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Interm Report of a pilot study to evaluate impacts to water quality and seagrass meadows from the green mussel (Perna viridis) invasion in Hillsborough Bay, Tampa Bay, Florida.

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INTERM REPORT OF A PILOT STUDY TO EVALUATE IMPACTS TO WATER QUALITY AND SEAGRASS MEADOWS FROM THE GREEN MUSSEL (*PERNA VIRIDIS)* INVASION IN HILLSBOROUGH BAY, TAMPA BAY, FLORIDA.

INTRODUCTION

The green mussel (*Perna viridis*) was discovered in Tampa Bay in 1999 and was first noted as a biofouler at a power generating plant. This was apparently the first record of this species in the U.S. Since 1999, green mussels have been found throughout Tampa Bay and in other marine locations outside Tampa Bay on the west-coast of Florida (Benson et al. 2001; Benson et al. 2002).

Several potentially severe impacts to the Tampa Bay ecosystem that may result from the invasion of the green mussel have been considered in the literature (Benson et al. 2002). The impacts considered to date have most often been associated with the green mussel attaching to a firm substrate, such as manmade structures or hard natural communities. However, during routine seasonal seagrass monitoring in Hillsborough Bay in February 2003 the City of Tampa Bay Study Group (BSG) found substantial areas of dense green mussel infestation in sandy sediments with established *Halodule wrightii* meadows near Catfish Point (Johansson 2003; Avery and Johansson in prep; Figure 1). Additional green mussel beds were found nearby, also in areas with sandy sediments. These areas currently lack extensive seagrass coverage, but are potential areas of seagrass colonization.

Continued invasion of the green mussel in established seagrass meadows and potential seagrass areas could eventually have a devastating impact on the seagrass habitat and the overall function of the Tampa Bay ecosystem. An urgent need exists to understand the extent and the rate of the invasion of seagrass areas, and its potential long-term impacts to the ecosystem.

In a proposal to the Tampa Bay Estuary Program (TBEP), the BSG offered to conduct a pilot research study to evaluate the current invasion of green mussels in Hillsborough Bay, specifically in areas with seagrass coverage and potential areas of seagrass colonization. Two anticipated and potentially counteracting influences to the seagrass meadows from the green mussel invasion will be examined. First, the negative impact to seagrass growth and area coverage caused by direct displacement from suitable substrates by the green mussels will be evaluated. Second, potentially positive effects to seagrass areas, located near green mussel beds as a result of the feeding activity of the mussels, will also be examined

This report constitutes an interim report provided to the Tampa Bay Estuary Program (TBEP) to describe progress on the project to date. A final project report, including a detailed discussion of study results, will be provided to the TBEP for possible inclusion in the next edition of the Baywide Environmental Monitoring Report (BEMR), expected to be published in 2005. Results from planned additional monitoring of the areal extent of green mussel beds near Catfish Point, and the potential impact of the beds on local water quality and seagrass condition, will be included in the final project report.

FIELD ACTIVITIES AND METHODS

An initial size determination of a nearshore green mussel site at Catfish Point (CP1) in Hillsborough Bay was made in March 2003. The perimeter of the mussel bed was measured by recording positions along the periphery every 5 seconds with a Trimble® ProXR differential Global Positioning System (DGPS). Smaller areas of green mussels, not contiguous with the main bed, were not included in the areal coverage estimate at this time. Further, a second large bed located offshore from CP1, called CP2, was noted, however its areal extent was not determined at the time due to poor water clarity.

A preliminary evaluation of the impact of green mussel filtration activity on the water column was conducted at the nearshore mussel bed, CP1, also in March 2003. Surface water samples were collected at sites up-current from the bed, in the center of the bed, and down-current from the bed during an incoming tide. These samples were analyzed for chlorophyll *a*, using a fluorometric "whole water" chlorophyll method developed by the BSG (City of Tampa 1998), and percent light transmission using a C-Star® transmissometer (660nm, 10cm path length).

A more detailed *in situ* water clarity investigation was conducted in a 200 x 200m study area at the CP1 mussel bed in June 2003. The C-Star transmissometer was towed by a boat along several transects within this area at a depth of about 0.5m at near slack high tide. *In situ* percent light transmission and DGPS determined positions were recorded every 30 seconds. The recorded water clarity information was interpreted and contoured using Surfer® computer software.

In July 2003, a similar detailed *in situ* water clarity investigation was conducted at a large green mussel bed located at Long Shoal in Hillsborough Bay (Figure 1). The area extent of this bed has not been determined in detail, however, it was assumed that a 400 x 400m study area would encompass most of the bed. Field measurements of water clarity and its interpretation were the same as for the CP1 bed. The tide was at slack minor low.

In February 2004, the mussel beds at Catfish Point were again surveyed for areal extent and locations using the same DGPS method as described for the March 2003 survey. However, the 2004 survey was conducted during good water clarity and at a very low tide with portions of both CP1 and CP2 exposed. The excellent visibility conditions allowed for detailed mapping and areal estimates of both CP1 and CP2.

