ELECTRONIC SUPPLEMENTARY INFORMATION

Keith *et al.* Coral mass spawning predicted by rapid seasonal rise in ocean temperature

(Appendix S1, Table S2-S3, Figure S1-S3)

Appendix S1: Environmental data

SST (°C), wind speed (10 m above surface), and rainfall rates in mm hr^{-1} were obtained from the Tropical Rainfall Measuring Mission's (TRMM) Microwave Imager (TMI) available at: ftp://ftp.remss.com/tmi/bmaps_v07.1/. These data have a 0.25° (~25 km) spatial resolution and the single satellite is used to minimise the number of sensors and time periods included in our analysis.

Monthly current speed data in m s^{-1} were downloaded from Ocean Surface Current Analyses Real-time [OSCAR; 1] at a spatial resolution of 1° (~100 km), available at http://oceanmotion.org/html/resources/oscar.htm. This product uses satellite altimeter and scatterometer data to combine geostrophic and wind-driven components of the surface current every five days. At this temporal resolution, there is no reproduction of high-frequency (e.g., tidal) currents. However, as the timing of spawning is constrained by lunar phase, tidal currently will be at or near their maximum magnitude during spawning. Data were extracted for pixels containing our spawning site. Mean values were constructed for each variable from the monthly data for the years 1998-2014 and missing data were filled in the zonal direction (towards the equator) with data from the closest pixel for which data were available, except for current speed, which was filled by calculating the mean current speed of the first expanding square outwards from the desired pixel to contain data.

PAR data (Einsteins m^{-2} day^{-1}) were obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Aqua satellite available at http://oceancolor.gsfc.nasa.gov. We used the monthly climatology for 2003-2014 at 4 km resolution. A monthly time step was necessary because daily data contain large gaps, and it matches the resolution of our data on the timing of coral spawning. Monthly resolution composites of PAR from satellite have been demonstrated to effectively represent *in situ* measurements, with a reduction in the RMS difference of >50% compared with daily measurements [2]. Difference in sunset time (minutes, using the Astronomical sunset, zenith=108) was calculated using PHP 5.4.30 for the year 2010.

Table S2. Environmental variables used and the potential mechanisms by which they might act to influence the evolution of spawning synchrony i.e., as ultimate cues.

Variable	Ecological justification
Mean monthly sea surface temperature	There is an optimum temperature range for most physiological processes [3], including fertilisation, larval survivorship and settlement in corals [4-6]. Consequently, natural selection should favour those individuals that spawn within this optimum temperature range to maximise reproductive success.
Photosynthetically available radiation (PAR)	Corals are symbiotic organisms and derive a high proportion of their energy from endosymbiotic photosythetic algae [7]. van Woesik [8] hypothesised that there was a minimum dose of sunlight that corals would need in order to produce their oocytes. However, the role the products of photosynthesis play in the development of oocytes remains unknown. High light levels, in particular when combined with high temperatures, are also a major cause of stress in photosynthetic organisms, including coral [9]. Therefore, corals may avoid spawning at times of the year when both light and temperature are high.
Precipitation	Small reductions in salinity have strong effects on both fertilisation success and larval survival [10, 11] so corals are likely to avoid spawning at times of year when rainfall is high. Mendes & Woodley [10] also suggested that wet season floods could provide a source of nutrients to coral larvae and, therefore, periods of high run-off might be beneficial shortly after spawning has occurred, as in some other marine invertebrates. However, most coral larvae do not feed [12] so the validity of precipitation as an ultimate mechanism behind spawning synchrony is unclear.
Wind speed	High wind speed is predicted to produce turbulence that would disperse gametes throughout the water column and therefore reduce density and fertilisation success [13, 14]. In addition, turbulent water can break up embryos which might reduce larval or post-settlement survivorship [15]. Moderate wind speeds, however, might help to break up gamete bundles to avoid self-fertilisation.
Difference in sunset time	Hypothesised to be a reliable proximate cue for tropical plants where there is little variation in day length [16]
Ocean current speed	Hypothesised to influence dispersal potential owing to the reliance of coral larvae on ocean currents [17]

Table S3. Pearson correlation coefficients between normalised and scaled environmental variables.

	PAR 10 month	PAR change	Rainfall	Wind speed	Sunset time	SST mean	Current speed
SST change	-0.27	0.32	-0.08	-0.37	-0.43	0.32	-0.02
PAR 10 month		-0.24	-0.38	-0.11	0.32	0.09	0.19
PAR change			-0.26	0.02	-0.51	-0.55	-0.02
Rainfall				-0.25	0.04	0.23	0.08
Wind speed					0.13	-0.33	-0.41
Sunset time						0.18	0.04
SST mean							0.06

Figure S1. Differences in the baseline likelihood of spawning across (a) sampled reefs, and (b) months. Offset is from the mean intercept of the spawning season model. Reef IDs can be linked to geographical information in Table 1.

