



# An Oral History of Sea Level Rise in Costa Abajo

Local Perception of Coastline Changes and Future Implications

Hélène Descoteaux  
Frances Grout-Brown

Presented to:  
Dr. Stanley Heckadon-Moreno  
Dr. Rafael Samudio  
Victor Frankel



McGill University  
Smithsonian Tropical Research Institution

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#### **Punta Galeta Staff**

Dr. Stanley Heckadon-Moreno  
 Sra. Illia Grenald  
 Sr. Gabriel Thomas  
 Sr. Jorge Morales  
 Sr. Alfredo Lanuza  
 Sr. Gilberto Chambers

#### **Academic Support**

Dr. Rafael Samudio  
 Dr. Roberto Ibanez  
 Victor Frankel

#### **Representatives of the Donoso District**

Sr. Abel Bhu (Gobea)  
 Sr. Alfredo (Guaisimo)  
 Sr. Luis Banque (Lawyer for the District of Donoso)

#### **Ministry of Commerce and Industry**

Prof. Sebastián Sánchez

#### **General Information**

#### **Gobea**

Sr. Thomas Penuela Hernandez  
 Sra. Elsa de Bernal  
 Sra. Juana Miller  
 Sra. Rosita Miller

#### **Rio Indio**

Sr. Marin  
 Sr. Narciso Muños

#### **Salud**

Sr. Santiago  
 Sr. Lazaro

#### **Palmas Bella**

Sr. Marcos Lopez  
 Sra. Felicita Aguilar

#### **Piña**

Sr. Martin Leguias

#### **La Playita**

Sr. Alberto "Tito" Raúl Cochez  
 Sr. Justino "Justo" Machore

**Host Institution:**

Punta Galeta Marine Laboratory  
 Smithsonian Tropical Research Institute  
 Unit 0948  
 APO AA 34002  
 Email: [galeta@si.edu](mailto:galeta@si.edu)  
 Telephone: 507-212-8191  
 Fax: 507-212-8148

República de Panamá  
 Email: [heckados@si.edu](mailto:heckados@si.edu)  
 Telephone: 507-212-8068  
 Fax: 507-212-8146

**Researchers:**

Frances Grout-Brown  
 McGill University, BA in Management  
[frances.grout-brown@mail.mcgill.ca](mailto:frances.grout-brown@mail.mcgill.ca)

**Supervisor:**

Dr. Stanley Heckadon-Moreno  
 Smithsonian Tropical Research Institute  
 Box 0843-03092  
 Balboa, Ancón, Panamá

Hélène Descoteaux  
 McGill University, BA in Geography  
[helene.descoteaux@mail.mcgill.ca](mailto:helene.descoteaux@mail.mcgill.ca)

***Time allocation:***

Month	Days Spent in the Field (1 day = 8 hrs)	Days Spent on Internship (1 day = 8 hrs)
January		2
February	2	6
March		2
April	2	12

Total Number of Days Spent on Internship = **26**

***Information on Host Institution******Smithsonian Tropical Research Institute***

Our internship was hosted by the Smithsonian Tropical Research Institute (STRI), at the Punta Galeta Marine Laboratory, under the supervision of Dr. Stanley Heckadon-Moreno. STRI is a bureau of the Smithsonian Institution, an American institution dedicated to understanding biological diversity. STRI was created in 1923 and holds a historic position with respect to research in the tropics. The Institution has become one of the leading institutions worldwide for research in the tropics, due to the extent and quality of research conducted. Through the Institution's mission to increase and diffuse knowledge, and their commitment to long-term programs, STRI attracts fellows and researchers from all around the world ("Mission and Vision | About | Smithsonian", n.d.).

*Punta Galeta Marine Laboratory*

The STRI Punta Galeta station is located at Galeta Point in the Province of Colón. Galeta Point has a historic reputation in Panamá as the Americans used it as a key location to defend the Canal against German and Japanese forces. The area was even considered to be the “eyes and ears of the Pentagon (“Visit Us at Galeta - History”, n.d.). The Punta Galeta Laboratory was created in 1964, when Dr. Ira Rubinoff requested that the military property be handed

over to the Smithsonian Institution. The Laboratory was initially created for research purposes. However, in 2000, the focus was expanded to include educational programs for children, resulting in the creation of the “marine pilot education program”. The STRI Punta Galeta Laboratory continues to be heavily involved in community outreach and environmental education with programs such as teacher training on coastal ecosystems and monthly public outreach presentations on current research. The laboratory also supports interns and fellows from that come from across Panamá and abroad.

***Information on Supervisor***

*Dr. Stanley Heckadon Moreno*

Our supervisor, Dr. Stanley Heckadon-Moreno, is a world-renowned staff scientist at STRI and holds the position of Director for the Office of Communications and Public Programs. He is also the Coordinator of Marine Laboratories in Colón. Dr. Heckadon-Moreno has a long withstanding reputation in Panamá, as he has served as a university lecturer, public servant, environmental coordinator, and international consultant. He is heavily involved in community outreach and education, and has produced over one hundred and fifty publications. Dr. Heckadon-Moreno’s research interests include rural sociology, social forestry, environmental policy, environmental education and the history of natural history in developing countries (“Stanley Heckadon-Moreno”, n.d.).

**Executive Summary**

**English**

Climate Change is a problem occurring in all corners of the world. In coastal communities, the most pressing concerns are sea level rise and increased frequency and intensity of storm surges that are provoked by climate change processes. The instrumental record has worldwide data for the increasing rate of sea level rise over the last century. Modern research has measured rates of sea level rise on a worldwide basis, indicating that some areas are changing at a faster rate than others. However, in order to better understand and mitigate the effects of sea level rise, it is important to speak with the coastal communities that are affected by these changes, such as the communities along Costa Abajo in the Province of Colón. These communities have had a long history of interacting with the coast and the sea. Most are descendants of labourers from the Panama Canal and the Panama Railway who settled along the coast due to its pleasing aesthetics, the potential for agriculture and fishing, and the ease of access to the marine waterways for transport. Recently, there have been anecdotes of the sea taking away cemeteries, houses, and roads in the region of Costa Abajo; however this is only second hand information that has not been formally documented. Therefore, the main objective of this investigation is to conduct an oral history of the sea level rise in Costa Abajo; to see what changes have been observed over time, what evidence there is of these and perspectives on the impacts of local livelihoods. To get the most relevant information for an oral history, we conducted interviews with elders in Gobeá, Río Indio, Salud, Palmas Bellas, Piña, and La Playita who have lived there the entirety or the majority of their lives. The target age range for our interviewees was 60 years or older as they would have observed changes in the coastline over the longest amount of time. We also interviewed three representatives of the District of Donoso in order to obtain information on the areas further west of Gobeá that we were not able to visit. These interviews were guided by the purpose of our report, which is to see the historical changes in the coastline through the eyes of the “costeros”. We also conducted a literature review throughout the duration of our research to deepen our knowledge on the processes of climate change and coastline morphology, as well as the history of Costa Abajo.

The results of the investigation are representative of the qualitative information obtained from our conversations with community residents, and the interviews with the three representatives of the District of Donoso. We present the oral histories by briefly introducing each community, outlining observations of coastline changes, inundation events and the impacts of these, and finally, the local perceptions on the causes of these changes. There were many trends of similarities and differences observed with respect to the perception of causes on the sea level rise in each area, the adaptation strategies used, the frequency and intensity of inundations, and the knowledge of other communities’ issues. The most common perceived cause is sand extraction, while others include deforestation,

climate change, “nature”, and boats from the Canal. When comparing the qualitative information from the oral histories with quantitative data obtained in literature review, it is clear that these oral histories support the data researched.

We further examined the activity of sand extraction as it is a common activity discovered throughout the interview process. In order to better understand the industry as a whole and to locate concession maps, we interviewed Professor Sebastián Sánchez from the Ministry of Commerce and Industry. It was found that there is a concession granted in the area of Miguel de la Borda, which supports the representatives of Donoso’s preoccupation that underwater sand extraction is causing the sea to encroach on their communities. As well, the map of *solicitudes* portrays the potential growth in sand extraction along Costa Abajo in the future, signalling that there may be further impacts to come. In our analysis of the future, we describe how sea level rise is a process that occurs at a slow rate over a large period of time, therefore the occurrence may not be noticeable to all community members. This led into the examination of the contrast between reactive adaptation strategies or preventative adaptation strategies in the locations visited. We further emphasize the need for education to focus on the long-term outlook, the need for further analysis of sand extraction, and the need for documentation in each community to track the changes over time.

Resumen Ejecutivo

### ***Español***

El cambio climático es un problema que ocurre en todos los rincones del mundo. En las comunidades costeras, las preocupaciones más importantes son el aumento del nivel del mar y el aumento de la frecuencia e intensidad de las tormentas que están provocados por los procesos de cambio climático. El registro instrumental tiene datos de todo el mundo para la tasa de aumento del nivel del mar durante el siglo pasado. La investigación moderna ha medido las tasas de aumento del nivel del mar en todo el mundo, lo que indica que algunas áreas están cambiando a un ritmo más rápido que otros. Sin embargo, con el fin de entender y mitigar mejor los efectos del aumento del nivel del mar, es importante hablar con las comunidades costeras que se ven afectados por estos cambios, como las comunidades de Costa Abajo de la provincia de Colón. Estas comunidades han tenido una larga historia de interacción con la costa y el mar. La mayoría son descendientes de los trabajadores del Canal de Panamá y el ferrocarril de Panamá que se instalaron sus viviendas a lo largo de la costa debido a su estética agradable, el potencial de la agricultura, la pesca, y la facilidad de acceso a los cursos de agua marina para el transporte. Recientemente, ha oído anécdotas que el mar se llevó cementerios, casas y carreteras en la región de la Costa Abajo, sin embargo esto sólo es información de segunda mano. Por lo

tanto, el objetivo principal de esta investigación es de realizar una historia oral del avance del mar en Costa Abajo, para ver qué cambios se han observado en el tiempo, qué evidencia existe de estos cambios y perspectivas sobre el impacto sobre los medios de vida locales.

