores 5 and 6: Seed Analysis

By Melanie Diedrich

On September 21, 2007, the two deep soil cores (5 and 6) were taken from the beach level near Test Unit 4 (TU4; see description in Punke, above). Core 5 was taken from directly west, in front of TU4 and achieved a depth of nine feet, three sections in three foot lengths. This core sample would have gone to deeper levels, but the coring crew lost the drilling head, due to suction. Work on Core 6 was more successful and went much deeper. This core had six 3 foot sections, achieving a depth of 18 feet, or slightly less than six meters. The sections were quickly capped, taped and labeled as they were brought up, transported to AINW and then split lengthwise at a later date.

During the lengthwise splitting, in core 6, section 5 a mammal bone was found at 15cm from the top of the section, which relates to approximately 4.15 m below the surface of the beach. A lithic core was also found in section 5 at 55 cm from the top of the section, or ~4.55 m below the beach surface. The charcoal for AMS dating was taken from close to these two locations in section 5 of core 6.

Dr. Punke created detailed drawings and notes for each of the core sections; samples for flotation and screening were taken from 13 of the 42 possible locations of interest along the length of the cores. In addition to these locations of interest it was decided to take samples from 5 cm above and 5 cm below each point as well (Table 4.4). Each sample resulted in three flotation screens: light fraction fine screen, light fraction coarse screen, and heavy fraction.

All of the screened samples were examined, described and digitally photographed under the dissecting microscope. Dr. Punke's samples were also examined for seeds, adding additional data. Seeds found were identified at least to genus when possible (Table 4.5), some were mere fragments, heavily coated in silt, and/or in such fragile condition it was difficult to make identification. The six taxa found in the pits in 2006 were evident within both of the 2007 cores. These were *Amaranthus sp., Chenopodium album, Eleocharis sp., Gaultheria shallon, Rubus sp.* and *Solanum sp.* A few unidentified seeds were noted. Though the NISP were far fewer in the cores than the pit samples due to sample size, the percent of *Gaultheria shallon* and *Rubus sp.* is comparable.

The *Amaranthus sp.* seeds were found in both cores; the *Chenopodium* were found primarily in core 6. This may be the result of disturbance along the shores of the channel adjacent to the site, possibly seasonal human traffic. Since *Amaranthus sp.* generally prefer the drier weather east of the coastal mountains along the Columbia River gorge and south into the Willamette valley, there is also a remote possibility these seeds washed downstream or blown in from other areas. A sprinkling of *Eleocharis sp.* seeds were found within both cores.

In total, five (5) *Solanum spp.* seeds were found in both cores at 0.15 m, 1.21 m, 2.81 m, 4.70 m, and 4.76 m. Although a species of this taxon, *Solanum americanum* P. Mill, is noted by the United States Department of Agriculture Natural Resources Conservation Service (USDA 2008) to be native, other sources, including the Burke Museum Herbarium Collection (2006), list this as introduced. Although they grow in abundance in the area now, *Amaranthus, Chenopodium, Eleocharis,* and *Solanum* are non-native plants that would not have been found at this location prior to Euro-American

Core 5		**Salal**	**Rubus**	**Core 6**		**Salal**	**Rubus**
Section 1	Meter level			Section 1	Meter level		
5cm	0.05	1					
10cm	0.1						
15cm	0.15			15cm	0.15		
20cm	0.2			20cm	0.2		
25cm	0.25			25cm	0.25		
30cm	0.3						
				35cm	0.35		
				40cm	0.4	3	
45cm	0.45			45cm	0.45	3	
50cm	0.5	1					
54cm	0.54		1				
Section 2				Section 2			
20cm	1.11						
25cm	1.16			25cm	1.16	1	
	1.21			30cm	1.21		1
				35cm	1.26		
				Section 3			
				55cm	2.37		1
				60cm	2.42		
				65cm	2.47		1
				Section 4	M. level		
				7cm	2.81	2	1
				12cm	2.86		1
				17cm	2.91	1	
				Section 5			
				10cm	3.75	3	
				15cm	3.8		
				20cm	3.85	1	
				50cm	4.15	1	
				55cm	4.2		1
				60cm	4.25		
				Section 6			
				15cm	4.71		1
				20cm	4.76		2

