FISHERS AND THE WEST AFRICAN MANATEE

IN THE FRESCO LAGOON COMPLEX, COTE D'IVOIRE:

COMMON PROPERTY, CONFLICT AND CONSERVATION

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ABSTRACT

*In this thesis I investigate the indigenous common property resource management system, and the conflict between the community and the endangered West African manatee (*Trichechus senegalensis*), in the lagoon complex of Fresco, one of the six most important habitats for manatee in Cote d'Ivoire. The Fresco lagoon has been, and still is, an important means of transport and a valuable fishery for the local community, which depend on it for their livelihood needs. The lagoon becomes temporarily disconnected from the Atlantic Ocean on a regular basis. Its water level rises to its highest when the inlet is closed, as freshwater inflow, resulting mainly from rain falling in the lagoon's catchment, continue to accumulate behind the closed inlet. The vegetation communities that appear on the flooded shoreline during the highest water level are composed of 63 species from 61 genera and 34 families. A degrading mangrove forest dominates much of the shoreline.*

The indigenous resource management system in the Fresco lagoon was established during the 17th century, and was structured under an informal indigenous resource management institution, known locally as the N'gni system. The N'gni system was based on customs and traditional beliefs over the spirit of the water. The N'gni system sought to regulate fishing in the lagoon, to prevent conflicts, which may arise from the commonly used gate fishing method, and to maintain continual reverence for the spirit of the water. This was achieved by a set of rules and regulations and by dividing the lagoon into family territories based on the prevailing traditional land tenure system. The state has adopted a new land tenure regime and a free enterprise economic system. The Administrative Decentralization Reform has allowed the establishment of Fresco Town Council. As a result, the N'gni system was abolished and replaced by a government driven co-management committee in 1967, with a strong community representation.

Fishing in the sea, which was more profitable for the community, has since stopped. The lagoon, which was initially set aside for fishing only during bad periods in the sea, is now a year round fishing ground, because access to the

sea is difficult since the 12 districts of Fresco have been resettled. Younger generations are now losing their skill at fishing in the sea. Finally, as the increasing human population causes further impoverishment of the community, pressure on the lagoon increases.

The community still generally retains a positive attitude towards the Fresco lagoon complex and recognizes the link between their cultural identity and its value as an important fishery. However, opinions on the success of present day management and options for future management vary according to ethnic origins, whether native or non-native, the length of residence in the area, and the villages in which users reside.

Fishes, crustaceans and molluscs from the lagoon are harvested by the community and methods used include thrown netting, laid netting, line fishing and baskets for shrimp, crabs and oysters. However, several factors constitute a serious challenge for future sustainability of resource use in the lagoon, including: the community now fish only in a lagoon of relatively small size; the human population is increasing; the inlet is breached almost every year giving little time for fish to grow; the degradation of the mangrove forest is ongoing resulting in lost of nutrients and of a refuge to fish and manatees and, the new coastal highway now improves access to the region.

The West African manatee is a solitary animal, less active during the day than during the night, that spends its time resting, moving, feeding and cavorting. Its activities are linked to tidal stage and season. Manatees feed on fruit, mud and deposited plant material, but leaves of emergent plants and grasses found on the water's edge constitute the bulk of their diet. Feeding occurs mostly during night and long feeding excursions are frequently undertaken to riverine locations in the wet season for periods lasting from 1 night to several weeks. Manatees show a high rate of site fidelity. The home ranges of individuals are independent but overlap almost completely, suggesting that the species is not territorial.

The time manatees spend on performing an activity is, in general, determined by the prevailing activity. However, human presence also impacts on time spent on certain activities, and manatees swim away or flee in response to humans at close distance. Manatee flight reactions are a direct response to approaching boats, the number of people transported and the type of activity in which they are engaged. Manatees avoid feeding on emergent plant along the water's edge when people are nearby. Nevertheless, the local community had a positive attitude towards the manatee overall, although most of them believe that manatee population in the Fresco lagoon had declined.

To minimize conflicts between manatees and humans in the Fresco lagoon, the number of users should be strictly limited and areas heavily used by manatees should be zoned and human activities regulated in these areas. Finally, the ongoing public awareness campaign should continue and even be improved.

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CHAPTER 1 GENERAL INTRODUCTION

1.1 Introduction

This thesis investigates the indigenous common property resource management system, and the conflicts that arise between humans and manatees, in the lagoon complex of Fresco, one of the six most important habitats of the West African manatees (*Trichechus senegalensis*) in Cote d'Ivoire.

The West African manatee probably plays an important role in its aquatic ecosystem and has various values for people. However, the species is little studied and is threatened with extinction in the near future (Hilton-Taylor 2003). Therefore, accurate information is required to develop sound and lasting conservation initiatives for the few remaining individuals, before it is too late.

In recent years, the needs of increasing numbers of people living in coastal areas and sharing habitats with manatees have spiralled. In future, this will lead to further competition between humans and manatees for limited resources. Thus, the conservation and management of the manatee has become a complex challenge that requires flexible strategies to meet the growing resource needs of humans, and of the manatees, in the same habitats. Hence, it is important to determine how manatees and people can continue to coexist in the same habitat, and at what cost. The only way to arrive at a genuine answer to this problem is by widely understanding the nature and the extent of conflict between manatees and people. This research aims to provide such understanding for the lagoon complex of Fresco.

1.2 Widlife and Humans: Conflicts and Coexistence

Humans and wildlife have coexisted since time immemorial, but there is now a global consensus that humans are causing species to be lost at a greater rate than ever before (Gray, 1993). Six major classes of human interference are now described as adversely affecting wildlife (Soulé, 1991; Norton, 1986, IUCN, 2003). These comprise: habitat loss; habitat fragmentation producing deleterious area, edge, demographic, and genetic effects; over-exploitation; spread of exotic species and disease; air, soil, and water pollution; and, climate change. The differential impact of any given factor upon particular species clearly depends on temporal, spatial and circumstantial factors.

Over-exploitation has often occurred after initial colonization of a new area by people and was particularly important in developing countries, particularly in Africa (Mackenzie, 1987). In these countries, major loss of species and habitats began in the latter part of the eighteenth century with colonial expansion and economic penetration (Grove, 1987). Exploitation of natural resources, particularly through commercial hunting and logging (Martin, 1991), was carried out on unsustainable basis. The export of large quantities of ivory from Africa by Europeans and the consequent destruction of many elephants is one striking example (Grove and Anderson, 1987; Gray, 1993). Likewise, in North America, great quantities of beaver and otter skins, and various other species of wildlife, was exported from the upper Hudson Valley (Borland, 1975). Such over-hunting resulted in the extinction of many species of birds, reptiles and mammals (Kranz, 1970).

Poverty is also an important factor causing the over-exploitation of species. Because of their high discount rate, poor people are more concerned with survival and short-term economic gains (Cheke, 1987; Murphree, 1992). Certainly the traditional African fisherman finds it difficult to appreciate the natural beauty of a swimming manatee, which may quickly destroy his small fishing net, which constitutes his main hope of protein throughout year. In fact, in some poor rural areas of Africa, indigenous peoples may be forced to endure not only failing crops and hungry families, but also destructive and dangerous wildlife, invading farmland in search of food and water (Glass *et al.*, 1993; Grace, 2004). Large mammals such as elephants, lions, leopards and buffaloes have become vermin to indigenous peoples. They may destroy their crops, cattle, sheep, and goats, in fact their whole livelihood (David and Roger, 1999).

Conversely, as human populations have continued to increase, production of fuel wood and charcoal for domestic cooking and heating has increased, fish stocks have decreased, while the livestock frontier and agricultural land have expanded. Such expansion has been to the detriment of many important natural areas and ecosystems, leading to drastic reduction of habitat and the size of wildlife areas (Myers, 1985; Soulé, 1984; Edgardo and Héctor, 1998).

Current projections of human population growth predict a global population of about 10 billion people by 2046, and 12 billion by 2100 (Soulé, 1984). The predicted effects of such growth on the global environment suggests that the continued survival of wildlife will be highly problematic, given its difficulty of coexisting with humans. More and more species will become threatened, and anthropogenic causes of extinction will continue to occur, unless sound and lasting conservation initiatives are undertaken (Myers, 1985).

Hopefully, the suite of different approaches adopted to improve biodiversity conservation will help to mitigate human impact. One now fairly universal approach to protecting biodiversity has been the creation of an increasing coverage of protected areas that exclude human and livelihood activities (McNeely and Pitt, 1985; Western and Wright, 1994; IUCN, 2003).

1.2.1 Biodiversity conservation through protected areas

A protected area has been defined as "an area of land or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (Alcorn, 1997).

Different types of protected areas, in terms of their objectives have been proposed (IUCN, 1998; IUCN, 2003). However, exlcusive protected areas, in the form of national parks and nature reserves, remain among the most important tools for many in the modern conservation movement (Oates, 1999). This conservation model originated in the United States (MacKinnon *et al.*, 1986; Runte, 1987). However, its evolution in different contexts of conservation in former European colonies was also remarkable, of which the case of the Cape colony in southern Africa was a striking example (Grove, 1987).

The idea of setting aside areas free from human impact and development was largely urban in origin. It emanated from the opinions and values of an increasingly educated urban public influenced by the aesthetic appeal of large mammals, from moral arguments that human impact should not cause the extinction of God's creatures, from the broader scale consequence of degradation exposed by scientists, and, finally, from the Westerner's wishes to creat their own "garden of Eden" where rich and royal would come for hunting and recreation (Anderson and Grove, 1987; IIED, 1994). The world's first National Park was established at Yellowstone in the United States in 1872, soon followed by Yosemite, Sequoia, Rocky Mountain and Grand Canyon National Parks (Hays, 1987). In Africa, the first National Parks were Albert National Park, created as Strict Nature Reserve in Belgian Congo to save world's last mountain gorillas, in 1925, and Kruger National Park created in South Africa in 1926. Countries were later exhorted, particularly by the 3rd World Congress of National Parks and Protected Areas held in Bali, Indonesia, in 1982, to allocate at least 10% of their national territories to the creation of protected areas. By the 1960's, some 10,000 protectedhad been established. To date, over 130 states have together established some 102,102 protected areas, covering and area of 18.8 million km^2 of which 17 million km^2 (equating to 11.5% of the planet's land surface) are terrestrial and 1.8 million km^2 (less than 0.5% of the seas and oceans) are marine protected areas (IUCN, 2003 a).

Although the creation of national parks and other types of protected areas have made a start at conserving large species of wildlife, they have less often provided for economic development that meets local livelihood needs. Instead, the creation of protected areas has often been characterized by a preservationist and top-down approach, or a nationalization of resources coupled with imposition of regulations over the use of resources (Machlis and Tichnell, 1985). Consideration was not given to traditional land-use systems nor to the local communities whose lives were affected (Lusigi, 1990). It has become increasingly clear that the top-down approach based on strict protection of species and habitats, has not always achieved its stated objectives (Brown and Wyckoff-Baird, 1994). In some areas indigenous peoples have been seen as a threat to conservation. Consequently, they have been displaced to areas with entirely different socioeconomic and climatic zones without adequate provision for alternative means of work and income (Cernea, 1997). There are numerous examples of displacements, including several thousand people from the Zakouma National Park In Chad (Moorehead and Diakite, 1991) the expulsion of Maasai from the Serengeti in Tanzania and the Ik from Kidepo Natianal Park in Uganda (West and Brechin, 1991). The highland Phoka people of Northern Malawi, decimated by malaria as a consequence of resettlement, is also a good example (Davey, 1993). Furthermore, benefits from most protected areas accure to peoples who do not bear the costs of conservation. The result was a lack of local support and conflict with indigenous peoples, leading to hostile relationships (IIED, 1994). Today, few governments can afford the economic costs of imposed conservation through fences and guards, or its political costs, through civil disorders and negative relations (Borrini, 1997). While protected areas are and should remain an important part of any conservation plan, some conservationists have begun to realize that they needed to find ways to overcome the limitations of protected areas through finding complementary conservation strategies.

In response to these limitations, over the past few decades, many conservationists have sought to address local livelihood needs to achieve conservation objectives. However, they initially relied on strategies where livelihood and conservation were only indirectly linked. One of the earliest of these indirectly linked approaches was the *biosphere reserve* concept (UNESCO, 1972). In a biosphere reserve, people are entitled to use biological resources according to defined spatial zones. A core zone is designated to provide strict protection where consumptive use of resources by people is prohibited. In contrast, a buffer zone allows use within limits that ensure the protection of the core zone. Nevertheless, these indirectly linked approaches have also been difficult to implement (Oates, 1999). Local people often have continued to use resources in the core zone even when prohibitions were posted or otherwise made public. Economically attractive activities in the buffer zone have often created incentives for expanding the buffer zone into the core area. Finally these approaches have not provided local people with the incentives to stop external threats to biodiversity (Wells and Brandon, 1994; Brandon et *al.*, 1998).

In response to these shortcomings, conservationists began to develop new approaches to meet economic well-being and conservation needs in the early 1990s. These new and more direct approaches were based on making livelihood activities dependent on, and hence directly linked, to biodiversity (Wells and Brandon, 1994; Western and Wright, 1995; Salafsky and Eva, 2000). Such approaches have recognized that biodiversity conservation and the needs of local people cannot be addressed independently of one another. Site selection for protected areas is increasingly based on considerations of both biological value and social feasibility (Amend and Amend, 1995). Increasingly, conservation and development priorities are being integrated in strategies and plans (Brown and Wyckoff-Baird, 1994; Wells and Brandon, 1994; Vane-Wright, 1996). There has been a major shift away from centralized management toward community-based conservation and management of resources. Hence, biodiversity conservation practices have been expanded to include a variety of participatory approaches, new institutions and multiple sustainable schemes (Borrini, 1997).

1.2.2 Conservation through social sustainability and participative approaches

From the failures of past top-down approaches, conservation professionals have come to realize that peoples play many direct and indirect roles in resource management (Amend and Amend, 1995). Therefore, social acceptance is crucial for conservation to be sustainable. Thus, a socially sustainable approach aims to incorporate social concerns into conservation, to learn more about such approaches, and to deal with them in a positive manner. In fact, it has been recognized that if people value and appreciate biodiversity, if social groups derive concrete benefits and incentives from it, this provides the best chance to succeed at conservation in the long run. Experience has shown a positive correlation between effective conservation and the provision of a wide range of social benefits and positive responses to social concerns. Increasingly, a variety of social groups are called on to participate in conservation efforts and to receive benefits in return (Borrini, 1997). Such benefits may be economic, such as access to resources, or sharing of revenues from hunting trophies, or the building of health centres. Or they may be cultural, such as the respect for sacred sites, or the simple recognition of local communities as the rightful stewards of local resources. The arrangement between the Anangu, aboriginal people of Australia and the Australian National Parks and Wildlife Service is a good example (Cordell, 1993; Hill, 1983). Social sustainability is therefore associated with the maintenance or improvement of people's well-being over time, based on equitable distribution of costs and benefits from production systems. It implies the presence of resource management systems that allow for the regeneration or replenishment of the resource base over time and the inter-generational compromise by which present resource users can guarantee future generations the right to a similar resource base and lifestyle (Borrini, 1997). Such initiatives are frequently centered on communal land, often rich in wildlife, which support low human population densities, around protected areas. The CAMPFIRE experience in Zimbabwe and Nazinga programme in Burkina Faso are good examples (Makombe, 1993; Thomas, 1994; Child *et al.*, 1997).

Participation is the process whereby people act in groups to influence the direction and outcome of development programmes that will affect them (Paul, 1987; Pretty *et al.*, 1995). Participation means taking part, sharing, acting together in policy, planning and overall management (Cernea, 1985; IIED, 1994). This is a condition by which local knowledge, skills and resources can be mobilized and fully employed. In some cases, local communities have been encouraged to take this a step further and become co-mangers of conservation areas. Professionals in biodiversity conservation agencies have increasingly come to realize that most traditional societies historically coexisted with biodiversity, and that cultures and local production systems were often grounded in utilizing those wild resources on a sustainable basis. Very few conservation agencies, however capable and well equipped, possessed the same capacities and comparative advantages necessary for the long-term sustainable management of natural resources. For instance, it is now known that state agencies can rarely do better than local communities in surveying the access to a protected area or detecting early warnings of fire (Borrini, 1997). Resource users possess detailed knowledge of local biodiversity and can be effective in monitoring it and suggesting how to preserve it locally.

Adequately planned and implemented, social sustainability and participative approaches are important tools to achieve the effectiveness, efficiency and sustainability of conservation initiatives. That is the reason why working at the grass-roots level through bottom-up approaches in an effort to ensure that people have both a voice and a stake is the direction towards biodiversity conservation is moving today. However, there are some issues ahead that still constitute real challenges, among which are the following:

- Full local participation is best developed in a fully democratic society. However, many communities involved in conservation initiatives are highly hierarchical in nature and generally follow the decisions of their leaders (Borrini, 1997). In those communities, the participation of certain groups may clash with customs;

- National governments may not support local participation or empowerment, especially if they regard it as a threat to their own authority (IIED, 1994);
- There are often some difficulties for conservation to benefit both the environment and the cultural identity of local society;
- Local knowledge and institutions are sometimes not sufficiently open to integrate non-local lessons and positive contributions;
- In some conservation areas, it is sometimes a complex issue to find legitimate stakeholders. If they exist, the issue is if they can all afford to participate in conservation and if they can develop an appropriate institution to take charge of resource management.

1.2.3. Conservation through indigenous common property management systems

Over many millennia, rural people throughout most cultures and societies across the world have developed complex social processes to live in harmony with their environments, to enhance their livelihoods and to gain control of their land and resources (Hitchcock, 1994). Forests, land and coastal waters have often been held and managed under traditional ownership by community groups, and resources in these areas are managed by mechanism such taboo and customs (Weber *et al.*, 2000). There are examples of well-documented common property resource management systems (McCay and Acheson, 1987; Berkes and Farvar, 1989; Ostrom, 1991; Berkes, 1992; Mckean, 2000).

Indigenous common property management systems aim to improve local self-sufficiency and the emphasis is on taking what is needed. Hence, use is entwined with sustainability and a community-based system of production. Practices emphasise respect, responsibility, stewardship, and participatory and self- management. The planning for, and the management of, resource held as common property is carried out by those most directly affected by their decisions, decisions that are designed to contribute to the continuing sustained use of the living resources (Jacobs, 1989). Community members generally share a common culture, knowledge of the resource and knowledge of resource-use rules, facilitate by a simple rule, "you must live in this community to use this resource"(Ostrom, 1985). Indigenous common property management systems are integral part of the local culture. Hunting, fishing, and fruit gathering are a way of life rather than merely a means of earning a living (Berkes and Farvar, 1989).

The effective functioning of common property resource management systems depends on the existence of appropriate local institutions, formal or informal, community-based rather than government-sponsored (Korten, 1986). Ignored by much development planning in the past, there is now abundant evidence from detailed case studies that indigenous common property systems play a crucial role in conserving biodiversity at grass-roots level (Ostrom *et al.,* 1990; Berkes and Farvar, 1989).

However, many communities today stand at a crossroads and face an uncertain future. The equation of relative balance between these communities and their environment has been severely disrupted, as they face mounting pressures from the outside such as encroachment by agribusiness, by petroleum, mineral, and timber combines, and by uprooted, landless farmers who reduce traditional territories (Weber et *al.*, 2000). Indigenous communities also face a growing internal challenge as their population densities increase and the market economy undermines subsistence strategies and the cultural traditions that supported them. They are increasingly under pressure to augment rates of resource extraction to unsustainable levels. If they resist doing so, someone else is ready to argue for the right to do so, and the state, starved for funds, is often more than ready to listen (Weber *et al.*, 2000).

Such challenges face countries like Cote d'Ivoire, which has rich biodiversity, many traditional societies, of which most have been suppressed by a centralized state structure.

1.3 Conservation in Cote d'Ivoire

Cote d'Ivoire is a West African country with an area of 322,463 km^2. A French colony until 1960, it extends over 700km in a north-south direction and has 520 km of coastal frontage. Its climate is transitional between the equator and the tropic of Cancer. The temperature and humidity are constantly high all the year round.

Bounded by the Gulf of Guinea to the south, by the forests of Liberia and Guinea to the west, by the plains of Burkina Faso to the north, and by the forest-savannah mosaic of Ghana to the east, Cote d'Ivoire can be divided into five main biodiversity zones: coastal wetland; evergreen forest; tropical moist forest; semi-deciduous forest; and, Guinea savannah. Cote d'Ivoire encompasses the most significant portion of the Guinean Forest Block. A dense network of rivers has served as a barrier to species migration, encouraging the development of locally high levels of endemism. Thus, 232 species of mammals, 756 bird species and 4700 species of plants are found in the country (IUCN, 1990; East 1991; Oates, 1986).

In terms of land ownership, the national territory is divided into three categories: the state permanent estate, essentially represented by protected areas; rural estate, land owned by the state but on which rural communities have equal usufruct right for the time being; and, private land.

1.3.1 History of natural resource management

Traditionally, most of the indigenous tribes in Cote d'Ivoire used to informally set aside pieces of land, particularly pieces of forest, as sacred sites. These sites, usually small in size, were revered and protected by custom and used for ritual and cultural ceremonies. However, biodiversity conservation was not a national priority following independence in 1960. Instead, the country's economic development has relied heavily on using its natural resource base. Timber in particular was believed to generate, over the very short term, the support needed for the development of other economic sectors. Thus, Cote d'Ivoire has been Africa's most important exporter of tropical timber (Martin, 1991). Logging has not only opened roads to carry timber out of the forest, but has also paved the way for incoming settlers. Increasingly, slash-and-burn clearance carried out particularly by small scale coffee and cocoa farmers, has resulted in uncoordinated and uncontrolled land use. This clearance has been reinforced by financial incentives and by the immigration of farmers from the desert regions of Burkina Faso and Mali (Martin, 1991).

The development of agriculture has also positively impacted on the national economy. For instance, during the 1960s and 1970s, Côte d'Ivoire experienced an average real GNP growth rate of 7% per annum (Hatier, 1994). As a result, per capita incomes rose at about 4% p.a. in real terms, and the standard of living in both urban and rural areas has improved greatly. Nevertheless, this impressive economic growth has caused further loss of forest cover. Some 160,000 km^2 of rain forest covered 38% of the national territory in 1950. However, this now only remains as scattered fragments, islands of biodiversity in a sea of agriculture and industrial plantations of cocoa, coffee, rubber and palm oil trees. The country's forest has drastically declined at an overall rate of 3500 km^2/annum. Agricultural land, once considered abundant, has become relatively scarce while fallow periods are being reduced, thereby preventing natural restoration of soil fertility. Logging and agriculture have thus affected wildlife by destroying their natural habitats, upsetting their ecological relationships, restricting their normal movements, reducing their population sizes, particularly of large mammals such as elephants, which cannot persist in the face of such drastic environmental change.

1.3.2 Protected Areas in Cote d'Ivoire

The national system of protected areas in Cote d'Ivoire represents some 6% of the country's land area (World Bank, 1995; IUCN, 2003). Nevertheless, this includes both the largest intact ecosystem within the Guinea-savannah ecosystem and the largest area of relatively undisturbed lowland rainforest in West Africa. Together, these areas cover over 15,000 km^2 and provide security for nearly 90% of the mammal and bird species known in the West Africa, including significant populations of regionally endemic birds, antelopes and primates.

Banco National Park, inside the city of Abidjan, was the first protected area established in Cote d'Ivoire in 1926. It was set aside by the former French colonial administration as a Nature Reserve with an area of 30 km^2, and became a National Park in 1953. Since 1968, eight National Parks have been established in Cote d'Ivoire with each representing the different habitats found in the country. The Comoe National Park, the largest National Park in West Africa with an area of 14,500 km^2, Tai National Park, the last extensive tract of dense evergreen moist forest remaining in West Africa and Mount Nimba, are of international importance as Biosphere Reserves under the UNESCO/MAB Programme and World Heritage Sites. Mount Nimba is a centre of plant diversity and a trans-boundary protected area between Cote d'Ivoire and Guinea. Azagny National, established in 1981 with an area of 214 km^2, is a RAMSAR site.

Beside its National Parks, there are five Nature Reserves in Cote d'Ivoire with a total area of 3396 km^2, 17 botanic gardens covering 2300 km^2, and several classified forests totaling 34,000 km^2 or 10% of the national territory.

As the land around them is converted to alternative and incompatible uses, protected areas in Cote d'Ivoire are becoming "islands"in a sea of humanity. Already under-funded, they have come under increasing pressure from the expanding scale of human activities outside, and sometimes inside, their boundaries. Tai National Park, for example, is included in the IUCN list of the world's most threatened areas. Moreover, with the economic crises of the 1980s, Government funding for protected areas has diminished below critical levels. In turn, this has had far reaching consequences for the protected area management system, which has almost completely collapsed. Protected areas were left almost unattended and poaching has increased to alarming levels.

1.3.3 New conservation strategy

In 1995, in response to the need to reform the management of existing nationally protected areas, the Government adopted a modern National Strategy for Parks and Reserves, called PCGAP (National Protected Area Management Programme) with three main areas of intervention:

- To improve the protection of existing national parks and reserves by involving other stakeholders such as the local communities, to decentralize the management administration by establishing an autonomous National Protected Area Management Parastatal (ONAP) and strengthening national capacity;
- To promote sustainable use of wild resources outside protected areas; and,
- To improve biological knowledge through the development of research programmes.

Because implementation of the strategy will have to involve important legal and institutional reforms as well as major capacity building efforts, and because staff capacity has reached very low levels, the PCGAP has been approached in four different phases: (1) institutional and legal framework building; (2) establishment and capacity building of an Ivorian Foundation for the Conservation of Protected Areas; (3) establishment and capacity building of a National Protected Area Management parastatal; (4) management and promotion of all protected areas. Various international donors such as the Global Environmental Facility and the Dutch International Assistance Agency have helped in the preparation of these different phases. Among the large and charismatic mammals that will certainly benefit from this new conservation strategy is the West African manatee.

1.4 Manatees and Sirenians

1.4.1 Evolution

Manatees are herbivorous aquatic mammals that belong to the order Sirenia. Despite their similarities in body shape, adaptations and habitat, manatees have no evolutionary relationship with other major groups of living marine or freshwater mammals, which are included in the order Cetacea (Reynolds and Odell, 1991). The two groups of mammals cited has having the closest affinity to sirenians are elephants and the extinct group of desmostylians. The evolution of manatees is not fully understood, but it is likely that sirenians originated in the Old World of Eurasia/or Africa, despite the fact that the oldest known fossils come from Jamaica (Reynolds and Odell, 1991). Within a few million years of their appearance, the sirenians were represented by several genera. The most charismatic sirenian was the Steller's sea cow (*Hydrodamalys gigas*), which measured at least 8 meters in length and was estimated by different scientists to weigh between 4 and 10 metric tons. It was discovered by a German naturalist Georg Wilhelm Steller on Bering Island in the year 1741 and was extinct just 27 years later as result of over hunting. Today sirenians are far less abundant and diverse than formerly. Now only four species remain, three species of manatee, all from the one family, *Trichechudae,* and one species of dugong (*Dogung dugong*). The three existing manatees are the Amazonian manatee (*Trichechus inungiuis*), the West Indian manatee (*Trichechus manatus)* and the West African manatee *(Trichechus senegalensis).* The West Indian species has been further differentiated using anatomical features and is currently divided into two subspecies: the Florida manatee (*Trichechus manatus latirostis*) and the Antillean manatee (*Trichechus manatus manatus*).

By the early Pliocene epoch, about 5 million years ago, some trichechids, manatees and manatee-like animals were isolated in the Amazonian basin, while others had migrated into the Caribbean and reached North America. The trichechids that remained in the Amazon basin gave rise to the Amazonian manatee. The manatees that successfully invaded the Caribbean gave rise to the

West Indian and the West African manatees. One school of thought suggests that the West African manatee evolved because of chance colonization of Africa by animals dispersing from the Caribbean region (Reynolds and Odell, 1991). Conversely, based on the direction of ocean currents, it was mistakely speculated that West African manatees evolved in Africa and then moved westward to the New World. However, the discovery of primitive Trichechus in South American Tertiary deposits tends to support the opinion that West African manatees originated in South America, and then dispersed by chance eastward to the African continent (Reynolds and Odell, 1991)

1.4.2 Morphology

Manatees are hydro-dynamically designed for life in water. All three species are large-bodied animals with a rounded paddle-shaped tail used for swimming. As with an elephant's trunk, the lips of manatees are used to manipulate vegetation when feeding. Their eyes are very small in comparison to their body size. Manatees lack an external ear and the ear opening is nearly invisible and located behind each eye. Manatees live underwater but need to surface to breathe through two valves like nostrils situated at the tip of their head.

The West African and the West Indian manatees are very similar in their exterior morphology. When laid side-by-side, most biologists would be hard pressed to distinguish between the two species (Reynolds and Odell, 1991). They are about the same size and shape, and possess the same wrinkled skin and sparse white hair. However, experts familiar with the appearance of both species have noted that the West African manatee is less robust, and more fusiform in shape, and its eyes slightly more protrude from their sockets. In contrast, the West Indian manatee has a spindle-shaped body that is elliptical in cross section. An average adult of both species is about 3m in length and weighs from 450 to 500kg, although some exceptional individuals can reach 4m long and weigh more than 1000kg (Reynolds and Odell 1991). However, the Amazonian manatee is the smallest of the living manatees, with the largest recorded specimen measuring only 2.8 m in length. It bears distinctive white or pink patches on the belly and chest, lacks nails on its pectoral flippers, and its teeth are smaller.

Although it is thought that adult female manatees may grow slightly longer and bulkier than males, there is very little sexual dimorphism in manatees. Hence, it is generally impossible to tell the sex of an individual animal unless its underside can be observed. Both sexes have an umbilical scar approximately midway along the belly. In males, the genital opening lies further toward the tail from the umbilicus, and the anus lies some distance further caudally. In females, the genital opening lies near the anus, with both openings located closer to the tail. The presence of a suckling calf, an extremely rotund appearance during pregnancy, and swelling of the genital area during estrous are, of course, usually a good gender clue.

1.4.3 Distribution

Manatees are tropical and subtropical in their distribution. The West African and the West Indian manatees are found in shallow coastal waters, rivers, estuaries and lagoons.

The West Indian manatee is confined along the Atlantic coast of America. The Antillean subspecies ranges throughout the Caribbean islands, from Texas along the east coast of Central America, to the northern coast of South America, as far south as Brazil. The Florida subspecies primarily inhabits the coastal waters of peninsular Florida and southern Georgia, ranging as far west as Texas and as far north as Rhode Island (Barbara and Jeff, 1998)

The West African manatee is found along the Atlantic coast of Africa from the Senegal River in the north to the Cuanza River of Angola in the south (Hatt, 1934; Husar, 1978; Nishiwaki *et al.*, 1982; Halternoroth and Diller, 1986). It has also been recorded far inland, some 2,000 km from the sea. Records exist for the

Niger River from Koulikoro to Gao, in Lake Debo in Mali, and in Lakes Léré and Tréné in Chad (Kienta, 1985; K. Bakary Persenal communication).

The Amazonian manatee is the only sirenian confined in its distribution to freshwater. It lives in the vast Amazonian basin, occupying rivers in Brazil, along the Brazil-Guyana border, in Peru and in Ecuador (Reynolds and Odell, 1991).

1.4.4 Status

All three species of manatees are listed as Vulnerable in the IUCN Red Data Book and are all legally protected by international agreements and national laws everywhere they occur (IUCN, 2003 b). The only known significant predator of manatees is human. The West African manatee is the least known compared to the West Indian and to the Amazonian manatees, for which research centers have been established several years ago to allow teams of scientists to address their anatomy, behaviour and ecology. The West African manatee is the most likely to face extinction in the near future unless appropriate conservation steps are taken. Urgent research is required to identify the action needed to encourage the recovery of the West African manatee population. Unfortunately, to date very few initiatives have been undertaken. Some short-term surveys, based mostly on questionnaires and information gleaned from fishermen, have been conducted to determine their status and distribution. Countries included in such surveys comprise Gambia, Ghana, Nigeria, Mali, Guinea-Bissau, Liberia, Cameroon, Congo (Robinson, 1971; Nishiwaki *et al.*, 1982; Reeves *et al.*, 1988; Sykes, 1974; Kienta, 1985; Akoi, 1994). These studies have provided useful first hand information on West African manatee status and distribution. However, to date follow-up activities have not yet been undertaken in most of these areas and there is still much research needed to provide adequate management for the species over the continent. The on-going West African Manatee Conservation project in Côte d'Ivoire, supported by the Wildlife Conservation Society since 1986, represents the only noticeable and long-term initiative.

1.4.5 Values to people

Through the ages, people have exploited manatees for their meat, oil, and hides and for their ivory like bones. Every part of a dead manatee can be used (Reynolds and Odell, 1991). The thick skin was cured and crafted into quality leather goods, including walking sticks, horsewhips, shoes, and the heavy leather whips once used on slave plantations. Lacking marrow, the dense rib bones were used as weapons or ivory for ornamental carvings. Even the manatee's body fat and clear oil were used for lubrication, and as lantern fuel to generate light.

As examples of traditional usage, people have worn manatee ear bones as charms in the hope of improving human hearing, and they have applied or ingested other manatee body parts as medicinal cures. The Spanish believed that the manatee's inner ear bones held special curative power (Reynolds and Odell, 1991). They burned and pulverized the bones, called stones, into a powder and then took a small amount of the powder on an empty stomach in the morning with a swig of white wine. The magic manatee stones were supposed to cure just about everything from aches, colic, and dysentery to kidney problems (Reynolds and Odell, 1991).

Soon after Columbus explored the Caribbean, the Spanish Catholic church declared manatees a fish, so that their meat could be eaten on Fridays (Reynolds and Odell, 1991). When boiled or fried in its own oil, the meat of manatee could apparently be preserved for a year or more. Because of this, an enterprising Dutch company chartered ships in 1643 and sailed to Guyana to capture manatees. The meat was then preserved and shipped to the Caribbean islands, where it was sold as food (Barbara and Jeff, 1998).

In the late 1800s, manatees attracted different values with the burgeoning era of museums and aquariums, which all wanted manatees for their collections. Museums paid $ 100 for a cleaned manatee skeleton and hide. Aquariums paid even more for a live specimen.

Manatees also have important traditional values in the culture, magic, and folklore of various peoples. For the *Mande* of Niger and *Ebrie* of Cote d'Ivoire in West Africa, the manatee is a tribal totem. The tribal name *Mande* is derived from the vernacular name of manatees, *Ma*, and the word for son or *Nde* or *Ndin* meaning son of manatees (Powell, 1996). The *Ebrie* tribe believes that manatees are their protector. In the history of this tribe it is said that in the past the mortal remains of a drowned woman was brought to the beach by a manatee after two days of unsuccessful searching by experienced divers from the village. From that day, elders from the *Ebrie* tribe established a covenant with manatees and even today, the manatee is still a tribal totem for the *Ebrie*.

Ceremonial smoking pipes in the shape of a manatee were used by pre-Columbian Indian tribes in Florida, while manatee bones have been found in their middens. In southern Florida, manatees appear to have had some ritualistic significance, as their head bones have been found buried in the graves of tribal chiefs (Barbara and Jeff, 1998). The Maya in Mexico used manatee skins to cover their shields and canoes. Today manatees continue to be a source of food and income for indigenous peoples, particularly in Africa, although hunting is banned. "I have five school children and every year I paid their school fees by selling manatee meat " said Lela Dominique, a manatee hunter in Cote d'Ivoire.

The manatee constitutes a great tourist attraction throughout their range, particularly in areas where they can easily be seen, such as the Blue spring and Crystal River in Florida where people can go snorkeling and scuba diving with manatees. In the lagoon complex of Fresco, tourists from Abidjan visit at weekends to look for manatees with banana boats. Although the organization of these tours needs to be improved, they are still very profitable for the organizers.

Manatees have been used as underwater "lawn mowers" to battle invasive alien weeds in some waterways, although the result of such experiments is minimal when few manatees graze over large areas. In various areas, the control of invasive aquatic plants, such as water hyacinth (*Eichhornia crassipes*) has become very expensive. Alien weeds have invaded and clogged many freshwater habitats, and routinely threaten boat traffic when they grow into huge floating islands. Blown by the wind, the plants cross the water surface and pile up into impenetrable heaps, blocking access to docks, boats, and the shoreline. Furthermore, if left unchecked, these plants disrupt native food chains and fish populations by depleting available oxygen and shading out bottom-dwelling plants. By quickly incorporating these alien weeds into their herbivorous diet, large manatee populations have kept some relatively small size waterways open from invasion by the water hyacinth. They have also helped to keep mosquito populations in check by eating the plants that form the insects' breeding habitats (Barbara and Jeff, 1998).

1.4.6 Human-manatee conflicts

For millions of years, manatees have evolved in plant-munching peace, until humans arrived on the scene. Now their co-existence with humans in the same habitat has been detrimental to manatees. Throughout their range, populations of manatees have been severely reduced, and even exterminated in some areas. Most manatee deaths are now attributable to human influence. Increases in human populations living in limited coastal wetland habitats have resulted in severe conflicts.

For example, the human population in Florida expands at a rate of about 1,000 new residents daily (Barbara and Jeff, 1998). An average of about 300 km^2 of wetlands have been destroyed annually between 1950 and the mid-1970s. As a result, many of the aquatic plants upon which Florida manatees once depended have been lost. Many manatees in Florida are accidentally killed due to collision with watercraft, entanglement in fishing gear or crushing and drowning in canal locks or flood control structures. Because manatees prefer shallow water, and surface to breathe air, swim slowly, and like to doze and float just beneath the surface, they are extremely vulnerable to boat hits. Manatees usually do not have time to manoeuvre out of the path of an oncoming speedboat, and their preferred shallow-water habitat does not leave them much room to dive deeper. Moreover, the animals cannot hear a boat, even in quiet water, until the craft is right on top of them. Thus, manatees are on the losing side of an escalating invasion of their shallow-water habitats.

In West Africa, the decline of the manatee population is largely attributable to hunting and incidental capture in fishing nets. Johnson (1937) reported that as many as 12 manatees a day were caught in a 100 mile stretch of the Gambia River, while Powell (1996) estimated that around two manatees per year were taken between 1978-1983 from the same area.

1.5 West African Manatees in Cote d'Ivoire

1.5.1 Distribution and status

Manatees are legally protected by the Ivorian Hunting and Wildlife Protection Code (Loi 65-255 du 04 Août 1965) in Annex I, Class A of fully protected species. In Côte d'Ivoire, West African manatees are distributed along the entire coast, including all major rivers and coastal lagoons, extending over more than 350 km and totaling about 1200 km^2 of brackish water (Blancou, 1960; Beal, 1939; Roth and Waitkuwait, 1986; Powell, 1996). Six main habitats can be distinguished: the Aby-Tendo-Ehy lagoon complex with the estuaries of Tanoh and Bia river; the Eastern Ebrié lagoon complex with the Comoé estuary; the Western Ebrié complex with the estuary of Agneby river; the Tagba-Makey-Tadio-Niouzoumou complex with Bandama; Gô and Boubo rivers, the N'gni lagoon with the Bolo and Niouniourou rivers; and, the coastal shallow water between Sassandra, San Pedro and Cavally rivers (Blancou, 1960; Beal, 1939; Roth and Waitkuwait, 1986; Powell, 1996).

1.5.2 Human-manatee conflicts in Cote d'Ivoire

As in the other parts of its range in West Africa, manatee populations in Cote d'Ivoire have decreased in the past and continue to decrease today, even though progress has been made in improving public awareness. Manatees are severely persecuted by hunting and by incidental killing in fishing nets. They have also most recently been threatened by the destruction of their limited habitat. It was speculated that around six manatees were killed per village every year (Roth and Waitkuwait, 1986).

Manatees live in coastal wetland habitats where human populations are constantly increasing. Coastal wetlands cover about 1% of the area of Cote d'Ivoire, but support 25 % of the total population, at densities of 273 people per km^2 compared with an average national population density of 48 people per km^2 (INS, 2001). Villages and encampments have sprung up on the edges of lagoons as a result of improved access and economic development. As a result, human impacts on manatee habitats have increased. Mangroves are being cleared and disappearing under the growing demands made by urban centers, particularly around larges cities such as Abidjan. For instance, a great part of the Ebrie lagoon is situated inside the city of Abidjan, a town of about 4 million inhabitants. A large canal has been opened between the lagoon and the sea to give easy access for boats to the harbour. This has significantly altered the quality of the water. Furthermore, high pollution generated by the harbour and by domestic waste water from the city, as well as increased boat traffic, have all contributed to eradicating manatees from this part of the lagoon.

In the past, in rivers such as the Bandama and the Sassandra, manatees moved from their estuaries to their far northern reaches for food, particularly during the wet season. Today manatees are confined only to the southern part of these rivers by the shutting of their path by hydroelectric dams. Not only have most of their historic habitats altered, but those that remain attract increasing numbers of indigenous people armed with nets, lines, hooks, and even poison which severely harm manatees. Serious injuries or death are caused to manatees by the discarding of monofilament lines, hooks, nets or other litter into the water.

1.5.2.1 Human-manatee conflicts in the N'gni Lagoon

Among the six manatee habitats remaining in Cote d'Ivoire, the Fresco lagoon complex is the best conserved. Lying in the western coastal area, it is less developed and has a very low human population density. Manatees may have been hunted there in the past, but manatee traps have not been found recently in this lagoon, although the species is well known by indigenous peoples. It seems that manatee hunting methods and skills have not been transferred from past to present generations around the Fresco lagoon.

Nevertheless, manatees are still threatened by incidental trapping in fishing nets, competition for limited space and habitat modification. Unfortunately, the situation is worsening due to the recent construction of a new coastal highway, which has made the region more accessible to other regional markets. Furthermore, people using the lagoon always complain that manatees destroy their nets and hooks, and sometimes even capsize their boats.

1.5.3 Conservation initiatives

The first information on manatees in Cote d'Ivoire was collected in 1978 and 1983 by a German Technical Assistance Project (Roth and Waikuwait, 1986). During that study, the current distributions and relative abundances of West African manatees were surveyed in 107 localities through questionnaires answered by government officials, local fishermen and hunters. The results showed that manatees still occurred sporadically in all lagoon systems. Based on a very rough estimate of numbers of manatees killed annually and on apparent population trends, it was proposed that the total numbers of manatees still surviving was well below 750-800 individuals (Roth and Waitkuwait, 1986).

From 1986, a full manatee conservation project was set up with four principal aims:

- To obtain basic information on the biology and status of the West African manatee and to identify potential conservation problems;
- To train local resource managers in manatee research and conservation techniques;
- To initiate a public awareness campaign; and,
- To develop and implement a long-term conservation strategy.

From 1986 to 1988, radio-tagging techniques were used to achieve the first aim of the project. Under the supervision of Dr J.A. Powell, several manatees were captured, tagged with radio transmitters constructed by the US Fish and Wildlife Service and located with a Telonics receiver from a boat or car with a pole mounted, hand-rotated yagi antenna. Locations were also made from a Cessna 172 airplane using an antenna attached to the wing strut. The opportunity offered by the radio-tracking operation was used for *in situ* training of local resource managers (Powell, 1988).

An ongoing public awareness and conservation education programme has been carried out as a follow-up activity since January 1990 (Akoi, 1992). An evaluation of the programme carried out in 1997 indicated a significant decrease of hunting and relative improvement in public awareness (Akoi, 1997).

This current study represents the first step toward the development and the implementation of a long-term conservation strategy for manatees in the Fresco lagoon.

1.6 Aims of the Study

The aim of this study is to investigate the indigenous common property resource management system, and the conflict between the community and the endangered West African manatee (*Trichechus senegalensis*), in the lagoon complex of Fresco, one of the six most important habitats for manatee in Cote d'Ivoire. This will provide the Ivorian Department of Wildlife Conservation, the staff of the West African manatee Conservation Project and other stakeholders in charge of developing and implementing a long-term conservation strategy of manatee in the lagoon complex of Fresco, with accurate information on which to base their management options. The main questions investigated in this study are as follows:

- How does the lagoon's ecology change seasonally?
- What vegetation types and plant species are found on the shoreline?
- How was the lagoon managed traditionally, and how have the management institutions changed in response to modernising forces?
- How do the indigenous peoples perceive the changes in the management system and what are their preferred future options?
- What natural resources are harvested from the lagoon and to what uses are these resources put?
- What is the ecology of the West African manatee?
- How do human activities impact on manatee behaviour?
- What are the attitudes of indigenous people towards the manatee?

1.7 Thesis Organization

Human-wildlife conflicts and coexistence, approaches to biodiversity conservation, the evolution of manatee throughout the history, its importance as valuable resource to humans, its status and known conflicts with human, the aims of the study and the main questions to be investigated have been outlined in Chapter 1. A description of the ecosystem of the Fresco lagoon complex and the general methods used in this research study are described in Chapter 2. Chapter 3 investigates how the ecology of the lagoon changes seasonally. Chapter 4 examines the vegetation types and coverage found on the shoreline of the lagoon. Chapter 5 determines the nature of the management system of the lagoon and how it has evolved over time. Chapter 6 examines the attitudes of indigenous peoples toward the current management of the lagoon and the preferred options of the future. Chapter 7 deals with the uses of the lagoon by indigenous peoples. Chapter 8 investigates the ecology of the West African manatee in the lagoon. Chapter 9 determines the interactions between manatees and indigenous peoples. Chapter 10 explores the attitudes of indigenous peoples towards the West African manatee. Chapter 11 summarizes the research findings, and discusses their conservation implications both in terms of management recommendations for the West African manatee, in particular, and for the long-term conservation of the Fresco lagoon and its surrounding areas in general.

CHAPTER 2 STUDY AREA AND GENERAL METHODS

2.1 Study Area

2.1.1 Location

The national territory of Cote d'Ivoire is divided into 18 main regions for administrative purposes. The Fresco study area is situated in the region of Sud-Bandama, in the Prefecture of Divo and the Sous-Prefecture of Fresco, on the western coast, about 200 km by road from Abidjan, the capital city (Figure 2.1). Bio-geographically, the Fresco study area falls into the coastal wetlands biodiversity zone of the country. The Fresco lagoon complex lies between latitude 5° 05' and 5° 20' North, and longitude and 5° 20' and 5° 40' West. It is limited to the east by the Grand-Lahou lagoon complex; to the north by the new coastal highway and the classified forests of Port Gauthier; to the south by the Atlantic Ocean; and to the west by the coconut agro-industrial complex of Fresco.

Linked to the lagoon complex of Grand-Lahou in the east by the excavated canal of Fresco, the Fresco study area is a relatively small stretch of water that includes: the Bolo and the Niouniourou rivers; their common estuary; the lagoon of Fresco; the Guitako, (a small and seasonal stream connected to the Niouniourou Rivers) and the shoreline (Figure 2.2).

Water is generally fresh in the inflowing rivers but brackish in the lagoon and the estuary. However, water quality varies according to seasons, and the influence of both freshwater and seawater.

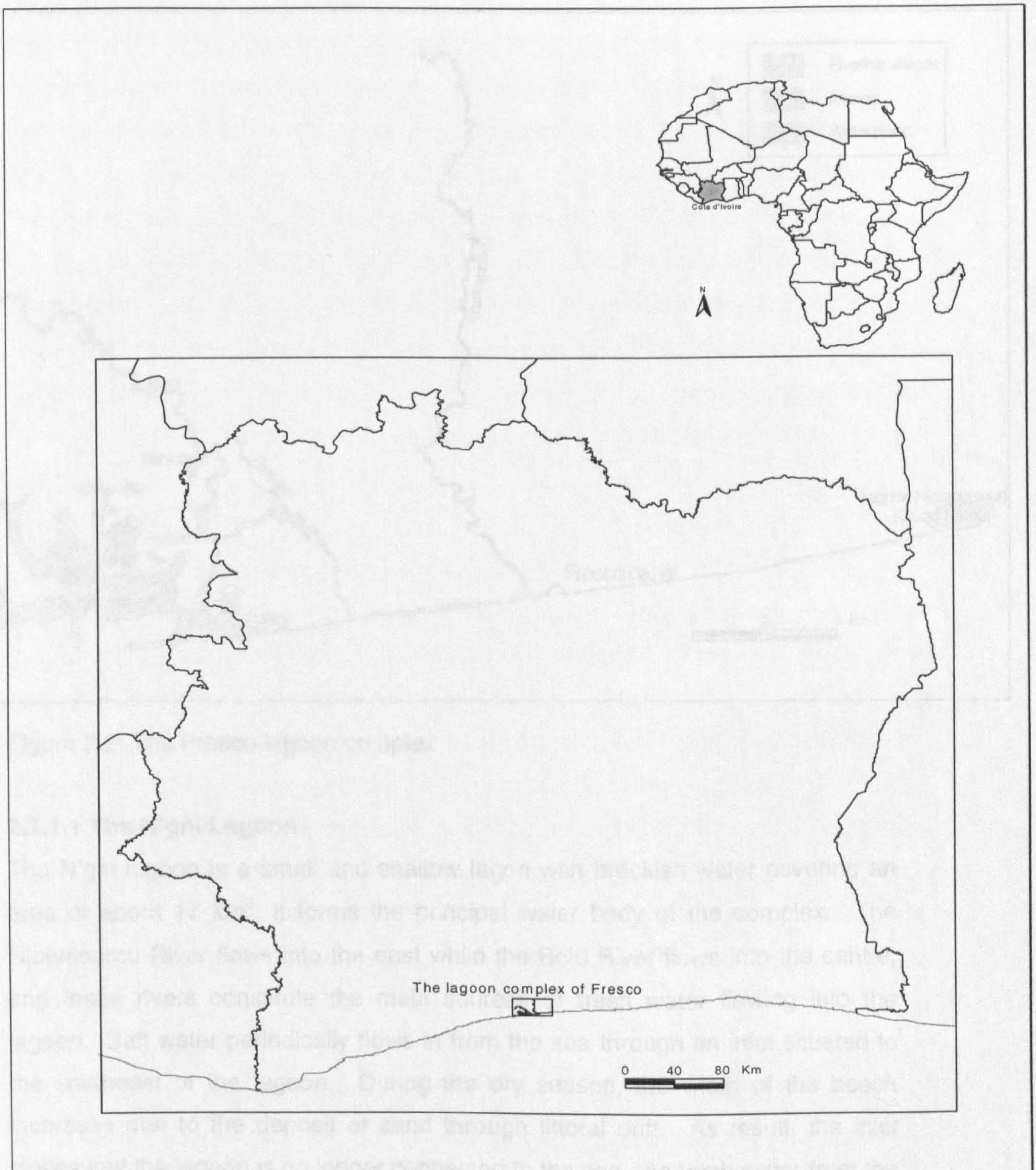


Figure 2.1: Location of Cote d'Ivoire in Africa, and of the Fresco study area in Cote d'Ivoire

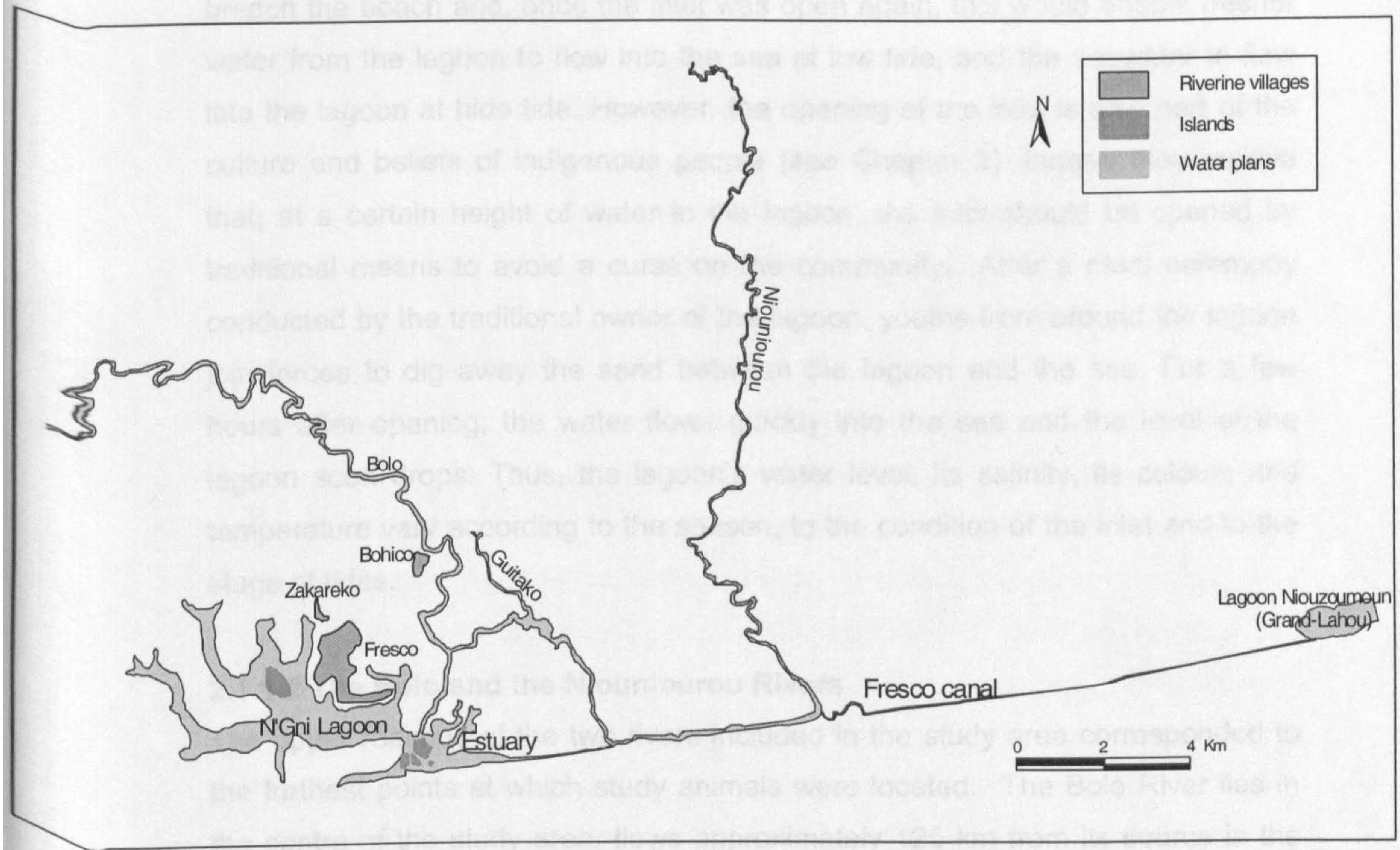


Figure 2.2: The Fresco lagoon complex

2.1.1.1 The N'gni Lagoon

The N'gni lagoon is a small and shallow lagon with brackish water covering an area of about 17 km^2. It forms the principal water body of the complex. The Niouniourou River flows into the east while the Bolo River flows into the centre, and these rivers constitute the main sources of fresh water flowing into the lagoon. Salt water periodically flows in from the sea through an inlet situated to the southeast of the lagoon. During the dry season, the width of the beach increases due to the deposit of sand through littoral drift. As result, the inlet closes and the lagoon is no longer connected to the sea. As fresh water from the Bolo and the Niouniourou rivers continues to flow into the lagoon, the height of the water rises progressively while the salinity drops progressively. In contrast, during the wet season, the beach becomes progressively narrower as the long-shore drift transports the sand away. The swollen lagoon would eventually breach the beach and, once the inlet was open again, this would enable fresher water from the lagoon to flow into the sea at low tide, and the seawater to flow into the lagoon at hide tide. However, the opening of the inlet is also part of the culture and beliefs of indigenous people (see Chapter 3). Indeed they believe that, at a certain height of water in the lagoon, the inlet should be opened by traditional means to avoid a curse on the community. After a ritual ceremony conducted by the traditional owner of the lagoon, youths from around the lagoon join forces to dig away the sand between the lagoon and the sea. For a few hours after opening, the water flows quickly into the sea and the level of the lagoon soon drops. Thus, the lagoon's water level, its salinity, its colours and temperature vary according to the season, to the condition of the inlet and to the stage of tides.

2.1.1.2 The Bolo and the Niouniourou Rivers

The upper reaches of the two rivers included in the study area corresponded to the furthest points at which study animals were located. The Bolo River lies in the centre of the study area, flows approximately 125 km from its source in the west of Cote d'Ivoire and remains in largely forested areas. In contrast, the Niouniourou River lies to the east, has its source 345 km away in the north of the country, and flows mainly through deforested areas before reaching the lagoon. The average width of each river increases progressively from the north towards the lagoon, and their depths range from 2.5 to 4 m at the their lower reaches, where the two rivers intersect and form a single body before flowing into the lagoon.

When the rains begin in the north, the Niouniourou River starts to fill and flow towards the N'gni lagoon. A few days later, as seasonal rains move toward the coast, the Bolo River also begins to flow. The flow of water on both rivers, particularly in their lower reaches, varies according to the condition of the inlet, and whether it is closed or opened. When the inlet is closed, water in the lower reaches of each river stagnates and rises. When the inlet is opened, their flows increase significantly, but water flushes faster on the Niouniourou than in the Bolo River. Several small streams also form temporarily during the wet season when the Niouniourou and the Bolo rivers are flooded, of which the main one is the Guitako connected to the Niouniourou. The sediment load of the Niouniourou River is greater than that of Bolo River (Powell, 1992), due to high erosion in the area traversed by this river before it flows into the lagoon.

2.1.1.3 The Fresco Canal

The Fresco Canal is an excavated canal dug in 1900 by indigenous peoples during the hard labour instituted by the French Colonial Administration. This canal links the Niouniourou River to the lagoon complex of Grand-Lahou. Before the establishment of terrestrial means of communication, the canal of Fresco was the only means of transport by boat and ferry linking the Fresco region to the rest of the country, particularly to the city of Grand-Lahou, the former administrative and commercial capital of the region. Today the canal is blocked by vegetation and boat traffic can no longer pass. However, water continues to flow, allowing aquatic species to move between the Fresco lagoon and the Grand-Lahou complex.

2.1.2 Physical Aspects

As in most coastal wetlands, the principal ecological factors that affect the study area are the climate, the hydrology, the costal morphology, the soil and induced vegetation type. These factors determine the quantity and quality of flooded water, the areas flooded and the degree of soil saturation.

2.1.2.1 Climate

The climatic map of Cote d'Ivoire divides the country into two broad climatic zones: a sub-equatorial climate characterized by four seasons (two wet and two dry seasons); and, a Soudanian climate with two seasons (one wet and one dry season). The two climate types are influenced, respectively, by the *mouson,* a wind blowing from the sea to the continent, and the *Harmattan* blowing from the continent towards the coast.

The climate of the Fresco study area falls into the sub-equatorial type and is characterized by:

- a long dry season, from December to March;
- a long wet season, from April to mid July;
- a short dry season, from mid July to mid September; and,
- a short wet season, from mid September to the end of November.

2.1.2.2 Geology and Soils

Historically, the lagoon complex of Fresco was formed in the same manner as other lagoons worldwide. During the last transgression, sea levels rose 10 m or so higher than today. At that time, the coast consisted largely of cliffs. During the Ogolien regression, the sedimentation of suspended river sediments caused the formation of low plateaus. During the Nouakchottien transgression the sea invaded the existing hydrological system and gave rise to a system of rias, or drowned valleys. Following the peak of this transgression, a slight regression created a series of dune cordons, while the delta formations emerged, isolating a number of lagoons systems. Among these lagoon systems is the lagoon complex of Fresco (Nicole *et al.*, 1994).

In terms of geomorphology, and due to the distinct terrestrial settings, the study area falls into a composite river and wave dominated setting (Thom, 1982). That can be divided in two different relief types. To the east of the city of Fresco, the relief is smooth with a sand beach representing an alluvial plain and an offshore bar. To the west the relief becomes more uneven with cliffs reaching more than 50m.

In general, soils of the lagoon are hydromorphic clay or sand-clay, which are more or less saline depending on the influence of tides and the supply of fresh water. Three types can be distinguished:

- sand clay soils with iron. These soils are found on relief and are rich in organic material but poor in calcium, potassium and nitrogen;
- organic and wet peat-bogs soils rich in organic materials; and,
- soils not well developed, rich in sand found on the beach and on areas where water is not far from the surface.

Two separate factors influence the sedimentary deposits that greatly contribute to soil development in the area, namely continental factors and oceanic factors. The continental factors are associated with the dead litter from forests that falls into the Niouniourou and the Bolo River. This material, whether dissolved or in suspension, is carried by the fresh water conveyed by the Niouniourou and Bolo Rivers while flowing into the lagoon. Most of this litter is deposited in the lagoon, before its water reaches the sea. In contrast, seawater carries several sediments constituted particularly with sand substratum to build the sandy soil of the offshore bar.

2.1.2.3 Vegetation

The vegetation of the study area corresponds to the coastal wetland vegetation, characterized by an abundance of aerial roots, comprising stilt roots and pneumatophores, and few species per unit area. Depending on whether the water is saline or fresh, and on dominant species, three main vegetation types can be distinguished:

- dense terrestrial forest dominated by *Berlinia confusa* and *Pycnanthus africanum;*
- swamp forests dominated by *Pterocarpus santaloides* and *Raphia hokerii;* and,
- mangroves forest dominated by *Rhizophora racemosa* and *Avicenia germinans.*

2.1.2.4 Fauna

The fauna of the Fresco study area can be divided in five main zoological groups: fishes, reptiles, birds, mammals and crustacean and molluscs. Much of this fauna is highly threatened by human pressure and illegal hunting.

2.1.2.4.1 Fishes

The lagoon of Fresco and its associated estuary appears to be an important nursery area for many fish species. The area supports important populations of lagoon species, as well as of marine species that migrate into the system when the inlet is opened. The most common are:

- Fishes
  - Lagoon species: *Tilapia guineensis, Tilapia heudelotii, Tylochromis jentinki, Cynoglossus canariensis, Chrysichthys nigrodigitata,* mudfishes (*Clarias* spp.)
  - Marine and brackish species: *Elops lacerta, Polydactylus quadrifilis, Liza falcipinnis, Lutjanus dentatus, Lutjanus goreensis, Sphryraenea piscatorum, Ethmalosa fimbriata, Mugil cepalophus.*

2.1.2.4.2 Crustaceans and molluscs

The most common crustacean and mollusks are found in the Fresco lagoon complex are:

- *Marobrachium macrobrachium* and *Machrobrachium vollenhovenii* are freshwater crayfish species that migrate down from the upstream of the Bolo and Niouniourou rivers in dry season for spawning in the estuary (Powell, 1990).
- Shrimp (*Penaeus duorarum*), crabs (*Callinectes latimanus* and *Cardisoma spp.*) and oysters (*Cassostrea cucullata*).

2.1.2.4.3 Reptiles

Reptiles are represented by the following: three species of crocodiles (*Crocodylus niloticus, Crocodylus cataphractus* and *Osteolamus tetraspis*); one species of lizard, the Nile monitor lizard (*Varanus niloticus*); four species of sea turtles nesting on the beach (the green turtle, *Chelonia mydas*, olive ridley turtle *Lepidochelys olivacea*, leatherback turtle *Dermochelys coriacea*, and the imbricated turtle *D. imbricata*); and, three fresh water turtles *Tryonix triungius*, *Pelusios niger*, and *Pelusios gabonensis*.

Snakes may also be well represented, although no definitive data exists on their distribution and abundance. Python (*Python sebae*) is the only well known species (Akoi and Michel, 1998).

2.1.2.4.3 Birds

The diversity of habitats that occur in the study area offers a range of different feeding areas for birds. Paradoxically, the area has numerically poor bird populations in comparison of other lagoons. Akoi and Michel (1998) found 41 waterfowl species including fresh water and marine species, as well as wintering species. The most commonly seen species are great white egretta (*Egretta alba*), gray heron (*Ardea cinera*), palmnut vulture (*Gypohierax angolensis*), African darter (*Anhinga rufa*), little egret (*Egretta garzeta*), and various terns (*Sterna albifrons*; S. *hirundo;* S. *caspia;* S. *nilotica*).

2.1.2.4.4 Mammals

The West African manatee (*Trichechus senegalensis*) is the most charismatic aquatic mammal found in the Fresco lagoon. As observed by Powell (1996), the N'gni lagoon appears to have the highest density of manatees of any area in Cote d'Ivoire. More sightings for a given search effort were noted here, with 5 to 6 sightings per hour compared with the Bandama River where a manatee might not be seen in 800 hours of searching.

Pygmy hippopotamus (*Choeropsis liberiensis*) are also reported to exist in the study area, particularly in the lower reaches of the Niouniourou River and in adjacent periodically inundated forests. However, its population seems to have been greatly reduced by illegal hunting and by the clearance of vegetation of the region to the north of the Fresco canal where they were particularly common. Other mammals infrequently observed in the mangrove and others associated forests, are elephants (*Loxodonta africanus cyclotis*), forest buffalo (*Syncerus caffer nanus*), red river hog (*Potamochoerus porcus*), water chevrotain (*Hyemoschus aquaticus*), Congo clawless otter (*Aonyx congica*), spotted neck otter (*Lutra maculicolus*) and various primates, among which the spot nose monkey (*Cercopithecus petaurista)* is the most common (Akoi and Michel, 1998).

2.1.3 Demography and socio-cultural aspects

In terms of its occupation by human populations, the study area has for long been included in the triangle of Guiglo, Tabou and Grand-Lahou, considered as a relatively empty area with 8 inhabitants per km^2 compared with the national averages of 48 inhabitants per km^2 in rural areas and of 200 inhabitants per km^2 in urban areas (INS, 2000). Due to difficult access, the area around Fresco was avoided, and even government officials posted to the main city considered their appointment as a punishment. However, this changed in 1995, when a coastal highway was built to link the Fresco region to the rest of the country.

2.1.3.1 History of Settlement

The native ethnic group is the Godie from the Krou tribe. Populations are mostly rural and are settled in three main areas, the villages of Bohico and Zakareko, and the city of Fresco. The Godie arrived early in the 17^{th} century from two different directions. One group, the most important came from Ghana and the second one from Grabo, a village in the south west of the Cote d'Ivoire, about 300km away from Fresco. The group from Ghana was led by Grah Lobo, and the group from Grabo by Gbape. Both groups were fleeing their native lands, which had been subjected to long-lasting social unrest, for a peaceful and remote region. They met in Gnabezaria, a village situated 100km away to the north west of the study area. In Gnabezaria, the two groups mixed because Grah Lobo married Zabian, the daughter of Gbape. Due to the lack of a suitable place to settle in Gnabezaria, the two groups continued their journey further south towards the sea. Their first obstacle was the Bolo River that they needed to cross before moving further. Without any boat, this exercise was a genuine challenge. The group led by Gbape decided to settle on the edge of the Bolo River rather than to cross for fear of drowning in the water. However, the group from Ghana walked along the river and finally found a shallow and rocky area of the riverbed where they could cross safely.

After crossing the Bolo River, the group from Ghana moved further south and were confronted by another obstacle in the form of the N'gni Lagoon, which caused the group to divide into two. The less courageous people decided to settle on the edge of the lagoon rather than to cross it, and the area where they settled became the village of Zakareko. The rest of the group comprising 12 families, including Grah Lobo and his wife Zabian, built rafts to cross the lagoon and settled on a relatively small strip of sandy land between the sea and the lagoon. This area became the village of Fresco.

A few months after settling on the bank, Grah Lobo and his wife Zabian went back to visit her parents settled on the edge of the Bolo River. Once there, Grah Lobo advised his wife's parents to cross and settle on the opposite side of the Bolo River to be more secure against invaders, very common at that period of history. The first person to accept this advice and cross the river was named Bohi. The area where he settled after crossing became the village of Bohico, "which means the village of Bohi" or "the land of Bohi" (Akoi, personal observation).

Godie are traditionally farmers. However, after settling close to the Bolo River, the N'gni lagoon and to the sea, fishing skills have been progressively added to their culture. Of the three newly established villages of Bohioco, Zakareko and Fresco, Fresco was the most important in terms of population and size. It consisted of 12 small districts, belonging to each of the 12 families of the group.

In 1967, the original village of Fresco was resettled to a new site that now forms the new city of Fresco, situated on the northern shoreline of the lagoon. The new city is made up of 12 districts representing the 12 resettled districts.

Following the introduction of cash crops and the recent creation of the new coastal highway, others groups of peoples have moved into the area. Among them are immigrants from Burkina Faso and Mali, as well as Baoule from the centre of the country.

2.1.3.2 Agricultural methods

Much of the study area comprises marshlands of peat, and permanently flooded land, so are not suited to intensive agriculture due to fairly mediocre fertility, excess water and salt soils. However, small scale farming, particularly of rice and cassava, can still occur.

The agricultural methods used in the area are slash-and-burn clearance. The land is usually cleared from January, for planting in April and May during the long wet season. Fires are set at the base of larger trees of undesirable species, though increasingly chainsaws are being using to fell such trees. All cultivation, clearance, weeding, and harvesting is done with hand tools, and the use of fertilizers and compost are uncommon. Farms generally belong to men who usually accomplish all the physical work of field preparation. All activities concerning sowing, weeding and keeping birds away from rice plantations as well as rice harvesting, are mostly undertaken by women, while men are heavily involved in fishing.

2.1.4 Socio-economic practices

Economically, the study area is a mixed subsistence and cash economy. Subsistence crops grown, in order of importance, are rice (*Orysa sativa*), Casava (*Manihot esculenta*), plantains (*Musa sapientum*) and various vegetables. Cash crops that have been recently introduced into the area are coconut (*Coco* *nucifera*) and cocoa (*Teobroma cacao*). Livestock rearing is not common here, although poultry is often kept.

Fish are generally caught for household consumption, although some are traded locally, and sent to Abidjan. Fishing is still carried out traditionally with hand nets and simple gear, while traditional banana boats are commonly used as mean of transport. A flourishing regional market where food crops are traded is held at Fresco city every Tuesday.

2.1.4.1 Infrastructure

The area is now well served by the new coastal highway, although it was long isolated. Villages have primary schools, a secondary school is located at Fresco city and the health needs of the population are met by the regional hospital of Fresco city, the administrative capital.

2.2 General Methods

Data were collected using a multidisciplinary approach. Detailed descriptions of methods, as well as of data analysis techniques, are presented in the relevant chapters. In this section I simply outline the field data collection protocols and the analytical methods used throughout the thesis.

2.2.1 Habitat Ecology

Water temperature and salinity were recorded using a thermometer and a hand held salinity refractometer respectively. Water levels were recorded using a graduated board installed at specific checkpoints.

A line intercept sampling method was used, following Kent and Coker (1996), to explore the vegetation found on the shoreline, between the highest wet season water level and lowest dry season water level. This method was preferred since the area included much degraded lands with extremely difficult access due the muddy soils. From this, vegetation types and species richness were determined.

2.2.2 Human use

The indigenous peoples harvest different natural resources from the lagoon and its shoreline. This includes fishery resources and firewood. The distribution and frequency of different uses were evaluated by monitoring boat traffic into, and out of, the system from a fixed point, and by recording different activities whilst travelling around the lagoon over 24 hours period. From this exercise, diurnal peaks and seasonal patterns of harvesting were determined.

2.2.3 Social surveys

Information on the lagoon management system, the indigenous peoples' attitudes towards the management system and toward manatee conservation, and distributions and population trends were investigated using a combination of participatory methods and individual interviews.

2.2.3.1 Participatory methods

Participatory methods were used early in the data collection process as a means of establishing a relaxed rapport with indigenous peoples from the three villages, since the key to success in collection of social data is their active participation. Methods used here followed guidelines provided by Chambers (1992), Pretty et *al* (1995), and Alcorn (1997).

An information letter from the Sous-prefet of Fresco, explaining the importance of the study, and the necessity of local participation, was sent to the chief of each village.

Following acceptance of this letter, a pre-appraisal dialogue was conducted in the three villages through group discussion as an introduction to the area and the indigenous peoples. Key informant interviews were conducted with knowledgeable individuals from the area to explore more in-depth points of specific interest.

2.2.3.2 Questionnaire surveys

A semi-structured interview schedule with both closed-ended and open-ended questions was administered to households living in the three villages around the lagoon (De Vaus, 1996; Frankfort-Nachmias and Nachmias, 1996). A disadvantage of closed-ended questions is that answers might be forced into categories that do not completely correspond with respondents' opinions. They are, however, easier to answer and encounter less refusal by respondents. On the other hand, open-ended questions have the disadvantage that details are lost during coding of the answers.

The questionnaire was divided into five key sections. The first section contained questions about personal information regarding respondents. Personal information collected included: age, gender, ethnicity, household size, education, occupation, and length of residence. The second section contained questions related to household economy. The third section was directed towards the resource uses. The fourth section was directed at the management system, its success and limitations and preferred future options. The fifth section was directed to the West African manatee. Attitudes of indigenous peoples towards the manatees were assessed by providing a range of attitude statements, 8 in total, to which the respondents were asked to state their level of agreement.

The questionnaire was presented to villagers in French. A pre-test was carried out and feedback from this exercise helped to give more reliability to the wording and a more logical flow of ideas. An introduction was provided at the beginning of the questionnaire to explain the purpose of the survey and, most importantly, to assure that all information generated would be treated anonymously, as several questions asked for sensitive information. A total of 243 households were sampled, 139 from Fresco city, 56 from Zakareko and 48 from Bohico.

2.2.4 Ecology of the West African manatee

2.2.4.1 Distribution and abundance

Interviews and aerial surveys were used to investigate manatee abundance and distribution. Aerial survey and interviews have been widely used in the last two decades to determine distribution and population size of the West Indian manatee in Florida and Central America (Belize: Bengtson and Magor, 1979; Dominican Republic: Belitsky and Belitsky, 1980; Haiti: Rathbun *et al.*, 1985; Honduras: Rathbun *et al.*, 1983; Puerto Rico: Powell *et al.*, 1981; Rathbun et *al.*, 1986; Venezuela: O'Shea *et al.*, 1988). Similar interviews have also been used to determine the distribution of the West African manatee (Nishiwaki *et al.*, 1982; Roth and Waitkuwait, 1986; Reeves *et al.*, 1988; Akoi, 1994; Powell, 1996; Grigione, 1996; Mouho, 1997).

2.2.4.2 Diet and feeding behaviour

Diet composition was estimated by recording feeding station intervals (FSI), which was the time a manatee spent at each stance feeding on one plant species (Becker and Lohrmann, 1992; Ngwa *et al.*, 2000). These were supplemented by gross inspection of 35 dung samples collected from the study area.

The foraging behaviour of the West African manatee was investigated, whenever possible, by direct observation during focal watches.

2.2.4.3 Activity Budget

Eighteen individuals manatees were caught and tagged with radio transmitters. The activities of individuals were studied over 24 hours, using instantaneous scan sampling at 5 minutes intervals following Altmann (1974) and Martin and Bateson (1993). Four categories of behavior were defined: Moving, cavorting, feeding and resting.

2.2.4.4 Habitat preference and spatial organization

Each individually tagged manatee was located at least twice per week. When an individual was sighted the following were recorded: location (GPS UTM coordinates), group size, habitat, date and time, tide stage, water depth, temperature and salinity. This information was used to calculate individual home range and group home range size, and habitat preferences.

2.2.5 Data Analysis

Data were analysed using Microsoft Excel 2002 and SPSS version 11 for Windows statistical packages. Maps and home ranges were produced using Arcview version 3.2 and Animal Movement Extension. Levels of significance were tested using parametric and non-parametric statistics. Simultaneous regression, logistic regression and weight analysis of variance with General Linear Models (GLM) procedure were use to predict discrete outcomes. Factor analysis was used to assess the suitability and the reliability of scales on the atitude study.

Like any coastal water body linked to the sea, the lagoon complex of Fresco is subjected to intensive ecological changes over the year. The next chapter will examine how these changes affected the level, the temperature, the salinity and the area of the lagoon during the study period.

PART I HABITAT ECOLOGY

As the world's human population has increased and as the power of people to alter the environment has expanded, there is wide public and scientific concern to achieve a wise use of nature by fully and more effectively understanding its structure and functions. The branch of science dealing with such an understanding is *ecology*.

The word *ecology* is derived from the Greek *oikos*, meaning "house" or "place to live". Literally, ecology is the study of organisms at home. Usually, ecology is defined as the study of the relation of organisms or groups of organisms to their environment, or the science of the interrelations between living organisms and their environment. Because ecology is concerned especially with the biology of groups of organisms and with functional process on the land, in the oceans, and in fresh waters, it is more commonly defined as the study of the structure and function of nature (Odum, 1971).

Living organisms and their non-living environment are inseparably interrelated and interact with each other. Any unit that includes all of the organisms in a given area interacting with the physical environment is an "ecological system" or "ecosystem".

The ecosystem is the basic functional unit in ecology, since it includes biotic communities and their abiotic environments, each influencing the properties of the other, and both necessary for the maintenance of life.

The study of habitat ecology in this section will involve first, the study of seasonal changes of the hydro-climatic factors of the lagoon complex of Fresco, and second, the structure and composition of flooded vegetation on its shoreline.

CHAPTER 3 SEASONAL CHANGES IN LAGOON ECOLOGY

3.1 INTRODUCTION

Lagoons and estuaries are natural interfaces between fresh water from rivers and marine habitats (Saiz and Gonsalez, 2000). Like other ecotones or transitional zones, they support intense biological activity with high levels of ecological production. Furthermore, lagoons and estuaries are also subjected to very frequent changes, in terms of their physical and abiotic environment conditions. Thus, lagoons and estuaries have been subjected to extensive investigation. For example, Odum (1971), Boaden and Seed (1985), Carter (1988), Woodroffe (1992), Wolanski et *al.* (1992), all describe and explain some observable physical and biological features of coastal water ecosystems.

Physical conditions in estuaries may vary from fully freshwater to marine conditions, due the interactions of tidal action, freshwater inflow, groundwater, evaporation and rainfall. The regular rise and fall in sea levels, caused by systematic variations in the relative positions of the Earth, Moon and Sun, is of considerable importance to coastal water ecosystems, not only through the effects of tidal currents, but also as it spreads the range and influence of marine processes over a wider area (Carter, 1993). Thus, the water salinity, temperature, height and extent of lagoons and estuaries, change considerably over the day, month and year, according to the volume of water, whether fresh or salt, flowing into the system. Wolanski *et al.* (1992) observed that the interaction of the variation in tidal height with rainfall and evaporation determines the salt balance in estuaries. In areas with little rainfall and high evaporation, very high water loss results in high concentrations of salt. In contrast, in periods of high rainfall and freshwater inflow, salt in the water is highly dissolved despite regular tidal flooding.

Rapid and frequent changes allow little time for acclimation of species and impose physical constraints on biota. Thus, the ability of species to live in coastal waters and estuaries largely depends on their tolerance of wide variations in water chemistry (Boaden and Seed, 1985). Only species that have developed mechanisms to respond to such changes, such as rapid regulation of their osmotic balance, can live permanently in lagoons and estuaries. Others respond to such changes by means of migration or acclimation. For instance, West Indian manatees are forced to travel to warm water in winter because of low water temperatures in much of the state of Florida (Reid *et al.*, 1991; Ackerman *et al.*, 1995). Likewise, West African manatees are limited to waters with temperatures over 18^0 C (Hatt, 1934). Below this limit the species must migrate to survive. Similarly, the growth and survival of mangrove plants are controlled by the salt balance, and extreme high salinity (over 40‰) would retard even the most resistant species (Simpson *et al.*, 1999).

A sound understanding of changes in physical environment is of great importance to the prediction of the spatial and temporal distribution of species such as manatees that live in the coastal waters. Hence, this chapter aims to understand the ecology and seasonal changes occurring in the lagoon complex of Fresco. The chapter quantifies seasonal changes in its level, size, salinity and temperature. The chapter also determines their relationship with the level of rainfall, evaporation, air-temperature, tidal stages, marine water temperature and salinity and inlet condition (whether closed or opened), in order to address following questions:

- What are the seasonal patterns of rainfall, air temperature and evaporation in the Fresco lagoon complex?
- What are the seasonal variations of temperature and salinity of oceanic water entering the inlet?
- What are the seasonal patterns of the water level, area, temperature and the salinity of the Fresco lagoon complex and how are these are influenced by

rainfall, air temperature, evaporation, tides stages and temperature and salinity of oceanic water?

3.2 METHODS

3.2.1 Rainfall, evaporation, air temperature and ocean water salinity

Raw data on rainfall, evaporation and air temperature were obtained from the Sassandra Meteorological Station, situated 70 km from the Fresco lagoon complex, for the period 1991-2002. These sets of data were used to determine yearly and monthly means for rainfall, air temperature and evaporation. Similarly, raw data on oceanic water salinity and temperature at sea surface were obtained for similar anlysis from the Sassandra Centre of Oceanographic Research, situated 78 km from the Fresco lagoon complex for the same period 1991-2002.

3.2.2 Water temperature, salinity and level

Water temperature, salinity and level of the Fresco lagoon were recorded during daylight hours from from September 2000 to August 2002. Data were recorded from 5 different stations: station A in the estuary; B and C in the N'gni lagoon; D in the Bolo River; and, station E in the Niouniourou River. As the water was well mixed, only surface temperature and salinity were collected. During periods when the inlet was opened, data were collected alternatively at the end of the ebb period, for low water level, and at the top of flood tide period, for high water level, as indicated by visual observation of current flow and from tides table obtained from the harbour of Abidjan. To measure water temperature, a mercury-in-glass thermometer was sunk vertically into the water column and the temperature (^{0}C) was read as soon as it was taken out of the water. Water level was measured using a gauge graduated in cm/m fixed to a wooden pole, at four of the 5 stations (A, B, D, E). The first measure was taken as the 00m level, and changes in level were compared against this first reading.

Data on salinity were collected using a refractometer (model A366ATC) that was first calibrated using a drop of distilled water. Scale readings were done by putting a drop of water on the prism, and directing the daylight plate towards the sunlight while observing through the eyepiece. The gradient unit used was parts of salt by weight per 1000 parts of water (parts per thousand or ‰)

3.2.3 Seasonal change in water area

The study area was usually covered by extensive clouds during the peak of the wet season, so only one suitable LANDSAT 7 ETM satellite image was obtained for 23rd of April 2001 (Path 197, Row 56). This image was digitized on screen to measure the extent of the lagoon during the height of the wet season. A dry season LANDSAT 7 ETM satellite image for December 2002 (Path 196, Row 55) was also digitized on screen to measure the extent of the lagoon at the height of the dry season. The extreme seasonal change in the size of the lagoon complex was determined by comparing the wet season surface area with the dry season surface area.

3.2.4 Data analysis

Throughout means are shown with standard deviations. The strength and direction of possible relationships between different hydro-climatic factors such as rainfall, water temperature, salinity, level, evaporation, air temperature, and salinity and temperature of oceanic water were determined using Pearson-moment Correlation. Independent sample t-tests and one way analysis of variance, combined with Tukey Honesty tests were used to examine the differences in mean water temperature, salinity and level between sampling stations, between high and low tides and between freshwater (Bolo and Niouniourou rivers) and brackish water (estuary and N'gni lagoon). Finally, simultaneous multiple regression analysis was used to determine the predictive power of rainfall, evaporation, oceanic water temperature and salinity on the level, salinity and temperature of the lagoon.

3.3 Results

3.3.1 Rainfall

Annual mean rainfall at Sassandra Meteorlogic Station was 1900mm±100mm for the period 1991-2002. However, mean monthly rainfall varied seasonally and showed a bimodal pattern with two maxima and two minima. The largest peak occurred in June with an average monthly rainfall of over 400mm. A secondary peak occurred in October with an average monthly rainfall of less than 200mm. The deepest minimum occurred in January with less than 20mm of rainfall on average while a secondary minimum occurred in August with about 55mm of rainfall on average. The mean number of rainy days and the mean rainfall in different months were strongly correlated ($r=0.924$, $N=12$, $P<0.01$).

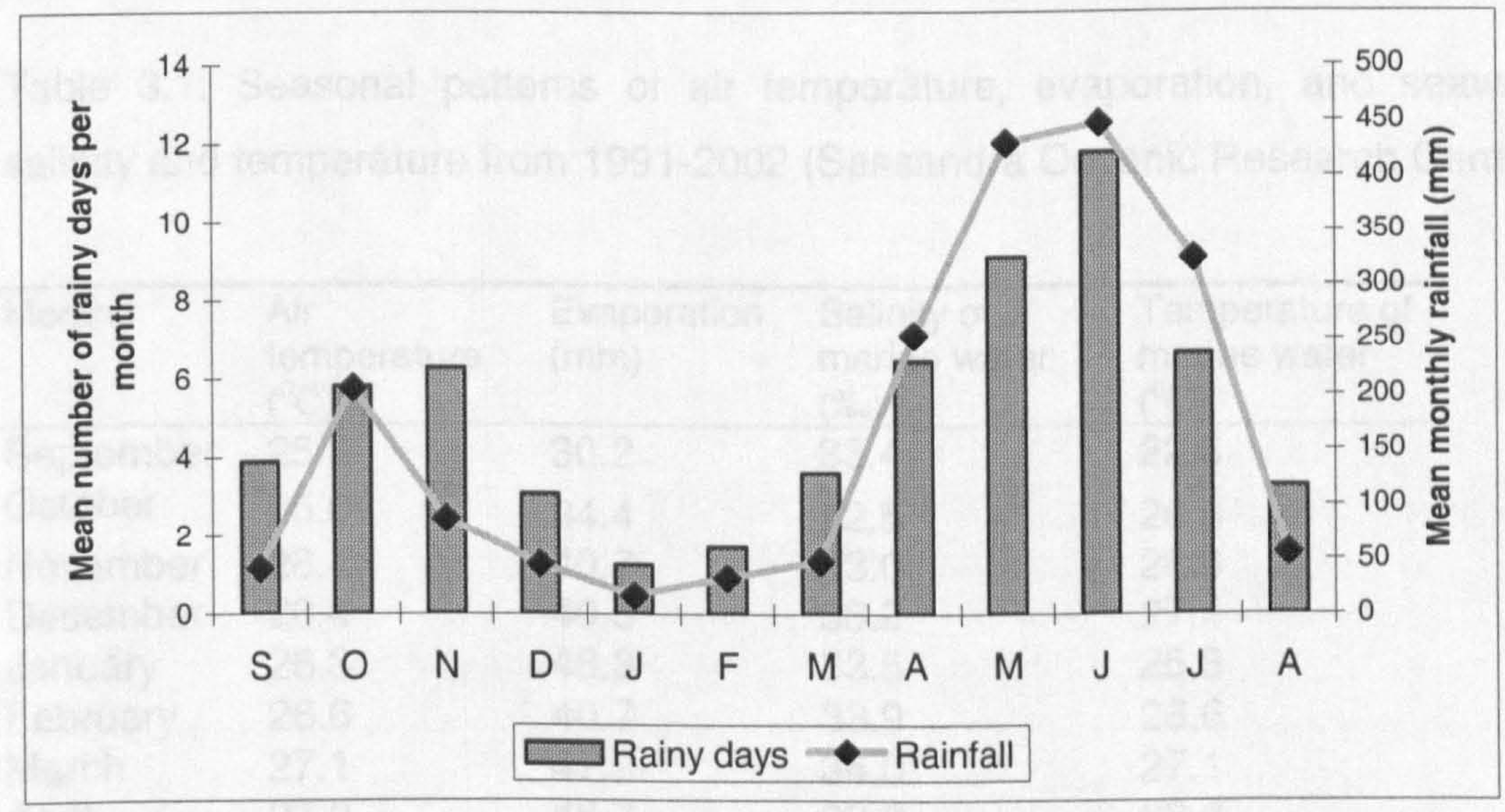


Figure 3.1: Mean monthly rainfall and mean number of rainy days per month from September 1991-2002 (data from the Meteorological Station of Sassandra).

3.3.2 Evaporation, air temperature, salinity and temperature of oceanic water

Mean monthly evaporation at Sassandra Meteorological Station ranged from 28 mm in August to 48.30 mm in January with an annual mean of 40.2±1.9 mm for the period 1991-2002. Mean monthly air temperature ranged from 27.3^{0}C in April to 24.5^{0}C in August with an annual mean of 25.9±0.27 ^{0}C. The temperature of seawater at Sassandra Centre of Oceanic Reseach ranged from 20.6^{0}C in August to 28.6^{0}C in April with an annual mean of 26.3±0.7^{0}C (Table 3.1). Evaporation and air temperature were strongly correlated (r=0.796, N=12, P<0.001). Similarly, there was a strong correlation between evaporation and temperature of marine water (r=0.765, N= 12, P<0.001) and between air temperature and marine water temperature (r=0.722, N=12, P<0.001).

The mean salinity of seawater at Sassandra Centre of Oceanic Reseach ranged from 34.8‰ in August to 30.3‰ in June with an annual mean of 33.2±0.32 (Table 3.1). There was no relationship (r = -294, N= 12, P> 0.05) between salinity of seawater and evaporation.

Table 3.1: Seasonal patterns of air temperature, evaporation, and seawater salinity and temperature from 1991-2002 (Sassandra Oceanic Research Centre).

Months	Air temperature (^{0}C)	Evaporation (mm)	Salinity of marine water (‰)	Temperature of marine water (^{0}C)
September	25.3	30.2	33.4	22.6
October	25.0	34.4	32.5	26.6
November	26.4	40.7	33.0	28.0
December	26.4	40.5	33.2	27.4
January	26.3	48.3	33.5	25.8
February	26.6	40.7	33.9	26.6
March	27.1	47.9	34.0	27.1
April	27.3	46.7	33.6	28.6
May	26.7	40.6	33.5	28.1
June	25.7	46.3	30.3	28.5
July	24.9	36.7	32.4	25.5
August	24.3	28.8	34.8	20.6
Annual mean	**25.9**	**40.2**	**33.2**	**26.3**

3.3.3 Seasonal changes in water levels in Fresco lagoon complex

The level of water in the Fresco lagoon varied seasonally from -0.07m to 2.71m with a mean of 0.38±0.19m. The highest mean level of 0.83±0.10m occurred in

May and the lowest mean level of 0.12±0.19m occurred in January. The Bolo and the Niouniourou Rivers differed (t_{318}=-5.6, P<0.001) in terms of their mean levels. The Bolo River (0.62±0.19 m) had a higher mean level than the Niouniourou (0.40±0.21 m). In contrast, the Estuary (0.25±0.39 m) and the N'gni lagoon (0.23±0.4 m) did not differ (t_{498}=-150, P>0.05) in terms of their mean water levels (Table 3.2).

Table 3.2: Mean water levels (m) in the Fresco lagoon complex from September 2000 to August 2002

Months	Bolo (D)	Niouniourou (E)	Estuary (A)	N'gni lagoon (B)	Overall mean level per month
September	0.68	0.35	-0.03	-0.04	0.24±0.34
October	0.82	0.51	0.23	0.12	0.42±0.31
November	0.51	0.35	0.15	0.15	0.29±0.17
December	0.48	0.15	0.15	0.15	0.23±0.16
January	0.40	0.11	-0.01	-0.01	0.12±0.19
February	0.47	0.43	0.25	0.11	0.31±0.16
March	0.36	0.12	0.65	0.65	0.44±0.25
April	0.70	0.60	0.51	0.51	0.58±0.09
May	0.96	0.86	0.75	0.75	0.83±0.10
June	0.88	0.46	0.30	0.30	0.48±0.27
July	0.65	0.45	0.38	0.39	0.35±0.12
August	0.59	0.41	-0.14	-0.18	0.17±0.38
Overall mean	**0.62**	**0.40**	**0.25**	**0.23**	**0.38**

Factors that might best predict changes in level of the lagoon were examined using simultaneous regression. The model that included rainfall and evaporation explained 69% of the variance in changes in the level of the water in Fresco lagoon. However, rainfall made a significant unique contribution to the prediction of water level in the lagoon (*Beta* = 0.825, P<0.005) (Figure 3.2; Table 3.3). In other words, an increase in rainfall generally resulted in an increase of water level in the lagoon. However, the level of the lagoon peaked in May and receded significantly from June, when the rainfall was peaking.

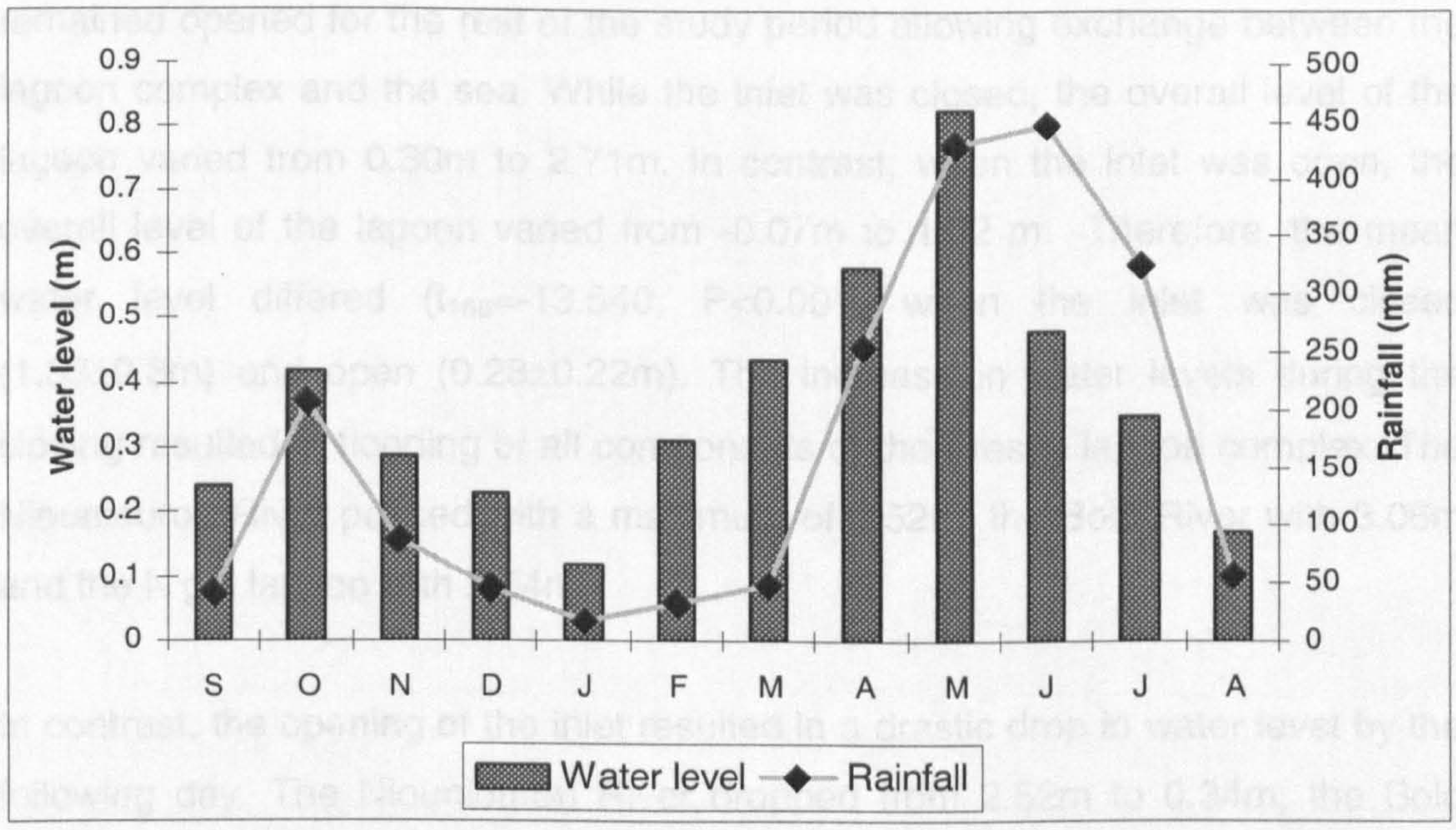


Figure 3.2: Mean monthly rainfall at Sassandra metherological station and monthly water levels of the Fresco lagoon complex

Table 3.3: Output of simultaneous regression of water level, rainfall and evaporation.

