GSA Data Repository 2016078

Yamada et al.

Data Repository Material: Centennial-scale East Asian summer monsoon intensity based on $\delta^{18}O$ values in ostracode shells and its relationship to land-ocean air temperature gradients over the last 1700 years

Additional figures：Figures DR1, DR2, DR3, DR4, DR5 and DR6
Additional tables：Tables DR1, DR2, DR3 and DR4
Discussions on a long-term trend in $\delta^{18}O_{ostracode}$ values
References

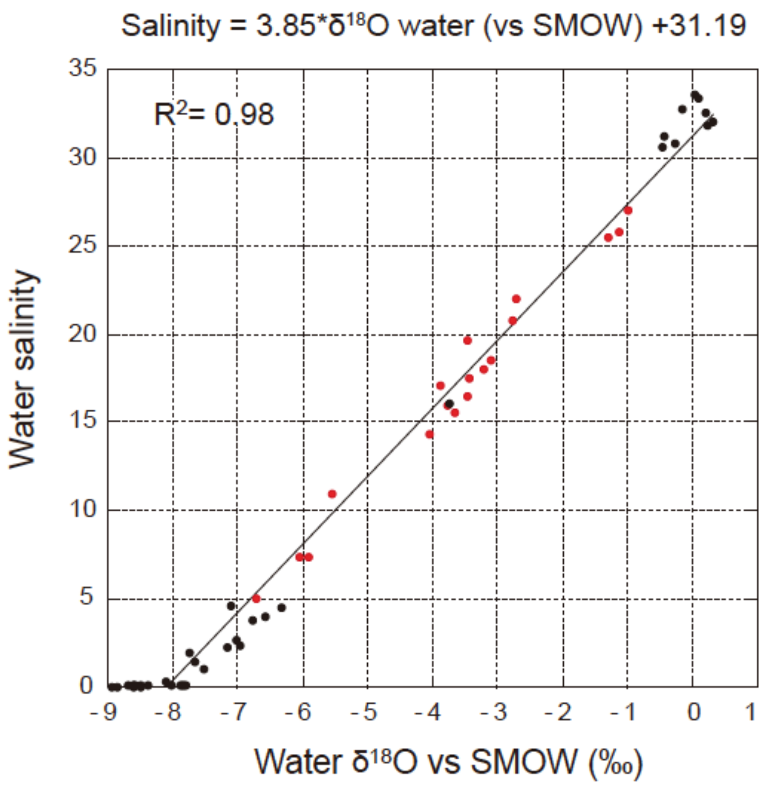


Figure DR1. Plot of surface water $\delta^{18}O$ values and salinity from Lake Nakaumi, Lake Shinji, a river connecting to Lake Shinji and the Sea of Japan. The red circles represent data from Lake Nakaumi.

