BELO MONTE AND THE LOCAL DEPENDENCY ON ORNAMENTAL FISH

Impact of hydroelectric dam Belo Monte in the Xingu River on ornamental fish species, local fishermen and local traders

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Impact of hydroelectric dam Belo Monte in the Xingu River on ornamental fish species, local fishermen and local traders

Final bachelor thesis

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Front page and title page show the ornamental fish species Acari Picota de Ouro (*Scobinancistrus aureatus*)

Preface

This research tells the story of the 'Acarizeiros' of the Big Bend of the Xingu River in Brazil. Acarizeiro is the local name for a fisherman who collects and sells ornamental fresh water fish as a source of income. According to the perception of local people operating in the production chain of the trade in ornamental fish, the impact of hydroelectric dam Belo Monte on ornamental fish species, the income and fishing practices of fishermen is measured. This document is the final product for my bachelor study Forestry and Nature Conservation at the University of Applied Sciences Van Hall-Larenstein in Velp, The Netherlands and a great addition to my previous studies conducted in South America.

I would like to use this section of the paper to thank a number of people who contributed significantly to this research and the research period.

First of all I would like to thank dr. prof. Juarez Carlos Brito Pezzuti of Universidade Federal do Pará, and his wife Danièla Felix, who offered me the opportunity to conduct this research and who were always present in the background for questions and suggestions. Next to this I would like to thank Cristiane Costa Carneiro, PhD student Aquatic Ecology and Fisheries at Universidade Federal do Pará and her mother Lucia for substantive issues and for always being around to assist in all kind of practical matters.

Secondly, I also thank Ir. Erika van Duijl, lecturer Tropical Forestry at University of Applied sciences Van Hall Larenstein for her content and counselling during this research period.

Most important, I very much would like to thank all interviewed fishermen and local traders, who spent their time on collaborating, while giving me the opportunity to get to know their practices. I sincerely hope for all that the impact study with the least damaging prognoses becomes your reality. May your future be bright.

Furthermore, I thank dr. prof. Leandro Melo de Sousa, expert on ornamental fish species of the Middle Xingu region for his additions to the interviews, his photographs, videos, and background information. I also thank Erik Macedo for sharing his information, research experiences, and his presence during field visits.

At last I would like to thank meu irmão, meu enamorado, meu colega de curso Menno de Boer, with whom I spent the time in Brazil while collecting data for this thesis report. His sharp mind, always critical reviews and ability to listen and reflect made this period even more interesting.

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Abstract

Over the past view years there has been a lot of commotion about the construction of hydroelectric dam Belo Monte in the Xingu River in the state of Pará, Brazil. National and international opposition fear for the consequences for nature and people living in the Xingu region, when this dam starts functioning. An important extractive economic activity of the Middle Xingu region is the collection of ornamental fish species. For this research the impact of hydroelectric dam Belo Monte on the five most important ornamental fish species for local fishermen, local fishermen self, and local traders of the Middle Xingu region is examined. For this research interviews and participatory research methods were used at two study locations: the city of Altamira and indigenous village Muratu in Terra Indigena da Paquiçamba Volta Grande of the Xingu River.

The impact of the dam on the five most important fish species for local fishermen seems negative. Acari Zebra (*Hypancistrus zebra*) is likely to go extinct as it is endemic to the area which is most affected by the dam. Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri 'xingu'*), Acari Picota de Ouro (Scobinancistrus aureatus), Acari Amareli (*Baryancistrus xantellus*), and Acari Assacú Pirarara (Pseudacanthicus sp. "vermelho") will probably decrease in abundance in the Big Bend area. It is likely that these species will disappear in the reservoir areas, because here the current disappears and the water will remain turbid of the sediment and oxygen-poor.

The local fishermen already experience a negative influence of the dam on fish and their fishing practices. Problems are related to the stronger current, more sediment, and the changed water level. Because of the environmental impact on fish, fishermen are convinced their income is about to decrease or even disappear. In Muratu catching ornamental fish was the main source of income, until recently. For fishermen in Altamira catching ornamental fish has a large share in their total income. In Muratu fishermen are planning to switch from being fishermen to becoming farmer to produce agricultural products which they can sell to gain an income. In Altamira most fishermen are planning to find another job in the city. Catching fish in other regions is not an option, as higher costs for fuel and spending an increased amount of time prevents the activity from being profitable.

Next to local fishermen, local traders who buy the fish from local fishermen are also impacted by the dam. They attribute the decrease in production of the river of ornamental fish and the increased death rates among in their aquarium to the construction of the dam. As a solution to future environmental problems the local traders will have to buy their fishes from fishermen living in other regions. Perhaps they have to invest more in navigating the river to pick up the production.

Perhaps the Belo Monte dam means the end of trade in ornamental fish in the region Middle Xingu region, or at least will cause a reduction of jobs within this sector. This means that the culture and lifestyle of the fishermen and the traders and an important economic sector in this region will disappear or to a lesser extent passed on to future generations.

In the end of the report some recommendations were given for NorteEnergia, ngo's which are involved in the region, governmental bodies which are currently occupied with the topic of compensation for fishermen (like the ministry of fisheries and aquaculture), and ACEPOAT (the associating for fishermen who collect ornamental fish in Altamira).

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Acronyms and abbreviations

°C	degrees Celcius
ACEPOAT	Associação dos Criadores e Exportadores de Peixes Ornamentais de Altamira
BNDES	Banco Nacional de Desinvolvimento e Econômico e Social
cm	Centimetre
EIA	Environmental Impact Assessment
FUNAI	Fundação Nacional do Índio (National Indian Foundation)
HBM	Hydroelectric dam Belo Monte
Hp	Horse power
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
ISA	Instituto Socioambiental (ngo)
km	Kilometre
LEME	Tractable Engineering (Brazilian company in energy and infrastructure sector)
m	Meter
m^3/s	Cubic meters per second
mm	Millimetres
NGO	Non-governmental organisation
NTFP	Non-timber forest product
R$	Brazilian real (Brazilian currency)
RESEX	Reserva Extrativista: A federal protected conservation unit categorized as extractive reserve
TEK	Traditional ecological knowledge
TI	Terra Indigena (indigenous reserve)
UFPA	Universidade Federal do Pará
US$	United States Dollar (USA currency)
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1. Introduction

Background

Over the past few years there has been a lot of commotion about the construction of hydroelectric dam Belo Monte (further referred to as HBM) in the Xingu River in the state of Pará, Brazil. National and international opposition fear for the consequences for nature and people living in impacted areas. Damming the river and forming artificial reservoirs is a threat to riverine aquatic fauna and so to the livelihoods of people depending on this fauna group for diet and income. This research takes a closer look at the impact of HBM on ornamental fish species, local fishermen, and local traders of the Xingu River.

Problem description

Several studies show that dams in the Amazon region (like the Tucuruí, Estreito and Belbina dam), have a large impact on their surroundings and cause environmental problems. The main problems are deforestation, eutrophication of the reservoir, trapping nutrient rich organic matter, problems with navigating the river by physical barriers, and the increase of the emission of greenhouse gases. All this leads to an increase of fish mortality rates and waterborne diseases and a decrease of territory for terrestrial and aquatic flora and fauna. Another problem are the direct and indirect changes in the social and economic structure and organisation of the segments of society. This is why there is great opposition both within Brazil and among the international community towards the construction of HBM in the Xingu River. Some examples of negative indirect impacts are: Large inflows of work searching migrants, displaced people from the riverbank and islands in the river (in the case of HBM officially 19,000 people have to be or are already displaced, most living in the city of Altamira and on islands where the reservoirs are planned (International Rivers, 2012)), an increased formation of slums, disruption of trading activities due to shipping problems, disruption of fishing activities, changes in farming activities, more health risks for communities downstream and living next to the reservoirs (La Rovere & Mendes, 2000). In the case of HBM, indigenous communities living along the Big Bend (the 120 km stretch downstream the dam, which is locally known as the 'Volta Grande do Xingu'), feel not consulted and ignored in the decision-making process beforehand. Nowadays they state that the impacts of HBM on their livelihoods is not fully compensated and that a plan to mitigate these impacts is lacking. The HBM complex, operating at its peak capacity, is able to generate 11,233 megawatts (providing more than 10 percent of Brazil's current electric capacity). A technical problem is that, due to the low water season it will only reach this capacity peak during three or four months per year. The rest of the year the dam complex will only run 10-30 percent of its full capacity and generate an average of only 1,000 to 4,500 megawatts (Leite, et al., 2014). Climate experts argue that hydroelectric dam complexes in the Amazon region cannot be seen as a sustainable source of renewable energy. Permanent flooding and the water in the reservoirs results in the decomposition of the inundated vegetation under anaerobic conditions (which contribute significantly to the emission of greenhouse gasses) and the deterioration of water quality (Fearnside, 2002). For this study the changes in the quality and quantity of water in the reservoirs and downstream the dam, and the disappearance of seasonality in the river ecosystem are most relevant. With the construction of HBM the river flow in the Big Bend of the Xingu River will receive less water and will no longer be exposed to seasonal floodwaters. The large dam diverts the water away from the Big Bend, into two man-made canals. The city of Altamira and other villages along the reservoirs suffer the same problem, except that they do not have to deal with a shortage of water, but an inundated artificial lake, where water remains stagnant (International Rivers, 2012).

The last 30 years, the collection of ornamental fish became the main source of income for most local fishermen from riverbank and indigenous communities (Camargo, Carvalho Júnior, & Estupiñan, 2012). Especially the "Acaris", the local name for ornamental freshwater tropical South American catfish belonging to the family *Loricariidae*[1], are an important export product of the region. Currently, there are around 200 to 350 fishermen[2] collecting ornamental fish in the Middle Xingu region. They collect ornamental fish and sell them to local traders (aquarists), who, in their turn, sell the fish on the national and international market. This report evaluates how local fishermen and local traders perceive the impact of HBM on important ornamental fish species, and so on their income and fishing practices.

