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# Analysis of a habitat used by Antillean manatee (*Trichechus manatus manatus*) in French Guiana

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# Preface

This Masterthesis (Diplomarbeit) describes the results of a study on a manatee habitat in French Guiana. The study was initiated by Kwata, a French Guianan NGO for nature conservation. After the implementation of a working group on marine turtles, Kwata wanted to draw more attention to the estuaries and looked for a related flagship species: the manatee. Through Kwata, the contact to PD Dr. Udo Gansloßer from the Friedrich-Alexander University of Erlangen-Nuremberg, Chair of Zoology, was initiated and Mr. Gansloßer gladly agreed to assist in this project.

Due to the changes in the methodology the study is divided into two sections. After the first part of the work, in which the submerged aquatic vegetation was investigated, is was clear, that the proposed procedure would not lead to any satisfying results. The methodology was changed and the bank vegetation moved into the centre of interest. Thus, the division of the thesis into two parts, the first study of the aquatic vegetation and the second study of the vegetation of the creek banks, reflects the temporal evolution and changes during the fieldwork.

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# Zusammenfassung


Eine Studie zur Beurteilung der Qualität der Sümpfe von Coswine als Habitat für die Seekuh (*Trichechus manatus manatus*) wurde von Juni bis September in Französisch Guyana durchgeführt.

Die Sümpfe von Coswine sind eines der größten Feuchtgebiete in Frannzösisch Guyana und vollständig unter dem Einfluss der Gezeiten. Das Klima ist tropisch und beeinflusst maßgeblich das Wasserregime. Im Arbeitsgebiet befinden sich drei verschiedene Schutzgebiete. Die Sümpfe sind relativ unberührt, was ein Grund für die in der jüngsten Vergangenheit hohe Anzahl an Seekühbeobachtungen und die vermutete große Population sein könnte.

Da Seekühe aquatische Herbivoren sind, wurde in einem ersten Teil der Studie die Unterwasservegetation untersucht und gleichzeitig einige für die Verbreitung der Seekühe wichtige Wasserparameter aufgenommen, die aus der Fachliteratur bestimmt wurden. Das Arbeitsgebiet wurde in Sektionen eingeteilt, in denen während einer Voruntersuchung die Unterwasservegetation und einige Wasserparameter aufgenommen wurden. Die erzielten Ergebnisse zeigten, dass keine submerse aquatische Vegetation in den Sümpfen von Coswine vorhanden ist. Die Wasserparameter sind den Werten aus anderen Studien in Französisch Guyana und Südamerika ähnlich, wenn klimatische Umstände in Betracht gezogen werden.

Der zweite Teil der Arbeit baut auf dem ersten auf und untersucht die Ufervegetation, da nun vermutet wird, dass diese die einzige für Seekühe erreichbare Nahrungsquelle darstellt. Der methodische Ansatz für die Aufnahme der Wasserqualität wurde nach den Erfahrungen der ersten Studie minimal verändert. Die Vegetation wurde in 100 m langen Transekten entlang des Ufers aufgenommen, die untereinander einen Abstand von 1 500 m aufwiesen.

Während der Studie wurden nur wenige Manatis gesichtet, was aber mehr an den angewandten Methoden lag, als an dem Nicht-Vorhandensein einer Seekuhpopulation. Die aquatischen Parameter variierten leicht mehr als in der vorangegangenen Studie. Die Salinität war unerwarteter Weise niedrig und ¾ aller Aufnahmen lagen in Süßwasser. Die aufgenommene Vegetation wurde im gesamten Arbeitsgebiet von der Roten Mangrove (*Rhizophora racemosa)* dominiert. Im Gegensatz zum ersten Eindruck des Gebiets sind die Sümpfe bezüglich der aquatischen Aspekte recht homogen. Es ist daher schwierig, Zonen mit veränderten Umweltbedingungen innerhalb des Arbeitsgebiets zu unterscheiden. Bezüglich der Vegetation sind die Sümpfe von Coswine ebenfalls homogen, aber nicht im gleichen Grad wie die aquatischen Parameter, da die Vegetation in erster Linie von dem Boden, auf dem sie gedeihen und nicht vom Wasser beeinflusst sind.

Für die Seekühe scheinen die Sümpfe von Coswine ein interessantes Habitat darzustellen mit viel Futter in Form von Blättern der Roten Mangrove, mouko-mouko (*Montrichardia arborescens*) und anderen von Manatis verwertbaren Pflanzen. Die aquatischen Parameter sind in einem Bereich, der in der Literatur als für Manatis passend bezeichnet wird. Die relativ unberührten Sümpfe von Coswine bieten Schutz vor Meereswellen, Menschen und Umweltverschmutzung. Sie werden daher als ein wichtiges Seekuh-Habiat eingestuft und Maßnahmen zur ihrem Schutz sollten getroffen und auf eine gesetzliche Grundlage gestellt werden.

# Abstract

A study was carried out from June to September to assess habitat quality for manatees (*Trichechus manatus manatus*) in the Coswine swamps in French Guiana.

The Coswine swamps are one of the largest wetlands in French Guiana and totally under the influence of the tides. The climate is typical for the tropics and has a huge impact on the water regime. In the area, three different protection zones exist. The swamps are quite untouched from humans, perhaps a reason for the high number of manatee sightings in the recent past and the its suspected large population size.

As the manatee is an aquatic herbivore, in a first part the submerged aquatic vegetation was investigated. At the same time, some parameters important for manatee distribution were measured, which had been determined by literature survey. The whole area was divided into sections and in each such section the vegetation and water parameters were recorded during a preliminary study. The results showed, that no submerged aquatic vegetation was present in the Coswine swamps. The aquatic parameters were similar to those obtained in other studies in French Guiana and South America if climatic circumstances are taken in account.

The second part of the study is based on the first one and deals with the bank vegetation, as it is supposed, that this is the only available food resource for manatees in the area. The methodological approach was slightly altered for the assessment of the water quality, considering the recommendations made after the first study. The vegetation was sampled in 100 m long transects at the banks with a distance of 1 500 m between each in the whole study area.

During the study rarely any manatee was spotted, but this more likely was due to the methods applied than an indicator for the non-presence of sirenians. The aquatic parameters varied slightly more than in the first part of the study. Salinity unexpectedly was low and more than ¾ of all samples were taken in fresh water. The vegetation sampling showed an overwhelming importance of Red Mangrove (*Rhizophora racemosa)* in the whole study area. In contrast to the first impression on the site, the swamps are quite homogenous when regarding only the aquatic parameters. It is therefore difficult to distinguish any zones of changing environmental aspects. Regarding the vegetation the Coswine swamps are also homogenous but to a lesser degree as the plants are more influenced by the soil on which they thrive than by the water quality.

For manatees, the Coswine swamps seems to provide a suitable habitat with plenty of food in the form of overhanging branches and leaves of Red Mangrove, some mouko-mouko (*Montrichardia arborescens*) and other consumable plants. The aquatic parameter are in a range which is described in literature as manatee-fitting. The quite untouched Coswine swamps provide shelter from wave action, humans and pollution. Therefore they can be judged to be important manatee areas. Corresponding steps for the conservation of this still natural area should be taken and secured by nature protection laws.

# 1 Introduction

## 1.1 Context of the study

The Antillean manatee (*Trichechus manatus mantatus*, Linneaus, 1758), a sub-species of the West Indian manatee, is restricted to the tropic and sub-tropic New World Atlantic (HUSAR 1977). Together with the three other living species of the order Sirenia, it is the only fully herbivore, large aquatic mammal in the world (BERTRAM and BERTRAM RICARDO 1973). All species are classified as endangered by the Red Data Book of the World Conservation Union (HILTON-TAYLOR 2000). In French Guiana, the manatee is totally protected by a decree of 1986 and 1995 (MINISTRE DE L'ENVIRONNEMENT 1986, 1995).

Throughout its range of distribution, the status of the West Indian manatee is more or less well studied. A good overview is given by the CARIBBEAN ENVIRONMENT PROGRAMME (1995) and LEFEBVRE *et al.* (1989). Nevertheless, the manatee population in French Guiana is virtually unknown. A first interview study among fishermen and residents was started in autumn 2000 by KWATA. First results suggest that manatees may be less abundant than thought to be 20 years ago, although they are still present and widespread. Furthermore, the study showed that a small but stabile manatee population lives in the estuaries of the River Maroni and the River Oyapock and in the swamps near Sinnamary (DE THOISY *et al.* 2001). As manatees have been living in the estuary of Maroni since a long time and are often seen, it is safe to assume that the mouth of the River Maroni is a well accepted habitat of manatees.

Even nowadays manatees are still hunted in French Guiana for meat. Additionally, but to a lesser degree, they are also killed out of traditional beliefs. But the decline is first of all caused by increasing human occupation of the coastline, which is in consequence followed by more boat traffic. Incidental catches by fishermen are also reported (DE THOISY *et al.* 2001). As many recent publications show, the adequate strategy to fight against further decline of a species is not to protect only individuals but to conserve its environment or its habitat, respectively to give the whole population a better chance to survive (LEFEBVRE and O'SHEA 1995).

Thus, for an efficient conservation of the species and for its protection against further reduction, the demands of manatees on their habitat must be investigated, because “the loss of suitable habitats constitutes the greatest threat to the survival of manatee populations (…)“ (REYNOLDS 1999:267). The few studies on this issue were all conducted in fairly clear water. BENGTSON (1981) and HARTMANN (1979) describe the habitat of the Florida manatee (*Trichechus manatus latirostis L.*), the other sub-species of the West Indian manatee, which lives around the Florida peninsula (RATHBUN *et al.* 1990). By assembling manatee habitat requirements and human impact on the coast, PACKARD and WETTERQVIST (1986) try to develop a method to evaluate areas of existing and potential conflicts between man and manatee. They worked with maps of different information which were juxtaposed, a method developed for urban planning. But transmission of the found aspects to the Antillean manatee must be regarded carefully, because the two subspecies differ at least in behaviour (AXIS ARROYO *et al.* 1998; REYNOLDS 1999).

AXIS ARROYO *et al.* (1998) published an interesting article on the variables associated with the use of manatee habitat in Quintanan Roo, Mexico, an area with turbid waters. Except for those articles little has been published yet on the habitats and the habitat use of the Antillean manatee in Central and South America, even though a large part of the world population of Antillean manatees lives in the coastal zone from Mexico to Brazil. As BENGTSON and MAGOR (1979) pointed out for Belize and BEST (1984) for the Amazonian manatee, the turbid waters which predominate those areas make observations very difficult or even not possible. Also the secretive behaviour and the inaccessibility of the habitat (TIMM *et al.* 1986) are important reasons why this topic has not been studied before.

## 1.2 Aims and main questions of the study

The aim of the study is the analysis and the description of the important parameters determining manatee habitat use in a typical estuarine environment in the Wider Caribbean Region.

Precisely, the main questions of the study are:

- What are the critical factors and in which amplitude do they occur?
- Are there any remarkable differences regarding the critical factors between distinguishable zones in the study area?
- How can the zones be classified into groups of similar character?
- Can any specific behaviour of manatees be related to these areas?
- Is there a difference between already described habitats and the habitat in the Coswine swamps?

Therefore, the different parameters were measured at stations distributed over the working area in a certain distance. At each station the critical factors of manatee habitat use which were identified during literature study are recorded. Then, in a second step, the stations will be grouped into zones of similar character by means of the vegetation and the aquatic factors. Finally the classified zones are mapped and described.

With such a classification and description of an existing area used by manatees, the author aims to contribute to a better knowledge of manatee habitats as it is demanded by MARSH *et al.* (1986:180), because "the major threat to sirenians is alteration of their habitat". POWELL *et al.* (1981:645) conclude for the population in Puerto Rico, which is similar to that in French Guiana – small and wide spread- that "destruction of their habitats or human-caused mortality (…) could have a deleterious impact on their status", because demographic factors, environmental variability and genetic variations can easily influence long-term survival (REYNOLDS 1999).

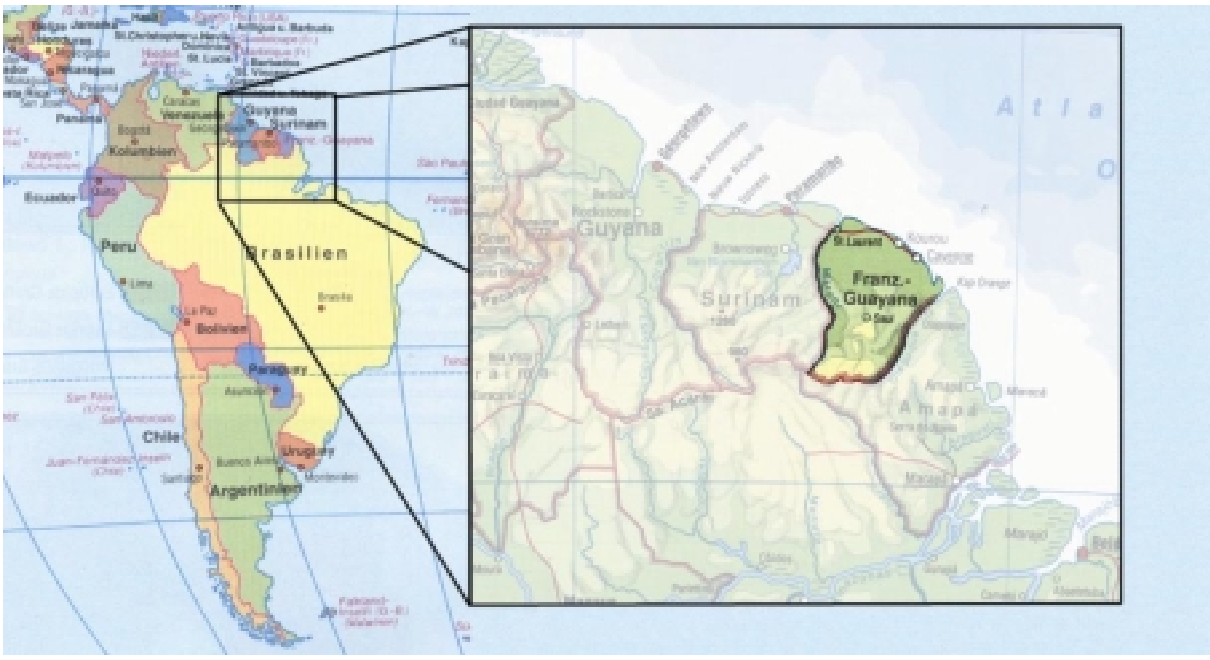
The results of this study may be used to identify potential manatee habitats with the aid of only a few important variables. This should result in a better adaptation of conservation plans to the specific needs of manatees in a certain area. In addition, monitoring can be focused on the main factors and therefore can be less expensive and easier to handle. Moreover, effects of habitat alteration are easier to predict and adequate countermeasures can be taken. All these improvements should enable nature conservation authorities to respond more quickly to any threats of habitat alteration. In consequence, conservation measures will be easier to apply and will be more efficient.

