Nonlinear responses of coastal salt marshes to nutrient additions and sea level rise

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Increasing nutrients and accelerated sea level rise (SLR) can cause marsh loss in some coastal systems. Responses to nutrients and SLR are complex and vary with soil matrix, marsh elevation, sediment inputs, and hydroperiod. We describe field and greenhouse studies examining single- or multiple-stressor effects of nutrients and accelerated SLR on *Spartina alterniflora* above- and below-ground biomass and crab abundances. The aboveground growth was optimal at intermediate elevations where flooding provides nutrients and sediments. Below the optimal elevation, plants drown, and at higher elevations the plants may be nutrient- or sediment-poor. However, at higher elevations *S. alterniflora* has elevation capital to face rising seas. Nutrient additions significantly increased belowground production and organic matter accumulation in minerogenic salt marshes, but decreased below-ground production in some organogenic marshes. Responses to nutrients apparently vary with organic matter content and oxidation-reduction status in the soil. We propose a threshold response in belowground production driven by sulfide accumulation in organic-rich soils under waterlogged conditions. Low belowground production in organic-rich soils can contribute to marsh loss. In addition, a threshold response was observed between marsh elevation and fiddler and purple marsh crab burrows, with highest burrow counts at intermediate elevations. We hypothesize that with an increase in flooding expected with accelerated SLR, crabs may initially increase in abundance, until flooding is too great for burrowing, and the crabs move to higher elevations. Negative feedbacks between high crab abundances and plant production also contribute to marsh loss. Understanding these sometimes complex responses to stressors, described by parabolic curves and a threshold-modeling framework will assist in developing predictive models to address marsh losses and assist in making restoration and climate adaptation decisions.