Effects of ocean warming on coral populations

New science on thermal stress since the BRT

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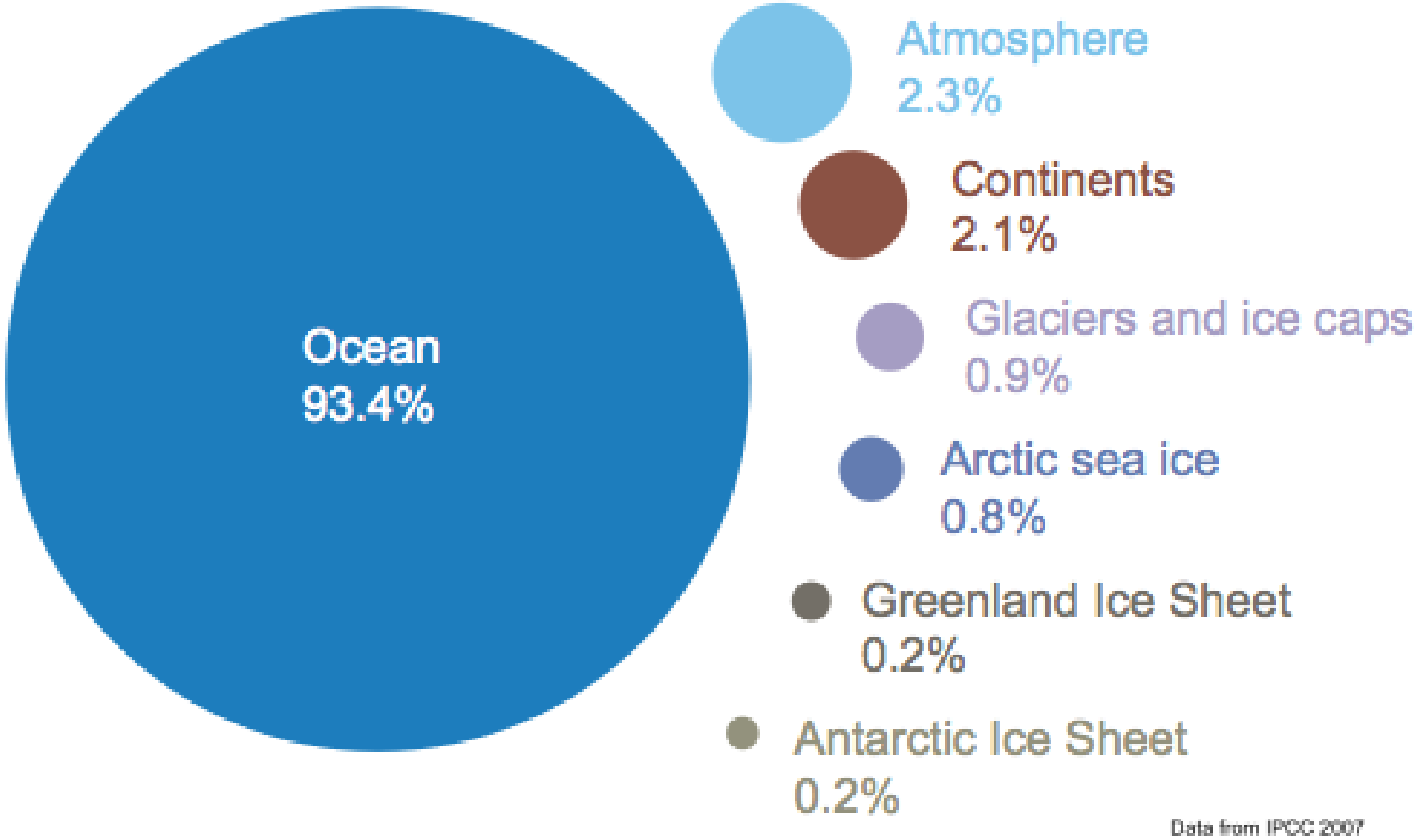
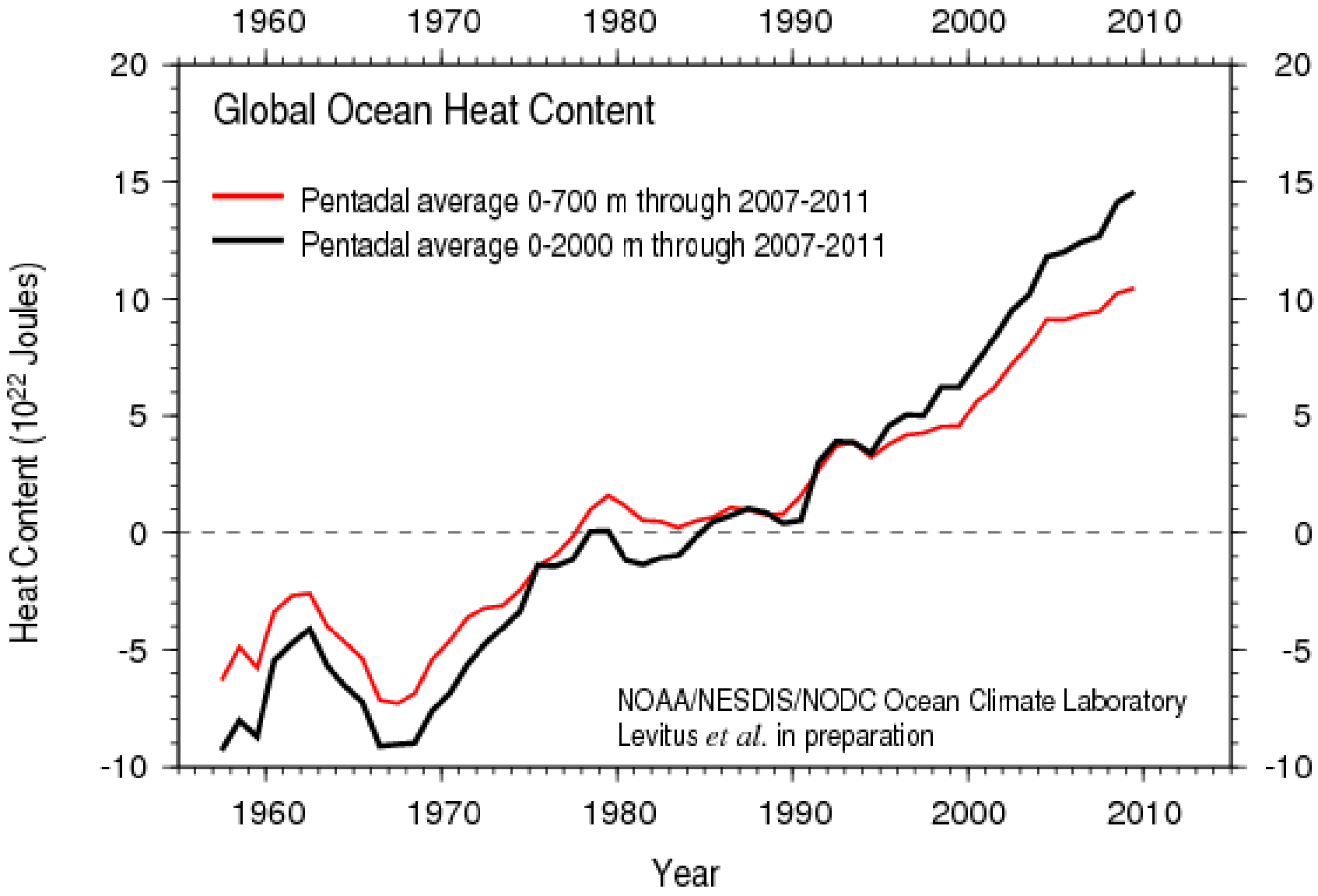
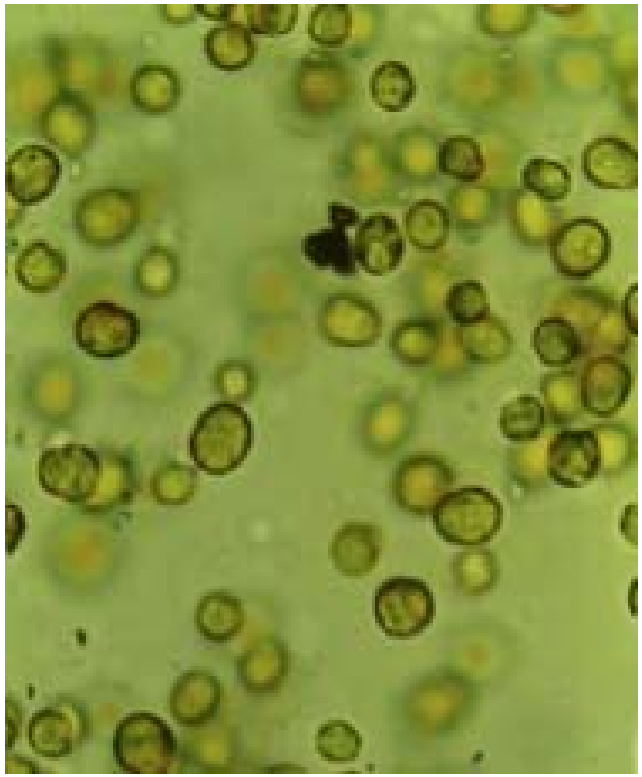
Where is global warming going?