[1] A pseudo-scientific classification system of tropical ornamental catfish species of the Loricariidae family published by the German aquarium magazine DATZ (Die Aquarien- und Terrarienzeitschrift). These fish species are also called 'plecos'.

[2] This number is based on the estimations of different people and studies: the president of the association of fishermen of Altamira, the environmental impact studies of NorteEnergia S.A. and local traders. This number always varies as the job fishermen collecting ornamental fish species (locally known as Acarizeiro) is highly opportunistic and dependent on the seasons.

Main research questions

What is the impact of hydroelectric dam Belo Monte on ornamental fish species, fishermen of indigenous and riverbank communities, and local traders?

Sub questions

1. What are the most important ornamental fish species for fishermen of indigenous and riverbank communities in the Middle Xingu region?

2. What is and will be the impact of hydroelectric dam Belo Monte on the environment and the ecology of these species, according to fishermen and literature?

3. What is and will be the impact of hydroelectric dam Belo Monte on the fishing practices and income of fishermen collecting ornamental fish from indigenous and riverbank communities, according to the fishermen?

4. What is and will be the impact of hydroelectric dam Belo Monte on the businesses of local traders in ornamental fish of Altamira?

Justification

It is of great importance that all impacts of hydroelectric dams are studied as the Brazilian government plans to construct 48 dams, the coming years, of which 30 will be constructed in the Amazon basin. Impact studies on dams that already function show many negative environmental, social, and economic implications (The Economist, 2013). This research focusses on the impact of HBM on an important NTFP (non-timber forest product) for local communities. River products are often forgotten when discussing NTFPs, although fish is the main commercial forest product in the Amazon region. Mostly large catfish and, to a lesser extent, ornamental fish contribute significantly to the income of rural communities in this region (Ros-Tonen & Freerk Wiersum, 2003). It is important to describe and document ornamental fishing practices and the lifestyles of fishermen of ornamental fish, as it is likely that this job gets less popular or will disappear the coming years in the Middle Xingu region: This report makes an estimation to what extend HBM will have an effect on the different facets of this job. In addition, a report with the consultation of the opinion of fishermen and other local stakeholders should not lack and be publicly accessible among the general collection of literature. This large group has a lot of knowledge on the local situation and probably will suffer from the construction of HBM, as the whole production chain of ornamental fish trade could be affected when the fish lose their habitat. Another important contribution of this report is the data on ecology and habitat specifications of five important species. Little is known about the feeding, breeding habits and life cycles of most ornamental species (Santos, Barbosa, & Hernandez, 2009). Furthermore, data on the changes in income can contribute, as the fishermen are still in dialogue with NorteEnergia S.A. (the consortium, composed of the state-owned company Eletrobras, responsible for the construction of the dam.) and the government (ministry of fisheries and aquaculture) on compensation for the loss of income caused by the dam. At last, the outcome of this research on several aspects of the habitat ornamental fish species can be used by the fishermen themselves, local traders or international traders to breed the species in captive.

This research is conducted in accordance and collaboration with NGO Instituto Socioambiental (ISA), which established a village organization for the village of Muratu (Associação da Aldeia Muratu) in the TI (Terra Indigena) Paquiçamba. In Muratu several monitoring and research projects are running. The results of this research will be translated in Portuguese and offered to ISA and Associação da Aldeia Muratu.

Content of this report

The next chapter, methodology, describes the chosen study area, the research methods and analyses. This chapter also gives an explanation on what traditional ecological knowledge is, as this report is, to a large extent, based on this kind of research. In the chapter on the local context, background information on HBM and ornamental fishing practices in the study area, is provided. Hereafter the results follow, answering the research questions, which are presented above. In the conclusions, discussions, and recommendations, a conclusion is drawn and the results are interpreted. Recommendations are done towards NGOs and governmental bodies, and ideas for future researches are brought forward.

2. Methodology

Study area

This study is conducted in the city of Altamira and indigenous village Muratu, located in the TI Paquiçamba, both located in the state of Pará, Brazil (figure 1). However, the information given in this research concerns the whole Middle Xingu region. This region extends from the Xingu-Irirí confluence to the Belo Monte waterfalls region and includes the city of Altamira and the communities in the Big Bend (Camargo, Júnior, & Estupiñan, 2012).

The research target groups

For this research several groups from different residential areas are consulted. These residential areas are representative for most groups habiting the Middle Xingu region: Fishermen living in the city, indigenous fishermen, and fishermen from small riverbank communities. During the research period it appeared that the research groups were quite homogeneous regarding ornamental fishing habits and practices. In addition, the individual fishermen within a group were very similar in habits and culture.

1. Ornamental fishermen of the city of Altamira

There is no clear number on the total number of ornamental fishermen living in the city of Altamira. It is estimated that there are around 200 to 350 fishermen collecting ornamental fish in the Middle Xingu region of which a large part lives in the city (NorteEnergia S.A., 2011).

2. Ornamental fishermen of indigenous village Muratu

This village is located within TI da Paquiçamba Volta Grande of the Xingu River. In this village, 11 families live (ten men, wife, with children-families and one women-headed family with children). Each adult men (ten in total) in the village is familiar with ornamental fishing practices and collected ornamental fish in the past.

3. Ornamental fishermen from other residential areas

In the city of Altamira three persons from other residential areas were interviewed: One person from riverbank community Ilha da Fazenda (a village on an island in the Big Bend). Six to ten ornamental fishermen live on Ilha da Fazenda (NorteEnergia S.A., 2011). Another person from the village Maia located in TI Arara da Volta Grande and one other person from the indigenous village Paquiçamba located in TI Paquiçamba were interviewed. These people live in an approximately identical way as the villagers of Muratu. A large difference is that villagers of Ilha da Fazenda and the city of Altamira do not have a conservation status like a TI, and thus have fewer privileges and receive less support from the government.

Hereafter these three target groups are addressed as 'local fishermen'. These groups are discussed separately where needed.

4. Local traders in ornamental fish

Three local traders in ornamental fish from the city of Altamira were interviewed. Nowadays only four legally acknowledged local traders are still functional, where there were 25 from 2005 until 2013. The clandestine traders in ornamental fish species of Altamira were not approached for this research. Two former local traders who stopped their businesses recently were interviewed.

The research period and interview locations

The research period extended from April until June 2014. The fishermen of Altamira and other residential areas were approached in two of Altamira's ports: Porto Carrosa and Porto seis. In these ports the aquaria of local traders are located to which fishermen sell their catch. In these businesses it is easiest to encounter fishermen. In Altamira it was sometimes difficult to find fishermen, as they were working all day. They were mostly approached in the afternoon, after arrival at the aquarium, delivering their catch. Some fishermen of Altamira were interviewed at their homes and at the association of fishermen of Altamira. A restraining factor was the period in which this research was conducted. In the winter season less fishermen are active collecting ornamental fish, because of the high water level and strong current of the river. The village of Muratu was visited during two one-weeks trips (16th of April, and 6th of June). Because of the lack of a licence to visit the TI I depended on the trips of my supervisor to access the village. In Muratu the interviews were carried out at the

homes of the fishermen, in their spare time. Local traders were interviewed in their own aquarium or at the Colônia de Pescadores (association of fishermen) of Altamira.

Local knowledge

Part of the results relies on traditional ecological knowledge (TEK) and the opinions and observations of local fishermen. This method of gathering data was chosen because little research is conducted on current situation of the ornamental fish sector in the Middle Xingu region, as it is a quite recent business. Moreover, it became clear during this research that fishermen are experts when it comes to habitats, environment, and ecology of the ornamental fish species. They spend their days under water, observing, chasing, and collecting the fish in their natural habitat.

Ecological research through traditional ecological knowledge

Traditional ecological knowledge comprises indigenous and local peoples' knowledge and beliefs about the natural world, ecological concepts, and natural resource management and practices. Ecological research through the gathering of this kind of knowledge has demonstrated that TEK is more complete and accurate than Western scientific knowledge of local environments. It is "*build upon the experience of earlier generations and adapting to the new technological and socio-economic changes of the present*" (Burgess, 1999). TEK is therefor used within the field of nature conservation as scientific investigations showed that conservation programs based on TEK is "*environmental sustainably and provides information for a long-term perspective on ecosystem dynamics, interaction with habitats and species, and thus assist in the analysis and monitoring of long-term ecological changes*" (Gonzalo, Oviedo, Gonzales, & Maffi, 2001). Quality of TEK varies among community members, depending on gender, age, social status, intellectual capability, and profession (hunter, spiritual leader, healer, etc.) (Burgess, 1999).

Cross-checking of the data was done by repeating the interviews as much as possible, comparing the results with impact studies on other dams, and by consulting ornamental fish expert dr. prof. Leandro Melo de Sousa.

Research methods and field surveys

At the start of the research period preliminary interviews were conducted in order to see if fishermen understood the questions and the terminology of the interviews. During the research period interviews and participative research activities were adjusted and questions were added to the original interview, after consulting specialists on the research topic (knowing, PhD students in anthropology and aquatic ecology and fisheries, and dr. pr. Leandro Melo de Sousa). Data was mainly collected though open, structured and semi-structured oral interviews with the stakeholders.

One general structured interview (n=24) on current income, fishing practices, and preferred and most caught fish species was conducted (see appendix I). The income of four years ago (before the construction of HBM started) and the income in May 2014 were inventoried. The importance of ornamental fish species (result 4.1.) is, among others, based on this interview, as the two factors 'preference', and 'catch frequency' were recorded according the judgment of local fishermen.

