

Relative Sea Level at Perniö in Finland since 10,000 BP

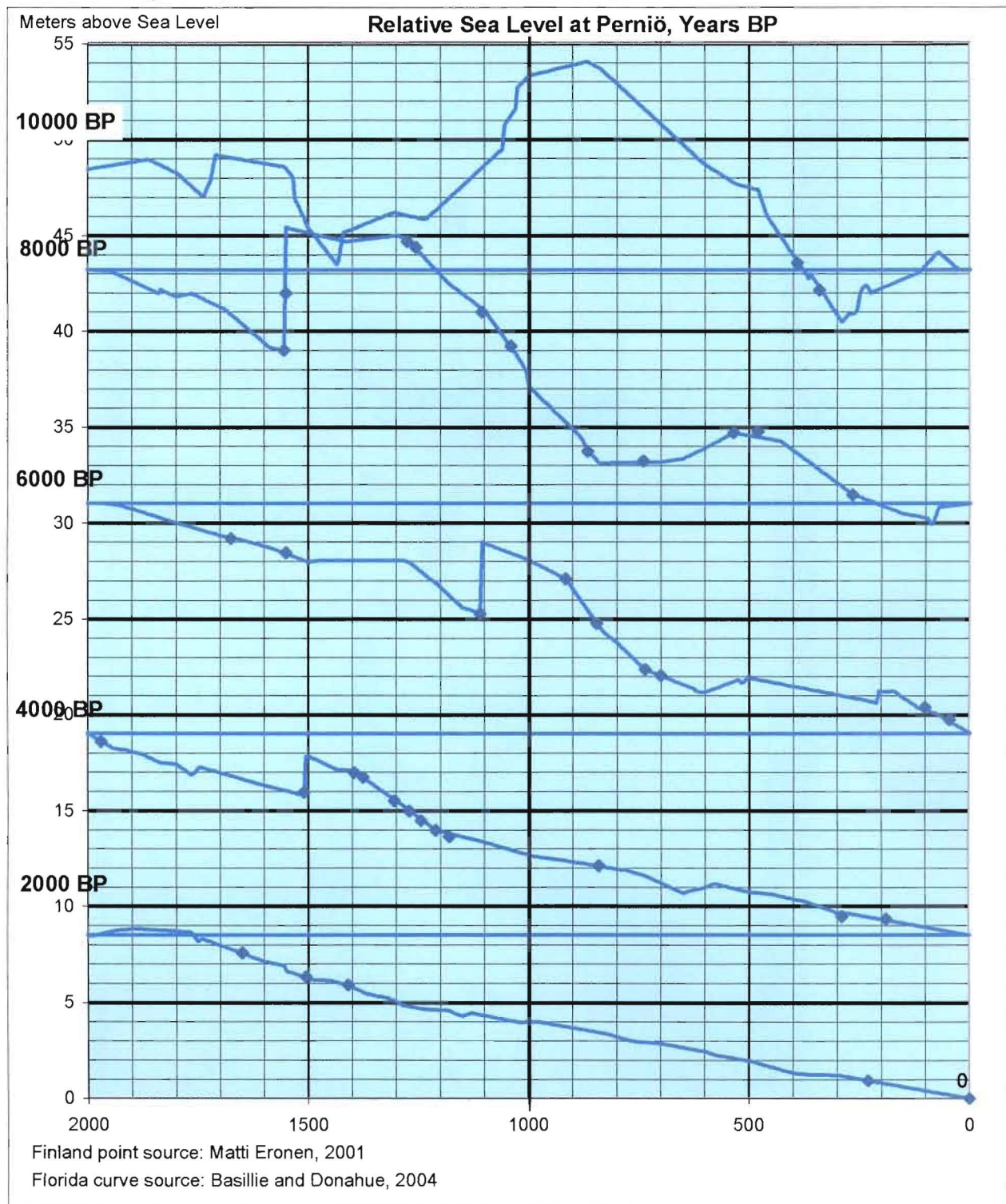
Stuart L. Harris, Nov. 2011, rev. July 2012, rev. Jan 2013

