Use of Radiocarbon Dating and Dendrochronology to Investigate a Submerged Forest in Eld Inlet

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Abstract

We use evaluation of historic maps and photographs, field investigations, and a combination of carbon dating and tree-ring analysis of exposed snags in Mud Bay (Eld Inlet) to test the evidence for, and possibly date subsidence in this estuary, 5 mi west-northwest of Olympia, Washington.

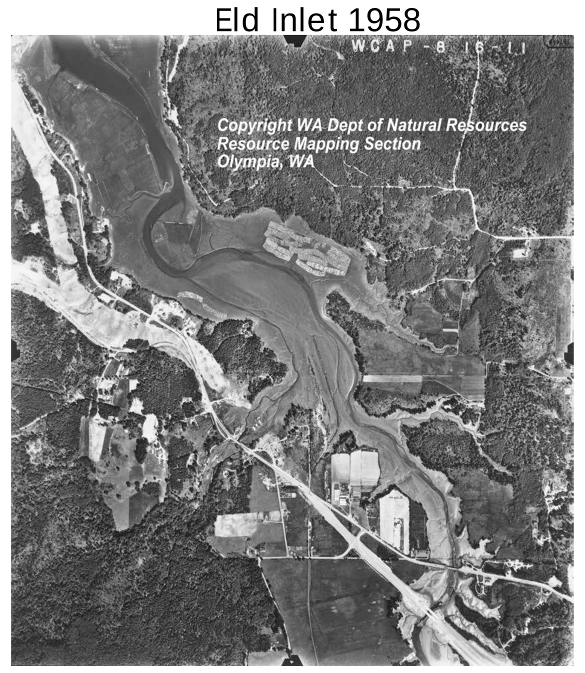
Studies of submerged forests in Puget Sound by previous researchers show evidence of subsidence, possibly caused by movement along shallow crustal faults that intersect the south Puget Lowland (Gower et al, 1985; Sherrod, 2001). The discovery of a submerged Squaxin Island tribal village site of Qwu?gwes in Mud Bay provided early evidence of submergence at Mud Bay (Croes and others, 2005). Carolyn Garrison-Laney turned up additional evidence of subsidence there (Garrison-Laney, 2003).

Investigations in Mud Bay are challenging because of the intense historical use of the area and the common pilings. To look for possible in-situ subfossil trees, we have sampled submerged snags using hand saws and increment borers, have mapped them geographically using GPS (global positioning system) to within several meters and have noted certain characteristics of each snag such as size and geologic/stratigraphic environment.

Two submerged (> 2m), bark bearing Douglas fir snags have yielded calibrated calendric radiocarbon ages of A.D. 1420 – 1690 and A.D. 1710 – 1940 respectively at 95.4 percent probability (k=1.6), and thus these snags are not correlative. In our future investigations we will complete the reconnaissance mapping and sample collection of submerged snags and use dendrochronology to test for correlations of the samples with nearby tree-ring chronologies.

This proposed research will assist in the interpretation of the paleoseismic and environmental history of Eld Inlet as well as provide an important link for local high school students to recent geologic history. The project has been greatly assisted by a Partners-in-Science grant from the M.J. Murdock Charitable Trust.

Eld Inlet 1958



Eld Inlet 2003

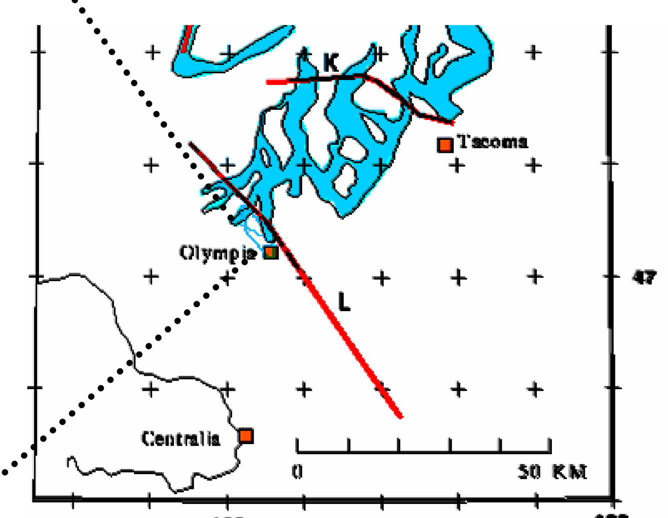


Fig. 2. Comparison of aerial photographs of Eld Inlet taken in 1958 and 2003. Locations of photos Map showing fault locations in the Puget Lowland, from Gower et al (1985). Photos courtesy of Washington Dept. of Natural Resources.