# 2 The Coswine swamps

Among the three important areas where manatees can be found in French Guiana (cf. chapter 1 Introduction) the Coswine swamps were chosen as the study site. They provide a better access than the estuary of River Oyapock, which is only accessible by aeroplane from Cayenne. Furthermore most of the recent observations have been made in the estuary of the Maroni.

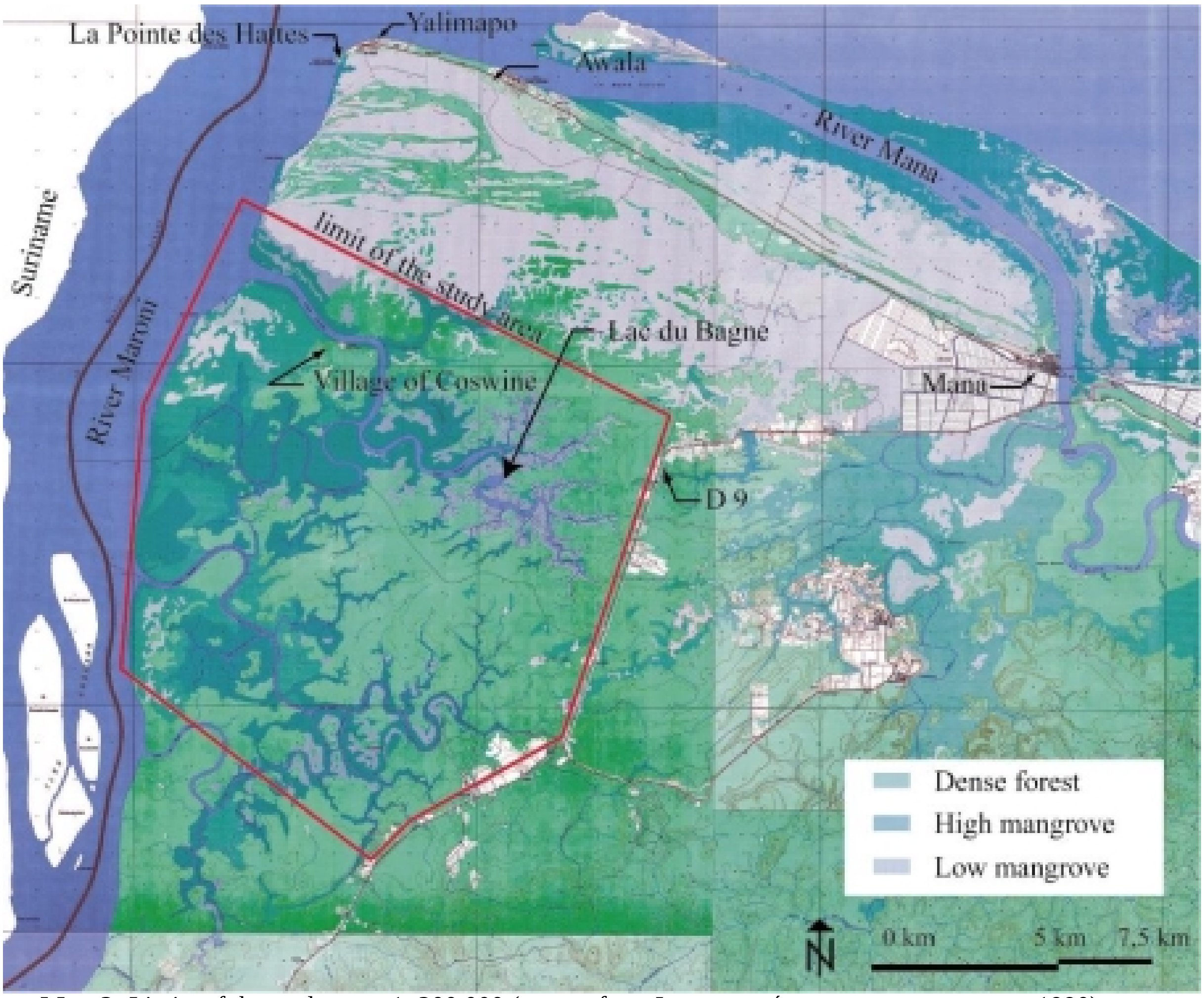
## 2.1 Location and geographical bounderies of the study area

French Guiana, the largest French over-sea department, is situated on the north-east coast of South America between 2° - 6° latitude North and 51° - 55° longitude East (see Map 1). It belongs to the equatorial zone of the northern hemisphere. The border with Surinam is marked by the Maroni River, the guianan-brazil border by the River Oyapock.




**Map 1:** Map of South America (extract from DIERCKE WELTATLAS 1988)

The study was carried out in the Coswine swamps (North 5°34’ to 5°41’, East 53°53’ to 54°00’) in the north-west of French Guiana. The area (Map 2) is restricted by the Crique Coswine with its side-rivers in the North and the Crique Vache in the South. In the West, the zone is limited by the Maroni, the largest river in French-Guiana. In the East, it is restricted by the D9, the departmental road linking the town of Mana to the town of St. Laurent du Maroni.




**Map 2:** Limits of the study area, 1: 200 000 (extract from INSTITUT GÉOGRAPHIQUE NATIONAL 1990)

The Coswine swamps are one of the largest wetlands in French Guiana and for a huge part only accessible by boat. Their total area is approximately about 160 km² (study area ca. 150 km²). Situated in the Southeast of the estuary of the Maroni, they are totally under the influence of the tides (CHOUBERT 1961) and communicate with a network of creeks widely branching out formed during the quaternary (TURENNE 1973). The canals are mainly bordered by mangroves and due to the movements of the tide still navigable (BOYÉ 1963) during high and low tide. The Coswine swamps may be characterised as a system of many meanders in a plain flooded for the most part and therefore be described as a transition zone between the sea and the inland.


**Map 3:** Names of the Criques, 1: 50 000 (extract from INSTITUT GÉOGRAPHIQUE NATIONAL 1990)

## 2.2 Abiotic factors

### 2.2.1 Climate

The climate is equatorial and therefore characterised by a wet and a dry season, and a maximal variation of the average temperature of 2° C over the year. The seasonal change is caused by the intertropical zone of convergence (IZC), which results from the meeting of the St. Helene anticyclone and the Azores anticyclone. The Azores anticyclone plays an important role for the duration and the style of the rain season. The St. Helene anticyclone in contrast influences the dry season. The IZC is responsible for the peaks of rainfall in January and May. Precisely the different seasons can be classified into a short wet season lasting from December to February, the short summer in March (in some years hardly remarkable), the long wet season from April to August and the long dry season from September to November.

The Coswine swamps belong to the climate region 1c (cf. Map 4). According to the Atlas of French Guiana (CNRS and ORSTOM 1979). The climate is characterised by:


**Map 4:** Climatic regions of French Guiana

- sometimes heavy rain, with a very remarkable variation within one year,
- a long and well marked dry season,
- high evaporation, even causing water deficit,
- important winds,
- a light thermal amplitude and,
- the Northeast of the coastal zone being a little bit drier with an average of 2 m of rainfall each year.

All following values are taken from the monthly Meteo France bulletin (METEO FRANCE 1998).

The annual precipitation in the villages surrounding the Coswine swamps is very low. In Awala-Yalimapo it is about 1746 mm, 2656 mm in St. Laurent and 2591 mm in Charvein (average precipitations)[1]. September and October (cf. Fig. 1) are the driest months with less than 30 mm of precipitation in Awala-Yalimapo, in contrast to the wet season with precipitation up to 312 mm in May. Charvein already has some more precipitation, with the minima (less than 80 mm) in September and October as well. In contrast, precipitation reaches nearly 400 mm during the wet season in May. In St. Laurent the precipitation is even higher with the minima in September (104 mm) and October (92 mm) as well, and the maximal precipitation in May (383 mm) and June (334 mm). The annual average humidity is about 80,6%, with peaks in May and June (84%) and its minima during the dry season in September and October with 76%. The Atlas of Guiana (CNRS and ORSTOM 1979), however, gives another value for the humidity (86% in average).

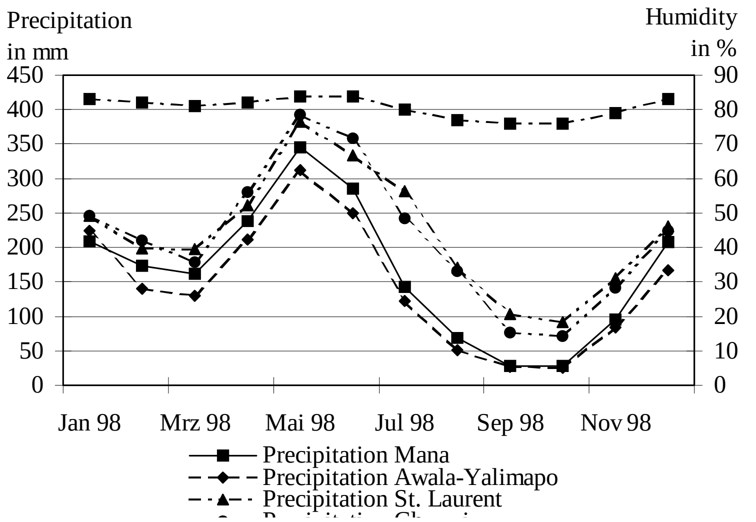



**Fig. 1:** Precipitation and humidity at different villages

[1] Calculations of the averages are made with 1961 as base year for Awala-Yalimapo, 1957 for the precipitation in Charvein, 1978 for the temperature in Charvein and 1949 for St. Laurent, as the records of Meteo France only started in these years.

The air temperature does not vary very much (cf. Fig. 2). The mean temperature is about 26,3° C in Charvein and reaches 27,0° C in St. Laurent. For Awala-Yalimapo, no temperature data is available. The highest values are noted during the dry season in September and October with 27,3° C and 27,4° C in Charvein and 28,9° C and 28,5° C in St. Laurent The minima are reached during the wet season in the months of January and February with average values of 25,2° C for Charvein, 25,8° C for St. Laurent and 26,0° C for Mana. The annual average soil temperature in St. Laurent, measured in a depth of 0,1 m, is 28,7° C with its maxima in September (29,6° C) and in October (29,5° C) and a minimum of 27,5° C in January.

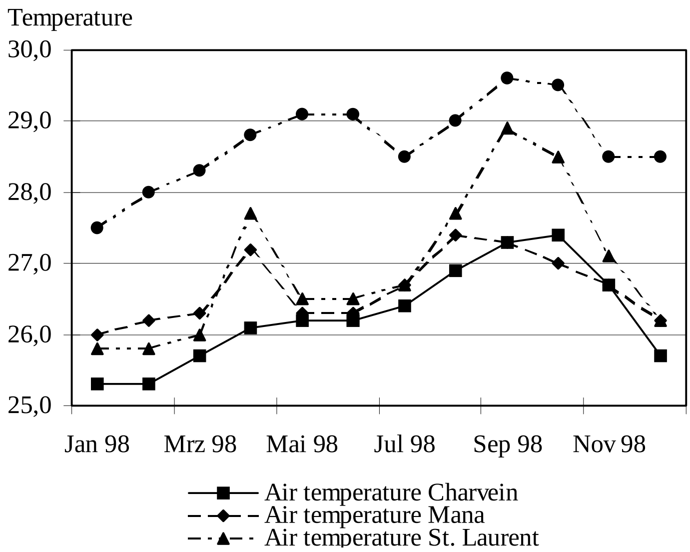



**Fig. 2:** Temperature at different sites

Evaporation is very high in the region with 900 mm/year in contrast to the rest of Guiana where the average evaporation is between 300 and 400 mm/year (LOINTIER and PROST 1986). Comparisons of the average evaporation values from 1955-1965, measured in a Piche evaporation meter (TURENNE 1973), to the precipitation shows that in August to October, evaporation is higher than the precipitation. In St. Laurent the precipitation is little higher in October than the evaporation (78 mm).

In conclusion, one can say that the study area is situated in one of the driest region of French Guiana, but has still a substantial quantity of precipitation.

