LETTER

Causal relationships among sea level rise, marsh crab activity, and salt marsh geomorphology

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Salt marshes and other coastal wetlands are responding rapidly to climate change and sea level rise (SLR). Although these systems are exhibiting the same broad morphology and ecology, their responses to SLR are varied and heterogeneous. It is vital that we understand what drives these responses in order to improve sustainability.

In PNAS, Crotty et al. (1) show the importance of increased activity of a keystone crab grazer in modifying marsh creek morphology. Indeed, it was illustrated in an earlier study of a marsh in Cape Romain, SC, that the burrowing and consumption of *Spartina* by *Sesarma reticulatum* and *Uca pugnax* are the primary processes causing headward erosion of tidal creeks (Fig. 1) (2). Hughes et al. (2) reasoned that these crabs were acting in concert with greater marsh hydroperiod resulting from accelerating SLR and subsidence of the region's deltaic sediments. Increased frequency and depth of marsh flooding translates to greater tidal prism exchange, which is accommodated by expanding the drainage density. Although increased flooding drives greater creek lengths, it is the impact of the crabs that enabled this expansion of the drainage capacity (1, 2). Wilson et al. (3) subsequently demonstrated that creek expansion was also driven by removal of belowground biomass (through active herbivory and aerobic decomposition from burrowing) and reduced soil strength, increasing erodibility (Fig. 2). Additionally, a mesocosm flume study demonstrated that burrowing and feeding by *S. reticulatum*, and, to a lesser extent, *U. pugnax,* increase surface roughness and decrease the threshold velocities and shear stresses required for sediment erosion (4). These biophysical feedbacks were found to increase tidal creek drainage density in the South Carolina system and similar creeks throughout mid-Atlantic marshes (3), including Florida and Georgia marshes (1). Likewise, impacts of *S. reticulatum* on creek head vegetation, soil stability, and geomorphology were found to be identical in the marshes of Georgia and South Carolina. However, the resulting morphology and headward erosion rates varied according to local tidal conditions (5).

The understanding of crabs as bioengineers follows the pioneering work of Holdridge et al. (6),

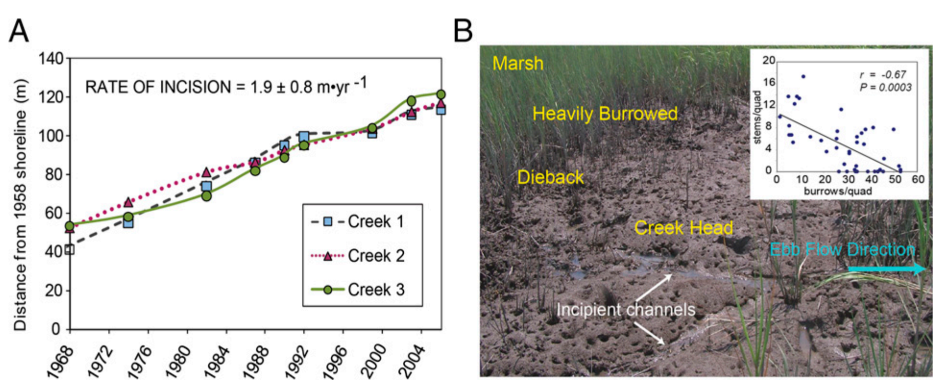

Fig. 1. **(*A*) Headward erosion rates of creeks at Cape Romain, SC, from 1968 to 2006 (average rate of three creeks = 1.9 m/y). (*B*) Photo of the creek head showing the dieback region, denuded area, and tiny incipient creeks in the bare region; *Inset* shows stem density versus crab burrow density; a clear negative correlation exists (data from four locations at Cape Romain along a transect from marsh into bare creek head, $n = 12$ creeks, quad = 0.0625 m^2). Image credit: Hughes et al. (2).**

