2000

Wetland Landscapes and Archaeological Sites in the Coquille Estuary: Middle Holocene to Recent Times

Scott Byram, *University of California, Berkeley*
Robert Witter

Wetland Landscapes and Archaeological Sites in the Coquille Estuary, Middle Holocene to Recent Times

Scott Byram
Department of Anthropology, University of Oregon and
Coquille Indian Tribe Cultural Resources Program

Robert Witter
William Lettis & Associates
Walnut Creek, California

For thousands of years the Native people of the Coquille estuary maintained and adapted their highly effective fishing technology while contending with massive earthquakes and tsunamis, instances of abrupt sea level rise, and continually shifting estuary shores.

During the 1990s, substantial research was conducted on the cultural and environmental history of the Coquille estuary. This was brought about by the development of the Coquille Indian Tribe's Cultural Resources Program (CITCRP), and by archaeologists' growing interest in the region's cultural history. Also during this period geologists were beginning to investigate earthquake hazards in the vicinity of the Coquille estuary. This paper brings together archaeological and geological research to shed light on the processes which transformed the Coquille estuary landscape and affected Native communities for over six thousand years. In terms of its archaeology and long-term environmental history, the Coquille is becoming one of the most intensively studied estuaries in the Pacific Northwest. This paper focuses on wetland sites and earthquake history investigated by University of Oregon archaeologists, CITCRP staff and other Coquille tribal members, and geologists from the Humboldt State University and the University of Oregon.

Buried beneath today's Coquille estuary and surrounding lowlands are the layered remains of ancient wetlands. Water-saturated and depleted of oxygen, these layers hold quantities of well-preserved organic material. This includes peats that represent former marsh surfaces, shell fragments that indicate former tidal flats, and most important to archaeologists, wooden artifacts, including the remains of fishing weirs. The research presented here focuses on Native people's fishing weir sites and their environmental settings. Initial archaeological investigations in the 1990s were aimed at determining the age and geographic extent of Coquille fishing weirs, and in exploring the role fishing structures once played in the local economy. As research progressed, the processes of landscape change became key in understanding the history of Coquille fishing traditions. Because weir use was closely linked to changes in the estuary, many of these changes are revealed in the spatial and chronological patterning of archaeological weir remains.

These new findings demonstrate that for thousands of years the Native people of the Coquille estuary maintained and adapted their highly effective fishing technology while contending with massive earthquakes and tsunamis, instances of abrupt sea level rise, and continually shifting estuary shores. The technology which once was the cornerstone of the Coquille economy is shown to have been highly resilient and adaptable. In their construction and use of weirs over generations, people took advantage of changes in the estuary landscape. In some settings the placement of weirs may even have enhanced wetland productivity by trapping sediments and redirecting tidal channel networks. The environmental changes which affected fishing weir use are also the reason weirs and wetland layers are preserved to this day in the Coquille estuary.

Today's landscape is very different from what it was 150 years ago, when the Coquille people were the sole residents of the valley.

Coquille Communities and the Estuary

Among the estuaries of the Oregon Coast, the Coquille has one of the most extensive tidewater lengths, extending inland some 40 miles (65 km). However, in surface area the estuary is comparatively small, primarily consisting of a narrow river channel surrounded by alluvial lowlands. In the lower estuary (below river mile 10) the intertidal zone ranges in size from a narrow strip of mudflat between the main channel and the steep riverbank, to an expansive tidal flat and salt marsh near the mouth of the river (Figure 1). The outflow of the Coquille is comparable to the Nehalem and Alsea rivers, and varies seasonally, being as much as ten times higher in winter than in summer (Proctor et al. 1980:2-41, 42).

On summer days, the lower Coquille River valley appears as a wide lowland surrounded by forested hills. The river flows through this lowland in a tidal

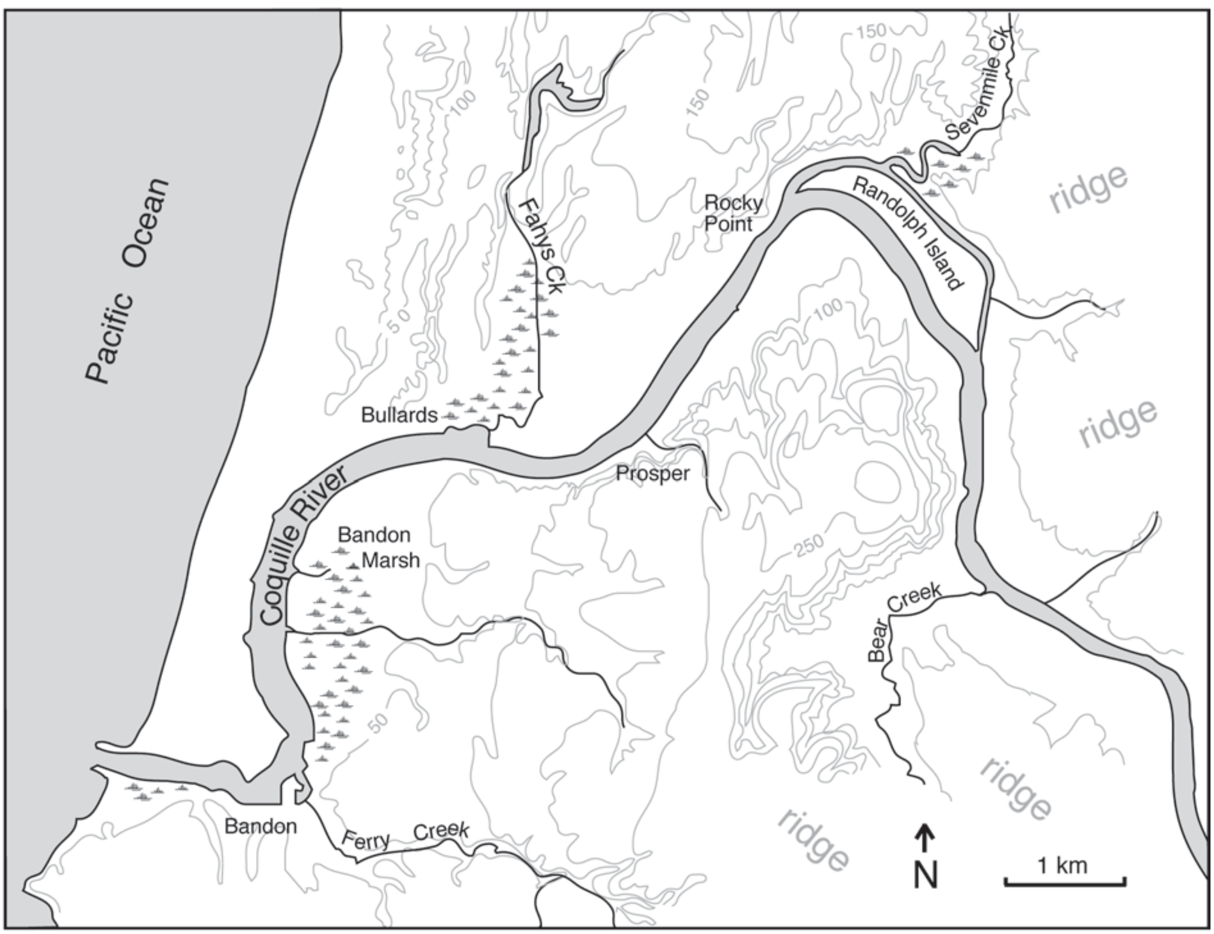


Figure 1. *Map of the lower Coquille estuary.*

channel that gradually widens as it nears the ocean. In winter this scene is often quite different in much of the valley. Frequent rains and coastal storm surges conspire to raise water levels in the estuary, at times submerging thousands of acres of lowlands. During these floods high ground is visible in a narrow strip of riverbank levee, where river-carried sediments have spilled out of the channel and come to rest. Although it limits use of the land seasonally, the winter flooding replenishes valley soils, increasing agricultural productivity in areas which drain in spring.

Today's landscape is very different from what it was 150 years ago, when the Coquille people were the sole residents of the valley. Constructed dikes border many of the fields, and tidegates have been built across tributary channels which were once tidally influenced. Before the mid-to late 1800s, when American settlement brought intensive farming to the Coquille Valley, many of these fields were marshes and tidal channels formed an extensive network through the lowlands (Benner 1991). At this time the Coquille wetlands provided rich sustenance for local residents, though different in nature from the products of today's farms and ranches. The wetlands supported large populations of waterfowl, elk, beaver and other fur bearers, and a variety of useful plants. But the key resource for the Coquille people was fish. The extensive tidal channels of the Coquille estuary were habitat for dozens of species of fishes. Massive spawning runs occurred in all seasons of the year, bringing salmon, herring, smelt, and other fishes in vast numbers.

Fishing stations were such an important part of the Coquille economy that permanent and seasonal villages were often located in relative proximity to the weirs.

One of the most effective systems the Coquille people used to harvest these fish involved weirs and traps of wooden stakes and woven lattice or basketry (Figure 2). These fishing structures were often built across the mouths of tidal channels. They were typically designed to allow fish to pass upstream as the tide rose, then trap the fish as the tide receded. With the use of large dugout canoes and dip nets, vast numbers of fish could be harvested at a fishing weir location during major runs. Archaeological, ecological, and historical evidence indicate that fishing structures were most productive in the lower portion of the Coquille estuary, where the ocean's influence was greatest and tidal channels were most extensive (Byram 1998; Byram and Erlandson 1996).

It appears that these fishing stations were such an important part of the Coquille economy that permanent and seasonal villages were often located in relative proximity to the weirs. Historically, the largest Coquille villages were found along the shores of the lower five to ten river miles of the estuary. There are no known photos or drawings of Coquille villages, but descriptions in historic accounts and archaeological information indicate that these were clusters of gabled houses made of split wood planks. Villages were often located in places where deep water approached the shore, providing good canoe access. During the drier months when water levels were low, fishing camps may have been occupied near good fishing locations along much of the riverbank. From these villages and camps people could travel to points along the estuary shore for hunting, plant food gathering, social visiting, and tending fishing weirs (Tveskov 2000).