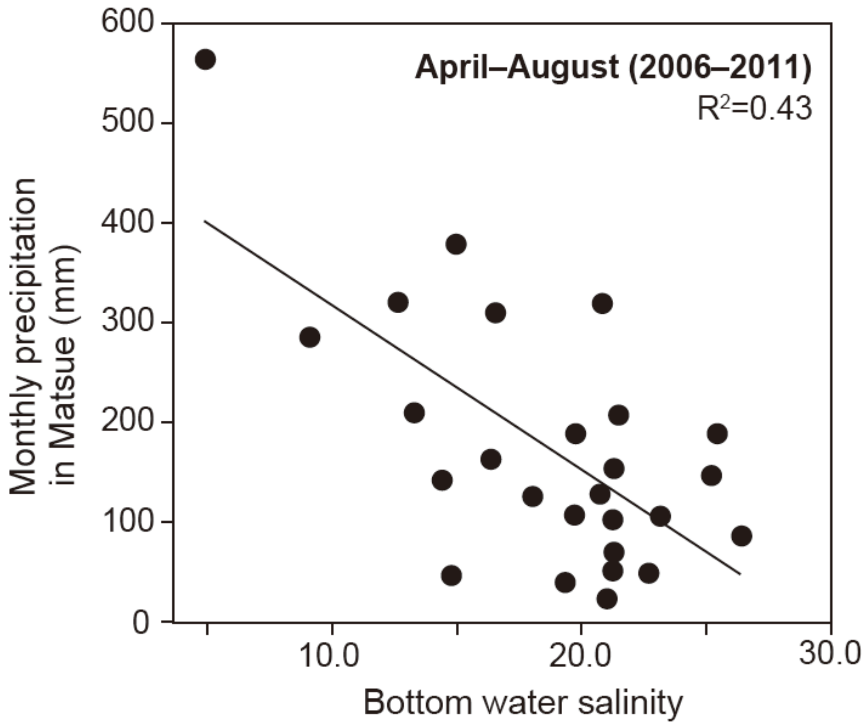


Figure DR2. Plot of summer monthly precipitation (mm) in the city of Matsue and bottom-water salinity in Lake Nakaumi. The precipitation data were obtained from the Japan Meteorological Agency website (http://www.data.jma.go.jp/obd/stats/etrn/view/monthly_s3.php?prec_no=68&block_no=47741&year=&month=&day=&elm=monthly&view=a13). Salinity was measured monthly in the central portion of Lake Nakaumi between April and August 2006–2011. The salinity measurement accuracy is 0.01.

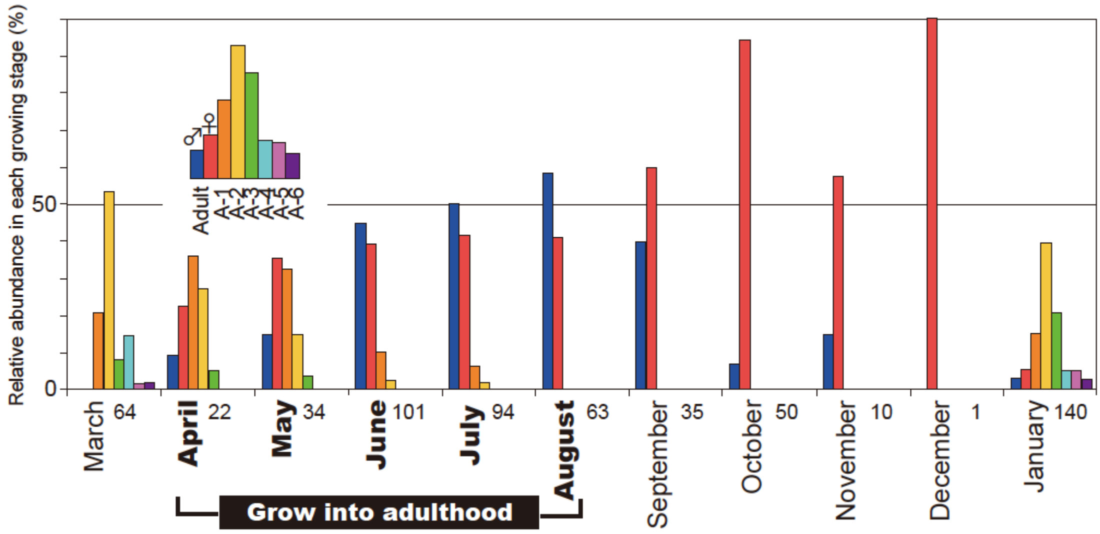


Figure DR3. *Bicornucythere bisanensis* population dynamics in Lake Nakaumi. A-1 indicates juveniles that reached adulthood after molting. All *B. bisanensis* carapaces with soft parts were collected from dredged bottom-surface sediments sampled monthly from the eastern portion of Nakaumi (35°29′ 47″ N, 133°12′ 00″ E) between March 2005 and January 2006. The numbers to the right of the month indicate the collected ostracode individuals. Adult specimens were not observed in March, and the variations in the adult specimen population throughout the year suggest that individuals grow into adulthood between April and August. This interval is consistent with the *B. bisanensis* population dynamics in Aburatsubo Cove, Japan (Abe, 1983).