## 2.2.2 Geology

Situated in the coastal low plain of French Guiana, the whole study area is more or less flat with only a few slight elevations not exceeding 9 m. The area can be divided into the actual coastal plain and the old coastal plain. ROSTAIN (1994) describes the actual coastal plain as low and swampy with elevations not exceeding 4 m. Therefore, it is flooded with each high tide. The deposits are those of the series Demerara with fine clayish, loamy-clayish and sandy parts. The old coastal plain, situated between 5 – 15 m, resembles more closely a landscape of savannah and forest island. The deposits are mainly from the series Coswine (also called Coropina), with marine clay at the bottom and sandy loam towards the surface. The basis for these deposits is the Guiana Shield formed during the Pleistocene.


**Map 5:** Extract from the geological map of Mana – St. Laurent (CHOUBERT 1961). Explications see text.

The evolution of the swamps started in the Enien age when the Coropina-Coswine clays were deposed in the tide canals. The sediments of the Coswine series are subdivided into an totally marine upper part, where mostly sands dominate, and a lower part formed by often bicoloured clays. This lather part progressively acquires an estuarine character towards the South (CHOUBERT 1961). At the same time, a network of thalwegs is caused by the preflandrien phase of erosion. That erosion also provoked the inversion of the relief and in consequence the development of the present landscape with its small islands. Afterwards, these canals were invaded by the transgression in ria of Demerara (BOYÉ 1963). The sediments of Demara are composed of mud (illite and kaolinit) and of sand (CHOUBERT 1961) and can only be found at the bottom of the creeks. The banks are covered with fine fluvial alluvium which was transported downstream by the creeks. (BOYÉ 1963).

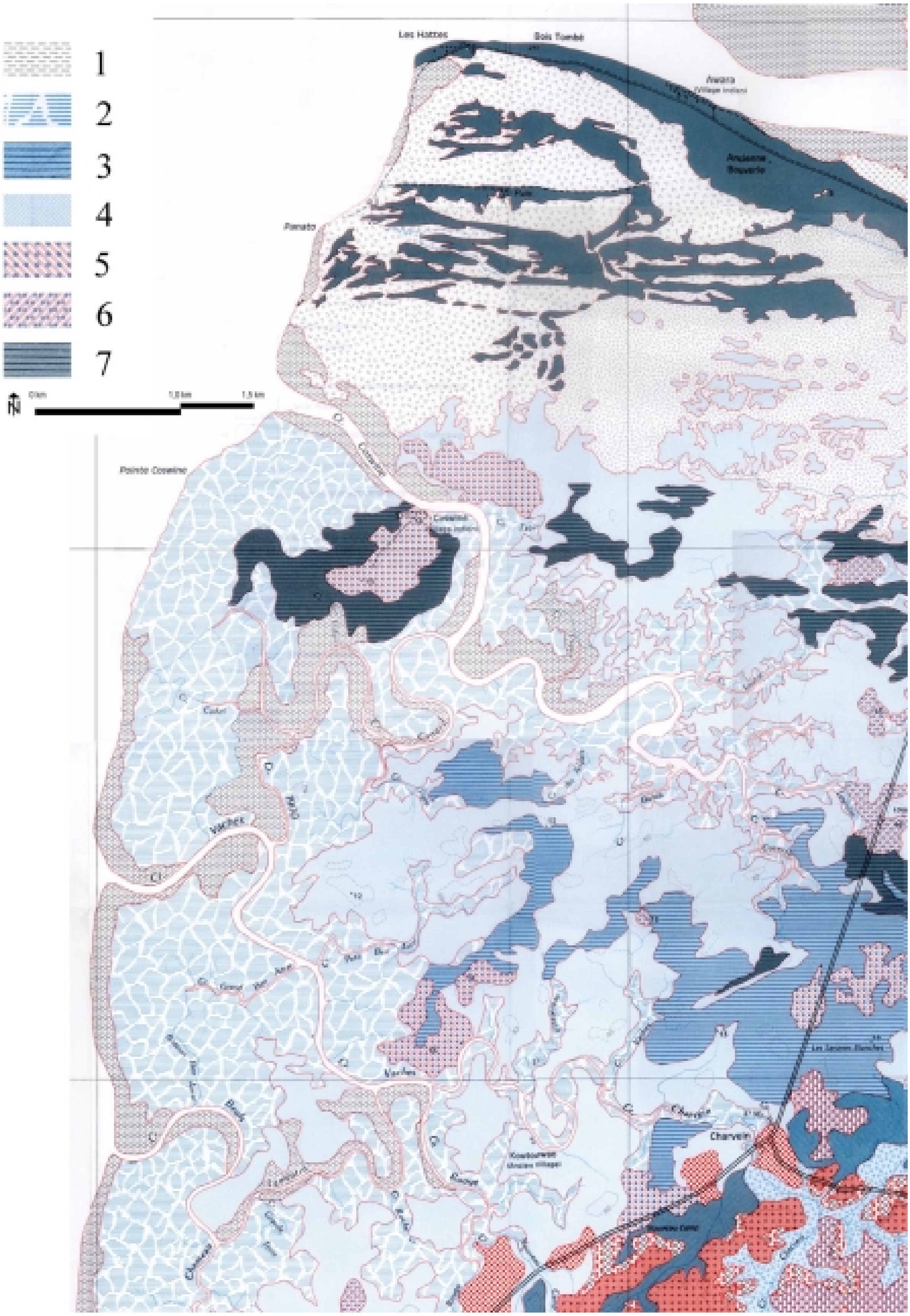
The thalwegs of the water streams are often deep, in particular in the Crique Vache and Crique Coswine (CHOUBERT 1961). In fact, it is been reported that the high basin of Crique Coswine is up to 65 m deep (DIJOSEF and DESBOIS, pers. comm.), which corresponds to the explications of CHOUBERT (1961), who mentions that the native granite rock in the Crique Coswine is found in a depth of 65 m and in 30 m for the Crique Vache. He writes further that some cliffs of 5 to 6 meters and of 10 to 12 meters (low Crique Margot, Crique du Nouveau Camp or Crique Rouge, etc.) can be seen. These cliffs result from the erosion of the banks which happens mainly on the concave side of the meanders (BOYÉ 1963).

**Fig. 3:** Cliffs in Crique Vache

Following the geological map of Mana – St. Laurent (cf. Map 5) three different types of deposits can be found in the study area:

1. Recent and sub-recent deposits: marine deposits: mud and sand (Q4)
2. Deposits of the series of Demerara (young coastal plain) (Q3):
    a. marine deposits: blue clay and sand
    b. river deposits: sandy clay and grey clay
3. Deposits of the series of Coswine (old coastal plain) (Q2):
    a. Marine deposits: red clay and white and sand more or less clay

The recent deposits are mainly found along the Maroni and on the banks of the greater creeks like Crique Vache or Crique Coswine. Where no recent deposits border the banks, the marine deposits of the Demerara series are normally close to the creeks. At very few locations the deposits of the Coswine series are found on the banks, forming mostly high slopes (e.g. village of Coswine, Ancien chantier 1900, etc.).




**Map 6:** Extract from the pedological map of Mana – St.Laurent, 1:250 000 (explications see text) (ORSTOM 1973)

The pedological map (cf. Map 6) of Mana-St. Laurent (ORSTOM 1973) shows seven different soils occurring in the study area, which TURENNE (1973) describes as follows:

1. Immature soils – of non-climatic origins – marine deposits – above marine clayish alluvium: (Ac 0-10 cm C 10-50 cm) These soils with an A-horizon not at all or only little differentiated are formed by recent deposits of marine salty clay. They show biological activity only in the first centimetres. Very little organic matter is present. They are often invaded by *Avicennia germinans* or *Rhizophora*. Under the influence of the tide, and - if colonised by vegetation - oxidation and desalination will start.

2. Hydromorphic soils – moderately organic – humic to gley – anmoor acide – on fluvio-marine alluvium: (A 1-20 cm B 20-50 cm BC 50-100 cm) The native rock is a grey, not salty clay, covered by a humid lowland forest sometimes changing into a palm swamp and flooded during the rain season and high tides. A very small layer of non-degraded organic matter covers the surface. The saturation is very high and the soil reaction lightly acid.

3. Hydromorphic soils – mineral or little organic – gley at the surface or in total – above old Coropina marine clay: The Coropina clay normally is covered by coarse clayish fluvial sands. These soils are often seen on clayish terraces, overgrown by wet lowland forest with a mince litter of leaves. The water sheet is in a depth of 90 cm[2]. The profile shows all aspects of a mature marine clay: red rusty stain and during the dry season well visible polyhedral structure. The percentage of organic matter is high, but it is only found in the upper 5 cm.

4. Hydromorphic soils – mineral or little organic –leached gley – above fine clayish Coswine sand: This profile is the most typical for the region of St. Laurent. It has a large percentage of fine sable. The leaching is indeed visible. The hydromorphic horizon can be found at 20 cm[3], the gley is individualised at 50 cm. At the surface, the highly desaturated soil is rich in organic matter.

5. Ferruginous soils – hydromorphic – above coarses fluvio-marine clayish sand: (A1 1-20 cm, A2 20-60 cm, B1 60-120 cm, C 120-200 cm) The native material is a Coswine sediment. The presence of more coarse elements indicates fluvial mixing. The leaching is well visible. A clayish layer, found at 60 cm, which conditions the hydromorphy begins sometimes to build up a carapace. The soils are limited in their distribution to the fluvio-marine zones in the quaternary plain.

6. Ferruginous soils – hydromorphic – above clayish Coswine sand: ($A_p$ 0-10 cm, $A_1$ 10-60 cm, $B_1$ 60-120 cm, BC 120-200 cm) These rather compact, hardly permeable soils of the Quaternary have now emerged to the surface. They contain up to 30 % of fine sand with a large part of coarse loam. The bleaching is well visible (accumulation at 40-60 cm) and indicates the begin of degradation. The soil reaction is acid (4,7 at the surface). During the wet season the water saturation is rather

[2] No profile depth were given by TURENNE

[3] No profile depth were given by TURENNE

high and signs of waterlogging appear in the profile, leading to the creation of a secondary pseudo-gley.

7. Podzols and podzolic soils– "mor" enriched with sesquioxides with gley horizon at the bottom – with ironpan – above coarse Coswine sand above Coropina clay : ($A_0$ 0-10 cm, $A_2$ 10-20 cm, $B_2$ 20-60 cm, $B_3$ 60-100 cm, II C 110-150) These soils are found in the zone of heterogeneous sedimentation which separates the actual marine clay of the native rock from the detritic sands at the border of zone of deposits. The content of organic matter is high at the surface. The clay in the deeper horizions is highly desaturated. The sandy matters are of continental origin.

## 2.2.3 Hydrology

LOINTIER and PROST (1986) describe the ion concentration of the river water for the great rivers in French-Guiana as identical. Sodium and chloride represent 70 % of the ions (average 10 $^{mg}/_{l}$), while the other ions occur in a maximal concentration of 1 $^{mg}/_{l}$. These values are constant all over the year. LOINTIER (1990) describes the average type of river waters as follows: rate of dissolved matter (> 8 µm) between 8 and 10 $^{mg}/_{l}$ (only approx. $^{1}/_{10}$ of the suspended matter of the lower Amazon (PAYNE 1986; SIOLI 1984), sum of major ions between 12 and 14 $^{mg}/_{l}$, dissolved silicate between 10 and 15 $^{mg}/_{l}$ and pH at 6,5 in contrast to the pH of the sea which normally lies at 8,0 units. The slopes are very low (0,03 mm/km) and therefore the velocity as well. The maximal speed of the ebb current has been recorded by BERTHOIS and HOORELBECK (1968) with 6,5 km/h in March during a period of medium discharge (about 2000 $^{m^3}/_{s}$), while the maximum is around 7730 $^{m^3}/_{s}$.

Regarding the high evaporation during the dry season and the low precipitation in the region during the whole year, the salinity changes considerably during the different seasons (LINDEMAN 1953). In the dry season, salt water flows upstream with the raising tide up to the inflow of Crique Bœuf aux Lamantins, while in the wet season marine waters enter the mouth of Maroni only up to the Crique Coswine (JOUNNEAU and PUJOS 1988). Salty water has a higher density and is transported in a lower depth than fresh water (GERLACH 1994). This explains why in the Coswine swamps, marine fishes and other organisms are found at the so-called site "Lac du bagne" (DIJOSEF, pers. comm.): the more dense salt water rises up the Crique Coswine to the "Lac du bagne" where it comes up in the lake-like opening in the Crique Coswine (cf. Map 2). In general, in French Guiana the estuaries are invaded during the tides with salt water (dry season) or brackish water (wet season) (LOINTIER and PROST 1986). The average salinity in the sea is 36,1 ‰, in the estuaries it does not exceed 35 ‰ (CNRS and ORSTOM 1979). Commonly, water with a salinity under 0,5 ‰ is called fresh water, between 0,5 ‰ and 30 ‰ it is brackish water and above 30 ‰, salt water (GERLACH 1994). The average water temperature is about 27° C and varies between 26° C and 29° C depending on the season (CNRS and ORSTOM 1979).

Two different systems of water importation into the swamps exist: rain and raising tide. The rain has its main influence during the wet season, when precipitation is - in contrast to the dry season - very high. At this time, the influence of the flooding on the swamp is mainly mechanical: raising tide only changes the water level, but does not have a huge impact on the already soaked swamp soils. In contrast, during the dry season the import of brackish water is of greater importance to the soils, as at that time precipitation is very low. With each raising tide or at least with the spring tide, the soil of the inland swamp is flooded (LOINTIER and PROST 1986).

