DELAWARE AMERICAN INDIAN CERAMICS RADIOCARBON DATES

Daniel R. Griffith
Griffith Archaeology Consulting

INTRODUCTION TO RADIOCARBON DATING

Radiocarbon dates provide a universal measure of time, independent of cultural-historical viewpoints and associative reasoning (van der Plicht and Bruins 2001:1164). The practical temporal limits of radiocarbon dating are approximately 55,000 to 60,000 calendar years (Higham 1999). As known human occupation in Delaware is well within those limits, radiocarbon dating is the absolute dating method best suited for chronological placement of American Indian ceramics in Delaware.

The evaluation of Delaware radiocarbon dates associated with American Indian ceramics is critical to an understanding of origins and technological developments of ceramics as well as placing the associated cultural components in a temporal framework. Once accomplished, this tool permits the investigation and description of culture history and dynamics ranging from inter-group interaction, population movement at different scales, conflict and adjustment, social and political structure, the entire range of shared values, beliefs and knowledge that contribute to the understanding of American Indian cultures in Delaware through time.

Radiocarbon dating is based on the physical properties of the radiocarbon isotope Carbon 14 (^{14}C). Generally, any material from a once living organism containing carbon can be used to obtain a date. In Delaware, the most commonly used material has been wood charcoal, marine shell and bone. Short-lived samples, like seeds and nuts, are of key importance, but multi-year charcoal or shell remains important (van der Plicht and Bruins 2001:1161). The half-life of ^{14}C is used as the standard for calculating the conventional radiocarbon age (CRA). There are three principal techniques used to measure the ^{14}C content of any given sample: gas proportional counting, liquid scintillation counting and accelerator mass spectrometry. Gas proportional and liquid scintillation counting count the products of ^{14}C radioactive decay known as beta particles. The accelerator mass spectrometry method (AMS) counts the actual ^{14}C content of the sample relative to the Carbon 12 (^{12}C) and Carbon 13(^{13}C) present in the sample. The Delaware radiocarbon dates for this study were derived from all three methods. The tables listing the radiocarbon dates for this study describe the analysis as either "Radiometric" (gas proportional or liquid scintillation counting) or AMS.

Both radiometric and AMS dating can provide very accurate dates. Accurate dates are those dates with small standard deviations. The sample size available for dating influences the choice of dating technique. Accurate radiometric dating requires sample sizes no less than 20 grams dry weight for charcoal and 50 grams dry weight for wood and shell. Accurate AMS dating requires no less than 10–50 milligrams for wood charcoal and 20–50 milligrams for shell (Beta Analytic 2011). There are, however some caveats in making the choice between methods. "There can be a tendency to collect and submit isolated flecks of charcoal for AMS dating" (van der Plicht and Bruins 2001:1160). The dating of small, isolated samples should be discouraged, as the possibility of dating erratic, post-depositional or even contemporary influences on the deposition of the sample is likely. "It is a 'myth' that AMS dating is better than conventional ^{14}C dating; standard deviations are not smaller" (van der Plicht and Bruins 2001:1160). The best use of the AMS dating technique is to derive dates from organic residues on artifacts or the direct dating of carbon-bearing artifacts as the carbon sample size required is quite small and would not damage the artifact.

Radiocarbon labs report dates as a CRA. This is the raw measured value of the age of the sample based on the analytical technique used. The discrepancy between a measure value and a "true value" is expressed as a standard deviation (1 sigma), which corresponds to a 68 percent probability that the "true value" falls within the 1 sigma range. A 2-sigma range generally represents a 95 percent probability, though calibration programs may calculate the probability more precisely. The variation in the 1 sigma and 2 sigma calibrated dates from the statistical normal of 68 percent and 95 percent is due to the variations in the calibration curves. The CRA never changes; it is the calculated date of a sample resulting from a specific laboratory technique. The interpreted calendar age dates and ranges though have changed through time as different calibration techniques were applied to the CRA's. In reporting a CRA, the following conventions are used:

1) ^{14}C half-life is 5568 years
2) Oxalic Acid I or II as the modern standard
3) $^{12}C/^{13}C$ isotope corrected to 25.0 mille
4) AD 1950 as 0 Before Present (BP)
5) ^{14}C reservoirs have remained constant

In calculating the CRA, radiocarbon labs must take into account the fractionation effects of carbon isotopes. Bio-chemical processes create a certain degree of variability in the $^{14}C/^{13}C/^{12}C$ ratios that has the potential to effect radiocarbon dates if not taken into account (Thomas 2008:345). While most reports used for this study did not report isotope fraction, conventional radiocarbon lab procedures normalize the isotope fractions to a common scale (Reimer 2011). For the purposes of this study, it is assumed that all reported CRA's have taken into account and normalized the effect of isotope fractionation based on well-established measured or estimated values.

The two largest ^{14}C reservoirs are the atmosphere and the oceans. Living organisms from the two different reservoirs take in ^{14}C differently. The Delaware radiocarbon dates from wood charcoal and bone samples were from organisms that absorbed ^{14}C from the atmospheric reservoir, while radiocarbon dates from marine shell samples were from organisms that absorbed ^{14}C from the marine reservoir. Potential differences in radiocarbon dates from different reservoirs are compounded by the fact that atmospheric ^{14}C has not remained constant (Stuiver and Braziunas 1993:137). In order to determine the "true" calendar age of a sample, the CRA is calibrated against a dataset that associates the CRA with a calendar date. The first internationally agreed upon calibration was published in 1982 (Klein et. al. 1982). Since that time, calibration datasets for both the atmosphere and marine reservoirs have been refined. It is not the purpose of this study to elaborate on the history of deriving atmospheric and marine calibration curves. However, it is important to discuss the issue of dates relating to marine shell as they represent 20 percent of the radiocarbon dates associated with ceramics in this study and in some cases provide the only radiocarbon dates available for specific ceramic types.

As early as 1977 in the literature reviewed for this study, there was some concern that radiocarbon dates derived from marine shell were not accurately representing the "true" calendar age of the sample. Daniel Griffith (1977:108) noted that a radiocarbon date on shell from the Bay Vista site (UGa-1440) did not conform to its expected temporal range based on Townsend ceramic design motif seriation. This issue was more explicitly addressed in the report on the Bay Vista and Cole sites in Sussex County, Delaware where the authors state that there are problems with shell dates on the Delmarva Peninsula (Doms et al. 1985:23). Recently this issue has been examined for the Chesapeake Bay and corrections developed (Colman et al. 2001; Rick and Lowery 2011). There are a number of advantages in deriving radiocarbon dates from marine shell (Highman and Hogg 1995:409). In Delaware, shell remains are widespread in the southern two-thirds of the state. Shell also has the potential to date an event closely as shellfish are typically processed close to where they are collected. For the purposes of determining a calendar age, radiocarbon dates on marine shell benefit from the fact that the marine calibration curve is smoother than the atmospheric calibration curve with fewer intercepts and narrower calibrated ranges. Perhaps most importantly, the association of shell with the artifacts and components to be dated is more reliable than loose charcoal in a given context. With respect to the Delaware radiocarbon dates on shell, shell was used even when charcoal was available because the association between the shell and the ceramics to be dated was more certain. In the case of the Wolfe Neck site, ceramic sherds were sandwiched between the shells submitted for radiocarbon dating (Griffith and Artusy 1977).

Research in the last 25 years has shown that apparent ^{14}C age differences occur when contemporaneously grown samples of different reservoirs are dated (Stuiver and Braziunas 1993:137). In other words, dates on shell where the ^{14}C originates from the marine reservoir produced different conventional radiocarbon ages as compared to contemporary wood charcoal where ^{14}C originates from the atmospheric reservoir. The nineteenth-century reservoir age of the global ocean, relative to the atmosphere, is estimated at 400 ^{14}C years (Stuiver et al. 1998:1131). That is, marine shell CRA's tend to be approximately 400 years earlier than contemporary wood charcoal dates. However, variations in ^{14}C do occur in the marine environment and the world average of 400 years does not take into account regional

variations in upwelling of ^{14}C deficient waters or regional atmospheric variations (Stuiver and Braziunas 1993:138).

For the purposes of archaeological research, it is generally not advisable to subtract 400 years from the shell CRA to derive a "corrected" CRA. First, an independent estimate of the calendar age of a sample is needed to determine a model-generated ^{14}C age. This age can be compared to the marine CRA of the sample for a given location. The difference between the two ages is known as ΔR (i.e., change in reservoir age), an assumed time-constant offset that should be removed from sample ^{14}C ages before the application of the marine calibration curve (Stuiver and Braziunas 1993:152). As the ΔR is measuring regional offsets, the ΔR value used must be derived from data in the study area. For example, due to different oceanic processes and the effect in estuaries of the mixture of materials from different watersheds, the ΔR value for the Delaware Bay and near-shore Atlantic Coast may be different from the ΔR value for the Chesapeake Bay. In fact, recent studies have shown there are differences in ΔR values within the Chesapeake Bay ranging from ΔR= 129±22 on the western shore to ΔR= -88±23 on the Eastern Shore, while Maryland's Atlantic Coast values range from ΔR=106±46 to ΔR=2±46 (Rick et al. 2011).

There are two methods for deriving the ΔR value. The first is to obtain radiocarbon dates on historic shell collected from a known location and on a precise calendar date (Rick and Lowery 2011; Thomas 2008:349). This is a highly reliable method as the true age of the dated shell is known and provides the basis from which to calculate the ΔR value to be applied to the conventional radiocarbon ages derived from the radiocarbon dates on the shell. The second method is the paired sample method. In the paired sample method, a sample of shell and a sample of wood charcoal from the same context are dated and the resulting CRA's compared. In the case of contemporaneous wood charcoal and shell samples from the same context, the reservoir deficiency (ΔR) may be estimated without direct calibration to the calendar time scale by using a curve, which models marine conventional radiocarbon ages plotted against atmospheric conventional radiocarbon ages (Stuiver and Braziunas 1993:154). Using the curve provided by Stuiver and Braziunas (1993:154) a good estimate is provided, but I attempted to use the more accurate method of calculating the Modeled Marine Reservoir Age using a series of iterations until the Modeled Marine Reservoir Age matched the re-calibrated wood charcoal sample age at the 2 sigma range. The ΔR value and its standard deviation (ΔR error) may also be calculated by subtracting the Modeled Marine Age from the calibrated age of the charcoal sample (Bourke and Hua 2009:182; Deo et al. 2004:771).

The disadvantage of the paired sample method is one must assume that the shell and wood charcoal samples are contemporary. As charcoal is long lasting and more mobile in the soil profile, it may be difficult at times to be certain that the samples are contemporary. The best method to control for contemporary contexts is to choose samples from single component contexts and to be very certain during the collection of the samples in the field that there is a high probability that the samples were deposited at the same time.

In order to produce a reliable ΔR value and ΔR Error, both methods require a sizable number of radiocarbon dates. For example, research on St. Catherine's Island, Georgia used 11

paired dates (22 samples) and 12 dates on known-age shell to derive a ΔR value (Thomas 2008:360). Unfortunately, for this study, no research has been published that was designed to calculate a ΔR value for the Delaware Bay or near-shore Atlantic Coast. However, research for this study located three paired dates from Delaware as follows:

Wolfe Neck Site (7S-G-141), Feature 1 (Hoffman et al. 1997) –

Beta 77642 (wood charcoal): CRA 1840±70 B.P.

Beta 77643 (marine shell): CRA 2180±60 B.P.

Island Field Site (7K-F-17), Feature 119 (Custer et al. 1990) –

Beta 29737 (wood charcoal): CRA 710±60

Beta 29738 (marine shell): CRA 800±70

Gray Farm Site (7K-F-11), Feature 10 (Diamanti et. al. 2012) –

Beta 307300 (wood charcoal): CRA 330±30 B.P.

Beta 307301 (marine shell): CRA 790±30 B.P.

The ΔR value calculated from the Wolfe Neck paired dates is ΔR = 12±93 at the 2 sigma level. The value calculated from the Island Field paired dates is ΔR = -296±84, while the value for the Gray Farm pair is ΔR = 30±45 at the 2 sigma level. The ΔR value calculated from the Island Field paired dates is well beyond the range of ΔR values for the Middle Atlantic. The ΔR value for the near-shore Atlantic Coast at Atlantic City, New Jersey is 170±50, while the value for Shark River, New Jersey is 130±60 (Stuiver and Reimer 1993). Delta R values in the Chesapeake Bay range from 129±22 to -88±23, which emphasizes the need to take sub-regional differences into account (Rick et. al. 2011). The large negative ΔR value from the Island Field site likely resulted from shell and charcoal samples that were not contemporary. It is likely that "old" charcoal contaminated the sample submitted, which would not be unexpected at the Island Field site as Feature 119, a Woodland II Townsend ceramics bearing context, overlapped the Woodland I Webb Phase cemetery. It is highly probable that charcoal originating from one of the earlier components at the site was incorporated into the sample submitted for dating.

An additional clue that there may be something wrong with the paired dates at the Island Field site comes from the fact the shell and charcoal radiocarbon dates are statistically the same at the 95 percent confidence limit; in most cases they should be different. The radiocarbon samples submitted were from two different ^{14}C reservoirs that research has shown produce significantly different dates. In contrast, the paired dates at the Wolfe Neck and Gray Farm sites are statistically different at the 95 percent confidence limit, a result that conforms to expectations. The Wolfe Neck and Gray Farm sites ΔR values produce corrected marine shell radiocarbon dates that are statistically the same. The Wolfe Neck samples are from an isolated, single component, sealed shell midden containing only Coulbourn ceramics, while the Gray Farm samples are from a single feature that contained only late Townsend and Killens ceramics. Based on the nature of the context alone, it is

highly probable that the shell and charcoal samples were contemporary at Wolfe Neck and the Gray Farm.

While it is tempting to use the ΔR value calculated from the Wolfe Neck and Gray Farm paired dates to re-calibrate the Delaware radiocarbon dates from marine shell, it is not statistically valid to rely on two pairs of dates. Using the Wolfe Neck and Gray Farm ΔR values may not produce reliable results. A larger sample of paired dates, or dates on known-age shell, is required to establish a statistically valid value for the Delaware Bay and near-shore Atlantic Coast. The Wolfe Neck and Gray Farm paired dates, along with other paired dates or dates on known-age shell that may be obtained in the future, will contribute to a database that will allow for the calculation of a reliable ΔR value. For the purposes of this study of radiocarbon dates in Delaware associated with American Indian ceramics, I will simply recalibrate all the marine shell dates using the current marine model curve without a ΔR correction. As the Gray Farm and Wolfe Neck ΔR values are in the low positive range, the error introduced by not calculating a combined value is likely only 20 years. When a reliable ΔR value is developed, it would be simple matter to recalibrate the shell dates using that value. As will be seen in the analysis, the recalibrated shell dates associated with the several ceramics types using the current marine model curve fall within the 2 sigma calendar age range of the types in question and do not produce any obvious outliers between dates derived from marine shell and dates derived from wood charcoal.