Summary

Essential to interpretation of Finnish archaeology is a calibrated curve of relative sea level. This paper presents relative sea level for the valley of Perniö in southwest Finland accurate to 20 years on the time scale and 0.1 meters on the height scale. This precision facilitates a rapid estimate of the year of construction of wood buildings, which were built as close to the sea as possible for ease of transportation, but no closer than 3 fathoms (18 feet, 5½ m) above sea level to guard against storm waves and tsunamis. To estimate age, find the elevation of the lowest corner of a building in meters, subtract 5½ meters, and look up the date of construction. This rule holds true for all buildings except piers, bridges, palisades, watch towers, cattle barns, saunas and army barracks. Perniö was chosen because within its confines originated the religion of numerous civilizations such as Norse, Greek, German, Italian, Cretan, Hebrew, Sumerian, Indian and Japanese. The 3-fathom rule held true until 1380 BC, when it started to decline toward zero as the sea retreated from Perniö.

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Figure 1: Relative Sea Level at Perniö, with data points shown as dots.

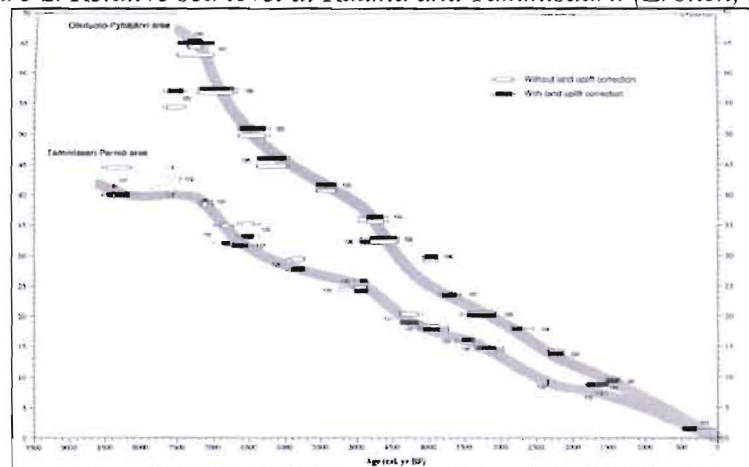


Matti Eronen: Relative sea level at Rauma and Tammisaari

During the last ice age, an ice sheet above Finland forced much of the country below sea level, especially in the south. As the ice melted, land emerged from the sea. The rate of uplift generally exceeded the rising sea, so that once land emerged, it remained dry. Thus if a building can be correlated with sea level, the building can be accurately dated.

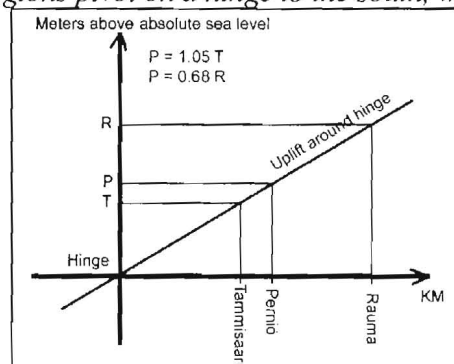
In 2001, Matti Eronen et. al. published two sets of relative sea level at Rauma and Tammisaari¹. He corrected for settling and applied tree-ring correction factors to radiocarbon dates. The resulting two sets of data are precise in altitude but somewhat uncertain in time (Figure 2).

Figure 2. Relative sea level at Rauma and Tammisaari. (Eronen, 2001)



These curves can be combined for Perniö, which lies between Rauma and Tammisaari. Uplift in southwest Finland can be modeled as a rigid plate that rotates around a hinge in the open sea between Finland and Estonia (Figure 3). Thus the two curves above should ratio exactly, with Perniö between them. To a first approximation, Perniö changes about 5% more than Tammisaari, and about 68% of the amount at Rauma.