The topics of the second interview (see appendix II) were; the impact of HBM on the Xingu River, the water of the river and ornamental fish, fishing practices, and the lifestyle of the fishermen. This interview had around 24 respondents, as not every interview question was answerable for the interviewee. This interview had the character of a conversation in which the fisherman was asked about his future perspective for when the dam fully functions. After each answer subsequent questions were formulated.

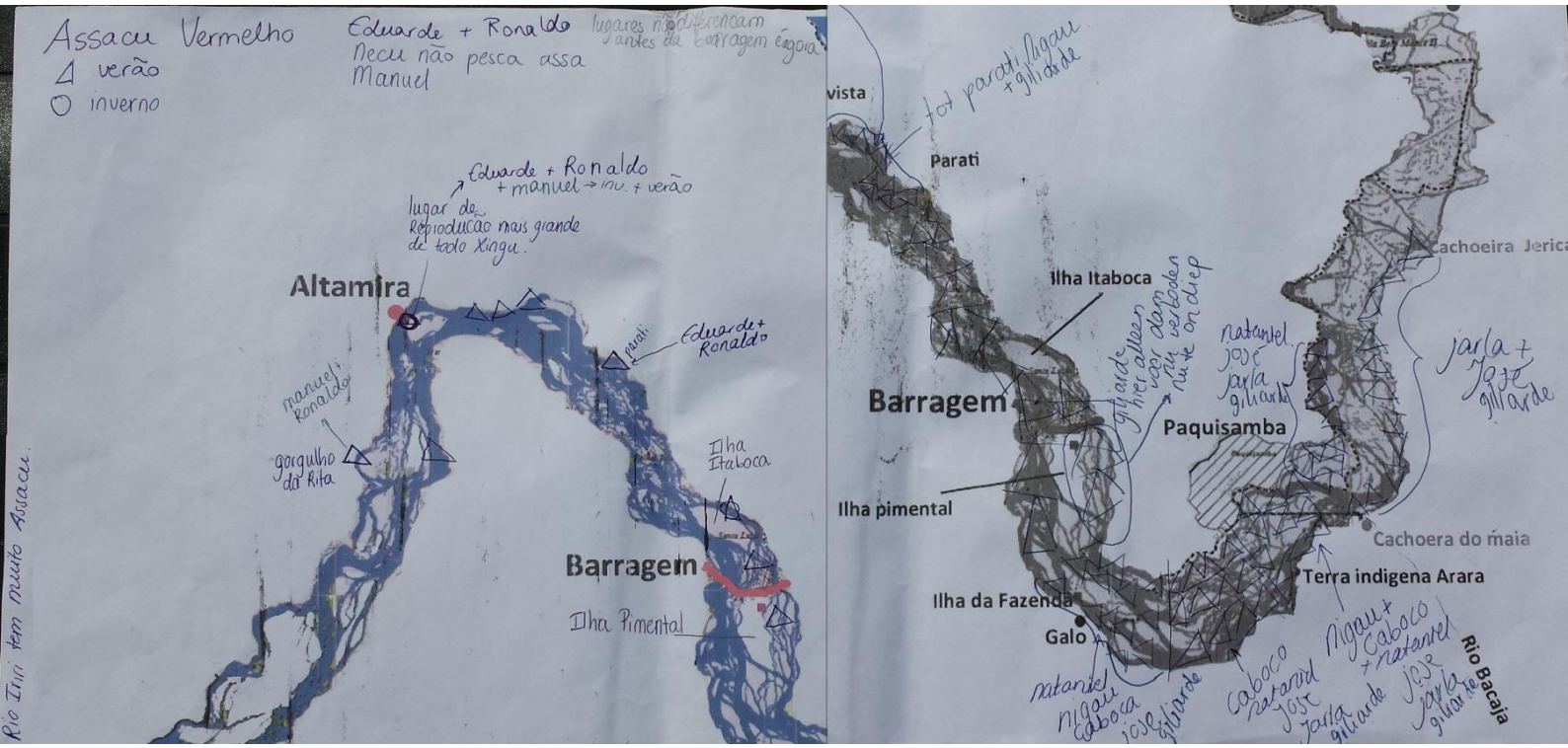
The third interview (with a different number of respondents per fish species, varying between 14 and nine) was done to reveal the ecology of the five important fish species and the type of habitat (see appendix III). The impact of the dam, according fishermen is documented this way. This interview was also carried out with fishermen who changed occupation or are retired.

The last interview, was an interview with local traders and employees of aquaria. The goal of the interview was to see what impact the dam has on the fish they sell and on their aquaria (see appendix IV). These people work with the fish every day and some used to collect ornamental fish in the past as well.

In The Netherlands three aquarium stores were contacted and two owners of these stores were interviewed. This way an idea was obtained on the share of Xingu River fish species in the businesses' turnover and to what extend a dam affects the international market. These data are not presented as results, as more stores should have been visited to make the data representative for the whole population.

When arriving in Brazil, I only had a basic understanding of Portuguese. This made the conversations with fishermen and local traders difficult and had an effect on the quality and profundity of the obtained information. Fortunately, the first interviews where done in the presence of a translator and later on my understanding improved significantly.

The interviews were complemented by several participatory methods. A seasonal calendar (with a total of 26 participants) was filled out with the fishermen to get an understanding on which fish species is captured in which time of the year. This gives an idea of in which time of the year each fish provides the fishermen of income. With 16 participants, maps (picture 1) on popular fishing locations of the five most important fish species were made. The fishermen were asked about the fishing locations before the dam and their current fishing locations. This gives an idea of which parts of the river are important to the fishermen, the fishing pressure (in the form of overlap) for each location, and if fishermen changed fishing locations since the dam was built.



Picture 1. Details of two participative maps of the fishing locations (Diemont, 2014)

With 26 participants (local fishermen and traders) a scheme was made on the dispersion of income over the most common ornamental fish species, in order to estimate the share of each fish species in the income of fishermen and traders. The important ornamental fish species (result 4.1.) is, among others, based on this activity, as it appeared that fish species are considered most important by fishermen and traders, when they receive a high price it. This scheme was filled out with a bean distribution method (see picture 2).

Additionally, two participatory observations were done. These observations took place during two fishing trips with fishermen. The purpose of the observations was to receive a better understanding of the working circumstances, fishing practices, and the time spent to collect the fish.

Data analyses

Determining the importance of ornamental fish species is done by assessing three factors: preference of local fishermen, catch frequency by local fishermen, and share in the local fishermen's income. These data were analysed by counting the times fishermen mentioned a fish species, answering the questions 'which species you collect most often' (catch frequency) and 'which are you favourite species' (preference). The reasons fishermen gave to mention the fish species are described. Fish were designated as important when being mentioned by 50% or more of the local fishermen and occurring in a 'most caught' table and a 'preference

table' (regardless of the residential area), and looking at the mean share of the fish species in the total income of local fishermen.

Picture 2. A bean distribution activity on income dispersion over ornamental fish species (de Boer, 2014)

Only the aspects of the ecology which are impacted by the dam are discussed and analysed in this research, although a more complete database was created with the interviews. The aspects discussed in this research were mentioned by fishermen, external experts and literature as crucial for the survival of the five most important ornamental fish species and used to examine the impact of the dam on ornamental fish species.
The data on the ecology and habitat were unanimous. If responses diverged from each other the data mentioned by more than 50% of the interviewees was incorporated. For the aspect 'depth' the most extreme numbers were documented, as fishermen fish at different locations, so 'depth' varies for each individual fish. For the aspect 'current' a range of one to five was presented to the fishermen, in which one indicated 'very strong current' and five 'stagnant water'. The mean of all answers was taken as indicator. There were no differences in results between summer and winter, so no distinction was made. One map per fish species is presented in the chapter 4.2. These maps indicate the location of where the fish species is presented and caught by the fishermen. A description under the map gives more details on summer and winter spots and the situation before and after the dam. At the end of this chapter a prognosis is given on what will happen to each of the important fish species. This prognosis is based on the interviews with local fishermen, the EIA (Environmental Impact Assessment) of NorteEnergia S.A., a critical review on the EIA by experts, and a subsequent examination study on the impact of the Tucuruí dam in the Tocantins River.

Most of the information in chapter 4.3. is based on average values of income, and the interview in appendix II. The results are presented in frequency tables in which answers of fishermen were counted and converted into a percentage. An independent T-test (two-tailed) was done to see if there is a difference between the number of species of which the income of the fishermen exists. This shows if there is significant difference in income dependency on species of fishermen in Muratu and Altamira. A distribution table of the amount of species caught per fishermen was made to see how many fishermen depend on a low number or on a broad range of species.

The important fish species for local traders were determined by filling out a scheme on the dispersion of their income over the ornamental fish species they sell, as it became clear that importance is highly related to the share in the income. These data were converted into mean percentages and shown in a table. The results of the interview about the current impact of the dam on the local traders and their future perspective were presented in frequency tables.

