The Fish and Invertebrate Community Associated with the Invasive Seagrass, *Halophila stipulacea* in St. Eustatius

La Comunidad de Peces e Invertebrados Asociada con la Hierba Marina Invasora *Halophila stipulacea* en San Eustaquio

La Communauté de Poissons et D'invertébrés Associée à L'herbier Envahissant *Halophila stipulacea* à Saint-Eustache

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EXTENDED ABSTRACT

INTRODUCTION

Seagrasses are submerged, marine flowering plants that live in clear, coastal waters protected from wave action and can form extensive meadows. Seagrasses provide nursery habitats for many fisheries species. Their roots and rhizomes stabilize sediments, prevent erosion, protect the shoreline, and produce and hold organic matter providing a huge carbon sink (Fourqurean et al. 2012). Seagrass blades slow currents, filter pollutants and with the rhizomes form an intricate habitat supporting a diversity of life. They serve as a direct food source for green sea turtles, herbivorous fishes and manatees, and an indirect food source via their detritus for many other organisms. Seagrasses have very high rates of primary productivity and are important for nutrient cycling (Waycott et al 2009). They also produce oxygen and decrease carbon dioxide. Despite their intrinsic value, seagrasses are an often ignored habitat declining from human activities (Waycott et al. 2009).

In St. Eustatius, the native seagrass species include *Halodule wrightii*, shoal grass, *Syringodium filiforme*, manatee grass and historically *Thalassia testudinum*, turtle grass. The latter two species were considered dominant by MacRae and Esteban (2007) but declining due hurricanes and port associated activities. In 2012, another threat arrived, the invasive seagrass, *Halophila stipulacea* (Willette et al. 2014), and today the turtle grass seems to have disappeared completely. *H. stipulacea* is native to the Red Sea, Persian Gulf and Indian Ocean. It first invaded the Mediterranean Sea following the opening of the Suez Canal, and circa 2002 journeyed across the Atlantic Ocean to Grenada likely via fragments attached to vessel hulls, anchors or propellers (Ruiz and Balantine 2004, Willette et al. 2014, Vera et al. 2014). Since then it spread quickly and extensively north to Puerto Rico and west to Aruba (Viana et al. 2019).

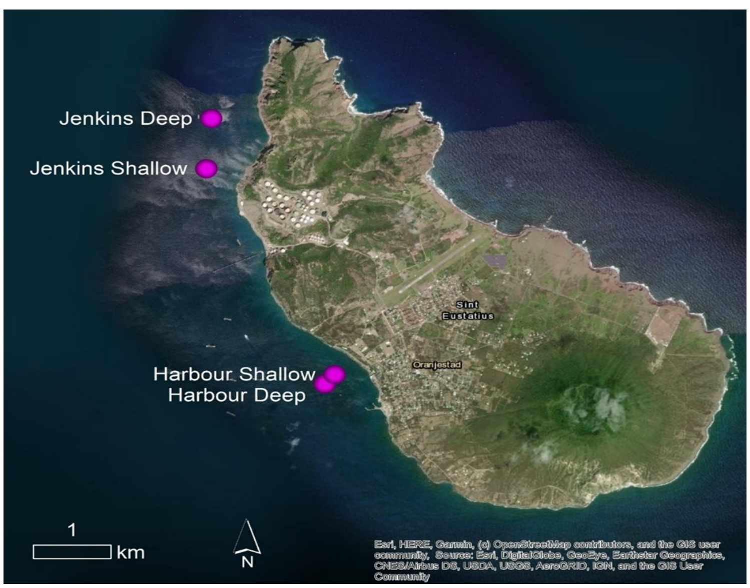

Figure 1. Map of St. Eustatius showing the four survey areas for *Halophila stipulacea* communities on the leeward side of the island. Shallow and deep sites were relative to each other. Northern sites were in Jenkins Bay and western sites in Oranje Bay