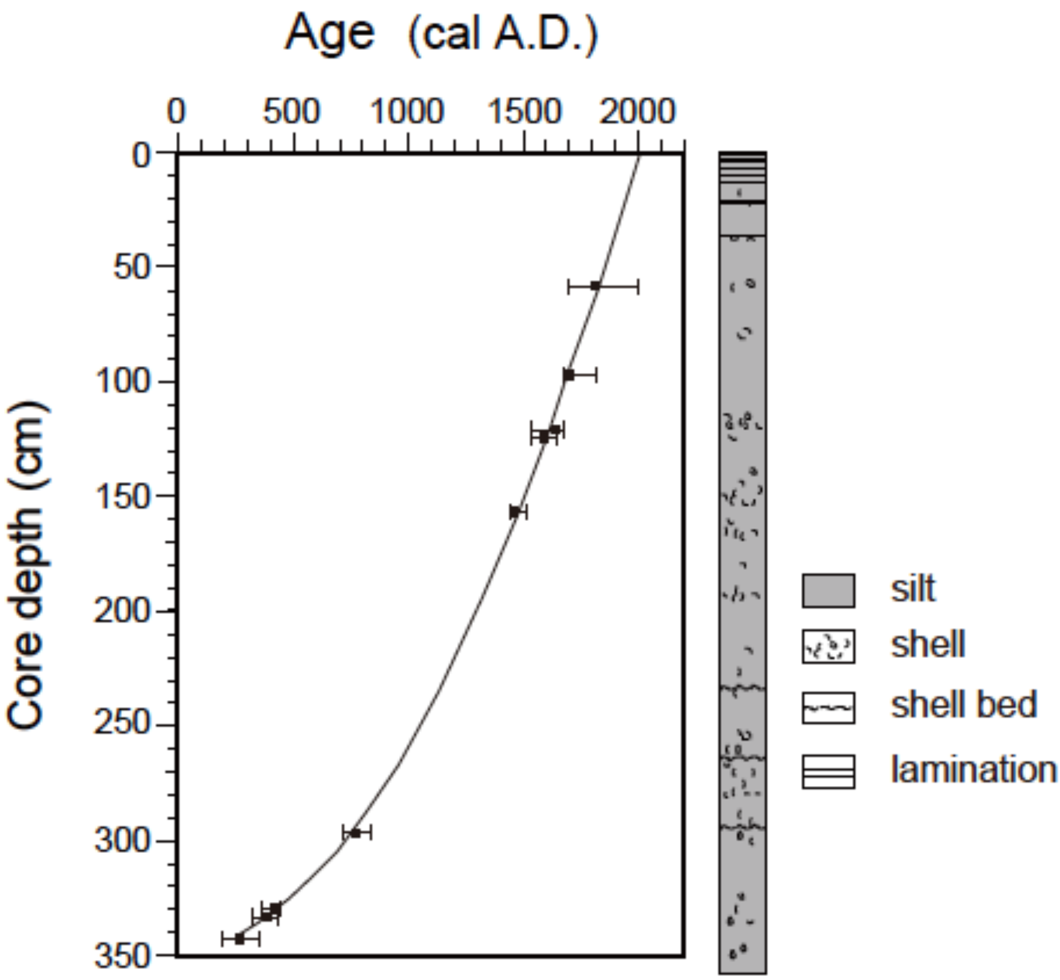
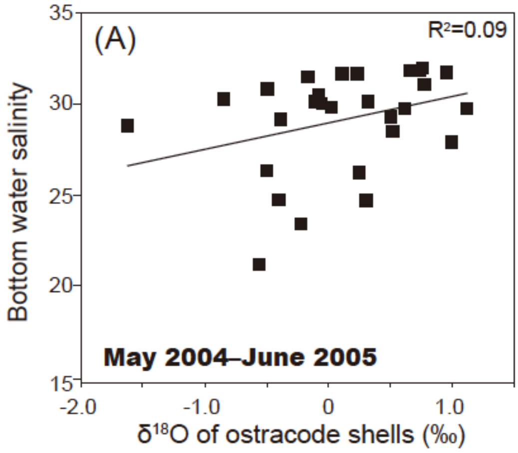


Figure DR4. Age model updated with seven additional ^{14}C data and a columnar section of the X core collected from the central portion of Lake Nakaumi. The regional reservoir age around the study area was calculated to be -27 years (close to 0) based on the mean of eight regional marine reservoir ages (between 345 and -128 years) in the Sea of Japan (Yoneda et al., 2000; Kuzmin et al., 2001; Kong and Lee, 2005). Thus, the 400-year average marine reservoir age was subtracted from each ^{14}C age.



