

MALA NOCHE RIVER ESTUARY: ASSESSING AND RAISING COMMUNITY AWARENESS



BY:

**Nediva Anderson, Biomedical Engineering
Courtney McCarthy, Biology and Biotechnology
Charlene Pizzimenti, Biomedical Engineering
Joshua Powell, Chemical Engineering**

ADVISORS:

**Professor Jeanine Skorinko, Department of Social Science and Policy Studies
Professors Jeanine Plummer, Department of Civil and Environmental Engineering**

An Interactive Qualifying Project Report submitted to the Faculty of Worcester
Polytechnic Institute in partial fulfillment of the requirements for the Degree of
Bachelor of Science

December 14, 2011

In cooperation with Sr Konrad Sauter of Berlitz Language Center

San José, Costa Rica Project Center

Abstract

The Mala Noche River Estuary in Playa Sámara, Costa Rica has been damaged from sediment accumulation and contamination. This damage has affected the estuary, the mangrove forest, and the aquifer that provides drinking water for the community. We surveyed and interviewed community members to assess community awareness of the importance of the estuary and problems in the estuary. Results showed that residents are not fully aware of the negative effects of sediment accumulation on the ecosystem and their water supply. Thus, we developed an environmental education program for local schools to help increase awareness of these issues. The hope is that increasing awareness of the importance of the estuary will encourage the community to support future estuary restoration efforts.

Acknowledgements

We would first like to thank our sponsor, Sr. Konrad Sauter, for his continued support throughout our project and his hospitality while we were on site in Playa Sámará. We would also like to personally thank Annelise Sauter, our fifth team member while we were in Playa Sámará. Without her our help would not have been nearly as successful. Additionally, we would like to thank our advisors, Dr. Jeanine Skorinko and Dr. Jeanine Plummer, for their constant support and desire to see us succeed.

For allowing us to interview them regarding the school systems and the community, we would like to thank ASADA, the school representatives, and an environmentalist in the area. We appreciate the willingness of the communities of El Torito and Santo Domingo to participate in our survey. They helped us to understand the community dynamics and move our project in the right direction. We would also like to thank the sediment basin and wetland restoration experts for sharing their knowledge on their areas of expertise. Thanks to their interviews, we further understood the effects of these mitigation and restoration processes.

For their hospitality and support while we were in Playa Sámará, we would like to thank Alvaro Terán, Annemarie Terán, Werner Sauter, and Annelise Sauter. Their willingness to let us stay in their home while we were doing field work made our project a true success.

Finally, we would like to thank the Costa Rica Project Site and Worcester Polytechnic Institute for allowing us this opportunity.

Executive Summary

The Mala Noche River Estuary in Playa Sámara, Costa Rica, has been degraded due to activities in the area, such as the construction of new hotels and the operation of a teak plantation. This estuary serves as a home to mangrove trees and many species of wildlife. It also protects the freshwater aquifer that provides drinking water for the town. The environmental damage has altered the water flow in the river and estuary, and the aquifer is threatened by overuse and salt water intrusion. While past research found that the estuary is in need of restoration, the recommended restoration efforts have not yet been implemented. Thus, the goals of this project were to examine community awareness of the issues surrounding the estuary and then develop an educational program to increase this awareness.

To examine community understanding of the problems in the estuary, we surveyed the residents in two of the towns bordering the river and estuary. We also conducted interviews with a representative from the local water distribution company, three representatives from local schools, and an environmentalist. Results indicated that the residents in the bordering towns were not fully aware of the importance of the estuary to both the environment and the community, such as its connection to their drinking water. For instance, few community members reported seeing any changes in the ecosystem, regardless of how frequently they visit the estuary and river. In addition, many of the community members support the companies that contribute most to the sediment problem because these companies supply economic stability to the region. While the community members did express concern about the estuary, none of the residents indicated the sediment buildup or threat to the drinking water source as specific concerns.

Given the limited awareness of the issues surrounding the estuary, we developed a pilot environmental education program for local schools. Before doing so, we investigated the environmental education programs already in place in three schools in Playa Sámara. We discovered that these programs lacked information about the estuary and instead focused on general environmental issues. Thus, we developed an environmental education program that could be adapted into the local school curriculum and focused on the estuary and mangrove

forest. For the primary school, we developed an information pamphlet for the teachers, several activities for the students, and a song about the estuary and aquifer. We also suggested community service projects for the secondary school students. These programs can be implemented in the next school year.

In addition to the recommendations for the school, we suggested reaching out to the rest of the community, as some residents are not affected by the school system. We presented our findings to the water distribution company to highlight key areas in which community awareness could be raised. From this, they can develop their own community outreach program for adults, if they so choose. With the development of the school education program and the materials provided to the water board, we hope that the community can become involved in future efforts to restore the Mala Noche River Estuary and protect the drinking water in the aquifer.

Table of Contents

Abstract	ii
Acknowledgements	iii
Executive Summary	iv
List of Figures	viii
Chapter 1: Introduction	1
1.1 The Community of Playa Sámará	1
1.2 The Mangrove Forest in the Mala Noche River and Estuary	2
1.3 The Playa Sámará Aquifer	2
1.4 Sediment Mitigation	9
1.4.1 Dredging.....	9
1.4.2 Sediment Basins.....	9
1.4.3 Wetland Restoration.....	10
1.5 Conclusion	10
Chapter 2: Assessing Community Awareness	11
2.1: Methodology	11
2.1.1 Community Awareness Survey	11
2.1.2 Organization Leaders Interviews	12
2.2 Results	12
2.2.1 River and Estuary Visits.....	13
2.2.2 Uses of the River and Estuary	13
2.2.3 Community Understanding of Importance of Estuary	14
2.2.4 Community Views on Industries	16
2.2.5 Perceived Changes and Concerns Regarding the Estuary.....	17
2.2.6 Estuary Restoration Efforts	19
2.2.7 Environmental Education in Sámará and El Torito Schools	20
2.2.8 Conclusion.....	20
Chapter 3: Environmental Education in the Schools	22
3.1 Introduction	22
3.1.1 Environmental Education for Children.....	22
3.1.2 Case Study in Tortuguero Bay, Costa Rica.....	23
3.1.3 Case Study in Quebrada Ganado, Costa Rica	24
3.1.4 Conclusion.....	25
3.2 Methodology	25
3.3 Results	26
3.3.1 Current Environmental Education	26

3.3.1.3 Centro Educativo Sámara.....	26
3.3.1.2 Centro Educativo El Torito	26
3.3.1.1 Liceo Rural El Torito	28
3.3.2 Pilot Program	28
3.3.2.1 Teacher Pamphlet	29
3.3.2.2 Activities Book.....	29
3.3.2.3 Extra Credit Trip	29
3.3.2.4 Community Service Projects	29
3.3.3: ASADA Booklet.....	30
Chapter 4: Discussion and Conclusions.....	31
References.....	34
Appendix A: Community Survey (English Version).....	37
Appendix B: Community Survey (Spanish Version).....	39
Appendix C: Questions for School Representatives	41
Appendix D: Questions for Environmentalist	42
Appendix E: Questions for ASADA Representative	43
Appendix F: Summary Tables of Statistical Analyses	44
Appendix G: Information Booklet for Teachers	48
Appendix H: Activities Book for School Children	48
Appendix I: Estuary and Aquifer Song	50
Appendix J: Proposed Community Service Projects for Secondary School Students.....	59
Appendix K: Booklet for ASADA	60

List of Figures

Figure 1: Map of Playa Sámara (Source: Google Maps; modified by Joshua Powell, 2011)	1
Figure 2: Mala Noche Aquifer, Playa Sámara (Source: Funke, 2005; modified by Joshua Powell, 2011)	3
Figure 3: Wells in Playa Sámara (Source: Solano, 2005; modified by Joshua Powell, 2011)	5
Figure 4: Development over catchment area in Playa Sámara (Source: Funke, 2005; modified by Joshua Powell, 2011)	6
Figure 5: Trash in Mala Noche Estuary (Source: Courtney McCarthy, 2011)	7
Figure 6: Mangrove tree in Mala Noche Estuary (Source: Courtney McCarthy, 2011)	7
Figure 7: Construction debris accumulation in Mala Noche River Estuary (Source: Courtney McCarthy, 2011)	8
Figure 8: Open ended survey responses on role of estuary in ecosystem	15
Figure 9: Open ended survey responses on role of estuary in community	16
Figure 10: Open ended survey responses on concerns about estuary	18
Figure 11: Tree made by students using recycled materials (Source: Nediva Anderson, 2011)	27

Chapter 1: Introduction

Estuaries offer one of the most unique ecosystems in the world because they contain both fresh and salt water (Franco, Elliott & Torricelli, 2007, p. 1). The Mala Noche River Estuary in Playa Sámará, Costa Rica is important to the community because it supports a mangrove forest and protects the aquifer that supplies drinking water to the community. If this estuary and the aquifer are not protected, the estuary ecosystem may be damaged and the water supply for the community could be compromised. Due to excess sediment accumulation in the estuary, both the estuary and aquifer are currently at risk.

1.1 The Community of Playa Sámará

Playa Sámará is located in the Nicoya region of Guanacaste, Costa Rica. This district includes several small communities, such as El Torito and Santo Domingo, as seen in Figure 1. El Torito directly borders the Mala Noche River, and is composed of approximately 80 homes, 20 of which are located in the squatter community of Pueblo Nuevo (personal observation, 2011). The squatter community was established only a few years ago and was partly constructed on the perimeter of the Mala Noche River Estuary (Funke, 2008, p. 4). Santo Domingo contains approximately 20 homes and is located upstream of the estuary at the beginning of the Mala Noche River.



Figure 1: Map of Playa Sámará (Source: Google Maps; modified by Joshua Powell, 2011)

The communities in Playa Sámara are rural, but the district has begun to grow in recent years. In 2000, the population was 2,600 residents (IX Censo Nacional de Población y V de Vivienda, 2000), but this increased with the addition of 300 new houses, 70 condominiums and 100 other residences similar to condominiums (Funke, 2005). This recent rise in population has created the need for more jobs, stimulating the ecotourism industry, which now supports 27% of the population in the Guanacaste province (Barrantes-Reynolds, 2011, pp. 58). From 1977 to 2005, the number of ecotourism businesses in Playa Sámara has risen from 50 to over 300 (Funke, 2005). Hotels and restaurants have been built along the beaches in Guanacaste and tour companies have moved into the area to support the growth in ecotourism.

1.2 The Mangrove Forest in the Mala Noche River and Estuary

The Mala Noche River Estuary is located on the beach in Playa Sámara. The river and estuary are home to over forty species of wildlife, including sardines, lisa fish, caiman and various birds (Funke, 2005). These species all rely on the mixture of salt and fresh water in the estuary to survive. The mangrove forest within the estuary is also reliant on the brackish water. The mangrove trees have aerial, waterlogged and soil roots to absorb nutrients from the air, water and ground, respectively (Evans et al., 2005, p. 537). In order to continue receiving nutrients, they require a yearly sediment deposition of 0.5-1.0 cm per year so that the soil roots remain covered as they grow (Ellison, 1999). The mangroves provide protection for the eggs and young of several marine species and also help maintain the composition of the estuary, as they help regulate the amount of salt and fresh water that mix within the estuary (Ellison, 2000). The roots of the mangrove trees act as a physical barrier, preventing an excessive amount of seawater from travelling upstream while also restricting the amount of freshwater flowing downstream (Ellison, 1999). It is important that this balance of salt and fresh water is maintained, so that the estuary can remain a healthy ecosystem (Franco et al., 2007).

1.3 The Playa Sámara Aquifer

The health of the estuary is important to the town because of its location above a freshwater aquifer and at the edge of the catchment area for the aquifer. The underground

roots of the mangrove trees act as a barrier protecting the aquifer from seawater that could otherwise seep into the catchment area (Environmentalist, personal communication, 2011). The aquifer beneath the Mala Noche River and Estuary is the source of drinking water for Playa Sámara. As a confined aquifer, it is bordered above and below by aquitards, which are layers of impermeable ground. The water contained within such an aquifer enters through a porous section of the ground, known as the recharge area (Davis, 2008, pp. 265-266). Rainfall in the catchment area flows to the recharge zone to replenish the water supply.