Coquille Wetlands Archaeology

1994-95 Osprey Site Project

Although oral history has provided much information about Coquille traditions, archaeology has contributed much to our knowledge of Coquille history. The first joint University of Oregon/Coquille Indian Tribe archaeological project on the Coquille estuary was conducted at the Osprey weir site (35-CS-130) in the summers of 1994 and 1995 (see cover photo), funded in part by the State's Historic Preservation Office. The Osprey site is located in the lower portion of the estuary on the north bank. It was investigated because of its great extent and high degree of preservation, and because the site was threatened by

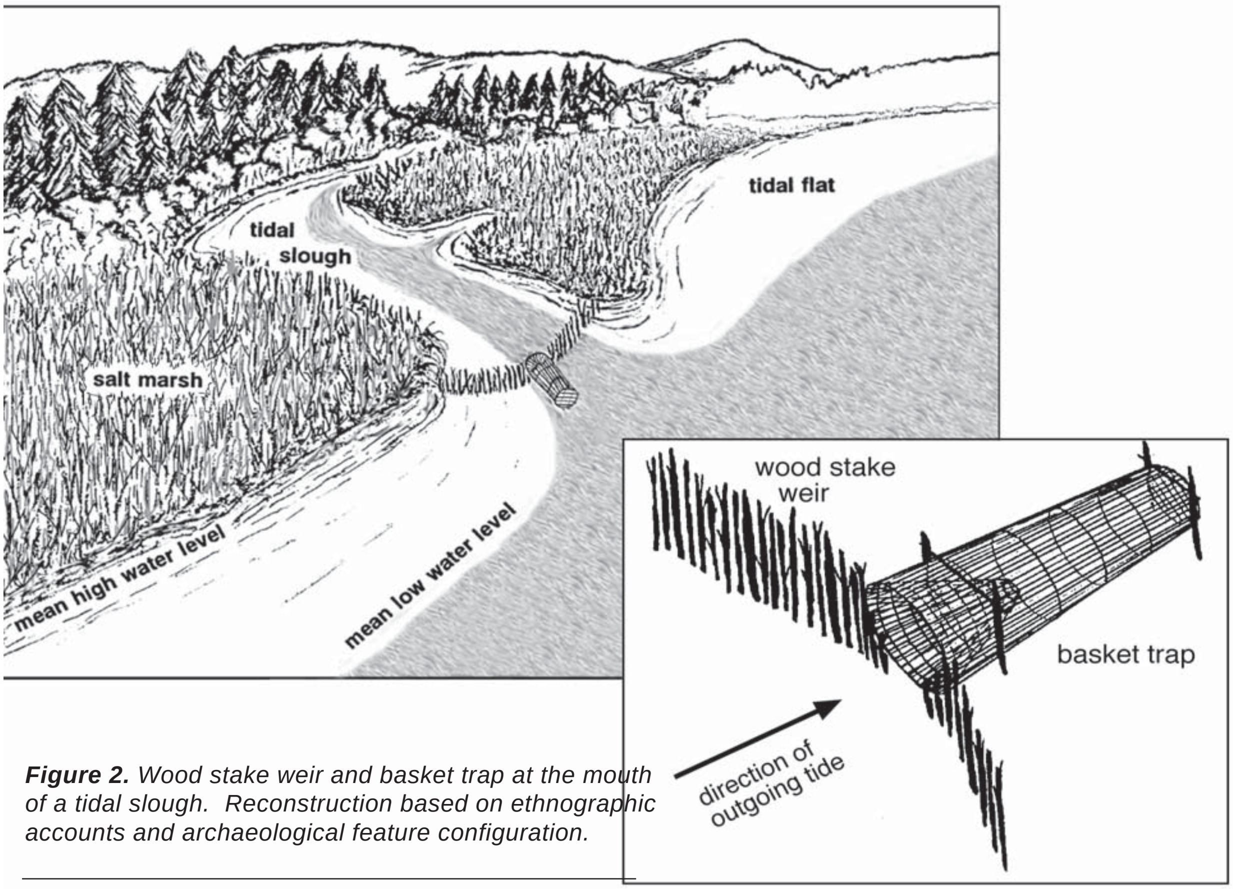


Figure 2. *Wood stake weir and basket trap at the mouth of a tidal slough. Reconstruction based on ethnographic accounts and archaeological feature configuration.*

erosion (which has since impacted the site severely). The Osprey project led to a better understanding of fishing weir technology in tidewater settings. Initial efforts focused on mapping, photographing, and radiocarbon dating the extensive wood stake weir features which were exposed at the site during low "minus" tides (Figure 3). These features consist of lines or clusters of vertical wooden stakes (cover photo). They are interpreted as the remains of fishing structures based on ethnographic accounts of tidewater weirs and their settings, feature orientation in relation to tidal channels, and their location on intertidal mudflats and channels edges (Byram and Erlandson 1996; Moss and Erlandson 1994).

During fieldwork at the Osprey site, over 2,000 stakes were mapped, representing 43 weir features. Six radiocarbon dates have been obtained from wooden stakes at the site (see Table 1, page 71), ranging from 480 to 830 years BP (i.e., before present). In addition to wooden weir stakes, eight split wood, woven lattice panels were identified at the site, some in association with weir features. One large feature of four overlapping panels over two meters in length has been radiocarbon dated to 150-300 years BP. Although many of the weir features at the site had been impacted by erosion and most were only partially exposed, detailed feature mapping revealed that some of the weir lines may be arms of V-shaped weirs which were oriented toward former tidal channels. The Osprey weir maps and radiocarbon dates allowed us to develop the hypothesis that these weirs were built across the mouths of tidal sloughs at places where these tributary channels entered the main river channel. Furthermore, patterns in the radiocarbon dates from the site suggested that channel networks shifted over time, requiring weirs to be built in new locations.

The Osprey project led to a better understanding of fishing weir technology in tidewater settings.

1997 Philpott Site Project

The spatial and chronological patterning first observed at the Osprey site became clearer during later investigations at the Philpott site.

The spatial and chronological patterning first observed at the Osprey site became clearer during later investigations at the Philpott site (35-CS-1). In summer, 1997, research was conducted here in response to a major episode of erosion which occurred at the site during the previous winter. The Philpott site had previously been investigated in 1978 by a team from Oregon State University, and subsequently listed on the National Register of Historic Places (Draper 1982). During this earlier project weirs had been noted in the narrow mudflat along the edge of the site, but excavations focused on the upper riverbank soil which contained dense cultural material consisting of flaked stone tools and debitage, bone and antler tools, fire-cracked rock, and faunal remains. This "midden" soil occurs in a natural riverbank levee which is slightly higher than the lowlands stretching northward from the site.

Several decades ago a dike was constructed along the portion of the riverbank which includes the Philpott site. This dike was built to keep flood waters out of the drained wetlands north of the site, but it is only effective in seasons when rainfall is moderate or low. Unfortunately, the levee at the Philpott site is continually eroding, and some areas where dikes have been built are being undermined. In the winter of 1996-97 after a period of heavy rains and storm surges, a break occurred in the dike near the center of the Philpott site, and much of the water from the flooded field behind the dike drained out through this opening. This flooding and draining continued through several tidal cycles, and eventually washed out an estimated 300 cubic meters of midden (Figure 4). Recognizing the significance of the loss, the CITCRP and UO archaeologists conducted investigations to assess the

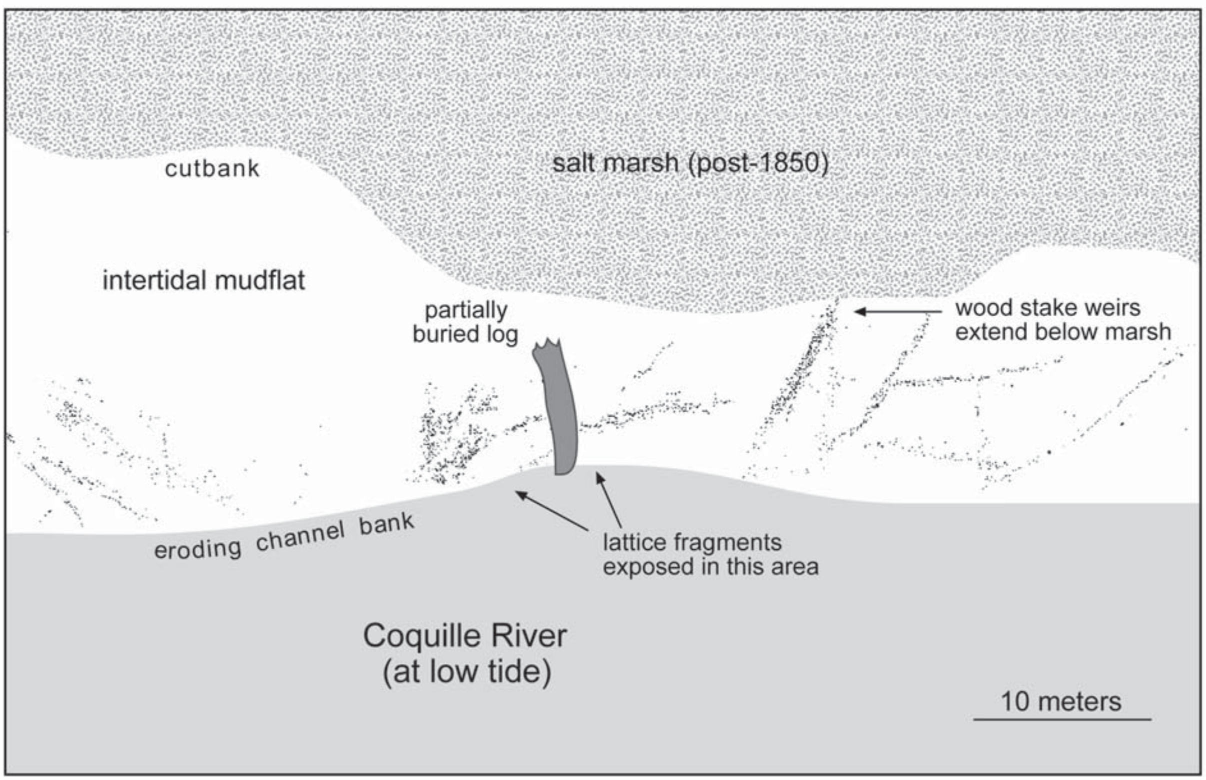


Figure 3. *Map of wood stake weir features in the eastern portion of the Osprey site (35-CS-130). Weir lines to the left of the log are oriented northwest-southeast, while those to the right of the log are oriented northeast-southwest. The configuration of these features indicates multiple episodes of V-shaped weir construction at the mouth of a former tidal channel. Split wood lattice fragments from basket traps, enclosures, or weir panels, are concentrated along the low tide shoreline between the east and west arms of the V-shaped weirs.*

Figure 4. *Photograph of the erosional washout which occurred at the Philpott site (35-CS-1) in 1996-97. Mark Tveskov (left) and Charles Hodges map exposed features and stratigraphic profiles in the eroded area during a joint Coquille Indian Tribe/University of Oregon salvage project in 1997.*

extent of the damage, and to learn more about the site from the exposed washout cutbanks (Byram et al. 1997).