*Table 4.4. Cores 5 and 6 sampling plan and occurrences of whole salal (*Gaultheria shallon*) and* Rubus *seeds in the 1 cm*^{3} *samples.*

	Pits A–N		Cores 5 and 6	
	Total NISP	Percent	Total NISP	Percent
Amaranthus	173	16.31%	92	28.66%
Chenopodium	68	6.41%	49	15.26%
Gaultheria	359	33.84%	94	29.28%
Rubus	146	13.76%	44	13.71%
Eleocharis	119	11.22%	13	4.05%
Unidentified	106	9.99%	25	7.79%
Solanum	90	8.48%	4	1.25%
Totals	1061		321	

Table 4.5. Seed type total counts (complete and fragments) and percentages in pit samples and 2007 core samples.

settlement; the occurrence of these seeds may reflect fall-in contamination that occurred during the coring process.

The culturally important *Gaultheria shallon* (salal) and *Rubus sp.* (most likely *R. spectabilis* or salmonberry, *R. parviflorus* or thimbleberry, and *R. ursinus* or trailing blackberry) were found in nearly all samples below 35 cm. As the samples were primarily taken, and very few seeds were found outside the charcoal layers, these layers appear to indicate both riverbed exposure and site use (Table 4.4 and see Punke's core diagrams, Figure 3.14, above). The presence of salal and all of the native *Rubus sp.*, which ripen from May to late August, when the acorns placed in leaching pits should be exposed and ready to retrieve (see Diedrich, above, Figure 2.5).

While analyzing these core samples it is important to keep in mind the small quantity of samples taken, their small size (approximately 1 cm^3), and the fact that the cores are only little more than 5 cm (2 in) in diameter. Additionally, possible contamination of the samples by fall-in during the coring process makes analysis difficult. Further sampling of these existing cores is warranted, and additional excavation or better controlled cores (such as vibracoring technologies) may help further explain the layers and seeds found to date.

4.5 Hazelnuts

By Bethany Mathews

The hazelnut fragments found at 35MU4 were identified as coming from *Corylus cornuta* Marsh var. *californica*. The California hazelnut is the only native variety of hazelnut currently growing in Oregon (USDA 2008). Though hazelnuts are found in larger quantity than the acorns at 35MU4 (60% of acorn and hazelnut total), they are not found in the same condition. Of the nearly 500 hazelnut fragments that were excavated, only one was found unbroken (from TVI, Pit M, surface). This single hazelnut represents about 0.2% of the excavated hazelnuts, while over 25% of the acorns were found whole, with the nut still encased. Many acorns were found fragmented, but because all parts of the nut and shell were found the acorns were likely placed in the features whole, where the hazelnuts appear to have been broken and probably eaten on the spot instead of stored.

The single hazelnut that was found complete was damaged at the radicle (pointed) and base (flat) ends of the shell. The marks look as if they are the result of the nut being set on its base on a stone, and struck with another stone at the radicle end. An experiment using store-bought large hazelnuts, a somewhat flat anvil stone, and a small hammerstone held parallel to the anvil demonstrated that this was the easiest way to crack open hazelnut shells without damaging your fingers. While the hazelnuts were from a different species, and were much larger than those at 35MU4, the breaking patterns seem to be comparable.

Hazelnuts are ripe in the late summer and early fall, as are acorns, so it is possible that they were eaten while acorns were being processed, stored, and safeguarded at the site. Like the acorns, many of the hazelnuts have scorch marks on the outside of the shell that suggests they were roasted before they were eaten.

4.6 Faunal analyses

Fauna elements recovered in the limited two excavations at 35MU4 were rare compared to the abundance of floral remains (above). For example, 32 salmon vertebrae were identified from the entire site in 2006, and since salmon generally have 64 vertebrae, this would be the equivalent of half a salmon. The brief 2006 faunal analyses are presented followed by a synthesized 2006–2007 overview report (data spreadsheets can be found in Appendix E, Tables 1–3:219 in website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf).