The Coswine swamps are drained by a system of tributaries which flow into the three largest creeks Crique Coswine, Crique Vache and Crique aux Bœuf Lamantins. Canals of changing streams depending on the tide connect the system: the Crique 1900 connects the Crique Canard to the Crique Vache, and the Bistouri Ben Amar connects the Crique aux Boeufs Lamantins to the Crique Grand Ben Amar. The three big creeks drain entirely to the Maroni River which flows into the Atlantic Ocean approximately 2 km in the north of the study area. The rivers in French Guiana do not transport many particles and the estuaries are mainly filled with marine silt. Sedimentation of river load is restricted to the inflow of smaller creeks where water velocity is slower because of the faster current of the main river (BERTHOIS and HOORELBECK 1968).The sedimentation of the Maroni River is very low before the inflow of the Crique aux Bœufs Lamantins (BERTHOIS and HOORELBECK 1968). Going downstream from this creek, the mud appears only locally at first and shows a wide distribution close to Pointe Coswine. This typical estuarine feature is observed in many estuarine situations and is called "estuarine circulation" (GERLACH 1994): at high tide, the salt water is transported upstream at the bottom, as it is more dense than the fresh water. Because the currents are rather fast, silty particles are taken away and deposed further upstream to the limit of the salt water transport. At low tide, the faster flowing water at the surface transports many particles into the other direction. As a result suspended matter is deposited in the estuary.

The tides are semi-diurnal with unequal duration. Every 12h 25' a new high tide is recorded. The schedule of the tides is made by the maregraph of the Iles du Salut; to get the exact time of the tide at the Pointe des Hattes (mouth of the Maroni, cf. Map 2) one must add 5 minutes for the high tide and 15 minutes for the low tide (APAVE 2000). During the study time, the maximal difference between low and high tide was 2,83 m (17/18. September), the minimum 0,72 m (25. September), calculated for Les Hattes (LES MAREES DANS LE MONDE 2000).

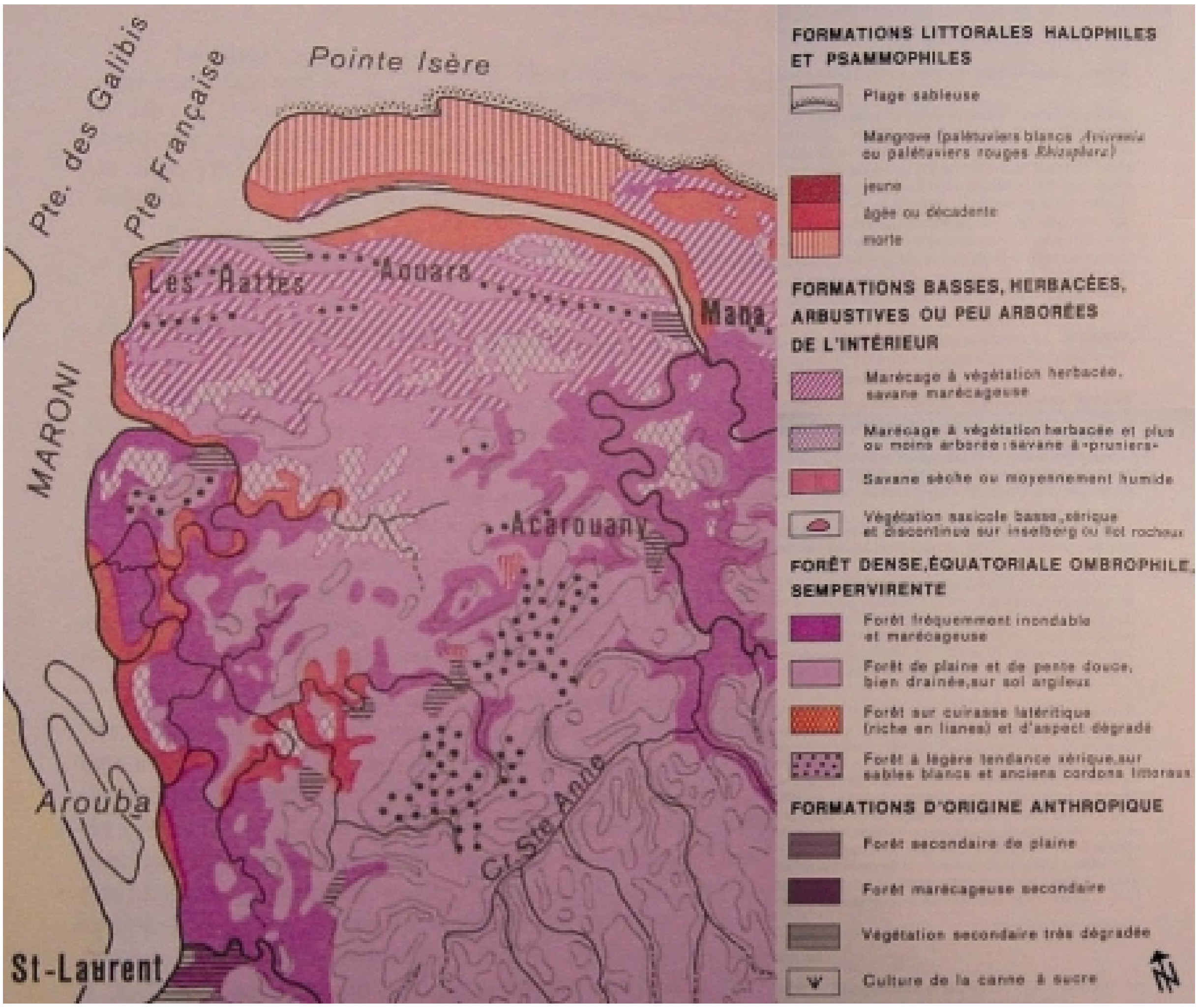
BOYÉ (1963:18) concludes from the existence of *Rhizophora* and *Montrichardia arborescens* in an area totally submitted to the influence of the tides that "nous sommes donc là en milieu proprement estuarien"[4].

[4] Engl. "we are here in a clearly estuarine milieu" (T.S.)

## 2.3 Vegetation and vegetation units

LINDEMAN and MORI (1989) give a rough overview over the existing vegetation types in the Guianas. Concerning the study area, three types are taken in consideration: a. mangrove, b. marsh forest and c. swamp forest. In contrast to marsh forests which have waterlogged soils during one part of the year and are dry during the rest of the year, swamp forests grow on soils which never dry out completely. Their distribution is restricted to fresh-water areas, whereas the saline swamp forest are treated as mangroves. The marsh and/or the swamp forest are commonly called “várzea” or “igapós”, two terms mainly employed for the vegetation types along the Amazonian Brazil (cf. PIRES and PRANCE 1985).

The classification of the vegetation types for French Guiana by GRANVILLE (1992) which is based on that of LINDEMAN and MORI (1989), is concentrated on one country and therefore more detailed. He notes six different vegetation formations for the actual coastal plain. Out of these, the herbaceous swamps, the swamp forest and the estuarine mangrove occur in the study area.




**Map 7:** Extract of the vegetation map, 1:250 000 (CNRS and ORSTOM 1979)

According to the topographic map (Map 2) of the INSTITUT GÉOGRAPHIQUE NATIONAL (1990), one can find three different types of vegetation on the borders of the creeks: Low mangrove (cf. Fig. 4), high mangrove (cf. Fig. 5), and dense forest. This classification is very rough, derived from aerial photos and sometimes not justified. The border between the low mangrove and the high mangrove for examples often cannot be seen. Furthermore the inland forest in French Guiana are also called “dense forest”, but both are not similar concerning species distribution. The more precise Atlas of Guiana (Map 7) shows more vegetation units as the topographic map. In total, five different units appearing in the study area are mapped in the Atlas: old or decadent mangrove, herbaceous swamp or swampy savannah, forest frequently flooded or swampy, forest with light xerice tendency above white sands and ancient coastal belt, secondary forest of the plain.

**Fig. 4:** Low mangrove

**Fig. 5:** High mangrove

The inventory of CORINE-BIOTOPES has not been finished in French Guiana until now. A preliminary list of vegetation units is under revision at the Herbarium of Guiana in Cayenne (de GRANVILLE, pers. comm.).

In the followings paragraphs, the three dominant vegetation types, mangrove, herbaceous swamp and marsh/swamp forest (sensu GRANVILLE 1992), will be described.

## 2.3.1 Mangrove

Mangroves are found at the coasts and on silty soil in the estuaries of tropical countries. In general, mangroves can be divided in two groups: the Atlantic Mangrove in Africa and America and the Oriental Mangrove in Southeast Asia, Malaysia and in the Pacific. Due to the warm Brazil Current the mangroves extend at the Atlantic coast of America from Florida (27° – 28° N) to Mid-Brazil (28°20’ S) in contrast to the Pacific coast of America where the mangroves are only found up to 3° 48’ S because of the cold Humboldt Current (SCHNELL 1987). On the northern Pacific coast of America, mangrove vegetation is limited to 25°38 N (CHAPMAN 1976b).WEST (1983) considers with *Avicennia* at St. Augustine, Florida (29°53’ N) and mangrove association with *Rhizophora* at the Bermuda Islands (32°20’ N) as the northmost distribution of mangrove vegetation association. In accordance with CHAPMAN (1976b), he explains the limited distribution of mangroves at the Pacific coast by the lack of quiet bays and the absence of river deltas with fine sediments. In French Guiana, mangroves cover only 70 km² of the land surface (~ 0,8 %) (LESCURE and TOSTAIN 1989). Estuarine mangroves can be found at the mouths of all big rivers in French Guiana and coastal mangrove nearly all along the shore (GRANVILLE 1986).

The distribution of the different species depends on temperature, mud substrate, protection, salt water, tidal range, ocean currents and shallow shores (HUTCHINGS and SAENGER 1987). To survive in this environment, the mangrove plants have developed different survival techniques: their seedlings are viviparous (*Avicennia* and *Rhizophora*), they have the ability to excrete salt through the leaves (*Avicennia*) or they have a membrane in the roots (*Rhizophora*) to separate the salt ions (CHAPMAN 1976a). Further root modifications lead to pneumatophores in *Avicennia* and to the typical stilt roots in *Rhizophora* (KING *et al.* 1990) or to buttress roots (*Pterocarpus*).

The mangroves appear in salt and in brackish water and settle on already existing land; afterwards they accelerate the sedimentation (BERTHOIS and HOORELBECK 1968; CHAPMAN 1976a; SEIBERT

**Fig. 6:** *Languncularia racemosa*

**Fig. 7:** *Rhizophora racemosa*

1996). In contrast to the coastal mangrove, the estuarine type has a lower salt concentration in the soil and elements of river sedimentation are mixed to marine mud. Moreover, the mangrove of the estuaries is a stable mangrove and not subjected to temporal changes of the mud banks. Therefore the estuarine mangrove is richer in species. The further it is away from the sea, the more intermediate vegetation units between those of the mangrove and those of swamp forests exist (GRANVILLE 1986). The productivity of the mangrove is about 2 kg $m^{-2}$ $a^{-1}$ of dry matter (GERLACH 1994).

The vegetation of the estuarine mangrove is often dominated by the Red Mangrove *Rhizophora racemosa* (cf. Fig. 7), which replaces and substitutes the Black Mangrove *Avicennia germinans*, the typical species of coastal mangroves. *Rhizophora ssp.* are sometimes even found at the level of the first rapids, i.e. at the limit of the tides away from any salt water (LESCURE and TOSTAIN 1989) or they can even live constantly in fresh (LINDEMAN 1953) or in slightly brackish water (WEST 1983). PIRES and PRANCE (1985) in contrast, sees the distribution of *Rhizophora ssp.* limited to the salty water areas. Locally, the White Mangrove *Languncularia racemosa* (cf. Fig. 6) replaces the Red Mangrove and develops mixed stands where the two species meet, but *Languncularia racemosa* never reaches tree habit in these areas (LINDEMAN 1953). *Rhizophora mangle* is another species of the Red Mangrove which occurs mainly along the coast and saline river banks. Where the *R. mangle* and *R. racemosa* meet, a hybrid of the two exsists, *Rhizophora harrison* (LINDEMAN and MORI 1989).

According to WEST (1983), the lower river courses of French Guiana are bordered by a fringe of *Rhizophora mangle*, while further upstream *Languncularia racemosa* appears. Besides these, typical mangrove plants like *Machaerium lunatum*, *Montrichardia arborescens*, *Conocarpus erecta*, and the two palm species *Mauritia flexuosa* and *Euterpe oleracea* are often present in the mangroves of

French Guiana (GRANVILLE *et al.* 1993) (cf. Fig. 8 and Fig. 9). In the transition zone to the swamp forest, the mangrove vegetation is enriched with species possessing more or less "bank character" like *Carapa guianensis*, *Pterocarpus officinalis*, *Pachira aquatica*. Behind this curtain, some swamp formations dominated by *Euterpe olerace* can be found (SCHNELL 1987). BENOIST (1924/1925) considers *Macrolobium bifolium* and *Muellera* to be important species beyond the limit of the mangrove.

**Fig. 8:** In the front *Machaerium lunatum* with *Montrichardia arborescens*, in the back *Rhizophora racemosa*

**Fig. 9:** Species rich formation with *Mauritia flexuosa*, *Pachira aquatica* and in the back *Rhizophora racemosa*

PIRES and PRANCE (1985) describes the mangrove appearing in a small strip in Amazonian Brazil along the coast as poor in species and dominated by *Rhizophora mangle*, *Avicennia germinans*, *Languncularia racemosa* and *Conocarpus erecta* all of which appear in great dominance. Besides these plants, only a few others occur: *Pterocarpus officinalis*, *Hibiscus tiliaceus*, *Annona palustris*, *Pithecelobium cochleatum* and *Spartina brasiliensis*.

