

**THE DYNAMICS AND DISTRIBUTION OF THE SLIME MOLD
LABYRINTHULA SP. AND ITS POTENTIAL IMPACTS ON
THALASSIA TESTUDINUM POPULATIONS IN FLORIDA**

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ABSTRACT

Data from three different studies were used to evaluate the distribution of the parasitic slime mold *Labyrinthula* sp. in Florida Bay, the eastern Gulf of Mexico, and the Tampa Bay area as well as predict potential impacts on *Thalassia testudinum* populations. A preliminary hypothetical model developed during the Florida Bay study was used to explain and predict impacts in the eastern Gulf of Mexico and Tampa Bay where sample sizes were much lower. Infection levels comparable to those found in Florida Bay where substantial seagrass losses have occurred were found in the eastern Gulf of Mexico and Tampa Bay. We propose that long-term careful monitoring of *Labyrinthula* sp. in *T. testudinum* be carried out in estuaries other than Tampa Bay, especially those with environmental stresses.

INTRODUCTION

The protist, *Labyrinthula*, is a parasite of the subtropical seagrass *Thalassia testudinum* Banks ex König (turtle grass). Data from 3 different studies were used to evaluate the distribution of this marine slime mold in Florida Bay, the eastern Gulf of Mexico, and the Tampa Bay area as well as to predict potential impacts on its host populations. This parasite had been proposed as a possible cause of a massive acute seagrass die-off in Florida Bay that began in the summer and fall of 1987. No definitive cause(s) of this acute die-off was ever determined, but many possible etiologies were proposed, including high temperatures and salinities, overdeveloped seagrass beds, elevated sediment sulfide levels, hypoxia, and disease (Porter and Muehlstein, 1989; Robblee et al., 1991; Durako and Kuss, 1994; Carlson et al., 1994). "Wasting disease" in the eelgrass *Zostera marina*, which decimated the seagrass beds of Europe and North America in the 1930s and 1940s had previously been shown to be caused by a species of *Labyrinthula*. Some of these seagrass beds took 40 years to recover. Such a possible outcome in Florida made it important to attempt to determine the distribution pattern of *Labyrinthula* in *T.*

testudinum populations in different Florida estuaries with varying environmental conditions and try to understand this parasite's potential impacts on the health and survival of those seagrass beds.

METHODS

Data were collected in three separate studies of *Labyrinthula* distribution in different geographical areas. The most extensive data set was collected over the last 5 years in a study initiated in Florida Bay in 1995. Two other preliminary studies were also done, one in the eastern Gulf of Mexico, and the other in the Tampa Bay area. The same field methods were used in all 3 studies so that results could be easily compared. Results from the Florida Bay studies were extrapolated to propose potential impacts of this slime mold on *T. testudinum* populations in the other areas of Florida where less extensive studies of *Labyrinthula* sp. have been done.

Florida Bay Studies (1995–present)

Four principal questions were asked during our Florida Bay studies:

1. Did *Labyrinthula* have a role in the initial acute *Thalassia* die-offs (summer, 1987)?
2. Is *Labyrinthula* involved in the chronic

die-off that we have been monitoring since the beginning of this study (1995-present)?

3. If it is involved, what role does *Labyrinthula* play in the chronic die-off?
4. Does *Labyrinthula* have a role in the current (first noticed in summer, 1999) acute die-off in Barnes Key?

Methods. Data from four years of biannual sampling in Florida Bay were examined to determine the relationship between the distribution and abundance of the seagrass *T. testudinum* and *Labyrinthula* sp. Ten basins with varied physical characteristics were studied intensively, including microscopic examination of thousands of *T. testudinum* blades from more than 2,500 sites within these basins. We used ArcView's extension Spatial Analyst and the Inverse Distance Weighted (IDW) method to visualize the pattern of and changes in distribution and abundance of infection in *T. testudinum* (Blakesley et al., 1999a).

Results. Both lab and field studies show that ongoing low salinities prevent *Labyrinthula* sp. from infecting *T. testudinum*. Field studies also suggest that a drop in salinity to below 15 ppt will reduce the existing level of infection. The data collected both during this field study and from associated laboratory studies (Blakesley et al., 1998) resulted in the formulation of a preliminary hypothetical model (Figs. 1 and 2) describing the effects of *Labyrinthula* sp. on *T. testudinum* populations in Florida Bay (Blakesley et al., 1999b). Where seagrass densities are low, *Labyrinthula* sp. does not cause major mortality. In moderate to high salinities and high seagrass densities, *Labyrinthula* sp. plays a major role in seagrass mortality. With optimal conditions for seagrass, *Labyrinthula* sp. can be a primary pathogen controlling seagrass densities. In suboptimal conditions for seagrass, such as lowered

light levels, stressed seagrass may be weakened by opportunistic *Labyrinthula* sp. that further contributes to chronic seagrass die-off.