4.6.1 Mammal, Bird, Fish and Shellfish Fauna from 35MU4 2006

By R. Todd Baker

The faunal collection from 35MU4 contains mammals, birds, fish, and shellfish. Most of the recovered faunal specimens represent animals that would have been commonly found within the area and some represent species that live close to water or in water. The animals represented in the faunal collection include Black-tailed Deer (*Odocoileus columbianus*), Elk (*Cervus elaphus*), Beaver (*Castor canadensis*), Bobcat (*Lynx rufus*), Mink (*Mustela vison*), Muskrat (*Ondatra zibethicus*), Jackrabbit (*Lepus sp.*), Harbor seal (*Phoca vitulina*), Canada Goose (*Branta canadensis*), and Western pearlshell Mussel (*Margaritifera falcata*). The fish bone from the site has been identified to genus and species by Dr. Virginia Butler, Portland State University, who has volunteered to do this for us, since so little fish fauna was recovered from the screening (though the fine screening of Pit P, Transect VI, reveals a number of smaller fish bones, that Dr. Butler has reviewed for us (below)). The majority of the faunal remains are burned and many have cut marks, which indicate animal processing was taking place at the site. Several of the unidentified bone fragments are pieces of bone shafts. An abundance of shaft fragments is usually a good indication of marrow processing taking place (see Table 1, Appendix E:219 in website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf).

4.6.2 Fish at Site and in 100% Samples 2006

By Virginia Butler

From the 100% sample collected from Pit P in 2006, the fish remains were recovered through wet screening to see any small fraction. Other examples of fish remains were recovered through surface collecting, either while hydraulically cleaning the surface of pits for mapping, or flagged on the surface survey.

In total, 53 specimens were identified (Table 4.6). Remains of *Onchorhynchus* sp. (salmon and trout) are most abundant, followed by *Acipenser* (sturgeon), then the Cyprinidae-Catostomidae (minnow and sucker) and *Catostomus* (sucker).

The Appendix E:224 – Table 2: 2006 in website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf) lists the taxon and element that were identified from each of the provenience units.

4.6.3 Synthesis and Summary of Sunken Village Fauna, 2006–2007 excavations

By Rebecca Wigen

The Sunken Village explorations in 2007 more than doubled the number of elements in the site assemblage. In 2007 a total of 292 elements were recovered from the beach surface collection and pit/unit sample with a further 1216 elements recorded from the fine screen samples of HTU and Pit P. The bulk of the elements from the surface collection and pit/unit samples are mammal (90%), with a few fish (5%) and birds (4.5%). In the fine screen samples this basic pattern is quite different, with the bulk of the sample being fish (97%), with only 2% mammal and 1% bird. The density of bone was so high in the fine screen samples that unidentified bone was not counted, so figures reported are NISP. New taxa identified from the 2007 material include peamouth chub, eulachon, three-spine stickleback, sculpin, trumpeter swan, small, medium, medium-large and large ducks, northern pygmy owl, a canid, raccoon and black bear (Table 4.7, and Appendix E, Table 3:225 in website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf). Considering the different collection techniques and resulting assemblages it is best to discuss the two data sets separately.

Taxon	**Frequency (NISP)**
Oncorhynchus sp.	32
Acipenser sp.	11
Cyprinidae-Catostomidae	5
Catostomus sp.	5
Total	53

Table 4.6. List of fish taxa from 2006 100% Samples.

4.6.3.1 Surface Collection and Pit/Unit Sample Bones

The bones in the 2007 assemblage found on the surface or in surface cleaned acorn leaching pits in the river sediments all appear to be in disturbed archaeological deposits. It could reasonably be asked whether these bones are actually associated with an archaeological deposit or whether they are from natural deaths. Several lines of evidence suggest they are indeed archaeological. Many of the elements show cultural modifications such as cutting, chopping or burning. In addition some of the species are no longer found in the area, such as elk and black bear, so could not be recent deposits on the river bank. Finally, these surface bones (as well as lithics) are only found concentrated on the intertidal beach in Transect II through Transect VI, and not north or south of these transects, and this is the only area containing the ancient *in situ* acorn leaching pits and stakes. As result, it is reasonable to assume the bulk of the assemblage is eroded from the archaeological deposit.