There is a slight tendency for the calibrated shell dates for Mockley, Hell Island and Townsend ceramics to be at the more recent end of the temporal range for the types. At least for the Townsend dates, however, the shell dates are primarily associated with ceramics which seriation studies have shown are at the more recent end of the Townsend sequence. Still, this pattern may argue for a negative ΔR value for the Delaware Bay and near-shore Atlantic coast, though the ΔR for the Gray Farm site suggests this is not the case. However, the calibrated shell dates for Coulbourn and Wolfe Neck ceramics are embedded within the range of the wood charcoal dates. This pattern suggests that using the marine model curve with little or no ΔR adjustment is appropriate. It is also possible that the ΔR value may change through time. Coulbourn and Wolfe Neck ceramics are earlier than Mockley, Hell Island or Townsend ceramics and perhaps the ΔR value becomes more negative the more recent the calibrated shell date. However, the ΔR value for the Gray Farm site associated with late Townsend and Killens ceramics is in the low positive range. Clearly more research is necessary to establish a reliable ΔR and ΔR Error for the study area that takes into account geographic and temporal changes in the value.

CALIBRATION OF DELAWARE RADIOCARBON DATES

The calibration program used in the study is CALIB 6.0.1 (Stuiver and Reimer 1993). The calibration datasets used by the program to derive the recalibrated calendar dates are "intcal09.14c" for wood charcoal dates and "marine 09.14c" for marine shell dates. These are the most current datasets available for this program. Some radiocarbon labs (e.g., Beta Analytic) use proprietary calibration programs in reporting calendar ages. In order to assure comparability of the data for this study, all reported CRA's were re-calibrated using CALIB 6.0.1 using the datasets cited. In addition, while there is some evidence of systematic

differences in the calculation of CRA's between some radiocarbon labs in Europe, studies show that it is not a widespread phenomenon (Scott et al. 1998). For the purposes of this study, I will assume that the radiocarbon labs cited produced accurate conventional radiocarbon ages. It should be noted that radiocarbon labs no longer report intercept dates for calibrations as it is statistically misleading (Telford et al. 2004:296). The "true" date has an equal chance of falling anywhere within the 1 sigma (68 percent) and 2 sigma (95 percent) calibrated ranges.

The question of "good" dates versus "bad" dates also needs some discussion. There are a number of instances in the literature reviewed for this study where the authors identify a radiocarbon date as being outside the accepted range for the ceramics types in question (cf. Custer et al. 1995:243). Such dates are often referred to as "bad" dates, while "good" dates tend to cluster with other dates for the same artifact class or component. Is there anything wrong with "bad" dates? There is a difference between the accuracy of a date and its precision (Higham 1999). Accuracy refers to the date being a true estimate of the age of the sample within the range of statistical limits, or standard deviations, of the date. Precision is the degree to which an accurate date actually reflects the time period of components or associated artifacts within a given context. The latter concept is particularly critical where the period, components or artifacts are dated by association with a dated radiocarbon sample as opposed to cases where carbon-bearing artifacts are dated directly. Archaeological recovery methods and archaeological laboratory handling of samples have the greatest effect on the precision of a date. In other words, a radiocarbon date that is older or more recent than expected is not likely a radiocarbon lab accuracy error, rather the age of the dated sample is simply older or more recent than the archaeological context within which it is found (van der Plicht and Bruins 2001:1160). Most "bad" dates are accurate in the sense defined above, but are not precise as the result of low quality association of the recovered radiocarbon sample with the context dated.

Radiocarbon dates that are "outliers" from the expected range of dates should not be quickly dismissed. They may lead to new interpretations. Assuming a date is accurate and precise; an outlier may indicate that a certain phase or artifact type continued beyond the accepted temporal range of a type or component indicating a type of lag effect in the replacement of one phase or type with another. If this is true, the outlier may show differences in geographic distribution at some scale. There should also be repeated outliers that exhibit the same pattern. The analysis of Delaware radiocarbon dates considers these concepts.

DELAWARE ^{14}C DATES ASSOCIATED WITH AMERICAN INDIAN CERAMICS

In preparation for this study, I examined the following sources:

1) Bulletin of the Archaeological Society of Delaware
2) *The Archaeolog* – Bulletin of the Sussex Society of Archaeology and History
3) All Delaware Department of Transportation Phase II and Phase III reports either on file at the Delaware Division of Historical and Cultural Affairs in Dover or on-line at deldot.gov/archaeology

4) Radiocarbon lab correspondence files at the Delaware Division of Historical and Cultural Affairs in Dover

5) Published syntheses of Delaware and Delmarva Peninsula Prehistory

6) Phase III data recovery reports at the Delaware Division of Historical and Cultural Affairs not associated with undertakings of the Delaware Department of Transportation

7) Correspondence with consultants on unpublished Delaware projects (e.g., Versar on their 2011 dig at the Blackbird Creek site)

8) Regional journals containing articles on Delaware prehistory

9) The Gray Farm Site: Phase II and III Excavations on the Murderkill River (Sites 7K-F-11 and 7K-F-169) (Diamanti et al. 2012)

The reader should refer to the report bibliography for exact citations for radiocarbon dates associated with American Indian ceramics. The summary tables of radiocarbon dates also list the specific sources cited for each date. Only radiocarbon dates with clear association with American Indian ceramics were included in this study. A number of other radiocarbon dates from sites where ceramics were recovered are reported in the literature, but in most instances the authors state that the association between the radiocarbon dates and the ceramics is not reliable (e.g., Heite and Blume 1995; Petraglia et al. 1998). I considered these dates low in precision and more likely to confuse interpretation that aide it.

In gathering the radiocarbon dates, I made two assumptions. First, the CRA's reported are accurate. That is, the CRA's did not contain any radiocarbon lab errors. Second, I assumed the authors of the reports correctly identified the American Indian ceramic types associated with the dated sample. The only way to verify the identification of ceramics would be to re-analyze all the collections, a task well beyond the scope of this study. I did examine the Frederica North Phase I/II ceramic collection and verified or modified the ceramic type identifications so the data could be incorporated into the ceramic distribution data obtained during the Phase III investigation. In reviewing the literature, there are very few instances where there may be cause to question the ceramic type identifications associated with radiocarbon dates. Where this occurs, I will discuss the issue in the following analysis.

Radiocarbon dating of samples associated with American Indian ceramics in Delaware first appeared in the literature in the 1970s (Griffith and Artusy 1975). The Delaware radiocarbon dates from the 1970s and early 1980s were not calibrated to a calendar age, as the first internationally recognized calibration curve was not available until 1982 (Klein et al. 1982). Consequently, the calendar dates reported for the associated ceramics from the 1970s and early 1980s were derived by simply subtracting the CRA from AD 1950 (0 BP). These dates were not true "intercept" dates either as intercept dates implies calibration. Since the mid-1980s, the reported 1 sigma and 2 sigma date ranges were the result of calibration. However, since the calibration curve for both the atmospheric and marine reservoirs are continually refined, the reported calibrated radiocarbon dates were calibrated against slightly different data sets. The fact that some dates in the literature are uncalibrated while others were

calibrated by different data sets complicates the comparison of calibrated calendar year ages between the dates and associated ceramics.

This study presents a summary in two formats of Delaware radiocarbon dates associated with American Indian ceramics. [*Note*: For a full list of the raw data gathered during this study, see: http://www.deldot.gov/archaeology/north_frederica/GrayFarmSite/phaseII_III/index.shtml. The full list contains all radiocarbon dates and associated data as it is found in the literature sorted by ceramic type.] When gathering the project data, the following information was obtained for each sample, arranged in columns:

Lab Code- The radiocarbon lab sample identification number.

Excavation sample- Site number and excavation context for the sample.

Site name- The name of the site reported in the literature.

Material (species) dated- The sample material submitted for dating; species listed where known.

Analysis- The technique used by the lab to derive the CRA.

CRA- The calculated years and standard deviation (1 sigma) before radiocarbon present (cal AD 1950).

Isotope Fraction- The $^{13}C/^{12}C$ ratio; where reported.

Calibration- The calibration data set used; where applicable.

Reported Date- In some cases, the reported date is the calibrated intercept date (BOLD), while in other cases it is the CRA subtracted from cal AD 1950. In some reports, a specific date is not reported (NR).

2 Sigma Range- The calibrated 2 standard deviation calendar date range; where reported. Otherwise Not Reported (NR).

Ceramic Association- The American Indian ceramics reported to be associated with the radiocarbon date.

References- The bibliographic reference for the radiocarbon date and ceramic associations.

Notes- Comments regarding the radiocarbon date and its ceramic associations.

Once the base study was completed, the data was re-calibrated dates using the CALIB 6.0.1 calibration program. [This re-calibration data is also presented in full at http://www.deldot.gov/archaeology/north_frederica/GrayFarmSite/phaseII_III/index.shtml.] In addition to the data fields defined above, this re-calibrated data table adds three fields as follows:

Delta R- The marine reservoir correction for the Delaware Bay and the Delaware Atlantic coast. Not reported for this study.

Delta R Error- The standard deviation of the Delta R value. Not reported for this study.

Probability- The probability that the "true" calendar age of the sample is within the 2 sigma range. The CALIB 6.0.1 program calculates this probability.

Since relying solely on the ΔR value calculated from the paired dates at the Wolfe Neck and Gray Farm sites has been questioned, these columns are blank. However, these columns should always appear in a report of radiocarbon dates on marine shell, as in the future there will be reliable value for ΔR. The re-calibration data table drops the data field for "Reported Date" used in the initial data collection, as a single calendar year date is statistically misleading after recalibration. Recalibration of the reported radiocarbon dates was undertaken to insure that analysis and interpretation of the calendar year date ranges is based on comparable data. The following analysis of ceramic types is based on the data in the re-calibration table and the accompanying scatter plots in Figures 1–14.

DELAWARE AMERICAN INDIAN CERAMIC TYPES ASSOCIATED WITH RADIOCARBON DATES

Before conducting detailed analysis of the ceramic type recalibrated date ranges and implications of those date ranges, it is necessary to define the types identified in this study. The type definitions below list the defining criteria for each type and bibliographic references for its definition. The majority of the types defined in the Middle Atlantic are temporal types in that the defining attributes were chosen that most reliably changed through time, thereby providing a tool to place the ceramics and associated phases in a temporal framework. The attributes in the definition that are most sensitive to changes through time are temper and surface treatment. In Delaware, the reliability of using temper and surface treatment as temporal markers was demonstrated in a report of a stratified shell midden at Wolfe Neck (Griffith and Artusy 1977). The following list represents only those types where radiocarbon dates are reported in the literature. Other types defined in the literature are found at sites in Delaware (e.g., Minguannan) for which radiocarbon dates have not been reported.

Accokeek - Temper – sand and/or finely crushed quartz
Surface Treatment – cord-marked
(Reference: Stephenson and Ferguson 1963)

Coulbourn - Temper – clay nodule/grog
Surface Treatment – cord-marked or net-impressed
(Reference: Wise 1974)

Dames Quarter - Temper – black stone (hornblende? Goethite?)
Surface Treatment – smoothed or cord-marked
(Reference: Lewis 1972; Wise 1975)

Hell Island - Temper – crushed quartz and mica
Surface Treatment – cord-marked or fabric-impressed
(Reference: Custer 1989; Thomas 1966; Wright 1962)

Keyser Farm - Temper – fine shell
Surface Treatment – cord-marked
(Reference: Manson et al. 1944)

Killen's - Temper – fine shell and very fine grit
Surface Treatment – smoothed or fabric-impressed
(Reference: Blume et al. 1993; Custer 1994; Wise 1984)

Marcey Creek - Temper – steatite
Surface Treatment – smoothed; plain
(Reference: Manson 1948)

Mockley - Temper – shell
Surface Treatment – cord-marked; net-impressed; fabric-impressed (minor)
(Reference: Robinson and Bulhack 2005; Wright 1973)

Nassawongo - Temper – crushed quartz and clay nodules/grog
Surface Treatment – cord-marked; net-impressed
(Reference: Wise 1974)

Potomac Creek - Temper – crushed quartz/coarse sand
Surface Treatment – cord-marked
(Reference: Stephenson et al. 1963)

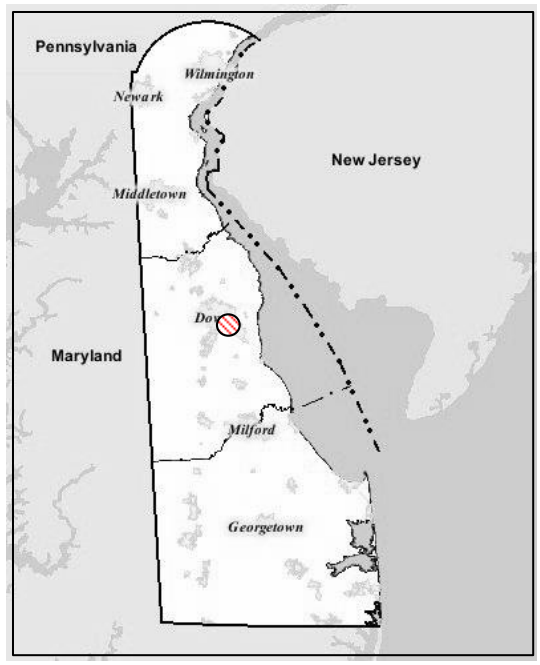
Selden Island	-	Temper – steatite Surface Treatment – cord-marked (Reference: Slattery 1946)
Townsend	-	Temper – shell Surface Treatment – fabric-impressed or smoothed (Reference: Blaker 1963; Griffith 1977; Lopez 1971)
Wilgus	-	Temper – clay nodules/grog and shell Surface Treatment – cord-marked; net-impressed (Reference: Custer 1983)
Wolfe Neck	-	Temper – crushed quartz Surface Treatment – cord-marked; net-impressed (Reference: Griffith and Artusy 1977; Lewis 1972)

ANALYSIS OF RADIOCARBON DATES BY CERAMIC TYPE

The analysis of the calendar date range of each ceramic type is illustrated by a scatter plot of the calibrated radiocarbon dates for each type. The points plotted for each radiocarbon date are the mid-points of the calibrated 2 sigma range for the date. The weighted average of the probability distribution function provides the best central point estimate (Telford 2004). While calculation of the "mid-point" in this fashion may adjust the location of the points on the scatter plot, it does not change the 2 sigma range of the date. Accordingly, to arrive at the mid-points for the scatter plots I simply added the early end and late end of the 2 sigma distribution and divided by two. In the case of 2 sigma date ranges crossing the cal BC/cal AD mark, I subtracted the result from the more recent end of the 2 sigma range to obtain the mid-point. The maximum 2 sigma range for all the dates associated with each ceramic type is also cited for each chart. The maximum 2 sigma range was determined by using the most recent and oldest ends of the 2 sigma distribution for each type. Samples with large standard deviations in the CRA stretch the 2 sigma calibrated range (e.g., UGa-3439). For the purposes of discussing the calendar date range of each ceramic type, all calibrated radiocarbon dates are used. In the summary analysis for each type and in establishing a reliable 2 sigma range for the type, the CRA's with a standard deviation of ±100 or more are scrubbed from the analysis. The reason for doing so is that large standard deviations are typically due to radiocarbon sample sizes smaller than recommended for the lab technique used. This situation calls into question the accuracy of the date in question.