H. stipulacea grows to 5-6 cm in height, much shorter than native species, and ~1 cm in width. It has a distinctive central vein and 11-18 angled cross veins. It can flourish under more variable conditions than most native seagrass species. Disturbances, such as excess runoff of nutrients and sediments, have left Caribbean seagrasses stressed and more susceptible to being outcompeted by *H. stipulacea*, which grows and spreads fast: 0.91 shoots/day (Smulders et al. 2017)! This community shift has negative effects, but we are also finding *H. stipulacea* where seagrasses didn't exist before, e.g. around coral reefs (Steiner and Willette 2015), in polluted harbours and at deeper depths. Viana et al. (2019) hypothesized that it could be acting as a pioneer species, so once human disturbances are managed, native seagrasses may return to dominance, while it also provides many ecosystem services in the interim. Therefore, we sought to investigate if there may be some additional positive attributes associated with the invasion in St. Eustatius.

OBJECTIVES AND METHODS

For this study, we described the community associated with *H. stipulacea* in shallow versus deeper areas of St. Eustatius (Figure 1) to see if this invasive seagrass could support high diversity of native flora and fauna. Our study area included a shallow and deeper site within Oranje Bay (Harbour) and Jenkins Bay (Figure 1). These four sites were surveyed by six SCUBA divers on May 11th and 12th, 2020. Each dive pair surveyed two separate belt transects 5 to 10 m apart and 4 m wide x 30 m long per site. Data on fish diversity and abundance were recorded. Six transects were surveyed per site across the four sites for a total of 24 transects.

Along each transect, three 1x1 m quadrats were photographed at the beginning, middle and end to determine percent coverage of seagrasses, macro-algae and macro-invertebrates. Whole quadrat photos were taken as well as zoomed in photos of 5 sub-quadrats (20x20 cm), one in each corner and one in the center. CPCe analysis of each photograph included the identification of the organisms present at 15 random points within each sub-quadrat photo equating to 75 points per quadrat, 225 per transect, 1,350 per site, and 5,400 total.

RESULTS

Three seagrass species were encountered with *H. stipulacea* (65.2% coverage) dominating the meadows while the two native species, *S. filiforme* and *H. wrightii*, covered <2% of the area. The transect depths ranged from 8.5m to 22m, while the salinity and temperature did not vary much across the study area (36.0-36.4 and 27.6-28.0° C respectively). We documented up to 33 algal species directly associated with *H. stipulacea* and 7 additional algal species on other nearby substrate. Approximately 75 species of macro-invertebrates were seen in the seagrass plus 13 more in the immediate vicinity. For the fishes we found 62 species in or above the seagrass and 16 more over other close by substrates. In total, our species richness across these taxa came to 189 species with 153 of them directly associated with *H. stipulacea*.

The dominant algal species included three species of filamentous red algae followed by mermaid's shaving brush, *Penicillus capitatus*. In some places the red algae and epiphytes were quite extensive indicating there may be