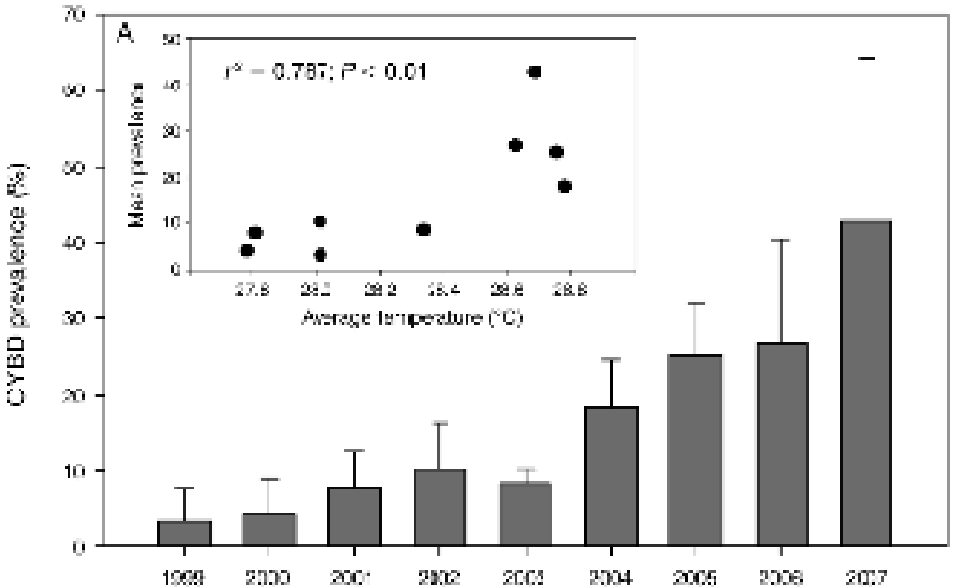
The ocean is warming



Coral bleaching



Relationship between ocean temperature and coral disease prevalence



Harvell et al. 2009 *Ecology*

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2010) **19**, 397–411

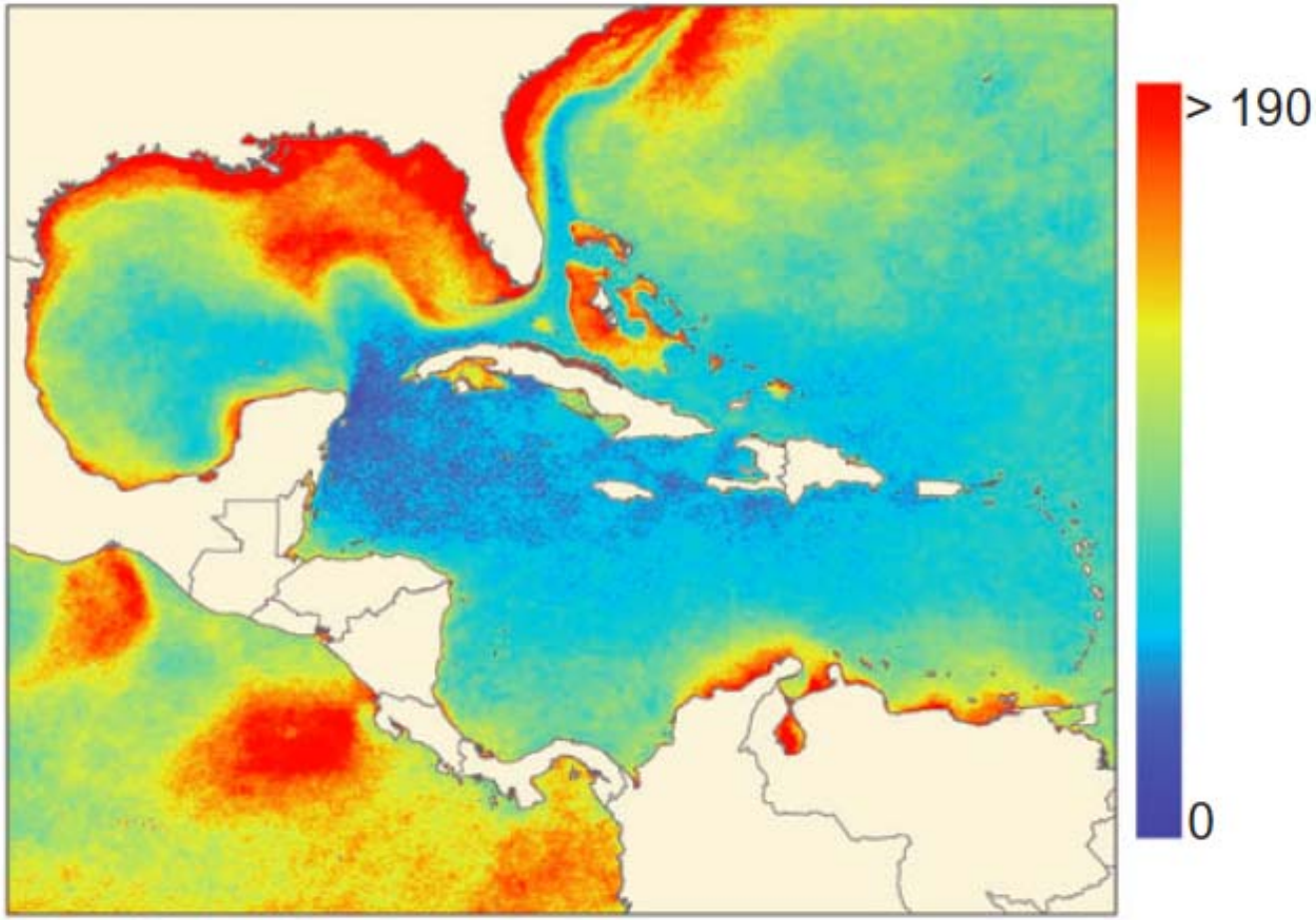
RESEARCH PAPER

New insights into global patterns of ocean temperature anomalies: implications for coral reef health and management

Elizabeth R. Selig[1,4]*†, Kenneth S. Casey[2] and John F. Bruno[3]

Metric	Definition	Application	Related references
Thermal stress anomalies (TSAs)	Observed weekly averaged temperature is ≥1 °C warmer than the maximum climatological week (the warmest week of the 52 climatological weeks averaged over 21 years); TSAs are deviations from typical summertime temperatures	Bleaching	Glynn (1993),) Podesta and Glynn (2001), Liu *et al.* (2003)
Weekly sea surface temperature anomalies (WSSTAs)	Observed weekly averaged temperature is ≥1 °C warmer than the weekly climatological value (averaged over 21 years); WSSTAs are deviations from typical weekly temperatures	Disease	Selig *et al.* (2006), Bruno *et al.* (2007)

Cumulative number of weeks with weekly sea surface temperature anomalies 1985-2005



Selig et al 2010 GEB

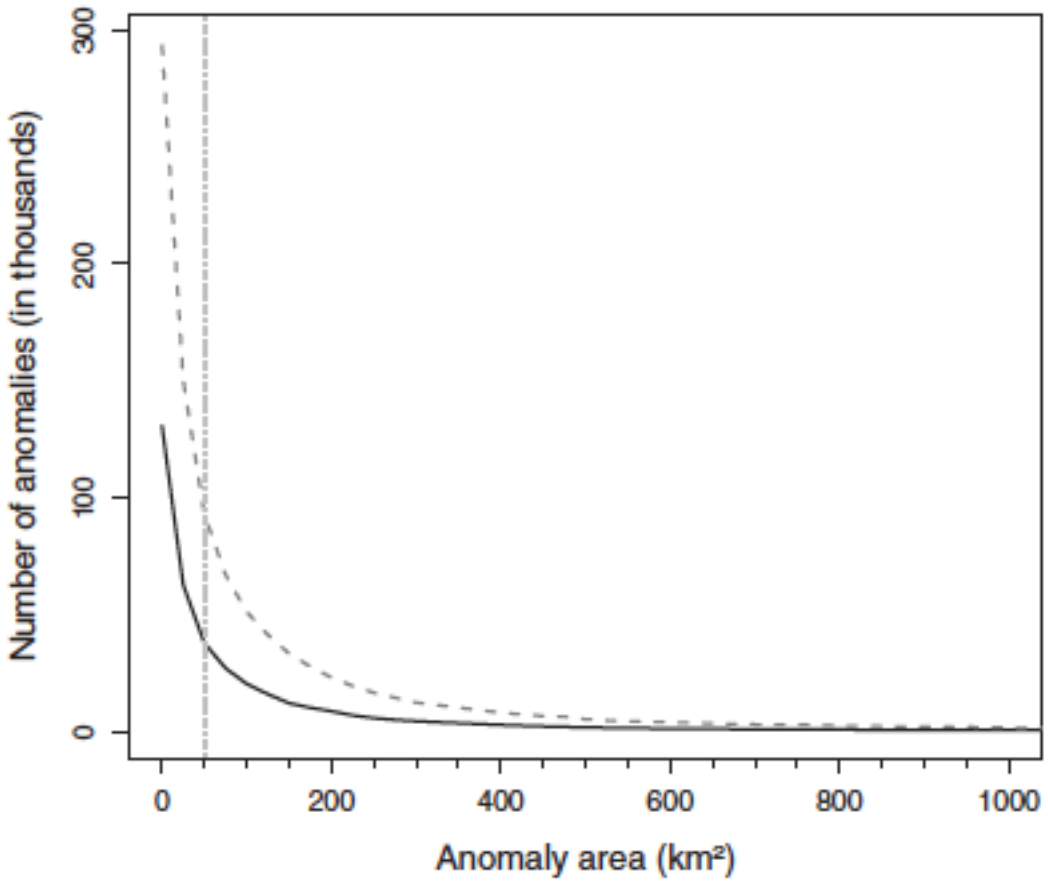


Figure 7 Frequency distribution of anomaly sizes for thermal stress anomalies (TSAs) and weekly sea surface temperature anomalies (WSSTAs) for 1985–2005. TSAs are shown with the solid black line and WSSTAs with the dashed grey line. Most climate studies occur at a spatial resolution of more than 50 km^2 (dotted grey line). Raw anomaly areas were categorized into 25 km^2 bins.

Selig et al 2010 GEB

Warmest years among locations

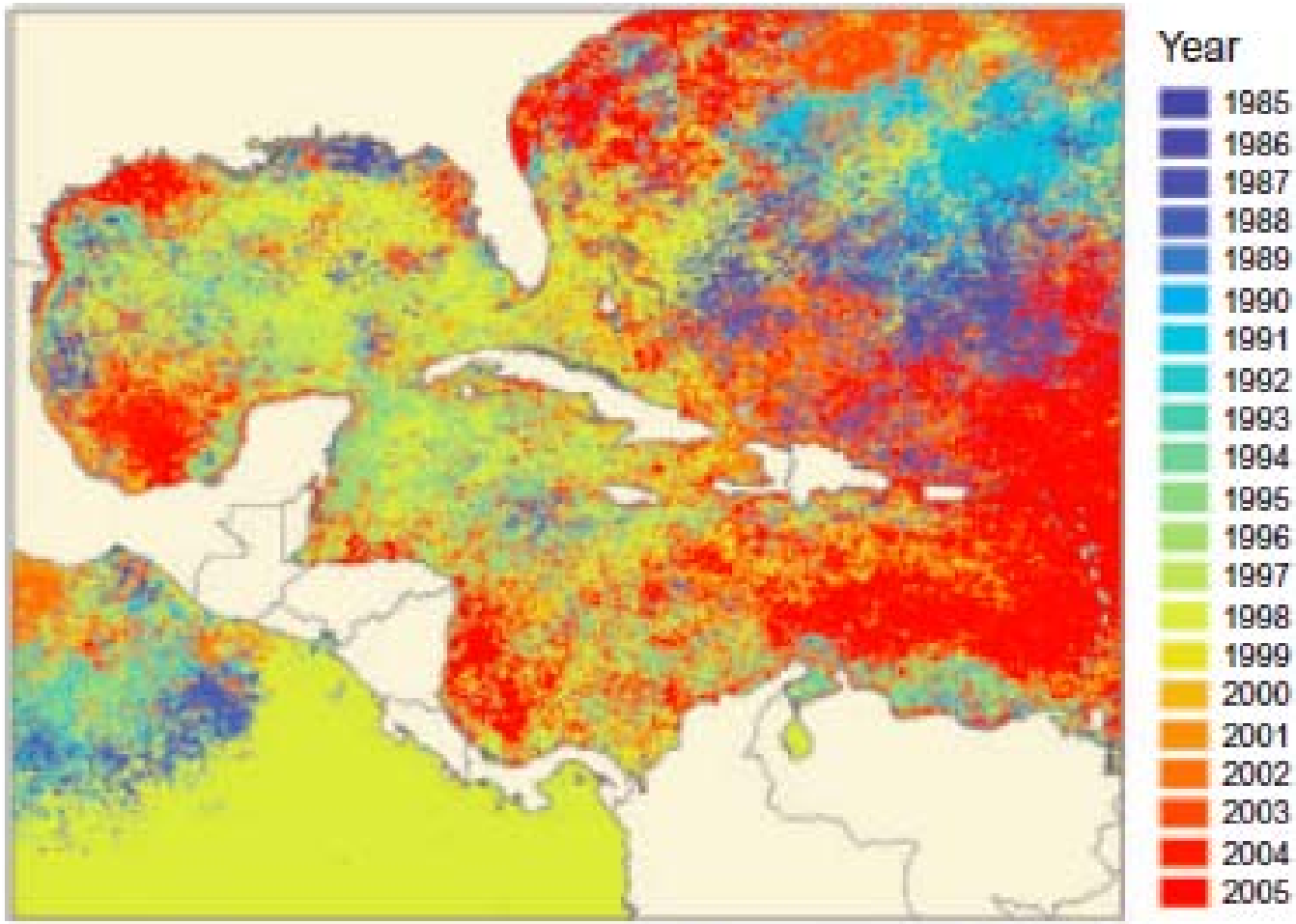


Figure 6 Year of the maximum number of thermal stress anomalies (TSAs) in the Caribbean. For each grid cell, the year with the greatest number of TSAs was recorded. The signature of the 2005 warm event is clearly visible in the Antilles region.

