

## AMS carbon-14 dating results Discussion and Analysis

### Report by Nick Pitt AMS Dates by Waikato Radiocarbon Dating Laboratory

#### 3.1.1 Introduction

Carbon-14 dating is not common on historical archaeological sites in Australia, as typically it is considered to yield any useful additional information. However the particular circumstances of Darling Walk meant that carbon-14 dating could yield valuable information about both the natural environment of the site prior to 1788, and processes of site modification at work in the early nineteenth-century before large-scale land reclamation took place at the site. In area 7, a deposit (context 8082) which was interpreted as a natural shell-bed, was discovered. In the same area, stratigraphically above this shell bed, were sandy and silty deposits, which were interpreted as intertidal mudflats. Part of these intertidal deposits also abutted early nineteenth-century timber fencing. Through carbon-14 dating shell from the shell bed and the intertidal deposits, it was hoped that two interrelated questions would be answered:

- what age range could be assigned to the 'ancient' shell bed (8082), found in TT11?
- what evidence did dating of shells from other deposits, which abutted early nineteenth-century fencing (8057), cast upon early, post-1788, disturbances of the site. Is there evidence that natural shell beds were being disturbed in the period, or was the shell in these intertidal deposits roughly contemporary with the fence-line running through them?

In order to answer the second of these research questions, contexts which were associated with early foreshore activity (phase 3) in area 7 were identified. Out of those contexts, those which had a clear relationship with the fencing (8057) were then preferred. In the end, three contexts from the intertidal zone were selected:

- **8053:** This context was described as naturally deposited coarse light grey sand with frequent crushed shell inclusions. It was found in TT6, but also extended beyond that area. The shell sample submitted most likely came out of shells collected in TT6. TT6 lay to the immediate west of the fence-line (8057) (and lay immediately underneath reclamation fills (8021 and 8031), which were phased to the 1830s and 1840s (phase 5). Pollen analysis suggested a post-1788 date, on the basis of cereal pollen identified in the context.<sup>1</sup> Dating shell from this context would provide an interesting point of comparison with the date based on pollen analysis.
- **7920:** This context was described as dark grey/black silty clay, and was interpreted as mudflat sediment typical of tidal accumulation. Wooden planking and sandstone fragments were embedded in this context, with the planking likely to have been related to the nearby fences (7997 and 8057). It was found in TT1, below a reclamation fill (7912), phased to the 1830s and 1840s (phase 5). Context 7920 also was known to be stratigraphically above context 8078. Dating shell from this context, which stratigraphically can be dated to being deposited just before reclamation in the 1830s and 1840s, would test if shell from older deposits was being disturbed in the early nineteenth century and then remaining on the waterfront's surface.
- **8078:** This context was described as coarse grey sand with occasional oyster and cockle shells. It was interpreted as an intertidal deposit lying above a more substantial shell deposit (8088) and abutting the fence (8057). Stratigraphically it lay beneath context 7920.

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<sup>1</sup> Pollen Report Macphail Vol 3 Section 8.6.

Dating shell from this context could aid the interpretation of the fence (8057) and whether the sandy deposit (8078) was a very old deposit which had been disturbed by the fence-line, or whether it was roughly contemporary with the fence, possibly accumulating after its construction.

For addressing the first research question, context 8082 was preferred over other likely natural shell bed contexts (8074 and possibly 8088), as it had a catalogued, unbiased sample (sample 11), from which shell for dating could be taken.

### 3.1.2 Methodology

The species of shell dated from Darling Walk was Sydney Cockle, *Anadara trapezia*. This species was selected as it was both a suspension feeder, which was recommended for carbon-14 dating,<sup>2</sup> and also the second-most abundant shell species by weight in both natural harbour deposits and intertidal deposits in area 7.<sup>3</sup> AMS [Atomic Mass Spectroscopy] carbon-14 dating was selected in preference to radiometric carbon-14 dating methods, as the sample sizes required for AMS dating allowed for individual shells to be dated, rather than a combined sample.

