Episodic coral growth in China's subtropical coral communities linked to broad scale climatic change

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SUPPLEMENTARY INFORMATION

METHODS

Our study was conducted on the protected leeward sides of Xiaolajia and Dalajia Islands (Daya Bay), Zhouzaitou Island (Daao Bay), and Sanmen Island, China, in October 2015 (Fig. 1; Table DR1). Although these islands lie below the Tropic of Cancer at 23.5˚N, which typically delineates the tropics from the subtropics, this region is considered subtropical as defined by Belda et al., (2014). According to the Trewartha climate classification, a subtropical region should have 8/12 months with mean air temperature over 10 °C and the temperature of the coolest month must be lower than 18 °C (Belda et al., 2014). For Daya Bay, annual mean air temperature is 22 °C, with minimum and maximum mean monthly temperatures of 15 °C (Jan-Feb) and 28 °C (Jul-Aug), respectively (Wang et al., 2008). Moreover, the average temperature of tropical waters typically exceeds 20 °C. Prior to the start of the 21st century, annual average sea surface temperatures (SSTs) were below 20 °C (Yu et al., 2010) – typical of subtropical waters. Yet since instrumental monitoring of Daya Bay began, SSTs have been increasing steadily – believed to be a result of global warming and the establishment of the Daya Bay Nuclear Power

Station. Between A.D. 1985 and 2005, sea-surface temperatures (SSTs) in Daya Bay rose steadily from an annual average of ~18 °C (A.D. 1988) to ~21 °C (A.D. 2005) at a rate of 0.07 °C yr^{-1} (Yu et al., 2010). Since A.D. 2005, annual mean SSTs similarly derived from nighttime satellite data at 4 km resolution from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite approximate 24 °C, with minimum and maximum monthly mean temperatures of ~15 °C and ~30 °C, respectively (Fig. 2A; Fig. DR1). Corals can be found in non-accreting, patchily distributed communities growing on basement rock and sand (Chen et al., 2009). Dead corals were collected haphazardly by hand on SCUBA at the sediment-water interface along a gradient of increasing depth (between 1.3 and 5.8 m depth relative to mean sea level [MSL]) at each site where present (Table DR1). Following collections, coral death assemblage samples were dried and photographed at the Guangzhou Institute of Geochemistry (China) where a small subsample from each colony (5 cm^3), cut using a diamond blade saw, was shipped to the Radiogenic Isotope Facility, The University of Queensland (Australia) for sample preparation and U-Th dating. To determine the age of each dead coral colony, ~1 g of skeletal material was removed from each subsample, crushed to ~1 mm grain size using an agate mortar and pestle and rigorously cleaned following methods described by Clark et al. (2014a) to remove organics. Samples were then inspected under an optical microscope to remove altered material and other contaminants. Following careful vetting, an aliquot of ~150 mg from each sample was digested using 15.8N double quartz distilled HNO_3 in a pre-cleaned Teflon beaker along with ~30 mg of a ^{229}Th-^{233}U mixed tracer solution. Once the sample had completely dissolved, several drops of H_2O_2 were added to the solution to remove organics and the beaker tightly capped and left on a hotplate overnight at 120°C to allow for complete sample-tracer mixing. Samples were then uncapped and allowed to come to incipient dryness before re-dissolving in 2 ml of 7N HNO_3. Each sample was then passed through conventional anion exchange columns to remove matrix material and separate U and Th (Clark et al. 2014a; Clark et al. 2014b). Following chemistry procedures, the concentration of U and Th in the eluent for each sample was then screened on a Thermo X-series II ICP-MS. The concentration of U and Th in the final U-Th-mixed solution to be measured on the Nu I MC ICP-MS was then determined according to the screening results and the instrument's current sensitivity following tuning. Final solutions with U concentrations aiming for 4-7 V ^{238}U intensity on the

Faraday detector were targeted. Samples were measured in dynamic mode according to Clark et al. (2014b). Raw data was exported to Excel with Isoplot Ex 3.75 add-in (Ludwig, 2012) for age determination following correction of instrumental drift, mass bias fractionation and blank extraction. All U-Th data was corrected for locally derived detrital and hydrogenous sources of ^{230}Th using a two-component mixing model derived by Clark et al. (2014a).

RESULTS

A total of 92 ^{230}Th ages were obtained from the death assemblages collected in and around Daya Bay (Table DR2). Uranium concentrations and δ^{238}U values average 3.1 ± 0.4 ppm (ranging from 2.3 to 3.6 ppm) and 145.3 ± 1.8 (ranging from 141.7 to 152.6), respectively, falling within modern coral and seawater values (e.g. Clark et al., 2014b). Despite rigorous cleaning, ^{232}Th concentrations average 31 ± 22 ppb (ranging from 0.4 to 99.8 ppb), suggesting substantial detrital ^{230}Th contamination from terrigenous sources. Three ^{230}Th /^{232}Th versus ^{238}U/^{232}Th isochrons of coeval material taken from corals ZZT.S1.2.3, DLJ.S2.2.2 and DLJ.S2.2.3 revealed a weighted average detrital ^{230}Th/^{232}Th value of 0.49 ± 0.12 (24%) (MSWD = 20, p = <0.005) (Fig. DR3). A weighted average hydrogenous ^{230}Th/^{232}Th value (weighted by assigned errors and constant external error) of 2.08 ± 0.05 (23%) and ^{232}Th value of 0.35 ± 0.03 ppb (7.6%) was obtained from two live collected branching *Acropora* spp. corals. Following initial ^{230}Th/^{232}Th correction using the locally determined detrital and hydrogenous values, coral ages range from 4.8 to 6,918 years with two-sigma age errors ranging between 2 and 115 years. Rather than being normally distributed, a relative probability plot of the ^{230}Th data reveal a bi-modal age distribution centered around two time periods at 5.8 ± 0.4 (6.1%, n=22, MSWD = 0.083, age range 6.85 ± 0.04 to 5.51 ± 0.02) and -0.02 ± 0.01 (-30%, n=64, MSWD = 179, age range 0.11 ± 0.12 to -0.052 ± 0.069) ka BP (before present, where present is defined as 1950 AD). Major coral genera included *Acropora, Favia, Favites, Pavona, Platygyra, Cyphastrea*, and *Porites*, with extensive amounts of external abrasion and bioerosion making it difficult for coral identification not only to species level, but to genera in some instances. Counterintuitively, older samples did not always suffer from a greater degree of alteration, with some specimens exhibiting excellent preservation (Fig. DR2).

