**Putting the Topic of Coral Bleaching Together**

**Claim/Thesis:** Rising sea surface temperatures are the main risk for coral bleaching in the Great Barrier Reef.

**Subpoint:** Vulnerability to climate change due to rising temperature (Sea surface temp.)

**Subpoint:** Rising sea surface temperatures.

**Subpoint:** Coral bleaching is the stress response of coral losing its photosynthetic pigments.

**Vulnerability to climate change due to rising temperature (Sea surface temp.)**

* Global warming rates are higher today, then those in the geological past (Pandolfi)
* Coral reefs have suffered dramatic declines as a result of climate change over geological time, with multiple expansions and contractions in reef growth associated with environmental drivers during the past 270 million years (Pandolfi)
* The tabular coral Acropora hyacinthus is fast-growing and typically dominates shallow wave-exposed habitats on the Great Barrier Reef, but it is extremely vulnerable to climate-induced coral bleaching and other disturbances (e.g. cyclones and outbreaks of crown-of-thorns starfish) (Linares C)
* Coral bleaching is a stress response to sea surface temperature (SST)

anomalies that are driven by global climate change leading to variations in regional climatology (Osman EO)

**Rising sea surface temperatures**

* SST is one of the 3 big effects of global warming. The other 2 are Ocean acidification and sea-level rise (Pandolfi)
* A common response to warmer SSTs is the migration of populations to track favorable temperatures, resulting in real and projected shifts in species ranges (Pandolfi)
* Tropical reef species have already moved to higher latitudes in Florida, east and west Australia, and Japan (Pandolfi).
* The onset of bleaching is typically predicted to occur when the SST exceeds a local climatological maximum by 1°C for a month or more (Donner SD)
* Increases in sst over the next several decades are projected to make coral bleaching a frequent occurrence and threaten the long-term viability of coral reef ecosystems around the world (Donner SD)
* the extent of bleaching is

inevitably affected by the duration (Anthony, Connolly, & Hoegh-

Guldberg, 2007) and periodicity (Pratchett, McCowan, Maynard, &Heron, 2013) of SST anomalies relative to historical SST patterns, For example, reoccuring thermal events can increase stress tolerance (Armoza-Zvuloni, Segal, Kramarsky-Winter,& Loya, 2011; Palumbi et al., 2014) particularly in corals with high energy reserves (Grottoli et al., 2014) and in those hosting phenotypically plastic symbionts (Osman EO)

* At elevated seawater temperatures, many scleractinian corals lose substantial numbers of their photosynthetic endosymbiotic dinoﬂagellates (Symbiodinium spp.) giving the colony a pale (hence bleached) appearance and often resulting in mortality (Grottoli AG)
* Global mean surface temperature has been substantially higher than preindustrial levels during past intervals of high atmospheric CO2 concentrations (Pandolfi).
* if SST increases by +2°C, as could occur by 2100 under current warming trajectories, the number of thermal stress events will increase (Ainsworth TD)
* The sensitivity of reefs to such warming varies geographically ([**Fig. 3, H, M, and R**](http://science.sciencemag.org/content/352/6283/338#F3)). For example, reefs in the southern GBR could experience more single bleaching trajectory events at lower temperature increases than elsewhere on the GBR (Ainsworth TD)
* there is a 1°C increase in SST, the majority of reefs are likely to experience single trajectory bleaching at least once per decade (Ainsworth TD)
* Thermal tolerance hasn’t been recognized, and not all reefs have adapted to the sst increases. This is because adaption rates in coral reefs is unclear. If we can figure out the mechanisms of adaption in corals then it may impact climate change and improve the chances of coral reefs ecosystem recovering (Ainsworth TD).

**Coral bleaching is the stress response of coral losing its photosynthetic pigments**

* when it comes to coral mortality, sometimes coral reefs die from coral bleaching (Pandolfi)
* Coral bleaching is the whitening of corals due to loss of symbiotic algae and/or their pigments, and this can be triggered by temperature increases (Mcwilliams JP)
* Coral bleaching is a stress-related response that can be triggered by elevated SST (Mcwilliams JP).
* In the past three decades, bleaching events have caused reef-wide declines in coral across the Great Barrier Reef (Ainsworth TD)
* The frequency and intensity of such bleaching events are expected to increase as sea surface temperature (SST) continues to rise under climate change (Ainsworth TD)
* Cell death is a conserved response to thermal stress and represents the cellular driver of partial- and whole-colony mortality (Ainsworth TD)
* These periods of anomalous sea surface temperature (SST) can lead to coral bleaching, a breakdown of the symbiosis between the host coral and symbiotic dinoflagellates which reside in coral tissue (Donner SD)
* If bleaching becomes an annual event later in this century, more than 90% of coral reefs worldwide may be at risk of long-term degradation. While corals can recover from single isolated bleaching and can acclimate to recurring bleaching events that are separated by multiple years, it is

currently unknown if and how they will survive and possibly acclimatize to annual coral bleaching. (Grottoli AG)

* Overall, these ﬁndings indicate that cumulative impact of annual coral bleaching could result in some species becoming increasingly susceptible to bleaching and face a long-term decline, while phenotypically plastic coral species will acclimatize and persist. Thus, annual coral bleaching and recovery could contribute to the selective loss of coral diversity as well as the overall decline of coral reefs in the Caribbean (Grottoli AG)
* Bleaching varies among species, depths, and locations (Grottoli AG)
* Cell death is a conserved response to thermal stress and represents the cellular driver of partial- and whole-colony mortality (Ainsworth TD)
* However, corals experiencing the single bleaching and repetitive bleaching trajectories did not acquire thermal tolerance, which resulted in poorer physiological outcomes and a greater loss of symbionts and coral tissue during coral bleaching (Ainsworth TD)
  + maximum monthly mean (MMM) temperature, which sets a baseline from which warming can be identified
  + SST event that exceeded the local MMM but remained below the bleaching threshold. The SST then returned below the MMM, for an average recovery period of 10 days, before increasing above the local bleaching threshold ([**Fig. 1A**](http://science.sciencemag.org/content/352/6283/338#F1) and table S1); we term this the protective trajectory.
  + The second trajectory was characterized by a direct SST increase from below the MMM to exceed the local bleaching threshold, with no pre-stress or recovery period. This trajectory, which we term the single bleaching trajectory,
  + The final trajectory exceeded the local bleaching threshold in two peaks, separated by an average recovery period of 9 days below the local MMM ([**Fig. 1, A and B**](http://science.sciencemag.org/content/352/6283/338#F1), and table S1). We term this the repetitive bleaching trajectory,
* **To help coral reefs recover from bleaching: forming coral energy reserves (Grottoli AG)**