Preliminary Survey of Point Sources of Pollution in La Parguera, Lajas Puerto Rico

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Summary:

- As part of the Green Infrastructure Project taking place in La Parguera historical community, we conducted a preliminary survey of suspected point sources of contamination.

- On the 7th and 8th of February, 2012, and a follow up on February 12th we surveyed the nearshore stilt houses and their surroundings via water as well as via terrain. Water transportation was provided by Mr Ivan Lopez in the "Playante" boat.

- General inspections were made beneath the majority of the stilt houses to determine misplaced and or improperly attached sewage pipes from the eastern portion of the town from Playita Rosada westward to the center of town. From there water quality conditions appeared too contaminated to put a person in the water.

- *In situ* samples were taken to measure ammonia using a Hanna Portable Photometer Kit (Hanna instruments, Woonsocket, RI).

- Some peak ammonia levels were recorded which are compatible with raw sewage discharges.

- Most of the stilt houses are connected to the PRASA sewage system. However, some residential systems lack proper maintenance and as a result of the difference in elevation, the system backflows into the mangrove lagoon, nearshore waters or stilt homes.

- In places where stilt houses were destroyed, often the remaining residential sewage pipes work as a backflow for the trunk main surcharging into the mangroves or nearshore waters during times of heavy flow or during storm events.

Introduction

Population growth and poorly planned construction have been pointed out as one of the major environmental stressors, resulting in major soil erosion, sewage and urban runoff affecting watersheds and thus coastal waters (Lapointe and Clark, 1992). Human activities on land inevitably increase nutrient inputs to coastal waters from deforestation, wastewater, fertilizers, and other sources (Lapointe and Clark, 1992; Wolanski *et al,* 2008). Phosporus (P) and Nitrogen (N) are the nutrients most often limiting to autotrophs in fresh and marine ecosystems. When rivers and estuaries receive additional inputs of the nutrients from anthropogenic sources, there are generally increases in the biomass of autotrophs, and sometimes dramatic changes in taxonomic structure and functional groups. These changes can radiate upwards through the food web, affecting primary and secondary consumers. Excessive nutrient loading can also lead to phenomena such as harmful algal blooms (Kennish, 2002). In some cases blankets of macroalgae that accumulate on the bottom of receiving estuaries can shade and eventually replace seagrass beds (Terrados *et al,* 1999) or cover coral reefs. Thus, it is important to identify point and non-point sources of nutrient and fecal contamination in order to prevent diseases and improve water quality (Scott, et al., 2002), as well as to manage human uses of coastal waters. High sediment loads (Rogers, 1990), excess nutrient inputs (Tomascik, 1990), turbid water pulses (Fabricius and Wolanski, 2000), sewage and a sort of non-point source pollutants (Bonkosky *et al*, 2008), are among the major threats to water quality. From the standpoint of marine ecosystem conservation, chronic water quality degradation associated to non-point source pollution, including sewage, can have profound long-term irreversible effects in the integrity and community structure of coral reefs, seagrass communities, mangroves and other associated coastal systems (Cloern, 2001), as well as in the composition of marine food webs (Livingston, 2001).

Although highly studied, La Parguera marine communities recieve an enourmous amount of antrophogenic insult. This has resulted from poorly planned development, irresponsable wastewater management and the innaction from local competent entities. As part of the Green Infrastructure Project taking place in La Parguera historical community, we conducted a preliminary survey of suspected point sources of contamination with the intention to apply low-tech measures that can resolve undesirable pollution immediately. On the 7th and 8th of February, 2012, and a follow up on February 12th we surveyed the nearshore stilt houses and their surroundings via water as well as via terrain from the eastern portion of the town past the “Club Nautico” westward up to the Poblado (Fig. 1). Additional surveying westward to the Poblado was made only visually by boat because of safety reasons. Water transportation was provided by Mr Ivan Lopez in the “Playante” boat.

FIGURE 1: Surveyed area at La Parguera, Lajas, Puerto Rico

General Findings

Inspections were made beneath the majority of the stilt houses from the Club Nautico westward to seek misplaced and or improperly attached sewage pipes. Photographic evidence was taken. While inspecting and taking photographic evidence of the actual residential sewer conditions, *in situ* samples were taken to measure ammonia (Table 1) using a Hanna Portable Photometer Kit (Hanna instruments, Woonsocket, RI). Some peak ammonia levels were recorded which are compatible with raw sewage discharges; ammonia sampling sites are presented in Figure 2. Most of the stilt houses are connected to the PRASA sewage system. However, some residential systems lack proper maintenance and as a result of the difference in elevation, the system backflows into the mangrove lagoon. In places where stilt houses were destroyed, the remaining residential sewage pipes work as a backflow for the trunk main surcharging into the mangroves or nearshore waters during times of heavy flow or during storm events. Table 2 is a result of our preliminary investigation into potential sources of sewage contamination. Coordinates for these locations have been provided as well as mapped using Google Earth (Appendix I). In addition, we have performed an analysis to locate stilt homes that have been destroyed or removed due to hurricanes, fires and other conditions since 1993 – based on a review of historic aerial images using Google Earth (Appendix II). We can provide those layers and are available to review the potential contamination sites with appropriate agencies.

