DR2005035

Data Repository Item

1. Sample preparation techniques.

Bulk sediment samples were screen-washed in the laboratory before mammal teeth were picked (*Thalerimys fordi, Theridomys bonduelli* and *Isoptychus* sp. of the extinct rodent family Theridomyidae). The first and second molars (undifferentiated in all three genera, M1/2), third molar (M3) and fourth permanent premolar (P4) were used. Depending upon availability, freshwater gastropod shells (*Lymnaea*), charophyte gyrogonites (*Gyrogona* and *Nitellopsis*) and fish otoliths (*Palaeoesox*) were collected from each mammal horizon. After picking, samples were washed in an ultrasonic bath containing de-ionised and distilled water before being air-dried and examined to ensure no host matrix remained attached. The teeth were crushed and enamel separated from dentine by hand picking. Preparation of the carbonate samples prior to analysis followed that of previous studies [gastropods (*White, R.M.P., Dennis, P.F. & Atkinson, T.C., 1999, Experimental calibration and field investigation of the oxygen isotopic fractionation between biogenic aragonite and water: Rapid Communications in Mass Spectrometry, v. 13, p. 1242 – 1247*), charophyte gyrogonites (*Jones, T.P., Fortier, S.M., Pentecost, A. & Collinson, M.E., 1996, Stable carbon and oxygen isotopic composition of recent charophyte oosporangia and water from Malham Tarn, U.K.: palaeontological implications: Biogeochemistry, v. 34, p. 99-112*), otoliths (*Patterson,W. P., Smith, G. R. & Lohmann, K. C., 1993, Continental paleothermometry and seasonality using the isotopic composition of aragonite otoliths of freshwater fishes, in Swart, P.K.,* *Lohmann,K.C., McKenzie, J. and Swart, S., eds, Climate change in continental isotopic Records: American Geophysical Union Monograph, v. 78, p. 191-202.)*].

2. Methodology for phosphate oxygen isotope analyses.

Phosphate oxygen isotope analysis ($\delta^{18}O$ phosphate) of enamel was conducted using the Direct Laser Fluorination (DLF) technique (*Grimes, S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047*). In-run analysis of NIST 120c gave a mean value of 21.18 ± 0.30‰ (n = 33) which is in agreement with that quoted by other labs (*Vennemann, T.W., Fricke, H.C., Blake, R.E., O'Neil, J.R., & Colman, A., 2002, Oxygen isotope analyses of phosphates: a comparison of techniques for analysis of Ag_3PO_4: Chemical Geology, v. 185, p. 321-336*) (21.70 ± 0.38‰). Results from the enamel samples, ZEQ56 and FZMAN-S8, were also in reasonable agreement with those obtained using the Silica Tube (ST) technique by Thomas Tütken (Universität Tübingen) (ZEQ56, DLF =13.68 ± 0.15‰, ST = 14.50‰: FZMAN-S8, DLF = 15.04 ± 0.17‰, ST = 15.50 ± 0.4‰). As there was insufficient sample mass to conduct multiple analyses the error on the individual tooth $\delta^{18}O$ phosphate values was taken to be the same as that on the enamel sample FZMANS8 (± 0.2‰).

3. Methodology for carbonate oxygen isotope analyses.

Oxygen isotope analysis of the carbonate samples ($\delta^{18}O$ carbonate) was conducted using a Micromass Isoprime with a multiflow preparation system (*Grimes,* *S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047*). In-run analysis of the NBS-19 standard gave a $\delta^{18}O$ carbonate value of –2.28 ± 0.05‰ (VPDB) (n = 19) and a $\delta^{13}C$ carbonate value of +2.1 ± 0.04 ‰ (VPDB) (n = 19). All the carbonate (aragonite) samples analysed were calibrated to the NBS-19 standards (calcite) and the difference in the acid fractionation factors between calcite and aragonite accounted for. As there was insufficient sample mass to conduct multiple analyses on all the carbonate samples the error on the individual $\delta^{18}O$ carbonate and $\delta^{13}C$ carbonate values was taken to be the same as that on the NBS-19 standard.

4. Methodology and summary of X-ray diffraction (XRD) analysis of carbonate samples.

Analyses of powdered gastropod shells and fish otoliths were conducted using a Philips Analytical XRD PW3710 machine with PC-APD diffraction software. Samples were scanned between 20˚ to 50˚ (2θ) using a copper tube anode. Results, which can be found in the Appendix DR[1], indicate that the gastropod shells (except all those from the Osborne Member and four from the Lacey's Farm Member, which were 100% calcite) were composed of >90% aragonite. However, the four calcite gastropods in the Lacey's Farm Member have $\delta^{18}O$ values indistinguishable from those in the same assemblage with >94% aragonite. This indicates that diagenetic alteration of aragonite to calcite has had a minimal effect on the $\delta^{18}O$ values of the gastropods. All except three of the fish otoliths were composed of 95% aragonite.

5. Additional evidence linking the palaeoproxies with a water body.

1) The carbonate proxies are all inhabitants of shallow freshwater (i.e. are homogeneous for habitat); 2) in four of the six horizons, all are found in consistent association; 3) assemblages are diverse biotically and show no evidence of long-distance transport; 4) the theridomyid rodents are consistent and abundant faunal elements in the Solent Group and they were ground dwellers (*Schmidt-Kittler, N. and Storch G., 1985, Ein vollständiges Theridomyiden-Skelett (Mammalia: Rodentia) mit Rennmaus-Anpassungen aus dem Oligozän von Céreste, S-Frankreich. Senckenbergiana: Lethaia, v. 66, p. 89-109*) like the *Apodemus* used in the modern study (*Lindars, E.S., Grimes, S.T., Mattey, D.P., Collinson, M.E., Hooker, J.J., & Jones, T.P., 2001, Phosphate* $\delta^{18}O$ *determination of modern rodent teeth by direct laser fluorination: an appraisal of methodology and potential application to palaeoclimate reconstruction: Geochimica et Cosmochimica Acta, v. 65, p. 2535-2548*); 5) observed local geographic variation in the composition of penecontemporaneous mammal assemblages in the Solent Group would have become obliterated if major postmortem transport was a feature of these beds; 6) ecological diversity analysis of the mammal assemblages indicate mesic environments (*Hooker, J.J., 1992. British mammalian paleocommunities across the Eocene–Oligocene transition and their environmental implications. In: Prothero, D.R. & Berggren, W.A., eds., Eocene–Oligocene Climatic and Biotic Evolution. Princeton University Press, Princeton, NJ, 494–515*), where mammals would have relied on drinking for their water intake.

6. Table DR1. The mean $\delta^{18}O$ values from the analysis of multiple palaeoproxies from six fossil assemblages from the Late Eocene (Priabonian) to Early Oligocene (Rupelian) Solent Group of the Hampshire Basin (Isle of Wight, UK). The Osborne Member results (Headon Hill Formation) are from a previously reported study (*Grimes, S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047*). The mean $\delta^{18}O$ local water values were calculated from the mean $\delta^{18}O$ values of the rodent tooth enamel using previously reported fractionation equations (*Grimes, S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047*). The log-normal mean $\delta^{18}O$ local water values were calculated to take into account the skewed distribution in the $\delta^{18}O$ local water values.

