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Part I
The structure and composition of the mangrove forests

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The fisherman's perspective

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Committee of Tropical Ecology
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Part I:
THE STRUCTURE AND COMPOSITION OF THE MANGROVE FORESTS

Abstract

For future mangrove restoration projects it is of great importance to know its composition and the distribution of species. Four mangrove species were found in Departamento de Atlántico, Colombia. The species were *Avicennia germinans* (Black mangrove), *Laguncularia racemosa* (White mangrove), *Rhizophora mangle* (Red Mangrove) and *Conocarpus erectus* (Buttonwood). The study was performed during the dry season between January and April 2006. Ten locations along the coastline of Departamento de Atlántico were inventoried. To characterize the mangrove stands in terms of dominating species; an index named Importance Value (IV) was used. This index describes the influence in percentage of each mangrove species in a stand of mixed species. In order to assess the IV for each species at the different locations, the mean sum of relative density, relative dominance and relative frequency was calculated. The dominating species in Departamento de Atlántico was *Avicennia germinans,* having an IV of 26.48% or higher in eight of ten sites inventoried.

In general, the mangroves of Departamento de Atlántico consist of small fragments, often in temporary coastal marshes with poor development. These temporary marshes are terrestrial during the dry season. The best developed mangrove was found in the marshes of Manatíes and Mallorquin. Both Manatíes and Mallorquin suffer from great erosion due to the construction of a bank, Tajamar, which separates the Magdalena River from the river delta.

Manatíes had the highest average height of trees, 8.59 m. The stand at Totumo had the biggest mean stand diameter, 16.31 cm, and the highest coverage of basal area, 25.76 m^2/ha.

Resumen

Es de gran importancia conocer la composición y distribución de especies de manglar para proyectos futuros de restauración. Este estudio fue desarrollado durante la época seca entre los meses de enero y abril del 2006 en el departamento de Atlántico, Colombia. Las especies encontradas fueron *Avicennia germinans* (manglar negro), *Laguncularia racemosa* (manglar blanco), *Rhizophora mangle* (manglar rojo) y *Conocarpus erectus* (Botoncillo). Se muestrearon 10 áreas de manglar en la línea costera del departamento de Atlántico. Para caracterizar los manglares en términos de especies dominantes se utilizo el índice de valor de importancia (IV). Este índice describe la influencia del porcentaje de cada especie de manglar en un grupo de especies variadas. Con el fin de estimar el IV para cada especie en diferentes áreas de muestreo, se calculo el promedio de la densidad relativa, dominancia relativa y frecuencia relativa. Las especies dominantes en el departamento de Atlántico fueron Avicennia germinans, con un IV de 26,48% o mas alto, en ocho de los diez sitios muestreados. En general los manglares del departamento del Atlántico están conformados por pequeños fragmentos con frecuencia localizados en humedales temporales costeros jóvenes. Estos humedales temporales son terrestres durante la época seca. Los manglares mejor desarrollados se encontraron en las ciénagas de Manatíes y Mallorquin. Ambas ciénagas sufren de mucha erosión debido a la construcción del banco tajamar que separa el rió Magdalena de su delta.

Manatíes tuvo el mayor promedio de altura de árboles, 8,59 metros. Los árboles del Totumo tuvieron el promedio de diámetro mayor, 16,31 cm. y la mayor cobertura de área basal, 25,76 m2/ha.

1. Introduction

1.1 Mangroves

Mangrove is the general name of a category of trees and shrubs, including ferns and palms (Spalding et al., 1997), which have adaptations to live in the variable environment in the intertidal zone with fresh and salt water. They are present in tropical and sub-tropical areas around the world and are generally found within 25° north and south of the equator, even though they can be found as high as 32° in some northern latitudes (Maltby, 1986). The diversity of the mangrove vegetation and species associated to mangrove is low compared to the exceptionally high biodiversity found in other tropical ecosystems, like coral reefs and rainforests (Ricklefs and Latham, 1993). There are somewhat different views about which species should be considered as mangrove. Referring to Tomlinson (1986), there are 54 true mangroves species in 20 genera belonging to 16 families, plus 60 mangrove associate species in 46 genera. This can be compared to Duke (1993) who claims there are 27 genera that include 62 true mangrove species and 7 hybrids.

The importance of mangrove ecosystems is well known; they constitute habitat for several species of fish, shrimps and crustaceans that live, feed, reproduce, and spend their time as juveniles among the mangrove roots. A majority of the commercially important fish and shellfish in the tropical coastal waters depend on mangrove environment. According to Hamilton and Snedaker (1984), 80% of all marine species of commercial or recreational value in Florida, USA, are considered to be dependent on mangrove during some stage of their life cycle. Although mangroves are essential for a large number of marine species, it is also an important habitat for some species of birds and terrestrial animals (Hong and San, 1993).

Other important benefits of mangroves are that they provide protection against coastline erosion and function as a natural filter which removes sediment and nutrients. Estimations of the total annual value of mangrove ecosystems services, including waste treatment, disturbance regulation, food production and recreation reach US$9900 per hectare (Costanza et al., 1997). The value of mangrove fisheries resources alone sometimes exceeds forestry resources (Gan, 1995).

Mangrove swamps have often been thought of as unproductive land and the exploitation of mangrove ecosystems for short-term economic benefits, such as shrimp farming, have led to their degradation and destruction (Thornton et. al. 2003). Other reasons for mangrove clearing are the expansion of tourism, human settlements in mangrove areas and cutting mangrove for building materials and for the use as charcoal and firewood (Saenger et. al., 1983). The decrease of mangrove ecosystems has been rapid, and these ecosystems are now considered to be one of the most threatened in the world (Barbier and Cox, 2003). From covering approximately 75% of the tropical coastlines and estuaries before suffering from any major human impacts (Farnsworth and Ellison, 1997), it has decreased to cover only about 25% (World Resources Institute, 1996). It has been estimated that about 35% of the total mangrove area was lost between 1980 and 2000, losses that exceed both the decrease of tropical rainforests as well as coral reefs (Valiela et al. 2001). The rapidly increasing human population in or close to the coastal zone is considered to be the root cause of the degradation and destruction of mangrove forests (Ong, 1995). An estimated 39% of the global population lives within 100 km from the sea (WRI, 2000). As a result, about 2.5 billion people (April, 2007) are heavily dependent on the marine environment as the resource for food and building materials.

1.2 Study area

Figure 1. The map of South America, with Colombia coloured in red.

Figure 2. Location of Departamento de Atlántico, Colombia.

The study was carried out from the 10th of January to the 10th of May 2006 in Departamento de Atlántico, located on the Caribbean Coast of Colombia (Figure 2). With an area of 3,388 km², it is one of the smallest of Colombia's 32 departments

The mangroves of Departamento de Atlántico are exposed to stress due to different kinds of human activities. This is one of the reasons why the coverage of mangrove in the area has decreased drastically in a relatively short period of time. There are no larger mangrove areas in Departamento de Atlántico, in comparison with the neighbouring departments of Bolivar and Magdalena. The total mangrove area is only 613 hectares (INVEMAR, 2005), mostly consisting of small isolated patches. Some areas along the Atlántico coast are state-owned, though large areas are private property (Juan Carlos Pino Renjifo, personal information). Four mangrove species are found in Departamento de Atlántico; *Avicennia germinans* (Black mangrove), *Rhizophora mangle* (Red mangrove), *Laguncularia racemosa* (White mangrove) and *Conocarpus erectus* (Buttonwood), although *C. erectus* often is referred to as a mangrove associated species because it lacks the special adaptations found in true mangrove species.

The Marsh of Mallorquin is situated close to Barranquilla. This marsh is part of what is called "Cienaga Grande de Santa Marta", a large mangrove ecosystem and declared to be of global importance by Unesco and Ramsar. Mallorquin has serious and increasing problems with regards to coastal erosion. The main reason for this is a constructed bank named "Tajamar" in the area. Most probably this bank is now affecting the whole coastline of Departamento de Atlántico. Tajamar is about 8 km long and separates the Magdalena River delta from the river itself. Before the construction of this bank, the sediment rich water fed the delta with sediment. Now the sediment is prevented from reaching the delta. The motive to build it was to connect the Caribbean coast to the centre of Colombia by making the mouth of the

Magdalena River deeper. The construction of the bank made it possible for big cargo ships to go up the river (Figure 36). Tajamar was built between 1924 and 1936 and played a fundamental role in Barranquilla's development to become a commercial and industrial centre (Bonet, 2005).

2. Aim of the Study

The purpose was to study the composition and structure of the mangrove forests in Departamento de Atlántico. With information on the mangrove composition and structure together with knowledge obtained from interviews with local people (Part II of this study) a better basis is obtained for planning, resource management, and future restoration projects of damaged areas.

3. Material and Methods

3.1 Field methods

To determine the composition and structure of mangrove stands, rectangular plots (strip transects) of 0.06 – 0.1 hectares were constructed perpendicularly towards the waterline nearby the stands at ten sites. All plots were subdivided into 10 x 10 m subplots, resulting in 6 – 10 subplots for each study plot (Figure 3). All trees with a diameter greater than 2.86 cm were counted and measured, and divided into two groups. The first group includes all trees in the diameter range of 2.86 – 10.0 cm; the second group includes all trees with a diameter greater than 10 cm. Trees and juveniles with a diameter less than 2.86 cm formed the third group. One exception is the plot at Tajamar, where the great abundance of juveniles and smaller trees resulted in estimating this group by selecting a square metre by random and counting all juveniles and propagules within that square metre. The number of juveniles and trees with a stem diameter less than 2.86 cm was then estimated for the subplot as a whole. In each survey plot, the species of every tree was determined and every tree was measured in terms of height and trunk diameter at 1.3 m (DBH). When determining the stem diameter a measuring tape was used to measure the girth, from which the diameter of the stem could be calculated. The data collected were later used to describe the forest according to the three structural parameters (density, basal area, and frequency) explained in section 3.3.

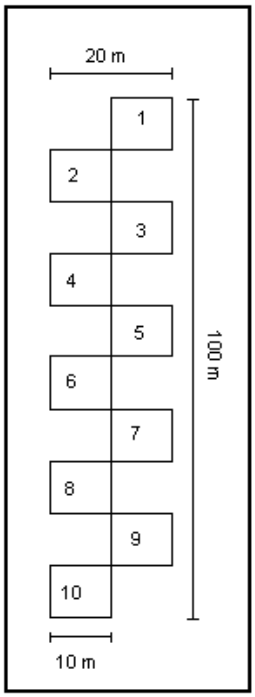

Figure 3. Model of strip transect used in the inventory of the mangroves in Departament de Atlántico, Colombia.

To measure the height of the trees, plastic tubes with a maximum length of 8 m were used. For trees that sprouted from a single base close to the ground or had a stem that forked before DBH, every bough was measured as a separate stem. When a stem forked at breast height or slightly above, the diameter was measured at DBH or just below the swelling point caused by the fork. For trees that had prop or stilt roots that reached above DBH (i.e. *Rhizophora mangle*), the diameter was measured above the prop/stilt roots. The stilt roots of some individuals reached heights of up to 4 m.

3.2 Location of transects

Along the 64.9 km long coastline of Departamento de Atlántico, ten locations were investigated (Figure 4). The coordinates for the locations are found in Table 1. The exact point of the survey sites was determined in the field with a Garmin® GPS. At each site a transect was established through the mangroves. The total area of the ten transects was 8450 m^2.

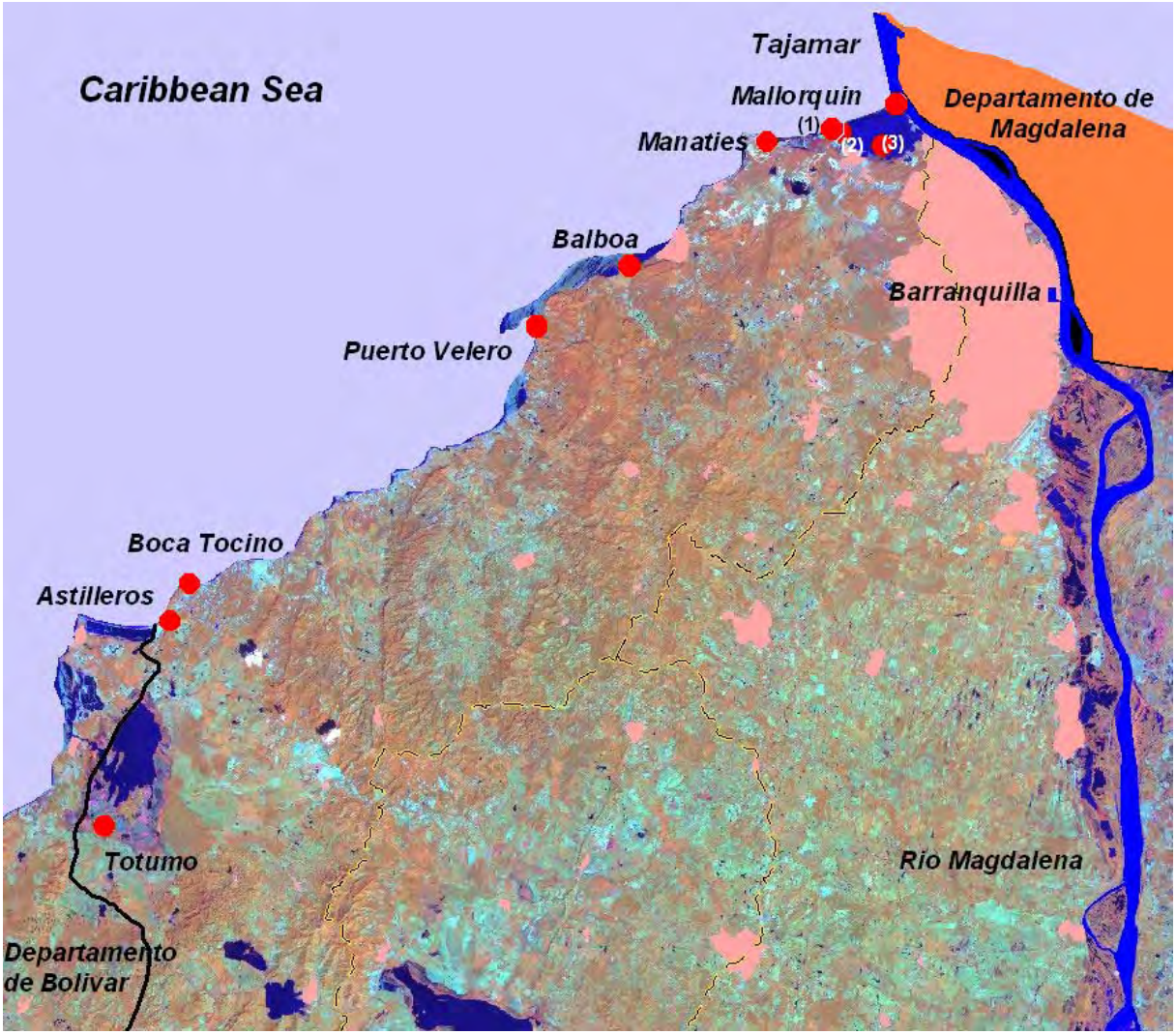

Figure 4. The coastline of Departamento de Atlántico, Colombia. The red points show the location of the 10 transects investigated.

Table 1. Coordinates for transects that were inventoried in Departamento de Atlántico, Colombia.

Location	N	W
Totumo	10°41'42.7	75°14'48.3
Astilleros	10°47'56.4	75°12'49.8
Boca Tocino	10°49'02.2	75°12'13.6
Puerto Velero	10°56'51.1	75°01'35.1
Balboa	10°58'43.0	74°58'42.3
Manatíes	11°02'27.2	74°54'28.2
Mallorquin [1]	11°02'50.0	74°52'30.3
Mallorquin [2]	11°02'43.8	74°52'12.5
Mallorquin [3]	11°02'19.9	74°50'55.1
Tajamar	11°03'34.5	74°50'32.2

3.3 Explanations of terms

3.3.1 Tree height

The height of the trees is the vertical distance between the ground and the tip of the tree, measured at a 90º angle from the ground. This means that trees that not are standing straight have a longer stem than the determined height of the tree.

3.3.2 Stem diameter

To measure the diameter of trees is an easy way to characterise a forest stand. Diameter of stems is strongly related to stand development (Cintrón and Schaeffer-Novelli, 1984b). It can easily be transformed to the area occupied by the tree stems, referred as the basal area. As the diameter decreases towards the crown, it is necessary to measure the trees at the same height. The standardised point for measuring diameter is at 1.3 m above the ground and is referred to as *diameter at breast-height (DBH).* By measuring the girth with a tape and dividing the reading with π the circumference is converted to diameter ($c/\pi = d$). When the stem has an eccentric form, measuring the girth and converting it to diameter will not be completely accurate. Tape measurements of these trees will overestimate the diameter, since the circumference of an eccentric stem is greater than that of a circular stem with the same area. Eccentricity in serious forms is not common in most mangrove species or stands. So for the purposes of describing the structure of a mangrove stands, errors from stem eccentricity can be ignored (Cintrón and Schaeffer-Novelli, 1984b).