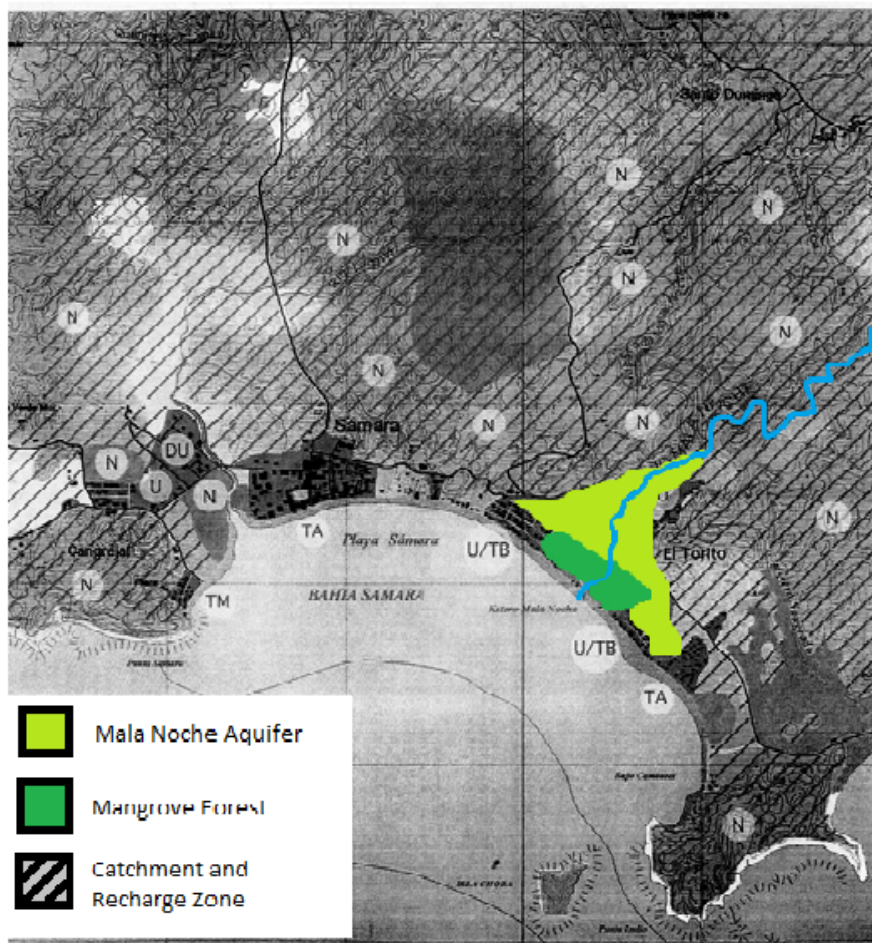


Figure 2: Mala Noche Aquifer, Playa Sámara (Source: Funke, 2005; modified by Joshua Powell, 2011)

The aquifer in Playa Sámara is only two square kilometers and has a catchment area that spans the hilltops close to the estuary, approximately 24 square kilometers (Funke, 2008,

p. 1), as seen in Figure 2. Water for the residents of Playa Sámara is obtained from the aquifer through two wells that both have a depth of 30 meters. These wells are operated by Asociación Administrativa de Acueducto Potable (ASADA, Association of Rural Water and Sanitation Systems, the local water distribution company). During the wet season, the surface of the water is at ground level; however, the surface of the water in the wells is 3.6 meters below ground level during the dry season (ASADA representative, personal communication, 2011). This demonstrates the difference in water level between the dry season and the wet season.

The aquifer in Playa Sámara is a coastal aquifer. As such, it is vulnerable to saline intrusion, which would render the water unsafe to drink. In addition, aquifers that lie below estuaries are often contaminated by downward leakage of brackish and/or saltwater from the surface (Cheng, 2003). Contamination typically occurs as a result of major changes to the surface of the land and excessive exploitation, or overdraw (Bocanegra, Da Silva, Custodio, Manzano & Montenegro, 2010). Overdraw occurs when the amount of water exiting the aquifer is greater than the amount of water entering the aquifer. There has been a progressive rise in exploitation of the aquifer in Playa Sámara. As shown in Figure 3, there are roughly 23 existing or planned wells in Playa Sámara, including the two town wells for Playa Sámara and 21 privately owned wells for business purposes. In January 2003, approximately 130,000 cubic meters of water were drawn from the aquifer in Playa Sámara, but in January 2005, the amount of water extracted had risen by 38% to 180,000 cubic meters (Funke, 2005). If this trend continues, it could cause saline intrusion, which would occur if the water level in the two town wells falls below the critical depth (8 to 10 meters below ground level). If this water level is reached, further pumping would then pull ocean water into the wells (Funke, 2008, p. 2; Solano, 2005, p. 6).

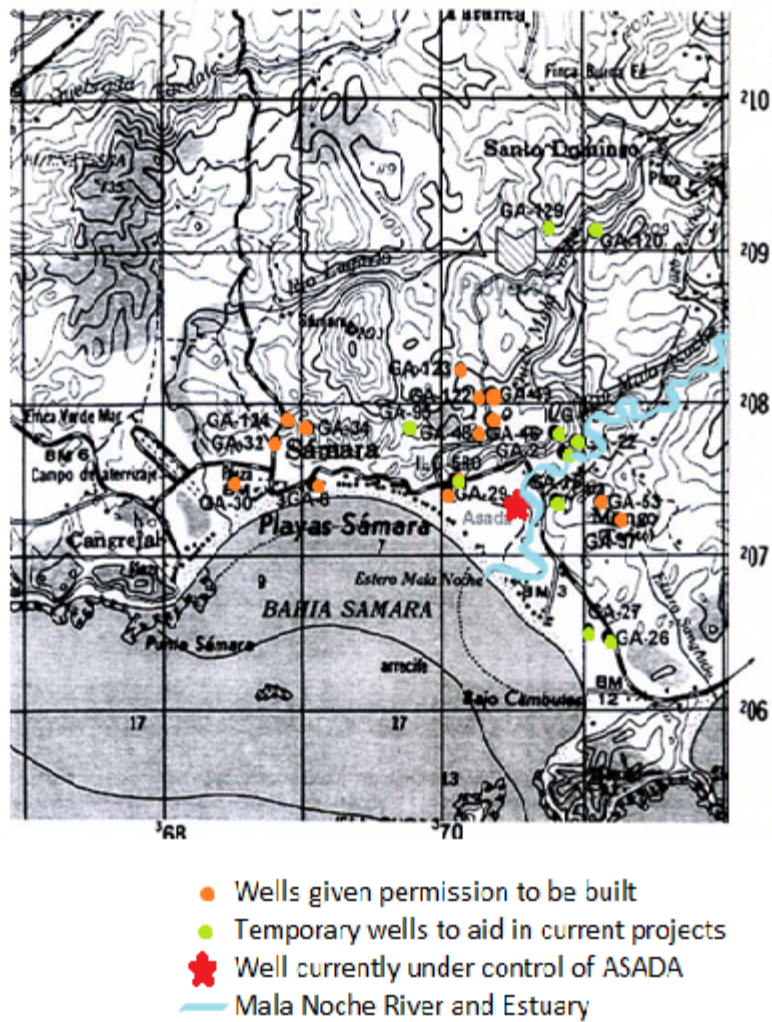


Figure 3: Wells in Playa Sámara (Source: Solano, 2005; modified by Joshua Powell, 2011)

An additional concern is that some businesses have recently been built over the catchment area of the aquifer (Funke, 2008, p. 4), represented by the red circles in Figure 4. Construction over the catchment area is negatively affecting the aquifer by preventing water from seeping into it. Coupled with increased demand, reduced recharge can result in overdraw. While building in the catchment area, many of these businesses also cut down trees found in this area. In 2005, 7,500 square meters of the mangrove forest were used for construction purposes, which greatly impacted the biodiversity of the surrounding estuary (Funke, 2005, p. 8).

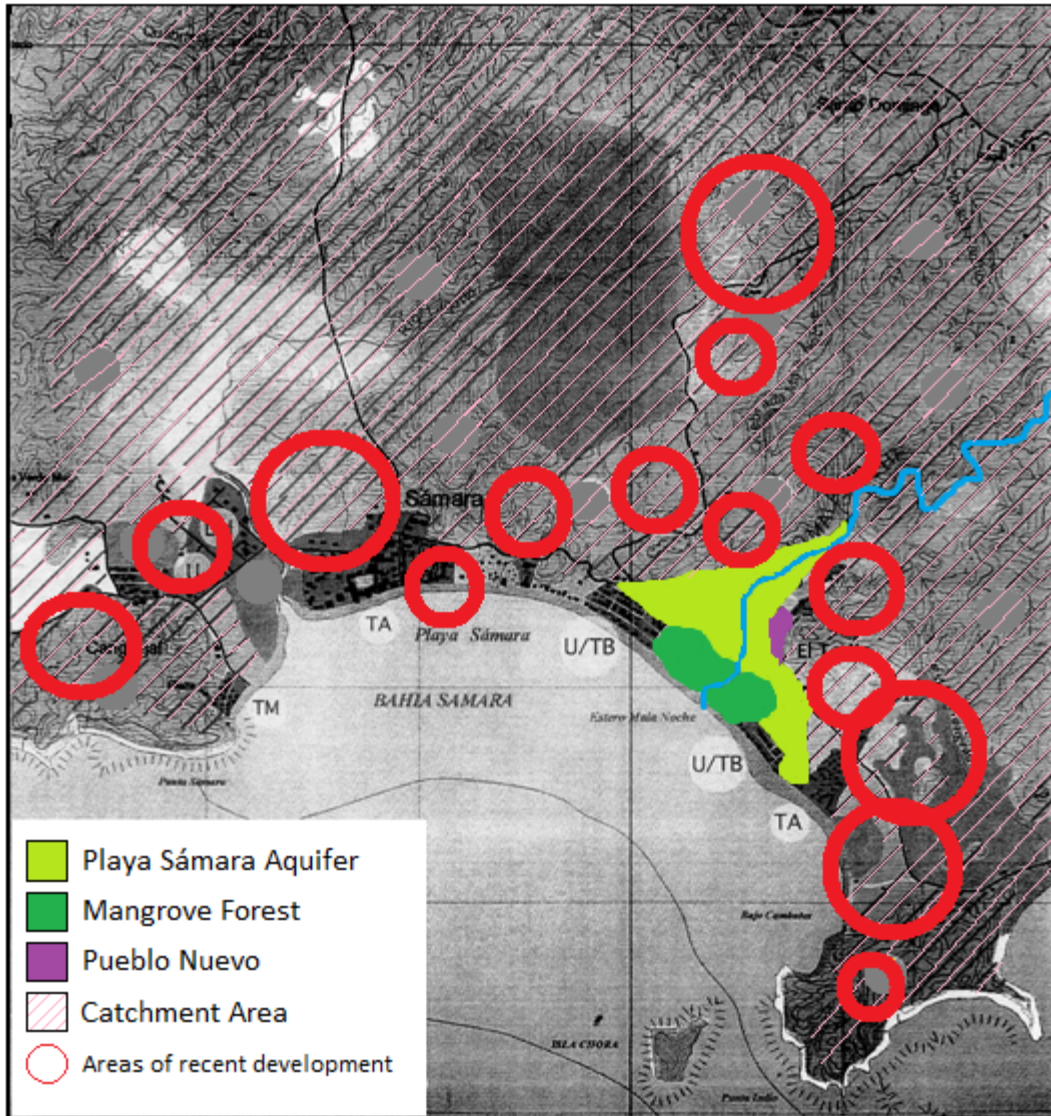


Figure 4: Developments over catchment area in Playa Sámara (Source: Funke, 2005 modified by Joshua Powell, 2011)

With regard to the estuary and its biodiversity, concerns arise from fishing activities and trash disposal. In the area, shrimp are a valuable source of food and income. The district of Playa Sámara is comprised of many fishermen and their families. Some of the fishermen in the area use a method of adding toxins to the river to make catching shrimp easier (Funke, 2008, p. 4). The toxins kill not only the shrimp but also the other fish in the area. Local leaders do not know what toxins are being added, but do know that the components of this toxin can be

purchased in local stores (Environmentalist, personal communication, 2011). The toxins harm the estuary by damaging the food web and decreasing the biodiversity. Pollution in the river and estuary also arises from trash disposal, which is shown in Figure 5. The level of trash found on the beach has increased with the influx of tourism (Resident, personal communication, 2011). In addition, some residents opt to burn their trash (Resident, personal communication, 2011), which produces a large amount of ash and results in the accumulation of particulate matter in the waters (Tian, 2008).



Figure 5: Trash in Mala Noche Estuary (Source: Courtney McCarthy, 2011)

Sediment from trash burning and other activities act to smother the roots of the mangrove trees, as shown in Figure 6. Sedimentation, which is a naturally occurring condition in which sediment accumulates within a water source, has increased in the estuary due to land use activities upstream. For instance, a teak plantation on the banks of the Mala Noche River contributes to the amount of sediment. Because the canopies of the teak trees block sunlight and do not allow other vegetation to grow, the clay and soil where the trees grow is loose and easily disturbed (Kirby, 2007). As a result, the soil easily runs off into the river and accumulates in the estuary (Funke, 2008, p. 1).



Figure 6: Mangrove tree in Male Noche Estuary with roots buried in sediment (Source: Courtney McCarthy, 2011)

Another source of sediment run-off is the construction of the new hotels and businesses. As new construction begins, the soil is loosened when vegetation is removed, and the sediment runs off when it rains (sediment basin expert, personal communication, 2011). As demonstrated by Figure 7, construction debris is also washed downstream and accumulates in the estuary. Mitigating the debris and sediment build up will help to restore and protect both the mangrove forest and the estuary.



Figure 7: Construction debris accumulation in Mala Noche River Estuary (Source: Courtney McCarthy, 2011)

1.4 Sediment Mitigation

Restoration of the estuary to improve water quality and maintain biodiversity has been investigated by previous researchers. Recommendations include dredging the estuary, adding sediment basins to the river upstream, and repopulating the mangrove forests through reforestation in the Mala Noche River and Estuary (Scott-Solomon et al., 2010). In concert, these efforts could restore the estuary and prevent further damage.

1.4.1 Dredging

Dredging is the most effective method for mitigating sediment buildup that has already occurred. It is the mechanical removal of sediment, which is then deposited elsewhere. It relieves blockages that have already formed and helps return a constant flow to an area. During the dredging process, the bottom sediment is disturbed, which can increase solids and contaminants in the water body. These can include silt, nutrients, and heavy metals. Depending on the composition of the sediments, these contaminants can temporarily change or degrade the surrounding ecosystem (Nayar, Miller, Hunt, Goh & Chou, 2007). Despite these concerns, dredging can permanently restore a water body if the source of excess sediment into the water body is also.

1.4.2 Sediment Basins

A second method for controlling the amount of sediment accumulating in a water source is the construction of temporary or permanent sediment basins. Temporary sediment basins are built at the site of run-off and catch the sediment-filled water before it reaches the river. This type of basin allows the sediment and water mixture to fill the basin and sediment to settle at the bottom of the basin while water overflows from the top (Sediment Basin expert, personal communication, 2011). Permanent sediment basins are implemented in the river itself and are built with baffles, or walls, to increase the residence time of the water in the basin. The water then flows through a porous media and sediment particles settle out or accumulate in the media. After the basin is half full, it must be cleaned because the sediment accumulation renders the sediment basin ineffective at this point (McLaughlin, 2005, pp. 1-3).