Para obtener la información más relevante para una historia oral, hicimos entrevistas con las personas mayores de Gobeá, Río Indio, Salud, Palmas Bellas, Piña y La Playita que han vivido en estos pueblos por la totalidad o la mayor parte de sus vidas. El rango de edad para nuestros entrevistados fue de 60 años o más, ya que se han observado cambios en la línea de costa sobre la cantidad más larga de tiempo. También entrevistamos a tres representantes del Distrito de Donoso, a fin de obtener información sobre las zonas más al oeste de Gobeá, que no pudimos visitar. Estas entrevistas de nuestro informe fueron guiadas con el propósito de: ver los cambios históricos en la costa a través de los ojos de los "Costeros". También llevamos a cabo una revisión de la literatura a lo largo de la duración de nuestra investigación para profundizar el conocimiento de los procesos de cambio climático y de la morfología de la costa, así como la historia de la Costa Abajo.

Los resultados de la investigación están representados por la información cualitativa obtenida de nuestras conversaciones con los residentes de la comunidad y las entrevistas con los tres representantes del Distrito de Donoso. Se presento las historias orales introduciendo brevemente a cada comunidad, destacando las observaciones de los cambios de la costa, eventos de inundación, impactos de estos, y por último, las percepciones locales sobre las causas de estos cambios. Habían muchas tendencias de similitudes y diferencias que fueron observadas con respecto a la percepción de las causas del avance del mar en cada área, las estrategias de adaptaciones utilizadas, la frecuencia e intensidad de las inundaciones y el conocimiento de las cuestiones de otras comunidades. La causa que más se percibe es la extracción de arena, mientras que otros incluyen la deforestación, el cambio climático, "naturaleza", y los barcos del Canal. Cuando comparamos la información cualitativa de las historias orales con los datos cuantitativos obtenidos en la revisión de la literatura, está claro que estas historias orales apoyan los datos investigados.

Además, se examinó la actividad de extracción de arena, ya que era una actividad común mencionada en todo el proceso de las entrevistas. Para entender mejor la industria y para localizar mapas de concesión, entrevistamos al profesor Sebastián Sánchez, del Ministerio de Comercio e

Industria, el cual nos mostró que existe una concesión otorgada en la zona de Miguel de la Borda. Este dato apoya a la preocupación de los representantes de Donoso que la extracción de arena submarina está causando el mar a avanzar sobre sus comunidades. Además, el mapa de solicitudes retrata el crecimiento potencial de la extracción de arena a lo largo de Costa Abajo, en el futuro, lo que indica que puede haber otras consecuencias por venir.

En nuestro análisis del futuro, describimos el avance del mar como un proceso que ocurre a una velocidad lenta durante un largo periodo de tiempo; por lo tanto, es posible que todos los miembros de la comunidad no lo noten a la ocurrencia de este fenómeno. Esto condujo en el examen de la diferencia entre las estrategias reactivas de adaptación o estrategias preventivas de adaptación en los lugares visitados. Destacamos además la necesidad de que la educación se centra en las perspectivas a largo plazo, la necesidad de un análisis más detallado de la extracción de arena, y la necesidad de documentación de los cambios en cada comunidad para realizar un seguimiento de los cambios en el tiempo.

### **Basis of Project**

In 1973, the Punta Galeta Laboratory, located on the Caribbean Coast of Panamá, began physically monitoring the Caribbean Sea. Over the years, the Laboratory has been collecting

instrumental data on sea level rise. According to our supervisor, Dr. Heckadon-Moreno, the measurements show that sea level has been increasing by small increments at this station. However, the station lacks staff to analyze this data. In addition, the Cristóbal hydrological station located at the Caribbean entrance of the Panamá Canal recorded an increase in relative sea level of 2.0mm/year (Guzmán, 2003).

Dr. Heckadon-Moreno's interest in sea level rise and climate change began in the 1980s through the research of John D. Cubit, a scientist conducting research on mangroves and coral reefs. While researching *El valor de los manglares y arrecifes en la costa de Colón* (Heckadon-Moreno & Espinosa González, 1985), Cubit noticed a rise in sea level in the Caribbean, a relatively new scientific theory for his time. When Cubit approached Dr. Heckadon-Moreno with these findings, he was hesitant to include them in his research because of the skepticism surrounding the theme of sea level rise. The theory of sea level rise had not yet been fully accepted by the scientific community, much like continental drift when it was first introduced. With some convincing, Cubit published his projections on sea-level rise in the book *Agonia de la Naturaleza* in 1985, which Dr. Heckadon-Moreno edited alongside Jaime Espinosa González. Through data obtained, Cubit illustrated four possible scenarios of increasing sea level over time due to climate change:

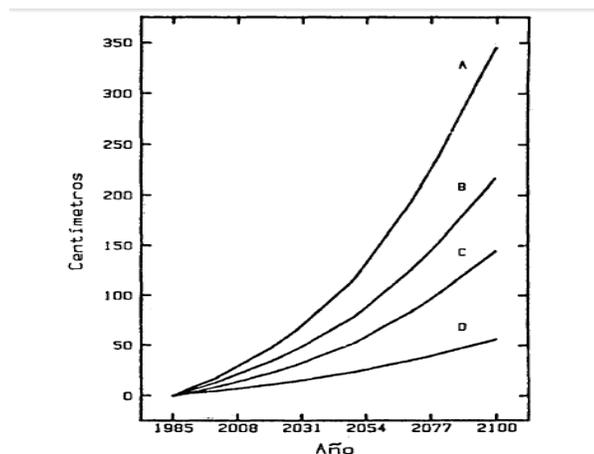


Figure 1: Projected sea level rise in four different scenarios. Heckadon-Moreno, Stanley (1985). *Agonia de la Naturaleza Ensayos sobre el costo ambiental del desarrollo Panameño*.

Presently, sea-level rise has been accepted in the scientific community as a theory that has impacted and will continue to impact coastal communities globally. In Panamá, the communities adjacent to Colón, Costa Abajo and Costa Arriba, have been voicing concern that “*la mar esta caminando*”, or the sea is advancing. Dr. Heckadon-Moreno had been hearing from local fisherman and

teachers in Costa Abajo and Costa Arriba that the sea has been encroaching on coastal villages. There were also anecdotes of cemeteries, schools, walkways, health centers and housing being damaged by inundations. However, these were all second hand accounts and have not been formally documented.

Therefore, the basis of this project is to gather first hand accounts from community members on any personal observations or other evidence surrounding the history of sea level rise. Due to time restrictions, the project was focused solely on Costa Abajo. We chose Costa Abajo because anecdotes of inundations and inherent topographical features indicated that the threat of sea level was more prominent in this region than in Costa Arriba.

### ***Question being addressed***

What changes in the coastline and sea level have been observed in the communities of Costa Abajo over time? What is the local perspective on both the causes and impacts of these changes?

Though climate change and resulting impacts on coastal communities has been extensively researched in past years, there is still a need to ensure that the regions most vulnerable are adequately prepared to mitigate these impacts. No two countries, regions, or communities are the same, and with a shifting development paradigm, it is crucial to notice that there is no “one size fits all” adaptation strategy for sea-level rise and coastal inundations. Each community will have it’s own perceptions, experience, challenges, and even opportunities when it comes to climate change. There may also be compounding factors present in one region that are not present in another. Landscapes can be deceiving, so it is important to speak with people that know their landscape best, the people that live there and have an associated history and identity, to find out the real story. An oral history is an illustrative situation analysis that encompasses not only specific events and processes that have occurred over time but as importantly, the local perceptions of their meaning.

### ***Area of Study***

Our area of study is located in the Costa Abajo region of the Province of Colón (Appendix - Figure 2). The coast bordering the Caribbean Sea in the Province of Colón is split between two regions: Costa Arriba, which is located east of the City of Colón, and Costa Abajo, which is located west of the city

of Colón. The coastal communities that were visited, from westernmost to easternmost, include Gobeá, Río Indio, Salud, Palmas Bellas, and Piña. Information on other communities of the Donoso District, namely Miguel de la Borda, was obtained solely through interviews. Lastly, the fishermen community of La Playita within the city of Colón was included in the investigation, even though it does not fall within the Costa Abajo region.

The following table represents preliminary information obtained on each community in Costa Abajo prior to visiting:

	<b>Gobeá</b>	<b>Río Indio</b>	<b>Salud</b>	<b>Palmas Bellas</b>	<b>Piña</b>
<b>Distance from Colón</b>	43.63km	36.74km	30.22km	24.77km	18.25km
<b>Population according to Census</b>	768 (2006 census)	1,012 (2006 census)	1,895 (2000 census)	1,690 (2000 census)	700 (2000 census)
<b>% dedicated to fishing (2000 census)</b>	unavailable	unavailable	1%	1%	1%
<b>% dedicated to agriculture (2000 census)</b>	unavailable	unavailable	45%	29%	33%
<b>% dedicated to mining (2000 census)</b>	unavailable	unavailable	0%	1%	9%

*Table 1: Background information on the communities of Costa Abajo.*

## Methodology & Limitations

Our methodology, in conducting an oral history was based on gathering information through interviews conducted along Costa Abajo, in the province of Colón. Due to time and resource restrictions, we visited all five communities on Tuesday, February 5<sup>th</sup>, 2013 beginning with the furthest from Colón

and travelling eastwards: Gobeá, Río Indio, Salud, Palmas Bellas, and Piña. Two employees accompanied us from the Smithsonian Tropical Research Institute Laboratory in Punta Galeta. The two employees were Señor Chambers, who grew up in the area and, as such, had preliminary contacts for some of the communities we visited, and Señor Alfredo Lanuza, who provided support in finding interviewees, facilitating introductions, and translating from Spanish to English (or from Spanish to Spanish that we could better understand). Being accompanied by two Panamanians from the area was extremely helpful given that our methodology meant approaching people at random in communities that we were not familiar with and with imperfect Spanish. The target interviewees were respected elders of the community, between the ages of 60 and 75 years old, as they would have the longest and most reliable perspective on changes over time.

