Context:
Gulf Islands, Gabriola, shell middens, radiocarbon dates

Citation:
Doe, N.A., Additions and corrections to dates for archaeological sites around False Narrows, *SHALE* 21, pp.43–52, July 2009.

Comments on this article:
Comments have been contributed by Dr. Roy Carlson and are reproduced here in part with his permission:

> …Most non-submerged shell middens in the Gulf Islands and Strait of Georgia were probably occupied either continuously or sporadically over the past 5500 years. Picking out and dating a shell from a culturally unknown layer in a multi-component midden may or may not give you a valid date on the shell, but that is all it will give you. It won't give you a date on the cultural component responsible for the deposition of that shell, since without proper archaeological excavation you don't know what that component is. Neither top layers nor basal layers in shell middens were deposited continuously and all shells from either the basal layer or the top layer in different parts of the same site may belong to different cultural phases and different time periods. It is well known from excavations that the False Narrows site as well as other sites have multiple components dating to different time periods and most middens probably do as well.
>
> Many non-archaeologists do not understand that prehistoric cultural phases such as Marpole and Locarno Beach are NOT defined on the basis of time. These phases are defined on the basis of culture content - associated artifact types and styles and other customs - and the temporal dimension of these units of culture content is determined by associated C-14 dates. In the case of the Gulf of Georgia sequence the dating of this phase chronology is based entirely on charcoal dates to which marine reservoir corrections and dates on shells that lack culturally specific cultural associations, even if valid dates, do not apply. These shell dates you have obtained are just a bunch of loose dates that don't date anything but themselves, the location where they were found, and that someone was digging clams at the time.
>
> C-14 dates on human bone from individuals in marine eco-systems do require a marine reservoir correction, and this is currently being worked on. Applying the same correction to marine shells and human bone, as you have done, is highly unlikely to yield valid results. Once this correction is determined, it is highly unlikely to be nearly as large as the one for shells. …

Roy Carlson, PhD
Professor Emeritus
Department of Archaeology
Simon Fraser University
Burnaby, B.C. V5A 1S6

Errors and omissions:

The caption on page 47 should identify the Thetis Island site as DgRw-141, not DgRw-41. Corrected in this version.

Later references:

Date posted:
July 26, 2009.

Author:
Nick Doe, 1787 El Verano Drive, Gabriola, BC, Canada V0R 1X6
Phone: 250-247-7858, FAX: 250-247-7859
E-mail: nickdoe@island.net

Additions and corrections to dates for archaeological sites around False Narrows

by Nick Doe

Radiocarbon dating[1] is a well known and very useful tool for determining the age of organic material from archaeological sites, but it is expensive and there are technical problems in interpreting the results of radiocarbon analysis, particularly, as we shall see in this article, results obtained from marine samples—shells from middens being the most common example. Because radiocarbon dating is so useful however, a lot of research has been, and continues to be, put into solving these problems. Substantial progress has been made in just the last few years, so much so that it is worth re-visiting measurements made some years ago on False Narrows sites. It addition to discussing these older measurement, I want to add the results of five new measurements. I'll begin with an account of these.

All the calendar dates were reckoned by the Beta Analytic Radiocarbon Dating Laboratory using the MARINE04 database together with a 390-year local reservoir correction—a term I'll explain later. "Conventional" ages are results after applying standard $^{13}C/^{12}C$ corrections to measured ages. Only shells were collected and then only from already exposed faces—no artifacts were seen or sought.

Sample 4 (DgRw-25)

In an earlier article, to which I shall be frequently referring,[2] there was much discussion on the effect of changing sea level on the prehistory of False Narrows. Some of the archaeological evidence—principally older deposits being farther from the sea than younger ones—suggests a falling sea level, while geological and archaeological research at other locations in the area supports the idea that sea level has been rising gradually for the past 2000 years, and that the cumulative rise in that time has been about a metre.

This new sample, Sample 4, was taken from a midden exposure on the southern tip of Mudge Island where there is a bar across to Link Island (49°07.339'N, 123°46.102'W). A severe winter storm had temporarily uncovered a cross-section of the midden.

The sample was taken 0.23 m *below* the normal top of the beach and 0.93 m down from the top of the shell deposits (M), which was in turn below 0.08 m of grass roots (H1). Some shells were whole and others broken in large pieces. There was a layer of ash about 0.40 m below the modern surface.