LINDEMAN (1953) gives an overview of the general appearance of mangroves in Surinam. He characterises the vegetation patterns along the riverbanks as follows: at the river mouth a belt of *Rhizophora mangle* is found if tidal action is low. Sometimes this fringe is interrupted by *Languncularia racemosa* or by *Machaerium lunatum*. Further inland with decreasing salt content, *Avicennia germinans* replaces *Rhizophora* and *Languncularia*. Where the riverwater becomes fresher, *Montrichardia arborescens* appears. Further upstream, when *Rhizophora mangle* and *Languncularia racemosa* are less common, *Pachira aquatica* and *Pterocarpus officinalis* border the riverbanks.

### 2.3.2 Herbaceous swamp

The herbaceous swamp is the most important vegetation unit of the recent coastal plain (GRANVILLE 1992) and occupies about 1500 km² in French-Guiana, mainly on recent marine mud (GRANVILLE *et al.* 1993). GRANVILLE (1986) and GRANVILLE *et al.* (1993) classify different types of herbaceous swamp formations into four groups and describe their increasing floristic variety from the mangrove to the interior:

1. Swamps of *Eleocharis mutata*: also called dead mangrove savannah, this formation mainly growing on still salty soil is the predecessor to the fresh water swamps and successor of the mangrove. The soil differs from the soil of the mangrove: due to the intake of rain water in the rainy season, organic matter is accumulated at the surface, the acidity is higher and the salinity lower. The vegetation is characterised by *Eleocharis mutata*, a plant which has a large tolerance of salt and is found from fresh water habitats to water with a salt rate of two times the sea water (LINDEMAN 1953). In addition, other *Cyperaceae*, *Machaerium lunatum*, *Montrichardia arborescens*, *Chrysobalanus icaco* and *Euterpe olearcea* can be found.
2. Swamps of *Typha angustifolia* and *Cyperus articulatus*: this is a transition formation making the conjunction to the following unit of fresh water swamps. The vegetation is very dense, attains a height of 2 m to 2,5 m and is dominated by *Typha angustifolia*. The fern *Acrostichum aureum* and some graminoides (*Cyperus articulatus* and *Leersia hexandra*) are often found as well.
3. Fresh water swamps of *Cyperaceae* and ferns: the most widely distributed formation. It grows on a small organic layer and it is under the influence of changing water levels due to the different seasons. The desalination is quite progressed and salt can only be found in a depth of 1 m. The flora is dominated by *Cyperaceae*, *Onagraceae*, *Convolvulaceae* and *Poaceae*. Two fern species (*Blechnum serrulatum* and *Thelypteris interrupta*) are very abundant and produce the main part of the peat layer. Often, *Montrichardia arborescens* is very abundant.
4. Swamps of *Echinochloa ploystachya*: Also called grass savannah this formation can be found in French Guiana only in the upperstream region of the River Kaw. The soil is not salty and sometimes the marine deposits are mixed with alluvials. Patches of *Chrysobalanus icaco* and *Maurita flexuosa* are less widespread than in the other formations and the herbaceous vegetation is dominated by *Leersia hexandra* and *Echinocloa polystachya*.

LINDEMAN (1953) gives a very similar but more detailed description for Surinam.

### 2.3.3 Swamp forest and marsh forest

This formation occupies approximately 3 000 km² in French Guiana (3,3 % of the total land surface). The different vegetation types can be classified by the period of flooding, the development and the hydromorphic level of the soil. GRANVILLE (1986) and GRANVILLE *et al.* (1993) distinguish four species of flooded forest:

1. Woody swamp: this formation corresponds to the "igapo" in the Brazilian nomenclature. Woody swamps are flooded permanently by stagnant fresh water and are mainly found in the coastal swamps or in the river meanders. The most common species are *Triplaris surinamensis* or *Inga sp.* LINDEMAN (1953) distinguishes three subspecies: (1) the mixed woody swamp with mainly *Annona glabra* and *Triplaris surinamensis*, (2) the woody swamps of *Erythrina glauca* forming isolated stands of *E. glauca* and (3) the association of *Machaerium lunatum* which reaches a height of 3- 4 m and sometimes entirely covers small creeks.

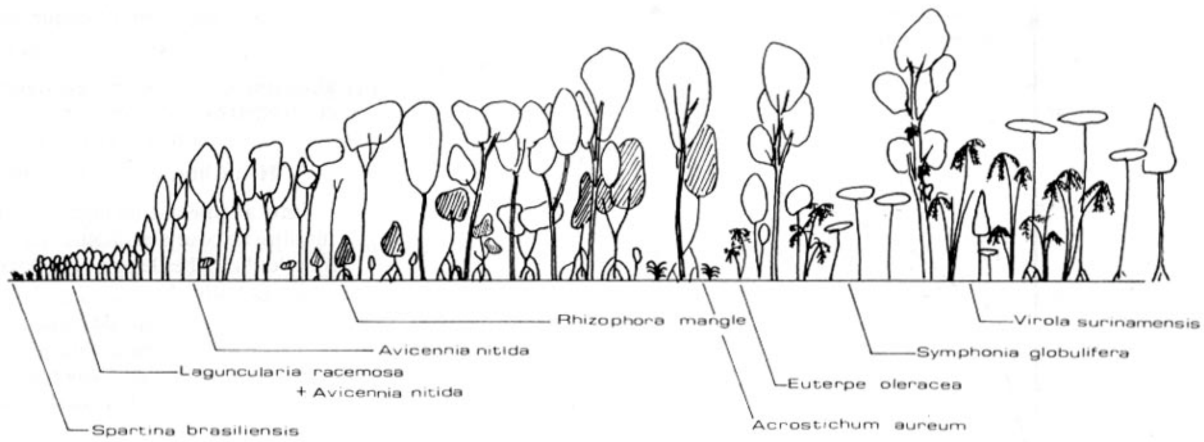



**Fig. 10:** Cross section from the sea to *Euterpe olerace* forest (after LESCURE and TOSTAIN 1989)

2. Swamp forest: also called "várzea" in Brazil, this floristically rich formation (170 to 210 different vascular plant only in the formations of the coastal plain) thrives on not always flooded, but hydromorphic soils. LINDEMAN (1953) has established a classification for the swamp forest of Surinam in which he describes two groups: (1) the swamp forest of *Triplaris surinamensis* and *Bonafusia tetrastachya* and (2) the swamp forest of *Symphonia globulifera* which prospers on clayish marine deposits of the rivers and streams (cf. Fig. 10). The two formations are dominated by different species. The most important are *Euterpe olearcea*, *Symphonia globulifera*, *Virola surinamensis*, *Pterocarpus officinalis* and *Mauritia flexuosa*.
3. Alluvial forest: this forest temporally flooded during the rain season is characterised by its non-existing undergrowth.
4. Riparian forest: the riparian forest normally grows on terra firme and is flooded only rarely. Being comprised of forest species, undergrowth species, canopy species and light requiring species, it is rich in species. The number of species in this formations in French Guiana is about 1500 to 2300, which is due to the circumstance that the forest canopy descends to the water level (OLDEMAN 1972).

The dominant plants of marsh and swamps forests are the palm species *Mauritia flexuosa* and *Euterpe oleracea*. *Machaerium lunatum* is a shrub which appears regularly in this vegetation type. Along the river banks a thick vegetation of *Montrichardia arborescens* is often found (GRANVILLE 1992). PIRES and (PRANCE 1985) are more categorical and defines the "estuarine várzea" as an area with extraordinary abundance of palms in particular *Astrocaryum murumuru*, *Raphia taedigera*, *Euterpe oleracea*, *Maximiliana regia*, *Oenocarpus distichus*, *Jessinia bataua*, *Mauritia martiana*, *Mauritia flexuosa*, and *Genoma ssp*.

SCHNELL (1987) draws special attention to the woody riparian formation. He mentions that a nearly pure formation of *Pterocarpus officinalis* is found in the Guiana-amazonian region. This formation is bordered by *Montrichardia arborescens* and often *Pachira aquatica* is abundant. In the convex meander *Inga sp.* is found.

## 2.4 Fauna

GRANVILLE *et al.* (1993) note that the fauna of the estuarine mangrove is relatively rich: White-tailed Deer *Odocoileus virginianus*, Mangrove Oyster *Crassostrea rhizophorae*, Mangrove Crab *Ucides cordatus*, and Caiman *Caïman crocidilus* can be found. Furthermore, some primates like the Common Squirrel Monkey *Saïmiri sciureus* lives in these zones. Further away from the sea, the diversity of the fauna increases, similar to the plant species richness. Thus some nectarivore birds like the Plain-bellied emerald *Amazilia leucogaster* and some fructivore birds, e.g. the Yellow-rumped Cacique *Cacicus cela*, appear. In contrast to that description, TOSTAIN *et al.* (1992) judge that the avifauna of the mangrove is not very rich. But these different assumptions are more a result of different classifications than a substantial disagreement: GRANVILLE *et al.* distinguish coastal and estuarine mangrove, while TOSTAIN, DUJARDIN *et al*. classify the coastal mangrove in one group and lagoons and subcoastal swamps, including estuarine mangrove, in another.

During the field work the following animals have been observed apart from manatees: Crab-eating Raccoon *Procyon cancrivorus*, Giant Otter *Pteronura brasiliensis*, Jaguar *Panthera onca*, Common Squirrel Monkey *Saïmiri sciureus*, Red Howler Monkey *Alouatta seniculis*, Caiman *Caïman crocidilus* and Green Iguana *Iguana iguana*.

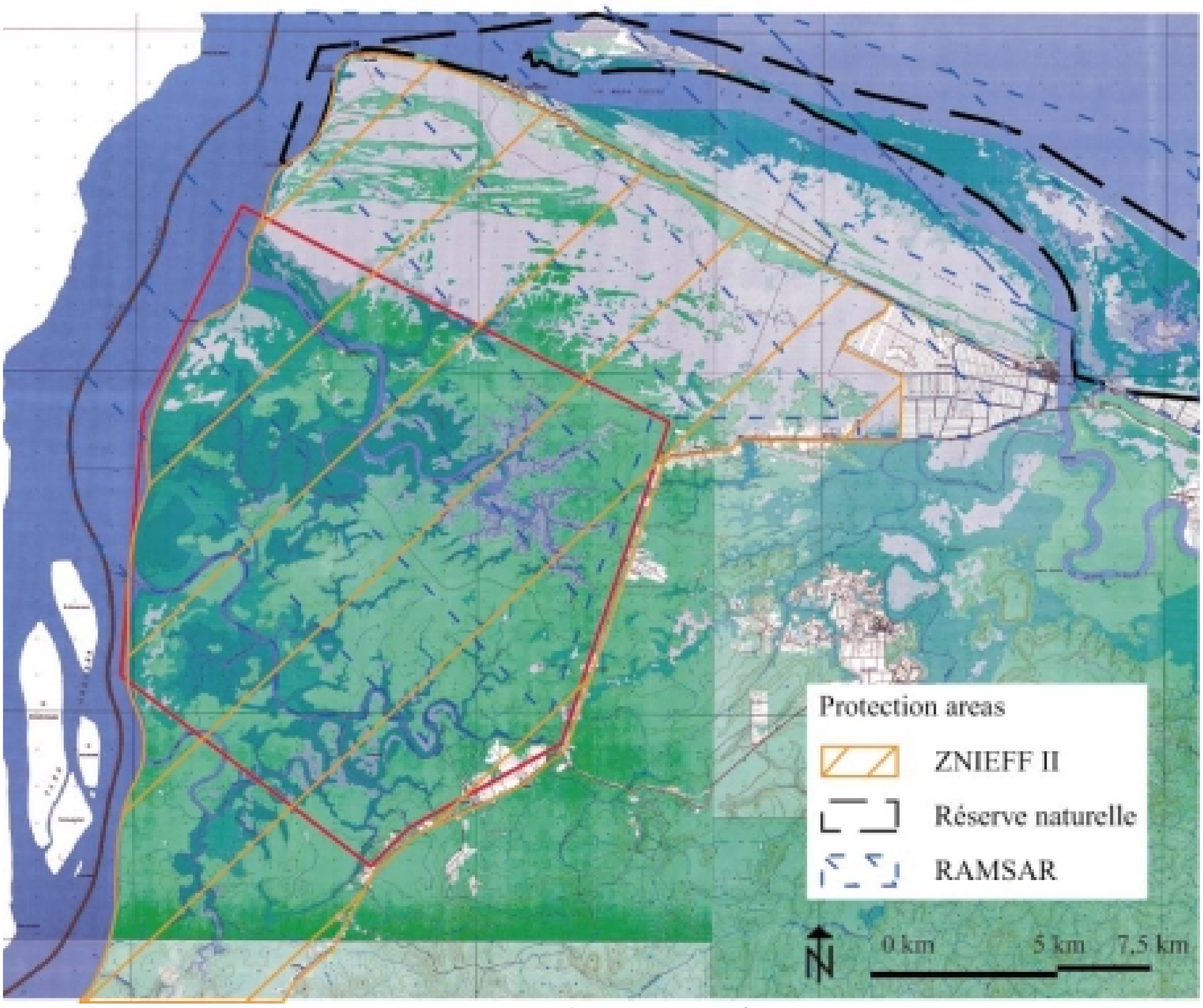
Birds often seen are the Yellow-rumped Cacique *Cacicus cela*, White-winged Swallow *Tachycineta albiventer*, Greater Ani *Crotophaga major*, Black Vulture *Coragyps atratus*, Muscovy Duck *Cairina moschata*, Sunbittern *Eurypyga helias*, Pied-Water Tyrant *Fluvicola pica*, Willet *Catoptrophorus semipalmatus*, Snowy Egret *Egretta thula*, White Egret *Egretta alba*, Little blue Heron *Egretta caerulea*, Little Kingfisher *Chloroceryle amaericana*. Even the Hoazin *Opistocomus hoazin*, the only ruminant bird in the world, was heard one time.