It was planned to establish several seagrass study sites in the vicinity of CP1 during the late summer of 2003. However, heavy rainfall during the summer resulted in very dark and cloudy water that made observations of seagrass coverage and condition difficult. The installment of seagrass study sites was therefore postponed to April 2004. At that time, five seagrass study sites, all consisting of monospecific *H. wrightii,* were selected in near proximity to CP1 (Figure 2). The locations of the study sites were determined with DGPS.

Measurements of seagrass condition at the five selected sites were initiated in June 2004. The measurements also included the BSG long-term seagrass study site SS11.1, located approximately 100m to the northwest of CP1 (Figure 2). This site was selected as reference site for this study. Measured parameters included: short-shoot density, canopy height, and water depth. Subjective observations of general seagrass condition, epiphyte composition and epiphyte load were also recorded.

A second seagrass evaluation of the five study sites and the reference site was conducted in September 2004. Continued seagrass surveys at CP1 are planned for 2005 on a quarterly schedule.

Further, low altitude aerial photography (courtesy of the Tampa Police Aviation Unit) of the shallow portions of primarily Hillsborough Bay has been conducted on a quarterly or more frequent schedule by the BSG. During flights in 2003 and 2004 special efforts were taken to secure pictures of the green mussel beds at Catfish Point and Long Shoal. Also, evidence of green mussel infestation in Hillsborough Bay, and other bay segments, are noted during other BSG seagrass and water quality monitoring efforts.

RESULTS

The areal extent of the main, and near continuous, portion of the CP1 green mussel bed at Catfish Point was approximately $1400m^2$ in March 2003. The February 2004 survey determined it to be about $1500m^2$. Although the areal estimates are similar, the DGPS position information from the two surveys shows that a 35m long section of the northeastern outer edge of the main bed was approximately 6m closer to shore in 2004 than in 2003. Also the nearshore edge of the main bed appears closer to shore in 2004 (Figure 3). The size of the offshore CP2 bed was approximately $2300m^2$ in February 2004. Further, the surface of the main portion of both beds was elevated approximately 20 to 30cm above the sandy sediment at the edge of the beds.

The CP1 bed contained mostly relatively large mussels with a total shell length generally ranging between 10 to 15cm during both the March 2003 and February 2004 surveys. Specifically, during the 2004 survey, there appeared to be a lack of small mussels.

The preliminary evaluation of water quality impacts from green mussel filtration activity at the CP1 bed in March 2003 indicated a decrease in chlorophyll *a* concentration and an increase in percent light transmission (water clarity) as the water flowed across the bed (Figure 4). Chlorophyll concentrations decreased from about $14ugl^{-1}$ at the up-current location to about $4ugl^{-1}$ above the main portion and the down-current location of the bed. Respective values for percent light transmission increased from about 65 to 69 percent.

The detailed *in situ* water clarity investigations with a towed transmissometer, conducted at the Catfish Point CP1 and the Long Shoal mussel beds in the summer of 2003, further confirmed that the mussel beds appear to significantly increase percent light transmission above and in close proximity to the beds (Figure 5 and 6). However, water clarity impacts outside the investigated areas appear minimal.

To date, only two evaluations of seagrass (*H. wrightii*) condition at the five selected seagrass study sites at the CP1 mussel bed have been conducted and compared to conditions at the reference site. Additional evaluations are planned for 2005. Due to the limited amount of information available, it is premature to provide conclusions of potential impacts from the green mussel beds on seagrass condition and distribution. The results from the two seagrass evaluations conducted to date are shown in Table 1.

Locations of live green mussel sites observed during BSG field activities in 2003 and 2004, in Hillsborough Bay and other bay segments, have been plotted on a Tampa Bay map (Figure 7). It should be emphasized that this map does not attempt to give a complete picture of the green mussel distribution in Tampa Bay, or that the identified sites currently have live mussels present. Further, the dots on the map do not imply size of the sites.

Finally, several examples of photos taken during low altitude flights in 2003 and 2004 over the green mussel sites at Catfish Point and Long Shoal can be seen in Figures 8, 9 and 11.

DISCUSSION

The presence of green mussel beds in established Hillsborough Bay seagrass meadows and potential seagrass areas, that was first observed in 2003, raised concerns that an aggressive invasion and expansion of mussel beds in such areas may ultimately displace large areas of Tampa Bay seagrass habitat (Johansson 2003; Avery and Johansson in prep.). A significant loss of this important habitat could potentially threaten the overall function of the Tampa Bay ecosystem.

It was, however, also recognized that a limited and stable establishment of green mussel beds in or near seagrass areas could benefit local seagrass meadows. Beneficial impacts might include improved water column clarity, as a result of mussel filter feeding, and also potentially increased availability of sediment nutrients from mussel fecal deposition.