Model components	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.115	0.243		0.472	0.648		
Rainfall	0.001	0.000	0.825	4.392	0.002	0.975	1.026
Evaporation	0.001	0.006	0.033	0.177	0.864	0.975	1.026

3.3.3.1 Water levels and inlet conditions

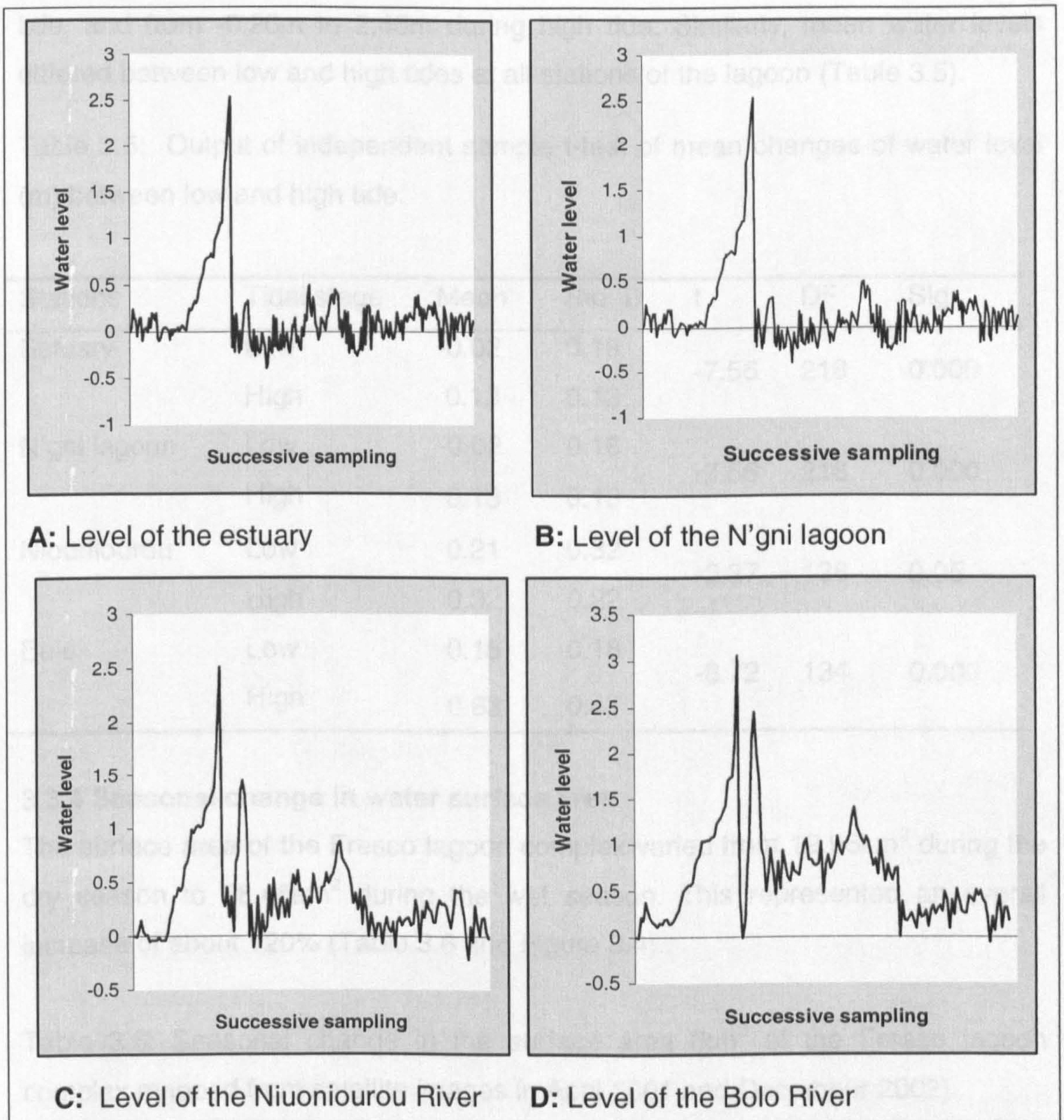
The inlet was silted-up by the sand bar from 28 February to the 6 June 2001, or 98 days, corresponding to 13% of observations. Only rainfall and inflow from the Niouniourou and the Bolo Rivers entered the lagoon complex during that period. The inlet was breached by the community on the night 6 June 2001, and remained opened for the rest of the study period allowing exchange between the lagoon complex and the sea. While the inlet was closed, the overall level of the lagoon varied from 0.30m to 2.71m. In contrast, when the inlet was open, the overall level of the lagoon varied from -0.07m to 1.32 m. Therefore, the mean water level differed (t_{168}=-13.540, $P<0.001$) when the inlet was closed (1.33±0.8m) and open (0.28±0.22m). The increase in water levels during the closing resulted in flooding of all components of the Fresco lagoon complex. The Niouniourou River peaked with a maximum of 2.52m, the Bolo River with 3.06m and the N'gni lagoon with 2.54m.

In contrast, the opening of the inlet resulted in a drastic drop in water level by the following day. The Niouniourou River dropped from 2.52m to 0.34m, the Bolo River from 3.06m to 0.42m and the N'gni lagoon from 2.54m to -0.17m (Table 3.4).

Table 3.4: Mean water levels (m) during the closing and the opening of the inlet

Station	**Inlet condition**	**n**	**Minimum**	**Maximum**	**Mean water level**	**Std. D**
Estuary	Closed	32	0.15	2.54	0.92	0.63
	Opened	218	-0.39	0.50	0.05	0.16
N'gni Lagoon	Closed	32	0.15	2.54	0.91	0.63
	Opened	218	-0.39	0.50	0.04	0.16
Bolo	Closed	24	0.50	3.06	1.18	0.58
	Opened	134	-0.06	2.45	0.57	0.42
Niouniourou	Closed	24	0.24	2.52	1.06	0.62
	Opened	138	-0.22	1.45	0.26	0.28

A few days after the inlet was opened, the water level recovered as the community breached the inlet at the peak of the wet season. However, it remained lower (2.45m) compared to the closed period (3.06m)(Figure 3.3).



A: Level of the estuary **B:** Level of the N'gni lagoon

C: Level of the Niuniourou River **D:** Level of the Bolo River

Figure 3.3: Changes of the water level at different stations in the Fresco lagoon complex from September 2000 to August 2002

3.3.3.2 Water levels and tidal stages

Water levels differed ($t_{708} = -9.56$, $P < 0.001$) between high tides (0.27 ± 0.3 m) and low tides (0.06 ± 0.25 m). Water levels varied from -0.39m to 1.45m during low tide, and from -0.20m to 2.45m during high tide. Similarly, mean water levels differed between low and high tides at all stations of the lagoon (Table 3.5).

Table 3.5: Output of independent sample t-test of mean changes of water level (m) between low and high tide.

Stations	Tidal stage	Mean	Std. D	t	DF	Sig
Estuary	Low	-0.02	0.16	-7.56	218	0.000
	High	0.13	0.13			
N'gni lagoon	Low	-0.02	0.16	-7.56	218	0.000
	High	0.13	0.13			
Niouniourou	Low	0.21	0.32	-2.27	138	0.05
	High	0.32	0.22			
Bolo	Low	0.15	0.18	-8.72	134	0.000
	High	0.63	0.41			

3.3.4 Seasonal change in water surface area

The surface area of the Fresco lagoon complex varied from 12.96km^2 during the dry season to 28.45km^2 during the wet season. This represented an overall increase of about 120% (Table 3.6 and Figure 3.4).

Table 3.6: Seasonal change in the surface area (km^2 of the Fresco lagoon complex mapped from satellite images in April 2001 and December 2002)

Stations	Dry season area	Wet season area	% increase
Estaury	1.79	4.60	157
N'gni lagoon	6.90	13.40	94
Niouniourou River	2.21	6.02	172
Bolo River	1.89	3.70	96
Guitako	0.15	0.70	366
Fresco canal	0.02	0.03	50
Total area	**12.96**	**28.45**	**120**

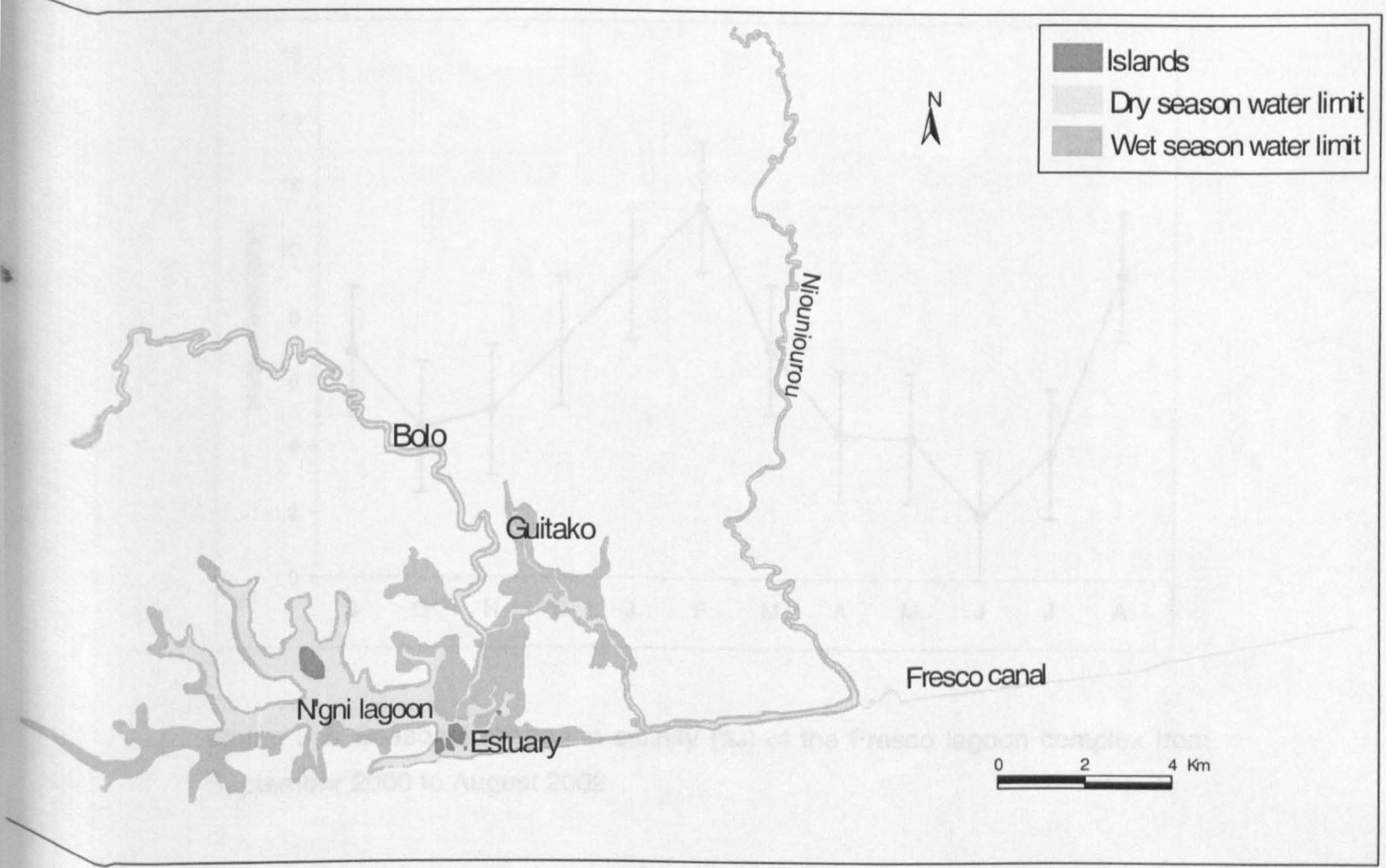


Figure 3.4: Seasonal changes in the size of the Fresco lagoon complex

3.3.5 Seasonal changes in salinity

Salinity ranged from 0 to 30‰ with an annual mean of 6.29‰. Changes in salinity followed a bimodal pattern, with two maxima and two minima. Salinity was highest in February with 11.39‰ and in August with 9.32‰. In contrast, salinity was lowest in June with 1.96‰ and in October with 4.62‰ (Figure 3.5).

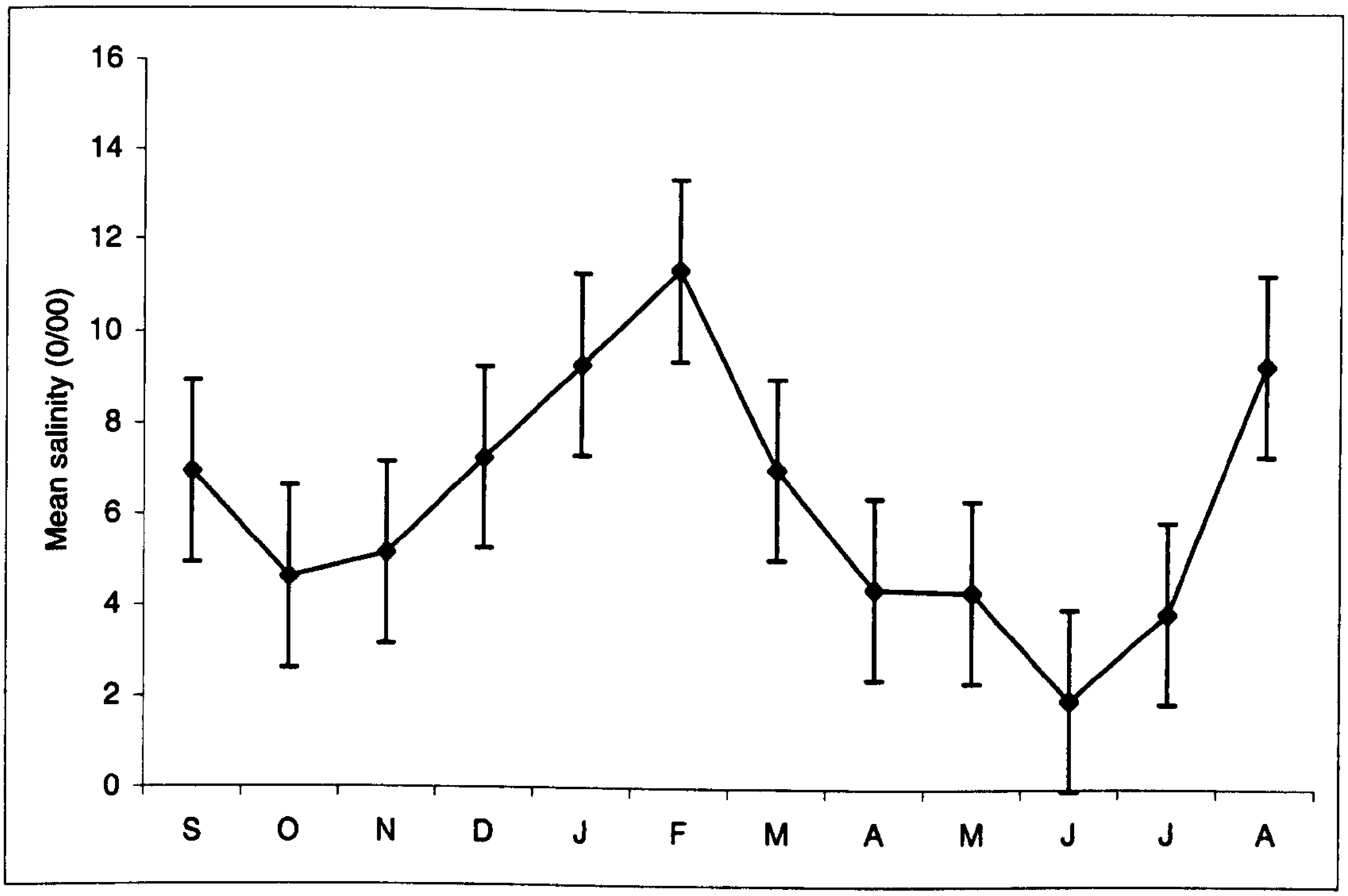


Figure 3.5: Seasonal change in salinity (‰) of the Fresco lagoon complex from September 2000 to August 2002

The salinity of freshwater ranged from 0 to 5‰ with a mean annual salinity of 0.15±0.5‰. Mean annual salinity in the Bolo River (0.16±0.5‰) (station D) and the Niouniourou River (0.13±0.46‰, station E) did not differ (t_{318} =0.791, P>0.05). Salinity in these rivers remained close to 0‰ throughout the year. The maximum salinity (5‰) occurred in February during the dry season. In contrast, salinity differed ($F_{2,\ 718}$= 138.232, P<0.05) between stations A, B and C. Mean annual salinity was 14.27‰ in station A, 12.46‰ in the station B and 4.46‰ in station C (Table 3.7).

Table 3.7: Seasonal change in salinity (‰) of the Fresco lagoon complex from September 2000 to August 2002

Months	Estuary	N'gni lagoon		Bolo	Niouniourou	Mean
	A	B	C	D	E	salinity
September	16.73	13.23	4.78	0	0.0	6.94
October	10.52	9.70	2.88	0	0.0	4.62
November	12.30	10.60	2.85	0	0.0	5.15
December	17.47	13.50	5.30	0	0.0	7.25
January	21.70	18.20	6.60	0	0.0	9.30
February	23.05	21.11	9.16	2	1.6	11.39
March	16.24	14.20	4.73	0	0.0	7.03
April	10.42	8.70	2.96	0	0.0	4.41
May	9.78	8.50	3.42	0	0.0	4.34
June	3.76	5.50	0.57	0	0.0	1.96
July	8.88	8.07	2.44	0	0.0	3.87
August	20.50	18.30	7.84	0	0.0	9.32
Mean annual salinity	**14.27**	**12.46**	**4.46**	**0.16**	**0.13**	**6.29**

There was a strong negative association between salinity and rainfall, overall mean water level, and level of fresh water of the Bolo and the Niouniourou Rivers. In contrast, salinity of the lagoon was positively correlated with the salinity of seawater (Table 3.8). Furthermore, there was no relationship ($r=182$, $n=12$, $P>0.05$) between salinity of the lagoon and evaporation.

Factors that might best predict changes in water salinity were examined using simultaneous regression. The model that included rainfall, evaporation and marine water salinity explained 79.6% of the variance in the salinity of the water in the system. However, rainfall made a significant unique contribution to the prediction of the level of salinity in the Fresco lagoon (*Beta* = -0.674 P<0.05) (Figure 3.6 and Table 3.8).

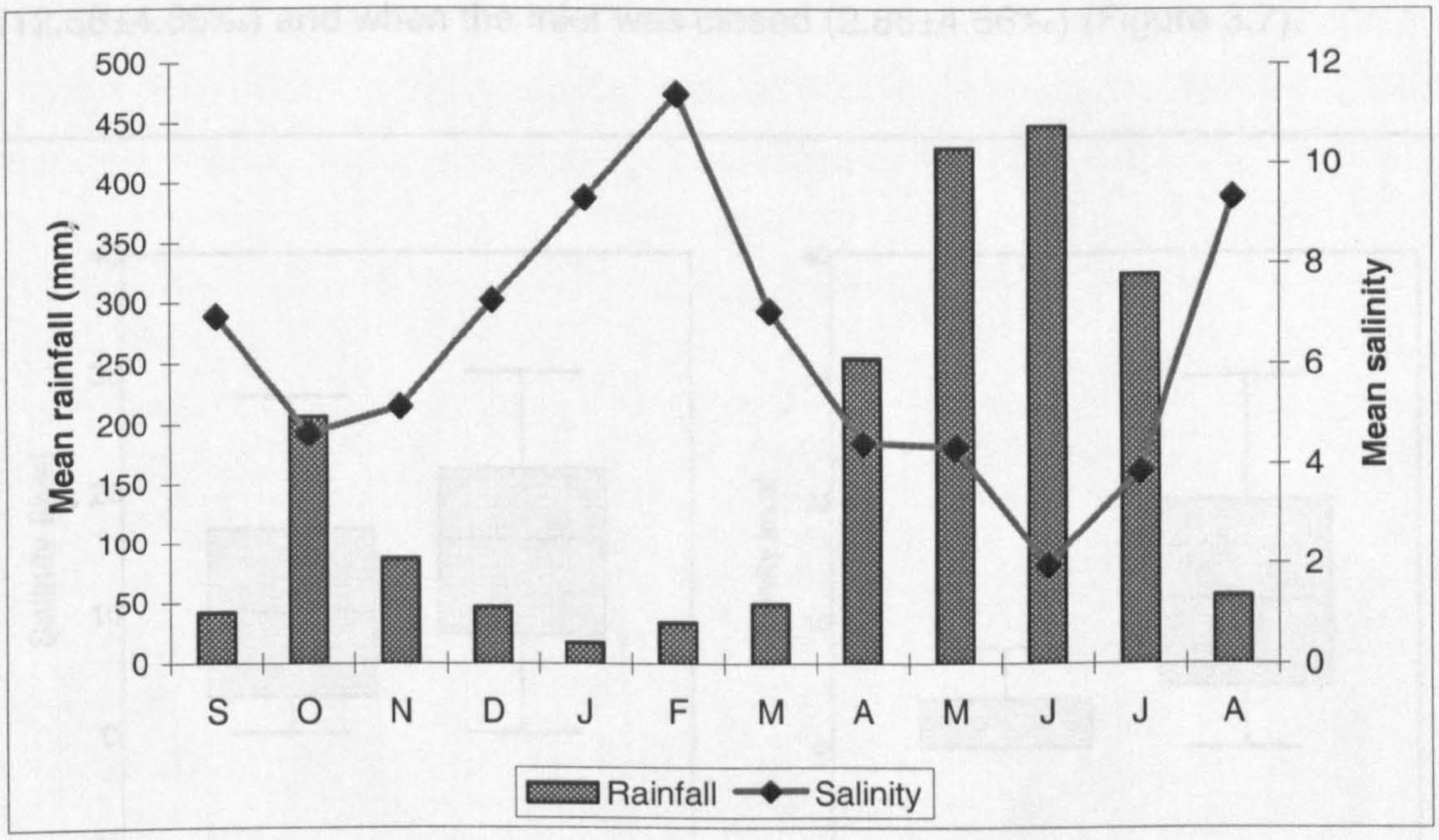


Figure 3.6: Mean monthly water salinity in the Fresco lagoon complex and mean monthly rainfall at the Sassandra Meteorological Station

Table 3.8: Output of simultaneous regression of water salinity, rainfall and marine water salinity.

	B	S. E	Beta	t	Sig	Tolerance	VIF
(Constant)	-44.954	31.639		-1.421	0.193		
Salinity marine water	1.518	0.879	0.339	1.728	0.122	0.665	1.504
Evaporation	0.020	0.069	0.049	0.295	0.775	0.912	1.097
Rainfall	-0.011	0.003	-0.674	-3.555	0.007	0.711	1.407

Salinity during high tide (10.46±8.47‰) differed (t_{623}= 612, P<0.001) from salinity during low tide (4.77±7.7‰). Similarly, there was a significant difference (t_{719}=204.46, P<0.001) between mean salinity when the inlet was opened (12.58±4.66‰) and when the inlet was closed (2.88±4.66‰) (Figure 3.7).

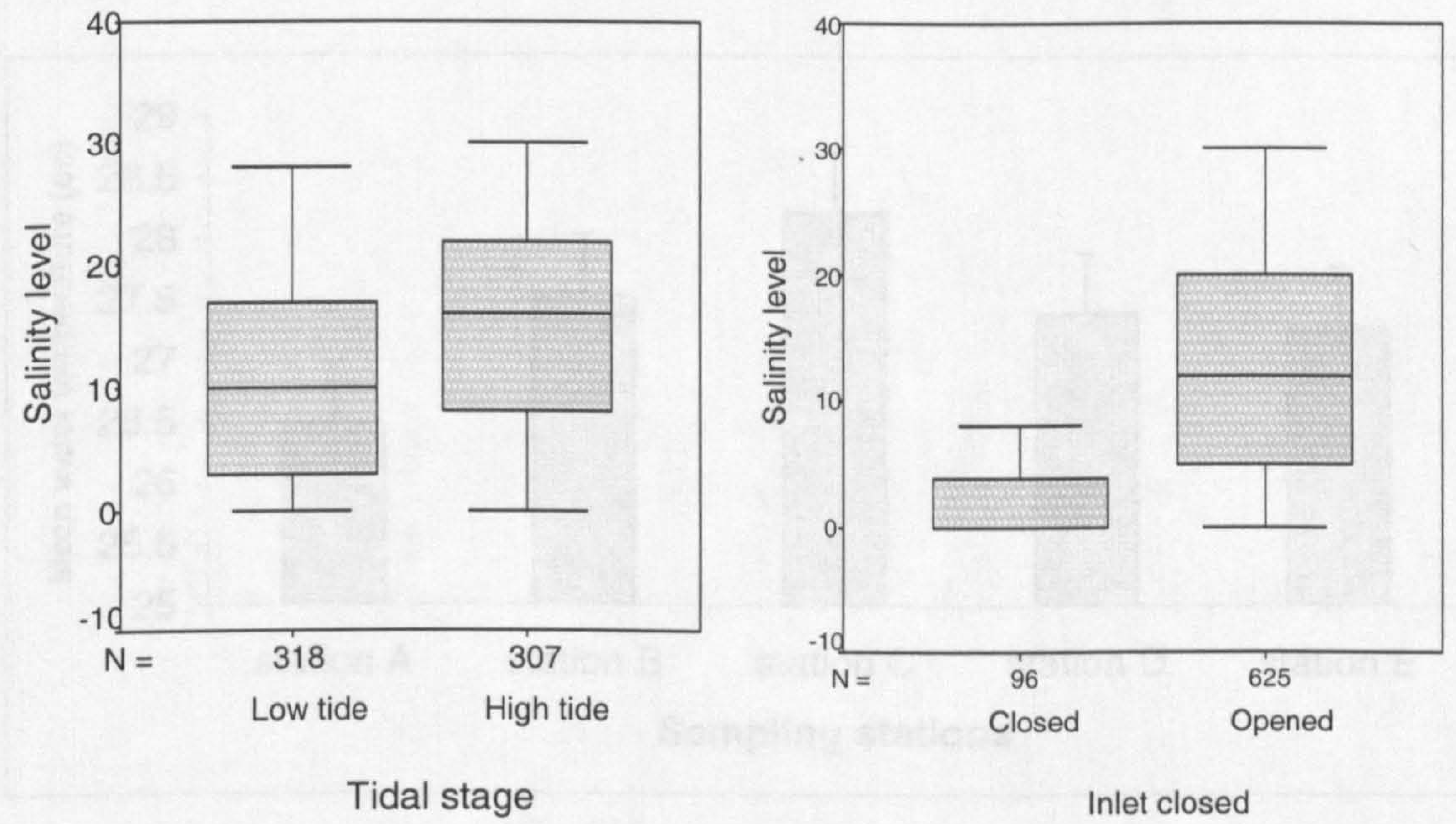


Figure 3.7: Salinity at station A, B & C,.in relation to tidal stage and inlet condition from September 2000 to August 2002.

3.3.6 Seasonal changes in water temperature

Water temperature ranged from 18 to 34^{0}c (mean=27.41±2.14 ^{0}c) in brackish water (N'gni lagoon & estuary) and from 24 to 34^{0}c (mean 27.30±1.38^{0}c) in fresh water (Bolo & Niouniourou). Overall mean temperature was 27.11±2.49^{0}c. August was the coldest month (23.93±1.55^{0}c) and April was the hottest (29.74±0.33^{0}c). In general, mean water temperature differed between stations A, B, C, D and E ($F_{4,\ 1041}$= 16.701 P<0.001). However, a Tukey analysis indicated that mean freshwater temperature at station D (27.39±1.92^{0}c) in the Bolo River and at station E (27.27±1.73^{0}c) in the Niouniourou River did not differ (P>0.05). However, difference was evident between brackish water temperatures at station A (26.49 ^{0}c) in the estuary, and station B (27.54^{0}c) and C (28.22^{0}c) in the N'gni lagoon (P<0.001). In other words, brackish water temperature increased from station A to C or as distance from the inlet increased (Figure 3.8).

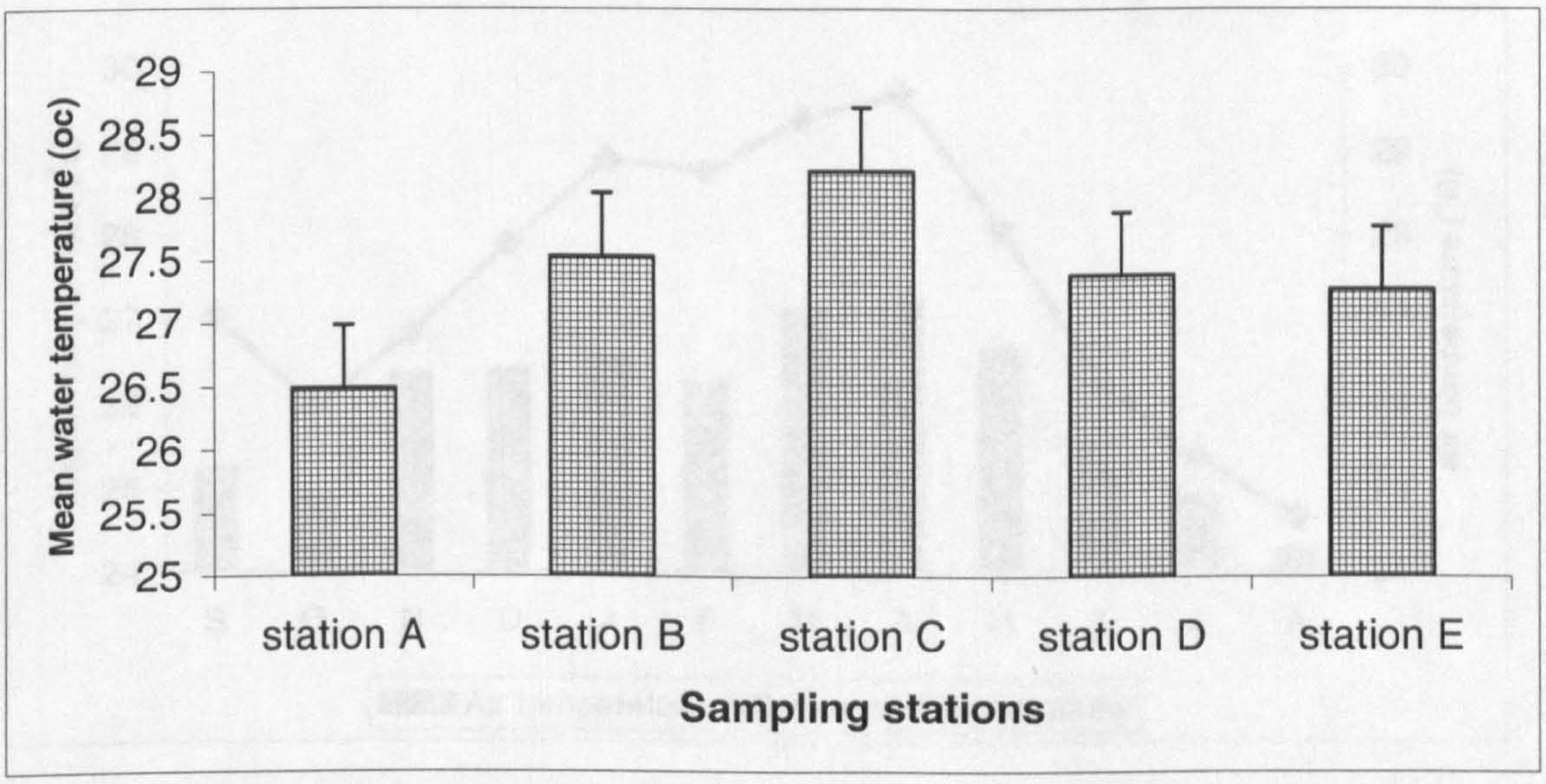


Figure 3.8: Mean water temperature at different sampling stations in the Fresco lagoon complex from September 2000 to August 2002.

Water temperature in the afternoon (27.72±2.61^{0}c) was higher (t_{1035}=-2.33, P<0.05) than in the morning (27.33±2.78^{0}c). There was a positive correlation between evaporation, air temperature and marine water temperature. Similarly, temperatures of brackish water from stations A, B, and C were strongly associated with temperatures of seawater. Unsurprisingly, there was no relationship between temperature of seawater and temperature of freshwater from the Bolo (station D) and the Niouniourou Rivers (station E). Likewise, an increase in air temperature resulted in an increase of water temperatures in the lagoon (Table 3.9).

Factors that might best predict changes in the temperature of the water of the lagoon were examined using simultaneous regression. The model that included evaporation, marine water temperature and air temperature explained 79.1% of the variance in the temperature of the water in the lagoon complex. However, air temperature made a significant unique contribution to the prediction of water temperature in the system (*Beta* = 0.872, P<0.05) (Figure 3.9 and Table 3.9).

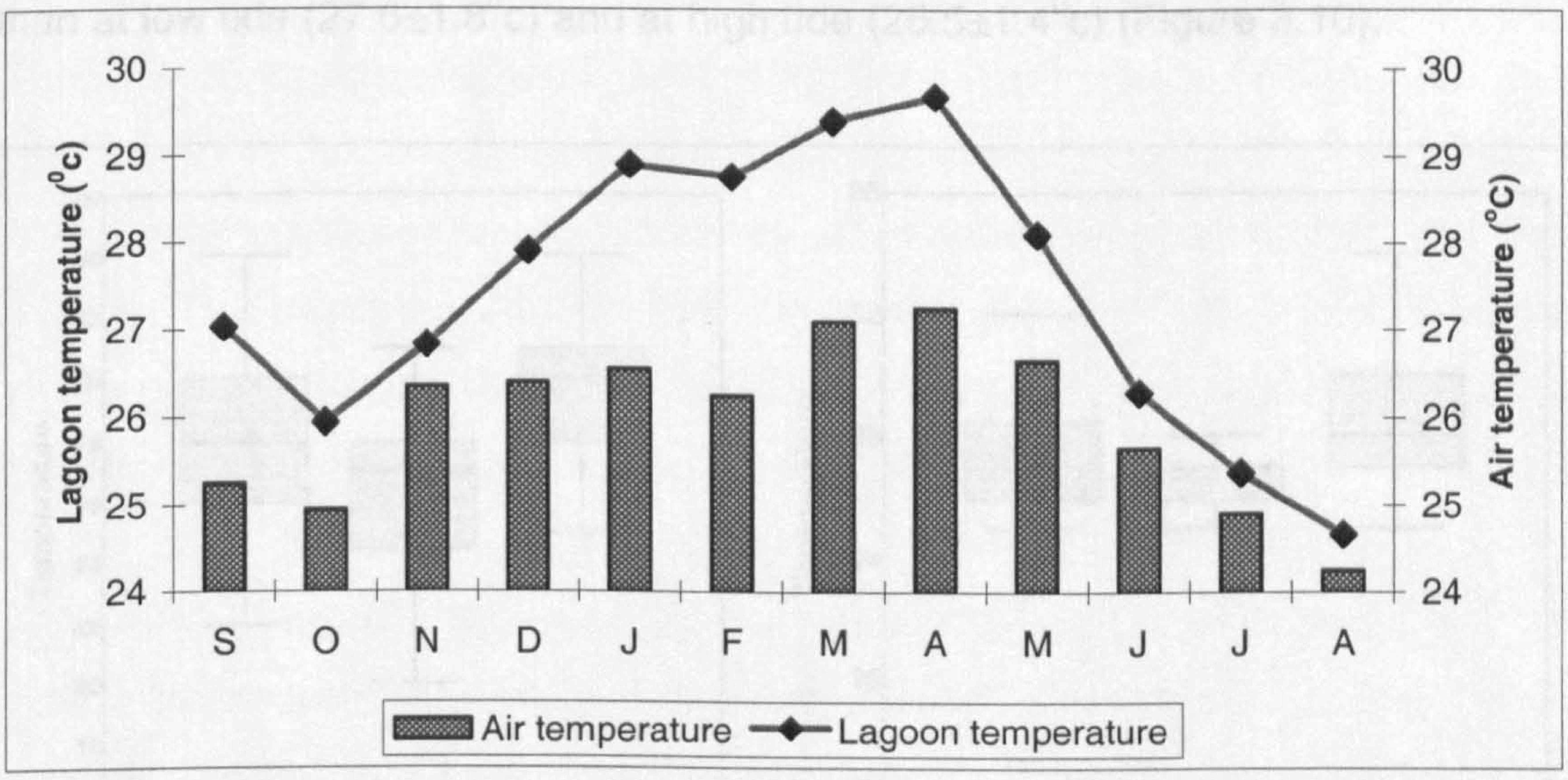


Figure 3.9: Mean monthly water temperature in the Fresco lagoon complex and mean montly air temperature at Sassandra Meteorological Station

Table 3.9: Output of simultaneous regression of lagoon water temperature, rainfall and marine water salinity

	B	S. E.	Beta	t	Sig	Tolerance	VIF
(Constant)	-15.703	9.202		-1.706	0.126		
Air temperature	1.624	0.443	0.872	3.662	0.006	0.336	2.977
Marine water Temperature	0.020	0.162	0.027	0.123	0.905	0.380	2.628
Evaporation	0.010	0.068	0.036	0.139	0.893	0.291	3.435

Mean temperature of brackish water (station A, B, and C) at low tide, high tide and at the closing of the inlet differed significantly ($F_{2,\ 718}$=76.34, P<0.001). Mean brackish water temperature was higher at low tide (28.4±2.8^{0}c) than during the closing of the inlet (27.6±2.1^{0}c) and at high tide (26.2±2.7^{0}c). Similarly, there was a significant difference ($F_{2,\ 317}$=27.2, P<0.001) between mean temperatures of fresh water (station D and E) at low tide, high tide and at the closing of the inlet. Fresh water temperature was higher during the closing of the inlet (28.4±2^{0}c) than at low tide (27.6±1.8^{0}c) and at high tide (26.5±1.4^{0}c) (Figure 3.10).

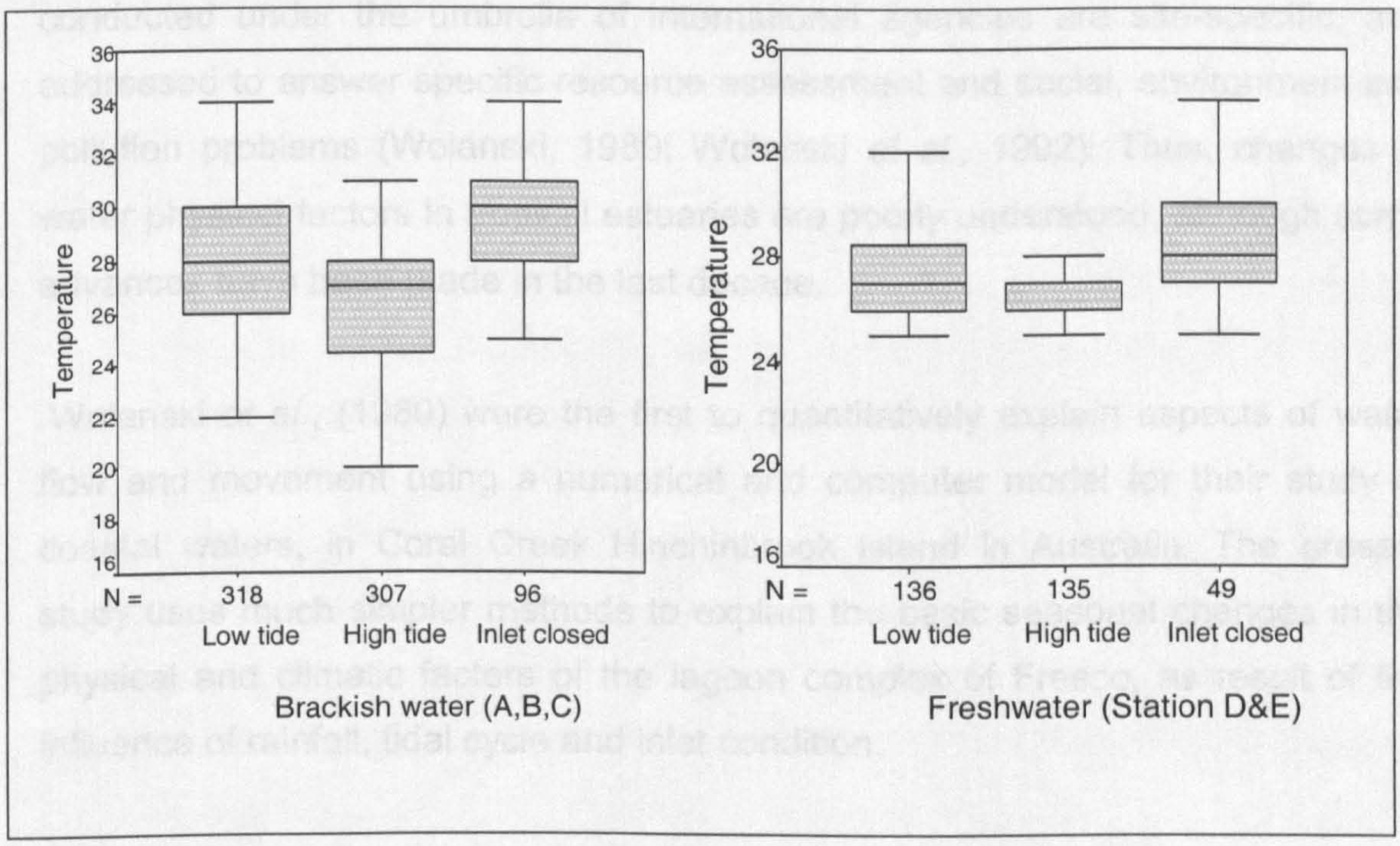


Figure 3.10: Changes in lagoon temperature in relation to tidal stages and inlet condition from September 2000 to August 2002.

3.4 Discussion

Coastal waters and estuaries support intensive hydrodynamic processes that determine the short and long-term sustainability of ecosystems that are linked to them (Awosika and Abe, 1971; Wolanski *et al.*, 1980). They are semi-enclosed water bodies connected to the sea, within which seawater is measurably diluted by fresh water as a result of discharge of terrestrial runoff and direct rainfall (Carter, 1988). Thus, coastal waters and estuaries are a somewhat "hybrid" environment incorporating terrestrial run off from rivers and ocean dynamics. A full understanding of these complex processes requires a detailed description of the dynamics of water circulation and a quantitative assessment of tidal flow and diffusion, as well as freshwater and groundwater influx. Unfortunately, studies of physical processes in tropical estuaries, particularly in the Gulf of Guinea, are few and far between compared to those of temperate estuaries. The main reason is that these estuaries are mostly in less-developed countries, where research funding is inadequate and field conditions are harsher. The few studies conducted under the umbrella of international agencies are site-specific, and addressed to answer specific resource assessment and social, environment and pollution problems (Wolanski, 1989; Wolanski *et al.,* 1992). Thus, changes in water physical factors in tropical estuaries are poorly understood, although some advances have been made in the last decade.

Wolanski *et al.*, (1980) were the first to quantitatively explain aspects of water flow and movement using a numerical and computer model for their study of coastal waters, in Coral Creek Hinchinbrook Island in Australia. The present study uses much simpler methods to explain the basic seasonal changes in the physical and climatic factors of the lagoon complex of Fresco, as result of the influence of rainfall, tidal cycle and inlet condition.

3.4.1 Changes in water level and lagoon size

Water level and the surface area of the Fresco lagoon complex showed extensive seasonal variations. The highest water level was recorded when the inlet was closed (Table 3.2; Figure 3.3). The fact that people opened the inlet suggested that the water level and size could have been greater naturally than those recorded in this study. Nevertheless, the opening of the inlet shows how important the inlet was in determining the level and the size of the lagoon complex. The main forcing function responsible for the increase in water level, particularly when the inlet was closed, is freshwater inflow, of which direct rainfall was the most important (see Table 3.3 and Figure 3.2). In the tropics, where the year is divided into wet and dry seasons, many physical and biological events are, to a large extent, directed by rainfall. When the inlet was closed, freshwater from direct rainfall and the subsequent terrestrial runoff, as well as the surplus conveyed by the upper reaches of the Bolo and the Niouniouroiu Rivers was retained in the Fresco lagoon complex, which rose quickly in level and size as a result.

Rainfall was highest in June with a secondary maximum level in October (Figure 3.1). The relatively high levels of rainfall in the study area were similar to patterns recorded in other coastal areas compared to the rest of the country (Gallardo 1971). Durant and Chantraine (1982) obtained a similar pattern of rainfall from data collected from 10 different stations on the coast from 1950 to 1970, although the total rainfall varied slightly from one year to another. Overall, Fresco appears to receive less rainfall (1900mm) than that recorded in extreme eastern and western costal areas (2200mm).

The generally high levels of rainfall on the coast (at least 30 km from the sea) are essentially due to the level and the distribution of the flux of oceanic humidity, that in turn also depends on the speed and the direction of the wind carrying it from the sea towards the continent (Collin *et al.*, 1971). The higher the speed of the wind, and the closer its approaches to a perpendicular direction to the coast, the more humidity it carries and the higher is the rainfall. On the coastline of Cote d'Ivoire, this wind approaches a perpendicular direction only in the extreme east and west of the country. From Sassandra to Abidjan, via Fresco, its direction is closer to parallel along to the coastline, and this may explain why the rainfall is lower in Fresco.

Oceanic humidity penetrated the coast and reached its highest level during the spring from May to June (Collin *et al.,* 1971) so rainfall also peaked in June.

From July, as the sea surface temperature and penetration of oceanic humidity decreased, rainfall in the coast deceased until the flux of humidity again increased from October to November, which in turn corresponded with the short rainy season peak in October.

The fact that the water level in the Fresco lagoon complex peaked in May, a month before the peak in rainfall, and decreased significantly in June while rainfall peaked (Figure 3.2), was because local people opened the inlet on June. However, as the opening corresponded with the month of peak rainfall, the water level rose quickly but remained lower than when the inlet remained closed (Figure 3.3).

The seasonal closing of the inlet suggested that the Fresco lagoon complex remained connected to the sea at certain seasons, so can be considered as a seasonally closed estuary (Lenanton and Hodhkin, 1985). However, two years of observation may not be enough to reach this conclusion, although it is also supported by the accounts of local people and the author's own experience of more than 10 years in the area. According to local people, the inlet has closed once each year for the past 20 years. However, the inlet did not close during the year 2002 because the sediments and sands accumulated in the channel were controlled by a project team established in Fresco to replant the degraded mangroves. In 2001, the newly planted area was destroyed by floods when the inlet was closed. In agreement with the co-management committee of the lagoon (see Chapter 5), the project team regularly dug the sand as the inlet progressively narrowed.

Water levels in the Fresco lagoon complex were also influenced by seawater flowing in at high tide when the inlet remained open (Table 3.4). Tidal lagoon systems incorporate a flood stage during rising tides and an ebb stage during falling tides. Tidal changes in some coastal water systems involve large-scale water masses and energy fluxes, resulting in extensive current generation, flooding and attendant sediment transport. However, in constricted situations, like estuaries and lagoons, tidal currents are generally weak (Carter, 1993). Moreover, for coastal waters linked to rivers that develop long-shore currents, that in turn drain directly into the sea, the quantity of oceanic water left in the system at low tide is often small (Wolanski and Ridd, 1990). Consequently, although the water level of the Fresco lagoon complex rose at high tide, it dropped markedly at low tide as the long-shore current of the Bolo and the Niouniourou Rivers increased the ebbing force to flush out the oceanic water. Moreover, the range of oceanic water entering in the inlet was relatively low comparing to the regional tidal range that varies from 1 to 3.5m (Awosika and Abe, 1991). This may be due to the sand bars that promoted the deposition of sediment in the inlet and progressively narrowed it until it slited up. As suggested by Davies (1980), bar growth reduces wave energy at the shoreline and acts as a natural breakwater. Bar breaking may result in dissipation of 78-99% of the incident wave energy (Balsillie and Carter, 1983).

3.4.3 Seasonal change in water salinity

Salinity is a critical factor in the life of fish and plants and other aquatic organisms in estuaries. It also determines the species of mangrove that can grow in a particular location (Ridd and Stieglitz, 2002). The processes causing the salinity to change in most estuaries are the baroclinic circulation, the tidal diffusion and evaporation. The baroclinic circulation in the estuary has the effect of transporting salt from regions of high salinity to low salinity. In a conventional estuary, water of high salinity moves upstream. However, where an inverse section of an estuary exists, salt is transported down stream. The tidal diffusion has the effect of transporting salt from high concentrations to low concentrations, while evaporation increases the salinity in an estuary by reducing the water level and increasing the salinity of the swamp soil (Wolanski and Ridd, 1986). The salt crystals that form on the surface of the swamp are then dissolved during tidal inundation and are washed back into the water. However, these processes are totally non-existent in an estuary with large freshwater inflow that can regularly flush the salt water out the estuary (Wolanski, 1981; Young *et al.*, 1997). It is therefore not surprising that the salinity of the lagoon dropped significantly during the period of high water when rainfall peaked.

The change of salinity in the lagoon is firstly attributed to the influence of oceanic water entering in the inlet during high tide, as indicated by the positive correlation between marine water salinity and salinity of the lagoon. However, rainfall was found to be the main force predicting the variance of the salinity as indicated by the regression analysis (Figures 3.6 and 3.7; Tables 3.7 and 3.8). The relatively high level of rainfall considerably increases the overall water level and the freshwater inflow from the Bolo and the Nionionrou Rivers, thereby fully dissolving any salt introduced into the complex. This was confirmed by the low salinity in June and October, months when rainfall peaked (Figure 3.1; Table 3.7). The oceanic surface water salinity is even highly influenced by the peak rainfall periods along the coast (Morliere, 1970).

In the dry season, under the condition of low freshwater inflow, the salinity of the lagoon increased and changes in salinity conformed to the patterns of seawater salinity. Salinity was highest in February and August, months that corresponded not only with the dry season and periods of low freshwater inflow, but also to the periods when salinity was highest in the sea (Morliere, 1970).

Evaporation had no impact on the salinity of the lagoon. This may be because evaporation was low relative to the high rainfall. According to Wolanski (1982), salinity can be influenced by evaporation only when rainfall is low, which was not the case at Fresco.

3.4.4 Seasonal changes in water temperature

Like the water salinity, water temperature is also an important physical factor that can influence the life, movements and distribution of aquatic organisms. For instance, it affects respiration, growth and reproduction of fish, as each species has a thermal tolerance zone in which it behaves normally (Mills, 1972). There is also a zone of higher temperature and one of lower temperature, in which species can survive for a certain length of time but above which the temperatures are lethal.

The main factor controlling lagoon water temperature was air temperature (Figure 3.9; Table 3.9). Lagoon temperature was highest in the afternoon as the cloud cover is generally low and the solar radiation heating effect is at its maximum. However, there were also temperature variations that were essentially related to tidal dynamics through temperature of seawater entering in the inlet. The minimum temperature level (18 ^{0}c in brackish water and 24 ^{0}c in freshwater) and the difference between the high tide temperature (26.51 ^{0}c) and low tide temperature (28.20 ^{0}c) of the lagoon (Figure 3.10) confirmed this. Moreover, the lagoon was coldest in August, which corresponded to the long cold season in the sea when oceanic water was coldest (Morliere, 1970). Similarly, the hottest month in the lagoon was April, which corresponded to the hottest season in the sea when oceanic water was hottest (Morliere, 1970). Since the oceanic water was cooler (26.3±2.4 ^{0}c) than the lagoon water (27.11±2.49 ^{0}c), the influx of oceanic water into the lagoon led to slight lowering of the temperature of the later although this is less significant in fresh water (0.6 ^{0}c) than in the brackish water (1.7 ^{0}c). This might be due to the distance from the sampling station to the inlet mouth as temperature increased with distance from the sea (Figure 3.7). The closer a sampling station was to the inlet, the greater was the influence of oceanic water temperature and the cooler was the lagoon temperature.

In summary, the temperature, the salinity, the level and the size of the lagoon complex of Fresco all vary seasonally in relation to rainfall, the condition of the inlet (whether closed or opened), air temperature, oceanic water salinity and temperature and tide stages. The lagoon area ranges from 12.96km^2 during the dry season to 28.45km^2 during the wet season. The Bolo and Niouniourou Rivers are fresh water while the lagoon and the estuary varied from fully freshwater when the inlet was closed, to brackish water when the inlet was open. Finally, the whole complex can fully be classified as a seasonally closed estuary as its was connected to the sea annually.

Seasonal changes, particularly changes in the level and the area of the lagoon complex, may affect the distribution of plant communities and the proportion of the shoreline available to manatees. Hence, the next chapter discusses the shoreline of the Fresco lagoon complex with emphasis on flooded vegetation types, their availability and species composition and richness.

CHAPTER 4 VEGETATION ON THE SHORELINE OF THE FRESCO LAGOON COMPLEX

4. 1 Introduction

Manatees are believed to use every aquatic habitat that allows them access to plants and grasses that form the main component of their diet (Best, 1981; Roth and Waitkuwait, 1986; Powell, 1996). This is particularly true when the period of high water allows them to disperse freely (see Chapter 8). Thus, favoured manatee habitats vary from the dry to the flooded seasons. Besides the main water bodies in lagoons and rivers, their habitats also include the shoreline with all its surrounding flat and periodically accessible floodplains.

Chapter 3 has already shown how the height and extent of the Fresco lagoon complex changed annually as a result of rainfall when the inlet was closed and during the wet season. The dynamic character and the highly changeable nature of these habitats requires species that live in them year round to adapt, and may affect the composition and distribution of plant species and communities surrounding the edge of the water body. A clear understanding of these plant communities, as well as of the distinct zonation patterns of constituent species, is needed to assess the quality and availability of manatee habitat across the shoreline of the lagoon.

In this chapter I aim to describe, by inductive approach (Kent and Coker, 1996), the vegetation along the shoreline of the Fresco lagoon complex and the following research questions will be addressed:

- what vegetation types are found on the shoreline of the lagoon and how are they distributed?
- what are the extent, the species richness and species composition of each habitat type?

4.2. Material and Methods

4.2.1. Vegetation types and extent

The whole shoreline of the Fresco lagoon complex was visited by boat in April 2001 during the highest water level. During these visits, direct observations were made on distinct vegetation boundaries. The most dominant plant species visible across the shore were used to subdivide the shoreline into different vegetation types. Each vegetation type was assigned to a manatee shoreline habitat type and classified into categories according to their external morphology (Elton and Miller, 1954; Elton, 1966). Further subdivision of vegetation was carried out according to their functional and conservation status.

A dry season (December 2002) LANDSAT 7 ETM satellite image of the study area was subsequently overlaid with a wet season (April 2001) image to show the flood limit. The flooded vegetation limit was then digitized on screen. A vegetation map was generated using bands 3, 4 and 5 and the area of each flooded habitat type was calculated on screen using Arcview version 3.2 software.

4.2.2 General site description and floristic composition

Based on the different vegetation types observed, 13 transects of varying length were randomly pegged out, with at least one transect in each different vegetation type, between the highest water limits along the shoreline in the dry season and the the wet season. Two transects were sampled on the shoreline of the N'gni lagoon (Transects 1 and 2), three along the Bolo (transects 3, 12 and 13) and eights transects were sampled along the Niouniourou River (Transects 4-11).

A 100m length of each transect was later sub-sampled for quantitative study during the dry season. A tape was laid out on each sub-sample and all species intercepting or touching the tape were noted (Kent and Cooker, 1996). The following were recorded: a general site description including a rough comment on soil type and condition, clines of vegetation, species presence/absence, names, number of individuals and morphological and biological types. Specimens of unknown plants were collected, labeled and sent to the National Floristic Centre of the University of Abidjan for identification. A herbarium was created for further references. Species were allocated to the relevant genus and families. The specific and relative frequencies, and absolute and relative densities as well as relative density and relative diversity of families, were estimated following Cotams and Curtis (1956) and Terry *et al.*, (2001), and were derived using using the following formula:

- Species specific frequency (SF) =Number of transects where the species was present;
- Species absolute density (AD) = Number of individuals per unit of surface or per unit of length;
- Species relative frequency (RF)= SF/ΣSFx100;
- Species relative density (RD) = AD/ΣAD x 100;
- Family relative diversity (DvrF) = Number of species in the family/total species x 100.

Species were divided into four morphological types: grass, tree, creeper and shrub, and further classified into five life forms: chamephyte, geophyte, therophyte, hemicryptophyte and phanerophyte. The phanerophyte life form was further classified into: megaphanerophyte, mesophanerophyte, nanophanerophyte and microphanerophyte (Raunkaier, 1937). The proportion of species per life form was determined to allow comparison.

4.3 Results

4.3.1. Habitat types and extent

Three main categories of vegetation were distinguished: **woodland** (dominated by mature trees over 8m), **shrub** (dominated by vegetation from 2 to 8m) and **open ground** (composed of vegetation less than 2m). These categories were subdivided into 6 principal vegetation types successively distributed from the coastline towards the upstream of the Niouniourou and Bolo Rivers. The sequence of distribution was as follows: mangrove forests; swamp forest of

Pterocarpus santalinoides covered by *Ipomea rubens;* forest with *Phonix reclinata;* grassland of *Echonocloa pyramidalis*; marshland of *Raphia hookerii;* and, dense terrestrial forest.

According to the location, the conservation status and the dominant plant species, the following sub-categories were distinguished within mangrove forests: riverine mangrove along the Niouniourou River; mangrove of *Avicenia germinans;* degraded mangrove comprising a grassland of *Paspalum vaginatum*, thickets of *Drepanocarpus lunatus* and mixed thicket of *Hibiscus tiliaceus* with *Drepanocarpus lunatus* and *Dalbergia ecastaphylum* (Figure 4.1).

The total flooded area accessible to manatees on the shoreline of the Fresco lagoon complex was estimated to be 16.77 km^2. This was dominated by the grassland of *Paspalum vaginatum,* which covered 36% of the total area, followed by dense terrestrial forest with about 20%, and, mangrove forest with 18%, while grassland of *Echinocloa pyramidalis*, thicket *of Phonix reclinata* and marshland of *Raphia hokerii* were the least represented, with each one covering less than 1% of the total flood area (Table 4.1).

Table 4.1: Vegetation type and their coverage on the shoreline of the Fresco lagoon complex.

Vegetation types	**Area covered (Km^2)**	**%**
Grassland of *Paspalum vaginatum*	6.08	36.0
Dense terrestrial forest	3.31	19.7
Mangrove of *Rhizophora racemosa*	3.17	18.8
Mixed *Drepanocarpus lunatus* with *Dalbergia escataphyllum* and *Hibiscus tiliaceus* L.	2.25	13.4
Thicket of *Drepanocarpus lunatus*	1.26	7.5
Swamp forest of *Pterocarpus santalinoides* L'Her	0.37	2.2

Mangrove of *Avicenia germinans* L.	0.23	1.3
Marshland of *Raphia hookerii* with *Calamus deerratus*	0.07	0.4
Thicket of *Phonix reclinata*	0.03	0.1
Grassland of *Echinocloa pyramidalis*	0.01	0.1
Total	**16.77**	**100**

4.3.2 Location of transects and general site description

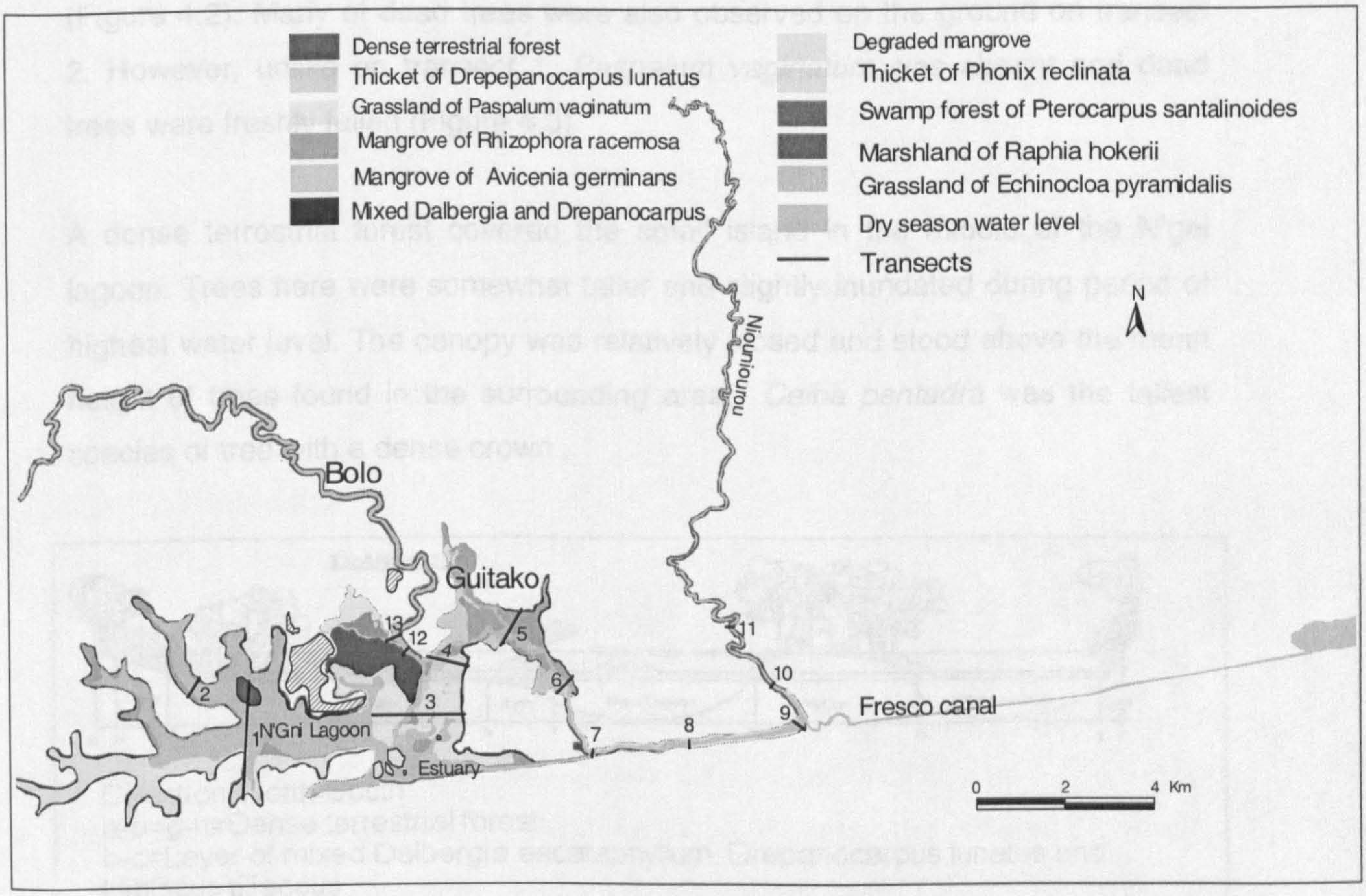
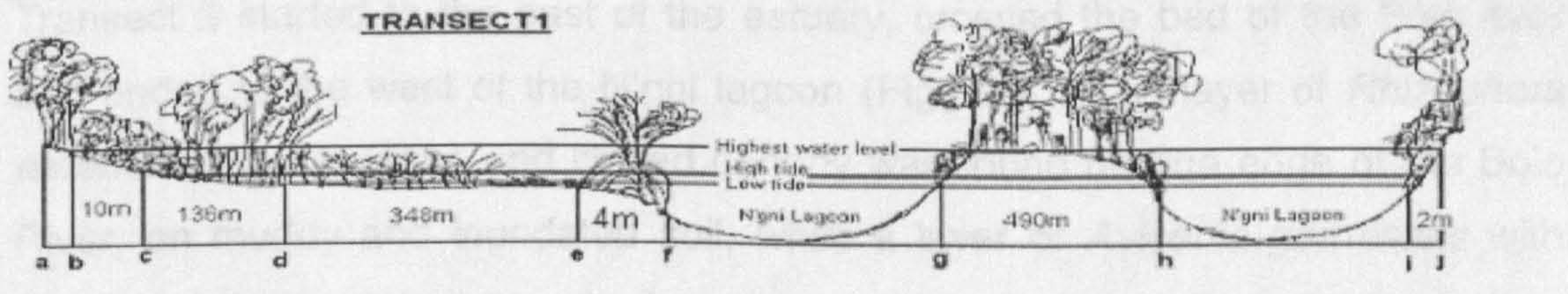


Figure 4.1: Transect distribution on the shoreline of the Fresco lagoon

4.3.2.1 Transects 1 and 2

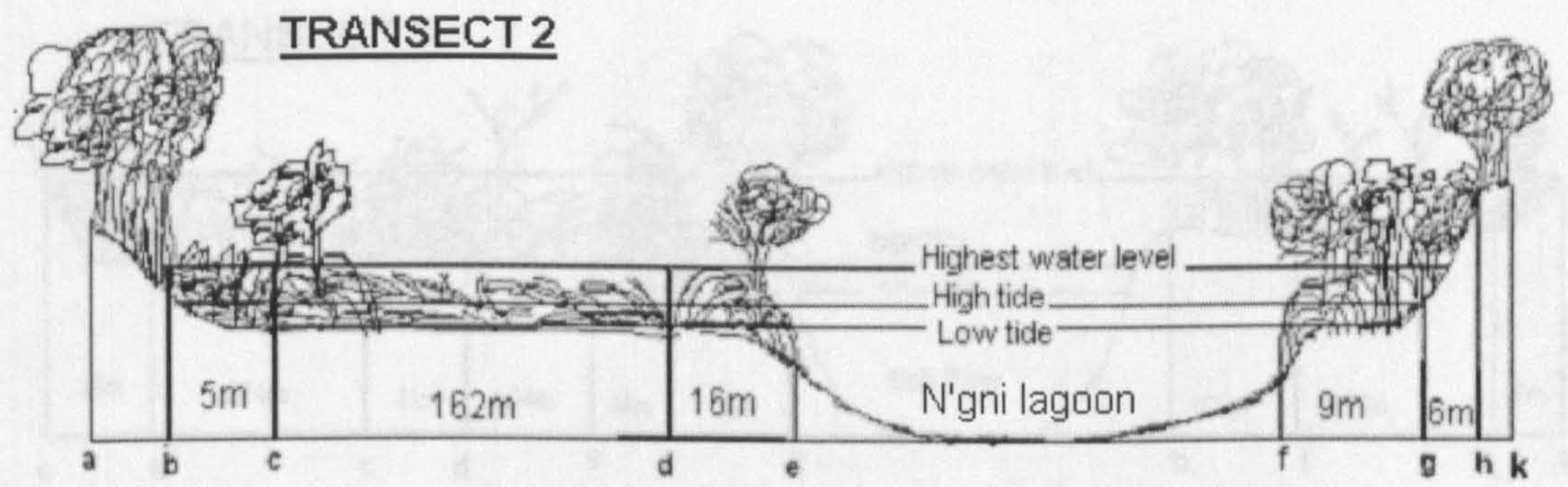
Transects 1 and 2 were pegged out on the shoreline of the N'gni lagoon in a north-south direction (Figure 4.1). Soil varied from muddy, flat and inundated to solid soil on a steep slope. *Rhizophora racemosa* occurred found on the muddy parts, on the edge of the water with roots permanently inundated, followed by a layer of *Avicenia germinans* with dead seedlings under the trees. A layer of *Drepanocarpus lunatus* associated with *Dalbergia ecastaphylum* and *Hibiscus tiliaceus* followed *Avicenia germinans* before the dense terrestrial forest on a steep slope. Much dead wood lay on the ground, while very few trees with very few leaves left on their tops were still standing. Gaps in the canopy were therefore evident. On transect 1, most of dead wood was heavily softened and embedded in the mud, while many seedlings of *Paspalum vaginatum* emerged (Figure 4.2). Many of dead trees were also observed on the ground on transect 2. However, unlike on transect 1, *Paspalum vaginatum* was absent and dead trees were freshly fallen (Figure 4.3).

A dense terrestrial forest covered the small island in the middle of the N'gni lagoon. Trees here were somewhat taller and slightly inundated during period of highest water level. The canopy was relatively closed and stood above the mean height of trees found in the surrounding area. *Ceiba pentadra* was the tallest species of tree with a dense crown .



Direction: North-South
a-b=g-h=Dense terrestrial forest
b-c=Layer of mixed Dalbergia escataphyllum, Drepanocarpus lunatus and Hibiscus tiliaceus
c-d=Layer of Avicenia germinans with seedling under trees
d-e=Baldly degraded mangrove with Paspalum vaginatum and much dead wood of Rhizophora racemosa on the ground
e-f=Slim layer of Rhizophora racemosa with rooths partialy in the water
i-j=Layer of Drepanocarpus lunatus

Figure 4.2: General outline profile of transect 1.



Direction: North-south
Lenght: 0.198 km
a-b=h-k=Dense terrestrial forest
b-c=Layer of mixed Dalbergia escataphyllum and Drepanocarpus lunatus
c-d=d-e=Degraded mangrove of Rhizophora racemosa with much dead wood on the ground
f-g=Layer of Rhizophora racemosa near the water and Avicenia germinans behind
g-h=Layer of mixed Dalbergia, Eleais guineensis, Acrostichum aureum and Bafia nitida

Figure 4. 3: General outline profile of transect 2.

4.3.2.2 Transect 3

Transect 3 started to the east of the estuary, crossed the bed of the Bolo river and ended to the west of the N'gni lagoon (Figure 4.1). A layer of *Rhizophora racemosa* with a dense and closed canopy was found on one edge of the Bolo River, on muddy and inundated soil, while a layer of *Avicenia germinans* with many seedlings and various herbaceous species under trees, was situated on solid and relatively dry soil on the other edge. *Paspalum vaginatum* on muddy and flat soil emerged under relics of *Avicenia germinans* with many dead and leafless branches. A thin layer of *Drepanocarpus lunatus* associated with *Dalbergia ecastaphyllum* succeeded *Paspalum vaginatum* before entring the dense terrestrial forest.

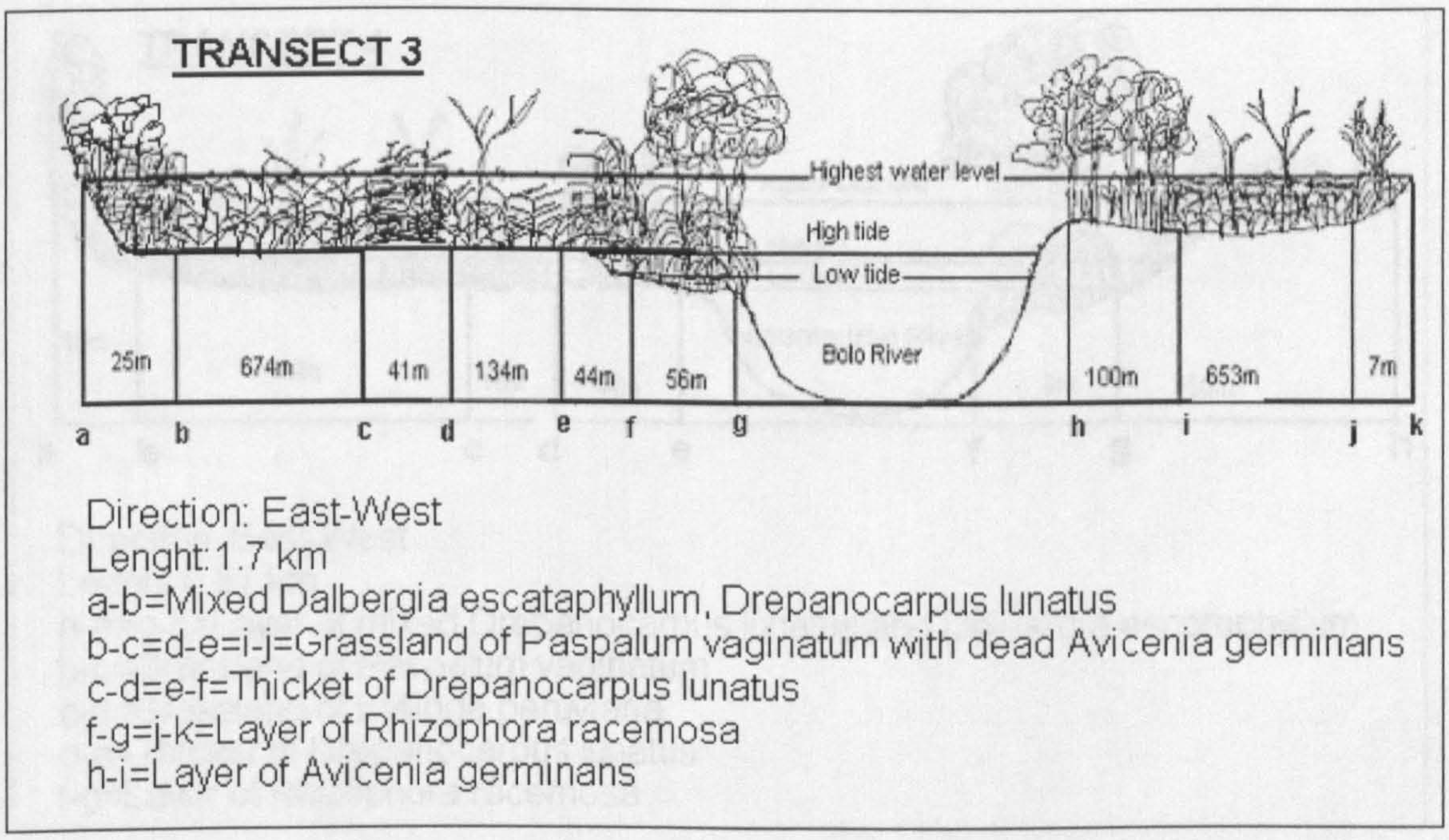
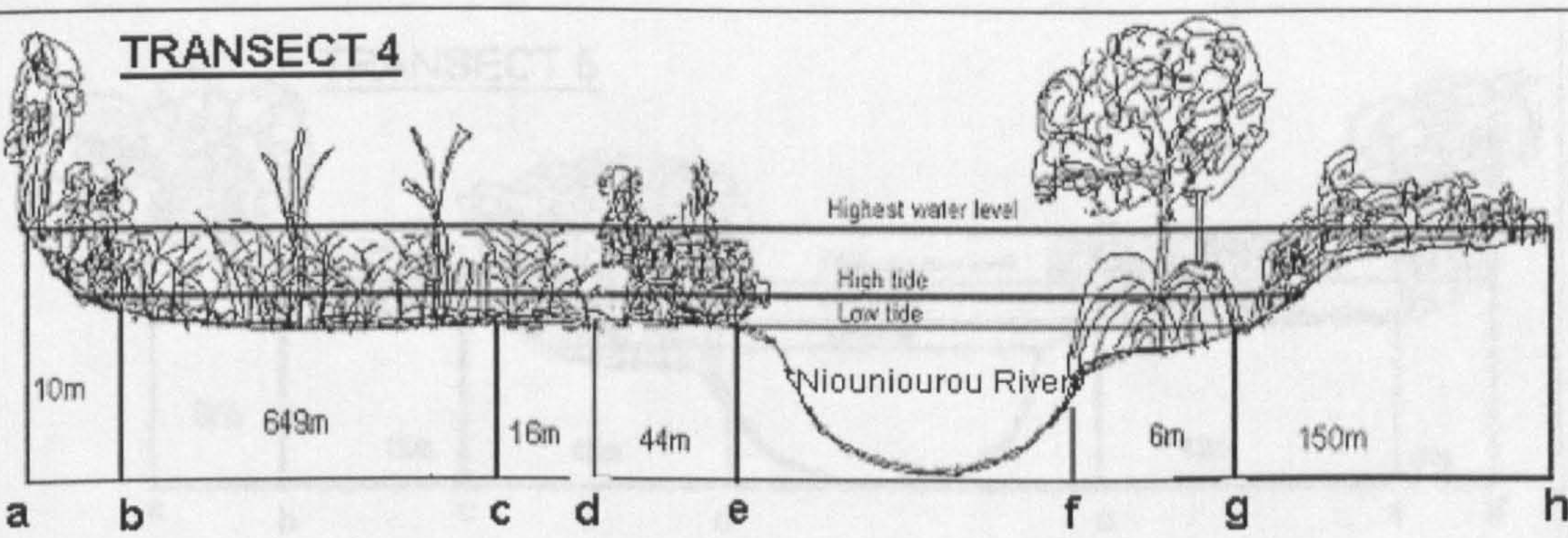


Figure 4.4: General outline profile of transect 3.

4.3.2.3 Transect 4

Transect 4 began in the lower reach of the Niouniourou River to the extreme north east of the estuary (Figure 4.1). It crossed three types of vegetation, a dense and thorny thicket of *Drepanocarpus lunatus,* a slim layer of *Rhizophora racemosa* with roots always inundated and a grassland of *Paspalum vaginatum.* Much dead wood of *Rhizophora racemosa* was found on the ground while very few trees were still standing. *Avicenia germinans* was absent on this transect (Figure 4.5).

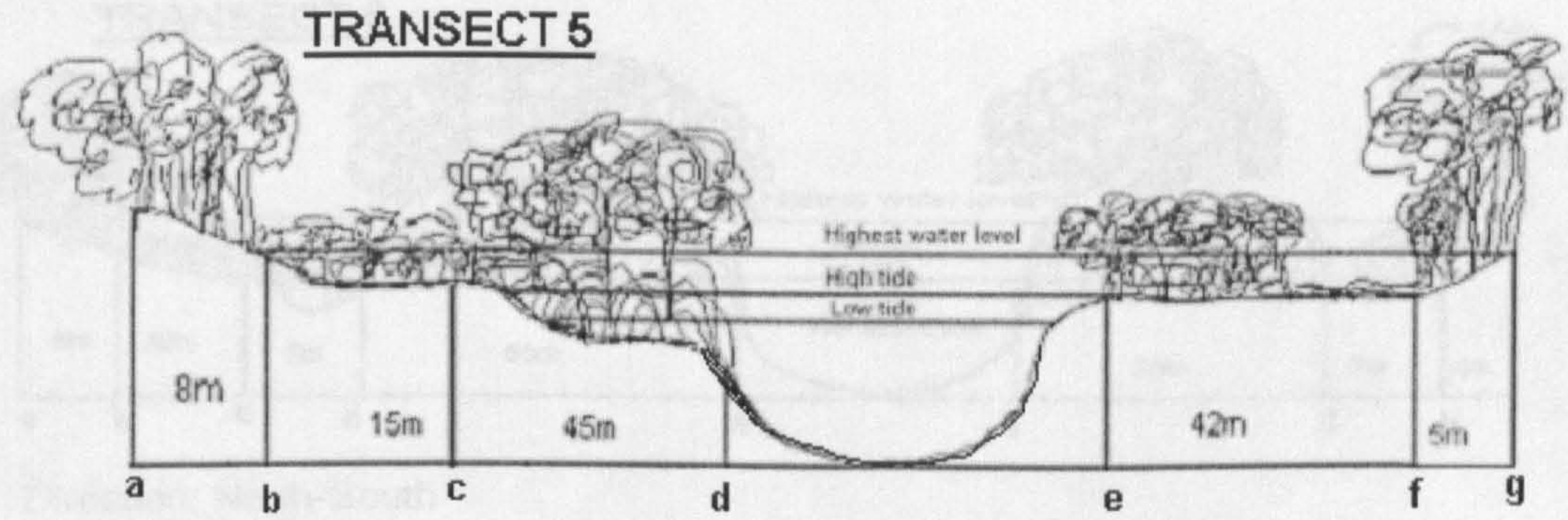


Direction: East-West
Lenght 0.87 km
a-b=g-h=Layer of mixed Drepanocarpus lunatus and Dalbergia escataphyllum
b-c=Grassland of Paspalum vaginatum
c-d=Grassland of Kyllinga peruviana
d-e=Thicket of Drepanocarpus lunatus
f-g=Layer of Rhizophora racemosa

Figure 4.5: General outline profile of transect 4

4.3.2.4 Transect 5

Transect 5 was situated on the shoreline of the Niouniourou River (Figure 4.1) and was dominated by *Hibiscus tiliaceus* on one side, and, on the other side by *Rhizophora racemosa*. *Avicenia germinans* was absent on this transect. Clay soil occurred under *Hibiscus* but was slightly dry with some bare ground. Trees were uniform in height and many dead trees lay on the ground. There were many Gaps in the canopy (Figure 4.6).



Direction: North-South
Lenght:0.115 km
a-b=f-g=Dense terrestrial forest
b-c=Layer of mixed Dalbergia escataphyllum, Hibiscus tiliaceus and Phonix reclinata
c-d=Mangrove of Rhizophora racemosa
e-f=Degraged thicket of Hibiscus tiliaceus

Figure 4.6: General outline profile of transect 5.

4.3.2.5 Transect 6

Transect 6 was situated on the shoreline of the Niounourou River (Figure 4.1) and was dominated by luxuriant riverine mangrove of *Rhizophora racemosa.* Unlike *Rhizophora* on the shoreline of the lagoon, trees here were taller and formed a relatively dense closed canopy. No dead individuals were found on the ground besides a large tree of *Rhizophora* that was freshly fallen near a small stream. Aerial roots were spectacular and inundated at all stages of the tidal cycle, even at low tide. A thick layer of *Drepanocarpus lunatus* mixed with *Dalbergia ecastaphylum* replaced the layers of *Rhizophora racemosa* on both side of the shoreline, before the dense terrestrial forest on solid soil (Figure 4.7).

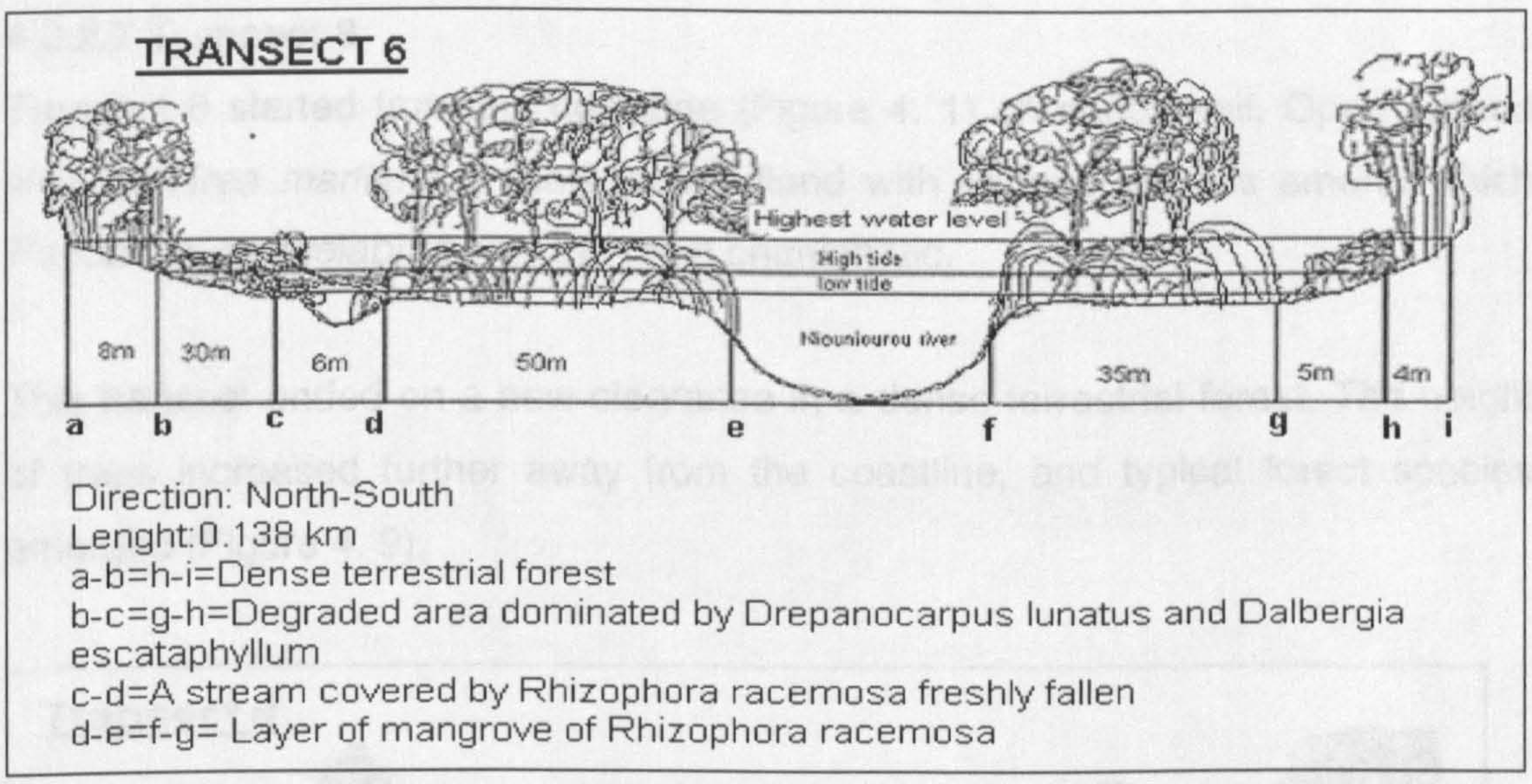


Figure 4.7 General outline profile of transect 6.

4.3.2.6 Transect 7

Transect 7 was situated on the shoreline of the Niouniourou River (Figure 4.1) and was dominated by a swamp forest of *Pterocarpus santalinoides* on bare ground with solid clay soil. Treetops were entirely covered by *Ipomea rubens.* A layer of *Drepanocarpus lunatus* succeeded *Perocarpus santalinoides* and *Rhizophora racemosa* before the dense terrestrial forest (Figure 4.8).

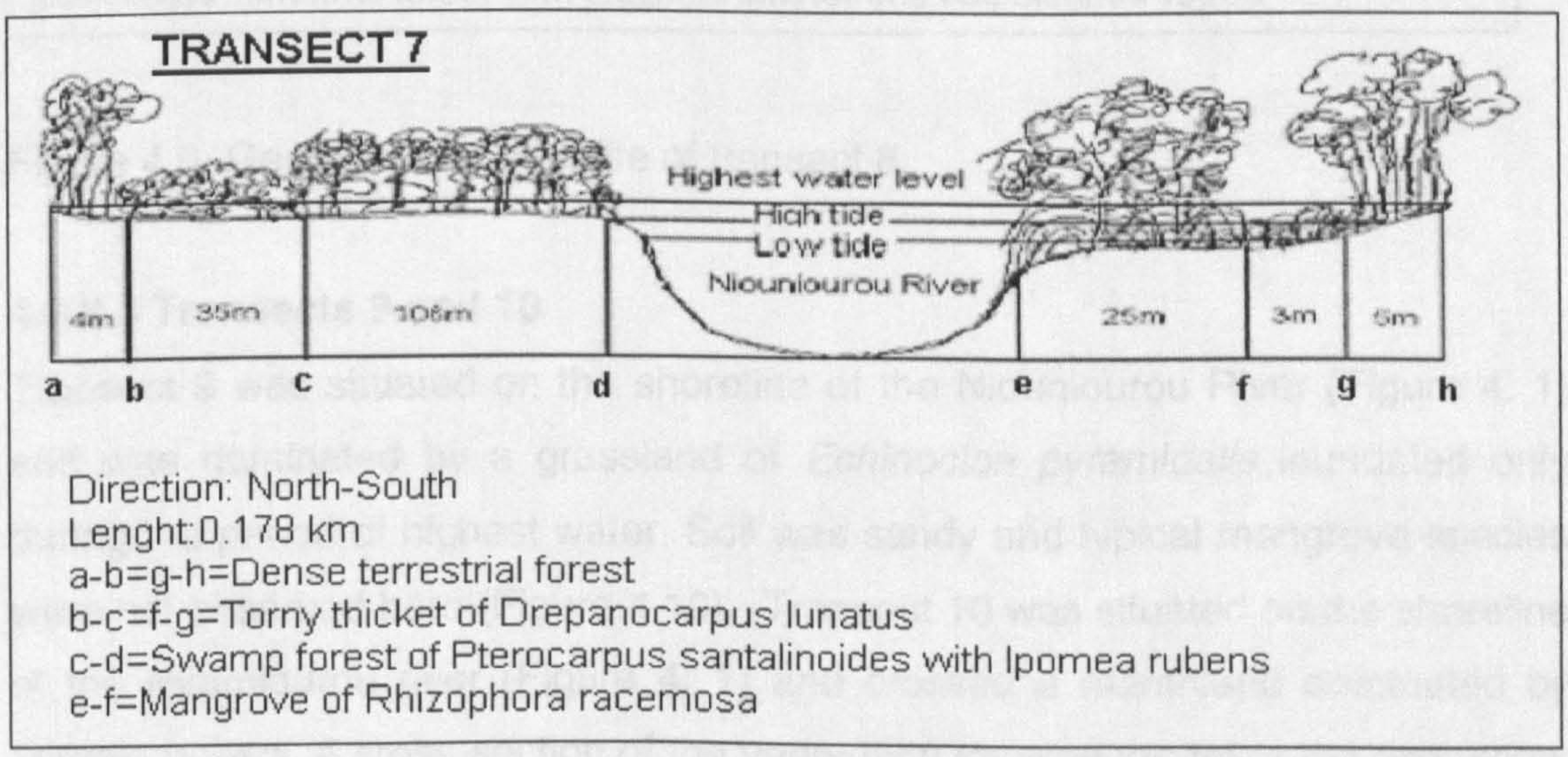


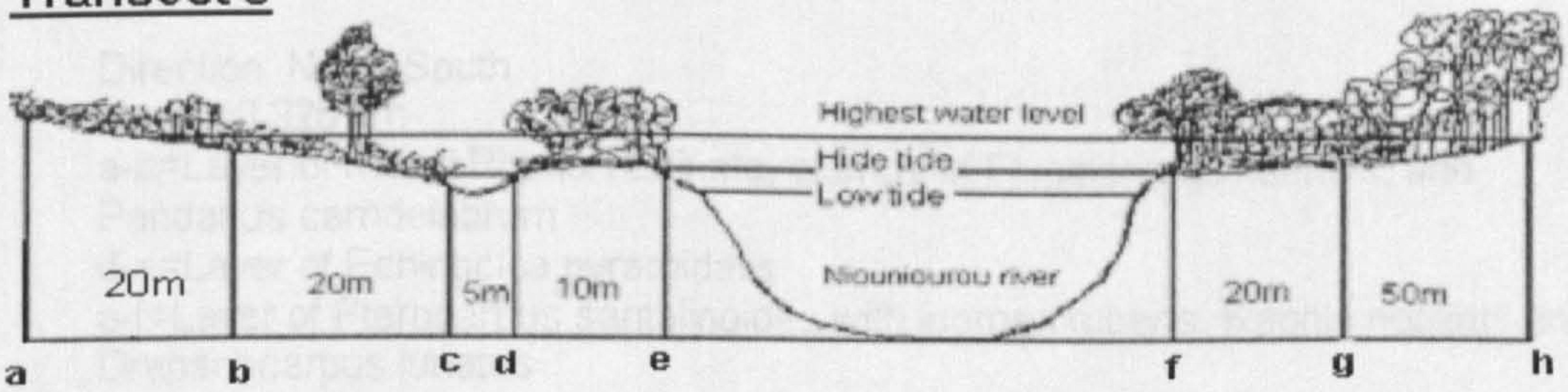
Figure 4.8: General outline profile of transect 7

4.3.2.7 Transect 8

Transect 8 started from the coastline (Figure 4. 1) on sandy soil. Open ground with *Remirea maritima* graded to woodland with various species among which *Pandanus camdelabrun* was the most charismatic.

This transect ended on a new clearance in a dense terrestrial forest. The height of trees increased further away from the coastline, and typical forest species emerged (Figure 4. 9).

Transect 8



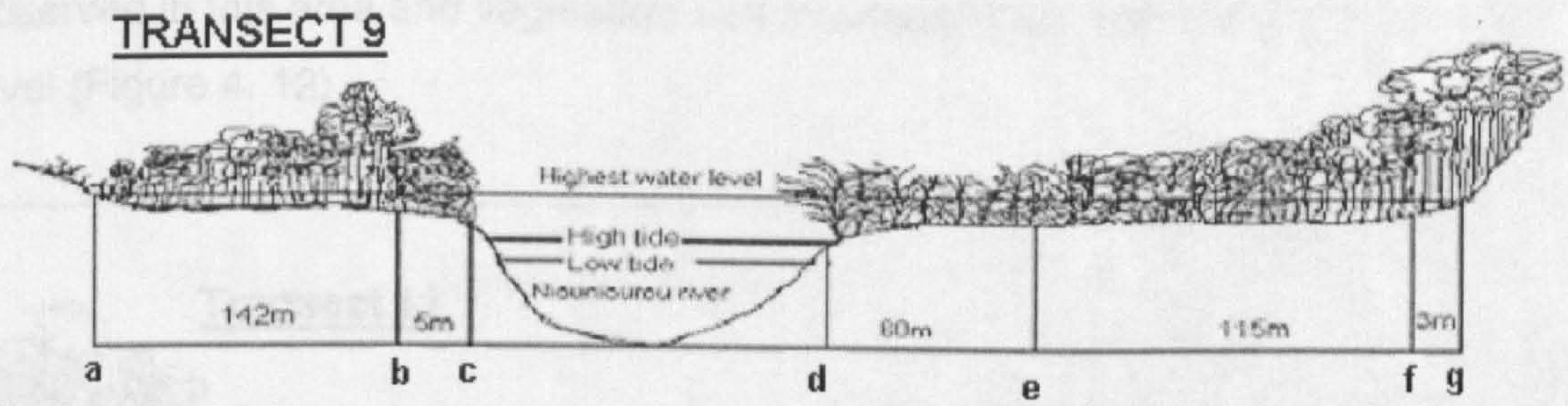
Direction: South-north
Lenght: 0.125km
a-b=Remirea maritima and Phonix reclinata mixed clumps of Flagelaria guineensis and Dalbergia ecastaphyllum
b-c= Avicenia germinans with Scoparia dulcis and Sesbania sericea under tree
c-d= Stream
d-e=Layer of Hibicus tiliaceus and dead Rhizophora racemosa along the stream
f-g=Pandanus camdelabrum with Calmus deeratus and Alcornea cordifolia
g-h=Dense terristrial forest with Eugenia whytei and Napoleonea vogelii

Figure 4.9: General outline profile of transect 8.

4.3.2.8 Transects 9 and 10

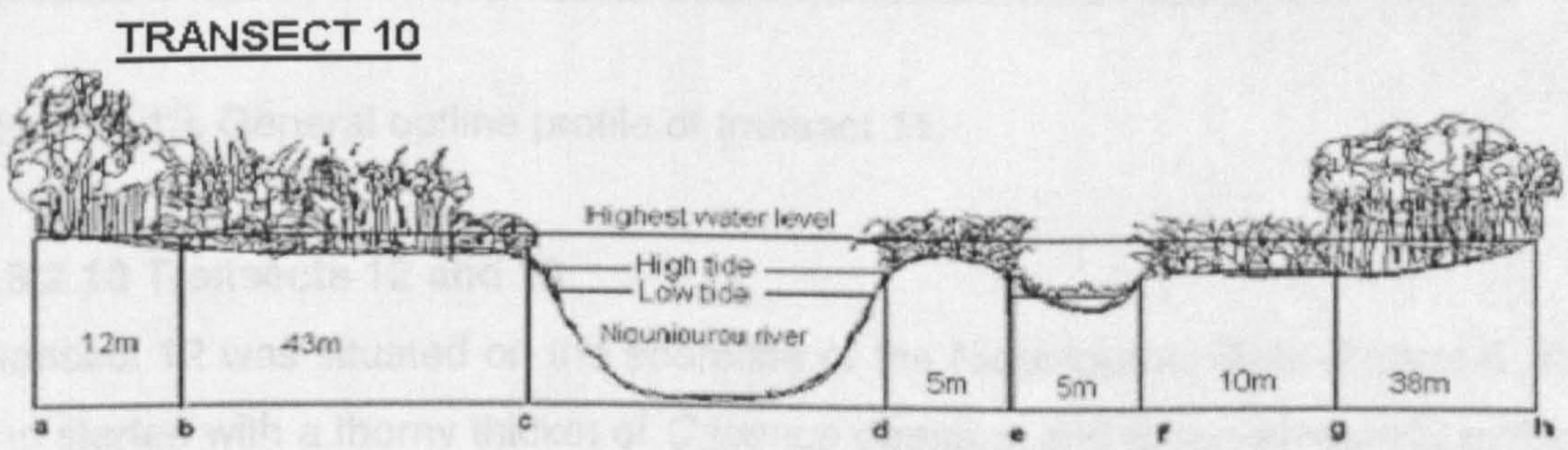
Transect 9 was situated on the shoreline of the Niouniourou River (Figure 4. 1) and was dominated by a grassland of *Echinocloa pyramidalis* inundated only during the period of highest water. Soil was sandy and typical mangrove species were not observed here (Figure 4.10). Transect 10 was situated on the shoreline of the Niouniourou river (Figure 4. 1) and crossed a marshland dominated by *Raphia hokerii.* A cross-section of the vegetation showed the following sequence: a layer of dense terrestrial forest, a swamp forest of *Raphia hokerii* mixed with

Calamus deeratus, a herbaceous layer of mixed *Bracharia ramosa* and *Echinocloa pyramidalis* and a swamp forest of *Pterocarpus santalinoides*. A small stream was covered by *Pistia stratioides* (Figure 4.11).



