Pyrodinium bahamense seeding potential in Tampa Bay: Executive Summary

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Introduction

The recovery of Old Tampa Bay (OTB) has lagged behind other Tampa Bay segments, in part, due to recurring summer blooms of the toxic dinoflagellate *Pyrodinium bahamense*. *Pyrodinium bahamense* has been documented in Tampa Bay since the 1960's, but persistent blooms of this taxon have only been recently observed. Through routine and event-response monitoring, local agencies including EPCHC and FWC have recorded bloom levels of *P. bahamense* in 14 of the last 17 years — with summer blooms now persisting four and a half months, on average.

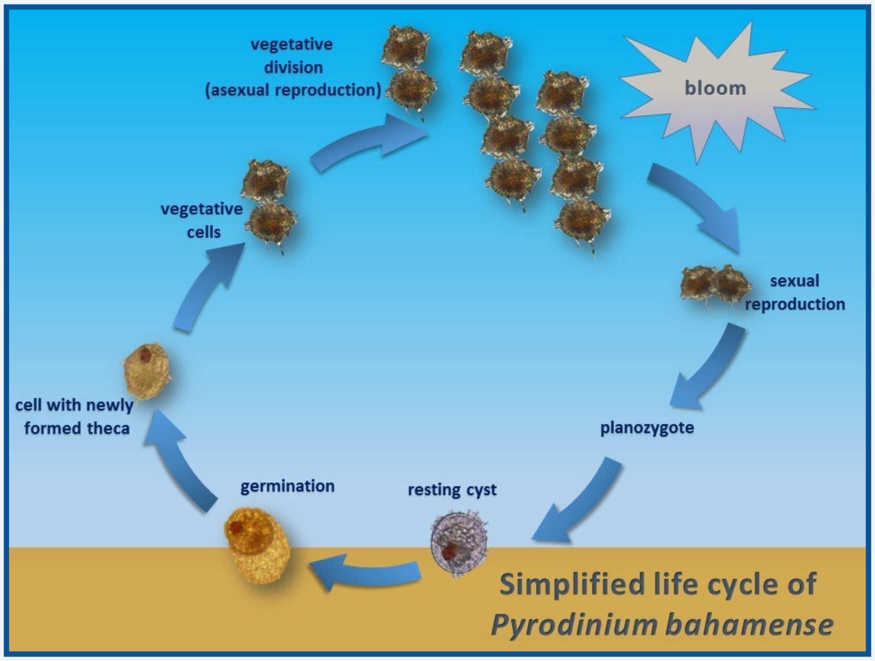

Fig 1. Simplified life cycle of *Pyrodinium bahamense* showing transitions from the resting stage (cysts) to vegetative (dividing) cells to sexual reproduction.

High biomass blooms of *P. bahamense* can have cascading effects of decreased light, degraded water quality, low dissolved oxygen (hypoxia), and hypoxia-related fish kills. In addition, *P. bahamense* produces saxitoxins, neurotoxins that can accumulate in filter-feeding shellfish, leading to paralytic shellfish poisoning in humans if contaminated shellfish are consumed[1].

As part of its life cycle (Fig 1), *P. bahamense* produces resting cysts, similar to seeds of higher plants. The immobile, dormant cysts settle to the seafloor, creating a cyst bed, or seed bank, to initiate future blooms. Germination occurs only after dormancy is alleviated and external environmental factors (e.g., oxygen, temperature, and light) initiate excystment. This life cycle strategy is comparable to that of some higher plants, in which seed production and dormancy at the end of the growing season ensure plant survival and continuation of species proliferation the following year [2, 3, 4].

The flux of germinated cysts from seafloor seed banks is a primary driver of bloom initiation in many cyst-forming dinoflagellates[5, 6]. Measures of cyst abundance in the sediment can be important to define initial location and magnitude of blooms[7], whereas the timing of dormancy release (i.e., when cysts can germinate given favorable conditions) each year is likely a primary predictor of *when* the bloom will initiate[8].

Approach

The overall goal of this project was to characterize seeding potential of cyst beds in OTB. We quantified cyst abundance, germination, and sediment mobility in the upper five centimeters of sediment cores taken seasonally from three sites in OTB between August 2015 and September 2016 (Fig 2), with the premise that buried cysts may serve as an important seeding source, especially in areas of increased sediment mobility. We also characterized temporal patterns in cyst dormancy.

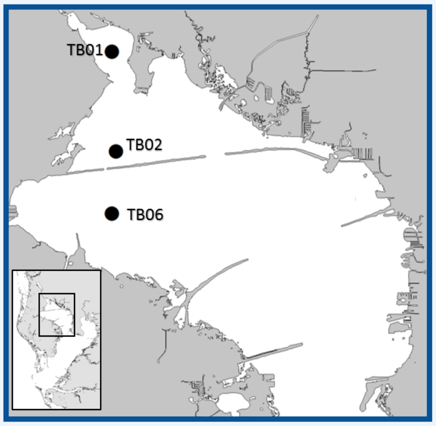

Fig 2. Location of Old Tampa Bay (inset) and coring sites, TB01, TB02, and TB06 .

The ultimate goal of this and future work is to develop simple indices of germination that can be integrated into existing modeling efforts to improve predictions of bloom initiation.