Discussion. The theoretical model suggests 3 different roles that *Labyrinthula* sp. might play in Florida Bay under different environmental conditions. These include: (1) a nonpathogenic parasite; (2) an opportunistic secondary pathogen; and (3) a primary pathogen. Five different factors are considered to be critical elements in determining the role(s) of *Labyrinthula* sp. in seagrass health at a particular site in Florida Bay (Blakesley et al., 1999c). Salinity controls infection (infection does not occur at <15 ppt). Seagrass density determines the extent to which *Labyrinthula* sp. infection spreads because the slime mold transmission is thought to depend on blade-to-blade contact (Muehlstein, 1992). Pathogenicity of a particular strain of *Labyrinthula* sp. will determine severity of infection. Environmental stressors (abiotic factors) such as low light or high temperatures may weaken *T. testudinum* and, in combination with the infection by pathogenic *Labyrinthula* sp., cause seagrass die-off. Resistance to disease due to genetic factors or production of phenolic compounds may be important in determining the health of *T. testudinum* in Florida Bay. The model predicts that in areas with high seagrass density, high salinity, suboptimal seagrass conditions (environmental stress), and presence of pathogenic *Labyrinthula* sp., the slime mold could contribute to either chronic or acute die-off acting as an opportunistic secondary pathogen. With the same conditions, but without environmental stress, it suggests that *Labyrinthula* sp. can still cause thinning or patchy die-off acting as a primary pathogen (Blakesley et al., 1999c)

Barnes Key (in Florida Bay) Die-Off Introduction. In late summer 1999, a new

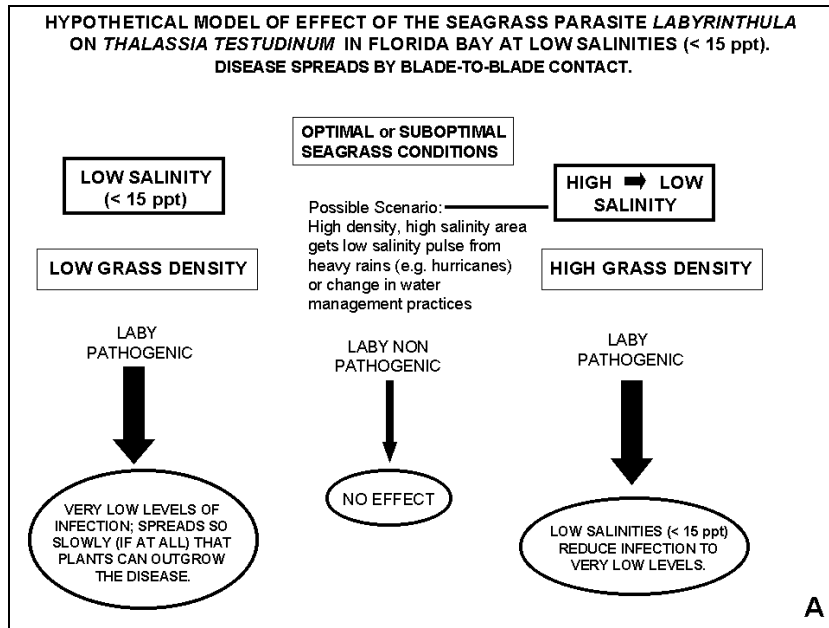


Figure 1. Hypothetical model describing the relationship between *Labyrinthula* infection of *Thalassia* and *Thalassia* mortality in Florida Bay in both high and low-density seagrass beds when either salinities are low or salinities were high and were then lowered to <15 ppt. The effects are the same in either stressed or unstressed seagrass conditions.