The mammal assemblage (combining both 2006 and 2007 material) is quite varied considering the small numbers present (Table 4.8, below), although most of the species are represented by less than 5 elements. Many of the species of small mammals, including muskrat, beaver, river otter, mink and raccoon, are typically found associated with riverine, lacustrine, shoreline or marshy habitats. These animals may not be found in the main river stream, but they would certainly find prime habitat along side-channels such as Multnomah Slough, and along the river edges.

Several elements have been identified as *Lynx* sp., either bobcat (*L. rufus*) or lynx (*L. canadensis*). These two small cats are quite difficult to separate skeletally. The bobcat would certainly be present in the general site area and is the most likely candidate. However, potentially lynx are present in the Washington or Oregon interior or Cascade Mountains and so might have been traded to this area or captured during a hunting trip. These cats are probably hunted mainly for their high quality pelt. A single canid element was recovered. Size suggests identification as either domestic dog (*Canis familiaris*) or coyote (*C. latrans*), and either of these is possible at this site. A single rabbit element was identified from the 2006 excavation, tentatively identified as one of the *Lepus* species. The most probable candidate is the snowshoe hare (*L. americanus*), which is recorded in the area and lives in a wide variety of habitats.

Few of these small mammal bones are modified. However in the 2007 sample, one of the muskrat elements is burned and a raccoon tibia shows faint grinding and scraping marks as well as having been chewed by a carnivore such as a dog.

In addition to these small mammals, black bear and harbor seal are identified from a single element each. Black bears are found throughout the region and could certainly have been hunted in the local vicinity. Harbor seals are typically a marine species, however they are known to enter the lower reaches of the Columbia River and reported to travel upstream to at least Willamette Falls.

The most abundant identified taxa in the 2006–2007 assemblages are deer and elk (elk are called red deer in British English) (Table 4.8). In the 2007 assemblage, deer contribute 33% of the mammal elements, while elk contribute 5%. The deer elements could come from either mule/black-tailed deer (*Odocoileus hemionus*) or white-tailed deer (*O. virginianus*). Both species are found along the Columbia River. Unfortunately, they

*Table 4.7. List of Taxa Identified from 35MU4 including all 2006–2007 samples. Note: * indicates species found only in HTU and Pit P samples.*

Bird	
Trumpeter swan	*Cygnus buccinator*
Canada goose	*Branta canadensis*
*Duck, small	Anatidae
Duck, medium	Anatidae
*Duck, medium-large	Anatidae
Duck (large)	Anatidae
Northern pygmy owl	*Glaucidium gnoma*
Fish	
Sturgeon	*Acipenser* sp.
*Eulachon	*Thaleichthys pacificus*
Salmon	*Oncorhynchus* sp.
Chub sp.	Cyprinid sp.
Peamouth chub	*Mylocheilus caurinus*
Sucker sp.	*Catostomus* sp.
Chub/Sucker	Cyprinidae/Catostomidae
*Three-spine stickleback	*Gasterosteus aculeatus*
*Sculpin sp.	Cottidae
Mammal	
Jackrabbit	*Lepus* sp.
Muskrat	*Ondatra zibethica*
Beaver	*Castor canadensis*
Canid	*Canis* sp.
Bobcat	*Lynx rufus*
Lynx/bobcat	*Lynx* sp.
River otter	*Lutra canadensis*
Mink	*Mustela vison*
Raccoon	*Procyon lotor*
Black bear	*Ursus americanus*
Elk (red deer)	*Cervus elaphus*
Mule deer	*Odocoileus hemionus*
Deer (mule or white-tail)	*Odocoileus hemionus/virginianus*
Ungulate sp.	Artiodactyla
Harbor seal	*Phoca vitulina*

are difficult to distinguish skeletally (although not impossible) and the comparative collection used in 2007 from the University of Victoria Department of Anthropology lacks a white-tailed deer specimen. As a result it was decided to leave the identification at the genus level. Black-tailed deer was definitely identified in the 2006 assemblage. It is probable that both are present in the assemblage.