Introduction

At the Squaxin village archeological dig on the eastern shore of Eld Inlet (Figs. 1 and 2; red circle on the photo to the right above) researchers found evidence of subsidence with a layer of forest floor debris more than a meter below the high tide line. Other researchers at various sites around the southern Puget Sound have found evidence of subsidence, with submerged trees in the growth position. Brian Sherrod combined analysis of diatoms in soil cores from the Little Skookum Inlet and several sites in the Nisqually delta with radiocarbon dates of submerged tree roots to provide evidence of subsidence of at least one meter in the Nisqually delta salt marshes and possibly three meters at Little Skookum Inlet. (Sherrod, 2001)

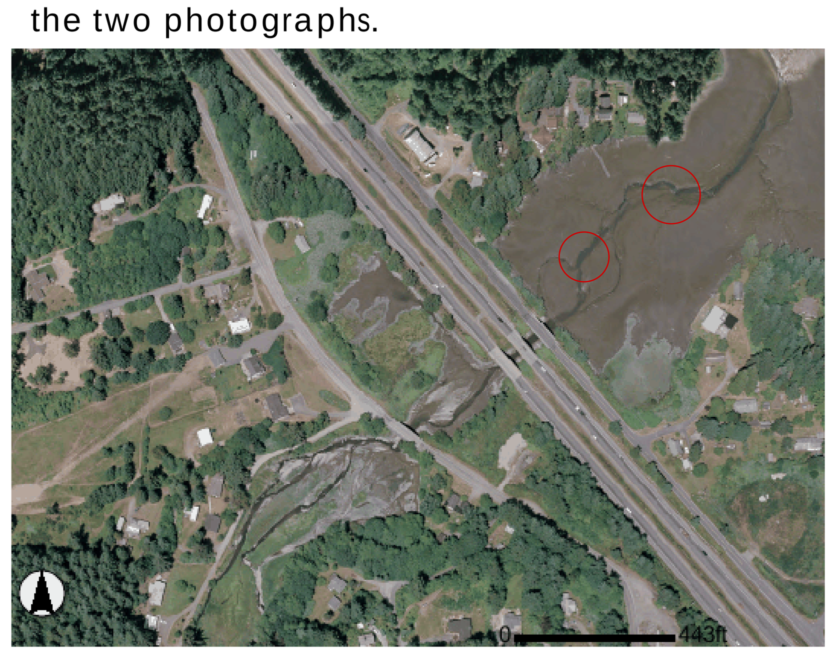
Background and Discussion

Shoreline erosion from changing creek beds can expose trees buried for centuries in anaerobic conditions that retard decay. Comparing aerial photographs of Eld Inlet taken decades apart allowed us to see changes in the creek beds as they meander towards salt water at low tides and helped focus our searches for more recently exposed snags. Changes in shore lines as well as changes in creek beds are visible when comparing the two aerial photographs of Eld Inlet above and its tributary, Perry Creek, Figs. 3 and 4 below. Any woody debris not in the growth position, such as horizontal logs or branches buried in the mud, were suspect because such debris could be the result of logs carried into creeks at high tide, during storms, from human activities, or the result of natural, but more recent, erosion on the edges of the inlet.

Also visible in the 1958 photographs are log booms and other signs of human development on the tide flats. These and other photographs, and nautical charts, became important tools in helping us differentiate between pilings left from logging operations and snags that possibly had been there for centuries and were now exposed due to erosion. Nonetheless, the only sure way to differentiate between pilings and subfossil trees is to examine them, and, if possible, use dating techniques on samples taken from snags.

Fig. 3. Perry Creek drainage into Eld Inlet, (1958) Development in the creek bed is the beginnings of the bridge for Highway 101.

Fig. 4. Perry Creek (2003) showing the locations of the two snags pictured above in red circles. Notice the changes in creek beds between the two photographs.