The substantial green mussel beds near Catfish Point apparently grew relatively quickly to their current size. Aerial photography from this area indicates that detectable mussel beds were not present 18 months prior to their discovery in February 2003. This rapid development suggested a potential for an aggressive invasion of green mussels to sandy areas in Hillsborough Bay. However, detailed areal measurements of mussel bed CP1 conducted in March 2003 and April 2004 did not indicate a major change in size of the main portion of the bed between the two measurements. In addition, no other significant areas of mussel infestation have been observed in sandy sediments in Hillsborough Bay since the start of the current study. Finally, there has been a notable lack of smaller size mussels at the CP1 bed during the study visits, suggesting a lack or reduced recruitment of young mussels.

The lack of expansion of the CP1 bed, and the lack of new developing mussel beds, suggest that the mussel infestation to shallow sandy Hillsborough Bay sediments has stagnated. The cause(s) of this apparent stagnation are unclear at this time, however, a primary hypotheses that needs further testing concerns the mussel persistence and survivability in low salinity water.

The reported initial Tampa Bay mussel infestation occurred during a period of several dry years (1999-2001) and concurrent relatively high bay salinity (Figure 10). However, the current study has been conducted during above normal rainfall years (2003 and 2004) and relatively low bay salinity. The literature reports that salinities less than 18PSU may limit the geographical distribution of the green mussel (Baker et al. 2004). There were extended periods of salinites less than 18PSU in Hillsborough Bay in 2003. An additional observation in support of the hypothesis that salinity may be an important regulator of green mussel infestation and expansion was noted in the Port of Tampa. Here, green mussels were attached to a boat dock prior to the summer rains in 2003, however, soon after the rains started and the salinity had been reduced substantially, the mussels died and later disappeared.

The water quality measurements conducted at the CP1 and Long Shoal beds show that mussel filtration unquestionably improves water column clarity above and in areas in close proximity to the beds. These results agree with previous studies describing impacts on the water column by filter feeding benthic organisms in Tampa Bay and elsewhere (see City of Tampa 1998). However, any bay-wide impacts on water clarity in Hillsborough Bay, as a result of filtration by the current Hillsborough Bay green mussel population, are most probably insignificant.

The water clarity improvements noted near the mussel beds at Catfish Point should benefit already established seagrass coverage in this area and improve recruitment of new seagrass to the area. Further, deposition of mussel fecal material could be expected to enrich the local sediments and to provide an additional source of nutrients for the established seagrass. However, it is premature in this interim report to provide detailed discussion and conclusions on these potential beneficial impacts due to the limited amount of field information collected to date. Currently, most of the limited amount of *H. wrightii* that is present in a 100-150m radius of the CP1 mussel bed, occurs within a few meters of the bed. It should be noted, however, that prior to 2003, the Catfish Point area was much more densely populated with *H. wrightii* than today (see Figure 8A and Figure 11). Much of the grass was lost between late 2002 and the summer of 2003, not as a result of green mussel impacts, but apparently due to poor water quality (City of Tampa 2004).

On several visits to the green mussel beds at Catfish Point it was noted that the 20 to 30cm high and abrupt offshore edges of the main portion of the beds substantially reduced the propagation of wind generated waves across the bars and over the areas inshore of the bars. The already discussed 6m nearshore shift of the northeastern outer edge of the CP1 bed, may also have resulted from absorption of wave energy. Consequently, it appears that the green mussel bars at Catfish Point act as efficient wave reduction structures.

Tampa Bay seagrass researchers have postulated that the presence of prominent shallow sandbars (long-shore bars) at the offshore edge of many near-shore areas at the periphery of Tampa Bay have historically protected seagrass meadows inshore of the bars from destructive wave impacts (Lewis et al. 1985; Lewis 2002). Losses of bars over time due to erosion in several areas of the bay are thought to have contributed to the substantial seagrass losses reported for Tampa Bay over the last half-century. Further, a lack of current seagrass colonization in areas with suitable depth and adequate water quality could indicate that wave energy prevents seagrass growth in those areas. The construction of artificial long-shore bars has been proposed in areas with degraded natural bars as a potential management option to increase Tampa Bay seagrass coverage and to protect current seagrass areas.

Because the green mussel bars at Catfish Point appear to act as efficient wave reduction structures, they could potentially be expected to promote seagrass survival and propagation in areas inshore of the bars. Currently, no seagrass appears to be present near CP2, and the seagrass that is present at CP1 occurs primarily very close to the offshore edge of the bed. However, it is recommended that the natural green mussel bars at Catfish Point be included, as test cases, when a seagrass management option for Tampa Bay is initiated that involves the creation of artificial long-shore bars.

ADDITIONAL ACTIVITIES RELATED TO THIS PROJECT

In July 2003, Walter Avery gave a presentation to the TBEP Technical Advisory Committee. In the presentation he outlined the green mussel project and provided some preliminary results from early field studies.

In October 2003 the authors were invited to give a presentation at the BASIS 4 symposium. Walter Avery gave the presentation and provided results from the green mussel project to date. The authors also prepared and submitted a manuscript for inclusion in the proceedings of the BASIS 4 symposium.

COVER PHOTO

The cover photo of this report shows the Catfish Point area of Hillsborough Bay. It was taken on February 19, 2004. The green mussel bed CP2 is in the foreground and the CP1 bed can be seen in the background to the right.

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