Direction: North-South
Lenght:0.325 km
a-b=Layer of mixed Phonix reclinata, clumps of Flagelaria guineensis, and Pandanus camdelabrum
d-e=Layer of Echinocloa pyramidalis
e-f=Layer of Pterocarpus santalinoides with Ipomea rubens, Raphia hookerii and Drepanocarpus lunatus

Figure 4.10: General outline profile of transect 9.

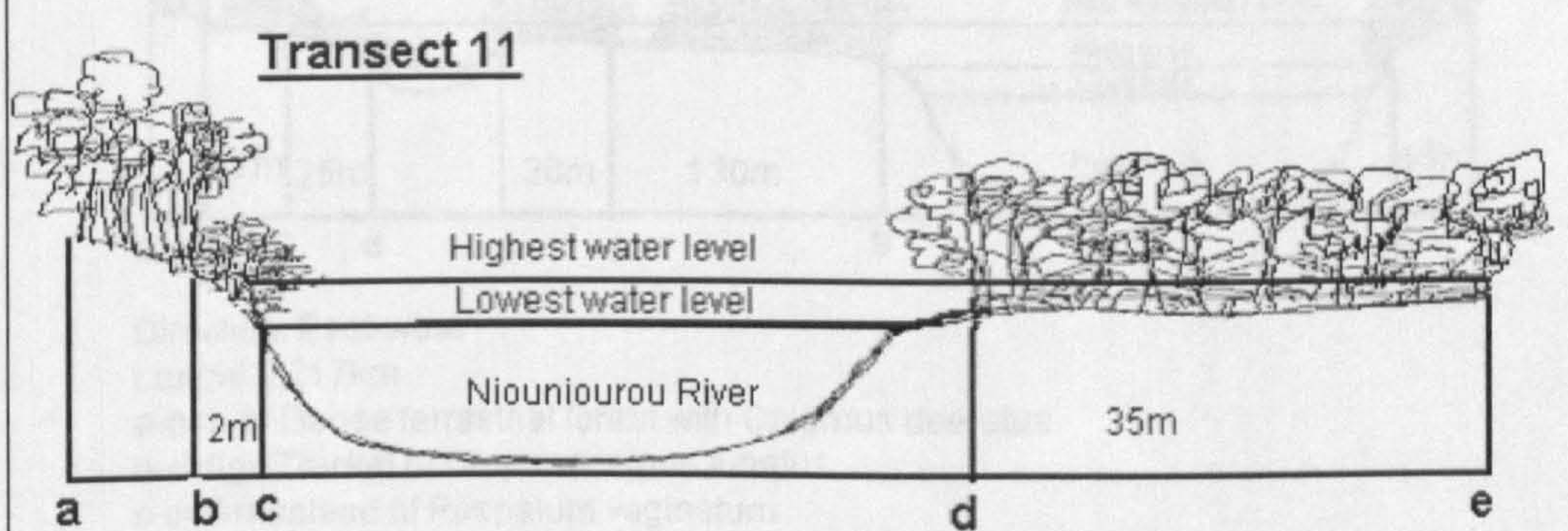


Direction:West-East
Lenght:0.113 km
a-b=Dense terrestrial forest
b-c=Swamp forest of Raphia hookerii with Calamus deeratus near the water
d-e=Mixed herbaceous layer of Bracharia ramosa and Echinocloa pyramidalis
e-f=A stream covered by Pistia stratioides
f-g=Layer of Echinocloa pyramidalis
g-h=Swamp forest of Pterocarpus santalinoides mixed with Raphia hookerii and Ipomea rubens

Figure 4.11: General outline profile of transect 10.

4.3.2.9 Transect 11

Transect 11 cut across the Niouniourou River from the east to the west (Figure 4.1). It was dominated on one side by a dense thicket of *Calamus deeratus* and on the other side by a forest with *Macaranga heudoletii.* Little tidal influence was observed in this area and vegetation was inundated only during the highest water level (Figure 4.12).



Direction: East-West
Lenght=0.037km
a-b=Dense terrestrial forest
b-c=Dense thicket of Calamus deeratus
d-e=Forest with Macaranga heudoletii, Ficus asperifolia and Raphia hokerii

Figure 4.12: General outline profile of transect 11.

4.3.2.10 Transects 12 and 13

Transect 12 was situated on the shereline of the Niouniourou River (Figure 4. 1) and started with a thorny thicket of *Calamus deeratus* and dropped sharply to the Bolo River, before a mosaic of vegetation dominated by *Drepanocarpus lunatus.* Herbaceous type vegetation was represented by *Paspalum vaginatum* and clumps of *Kilinga peruviana* (Figure 4.13).

Transect 13 sloped down to the creek (Figure 4.1) and cut across a forest with *Phonix reclinata* mixed with *Hibiscus tiliaceus* and *Pterocarpus santalinoides* on the shoreline of the Bolo River. There was a fairly uniform upper boundary to the canopy, but the height of trees was appreciably less than on *Rhizophora* or *Avicenia*. The ground was relatively bare without any seedlings. *Flagellaria guineensis* was the only species of creeper recorded (Figure 4.14).

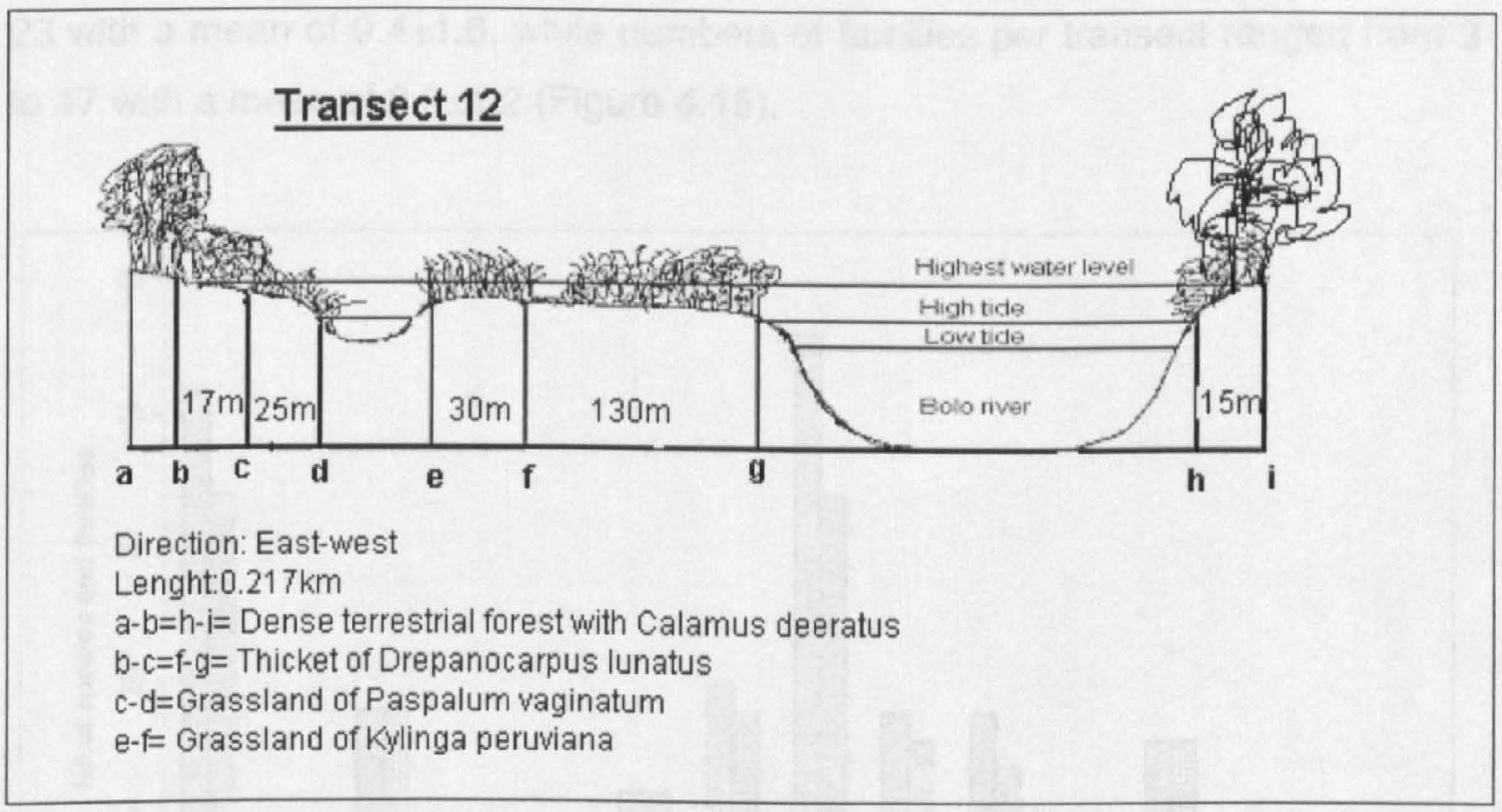


Figure 4.13: General outline profile of transect 12.

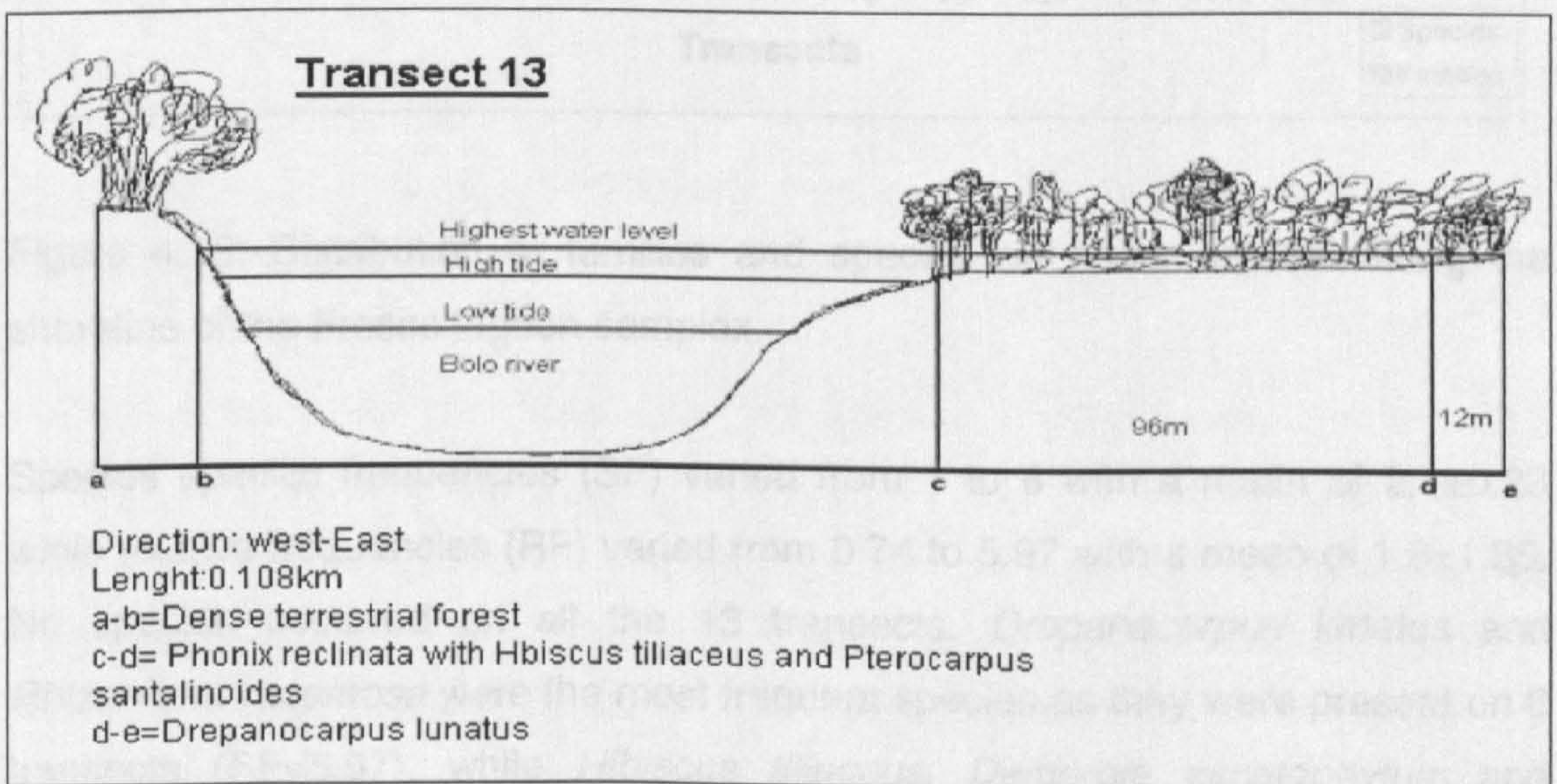


Figure 4.14: General outline profile of transect 13.

4.3.3 Floristic composition

4.3.3.1 Species richness and families diversity

A total of 63 different species from 61 genera and 34 families were found along the transects (Appendix I). The number of species per transect ranged from 3 to 23 with a mean of 9.4±1.6, while numbers of families per transect ranged from 3 to 17 with a mean of 8.3±1.2 (Figure 4.15).

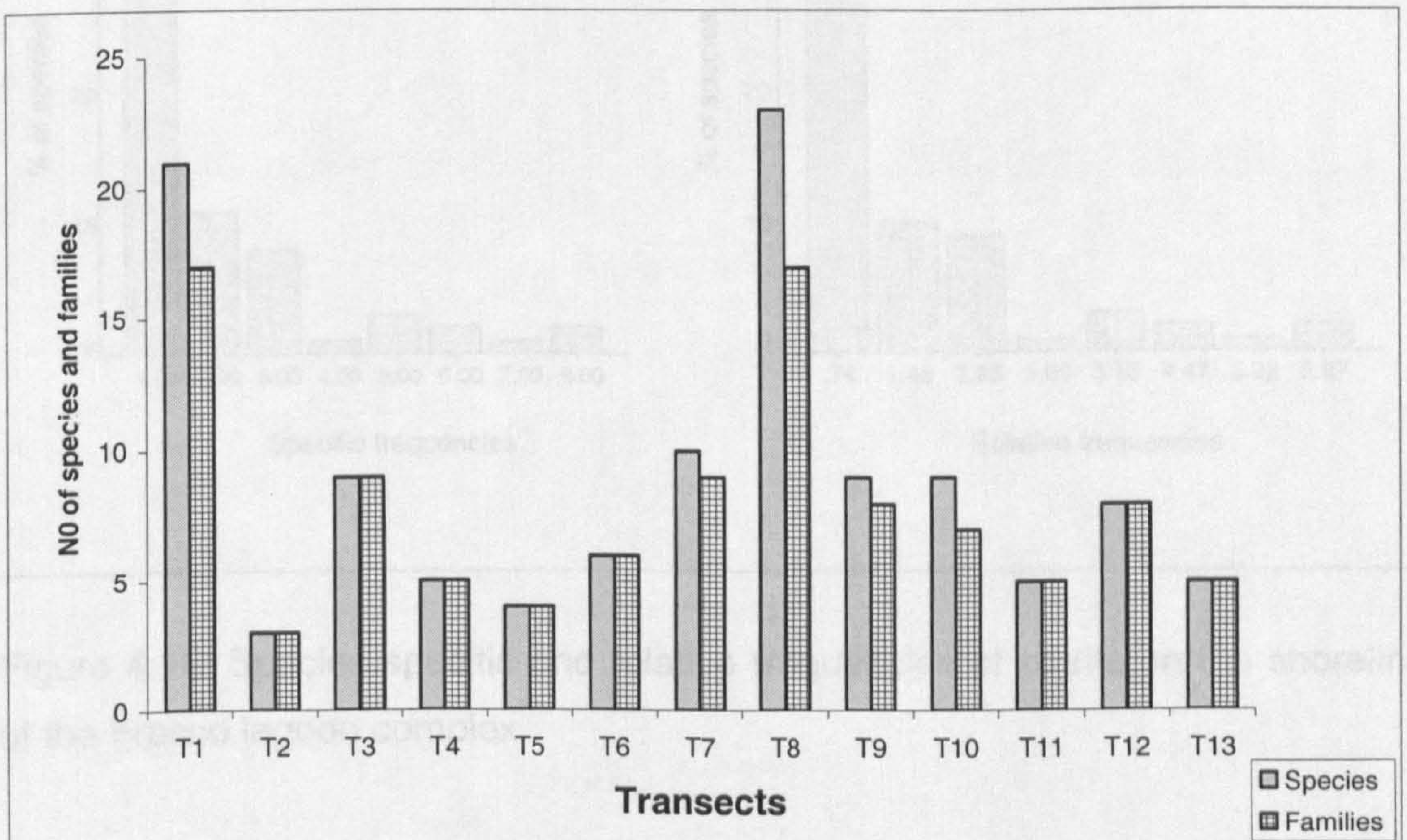


Figure 4.15: Distribution of families and species on each transect along the shoreline of the Fresco lagoon complex.

Species specific frequencies (SF) varied from 1 to 8 with a mean of 2.1±0.23 while relative frequencies (RF) varied from 0.74 to 5.97 with a mean of 1.6±1.35. No species occurred on all the 13 transects. *Drepanocarpus lunatus* and *Rhizophora racemosa* were the most frequent species as they were present on 8 transects (RF=5.97), while *Hibiscus tiliaceus*, *Dalbergia escataphylum* and *Paspalum vaginatum* were present on 5 different transects (RF=5.22). Most species (55% of total species recorded) were rare (RF=0.74) and were recorded on only one transect) (Figure 4.16).

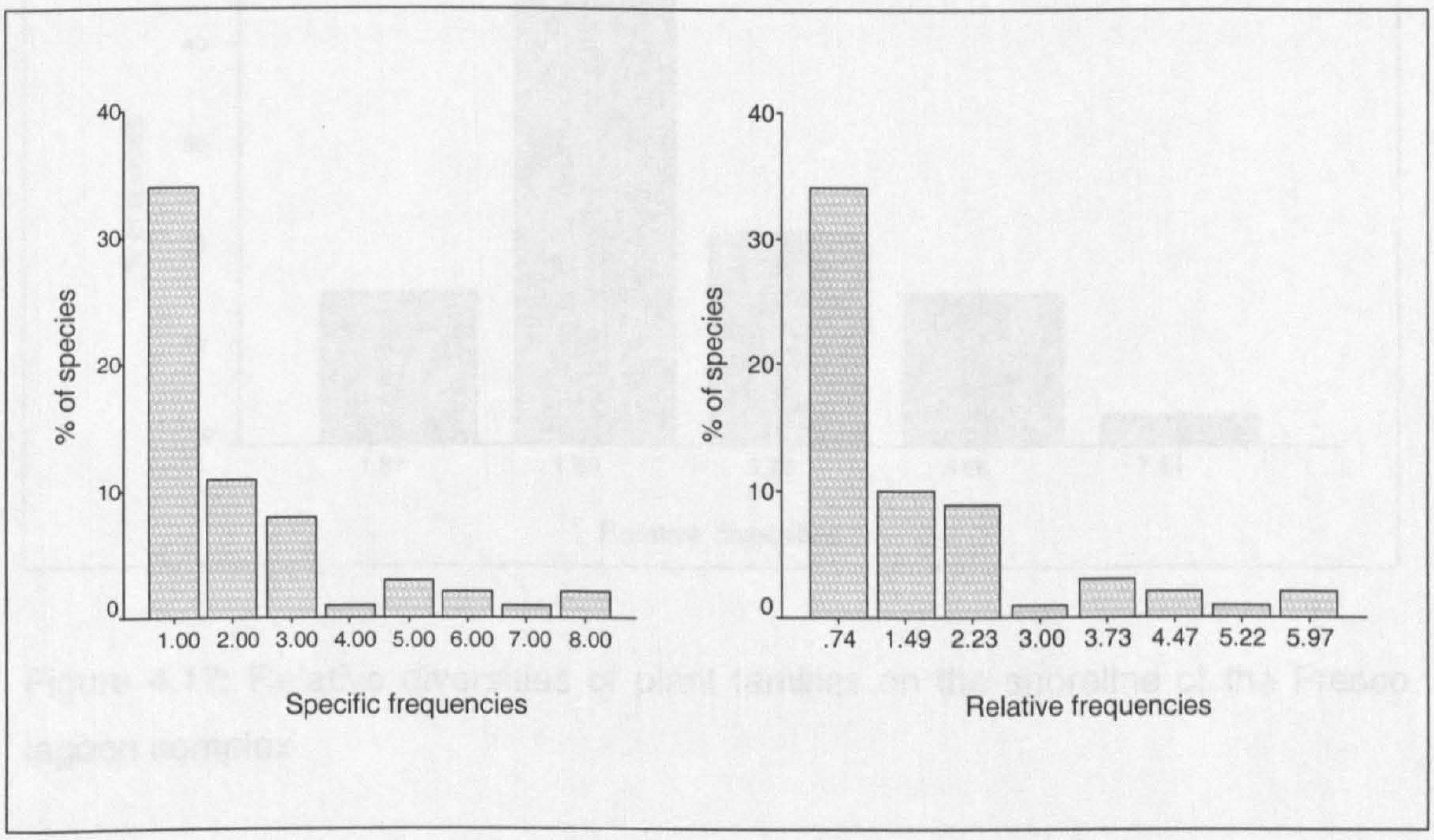


Figure 4.16: Species specific and relative frequencies of plants on the shoreline of the Fresco lagoon complex.

Species relative densities (RD) varied from 0.02 to 43.5 with a mean of 1.8±0.8. *Paspalum vaginatum* had the highest relative density (RD=43.5) followed by *Avicenia germinans* (RD=15) and *Echinocloa pyramidalis (*RD=11.8*)*.

Many families (40%) comprised only one species, 21% were represented by 2 species, a further 15% comprised 3 species and only 3% were represented by 4 species. Thus, family relative diversities (DvrF) varied from 1.8 to 7.5 with a mean of 3±0.28. Most of families (60%) had a family relative diversity (DvrF) of less than 2. The family of Poaceae was the most diverse (RD= 7.5; Figure 4.17 and 4.18).

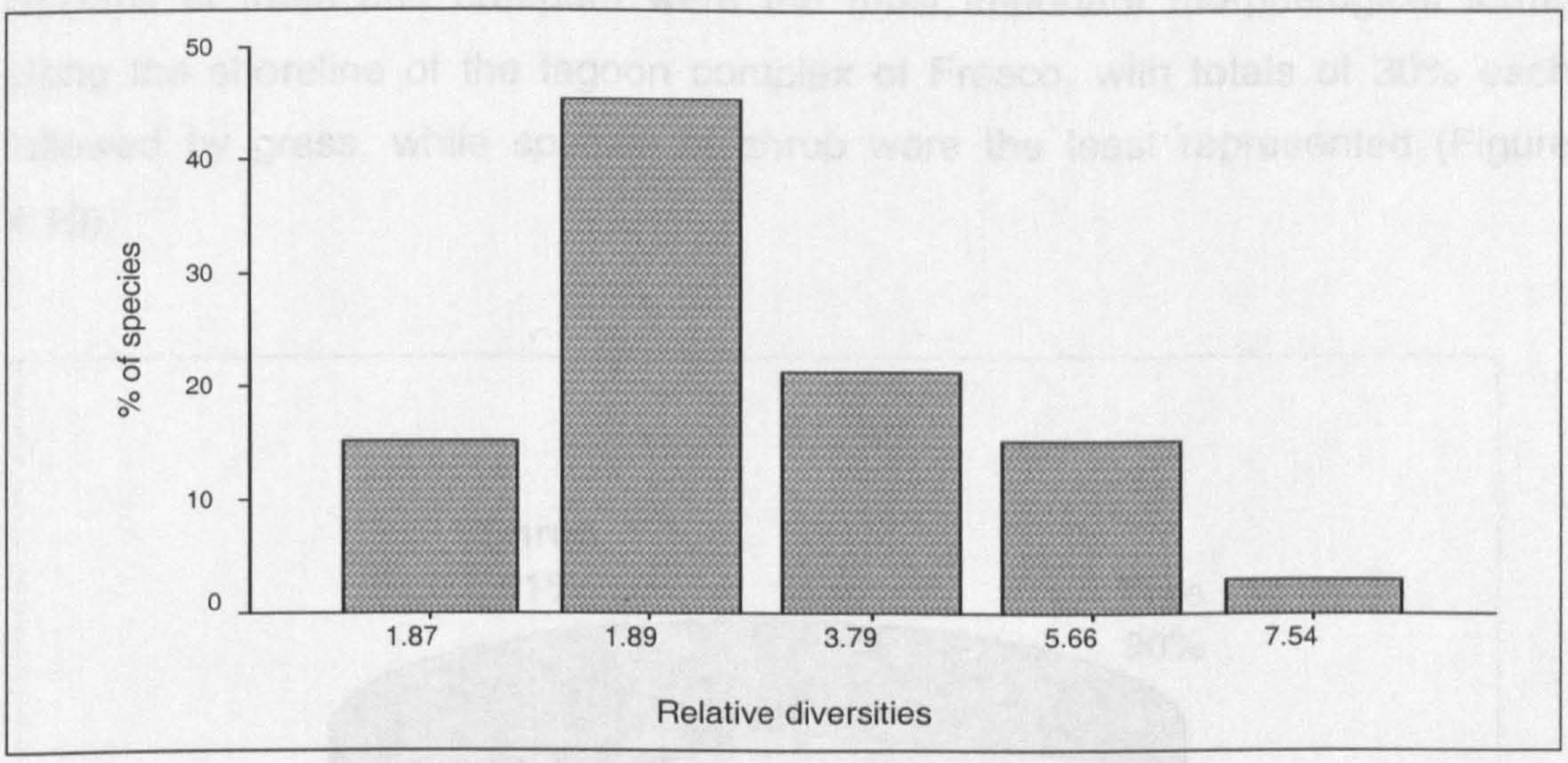


Figure 4.17: Relative diversities of plant families on the shoreline of the Fresco lagoon complex

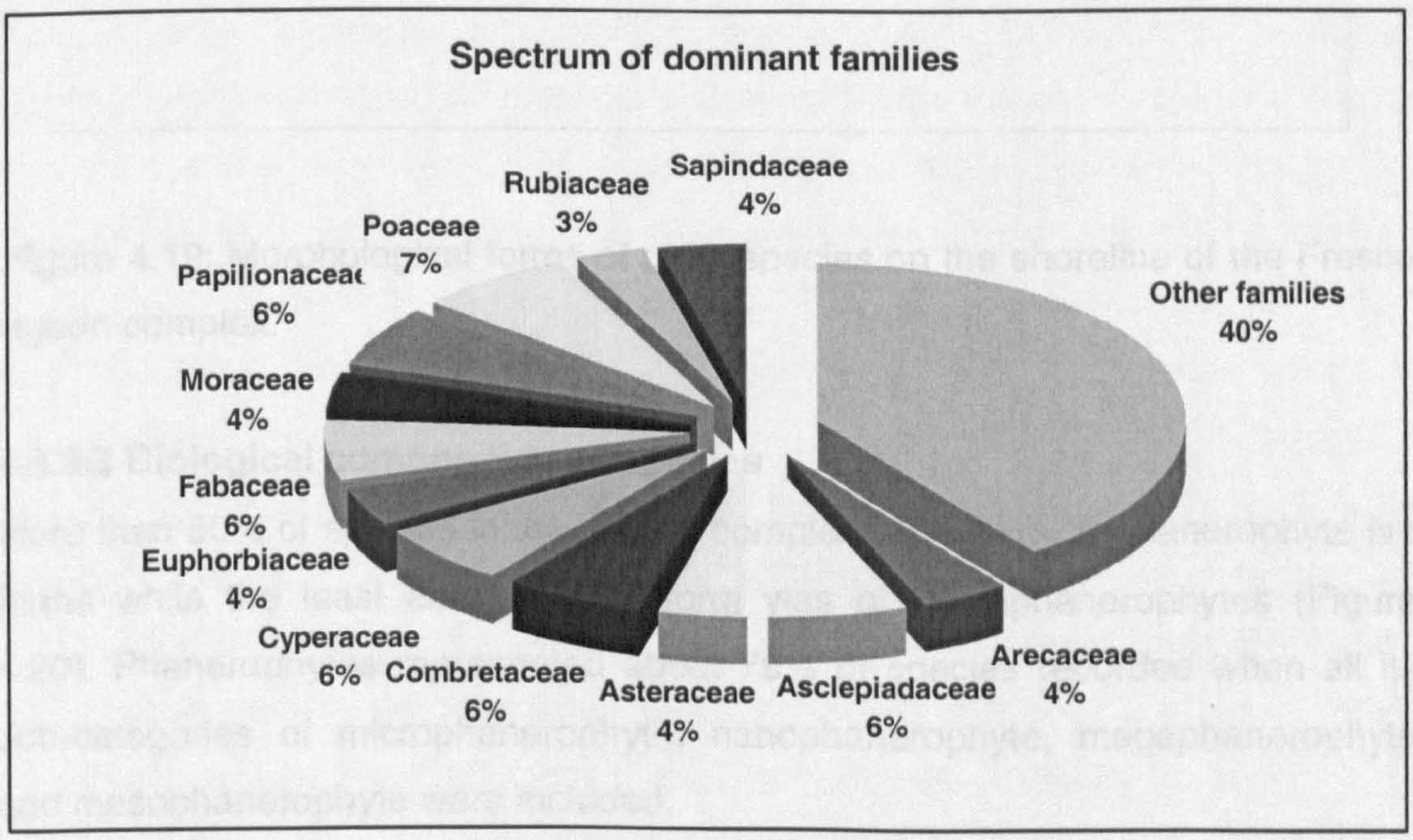


Figure 4:18: Spectrum of dominant plant families (% of species per family) on the shoreline of the Fresco lagoon complex.

4.3.3.2 Morphological forms of species

Species of trees and creepers were the most important morphological forms along the shoreline of the lagoon complex of Fresco, with totals of 30% each followed by grass, while species of shrub were the least represented (Figure 4.19).

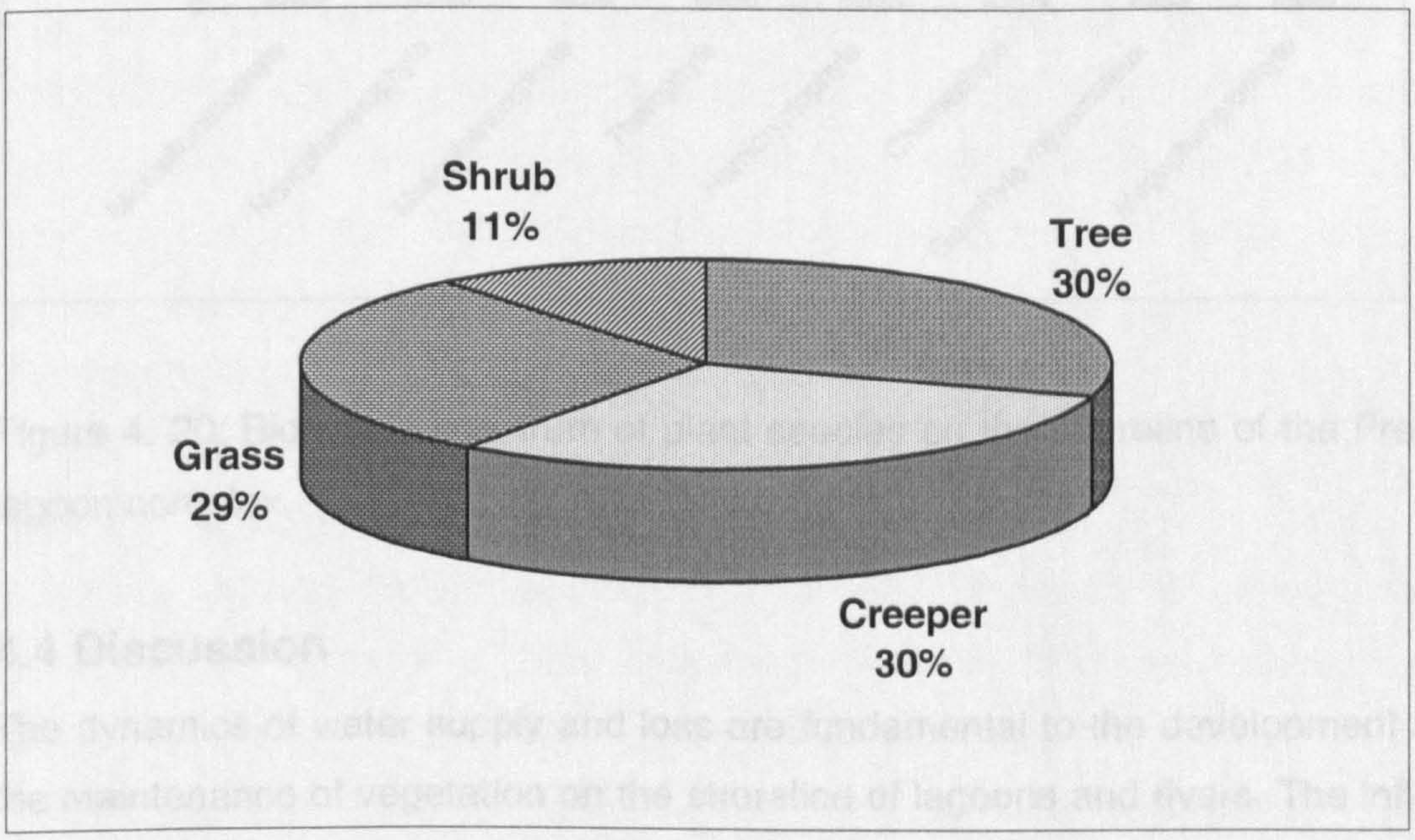


Figure 4.19: Morphological forms of plant species on the shoreline of the Fresco lagoon complex.

4.3.3.3 Biological composition of species

More than 50% of species in the lagoon complex were of microphanerophyte life forms while the least abundant life form was of megaphanerophytes (Figure 4.20). Phanerophytes represented about 79% of species recorded when all its sub-categories of microphanerophyte, nanophanerophyte, megaphanerophyte and mesophanerophyte were included.

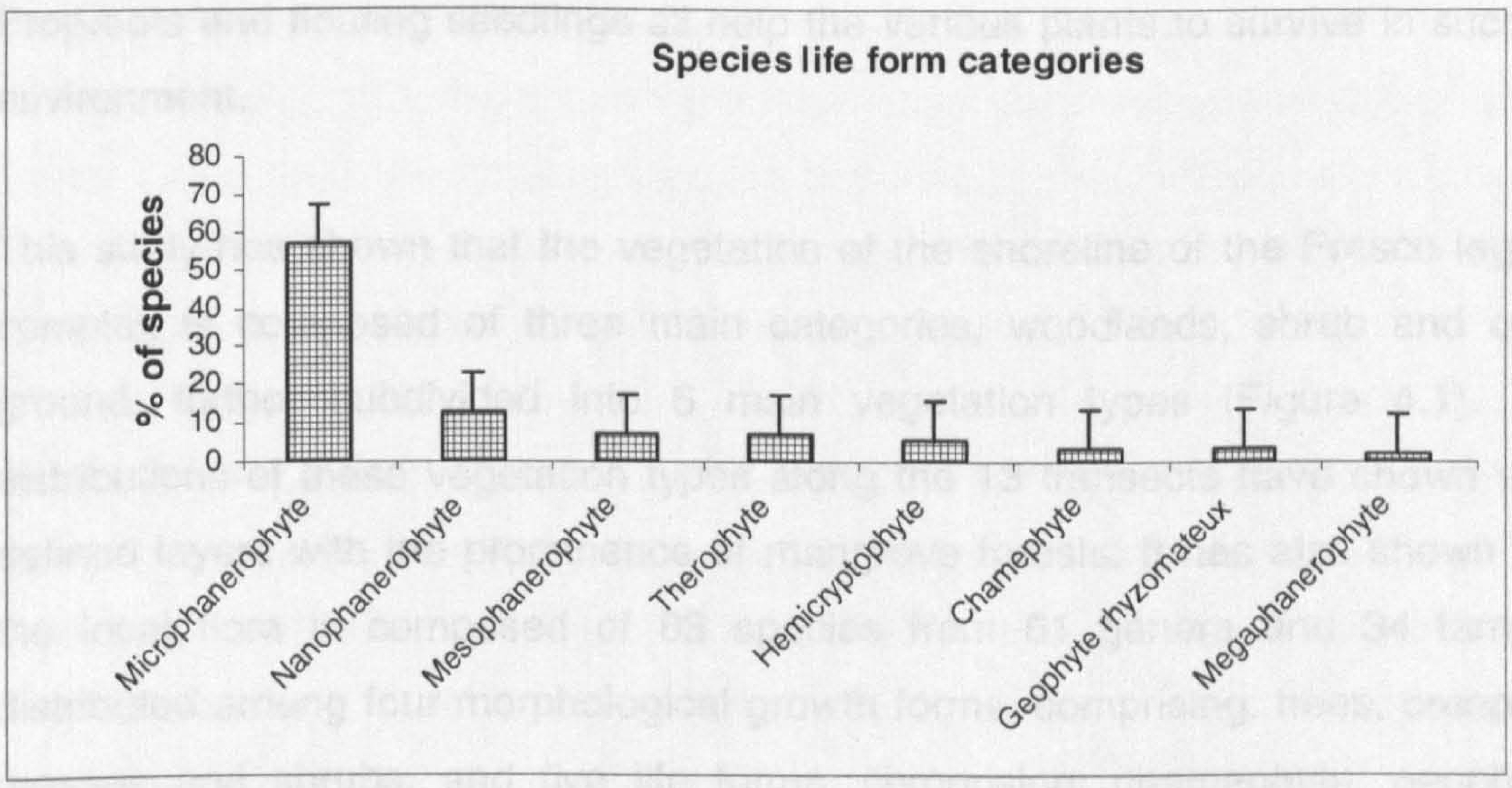


Figure 4. 20: Biological spectrum of plant species on the shoreline of the Fresco lagoon complex

4.4 Discussion

The dynamics of water supply and loss are fundamental to the development and the maintenance of vegetation on the shoreline of lagoons and rivers. The inflow-outflow balance of water on the shoreline is influenced primarily by climate (Chapter 3) and catchment configuration, while the timing and the duration of flooding is controlled more by geological characteristics and the local geomorphology that makes up the configuration of the land (Maltby, 1991). In places where the terrain is flat, large areas are subject to flooding. Vegetation types and species composition reflect the flooding regime and the chemical quality of the water, whether fresh or saline. Plant species on the shoreline are highly adapted to the stresses of flooding. Adaptations include specialized root-cell membranes that prevent or reduce entry of salt. Other adaptations include the ability to exchange gas more efficiently through lenticels, or even more elaborate tube-like breathing structures called pneumatophores, which grow vertically upwards from the roots, often in dense arrays (Nicole *et al.*, 1994).

Proproots and floating seedlings all help the various plants to survive in such an environment.

This study has shown that the vegetation of the shoreline of the Fresco lagoon complex is composed of three main categories, woodlands, shrub and open ground, further subdivided into 6 main vegetation types (Figure 4.1). The distributions of these vegetation types along the 13 transects have shown well-defined layers with the prominence of mangrove forests. It has also shown that the local flora is composed of 63 species from 61 genera and 34 families distributed among four morphological growth forms, comprising: trees, creepers, grasses and shrubs, and five life forms, comprising: chamephyte, geophyte, therophyte, hemicryptophyte and phanerophyte.

4.4.1 Vegetation types on the fresco lagoon shoreline

Mangrove forests (whether degraded or in good condition) on the shoreline were dominated by typical mangrove species such as *Rhizophora racemosa* and *Avicenia germinans.* This was not surprising in a tidally dominated environment that offered good physical conditions, such as regular connection to the sea, a high rainfall (see Chapter 3), and high sediment accumulation, extremely favourable to the development of such a vegetation type. Nevertheless, much of this mangrove was highly degraded. The large amount of dead wood of *Rhizophara* and *Avicenia* found on the ground (Transects 1 and 2) and the many areas of bare ground constituted clear evidence of this degradation. However, this may favour succession on the shoreline towards the development of a different plant community. The emergence of *Paspalum vaginatum* and *Drepanocarpus lunatus* (Transects 1, 3 and 4) in place of dead *Avicenia* and *Rhizophora* may indicate such ecological succession. In fact, ecological succession is common in wetlands throughout the world and underlines both their dynamic character and their highly changeable nature, making them vulnerable to both man-induced, as well as environmental, changes (Malby, 1991). Succession of one plant community by another produces distinct zonation of vegetation and habitat around open water bodies. Disturbances play a central role in determining the distribution and abundance of trees species. Disturbances create canopy openings that provide the opportunity for tree recruitment, and the scale, intensity and spatial pattern of tree mortality defines the consequences of disturbance for vegetation composition (Sherman *et al.*, 2000).

Rhizophora and *Avicenia* first lose their leaves before the dead trunk topples over. This natural degradation is subjected to considerable discussions among mangrove ecologists, but appropriate scientific investigations have not so far been carried out, and the exact cause of degradation is poorly understood (Egnakou, 1987). Wood of *Rhizophora racemosa* is locally used for fuel by neighboring peoples (see Chapter 7). However, death of *Rhizophora* cannot be attributed to the collection of firewood as collection was restricted to dead wood. According to Egnankou *et al.* (1990) the death of *Rhizophora* and *Avicenia* in the Fresco lagoon is due to the closing of the inlet, which stops any exchange between the lagoon and the sea for at least three months every year. As a result, the water becomes fully fresh and lacks any salt to meet the requirements of *Avicenia* and *Rhizophora*. Although this provides a good hypothesis for further research, it was contradicted because riverine mangrove on the Niouniourou Riveris, also subjected to the same seasonaly interruption of salt inflows, but was in a very good condition.

The fact that many seedlings were observed under *Avicenia germinans* (Transect 3) suggested that the species can regenerate well. Unfortunately, like old trees, most of these seedlings were also dead, possibly due to asphyxia because of a long period of over-flooding (Egnankou *et al.*, 1990). An attempt to replant the mangrove forest around the Fresco lagoon is ongoing, but may not succeed because the cause of degradation is still unknown.

Layers of *Drepanocarpus lunatus, Hibiscus tiliaceus* and *Dalbergia escataphylum* always occurred between *Rhizophora racemosa* and *Avicenia germinans* before the dense terrestrial forest. This was not surprising as these non-halophytic species are always described as "mangrove associates" (Lugo, 1980; Snedaker, 1982; Norman, 1992).

Transect 6 crossed a luxuriant riverine mangrove on the Niouniourou River. This mangrove forest is considered one of the best among the entire coastal wetlands of Cote d'Ivoire (Nicole *et al.*, 1994). The luxuriance of this mangrove may be attributed to the interaction of three factors: the low level of pore water salinity, as observed by Bassalia (1998); the high level of sediment carried by the Niouniourou River, as suggested by Powell (1992); and, the efficiency of mangrove roots as sediment trappers and binders (Zimmermann and Thom, 1982; Woodroffe, 1992). Unfortunately this mangrove is also subject to a natural disturbance that particularly affected the oldest and tallest trees on the edge of the water (Figure 4.8). According to the author's personal observation, one to two tall trees fall down every year during the fruiting period as a result of wind pressure combined with the heavy extra weight of fruits. This may also be attributed to a lack of lateral support from the neighbouring community of trees due to their critical location on the water edge. Norman (1992) observed that lateral support from nearby trees was essential to maintain the above groundmass of mangrove trees and supplement the root structures in a water-saturated environment. This type of disturbance is very common to mangroves forests around the world. In hurricane areas, large-scale stand-initiating disturbances are known to influence the regeneration dynamics of mangroves forests (Roth, 1992; Smith *et al.*, 1994; Baldwin *et al.*, 1995). However, depending upon the position of particular mangrove forests relative to the tracks of intensive tropical cyclones such as hurricanes, typhoons, the frequency of large-scale, stand-replacing disturbances may vary markedly among mangroves (Sherman *et al.*, 2000).

4.4.2 Floristic composition and distribution

A total of 63 different species from 61 genera and 34 families were recorded on the shoreline of Fresco lagoon complex, which was similar to Nicole *et al.* (1994) who found 56 species in mangroves throughout Cote D'Ivoire. There are an estimated 80 species of mangrove tree and shrub worldwide (Maltby, 1991). The dominance of phanerophyte life forms in the local flora reflected the bioclimatic environments of the lagoon complex. Phanerophytes are always dominant in warm-moist areas (Dansereau, 1951), which are the main bioclimatic conditions found along the shoreline of the Fresco lagoon complex.

From the lagoon towards the upper reaches of the Niouniourou River, *Avicenia gerrninans* and *Rhizophora racemosa* differed in their distribution. On transects where the two species coexisted, *Avicenia germinans* was always found on a more solid and relatively dry soil behind *Rhizophora racemosa* (Transect 3 and 8), which was always situated at the water's edge with its roots permanently inundated. Moreover, *Avicenia germinans* was only recorded on transects close to the coastline (Transects 2, 3, 8) and was totally absent from the riverine mangrove on the shoreline of the Niouniourou River further from the coastline, where *Rhizophora racemosa* was more luxuriant. This difference in distribution could be attributed to the requirements of each of the two species in terms of soil type, the nature of the flooding regime and most importantly their tolerance limit to saline water. In fact, *Rhizophora racemosa* grows well on the edge of the water on muddy and inundated soil with low salt concentrations while *Avicenia germinans* required a higher salinities (Nicole *et al.*, 1994; Bassalia, 1998). Therefore, *Avicenia* is less common as the salinity decreases or as distance from the sea increases.

Despite its highly changeable ecology, the Fresco lagoon complex has been used and managed by the local community for many years. I will now examine in more detail the management system established by indigenous peoples to control use of the lagoon.

PART II USES BY INDIGENOUS PEOPLES

Natural resources are those components of nature that are used or are estimated to have value for people. People use natural resources to meet their daily needs. Many human needs are built upon the natural resource base of the biosphere. These resources are renewable if used with care and concern, but resources are not limitless. Resources will have to be shared by a global population that will double in the early part of this millennium. Of the living resources of the planet, enormous reservoirs are used and managed as common property, property that is shared by a wide array of social groups. Management strategies associated with the use of common property resources are as diverse as the social, cultural, and ecological contexts in which they are practiced (Peter Jacobs, 1989).

This section deals with the common property regimes associated with use by local people of the resources of the Fresco lagoon complex, the attitudes of users towards present day management system and finally types and patterns of use of natural resources in the lagoon.

CHAPTER 5 HISTORICAL AND PRESENT MANAGEMENT SYSTEMS IN THE FRESCO LAGOON

5.1 Introduction

In recent years there has been a growing interest in understanding and integrating traditional ecological knowledge into systems of modern development planning and natural resource management. This growing interest stems from the search for viable and sustainable alternatives to imposed development and other top-down approaches. In most cases, such approaches have resulted in staggering costs and subsequent failure (Alcorn, 1997). Moreover, conservation professionals and agencies, both at national and international levels, have come to recognize that, for thousands of years, many indigenous communities around the world have experimented with local strategies, social systems and institutions, beliefs and value. In turn, these have allowed indigenous communities to coexist with biodiversity and manage their common property resources on a sustainable basis (Berkes and Farver 1989; Lalonde, 1993; Murphree, 1997; Alcorn, 1997).

The term "common property" refers to those classes of resources which are regarded as collective assets and for which there exists a communal system of management (Taylor, 1987; Berkes and Faver 1989; Matthews, 1993; Murphree, 1997; Mckean, 2000). To ensure sustainability of management, a common property regime has a defined membership with spatial and social boundaries, and rules for inclusion and exclusion. It has rules regarding access to resource which regulate internal competition, and which provide an efficient means of conflict resolution (Berkes and Faver, 1989). It has institutional means to ensure that collective goods are not eroded by specific interests. Finally, common property regimes have appropriate legitimacy, both internally and externally, and promote the ideals of communal welfare and responsibility.

A good understanding of any local indigenous common property resource management systems, and lessons learnt from their successes, weaknesses or failures, might well help modern conservation projects to elaborate more appropriate strategies to achieve effectiveness and efficiency. Hence, this chapter seeks to determine the nature of the indigenous common property resource management system that originally operated in the lagoon of Fresco, and how this management system has adapted to modern development pressure. Historical and present resource management systems will be surveyed using the following questions:

- who were and are the owner(s) of the lagoon complex of Fresco?
- how was and is ownership transmitted between generations?
- how was and is the lagoon shared between, and within villages, and between families?
- who had and has the right to use the lagoon's resources and how was and is this right given?
- what restrictions did villagers agree upon and what sanctions and corrective measures were applied when members departed from agreed rules?
- to what changes has the management system been subjected, and how are resource uses currently controlled?

5.2 Methods

An understanding of the historical and present systems of resource management in the lagoon of Fresco was gained using methodologies advocated by Chambers (1992) and Alcorn (1997).

5.2.1 Pre-appraisal dialogue and land-use mapping

A pre-appraisal dialogue with a group discussion method was used to obtain a general insight into the type of management system set up in the lagoon, and to trace its historical trends. Contrary to general belief, group discussion has the advantage of stimulating interactions between group members. In turn this enriches the quality and quantity of information provided, as a group has overlapping levels of knowledge that cover a wider field (Chambers, 1992). More generally, groups can build up collective and creative enthusiasm, which can especially lead to showing, sharing and familiarizing new ideas and concepts with an outsider. Participants in group discussion can fill in gaps that are omitted by other members of the discussion group, and add or correct detail. Equally, there are disadvantages of group discussions, such as dominance of a group by one or more individuals.

Three different group discussions were held in each of the three villages for the Godie community that shared the lagoon. Discussions always took place on a Friday, which is the holy and resting day of the week for the entire community, at a date, time and place selected by participants. The size of group discussion meetings varied from 29 to 38 participants, with an average of 33 participants. Open-ended questions were asked and discussed in French on the history of the lagoon, its past and present management systems, types of fishing practices, trends in abundance of fish and other lagoon resources. Discussion results were summarized and reviewed with the participants to allow them to check that their comments were recorded correctly. This summary was used to establish further detailed discussion points as the basis for key informant interviews.

Additionally, a land-use mapping method was used to provide a snapshot of the geographical boundaries of different sub-divisions of the lagoon for the purpose of sharing resources among and within villages (Alcorn, 1997). Thus, during the group discussions, participants were asked to draw on the ground a map of family territories in the lagoon.

5.2.2 Semi-structured interviews with key informants

Key informant interviews involved meeting with knowledgeable individuals in relaxed and informal conditions in order to obtain specific, in-depth, quantitative and qualitative information on specific points of interest (Chambers, 1992; Alcorn, 1997). A key informant interview has the advantage of encouraging two-way communication and the development of relationships with key individuals in the community. It is more convenient for respondents, as the interview time can be suited to their specific schedule and can take less time than participation in a group process.

A list of key informants was obtained from elders in the three villages after their respective group discussions. Most of them were elderly people who had spent their entire life in the village and whom the village authorities thought had good knowledge of events and local histories. A written checklist of open-ended questions was established, including the following topics: history of the ownership of the lagoon and mode of transmission between generations; ecological history of the lagoon; change in villages settlements; changes in fishing practices; changes in trends of fish abundance and the causes of any changes (Appendix II). Interviews were conducted in French by special appointment with an individual participant. A total of 53 key informants were interviewed.

5.3 Results

5.3.1 Traditional system of lagoon management

The group discussions and key-informant interviews revealed that the community of Godie had started using the lagoon of Fresco in the 17th century, following their arrival from their native Ghana which they had fled due to long-lasting social unrest. When they first arrived, the community mostly fished in the sea (*djire*), generally from December to March. During wet seasons, from April to July and from September to November, activities in the sea ceased due to bad weather. Thus, the lagoon (*N'gni*) was set aside by the body of elders, for the primary purpose of fishing during bad periods of the year as an alternative to the sea.

The historical roots of an indigenous resource management system in the lagoon relied heavily on the Godie's customary sharing of lands and traditional beliefs. The Godie believed that the land (*dodou*), including lagoons and rivers, was the source of their life, the home of their ancestors and a provider of their material needs, and which had a spirit that they always revered. Fishes in the lagoon were believed to be protected, hidden or given to them by the spirit of the water, to be used with care. For example, everyone from elders to children, knew that the spirit of the water (*Monagnro*) in Fresco moved from the lagoon to the sea and vice-versa every Friday (*N'beyro*).

5.3.1.1 Lagoon ownership

According to key informants, the N'gni lagoon had a traditional owner (*kodoguegnon*). The background of appointing this traditional owner stemmed from the wedding of *Zahiro*, a young daughter of Dati to the spirit of the water (*Monagnro*). Dati was the family head who established the district of Datibery, one of the 12 districts of the former village of Fresco. Once, *Zahiro* and her friend, another young girl, were playing on the sand beach close to the inlet. To her friend's question asking whom from the village she planned to have for her future husband (*gnopoou*), *Zahihro* revealed that she had already promised the spirit of the water that she would be his wife (*wron*). This confidential revelation spread quickly and villagers joked with *Zahihro* by calling her the future wife of the spirit of the water

A few years later, the N'gni lagoon surprisingly flooded as never seen before. The entire village was inundated. A medium (*gplegroin*) revealed to Gouinzin Lobo, the chief of Fresco village, that the flood was an indication given by the spirit of the water to *Zahihro* that she was now mature and that the time had come for her to fulfill her promise of marriage. According to the medium, once *Zahihro* had been given to the spirit, the flood would stop. However, Dati and his wife were so close to their dear daughter that they refused to do so. Instead of *Zahihro*, Dati gave a slave girl (*kongroin*) of the same age to the spirit who refused and the flood worsened. In the end and against his will, Dati gave his daughter to save the village. *Zahihro* was nicely dressed as was required by custom for a wedding day (*akaninin*), put into a banana boat (*koilou*) and left on the water on a Friday (*N'beyro*) evening. On Saturday morning, the boat was found empty and suddenly the water level started to drop. It was believed from that day that *Zahihro* has been transported to the spiritual world to marry the spirit of the water. Henceforth, she was in a position to ask for the continual blessing of the spirit upon the village. In gratitude for giving his dear daughter, *Zahihro,* to save the entire village, the body of elders decided to offer Dati and his family the traditional ownership (*N'gni kodoguegnon*) of the lagoon.

5.3.1.2 Access rights and family territories

Respondents revealed that the N'gni lagoon was open to all as a means of transport. However, only the existing community of Godie could fish in the N'gni lagoon. This community was composed of 14 principal families distributed in three villages around the lagoon: the village of Fresco with 12 families (*Gbaco, Lezeko, Datiberi, Logodou, Ziperi, Docotieko, Logoberi, Awaze, Zigreberi, Gbahiri, Logozaria* and *Diprimda*); and, the villages of *Zakareko* and *Bohico* with one family each. The right to fish was therefore based on family origin. Only individuals who could prove, through their ancestors, that they were *Godie* and native of Fresco, Zakareko or Bohico, had the automatic right to fish in the N'gni lagoon.

To promote the sustainable use of resources, the area of the lagoon was subdivided into 14 territories based on the customary usage of the 14 families. This usage was defined by projecting, on the lagoon, the terrestrial boundaries of each family's land. Each defined territory was considered as a family's lagoon territory and labeled with a local name (Figure 5.1). The sharing and management of fishing activities within each territory was led by the head of each family (*Kamagnon*) during his whole lifetime.

Members of the Godie community could fish with nets and lines anywhere in the lagoon. However, the common method of using a fishing gate (*wikou*), could only be practiced within individual family territories. Any group of fishermen wishing to establish a fishing gate outside their family territory had to see the family head who would indicate the appropriateness of establishing a fishing gate in their territory. A person could only establish a fishing gate in a different family's territory if members of this family were not engaged in such a project at the same time and if it had been agreed by the head of this family. A head of family could only decide to allow an individual to use the territory under his control if he had the agreement of at least three quarters of his family's members. If such an agreement was made, the owner of the fishing gate would bring to the family a basket (*menongnon*) of dry fish at the end of his production.

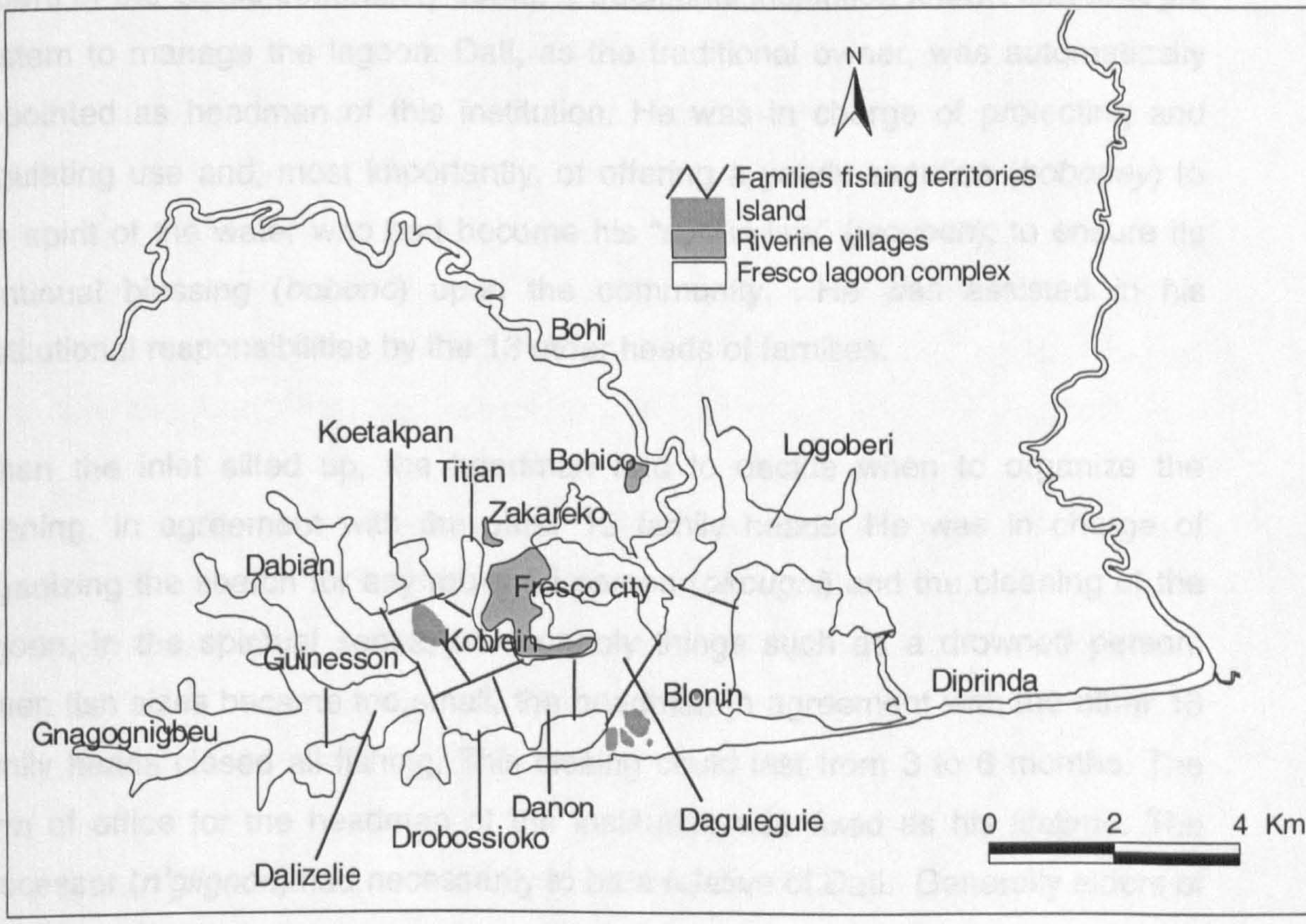


Figure 5.1: Traditional family territories in the Fresco lagoon complex

Fishing was prohibited on Friday, which was believed to be the day of the water spirit. Anyone engaged in night fishing on Thursday had to leave the lagoon before midnight. Fishing was also not allowed during two days following the opening of the inlet. The number of fishing methods was also limited. For example, big fishing nets requiring more than eight persons operating together were not allowed. No foreigner (*peowo*), regardless of the length of time spent in the area, had the right to fish in the N'gni lagoon. However, a rightful user within the Godie community could allow a visitor to fish on his behalf after obtaining the agreement from his family's head to fish for his subsistence needs only.

5.3.1.3 Institutional arrangements

Elders of the Godie community set up a traditional institution known as the *N'gni* system to manage the lagoon. Dati, as the traditional owner, was automatically appointed as headman of this institution. He was in charge of protecting and regulating use and, most importantly, of offering a yearly sacrifice (*boboney*) to the spirit of the water who had become his "son-in-law" (*woupoh*), to ensure its continual blessing (*bobono*) upon the community. He was assisted in his institutional responsibilities by the 13 other heads of families.

When the inlet silted up, the headman had to decide when to organize the opening, in agreement with the other 13 family heads. He was in charge of organizing the search for any drowned person (*okougni*) and the cleaning of the lagoon, in the spiritual sense, from unholy things such as a drowned person. When fish sizes became too small, the headman in agreement with the other 13 family heads closed all fishing. This closing could last from 3 to 6 months. The term of office for the headman of the institution was fixed as his lifetime. The successor (*n'glignon*) had necessarily to be a relative of Dati. Generally elders of Dati's family held a meeting to choose the successor.

5.3.1.4 Rules and enforcement

Laws were enforced under the *N'gni* system to protect the lagoon resources. This worked in two different ways. First, the belief in the existence of *Monagnro*, the spirit of the water, acted as a powerful watch-tower upon the community. The following account happened to 77 year-old key informants from Fresco:

> "I was engaged in night fishing with my grand brother on the area called *Dabian,* in the north of the lagoon, a few years ago. We knew it was Thursday and we planned to come back before midnight. Unfortunately a strong storm suddenly started and the lagoon was so stormy that it was not safe for us to go with our small banana boat (*koilou*). We decided to take cover under mangrove roots and wait until the water become calm. When the storm stopped, midnight was already past. We realized that it was the visiting hour for *Monagnro,* the water spirit. We were so afraid that we couldn't even talk. We saw stars in the water around us. We immediately tied up the boat on the edge of the water and ran in the forest to come home. In the morning we went to see the headman (who was Kokora Pascal at that time) with my father to tell the story and expressed our sincere repentance. No sacrifice (*boboney*) was requested from us, as we immediately stopped fishing and got out from the water when we realized that it was midnight but, I had never been so afraid before and this was a lesson for me!"

Secondly, the Godie community was very small, and members lived and worked closely with each other, which helped each one to control his neighbour. Moreover, most fishing methods were collective and therefore it was difficult for a single individual to hide. Hence, the whole community worked as one body with the family heads under the leadership of the headman of the institution.

Nevertheless, various rules were enacted to enforce the protection of the lagoon. Informants revealed that a user found fishing on Friday was tied up and beaten before the institution's headman. Furthermore, he was liable to pay a fine of a *noteto,* large bottle of dry gin, and a *wle,* a goat, as a sacrifice to the spirit of the water, and his boat was confiscated. A goat was expensive and hard to get in the surrounding area. A boat was also very expensive as its construction took at least six months due to the lack of appropriate equipment and it was not made locally, and so had to be ordered from Grand-Lahou or Sassandra. When the construction was complete, the owner had to hire people to pull it into the water. He would then have to paddle from Grand-Lahou or Sassandra to Fresco, which was not easy. Moreover, as the family depended on a boat for most of its activities, this made it hard for someone to have his confiscated.

5.3.2 Changes in the management system after the year 1967

Cote d'Ivoire became independent in 1960. The new land tenure code (*code foncier*) distinguished three main categories of land within the new state:

- the permanent estate comprising mainly Protected areas;
- the rural estate; and,
- private estate.

The lagoon system of Fresco fell into the rural estate, to which all the country's citizens had a uniform usufruct right under state ownership. Since the *N'gni* system was based on a customary land sharing system mixed with traditional beliefs unrecognized by the new law, it no longer had a legal basis on which to exist. Hence, access to the lagoon became open to all non-local and non-national fishermen, as free enterprise was the economic option now chosen by the state. Nevertheless, since the lagoon was located in a remote area that did not attract much outside interest, the N'gni system continued to operate until 1967.

In 1967, the village of Fresco with its 12 districts was resettled to a new site by the central government. This resettlement was motivated by several different reasons. Firstly, the original village was located on a very small strip of sand between the sea and the lagoon and was regularly subjected to the tidal flood and coastal erosion. Secondly, the government planned to group together several small villages in order to provide the basic administrative services. This plan ultimately aimed to provide the community with the opportunity to gain access to a school, a health centre and other social facilities. A fishery service was also among the basic administrative services established by the government in the new village of Fresco. Following this resettlement and the implementation of new state legal dispositions by the fishery service, various changes occurred over access to the lagoon, including the composition of its users and its management system.

Firstly, the location of what was now known as the new city of Fresco was about 1.5 km from the sea. This distance appears relatively short, but the resulting extra effort needed to gain access to the sea was considerable. A 79 year old key informant described the new situation as follows:

> "Fishing in the sea became very hard. We had to wake up very early in the morning and cross the whole lagoon. This was particularly difficult if it was during the high tide. We had to paddle against the water current. After crossing the lagoon, we had to pull the boat across the sand before gaining access to the sea. We avoided passing through the inlet because it was too dangerous. After fishing, we had to repeat the same exercise on our way back. The only way we could avoid this extra effort was to possess at least two boats, one kept on the lagoon and another one on the coast. None of us could afford this luxury."

As a result, villagers progressively avoided fishing in the sea and increasingly fished in the lagoon. A 75 year-old informant argued:

> "Fishing in the sea was indeed more profitable but we had no choice. We had to cope with the lagoon which was more accessible and where fishing was relatively easier."

Secondly, the traditional common property resources management system was effectively abolished. An informal co-management board was arranged between the government representatives and the native users' community. The composition of this co-management board was as follows:

- Head of the committee: local state administrator (Sous-prefet); and

- Native users representatives: cheif of Fresco assisted by the heads of the 12 districts of Fresco and the cheifs of the villages of Zakareko and Bohico.

The allocation of licenses, file keeping, advisor and other administrative activities were undertaken by the local state fishery service. Law enforcement, the charging and fining of offenders were undertaken by rangers of the Department of Water and Forests (Division of Fresco). Non-local and non-national fishermen settled or recently arriving in Fresco could purchase a fishing license from the local state fishery service for commercial fishing in the lagoon or in the sea. However, the native users' community vigorously complained that the lagoon was too small in size. They finally obtained an agreement with the fishery service, under the mediation of the local state administrator, to strictly limit the number of non-native users to six individuals. Moreover, the six non-natives user as well as their proposed fishing methods, had to be approved by the natives users' representatives in the co-management board before they could purchase any license from the local state fishery service.

Regarding the sea, respondents explained that a few months after the resettlement of the 12 districts, a group of *Fanti* composed of professional fishermen from Ghana, immigrated to the region and requested to establish their operation in the recently vacated site of Fresco village, and fish in the sea. The local government representatives, including the local state fishery service, agreed but the native community was divided with elders in favour but the youths against this proposal. Nevertheless, the area was given to the *Fanti* community. When this new settlement became established, tremendous conflicts occurred between the *Fanti* and the Godie, particularly among the youths, which resulted in the first Fresco "fishing war". Below is the description of events given by respondents as consequence of the settlement of the *Fanti*:

- The *Fanti* fishermen were professional and relatively well equipped with some motorized boats to fish in the sea. Thus, the native community had to face not only the distance from their new settlement to the sea, but also competition with better equipped *Fanti* fishermen. As a result, Godie fishermen who continued to fish in the sea totally stopped and concentrated their fishing in the lagoon, whose status, therefore, moved from a seasonal to a year round fishing ground.

- *Fanti* fishermen were not allowed to fish in the lagoon. However, when the weather was bad at the sea, they organized nocturnal poaching in the lagoon. Furthermore, *Fanti* women needed fuel wood to smoke fish caught by their men. Hence, mangrove forest around the lagoon became heavily used.
- Finally, *Fanti* were suspected of drowning a youth in the sea every year for ritual purposes. In 1999, a youth from the Godie community mysteriously disappeared on the coast. This was the spark that ignited the conflict, although there was no direct evidence linking this death to the *Fanti*. However, the Fresco "fishing war" started, and the *Fanti* village was burnt by youths of Fresco, many boats were destroyed and the entire group of *Fanti* was expelled from the area.

Thirdly, the head of Dati's family lost much of his power, but retained his traditional belief in the spirit of the water. As a head of the district of Datibery, he was included in the co-management committee as one of the native users' representatives under the Sous-prefet of the city of Fresco. Nevertheless, he remained the keeper of traditional culture by continuing to offer annual sacrifices to the water spirit, by deciding on and organizing the opening of the inlet, as well as by searching and organizing burial ceremonies for a drowned fisherman.

Fourthly, based on an Administrative Decentralization Reform undertaken by the state in 1990, the city of Fresco became a district and a town council was elected. Under this reform, the area of the district managed by the town council extended 9 km around the city. Therefore, this now included the lagoon which fell under the control of the Fresco town council. As a result, the Fresco town council gained the legal right to request council taxes from those using the lagoon. The council was admitted as member of the co-management board in charge of collecting annual council taxes from users.

Most respondents described the co-management of their former common property resources as ineffective since 1967. For instance, the ranger service of Fresco, charged to enforce laws, had no boat to patrol on the lagoon. Most rangers could not even swim and were afraid to work on the water. Before their expulsion, no one tried to fine the *Fanti* fishermen although they poached on the lagoon. Nevertheless, the amount of annual fishing taxes paid to the Fresco town council now represented about 70% of the council budget. Below is the description of the situation by a 63 year-old respondent from the *Gbaco* district of Fresco.

> "Finding fish in the lagoon today is very hard. In the past fishing lasted 1 to 2 hours but today we spend the whole day on the water with few caught. The fishery, the town council and rangers service do not care about our future. We always complain and report people who practice harmful fishing but nothing had been done to stop them. The rangers know who is using "*gamarine*" (local toxic products) to poison the lagoon. They know were they live but they do not take any action. Surprisingly, we always see them sitting and drinking together."

5.4. Discussion

For people in the developing world whose lives are directly dependent on renewable resources, common property regimes, grounded in a set of accepted social norms and rules, provide assurances that the resources on which all rightful users collectively depend will be available sustainably (Gibbs and Bromley, 1989; Mckean, 1996). The regulation of resource use is integrated into a broader system of community that defines and allocates individual and group rights to particular resources within the lands or waters held by the community. The idea of common property is well established in formal institutions such as Anglo-saxon common law and Roman law (Berkes and Farvar, 1989). Equally, the idea is also well established in informal institutional arrangements based on custom and tradition with many examples documented from Asia and Oceania (Ruddle and Akimichi, 1984; Ruddle and Johannes, 1985).

For centuries in Cote d'Ivoire, customs, traditions, rules and rituals upheld by tribal chiefs and village elders have played an important role in sustainable use of natural resources and sharing of lands among peoples. From the forest to the savannah customs and traditions varied according to the tribal groups. However, in most cases, the land belonged to the first settlers in the area or those credited with the original clearing or establishing of a recognized claim to it. From generation to generation, this holding was shared among the pioneer owner's descendants to whom usufruct rights for sharing were conferred when any claim was laid (Vial, 2002). The holding represented the area for farming, collection of firewood, grazing and thatching materials. Family territories in lagoons and rivers were defined by the projection on the water space of the terrestrial boundaries of the families' land. In other words, parts of rivers or lagoons next to individual or family land, were considered as that family river or lagoon territory (Regis, 2000; Vial, 2002).

This study is the first detailed study of the traditional common property resource management system in the lagoon complex of Fresco. The study has shown the positive influence of traditional values and beliefs, such as the spirit of the water, on the management system that once operated to control resource use in the lagoon, but that has since been replaced by a government driven co-management committee. The study has shown how the native users' community acted in their long-term common-interest to "specifying the commons" and so avoid what could have earlier become a Tragedy of the Commons in the lagoon (Hardin, 1968). Finally, the study has shown the adverse effects of redefining property rights and a resettlement undertaken with very little thought for the indigenous socio-economy and livelihood needs.

Hence, the *N'gni* system has shown all the attributes of a successful common property regime. It has demonstrated its capacity to cope with change occurring from the year 1967. Even today, an institution for the management of resource use still exists in lagoon of Fresco, despite all the government-driven changes imposed on it, and the consequent need to improve its effectiveness.

5.4.1. The N'gni Indigenous Resource Management System

The *N'gni* system was an indigenous common property resource management institution that incorporated rules and customs, and that was also influenced by the traditional belief in the spirit of the water. It developed as an informal institution established in response to the need to regulate uses in the lagoon, particularly fishing, and avoid conflicts, which may result from the commonly used gate fishing method. As importantly, the system sought to maintain continual reverence for the spirit of the water whose blessing was needed by the community.

Access to the lagoon for fishing was only allowed to fishermen who could prove that they were native of Fresco, Zakareko or Bohico. Therefore, the common property of the lagoon was not "everybody's property". The basic and probably the universal distinguishing feature of a common property regime, particularly in fisheries, is the limitation of access to resource (Scudder and Conelly, 1985). It is this feature that, if left unregulated, would indeed set the stage for the tragedy of the commons. Access for everyone means property for no one. Thus, without some kind of access limitation, a productive fishery would sooner or later attract enough fishermen to render it unproductive, a situation well illustrated by the Malaysian "tragedy of the commons" described by Anderson (1987).

Although rightful users could freely fish everywhere in the lagoon, they were further grouped into families with defined territories controlled by the family members under the leadership of heads of families. Fish are mobile resources that can freely swim from one area of water to another. Thus, there would indeed be a practical difficulties involved in claiming and enforcing exclusive rights to fish or to their habitats (Hardin, 1968). However, it is sometimes possible to develop strong notions of territorial rights to valued fishing grounds (Acheson, 1987; Carrier, 1987). A well-known fishermen's argument is that if they can keep others out, it makes sense for them to do something about their own behaviour. Hence, the carving out of smaller commons within the lagoon was an important means to avoid conflicts over gate fishing. Moreover, it represented a tool for the *N'gni* system to be more restrictive and more efficient in enforcing rules, controlling use, and more easily transferring rights from generation to generation across the entire commons.

The body of elders gave the traditional ownership of the lagoon to Dati and his family in gratitude for offering his daughter *Zahiro* in marriage to the water spirit to save the former Fresco village. However, access to the lagoon was open to the entire community and each family had its own territory so use of the lagoon was equally shared. Thus, the traditional ownership given to Dati and his family was not a private appropriation of the commons. Instead, it represented an honorary arrangement that was common to most traditional societies over the country. Nevertheless, as the only person who communicated and offered continual sacrifice to the water spirit, Dati and his successors had great influence within the community, as the water spirit was an important means of enforcing rules. In addition, the belief in the water spirit made ecological sense, as it made users to stop fishing from Thursday midnight untill Saturday morning.

5.4.2. The Decline of the N'gni System

The decline of the traditional management system occurred for two main reasons. First and indirectly, due to the resettlement of the 12 districts of Fresco to a new site. Second and directly, as result of the free-enterprise economic option of the newly independent Cote d'Ivoire and the implementation of a new land tenure and Administrative Decentralization Reform.

The resettlement of the 12 districts of Fresco was necessary because the original site was subject to successive floods when the inlet was closed, and to the coastal erosion. Furthermore, the state saw the need to improve the standard of living of the community. Unfortunately, the resettlement was not planned in a way that protected the livelihoods of the native community and their long-term socio-economic welfare. Fishing in the sea which had previously proved more profitable for the community of Godie, became a challenge. Furthermore, they faced the competition from well-equipped *Fanti* fishermen. As a result, fishing in the sea stopped. The loss of access to the sea represented a loss of income, and livelihood deterioration for the community of Godie. As a result, the lagoon, which had initially been set aside for the primary purpose of fishing during bad weather at sea, has become a year round fishing ground. Moreover, the native community may progressively lose their skill at fishing in the sea since the new generation will not gain the opportunity to learn from elders. Finally, as the human population has increased, the pressure on the lagoon may further increase threatening the fish stock. All this has resulted in an impoverishment of the community, confirming that a resettlement inequitably planned and irresponsibly implemented, often causes increased poverty (Cernea, 1997).

The settlement of a community of *Fanti* fishermen from Ghana on the former site of Fresco village, and the subsequent competition with native and poorer Godie fishermen in the sea, confirmed the fallacy of the free-enterprise economic option of the state. Although this option has had some positive effects on the development of some economic sectors, it has also resulted in uncontrolled and uncoordinated immigration with, in most cases, tremendous conflicts between native communities and outsiders (Martin, 1991). Thus, the Fresco "fishing war" between Godie and *Fanti* was not surprising. As McCay (1987) pointed out, a free-enterprise option in a fishing ground means freedom of navigation and fishing. In turn, such a process leads to resource depletion, while the commons is captured by powerful and wealthy fishers. In the case of the lagoon, mangrove forests were threatened for fuel wood for fish smoking, and the native community was expelled from the commons as they were unable to face the competition in the sea. Moreover, the *Fanti* were engaged in poaching practices in the lagoon during bad conditions in the sea. This confirms that the two communities had opposing objectives that increased the difficulty of cohabitation. *Fanti* were motivated to fish intensively to profit as much and as quickly as possible. In contrast, the native community was guided by their belief in the water spirit, and by their rules for preserving their local resources for long-term use and sustainability.

According to the new land tenure regime in Cote d'Ivoire, the lagoon of Fresco is included in the rural estate. As a result all the country's citizens have a uniform usufruct right under state ownership. Although the lagoon was not legally owned by the Godie community, it was managed in accordance with community-based norms, rules and traditional beliefs and was an integral part of the local culture. Throwing these traditions away proved a case of "throwing out the baby with the bathwater." The change in rights to the common property, and the subsequent setting up of a co-management committee, has rendered the management inefficient. This confirms the warning of Bromley (1985) who observed that the redefinition of property rights was the second major source of resource depletion. Hopefully, the strong complaints of the community have further avoided the Tragedy of the Commons, as the number of non-native users has been strictly limited.

How do the communities of native users from Fresco, Zakareko and Bohico and the non-native users of the lagoon perceive the current co-management system and what is/are their future management options? The next chapter deals with their attitudes towards the present day management and preferred future options.

CHAPTER 6 ATTITUDES TOWARDS THE CURRENT MANAGEMENT SYSTEM

6.1 Introduction

Many countries worldwide face environmental degradation, including deforestation, overgrazing, soil erosion and loss of cropland, misuse of biocides and other agrochemicals, and over-fishing. These problems can result in considerable human suffering, which in turn can seriously undermine future prospects for sustainable development. The failure of human societies to prevent such wide spread degradation is often discussed in terms of common property resource "mismanagement" (Hardin and Baden, 1977). In the developing world, the redefinition of property rights and the breakdown of traditional culture and systems are among the most important causes of natural resource depletion (Bromley, 1985; Anderson, 1987). In post-colonial societies throughout the world, new legislation has been enacted which redefines the rights of the state and sometimes breaks down traditional common property management systems and institutions (Mckean, 2000). In particular, land and water resources have been nationalized in the interest of all citizens of the state. Thus, villagers have seen their customary rights replaced and their incentives to conserve resources removed.

Common property regimes seek to provide assurances that resources on which all persons collectively depend will be available sustainably. The same assurance cannot be provided when the state adopts ownership in a free enterprise economic system, since the consequences for productivity, sustainability and equity are different. Indeed, the previous chapter described how the choice of a free enterprise economic system, and the resettlement of the 12 districts of Fresco with little care for their socio-economic and future livelihood needs resulted in increased pressure on the resources of the Fresco lagoon complex. It also showed how fishing activities in the lagoon were managed under the traditional *N'gni* system and how its subsequent replacement by a co-management committee resulted in weakened management.

Due to changes in the institutional arrangement for managing the resources of the lagoon, and inefficiency of the current management system, this chapter examines the present attitudes of the Godie community living around the lagoon towards the co-management of their former common property resources initiated after 1967. The study aims to compare the attitudes of Godie from the village of Fresco, who used to fish in the sea but now concentrate their fishing in the lagoon against their will, with the attitudes of villagers from Bohico and Zakareko who have always used the lagoon, and finally with the attitudes of non-native users who have recently become lagoon users. Native and non-native users have different historical perspectives regarding the management of the lagoon. Following a basic demographic and social description of those respondents interviewed in Bohico, Zakareko and Fresco, the following questions are examined:

- do views on the effectiveness of the traditional N'gni system differ between the Godie of Fresco and the Godie of Zakareko and Bohico?
- do native and non-natives respondents have different views on the effectiveness of the co-management system ? and,
- what factors determine the different views between users and what future management system do they prefer ?

6.2 Methods

A semi-structured questionnaire interview schedule with both closed-ended and open-ended questions was conducted in French among a sample of households from Fresco, Zakareko and Bohico (De Vaus, 1996; Frankfort-Nachmias and Nachmias, 1996). Different definitions for household may be relevant in different societies, but for the purpose of this study, a household was considered as those people sleeping under the same roof or sharing the same compound. The questionnaire had three main sections:

- respondents' profiles, to gain an insight into the composition of the community. This included demographic data such as sex, age, household size, ethnicity, level of education and length of residence;
- socio-economic data, to assess income levels;
- preferred future management systems for the lagoon.

The two first sections consisted of closed-ended questions, while the third part comprised open-ended questions, which began with a filter question to which "Yes" or "No" response was appropriate (Appendix III).

As complete lists of households were not available for the villages, half the respondents were selected by sampling every third house while the other respondents were selected by sampling every fifth person on the street or on the lagoon. Males and females were sampled as evenly as possible to obtain an approximately even sex ratio among respondents. A total of 243 individuals comprising, 218 natives Godie and 25 non-natives, were interviewed in the three villages.

6.2.1 Statistical Analysis

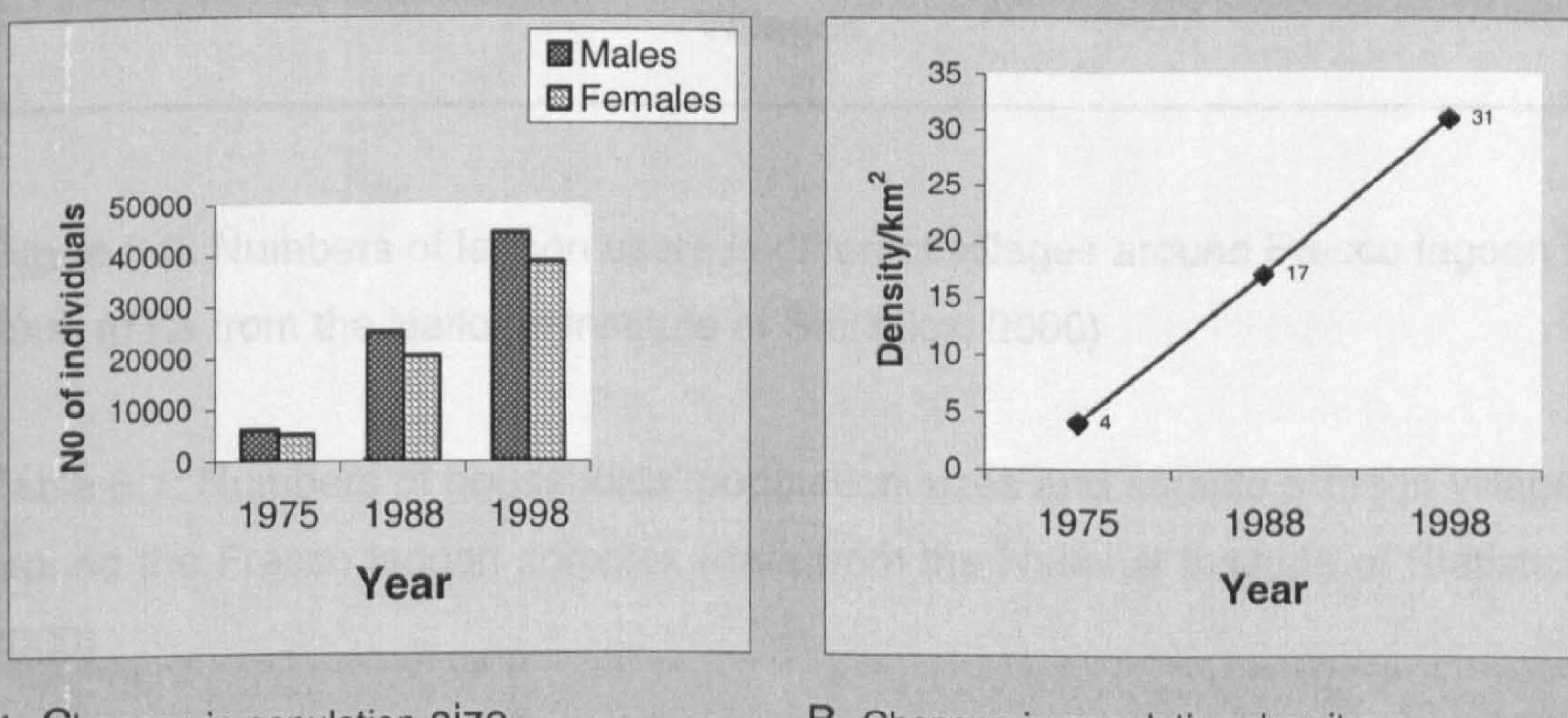
All data were analyzed using SPSS version 11.5 and Excel 2002 for Windows. Parametric and non-parametric statistics (Independent samples t-test, Pearson product-moment correlation, Chi-square and one-way ANOVA) were used to examine relationships between attitudes and socio-economic variables. Significant differences between respondents were investigated using the Tukey Honesty test after ANOVA test. Logistic regression was used to examine the extent to which sex, education levels, origin (whether native or non-native), village, age and length of residence were associated with, or might predict views on whether or not present day management was effective. Logistic regression was used because of its ability to describe the relationship of several independent variables to a dichotomous dependent variable (Tabachnick and Fiddell, 1996). Its flexibility allows the use of any mix of predictor, continuous, discrete and dichotomous variables. The dependent variable was taken as dummy of 0 if the response was negative, and 1 if the response was positive.

Crops cultivated were grouped into two categories. Subsistence crops comprised: casava, rice, maize, and banana. Commercial crops comprised: cocoa, coffee, rubber and coconut. Based on their ethnic groups, respondents were classified into two different origins: native respondents from the Godie ethnic group, and non-native groups.

6.3 Results

6.3.1 Demography and socio-economic patterns

The human population living in the Fresco region increased from 11,667 inhabitants with a density of 4 inhabitants per km^2 in 1975, to 83,462 inhabitants with a density of 31 inhabitants per km^2 in 1998 (Figure 6.1).



A. Changes in population size B. Changes in population density

Figure 6.1: Change in human population size and population density in Fresco region from 1975-1998 (data from National Institute of Statistics, 2000)

The lagoon users' community comprised around 10% (8,667 individuals) of the total population in Fresco region in 1998. Fresco city contained most users, some 80%, followed by Zakareko with 13% of users and Bohico with only 7% of users. Males represented 53% of users, while females represented 47% of the users (Figure 6.2 and Table 6.1).

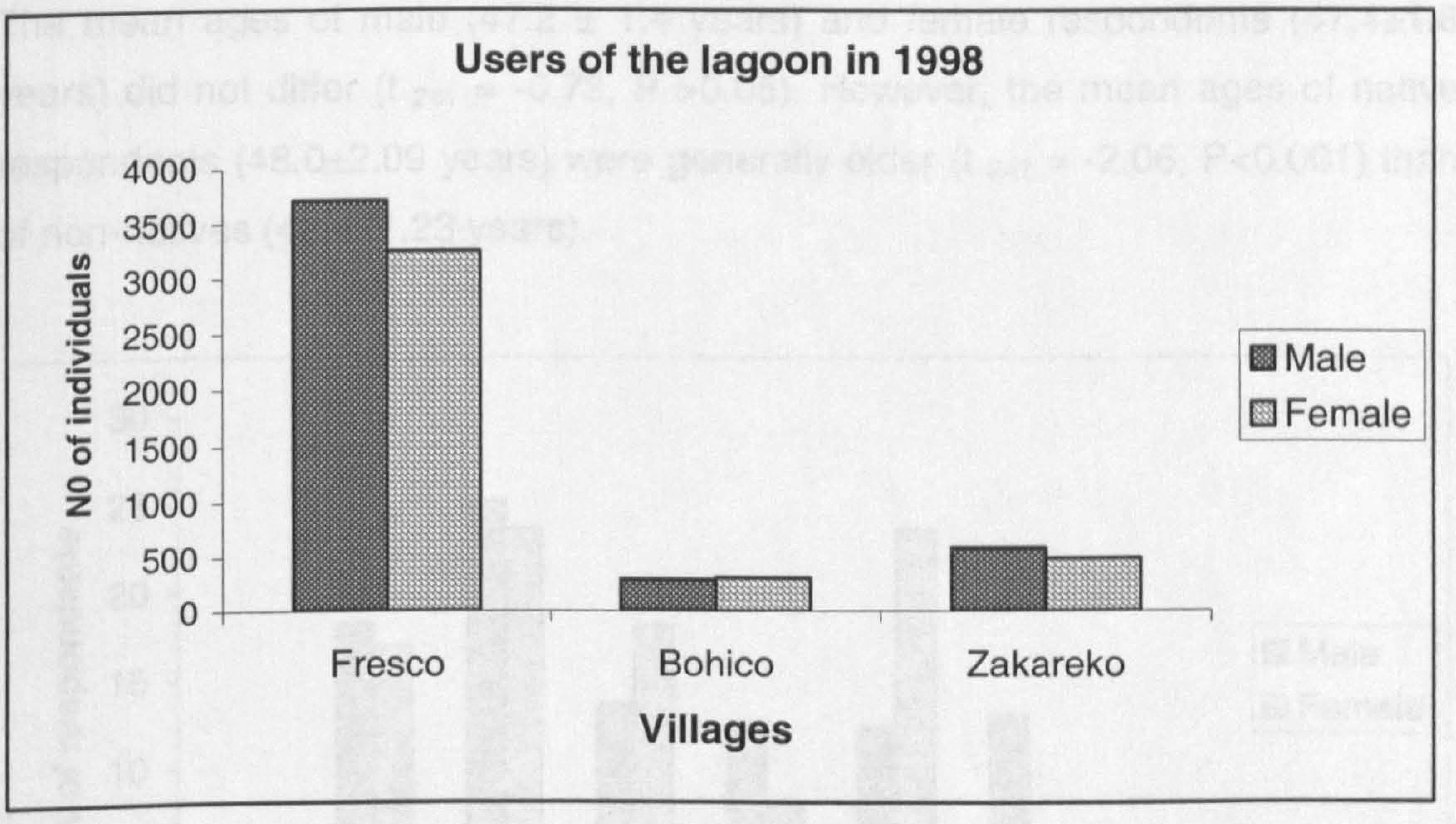


Figure 6.2: Numbers of lagoon users in different villages around Fresco lagoon in 1998 (data from the National Institute of Statistics, 2000)

Table 6.1: Numbers of households' population sizes and sample sizes in villages around the Fresco lagoon complex (data from the National Institute of Statistics, 2000)

Village	Household	Male	Female	Total	Sample size
Fresco	1487	3714	3261	6975	139
Zakareko	218	592	496	1088	56
Bohico	133	293	311	604	48
Total	1838	4599	4068	8667	243

The ages of respondents ranged from 15 to 82 years. The most represented age group was 30-39 years with 25% of the total sample, followed by the 20-29 year age group with 18%, while the 15-19 year and 80-89 year age groups were the least represented, each with 2.5% of the total sample (Figure 6.3).

The mean ages of male (47.2 ± 1.4 years) and female respondents (47.4±1.8 years) did not differ (t_{241} = -0.73, P >0.05). However, the mean ages of native respondents (48.0±2.09 years) were generally older (t_{241} = -2.06, P<0.001) than of non-natives (40.4±1.23 years).

Figure 6.3: The age and sex classes of respondents from the three villages around the Fresco lagoon complex.

The length of residence of respondents in the study area ranged from 1 to 82 years. The length of residence of male respondents (29.8±1.77 years) and female respondents (31.4±2.4 years) did not differ (t_{241}= -0.52 P>0.05). However, unsurprisingly, native respondents (32.6±1.5 years) had resided for considerably longer (t_{241} = 21.55, P<0.05) in the area than non-native respondents (11.4±1.7 years). Similarly, the length of residence did not differ ($F_{2, 240}$=1.180 P>0.05) between the three villages, although respondents from Bohico (33.6±3.3 years) have resided in their village for slightly longer than respondents from Zakareko (32.3±2.9 years) and from Fresco (22.3±1.9 years).

Household size among respondents ranged from 1 to 30 with a mean of 7.18±4.7. Household size did not differ ($F_{2, 240}$=2.310, P>0.05) between the three villages, although household size in the village of Fresco (7.7±0.4) was slightly higher than Bohico (6.7±0.7) and Zakareko (6.2±0.4). However, non-native respondents (6.7±0.8) had similar household size (t_{241} = -0.592 P>0.05) to native respondents (7.2±0.3).

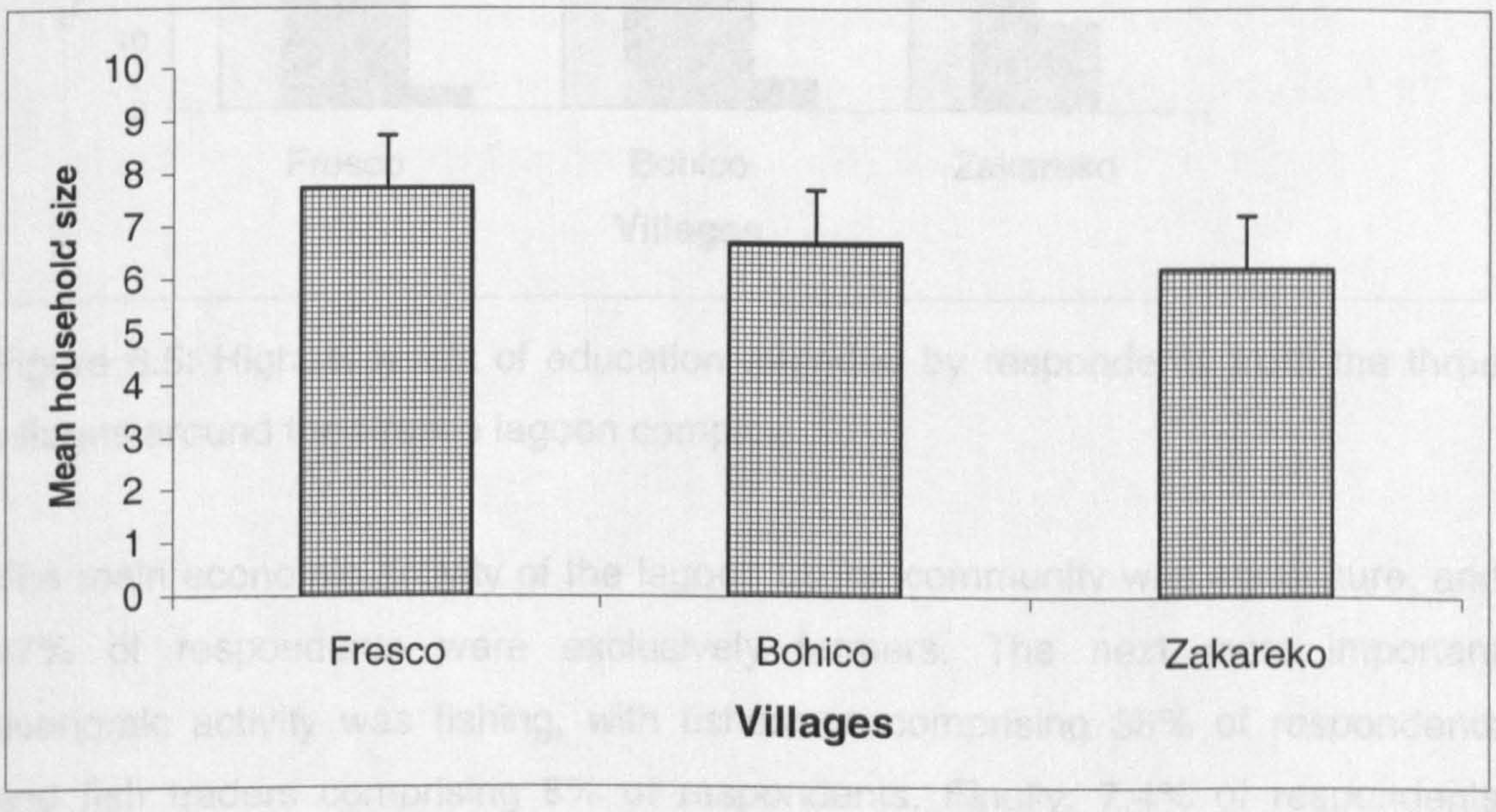


Figure 4: Mean household size of respondents from the three villages around the Fresco lagoon complex

Most (47%) respondents had not attended any school. Some (26%) respondents had attended only primary school while a further 25% of respondents had attended secondary school. However, only 2% of respondents had attended the university. Education levels differed (x^2=13.61, df=6, P<0.05) between the three villages. Respondents from Bohico were generally more educated, while respondents from Zakareko had the least education (Figure 6.5). Native respondents were generally better educated than non-native respondents (x^2= 4.2, df=3, P<0.05), and male respondents were better educated than female respondents (x^2 = 30.74, df =3, P<0.001).