Lithostratigraphy	Age (Ma)		**Mean $\delta^{18}O_{phosphate}$ from rodent tooth enamel (‰ VSMOW)**	**Mean $\delta^{18}O_{Local\ water}$ from rodent tooth enamel (‰ VSMOW)**	**Log-Normal Mean $\delta^{18}O_{Local\ water}$ from rodent tooth enamel (‰ VSMOW)**	**Mean $\delta^{18}O_{carbonate}$ from gastropod shells (‰ VPDB)**	**Mean $\delta^{18}O_{carbonate}$ from charophyte gyrogonites (‰ VPDB)**	**Mean $\delta^{18}O_{carbonate}$ from fish otoliths (‰ VPDB)**
Upper Hamstead Member of the Bouldnor Formation	33.10	Value	**18.20**	**0.91**	**0.86**		**-1.85**	
		2σ Std. Error	± 0.40	± 0.68	± 0.66		± 0.22	
		2σ Std. Deviation	± 2.21	± 3.74	± 3.60		± 1.50	
		Number	30	30	30		46	
Lower Hamstead Member of the Bouldnor Formation	33.55	Value	**19.14**	**2.51**	**2.19**	**-0.09**	**-0.73**	
		2σ Std. Error	± 0.23	± 0.55	± 0.84	± 0.30	± 0.22	
		2σ Std. Deviation	± 1.41	± 2.38	± 3.47	± 2.04	± 1.07	
		Number	19	19	30	45	23	
Bembridge Limestone Formation	34.02	Value	**18.82**	**1.97**	**1.91**	**-1.16**	**-2.10**	**-2.33**
		2σ Std. Error	± 0.52	± 0.88	± 0.79	± 0.34	± 0.08	± 0.19
		2σ Std. Deviation	± 2.38	± 4.03	± 3.61	± 1.56	± 0.43	± 1.33
		Number	21	21	21	25	27	50
Osborne Member of the Headon Hill Formation	34.58	Value	**17.66**	**0.00**	**-0.18**	**-1.71**	**-2.38**	**-3.83**
		2σ Std. Error	± 0.47	± 0.80	± 0.44	± 0.35	± 0.24	± 0.35
		2σ Std. Deviation	± 4.04	± 6.85	± 3.77	± 2.51	± 1.09	± 1.12
		Number	74	74	74	50	20	10
Lacey's Farm Member of the Headon Hill Formation	34.90	Value	**18.69**	**1.74**	**1.64**	**-0.85**	**-1.60**	**-2.40**
		2σ Std. Error	± 0.89	± 1.51	± 1.02	± 0.39	± 0.28	± 0.09
		2σ Std. Deviation	± 3.22	± 5.45	± 3.68	± 2.13	± 1.20	± 0.22
		Number	13	13	13	30	18	6
Totland Bay Member of the Headon Hill Formation	36.10	Value	**17.46**	**-0.33**	**-0.37**	**-1.61**	**-3.21**	**-3.45**
		2σ Std. Error	± 0.25	± 0.43	± 0.25	± 0.23	± 0.19	± 0.30
		2σ Std. Deviation	± 1.89	± 3.21	± 1.89	± 2.03	± 1.33	± 0.68
		Number	56	56	56	79	51	5

7. Table DR2. Mean summer season palaeotemperatures for six fossil assemblages from the Late Eocene (Priabonian) to Early Oligocene (Rupelian) Solent Group of the Hampshire Basin (Isle of Wight, UK). All the palaeotemperatures were calculated using published thermometry equations involving both the log-normal mean $\delta^{18}O$ local water value and the $\delta^{18}O$ value of another palaeoproxy. The Osborne Member palaeotemperatures (Headon Hill Formation) were recalculated from the raw data in a previously reported study (*Grimes, S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047*).

Temperature			**Summer season temperatures**		
			Mean Growing Season Temperature (˚C)	**Mean Temperature of the Warmest Months of the Growing Season (˚C)**	**Mean Temperature of a Single Month Towards the End of the Growing Season (˚C)**
Palaeoproxies			$\delta^{18}O_{local\ water}$ from rodent tooth enamel + $\delta^{18}O_{carbonate}$ from gastropod shells	$\delta^{18}O_{local\ water}$ from rodent tooth enamel + $\delta^{18}O_{carbonate}$ from fish otoliths	$\delta^{18}O_{local\ water}$ from rodent tooth enamel + $\delta^{18}O_{carbonate}$ from charophyte gyrogonites
Equation			*Lymnaea* gastropod genus-specific carbonate thermometer (White et al., 1999)	Freshwater otolith specific thermometer (Patterson et al., 1993)	Freshwater carbonate thermometer (Jones et al., 1996)
Members	**Age (Ma)**				
Upper Hamstead Member of the Bouldnor Formation	33.10	Value			**28.4**
		2σ Std. Error			± 1.6
		2σ Std. Deviation			± 19.5
Lower Hamstead Member of the Bouldnor Formation	33.55	Value	**32.4**		**29.4**
		2σ Std. Error	± 2.9		± 1.7
		2σ Std. Deviation	± 13.9		± 18.4
Bembridge Limestone Formation	34.02	Value	**36.2**	**37.8**	**35.1**
		2σ Std. Error	± 2.9	± 4.2	± 1.8
		2σ Std. Deviation	± 13.5	± 20.0	± 8.3
Osborne Member of the Headon Hill Formation	34.58	Value	**28.7**	**34.9**	**25.9**
		2σ Std. Error	± 1.9	± 2.8	± 2.4
		2σ Std. Deviation	± 15.5	± 20.0	± 19.2
Lacey's Farm Member of the Headon Hill Formation	34.90	Value	**33.4**	**36.8**	**31.1**
		2σ Std. Error	± 3.7	± 5.3	± 2.2
		2σ Std. Deviation	± 14.6	± 19.1	± 19.9
Totland Bay Member of the Headon Hill Formation	36.10	Value	**27.3**	**31.9**	**28.2**
		2σ Std. Error	± 1.4	± 1.9	± 1.6
		2σ Std. Deviation	± 11.9	± 10.0	± 11.6

8. Individual phosphate and carbonate isotope results, plus XRD carbonate results, from each fossil horizon.

Table DR3. Upper Hamstead Member enamel $\delta^{18}O_{phosphate}$ results.

Sample ID	Genus	Tooth type	Measured enamel $\delta^{18}O_{phosphate}$ (‰ VSMOW)
317 S1	*Isoptychus* sp.	Upper right M1/2 molar	17.70
317 S2	*Isoptychus* sp.	Upper left M1/2 molar	19.85
317 S6	*Isoptychus* sp.	Upper right M1/2 molar	19.45
317 S9	*Isoptychus* sp.	Lower left M1/2 molar	18.23
317 S10	*Isoptychus* sp.	Upper right M1/2 molar	18.92
317 S13	*Isoptychus* sp.	Upper right M1/2 molar	17.93
317 S14	*Isoptychus* sp.	Upper right M1/2 molar	17.42
317 S16	*Isoptychus* sp.	Upper left M1/2 molar	17.86
317 S20	*Isoptychus* sp.	Lower right M1/2 molar	17.70
317 S21	*Isoptychus* sp.	Lower right M1/2 molar	20.99
317 S22	*Isoptychus* sp.	Upper left M1/2 molar	18.43
317 S23	*Isoptychus* sp.	Lower right M1/2 molar	17.07
317 S26	*Isoptychus* sp.	Upper left M1/2 molar	17.54
317 S30	*Isoptychus* sp.	Lower left M1/2 molar	16.80
317 S33	*Isoptychus* sp.	Lower right M1/2 molar	17.35
317 S34	*Isoptychus* sp.	Lower right M1/2 molar	19.52
317 S35	*Isoptychus* sp.	Upper right M1/2 molar	19.93
317 S43	*Isoptychus* sp.	Lower right M1/2 molar	17.41
317 S4	*Isoptychus* sp.	Lower right M3 molar	18.46
317 S5	*Isoptychus* sp.	Upper right M3 molar	16.64
317 S7	*Isoptychus* sp.	Lower right M3 molar	17.41
317 S8	*Isoptychus* sp.	Upper right M3 molar	20.54
317 S12	*Isoptychus* sp.	Lower right M3 molar	16.98
317 S18	*Isoptychus* sp.	Upper left M3 molar	17.49
317 S19	*Isoptychus* sp.	Upper left M3 molar	17.89
317 S25	*Isoptychus* sp.	Lower right M3 molar	18.24
317 S27	*Isoptychus* sp.	Lower right M3 molar	17.66
317 S36	*Isoptychus* sp.	Upper right M3 molar	18.81
317 S38	*Isoptychus* sp.	Upper left M3 molar	17.89
317 S24	*Isoptychus* sp.	Upper right P4 premolar	17.84

Table DR4. Upper Hamstead Member carbonate $\delta^{18}O$ and $\delta^{13}C$ results.