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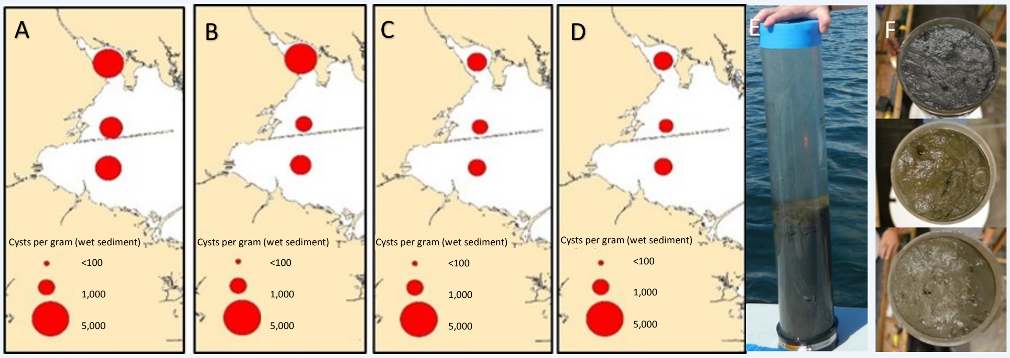

Fig 3. Depth integrated cyst abundance in the top 5 cm at the three coring sites for (A) August 26, 2015, (B) November 4, 2015, (C) February 1, 2016, and (D) April 4, 2016.
(E) A sediment push core taken with diver assistance (F) Surface of cores taken at TB01 (top), TB02 (middle), and TB06 (bottom) on November 4, 2015.

Results

Over the sampling period, *P. bahamense* cyst abundance was high (>1000 cysts per gram of wet sediment, Fig. 3) and generally uniform in the upper five centimeters of sediment at all sites.

The percent mud (silt + clay) was highest in Safety Harbor (TB01) cores and decreased down bay. However, there was no significant correlation between cyst abundance and percent mud or mean grain size among the three sites. We did observe significant changes in cyst distribution through time, suggesting that the period preceding bloom season (late winter) is the optimal time to map cyst abundance and distribution.

Cysts collected from both surface and buried sediment in August 2015, November 2015, and in September 2016 were dormant (unable to germinate), indicating cyst beds in the summer and fall had little potential to seed the water column with vegetative cells. These findings are supported by a complementary project that demonstrated summer temperatures induce dormancy and extended cool temperatures alleviate dormancy. Such a strategy may allow the algae to 'overwinter'—in effect, synchronizing the timing of dormancy release to occur in late winter or early spring when conditions in the water column are more favorable for vegetative cell growth. Indeed, we found that by February 2016, cysts collected from the field were beginning to germinate and by April 2016—the time when vegetative cells were first observed in the water column— cysts were germinating at their maximum potential. These results are also consistent with the *P. bahamense* bloom timing in OTB—blooms generally begin by mid-May and end by late-September.

The radionuclide Beryllium-7 (^{7}Be) occurred at variable depths through space and time, with an overall average depth of 2.3 cm. Because ^{7}Be has an atmospheric source and short half-life, detection of ^{7}Be in buried sediments suggests vertical reworking of the sediment. For example, observation of ^{7}Be in sediment collected from 5 cm during August 2015 suggested that some of that sediment had recently been located at the surface. The mechanisms of vertical sediment reworking (e.g., deposition, bioturbation, sediment resuspension) are likely variable and site-specific and require further studies to identify. Regardless of mechanism, these results suggest the sub-surface sediment (in addition to surface sediment) may be able to contribute to seeding the water column with *P. bahamense* cells.

Summary of Key Findings

- ***P. bahamense*** **cyst abundance was high throughout the upper five centimeters of sediment in all cores**
- ***P. bahamense*** **cysts displayed a seasonal cycle in dormancy with little to no germination in the summer and fall and peak germination in the spring**
- **Cyst distributions change over time, so late winter is the optimal time for cyst surveys**
- **^{7}Be data suggest vertical mobility of sediment, indicating sub-surface cysts can potentially seed blooms**

References

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Glossary

Bloom – An algal bloom is an overgrowth of algae. Harmful algal blooms are blooms that cause harm to humans, animals, or the environment. (go back)

Bloom levels -- Generally, *P. bahamense* abundance above 5000 cells L^{-1} is considered a bloom. (go back)

Beryllium-7 (^{7}Be) – Beryllium-7 is a naturally occurring radioisotope of beryllium with a half-life of 53.22 days. Because the source of ^{7}Be is atmospheric, its presence in sediments indicates that the sediments have been recently deposited (within about 79 days to a year, depending on the initial activity). (go back)

Dormant/dormancy – Dormancy describes a resting cyst that is unable to germinate, even under favorable conditions. It is important to distinguish dormancy from quiescence (a quiescent cyst can germinate if exposed to favorable conditions). (go back)

Germination – Germination is the emergence of a viable algal cell (germling) from a resting cyst. Germination is sometimes used interchangeably with excystment. Germlings develop into vegetative cells. (go back)

Paralytic shellfish poisoning – Paralytic shellfish poisoning, or PSP, is a syndrome in humans caused by consuming shellfish that have accumulated high levels of saxitoxins in their tissues from feeding on toxic algae. Saxitoxins are neurotoxins and symptoms of PSP include numbness, paralysis, and disorientation. (go back)

Resting Cysts – Dinoflagellate resting cysts are an immobile benthic life stage characterized by a thick, resistant cell wall and some required period of dormancy. The ecological function or resting cysts may be genetic recombination, propagation, or dispersal, among others. (go back)

Vegetative Cells – Vegetative cells in this context are the asexually dividing, swimming cells of *P. bahamense*. This life stage is planktonic, or found in the water column. (go back)