3.3.3 Basal area of the stem

The space covered by the tree stem is described as basal area. The basal area is the same as the cross section of a stem at the point of DBH. By adding the cross sections of trees, a basal area for a group of trees or for the complete stand can be determined. In this investigation two groups of diameter limits were used; 2.86 – 10 cm and >10 cm. Basal area (BA) is an important parameter to illustrate the development of a stand, and it can easily be linked to biomass and wood volume (Cintrón and Schaeffer-Novelli, 1984b). In the present report it is expressed as m^2 per hectare.

The basal area per tree stem (g) is computed by using the formula, $g = \pi * r^2$, but since the radius is DBH/2, the basal area per tree stem (g) is calculated as $g = \pi/4*(DBH^2)$. To describe the area occupied by the stems of a tree stand, g needs to be expressed in m^2 as a function of DBH measured in centimetres. The formula to express g in m^2 is as follows:

$$g = \pi/4\ (DBH*0.01)^2 = (\pi/4*DBH^2)/100^2 \Rightarrow g\ (m^2) = 0.00007854*DBH^2$$

3.3.4 Stand density

The stand density reflects the recent history of the mangrove forest (Douglas et. al. 1977), and it is a useful parameter to describe the development of the forest. Stand density is described as individuals per hectare (n). Younger stands usually have a high density of thin stems, whereas an older stand in most cases has a lower density consisting of a higher amount of mature trees with a larger basal area.

3.3.5 Mean stand diameter

The definition of the mean stand diameter is “the diameter of the stem of mean basal area”. The calculation for the diameter of the stem of mean basal area is determined by:

$$dbh = \sqrt{\frac{BA}{0.00007854 * n}}$$

where *dbh* is the diameter of the stem of mean basal area, *BA* is the basal area for the stand and *n* is the stand density. This is a useful measure when comparing the maturity of different stands of mangrove, as the mean stand diameter increases when the stand matures (Cintrón and Schaeffer-Novelli, 1984b).

3.3.6 Importance Value (IV)

An Importance Value (IV) for species has been calculated at every site for each species present. This index was developed by Curtis and McIntosh (1951) and describes the structural importance and influence in percentage of each mangrove species in a stand of mixed species. The index is calculated by the mean sum of three quantitative parameters; relative density, relative dominance and relative frequency. A monospecies stand therefore has the IV=100. The frequency of a species is the percentage of subplots in which the given species is present.

$$\text{Relative density} = \frac{\text{Number of trees for one species}}{\text{Number of trees for all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Sum frequency of all species}} \times 100$$

3.4 Abiotic factors

3.4.1 Salinity

Water salinity was determined with a refractometer at the beginning and at the end of each transect. This parameter was excluded in transects where no interstitial water could be found at the depth of 70 cm.

3.4.2 pH

pH was determined in field with a pH-meter at the beginning and at the end of each transect. This parameter was excluded in transects where no interstitial water could be found at the depth of 70 cm.

3.4.3 Water temperature

The temperature of the water was determined with a digital thermometer at the beginning and at the end of each transect. This parameter was excluded in transects where no interstitial water could be found at the depth of 70 cm.

3.4.4 Organic content in the soil

The organic content of the soil was determined from the samples of soil which were collected at all sites, at the beginning of the transect and at the end. To prevent fermentation, the samples were immediately stored in a frigolit box together with ice, and later the same day in a freezer. The samples were examined in terms of organic content at Universidad del Atlántico, Barranquilla. The method used for determining soil organic matter was the Loss on

Ignition method (LOI) (Schulte, E. E. and Hopkins B. G., 1996), which is described as followed:

1. All samples were placed in crucibles and dried in an oven at 60 ºC for 72 hours.
2. All crucibles were individually weighed. The soil samples were crushed in a pestle and 8 g from each of the oven-dried samples was added to a crucible.
3. The crucibles were placed in the oven for 2 hours at 360 ºC.
4. After the crucibles had cooled off, they were individually weighed. The weight difference was calculated and determined as the organic content in the soil.

4. Results

4.1 Descriptions of inventoried areas

4.1.1 Marsh of Totumo

This forest is dominated by *Conocarpus erectus* (73.5% IV); of the 74 trees present in this transect, 61 are *C. erectus* with an average height of 5.6 m. The other species in the area is *Avicennia germinans* (26.5% IV), represented by 13 trees ranging from 4 to 17 m (Figure 6), and averaging 9.5 m in height. The total density of trees in the plot is approximately 1200 per ha, with a basal area of 25.8 m^2/ha. The basal area of tree stems greater than 10 cm is 23.5 m^2/ha, which indicates that the stand is in a mature stage (Figure 5 and 6).

The forest is well developed and not dense. Very few young plants are present and the dominating process of regeneration is asexual from already existing individuals. Approximately 9% of the trees with stems greater than 2.86 cm had been cut down.

Abundant grazing damage of leaves was observed. The grazer was not determined but some kind of insect was suspected. Parts of the water surface are covered by *Lemna minor L.* (Common Duckweed). During the rainy season the lagoon is filled with water. There are no open channels connecting the marsh with the sea, which explains the relatively low salinity. The water depth at the time of investigation was 10-50cm, and does not change significantly during the daily cycle. The depth increases during the rainy season. There is a high abundance of termites in the area, and ants are also common. The species of the termites and ants were not determined. The same type of forest continues outside the transect (600 m^2) towards the marsh of Totumo. The water temperature was 27ºC, pH 7.1-7.2, and the salinity 11‰ (Feb. 10, 2006). A lot of organic matter in the form of litter was noted. The organic matter in the soil determined from LOI was between 8.2 % and 11.3 %.

Table 2. Data of the inventoried mangrove stand at the marsh of Totumo, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density		Basal Area (m2/0,1 ha)		Height (m)	Importance value (IV)	
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Conocarpus erectus	Avicennia germinans
2	16,31	39	35	1233	2,5765	0,2242	2,3523	6,31	73,52	26,48

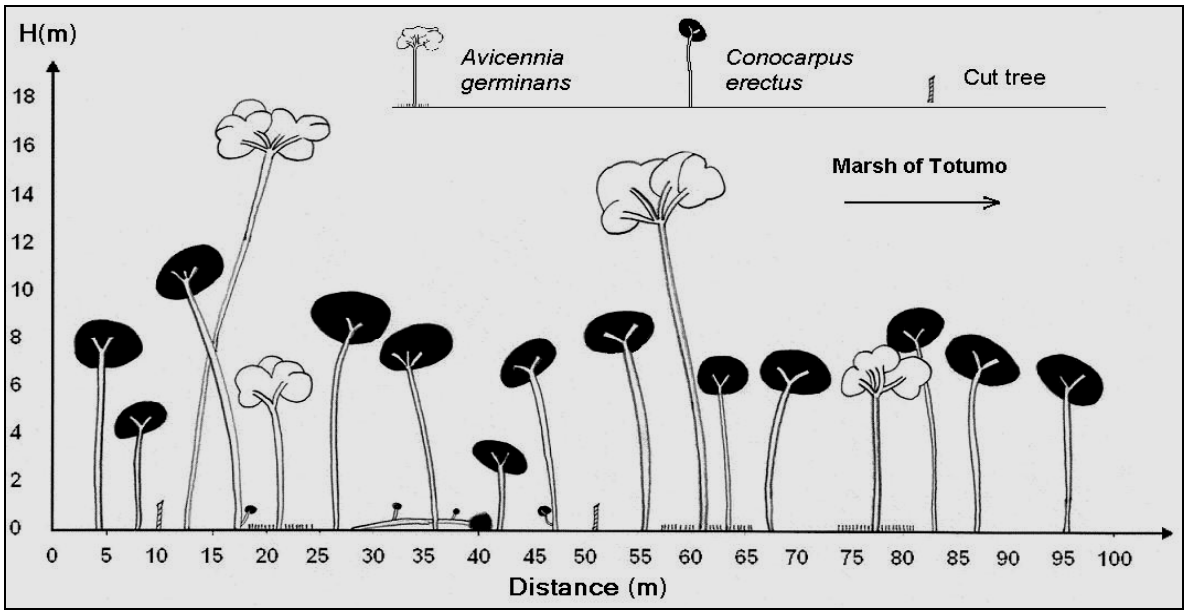

Figure 5. Profile of the inventoried mangrove at the marsh of Totumo, Departamento de Atlántico, Colombia.

Figure 6. Trees of *Avicennia germinans* reach heights up to 17 m at the marsh of Totumo, Departamento de Atlántico, Colombia.

Figure 7. Trees that lie down but have regeneration from the stem is a common sight at Totumo, Departamento de Atlántico, Colombia.

4.1.2 Astilleros

This forest is dominated by *Conocarpus erectus* to 100%. The forest is far from mature and the average height is 4.46 m, with individuals ranging from 2.6 to 8.5 m. Of the 50 trees present in the plot (600m^2), only 10 had a DBH greater than 10 cm. The density is approximately 830 trees/ha, and the basal area covers almost 6.5 m^2/ha (Table 3).

A common plant species in the area is *Sesuvium portulacastrum* (Sea purslane) (Figure 10), and *Capparis* sp. and *Batis maritima* (Turtleweed) are also present. Visible organic matter is scarce, represented by dead branches and litterfall. A few dead trees were found, and approximately 10% of the trees in the plot had been cut down. Some of the dead and cut trees are regenerating from the stem. During the dry season this area dries out completely and the soil crack. A road has been constructed through the forest so that it cuts the connection with the sea, thereby blocking the mixing of fresh and marine waters. The organic matter in the soil was 7.7% in the beginning of the transect and 8.3% at the end. The environment here is terrestrial during the dry period and as no interstitial water was present at a depth of 70 cm, neither salinity, pH or water temperature was measured.

Table 3. Data of the inventoried mangrove stand at Astilleros, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Conocarpus erectus
1	9,91	40	10	833	0,6431	0,3323	0,3108	4,45	100

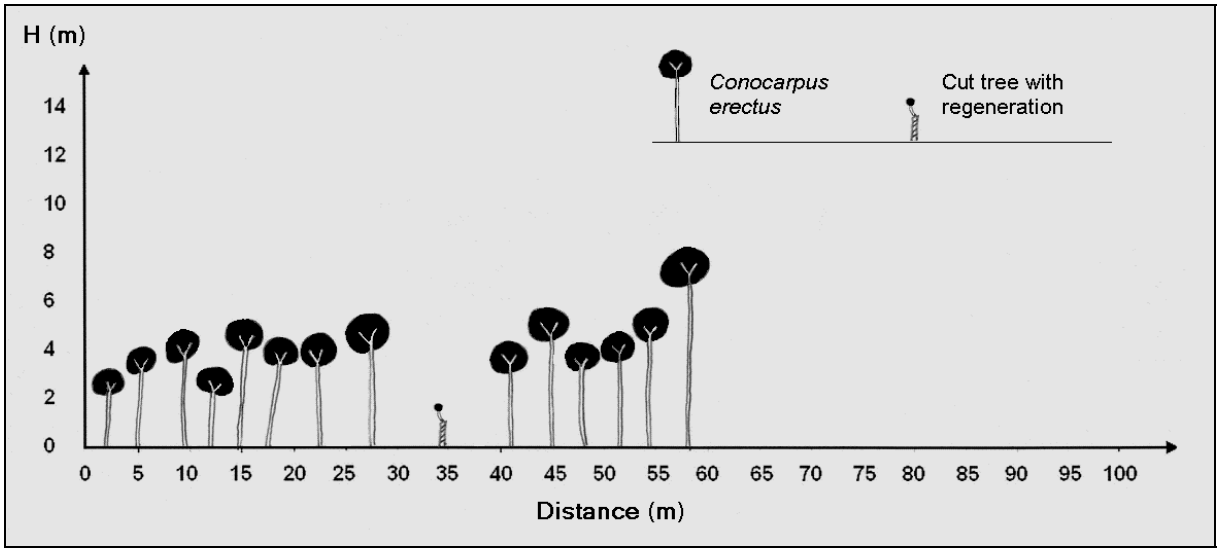

Figure 8. Profile of the inventoried mangrove at Astilleros, Departamento de Atlántico, Colombia.

Figure 9. The stand at Astilleros, Departamento de Atlántico, Colombia, is a monospecies stand of *Conocarpus erectus*.

Figure 10. *Sesuvium portulacastrum* is a common plant in the area of Astilleros, Departamento de Atlántico, Colombia.

4.1.3 Boca Tocino

Approximately four metres from the sea there is an almost impenetrable belt of *Conocarpus erectus* of 2-3 m width. This belt of bushes is about 3 m high with thin stems. The transect starts directly after those bushes and the rest of the forest is dominated by *Conocarpus erectus* (~71% IV), 41 trees and *Avicennia germinans* (~29% IV), 6 trees. The *A. germinans* are all old and well developed trees, the smallest being 5 m high with a DBH of 10.5 cm. The density is about 780 trees/ha, and the coverage of the basal area is almost 13 m^2/ha (Table 4). Regeneration in the form of juveniles is very sparse; regeneration occurs from the stems of old individuals. One plant species, *Batis maritima,* exists in the area. During the dry season the lack of water makes the soil crack, and the scarcity of water is likely to be a significant stress factor for the trees. Holes dug by crabs are abundant in the area. These holes most likely provide for good soil aeration. As no interstitial water was found at the depth of 70 cm, there are no measures of salinity, pH and temperature. The soil contains 6.0% organic matter.

Table 4. Data of the inventoried mangrove stand Boca Tocino, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)	
No.		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Conocarpus erectus	Avicennia germinans
2	14,47	26	21	783	1,2881	0,1799	1,1082	5,7	70,69	29,31

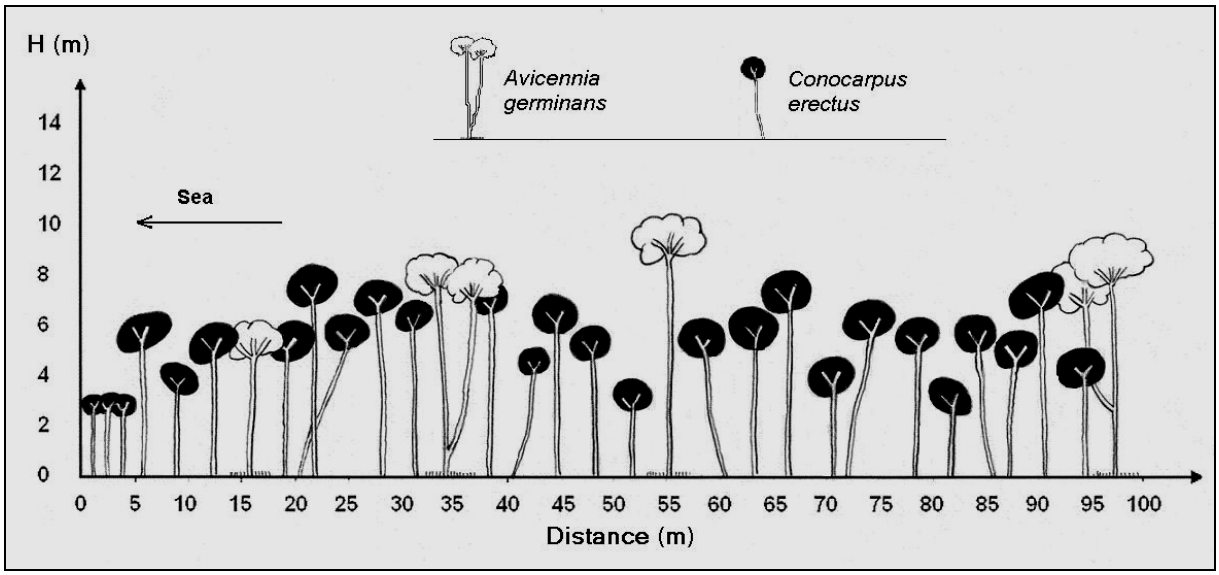

Figure 11. Profile of the mangroves at Boca Tocino, Departamento de Atlántico, Colombia.

Figure 12. Natural regeneration in form of juveniles is sparse at Boca Tocino, Departamento de Atlántico, Colombia.

Figure 13. Mature trees of *Avicennia germinans* at. Boca Tocino, Departamento de Atlántico, Colombia.

4.1.4 Puerto Velero

During the dry period of the year this forest is terrestrial. At the time of inventory (February 21, 2006) the distance between the sea and the first tree of *Conocarpus erectus* was 45 m. Behind the first stands of trees there is an open space of approximately 20 m, covered by grass (Figure 15). Even though all four species of mangrove that are found in Departamento de Atlántico are present in Puerto Velero, it has the least mature structure of all stands investigated. It has the smallest basal area coverage, about 3 m^2/ha and the lowest average tree height, approximately 4.3 m (Table 5). Only one tree had a DBH greater than 10 cm. The density is about 1150 trees/ha. The least important species is *Rhizophora mangle* (~5% IV). The importance values of the other three species are almost equal; *Conocarpus erectus* (~34% IV), *Avicennia germinans* (~32% IV) and *Laguncularia racemosa* (~29% IV). Two other plant species are found in the area, *Prosopis juliflora* and *Batis maritima.* As no interstitial water was found at the depth of 70 cm, there are no measures of salinity, pH and temperature.

