Supplementary Information for *Formation of 'Southern Component Water' in the Late Cretaceous: evidence from Nd-isotopes*
by Robinson, S.A., et al.

1. Age models

Age models were constructed for each site using linear interpolation between datums. Extrapolation of sedimentation rates was used to constrain the age of samples that were not bracketed by precise age constraints. All age models are calibrated to the timescale of Gradstein et al. (1995) (as presented in Bralower et al. 2002) with the exception of datums around the Cenomanian/Turonian boundary, which are tied to Sageman et al. (2006). These timescales were chosen to allow comparison with older Nd-isotope datasets.

*Hole 511**

Datum	Depth (mbsf)	Age (Ma)	Comments/Reference
Sr isotopes	195.38	71.8	Huber et al. (2002)
LAD *G. imensus*	204.7	74.8	Huber et al. (2002)
Top of C34N	225	83	Huber et al. (2002)
Base *A. parcus parcus*	245	83.4	The age used by Huber et al. (2002) was 82.5 Ma; consistent with the age of *A. parcus constrictus* but not *A. parcus parcus* which has FO of 83.4 Ma.
Top *L. septenarius*	366	84.7	Huber et al. (2002)
Base *M. decussata*	399	87.2	Huber et al. (2002)
Base *M. furcatus*	399	89.3	Huber et al. (2002)
Base *E. eximus*	414	91	Huber et al. (2002)
Base *E. turriseiffeli*	434	101.7	Huber et al. (2002)
Base *A. albianus*	447	106.5	Huber et al. (2002)

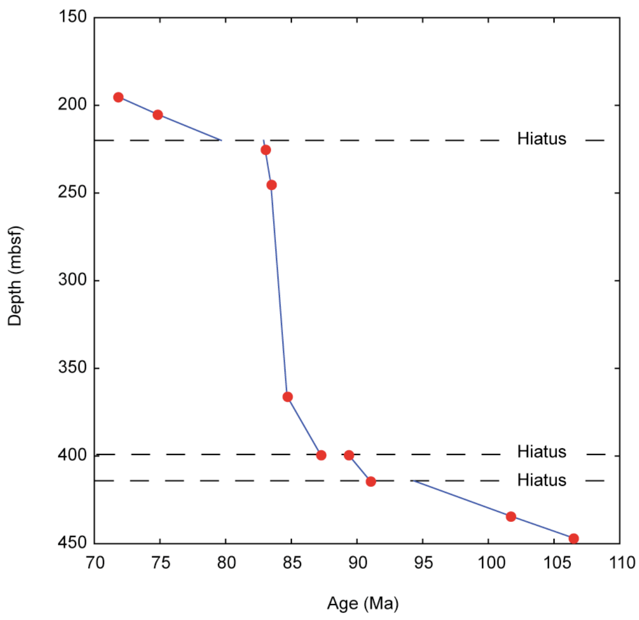

Figure DR1. Age model for Hole 511*. Red dots indicate datums; blue line signifies age model.

Hole 530A

Datum	Depth (mbsf)	Age (Ma)	Comments/Reference
End Maastrichtian	592.6	65	Minimum age, see Stradner & Steinmetz, (1980) and Keating & Herrero-Bervera (1980)
Top of C33N	680	73.6	Keating & Herrero-Bervera (1980)
Base of C33N	832.5	79	Keating & Herrero-Bervera (1980)
Top of C34N	880	83	Keating & Herrero-Bervera (1980)
FO *M. furcatus*	999	89.3	Stradner & Steinmetz (1980)
FO *Q. gartneri*	1026.2	93.4	Forster et al. (2008); Sageman et al (2006)
Onset of positive $d^{13}C$ excursion	1039	94.09	Forster et al. (2008); Sageman et al (2006)
FO *L. acutus*	1055	96.8	Maximum age, see Stradner & Steinmetz (1980)