The most significant finding during this project was the presence of a single wood stake weir feature on the floor of the washout area, in a wetland layer which is stratigraphically beneath the riverbank midden (Figure 5). The weir was partially excavated and found to be in line with another weir segment exposed on the mudflat south of the riverbank. Prior to this erosion, it was not evident that the weirs exposed in the narrow mudflat were from a stratigraphic layer which predated the riverbank levee and midden, but this was now clearly demonstrated.

The most significant finding during this project was the presence of a single wood stake weir feature on the floor of the washout area, in a wetland layer which is stratigraphically beneath the riverbank midden.

The Philpott project also entailed fine-grained analysis of the midden (Hodges 1997; Tveskov 2000) and core sampling for sediment data in the surrounding area. The midden was found to contain extensive faunal remains, with over two thousand bones of herring, salmon, and other species in a 0.4 cubic meter excavation unit, a diversity of lithic and bone tools (Draper 1982), and a number of small hearth and pit features. Two radiocarbon dates were obtained from the midden layer, and combined with two from Draper's earlier excavation, indicate that the riverbank levee formed at the site approximately 600 years ago, and was used with some intensity until 300 years ago, when the site was abruptly abandoned. Two radiocarbon dates from weir stakes, including the feature which extends into the washout area, indicate the site was a tidal wetland fishing station some 700 years ago, before the riverbank levee had developed.

Sediments examined along the nearby riverbank and in probes extending northward show that the buried riverbank soil gradually transitions into a buried marsh soil. Apparently the site was located on the highest dry ground on the riverbank levee, and areas to the north, east, and west were too marshy for residential use. Beneath the buried midden soil is a sandy levee layer which contains artifacts, but in much lower frequency. This is the sand which appears to have buried the weirs as the levee encroached westward, and although it remained in the intertidal zone, people may have used it as a work area during periods of low water.

Archaeological investigations of eroding exposures have become a central dimension in Oregon coast archaeology, and the Coquille project utilized a suite of techniques which were proven effective over the last decade

1998-99 Coquille River Archaeological Mapping Project

Beginning in June, 1998 the CITCRP conducted an 18 month project to survey, map, and characterize several known and reported intertidal sites in the Coquille estuary. The Coquille River Archaeological Mapping Project was funded by the Coquille Indian Tribe and the National Park Service Historic Preservation Fund and led by Donald Ivy and Scott Byram (CITCRP 1999). Prior to the project, several sites had been reported along the banks of the lower estuary, but few had been studied in detail. Riverbank erosion has been severe in recent years through much of the project area, and one goal of the project was to document sites that were being eroded, and to begin to monitor this erosion through careful mapping, photography, and videotaping. Archaeological investigations of eroding exposures have become a central dimension in Oregon coast archaeology, and the Coquille project utilized a suite of techniques which were proven effective over the last decade (Erlandson and Moss 1999; Losey et al., this volume).

Twenty-eight riverbank sites have been inventoried at this time, including lithic scatters, sites with fishing weir components only, sites with weir and midden components, and sites with middens only. Examination of cutbank exposures and intertidal mudflats revealed that the stratigraphic sequence identified at the Philpott site appears to be repeated at six other weir and midden sites. At the close of 1999 fieldwork a total of 18 new radiocarbon dates had been obtained, including three that were submitted as part of a collaborative University of Oregon project funded by the State Historic Preservation Office (Erlandson et al. 1999). Complete transit and GPS maps and feature profiles have been made for all weir sites and several midden exposures, and individual stakes have been mapped in over 95% of the known Coquille River weir features.

Research at these sites has begun to provide a picture of activities including weir fishing, a variety of other subsistence activities, and residential practices. Archaeological lattice and lithics were collected for conservation and interpretation at Coquille Tribal facilities. At four eroding midden sites, excavation of surface transect units on mudflat surfaces was conducted to determine the extent of midden materials which remained after their erosion by tidal currents. These materials are currently being analyzed. Detailed fieldwork was also conducted at the Randolph Island site (35-CS-17), which has undergone severe erosion in recent decades. In addition to lithics, perishables, including worked wood and antler, were recovered here. Altogether, the sites appear to represent a wide range of cultural activities, though weir fishing and riverbank settlement are best represented.

Age and Settings of Archaeological Fishing Weirs

As noted in the foregoing project descriptions, radiocarbon dating of wooden weir stakes has been undertaken through the last decade of archaeological investigations on the Coquille River. These dates are listed in Table I. Although sampling for radiocarbon dating was initially aimed at exploring chronological variation in weir technology and its development on the Oregon coast, patterns in radiocarbon dated features have provided considerable insight into long term changes in the estuary. These changes form the context for weir construction, maintenance, and abandonment over many generations. Of the 23 radiocarbon dates obtained from weir features, 90% fall between ~1200 and 600 years ago. One outstanding date of 3365 years BP was obtained from a weir in an unusual setting, a tributary channel upriver from most other known sites. This date is nearly one thousand years older than any other yet obtained from a weir on the Oregon coast and is the oldest known weir on the Pacific coast south of Canada (Byram 1998; Moss and Erlandson 1998). So far, only one Coquille weir-related feature has been dated to the last 300 years, a lattice panel at the Osprey site.

Changes in the location of weirs appear to be related to landform changes over time. Within the Coquille estuary there is a general tendency for weirs to be older in the east (upstream) and younger in the west (downstream) (see Table 1, page 71). This pattern is especially evident within certain segments of the riverbank. These riverbank areas are the margins of marshy alluvial lowlands which have been drained for agriculture but still flood during episodes of high runoff in winter. Along the shore of one expansive lowland on the north bank, weirs date to 500 and 550 years BP at the downstream edge (site 35-CS-130 central area). A concentration of 650 BP weirs lies 200 meters upstream from these (eastern CS-130), followed by two weirs from upstream that date to 700 and 750 BP (site 35-CS-1). Upstream from these are several more weirs, three of which have been dated to 800-900 years BP. These weirs are distributed over more than one kilometer of the riverbank (sites 35-CS-159 & 160). Finally, a weir upstream from these has been dated to 1000 BP (eastern edge of 35-CS-160).

A similar situation occurs on the south bank, at site 35-CS-97, which also has an upper intertidal midden component. Five dates have been obtained from stakes in this extensive weir site. The oldest is 1200 BP, and this is also the most upstream of the dated weir features. The youngest, 600 BP, is the most downstream of the dated weirs at this site. Dates between these two features range from 800 to 650 years BP.

Downstream from both the Philpott site and site 35-CS-97, weirs occur in similar wetland strata but do not underlie a buried riverbank soil, though some are capped by marsh. These downstream weirs are for the most part younger than the upstream weirs which underlie the buried soil in the riverbank upstream. The most likely explanation for the apparent shift in weir building over time is that it corresponded to shifts in tidal channel networks. These shifts likely occurred in response to large-scale changes in the estuary relating to geological processes. We will return to the topic of downstream shifts in weir construction following a discussion of recent geological research on landscape history in the Coquille estuary.

Earthquake Hazard Research

In the late 1980s, geologists began uncovering evidence indicating that massive earthquakes occur every five hundred years or so in the Pacific Northwest. These earthquakes occur along the entire Cascadia Coast, the region which extends from Humboldt Bay in Northern California to Vancouver Island, British Columbia. The tectonic consequences of these earthquakes involve sudden vertical shifts in the elevation of the land, and these catastrophic shifts have greatly altered estuary landscapes.

The Cascadia Coast lies at the junction of two of the earth's tectonic plates. Lying under the ocean, the Juan de Fuca plate is moving eastward toward the continent. Where it meets the North American continental plate, the Juan de Fuca plate slides underneath and descends into the earth's mantle. Although the subduction process is very gradual, the massive forces that drive the converging plates cause strain to accumulate at the edge of the North American plate. Over decades this strain causes the edge of the continental plate to bend and rise in elevation. Periodically the strain releases, and the edge of the North American plate rapidly drops downward as much as one to two meters along the coast. The effect is a great earthquake, sudden lowering of the coastline, and corresponding relative sea level rise. The region affected by these earthquakes is termed the Cascadia Subduction Zone (Nelson et al. 1995). The strain accumulation process is known as uplift, and the elevation drop which occurs during an earthquake is termed subsidence.

Investigations by geologists in the 1990s (Nelson 1992; Witter 1999) focused on assessing earthquake hazards in the Coquille estuary. In documenting this earthquake history, geologists uncovered a stratigraphic record which reveals over 6000

One outstanding date of 3365 years BP was obtained from a weir in an unusual setting, a tributary channel upriver from most other known sites. This date is nearly one thousand years older than any other yet obtained from a weir on the Oregon coast and is the oldest known weir on the Pacific coast south of Canada.