Selig et al 2010 GEB

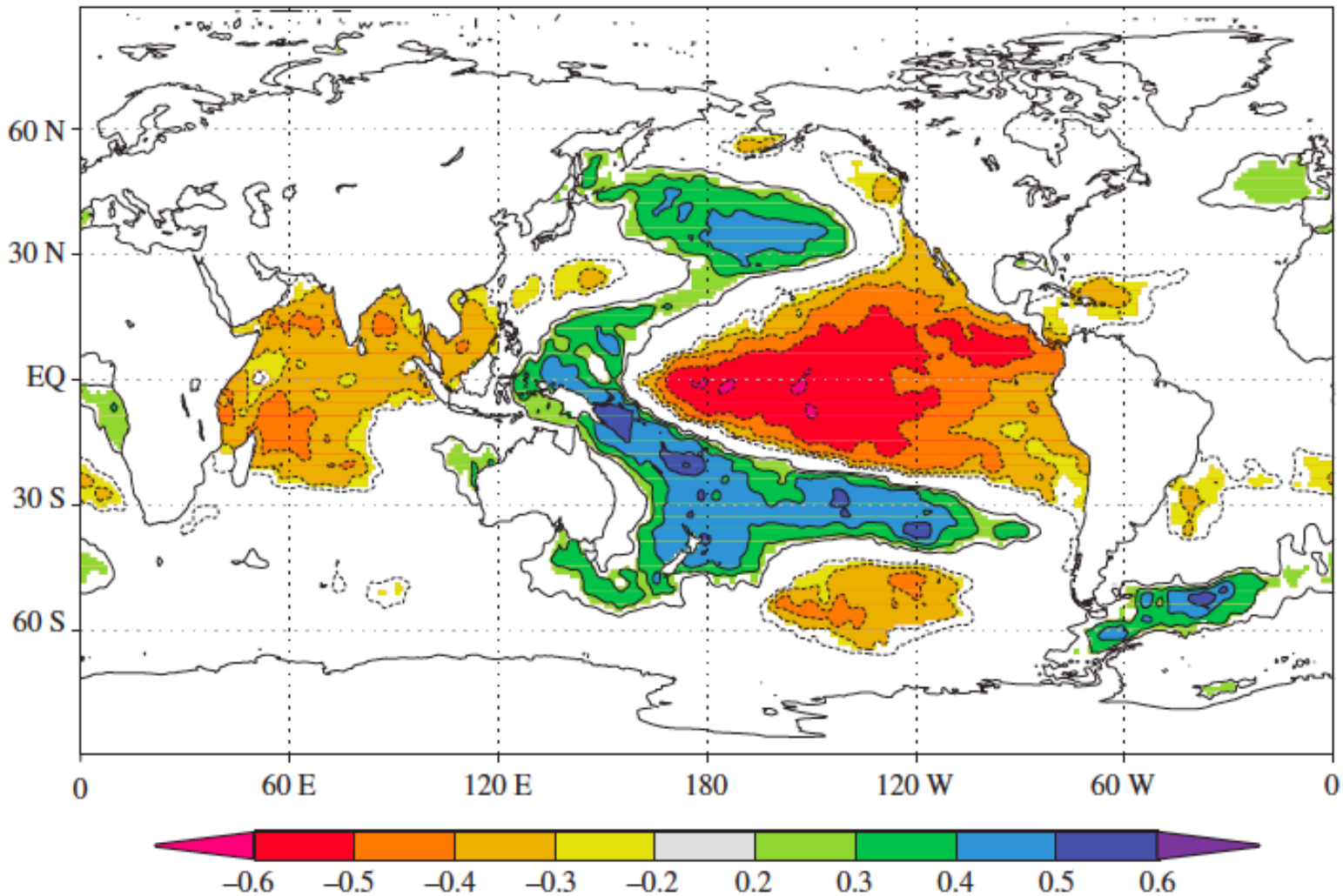


Figure 4. Correlation of the annual mean of the high-frequency (>5.7-year) component (reconstructed component 2_3 RC2_3, which explained 7.2% of the variance) with the detrended, annually resolved 1° by 1° globally gridded HadISST1.1 sea-surface temperature data over the common time period (1886–1993), where shading represents the strength of the correlation and contours mask out correlations that were not significant at the 95 per cent confidence level (map created using climate explorer, http://climexp.knmi.nl/start.cgi?someone@somewhere).

Thompson and van Woesik 2009 PRS

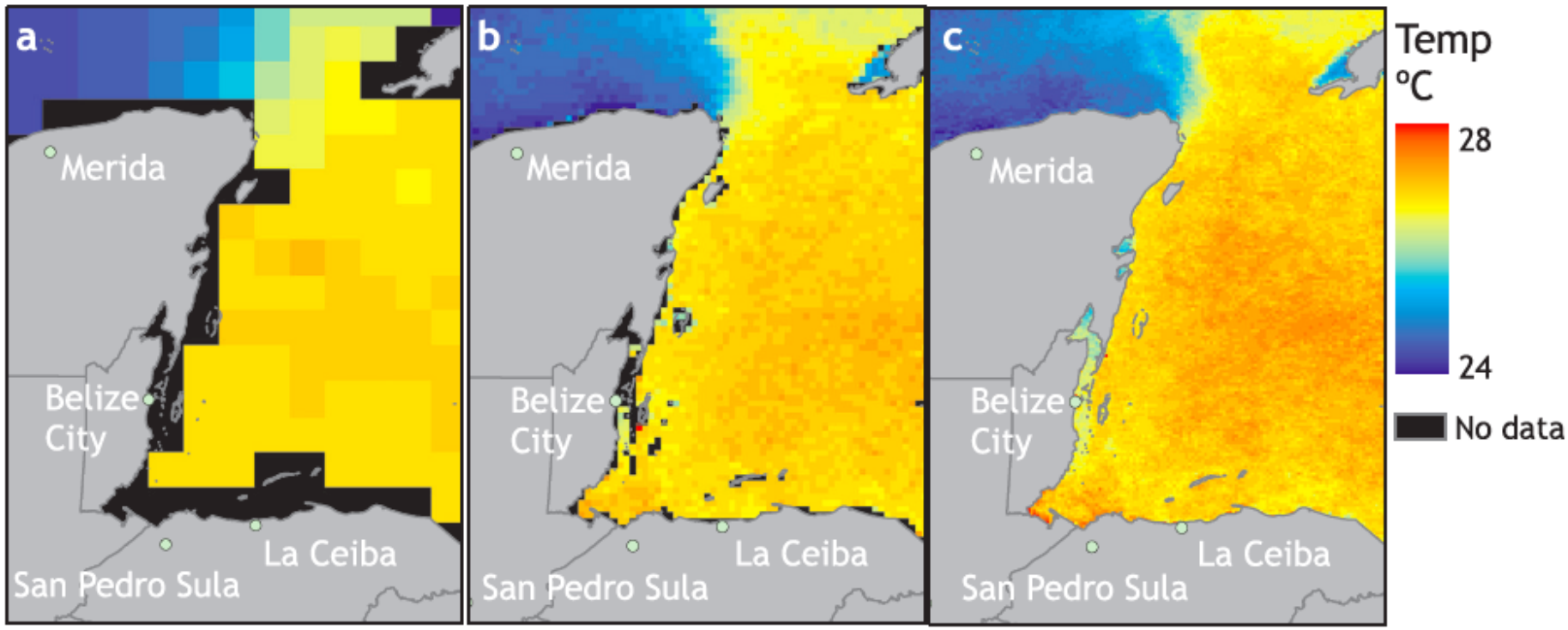
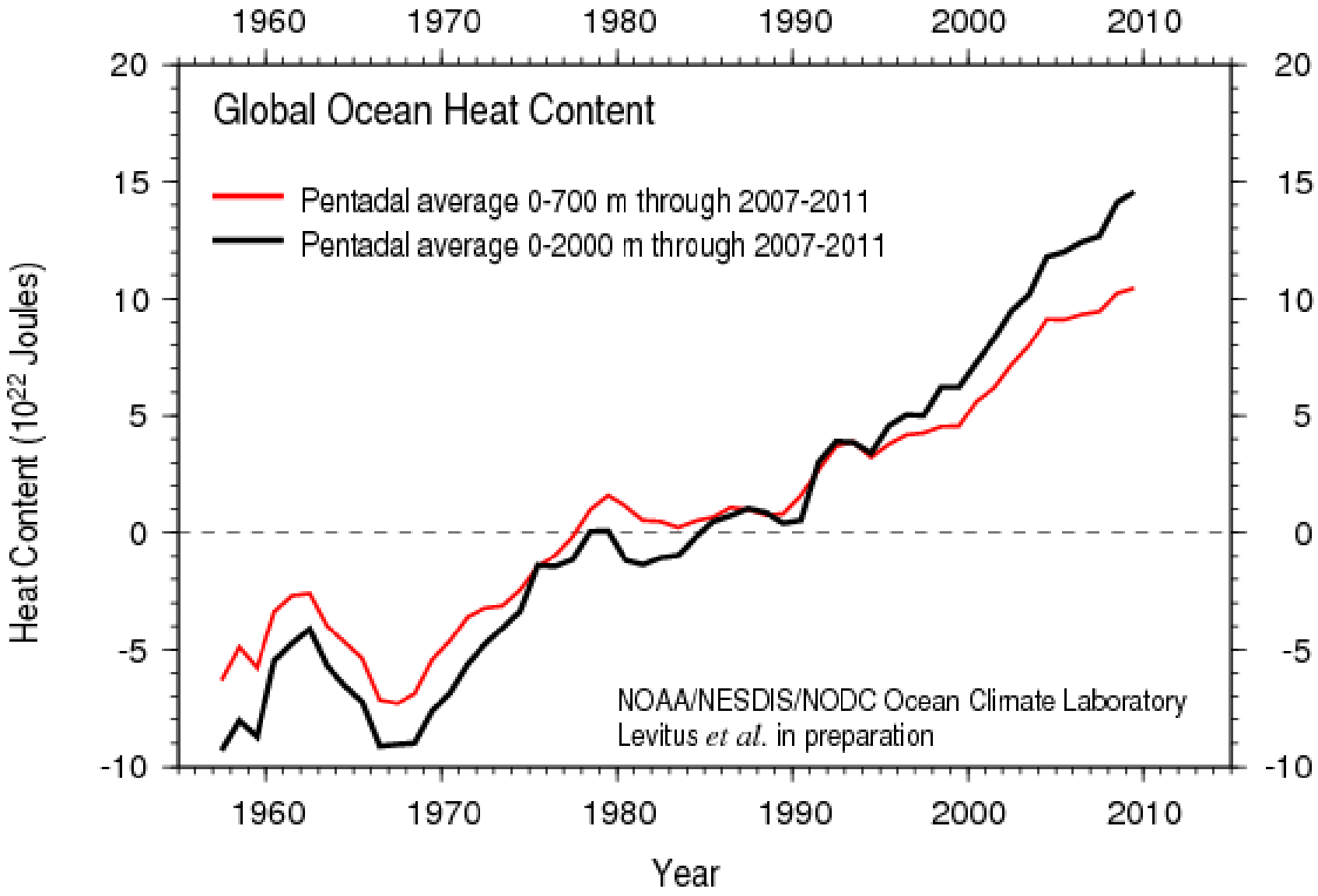
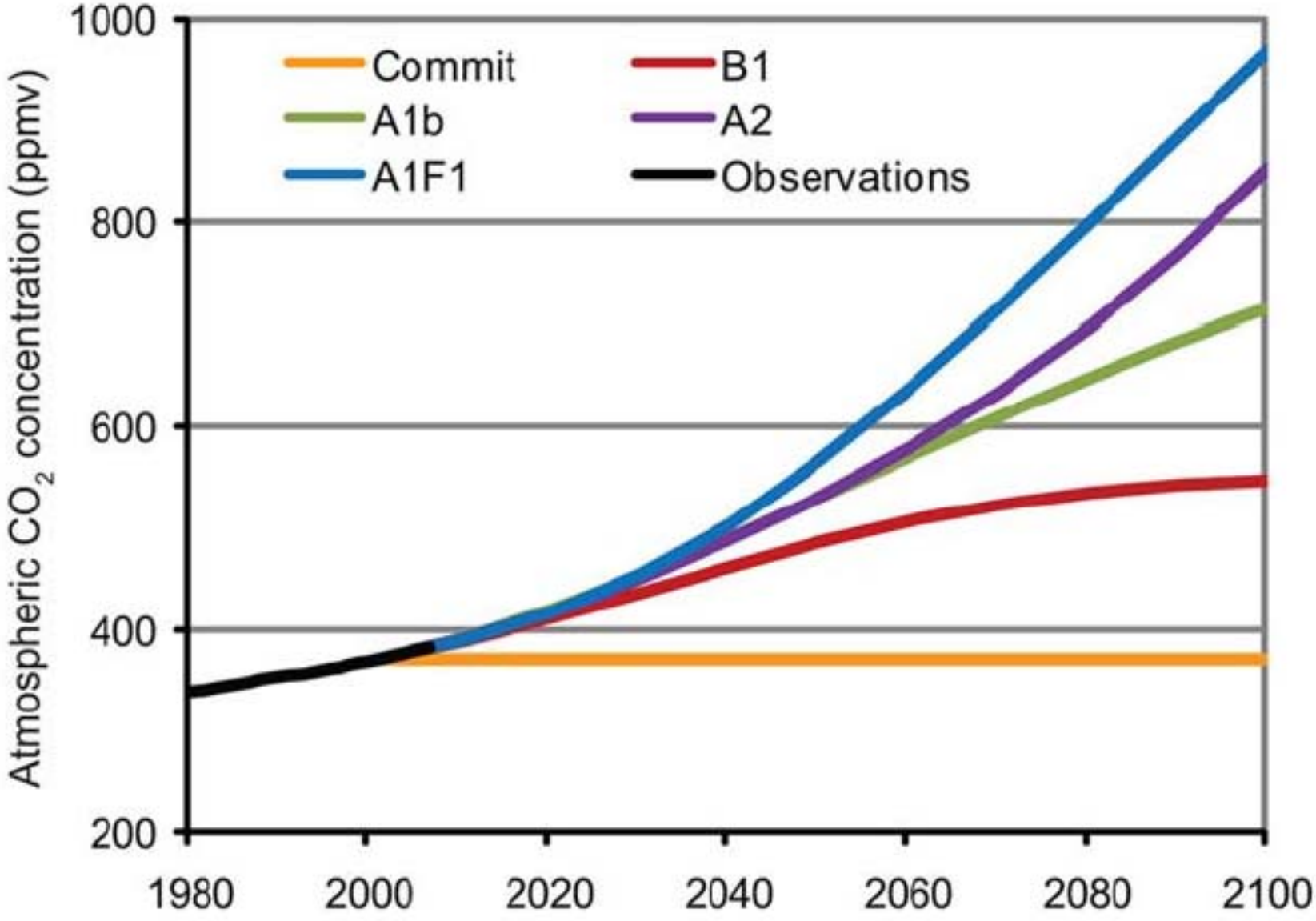