It was not possible to see the bottom of the midden—that would have required digging—but judging from exposures around the site I would guess, and it is a guess, that it is around a metre deep in total, so I was pretty close to the bottom. The site has now been covered with large boulders as a protection against further erosion and what's left, if anything, of the sampling site is no longer visible or accessible.

Sample 4 was reported as:
1460 ± 50 BP ^{14}C conventional
which the BARDL interpreted as:

[1] A note explaining the principles of the method can be found in *SHALE* 15, p.43, May 2007.

[2] *SHALE* 16, *New radiocarbon dates for False Narrows*, pp.29–42, July 2007.

General view Sample 4 site. The scale is 40 cm. The cut was made by a storm and by clearing away debris it was possible to see deeper into the midden, but not to the bottom. The beach in the picture is below high tide and what is seen here has since been swept away or been buried.

1310 AD, 1280–1340 AD (1-sigma)
0.55 m below HHW datum.[3]

This startlingly-recent date means the sample gives no information about sea level changes, as had been hoped, in the early period of the False Narrows site. It is however entirely consistent with the prevailing view that sea level has been gradually rising for at least the last several hundred years and more.[4]

Sample 5 (DgRw-141)

In the earlier article, I described a measurement on a shell sample (Sample 1) from the rapidly eroding midden at the beach in False Narrows. It was taken from the bottom of the midden shell layer (M), about 40 mm above the interlayer (Mt), at the east end of the midden.

Sample 1 was reported as:
2340 ± 70 BP ^{14}C conventional
which the BARDL interpreted as 440 AD,[5]
380–540 AD (1-sigma). Re-calibrating using a more up-to-date database, MARINE04, gives:

440 AD, 375–545 AD (1-sigma)
1.84 m above HHW datum (49°08.032'N, 123°46.569'W).

This new sample, Sample 5, was taken at nearly the same height above sea level and at the same stratigraphic position at the

[3] My surveying datum is described in the earlier article. It is 4.81 m (15 ft. 9 in.) above the LLW at Ladysmith (Chart 3475) and usually around 0.3 m (a foot) above the "top of the beach" where the sand meets the foot of the eroding bank or cliff.

[4] The following is a note from Dr. Colin Grier (personal communication, Oct.28/2005): "The schemes for sea level change in the Gulf Islands generally and False Narrow specifically presented by Don Mitchell in the 1960s and reiterated by David Burley in the Senewelets monograph were somewhat speculative and invoked to explain some things that have turned out to be non-issues, for example, why the site was spread over multiple "beach" terraces. Those schemes were/are largely unsupported in terms of the overall picture of sea level change that we now have. It is true that the geological context of the Gulf Islands—the faulted Cretaceous formations—may have resulted in more localized sea level change histories due to variations caused by irregular faulting and tectonic uplift/subsidence—but I see no compelling evidence for swings of three metres and such over the last few thousand years, as claimed by Mitchell."

[5] Reckoned using the MARINE98 database.

Midden in North Bay, Thetis Island, site of Sample 5. The midden exposed here is similar in size, outward appearance, and situation to the midden exposures at False Narrows. It contains a thick lens of finely crushed shell and ash (visible in the picture); rests directly on top of hard-packed glacial till; and has Northumberland Formation shale as its bedrock (not shown). Sample was taken from the bottom of the midden, taking care to avoid material that has tumbled down the exposed face, and to avoid small shell fragments that can easily be moved.

bottom of the midden shell layer (M) and at the top of the glacial till (T),[6] but in North Bay on Thetis Island (49°0.846'N, 123°41.256'W). The midden there is around 0.7 m thick.

The purpose of this new sampling was to see if the mysterious complete lack of an interface between the bottom of the midden and the top of the glacial till—representing a time gap of the order of ten thousand years—could be explained by a catastrophic event of some kind which led to a population or re-population of the site. My favourite working hypothesis at the time was that there had once been a large tsunami in the Gulf Islands that had cleared the banks of loose soil down to the surface of the hard-packed till. A common date for shells resting on the glacial till would support this conjecture.

Sample 5 was reported as:
1830 ± 60 BP ^{14}C conventional
which the BARDL interpreted as:

980 AD, 900–1030 AD (1-sigma)
1.30 m above HHW datum.

So, bang goes the tsunami theory. Given the over five-hundred years difference in date between this midden and the one in False Narrows, it is hard to argue that the populating of the surface of the glacial till was a regional event. This conclusion is re-inforced by the result of the next sampling.