1.4.3 Wetland Restoration

Once steps have been taken to mitigate sediment accumulation, the estuary can then begin to be revived. One way to do this is through wetland restoration, which can include replanting mangrove trees. Wetland restoration has significant benefits to the ecosystem by reintroducing the species of flora and fauna that encourage biodiversity in aquatic life. In Playa Sámara, the repopulation of the mangrove forest would help to increase the number of fish and shrimp in the estuary, thus revitalizing the food web.

1.5 Conclusion

There are several factors contributing to the problems in the Mala Noche River Estuary such as the rise in ecotourism, the excessive exploitation of the aquifer beneath it, and the toxins added by fishermen. Community involvement is beneficial to efforts to mitigate these issues. However, the community members are employed by businesses partaking in these practices and may not be concerned about the environmental effects. At a town meeting held in November, 2011 by ASADA, the residents of Playa Sámara were informed about the current degradation of the estuary. Topics included in the meeting were the mangrove forest and the local marshes, which are being used for construction purposes. The town meeting was open to residents who obtained water from the town wells located next to the estuary, but of the hundreds of residents who could attend, only thirty came (resident, personal communication, 2011). The poor attendance at the town meeting coupled with the continued efforts to build the ecotourism industry reflects the need to assess the community awareness of the issues regarding the Mala Noche River and Estuary. Our first study examined community awareness and concerns regarding the importance and current state of the estuary. Based on the results of our first study, we developed a second study with the goal of increasing awareness in the school system of Playa Sámara.

Chapter 2: Assessing Community Awareness

2.1: Methodology

In order to determine what the residents of Playa Sámara knew about the condition of the Mala Noche River Estuary and its importance to the community, we conducted a survey and interviewed residents. We primarily focused on the communities of El Torito, Pueblo Nuevo, and Santo Domingo in our investigation. We interviewed local community and organization leaders, surveyed residents in the communities, and interviewed school representatives. We then analyzed the data to assess the current level of awareness within these groups.

2.1.1 Community Awareness Survey

We surveyed a total of 51 residents (20 males and 31 females), accounting for approximately half of the households in these communities. However, data from three surveys were discarded because the participants were minors (under the age of 18), resulting in a survey population of 48 people (18 males and 30 females).

Our sampling pool consisted only of people living within the clustered houses in each town. We used a method of random sampling to select participants without any predetermined selection process. We approached the houses in the communities around the estuary (El Torito, Santo Domingo, and Pueblo Nuevo) to assess their awareness regarding the watershed. The participants either completed the survey themselves or a translator asked the questions verbally and recorded their responses. When given the survey, the participants were told the study was to assess the state of the estuary and how they use it. We assessed how often residents used the river and for what purposes through 5-point Likert-Type Scales, ranging from never to daily. We also assessed participants' awareness of the importance of the estuary and what concerns they had about the state of the estuary through open-ended questions. In addition, residents were asked about the source of their household water. The survey can be found in Appendix A in English, and Appendix B in Spanish.

2.1.2 Organization Leaders Interviews

To supplement the surveys, we interviewed five organization leaders to investigate prior attempts to restore the estuary, community involvement in restoration efforts, and the environmental education curricula in the local schools. We conducted these interviews using a semi-standardized format, so that we were able to reword and reorder the questions during the interview and could answer questions and make clarifications (Elmer). The people we interviewed included an environmentalist, an ASADA representative, and three local school representatives. The interview questions can be found in Appendices C - E.

The interviews focused primarily on obtaining information regarding the current level of awareness the community has regarding the estuary and aquifer. We interviewed the environmentalist to gain a better understanding of the problems occurring in the estuary and aquifer and to investigate the community interest in the issues. We interviewed an ASADA representative about previous mitigation attempts and attended an ASADA meeting to understand current and future efforts to mitigate the sediment accumulation and pollution.

To assess the level of student awareness of the problems in the estuary, we interviewed three local school representatives. The interviews with the school representatives asked about the student interest in the watershed. We also asked about the curriculum and the community service projects in which the students were involved, specifically environmentally based programs.

2.2 Results

Through our survey and interviews, we assessed many factors regarding the awareness of sediment buildup in the Mala Noche River Estuary. Our investigations examined who visits the river and estuary and for what purposes, community understanding of the importance of the estuary, opinions on local businesses, perceived changes in the estuary, and prior restoration efforts. To analyze relationships between each variable and the age and gender of our participants, we utilized an age by gender analysis of variance (ANOVA) for each dependent variable. We did not include the town of residence of the participants in our analyses because

the sample population was not large enough. Correlational analyses were also performed to highlight any other correlations between the variables. We analyzed the frequency of responses to the open-ended questions about the functions of the estuary, the perceived changes in the watershed, and the concerns people had for the estuary. The summary tables for all statistical analyses can be found in Appendix F.

2.2.1 River and Estuary Visits

Through analysis of the survey responses, we evaluated the frequency with which the residents visited the river and estuary. The survey question was designed on a scale of 1 to 5, with 1 meaning the participant never visited the estuary and 5 representing the participant visited the estuary daily. The survey showed that on average, the residents of El Torito, Pueblo Nuevo, and Santo Domingo visited the river and estuary approximately once a month ($M = 3.06$; $SD = 1.27$), as 3 on the survey corresponded to once a month. To examine who visits the river and estuary further, we performed an age by gender ANOVA and a correlational analysis on the number of times that people go to the river and estuary. The ANOVA indicated a relationship between the frequency with which people visit the estuary and their gender, $F(1, 40) = 4.55$, $p = .039$. In general, men ($M = 3.42$; $SD = 1.17$) visited the estuary more often than women ($M = 2.85$; $SD = 1.31$). Our analyses also showed a negative correlation between the frequency of visits to the river and estuary and the age of the participant, indicating that younger residents tend to go to the river and estuary more often than older residents, $r = -0.35$, $p = .014$.

2.2.2 Uses of the River and Estuary

In addition to obtaining data on resident visits to the estuary, we investigated how the community used the river and estuary by analyzing the responses to the questions on the survey that asked how frequently the resident used the estuary for various activities. This survey question was designed on a scale of 1 to 5, where 1 corresponded to the participant never using the river for activities and 5 corresponding to the participant using the river daily. On average, the residents of the three towns we surveyed swim and bathe in the water one to

two times a week ($M = 1.80$; $SD = 1.05$), as a response of 2 represented a frequency of once or twice a week. When asked how often they used the watershed for laundry and trash disposal, all participants either did not answer or responded that they never did. Residents of these towns do their laundry in their homes and have their trash removed by the truck that comes regularly, as they noted on the survey and in conversations. This contradicted previous research that cited laundry and trash disposal as possible contributors to the sediment problem in the estuary (Scott-Solomon et al., 2010). The survey also showed that few people use the estuary for other purposes than bathing and swimming. Of the eleven participants who responded that they used the estuary for other purposes, the most common responses for other uses were fishing (3 people) and entertainment (4 people). To investigate the uses of the estuary further, we performed ANOVA and correlational analyses, but they did not show any significant effects of age or gender of the participant on river usage.

2.2.3 Community Understanding of Importance of Estuary

We also explored what the community members thought about the estuary and its significance as an ecosystem and in the community. To assess the understanding of the functions of the estuary in the environment, we examined their open-ended responses and performed a chi-squared analysis of those who believed the estuary impacted the environment versus those who did not provide responses pertaining to the environment. When asked what the role of the estuary in the ecosystem was, common responses were: a) tourist attraction, b) garbage disposal location, c) home to various wildlife, d) had no effect on the environment, or e) unaware of its significance. The frequency of each response is illustrated by Figure 8. Of these responses, only the one about wildlife (20.8% of residents surveyed) demonstrates awareness of the role of the estuary in the environment, indicating a significant difference between this response and the others (45.8% of residents surveyed), $\chi^2 (1, N = 48) = 9.4, p = .002$. This indicates that the population is not fully aware of the environmental significance of the estuary in the Mala Noche River Estuary ecosystem.

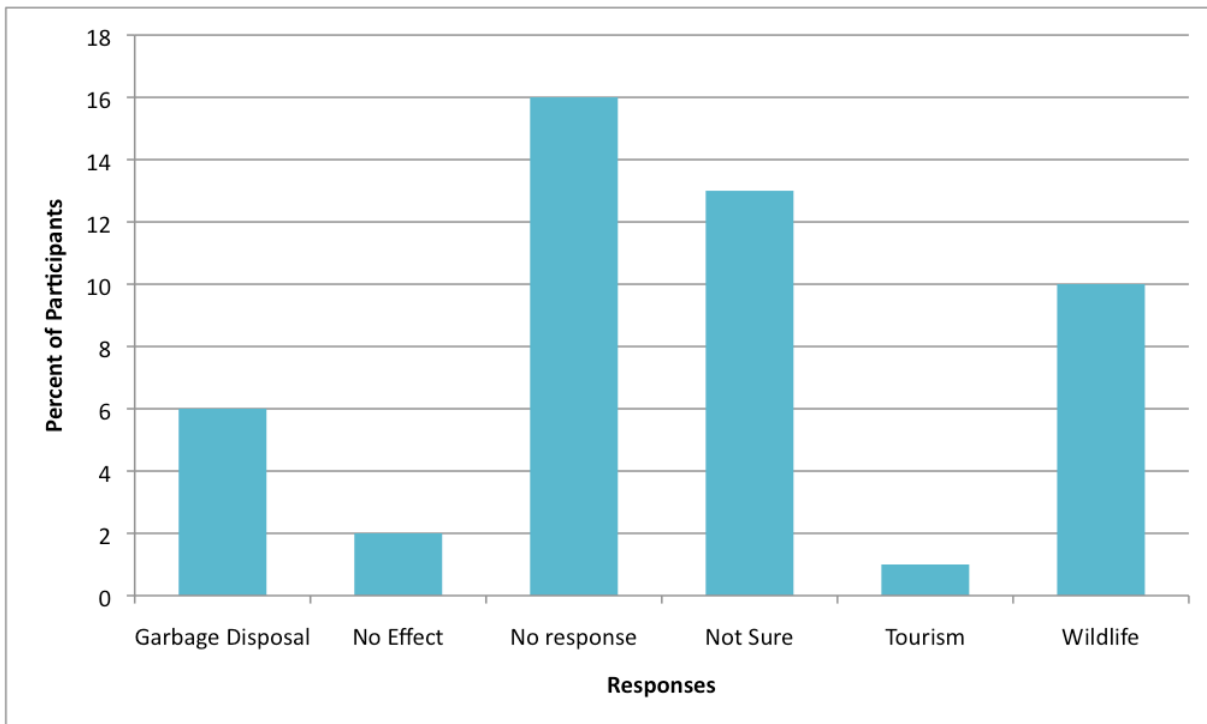


Figure 8: Open ended survey responses on role of the estuary in the ecosystem

We next assessed what the residents believed the importance of the estuary to the community was. The responses included: a) unaware of its significance, b) had no effect on the community, c) recreation, d) impacted their water source, e) influenced businesses, f) location for construction, and g) it is contaminated by trash. These responses, as well as their prevalence, are shown in Figure 9. There were significant differences in the number of people who indicated awareness of the role of the estuary in the community (responses c, d, and e; 25.0% of residents surveyed) and those that indicated unawareness of the importance of the estuary (responses a, b, f, and g; 47.9% of residents surveyed), $\chi^2 (1, N = 48) = 7.25, p = .007$. Interestingly, 6% of respondents indicated that the estuary is a place for construction when Costa Rican laws state that no construction can take place within 50 meters of this body of water (Ley de Aguas, 1946). Overall this analysis shows a widespread unawareness of the impacts the estuary has on the communities of Playa Sámara.

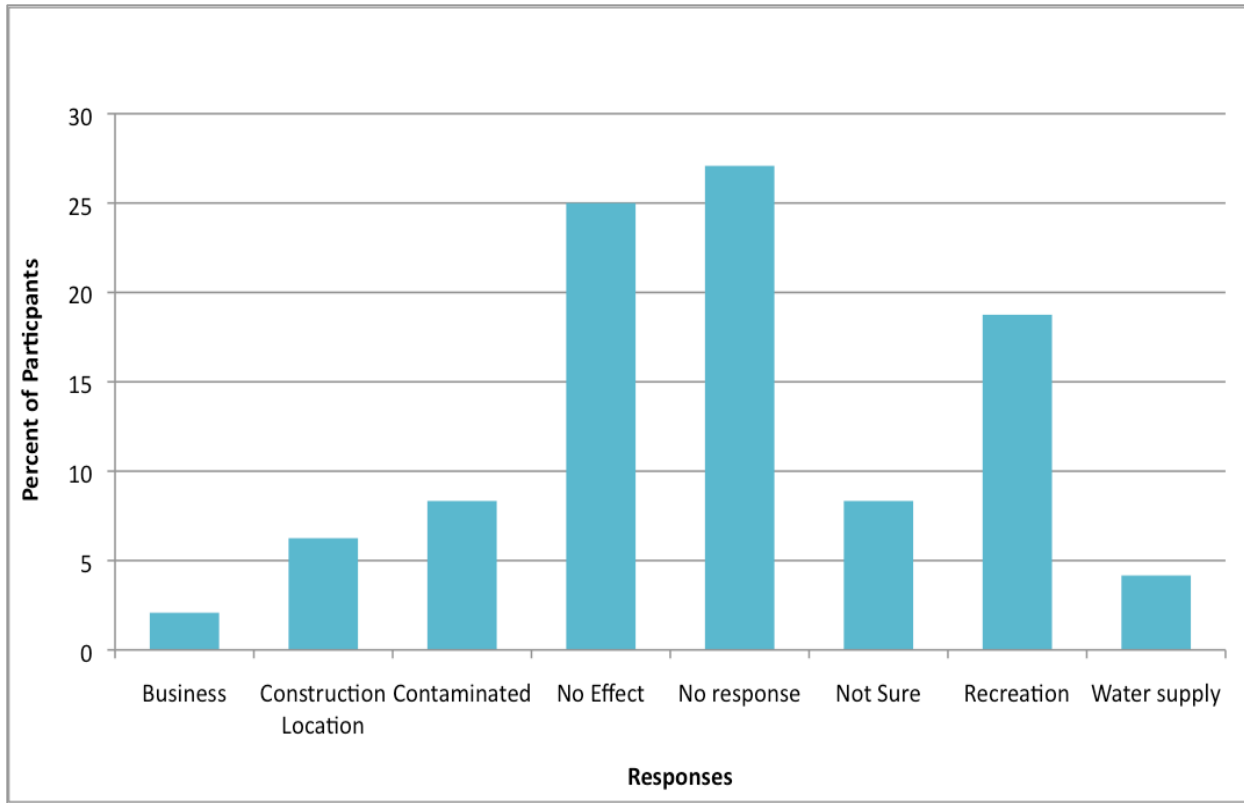


Figure 9: Open ended survey responses on role of estuary in community

2.2.4 Community Views on Industries

During our interview with an ASADA representative, we discussed the opinions of the local residents on the industries in the area. According to the representative, the town residents view businesses, such as the teak plantation and hotels, as beneficial to the community. The teak plantation has created 200 to 300 jobs for the residents of Playa Sámará. In addition, the influx of tourists has given rise to several resorts, tour companies, and souvenir shops, further increasing the number of job opportunities for the town. However, the ASADA representative stated that these new businesses are providing jobs at the expense of the environment, as the plantation contributes to the excess sediment accumulating in the estuary and many of these businesses are built over the recharge zone of the aquifer, causing damage to the estuary and aquifer below (Funke, 2008, p. 4). Community support of these businesses reflects further unawareness of the connection between the community and the estuary.