Supplementary Table DR1. Site locations and description of death assemblage samples collected in 2015 from Sanmen, Dalajia, Xiaolajia and Zhouzaitou Islands, China.

Location	Time and Date	Site	Latitude (N)	Longitude (E)	Death assemblage sample code	Collection depth (m)[1]	Tide height at time of collection (mLAT)[2]	Collection depth relative to LAT (m)[3]	Collection depth relative to present MSL (m)[4]
Sanmen (Ghost Bay)	10:18-11:00; 14 October	1	22°27.1544	114°38.4988	SAN-S1.1	-3.4	1.9-2.0 m	-1.4-1.5	-2.8-2.9
					SAN-S1.2				
					SAN-S1.3				
					SAN-S1.4				
					SAN-S1.5				
					SAN-S1.6				
Dalajia (Shuazhou)	12:50; 14 October	1	22°34.62529	114°38.18048	SHZ-S1.1	-1.5	1.6 m	+0.1	-1.276
					SHZ-S1.1				
					SHZ-S1.1				
					SHZ-S1.1				
					SHZ-S1.1				
					SHZ-S1.1				
Dalajia	13:52; 15 October	2	22°35.07680	114°38.00440	DLJ-S2.1	-3.5	1.5	-2.0	-3.376
					DLJ-S2.2				
Xiaolajia	11:21-12:30; 15 October	1	22°36.93520	114°37.83060	XLJ-S1.1	-3.5	1.85-1.9	-1.6-1.65	-2.976-3.026
					XLJ-S1.2	-4		-2.1-2.15	-3.476-3.526
					XLJ-S1.3	-4		-2.1-2.15	-3.476-3.526
					XLJ-S1.4	-5.5		-3.6-3.65	-4.976-5.026
Xiaolajia	12:44-13:08; 15 October	2	22°36.74391	114°37.67233	XLJ-S2.1	-5.5	1.8	-3.7	-5.076
Zhouzaitou	10:52; 16 October	1	22°33.6	114°27.65	ZZT-S1.1	-2	1.6	-0.4	-1.776
					ZZT-S1.2	-3		-1.4	-2.776
					ZZT-S1.3	-4.5		-2.9	-4.276
					ZZT-S1.4	-6		-4.4	-5.776
					ZZT-S1.5	-3.5		-1.9	-3.276

[1]Water depth at time of collection taken using a dive computer
[2]Tide height at time of collection reported at Quarry Bay, Hong Kong, in 2015 (Source: Hong Kong Observatory)
[3]Depth relative to lowest astronomical tide (LAT)/chart datum (1.376 m below mean sea level) at Quarry Bay, Hong Kong (Source: Hong Kong Observatory)
[4]Depth relative to mean sea level (1.376 mLAT) at Quarry Bay, Hong Kong (Source: Hong Kong Observatory)

Supplementary Table DR2. MC ICP-MS ^{230}Th age data for 92 death assemblage samples collected from Daya Bay and surrounding islands.