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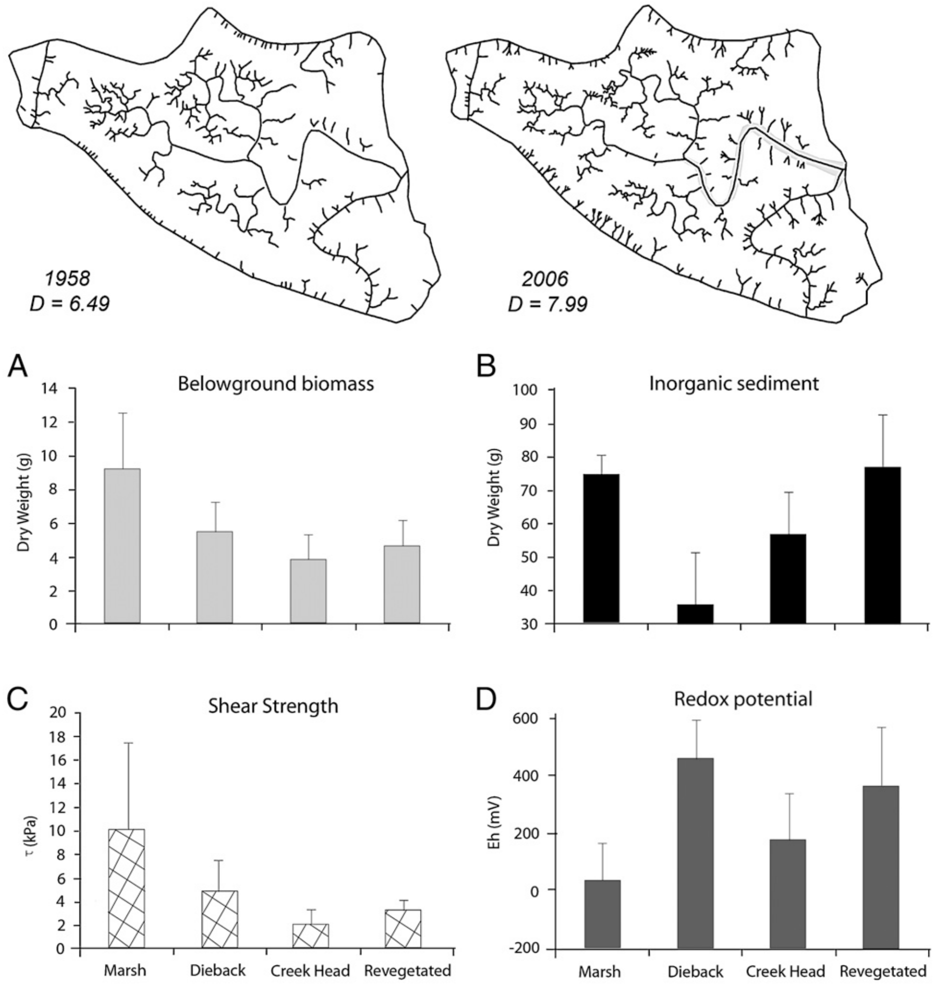

Fig. 2. **(*Top*) A representative marsh area in Cape Romain, SC, experienced a 23% increase in drainage density from 1958 to 2006. This increase was attributed to biophysical feedbacks of crab burrowing, *Spartina* dieback, and enhanced tidal flows as a consequence of sea level rise and increasing marsh flooding. (*Bottom*) Measurements of belowground biomass (*A*), inorganic sediment mass (*B*), shear strength (*C*), and redox potential (*D*) from the top 10 cm in marsh geomorphic zones impacted by burrowing. Image credit: Wilson et al. (3).**

who investigated the vegetation die-off along creek banks on Cape Cod and found a link between burrowing and herbivory of *S. reticulatum*. As was later shown, the dieback was likely a response to increased density of *S. reticulatum* resulting from decreased predation on crabs due to increased fishing pressure (7, 8). Widdows and Brinsley (9) first recognized that salt marsh morphology is strongly influenced by biotic processes. More recent work has alerted the ecological community that burrowing marsh crabs can facilitate the release of CO_2, thereby reducing carbon sequestration (10). Further research is needed to evaluate the benefits or adverse impacts of *Sesarma* spp. to marshes experiencing SLR, and to identify other important feedbacks between salt marsh morphological evolution and their resident biota.

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