Accokeek

One radiocarbon date is reported for Accokeek ceramics (Beta-52096) from the Island Farm site in Kent County (Custer et al. 1995:244). The calibrated 2 sigma date range is cal AD 23 to cal AD 223 (Figure 1). This date falls within the more recent end of the accepted range for the type (Dent 1995:226). The standard deviation for the date is ±140 years. A large standard deviation is usually caused by a small radiocarbon sample size, which diminishes the accuracy of the resulting date. As this is the only date for Accokeek ceramics in Delaware, it is retained in the summary analysis of the radiocarbon date range of Delaware American Indian ceramics. Accokeek ceramics are rarely reported in Delaware. The calibrated calendar dates overlap significantly with the calibrated calendar dates of Wolfe Neck and Coulbourn ceramics. It is possible that Accokeek ceramics, abundant in the Chesapeake Bay coastal plain, represent a type that is occasionally traded into Delaware or brought to Delaware by small groups or individual potters who became part of the resident American Indian community.



Accokeek Ceramic Date Locations

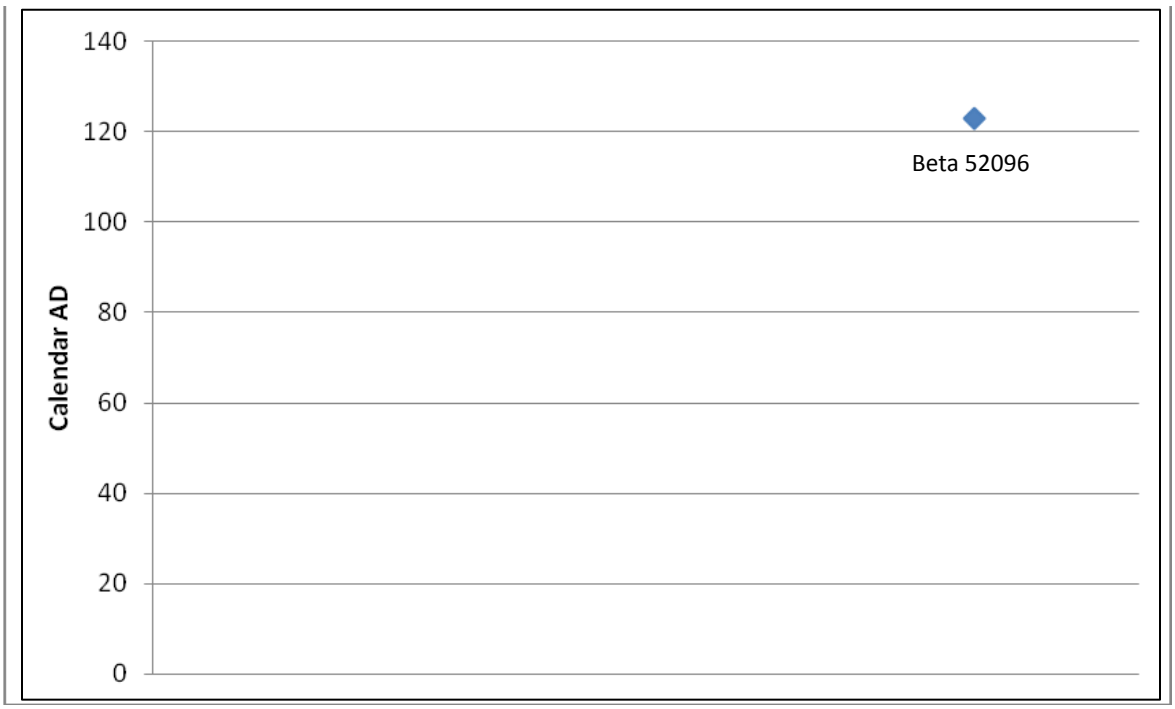
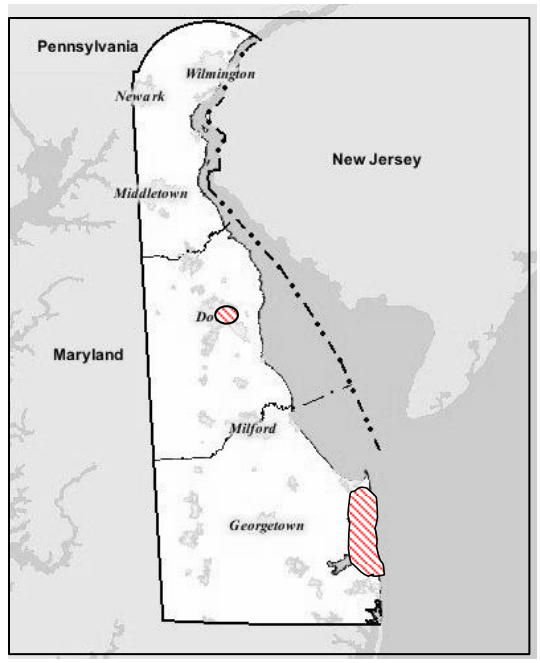


Figure 1: Accokeek Corrected Dates.

Coulbourn

Twelve radiocarbon dates are reported for Coulbourn ceramics. The scatter plot shows two clusters of dates (Figure 2). The cluster labeled "Accepted Range" encompasses six radiocarbon dates where Coulbourn ceramics were the only ceramics in the dated context. It is probable that this cluster represent the temporal range of Coulbourn ceramics. The cluster exhibits a calibrated 2 sigma date range from cal BC 55 to cal AD 349. The second cluster of dates comes from contexts where Mockley ceramics are also present in the dated context (SI-4942, UGa-1762, Beta-76644 and Beta-76838). The dates fall well within the known date range of Mockley ceramics, and it is likely that the Coulbourn ceramics were re-deposited into a Mockley bearing feature when it was filled. It is not uncommon for older ceramics to be re-deposited by later occupations. I consider these four dates to be precise Mockley dates and they are incorporated into the Mockley analysis and scatter plot. The discussion of Mockley dates allows for the possibility that the dates could be associated with Coulbourn ceramics as well.



Coulbourn Ceramic Date Locations

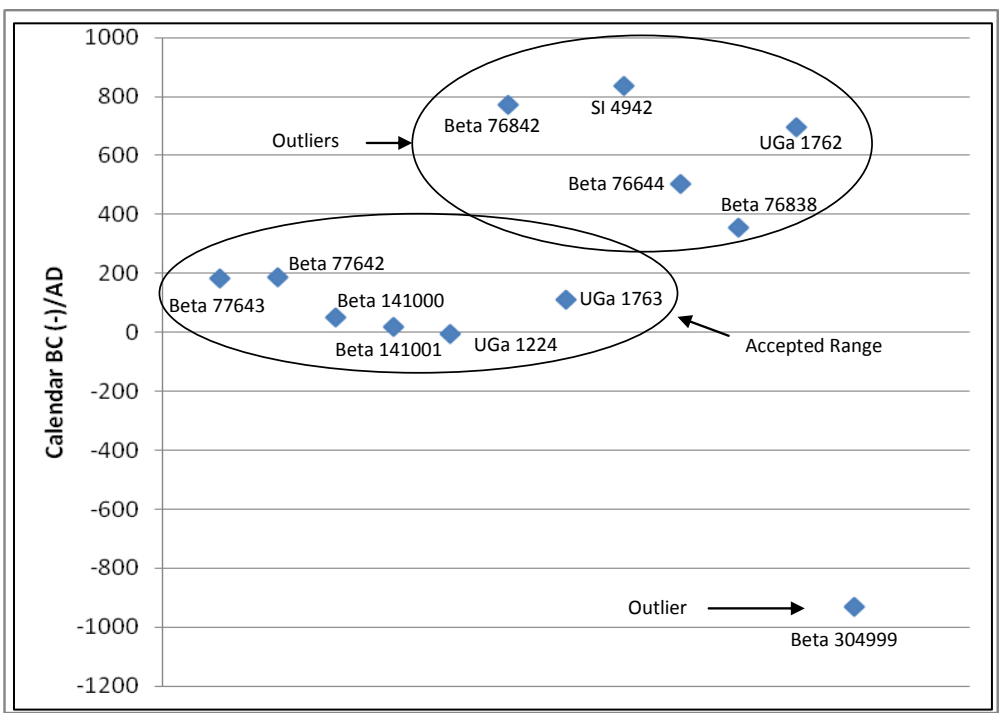
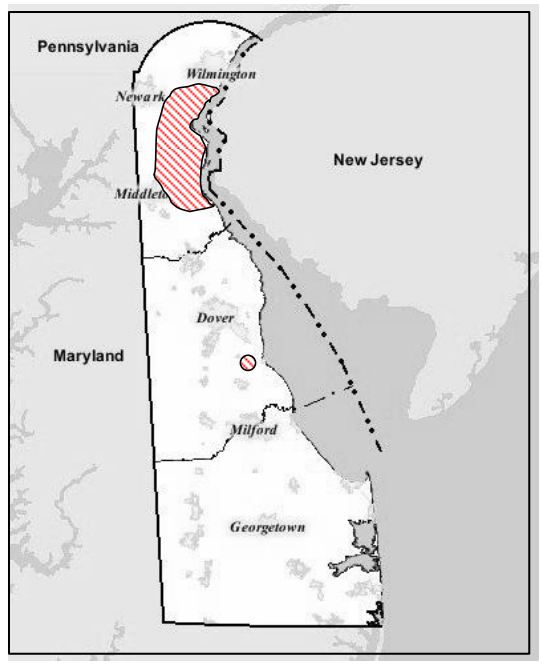


Figure 2: Coulbourn Corrected Dates.

Dames Quarter

One date (Beta-76842), noted as an outlier with a calibrated calendar date of cal AD 649 to cal AD 897, is from a context also containing Coulbourn ceramics. The authors of the Island Farm report note that the date is too recent for Coulbourn ceramics (Custer et al. 1995:146). This date could have resulted from sample contamination by more recent wood charcoal or the date is correct for a Mockley component feature, but no Mockley ceramics were deposited in the feature. This date falls within the range of Mockley ceramics, but without a clear association it cannot be considered a date for these ceramics. It is also possible that the ceramics were misidentified. This date is dropped from further analysis of Coulbourn and Mockley ceramics. Another date from the Gray Farm site (Beta-304999) is an early outlier with a 2 sigma mid-point of cal BC 932. The context associated with this date also included Wolfe Neck and Selden Island ceramics, with Selden Island ceramics dominant. The radiocarbon date likely represents the Selden Island component. Nine dates are reported for Dames Quarter ceramics. The dates are tightly clustered in the calibrated mid-point scatter plot and appear to be both accurate and precise for the type (Figure 3). The maximum 2 sigma calendar age range for Dames Quarter is cal BC 1419 to cal BC 970.



Dames Quarter Ceramic Date Locations

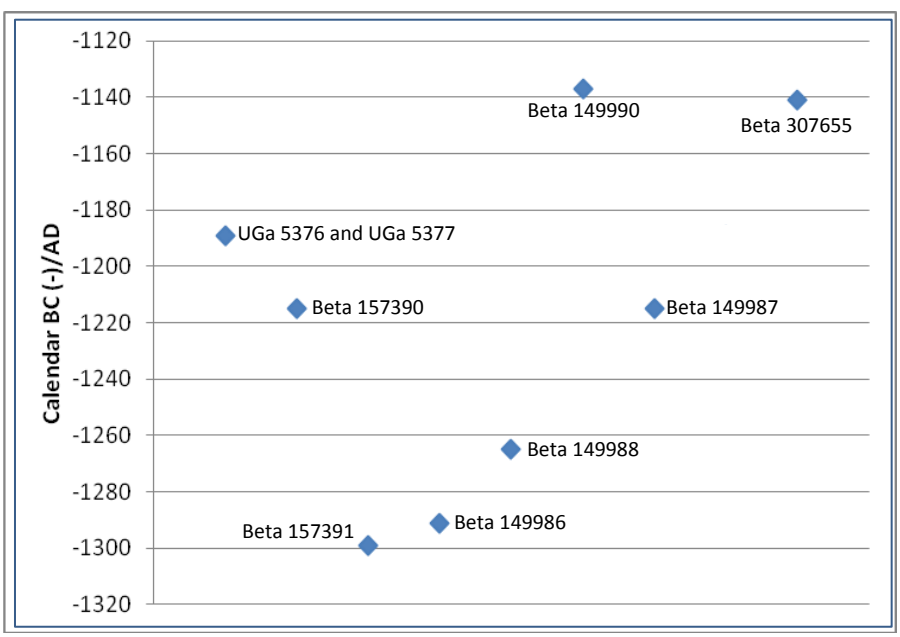
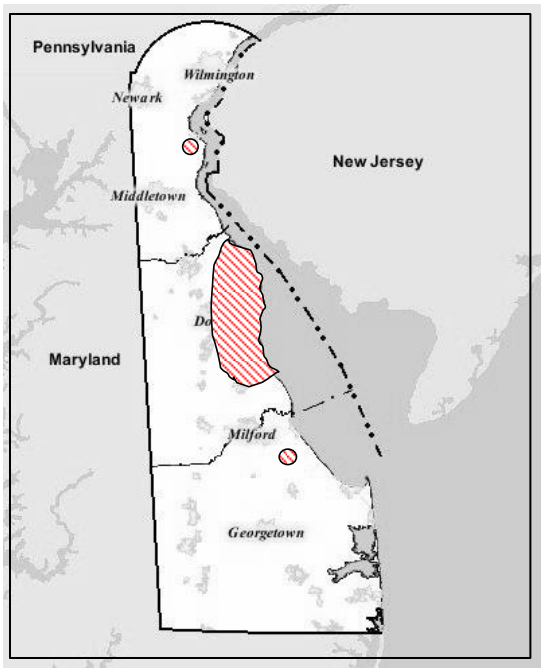


Figure 3: Dames Quarter Corrected Dates.

Hell Island

Ten dates are reported for Hell Island ceramics. The calibrated mid-points of the dates are tightly clustered on the scatter plot (Figure 4). One date (Beta-56361) was from a context containing both Hell Island and Marcey Creek ceramics. The authors of the report note that the date is too recent for Marcey Creek ceramics, but consistent with Hell Island ceramics (Custer and Silber 1995:103). One date (Beta-128586) is in the more recent end of the scatter plot, but within the accepted range for the type. Three dates (UGa-3437, UGa-3439 and Beta-42881) exhibit standard deviations exceeding ±100, which compromises the accuracy of the resulting date by the standard I have adopted. It is likely that these dates were derived from wood charcoal samples that were smaller than the recommended size. The large standard deviations stretch the 2 sigma ranges for the type as a whole. The 2 sigma range for Hell Island ceramics based on all the reported dates is cal BC 181 to cal AD 1408. The 2 sigma range without the three dates with large standard deviations is cal AD 526 to cal AD 1230. The conservative range for Hell Island ceramics is likely more precise and those seven precise dates are used to create the ceramics type date range summary (Figure 15).



