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NOTES AND COMMENTS

CALIBRATING NEW ZEALAND RADIOCARBON DATES OF MARINE SHELLS

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ABSTRACT. Radiocarbon activity of 11 modern marine shell samples from the New Zealand region is enhanced compared with the surface layers of the average world ocean. The measured enhancement, ΔR, is equivalent to −31 ± 13 years. On this basis, the Institute of Nuclear Sciences will now use a value of −30 years in reporting calibrated ages for marine shell samples.

INTRODUCTION

Stuiver, Pearson and Braziunas (1986) modeled the history of radiocarbon variations in the surface ocean layers using measured atmospheric changes and knowledge of gas exchange rates between the atmosphere and the oceans. The resulting calibration curve for the average world ocean has a long-term trend which parallels that of the atmosphere, with much smoother short-term variations.

To use the curve for a particular region, we calculate a factor, ΔR, which is a measure of the regional enhancement or depletion of radiocarbon due, for example, to local anomalies such as upwelling of old sea water. ΔR is the difference between the radiocarbon activity of the regional ocean and the surface layers of the average world ocean in AD 1950. Calculation of ΔR is based on the conventional radiocarbon age of samples of known calendar age collected from the area. Stuiver, Pearson and Braziunas (1986) give values for many parts of the world including New Zealand. The value given for New Zealand (−65 ± 25 yr) was calculated from the results of five samples, four of which were unreferenced (Stuiver, Pearson & Braziunas 1986, Table 1). We present here a new estimate of ΔR for the New Zealand region, which is based on 11 marine shell samples dated by the Institute of Nuclear Sciences, for which we are confident of the actual age and provenience.

CALCULATION OF ΔR

Table 1 lists the 11 shell samples. Some of these results include early measurements in which samples were compared to a *Pinus radiata* standard. These were modified slightly from previously published values following a re-evaluation of this older standard relative to the conventional NBS oxalic acid standard (Melhuish, pers commun, 1989). McFadgen (1978) previously published Samples 1-7. Samples 8-11 were not published; Table 2 lists sample details. We calculated conventional ages with respect to the 0.95 oxalic acid standard and included isotopic fractionation corrections as defined by Stuiver and Polach (1977). We determined model age from Stuiver, Pearson and Braziunas (1986, Fig 10A). The difference between conventional age and model age for each sample is an estimate of ΔR. The estimates range between −100 and +40 years. The range is not significant (T' test, Ward & Wilson 1978, Chi-squared = 9.07, df = 10, P = 0.525);

TABLE 1
Calculation of ΔR

Sample	Date coll	Date run	NZ no.	R no.	PR no.	$\delta^{13}C$	$\Delta^{14}C$	Conv age (P)	Model age (Q)	ΔR (P-Q)
1	1955	1956	2439	42/2	A0854	+1.2	-52 ± 5	427 ± 39	490	-63 ± 39
2	1953	1957	114	151/1	A0886	-1.3	-62 ± 5	506 ± 39	490	+16 ± 39
3	1957	1958	3203	333/1B	A1193	+0.4	-60 ± 5	489 ± 40	490	-1 ± 40
4	1954	1972	1481	4292/1	A6284	+2.7	-62 ± 4	494 ± 35	490	+4 ± 35
5	1949	1973	1813	4349	C0221	-0.2	-55 ± 6	432 ± 46	490	-58 ± 46
6	1925	1973	1814	4350	C0218	+1.1	-65 ± 7	515 ± 56	475	+40 ± 56
7	1923	1973	1799	4519/1	C0340	+0.2	-52 ± 6	410 ± 46	475	-65 ± 46
8	1954	1979	4698	5823/1	A7733	+0.8	-58 ± 4	451 ± 32	490	-39 ± 32
9	1954	1955	2421	AB1192/7	A0322	-0.6	-52 ± 8	422 ± 62	490	-68 ± 62
10	1954	1955	2433	AB1519/1	A0335	+3.2	-57 ± 8	464 ± 62	490	-26 ± 62
11	1954	1955	2431	AB1402/1A	A0343	-0.9	-48 ± 6	390 ± 44	490	-100 ± 44

Weighted mean of ΔR = −31 ± 13 years
Scatter in unweighted mean = 41 years
Range of ΔR is not significant
(Chi-squared = 9.07 df = 10, P = 0.525)

we can infer no significant variation in the radiocarbon activity of surface sea water around New Zealand from these data. The weighted mean of ΔR has a value of −31 ± 13 years.