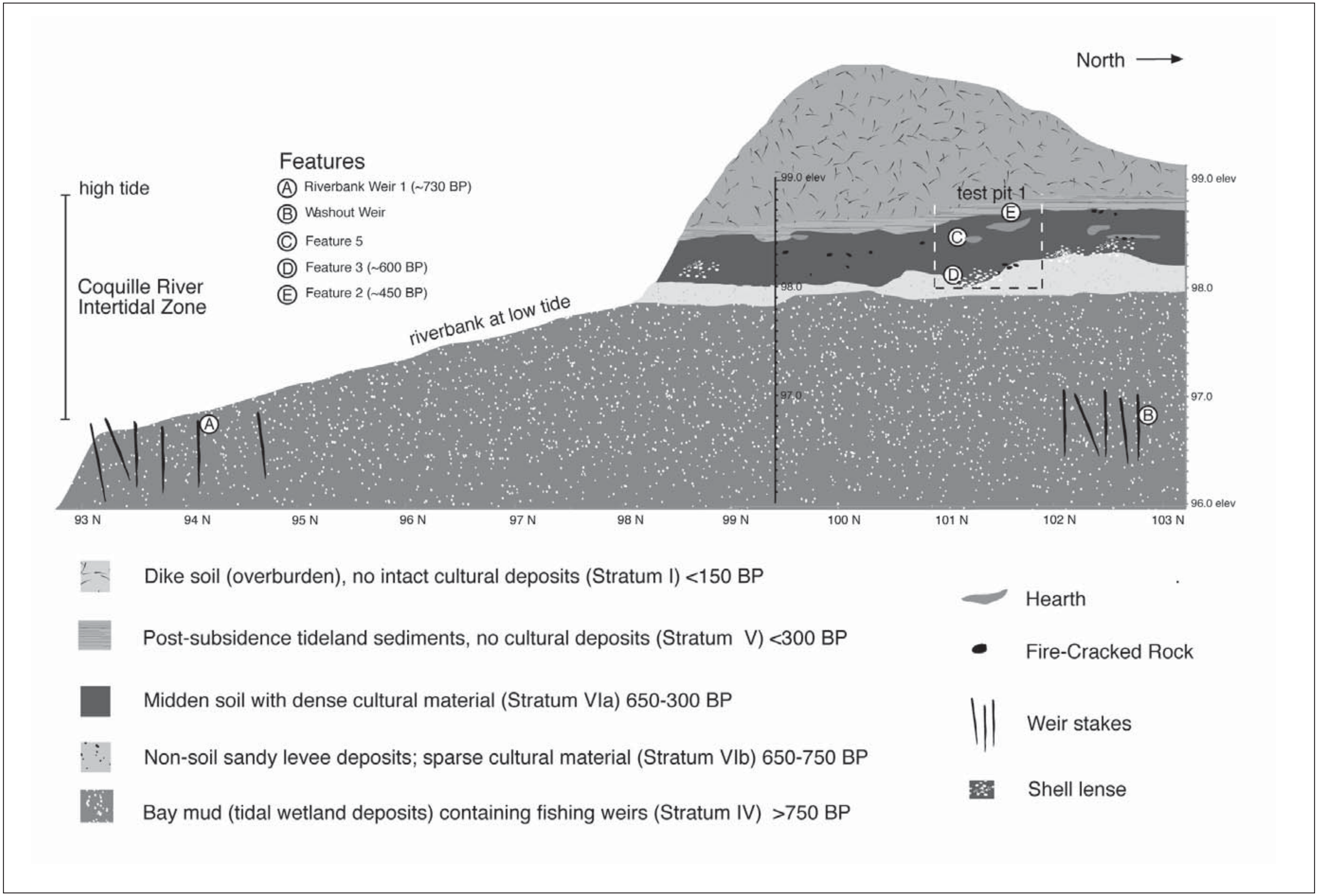


Figure 5. *Composite profile of weirs, hearths, and strata in the western portion of the Philpott site erosional washout. Wooden fishing weir stakes in a tidal wetland stratum (>700 BP) underly the midden stratum (650-300 BP). The two weirs appear to be part of a single weir exposed in both the washout and the riverbank. This stratigraphic sequence, with weirs underlying midden, is present in at least five other Coquille Estuary sites.*

years of landform and sea level change. In 1992, Alan Nelson of the U.S. Geological Survey examined riverbank exposures of the buried soil visible in portions of the lower estuary above Bandon Marsh. This is the soil which contains cultural material at Philpott and several other sites in this area. Nelson obtained radiocarbon dates from buried sedge leaves and a buried tree stump in the riverbank, and based on these he concluded that the soil these plants grew in had been above the intertidal zone until it underwent subsidence during a massive event which occurred along the Cascadia Subduction Zone some 300 years ago (Nelson 1992; Nelson et al. 1995:373). During this event the surface of the Coquille riverbank levee dropped between one and two meters in elevation, which explains why the riverbank soil/midden is now within the intertidal zone.

Investigations by geologists in the 1990s focused on assessing earthquake hazards in the Coquille estuary. In documenting this earthquake history, geologists uncovered a stratigraphic record which reveals over 6000 years of landform and sea level change.

For his doctoral research in geology at the University of Oregon, Witter (1999) investigated a longer record of earthquake history in the Coquille River Valley. He first examined riverbank sediments between Randolph Island and Bullards for buried soils predating the one which subsided 300 years ago. Finding none, he concluded that the riverbank levee soil along much of this shoreline (and which became intertidal 300 years ago) was the first to emerge in this portion of the estuary. Prior to levee formation, the area which is now riverbank was either open bay or tidal flat. To find a longer record of earthquake events Witter looked at marshes which may have been estuary margins in the past. Twelve core samples from Fahys Creek swamp and eight from Sevenmile Creek yielded long stratigraphic records that reach depths greater than 9 meters (Figure 6). Stratigraphy in these marshes shows a sequence of layers alternating between marsh and bay mud over several millennia.

The Sevenmile Creek core samples provided the longest available record of subsidence, uplift, and sea level change in the Coquille estuary. The stratigraphy here records the burial of eleven salt marsh soils over the last 6600 years. (The 300 year old buried soil evident in cutbank exposures along the river was not identified in the Sevenmile Creek locality.) A typical burial sequence includes several centimeters of intertidal mud that contains broken shells of mudflat clams and fossil diatoms (aquatic microorganisms) indicative of tidal flat environments. The mud grades upward into a marsh soil containing diatom assemblages from high marsh and upland environments. The soil is in turn abruptly buried by deposits of sand or mud, in some cases multiple sand beds that fine upwards and contain sparse fragments of diatoms from sand flat environments. The sparse preservation of the diatom fragments suggests the deposit was transported from lower portions of the estuary (c.f., Hemphill-Haley 1995).

These repeated sequences of buried marsh soils appear to represent instances of rapid relative sea level rise that abruptly submerged the marsh, followed by periods of gradual emergence of the marsh as sediment filled the estuary and marsh plants re-colonized the shores (Figure 7). We believe that these instances of sudden relative sea level rise reflect regional coseismic subsidence during great Cascadia earthquakes. In some cases, tsunamis generated by these earthquakes deposited beds of sand in the distal reaches of the estuary. Some sand deposits contained as many as eight fining upward beds, suggesting that the estuary was inundated by several tsunami waves. During the interseismic periods between earthquakes the marsh emerged as sediment rapidly filled the estuary and interseismic uplift influenced a more gradual rate of sea level change.

The alternating marsh to bay mud core sequence documented at Sevenmile Creek and Fahys Creek provides evidence for twelve subsidence-inducing earthquakes with an average recurrence interval of one every 580 years. The elevation drop during these events is estimated at 0.5 meter or more. Many of the dated events overlap with the ages estimated for events documented in other estuaries of the Cascadia coast, suggesting that several prehistoric earthquakes may have ruptured the entire Cascadia Subduction Zone. However, not all parts of the coast have been affected in the same way. Some areas appear to undergo more subsidence than others. Even within the Coquille estuary there appears to be variation in subsidence and uplift rates. The southern edge of the estuary near Bandon may undergo less subsidence during earthquakes than the northern portion of the lower estuary. This may relate to the presence of the Coquille fault, which extends offshore from the Coquille river mouth northwest along the floor of the Pacific, or to shifts in an upper plate fold which underlies the region (McInelly and Kelsey 1990; Witter 1999:93-96, 105-109).

Long-Term Changes in the Coquille Estuary

The Coquille estuary has undergone substantial changes due to sea level rise, subsidence, and uplift. The geological core samples from the Coquille River area allow us to model relative sea level change and sediment accumulation within the estuary. During the early Holocene (11,000-8000 years ago) global sea levels rose from more than 50 to less than 20 meters below today's level, and the portion of the Coquille Valley now tidally influenced was likely drained by a non-tidal, freshwater river. We do not know exactly when the Coquille estuary began to form in its current location, but the core samples from Sevenmile Creek indicate that this part of the valley was under tidal influence by 7000 years ago, when sea level was approximately seven meters below its current level in the estuary. The actual shoreline at that time can only be estimated based on the valley's topography and the stratigraphic record at localities such as Sevenmile and Fahys creeks, but the estuary may have appeared as depicted in Figure 8b. Global sea-level rise following the most recent glaciation caused rapid sea-level rise in the estuary before 3500 years ago (Figure 7). The rate of sea-level rise at the Coquille estuary slowed after 3500 years ago due to a decrease in the rate of global sea-level rise (Witter 1999:95-96).

The decrease in the size of the estuary since 3500 years ago is due to a combination of reduced rates of global sea-level rise and continued infilling sedimentation in the estuary. Infilling occurs as runoff from precipitation washes sediments from slopes into streams or their flood plains, and eventually the main river. Sediments are eventually transported downstream to the estuary, and where the river reaches sea level it becomes influenced by tides. Tidal influence causes a major change in the river's current. Although tidal force is very strong, tidal currents move slowly in comparison with freshwater stream currents during high runoff. The result is that sediments carried down river slow and settle when they reach the estuary (Simenstad 1983:18-21). Tons of new sediment wash into the estuary every year. Much of the coarser material settles-out near the bank, forming a natural levee along both banks of the river. Finer materials remain suspended longer, and these settle throughout the intertidal zone and flooded lowlands of the river valley. Infilling may also occur as sediments are moved into the lower estuary from the ocean shore by tsunamis, storm surges, and dune building. Gradual uplift in the period between earthquakes may also reduce the size of the estuary, but this effect is temporary, being offset by episodic subsidence during the earthquakes.

Although we currently lack radiocarbon dated cultural material from the 7000-3500 BP period, weirs may have been built along the margins of the emerging Coquille estuary at this time. It is significant that the oldest dated weir (3370 years BP) is from the time when the rate of sea-level rise slowed. Unlike other known Coquille weirs, this feature is located in a tributary channel over one kilometer from the main river. It was likely built when the estuary shore extended to the vicinity of the weir. It is also worth noting that the two earliest radiocarbon dates from residential sites near the Coquille estuary are of comparable age, 3170 BP from the Bussmann site (CITCRP 1999) and 3550 RYBP (radiocarbon years before present) from Nah-so-mah village at Bandon (Hall, this volume; Hall and Radosevich 1995). The Bussmann site is on a bluff at the northern edge of a large alluvial lowland that once was bay. Gaper clam (Tresus sp.) in the Bussmann site

Table 1. Radiocarbon Dates from 1995-1999 Coquille Investigations

Calibrated ages (rounded to the nearest 10-year increment) are derived from Stuiver and Reimer (1993); dating performed by Beta Analytic Labs and shown at 1σ.Weir dates are arranged upstream to downstream for each bank.