Sample 6 (DgRw-4)

Sample 6, was again taken at nearly the same height above sea level as Sample 1 and Sample 5, and at the same stratigraphic position at the bottom of the midden shell layer (M) and at the top of the glacial till (T),[7] but at the west end of the midden (about 1.5 km west) on Gabriola, just around the corner from Brickyard Beach (49°08.220'N, 123°47.094'W).

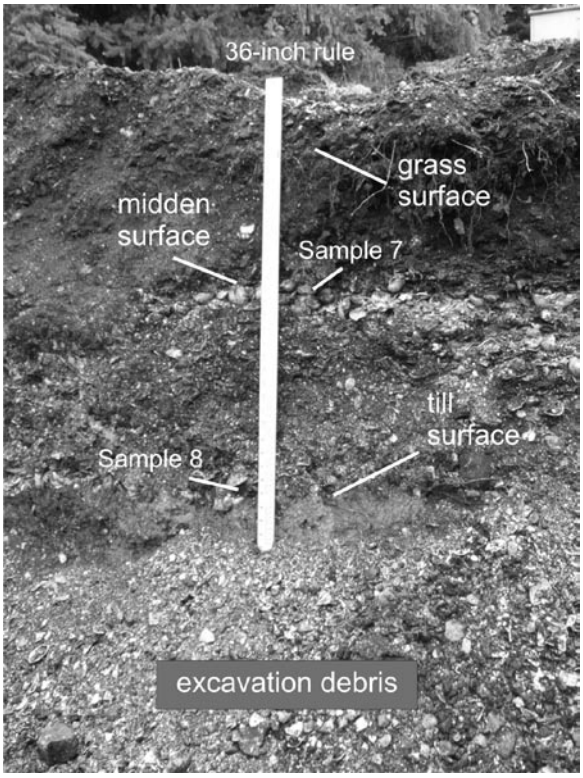
Sample 6 was reported as:
1560 ± 50 BP ^{14}C conventional
which the BARDL interpreted as:

1250 AD, 1190–1290 AD (1-sigma)
1.38 m above HHW datum.

[6] There was no Mt layer here.

[7] There was no Mt layer at the sampling site.

Above: Sample 6 site from the midden at the west end of False Narrows. The midden here sometimes rests directly on till, sometimes on bedrock (shale), and sometimes on a thin interlayer (Mt). The picture shows shells resting directly on the till. What appears to be a dark shell-less layer that is level with the top of the hole is just wet till (it's obviously so in colour). The sample was teased from the roof of the long-abandoned 4-inch diameter kingfisher hole.



Right: Samples 7 & 8 site.

So here again, not what we were looking for. There are two messages I think in this observation. The first is that there was no common event that accounts for the lack of an interlayer between the midden and the underlying till; and second, it is a mistake to think of the DgRw-4 site on El Verano as being a single midden. Not only was the site occupied at different times as you move away from the sea, but the age of the deposits vary as you traverse its length. The site is best thought of as a complex of middens, not all of which may indicate where people were living at the time. The final two samples just emphasize this point.

Samples 7 and 8 (DgRw-4)

By luck, a septic field project on El Verano Drive, made with archaeological alteration permit 2007-068, revealed a perfect cross-section of the midden from grass to glacial till (49°8.110'N, 123°46.788'W).[8] The modern surface is just 2.24 m above my HHW datum.

Sample 7 at the top of the midden was reported as:
1090 ± 30 BP ^{14}C conventional
which the BARDL interpreted as:

1630 AD, 1540–1660 AD (1-sigma)
1.94 m above HHW datum.

Sample 8 at the bottom of the midden was reported as:
1250 ± 30 BP ^{14}C conventional
which the BARDL interpreted as:

1460 AD, 1440–1480 AD (1-sigma)
1.48 m above HHW datum.

The midden thus grew a total of 0.46 metres in 170 years, which is a surprisingly very

[8] The pit was 11 by 8 feet and 3.5 feet deep about 23 m from the top of the beach. The midden surface was covered by 0.30 m of rich black farm soil.