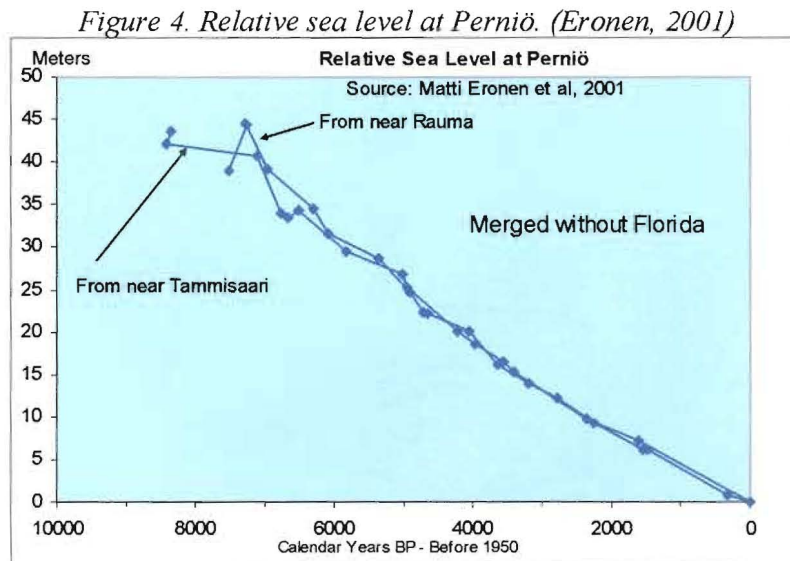
Figure 3: The two regions pivot on a hinge to the south, with Perniö in between.



¹ Eronen, Matti; Glückert, Gunnar; Hatakka, Lassi; Van de Plassche, Orson; Van der Plicht, Johannes; Rantala, Pasi; Rates of Holocene isostatic uplift and relative sea level lowering of the Baltic in SW Finland based on studies of isolation contacts, 2001, Boreas, V30, pp17-30, Oslo. Matti.Eronen@helsinki.fi

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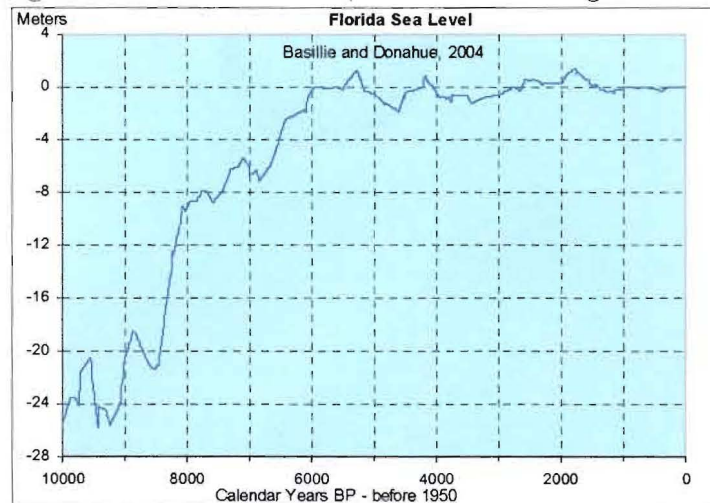
Figure 4 merges the two sets of data. The general trend is clear, but there are significant deviations. These differences can be resolved by adjusting for changes in absolute sea level.



Russell Dorsey: absolute sea level at Florida

In 1997, the late Russell A. Dorsey of Florida State University published a curve of absolute sea level in Florida², which was relatively unaffected by ice-age glaciers. In 2004 James Balsillie and Joseph Donoghue updated Dorsey's estimate by using a seven-point average of a score of different surveys in the Gulf of Mexico³. The resulting curve has abrupt transitions (Figure 5).

Figure 5: Florida sea level. (Balsillie and Donoghue, 2004)



² Dorsey, Russell A.; Predicted sea level changes, Florida gulf coast over the past 21,000 years; 1997; GARI Research Series Number 9, Lecanto, Florida.