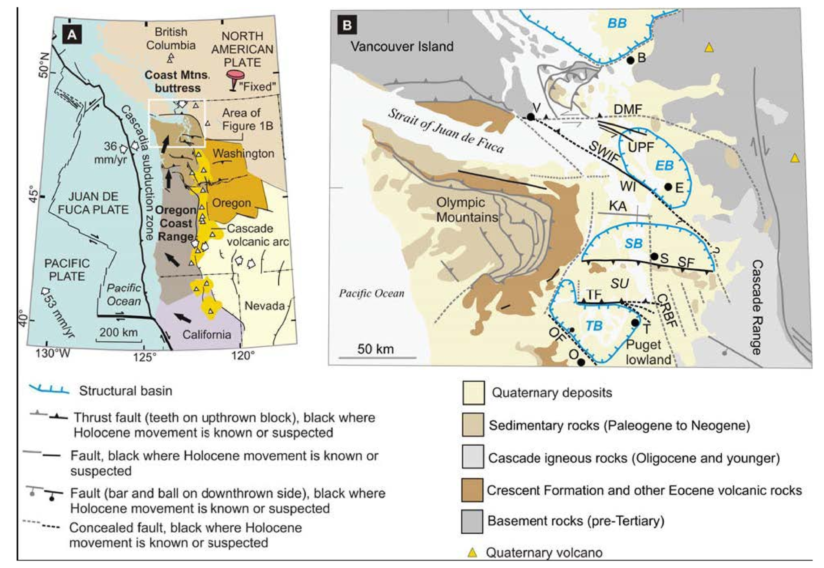


Figure 1—From Sherrod and others (2005): (A) Above, kinematic model of Cascadia forearc, simplified from Wells and others (Wells and others, 1998) and Wells and Simpson (2001). (B) Above right, enerallized map of the Puget Lowland and surrounding regions. BB, Bellingham basin; EB, Everett basin; SB, Seattle basin; TB, Tacoma basin; DMF, Devils Mountain fault; UPF, Utsalady Point fault; SWIF, southern Whidbey Island fault; SF, Seattle fault; TF, Tacoma fault; OF, Olympia fault; V, Vancouver; B, Bellingham; E, Everett; S, Seattle; T, Tacoma; O, Olympia; WI, Whidbey Island; KA, Kingston arch; SU, Seattle uplift. Redrawn from Brocher and others (2001).

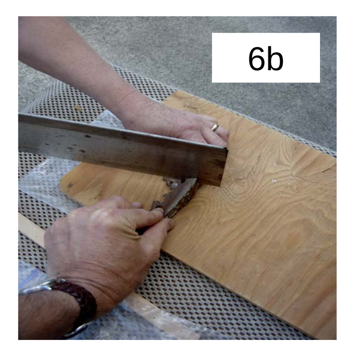
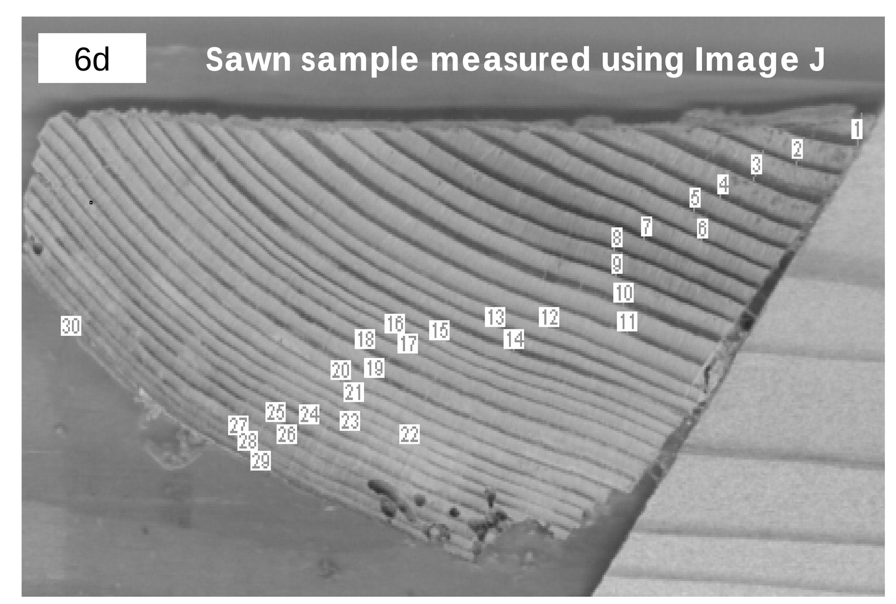


Fig. 5. Samples were taken from these two sub-fossil trees exposed in the bed of Perry Creek Tree ring analysis and radiocarbon dating were used in an attempt to date the death of these trees and correlate it to dates established by other researchers (5a. MudBay 6 at left; 5c., pc-1 at lower right; see also text and Figs. 7 and 8). Pilings left over from logging operations were often arranged in straight, sometimes parallel, lines (shown in white dashed line in the photograph below). In picture 5b, an apparent submerged forest layer can be seen next to the pocket knife, darker colored than the tidal mud above it, with light colored twigs and grass stems exposed. It resembles the forest floor debris found across the inlet at the Squaxin village archeological dig.