Table 1. Mean Ammonia levels (NH3-N)			
Site	**Ammonia (mg/L)**	**Lat**	**Long**
LAP-1	0.06	17.973001°	-67.034619°
LAP-2	0	17.973500°	-67.035921°
LAP-3	0	17.972876°	-67.038918°
LAP-4	0.12	17.973316°	-67.040470°
LAP-5	0.35	17.971528°	-67.042309°
LAP-6	0	17.972092°	-67.041619°
LAP-7	0.15	17.971382°	-67.042886°
LAP-8	0	17.971550°	-67.043982°
LAP-9	0.11	17.971597°	-67.045152°
LAP-10	0.40	17.973448°	-67.050515°
LAP-11	**	17.973641°	-67.051668°

**Could not get reading; water may have been too turbid and polluted

Table 2. Specific locations of potential sites of contamination				
Problem	Existing Home	Lat	Long	Notes
1	Y	17.973297°	-67.035102°	Sewer pipe extends into the water (Figure 3)
2	N	17.973784°	-67.040025°	Open sewer pipe (Figure 6)
3	Y	17.973192°	-67.036534°	Open sewer pipe valve sideways and open (Figure 8)
4	Y	17.973340°	-67.040710°	Broken pipe
5	Y	17.972058°	-67.042669°	Leaking sewer pipe (Figure 12)
6	N	17.973412°	-67.050248°	Open sewer pipe -- no longer connected to house (Figure 15)

FIGURE 2: Sampling sites for ammonia

Selected Photographs from the Survey

FIGURE 3: PVC pipe discharging directly into the water. This was a common finding among the stilt houses. Undesirable greases and detergents can enter the ecosystem. We observed surface greasy spots in the morning of the 8th of February apparently from sinks and or boat cleaning activities.

FIGURE 4: Residential PVC sewage profile. A common practice among most of the observed pipes is the use of loose caps. These may serve as a pressure breaker.

FIGURE 5: Residential PVC sewage profile with direct contact to seawater. We suspect that leakage can be occurring since there is no visible continuity.

FIGURE 6: Where stilt houses were destroyed, the remaining residential sewage pipes can work as surcharge for the trunk main and as saltwater entrance to the sewer system which may interfere with the processes at the treatment plant.

FIGURE 7: Suspicious open drainage. This is a possible pathway to any kind of household contamination including sewage and detergents.

FIGURE 8: An open valve laying on its side (note discoloration) part of the sewage line near a stilt house entrance. These instances represent probable sources of contamination – certainly during heavy use and rain events if not general usage.

FIGURE 9: Residential sewer pipes with visible damages that can be leaching crude wastewater to the environment.

FIGURE 10: Bloom of green macroalgae (genus: *Enteromorpha*) which indicates unequivocal fecal contamination.

FIGURE 11: Manhole in front of UPR-Marine Sciences Laboratory. This manhole, when over flooded has been identified as a main contributor of raw sewage into the marine environment.

FIGURE 12: Spilling pipe near the mangrove lagoon. This pipe may be back flowing from the main trunk or from the connection of various houses to such a small system. The observed flow was consistent.

FIGURE 13: Note open pipe next to probable sewage end cap

FIGURE 14: Location of past stilt home – note excessive algal growth

FIGURE 15: Old sewer line for stilt house behind Villa Parguera – open but no longer connected to a house but still connected to sewer line