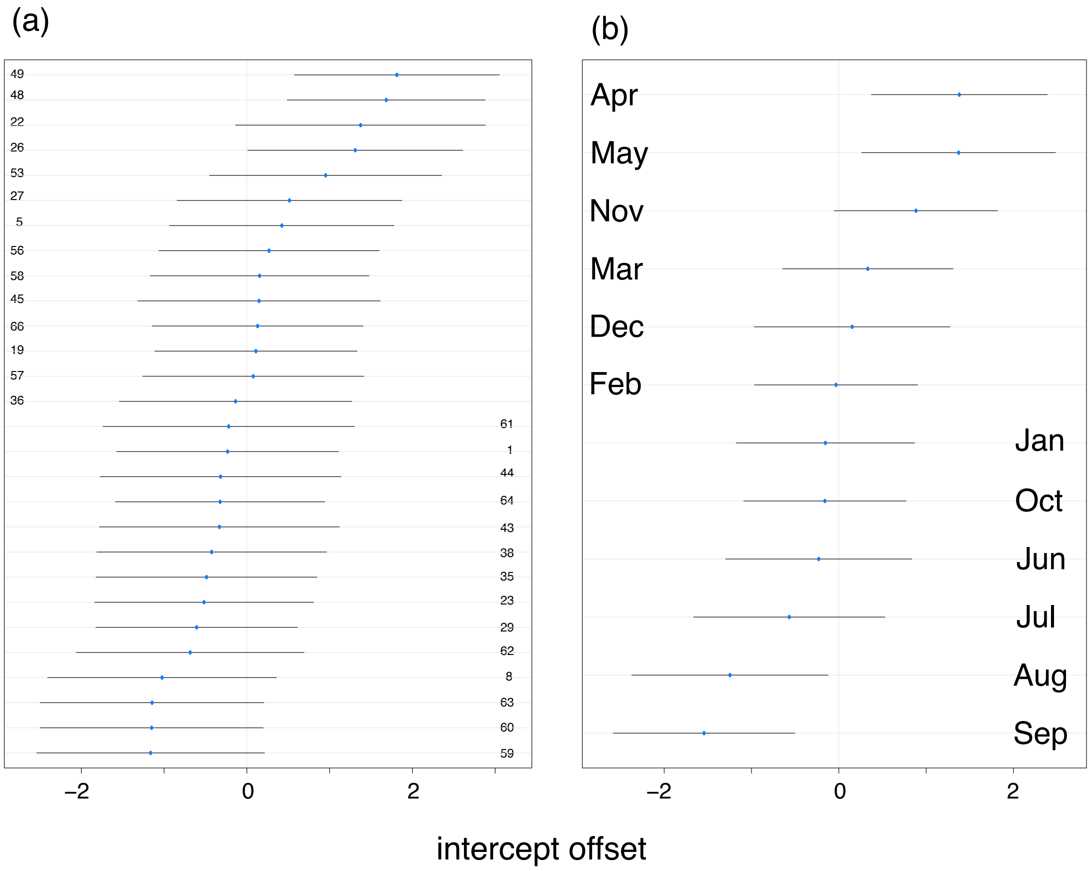


Figure S2. Differences in the baseline likelihood of spawning across months. Offset is from the mean intercept of the peak spawning model.