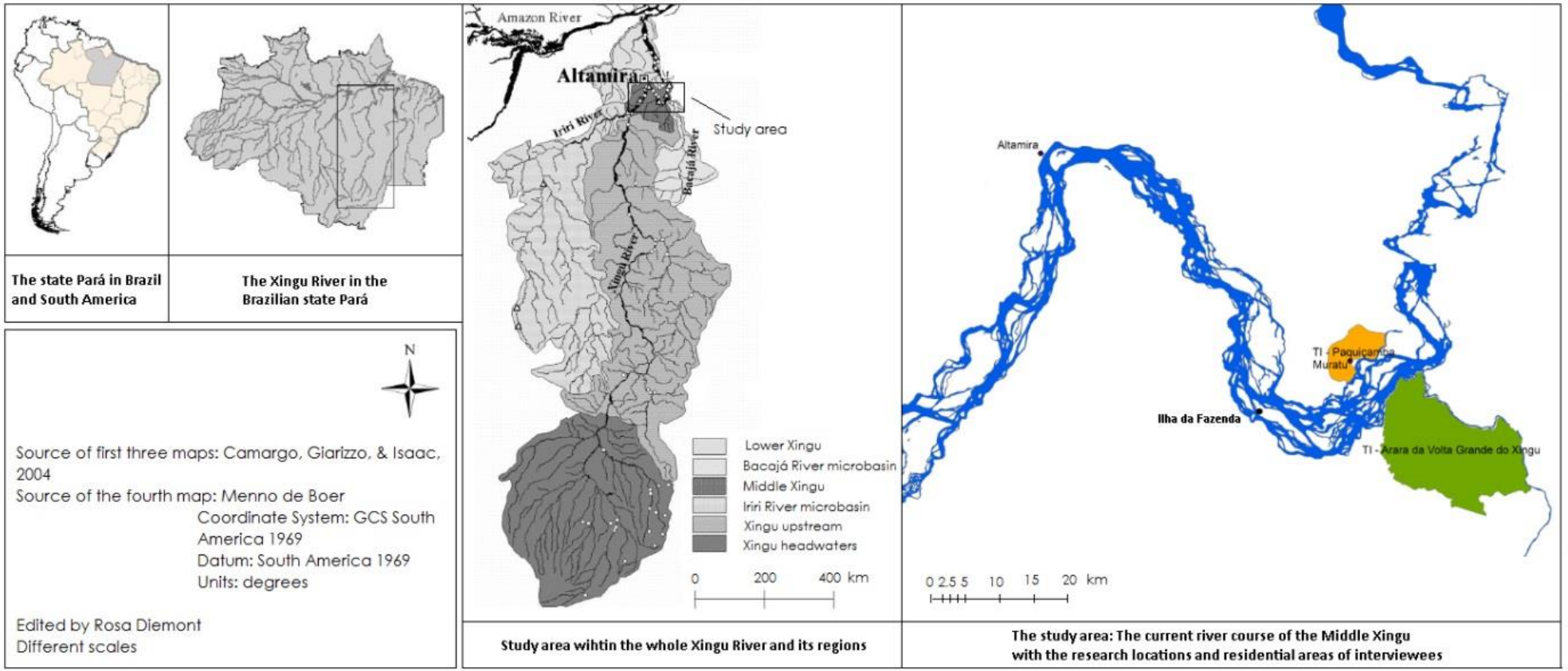


Figure 1. The location of the study area, the residential areas of interviewees in the Big Bend and the Xingu River within Brazil and the state Pará

3. Local context

Climatic conditions and seasonality

According to the international climatic classification system of Köppen, the predominant climate in the study area is humid tropical without a dry season, with a mean air temperature of 26 °C, a mean annual rainfall of 2,289 mm, and a short dry season occurring during August and September with average precipitation rates of 33.4 and 39.3 mm (Cunha & Valle Ferreira, 2012). The high water period of the Xingu River is in the months from March to May (winter season). The water level drops in the period between June to August (beginning of the summer). The river is driest between the months September and November (summer). In the months December to February the water level rises and the riverbanks get flooded again (beginning of the winter) (LEME Engenharia, 2008).

Hydroelectric dam Belo Monte

The most important reason for the construction of BHM in the Xingu River is Brazil's rapid economic growth over the last decade. This provoked a strong demand for new and stable sources of energy, especially to supply the growing aluminium and iron mining and manufacturing industries in the Eastern Amazon (Wohl, 2012). The capacity of the dam complex will reach 11,233 megawatts, which makes it the second-largest hydroelectric dam complex in Brazil and the third largest of the world in installed capacity. The current project includes the construction of two dams, one artificial canal, two reservoirs (one on dry land), and an extensive system of dikes (Eletrobras, 2010). The dam is financed by public funds of the Brazilian national development bank, BNDES (Banco Nacional de Desinvolvimento e Econômico e Social) (Instituto Ambiental, 2013). The construction costs are estimated between US$ 11 and 17 billion (Hance, 2012). The HBM complex was first proposed in 1989, but was defeated due to pressure by indigenous and social groups (The Rainforest Foundation, 2009). This raised international media attention attracting NGOs and celebrities like rock star Sting, Arnold Schwarzenegger, and the founder of Body Shop, Anita Roddick. The lobbying against the dam project ultimately resulted in the World Bank withdrawing its loan (Baptista & Thorkildsen, 2011). In April 2010, the government offered the project to the NorteEnergia S.A. The Brazilian environmental agency IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) granted the project an installation license in June 2011, and construction of the dams began in July 2011. In October 2014 the water course to the Big Bend will get dammed off. In February 2015 the first turbine will become active. The Canadian company Belo Sun is planning to build the largest gold mine next to HBM (Instituto Ambiental, 2013).
In August 2014, all indigenous villages along the Xingu River united in Muratu for two weeks to execute a farewell ritual of the Xingu River (Juruna, 2014).

Forecasted changes in the river patterns and ecosystem

As 80% of the river will be diverted through artificial channels to feed the turbines of HBM, the Big Bend of the Xingu River will suffer drastic reductions in water flow volumes and the seasonal flooding (Baptista & Thorkildsen, 2011). Figure 2 presents the expected impact, and its locations, of the dam on its surroundings. The Big Bend is known as one of the most important areas in the lower Amazon basin in terms of its flora, fauna and indigenous and riverbank communities. The combination of reduced water volumes and a reduced hydrological cycle in this area will certainly result in changes in the reproductive life cycles of many species. During the natural flooding period, when the river level rises 3 to 4 m, vegetation becomes partially or totally submerged. When the river flow decreases, faults and fractures of rock outcrops form a network of channels through which the water flows. The flora and fauna species occurring in this region (of which some are endemic) depend on this seasonal pattern. Moreover, the indigenous and riverbank communities depend highly on the river and its aquatic fauna for food and income (Cunha & Valle Ferreira, 2012). Some species are likely to disappear from the region. Studies on other dams in Brazil, like the Tucuruí dam show a 50% reduction in fish diversity downstream (Wohl, 2012).

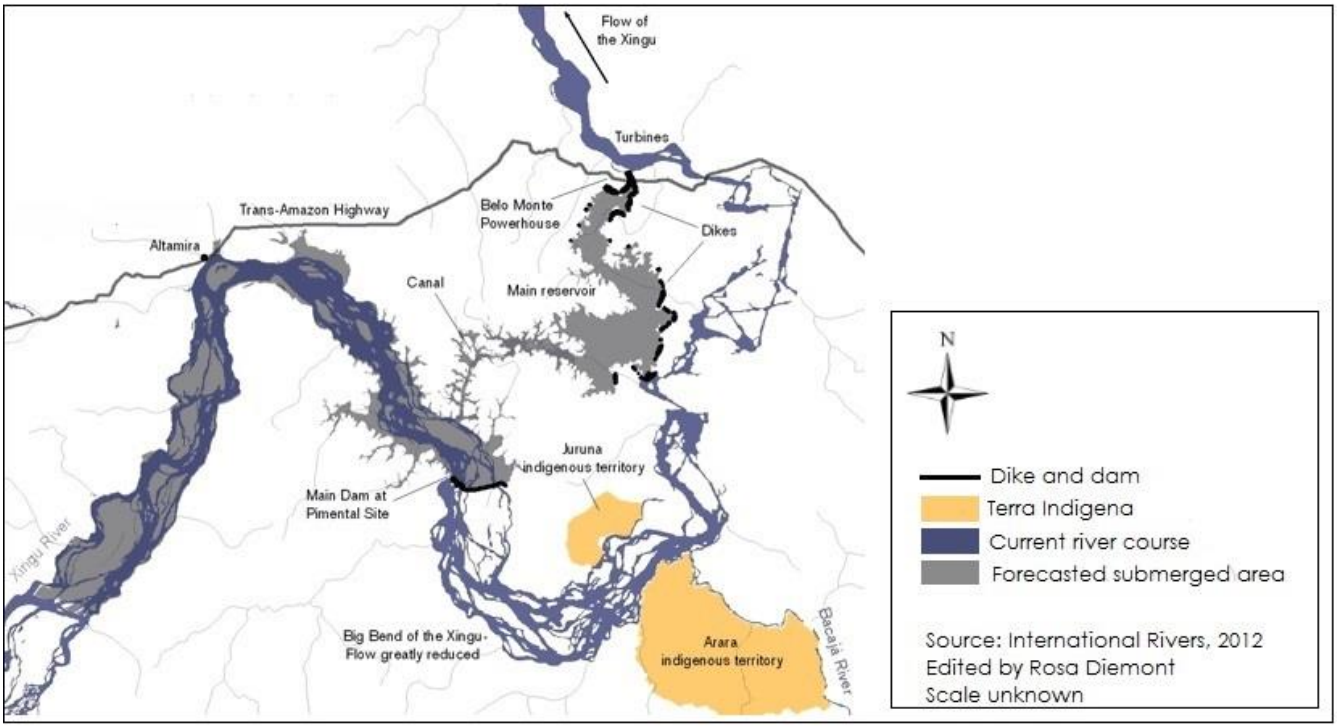


Figure 2. The impact prognosis of HBM on the course of the Xingu River

Socioeconomic situation of the Middle Xingu region

The first colonists who settled and formed riverbank communities along the watercourses of the Middle Xingu region practiced rubber tapping, and the mining of diamonds and gold. These were their major economic activities. Subsistence agriculture became the predominant means of survival. Fishing had always been a very important activity widespread in the region both for indigenous communities as for the colonists. In the 20th century the trade in cat skins (especially jaguar skins), the cultivation of black pepper and cocoa as cash crops contributed significantly to the local economy and the incomes of indigenous villages. The riverbank communities also raised cattle (Macedo, 2014). Late 1980, extractivism of ornamental fish became an economically viable alternative for riverbank and indigenous communities, who formerly maintained themselves exclusively by commercial fishing for human consumption and extraction of alluvial gold. Adapting old techniques used in gold mining at large depths, as the use of an air compressor, diving mask and lanterns, enabled the capture of ornamental species for national and international trade. This kind of extractivism is in many cases, the main source of income for hundreds of people in the Middle Xingu region. From this period, several species have become quite popular on the international market (Carvalho Junior, et al., 2009).

