Competition under the Sea: Exploring the competitive interaction between native and non-native seagrasses in the Caribbean

Introduction

In this mini-case study you and your classmates will learn about competition taking place between seagrasses in the shallow coastal waters around islands in the Caribbean Sea. Specifically, you will be presented with three sets of real-world data to explore the interaction between the native Caribbean seagrass *Syringodium filiforme* and the non-native Red Sea seagrass *Halophila stipulacea*. In pairs, you will learn some background information about seagrass habitats and our featured species and examine and interpret presented figures and tables from field surveys and mesocosm experiments to answer a series of associated questions. Lastly, from your gained understanding of the interaction among native and the non-native seagrass, you will be asked to make an action recommendation to resources managers in the Caribbean on how to deal with *H. stipulace*a.

Background

Seagrasses are marine flowering plants that form extensive meadows on soft-bottom substrates in temperate and tropical regions around the world. There are over 60 seagrass species and in many ways are able to survive, thrive, and reproduce like their terrestrial cousins, with the distinction of accomplishing all life stages underwater. As an ecosystem, seagrass meadows provide valuable ecological functions including sediment stabilization and wave attenuation that protect shorelines, nursery and foraging habitat for a wide range of marine organisms including fishes, invertebrates, sea turtles, and manatees, and a sink for carbon sequestration in the oceans – also known as 'blue carbon' (Viana et al. 2019).

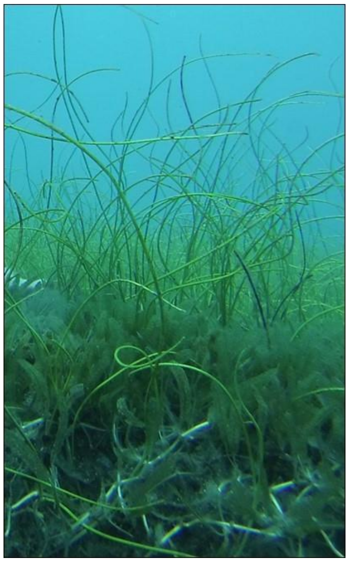


Figure 1. A Caribbean seagrass meadow. Tall, spaghetti-like native *Syringodium filiforme* growing mixed with the shorter, dense non-native *H. stipulacea*.

The Caribbean Sea is home to multiple species of seagrass including the very common species of *Thalassia testudinum* turtle grass, *Syringodium filiforme* manatee grass, and *Halophila decipiens* paddle grass. If you were to search the internet for pictures of Caribbean seagrass meadows, these are the species that would likely be pictured. Since 2002, however, a new species has taken hold in the region – *Halophila stipulacea*. *Halophila stipulacea* is native to the Red Sea and Indian Ocean. In the mid-1800s and coinciding with the opening of the Suez Canal, this seagrass spread into the Mediterranean Sea and spread westward reaching Italy and Tunisia by the 2000s. In 2002, *H. stipulacea* was found growing in a single tennis-court size patch along the island-nation of Grenada in the southwest Caribbean. Trans-oceanic 'jumps' are rare in marine angiosperms with only one other case known –

the introduction of the seagrass *Zostera japonica* to the Pacific Northwest coast of the U.S. and Canada in the mid-1900s. In the 16 years since its arrival to the Caribbean Sea, *H. stipulacea* has spread to over 19 islands and reached the mainland of South America (Vera et al. 2014, Willette et al. 2014). The spread of this seagrass is believed to be facilitated by inter-island marine transportation, especially with tourist activity in the area (Willette and Ambrose 2009). The seagrass has been reported growing mixed with native seagrasses including *Syringodium filiforme* (Figure 1).

At first glance, a new seagrass species in the Caribbean may seem like a positive development, given seagrass meadows worldwide have been declining at a precarious rate of 110 km^2 per year (Waycott et al. 2009). **So, is the arrival of *H. stipulacea* a 'benefit' to the Caribbean by adding another player in supporting seagrass communities, or is *H. stipulacea* a competitor to native seagrasses that could replace native seagrasses and transform the region's coastal structure?** Your task is to use the provided data to decide. Let's get started!

Please answer questions 1-3 using the below table of architectural and dynamic growth traits of different species of seagrass adapted from Duarte 1991. The measurements are of each species as it grows in its native range. Understanding that you are not yet an expert in seagrass biology and ecology, in general you may interpret the architectural traits that the larger the value means the larger the size of the plant; and for dynamic trait the larger the value the more growth that occurs for the given property. A simple diagram showing parts of a typical seagrass plant is included to the right for your reference.