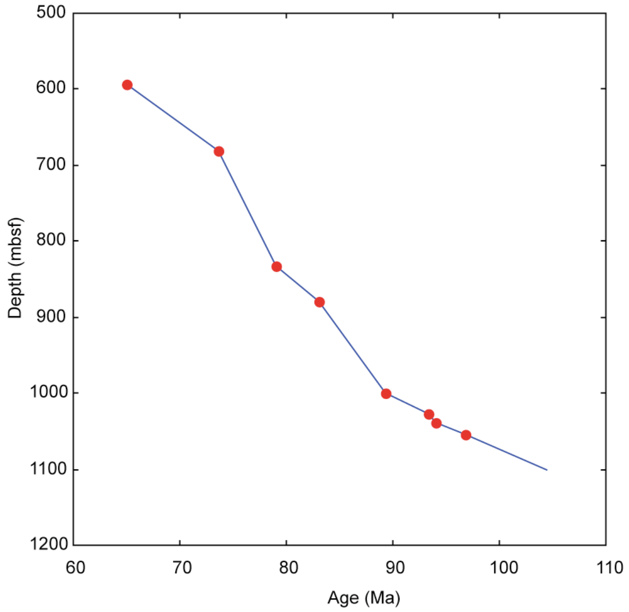

Figure DR2. Age model for Hole 530A. Red dots indicate datums; blue line signifies age model.

Hole 766A

Datum	Depth (mbsf)	Age (Ma)	Comments/Reference
LO *R. Levis*	89.43	69.2	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *R. Levis*	106.31	76	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *A. parca*	115.69	83.4	Moran (1992)
FO *R. anthophorus*	118.3	85.5	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *M. staurophora*	124.08	87.2	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *M. furcatus*	126.95	89.3	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *Q. gartneri*	134.35	93.4	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
LO *W. britannica*	139.79	97.6	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *E. turriseiffelli*	154.37	101.7	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)
FO *A. albianus*	170.15	106.1	Gradstein et al., (1990); Bown, (*pers. comm.* 2010)

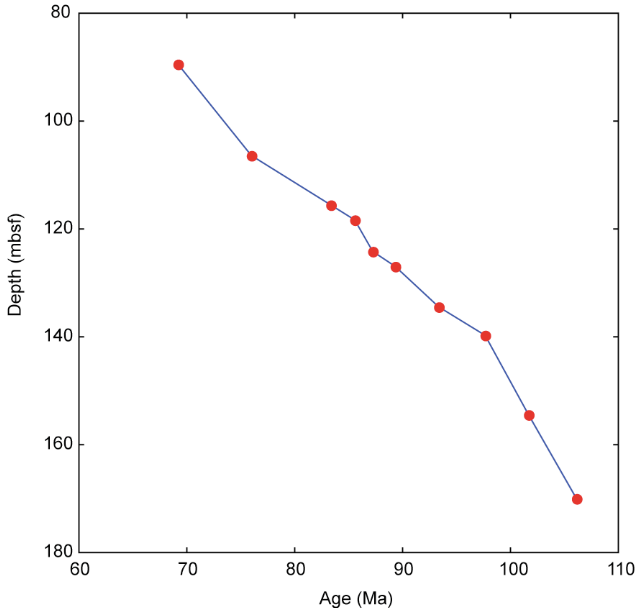

Figure DR3. Age model for Hole 766A. Red dots indicate datums; blue line signifies age model.

Hole 1149B

Datum	Depth (mbsf)	Age (Ma)	Comments/Reference
LO *R. wisei*	359.43	133.1	Lozar & Tremolada (2003)
Base of UAZ16	408.48	134.1	Maximum age at base of hole; Lozar & Tremolada (2003)

2. Analytical Methods

~20 to 30 cc samples were disaggregated using water, <10% H_2O_2 and then sieved. Fossil-fish debris (teeth and skeletal fragments) were picked from the >63μm fraction and between 4 and 15 fragments were selected from each productive sample for analysis. These samples were cleaned using a standard oxidative-reductive cleaning method (modified from Boyle, 1981; Boyle & Keigwin, 1985) to remove any Fe-Mn coatings.