The ecosystem and ornamental fish species of the Middle Xingu region

The Xingu River is a clear water river and flows 1800 kilometres from the central savannah region, Mato Grosso to the Amazon River (Kricher, 2011). The Middle Xingu region and is very rich in aquatic fauna diversity, which is favoured by several geological events occurring from the upper to the lower Xingu estuary, like an extended and complex network of islands, inland forests, rock formations, resulting in waterfalls, rapids, and watersheds separating small streams (picture 3).

Picture 3. A panoramic view on the main channel of the Xingu River, its rapids, overflown islands and surrounding forests (Giarrizzo, 2011)

These habitats contributed to the large abundance of aquatic species. Rapids and waterfalls are responsible for a high water flow and well-oxygenated waters (Camargo, Giarrizzo, & Isaac, 2004). The natural barriers of waterfalls define restricted geographic distributions and so provoke endemism of species (Camargo, Carvalho Júnior, & Estupiñan, 2012). The surroundings of the river used to be covered by ombrophilous open forests. This region suffers from strong anthropogenic disturbance (Camargo, Giarrizzo, & Isaac, 2004), like soy monocultures and cattle ranching. Other terrain along the river is protected by indigenous reserves and conservation units where ethnic groups live. The Xingu River basin is home to 25,000 indigenous people from 18 ethnic groups (International Rivers, 2012).

In the Xingu River 55 ornamental fish species of the family *Loricariidae* occur. This fish are noted for the bony plates covering their bodies and their suckermouths. Several genera are sold as "plecos" or L-numbers, or sucker mouth armoured catfish. Some of the 55 *Loricariidae* species are endemic (Pedrosa Gonçalves, 2008): Acari Zebra (*Hypancistrus zebra*), Acari *Pão* (*Hypancistrus sp. "pão"*), Acari Zebra marrom (*Hypancistrus sp. "marrom"*), (*Pseudacanthicus leopardus*), and Acari Picota de Ouro (*Scobinancistrus aureatus*) (Camargo, Giarrizzo, & Isaac, 2004). Of this family 38 species are caught for ornamental purposes (Camargo, Carvalho Júnior, & Estupiñan, 2012). Other fish species captured for ornamental purposes in the Middle Xingu are two species belonging to the family *Cichlidae*, some species of the family *Serrasalmidae* and the stingray *Potamotrygon leopoldi* (Camargo, Giarrizzo, & Isaac, 2004).

Riverbank communities

Typical for fishermen of the city is that most of them undertake one-day trips, for which they rent a boat from the local trader, part in the morning, and return in the afternoon with the fish species demanded by the local trader. Fishermen from riverbank communities live in the rural areas of the municipality of Altamira.
The majority of fishermen is male, although a few are accompanied on trips by their wives. The wives also collect fish, but mainly in shallow waters. Collection of ornamental fish is closely linked to the hydrological cycle of the river (most fishermen are active in the summer, when the water level is low) and driven by market demand. Fishing occurs primarily in rapids and parts of the river with a strong current. The high demand for the fish make that a smaller group of fishermen dive in the winter period, when the water level is high and there is a strong current (Camargo, Carvalho Júnior, & Estupiñan, 2012). Production is primarily intended for the international market. By socio-cultural issues and the context of work, fishermen of ornamental fish are at the mercy of local traders (Carvalho Junior, et al., 2009)**.** The majority of the fishermen who collect ornamental fish attended primary education only. Around 10% of the fishermen is illiterate. Only 8% attended high school (NorteEnergia S.A., 2011).

The number of marketed ornamental fish species is greater than the number of species allowed by IBAMA, as some are endemic to the Middle Xingu and registered on the Red List of the Brazilian Fauna Threatened with Extinction. Due to the difficulties of monitoring, trade numbers of illegal species are not known. It is likely that there is a high rate of illegal trade of protected fish, as they are very popular on foreign markets and local fishermen receive a high price for these species, compared to unprotected species. Next to this, the number of fishermen under the legal age of 16 is high in the ornamental fish business. In riparian communities this fishing activity is being held in family or "neighbourhood groups" (Camargo, Carvalho Júnior, & Estupiñan, 2012).

Indigenous communities

This target groups is described on the basis of research in the village of Muratu. This village is located on the downstream riverbank in Big Bend of the Xingu River, in Terra Indigena da Paquiçamba Volta Grande and exists of decedents of the indigenous Juruna tribe. Muratu in one of the three villages in this TI and established two years ago. In Muratu, families live according a mixture of 'Western' standards and tribal habits. Almost every family owns a television, fridge, PlayStation, motorcycle and wears 'Western' clothing, but the traces of their indigenous background show in their genetics and culture: They are less mixed with other cultures, they are superstitious and make decisions based on traditional knowledge, they make and sell traditional jewellery, and talk proudly about their indigenous origin. The village is leaded by a 'cacique' or chief. The major source of protein is fresh water fish caught from the river with small nets, traps and fishing rod. Most men only fish for subsistence. Women also fish, but they stay close to the village and do not go on fishing trips. Both men and women practice small-scale diversified agriculture, using manioc as main staple crop. The recently planted agricultural plots are not running their full capacity yet, so the largest part of the diet is bought in Altamira. NTFPs are not collected frequently. The most important ones are Cupuaçu (*Theobroma grandiflorum*), Brazil nut (*Bertholletia excelsa*) and Açaí (*Euterpe oleracea*). Men hunt on game in the forested terrains of the

reserve. Villagers mention that the forested territory of Muratu is too small to commercialize NTFPs, which make the collection of ornamental fish the main commercial activity of this moment. This source of income gives the villagers ability to buy products they do not produce themselves, like rice, beans, meat, sugar, oil, and alcoholic beverages (information based on own observations and interviews with the villagers of Muratu).

Some local traders navigate the Xingu River to visit riverbank and indigenous communities, to buy the fish the community members collect.

Fishing practices

Accessories used to collect ornamental fish species are a diving mask, gloves (only used when collecting a spiny species), a thin wooden stick to pick the fish out of crevices and holes in rocks, a small gill net, and a perforated plastic jar to collect the fish under water. On the boat of the fishermen (most often a an wooden canoe of 6 meters long with an average vessel capacity of 150 kg or 500 kg, driven by a 3.5 to 5 HP motor) an oxygen tank is placed to which the fishermen is connected under water by a plastic hose. Sometimes fishermen capture the fish on shallow spots, where no oxygen tanks are needed. The fish are transported from the river to the local trader in Altamira in large plastic baskets. See picture 4, 5, and 6 for ornamental fishermen and their equipment. In most cases fishermen conduct fishing trips alone or in groups of two to five persons (Camargo, Júnior, & Estupiñan, 2012).

Collecting ornamental fish can be dangerous. There are several cases of fishermen with hearing disabilities because they did not achieve adequate decompression after diving at great depths, causing the rupture of eardrums. Other harmful health effects of this practice go from visual changes, hearing loss, nausea, and dizziness (symptoms of hypoxia), to death (when the oxygen compressor or hose suffers from problems) (Carvalho Junior, et al., 2009).

The extractivism of ornamental fish can be considered as a potentially harmful activity for the conservation of Amazonian biodiversity, because large amount of species are exploited without control. Of some species the taxonomy and ecological aspects are not even known yet (Carvalho Junior, et al., 2009). In addition, the transport process of the fish is not sustainable, as there is a lot of loss of fish during exportation. Another problem is the opportunistic character of the job, which makes it difficult to unite fishermen in an association to organise and control the activities (Melo de Sousa, 2014).

Picture 4. Ronaldo caught five Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"* (Diemont, 2014) Picture 5. Gelson Juruna shows two Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri 'xingu'*) (Folhapress, 2013) Picture 6. A 'rabeta'; a typical boat with fishing equipment (Diemont, 2014)

Trade in ornamental fish

Ornamental fish from the Amazon region are of great interest worldwide. The production chain of trade in ornamental fish includes five actors: fisherman, local trader, exporter, foreign merchant and final buyer overseas. See pictures 7, 8, 9, and 10 for the buying, stocking, and exporting process in aquaria of Altamira. Local traders pass on the species demanded by the exporter which usually depends on the demands of the foreign market (Carvalho Junior, et al., 2009). The difference between the price fishermen receive for a fish and the price paid by the final purchaser is alarming. An example is Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*), which is sold by the fishermen to the local traders for US$ 7, and can be bought by the final consumer for US$ 357 (Japan) or US$ 270 (the Netherlands) (Gonçalves, Camargo, Carneiro, Tambara, & de Paula, 2009).