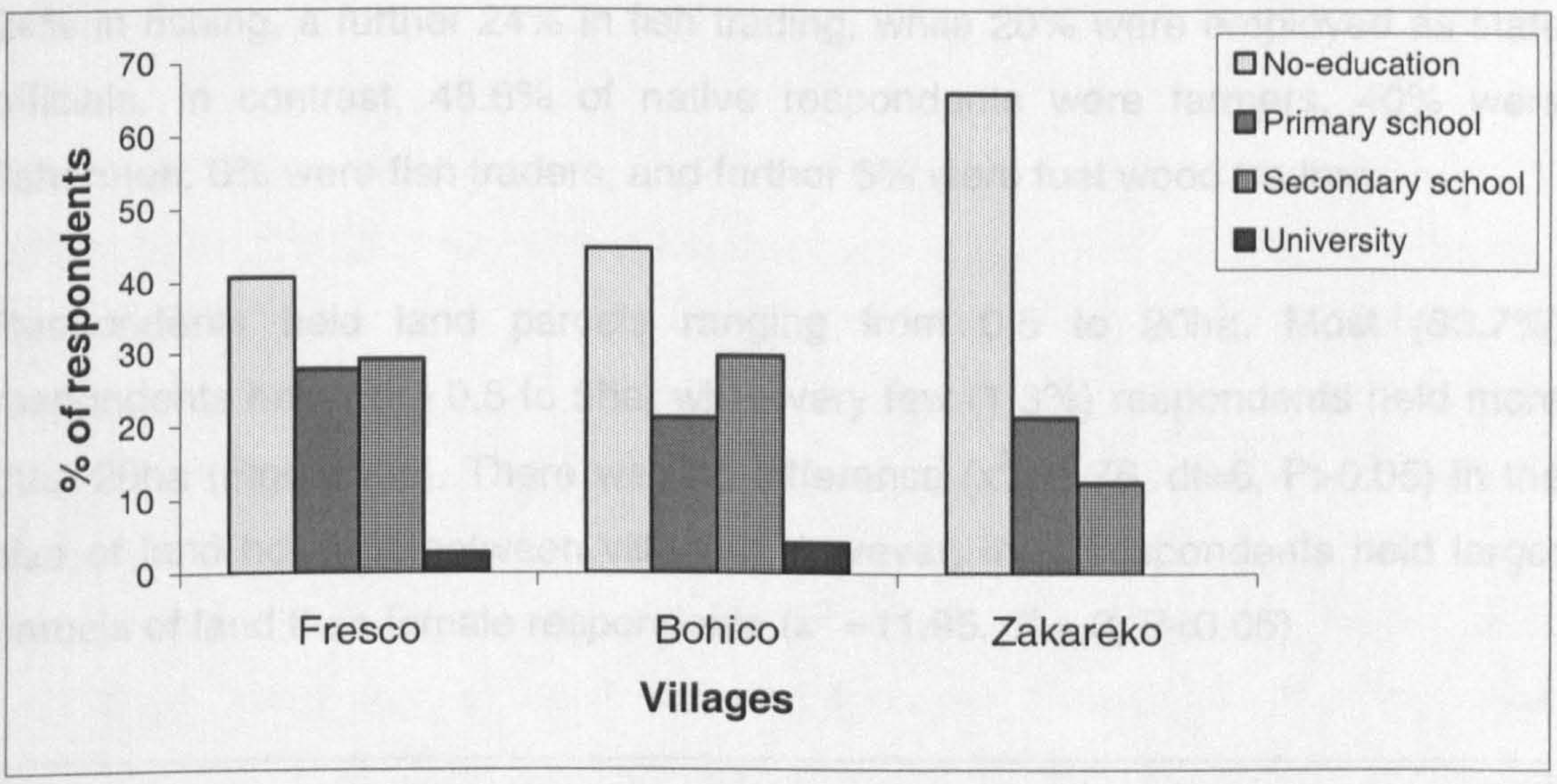


Figure 6.5: Highest levels of education attended by respondents from the three villages around the Fresco lagoon complex

The main economic activity of the lagoon users' community was agriculture, and 47% of respondents were exclusively farmers. The next most important economic activity was fishing, with fishermen comprising 38% of respondents and fish traders comprising 8% of respondents. Finally, 7.4% of respondents were engaged in firewood collection. Many (38%) respondents reported having a secondary activity. Among these, 39% considered farming as their secondary activity, while another 38% and 23%, respectively, reported fishing and fish trading as their secondary activity.

Male and female (x^2 = 67.92, df=6, P<0.001), and native and non-native (x^2 = 29.87, df=6, P<0.001) respondents differed in terms of the principal activities in which they were engaged. Most (56%) male respondents were engaged in fishing, while 38% were principally farmers, and only 1% of males were engaged in fish trading and further 5% were involved in other activities. In contrast, most (63%) female respondents said farming was their principal activity, while 20% of female respondents were engaged in fish trading, 10% in fishing and 7% in fuel wood trading. Among non-native respondents, 32% were engaged in farming, 24% in fishing, a further 24% in fish trading, while 20% were employed as state officials. In contrast, 48.6% of native respondents were farmers, 40% were fishermen, 6% were fish traders, and further 6% were fuel wood traders.

Respondents held land parcels ranging from 0.5 to 20ha. Most (83.7%) respondents held from 0.5 to 5ha, while very few (1.3%) respondents held more than 20ha (Figure 6.6). There was no difference (x^2 =5.76, df=6, P>0.05) in the size of land holdings between villages. However, male respondents held larger parcels of land than female respondents (x^2 =11.95, df = 3, P<0.05).

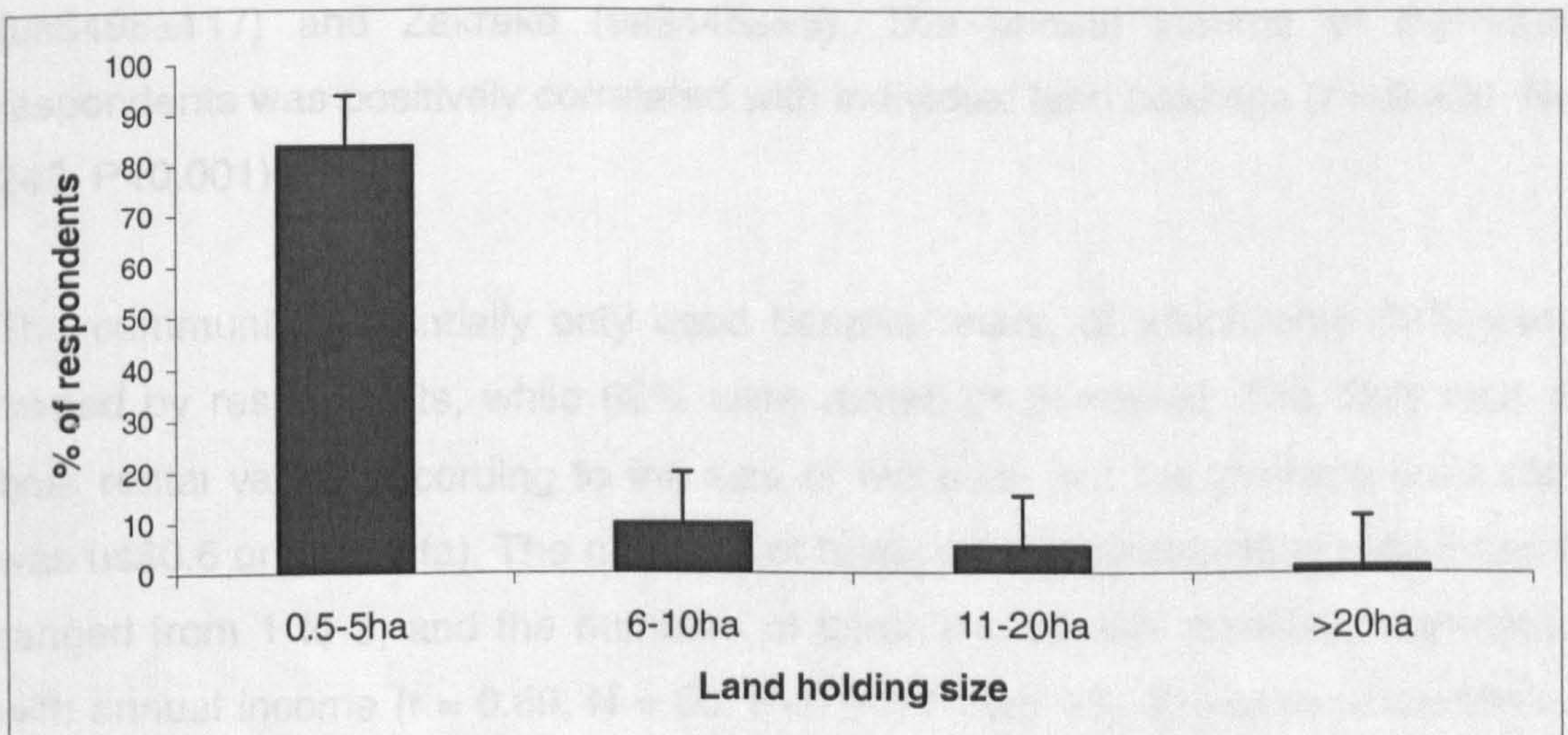


Figure 6.6: Size of land holdings (ha) among respondents from the three villages around the Fresco lagoon complex

Most (59%) farmers who responded grew subsistence crops, while 27% grew commercial crops and 14% grew both subsistence and commercial crops. There was no difference in the type of crops grown by the three villages (x^2=8.744, df=4, P>0.05). However, male and female respondents differed (x^2=37.89, df=2, P<0.001) in the types of crop they grew. More males (42%) grew commercial crops than females (3.5%). In contrast, more females (89%) than males (39%) grew subsistence crops.

Annual incomes among respondents ranged from us$85 (50,000 fcfa) to us$3,060 (1,800,000 fcfa) with a mean of us$501±47.7. Male respondents had considerably higher (t_{242} = 5.360 P<0.001) income (us$686±70) than female (us$183±22.2) respondents. There was no significant difference (t_{242}= 1.238 P>0.05) between non-native (us$676±183) and native respondents (us$ 481±49) in terms of annual income. Similarly, incomes from the three villages did not differ ($F_{2,\ 240}$ = 0.219, P>0.05), although mean income of respondents from Fresco (us$524±63) was slightly higher than mean income of respondents from Bohico (us$498±117) and Zakreko (us$446±95). The annual income of individual respondents was positively correlated with individual land holdings (r = 0.420, N= 243, P<0.001)

The community essentially only used banana boats, of which only 32% were owned by respondents, while 68% were rented or borrowed. The daily cost of boat rental varied according to the size of the boat, but the average daily cost was us$0.6 or (300 fcfa). The numbers of boats owned by individual respondents ranged from 1 to 3, and the numbers of boats owned was positively correlated with annual income (r = 0.69, N = 80, P<0.001). Only 4% of female respondents owned a boat compared with 28% of male respondents. Furthermore, the number of boat owners differed between villages (x^2 = 38.55, df = 2, P<0.001). More respondents (21%) from Fresco owned boat than from Zakareko (6%) and Bohico (5%). In contrast, the numbers of boat owners did not differ between native and non-native respondents (x^2=3.23, df=1, P>0.05).

6.3.2 Attitudes towards the management system

The lagoon users community considered the lagoon complex of Fresco to be important for various uses. The values placed upon different non-consumptive uses, in descending order, comprised: fish habitat; natural heritage; water source; cultural values, as home of the water spirit; and, aesthetic value (Figure 6.7).

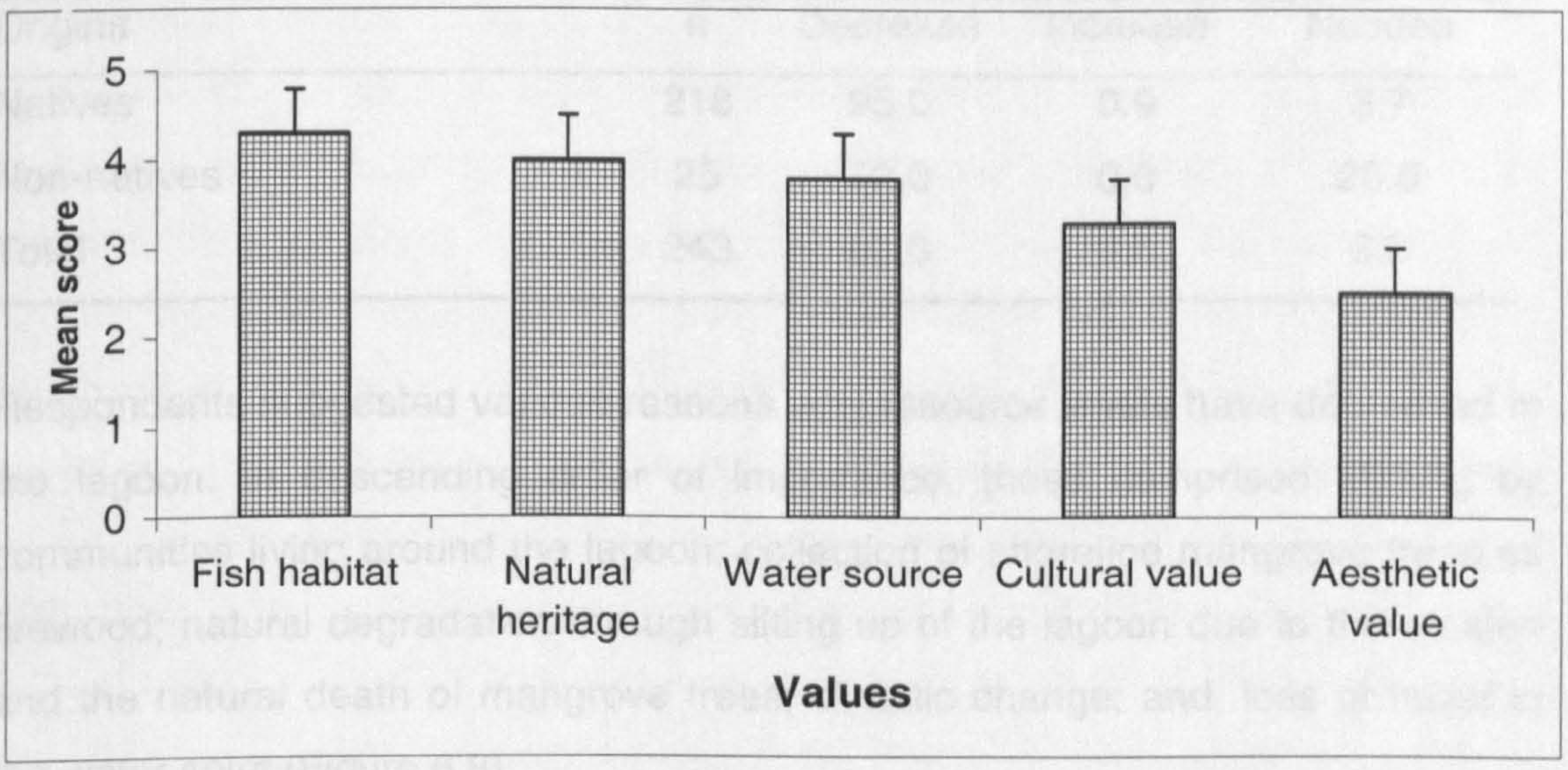


Figure 6.7: Mean ± SE of values placed by respondents upon different uses of the Fresco lagoon complex.

6.3.2.1. Success of lagoon resources conservation

Most respondents (93%) reported that the level of different resources in the lagoon had decreased over the last 25 years, while very few (0.8%)of respondents thought resource levels had not changed, and 6% of respondents had no idea of trends in levels of different resources. Views of respondents did not differ between villages (x^2 = 2.04, df=4, P>0.05) or between sexes (x^2 = 3.95, df=2, P>0.05). However, there was a marked difference of opinion between native and non-native users (x^2 = 23.05, df=2, P<0.001). Some 72% of non-native respondents reported that resource levels had decreased, while 28% did not know. In contrast, 95% of native respondents reported that resource levels had decresed, while only 0.9% thought resource levels had not changed, and 3.7% had no idea of trends. No differences were observed between the views of different age groups (x^2 =15.91, df=14, P>0.05), and of those with different levels of education (x^2= 2.26, df =6, P>0.05).

Table 6.2: The contrasting views of native and non-native respondents on the changes in resource level in Fresco lagoon over 25 years

Origins	n	Decrease	Increase	No idea
Natives	218	95.0	0.9	3.7
Non-natives	25	72.0	0.0	28.0
Total	243	93.0	0.8	6.2

Respondents suggested various reasons why resource levels have decreased in the lagoon. In descending order of importance, these comprised: fishing by communities living around the lagoon; collection of shoreline mangrove trees as firewood; natural degradation through silting up of the lagoon due to the erosion and the natural death of mangrove trees; climatic change; and, loss of belief in the water spirit (Figure 6.8).

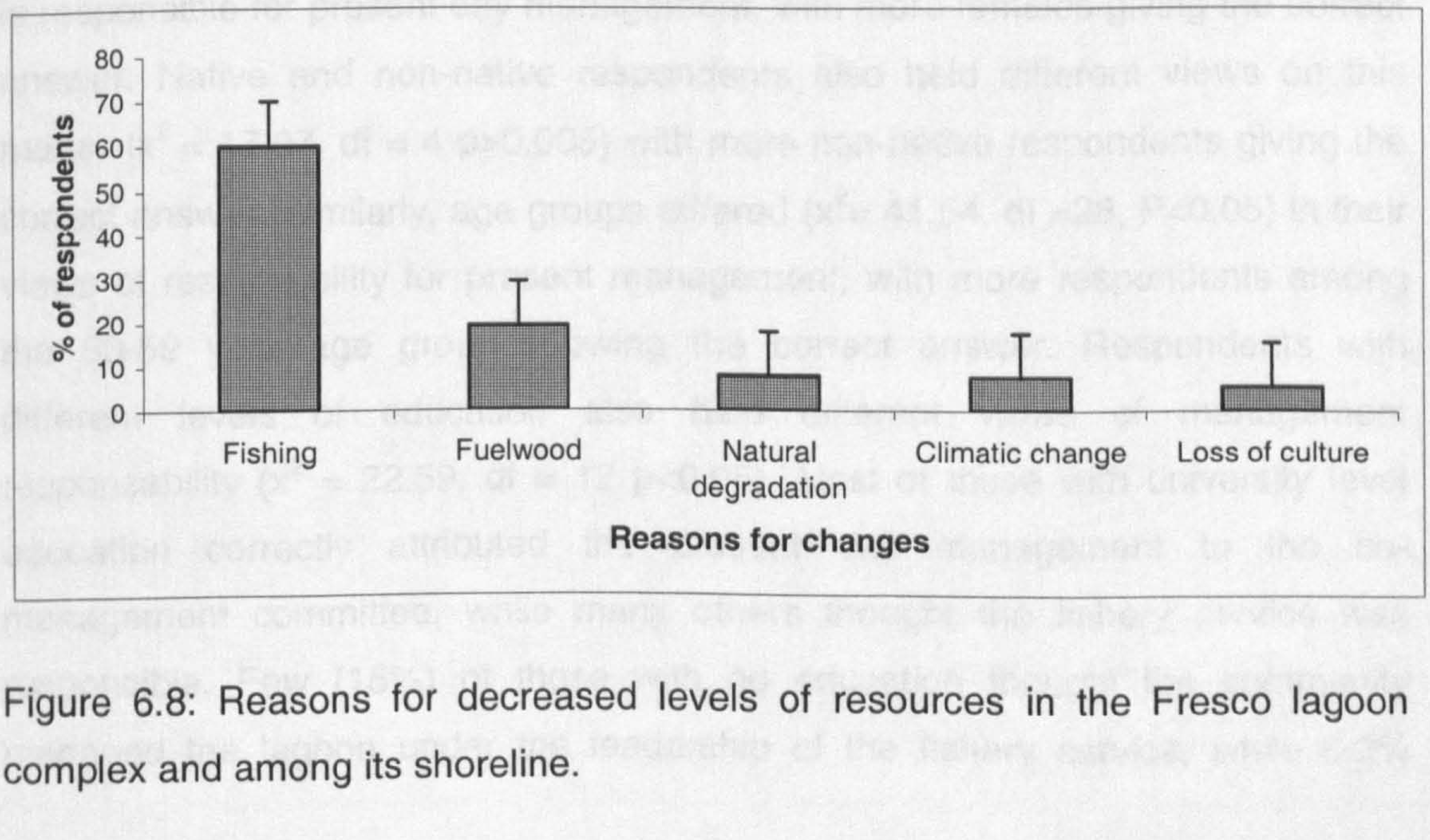


Figure 6.8: Reasons for decreased levels of resources in the Fresco lagoon complex and among its shoreline.

6.3.2.2 Knowledge of past and present management systems

The management of resources in the lagoon under the N'gni system was considered as effective by all native respondents. Most members (99.8%) of the Godie community from the three villages had observed a decline in the level of resources in the lagoon since 1967.

Respondents held different views as to who is responsible for the present day management of Fresco lagoon (Table 6.3). Some respondents (17%) continued to believe that resources were still managed by the communities under the leadership of the traditional owner of the lagoon. In contrast, 24% of respondents believed that the Fishery service is responsible for the present day management, while further 21% believed the body of chiefs of the three villages was responsible, and 8.6% thought the Fresco town council was responsible. However, only 28.8% of respondents believed that the co-management committee was currently responsible for the management of the lagoon. Views as to who is responsible for the present day management of the lagoon differed ($x^2 = 33.68$, df = 8, $P<0.001$) between the three villages with more villagers in Zakareko giving the correct answer (Table 6.3). Likewise, male and female respondents differed ($x^2 = 11.60$ df = 4 $p>0.05$) in their views of which institution is responsible for present day management, with more females giving the correct answer. Native and non-native respondents also held different views on this matter ($x^2 = 17.07$, df = 4 $p>0.005$) with more non-native respondents giving the correct answer. Similarly, age groups differed ($x^2 = 41.54$, df =28, $P<0.05$) in their views of responsibility for present management, with more respondents among the 50-59 year age group knowing the correct answer. Respondents with different levels of education also held different views of management responsability ($x^2 = 22.59$, df = 12 $p<0.05$). Most of those with university level education correctly attributed the present day management to the co-management committee, while many others thought the fishery service was responsible. Few (15%) of those with no education thought the community managed the lagoon under the leadership of the fishery service, while 5.2%

thought it was under the leadership of the Fresco town council, 27.8% thought that the villages heads were responsible, 33.9% thought it was under the leadership of the traditional owner of the lagoon and only 17.4% thought it was managed by the communities under the co-management committee. Views as to who now manages the lagoon also differed (x^2=49.76, df=24, p<0.005) according to the major activities in which respondents were engaged. Surprisingly, fishermen gave the least correct answers. However, views did not differ (x^2 = 20.50, df =16, P>0.05) according to length of residence.

Table 6.3: Views of different groups of respondents as to who is currently responsible for managing the Fresco lagoon complex.

Groups	n	Fishery service (%)	Town Council (%)	Villages' Chiefs (%)	Traditional owner (%)	Co-management Committee (%)
Villages						
Fresco	139	24.5	10.8	25.9	18.7	20.1
Zakareko	56	7.1	7.1	17.9	16.1	51.8
Bohico	48	43.8	4.2	10.4	14.6	27.1
Sexes						
Males	154	30.5	8.4	20.8	13.	27.3
Females	89	13.5	9.0	21.3	24.7	31.5
Origins						
Natives	218	21.1	9.2	22.5	19.3	28
Non-natives	25	52.0	4.0	3.9	0.0	36
Ages						
15-19 years	6	0.0	16.7	50.0	16.7	16.7
20-29 years	43	20.9	9.3	16.3	16.3	37.2
30-39 years	60	25.0	5.0	20.0	25.0	25.0
40-49 years	37	24.3	10.8	5.4	24.3	35.1
50-59 years	26	42.3	0.0	15.4	3.8	38.5

60-69 years	40	17.5	17.5	32.0	15.0	17.5
70-79 years	25	20.0	8.0	32.0	8.0	32.0
80-89 years	6	50.0	0.0	33.3	16.7	0.0
Education levels						
No-education	115	15.7	5.2	27.8	33.9	17.4
Primary	61	26.2	9.8	18.0	16.4	29.5
Secondary	62	21.0	14.5	12.9	19.4	32.5
University	5	40	0.0	0.0	0.0	60.0
Activities						
Farmers	114	21.9	7.0	17.0	19.3	34.2
Fishermen	93	23.7	12.9	25.8	12.9	24.7
Fish traders	19	15.8	0.0	26.3	21.1	36.8
Other	17	40.0	0.0	40.0	20.0	0.0
Total	**243**	**24.3**	**8.6**	**21**	**17.3**	**28.8**

6.3.2.3 Effectiveness of present management

Most (69.1%) respondents considered the current management of the lagoon to be ineffective, while 30.9% thought it was effective (Table 6.4). Respondents from each village differed (x^2 = 5.38, df =2, P<0.05) in their view of the effectiveness of present management. Most villagers in Fresco thought present management was ineffective, while more villagers from Zakareko thought it was effective. In contrast, views on the effectiveness of present management did not differ between the sexes (x^2 = 0.195, df = 1, P>0.05). Non-native and native respondents differed (x^2 = 22.09, df =1, P<0.001) in their views of the effectiveness of the present day management. Most (72%) non-native respondents thought the current management was effective, while most (73.9%) native respondents thought it was ineffective. Likewise, views on the effectiveness of of the present day management differed (x^2 =16.36, df =7, P<0.05) between age groups. In contrast views on the effectiveness of present management did not differ between education levels (x^2 =5.52, df = 3, P>0.05), between respondents following different major occupations (x^2 = 10.81, df = 6, P>0.05), or between lenght of residence (x^2 = 68.76, P>0.05).

Table 6.4: Views of respondents from the three villages on whether or not present day management of the Fresco lagoon complex is effective.

Groups	n	Effective (%)	Not effective (%)
Villages			
Fresco	139	25.9	74.1
Bohico	48	32.1	67.9
Zakareko	53	43.8	56.3
Origin			
Natives	218	26.1	73.9
Non-natives	25	72.0	28.0
Age groups			
15-19 years	6	33.3	66.7
20-29 years	43	35.0	65.0
30-39 years	60	26.7	73.3
40-49 years	37	46.0	54.0
50-59 years	26	46.2	53.8
60-69 years	40	12.5	87.5
70-79 years	25	20.0	80.0
80-89 years	6	50.0	50.0
Total	**243**	**30.9**	**69.1**

Various reasons were identified for the ineffectiveness of present day management of the lagoon. In order of descending importance, these comprised: weak law enforcement (29.2%); increasing numbers of users (27.2%); resource over- exploitation (20.6%); poaching (14.4%); and, market pressures (8.6%) (Figure 6.9).

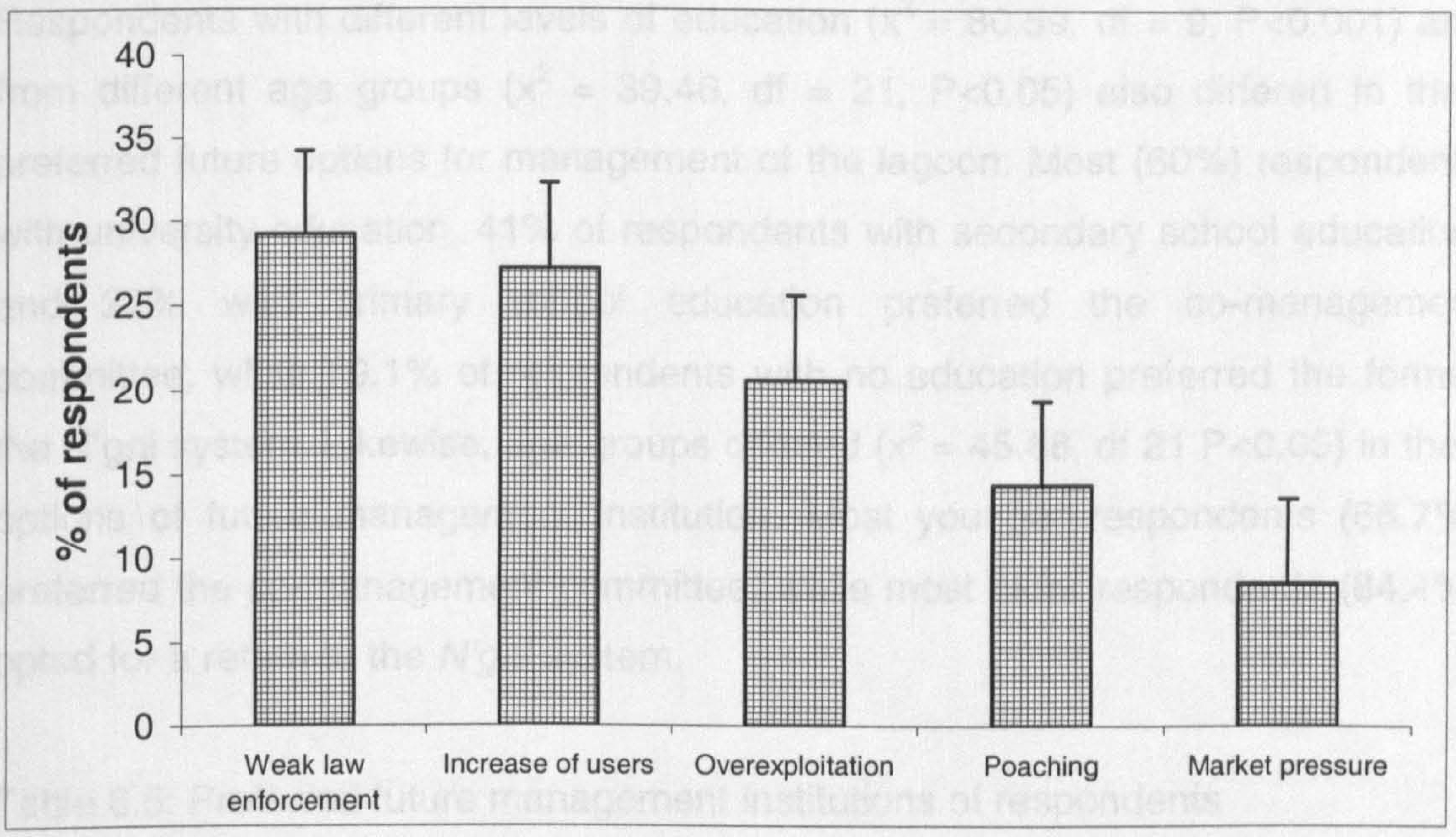


Figure 6.9: Problems responsible of the inefficiency of present day management of the lagoon complex of Fresco.

6.3.2.4 Preferred options for future management

Most (52.3%) respondents thought the management of resources in the lagoon would be effective only if it was returned to the former N'gni system. However, because of the increasing number of users from different cultural backgrounds, many respondents (25.5%) thought the management should remain under the co-management committee, but that law enforcement should be improved. A few respondents (18.5%) opted for the fishery service and even fewer (3.7%) opted for the Fresco town council. There was a difference in their preferred options for future management between villages (x^2= 8.61, df = 6, P>0.05), between male and female respondents (x^2 = 8.26, df = 3, P<0.05), and, between native and non-native respondents (x^2 = 43.78, df = 3, P<0.001). Most non-native respondents were divided between the fishery service and the co-management committee as their preferred future option, while most native respondents preferred a return to the N'gni system. Furthermore, most female respondents would prefer a return to the N'gni system (Table 6.5).

Respondents with different levels of education ($x^2 = 80.59$, df = 9, P<0.001) and from different age groups (x^2 = 39.46, df = 21, P<0.05) also differed in their preferred future options for management of the lagoon. Most (60%) respondents with university education, 41% of respondents with secondary school education, and 27% with primary school education preferred the co-management committee, while 79.1% of respondents with no education preferred the former the N'gni system. Likewise, age groups differed ($x^2 = 45.68$, df 21 P<0.05) in their options of future management institution. Most younger respondents (66.7%) preferred the co-management committee, while most older respondents (84.4%) opted for a return to the *N'gni* system.

Table 6.5: Preferred future management institutions of respondents

Groups	n	Fishery Service (%)	Fresco Twon council (%)	N'gni System (%)	Co-management Committee (%)
Villages					
Fresco	139	21.4	4.3	48.6	25.7
Bohico	48	21.3	4.3	44.7	29.8
Zakareko	56	8.9	1.8	67.9	21.4
Sexes					
Males	154	22.7	3.2	46.1	27.9
Females	89	11.2	4.5	62.9	21.3
Origins					
Non-natives	25	40	20.0	0.0	40.0
Natives	218	16	1.8	58.3	23.9
Ages groups					
15-19 years	6	16.7	0.0	16.7	66.7
20-29 years	43	25.6	4.7	37.2	32.6
30-39 years	60	28.3	3.3	40.0	38.3
40-49 years	37	21.6	10.8	45.9	21.6

50-59 years	26	19.2	3.8	50.0	26.9
60-69 years	40	12.5	0.0	75.0	12.5
70-79 years	25	8	0.0	88.0	4
80-89 years	6	33	0.0	66.7	0.3
Education levels					
No-education	115	5.2	1.7	79.1	13.9
Primary	61	26.2	3.3	42.6	27.9
Secondary	62	37.1	8.1	12.9	41.9
University	5	0.0	0.0	40.0	60.0
Total	243	18.5	3.7	52.3	25.5

6.3.2.4. Factors determining attitudes to management

Factors that might have predicted the attitudes towards the present management were examined using logistic regression only for the question related to whether or not present day management was effective, because this had a binary response

The model for factors which included village, origin, education level, sex, age, and length of residence explained 74.5% of the variance as to whether or not the present day management was effective, with a predicted probability (area under curve) = 0.737 (Table 6.6). Origin, village and length of residence were the most important factors in determining their response. Non-native respondents with the shortest length of residence were more likely to think the present management was effective, while native respondents from the village of Fresco, and respondents with the longest length of residence in the area, were more likely to think that the present management was ineffective.

Table 6.6: Factors determining the answers by respondents on whether or not present day management is effective, based on logistic regression.

Variables	B	SE	df	Significance
Village	0	0	2	0.021**
Fresco	-1.108	0.384	1	0.008**
Origin	1.829	0.507	1	0.000***
Length of residence	-0.20	0.008	1	0.010***
Constant	0.233	0.402	1	0.563

Level of significance show with **= P<0.05; ***=P<0.001

6.4 Discussion

Common property regimes, used by communities to manage natural resource for long-term benefit, were once widespread around the globe. Some may have disappeared naturally as communities opted for other arrangements, particularly in the face of technological and economic change. However, many still exist but many are mismanaged due either to economically and socially unjustified projects, or to breakdown of traditional systems by new land reform and transfer of property rights (Berkes, 1985; Acheson, 1987; McKean, 2000).

Common property regimes, however elaborate and long lasting, but that have never been codified, may simply have been left out of the first attempts by an emerging, newly independent state to formalize and codify property rights. Where common property regimes had legal recognition (McKean, 2000), there may have been in essence a land reform that transferred all such rights to particular individuals or to government itself in a massive process of nationalization. Among the many justifications usually advanced for eliminating community ownership of natural resources was the argument that individual or public ownership would offer enhanced efficiency in resource use and greater long-term protection of the resource. But in many instances around the world today, it is apparent that the arrangements that emerged to replace common-property regimes or property rights, have been ineffective in promoting sustainable resource management. Where people still live near the natural resource that their lives depend on, the transfer of their traditional rights into the hands of the state does not simultaneously transfer the physical opportunity to use the resource. The people who live nearest these areas still have ample opportunity to use them but when they lose secure property rights in the resources to the state, they also lose any incentive they might have felt in the past to manage these resources for maximum long-term benefit (Acheson, 1987; McKean, 2000). Now they might as well compete with each other and new users and claimants in a race to extract as much short-term benefit from the resource as possible. Thus, the transfer of property rights from traditional user groups to the state eliminates the incentives for monitoring and restrained use, converts owner-protectors into "poachers" and thus exacerbates the resource depletion it was supposedly intended to prevent (McKean, 2000).

The sequence above has been repeated in many places, from common property forests to fisheries (Henry *et al.*, 1989; Gibson *et al.*, 2000). A similar situation pertains to the lagoon complex of Fresco where the traditional community ownership has been transferred to the state, following the adoption of new land tenure system in 1990 and later to the Fresco town council, and the former management institution (the *N'gni* system), being replaced by a co-management committee in a free enterprise economic system (Chapter 5). Nevertheless, this study has shown that the community living around the lagoon continued to hold a positive attitude towards it. They consider the lagoon as an important fish habitat, a natural heritage, water source and an area strongly linked to their cultural identity, particularly to their belief in the water spirit from which they believed they receive a continual blessing.

6.4.1 Attitudes to past management

Most respondents reported that the level of different resources of the lagoon has decreased over the last 25 years due to fishing, fuel wood collection, natural degradation, climatic change and loss of culture (Figure 6.9). However, changes in levels of resource use are viewed differently by native and non-native respondents. Some non-natives reported a decrease of resources but many others said they had no idea. This may be because non-native users fear saying anything that may result in a decision to limit the number of users. Indeed, they may certainly be the first affected, as they were always suspected of having overused resources by natives, without any care for their traditions.

Fishing was mentioned as one factor that impacted on the resources, the second most important activity of the community, in which many males and a few females were involved. Fishing has impacted on the lagoon's resources because the lagoon was set aside by the community for the primary purpose of fishing during bad periods in the sea, but is now instead a year round fishing ground. Fishing in the sea stopped a few years after the resettlement of the former village of Fresco. As the population has increased, the number of rightful users has increased to the detriment of available resources. Moreover, the user community has been extended to natives and non-natives, since the transfer of ownership to the state in a free enterprise economic system gave equal usufruct right to both natives and non-natives users.

Firewood collection has also been listed as a factor responsible for reducing the level of resource in the lagoon. Firewood was needed by communities for domestic cooking and, most importantly, for smoking fish. Some 8% of respondents were fish traders and the only means to preserve caught fish was by smoking. Women engaged in oyster fishing also needed large amounts of fuelwood to boil oysters harvested to enable the extraction of the meat. *Rizophora racemosa* bordering the lagoon was the most preferred tree, as it was known to be very combustible. It is believed that the thick roots of *Rizophora* are hiding and breeding places for fish. Thus, the removal of these trees may adversely impact on fish breeding. The degradation of the mangrove of *Rizophora racemosa* is also attributed to the former *Fanti* fishermen communities.

Natural degradation was also mentioned by the communities as important for the mangrove forest (Chapter 4). The lagoon itself is also reducing in size due to soil erosion. Erosion is caused by the run off water that flows from the hills surrounding the northern part of the Fresco lagoon complex. Vegetation on these hills is being replaced by housing that extends the city of Fresco. Every year during the wet season, much of the topsoil is carried down to the lagoon and is progressively reducing it size and depth. The volume of sediment carried by the Niouniourou and the Bolo Rivers into the lagoon was also believed to play an important role.

Other respondents were concerned that cultural erosion had resulted in loss of belief in the spirit of the water. According to the native users, non-natives do not respect their beliefs as they fish even on Friday, and native youths now tend to follow the same practices.

The *N'gni* system was viewed as the most effective management institution, and many respondents recommended a return to this institution to achieve sustainable use while maintaining their traditions. However, due to the increasing numbers of users from different cultural backgrounds, others thought the current co-management committee, linked to institutions that hold part of the state power should remain but that enforcement of the law should be strengthened.

Views of respondents on who is responsible for the present day management were as diverse as board members of the current co-management committee (Table 6.3). This explained the confusion respondents felt in defining the role of each group of members of the co-management committee. Most non-natives believed that management responsibility lay with the fishery service of Fresco. This could be because the fishery service was in regular contact with them, particularly with fishermen through charging to issue fishing licenses, and weighing fish production.

The body of chiefs from the three villages and the water headman mentioned by some respondents represented the native community in the co-management committee. As such, they played a key role in including or excluding individuals from the users' group. Usually, non-native applicants have to see this body to get its agreement before seeing the fishery service.

Finally, the Fresco town council was listed by others as being in charge of the management, because it was also included in the co-management committee, and is in charge of collecting annual taxes (Chapter 5).

6.4.1 Attitudes towards present management and preferred future options

Most respondents acknowledged the ineffectiveness of the present day management. However most non-natives believed that it was effective (Table 6.4). Hence, the logistic regression shows the importance of origin of users in explaining the effectiveness of the present day management (Table 6.6), with non-natives more likely to say the present day management is effective. Villages and length of residence of respondents were also important in determining their response.

Various factors were listed about why the present day management was ineffective (Figure 6.10). The weak law enforcement, the increase in numbers of users and the subsequent over-exploitation of resources have all made the management ineffective. Poaching performed by peoples not admitted to the users group and increasing market demand, particularly for fish and fuel wood, have also adversely impacted on the effectiveness of present day management.

Most respondents viewed a community resource management system as the best future management option for the Fresco lagoon complex. However natives and non-natives differed in their views, with most natives preferring a return to the former *N'gni* system and most non-natives divided between the fishery service and the current co-management committee (Table 6.5). A return to the former *N'gni* system means exclusion of the non-native users. The preference for the fishery service or the co-management committee by non-natives could therefore be explained by their wish to ensure that they remain members of the users' group.

Educated and younger respondents preferred a community resource management system under the leadership of the co-management committee while the least educated and elders opted for a return to the *N'gni* system. This could because younger and educated users were more likely to understand that a return to the former *N'gni* system will certainly be difficult or impossible due to the new context of state ownership which gives equal usufruct rights not only to the natives but also to the non-natives, the presence of the fishery service and the right of the Fresco town council to request taxes from users.

Given that the community of users still hold positive attitudes towards the lagoon and the management system set up to control resource use, I will now examine, in more detail, the types of resources harvested from the lagoon and types of use to which harvested resources are put.

CHAPTER 7 USES OF THE LAGOON

7.1 Introduction

Many traditional societies across the world still meet their livelihood requirements from forests, wetlands, grassland, marine and freshwater resources that immediately surround them (Hutton and Leader-Williams, 2003). "Livelihood" is defined as the way of life and work that helps persons or communities to meet their needs for survival (Kothari, 1997; Salafsky and Eva, 2000; Allison and Ellis, 2001). An understanding of the relationships between livelihood and biodiversity is essential in planning conservation strategies.

Communities who follow different types of existence, such as hunting, gathering, fishing, pastoralism and agriculture have varying degrees and kinds of dependence on biodiversity. For example, predominantly hunting, gathering and subsistence fishing communities depend heavily on wildlife to meet their survival requirements. Many plant species are also used for various requirements, including food, fodder, fuel, housing and medicine. Even the market requirements of many such communities are met by natural resources. Across the world, a great variety of non-timber forest products are extracted and they are also important sources of income for rural populations (Kothari, 1997).

Any strategy for conservation of biodiversity needs therefore to be sensitive to the dependence of peoples on natural resources (Hutton and Leader-Williams 2003). However, given that natural resources are not limitless, and that they have to be shared by a population that will double in the early part of this millennium, the challenge facing many nations is how to meet the needs of present without compromising the ability of future generation to meet their own need (WCED, 1987). Moreover, as humans are believed to be primarily motivated by self-interest, it is widely held that resources to which any individual has open access are apt to be overused and exhausted (Hardin, 1968).

In recent years, the management of common property resources has attracted increasing attention (Berkes and Farvar, 1989; Jacob, 1989; Mckean, 2000). Based on co-operation rather than competition, such resources are shared collectively instead of the individual attempting to maximize yield without reference to the community. Such approaches are seen as crucial to livelihood security and sustainable resource use.

Indeed, traditions and beliefs under the *N'gni* system that operated in the lagoon of Fresco until 1967 are an example of such a system. Furthermore, even since its replacement by a co-management committee as result of the transfer of traditional ownership of the lagoon from the native community of Godie to the state (Chapter 5), the lagoon has continued under a common property system. Unfortunately, in many instances around the world today, it is apparent that the arrangements that emerged to replace common property regimes or property ownership have been ineffective in promoting sustainable resource management (Ostrom, 1990; McKean, 2000). Nevertheless, the Fresco communities continue to hold a positive attitude to the lagoon, although many thought that the present day management needed strengthening (see Chapter 6).

In this chapter, I aim to identify types of natural resources currently harvested by the community of users. The following questions will be addressed:

- what natural resources are currently harvested by the community and to what use are harvested resources put?
- what is the level of boat traffic and this is how distributed spatially and temporally?
- what methods of harvesting are used and how is resource use distributed spatially?
- what are the current patterns and extent of uses, and how are these influenced by hydro-climatic factors such as water level, salinity, rainfall, and tidal condition?

7.2 Methods

Primary information on the types of natural resources harvested from the lagoon was collected during group discussions and key informant interviews in the villages of Fresco, Zakareko and Bohico (Chapter 5; Appendix II). Based on these group discussions and key informant interviews, a semi-structured questionnaire was prepared (Appendix III) to investigate the importance attached to different resources enumerated by the community and the frequency of resource harvesting by households.

Boat traffic was monitored continuously from a fixed point throughout daylight hours, from 0600 to 1800 hours, once every month from September 2000 to August 2002. During observation the following were noted: the time at which each boat passed, the number and social classes of people in the boat, the type of boat, the type of activity (as inferred from the contents of the boat), the direction of travel (whether into or out of the lagoon), tidal stages (low or high) and inlet condition (whether closed or opened).

A complete circumnavigation of the lagoon was conducted once every month from August 2000 to September 2002. While traveling, type of resources harvested, the habitat, the number of peoples, their social classes and total numbers of boats involved were recorded over 24 hours, following total count method (Krebs, 1999). These data were used to determine spatial distribution, density and seasonal patterns of natural resource harvesting in the Fresco lagoon complex.

Data on fish catches by the community from September 2000 to August 2002 were obtained from the Fresco fishery service and were based on the catches of 15 households. Firewood collected from the shoreline was weighed at the landing stage. When a load of firewood from the shoreline was seen to be landed, collectors were asked if they were willing to allow their load to be weighed. If they granted permission, weight was taken to the nearest kg, and the different plant species were identified. A line mark was set at the interface of cut and uncut areas in September 2000. In August 2002, GPS coordinates of the area between the line mark and the newly cut interface area, were recorded to evaluate the total area of the shoreline cut for firewood collection over the two years.

7.2.1 Data analysis

Chi-square tests were used for categorical variables to explore the possible differences between villages, sex and origin, on the importance attached to resources harvested and the association between tidal stages and boat traffic. Resource users were subdivided into males and females. Males were further subdivided by visual observation into age classes, youths and adults, and descriptive statistics were used to compare the proportion of each age and social class involved in resource harvesting. The strength and direction of the linear relationship between the extent of use and hydro-climatic factors were explored using Pearson product-moment correlation. Catches of fish from 15 households were subdivided into freshwater, marine and brackish water species, and simultaneous multiple regression analysis was used to determine the predictive power of water level, water temperature, and water salinity on the variance in the catch. Simultaneous regression allows each independent variable to be evaluated in terms of its predictive power, over and above that offered by all the other independent variables. It also tells how much unique variance in the dependent variable of catch that each of the independent variables explained (Field, 2000)

7.3 Results

7.3.1 Important natural resources harvested

Two types of natural resources were harvested by the community: aquatic resources, comprising fish, molluscs and crustaceans from open water; and, firewood from the shoreline. Different degrees of importance were attached to different natural resources. The values placed upon different resources were in decreasing order: fishes, crustaceans, firewood and molluscs.

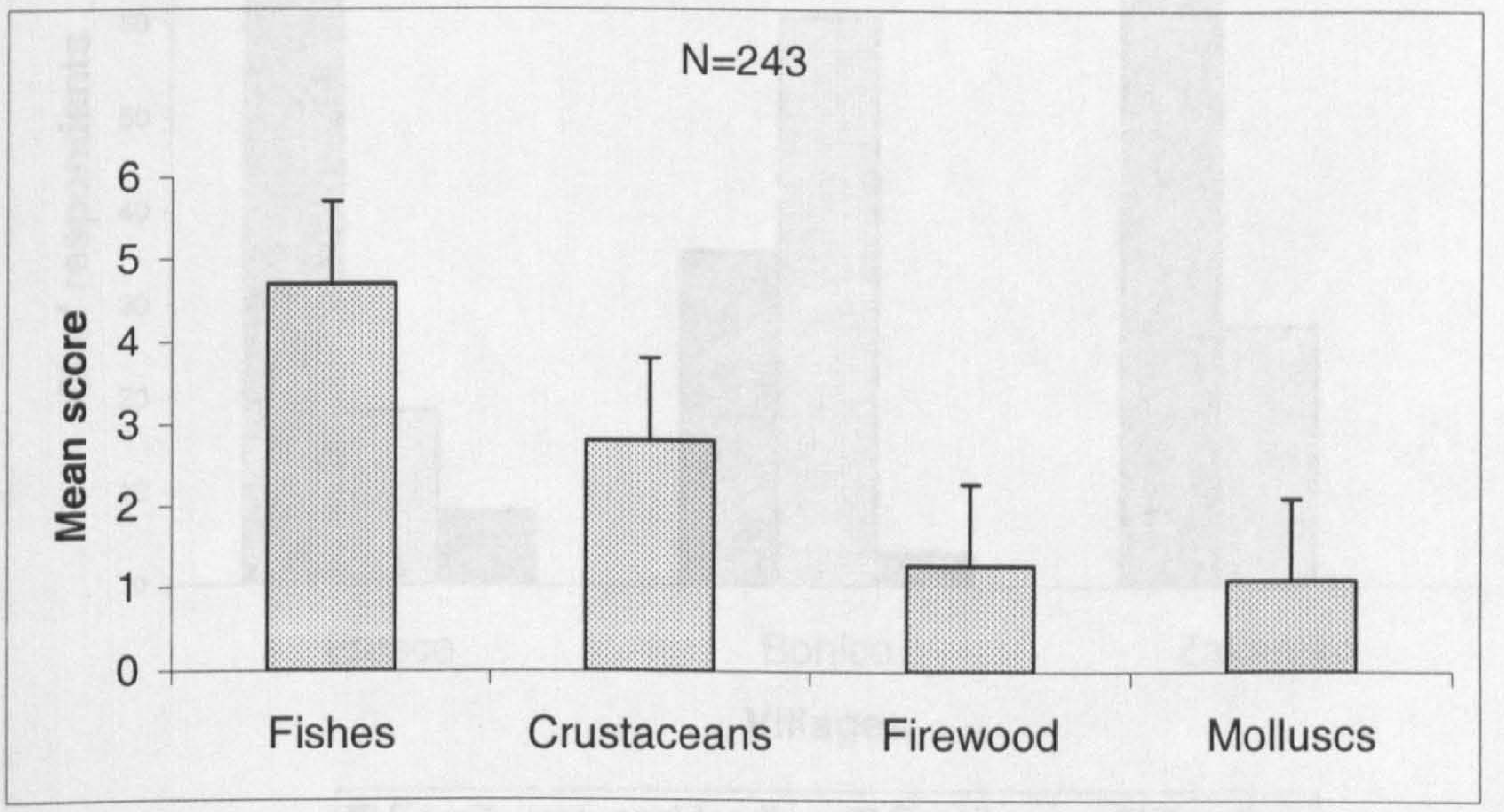


Figure 7.1: Mean of values placed upon different resources used by the community of the Fresco lagoon complex

Most respondents (67%) harvested resources for both family consumption and trading. Others (28%) only harvested resources for family consumption, while a few respondents (5%) harvested resources only for trading. Fresco, Zakareko and Bohico differed (x^2=22.44, df=4, P<0.001) in terms of allocation of resources harvested. More respondents from Fresco (8%) harvested resources only for trading than Bohico (4%). In contrast, no respondents from Zakareko harvested resources only for trading (Figure 7.2). Native and non-native users also differed (x^2=11.40, df=2, P<0.05) in terms of allocation of resource harvested. More non-natives (25%) than natives (4%) harvested resources only for trading. Similarly, males and females differed (x^2=12.35, df=2, P<0.05) in terms of allocation of resource harvested. More females (51%) than males (22%) harvested resource only for family use.

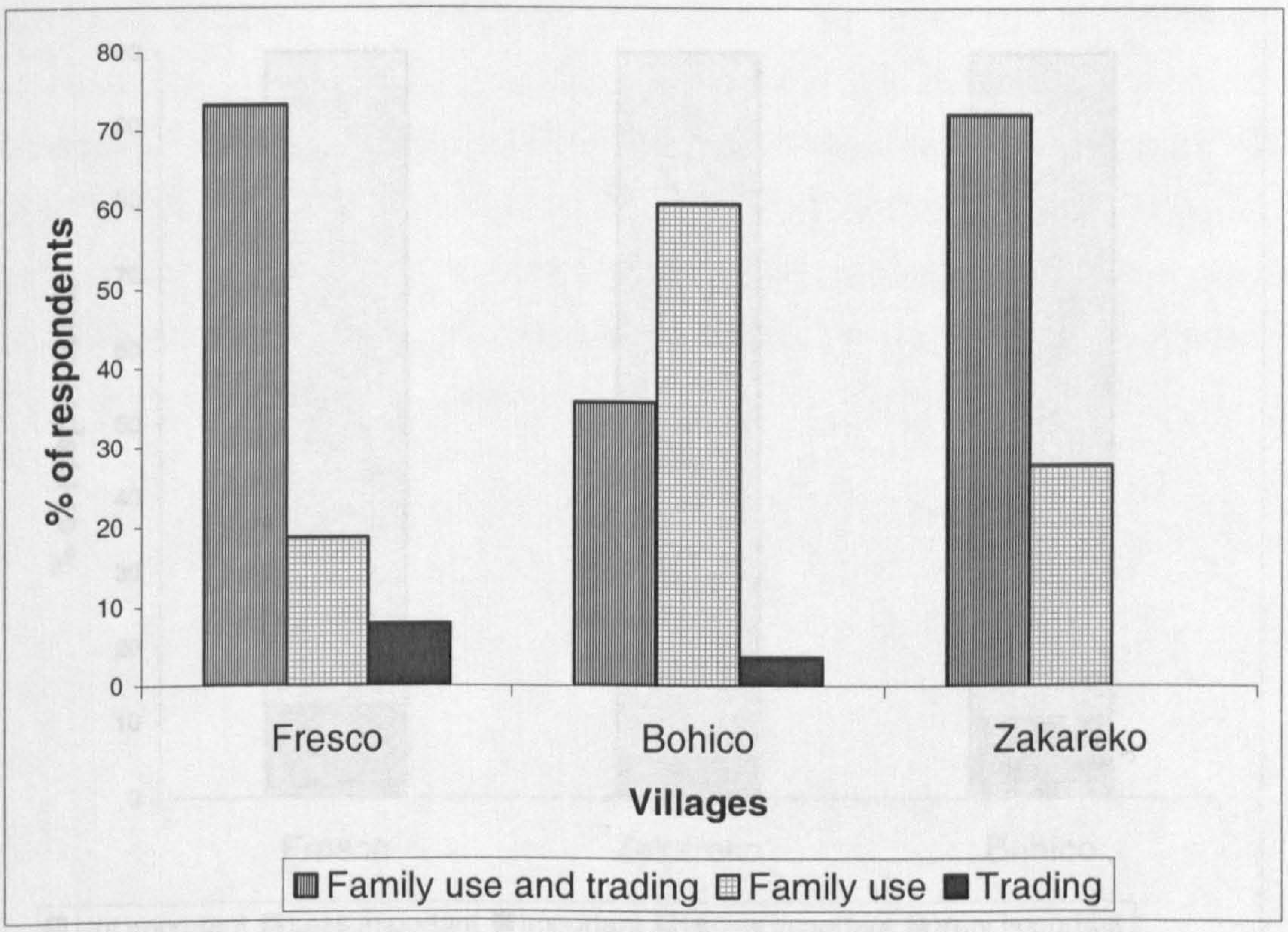


Figure 7.2: Use of resources harvested by each village from the Fresco lagoon complex

7.3.1.1 Importance of the lagoon as a fishery

Users from Fresco, Zakareko and Bohico villages did not differ (x^2=9.61, df=8, P>0.05) in the importance they attached to the lagoon as a fishery. Most respondents (about 90%) from the three villages considered the lagoon as a very important fishery (Figure 7.3). However, male and female respondents held different views (x^2=11.17, df=4, P<0.05) and more females (3.4%) than males (0.3%) did not see the lagoon as important fishery. Similarly, native and non-native held different views (x^2=11.87, df = 4, P<0.05), and more native (91%) than non-natives (80%) saw the lagoon as very important fishery.

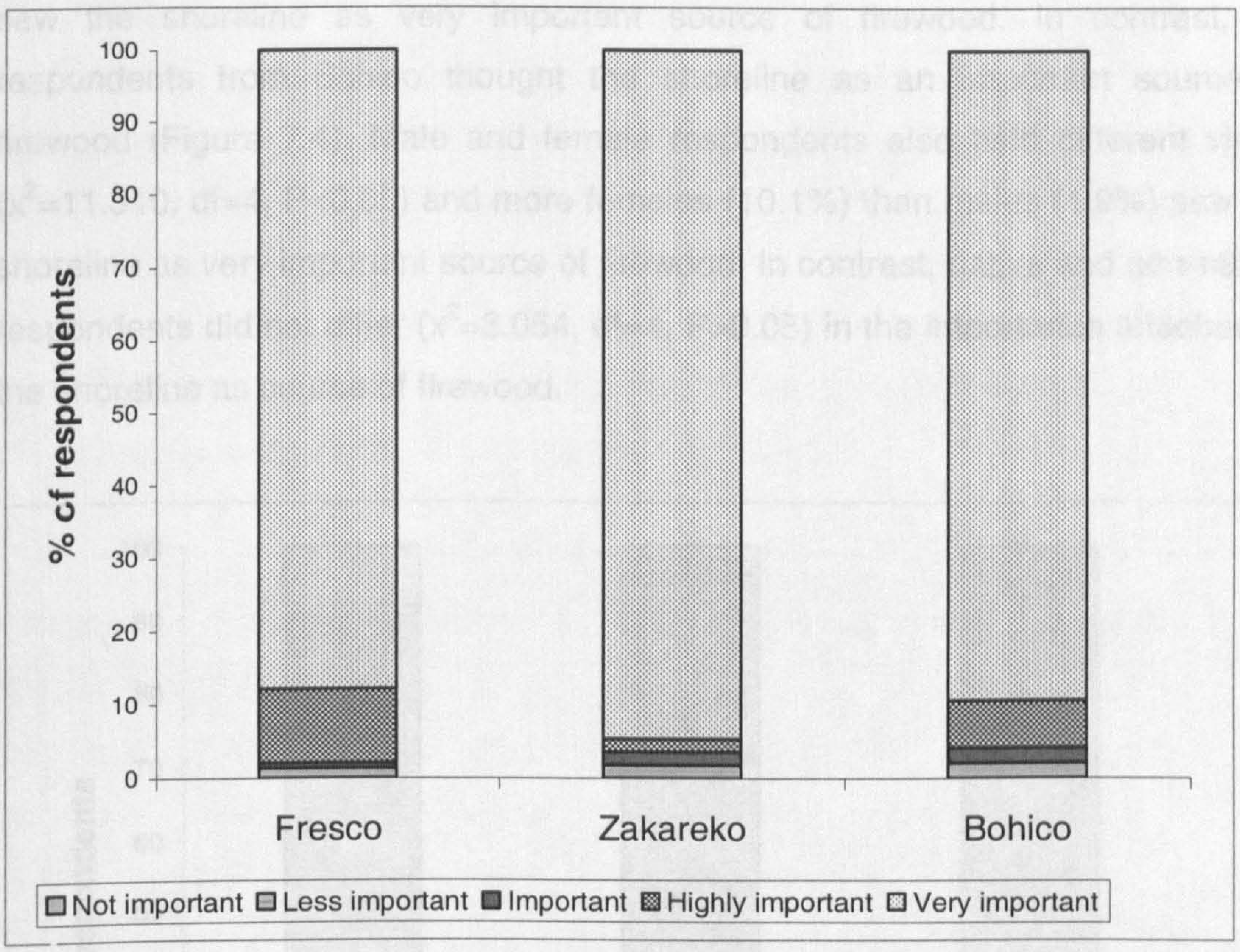


Figure 7.3: Degree of importance attached by different villages to Fresco lagoon complex as a fishery

7.3.1.2 Importance of the shoreline as a source of firewood

Most respondents (92.6%) described dry branches and twigs, as well as by-products from clear-cutting operations to convert forests to croplands and shifting cultivation, as their most important source of firewood. Nevertheless, firewood was also cut from the shoreline of the lagoon complex and 7.4% of respondents indicated that they collected dead wood of *Rhizophora racemosa* from the shoreline.

Respondents from Fresco, Zakareko and Bohico held different views (x^2=16.89, df=8, P<0.05) on the importance they attached to the shoreline of the lagoon as a source of firewood. More respondents from Fresco (7.9%) than Zakareko (1.8%)

saw the shoreline as very important source of firewood. In contrast, no respondents from Bohico thought the shoreline as an important source of firewood (Figure 7.4). Male and female respondents also held different views (x^2=11.510, df=4, P<0.05) and more females (10.1%) than males (1.9%) saw the shoreline as very important source of firewood. In contrast, native and non-native respondents did not differ (x^2=3.054, df=4, P>0.05) in the importance attached to the shoreline as source of firewood.

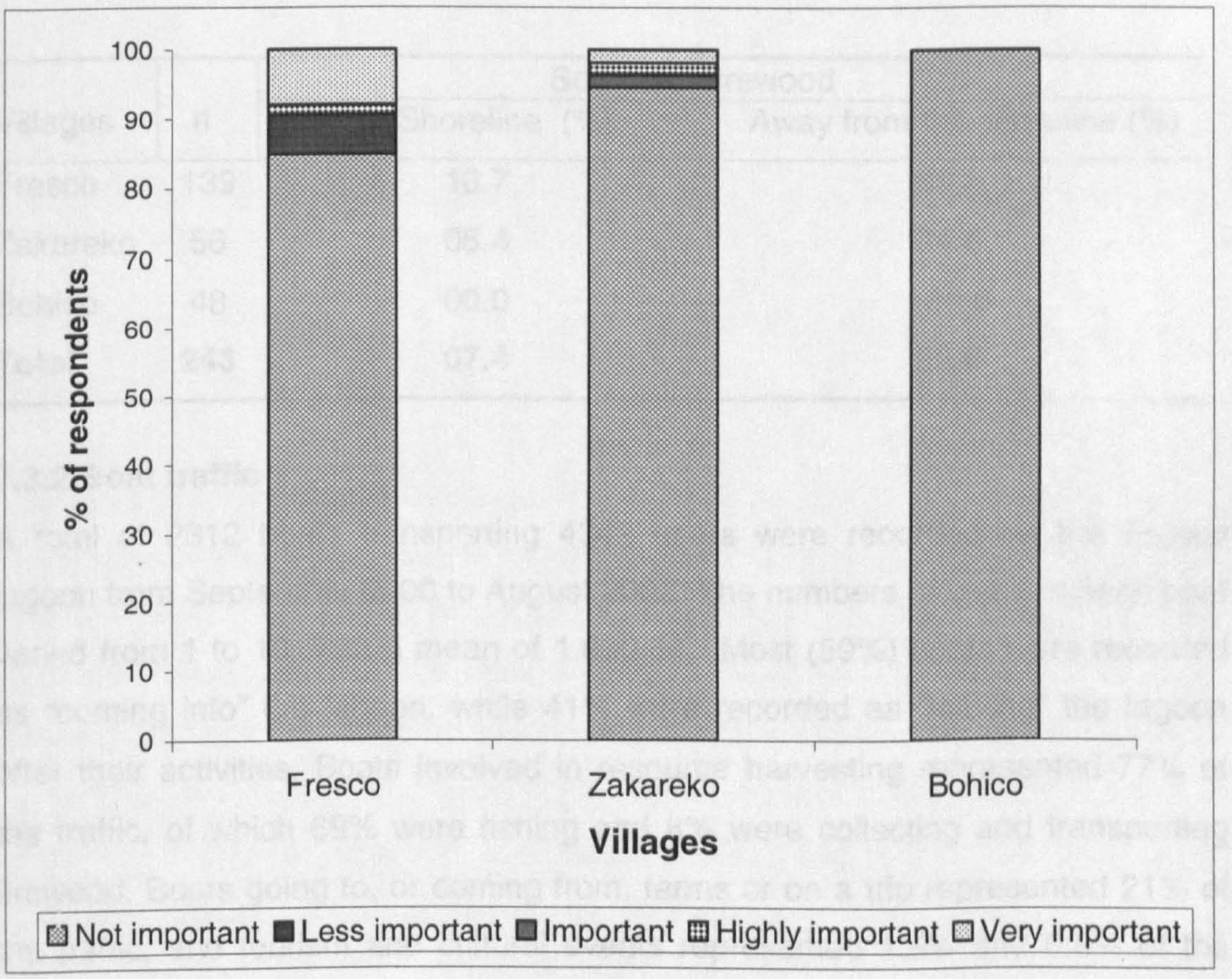


Figure 7.4: Degree of importance attached by different villages to the shoreline of Fresco lagoon complex as a source of firewood.

There was a significant difference (x^2=6.335, df=2, P<0.05) between Fresco, Zakareko and Bohico in terms of areas where they actually collect their firewood.

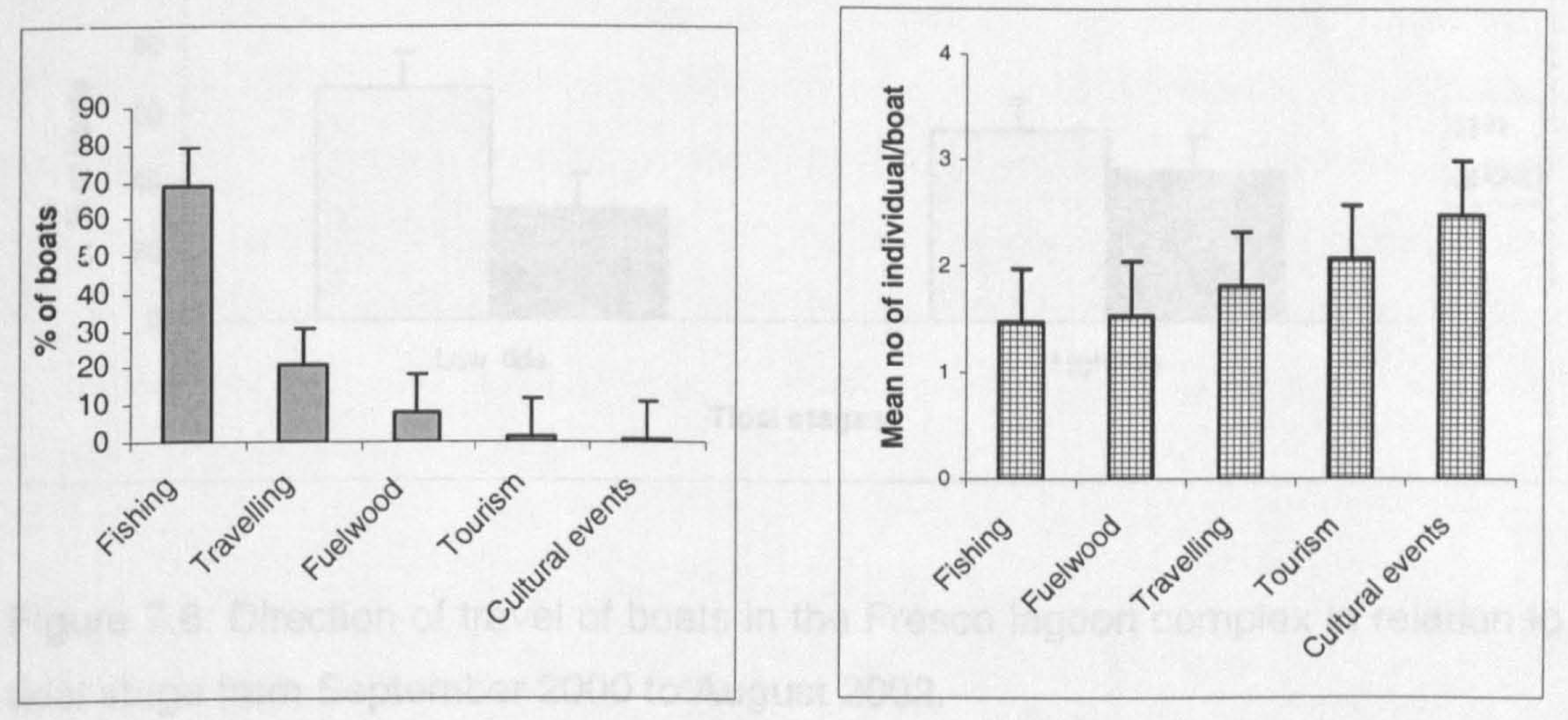
More collectors (10.7%) from Fresco than Zakareko (5.4%) collect firewood from the shoreline while none from Bohico did so (Table 7.1). Similarly, males and females were different (x^2=14.18, df=1, P<0.001) as to where they actually collect their firewood. More females (15.7%) than males (2.6%) collect firewood from the shoreline.

Table 7.1: Percentage of respondents from different villages using the shoreline of the Fresco lagoon complex as source of firewood

Villages	n	Source of firewood	
		Shoreline (%)	Away from the shoreline (%)
Fresco	139	10.7	89.3
Zakareko	56	05.4	94.6
Bohico	48	00.0	100.0
Total	**243**	**07.4**	**92.6**

7.3.2 Boat traffic

A total of 2312 boats transporting 4342 users were recorded on the Fresco lagoon from September 2000 to August 2002. The numbers of users in each boat varied from 1 to 10, with a mean of 1.8±0.84. Most (59%) boats were recorded as "coming into" the lagoon, while 41% were recorded as "leaving" the lagoon after their activities. Boats involved in resource harvesting represented 77% of the traffic, of which 69% were fishing and 8% were collecting and transporting firewood. Boats going to, or coming from, farms or on a trip represented 21% of the traffic, and tourism and cultural events represented 1.5% and 0.8% of the traffic, respectively (Figure 7.5a). More males (82%) than females (18%), and more youths (53%) than adults (47%), were traveling in boats.



A. Proportion of boats by activity type B. No of users in boats by activity type

Figure 7.5: Use types and boat traffic in the Fresco lagoon complex from September 2000 to August 2002.

7.3.2.1 Boat traffic and tidal stage

Most boats (88%) were observed when the inlet was open and very few (12%) when the inlet was closed. When the inlet was open, a few more (53%) boats used the lagoon at low tide than at high tide (47%). The direction of travel whether "into" or "out of" the lagoon, was strongly associated with tidal stages (x^2=22.67, df=1, P<0.001). More boats (68%) came into the lagoon at low tide compared to 56% at high tide. In contrast, more (44%) boats left the lagoon at high tide compared to 32% at low tide (Figure 7.6).

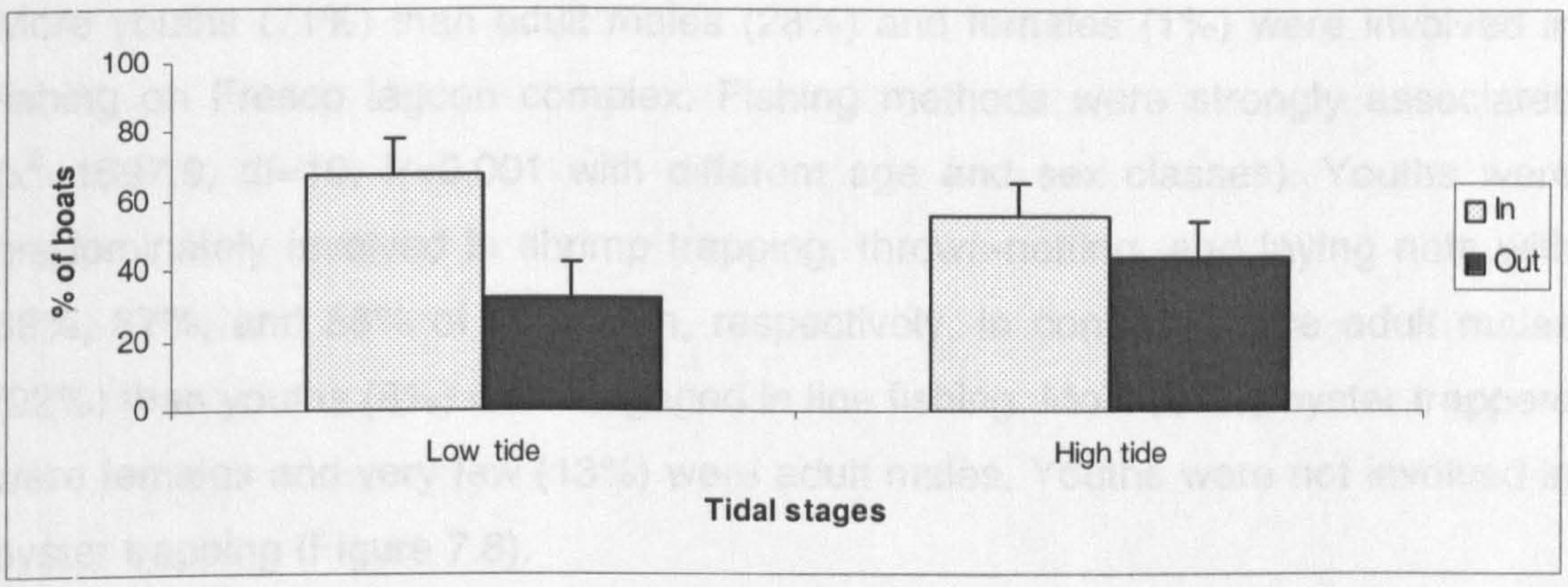


Figure 7.6: Direction of travel of boats in the Fresco lagoon complex in relation to tidal stage from September 2000 to August 2002.

7.3.2.2 Fishing Methods

Fishing boats followed six different fishing methods: thrown-netting (Tn), laid netting (Ln), line fishing (Lf), trapping crabs (Tcrab), trapping shrimps (Tshrp) and trapping oysters (Of). Thrown-netting was the most important method of fishing, involving 38% of boats fishing and 52% of fishermen, while trapping oysters was the least common method involving only 1.5% of fishing boats and only 1% of fishermen (Figure 7.7).

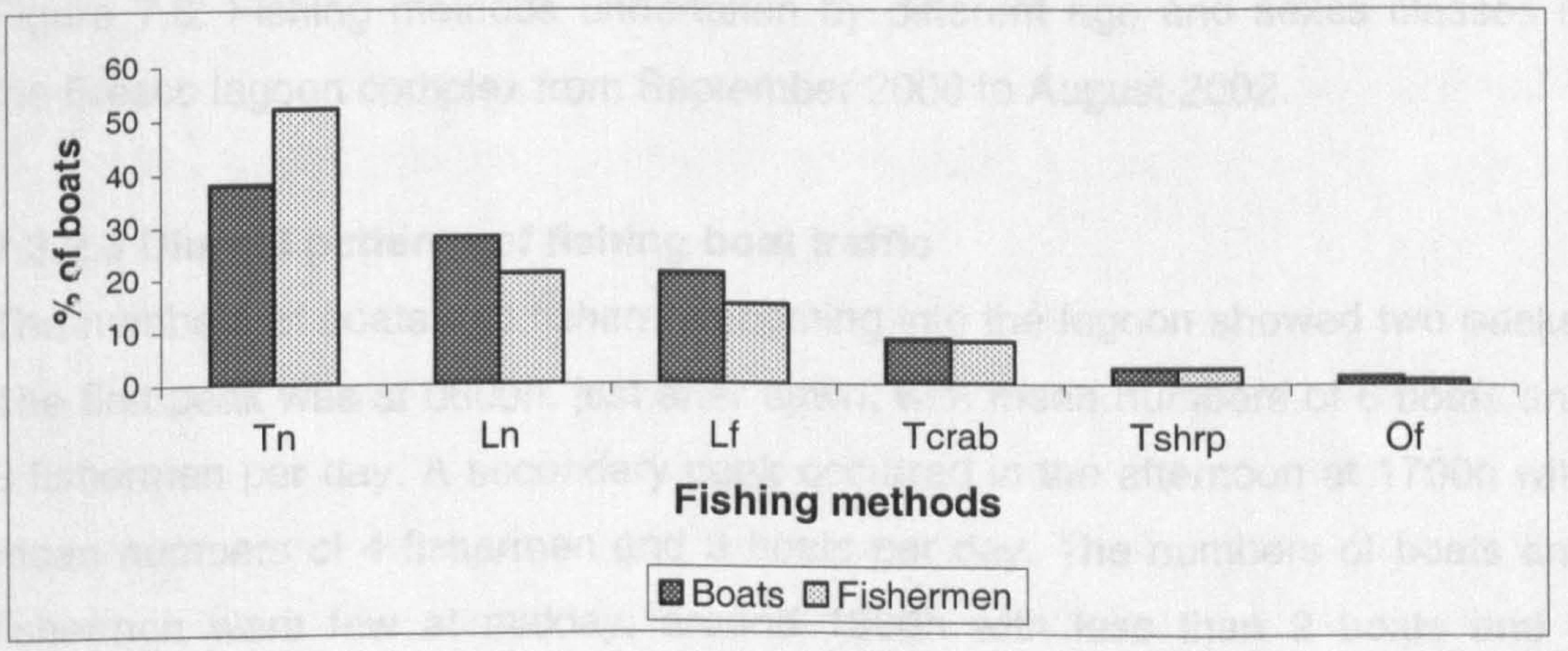


Figure 7.7: Boat traffic and fishing methods in the Fresco lagoon complex from September 2000 to August 2002.

More youths (71%) than adult males (28%) and females (1%) were involved in fishing on Fresco lagoon complex. Fishing methods were strongly associated (x^2=1697.9, df=10, P<0.001 with different age and sex classes). Youths were predominately involved in shrimp trapping, thrown-netting, and laying nets with 88%, 87%, and 56% of fishermen, respectively. In contrast, more adult males (92%) than youths (8%) were engaged in line fishing. Most (87%) oyster trappers were females and very few (13%) were adult males. Youths were not involved in oyster trapping (Figure 7.8).

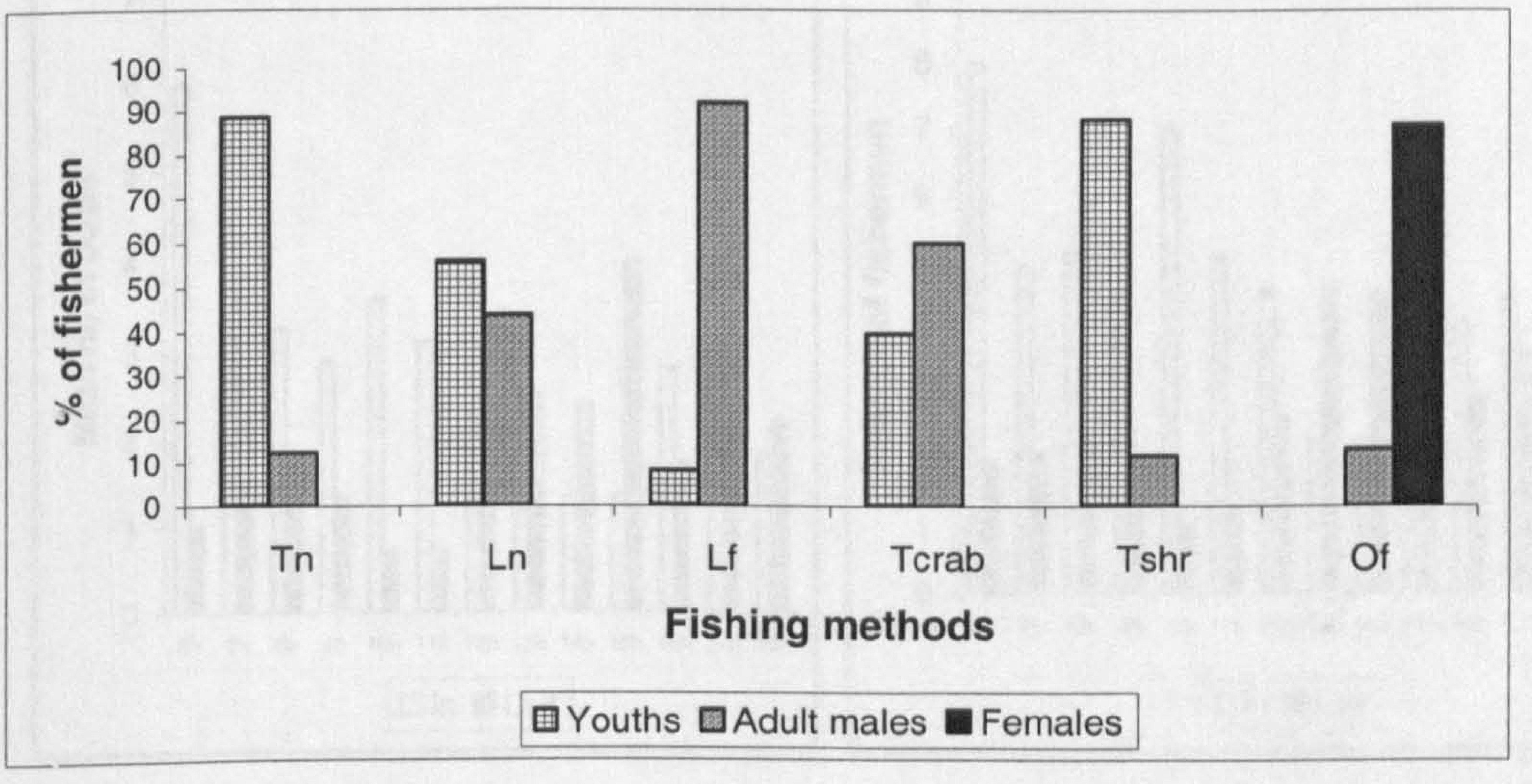


Figure 7.8: Fishing methods undertaken by different age and sexes classes in the Fresco lagoon complex from September 2000 to August 2002.

7.3.2.3 Diurnal patterns of fishing boat traffic

The numbers of boats and fishermen coming into the lagoon showed two peaks. The first peak was at 0600h, just after dawn, with mean numbers of 6 boats and 8 fishermen per day. A secondary peak occurred in the afternoon at 1700h with mean numbers of 4 fishermen and 3 boats per day. The numbers of boats and fishermen were few at midday, around 1300h with less than 2 boats and 3 fishermen per day. In contrast, few boats and fishermen left the lagoon in the morning, and departure time peaked in the afternoon with mean numbers of 4 boats and 6 fishermen at 1500h. The number of boats coming into the lagoon was negatively associated with the number of boats leaving the lagoon (r=-0.692, N=13, P<0.001). Similarly, the numbers of fishermen leaving the lagoon was negatively correlated with the numbers of fishermen coming into the lagoon (r=-0.829, N=13, P<0.05). In other words, as numbers of boats and fishermen coming into the lagoon increased, the numbers of boats and fishermen leaving the lagoon decreased and vice-versa (Figure 7.9).

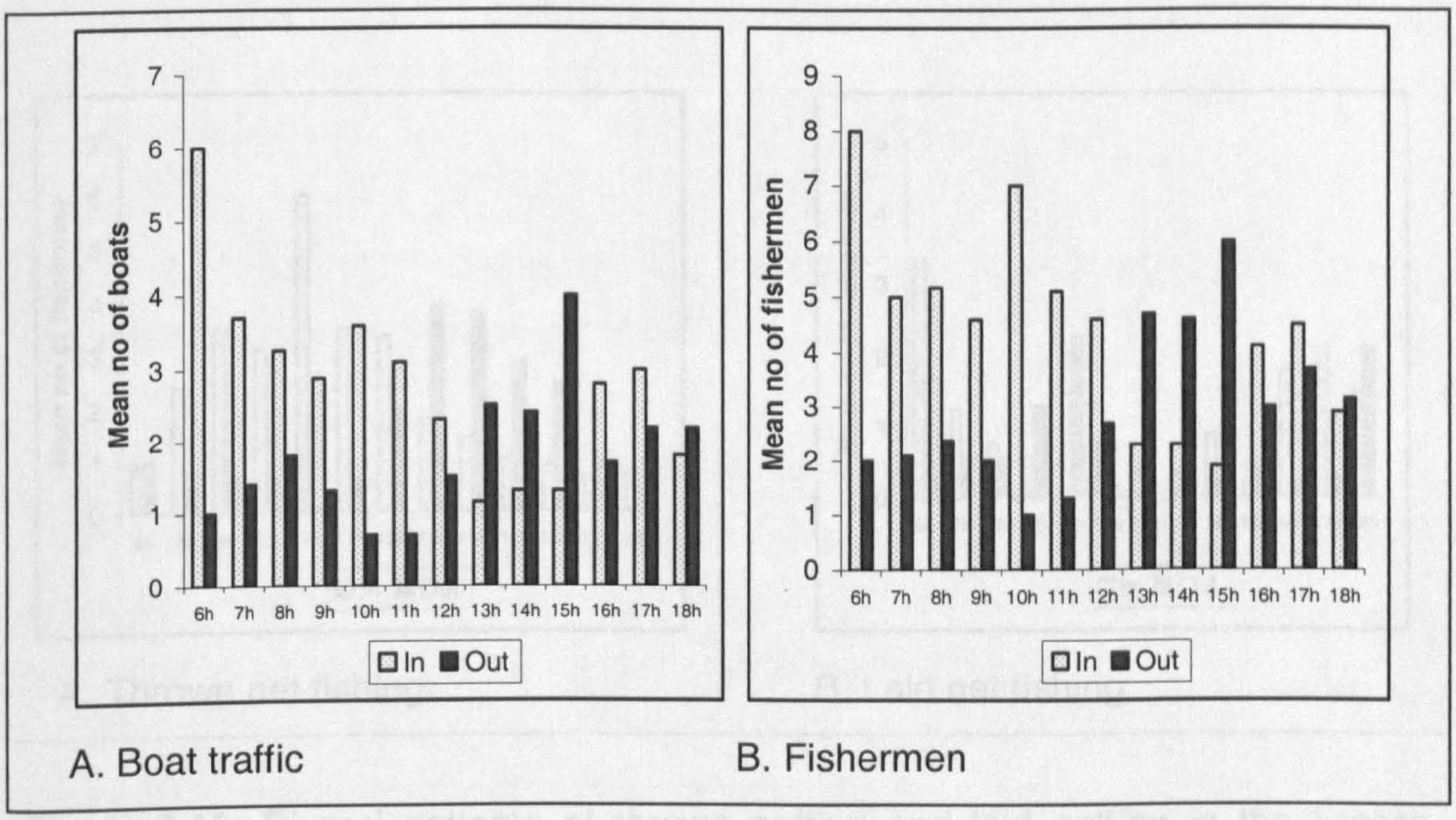


Figure 7.9: Diurnal patterns of boat traffic and fishermen by direction of travel in the Fresco lagoon complex from September 2000 to August 2002

Each fishing method was followed at distinctly different diurnal patterns of occurrence in the lagoon. The numbers of fishermen coming into the lagoon to throw nets increased progressively from 0600h, to peak at 1000h with a mean of 6 fishermen throwing nets per day, and the numbers decreased progressively from 1000h to 1800h. Those leaving the lagoon after throwing nets peaked at 1300h with a mean of 4 fishermen throwing nets per day, and decreased progressively until 1800h (Figure 7.10a).

The numbers of fishermen on the lagoon involved in net laying showed two peaks. The first peak occurred early in the morning at 0600h with a mean of 3 fishermen laying nets per day, while a secondary peak occurred at 1700h with a mean of 2 fishermen laying net per day. Those leaving the lagoon after collecting their nets also showed a first peak at 1000h with 2.3 fishermen laying nets per day, and a secondary peak at 1800h with a mean of 2 fishermen laying nets per day (Figure 7.10b)

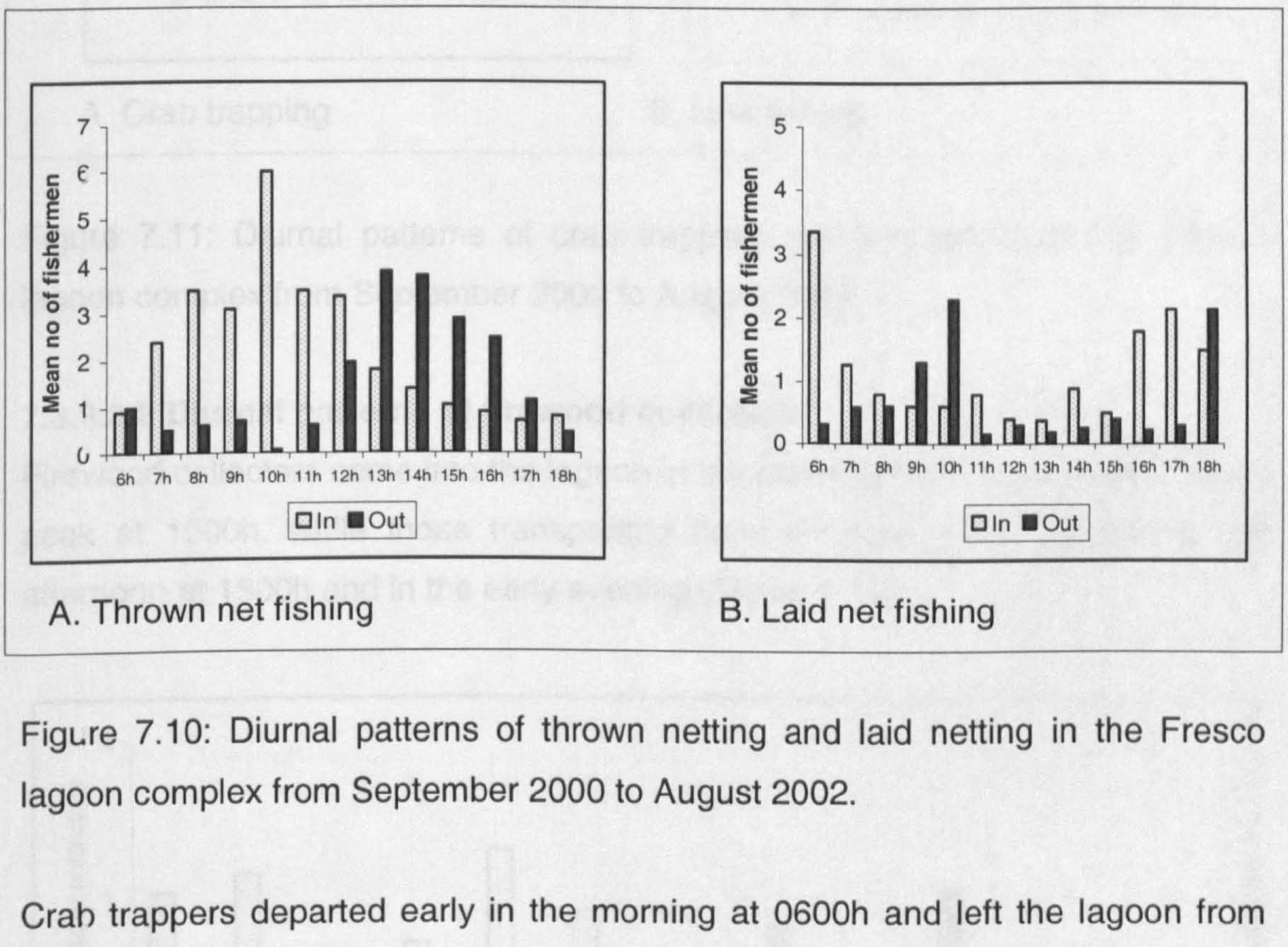


Figure 7.10: Diurnal patterns of thrown netting and laid netting in the Fresco lagoon complex from September 2000 to August 2002.

Crab trappers departed early in the morning at 0600h and left the lagoon from 1700h (Figure 7.11a). Similarly, the numbers of fishermen departing for line fishing peaked at 0600h, and those leaving the lagoon peaked at 1800h (Figure 7.11b).

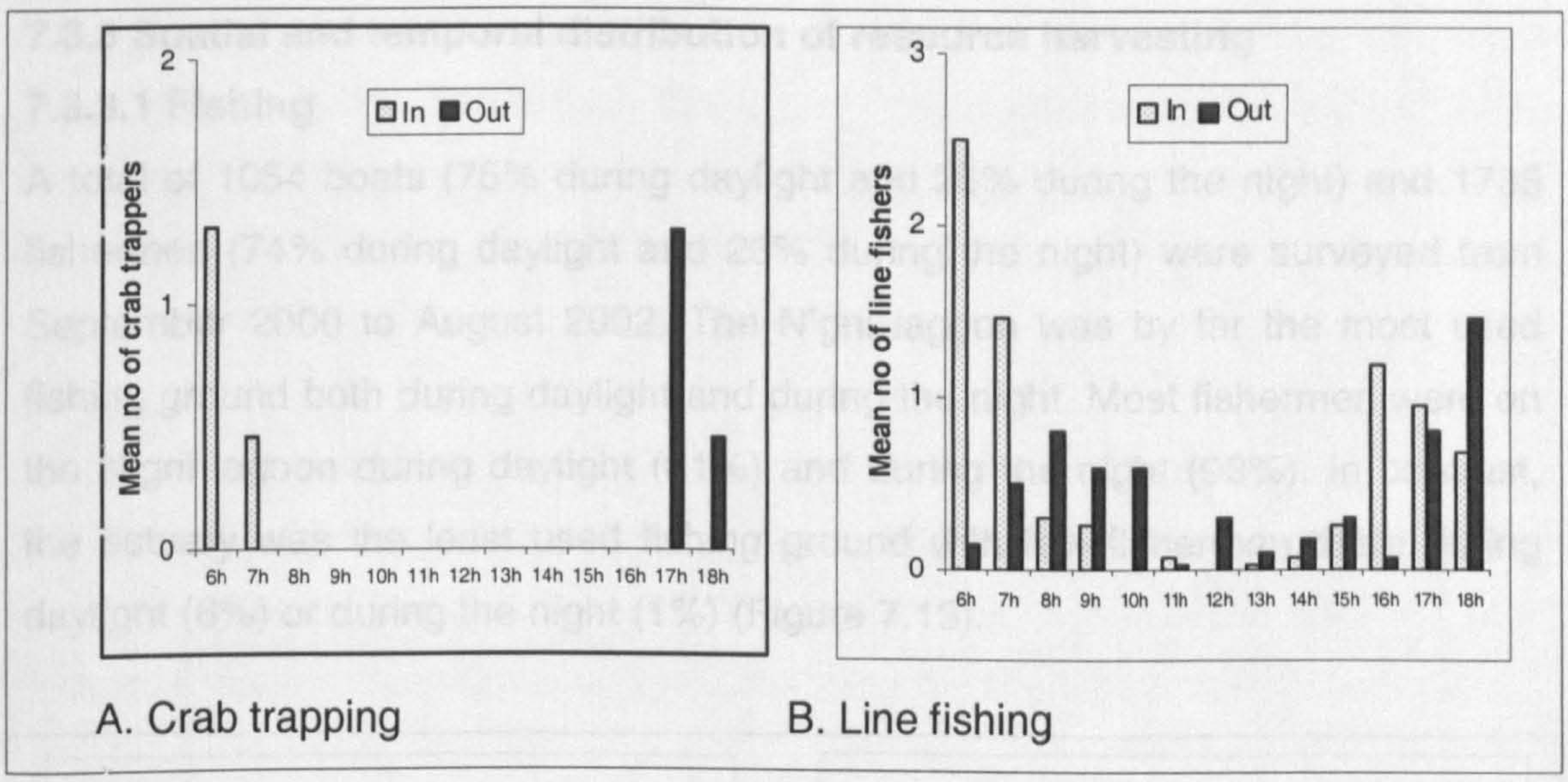


Figure 7.11: Diurnal patterns of crab trapping and line fishing in the Fresco lagoon complex from September 2000 to August 2002.