Plate 1. An example of the benefits of increasing resolution on the Yucatan peninsula and Caribbean Sea from; (a) 50 km HotSpot data to (b) 9 km Pathfinder data to (c) 4 km Pathfinder data. In the 4 km data, there is less missing data, allowing for greater coverage of coastal areas where many reefs occur. In addition, the 4 km data displays more spatial structure and precision in the temperature values. Data are from January climatological averages, monthly for the 50 km data and from the first week of January for the 9 km and 4 km data.

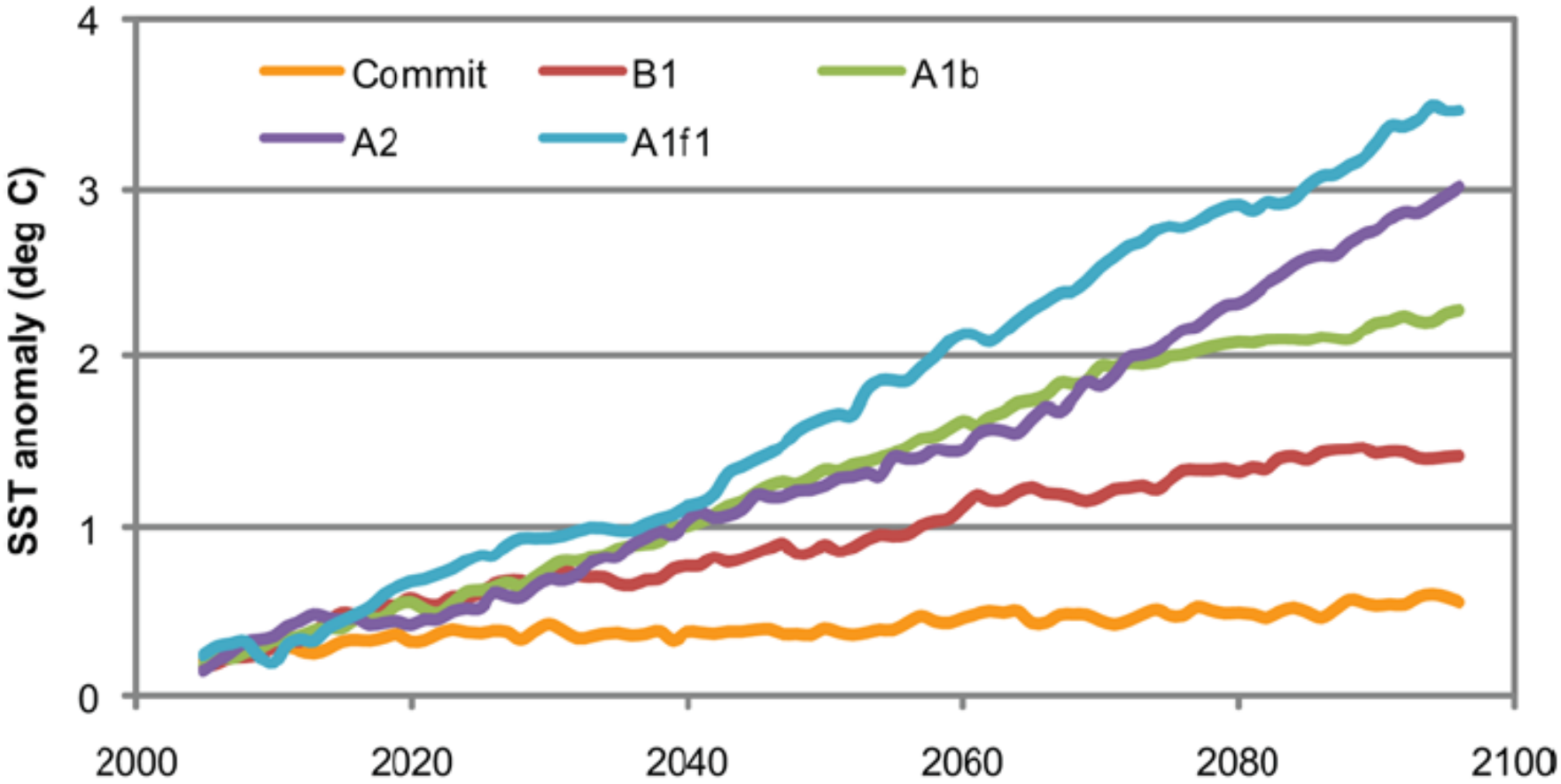
Selig et al 2006

The ocean is warming





Donner 2009 PLoS One



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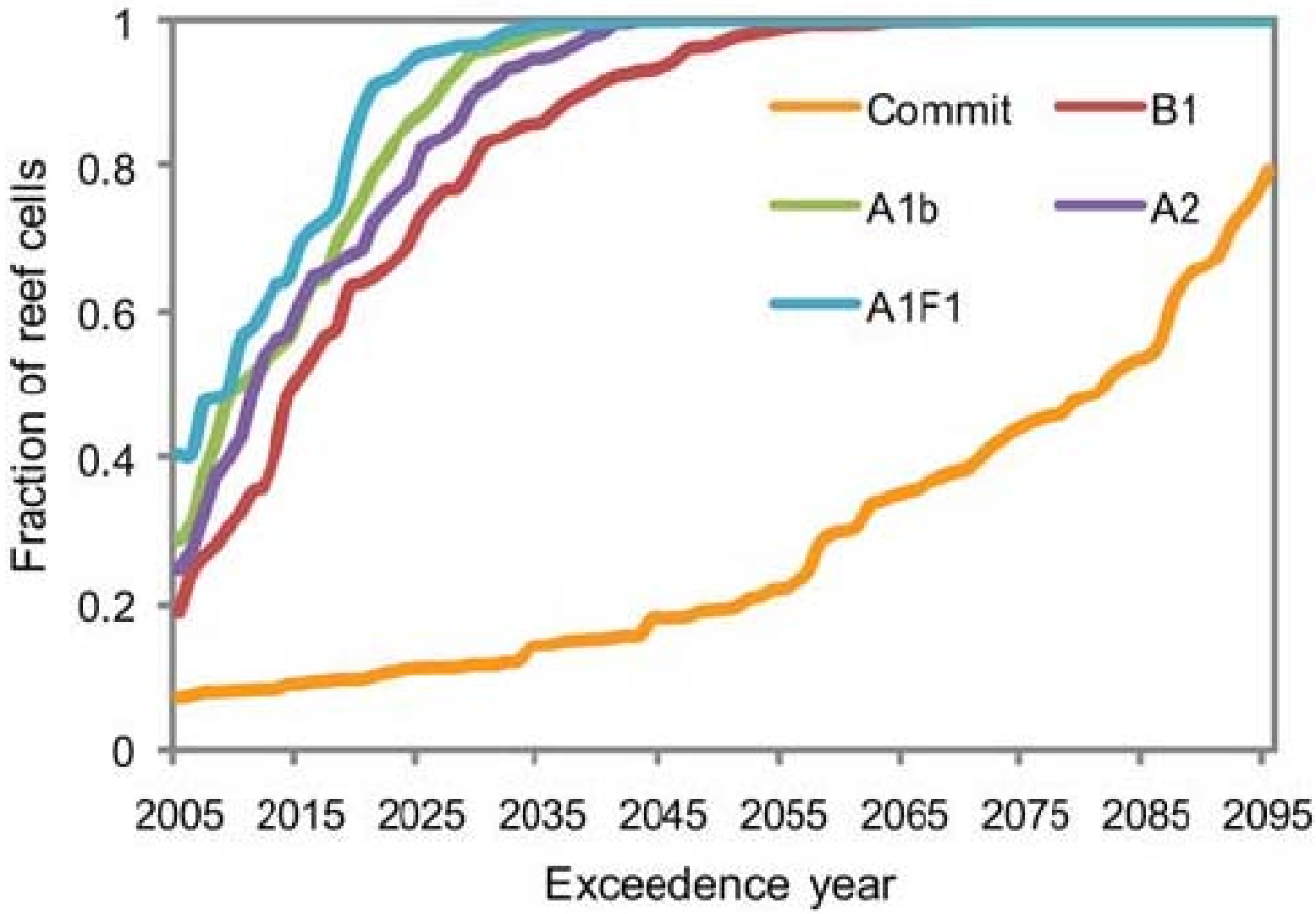