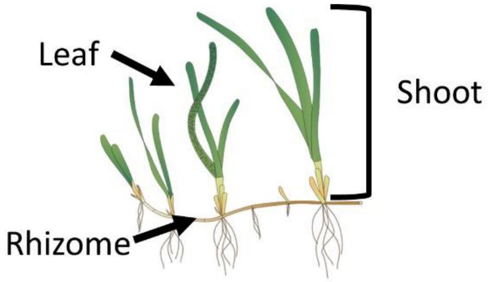


Table 1. Architectural and dynamic growth traits of four seagrasses. Adapted from Duarte 1991.

	Architectural traits		**Dynamic growth traits**			
Species	**Leaf surface area (cm^2)**	**Shoot weight (mg shoot^{-1})**	**Rhizome elongation rate (cm yr^{-1})**	**Leaf production rate (leaves yr^{-1})**	**Leaf longevity (d)**	**Leaf turnover rate (yr^{-1})**
Halophila stipulacea	2.8	15.1	-	45.1	74.0	5.6
Halophila decipiens	0.9	2.3	215.0	200.5	8.6	32.3
Syringodium filiforme	3.2	30.4	134.0	16.6	45.0	13.7
Thalassia testudinum	18.2	264.0	151.5	34.4	40.0	7.7

1. Please rank the seagrasses from largest in size to smallest in size by comparing their architectural features.

2. By contrasting dynamic growth traits, estimate a ranking of seagrasses from ones that grow the fastest to the ones that grow the slowest.

3. All the data in the table was measured of the seagrasses in their native ranges. Assume you could plant and grow all four species together in a single common garden – which species might have a competitive advantage if all four competed for the same resources? Kindly provide a 1-sentence justification for your answer.

In 2007, *H. stipulacea* was reported for only the second time in the Caribbean Sea, this time along the west coast of the island-nation of Dominica. To assess competition between *H. stipulacea* and *S. filiforme* Willette and Ambrose (2012) conducted a reciprocal transplant experiment for a length of 14 weeks. The experiment removed 10cm diameter plugs of whole plants with sediment taken from a meadow of each seagrass and transplanted into the other meadow of comparable profile and depth. The experiment was conducted in a bay where both species were already well established. After transplanting, researchers returned to the field site every few weeks to measure the rhizome lateral expansion of each transplanted plug. This was determined by measuring the maximum distance between two shoots from the same plug. Results from the study are show in the bar graph below.

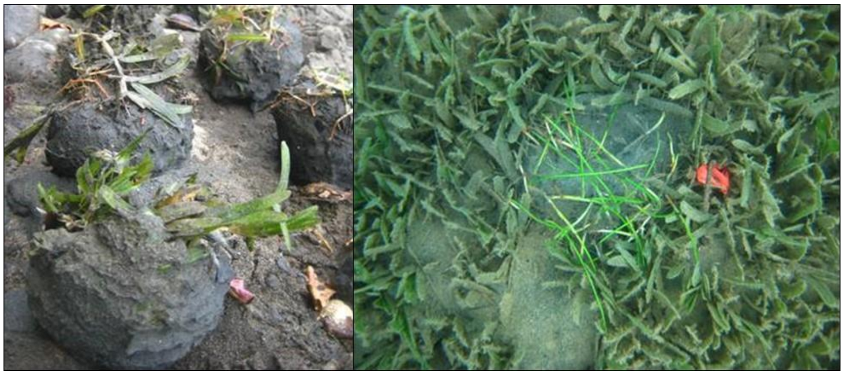


Figure 2. Left – 10-cm diameter plugs of seagrass *H. stipulacea* ready for transplanting. Right – 10cm diameter plug of light green *S. filiforme* planted within a dark green *H. stipulacea* meadow.

Please answer questions 4-6 using the bar graph below.