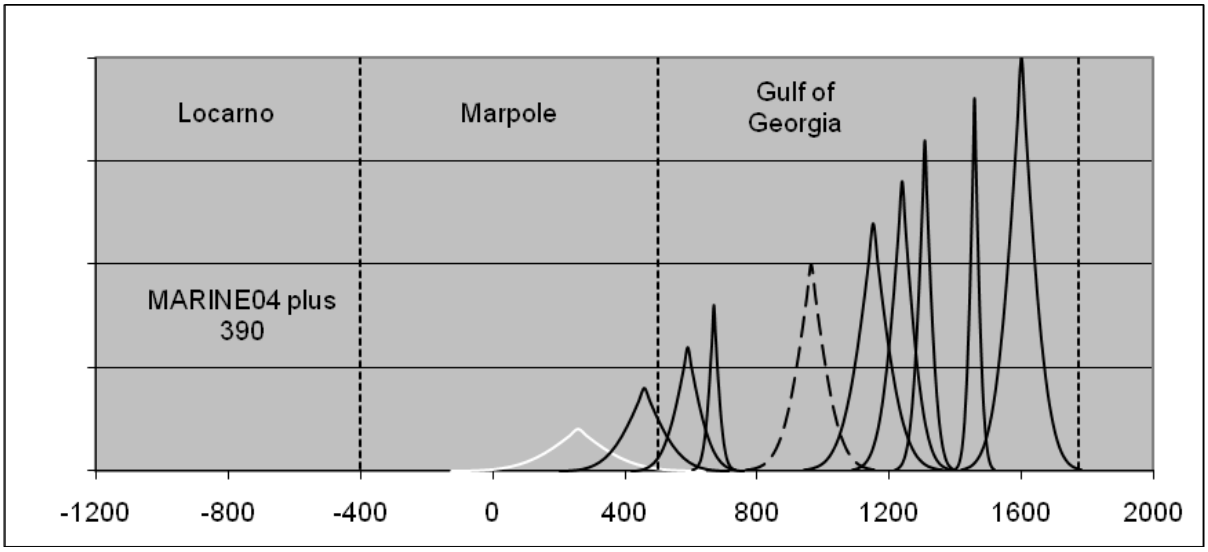


Figure 1: Calendar dates of shells from DgRw-4 and DgRw-25 (False Narrows), one sample, shown dashed, from DgRw-141 (North Bay, Thetis Island), and one sample of charcoal (Burley FN II), shown white, from False Narrows, calibrated using INTCAL04. The horizontal scale is a calendar; negative values are BC, positive ones are AD.

The shapes of the entries for the dates (the bell curves) reflect their uncertainty. The vertical scale simply indicates a number assigned to the date starting with 1 for the oldest date on the left and increasing by steps of 1 to 10 for the most recent date on the right.

modest 2.7 mm/year.

These dates too make the point that characterizing the midden as "Marpole" runs a danger of encouraging the overlooking of its long, and probably complex, post-Marpole history. Again, the interface of the midden with the till underneath showed a very different date from that at other locations.

Summary discussion

The dates I'll leave until after I have discussed radiocarbon dating corrections.

Sea level

The theory that older sites at False Narrows occur further from the sea than younger sites because in prehistoric times sea levels were higher is wrong. The older sites are where they are for reasons other than sea level has fallen—shelter from wind or ease of defence—; they were not "beach" sites.

> "My grandfather, told me that there once was a village at False Narrows. There is a big field at the top of the hill. As you walk from the beach you cross the road. The bighouses were right on top of that open ground. My father used to say that there were two or three bighouses here. The Indians lived right there. That ground was open for a long time but white people are now building houses there."
>
> Tommy Anderson—Snunéymux[w] Elder

The new evidence reported here supports the notion that sea level has been gradually rising in False Narrows throughout recent prehistoric times (the last two thousand years).[9] [10]

[9] Casual inspection also confirms this. Midden deposits on Mudge Island in Davidson Bay are now occasionally flooded in winter storms, and at

Lack of Holocene deposits

One of the objectives of the research reported here was to show that midden deposits lying directly on glacial till with no intervening layer were at least approximately of the same age at all locations, the implication then being that some event, possibly catastrophic, had removed the pre-midden natural soil from the hardpan surface. The evidence is that this idea is wrong.

I'm certainly not the first person to postulate that tsunamis have from time to time swept by Gabriola.[11] In 2001, a study was conducted in Lock Bay by James Fern, of the Department of Geography in Loughborough University, UK, and the subsequent thesis was entitled: *Analysis of Lock Bay coastal marsh deposits as evidence of the slumping of the Fraser River Delta due to paleoseismic events.* However, experts in the Earth Sciences Department of Simon Fraser University disagree with the conclusions.[12] There is no known evidence of tsunamis around Gabriola.

What then is the explanation for the disappearance of the pre-midden soil? I have a couple of ideas, but have to admit, I don't find them completely convincing.