Table 5. Data of the inventoried mangrove stand at Puerto Velero, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of Individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)			
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Conocarpus erectus	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
4	5,82	108	1	1080	0,3033	0,0113	0,292	4,28	34,16	31,86	29,29	4,69

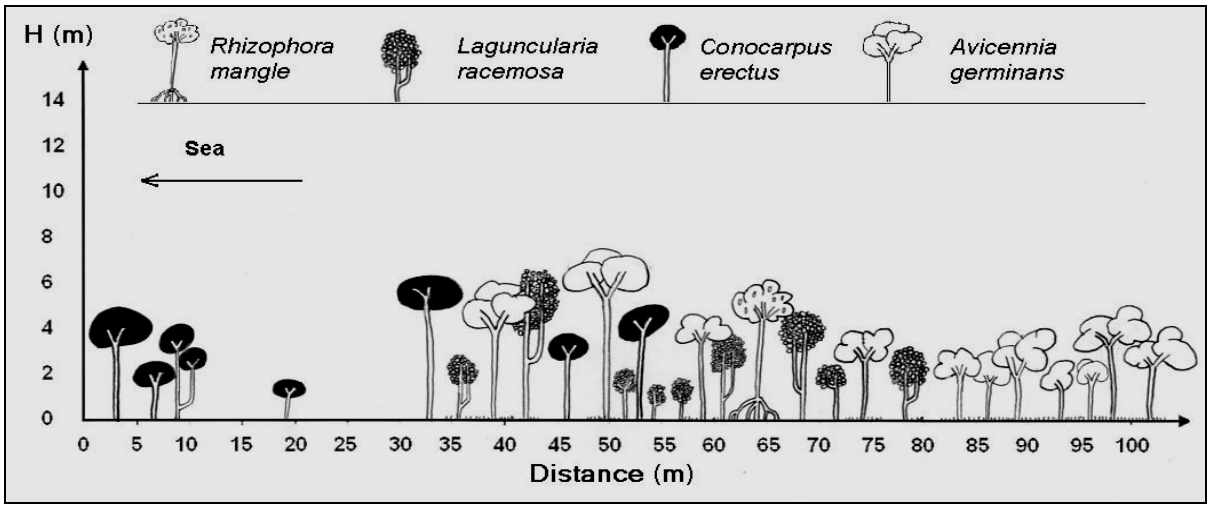

Figure 14. Profile of the mangroves at Puerto Velero, Departamento de Atlántico, Colombia.

Figure 15. Some areas are open with sparse mangrove representation where a few individuals of *Conocarpus erectus* and *Prosopis juliflora* are found. Puerto Velero, Departamento de Atlántico, Colombia.

Figure 16. The mangrove stands at Puerto Velero has low maturity and looks more like brushwood than mangrove forest. Departamento de Atlántico, Colombia.

4.1.5 Marsh of Balboa

The distance from the beginning of the mangrove to the water body of the Marsh of Balboa was 85 m. The water body increases during the rainy season. The soil was cracked at the time of the investigation due to the annual period of drought from mid-December to April (Figure 18). A lot of garbage covered the ground, spanning the first metres of the transect. The garbage had been brought there with the water currents during the rainy season. The forest is completely dominated by *A. germinans* (~97% IV) (Figure 19). Of the 358 trees found in the plot, only one was from another species, *L. racemosa* (~3% IV). This tree had poor development and was dying. The density of trees was 1930/ha, but the trees were generally small and only three trees had a stem with a DBH greater than 10 cm. This resulted in a low basal area coverage, 4.25 m^2/ha (Table 6). The three individuals with DBH greater than 10 cm were all in the last two subplots.

Table 6. Data of the inventoried mangrove stand at Balboa, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)	
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Avicennia germinans	Laguncularia racemosa
2	5,29	190	3	1930	0,425	0,3962	0,0288	4,47	96,97	3,03

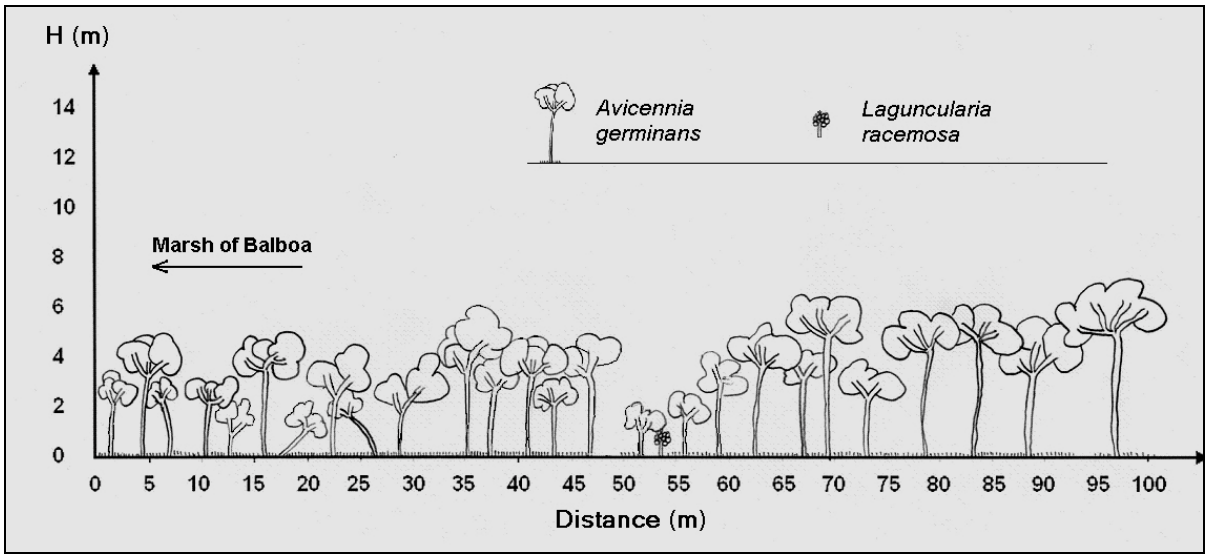

Figure 17. Profile of the mangroves at Balboa, Departamento de Atlántico, Colombia.

Figure 18. During the dry period, mid December to April, many of the small mangrove areas dry out which makes the soil crack and prevents higher development of mangrove. Marsh of Balboa, Departamento de Atlántico, Colombia.

Figure 19. The forest at Balboa is highly dominated by *Avicennia germinans*, the most common mangrove species in Departamento de Atlántico, Colombia.

4.1.6 Marsh of Manatíes

This area is dominated by mature trees of *Rhizophora mangle* (~52% IV) and *Avicennia germinans* (~39% IV). The transect (9 subplots) started close to the marsh and ended 90 metres inland with a fence separating the mangrove from private property. At the private property no mangrove was present. A few *A. germinans* with heights of up to 3 m were found beyond the beginning boundary of the transect. These trees were rather small, with heights between 3 and 4.5 m. In the plot there were a total of 106 trees, of which approximately 60% had a DBH of 10 cm or more. Most of the *A. germinans* present grew in the first 20 m of the transect (Figure 21). After 20 m there was a clear change, as *R. mangle* becomes the dominating species (Figure 22). Many *R. mangle* trees in the area had heights around 13 m, with stilt roots that were 3-4 m high. All *R. mangle* with a DBH greater than 10 cm grew in subplots 3-8 (20-80 m) of the transect. *R. mangle* were only represented by juveniles in the

first 20 meters of the transect. This was not consistent in the whole area, as many big *R. mangle* trees were growing in the zone closest to the marsh. In the last subplot grew three big trees of *Conocarpus erectus* (~6% IV). The largest had a DBH of 34.4 cm. The only individual present of *Laguncularia racemosa* (~2% IV) was a juvenile and the species was not important in the area.

The average height of the trees was about 8.6 meters. The density was almost 1200 trees/ha, and the basal area coverage was about 16 m^2/ha (Table 7). Organic matter in terms of fallen leaves was abundant throughout the plot, with higher amount in subplot 6 and 7. The soil contained 9.18% organic matter in the first subplot and 35.94% in the last subplot. The last 20 meters was terrestrial and therefore the data for salinity, temperature and pH were only taken at the start (subplot 1) and 50 meters into the plot (subplot 5). The temperature ranged between 25.4 Cº (subplot 1) and 26.7 Cº (subplot 5). Salinity was between 28‰ (subplot 1) and 12‰ (subplot 5). pH ranged between 7.4 and 7.1.

Table 7. Data of the inventoried mangrove stand at Manatíes, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of Individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)			
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Conocarpus erectus	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
4	13,04	46	60	1178	1,5721	0,2153	1,3568	8,59	6,26	39,25	2,08	54,41

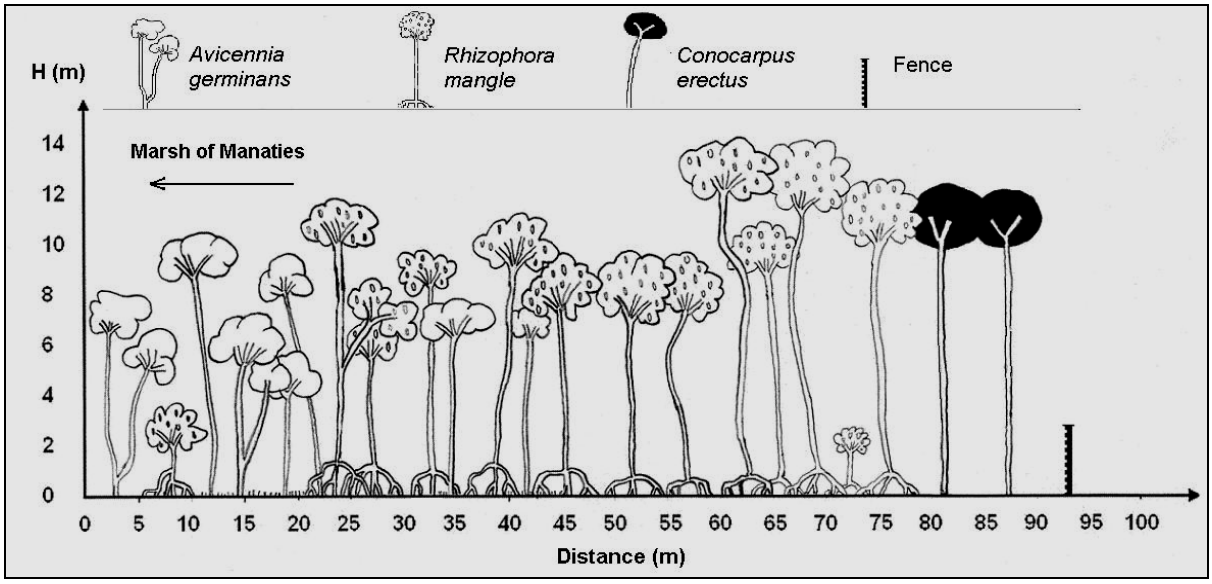

Figure 20. Profile of the mangroves at Manatíes, Departamento de Atlántico, Colombia.

Figure 21. *Avicennia germinans* dominates the parts closest to the marsh in the transect at Manatíes, Departamento de Atlántico, Colombia.

Figure 22. The best developed stands of *Rhizophora mangle* in Departamento de Atlántico, Colombia are found at Manatíes.

4.1.7 Marsh of Mallorquin, [1]

This part of the Mallorquin mangroves was clearly affected by erosion of the coastline (Figure 24). At the time of the inventory (March 7, 2006), the distance between the sea and the mangrove was 17 meters. The high abundance of tilted trees and trees that were lying on the ground characterised the area. In the subplots 5, 6 and 7, over 60% of the trees were tilted or lying on the ground. For the plot as a whole, this proportion was 27.5%. The branches of the lying trees often reached heights of 6-7 meters and could be mistaken as individual trees if viewed from a distance (Figure 25). Around 18% of the trees in the plot had been cut down, the highest numbers being found in subplot 2 where 23 trees had been cut.

In the first seven subplots, *Avicennia germinans* (55.44% IV) and *Laguncularia racemosa* (~36% IV) were the dominating species. There was a change in the last 30 meters of the plot, where *A. germinans* became clearly dominant, with several specimens reaching a height of 9-10 meters. *Rhizophora mangle* (~8% IV) was represented by 10 trees, but was not found in the final 40 meters of the plot. The largest *R. mangle* had a DBH of 8 cm and a few reached a height of 6 meters.

The basal area coverage for the plot was about 16 m^2/ha and the density 2650 trees/ha. The average tree height was almost 6 m (Table 8). The organic content was 8.27% at the start of the plot and 7.70% in the last subplot. The salinity was 29.5‰ in the first subplot and 9‰ in the last subplot.

Table 8. Data of the inventoried mangrove stand at Mallorquin [1], Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)		
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
3	8,84	198	67	2650	1,6285	0,6665	0,962	5,82	55,44	36,22	8,34

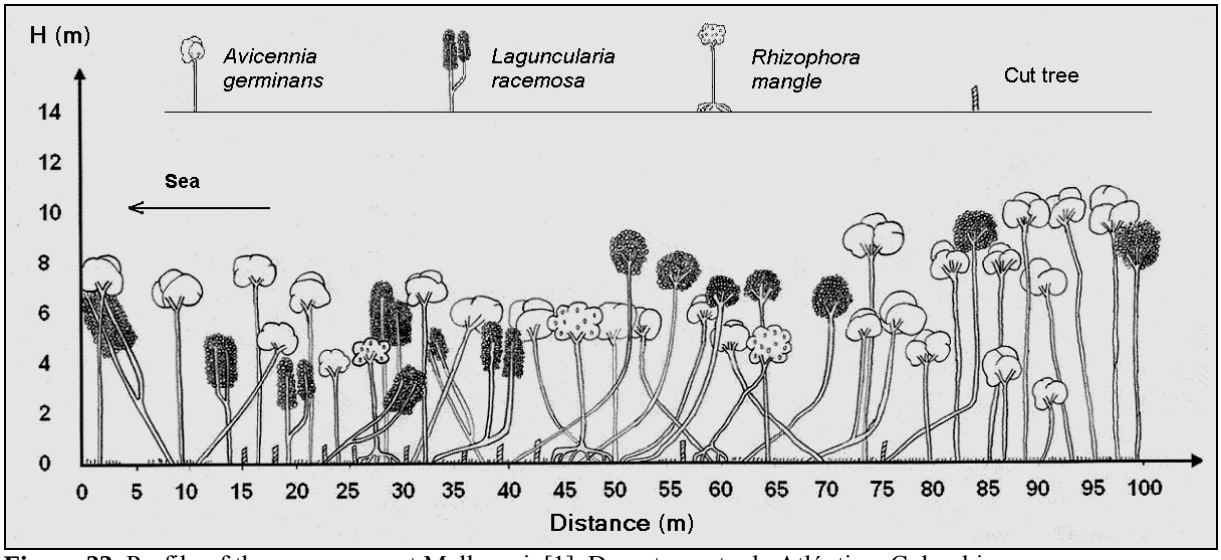

Figure 23. Profile of the mangroves at Mallorquin[1], Departamento de Atlántico, Colombia.

Figure 24. The high-energy waves at the coastline cause great erosion in the marsh of Mallorquin. Photo is taken at Mallorquin[1], Departamento de Atlántico, Colombia.

Figure 25. At Mallorquin[1], a high proportion of the forest was lying down. From a distance the branches of the trees lying down can be mistaken as individual trees. Departamento de Atlántico, Colombia.

4.1.8 Marsh of Mallorquin, [2]

The forest was strongly dominated by *Avicennia germinans* (~92% IV) (Figure 27). The few trees that were found of *Laguncularia racemosa* (~5% IV) and *Rhizophora mangle* (~3% IV) were all juveniles. The forest was well developed with 44% of the trees present having a DBH greater than 10cm. The site had the highest coverage of basal area of all plots in the study; 18.61 m^2/ha. The density of trees was approximately 2000 trees/ha (Table 9). 51 cut trees were found, which corresponded to 20% of the stand. Trees that had been cut down were almost equally distributed throughout the plot.

In the first 40 meters of the plot the tallest trees reached beyond 8 m. Further into the plot the stand became more mature with higher specimens. The tallest individuals were found in the last subplot and reached 12 m. The average height of the stand was about 7 m. The ground was covered with pneumatophores of 30-40 cm height. The salinity ranged from 30.0‰ (March 14, 2006) close to the marsh to 10.0‰ at the end of the plot. The organic matter in the soil constituted 16.98% in the first subplot and 9.42% in the last subplot.