2.2.5 Perceived Changes and Concerns Regarding the Estuary

Although a lack of awareness of the estuary's role in the community became apparent during our study, the residents reported changes in and concerns about the estuary through the survey. The survey questions were designed on a 1 to 5 scale, with 1 representing the participant saw no changes and had no concerns for the estuary while 5 represents the participant saw many or severe changes and had great or multiple concerns in the estuary. In general, the residents reported observing moderate changes in the estuary ($M = 2.62$; $SD = 1.58$) and being moderately concerned about the estuary ($M = 2.50$; $SD = 1.50$). During the ASADA meeting we attended, the members of the organization noted that the community seems unaware that there are problems in the aquifer. They also noted that the community was not motivated to help with the restoration efforts, and that the community will not aid in the process until the situation becomes dire. To verify these statements, we investigated residents' observations of the changes in the estuary and how concerned they were about the estuary. The correlational analysis showed a negative correlation between the age of the participant and the amount of change observed in the estuary, indicating that younger residents tended to notice more changes than older residents, $r = -.33$, $p = .034$. The ANOVA did not yield any significant results for perceived changes, and neither analysis showed significant results for concerns.

To identify what changes the communities observed in the estuary, we examined the open-ended responses of the participants. When asked what changes they saw in the estuary and river, the residents most commonly answered: a) changes in water level, b) a change in the course of the river, c) increased sediment, d) the presence of trash, or e) deforestation. Significantly more people made observations about changes in the level and course of the water (41.7% of residents surveyed) than observations about factors that affect the health of the estuary (20.8% of residents surveyed), such as sediment, trash, and deforestation, $\chi^2 (1, N = 48) = 6.94$, $p = 0.008$.

After determining what changes the community perceived within the estuary, we analyzed the concerns and fears they had about the bodies of water. We performed a chi-squared analysis of those who reported concerns about the estuary versus those who reported

fears when they responded to the open-ended question about concerns. The responses, which are shown in Figure 10, included: a) decreasing water level, b) contamination, c) the decline in biodiversity, d) deforestation, e) unawareness of the community about the issues facing the estuary, f) alligators in the estuary, and g) fear of the estuary itself. Of the people we surveyed, 52.1% expressed concerns for the estuary (i.e. contamination, biodiversity, deforestation, unawareness, and water level) and 12.5% reported fears of the estuary (alligators, fear of the estuary, and water level). A chi-squared analysis showed that concerns were more prevalent than fears ($\chi^2 ((1, N = 48)) = 24.3, p = .0000008$); however, future researchers could examine why the fears are still present in the community. In addition, we noted that no participants reported concern about the sediment buildup in the estuary, despite it being a root cause of several of their concerns, such as the decline in biodiversity and the change in water level.

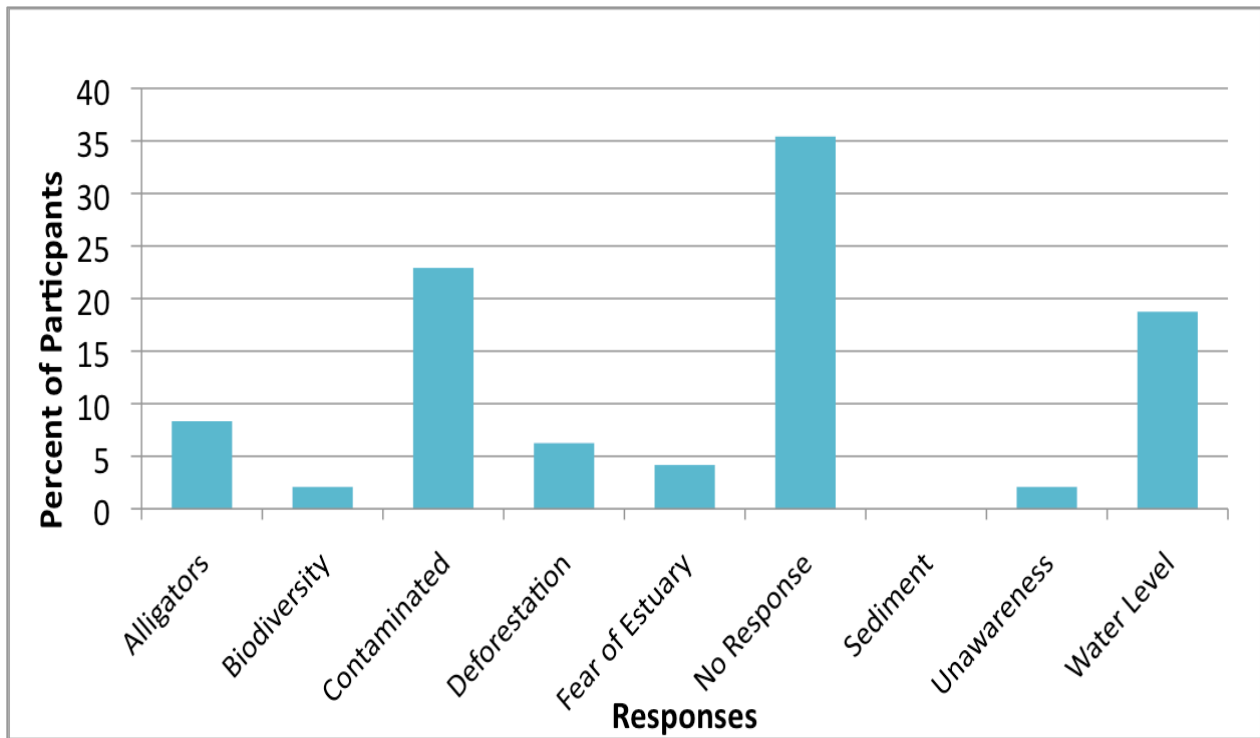


Figure 10: Open ended responses on concerns about estuary

2.2.6 Estuary Restoration Efforts

To investigate previous attempts at mitigating the sediment buildup, we interviewed a representative of ASADA from Sámara. ASADA dredged the sediment near the ocean in 2009. This dredging process, according to the representative, was unsuccessful because they dredged incorrectly and discovered they had dredged the wrong location after the process was complete. When they dredged, they dug too deep into the ground, almost causing saline intrusion in the two town wells. In addition, the dredging occurred too close to the estuary, and more sediment accumulated there, further contributing to the problem. If the dredging process had taken place further upstream, less sediment would have flowed down the river into the estuary and the threat of saline intrusion into the well would be less severe, thus protecting both the estuary and aquifer from further damage.

The prior efforts to restore the estuary also involved the reforestation of mangrove trees and other native vegetation. Beginning in 2009, native tree and plant species were replanted 50 meters from the banks of the river and estuary, in hopes of reviving the damaged ecosystem. The reforestation attempt was unsuccessful, as the replanted trees were soon cut down for construction purposes. The ASADA representative stated that the town does not acknowledge that these efforts are attempts at restoring the natural habitat of the Mala Noche River and Estuary.

Currently, ASADA is attempting to purchase the land near the riverbanks over the catchment area from a local company, but has encountered legal difficulties in transferring the land. One member of the organization mentioned that an alternative to buying the land is to ask the owners of the properties to plant trees on their lands to reforest the area. However, ASADA acknowledged that having the owners make the changes was not viable, but attempts needed to be made.

To further their restoration efforts, ASADA has been in contact with the municipality of Nicoya, proposing regulations to help protect the aquifer by regulating the land around it. ASADA wants regulations placed on tourism in the area and on how many non-native species of wildlife and vegetation are brought to the area. These new regulations coupled with the

purchase of lands would help to protect the estuary from further damage and initiate the restoration efforts. These endeavors are ongoing, but have stalled due to a lack of funds.

The ASADA meeting also showed disagreement in how to continue the efforts, though ASADA recognizes the town needs to be involved. They expressed the need for total community involvement, and decided to postpone further discussion until a future meeting with all four local ASADA groups from Sámara, El Torito, Santo Domingo, and Cangrejal. They also planned to hold another town meeting for everyone who receives water from the aquifer with the goal of unifying the community in the restoration efforts.

2.2.7 Environmental Education in Sámara and El Torito Schools

To conduct a complete analysis of the level of awareness throughout the community, we interviewed school representatives to examine the current environmental programs and the areas where it could be improved. We also asked questions regarding the extent of the children's awareness of the estuary and the issues facing it. From these interviews, we determined that the local high school is considered a rural school and therefore has fewer classes than urban schools. The school representative stated that they do not have a strong environmental curriculum. The representative also indicated that although the students know the function of the estuary, they do not see the connection between it and themselves. As for the primary schools, the representatives noted that they focus their environmental education on more general topics. We found that although all of the schools we interviewed had some form of environmental program, none of them had any programs that focused on the local river or estuary.

2.2.8 Conclusion

Overall, the community is not fully aware of the problems in the estuary. They express moderate concern about the health of the estuary, but seem generally unaware of the exact issues facing the estuary and the negative impacts of local businesses on the environment. Also, the school programs appear to be lacking an environmental education program

specifically regarding the estuary, and for future mitigation attempts to be successful, it is important these issues be addressed.

Chapter 3: Environmental Education in the Schools

3.1 Introduction

Our first study indicated that community members are generally unaware of the issues in the estuary, and we concluded that increasing community awareness regarding the estuary was important for future restoration efforts to succeed. Based on previous research stating that school children are most receptive to new information (*Preschool education in Cuba, 2002*), we decided to further investigate the school programs in Playa Sámara. From Study 1, we learned that the primary schools all have environmental programs focused on water in general, but none specifically focus on the estuary and its problems. Also, at the secondary school, students must complete thirty hours of community service to fulfill the graduation requirement mandated by the government (Helmuth, 2000). Taking these things into account, we developed recommendations for an environmental education program for students based on interviews with the school representatives. In order to do this, we investigated child environmental education.

3.1.1 Environmental Education for Children

To help develop the students' understanding of environmental issues, it is important to increase the students' awareness of the environment, more specifically the river and estuary. Targeting the children will work to spread awareness throughout the rest of the community. According to Sabo (2010), environmental feelings that are developed as a young child tend to last for life. The goal of environmental education is to have students express their personal feelings and take responsibility for their actions regarding the environment. In order to achieve this goal, there is a five step plan that is often taken (Sabo, 2010).

For the first step, the young students are exposed to the environment in which they live. An example activity is a field trip to a local environmental landmark, allowing students to connect with nature. In the case of the students in Playa Sámara, this could entail visiting the Mala Noche River Estuary. The second step is bringing awareness to the students about the

issues in the environment, such as pollution, and emphasizing the importance of alleviating these issues. Next, it is important to establish the connection between people and the environment, as well as how people positively and negatively affect the environment. Once the students understand the importance of the environment and the ways they can become involved in conservation, they can take personal responsibility for the decisions they make regarding the environment. After accountability is established, the last step is to create a plan of action. Students are encouraged to become involved outside the classroom and take steps to try and improve the environment on their own (Sabo, 2010).

Lee and Ma (2006) take a similar approach to environmental education. They propose a three step plan including “education about, in, and for the environment” (p. 84). In this process, the first step, education about the environment, includes advancing students’ knowledge and understanding of natural processes and environmental concerns. Education in the environment promotes outdoor activities and hands-on learning, encouraging personal interaction within the local environment. For the students in Playa Sámara, this could be achieved through a trip to the Mala Noche River Estuary. Finally, education for the environment involves developing solutions to environmental problems that students can participate in, such as picking up trash. It is important that these approaches are taken at a young age so that students develop positive attitudes towards nature that they will retain for the rest of their lives (Lee & Ma, 2006). From these two approaches, an educational plan for the primary and secondary school children in Playa Sámara can be created to supplement their existing environmental education.

