COASTAL ZONE CLIMATE CHANGE: UNDERSTANDING AND ADAPTATION

There has been a clear awakening to the fact that climate change is underway. Lying at the interface of continental and oceanic realms, coastal systems can be expected to be especially impacted, experiencing the effects of climate change from both the land and the sea. With more than 50% of the U.S. population living in coastal counties, these changes will play out in coastal communities and economies. The LTER provides a network of coastal sites that differ in their biophysical vulnerability to various aspects of climate change, with some being more affected by sea level rise and storm surge (e.g. VCR, FCE); others by acidification (e.g. MCR, CCE); changes in temperature and loss of sea ice (e.g. PAL); or changes in freshwater inflow (e.g. PIE, GCE). These sites will also likely show gradients in human vulnerability, with differences attributable not only to their coastal population density and demographic composition (e.g. FCE vs. VCR) but also in the location and resilience of their built infrastructure (e.g. BES vs. SBC). This range of potential vulnerability positions the LTER network to be able to examine climate change and to better understand the factors controlling human and natural system vulnerability and response. The overarching question we seek to address is: **How do human and natural templates interact to affect vulnerability to climate change in coastal systems?**

Science to understand and anticipate the effects of climate change, to assess vulnerabilities of natural and human elements of coastal systems, and to adapt to or mitigate the effects of changes is prompting new efforts to integrate across academic disciplines and to create partnerships among academic, public and governmental constituents. Following the theoretical framework of the ISSE, we can ask the following types of questions of these coupled socio-ecological systems: How do the presses and pulses associated with climate change (temperature, pH, sea level precipitation, runoff, solar radiation, wind and wave climates, and salinity) affect the structure and function of coastal ecosystems and what attributes affect their vulnerability?; How do climate-induced changes in coastal systems affect critical ecosystem services, such as carbon sequestration, wildlife habitat, food web support and coastal fisheries, and storm protection?; What attributes of human systems (e.g. built infrastructure, working waterfronts, land use, demographics) influence vulnerability to climatic presses and pulses, and how do these interact with changes in ecosystem services to prompt responses of adaptation and mitigation? How would mitigation and adaptation strategies (e.g., coastal engineering, reductions in greenhouse gases) feed back to affect climate drivers and vulnerability of coastal systems?

Approach

We propose to take advantage of the distribution of coastal LTER sites and their differing socio-ecological characteristics. We will use a multifaceted approach including monitoring to assess status and trends; observations across gradients to infer controls on vulnerability, resilience, response and adaptation of human and natural systems; manipulative experiments to test key control mechanisms; and scenario development and modeling to assess the consequences and interactions of climate change, continuing coastal development and potential adaptation strategies on ecosystem services.

Our specific objectives are to:

1. Evaluate the pulses and presses of climate change to determine the most important drivers at each site and how they interact to impact human and natural systems. This will include observations of temperature, pH, sea level, precipitation, runoff, solar radiation, wind and wave climates, and salinity evaluated to understand deterministic and stochastic trends and their interactions.
2. Characterize the vulnerability of the natural template of each site to climate change based on factors such as saturation state of calcium carbonate, topography / bathymetry, tide and wave climate, geomorphology, and habitat distribution. This will involve accessing high-resolution, spatial data (such as LIDAR and other imagery) to map elevation and

habitat distribution and characteristics, and assessments of factors such as sediment supply, calcification of shells, and the structure of marine food webs.

3. Characterize the vulnerability of the human template at each site to climate change based on parcel level analysis of property characteristics, population, demographics, fishing and mariculture industries, cultural attitudes, transportation and utility infrastructure, property value insurance maps, GDP and governance structure. Here we might expect differences in vulnerability to climate change across the LTER network because of prior adaptation in regions already experiencing severe aspects of climate change, e.g., hurricanes.
4. Assess the recent human response to climate change at each site. This would include information on adaptation and mitigation efforts in each community such as revised building codes, shoreline engineering, use of artificial reefs, flood management planning, as well as general awareness of climate change. What knowledge triggers an adaptation response?
5. Evaluate expected future changes in both the natural and human template. This will require downscaling national and regional predictions to make them appropriate for management units, as well as predictions of population growth and shifts in natural resource dependencies.
6. Develop scenarios to assess future vulnerability to climate change in relation to potential adaptive or mitigation responses. This will be accomplished by combining socio-economic and physical models to evaluate the effects of changes in permitting, zoning, natural area preservation, or other policy scenarios in the context of projected climate change. This will be important at local, national and global scales. We will draw on existing multi-site LTER efforts to produce such scenarios, to provide a basis for a suite of scenarios tailored to this particular application. In the process, we will contribute to an emerging multi-site LTER effort to advance knowledge on the general conditions under which a coastal coupled human-environment system may or may not become vulnerable to the effects of climate and other relevant changes.

Cyberinfrastructural Needs

We will have extensive needs for Embedded Cyber-Infrastructure and protocols for managing instrumentation and sensor arrays. Support will be needed to link the wide variety of models that will be employed and to assimilate remote sensing data and to develop effective visualizations for conveying long-term forecasts of climate change as well as displaying landscape change scenarios for interpretation by scientists, community leaders, educators, and the general public..

Lead Coordinators

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Initiating LTER Participants

BES, CCE, FCE, GCE, MCR, PAL, PIE, SBC and VCR.

Potential Partners

NOAA (including Sea Grant, NMFS, CSC, NOS, NEERS), USGS, NASA, ONR USACE, NPS and EPA. We expect that some of these partners will provide modeling data (e.g. USGS, NOAA) while others will help test model predictions (e.g. NEERS) or provide outreach to local communities (e.g. Sea Grant). We will also involve state and local governments and non-governmental agencies, in light of the importance of this research to policy decisions.

Potential Budget

$1.6M/yr for 5 years: Salary (support for students, post-docs, IT support, and PIs to collect data on climate drivers, map biophysical and human templates, develop scenarios, run models 65%); Travel (site and system-wide workshops, scientific meetings, 10%); and supplies (LIDAR, aerial photography, sample analysis, 25%).