Table 9. Data of the inventoried mangrove stand at Mallorquin [2], Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)		
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
3	10,83	113	89	2020	1,8608	0,3918	1,469	6,97	92,2	5,24	2,56

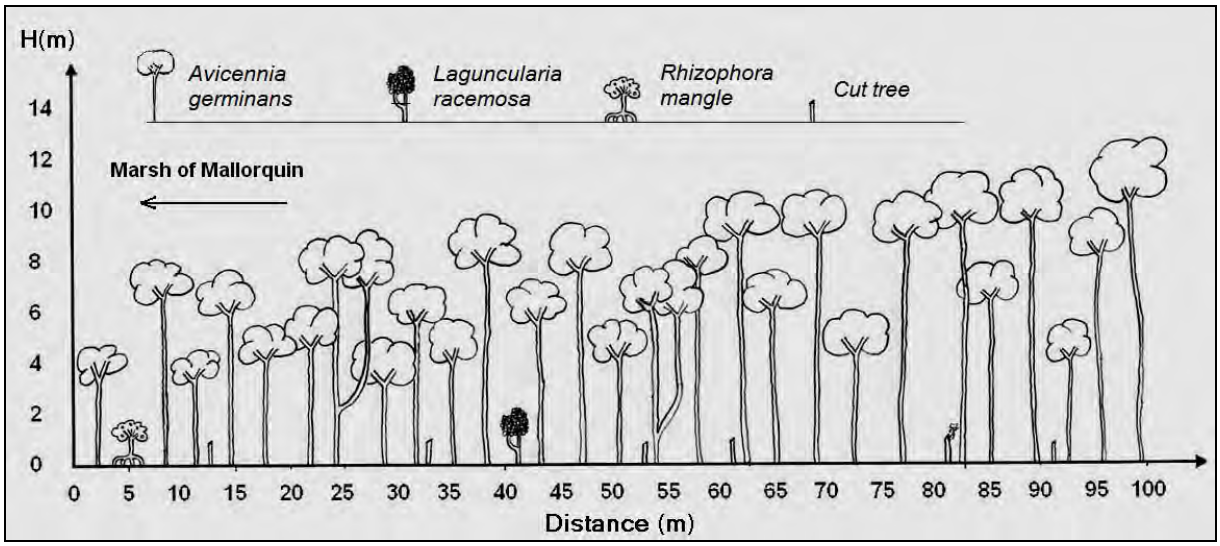

Figure 26. Profile of the mangroves at Mallorquin[2], Departamento de Atlántico, Colombia.

Figure 27. The *Avicennia germinans*-dominated forest at Mallorquin[2] has the highest coverage of basal area of all sites in the study. Departamento de Atlántico, Colombia.

Figure 28. The mangrove ecosystem at Mallorquin is a source of food production for the local people. The picture shows a man searching for crabs. Mallorquin[2], Departamento de Atlántico, Colombia.

4.1.9 Marsh of Mallorquin, [3]

This area was dominated by *Avicennia germinans* (~93% IV). The plot had a total of 136 trees with a diameter greater than 2.86 cm. 135 of these trees were *A. germinans,* of which 31% had a DBH greater than 10 cm. The only exception was a specimen of *Rhizophora mangle* (~4% IV) found in subplot 2, with a height of 4 meters and a DBH of 3.5 cm. *Laguncularia racemosa* (3.33% IV) was only represented by one juvenile in subplot 3.
The ground was covered with pneumatophores of *A. germinans* with a general height of 30-40 cm. The salinity ranged from 51‰ (March 13, 2006) close to the marsh to 66‰ at the end of the transect. This area had the highest salinity recorded in the study. The tallest trees were 8.5 meters, and the average height for the stand 5.95 m. The basal area coverage was 12.02 m^2/ha and the density of trees 1360/ha (Table 10). The organic content of the soil was 9.42% at the beginning of the transect and 10.04% at the end.

Table 10. Data of the inventoried mangrove stand at Mallorquin [3], Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)		
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
3	10,61	94	42	1360	1,2023	0,3331	0,8692	5,95	93,06	3,33	3,61

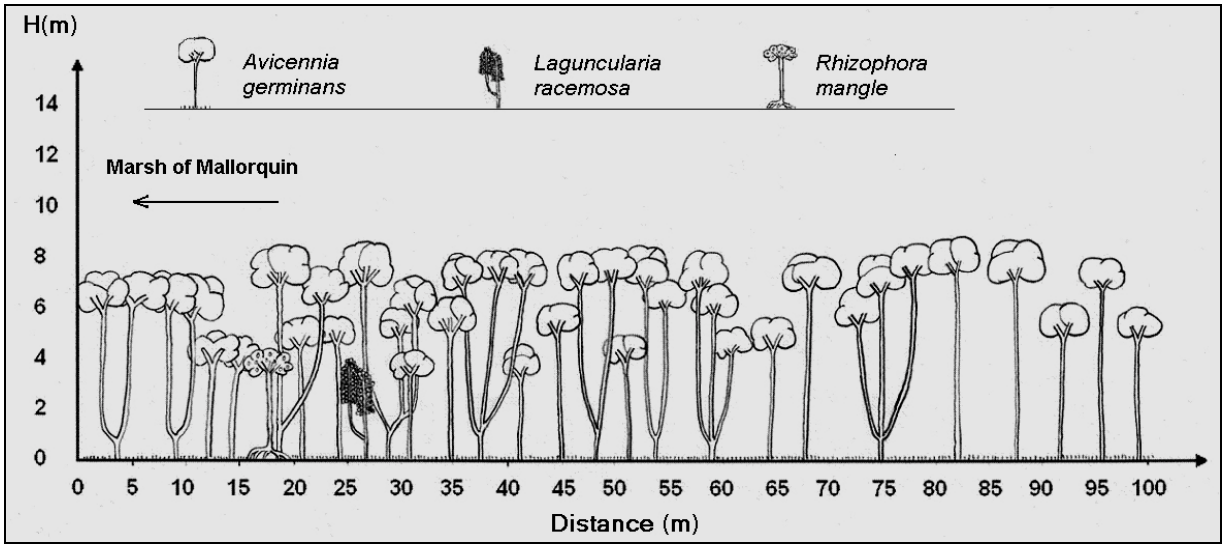

Figure 29. Profile of the mangroves at Mallorquin[3], Departamento de Atlántico, Colombia.

Figure 30. Mallorquin[3] had the highest salinity of the sites in the study. The area is dominated by the high salinity tolerant species *Avicennia germinans*. Departamento de Atlántico, Colombia.

Figure 31. Ground coverage by pneumatophores (aerial roots) of *Avicennia germinans.* Mallorquin[3], Departamento de Atlántico, Colombia.

4.1.10 Marsh of Mallorquin, Tajamar

The belt of mangrove between the marsh and the constructed river bank, Tajamar, was 75 meters wide. The first 25 meters consisted of very dense transplanted *Rhizophora mangle* (Figure 35). This transplantation was made in November 2002. Hence at the time of the inventory the transplanted trees had an age of 3.5 years, with a general DBH of 4.2 cm and a medium height of 7 meters. The survival percentage of these trees was approximately 90%, and the density of the transplanted trees was as high as 9000/ha. The natural mangrove stand density in the plot was 560 trees/ha (transplanted area excluded). The site was the least dense area in the study.

25 meters into the transect, the forest was mature with well-developed specimens of *R. mangle* (~91% IV). Even though the canopy is rather closed, it has some openings through

which light can penetrate to the ground. In these openings many seedlings were observed. The density of seedlings in the plot varied between six seedlings/m^2 in subplot 4 to eleven seedlings/m^2 in subplot 6. This area had the best natural regeneration observed in the study. Many *R. mangle* trees had more than one stem, and the most extreme example was found in subplot 6, with one individual tree having nine stems. The tallest trees reached 11 meters, and the average height in the transect was 7.20 m. The basal area coverage was 14.33m^2/ha.

The two individuals of *Avicennia germinans* (~4% IV) were found in subplot 6, and in the last subplot five small *Laguncularia racemosa* (~4% IV) were present. The organic matter in the soil were 13.32% at the start of the transect and 6.7% at the end. The salinity at the start of the transect was 19.5‰ and 16.0‰ in the last subplot. The temperature ranged from 26.3 Cº to 26.6 Cº.

Table 11. Data of the inventoried mangrove stand at Tajamar, Departamento de Atlántico, Colombia.

No. of Species	Mean Stand Diam. (cm)	No. of individuals		Density	Basal Area (m2/0,1 ha)			Height (m)	Importance value (IV)		
		2,86-10 cm	>10 cm	Ind >2,86/ha	Total	2,86 - 10 cm	>10 cm	Average	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
3	7,14	9	18	540	1,4329	0,0481	1,3848	7,2	8,25	11,21	80,54

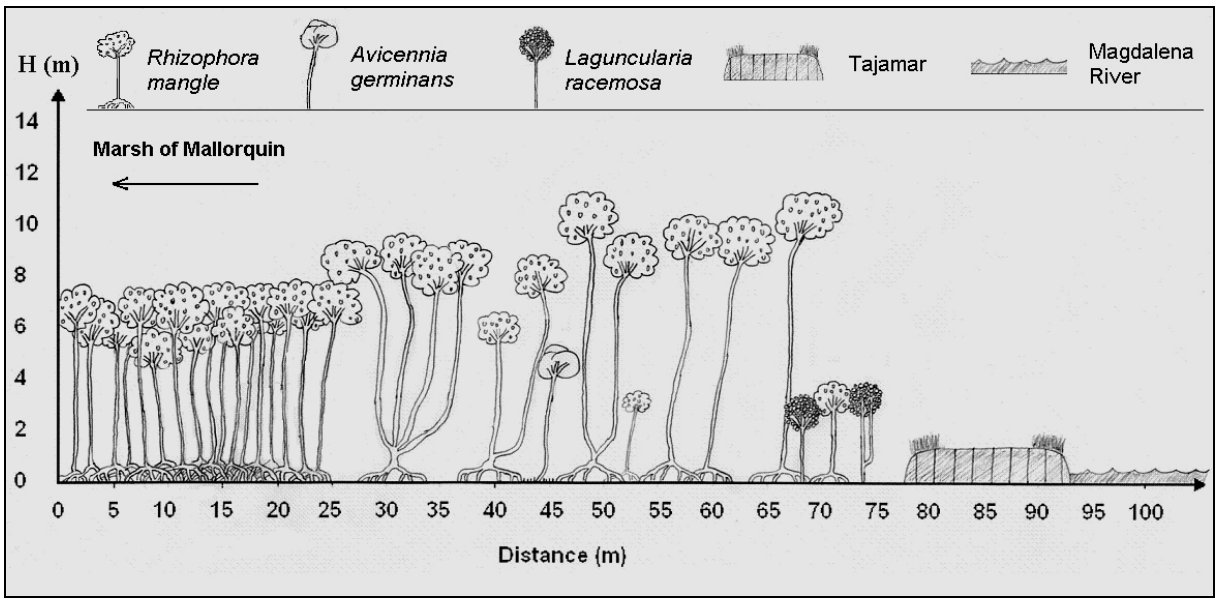

Figure 32. Profile of the mangroves at Tajamar, Departamento de Atlántico, Colombia.

Figure 33. Good developed *Rhizophora mangle* grows close to the bank of Tajamar. The species is favoured by the low salinity measured at Tajamar, Departamento de Atlántico, Colombia.

Figure 34. The transplanted *Rhizophora mangle* has a high survival rate at Tajamar, Departamento de Atlántico, Colombia.

Figure 35. Transplanted seedlings of *Rhizophora mangle* in the marsh of Mallorquin outside the inventoried plot at Tajamar, Departamento de Atlántico, Colombia.

Figure 36. The Tajamar bank makes it possible for big cargo ships to go up the Magdalena River. The photo is taken from the bank. Departamento de Atlántico, Colombia.

4.2 Dominating species

The dominating mangrove species in Departamento de Atlántico was *Avicennia germinans* (Black mangrove), which had an IV (Importance Value) of 26.48% or more in eight of the ten plots that were inventoried. At the marsh of Balboa and at Mallorquin [2] and [3], the IV of *A. germinans* was 92.2% or higher. *A. germinans* was also the dominating species at the marsh of Mallorquin [1] (IV of 55.44%). Furthermore, the rarest of the four mangrove species in Departamento de Atlántico, *Laguncularia racemosa* (White mangrove) had its tallest individuals, with heights over 9 m, and its strongest representation in this area with an IV of 36.22%. The influence of *L. racemosa* was only strong in one other location, Puerto Velero, with an IV of 29.29%. *Conocarpus erectus* (Buttonwood) is present at five locations but only important in four; Totumo (IV 73.52%), Astilleros (IV 100%), Boca Tocino (IV 70.69%) and Puerto Velero (IV 34.16%). *Rhizophora mangle* (Red mangrove) was present at six sites but only important at Tajamar (IV 80.54%) and the marsh of Manatíes (IV 54.41%). For data of all sites, see Table 12.

Table 12. Data of the mangrove stands for the 10 inventoried sites in Departamento de Atlántico, Colombia.

Location	Species	Mean Stand Diam.	No. of trees		Density	Basal Area (m2/0,1 ha)			Height	Importance value (IV)			
	No.	(cm)	2,86-10 cm	>10	Ind >2,86/ha	Total	2,86 - 10cm	>10	Average (m)	Conocarpus erectus	Avicennia germinans	Laguncularia racemosa	Rhizophora mangle
Totumo	2	16,31	39	35	1233	2,5765	0,2242	2,3523	6,31		26,48		
Astilleros	1	9,91	40	10	833	0,6431	0,3323	0,3108	4,45	100			
Boca Tocino	2	14,47	26	21	783	1,2881	0,1799	1,1082	5,7	70,69	29,31		
Puerto Velero	4	5,82	108	1	1090	0,3033	0,0113	0,292	4,28	34,16	31,66	29,29	4,89
Balboa	2	5,29	190	3	1930	0,425	0,3962	0,0288	4,47		96,97	3,03	
Manaties	4	13,04	46	60	1178	1,5721	0,2153	1,3568	8,59	6,26	39,25	2,08	54,41
Mallorquin [1]	3	8,84	198	67	2650	1,6285	0,6665	0,962	5,82		55,44	36,22	8,34
Mallorquin [2]	3	10,83	113	89	2020	1,8608	0,3918	1,469	6,97		92,2	5,24	2,56
Mallorquin [3]	3	10,61	94	42	1360	1,2023	0,3331	0,8692	5,95		93,06	3,33	3,61
Tajamar	3	17,14	9	18	540	1,4328	0,0481	1,3848	7,20		8,25	11,21	80,54

4.3 Maturity of mangrove stands

The best developed stands were found at Totumo, Tajamar, Manatíes and Mallorquin. Totumo had the biggest basal area coverage of the studied plots, with 25.76 m^2/ha, followed by Mallorquin [2] (18.61m^2/ha), Mallorquin [1] (16.28 m^2/ha) and Manatíes (15.72m^2/ha). Tajamar had the largest mean stem diameter with 17.14 cm, followed by Totumo, 16.31 cm, Boca Tocino, 14.47 cm and Manatíes with 13.04 cm. Manatíes had the highest average tree height of 8.59 m. Manatíes has Atlántico's tallest individuals of *R. mangle* (14 m) and *C.*

erectus (12 m). The stand of Tajamar had the second tallest average height, 7.20 m. The tallest individual of *A. germinans* had a height of 17 m, found in Totumo. The average height of this stand was 6.31 m.

The mangrove formation at Puerto Velero was not well developed. However this was the only location where all four mangrove species found in Departamento de Atlántico were present. With a mean stand diameter of 5.82 cm, the smallest basal area coverage, 3.03 m^2/ha and the shortest average tree height, 4.28 m, it looked more like a brushwood than a forest. Balboa had similarly low development with a mean stand diameter of 5.29 cm, a basal area coverage of 4.25 m^2/ha and an average tree height of 4.47 m. Although the stand diameter of the plot at Astilleros was 9.91 cm, it had low development with a basal area coverage of 6.42 m^2/ha and an average tree height of 4.45 m. For data of all sites, see Table 12.

4.4 Densities of trees

The highest densities of trees with a diameter >2.86 cm were at Mallorquin[1] (2650/ha), Mallorquin[2] (2020/ha) and Balboa (1930/ha). Tajamar had the lowest density of trees (560/ha). For data of all sites, see Table 12.

4.5 Mangrove associates

Not many mangrove associated plants were found in the inventory. *Lemna minor* (Common Duckweed) was found in the Marsh of Totumo. In Astilleros, *Sesuvium portulacastrum* (Sea purslane) was common and a few individuals of *Capparis* sp. were present. *Batis maritima* (Turtleweed) was found in Astilleros and Boca Tocino.

4.6 Abiotic factors

This inventory was carried out during the dry season. Therefore some of the mangrove areas were dry and no interstitial water was present at a depth of 70 cm. As a consequence, no salinity, pH or water temperature could be measured at those sites. Astilleros, Boca Tocino, Puerto Velero and Balboa were all dry during the study period.