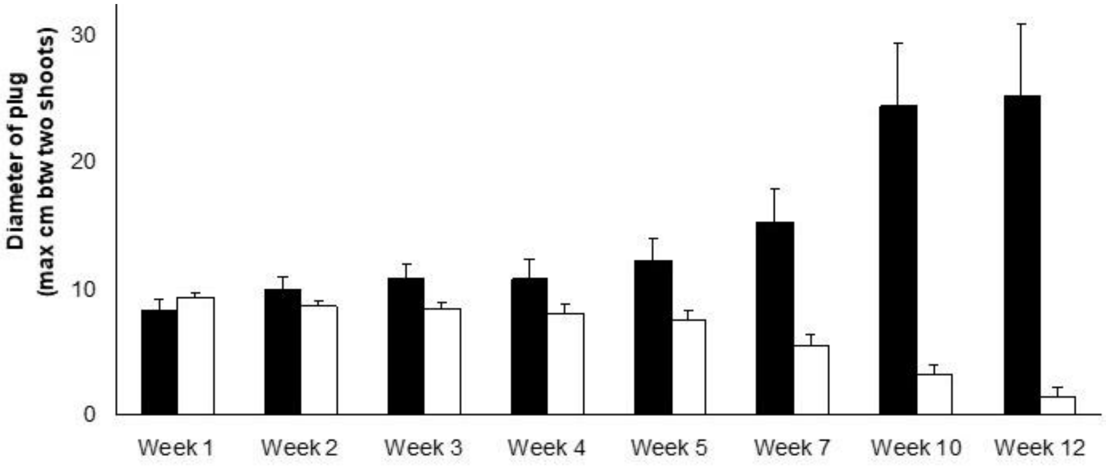


Figure 3. Mean diameter (+ standard error) of *Halophila stipulacea* (black bar) and *Syringodium filiforme* (white bar) plugs transplanted into meadows of the opposite species by week. N = 25 transplant plugs per species. Adapted from Willette and Ambrose 2012.

4. Which transplanted species had the greatest growth in diameter over the 12-week study period? Roughly how many folds (e.g. 2-fold, 4-fold) did this species increase in diameter?

5. Recalling that the transplant plugs were placed in meadows of the opposite species. Speculate on the competitive interaction between the two species for:
    a. *H. stipulacea* growing surrounded by *S. filiforme*.

    b. *S. filiforme* growing surrounded by *H. stipulacea*.

6. The competitive exclusion principle proposed by Gause (1934) suggests that two species competing for the same limited resource cannot co-exist indefinitely, and the species with the slight advantage will come to dominate the habitat long-term. Based on the field experiment data above, do you think the species will co-exist or will one species dominate? Point to evidence above to support your answer.

Experiments run *in situ*, or out in the field, do make it difficult for researchers to account for potential confounding factors. One option is to use a mesocosm. A mesocosm, literally *meso* = 'medium' and *cosm* = 'world', is an experiment outdoors but under controlled conditions, such as in aquaria or tanks. Recent research by Chiquillo et al. (2019) set up mesocosm competition experiments to examine interactions between non-native *H. stipulacea* and native *S. filiforme*. Her research planted the seagrasses alone or mixed together, and randomly arranged plugs in a common garden (Figure 4.)

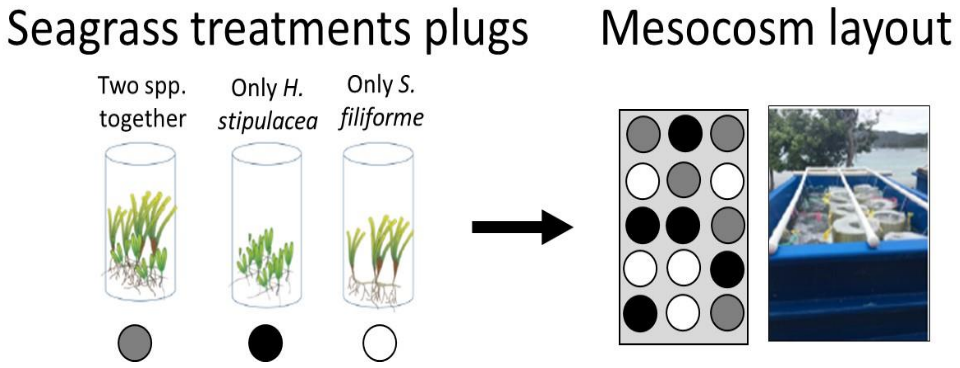


Figure 4. Experimental design of mesocosm competition experiments with individual or mixed species plugs used as the experimental units, run for a total of six weeks.

7. Using the box plot data in Figure 5, do these data show that the invasive seagrass negatively impacts the growth of the native seagrass?