Site	Weir Feature	Uncalibrated Age (RYBP)*	Calibrated Age BP	Beta Lab Number	Referenced Report
North Shore Coquille Estuary					
35-CS-176	1	1010 ± 60	960 (930) 800	134318	CITCRP 1999
35-CS-17	1	810 ± 60	790 (720) 670	134322	CITCRP 1999
35-CS-108	1	860 ± 60	880 (740) 690	132215	Erlandson et al. 1999
The following north shore sites occur along the shore of a single lowland area. They show a gradation from older upriver weirs to younger down river weirs.					
35-CS-160	10	1120 ± 50	1070 (1040) 960	124338	CITCRP 1999
	3	960 ± 50	930 (810) 790	124337	CITCRP 1999
35-CS-159	8	990 ± 60	960 (930) 800	124339	CITCRP 1999
	3	960 ± 50	930 (810) 790	124340	CITCRP 1999
35-CS-1	1	850 ± 70	880 (740) 680	106993	Byram et al.1997
	2	800 ± 60	740 (690) 670	106992	Byram et al. 1997
35-CS-130	E1	660 ± 50	660 (650) 560	72791	Byram and Erlandson 1996
(East)	E1	670 ± 50	670 (650) 610	72790	Byram and Erlandson 1996
(East)	E2	790 ± 60	690 (650) 610	86017	Byram and Erlandson 1996
(Central)	C1	600 ± 70	650 (560) 540	88466	Byram and Erlandson 1996
(Central)	C2	400 ± 60	510 (480) 320	88465	Byram and Erlandson 1996
The western portion of the site 35-CS-130 lies beyond the shore of the lowland.					
35-CS-130					
(West)	W1	940 ± 50	930 (830) 760	74746	Byram and Erlandson 1996
South Shore Coquille Estuary					
35-CS-168	2	910 ± 50	920 (790) 740	134320	CITCRP 1999
35-CS-167	1	3180 ± 70	3450 (3370) 3280	134321	CITCRP 1999
Weirs at site 35-CS-97, below, occur along a single lowland margin. Here, too, the downriver weirs are younger than the upriver weirs.					
35-CS-97	10	1260 ± 60	1260 (1180) 1080	134323	CITCRP 1999
	12	970 ± 60	950 (810) 790	132214	Erlandson et al. 199
	18	740 ± 60	690 (670) 660	134317	CITCRP 1999
	30	970 ± 60	950 (810) 790	134324	CITCRP 1999
	25	610 ± 60	660 (600) 540	132213	Erlandson et al. 1999
35-CS-116	1	690 ± 60	670 (660) 560	134325	CITCRP 1999
Dates from Other Objects					
35-CS-97	lattice	990 ± 70	960 (930) 800	134319	CITCRP 1999
35-CS-1	hearth	460 ± 90	540 (510) 340	106991	Byram et al. 1997
	shell	610 ± 80	680 (630) 540	106990	Byram et al. 1997
35-CS-130	lattice	180 ± 50	280 (150) 0	111760	CITCRP 1999
35-CS-158	shell	3090 ± 90	3320 (3170) 3020	124336	CITCRP 1999

*Radiocarbon Years Before Present (i.e., before AD 1950).

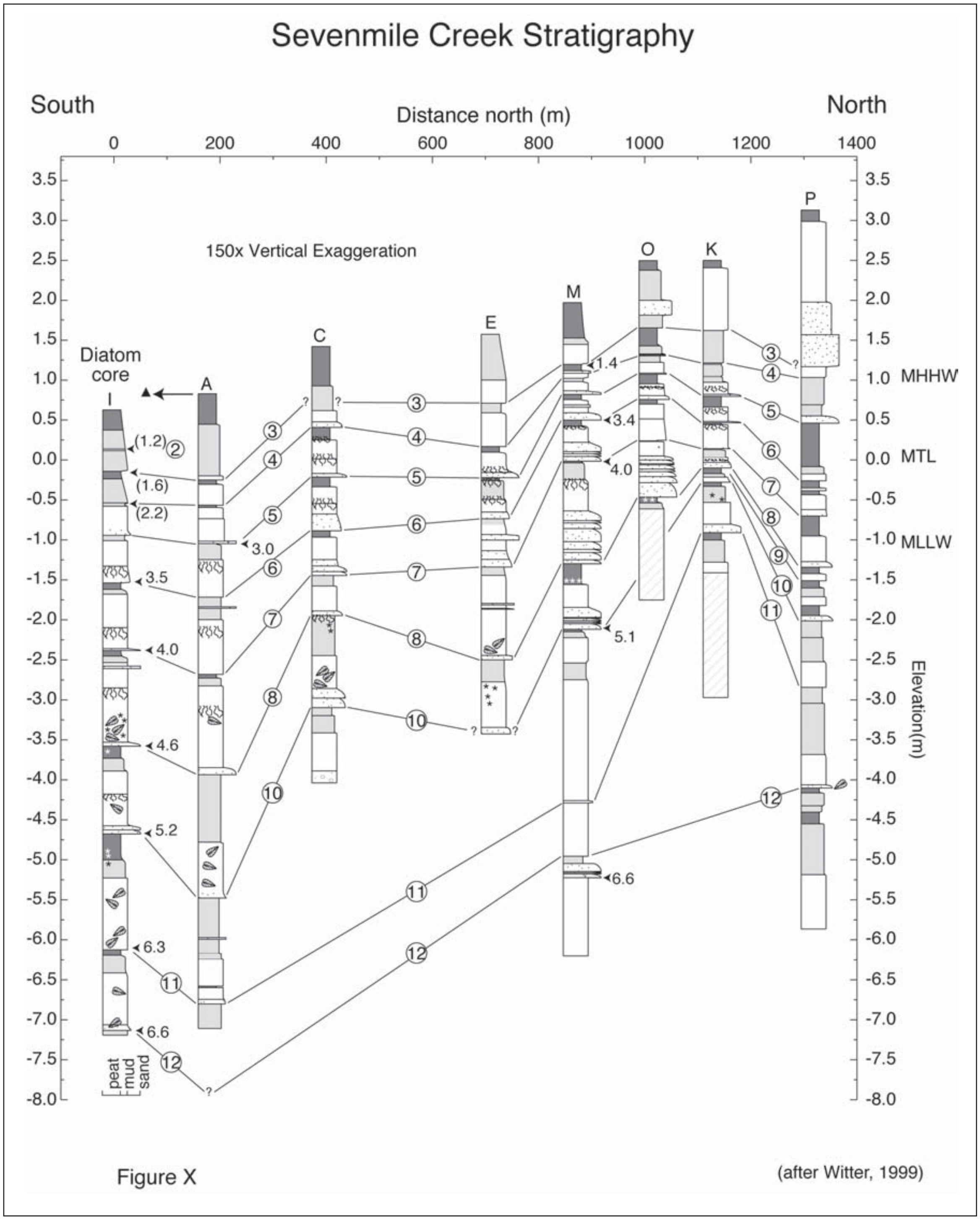
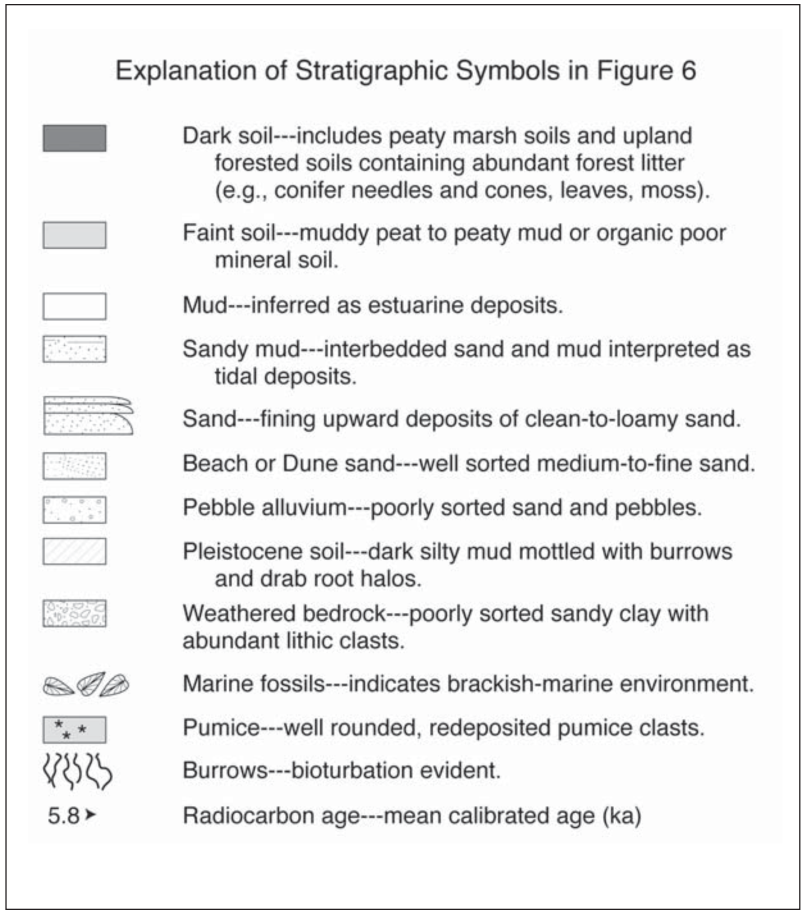


Figure 6. *Stratigraphy of Sevenmile Creek. Circled numbers correspond to abruptly buried soils capped by sandy mud that indicate widespread submergence of the estuary. For buried soils 8-12, brackish marine fossil shell material (*Macoma *spp.) preserved in the mud overlying intertidal marsh soils records several decimeters to perhaps 1-2 meters of sudden relative sea-level rise. Rounded pumice clasts, probably reworked from tephra deposits in the Coquille headwaters, aided in correlation of the buried soils. Refer to the stratigraphic key (opposite page) for explanation. Black triangle below core A indicates position of core site with respect to distance north. Elevations based on survey with an electronic theodolite (±0.05 m closure error) tied to U.S. Coast and Geodetic Survey tidal benchmarks. MHHW, mean higher high water; MTL, mean tide level; MLLW, mean lower low water (NOS 1992). After Witter (1999)*



assemblage is also indicative of an open bay and tidal flat setting, different from today's estuary. The presence of a midden over 3,000 years old at Nah-so-mah village also seems reasonable because the Bandon area, as noted above, is adjacent to a part of the estuary thought to have undergone less subsidence than other parts of the estuary. Earlier shoreline residential sites throughout the lower estuary may be buried beneath sediments brought into the estuary during the period of more rapidly rising sea level.

Today, most of the intertidal area exposed at low tide in the Coquille estuary occurs within 15 kilometers of the coast. Here the estuary consists of a small bay, expansive tidal flats, and tidal marsh and alluvial lowlands bordered by the riverbank levee. These down-river progradational environments reflect the history of a larger Coquille estuary in the past. Once a more expansive bay, infilling began outpacing sea-level rise 3500 years ago, and tidal flats and salt marshes emerged along the margins of the lower estuary. In the upper estuary marsh surfaces were buried, forming marshy alluvial lowlands, and the riverbank levee grew in height and length, encroaching toward the river mouth (c.f., Kelsey et al. 1998).

Radiocarbon dates from weirs and midden soils along a portion of the Coquille estuary north bank document the process of marsh emergence, alluvial lowland development, and riverbank levee formation over five centuries, from 1100 to 600 years ago. Figure 9 is a model of these changes based on modern topography, wetland core sampling, and archaeological features and radiocarbon dates from weir and midden sites. It appears that on this part of the riverbank, Coquille fishing stations were rarely maintained in a single location for more than a few generations. This model projects riverbank development at a rate of over 200 meters per century. Networks of tidal channels shifted downstream as the estuary gradually infilled toward the river mouth.