Early measurements of dissolved inorganic carbon in surface sea waters in the New Zealand region give closely comparable $\Delta^{14}C$ values to those shown in Table 1. For example, NZ2419, collected December 1954, gave $\Delta^{14}C = -53 \pm 8‰$ and NZ2751, collected September 1956, gave $\Delta^{14}C = -58 \pm 5‰$.

TABLE 2
Details of Samples 8-11 (unpub). All 4 samples are from the west Wellington coast on the southwest corner of the North Island

Sample	Shell species	Provenience
8	*Alcithoe arabica*	Pauatahanui Inlet
9	*Haliotis* sp	Makara Beach
10	*Cellana* sp	Makara Beach
11	*Chione stutchburyi*	Makara Beach

CALIBRATION OF NEW ZEALAND MARINE SHELL DATES

New Zealand marine shell dates have usually been reported by the Institute of Nuclear Sciences with respect to a New Zealand Marine Shell Standard. The standard was intended to take into account radiocarbon depletion of the marine environment by making a constant offset to the conventional radiocarbon age.

Rafter *et al* (1972) estimated the depletion from one shellfish collected live from Pounawea in 1955, which gave a $\Delta^{14}C$ of −54‰ for the marine environment in 1950. In order to compensate for depletion of ^{14}C in the surface oceans due to burning of fossil fuels, a further correction of +13‰ is applied to samples from the pre-industrial marine environment, based on a simple 3-box carbon cycle model developed by O'Brien (Rafter 1968). The net estimated depletion of −41‰ gave an offset of 336 years (Jansen 1984).

More recent ocean carbon models (eg, Maier-Raimer & Hasselmann 1987; Toggweiler, Dixon & Bryan 1989) suggest that the surface of the western Pacific Ocean would have been rather more depleted in ^{14}C in pre-industrial times and, hence, a larger correction should be used. We consider that such models are not yet robust enough to be used to calibrate radiocarbon dates.

A serious defect in using a constant correction for marine shells is that it does not allow for secular variations in atmospheric and oceanic ^{14}C. The effect of secular changes in the world average surface ocean value for ^{14}C over the last 2000 years has been at least as large as the industrial effect, and in the opposite direction (Stuiver, Pearson & Braziunas 1986, Fig 3). Stuiver, Pearson and Braziunas' calibration procedure, which we prefer, allows for simultaneous consideration of both secular and regional variation of ^{14}C in the marine environment.

Until such time as a better calibration procedure is determined, the Institute will report calibrated ages for marine shells from the New Zealand region using the marine calibration curve of Stuiver, Pearson and Braziunas (1986), and $\Delta R = -30$ years. Note that we implicitly assume that ΔR itself has not changed with time (eg, that there has been no change in ocean circulation patterns affecting the New Zealand region) because we have no historical marine samples of known age with which to determine such a change.

Previously reported shell dates may be converted to calibrated dates under the new procedure using Stuiver, Pearson and Braziunas' (1986) calibration curve, either in graphic form or in the computer program (Stuiver and Reimer 1986). The old marine shell dates are first converted to conventional dates by adding 336 years to the dates reported in terms of the 5568-yr half-life. If dates are to be converted graphically, then Stuiver, Pearson and Braziunas' curve (1986, Figs 11A-S) should be used with $\Delta R = -30$ years. If the computer program is used, then ΔR (−30 years), and the standard error of ΔR (±13 years), should be entered at the appropriate prompts.

If the above procedure is used to correct previously reported dates to calibrated dates using Method A of Stuiver and Reimer (1986), the magnitude of the correction can be summarized as follows in Table 3:

TABLE 3
Difference between previously reported ages and ages calibrated using $\Delta R = -30$ years

Previously reported age (yr BP)	Approximate change in years (new calibrated age - previously reported age)
250 - 500	between +20 and −30, variable
500 - 750	between −10 and −90, decreasing with age
750 - 1650	between −70 and −120, variable
1650 - 2100	between −100 and 0, increasing with age

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