In general it can be said that the fauna of the estuarine mangrove is quite untouched. Hunting occurs only rarely (GRANVILLE *et al.* 1993). This is valid even more for the Coswine swamps, as they are rather badly accessible except by boat.

## 2.5 The conservation areas

Situated in the North of the study area, the “Réserve naturelle de l’Amana” (cf. Map 8) was created in 1997. The reservation is dedicated to the conservation of Leatherback turtles *Dermochelys coriacea*, Olive Ridley turtle *Lepidochelys olivacea* and Green turtles *Chelonia mydas*, which nest on the sandy beaches. According to SPOTILA *et al.* (1996) the Plage des Hattes (cf. Map 2) is considered to be the most important Leatherback turtle laying site of the world.

Since 1992, the Coswine swamps are part of the Ramsar zone “Basse Mana”. The Ramsar perimeter includes 15 000 ha of marine waters and estuaries, and 44 000 ha of terrestrial zones. The area is subject to constant changes of its shoreline by the accumulation of deposits and erosion (DIRECTION REGIONAL DE L'ARCHITECTURE ET DE L'ENVIRONNEMENT 1992). Beginning in the North at the Plage des Hattes, a ZNIEFF II (“Zones d’Intérêt Ecologique, Faunistique et Floristique”: zone of ecological, faunistic and floristic interest) was created in 1992. The ZNIEFF is restricted in the South by the Crique Vache and in the East by the departmental road. A ZNIEFF II is either a large natural ensemble rich and little modified, or one which offers important biological potentials compared to an ZNIEFF I, which is an area limited in surface, characterised by its remarkable biological interest (LÉVY-BRUHL and COQUILLARD 1998).




**Map 8:** The protection areas, 1: 200 000 (extract from INSTITUT GÉOGRAPHIQUE NATIONAL 1990)

## Summary

The Coswine Swamps, the study area for this project, are one of the biggest wetlands in French Guiana. They are situated in the Northwest near the Guianan-Surinamese border in one of the driest regions in French Guiana. The climate is characterised by a dry and a wet season, both of which have a major influence on the water regime in the swamps. The swamps are drained by a system of different tributaries flowing into three bigger creeks.

The soils are mainly formed by recent marine deposits without much organic matter. On these soils, different vegetation formations thrive: mangrove, swamp/marsh forest and herbaceous swamps. Chemical water properties of all big rivers in French Guiana are the same and rivers do not transport much suspend matter. The estuaries are filled with marine mud brought in by the flood and varying between 0,7 and 2,8 m in height. The fauna is quite untouched and animal observations are numerous. Therefore, different conservation areas have been installed in the area: the “Réserve naturelle de l’Amana”, the Ramsar zone “Basse Mana” and the ZNIEFF II.

# 3 The Antillean Manatee (Trichechus manatus manatus)

## 3.1 Systematic of the Antillean manatee

The Antillean manatee (*Trichechus manatus manatus* Linneaus, 1758) (Fig. 11) belongs to the Phylum Chordata, the Class Mammalia and the Order Sirenia. This order is divided into two families: Dugongidae and Trichechidae.

**Fig. 11:** Couple of manatees (photo BATEMAN 1987)

The family Dugongidae consists of only one still living species, the Dugong *Dugong dugong*. It lives in the Indo-pacific area and is the only completely marine Sirenia species. The extinct Steller's sea cow (*Hydrodamalis gigas*) in contrast, belonging to the family Dugongidae as well, lived in the Bering Sea. That species demonstrates the vulnerability of sirenians, as it was hunted to extinction in 1768, only 27 years after its discovery (MARMONTEL *et al.* 1997). The family Trichechidae contains one genus, *Trichechus*, which includes three species: *T. manatus* (West Indian manatee), *T. inunguis* (Amazonian manatee) and *T. senegalensis* (African manatee). *T. manatus* has two subspecies, which can be distinguished by morphological criteria (DOMNING and HAYECK 1986). *T. m. manatus* is found on the Atlantic coast of South and Middle America and *T. m. latirostris* (Florida manatee) around the Florida peninsular to Louisiana. The two subspecies are separated by the cool winters of the Northern Gulf coast and the deep water and strong currents of the Straits of Florida (DOMNING and HAYECK 1986). There are some doubts about the classification of the subspecies (cf. Introduction), but the discussion of this topic is far beyond the aims of this study. Nevertheless, the new results based on DNA analysis from GARCIA RODRIGUEZ *et al.* (1998) show that three lineages exist which correspond in geography approximately to Florida and the West Indies, Gulf of Mexico to the Caribbean rivers of South America, and the Northeast Atlantic coast of South America.

*T. manatus* mainly lives in rivers, estuaries and bays in the Caribbean and the Gulf of Mexico, while *T. senegalensis* occupies the same zones in West Africa. *T. inunguis* is only found in the freshwater areas of the Amazon and Orinoco, but there is some evidence that Amazonian manatees appear in slightly salty water as well (DOMNING 1981). At the mouth of the Amazon, *T. inunguis* and *T. manatus manatus* meet (DOMNING 1981), but no hybrids are formed (DOMNING and HAYECK 1986).

The evolution of the manatee species shows that the West African and the West Indian manatee share a more common ancestor than they do with Amazonian manatee. DOMNING (2001) gives a more precise overview of the prehistoric development of manatees.

## 3.2 Biology and Ecology of the Antillean manatee

As the only fully herbivore and aquatic mammals, Sirenians are highly specialised and very well adapted to their environment. In the following paragraphs the most important features are explained.

### 3.2.1 Biology of the manatee

**Morphology**

An overview over the morphology is provided by HUSAR (1977) from which the following extracts are taken.

Manatees are large, totally herbivorous aquatic mammals with a total length of 2,5 m to 4,5 m and a weight of 200 kg to 600 kg. Their body is streamlined and covered with short hairs. The colour is uniform grey but sometimes obscured by algal growth, barnacles or incrustations. Manatees have one paddle-like tail and two forelimbs with nails on the dorsal surface. The flippers are quite movable and used for feeding and social behaviour.

Manatees have a low metabolic rate of only 20 % to 30 % compared to other animals of the same body size.For this reason manatees, are not able to keep their body temperature up at a certain level (WELLS *et al.* 1999), what can, in consequence, cause in extrem cases the death of an animal.

**Behaviour**

Manatees are described by HARTMANN (1979) from whom the following information is taken, to be secretivly, but they are active during night and day. Their daily course is arhythmic and they show no certain behaviour which is repeated several times per day.

Manatees are slow swimming animals with an average speed of only 3 to 7 km/h. As herbivores they do not need speed and acceleration. But when fleeing, they can reach 25 km/h over a short distance. Cruising depth for manatees is usually between 1 – 3 m with a maximal depth of about 8 m, due to the higher water pressure in the depth. Occasionally, they descend down to 20 m. While swimming acceleration is achieved with the paddle-like tail and steering with the two forelimbs. In shallow water manatees move their body back and forwards by strong strikes of the forelimbs (TSCHADA 1994).

Diving time increases from calves to adult manatees. The average time is about 4 ¼ minutes (HARTMANN 1971), but other authors give 2-3 min (WELLS *et al.* 1999). For breathing, manatees raise their snout out of the water and breath through the movable nostrils (TSCHADA 1994).

**Reproduction**

Manatees are typical K-selected species: they breed repeatedly during their lifetime, litter size is small, it takes years to reach sexual maturity, and lifespans are long (REYNOLDS 1999).

Concerning reproduction, little is known about the Antillean manatee in contrast to the Florida manatee. BOYD *et al.* (1999) see female *T. m. latirostis* reaching sexual maturity between the ages of 2,5 and 6 years, approximately at the same time as the males ones, while MARMONTEL *et al.* (1997) give an age of 3 - 4 years. The gestation takes 12 - 14 months (BOYD *et al.* 1999). HUSAR (1977) and BELITSKY and BELITSKY (1980) suggest from observation of young manatees during any time of the year that manatees breed throughout the year, but more recent publications show that breeding peaks exist for the Florida and the Amazon manatee (BOYD *et al.* 1999) and the Antillean manatee (COLMENERO- ROLON 1985). For the two last ones, this is caused by the change of wet and dry season, while for the Florida manatee temperature may be responsible. Normally, only one calf is born, but twin birth has been reported (WELLS *et al.* 1999). For giving birth manatees select quiet backwaters (HARTMANN 1979). Cows probably breed at least every 2 years (BENGTSON 1981); MARMONTEL *et al.* (1997) suggest three years, but more recent publications show, that the calving interval is between 2,5 to 5 years (BOYD *et al.* 1999). After birth cows and calves form a strong unit during 1-2 years (HARTMANN 1971). The long period of calf dependence is perhaps used to transmit acquired traditions from cow to calf (BENGTSON 1981).

Manatees are long-lived animals and may live about 60 years (REYNOLDS 1999), but population models work with 39 years as life expectancy (MARMONTEL *et al.* 1997). In contrast to other large bodied mammals, manatees do not have a stable mid-age population and survivorship curves resemble curves of exploited populations. The reproduction rate $R_0$ = 1,09 of Florida manatees is low and the finite rate of increase R = 0,005 close to zero (MARMONTEL *et al.* 1997). This makes manatees vulnerable to exploitation and it is further difficult for them to recuperate from reductions (MARSH *et al.* 1986; REYNOLDS 1999).

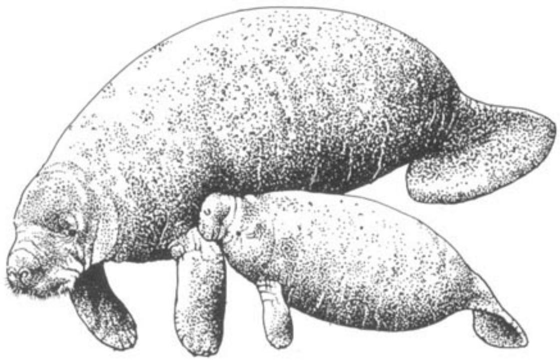


**Fig. 12:** Female manatee with young (drawing BATEMAN 1987)

**Alimentary system**

The manatee's snout is well adapted to the aquatic environment. It is used to discriminate different surfaces (BACHTELER 1997) and for food intake. The lower and upper lip pads are covered with bristles of which the upper lip bristles are used to bring plants to the rear of the mouth (HUSAR 1977). Manatees have horny pads in the forward parts of the mouth and in the backward teeth replaced regularly throughout life from the rear (BERTRAM and BERTRAM RICARDO 1973). The old teeth, worn out by sand and grit ingested during feeding, fall out. This pattern is unique among placental mammals. Chemical receptors in the mouth may help manatees to avoid plants containing alkaloids (BENGTSON 1981). They chew incessantly emitting little sounds which can be used to record chews per minute (for example used by ETHERIDGE *et al.* (1985) or BENGTSON (1981).

Sirenians have a single stomach and do not ruminate. The stomach is small in size, but the intestines are long (BERTRAM and BERTRAM RICARDO 1973). The digestive system is similar to those of other herbivores, with bacterial digestion of cellulose in the hindgut (VAN METER 1989).

Manatees and dugongs possess kidneys which allow them to survive for longer periods in marine environment and even to drink salt water. But access to a fresh water source is "an overwhelming consistent pattern" (LEFEBVRE *et al.* 1989:591). The influence of fresh water is reviewed by POWELL and RATHBURN (1984) (taken from PROVANCHA and PROVANCHA 1988). ORTIZ *et al.* (1999) found out that manatees consume small amounts of salt water or must feed in marine areas to avoid hyponatremia[5].

## 3.2.2 Feeding ecology

**Foraging behaviour**

Manatees are known to eat a wide variety of aquatic and semi-aquatic macrophytes (BERTRAM and BERTRAM RICARDO 1964; CAMPELL and IRVINE 1977; THE NATIONAL SCIENCE RESEARCH COUNCIL 1974). They favour submergent vegetation to floating and floating to emergent and show preference for luscious, non-woody and plants which are easy to eat (ALLSOPP 1969). Plants are selected due to their palatability, digestibility and nutritional value (HEINSOHN and BIRCH 1972). By comparing feeding behaviour of manatees in Florida and Puerto Rico, LEFEBVRE *et al.* (2000) suggest that manatees in Florida eat whatever they find along their travel routes, while manatees in Puerto Rico have developed more specialised feeding strategies, as they are not restricted by thermal regimes. Manatees in Florida are also selective in their choice of feeding sites and regularly return to one place until it is depleted or another area is favoured (HARTMANN 1979).

Manatees use their pectoral flippers to pull food under water to eat it (REYNOLDS *et al.* 1999; TSCHADA 1994). It has been observed that they "grab" grasses with their forelimbs (TIMM *et al.* 1986) or "walk" with their flippers on the creek bottom during foraging (HARTMANN 1979). Moreover, they push their body up to 30 cm out of the water to graze on the banks (BERTRAM and BERTRAM RICARDO 1964; HAIGH 1991) or browse on plants hanging over the water if they can reach them (EISENBERG and REDFORD 1999; MOU SUE *et al.* 1990). The degree of rostral deflection of the skull seems to indicate in which environment a manatee prefers to feed: Sirenians feeding in seagrass areas have higher deflections as animals browsing on floating, bank or overhanging vegetation (DOMNING and HAYECK 1986). This has been proved by a skull found in Panama which showed the smallest rostral deflection ever seen. In this area, manatees live mostly in fresh water or brackish environments than in seagrass dominated areas (MOU SUE *et al.* 1990). DOMNING (1980) found in experiments with *Trichechus mantatus* and *Trichechus inunguis* that *T. manatus* feeds with a weaker preference in the low water column than *T. inunguis*. DOMNING attributes it to the fact that *T. manatus* is more a "generalist" than *T. inunguis* concerning foraging behaviour.