The shell samples for dating were selected from those shells which had already been catalogued as part of the post-excavation analysis of Darling Walk. For contexts 7920, 8053 and 8078, this shell had been hand-collected from the deposits during excavation, while the catalogued shell from context 8082 came from an unbiased sample. As part of the cataloguing process, these shells had been hand-washed in water, dried, and then stored in polyethylene snap-lock bags together with a paper shipping tag. Before dispatching the samples, the samples were weighed and placed in new polyethylene snap-lock bags. They were double-bagged to separate the paper tags from the shell.

All samples were dated through the University of Waikato, Radiocarbon Laboratory, New Zealand. The shells were dispatched to the laboratory on 31 March 2012. The results were supplied to Casey & Lowe on 5 June 2012.

### 3.1.3 Results and discussion

The dating results were provided to Casey & Lowe as individual reports for each sample, which are summarised in Table 1. The individual reports are included in as an appendix to this report (appendix 1). The calibrated dates with a 95.4% probability are those which will be used in the discussion of the results.<sup>4</sup>

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<sup>2</sup> Waikato Radiocarbon Dating Laboratory nd

<sup>3</sup> Shell Report Carter Vol 3 Section 8.5.

<sup>4</sup> 95.4% probability is equivalent to a range of plus or minus two standard deviations, in the case of a normal distribution.

**Table 1: Results of AMS carbon-14 dating, summarised from appendix 1**

Waikato lab #	Sample #	Context	Cat #	Sample weight (g)	$\delta^{13}\text{C}$ (‰) <sup>5</sup>	$\text{D}^{14}\text{C}$ (‰)	$\text{F}^{14}\text{C}$ (%) <sup>6</sup>	Result (BP) <sup>7</sup>	Calibrated date (68.2% prob.) <sup>8</sup>	Calibrated date (95.4% prob.)
Wk-33746	1-8053	8053	3148	3	1.3±0.2	-286.4±2.3	71.4±0.2	2710±26	500-385 calBC	595-355 calBC
Wk-33747	2-7920	7920	3162	4	1.3±0.2	-406.6±2.2	59.3±0.2	4192±29	2410-2265 calBC	2450-2200 calBC
Wk-33748	3-8078	8078	3042	3	1.0±0.2	-66.0±2.9	93.4±0.3	549±25	1700-1815 calAD	1675-1895 calAD (95.2% prob) 1940-1950 calAD (0.2% prob)
Wk-33749	4-8082	8082	4086	15	0.3±0.2	-321.8±2.4	67.8±0.2	3119±28	1000-880 calBC	1060-820 calBC
Wk-33750	5-8082	8082	4086	4	1.0±0.2	-464.1±2.0	53.6±0.2	5012±29	3465-3355 calBC	3510-3325 calBC

Based on these dates (Table 1), the natural deposit, 8082, contains shells dating between 1060-820 calBC and 3510-3325 calBC. It seems likely that if more shells from that context were dated, shells with ages between these two dates would be found. Therefore it appears that the 'ancient' shell bed, 8082, is indeed ancient, forming between 2800 and 5500 years ago, over a period of 2200 to 2700 years. This has implications for any discussion which uses context 8082 as representative of the pre-1788 proportions of shell species present, as it cannot be necessarily assumed that the relative proportions of shell species present in the harbour remained constant over two and a half thousand years.