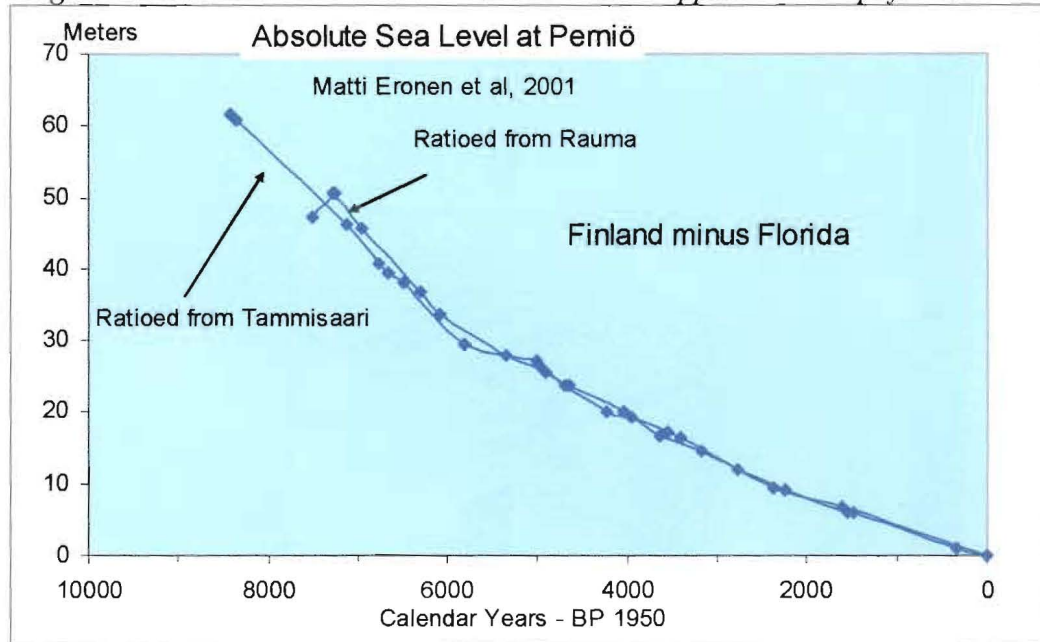
³ Balsillie, James H. (FGS) and Donoghue, Joseph F. (FSU Department of Geological Sciences); "High Resolution Sea-Level History for the Gulf of Mexico Since the Last Glacial Maximum"; FGS Report of Investigations No. 103, 2004 Jim.Balsillie@dep.state.fl.us. For a slide show, see <http://www.flconservationscience.org/pdfs/Donoghue.pdf>.

Relative Sea Level at Perniö in Finland since 10,000 BP

Subtract absolute sea level from relative sea level

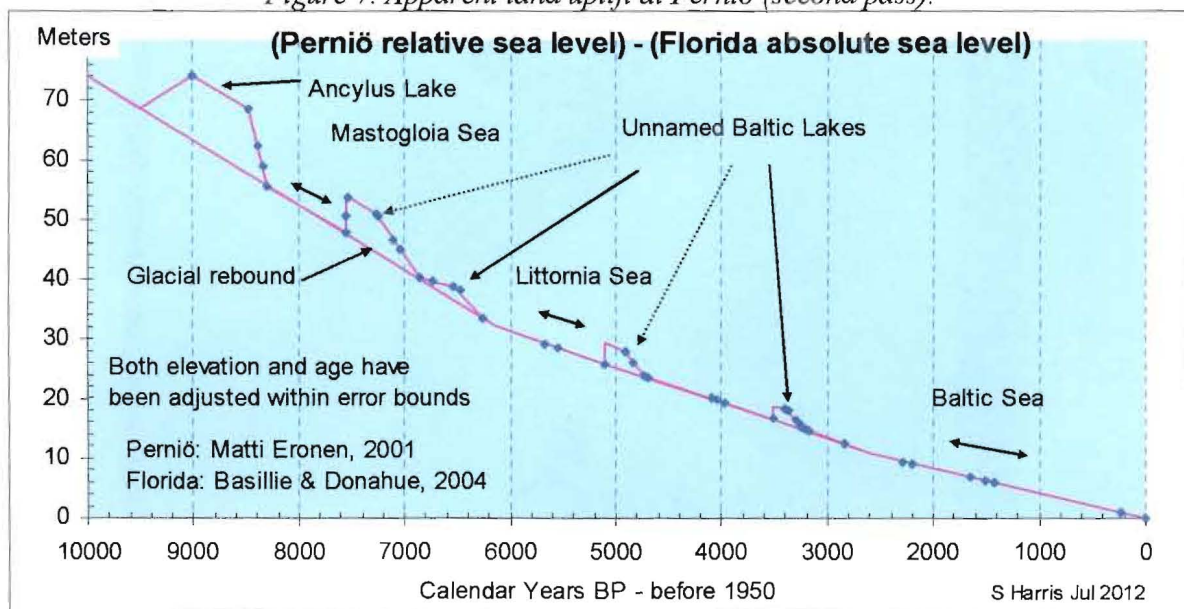
To get an approximate measure of land uplift, subtract Florida absolute sea level from Perniö relative sea level (Figure 6).