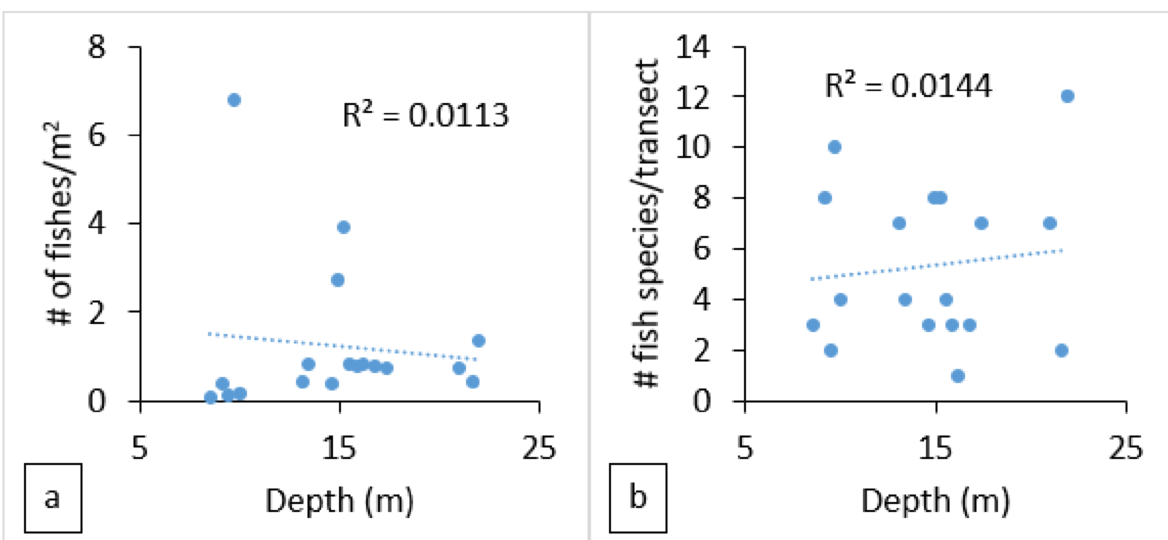

Figure 2. Graphs showing the relationships between fish density/number of fishes per m^2 and depth (a), and number of fish species per transect and depth (b) at seagrass sites dominated by *Halophila stipulacea* on the leeward side of St. Eustatius.

an excess of nutrients in the water. The macro-invertebrates encountered were predominantly cerith snails (1,712) followed by far fewer amber pen shells (37) and fire worms (22). There was not much evenness for the macro-invertebrates given the high occurrences of cerith snails and low counts for most of the other species. The most common fish species were *Xyrichtys martinensis*, rosy razorfish (1,344), *Selar crumenophtalmus*, bigeye scad (770) and *Heteroconger longissimus*, brown garden eel (326). In total over 2,776 fishes were surveyed along the transects. Figure 2 shows the lack of a relationship between number of fishes per m^2 and depth (a), and number of fish species per transect and depth (b).

DISCUSSION/CONCLUSION

The species richness of macro-organisms is quite high within *H. stipulacea* beds at nearly 200 species without us investigating the infauna. However, we don't know how this diversity may have compared to native seagrass beds that once existed in St. Eustatius. A study by Barry et al. (2021) found 161 macro-invertebrates (both epifauna and infauna) associated with native seagrasses in the Gulf of Mexico off Florida and another study of native seagrasses in St. Croix and Nicaragua by Fry et al. (1982) found lower species richness than we did (St. Croix – 21 algae, 13 macro-invertebrates, 14 fishes and Nicaragua – 10 algae, 10 macro-invertebrates, 8 fishes). This could however be due to differences in the sampling methods used. The shorter blades of *H. stipulacea* compared to local seagrasses may prevent some seagrass-associated species from inhabiting these areas while also allowing us to more easily record species due to the reduction in canopy height and habitat complexity. This likely makes prey species more susceptible to predators as well. The dominant fish species observed, rosy razorfish, avoids predation by darting into the sediment; a trait which is more typical of fishes occupying bare, unconsolidated sediment. Ecologically and commercially important species were using these meadows including queen conchs (*Aliger gigas*), long-spined sea urchins (*Diadema antillarum*), parrotfishes (Sparidae), barracuda (*Sphyraena barracuda*), jacks (Carangidae) and snappers (Lutjanidae). No relationships with the fish community and depth were found, but there may be differences with depth when algae and macro-invertebrates are included in the analysis to come. *H. stipulacea* does well in deeper depths, disturbed areas and within coral reef sand halos and this may be extending the available habitat for seagrass-associated species and creating safer corridors to coral reefs. However, it is very concerning that turtle grass was absent and the other two native species covered <2% of the substrate. More study is needed to understand the ecology and succession of habitats dominated by introduced species. *H. stipulacea* is providing a plethora of ecosystem services and as native species are depleted by human activities, invasives may be able to fill in as pioneer species to help rehabilitate disturbed ecosystems

KEYWORDS: alien species, Caribbean Sea, biodiversity, community ecology, human impacts

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