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A tale of two algal blooms: Differential negative effects of *Ulva* and *Gracilariopsis* on seagrass and its epiphytes

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Abstract

Seagrass beds worldwide are experiencing major declines due to harmful algal blooms (HABs) associated with nutrient-rich runoff. The effects of phytoplankton HABs on seagrass beds are well documented. Recent evidence suggests macroalgae plays a role as well, but the "dose-response" relationships between seagrass bed health and dominant forms of bloom-forming macroalgae are poorly characterized. We investigated the impact of varying abundances of two common macroalgal genera in California estuaries, Ulva spp. and *Gracilariopsis* spp., on the health of the eelgrass *Zostera* marina. We conducted a caging experiment in 1m2 plots of a Z. marina bed in Bodega Bay where we maintained six densities of both Ulva (0, 1.0, 1.5, 2.0, 3.0, and 4.0kg/m2) and *Gracilariopsis* (0, 0.75, 1.0, 1.5, 1.75, and 2.0kg/m2) as well as uncaged controls over a 10-week period. Treatments were based upon surveys of natural abundances and previous studies on negative effects. Every two weeks, Z. marina growth, epiphyte load, and shoot density were measured; algal treatment levels were also reset. Linear or non-linear least squares models were fit to the data and compared by Akaike information criterion (AIC). Final measurements of shoot density and epiphyte load were best modeled as an exponential decay with Ulva abundance. In treatments >2.0kg/m2 shoot density decreased by ~60% compared to initial measurements and epiphyte load decreased at least 3-fold in all treatments but the 0 kg/m2 treatment. A significant negative linear relationship between shoot density and *Gracilariopsis* was found with an approximately 45% decline in shoot density at 2.0kg/m2. In contrast to Ulva spp., the abundance of *Gracilariopsis* had no effect on epiphyte load. Thus, we found negative impacts to Z. marina by decline in shoot density and potential impacts to food webs by loss of epiphytes, but these effects varied by algal species and occurred at abundances that are currently observed in California estuaries.