7.3.2.3.2 Diurnal patterns of firewood collection

Firewood collectors came into the lagoon in the morning from 0600h, with a slight peak at 1000h, while those transporting firewood back home peaked in the afternoon at 1500h and in the early evening (Figure 7.12).

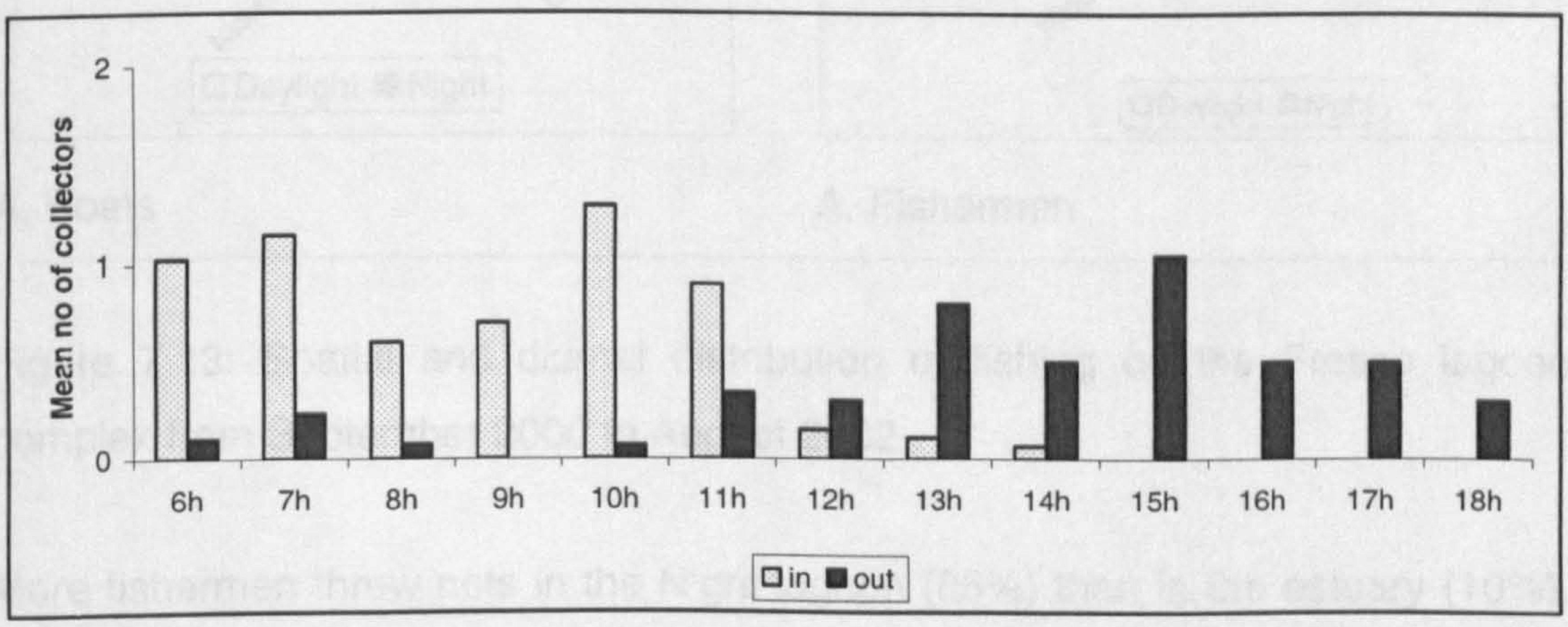
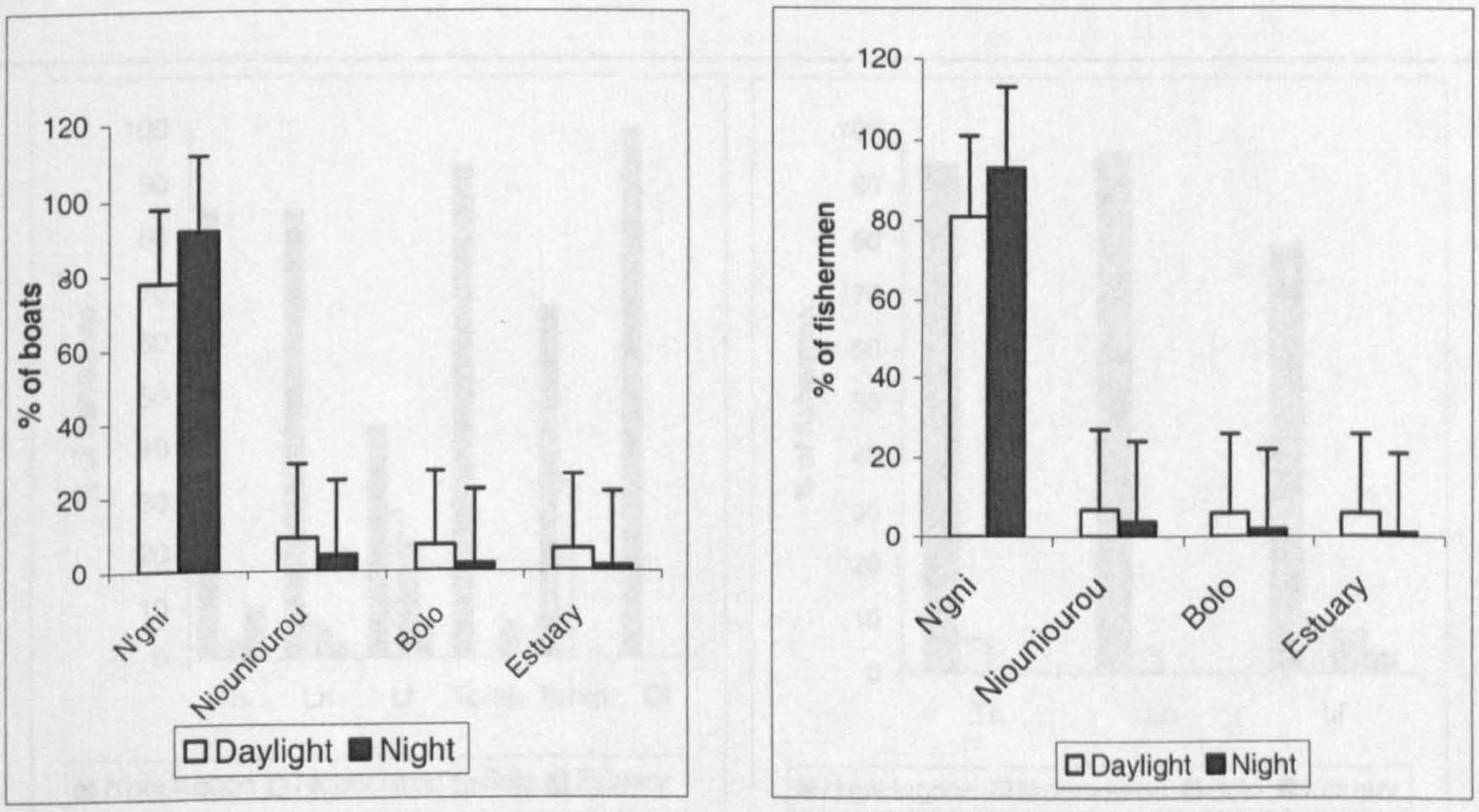


Figure 7.12: Diurnal patterns of firewood collection along the shoreline of the Fresco lagoon complex from September 2000 to August 2002.

7.3.3 Spatial and temporal distribution of resource harvesting

7.3.3.1 Fishing

A total of 1054 boats (75% during daylight and 25% during the night) and 1785 fishermen (74% during daylight and 26% during the night) were surveyed from September 2000 to August 2002. The N'gni lagoon was by far the most used fishing ground both during daylight and during the night. Most fishermen were on the N'gni lagoon during daylight (81%) and during the night (93%). In contrast, the estuary was the least used fishing ground with few fishermen there during daylight (6%) or during the night (1%) (Figure 7.13).



A. Boats　　A. Fishermen

Figure 7.13: Spatial and diurnal distribution of fishing on the Fresco lagoon complex from September 2000 to August 2002.

More fishermen threw nets in the N'gni lagoon (85%) than in the estuary (10%), the Bolo (3.2%) and the Niouniourou Rivers (1.6%) during daylight. Fishermen engaged in line fishing also used the N'gni lagoon (44%) more than the Niouniourou (28%), the Bolo (21%) and the estuary (6%) during daylight. Fishing during the night was limited to thrown nets, laid nets and line fishing, and more fishermen laid nets (50%) than threw nets (36%) or line fished (14%). Most fishermen throwing nets during the night used the N'gni lagoon (94%) and very few used the Estuary (6%). In contrast, no fishermen threw nets in the Niouniourou and the Bolo Rivers during the night.

Crab, shrimp and oyster trapping occurred exclusively (100%) during daylight. Most crab trappers used the N'gni lagoon (93%) and very few used the estuary (7%). In contrast, no crab trapping occurred in the Niouniourou and the Bolo Rivers. Oyster trappers invariably (100%) used the N'gni lagoon (Figure 7.14).

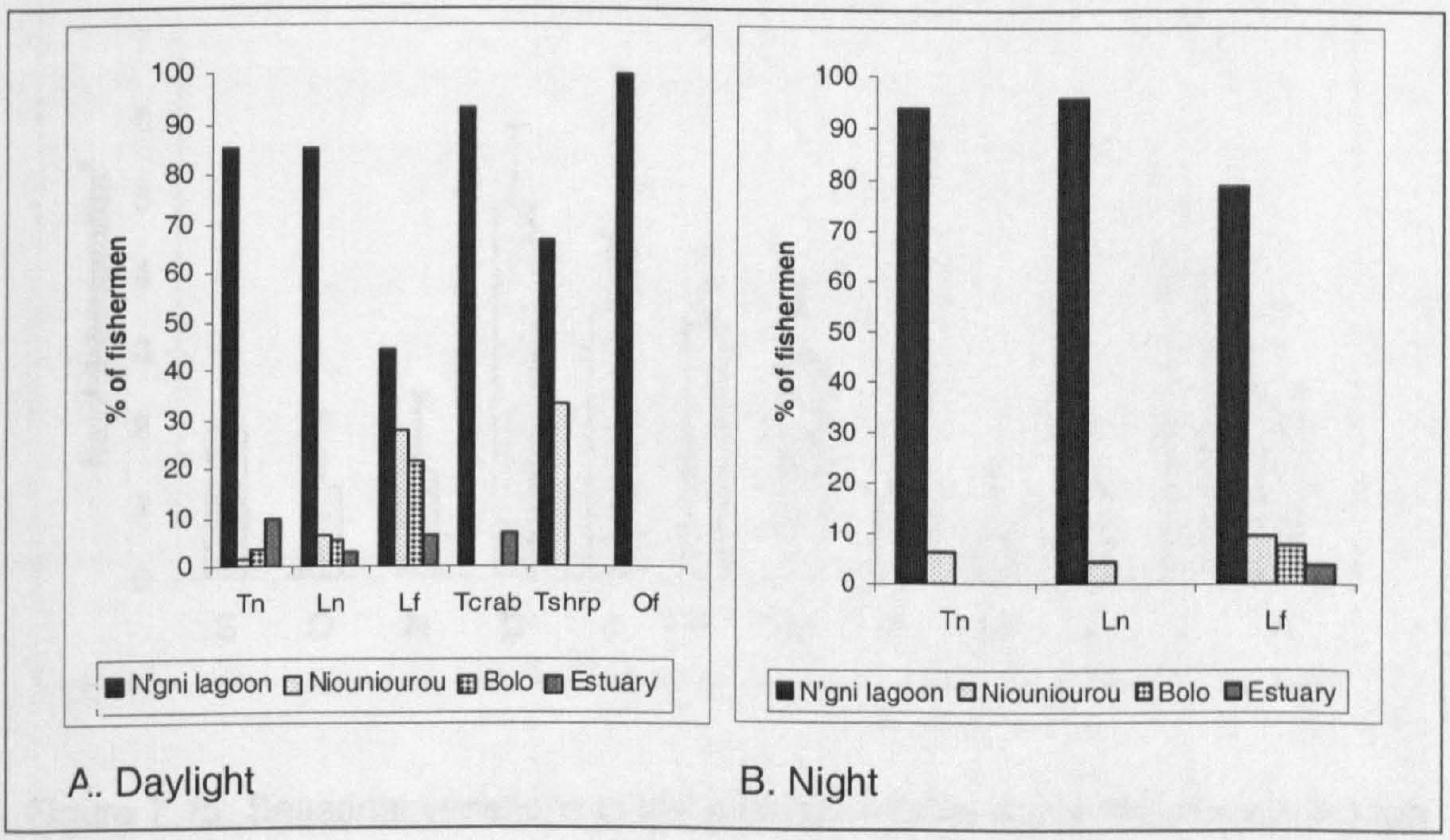


Figure 7.14: Spatial and diurnal distribution of fishing methods in the Fresco lagoon complex from September 2000 to August 2002.

7.3.3.2. Firewood collection

Firewood was invariably collected in daylight and all collectors used the shoreline of the N'gni lagoon.

7.3.4 Seasonal patterns of natural resources harvesting

7.3.4.1 Fishing

Fishermen from different households engaged in fishing from 1-8 times/week with a mean frequency of 3.27±0.13 times/week. This was equivalent to 13 times/month/household or 156 times/year/household. The density of fishermen on the Fresco lagoon complex per month ranged from 0.57 to 4.90 fishermen/km^2 with a mean of 2.39±0.39 fishermen/km^2. Nevertheless, the densities of fishermen on the lagoon followed a seasonally bimodal pattern, with peaks in December and July and troughs in May and October (Figure 7.15).

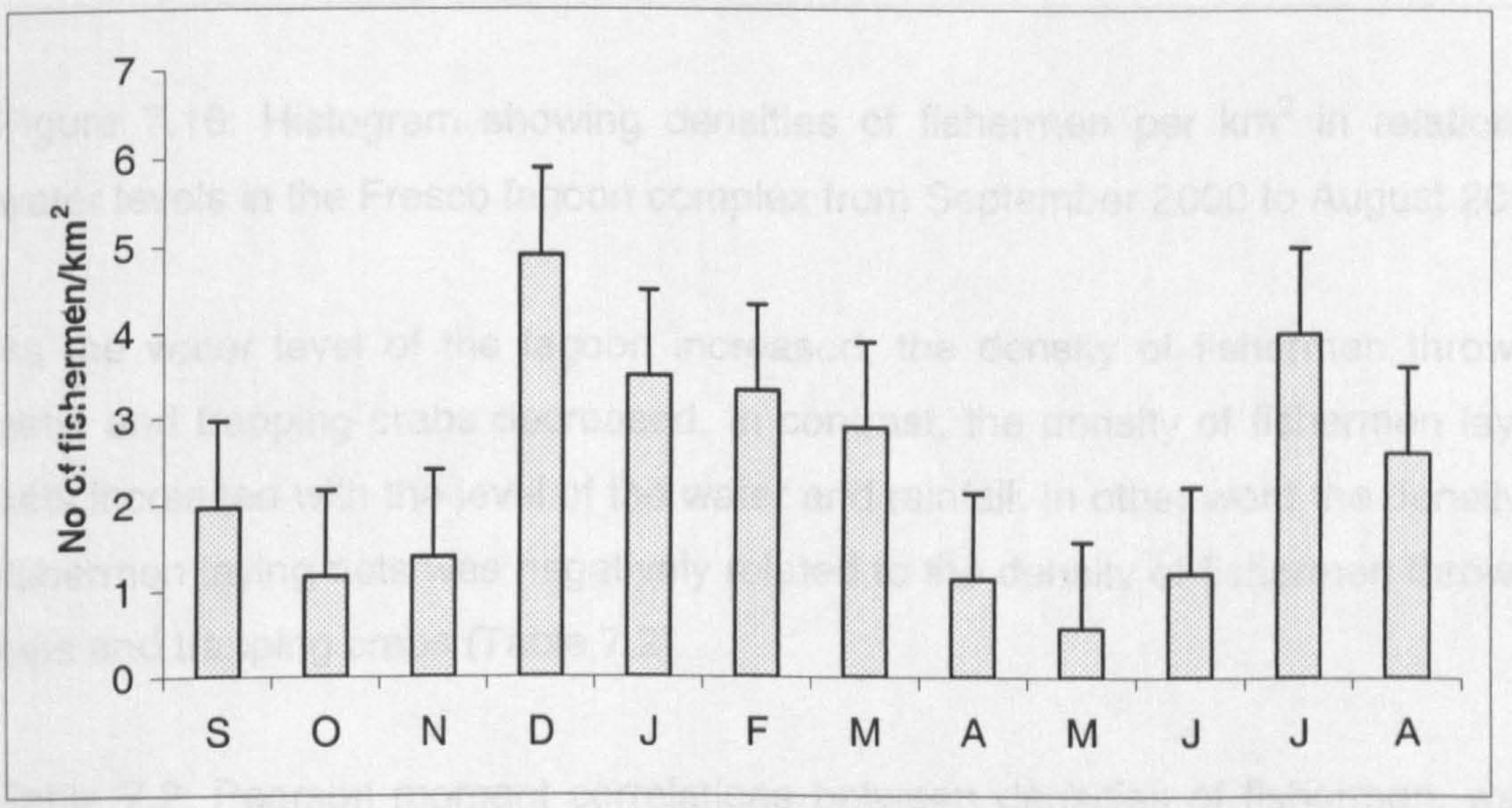


Figure 7.15: Seasonal variations in the density of fishermen in the Fresco lagoon complex from September 2000 to August 2002.

Densities were negatively related (r=-7.20, N=12, P<0.001) to water levels in the Fresco lagoon complex. In other words as water levels increased, densities of fishermen decreased (Figure 7.16).

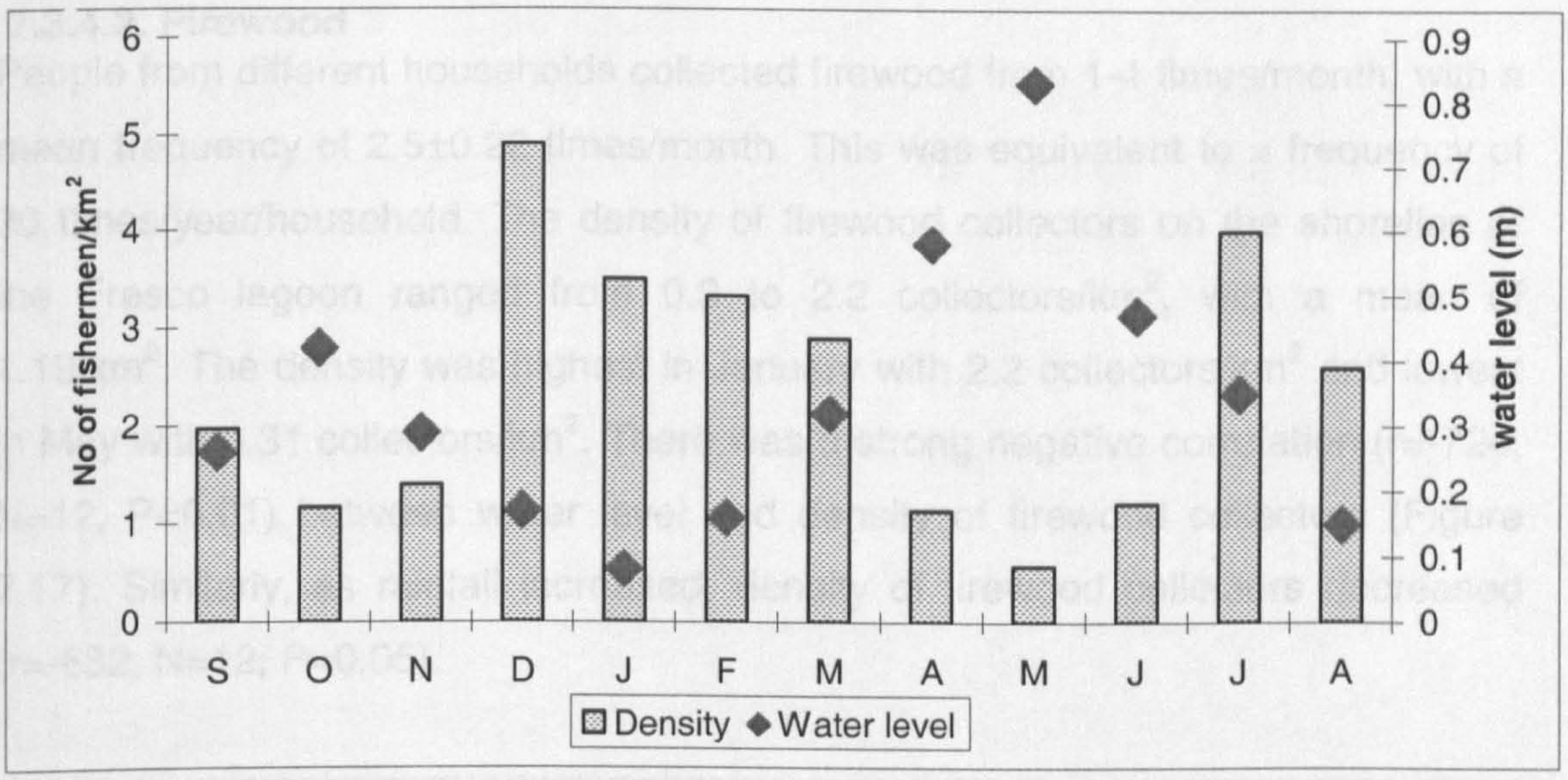


Figure 7.16: Histogram showing densities of fishermen per km^2 in relation to water levels in the Fresco lagoon complex from September 2000 to August 2002.

As the water level of the lagoon increased, the density of fishermen throwing nets, and trapping crabs decreased. In contrast, the density of fishermen laying nets increased with the level of the water and rainfall. In other word the density of fishermen laying nets was negatively related to the density of fishermen throwing nets and trapping crabs (Table 7.2).

Table 7.2: Pearson moment correlations between densities of fishermen, water levels and rainfall in the Fresco lagoon complex.

Fishing method	Ln	Tn	Lf	Tcrab	Density	Water level	Rainfall
Ln	1	-.705*	-.363	-.652*	-.596*	.833**	.766**
Tn	-.705*	1	.683*	.802**	.811**	-.706*	-.624*
Lf	-.363	.683*	1	.787**	.637*	-.558	-.379
Tcrab	-.652*	.802**	.787**	1	.720**	-.696*	-.551

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

7.3.4.2. Firewood

People from different households collected firewood from 1-4 times/month, with a mean frequency of 2.5±0.22 times/month. This was equivalent to a frequency of 30 times/year/household. The density of firewood collectors on the shoreline of the Fresco lagoon ranged from 0.3 to 2.2 collectors/km^2, with a mean of 1.19/km^2. The density was highest in January with 2.2 collectors/km^2 and lowest in May with 0.31 collectors/km^2. There was a strong negative correlation (r=-724, N=12, P<0.01) between water level and density of firewood collectors (Figure 7.17). Similarly, as rainfall increased, density of firewood collectors decreased (r=-632, N=12, P<0.05).

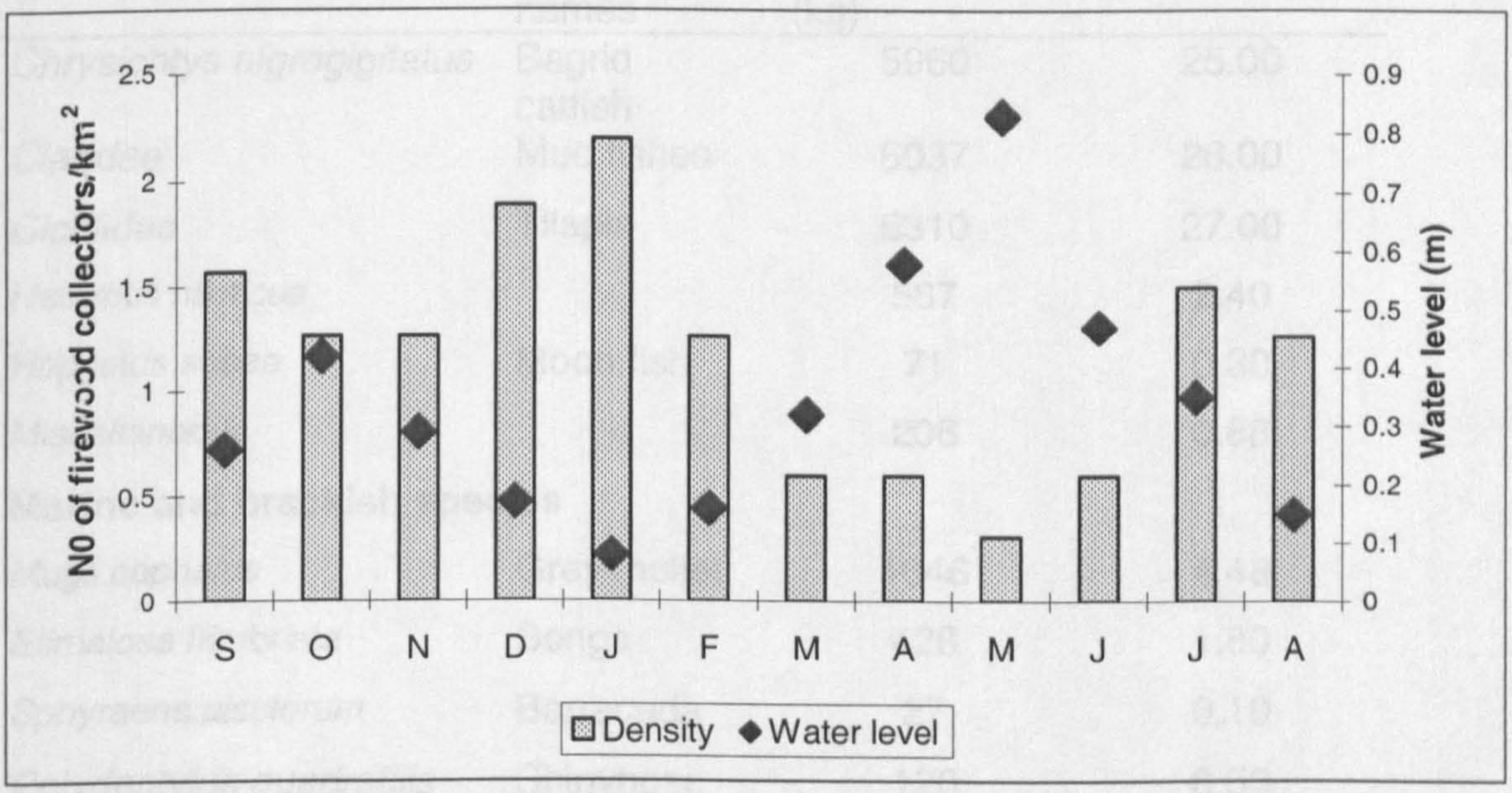


Figure 7.17: Histogram showing density of firewood collectors in relation to water levels in the Fresco lagoon complex from September 2000 to August 2002.

7.3.5 Extent of harvesting

7.3.5.1 Fish catches

The catches of 15 households was weighed and sorted at the Fresco Fishery Service. The total annual landing of fishes from the Fresco lagoon complex by the 15 households was 23,345 kg. The catch mainly comprised of fishes (92%), of which most (89%) were typically freshwater species and only 11% were marine and brackish species. Crustaceans and molluscs represented 8.4% and 0.6% of the catch, respectively. Freshwater species mainly comprised *Cichlidae* (*Tilapia*), *Claridae, and Chrysichthys nigrodigitatus.* Marine and brackish water species was predominated by *Mugil cephalus* and *Ethmolosa fimbriata* (Table 7.3).

Table 7.3: Annual landing of aqautic resources and species composition based on catch of 15 households (source Fresco Fishery Service)

Freshwater species			
Species/family	English FAO names	Annual catch (kg)	% composition
Chrysichtys nigrogigitatus	Bagrid catfish	5960	25.00
Claridae	Mud fishes	6037	26.00
Cichlidae	Tilapia	6310	27.00
Heterotis niloticus		567	2.40
Hepsetus sebae	Moon fish	71	0.30
Miscellaneous		206	0.88
Marine and brackish species			
Mugil cephalus	Grey mullet	1046	4.48
Etimalosa frimbriata	Bonga	428	1.80
Sphyraena pisctorum	Barracuda	27	0.10
Polydactylus quadrafilis	Shinynose	120	0.50
Epinphlus aenus		18	0.07
Cynoglossus canariensis		113	0.40
Pomadasys jubelini		60	0.20
Miscellaneous		440	1.80
Shellfish			
Crustaceans		1797	8.40
Moluscs		145	0.67
Total annual landing		**23,345**	**100**

Catches by 15 households peaked in December with 3,851 kg and was lowest in May with only 741 kg. Monthly catches and water levels were negatively associated (r=-0.623, N=12, P<0.05).

Factors that might predict variations in the catch were examined using simultaneous regression. The model that included, water temperature, water level and salinity explained 46.8 % of the variance in annual catch. Of these three variables, water level made the largest unique contribution (Beta= -0.1.035 P<0.05; Figure 7.18).

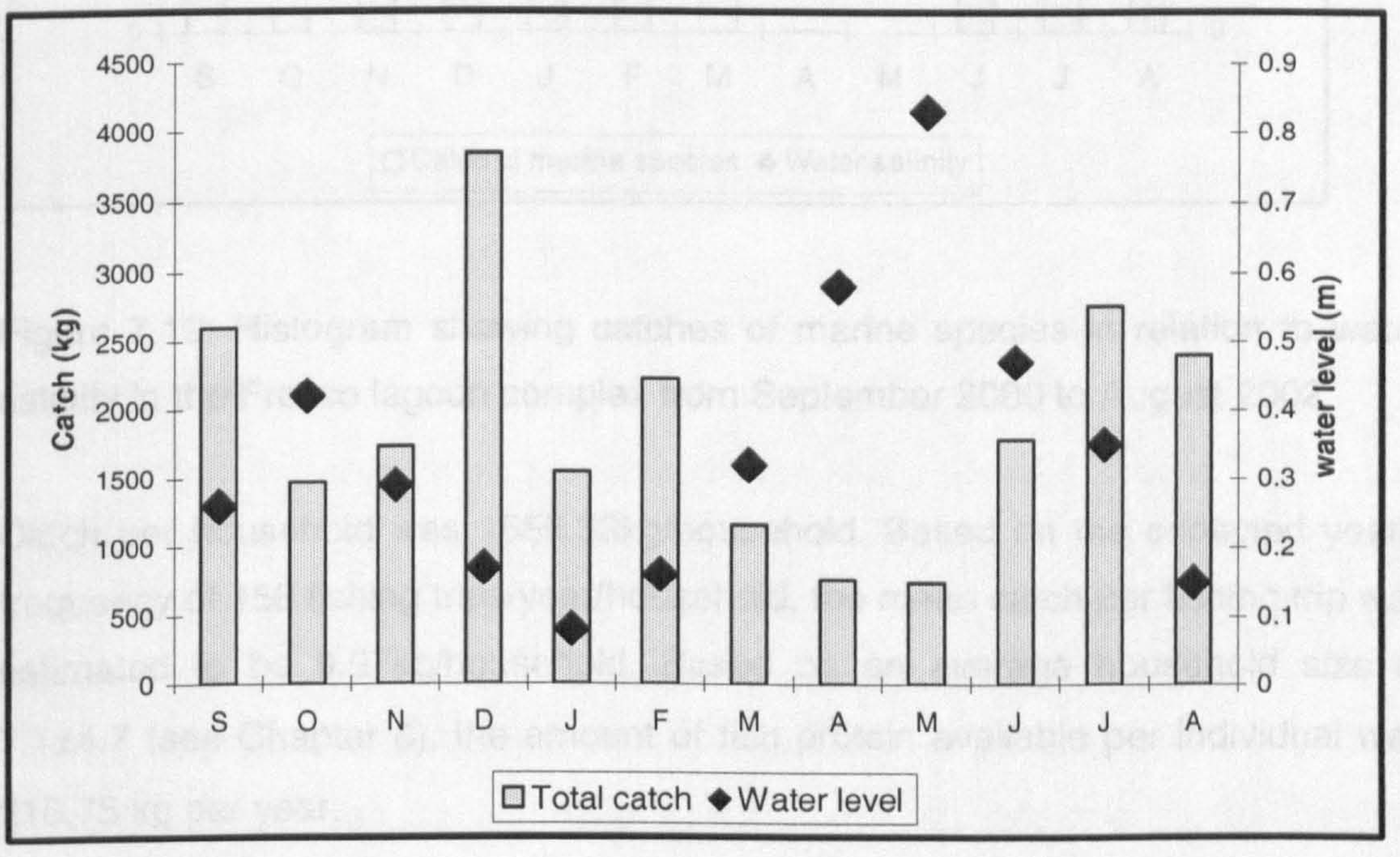


Figure 7.18: Histogram showing catches of fish in relation to water levels in the Fresco lagoon complex from September 2000 to August 2002.

Marine and brackish species were mainly present in the catch from June to March with a peak in February. In contrast, they were almost absent in the catch from April to May. Catches of marine species were strongly correlated (r=0.747, N=12, P<0.001) with the water salinity in the Fresco lagoon complex (Figure 7.19).

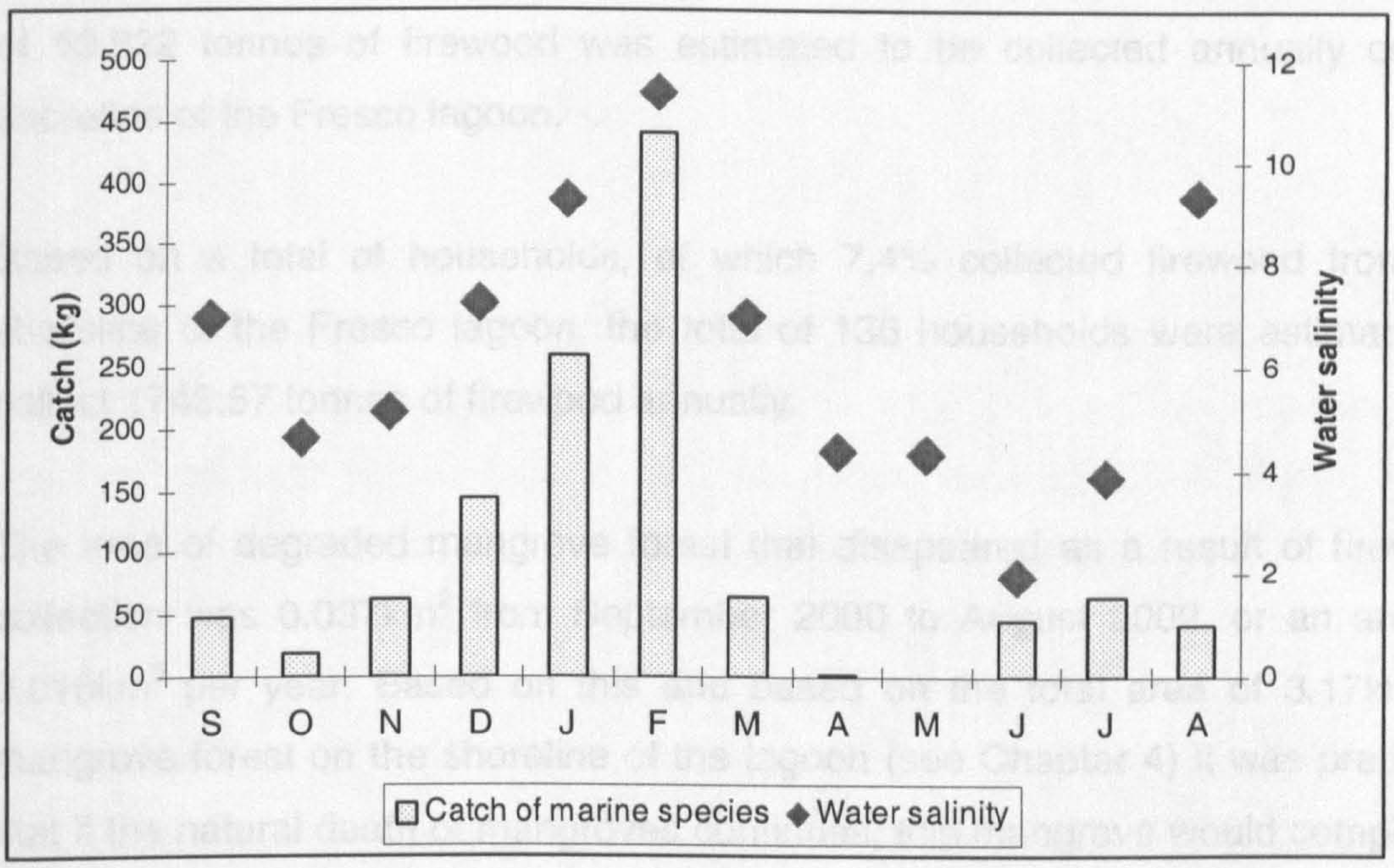


Figure 7.19: Histogram showing catches of marine species in relation to water salinity in the Fresco lagoon complex from September 2000 to August 2002.

Catch per household was 1556.33kg/household. Based on the expected yearly frequency of 156 fishing trips/year/household, the mean catch per fishing trip was estimated to be 9.97kg/household. Based on an average household size of 7.1±4.7 (see Chapter 6), the amount of fish protein available per individual was 216.75 kg per year.

Based on the total number of households, of which 37% fished in the Fresco lagoon complex, the total of 680 fishing households were estimated to extract 1,058.304 tonnes of fish annually.

7.3.5.2 Firewood

A total of 28,210 tonnes of firewood were collected from the shoreline from September 2000 to August 2002, based on the contents of 66 boats. This was equivalent to 427.42 kg per boat on each firewood collection trip. Based on the expected yearly frequency of 30 firewood collection trips/year/household, a total of 12,822 tonnes of firewood was estimated to be collected annually on the shoreline of the Fresco lagoon.

Based on a total of households, of which 7.4% collected firewood from the shoreline of the Fresco lagoon, the total of 136 households were estimated to collect 1743.87 tonnes of firewood annually.

The area of degraded mangrove forest that disapeared as a result of firewood collection was 0.037km^2 from September 2000 to August 2002, or an area of 0.018km^2 per year. Based on this and based on the total area of 3.17km^2 of mangrove forest on the shoreline of the lagoon (see Chapter 4) it was predicted that if the natural death of mangroves continues, this mangrove would completely disappear in 176 years.

7.4 Discussion

Lagoons and estuaries have played a crucial role in human history. They have provided an important livelihood source for people in most coastal areas across the world (McGoodwin, 2001) and major stages in the evolution of human life probably took place around coastal waters (Maltby, 1991). Unfortunately, some lagoons are depleted or heavily overexploited and face an increasing scarcity of resources as consequence of changing tenancy regulations or common property rules, and rising commercialisation (Allison and Ellis, 2001). In contrast, resources in other lagoons have been preserved for centuries by indigenous knowledge and powerful management systems for the long-term benefit of communities who greatly depend on them for their social sustainability (Scuder and Conelly, 1985; Kone, 1985).

This study has clearly shown that the resources of the Fresco lagoon complex have been protected based on customs and traditional beliefs, successively under the *N'gni* system and more recently by the co-management committee. As a result, the community can continue to use these resources to meet their livelihood requirements, and this study is the first to detail uses of natural rescurces from the lagoon of Fresco.

7.4.1 Fishing

The principal reason why the community sought to protect the lagoon of Fresco was to ensure a sustainable production of fish. It was not surprising that respondents from Fresco, Bohico and Zakareko villages all viewed the lagoon as a very important fishery and that most resources harvested were consumed locally rather than traded.

7.4.1.1 Methods of Fishing

The most important fishing methods were thrown netting, laid netting and line fishing, while banana boats served as the main means of transport. The use of simple fishing methods and gear and the small number of fishermen per fishing unit, suggested that the fishery supported by the lagoon was a small scale, or artisanal fishery (McGoodwin, 2001; Moses *et al.*, 2002). This reflected the general picture of estuarine fisheries across the world. Nearly 95% of the world's fishermen are small-scale or artisanal fishermen and the majority (95%) of them are in developing countries (FAO, 2000). Similarly, of the 14,000 fishermen found in Cote d'Ivoire, many (43%) are small-scale fishermen (Ivorian Ministry of Agriculture, 2000).

Throwing nets was the most important fishing method used by the community during daylight, and is a collective fishing method that involves at least two people usually from the same household. A boat operator sits or stands in the back of the boat while a fishermen stands in the middle or in the front and holds a cast net. Nets used varied in size according to the depth of the water. Pieces of lead are attached at the circular bottom of the net to give it enough weight. While the boat is moving, the fishermen, in standing position, first throws a stone in the water in front of him, because local belief has it that the stone will attract fish. The net is then thrown in an arc around the area where the stone fell. The pieces of lead keep the lower side of the net in contact with the lagoon floor in a radius of about 5 to 10m, depending on the size of the net. The fishermen hold the ropes attached to each end of the net to box in fish retained in the radius of the net. The net is then slowly lifted into the boat. Rubbish caught by the net is also removed before fishing resumes.

Throwing nets requires intensive physical effort, and so fishermen may become tired just after few hours of fishing, which may explain why more youths (87%) than adult males (13%) were involved (Figure 7.8). Likewise, fishermen also only use this method for short periods, as shown by peaks of fishing activity (Figure 7.10a). The negative correlation between the densities of fishermen throwing nets and water level suggests this is ineffective when water levels are high. Moreover, the negative relationship between densities of fishermen throwing and laying nets and the strong positive correlation between laying nets and water level (Table 7.3) suggest that fishermen shift from thrown-net fishing to laid-net fishing methods during periods of high water. Net throwing is a more appropriate fishing method in shallow water, as fish may easily escape from the net in deeper water.

Laid netting is an easier fishing method, that requires a long net held vertically in the water column with a series of floats attached to its upper edge, and of weights attached to its lower edge. Nets are generally set in the water before dusk and collected at dawn (Figure 7.10b). The catching ability of the net relies on the movement or migration of fish through the area where it is set. A more aggressive method of net laying is also used, particularly by youths. It consists of placing the net against the roots of mangroves and beating the water surface for 100 to 200m around for 15 to 20 minutes. Fishermen believe that, by beating the water surface, fishes feeding or seeking protection under the roots of mangrove trees will swim into the net when fleeing.

Line fishing is another important fishing method that involves more adult males (92%) than youths (8%). Two types of line are distinguished: single hook line and multiple hook line. Single hook line method consists of baiting a fishhook already attached to a long line, and throwing it in the water. Usually, the fisherman holds the line while sitting in a boat or standing on the shore, and waiting until a fish is caught. This is a very time consuming method that needs considerable patience from the fisherman, and a quiet area. Multiple hook line consists of a single long line (150 to 200m) with 500 to 1000 hooks set on short sidelines. Hooks are not baited and the catching ability of the method relies only on the movement of fish. The line is laid in the water at dusk checked at mid-night and collected early in the morning (Figure7.11b).

Multiple hoops made with a net, steel or a branch of *Raphia hookeri* are used to trap crabs and shrimp. Hoops are baited and set into the water. Crabs and shrimps can easily enter the hoops but, once inside, a mechanism will prevent them from escaping. Shrimp trappers check the hoops and change its bait every two days. In contrast, crab trappers stay on the water throughout daylight hours checking, removing crabs caught and renewing the bait at least every 20 minutes. Hence, the number of crab trappers coming into the lagoon peaked at 0600h and those leaving peaked at 1700h (Figure 7.11a).

Oyster trapping occurred usually in shallow areas. Collection is done by hand while women slowly walk in the water. Collection lasts the whole day and the oysters are processed at the end of the day, by boiling and extracting the meat. This processing work, particularly boiling, is typically reserved for women in most African cultures. After extracting the meat, the shells are piled in specific areas for later use. Thus, areas where oysters are processed are always characterized by mounds of oyster shells.

7.4.1.2 Boat traffic and tidal stages

Most users departed at low tide (Table 7.3). The use of small banana boats and simple methods of fishing may, in part, explain this. At high tide, the water surface is wavy, whereas at low tide the lagoon surface was flatter and therefore more secure for the type and size of banana boat used. Moreover, for fishermen engaged in throwing nets, flat water is important so the main operator retains more equilibrium and can more efficiently cast the heavy net as far as possible into the water. The departure of fishermen at low tide may also be related to the movements of fishes, and to the difficulty of catching fish at high tide. Indeed, as water levels rose during high tides, fishes are believed to disperse to feed or seek protection under mangrove roots and areas of difficult access for fishermen (Mcses, 2001). During low tides, as the water level dropped, fishes return to the main water body by following the seaward direction of the water. Thus, by departing at low tide, fishermen may expect to maximize their catches in as a short time as possible, while reducing physical effort.

7.4.1.3 Spatial distribution of fishing

The N'gni lagoon was the most used fishing ground, both during daylight and at night. This was not surprising due to its proximity to the village of Zakareko and the city of Fresco where most users live. Moreover, the lagoon may be more suitable for the type of fishing gear used, particularly nets, as the lagoon bottom was relatively free of dead branches compared to the Bolo and the Niouniourou Rivers. Furthermore, due to its connection and proximity to the sea, the lagoon may offer a wider diversity of fish species to fishermen than the Bolo and the Niouniourou Rivers.

7.4.1.4 Patterns of fishing

Density of fishermen on the lagoon and fishes catch peaked in December (Figure 7.15). This finding differed from Nicole *et al.* (1994) who observed that the most important fishing season in most of lagoons in the coastal areas of Cote d'Ivoire was in June, following the opening of their inlets. Various factors may explain the current finding. The community living around the Fresco lagoon complex are mostly committed to agriculture, and fishing is generally considered as second activity. The main crop grown is rice, for which land is cleared in January, while all field preparation and planting lasts from February to March. From April, most people leave their villages to stay in small camps set around their rice farms in order to keep birds away. This situation also even adversely impacted on the time available for questionnaire surveys, as many households sampled were difficult to meet at home. Farmers stay in their camps until rice is harvested and transported home from the end of August. Although fish are still needed during time spent in the camps, the frequency of fishing and number of fishermen was generally less (Figure 7.15). December corresponded to the end of the agricultural calendar for both men and women in the Fresco community, while the preparations for the Christmas and New Year's festivities required both fish and money.

7.4.1.4.1 Relationship between catch, density and hydro-climatic factors

The water level and salinity were important factors influencing density and level of catch (Table 7.3; Figures 7.18, and 7.19). However, the relationships between hydro-climatic factors and the behaviour of fish, which resulted in good or poor catches, and in high or low densities of fishermen, are indeed very complex. As suggested by Laevastu and Hela (1970), any simple correlation between environment conditions, and catches of fish need to be interpreted with caution. Moreover, the number of households included in the analysis of catch data was relatively small compared to the total number of households fishing in the lagoon, while fishing effort, which is also believed to influence the size of catches, has not been estimated.

Nevertheless, the addition of freshwater to the lagoon during the wet season and the increased water levels lowered the salinity of the estuary and the lagoon (see Chapter 3). As consequence, truly marine pelagic fishes such as *Ethmalosa fimbriata* and *Mugil cephalus* may avoid the lagoon and the estuary, and move further offshore to maintain their osmotic balance (Moses, 1999; Moses *et al.*, 20C2). Moreover, the closing of the inlet, which occurred at the end of February prevented any migration of marine fishes into the lagoon complex. The absence of marine species in the catch from April to May was therefore not surprising (Figure 7.15).

In contrast, during the dry season less freshwater flows into the lagoon complex, so the level of the water dropped significantly from December while its salinity rose (see Chapter 3). This induced marine fishes to migrate into the lagoon complex through the inlet, and some even appeared the Bolo and the Niouniourou Rivers to be caught by fishermen. This may, in part, explained the peak of catch in the dry season.

The negative correlation between catch and water level also suggests the difficulty of catching fish in the large water volume during the wet season and while the inlet is closed. Fish species such as *C. nigrodigitatus,* mudfish (Claridaea) and Cichlidae, may disperse in the floodwater during the wet season to feed on various allochthonous materials such as fruits, insects, insect larvae, and snails. Leaves, branches and stems of macrophytes may also provide sufficient cover, thereby increasing the difficulty of catching them. Similar fish behaviour was observed by Moses (1997) in artisanal fisheries of South-eastern Nigeria.

7.4.1.5 Extent of catch

The productivity and incomes derived from small-scale fisheries are generally small. Nevertheless, their production accounts for over 45% of the total world fish catch and constitutes over 40% of the total world supply of fish designated for human consumption (Mc Goodwin, 2000). In Cote d'Ivoire, where fish constitutes a primary source of protein, the national annual production of fish is 102,000 tonns of which artisanal fisheries represent 62,000 tonnes or 61% of total production. An important part of the annual requirement of fish in Cote d'Ivoire, estimated at 242,000 tonnes or 20kg of fish food per inhabitant (the highest in the whole Africa), is still not covered (Ivorian Ministry of Agriculture, 2000). The current estimate of 216kg of fish that is available annually to individual members of households around Fresco lagoon is well above the national requirement. The low density of the human population, the lowest of the country (see Chapter 2) may partly explain this high level of production per household.

Nowadays, most of the world's major fisheries are in peril. Nearly all of the approximately 200 fisheries monitored by the FAO are fully exploited, with one in three being either depleted or heavily over-exploited (McGoodwin, 2001). At the national level, fish catches in major fisheries have dropped as result of increasing demand, in turn causing over-harvesting of the available stock (Powell, 1992). The current level of fish catch in the Fresco lagoon complex cannot be interpreted further unless the available stock is assessed. However, several factors are all causes for concern: the community now fish only in the lagoon, since fishing in the sea was stopped, (see Chapter 5); non-native users have been admitted to the lagoon; the lagoon complex is small in size; and, the new coastal highway may open the access of the region to new markets. Moreover, Egnankou *et al.* (1990) observed that fish caught in the Fresco lagoon were getting smaller in size. They also observed that during the opening of the inlet by the indigenous people, the lagoon lost an important proportion of its fish stock. Over a distance of 500m, 150 dead fishes were found ejected on the sand beach by the heavy water current created by the breached of the inlet (Egnankou *et al.*, 1990). Furthermore, the breaching of the inlet may allow little time for fish to breed and reach maturity. Nevertheless, several factors are encouraging for the long-term sustainability of the fishery: the presence and the dominance of cichlid species in the catch; the connection of the lagoon to the sea through the inlet that allows the immigration of marine species; the relatively abundant supply of nutrients conveyed by the Bolo and the Niouniourou Rivers; the relative difficulty of catching fish during high water level that may allow fishes to hide and breed; and, the existence of a co-management committee (Chapter 5). Tilapias for instance, are very flexible in growth rate and maturation size according to prevailing environmental conditions and food is rarely a limiting factor. Moreover, Tilapias are among the last three species (with *Clarias* and *Barbus*) that survive when abiotic factors are close to or beyond, the tolerance limits for most fish life in aquatic habitats. Fishery biologists have documented many cases where Tilapia species to some extent improve local fisheries production. One peculiar aspect of the reproductive biology of Tilapias is the phenomenon of stunting and dwarfing. This is an adaptation towards survival under extreme physical conditions. Stunted populations are characterised by a low maximum size and precocious breeding. They can mature in 3 months compared with 2-4 years in other populations. Tilapias increasingly contribute to the world food supply for humans and it is not surprising that it has been introduced in different parts of the world to improve fisheries or to develop aquaculture (Wade *et al.*, 2002). The name "aquatic chicken" has been given to Tilapia to emphasize their importance (Beveridge and McAndrew, 2000).

7.4.2 Firewood

About half of the world 's population uses wood biomass as their main, and often only, household fuel source. These fuels are used for cooking, heating and lighting. In global terms, firewood represents about 7% of the world's total primary energy consumption. Most firewood use (76%) is in developing countries, where about 77% of the world's population lives. For instance in 1985, firewood accounted for 85% of total household energy consumption in Cote d'Ivoire (UNDP/World Bank, 1985). Almost 50% of the wood cut annually worldwide is used as fuel. Progressive increases in the demands placed on the energy supply due to population growth and urbanization, especially in Africa, have raised concerns among environmentalists and those responsible for forest development and management. In a report to the 1981 United Nations Conference on New and Renewable Source of Energy, FAO forecast that almost 2.8 billion people in developing regions would experience a deficit of firewood by 2000, and that 356 million people would suffer acute shortages. However, this firewood crisis has never yet happened, and the alarming firewood deficit situation predicted for many developing countries did not occur (Trossero, 2002). Studies showed that firewood materials are supplied from many sources, not only from forests (Trossero, 2002). Nevertheless, ensuring a sustainable firewood supply is available for the poorest people of the developing countries remains a serious problem.

This study has shown that the population living around the Fresco lagoon complex has diverse sources of firewood supply, and only very few people (7.4%) collected *Rhizophora racemosa* from the shoreline. Although the degradation of mangrove on the shoreline is a cause of great concern, it could not be attributed to the collection of firewood, since only dead wood was collected. The most important issue was the natural degradation of the whole mangrove forest surrounding the lagoon (see Chapter 4). The role of mangroves in the production of leaf litter and nutrients that support the rich aquatic and benthic plankton food supply for coastal fisheries is very important (Odum, 1971). A portion of the diet of many fishes and most crustaceans is also derived directly from the mangrove detritus material (Saenger *et al.*, 1983). In tropical areas, it is estimated that 80 to 90% of demersal fisheries are dependent on mangroves. Mangrove provides physical factors important for the recruitment success of many fish and invertebrate species. Refuge from predation and food is provided for fish species that move around this ecosystem during different life stages by the intertwining roots. Clearly the degradation of the mangrove could cause an important break in the food chain and will threaten the future of the fishery in Fresco lagoon unless urgent action is undertaken.

Firewood collection peaked in January, corresponding with the dry season, and the density of collectors was negatively correlated to water level in the lagoon. In most coastal areas of Cote d'Ivoire where mangrove trees are collected as firewood, collection peaked in June during periods of high water, which gives easier access and transport (Nicole *et al.*, 1994). The peak of collection in Fresco lagoon during January may be because only dead wood was collected. These woods remain hidden during periods of high water level, so collection is therefore only possible in the dry season.

The two previous parts of this thesis have dealt with the ecology of the habitat and the use of the lagoon by humans. In the next part, I will examine, in detail, the ecology of the West African manatee using the lagoon complex in Fresco

PART III THE WEST AFRICAN MANATEE

"They were sea nymphs, half women, half birds, who lured love-struck sailors to shipwreck on the rocks by singing to them. Today the story may be given a reverse twist, for the real-life sea cows or manatees are slowly but surely being killed off by man" (McClung, 1978).

People should work hard to preserve manatees, whose only reason for being on a tl.reatened species listing is human acitivity. However, the more accurate knowledge of the species that people acquire, the better the understanding of the species' needs for incorporating into management decisions. Thus, this section examines the ecology of the West African manatee in the Fresco lagoon complex

CHAPTER 8 MANATEE ECOLOGY

8.1 Introduction

Until fairly recently, the West African manatee (*Trichechus senegalensis*) was among "forgotten" marine mammals (Reynolds and Odell, 1991). Other living sirenians had received considerable attention, while the West African manatee remained the species about which the least information was known. Only a handful of individual scientists had attempted to carry out preliminary studies on the distribution and the biology of the species. A broad scale survey, based mostly on information gleaned from fishermen, was first conducted by Nishiwaki *et al.* (1982) who visited 13 African countries in July-August 1980 and January-March 1981. Nishiwaki *et al.* (1982) presented a regional picture of the West African manatees based on their travels and interviews, and reported numerous manatees occupying a variety of habitats. Reeves *et al.*, (1988) studied the West African manatee in Sierra Leone and Nigeria, while Roth and Wait ku Wait (1986) investigated manatee distribution and status in Cote d'Ivoire. More recently, Powell (1996), spent nine years in West Africa studying manatee biology and management in seven West African countries. His report contains perhaps the best up-to-date presentation of regional information on the species.

Manatees were believed to inhabit several aquatic habitats (Hartman, 1979; Rathbun *et al.* 1983). However, optimal habitats for manatees, based on reported sighting in various areas, are coastal lagoons and estuaries with abundant growth of mangrove or emergent herbaceous growth (Powell, 1996). Observations of 17 radio tagged individuals in Cote d'Ivoire revealed that manatees are often alone, but seemed to congregate in certain locations in groups of 25-30 during the rainy season. Tagged animals were reported generally to remain within a radius of about 10 km of the site where they were originally radio-tagged, although some individuals may travel extensively (30-40km per day) through lagoon and rivers, generally, in search of food (Powell, 1996). Manatees have been reported to make seasonal movements in response to changing water levels that affect their ability to obtain food, and to changes in water salinity and current (Best, 1981).

Very little is known about the feeding behavior and ecology of the West African manatee. Although manatee are believed to have a diverse diet, recent reports suggest that their diets mostly comprised emergent grasses, plants and even fruits that fall from trees into the water (Roth and Waitkuwait, 1986; Powell, 1996). Species from the family of Poacae (Gramineae) appear to be dominant in their diet. Emergent grasses and leaves of plants become more available to manatees when lagoons are flooded and tides are high. Manatees might therefore be expected to link their feeding activity with water levels and tidal cycles, particularly in estuarine habitats. However, the feeding habits of West African manatees have never before been studied systematically.

Moreover, no detailed behavioral studies have been carried out to date on the West African manatee, using either wild or captive specimens. However, the species is known to respond behaviorally to miscellaneous human and environmental stimuli. It is believed that manatees shift their activity patterns and are more nocturnal, probably in response to human pressure. Feeding, for instance, is believed to occur at night and manatees spend most of the daylight hours resting under mangrove roots to avoid humans (Powell, 1996).

The lack of research on manatees is in part due to the relatively harsh environment in which the species lives. The conservation and management of a species for which so little information exists remains a real challenge. Clearly, appropriate knowledge on the ecology of the West African manatee is needed to allow better decisions for the long-term management of the species.

Hence this chapter aims to increase the understanding of the ecology of the West African manatee in the lagoon complex of Fresco and the following questions will be examined:

- what is the population size and density of manatees?
- what are the preferences and patterns of spatial organization?
- how do activity budgets and patterns change in relation to water level, tide stages, seasons and habitats?
- what is the diet and feeding behavior of manatees, and how does this change in relation to seasons?

8.2 Material and Methods

8.2.1 Population estimate and density

Primary information on areas and times of day where manatees were usually sighted on the lagoon was obtained by group discussions and from key informant interviews in the villages of Fresco, Zakareko and Bohico (Appendix III). Based on this information and on the locations of tagged manatees, the study area was subdivided into 4 relatively small blocks or sampling units so that the surface area could be constantly kept in view. Two blocks were in the N'gni lagoon, one was in the estuary, and one was at the meeting point between the Niouniourou River and the Fresco canal.

Later aerial surveys were conducted in a Cessna 172 at air speeds of 150-160 kmh^{-1} and at a cruising altitude of 137 m, in each block following intensive search technique (Irvine and Campbell, 1978; Lyn, 1995). Counts took place in the dry season when the surface coverage and the turbidity of the water were minimal. The survey crew comprised four people: the pilot, a front-right survey leader, and two observers, one on either side of the aircraft, with polarized sunglasses to reduce the water glare. A survey route was designed and each block was circled separately and continuously for a period longer than the mean surfacing interval of a manatee of 8 minutes (Powell, 1988) to give time for most individuals to surface. As counts took place during the dry season, the area covered and the population density (no of manatees/km^2) were calculated using the dry season water surface (see Chapter 3).

The population estimate was calculated with a correction factor for less-than-complete coverage of the study area using the following equation: $N = N'/\alpha$, where α is the proportion of the total covered area, N' is the highest count for the covered area, and N is the estimate of the total area (Lancia *et al.*, 1994; Ackerman, 1995).

8.2.2 Spatial organization and habitat preference

8.2.2.1 Radio telemetry

8.2.2.1.1 Captures

Manatees were captured from September 2000 using traditional traps similar to the one described by Powell (1988). The traps were constructed of multiple wooden sticks, secured together with vines and sunk in the lagoon bottom. They are aligned in an oval semi-circle with a length of 2m and a width of 1.5m, but open at one end. At this end a sliding door made of sticks and weighted with a large rock was constructed. The door was held open by a system of smaller stakes that were balanced together to act as a trigger mechanism. The traps were placed in the N'gni lagoon in a shallow area of 1-1.5m deep and about 100m from the shoreline. The traps were then baited every day with fresh cassava peel (*Manihot esculenta*), that were thrown randomly inside and around the trap. When a manatee entered to eat the cassava, it accidentally pushed the trigger stick and the door fell.

The capture team consisted of a core of the manatee project personnal and 8-10 additional volunteers from the city of Fresco and the village of Zakareko. The construction of the first trap was completed in the morning of 11 September 2000, and the first individual was trapped the following day at 1500h. A net in the form of a large pocket was set in front of the door of the trap. The door was then sufficiently lifted allowing the manatee to escape from the trap and simultaneously enter into the net. It was then slowly pulled to the shore for handling. Manatees were found very tolerant of capture and handling. Two criteria were used to determine which manatees were suitable for radio tagging. Female manatees with nursing calf, and manatees with a body length less than

150m, were not tagged. Manatees that met those criteria were fitted with VHF radio telemetry assemblies.

8.2.2.1.2 Transmitter assemblies

Radio transmitter assemblies were designed by the Florida Marine Research Institute and the Sirenia Project of the National Ecology Research Center of the US Fish and Wildlife Service. Assemblies included a rubber-coated peduncle belt, a flexible nylon tether about 1 cm in diameter and 2 m in length, and a floating transmitter package. Each transmitter package comprised a PVC torpedo shaped cylinder (30x6cm) with a 40 cm long whip antenna. A tether coupled the transmitter package to the peduncle belt and was designed to break off if it became snagged as safety precaution for the manatee. The belt was adjusted to custom fit each individual and placed around the manatee's caudal peduncle, the narrowest point between the body and the fluke (Figure 8.1).

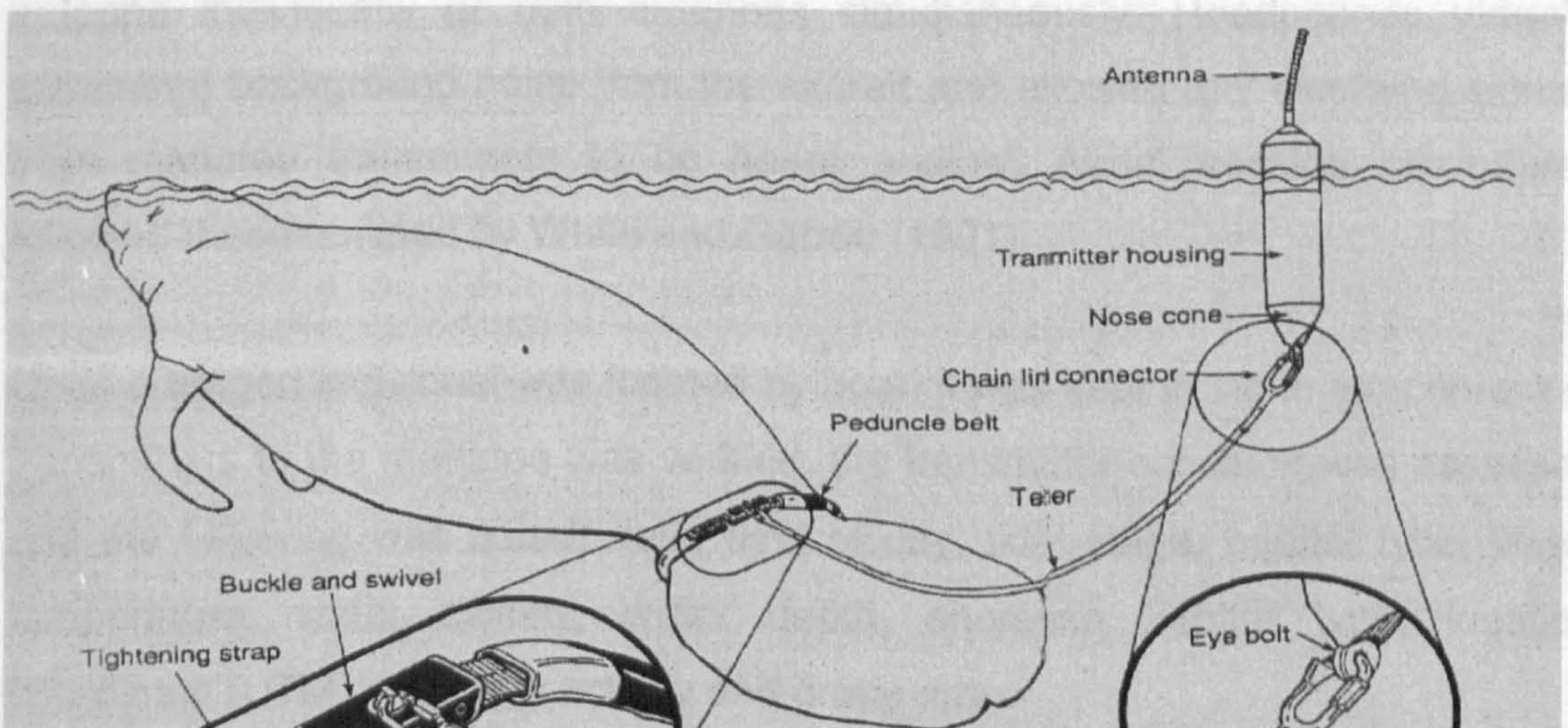


Figure 8.1: Transmitter assembly used for manatees in Fresco lagoon complex (drawing from Rathbun *et al.*, 1990)

The expected battery life of the VHF transmitter was up to 24 months. Signal reception was generally 8 to 10km from the ground and 30 to 50 km from the air. Manatees lost their radio-tags on 6 occasions. Lost tags were recovered where possible and re-fitted to freshly trapped manatees. In this way, the tags bought for the project were kept in use on different manatees (Tables 8. 1).

8.2.2.2 Spatial organization

Radio tagged manatees were located with a Telonics receiver from a boat with a hand held rotated yagi antenna. Locations were generally fixed at least three times a week with no more than a week passing between visual locations. Radio-tracking was also conducted by aircraft when a tagged manatee had not been radio located for more than a week, despite concerted efforts with cooperating fishermen. A Cessna 172 aircraft fitted with a Yagi antenna below each wing strut was used for aerial tracking and a portable switch box permitted the use of either antenna individually or both antennas simultaneously. Headphones virtually eliminated background noise from the aircraft and allowed any incoming signals from manatee transmitters to be heard audibly. Aerial tracking procedures followed those outlined by White and Garrott (1991).

Once a tagged individual was located by boat, it was kept in sight, attachment of transmitters to the manatee was verified, the transmitter condition was assessed and the following was noted: date, time of day, tidal stage, habitat type, water temperature, water salinity, water depth, shoreline habitat type, location coordinate (UTM), manatee activity and group size.

The minimum convex polygon (MCP) method was used to estimate home range. The analysis was done using Animal Movement, an Arc-View 3.2 extension programme. The minimum convex polygon method, a standard non-parametric method, is the oldest and still most common method for estimating home range size. Its main advantages are comparability across studies, simplicity and ease of calculation (White and Garrott, 1991).

The group sizes of manatees were subdivided into different categories and associations between group sizes and season, time of the day, sex and area of the Fresco lagoon complex were explored using Chi-square tests. Pearson moment correlation was used to test the relationship between group size and water temperature.

8.2.2.3 Area preferences

The area preferences West African manatees were based on measures of use and availability of habitats. For each manatee, a measure of usage was defined as the percentage of locations recorded in each area of the study area. Availability was taken to be the percentage of the water area in an individual manatee's home range constituted by each water system. Pearson moment correlation was used to examine the relationship between time spent in an area and the proportion of the lagoon occupied by this area. Based on measures of usage of each area type and the availability of that area, area preference was calculated using the rank preferences index following methods described by Johnson (1980) and Krebs (1999). Usage and availability of areas within each manatee home range were ranked. Next, for each manatee, the differences between the rank of usage and the rank of availability were calculated and one-way ANOVA was used to determine difference in intensity of use of different areas by manatees. The major advantage of the ranking method is that the analysis is usually not affected by the inclusion or exclusion of habitats that are rare in the study area (Johnson, 1980).

8.2.3 Behavioural observations

Manatee behaviour was identified and recorded 5min intervals accross 24 hours, during observation period using a method similar to that of Altman's (1974), and Martin and Bateson's (1996) focal animal sampling. Observation period generally began one to two min after sighting the animal and ended when the animal disappeared. Breathing interval was recorded whenever the animal surfaced with its nose out of the water to breathe. Behavioral categories and definitions followed Bengston (1981), who radio-tracked the West Indian manatee in the St Johns River, in Florida, except that surface resting and social travelling were excluded, as these activities were not observed in Fresco. Activities were grouped into four main behavioural types and each one was subdivided into different sub-categories:

- Moving:
  - Travelling: moving steadily in one direction;
  - Milling: moving about in the same small area without cavorting or feeding;
- Cavorting: any social encounters;
- Feeding
  - Steady feeding: feeding in vegetation;
  - Intermittent feeding: taking bites of food while travelling or milling;
- Resting
  - Bottom resting: remaining in one spot, body entirely under water, breathing less frequently (4min interval)
  - Idling: remaining in one spot, breathing more frequently than every 4min;
  - Stationary: specific activity unknown but animal not moving;
- Unknown: no data.

Because water was generally turbid and manatees were not always seen, particularly during night observations, indirect cues were often used. During daylight, respiration rate, for example, was important in discerning between manatees that were resting and idling. Resting manatees surfaced to breathe typically not more than once every 4min while idling manatees surfaced approximately once every 2 to 4min (Powell, 1988). The number of noses that surfaced to breathe around the tagged manatee was used to assess group size. The position and direction of the floating transmitter were used to discern manatees that were traveling, from manatees that were milling or bottom resting. Distinctive radio signals of 1 to 3 pulses alternating with 2 to 3min periods of silence were occasionally used at night to identify traveling manatees. The head-raising posture of manatees that surfaced to breathe was also used to distinguish between manatees that were milling and those that were feeding in the mud and organic material along the lagoon bottom. Manatees that were feeding on the mud and organic material typically lifted their heads higher out of the water and often exposed their mouthparts, which were generally covered by the mud, while breathing. Manatees that were milling simply lifted their nostrils clear of the water to breathe and rarely exposed any other part of their head.

To minimize possible disturbance on manatees, the canoe was paddled, or pushed with a long mangrove pole or occasionally allowed to drift with the water current, particularly in the Bolo and the Niouniourou Rivers when the manatees moved seawards. The use of a torch at night was kept to a minimum as the shining of a light tended to alarm the manatees. However, the receiver was kept on almost permanently and the focal animal was followed slowly, at a reasonable distance.

Within each continuous observation period, discrete activity bouts and sessions were defined. A bout is defined as a "continuous period during which a manatee's recorded behaviour fell into only one of the four main behavioural types". An activity session began with at least 10 continuous minutes of one behaviour and is defined as one or more bouts of the same major behaviour separated by less than 10min of any other major behaviour. Pearson moment correlation was used to explore the relationship between observation duration and number of bouts of each major behaviour.

The session lengths of each major activity were summed for each manatee and the mean time spent in each behaviour was determined. Differences in mean session length of each major behaviour between the dry and the wet seasons was compared using an independent sample t-test. The proportion of time the manatees spent performing each of the four major activities in each period of the day was estimated and an activity diagram was constructed for each season. The associations between the proportions of time manatee fed, cavorted, rested and moved and tidal stage, seasons of the year, time of the day (night or daylight) and areas of the Fresco lagoon complex were explored using Chi-square tests. Tidal stages were determined by visual observation of current flow and adjusted later by tide table records obtained from the harbour of Abidjan.

8.2.4 Diet and feeding ecology

Vegetation that was consumed by tagged manatees was identified by direct observation whenever possible (Appendix 4). Specimens of unknown plants were collected, labeled and sent to the National Floristic Centre of the University of Abidjan for identification. Diet composition was estimated by recording feeding station intervals (FSI), which was the time a manatee spent at each station feeding on one plant species (Becker, 1992; Ngwa *et al.*, 2000). From these recordings, the average feeding time and proportion of each plant species in the diet were estimated, with the assumption that the time spent on a plant reflected the proportion of that plant in the diet. Gross inspection of 35 dung samples collected in the study area supplemented these data on direct feeding observations.

8.2 Results

8.3.1 Density and population estimate

The total area surveyed by air was 7.5km^2 representing 58% of the total dry season surface of the lagoon complex (Figure 8.2).

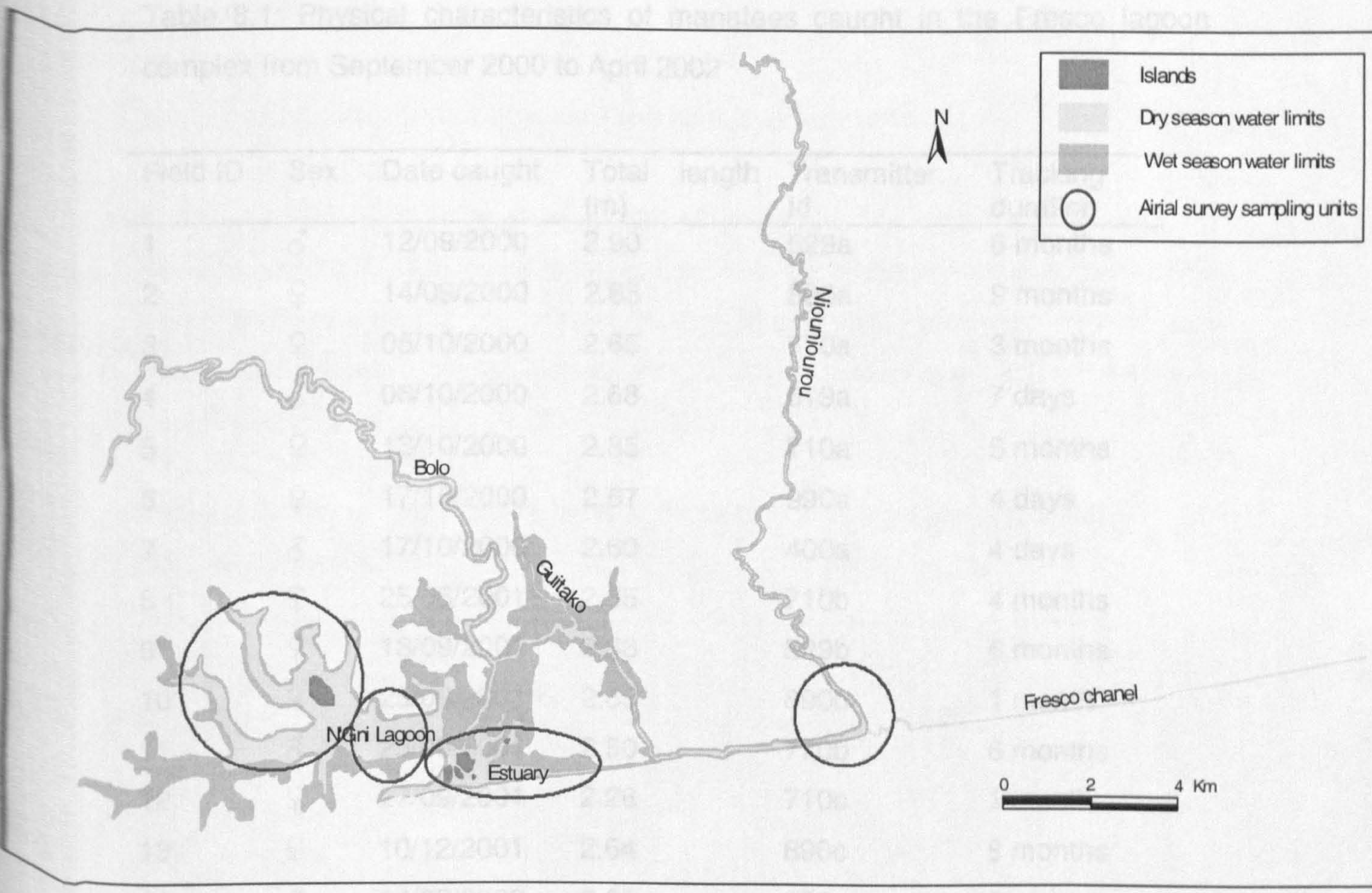


Figure 8.2: Blocks circled during aerial surveys over the Fresco lagoon complex in December 2001.

The highest count was 13 manatees, comprising 9 in the N'gni lagoon; 2 in the estuary and 2 in the Niouniourou River. Based on this, the manatee population in the whole lagoon complex was estimate to be 22 individuals or 1.6 individuals per km^2 of dry season water.

8.3.2 Physical Characteristics

Eighteen manatees (8 males and 10 females) were trapped. Body length ranged from 2.04m to 2.94m with a mean length of 2.57±0.25m (Table 8.1).

Table 8.1: Physical characteristics of manatees caught in the Fresco lagoon complex from September 2000 to April 2002

Field ID	Sex	Date caught	Total length (m)	Transmitter Id	Tracking duration
1	♂	12/09/2000	2.90	529a	6 months
2	♀	14/09/2000	2.63	890a	9 months
3	♀	05/10/2000	2.65	770a	3 months
4	♂	06/10/2000	2.68	619a	7 days
5	♀	13/10/2000	2.85	710a	5 months
6	♀	17/10/2000	2.67	990a	4 days
7	♂	17/10/2000	2.60	400a	4 days
8	♀	25/06/2001	2.65	710b	4 months
9	♀	13/09/2001	2.33	529b	6 months
10	♀	25/09/2001	2.65	890b	1 month
11	♂	25/09/2001	2.50	770b	6 months
12	♀	27/09/2001	2.26	710c	1 month
13	♀	10/12/2001	2.64	890c	8 months
14	♂	14/03/2002	2.65	529c	5months
15	♂	20/03/2002	2.70	529d	9 days
16	♂	21/03/2002	2.94	770c	5 months
17	♀	25/04/2002	2.06	612a	4 months
18	♂	04/05/2002	2.04	672a	3 months

❖ Radio tags that were retrieved were re-used. Thus, tag 529 was fitted to four different manatees (529a-529d) over the course of the study.

The radio transmitters fitted to 6 manatees quickly failed in less than a month and these individuals were excluded from the home range analyses due to the small number of fixes. The 12 individuals included in the analysis comprised 5 males and 7 females (3 males and 3 females in the wet season and 2 males 4 females in the dry season).

8.3.3 Group size, spatial organization and habitat preference

8.3.3.1 Group Size

A total of 995 radio fixes were made, of which 76.5% were recorded during daylight and 23.7% during the night, and 56.5% during the dry season and 43.5% during the wet season. Group sizes of tagged and untagged manatees around them varied from 1 to 10 individuals. However, group sizes of <2 animals constituted most sightings (94%) (Table 8.2).

Table 8.2: Group sizes of manatee in Fresco lagoon complex from September 2000 to August 2002.

Group size categories	**Frequency**	**Percent**
<2	934	93.9
2-4	46	04.6
4-8	10	01.0
8-10	5	0.5
Total	995	100.0

The group size of manatees within the Fresco lagoon was not associated with time of day (x^2= 3.093, df = 3, P>0.5). However, manatee group size changed (x^2=33,979, df = 33, P<0.001) in different months, and manatees were found more often in larger groups in the dry season than during any other months of the year. Similarly, the group size of manatees in the Fresco lagoon changed according to season (x^2= 11.134, df = 3, P <0.05). Manatees were observed less often in groups of <2 and more often in larger groups during the dry season than the wet season (Figure 8.3).

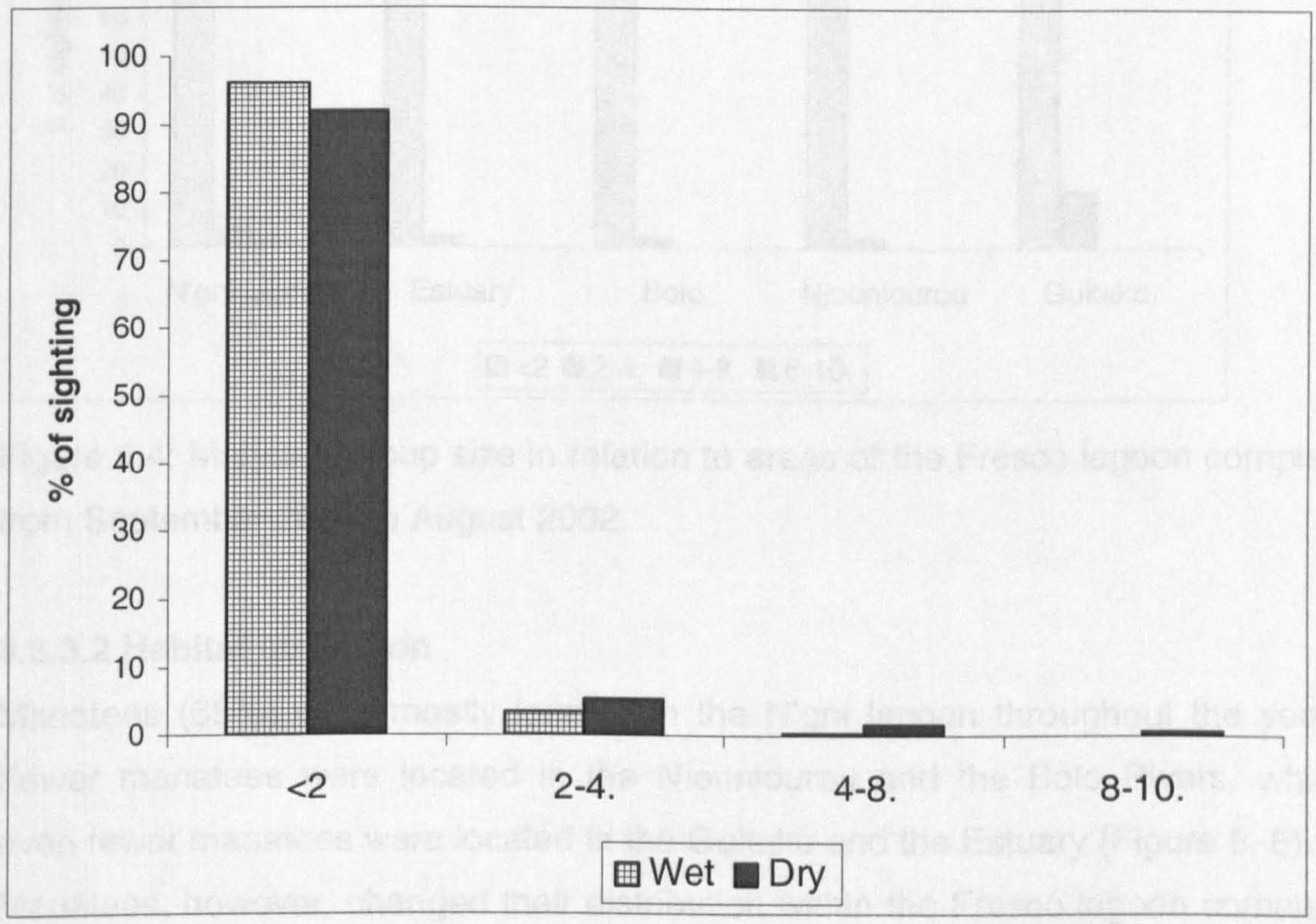


Figure 8.3: Manatee group size in relation to season in the Fresco lagoon complex from September 2000 to August 2002.

Manatee group size was also significantly associated (x^2= 23,456, df=12, P<0.05) with areas of the Fresco lagoon complex. Manatees were more often seen in larger groups in the N'gni lagoon than any other part of the Fresco lagoon complex (Figure 8.4). As the water temperature decreased manatee group size increased (r=-0.067, N=995, P<0.05).

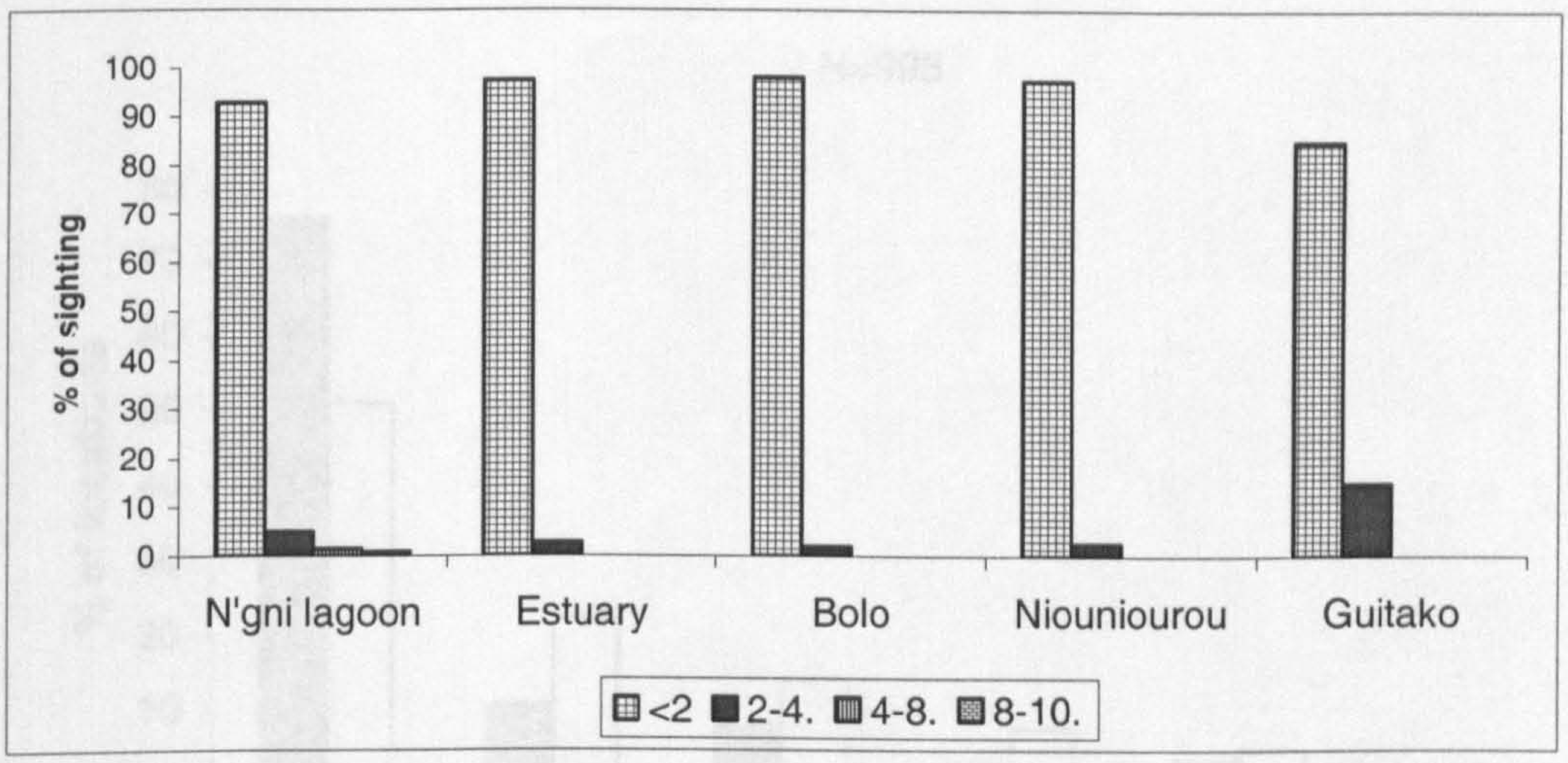


Figure 8.4: Manatee group size in relation to areas of the Fresco lagoon complex from September 2000 to August 2002.

8.3.3.2 Habitat utilization

Manatees (65%) were mostly located in the N'gni lagoon throughout the year. Fewer manatees were located in the Niouniourou and the Bolo Rivers, while even fewer manatees were located in the Guitako and the Estuary (Figure 8. 5). Manatees, however, changed their distribution within the Fresco lagoon complex according to season (x^2=69.05, df=4, P<0.001). Manatees were located in the N'gni lagoon more often in the dry than in the wet season. In contrast, manatees were located in the Niouniourou, the Bolo, the Guitako and the estuary more often in the wet than in the dry season (Figure 8.5).

There was a positive correlation between the numbers of times manatees were located in each area, and the size of each area of the Fresco lagoon complex in the dry season (r=0.959, N=5, P<0.01). In contrast, there was no relationship between the numbers of times manatees were located in each area, and the size of each area, in the wet season (r=0.865, N=5, P>0.05).

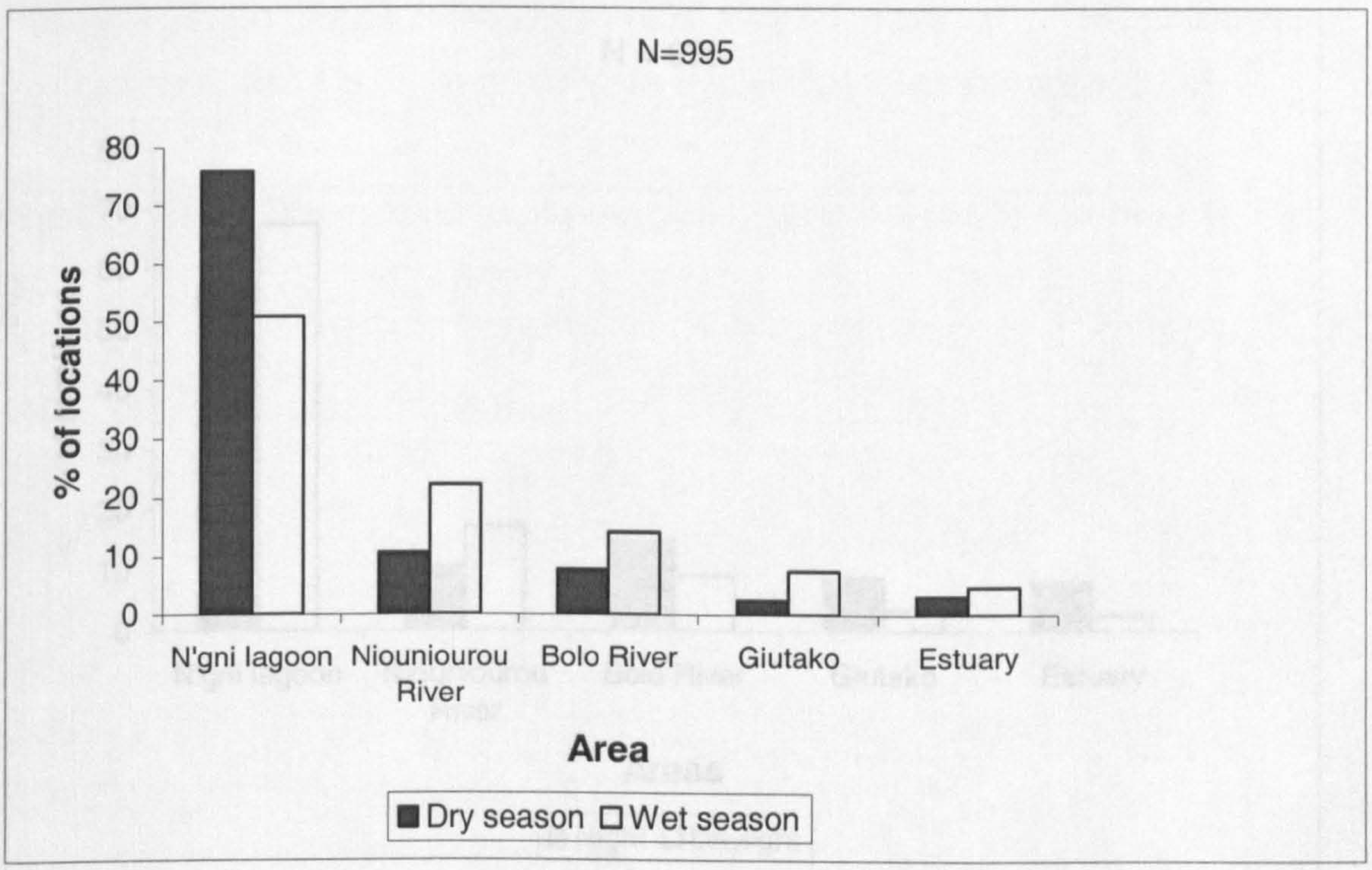


Figure 8.5: The locations of manatees in different areas of the Fresco lagoon complex during the dry and the wet seasons from September 2000 to August 2002.

Manatees also changed their distribution within the Fresco lagoon complex according the time of the day (x^2= 38.58, df=4, P<0.001). Manatees were located in N'gni lagoon and the Niouniourou River more often in daylight than during the night. In contrast, manatees were located in the Bolo River, the Guitako and the estuary more often during the night than during daylight (Figure 8.6).

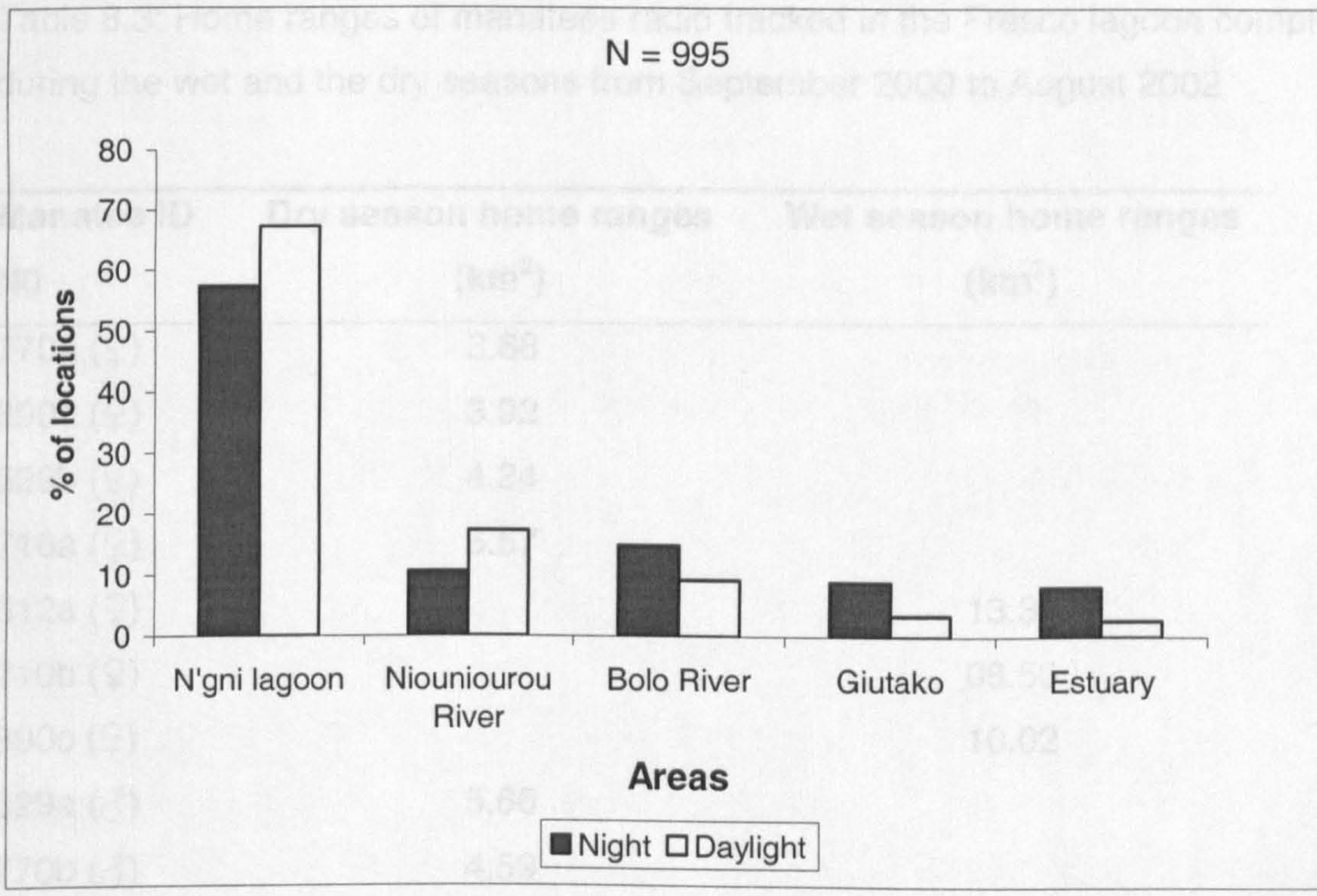


Figure 8.6: The location of manatees in different areas of the Fresco lagoon complex during daylight and during the night from September 2000 to August 2002.