The deer bones from 2007 are all from adult (epiphyses fused or adult size) or sub-adult (epiphyses unfused but adult size) individuals. A single cranial fragment with

Table 4.8. NISP by Transect, 2007 data.

	II	III	IV	V	VI	Total
Sturgeon			1	1		2
Salmon		2	1	4	1	8
Peamouth chub	1					1
Chub sp.	1					1
Sucker sp.				1		1
Unidentified fish		1		1		2
Total fish	2	3	2	7	1	15
Trumpeter swan				1		1
Duck (large)	1					1
Unidentified large bird	2					2
Unidentified bird		1	2	3	3	9
Total bird	3	1	2	4	3	13
Small mammal\bird			1			1
Beaver				3		3
Muskrat				1		1
Raccoon	1		2			3
Canid				1		1
Lynx/bobcat	1				1	2
Black bear	1					1
Deer	11	17	21	27	12	88
Elk	3	4	2	4		13
Ungulate (antler fragments)			1	2		3
Very large land mammal				2		2
Large land mammal	14	13	25	31	24	107
Large mammal			1			1
Unidentified mammal	4	8	1	21	4	38
Total mammal	35	42	53	92	41	263

the antler chopped off was present, indicating the capture of a male sometime in the fall/winter season. At least four individuals were present based on the presence of four left astragali. All parts of the body were present with front and hind limb elements most common, suggesting complete, or substantially complete, deer were being processed at the site. Metacarpals and metatarsals were particularly common, 21 in total, and of these 8 were cut or worked in some fashion. The cut marks on these bones, which have little flesh on them, probably indicate debris from bone tool manufacturing and their abundance suggests they were being preferentially chosen. In contrast, cuts on a humerus, rib and scapula probably result from food preparation.

Elk are the second ranked mammal (Table 4.8), but with many fewer bones than the deer. At least two elk are present based on the presence of 2 left femurs from an adult and juvenile individual. Although there are not very many elements, there are still representatives from most parts of the body, including the hind limb, skull (teeth), ribs, and fore limb (a carpal) indicating complete or substantially complete animals were present. Two of the podials (a calcaneous and radial carpal) have deep cut marks and one of the rib shaft fragments has shallow cuts. The cuts on the podials probably occurred during removal of the metapodials and the cuts on the rib shaft may indicate flesh removal for consumption.

The single most abundant faunal category is the large land mammal group. This accounts for 41% of the mammal assemblage. This size category could include bones from such mammals as deer, black bear and wolf. These bones are usually shaft fragments that are thick enough to indicate they came from a large mammal. Considering the abundance of deer in the assemblage, it is probable most of these are deer as well. Many are spirally fractured suggesting humans as the agent of breakage.

Very few bird bones were recovered either in 2006 or 2007 and the majority is unidentifiable. A single swan element is identified as trumpeter swan rather than whistling swan (*Cygnus columbianus*), based on its large size. Both swans winter on the Columbia River, and in the past, in very large flocks (Jewett *et al* 1953, 101–102). A single goose element, identified as Canada goose, was identified in the 2006 assemblage. Canada geese are also most common during spring and fall migration, but some might be found in the area all year. The only other bird identification is large duck, which is too generic to provide any seasonal or habitat information.

The sample of fish bones is also quite small (Table 4.8). In the 2007 sample only 15 fish bones were present. More than half of these are salmon. The salmon bones are all vertebra from medium sized individuals (estimated to be between 45–60 cm in length). The dominance of salmon is not a surprise as the Columbia River has enormous salmon runs. A few sturgeon elements were identified. It was not possible to identify the sturgeon to species, so the elements could either be white (*Acipenser transmontanus*) or green (*A. medirostris*) sturgeon. The other elements belong to freshwater taxa, including the peamouth chub and unidentified chub and sucker bones. The peamouth chub is a permanent resident in the area, preferring slower flowing areas of the river (Page and Burr 1991, 70). Suckers (Catostomidae) are difficult to identify to species. In this case the bones were from one of the larger species such as the largescale sucker (*Catostomus macrocheilus*), bridgelip sucker (*C. columbianus*) and mountain sucker (*C. platyrhynchus*).