Shifts in tidal channels are unlike shifts in non-tidal stream channels. Typical stream channels have banks of coarse sand and gravel which undermine and collapse, causing the channel to meander. In contrast, tidal channels form in cohesive, fine muddy sediments more resistant to lateral erosion. Lacking a source of new sediment, tidal channels can last for centuries in the same location. Yet the mouths of tributary channels in the Coquille estuary coincide with a developing riverbank levee, and overbank sedimentation - along with the presence of weir structures that trapped sediments - most likely caused these channels to fill within decades of their initial formation. As one outlet filled, another outlet farther downstream was formed or expanded; as weirs became buried in the old channel people built new weirs in the new outlet to the wetland.

Environmental Change and Coquille Communities

The Sevenmile Creek core samples provided the longest available record of subsidence, uplift, and sea level change in the Coquille estuary.

Earthquakes and Tsunamis

It is difficult to estimate the full effect Cascadia Subduction Zone earthquakes and related tsunamis may have had on Native communities, but it must have been severe. The AD 1700 earthquake was in the range of magnitude 9 on the Richter scale (Nelson et al. 1995), and earlier events may have also been massive. When an earthquake of comparable size struck the coast of Alaska in 1964, the consequences were disastrous (Pflaker 1965). Many lives were lost, and structures were destroyed by ground movement and tsunamis. The impacts outlined by Losey et al. (this volume) for Northern Oregon coast estuaries could also have affected residents of villages along Coquille estuary shores. For people residing in villages closest to the ocean, the effects would have been devastating, while farther upstream the effects may have been less severe.

There is archaeological evidence for impacts to some Coquille villages during the most recent Cascadia earthquake at several of the riverbank sites. By 700 years ago, in places where the riverbank levee had emerged sufficiently, people had taken advantage of the high ground for work areas and probably seasonal resi-

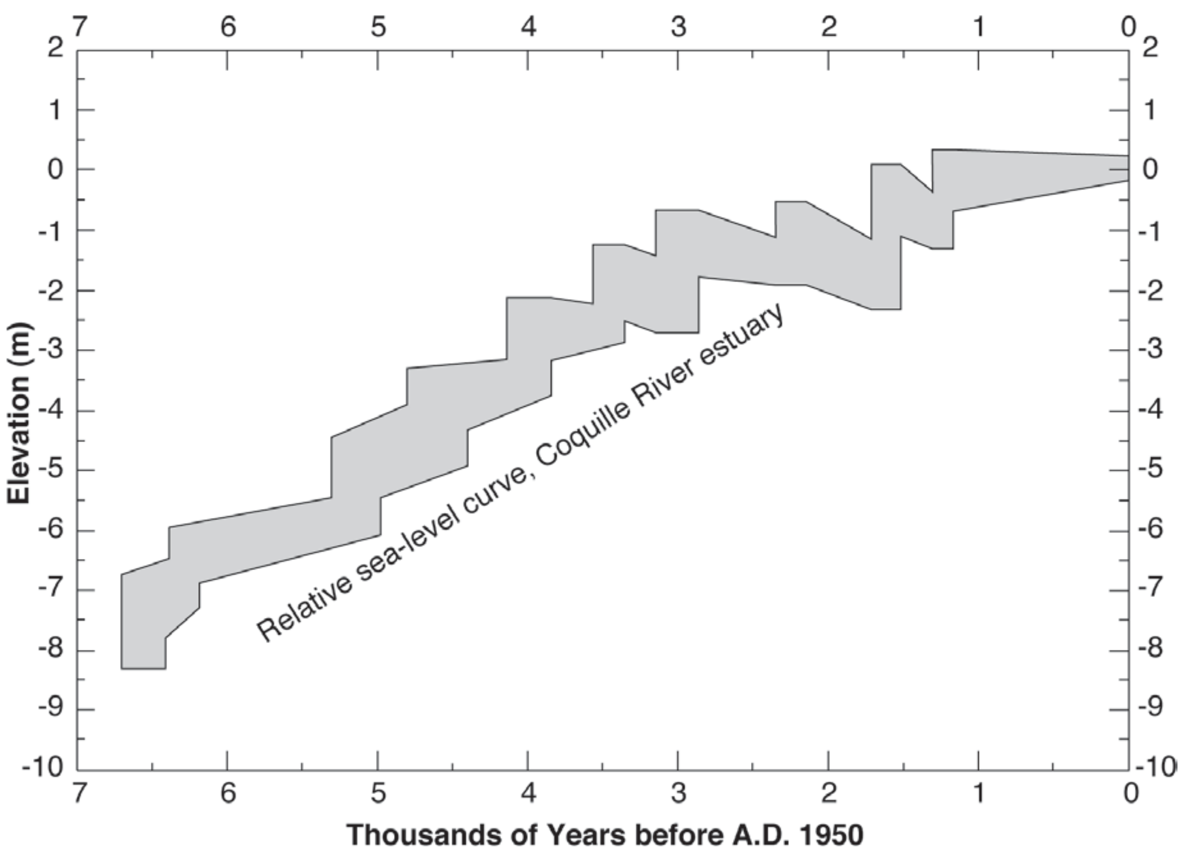


Figure 7. *Relative Sea-Level Curve. This relative sea-level curve traces the paleo-elevation of sea-level with respect to a fixed elevation datum through time in the Coquille estuary. The curve tracks mean tide level (MTL) specifically, based on peat-mud contacts, diatom assemblages, and radiocarbon data. Instantaneous relative sea-level rise indicated by the peat mud contacts appears as abrupt upward zigs in the curve and these likely record instances of coseismic subsidence. The more gradual zags in the curves indicate times where relative sea level change was gradual or where the trend of relative sea-level change may have reversed. These parts of the curve represent interseismic periods between earthquakes. The band width of the relative sea-level curve incorporates error related to the estimation of intertidal zones indicated by fossil diatom assemblages and error attributed to the radiocarbon age of the peat mud contact. (after Witter, 1999)*

dence near fishing weirs. The dense cultural material at locations such as the Philpott site demonstrates that riverbank sites were very heavily used for many generations. These sites were likely abandoned 300 years ago after they dropped into the intertidal zone during subsidence. Yet it is not clear that these subsided riverbank villages were occupied during winter, when the last massive earthquake is thought to have occurred (Satake et al. 1996). Whether or not people were at these villages during the earthquake, the flooded sites could not have been used residentially after this time.

Further archaeological evidence of the effects of earthquakes comes from a site near the mouth of the river. Hall and Radosevich (1995; Hall, this volume) have proposed that the Nah-so-mah village site at Bandon, periodically occupied between 3500 BP and 100 years ago, was abandoned after flooding events possibly associated with earthquake-induced tsunamis.

Accounts of the AD 1700 earthquake and tsunami may be preserved in the oral history of the Coquille Indians or the nearby Hanis Coos. Earthquakes are mentioned in some stories, but these provide little detail on damage to villages. In contrast, the stories which describe a great flood coming in from the ocean tell of substantial impacts in coastal communities. In one story told by Annie Peterson (Jacobs 1939) several people were swept away by a tsunami as punishment for being disrespectful to the salmon. This story was told as a lesson, and is not clearly connected with a specific historical event. "Now water (a tidal wave) rushed in...So all those people drifted away. Pretty near all the people were gone."

In another of Peterson's texts, she recounts a story of an historic tsunami:

> All the people dashed towards their canoes, and those people who were still running afoot were all caught by the water (and drowned). When the water went back it returned slowly. Then many people were saved....After that when the people were out hunting they found canoes that were just nothing but moss, moss and dirt. Their paddles just hung from them wherever they (the canoes) had dropped (when the waters receded). They never learned what had become of (those people who had tried to escape in the now empty canoes). (Jacobs 1939:58-59)

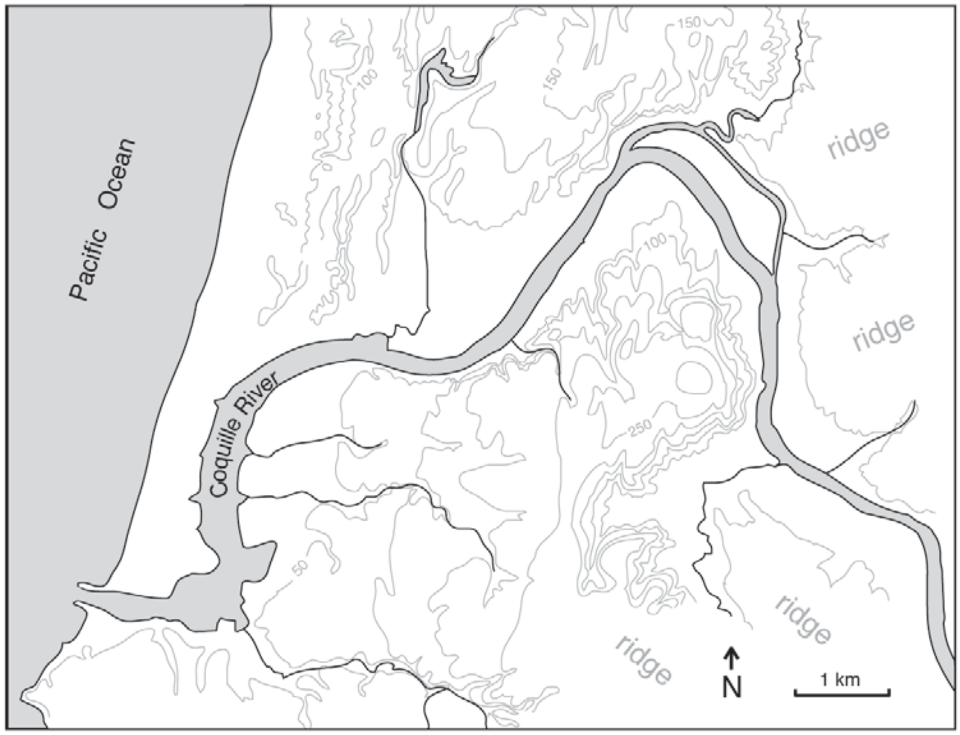
Mrs. Peterson also recalled that her grandfather, Minkwis, had as a young man met an old woman who long before had survived this great flood from the ocean. She had clung to branches high up in a tree as the waters receded, but severely injured her back in a fall while trying to climb down. Minkwis was probably born in the late 1700s, and the tsunami described may be the event associated with the AD 1700 earthquake.