Sample ID	Taxon	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
S1	Charophyte gyrogonite	-2.39	-5.53
S2	Charophyte gyrogonite	-2.54	-6.67
S3	Charophyte gyrogonite	-2.89	-5.96
S4	Charophyte gyrogonite	-2.69	-1.85
S5	Charophyte gyrogonite	-1.85	-3.59
S6	Charophyte gyrogonite	-2.04	-6.36
S7	Charophyte gyrogonite	-1.72	-5.68
S8	Charophyte gyrogonite	-0.79	-4.73
S9	Charophyte gyrogonite	-1.84	-5.81
S10	Charophyte gyrogonite	-2.05	-0.50
S11	Charophyte gyrogonite	-2.54	-5.40
S12	Charophyte gyrogonite	-1.01	-6.56
S13	Charophyte gyrogonite	-1.40	-5.40
S14	Charophyte gyrogonite	-2.42	-1.78
S15	Charophyte gyrogonite	-0.86	-2.30
S16	Charophyte gyrogonite	-2.52	-3.08
S17	Charophyte gyrogonite	-0.31	-3.26
S18	Charophyte gyrogonite	-2.43	-4.48
S19	Charophyte gyrogonite	-2.49	-6.13
S20	Charophyte gyrogonite	-1.44	-1.10
S21	Charophyte gyrogonite	-2.63	-5.69
S22	Charophyte gyrogonite	-2.71	-1.76
S23	Charophyte gyrogonite	-2.47	-4.93
S24	Charophyte gyrogonite	-1.18	-2.14
S25	Charophyte gyrogonite	-1.79	-3.41
S26	Charophyte gyrogonite	-2.01	-5.83
S27	Charophyte gyrogonite	-2.64	-4.39
S28	Charophyte gyrogonite	-1.69	0.07
S29	Charophyte gyrogonite	-0.77	-6.28
S30	Charophyte gyrogonite	-2.78	-5.15
S31	Charophyte gyrogonite	-0.77	-2.80
S32	Charophyte gyrogonite	-1.79	-5.70
S33	Charophyte gyrogonite	-3.05	-6.15
S34	Charophyte gyrogonite	-1.01	-6.05
S35	Charophyte gyrogonite	-1.27	-5.88
S36	Charophyte gyrogonite	-2.03	-0.40
S37	Charophyte gyrogonite	-0.54	-3.60
S38	Charophyte gyrogonite	-2.05	-6.81
S39	Charophyte gyrogonite	-1.41	-3.45
S40	Charophyte gyrogonite	-0.52	-0.97
S41	Charophyte gyrogonite	-2.21	-0.26
S42	Charophyte gyrogonite	-1.62	-2.01
S43	Charophyte gyrogonite	-2.02	-2.54
S44	Charophyte gyrogonite	-2.98	-4.67
S45	Charophyte gyrogonite	-0.82	-5.13
S46	Charophyte gyrogonite	-2.25	-5.54

Table DR5. Lower Hamstead Member enamel $\delta^{18}O_{phosphate}$ results.

Sample ID	**Genus**	**Tooth type**	**Measured enamel $\delta^{18}O_{phosphate}$ (‰ VSMOW)**
333 AP2	*Theridomys bonduelli*	Lower right M1/2 molar	19.01
333 C	*Theridomys bonduelli*	Upper left M1/2 molar	18.51
333 K1	*Theridomys bonduelli*	Lower left M1/2 molar	18.73
333 K2	*Theridomys bonduelli*	Upper right M1/2 molar	18.54
333 L1	*Theridomys bonduelli*	Upper left M1/2 molar	19.36
333 M2	*Theridomys bonduelli*	Upper right M1/2 molar	18.72
333 M3	*Theridomys bonduelli*	Upper right M1/2 molar	19.17
333 M4	*Theridomys bonduelli*	Upper left M1/2 molar	18.68
333 S1	*Theridomys bonduelli*	Lower right M1/2 molar	19.59
333 S2	*Theridomys bonduelli*	Upper right M1/2 molar	19.04
333 T1	*Theridomys bonduelli*	Lower right M1/2 molar	20.83
333 T2	*Theridomys bonduelli*	Lower left M1/2 molar	18.21
333 U	*Theridomys bonduelli*	Lower right M1/2 molar	19.12
333 V	*Theridomys bonduelli*	Upper left M1/2 molar	19.19
333 W	*Theridomys bonduelli*	Lower right M1/2 molar	18.41
333 Z	*Theridomys bonduelli*	Upper right M1/2 molar	19.98
333 AB1	*Theridomys bonduelli*	Upper right M1/2 molar	18.60
333 AB2	*Theridomys bonduelli*	Lower right M1/2 molar	19.40
333 O2	*Theridomys bonduelli*	Lower left M3 molar	20.55

Table DR6. Lower Hamstead Member carbonate $\delta^{18}O$ and $\delta^{13}C$ results.

Sample ID	Taxon	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
S 333 T2	Charophyte gyrogonite	-3.01	-0.69
S 333 T3	Charophyte gyrogonite	-1.29	-2.34
S 333 T4	Charophyte gyrogonite	-1.29	-1.22
S 333 S1	Charophyte gyrogonite	-0.79	1.54
S 333 S2	Charophyte gyrogonite	-0.30	-1.91
S 333 P1	Charophyte gyrogonite	-1.33	-1.37
S 333 P2	Charophyte gyrogonite	-1.99	0.41
S 333 P3	Charophyte gyrogonite	-0.28	-0.19
S 333 P4	Charophyte gyrogonite	-0.87	-1.47
S 333 A1	Charophyte gyrogonite	-1.42	-1.09
S 333 A2	Charophyte gyrogonite	-0.51	0.84
S 333 A3	Charophyte gyrogonite	-0.30	-1.43
S 333 A4	Charophyte gyrogonite	-1.33	-0.44
S 333 A5	Charophyte gyrogonite	-0.66	-0.43
S 333 A6	Charophyte gyrogonite	-0.25	0.26
S 333 A7	Charophyte gyrogonite	-0.34	-2.34
S 333 A8	Charophyte gyrogonite	-1.05	-1.87
S 333 A9	Charophyte gyrogonite	-0.38	-2.60
S 333 W1	Charophyte gyrogonite	-0.97	-0.28
S 333 W2	Charophyte gyrogonite	-0.99	1.40
S 333 W3	Charophyte gyrogonite	-0.17	-3.73
S 333W4	Charophyte gyrogonite	-0.22	0.34
S 333 W5	Charophyte gyrogonite	-0.02	-0.56
S 333A	Gastropod shell	-0.33	-7.53
S 333A	Gastropod shell	-1.21	-4.91
S 333A	Gastropod shell	1.20	-7.37
S333A	Gastropod shell	-0.63	-7.45
S 333P	Gastropod shell	-0.44	-4.31
S 333P	Gastropod shell	-1.01	-5.57
S 333P	Gastropod shell	0.45	-5.94
S 333P	Gastropod shell	0.57	-6.76
S 333L	Gastropod shell	-0.11	-6.26
S 333L	Gastropod shell	0.67	-5.79
S 333L	Gastropod shell	2.05	-8.41
S 333L	Gastropod shell	-0.47	-8.74
S 333L	Gastropod shell	-0.47	-7.26
S 333S	Gastropod shell	-0.35	-3.50
S 333S	Gastropod shell	1.73	-7.40
S 333S	Gastropod shell	-0.10	-6.52
S 333S	Gastropod shell	1.97	-5.71
S 333S	Gastropod shell	0.17	-6.18
S 333T	Gastropod shell	-0.91	-7.82
S 333T	Gastropod shell	-0.58	-6.23
S 333T	Gastropod shell	-1.51	-9.25
S 333U	Gastropod shell	-1.63	-6.54
S 333U	Gastropod shell	2.01	-6.27
S 333U	Gastropod shell	1.55	-6.46
S 333U	Gastropod shell	-1.21	-2.80
S 333M	Gastropod shell	0.03	-5.60
S 333M	Gastropod shell	0.37	-5.45
S 333M	Gastropod shell	-1.17	-4.36
S 333M	Gastropod shell	-1.62	-8.16
S 333M	Gastropod shell	-0.28	-5.28
S 333W	Gastropod shell	0.05	-5.68

S 333W	Gastropod shell	1.43	-4.71
S 333W	Gastropod shell	0.54	-7.60
S 333W	Gastropod shell	0.20	-8.86
S 333W	Gastropod shell	1.26	-4.03
S 333M	Gastropod shell	-0.44	-4.26
S 333M	Gastropod shell	0.25	-3.76
S 333M	Gastropod shell	-1.31	-2.39
S 333M	Gastropod shell	-1.11	-4.22
S 333M	Gastropod shell	0.00	-6.17
S 333L	Gastropod shell	-0.81	-4.64
S 333L	Gastropod shell	-0.46	-5.41
S 333L	Gastropod shell	-0.26	-5.11
S 333L	Gastropod shell	-1.26	-4.69
S 333L	Gastropod shell	-0.84	-3.73

Table DR7. Bembridge Limestone Formation enamel $\delta^{18}O_{phosphate}$ results.

Sample ID	Genus	Tooth type	Measured enamel $\delta^{18}O_{phosphate}$ (‰ VSMOW)
340A 16	*Isoptychus* sp.	Upper left M1/2 molar	18.84
340A 14	*Isoptychus* sp.	Lower left M1/2 molar	19.56
340A 11	*Isoptychus* sp.	Lower left M1/2 molar	19.86
340A 5	*Isoptychus* sp.	Upper left M1/2 molar	19.33
340A 10	*Isoptychus* sp.	Lower right M1/2 molar	17.48
340A 9	*Isoptychus* sp.	Upper left M1/2 molar	20.75
340B 2	*Isoptychus* sp.	Lower right M1/2 molar	17.66
340A 20	*Isoptychus* sp.	Upper right M1/2 molar	19.95
340A 32	*Isoptychus* sp.	Upper left M1/2 molar	18.73
340B 17	*Isoptychus* sp.	Upper right M1/2 molar	19.44
340A 36	*Isoptychus* sp.	Upper right M1/2 molar	19.00
340B 4	*Isoptychus* sp.	Lower right M1/2 molar	17.51
340A 30 + 340B 10	*Isoptychus* sp.	Upper left and lower right M1/2 molars	19.32
340B 3	*Isoptychus* sp.	Lower left M3 molar	18.96
340A 28	*Isoptychus* sp.	Lower left M3 molar	18.80
340A 6	*Isoptychus* sp.	Upper right M3 molar	21.24
340A 12	*Isoptychus* sp.	Lower right M3 molar	17.24
340A 37 + 38	*Isoptychus* sp.	Two upper right M3 molars	16.89
340A 7	*Isoptychus* sp.	Lower right P4 premolar	18.24
340A 18	*Isoptychus* sp.	Upper left P4 premolar	17.05
340A 6 +14	*Isoptychus* sp.	Lower left and upper left P4 premolar	19.40

Table DR8. Bembridge Limestone Formation carbonate $\delta^{18}O$ and $\delta^{13}C$ results.