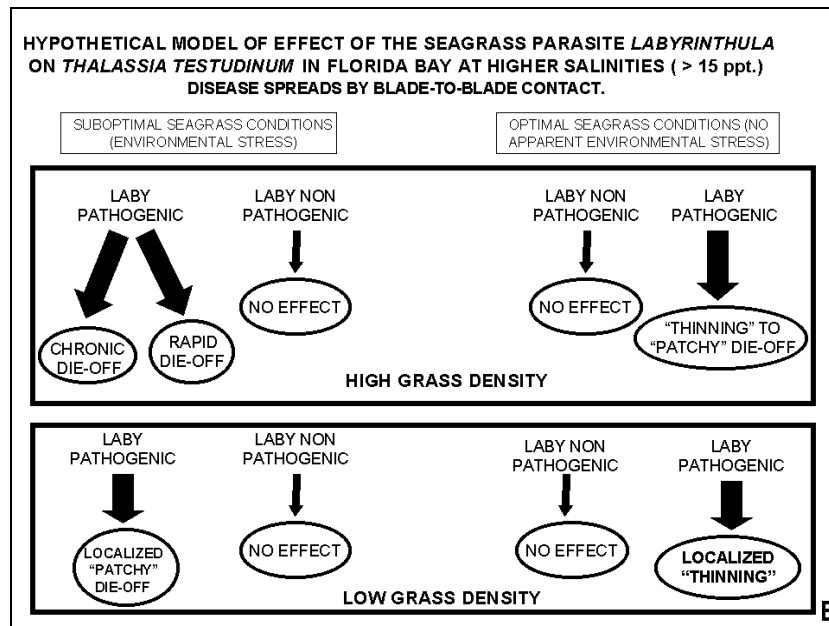


Figure 2. Hypothetical model describing the relationship between *Labyrinthula* infection in *Thalassia* and *Thalassia* mortality in Florida Bay at salinities >15 ppt. in stressed and unstressed conditions and in high and low seagrass densities.

seagrass die-off was first noticed north of Barnes Key that resembled the acute die-off of 1987, but was very different from the chronic die-off we had been studying since 1995. As in the acute event of 1987–89, *T. testudinum* appeared to be the only seagrass affected and the die-offs were occurring in dense, apparently “healthy” seagrass beds. Seagrass affected by the new acute die-off exhibited symptoms like those of the 1987 event, i.e. the lateral meristem tissue appeared to be the tissue most immediately affected (P. Carlson, personal communication). Meristem tissue seemed mushy and smelled like “mustard” while the rest of the blade looked green and healthy.

Methods. Beginning in early winter 1999, an investigation of the new acute seagrass die-off in Barnes Key was initiated to try to readdress the question first asked and unresolved 12 years before; why did the *T. testudinum* suddenly start dying in Florida Bay? Three 150 m transects were set up and monitored every 2–6 weeks. Changes in vegetative cover and infection by *Labyrinthula* sp. were recorded and sediment sulfide levels in different vegetative categories were monitored. In addition a total of 9 die-off patches were marked and monitored.

Results and Discussion. Preliminary data from our investigation of this event show that *Labyrinthula* sp. is probably not the initial cause of the acute die-off but instead appears to be an opportunistic secondary pathogen. There may be a seasonal component; our extensive data from Florida Bay, both field and laboratory, indicates that *Labyrinthula* sp. activity is related to temperature. When we first evaluated the site, in January, *Labyrinthula* sp. was rarely present anywhere in the Barnes Key area and this remained the case in repeated sampling through July. In September, we first noticed *Labyrinthula* sp. lesions, but only around old die-off

patches. In November, we recorded the highest levels of *Labyrinthula* sp. infection since our studies began in Florida Bay in 1995. Infection was found in the margins of both active and inactive die-off patches as well as in the dense beds around those patches. Additional studies of this area are needed to follow the progression of the infection and die-off through time.

Apparent impacts of *Labyrinthula* sp. on *T. testudinum* seagrass beds in Florida Bay are summarized below:

- In low salinity areas (<15 ppt): **no impact**
- In dense beds with no apparent environmental stress (and salinity >15 ppt): **thinning, patchy die-off**
- In dense beds with environmental stress (and salinity >15 ppt): **chronic patchy die-off**
- In areas that have experienced an acute die-off (environmental stress present, and salinity >15 ppt): **severe loss**

Eastern Gulf of Mexico Studies (1997–1999)

Methods. In this study of 10 sites in the eastern Gulf, 10 *T. testudinum* shoots from 30 stations at each site were evaluated annually for lesion coverage and *Labyrinthula* sp. infection. The sites were chosen based on perceived environmental stress such as salinity fluctuations, thermal stress from power plants, and urban stresses, including several sites categorized as pristine.