Sample Name	Morpho -logy	Family or genus	Sample wt.(g)	U (ppm)	^{232}Th (ppb)	(^{230}Th/ ^{232}Th)	(^{230}Th/^{238}U)	corr. δ^{238}U[1]	uncorr. ^{230}Th Age (ka)	Date of chemistry	Corr. Year (BC/AD)[2]	Corr. Year (BP)[3]	±2s
Dalajia													
DLJ-S2.1.1a	M	*Faviid*	0.154	2.5637 ± 0.0018	49.591 ± 0.086	1.7128 ± 0.0074	0.010919 ± 0.000044	144.9 ± 1.2	1.0453 ± 0.0044	2017.4	1277	673	73
DLJ-S2.1.1b	M	*Faviid*	0.15996	3.5401 ± 0.0014	63.28 ± 0.17	0.6561 ± 0.0043	0.003865 ± 0.000023	147.4 ± 1.2	0.3680 ± 0.0023	2017.4	1929	21	67
DLJ-S2.2.2	B	*Acropora*	0.12285	3.0974 ± 0.0006	25.913 ± 0.069	3.643 ± 0.029	0.010045 ± 0.000075	148.3 ± 1.0	0.9580 ± 0.0072	2017.4	1193	757	33
DLJ-S2.2.1	B	*Acropora*	0.03227	3.3657 ± 0.0010	98.10 ± 0.10	0.697 ± 0.013	0.00669 ± 0.00012	153.4 ± 1.0	0.635 ± 0.012	2017.4	1834	116	110
DLJ-S2.2.3	B	*Acropora*	0.15476	3.2795 ± 0.0016	37.544 ± 0.087	0.7633 ± 0.0077	0.002880 ± 0.000028	145.6 ± 1.0	0.2745 ± 0.0027	2017.4	1924	26	44
DLJ S2 1.2	M	*Faviid*	0.10242	3.4601 ± 0.0014	16.669 ± 0.013	1.173 ± 0.014	0.001862 ± 0.000022	144.7 ± 1.0	0.1775 ± 0.0021	2018.17	1920	30	19
DLJ S2 2.1	B	*Acropora*	0.10366	3.3524 ± 0.0011	35.351 ± 0.019	0.8527 ± 0.0091	0.002964 ± 0.000032	144.9 ± 1.0	0.2827 ± 0.0030	2018.17	1903	47	40
Sanmen													
SAN-S1-2-2	B	*Acropora*	0.15366	3.2724 ± 0.0018	9.616 ± 0.023	0.698 ± 0.014	0.000676 ± 0.000013	146.1 ± 1.0	0.0644 ± 0.0013	2017.4	2003	-53	12
SAN-S1-2-3	B	*Acropora*	0.1555	3.1902 ± 0.0013	13.419 ± 0.019	0.6904 ± 0.0099	0.000957 ± 0.000014	147.6 ± 1.0	0.0910 ± 0.0013	2017.4	1996	-46	17
SAN-S1-6-2	M	*Porites*	0.16398	3.5345 ± 0.0014	75.230 ± 0.123	0.6090 ± 0.0047	0.004272 ± 0.000032	144.0 ± 1.3	0.4081 ± 0.0031	2017.4	1942	7.6	80
SAN S1 1.1	M	*Favites*	0.10317	2.64265 ± 0.00079	10.427 ± 0.011	0.782 ± 0.012	0.001017 ± 0.000015	145.4 ± 0.9	0.0969 ± 0.0015	2018.17	1989	-39	16
SAN S1 1.2	B	*Acropora*	0.11058	3.2402 ± 0.0015	15.799 ± 0.023	0.743 ± 0.014	0.001194 ± 0.000023	143.7 ± 0.7	0.1139 ± 0.0022	2018.17	1985	-35	20
SAN S1 2.2	M	*?*	0.08585	3.4231 ± 0.0012	99.809 ± 0.097	0.5996 ± 0.0042	0.005762 ± 0.000040	144.2 ± 1.4	0.5508 ± 0.0039	2018.17	1922	28	110
SAN S1 2.3	B	*Acropora*	0.10241	3.5547 ± 0.0013	6.0333 ± 0.0048	102.73 ± 0.28	0.05746 ± 0.00015	144.5 ± 0.9	5.612 ± 0.016	2018.17	-3563	5513	18
SAN S1 2.4	B	*Acropora*	0.10487	3.3547 ± 0.0010	6.8907 ± 0.0057	87.57 ± 0.21	0.05928 ± 0.00014	144.7 ± 0.9	5.793 ± 0.015	2018.17	-3738	5688	17
SAN S1 3.1	M	*Favites*	0.10157	2.8035 ± 0.0012	8.5737 ± 0.0081	0.740 ± 0.021	0.000746 ± 0.000021	145.9 ± 0.9	0.0710 ± 0.0020	2018.17	2000	-50	13
SAN S1 3.2	B	*Acropora*	0.1014	3.5281 ± 0.0012	29.405 ± 0.063	0.6233 ± 0.0094	0.001712 ± 0.000025	145.4 ± 0.8	0.1632 ± 0.0024	2018.17	1988	-38	32
SAN S1 3.3	M	*Faviid*	0.10621	3.0208 ± 0.0010	6.7150 ± 0.0069	80.69 ± 0.26	0.05912 ± 0.00018	142.2 ± 1.1	5.789 ± 0.019	2018.17	-3731	5681	21
SAN S1 3.4	B	*Acropora*	0.09936	3.5452 ± 0.0013	28.877 ± 0.053	23.612 ± 0.067	0.06339 ± 0.00014	144.5 ± 0.9	6.207 ± 0.015	2018.17	-4059	6009	34
SAN S1 4.1	M	*Faviid*	0.11084	2.86321 ± 0.00087	13.098 ± 0.016	41.062 ± 0.099	0.06191 ± 0.00013	143.9 ± 1.0	6.062 ± 0.014	2018.17	-3967	5917	23
SAN S1 4.2	M	*Pavona*	0.10906	3.30671 ± 0.00074	3.139 ± 0.010	187.56 ± 0.73	0.05867 ± 0.00014	144.0 ± 1.0	5.736 ± 0.015	2018.17	-3698	5648	16
SAN S1 4.3	M	*Platygyra*	0.10098	2.5818 ± 0.0010	11.527 ± 0.012	0.868 ± 0.020	0.001277 ± 0.000030	145.5 ± 1.1	0.1216 ± 0.0028	2018.17	1972	-22	19
SAN S1 5.1	B	*Acropora*	0.09198	3.4592 ± 0.0018	51.550 ± 0.071	12.846 ± 0.041	0.06309 ± 0.00018	142.1 ± 1.1	6.192 ± 0.020	2018.17	-3939	5889	59
SAN S1 5.2	M	*Porites*	0.06249	2.8637 ± 0.0012	34.337 ± 0.029	16.006 ± 0.052	0.06325 ± 0.00020	144.5 ± 1.1	6.194 ± 0.021	2018.17	-3986	5936	50
SAN S1 6.1	M	*Porites*	0.03025	3.48471 ± 0.00085	26.422 ± 0.026	0.675 ± 0.016	0.001687 ± 0.000040	146.0 ± 1.2	0.1607 ± 0.0038	2018.17	1979	-29	30
SAN-S1-Z?-1	B	*Acropora*	0.16159	3.2191 ± 0.0045	40.593 ± 0.092	14.944 ± 0.056	0.06211 ± 0.00020	147.3 ± 1.5	6.063 ± 0.022	2017.4	-3847	5797	52
SAN-S1-2-1	B	*Acropora*	0.15344	3.5965 ± 0.0043	39.711 ± 0.062	19.666 ± 0.051	0.07157 ± 0.00017	141.9 ± 1.3	7.050 ± 0.020	2017.4	-4858	6808	46
SAN-S1-2-1	M	*?*	0.02651	3.5358 ± 0.0043	38.864 ± 0.068	17.50 ± 0.11	0.06341 ± 0.00040	146.3 ± 1.7	6.200 ± 0.041	2017.4	-4009	5959	59
SAN-S1-4-4	B	*Acropora*	0.03311	3.3915 ± 0.0028	19.868 ± 0.028	30.62 ± 0.14	0.05912 ± 0.00027	148.4 ± 1.9	5.757 ± 0.028	2017.4	-3645	5595	36
SAN-S1-5-1	B	*Acropora*	0.15822	3.4329 ± 0.0025	55.023 ± 0.083	12.365 ± 0.037	0.06532 ± 0.00018	144.2 ± 1.2	6.405 ± 0.019	2017.4	-4136	6086	63
SAN-S1-5-2	B	*Acropora*	0.03552	3.3849 ± 0.0050	38.79 ± 0.10	16.56 ± 0.10	0.06252 ± 0.00036	147.4 ± 1.9	6.105 ± 0.038	2017.4	-3907	5857	57
SAN-S1-5-3	B	*Acropora*	0.1561	3.4376 ± 0.0035	48.963 ± 0.072	14.213 ± 0.040	0.06672 ± 0.00017	144.6 ± 1.1	6.544 ± 0.018	2017.4	-4303	6253	56
Dalajia (Shuazhou)													
SHZ-S1.1.3	M	*Favia*	0.15811	2.7126 ± 0.0011	8.405 ± 0.017	0.728 ± 0.010	0.000744 ± 0.000010	147.2 ± 1.3	0.0707 ± 0.0010	2017.4	2001	-51	13
SHZ-S1.4.1	M	*Porites*	0.13798	2.7991 ± 0.0010	85.772 ± 0.144	0.5989 ± 0.0042	0.006048 ± 0.000041	145.8 ± 1.5	0.5774 ± 0.0040	2017.4	1918	32	115
SHZ-S1.6.3	M	*Favia*	0.15484	2.55064 ± 0.00075	14.597 ± 0.024	0.671 ± 0.012	0.001266 ± 0.000023	146.5 ± 1.1	0.1205 ± 0.0022	2017.4	1992	-42	23
SHZ S1 1.2		*?*	0.10136	2.7136 ± 0.0010	1.6446 ± 0.0018	1.076 ± 0.039	0.0002149 ± 0.0000078	145.4 ± 1.0	0.0205 ± 0.0007	2018.17	2013	-63.4	3.9
SHZ S1 1.4	M	*Platygyra*	0.10541	2.6562 ± 0.0010	8.6652 ± 0.0092	0.681 ± 0.012	0.000732 ± 0.000013	147.8 ± 1.1	0.0696 ± 0.0013	2018.17	2005	-55	14
SHZ S1 2.1	M	*Platygyra*	0.10259	2.8603 ± 0.0011	9.3968 ± 0.0084	0.681 ± 0.016	0.000737 ± 0.000018	146.3 ± 1.1	0.0702 ± 0.0017	2018.17	2005	-55	14
SHZ S1 1.5	M	*Platygyra*	0.11127	2.54124 ± 0.00075	1.6037 ± 0.0012	1.085 ± 0.032	0.0002257 ± 0.0000066	148.9 ± 1.1	0.0214 ± 0.0006	2018.17	2013	-63.2	4.0