Sample ID	Taxon	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
S 340A S1	Charophyte gyrogonite	-2.26	-1.25
S 340A S2	Charophyte gyrogonite	-2.26	-0.44
S 340A S3	Charophyte gyrogonite	-2.54	-0.73
S 340A S4	Charophyte gyrogonite	-2.02	-0.84
S 340A S5	Charophyte gyrogonite	-2.49	-0.63
S 340A S6	Charophyte gyrogonite	-2.34	-0.51
S 340A S7	Charophyte gyrogonite	-2.01	-1.98
S 340A S8	Charophyte gyrogonite	-1.80	-0.49
S 340A S8	Charophyte gyrogonite	-1.98	-1.17
S 340A S10	Charophyte gyrogonite	-2.21	-0.43
S 340A S11	Charophyte gyrogonite	-1.84	-1.13
S 340A S12	Charophyte gyrogonite	-2.04	-0.96
S 340A S13	Charophyte gyrogonite	-2.22	-0.17
S 340A S14	Charophyte gyrogonite	-2.06	-0.60
S 340A S15	Charophyte gyrogonite	-1.89	-1.07
S 340A S16	Charophyte gyrogonite	-2.02	-0.97
S 340A S17	Charophyte gyrogonite	-2.04	-1.12
S 340A S18	Charophyte gyrogonite	-1.97	-0.78
S 340A S19	Charophyte gyrogonite	-2.07	-1.31
S 340A S21	Charophyte gyrogonite	-1.98	-0.50
S 340A S22	Charophyte gyrogonite	-2.05	-1.14
S 340A S23	Charophyte gyrogonite	-2.30	-0.55
S 340A S24	Charophyte gyrogonite	-2.13	-1.35
S 340A S25	Charophyte gyrogonite	-2.30	-0.65
S 340A S26	Charophyte gyrogonite	-2.30	-0.15
S 340A S27	Charophyte gyrogonite	-1.57	-0.84
S 340A OT1	Fish otolith	-2.90	-2.42
S 340A OT2	Fish otolith	-2.60	-1.89
S 340A OT3	Fish otolith	-1.82	-2.99
S 340A OT4	Fish otolith	-2.73	-1.95
S 340A OT5	Fish otolith	-2.04	-2.87
S 340A OT6	Fish otolith	-2.16	-0.71
S 340A OT7	Fish otolith	-2.14	-1.82
S 340A OT8	Fish otolith	-2.92	-2.66
S 340A OT9	Fish otolith	-2.24	-2.69
S 340A OT10	Fish otolith	-3.25	-1.17
S 340A OT11	Fish otolith	-3.11	-4.34
S 340A OT12	Fish otolith	-2.83	-2.50
S 340A OT13	Fish otolith	-2.48	-3.27
S 340A OT14	Fish otolith	-2.01	-3.09
S 340A OT15	Fish otolith	-2.92	-2.69
S 340A OT16	Fish otolith	-1.86	-2.79
S 340A OT17	Fish otolith	-3.15	-1.31
S 340A OT18	Fish otolith	-2.54	-3.35
S 340A OT19	Fish otolith	-2.54	-2.43
S 340A OT20	Fish otolith	-2.05	-4.31
S 340A OT21	Fish otolith	-1.97	-2.13
S 340A OT22	Fish otolith	-3.10	-3.46
S 340A OT23	Fish otolith	-3.16	-1.38
S 340A OT24	Fish otolith	-3.66	-3.86
S 340A OT25	Fish otolith	-3.27	-1.34
S 340A OT26	Fish otolith	-3.02	-4.34
S 340A OT27	Fish otolith	-3.02	-2.91
S 340A OT28	Fish otolith	-2.95	-2.61

S 340A OT29	Fish otolith	-2.40	-4.51
S 340A OT30	Fish otolith	-2.62	-2.53
S 340A OT31	Fish otolith	-1.70	-6.49
S 340A OT32	Fish otolith	-2.08	-4.34
S 340A OT33	Fish otolith	-1.15	-2.61
S 340A OT34	Fish otolith	-3.00	-7.19
S 340A OT35	Fish otolith	-1.34	-3.98
S 340A OT36	Fish otolith	-1.47	-3.74
S 340A OT37	Fish otolith	-2.50	-4.28
S 340A OT38	Fish otolith	-1.66	-3.57
S 340A OT39	Fish otolith	-1.21	-3.15
S 340A OT40	Fish otolith	-1.97	-2.74
S 340A OT41	Fish otolith	-1.24	-1.63
S 340A OT42	Fish otolith	-2.46	-2.57
S 340A OT43	Fish otolith	-2.18	-6.11
S 340A OT44	Fish otolith	-0.80	-3.18
S 340A OT45	Fish otolith	-1.66	-1.63
S 340A OT46	Fish otolith	-1.75	-5.64
S 340A OT47	Fish otolith	-3.23	-4.11
S 340A OT48	Fish otolith	-1.80	-3.54
S 340A OT49	Fish otolith	-2.14	-2.06
S 340A OT50	Fish otolith	-1.70	-5.15
S 340A L1	Gastropod shell	-1.62	-5.21
S340A L2	Gastropod shell	-0.68	-5.71
S 340A L4	Gastropod shell	-0.94	-4.15
S 340A L5	Gastropod shell	-1.33	-5.25
S 340A L7	Gastropod shell	-0.90	-5.64
S 340A L8	Gastropod shell	0.27	-4.70
S 340A L9	Gastropod shell	-0.09	-4.05
S 340A L10	Gastropod shell	0.40	-5.70
S 340A L11	Gastropod shell	-1.98	-4.48
S 340A L13	Gastropod shell	-0.34	-5.45
S 340A L14	Gastropod shell	-1.84	-5.84
S 340A L15	Gastropod shell	-1.60	-5.23
S 340A L16	Gastropod shell	-1.72	-6.53
S 340A L17	Gastropod shell	-0.38	-6.44
S 340A L18	Gastropod shell	-1.87	-2.78
S 340A L19	Gastropod shell	-2.03	-5.07
S 340A L20	Gastropod shell	-1.50	-5.74
S 340A L21	Gastropod shell	-1.23	-3.29
S 340A L22	Gastropod shell	-1.24	-7.09
S 340A L23	Gastropod shell	-2.42	-5.62
S 340A L25	Gastropod shell	-1.32	-3.23

Table DR9. Osborne Member enamel $\delta^{18}O_{phosphate}$ results from *Grimes, S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047.*