[5] Hyponatremia is deficiency of $Na^+$ ions. To avoid that the $Na^+$ content in the blood falls beyond a certain level, manatees consume small amounts of salt water.

As mentioned above, manatees are restricted to shallow waters where aquatic macrophytes productivity is high (Best 1981). Feeding normally takes place in shallow water in a depth of 0,4 – 1,6 m in Florida or of 1 – 5 m in Puerto Rico, maybe for energetically purpose (Lefebvre *et al.* 2000). Manatees feed for 6-8 h per day (Best 1981), but more recent research on Florida manatee suggests 5,1 h per day (Bengtson 1983). One feeding session normally takes 30 – 90 min, but hungry manatees were observed to graze for more than two hours (Hartmann 1979). Bengtson (1983) explained seasonal differences in feeding behaviour with changes in the nutritional needs, temperature or forage quality. As the nutrition quality of plants eaten by the manatees is not very high - aquatic macrophytes are composed of water by 70 % to 95 % (Junk 1983) - they must consume large quantities of food every day (Best 1981). Non-breeding captive Amazonian manatees consume 8 – 9 % of their body weight in plants per day, and growing, lactating or pregnant ones 10 – 13 % (Best 1981). With those values Best is in accordance with Bengtson (1981), Bengtson (1983) (4 – 9 %) and Etheridge *et al.* (1985), even if Etheridge and co-workers believe that results from captive manatees can not be extrapolated to free-ranging animals. If calculation of food is made in kg, Bengtson (1983) gives 33,2 $^{kg}/_{day}$ and Etheridge *et al.* (1985) 33,4 $^{kg}/_{day}$ of wet matter for an "average" manatee. Converted to dry matter by a ration of 1 g wet weight to 0,18 g dry weight (Provancha and Hall 1991) this gives a daily dry plant biomass consumption of 5,9 $^{kg}/_{day}$.

**Feeding plants**

For Florida manatees the food mainly consists of the seagrasses *Syringodium filiforme*, *Thalassia testudium*, *Halodule wrightii*, *Ruppia maritima* and *Halophila sp.* (Powell and Rathburn 1984). Algae normally do not belong to the diet of manatees, but in captivity or in turbid waters with not sufficient vascular plants, they feed on these plants as well (Hartmann 1979).

Feeding on mangrove occurs regularly, in particular during the dry season, when leaves of mangroves are the main food resource (Mignucci-Giannoni and Beck 1998; O'Shea *et al.* 1988). From Surinam and Brazil it has been reported that manatees feed on mangroves (*Avicennnia nitida*, *Rhizophora mangle*, *Languncularia racemosa*) and *Monrichardia arborescens* (Best 1981), on *Rhabdadenia biflora* (Domning 1981) and even on the thorny *Machaerium lunatum* (Duplaix and Reichard, cited after de Thoisy *et al.* (2001). This, however, has been denied by Dekker (1974). From Puerto Rico it has been reported (Smethurst and Nietschmann 1999) that manatees feed - among other plants - on *Pachira aquatica* and in Panama, various *Poaceae* seem to play an important role in daily diet (Mou Sue *et al.* 1990).

Incidentally, manatees consume invertebrate periphyton when feeding on submerged plants (Hartmann 1979). Piscivority is reported from Jamaica, where manatees regularly seem to "steal" fish entangled in fishermen's nets (Powell 1978 in O'Shea 1986).

### 3.2.3 Habitat use

Manatees live in fresh, brackish and salt water and inhabit rivers, estuaries and coastal areas of the tropical and subtropical regions of the New World Atlantic coast (HUSAR 1977). In general, they seem to prefer estuarine and riverine habitats (POWELL and RATHBURN 1984).

Many authors agree that manatees need lush vegetation (e.g.DOMNING 1981; POWELL *et al.* 1981; REYNOLDS *et al.* 1995; SMITH 1997; TIMM *et al.* 1986). Furthermore areas sheltered from heavy wave action and human water activities, and with fresh water access are important as well (O'SHEA *et al.* 1988; O'SHEA and SALISBURY 1991; RATHBUN *et al.* 1983; REYNOLDS 1999). This corresponds to the observations of POWELL *et al.* (1981) in Puerto Rico, who made over 93 % of their sightings in areas with calm seas, extensive seagrass beds and freshwater. BELITSKY and BELITSKY (1980) observed manatees living all the time in sea water around the Dominican Republic, which includes feeding and drinking in salt water and REYNOLDS (1999) suggested that access to fresh water is not a physiological necessity but an apparent preference.

In Surinam, mangrove forests provide habitat for manatees (DUPLAIX and REICHARD in DE THOISY *et al.* (2001). According to REYNOLDS *et al.* (1995) an excellent habitat is characterised by lush vegetation, quiet, overgrown small canals and freshwater.

**Climatic conditions**

Water temperature is the most important factor limiting manatee distribution (SMITH 1993) to the South and North (LEFEBVRE *et al.* 1989). To the question of the minimum water temperature needed by manatees several opinions exist: ALLSOPP (1961) mentions 21° C, HARTMANN (1971) observed winter aggregations of the Florida manatee beginning at 20°-23° C and BENGTSON (1981) fixed the beginning of winter aggregation at 21° C. LEFEBVRE *et al.* (1989) and BATEMAN (1987) see the manatees restricted to areas with water temperatures of at least 20° C, while WELLS *et al.* (1999) favours 19° C as minimal temperature. IRVINE (in O'SHEA *et al.* (1988) sees the lower limit of thermoneutrality of about 24° C. In the inner tropics, temperature does not affect manatee distribution (COLMENERO 1981 in COLMENERO- ROLON 1985; AXIS ARROYO *et al.* 1998). The low metabolic rate is one of the reasons why manatees are restricted to the tropics.

Other climatic parameter like cloudiness, sunshine intensity and duration have no influence on the manatee distribution (AXIS ARROYO *et al.* 1998; HARTMANN 1979).

**Movements and temporally aggregation**

Manatee populations are mobile and regularily change their residence (SMETHURST and NIETSCHMANN 1999). REID *et al.* (1991) describe a 850 km journey of a manatee and DEUTSCH *et al.* (1998) followed a manatee by satellite tracking over 2500 km from Florida to Rhode Island, the most northern appearance of the species. The Florida manatees aggregate in large herds at thermal outflows of power plants around Florida peninsula from autumn to spring to avoid cold temperature (BENGTSON 1981; HARTMANN 1979; PACKARD *et al.* 1989; WELLS *et al.* 1999 and others). Seasonal movements due to different seasons and food availability are also reported from the Amazonian manatee (BEST 1983; ROSAS 1994) and from South Mexico (COLMENERO- ROLON and ZÁRATE 1990).

The aggregations around power plants in Florida are explained by some authors as resource-based, and as an expression of the cold weather (WELLS *et al.* 1999), while others see this aggregation as social- and resources-based (PROVANCHA and PROVANCHA 1988). The total number of manatees around the out-falls of power plants can reach 400 individuals per day (WELLS *et al.* 1999) which is approximately $^{1}/_{3}$ of the whole manatee population in Florida. Within the distribution area of the Florida manatee, fluctuations in number at winter aggregation sites in one specific area may be caused by changes in the composition of the submerged aquatic vegetation and the increased human activity (PROVANCHA and PROVANCHA 1988). Other types of aggregation exist for the West Indian manatee: feeding herds, travelling herds, mating herds and cavorting herds (BENGTSON 1981; HARTMANN 1979).

**River topography and currents**

River topography seems to play an important role for manatee distribution as *T. manatus* needs a minimum depth of 50 cm to swim (PACKARD 1984). Already at a water depth of less than 1m manatees balked to swim in creeks with shallow waters except for feeding when adjacent to deeper canals (HARTMANN 1971). In Brazil and Honduras, manatees died during the dry season when locked in creeks with shallow water, which they had entered during the wet season to browse on the adjacent vegetation (ROSAS 1994). On the other hand, it seems that manatees avoid areas deeper than 8 m (HARTMANN 1971; POWELL and RATHBURN 1984). In conclusion, manatees prefer a water depth from 2 to 5 m, with a minimum depth of 1 m (HAIGH 1991). SMETHURST and NIETSCHMANN (1999) used a fishfinder to map river topography and, in particular, blowing holes, where manatees congregate to wait for rising tide to swim up shallow rivers or to play.

Fast currents cause a navigation problem for manatees which have never been seen swimming in creeks with currents exceeding 6 km/h. Correspondingly manatees prefer to swim more closely to the slower shore than in the middle of a canal and tend to lay in the eddies at elbows of rivers when resting (HARTMANN 1979). Distribution of the Amazonian manatee can be limited by fast turbulent water and rapids (BEST 1984).

**Predators and concurrence**

Manatees hardly have any natural enemies beside man (HUSAR 1977; WELLS *et al.* 1999). Potential predators may be caimans or parrot-fishes (BERTRAM and BERTRAM RICARDO 1964), piranhas (ALLSOPP 1961), jaguars or sharks (BERTRAM and BERTRAM RICARDO 1973; WELLS *et al.* 1999). Normally only young or hurt animals are in danger of being attacked. Only one case of shark attack is proved in literature (MOU SUE *et al.* 1990). Hence manatees did not develop anti-predator behaviour. Further their secretive habitat seems to be a very effective protection (WELLS *et al.* 1999).

Manatees share their environment with only few other animals. While grazing in seagrass communities, manatees compete with sea urchins, fish, and green turtles (THAYER *et al.* 1984). In estuaries and river systems, river dolphins (*Inia geoffrensis* and *Sotalia fluviatilis*), giant otter (*Pteronura brasiliensis*), capybara (*Hydrochoerus hydrochoaeris*) and caimans use the same area. Out of these only the capybara is herbivorous. Because of its low consumption of only about 4 kg fresh grass per day (BEST 1984) and the small population size in the Coswine swamps (de Thoisy, pers. comm.) it can not be considered a strong competitor to manatees.

**Observations of manatees**

In clear waters, manatees are easy to observe. Often, the population size and the distribution are assessed by aerial counts (see for example (BELITSKY and BELITSKY 1980; MOU SUE *et al.* 1990; O'SHEA and SALISBURY 1991; PACKARD *et al.* 1989; PROVANCHA and PROVANCHA 1988; RATHBUN *et al.* 1983). In Florida, many animals even are individually identifiable by scar patters on their back caused by collisions with boats (REID *et al.* 1991).

Observations of manatees in turbid water by aerial studies are fairly difficult (e. g. BENGTSON and MAGOR 1979; O'SHEA *et al.* 1988; REYNOLDS *et al.* 1995). According to POWELL (cited in (POWELL *et al.* 1981) manatees can only be seen for 15 sec while breathing at the surface, this secretive behaviour does not allow to make long-time observations. The poor visibility prevented further aerial surveys in French Guiana after a first one had beencarried out without success (DE THOISY *et al.* 2001). DEKKER (1974) had the same problem of turbidity in Surinam.

**Habitat degradation**

Human activity has the main influence on the decline in numberof sirenians (LEFEBVRE *et al.* 1989). Intensive settlement of the coast (PACKARD and WETTERQVIST 1986) or installation of tourist resorts (COLMENERO- ROLON and ZÁRATE 1990) contributes strongly to manatee decline. Furthermore, manatees concentrate in areas where less environmental degradation has taken place and not much boat traffic exsists. Residents in Costa Rica quoted that the noise of the outboard engines as well as the gasoline released to the water frightens manatees (SMETHURST and NIETSCHMANN 1999, cf. also DEKKER 1974). This confirms the hypothesis, that manatees seek isolation areas (PROVANCHA and PROVANCHA 1988). In general, habitat alteration by pollution or silting of rivers results in reduced food supply which in consequence forces manatees to find other habitats (HUSAR 1977).

## 3.3 Distribution and status in French-Guiana

The distribution and status of the manatee in the Wider Caribbean Region is well studied. The CARIBBEAN ENVIRONMENT PROGRAMME (1995), LEFEBVRE *et al.* (1989) and CARMEN COLMENERO ROLON (1991) give a good overview. Except for Belize and Quintanan Roo in Mexico, distribution of manatees in the area is patchy which REYNOLDS (1999) relates to the poor availability of suitable habitats and the long history of exploitation.

The first report on the status of manatees in the Guianas by BERTRAM and BERTRAM RICARDO (1964) characterises the environment to be not very promising for the Sirenias in the Northeast region of South America mainly due to the shallow and turbid waters with a brown colour and the almost complete lack of vegetation. Nevertheless, manatees are found along the Guianan coast, and to a lesser degree also in French Guiana, although suitable habitats are rare because of the narrow coastal plain (cf. 2.2.2. Geology). The coastal plain has an average width of 16 km in French Guiana whereas in the other Guyanas, it is 40-50 km wide (BLANCANEAUX 1981) (cf. Fig. 13). The coastal plain is important for the distribution of manatees as the waters are shallow and without heavy wave action. Hence, the manatees of the Guyanas travel around from one river to another to find the habitat which provides the best environment (BERTRAM and BERTRAM RICARDO 1964).