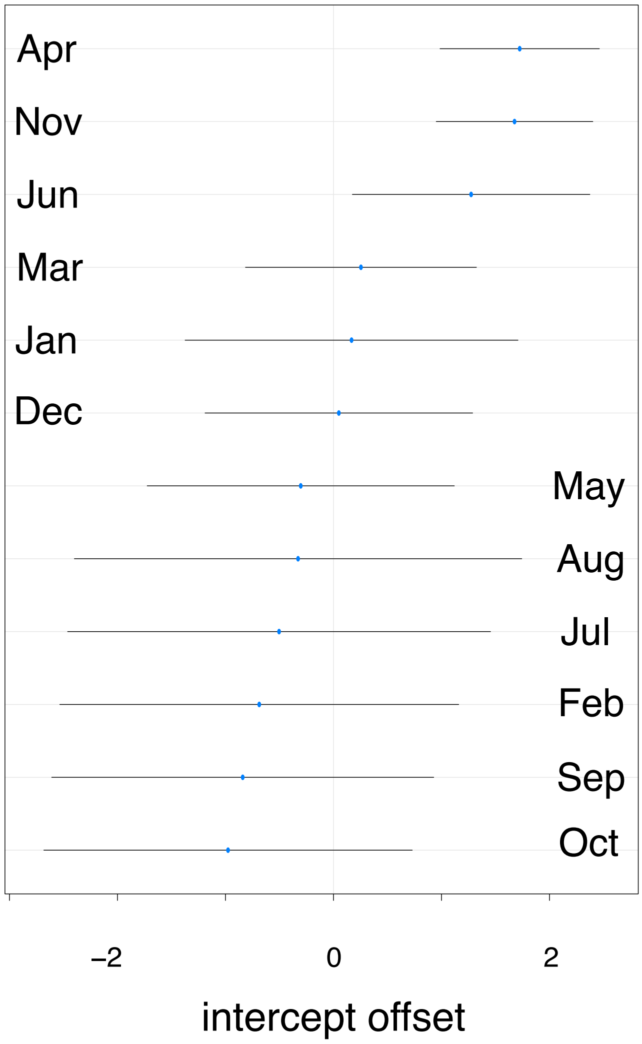
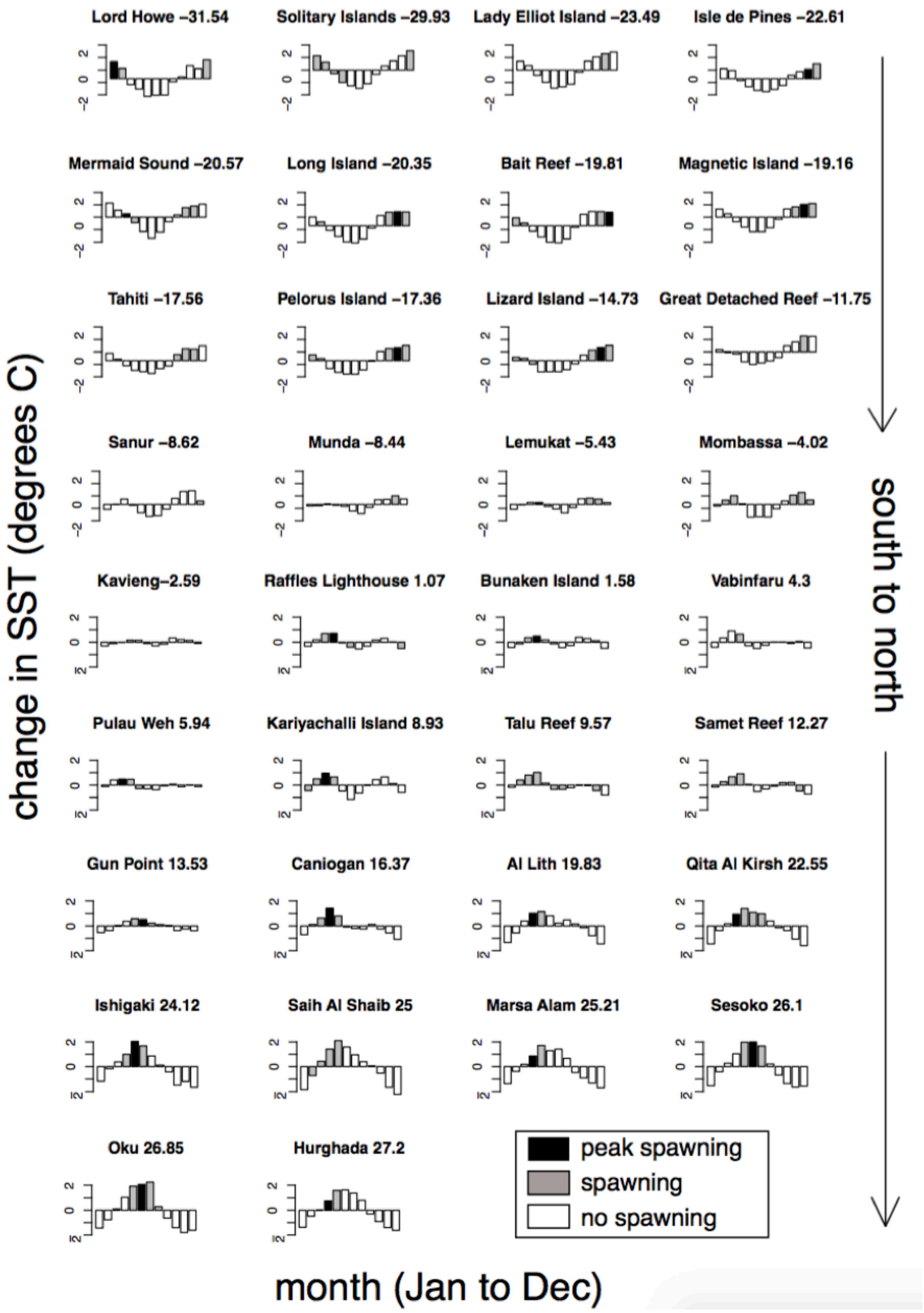


Figure S3. Actual change in sea surface temperature (SST) between months by individual reef. Plot titles include reef name and latitude. Bars represent months from January to December (left to right).



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