SHZ S1 2.2	M	*Platygyra*	0.1003	2.69820 ± 0.00084	25.193 ± 0.019	0.6123 ± 0.0093	0.001884 ± 0.000029	147.0 ± 1.0	0.1793 ± 0.0027	2018.17	1989	-39	36
SHZ S1 3.1	M	*Cyphastrea*	0.0407	2.90580 ± 0.00080	53.304 ± 0.059	0.6271 ± 0.0093	0.003791 ± 0.000056	147.3 ± 1.2	0.3611 ± 0.0054	2018.17	1945	5.0	70
SHZ S1 3.2	M	*Cyphastrea*	0.08049	2.98432 ± 0.00077	37.035 ± 0.030	0.656 ± 0.010	0.002682 ± 0.000043	143.7 ± 1.0	0.2561 ± 0.0041	2018.17	1959	-9.1	48
SHZ S1 4.2(a)	M	*Pavona*	0.09103	3.3092 ± 0.0011	15.140 ± 0.014	0.635 ± 0.012	0.000957 ± 0.000017	144.7 ± 1.3	0.0912 ± 0.0016	2018.17	2003	-53	18
SHZ S1 4.2(b)	M	*Pavona*	0.10903	3.1734 ± 0.0015	10.872 ± 0.011	0.619 ± 0.015	0.000699 ± 0.000017	144.5 ± 1.1	0.0666 ± 0.0016	2018.17	2010	-60	14
SHZ S1 5.1	M	*Platygyra*	0.10651	2.59819 ± 0.00094	8.2862 ± 0.0081	0.724 ± 0.016	0.000761 ± 0.000016	144.4 ± 0.8	0.0725 ± 0.0016	2018.17	2001	-51	14
SHZ S1 5.2	M	*Cyphastrea*	0.10372	2.68735 ± 0.00081	5.9061 ± 0.0054	1.226 ± 0.026	0.000888 ± 0.000019	145.3 ± 1.1	0.0846 ± 0.0018	2018.17	1974	-23.8	9.9
SHZ S1 5.3	M	*Platygyra*	0.10912	2.5695 ± 0.0010	12.435 ± 0.010	0.756 ± 0.012	0.001206 ± 0.000018	145.0 ± 1.2	0.1149 ± 0.0018	2018.17	1984	-34	20
SHZ S1 5.4	M	*Goniastrea*	0.10348	2.9682 ± 0.0011	3.3602 ± 0.0025	0.979 ± 0.030	0.000365 ± 0.000011	147.5 ± 1.0	0.0347 ± 0.0011	2018.17	2007	-56.6	5.7
SHZ S1 6.1	B	*Acropora*	0.10653	3.2068 ± 0.0013	12.016 ± 0.014	0.835 ± 0.015	0.001031 ± 0.000019	146.2 ± 1.1	0.0982 ± 0.0018	2018.17	1983	-33	15
SHZ S1 6.2	M	*Cyphastrea*	0.0995	2.63550 ± 0.00089	15.437 ± 0.013	0.670 ± 0.013	0.001293 ± 0.000024	146.5 ± 0.9	0.1231 ± 0.0023	2018.17	1992	-42	23
SHZ S1 6.4	M	*Cyphastrea*	0.07078	2.70938 ± 0.00093	28.265 ± 0.026	0.638 ± 0.010	0.002193 ± 0.000036	144.8 ± 1.3	0.2091 ± 0.0034	2018.17	1976	-26	40
SHZ S1 1.1	M	*Platygyra*	0.10665	2.79107 ± 0.00093	0.43401 ± 0.00061	3.97 ± 0.16	0.0002033 ± 0.0000082	147.8 ± 1.0	0.0193 ± 0.0008	2018.17	2007	-57.4	2.2
Xiaolajia													
XLJ-S1.1.1	M	*Faviid*	0.16114	2.8552 ± 0.0024	29.936 ± 0.057	0.7987 ± 0.0084	0.002760 ± 0.000029	146.1 ± 1.2	0.2629 ± 0.0027	2017.4	1922	28	40
XLJ-S1.1.2	B	*Acropora*	0.15198	3.4256 ± 0.0013	55.906 ± 0.089	0.6530 ± 0.0048	0.003512 ± 0.000025	145.2 ± 1.1	0.3350 ± 0.0024	2017.4	1939	11	62
XLJ-S1.2.1	B	*Acropora*	0.15484	3.5904 ± 0.0025	51.303 ± 0.057	0.7344 ± 0.0068	0.003458 ± 0.000032	146.5 ± 1.4	0.3295 ± 0.0031	2017.4	1912	38	54
XLJ-S1.2.2	B	*Acropora*	0.07449	3.3399 ± 0.0019	10.380 ± 0.021	1.151 ± 0.020	0.001179 ± 0.000021	150.2 ± 1.3	0.1118 ± 0.0020	2017.4	1958	-8.3	13
XLJ-S1.3.1	B	*Acropora*	0.18906	3.5750 ± 0.0016	49.445 ± 0.086	0.6797 ± 0.0065	0.003098 ± 0.000029	142.2 ± 1.4	0.2963 ± 0.0028	2017.4	1939	11	53
XLJ-S1.3.2	B	*Acropora*	0.15673	3.4615 ± 0.0015	25.955 ± 0.038	0.7813 ± 0.0096	0.001931 ± 0.000024	144.4 ± 1.5	0.1842 ± 0.0023	2017.4	1954	-3.7	29
XLJ-S1.3.3		*?*	0.21883	3.3456 ± 0.0013	27.586 ± 0.046	0.6224 ± 0.0066	0.001691 ± 0.000018	148.3 ± 0.8	0.1608 ± 0.0017	2017.4	1988	-38	32
XLJ-S1.4.1	B	*Acropora*	0.15614	3.1765 ± 0.0019	46.588 ± 0.060	0.6023 ± 0.0067	0.002911 ± 0.000032	147.2 ± 1.1	0.2772 ± 0.0031	2017.4	1971	-21	56
XLJ-S1.4.2	B	*Acropora*	0.18653	3.3034 ± 0.0014	43.847 ± 0.051	0.6054 ± 0.0074	0.002649 ± 0.000032	146.0 ± 1.0	0.2524 ± 0.0031	2017.4	1974	-24	51
XLJ S1 1.2	M	*?*	0.10165	3.1189 ± 0.0011	39.249 ± 0.095	0.6132 ± 0.0065	0.002543 ± 0.000026	145.3 ± 0.9	0.2425 ± 0.0025	2018.17	1975	-25	48