Figure 6: *Relative Sea Level - Absolute Sea Level = apparent land uplift at Perniö.*



Next, within the error bounds of the data, modify both time and elevation to bring the two curves closer together (Figure 7). Magically, the two curves become congruent!

Figure 7. *Apparent land uplift at Perniö (second pass).*

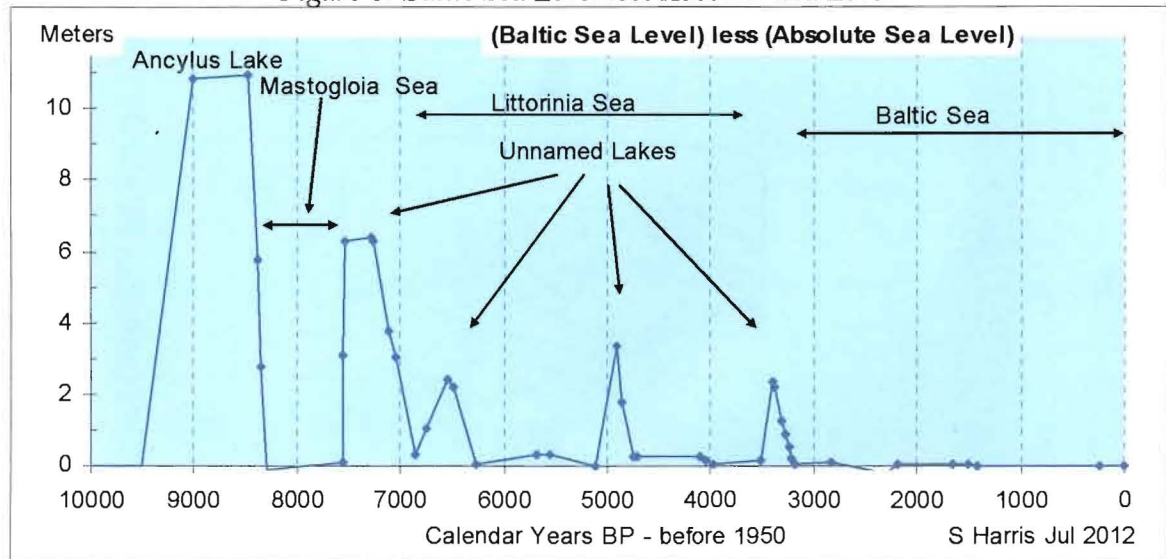


Relative Sea Level at Perniö in Finland since 10,000 BP

Subtract local land uplift

As seen in the chart above, land uplift slowed down after 6150 BP (4200 BC). Notice that a number of points lie above the slope of land uplift. These represent lakes formed when the outlet to the sea became temporarily blocked and turned Baltic Sea into Baltic Lake. Subtracting local land uplift shows these lakes more clearly (Figure 8).

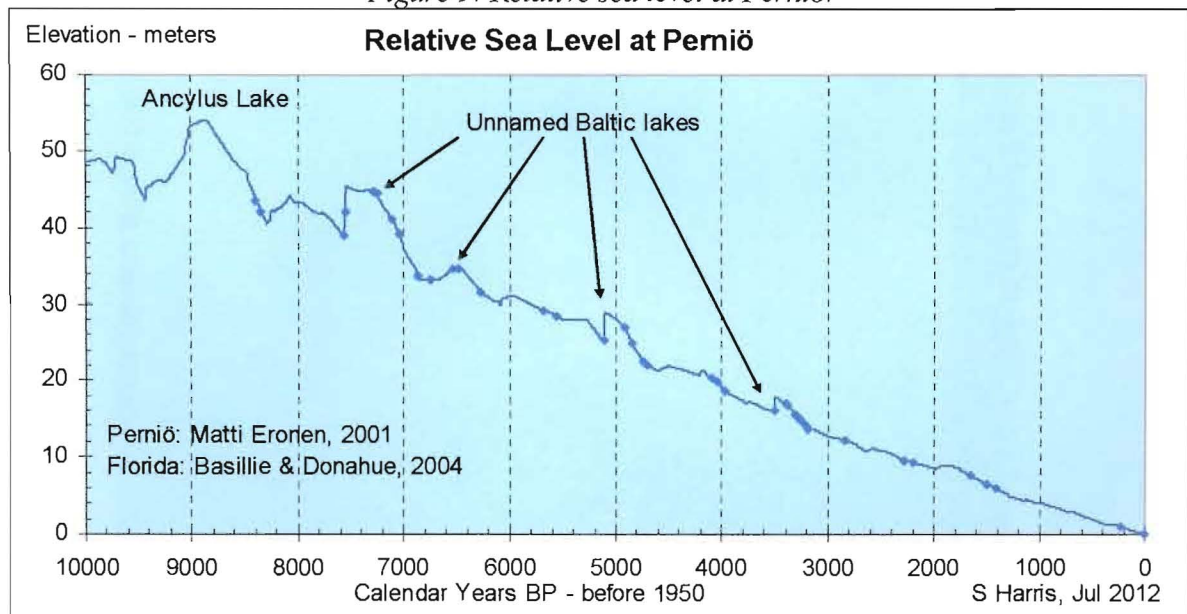
Figure 8: Baltic Sea Level less Absolute Sea Level.