The first idea is that before human settlement, the False Narrows site was most likely a Douglas-fir forested area with some cedar. In present-day forested areas nearby—across to the north of South Road for example—the soil is typically 15- to 45-cm thick with no obvious horizons other than the organic litter and duff (O with no E). It's a stony, sandy, brown, *podsol*.[13] Most of the "stones" are igneous, and not from Gabriola's bedrock.

With the arrival of humans, there were changes. Trees were felled, fires were set, and calcium in the form of shells and other "nutrients" were added to the soil. The shells would have changed the soil from acidic to alkaline, which together with the increased light, would encourage development of a thicker organic-rich soil, a *mollisol*. The calcium in the shells would have encouraged the growth of big-leaf maples, a tree commonly associated with shell middens on the coast, and maples produce far more litter than do conifers. And so the soil was gradually added to and transformed…

The second idea is that throughout the period when the population density was high, trampling feet caused the soil to gradually migrate down slopes toward the sea, where it would eventually be lost. Slash and burn followed by heavy rain might do the same.

The difficulty I have with both ideas is that they don't account for the lack of stones—

Blackberry Point on Valdes Island, the bottom of the midden is only 0.1 m above my HHW datum .

[10] The last sentence of Appendix 1 in *SHALE* 16 on page 38 doesn't make sense. It should be deleted.

[11] It is generally agreed that the megathrust earthquakes that rock the west coast every few hundred years or so would not generate tsunamis of any size in the Gulf Islands because they and the San Juan Islands provide a very effective baffle for surges travelling up the Juan de Fuca Strait. However, crustal earthquakes with epicentres in and around the Strait of Georgia might have generated more local tsunamis.

[12] Dr. Ian Hutchinson (personal communication, Mar.7/2009) "…his argument is that all the gravel beds that are interdigitated with marsh peats at Lock Bay are the product of tsunamis. I'd suggest that he's over-reaching the evidence by a considerable margin; they are more likely just the products of severe storms."

[13] *Podzol*, *spodosol*. One boulder-free sample was 15% pebbles, 15% granules, = 30% gravel plus 66% very-coarse and coarse sand, 4% medium sand, = 70% sand, with traces of unmeasured fines.

gravel-sized and up—that could have survived both effects, and that would have formed a distinct base layer on the hardpan, even if the original sand, silt, and clay had been lost.

Corrections

Advances in radiocarbon dating techniques are always improving. The three areas of interest where progress has been made in the last few years are:

- production of new calibration curves in 2004 to replace those of 1998
- a greater understanding of variation of marine reservoir age of ^{14}C in seawater in the Pacific Northwest
- a wider appreciation of the fact that diet affects the age of the carbon in bone (Yoneda, 2002).

New calibration curves

The new calibration curves published in 2004 greatly improved the resolution for older samples more than 10,000 years old, but, for the most part, just fined-tuned the resolution for samples in our range of interest (Reimer 2004, Hughen 2004). The differences between the older calibration curve and the new one amount to less than 40 years, and unless one is looking for a specific event such as an earthquake or volcanic eruption, which we aren't, it doesn't make a lot of difference which one uses.

Variable local reservoir corrections

One of the problems with marine samples—shells and fishbones—is that carbon dioxide dissolved in the ocean from the atmosphere remains as such for, on average, hundreds of years before entering the food chain. Shells thus appear older than they actually are.

The traditional way of coping with this was to use a terrestial calibration database with a so-called ocean *reservoir* correction factor. This had two components, an average *global reservoir age* equal to about 400 years (about what it is around Britain), and a supplementary *local reservoir age*. The local component varies with location because deep-ocean currents store the carbon dioxide longer than surface currents, and currents mix in different proportions in different places.

Nowadays, the global reservoir age is integrated into a separate marine calibration database leaving the user with only the local reservoir age to provide. In the southern Strait of Georgia, this is usually reckoned to be 390 years. For the time being, you can safely assume that this figure has been used in any articles about the local archaeology or local geology you might read.

HOWEVER, there is a but… Evidence is slowly appearing suggesting that our local reservoir age is not the convenient constant everyone hoped it would be. It probably varies with time, which is not good news.

One of the age brackets I have been following is the post-glacial period—some of even the upland areas of Gabriola have nice marine deposits full of datable shells and an occasional whalebone. In those far-off days, the local reservoir correction alone may have been higher than 600 years (Kovanen 2002, Hutchinson 2004).