Results. Results are shown in Figure 3. Infection levels were high at all sites except Charlotte Harbor and Perdido Bay; these sites had salinity fluctuations (Charlotte Harbor, 10–25 ppt; Perdido Bay, 12–34 ppt). Most other sites (including Tampa Bay) had infection levels higher than those found in the one Florida Bay site in this study (Rabbit Key basin) where seagrass losses have been substantial in the past. These results led to a request by the Tampa

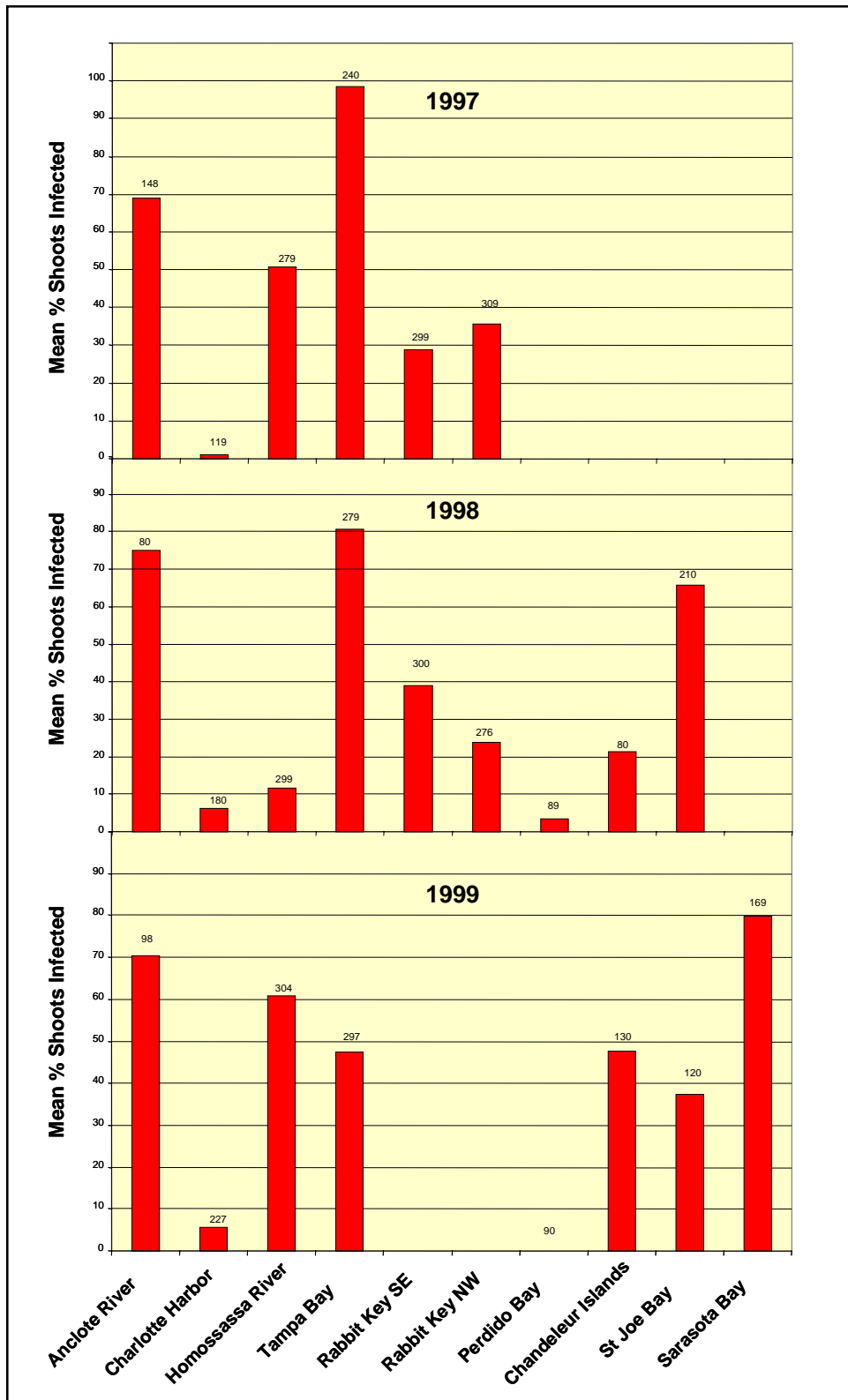


Figure 3. Mean percent *Thalassia* shoots infected with *Labyrinthula* at 10 sites along the east coast of the Gulf of Mexico.