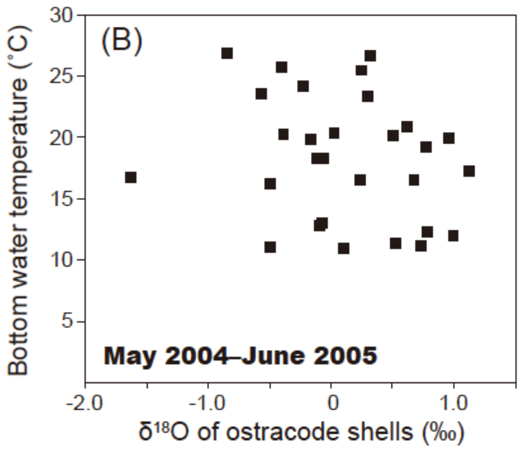
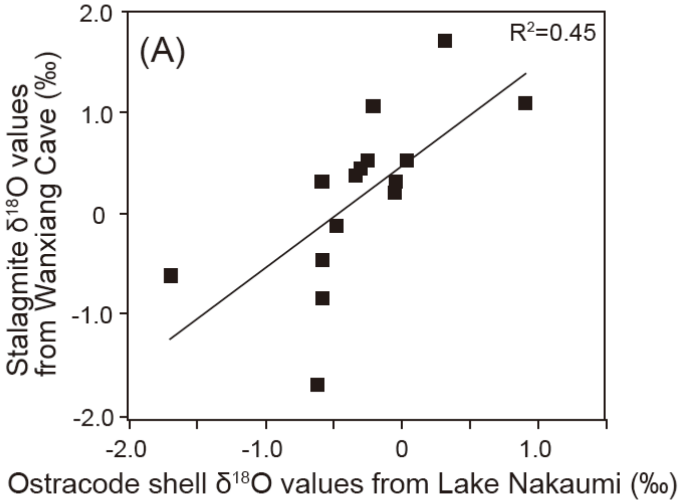


Figure DR5. Plots of $\delta^{18}O_{ostracode}$ values vs. bottom-water salinity (A) and bottom-water temperature (B) in Lake Nakaumi for May 2004 and June 2005.



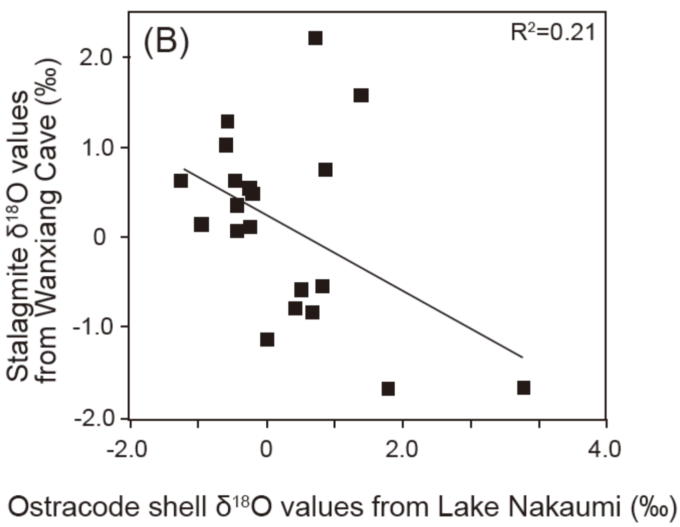


Figure DR6. Plots of 50-yr moving averages for ostracode shell $\delta^{18}O$ values from Lake Nakaumi vs. stalagmite $\delta^{18}O$ values from Wanxiang Cave between 1100 and 1700 AD (A), 300 and 1100 AD and since 1700 AD (B).

Table DR1. Ostracode *Bicornucythere bisanensis* occurrences from March 2005 to January 2006 in Lake Nakaumi.

Age / Date	March 11, 2005	April 11, 2005	May 12, 2005	June 10, 2005	July 14, 2005	August 8, 2005	September 9, 2005	October 13, 2005	November 10, 2005	December 20, 2005	January 16, 2006
Male (Adult)		2	5	47	47	37	14	3	2		5
Female (Adult)		5	12	40	39	26	21	47	8	1	9
A-1	14	8	11	11	6						22
A-2	34	6	5	3	2						55
A-3	5	1	1								29
A-4	9										8
A-5	1										8
A-6	1										4
Total number of specimens	64	22	34	101	94	63	35	50	10	1	140

Table DR2. AMS ^{14}C data from the X core. The two samples marked with an asterisk at the end of the sample number are from Yamada et al. (2015).