Upon arrival at each location, Señor Chambers would approach elders that he knew of in the community and would commence introductions. Afterwards, the “snowball sampling” technique was used to recruit other interviewees. Where a direct contact wasn’t established before arrival, local residents were approached based on if they fit the age minimum of approximately 60 years. Afterwards, they were informed of our project and asked if they would like to participate. The target number of interviews for each town was between 2-3 elders. On this day, we interviewed a total of 10 people. Prior to each interview, it was ensured the interviewee understood our project and felt comfortable with the questions being asked. The interview questionnaire (Appendix- Figure 3) was developed through the use of the following main topics:

1. Personal accounts of changes in the coastline or sea level
2. Physical evidence or indicators of these changes
3. Impacts the community members have experienced or foreseeable impacts on future livelihoods

The interview methodology took on a conversational style rather than a survey style. It was believed this would be the most appropriate method to obtain an oral history by creating a more comfortable, less intimidating platform for discussion. As well, it allowed the elders to be able to speak freely about their stories and not be limited to certain questions.

Information gathered in the interview process was then used to complement the quantitative instrumental data obtained through literature review. This would allow for the addition of a social component to the quantitative measures, to give the numbers meaning and social context. As well, photos were taken during the interview process to use as evidence and indicators to support the oral

data obtained. Where available, photos from the past were obtained to gain an understanding of the changes over time.

On February 21st interviews were conducted at La Playita in the city of Colón. This would allow for a comparison between villages west of the city of Colón and a coastal community within the City itself. A STRI employee accompanied us from the Punta Galeta station, Señor Jorge Morales. Señor Morales has contacts in La Playita; therefore, he was able to set up interviews with two fishermen that have long been working there. The same questionnaire methodology used in the previous interview process was applied.

Interviews were also conducted with three representatives from the District of Donoso of the province of Colón: Señor Alfredo, representative of Guasimo, Señor Abel Bhu, representative of Gobeá, and Señor Luis Banque, lawyer representing District of Donoso. Señor Luis Banque, whom we met by chance at a conference in Colón, facilitated this interview. It took place at the Punta Galeta Station and was led by our supervisor, Dr. Stanley Heckadon-Moreno. Therefore, the questionnaire varied from the questionnaire used in Costa Abajo. However, the same conversational methodology was applied.

On April 1st, 2013 an interview was conducted with Professor Sebastián Sánchez at the Ministry of Commerce and Industry in Panamá City regarding sand extraction in Panamá. This interview was arranged in response to the concern that was frequently expressed over sand extraction during our conversations in Costa Abajo. This information was essential in gaining a better understanding of sand extraction. A questionnaire was prepared beforehand to guide the interview, however the same conversational style of interview methodology was applied. The information obtained was used to compare with the recollections of the interviewees in Costa Abajo regarding sand extraction sightings.

Literature review was ongoing throughout the project. Before fieldwork commenced we gathered information on climate change and sea level rise in coastal communities, as well as any history or additional information we could find about the communities being visited. As interviews revealed more layers to the problem of sea level rise and inundations than we had initially thought, we sought out more information on topics such as sand extraction, deforestation and adaptation strategies among others.

### ***McGill Code of Ethics***

Due to the nature of our research, being based primarily on interactions with communities, important ethical considerations were taken into account. All of our interviews complied with McGill University's *Code of Ethics*. Prior to each interview, our affiliation to McGill University and the Smithsonian Tropical Research Institution was declared, and the purpose and goal to us the interviews in a report that will be submitted to our university and be distributed to teachers of Costa Abajo communities for educational purposes was stated. As well, consent to use the interviewee's name and information was obtained.

### ***Limitations***

There were certain limitations that arose throughout the project. One significant limitation encountered was the difficulty in conducting the amount of interviews we deemed adequate to compile an oral history. We were limited in time by our four month internship period, as well as the availability of staff at the Punta Galeta Station. Therefore, because the staff was occupied preparing for the upcoming school semester during our field research week at Galeta Station, we only had the opportunity to spend one day visiting five communities in Costa Abajo. Furthermore, we were not able to visit Miguel de la Borda, a key location experiencing impacts from sea-level rise. This community is only accessible by boat and, as such, there is a high potential of becoming stranded, particularly during the rough weather conditions occurring over our internship period. The sea conditions also prevented a representative from Coclé del Norte in attending our meeting with other representatives from the Donoso District that, besides inhibiting us from interviewing this individual, reaffirmed the safety issue of traveling further west than Gobeá.

It was also difficult obtaining detailed information during the interview process, primarily due to the time limitation described above. We conducted a total of ten interviews in one day, and at times were not able to spend more time in the towns closest to Colón as we had to make it back in time to Colón for the departure of the staff bus. Although we received enough information to analyze for the purposes of the report, it would have been beneficial to spend more time with each interviewee.

A third limitation involved the inability to organize a community meeting with communities visited and staff at the Galeta Station to show the results of our investigation. Unfortunately, the timing of the completion of the investigation fell during the teacher training program at Galeta. We will be

bring a copy of our report to be made available at the library in the Punta Galeta Station, as well as in each of the communities visited.

As well, the observations collected were limited to the knowledge of the interviewee. Each interviewee observes and sees things differently. One may be more observant to changes over time, whereas others may pay less attention to details as such. However, this limitation is not necessarily negative and does reinforce the purpose of our project, to investigate the perceptions of the locals of Costa Abajo on sea-level rise in the area over time.

Lastly, our investigation lacked quantitative data at each site visited. As mentioned, the purpose of our investigation was to conduct an oral history, however, it would have been useful to support these oral accounts with instrumental measurements. In each case, no quantitative measures were taken by community members to track the changes in the shoreline; rather, they relied on memory, observations, and estimations based on natural markers. The quantitative data used in the investigation that relates most to the area studied is located in Costa Arriba of the province of Colón at the Cristóbal Hydrological Station. Even though the information is not measured specifically in the area of Costa Abajo, this was the only quantitative measure available of sea-level rise along the Caribbean coast in Panamá, so may be the most appropriate approximation of sea-level rise in Costa Abajo.

## Context and Background Information

### *Climate Change: Global*

The impacts of climate change are a result of an overall average global warming and are attributed to increased concentrations of 'greenhouse gases' in the atmosphere. These gases are naturally occurring in the atmosphere and are necessary to keep the planet warm enough to sustain life. They do this by reflecting and retaining some of the sun's rays, much like a greenhouse. These gases are usually kept in equilibrium through natural processes, however, over the past decades the levels of gases, such as carbon dioxide, methane and nitrous oxide, have significantly increased (IPCC, 2007; David Suzuki Foundation, n.d.).

Human activities are responsible for much of this imbalance, and have increased the amount of gases in the atmosphere by 32% since the industrial revolution. These activities include burning fossil fuels (coal, oil and gas) for transportation and industry, deforestation, cattle farming, rice farming and using chemical fertilizers (David Suzuki Foundation, n.d.).

Coastal communities are particularly vulnerable to the impacts of *sea level rise, extreme weather events, alterations in the precipitation and runoff regime, and changes of the shoreline* that result from climate change (Nicholls et al., 2007).

### *Sea Level Rise*

Sea level has been rising as the result of two main processes related to climate change. Firstly, a warmer atmosphere melts land ice in the polar regions and contributes to the overall volume of water in the ocean. Second, the warming of sea surface temperatures leads to thermal expansion of ocean water so that the same amount of water takes up more space. These driving factors each account for approximately half the observed rise in sea level (Meehl et al., 2007).

Although sea level rise is not a novel phenomenon (the sea rose approximately 120 m over several millennia following the last ice age), the period of 0-1900 AD was a period of little change. During the 20th century, however, global sea level began to rise at an estimated rate of 1.7 mm/year (Bindoff et al., 2007). The average rate of sea level rise in the 21st century is expected to exceed this, with one estimate projecting an average increase of 3.8 mm/yr between 2090-2099 (Bindoff et al., 2007). Both satellite imagery and tide gauges have already observed a recent increase in sea level rise rates, measuring a global average of 3 mm/year since 1993 (Bindoff et al., 2007). Nonetheless, global average projections do not necessarily reflect local realities. This is because, regional variability leads to non uniform sea level rise, with sea levels rising at several times this rate in some regions, and even falling in others (Meehl et al., 2007; Bindoff et al., 2007; Appendix- Figure 4).