XLJ S1 1.3	M	*Platygyra*	0.10882	2.9172 ± 0.0012	5.080 ± 0.013	0.802 ± 0.022	0.000461 ± 0.000013	144.4 ± 1.0	0.0439 ± 0.0012	2018.17	2007	-57.0	8.0
XLJ S1 1.4	M	*?*	0.10727	3.5594 ± 0.0018	15.384 ± 0.033	0.8181 ± 0.0097	0.001165 ± 0.000014	143.9 ± 0.9	0.1112 ± 0.0013	2018.17	1978	-28	17
XLJ S1 2.1	M	*Platygyra*	0.11402	2.5948 ± 0.0012	15.039 ± 0.014	0.837 ± 0.013	0.001598 ± 0.000025	143.2 ± 0.9	0.1525 ± 0.0023	2018.17	1962	-12	23
XLJ S1 2.2		*?*	0.10352	3.3102 ± 0.0012	37.534 ± 0.075	0.6686 ± 0.0085	0.002499 ± 0.000031	144.9 ± 1.3	0.2383 ± 0.0030	2018.17	1960	-9.7	43
XLJ S1 2.3	M	*Platygyra*	0.10167	3.0584 ± 0.0011	8.0283 ± 0.0081	71.21 ± 0.20	0.06161 ± 0.00017	144.5 ± 1.0	6.0273 ± 0.0174	2018.17	-3963	5913	21
XLJ S1 2.4	M	*Favia*	0.10372	2.5144 ± 0.0012	1.5937 ± 0.0015	283.48 ± 0.98	0.05922 ± 0.00020	145.2 ± 1.1	5.7837 ± 0.0209	2018.17	-3749	5699	21
XLJ S1 3.1	M	*Faviid*	0.10126	2.6759 ± 0.0010	24.450 ± 0.025	0.6414 ± 0.0096	0.001932 ± 0.000029	145.3 ± 1.1	0.1841 ± 0.0027	2018.17	1981	-31	36
XLJ S1 3.3	M	*?*	0.10779	3.1902 ± 0.0011	38.488 ± 0.034	0.6581 ± 0.0094	0.002617 ± 0.000037	144.2 ± 1.1	0.2497 ± 0.0036	2018.17	1960	-9.7	46
XLJ S1 3.4	M	*Cyphastrea*	0.10198	2.52426 ± 0.00064	18.099 ± 0.015	0.631 ± 0.014	0.001490 ± 0.000032	146.6 ± 1.2	0.1419 ± 0.0031	2018.17	1993	-43	29
XLJ S1 4.1		*?*	0.05029	2.97829 ± 0.00047	52.176 ± 0.059	0.6278 ± 0.0095	0.003625 ± 0.000055	145.9 ± 1.1	0.3456 ± 0.0052	2018.17	1948	2.0	67
XLJ S1 4.2		*?*	0.10495	2.89323 ± 0.00078	45.509 ± 0.040	6.558 ± 0.029	0.03400 ± 0.00015	143.5 ± 0.9	3.2900 ± 0.0146	2018.17	-1024	2974	61
XLJ S2 1.1	M	*Favia*	0.11516	2.33638 ± 0.00086	11.2810 ± 0.0074	0.832 ± 0.013	0.001324 ± 0.000021	144.8 ± 1.0	0.1262 ± 0.0020	2018.17	1974	-24	20
XLJ-S1.3.2	M	*Faviid*	0.15279	2.8817 ± 0.0033	28.853 ± 0.050	21.850 ± 0.068	0.07210 ± 0.00020	146.1 ± 1.7	7.078 ± 0.023	2017.4	-4901	6851	45
XLJ-S1.1.1	B	*Acropora*	0.15753	3.1464 ± 0.0034	41.955 ± 0.053	14.609 ± 0.042	0.06420 ± 0.00018	143.9 ± 1.3	6.293 ± 0.019	2017.4	-4065	6015	54
XLJ-S1.1.3	B	*Acropora*	0.15682	3.1917 ± 0.0033	55.63 ± 0.11	11.423 ± 0.036	0.06562 ± 0.00018	148.3 ± 1.4	6.411 ± 0.020	2017.4	-4121	6071	68
XLJ-S1.2.3	B	*Acropora*	0.06283	3.2033 ± 0.0031	45.260 ± 0.083	13.819 ± 0.055	0.06435 ± 0.00023	146.7 ± 1.8	6.292 ± 0.026	2017.4	-4053	6003	59
XLJ-S1.4.3	B	*Acropora*	0.17448	3.3988 ± 0.0037	47.484 ± 0.063	7.457 ± 0.031	0.03433 ± 0.00014	143.7 ± 1.2	3.323 ± 0.014	2017.4	-1085	3035	55
XLJ-S1.1.2	M	*Favia*	0.03367	2.4547 ± 0.0023	34.718 ± 0.072	5.581 ± 0.044	0.026016 ± 0.000198	144.2 ± 2.5	2.508 ± 0.020	2017.4	-266	2216	58
Zhouzaitou													
ZZT-S1.2.3	B	*Acropora*	0.15505	3.5101 ± 0.0025	32.927 ± 0.064	1.048 ± 0.010	0.003241 ± 0.000030	145.6 ± 1.4	0.3089 ± 0.0029	2017.4	1858	92	36
ZZT-S1.3.1	B	*Acropora*	0.14882	3.18214 ± 0.00085	21.736 ± 0.031	0.598 ± 0.011	0.001347 ± 0.000024	143.9 ± 1.0	0.1285 ± 0.0023	2017.4	2000	-50	27
ZZT-S1.3.2	B	*Acropora*	0.15785	2.9304 ± 0.0012	75.68 ± 0.10	0.5516 ± 0.0044	0.004695 ± 0.000037	143.6 ± 1.0	0.4488 ± 0.0036	2017.4	1973	-23	97
ZZT-S1.3.3	B	*Acropora*	0.16067	3.3306 ± 0.0012	61.08 ± 0.12	0.5251 ± 0.0064	0.003174 ± 0.000038	145.1 ± 1.2	0.3027 ± 0.0037	2017.4	2002	-52	69
ZZT-S1.random. 1	B	*Acropora*	0.15482	3.5450 ± 0.0014	43.225 ± 0.087	0.998 ± 0.011	0.004011 ± 0.000043	145.9 ± 1.4	0.3825 ± 0.0041	2017.4	1827	123	47
ZZT-S1.random. 2	B	*Acropora*	0.15657	3.4451 ± 0.0012	61.19 ± 0.11	0.6839 ± 0.0043	0.004003 ± 0.000024	145.3 ± 0.8	0.3820 ± 0.0023	2017.4	1914	36	67