Bay Estuary Program to begin a monitoring study of *Labyrinthula* sp. in the Tampa Bay area in the fall of 1999.

Discussion. Potential impacts of *Labyrinthula* sp. on *T. testudinum* in the Eastern Gulf of Mexico were extrapolated based on our data from these 10 sites and the information gained in the Florida Bay studies. The impacts are not now known, but the few data from this study suggest that the role(s) of *Labyrinthula* sp. in these areas may be similar to that found in Florida Bay. In summary:

- Low salinity sites (Charlotte Harbor, Perdido Bay): **no impact?**
- Environmentally stressed sites (Anclote River, Homossassa River, Tampa Bay, Rabbit Key, Sarasota Bay): **acute or chronic die-off?**
- Pristine sites (Chandeleur Islands, St. Joe Bay?): **thinning to patchy die-off?**

The St. Joe Bay site, which is categorized as pristine, may actually be experiencing some stress from elevated sediment sulfide levels caused by sea urchin grazing in the area (Paul Carlson, public communication, this meeting). Alternately, the *Labyrinthula* sp. may have been able to invade the blade tissue more easily because of mechanical damage caused by the urchins, with a subsequent indirect increase in sediment sulfide levels (microbial activity produces sulfide during the decay of below ground tissue from sick and dying plants). The Chandeleur Islands site may be a site similar to the Sunset Cove site in Florida Bay, where we hypothesize that *Labyrinthula* sp. plays the role of primary pathogen, thinning the dense seagrass beds and causing patchy die-off.

Tampa Bay Area (1999)

Methods and Results. Samples were collected during the fall 1999 Tampa Bay Estuary monitoring program to begin

looking at the distribution of *Labyrinthula* sp. and severity of lesions in *T. testudinum* in this area. The data are very limited, but our analysis of 5-10 shoots randomly collected from 32 transects showed that most of the sites were positive for *Labyrinthula* sp. (Fig. 4). Results of our monitoring studies show that the largest number of transects infected was in Old Tampa Bay (Fig. 5), but the highest percentage of shoots infected was in Clearwater (Fig. 6). Infection levels at all of the sites except the 3 transects in Sarasota Bay were either comparable or higher than those found in the western parts of Florida Bay where most seagrass losses have occurred. Potential impacts of *Labyrinthula* sp. on *T. testudinum* populations in the Tampa Bay area could range from no impact, through seagrass losses resulting in beneficial thinning of overdeveloped beds, to chronic or acute patchy die-off.

DISCUSSION

In summary, the distribution and potential impacts of *Labyrinthula* sp. infection on *T. testudinum* populations depend on a suite of interacting factors (salinity, seagrass density, pathogenicity, environmental stressors, seagrass resistance to disease). All of these factors, as well as others that may as yet not have been identified, need to be taken into consideration before the potential impacts of *Labyrinthula* sp. infections on *T. testudinum* populations in any particular geographic area can be predicted. The roles of *Labyrinthula* sp. in seagrass health in Florida Bay have been studied for 5 years. We are presently testing our model in Florida Bay in two areas (Barnes Key and Sunset Cove) with different environmental conditions, one with acute die-off and the other with chronic die-off. Only very preliminary *Labyrinthula* sp. and lesion distribution data have been collected elsewhere in the state.