Donner 2009 PLoS One

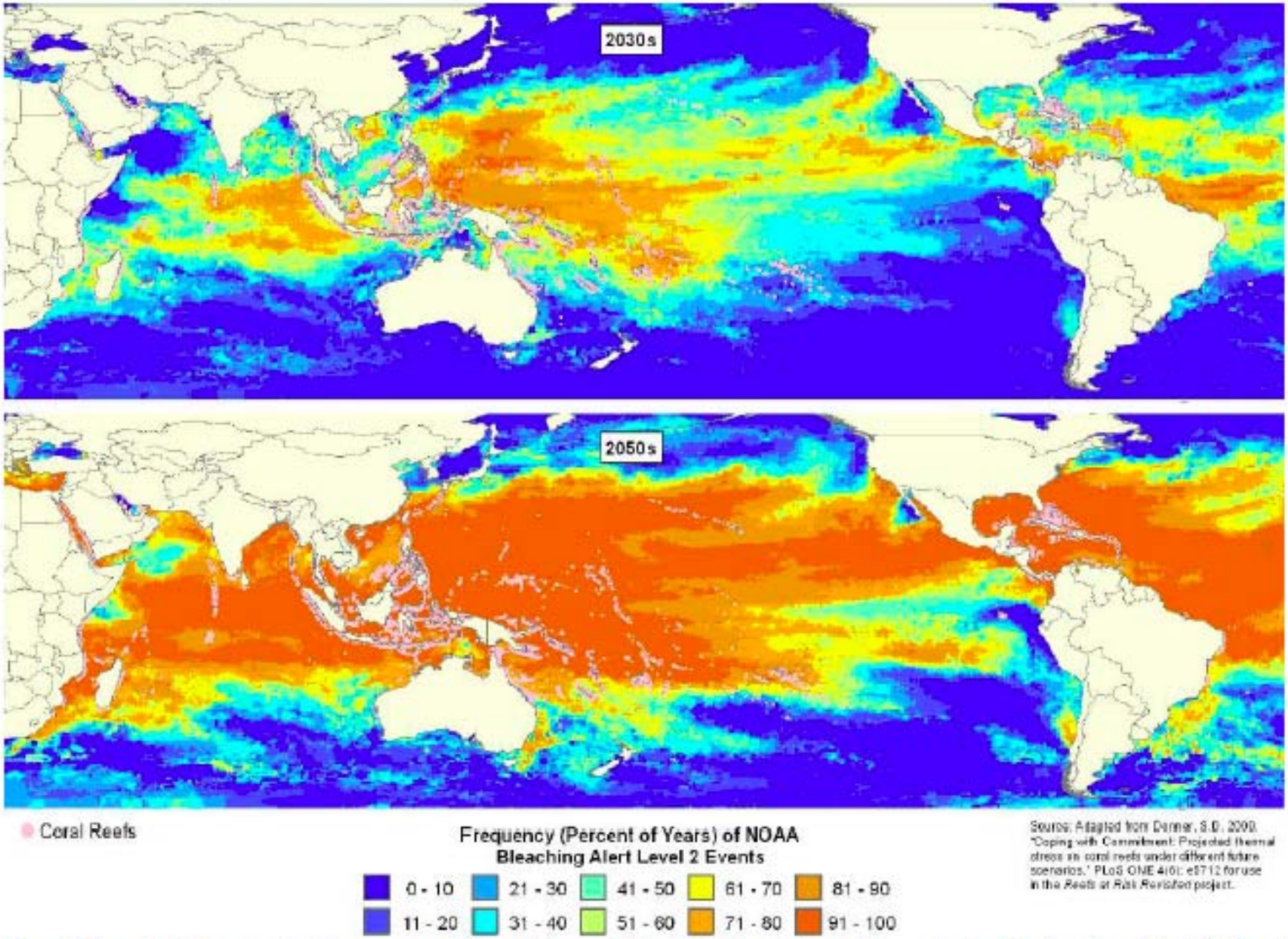
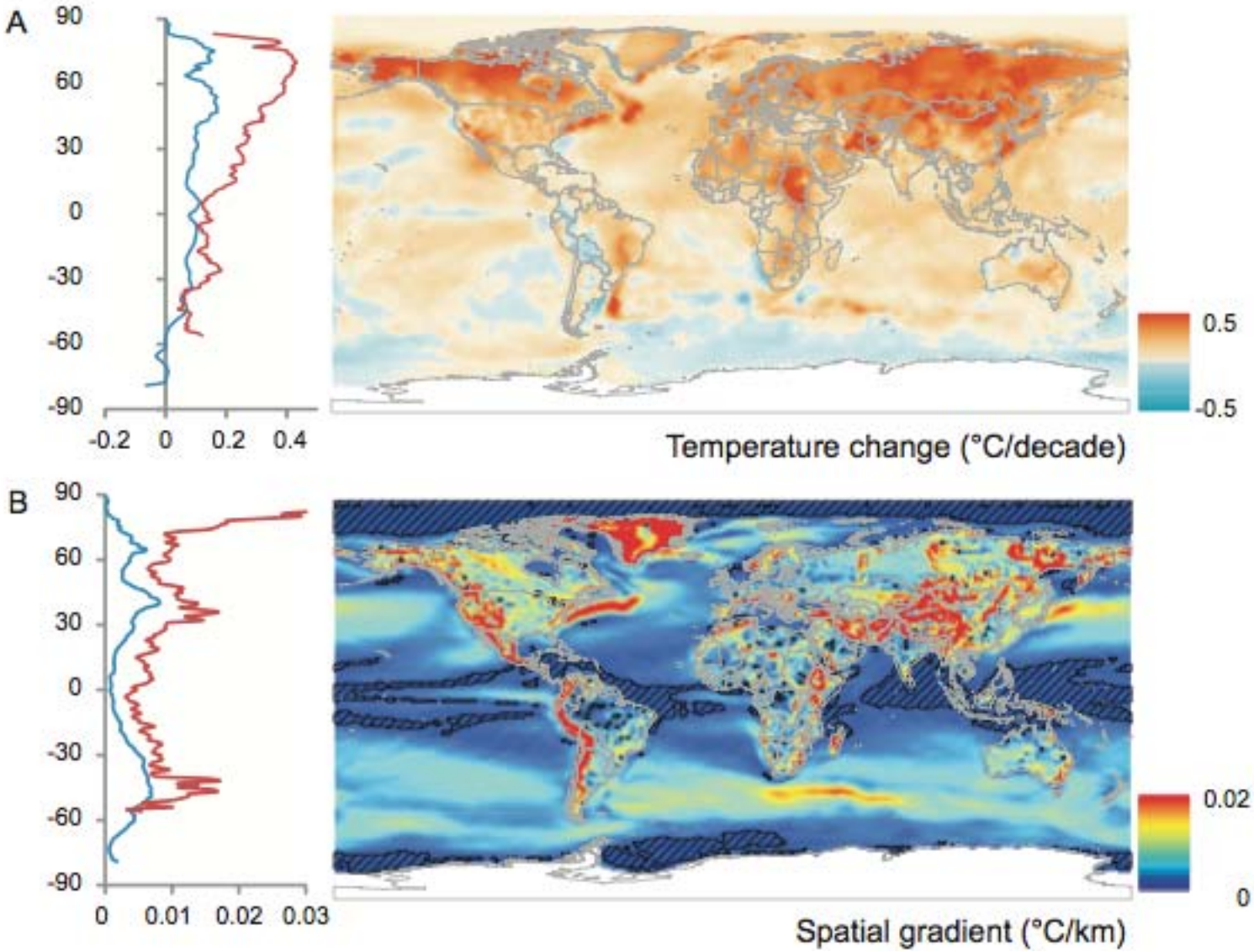


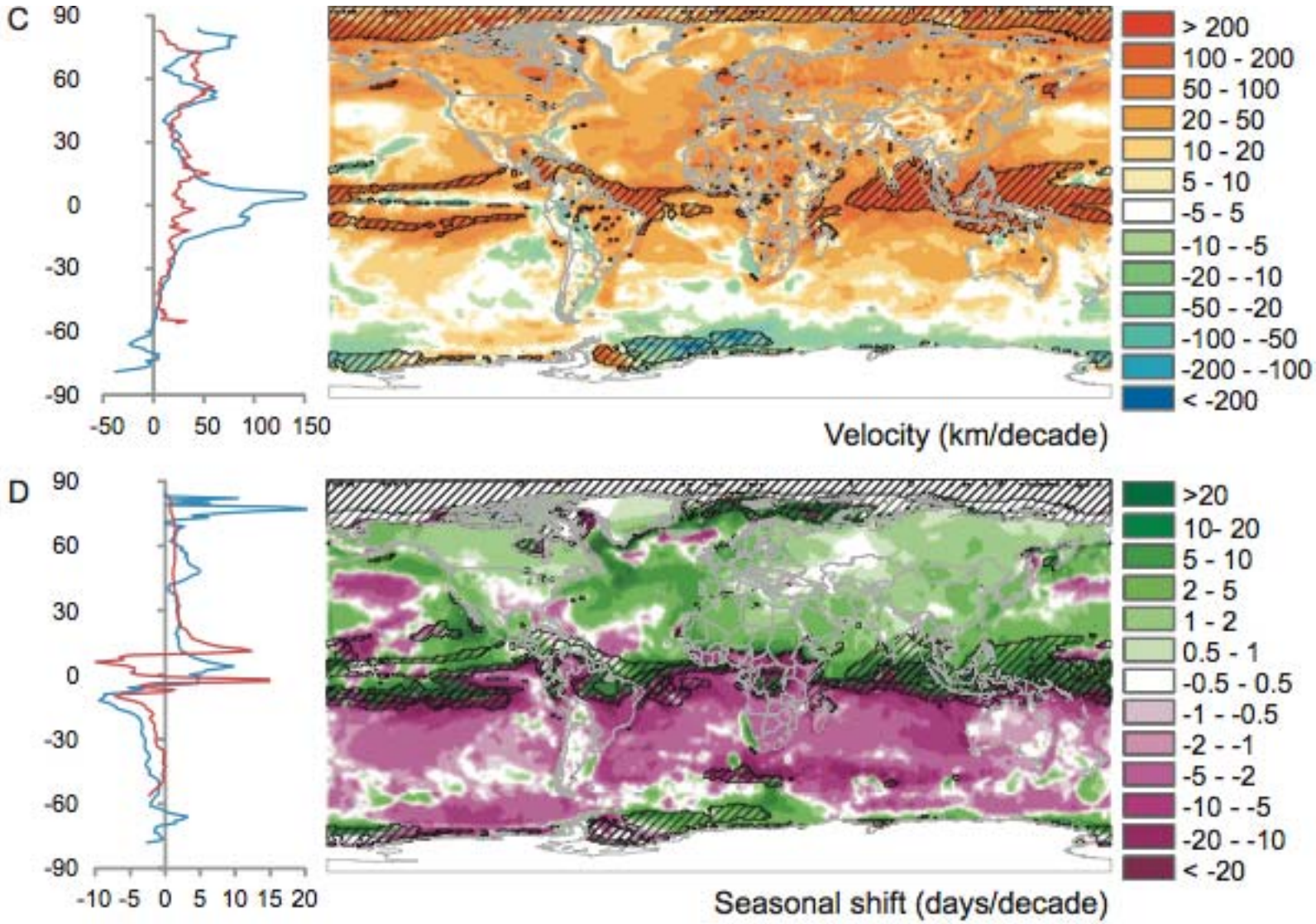
Figure 3.2.7. Global map of reef areas expected to suffer coral bleaching from thermal stress during the decades of the 2030s and 2050s. Risk was assessed through a GIS-based analysis of risk compiled from model data using the IPCC A1B "business as usual" scenario. For details on methods, please see the original publication. Source: Reefs at Risk Revisited (Burke et al., 2011) adapted from Donner (Donner, 2009).