Figs. 6 a to e. From various sites throughout Eld Inlet, sawn and core samples were taken from snags. We cleaned and dried the sawn samples, cut them into smaller sizes and glued each sample onto blocks of wood. Once the mounting was done, the sawn samples were sliced with a band saw into thin layers. Once dry, core samples were very carefully mounted onto thin pieces of wood, routed to fit the shape of the sample. All samples were sanded with progressively finer grit sandpaper (up to 2000 grit) until they were polished. The sanded samples were then scanned at 1600 dpi, and program *ImageJ* was used to measure annual growth rings.



Methods:

We investigated the deposits and snags in Eld Inlet during low low tides using boats to access areas distant from the shoreline. We sampled snags using saws and increment borers and documented the locations of the snags using compass, maps, GPS, and verbal descriptions. Where possible, we attempted to core the subsurface using a soil coring tool. We used Government Land Office plat maps and historic photos to help us distinguish pilings and other human artifacts from potential subfossil trees and to document the effects of historic sedimentation. Each sample had to be carefully prepared for scanning and analysis. Using ImageJ software (Rasband, 2006), we measured tree rings of scanned samples. We will compare the measured series with established tree ring chronologies using another program, COFECHA, (Holmes, 1983).

Acknowledgements

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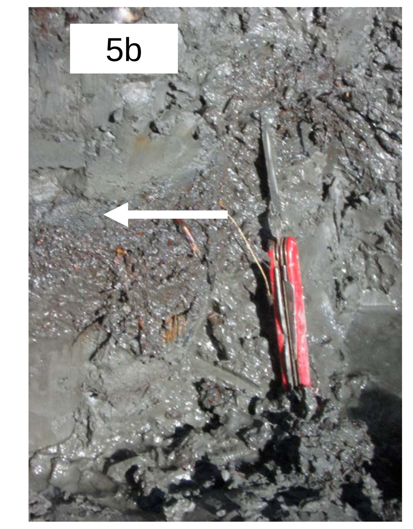

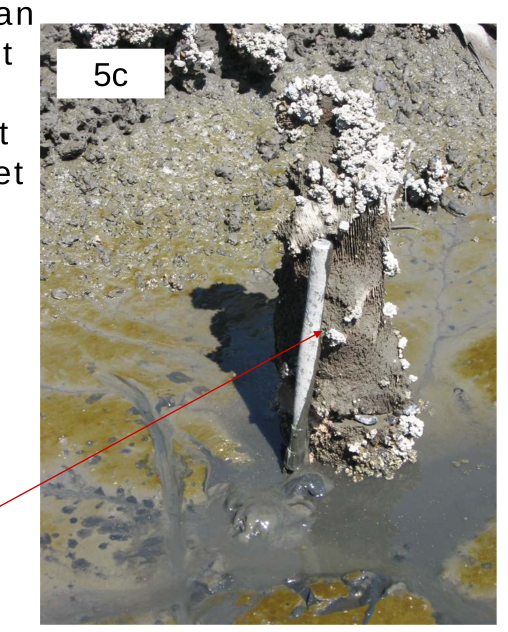

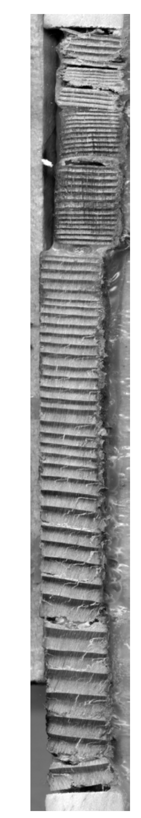

Fig. 5e. At left, core sample 06071101B.

While excavating mud from around an exposed snag in Perry Creek (Fig. 5d), we uncovered an apparent layer of forest floor, identifiable by grass stems, pieces of leaf material, and other small woody debris. This layer measures 6 cm in thickness. Immediately above it is a layer of dark sand about 1 cm in thickness (white arrow in Fig. 5b). The top of the modern tide flat is about 132 centimeters above this darker layer of woody debris, and the present salt marsh plants are another 70 centimeters above the tide flat. This implies about 2 m of apparent subsidence that could be attributed to earthquake-triggered lateral spreading and/or subsidence. A nearby subfossil snag, MudBay 6, was previously dated at 380 yr B.P. (Pat Pringle and Michael Polenz, written communication; see Fig. 8, below.), however we could not locate the horizon on which the snag was rooted.