The samples from Astilleros, Boca Tocino, Puerto Velero and Balboa all had organic content of less than 10 %. A higher content of organic material were found at Tajamar and parts of Mallorquin, even though all tests did not confirm this. The soil of Manatíes had the highest percentage of organic matter. For data on organic content in soil, see Table 16.

Table 13. Water salinity of inventoried sites in the Departamento de Atlántico, Colombia, with interstitial water at depths lower than 70 cm.

Location	Salinity (‰) start/end
Totumo	11.0 / 11.0
Manaties	28.0 / 12.0
Mallorquin[1]	29.5 / 9.0
Mallorquin[2]	36.0 / 10.0
Mallorquin[3]	51.0 / 66.0
Tajamar	19.5 / 16.0

Table 14. Water pH of inventoried sites in the Departamento de Atlántico, Colombia, with interstitial water at depths lower than 70 cm.

Location	pH
	start/end
Totumo	7.1 / 7.2
Manaties	7.4 / 7.1
Mallorquin[1]	8.2 / 8.1
Mallorquin[2]	8.0 / 8.0
Mallorquin[3]	8.1 / 8.0
Tajamar	8.2 / 8.1

Table 15. Water temperature of inventoried sites in the Departamento de Atlántico, Colombia, with interstitial water at depths lower than 70 cm.

Location	Temperature (°C)
	start/end
Totumo	27.0 / 27.0
Manaties	26.4 / 26.7
Mallorquin[1]	27.2 / 28.0
Mallorquin[2]	26.4 / 26.7
Mallorquin[3]	26.9 / 27.4
Tajamar	26.2 / 26.5

Table 16. Percentage of organic content in soil at the 10 sites investigated in Departamento de Atlántico, Colombia. Samples were taken at the beginning and at the end of each transect.

Organic content in soil (%)		
	start	end
Totumo	11.35	8.19
Astilleros	7.74	8.30
Boca Tocino	5.99	6.83
Puerto Velero	0.84	2.23
Balboa	7.85	2.02
Manaties	9.17	35.93
Mallorquin[1]	8.27	7.70
Mallorquin[2]	16.98	9.42
Mallorquin[3]	9.42	10.04
Tajamar	13.32	6.7

5. Discussion

In general the mangroves of Departamento de Atlántico consist of small, often isolated patches, with low maturity. The total mangrove area is estimated to be 613 hectares (INVEMAR, 2005). The best developed forests are found in the marshes of Manatíes and Mallorquin. Areas like Astilleros, Boca Tocino, Balboa, and Puerto Velero are characterised by small isolated mangrove stands. These isolated pockets are close to the coastline, near small coastal marshes or temporary marshes that only experience some freshwater fluxes during the rainy season. These temporary marshes allow the growth of small patches of mangrove vegetation along many parts of the coast of Departamento de Atlántico. In addition a number of disturbance factors result in the low development of these areas. The most critical factor is probably the deficit of water, as the evaporation (1677 mm/year) is twice as high as the precipitation (825 mm/year) (INVEMAR, 2005). However, the low tidal level (≈50 cm) of this part of the Caribbean Sea and the high temperatures (annual average 28º C), also make the Caribbean zone a difficult area for optimum mangrove development. Salinity, temperature, and rainfall are environmental factors that strongly influence the distribution, growth and survival of mangroves (Blasco, 1984).

The construction of Tajamar has caused great coast erosion problems and a total change of the ecosystem in the Marsh of Mallorquin (Suárez, 2001). The change is still on-going and parts of the Mallorquin marsh is disappearing each year. Also the nearby marsh of Manatíes is affected by erosion. In the past, the sediment rich water fed the delta with sediment, but now this sediment enters into the deep sea instead (Figure 37). In some parts of the marsh the erosion is more than 60 m per year. The total land loss between 1968 and 2005 in the marsh of Mallorquin was 1222 hectares, divided into 212 hectares of mangrove, 439 hectares of water covered land, and 571 hectares of sand (Jaramillo, 2005). The sediment from the Magdalena River is now transported to the coast west of Barranquilla towards Cartagena and causes sedimentation on some of the coral reefs along the coast (Juan Carlos Pino Renjifo, personal information).

Figure 37. The constructed bank Tajamar has caused great erosion in the marshes of Mallorquin and Manatíes. The total land loss between 1968 and 2005 in the marsh of Mallorquin was 1222 hectares The satellite photo shows how sediment rich water from the Magdalena River that earlier fed the marsh with sediment now enters into the deep sea at "Bocas de Ceniza". Departamento de Atlántico, Colombia.

5.1 Zonation patterns

Most of the investigated areas show some structural zonation patterns. Trees of slightly lower height and smaller stem diameter have a higher representation closer to the sea or marsh, than trees in the centre of the stands. This structural pattern was most obvious at Manatíes, Puerto Velero, Balboa and at the four plots bordering the marsh of Mallorquin.

Species zonation patterns, with bands of monospecific tree stands parallel to the shoreline, which is the typical feature in undisturbed mangrove forests (Thom; 1967, Rabinovitz, 1978; Ball, 1980 among others), are less common in the Caribbean Sea and do not occur in Departamento de Atlántico. According to Smith III (1992), West (1956) was unable to find this kind of mangrove zonation in the Atlantic coast of Colombia. Even though the influence of man is probably the most important factor that shapes mangrove distribution today, many other factors affect their distribution (Macintosh, D.J. and Ashton, E.C., 2002). These factors include soil type, geomorphology, availability of minerals, soil aeration, winds, currents, wave action and tides. They all affect the distribution of mangroves at a local level (Robertson and Alongi, 1992).

Rhizophora mangle is often mentioned in species zonation patterns as the species that dominates in border areas or coastal areas of a mangrove forest (Kin and Sternberg, 1992). A reason for this is their physiological adoptions in the form of stilt roots that makes it possible for them to survive in deeper water. *Avicennia germinans* on the other hand must have its aerial roots exposed to the atmosphere at least during periods of low tide. One reason for the absence of any species zonation pattern in Departamento de Atlántico is probably the small difference between low and high tide of the Caribbean Sea.

In the most important and largest marsh in Departamento de Atlántico, Mallorquin, there are large areas where *A. germinans* is the dominating species facing the sea. This is not the natural condition. But due to the construction of Tajamar, which prevented fresh water from the Magdalena River to enter the marsh and led to hyper saline water conditions, all individuals of *R. mangle* died. At the initiative of fishermen, channels were later constructed under the Tajamar bank to connect the river with the marsh. The marsh now receives some fresh water through these channels. As a result, recolonisation of *R. mangle* has been taking place along the bank of Tajamar. Most of the other stands of *R. mangle* in the marsh have been transplanted.

In this study three different species were found close to the sea at different locations. *Conocarpus erectus* is the species closest to the sea at the sandy sites of Boca Tocino and Puerto Velero. These areas are both dry during the dry season and rarely or never flooded by sea water. *Avicennia germinans* is the species closest to the sea in Balboa and in Mallorquin[1], [2] and [3], while *Rhizophora mangle* is the species closest to the marsh at Tajamar, occurring naturally and transplanted. At Manatíes, *A. germinans* was dominating the first 20 meters of the transect, although *R. mangle* was the dominating species close to the sea at other sites of Manatíes.

5.2 Densities and development

High stem density, but low heights and basal areas are, according to Pool *et al.* (1977), often found in arid regions of the Caribbean zone and indicate low complexity. The least complex

and most dense mangrove segments in Departamento de Atlántico are in Puerto Velero and Balboa. Most of the trees in those areas have diameters <2.86 cm. Even though the majority of trees in these areas have thin stems, it does not necessarily indicate low age. Probably it is a result of long periods of drought. However, low organic content in the soil may also explain the low complexity and development of the stands in Puerto Velero and Balboa. The result indicates that Mallorquin[1] and Mallorquin[2] have the highest density of trees, but these statistics refer only to stems greater than 2.86 cm. In Departamento de Atlántico it appears that only the marshes of Mallorquin and Manatíes have the type of soil and fresh water fluxes that are necessary for the development of more complex mangroves. The stand with the largest mean stand diameter, 17.14 cm, is found at Tajamar in the Marsh of Mallorquin.

5.3 Abiotic factors

5.3.1 Salinity tolerance

The lowest salinity measured in Mallorquin was at Tajamar (19.5 ‰), and this is probably why *Rhizophora mangle* is dominating this area. The reason for the lower salinity in this part of the marsh is the fluxes of fresh water coming through channels under the Tajamar bank from the Magdalena River. It is of great importance to keep these channels from the river open to avoid high salinities, which would harm the R. *mangle* stand. *R. mangle* is tolerant to salinities up to 65 ‰ (Macnae, 1968; Teas, 1979 in Macinosh & Ashton, 2002), but it appears that optimum salinity conditions for seedlings of *R. mangle* are lower than regular seawater (35 ‰) (Smith and Snedaker, 1995).

The highest salinity in the study (66 ‰) was noted at Mallorquin[3] and this area is totally dominated by *Avicennia germinans*, the most salt tolerant of the four species in Departamento de Atlántico. It tolerates salinities up to at least 90 ‰ (Cintrón & Schaeffer 1984a). *Laguncularia racemosa* is tolerant to salinities lower than approximately 70 ‰ (Cintrón & Schaeffer 1984a).

The stand at Totumo is dominated by *Conocarpus erectus*. *C. erectus* is not considered to be a true mangrove species due to its lack of mangrove characteristics and low tolerance to salinity. According to Cintrón & Schaeffer (1984a) it needs salinities lower than 5‰ to be able to form monospecies stands. The Marsh of Totumo is now clearly influenced by low salinity since the permanent connection with the sea has been blocked. According to the interview with Roberto Cortina in Loma Arena, the number of fresh water oysters has been increasing in the marsh. Parts of the water surface in the investigated plot were covered by *Lemna minor* (Common Duckweed), which indicates constantly low salinity. A salinity higher than 16.65‰ is toxic to *Lemna minor* (Haller, W.T. et. al, 1974). The mangrove forest at Totumo consists of *C. erectus* and *A. germinans.* All *A. germinans* in the area are mature trees and no regeneration could be found, except for some vegetative regeneration from stems. The influence of *A. germinans* will probably be weaker in the future because the disadvantage of competing with *C. erectus* which is more favourable by low salinity.

5.3.2 Water temperatures

The water temperature was normal at all sites, ranging between 26.2 and 28.0 ºC and does not have any influence on the distribution of the mangrove. However, in shallow and un-shaded areas, the water temperature often reaches above 40 ºC. Together with direct sun light it would definitely have a negative effect when transplanting mangrove.

5.3.3 pH

Seawater is slightly basic (alkaline) with pH ranging between 7.5 and 8.4, and due to its buffering capacity the variation in pH is smaller then in fresh water (Bydén, S et. al., 2003). The pH values measured in the study were normal and ranged between 7.1 and 8.2. Totumo and Manatíes were the only two locations where the pH was below 8. Those two locations certainly have the highest input of fresh water, which explains the lower pH. The pH values measured in the study were as expected slightly basic. Most probably it does not have any influence on the distribution or composition of mangrove species in the area.

5.3.4 Organic content in soil

The shores of Departamento de Atlántico are in general sandy. The results of the analysis of organic content in soil confirm this. In the Caribbean region, *Laguncularia racemosa* often colonize low energy sites, protected by coral reefs were the soil has a high content of dissolved limestone, but also flat beaches with sandy soil. This kind of soil, with a high percentage of sand is also suitable for *Avicennia germinans*, which is the most common mangrove species in Departamento de Atlántico. *A. germinans* is often found further into the mangrove stand with sandy and compact soils. *A. germinans* is also very common in sites where the land has increased due to sedimentation.

Rhizophora mangle prefers muddy soils with a high content of organic matter, rich in detritus. This detritus layer can be more than one meter deep at the Caribbean coast (Juan Carlos Pino Renjifo, personal information). Of the three true mangrove species in Departamento de Atlántico, *R. mangle* is the one that prefers the highest organic content in the soil; 49.26 % ± 8.05 (Cintrón & Schaeffer, 1984a). The results of the analysis of organic matter in soil indicate that, as the two sites with the highest content of organic matter in the soil, Manatiés and Tajamar, were dominated by *R. mangle*.

5.4 Mangrove associates

According to Macintosh & Ashton (2002), mangrove associates never grow in true mangrove communities and the result of the inventory seem to confirm this. None of Totumo, Astilleros or Boca Tocino, the three locations where other types of plants were found, had well developed mangrove communities. A reason for the scarcity of mangrove associates and limited understory vegetation is probably the scarcity of rainfall, particularly during the dry period (Jan-Apr) in this part of the Caribbean. In areas with year-round rainfall and freshwater runoff a higher number of mangrove associates can be found (Tomlinson, 1986). The inventory does not cover all mangrove areas in Departamento de Atlántico and other associates may be present. In the inventory made by INVEMAR (Instituto de Investigaciones Marinas) in 2005, *Typha domingensis* (Southern cattail) was found in the mangroves of Mallorquin and Totumo. *T. domingensis* is common in areas influenced by high input of freshwater, especially in the rainy season when the salinity decreases. (Juan Carlos Pino Renjifo, personal information).

5.5 Restoration in Departamento de Atlántico

The marsh of Totumo has been mentioned as a suitable area for mangrove restoration. But the possibility whether or not the marsh is going through a natural transformation to become a fresh water marsh or if canals should be constructed to connect it with the sea needs to be

further investigated and discussed. Sites suitable to carry out restoration programs are in Mallorquin, Manatíes and Astilleros. At those locations there is natural regeneration, the right kind of soil and sufficient fresh water input. In some cases it would be necessary to open canals to improve the environmental conditions or reconnect water fluxes to allow optimal conditions.

Preventing erosion at Mallorquin and Manatíes is a very important but difficult task. The construction of the bank between the Magdalena River and its natural estuary has cut the feeding of sediment from the river into the marsh of Mallorquin. The bank is indirectly the cause of the erosion problems in the area even though it is the strong waves that are the direct reason for the decrease of the marsh. To replant mangrove at the high-energy sites where the erosion occurs would not be successful as the plants would not be able to establish. The option to prevent further erosion could be to build underwater wave-breakers or revetments. Berg et. al. (1998) give a detailed analysis of replacement costs to prevent erosion in Sri Lanka. Their analysis shows average costs between US$ 246 000 and US$ 836 000/km. Replantation in low-energy parts of Mallorquin has in most cases been highly successful. But to sustain the marsh of Mallorquin as an important food-producing ecosystem, further erosion has to be prevented.

Figure 38. An area that earlier was used for salt extraction could be suitable for restoration. Astilleros, Departamento de Atlántico, Colombia.

Parts of the area at Astilleros that earlier were used for salt extraction (Figure 38), were after the rainy season 2006 naturally colonised by *Avicennia germinans* juveniles. These plants could not survive the dry season. To achieve a good result of restoration at Astilleros it would be necessary to ensure a satisfactory hydrology in the area. This could lead to a natural establishment of mangrove.

When restoring mangrove vegetation, a variety of species should be planted (Macintosh and Ashton, 2002). Until now, all transplantations that have been carried out in Departamento de Atlántico consisted only of *R. mangle*. Because of the strong dominance of *A. germinans* in Atlántico, this species should probably be included when transplanting mangrove. Transplantation in Departamento de Atlántico has to be done at the beginning of the rainy season to increase the survival rate of the plants. To achieve a satisfactory result in management planning and restoration projects it is important to have a close working relationship with local people and to promote a sense of ownership to the area they live in (Macintosh and Ashton, 2002). According to the result of the interviews (Part II) the local fishermen are interested in mangrove restoration projects.

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Part II:
THE FISHERMAN'S PERSPECTIVE

Abstract

To achieve positive results in mangrove restoration projects it is of great importance to involve people living in the area where the restoration will take place. Many times local people hold unique information about the area and its history. In this study, six fishermen living in different parts of the coast of Departamento de Atlántico in Colombia were interviewed. The fishermen were interviewed about the function of the mangrove vegetation and the management of mangroves. Examples of discussed topics were the relation between mangroves and fish catch, change in mangrove coverage and fish catch changes.

The interviewees showed good knowledge about the interaction between mangrove and the reproduction of fish. According to the fishermen, the population of fishermen has increased in five of the six locations, which has led to a higher pressure on fish resources. Mangrove swamps used to cover a bigger area at Loma Arena, Astilleros, Puerto Colombia, La Playa and Las Flores. The results indicate great decline in fish resources, reduced mangrove areas and problems with coastal erosion. All interviewees were positive about mangrove replantation projects.