Three archaeologists from Washington State (Deo, Stone, and Stein 2004) have made some interesting obervations of the radiocarbon ages of charcoal-shell pairs from the same midden source and same

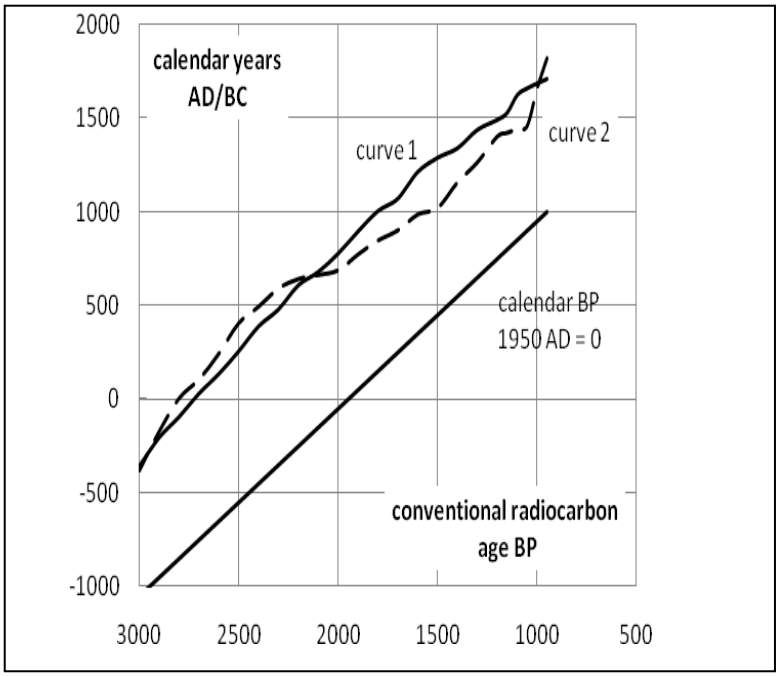


Figure 2: Calibration curves. The horizontal axis is the radiocarbon age in years before present (BP), "present" being defined by convention as 1950 AD. The vertical axis is the calendar date ranging from 1000 BC to 2000 AD. The straight-line shows the relationship between "calendar years BP" and "the date". For example 1500 years BP is 450 AD.

Because the rate that radioactive carbon is created in the atmosphere varies, a calibration curve is needed to relate "radiocarbon years BP" to "the date". Curve 1 shows the international standard MARINE04 relationship plus a constant local reservoir correction of 390 years. For example, a shell dated 1500 years BP is dated at 1289 AD. All marine samples are currently dated this way. However, the constant 390 year correction may be wrong. Curve 2 shows the correction for MARINE04 with a variable local reservoir correction (see text). It dates a 1500 year BP sample at 1022 AD.

presumed age. My interpretation[14] of their results is shown in Figure 2 above.

Their analysis suggests:

"…that between 0 and 500 BP, the regional correction value, [local reservoir] ΔR, is 400 years, which agrees with the modern value determined by Stuiver and others. Between 500 and 1200 BP however, ΔR dips to close to zero, possibly reflecting a decrease in offshore upwelling. From 1200 to 3000 BP, ΔR returns to 400 years. These data are presented as a Puget Sound/Gulf of Georgia regional correction curve for the late Holocene…".

What all this means in practice for the False Narrows samples is that samples older than about 600 AD are being judged too old, while samples more recent than 600 AD are being judged too recent. The sample dates should be "tighter".

In Figure 3, I have shown the same data as in Figure 1, but calibrated using the Deo/Stone/Stein variable ΔR curve rather than with the standard fixed value of 390 years.[15]

The most interesting differences are that the most recent sample, Sample 7, has a date of 1630 AD when calibrated conventionally, but this becomes 1445 AD when calibrated with a variable local reservoir correction. Sample 8's date of 1460 AD becomes 1280 AD. Not significant for geologists, but, who knows, perhaps very significant for historians and climatologists.

[14] Using the calibration curve is tricky. I think what's required is to solve $x = F_M^{-1} (y - R_L(x))$ where "x" is the calendar age, and "y" is the conventional radiocarbon age. $F_M(x)$ is the marine calibration curve, and $R_L(x)$, the local reservoir correction, both in radiocarbon years BP. I could only solve for x by iterating $x_{n+1} = F_M^{-1} (y - R_L(x_n))$.

[15] The difference between the value for the southern Strait of Georgia and the slightly older value for Puget Sound is negligibly small.

