UNIVERSITY OF MIAMI
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GLYNN LAB

The Alien Brittle Star *Ophiothela mirabilis* in South Florida: Abundance, Distribution, Ecological Interactions, and Asexual Reproduction

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Introduction

- The introduction of marine alien/invasive species can have cascading ecological, social, and economic effects that exacerbate biodiversity loss
- The brittle star *Ophiothela mirabilis* Verrill, 1867 are ophiuroids native to the Eastern Pacific and are epizoic associates of gorgonians, sponges, and scleractinian corals in reef systems
- In the past two decades, *O. mirabilis* have been discovered inhabiting Atlantic reefs off Brazil[1], the Lesser Antilles[1], and most recently, South Florida in 2019[2]
- The recent introduction and rapid expansion of this potentially invasive species poses a threat to the future stability of Atlantic reefs through the displacement of native octocoral associates such as the benthic ctenophore *Coeloplana waltoni* and possible feeding disruption of octocoral hosts
- Here, we document the seasonal abundance, spatial distribution, ecological interaction, and asexual reproduction of *O. mirabilis* in South Florida with the aim of understanding the potential impacts of this alien species on Atlantic reef systems

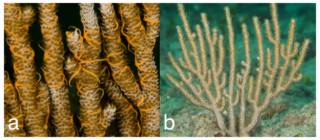

Figure 1. *In situ* images of Octocoral hosts harboring *O. mirabilis*. A) Orange *O. mirabilis* residing on a colony of *Eunicea* B) Mixture of beige and orange *O. mirabilis* inhabiting *Muricea*

Methods

- To document the spatial distribution of *O. mirabilis*, surveys were performed at various localities in South Florida in 2019 through early 2020 ranging from Hillsborough Beach south to Vaca Key. Surveys were performed by surface diving with either visual investigation or octocoral collection to confirm the presence/absence of brittle stars
- The temporal variation of brittle star abundance was evaluated at a single survey site located off Dania Beach, FL. To quantify the abundance of brittle stars, collections were performed monthly during 2019 by surface diving on shallow (3-5 m depth) patch reefs. After collection, counts were made on each octocoral stem and brittle star density was standardized to Individuals per 10 cm octocoral length.
- In addition to monitoring *O. mirabilis* at the Dania Beach site, the density of the benthic ctenphore *Coeloplana waltoni* was quantified over time. From this data, a mixed-effects model was constructed in R[3] using the package glmmTMB[4] in order to examine the abundance of *C. waltoni* as a function of increasing *O. mirabilis* density. This model aims to illustrate the potential affects of *O. mirabilis* on a native species.
- To investigate the possibility of feeding disruption of native octocoral hosts by *O. mirabilis*, a pairwise comparison of polyp extension between octocorals with *O. mirabilis* present (treatment) and octocorals without *O. mirabilis* present (control) was performed. This was quantified via weekly measurement of polyp extension in 24 octocoral colonies (12 control, 12 treatment) under consistent laboratory conditions for a total of 4 weeks.
- Research on the asexual reproduction of *O. mirabilis* is ongoing with an experiment that aims to examine the effects of temperature on fission rate by evaluating the frequency of fission at three temperature intervals. From this experiment, the effects of temperature on fission rate will be modeled over time. This analysis will elucidate the potential for enhanced dispersal as a result of rising temperatures.

Results

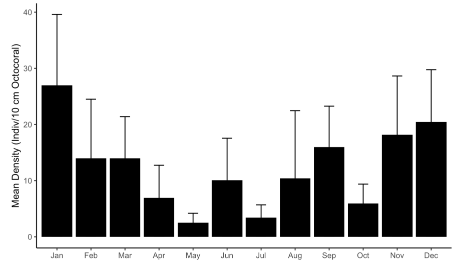

Figure 2. Monthly mean sample densities (Individuals per 10 cm of Octocoral length) of *Ophiothela mirabilis* collected off Dania Beach, FL from January – December 2019. Modified from Glynn et al. 2020[5].

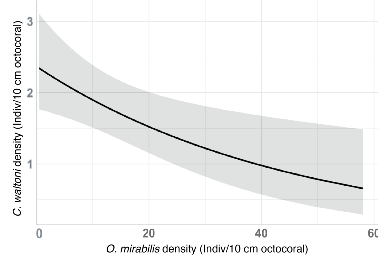

Figure 3. Effects plot derived from a mixed-effects model that predicts the density of the resident benthic ctenophore *C. waltoni* as a function of *O. mirabilis* density. Model results indicate a 3.8% decrease in *C. waltoni* density with each *O. mirabilis* individual. Taken from Glynn et al. (In Review)[6].

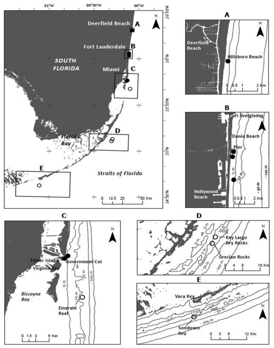

Figure 4. Sampling localities in south Florida ranging from Deerfield Beach in Broward County to Vaca Key in the Florida Keys. Dark circles indicate the presence of *O. mirabilis*, translucent circles indicate absence of *O. mirabilis*. Taken from Glynn et al. 2020[5].