A larger number of fish elements (53) were recovered in the 2006 surface collection and pit/unit excavations, although this is still not a large number. Again, salmon is most common, followed by about equal quantities of sturgeon and chub/sucker. So, despite the small samples, the 2006 and 2007 assemblages produced quite similar results.

Despite the relatively small samples, some patterns seem clear in this assemblage. Certainly the abundance and variety of mammals indicates that hunting was a significant activity at this site. Deer and elk were the primary mammal resources, but the wide variety of other species indicates they were not the sole focus. The presence of many deer metapodials, some with cut marks, shows that bone tool manufacturing was a significant activity. The smaller mammals include several species, such as bobcat, river otter and mink, which may have been hunted for their pelts. The raccoon may have been an invader, interested in the hundred plus acorn leaching pits containing millions of acorns (Mathews, above) and/or been hunted for its pelt as well. Others, such as muskrat and beaver, would have supplied both high quality pelts and substantial food.

Apparently few birds were hunted. Water birds were the only group represented suggesting a focus on riverine habitats, although the sample is very small. The presence of the swan and Canada goose suggests some bird hunting took place in the fall through spring.

The small fish assemblage also shows some clear patterns. Salmon is the most abundant fish taxa identified by far, followed by sturgeon and then the suckers and chubs. However, the most striking aspect of the fish assemblage is its small size, as the setting of the site, on the Multnomah Channel, would appear to lend itself to a focus on fishing.

At this point in the analysis, it appears fishing was not a particularly important activity at this site, despite the ethnographically recorded preference for fish as a resource (Boyd and Hajda 1987). Considering the abundance of plant resources recovered, particularly acorns, it is possible that the focus here was on those resources rather than fish. Acorn harvesting would take place in the fall and then would be collected from the leaching pits in the late winter/spring. In the fall, chum salmon (*O. keta*) and possibly the last of the summer run sockeye (*O. nerka*) and chinook (*O. tschawytsha*) would be available in the channels around Sauvie Island. In the late winter/spring eulachon (*Thaleichthys pacificus*), white sturgeon (*Acipenser transmontanus*), which feed upon the eulachon and spring chinook salmon are available. So it would theoretically be possible to collect acorns and catch a variety of fish in the same season. Hunting was obviously important, so why not fishing as well? And the evidence for bone tool manufacturing adds to the picture of a variety of activities taking place at this site.

Alternatively, if fall acorn harvesting and processing and late winter/spring collection was the focus of activities by a large group of people at Sunken Village and it was occupied by only a few people through the winter to guard the acorn leaching pits then large scale harvest of salmon and/or eulachon may not have occurred. In that case, the few fish bones may accurately reflect occasional fishing by the small number of longer-term residents.

Another possibility is that site deposition is affecting the recovery of fish bones. All but one of the 2007 fish bones were recovered from the pit deposits. The acorn pits were presumably left open when not in use and when abandoned and subsequently were filled in with river sediments. When open they could have created an eddy, slowing the slough current and trapping smaller, lighter weight bones. Larger, heavier mammal bones would also be caught in the eddy created by the pits, but would also be deposited in the bank sediments, while many (most?) of the lighter weight fish bones could have been carried away by the currents. So, if there were more fish remains in the eroding midden, they may have been carried away by the slough, rather than being deposited on the adjacent river bank.

This is where the analysis stood when I was given the opportunity to examine fine-screened samples that were collected from the Half Test Unit and Pit P. As a result of this analysis, the interpretation of the fish bone in particular changed dramatically.

4.6.3.2 Half Test Unit (HTU) and Pit P Fine Screened Samples

HTU Assemblage. The Half Test Unit was excavated into the cutbank above the beach (see Punke, above). The faunal samples came from Stratigraphic Unit 5, an area with fire-cracked rocks, charcoal and burnt bone (Figure 3.7). This appears to be an in-situ cultural layer. This unit is above the water level and so there are no waterlogged wood and fiber materials present.

Two level samples were water-screened through a 1.00 mm mesh and produced more bone than had been recovered in both the 2006 and 2007 excavations. Almost all of this bone was burnt and/or calcined, probably the only reason it survived. No attempt was made to count the unidentifiable bone due to the high density of bone and time constraints, so the figures in Table 4.9 are NISP only.