3.1.2 Case Study in Tortuguero Bay, Costa Rica

A case study on community involvement in the conservation of natural resources in Tortuguero Bay, Costa Rica was reviewed for its relevance to our research. This case study is similar to our research in that it had a component of assessing awareness in the community and then created programs to increase awareness. Specifically, Jacobson and Robles (1992) developed a tour guide training program to promote education about beach conservation in Tortuguero. Many turtles stopped nesting in the area due to the effects of the 24 fold increase in visitation to the national park. To develop this program, the researchers first surveyed local

scientists and park managers to assess resource management, impacts of tourism on these resources, and what information should be shared with the community in order to protect these resources. To determine the environmental activities and needs of tourists, a group of 400 tourists were surveyed. Then, hotel owners were interviewed to determine the feasibility of implementing new tour guide programs. Using this information, the researchers determined a set of topics to include in their tour guide educational program and formed a pilot training course for twelve volunteers residing in Tortuguero. This pilot program showed that environmental training helped lessen the negative impact of tourists on the park. The increased awareness in tour guides also increased environmental awareness in the community and with tourists.

The problem in Tortuguero Bay is very similar to that in Playa Sámara. In both cases the level of awareness within the communities and the increase in tourism had negatively affected the local environment. This demonstrates an opportunity for programming to raise community awareness and illustrates how pilot programs can be successful.

3.1.3 Case Study in Quebrada Ganado, Costa Rica

A second case study we examined for its relevance to our research took place in Quebrada Ganado, a small Costa Rican village. A group of researchers studied the effects of teaching elementary school students about the environment on their parents and other members of the communities. The study began by pre-testing the students, their parents, and a separate group of adults in the community about their knowledge of Scarlet Macaws, an endangered bird found in the area. After the test, the students participated in a one month educational course on Scarlet Macaw conservation and history. The three groups were then administered a post-test, consisting of the same questions as the pretest. The results of this test were compared to the pretest, and researchers found that the students made a 71% improvement while parents made a 38% improvement, showing that there was transmission of information from the students to their parents. On this post-test, there was no improvement seen in the other members of the community; however, the same post-test was administered again eight months later. The students made a 67% improvement, the parents made a 52%

improvement, and the third test group made a 29% improvement from the pre-test. The researchers concluded that the students and their parents shared parts of what they learned with the remaining members of the community (Vaughan, Gack, Solorazano & Ray, 2003).

In our research, we intend to focus on school children for our environmental education program and hope that the situation in Playa Sámara follows the same pattern as in Quebrada Ganado. The study in Quebrada Ganado expressed the students shared information with their parents, helping to raise awareness. If the children of Playa Sámara are taught about the importance and condition of the Mala Noche River Estuary, the same effect can occur there.

3.1.4 Conclusion

Child education is a critical component in increasing community involvement because their awareness can raise overall awareness. As shown by previous research, children share their knowledge with their parents, creating a new information network (Vaughan et al., 2003). It is for these reasons that we investigated the school systems in Playa Sámara and their environmental education programs.

3.2 Methodology

In order to increase awareness of the importance of the Male Noche River Estuary in the communities of Sámara, we focused on the primary and secondary schools of El Torito. We interviewed representatives from three schools and obtained information about their existing environmental curricula and their willingness to implement any programs that we developed. At the secondary school, we gathered information on the community service projects required for graduation. We specifically discussed two previous projects that had environmentally based topics in order to determine the scope of the projects and the allotted time for completion.

Based on interviews with the school representatives, we established methods to raise awareness in both the primary and secondary schools in El Torito and determined the areas where their existing environmental education could be improved. We also included topics from Study 1 on which the community had demonstrated a general lack of awareness, such as the problems occurring in the estuary. From this we then created recommendations in order to

raise the students' awareness of the estuary by researching previous environmental education efforts for young children, specifically those programs pertaining to estuaries. Some of the sources we used for this research were the U.S. Department of Commerce (National Oceanic and Atmospheric Administration) and the Charlotte Harbor National Estuary Program. For the high school students, we examined ways to incorporate their community service requirements into increasing their awareness of the estuary.

3.3 Results

3.3.1 Current Environmental Education

Through interviews with representatives from the secondary school in El Torito and the primary schools in El Torito and Sámara, we investigated the existing environmental education programs. The programs at the school varied greatly. However, one commonality was that they did not include information about the estuary.

3.3.1.3 Centro Educativo Sámara

The students in Centro Educativo Sámara participate in a beach clean-up twice a year; however, the estuary is not within walking distance of this school and there are not enough teachers for them to bring the students there. Therefore, the children do not visit this portion of the beach with the school. Because of their location and the distance, the teachers feel that the issues in the estuary are not evident to the students. Other than the beach cleanup, the school has very little environmental education in place. The school representative expressed that although it was not part of the current curriculum, there was a possibility of including a day about the importance of the estuary and river.

3.3.1.2 Centro Educativo El Torito

Since 2005, the students of the primary school in El Torito have visited the beach twice a year to pick up trash as part of the International Beach and Coasts Clean-up Day as well. This trash clean up includes the area surrounding the estuary, but this is the only real interaction the

students have with the estuary during school. The school also has an internal campaign to teach the students to pick up trash on their own and keep the school clean. The school has received the Bandera Azul certification, an award given to organizations that meet high standards for an environmental program that helps protect the beaches of Costa Rica. This is attained by passing government evaluations of several different factors including wastewater treatment, drinking water quality, and environmental education. The teachers feel these campaigns are not as successful as they could be because of the contradictions between what the students are taught at school and what they are told at home. Furthermore, the community as a whole has not been able to complete the Bandera Azul certification.

Approximately half of the students participate in an after school program. This program is organized by Fundación Crear, a foundation that works to promote social problems through art, media and sports. Some of the programs include recycling and making art to display around the town, such as the tree made from recycled materials shown in Figure 11. In addition to the after school programs, Fundación Crear organizes a summer camp for the students that further works to introduce young students to the social problems in their area.



Figure 11: Tree made by students using recycled materials (Source: Nediva Anderson, 2011)

3.3.1.1 Liceo Rural El Torito

The high school in El Torito is a rural school and teaches six of the fifteen courses taught in urban schools. In order to supplement the six courses, the Ministerio de Educación (MEP) recommends that teachers in rural schools incorporate additional topics such as health, tolerance and environment into their classes. However, this is not always possible. According to the school representative, teachers must comply with the mandatory curriculum and often have trouble including these topics in their classes.

To compensate for this, the school has voluntary workshops that include some of the topics the MEP suggests. The workshops, which change topics every trimester, are available to all students and are six hours a week. One trimester a year is dedicated to environmental education. This education focuses on the environment in general and the garden on the school grounds. Thus, it does not include information specific to the river and estuary. Furthermore, MEP Regulations do not allow for the workshops to be mandatory. As a result, the teachers noted that students see them as more of a social event and tend to only participate in those that interest them. For example, a larger number of students participate in the soccer workshops than the environmental workshops.

Beyond the voluntary workshops, the MEP mandates that tenth grade students must complete thirty hours of community service in order to graduate. To fulfill this requirement, tenth grade students at Liceo Rural El Torito propose and implement their own service projects, including a schedule and a budget. The school representative stated that some of the projects have environmentally based topics, but none have dealt with the river or estuary.

3.3.2 Pilot Program

From these data we developed programming to raise awareness of the estuary for the school system and designed a pilot program for the schools of El Torito. The materials for this program include a pamphlet for the teachers, an activity book for the students, and an extra credit trip to the estuary for the students. In addition, we provided suggestions to Liceo Rural El Torito regarding potential community service projects for the students.

3.3.2.1 Teacher Pamphlet

One aspect of the environmental education program we developed was a teacher pamphlet. This pamphlet, found in Appendix G, gives a brief overview of our findings and offers facts about the estuary. The pamphlet was intended to provide teachers with information that they can incorporate into the environmental education programs already in place, as the results of the first study indicated that current programs did not include any information regarding the estuary. It also contains a brief overview of our findings on community awareness of the conditions in the estuary.

3.3.2.2 Activities Book

Another part of the environmental education program was an activity book for the students. We included a variety of tasks in the book, such as a crossword puzzle, a word find, two mazes, coloring pages, a matching game and the lyrics to a song we wrote. These activities can be seen in Appendices H and I. All activities have a focus on the estuary and aquifer, with a glossary of terms to help the students learn while having fun, which makes learning more appreciable and offers more retention (Malone & Lepper, 1987).

3.3.2.3 Extra Credit Trip

In accordance with previous research, which states that students must experience the environment in order to fully learn about problems that face the habitat around their community (Sabo, 2010), we designed an extra credit trip in which students can visit the estuary with their parents. There, they complete a checklist of several species of plants and animals in the estuary. Upon their return home, the students create a poster about their experience.

3.3.2.4 Community Service Projects

Since the high school Liceo Rural has a community service requirement to graduate, we developed specific project ideas that involve the estuary and river. These projects included a clean-up trip to the estuary, designing and advertising proposed clean-up days, and hosting an

event to help teach younger students about the estuary and aquifer (see Appendix J). These projects were designed to form connections between the students and the estuary, which is only 250 meters away from the school (Resident, personal communication, 2011).

3.3.3: ASADA Booklet

Along with the school pilot program, we developed a booklet for the local ASADA representatives from El Torito, Santo Domingo, and Sámara. This booklet, which can be found in Appendix K, included the findings from our first study regarding the changes and concerns the residents noticed in the estuary as well as the frequency of visits to the estuary. We also discussed the school pilot program in the booklet. This booklet provided ASADA the tools they would need if they decide to begin raising awareness on their own.

Chapter 4: Discussion and Conclusions

In our studies, we assessed community awareness of the environmental problems in the Mala Noche River and Estuary, which has been degraded by sediment buildup and overexploitation. In doing so, we surveyed community members about their opinions and their usage of the Mala Noche River and Estuary. Overall, our survey showed that residents are not very aware of the importance of the estuary in the environment or the community, such as its connection to their water supply. Many community members support local businesses, such as new hotels and the teak plantation, because they help to provide economic stability to the communities; however, these businesses contribute to the sediment buildup. Many younger members of the community visit the estuary and river frequently to swim and bathe while older members of the community visit the Mala Noche infrequently. Thus, our findings suggest that community members have limited awareness of the environmental issues facing the estuary, and this may be due to the frequency at which individuals visit the estuary and the purposes for which they use it. Given the limited awareness of the environmental issues, we developed educational programming that we recommend be implemented in the local schools and community.

In order to gain support to restore the estuary, it is important to increase awareness in the community about the environmental issues surrounding the estuary. Past research shows that one way to improve community awareness to environmental issues is to educate younger generations, as they transfer information to the rest of the community and encourage older generations to become involved (Vaughan, 2010). Thus, we recommend teaching the youth of Playa Sámara about the environmental issues surrounding the estuary.

From interviewing school officials, we learned that the environmental education programs in schools in Playa Sámara have limited funding and existing programs do not include information specific to the Mala Noche River and Estuary. Thus, we developed inexpensive activities for primary school students that can help increase awareness about the issues in the estuary. These activities include crosswords, word searches, coloring pages, and a song to teach about the environmental effects of sediment buildup in the estuary. Based on previous

research that says students need to visit the environment to fully understand it (Sabo, 2010), we also recommended an extra credit opportunity in which students visit the estuary with their parents. Past research also suggested that students learn more from activities that are more enjoyable (Malone & Lepper, 1987), and therefore we suggested an evening event for students and parents with a performance of the song included in the activities book and other activities such as arts and crafts.

Past research shows that piloting programs in a smaller sample allows researchers to gauge its success before investing in implementation throughout an entire community (Jacobson & Robles, 1992). Based on this research, we recommend that the programming for primary school students be piloted in Centro Educativo El Torito. We chose this school because the existing environmental education program at this school is the most developed, and the program can be incorporated the most easily. Also, they are located closest to the estuary, and the information is therefore most relevant to them. Since the 2011 school year has already ended, this program will be implemented during the 2012 school year.

We also recommended a pilot community service program to the local high school, given its proximity to the estuary (250 m). The school representative had discussed in the interview that the current projects did not pertain to the estuary. Therefore we designed projects that focused on the estuary and river in hopes that the older students can also learn more about the estuary. These projects will be suggested for the 2012 school year since this academic year has already ended. Future research can evaluate the success of the pilot programs for both schools, and if they prove to be successful, they can be extended to other schools in the district.

To share our findings with ASADA, we designed and distributed a booklet to the Sámara, El Torito, and Santo Domingo branches highlighting the key findings from our research. This information illustrates the level of awareness the community has about certain aspects of the estuary. ASADA can use this information to prioritize what should be included in their own outreach program, if they choose to develop one. The presentation of information about the estuary to the people of Playa Sámara will begin to raise awareness about the sedimentation and its effects on the estuary.

After this awareness has been raised, the willingness of the community to move forward with the restoration efforts should be assessed through further research. If the community demonstrates willingness to proceed, the methods of sediment mitigation (i.e., dredging, sediment basins, and wetland restoration) recommended by prior researchers (Scott-Solomon, 2010) can be evaluated for community acceptance and then initiated. In addition, research can be done to monitor the outcome of these mitigation techniques to ensure that the efforts are effective and long lasting.

Through our research, we determined that the community of Playa Sámara is generally unaware of the importance of the estuary to the community and the environment, as well as the problems in the estuary. Previous research has established the importance of mitigating the sediment accumulation issues to maintain the biodiversity and protect the water in the aquifer under the estuary (Scott-Solomon et al., 2010). Furthermore, we determined that community support is needed for restoration efforts to be successful. To increase awareness of the importance and current state of the estuary, we organized an outreach program for the schools based on the results of our research. We also shared the results with the local water distribution company so that the program can be implemented in the near future. If the awareness programs are successful, it is hoped that restoration of the Mala Noche River Estuary can begin and the valuable source of drinking water that lies beneath it can be protected.