ZZT-S1.random. 3	B	*Acropora*	0.15547	3.4686 ± 0.0010	27.951 ± 0.057	2.783 ± 0.016	0.007390 ± 0.000040	143.9 ± 1.4	0.7068 ± 0.0040	2017.4	1440	510	31
ZZT-S1.4.1	B	*Acropora*	0.19359	3.2969 ± 0.0012	65.161 ± 0.082	0.5668 ± 0.0050	0.003692 ± 0.000033	144.2 ± 1.1	0.3525 ± 0.0031	2017.4	1975	-25	75
ZZT-S1.4.2	B	*Acropora*	0.15113	3.4185 ± 0.0017	62.063 ± 0.096	0.5311 ± 0.0056	0.003178 ± 0.000033	144.0 ± 1.1	0.3034 ± 0.0032	2017.4	1999	-49	69
ZZT-S1.4.3	B	*Acropora*	0.15677	3.3265 ± 0.0014	33.091 ± 0.064	0.5829 ± 0.0083	0.001911 ± 0.000027	144.1 ± 1.2	0.1823 ± 0.0026	2017.4	1994	-44	38
ZZT-S1.2.1	B	*Acropora*	0.16435	3.4191 ± 0.0045	35.731 ± 0.072	17.912 ± 0.070	0.06169 ± 0.00022	147.3 ± 1.2	6.022 ± 0.023	2017.4	-3839	5789	46
ZZT-S1.2.2	B	*Acropora*	0.15332	3.2198 ± 0.0033	41.930 ± 0.072	0.6988 ± 0.0082	0.002999 ± 0.000035	147.4 ± 1.0	0.2855 ± 0.0033	2017.4	1937	13	50