Dames Quarter Ceramic Date Locations

Hell Island Ceramic Date Locations

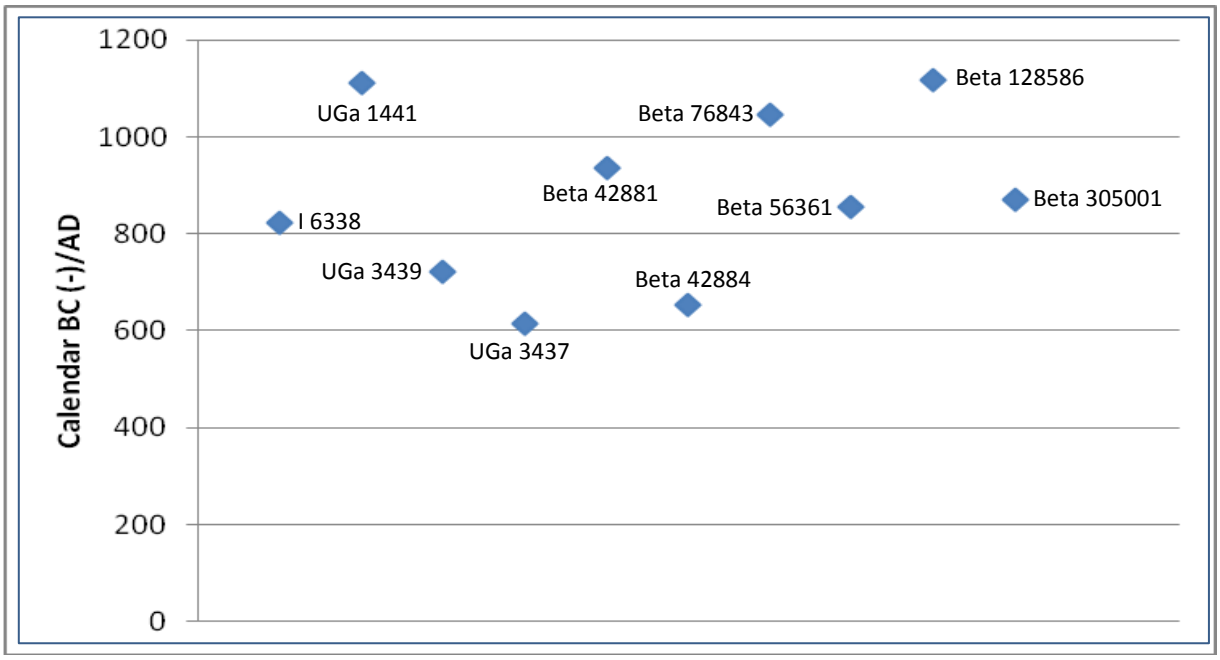
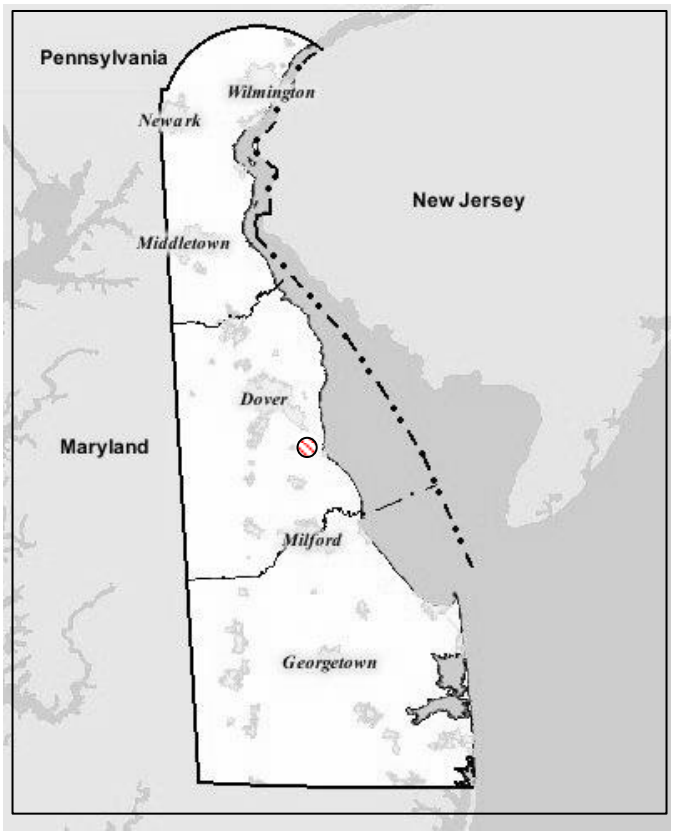


Figure 4: Hell Island Corrected Dates.

Keyser Farm

There is one reported date for Keyser Farm ceramics (Figure 5). The calibrated 2 sigma dateis cal AD 1466 to cal AD 1664, which is well within the accepted range for these ceramics (Wall 2001). The type is very rare in Delaware occurring only at the Robbins Farm site in southern Kent County (Stocum 1977).

Its presence likely represents the relocation of a small group or family moving into the area in the sixteenth century AD. The presence of the ceramics is not likely the result of trade, as trading relationships between western Maryland and central Delaware should be manifested at more than one site and in more ways than a single artifact class.



Keyser Farm Ceramic Date Locations

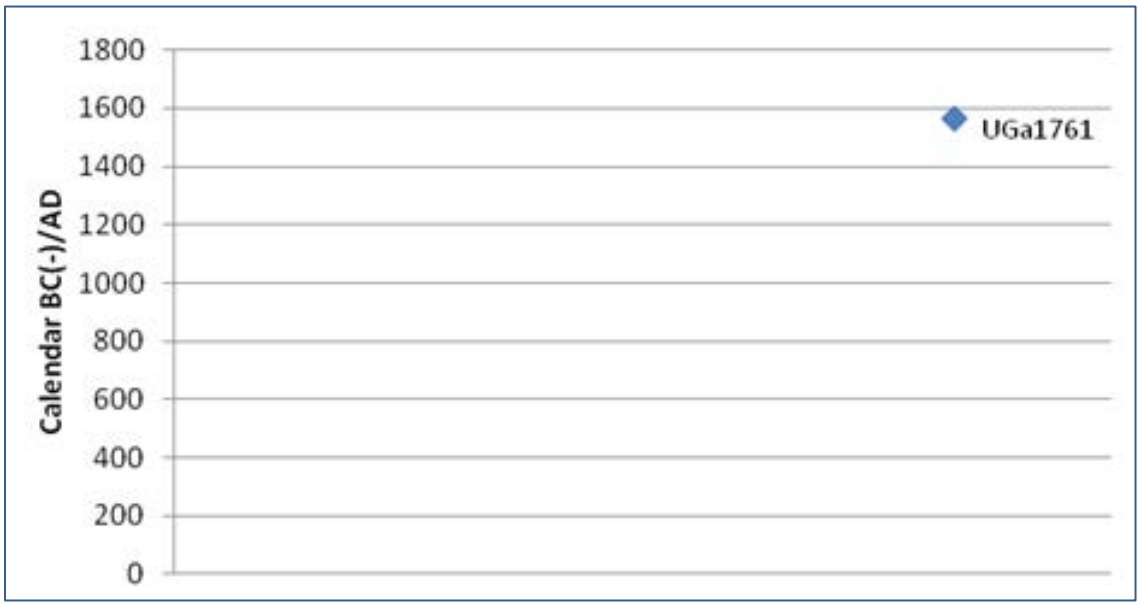
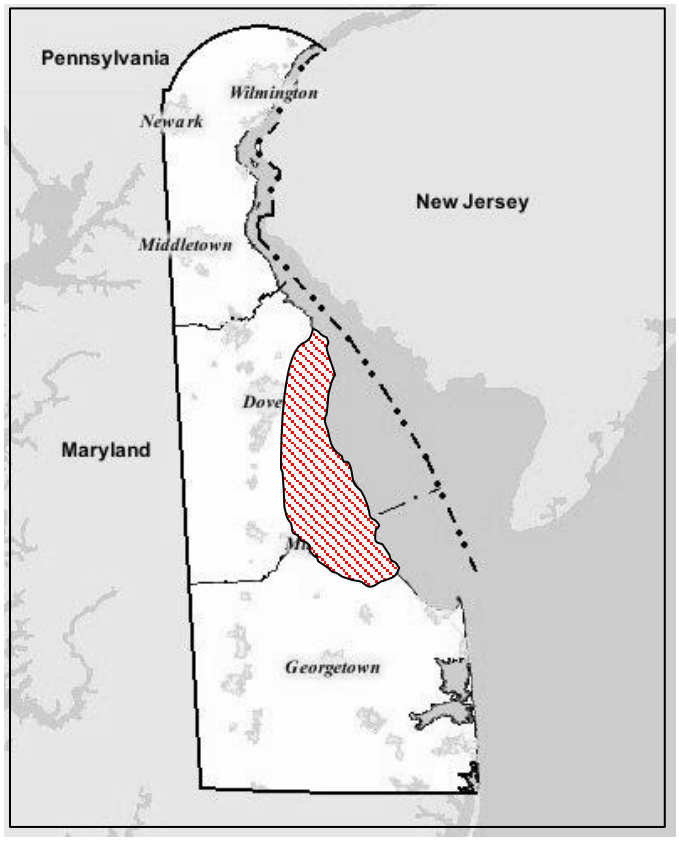


Figure 5: Keyser Farm Corrected Dates.

Killens

There are six reported dates for Killens ceramics (Figure 6). One date (Beta-42882) has a standard deviation of ±170, which calls into question the accuracy of the date. The large standard deviation was likely caused by a wood charcoal sample smaller than the recommended size for the analysis. Another date from the Gray Farm site (Beta-307304) has a CRA of 3270±30 producing a 2 sigma date range of cal BC 1622 to cal BC 1458. The one Killens sherd in the context is likely an intrusion into a much earlier feature and this date is not used in the scatter plot (Figure 6) or the calibrated ceramic type date range summary (Figure 15). The 2 sigma range of the remaining four dates is cal AD 1286 to cal AD 1706. Killens ceramics is a late Woodland II ware contemporary with Townsend ceramics in central and southern Delaware.



Keyser Farm Ceramic Date Locations

Killens Ceramic Date Locations

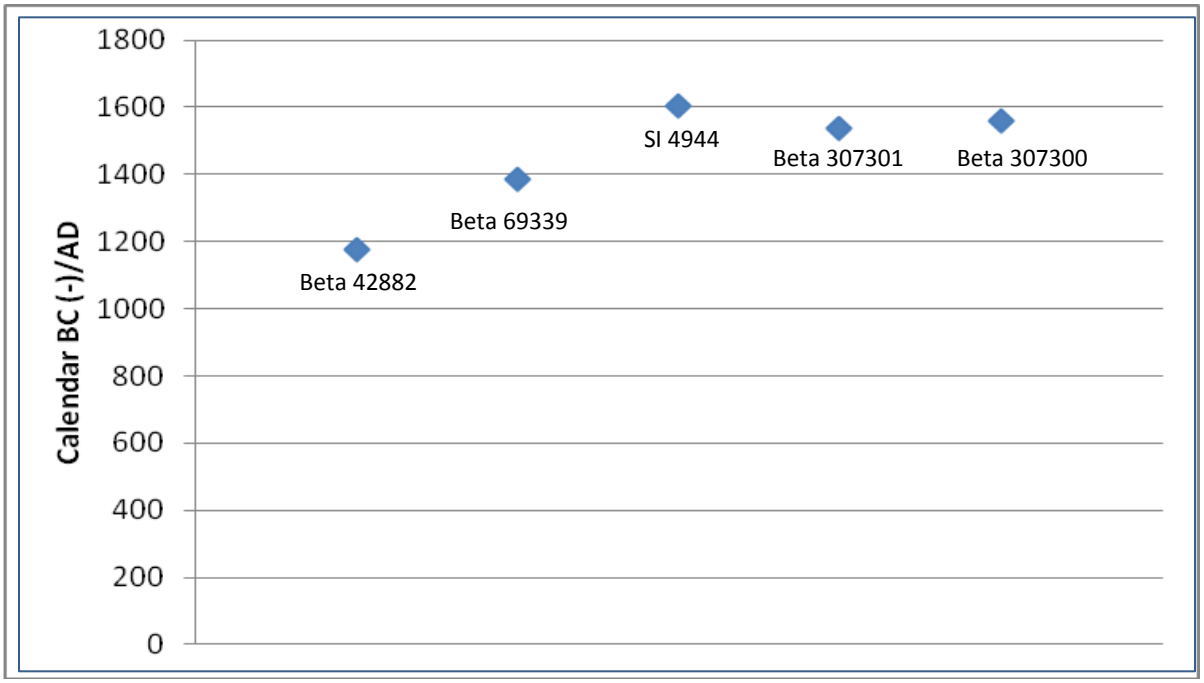
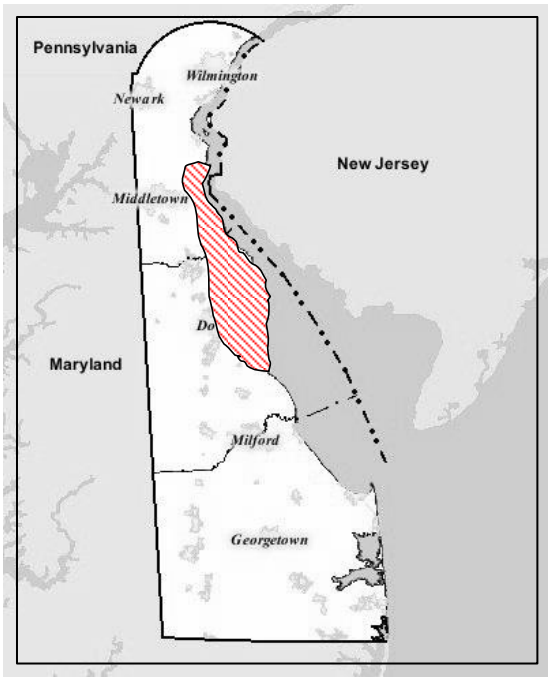


Figure 6: Killens Corrected Dates.

Marcey Creek

Seven dates are reported for Marcey Creek ceramics. The scatter plot shows two clusters of dates without a 2 sigma overlap (Figure 7). The authors of the report containing Beta-56360 and Beta-56361 state that the dates are too recent for Marcey Creek ceramics (Custer and Silber 1995:103). It is likely that wood charcoal from more recent components was incorporated into the sample submitted for analysis. The dates are more consistent with dates for Mockley and Hell Island ceramics, but there is no evidence these types were present in the dated contexts. It is possible that the ceramics were misidentified, but it is not likely as Marcey Creek ceramics have distinct defining attributes.



Marcey Creek Ceramic Date Locations

One date, Beta-149987, falls within the accepted range of Marcey Creek ceramics. The 2 sigma date range is cal BC 1319 to cal BC 1110. This range is consistent with the radiocarbon date range in the region (Dent 1995:226). Two other dates (Beta-128589 and Beta-117149) from the Hickory Bluff site are at the more recent end of the accepted range, overlap the range of dates for Selden Island ceramics and may represent the end of Marcey Creek manufacture in the area. Two dates from the Gray Farm Site (Beta-304997 and Beta-307658) are at the very early end of the accepted range in the region for Marcey Creek ceramics. The earliest date (Beta-307658) is a direct dating of the ceramics by bulk sherd organics and is considered accurate and precise. The two dates are included in the scatter plot (Figure 7) and the ceramic date range summary (Figure 15) as references for further discussion.