Sample ID	Genus	Tooth type	Measured enamel $\delta^{18}O_{phosphate}$ (‰ VSMOW)
279A S47	*Thalerimys fordi*	Upper left M1/2 Molar	18.05
279A S52	*Thalerimys fordi*	Lower left M1/2 Molar	17.76
279A S53	*Thalerimys fordi*	Upper left M1/2 Molar	19.44
279A S57	*Thalerimys fordi*	Lower left M1/2 Molar	17.09
279A S64	*Thalerimys fordi*	Upper right M1/2 Molar	17.25
279A S73	*Thalerimys fordi*	Upper right M1/2 Molar	17.16
279A S79	*Thalerimys fordi*	Upper left M1/2 Molar	18.16
279A S94	*Thalerimys fordi*	Lower left M1/2 Molar	17.47
279A S97	*Thalerimys fordi*	Lower right M1/2 Molar	16.69
279A S171	*Thalerimys fordi*	Lower right M1/2 Molar	17.17
279A S187	*Thalerimys fordi*	Upper right M1/2 Molar	15.48
279A S190	*Thalerimys fordi*	Upper right M1/2 Molar	17.26
279A S207	*Thalerimys fordi*	Lower right M1/2 Molar	16.76
279A S208	*Thalerimys fordi*	Lower left M1/2 Molar	17.58
279A S210	*Thalerimys fordi*	Upper right M1/2 Molar	17.09
279A S212	*Thalerimys fordi*	Lower right M1/2 Molar	16.19
279A S213	*Thalerimys fordi*	Upper left M1/2 Molar	15.44
279A S216	*Thalerimys fordi*	Lower left M1/2 Molar	15.28
279A S217	*Thalerimys fordi*	Lower right M1/2 Molar	15.69
279A S219	*Thalerimys fordi*	Upper left M1/2 Molar	17.62
279A S39	*Thalerimys fordi*	Lower right M3 Molar	17.49
279A S84	*Thalerimys fordi*	Lower right M3 Molar	16.70
279A S86	*Thalerimys fordi*	Lower right M3 Molar	21.51
279A S87	*Thalerimys fordi*	Upper left M3 Molar	17.24
279A S96	*Thalerimys fordi*	Lower left M3 Molar	18.21
279A S105	*Thalerimys fordi*	Upper right M3 Molar	16.81
279A S116	*Thalerimys fordi*	Lower right M3 Molar	17.18
279A S145	*Thalerimys fordi*	Upper left M3 Molar	19.21
279A S151	*Thalerimys fordi*	Lower left M3 Molar	16.22
279A S195	*Thalerimys fordi*	Lower right M3 Molar	16.63
279A S200	*Thalerimys fordi*	Upper right M3 Molar	15.18
279A S211	*Thalerimys fordi*	Lower left M3 Molar	16.98
279A S215	*Thalerimys fordi*	Lower right M3 Molar	16.20
279A S31	*Thalerimys fordi*	Lower left P4 Premolar	18.47
279A S70	*Thalerimys fordi*	Upper right P4 Premolar	16.06
279A S71	*Thalerimys fordi*	Lower right P4 Premolar	19.61
279A S78	*Thalerimys fordi*	Lower left P4 Premolar	17.54
279A S81	*Thalerimys fordi*	Upper right P4 Premolar	16.41
279A S83	*Thalerimys fordi*	Upper left P4 Premolar	16.63
279A S98	*Thalerimys fordi*	Lower right P4 Premolar	17.77
279A S108	*Thalerimys fordi*	Lower right P4 Premolar	21.62
279A S114	*Thalerimys fordi*	Lower left P4 Premolar	17.70
279A S117	*Thalerimys fordi*	Lower left P4 Premolar	23.95
279A S120	*Thalerimys fordi*	Lower left P4 Premolar	16.40
279A S133	*Thalerimys fordi*	Upper right P4 Premolar	18.47
279A S144	*Thalerimys fordi*	Lower right P4 Premolar	17.47

279A S146	*Thalerimys fordi*	Upper right P4 Premolar	15.86
279A S199	*Thalerimys fordi*	Upper left P4 Premolar	15.19
279A S204	*Thalerimys fordi*	Upper left P4 Premolar	15.70
279A S209	*Thalerimys fordi*	Upper right P4 Premolar	16.65
279A S220	*Thalerimys fordi*	Lower left P4 Premolar	15.96
279A S20	*Isoptychus* sp.	Lower left M1/2 Molar	15.73
279A S22	*Isoptychus* sp.	Upper left M1/2 Molar	22.53
279A S41	*Isoptychus* sp.	Upper right M1/2 Molar	15.58
279A S43	*Isoptychus* sp.	Lower left M1/2 Molar	18.47
279A S48	*Isoptychus* sp.	Upper left M1/2 Molar	16.38
279A S56	*Isoptychus* sp.	Upper left M1/2 Molar	17.37
279A S58	*Isoptychus* sp.	Upper right M1/2 Molar	17.79
279A S88	*Isoptychus* sp.	Upper left M1/2 Molar	19.06
279A S89	*Isoptychus* sp.	Upper left M1/2 Molar	16.09
279A S90	*Isoptychus* sp.	Lower right M1/2 Molar	21.03
279A S100	*Isoptychus* sp.	Upper left M1/2 Molar	22.95
279A S142	*Isoptychus* sp.	Upper left M1/2 Molar	17.20
279A S156	*Isoptychus* sp.	Upper left M1/2 Molar	17.94
279A S14	*Isoptychus* sp.	Upper right M3 Molar	20.18
279A S40	*Isoptychus* sp.	Lower left M3 Molar	19.64
279A S68	*Isoptychus* sp.	Upper right M3 Molar	17.58
279A S163	*Isoptychus* sp.	Lower right M3 Molar	15.66
279A S228	*Isoptychus* sp.	Upper left M3 Molar	18.43
279A S229	*Isoptychus* sp.	Upper right M3 Molar	16.55
279A S66	*Isoptychus* sp.	Upper right P4 Premolar	24.51
279A S80	*Isoptychus* sp.	Upper left P4 Premolar	20.34
279A S121	*Isoptychus* sp.	Lower left P4 Premolar	16.08

Table DR10. Osborne Member carbonate $\delta^{18}O$ and $\delta^{13}C$ results from *Grimes, S.T., Mattey, D.P., Hooker, J.J. & Collinson, M.E.., 2003, Eocene – Oligocene palaeoclimate reconstruction using oxygen isotopes: problems and solutions from the use of multiple palaeoproxies: Geochimica et Cosmochimica Acta, v. 67, p. 4033-4047.*

Sample ID	Taxon	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
279A CG1	Charophyte gyrogonite	-2.07	-2.68
279A CG2	Charophyte gyrogonite	-3.04	-2.26
279A CG3	Charophyte gyrogonite	-3.18	-2.19
279A CG4	Charophyte gyrogonite	-2.33	-2.75
279A CG5	Charophyte gyrogonite	-2.63	-3.32
279A CG6	Charophyte gyrogonite	-2.44	-2.72
279A CG7	Charophyte gyrogonite	-1.77	-1.04
279A CG8	Charophyte gyrogonite	-2.38	-2.64
279A CG9	Charophyte gyrogonite	-2.65	-2.37
279A CG10	Charophyte gyrogonite	-1.95	-2.95
279A CG11	Charophyte gyrogonite	-2.28	-3.03
279A CG12	Charophyte gyrogonite	-3.96	-1.97
279A CG13	Charophyte gyrogonite	-2.00	-2.97
279A CG14	Charophyte gyrogonite	-2.56	-2.56
279A CG15	Charophyte gyrogonite	-1.69	-3.31
279A CG16	Charophyte gyrogonite	-2.04	-2.85
279A CG17	Charophyte gyrogonite	-1.85	-3.37
279A CG18	Charophyte gyrogonite	-2.51	-2.65
279A CG19	Charophyte gyrogonite	-2.08	-2.75
279A CG20	Charophyte gyrogonite	-2.10	-2.29
279A FO1	Fish otolith	-2.72	-5.87
279A FO2	Fish otolith	-4.08	-6.66
279A FO3	Fish otolith	-3.72	-6.62
279A FO4	Fish otolith	-3.60	-5.30
279A FO5	Fish otolith	-4.06	-7.19
279A FO6	Fish otolith	-3.66	-7.53
279A FO7	Fish otolith	-4.42	-7.15
279A FO8	Fish otolith	-3.64	-6.87
279A FO9	Fish otolith	-3.41	-6.42
279A FO10	Fish otolith	-3.72	-7.56
279A FO11	Fish otolith	-4.60	-6.97
279A FO12	Fish otolith	-4.54	-6.56
279A FO13	Fish otolith	-3.55	-8.04
279A FO14	Fish otolith	-2.68	-6.00
279A FO15	Fish otolith	-3.38	-7.10
279A FO16	Fish otolith	-3.69	-8.37
279A FO17	Fish otolith	-2.46	-5.26
279A FO18	Fish otolith	-3.58	-6.41
279A FO19	Fish otolith	-3.27	-6.89
279A FO20	Fish otolith	-3.57	-6.59
279A FO21	Fish otolith	-2.94	-7.06
279A FO22	Fish otolith	-3.11	-5.63
279A FO23	Fish otolith	-2.42	-6.14
279A FO24	Fish otolith	-2.86	-6.35
279A FO25	Fish otolith	-4.51	-11.14
279A FO26	Fish otolith	-3.35	-8.85