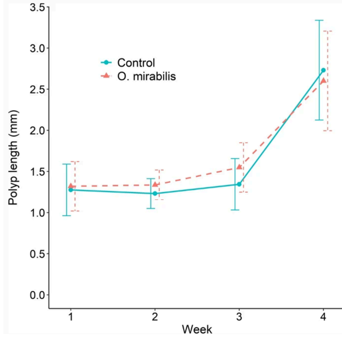

Figure 5. Mean polyp lengths (mm) of octocoral colonies as a function of time. Control group (*O. mirabilis* absent) denoted by the solid light blue line. Treatment group (*O. mirabilis* present) denoted by the dashed red line. Taken from Glynn et al. 2021[7].

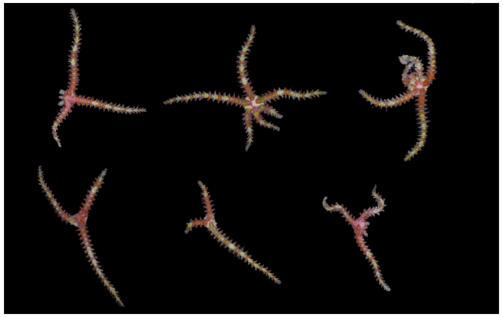

Figure 6. Image of *O. mirabilis* at various stages of fission. Individuals undergo clonal fission forming a new, independent animal by splitting along the medial axis of the disc. Upon a fission event, two new "half discs" with 3 arms are formed followed by the development of whole discs with 6 arms. Research on the factors that drive asexual reproduction are ongoing, with a particular emphasis on the influence of temperature on fission frequency.

Discussion

- Seasonal abundance of *O. mirabilis* at the Dania Beach survey site is highly variable, with densities ranging from 2.5 ± 1.7 indiv/10cm octocoral to as high as 27 ± 12.6 indiv/10 cm octocoral (Fig 2).
- Monthly sampling of *O. mirabilis* suggest higher abundances in cool months (Fig 2) although with considerable variability. The greater abundance in winter months may suggest a preference for cooler environmental conditions that more closely resemble their native range in the Eastern Pacific
- The spatial distribution of *O. mirabilis* in south Florida indicates a range of ~70 km, with limited expansion beyond patch reefs adjacent to the shoreline (Fig 4)
- A striking pattern of *O. mirabilis* occurrence is the proximity to major shipping ports including Government Cut and Port Everglades (Fig 4). This spatial pattern strongly implies that *O. mirabilis* may have been transported and introduced via shipping (ballasts or biofouling), a mechanism that is known to drive non-native species introductions globally[8]
- The mixed-effects model demonstrates an inverse relationship between *O. mirabilis* and *C. waltoni* (Fig 3). This result strongly suggests interference competition, where *O. mirabilis* outcompete resident ctenophores for substrate space ultimately leading to declines in *C. waltoni* abundance. This conclusion is supported by observations in the lab, wherein *O. mirabilis* were observed disturbing *C. waltoni* during cohabitation.
- The question of whether *O. mirabilis* may negatively impact their octocoral hosts is still up for debate. A recent study conducted in Martinique Island, French Lesser Antilles reported observations of octocoral polyp impairment due to *O. mirabilis* residence[9]
- However, here we report no significant difference in octocoral polyp extension between control and treatment groups (Fig 5). Based on this result, there is likely a commensal symbiosis between *O. mirabilis* and their octocoral hosts, however more research is necessary in order to confirm this relationship
- The ability of *O. mirabilis* to reproduce asexually via fission has significant implications for the future dispersal of this invader to other regions in the Atlantic. Identifying the factors that drive the frequency of fission will be important in understanding how *O. mirabilis* spreads through Atlantic reefs. Our ongoing work aims to evaluate whether temperature is a key factor that triggers this form of asexual reproduction.
- A source of contention in the study of *O. mirabilis* is whether this species should be classified as "invasive" to Atlantic ecosystems. The definition of invasive itself is controversial, although it is typically applied to introduced species that cause direct ecological harm. Here, we demonstrate the negative impact of *O. mirabilis* on the native epizoite *C. waltoni* and conclude that this introduced species may be classified as invasive with respect to octocoral associates. However, we abstain from using "invasive" here until further ecological interactions are documented.

References

[1]Hendler, G., *et al.* (2012) *Mar. Bio. Rec.*, 6. [2]Glynn, P. W., *et al.* (2019) *Invert. Biol*, 138(3), e12256. [3]R Core Team (2013). [4] Brooks ME, *et al.* (2017). *The R Journal*, 9(2), 378–400 [5]Glynn, P. W., *et al.* (2020). *Adv. Mar. Biol., 99*. [6]Glynn, P. W., *et al.* (In Review) *Mar. Biol.* [7]Glynn, P.W., *et al.* (2021) *Coral Reefs,* 40, 323-334. [8]Molnar *et al.* (2008) *Frontiers in Ecology and the Environment*, 6(9), 485-492. [9]Ferry *et al.* (2020) *BioInvasion Records*, 9(2), 228-238.

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