References

- Barrantes-Reynolds, M. P. (2011). The expansion of “real estate tourism” in coastal areas: Its behaviour and implications. *Recreation and Society in Africa, Asia and Latin America*, 2(1), 51-70.
- Berger, U., Glaser, M., Koch, B., Krause, G., Lara, R., & Saint-Paul, U. (1999). An integrated approach to mangrove dynamics and management. *Journal of Coastal Conservation*, 5(2), 125-134.
- Bocanegra, E., Da Silva, G., Custodio, E., Manzano, M., & Montenegro, S. (2010). State of knowledge of coastal aquifer management in South America. *Hydrogeology Journal*, 18(1), 261-267.
- Cheng, A. H., & Ouazar, D. (2003). *Coastal aquifer management-monitoring, modeling, and case studies: Monitoring, modeling and case studies*. Florence: CRC Press Inc.
- Cortés, J., Fonseca, A. C., Nivia-Ruiz, J., Nielsen-Muñoz, V., Samper-Villarreal, J., Salas, E. and Zamora-Trejos, P. (2010). Monitoring coral reefs, seagrasses and mangroves in costa rica (CARICOMP). *Revista De Biología Tropical*, 58 Suppl 3, 1.
- Davis, M., & Masten, S. (2008). *Principles of environmental engineering and science* (2nd ed.) McGraw-Hill Science Engineering. New York, NY.
- Departamento de Servicios Parlamentarios. (1946). No. 276: Ley De Aguas. Retrieved 9/21/2011, from http://www.oas.org/dsd/environmentlaw/waterlaw/documents/Costa_Rica-Ley_276.pdf
- Ellison, A. M. (2000). Mangrove restoration? Do we know enough? *Restoration Ecology*, 8, 219-229.
- Ellison, J. C. (1999). Impacts of sediment burial on mangroves. *Marine Pollution Bulletin*, 37(8-12), 420-426.
- Elmer, M.B. The Interview Process. *National Association of Personnel Services*. Retrieved on 9/25/2011 from http://www.recruitinglife.com/educert/downloads/isccourses/isc_18.pdf
- Evans, L., Okawa, Y., & Searcy, D. (2005). Anatomy and morphology of red mangrove (rhizophora mangle) plants in relation to internal airflow. *Journal of the Torrey Botanical Society*, 132(4), 537-550.
- Franco, A., Torricelli, P., & Elliott, M. (2007). Biodiversity and ecosystem functioning in coastal and transitional waters. ++

Distrito Sámará, Canton Nicoya, Guanacaste, Costa Rica: ASADA.

Helmuth, C. (2000)., *Culture and customs of Costa Rica* (1st ed.). Westport, Connecticut: Greenwood Press.

IX censo nacional de población y V de vivienda del 2000 (2001). . Costa Rica: Instituto Nacional de Estadística y Censos.

Jacobson, S., & Robles, R. (1992). Ecotourism, sustainable development, and conservation education: Development of a tour guide training program in Tortuguero, Costa Rica. *Environmental Management*, 16(6), 701-713.

Kirby, K., & Potvin, C. (2007). Variation in carbon storage among tree species: Implications for the management of a small-scale carbon sink project. *Forest Ecology and Management*, 246(2-3), 208-221.

Lee, J. C., & Ma, W. (2006). Early childhood environmental education: A Hong Kong example. *Applied Environmental Education and Communication*, 5(2), 83-94.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude Learning and Instruction*, 3(3), 223-253.

McLaughlin, R. (2005). *SoilFacts: Using Baffles to Improve Sediment basins*. North Carolina: North Carolina Cooperative Extension.

Moreno, P. S. (2005). Ecotourism along the Meso-American Caribbean Reef: The impacts of foreign investment. *Human Ecology*, 33(2), 217-244.

Nayar, S., Miller, D. J., Hunt, A., Goh, B. P. & Chou, L. M. (2007). Environmental effects of dredging on sediment nutrients, carbon and granulometry in a tropical estuary. *Environmental Monitoring and Assessment*, 127(1-3), 1-13.

"Preschool education in Cuba." *Childhood Education* 78.6 (2002): 363+. *Academic OneFile*. Web. 7 Dec. 2011.

Sabo, H. M. (2010). Why from early environmental education?8(12), 57-61.

Scott-Solomon, E. R., Obasare, R. E. , Degnall, E. Y., Armstrong, E. L., (2010). *Sedimentation in mangrove forests in Sámará, Costa Rica*. Worcester, MA: Worcester Polytechnic Institute.

Skylander, K. B. (2005). *A description of adult environmental education programs in residential environmental education centers and their use of experiential learning theory and environmental citizenship concepts*.

Solano, C. (2005). *Recopilacion de informacion respecto a la ASADA del acueducto rural de Sámara, conforme con expediente 5-2-5 A y A. No. 83*. Nicoya, Costa Rica: Registro de Pozos Senara y Otros Documentos Tecnicos.

Tian, Y., Liu, H. J., Zheng, T. L., Kwon, K. K., Kim, S. J., & Yan, C. L. (2008). PAHs contamination and bacterial communities in mangrove surface sediments of the Jiulong River Estuary, China. *Marine Pollution Bulletin*, 57(6-12), 707-715.

Vaughan, C. , Gack, J., Solorazano & Ray, R. (2003). The effect of environmental education on schoolchildren, their parents, and community members: A study of intergenerational and intercommunity learning. *The Journal of Environmental Education*, 34(3), 12-21.

Appendix A: Community Survey (English Version)

Mala Noche River Estuary and Community Relationship

This survey serves to aid in the restoration efforts of the Mala Noche River Estuary through questions pertaining to your relationship with the estuary. Your personal information will not be disclosed.

What is your gender?

- Male
- Female

What is your age?

How often do you visit the river?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|-----------------------------|
| Never | Each year | Each month | Each week | Frequently (At least daily) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

How often do you visit the estuary?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|-----------------------------|
| Never | Each year | Each month | Each week | Frequently (At least daily) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Have you noticed any changes in the estuary?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| No changes | A few | Some | | Severe change(s) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

If there are, please specify what changes.

How concerned are you about the estuary?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Not at all | A few | Some | | Extremely |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

If you are, please specify.

On a weekly basis, how frequently do you use the river for each of the following?

	Never	1-2 times a week	3-4 times a week	5-6 times a week	Daily
Bathing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Laundering Clothes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Swimming	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dumping ground	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If you said other, please specify the task: _____

What do you know about the estuary in terms of its function in the ecosystem?

What do you know about the estuary and ecosystem in terms of its function in the community?

What is the source of the water that your family uses in your home? If you do not know, please respond "not sure".

Thank you for completing this survey. Your participation in this study is greatly appreciated.

Appendix B: Community Survey (Spanish Version)

El Estero del Río Mala Noche y sus relaciones con la comunidad

Este estudio es para los esfuerzos de la restauración del Estero del Río Mala Noche por preguntas que pertenecen a sus relaciones con el estero.
Su información personal no será compartida.

¿Cuál es su género?

- Varón
- Mujer

¿Cuántos años tiene?

¿Con cuánta frecuencia visita Usted el río?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Ninguna vez | Cada Año | Cada Mes | Cada Semana | Todos los días |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

¿Con cuánta frecuencia visita Usted el estero?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Ninguna vez | Cada Año | Cada Mes | Cada Semana | Todos los días |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Si los ha visitado, ¿nota algún cambio entre las visitas?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Ningún cambio | Pocos | Algunos | | Muchos cambios |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Si su respuesta es <<sí>>, por favor explique los cambios.

¿Tiene alguna preocupación sobre el estero?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Ninguna preocupación | | | | Muchas preocupaciones |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | Pocas | Algunas | | |

Si su respuesta es <<sí>>, por favor explique.

Durante una semana, ¿Con cuánta frecuencia utiliza Usted el río para cualquiera de los siguientes?

Tarea	Ninguna vez	1-2 veces en una semana	3-4 veces en una semana	5-6 veces en una semana	Todos los días
Bañarse	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lavar las ropas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nadar	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Como un basurero	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Otro	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Si su respuesta es <<otro>> por favor explique: _____

¿Qué sabe sobre el estero y su función en el medio ambiente?

¿Qué sabe sobre el estero y el ecosistema y sus funciones en la comunidad?

¿Qué es la fuente de agua que su familia utiliza en casa? Si no sabe, por favor escriba <<no sé>>.

Muchas gracias para completar este estudio. Su participación en este estudio está agradecida.

Appendix C: Questions for School Representatives

Do you know of any issues occurring within the Mala Noche River Estuary? If so, what issues?

In your opinion, are students aware of any issues occurring in the estuary? Are they concerned?

Do you think your students would be willing to go on a field trip where they went to the estuary and learned about its benefits to the ecosystem and community?

Would the school be able to include a day in their school year to help educate the students about the importance of the estuary?

Do the children of your school have to complete a certain amount of community service hours to receive their diploma? If so, what are the requirements and what types of service do they partake in?

Would the students/faculty be willing to make cleaning the estuary part of this community service requirement?

Appendix D: Questions for Environmentalist

Do you know of any issues occurring within the surrounding habitat, such as the estuary and river? If so, what issues?

Has the community noticed these changes? If so, have they tried to fix the issue? How? Were they successful?

Do you think other adults in the area would appreciate a community day where they helped to clean up debris around the estuary?

Appendix E: Questions for ASADA Representative

ASADA works very closely with the Mala Noche watershed, what recent changes have you noticed that could impact the amount of sediment within the watershed?

If there were changes, what do you feel caused them?

Is ASADA concerned about any changes that might be happening to the watershed?

Do you know of any issues occurring within the surrounding habitat, such as the estuary and river? If so, what issues?

Are these issues affecting the aqueduct where you work?

If there were issues, were there any concerns expressed about by the community, and has ASADA made any attempts to mitigate the issue?

Appendix F: Summary Tables of Statistical Analyses

Table 1: ANOVA summary table for survey data

<i>DV</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>F</i>	<i>p</i>
Visits					
Age				2.217	0.101
19 to 29	3.5	1.0308	9		
30 to 39	3.2813	1.3413	16		
40 to 49	2.8571	1.2315	14		
50+	2.5556	1.424	9		
*Gender				4.545	0.039
Male	3.4167	1.1663	18		
Female	2.85	1.3141	30		
Age x Gender				1.771	0.168
19 to 29 Male	3.2	1.1511	5		
19 to 29 Female	3.875	0.8539	4		
30 to 39 Male	5	-	1		
30 to 39 Female	3.1667	1.3048	15		
40 to 49 Male	3.5714	0.9759	7		
40 to 49 Female	2.1429	1.069	7		
50+ Male	3.1	1.4748	5		
50+ Female	1.875	1.1815	4		
Swimming					
Age				0.673	0.577
19 to 29	2.13	1.246	8		
30 to 39	2.56	0.726	9		
40 to 49	2.33	1.581	9		
50+	1.43	0.787	7		
Gender				0.012	0.915
Male	1.82	0.603	11		
Female	1.91	1.377	22		
Age x Gender				1.032	0.395
19 to 29 Male	2	0	4		
19 to 29 Female	2.25	1.893	4		
30 to 39 Male	3	-	1		
30 to 39 Female	1.38	0.518	8		
40 to 49 Male	1.67	0.577	3		
40 to 49 Female	2.67	1.862	6		
50+ Male	1.33	0.577	3		
50+ Female	1.5	1	4		

<i>DV</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>F</i>	<i>p</i>
Bathing					
Age				1.827	0.167
19 to 29	2	1.549	6		
30 to 39	1.64	0.633	14		
40 to 49	2.13	1.246	8		
50+	1.17	0.408	6		
Gender				0.483	0.493
Male	1.58	0.669	12		
Female	1.82	1.14	22		
Age x Gender				1.937	0.148
19 to 29 Male	1.5	0.577	4		
19 to 29 Female	3	2.828	2		
30 to 39 Male	3	-	1		
30 to 39 Female	1.54	0.519	13		
40 to 49 Male	1.75	0.5	4		
40 to 49 Female	2.5	1.732	4		
50+ Male	1	0	3		
50+ Female	1.33	0.577	3		
Changes					
Age				0.466	0.708
19 to 29	3	1.658	9		
30 to 39	2.6	1.595	15		
40 to 49	2.73	1.618	11		
50+	2	1.528	7		
Gender				0.286	0.596
Male	2.93	1.73	14		
Female	2.46	1.503	28		
Age x Gender				0.354	0.787
19 to 29 Male	3	2	5		
19 to 29 Female	3	1.414	4		
30 to 39 Male	2	-	1		
30 to 39 Female	2.64	1.646	14		
40 to 49 Male	3.2	1.789	5		
40 to 49 Female	2.33	1.506	6		
50+ Male	2.67	2.082	3		
50+ Female	1.5	1.503	4		

<i>DV</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>F</i>	<i>p</i>
Concerns					
Age				1.831	0.161
19 to 29	2.57	1.813	7		
30 to 39	2.57	1.555	14		
40 to 49	3	1.414	12		
50+	1.43	0.787	7		
Gender				0.935	0.341
Male	2.94	1.652	16		
Female	2.21	1.351	24		
Age x Gender				1.819	0.163
19 to 29 Male	3	2.309	4		
19 to 29 Female	2	1	3		
30 to 39 Male	1	-	1		
30 to 39 Female	2.69	1.548	13		
40 to 49 Male	3.86	1.069	7		
40 to 49 Female	1.8	0.837	5		
50+ Male	1.75	0.957	4		
50+ Female	1	0	3		

* indicates $p \leq 0.05$

Table 2: Chi-squared summary table for open ended survey questions

	%	$\chi^2 (1, N=48)$	<i>p</i>
Estuary Importance to Community		7.25	0.007
Demonstrates Knowledge	25		
Does Not Demonstrate Knowledge	48		
Estuary Importance to Environment		9.328	0.002
Demonstrates Knowledge	19		
Does Not Demonstrate Knowledge	56		
Perceived Changed in Estuary		7.806	0.005
Water Changes	42		
Land Changes	20		
Concerns About Estuary		0.0625	0.802
Concerns	33		
Fears	12		

Table 3: Correlations summary table for survey data

Questions	N	r	p
Town and Visits	48	0.06	0.687
Town and Changes	42	-0.165	0.295
Town and Concerns	40	-0.095	0.558
Town and Usage	41	0.154	0.336
*Age and Visits	48	-0.354	0.014
*Age and Changes	42	-0.328	0.034
Age and Concerns	40	-0.212	0.19
Age and Usage	41	-0.21	0.188
Gender and Visits	48	-0.217	0.139
Gender and Changes	42	-0.141	0.375
Gender and Concerns	40	-0.241	0.134
Gender and Usage	41	0.074	0.647
Visits and Changes	42	0.064	0.686
Visits and Concerns	40	0.201	0.214
Visits and Usage	41	0.108	0.503
*Changes and Concerns	35	0.481	0.003
Changes and Usage	39	0.092	0.578
Concerns and Usage	34	-0.1	0.572

* indicates $p \leq 0.05$

La Comunidad Piensa...