Resumen

Para obtener resultados positivos en el desarrollo de proyectos de restauración de manglares es de gran importancia involucrar a la comunidad local. Muchas veces los habitantes locales tienen información muy importante sobre el área y la historia de la misma. En este estudio se entrevistaron 6 pescadores habitantes de diferentes áreas de la línea costera del departamento del Atlántico en Colombia. Los pescadores fueron entrevistados sobre las funciones de la vegetación de manglar y el manejo de los manglares. Algunos ejemplos de temas discutidos fueron la relación entre los manglares y la captura de peces, los cambios en la cobertura de manglar y su relación con los cambios en la captura de peces. Los entrevistados mostraron buen conocimiento sobre las interacciones entre el manglar y la reproducción de los peces. De acuerdo con los entrevistados la población de pescadores ha aumentado en cinco de las seis áreas. Los manglares cubrían una mayor extensión en Loma Arena, Astilleros, Puerto Colombia, La Playa y las Flores. Los resultados muestran una gran disminución en el recurso pesquero, reducción de las áreas de manglar y problemas de erosión costera. Todos los entrevistados tuvieron una actitud positiva sobre el proyecto de restauración del manglar.

1. Introduction

A considerable part of the local communities in Departamento de Atlántico depend on fishery and the extraction of various products from the mangrove forest. Part of the poverty currently affecting these communities can certainly be attributed to overfishing and to the deterioration of the mangrove ecosystems. This deterioration also leads to decreasing fish catches. The lack of opportunities to make a living in other fields makes more people move to the coastal zone, increasing the competition for fishery resources.

2. Aim of the interviews

The aim was to collect more information about the situation for the people depending on the products and services provided by the mangrove ecosystem. In addition the purpose was to learn about the knowledge these people have about the mangrove ecosystem. In order to succeed with the study it was important to find fishermen with great local experience in living in the area to obtain information about environment changes, fish catch changes, and their opinion about mangrove restoration.

3. Methods

In-depth interviews were conducted with six fishermen living in different areas along the coast of Atlántico. Those areas were Loma Arena (Marsh of Totumo), Astilleros, Puerto Velero, Puerto Colombia, La Playa (Mallorquin) and Las Flores (Mallorquin). The questions were asked in a neutral way to avoid influencing the interviewees in a certain direction. The interviews lasted between 28 and 55 minutes. All interviews were made in Spanish and recorded for later translation into English. The persons interviewed were not informed in advance about the interviews. They were all asked in the field to participate in the interviews. The complete interviews are set out in appendix 2.

4. Results

All fishermen that were interviewed held the opinion that mangroves are something important or very important. All six interviewees said that mangroves are necessary for many species of fish, and one also discussed the importance of mangrove as an effective protection against coast erosion. One of the fishermen did not point out any certain fish species as depending on mangrove, but believed that the lack of mangrove was the main reason for declining fishery resources. Five fishermen mentioned *Centropomus* sp. (Snook) to be dependent on mangrove ecosystems. Furthermore four interviewees expressed the opinion that mangroves are crucial for *Megalops atlanticus* (Tarpon), while three fishermen were of the opinion that *Eugerres plumieri* (Striped mojarra), *Mugil liza*, (Lisa) and *Mugil incilis* (Parassi mullet) depended on mangroves.

Figure 1. Santander Caraballo told about his experiences as a fisherman. Las Flores, Mallorquin. Departamento de Atlántico, Colombia.

Figure 2. Attaraya (Casting net) is the most common fishing equipment in the Marshes of Departamento de Atlántico, Colombia.

The fishermen of Loma Arena, Astilleros, Puerto Colombia, La Playa and Las Flores said that the mangrove swamps used to cover a bigger area. The fisherman at La Playa described how in the past the sea could not be seen from the village and that it took five hours to reach the sea through the system of many small marshes and extensive mangroves. Today however, the coastline is only about 1 km away, and there are no small marshes or mangrove in between it and the village.

In five of the six locations, the population of fishermen has increased. The only exception is Puerto Colombia. According to the interviewee, some fishermen from Puerto Colombia instead try to find job in Barranquilla because of the difficulties surviving as a fisherman. In Loma Arena the population has increased significantly, from around 400 inhabitants in the 1940's to 7000 today. The interviewed fisherman in Loma Arena stated that the number of fishermen in the Marsh of Totumo exerts very high pressure on the fishery resources.

At three of the sites, Loma Arena, Astilleros and Puerto Colombia, interviewees said they would like to see more motor boats to make it possible for unemployed people to make a living from fishing. However, one fisherman stated that the motorboat is one of many bad things that are used by man. Two interviewees named the big fishing industry as a main cause of the deterioration of fishery and claimed that harder laws for these companies are necessary. Another thing mentioned as destructive for the fishery and the fish reproduction was that the purchasers ask the fishermen to catch small fish because it is more profitable for purchasers to sell. Several fishermen expressed negative opinions about certain fishing equipment that harmed the fishery. The equipment mentioned as harmful was trasmallo (a kind of trawl) and nets that catch small sized fish. The most common way to fish in the marshes of Atlántico is to use a casting net, referred to as attaraya or chinchorro (Figure 2).

All fishermen had experienced a marked decline in the fish catches. They made very strong statements about decreasing number of fish and the smaller sizes. According to the fishermen the same negative trend is obvious for most of the species. The species where a particularly

negative trend was observed seem to be in *Mugil liza* (Lisa), *Megalops atlanticus* (Tarpon) and *Centropomus* sp. (Snook).

Mangrove restoration through replanting was suggested as an alternative by all the fishermen. The fisherman in Las Flores made a reservation as he stated that restoration is bad if it is just a political act with wrong motivations, but it is good if it is done by an independent organisation without economic purposes. Most positive reflections about restoration came from the interviewees at Astilleros, Loma Arena and La Playa. Restoration projects were carried out earlier in the Marsh of Mallorquin and according to the interviewee at La Playa with good results. The fisherman in Loma Arena believes that mangrove restoration is necessary for the area and for the people living there.

When discussing the future they are generally worried about declining fishery and the deterioration of mangrove ecosystems. The dilemma expressed by a few of the interviewed fishermen is that even if most people understand that the ongoing fishery is not sustainable, they do not have any choice at the moment as all people must find ways to feed their families. The full interviews can be read in appendix 1.

5. Discussion

The interviews show that fishermen in the area have a good understanding of the importance of mangrove ecosystems. They all had knowledge about different fish species that are associated to mangroves. That most inshore fish species and a majority of the commercial fishery are dependent on mangrove ecosystems has been shown in many studies (Macintosh, 1982; Untawale, 1986; Singh et al., 1994). One of many examples is from eastern Australia, where 67% of all commercial fish species caught are linked to mangrove (Hamilton and Snedaker, 1984).

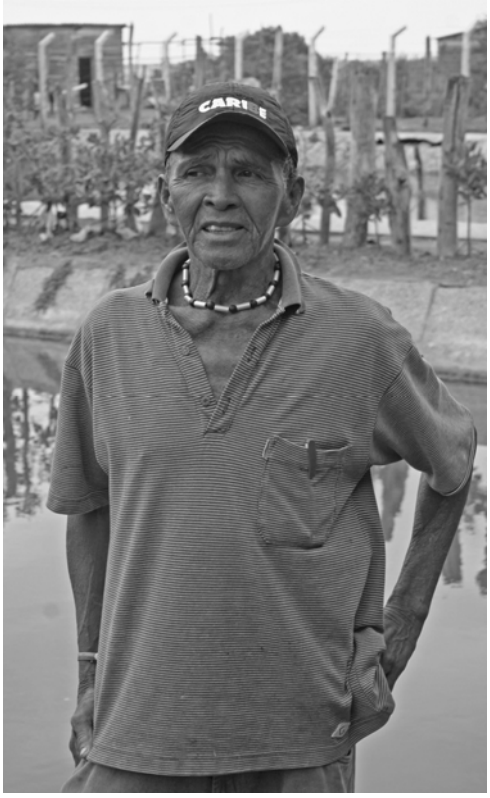

Figure 3. José M de la Rosa is positive to mangrove restoration projects and has good experience of earlier projects. La Playa, Mallorquin, Departamento de Atlántico, Colombia.

There seem to be various reasons for the declining mangrove coverage. In Totumo marsh, two reasons were mentioned. The first was that people from other areas have been cutting a lot of mangrove to produce charcoal. The other reason was that landowners had filled the edges of the marsh with soil to increase the pasture areas and this has reduced the area of the marsh. The transplantations of *Rhizophora mangle* that have been made in different parts of the marsh of Mallorquin have shown mixed but generally positive results.

At Mallorquin the interviewees named the construction of Tajamar as the major reason for mangrove coverage decline, along with the sediment filling at the edges of the marsh in order to increase the land.

It was encouraging to hear the positive views about mangrove restoration as it is of highest importance to involve local people in projects like mangrove transplantation. To achieve a satisfactory result in management planning and restoration projects it is important to have a close working relationship with local people and to promote a sense of ownership to the area they live (Macintosh and Ashton, 2002).

Scientists have published many reports about the alarming decline in the fishery resources (Pauly et al., 1998; Rogers and Beets, 2001; Hutchings and Reynolds, 2004, among others). The results of the interviews indicate a drastic change in sizes of fish as well as numbers of fish caught. Even though the mangrove ecosystem certainly is an extremely important factor for fish production it is not obvious that the destruction of the mangrove ecosystem alone can explain declining fish stocks. As a couple of the interviewees stated; big fishing fleets and politicians have a large responsibility in relation to the declining fishery resources. As suggested by two fishermen, stricter regulations and laws for commercial fishery could be a step in the right direction. According to the interviewees, the population of the coastal zone of Departamento de Atlántico has increased dramatically. More effective fishing equipment combined with increasing populations of people without a stable economic situation, and who only survive on what the nature produces also reduce the possibility of sustainable fishery. Some of the interviewees stated that a solution could be to provide more motorboats to solve the unemployment problems in the areas and get more people involved in fishery. This has to be considered a short-term solution, as the problems will increase in the long-term.

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Appendix 1. Interviews with fishermen in Departamento de Atlántico

Roberto Cortina, Loma Arenas (Totumo)

How many years have you been working as a fisherman and where do you normally fish?

-I've been a fisherman for more than 40 years. Most of the time I fish at the Marsh of Totumo (Cienega del Totumo), but sometimes also in the sea. The sea is seasonal and we can only fish at the sea during the "winter" (rainy seasons, May and August – November). When the summer comes again we get back to the marsh with good profits and the debts created by the sea are paid by the marsh.

What other activities do people living in this area do?

-Fishery is the main activity here; we have been fishermen for years and years. Because we don't have cattle around, so farmers are very few. All people are devoted to fishing, but sometimes when the fish are scarce and fishing is not good, there are only small jobs like masonry that can be done.

Do you think that the mangrove is important for the fishing activity? What species of fish are dependent on the mangrove?

-Of course mangrove is important for the fishery. It is number one. Because we know that fish go to the mangrove to take shelter. Lisa (*Mugil incilis*), lebranche (*Mugil liza*), sábalo (*Megalops atlanticus*) and róbalo (*Centropomus* sp.), all of them get shelter from the mangrove, but also other animals, like turtles and caimans. The oysters were lost for 10-15 years, but now they are here again. At the moment there is a large amount of the fresh water oysters. We use their meat for food and the shells for handicrafts. These oysters have a long time without being seen. It was lost, and now it is appearing again.

How do people use the mangroves?

-Some people use the mangrove to make fire to cook food. Other uses it to make fences. It is a difference from the people who makes charcoal as they take all the trees, to make fences you can only use the straight branches and they leave the crooked ones, so the damage is not complete.

What is the difference between the present mangrove and the mangrove in the past?

-There is a difference in mangrove coverage now compared to before, because many people used to cut the mangrove to make charcoal. Especially people from Departamento de Atlántico, because their job was to make charcoal. Practically they clear-cut large areas of mangrove, cutting mangrove - making charcoal and so on. They didn't care about the place. They obtained benefits but destroyed the land and they went anywhere to make their charcoal. Since 15-16 years people have been doing this cutting to make charcoal. Before it was very difficult to do it, because it was very dense, but now with the continuous cut of mangrove it is more open and easier to get in and go on cutting. Many people go there and cut trees. That's why it is very important to replant all those areas where the damaged has been done.

What do you think about mangrove restoration projects?

-I am very happy hearing about restoration projects. It is one of the best ways to get rest to the marsh, because the replanting of mangrove could give job to 15-20 families. If the project becomes a reality, it would be positive for the community. We would be able to give some people work together with the association. In this way the marsh will get rest.

Has the number of people depending on fishery increased or decreased in Totumo?

-This village, La Mita Arena had a great expansion of people. In the 1940's there were 350-400 inhabitants, but presently we are 7000 living here. Now, with more people, every space in the marsh is taken. The places where the fish could grow in the marsh are not available anymore, because of the presence of people. We fish approximately 6-8 hours daily, so practically the marsh has no rest. We are trying to get the fisherman aware on the importance to let the marsh rest, so we propose that one Sunday in the month there will be no fishing. We are in contact with the department government to get some financial help to the fishermen who would stop capturing that Sunday. We have a traditional day, the 24th of June, devoted to fishermen. That day we would like to give special attention to the fishermen. During that meeting many awareness activities could be obtained, by bringing some officers here from CRA (Corporación de Autonoma del Atlántico) to give the people information.

We have made a classification of people and we have found more than 260 boats, and that means at least 520 people are fishing in the marsh. Just compare, before we only had 25 boats. But there are many people without work, and many of those would like to work with fishery. We are trying to get 20 more boats, that means 280 boats and those 20 boats are not enough for the unemployed people in the marsh. You have to remember that the job as a fisherman is not profitable enough. Sometimes it is good, sometimes not. For instance, if you have a good fishing week you can go and buy some cement to fix up your house, and perhaps in a good moment, you will think about buying a new boat. But most fishermen don't catch enough fish to have a house or a boat.

Have the fishery resources changed? Were there more or less fish before than presently?

-Before there was less people in our community and the fishing was good, because there was more space and supposedly there was a larger amount of fish. Presently a lot of people are fishing here, even people from other places. People from Repelon, La Boquilla, Las Playas, San Juan and Luruaco are always fishing here, because this is the only place where you can find how to make a living. The Marsh of Totumo has been reduced in size, so there was more space in the past. It used to be 3800 hectares, but the landowners have made their fences closer to the water and made many dikes around the edge of the marsh and in the new areas they have established pastureland. The water body has decreased because of this land robbery and at the same time our community has increased.

Has the size of the fish changed?

-In old times only the big fish were disposed, but now people catch fish of all sizes. It is very difficult situation, because if we catch the small fish, we will not have any fish "tomorrow". For instance, look (and he points at the little kids around), there we have the seeds of the community of fishermen. Some of them may stay and some may go away. But there we have

our fishermen of the future. What about if all of them becoming new fishermen, we would not have any space for them, nor fish anymore. Only the large fish should be taken, in order to wait for the small ones grow. This is a struggle we have to deal with, with other fishermen, and it has been a hard fight for us avoiding the catching of small size fish.

Have you been able to make people that catch small fish aware of the problems these actions generate?

-Our job has been hard and tough, we have been trying to make our friends aware of the problem. Especially the purchasers, the women that buy the fish, because as our president (Álvaro Uribe) says, you don't have to harass the ones who crops the cocaine, but the one who deals with it. Our purposes are to talk to the purchasers. We know that the purchasers advise the fishermen to catch smaller fish, because for them is more profitable to sell a large amount of small fish than selling only one large fish. They don't understand that this is destructive for the fishery. "Tomorrow" the purchasers are not going to be able to obtain fish, because presently they are taking both the larger and the smaller ones. For example Mojarra lora (*Oreocromis niloticus*) are caught at the size of 15 cm and people think it's a good food resource. It means that it will not have the chance to reproduce abundantly as it normally does. It is not advisable to catch the fish at this size, but the dilemma is that people need food to survive.

What equipment do people use for fishing?

-The only equipment fitted to fish in Totumo is attaraya (casting net) and hooks. Not trasmallo, nor chinchorro(casting net, bigger than an attaraya). We have spent a lot of time struggling to stop those who use prohibited methods and to make the purchasers stop dealing with fish caught in this way. But some purchasers buy this equipment and provide it to fishermen in order to obtain large amount of any size of fish. Last Saturday we burned 18 trasmallos and at this moment I have another one that will be burned as well. Our job is to capture sábalo (*Megalops atlanticus*) by our techniques, not by using trasmallo, and to make people aware of the damage this kind of equipment makes. Some fishermen from other regions use a technique that is very harmful. In the mangrove they use paddles to scare the fish to go into the nets, and this cause a lot of turbidity in the water and mud particles go into the gills of the fish and cause death. Many species are affected, for example sábalo (*Megalops atlanticus*).

What kind of species do you catch? Is it the same species here now as before?

