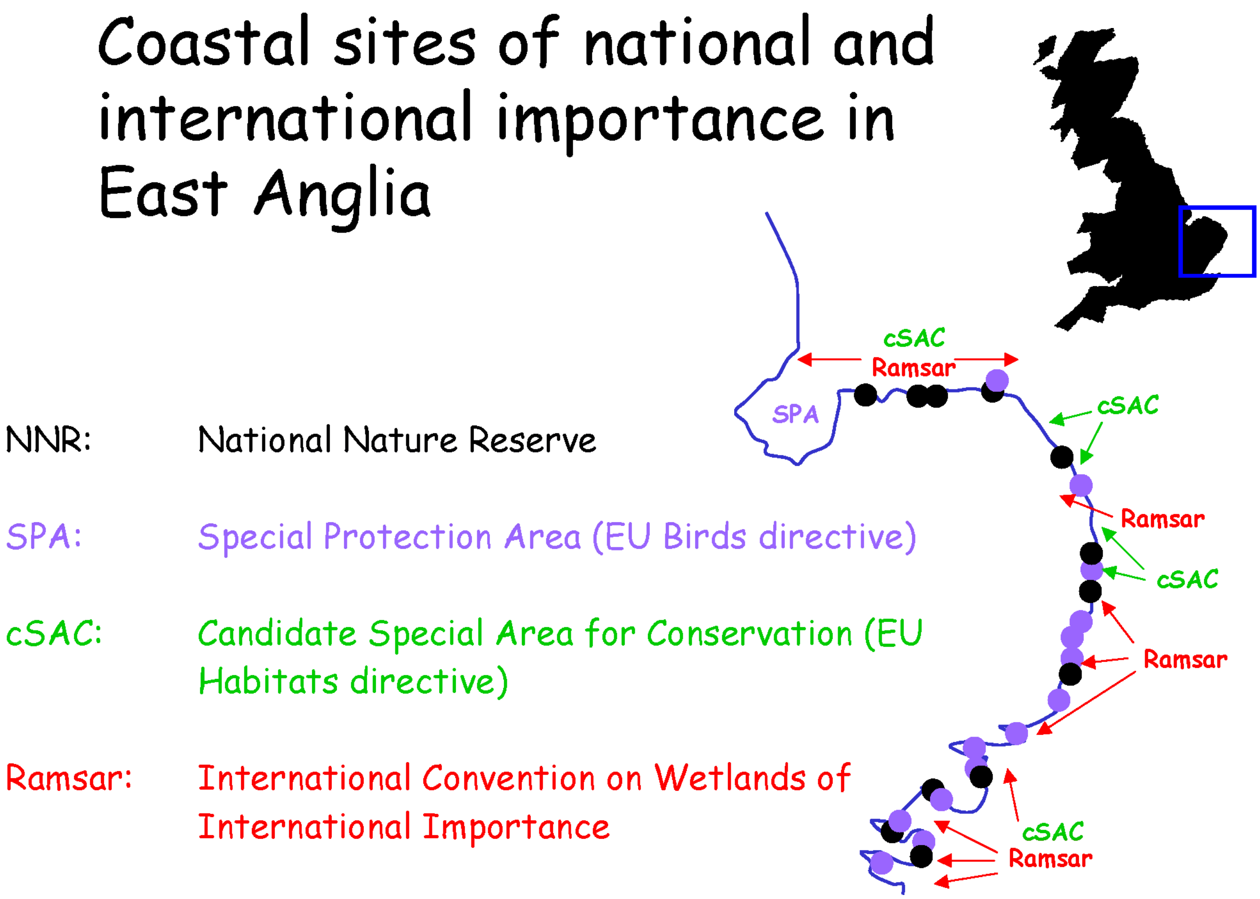
distribution are linked to models of species' responses to climate change and sea level rise. The Regional Coastal Simulator, which is being developed at the Tyndall Centre, aims to integrate these processes to provide a tool for coastal managers to explore the consequences of sea level rise and associated policy decisions in East Anglia.



Coral reefs and global climate change: implications of changed temperatures, sea level, atmospheric carbon dioxide and cyclone regimes

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Global climate change poses a substantial risk to the biodiversity, ecosystem functioning and productivity of coral reefs worldwide, and thus threatens their socio-economic value to human societies. In addition to impacts from climatic change, coral reefs are also under pressure from human activities (eg pollution, harvesting and coastal development) and natural stressors (eg crown-of-thorns starfish and disease).

Historically, these ecosystems have typically been managed through marine protected area systems that focus on the threat from readily identifiable and 'tangible' anthropogenic activities such as fishing and development projects. Incorporating the concept of climate change into the management of marine ecosystems is a relatively recent development that has yet to become widespread. However, it is increasingly evident that it is important to view the potential impacts of climate change in context with the other influences acting upon coral reef ecosystems.

In terms of climate change, increasing sea temperatures are a matter of major concern for coral reefs throughout the world. Coral bleaching is a stress response where the algae symbionts (zooxanthellae) are ejected from the coral host, depriving the coral of nutrition from the products of photosynthesis. Death of the host may result in severe cases. Bleaching can be triggered by a variety of stressors, but temperature-related events are the most widespread. Coral reefs have already suffered major mortalities in many parts of the world as a result of high-temperature events, and there are projected increases in the number and magnitude of anomalously warm episodes. Increasing global sea temperatures may allow further expansion of coral reefs into the sub-tropics, but such processes are likely to be too slow to compensate for the loss of coral reefs to increased bleaching impacts associated with rising temperatures. Also expected to increase are the intensity and breadth of the destructive impact of extreme cyclones and flood plumes.

