Chemical Warfare in Narragansett Bay: Determining the Allelopathic Effects of Ulva

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Introduction

Ulva compressa, U. rigida and U. lactuca are common species of macroalgae in Narragansett Bay that provide food and shelter for many organisms (Guidone & Thornber 2013). They are fast growing primary producers that also remove excess nutrients from the environment (Sogard & Able 1990). Ulva blooms can have detrimental effects on the environment and economy by causing anoxia conditions that lead to decreased species diversity, finish and shellfish kills, and disruption of recreational activities and fisheries (Teichberg et al. 2009). Previous studies have shown that Ulva lactuca in other systems produce and release allelopathic chemicals that inhibit growth of microalgae (Tang & Gobler 2011). Therefore, it is possible that either Ulva compressa, U. rigida or U. lactuca may be releasing allelopathic chemicals that have detrimental impacts on macroalgae in the Narragansett Bay ecosystem.

Objectives

Determine if Ulva compressa, U. rigida and/or U. lactuca have allelopathic effects on three species of macroalgae found in Narragansett Bay: Chondrus crispus, Cystoclonium purpureum, and Ceramium virgatum (Figure 1).

Methods

• Tips of Chondrus, Cystoclonium, and Ceramium were isolated, cleaned in agar if needed, and grown in sterile seawater before use in experiments.
• Algae were placed in 1 L ball jars separated by mesh to ensure no direct contact between the species (Figure 2). Samples were grown in autoclaved seawater and provided constant filter-sterilized air.
• NO₂ levels were tested daily as a proxy for nutrient levels and cultures were re-enriched when necessary (Von Stosch Enrichment, OI 1966).
• Experiments were conducted at 22°C, 100 µmol photons m⁻² s⁻¹ and 16.8:16.8 (Light:Dark).
• Wet mass was recorded on days 0, 2, 4, 6, and 8. Percent growth was calculated as % day⁻¹=100 ln [(L₂/L₁)/(t₂−t₁)], with L₁ and L₂ are the blade wet weights at times t₁ and t₂.
• Starting Ulva concentration was 1 g/L to reflect concentrations observed during blooms (Thornber, unpublished data).
• Each trial (n=3) contained 7 replicates of 4 “treatments”: U. rigida, U. compressa, or U. lactuca and control (no Ulva).
• Results of each trial were analyzed using separate repeated measures ANOVAs with Greenhouse-Geisser corrections for sphericity.

Discussion

• Overall in two trials Ulva compressa had the most effect on the Cystoclonium and Chondrus, with both losing mass over time.
• U. rigida and U. lactuca had less of an effect, with the growth of Cystoclonium and Chondrus stagnating over the course of the trials, in comparison to the controls which had a significant gain in mass.
• Ceramium growth stagnated when grown with the all of Ulva species in comparison to the controls, but the effect of each Ulva species was not significantly different at the end of the trial.
• Even though bloom formations in Greenwich Bay (Figure 3) are not long lived, lasting only 1-2 weeks, based on our results, it is long enough to potentially harm the growth of other species of algae in the area (Granger et al. 2000).
• Algal blooms have been currently noted to reduce the algal diversity in areas where they occur, though this is most frequently attributed to anoxia or reduced light levels during bloom formation and die-off (Teichberg et al. 2009).
• We propose that there are secondary effects of bloom formations by certain species of Ulva that would lead to reductions in diversity based on the chemical effects on other macroalgae.
• Future directions: implementing field experiments and testing the effects on other life stages of macroalgae.

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Literature Cited

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Figure 1. Top view of divided mistaken (left) and trial set up with jars of each treatment randomly placed (right).

Figure 2. Ulva compressa, Ulva rigida and Ulva lactuca had the most effect on stagnating over the course of the trial. Each trial (n=3) contained 7 replicates of 4 “treatments”: U. compressa, U. rigida and U. lactuca. Figure 2 shows the growth of all three species in a time series with nitrogen concentrations measured as mg/L. Figure 3 shows the growth of all three species in a time series with nitrogen concentrations measured as mg/L. Figure 4 shows the growth of all three species in a time series with nitrogen concentrations measured as mg/L.