For the isotopic analyses done at Bristol, a mixed $^{149}Sm/^{150}Nd$ spike was added following dissolution to allow measurement of $^{147}Sm/^{144}Nd$ ratios and the correction for post-sedimentation production of ^{143}Nd by decay of ^{147}Sm. Column chemistry techniques follow those in Cohen et al. (1988) except that Ln resin was used to separate Nd and Sm as described by Pin and Zalduegui (1997). The total blank for the dissolution and chemical separation was 15-20 pg and is negligible. Isotope ratios were measured on a Thermo-Finnigan Neptune multi-collector ICP-MS at the University of Bristol, using the approach described in Vance and Thirlwall (2002). Replicate analyses of the La Jolla standard (between 14 and 29 per analytical session) gave values ranging from 0.511840±0.000005 to 0.511871±0.000002. All sample data were adjusted assuming a correct value of 0.511858 for La Jolla, and using the day average value for that standard.

Samples analysed at UNC-Chapel Hill were run as NdO^+ using a multi-collector VG Sector 54, and at Texas A&M on the Thermo Triton thermal ionization mass spectrometer as Nd^+. The procedural blank is ~15 pg and is considered negligible. At UNC-CH external analytical precision, based upon replicate analysis of the international standard JNdi (Tanaka et al., 2000), yielded 0.512111 ± 0.000011 (2σ, n=30). Replicate analyses of the JNdi standard (n=28) on the TAMU Thermo Triton gave 0.512102±0.000004 (2σ). Replicate analysis of the La Jolla standard (n=22) on the TAMU Triton yields a value of 0.511846±0.000003 (2σ). No adjustments were made to the sample values on the basis of the standards analysed.

e_{Nd} (0), defined as:

$$\varepsilon_{Nd}(0) = \left[\frac{({}^{143}Nd/{}^{144}Nd)_{SAMPLE} - ({}^{143}Nd/{}^{144}Nd)_{CHUR}}{({}^{143}Nd/{}^{144}Nd)_{CHUR}} \right] 10{,}000$$

with $^{143}Nd/^{144}Nd_{CHUR}$ = 0.512638 (Jacobsen and Wasserburg, 1980) was corrected for post-sedimentation decay of ^{147}Sm to give e_{Nd} (t) (see notes on data tables below for details).

3. Data Tables

Notes (apply to all tables)

[1] For the University of Bristol analyses, sample $^{147}Sm/^{144}Nd$ was measured by isotope dilution. For the Texas A&M University (TAMU) and University of North Carolina, Chapel Hill (UNC-C.H.) samples a $^{147}Sm/^{144}Nd$ value of 0.13 was assumed, similar to the average for samples measured at Bristol. Use of the most extreme values actually measured for the Bristol samples, as opposed to the assumed value of 0.13, results in a shift of ≤0.3 epsilon units in ε_{Nd} (t) for the UNC-C.H. samples.

[2] Listed 2 sigma uncertainties on ε_{Nd} reflect internal errors. Propagation of the external uncertainty, as estimated from the reproducibility of La Jolla (maximum 0.1 epsilon units for a single analytical session on the Bristol Neptune (n = 14-29) or from the long-term reproducibility of standards on the UNC-C.H. Triton (0.06 epsilon units), would result in a minor increase in quoted uncertainties.

[3] Bristol – Univeristy of Bristol; UNC-C.H. – University of North Carolina, Chapel Hill; TAMU – Texas A&M University

Table DR1: Sm-Nd isotopic data for Cretaceous fish teeth and bones from ODP Hole 511* (Leg 71).