The following figure illustrates the drastic changes in sea level rise rates over time, and the projections for the future:

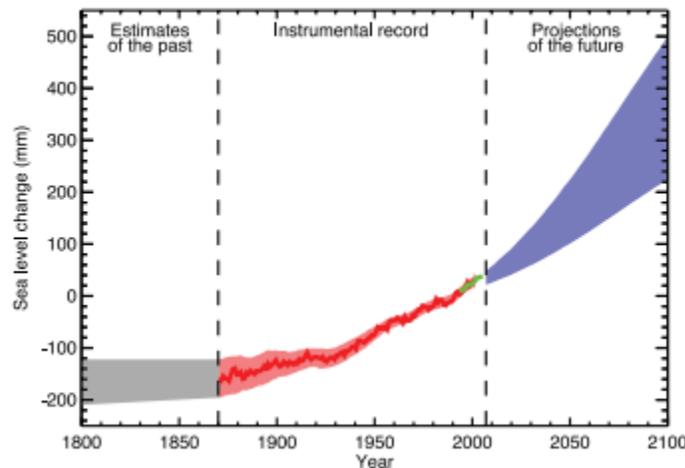


Figure 5: Global Climate Projections. Retrieved from “Global Climate Projections” In: *Climate Change 2007: The Physical Science Basis*, by Meehl et al., 2007, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

#### *Extreme Weather Events- Extreme Waves and Storm Surges*

Also linked to climate change is an increase in both the frequency and severity of extreme weather events. This is related to climate change because a warming atmosphere, and sea surface, has more stored energy. Although some scientists still challenge this claim of causation, since the 1970’s an increase in tropical sea surface temperatures can be correlated with longer duration and intensity of storms (Dasgupta et al., 2009; Nicholls et al., 2007). The most devastating impacts on coastal communities are more likely to be caused by these storm events than by a gradual increase in mean sea level (Nicholls et al., 2007). However, increase in sea level is still important because this slow encroachment of the sea inland will increase the reach of extreme sea levels during passing storms. This could mean damage to infrastructure that was previously protected by further distance from the sea. With respect to Panamá, the estimated increase in storm surge attributable to sea-level rise is approximately 21% (Appendix -Figure 6).

#### *Alterations in the precipitation and runoff regime*

Changes in runoff driven by changes to the hydrological cycle appear likely, but the uncertainties are large. These terrestrial sourced hazards include disruption in the downstream flow of water, sediment and nutrients, from catchment areas that drain to the coast (Nicholls et al., 2007).

### *Changes of the shoreline*

According to Hoffman (1983), there are three major physical effects of sea-level rise : shoreline retreat, increased flooding, and landward movement of saltwater. For the purpose of this report, we will focus on the impacts of sea-level rise on shorelines and increased flooding, as this relates to the geography of the areas studied. There is a balance created between sediments eroded by storms and sediments deposited back on beach during calm periods that allows a shoreline to be maintained under normal conditions (Hoffman, 1983). However, with an increase in the level of sea, the beach is further eroded inland upon storm occurrence. This erosion makes it more difficult for calmer waves to redeposit sand back on the beach, ultimately causing a shoreline retreat. This process is further detailed in the following image:

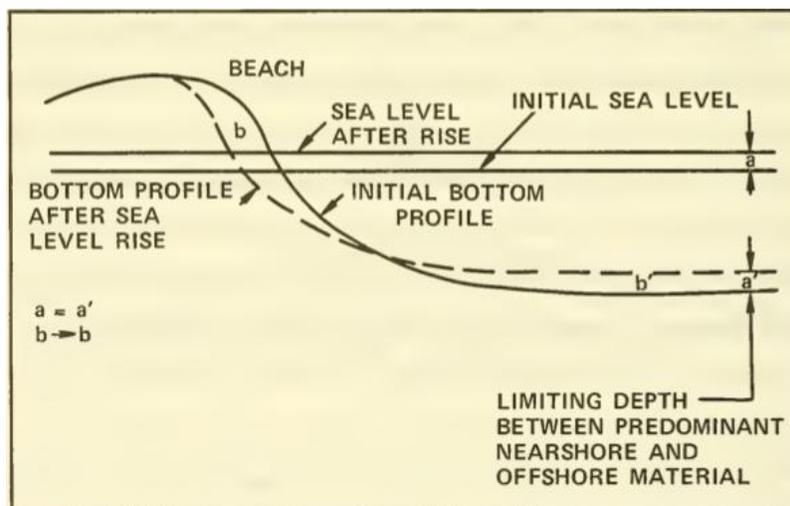


Figure 7: Process of Beach Erosion. Retrieved from "Projecting Future sea level rise: methodology, estimates to the year 2100, and research needs," by J.S. Hoffman, D.L. Keyes & J.G. Titus, 1983, Vol.9, No. 7, US Environmental Protection Agency.

### ***Climate Change: Latin America & the Caribbean***

Regional differences from the geological uplift or subsidence of continental plates will impact the *relative sea level* seen at the local level. Relative sea level rise differs from sea level rise because it accounts for an increase or decrease in water level as well as the upward or downward movement of continental plates. For example, an increase and expansion of ocean water in a particular region would be compounded if there were also subsidence of the continental plate in this same region. The lowering

of the continent along with the rising of sea level would make it seem like the sea rose even higher *relative* to the continent. Furthermore, coasts subsiding due to natural or human-induced causes will experience larger relative rises in sea level (Bird 2000). Moreover, future wave climate is uncertain, although extreme wave heights will likely increase with more intense storms. These weather events will also have substantial regional differentiation.

According to a report from the United Nations Development Program Barbados in partnership with CARIBSAVE, the rate of sea-level rise in the Caribbean had reached  $3.4 \pm 0.7$  mm/year in 2010 (Simpson, 2010). Records from an instrument located at Cristóbal, Panamá on the Caribbean coast, has measured a mean sea level trend of approximately  $1.41 \pm 0.22$  mm/year based on monthly mean sea-level from 1909-1980 (“Sea Level Trends”, n.d). The dramatic acceleration of increasing sea level rise can be attributed to the effects of global warming in the Caribbean; warming that is projected to increase by a median of 3.2 degrees Celsius more before the end of the 21st century (Simpson, 2010; Meehl et al., 2007).

### ***Human Influence on Coastlines***

According to the International Panel on Climate Change (IPCC) “the direct impacts of human activities on the coastal zone have been more significant over the past century than impacts that can be directly attributed to observed climate change” (Nicholls et al., 2007). Thus, it is important to recognize the influence that human utilization of the coastlines can have on exacerbating the impacts of sea level rise through practices such as deforestation, sand mining and harvesting of living resources, such as coral reefs.

### ***Deforestation***

Main causes for deforestation in Latin America include clearing for agriculture and livestock, selective logging, and large-scale projects such as hydroelectric dams among others (Magrin et al., 2007). Deforestation can impact coastal zones when changes in the watershed catchment influence water, sediment and nutrient flows towards the coast. Moreover, deforestation along the coastline itself, particularly of wetland ecosystems such as mangroves, removes a natural barrier that may help buffer the extent of damage caused by storm surges and flooding (Nicholls et al., 2007).

### ***Sand Mining***

Sand acts as a natural cushion against strong tidal waves, providing natural protection against storm surges for coastal communities. However, sand had become a highly demanded material in construction due to its ease of extraction, low cost and range of useful properties. With regards to Panamá, the country is undergoing major construction projects: the Panamá Canal Expansion and the subway system in Panamá City. Sand is a particularly important ingredient in water resistant construction material being used in the expansion of the Panamá Canal (S. Sánchez, personal communication, April 1st, 2013). However, humans also value sand for making concrete, roads, bricks and sandpaper and is thus a common and highly demanded material used in construction (“Case 6”, n.d.). This provisioning service of sand may be perceived as more valuable than the protective service of non-extracted sand because it can more easily be assigned a monetary value. Professor Sánchez approximates the current price of sand in Panamá to be at \$40 per meter cube (personal communication, April 1st, 2013). It is difficult to quantify whether the short term economic gains accrued from sand extraction will outweigh the potential social and infrastructural costs of coastal communities that have been made more vulnerable through the loss of natural protective barriers.

Although sand provides valuable economic use, the extraction of such can cause beach erosion as the beach morphology changes. This causes the waves to break closer to shore, which ultimately results in the coastal community becoming increasingly vulnerable to wave attacks. With the projected increase in storm surges attributable to climate change, this has become an increasingly important issue for coastal communities. Another impact includes the penetration of the sea further inland (O’Brien-Delpesh, n.d.).

As per a discussion with Professor Sebastián Sánchez, there are two forms of sand extraction used in the coastal regions of Panamá: the traditional method the industrial method (personal communication, April 1st, 2013). The traditional method involves “*paleros*”, who manually shovel sand from the beach into large trucks for use within the community. This method removes a minuscule amount of sand relative to the mechanized industrial method. The industrial method involves dredging sand from the ocean floor just off the coastline and using large boats to then transport the material for commercial sale to construction companies. Industrial sand extraction has the greatest impact, and it is very difficult to monitor because the extraction is occurring underwater. The Government of Panamá profits from, and attempts to regulate, sand mining through granting concessions to sand extraction companies. These contracts stipulate the area of the concession and the amount of sand per day that is

permissible for extraction. The size of the boat and the distance from the port are factors that affect the amount of sand a company will solicit for extraction. Logically, larger boats will be able to extract more sand because they are able to transport more. The further the mining concession is from the port, the more a company will require to extract in order to make it worth the travel time and expenses. Also, in order to be granted a concession, the Panamanian governmental authority of the environment, ANAM, must perform an Environmental Impact Assessment. Companies create *solicitudes* to request to be granted access by the Government to the concessions.

### *Coral Mining*

Another way that humans are altering coastal zones is through mining of coral reefs. Coral mining has been traditionally used in Panamá to source construction materials and to landfill artificial islands or add area to already existing island (Guzmán, 2013). The destruction of coral ecosystems through mining removes the natural protection they provide by calming waves before they reach the shoreline (Nicholls et al., 2007). This is particularly problematic when the impacts of climate change are also brought into consideration. Firstly, climate change can exacerbate a perceived need to mine coral as a short term strategy to build up areas that are becoming submerged by higher sea levels (Guzmán, 2013). Furthermore, coral reefs are extremely sensitive to fluctuations in both sea depth and temperature, two factors that are being influenced by increases in sea-level and a projected increase of 1 to 3 degrees Celsius of sea surface temperatures. Though these changes may seem insignificantly incremental, it will mean increased coral bleaching and mortality (Nicholls et al., 2007). Thus, the dual impact of human induced climate change, and local coral mining activities act in conjunction to threaten the vitality of these natural barriers.