8.3.3.3 Dry season home range and habitat availability

Based on the 100% minimum convex polygon (MCP) method (Figure 8.7), the home ranges of the six manatees tracked during the dry season ranged from 3.7 to 6.5 km^2 (Table 8.3). Hence, the mean home range size for the six manatees tracked during the dry season was 4.8±0.4 km^2. The home range sizes of males and females did not differ (t (3.6)=0.612, P>0.05) although the mean home range size of males (5.12±0.53 km^2) tended to be larger than that of females (4.60±0.66km^2). Home ranges of the six manatees tracked during the dry season overlapped extensively within the area of the N'gni lagoon (Figures 8.7; 8.8).

Table 8.3: Home ranges of manatees radio tracked in the Fresco lagoon complex during the wet and the dry seasons from September 2000 to August 2002

Manatee ID NO	**Dry season home ranges (km^2)**	**Wet season home ranges (km^2)**
770a (♀)	3.68	
890a (♀)	3.92	
529b (♀)	4.24	
710a (♀)	6.57	
612a (♀)		13.34
710b (♀)		08.50
890c (♀)		10.02
529a (♂)	5.66	
770b (♂)	4.59	
770c (♂)		08.04
529c (♂)		10.38
672a (♂)		15.69
Mean	**4.8±0.4**	**10.9±1.2**

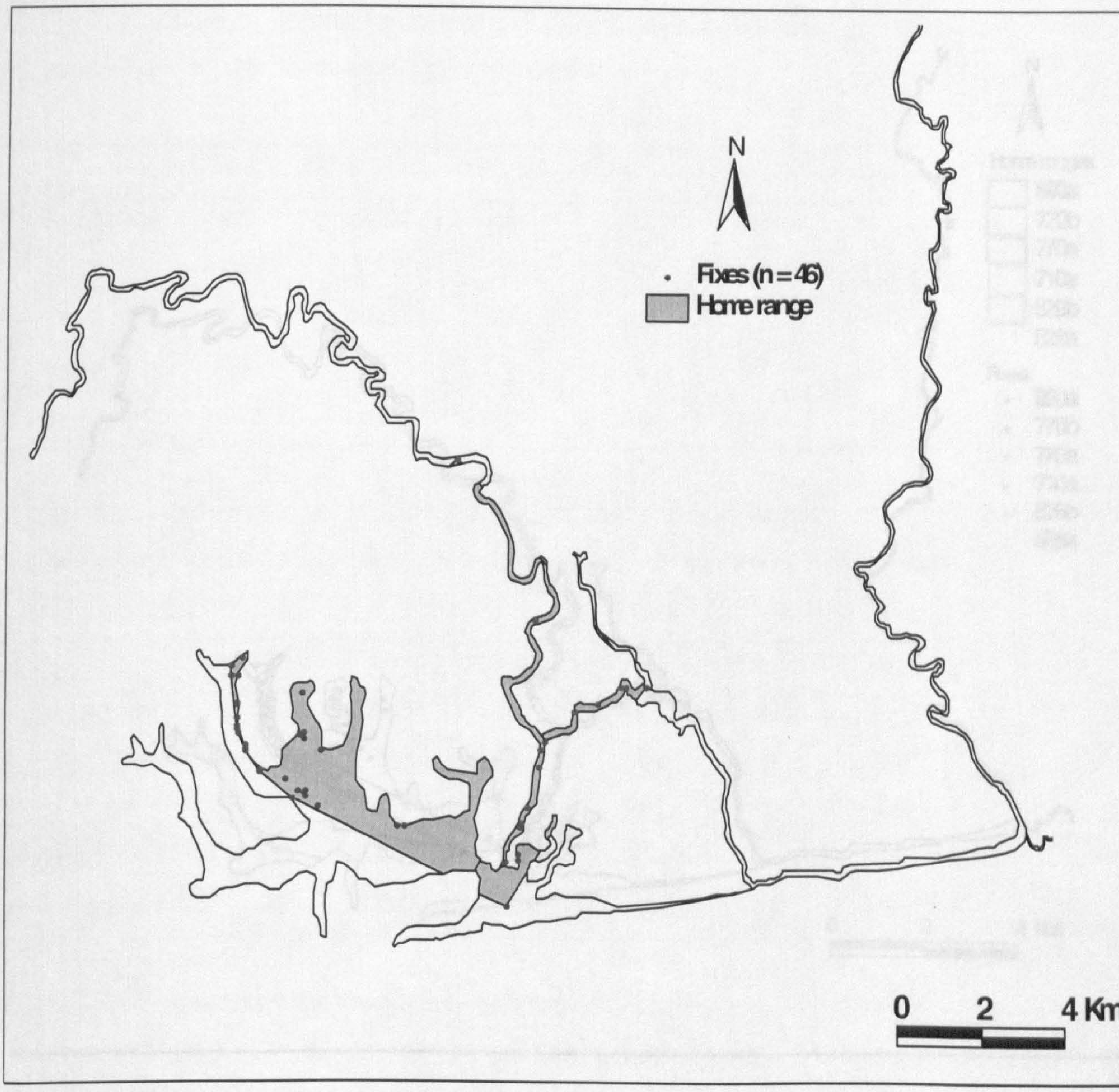


Figure 8.7: Home range of animal 529b tracked during the dry season in the Fresco lagoon complex.

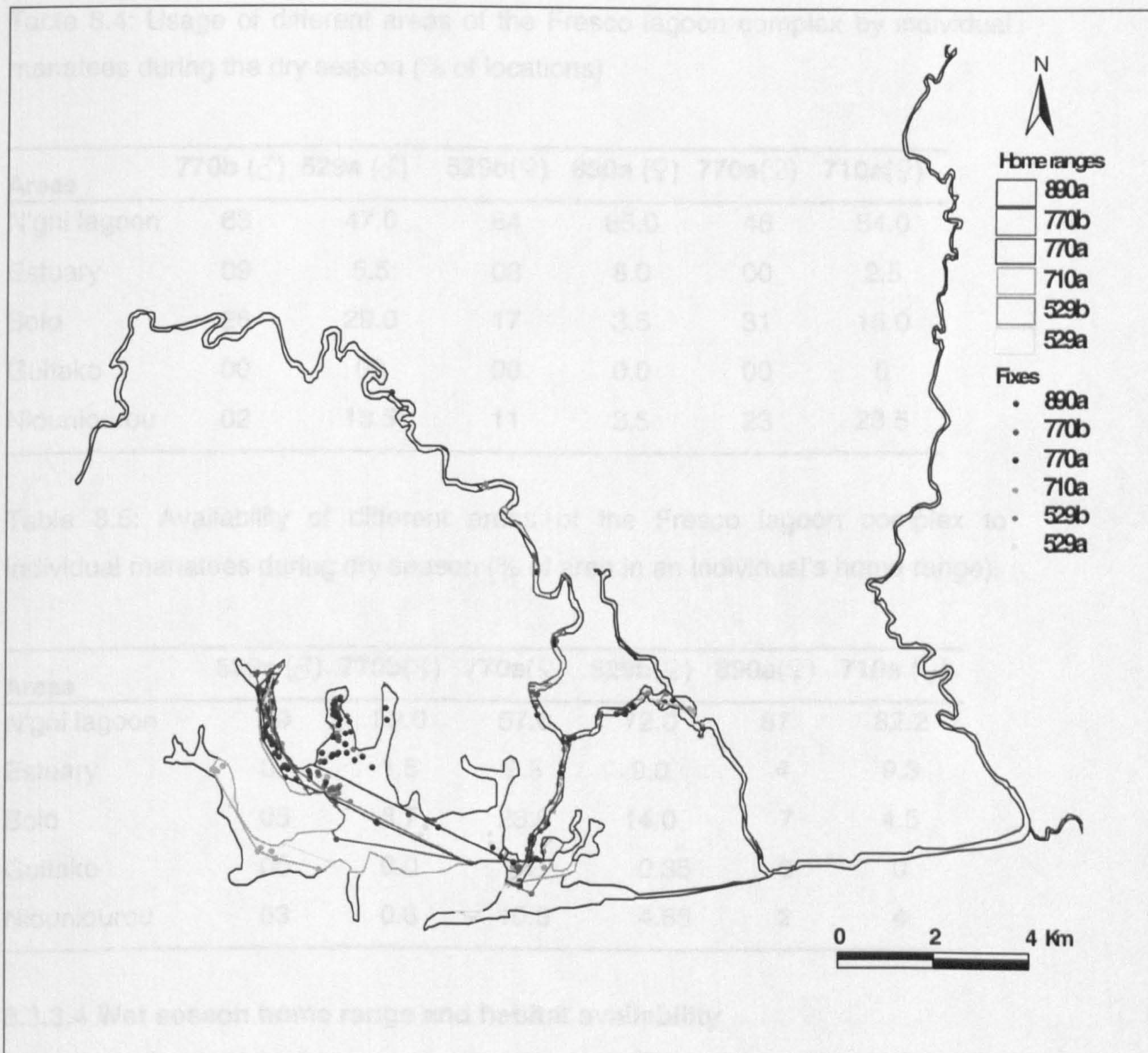


Figure 8.8: Home ranges of the six manatees radio-tracked during the dry season in the Fresco lagoon complex.

The availability and usage of different areas within the Fresco lagoon complex to each radio tracked manatee during the dry season varied for each manatee. However, the N'gni Lagoon represented the largest area used and available within each manatee home range (Table 8.4; 8.5).

Table 8.4: Usage of different areas of the Fresco lagoon complex by individual manatees during the dry season (% of locations)

Areas	770b (♂)	529a (♂)	529b(♀)	890a (♀)	770a(♀)	710a(♀)
N'gni lagoon	63	47.0	64	85.0	46	54.0
Estuary	09	5.5	08	8.0	00	2.5
Bolo	26	29.0	17	3.5	31	15.0
Guitako	00	00	00	0.0	00	0
Niouniourou	02	18.5	11	3.5	23	28.5

Table 8.5: Availability of different areas of the Fresco lagoon complex to individual manatees during dry season (% of area in an individual's home range).

Areas	529a (♂)	770b(♂)	770a(♀)	529b(♀)	890a(♀)	710a (♀)
N'gni lagoon	89	89.0	57.0	72.0	87	82.2
Estuary	03	1.5	9.5	9.0	4	9.3
Bolo	05	8.7	23.0	14.0	7	4.5
Guitako	00	0.0	0.2	0.35	0	0
Niouniourou	03	0.8	10.3	4.65	2	4

8.3.3.4 Wet season home range and habitat availability

Based on the 100% minimum convex polygon (MCP) method (Figure 8.9), the home ranges of the six manatees tracked during the wet season ranged from 8.04 to 15.69 km^2 (Table 8.3) Hence, the mean home range size for the six manatees tracked during the wet season was 10.99±1.20 km^2. The home range sizes of males and females did not differ (t (3.37)=0.28, P>0.05) although the mean home ranges of males (11.37±2.26 km^2) tended to be larger than those of females (10.62±1.4 km^2). Home ranges of the six manatees tracked during the wet season overlapped extensively with area of the N'gni lagoon (Figure 8.10).

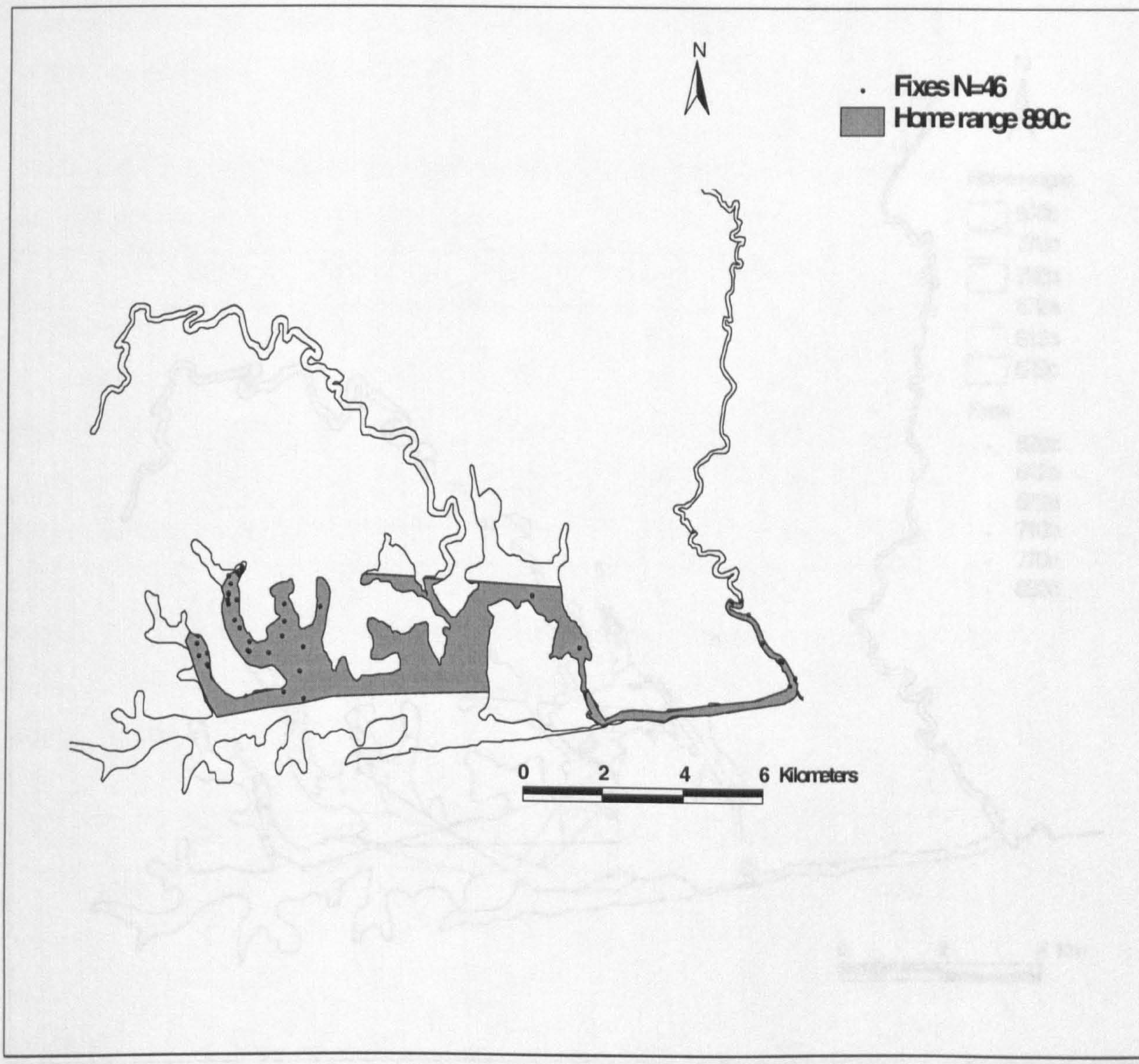


Figure 8.9: Home range of animal 890c tracked during the wet season in the Fresco lagoon complex

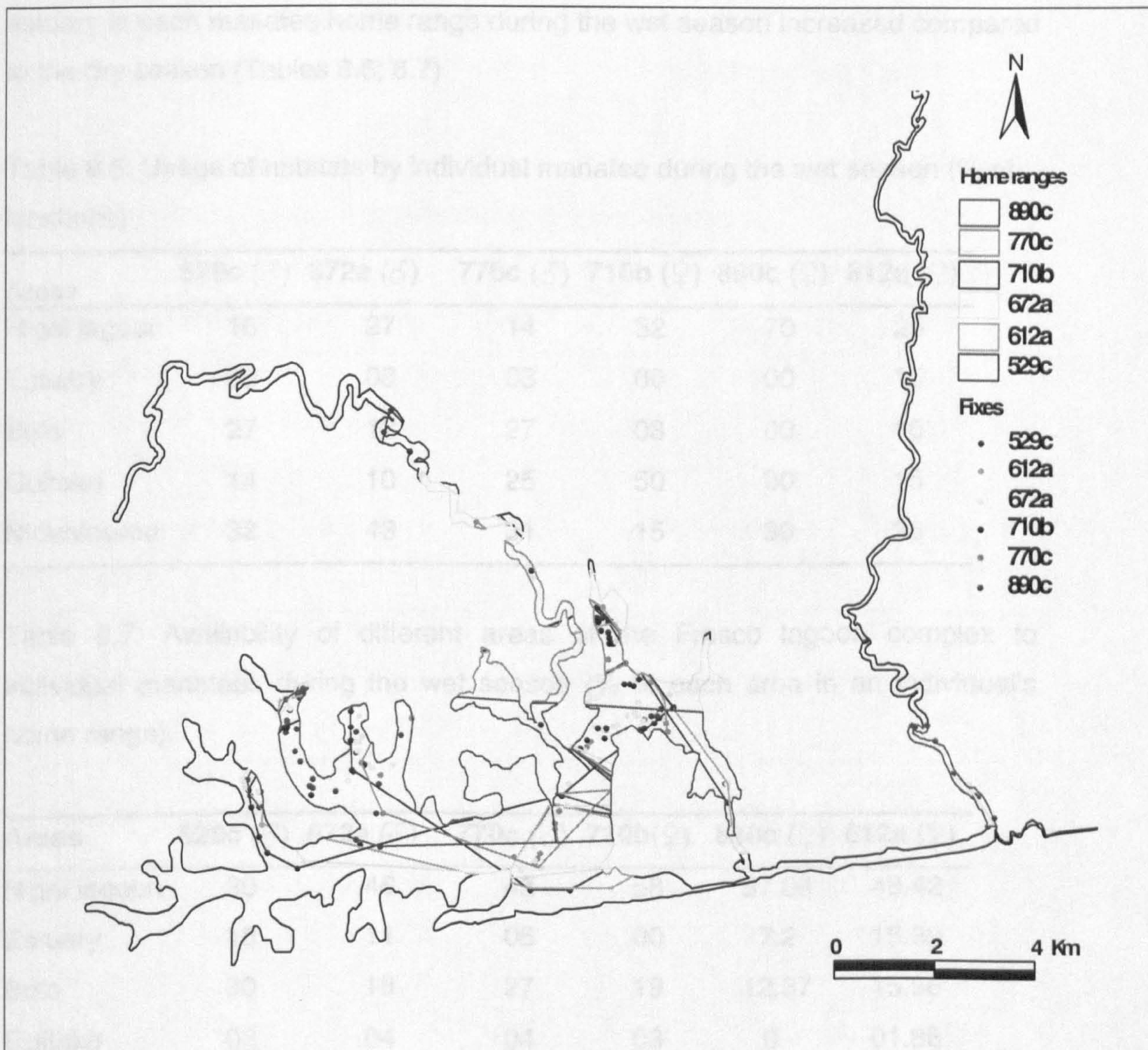


Figure 8.10: Home ranges of the six manatees tracked during the wet season in the Fresco lagoon complex

The availability and usage of different areas within the Fresco lagoon complex varied from 0 to 57% during the wet season. Although usage of the N'gni lagoon remained important in each individual manatee's home range, its area of availability decreased significantly in the wet season compared to the dry season. In contrast, the Niouniourou River, the Guitako, the Bolo River and the estuary in each manatee home range during the wet season increased compared to the dry season (Tables 8.6; 8.7)

Table 8.6: Usage of habitats by individual manatee during the wet season (% of locations)

Areas	529c (♂)	672a (♂)	770c (♂)	710b (♀)	890c (♀)	612a (♀)
N'gni lagoon	18	27	14	32	70	25
Estuary	09	08	03	00	00	15
Bolo	27	12	27	03	00	10
Guitako	14	10	25	50	00	15
Niouniourou	32	43	31	15	30	35

Table 8.7: Availability of different areas of the Fresco lagoon complex to individual manatees during the wet season (% of each area in an individual's home range).

Areas	529c (♂)	672a (♂)	770c (♂)	710b(♀)	890c (♀)	612a (♀)
N'gni lagoon	30	46	42	58	57.08	48.42
Estuary	18	11	06	00	7.2	15.89
Bolo	30	18	27	19	12.37	15.96
Guitako	03	04	04	03	0	01.88
Niouniourou	19	21	21	20	23.35	17.85

8.3.3.5 Area preferences

The intensity of use of different areas of the Fresco lagoon complex by individual tagged manatees differed during both the dry season ($F_{4, 34}$=4.45, P<0.05) and the wet season ($F_{4, 29}$=10.31, P<0.001). Manatees most preferred using the Niouniourou River (-0.66), the N'gni lagoon (0) and the Guitako (0.08), and avoided the Bolo River (0.25) and the estuary (0.5), during the dry season. In contrast, during the wet season, the Guitako (-1.58) was the most preferred followed by the Niouniourou River (-0.83), the estuary (0.41) and the Bolo River (0.75), while the N'gni lagoon (1.25) tended to be avoided (Table 8.8; 8.9).

Table 8.8: Difference between rank of usage and rank of availability of different area of the Fresco lagoon complex during the dry season.

Areas	890a	529a	529b	770b	770a	710a	Average rank differences
N'gni lagoon	0.0	0.0	0	0	0.0	0	0.00
Estuary	-1.0	0.5	1	0	0.5	2	0.50
Bolo	1.5	0.0	0	0	0.0	0	0.25
Guitako	0.0	0.0	0	0	0.5	0	0.08
Niouniourou	-0.5	-0.5	-1	0	0.0	-2	-0.66

Table 8.9: Difference between rank of usage and rank of availability of different areas of the Fresco lagoon complex during the wet season.

Areas	529c	672a	890c	710b	770c	612a	Average rank differences
N'gni lagoon	1.5	1	0	1	3	1.0	1.25
Estuary	1.0	1	0	0	1	-0.5	0.41
Bolo	0.5	0	1	1	0	2.0	0.75
Guitako	-1.0	-1	-1	-3	-2	-1.5	-1.58
Niouniourou	-2.0	-1	0	1	-2	-1.0	-0.83

8.3.4 Behaviour

A total of 204 observation periods were included in the behavioural analyses, comprising: 88 in the wet season and 116 in dry season. Observation periods ranged from: 110 min to 655 min with a mean of 315 min in the wet season; and from 60 min to 760 min with a mean of 304 min in the dry season (Figure 8.11). The number of observation periods per individual manatee varied greatly, ranging from 13 to 23 (Table 8.10).

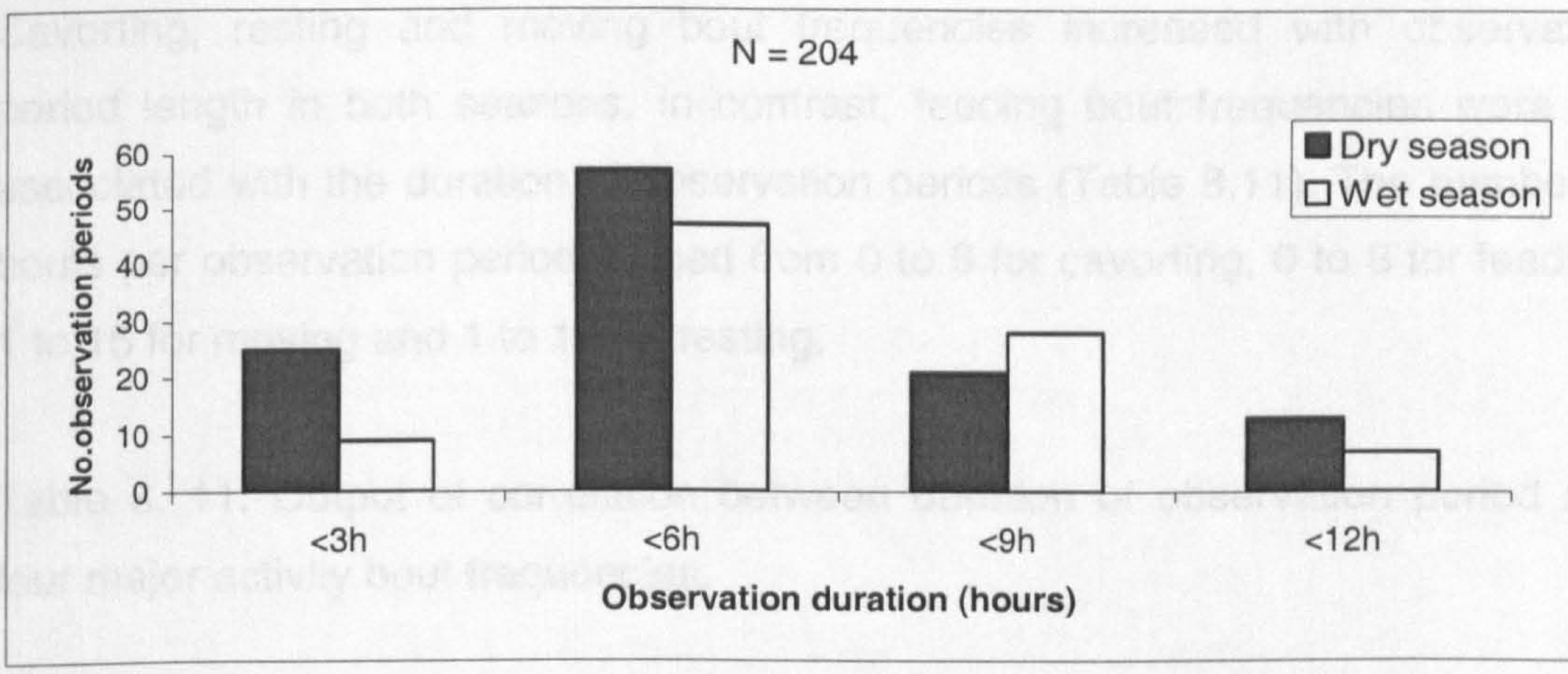


Figure 8.11: Frequency and length of observation periods on manatee in wet and dry seasons on the Fresco lagoon complex.

Table 8.10: Observation periods of tagged manatees in the Fresco lagoon complex from September 2000 to August 2002.

Animal ID	N0 of Observations periods	Total duration	Mean per observation period (min)
612a	15	4350	290
672a	13	4170	347
529c	13	3545	272
890c	14	5460	390
710b	15	5155	368
770c	18	5665	315
890c	18	4870	288
710a	20	5208	248
529a	19	3550	187
529b	20	8830	441
770b	23	9025	392
770a	16	3865	241
Total	**204**	**63687**	**314**

Cavorting, resting and moving bout frequencies increased with observation period length in both seasons. In contrast, feeding bout frequencies were not associated with the duration of observation periods (Table 8.11). The number of bouts per observation period ranged from 0 to 6 for cavorting, 0 to 8 for feeding, 1 to 15 for moving and 1 to 16 for resting.

Table 8. 11: Output of correlation between duration of observation period and four major activity bout frequencies.

	Feeding	Cavorting	Moving	resting
Total observation duration	0.11	0.322**	0.569**	0.806**
Total observation periods	204	204	204	204

** Correlation is significant at the 0.01level (2-tailed).

Feeding session length ranged from 20 to 205 min in length with a mean of 79.96±30.06 min. The mean length of feeding sessions was longer during the wet season than during the dry season (Table 8.12). The length of moving sessions ranged from 5 to 205 min with a mean of 85± 39.69 min. The mean length of moving sessions was longer during the wet than during the dry season. Resting sessions lasted from 10 to 555min with mean session duration of 166±115,36 min. There was no difference between the duration of resting sessions during the wet and dry seasons. Cavorting sessions lasted from 25 to 115 min with a mean of 49 min and similarly did not differ between seasons (Table 8.12).

Table 8.12: Difference in duration (min) of four major activity categories in wet and dry seasons for manatee in Fresco lagoon complex from September 2000 to August 2002.

Activity	Mean session length (min) (t-test)		Df	P
	Dry season	Wet season		
Feeding	71	89	136	<0.001
Cavorting	51	45	48	NS
Moving	75	92	202	<0.05
Resting	162	170	202	NS

The duration of travelling and stationary subcategories were longer during the wet than the dry season. In contrast, mean session duration of bottom resting, milling and idling did not differ between the wet and dry seasons (Table 8.13).

Table 8.13: Difference in lengths (min) of activity subcategories in wet and dry seasons for manatees in Fresco lagoon complex from September 2000 to August 2002.

Activity subcategories	Mean session length (min) (t-test)		Df	P
	Dry season	Wet season		
Bottom resting	132	117	125	NS
Travelling	42	55	186	<0.05
Milling	39	36	198	NS
Idling	56	59	202	NS
Stationary	23	38	202	<0.05

8.3.4.1 Activity budget

A total of 13,247x 5 min sampling units were recorded during the 204 observation periods, of which 52.1% were resting, 26.7% were moving, 17.4% were feeding and 3.8% were cavorting (Figure 8.12). In both seasons, feeding and moving showed two peaks. The first peak occurred at dawn, from 0300 to 0500 hours and the second peak at dusk from 1800 to 2100 hours. Resting peaked at 1400 hours during the wet season and one hour later at 1500 hours during the dry season. Cavorting peaked at 0800 hours in the morning during the wet season and 1200 hours during the dry season (Figure 8.13; Figure 8. 14)

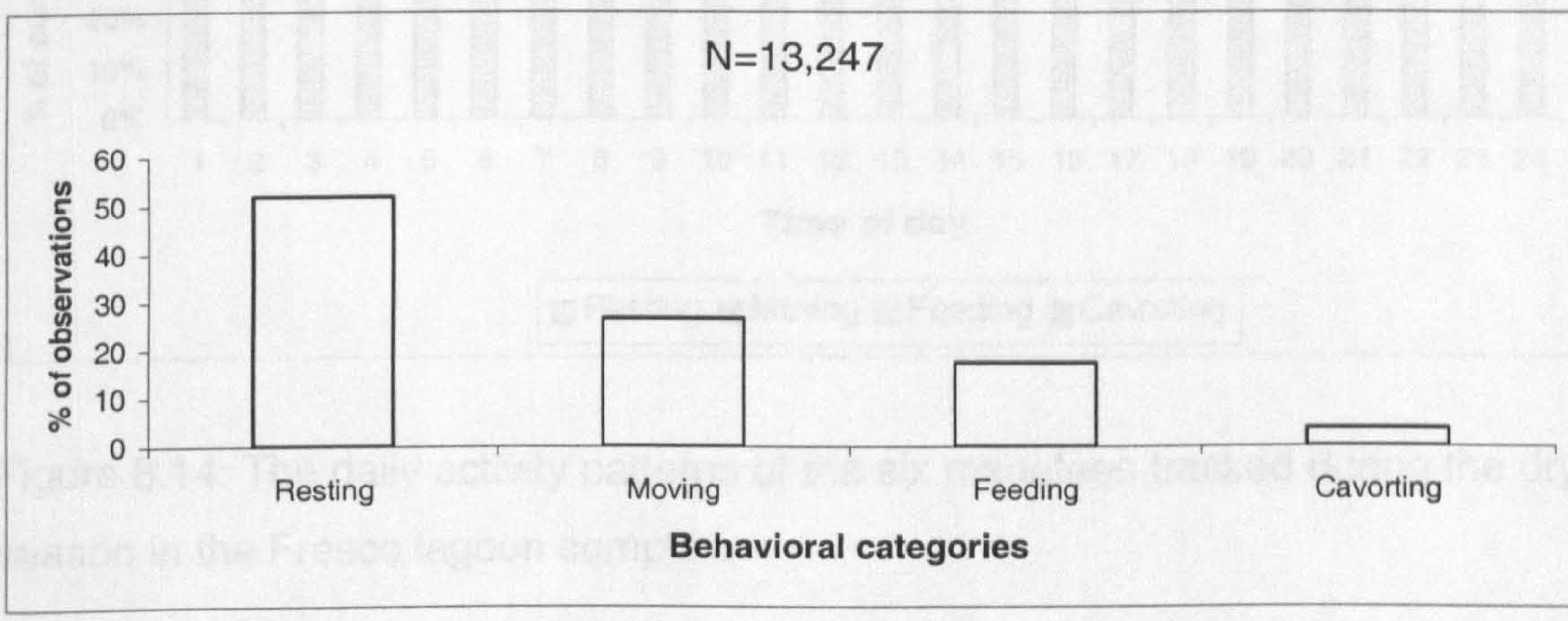


Figure 8.12: Proportion of manatee four major behavioural categories.

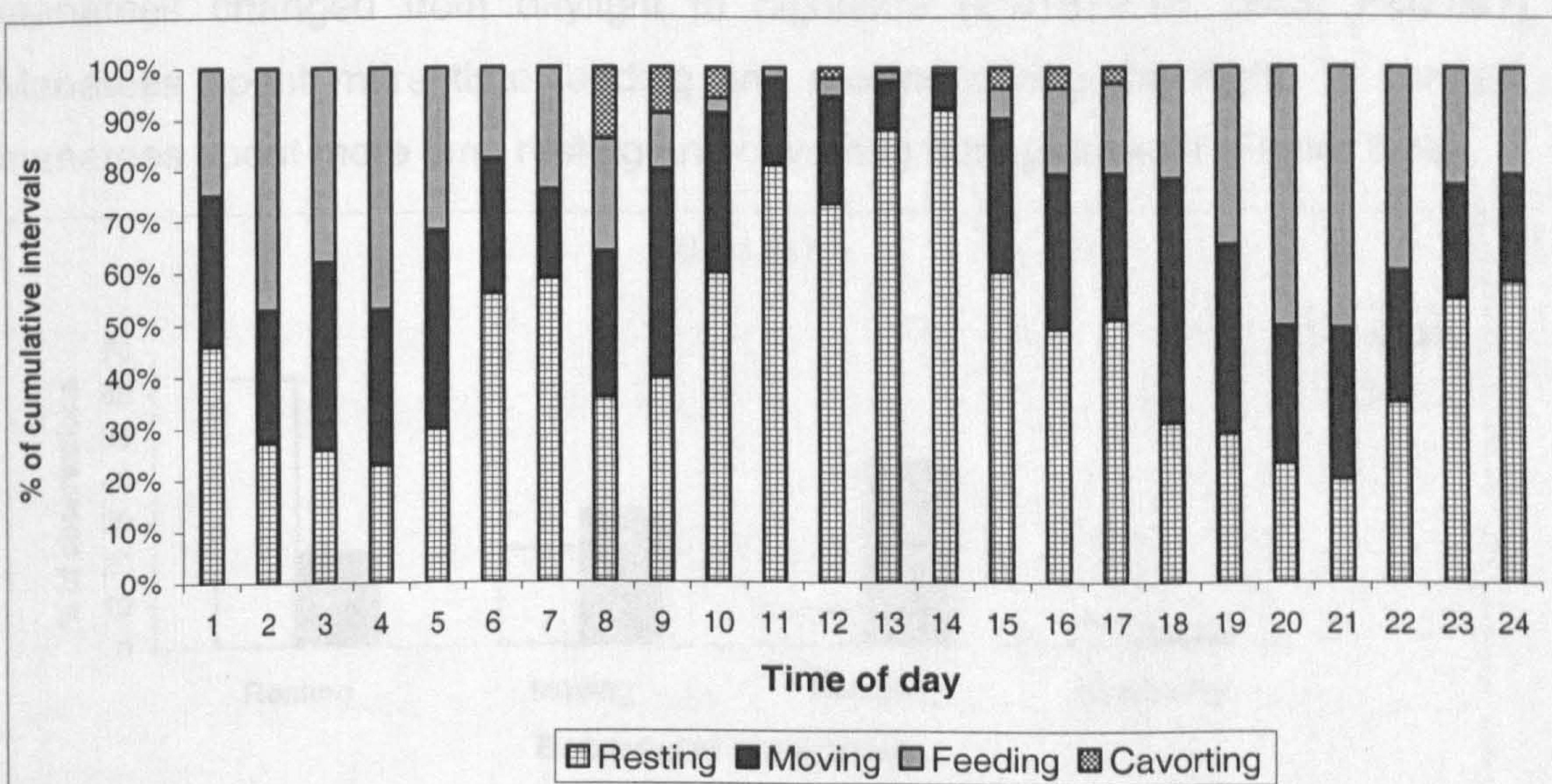


Figure 8.13: The daily activity patterns of six manatees tracked during the wet season in the Fresco lagoon complex.

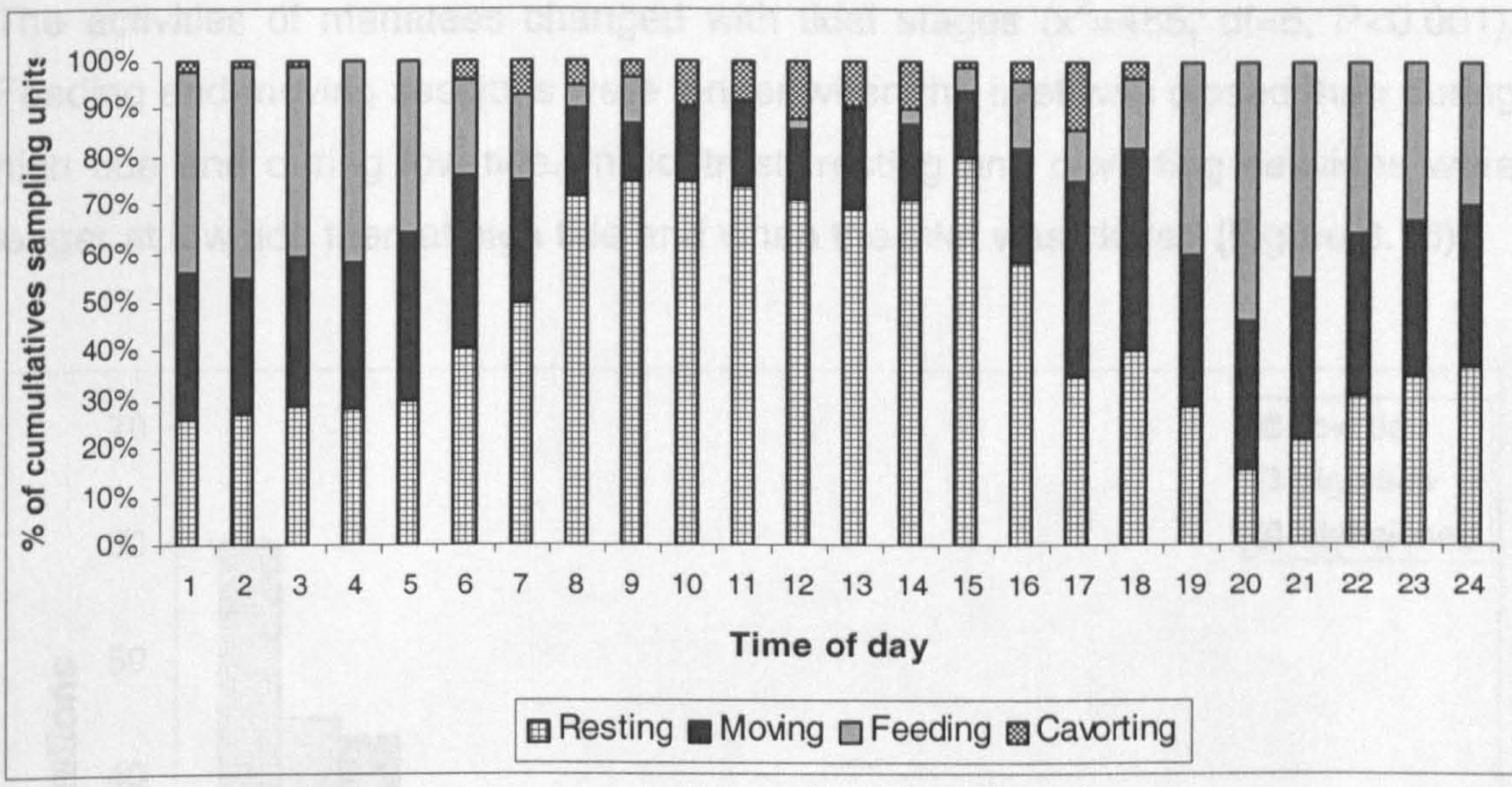


Figure 8.14: The daily activity patterns of the six manatees tracked during the dry season in the Fresco lagoon complex.

A total of 62.5% of 5 min sampling units (N=8,274) were recorded during daylight and 37.5% of units were recorded at night (N= 4,973). The behaviour of manatees changed from daylight to nighttime (x^2=1879.13, df=3, P<0.001). Manatees spent more time feeding and moving during the night. In contrast, manatees spent more time resting and cavorting during daylight (Figure 8.15).

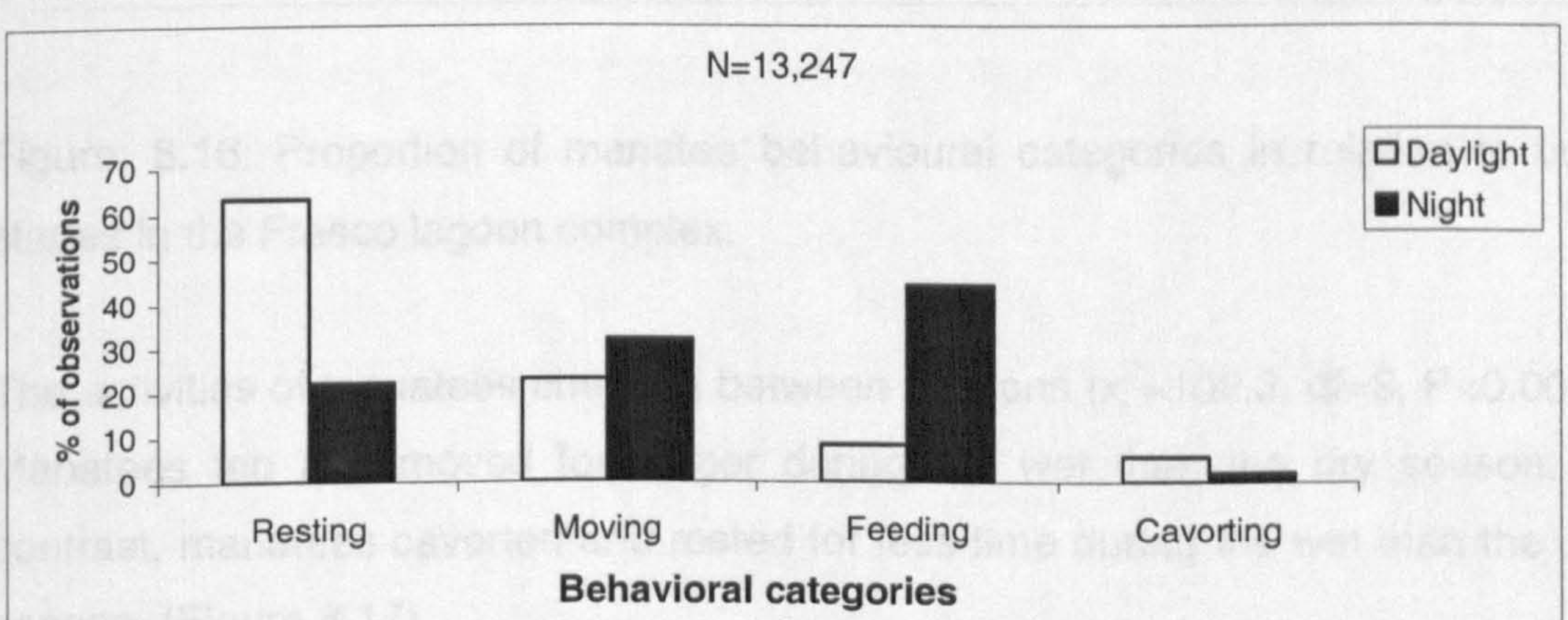


Figure 8.15: Proportion of manatee behavioral categories in relation to period of the day in the Fresco lagoon complex

The activities of manatees changed with tidal stages (x^2=485, df=6, P<0.001). Feeding and moving sessions were longer when the inlet was closed than during high tide and during low tide. In contrast, resting and cavorting sessions were longer at low tide than at high tide and when the inlet was closed (Figure 8.16).

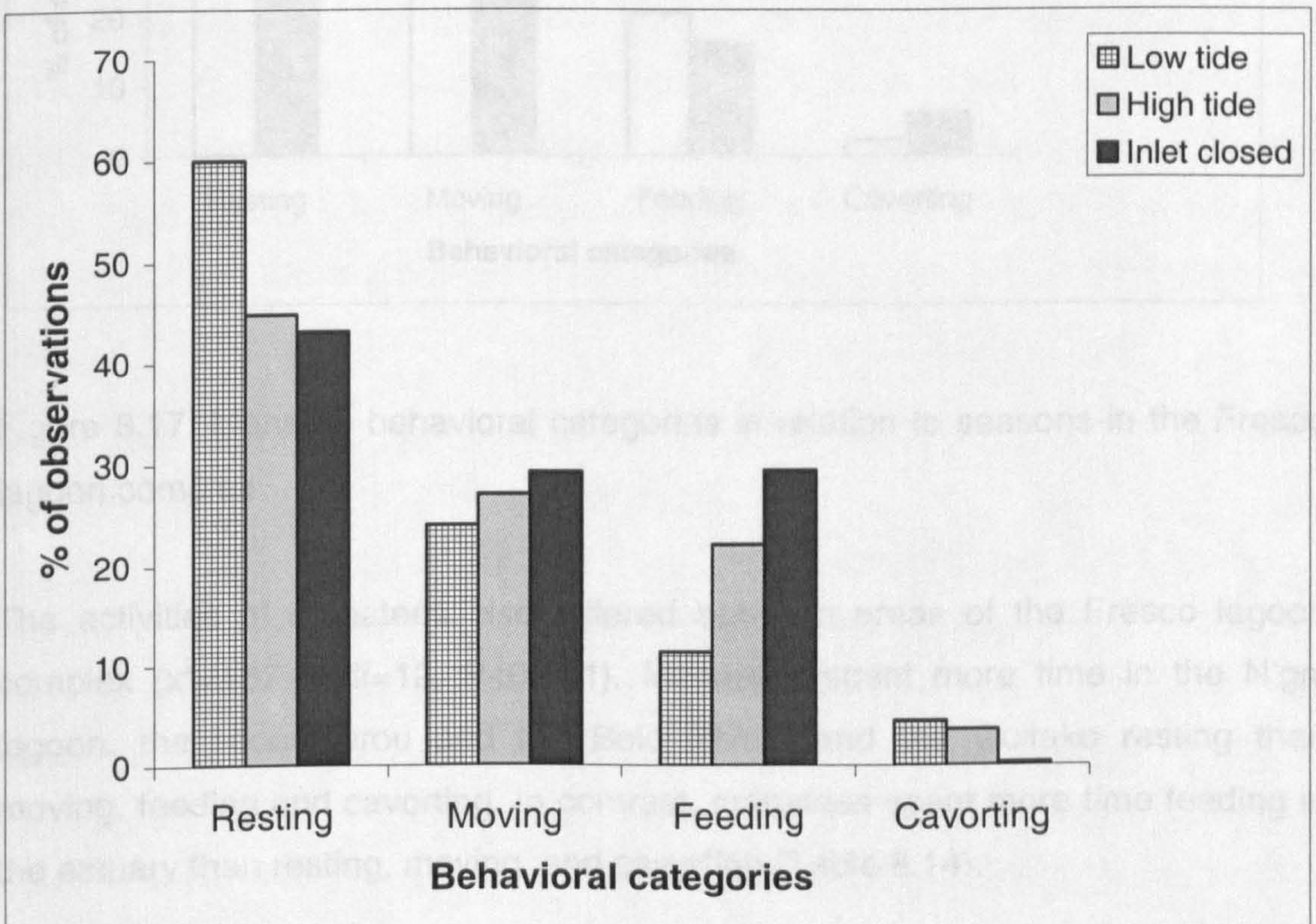


Figure: 8.16: Proportion of manatee behavioural categories in relation to tidal stages in the Fresco lagoon complex.

The activities of manatees changed between seasons (x^2=102.3, df=3, P<0.001). Manatees fed and moved for longer during the wet than the dry season. In contrast, manatees cavorted and rested for less time during the wet than the dry season (Figure 8.17).

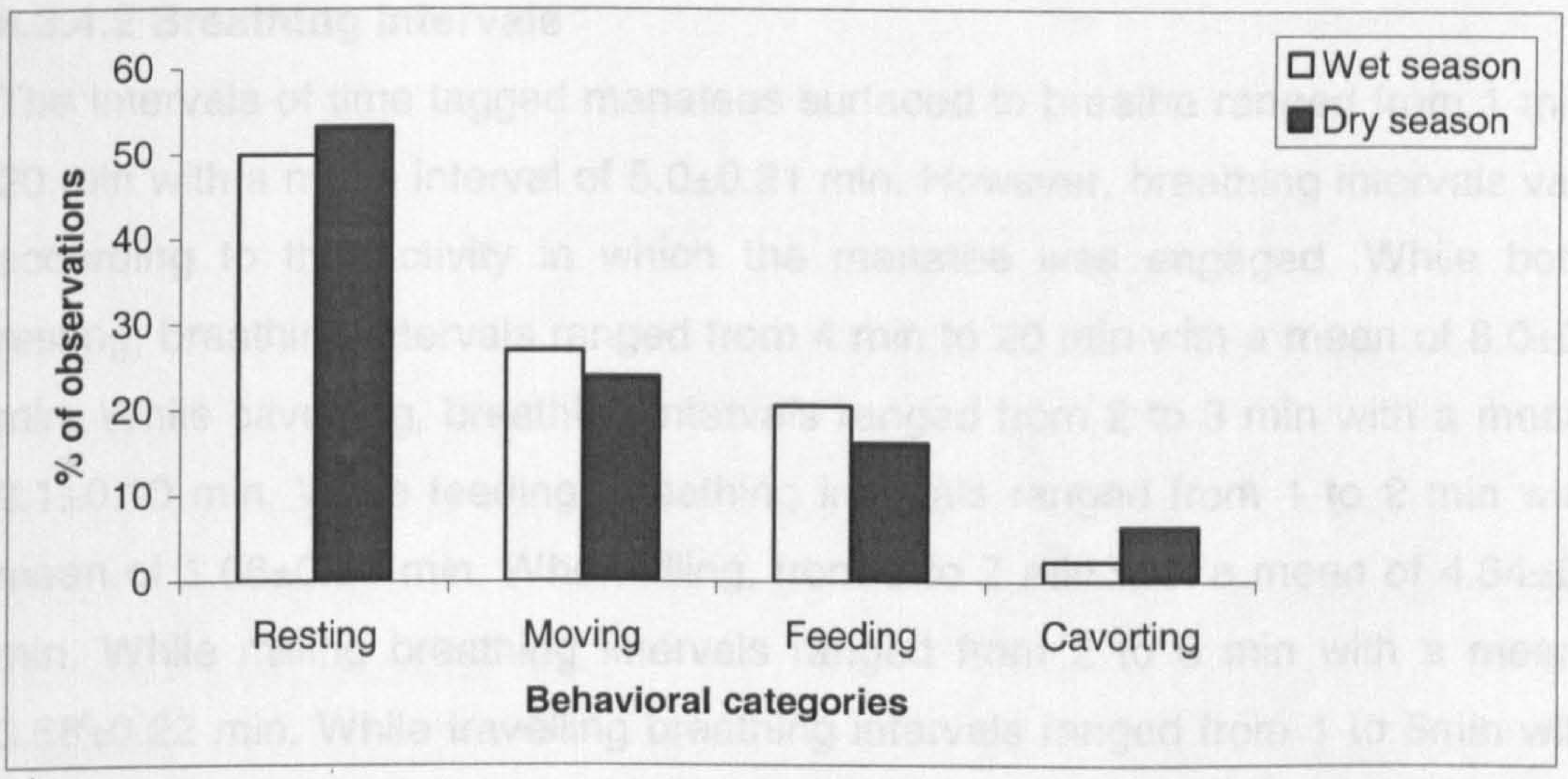


Figure 8.17: Manatee behavioral categories in relation to seasons in the Fresco lagoon complex

The activities of manatees also differed between areas of the Fresco lagoon complex (x^2=137.4, df=12, P<0.001). Manatees spent more time in the N'gni lagoon, the Niouniourou and the Bolo Rivers and the Guitako resting than moving, feeding and cavorting. In contrast, manatees spent more time feeding in the estuary than resting, moving, and cavorting (Table 8.14).

Table 8.14: Proportion of behavioural observations in which manatees were recorded in different activities in each area of the Fresco lagoon complex from September 2000 to August 2002.

Areas	Feeding	Moving	Cavorting	Resting
N'gni lagoon	8.6	23.2	7.2	61.0
Estuary	38.9	28.4	0.0	32.7
Bolo	28.5	34.3	0.3	37.0
Niouniourou	19.1	28.1	1.2	51.6
Guitako	27.6	26.2	1.2	44.9

8.3.4.2 Breathing intervals

The intervals of time tagged manatees surfaced to breathe ranged from 1 min to 20 min with a mean interval of 5.0±0.21 min. However, breathing intervals varied according to the activity in which the manatee was engaged. While bottom resting, breathing intervals ranged from 4 min to 20 min with a mean of 8.0±0.29 min. While cavorting, breathing intervals ranged from 2 to 3 min with a mean of 2.1±0.10 min. While feeding, breathing intervals ranged from 1 to 2 min with a mean of 1.66±0.21 min. When idling, from 3 to 7 min with a mean of 4.34±0.24 min. While milling breathing intervals ranged from 2 to 6 min with a mean of 3.68±0.22 min. While travelling breathing intervals ranged from 1 to 5min with a mean of 2.34±0.17 min.

8.3.5. Diet and feeding behaviour

8.3.5.1 Diet of the West African manatee

A total of 138 sessions of feeding were recorded during the 204 behavioural observation periods, which represented 2266 x 5min sampling units of feeding, or 17% of total behavioral observation time. A total of 16 species of plant were observed to be eaten by manatees (Table 8.15 and Annexe 3). A mixture of *Paspalum vaginatum* and *Paspalidium geminatum* were the most commonly observed food plant, followed by *Rhizophora racemosa, Drepanocarpus lunatus, Calamus derratus, Ficus asperifolia, Althernantera sessilis* and *Echinoclhoa pyramidalis.* Plant parts eaten varied greatly depending on the growth form of the plant. Ripe fruits of *Macaranga heudoletii, Dalbergia ecastaphyllum, Chrysophyllum delevoyi* and *Drepanocarpus lunatus* fallen in the water were also eaten. On a few occasions manatees were observed rooting along the bottom of the water, particularly in the N'gni lagoon, eaten a mixture of mud and organic material. However, leaves and stems of grass constituted the most important (88.6%) plant parts observed to be eaten. The 35 dung samples were found to be essentially (100%) composed of grass.

Table 8.15: Composition of manatee diet expressed as percentage of total feeding time.

Plant species	Sampling units	%	Growth form	Parts eaten
Paspalum vagiantum and *Paspalidium geminatum*	1075	47.4	Grass	Leaves & stems
Rhizophora racemosa	217	9.5	Tree	Leaves & flowers
Mixed mud and deposited plant materials	215	8.4		
Drepanocarpus lunatus	153	7.0	Tree	Leaves & fruits
Calamus derratus	138	6.0	Creeper	Leaves & stems
Fiscus asperifolia	89	3.9	Grass	Leaves
Echinochloa pyramidalis	92	4.0	Grass	Leaves & stems
Althernanthera sessilis	80	3.5	Grass	Leaves & stems
Macaranga heudoletii	53	2.3	Tree	Fruits
Bracharia ramosa	46	2.0	Grass	Leaves & stems
Ipomea repens	41	2.0	Creeper	Leaves
Merremia hederacea	38	1.8	Grass	Leaves & stems
Polygonum salicifolia	23	1.0	Grass	Leaves & stems
Dalbergia ecastaphyllum	13	0.4	Tree	Fruits
Chrysophyllum delevoyi	9	0.3	Tree	Fruits
Flagellaria guineensis	7	0.3	Grass	Leaves & stems
Total	**2266**	**100**		

There was a marked difference in the composition of the diet between the wet and the dry seasons. During the wet season, manatees were observed to have fed on 15 plants species. Only *Chrysophyllum delevoyi* did not appear in the diet during wet season. In contrast, manatees were observed to have fed on only 7 species in the dry season, namely a mixture of *Paspalum vaginatum* and

Paspalidium geminatum (52.2%), *Calamus derratus* (10.7%), *Rhizophora racemosa* (8.5%), *Drepanocarpus lunatus* (8.4%), *Ipomea repens* (2%) and *Chrysophyllum delevoyi* (0.8%). Mud and organic material represented 16.7% of the feeding observation in the dry season while it contributed for only 0.5% to the feeding observation during the wet season (Figure 8.18).

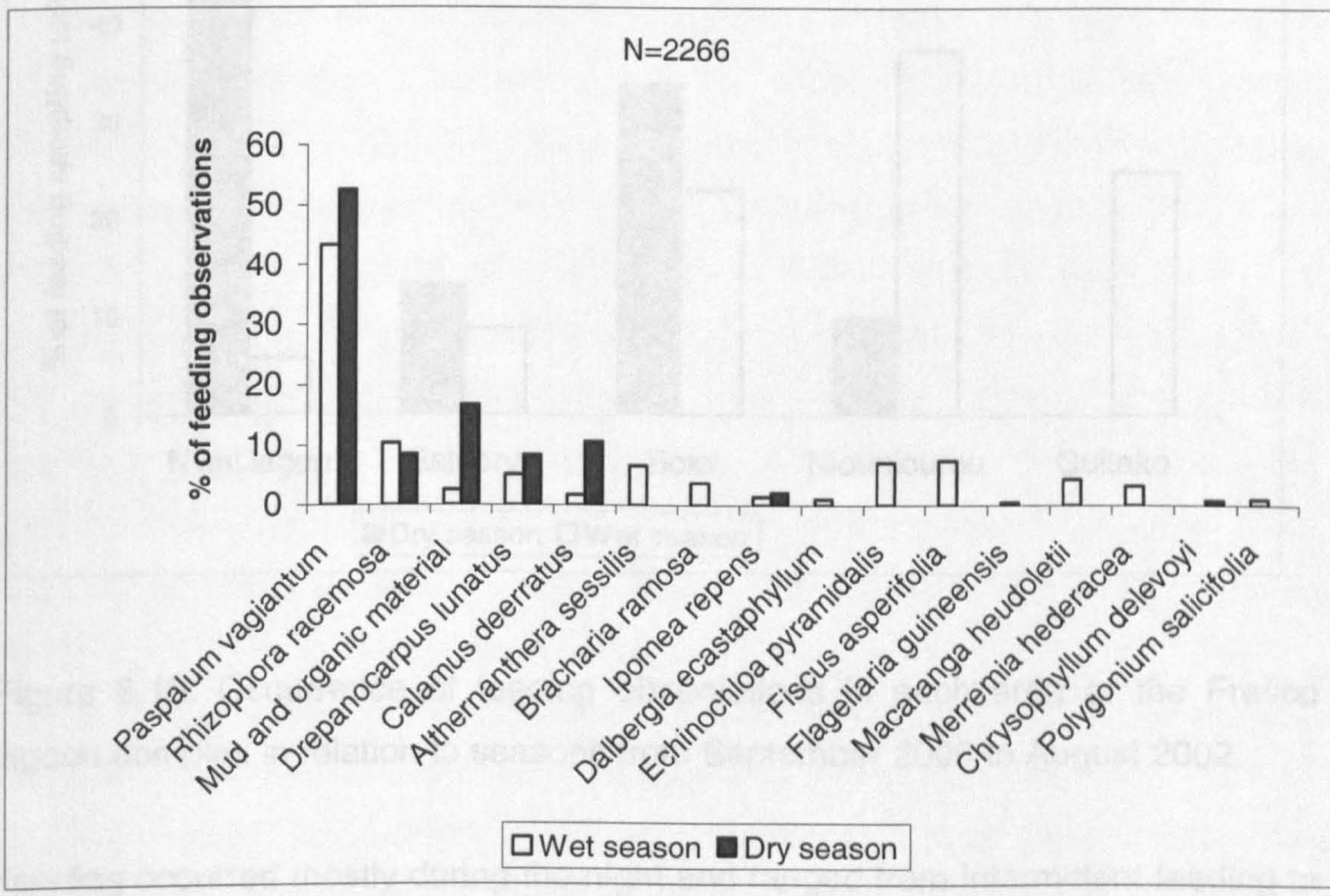


Figure 8.18: Feeding observation on manatee in relation to seasons in the Fresco lagoon complex from September 2000 to August 2002.

8.3.5.2 Feeding sites and feeding behavior

Overall, the Bolo River was the most important feeding site with 27.9% of total feeding observations, followed by the Niouniourou River (24.6%), the N'gni lagoon (24%), the Guitako (13%) and the estuary (10.5%). However, the number of feeding observations in each area differed according to season (x^2=790.8, df=4, P<0.001). There were more observations of feeding in the N'gni lagoon, the Bolo River and the estuary during the dry season than during the wet season. In contrast, there were more observations of feeding in the Niouniourou River in the wet season than in the dry season. Manatees were only seen feeding in the Guitako during the wet season (Figure 8.19).

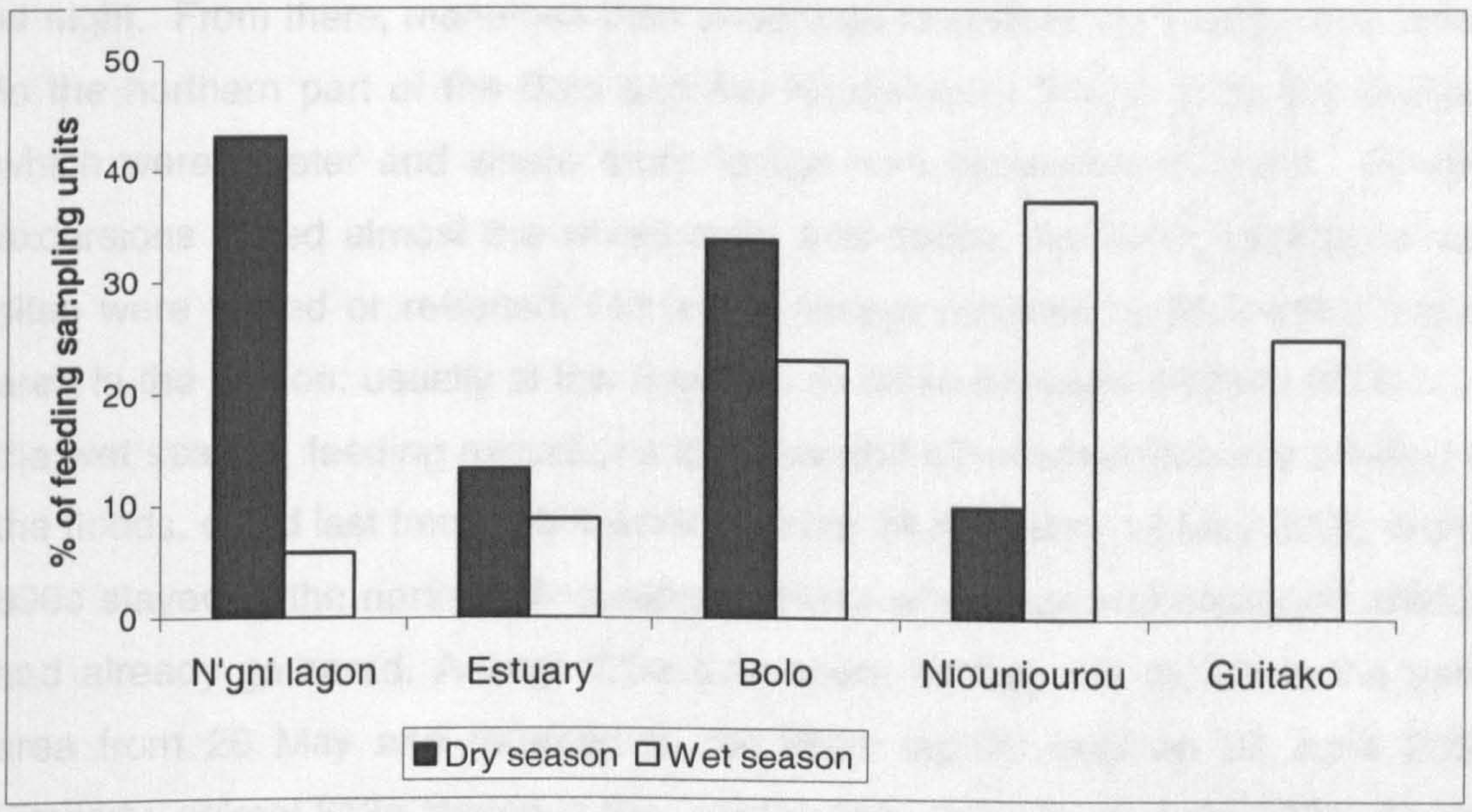


Figure 8.19: Occurrence of feeding observations in each area of the Fresco lagoon complex in relation to seasons from September 2000 to August 2002.

Feeding occurred mostly during the night and ranged from intermittent feeding to uninterrupted intensive feeding on emergent plants along the water's edge. Manatees fed solitary on emergent plants along the Bolo and the Niouniourou Rivers and the Guitako. However, when manatees were aggregated in the N'gni lagoon during the dry season, they rooted along the lagoon bottom mud and deposited organic material in groups, usually of 3 to 5 individuals, although a group of 8 to 10 individuals was observed on a single occasion.

Feeding began at 1630 to 1700 h, generally after a long period of bottom resting. However, manatees did not approach the water's edge to feed intensively on emergent grasses either before the level of the water became high enough or the lagoon became quiet enough once fishing reduced (see Chapter 7). Feeding usually started by intermittently "rooting" along the water bottom in search for deposited organic material, while still moving about the same general area where they had rested. Finally manatees travelled slowly but progressively from their resting site to the entrance of the Bolo River and the lower reaches of the estuary at night. From there, manatees then undertook long distance feeding excursions to the northern part of the Bolo and the Niouniourou Rivers or to the Guitako, which were quieter and where more forage was accessible to them. Feeding excursions lasted almost the whole night and during that time, several feeding sites were visited or revisited. Manatees always returned to their initial resting area in the lagoon, usually at low tide, and at dawn between 0400 to 0500 h. In the wet season, feeding excursions to rivers and other small streams swelled by the floods, could last from 1 to 4 weeks. From 24 April until 14 May 2002, animal 890c stayed in the northern Niouniourou River where several untagged animals had already gathered. Animal 672a also spent almost one month in the same area from 26 May and returned to the N'gni lagoon only on 23 June 2002. Similarly, animal 612a stayed in the Guitako from the 1 to 28 June 2001. During that time, manatees rested during daylight in areas very close to their feeding sites and fed intensively during the night and less often in daylight, on leaves and stems of *Bracharia ramosa, Ficus asperifolia, Merremia hederacea*, mats of *Polygnium salicifolia, Althernanthera sessilis and Echinocloa pyramidalis* in the Niouniourou River and essentially on *Paspalum vaginatum* while in the Guitako.

When feeding *in situ* on emergent plants on the water's edge, stems and leaves of selected plants (generally young shoots) were seen trembling before they disappeared below the water's surface. Manatees took the plant from close to the water surface, with their body facing the shoreline. Grasses were grasped, manipulated into the mouth by the fore flipper or their highly prehensile lip pads and pull towards them and downward as they were consumed. The breaking of grass stems as they were pulled into the water by the submerged manatees was audible from 60 to 80m. Manatees were never observed feeding for an extended period in one local site. Various sites were visited or revisited in a single feeding excursion and feeding areas were characterised by specific scars on remaining parts of consumed plants.

When feeding on ripe fruits, manatees spent considerable time moving about in the same area under the fruiting tree, rooting in the bottom or waiting for fruits to fall in the water. On one occasion, animal 710b spent 3 hours and 25 min under a *Macaranga heudoletii* tree in the Bolo River. When a fruit fell in the water, the animal quickly moved to get it before it disappeared with the water current. When two or three ripe fruits fell at the same time in the water, the animal moved even faster trying to collect them all. Animal 710b also spent 12 days in the Bolo in the vicinity of this tree and regularly returned to the same area.

In the dry season, particularly in January, access to forage became difficult for manatees, even at high tides as water levels receded. Feeding on emergent grasses was limited to the estuary and the lower reach of the Bolo River. Manatees moved for 0.5 to 1 m across the wet and muddy edge of the water by supporting themselves using their pectoral flippers to gain access to the vegetation. Characteristic manatee tracks remained left on the muddy edge in several feeding areas across the shoreline of the estuary.

8.4. Discussion

There have been no previous detailed studies of the ecology and the behaviour of the West African manatee in their native habitat. This study in the Fresco lagoon complex has shown that a substantial population of manatees still exists there, and that resting, cavorting, moving and feeding on selected plants constitute their major activities. The leaves of selective emergent plant species on the water's edge predominate the diet of the West African manatee.

8.4.1 Population estimate and manatee group size

Estimating population sizes of free-ranging aquatic mammals presents a problem for marine wildlife biologists. Manatees are not always at the surface or visible when submerged, and once seen, they are often difficult to count accurately. Thus, aerial counts are generally assumed to be underestimates (Ackerman, 1995). Nevertheless, aerial survey has been widely used in recent years to estimate the population size of West Indian manatees and is the only cost-effective method by which to count large numbers of manatees over large areas (Hartman, 1979).

The population of manatees in the Fresco lagoon complex was estimated to be 22 individuals living at a density of 1.6/km^2. This was the first estimate of population size for manatee in the Fresco lagoon complex and, so no population trends could be inferred in absence of any previous data. However, the result was encouraging compared to the population size of manatees in the nearer lower Bandama River and the Grand-Lahou lagoon, where only 13 manatees were counted in 230 km^2 (0.05/km^2) using a similar survey method (Powell, 1988). The Fresco lagoon complex was believed to have the highest density of manatees of any area in Cote d'Ivoire. Five to six manatees were seen here in one hour of searching, compared with the Bandama River, where no manatee was seen in 800 hours of searching (Powell, 1988). The present count has probably been under-estimated due to poor visibility, particularly, in areas close to the water's edge where tree branches hanging over the water obscured the shorelines. Decreased diurnal movements of manatees may have also negatively affected this count. The survey could only be conducted during daylight although manatees were less active and mostly bottom rested (Figures 8.13 and 8.14).

Manatees are essentially solitary animals but were occasionally found in small groups, similar to the finding of Powell (1988) in the Bandama River and in the Grand-Lahou lagoons. West Indian manatees are also essentially solitary animals and do not form stable, close-knit social groups or herds (Rathbun and O'Shea, 1984). Groupings are usually ephemeral and the only social bond is between a cow and her calf. Group sizes of manatees were larger in December and during the dry than the wet seasons (Figure 8.3). December was the beginning of the dry season, during which the water level and lagoon area receded considerably, so limiting the ability of manatees to use rivers and small streams. Reduced food availability and the need for deep-water refuges dictate the lifestyle of manatees during the dry season. Thus, they mostly aggregated in the N'gni lagoon and this may explain why manatee group size was larger in that area. Mean group size was negatively related to water temperature so the lower the water temperature, the larger the manatee group size. The water temperature was coldest in August (23.9±1.55°c; see Chapter 3), corresponding to the short dry season and to a secondary peak in manatee group size. In August, manatees mostly aggregated during daylight in one area of shallow water with a muddy substrate in the northern part of the lagoon with their abdomen slightly enclosed in the mud. This area was influenced by warm water flowing from a small stream, where the mean temperature in August was a surprising 29°C, while the temperature of the rest of the N'gni lagoon, because of the influence of the colder water from the sea during high tides, varied from 18°C to 25°C (see Chapter 3). Therefore, West African manatees may congregate in particular areas to avoid relatively cold water. Similar behaviour has been observed with the West Indian manatee in Florida where, during the winter, the species responded to lower water temperature by undertaking a north-south migration to aggregate in large groups around warm-water refuge (Irvine and Campbell, 1978; Reynolds and Wilcox, 1986). Hartman (1968) suggested that aggregations at warm-water springs, or at power plant or industrial outfalls, are stimulated by water temperatures below 20°C (68°F). A similar situation may also hold for the West African manatee.

8.4.3 Habitat preference and spatial organization

Central to the study of animal ecology is the usage an animal makes of its environment, and specifically the variety of habitats it occupies (Johnson, 1980). The preference of specific habitats is reflected in the degree of selection or usage of these habitats. The quantification of such usage is an important tool to assess the biological requirements of a species, predict effects of habitat changes and justify the protection of key areas (Garner *et al.,* 1996). Many features have been suggested as key components of the West African lagoon and estuarine habitats, including the presence of abundant growths of mangrove or emergent vegetation, and access to shallow areas for resting, as well as deeper pools for hiding from human activity, particularly during dry season (Powell, 1996).

This study has shown that all major components of the lagoon complex of Fresco were used by manatees. Although the majority of sightings occurred in the N'gni lagoon the patterns of use of each component were associated with different periods of the day (Figure 8.5) and seasons of the year (Figure 8.6). Manatees used the N'gni lagoon and the Niouniourou River more during daylight than during the night while the Bolo River, the Guitako and the Estuary were used more during the night than during daylight. Moreover, the comparison of usage and availability of each habitat has shown that the Niouniourou River and the N'gni lagoon were most preferred during the dry season. In contrast, the Guitako and the Niouniourou were most preferred during the wet season, while the N'gni lagoon tended to be avoided. These spatial patterns among components of the lagoon could be related to the suitability of each habitat to manatees' spatial and temporal requirements. The N'gni lagoon was selected during daylight because it offers shallow areas, largely opened to the sunlight and suitable for resting and to a lesser extent to socialize. The lagoon was little used during the night as few emergent food plants were found there. Similarly, imposing aerial roots of *Rhizophora racemosa* are abundant on the edge of the Niouniourou River, and are suitable for hiding to avoid human disturbance during daylight. Similar selection of habitat by manatees has been reported previously by Powell (1996) who found that manatees rested in shoal areas, generally in the middle of the water or under the stilt roots of mangrove in the Grand-Lahou lagoon.

The preference of manatees for particular sites during the wet season, namely the Guitako and the Niouniourou rivers, may be because of the abundance of food plants and other aquatic macrophytes not found elsewhere in the Fresco lagoon complex. These food plants and aquatic macrophytes were accessible only during the wet season when the water level was sufficiently high.

In both seasons, home ranges of individual manatees were independent but overlapped almost completely. This suggested that the West African manatees are non-territorial and shared almost identical ranges. Similar spatial organization has been reported for the West Indian manatee by Bengston (1981). Manatees showed great site fidelity, by always returning to the N'gni lagoon where they were originally caught, after occasional movements lasting for 1 day to several weeks to the Bolo and the Niouniourou Rivers and the Guitako, which all lay within a radius of about 5 km.

In some areas of West Africa, manatees have been reported to make seasonal movements in response to highly variable water levels that affected their ability to obtain food. This study has shown that manatees regularly undertook feeding excursions from the N'gni lagoon but they generally stayed within the complex, and no distinct seasonal patterns of movements were observed. This contrasted with Powell, (1988) who reported that some tagged manatees moved from their core home range in the Tadio and the Niouzomou lagoon system in Grand-Lahou, to the Niouniourou River using the Fresco canal during the wet season. Only animal 619a, that was not included in the analysis because it produced only small number of fixes, was located in the Fresco canal, where he spent four days but subsequently disappeared before his transmitter was found 6 months later entangled in dead mangrove branches in the Niouniourou River. Unsuccessful searches for that animal, both by boat and by air in the Grand-Lahou lagoon system did not fully confirm Powell's finding. However, the great number of untagged manatees found at the intersection between the Niouniourou and the Fresco Canal during the wet season indicated that animals from other sites moved to that area to take advantage of the abundant forage accessible only during that season.

In both seasons, the mean home range of males tended to be larger than those of females altough the difference was not significant due to the small sample size of tagged manatees. Likewise, Bengtson, (1981) found that male West Indian manatees range much more widely than females. Manatees readily moved long distances, particularly where travel corridors were continuous and when they were seeking warm-water refugia and mates (O'Shea, 1988).

8.4.4 Behaviour and activity budget

West African manatees spend most of their time performing four major activities: resting, moving, feeding and cavorting of which resting was the most time intensive and cavorting the least time intensive (Figure 8.12). Manatees rested for much of the day. In contrast, they moved and fed for much of the night (Figures 8.13; 8.13; 8.14; 8.15). These findings differed from West Indian manatees, which were reported to be active both during the day and during the night (Reynolds, 1977). Manatee activities were associated with tidal stages (Figure 8.16). At high tide and when the inlet was closed, water levels rose and more food plants were accessible to manatees than during low tide. In contrast, at low tides, as the water level receded and became calm, conditions become more suitable for resting and cavorting. Activities of the West Indian manatee are reported to be similarly associated with tidal stages. Manatee behaviour was also influenced by seasons of the year. Manatees spent more time moving and feeding during the wet season when there was a marked increase in water area and level (see Chapter 3), offering more feeding sites and more space for manatees to move. In contrast, manatees were restricted to fewer areas in the dry season and so spent more time resting and cavorting.

8.4.5 Diet and feeding behavior

Manatees are known to eat a wide variety of aquatic and semi-aquatic macrophytes (Best, 1981), as confirmed by the present results. Manatee diet was mainly composed of leaves and stems from sixteen food plant species, of which a mixture of *Paspalum vaginatum* and *Paspalidium geminatum* was the most dominant in both seasons. The number of species identified as manatee food plants in the Fresco lagoon complex was relatively low compared to previous studies. Based on the results of interviews surveys with fishermen in Cote d'Ivoire, Roth and Waitkuwait (1986) reported 48 potential food species. Powell (1996) reported 30 species that included some of the species found in the present study. This difference between studies is because these previous studies covered more than one region of the country, including the Fresco lagoon complex. The predominance of grasses in manatee diet was confirmed by the gross inspection of the 35 faecal samples. Similar findings were made by Powell (1998) from the inspection of 205 dung samples collected from the Bandama River in Cote d'Ivoire. However, manatees also ate fruits, mud and deposited organic material particularly during the dry season, when emergent vegetation was less available as water levels receded. Feeding on mud and other organic material has also been observed with the Amazonian manatee when the water level receded and little food was available (Best, 1981).

Reeves *et al* (1988) reported that fishermen in Sierra Leone frequently complained about manatees removing fish from gill nets. In the same country, manatees are also believed to be a serious pest to rice farming (Powell, 1996). Similarly, in Guinea-Bissau, local farmers reported that manatees cross very short distances on land if the soil is moist or clamber over low barriers to reach rice fields (Reeves *et al*, 1988). These feeding behaviours have not been observed nor reported by fishermen around the Fresco lagoon complex. However, West African manatees do feed mostly during the night, in contrast to the West Indian manatee which is known to feed both during the day and night (Hartman, 1979).

Manatees were found to be more active during the night than during daylight. The next chapter will determine if this is a response to human disturbances, by examining, in more detail the effect of human presence on manatee behaviour and flight distances.

PART IV MANATEE-HUMAN INTERACTIONS

Manatees are large, slow-moving and gentle mammals which have evolved in plant-munching peace for millions of years, until humans arrived on the scene. Now, manatees compete with humans for their rights to the limited coastal waters. Thus, increases in human populations in coastal wetland habitats have resulted in severe conflicts, and manatees may be on the losing side of an escalating invasion of their habitats.

How do manatees cope with co-existing with humans in the Fresco lagoon complex and how do the indigenous peoples perceive the species? This section seeks to answer these questions by examining, first, the effect of humans on manatee behaviour and, second, the attitudes of indigenous peoples towards manatees.

CHAPTER 9 EFFECTS OF HUMAN ACTIVITIES ON MANATEE BEHAVIOUR

9.1 Introduction

The increasing numbers of people that now live near coastal waters has been a cause for concern among conservationists in recent years, partially because of the increasing competition for limited habitats and subsequent effects of human activity on aquatic wildlife species (Burger 2001; Carney and Sydeman, 1999). In response to recurring human disturbance, many species have exhibited changes in their foraging habits and habitat selection patterns that, in turn, have also negatively impacted on the long-term viability of their populations.

Disturbance to shore birds, for instance, causes abandonment of their colonies (Cairns *et al.*, 1998) and reduced nesting success, due to slower nestling growth rates and increased egg or nestling mortality (Anderson and Keith, 1980). Burger (1993) found that, in areas of limited human activity, shorebirds devoted nearly 70% of their time foraging and 30% of their time avoiding people. However, when human populations increased, shorebirds foraged less than 40% of their time, resulting in decreased food consumption and increased energy expenditure. Burger and Gochfeld (1981) found sanderlings not only concentrated their foraging activities in areas with fewer people, but also increased time spent foraging nocturnally.

As coastal populations of humans increase, so does also the potential for disturbance to large aquatic mammals. Sander (1980) reported that dugongs in New Guinea feed at night in areas where they were hunted. Similarly, West Indian manatees in Honduras have been reported by local residents to become nocturnal in response to human pressure (Rathbun *et al.*, 1983). Powell (1996) suggested that, due to human presence on water systems in Cote d'Ivoire, the West African manatee shifted its activity patterns and was more nocturnal. Reports from Florida indicated that many West Indian manatees are involved in accidents with watercraft, and fatal collisions with watercraft of various sizes and speeds are the main cause of the manatee (Ackerman *et al.*, 1995).

Wildlife species may also be affected by repeated flushing responses and flight reactions to increasing use of waterways by sport and fishing boats. Flushing in response to boat traffic has been widely investigated in shorebird species (Bratton, 1990; Keller, 1991; Pierce *et al.*, 1993; Rodgers and Smith, 1995). West Indian manatees are also believed to refrain from "body-surfing", "cruising" and "following-the-leader" during mid-day to avoid periods of heaviest boat traffic (Reynolds, 1981). However, there is a lack of knowledge on how close a boat can get to the manatees and the precise circumstance that promote flushing responses. On the other hand, local fishermen using banana boats frequently complained about manatee capsizing their boats (see Chapter 10). This information has never been refuted or confirmed by a systematic study.

Chapter 7 of the present thesis has documented the level of boat traffic in the lagoon complex of Fresco and the importance of the lagoon in underpinning the livelihood requirements of communities living around it. Chapter 8 has highlighted the way that manatee use the lagoon. Hence, a clear understanding of the nature and effects of the interactions between manatees and humans in this limited habitat is important in designing a management strategy for the long-term conservation of the species. Thus, this chapter aims to determine the behavioural responses of manatees to the presence of humans, to assess how close a fishing boat can get to individual manatees, and to determine factors that may influence manatee flight distances in the lagoon. The following questions will be examined:

- what is the probability of manatees fleeing in the presence of humans?
- what is the closest distance to which an approaching boat can get to the manatee, and what factors determine the flight distance to manatees?

9.2 Methods

9.2.1 Human effect on manatee behaviour

Tagged manatees were located and behavioural studies were undertaken throughout the study (see Chapter 8). Untagged manatees were also included whenever seen. Once an animal was located, data were collected using focal watches and continuous recording (Altman, 1974; Martin and Bateson, 1993). Animals were observed for periods of up to 15 minutes whenever possible. The following data were collected: the location of the focal animal (GPS UTM coordinates); tidal stage; water depth; activity of manatee (see Chapiter 8); presence or absence of humans; human activity and location; distance from humans estimated to the nearest 5m; and manatee responses to the presence of humans. The response of focal manatee to human presence was classified as: diving; swimming away; fleeing with a splash of water; and ignore, when the manatee does not respond to the presence of humans. The locations of human activities were plotted and compared to areas used by manatees.

9.2.2 Flight distance

When a boat was approaching a manatee, the animal and the boat were simultaneously kept under observation until the boat passed or the animal reacted by diving or fleeing. The following data were collected: initial and subsequent activity of the manatee classified as moving; feeding; resting; cavorting; diving; swimming away; and fleeing (see Chapter 8); water depth; tidal stages; boat type; number of persons in the boat; and activities in which they were engaged. The activity categories of "diving", "swimming away" and "fleeing" were all considered as flight reactions by manatees. When the manatee switched to one of these activities while under observation, the distance from the boat to the animal, estimated to the nearest 5m was considered as the flight distance.

9.2.3 Data analysis

Maps showing the distribution of human activities were created using the locations coordinates and compared to utilization by manatees. The different types of manatee response to human presence were compared to total response types recorded while humans were absent from the vicinity. Data were analyzed using a chi-square and a General Linear Model (GLM) with normal error structure. GLM was used to estimate the effects of human presence on the length of time a manatee performed a given activity. The length of effective observation time was taken as the dependent variable. Two independent categorical variables, comprising presence or absence of humans and the different categories of manatee activities (a categorical variable with 4 levels) were fitted to the model to estimate their main effects, as well as their interaction in the variance of the dependent variable.

One-way analysis of variance was used to explore the difference in mean flight distances between different parts of the lagoon complex, between different types of activities of the approached manatees, different types of activities in which the approaching boats were engaged and between low tide, high tide and the closure of the inlet. The relationships between flight distances and number of peoples transported by the approaching boats, the depth of the water, the temperature and the salinity were examined using Pearson moment correlation. A General Linear Model was used to estimate the effects of activities of approaching boats on the flight distance of approached manatees. Flight distance was taken as the dependent variable. Two independent categorical variables, comprising activities of approaching boats and different activities of approached manatees were fitted in the model. Number of peoples transported by the approaching boats was used as a covariate to control for potentially obscuring or confounding variation.

9.3 Results

9.3 Overlap with areas of human use

Manatees were sensitive to human presence and generally avoided the areas highly used for human activities. They moved to those areas only when humans were absent. In the Niouniourou River manatees were most frequently found under roots of *Rhizophora racemosa* during the day. In the N'gni lagoon manatees stay near the edges of the water, generally close to a deeper bottom. The simultaneous use of an area by manatees and humans occurred mostly during the night when manatees left their resting areas to move in search of food, or when fishermen or a traveller entered into manatee resting areas (Figures 9.1 and 9.2). However, manatees always return to their resting areas early in the morning before human activity peaked.

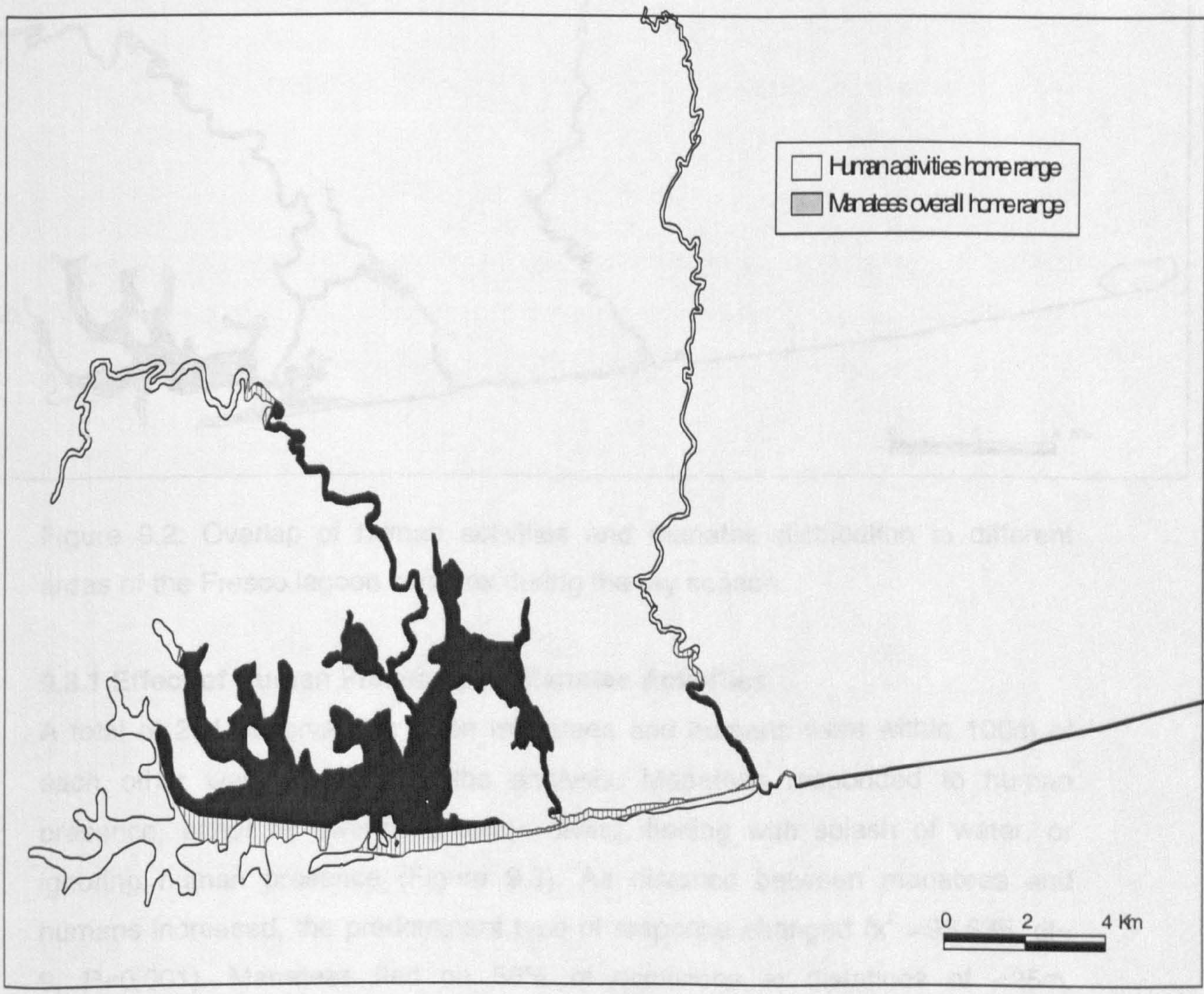


Figure 9.1: Overlap of human activities and manatee distribution in different areas of the Fresco lagoon complex during the wet season.

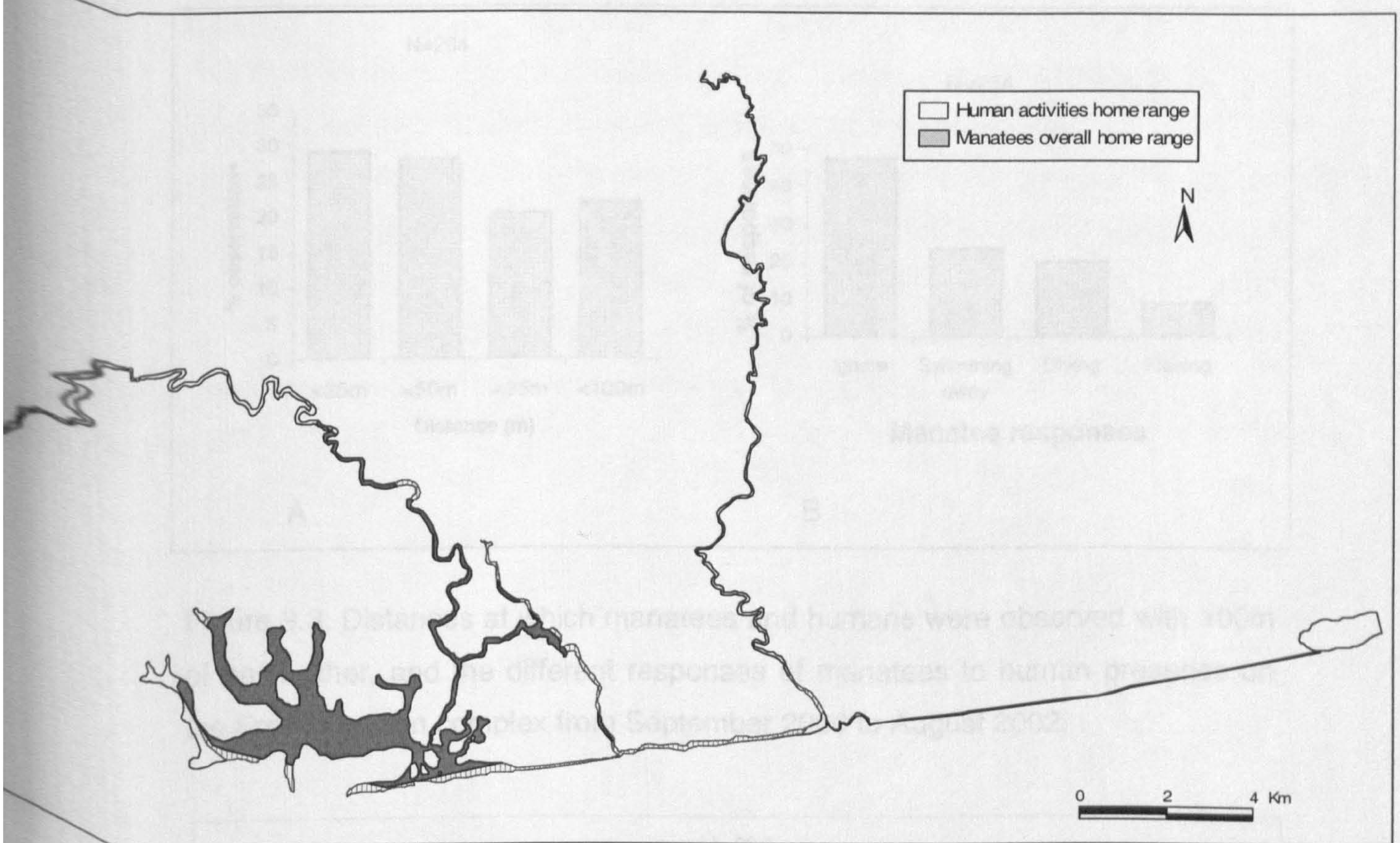


Figure 9.2: Overlap of human activities and manatee distribution in different areas of the Fresco lagoon complex during the dry season.

9.3.1 Effect of Human Presence on Manatee Activities

A total of 264 observations when manatees and humans were within 100m of each other were included in the analysis. Manatees responded to human presence, either by swimming away, diving, fleeing with splash of water, or ignoring human presence (Figure 9.3). As distance between manatees and humans increased, the predominant type of response changed (x^2 =93.635, df= 9, P<0.001). Manatees fled on 56% of occasions at distances of <25m, compared with 4% of occasions at distances of 75-100m. Likewise, manatees ignored the presence of humans on 9.6% and 46% of occasions over the same ranges of distance respectively (Figure 9.4)

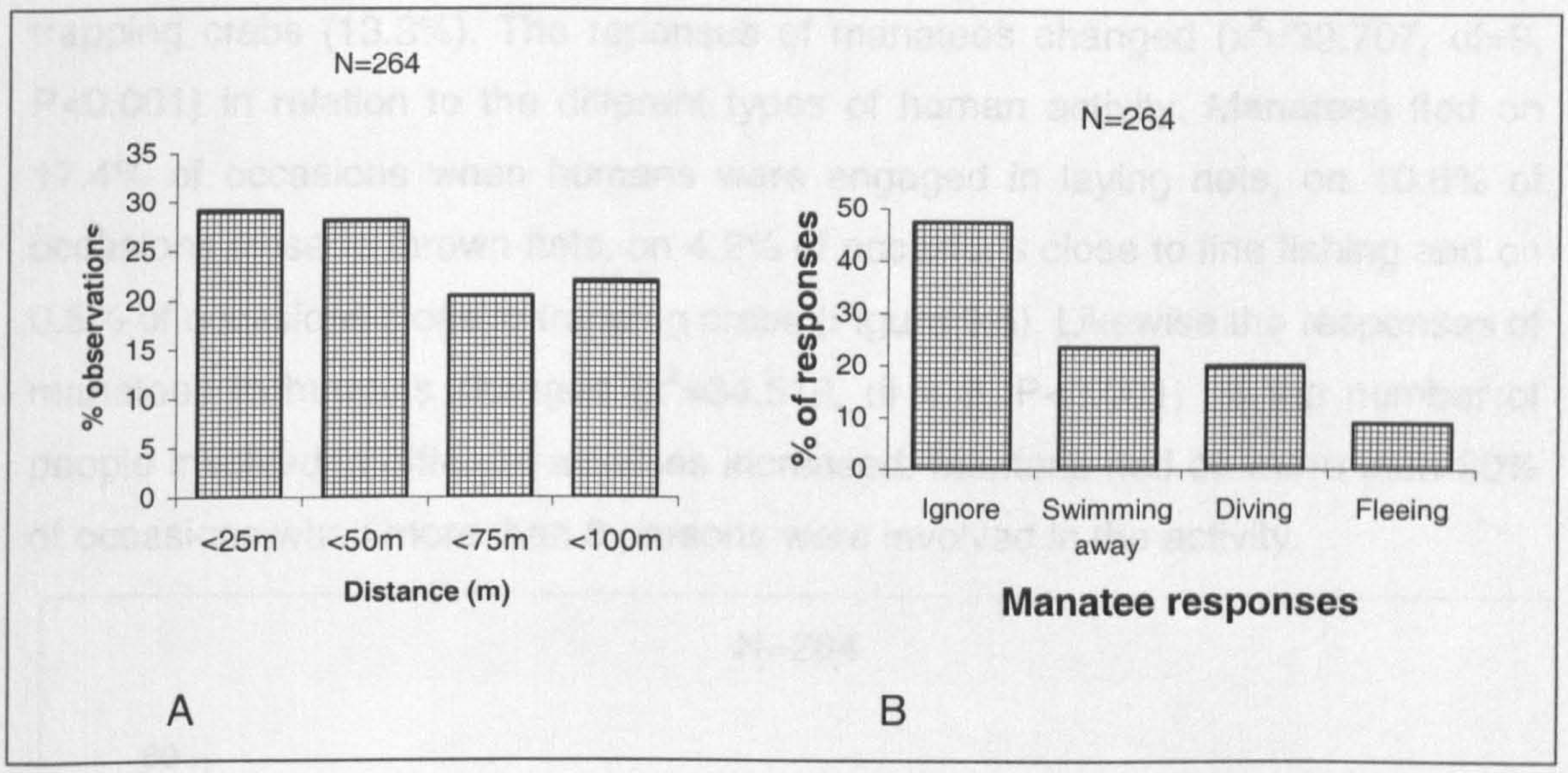


Figure 9.3: Distances at which manatees and humans were observed with 100m of each other, and the different responses of manatees to human presence on the Fresco lagoon complex from September 2000 to August 2002.