Sample (core-section, interval [cm])	Depth (mbsf)	Age (Ma)	$^{147}Sm/^{144}Nd$ [1]	$^{143}Nd/^{144}Nd$	εNd(0)	εNd(t)	±2σ [2]	Lab [3]
24R-1, 101-103	205.51	75.06	0.1287	0.512153	-9.46	-8.81	0.09	Bristol
24R-3, 101-104	208.51	76.03	0.1259	0.512162	-9.29	-8.60	0.08	Bristol
24R-5, 59-63	210.81	76.77	0.1275	0.512166	-9.20	-8.53	0.12	Bristol
27R-1, 50-52	219.51	79.57		0.512268	-7.22	-6.55	0.24	UNC-C.H.
28R-1, 14-16	223.64	82.97	0.1528	0.512305	-6.50	-6.04	0.05	Bristol
28R-2, 50-52	225.51	83.01		0.512296	-6.67	-5.96	0.20	UNC-C.H.
28R-3, 78-80	227.28	83.05	0.1514	0.512292	-6.76	-6.28	0.08	Bristol
29R-1, 15-17	233.16	83.16		0.512274	-7.11	-6.40	0.34	UNC-C.H.
30R-1, 50-51	243.01	83.36		0.512279	-7.00	-6.29	0.30	UNC-C.H.
30R-2, 16-20	244.16	83.38	0.1287	0.512266	-7.26	-6.54	0.08	Bristol
30R-4, 50-51	247.5	83.43		0.512282	-6.95	-6.24	0.18	UNC-C.H.
30R-6, 24-27	250.15	83.46	0.1473	0.512287	-6.85	-6.32	0.25	Bristol
31R-1, 50-51	252.5	83.48		0.512268	-7.21	-6.50	0.20	UNC-C.H.
31R-3, 103-107	256.03	83.52	0.1518	0.512324	-6.12	-5.64	0.09	Bristol
31R-5, 50-51	258.5	83.55		0.512263	-7.32	-6.61	0.20	UNC-C.H.
31R-5, 75-77	258.75	83.55	0.1427	0.512286	-6.86	-6.29	0.12	Bristol
32R-3, 71-74	265.21	83.62	0.1480	0.512288	-6.84	-6.32	0.07	Bristol
32R-4, 64-65	266.64	83.63		0.512285	-6.89	-6.18	0.11	TAMU
32R-5, 35-38	267.85	83.65	0.1447	0.512318	-6.25	-5.69	0.09	Bristol
33R-1, 75-77	271.76	83.69		0.512270	-7.18	-6.47	0.20	UNC-C.H.
33R-3, 55-58	274.55	83.72	0.1431	0.512332	-5.96	-5.39	0.14	Bristol
34R-1, 28-31	280.78	83.78	0.1434	0.512325	-6.11	-5.54	0.09	Bristol
34R-1, 50-52	281.01	83.79		0.512313	-6.34	-5.63	0.20	UNC-C.H.
34R-3, 117-120	284.67	83.83	0.1360	0.512340	-5.82	-5.17	0.17	Bristol
35R-1, 51-53	290.52	83.89		0.512291	-6.77	-6.06	0.32	UNC-C.H.
36R-1, 50-52	300.01	83.99		0.512196	-8.61	-7.90	0.44	UNC-C.H.
36R-1, 56-60	300.06	83.99	0.1144	0.512222	-8.12	-7.24	0.12	Bristol
36R-3, 112-116	303.62	84.03	0.1484	0.512317	-6.26	-5.75	0.17	Bristol