Brazil is the second largest exporting country of ornamental fish in Latin America. The largest country is Colombia. In 2009 Brazil had an income of around US$ 7.107.000,- (trade value) out of ornamental fish. The largest importer of ornamental fish from Brazil is the Japan, there after USA, Germany, and Thailand. The Netherlands imported for US$ 77,972 from Brazil in 2009. Largest part of the ornamental fish come from small scale extractivism (Camargo, Júnior, & Estupiñan, 2012). Amazonas is the leading exporting state in Brazil, accounting for 90% of all production. The state of Pará generates around US$ 200-250.000 per year (Isaac & Barthem, 2004). The City of Altamira is considered the place to be for collectors of ornamental fish of the Middle Xingu region, as this city has an airport, which makes it possible to transport the fish to Manaus or Belém (Camargo, Carvalho Júnior, & Estupiñan, 2012). The fishermen of the Middle Xingu region used to be united in the association ACPOAT for fishermen collecting ornamental species, in which they found assistance with paperwork, regulations, and other problems. Since three years, this association is less active and no reunions take place anymore. The nearest city where other local traders operate is Belo Monte, with two operating local traders (NorteEnergia S.A., 2011). Some local traders navigate the Middle Xingu region to buy ornamental fish from riverbank and indigenous communities. This is very beneficial for these communities as it offers them a source of income, without paying transport costs to sell their catch in the city.

Picture 7, 8, 9, and 10. An overview of the purchasing process, stocking the fish, and the packing process before export at the aquaria of local traders (Diemont, 2014)

4. Results

4.1. Important ornamental fish species

Acari Amareli (*Baryancistrus xantellus*), Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri '*xingu'), Acari Zebra (*Hypancistrus zebra*), Acari Picota de Ouro (*Scobinancistrus aureatus*), and Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*) appear to be the five most important species for local fishermen. These species are mentioned by half or more of the local fishermen as most caught, preferred to collect, and share a large part in the mean income of local fishermen. Acari Tigre Comun (*Peckoltia vittata*) is only frequently caught in Altamira, and so appearing just once in the tables 1 and 2. The rest are at least mentioned twice as preferred or most caught. The complete tables can be consulted in appendix V.

Table 1. Most caught ornamental fish species (multi response)

		Altamira (n=21)	Muratu (n=10)
Scientific name	Common name	%	%
Scobinancistrus aureatus	Acari Picota Ouro	90	-
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	76	-
Baryancistrus xantellus	Acari Amareli	67	80
Peckoltia vittata	Acari Tigre Comun	57	-
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	-	50
Hypancistrus zebra	Acari Zebra	-	50

In Altamira fishermen mentioned eighteen species as being most caught. Four of them were mentioned by half of the respondents. In Muratu fishermen mentioned 16 species as being most caught, of which three were mentioned by more than half of the men.

Table 2. Preferred ornamental fish species (multi response)

		Altamira (n=20)	Muratu (n=8)
Scientific name	Common name	%	%
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	85	-
Scobinancistrus aureatus	Acari Picota Ouro	60	-
Hypancistrus zebra	Acari Zebra	50	88
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	-	63

In Altamira fishermen had 11 as being preferred species. Only three where mentioned by half or more of the respondents. In Muratu fishermen had five preferred five species of which two were mentioned by more than half of the men.

Share of fish species in the income of local fishermen

The most important species considering the contribution to the income of local fishermen are the same species which are most caught and preferred to collect. In figure 3, their share in the income of local fishermen is shown. In Altamira and Muratu a broader total range of fish is captured in the summer than in winter. In the summer, the total number of species contributing to the income of fishermen of Altamira is 19, in Muratu this number is 16 (here the five important species are included). In Muratu in the winter season a smaller number of species provide the fishermen from income (six species form the section 'other' in figure 3). This means that in Muratu the fishermen mainly live from the five important species in winter. In Altamira a total 17 species contribute in the winter season to the fishermen's income (12 species form the section 'other').

Acari Picota de Ouro (*Scobinancistrus aureatus*), Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*) are important sources of income in the winter for fishermen of Altamira. In Muratu Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri 'xingu'*) and Acari Zebra (*Hypancistrus zebra*) are important sources of income in the winter. Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*) does not contribute to the winter income of fishermen of Muratu, as this fish is not abundant close to the village. In the summer season the share of 'other' fish species is quite large in Altamira. In Muratu Acari Zebra (*Hypancistrus zebra*) is very important for the summer income.

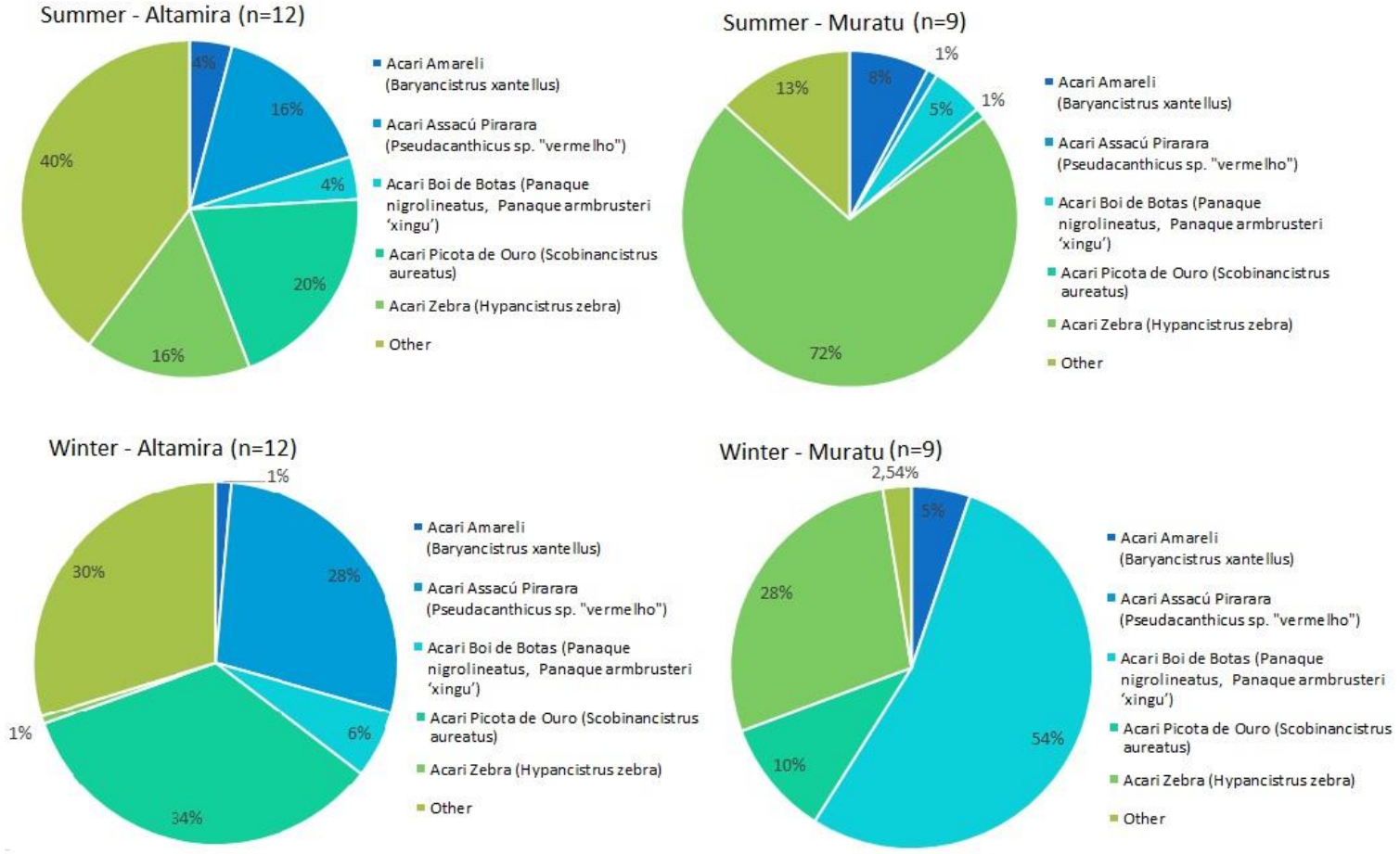


Figure 3. Share of the five important fish species in the income of local fishermen

Reasons of fishermen for the indication of important species

Looking at the reasons why the above named species are caught often and are preferred by the fishermen, it appears that there are a couple of leading factors: price, demand of the local trader (the two most important incentives), abundance and appearance of the species, and the effort to collect the species, which in some cases depends on the season. The catch frequency of species is mostly dominated by the demand of the local trader. This determines to a great extent the daily work scheme of the fishermen, especially for the fishermen who live in the city and have frequent contact with the local trader. The price fishermen receive per species is an important factor in determining importance, as preference of fishermen for particular species is dominated by this. Therefor a list of prices of April to June 2014 with the most common species was established (table 3), to see if there are similarities with the above mentioned species and the prices. This price list is taken as a starting point, to discuss the reasons fishermen gave to mention the important species.