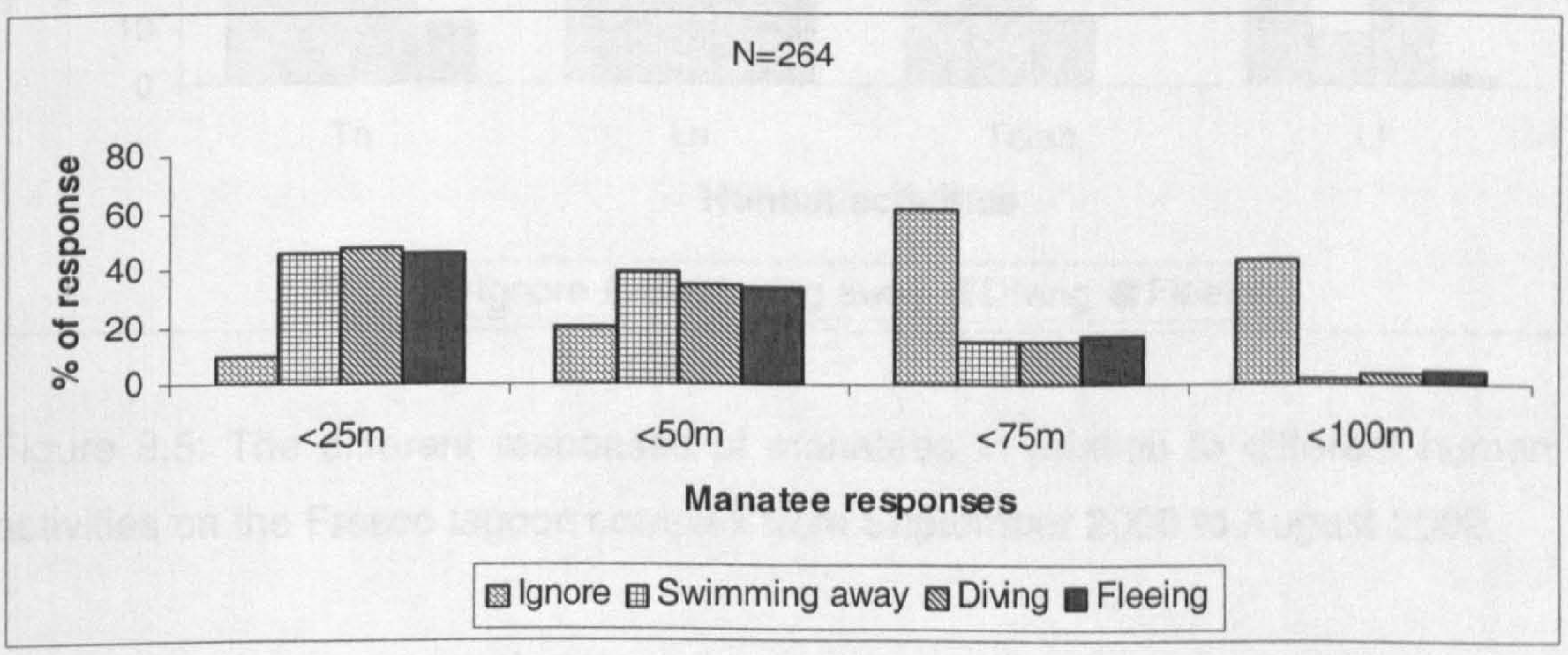


Figure 9.4: Change in predominant responses of manatees to the presence of humans, in relation to distance between manatees and humans on the Fresco lagoon complex from September 2000 to August 2002.

Humans found in the vicinity of focal animals were engaged in four main types of activity: net throwing (39.4%), laying nets (26.1%), line fishing (21.2%) and trapping crabs (13.3%). The reponses of manatees changed (x^2=39.707, df=9, P<0.001) in relation to the different types of human activity. Manatees fled on 17.4% of occasions when humans were engaged in laying nets, on 10.6% of occasions close to thrown nets, on 4.2% of occasions close to line fishing and on 0.5% of occasions close to trapping crabs (Figure 9.5). Likewise the responses of manatees to humans changed (x^2=34.519, df = 6, P<0.001) as the number of people involved in different activities increased. Mantees fled on more than 90% of occasions when more than 8 persons were involved in the activity.

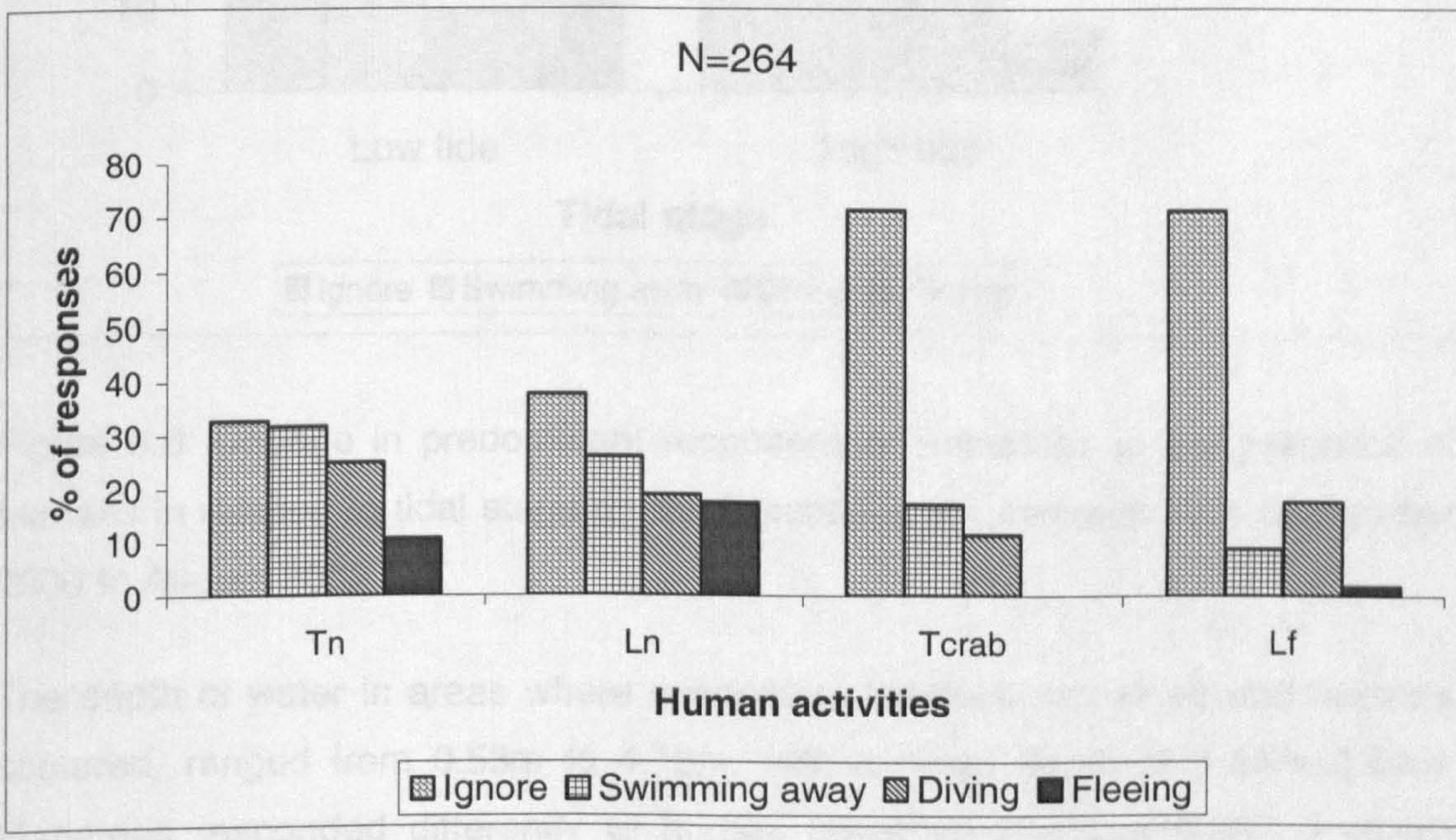


Figure 9.5: The different responses of manatees in relation to different human activities on the Fresco lagoon complex from September 2000 to August 2002.

Manatees also responded differently to human presence according to tidal stages (x^2=20.833, df= 3, P<0.001). Manatees swam away more often at low tide than at high tide. In contrast, manatees dived more often at high tide than at low tide (Figure 9.6).

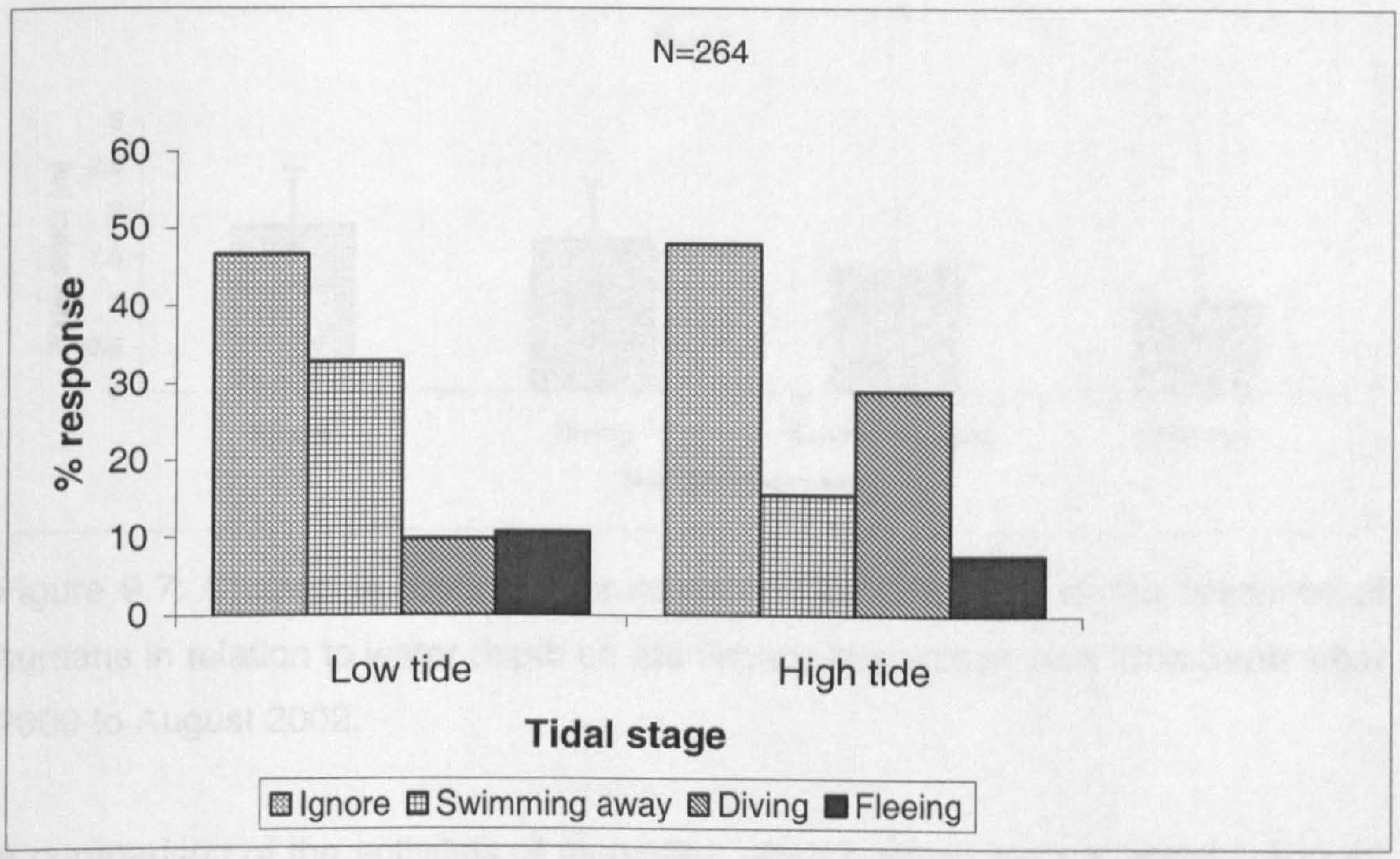


Figure 9.6: Change in predominant responses of manatees to the presence of humans in relation to tidal stage on the Fresco lagoon complex from September 2000 to August 2002.

The depth of water in areas where encounters between manatees and humans occurred, ranged from 0.53m to 4.15m, with a mean depth of 1.66m±0.64m. Manatees responded differently to human presence ($F_{3,\ 260}$=16.857, $P<0.05$) depending on the depths of water at which the encounters occurred. Manatees tended to ignore human presence at mean water depths of 1.83m± 0.70m, to dive at depths of 1.67m± 0.48 m, to swim away at depths of 1.38± 0.52 m, and fled to depths of 1.02m± 0.26m. However, a Tukey analysis indicated that mean water depth in areas where manatees ignored human presence did not differ from depth of areas where manatees responded by diving (Figure 9.7).

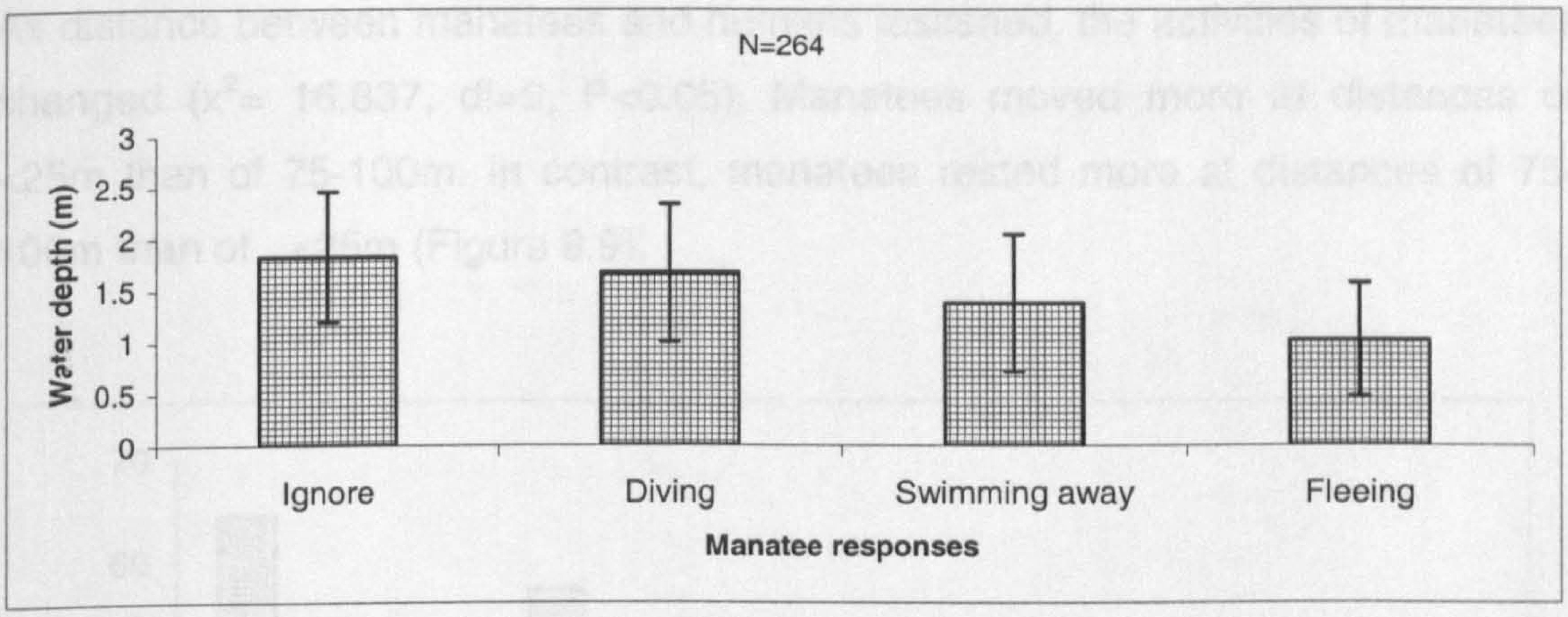


Figure 9.7: Change in predominant responses of manatees to the presence of humans in relation to water depth on the Fresco lagoon complex from September 2000 to August 2002.

A comparison of the activities of manatees when humans were present (<100 m: N=264) and absent (>100m: N=212) from the vicinty showed that, overall, manatees fed (x^2=7.451, df=1, P<0.05), rested (x^2= 32.141, df=1, P=0.05) and cavorted (x^2=3.740, df=1, P<0.05) more when humans were not in the vicinity. In contrast, manatees moved more (x^2=4.043, df=1, P<0.05) when humans were in the vicinity (Figure 9.8).

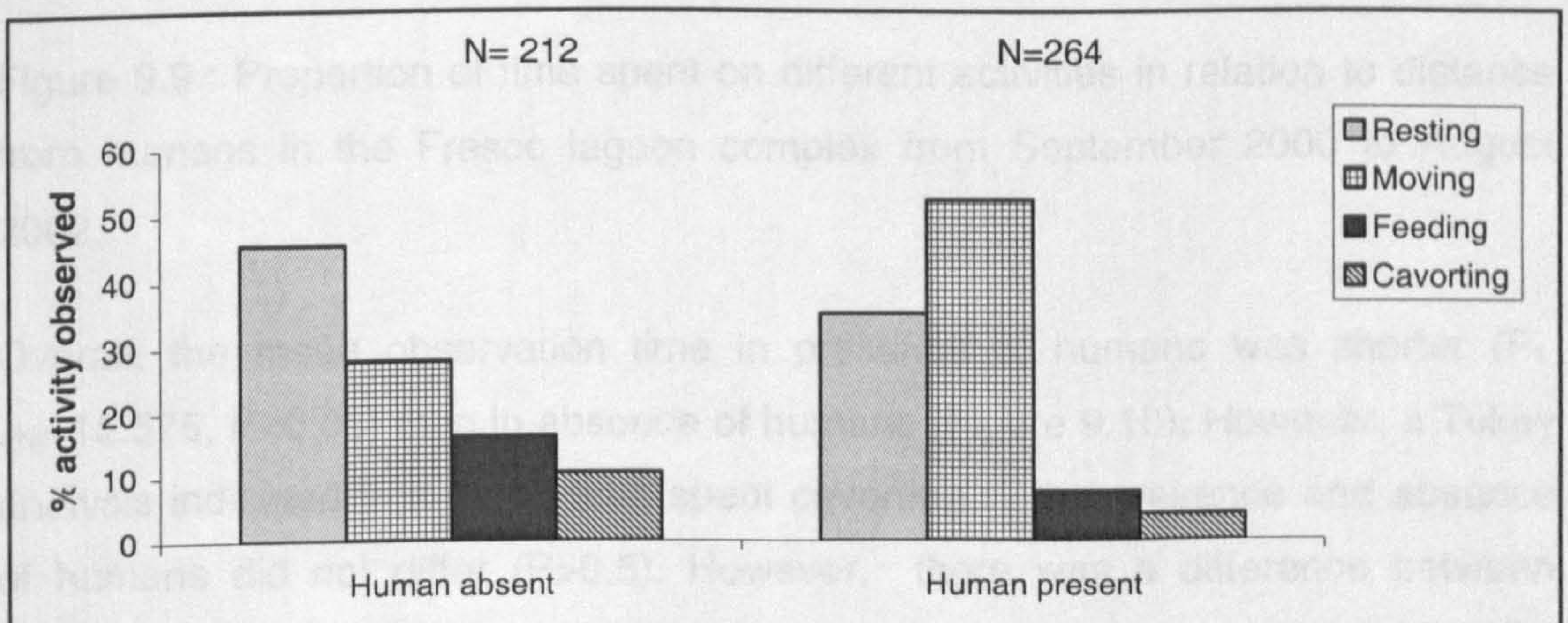


Figure 9.8: Proportion of time spent on different activities by manatees when humans were present and absent from their vicinity in the Fresco lagoon complex from September 2000 to August 2002.

As distance between manatees and humans lessened, the activities of manatees changed (x^2= 16.837, df=9, P<0.05). Manatees moved more at distances of <25m than of 75-100m. In contrast, manatees rested more at distances of 75-100m than of <25m (Figure 9.9).

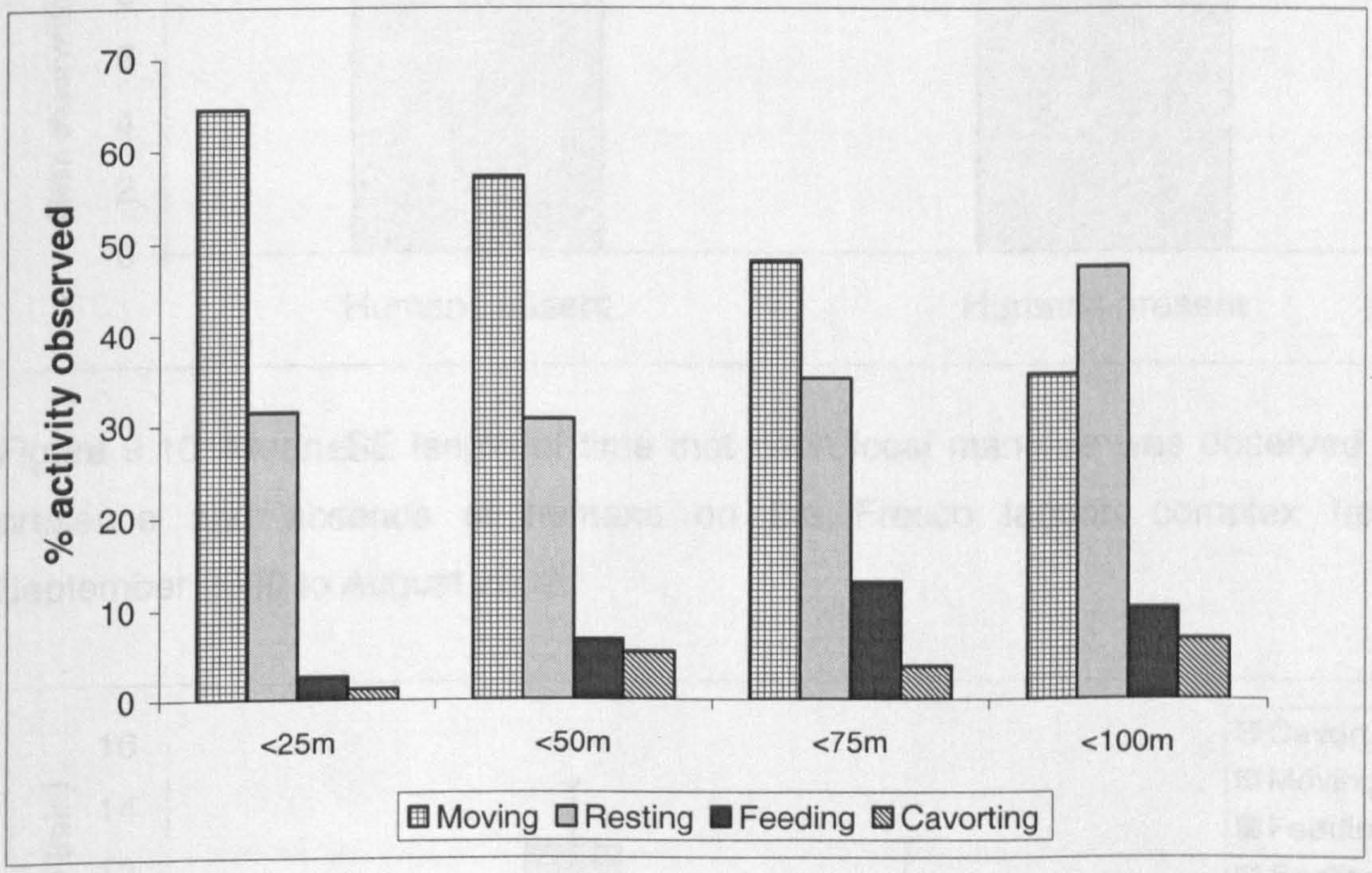


Figure 9.9 : Proportion of time spent on different activities in relation to distance from humans in the Fresco lagoon complex from September 2000 to August 2002.

Overall, the mean observation time in presence of humans was shorter ($F_{1, 474}$=12.575, P<0.05) than in absence of humans (Figure 9.10). However, a Tukey analysis indicated that mean time spent cavorting in the presence and absence of humans did not differ (P>0.5). However, there was a difference between resting, moving and feeding while humans were present and absent (P<0.05; Figure 9.11).

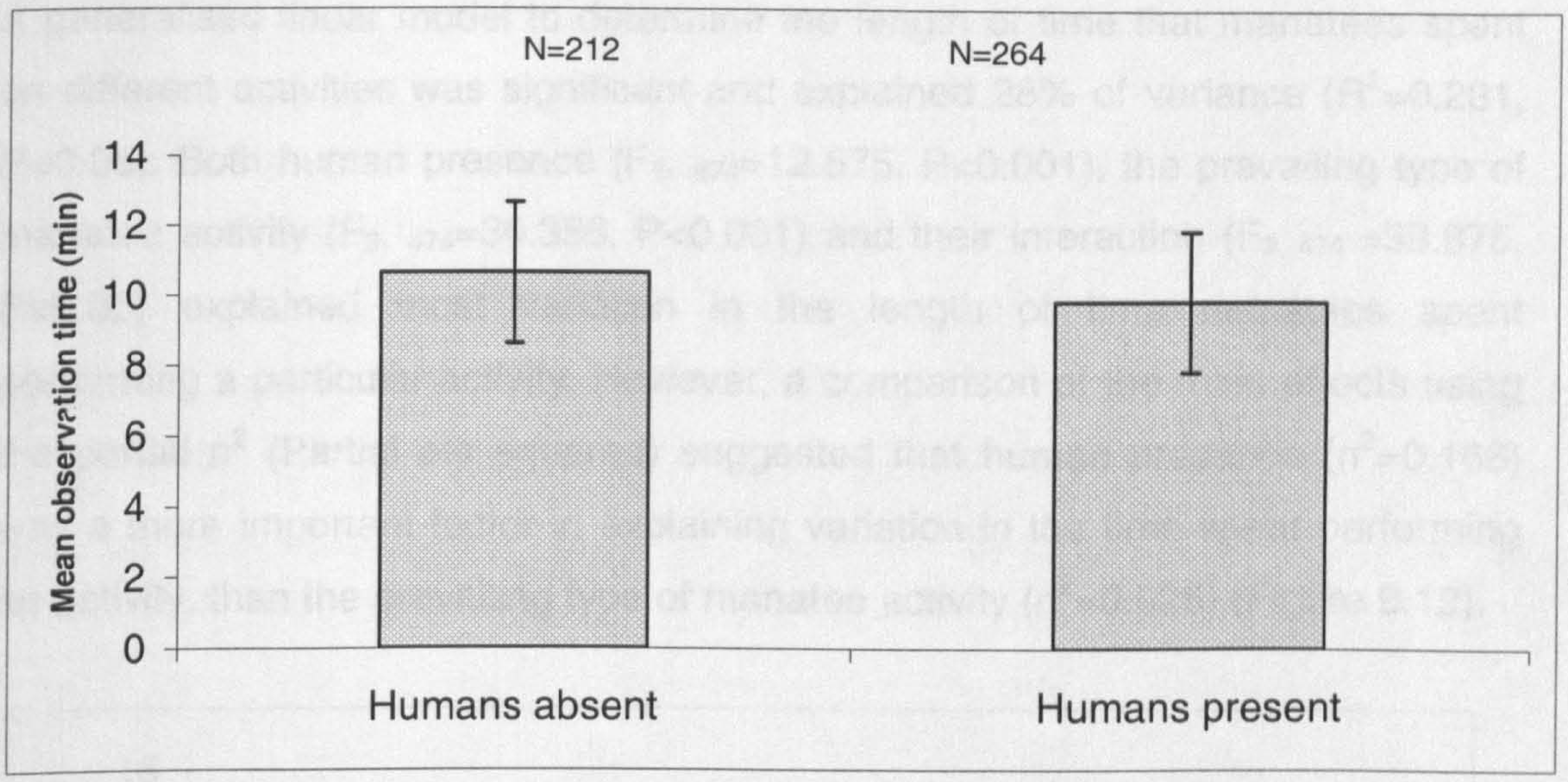


Figure 9.10: Mean±SE length of time that each focal manatee was observed in presence and absence of humans on the Fresco lagoon complex from September 2000 to August 2002.

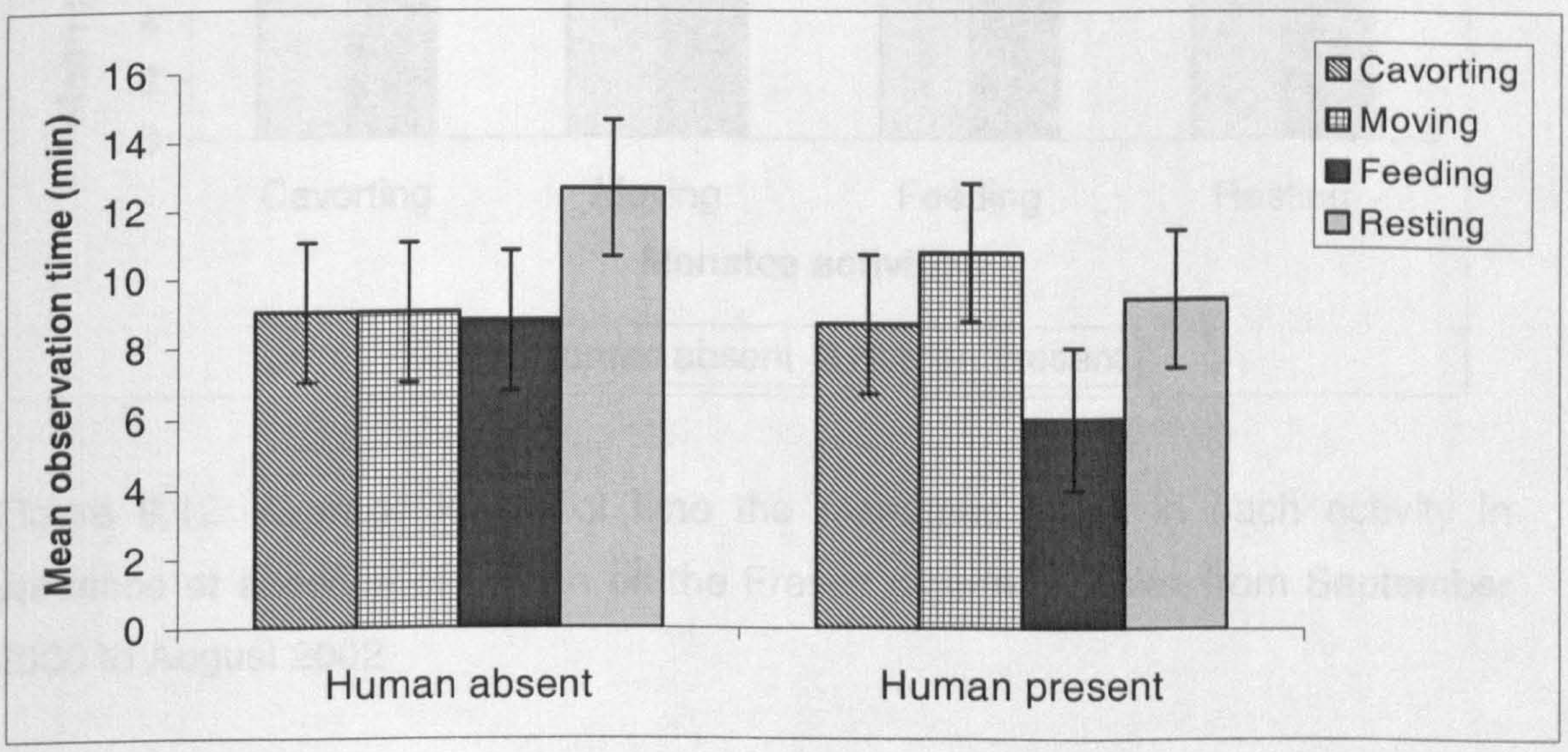


Figure 9.11: Mean±SE length of time that manatees undertook different activities in the presence and absence of humans on the Fresco lagoon complex from September 2000 to August 2002.

A generalised linear model to determine the length of time that manatees spent on different activities was significant and explained 28% of variance (R^2=0.281, P<0.05). Both human presence ($F_{1, 474}$=12.575, P<0.001), the prevailing type of manatee activity ($F_{3, 474}$=30.356, P<0.001) and their interaction ($F_{3, 474}$ =30.875, P<0.05) explained most variation in the length of time manatees spent performing a particular activity. However, a comparison of the main effects using the partial n^2 (Partial eta squared) suggested that human presence (n^2=0.166) was a more important factor in explaining variation in the time spent performing an activity, than the prevailing type of manatee activity (n^2=0.026) (Figure 9.12).

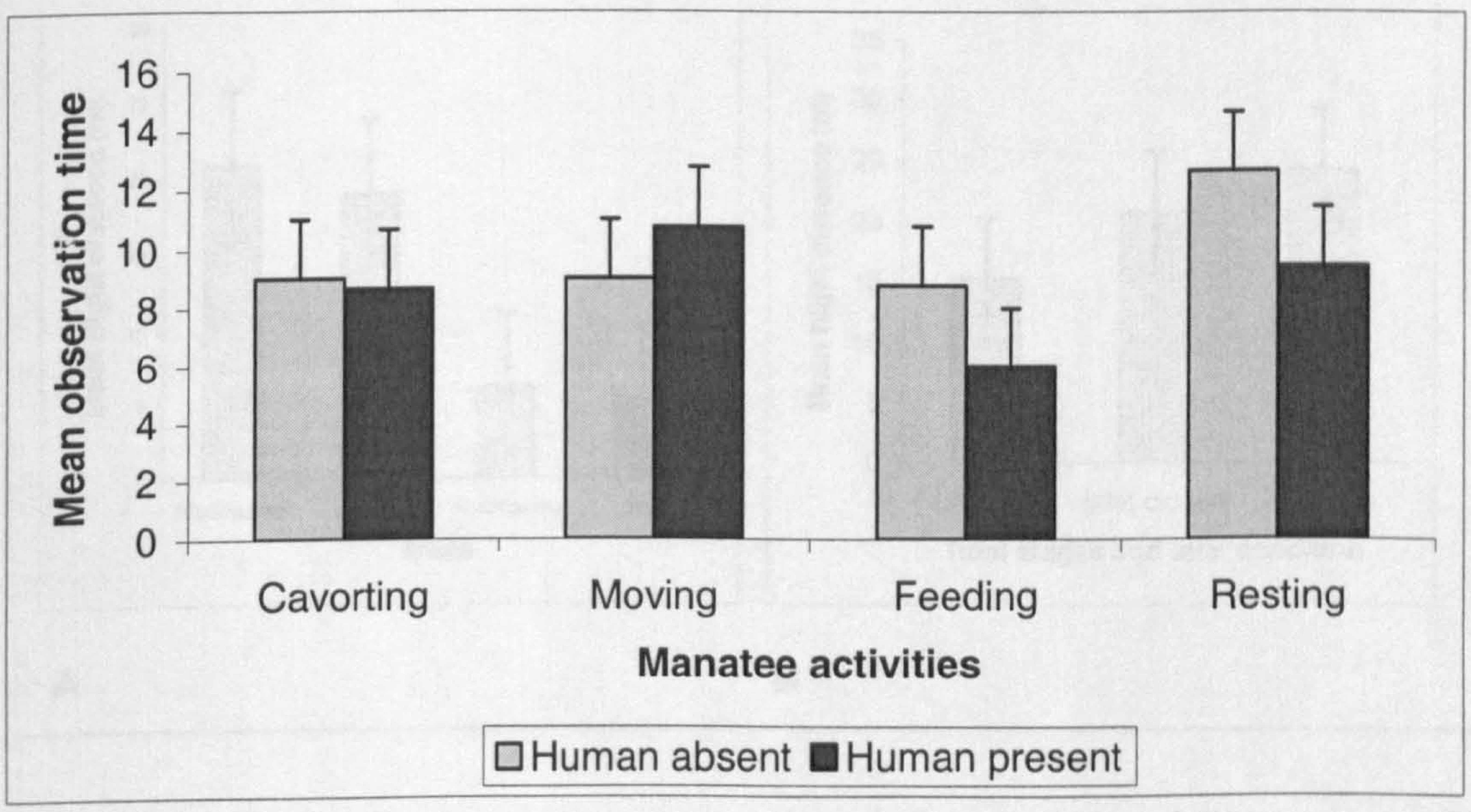


Figure 9.12: Average length of time the manatees spent in each activity in presence or absence of human on the Fresco lagoon complex from September 2000 to August 2002

9.3.2 Flight distance

A total of 406 boats were observed approaching manatees. In 65% of cases, manatees did not change their activity suggesting that the animals did not react to the approaching boats. Flight reactions were observed in 35% of approaches. The approaches distances ranged from 1 to 100m with a mean of

26.86m±25.04m. However, mean flight distance was shorter than mean non-flight distance (t (397)=3.820, $P<0.001$). Flight distances differed ($F_{3, 140}=5.36$, $P<0.05$) according to area of the lagoon and were shorter in the Bolo and the Niouniourou Rivers than in the N'gni lagoon and the estuary (Figure 9.13a). Similarly, flight distances differed ($F_{2, 140} = 4.955$, $P<0.05$) according to tidal stage and the closure of the inlet. However, a Tukey test showed that a difference was only evident ($P<0.05$) between low tide and high tide (Figure 9.13b).

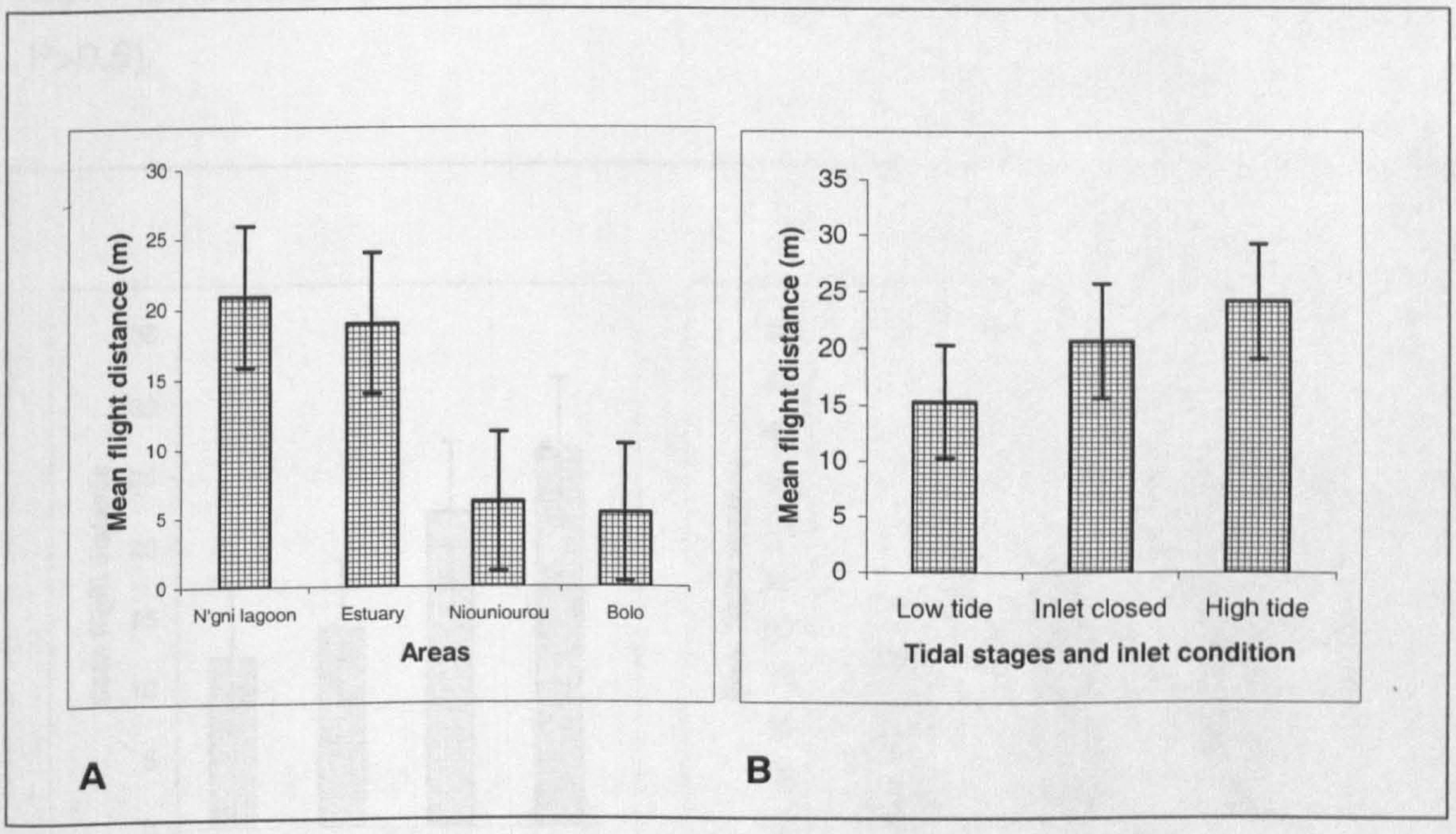


Figure 9.13: Flight distance of manatees in relation to area of the lagoon, tidal stage and inlet condition in the Fresco lagoon complex from September 2000 to Agust 2002.

Humans who were observed approaching manatees were involved in four types of activity. A total of 48.1% of people travelling (going to or from farms, transporting firewood, and going to or from fishing) 37.6% were throwing nets 14.9 % were laying nets and 7.5% were line fishing. The number of people in approaching boats ranged from 1 to 9, with a median of 2. In general, flight distance differed ($F_{3, 140}=5.575$, $P<0.05$) between the type of activities in which the approaching boats were involved. The flight distances of manatees increased when approaching boats were laying nets, and throwing nets than when boats were travelling and line fishing (Figure 9.14a).

Flight distances also increased when the approaching boats were carrying more people (r=435, N=141, P<0.05) (Figure 9.14b). In contrast, there was no relationship between flight distance and water depth (r=-0.026, N=141, P>0.5), water temperature (r=-0.070, N=141, P>0.05) and water salinity (r=0.101, N=141, P>0.5).

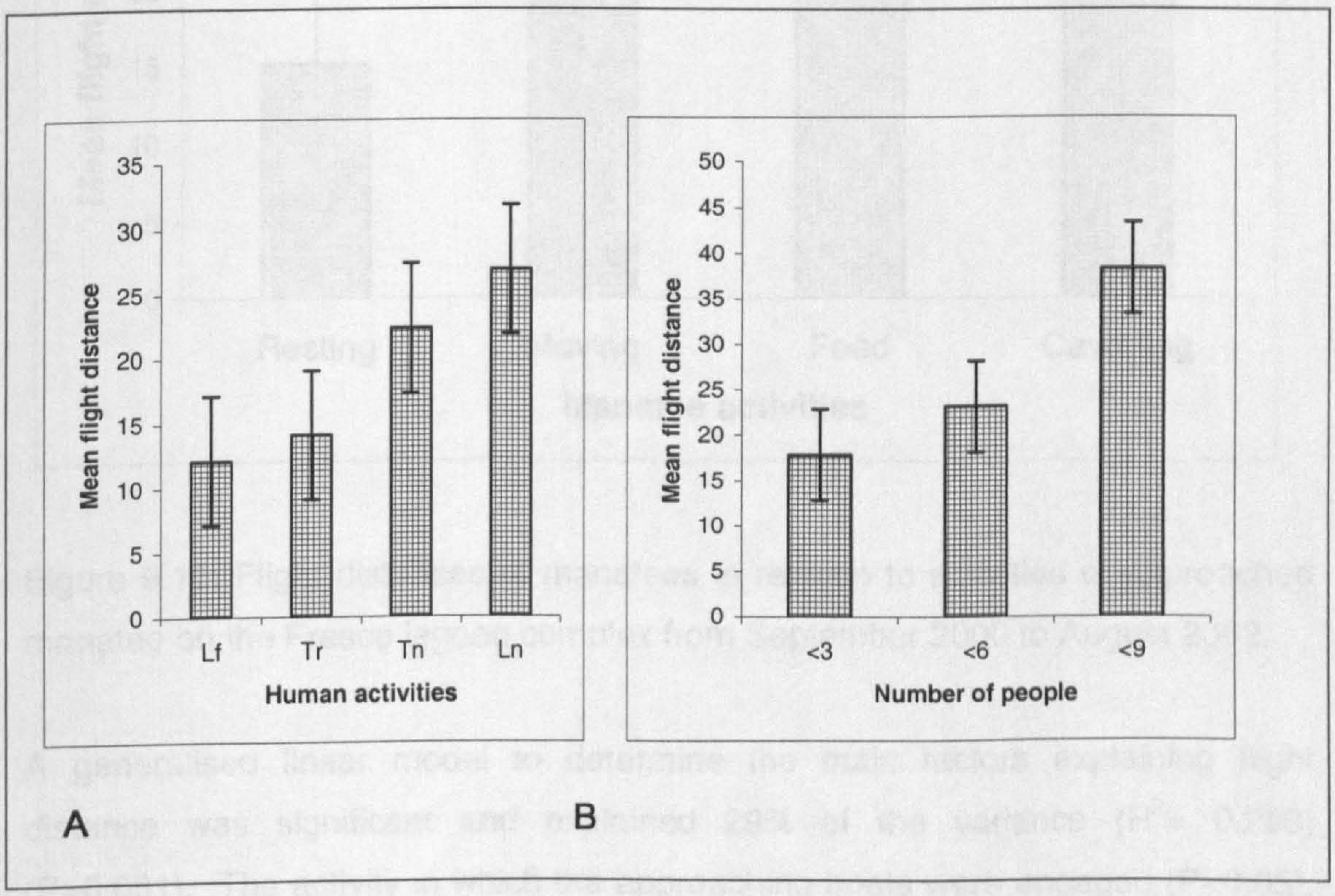


Figure 9.14: Flight distances of manatees in relation to activities of approaching boats in the Fresco lagoon complex from September 2000 to August 2002 (Lf=line fishing; Tr=travelling; Tn=throwing nets and Ln=laying nets).

Manatees that were being approached by boats were engaged in moving (40%), resting (38%), feeding (17%) and cavorting (3.5%). Mean flight distance changed

($F_{3,\ 140}$ =3.229, $P<0.05$) according to the activity in which the approached manatee was engaged. Flight distances were shorter for resting manatees than for manatees engaged in other types of activities (Figure 9.16). On five occasions flight distances of resting manatees were less than 5m.

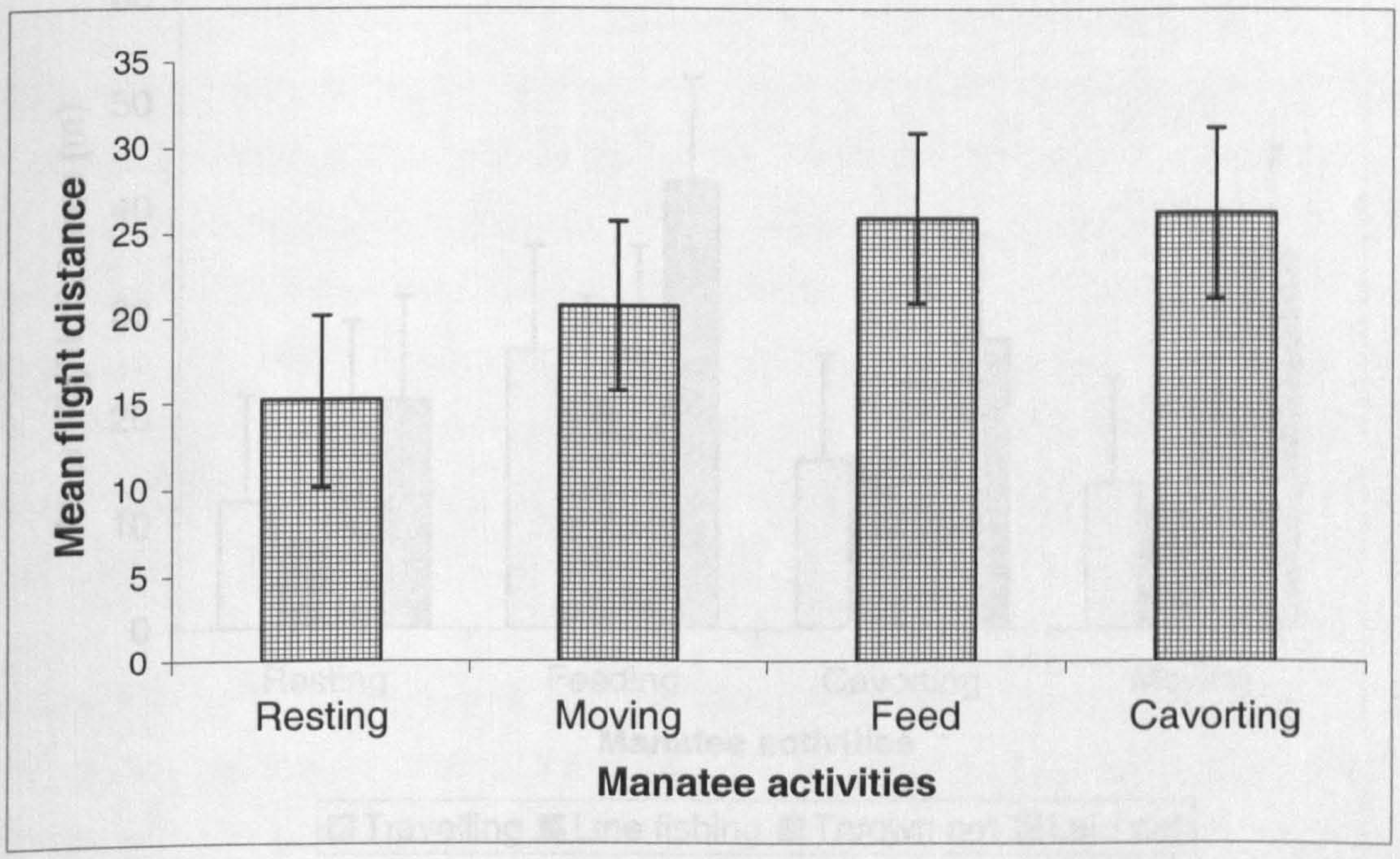


Figure 9.15: Flight distances of manatees in relation to activities of approached manatee on the Fresco lagoon complex from September 2000 to August 2002.

A generalised linear model to determine the main factors explaining flight distance was significant and explained 29% of the variance (R^2= 0.288) ($P<0.001$). The activity in which the approaching boats were engaged ($P<0.05$), the number of people in the boat ($P<0.05$), and the activity of the approached manatee ($P<0.05$) best explained variation in flight distance. However, an interaction between activities of approached manatee and the approaching boat was not significant ($P>0.05$). A comparison of main effects using the partial n^2 (Partial eta squared) suggested that the activity of approaching boat (n^2=0.17) followed by activities of the approached manatees (n^2=0.063) were more important in explaining variation in manatee flight distance than the number of people carried by approaching boats (n^2=0.06) (Figure 9.17).

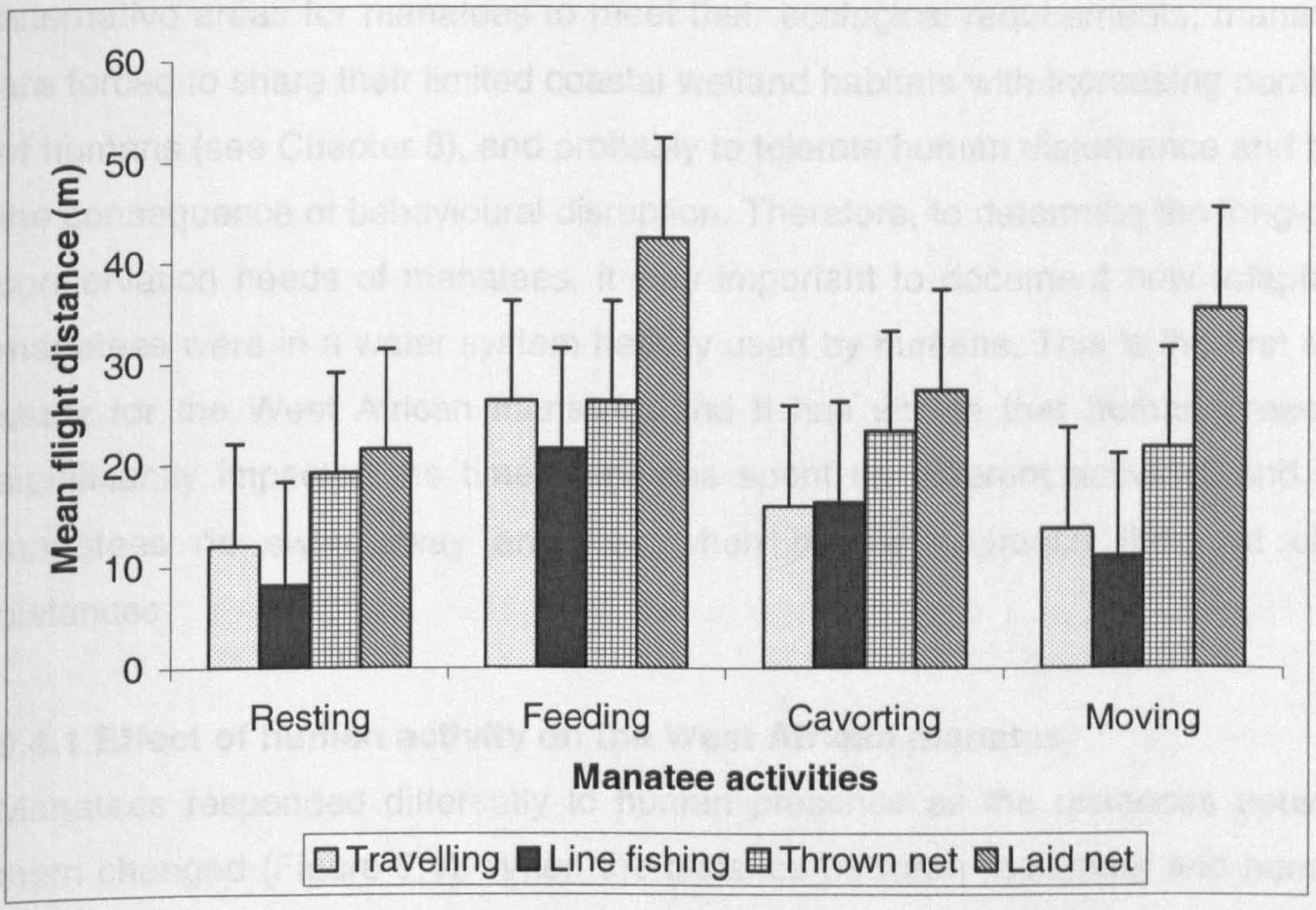


Figure 9.16: Flight distances of manatees in relation to activities of approaching boats and to the activities in which the approached manatees were engaged in the Fresco lagoon complex from September 2000 to August 2002.

9.4 Discussion

There are few studies of the behavioural impacts of human activities on living sirenians in general, and on the West African manatee in particular. Most studies of sirenians involve documenting the distribution, abundance, and the ecology of the species. Relatively few researchers have investigated sirenian behaviour and changes in relation to human activities. However, the short-term human disturbance to dolphins (cetaceans) is reviewed by Simmonds and Hutchinson (1996). Typical short-term disruptions on dolphins include: longer dive length;

shorter surfacing intervals; increased swimming speeds; evasive movements; orientation away from noise sources; and, departure from the area. Similarly, human disturbance to manatees may cause both short-term behavioural disruptions and permanent impairment. Because there appears to be no alternative areas for manatees to meet their ecological requirements, manatees are forced to share their limited coastal wetland habitats with increasing numbers of humans (see Chapter 8), and probably to tolerate human disturbance and bear the consequence of behavioural disruption. Therefore, to determine the long-term conservation needs of manatees, it was important to document how adaptable manatees were in a water system heavily used by humans. This is the first such study for the West African manatee, and it has shown that human presence significantly impacted the time manatees spent on different activities and that manatees do swim away and flee when people approach them at close distances.

9.4.1 Effect of human activity on the West African manatee

Manatees responded differently to human presence as the distances between them changed (Figure 9.4). When the distance between manatees and humans was less than 25m, they were more likely to flee and swim away. At greater distances of 75-100m, manatees ignored the presence of humans and swam away or fled less often. Human activities and the number of peoples involved were also important in determining the response of manatees to human presence (Figure 9.5). Manatees in the vicinity of people engaged in laying and throwing of nets were more likely to flee. This was not surprising as laid and throwing netting were more disruptive to the water body. Thrown net fishermen, for instance, always throw a stone in front of them before casting their heavy nets into the water (see Chapter 7). It was also observed that manatees responded to human presence according to the depth of the area where the encounter occurred. In deeper areas, manatees tended to ignore the presence of humans, but fled more frequently in shallow areas. Manatees may feel more secure in deeper areas, where they tended to mostly congregate in the lagoon (see Chapter 8).

Time spent by manatees on feeding, moving and resting in the presence or absence of humans varied according to the type of activity (Figures 9.8; 9.9). Less time was spent feeding and resting and more time was spent moving when people were in the vicinity. Manatees were rarely seen feeding on emergent plants along the shoreline of the N'gni lagoon, and never seen feeding outside the water, during daylight hours. During daylight and in the presence of people on the lagoon, manatees were only observed feeding in the water, on mud and deposited organic material under the water. On only two occasions, were manatees observed feeding on leaves of *Calamus deeratus* during daylight in presence of people, once each in the Bolo and Niouniourou Rivers. However, feeding had always started before the people arrived and the manatees stopped feeding and disappeared as soon as the boat got close. The influence of human activity may be why manatees mostly feed during the night (see also Chapter 8).

Sai and Sze (2003) observed that dolphins in human dominated-waters have established a sophisticated pattern of association with moving vessels and they are well adapted to the surrounding traffic and human activities. For instance, there is a mutually beneficial feeding association between dolphins and fishing vessels because the vessels provide more efficient hunting opportunities for dolphins. West Indian manatees are reported to exhibit three general responses to human activity: attraction, habituation, and avoidance (Whittaker and Knight, 1998). They have proved docile to thousands of people who regularly swim with them at Crystal River in Florida without incident (Barbara and Jeff, 1998). In the case of the West African manatees, this study has provided no evidence that manatees have successfully habituated to human impacts by such behavioural adjustments.

Determining the exact physiological significance of disruptions to manatees as a result of human activities was beyond the current study and should be the subject of further research. However, it is believed that human disturbances to cetaceans are detrimental to their social order and behaviour because cetaceans often need several hours to engage in co-operative social activities and sexual engagement (Richardson *et al.*, 1995). This may also be applicable to West African manatees. For instance, during the mating period, oestrous female West Indian manatees are believed to attract 5 to 22 males, who will escort her closely for up to a month in a selective competition for the privilege of mating (Barbara and Jeff, 1998). Therefore any human disruption may be detrimental to mating success. Behavioural disruption may also have implications for energy balances. For example, fleeing close to people may result in more energy expenditure, and interrupted feeding implies reduced energy intake. Such energy implications may have a subtle long-term effect on the performance of individual manatees. Distribution of manatees throughout the lagoon may be influenced by human activities. Manatees, particularly the younger ones, were sometimes caught incidentally by fishing nets. Two transmitters failed during data collection when tagged animals were entangled in fishing nets and multiple hooks lines.

9.4.2 Flight distance

Animals commonly flee approaching humans and the flight or flushing distance at which an animal moves away from approaching humans is an important management tool used by wildlife managers to quantify human disturbance and to define set back distances or buffer zones, areas beyond which people can be said to minimally disturb or impact wildlife (Louis and Le Berre, 2000). Flight distance has also been used as a standardized way to quantify the perception of predation risk. Behavioral ecologists have realized that individuals should vary their flight distances dynamically, so as to minimize the costs of disturbance while maximizing the chance of survival (Ydenberg and Dill, 1986; Bonenfant and Kramer, 1996). Studies have demonstrated that flight distance depends on many variables including: angle of approach, whether directly or tangentially; season; time the day; reproductive state; distance to safety; whether or not a population is hunted; and type of human disturbance (Rodgers and Smith, 1995; Richardson and Miller, 1997). While managers acknowledge the variability of flight distance

(Carney and Sydeman, 1999), they nevertheless use estimates of flight distance to attempt to minimize human impact on particular species.

This study has shown that observed flight reactions of manatees were a direct response to approaching boats, the number of peoples transported and the activities in which they were engaged (Figure 9.14). However significant differences in manatee's flight distance occurred between tidal stages and inlet condition (Figure 9.13b), between areas of the lagoon complex (Figure 9.13a), and between types of activity in which the approached manatee was engaged (Figure 9.15).

As might be expected, manatees tended to be disturbed and flee at distance further away from approaching boats engaged in throwing and laying nets. This reflects the nature and the impact of these types of fishing on the water body (see Chapter 7). In contrast, manatees could be approached more closely by boats engaged in line fishing and travelling. Line fishing, particularly multiple hook line fishing, always involved a single fishermen moving slowly and usually in very small boat to set his line in the water. In contrast, laying nets, particularly when moving them and throwing nets always involved a team of from 2 to 8 people, and was therefore expected to be more disruptive.

Flight distance was longer in the N'gni lagoon and the estuary than in the Bolo and the Niouniourou Rivers. The N'gni lagoon is the area of the Fresco lagoon complex most used by people (see Chapter 7). As flight distance decreases with repeated exposure to humans (Smith and Visser, 1993; Lord *et al.*, 2001; Miller *et al.*, 2001), manatees in the lagoon may be expected to be more habituated to human presence, and consequently to show shorter flight distances. The fact that this was not the case here confirmed the complex factors underlying causes of flight distance (Pierce *et al.*, 1993). However, this could be explained, in part, by the different types of human activity occurring in the N'gni lagoon and the estuary compared to the Bolo or the Niouniourou Rivers. Thrown and laid netting are the most disruptive types of fishing, and these are not practiced in the Niouniourou and the Bolo Rivers (see Chapter 7), probably because the relatively deeper water and the bottom clutter of dead mangrove branches, which are both inappropriate to these types of fishing.

Fight distance also varied with type of activity in which the approached manatees were engaged. Manatees were more approachable when resting. In several cases the approaching boat passed as close as 5m without any reaction from the resting manatee. However, flight reactions sometimes occurred after the disturbance created by the boat had reached the resting manatee by the water current. Thus, in some cases, the boat had passed a few seconds before the manatee reacted. The delayed reactions of resting manatees can be dangerous for smaller banana boats, and may be the reason why fishermen believed that manatees can capsize their boats.

While the future of the West African manatee in the lagoon of Fresco seems to be affected, to some extent, by increasing numbers of people engaged in different fishing activities, the next chapter will examine the attitudes of the users of the lagoon towards manatees.

CHAPTER 10 LOCAL ATTITUDES TOWARDS WILDLIFE AND THE WEST AFRICAN MANATEE

10.1 Introduction

All living sirenians are listed as Vulnerable in the IUCN Red Data Book (IUCN, 2003). Habitat degradation, accidental killing as a by-product of human activity and hunting are the most important threats to sirenians (Barbara and Jeff, 1998). Many manatees are accidentally killed by watercraft, while traditional migration routes have been closed or modified by coastal development, and human activities have impinged on habitat quality throughout their range. Sirenians face hunting pressures of at least three kinds: subsistence hunting, in which the hunter and his family or tribe use the meat, hide or other products themselves; commercial hunting, in which the hunter sells his catch, or parts thereof; and incidental take, in which the animal is not the target of the hunter, but rather is harvested during some other activity such as net fishing.

Historically, human perceptions and attitudes towards manatees have varied widely between different cultures. Particular traditions of many peoples are also based on myths and legends about manatees (Reynolds and Odell, 1991; Powell, 1996). Throughout their evolution, sirenians have been mistakenly described as fish, as whales, as half-human or as evil, and have inspired both legend and controversy (Reynolds and Odell, 1991). The best-known legend about the sirenians is that they are mermaids, imaginary sea creatures fabled to have a woman's head and upper body and a fish's tail. Although it is extremely difficult to see the resemblance between a manatee or a dugong and these fabled creatures, the connection between sirenians and mermaids has persisted through time (Reynolds and Odell, 1991; Powell, 1996).

For example, in January 1493, Christopher Columbus thought he had seen three "mermaids" when three manatees lifted their heads out of the water off the coast of Hispaniola (the modern-day Dominican Republic and Haiti). In his journal he wrote: "They are not so beautiful as they are painted, though to some extent they have the form of a human face". He is believed to have made the first documented sighting of a manatee by a European in the New World (Barbara and Jeff, 1998).

Portuguese explorers perpetuated the stories of mermaids and mermen (male counterparts of the mermaid) when they encountered dugongs off the coast of Ceylon (modern-day Sri Lanka). In 1560 they captured seven of the strange animals near Mannar in northern Ceylon and shipped them to India. There, a viceroy's physician conducted a thorough investigation of the mysterious mammals and found the creatures "comparable with humans in every respect" (Reynolds and Odell, 1991).

Throughout West Africa, there are strong beliefs in "Mammy-Wata", water deity of god or evil, almost always associated with manatees. The Peulh, who are found from Senegal to Chad do not eat manatees and have strong mythical beliefs associated with the species (Powell, 1996). In the village of Akpasang in Cameroon, manatees are believed to receive their power from the devil. If a person killed a manatee, the animal would punish the hunter's family (Gregorine, 1996). For the Godie of Fresco, only a widower would attempt to kill a manatee, as the Godie believe that the spirit of a manatee killed by a married person will kill the wife of that person in compensation.

Although erroneous in some cases, the connection between sirenians and mermaids and other myths and legends has endeared sirenians to some people or generated fear in others and prevented excessive hunting. This has not been the case, however, with other stories. For example, non-aggressive and virtually harmless sirenians have been considered dangerous to people. In parts of their range, some fishermen have claimed that manatees are ferocious beasts that steal fish from their nets. In some areas, they are believed to drown people. In Sierra Leone and Guinea-Bissau, manatees are even considered as serious pests to rice farming (Powell, 1996). Such people may not themselves injure manatees, but they generally do not step forward to support manatee protection. These perceptions are not peculiar to manatees, but are common to most animals, particularly large mammals and predators in areas where they co-exist with people, which has resulted in a long history of human-wildlife conflict (Nowell and Jackson, 1996).

Causes of human-wildlife conflict, both perceived and actual, are numerous but can be summarized as: conflict over livestock depredation; crop raiding; direct threats to human life and livelihood (Kellert, 1985; Glass *et al.*, 1993; Blanco *et al.*, 1992) and disease transmission (Howard, 1985). Conflict has led to active persecution of wildlife over much of the globe and has resulted in the extinction, near extinction or severe reduction in the range of many species. The red wolf (*Canis rufus*), the Asian Lion (*Panthera leao persica*) and the African wild dog (*Lycaon pictus*) are some good examples (Ginsberg and Macdonald, 1990; Nowell and Jackson, 1996). Wildlife-human conflict is more common near protected areas, as people living there have to interact more frequently with wildlife species, particularly predators and other "charismatic" mammals (Fiallo and Jakobson, 1995). Unfortunately, the traditional approach to protected areas which relied on guards patrols and penalties, an approach described by Wells and Ballenberghe (1992) as "fines and fences", has generated potential side-effects with considerable resentment, hostility and lack of support from local people (Hough, 1988).

Reducing persecution on wildlife depends as much on reducing conflict as it does on changing peoples' perceptions and attitudes (Kellert *et al.*, 1996). A number of solutions have been proposed in recent years to mitigate human-wildlife conflict. Among them, there is a growing consensus that the local community needs to be involved in wildlife conservation and to share tangible benefits as a prerequisite for reducing conflicts (Fiallo and Jacobson, 1995). However, an understanding of the attitudes of the local community towards a conservation programme, and their perception towards the resource to be conserved, should be the first step in the process of developing any policies.

Previous chapters have shown that the city of Fresco and the villages of Zakareko and Bohico depend on the Fresco lagoon complex, which they have traditionally managed as common property, successively under the N'gni system and laterly under the co-management committee (Chapters 5 and 7). Chapter 6 has shown the positive attitudes held by the community towards the lagoon and the management institution, although they recognise the need for it to be strengthened. Because there appears to be no alternative area to meet their ecological requirements, manatees share the limited lagoon (see Chapter 8) with the communities and to some extent bear the costs of disturbance resulting from these interactions (Chapter 9). Chapter 8 has described the current density of manatees in the lagoon. However, without any previous estimates, it has not been possible to determine the trend of the manatee population. This chapter examines the attitudes of the lagoon users community to the wildlife of the area in general, and to the West African manatee in particular based on the following questions:

- what levels of support exist for, and what levels of hostility are held towards conservation of wildlife in general, and the West African manatee in particular? and,
- which factors best explain such support and hostility, for example in relation to villages and origin of users and to previous participation in public awareness campaigns?

10.2 Methods

A semi-structured questionnaire interview schedule was conducted in French among a sample of households from Fresco, Zakareko and Bohico. The following was measured: knowledge about the wildlife species in the area, their present population status and whether or not wildlife poses a problem to the community. Specific information related to the West African manatee included its perceived population trend, whether or not manatees were a problem to the respondents and any reasons why it was a problem. Attitudes towards the manatee were assessed by providing a total of eight ranges of attitude statements to which the respondents were asked to state their level of agreement (1=strongly agree, 2=agree, 3=neutral, 4=disagree and 5=strongly disagree; see Appendix III).

Data were analyzed using descriptive statistics and responses were compared using chi-square tests with cross-tabulation tables. Thirteen statements of attitudes towards manatees were subjected to factor analysis to allow the formation of one scale, namely "support to manatee conservation". Prior to performing the factor analysis, the suitability of the data for factor analysis was assessed. A correlation matrix was inspected to ascertain the presence of coefficients above 0.30. The Kaiser-Meyer-Oklin (KMO) value of 0.60 or above and the significance of the Barlett's Test of Sphericity (0.05 or smaller) were used to support the factorability of the correlation matrix. A Catell's scree test was performed to determine both the reliability and validity of the scale. Combined attitude scores were eventually calculated by summing up the responses to all individual attitude statements. An extreme positive response was assigned a score of 1, while an extreme negative response was assigned a score of 5 (Frankfort-Nachmias and Nachmias, 1992; Fiallo and Jacobson, 1995; Field, 2000). Therefore a low mean score represented more favorable perceptions. T-tests and one-way analysis of variance (ANOVA) were performed to determine whether differences in attitude scores were best explained between villages, school education levels, gender, age groups and ethnic origins.

Logistic regression, a multivariate technique for binary dependant variables that assumed non-linearity, was used to identify factors determining support or hostility towards the conservation of wildlife in general, and, the West African manatee in particular. A dummy of the respondent's attitude, with 0 if the response was negative and 1 if the response was positive, was taken as the dependent variable. Total score on attitude items was dichotomized into two categories, positive attitude and negative attitude, and, logistic regression was performed to help determine which factors best predict attitudes. Based on attitude questions, people with positive attitudes included respondents with combined attitude score from 8 to 20, while those with negative attitudes comprised those above this level. The explanatory variables included: village; age; sex; education level; experience of damage of fishing gear by manatees; and attendance at public awareness campaigns. The likelihood ratio goodness of fit test of the model was described using the chi-square goodness of fit statistics.

10.3 Results

10.3.1 Attitudes of lagoon users towards wildlife

10.3.1.1 Knowledge of wildlife species

Many users of the lagoon knew at least some of the wildlife species found in their area. Most could name one to four species of wildlife, many could name five to seven species and a few could name more than eight species (Table 10.1). Knowledge of wildlife species differed (x^2=12.304, df=4, P<0.05) between people from the city of Fresco, and the villages of Zakareko and Bohico. Respondents from Bohico knew more species than respondents from Zakareko and Fresco. Residents from the city of Fresco had the least knowledge of wildlife species of the area (Table 10.1).

Table 10.1: Number of species named by respondents living within three villages around the Fresco lagoon complex.

Villages	n	1-4 species (%)	5-7 species (%)	>8 species (%)
Fresco	140	51.4	36.4	12.2
Zakareko	56	39.3	41.1	19.6
Bohico	47	29.8	38.3	31.9
Total	**243**	**44.4**	**37.9**	**17.7**

Knowledge of wildlife species differed (x^2= 11.24, df= 2, P<0.005) between native and non-native respondents. Native residents knew more wildlife species than non-native users. The sex of respondents was also important in determining knowledge of wildlife (x^2= 16.43, df=2, P<0.001). Some 22.7% of males could name more than eight species, 42.2% could name five to seven species and 35.1% could name one to four species. In contrast, 60.7% of female respondents could name one to four species, 30.3% could name five to seven species and only 9% could name over eight species. School education levels were also significantly associated (x^2= 18.94, df=4, P<0.05) with knowledge of wildlife species. Those who had attended secondary schools could name more species than those who had no education or had only attended primary schools. Knowledge on wildlife differed (x^2=48.88, df=14, P<0.001) between age groups. Respondents above 30 years of age knew more wildlife species than younger people below 30 years of age.

10.3.1.2 Trends in wildlife populations

Most respondents thought that the wildlife of the area around the lagoon was decreasing, while some had no idea about the present status of wildlife, but very few indicated that wildlife was increasing (Table 10.2). There was no difference between villages (x^2= 7.219, df=4, P>0.5), between education levels (x^2=3.88, df=6, P>0.05) and between age groups (x^2=17.22, df=14, P>0.5) in views about the trends of wildlife of the area. However, the views of each sex differed (x^2=11.31, df=2, P<0.005) and almost all male respondents (90%) thought that wildlife was decreasing, while somewhat fewer (75%) female respondents thought so. Similarly, views of native users differed (x^2=61.42, df=2, P<0.001) from non-native residents, and more non-natives (60%) had no idea about the trends of wildlife, while most (90%) natives thought that wildlife around the lagoon was decreasing.

Table 10.2: Views of respondents living within three villages on trends in wildlife population around the Fresco lagoon complex.

Villages	Decreasing (%)	Increasing (%)	No idea (%)
Fresco	80.0	3.6	16.4
Zakareko	92.9	1.9	5.4
Bohico	91.5	2.1	6.4
TOTAL	**85.2**	**2.9**	**11.9**

Respondents thought various factors were responsible for the decline of wildlife populations around the lagoon (Figure 10.1). The majority of respondents who thought that wildlife populations had declined said it was due to habitat destruction (28%); increasing human populations (18%), weak law enforcement (17%), poaching (16%) and migration (12%).

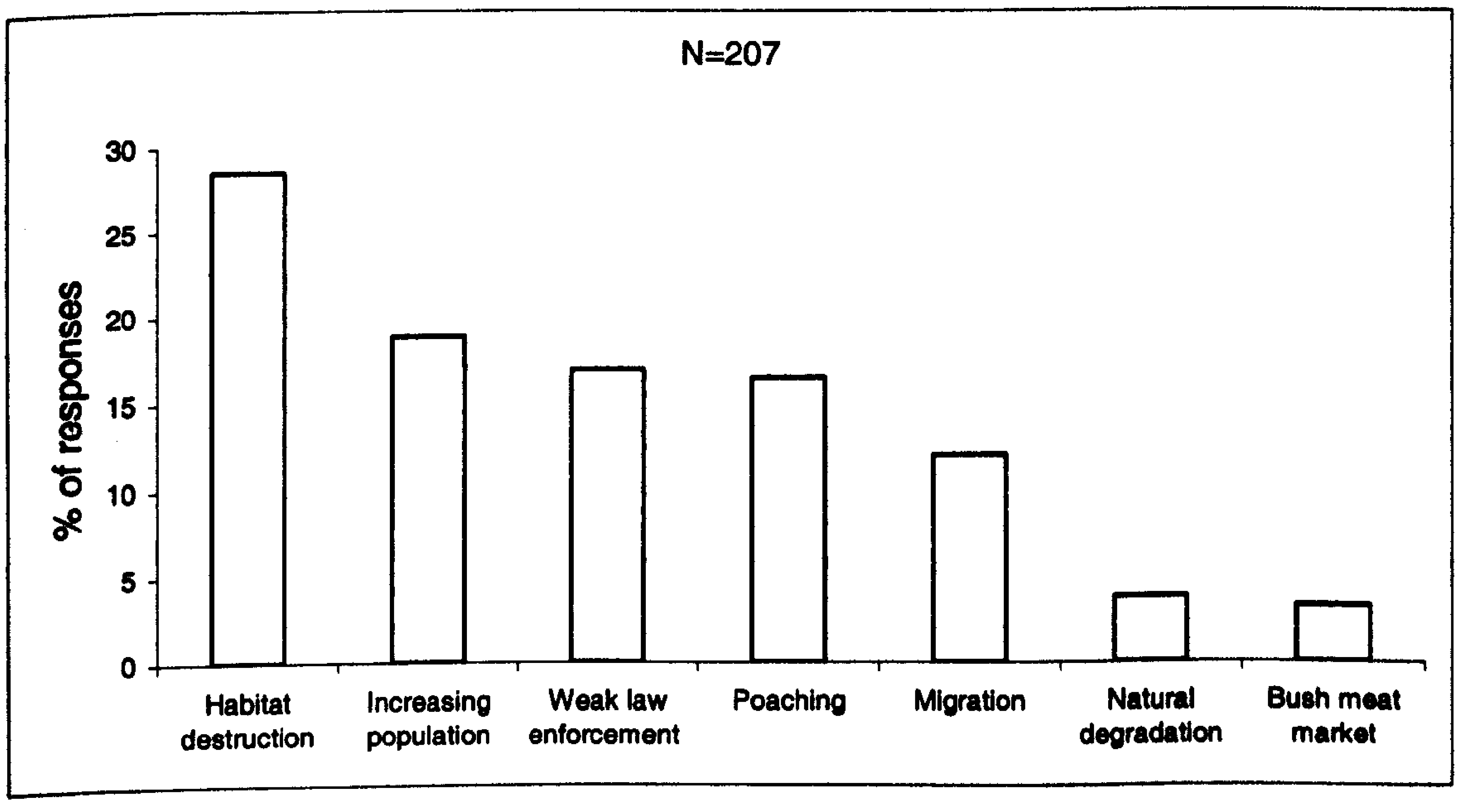


Figure 10.1: Factors identified by respondents as most responsible for the decline of wildlife populations around the Fresco lagoon complex.

10.3.1.3 Problems with wildlife

Most respondents had not encountered any problems with wildlife, but some respondents believed that wildlife brought problems, and consequently had negative attitude towards wildlife (Table 10.3). Villages did not differ (x^2= 0.066, df= 2, P>0.05) in their views on whether wildlife caused problems (Table 10.3). In contrast, levels of school education were important (x^2= 42.26, df=2, P<0.001), and most respondents (97%) with a secondary education level and most (79%) of those with primary school education level had not encoutered any problems with wildlife. Only 3% of respondents with a secondary education and 21% of those with a primary school education thought wildlife brought problems. In contrast, many (47%) respondents with no school education thought wildlife brought problems and only 53% thought they had not encoutered any problem with wildlife. Similarly, views on problems with wildlife differed (x^2=5.70, df=1, P<0.05) between native and non-native respondents and between males and females (x^2=16.43, df=1, P<0.001). More non-natives (92%) and more males (80%) had no problems with wildlife. In contrast, 28% of native respondents and many (40%) female respondents thought wildlife brought problems. There was also a marked difference between age groups (x^2=43.87, df=7, P<0.001). Most (87%) young (<40 years) people had not encountered any problem with wildlife and only 13% thought wildlife brings problem. In contrast, many (35%) older people thought wildlife brings problem and 65% had not encountered any problems.

Table 10.3: Views of respondents living within three villages around the Fresco lagoon complex on whether or not wildlife brings problems.

Villages	n	No problem (%)	Wildlife brings problem (%)
Fresco	140	73.6	26.4
Zakareko	56	78.1	21.4
Bohico	47	68.1	31.9
Total	**243**	**73.7**	**26.3**

10.3.1.4 Support for wildlife conservation

Respondents were divided on their support for wildlife conservation (Table 10.4). There was more (x^2= 11.96, d=1, P<0.005) support for wildlife conservation among males (53.2%) than among females (30.3%). There was more (x^2=27.94, df=2, P<0.001) support for conservation among respondents with secondary school education (68.7%) than among respondents with primary education (49.2%) and with no school education (28.7%). There was more support (x^2=6.760, df=2, P<0.05) for wildlife conservation among residents of Bohico than the residents of Fresco and Zakareko (Table 10.4). There was more support (x^2=39.30, df=7, P<0.001) for conservation among young respondents below 30 years of age. There was also more support (x^2=6.03, df=1, P<0.05) for conservation among non-native respondents than native respondents.

Table 10.4: Views of respondents living within three villages around the Fresco lagoon complex on whether or not wildlife should be conserved.

Villages	**n**	**Should be conserved (%)**	**Should not be conserved (%)**
Fresco	140	41.4	58.6
Zakareko	056	39.3	60.7
Bohico	047	61,7	38.3
Total	**243**	**44.9**	**55.1**

Respondents supporting the conservation of wildlife thought that wildlife can generate income throughout tourism and constitute a source of food protein. In contrast, some people would only support conservation if they were forced to by the government. However, fewer supported wildlife conservation as source of regional pride (Figure 10.2).

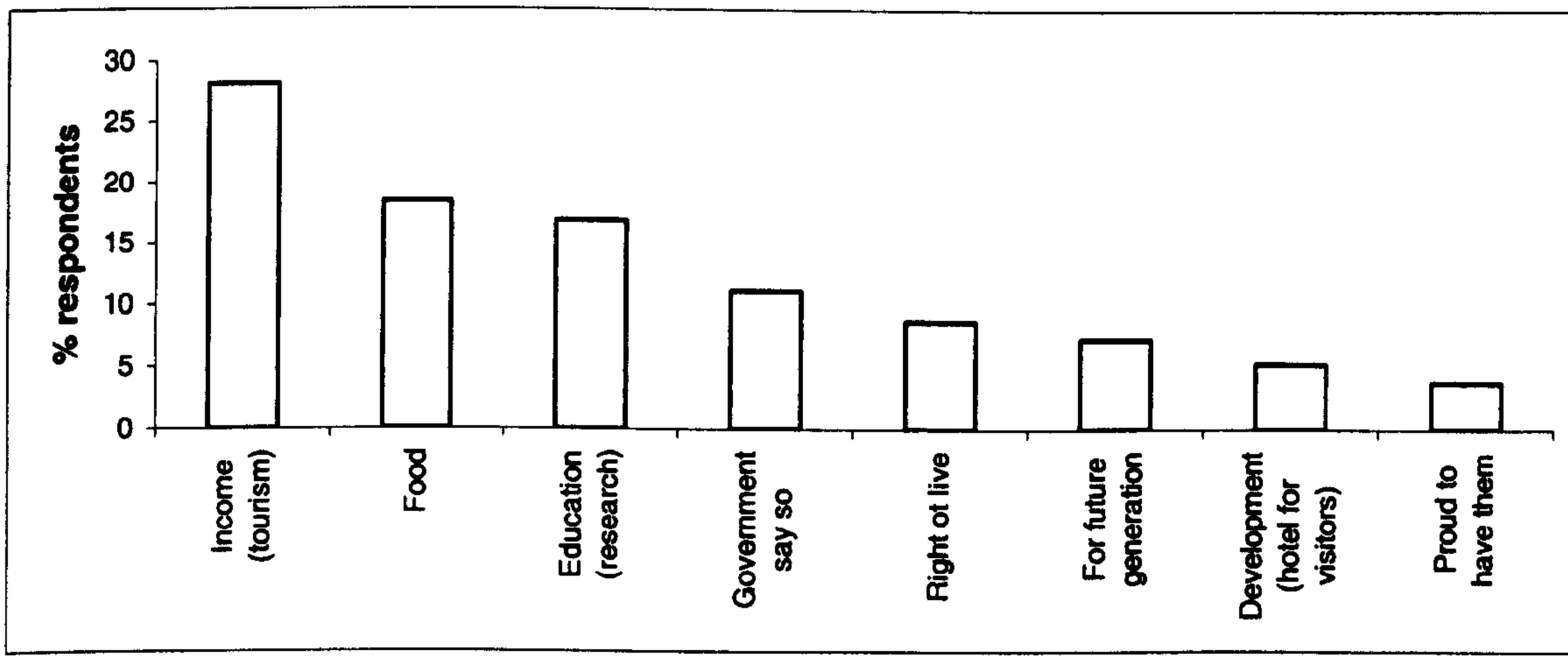


Figure 10.2: Motives for supporting wildlife conservation identified by respondents living within three villages around the Fresco lagoon complex from September 2000 to August 2002.

10.3.1.5. Factors determining attitudes towards wildlife

The model for factors that might have played a role in determining whether or not wildlife bring problems explained 72.8% of the variance, and the likelihood ratio goodness of fit test showed good fit for the model ($P<0.001$). Sex of respondents, ethnic origin and education levels of respondents were important in determining their views on problems (Table 10.5). Non-native respondents were less likely to consider that wildlife brought problems than native respondents. Similarly, males were less likely to consider that wildlife brought problems than females. In contrast, residents that had no school education and those who had attended primary school education only were more likely to consider that wildlife brought problems.

Table 10.5: Factors determining views of respondents on whether or not wildlife brings problem, based on logistic regression.

Variable	B	S.E.	df	Sig.
Origin (non-native)	-1.522	.790	1	0.054

Sex (Male)	-.691	.325	1	0.034**
School education	000	000	2	0.000***
No school education	3.059	.752	1	0.000***
Primary school level	1.972	.790	1	0.013**
Constant	-2.760	.767	1	0.000***

The model of factors that might have played a role in determining whether or not wildlife conservation should be supported (Table 10.6) explained 65.4% of the variance, and the likelihood ratio goodness of fit test shows a good fit to the model (P<0.001). The villages of respondents, attendance at public awareness campaigns, sex and ethnic origin were important in determining their views. Male respondents, non-native residents and those who had attended public awareness campaigns were more likely to say wildlife should be conserved, while the three villages around the lagoon did not support wildlife conservation (Table 10.13).

Table 10.6: Factors determining views of respondents on whether or not conserving wildlife is worthwhile, based on logistic regression

Variable	**B**	**S.E.**	**df**	**Sig.**
Village			2	0.003**
Fresco	-1.376	.402	1	0.001**
Zakareko	-.977	.447	1	0.029**
Bohico	0	-	-	0
Attendance to public awareness campaign (Yes)	1.189	.341	1	0.000***
Sex (Males)	1.004	.308	1	0.001**
Origin (Non-native)	1.523	.524	1	0.004**
Constant	-.845	.411	1	0.040**

10.3.2 Attitudes of the lagoon user community towards the West African manatee

10.3.2.1 Sightings of manatees in the lagoon

Most respondents reported frequent or very frequent sightings of manatees in the lagoon. In contrast, fewer respondents rarely or very rarely saw manatees (Table 10.7). Sightings of manatees in the lagoon differed (x^2=13.41, df=6, P<0.001) among residents of the three villages. Residents of Fresco more often saw manatees than residents of Bohico and Zakareko (Table 10.7). Males more often (x^2=32.11, df=3, P<0.001) saw manatees very frequently (31.8%) than females (15.7%). More (x^2=22.27, df=3, P<0.005) non-natives respondents (64%) saw the manatee very frequently than native residents (21.6%).

Table 10.7: Views on the frequency of sighting manatee population among respondents living within three villages around the Fresco lagoon complex.

Villages	**Frequently (%)**	**Very frequently (%)**	**Rarely (%)**	**Very rarely (%)**
Fresco	30.7	42.1	19.3	7.9
Zakareko	12.5	42.8	39.3	5.4
Bohico	27.7	31.9	31.9	8.5
Total	**25.9**	**40.1**	**26.3**	**7.4**

Most residents reported that they had last seen a manatee in the lagoon during the past 15 days before their interview, and most others recorded having seen a manatee within the last six months (Table 10.8). However, a very few respondents did not remember when they last saw a manatee. Villages differed (x^2=18.26, df=8, P<0.05) in terms of when they had last seen a manatee, with more residents of Zakareko reporting more recent sightings than residents of Bohico and Fresco (Table 10.8).

Table 10.8: Latest sighting of a manatee reported by respondents living within three villages around the Fresco lagoon complex

Villages	<15days (%)	<30days (%)	<90 days (%)	<180days (%)	Not remember (%)
Fresco	55.0	13.6	2.1	26.4	2.9
Zakareko	67.9	17.9	0	14.3	0.0
Bohico	61.7	04.3	0	23.4	10.6
Total	**59.3**	**12.8**	**1.2**	**23.0**	**3.7**

10.3.2.2 Changes in manatee populations

Respondents were divided on whether they thought the manatee population was decreasing (Table 10.9). The sex of respondents was important (x^2=18.52, df=1, P<0.001) in determining the views of respondents on the trends in the manatee population. More females (62.9%) thought that the manatee population was increasing, while more males (65.6%) thought that the population was decreasing. Likewise, education levels were important in determining views on whether the manatee population was increasing (x^2=8.88, df=2, P<0.05. More respondents (68.7%) with secondary school education thought that the manatee population was decreasing, while fewer respondents (57.4%) with primary school education and with no school education (46.1%) did so. Neither age nor village nor origin was important in respondents' views on manatee population trends (all P >0.05).

Table 10.9: Views on the trends of manatee population by respondents living within three villages around the Fresco lagoon complex.

Villages	n	Increasing (%)	Decreasing (%)
Fresco	140	42.1	57.9
Zakareko	56	46.4	53.6
Bohico	47	51.1	48.9
Total	**243**	**44.9**	**55.1**

Respondents thought that the decline of manatee populations in the lagoon was due to various factors (Figure 10.3). Most lagoon users who considered that the manatee population had declined attributed this to: annual migration; the lagoon had become too shallow; human disturbances; the slow reproduction of the species; and ecological changes. In contrast, respondents who thought that the manatee population was increasing attributed this to: legal protection, public awareness and reproduction. However, fewer thought that the manatee population was increasing because they are in a suitable habitat and not disturbed (Figure 10.4)

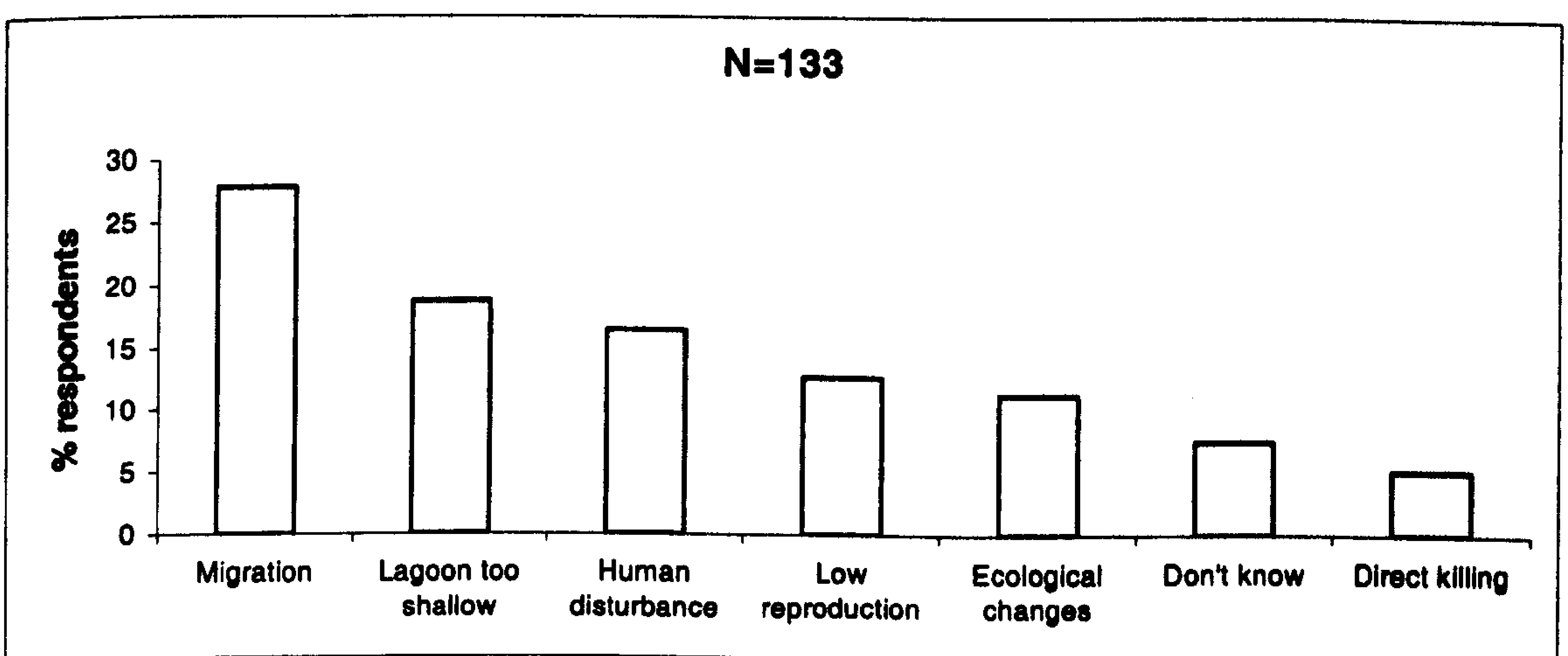


Figure 10.3: Factors identified by respondents as responsible for the decline of manatee population in the Fresco lagoon complex.