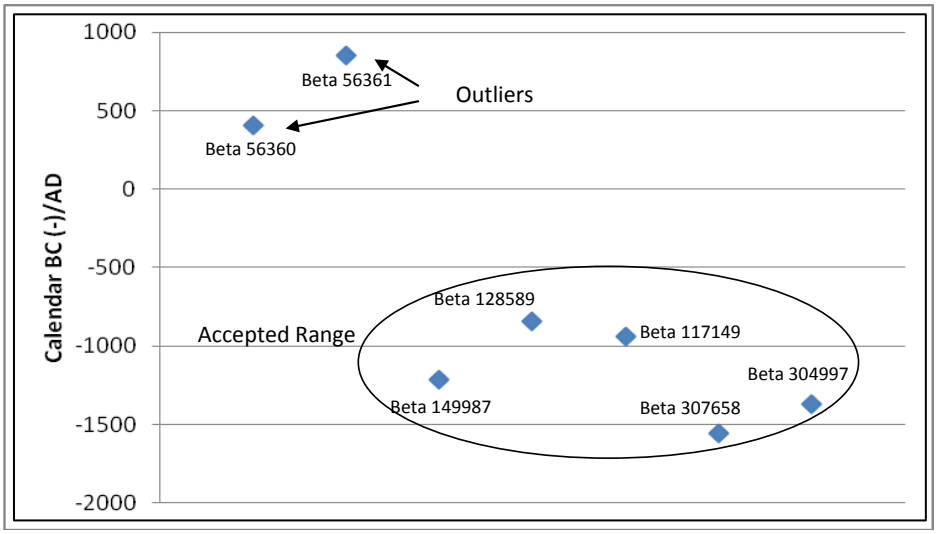
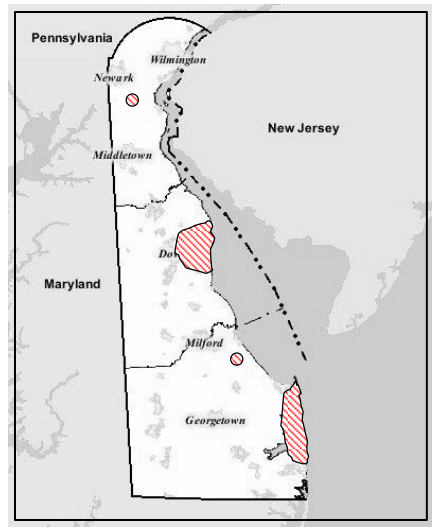


Figure 7: Marcey Creek Corrected Dates.

Mockley

Eighteen dates are reported for Mockley ceramics. The scatter plot exhibits a consistent cluster of calibrated dates with a 2 sigma range for the type from cal AD 47 to cal AD 1106 (Figure 8). Ruling out two dates with large standard deviations (UGa-1273b and Beta-42883), the resulting 2 sigma range for the type is cal AD 47 to cal AD 993.



Marcey Creek Ceramic Date Locations

Mockley Ceramic Date Locations

Five dates (SI-4942, UGa-1762, Beta-76644, Beta-309416 and Beta-76838) were from features where Coulbourn ceramics also occurred and for UGa-1762 Coulbourn and Wilgus ceramics were in the same context with the Mockley ceramics. In reviewing the published reports for these dates, it was noted that for UGa-1762 Mockley ceramics were dominant in the context. I consider UGa-1762 a precise Mockley date and it is included in the ceramics type summary. The context for the Gray Farm Site producing the radiocarbon date (Beta-309416) also included Coulbourn and Townsend ceramics. As the context is mixed and Coulbourn ceramics are dominant, it is likely the date was derived from a blend of charcoal and it is not used in the scatter plot (Figure 8) or the ceramic type date range summary (Figure 15). In discussing the three other dates, the reports simply note that Mockley and Coulbourn ceramics were found in the dated context. It is possible that Mockley and Coulbourn ceramics were contemporary and these three dates represent a later expression of Coulbourn ceramics. It is equally likely that the dates represent Mockley producing components where earlier Coulbourn ceramics were incorporated into the feature when filled. A re-analysis of each context may or may not answer this question. Future excavations of Mockley-bearing contexts should be open to either hypothesis and field strategies designed to answer this question. For the purposes of the Mockley chronological summary chart, these dates are included as Mockley ceramics were clearly present in the dated contexts.

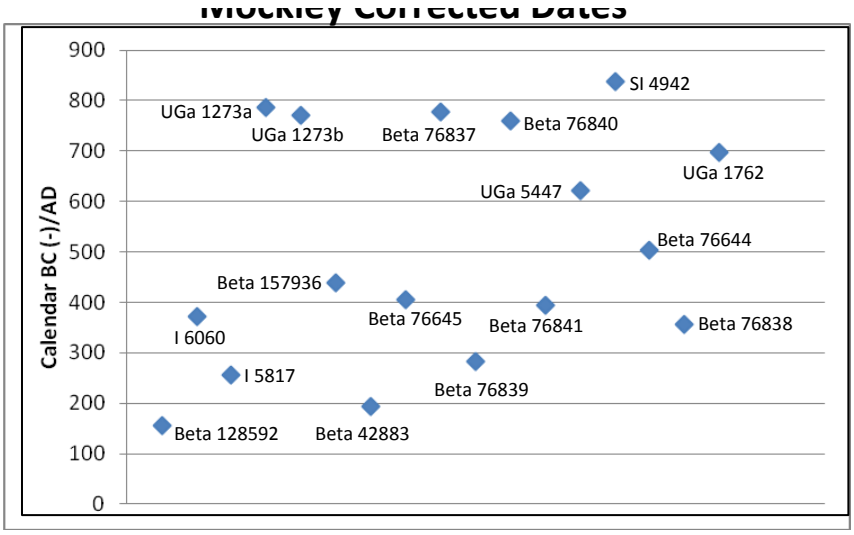
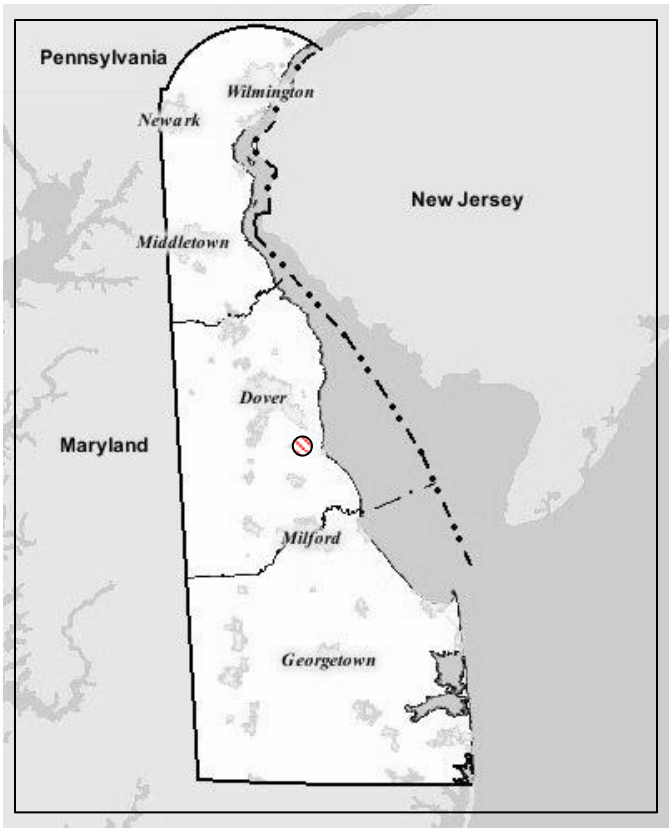


Figure 8: Mockley Corrected Dates.

Potomac Creek

There is one reported radiocarbon date for Potomac Creek ceramics (UGa-1761). The calibrated 2 sigma calendar date range is cal AD 1446 to cal AD 1664 (Figure 10). This date range is well within the reported date range for Potomac Creek ceramics in the Middle Atlantic (Dent 1995:246). Keyser Farm ceramics were also present in the dated context and the two types should be considered contemporary. Potomac Creek ceramics, like Keyser Farm, are very rare in Delaware. Their presence is likely the result of the relocation of a small group or family from the central western shore of the Chesapeake Bay sometime during the sixteenth century AD.



Potomac Creek Ceramic Date Locations

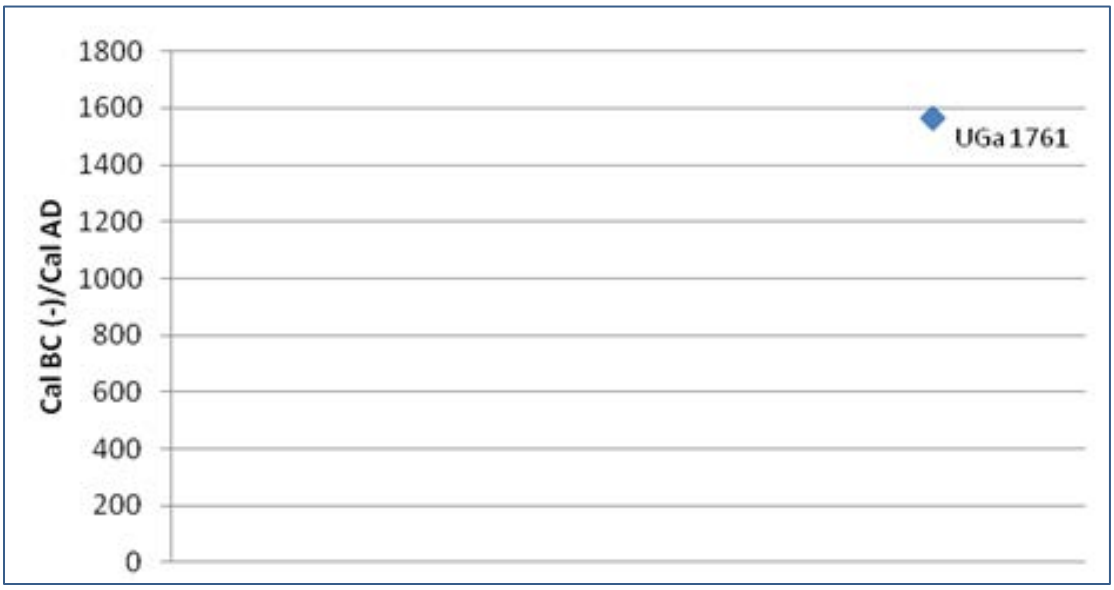
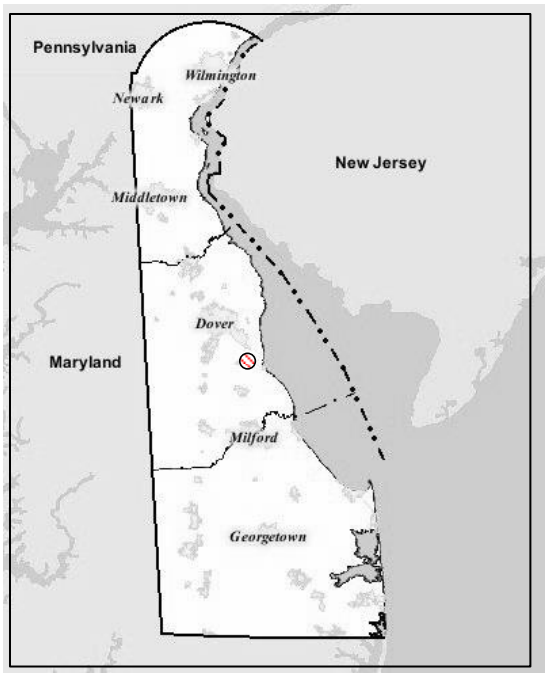


Figure 9: Potomac Creek Corrected Dates.

Selden Island

Five dates are reported for Selden Island ceramics. One date (Beta-52097) has a 2 sigma calibrated date range is cal AD 209 to cal AD 652. The published report states that the date is too recent for the type (Custer et al. 1995:243). The standard deviation for the date is ±120, which calls into question the accuracy of the date. The reported date is well beyond the accepted date range from cal BC 1000 to cal BC 700 (Artusy 1976). This date is not used in the Selden Island scatter plot (Figure 11) or in the date range summary for Selden Island ceramics in Delaware (Figure 15). Four dates for Selden Island ceramics were obtained from the research at the Gray Farm Site. One date (Beta-304998) has a calibrated age range of cal BC 2872 to cal BC 2577 and is well beyond the accepted range for the type and likely resulted from Selden Island ceramics intruding into a much earlier feature. Three dates (Beta-307657, Beta-307656 and Beta-304999) form a consistent cluster in the scatter plot. Two dates (Beta-307656 and Beta-307657) are from bulk sherd organics and are considered accurate and precise. All three dates are used to produce the ceramic type summary chart (Figure 15). The 2 sigma calibrated date range for Selden Island ceramics is cal BC 1195 to cal BC 811.



Selden Island Ceramic Date Locations

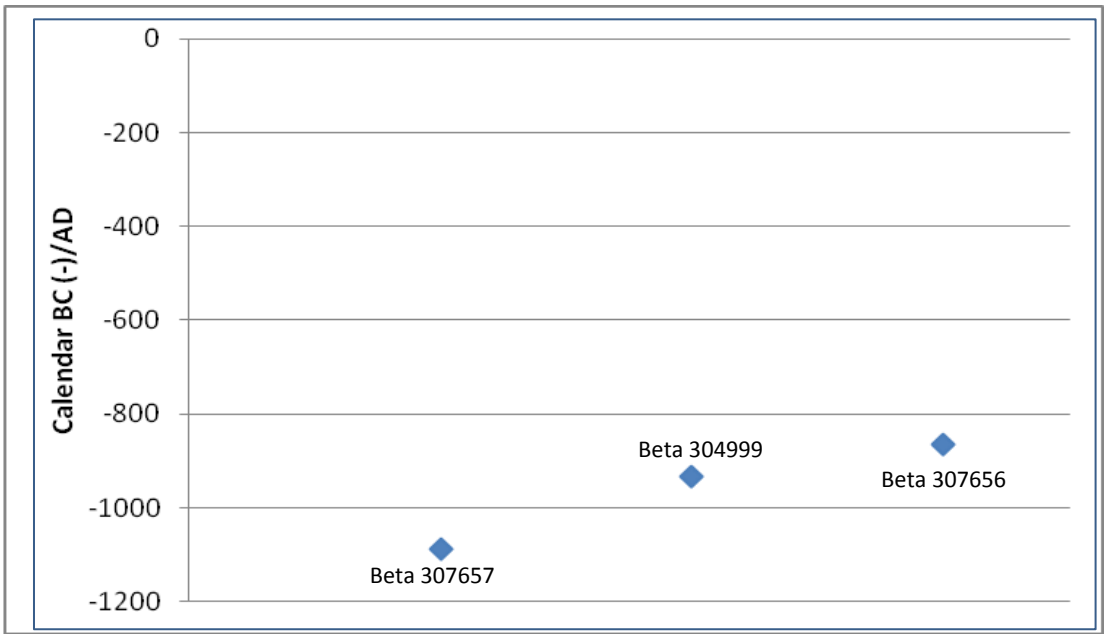
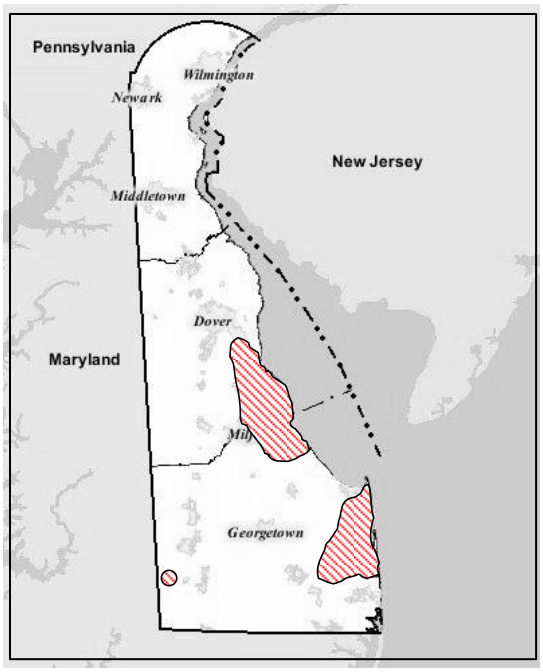


Figure 10: Seldon Island Corrected Dates.