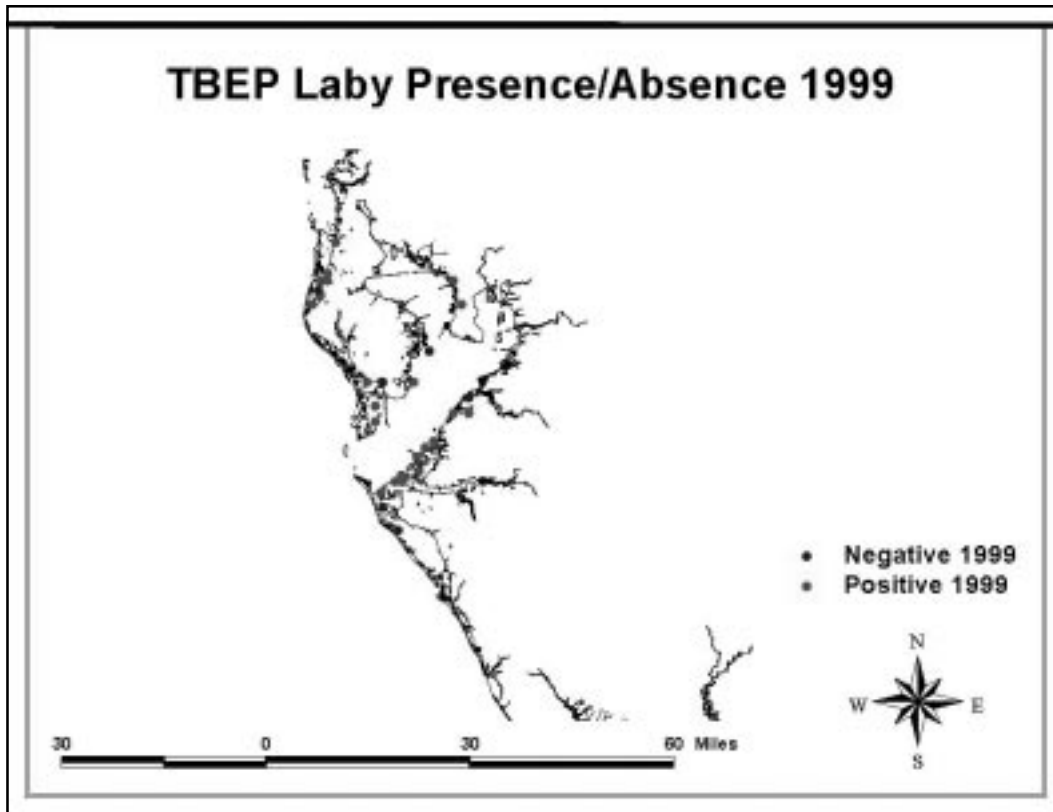


Figure 4. Map of sites sampled in the Tampa Bay area in the fall of 1999. Positive sites contained lesioned grass infected by *Labyrinthula* sp. cells.

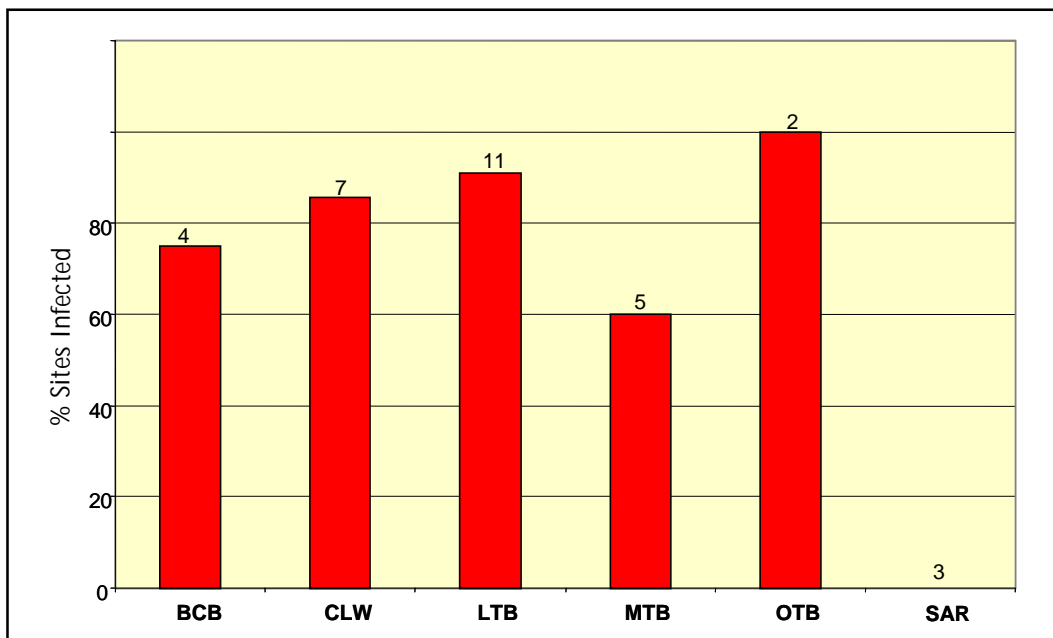


Figure 5. Percent of transects with *Thalassia* shoots infected with *Labyrinthula* in the Tampa Bay area in fall 1999. BCB = Boca Ciega Bay; CLW = Clearwater; LTB = Lower Tampa Bay; MTB = Middle Tampa Bay; OTB = Old Tampa Bay; SAR = Sarasota Bay.