En nuestro estudio de la comunidad, les preguntamos a los habitantes su opinión respecto al Río Mala Noche y su estero, por medio de preguntas sobre la función del estero en la comunidad y como ecosistema. Las resulas reflejan un muy bajo nivel de consciencia sobre la importancia del ambiente. Los adultos de la comunidad expresan sus opiniones a sus hijos y hay un ciclo de desinterés hacia el ambiente a causa de esto. Según una entrevista, los padres de los estudiantes les dicen a sus hijos que el ambiente no es importante.



Comienza con los jóvenes
Necesitamos añadir un programa para que los niños establecer un nivel de consciencia con el estero. Si los niños y sus padres expresan un interés en el ambiente y el estero, es posible que el acuífero debajo del estero sobreviva y el suministro de agua no se envenene porque la comunidad en su totalidad defendería su derecho de tener un acuífero protegido, y un río al igual que un estero saludable ejerciendo presión sobre los entes gubernamentales.



Recomendaciones Para las Escuelas

Appenc

Una nueva perspectiva

El programa de educación ambiental es bueno, pero los estudiantes necesitan a comprender las decisiones de su vida y los efectos de sus decisiones en el ambiente. Cuando caminen por el estero para los días de limpiar la playa, los profesores reflexionarían con los estudiantes sobre el ambiente y las influencias que sus vidas tienen en el estero. Hablarían también del acuífero y resaltarían la necesidad de parar la contaminación del río para permitir la restauración y sobrevivencia del estero. El acuífero está debajo del estero y es su suministro de agua. La contaminación envenenará el acuífero si continúa.



Los datos necesarios

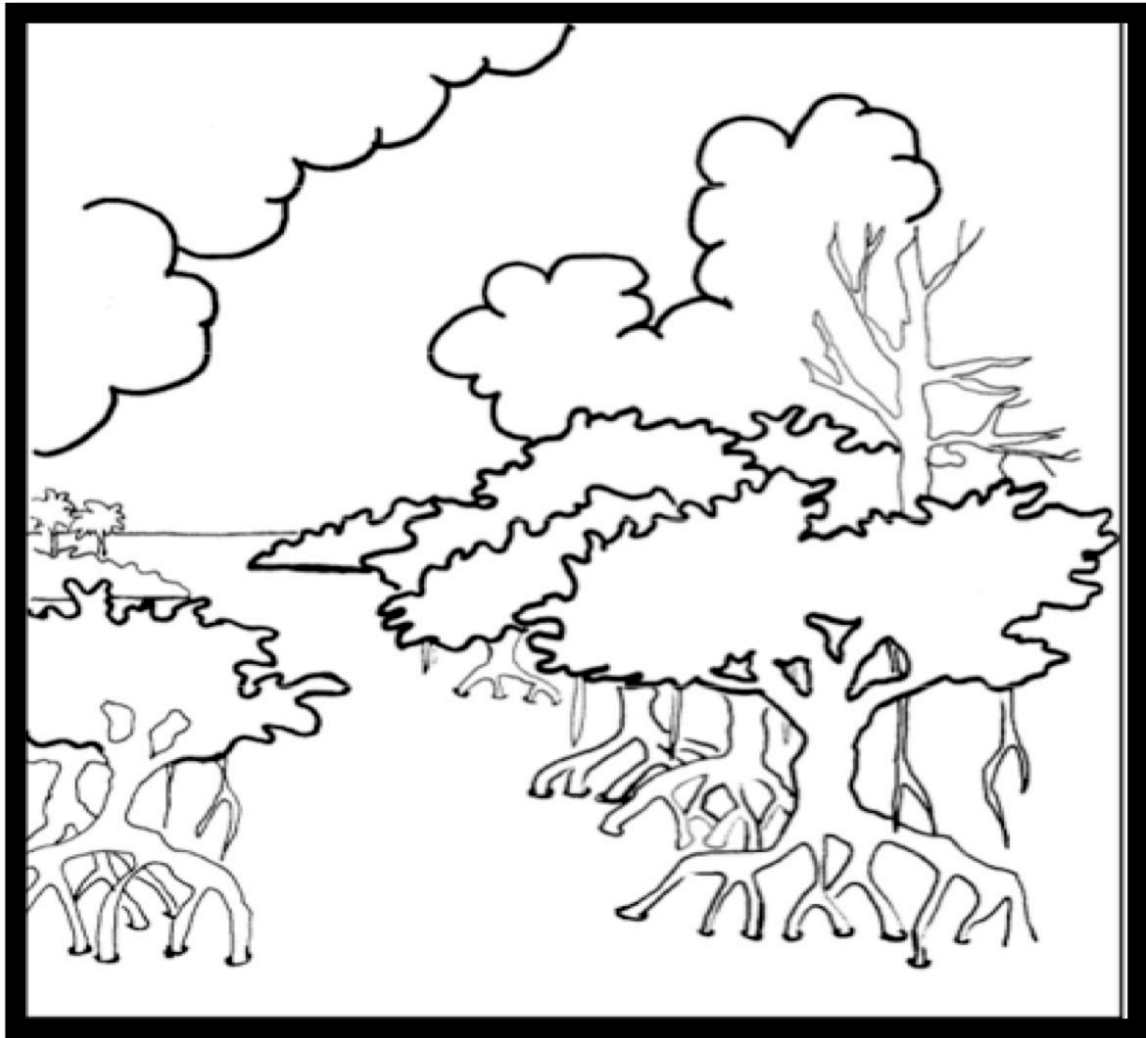
- Hay un acuífero debajo del estero y el agua de la comunidad es de este acuífero
 - Un acuífero es un recurso de agua en la tierra
- La contaminación del estero está envenenando el acuífero
 - Si la contaminación dura, el acuífero se perderá y el suministro de agua desaparecerá
- Los árboles se mueren a causa de esta contaminación
 - Los árboles protegen al acuífero con sus raíces. Las raíces protegen la tierra y la tierra arriba del acuífero para que ningún agua salina se filtre en el acuífero
- El estero es un lugar en que los animales viven (un ecosistema)
 - La contaminación del estero está obligando a los animales a salir del área
 - Los peces usan las raíces de los árboles que viven en el agua para protección contra animales grandes como cocodrilos
 - Si los árboles se mueren, los peces se mueren
- Los pescadores no tiene un trabajo si los peces se mueren



Appendix H: Activities Book for School Children

Ayuda a los Manglares

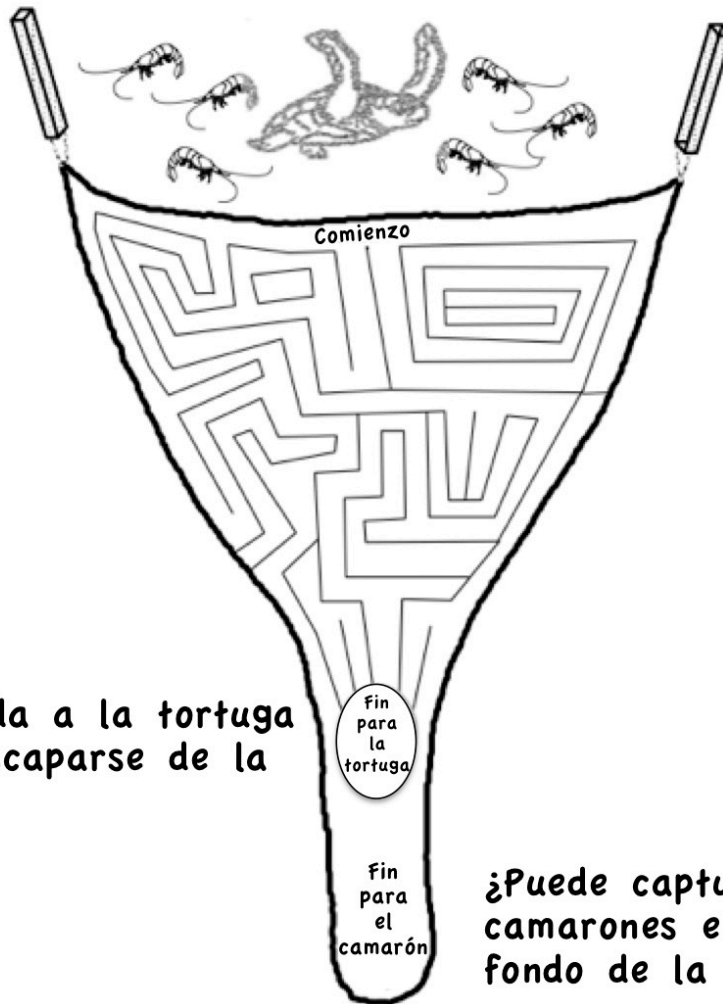




Los manglares son árboles que protegen los peces de otros animales en esteros. Los manglares necesitan nutrientes del agua y la tierra para sobrevivir. Si el sedimento aumenta en el estero, no recibe nutrición adecuada.

Glossary

Biodiversidad	La diversidad de vida en el mundo
Bioma	Un tipo de comunidad ecológica parecido a un desierto o una selva
Caimán	Un animal similar a un lagarto
Comunidad	Un grupo natural de animales diferentes viviendo juntas
Ecosistema	Una comunidad de animales y su ambiente
Especies	Una población de individuos que son similares y pueden tener cría
Estero	El parte del río que toca el mar
Impotable	No potable
Mar	El agua que está cubriendo setenta y cinco por ciento de la superficie del mundo
Meandro	Un cambio en el curso del río
Manglar	Arboles que crecen en los esteros y tienen raíces arriba de la tierra y el agua
Nutrientes	Sustancias químicas que los animales necesitan para vivir y crecer
Plancton	Animales súper pequeños que viven en el mar
Pozo	Un hueco perforado en la tierra para obtener agua
Río	Una corriente natural y grande de agua fluyendo en un curso definido

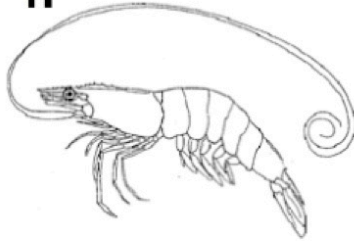


Ayuda a la tortuga a escaparse de la red.

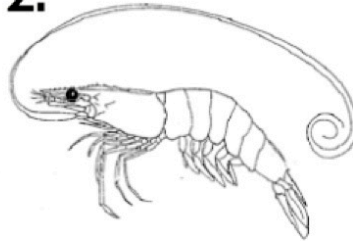
¿Puede capturar los camarones en el fondo de la red?

¿Cuáles dos camarones son iguales?

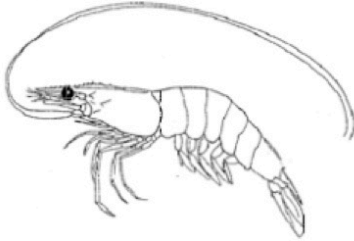
1.



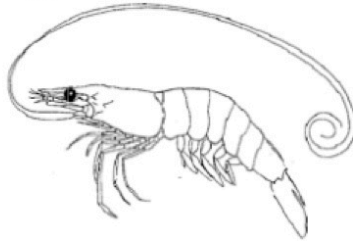
2.



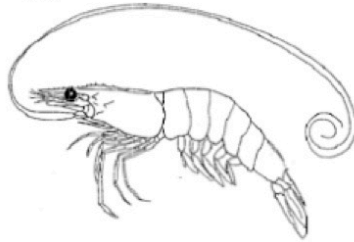
3.



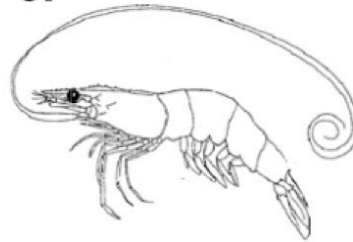
4.



5.



6.