The velocity of climate change

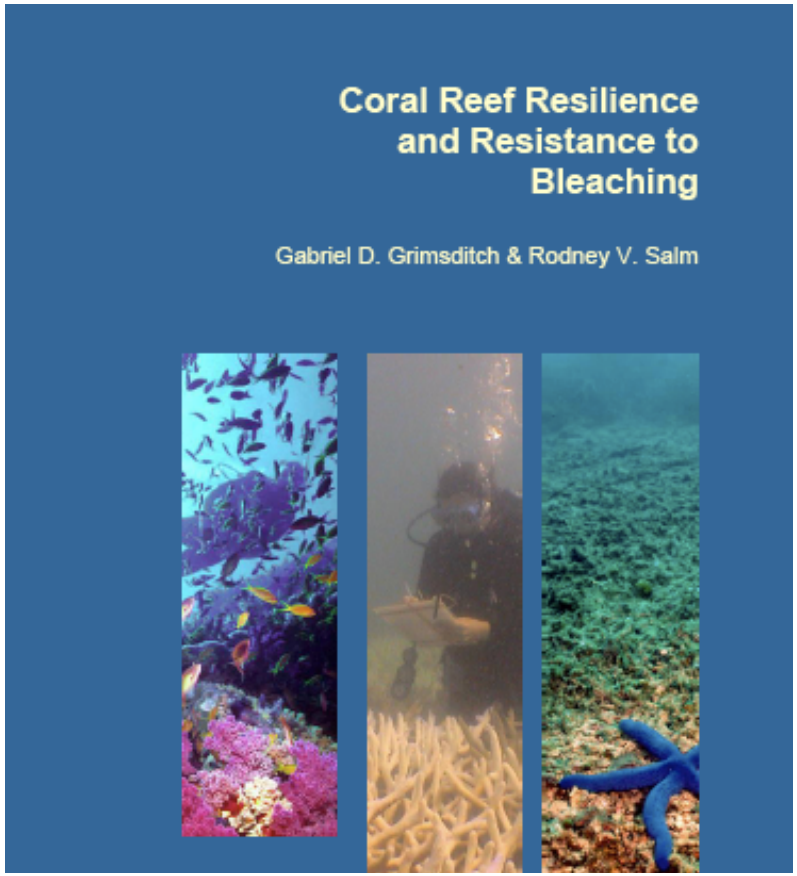


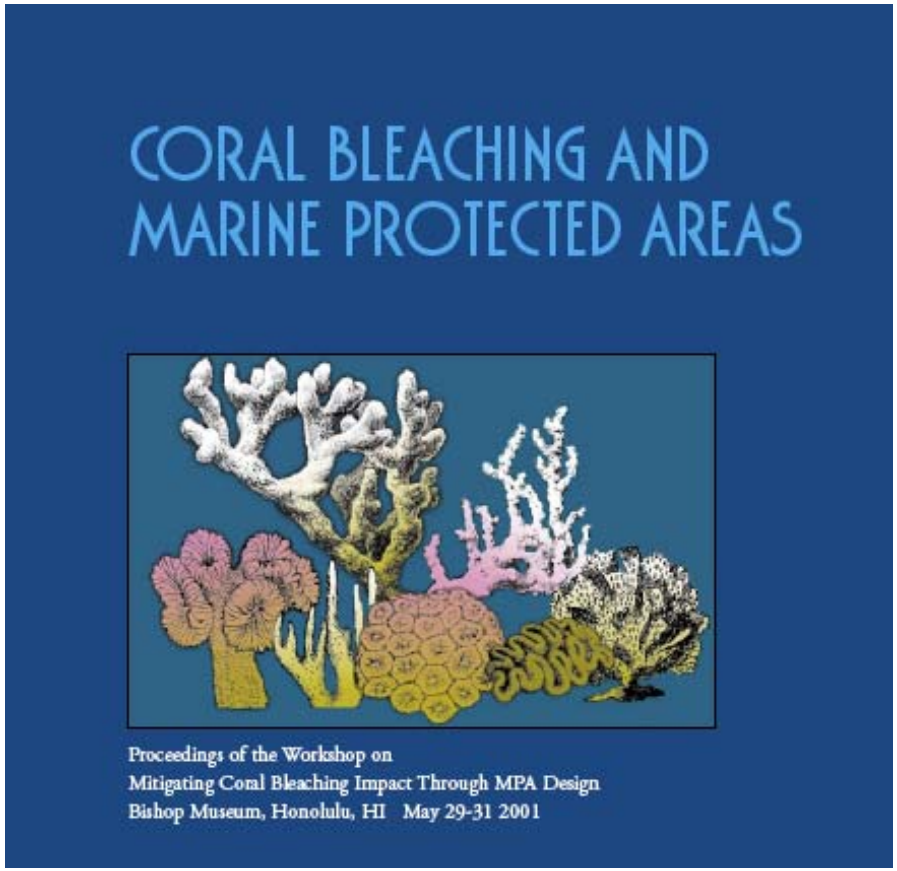
Burrows et al 2011 Science

The velocity of climate change



Burrows et al 2011 Science

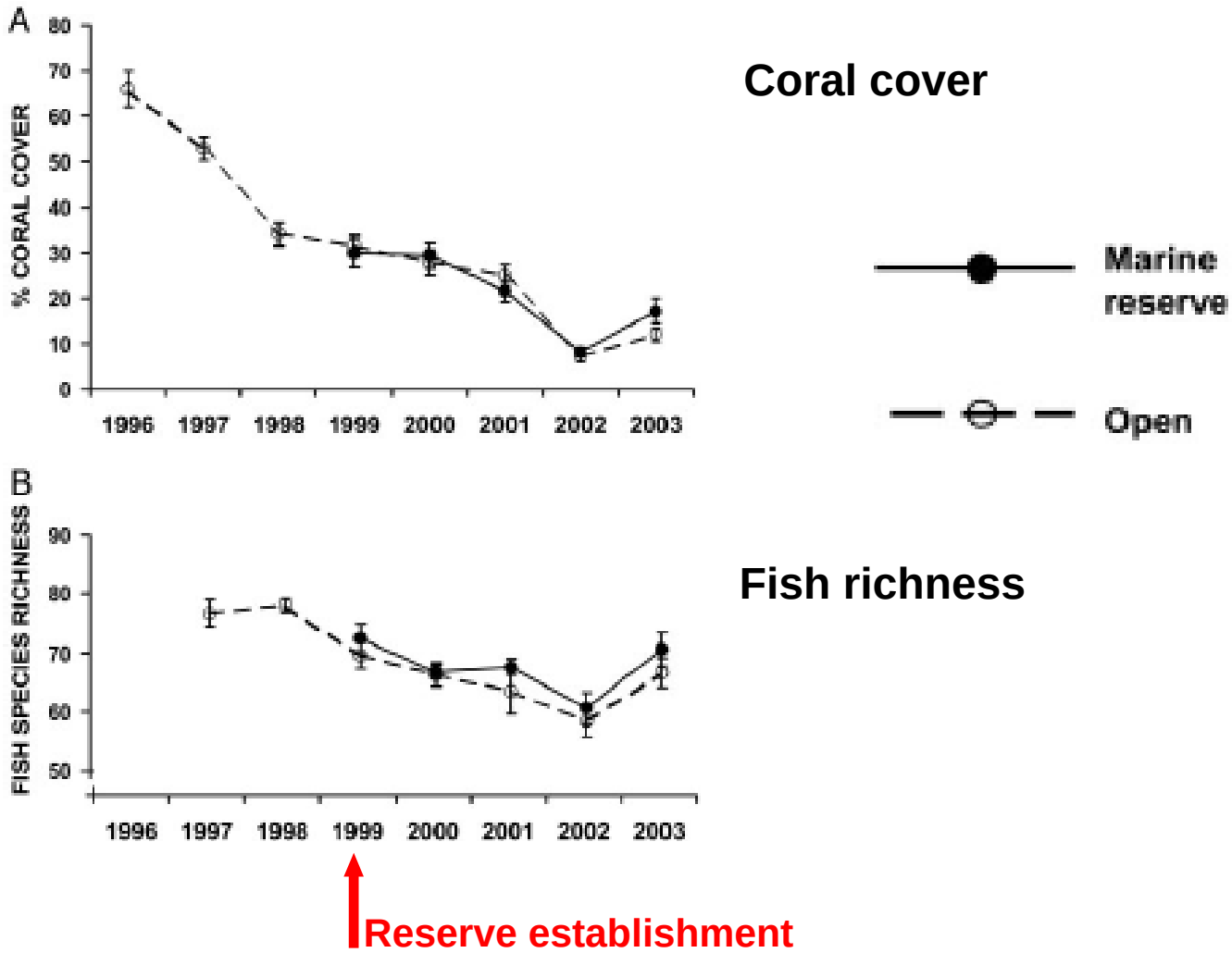




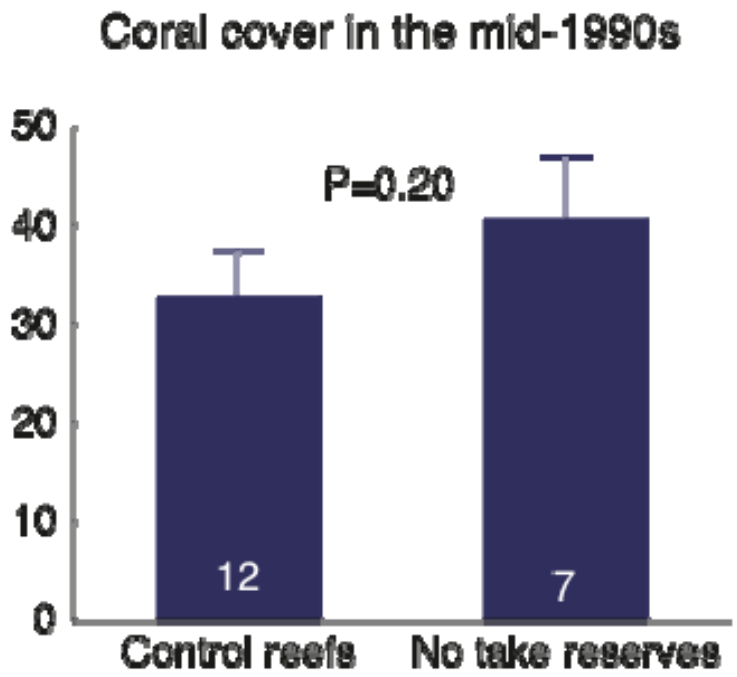
"local protection can make reefs resilient to the impacts of global change"