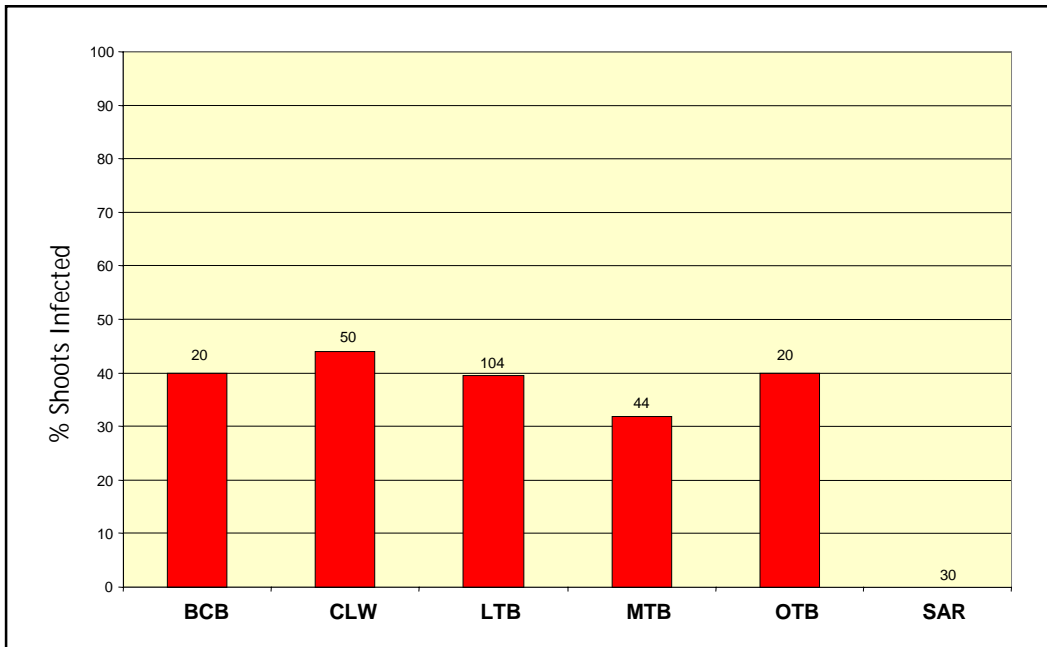


Figure 6. Percent of *Thalassia* shoots infected with *Labyrinthula* in the Tampa Bay area in fall 1999. BCB = Boca Ciega Bay; CLW = Clearwater; LTB = Lower Tampa Bay; MTB = Middle Tampa Bay; OTB = Old Tampa Bay; SAR = Sarasota Bay.

Long-term careful monitoring of *Labyrinthula* should be carried out in estuaries other than Florida Bay, especially in those with environmental stresses. The dynamics of *Labyrinthula* sp. distribution must be more clearly understood before the impacts of this slime mold on seagrass populations can be predicted. Seagrass recovery in urban estuaries must include health evaluations of seagrass beds to insure that gains in seagrass coverage can be maintained over time.

ACKNOWLEDGEMENTS

We would like to thank the many researchers who have helped on this study including Bruce Ackerman, Marit Alanen, Angela Baker, Paul Carlson, Rebecca Conroy, Jenny Davis, Nancy Diersing, Mike Durako, Scott Fears, John Hackney, Jeff Hall, Jan Landsberg, Susan Lukas, Gil McRae, Lisa Muehlstein, Claire Obordo, James Pallias, Jill Paxson, Noretta Perry, Iliana Quintero, Ruth Reese, Paula Reichert, Leanne Rutten, and Justin Styer. In addition we want to acknowledge the many volunteers who collected samples during the Tampa Bay Monitoring Program. This work was supported in part by the Department of Interior, National Park Service, Everglades National Park Cooperative

Agreement No. CA5280-7-9028 and the Florida Fish and Wildlife Conservation Commission (formerly the Florida Department of Environmental Protection), Florida Marine Research Institute; the U.S. Environmental Protection Agency award R825145; and the U.S. Environmental Protection Agency and Tampa Bay Estuary Program. Although the research described in this article has been funded in part by the United States Environmental Protection Agency, it has not been subjected to the Agency's required peer and policy review and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred.

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