Townsend

There are fifteen reported dates for Townsend ceramics (Figure 12). The mid-points of the calibrated dates cluster tightly with a combined 2 sigma date range of cal AD 941 to cal AD 1706. The standard deviations of all dates are less than ±100, which leads to the conclusion that the dates are highly accurate. The lack of other ceramic associations in the dated contexts, with three exceptions, indicates the dates are precise in dating the temporal range of Townsend ceramics. The three exceptions (SI-4944, Beta-307300 and Beta-307301), contain Killens ceramics in the same context. One date is from the Slaughter Creek site (Custer 1989:353), while the remaining two are from the Gray Farm site. As Killens ceramics are contemporary with Townsend ceramics, and may be considered a regional variant of Townsend, this date can be considered precise for both Killens and Townsend ceramics. The Townsend date on wood charcoal from the Island Field site (Beta-29737) was questioned in comparison to the shell date (Beta-29738) in the same context. While it seems that the wood charcoal sample may have been contaminated by earlier charcoal, the resulting calibrated 2 sigma date range is well within the range for Townsend ceramics. As the date may be both accurate and precise, it will be retained for the summary analysis. Dismissing this date does not change the 2-sigma date range for Townsend ceramics. All reported Townsend dates are used in producing the chronological summary for the type.



Townsend Ceramic Date Locations

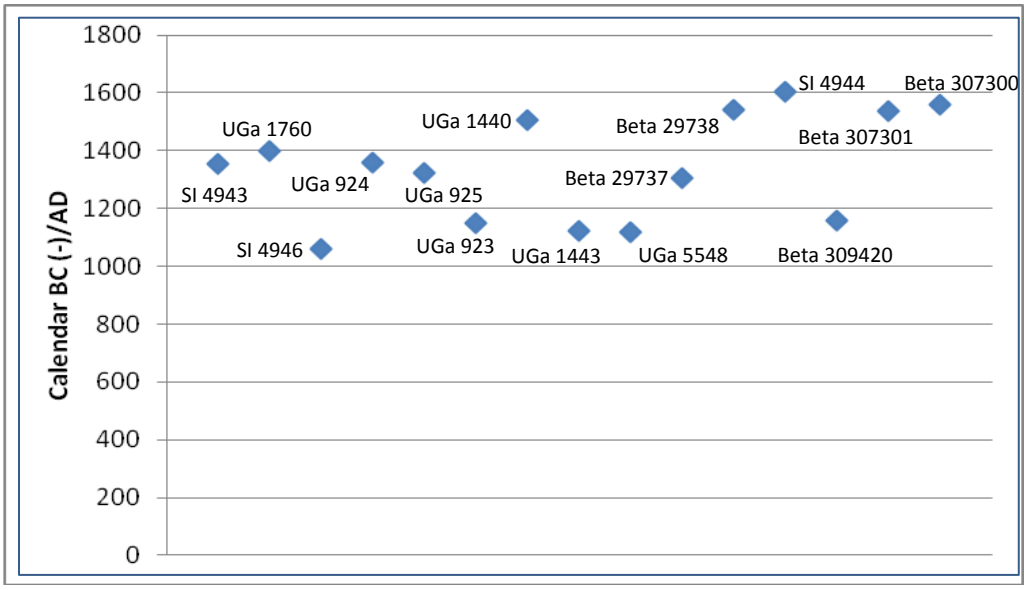
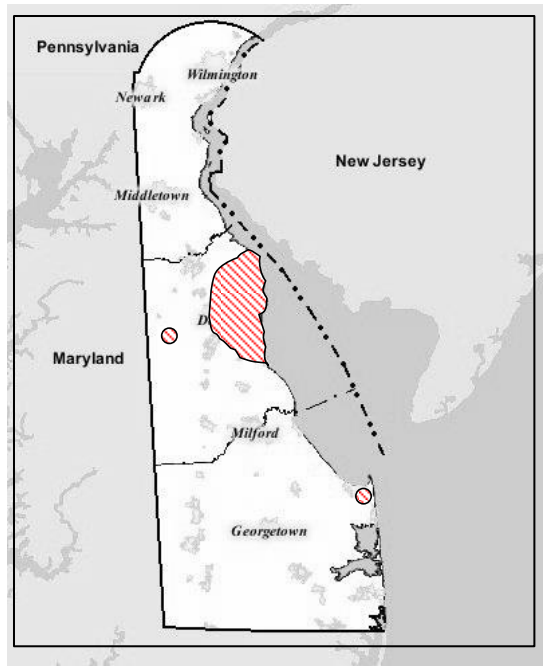


Figure 11: Townsend Corrected Dates.

Wolfe Neck

There are eight reported radiocarbon dates for Wolfe Neck ceramics (Figure 14). The scatter plot of the calibrated mid-points exhibit a cluster of five dates that likely represent the temporal range of Wolfe Neck ceramics (Beta-141542, I-6891, UGa-1223, Beta-309419 and Beta-42879). The 2 sigma calibrated range for Wolfe Neck ceramics based on these five dates is cal BC 782 to cal AD 74. Three reported dates, UGa-1763, Beta-304999 and Beta 52097, appear to be outliers. A re-analysis of the context containing the date for UGa-1763 reveals Coulbourn ceramics as the dominant type. This date is incorporated into the discussion of Coulbourn ceramics. It is possible that Wolfe Neck and Coulbourn ceramics were briefly contemporary, but further research is needed, as this is the only reported case of this association. The date for UGa-1763 is not used in producing the temporal summary for Wolfe Neck ceramics. Beta-52097 is reported to be too recent for Wolfe Neck (Custer et al. 1995:243). The standard deviation for the date is ±120, which indicates that the date is not very accurate for reasons previously stated. Beta-52097 is not used in producing the chronological summary for Wolfe Neck ceramics. Beta-304999 from Gray Farm is from a context that includes Selden Island ceramics and the associated radiocarbon date likely represents that component. This date is not used in the Wolfe Neck scatter plot (Figure 14) or in the ceramic type date range summary (Figure 15). Beta-309419 is from a cultural feature at the Gray Farm site and is considered both accurate and precise for the type.



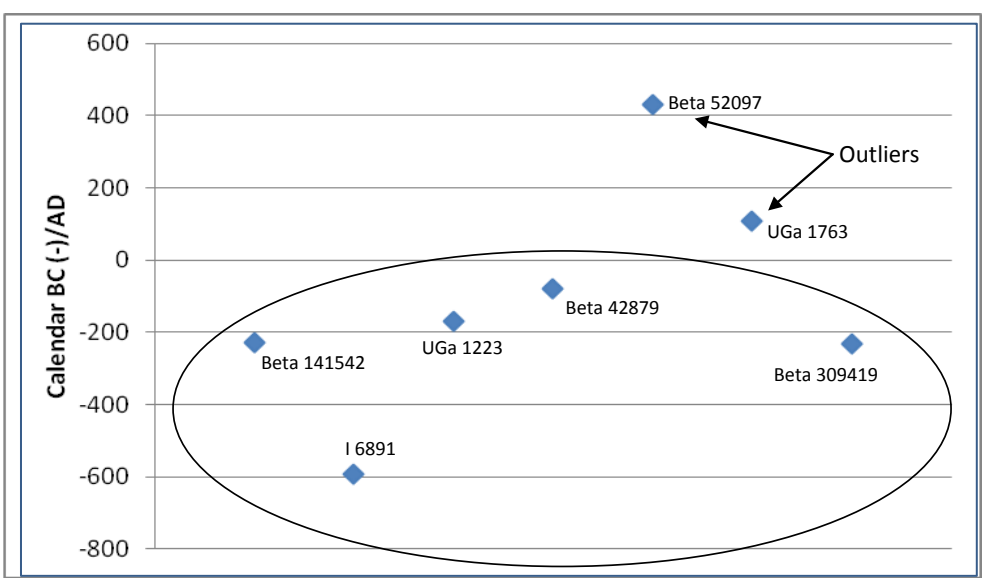


Figure 12: Wolfe Neck Corrected Dates.

Nassawongo

Because there are no precise radiocarbon dates in Delaware for Nassawongo and Wilgus (see below), a location map is not provided for these varieties. Both of these types may have a presence in Delaware, thus information from southern and coastal Maryland is presented here.

Two dates are reported for Nassawongo ceramics. The authors of the report containing the dates state that both dates are too recent for the type (Custer et al. 1995:243). Nassawongo ceramics have an expected date range around cal BC 500 (Custer 1984:183), while the reported dates from Delaware have a combined 2 sigma range of cal AD 501 to cal AD 1817 (Figure 9). In addition, the standard deviation of the CRA's for these dates is great than or equal to ±100, which calls into question the accuracy of the dates. These dates are considered neither accurate nor precise. Consequently, a Nassawongo ceramics type chronological summary is not included in this report.

Figure 13: Nassawongo Corrected Dates.

Wilgus

Two dates are reported for Wilgus ceramics (UGa-1762 and UGa-1763). The report notes that both dates are too recent for Wilgus ceramics (Custer 1983:39). However, the dominant ceramic type in the UGa-1762 context was Mockley while the dominant ceramic in the UGa-1763 context was Coulbourn. It is likely these dates are precise for those types. Wilgus ware is a cord marked or net impressed ceramic tempered with clay nodules/grog and shell, while Mockley is tempered with shell only and Coulbourn is tempered with clay nodules/grog only.

Wilgus ware has been offered as a transitional type between Coulbourn and Mockley (Custer 1983:39). While this is possible, it is equally likely that Wilgus ware is simply a variant within Coulbourn and Mockley wares and not a separate type with a distinct geographic distribution and temporal range. The two reported dates suggest the latter interpretation (Figure 13). The temporal framework summary does not include Wilgus ware for these reasons.

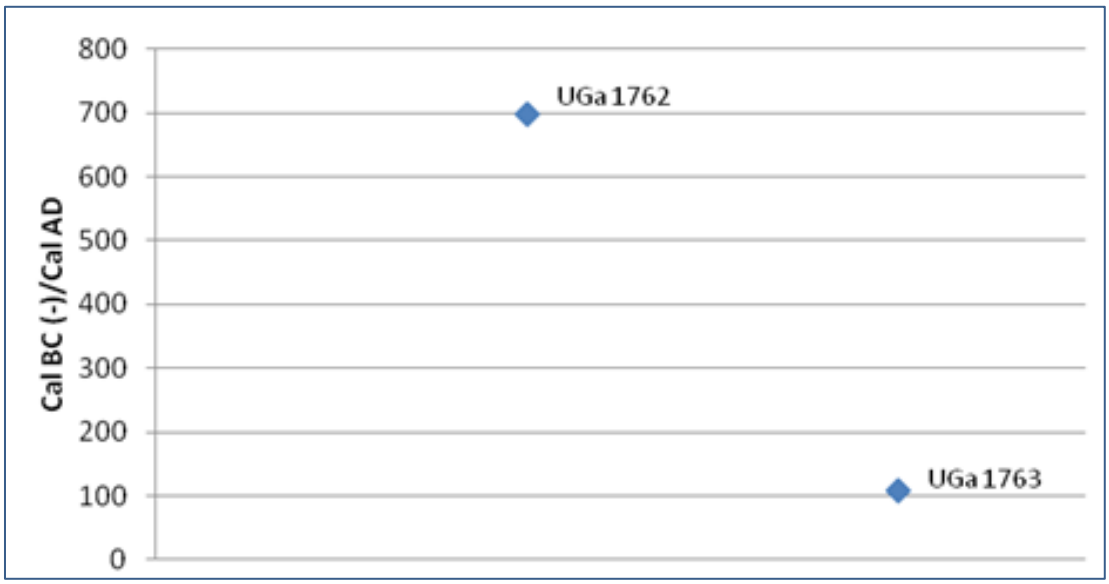


Figure 14: Wilgus Corrected Dates.

TEMPORAL RANGE OF AMERICAN INDIAN CERAMICS IN DELAWARE

The temporal ranges for radiocarbon dated American Indian ceramics is illustrated by a summary chart (Figure 15). The temporal range for each type is established using the combined 2 sigma date ranges of the component types that are considered both accurate and precise. The chart also plots the earliest and most recent mid-points of the 2 sigma range for each type, where there is more than one date for the type. Radiocarbon dates with standard deviations greater than or equal to ±100 or where the precision of the date has been questioned were not used to produce the summary chart or included in the associated data table in the aforementioned archaeological reports found online representing the full data set for this study. The data for the chart is in the re-calibrated data table contained in the report link above, Figures 1–14, and the accompanying text for each ceramic type. The geographic location of sites producing radiocarbon dates associated with American Indian ceramics is illustrated in Figure 16.

RECOMMENDATIONS AND FACTORS TO CONSIDER FOR FUTURE RADIOCARBON DATES

Radiocarbon dates are essential to establish calendar date ranges for American Indian ceramics in Delaware. To date 72 radiocarbon dates have been obtained from 25 sites (Table 1). The radiocarbon dates associated with American Indian ceramics from the Delaware Park site were shown to not be precise.

For the purpose of establishing the general calendar date range for a specific ceramic type, I recommend acquiring a minimum of five dates from different sites, assuming one or two of the dates will be outliers due to an insufficient sample size, poor association of the sample with the target ceramic and/or contamination of the sample. However, the ceramic types in this report vary considerably in their period of production and use. Mockley ceramics, for example, span at least 900 years (2 sigma) and Townsend ceramics 550 years (2 sigma). Consequently, for site specific research designed to determine periods of occupation, it is not accurate to rely solely on the date range of the associated ceramics established in this report (Griffith 2012).

The geographic distribution of precise radiocarbon dates is also of anthropological significance. The nature and direction of regional or sub-regional influences on American Indian ceramics technology and style can be interpreted by examining temporal and geographic distributions of ceramic series, types and varieties at a fine scale (cf. Griffith 2012). It is possible, even likely, that some types are not evenly distributed within Delaware, while some types may not be present in some areas. It is precisely this kind of geographic and temporal pattern that leads to finer grained knowledge of social dynamics. The scale of the space and time framework is significant. In order to address questions at the level of living communities and even individuals, it is necessary to establish a very fine-grained space and time framework of high data quality.