It is significant that the oldest dated weir (3370 years BP) is from the time when the rate of sea-level rise slowed.

Another Hanis Coos elder, Lottie Evanoff, contributed accounts of a massive flood at Coos Bay which came from the ocean and "sank" most of the land (Harrington 1942:reel 23:951, reel 24:124). The only part of the land which did not sink was the area near the modern town of Glasgow, on the northeast shore of Coos Bay. A similar account was given on a separate occasion by Coos elder Jim Buchanon (Frachtenberg 1913). "The earth sank into the water. Wherever a small (piece of land) was sticking out, there they went." Elsewhere, Mr. Buchanon related that many people relocated further inland after the flood (Jacobs 1933:156). These two accounts appear to describe widespread subsidence as well as tsunami flooding.

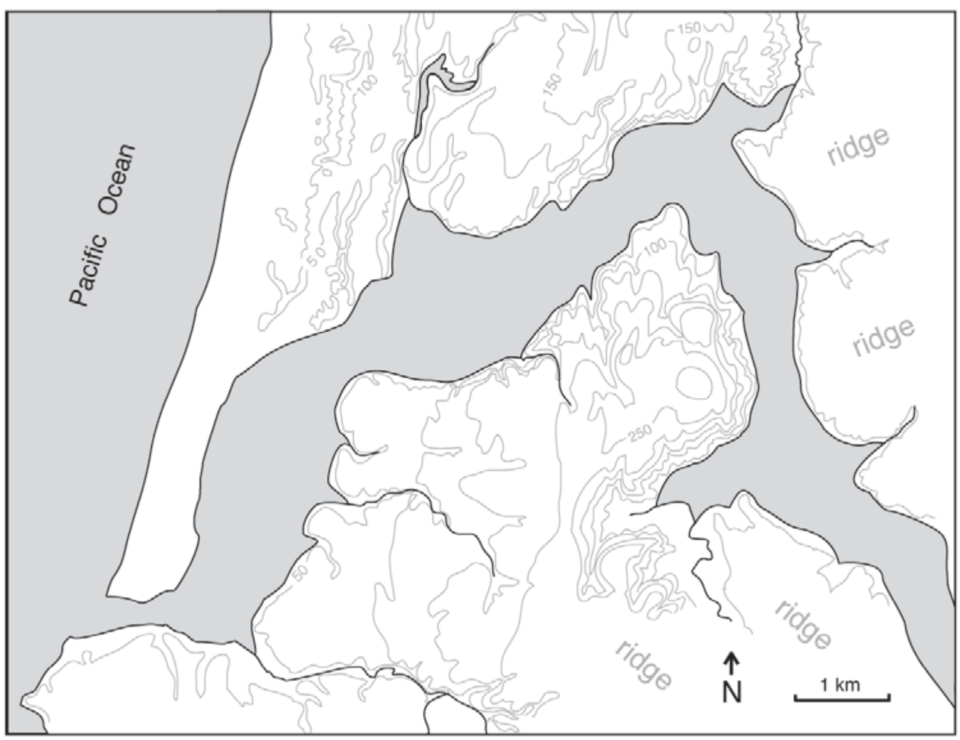
Stories of a great flood are still told by the Coquille people. In these accounts many lives were lost during the flood, but those who sought high ground or reached their canoes in time were saved (George Wasson, personal communication, 1999).

Although much Coos/Coquille oral history has been lost due to the effects of American settlement and the passing of native language speakers, available accounts indicate that in the past a devastating tsunami flooded the heavily populated shores of the Coos and Coquille estuaries. These accounts do not



Today's Lower Coquille Estuary

Figure 8a. *The modern extent of the lower Coquille estuary (at mean tide level).*



The Estuary ~4000 Years Ago

Figure 8b. *The former extent of the estuary during a period of more rapid sea-level rise, estimate based on core sequences from Sevenmile and Fahys Creeks, and modern topographic maps.*

describe a forceful impact from a large wave, as may have occurred along the outer coast. Instead, they indicate the tsunami came into the estuary as a massive swell which flooded low-lying areas, including several villages. During the flood much of the land sank, and afterward some of the people had to move inland from their former homes. For the people of this portion of the Oregon coast, this tsunami flood is one of the greatest natural disasters recounted in oral history, and its effects on coastal communities appear to have been severe.

Wetland Emergence and Shifting Land Use

Although less devastating than tsunamis and subsidence, sea level change and infilling brought even greater changes to the Coquille estuary over centuries and millennia. As the sea level rose during the early and middle Holocene, emergent marshes and high riverbanks common in the estuary today would have been more ephemeral, as sea level rise was outpacing infilling. Shoreline settings suitable for residential use may have been present in what is now the upper estuary, closer to the head of tide, but they may have been rare along the shore of the lower estuary. From 7000 to 3500 years ago the lower portion of the Coquille Valley was a deep bay surrounded by bluffs and upland terraces (Figure 8b). Lower river valley villages and camps may have been located in these upland areas, or in more dynamic dune settings near the mouth of the estuary.

The remains of many early shoreline sites may now be buried under meters of bay mud and marsh sediments, but initial investigations at one upland terrace site on the margins of the lower Coquille estuary indicate these settings were occupied over 3000 years ago (CITCRP 1999). Similarly, it appears that high ground at the modern town site of Bandon was occupied between 3000 and 4000 years ago (Hall, this volume). It is not clear if villages had to be abandoned due to sea level rise during the middle Holocene, but this would have been so for sites located close to the estuary shore. It is likely that abandonment of these villages would have been triggered by subsidence events in some cases.

Although many questions remain about the effects of subsidence and sea-level change on village sites, the relationship between these environmental changes and Coquille fishing systems is becoming clearer. In some parts of the estuary earthquake-induced subsidence may have actually improved some conditions for the Coquille economy by rejuvenating the estuary and reestablishing channels in silted-in tidelands, thereby expanding fish habitat and deepening boat transportation corridors. Archaeological evidence shows that people took advantage of changes in the Coquille wetlands, maintaining weirs for generations then rebuilding them in new locations as conditions changed.

It is also likely that some Coquille estuary changes were partly the result of people using weir structures to alter the wetland landscape, improving fishing habitat and making weir fishing systems more efficient. Resource management involving conservation and enhancement is a longstanding tradition among Native communities in the Northwest, and this approach was used in several subsistence activities. Most well known is the use of fire to manage the botanical landscape (Boyd 1999). Considering the rate of riverbank change indicated by radiocarbon dated weirs (Figure 9), it seems the people who used these weirs would have been well-aware of their effects as sediment traps in tidal channels. The rapid rate of riverbank accretion and shifting weir locations in a downstream direction may result, in part, from planned sediment trapping intended to expand the extent of wetlands in this part of the estuary, thereby improving fish habitat and resource productivity. This activity may have been most intense approximately 800 years ago, when patterns in dated weirs indicate tidal channel shifts of over one kilometer along the north bank in a time span of just a few generations. The possible use of weirs in wetland enhancement could be explored through further research at Coquille wetland sites.

"Now water (a tidal wave) rushed in...So all those people...drifted away. Pretty near all the people were gone."

—Annie Peterson 1939

There is archaeological evidence for impacts to some Coquille villages during the most recent Cascadia earthquake at several of the riverbank sites.

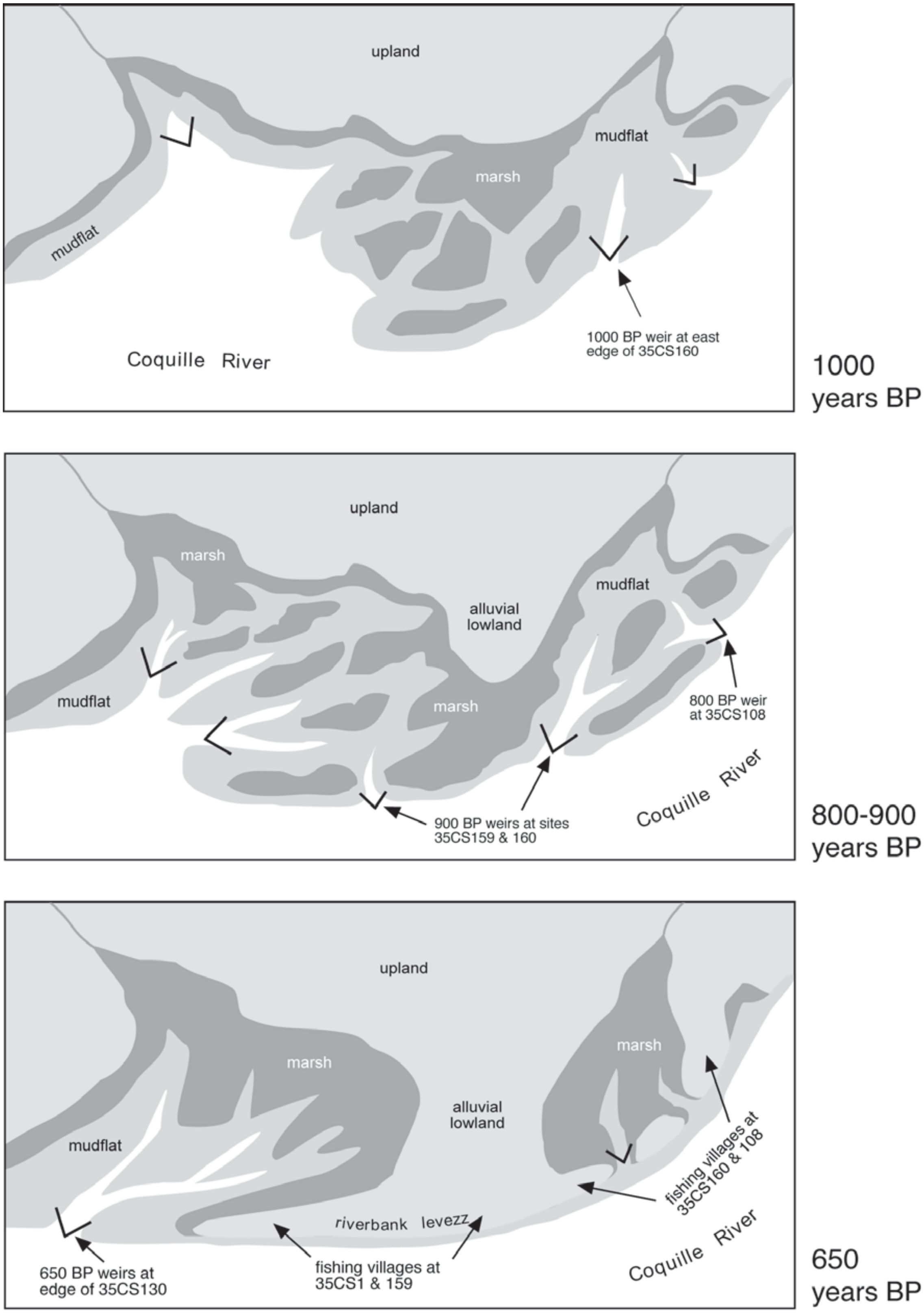


Figure 9. *Model of marsh emergence and riverbank/alluvial lowland development based on stratigraphic profiles and radiocarbon dates from archaeological sites on a portion of the lower Coquille estuary shore. Arrows mark confirmed weir and midden features.*

Conclusion

Thanks to the collaborative and interdisciplinary efforts of the Coquille Indian Tribe Cultural Resources Program and University archaeologists and geologists, we now have a better picture of long-term landscape change and cultural history in the wetlands of the Coquille estuary. As they have in the past, Coquille tidewater fishing weirs are again contributing to Coquille society, not in economic terms as before, but as tangible links to the region's cultural and environmental heritage. These wetland sites and nearby marsh sediments tell a piece of the story of thousands of years of Coquille history. This is a story of persistent change and periodic catastrophe, but through it all the people of the Coquille estuary maintained their livelihood and continued to rebuild their communities. Their determination is a testament to the richness and abundance of the Coquille estuary.