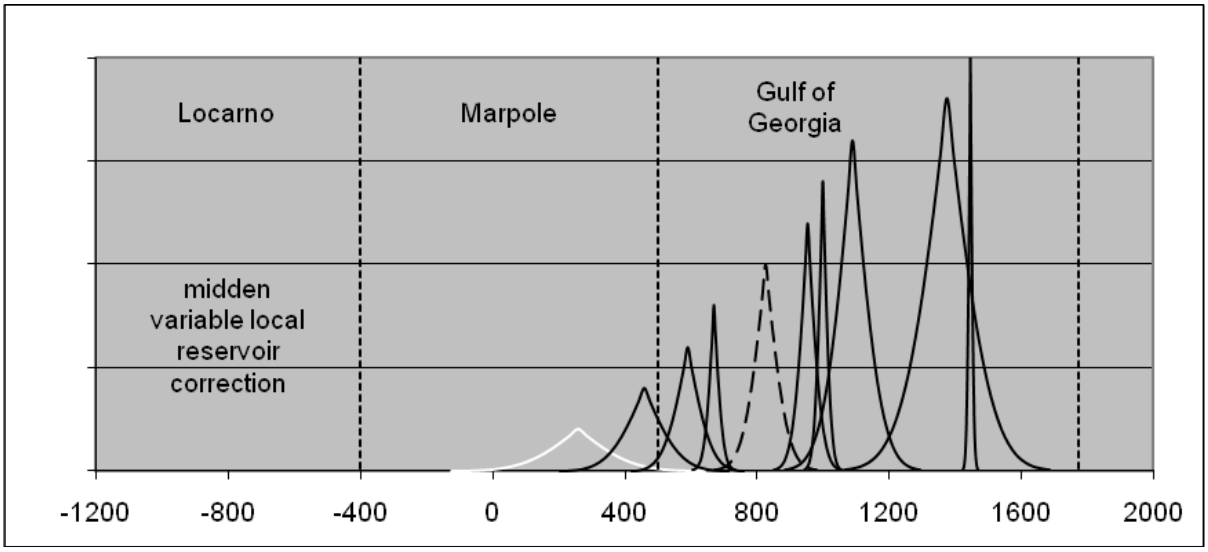


Figure 3: Calendar dates of the samples shown in Figure 1, but calibrated using the Deo/Stone/Stein data for local reservoir corrections instead of the usual fixed 390 years. The sample in white was charcoal and so doesn't change.

The dotted vertical line indicating the boundary between the Gulf of Geogia cultural phase and the post-European contact phase has been set at 1774 AD (the voyage of Juan Pérez), but perhaps it should be a lot earlier. Diseases and new technologies travel faster than explorers.

Marine component of bone

The third correction factor is perhaps the most significant. Readers of the earlier report may have noticed that an attempt to calibrate the radiocarbon dates from bone samples in the False Narrows burial caves (Curtin, 2002) produced dates that were considerably older than the ones reported here.[16] The mean date of the cave samples and their standard deviation, using INTCAL04, is 200 BC ±624 (824 BC–424 AD). This spans the Locarno-Marpole cultural phases. In contrast, the mean date of the midden samples, and their standard deviation, using MARINE04+390, is 1040 AD ±406 (554 AD–1446 AD). There is no overlap.

I think this is wrong. The mistake has been to regard the human bone samples as terrestial samples. Joanne Curtin reports, for example, that 91% of the non-human vertebrate fauna found in one of the caves (DgRw 199-F1) was fish. Together with the reasonable supposition that the people buried there were from False Narrows, it seems to me that the samples should be taken as essentially marine samples and dated accordingly—the people were mostly part of the marine food chain, despite their occasional use of terrestial food such as deer and berries.

Figure 4 shows what happens when you re-calibrate the bone samples using MARINE04 plus the generally accepted standard 390 year-local reservoir correction. The mean date of the cave samples and their standard deviation is now 540 AD ±500 (40 AD–1040 AD). This spans the late-Marpole, early-Gulf of Georgia cultural phases and the much better match with the midden dates is obvious.

[16] *SHALE* 16, page 30.