-The principal species before was lisa (*Mugil incilis*), lebranche (*Mugil liza*), sábalo (*Megalops atlanticus*), róbalo (*Centropomus* sp.), moncholo (*Hoplias malabaricus*) and mojarra amarillo (*Caquetaia kraussi*). And the production was large enough for the people living here. In the past the floods came together with large amount of fish and when the fish tried to navigate, they jumped out from the marsh and fell on the road nearby. And people could catch fish on the road, but presently this does not happen. Lisa (*Mugil incilis*) is usually present in the marsh from January to March, but the fresh water is not good for this species to lay eggs. It is only good for the mojarra (*Eugerres plumieri*), moncholo (*Hoplias malabaricus*) and shrimps. Mojarra lora (*oreocromis niloticus*) has been introduced by the INPA (Instituto Nacional de Pesca y Acuicultura) ten years ago, and is present all year around in the marsh.

How many fishermen are linked with the fishermen association? Do you think all people in the association would agree to work in a restoration project?

-We have our association APESCOCITO (Association Pescadores del la Cienega del Totumo) since three years ago. Officially constituted there are 68 fishermen with their families associated to our organisation. But it is only about 45 that are active and constantly participating in meetings. Most of the fishermen belong to the villages of Loma Arena and Pueblo Nuevo. The people have nominated me to be in charge of the association. So when I introduce a project to the community they normally say yes. When the association gets a project it is not to do me good, it is good for the community, so they will agree. The project would be of benefit for all people of Totumo.

What do you think of the future in this area if a restoration project is not accomplished?

-If we don't restore the marsh, I think that Loma Arena will be over. The three villages of Loma Arena, Pueblo Nuevo and Colorado will disappear, because they live from fishing. The community is trying to get a dredging project. We have already talked to the environment minister about this. This project is very important to keep the marsh alive and for the villages around the marsh.

Manuel Redondo, Astilleros

Between the area of the inventory and the sea there is a road. On the other side of the road there is an area that in earlier days was covered by mangrove. The mangrove was clear cut and later used for salt extraction (Juan Carlos Pino Renjifo, personal information). Nowadays it is only sand and the area is not used for any human activities. The fact that the mangrove is gone has affected the ecosystem and the neighbouring communities in a negative way.

How many years have you been a fisherman and where do you normally fish?

-I am more than 50 years old and I have been fishing all my life. Now we have to go to the open sea to fish. Sometimes we get fish, sometimes we don't. In the marsh there are no trees and the water level is too low, so it is impossible for the fish to live in this environment. The róbalo (*Centropomus* sp.) and the mojarra (*Eugerres plumieri*) have begun to die. They die before they have any possibility to go to the sea, where they could grow larger. There is only some tiny lebranches (*Mugil liza*) in the marsh now. But the water is not enough to give a constant water body.

How many families live in this area?

-There are two villages and it's around 45 families totally.

What is the difference between the present mangrove and the mangrove in the past?

-About 50-60 years ago it was mangrove there by the road, but the situation was very good. There were wild ducks, egrets, herons, snakes and a lot of foxes and many bee nests. The mangrove has been used for charcoal, and now it is only desert. When I was born, the mangroves were already dead. It was all kind of mangrove species. Years ago they built the

road through and it stops the entrance of water in to the mangrove. The road was built without any chance for the water to pass, so the mangrove died. The constructers of the road didn't make it possible for any water exchange. There was a salt-water channel, and it helped to kill even more of the mangrove.

Do you think there is a need to restore mangrove?

-Yes of course, because then the fish would have breeding places again.

How do you think the restoring of the mangrove could be obtained?

-By replanting mangrove and opening channels for the water to come in from the sea. But it must be deep channels. We who live around here obtain our food from fishery, so it is important with mangrove for us.

What fish species depend on the mangrove?

-Sábalo (*Megalops atlanticus*), lebranche (*Mugil liza*), róbalo (*Centropomus* sp.) lisa (*Mugil incilis*) all kinds of fish.

What other uses do people around here have of the mangrove?

-We don't accept anyone to make use of the mangrove.

Do you think the amount of fish increased or decreased?

-The fish have decreased a lot. We used to capture 5-8 large fish per day during the time of the year when the size of the water body is big. At that time of the year the fish come from the sea, that's during the rainy season. During the dry season the capture decreased. Before we had small artificial water bodies that were very good and productive in the dry season and there were small streams deep enough to hold in many fish, and to permit the fish to reproduce and grow. We used to catch lebranche (*Mugil liza*), róbalo (*Centropomus* sp.), big mojarras (*Eugerres plumieri*) and pargos (*Lutjanus* sp.) and other species before. But this is not the situation anymore, now it's over. Also the mero (*Ephinephelus striatus*) was possible to catch, but now it is very scarce and very small. Before there was a large amount of sábalo (*Megalops atlanticus*), but now they can't reproduce as before. We still catch the same species but a less amount, because they don't reach the reproduction age. The water from the mountain contains a lot of mud (partly because of deforestation), so the marsh has been filled with sediment.

Has it been any change in the number of fishermen in this area?

-There are more fishermen here now and we need more boats, especially with motor.

What equipment do fishermen use around here?

-Nets and trasmallo. We don't use chinchorro. There is a kind of trasmallo that is very harmful, that they drag after the boats and catches large amount of juvenile fish. Groups of fishing boats come here, 7-10 boats every day and every boat has 17-20 people that practise this kind of fishery. Those draggers fish from 6 in the morning to 5 in the afternoon. This

kind of fishing must be prohibited, because it's very harmful for the fish. Millions of fish are caught like this, and they are not useful for food because they are too small. Sometimes we have to take care of these fish and put them in the ground.

Gonzalo Restrepo, Puerto Velero

How many years have you been a fisherman in this area?

-All my life I have lived here, 53 years. My father fished a bit, but he used to go in boats. They fished in the deep sea. But that was when Puerto Colombia's Port still was in function, when many fishing boats arrived in Puerto Colombia. I'm talking about many years ago. It happened with all the sedimentation that the river has brought here. It has finished a lot of the fishing. The sediment has filled the places where the fish used to eat, and the coral reefs. All of it has been blocked by the sedimentation. There was never any mangrove in the water here. By here the mangrove is salty. The men that are older than me, they are not fishing anymore; they have told me that there was mangrove here when Isla Verde existed, before the Tajamar was built. This place was filled due to sedimentation and that finished the possibilities for people to come here to swim. The sea was closer before than now; the sea line has moved. All that you see here is sedimentation from the Magdalena River.

Do you think the mangrove is important for the fishery?

-The red mangrove is important. In the good fishing time the Cienaga Grande de Santa Marta used to be the mother of róbalo (*Centropomus* sp.) and mojarra blanca (*Diapterus rhombeus*). I was fishing two years over there when I was young. Before we could catch 150-200 kg of róbalo every day, but that is not longer possible because of use of dynamites, trasmallo and boliche (a non-selective net). All the fish go to the "mochila" at the end of the boliche. This kind of fishing is used in the rainy season, only in the rainy season. When the wind comes in the dry season the waves are too big and boliche cannot be used.

Over here the mangrove is not important. It was never mangrove here. Maybe in some small marshes close to here there is some mangrove, and fish have their nursery there. That is when it is the rainy season when the marshes are filled. Maybe other animals bring the fish and shrimps eggs there. In dry season there is nothing, only mud, but when it is raining I guess that some animals bring the little eggs. Maybe the herons bring the eggs there, because you can find small fish and shrimps there in the rainy season. Mojarra (*Eugerres plumieri*), macabi and shrimps can go out from the marsh in the rainy season.

Are people around here cutting mangrove?

-The people here do not respect anything. If you want mangrove you take a machete and cut it.

Was the mangrove covering a bigger area before?

- We only have terrestrial mangrove here, nothing in the water. So here is not like other places, like Turbo or Choco, San Antero where they have "mangrove on feet" (*Rhizophora mangle).* That place is good for finding eggs and fish. The mangrove was never covering a lot of area here. In the past the mangrove did not exist here, but because of the sedimentation there is mangrove here. Not even in Puerto Colombia it was a lot of mangrove. But in

Manatíes and Mallorquin the mangrove has existed a long time. I know that a lot of mangrove died over there. It is similar to the big mortality of the mangrove in Cienega Grande de Santa Marta. It was good in the past; you could find macaws, monkeys and caimans. Now it is not easy to find a caiman. The people are terrible; maybe they can even eat each other. About 5-7 years ago, the people of El Morro, Buena Vista and Pueblo Viejo they used a lot of dynamite and they was in an alliance with the paramilitaries, and the paramilitaries killed the fishermen! In the past it was big trouble because it was paramilitaries, but now the zone it has calmed down and it is more peaceful. Maybe in Puerto Caiman you can find small patches of mangrove, maybe when the seedlings were going in to the rivers, when the sea had connection with the sea. But that is also finishing. Puerto Colombia was the same; it had small patches of mangrove. In the past you had more sea, which is why Puerto Colombia was a harbour (port). But now what you see, the sedimentation is what caused the mangrove growth in the zone. In those sites where the mangrove grows, in the past you could find many rivers. But because of the sedimentation of the marsh, the mangrove is growing there. If you see the marsh of Balboa, it is a great marsh of salt. 15-20 days it was a big mortality of fish, everything died because the salinity became very high. All the things died, but I never saw anything about it in the newspapers or in the news. But you cannot do anything about it; the mouth of the marsh is opened in a natural way, and closed in the same way. When the marsh is filled with fresh water a mouth opens to the sea, it is a natural way. In that season we don't need to walk a lot, because we can go by the boat. If you go now to Balboa now, you can see the same hypersalinity like in Manauri (Manauri in Departamento de La Guajira state is the major marine salt production in Colombia). Now when the marsh is dry, you can see that the water mirror is decreasing. It is because of the sedimentation that is filling the marsh.

For what purposes are people using the mangrove in this area?

-It is not used so much. It is used a bit in construction to support the houses that are falling or to make some kiosks or small houses and to make fences. The mangrove is not so much used for heating or for making fire. It is too much smoke. You can make coal, but it is not so much used for that. The mangrove is not used so much in this area.

Is it any difference in the fishery now compared to old days?

-If I told you how the fishing was here before…it wasn't even transport enough to take the fish away. Of course and that time it was not the problem we have now with sedimentation. I told you about the corals, I told you about the feeding zones. You know that sea is like land, where there are higher and lower places, different depth levels. Between those higher and lower depths are the feeding zones, and they have been filled with sediment. This sea bottom is like a road now; there are no coral reefs around here anymore. The corals, the sea plants, the sponges, the seaweed are all dead now. And the fishery is almost over.

What kind of species do you fish here?

-We fish pargo (*Lutjanis* sp.*)*, sierra (*Scomberomorus cavalla*), carite (*Scomberomorus regalis)*, cojinua (*Caranx crysos*), corvinata (*Umbrina broussonnetii*), ronco, chivo and sable (*Trichiurus lepturus)*. Sable pays great. It looks like a stick or a snake, but it is really delicious.

Have any of the species disappeared?

-No, the species have not disappeared. They are scarce. But the species have not changed. Before we used to get huge humeros, and now you can get them but only a few small ones that seem to be lost in the sea.

Has the size of fish changed over time?

-Of course, there is only by chance that you can get a big fish, but most of them are small ones. And of that we have to live. We that are fishermen, we feel it is a pity to take the small fish, because it doesn't get the chance to grow up. We have to do this because we need to feed our families.

Imagine that once upon a time, I caught sábalos (*Megalops atlanticus*) with weight of 120 kg, when Boca Tecinisa was the mother of fishing. I was raised as a fisherman in Boca Tecinisa, so I used to fish there. It was when there were sailing boats, now all boats have a motor. I think that everything in the life of man, all the struggles in nature, the motorboat is a bad thing, it scares fish with the smell of the oil and the sound of the engine.

If you knew Boca Tecinisa before, you would be amazed. It was like watching that amount of bushes over there. When they began to bring that trasmallos, they could not even carry the amount of fish. It was thousands of tons, people came one after the other to carry the fish. I experienced that moments and I could catch 30 big sábalos in one journey.

What equipment do people here use for fishing?

-Here we use the hook and manta and trasmallo.

How many hours a day do you fish?

-In this situation we don't want to go out to fish, because it is so sad. In these days it has been too bad for us. The past week they got some pargos (*Lutjanis* sp.*)* of 30-40 kilos. Some times you fish all day, sometimes all night and you go to your house the next day.

Have the number of fishermen increased or decreased in this area?

-It is more people that fish now, and the needs are more, but there is less fish. It is a lot of people that are asking for jobs. Take a look at how much is the cost of a boat with an engine now. The people that have engine are people that in some time in their life had another source of money. It is just a few people that have the chance to buy a boat with an engine, maybe the people that are retired or that have a company in Barranquilla. For most people it is very difficult to get an engine, because it costs about 7-8 million pesos.

What do you think about mangrove restoration projects?

-I think it marvellous for the fishermen, for the farmers or the hotel owners. These things attract the people. The mangrove in San Antero is a beauty. Go to San Antero and you will see really good mangrove. You can find caiman and nurseries for sábalo (*Megalops atlanticus*), or cultivation of sábalo. You can see the red mangrove, and the people are cutting the mangrove. But they have the measure to cut it, so it is a managed mangrove.

What do you think of fishery management?

-In this region it does not exist any law about fishery. It is lack of authorities, lack of laws, like a law that says "don't fish in this season" or "don't fish this species". The fishing is not controlled. It is necessary to have some control of the fishery. The fish is like a material, if you cannot catch a big fish, you need to catch a lot of small ones to give to your family, or to sell to buy other food than fish. We are conscious about what is happening, but we can't do anything about it. I wonder why the authorities do not make surveillance to check the fishing activity. The boats are filled with fish, but there is no control. The Vikingo's company has production of fish, and when they fish they don't try to avoid catching the small fish, because they use it to feed the fish in the cultivation. Before they measured the fish and selected the bigger fish, because they had control of the fishery and the small ones were put back again, but not anymore. The boliche catch everything because it is made to catch shrimps. Before when we saw big groups of frigate birds and pelicans it was because there were groups of small fish, but now when we see big groups of birds it is because there is a fishing boat that have left some small fish in the water. These boats are going near the coast, maybe 5-6 miles from the coast. And that is not allowed; sometimes you can see the fishing boats really close to the shore. These boast have destroyed this coast. We were in Cartagena to talk about this problem with the fishing authorities, IMPA. And they answered that the industrial companies was not a problem, because they had a permission to do this activity.

How many fishermen live in Puerto Velero?

-About 30-40 fishermen, and other about 30 people do other things but all are depending on fishery in some way. Everyone here is dedicated to fishery in some way. Some have restaurants and others have kiosks. Some have tourist facilities in the weekends, and during the week they fish. Until last year I was the president of the fishermen association. We belong to the Puerto Colombia association (Associon de Pescadores de Puerto Colombia).

Maximiliano Bustillo, Puerto Colombia

How many years have you been working as a fisherman and where do you normally fish?

-I've been a fisherman for 45 years and I fish in the sea. These days I go to Cartagena to fish, because it is very difficult here now.

Do you think that the mangrove is important for the fishing activity?

-Yes mangrove is important, but only if you have a marsh. Under the rainy season the marshes get connection with the sea, and the fish in the marsh can go to the sea. They reproduce in the marsh and they go out to the sea. I have noticed in other marshes where they have opened channels, the fish pass through these channels between the sea and the marsh. Here in Balboa is different, because the Marsh of Balboa dried out. Before when the marsh was bigger the mangrove was important.

What species of fish are dependent on the mangrove?

Róbalo (*Centropomus* sp.), sábalo (*Megalops atlanticus*), and mojarra (*Eugerres plumieri*),These species like to be in the shadow of the mangrove. You could fish a lot before, when the fish stayed among the roots of red mangrove (*Rhizophora mangle*).

What use do people have of the mangroves?

We use the mangrove to make a solution to treat the attarayas. You boil the attaraya in this solution to give it colour. They have not cut the mangrove in Puerto Colombia. It has disappeared because of the erosion from sea.

What are the differences between the mangrove of today compared with the mangrove that existed in the past?

-Next to the pier there was a big mangrove forest, but the sea has been destroying the mangrove. Also in other parts of Puerto Colombia the sea has destroyed the mangrove. There are two formations of mangrove in this area; one is in the Marsh of Balboa. The other one grew up 20 years ago next to the place where the island "Isla Verde" was, but the island disappeared because the sea here is very strong. That area of mangrove was bigger before than now. In the past there was a big marsh, and in the middle was Isla Verde. If you wanted to go to fish, you had to go in a boat and through a channel to reach the sea, and it was far.

What do you think about mangrove restoration projects?

-Look, if you go to the pier and look to the left, you can see mangrove that was not there before, and you see a lot of chairs. Restoration project of mangrove would be the best thing. If they plant mangrove in other parts than the marsh the people can go there and get shade and they don't have to be in the marsh.

Do you think that the productivity of the fishery has changed? Has the quantity of fish changed in the present? Have the sizes of the fish changed?