36R-4, 50-52	304.51	84.04		0.512296	-6.67	-5.96	0.24	UNC-C.H.
37R-1, 50-52	309.51	84.09		0.512312	-6.35	-5.64	0.22	UNC-C.H.
38R-1, 62-66	319.12	84.20	0.1401	0.512293	-6.74	-6.13	0.18	Bristol
38R-3, 96-99	322.46	84.23	0.1465	0.512329	-6.02	-5.48	0.10	Bristol
39R-1, 48-51	328.48	84.30	0.1514	0.512326	-6.09	-5.60	0.10	Bristol
39R-3, 47-50	331.47	84.33	0.1428	0.512282	-6.94	-6.36	0.11	Bristol
40R-1, 24-27	337.74	84.40	0.1191	0.512206	-8.44	-7.60	0.13	Bristol
40R-3, 60-62	341.1	84.43	0.1486	0.512359	-5.45	-4.93	0.06	Bristol
41R-1, 85-89	347.85	84.51	0.1344	0.512284	-6.90	-6.23	0.08	Bristol
41R-3, 119-122	351.19	84.54	0.1536	0.512331	-5.99	-5.53	0.11	Bristol
42R-4, 31-35	361.31	84.65	0.1305	0.512274	-7.11	-6.39	0.11	Bristol
46R-3, 50-52	398.01	87.13		0.512348	-5.65	-4.91	0.12	TAMU
47R-1, 79-81	404.79	89.96	0.1558	0.512344	-5.74	-5.27	0.18	Bristol
48R-3, 29-32	416.79	95.35	0.1618	0.512351	-5.59	-5.17	0.07	Bristol

Table DR2: Sm-Nd isotopic data for Cretaceous fish teeth and bones from DSDP Hole 530A (Leg 75)

Sample (core-section, interval [cm])	Depth (mbsf)	Age (Ma)	$^{147}Sm/^{144}Nd$[1]	$^{143}Nd/^{144}Nd$	εNd(0)	εNd(t)	±2σ[2]	Lab[3]
51R-3, 25-28	603.25	66.05	0.1261	0.512087	-10.76	-10.16	0.12	Bristol
55R-3, 23-26	641.23	69.79	0.1216	0.512110	-10.29	-9.63	0.12	Bristol
55R-5, 7-9	643.97	70.05	0.1220	0.512130	-9.91	-9.24	0.16	Bristol
56R-1, 40-42	647.91	70.44		0.512040	-11.66	-11.07	0.22	UNC-C.H.
57R-1, 39-41	657.40	71.38		0.512197	-8.61	-8.02	0.12	TAMU
61R-1, 43-44	695.43	74.15		0.512084	-10.80	-10.19	0.12	TAMU
62R-2, 38-40	706.38	74.53	0.1198	0.512103	-10.43	-9.70	0.09	Bristol
67R-1, 24-25	752.24	76.16		0.512181	-8.92	-8.28	0.07	TAMU
68R-1, 58-60	762.08	76.51	0.1261	0.512329	-6.04	-5.35	0.29	Bristol
68R-5, 71-73	768.11	76.72	0.1245	0.512210	-8.36	-7.65	0.16	Bristol
75R-1, 40-42	828.41	78.86		0.512779	2.76	3.44	0.06	TAMU
75R-3, 90-93	831.90	78.98	0.1526	0.512386	-4.91	-4.46	0.10	Bristol
75R-5, 7-10	834.07	79.13	0.1635	0.512392	-4.79	-4.46	0.11	Bristol
78R-2, 54-57	858.54	81.19	0.1274	0.512433	-4.00	-3.28	0.10	Bristol