The dates from intertidal deposits also range quite widely, pointing to both the disturbance of older shell beds, but also the continual deposition of material post-1788. The shell sample from context 8053 was dated to between 595-355 calBC. This contrasts with the pollen analysis, which found 2% of pollen in the sample from 8053 was from exotic cereals, which suggested a post-1788 date for the context.<sup>9</sup> Although it is just possible that the cereal pollen was washed in from reclamation fills,<sup>10</sup> it is more likely that 8053 represents redeposited material from an older shell bed mixed with sand in the intertidal area during early, post-1788, foreshore activity. This is the interpretation suggested by the stratigraphic relationships recorded on site. Context 8053 lay above coarse grey sand (8079), which appeared to predate the paling fence (8057), and abutted more dark grey sand (8059), which abutted the paling fence (8057).<sup>11</sup> Also context 8053 was not found east of the paling fence (8057). From these relationships, it appears that the paling fence was erected in the existing foreshore sand (8079). Foreshore sand continued to build up against the fence, forming deposit 8059, while at roughly the same time material from an older shell bed was brought in and dumped on the site. This interpretation of events is further supported by the one artefact recorded from context 8053 (#59888), which is a fragment of blue-edged pearlware (c1780-c1860). Although it

<sup>5</sup> Note from University of Waikato, Radiocarbon Dating Laboratory reports (appendix 1) "The isotopic fractionation,  $\delta^{13}\text{C}$ , is expressed as ‰ wrt [with regards to] PDB [Peedee Formation]."

<sup>6</sup> Note from University of Waikato, Radiocarbon Dating Laboratory reports (appendix 1), " $\text{F}^{14}\text{C}$  is also known as *Percentage Modern Carbon (pMC)*."

<sup>7</sup> Note from University of Waikato, Radiocarbon Dating Laboratory reports (appendix 1), "Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied."

<sup>8</sup> Calibrated dates from University of Waikato, Radiocarbon Dating Laboratory reports (appendix 1), using OxCal v4.1.7, (Bronk Ramsay 2010), using data from Reiner et al (2009),  $\Delta R=4.25$ .

<sup>9</sup> Pollen Report Macphail Vol 3 Section 8.6.

<sup>10</sup> Pollen Report Macphail Vol 3 Section 8.6.

<sup>11</sup> Context 8059 was interpreted as being the same as context 8079.

can be misleading to place too much emphasis on a single artefact, in this case the collected artefact supports the larger interpretation of the context as redeposited material.

The shell sample from context 7920 was dated to 2450-2200 calBC. This old date for the shell contrasts with the other strong evidence that context 7920 is the latest of the deposits from which shell was dated. Context 7920 was stratigraphically immediately below the reclamation fill (7912) and above context 8078, which contained shell no more than around 150 years old when the area would have been reclaimed. Also some post-1788 artefacts came from 7920, including a small fragment of crown window glass (#75795), an unidentified blue transfer printed ceramic fragment (#59467) and cow and sheep bones (#3813, #4117). Hence it seems likely that this shell sample is an instance of material from a disturbed ancient shell bed re-entering circulation, and being found quite near the surface of the foreshore intertidal zone in the early nineteenth century, prior to the later land reclamation.

The shell sample date from context 8078 is markedly different to all others from the intertidal deposits, as it was dated to 1675-1895 calAD (95.2% prob) and 1940-1950 calAD (0.2% prob). Given that the context pre-dates 1830s and 1840s land reclamation deposits (phase 5), the shell must have been no more than around 150 years old when the paling fence (8057) was erected. This makes its interpretation that 8078 is the accumulation of tidal sands against the fence (8057) possible, but not guaranteed. What this dating information does provide is evidence that not all Sydney Cockle (*Anadara trapezia*) shells found in the intertidal zone came from disturbed, ancient deposits, but some do represent molluscs alive in the harbour in the last few hundred years.

The evidence from dating shell from the phase 3, early foreshore use, intertidal deposits from area 7 is therefore indicative of both the disturbance of ancient shell beds, and the deposition of contemporary or near contemporary shells. Context 8053 appears to represent shell from an ancient shell bed which was redeposited during phase 3. The ancient shell from context 7920 demonstrates how shell from these disturbed ancient deposits continued to circulate in the intertidal zone during the period of early foreshore use. The contemporary or near contemporary shell from context 8078 demonstrates the continual presence of Sydney Cockles to at least the beginning of post-1788 foreshore use.