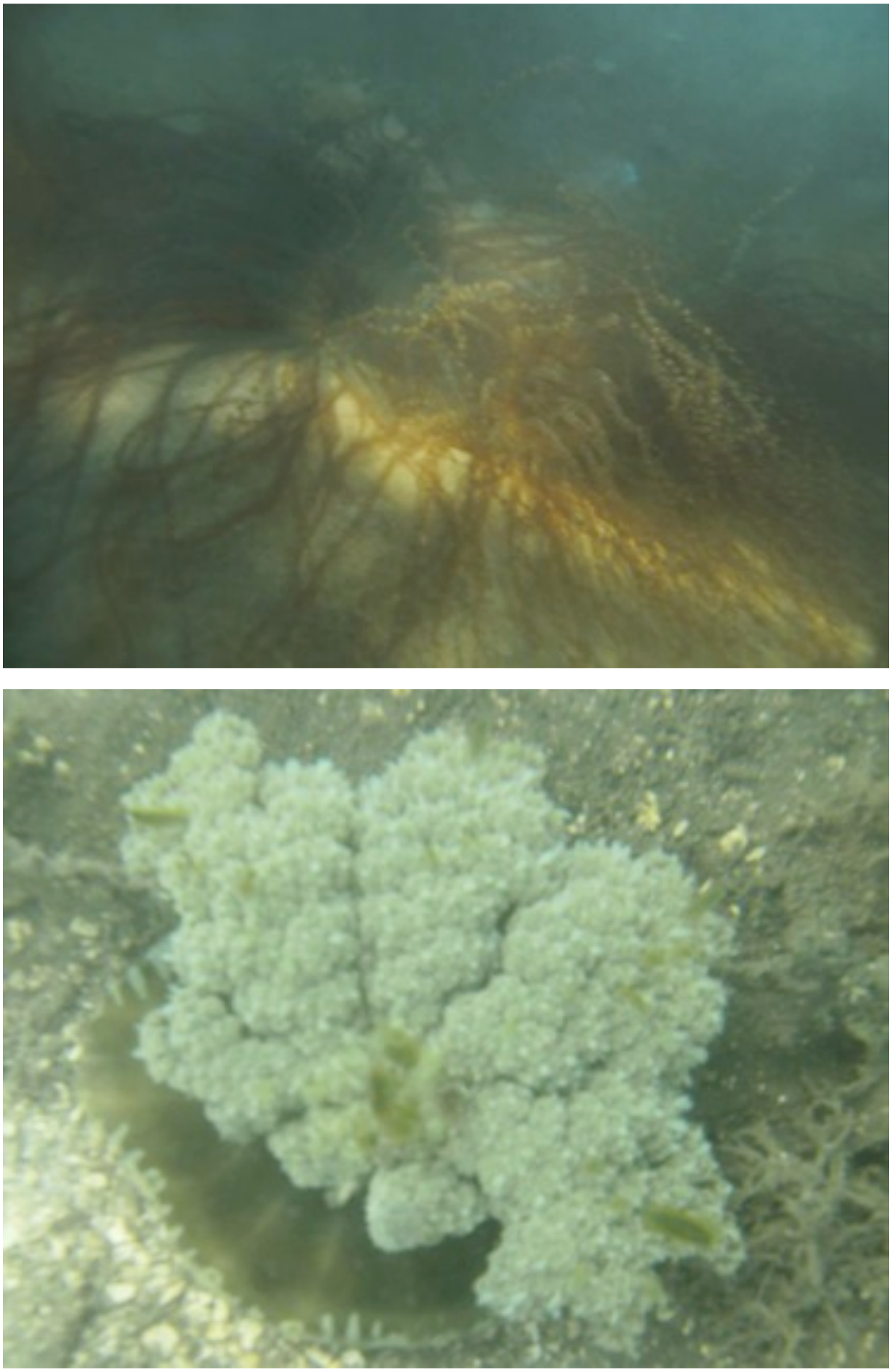

FIGURE 16: Predominant invertebrate species

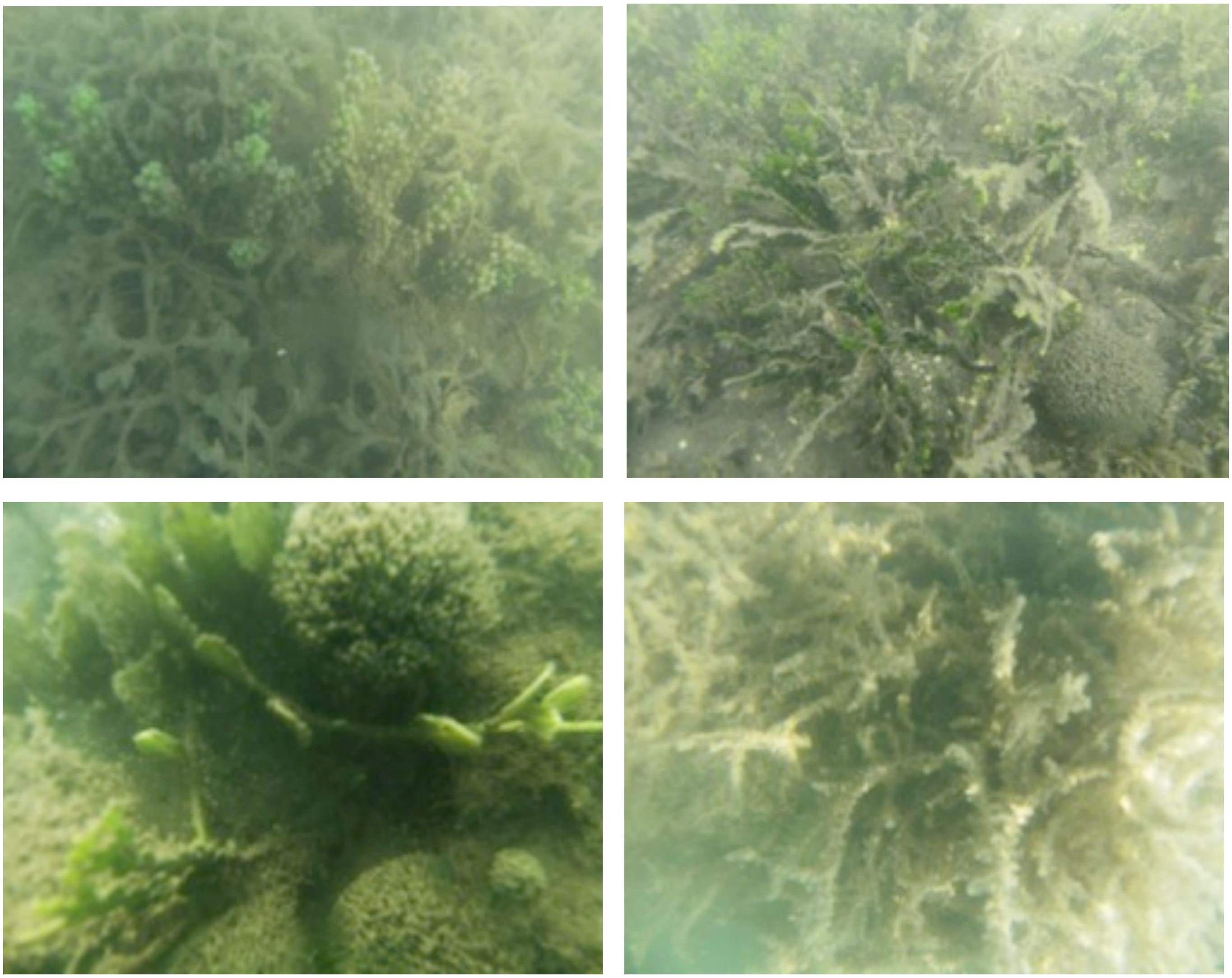

FIGURE 17: Predominant macroalgal arrangements