Add everything back together

To these temporary lakes add the smooth curve of glacial rebound plus the jagged curve of absolute sea level from Florida to obtain relative sea level at Perniö (Figure 9 and Figure 1).

Figure 9: Relative sea level at Perniö.

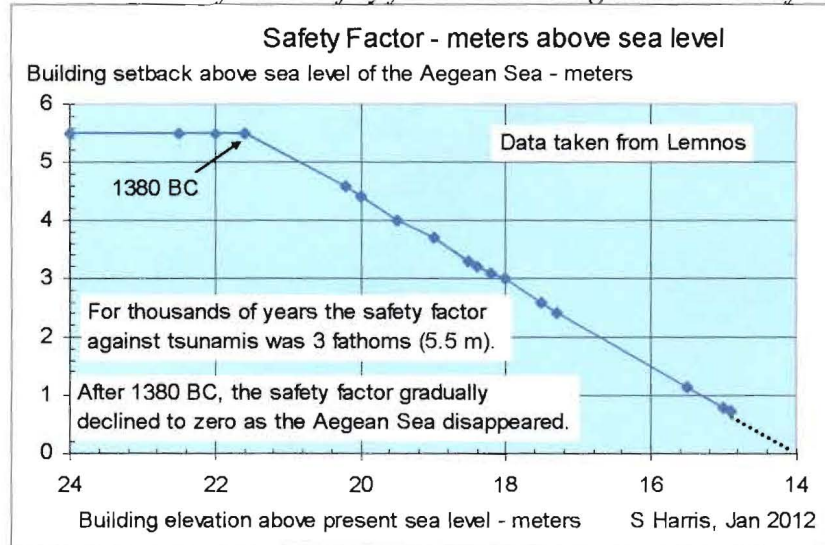


Application: Estimate the construction date of a building

With Relative Sea Level, it is possible to estimate the year of construction of a building. Because water was a principal means of transport and sea level generally declined, Finns built new buildings as close to the sea as possible, with a safety margin for storm waves and tsunamis. The traditional rule of thumb placed the lowest posthole exactly 3 fathoms (5.5 meters) above sea level, an easy measurement with a level since the Baltic Sea lacks a tide. I found two exceptions:

- Non-habitation structures like docks, bridges, palisades, barns and saunas.
- After 1380 BC, as the Baltic Sea retreated beyond Perniö, builders gradually reduced the safety factor to zero (Figure 10).

Figure 10: Reduction in 3-fathom safety factor in buildings constructed after 1380 BC.



In order to make this curve useful, I expanded the time scale by folding it back every 2000 years (Figure 1). I've tested the accuracy over the last 7500 years, and it is surprisingly good, within 20 years when elevation can be estimated in tenths of a meter. That all these points lie on the Florida curve is a tremendous tribute Matti Eronen's care in obtaining samples and not throwing away strange looking data.

To extend the curve beyond 10,000 years requires an assumption on the rate of land uplift. Places other than Perniö can be ratioed.

You are invited to contact Stuart Harris about this or any other archeological topics at PO Box 60281, Palo Alto, CA, 94306; Stuart.Harris -at- sbcglobal.net; 650-888-1859