## References

Bronk Ramsay, C, 2010. OxCal v4.1.7 [radiocarbon dating calibration software]

Reimer, P J, Baillie, M G L, Bard, E, Bayliss, A, Beck, J W, Blackwell, P G, Bronk Ramsey, C, Buck, C E, Burr, G S, Edwards, R L, Friedrich, M, Grootes, P M, Guilderson, T P, Hajdas, I, Heaton, T J, Hogg, A G, Hughen, K A, Kaiser, K F, Kromer, B, McCormac, F G, Manning, S W, Reimer, R W, Richards, D A, Southon, J R, Talamo, S, Turney, C S M, van der Plicht, J, and Weyhenmeyer, C E, 2009. "IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP", *Radiocarbon*, 51(4), pp. 1111-1150.

Stuiver, M, and Polach, H A, 1977. "Discussion: reporting of  $^{14}\text{C}$  data", *Radiocarbon*, 19(3), pp. 355-363.

Waikato Radiocarbon Dating Laboratory nd "Shellfish database", Available at <http://www.radiocarbon dating.com/imagesOMR/shellfishdiet2.html> [accessed 22/02/2012].

**Appendix 1 – Results from Waikato, Radiocarbon Dating Laboratory**



**Report on Radiocarbon Age Determination for Wk- 33746**

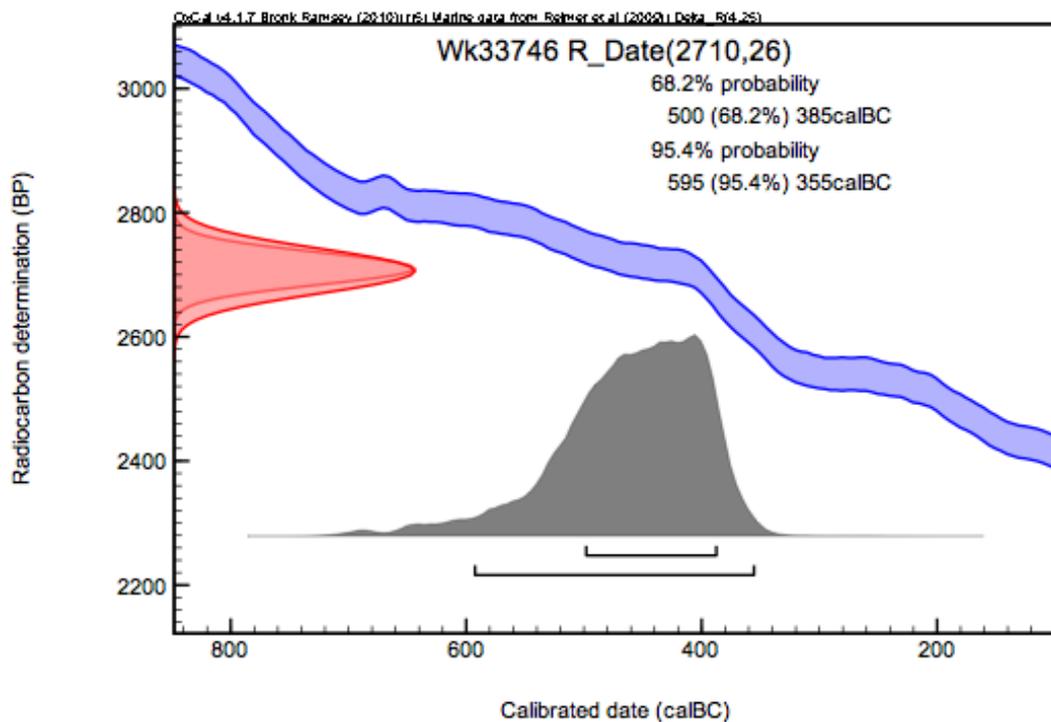
<b>Submitter</b>	M Casey
<b>Submitter's Code</b>	1-8053
<b>Site &amp; Location</b>	Darling Walk, Darling Harbour, Sydney, Australia
<b>Sample Material</b>	Anadara trapezia
<b>Physical Pretreatment</b>	Surfaces cleaned. Washed in an ultrasonic bath. Tested for recrystallization: aragonite.
<b>Chemical Pretreatment</b>	Sample acid washed using 0.1N HCl, rinsed and dried.