78R-3, 100-104	860.50	81.36	0.1470	0.512237	-7.82	-7.31	0.07	Bristol
78R-5, 41-43	862.91	81.56	0.1375	0.512519	-2.33	-1.71	0.74	Bristol
78R-6, 114-116	865.14	81.75	0.1246	0.512413	-4.39	-3.64	0.09	Bristol
79R-1, 22-24	866.22	81.84	0.1351	0.512361	-5.40	-4.76	0.08	Bristol
79R-3, 22-24	869.22	82.09	0.1332	0.512284	-6.91	-6.25	0.11	Bristol
79R-5, 107-111	873.07	82.42	0.1288	0.512469	-3.30	-2.59	0.10	Bristol
81R-1, 30-32	885.31	83.28		0.512489	-2.90	-2.19	0.06	TAMU
81R-1, 115-117	886.15	83.33	0.1222	0.512285	-6.89	-6.10	0.08	Bristol
83R-1, 120-124	905.20	84.33	0.1706	0.512339	-5.84	-5.56	0.18	Bristol
86R-1, 30-32	931.31	85.72		0.512202	-8.50	-7.77	0.08	TAMU
86R-1, 65-68	931.65	85.73	0.1242	0.512184	-8.86	-8.07	0.07	Bristol
87R-3, 41-43	943.41	86.36	0.1380	0.512240	-7.77	-7.12	0.09	Bristol
89R-2, 50-52	960.00	87.24	0.1385	0.512213	-8.28	-7.64	0.06	Bristol
91R-1, 37-39	976.37	88.10	0.1542	0.512249	-7.59	-7.11	0.14	Bristol
93R-4, 137-139	995.87	89.13	0.1629	0.512261	-7.36	-6.97	0.08	Bristol
94R-2, 78-80	1001.28	89.64	0.1361	0.512260	-7.38	-6.69	0.74	Bristol
96R-5, 61-62	1023.61	93.01	0.1434	0.512221	-8.14	-7.51	0.14	Bristol
97R-1, 126-128	1027.26	93.46	0.1438	0.512220	-8.15	-7.52	0.08	Bristol
97R-3, 42-44	1029.42	93.57	0.1451	0.512210	-8.35	-7.73	0.06	Bristol
97R-4, 80-82	1031.30	93.67	0.1467	0.512214	-8.28	-7.68	0.10	Bristol
98R-2, 86-88	1037.36	94.00	0.1481	0.512202	-8.50	-7.91	0.09	Bristol
98R-3, 52-54	1038.52	94.06	0.1628	0.512205	-8.45	-8.05	0.06	Bristol
104R-5, 69-73	1091.69	103.01	0.1363	0.512229	-7.98	-7.19	0.20	Bristol

Table DR3: Sm-Nd isotopic data for Cretaceous fish teeth and bones from ODP Hole 766A (Leg 123)

Sample (core-section, interval [cm])	Depth (mbsf)	Age (Ma)	$^{147}Sm/^{144}Nd$[1]	$^{143}Nd/^{144}Nd$	εNd(0)	εNd(t)	±2σ[2]	Lab[3]
11R-2, 117-119	97.38	72.40		0.512102	-10.47	-9.85	0.12	TAMU
11R-3, 60-62	98.31	72.78		0.512107	-10.35	-9.73	0.12	TAMU
11R-3, 117-119	98.87	73.00	0.1304	0.512133	-9.84	-9.23	0.24	Bristol
11R-4, 79-81	100.00	73.46		0.512087	-10.76	-10.13	0.10	TAMU
11R-5, 33-35	101.04	73.88		0.512099	-10.51	-9.89	0.08	TAMU
11R-5 46-48	101.16	73.93	0.1247	0.512220	-8.15	-7.48	0.18	Bristol
11R-5, 103-105	101.73	74.15	0.1304	0.512142	-9.68	-9.05	0.10	Bristol
11R-6, 40-42	102.61	74.51		0.512103	-10.44	-9.81	0.10	TAMU
11R-7, 21-23	103.92	75.04		0.512099	-10.51	-9.87	0.08	TAMU
12R-1, 119-121	105.50	75.67		0.512098	-10.54	-9.89	0.15	TAMU
12R-2, 10-12	105.91	75.84		0.512098	-10.53	-9.89	0.13	TAMU
13R-1, 87-89	114.78	82.68		0.512228	-7.99	-7.29	0.11	TAMU
13R-1, 103-105	114.93	82.80	0.1293	0.512248	-7.60	-6.89	0.19	Bristol
13R-3, 66-68	117.56	84.90	0.1268	0.512261	-7.36	-6.60	0.14	Bristol
13R-3, 97-99	117.88	85.16		0.512294	-6.71	-5.99		TAMU
14R-1, 28-31	123.88	87.14	0.1241	0.512293	-6.74	-5.93	0.12	Bristol
14R-1, 35-37	123.96	87.16		0.512274	-7.10	-6.36	0.13	TAMU
14R-1, 112-114	124.72	87.67	0.1322	0.512341	-5.79	-5.07	0.40	Bristol
14R-2, 87-89	125.98	88.59		0.512319	-6.22	-5.47	0.07	TAMU
14R-3, 56-58	127.17	89.42		0.512310	-6.39	-5.63	0.05	TAMU
14R-3, 114-117	127.74	89.74	0.1263	0.512318	-6.25	-5.44	0.11	Bristol
14R-4, 36-38	128.46	90.14	0.1283	0.512254	-7.49	-6.71	0.18	Bristol
14R-4, 66-68	128.77	90.31		0.512298	-6.64	-5.87	0.14	TAMU
14R-5, 45-47	130.06	91.02		0.512225	-8.05	-7.28	0.14	TAMU
15R-2, 17-19	134.88	93.81		0.512279	-7.01	-6.21	0.14	TAMU
15R-2, 34-36	135.04	93.93	0.1347	0.512295	-6.69	-5.95	0.14	Bristol
15R-3, 6-8	136.26	94.87	0.1345	0.512275	-7.09	-6.34	0.20	Bristol
15R-3, 67-69	136.88	95.35		0.512228	-8.00	-7.19	0.11	TAMU