### ***Brief History of Costa Abajo***

The Costa Abajo region is inhabited with *Playeros*, “descendants of African-slaves brought to the Americas, and became acculturated by encounters with other ethnic groups during European colonialism” (Adames, 1981).

. These *Playeros* are descendents of labourers from two important historical endeavours in the history of Panamá: Panamá Railway (1904 -1914), and the Panamá Canal (1850-1855). The companies involved in the construction of the Canal and the Railway contracted labourers from China, India, Europe, the U.S and French Antilles, and Colombia. Once these infrastructures were completed, the labourers moved to the Lower Coast, attracted by the greater access for marine transportation provided

by the geography of the region. This positioning allowed them to be involved in the import/export trade. The *Playeros* grew to control marine transportation in the region and often times the general merchandisers relied on them for this role. Therefore, they became the primary transporter of products to the urban transisthmian center (Adames, 1981).

Currently, the main economic activities differ from the past along Costa Abajo. In the areas further west of the city of Colón, the main livelihood activities are comprised of fishing, with some agriculture. In the areas closer to the city of Colón, the main livelihood activity is commuting to the city of Colón to work in construction or *Zona Libre*.

## Results

**Gobea**

The community of Gobea has a historical relationship with the surrounding waterways that began with the arrival of the seven founders by river. Señora Juana Miller is known as the woman to speak to about the history of her community. She was born and raised in Gobea, and later lived in the city of Colón to become educated and work. She later returned to Gobea after twenty years of living in the city of Colón. With a warm smile and enthusiasm, she invited us to join her on her porch as she recounted the recent history of this community. The original settlers were African slaves that were brought over to work on the Canal. Also referred to as *chombos*, they escaped the bad treatment of their slave masters and took a *lancha* to travel down the Río Sambo. They were seven and four of their names were Jancin, Bosta, Darkin and Miller. Señor Miller is an ancestor of Señora Juana Miller herself. Where the mouth of the river spills into the Caribbean Sea, they encountered indigenous peoples, also referred to as *morenas*, and there they rested their paddles. The African men found the Indian women irresistibly beautiful and fell in love with them. Everyone that lives in the town today is a descendant of one of these seven escaped slaves. Moreover, many people come from mixed African and indigenous lineage, including Señora Miller whose mother is of African descent and father is indigenous.

In regards to livelihoods, Gobeans were fishermen and agriculturalists. They would grow *café* and *arroz*. Fish, pork, goat and *verduras* were eaten, among other foods. The majority of the community today still dedicate themselves to these subsistence activities. Some agricultural activities contributed to proliferation of insects and the associated diseases of malaria and leishmaniasis. There was also a time when leprosy threatened the health of community members.

Cultural diversion for the community included dancing the *congo* and *cumbia*. Before the arrival of technology, conch shells were used for communication. It was only ten years ago that Gobea began receiving electricity and light. Seven years ago the *carretera*, which connects Colón to the villages of Costa Abajo, arrived in Gobea. Before, people would travel in boat by means of the ocean or by horse on the mainland to get to neighbouring areas or the city to trade.

The river and the Caribbean Sea act as natural borders encompassing the homes of the Gobeans population. The geography of the landscape offers livelihood opportunities and a sought after coastal lifestyle for many people in Gobea. However, being surrounded by water on both sides also makes the community particularly susceptible to changes in the water regime, extreme weather events and sea level rise.

Several long term residents of Gobea indicate that they have noticed changes in the coastline over the years. Moreover, there has been an increased frequency and extremity of inundation events,

with the most recent and severe occurring in November of 2012. Residents estimate that around 10 or more homes were affected by this inundation, which came both from the sea and the river. Where some homes experienced severe flood damage, others were completely destroyed and rendered uninhabitable.

Señor Thomas Penuela Hernandez was born in Buena Vista but has resided on the beach of Gobeá for the past twenty years. As such, he has observed, over time, the increasing level of the sea at high tide near his home. Further west on the coastline there are several homes that were destroyed in November and are now abandoned (Appendix - Figure 8). Most families that were forced to relocate still reside in Gobeá, and one family now lives directly behind the skeleton of their former home. There is a white and blue two-story home that is the westernmost along the coastline in Gobeá. It was able to withstand completely succumbing to the sea but the owners have now built a fence and stacked white sand bags two rows high as a precaution against future inundations (Appendix - Figure 9). Other changes that have occurred on the coastline in reaction to the inundation have been the replacement of large coconut palms by young palms. Señora Elsa de Bernal explained that after November people were concerned about the larger palms being uprooted by the sea and falling on homes. The removal of these palms may protect future damage of homes, but deforestation of a natural buffer along the shore could also prove to be equally damaging. Señora de Bernal reiterates that it has been a while that the sea level has been advancing, however, was not able to specify a time frame.

Continuing along the beach eventually leads to the mouth of the Río Sambo where children play on the river side. This is the river that led the founders of Gobeá to the coast, and many families have settled their homes on its banks. The inundation of November 2012 increased the height of the river to an unprecedented level for Gobeá residents. While the river did not flood over the banks, the force of the water caused the banks to severely erode and threaten the foundations of the homes. All the erosion that can be seen (Appendix - Figure 10) was caused by this single inundation event. Señor Hernandez's niece and Señor Eduardo Darkin are among those living on the riverside that have experienced damage to their homes. Though the river has been less of a threat than the sea so far, people are concerned about the future of their homes, as the November event has exacerbated the slow widening of the river that has been observed over the years (Appendix - Figure 11).

The community of Gobeia has varied perceptions on the causes behind these changes in sea level and extreme inundations. Some do not seek an explanation for these phenomena, such as Señora Elsa de Bernal who expressed her perspective,

*“es la naturaleza...no se porque, es así”.*

Others, namely Señor Eduardo Darkin, attribute the threat of a rising sea and widening river to global climate change. Coincidentally, Señor Darkin is a former colleague of John Cubit, whose mangrove research inadvertently revealed evidence of Caribbean sea level rise in the 1980s. At the local level, increased sand mining has been correlated with the waves arriving at the town more quickly and with more force. According to Rosita Miller, sand mining boats have been sighted off the coast, directly in front of the community, and may stay for a month at a time mining sand from the ocean floor.

Though concern for the sea and riverside homes in Gobeia was expressed by many, overall there was no indication that sea level rise or inundations were impacting the livelihoods of locals in this community. Some did believe that sand extraction was negatively impacting fishing in the region.

### **Río Indio**

Río Indio, located east of Gobeia, is a community that was founded 23 years ago and whose residents dedicate themselves to fishing and some agriculture. There have been damaging inundation events in this region and noticeable increase in sea level over the past two years. However, contrary to the situation further west, Señor Marín explains that,

*“el río es más peligroso que el mar”.*

There have been approximately four inundation events in recent years, with the most recent being in November of 2012. Evidence of destruction from the river can be seen in the remains of the former bridge, which stands beside the replacement bridge that was built four years ago (Appendix - Figure 12).

Señor Narciso Muños and his family moved to his home on the beach fifty years ago. He began noticing the coastline encroaching upon his home around twenty years ago. It was fifteen years ago that he decided to move across to the other side of the *carretera* because the sea would enter his home very easily (Appendix - Figure 13) However, despite moving several meters further back from the coastline and across the paved road, Señor Muños' and his family have experienced sea inundation

twice more in recent years, in 2006 and November 2012. The water travelled up the width of the beach, across the road, and into his house up to around 3-4 feet (Appendix - Figure 14). Not only did this inundation create water damage in the home, but contributed to soil erosion at the sides of the road. Señor Muños now believes he will have to move his family again.

Though people in the community are aware of the threat from the river and the sea, they do not believe their livelihoods have been impacted and they choose to remain there because they desire a coastal lifestyle. Moreover, many years may pass where there are periods of calm. Nonetheless, there have been some local adaptation strategies implemented, such as avoiding cutting down any palm trees near the coastline and placing barrels to buffer the impacts of inundations. Not all areas of the community have these natural or human barriers, however, and some are waiting on government intervention to help them with the financial capital necessary to build a protective wall. While some perceptions of these events were that they were just “parte de la naturaleza”, others believe sea level rise and the increasing extremity of inundations was related to sand mining off the coast and the deforestation of coconut palms along the shore. Both traditional and commercialized sand mining has been observed and the once abundant presence of coconut palms has been completely diminished over the last 30-40 years.

### **Salud**

Salud is a community in Costa Abajo that rests along the coast between an *ensenada* and a river. In this region, people are involved in fishing, some agriculture (there used to be more) and many people commute to Colón to work in construction or in *Zona Libre*. There has been noticeable sea encroachment over the years estimated at around fifteen meters. From the perspective of Señor Lazaro,

*“poco a poco la mar esta caminando”.*

While inundations here appear to be much less severe than in communities further west, there is at least one home known of that was taken by the sea. The river here is calm and houses are even being constructed riverside, indicating that there is no concern of inundations or widening of the banks in the future.

To buffer from potential impacts of inundation, locals in Salud do not cut the grass near the river so that it may act as a natural barrier. Señor Lazaro indicates that Salud does not have problems in relation to sea-level rise, but knows that neighbouring communities have been experiencing them. The reasons that Salud is less vulnerable to sea inundations, Señor Lazaro reflects, may be due to the lack of deforestation, higher topography than areas such as Miguel de la Borda, and the natural calming of the ocean provided by the *ensenada*. Furthermore, Señor Lazaro confirmed that there was no sand extraction off the coast of Salud as it is not allowed.