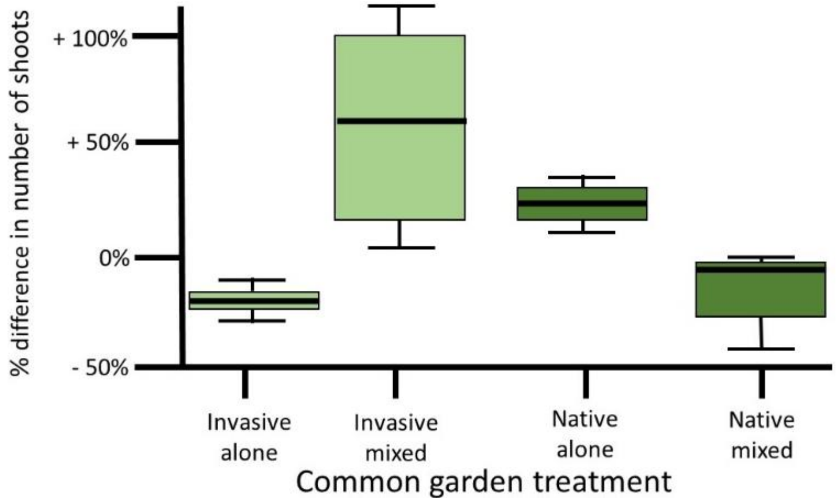
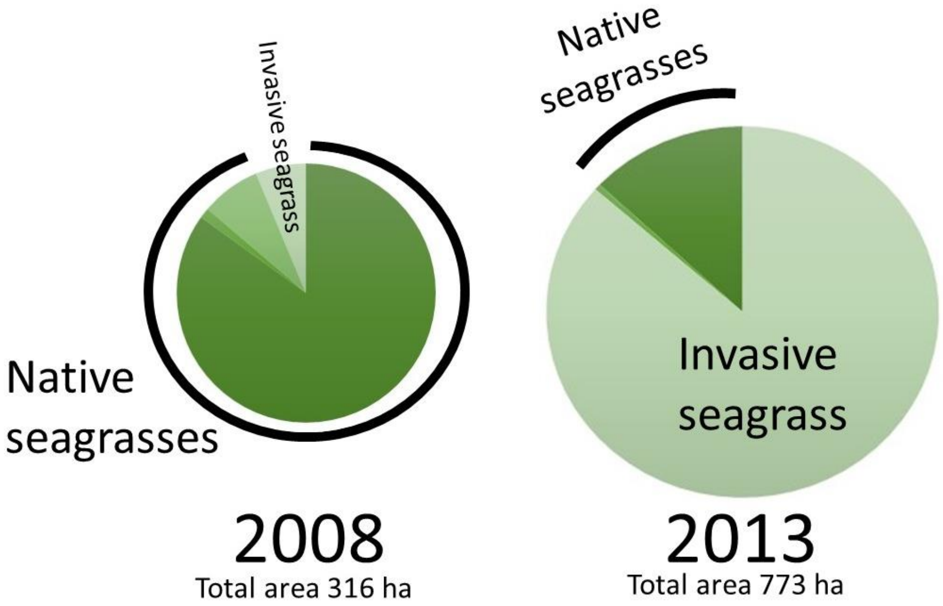


Figure 5. Box plot data illustrating the change in the median (bold black line) and Interquartile range/middle 50% (box) of shoots for each treatment after six weeks. Positive difference means new shoots grew, negative difference means shoots died out. Adapted from Chiquillo et al. 2019.

8. Do these data show that the native seagrass negatively impacts the growth of the invasive seagrass?

9. What can you conclude about the competitive interaction between the native and invasive seagrass species from these mesocosm experiments?

Field surveys of the total number of hectares of the invasive seagrass *H. stipulacea* and four native seagrasses around the island of Dominica were taken in 2008 and five years later in 2013. These data are adapted from Steiner and Willette (2015) and shown below. Please answer questions 10 – 12 using these pie charts.



10. How has the total area covered by the invasive seagrass change between 2008 and 2013?

11. How has the total area covered by the native seagrasses changed between 2008 and 2013?

12. In 2008 there was a total of 316 ha, and in 2013 there was a total of 773 ha. What does this data tell you about capacity of the invasive seagrass beyond its interaction with native seagrass meadows?

13. **Management tie-in:** Given what you've learned about the competitive interaction between the invasive seagrass *H. stipulacea* and the native Caribbean seagrasses, please make a 2-3 sentence recommendation to coastal resource manager in the Caribbean on how to deal with *H. stipulacea*. Cite information you've learned from the above data sets to support your recommendation.

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