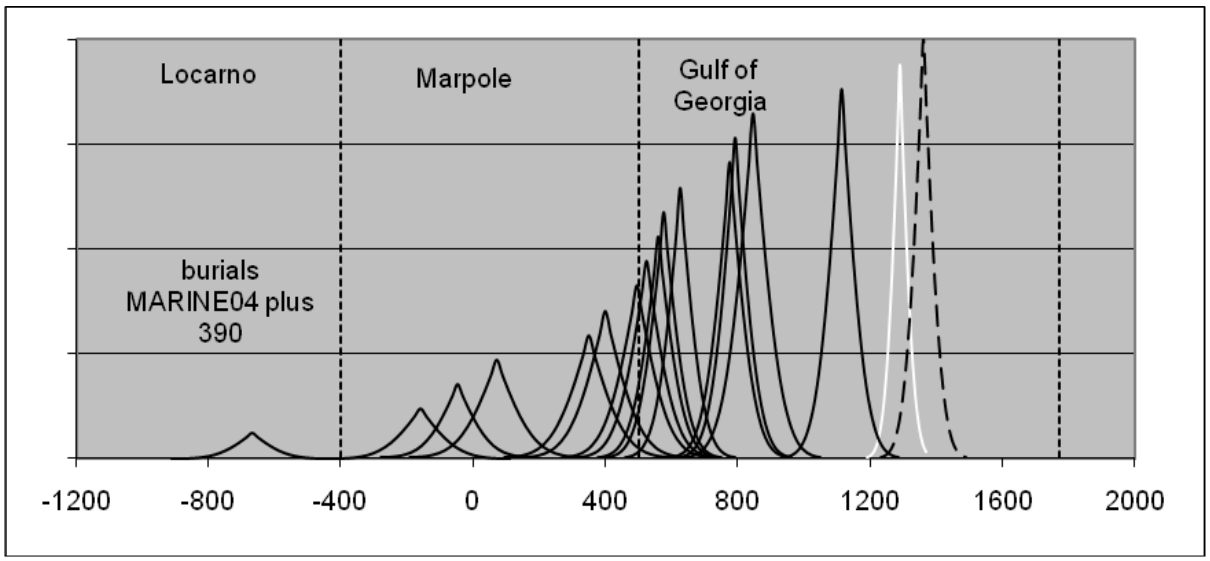


Figure 4: Calendar dates of samples taken from the burial caves at False Narrows and reported by Curtin, 2002. The samples have been calibrated using MARINE04 plus 390 years on the basis that the diet of the people buried there was provided mainly from marine sources (fish, shellfish, ducks…). The sample in white was wood of "unclear origin". The sample dotted, a mandible, was contaminated by "fine rootlets".

In general, assigning a more recent date to the main occupation period of False Narrows also accords with my own feeling that, based on geological evidence, the age of the island's petroglyhs is often over-stated.[17] Classifying False Narrows as a "Marpole" site is perhaps only justified if the Marpole phase is prolonged from 500 AD to 1000 AD, as some archaeologists have already suggested. ◊

References

A. Joanne Curtin, *Prehistoric Mortuary Variability on Gabriola Island, BC*, Simon Fraser University, 2002.

Jennie N. Deo, John O. Stone, and Julie Stein, *Building confidence in shell: Variations in the marine radiocarbon reservoir correction for the northwest coast over the past 3000 years,* American Antiquity 69 (4); pp. 771-786, 2004.

Konrad A. Hughen et al., *MARINE04 marine radiocarbon age calibration, 0-26 Cal Kyr BP*, Radiocarbon, 46 (3), pp.1059–1086, 2004.

Ian Hutchinson, Thomas S. James, Paula J. Reimer, Brian D. Bornhold, and John J. Clague, *Marine and limnic radiocarbon reservoir corrections for studies of late- and postglacial environments in Georgia Basin and Puget Lowland…*, Quaternary Research 61; pp. 193-203, 2004.

Douglas J. Kennett, B. Lynn Ingram, Jon M. Erlandson, Phillip Walker, *Evidence for Temporal Fluctuations in Marine Radiocarbon Reservoir Ages in the Santa Barbara Channel, Southern California*, Journal of Archaeological Science 24, pp.1051–1059, 1997.

D.J. Kovanen and D.J. Easterbrook, *Paleodeviations of radiocarbon marine reservoir values for the northeast Pacific,* Geology 30 (3); pp. 243-246, March 2002.

Paula J Reimer et al., *INTCAL04 Terrestrial radiocarbon age calibration, 0–26 Cal Kyr BP*, Radiocarbon, 46 (3), pp.1029–1058, 2004.

Minoru Yoneda et al., *Radiocarbon marine reservoir effect in human remains from the Kitakogane site, Hokkaido, Japan*, Journal of Archaeological Science, 29 (5), pp. 529–536, May 2002.

[17] *SHALE* 17, pp.49–55, September 2007.