279A FO27	Fish otolith	-4.83	-9.01
279A FO28	Fish otolith	-3.45	-7.39
279A FO29	Fish otolith	-2.97	-6.55
279A FO30	Fish otolith	-4.08	-7.35
279A FO31	Fish otolith	-4.26	-7.48
279A FO32	Fish otolith	-4.05	-8.47
279A FO33	Fish otolith	-3.11	-7.54
279A FO34	Fish otolith	-2.24	-7.77
279A FO35	Fish otolith	-3.06	-6.68
279A GS1	Gastropod shell	-1.62	-4.06
279A GS2	Gastropod shell	-2.06	-3.59
279A GS3	Gastropod shell	-2.10	-8.46
279A GS4	Gastropod shell	-2.44	-3.53
279A GS5	Gastropod shell	-0.15	-10.01
279A GS6	Gastropod shell	-1.60	-5.37
279A GS7	Gastropod shell	-3.46	-4.74
279A GS8	Gastropod shell	-4.33	-6.28
279A GS9	Gastropod shell	-1.68	-7.40
279A GS10	Gastropod shell	-1.97	-7.75
279A GS11	Gastropod shell	-2.90	-9.55
279A GS12	Gastropod shell	-0.47	-3.64
279A GS13	Gastropod shell	-0.27	-5.87
279A GS14	Gastropod shell	-1.54	-7.76
279A GS15	Gastropod shell	-1.42	-8.62
279A GS16	Gastropod shell	0.07	-5.70
279A GS17	Gastropod shell	-3.11	-9.27
279A GS18	Gastropod shell	-4.94	-6.49
279A GS19	Gastropod shell	-3.23	-11.13
279A GS20	Gastropod shell	-2.63	-9.71
279A GS21	Gastropod shell	0.43	-8.47
279A GS22	Gastropod shell	-2.28	-4.25
279A GS23	Gastropod shell	-2.23	-4.60
279A GS24	Gastropod shell	-2.63	-8.27
279A GS25	Gastropod shell	-2.78	-1.36
279A GS26	Gastropod shell	-1.08	-3.20
279A GS27	Gastropod shell	-2.76	-8.36
279A GS28	Gastropod shell	-1.54	-4.53
279A GS29	Gastropod shell	-1.77	-4.19
279A GS30	Gastropod shell	-2.41	-9.01
279A GS31	Gastropod shell	-0.24	-7.17
279A GS32	Gastropod shell	-0.30	-8.85
279A GS33	Gastropod shell	-2.30	-5.83
279A GS34	Gastropod shell	0.20	-5.11
279A GS35	Gastropod shell	-2.88	-8.87
279A GS36	Gastropod shell	-0.34	-4.00
279A GS37	Gastropod shell	0.06	-5.73
279A GS38	Gastropod shell	-1.05	-3.50
279A GS39	Gastropod shell	-0.53	-5.25
279A GS40	Gastropod shell	-0.79	-6.72
279A GS41	Gastropod shell	-1.57	-5.26
279A GS42	Gastropod shell	0.27	-8.32
279A GS43	Gastropod shell	-1.14	-3.73
279A GS44	Gastropod shell	0.18	-3.63
279A GS45	Gastropod shell	-2.46	-7.09
279A GS46	Gastropod shell	-1.60	-3.64
279A GS47	Gastropod shell	-1.30	-6.27
279A GS48	Gastropod shell	-2.14	-5.42
279A GS49	Gastropod shell	-3.22	-6.12
279A GS50	Gastropod shell	-3.29	-2.26

Table DR11. Lacey's Farm Member enamel $\delta^{18}O_{phosphate}$ results.

Sample ID	**Genus**	**Tooth type**	**Measured enamel $\delta^{18}O_{phosphate}$ (‰ VSMOW)**
73 S1 + S4	*Thalerimys fordi*	Upper right and Upper left M1/2 molars	17.83
73 S5 + S9	*Thalerimys fordi*	Upper left and lower left M1/2 molars	17.47
73 S7	*Thalerimys fordi*	Lower left M1/2 molar	18.51
73 S8	*Thalerimys fordi*	Lower left M1/2 molar	17.70
73 S10	*Thalerimys fordi*	Lower left M3 molar	17.08
73 S22	*Thalerimys fordi*	Upper right P4 premolar	18.38
73 S28	*Thalerimys fordi*	Lower right P4 premolar	17.66
73 S11 + S16	*Isoptychus* sp.	2 Upper right M1/2 molars	18.29
73 S24 + S25	*Isoptychus* sp.	2 Lower right M1/2 molars	21.36
73 S26	*Isoptychus* sp.	Upper right M1/2 molar	22.02
73 S12	*Isoptychus* sp.	Lower left M3 molar	20.63
73 S14 + S19	*Isoptychus* sp.	Lower right and lower left M3 molars	18.70
73 S27 + S29	*Isoptychus* sp.	Lower right M3 molar and lower left molar	17.30

Table DR12. Lacey's Farm Member carbonate $\delta^{18}O$ and $\delta^{13}C$ results.

Sample ID	Taxon	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
S 73 OT1	Fish otolith	-2.60	-5.19
S 73 OT2	Fish otolith	-2.37	-3.96
S 73 OT3	Fish otolith	-2.35	-5.11
S 73 OT4	Fish otolith	-2.29	-4.83
S 73 OT5	Fish otolith	-2.44	-4.46
S 73 OT6	Fish otolith	-2.35	-4.73
S 73 L1	Gastropod shell	-0.03	-2.28
S 73 L2	Gastropod shell	-1.09	-2.22
S 73 L3	Gastropod shell	0.90	-2.65
S 73 L4	Gastropod shell	-2.30	-1.00
S 73 L5	Gastropod shell	-0.86	-7.75
S 73 L6	Gastropod shell	0.33	-1.56
S 73 L7	Gastropod shell	-1.40	-1.04
S 73 L8	Gastropod shell	-0.27	-4.06
S 73 L9	Gastropod shell	-0.92	-4.17
S 73 L10	Gastropod shell	-2.01	-3.31
S 73 L11	Gastropod shell	-2.50	-6.12
S 73 L12	Gastropod shell	0.50	-3.26
S 73 L13	Gastropod shell	-0.94	-6.68
S 73 L14	Gastropod shell	-0.58	-3.09
S 73 L15	Gastropod shell	0.13	-2.79
S 73 L16	Gastropod shell	1.12	-6.79
S 73 L17	Gastropod shell	-0.64	-3.63
S 73 L18	Gastropod shell	-1.21	-7.33
S 73 L19	Gastropod shell	-0.74	-4.88
S 73 L20	Gastropod shell	-2.32	-6.34
S 73 L21	Gastropod shell	-0.64	-3.86
S 73 L22	Gastropod shell	-3.07	-6.08
S 73 L23	Gastropod shell	-0.60	-1.66
S 73 L24	Gastropod shell	-0.37	-0.86
S 73 L25	Gastropod shell	-2.34	-4.02
S 73 L26	Gastropod shell	-1.76	-5.08
S 73 L27	Gastropod shell	-1.31	-4.49
S 73 L28	Gastropod shell	-0.34	1.68
S 73 L29	Gastropod shell	0.86	-5.61
S 73 L30	Gastropod shell	-1.19	-4.95
S 73 C1	Charophyte gyrogonite	-1.11	-1.22
S 73 C2	Charophyte gyrogonite	-0.81	-1.87
S 73 C3	Charophyte gyrogonite	-0.94	-3.55
S 73 C4	Charophyte gyrogonite	-1.82	-3.68
S 73 C5	Charophyte gyrogonite	-1.49	-3.73
S 73 C6	Charophyte gyrogonite	-1.52	-2.19
S 73 C7	Charophyte gyrogonite	-1.66	-3.34
S 73 C8	Charophyte gyrogonite	-1.96	-2.31
S 73 C9	Charophyte gyrogonite	-0.86	-1.42
S 73 C10	Charophyte gyrogonite	-2.14	-2.00
S 73 C11	Charophyte gyrogonite	-2.67	-3.43
S 73 C12	Charophyte gyrogonite	-0.93	-2.30
S 73 C13	Charophyte gyrogonite	-0.78	-2.60
S 73 C14	Charophyte gyrogonite	-1.68	-3.82

S 73 C15	Charophyte gyrogonite	-2.63	-4.23
S 73 C16	Charophyte gyrogonite	-2.04	-3.44
S 73 C17	Charophyte gyrogonite	-1.72	-3.21
S 73 C18	Charophyte gyrogonite	-2.08	-1.51

Table DR13. Totland Bay Member enamel $\delta^{18}O_{phosphate}$ results.