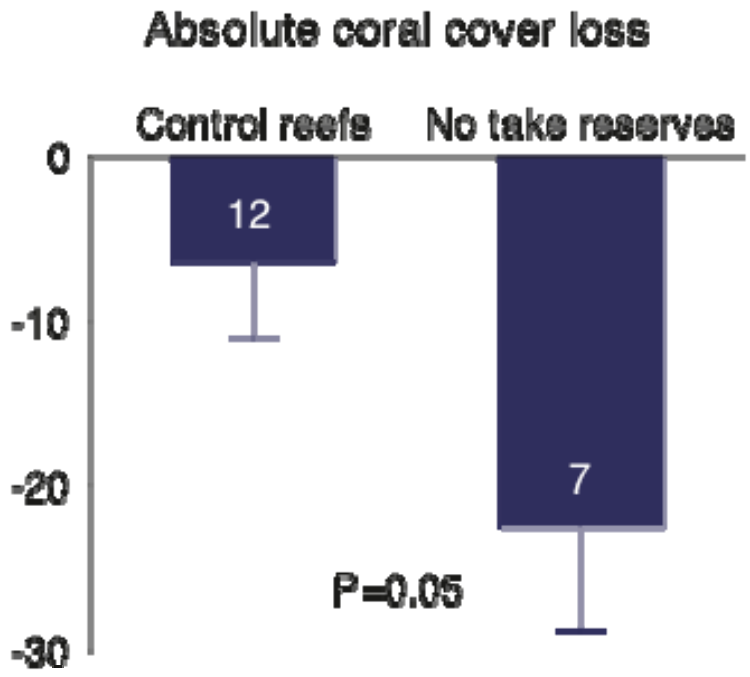
“when the ecosystem structure is intact, the corals appear to bounce back better from previous warm water events that have killed coral."

Papua New Guinea: no-take reserves did not prevent coral or fish loss (Jones et al. 2004)



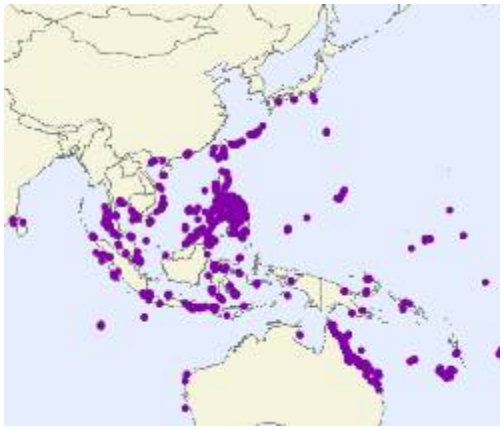
Indian Ocean: no-take reserves did not reduce coral loss during the 1998 El Niño (Graham et al. 2008 *PLoS One*)





Do reserves increase resilience to climate change?

Selig 2008, Selig et al 2012



Coral cover surveys

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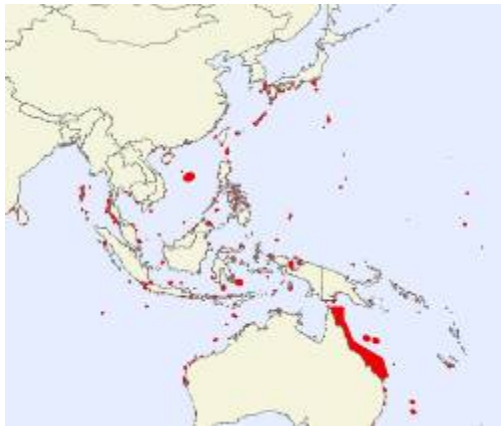

MPAs

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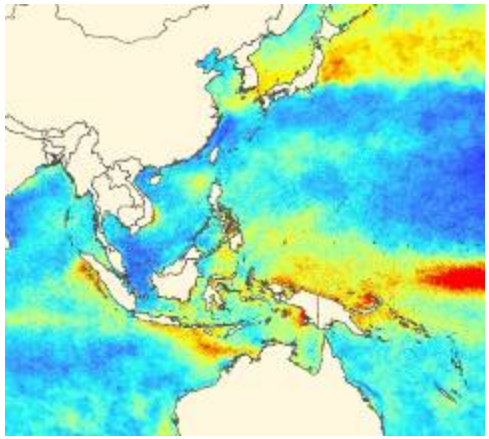
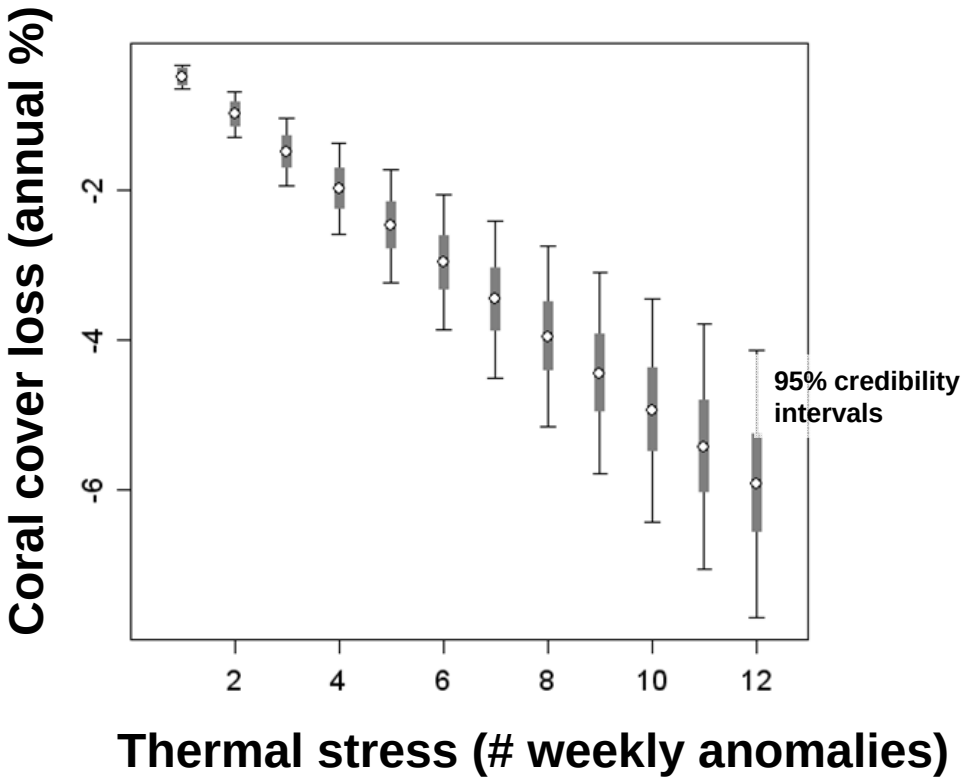


Number of warm temperature anomalies
Selig et al. 2006

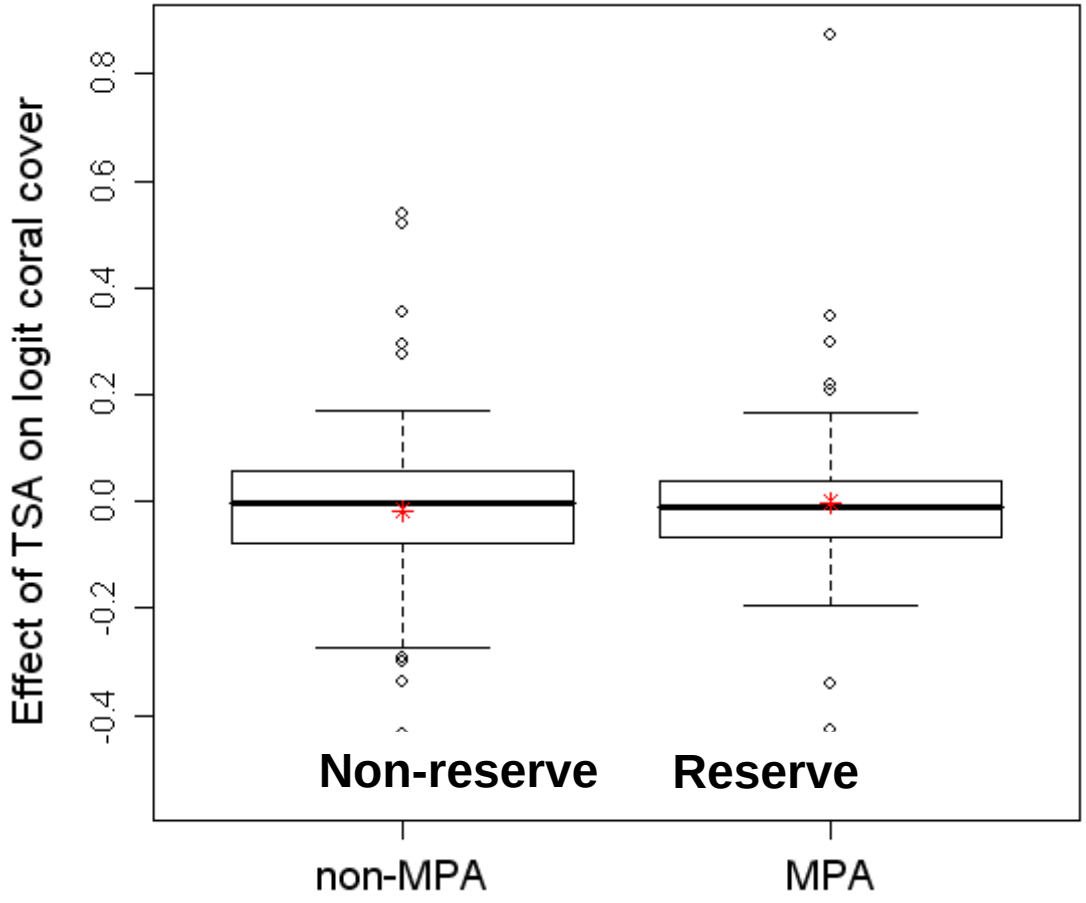
Relationship between thermal stress and coral loss