Sample No.	Labo ID	Core depth (cm)	Materials	measured radiocarbon age (y BP)	$\delta^{13}C$ (‰)	Conventional radiocarbon age (y BP)	Calibrated age (2σ) (Cal AD)
X-058B	Beta-386123	58	shell	140±30	-2.0	520±30	1815 (1700–1895 and 1940–post 1950)
X-097B	Beta-386124	97	shell	190±30	-1.9	570±30	1705 (1675–1820)
X-121B	Beta-386125	121	shell	300±30	-1.4	690±30	1640 (1535–1675)
X-M-24*	Beta-189760	124	shell	330±40	-1.0	720±40	1590 (1530–1650)
X-157B	Beta-386126	157	shell	480±30	-2.2	850±30	1465 (1440–1505)
X-296B	Beta-386127	296	shell	1310±30	-6.9	1610±30	775 (705–835)
X-M-56*	Beta-184671	330	shell	1610±40	-1.7	1990±40	420 (360–440)
X-333B	Beta-386128	333	shell	1640±30	-2.5	2010±30	390 (320–435)
X-343B	Beta-386129	343	shell	1710±30	-1.4	2100±30	265 (195–350)

* after Yamada et al. (2015)

Table DR3. Ostracode *Bicornucythere bisanensis* shell $\delta^{13}C$ and $\delta^{18}O$ values from the X core. The term "av" to the right of the sample number indicates that the $\delta^{13}C$ and $\delta^{18}O$ values were averaged among several measurements. The salinity was calculated based on the equation that describes the relationship between bottom-water salinity and *B. bisanensis* $\delta^{18}O$ values in Figure DR5.