$\delta^{13}\text{C}$	$1.3 \pm 0.2 \text{ ‰}$
$\text{D}^{14}\text{C}$	$-286.4 \pm 2.3 \text{ ‰}$
$\text{F}^{14}\text{C}\%$	$71.4 \pm 0.2 \%$

**Result**     **2710  $\pm$  26 BP**

( AMS measurement )

**Comments**



- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation,  $\delta^{13}\text{C}$ , is expressed as ‰ wrt PDB.
- $\text{F}^{14}\text{C}\%$  is also known as *Percent Modern Carbon (pMC)*



*Report on Radiocarbon Age Determination for Wk- 33747*

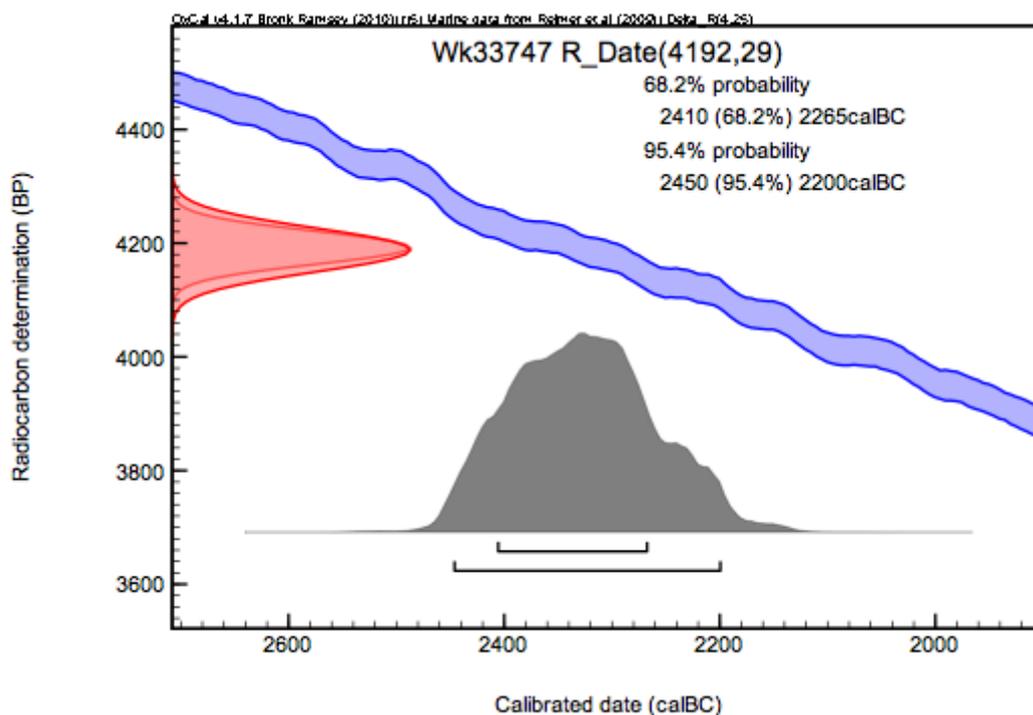
<b>Submitter</b>	M Casey
<b>Submitter's Code</b>	2-7920
<b>Site &amp; Location</b>	Darling Walk, Darling Harbour, Sydney, Australia
<b>Sample Material</b>	Anadara trapezia
<b>Physical Pretreatment</b>	Surfaces cleaned. Washed in an ultrasonic bath. Tested for recrystallization: aragonite.
<b>Chemical Pretreatment</b>	Sample acid washed using 0.1N HCl, rinsed and dried.