Most of the bone identified is fish, 594 of 601 elements (Table 4.9). The only identifiable mammal element is from a medium sized rodent, possibly mountain beaver. There are 6 other fragments that appear to be antler. There is more mammal bone present in the sample, but it was all unidentifiable and so was not counted in this case. There is a small amount of bone from salmon, sturgeon and the sucker/chub group (more than was recovered in the rest of the site!), but there is an astonishing amount of three-spine stickleback, 542 elements, contributing 91% of the sample. Most of the stickleback bones are dorsal and pelvic spines. The MNI for stickleback is at least 60 based on the pelvic spines (see Appendix E, Table 3e in website: http://www.library.spscc.ctc.edu/crm/JWA9.pdf).

The association with fire-cracked rock and charcoal and the calcined nature of the bone, suggests this deposit might be from a hearth. If so, this deposit might represent a short-term event. Although the great abundance of 3-spine stickleback might seem unusual, it has been recovered in large quantities at Cathlapotle (a similar site on the Columbia River) when fine screens were used (Virginia Butler, personal communication). Whether people are collecting three-spine stickleback as bait, inadvertently while netting other fish, in the stomach of other animals or deliberately for food is unknown at this point. The burning of the bones indicates they were deliberately discarded into the fire, which might suggest these small fish were discarded whole.

Pit P Assemblage. The second group of samples taken from each level of Pit P were also water-screened through 1.00 mm mesh and produced an abundance of bone; a total NISP of 615 (Table 4.9; also see Pit P description in Punke, above, Table 3.3, Figure 3.12). This bone is about 38% calcined or burnt, a lower proportion than in the HTU. In addition to the bone, the samples contained some stone flakes, small bits of shell, some wood chips, fragments of worked bone and abundant charcoal. Although excavated in 10 cm levels, I could see no particular vertical pattern beyond an overall increase in the density of bone in the lowest levels. As a result all bone from Pit P was combined into a single assemblage for analysis.

There is a modest amount of bird and mammal bone. In fact, there is more identifiable bird bone in these samples than in the rest of the site (Tables 4.8 and 4.9). Ducks of varying sizes are most common, contributing 64% of the bird NISP. Variation in size of the elements indicates an MNI of at least four ducks in this pit. The only other bird present is northern pygmy owl, represented by three vertebrae and a foot phalanx

Taxon	HTU	Pit P	Total NISP
Sturgeon	11	43	54
Salmon	13	169	182
Chub sp.	1	64	65
Sucker sp.	3	28	31
Chub/Sucker	23	108	131
Eulachon	1	148	149
3–spine stickleback	542	17	559
Sculpin sp.		3	3
Total fish NISP	594	580	1174
Small duck		1	1
Medium duck		4	4
Medium-large duck		1	1
Large duck		1	1
Northern pygmy owl		4	4
Total bird NISP		11	11
Small rodent		2	2
Mountain beaver?	1		1
Muskrat		3	3
Canid		1	1
Deer		2	2
Ungulate (antler?)	6	19	25
T*otal mammal NISP*	7	27	34

Table 4.9. NISP for Half Test Unit (HTU) and Pit P Bulk Samples.

probably from the same individual. This sparrow-sized owl is an unusual find in an archaeological site, but they are permanent, and probably common, residents in this area (Jewett *et al*. 1953, 361).

More mammal bones were identified than bird (Table 4.9), although 67% of the NISP is antler fragments. Several of these fragments appear to be detritus from chopping or adzing the antler. Muskrat is the next most common mammal taxon with 12.5% of the NISP, followed by deer (8%) and a small rodent (8%). A single canid tooth was recovered. Size suggests this is either domestic dog or coyote.

By far, the largest portion of bone was fish (NISP = 580), a bit lower than in the HTU samples. The breadth of species is almost the same, only adding sculpin to the list. However, the proportions are fundamentally different.