Selig 2008, Selig et al 2012

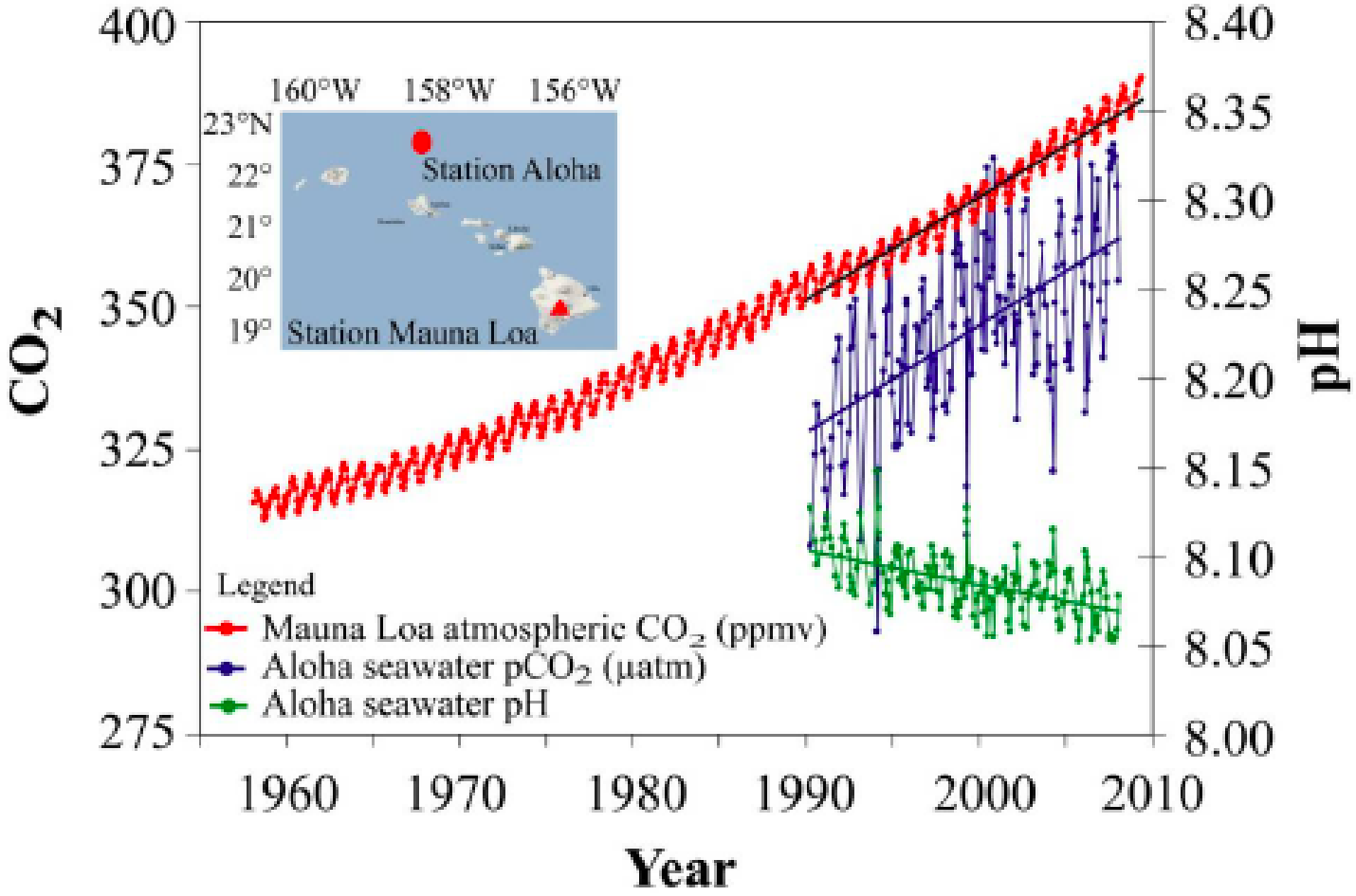
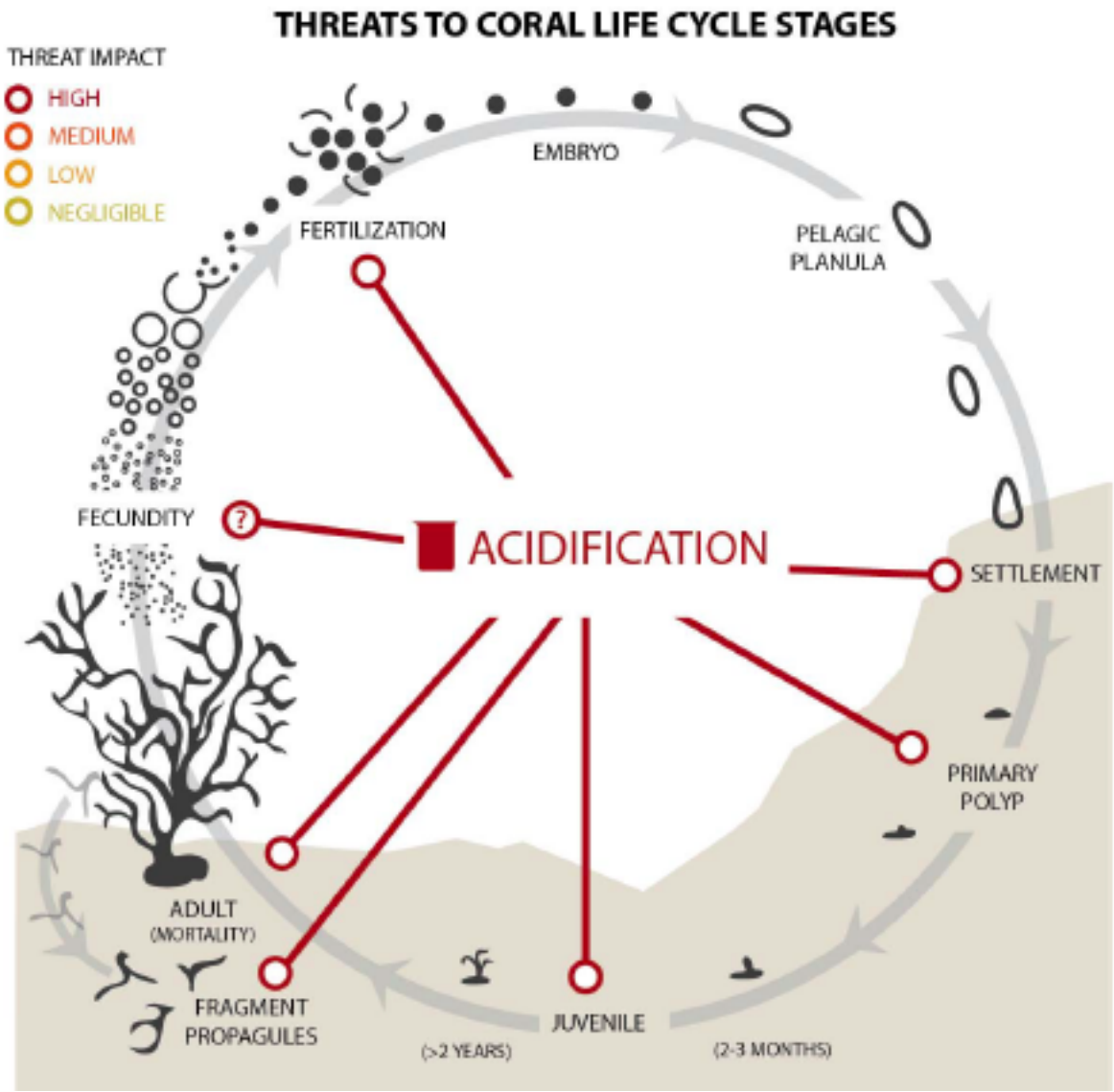
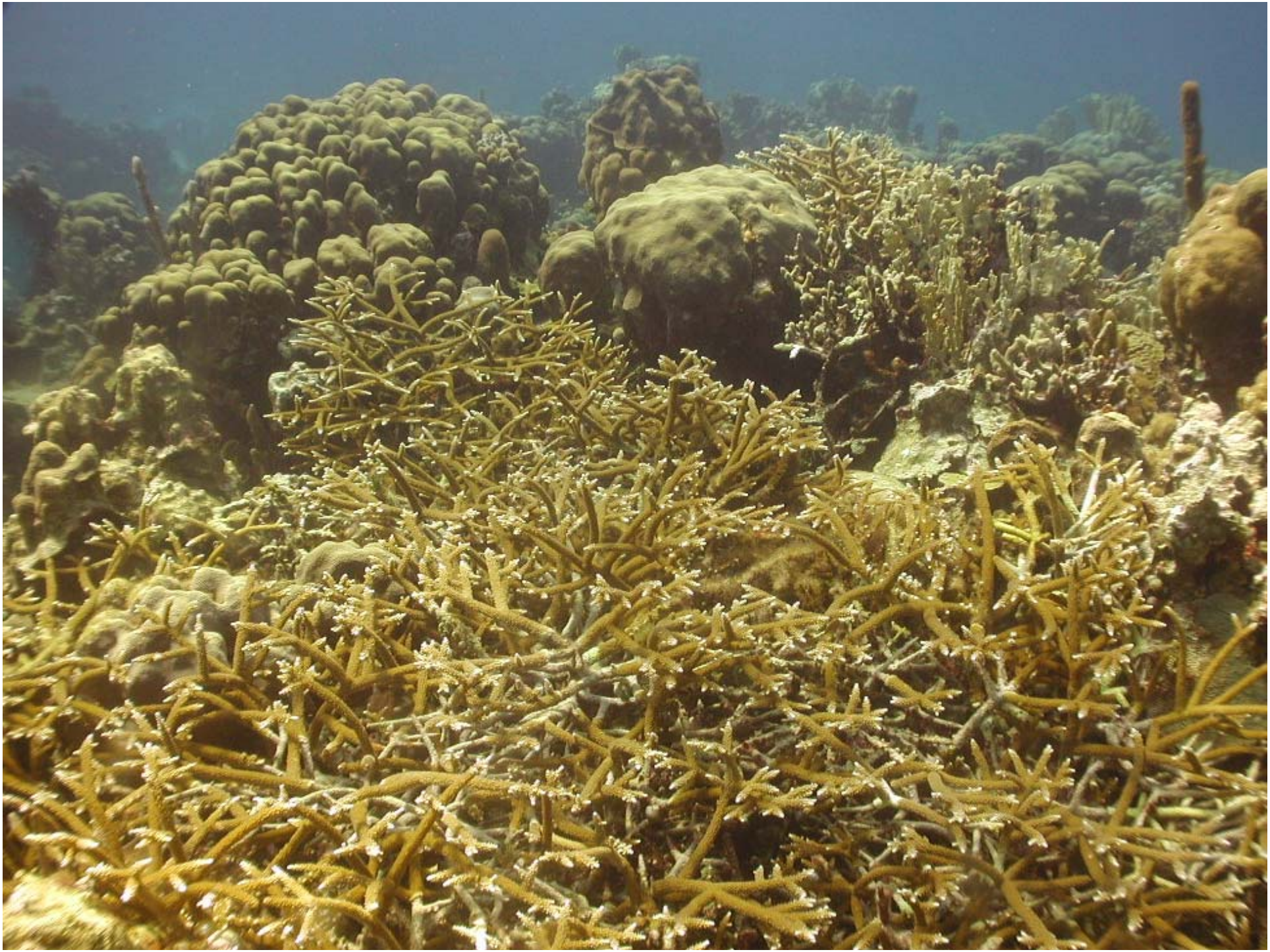


***loss at initial cover of 50%**

Protection did not moderate the effect of temperature anomalies on coral loss (Selig 2008, Selig and Bruno in prep.)



Ocean acidification



Ocean acidification