Median core depth (cm)	Age (cal. AD)	Sample No.	No. of individuals	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	Calculated salinity
0.5	1971	X-01B	1	-4.93	-1.48	26.8
10.5	1953	X-11B	1	-5.51	-0.87	27.8
13.5	1947	X-14B av	4	-4.70	-0.98	27.6
17.5	1938	X-18B	1	-5.56	-0.76	27.9
18.5	1936	X-19B av	6	-4.91	-0.17	28.9
19.5	1934	X-20B av	5	-4.97	-0.90	27.7
20.5	1932	X-21B	1	-6.08	-1.15	27.3
22.5	1928	X-23B av	5	-4.87	-0.92	27.7
27.5	1917	X-28B	1	-5.57	-1.67	26.5
28.5	1914	X-29B	1	-5.06	-0.99	27.6
35.5	1898	X-36B	2	-6.11	-1.47	26.8
39.5	1888	X-40B	4	-5.55	-1.07	27.5
41.5	1883	X-42B	2	-6.02	-0.16	28.9
43.5	1878	X-44B	1	-5.82	-0.56	28.3
46.5	1871	X-47B av	4	-5.88	-2.94	24.5
51.5	1857	X-52B av	3	-5.60	-1.13	27.4
53.5	1852	X-54B	1	-5.44	0.01	29.2
56.5	1844	X-57B av	4	-5.70	-1.45	26.9
59.5	1835	X-60B av	5	-5.20	-1.12	27.4
61.5	1830	X-62B	4	-5.38	-0.88	27.8
64.5	1821	X-65B	1	-4.56	-2.01	26.0
68.5	1809	X-69B av	5	-5.57	-1.24	27.2
73.5	1794	X-74B	2	-4.33	-1.15	27.3
76.5	1785	X-77B	4	-5.94	-2.03	26.0
78.5	1779	X-79B av	4	-4.86	-1.25	27.2
81.5	1769	X-82B	4	-6.21	-1.33	27.1
84.5	1759	X-85B av	6	-4.94	-1.09	27.4
88.5	1746	X-89B av	5	-4.67	-1.04	27.5
93.5	1729	X-94B	1	-4.30	-1.22	27.2
98.5	1712	X-99B av	6	-5.65	-0.91	27.7
104.5	1691	X-105B	7	-6.51	-1.65	26.6
108.5	1676	X-109B	2	-5.14	-1.41	26.9
111.5	1665	X-112B av	9	-4.97	-1.44	26.9
113.5	1657	X-114B av	6	-5.58	-0.86	27.8
116.5	1646	X-117B av	6	-5.07	-1.28	27.1
118.5	1638	X-119B av	5	-5.11	-1.13	27.4
121.5	1627	X-122B	8	-5.63	-1.20	27.3
123.5	1619	X-124B av	5	-5.72	-1.01	27.6
126.5	1607	X-127B	7	-6.33	-1.06	27.5
128.5	1599	X-129B av	6	-4.99	-1.28	27.1
131.5	1587	X-132B	7	-6.09	-1.54	26.7
133.5	1578	X-134B av	6	-5.54	-1.13	27.4
137.5	1562	X-138B av	6	-5.33	-1.45	26.9
141.5	1545	X-142B	8	-6.03	-1.45	26.9
143.5	1536	X-144B av	6	-5.28	-1.59	26.6
146.5	1523	X-147B	3	-5.78	-1.86	26.2
148.5	1515	X-149B av	7	-5.39	-1.03	27.5
151.5	1501	X-152B	8	-5.05	-0.02	29.1
153.5	1492	X-154B av	8	-5.99	-1.39	27.0
157.5	1474	X-158B av	6	-5.09	-0.88	27.8
161.5	1456	X-162B	4	-5.42	-2.22	25.7
163.5	1447	X-164B av	6	-4.80	-1.15	27.3
171.5	1409	X-172B	5	-5.71	-0.86	27.8
174.5	1395	X-175B	5	-5.40	-1.18	27.3
176.5	1385	X-177B	6	-5.31	-1.18	27.3
178.5	1375	X-179B av	4	-5.06	-0.59	28.2
183.5	1350	X-184B av	6	-5.48	-1.30	27.1
188.5	1325	X-189B av	6	-5.88	-1.29	27.1
193.5	1299	X-194B av	6	-5.07	-0.84	27.8
199.5	1268	X-200B	1	-6.14	-1.68	26.5
209.5	1214	X-210B	1	-4.66	-2.03	26.0
213.5	1192	X-214B	1	-5.51	-0.93	27.7
214.5	1187	X-215B	1	-5.53	-1.08	27.5
216.5	1176	X-217B av	7	-4.63	-0.93	27.7
219.5	1159	X-220B av	6	-5.58	-1.01	27.6
223.5	1136	X-224B av	5	-6.00	-0.96	27.6
227.5	1113	X-228B av	6	-5.46	-1.12	27.4
229.5	1101	X-230B	4	-5.46	-0.91	27.7
233.5	1078	X-234B av	7	-5.19	-0.60	28.2
238.5	1048	X-239B	1	-4.83	-1.32	27.1
239.5	1042	X-240B	8	-5.33	-0.59	28.2
243.5	1018	X-244B av	3	-4.64	-0.75	28.0
249.5	982	X-250B av	4	-4.82	0.21	29.5
253.5	957	X-254B	1	-5.03	0.56	30.0
256.5	938	X-257B av	8	-5.82	-0.28	28.7
258.5	926	X-259B av	5	-5.41	-0.21	28.8
261.5	906	X-262B av	8	-5.46	-0.56	28.3
263.5	894	X-264B av	6	-5.49	-0.71	28.0
266.5	874	X-267B av	6	-4.86	-0.32	28.6
268.5	861	X-269B av	7	-5.49	-0.33	28.6
269.5	855	X-270B av	5	-5.89	-0.60	28.2
271.5	842	X-272B	8	-5.07	0.03	29.2
273.5	829	X-274B	1	-5.80	-1.02	27.6
274.5	822	X-275B	3	-5.58	-0.57	28.2
276.5	809	X-277B	8	-4.96	-0.87	27.8
278.5	796	X-279B	2	-4.13	-1.63	26.6
279.5	789	X-280B av	6	-5.36	-0.23	28.8
281.5	775	X-282B	7	-5.29	-0.56	28.3
283.5	762	X-284B av	4	-6.04	-0.91	27.7
286.5	742	X-287B av	7	-4.87	-0.27	28.7
288.5	728	X-289B av	6	-5.39	-0.45	28.4
291.5	707	X-292B	8	-5.54	-0.58	28.2
293.5	693	X-294B	1	-4.10	-1.35	27.0
294.5	686	X-295B av	6	-4.47	-0.43	28.5
296.5	672	X-297B	7	-4.84	-0.52	28.3
299.5	651	X-300B av	4	-5.68	-0.88	27.8
303.5	623	X-304B av	6	-4.70	-0.31	28.7
306.5	602	X-307B	6	-4.57	-0.33	28.6
308.5	587	X-309B av	7	-5.32	-0.28	28.7
311.5	566	X-312B	8	-4.91	0.39	29.7
313.5	551	X-314B av	8	-5.20	-0.01	29.1
315.5	536	X-316B	8	-5.32	-0.37	28.6
318.5	514	X-319B av	6	-5.47	-0.27	28.7
323.5	477	X-324B av	8	-5.74	-0.41	28.5
326.5	455	X-327B	8	-4.94	-0.41	28.5
328.5	440	X-329B av	6	-4.59	-0.37	28.6
331.5	417	X-332B	8	-5.45	-0.14	28.9
333.5	402	X-334B	2	-5.87	-0.67	28.1
336.5	379	X-337B	8	-4.99	-0.15	28.9
338.5	363	X-339B av	6	-5.40	-0.44	28.5
341.5	340	X-342B	8	-5.01	-0.36	28.6
343.5	324	X-344B	1	-5.00	0.42	29.8
345.5	309	X-346B av	7	-5.54	-0.20	28.8