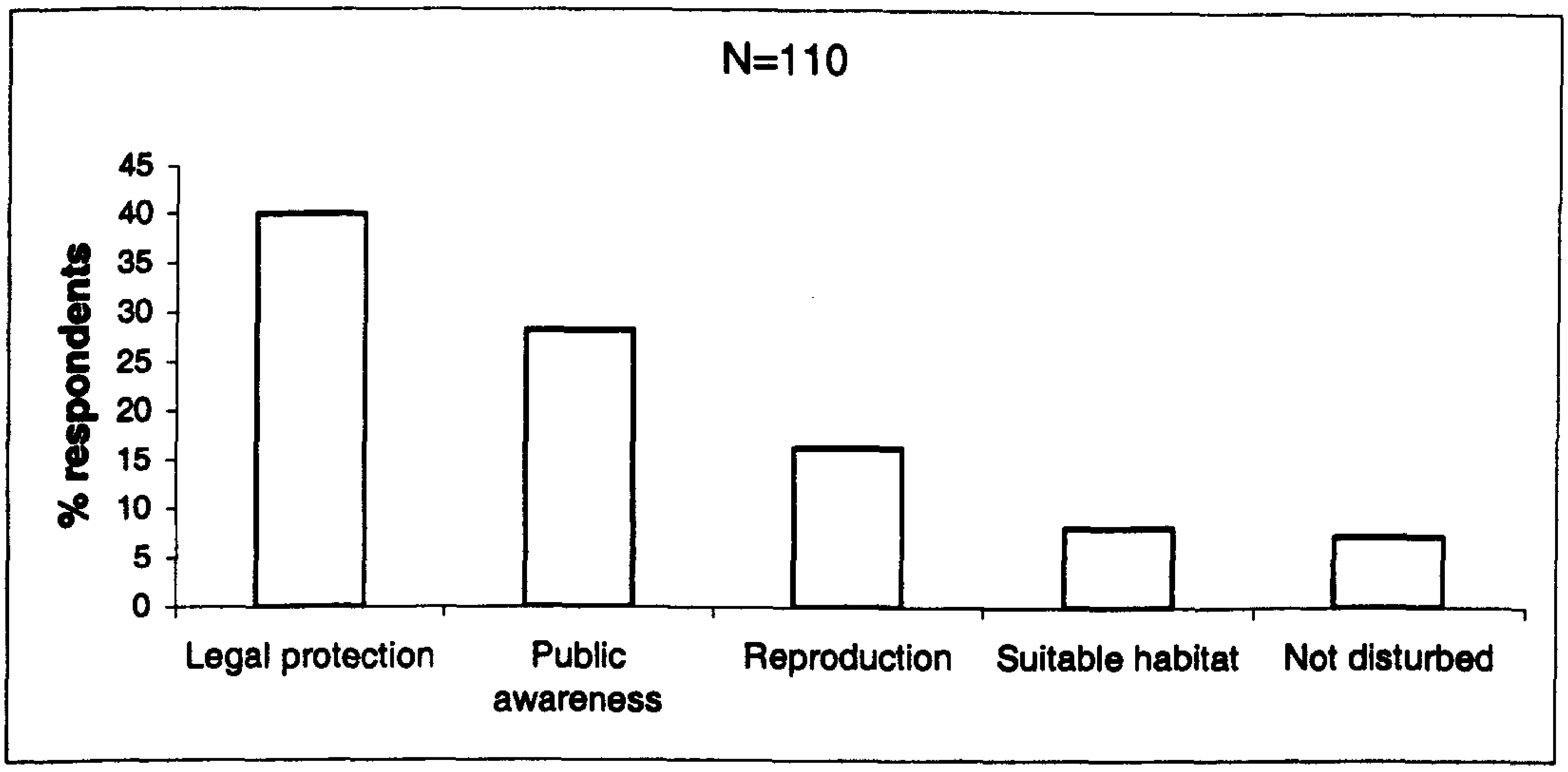


Figure 10.4: Factors identified by respondents as responsible for the increase of manatee population in the Fresco lagoon complex.

10.3.2.3 Support for conserving the West African manatee

Most respondents supported conservation of the manatee and thought that the existence of manatees in the lagoon was not a problem to them (Table 10.10). However, some users of the lagoon felt constrained in their daily activities due to the presence of manatees. Villages differed (x^2 =9.028, df=2, P<0.05) in terms of their support for conserving the manatee. Respondents from Zakareko had least problems with the presence of manatees in the lagoon (Table 10.10). Education levels were important (x^2=13.05, df= 2, P<0.005) in determining whether or not manatees were considered a problem. More respondents (34.81%) with no school education considered the manatee as a problem than those with primary school education (26.2%) and secondary school education (10.4%). Support for manatees was also associated (x^2=15.47, df=7, P<0.05) with ages of respondents. More respondents (90.7%) aged 40 years or less supported the manatee than those above this age (63.5%).

Table 10.10: Attitudes towards the West African manatee of respondents living within three villages around the Fresco lagoon complex.

Villages	n	Problem (%)	Not a problem (%)
Fresco	140	31.4	68.6
Zakareko	56	10.7	89.3
Bohico	47	27.7	72.3
Total	**243**	**25.9**	**74.2**

The origin (x^2=0.53, df=1, p>0.05) and sex (x^2=1.42, df=1, P>0.05) of respondents were not important in determining whether the manatee was viewed as a problem. Most (73.8%) respondents who considered manatees as problem thought they capsized boats, while some (14.3%) thought that they terrified people, and others (9.5%) thought they are a threat to fishing and 2.5 % thought the manatee was evil.

10.3.2.4 Attitude scale

The original thirteen attitude statements were reduced to eight statements after being subjected to factor analysis. The eight statements loaded highly on one common component, indicating that the scale was both reliable and valid (Figure 10.5). The Kaiser-Meyer-Oklin (KMO) value was 0.79, exceeding the recommended value of 0.6 and the Barlett's test of Sphericity reached statistical significance (P<0.001) supporting the factorability of items (Figure 10.5).

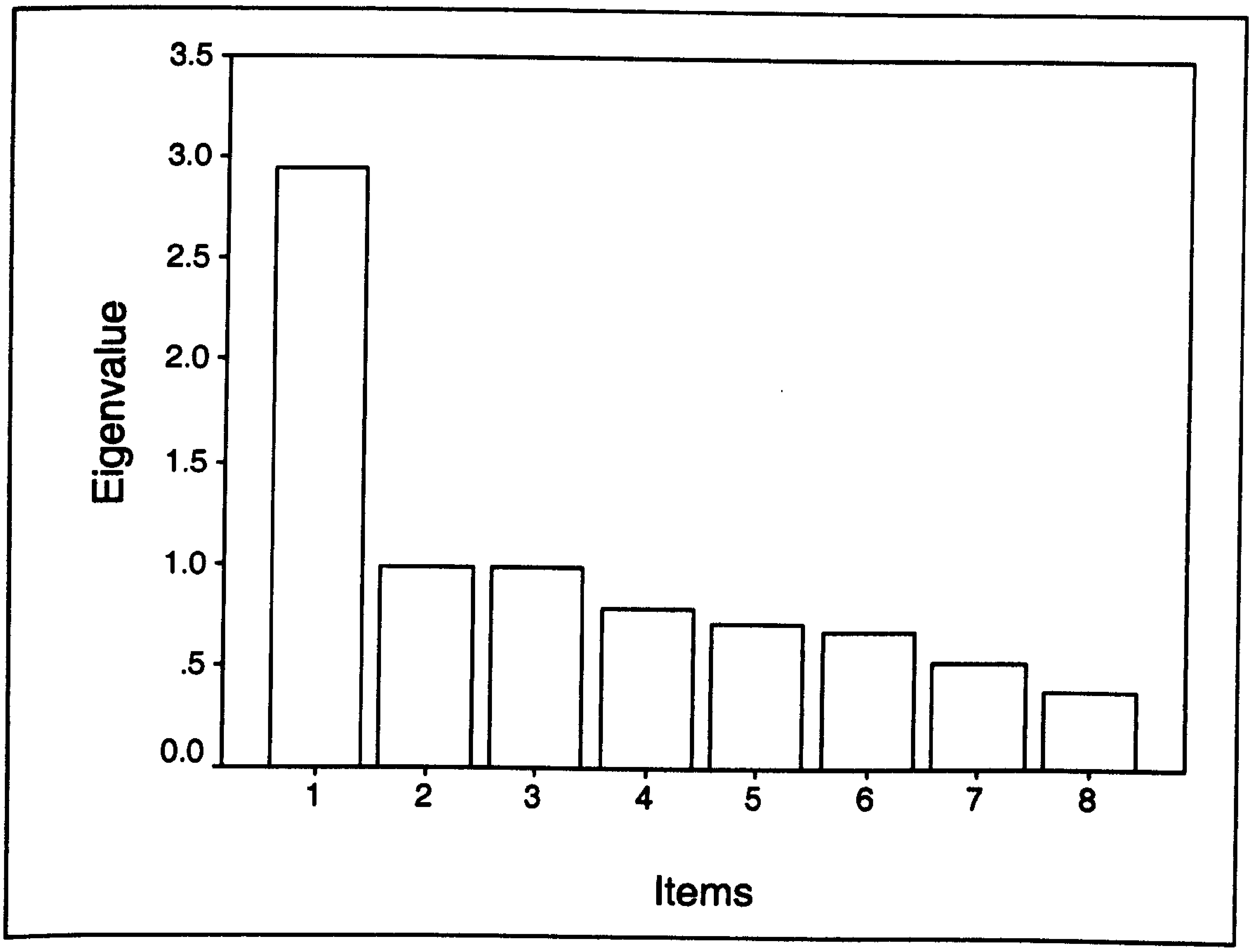


Figure10.5: Factor validation screeplot.

The total score on the eight attitude statements ranged from 8 to 28 points of the 40 points possible with a mean of 15.92± 4.28, indicating a good level for support to the protection of the West African manatee. A total of 23.5% of respondents strongly agreed and 58% agreed that manatee was part of their heritage. However, when neutral respondents assumed to be negative, were combined with agree and strongly agree scores, 26% of respondents thought that manatees belonged to the government and 24.2% that the manatee was a danger to human life (Table 10.11)

Table 10.11: Factor loading and percentage of respondents on attitude statement

Questions	Factor loading	SD	D	N	A	SA
Part of our heritage	0.825	1.6	5.8	10.7	58	23.9
Should be eradicated	0.706	51.4	36.6	8.2	2.9	0.8
Valuable only for its meat	0.666	39.5	42	11.1	5.8	1.6
Will never decline even if regularly hunted	0.661	25.5	50.2	11.9	9.1	3.3
Belong to the government	0.575	23.5	50.2	13.2	10.7	2.5
A threat to human life	0.564	30.5	45.3	14	8.6	1.6
A useless animal	0.546	18.1	54.7	14.4	8.2	4.5
Should not be protected	0.725	44.9	43.2	9.1	2.1	0.8

SD= strongly disagree; **D**= disagree; **N**=neutral; **A**= agree; **SA**= strongly agree

Combined attitude scores did not differ ($F_{2, 242}$=1.13, P>0.05) between villages, although residents of the village of Zakareko (16.67±3.20) were slightly less positive to manatees than Bohico (15.65±4.43) and Fresco (15.70±4.90). Similarly, native respondents (16.06±4.25) were slightly less positive than non-native respondents (14.60±4.43) although the difference was not significant (t (29)=1.532, P>0.5). However, combined attitude scores differed ($F_{5, 242}$=4.14, P<0.005) between age groups, with most respondents aged between 20 to 40 years having more positive scores than those above and below this age. Combined attitude scores of male respondents (14.53±4.09) were more positive (t (230)=-7.651 P<0.001) than scores of females (18.32±3.49). Likewise, combined attitude scores differed ($F_{2, 242}$=60.35, P<0.001) according to education levels. Respondent with secondary school education had more positive scores (12.13±2.77) than respondents with primary school (16.049±3.51) and those with no school education (18.06±3.88).

10.3.2.5 Reported conflicts

Most lagoon users said their fishing gear had never been damaged by manatees (Table 10.12). However, those respondents who reported having their fishing gear damaged by manatees, 47.7% (n =32) reported one incident, 23.2% reported two incidents and 29% reported three incidents. Reports comprised damage to gill nets (54.7%), cast nets (40.6%), multiple hooks lines (3.1%) and fishing fences (1.6%). The scale of damage varied from heavily damaged but repairable (50.8%), to slightly damaged and repaired (35%) to "not recoverable" (13.5%). Villages did not differ (x^2=1.076, df=2, P>0.05) in levels of damage reported (Table 10.12). Similarly, there was no difference (x^2=5.17, df=1, P<0.05) between native and non-native respondents in terms of level of damage reported.

Table 10.12: Reports by respondents living within three villages around the Fresco lagoon complex on whether or not their fishing gear had been damaged by manatees

Villages	n	Yes (%)	No (%)
Fresco	140	30.4	69.6
Zakareko	56	23.6	76.6
Bohico	47	27.7	72.3
Total	**243**	**25.9**	**74.1**

Most (60.3%) respondents reporting damage to fishing gear spent less than 10,000 cfa (less than £10) to repair the damage, while 15.7 % spent from 10,000-20,000 cfa, 12.7% spent from 20,000-30,000 cfa and 11.1% spent from 40,000cfa (Figure 10.6).

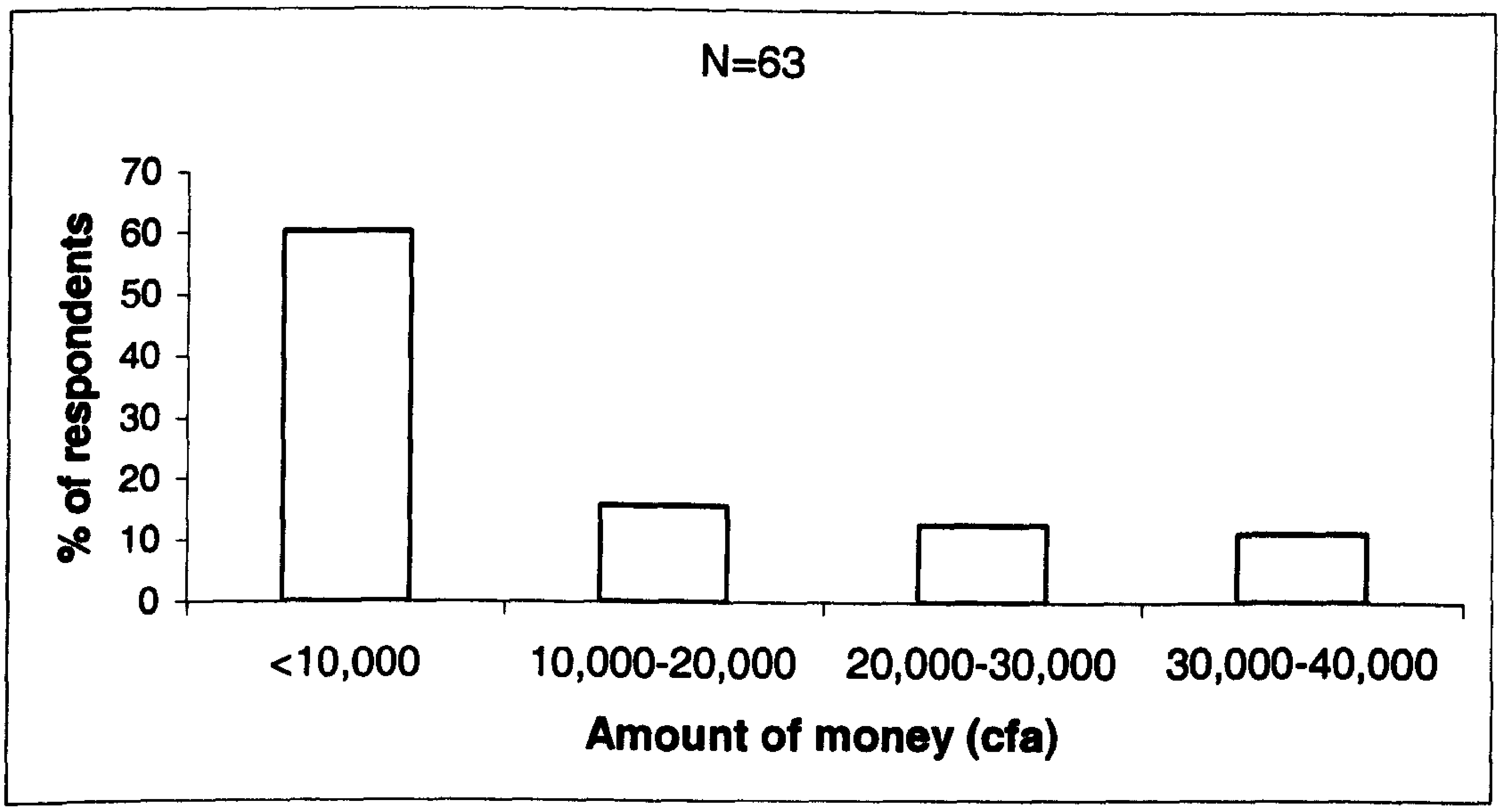


Figure 10.6: Cost of repair or change to damaged fishing gears by respondents living within three villages around the Fresco lagoon complex.

10.3.2.6 Attendance at public awareness campaigns

Most respondents had attended public awareness campaigns held in the region on wildlife conservation in general, and on the West African manatee in particular. However, some of respondents had never attended such campaigns (Table 10.13). Villages differed (x^2=6.726, df= 2, P<0.05) in terms of their attendance at public awareness campaigns. More respondents from Zakareko had attended public awareness campaigns than respondents from Fresco and Bohico (Table 10.13). Similarly, more males (76%) had attended campaigns (x^2=6.33, df=1, P<0.05) than females (60.7%). Attendance at public awareness campaigns was associated (x^2=10.13, df=2, P<0.05) with educational levels. More respondents (82.1%) who had attended secondary school had attended public awareness campaigns than respondents who had attended primary school (75.4%) or had no education (60.9%).

Table 10.13: Attendance by respondents from different villages around the Fresco lagoon complex at public awareness campaigns on wildlife conservation.

Villages	Attended	Not attended
Fresco	66.1	33.9
Zakareko	76.4	23.6
Bohico	57.4	42.6
Total	**70.4**	**29.6**

10.3.2.7 Factors determining attitudes towards manatees

The model for factors that might have played a role in determining views on the manatee population trends in the Fresco lagoon complex (Table 10.14) explained 73.3% of the variance, and the likelihood ratio goodness of fit test showed good fit for the model (P<0.001). Past experience of damage to fishing gear and attendance at public awareness campaigns were important in determining views on population trends of the West African manatee (Table 10.14). Respondents who had attended a public awareness campaign and those who have experienced damage to fishing gear were more likely to believe that the population of the manatee is decreasing in the lagoon.

Table 10.14: Factors determining views of the population trend of the manatee in the Fresco lagoon complex, based on logistic regression.

Variables	B	S.E.	df	Sig.
Public awareness campaign (Yes)	-2.484	0.368	1	.000***
Damaged of fishing gears (Yes)	-0.868	0.372	1	.020***
Constant	1.788	0.352	1	.000***

The model for factors that might have played a role in determining whether or not the West African manatee is a problem explained 77.8% of the variance, and the likelihood ratio goodness of fit test showed good fit to the model (P<0.001). The villages of respondents, school education levels, support to wildlife conservation in general, attendance at public awareness campaigns and past experience of damage to fishing gear were important in determining their views on whether or not the manatee was a problem (Table 10.15). Residents of Zakareko, those who had attended a public awareness campaign on wildlife conservation and those who supported wildlife conservation in general were more likely to consider the manatee as a good species. In contrast, respondents with no school education and those with primary school level were more likely to believe that manatees bring problems. Similarly, respondents who reported damage to fishing gears as a result of manatees were more likely to say that manatees are a problem animal.

Table 10.15: Factors determining views of respondents on whether or not the manatee is a problem animal, based on logistic regression.

Variable	B	S.E.	df	Sig.
Villages			2	0.000***
Fresco	0.432	0.425	1	0.309
Zakareko	1.603	0.590	1	0.007**
School education levels			2	0.004**
No school education	-1.641	0.488	1	0.001**
Primary school	-1.232	0.528	1	0.020**
Support wildlife conservation (Yes)	0.0974	0.446	1	0.029**
Attend public awareness campaign (Yes)	0.878	0.359	1	0.014**
Damage of fishing gear (Yes)	-1.089	0.372	1	0.003**
Constant	1.178	0.650	1	0.070**

The model for factors that might have played a role in determining a positive attitude to manatees based on combined attitude scores explained 87.7% of the variance, and the likelihood ratio goodness of fit test showed good fit to the model ($P<0.001$). School education levels, support to wildlife conservation in general, and attendance at public awareness campaigns were important in determining positive attitudes to manatees (Table 10.16). Respondents supporting wildlife conservation in general and those who attended public awareness campaign were more likely to hold positive attitudes to manatees, while respondents with no school education and those with primary education levels were least likely to do so.

Table 10.16: Factors determining score of respondents on attitude statement.

Variable	B	S.E.	df	Sig.
Support wildlife conservation (Yes)	1.669	0.496	1	0.001**
No school education	-2.562	1.078	1	0.018*
Primary school education level	-2.297	1.139	1	0.044*
Attendance to public awareness campaign (Yes)	2.775	0.486	1	0.000***
Constant	1.234	1.125	1	0.273

10.4. Discussion

Studies on assessment of human attitude to wildlife are widespread (Kellert, 1985; Glass et al. 1993; Kellert *et al.*, 1996). However, assessments of human attitude to aquatic mammals in general, and, to sirenians in particular are very uncommon. This is the first study of attitudes of local fishermen performing their daily livelihood activities among a population of West African manatees. The results have shown that the community living around the lagoon knows about wildlife of the area and experience little problem with it, although most of them do not support wildlife conservation. Some of the community believed that the population of the West African manatee in the lagoon was decreasing. However, the data indicate a positive attitude among respondents towards the manatee. Attitudes are determined by: respondents' villages, sex, attendance at public awareness campaigns, education level, support to wildlife conservation in general, and past experience of damage to fishing gear by the West African manatee.

10.4.1 Attitude of the lagoon users towards wildlife

Most residents around the lagoon had good knowledge of the wildlife species found in the area, but the residents of Bohico knew more species than those of Zakareko and Fresco (Table 10.1). Most non-native users of the lagoon reside in the city of Fresco and Zakareko and very few live in Bohico. This may, in part, explain the lesser knowledge of wildlife among residents of Fresco and Zakareko compared to Bohico. Moreover, of the three villages, Bohico is the only one situated on the shoreline, lying as it does on the Bolo Rivers surrounded by relatively deep forest (see Chapter 2). Fresco was originally established on the coastline (see Chapter 5) before being resettled in its present location, in front of the N'gni lagoon very close to the village of Zakareko (Figure 2.1).

An overwhelming majority of respondents reported that wildlife in the area was decreasing (Table 10.2), a view held in common across the whole of Cote d'Ivoire. Declining wildlife populations were expected as the natural forest across the country that constituted the primary wildlife habitat has been converted into large farmlands of coffee, cocoa and oil palm trees (see Chapter 1). It was not surprising that habitat destruction was quoted as the most important factor in this decline (Figure 10.1). Weak law enforcement, poaching and developing bush meat markets were also enumerated as causes of decline. Officially, hunting has been banned in Cote d'Ivoire since 1974. In practice this law has never been effectively enforced and bush meat is an important business, particularly for females. A study by the World Bank suggested that 65,000 tons of bush meat is consumed every year in Cote d'Ivoire. The existence of four bush meat restaurants, always busy, in the city of Fresco is a clear evidence of that fact.

Most respondents did not consider wildlife as a problem and held positive attitudes towards wildlife living in the area (Table 10.3). Residents of the three villages held similar views on problems brought by wildlife, although more residents of Zakareko held positive attitudes. The logistic regression model predicted that males and non-native residents were more likely to hold positive attitude towards wildlife (Table 10.6). The fact that females are more involved in agriculture activities than males may explain their more negative attitude. In the custom of Godie people, males are mostly involved in fishing and their role in agriculture is generally limited to field preparation. The remaining agricultural activities such as keeping the rice farms from birds are left to the charge of females. Therefore, females spend more time in the fields and are more likely to have adverse contact with wildlife, particularly pest animals, than males who spend most of their time on the water. In similar situation in Uganda, Hill (1997) found that the lack of support of women for any wildlife conservation programme was due to their concern about the presence of elephants that significantly impact on their ability to collect firewood and water from the forest sources. Attitude is also influenced by experience that is linked to knowledge. Men are more likely to have a better knowledge of wildlife than women, and that results, in part, from the position of women in society. Women have less access to knowledge, as many of those women interviewed only spoke their mother tongue, leading to the need of an interpreter.

Only 44.9% of residents supported wildlife conservation in the area (Table 10.4) and the logistic model showed that females and natives residents tended to have a more negative attitude towards wildlife conservation (Table 10.6). This was not surprising, as it reflects the strained relationship between the community and the state Water and Forestry Department. The forest area surrounding the lagoon was traditionally owned by the district of Diprinda (a district of the city of Fresco) and managed with well-established traditional arrangements for its exploitation. A large proportion (23,000 ha) of this forest has been classified by the State's Water and Forestry Department as high-priority area since 1977 (Sodefor, 1995). In 1992, a management plan was prepared which divided the forest into two parts: an agro-forestry zone to consolidate existing farmers and a biological or strict protection zone. To recover control of the entire biological zone, a crash campaign was initiated by the Water and Forestry Department, using forestry staff trained as paramilitary force. The community was evicted with little concern and with no compensation for losing access to the forest. A project supported by a development agency has followed up to manage the forest, but priorities assigned to this project have never met the priorities of this resource-dependent local community. A consultative committee was set up with local administrative and political authorities to find an approach to the issue, but promises to help have not been kept. The community has always been asked to show patience due to lack of funding. On other hand, new local headquarters and houses were built in Fresco and Zegban, near Bohico, for more rangers to ensure the effective enforcement of laws in the forest. This was not acceptable to the community and the result has been antagonism, resentment and even threats to the life of local rangers in charge of enforcing the laws of the forest. The community cannot see any reason why they have been barred from using resources that were once theirs, and their lack for support to wildlife conservation may be a reflection of their annoyance. This finding is consistent with other studies of local community support for wildlife conservation in the developing countries (Infield, 1988; Newmark *et al.*, 1993). For example, Ite (1996) reported a similar situation from the Cross River National Park in Nigeria, where park staff have been barred physically from access to some villages around the park and threats have even been issued against their lives by the community as result of a conflicting situation between the Federal National Parks Boards and the community adjacent to the Park. Fiallo and Jacobson (1995) reported a gradual waning of initial community support to conservation as result of local perceptions of deceit by the management of the Michalila National Park Administration in Ecuador, who failed to provide development amenities 14 years after they had been promised to the surrounding communities.

In many instances, local community support to wildlife conservation is very much dependent on community perceptions of benefits and costs. Furthermore, restricted access to natural resources on which their livelihoods heavily depends, the dissatisfaction arising from falsely raised expectations, poor public relations strategies, disregard and ignorance of local historical control of resource cannot engender nor sustain community support for wildlife conservation (Ite, 1996; Fiallo and Jacobson, 1995; Jacobson, 1991).

10.4.2. Attitude of the the lagoon users towards the West African manatee

The community of users reported frequent sightings of manatees in the lagoon and a substantial number of them reported sightings within the previous 15 days preceding their interviews (Tables 10.7,10.8). However, sightings differ significantly among residents of the three villages, between natives and non-natives and between females and males. Women only use the lagoon generally as mean of transport, from the village to the farms or to the sites of firewood collection. Therefore they spend less time on the water than men involved in fishing. Non-native residents are essentially engaged in fishing and very few of them have a secondary occupation, while natives share their time between fishing and farming so spending less time than non-natives on the lagoon.

Most of the community believed that the manatee population is decreasing but substantial numbers of respondents believed it was increasing (Table 10.9). Determining the trends in the manatee population is problematic, and counts are highly variable (Garrot *et al.*, 1995). Although significant progress has been made in recent years by identifying environmental variables that influence counts and by the development of statistical models to adjust counts for these effects, the interpretation of results and their integration to develop a population index always requires extreme caution (Ackerman *et al.*, 1995). However, because manatees are long-lived mammals with low rates of reproduction, any significant increase in mortality may lead to a decline in the population (O'Shea, 1988). This was generally the case of manatee in their range in Cote d'Ivoire (Roth and Waitkuwait, 1986; Powell, 1996). It was not surprising that low reproduction and direct killing were quoted by respondents as factors causing the decline of the manatee population (Figure 10.3). Respondents also listed migration as cause of decline of the manatee population. Manatees move, for some period, from the lagoon of Fresco to the lagoons of Grand-Lahou and vice-versa, throughout the Fresco canal (Powell, 1988). Furthermore, in the wet season from May to June, manatees are seen less in the Fresco lagoon. This, in part, can be attributed to the high water levels that decreases the likelihood of sighting manatees. Moreover, manatees also move from the lagoon to rivers and streams to gain more food (see Chapter 8).

The logistic model showed that lagoon users who have attended public awareness campaigns and those who have experienced damage to their fishing gear as a result of manatee activity were more likely to consider that the population of manatee is decreasing (Table 10.14). Since 1996, several education and public awareness campaigns, including video shows, drawing competitions and stories about manatee in schools, and meetings with the community over the importance of conserving manatees, have been organized in the region by West African Manatee Conservation Project team. Only a few residents, predominantly females, have never attended those campaigns (Table 10.13). The views on manatee population trends among those who had attended these education campaigns reflect what they have learned. Similarly it was not a surprise that lagoon users who have experienced damage to their fishing gear were also likely to see a decrease in the manatee population, as any decrease in damage to fishing gear could be interpreted as a sign of fewer manatees in the water. In contrast, respondents who considered that the manatee population in the lagoon was increasing generally thought that legal protection, and public awareness were the main reasons for the increased population (Figure 10.4).

Remarkably few people had experienced any problems with manatees and the generally positive attitude towards them was really promising. However, opinions differed between villages with residents from Zakareko having a more positive attitude than Bohico and Fresco (Table 10.10). Encouraging also was the average scale and item scores of respondents confirming the good level of support to the conservation of the West African manatee (Table 10.11).

The logistic regression indicated that residents of Zakareko, those who had attended public awareness campaigns, and those supporting wildlife conservation in general, were more likely to be supportive to the conservation of the West African manatee. In contrast, those residents with past experience of damaged fishing gear and those without school education and those with only primary school education generally held negative attitudes towards manatee conservation (Tables 10.15, 10.16). Support for the conservation of manatees was not too surprising. Beside the public awareness campaigns, residents living around the lagoon have already seen the direct benefits of conserving manatee because some of them, particularly large boat owners, have conducted week-end visits for tourists to mangroves with the objective of viewing manatees.

Respondents who were not supportive of manatees thought that manatees are danger to human life because they capsize boats and terrify people. This option is confirmed by the proportion of respondents who strongly agreed, agreed or were neutral to the scale item "Manatee is a threat to human life" (Table 10.11). Manatees are known to be harmless animals and their only defense when in danger is to flee. Manatees will never deliberately harm human life. However, resting manatees can be approached very closely (see Chapter 9) and their sudden flight reaction may throw a full banana boat off balance. For example, boats transporting firewood, and carrying women, are always very full and any significant movement in the water can easily lead to loss of balance. Similarly, a manatee lifting its nose or head out of the water, particularly during the night to breath close to a passing boat, will terrify anyone who has never had such an experience as this is accompanied by a noisy ejection of vaporous water. Manatees are believed to replace up to 90% of the air in their lungs with a single vaporous breath of air (Barbara and Jeff, 1998). However, no such incidents were observed with boats full of luggage passing close to a focal manatee during behavioural observations. Moreover, information gleaned from key informants on this issue was always in the form of account given by grandparents years ago, rather than a recent event. Therefore, concerns of peoples about manatees capsizing boats should be taken with caution, as they may be rooted in past stories rather than today's reality.

Few respondents reported damage of their fishing gear by manatee. Gill nets, cast nets, multiple hooks lines and fishing fences were the most important (Table 10.12). The cost of repair or replacing gear ranged from US $19 to US $ 77 (Figure 10.6). Large cast nets incidentally fall on or trap a resting manatee quite frequently. However, the animal generally escaped and while escaping, less strong nets may be slightly or heavily damaged. Damage to gill nets, multiple hooks line and fishing fences was more likely to occur in the Niouniourou and the Bolo Rivers, as they were set across the river bed leaving no room for any passing animal or fish. However, other animals such as crocodiles, water chevrotain (*Hyemoschus aquaticus*), Congo clawless otter (*Aonyx congica*) and spotted neck otter (*Lutra maculicolus*) that compete with people for fish, may also damage fishing gear. Thus, it can be problematic for fishermen to distinguish between damage caused by manatees and those caused by other animals. Therefore, the cost for repair or for purchasing new gear reported by respondents should be taken with caution, as reports may be inflated with the expectation of being reimbursed by the Manatee Conservation Project.

Education levels were also important in shaping the attitudes of respondents. Attitude is influenced by experience that is also influenced by knowledge partly gleaned from education. The differences in attitudes between males and females that have already been discussed are good example (See Chapter 5) and this is consistent with Hill (1998) and Kellert (1985). The Fresco area is a semi-urban area with most basic facilities such as local and national broadcasting, television, telephone and newspapers that constitute important means of information. The first school was built in Fresco in the colonial time before Cote d'Ivoire became independant in 1960. This has given the opportunity to most residents of gaining access to primary education. Moreover, following the government policy to encourage youths to return to their homelands after unsuccessful study in order to reduce the rural exodus, youths between 30 to 40 years old with at least a secondary school education level constitute an important proportion of the community.

Nevertheless, the largely positive attitude of the local community towards wildlife in general, and to manatees in particular, is encouraging. The continued survival of manatees in this common property resource management area will depend on the goodwill and support of the lagoon users. At the same time, their lack of support for formalized conservation measures (Table 10.4) show the danger of adopting conservation measures that do not meet with community support, such as taking resources from local control. On this basis, the final chapter summarizes key results of the study.

CHAPTER 11 Research Findings and Conclusions

Lagoons and coastal waters in Cote d'Ivoire are subjected to a heavy human pressure. They cover less than 1% of the total area of the country, but support 25% of the total population (Abe and Kaba, 1995). Urban as well as rural populations have increased around coastal waters due to uncontrolled demographic growth and uncoordinated inflow of migrants from neighbouring countries, a consequence of improved access and relative economic development. In the east of Cote d'Ivoire for instance, villages and encampments have sprung up along major roads and on the edges of the lagoons and the sea. This coastal region now contains 80% of the population of eastern Cote d'Ivoire and is heavily influenced by the rapid growth of Abidjan, the capital city, where the population rose ten-fold between 1960 and 1985 (Nicole *et al.*, 1994).

Lagoon and coastal waters are also very important for biodiversity and play a major role in the life cycles of fish and shellfish by providing feeding, breeding, and nursery grounds. Thus, in future, the growth of human populations and the intensive use of coastal waters will raise the problem of how to conserve lagoons and their biodiversity while ensuring the livelihood needs of peoples. Fish stocks are already becoming depleted in many lagoons, large mammals such as manatees are threatened, woodlands and mangrove forests are disappearing on the shoreline under the growing demands made by urban centres for firewood and food crops.

In some lagoons and estuaries, however, people and biodiversity have co-existed for millennia, and people in these areas have managed their resources in a wise and responsible way based on traditional beliefs and customs. Although social, economic and political changes imposed from outside modernising forces have weakened traditional systems in many of them, they still exist and operate in few areas. The Fresco lagoon complex is one such area, shared between the

West African manatee and the local Godie community, and where a common property management regime is still operating.

11.1 Ecology of the Fresco Lagoon Complex

The basic seasonal changes within the Fresco lagoon complex are influenced by rainfall, tidal cycles and inlet condition (Chapter 3). Water level and surface area of the lagoon was highest when the inlet was closed and there was freshwater inflow, as result of rainfall and the subsequent terrestrial runoff, and the surplus conveyed by the Bolo and the Niouniourou Rivers. In contrast, when the inlet was open, the water level of the lagoon complex was also influenced by oceanic water throughout tidal inflow. However, due to the long-shore current and the inflow from the Niouniourou and the Bolo Rivers, the strong ebbing force draining directly into the sea, little oceanic water remained in the system at low tide. Similarly, salt water introduced into the system during high tide was fully dissolved by fresh water inflow during the wet season. The influence of seawater on the lagoon was most evident during the dry season, when there was little freshwater inflow.

The Bolo and the Niouniourou Rivers contained only fresh water throughout the year. In contrast, the lagoon and the estuary were primarly freshwater when the inlet was closed, but contained brackish water when the inlet was open. Finally, the lagoon was a seasonally closed complex as its connection to the sea was temporary. The temperature of the complex was influenced by the intensity of solar radiation, although the influx of cold oceanic water led to slight lowering of lagoon temperature.

The flooded vegetation along the shoreline during high water levels comprised 63 species from 61 genera and 34 families, and was dominated by a degraded mangrove forest (Chapter 4). The degraded mangrove forest has made environmental conditions more favourable to the development of grasslands of *Paspalum vaginatum* and thickets of *Drepanocarpus lunatus*.

11.2 Resource Management in The Fresco Lagoon Complex

The resources of the Fresco lagoon complex were managed by a common property resource regime under an indigenous institution known as the *N'gni* system (Chapter 5). The *N'gni* system was based on customs and a traditional belief in the spirit of the water. It was developed as an informal institution established in response to the need to regulate fishing in the lagoon and to prevent conflicts that may have arisen from the commonly used gate fishing method. Instead, the community maintained continual reverence for the spirit of the water whose blessing they needed. This was achieved by a set of rules and regulations and by dividing the lagoon into family territories based on the prevailing traditional land tenure systems. The rules were simple and provided for protection and limitation in number of fishing days, as well as rules for their enforcement. All these were essential aspects of the traditional management system for the common property resources in the Fresco lagoon complex.

The state adopted a new land tenure system, and a free enterprise economic system in 1960. The Administrative Decentralization Reform took place in 1990, and resulted in the establishment of the Fresco town council. As a result of these measures, the *N'gni* system was abolished and replaced by a government driven co-management committee. However, when it became apparent that the new laws would allow equal access to the lagoon to all citizens of the country, as well as to foreigners holding a fishing license, the native users' community acted in their own interests to protect the sustainability of their livelihoods, and confronted the government representatives to strictly limit the number of users. The community reaction to the break down of their traditional system and to what could have quickly become a Tragedy of the Commons in the lagoon, follows previous descriptions of well-functioning common property resource regimes. These indicate an ability to accommodate surprise or sudden shocks, which increase the resilience and stability of the system caused by modernising forces (Gibbs and Bromley, 1989).

The resettlement of the 12 districts of Fresco was necessary because of environmental threats to the former site of this village and the need to improve the standard of living of the community. Unfortunately, this resettlement was undertaken with very little thought for the indigenous socio-economic and livelihood needs. Fishing in the sea, which had previously proved more profitable for the community, stopped and the lagoon became a year round fishing ground. New generations have lost their skill at fishing in the sea. Finally, as the human population has increased, so too has the impoverishment of the community increased. Hence, as the pressure on the lagoon increased, so too did resource management become a greater challenge. This situation confirmed previous warnings about a resettlement inequitably planned and irresponsibly implemented (Cernea, 1997).

The majority of the communities around the Fresco lagoon complex continued to hold a positive attitude towards the lagoon and consider it as high and integral part of their cultural identity. They believe that the *N'gni* system was more effective than the present day management and many of them recommended a return to this institution to achieve sustainable use, while also upholding their tradition (Chapter 6). However, the community also noted the difficulty of returning to this system because of the new context of state ownership, which gives equal usufruct rights not only to natives, but also to the non-natives. Despite the authority given to the fishery service and to the Fresco town council over the lagoon, the communities still encourage a strong presence of its representatives in the current co-management committee and wish to see that law enforcement is strengthened.

11.3 Resource use patterns in the Fresco Lagoon Complex

The livelihoods of the community living in the city of Fresco and the villages of Zakareko and Bohico, are heavily dependant on fisheries resources from the Fresco lagoon complex. These include: fishes, crustaceans and molluscs harvested through small-scale production, mostly for family consumption

(Chapter 7). The water level and salinity were important factors determining changes in the density of fishermen and, therefore, of the level of catch. The sustainability of the current level of catch could not be determined, as the current stock of fish in the lagoon was not estimated. However, there are many causes of concern over future sustainability, including: the fact that fishing in the sea has stopped; that the community now fish only in a relatively small lagoon; the increasing human population (Chapter 6); the regular opening of the inlet almost every year that gives little time for fish to grow; and, the new coastal highway that has improved access to the region.

The community from the three villages had diverse sources of firewood supply. Furthermore, several of these sources depended on the shoreline of the lagoon, as fuelwood was collected in the form of dead wood from the degraded mangrove of *Rhizophora racemosa*. The degradation of the mangrove forest around the lagoon (Chapter 4) is also a cause of concern as it plays an important role in maintaining the fishery and an important habitat for manatees.

11.4 The West African manatee in the Fresco Lagoon Complex

As in most of the major manatee habitats in Cote d'Ivoire, the West African manatee in the Fresco lagoon lives in a human-dominated water system. The species is legally protected by the Ivorian Hunting and Wildlife Protection Code but the lagoon itself has no protection status. Only the surrounding Port Gauthier forest is protected as a classified forest. Therefore, better knowledge of the manatee population in Fresco lagoon should help future conservation of the species in other unprotected habitats freely open to human use.

The present estimate of manatee population size in the Fresco lagoon cannot be interpreted against any previous estimate. However, the population density of manatees in the Fresco lagoon was higher than in the nearer lower Bandama River and the Grand-Lahou lagoon. The Fresco lagoon was once assumed to have the highest density of manatees of any area in Cote d'Ivoire. More manatees were seen here per unit of time spent searching, whereas in the Bandama River, no manatee were seen during several hours of searching (Powell, 1988).

The West African manatee is a solitary animal, but it was sometimes found in groups, with a median size of 2 individuals. Manatees also aggregate in response to cold water in August. Their individual home range size was 4.8 km^2 in the dry season and 11km^2 in the wet season. In both seasons, home ranges of individual manatees were independent, but overlapped almost completely suggesting that the species was non-territorial. Manatees showed a high rate of site fidelity by always returning to the area they were originally caught. The home ranges of males tended to be slightly larger than of females in both seasons.

The West African manatee used all the available areas in the Fresco lagoon, but patterns of use of different components depended on periods of the day and seasons of the year. The Niouniourou River and the N'gni lagoon were preferred during the dry season due to their suitability as hiding and resting areas. In the wet season, the Guitako and the Niouniourou Rivers were preferred due to the presence of abundant food while the N'gni lagoon tended to be avoided. Distinct seasonal patterns of movement were not observed but feeding excursions lasting for 1 day to several weeks were frequently undertaken.

The West African manatee in the Fresco lagoon spent its time resting, moving, feeding and cavorting but the species was less active during the day than during the night. Differences in manatee activities depend on periods of the day, tidal stages and seasons of the year. During the wet season, manatees moved and fed for more time than during the dry season. In the dry season, manatees were restricted to very few areas as the water level receded considerably.

The diet of the West African manatee was dominated by emergent vegetation of which *Paspalum vaginatum* and *Paspalidium geminatum* were the most important food plants in both seasons. Manatees also ate fruits, mud and deposited organic material, particularly during periods when little food was available. Feeding occurred mostly during the night and manatees visited several feeding sites along the water edge in a single night. Manatees usually fed alone but when aggregated in the N'gni lagoon, they rooted along the lagoon bottom for mud and deposited organic material in groups of 3 to 10 individuals.

The Fresco lagoon complex was subjected to intensive banana boat traffic, as the communities living around pursued different fishing activities to meet their livelihood requirements (Chapter 7). Therefore, manatees in the Fresco lagoon complex lived in a human dominated water system. The time manatees spent on performing an activity was, in general, determined by the type of activity in which the animal was engaged, However, human presence also impacted on time spent on particular actitivites and manatees did swim away and flee in response to close encounters with people (Chapter 9). When the distance between manatees and humans was less than 25m, manatees were more likely to flee and swim away. At greater distances of >100m, manatees ignored the presence of humans and fled or swam away less often. The prevailing type of human activity was also important in determining the response of manatees to human presence. Manatees mostly fled or swam away when close to people laying or throwing nets. Resting manatees were more approachable, while manatees never fed on the water's edge in presence of people. Manatee flight reactions were a direct response to the distance of approaching boats, number of peoples in each boat, and the type of activity in which they were engaged.

11.6 Human attitudes towards wildlife and the West African manatee

The community living around the lagoon knew about wildlife of the area and had little problem with it, but many of them would not support formal efforts to conserve wildlife. Overall, the community felt that wildlife in the area was decreasing due to habitat destruction, weak law enforcement, poaching, and the existence of important bush meat market. Attitudes towards wildlife of the area were generally negative. This reflected the annoyance of the community with the state restricting access to the nearby Port Gauthier forest surrounding the lagoon, which was once traditionally owned by the community.

Most of respondents believed that the population of the West African manatee in the lagoon is decreasing, because of its low reproductive rate, direct killing and migration. In contrast, some others thought the manatee population was increasing due to better legal protection and public awareness. Those users of the lagoon who have attended public awareness campaigns and those who had experienced damage to their fishing gear were more likely to consider that the population of manatee is decreasing. Most respondents thought the existence of manatee in the lagoon did not pose them a problem. However, a few respondents felt they were restrained in their daily activities because of the presence of manatees. Those respondents who were not supportive of manatees thought manatees posed a danger to human life, because they capsize boats, terrify people, or were evil and/or a threat to fishing. However, most lagoon users reported never having had their fishing gears damaged by manatees.

Attitudes towards manatees were in general, positive and were determined by: respondents' villages, sex, educational level, attendance at public awareness campaigns, support for wildlife conservation in general, and past experience of damage of fishing gear by the West African manatee. Respondents who had attended public awareness campaigns and those supporting wildlife conservation in general were more likely to be supportive of the conservation of the West African manatee. In contrast, those residents with past experience of damage to their fishing gear and those having no school education, or only with primary school education, generally held negative attitudes towards manatee conservation.

11.7 Conservation implications

The Fresco lagoon complex and its surrounding wetlands appear to be one of the least disturbed and richest in Cote d'Ivoire (Nicole *et al.,* 1994). This area, which is an extension of the wetlands to the extreme west of Grand-Lahou complex, is one of the last refuges of endangered species of fauna. Its role in maintaining various species of fishes important to the livelihood of local people is significant. Because of relatively difficult access, the region has not been exploited to the extent of other coastal regions to the east. However, a coastal road now passes through some of the most biologically rich and environmentally sensitive areas of the region. Soon, the whole region may come under serious threat from immigrants attracted to the area, if an integrated regional development plan is not developed and implemented. The mitigation of environmental impacts by the promotion of sustainable use of natural resources should be the priority of any development planning in the area.

As with most lagoons in Cote d'Ivoire, the Fresco lagoon is not a protected area. Thus, the future of the fishery and other resources such as its manatee population heavily depends on the protection that is provided by the local community. Communities have a vested interest in protecting resources as long as they perceive a benefit from such protection. Rural livelihoods depend on access to the resources necessary to meet their basic needs. For conservation activities to be successful and sustainable, they must have the dual objectives of protecting the resources and improving local livelihoods (Kothari, 1997). The traditional management system of the Fresco lagoon has followed the basic principles of equitable sharing of fishery resources among the community. It has also helped to preserve the other resources and the cultural identity of the region.

In countries like Cote d'Ivoire, where fish are the main source of protein and income for coastal populations, and supplies more than 30% of all the animal protein consumed (Abe and Kaba, 1995), these resources should be well managed. The main task of fisheries management is to follow strategies which ensure the long-term sustainability of resources, and which prevent both biological and economic over fishing, as well as minimizing disruption to lagoon ecosystems. This sustainable management can probably only be achieved by implementing pragmatic approaches based on the recognition of traditional property rights, the understanding of indigenous knowledge and practices, and the empowerment of the local community in the management of resources. Given that the local community heavily depends on the resources of the lagoon for their daily life, this option should be the favoured approach that must be fostered in the future. Rural people throughout most cultures and societies have traditionally been practitioners of complex environmental processes designed to use their resource bases in a sustainable way over many millennia. Areas of coastal water in some countries are held and managed under traditional ownership by adjacent community groups. Fisheries resources in these areas are managed by mechanisms such as taboo and custom and this has been suggested as a way of overcoming problems of common property resource management in large fisheries (Keen, 1991).

Top-down conservation efforts, which were introduced during the colonial period, when specially selected sites were set aside and most human exploitation within them was prohibited, is now recognised as not always being appropriate (WWF, 2000; Weber et al., 2000). Given the historical antecedents of today's protected area system, and its lack of integration into the existing social system, it is perhaps not surprising that the attitudes of local people living near national parks and reserves reflect suspicion and mistrust of conservation policies (Weber *et al.*, 2000). The protection of natural resources from lagoons under the communal management of local communities will experience less conflict in resource appropriation and, above all, is free from conflicts inherent between protected areas and adjacent communities.

11.8 Management Recommendations

The main objectives of this study were to obtain accurate information on manatees and to understand the nature and the extent of conflict between manatees and indigenous people in the Fresco lagoon, in order to formulate recommendations for the development of sound and lasting conservation initiatives for the few remaining manatees, before it is too late.

The human induced breaching of the inlet of the Fresco lagoon complex by the community should be stopped to allow the natural processes of flooding to work on their own. A research study should be set up to improve the understanding of the process causing the continuing degradation of the mangrove around the Fresco lagon complex and a management programme should be designed and implemented to ensure the long-term conservation of this mangrove forest. The success of any ongoing re-forestation projects will depend on this understanding.

The indigenous resource management system in the Fresco lagoon has allowed the community to utilise their fishery resources in a sustainable way until it was challenged by modernising forces. Today, the community also faces a growing internal challenge as their population densities increase and the market economy undermines their subsistence strategies and cultural traditions. To avoid Tragedy of the Commons in the lagoon, the government should address the issue of ownership of the lagoon. For example, the customary land tenure, which extends the ownership right over the adjoining lagoon water to families who own or are established on the adjacent shoreline, should be recognized in order to give more management responsibilities to the community.

Communities around the Fresco lagoon have shown a preference for community management over state control and attributed the ineffectiveness of present day management to weak law enforcement and increasing number of users allowed since the state assumed control. An effective partnership should be developed between the state, the community and the Fresco town Council in which the community should be empowered to protect and sustainably use their resources, while promoting their belief in the spirit of the water, which is their cultural heritage. The number of non-native users of the lagoon should be strictly maintained at the current level as agreed by native users.

Fishing in the sea, which was more profitable, has ended and the community now fish only in the Fresco lagoon. The possibility of the community starting to reuse the sea as fishing ground should be evaluated and the government should encourage and assist the community, particularly, youths to do so. In the meantime, fishing in the lagoon should be observed more closely to detect any side effects as technology and methods of fishing evolve from gates to nets. A programme of monitoring subsistence catches and profiling the characteristics of the fishery should be planned in order to develop a strategy for sustainable harvesting that will promote the long-term survival of fish in the Fresco lagoon. Fishing seasons, mesh size, and type of nets should also be strictly controlled.

The Fresco lagoon complex represents an important habitat of the West African manatee. The current conservation status of the species in this lagoon should be secured by serious conservation measures. The study has shown that time spent by manatees feeding, cavorting, resting and moving was affected by human presence and their prevailing activity. Manatees in the vicinity of people engaged in laying and throwing nets always flee or swim away. The study has also shown that manatee flight distances were determined by approaching boats, the number of occupants and type of human activity. Therefore, areas heavily used by manatees should be restricted and people should be encouraged to stay at a minimum distance of 50m from those areas of high concentration. Signal panels recommending caution to users could be posted nearby.

The current state of the Port Gauthier classified forest, which protects the Bolo, the Guitako and the Niouniourou Rivers, where manatees feed, should be maintained and a management plan established.

There is a positive attitude among the community towards the West African manatee. However, those with no school education or having only attended primary school did not see the need to protect manatees. The ongoing public awareness campaign should be improved to emphasise the importance of protecting manatees. The community should be encouraged to release manatees incidentally entangled in set nets.

Finally, the West African manatee can serve as a flagship species (Leader-Williams and Dublin, 2000) for the conservation of the wetlands extending from Fresco to Grand-Lahou. Worldwide, the manatee is excellent flagship species for wetlands, reflecting the enthusiasm with which the public often address issues related to the species (Reynolds, 1994). High interest in manatees should be exploited to highlight the importance of the Fresco lagoon and its surrounding areas, and to generate more support and interest at regional, national and international levels for its protection.

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APPENDIX 1:

Floristic composition of the vegetation of the shoreline

SPECIES CHECKLIST	Families	Embranchement	Biological types	Morphological types
Aida genipflora	Rubiaceae	Dicotyledone	Nanophanerophyte	Shrub
Alchornea cordifolia	Euphorbiaceae	Dicotyledone	Chamephyte	Creeper
Alternanthera sessilis	Amaranthaceae	Dicotyledone	Microphanerophyte	Grass
Anthiaris africana	Palmaceae	Dicotyledone	Therophyte	Tree
Avicennia germinans	Avicenniacae	Dicotyledone	Mesophanerophyte	Tree
Baphia nitida	Malvaceae	Dicotyledone	Megaphanerophyte	Shrub
Berlinia confusa	Ceasalpiniaceae	Dicotyledone	Megaphanerophyte	Tree
Blighia sapida	Sapindaceae	Dicotyledone	Nanophanerophyte	Tree
Brachiaria ramosa	Poaceae	Dicotyledone	Microphanerophyte	Grass
Calamus deeratus	Arecaceae	Dicotyledone	Microphanerophyte	Creeper
Ceiba Pentadra	Bombacaceae	Dicotyledone	Microphanerophyte	Tree
Combretum cuspidatum	Combretaceae	Dicotyledone	Microphanerophyte	Grass
Combretum paniculatum	Combretaceae	Dicotyledone	Microphanerophyte	Creeper
Commelina erecta	Commelinaceae	Monocotyledone	Microphanerophyte	Grass
Cuervea macrophylla	Hippocrateaceae	Dicotyledone	Hemicryptophyte	Creeper
Cyperus ferax	Cyperaceae	Dicotyledone	Microphanerophyte	Grass
Dalbergia ecastaphyllum	Fabaceae	Dicotyledone	Microphanerophyte	Creeper
Diospiros soubreena	Ebenaceae	Dicotyledone	Nanophanerophyte	Shrub
Drepanocarpus lunatus	Combretaceae	Dicotyledone	Mesophanerophyte	Creeper
Echinochloa pyramidalis	Poaceae	Dicotyledone	Microphanerophyte	Grass
Elaeis guineensis	Arecaceae	Dicotyledone	Hemicryptophyte	Tree
Ethulia conyzoides	Asteraceae	Dicotyledone	Microphanerophyte	Grass
Eugenia whytei	Myrtaceae	Dicotyledone	Hemicryptophyte	Shrub
Ficus asperifolia	Moraceae	Dicotyledone	Nanophanerophyte	Shrub
Flagellaria guineensis	Flagellariaceae	Monocotyledone	Microphanerophyte	Creeper
Glinus lotiodes	Aiziaceae	Dicotyledone	Microphanerophyte	Grass
Heliotropium indicum	Boraginaceae	Dicotyledone	Microphanerophyte	Grass
Hibiscus tiliaceus	Malvaceae	Dicotyledone	Microphanerophyte	Shrub
Ipomea rubens	Convolvulaceae	Dicotyledone	Microphanerophyte	Creeper
Jasminum dichotonum	Oleaceae	Dicotyledone	Microphanerophyte	Creeper
Keetia venossisima	Rubiaceae	Dicotyledone	Nanophanerophyte	Creeper
Kyllinga peruviana	Cyperaceae	Monocotyledone	Microphanerophyte	Grass
Leptatina densiflora	Rubiaceae	Dicotyledone	Nonophanerophyte	Tree

Leptodremis fasciculata	Fabaceae	Dicotyledone	Nanophanerophyte	Creeper
Lonchocarpus sericens	Papilionaceae	Dicotyledone	Microphanerophyte	Tree
Macaranga heudelotii	Euphorbiaceae	Dicotyledone	Mesophanerophyte	Tree
Maranttres aubrevillei	Chrysobalgnacae	Dicotyledone	Megaphanerophyte	Tree
Mariscus ligularis	Cyperaceae	Dicotyledone	Microphanerophyte	Grass
Melicia regia	Moraceae	Dicotyledone	Therophyte	Tree
Merremia hederacea	Convolvulaceae	Dicotyledone	Microphanerophyte	Grass
Napoleonaea vogelii	Napoleonaceae	Dicotyledone	Geophyte rhyzomateux	Shrub
Pandanus camdelabrum	Pandanacea	Monocotyledone	Chamephyte	Shrub
Paspalum vaginatum	Poaceae	Monocotyledone	Mesophanerophyte	Grass
Passiflora foetida	Passifloraceae	Dicotyledone	Microphanerophyte	Creeper
Paullinia pinata	Sapindaceae	Dicotyledone	Microphanerophyte	Creeper
Pentodon pentandrus	Rubiaceae	Dicotyledone	Microphanerophyte	Grass
Phaseolus adenanthus	Apocynaceae	Dicotyledone	Therophyte	Tree
Phoenix reclinata	Arecaceae	Monocotyledone	Geophyte rhyzomateux	Tree
Phyllanthus reticulatus	Euphorbiaceae	Dicotyledone	Microphanerophyte	Creeper
Pstia stratioides	Araceae	Dicotyledone	Idrophyte	Grass
Pterocarpus santalinodes	Fabaceae	Dicotyledone	Microphanerophyte	Tree
Raphia hookerii	Palmaceae	Dicotyledone	Microphanerophyte	Tree
Rauvolfia vomitoria	Bombacaceae	Dicotyledone	Therophyte	Tree
Remirea maritima	Poaceae	Dicotyledone	Microphanerophyte	Grass
Rhyzophora racemosa	Rhizophoracae	Dicotyledone	Microphanerophyte	Tree
Scoparia dulcis	Scrophulariaceae	Dicotyledone	Mesophanerophyte helophyte	Grass
Secamone afzelii	Asclepiadaceae	Dicotyledone	Nanophanerophyte	Creeper
Sesbania sericea	Papilionaceae	Dicotyledone	Microphanerophyte	Tree
Sterculia tragacanta	Sterculicea	Dicotyledone	Nanophanerophyte	Tree
Taberna montana crasa	Apocynaceae	Dicotyledone	Mesophanerophyte	Tree
Telosma africanum	Asclepiadaceae	Dicotyledone	Nanophanerophyte	Creeper
Tylophora sylvatica	Asclepiadaceae	Dicotyledone	Microphanerophyte	Creeper

APPENDIX II

Questionnaire of Group discussion and Key informant interview

1.Traditional water resource management system

1.1 Who is/are traditional owner(s) of the lagoon?

1.2 How the lagoon is shared within and between indigenous villages?

1.3 Who traditionally has the right of using water resources?

1.4 Who gives the right of use of water resource (e.g. fishing right) and how is it given?

1.5 Was there any traditional restriction on water resource use? e.g. Days of fishing; times; periods; methods allowed,

1.6 If yes why these traditional restrictions?

1.7How resource use was controlled?

1.8 Has the management of water resource system changed?

1.9 If so, how has it changed?

1.10 How does it work now?

2. Resources utilisation

2.1 What resources were there in the lagoon in the past?

2.3 What is there now a day?

2.4 What is used?

2.5 Who is using what? Social differentiation of use

2.6 Is water resource stock increase/discrease?

2.7 What are the possible reasons?

APPENDIX III

I. Introductory questions

1.1Village

1.1 Ethnic group

1.3 Nationality

1.4 Sex

1.5 Age

1.6 Residence in the region

1.7 Household size

2.1 Educational level

II. Socio-economic data

2.1 What do you work for a living?

1.2 What other activity do you have?

2.3 If you are a farmer what is the size of your farmland?

2.4 What crops do you grow?

2.5 What is your average production per day?

2.6 What is your average annual income?

2.7 what type of boat do you use?

2.8 Do you own boat (s)?

2.9 If yes how many boats do you own?

III Attitude towards the lagoon and its management and preferred future option

3.1 How do you value the Fresco lagoon in terms of non-consumptive and consumptive use?

Value	Not important (1)	Less important (2)	Important (3)	Highly important (4)	Very important (5)
As fish habitat					
As a natural heritage					
As water source					
As cultural area					
Esthetic value					
As a fishery					

As a source of firewood					

3.2 Is resource stock in the Fresco lagoon decreasing or increasing?

3.3 What is/are the possible reason (s)?

3.4How do you view the past management of resources? effective/ineffective?

3.5 What institution is responsible of the present day resource management?

3.6 Is the present day resource management effective/ineffective?

3.7 Why?

3.8 How to you want the Fresco lagoon to be managed?

3.8 Who should be responsible for the management of the Fresco lagoon?

VI Resource use in the Fresco lagoon

4.1 How do you value different resource of the Fresco lagoon?

Resources	Not important (1)	Less important (2)	Important (3)	Highly important (4)	Very important (5)
Fish					
Crustaceans					
Firewood					
Mollusks					

4.2 To what use do you put resources harvested?

4.3 Where do you collect your firewood?

4.4 How many times do you collect firewood in one month?

4.5 How many times do you fish in one week?

V Knowledge and attitudes towards wildlife of the area

5.1 What wildlife do you know around the Fresco lagoon?

5.2 Is the wildlife population around the lagoon decreasing or increasing?

5.3 If yes/no why?

5.4 Do you think wildlife brings problem?

5.5 Do you believe wildlife is a useful resource to be conserved?

5.6 If yes/no why?

VI Knowledge and attitudes towards the West African manatee

6.1 Do you know the West African manatee? Yes/No

6.2 How often do you see the manatee in the lagoon?

6.3 When did you see your last manatee in the Fresco lagoon?

6.4 Where do you usually see the manatee?

6.5 Is the number of manatee in the Fresco lagoon increasing or decreasing?

6.6 If yes/no why?

6.7 Is the West African manatee a problem or not a problem animal?

6.8.Have your fishing gears ever been damage by manatee?

6.9 If yes what type of gears were usually damaged

6.10 How was the importance of the damage?

6.11How much did you pay to repairs?

Attitude statements

Statements	**Level of agreement**				
	SD	**D**	**N**	**A**	**SA**
Manatee is part of our heritage					
Manatee should be eradicated					
Manatee is valuable only for its valuable meat					
Manatee population will never decline even regularly hunted					
Manatee is a danger to fishermen					
Manatee is not a valuable animal					
Manatee has right to live					
Conserving manatee should only in charge of the government					

I love manatee
Manatee belong to the government
Manatee is a threat to human life
Manatee is a useless animal
Manatee should not be protected

SD= strongly disagree; **D**= disagree; **N**=neutral; **A**= agree; **SA**= strongly agree

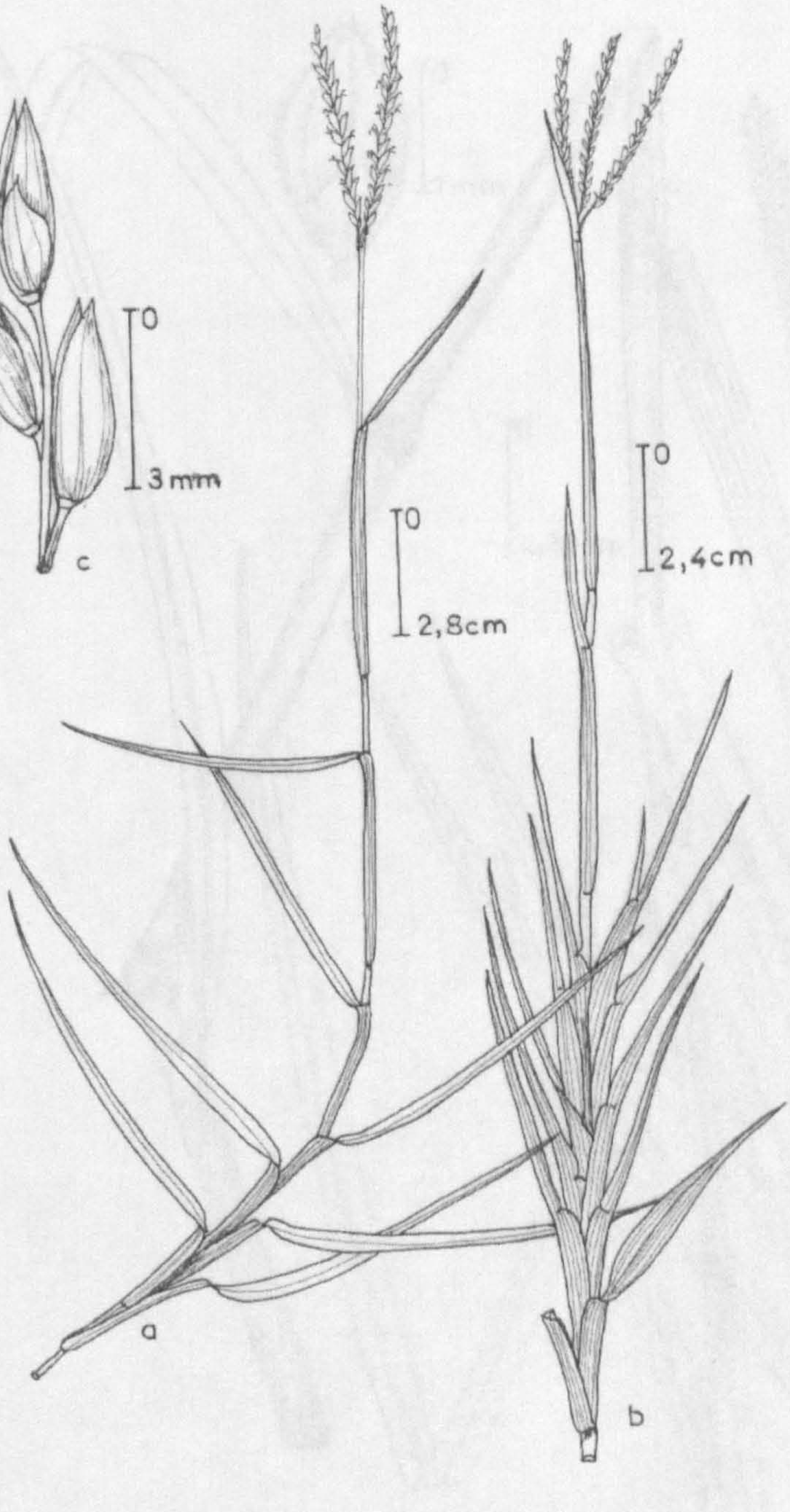
6.12 Have you ever participated to the conservation education awareness campaign held in the region? Yes/No

This is the end of the interview. Thank-you very much for your co-operation

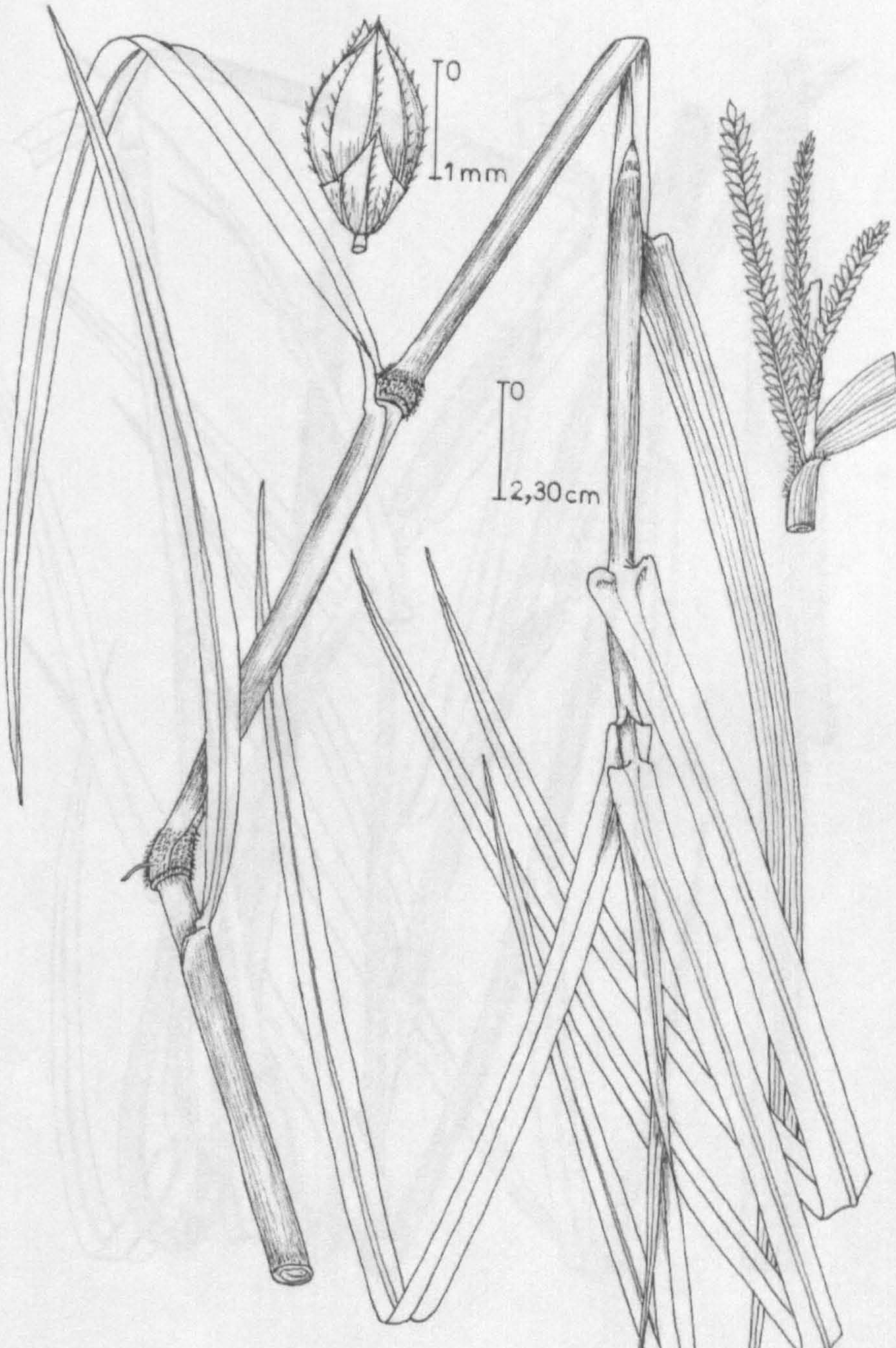
APPENDIX IV

Somes grass, plant and fruits consumed by the West African Manatee

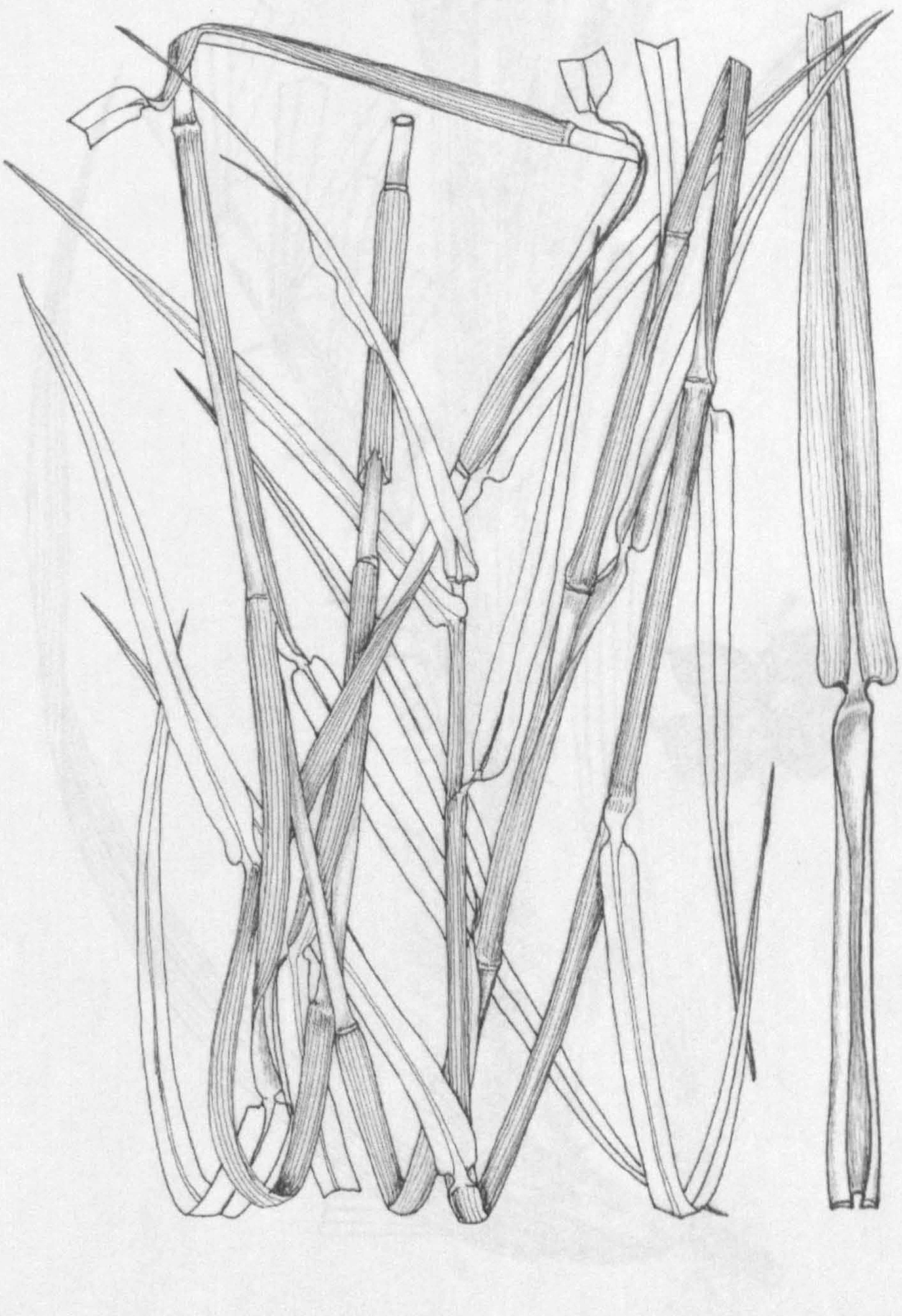
Paspalidium geminatum (Poaceae)



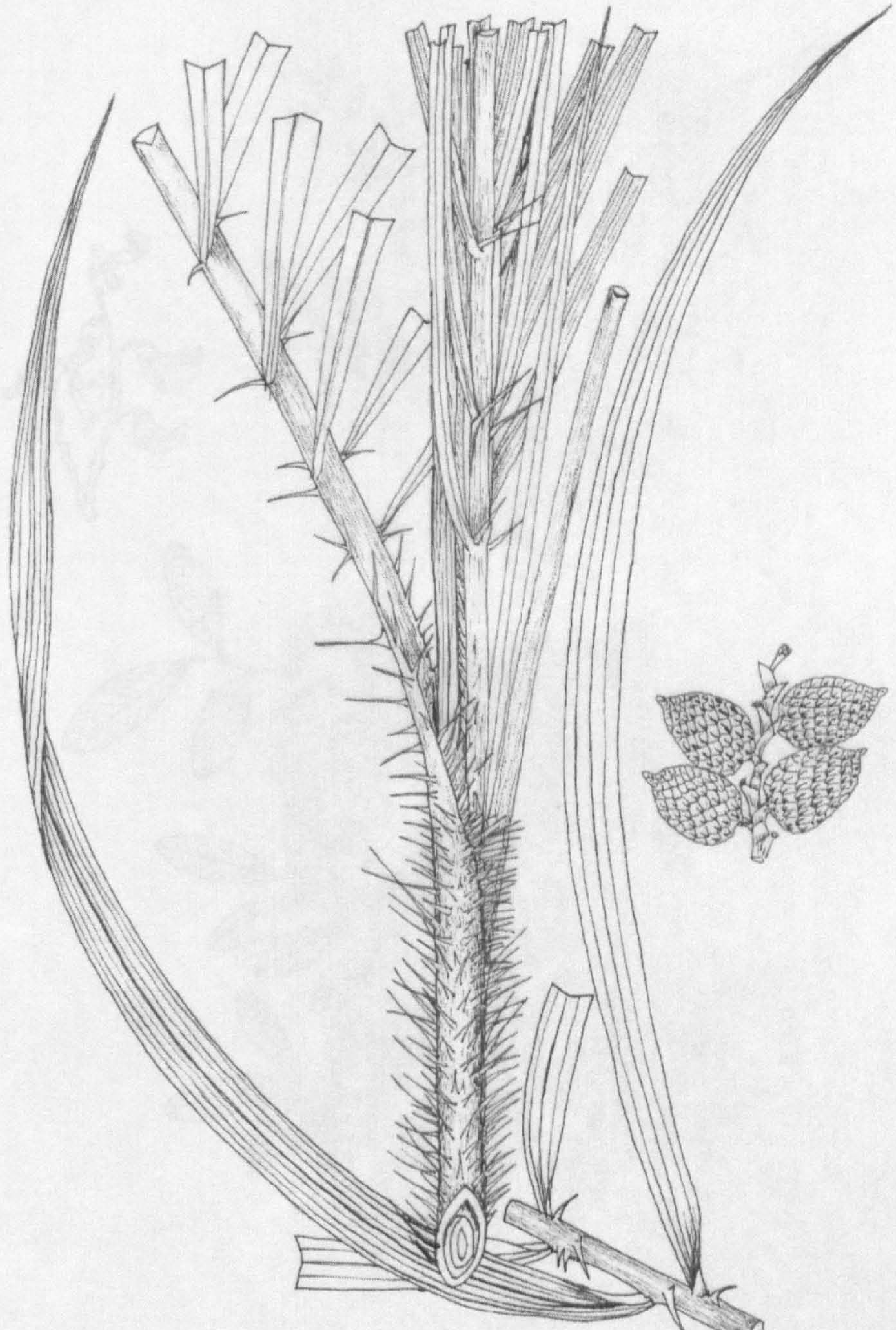
Paspalum vaginatum sw. (Poaceae)



Echinochloa pyramidalis (Poaceae)

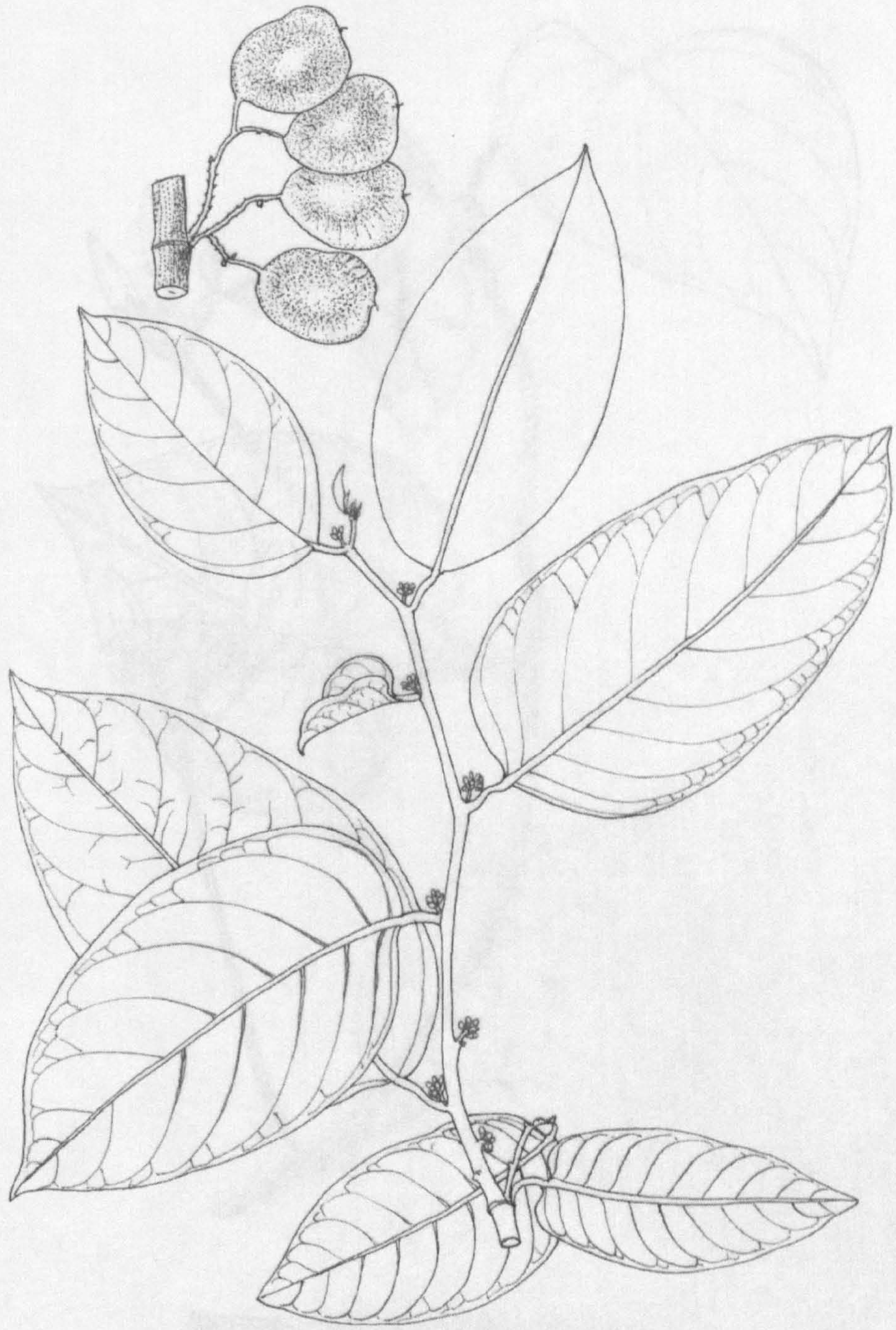


Bracharia ramosa (Poaceae)

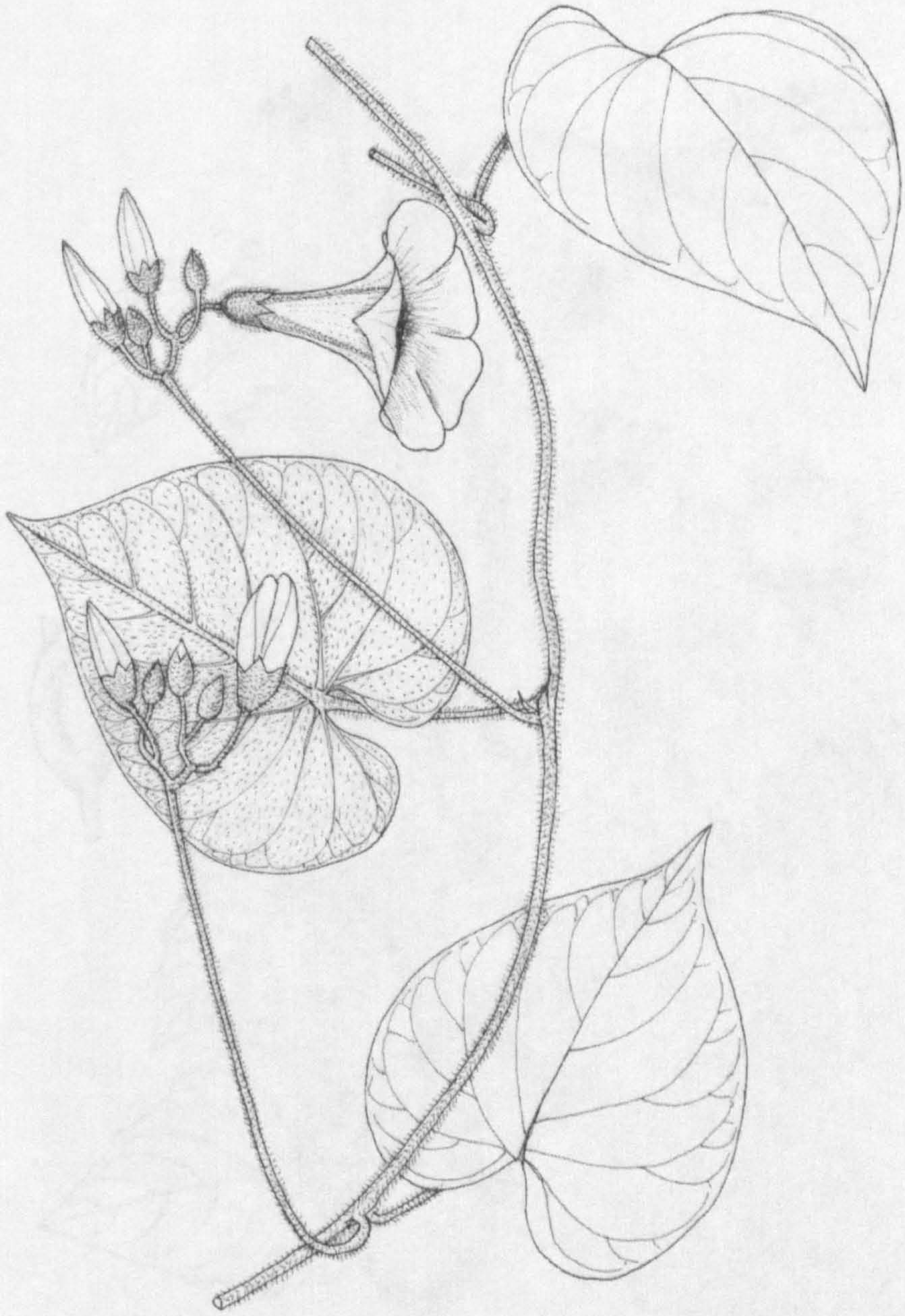


***Calamus deeratus* (Arecaceae)**

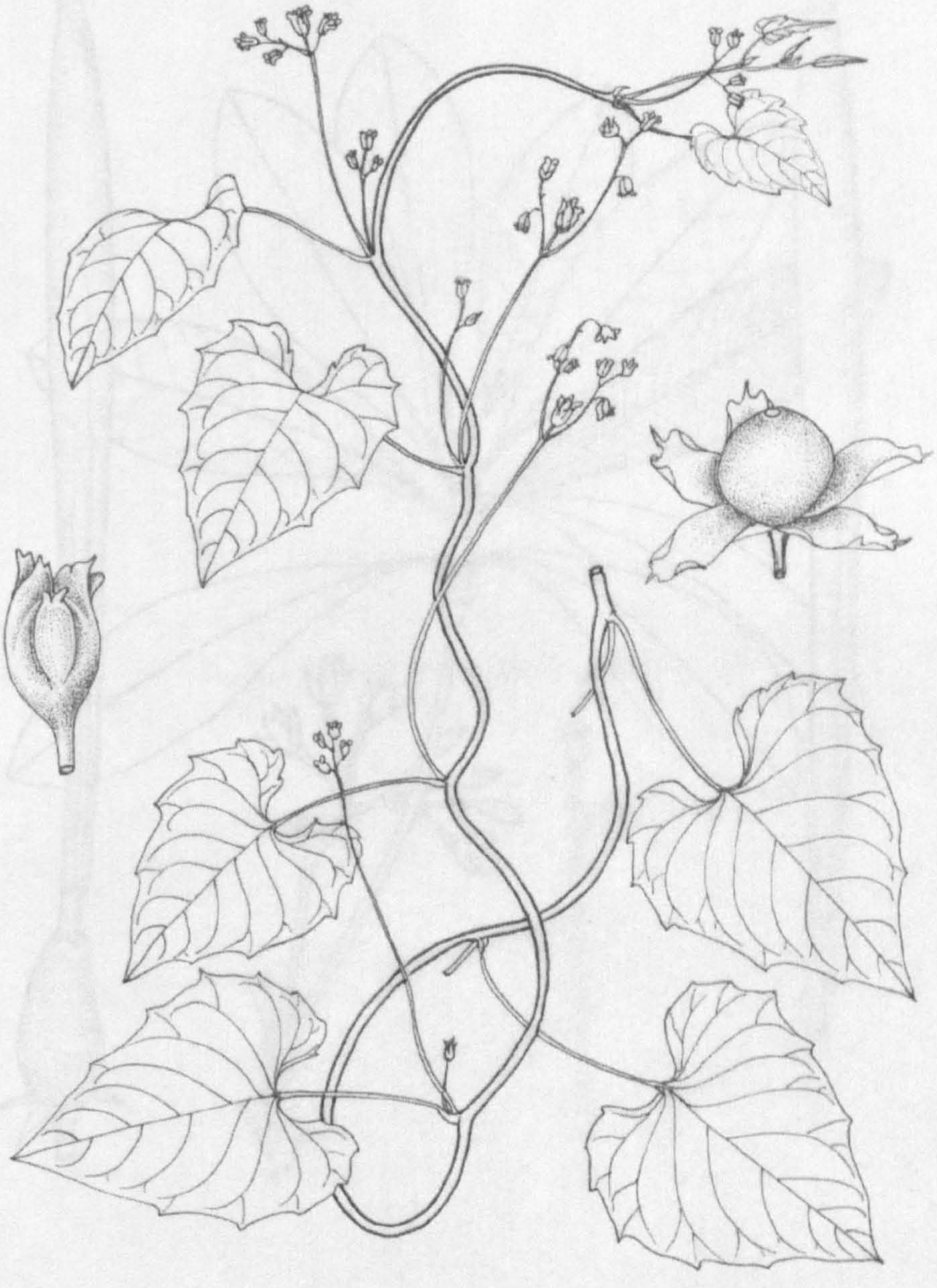
Drepanocarpus lunatus (Papilionaceae)



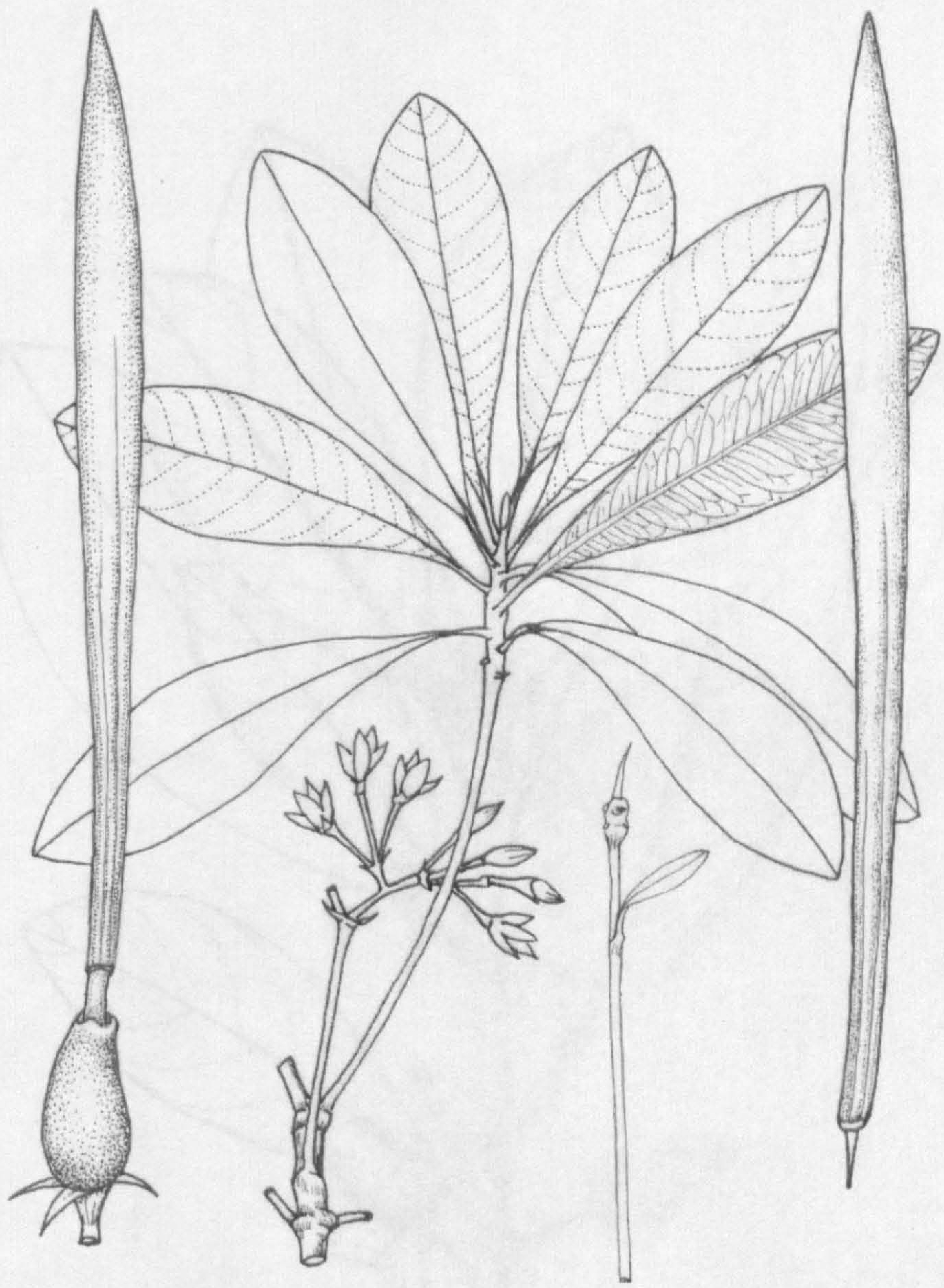
***Dalbergia ecastaphyllum* (Papilionaceae)**



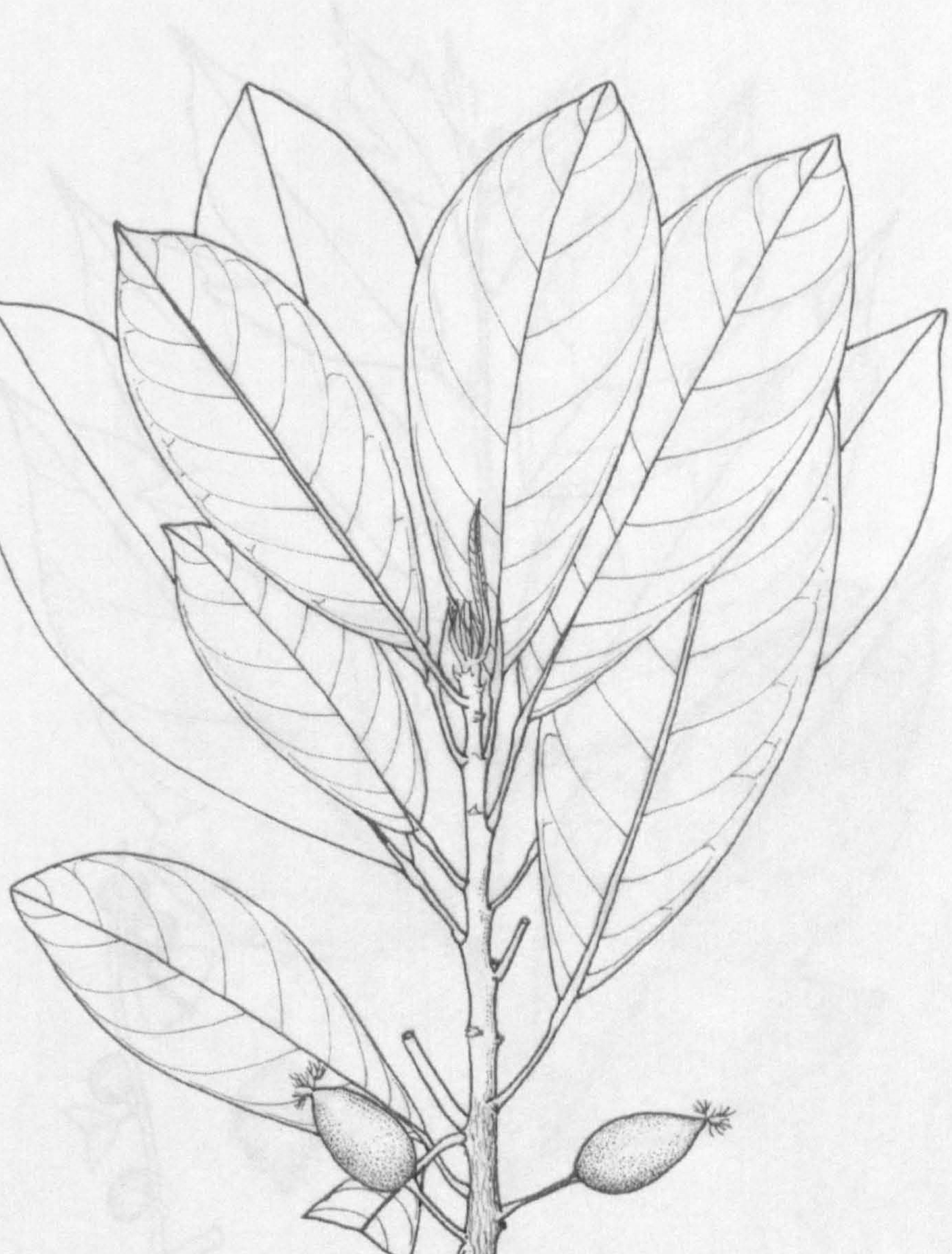
***Ipomoea rubens* (Convolvulaceae)**



Merremia hederaceae (Convolvulaceae)



Rhizophora racemosa (Rhizophoraceae)



Macaranga heudelotii (Euphorbiaceae)

Ficus asperifolia (Moraceae)