Sample ID	Genus	Tooth type	Measured enamel $\delta^{18}O_{phosphate}$ (‰ VSMOW)
292 S11	*Thalerimys fordi*	Lower right M1/2 molar	17.48
292 S16	*Thalerimys fordi*	Lower left M1/2 molar	18.04
292 S17	*Thalerimys fordi*	Lower left M1/2 molar	18.61
292 S20	*Thalerimys fordi*	Upper left M1/2 molar	17.41
292 S27	*Thalerimys fordi*	Lower left M1/2 molar	17.73
292 S28	*Thalerimys fordi*	Upper right M1/2 molar	17.17
292 S34	*Thalerimys fordi*	Lower right M1/2 molar	17.33
292 S38	*Thalerimys fordi*	Lower left M1/2 molar	18.38
292 S43	*Thalerimys fordi*	Upper left M1/2 molar	17.03
292 S47	*Thalerimys fordi*	Upper left M1/2 molar	18.34
292 S58	*Thalerimys fordi*	Upper right M1/2 molar	16.32
292 S62	*Thalerimys fordi*	Lower left M1/2 molar	18.19
292 S66	*Thalerimys fordi*	Lower left M1/2 molar	16.14
292 S71	*Thalerimys fordi*	Lower left M1/2 molar	18.62
292 S77	*Thalerimys fordi*	Lower left M1/2 molar	19.35
292 S78	*Thalerimys fordi*	Upper left M1/2 molar	18.69
292 S79	*Thalerimys fordi*	Lower left M1/2 molar	17.61
292 S85	*Thalerimys fordi*	Upper right M1/2 molar	18.57
292 S105	*Thalerimys fordi*	Upper left M1/2 molar	17.40
292 S124	*Thalerimys fordi*	Lower right M1/2 molar	18.52
292 S5	*Thalerimys fordi*	Lower left M3 molar	17.90
292 S18	*Thalerimys fordi*	Upper right M3 molar	17.84
292 S21	*Thalerimys fordi*	Lower left M3 molar	17.60
292 S24	*Thalerimys fordi*	Upper left M3 molar	18.75
292 S29	*Thalerimys fordi*	Lower left M3 molar	15.91
292 S33	*Thalerimys fordi*	Lower right M3 molar	16.71
292 S39	*Thalerimys fordi*	Upper right M3 molar	15.93
292 S44	*Thalerimys fordi*	Lower right M3 molar	17.37
292 S52	*Thalerimys fordi*	Upper left M3 molar	16.74
292 S54	*Thalerimys fordi*	Upper left M3 molar	18.22
292 S64	*Thalerimys fordi*	Upper right M3 molar	17.28
292 S65	*Thalerimys fordi*	Lower right M3 molar	16.32
292 S67	*Thalerimys fordi*	Lower left M3 molar	17.96
292 S72	*Thalerimys fordi*	Lower left M3 molar	16.67
292 S73	*Thalerimys fordi*	Upper right M3 molar	18.04
292 S87	*Thalerimys fordi*	Upper left M3 molar	16.65
292 S94	*Thalerimys fordi*	Upper left M3 molar	16.02
292 S96	*Thalerimys fordi*	Lower left M3 molar	18.11
292 S104	*Thalerimys fordi*	Lower right M3 molar	18.29
292 S120	*Thalerimys fordi*	Upper left M3 molar	16.49
292 S7	*Thalerimys fordi*	Lower left P4 premolar	16.34
292 S9	*Thalerimys fordi*	Upper right P4 premolar	18.31
292 S22	*Thalerimys fordi*	Upper left P4 premolar	17.88
292 S23	*Thalerimys fordi*	Upper left P4 premolar	18.78
292 S30	*Thalerimys fordi*	Lower right P4 premolar	16.68
292 S41	*Thalerimys fordi*	Upper left P4 premolar	16.02
292 S51	*Thalerimys fordi*	Upper left P4 premolar	17.10
292 S55	*Thalerimys fordi*	Lower left P4 premolar	15.88
292 S84	*Thalerimys fordi*	Lower right P4 premolar	17.46
292 S90	*Thalerimys fordi*	Lower right P4 premolar	15.85
292 S91	*Thalerimys fordi*	Lower left P4 premolar	19.11
292 S93	*Thalerimys fordi*	Lower left P4 premolar	17.73
292 S108	*Thalerimys fordi*	Upper left P4 premolar	16.63

292 S114	*Thalerimys fordi*	Upper right P4 premolar	18.11
292 S116	*Thalerimys fordi*	Upper right P4 premolar	18.12
292 S125	*Thalerimys fordi*	Lower left P4 premolar	16.29

Table DR14. Totland Bay Member carbonate $\delta^{18}O$ and $\delta^{13}C$ results.

Sample ID	Taxon	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
S292 L1	Gastropod shell	-2.35	-5.54
S292 L2	Gastropod shell	-1.25	-5.03
S292 L3	Gastropod shell	-2.39	-5.26
S292 L4	Gastropod shell	0.07	-3.84
S292 L5	Gastropod shell	-1.69	-4.20
S292 L6	Gastropod shell	-0.97	-4.62
S292 L7	Gastropod shell	-2.60	-6.91
S292 L8	Gastropod shell	-0.37	-3.05
S292 L9	Gastropod shell	-3.99	-4.91
S292 L10	Gastropod shell	-2.76	-6.66
S292 L11	Gastropod shell	-0.76	-4.42
S292 L12	Gastropod shell	-3.35	-4.41
S292 L13	Gastropod shell	-1.81	-5.35
S292 L14	Gastropod shell	-0.98	-2.69
S292 L15	Gastropod shell	-1.27	-4.78
S292 L16	Gastropod shell	-3.24	-7.50
S292 L17	Gastropod shell	-1.28	-5.10
S292 L18	Gastropod shell	-3.10	-8.96
S292 L19	Gastropod shell	-0.08	-3.79
S292 L20	Gastropod shell	-3.01	-8.63
S292 L21	Gastropod shell	-2.50	-3.85
S292 L22	Gastropod shell	-2.33	-6.58
S292 L23	Gastropod shell	-1.21	-7.40
S292 L24	Gastropod shell	-2.53	-4.93
S292 L25	Gastropod shell	-2.92	-7.01
S292 L26	Gastropod shell	-2.51	-6.55
S292 L27	Gastropod shell	-0.93	-7.99
S292 L28	Gastropod shell	-3.19	-5.75
S292 L29	Gastropod shell	-1.93	-9.48
S292 L30	Gastropod shell	-0.91	-3.88
S292 L31	Gastropod shell	-1.61	-5.40
S292 L32	Gastropod shell	-0.71	-3.38
S292 L33	Gastropod shell	-2.46	-7.73
S292 L34	Gastropod shell	-2.07	-7.62
S292 L35	Gastropod shell	-0.36	-4.21
S292 L36	Gastropod shell	-1.80	-8.00
S292 L37	Gastropod shell	-0.60	-2.86
S292 L38	Gastropod shell	-2.69	-7.45
S292 L39	Gastropod shell	-1.38	-7.33
S292 L40	Gastropod shell	-0.89	-8.66
S292 L41	Gastropod shell	-1.30	-1.38
S292 L42	Gastropod shell	0.13	-2.13
S292 L43	Gastropod shell	-1.24	-0.76
S292 L44	Gastropod shell	-0.67	-5.08
S292 L45	Gastropod shell	-1.48	-8.06
S292 L46	Gastropod shell	-2.48	-6.16
S292 L47	Gastropod shell	-0.26	-5.96
S292 L48	Gastropod shell	-1.95	-5.21
S292 L49	Gastropod shell	-1.42	-3.65
S292 L50	Gastropod shell	-4.16	-6.51
S292 L51	Gastropod shell	-1.47	-3.70
S292 L52	Gastropod shell	-1.98	-4.49
S292 L53	Gastropod shell	-1.96	-2.98
S292 L54	Gastropod shell	-2.30	-4.22