Ratios in parentheses are activity ratios calculated from atomic ratios using ISOPLOT 3.75 (Ludwig 2012) using decay constants λ_{238}= 1.55125 × 10^{-10} yr^{-1} (Jaffey et al. 1971), λ_{234} = (2.8262±0.0057) × 10^{-6} yr^{-1}, λ_{230} = (9.158±0.028) × 10^{-6} yr^{-1} (Cheng et al. 2000). All values have been calculated after mean laboratory blank extraction. All errors reported in this table are quoted as 2σ.

1. $\delta^{234}U(T)=\delta^{234}U(O)e^{\lambda 234T}$ where $\delta^{234}U=[(^{234}U/^{238}U)-1] \times 1000$

2. To account for both hydrogenous and terrestrially derived $^{230}Th_0$, the corrected (corr.) ^{230}Th age of each sample was calculated using a sample specific non-radiogenic ($^{230}Th/^{232}Th$) value using the following equation in Clark et al. (2014):

$$\left(\frac{^{230}Th}{^{232}Th}\right)_{mix} = \left(\left(\frac{^{232}Th_{live}}{^{232}Th_{dead}}\right) \times \left(\frac{^{230}Th}{^{232}Th}\right)_{live}\right) + \left(\left(\frac{^{232}Th_{dead} - ^{232}Th_{live}}{^{232}Th_{dead}}\right) \times \left(\frac{^{230}Th}{^{232}Th}\right)_{sed}\right)$$

where $^{232}Th_{dead}$ is the measured ^{232}Th value (ppb) in the individual dead coral sample. $^{232}Th_{live}$ is the mean ^{232}Th value (ppb) measured in live coral samples collected from the region determined to be 0.35 ± 0.03 ppb (7.6%, N=2). $^{230}Th/^{232}Th_{live}$ represents or approximates the isotopic composition of the hydrogenous component in the live coral skeleton during growth with an activity value of 2.08 ± 0.05 (23%). $^{230}Th/^{232}Th_{sed}$ represents the detrital component incorporated into the coral skeleton post-mortem with a mean activity value of 0.49 ± 0.12 (24%) based on y-intercept values of $^{230}Th/^{232}Th$ versus $^{238}U/^{232}Th$ isochrons (Appendix DR3).

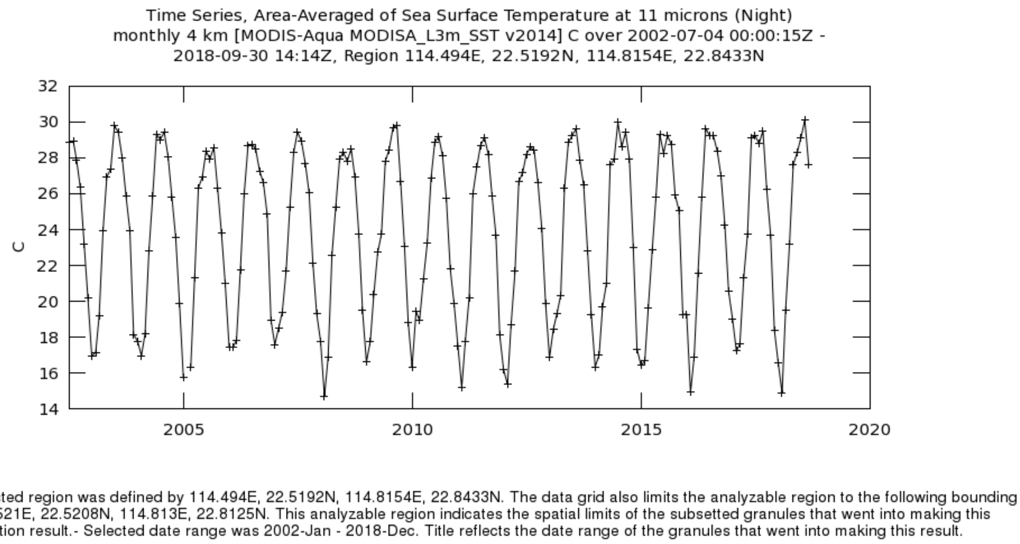
3. BP = before present, where present is defined as 1950 AD.

Supplementary Table DR3. Calculated mean low water spring (MLWS) tide level[1] at Quarry Bay, Hong Kong, in 2015.