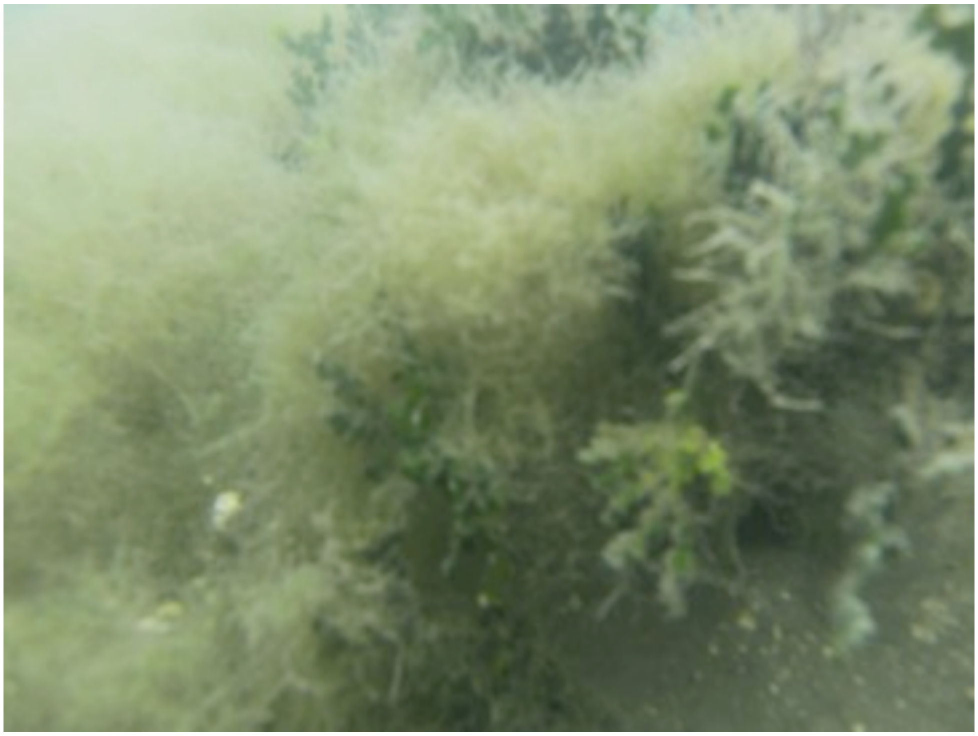

FIGURE 18: Indicator green macroalgae; *Chaetomorpha linum* (top); and *Enteromorpha sp.* (bottom)

FIGURE 19: Predominant fish species.