S292 L55	Gastropod shell	-0.90	-4.40
S292 L56	Gastropod shell	-0.94	-6.57
S292 L57	Gastropod shell	-2.37	-9.57
S292 L58	Gastropod shell	-3.91	-6.55
S292 L59	Gastropod shell	-0.54	-3.42
S292 L60	Gastropod shell	-0.85	-5.43
S292 L61	Gastropod shell	-1.41	-4.72
S292 L62	Gastropod shell	-2.70	-6.45
S292 L63	Gastropod shell	-0.08	-3.19
S292 L64	Gastropod shell	-0.49	-3.60
S292 L65	Gastropod shell	-1.10	-2.85
S292 L66	Gastropod shell	-1.64	-5.39
S292 L67	Gastropod shell	-0.19	-4.20
S292 L68	Gastropod shell	-0.16	-1.37
S292 L69	Gastropod shell	-0.05	-3.23
S292 L70	Gastropod shell	-0.17	-4.90
S292 L71	Gastropod shell	-1.15	-3.73
S292 L72	Gastropod shell	-1.43	-7.30
S292 L73	Gastropod shell	-1.22	-3.33
S292 L74	Gastropod shell	-2.43	-4.00
S292 L75	Gastropod shell	-1.95	-5.24
S292 L76	Gastropod shell	-1.70	-4.79
S292 L77	Gastropod shell	-0.95	-0.29
S292 L78	Gastropod shell	-2.22	-1.78
S292 L79	Gastropod shell	-1.32	-3.36
S292 C1	Charophyte gyrogonite	-3.16	-1.70
S292 C2	Charophyte gyrogonite	-3.76	-2.55
S292 C3	Charophyte gyrogonite	-1.79	-2.91
S292 C4	Charophyte gyrogonite	-3.32	-3.13
S292 C5	Charophyte gyrogonite	-3.45	-4.34
S292 C6	Charophyte gyrogonite	-2.85	-2.10
S292 C7	Charophyte gyrogonite	-2.32	-4.11
S292 C8	Charophyte gyrogonite	-2.28	-2.70
S292 C9	Charophyte gyrogonite	-3.76	-2.55
S292 C10	Charophyte gyrogonite	-4.12	-3.96
S292 C11	Charophyte gyrogonite	-4.18	-4.61
S292 C12	Charophyte gyrogonite	-3.74	-3.21
S292 C13	Charophyte gyrogonite	-2.66	-3.07
S292 C14	Charophyte gyrogonite	-2.64	-3.77
S292 C15	Charophyte gyrogonite	-4.31	-3.40
S292 C16	Charophyte gyrogonite	-4.65	-3.77
S292 C17	Charophyte gyrogonite	-4.18	-4.68
S292 C18	Charophyte gyrogonite	-2.70	-1.78
S292 C19	Charophyte gyrogonite	-3.34	-2.65
S292 C20	Charophyte gyrogonite	-3.70	-2.34
S292 C21	Charophyte gyrogonite	-2.68	-2.58
S292 C22	Charophyte gyrogonite	-2.83	-2.27
S292 C23	Charophyte gyrogonite	-2.38	-1.24
S292 C24	Charophyte gyrogonite	-3.91	-3.17
S292 C25	Charophyte gyrogonite	-3.43	-3.46
S292 C26	Charophyte gyrogonite	-2.63	-3.18
S292 C27	Charophyte gyrogonite	-2.32	-3.72
S292 C28	Charophyte gyrogonite	-3.36	-3.05
S292 C29	Charophyte gyrogonite	-4.33	-3.37
S292 C30	Charophyte gyrogonite	-2.90	-2.82
S292 C31	Charophyte gyrogonite	-1.94	-1.29
S292 C32	Charophyte gyrogonite	-3.92	-2.46
S292 C33	Charophyte gyrogonite	-2.62	-0.71
S292 C34	Charophyte gyrogonite	-2.85	-2.57

S292 C35	Charophyte gyrogonite	-2.35	-2.32
S292 C36	Charophyte gyrogonite	-3.07	-2.12
S292 C37	Charophyte gyrogonite	-3.06	-1.90
S292 C38	Charophyte gyrogonite	-2.75	-1.57
S292 C39	Charophyte gyrogonite	-2.62	-1.75
S292 C40	Charophyte gyrogonite	-2.48	-1.14
S292 C41	Charophyte gyrogonite	-2.72	-1.29
S292 C42	Charophyte gyrogonite	-2.86	-1.43
S292 C43	Charophyte gyrogonite	-2.47	-1.43
S292 C44	Charophyte gyrogonite	-2.71	-1.39
S292 C45	Charophyte gyrogonite	-2.82	-1.51
S292 C46	Charophyte gyrogonite	-2.85	-1.67
S292 C47	Charophyte gyrogonite	-2.59	-1.39
S292 C48	Charophyte gyrogonite	-2.67	-0.76
S292 C49	Charophyte gyrogonite	-2.51	-0.97
S292 C50	Charophyte gyrogonite	-2.82	-1.63
S292 C51	Charophyte gyrogonite	-2.70	-1.61
S292 OT1	Fish otolith	-3.51	-6.85
S292 OT2	Fish otolith	-3.93	-5.92
S292 OT3	Fish otolith	-3.54	-6.97
S292 OT4	Fish otolith	-3.02	-5.09
S292 OT5	Fish otolith	-3.26	-5.98

Table DR15. XRD results from the analysis of carbonate palaeoproxies.

Sample ID	Taxon	% Aragonite	% Calcite	Measured $\delta^{18}O_{carbonate}$ (‰ VPDB)	Measured $\delta^{13}C_{carbonate}$ (‰ VPDB)
S292 L1	Gastropod shell	98	2	-2.35	-5.54
S292 L2	Gastropod shell	98	2	-1.25	-5.03
S292 L6	Gastropod shell	98	2	-0.97	-4.62
S292 L9	Gastropod shell	100		-3.99	-4.91
S292 L19	Gastropod shell	100		-0.08	-3.79
S292 L24	Gastropod shell	100		-2.53	-4.93
S292 L30	Gastropod shell	98	2	-0.91	-3.88
S292 L36	Gastropod shell	100		-1.80	-8.00
S292 L43	Gastropod shell	100		-1.24	-0.76
S292 L46	Gastropod shell	100		-2.48	-6.16
S292 L51	Gastropod shell	100		-1.47	-3.70
S292 L58	Gastropod shell	100		-3.91	-6.55
S292 L62	Gastropod shell	100		-2.70	-6.45
S292 L69	Gastropod shell	100		-0.05	-3.23
S292 L76	Gastropod shell	100		-1.70	-4.79
S73 L1	Gastropod shell	100		-0.03	-2.28
S73 L3	Gastropod shell	99	1	0.90	-2.65
S73 L5	Gastropod shell	99	1	-0.86	-7.75
S73 L7	Gastropod shell	100		-1.40	-1.04
S73 L9	Gastropod shell	99	1	-0.92	-4.17
S73 L11	Gastropod shell	100		-2.50	-6.12
S73 L13	Gastropod shell	94	6	-0.94	-6.68
S73 L15	Gastropod shell	100		0.13	-2.79
S73 L17	Gastropod shell	100		-0.64	-3.63
S73 L19	Gastropod shell	99	1	-0.74	-4.88
S73 L21	Gastropod shell	99	1	-0.64	-3.86
S73 L23	Gastropod shell		100	-0.60	-1.66
S73 L25	Gastropod shell		100	-2.34	-4.02
S73 L27	Gastropod shell		100	-1.31	-4.49
S73 L29	Gastropod shell		100	0.86	-5.61
S73 OT2	Fish otolith	100		-2.37	-3.96
279A GS1	Gastropod shell		100	-1.62	-4.06
279A GS4	Gastropod shell		100	-2.44	-3.53
279A GS5	Gastropod shell		100	-0.15	-10.01
279A GS12	Gastropod shell		100	-0.47	-3.64
279A GS15	Gastropod shell		100	-1.42	-8.62
279A GS22	Gastropod shell		100	-2.28	-4.25
279A GS32	Gastropod shell		100	-0.30	-8.85
279A FO1	Fish otolith	66	34	-2.72	-5.87
279A FO2	Fish otolith	58	42	-4.08	-6.66
279A FO3	Fish otolith	72	28	-3.72	-6.62
279A FO4	Fish otolith	100		-3.60	-5.30
279A FO5	Fish otolith	100		-4.06	-7.19
279A FO6	Fish otolith	100		-3.66	-7.53
279A FO11	Fish otolith	100		-4.60	-6.97
279A FO13	Fish otolith	100		-3.55	-8.04
279A FO23	Fish otolith	100		-2.42	-6.14
S340A L2	Gastropod shell	100		-0.68	-5.71
S240A L7	Gastropod shell	100		-0.90	-5.64
S340A L8	Gastropod shell	100		0.27	-4.70
S340A L13	Gastropod shell	90	10	-0.34	-5.45
S340A L14	Gastropod shell	92	8	-1.84	-5.84
S340A L17	Gastropod shell	98	2	-0.38	-6.44
S340A L18	Gastropod shell	100		-1.87	-2.78

S340A L19	Gastropod shell	80	20	-2.03	-5.07
S340A OT1	Fish otolith	100		-2.90	-2.42
S340A OT3	Fish otolith	100		-1.82	-2.99
S340A OT5	Fish otolith	100		-2.04	-2.87
S340A OT6	Fish otolith	98	2	-2.16	-0.71
S340A OT8	Fish otolith	98	2	-2.92	-2.66
S340A OT10	Fish otolith	95	5	-3.25	-1.17
S340A OT12	Fish otolith	100		-2.83	-2.50
S340A OT14	Fish otolith	100		-2.01	-3.09
S340A OT17	Fish otolith	100		-3.15	-1.31
S333A L2	Gastropod shell	100		-1.21	-4.91
S333L L4	Gastropod shell	100		-0.47	-8.74
S333L L5	Gastropod shell	100		-0.47	-7.26
S333M L5	Gastropod shell	100		-0.28	-5.28
S333M L1	Gastropod shell	100		0.03	-5.60
S333P L1	Gastropod shell	100		-0.44	-4.31
S333S L5	Gastropod shell	100		0.17	-6.18
S333T L2	Gastropod shell	100		-0.58	-6.23
S333U L2	Gastropod shell	100		2.01	-6.27
S333W L3	Gastropod shell	90	10	0.54	-7.60