On a positive note, cyclones can be beneficial to coral reefs by encouraging mixing of surface and deep water, thereby cooling temperatures for a few days, which could be critical during times of harmfully warm waters. Rising sea level may promote growth of some shallow reef communities currently limited by water depth, but some deep areas may suffer from reduced light intensity as water depth increases, particularly where vertical accretion rates are reduced in stressed reefs. Increased atmospheric CO_2 will marginally reduce the alkalinity of reef waters, causing an increase in the rate of chemical dissolution of existing reef limestone, and a decrease in the deposition rate and strength of new limestone deposits. The net effect of climate change on coral reefs will depend on their ability to adapt, but these ecosystems are generally regarded as already living near or at their thermal tolerance limits.

Reef systems are highly heterogeneous in relation to the various influences acting upon them, which include responses and vulnerabilities to temperature-related bleaching events. When considering potential impacts of global warming, a marine park manager will want to know which areas of reef are more likely to escape heat stress or are more resistant to the impacts of climate-related bleaching. Coral bleaching research at AIMS includes spatial risk assessment and forecasting of ecological responses under various IPCC (Intergovernmental Panel on Climate Change) scenarios. Modelling spatial variation in the likelihood of reef areas being exposed to harmfully high temperatures combines regional sea temperature predictions, local patchiness from satellite-derived sea surface temperatures and data on bleaching thresholds. The Great Barrier Reef suffered a major bleaching event in 2002, and systematic ecological assessments of this event provided data on taxonomic patterns of coral survival, injury and death. Mapping the future risk in terms of ecological impact and recovery will be relevant to short-term interests of the tourism industry, and also to management actions seeking to sustain the long-term ecological structure and functioning of coral reefs. The products of this research will be important tools for decision-makers who can implement the scientific findings into policy-making processes.

GLOBAL CLIMATE CHANGE AND BIODIVERSITY
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Figure 1. *Sea temperature anomalies on the Great Barrier Reef in 1997–98 and 2001–02. The highest sea temperature on record occurred in 2002.*

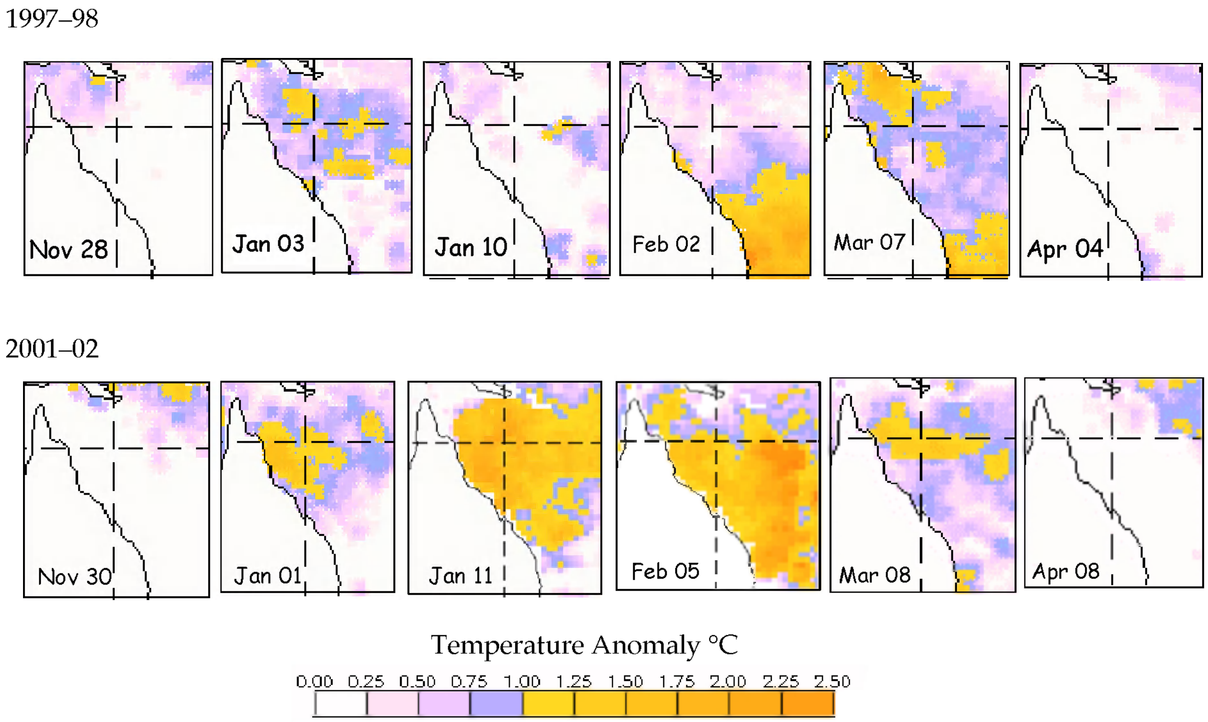

Figure 2. *Recent and projected probability distributions for durations of periods of exceedance of threshold sea temperature for damage to corals on the Great Barrier Reef. Vertical lines separate classes of expected coral damage.*