$\delta^{13}\text{C}$	1.3 $\pm$ 0.2 ‰
D <sup>14</sup> C	-406.6 $\pm$ 2.2 ‰
F <sup>14</sup> C%	59.3 $\pm$ 0.2 ‰

**Result**     **4192  $\pm$  29 BP**

( AMS measurement )

**Comments**



*F. Patten*  
5/06/12

- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation,  $\delta^{13}\text{C}$ , is expressed as ‰ wrt PDB.
- F<sup>14</sup>C% is also known as *Percent Modern Carbon (pMC)*



**Report on Radiocarbon Age Determination for Wk- 33748**

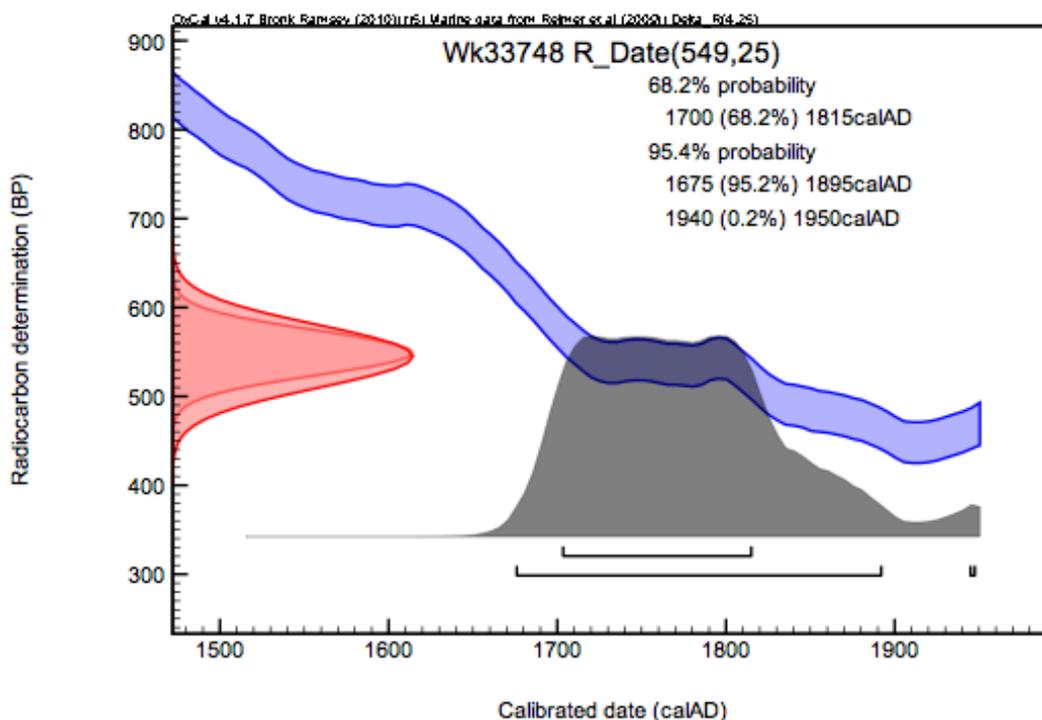
**Submitter** M Casey  
**Submitter's Code** 3-8078  
**Site & Location** Darling Walk, Darling Harbour, Sydney, Australia  
**Sample Material** Anadara trapezia  
**Physical Pretreatment** Surfaces cleaned. Washed in an ultrasonic bath. Tested for recrystallization: aragonite.  
**Chemical Pretreatment** Sample acid washed using 0.1N HCl, rinsed and dried.

