MOVING BEYOND THE BATHTUB MODEL:

Physical, Biological, & Human Responses to Sea Level Rise

San Diego Group # 24

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We propose an integrative, multi-disciplinary effort to address the major knowledge gaps related to sea-level rise (SLR), an ongoing and accelerating problem that affects people around the globe, both directly and indirectly. We ultimately need an equitable, workable process for human adaptation and movement in response to SLR. This must be informed by models that consider SLR not as a simple, static process of inundation, landward migration, and human mobility, but rather as the dynamic interactions of physical, biological, and human forces that produce a complex of local effects relevant to human life, livelihood, and quality.

Research on these three dimensions of SLR – the physical, biological, and human – will generate data on the wheres, whens, and whats of coastline change to inform public policy. We currently lack formal frameworks for who makes decisions about human displacement under SLR to address the three looming questions:

- When do they go?
- Where do they go?
- Who decides?

Policies underlying these decisions need to be based on the best, broad-based scientific evidence and must involve local communities in the early, knowledge-generation phase -- the communities of displaced persons and of soon-to-be displaced persons ought to have agency. Populations of Pacific Islanders, already moved from their homes, and Alaska Native communities, already engaged in a multi-decadal community relocation process, are ‘canaries’ of the interwoven social, economic, and political issues for displaced populations. There is an urgent need for authentic two-way communication between scientists and these impacted communities. Because SLR is already underway, it’s time for significant conversations and developing expertise.

Knowledge gaps in our understanding of relevant physical systems include characterizing fundamental processes related to sea-level rise (e.g., scales of variation, rate, and magnitude), for example, reflecting not only global-level forces but the near-, mid-, and far-field effects of ice loss, modes of crustal subsidence, and regional-climate variation on short time-scales (e.g., wind).

Feedback systems among physical processes alone produce dynamic bathymetry (including but not limited to the redistribution of sediments), alter coastal geomorphology dramatically, and can lead to salinization of water supplies. The physical thresholds and erosional feedback mechanisms that govern nonlinear retreat have yet to be well quantified. Understanding all these factors is critical to better and more accurate predictions of the changes that will occur due to SLR.

Knowledge gaps in our understanding of the biological responses to SLR are also both fundamental and complex, including feedbacks, thresholds, and lags and interactions with physical systems and multiple human stressors. For example, biota respond not just to rising temperatures, but often more strongly to reduced oxygen levels, altered currents, and nutrient concentrations, resulting in ecological change – even dramatic regime change in carbon and energy flow -- and altered ecosystem services. At the shoreline, compression of the coastal zone against natural and built environments “squeezes” or even eliminates the transitional habitats that are so important as food sources, nurseries, carbon sequestration, recreation, and protection against erosion. Departures and arrivals of species, and changes in the abundance of those that stay, will create new communities that, like those of people under such stress, may differ significantly in structure and services than those before.

Huge knowledge gaps also exist in the governance of human mobility. In the United States, no government agency has the mandate or funding to facilitate the movement of populations caused by sea level rise. Government-mandated relocations are the only model that exist, and research has documented that this type of relocation both impoverishes populations and fractures their social, cultural and kinship connections. As a consequence, interdisciplinary research needs to resolve how relocated populations can be resilient, and to ensure how their livelihoods, cultural and kinship ties, and essential infrastructure are maintained or improved. These concerns also apply to the host communities that receive relocated populations. The urgency of such issues is illustrated, for example, in the likely 2022-2023 end of Compact of Free Association funding and subsequent increased influx of Micronesian migrants into the US. A key concept here is that of ‘coastline as cultural construct,’ the fact that changing coastlines results in alterations and inevitable inequities in the flows of resources to various regions and populations, with resulting differential economic impacts.

Within and among these three areas, non-linear responses and feedback loops exist. These multi-dimensional, mutual, interwoven impacts highlight the need for simultaneously solving the physical, biological, and human problems, and the requirement for the broadest possible inclusion of impacted community members, as well as a wide spectrum of scientists from diverse disciplines.

We propose a hub to address these knowledge gaps and investigate the physical, biological, and social processes associated with SLR under different boundary conditions, such as latitude (climate), tectonics (subsidence), ecological disruptions, and human dimensions. To begin this process, pilot sites are recommended from the locations where SLR and other climate-related environmental changes are causing people to move. The aim is to develop a replicable model of interdisciplinary science that informs public policy and generates data in the context of cultural concerns and community needs, thus developing community buy-in and effective formal frameworks for managing adaptation and/or retreat. Work at each pilot site will start with community conversations to identify needs, respect cultural traditions, and create ways to engage members and regional leaders (mayors, tribal governments, agency leads from transportation, water, utilities, natural resources, etc.) in data collection and other research elements, and will thus bring together scientists, engineers, community decision makers, and policy experts. We propose to begin with prioritized sites where SLR impacts have already commenced and/or are expected to be especially critical (e.g., Alaska, Louisiana, Florida, the mid-Atlantic states, and the US affiliated islands). These specific place-based issues will be shared and generalized to produce a more broadly usable set of decision-making tools can be effective across a spectrum of climates, physical settings, and communities of diverse density, states of development, and, resources.