SCCWRP #1064

A tale of two algal blooms: Negative and predictable effects of two common bloom-forming macroalgae on seagrass and epiphytes

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ABSTRACT

Recent evidence suggests macroalgal blooms may play a role in the worldwide decline in seagrass, but the shape of the functional relationship between seagrass health and dominant bloom-forming macroalgae is poorly characterized. We tested whether the impact of varying abundances of two cosmopolitan bloom-forming macroalgal genera caused linear/quasi-linear or sudden threshold changes in measures of eelgrass, *Zostera marina*, meadow health. We conducted two caging experiments in a shallow *Z. marina* bed (∼1 m depth) in Bodega Harbor, California, USA where we maintained six densities within the range of natural abundances of macroalgae, *Ulva* (0–4.0 kg m−2) and *Gracilariopsis* (0–2.0 kg m−2), as well as uncaged controls over a 10-week period. Shoot density, blade growth, and epiphyte load were measured every two weeks and algal treatments reset. We did not find support for threshold transitions between algal abundance and measures of seagrass bed health using sigmoidal and broken-stick regression analyses for each data set; these models are commonly used to identify threshold patterns in ecological shifts. Instead, final measurements of shoot density and epiphyte load were best modelled as linear or slightly non-linear declines with increasing *Ulva* abundance. A negative linear relationship also existed between shoot density and *Gracilariopsis* abundance and a trend towards linear negative effects on epiphyte load. The similar shape of these functional relationships across different types of algae suggests the relationship may be generalizable. At algal abundances that are commonly observed, we found smooth and predictable negative impacts to *Z. marina* by decline in shoot density and potential impacts to food webs by loss of epiphytes rather than sudden threshold shifts or "ecological surprises". Our work contrasts with the growing body of literature suggesting highly non-linear shifts in response to human impact; thus, it is important to broaden understanding of shifts to more than just pattern but to the processes that drive different patterns of shifts.