Sopa de Letras

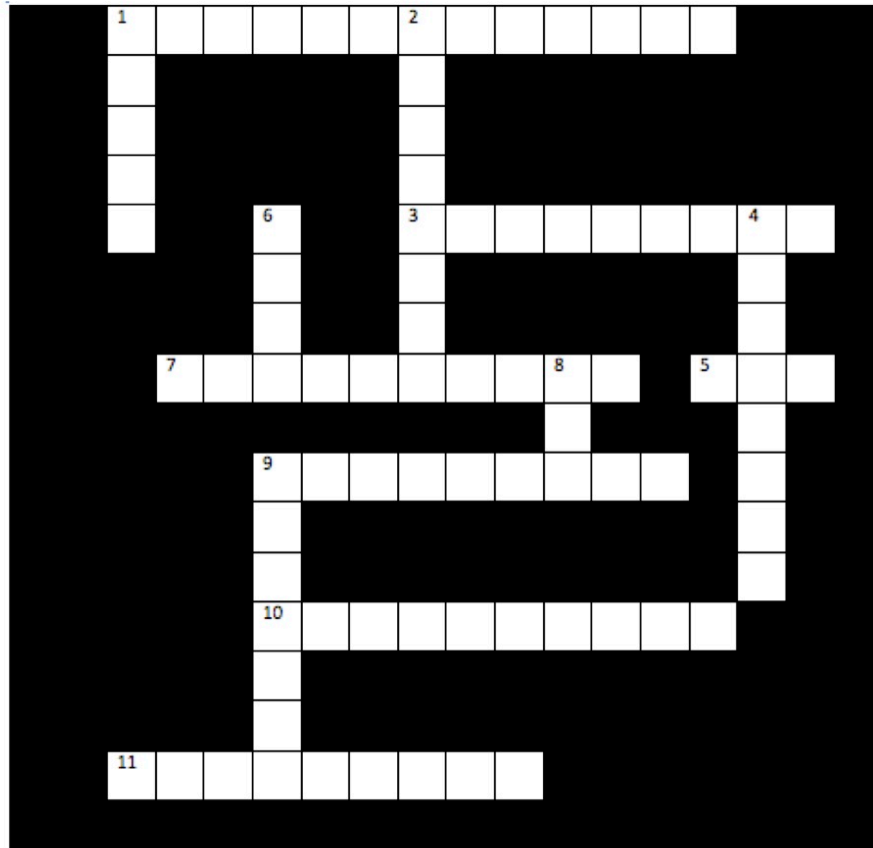
G S V N S R L H K I L B A S F R E W V C
H D R A O D A B É C E F G P É P Í D C B
O T S G H L B D B R R D F U W A P U O A N
R Í D M A R R I V B R R P O Í L J T M G I T
A Z B A B R O E A I L I O G L A R T M Á U
A M A N R O D N D E A L F I N M L R É N G
D I V G E R I S I D A C C R D D S N W B F
E R B L Ñ D V O Ñ A C C R D D S N W B F
I J F A N L E U F J T V M E E T C H D D
R G X R S T R L Y G O R Á T T E T I G A
Q F H V S T S U I É Q Y J N O U T H R O N I H B
G G R É T U I Q É Q Y N J R R O O N I H B
W E R C V H D F A Y N N U R U I C Y T N M
T U Ñ N Í D A H D D E T R I T O A T U Ó U
A E B N W H D Í R N M B I T U N I E N W I
S É C B H A K B U T T T K O G B É H O R
B G D C A M A R Ó N J I G Á A C É H O R
A O H D G U L C F O R P T Q D E N D Í Y
S T O R T U G A S P W Ó H E S U E A P T
T V P R G L Q M W M B G K G D E L F Í N

Manglar
Estero
Plancton

Camarón
Caimán
Delfín

Biodiversidad
Tortuga

Crucigrama del Estero



A Través

1. La diversidad de vida en el mundo
3. Un grupo natural de especies diferentes viviendo juntas.
5. Una corriente natural y grande de agua fluyendo en un curso definido.
7. Una comunidad de organismos juntos con el medio ambiente donde viven.
9. Árboles que crecen en los esteros y tienen raíces arriba de la tierra y el agua.
10. Sustancias químicas que los animales necesitan para vivir y crecer.
11. No potable.

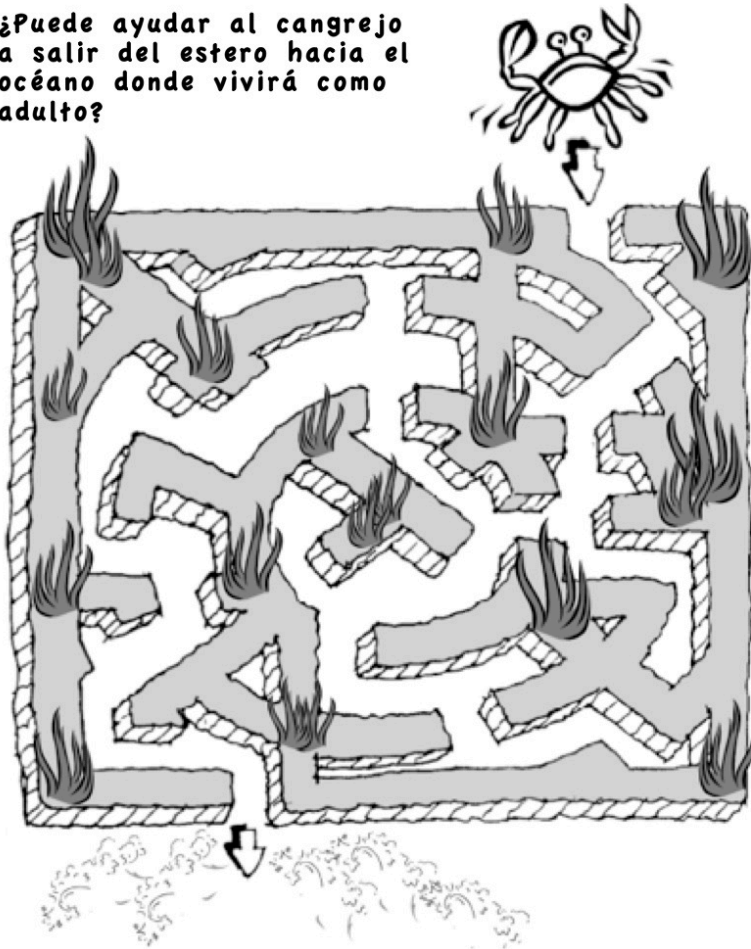
Abajo

1. Un tipo de comunidad ecológica parecido a un desierto o una selva.
2. Una población de individuos que son similares y pueden tener cría.
4. Un parte de la tierra con agua subterránea.
6. Un hueco perforado en la tierra para obtener agua.
8. El agua que está cubriendo setenta y cinco por ciento de la superficie del mundo
9. Un cambio en el curso del río.

El laberinto del estero

Esteros son hábitats muy importantes para los animales marinos. Los animales viven ahí parte de su vida, pero salen antes de ser adultos. El área favorita para los animales son en las plantas cerca del agua.

¿Puede ayudar al cangrejo a salir del estero hacia el océano donde vivirá como adulto?



Appendix I: Estuary and Aquifer Song

Canción Acuífero

Hay un acuífero abajo del estero
De aquí sacamos agua pero
Está en peligro, necesita alivio
Ven a ser su AMIGO!

El estero es la casa para los peces
Ellos crecen en las raíces
Los protegen de otros peligros
Como otros peces y sus amigos

Hay un acuífero abajo del estero
De aquí sacamos agua pero
Está en peligro, necesita alivio
Ven a ser su AMIGO!

Cuando hay basura en el río
Termina en el estero (QUE)
La basura lo daña y ensucia el agua (EHH)

Hay un acuífero abajo del estero
De aquí sacamos agua pero
Está en peligro, necesita alivio
Ven a ser su AMIGO!

Necesitas agua para vivir,
Para nadar y para beber
Escasa es agua potable
Se puede prevenir si eres ecoamigable

Hay un acuífero abajo del estero
De aquí sacamos agua pero
Está en peligro, necesita alivio
Ven a ser su AMIGO!

Appendix J: Proposed Community Service Projects for Secondary School Students

Objetivo: Comienza a limpiar el estero mientras aumentar la consciencia sobre la función del estero en la comunidad.

Modos posibles:

1. Crear papeles de hechos para distribuir a la comunidad (por escuelas, iglesias, negocios y puerta a puerta)
 - a. La necesidad del estero en la comunidad
 - i. Acuífero
 - ii. Fuente de agua
 - b. La necesidad del estero en el ambiente
 - i. Plantas
 - ii. Animales
 1. Peces
 2. Camarones
2. Presentar información sobre el estero a otros estudiantes
 - a. Durante la sección escolar para el ambiente
3. Crear afiches para colgar alrededor de la comunidad
 - a. Hechos sobre el estero
 - b. Un día para limpiar el estero
4. Día para limpiar la basura cerca del estero
 - a. Mientras que limpien, comparten hechos sobre el estero y su
 - b. Invitar a las primarias a participar

Appendix K: Booklet for ASADA

Recomendaciones

Nuestro objetivo es establecer una conexión entre la comunidad de Playa Sámara y el Río Mala Noche y Estero.

Noviembre 2011



Planes actuales

- 1 Dar recursos para aumentar la consciencia de estudiantes primarias.
- 2 Implementar programas para incorporar los padres en la educación ecológica.
- 3 Conducir reuniones municipales para aumentar la consciencia de los que recibir su agua del acuífero.
- 4 Establecer participación de los negocios en la restauración del estero

¿Qué pasará en el futuro?

Nuestro objetivo principal fue investigar el nivel de consciencia en la comunidad. Basado en esto creamos un segundo objetivo: aumentar este nivel de consciencia. Escribimos nuestras recomendaciones según los estudios que recogimos de la mitad de la población de El Torito, Pueblo Nuevo y Santo Domingo. El próximo paso sería implementar nuestras recomendaciones para aumentar el nivel de consciencia sobre el estero y su función en las vidas de los habitantes de la comunidad. Esperaríamos que por aumentar el conocimiento sobre el estero y sobre la importancia de proteger su propia fuente de agua, los residentes hagan esfuerzos por mejorar la salud del estero.



El estero necesita su ayuda

El estero es el ecosistema principal para muchos animales, pero la biodiversidad del estero está bajando a causa de la contaminación. También el pozo está trabajando mucho y hay una falta de agua, estableciendo la posibilidad a intrusión salina.



El Programa para las Escuelas

Recomendamos que las escuelas implementen un programa adicional de educación ambiental para suplementar el programa existente. El programa debe utilizar días de servicio en la comunidad y actividades en la escuela para enseñarles a los estudiantes la importancia de los animales y el ambiente. Los programas necesitan comenzar cuando los estudiantes están jóvenes y continuar hasta que se gradúen. Consecuentemente, los

estudiantes sentirán que el estero es una parte significativa de sus vidas y lo protegerán para siempre.

Aunque los estudiantes ya saben la importancia del ambiente en general, no hay mucha educación sobre el río y el estero específicamente. Los estudiantes de primaria en El Torito visitan el estero dos veces cada año para limpiarlo, pero esta es su única interacción escolar con el estero. Por eso, es posible que

no estén tan conscientes del problema que está ocurriendo en el estero.

Para resolver esta situación, un programa adicional fue creado para avanzar el conocimiento de los estudiantes sobre el estero y el ambiente alrededor de él. Hemos creado un proyecto de puntos extra en el cual los estudiantes de

Establecer una conexión con el estero



primaria visitan el estero con sus padres. La visita se enfocará en los cambios en el estero y la necesidad de mantenerlo saludable.

Para completar el décimo año de colegio, los estudiantes necesitan completar treinta horas de servicio a la comunidad. Los estudiantes del Liceo Rural de El Torito completan estas horas con

proyectos que los mismos estudiantes crean. Los proyectos pasados no se enfocaban en el estero y río, sino que se han enfocado en la área directamente alrededor de la escuela. Para incorporar a estos estudiantes en los esfuerzos por recuperar el estero y el río, le propondremos proyectos al director de la secundaria enfocados específicamente en éstos. Un ejemplo de estos proyectos es

organizar un día en que la comunidad entera participe en una limpieza de playa. Esta actividad se promocionará con afiches en puntos céntricos de la comunidad que anunciarán la actividad y dirán por qué deben asistir.



El Programa para la Comunidad

Necesitamos que la comunidad esté de acuerdo con los esfuerzos para la restauración del estero y los manglares. Por eso, llevamos a cabo un estudio con los residentes de El Torito, Pueblo Nuevo y Santo Domingo para investigar su consciencia sobre el estero. Estos son los resultados.

A causa de nuestro estudio en la comunidad, obtuvimos bastante información para saber el nivel de conocimiento y las preocupaciones sobre el estero en las comunidades de El Torito, Pueblo Nuevo y Santo Domingo. Cincuenta y tres por ciento de la población encuestada no saben la conexión entre el estero y la comunidad o dicen que no hay una conexión entre ellos. Veintisiete por ciento de los habitantes expresaban que no saben el papel del estero en el ecosistema. El pueblo donde los participantes viven no afecta significativamente el nivel de preocupación, pero el nivel de preocupación si cambia dependiendo del género del participante. Los hombres expresan más preocupación que las mujeres. El análisis de la encuesta también refleja una relación entre la edad del participante y su preocupación sobre el estero. Habitantes entre

los años 26 y 50 tienen más preocupaciones sobre el acuífero mientras que los que están entre los años 51 y 75 tienen menos. Hay mucha variedad en las respuestas de cuando fueron preguntados sobre sus preocupaciones con el estero. Las respuestas más comunes indican preocupaciones con la contaminación del río y el estero y la variación en el nivel del agua. Una porción pequeña de los participantes expresan preocupación sobre la deforestación ocurriendo cerca del estero y una porción aún más pequeña expresa preocupación sobre la falta de biodiversidad, el nivel de conocimiento en la comunidad o los lagartos.

La población encuestada expresa que el pozo es su fuente de agua: sin embargo, hay un dos por ciento que contestó que el acuífero abajo del estero es la fuente. La población no establece la conexión entre su

fuentes de agua y el estero. Por eso, las actividades durante sus vidas diarias no cambian. Usan el río y el estero para nadar primordialmente. Si el estero y el acuífero se secan, su fuente de agua se acaba.





Tenemos el poder de mantener el estero

El objetivo principal de este proyecto fue conocer las comunidades que tienen más contacto con el estero y su nivel de consciencia sobre el problema en éste. Después de analizar el estudio y las entrevistas, descubrimos que aunque la población sabe mucho sobre la contaminación, no conectan la importancia del estero con la comunidad y el ambiente. Por eso, creamos un segundo objetivo: aumentar el conocimiento sobre estos problemas. Creamos programas de educación ambiental para las escuelas de primaria y secundaria en Playa Samara y esperamos que los estudiantes expresen su interés por el estero, resultado de estos programas, a sus padres. Es necesario que los habitantes comprendan la importancia del estero en sus vidas diarias antes que el estero y el acuífero no contengan más agua potable.

Gracias por su tiempo,

El Instituto Politécnico
Worcester, Massachusetts, Los Estados Unidos.

Por:

Nediva Anderson

Courtney McCarthy

Charlene Pizzimenti

Joshua Powell