### ***Palmas Bellas***

Palmas Bellas, founded as Lagarto after el Río Lagarto, was renamed in 1945 after a visitor that came to Panamá to participate in building the Canal and found the palm trees very beautiful. Many people commute to Colón for work in the port, the Canal, and *Zona Libre*. Others are agriculturalists, fishermen or work in the informal sector. In Palmas Bellas, sea level rise is a serious problem. The sea has advanced to the extent that a total of twenty seven or twenty eight houses, two complete rows of houses, have disappeared. Señora Felicita Aguilar used to live on the shore with her family (Appendix - Figure 15) but had to move her home 10 years ago further from the coastline towards the *carretera* once the sea level became too high. Most people from these homes were able to relocate elsewhere in Palmas Bellas. According to Señora Aguilar, people began noticing that the sea was threatening their homes in 2001 and by 2003 everyone had to move further inland. Señor Marcos Lopez, a long term resident of Palmas Bellas, began noticing the encroachment of the sea around 1992-3. Señor Lopez expresses that,

*“en todos los pueblos hay problemas”*

Furthermore, in his opinion, deforestation and climate change are causing the problems of sea level rise from Piña to Miguel de la Borda. Sand mining was also indicated to be a causal factor. Señora Aguilar has been noticing people taking sand out of ships off the coast of her former home since August 1999.

After President Ricardo Martinelli was elected, talks began about constructing a wall along the coastline to protect against sea inundations. A wall was built in 2008 and is situated behind the shore where the two rows of homes once were (Figure 16b). Comparing a photo taken in 1951 (Figure 16a) during the research of ornithologist, Dr. Andrew Whitaker, the difference in the coastline is incredible:



Figure 16a: Source: Alexander Wetmore Papers.  
Photographic Material, Fieldwork and Travel.1951 Panama.SIA



Figure 16b: Photo taken in Palmas Bellas. Señor Marcos Lopez showing us the government constructed wall that was built to protect from further inundations.

The construction of this wall was a result of the community putting a lot of pressure on the government, namely through protests, or *huelgas*. So far, the wall has been successful in protecting from inundation. According to Señor Lopez, they are still vulnerable to inundations in some areas because the seawall does not extend across the entirety of coastline in Palmas Bellas. Particularly, the *carretera* that enters Palmas Bellas used to have the natural protection of palm trees that have been deforested, and is now threateningly close to the encroaching sea.

### **Piña**

Piña is the closest community we visited, situated west of the city of Colón in Costa Abajo. As such, many people here are employed in Colón, but are also involved in fishing and agriculture. In the past, there were many problems here with both sea level rise and inundations. Señor Leguías has lived here all his life and had his home taken by the sea. According to him,

*“ahora mismo hay un tranquilidad gracias al muro que estaba construido por el gobierno en el año pasado”*

Approximately six years ago, the sea was much further back. The sea used to be 40-60 meters from the coastline and now is much less (Appendix - Figure 17). Señor Leguías describes that the sea

used to be even further back than *la puntita*, exemplifying an indicator of change. The construction of the wall came about when local residents pressured the government and protested. The reasons perceived for the encroachment of the sea include sand mining, that has been observed for more than 10 years off the coast of Piña, and impacts to the topography of the seabed caused by passing of *barcos* in and out of the canal.

### ***District of Donoso***

Interviews with political representatives from communities within the District of Donoso were conducted at the Punta Galeta Station (Appendix - Figure 2). These shed further light on the history of sea level rise and inundations in Gobeá, which we had previously visited, and Miguel de la Borda and Coclé del Norte, which we had not visited due to safety limitations. In attendance was Señor Alfredo, representative of El Guasimo, the Honorable Señor Abel Bhu, representative of Gobeá, and Señor Luis Banque, a lawyer representing the District of Donoso.

The Honorable Señor Abel Bhu describes Gobeá as a community of subsistence fishermen and agriculturalists. Much of the agriculture consists of *coco* that is sold directly or indirectly to Colón. There are approximately twenty to thirty homes, all made of cement. According to our previous interviews in the community, this means that one third to one half of the homes were impacted by the inundation in November 2012. Señor Abel Bhu depicts the situation of the inundations that occurred last year:

*“En este año que pasó, [el mar] subió mucho en el parte que la carretera en el entre de Gobeá se la llevo el mar y casi golpeó varias casas aquí”*

This storm surge also collapsed many palm trees, which are very difficult to topple, emphasizing Señora Elsa de Bernal’s concern that fallen palms would damage the beach side homes in Gobeá. In the past, when people would travel by horseback along the beach for lack of a road, Señor Abel Bhu recalls being surrounded by beautiful palm trees. Today, the palm trees have completely disappeared, and there is barely a beach left. According to Señor Abel Bhu, the seasonally strong winds in November and December contribute to the flooding that occurs in Palmas Bellas, Río Indio, Gobeá, Miguel de la Borda, Coclé del Norte, and Belén. In Belén, the sea has already taken around twenty to thirty homes, and people are worried about losing more homes or even the school. In Miguel de la Borda, the sea has reached the Catholic church and has already taken three or four houses. In Coclé del Norte, the

situation is similar, and there has been talk of moving the community further inland to more secure areas. Señor Abel Bhu approximates that in each community along Costa Abajo the sea has advanced approximately 50 meters, and specifies an advancement of approximately 20 meters at La Palmera.

People have been noticing sea level rise in Gobeá for approximately ten years. Señor Abel Bhu correlates this with the time that a sand extraction concession was granted in the area. While acknowledging that climate change must also be implicated, for him, sand extraction is the most pertinent cause of sea level rise and inundations that are being experienced along Costa Abajo. On the one hand, Señor Abel Bhu expresses that people want an analysis of the situation. On the other hand, he admits that many people do not see what is going on and do not pay attention because they are conformists. There is an urgent need for analysis of the situation and education of local residents so they can act to ensure the vitality of the community in coming generations.

### ***La Playita***

La Playita is a small fishing community within the city of Colón. Currently, there are six boats that go out to fish from here, a significant decrease from past years. Since Señor Tito and Señor Justo have been fishing there since 1955 and 1980 respectively, they have noticed a decline in fish populations and decline in the size of individual fish. Because of this, and opportunities presented for them to purchase new housing developments between calle seis and calle nueve, many fishermen moved away from La Playita in the year 2000. Although there are still sufficient numbers of fish for the lesser number of fishermen to sustain themselves, Señor Justo describes,

*“No hay en abundancia como antes. Antes había peces en abundancia. Pero ahora, ha disminuido la cantidad. No se porque, si están por otro lado, pero parece que ya no hay como antes”*

He does theorize that sediment from excavation of the canal kills fish, and forces them to move away.

To add to their problems with fish population decline, the fishermen at La Playita have been observing encroachment of the sea on their homes. Señor Tito, while looking out to the sea, indicates,

*“la tierra estaba más allá...como unos cincuenta metros”*

He further explains that there used to be a *muellecito*, or dock, that is no longer there because in the 1960's,

*“el mar se puso malo de lo tumbo”.*

Furthermore, there were homes before where the boats now rest on the beach (Appendix - Figure 18) that were taken by the sea.

In terms of inundations Señor Justo has not observed an increase in frequency or extremity of these:

*“No visto nada de esto phenomenon aquí ahora mismo. La fuerza de las olas son menores. Antes eran más fuerte. Enero, febrero, marzo, en un tiempo...ningun pescadores podía pescar, hasta que no pasar este tiempo”*

Though this has been the trend, there was an incident that occurred three weeks prior to our interview when Señor Justo was fishing further west along the coast and was encountered by the tallest wave, three or four meters high, that he had ever seen.

## Analysis of Results

Change in coastline along Costa Abajo was not an isolated event. There was a clear pattern of destruction to infrastructure along the coast, as this event occurred in each area that we investigated. The extent of the damage and the timing were the differing factors. Furthest west, the damage seemed more linked to the inundations that had happened in recent years. Closer to the city of Colon, the damage appeared to be more linked to sea encroachment as the changes in coastline were more drastic and happened 10 years ago. For example, in Gobeia only 10 houses were supposedly taken by November 2012 inundation in comparison to Palmas Bellas, where supposedly 28 families were moved out of their houses in 2003.

As well, there was a recurrence of certain themes became apparent throughout the interview process. There were trends, similarities, and differences observed with respect to the perceptions of causation of sea-level rise, the frequency and intensity of inundations, and the adaptation strategies used. These themes are further explored below:

### ***Perceptions of causation***

When asked about the cause of sea-level rise after establishing it has been an issue in the *community*, the response varied from interviewee to interviewee. The different responses include deforestation of palms (natural barrier to the sea), boats from the canal, and nature. The two main responses include sand mining and climate change, which are further analyzed below:

#### *Sand Mining*

The most common response was sand mining, as it was mentioned in relation to six out of the seven areas, where the one town not included, Salud, did not perceive a large problem in relation to sea-level rise and said that sand extraction was not allowed. Most interviewees also appeared to speak quite passionately about the subject, apparent through the frustration and anger in their voice. The following maps depict the areas where there are underwater sand extraction concessions (Figure 19) or *solicitudes* granted along Costa Abajo.