As presented in the report entitled "Delaware American Indian Ceramics: Radiocarbon Dates" (Griffith 2012), there are ceramics types known to be present in Delaware for which there are no precise dates (e.g., Minguannan), there are ceramics types that do not have five precise dates, and the geographic pattern of precise dates is uneven and restricted.

The distribution of precise dates reflects the pattern of archaeological excavations driven by the location of data recovery projects and isolated research investigations. Table 2 lists the precise dates from Table 1 by geographic region within the state. It is clear from Table 2 that the location of precise radiocarbon dates within Delaware were derived from a number of restricted areas. The hatched areas on the maps shown above for each ceramic types recovery location encompass single sites or clusters of sites where precise dates were obtained for each ceramic type.

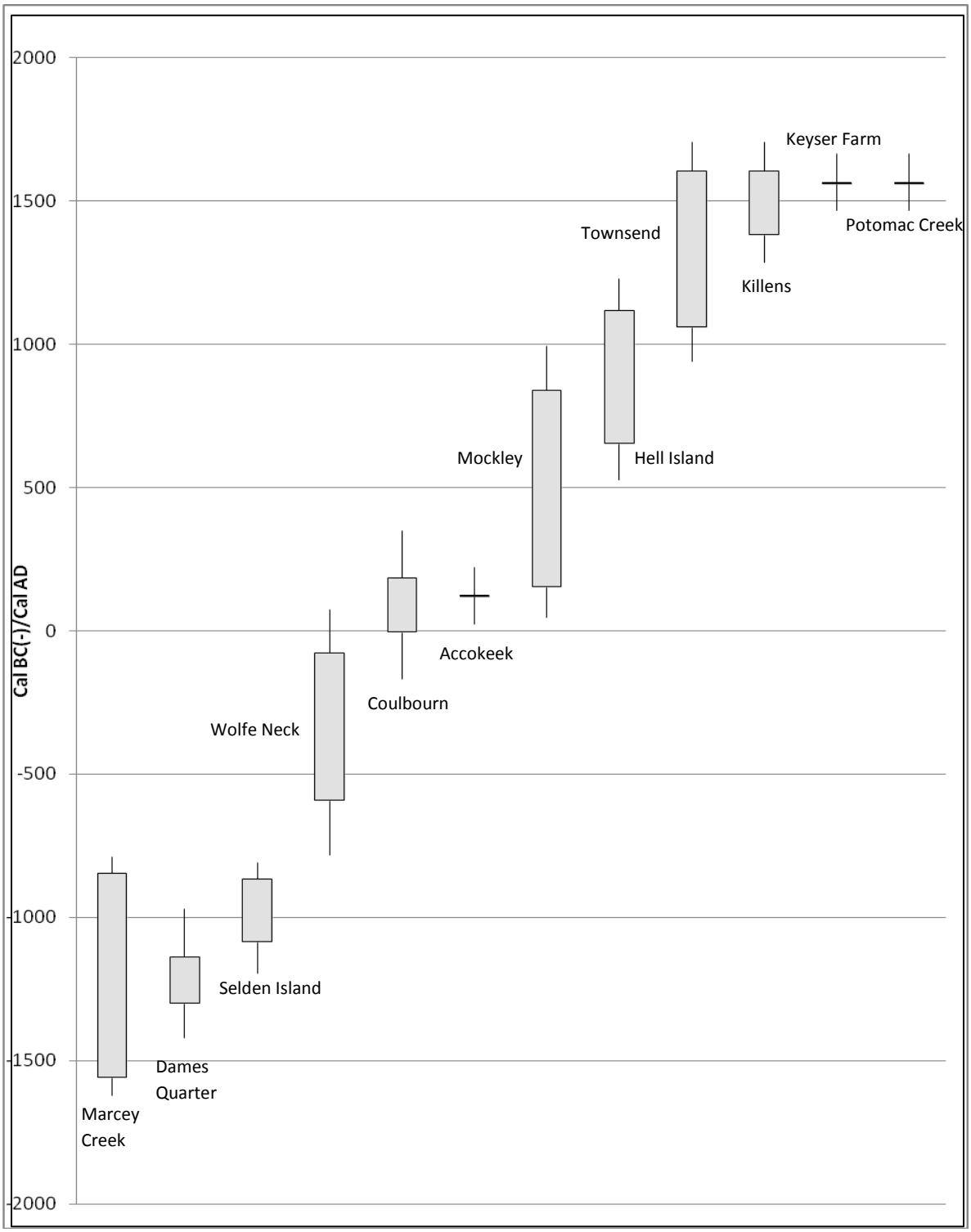


Figure 15: Delaware American Indian Ceramics Calibrated Date Range Summary (Shaded areas are the mid-point ranges; extensions are the maximum 2 sigma ranges).

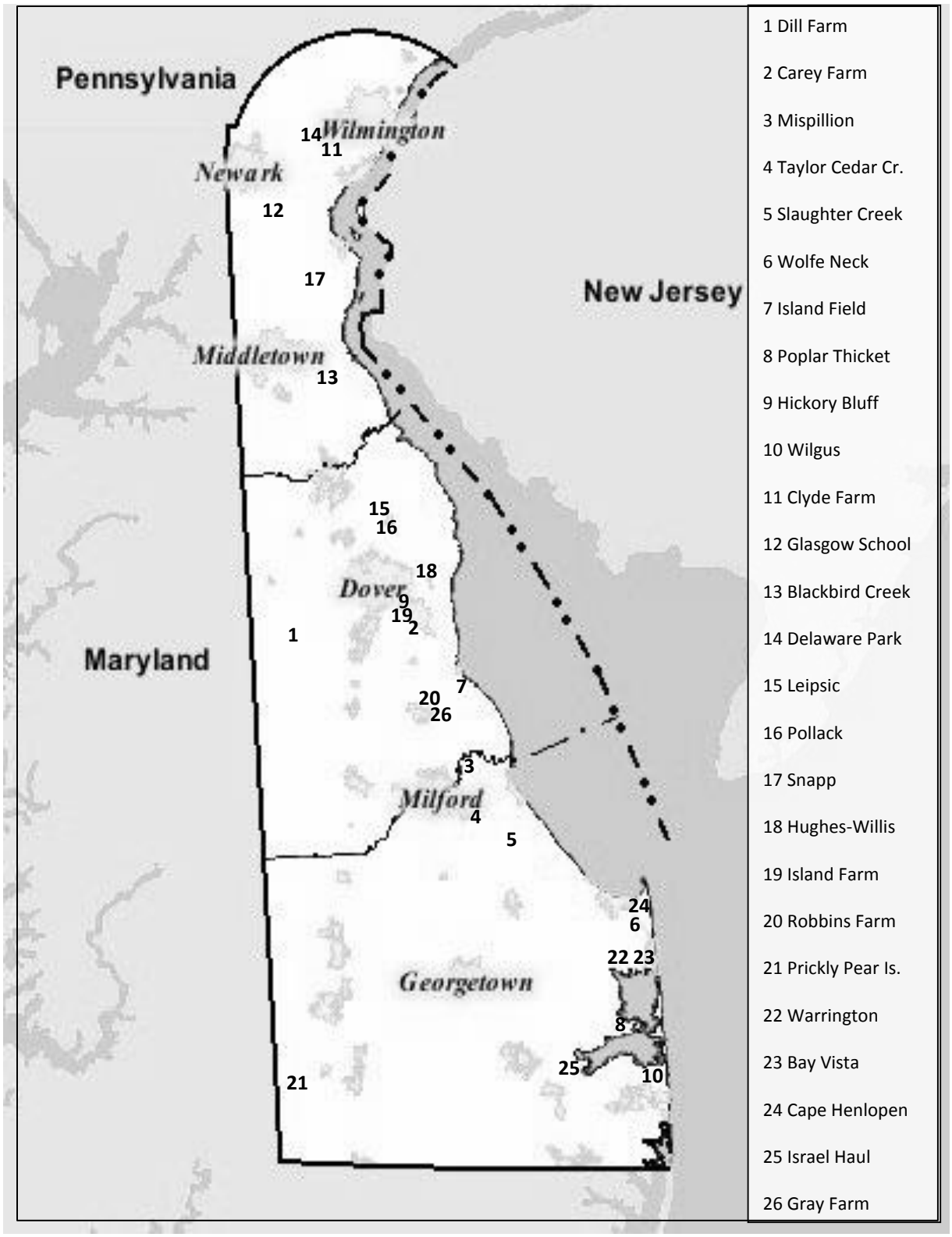


Figure 16: Site Locations of Radiocarbon-Dated American Indian Ceramics in Delaware.

Table 1: Ceramic Temporal Ranges and Sites, Re-Calibrated Dates.

Ceramic Type	Lab Code	Site	2 Sigma Range	Mid-Point
Accokeek	Beta-52096	Is. Farm	AD 23: AD 223	AD 123
Coulbourn	UGa-1224	Wolfe Neck	BC 168: AD 161	BC 4
	Beta-141001	Hickory Blf	BC 55: AD 91	AD 18
	Beta-141000	Hickory Blf	BC 39: AD 139	AD 50
	UGa-1763	Wilgus	BC 41: AD 260	AD 109
	Beta-77643	Wolfe Neck	AD 31: AD 339	AD 185
	Beta-77642	Wolfe Neck	AD 23: AD 349	AD 186
Dames Quarter	Beta-157391	Glasgow	BC 1407: BC 1191	BC 1299
	Beta-149986	Blackbird	BC 1395: BC 1187	BC 1291
	Beta-149988	Blackbird	BC 1419: BC 1111	BC 1265
	Beta-157390	Glasgow	BC 1319: BC 1110	BC 1215
	Beta-149987	Blackbird	BC 1319: BC 1110	BC 1215
	UGa-5377	Clyde Fm.	BC 1407: BC 971	BC 1189
	UGa-5376	Clyde Fm.	BC 1407: BC 970	BC 1189
	Beta-307655	Gray Fm	BC 1259: BC 1024	BC 1141
	Beta-149990	Blackbird	BC 1264: BC 1010	BC 1137
Hell Island	Beta-42884	Leipsic	AD 526: AD 779	AD 653
	I-6338	Is. Field A	D 659: AD 989	AD 824
	Beta-56361	Snapp	AD 689: AD 1020	AD 855
	Beta-305001	Gray Fm.	AD 776: AD 966	AD 871
	Beta-76843	Carey Fm.	AD 932: AD 1162	AD 1047
	UGa-1441	Cedar Crk.	AD 994: AD 1230	AD 1112
	Beta-128586	Hickory Blf.	AD 1023: AD 1213	AD 1118
Keyser Farm	UGa-1761	Robbins	AD 1466: AD 1664	AD 1565
Killens	Beta-69339	Pollack	AD 1286: AD 1481	AD 1384
	Beta-307301	Gray Fm.	AD 1457: AD 1617	AD 1537
	Beta-307300	Gray Fm.	AD 1477: AD 1642	AD 1559
	SI-4944	Slaughter Cr.	AD 1500: AD 1706	AD 1603
Marcey Creek	Beta-307658	Gary Fm.	BC 1622: BC 1492	BC 1557
	Beta-304997	Gray Fm.	BC 1435: BC 1298	BC 1366
	Beta-149987	Blackbird Cr.	BC 1319: BC 1110	BC 1215
	Beta- 117149	Hickory Blf.	BC 1039: BC 835	BC 937
	Beta– 128589	Hickory Blf.	BC 900: BC 790	BC 845
Mockley	Beta-128592	Hickory Blf.	AD 47: AD 263	AD 155
	I-5817	Carey Fm.	AD 72: AD 441	AD 257
	Beta-76839	Carey Fm.	AD 133: AD 433	AD 283
	Beta-76838	Carey Fm.	AD 237: AD 474	AD 356
	I-6060	Hughes Wls.	AD 134: AD 608	AD 371
	Beta-76841	Carey Fm.	AD 256: AD 534	AD 395
	Beta-76645	Carey Fm.	AD 245: AD 564	AD 405
	Beta-157936	GlasgowA	D 317: AD 560	AD 439
	Beta-76644	Carey Fm.	AD 404: AD 604	AD 504
	UGa-5447	Cape Hnlpn.	AD 549: AD 692	AD 621
	UGa-1762	Wilgus	AD 548: AD 848	AD 698
	Beta-76840	Carey Fm.	AD 644: AD 876	AD 760
	Beta-76837	Carey Fm.	AD 660: AD 896	AD 778
	UGa-1273a	Wolfe Neck	AD 651: AD 923	AD 787
	SI-4942	Slaughter Cr.	AD 682: AD 993	AD 838

Table 1 (continued): Ceramic Temporal Ranges and Sites, Re-Calibrated Dates.

Potomac Creek	UGa-1761	Robbins	AD 1466: AD 1664	AD 1565
Selden Island	Beta-307657	Gray Fm.	BC 1195: BC 977	BC 1086
	Beta-304999	Gray Fm.	BC 1029: BC 835	BC 932
	Beta-307656	Gray Fm.	BC 918: BC 811	BC 865
Townsend	SI-4946	Slaughter Cr.	AD 941: AD 1180	AD 1061
	UGa-5548	Israel Haul	AD 1016: AD 1218	AD 1117
	UGa-1443	Poplar Thkt.	AD 1021: AD 1225	AD 1123
	UGa-923	Mispillion	AD 1028: AD 1270	AD 1149
	Beta-309420	Gray Fm.	AD 1052: AD 1261	AD 1157
	Beta-29737	Is. Field	AD 1213: AD 1398	AD 1306
	UGa-925	Warrington	AD 1215: AD 1430	AD 1323
	SI-4943	Slaughter Cr.	AD 1283: AD 1422	AD 1353
	UGa-924	Poplar Thkt.	AD 1290: AD 1432	AD 1361
	UGa-1760	Prickly Pear	AD 1316: AD 1485	AD 1401
	UGa-1440	Bay Vista	AD 1393: AD 1617	AD 1505
	Beta-307301	Gray Fm.	AD 1457: AD 1617	AD 1537
	Beta-29738	Is. Field	AD 1421: AD 1659	AD 1540
	Beta-307300	Gray Fm.	AD 1477: AD 1642	AD 1559
	SI-4944	Slaughter Cr.	AD 1500: AD 1706	AD 1603
Wolfe Neck	I-6891	Dill Farm	BC 782: BC 399	BC 591
	Beta-309419	Gray Fm.	BC 358: BC 107	BC 232
	Beta-141542	Hickory Blf.	BC 366: BC 88	BC 227
	UGa-1223	Wolfe Neck	BC 337: BC 1	BC 169
	Beta-42879	Leipsic	BC 231: AD 74	BC 79

Table 2: Radiocarbon Dates by Region.