15R-4, 97-98	138.67	96.74	0.1301	0.512185	-8.85	-8.03	0.19	Bristol
15R-4, 104-106	138.75	96.80		0.512161	-9.31	-8.48	0.20	UNC-C.H.
15R-5, 34-36	139.55	97.41		0.512171	-9.11	-8.28	0.12	TAMU
15R-5, 136-138	140.56	97.82	0.1375	0.512220	-8.14	-7.41	0.34	Bristol
15R-6, 25-27	140.96	97.93		0.512163	-9.26	-8.43	0.14	TAMU
16R-1, 47-49	143.38	98.61		0.512173	-9.07	-8.24	0.10	TAMU
16R-1, 132-134	144.22	98.85	0.1266	0.512180	-8.94	-8.06	0.11	Bristol
16R-2, 97-99	145.38	99.17		0.512191	-8.72	-7.88	0.34	TAMU
16R-3, 113-115	147.04	99.64		0.512193	-8.67	-7.83	0.17	TAMU
16R-3, 117-119	147.07	99.65	0.1289	0.512198	-8.58	-7.72	0.39	Bristol
16R-4, 29-31	147.70	99.82		0.512180	-8.94	-8.09	0.14	TAMU
16R-5, 42-44	149.32	100.28	0.1287	0.512185	-8.83	-7.96	0.11	Bristol
16R-6, 22-24	150.63	100.65		0.512176	-9.02	-8.17	0.11	TAMU
17R-2, 62-64	154.62	101.77	0.1315	0.512198	-8.58	-7.73	0.14	Bristol
17R-3, 121-123	156.71	102.35	0.1345	0.512199	-8.56	-7.75	0.19	Bristol
17R-5, 93-95	159.43	103.11	0.1333	0.512240	-7.76	-6.92	0.29	Bristol
18R-3, 39-42	165.49	104.80	0.1319	0.512203	-8.48	-7.61	0.14	Bristol
18R-5, 40-42	168.50	105.64	0.1280	0.512179	-8.95	-8.02	0.21	Bristol

Table DR4: Sm-Nd isotopic data for Cretaceous fish teeth and bones from ODP Hole 1149B (Leg 185)

Sample (core-section, interval [cm])	Depth (mbsf)	Age (Ma)	$^{147}Sm/^{144}Nd$ [1]	$^{143}Nd/^{144}Nd$	εNd(0)	εNd(t)	±2σ [2]	Lab [3]
26R-1, 1-3	378.11	133.86	0.1210	0.512307	-6.46	-5.17	0.25	Bristol
26R-1, 29-31	378.39	133.87	0.1217	0.512314	-6.31	-5.03	0.12	Bristol
28R-2, 1-3	398.43	134.69	0.1248	0.512323	-6.15	-4.91	0.15	Bristol

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