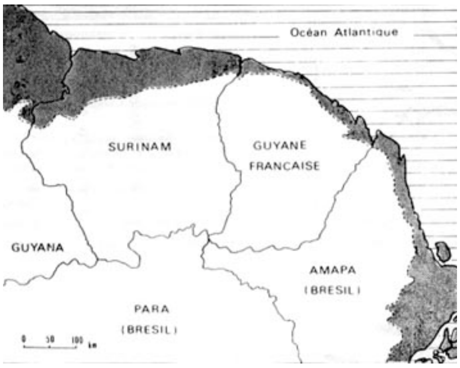



**Fig. 13:** The coastal plain (grey) of the Guiana region. The narrowness is well visible (GRANVILLE 1986)

As mentioned in the Introduction, the NGO KWATA carried out a first interview survey in 2000. DE THOISY *et al.* (2001) pointed out that the manatee is still well present in many estuaries and in a large part of the coastal area, but the populations probably are weak in number, because only a few suitable habitats – especially those excluded from any perturbation by man - exsists. The DIRECTION REGIONAL DE L'ARCHITECTURE ET DE L'ENVIRONNEMENT (1992) in its resume of the report for the Ramsar secretary mentions that the manatee is common in the estuary of the River Mana and the River Maroni, but the numbers of the population remain unknown.

According to DE THOISY *et al.* (2001) the actual distribution of the manatee in French Guiana is limited to a few areas: beginning in the Northwest, manatees are often seen in the estuaries of the Maroni and the Mana. Further South, they dwell in the estuary of the creek Malmanoury, near Cayenne at the Point Montravel, close to Brazil in the estuary of the Oyapock and the River Ouanary. Some offshore observations were made around Ilet la Mère, about 10 km from the coast.

In contrast to earlier observations, the estuary of the Sinnamary does not shelter any important manatees populations anymore.

### 3.3.1 Traditional significance of manatee

As in many others areas where manatees or dugongs are widespread, their traditional and spiritual value is very high.

Since a long time, manatees have been played an important role in the history of the indigenous people. The names of the creeks give a good example: beginning in the North with Crique Coswine, which is derived from the Dutch word[6] "koe zwem", meaning "swimming cow", thus manatee. A little bit more to the South, Crique Vache (French, "creek cow") and Crique aux Bœuf Lamantin (French, "creek of manatee bull") follow. Similar evidences are given by ALLSOPP (1961:548) who mentions the town of Manati in Puerto Rico, Lamantin in Martinique and the district Manatee County in Florida. He concludes that "Sirenians were once common in all these places".

The high traditional significance can also be seen in the existence of different legends around the manatee. One is told by the Galibis Indians (quoted after DE THOISY *et al.* 2001:17):

*"Two sisters are married to a tapir. One day, the sisters went to festivities, and their brothers went to hunt, where they killed the tapir. Back from the festivities, the sisters are invited to eat the bag which they appreciated particularly. As the sisters were told that their brothers gave them their husband to eat, they plunged into the Maroni in mourning and anger: one became manatee, the other dolphin. Since this time, the two sisters are held responsabile for sunken and capsized".*

The same legend is reported by O'SHEA *et al.* (1988) from the Warauno tribe in Venezuela and from Suriname (DUPLAIX and REICHARD in DE THOISY *et al.* (2001).

The manatee for a long time was (and still is) much appreciated for meat and oil (e.g. DOMNING 1981; HUSAR 1977; O'SHEA *et al.* 1988; REYNOLDS *et al.* 1995; THE NATIONAL SCIENCE RESEARCH COUNCIL 1974). Manatees were commercially exploited in Surinam (HUSAR 1977), Brazil and Guyana (BERTRAM and BERTRAM RICARDO 1973) and transported to the West Indies. BERTRAM and BERTRAM RICARDO (1973) even proposed the rational use of manatees for meat production. The ear bone of the manatee is supposed to have medical properties against teeth eruption of children (O'SHEA *et al.* 1988), or in general for several medical problems (DOMNING 1981). Aphrodisiac and digestive effects are also attributed to these ear bones and for these manatees are still hunted near the estuary of Maroni in French Guiana (DE THOISY *et al.* 2001). In the shaman tradition, the sternum of the manatee is used as an insignia (O'SHEA *et al.* 1988) and the rib bones can be used as a substitute for ivory (HUSAR 1977; THE NATIONAL SCIENCE RESEARCH COUNCIL 1974).

In French Guiana, manatees were introduced as weed control agents in the Polder Marianne near the river Mahury, but without success (DE THOISY *et al.* 2001). In contrast *T. manatus* is used in Guyana to clear small canals from invading plants since the 1960s (ALLSOPP 1961, 1969).

[6] The region of Coswine was Dutch territory until 1875. Today, many Surinamese refugees settled on the other side of Maroni River after the beginning of the civil war in 1986.

## 3.3.2 Actual threats

**Hunting** was more or less common in all countries with manatee populations (cf. DOMNING 1981; MORALES-VELA *et al.* 2000; O'SHEA *et al.* 1988; REYNOLDS *et al.* 1995; ROSAS 1994). The impact of hunting and poaching is estimated differently: O'SHEA *et al.* (1988) do not think that hunting is the main reason for the decline of manatees in Venezuela. MORALES-VELA *et al.* (2000) speak of poaching as a serious problem for manatees in Belize and Mexico, and THE NATIONAL SCIENCE RESEARCH COUNCIL (1974) and RATHBUN *et al.* (1983) attribute the decline of the manatee population to hunting. For REEVES *et al.* (1996), still ongoing hunting and trapping of manatees for food is the main reason for the decline of *T. inunguis* in Peru.

In French Guiana, manatees are still hunted in the waters of Oyapock and Maroni either for private consummation or because of religious traditions (DE THOISY *et al.* 2001).

**Increasing human activity** and **boat traffic**, the main problems for the manatees in Florida (see for example GARROTT *et al.* 1994; HARTMANN 1979; MARMONTEL *et al.* 1997), is not intense in Crique Coswine and its side rivers, except around the village Coswine. More boat traffic can be found in the Crique Vache, as it is used as an access for clandestine rice transports from Surinam and for Surinamese hunters. For the Swamps of Kaw – well known for the presence of caimans and Scarlet Ibis – the increasing boat traffic caused by eco-tourism, may be a reason for the decline of manatees in that region.

**Incidental killing in fishing nets** happens from time to time in French Guiana. Between 1998 and 2001, five cases have been reported. When entangled in the nets, manatees were either found drowned or were slaughtered and eaten (DE THOISY *et al.* 2001).

**Pollution** with mercury due to gold mining has a huge impact on the fauna in the Amazonian region (ROSAS 1994). No such activities are reported from the Coswine Swamps. Runoffs by agricultural pesticides observed in Costa Rica (REYNOLDS *et al.* 1995) and Panama (MOU SUE *et al.* 1990) do not take place in the Coswine swamps, but rice cultivation may also lead to such pollution. Whether poison on plants effects manatees is not clear. BENGTSON (1981) showed that manatees avoid plants sprayed with the herbicide 2-4-D.

**Debris** like plastic bags, unattached fishing nets, or floating ropes where seen several times swimming on the surface or drifting in the current in the Coswine swamps. Manatees can become entangled in the bags, nets or ropes, or may swallow smaller items.

## 3.4 Selected variables

Out of the total of factors influencing the distribution of manatee, only a few can be considered in this study. In this chapter, the most important and easily investigable parameters are examined.

One of the first studies which called for more research on manatee environments was the report of THE NATIONAL SCIENCE RESEARCH COUNCIL (1974). It proposes to study relations between manatees and their environment. In particular the authors suggested investigations on the chemical, physical and topographical conditions of the water environment, on quality of the water, food plants and populations structure. Concerning the quality of the water, they consider pH, oxygen content, salinity and temperature to be important factors (cf. Tab. 1).

Out of the variables which influence the distribution and the habitat use of manatees, vegetation is among the most important. This opinion is shared by a large numbers of authors (for example AXIS ARROYO *et al.* 1998; BOYD *et al.* 1999; ETHERIDGE *et al.* 1985; PACKARD and WETTERQVIST 1986; ROSAS 1994; WELLS *et al.* 1999, see chapter 3.2.2 as well). Distribution of *T. inunguis* is limited by the lack of vegetation in some regions. BEST (1984) and BENGTSON (1981) suggest that manatees leave their winter aggregation sites because food availability is reduced.

HARTMANN (1979) conducted research on different parameters (climate, depth, tides, salinity, currents, storms, sun, turbidity and dense vegetation) in order to find out whether they have any influence on manatee movements. Among these, tides have a huge influence on manatee distribution as they deny the animals access to shallow feeding grounds during low tide. Furthermore salinity is strongly responsible for the manatee's habitat selection, as the animals seem to prefer rivers and estuaries with a salt concentration less the 25 ‰ and use salt water only for travelling.

Outside the tropics, temperature is an important factor of distribution (see 3.2.3). GARROTT *et al.* (1994) and PACKARD *et al.* (1989) investigated wind, turbidity, water and air temperature and their influence on manatee aggregations around power plants in Florida. During two winters, no significant relation between the environmental factors and manatee aggregation were found. One of the first studies on habitat use of manatees in turbid water was carried out by COLMENERO- ROLON (1985) in Mexico. He recorded water depth, turbidity, currents, temperature and vegetation and explained their influence on manatee distribution except for currents. AXIS ARROYO *et al.* (1998), who recorded temperature, winds, cloudiness, depth, salinity, water temperature, grass and algal abundance and group structure of manatee population, showed that wind intensity and food availability were most influential on the distribution of manatees. As their study was carried out along the coastline of Mexico (the study site for the present project lies in less windy areas in the inland) and as HARTMANN (1971) observed that even heavy storms do not affect manatee distribution, wind intensity was not considered to be an important parameter for the actual study.

In contrast to Florida the Coswine swamps are only to a very small degree under the influence of humans. Therfore conflicts between man and manatee are rare. PACKARD and WETTERQVIST (1986) used town planning methods to map potential and existing conflict areas, human influence and negative impact on manatee conservation efforts in Florida. They defined the components of a manatee habitat system in two different parts: human and manatee system. The human system includes information on boat traffic, boating facilities and urban areas, the second informs about vegetation, bathymetry/topography, seasonal water temperature, manatee sightings and manatee activities.

| Author | COLMENERO-ROLON (1985) | AYIS ARROYO *et al.* (1998) | PACKARD *et al.* (1989)[7] | PACKARD AND WETTERQVIST (1986) | LEFEBVRE *et al.* (1989) | HARTMANN (1979) | THE NATIONAL SCIENCE RESEARCH COUNCIL (1974) | This study |
|---|---|---|---|---|---|---|---|---|
| Species | *T. m. m.* | *T. m.manatus* | *T. manatus* | *T. manatus* | *T. manatus* | *T. manatus* | *T. manatus* | *T. m. m.* |
| Place | Mexico | Mexico | Florida | Florida | Wider Carib. area | Florida | Wider Carib. area | French Guiana |
| Remarks | | | | Town planning methods | | | Only proposal | |
| Water temperature | - | - | + | + | + | ++ | x | x |
| Vegetation | ++ | ++ | ++ | + | + | ++ | x | x |
| Water depth | ++ | + | | + | + | + | x | x |
| Tides | | | | | | ++ | x | (x) |
| Currents | o | | | | + | + | x | |
| Storms/winds | | ++ | - | | | - | | |
| Sun/cloudiness | | - | | | | - | | |
| Turbidity | - | | - | | | - | x | |
| Population | | + | | | | | x | |
| pH | | | | | | | x | x |
| Oxygen | | | | | | | x | x |
| Salinity | | + | | | + | ++ | x | x |
| Shelter | | | | | + | | | |
| Fresh water access | | | | | ++ | | | (x) |
| Human influence | | | | + | | | | (x) |

x should be investigated, (x) can be derived from other sources, + influences the distribution, ++ strongly influences the distribution, - does not influence or only to a small degree the distribution, o investigated but not classified

**Tab. 1:** Parameters investigated in fifferent studies of manatee habitat

[7] A similar study was also made by GARROTT, ACKERMAN *et al.* (1994)

All parameters, investigated during several studies, are summarised in Tab. 1. After comparing the studies, those parameters were considered for the study in hand, which

1. are important for manatee distribution,
2. are easy to record,
3. can be worked out within two months,
4. can be measured from a canoe and
5. are not to expensive to investigate.

Based on theses criteria the following parameters were chosen for the present study (cf. Tab. 1):

1. submerged aquatic vegetation,
2. water depth,
3. salinity of the water,
4. pH of the water,
5. temperature of the water and
6. oxygen content of the water.

## 3.5 Summary

The Antillean manatee is a subspecies of the West Indian manatee, which inhabits the coast, estuaries and rivers in Middle and South America. The only living fully aquatic and herbivorous mammal, manatees are well adapted to their special environment: the body is streamlined, the forelimbs are used to manipulate nutrition, and teeth are replaced during life-time. Because of their low reproduction rate and the small litter size, manatees populations experience steep declines after habitat destruction or man-made threats.

An important occupation for manatees is feeding, which can take up to 8 hours per day. While grazing, manatees consume 8 – 13 % of their body weight which is around 6 kg/day in dry plant matter for an average manatee. Feeding normally takes place in shallow water and nearly every aquatic plant is eaten, but mangrove vegetation and grasses as well.

For the distribution of manatees, different factors are important besides vegetation. Among these, temperature seems to play a major role, as it restricts manatees to the tropics. Furthermore, tides and river topography can limit the access for manatees to certain regions. Man is as well responsible for the (non-) occurrence of manatees, as nowadays many former manatee habitats are degraded or occupied by man.

Out of all parameter determining manatee distribution, six are selected for the present study: vegetation, water depth, salinity, pH, temperature and oxygen content.

Manatees are widely distributed in the Wider Caribbean Region, but only in patchy populations, caused by unsuitable habitats. In French Guiana, the present populations are weak in number, but at least still existing. The traditional significance of manatees is reflected by the incorporation of the manatee's local name for labelling creeks, towns or counties and their traditional importance for indigenous people as talisman. Hunting out of traditional believes and for meat stays a important factor for manatee decline in French Guiana, in contrast to boat traffic, which seems to be less important than in Florida.