Ceramic Type	# Precise Dates	# Sites with Precise Dates	Piedmont	Delaware River	Delaware Bay	Atlantic Coast	Chesapeake Bay
Accokeek	1	1	0	0	1	0	0
Coulbourn	6	3	0	0	2	4	0
Dames Quarter	9	4	0	8	1	0	0
Hell Island	7	7	0	1	6	0	0
Keyser Farm	1	1	0	0	1	0	0
Killens	4	3	0	0	4	0	0
Marcey Creek	5	3	0	1	4	0	0
Minguannan	0	0	0	0	0	0	0
Mockley	15	8	0	1	11	3	0
Nassawongo	0	0	0	0	0	0	0
Potomac Creek	1	1	0	0	1	0	0
Selden Island	3	1	0	0	3	0	0
Townsend	15	9	0	0	9	5	1
Wilgus	0	0	0	0	0	0	0
Wolfe Neck	5	5	0	0	3	1	1

General recommendations for additional radiocarbon dates:

1) Date any new or newly defined type within an existing series or any unknown series or type.

2) Obtain at least two additional paired shell and charcoal dates from the Delaware Bay/Atlantic Coast to establish a marine reservoir correction for those areas. Refer to Griffith 2012 for a discussion of the need for and methods of determining a locally established marine reservoir correction.

3) Date any ceramic series or type with less than five precise dates from different sites with high quality contexts where the association is clear between the material submitted for radiocarbon dating and the target ceramic type.

4) Date any ceramics series or types outside the known recovery areas for each type, as shown on the maps above.

5) Date any non-local ceramic series or type (e.g., Potomac Creek).

6) Date high quality contexts for site specific research to determine periods of settlement.

The recommendations in this summary are based on the current state of knowledge of American Indian ceramics and their temporal and geographic distributions. As research continues, it is likely that new ways of organizing and interpreting the American Indian ceramics of Delaware will require additional radiocarbon dates or other means of absolute dating. Additionally, the radiocarbon dates evaluated here are the result of nearly 40 years of research and radiocarbon dating in Delaware. It may be determined that some of the dates are not accurate or precise, necessitating the application of more modern absolute dating techniques to address the questions of chronology and geographic distribution of the types.

REFERENCES

Artusy, Richard E., Jr.

1976 An Overview of the Proposed Ceramic Sequence in Southern Delaware. *Maryland Archaeology*, 12(2).

1978 The Wilgus Site. *The Archeolog,* Publication of the Sussex Society of Archeology and History, 30(1). Bethel, Delaware.

Beta Analytic, Inc.

2011 http://www.radiocarbon.com/required-carbon-dating-sample-size.htm, accessed on March 11, 2011.

Blume, Cara L., Cherie A. Clark and Michael Scholl

1993 *A Cultural Resource Management Plan for Killens Pond State Park.* Delaware Department of Natural Resources and Environmental Control Dover, Delaware.

Bourke, Patricia, and Quan Hua
2004 Examining Late Holocene Marine Reservoir Effect in Archaeological Fauna at Hope Inlet, Beagle Gulf, North Australia, in *New Directions in Archaeological Science, Terra Australis,* Vol. 28. Darwin, Australia.

Bowen, Christopher, Patrick O'Neill and Elizabeth A. Crowell
2003 *Archaeological Data Recovery Excavations at the Glasgow Elementary School Site, 7NC-D-212.* Parsons Engineering Science. Report on file with the Delaware Division of Historical and Cultural Affairs, Dover, Delaware.

Colman, Steven M, Pattie C. Baucom, John Bratton, et. al.
2001 Radiocarbon Dating Chronologic Framework, and Changes in Accumulation Rates of Holocene Estuarine Sediments from Chesapeake Bay. *Quaternary Research,* Vol. 57.

Custer, Jay F.
1984 *Delaware Prehistoric Archaeology: An Ecological Approach*. University of Delaware Press, Associated University Presses, London and Toronto.

1989 *Prehistoric Cultures of the Delmarva Peninsula: An Archaeological Study,* University of Delaware Press, Newark.

Custer, Jay F., Angela Hoseth, Barbara Silber, David Grettler and Glenn Mellin
1994 Final Archaeological Investigations at the Pollack Prehistoric Site (7K-C-203), State Route 1 Corridor, Kent County, Delaware. *Delaware Department of Transportation Archaeology Series* No. 126, Dover, Delaware.

Custer, Jay F., and Glenn Mellin
1987 Recent Archaeological Survey and Testing in the Atlantic Coast Zone of Delaware. *Bulletin of the Archaeological Society of Delaware,* No. 24, New Series. Wilmington, Delaware.

Custer, Jay F., Lynn Riley and Glenn Mellin
1996 Final Archaeological Excavations at the Leipsic Site (7K-C-194A), State Route 1 Corridor, Kent County, Delaware. *Delaware Department of Transportation Archaeology Series* No. 118, Dover, Delaware.

Custer, Jay F., Karen Rosenberg, Glenn Mellin and Arthur Washburn
1990 An Update on New Research at the Island Field Site (7K-F-17), Kent County, Delaware. *Bulletin of the Archaeological Society of Delaware,* No. 27, New Series, Wilmington, Delaware.

Custer, Jay F., and Barbara Silber
1995 Final Archaeological Investigations at the Snapp Prehistoric Site (7NC-G-101), State Route 1 Corridor, Chesapeake and Delaware Canal Section, New Castle County, Delaware. *Delaware Department of Transportation Archaeology Series No. 122,* Dover, Delaware.

Custer, Jay F., M.C. Steiner and S.C. Watson
1983 Excavations at the Wilgus Site (7S-K-21), Sussex County, Delaware. *Bulletin of the Archaeological Society of Delaware,* No. 15, New Series. Wilmington, Delaware.

Custer, Jay F., Scott Watson and Colleen DeSantis
1986 Archaeological Investigations of the Churchman's Marsh Area, *University of Delaware Center for Archaeological Research Monograph* No. 5, Newark, Delaware.

Custer, Jay F., Scott Watson and Barbara Silber
1995 Final Archaeological Investigations at the Carey Farm (7K-D-3) and Island Farm (7K-C-13) Sites, State Route 1 Corridor, Kent County, Delaware. *Delaware Department of Transportation Archaeology Series* No. 146, Dover, Delaware.

Dent, Richard J.
1995 Chesapeake Prehistory: Old Traditions, New Directions. Plenum Press, New York.

Deo, Jennie N., John O. Stone and Julie K. Stein
2004 Building Confidence in Shell: Variations in the Marine Reservoir Correction for the Northwest Coast Over the Past 3,000 Years. *American Antiquity,* 69(4):771–786.

Diamanti, Melissa, Conran Hay, and David Rue
2012 The Gray Farm Site: Phase II and Phase III Excavations on the Murderkill River (Sites 7K-F-11 and 7K-F-169), SR 1 Frederica North Grade Separated Intersection, Kent County, Delaware. *Delaware Department of Transportation Archaeology Series,* Dover, Delaware.

Doms, Keith, Jay F. Custer, Gwen Davis and Cheryl Trivelli
1985 Archaeological Investigations at the Bay Vista (7S-G-26) and the Cole Site (7S-G-79). *Bulletin of the Archaeological Society of Delaware,* No. 19, New Series, Wilmington, Delaware.

Griffith, Daniel R.
1977 Townsend Ceramics and the Late Woodland of Southern Delaware. M.A. Thesis, The American University, Washington, D.C.

2012 *Delaware American Indian Ceramics: Radiocarbon Dates,* in The Gray Farm Site: Phase II and Phase III Excavations on the Murderkill River (Sites 7K-F-11 and 7K-F-169), SR 1 Frederica North Grade Separated Intersection, Kent County, Delaware. *Delaware Department of Transportation Archaeology Series*, Dover.

Griffith, Daniel R., and Richard E. Artusy, Jr.
1975 A Brief Report on Semi-Subterranean Dwellings in Delaware. *The Archeolog,* Publication of the Sussex Society of Archeology and History, 27(1). Bethel, Delaware.

Griffith, Daniel R., and Richard E. Artusy
1977 Middle Woodland Ceramics from Wolfe Neck, Sussex County, Delaware.*The Archeolog,* Publication of the Sussex Society of Archeology and History, 28(1). Laurel, Delaware.

Heite, Edward F., and Cara Blume
1995 Data Recovery Excavations at the Blueberry Hill Prehistoric Site, *Delaware Department of Transportation Archaeology Series* No. 130, Dover, Delaware.

Higham, Thomas
1999 http://www.c14dating.com/agecalc.html, accessed on March 25, 2011.

Higham, T.F.G., and A.G. Hogg
1995 Radiocarbon Dating of the Prehistoric Shell from New Zealand and Calculation of the ΔR Value Using Fish Otoliths, *Radiocarbon,* 37(2):409–416.

Hoffman, Robert , Daniel Wagner, Jesse Rouse, Cheryl Classen and Roger Moeller
1997 Archaeological Data Recovery at a Single Component Woodland I Prehistoric Site (7S-D-61A) Located on Wolfe Neck, Near the Town of Rehoboth in Sussex County, Delaware. Copy on file at the Delaware Division of Historical and Cultural Affairs, Dover, Delaware.

Klein, Jeffery, J.C. Lerman, P.E. Damon and E.K. Ralph
1982 Calibration of Radiocarbon Dates: The Tables Based on the Consensus Data of the Workshop on Calibrating the Radiocarbon Time Scale. *Radiocarbon,* 24(2):103–150.

Lewis, Cara L.
1972 A Crushed Quartz Tempered Vessel from Indian River, *The Archeolog,* Publication of the Sussex Society of Archeology and History, Vol. 24:1–6. Bethel, Delaware.

Lopez, Julius
1961 Pottery from the Mispillion Site, Sussex County Delaware and Related Types in the Surrounding Area, *Pennsylvania Archaeologist,* 31(1).

Manson, Carl
1948 Marcey Creek Site: An Early Manifestation in the Potomac Valley, *American Antiquity,* 13:223–227.

Manson, Carl, Howard A. McCord and James B. Griffin
1944 The Culture of the Keyser Farm, Papers of the Michigan Academy of Sciences, Arts and Letters, Vol. 29, Ann Arbor.

Petraglia, Michael D., Susan L. Bupp, Sean P. Fitzell and Kevin W. Cunningham
2002 Hickory Bluff: Changing Perceptions of Delmarva Archaeology. *Delaware Department of Transportation Archaeology Series* No. 175, Dover, Delaware.

Petraglia, Michael D., Dennis Knepper, John Rutherford, et. al.
1998 The Prehistory of Lums Pond: The Formation of an Archaeological Site in Delaware. *Delaware Department of Transportation Archaeology Series* No. 155, Dover, Delaware.

Reimer, Paula
2011 Personal communication, June 10, 2011.

Rick, Torben, Darren Lowery, Gregory Henkes and John Wah
2011 *Shell Middens, Marine Reservoir Corrections and Cultural Chronologies* , Paper presented at the Middle Atlantic Archaeology Conference, March 19, 2011, Ocean City, Maryland.

Rick, Torben, G. Henkes, D. Lowery, S. Colman and B. Culleton
2011 Marine Radiocarbon Reservoir Corrections (ΔR) for the Chesapeake Bay and the Middle Atlantic Coast of North America, *Quaternary Research,* 77(1):205–210.

Robinson, Johnna, and Lynn Bulhack
2005 An Analysis of Fabric Impressions on the Surface of Early Mockley Sherds from Point Lookout State Park, Maryland (18ST772 and 18ST729), *Maryland Archaeology,* 41(1).

Scott, E.M., T.C. Aitchison, D.D. Harkness, G.T. Cook and M.S. Baxter
1998 An Overview of All Three Stages of the International Radiocarbon Intercomparison, *Radiocarbon,* 33(3):309–319.

Slattery, R.G.
1946 A prehistoric Indian site on Selden Island, Montgomery County, Maryland *Journal of the Washington Academy of Sciences,* 36:262–266.

Stephenson, R.L., and A.L.L. Ferguson
1963 The Accokeek Creek Site: A Middle Atlantic Cultural Sequence, *Anthropological Papers No. 20,* Museums of Anthropology, University of Michigan, Ann Arbor.

Stocum, Faye L.
1977 An Important Ceramic Discovery at the Robbins Farm Site (7K-F-12), *Bulletin of the Archaeological Society of Delaware,* Fall 1977, Wilmington, Delaware.

Stuiver, Minze, and Thomas F. Braziunas
1993 Modelling Atmopheric ^{14}C Influences and ^{14}C Ages of Marine Samples to 10,000 B.C. *Radiocarbon,* 35(1).

Stuiver, Minze, Paula Reimer and Thomas F. Braziunas
1998 High-Precision Radiocarbon Age Calibration for Terrestrial and Marine Samples. *Radiocarbon,* 40(3).

Stuiver, Minze and Paula Reimer
1993 Marine Reservoir Correction Database, http://calib.qub.sc.uk/marine/, accessed on March 25, 2011.

Telford, R.J., Heegard, E., H.J.B. Birks
2004 The Intercept is a Poor Estimate of a Calibrated Radiocarbon Age, *The Holocene,* 14(2):296–298.

Thomas, David Hurst
2008 Native American Landscapes of St. Catherines Island, Georgia, *American Museum of Natural History, Anthropological Papers* No. 88, Washington, D.C

Thomas, Ronald A.
1966 7NC-F-7, The Hell Island Site, Bulletin of the Delaware Archaeological Board, 2(2).

1981 Archaeological Investigations at the Delaware Park Site (7NC-E-41), Delaware Department of Transportation Archaeology Series No. 11, Dover, Delaware.

Thomas, Ronald A., and Nancy Warren
1970 A Middle Woodland Cemetery in Central Delaware: Excavations at the Island Field Site, *Bulletin of the Archaeological Society of Delaware,* No. 8, New Series, Wilmington, Delaware.

van der Plicht, Johannes and Hendrik J. Bruins
2001 Radiocarbon Dating in Near-Eastern Contexts: Confusion and Quality Control, *Radiocarbon,* 43(3):1155–1166.

Vesar, Inc.
2012 Early Ceramic Occupations along Blackbird Creek: Archaeological Investigations at the Blackbird Creek Site (7NC-J-195D), New Castle County, Delaware. *Delaware Department of Transportation Archaeology Series,* Dover, Delaware.

Wall, Robert D.
2001 Late Woodland Ceramics and Native Populations of the Upper Potomac Valley, *Journal of Middle Atlantic Archaeology,* 17:15–37.

Wise, Cara L.
1974a The Nassawongo Adena Site, Report in Eastern States Archaeological Federation: Proceedings of the Annual Meeting, Bulletin No. 33:5. Dover, Delaware.

1974b Mockley Ware and Its Precursors and Successors on the Delmarva Peninsula, paper presented at the Middle Atlantic Archaeology Conference, Baltimore, Maryland.

1975 A Proposed Early to Middle Woodland Ceramic Sequence for the Delmarva Peninsula, in Maryland Archaeology, 11(1).

1984 *A Cultural Resource Management Plan for Killens Pond State Park,* Delaware Department of Natural Resources and Environmental Control, Dover, Delaware.

Wright, Henry T.

1962 *The Hell Island Report,* Manuscript on file with Delaware Division of Historical and Cultural Affairs, Dover, Delaware.

1973 An Archaeological Sequence in the Middle Chesapeake Region, Maryland, *Maryland Geological Survey Archaeological Series* No. 1, Annapolis, Maryland.