Figure 19: Map of Concessions granted in Costa Abajo of Colón. Retrieved from “Solicitudes y Concesiones Mineras (Marzo 2013)” from the Ministerio de Comercio y Industrias website: [www.mici.gob.pa/detalle.php?cid=16&sid=53&id=1412](http://www.mici.gob.pa/detalle.php?cid=16&sid=53&id=1412)

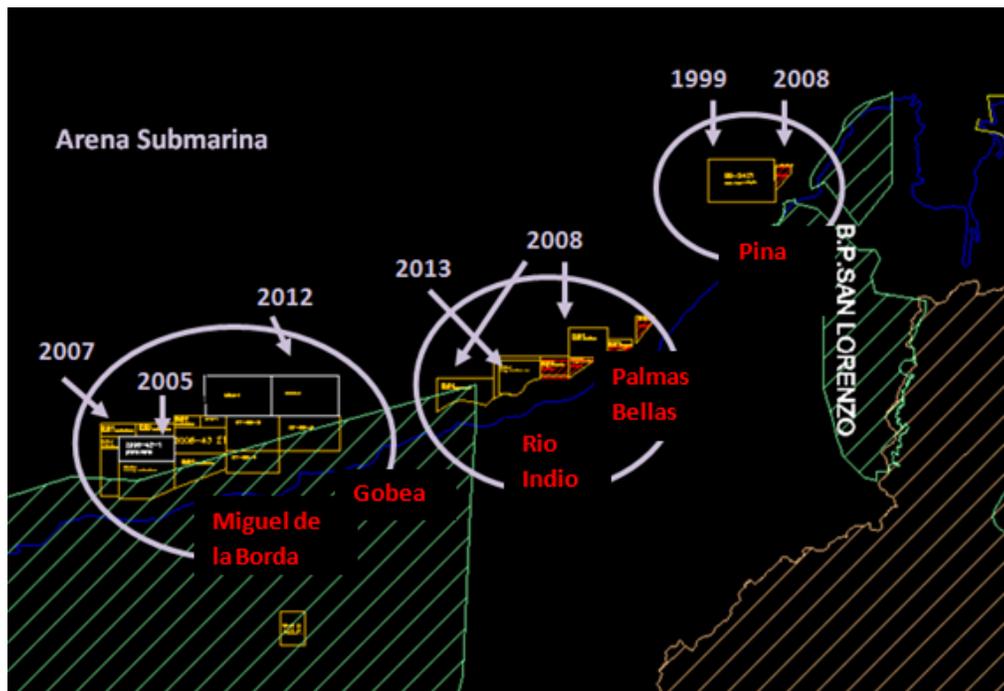


Figure 20: Map of Solicitudes in Costa Abajo of Colón. Retrieved from “Solicitudes y Concesiones Mineras (Marzo 2013)” from the Ministerio de Comercio y Industrias website: [www.mici.gob.pa/detalle.php?cid=16&sid=53&id=1412](http://www.mici.gob.pa/detalle.php?cid=16&sid=53&id=1412)

From Figure 19, we can see that there is a concession granted in Miguel de la Borda, and has been in place since 2007 (“Solicitudes y Concesiones Mineras (Marzo 2013)”, n.d.). This data further supports the representatives’ belief that sand extraction is causing the sea to rise in the area of Donoso. This may also further support the fact that interviewees in different communities along the coast spotted boats, as they may have been boats travelling back and forth from Miguel de la Borda to Colón to drop off their material.

From Figure 20, we can see the extent to which sand extraction has become a large activity along Costa Abajo. There are many recent applications in place, all at different stages, focused on exploration or extraction. The areas of the *solicitudes* coincide with the areas where the interviews were conducted. As well, the majority of the *solicitudes* have been created within the last 8 years, which coincides with the boom in growth in the entire Country. The extent of the applications of sand extraction in relation to the concessions reveals that sand extraction will become a large activity along Costa Abajo in the future, and may further impact these coastal communities.

As well, sightings of sand extraction were also in the form of *paleros* shoveling sand off beach into a truck, or smaller sized boats. These two activities fall under traditional sand mining, and are not activities granted by the Government, thus are illegal in nature. They are considered minor in relation to impacts caused on shoreline in comparison to the industrial method (S. Sánchez, personal communication, April 1st, 2013).

### *Climate Change*

As we would have expected, given the literature reviewed pertaining to the causes of sea level rise in the Caribbean, climate change was stated as a factor in sea level rise and inundations by three of our twelve interviewees. These interviewees included a previous employee of the Smithsonian, a schoolteacher and a political representative from Gobeia and Palmas Bellas. As such, they were generally among those with higher social standing or educational backgrounds in the community.

### *Visible vs. Non visible Causes*

The most common perceived cause mentioned for sea-level rise and inundations in Costa Abajo was sand extraction. Out of the 12 people interviewed, only three mentioned climate change as a perceived cause.

Thus, it is interesting to note that most interviewees attributed the perceived causes to the visible, for example sand extraction, rather than to the non visible, such as climate change. Perhaps the focus is placed on the visible as it is more feasible to understand, attribute blame to and find solutions for, than a global process that is scientific, may seem somewhat abstract and does not necessarily come from local activities.

In addition, the interviewees seemed to place more focus on immediately visible events with instantaneous impacts, such as inundations. There was less emphasis on the less immediately noticeable sea-level rise.

As well, it appears as though the interviewees only noticed events that caused immediate visible impacts, such as inundations. As sea-level rise and the impacts occur slowly over time, most interviewees did not think it affected their livelihoods. The exceptions were in Palmas Bellas and Piña where the residents self-organized to obtain protection from further damage in the form of a government funded wall.

### ***Frequency and Intensity of Inundations***

Most communities indicated that inundations had the most profound impact on their communities: erosion, flooding, and taking away houses. The increased intensity and frequency of inundations was also a common theme brought up throughout the interview process. This information further supports modern literature's indication that climate change has increased storm severity, increasing the vulnerability of coastal communities to these storms.

### ***Motivation***

Senor Abel Bhu's comment on people not paying attention to what is going on and not being motivated to take action is supported by the response of the interviews saying that they were not sure exactly why the sea-level is rising, that it is just part of nature. It appears as though this type of response signals an acceptance of the situation, and a resultant lack of motivation to take action. This reinforces Abel Bhu's desire to educate local residents on the situation at hand.

### ***Knowledge of Other Communities***

It was also noted that communities knew of the other communities most affected by the sea. For example, both in Salud and Piña the interviewees had knowledge on the areas most hit by

inundations and sea-level rise, such as Miguel de la Borda and Gobeá. This shows that it is a well-known problem in the area, and there are concerns for other villages.

### ***Adaptation Strategies***

Trends of differences in adaptation strategies were observed along the coast. The further the communities from the city of Colón, the more basic and short-term the adaptation strategies were compared to the communities closer to Colón that were using long-term and extensive adaptation strategies. For example, in Gobeá, sacks of sand were being used to protect houses, whereas in Piña, a wall costing \$120,928.28 US was constructed (Appendix - Figure 21). The communities of Palmas Bellas and Piña appeared organized and motivated to take action, as exemplified by the walls built. However, the communities further west did not appear as motivated or as organized, other than people in political positions. As well, it seems as though these communities, being further away, have less interaction with the city of Colón, especially when it came to commuting to and from the city for work. This separation of physical distance may manifest in a feeling of political separation from centrally located government institutions.

### Future Considerations & Recommendations

As per Hoffman (1983), businesses, governments, and individuals in low-lying areas have the opportunity to adjust to sea level rise before it occurs. Moreover, as recognized by the IPCC, human activities at a local level have the ability to impact coastal zones over shorter time periods and more severely than the effects of climate change (Nicholls et al. 2007). Because sea-level rise is a process that occurs at a slow rate over a large period of time, its occurrence may not be noticeable to all community members. This concept was observed throughout the interview process, as there were interviewees in each location that did not notice the sea level rising, or if they did, they did not notice any immediate impacts on the community's livelihoods. Many did not consider the future implications for this issue. Rather, short-term adaptation strategies were in place, without any long-term management or strategy to support it. These strategies were limited to refraining from removing grasses, using sandbags as a protective barrier for homes, and, in two communities, constructing government-funded walls from cement or ruff raff. While these preventive actions are important, they came about as a *reaction* to inundation events after they occurred. The problem of a reactionary, rather than preventative mentality, is illustrated by the following quote from an IPCC report speaking to climate change in Latin American countries (Magrin et al., 2007):

“currently, the typical response to a severe climatic event consists of intervening after the fact, usually with insufficient funds to restore the conditions prior to the event. A necessary change would be to migrate from a culture of response to a culture of prevention”

As seen in Palmas Bellas and Piña, foresight could have saved the emotional and infrastructural costs of homes that were taken by the sea if preventive, rather than reactive, strategies were in place. In these rural communities, economically dependent on agriculture, fishing and wage labor, funding is a crucial barrier to overcome when it comes to successfully implementing protective measures from human induced climate change and locally damaging coastline activities. Therefore, we believe it is of utmost importance to create awareness and education on sea-level rise, storm surges, their driving factors and implications. Scientific monitoring, such as the recent sea level monitoring station at STRIs Bocas del Toro Station, is important to support local observations (STRI News, 2013). With increased knowledge, the coastal communities of Costa Abajo will be better able to organize and adopt adaptation strategies before these threats become significantly worse as projected in modern literature.

There is also a need for documentation and detailed information from each coastal community. During interviews, the indicators we obtained on sea advancement and inundations were based on memory, not any hard data. For example, most interviewees could not project in meters how much distance the sea had encroached and had difficulty in estimating a time frame for this encroachment. Also, dates given for the occurrence of inundations events were only specified to a year or month. It was also difficult to obtain photos of what the shoreline looked like in the past. With today's technology, photographs could be an efficient measurement of change. There is also a need, expressed by the representatives of the Donoso District, for more research on sand extraction and its impact on coastal geomorphology.

## Conclusion

Climate change and sea level rise are global phenomena, as the impacts are experienced on a worldwide scale. Therefore, there are many reports and research papers attempting to consolidate this information into a “world view”. Nonetheless, every community is unique in its historical interaction with the shoreline. In order to better understand the changes in shoreline overtime, and its impacts on coastal communities, it is imperative to analyze these micro-scale qualitative observations through the locals’ perspective to add to the macro scale quantitative measurements and projections.