Wetlands management may be as important today as it appears to have been in the past. The preservation of Coquille wetland archaeological sites is a growing concern as the estuary continues to decrease in size due to ongoing infilling, draining of wetlands for agricultural use, and related channel bank erosion. Site conservation depends on preservation of the wetland settings where sites are formed, and restoration of historic tidewater habitats may prove a worthwhile step in the ongoing management of this important dimension of Coquille Tribal heritage. The recent creation of the Ni-les'tun Unit of the Bandon Marsh National Wildlife Refuge sets the stage for the restoration of significant parts of the Coquille estuary and preservation of several important sites. Preservation of sites in other localities will depend on the continued stewardship of the Coquille Indian Tribe and its collaborators, as well as public support.

These wetland sites and nearby marsh sediments tell a piece of the story of thousands of years of Coquille history. This is a story of persistent change and periodic catastrophe, but through it all the people of the Coquille estuary maintained their livelihood and continued to rebuild their communities.

Acknowledgements

Dozens of people have contributed to Coquille wetlands archaeological and geological work, though only a few can be mentioned here. Donald Ivy, program coordinator for the CITCRP, led several field projects and continues to oversee site stewardship for the Coquille Tribe. Jon Erlandson, Byram's dissertation advisor, and Professor Madonna Moss and Mark Tveskov are university faculty who initiated much of the research at Coquille wetland sites. Harvey Kelsey, professor of geology at Humboldt State University, chaired Witter's Ph.D. committee and conducted fieldwork on the Coquille. Eileen Hemphill-Haley of the U.S. Geological Survey and the University of Oregon Department of Geology provided paleoecological data. Robert Losey, in addition to editing this article, participated in Coquille archaeological work along with geoarchaeologist Charles Hodges. Patty Whereat and George Wasson provided Coos and Coquille tribal oral history. Coquille Tribal staff and Tribal members who participated include Jason Younker, Denise Mitchell, Julie Chouquette, Chris Tanner, Michele Burnette, Jerry Running Foxe, Sharon Parrish, Judy Rocia, and many others. Several students from the University of Oregon, Oregon State University, and Southern Oregon University also participated. Collaboration with agency representatives has facilitated research as well as site protection, and we would like to thank the U.S. Fish and Wildlife Service, the State Historic Preservation Office, Oregon State Museum of Anthropology, the Archaeological Conservancy, the Port of Bandon, and the Bureau of Land Management. Funding for this research was provided by the Coquille Indian Tribe, the National Park Service Historic Preservation Fund, the State Historic Preservation Office, the U.S. Geological Survey, Geological Society of America, and the National Science Foundation.

References Cited

Benner, Patricia

1991 Historical Reconstruction of the Coquille River and Surrounding Landscape. *In* Near Coastal Water Pilot Project Report. Portland: Oregon Department of Environmental Quality.

Byram, Scott

1998 Fishing Weirs in Oregon Coast Estuaries. *In* Hidden Dimensions, the Cultural Significance of Wetland Archaeology. Kathryn Bernick, ed. Pp. 199-219. University of British Columbia Laboratory of Archaeology Occasional Papers 1, Vancouver, B.C.

Byram, Scott, and Jon Erlandson
1996 Fishing Technologies at a Coquille River Wet Site: The 1994-95 Osprey Site Archaeological Project. On file at the Oregon State Historic Preservation Office, Salem, Oregon.

Byram, Scott, Mark Tveskov, Jon Erlandson, Charles Hodges, and Robert Witter
1997 Research in Response to Erosion at the Philpott Site, Coquille Estuary. Report prepared for the Coquille Indian Tribe Cultural Resources Program, Coos Bay, Oregon.

CITCRP (Coquille Indian Tribe Cultural Resource Program)
1999 Coquille River Archaeological Mapping Project Final Report, HPF-41-98-NA-4110. On file at the offices of the Coquille Indian Tribe, North Bend, Oregon.

Draper, John A.
1982 An Analysis of Lithic Tools and Debitage from 35CS1: A Prehistoric Site on the Southern Oregon Coast. TEBIWA 19:47-79.

Erlandson, Jon M., R. Scott Byram, Robert J. Losey, and Mark A. Tveskov
1999 Oregon Coast Archaeological Survey: Summary of 1998-1999 Historic Preservation Fund Grant Activities (HPF-9808). Salem, OR: State Historic Preservation Office.

Erlandson, Jon M., and Madona L. Moss
1999 The Systematic Use of Radiocarbon Dating in Archaeological Surveys in Coastal and Other Erosional Environments. American Antiquity 64(3):431-443.

Frachtenberg, Leo J.
1913 Coos Texts. Columbia University Contributions to Anthropology Vol. I. New York: Columbia University Press.

Hall, Roberta and Stephan Radosevich
1995 Episodic Flooding of Prehistoric Settlements at the Mouth of the Coquille River. Oregon Geology 57(1):18-22.

Harrington, John P.
1942 Reel 23, Notes of Interviews with Alsea, Siuslaw, and Coos Informants. John Peabody Harrington Papers, Alaska/Northwest Coast, Microfilm Reel 23. Edited by Elaine Mills. National Anthropological Archives, Smithsonian Institution, Washington D.C.

Hemphill-Haley, Eileen
1995 Diatom Evidence for Earthquake-Induced Subsidence and Tsunami 300 Years Ago in Southern Coastal Washington. Geological Society of America Bulletin, 107:367-378.

Hodges, Charles
1997 Field notes and stratigraphic profile diagrams from the Philpott archaeological site (35CS1), Coquille River. Copies in possession of Scott Byram.

Jacobs, Melville
1933 Coos Ethnographic Notes, Notebook 92, Melville Jacobs Collection. University of Washington Libraries, Seattle.

1939 "Salmon Did Ill to Boys," in Coos Narrative and Ethnologic Texts. University of Washington Publications in Anthropology 8(1):1-126.

Kelsey, Harvey M., Robert C. Witter, and Eileen Hemphill-Haley
1998 Response of a Small Oregon Estuary to Coseismic Subsidence and Postseismic Uplift in the Past 300 Years. Geology 26(3):231-234.

McInelly, G.W., and H. M. Kelsey
1990 Late Quaternary Tectonic Deformation in the Cape Arago-Bandon Region of Coastal Oregon as Deduced from Wave-Cut Platforms. Journal of Geophysical Research 95:6699-6713.

Monaco, M. E., R.L Emmett, D. M. Nelson and S. A. Hinton
1990 Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volumes I and II. ELMR Report No. 4 NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD, 232 pp.

Moss, Madonna and Jon Erlandson
1994 An Evaluation, Survey, and Dating Program for Archaeological Sites on State Lands of the Southern Oregon Coast. Report on file, State Historic Preservation Office, Salem, Oregon.

1998 A Comparative Chronology of Northwest Coast Fishing Features. *In* Hidden Dimensions, the Cultural Significance of Wetland Archaeology. Kathryn Bernick, ed. Pp. 180-198. University of British Columbia Laboratory of Archaeology Occasional Papers 1, Vancouver, B.C.

Nelson, Alan R.
1992 Discordant 14C Ages from Buried Tidal-Marsh Soils in the Cascadia Subduction Zone, Southern Oregon Coast. Quaternary Research 38:74-90.

Nelson, Alan R., Brian F. Atwater, Peter Bobrowsky, Lee-Ann Bradley, John J. Clague, Gary A. Carver, Mark E. Darienzo, Wendy C. Grant, Harold W. Krueger, Roger Sparks, Thomas W. Stafford Jr. and Minze Stuiver.
1995 Radiocarbon Evidence for Extensive Plate-Boundary Rupture About 300 Years Ago at the Cascadia Subduction Zone. Nature 378(23):371-374.

Pflaker, G.
1965 Tectonic Deformation Associated with the 1964 Alaska Earthquake. Science 148:1675-1687.

Proctor, Charles M., John Garcia, David Galvin, Gary Lewis, Lincoln Loehr, and Alison Massa
1980 An Ecological Characterization of the Pacific Northwest Coastal Region. Volume 2: Characterization Analysis, Regional Synopsis. Prepared for the U.S. Fish and Wildlife Service Office of Biological Services, U.S. Dept. of the Interior, Portland, Oregon.

Satake, K., K. Shimazake, Y. Tsuji, and K. Ueda
1996 Time and Size of a Giant Earthquake in Cascadia Inferred from Japanese Tsunami Records of January, 1700. Nature 379:246-249.

Simenstad, C. A.
1983 The Ecology of Estuarine Tidal Channels of the Pacific Northwest Coast: A Community Profile. U.S. Fish and Wildlife Service FWS/OBS-83/05, 181pp.

Stuiver, M., and P.J. Reimer
1993 Extended 14C Database and Revised CALIB 3.0 14C Age Calibration Program. Radiocarbon 35:215-230.

Tveskov, Mark A.
2000 The Coos and Coquille Indians: A Historical Anthropology of the Northwest Coast. University of Oregon Department of Anthropology Ph.D. dissertation, University Microfilms, Ann Arbor, Michigan

Witter, Robert C.
1999 Late Holocene Paleoseismicity, Tsunamis and Relative Sea-Level Changes Along the South-Central Cascadia Subduction Zone, Southern Oregon, U.S.A. University of Oregon Department of Geology Ph.D. Dissertation, University Microfilms, Ann Arbor.