-The fish have decreased a lot, so the fishing was better before. I don't know, maybe because people were fishing with dynamite. It has destroyed a lot from here to La Guajira. But now they have better control of that activity, because now if you have dynamite in your hand, they think you are a terrorist. It also decreased because of the contamination of the Magdalena River, and there is no control of the poison that the companies along the river put in to the river. The fishery has decreased about 80-90%. Many years ago, if you wanted to fish sábalo (*Megalops atlanticus*) you could fish sábalo, or if you wanted to fish róbalo (*Centropomus* sp.), you went to fish róbalo. Now if you can catch 20 fish, you are lucky.

Has the number of people depending on fishery increased or decreased in Puerto Colombia?

The number of fishermen has declined here, because many people go to Barranquilla to work with construction or other things. When you go fishing you spend about 60000 pesos (25 USD) on gasoline, and if you don't catch enough fish you loose money, so that is why the fishermen have decreased.

There are 15 boats here; it is about 3 fishermen per boat, so there are about 50 fishermen totally. About 30 families are depending on fishery, but many fishermen are young and don't have families. There is a project were they are going to buy three more boats for the fishermen.

What equipment is used here for fishing?

-We fish with hook and trasmallo in the sea. In the marsh we fish with attaraya, and with chinchorro we catch róbalo (*Centropomus* sp.).

What kind of species do you catch? Is it the same species here now as before?

-Before there were all kinds of species in the marsh. Next to the sunken ship "El Balboa" we could fish big amounts of fish. In the marsh we have lebranche (*Mugil liza*), mojarra blanca (*Diapterus rhombeus*), lisa (*Mugil incilis*), macabi (*Elops saurus*), róbalo (*Centropomus* sp.) and sardines, but now the fish is dying because of the increasing salinity in the marsh.

Some species have disappeared. Sharks are disappearing, before we didn't fish shark, because we did not like to eat it, but now we do. The pargo (*Lutjanis* sp.) has decreased, before we fished pargo rojo (*Lutjanus purpureus*), pargo rayado (*Lutjanus sinagrys*), pargo mulato (*Lutjanis analis*) and pargo negro (*Lutjanus griseus*). In the past we could fish bigger amounts of sierra (*Scomberomorus cavalla*). You could catch like 10 individuals of this species. Now if you want to catch one you have to spend all day for that, because the water is contaminated. Sábalo (*Megalops atlanticus*) is disappearing, before you could catch big amounts of sábalo. But not anymore, because there is no control and people fish very small individuals. If you go to a place in Barranquilla where they sell fish you can see that they sell small individuals. We fish a lot of coginua (*Harengula clupeola*) here in November-December. All the mojarra (*Eugerres plumieri*) died because of the things that happened in the marsh (a rapid increase of salinity in the marsh in April 2006). They were opening a channel here in Balboa to connect the marsh with the sea, but it did not work and all the fish in the marsh died.

What do you think about the future? What will be the consequences of the on-going erosion?

- If the sea comes closer the fishing will get better. If the sea comes closer the fish in the marsh will decrease, but the fish that don't live in the marsh will not disappear.

But if the sea comes closer, the marsh will disappear, and the marsh is important because that is where the fish grows up. What is your opinion on that?

-Yes of course the marsh will disappear, but there are other marshes. About three kilometres from here there are more small marshes. There will always be a marsh, because all the sediment that comes from the river forms it.

José M de la Rosa, La Playa (Mallorquin)

How many years have you been living here?

-About 48 years.

During these 48 years, have the places around changed?

-When I opened my eyes here, the sea could not be seen. We left home at 9am and reached the see at 2pm in the afternoon, because there were a lot of marshes. No one came around here, because in this place there were extensive mangrove fields and the water reached where the 40th avenue is now. The town was in a different place than today, but because of very

heavy water floods it had to be moved to the present place. It was better before; more mangrove, more bird and fish species, but presently the sea is eating the marsh. It was even possible to get lost in the mangrove. Up to the1970s there used to be trees of red mangrove (*Rhizophora mangle*) that were 15-20 meters high. The present Mallorquin marsh is not really the marsh; it is just a branch of La Playa marsh. The real Marsh of Mallorquin is now out in the sea. Mallorquin used to be fresh water, because the water from Rio Magdalena came in to the marsh through small channels. At that time we had river doves here and there were places where large caimans came to get sun. In 1930´s when the Tajamar were going to be built, one of the inspectors of the project had a pineapple farm, and he didn't want it to be flooded, so they didn't construct any channels to let the fresh water come in to the marsh. That is why it changed to salt water.

Do you think that the mangrove is important for fish?

-Yes, and at the same time they protect the shore from sea erosion. The mangrove is very good for fish. I think that the special reason for the lack of fish is the lack of mangrove. Because I remember when there was a lot of mangrove, you saw fish all around. Now it is like everything is gone, mangrove is gone and fish are gone too. Mangrove is necessary.

Do you have problem with people cutting mangrove here?

-Before people didn't use to clear cut the mangrove, they used to select larger trees. There are a lot of people that lack education; we have had problems with people cutting trees that we have transplanted. In some places where they are 5-6 meters high, people are presently cutting them. Some landowners have made roads by cutting the mangrove in order to survey their properties. People used to gather the logs coming from the river, from the inner of the country. They moved them from the river to a certain place where they were loaded into trucks in order to sell them. That was before, but presently people cut a lot of mangrove because of the development. They use the wood to make beams for roofs, and to make fences and so on.

What do you think about mangrove restoration projects?

-I think it is good, we have done about ten mangrove plantations, and they all worked out well. We had good results, even presently we are still working in such projects.

How do people use mangrove around here?

-For furniture, building frames, house construction, and fences. It is very commercial. They cut a lot of red mangrove for house construction because it's very hard, resistant and flexible.

Do you notice any difference comparing old days with the present regarding to fishery?

-The fishing was better before. We used to catch large amount of fish. For instance we left at 10 am and returned next day at dawn. We have to return fast, because we didn't use ice blocks to keep the fish fresh. The fish was conserved by smoking. In order to earn one peso before, we had to work a lot. Things were bought in cents. I don't know why the difference is so huge, now we earn 30000-50000 pesos but it is not enough for our needs. It was better before, because you had the opportunity to catch more fish. Before we used to eat the better fish, now we have to sell the best fish.

Are the present species the same as before?

-Many species have decreased, for example the lebranche (*Mugil liza*) and mojarra (*Eugerres plumieri*) are very limited. It was the same with the róbalo (*Centropomus* sp.) and the sábalo (*Megalops atlanticus*). Before we had some special places where we could go and capture the species we wanted. For instance, if we wanted to catch róbalo, we went to the place where they supposed to be, and they were there. The mero (*Epinephelus striatus*) was present in many places. Before the nets were so full of fish so the netman needed help from the paddleman. Presently there are the same species as before but they are smaller. Now there is a lot of hunger. Before we used to fish with large-eyed nets. Presently we have to use nets with small eyes, which means that small fish are caught, because people need to eat. When you go on fishing like this the fishery decreases.

What equipment is used here for fishing?

-Attaraya. Before there was so much mangrove so it was not possible to fish with nets. So we used to fish with carbide lamps. You put the lamp in the head, and go slowly, slowly in the canoe in the mangroves. You could see the fish clearly in the water, and you chose the larger fish and kill them with a chuzo (a kind of a spear).

Where do the fishermen come from?

-Some from La Flores, La Playa and some from Puerto Colombia. There are some from Barranquilla, Carisal, El Bosque, La Victoria. People which come and fish with hooks and rods.

Do all fishermen around here in La Playa belong to an association?

-Our association has 120 members. But there are many that don't belong to our association; they are a kind of pirate fishermen. There are many sport fishermen, they come on weekends to fish.

How many people depend on fishing here?

-About 80 to 90 families. Others work in local companies, and some other with masonry, but they are fishermen anyway. If the fish are abundant, they come to fish.

Where do people fish?

-Presently the only water body is Mallorquin. The whole fishermen population are fishing in the marsh of Mallorquin.

Have the number of fishermen increased or decreased?

-Now there are more fishermen, because there are more inhabitants. The present census says it is about 28000 inhabitants in La Playa. But before there were only two or three streets. There is a lot of unemployment and many displaced people are coming here.

How do you project the future of fishing activities and the state of water bodies?

-I think it is necessary to handle the situation with special care. If you don't handle with special care, the mangrove will be over. Remember, the marsh used to be very large. Remember we talked about how long time it was to get to the sea, and now we have only one kilometre to go there. If we don't pay special attention to this and the problem with people filling with land artificially around the marsh to build houses, the marsh will be finished. I think the marsh will disappear.

Do you want to say something else that we haven't talked about?

-The mangrove plantations have changed the place a lot. We started to plant mangrove in 1985. We did not know many things about the mangrove, but when CRA came with the programs, we started to plant and started to know about the benefits. So many channels have enhanced the quality of the mangrove.

Santander Caraballo, Las Flores (Mallorquin)

How many years have you lived in Las Flores?

-40 years, but since I was young I knew this entire zone. I was lucky in my youth, because some friends helped to build a wooden boat and I went to the sea. At that time the larger boats were about 21 feet long. I had a Swedish engine of 15-20 horse power, called "Albin".

How has this area changed from the past?

-It was a little harbour and only two streets. The rest of the things that you see now were water in those days. At that time the mangrove coverage was bigger. And the river was here where we are at this moment. One side of the Tajamar (Mallorquin) is loosing land and the other side (Salamanca) is increasing. Everything is changed by man; wanting to improve the things that already exist. Man destroys everything.

Can you describe how the mangrove forest was before?

-When I was 16 years old the Marsh of Mallorquin (Cienaga de Mallorquin) was a great place full of many pretty things and a lot of mangrove. At that date the Las Flores town was only fishermen neighbourhood. The mangrove was bigger, but the sea has been making it smaller. The belt close to the shore was about 30 meters wide, and there were a lot of islands with mangrove. There are other things that are negative, for example the change from a fresh water marsh to a salt water marsh. Because of this they built channels under the Tajamar, now there is growing fresh water mangrove there again.

Do you think the mangrove is important for the fishery?

-Yes mangrove is the source of life and maybe we come from there too. We are all in a chain in this world. The theory is that life comes from the sea.

What species are depending on mangrove?

Róbalo (*Centropomus* sp.) are depending on the mangrove. Sábalo (*Megalops atlanticus*) too, but the reproduction is not there, so it is less important for the sábalo. Lebranche (*Mugil liza*),

lisa (*Mugil incilis*) and mojarra (*Eugerres plumieri*) are the species for which mangrove is so important for their life cycle. A lot of problem has been caused to the mangrove and to the fauna. For example the damage that was done to the Salamanca Island. There they had a channel called Almendros channel. This channel allowed interchange of the water, but when the Tajamar was built, people damaged the channel and they built another channel in the upper zone, but it is not the same because it is dry sometimes. It is not natural and some of the mangroves have died the last years, because the lack of fresh water, and there is no inter-exchange of water.

How do people use the mangrove?

-The mangrove is used for firewood, constructions…many uses. I think that it is important to make the cutting, but in a rational way. All this problems is coming because it was too late when the ministry of environment affairs was created. About 15 years ago it was no clear direction about the environment. If the ministry had been created a direction before, maybe many problems would have been solved, like avoid cutting of the trees close to the rivers. More education to farmers and fishermen would be positive.

How do you see the future of the mangrove in this area?

-Totally destroyed. It will happen the same as what happened with the "Cienaga Grande de Santa Marta" when they constructed the highway from Barranquilla to Santa Marta and the entire mangrove died. When they built that they didn't build the box culverts under the road to make the exchange of salt and fresh water. So if you have fresh water mangrove and leave them in salt water, they are going to die. That was what happened there.

What do you think about mangrove restoration projects?

-I see it in a negative way, because the intention is to finish this marsh. How is it possible to make restoration projects when you want to finish the mangrove? If they are going to build a port they have to cut the mangrove. It is possible that they have to fill the whole marsh with sediment. Restoration is good if it is independent. If the port project is not coming true, I support mangrove restoration. There are several impact studies for what the port is going to create, and I have participated in six environmental impact studies. In only one of the six studies the license would be given if they could sustain the condition of the marsh. The company that will build the super port had to compromise by sustaining the marsh. The compromise of the company was to restore the old trash dump and to make an ecological park there and at the same time build the carbon (charcoal) port in Mallorquin. It is a contradictory. It is not possible. It is going to be the same as in Santa Marta (where they have a port for carbon that is affecting the water around Santa Marta and the Tayrona National Park). It is difficult to imagine a park near the port, because in 9 months of the year we have strong wind, which will carry the dust from the port to the Mallorquin Park. A lot of coal is going to fall in the park. By the experience by the people in Santa Marta, they want to move the port here. Economic interests of the people make them want to put the port here.

Do you think the whole community here is interested in restoring programs of mangrove?

-Yes, but only with projects that help people and are good for the environment and are without economic interests. I don't want a political game here, because I have seen a lot of projects and it gives nothing. I have seen many projects where people have been planting

mangrove, and three days after, the plants are dry. 75% of Las Flores has been taken from Mallorquin. Before they built the Tajamar it was only marsh. And when they built the Tajamar the marsh at that place was destroyed. After they built the Tajamar the marsh was separated from the river. The community of La Cangrejera used to be mangrove, but because they filled it with junk, leftovers and sand to build houses the mangrove is gone now. How can you avoid the invasion of people? In the past I proposed to build a canal, about 40 meters wide, in the front of Las Flores in the marsh to avoid more people to build houses close to the marsh. If you don't stop the filling, you can go on with mangrove projects but it is of no use. Many poor people agree in that kind of project because they are manipulated by the political power.

Have you noticed any difference in number of individuals and the size of the fish you catch nowadays? Is it the same species now as before?

-The species are the same now as before, róbalo (*Centropomus* sp.*),* sábalo (*Megalops atlanticus*), carito (*Scomberomorus* sp.), mero (*Epinephelus striatus*) and pargo (*Lutjanus* sp.). The fishing was richer before, but now they use nets for everything, and that has made the fish go away from the coast. It is like visual contamination. It is almost the same for us when we see the advertisement in the streets, the fish goes along the coast and see walls of nets, and they go away. Now the fish are more far out in the sea. I have talked to the industrial fishermen and they say it is a lot of fish far out in the sea. But we can not do the same activity as the industrial fisheries. In sábalo you can see changes, they are smaller now, but it is still possible to catch big sábalos. In Boca Tecenisa the róbalos always have been big. The small róbalos are coming from the marshes, maybe it is the natural habitat when they are growing up, and then they get out to the sea and grow bigger.

Has the number of fishermen increased or decreased?

- Now there are maybe 700 fishermen that are distributed in different associations, not only ASOPESCAR. In the past the fishing was very abundant and there were a lot of fishermen at several sites. Like Puerto Colombia, Tobara and Salgar, and a few fishermen at La Playa. Maybe at this time is not so good, so the new generation has left the fishing activity. Comparing with the past the number of fishermen has decreased. But if you see the situation in the past, maybe three fishermen went out in a boat, now there is five to six in one boat.

How many families are depending on fishing activity?

-Maybe 60% of the neighbourhood of Las Flores lives from fishery. Including some companies trading the fish. It is a great economic chain and you can find a lot of trucks coming to buy a lot of fish, and they trade in other sites of Barranquilla and other parts of Departamento de Atlántico.

What equipment is used here for fishing?

-Nets, hooks and palangre (equipment consisting of a horizontal cord to which many lines with hooks are attached). All the fishermen use the same kind of equipment.

Is there any problem with illegal fishing?

-Dynamite is not used now. There are some conflicts among the people in the marsh, because there is not any control of the fishery. But if you use a trasmallo with four points, you are going to catch big fish. But if the attaraya is used with two points (small sized nets) you will catch the small fish.

How do you see the scenario in this area in the future?

-The fishermen are condemned to disappear, people don't want us here. The whole zone of Tajamar maybe will be an international port in the future, and the land will be retained by the state for the port zone. Maybe we will have to sell our business for the price that they decide. Maybe if the port comes true, the value of the land will increase and the fishermen will be displaced. We will disappear from this site. It is incredible because 60% of the economy is depending on fishery. If the port is built the fish will die and the fishery here will come to an end.

Barranquilla, like the rest of the country is making all things in the wrong way. Barranquilla is growing but they don't think about the Magdalena River. I see this site in the future like a big port full of docks. Some work that the government is doing now, for example to make the river deeper to make it possible for the boats to pass is damaging this place. I think the fishing activity will disappear in the future. In the next three years we will not be able to fish corvina (*Cynoscion* sp.), because the bottom of the sites where we fish corvina will be destroyed. When they will move the Tajamar because of the construction of the port, the turbidity will increase and it will be almost impossible to get any fish there. They hope that those constructions are going to make the river 40 feet deep. But they don't see that maybe those wishes will make the Tajamar break down. If that happens there is going to be a flood first in La Playa and Las Flores and then in the lower parts of Barranquilla. They say that the river is getting shallower, and that the solution is to make it deeper, so the flow of the water will increase and it will be more water pressure. Some day that water has to go somewhere and it is going to break something.