$\delta^{13}\text{C}$  1.0  $\pm$  0.2 ‰  
 $\text{D}^{14}\text{C}$  -66.0  $\pm$  2.9 ‰  
 $\text{F}^{14}\text{C}\%$  93.4  $\pm$  0.3 %

**Result** 549  $\pm$  25 BP

( AMS measurement )

**Comments**



*Alan Hogg*  
 5/06/12

- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation,  $\delta^{13}\text{C}$ , is expressed as ‰ wrt PDB.
- $\text{F}^{14}\text{C}\%$  is also known as *Percent Modern Carbon (pMC)*



**Report on Radiocarbon Age Determination for Wk- 33749**

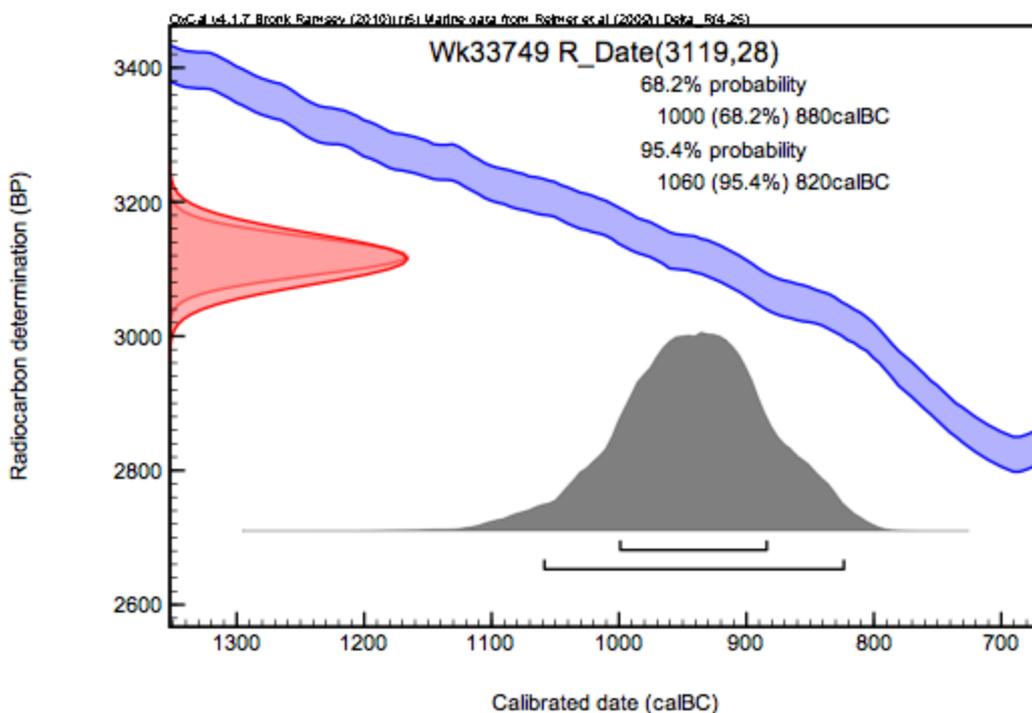
**Submitter** M Casey  
**Submitter's Code** 4-8082  
**Site & Location** Darling Walk, Darling Harbour, Sydney, Australia  
**Sample Material** Anadara trapezia  
**Physical Pretreatment** Surfaces cleaned. Washed in an ultrasonic bath. Tested for recrystallization: aragonite.  
**Chemical Pretreatment** Sample acid washed using 0.1N HCl, rinsed and dried.