In relation to the specific questions addressed for this investigation, it is apparent through the interviews conducted along Costa Abajo that the shoreline in each community has changed over time and that these coastal communities are increasingly vulnerable to inundations. The perceived causes for these changes included climate change, sand extraction, “nature” and deforestation. The communities further west of the City of Colón have adapted to these changes by using sandbags and moving houses further back. Close to the city of Colón, the communities have adapted to these changes by pressuring the government into funding protective walls along the shore. Also, it was discovered that underwater sand extraction, which will become a main activity along the coast in coming years, is an activity that has been enhancing the speed at which the shoreline changes. There is a spoken desire to further analyze its effect on the coast communities, especially in the District of Donoso. Others believe there have been no impacts on the *pueblos* with regards to the sea level rising. This may be indicative of the reactive, not preventative, mentality along the Coast, and a need to emphasize long-term adaptation *and* mitigation strategies. The consequences of not acting in a preventative manner is exemplified in the case of Palmas Bellas, where a wall was not constructed until 5 years after 28 families lost their homes and were forced to move further inland. Education is a key factor in this regard as awareness can be raised on the potential and projected impacts of slow occurring sea level rise in order to effectively manage the problem before the impacts become significantly worse. As per the observation of HG Wells: “history is a race between education and catastrophe” (Meredith, 2013).

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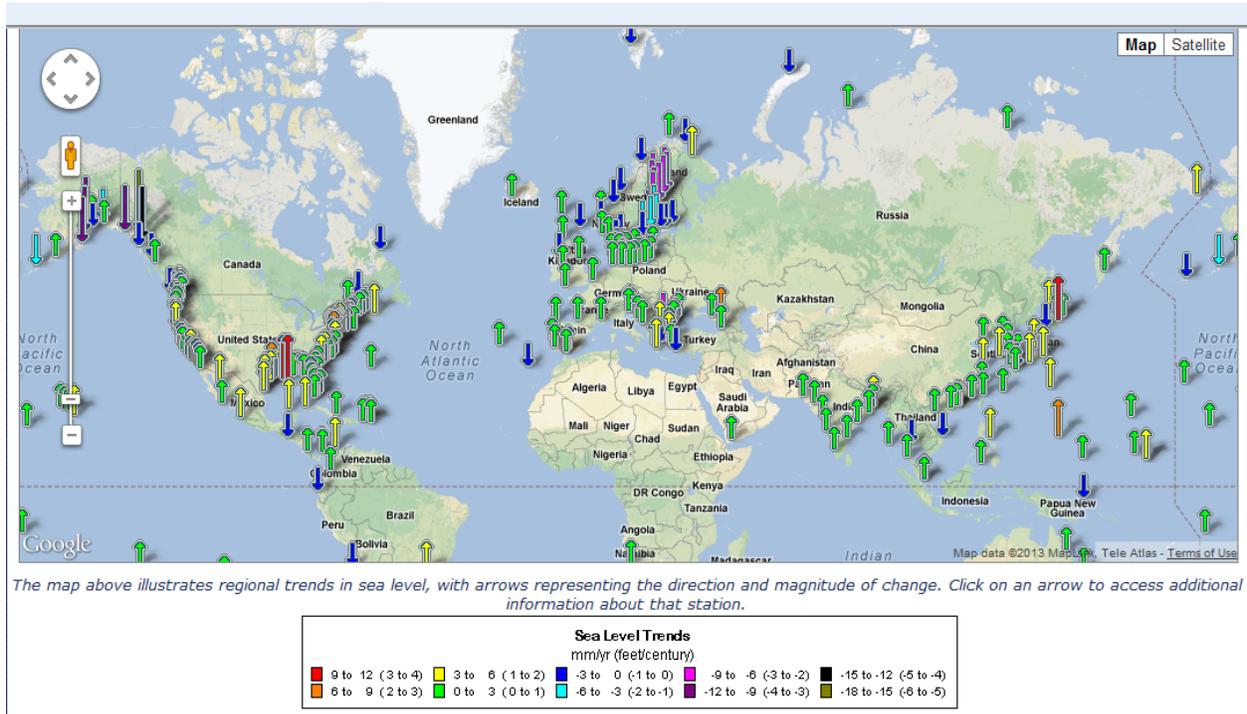
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Figure 4- Sea Level Rise around the World

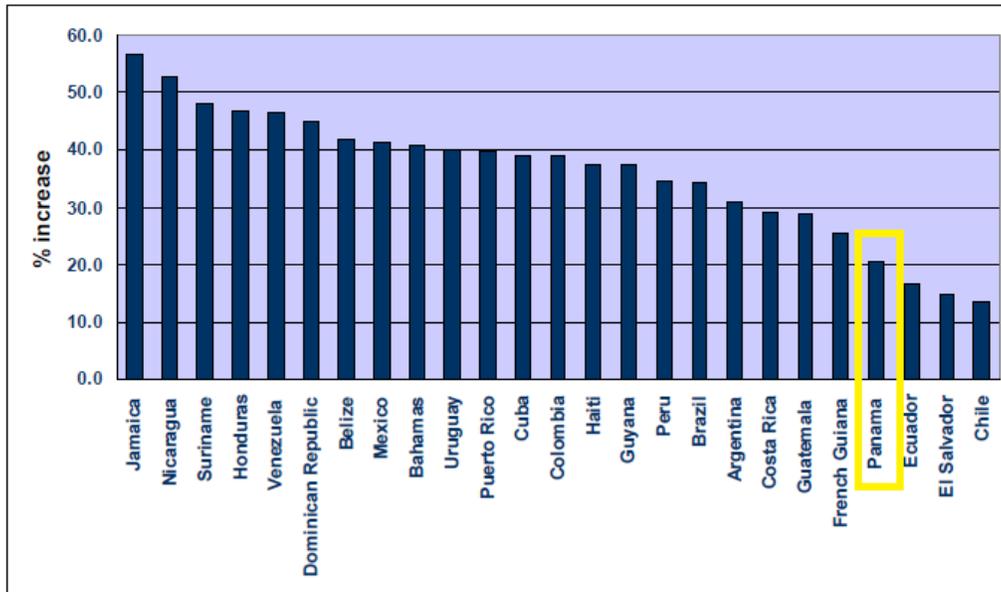


The sea level trend in Panamá appears to have a similar trend to the increase in sea level worldwide, as indicated by extensive number of green upward arrows. Two green arrows in Central America pertain to Panamá.

Source: Sea Level Trends. (n.d.). *NOAA Tides and Currents - Home*. Retrieved April 20, 2013, from <http://tidesandcurrents.noaa.gov/sltrends/sltrends>

**Figure 6- World Bank Predicted Increase in Storm Surges**

**Figure 4: Percentage increase in storm surge zone, LAC Region**



Source : World Bank, Development Research Group, Environment and Energy Team. (2009). *Sea Level Rise and Storm Surges: A Comparative Analysis In Developing Countries*. Washington, DC: Dasgupta, S.; Laplante, B.; Murray, S.; Wheeler, D.

**Figure 8- Impact of Inundation from November 2012, Gobeia**



Photo taken on the beach in Gobeia, Señor Thomas Penuela Hernandez showing us the damage done to houses along the sea

**Figure 9- Local Adaptation Strategy, Gobe**



*Photo taken on the beach in Gobe, Señor Thomas Penuela Hernandez showing us the damage done to houses along the sea*

**Figure 10- Riverbank Erosion caused by November 2012 inundation, Río Sambo, Gobe**



*Photo taken on by the river in Gobe, Señor Thomas Penuela Hernandez showing us the erosion from November 2012*

**Figure 11- River Widening of Río Sambo, Gamboa**



*Photo taken on the beach in Gobeá, Señor Eduardo Darkin showing us the proximity of the widening river to homes*

**Figure 12- Bridge that had to be replaced 4 years ago, Río Indio**



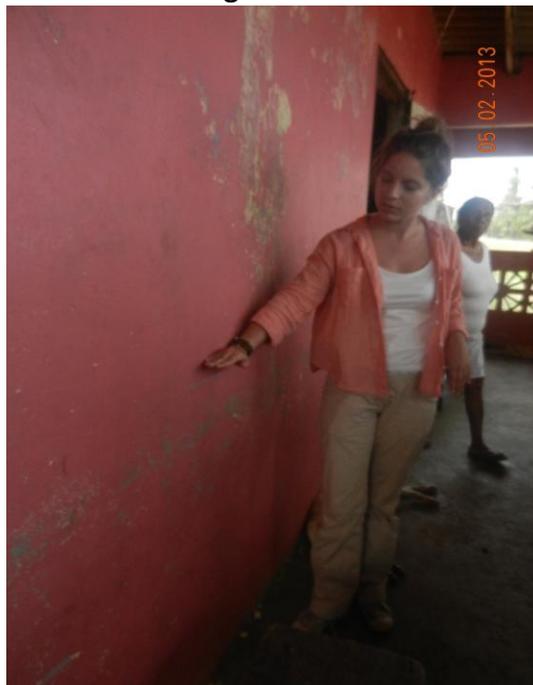
*Photo taken from the new bridge in Río Indio, that replaced this one that had been damaged by the river.*

**Figure 13- Forced to move house further back, Río Indio**



*Photo taken of Señor Narciso Muños' house, which was moved from the beach to across the street because of sea encroachment*

**Figure 14- Height of water during November 2012 inundation, Río Indio**



*Photo taken at house of Señor Narciso Muños, the same house from Figure 13.*

**Figure 15- Photo taken in 2000 of the beach, now all part of the sea, Palmas Bellas**



*Photo of Severina del Gado, mother of Felicita Aguila. This picture was taken in 2000 at Felicita's house that she lived in prior to her move. She described how what is seen in the background is now all part of the sea.*

**Figure 17- Piña Shoreline**



*Photo of wall built by Government in 2009 to mitigate the effects of sea level rise in the community.*

**Figure 18- Changes in shoreline, La Playita**



*Photo taken at La Playita showing the extent of sea encroachment.*

**Figure 21- Protective wall, Piña**



*Photo taken on the beach in Piña of a plaque indicating information about the protective wall that was built.*