Discussion

Although most environmental problems have no easy solutions, there is a pressing need for alternatives that can relieve the stresses from anthropogenic activities. Coastal marine communities need management tools and policies that can lower the impacts from nutrients, sediments, and fecal bacteria. Where tertiary treatment of sewage cannot be accomplished by means of a PRASA facility, riparian and mangrove forest are major necessities. These types of forests have demonstrated that they reduce dramatically the pollution insult represented by sediment-laden and nutrient-charged runoff.

It is of paramount importance to foster a governance and management approach that includes climate, topography, hydrology, and geology, as well as cultural and sociodemographic features within the Parguera catchment. This governance structure must implement, maintain and strongly enforce existing regulations regarding sewage contamination, sediment-erosion controls, and stormwater management to ensure healthy coastal waters. Coastal seagrass communities were designated by the U.S. Federal government in 1994 as Resource Category 1, and in 1998 as Designated Critical Habitat (DCH) for the endangered green turtle (*Chelonia mydas*). Coral reef habitats were designated in 2008 as DCH for threatened Acroporid corals. According to Heathcote (1998), many water management strategies have failed because they neglected to incorporate the full range of values and perspectives present among water users or agencies with an interest in water management Thus, it is critical to incorporate a well planned, community oriented, realistic management plan. In this way several pollutants can be addressed, and the public can be involved in cleaning up the environment and protecting their coastal habitat. This is particularly important given the contribution of anthropogenic activities to the decline of coral reefs assemblages.

As a result of this analysis – we respectfully make the following recommendations:

1. Re-line or re-engineer the main trunk of the sewer system in La Parguera, sealing all connections that are no longer needed and removing defunct pipes; consider a vacuum or other system that will withstand future sea level rise which will further exacerbate inflow and infiltration (I and I) conditions leading to additional coastal pollution.

2. Implement mandatory grinder pumps or composting toilets and 3 year inspections of the sewage lines at the stilt homes. As these homes are currently located in an extremely sensitive ecosystem area and in many instances using a primitive sewage disposal system that defies logic where the pipes are expected to defy the laws of gravity and pressure. This could be implemented with coastal health of both human and marine organisms in mind. We estimate these costs are approximately $500 - $1500 per household for composting toilets, and $1500 - $5000 for effective pumps and replacement of failing pipe systems where needed. Note a number of homes have already put into place effective pumps and well sealed sewer lines.

3. These threats and specific contamination sources need to be related specifically as threats to coral reefs, sea grass beds and mangroves which together function as part of the nearshore coastal continuum that allows for healthy coral reef

development. These sources of contamination need to be addressed accordingly thru all means – swimming and human health standards, threatened species protection of West Indian Manatee Green Turtles and Acroporid corals, as well as federal illicit discharge provisions of the Code of Federal Regulations (CFR).

4. Continued tracking and removal of sources of nearshore contamination via bi-annual monitoring of indicators such as ammonia, optical brighteners, bacteria (E.Coli or Enterococci), and Chlorophyll *a* and tracking these sources to their sources.

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Appendix I Locations of Potential Contamination


Open sewer pipe
2 former homes
© 2012 Google
Image © 2012 GeoEye
Google earth
Imagery Date: 9/15/2010
1993
17°58'24.67" N 67°03'01.79" W elev 1 ft
Eye alt 956 ft

Appendix II. Locations of past stilt homes


9/15/2010
La Parguera
former homes
Future sampling location
Future sampling location
Former homesite
former homesite
Former homesite
© 2012 Google
Image © 2012 GeoEye
Google earth
Imagery Date: 9/15/2010
1993
17°58'21.08" N 67°02'49.01" W elev 9 ft
Eye alt 2516 ft


9/15/2010
1993
2010
former homesites
Former homesite
Former homesite
former homesite
Caleta Parguera
former homesites
former homesite
former homesite
former homesite
Former homesite
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Image © 2012 GeoEye
Google earth
Imagery Date: 9/15/2010
1993
17°58'24.90" N 67°03'26.14" W elev 0 ft
Eye alt 2516 ft