$\delta^{13}\text{C}$  0.3  $\pm$  0.2 ‰  
 $\text{D}^{14}\text{C}$  -321.8  $\pm$  2.4 ‰  
 $\text{F}^{14}\text{C}\%$  67.8  $\pm$  0.2 ‰

**Result** 3119  $\pm$  28 BP

( AMS measurement )

**Comments**



*Alan Hogg*  
 5/06/12

- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation,  $\delta^{13}\text{C}$ , is expressed as ‰ wrt PDB.
- $\text{F}^{14}\text{C}\%$  is also known as *Percent Modern Carbon (pMC)*



**Report on Radiocarbon Age Determination for Wk- 33750**

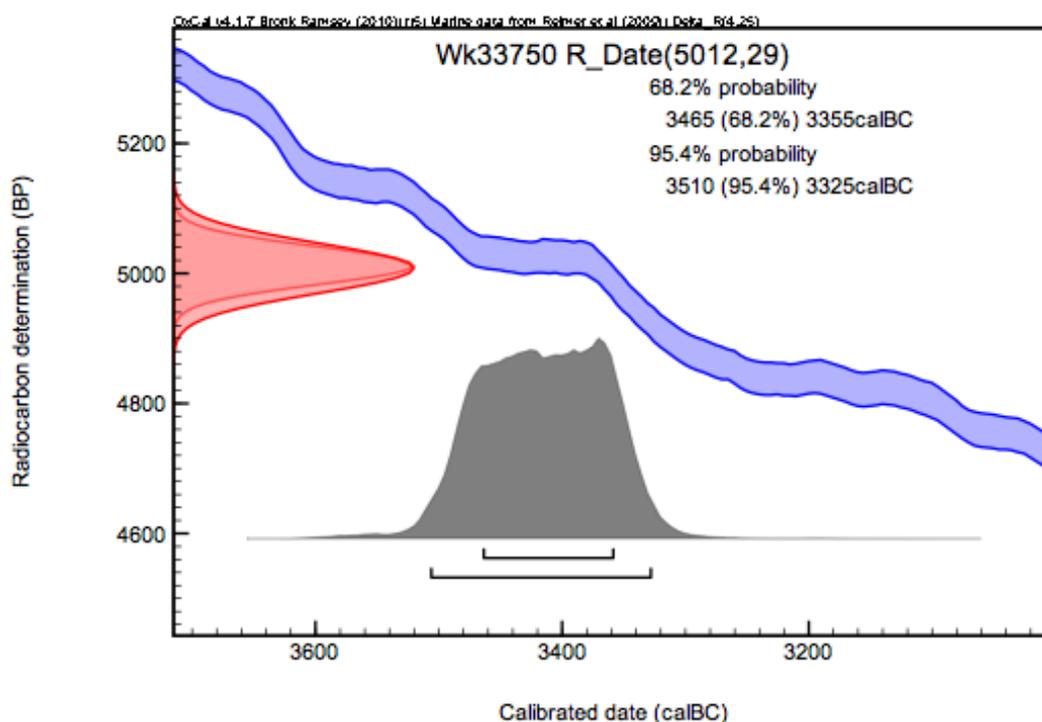
<b>Submitter</b>	M Casey
<b>Submitter's Code</b>	5-8082
<b>Site &amp; Location</b>	Darling Walk, Darling Harbour, Sydney, Australia
<b>Sample Material</b>	Anadara trapezia
<b>Physical Pretreatment</b>	Surfaces cleaned. Washed in an ultrasonic bath. Tested for recrystallization: aragonite.
<b>Chemical Pretreatment</b>	Sample acid washed using 0.1N HCl, rinsed and dried.

$\delta^{13}\text{C}$	$1.0 \pm 0.2 \text{ ‰}$
$\text{D}^{14}\text{C}$	$-464.1 \pm 2.0 \text{ ‰}$
$\text{F}^{14}\text{C}\%$	$53.6 \pm 0.2 \%$

**Result**     **5012  $\pm$  29 BP**

( AMS measurement )

**Comments**



*Alan Hogg*  
5/06/12

- Result is *Conventional Age* or *Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation,  $\delta^{13}\text{C}$ , is expressed as ‰ wrt PDB.
- $\text{F}^{14}\text{C}\%$  is also known as *Percent Modern Carbon (pMC)*