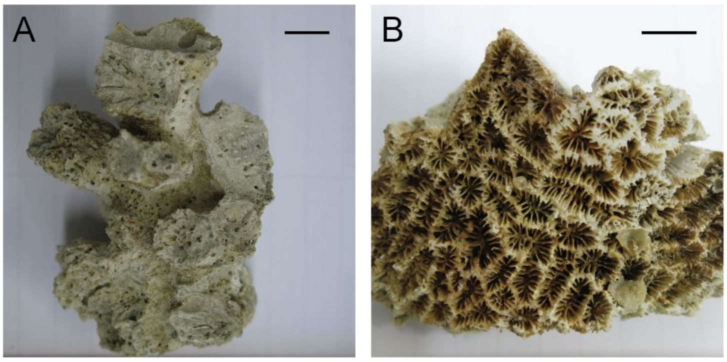
Month	Lunar status	Date	Tide height (mLAT)[2]		Date, time
Jan	New moon	20-Jan	Low water 1	0.4	20 Jan, 0330
			Low water 2	0.34	21 Jan, 0400
	Full moon	5-Jan	Low water 1	0.48	5 Jan, 0400
			Low water 2	0.46	6 Jan, 0530
Feb	New moon	18-Feb	Low water 1	0.4	18 Feb, 0300
			Low water 2	0.35	19 Feb, 0400
	Full moon	3-Feb	Low water 1	0.5	3 Feb, 0330
			Low water 2	0.49	4 Feb, 0400
Mar	New moon	20-Mar	Low water 1	0.5	20 Mar, 0300
			Low water 2	0.55	21 Mar, 0400
	Full moon	5-Mar	Low water 1	0.6	5 Mar, 0330
			Low water 2	0.65	6 Mar, 0430
April	New moon	18-Apr	Low water 1	0.42	19 Apr, 1600
			Low water 2	0.39	20 Apr, 1600
	Full moon	4-Apr	Low water 1	0.7	6 Apr, 1330
			Low water 2	0.68	7 Apr, 1700
May	New moon	18-May	Low water 1	0.38	18 May, 1530
			Low water 2	0.32	19 May, 1600
	Full moon	4-May	Low water 1	0.5	6 May, 1700
			Low water 2	0.5	7 May, 1800
June	New moon	16-Jun	Low water 1	0.35	16 Jun, 1600
			Low water 2	0.3	17 Jun, 1630
	Full moon	2-Jun	Low water 1	0.42	3 Jun, 1600
			Low water 2	0.48	4 Jun, 1700
July	New moon	16-Jul	Low water 1	0.36	16 Jul, 1600
			Low water 2	0.38	17 Jul, 1630
	Full moon	2-Jul	Low water 1	0.3	3 Jul, 1630
			Low water 2	0.3	4 Jul, 1700
	Full moon	31-Jul	Low water 1	0.35	31 Jul, 1530
			Low water 2	0.34	1 Aug, 1630
Aug	New moon	14-Aug	Low water 1	0.52	13 Aug, 1500
			Low water 2	0.52	14 Aug, 1600
	Full moon	29-Aug	Low water 1	0.5	29 Aug, 1500
			Low water 2	0.5	30 Aug, 1600
Sep	New moon	13-Sep	Low water 1	0.72	11 Sep, 1430
			Low water 2	0.75	12 Sep, 1500
	Full moon	28-Sep	Low water 1	0.75	29 Sep, 0330
			Low water 2	0.7	30 Sep, 0400
Oct	New moon	13-Oct	Low water 1	1.05	13 Oct, 0300
			Low water 2	0.95	14 Oct, 0400
	Full moon	27-Oct	Low water 1	0.7	27 Oct, 0200
			Low water 2	0.62	28 Oct, 0300
Nov	New moon	11-Nov	Low water 1	0.78	13 Nov, 0400
			Low water 2	0.72	14 Nov, 0500
	Full moon	25-Nov	Low water 1	0.48	27 Nov, 0400
			Low water 2	0.48	28 Nov, 0500
Dec	New moon	11-Dec	Low water 1	0.58	13 Dec, 0430
			Low water 2	0.54	14 Dec, 0500
	Full moon	25-Dec	Low water 1	0.4	26 Dec, 0400
			Low water 2	0.4	27 Dec, 0500
			Average	**0.517**	

[1]MLWS = The long-term mean of the heights of two successive low waters during those periods of 24 hours (approximately once a fortnight) when the range of tide is greatest, during full and new moon.
[2]Source: Hong Kong Observatory

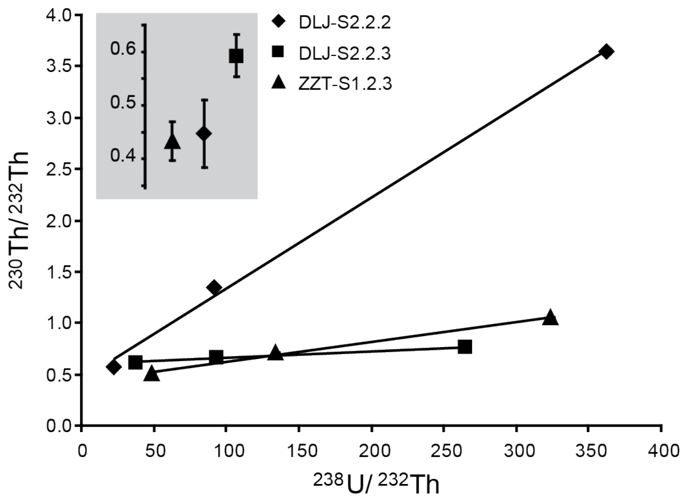
Supplementary Figure DR1. Satellite monthly average sea surface temperature (SST) data between 2002-2018 obtained from NASA'a MODIS-Aqua at 4 km resolution for co-ordinates 114.494-114.815°E, 22.5192-22.8433°N (Source: https://giovanni.gsfc.nasa.gov).



Supplementary Figure DR2. Figure 2. A: A well-preserved dead *Acropora* sp. branch from Sanmen Islands (China) dating to 6.1 ± 0.6 kyr B.P. B: *Platygyra* sp. from Dalajia (Shuazhou) Island dating to –0.057 ± 0.002 kyr B.P. Scale bar represents 1 cm.



Supplementary Figure DR3. $^{230}Th/^{232}Th$ versus $^{238}U/^{232}Th$ isochron for three coeval sets of sub-samples obtained from dead coral skeletons collected from Dalajia and Zhouzaitou Island, China. Inset shows the isochron-inferred $^{230}Th/^{232}Th_0$ ratios (y-intercepts with 2σ errors) of the detrital component (average 0.49 ± 0.12 (24%) (1σ)).



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