Table 3. Prices of ornamental fish from April to June 2014, sold in Altamira

Scientific name	Common name	Average price R$	Average price US$
Potamotrygon leopoldi	Raia Pintada	75.00	33
Hypancistrus zebra	Acari Zebra	42.80	19
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	16.82	7
Hypancistrus sp. "marrom"	Acari Zebra Marrom	5.00	2
Hypancistrus sp. "pao"	Acari Pão	3.50	1.5
Baryancistrus chrysolomus	Acari Aba Laranja	3.35	1.6
Scobinancistrus aureatus	Acari Picota Ouro	2.94	1.3
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	2.75	1.2
Scobinancistrus pariolispos	Acari Cutia Preto	1.10	0.5
Leporacanthicus heterodon	Acari Onça	1.00	0.4
Baryancistrus xantellus	Acari Amareli	0.89	0.4
Hemiancistrus sabaji	Acari Tigre de Poço	0.75	0.3
Oligancistrus punctatissimus	Acari Bola Azul	0.50	0.2
Peckoltia vittata	Acari Tigre Comun	0.50	0.2
Ancistrus ranunculus	Acari Preto Velho	0.50	0.2
Ancistrus sp., Pseudancistrus sp.	Acari Cara Chata	0.50	0.2
Oligancistrus sp.	Acari Bola Branca	0.50	0.2

Although stingray Raia Pintada (*Potamotrygon leopoldi*) gives the highest price for fishermen, it was never mentioned as preferred species, because of the risk of being pinched by its sting and the erratic pattern of demand from local traders due to quotas. Acari Zebra (*Hypancistrus zebra*) is the next most expensive fish and highly preferred by both fishermen from Altamira as fishermen from Muratu. Most important reason for this preference is that this fish is the only fish which gives a high price throughout the whole year, especially in the summer (in which the price of the ornamental fish drops as it is easier to collect ornamental fish when the water level is less high and more fishermen become active). Acari Zebra (*Hypancistrus zebra*) is not frequently caught by fishermen of Altamira, because this fish is not allowed by law to collect. Legal local traders refuse to buy this fish, as it is very risky for their businesses when control takes place. Fishermen of Muratu do collect this fish often and sell this fish to clandestine local traders. Next to the high price, fishermen mention that this species is not only found water with a high current, but also in calm, shallow waters, which makes it less dangerous to capture this species (compared with other species). Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*) is preferred and often caught by Altamira's fishermen, because of its high abundance close to the city and tis high price. This fish is not mentioned by fishermen of Muratu, as this fish does not occur abundantly in the surroundings of the village. Acari Zebra Marrom (*Hypancistrus sp. "marrom"*) and Acari Pão(*Hypancistrus sp. "pao"*) also have a high price, but are not preferred as these species are found in very deep waters, which makes it difficult to dive for them. Acari Picota Ouro (*Scobinancistrus aureatus*) and Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri '*xingu') are also preferred species as these fish are relatively easy to collect in the winter period when these fish leave the main channel (where the current is very strong in winter) and migrate to the overflown island of the river. Despite the low price, Acari Amareli (*Baryancistrus xantellus*) is also a preferred species of fishermen both in Muratu as in Altamira because this fish is relatively easy to collect and very abundant. Acari Aba Laranja (*Baryancistrus chrysolomus*) gives also a high price but is not preferred or most caught because of its low abundance in the Middle Xingu region. The rest of the fish with a lower price only serve as complementation to the income of the fishermen. When the fishermen are looking for a specific species to collect, all other easy encountered species are also taken to the aquarium, to contribute to the total income. The fish with a lower price are also caught when the local trader specifically ask for them.

4.2. Impact on ornamental fish

To get a better understanding of the impact of the dam on the five most important species for local fishermen some aspects of the habitat and ecology are assessed. The information on these species (Acari Amareli (*Baryancistrus xantellus*), Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri '*xingu'), Acari Zebra (*Hypancistrus zebra*), Acari Picota de Ouro (*Scobinancistrus aureatus*), and Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*)) is combined with literature to make a prognosis on what will happen to each species (which is presented in chapter 5). Some local terms are used to describe the aspects of habitat and ecology, as the translation to English itself does not covers the meaning completely. Appendix VI contains an overview of explanations on local terms for river habitats, elements and organisms.

4.2.1. Ecological aspects and habitats of the five important fish species

Acari Zebra (*Hypancistrus zebra*)

Habitat summer	"Remansos" and "poços"
Habitat winter	"Remansos" and "poços". These locations differ per season, as the river contains less water in the winter period. Acari Zebra follows this fluctuation
Reproduction period (spawn and juvenils)	August - October
Reproduction habitat: eggs	"Remansos" and "poços". Eggs are spawned in holes and fractures of rock formations and "mocororo" rocks
Reproduction habitat: juvenile fish	"Remansos" and "poços". The juvenile fish remain in and around the holes and fractures of rock formations and "mocororo" rocks
Alimentation summer	Living algae on stones, small crustaceans, and a white fresh water sponge with microorganisms
Alimentation winter	Living algae on stones, small crustaceans, and a white fresh water sponge with microorganisms
Current (1 = 'very strong'; 5 = 'stagnant')	3
Minimum depth (m) summer	0.05
Maximum depth (m) summer	40
Minimum depth (m) winter	1
Maximum depth (m) winter	50
Already noticed impact on this species	This species already occurred less before the dam constructions started, because of overexploitation and uncontrolled illegal trade. The past four years the dam is built on the most important fishing location, where this species occurred abundantly. Downstream the dam, juveniles and adults are weaker nowadays; individuals die faster, their skin turns red and the tail drops off after being captured. Another problem downstream is the sediment covering the living algae, which is an important food source for the fish.
Future perspective for this species	All fishermen believe the dam will have a negative influence. The dam will provoke the extinction of this species, because of the location of the dam, the disappearance of current in the reservoir of Altamira (this fish needs current and oxygen rich, clean water) and the reductions in water flow volumes and the seasonal flooding downstream the dam (the number of “remanso” habitats will decrease in the Big Bend. The only habitat where this species could remain, if it survives, are “poços”, as the water is cold here (because of depth). Here the number of reproduction locations (holes in rock formations) will decrease as rocks will appear above the water surface, due to the reduced water flow. The fishermen think that another problem in the Big Bend will be that because of the reduced water level lots of fishermen will be attracted to catch this species, as it very easy to catch it when the water level is low. All fishermen are aware of the fact that this species is endemic. They think this species cannot live on other locations of the river or adapt to the new situation and think this species will only survive by captive breeding.

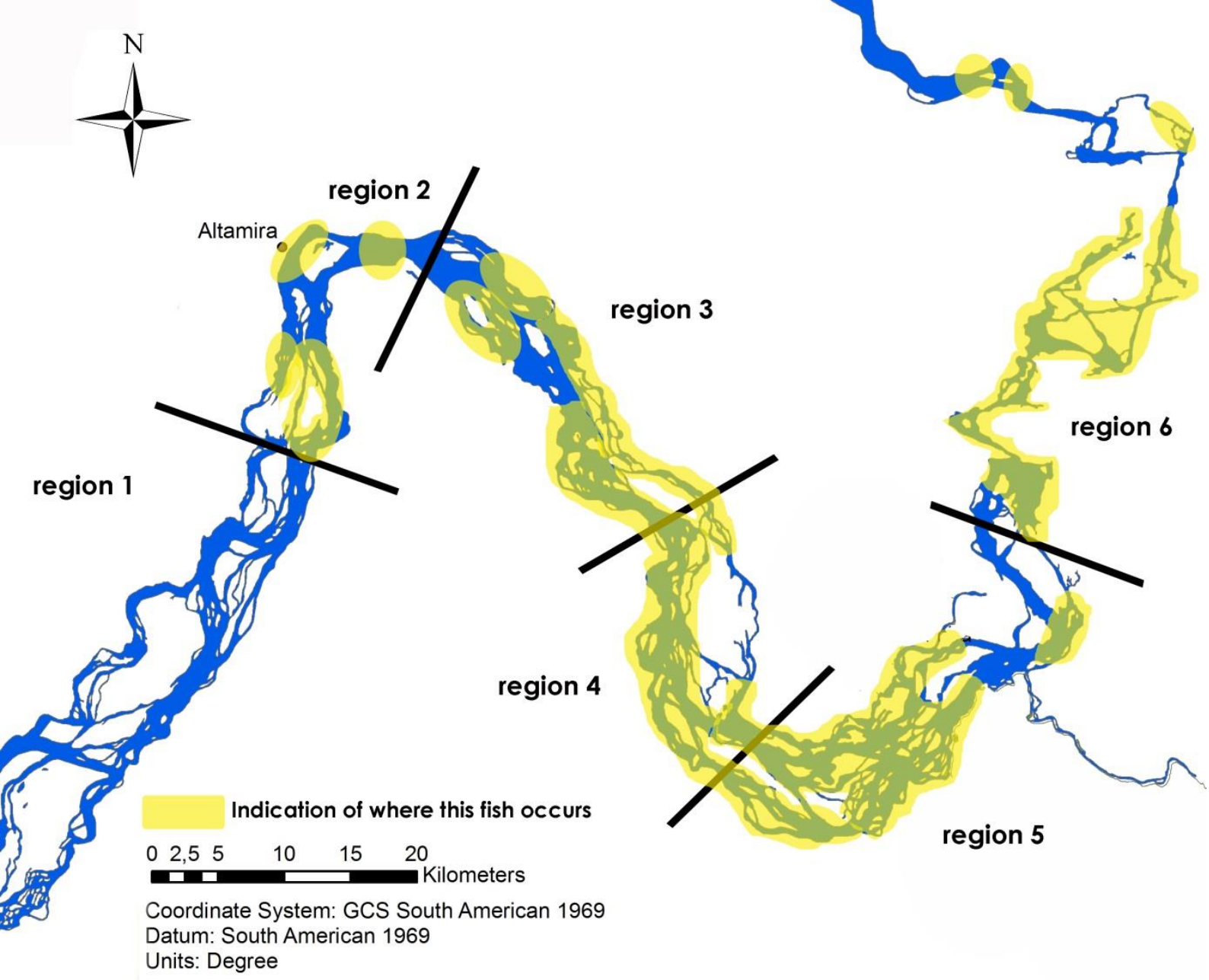


Figure 4. Fishing map, showing the regions where Acari Zebra (Hypancistrus zebra) occurs and is caught by local fishermen (n=15)

In figure 4, the region is indicated of where Acari Zebra (*Hypancistrus zebra*) occurs and is caught by local fishermen. The fishing spots on this map are used in both the winter and summer season. Before the construction work for the dam started, region four was the principal fishing location for Acari Zebra (*Hypancistrus zebra*). It is now prohibited to fish in this fishing spot, because of construction work for the dam. Most fishermen had to change fishing location because of this and moved to surrounding areas, where this species is less abundant. Catch pressure of this species is mostly concentrated in the fishing location in the regions four, five, and six. This is because almost no fishermen of Altamira collect this fish anymore. By the fishermen of Muratu this fish is very frequently collected.