In Pit P, salmon is most abundant, 29% of the NISP. The elements consist mainly of vertebra and vertebra fragments, with a few teeth present, indicating at least some whole salmon were being processed. About half of the salmon bone is calcined. The bones appear to be from medium-sized individuals, although size is a bit difficult to determine with fragmentary vertebra.

Following closely behind the salmon is eulachon with 25.5% of the NISP. All of the eulachon bones are vertebra and they are the only abundant taxon where none of the bones are burned or calcined. These are very fragile vertebra (essentially a thin ring) and it is possible burning, which tends to make bone more brittle, caused them to disintegrate. Of course, it is also possible none of them were burned. Eulachon are the best seasonal indicator of the faunal remains, entering the area in February and March to spawn (see Diedrich, 2.2.8 above).

The next ranked group is the sucker/chub group, which consists mostly of vertebra. Chub and sucker vertebra are difficult to identify, so have been combined. Cranial bones of chubs and suckers are more distinctive and indicate both are present, although it wasn't possible to identify any to species. For comparison purposes it is easiest to combine all three groups together. If you do that, this group becomes the most abundant in the sample, with a combined NISP of 200 or 34%. Both vertebra and cranial elements are present for these fish and in a variety of sizes, from large to small.

Sturgeon is fourth ranked. Unfortunately, these were mostly small fragments of large elements identified mainly by the texture. As a result it was usually not possible to identify either element or to estimate the size of the sturgeon. Some scutes were present and some fin rays, but that was the most that can be determined.

And in complete contrast to the sample from the Half Test Unit, only a few 3-spine stickleback elements were present (Table 4.9). Again, these were mostly spines, but in this case not all were calcined.

The derivation of this sample is a complex question. It is likely that Pit P was left open the last time it was emptied of acorns leaving behind its hemlock branch lining (dated to 130±60 calibrated C14 years ago, Table 3.5, above). Presumably it was filled by sediments settling into the eddy it would create. So these bones, artifact fragments, flakes, etc, may have been washed into the pit after eroding from the bank. The eddy created by the open pit would certainly tend to catch this type of material as well as the silt in the water. However, none of the bone appears to be water worn. Potentially it didn't move far enough to be worn, but this is at least suggestive of the notion that the material might not have been washed into the pit.

The large amount of charcoal and calcined/burnt bone suggests an alternative possibility. As has been noted by Beth Mathews above, charcoal and/or ash were sometimes included in the acorn processing. Perhaps in addition to the pit being lined with hemlock branches, it was also lined with ash or ash was layered in with the acorns. The most obvious source of ash and charcoal would be fire hearths, and hearths might contain all of the material listed above. The unburnt bone might have been included if some floor material was collected along with the hearth material. I believe this is the most likely source of this sample.

4.6.3.4 Summary. With the addition of the bulk samples, fish become the most abundant fauna recovered from this site; a very different conclusion than was reached before the bulk samples were analyzed. The most common fish are stickleback, the chub/sucker group, salmon, eulachon and sturgeon, although not necessarily in that order. The abundance of stickleback and eulachon is quite variable, with a very high number in the HTU and few in Pit P. The sheer quantity of fish in the two samples from the Half

Test Unit and Pit P suggests that fishing *was* important at this site, in direct contrast to the conclusion drawn when only the surface and test unit materials were present. However, these are only two small samples from what may be unusual settings. More work would be necessary to determine if they are typical of the site. Certainly the proportions and species present are quite similar to those from Cathlapotle, suggesting this sample may be typical for the area.

It is also clear that mammal hunting was important as well, perhaps just as much as fishing. The breadth of the species recovered from what is a still a small sample of the site seems a good indication of this importance. Deer and elk are the most common mammals hunted, but a wide variety of smaller fur-bearers were also hunted. The presence of a deer cranial fragment with antler attached indicates at least late summer to early winter hunting.

Surprisingly, birds don't seem to have been particularly important, even though this area is known for large wintering populations of ducks, geese and swans.

The cut deer metapodials and fragments of antler detritus also indicate bone and antler tool manufacturing was taking place on site.

In the end, the faunal remains suggest a broad range of resource collection was taking place at this site and lends support to the suggestion that it was occupied by at least some people for most of the year.