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Coral Reefs

Coral bleaching relative to elevated seawater temperature in the Andaman Sea (Indian Ocean) over the last 50 years

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The coral communities around the coast of Ko Phuket, South Thailand have been regularly monitored over the last 16 years (Chansang et al. 1981; Brown and Holley 1982; Brown et al. 1990). During that time there have been two incidences of extensive intertidal and sub-tidal coral bleaching, the first in 1991 and again in 1995. In both cases bleaching has occurred at the time of maximum seasonal sea surface temperature (SST) in May.

Analysis of monthly mean SST for the Phuket area for the last 50 years (MOHSST 6 data set; Parker et al. 1995) (Fig. 1) reveals that both 1991 and 1995 are years when the highest seasonal temperatures have been recorded (30.27 °C and 30.28 °C respectively in May). The next highest seasonal SSTs were in 1988 and 1966 (30.11 °C and 30.09 °C respectively in April). No bleaching was observed in 1988. We have calibrated the MOHSST 6 data set against our own in situ continuous thermistor record (absolute accuracy ± 0.04 °C) for the past 25 months and found a close correlation ($R^2 = 0.79$).

Closer examination of the monthly mean SST for the bleaching years of 1991 and 1995 with the non-bleaching year of 1988 (Fig. 2) shows different patterns of SST rise (the data for 1991 and 1995 have been independently corroborated from in situ measurements). In 1991 the anomaly of +0.65 °C (above mean seasonal peak temperature) was preceded by high temperature in the antecedent four months, similar to 1988, while in 1995 SST only rose rapidly from mid March to a peak of +0.66 °C in May. In 1988 temperatures started falling in April before reaching the normal seasonal maximum. The extent and pattern of corals species susceptibility to bleaching was the same in both 1991 and 1995 as was the coincidence of rapid bleaching and departure from the seasonal maximum temperature. The magnitude of these observed anomalies are smaller than those previously recognized to elicit bleaching in other parts of the world (Goreau and Hayes 1994) and the pattern of the 1995 SST rise suggests that no extended pre-exposure of corals to elevated SST is required to cause bleaching.

The long-term trend in SST at Phuket (Fig. 1) shows a decadal increase of 0.126 °C ($P < 0.001$). This trend is consistent with positive trends in the Indian Ocean area,

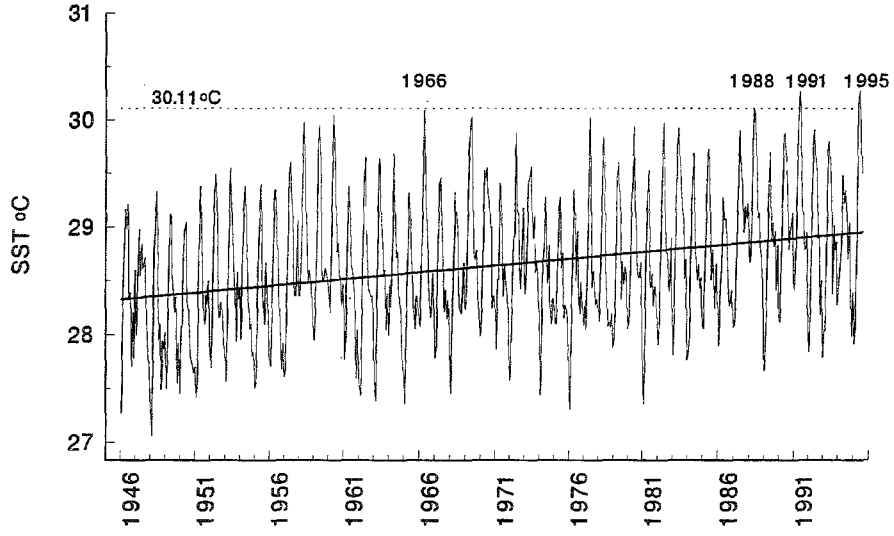

Fig. 1. Monthly mean sea surface temperatures (SST) 1945–1995 from the Meteorological Office Historical Sea Surface Temperature (MOHSST 6) dataset for the sea area 5°–10° N, 95°–100° E. Regression line for all points shown ($P < 0.001$). The 30.11 °C line is shown for cross reference to Fig. 2 and the text. The relationship of the MOHSST6 temperature values to our in situ thermistor temperature data at Phuket, Thailand (7° 50′N, 98° 25′E) is MOHSST6 = Thermistor * 0.999020 ($R^2 = 0.79$, $P < 0.0001$) with values computed in degrees Kelvin

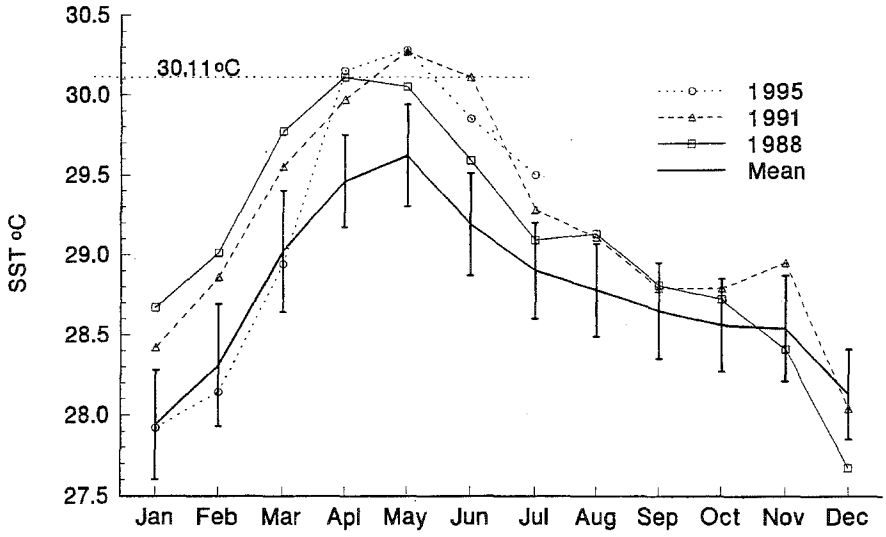

Fig. 2. Seasonal changes in monthly mean SST from MOHSST6 data for the years 1988, 1991, and 1995. The mean monthly SST for the data set is based on the year 1961–1990. Error bars represent standard deviations

and the tropical belt (20° N–20° S) as a whole (Bottomley et al. 1990; Parker et al. 1995). Current predictions by the Intergovernmental Panel on Climate Change for the next century are that a positive trend in SST warming will occur of about the magnitude we have documented (Houghton et al. 1990). Given this long-term future scenario we would expect an increased frequency of bleaching at Phuket and possibly at other sites worldwide. In making this assessment we have not ignored the potential synergistic role of solar radiance to coral bleaching (Brown and Ogden 1993; Dunne 1994), either through reduced cloudiness or changes in water clarity. Our findings, however, suggest that corals face an increasingly hostile sea temperature environment.

While elevations in maximum SST may increase the frequency of temperature-induced stress and related mortaility events on existing coral reefs, continuing increases in the future may also extend the latitudinal range of coral reefs over the long term (Smith and Buddemeier 1992). For existing reefs the critical question is the degree to which corals can adapt to temperature increases in the short term. Preliminary results from Phuket suggest that such capabilities may be limited.

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