Table DR4. *Bicornucythere bisanensis* shell δ^{13}C and δ^{18}O values from the bottom-surface sediments in Lake Nakaumi. Both the bottom-water salinity and temperature at the time of sample collection are also listed.

Sample no.	Sampling month and year	No. of individuals	δ^{13}C of *Bicornucythere bisanensis* VPDB (‰)	δ^{18}O of *Bicornucythere bisanensis* VPDB (‰)	Bottom water salinity	Bottom water temperature (°C)
OI-8	May 2004	12	-4.09	-0.05	30.07	18.23
OI-31	May 2004	3	-5.10	-0.12	30.07	18.33
OI-32	May 2004	4	-5.11	-0.28	30.07	18.23
OI-6	June 2004	3	-4.78	-0.14	29.84	20.85
OI-7	June 2004	2	-4.13	0.60	29.84	20.85
OI-33	June 2004	4	-4.81	0.62	29.84	20.85
OI-36	August 2004	4	-5.44	-0.84	30.32	26.80
OI-37	August 2004	3	-4.91	0.31	30.17	26.63
OI-38	September 2004	3	-4.22	0.24	26.38	25.49
OI-39	September 2004	4	-4.93	0.01	24.90	25.66
OI-40	October 2004	4	-4.38	-0.44	23.58	24.19
OI-41	October 2004	2	-5.34	0.30	24.93	23.32
OI-42	October 2004	3	-4.51	-0.57	21.34	23.48
OI-43	November 2004	4	-5.13	0.45	29.44	20.15
OI-44	November 2004	4	-4.44	-0.10	29.89	20.36
OI-45	November 2004	2	-4.57	-0.39	29.31	20.27
OI-46	December 2004	4	-4.69	-1.63	28.92	16.70
OI-47	December 2004	2	-4.28	1.12	29.87	17.20
OI-48	December 2004	2	-4.54	-0.50	26.50	16.22
OI-49	January 2005	3	-4.22	0.52	28.64	11.36
OI-50	January 2005	2	-4.41	-0.10	30.27	12.81
OI-51	January 2005	2	-4.01	1.00	28.11	12.01
OI-52	February 2005	3	-4.97	0.10	31.79	11.03
OI-53	March 2005	2	-4.91	-0.49	30.94	11.07
OI-54	March 2005	2	-5.11	0.73	31.87	11.16
OI-55	April 2005	3	-5.27	-0.08	30.56	12.95
OI-56	April 2005	3	-5.14	0.77	31.23	12.26
OI-57	May 2005	3	-4.69	0.24	31.84	16.52
OI-58	May 2005	3	-4.88	0.67	31.91	16.47
OI-59	June 2005	3	-4.69	0.95	31.81	19.86
OI-60	June 2005	3	-5.62	0.77	31.99	19.24
OI-61	June 2005	2	-4.69	-0.17	31.51	19.80

Discussions on a long-term trend in δ^{18}O$_{ostracode}$ values

Overall, a long-term decrease in δ^{18}O$_{ostracode}$ values (from 0 to -1.5‰, equivalent to a salinity decrease from ca. 30 to 27) was observed for 300–1200 A.D. (Fig. 2). Subsequently, the δ^{18}O$_{ostracode}$ values stabilized (with a corresponding salinity of 27–28) between 1200 and 1900 A.D. A period with an environmental shift from an inner bay to brackish lake was previously identified for the ostracode assemblage (Yamada et al., 2015), and the Lake Nakaumi shift coincides with the interval where salinity stabilized at 1200 A.D. This consistency suggests that the long-term δ^{18}O$_{ostracode}$

decreases occurred because of the salinity decreases associated with regional factors, such as sand bar expansion at the Lake Nakaumi entrance.

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