Preliminary Results

We submitted a sample from a bark-bearing snag (pc-1) in Perry Creek (Fig. 6d) for radiocarbon dating. The results (Figs. 7; 8) did not match the date of the snag from the same area previously dated by P. Pringle and M. Polenz. This leaves us with many questions. Why are two snags in close proximity showing such wide variation in radiocarbon dates? If it were possible to excavate down through the mud, could we find a root system for either snag? Is there some process other than sudden coseismic submergence such as a lateral spreading, that is responsible for their proximity? Using a technique of Yamaguchi (1990), we were able to provisionally cross date as many as two snags with pc-1 shown in 5c, the younger of the two radiocarbon dated snags. Because of the large errors inherent with standard radiocarbon ages in this range, more sophisticated testing will be needed to better resolve the calendric ages of the snags.

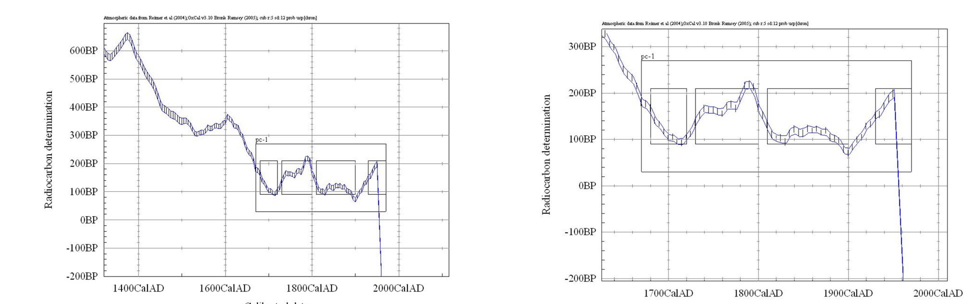

Fig. 7. Plot of a segment of the calibrated decay curve for radiocarbon showing 4 intercepts (nested sets of boxes) for sample pc-1.From left to right, inner boxes show the probability ranges for the intercepts at 11.1%, 22.6%, 22.7%, and 11.7 % respectively. The outer box surrounding the nested boxes show a 68.2% probability (Ramsay, 2001).

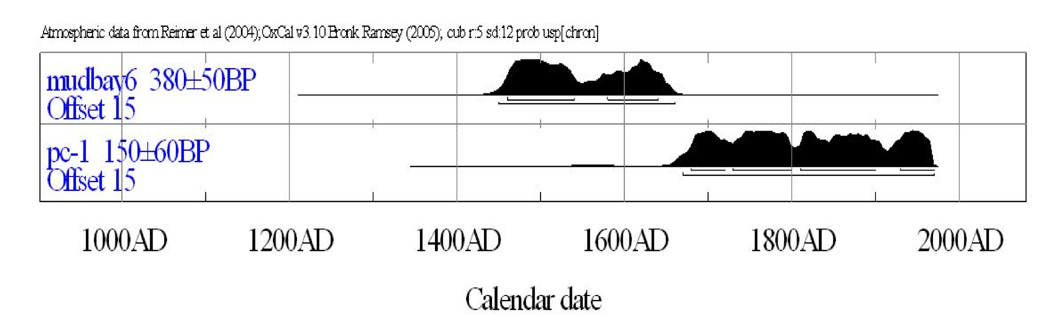

Fig. 8. Radiocarbon probability plots (using program Oxcal) showing the likely calibrated calendric ages (X axis) of submerged snags in Eld Inlet previously sampled by Jo Martens (pc-1) and by Pat Pringle and Michael Polenz (mudbay6). Radiocarbon lab result is on Y axis. The plots show that the two snags are likely not correlative.

Future Investigations

We will continue our search for recently exposed snags in lower Perry Creek. There are other areas of interest as well: perhaps McLane Creek which enters Eld Inlet from the south, and the Nisqually area. Heavy winter rains might lead to new exposures of snags in all of these areas. We will be able to obtain a radiocarbon analysis from at least one more sample. We hope to compare the tree rings of snags in Perry Creek with other trees of known ages found elsewhere, and we will continue our reconnaissance of possible subfossil trees in Eld Inlet to better assess the calendric age of subsidence.

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