PART I. BLEACHING

HISTORY OF RESEARCH
- Sunbleach was first observed in laboratory cultures in early 1980s
- Occurred in response to photic stress
- Holbrook et al. (1986)
- First observed in field populations at Lee Stocking Island in 1998
- Coral post-bleaching survey
- First observed in Florida Keys populations in late June 1991 but present in May 1991
- Observed in Florida Keys populations 1991 through present
- Observed in all tropical oceans since 1991 (opportunistic sampling)
- Increased prevalence at higher subtropical latitudes

MAJOR FINDINGS
- Bleaching in Amphistegina occurs in response to photic stress
  - Primarily wavebands 680-700 nm
  - Intensity of photic stress fluctuates
- Bioerosion - peaks near summer solstice
- Isotopically
- Acute photic stress impacts reproduction and reduces recruitment
- Chronic photic stress increases susceptibility to predation and microbial infection
- Bleaching in reef-dwelling foraminifers appears to be related to the effects of stratospheric ozone depletion
- Including anomalous CO2 breakdown

PARADOX
Amphistegina still thrive in the clearest offshore waters of the Florida Reef Tract, where stony coral cover has declined most!
- Paradox solution:
  - Amphistegina populations can recover from mortality events in a few years
  - They remain most abundant in best habitat
  - Corals require years to decades to recover from mortality events
  - Photo-oxidative stress is reduced in unshaded waters
  - Corals are currently "squeezed" between
    - Exposure potentially harmful terrestrial runoff
    - Offshore higher photo-oxidative stress

IMPLICATIONS
- Urgent need to preserve mangroves and coastal habitats
- Protect land from the sea
- Protect reefs from terrestrial runoff
- Protect reefs by producing photo-protective CO2

PART II. FORAMINIFERS AS BIOINDICATORS

QUESTION
Might resource managers utilize indicators of biological condition of reef environments that can relate data acquired through remote-sensing, water-quality and benthic-community monitoring to stress responses in reef organisms?

RATIONAL FOR FORAMINIFERS AS BIOINDICATORS
- Foraminifers are widely used as environmental and palaeo-environmental indicators
- Reef-building corals and larger foraminifers have similar environmental requirements
- A common, easily identifiable genus, Amphistegina, responds to stress similarly to corals
- Short life spans facilitate differentiating between long-term decline and episodic stress events
- Foraminifers are relatively small and abundant, and can be collected quickly and inexpensively
- Foraminifers are not protected species and their collection has minimal impact on reef resources

FoRAM (Foraminifera in Reef Assessment and Monitoring)
- FoRAM Index: Uses foraminiferal assemblages as indicators of suitability of sites for continued reef growth or recovery
- Application for resource assessment; monitoring frequency 3-5 years
- Amphistegina Index: Uses population parameters including abundance on reef flats, as well as prevalence of bleaching, breakage and predation
- Indicators of specific stressors in reef environments
- Application for resource and risk assessment; recommended frequency: twice per year, late spring and late summer
- Biocores: Experimental use of Amphistegina to assess stress responses
- Risk assessment tool needed - protocols in development

FoRAM ASSEMBLAGE INDEX
- Reference: Holbrook et al. (2005), Curran et al. (2008)
- Diagrams: Reed et al. (2011)

AMPHISTEGINA INDEX
Amphistegina spp.
- Occurs on coral reefs worldwide
- Absolomorpha susceptibility to environment for satisfying organisms with algal symbionts
- Bleaching includes photic stress induced by high energy solar radiation (470 nm)
- Tolerates seawater temperature range that most reef-building

FoRAM METHODS
- Collect pieces of reef table (-50-150 cm²) bottom area
- Add sodium with small bottle, using vacuum
- Rinse in covered dish in seawater overnight
- Examine at x40 magnification
- Estimate number of Amphistegina
- Determine % of population with bleached symbionts
- Bleaching can distinguish chronic stress photos stress

REFERENCES: http://www.marine.usf.edu/reeflab/