Acari Assacú Vermelho (*Pseudacanthicus sp. "vermelho"*)

Habitat summer	"Corredeiras", "poços", and the main river channel
Habitat winter	"Beira da ilha", "Corredeiras", "poços", and the main river channel
Reproduction period (spawn and juvenils)	October - March
Reproduction habitat: eggs	"Corredeiras", "poços", but mostly the main river channel. The eggs are spawn in fractures of and under rock formations and mocororo rocks
Reproduction habitat: juvenile fish	"Corredeiras", "poços", but mostly the main river channel. The juvenils remain around the rock formations and mocororo rocks
Alimentation summer	Living algae on stones and the white fresh water sponge
Alimentation winter	Living algae on stones and the white fresh water sponge and living algea on fallen trunks and decomposed wood
Current (1 = 'very strong'; 5 = 'stagnant')	2
Minimum depth (m) summer	1
Maximum depth (m) summer	25
Minimum depth (m) winter	1
Maximum depth (m) winter	30
Already noticed impact on this species	More than half of the fishermen (67%) mention that the last years the abundance of this fish has decreased. Others (33%) did not noticed any differences. Fishermen who noticed changes say that the fish is weaker and dies easier after being captured (as also mentioned by local traders), and that the fish is thinner now because of the coverage of living algae by sediment.
Future perspective for this species	All fishermen believe the dam will have a negative influence on this fish, but that it will remain in other parts of the Xingu River. According to them, the fish will reduce significantly in quantity, both in the reservoir (stagnant water with chemical pollution of decomposing vegetation, oxygen-poor water) and downstream the dam (because of sediment, increased water temperature, lack of current and depth). If the fish remains in the reservoir at Altamira, the fishermen think the fish will be located too deep to catch it. Another important problem is the principal reproduction spot for this species in front of the city of Altamira. Fishermen think that this spot will be damaged with the formation of the reservoir.

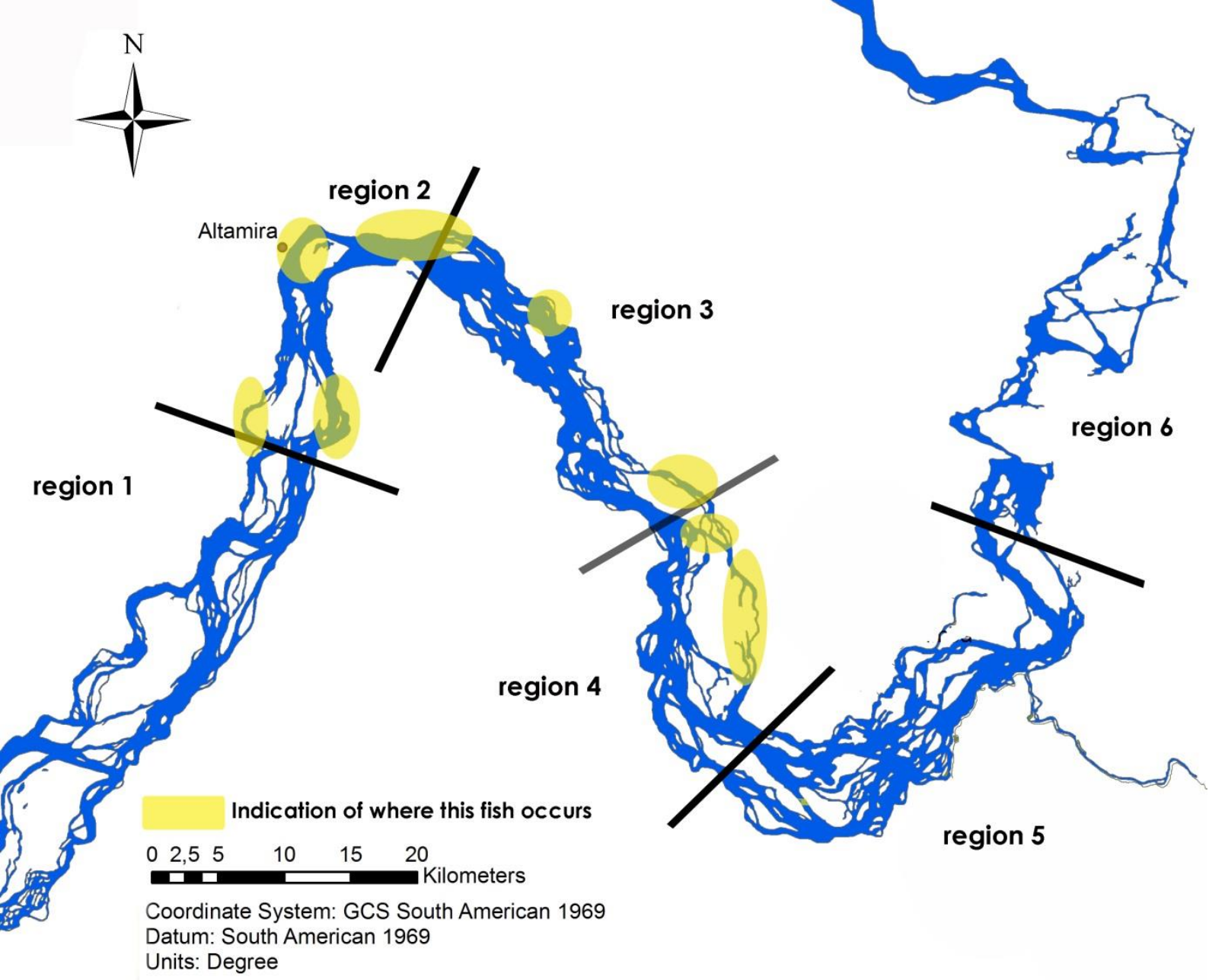
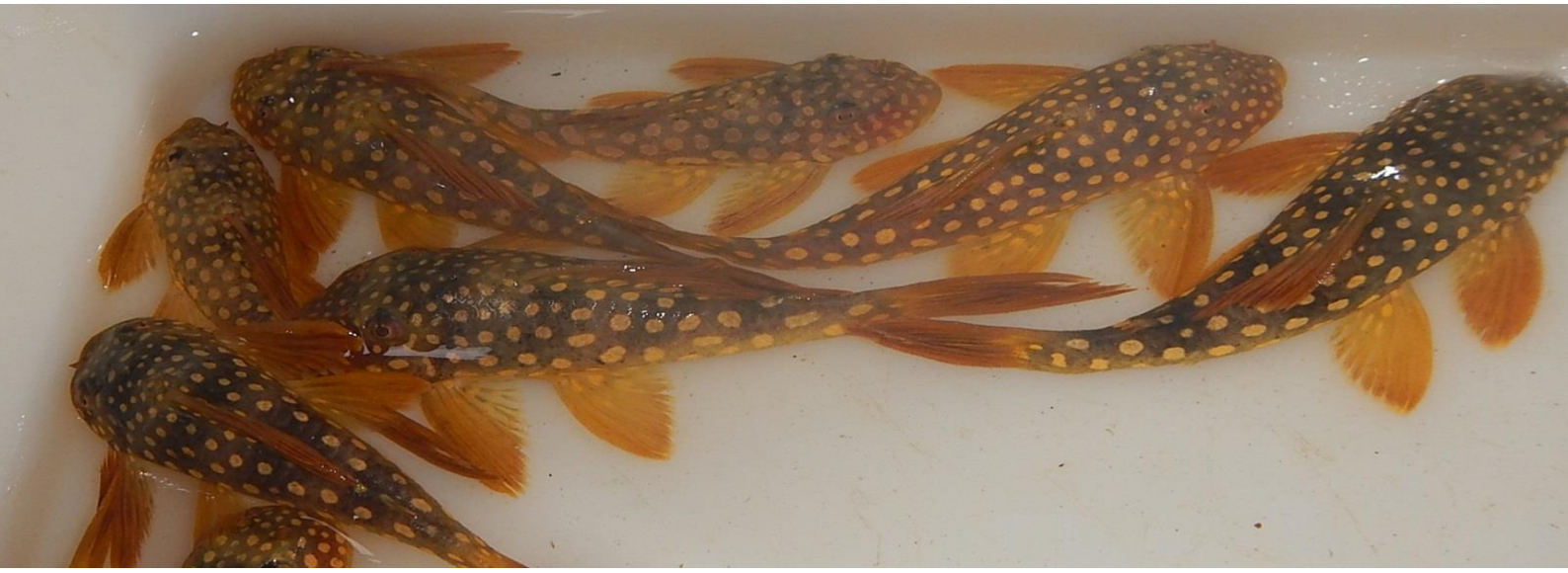


Figure 5. Fishing map, showing the regions where Acari Assacú Vermelho (*Pseudacanthicus sp. "vermelho"*) occurs and is caught by local fishermen (n=4)

For figure 5, 14 fishermen were asked about the fishing locations they use to collect Acari Assacú Vermelho (*Pseudacanthicus sp. "vermelho"*), but only four collect this species. This is because in Muratu no one collects this species, as it does not occur in region five. In front of Altamira this species is only caught in the winter period as this species reproduces here in this time of the year. This spot is the main location to collect the fish for fishermen of Altamira. On the rest of the spots, this fish is only collected in the summer season. Before the construction of the dam started region four was used by the fishermen to collect this fish. Nowadays the fishermen do not collect this fish here anymore. Catch pressure of this species is more or less equally spread over the different locations.

Acari Picota de Ouro (*Scobinancistrus aureatus*)



Habitat summer	"Corredeiras", "lajems", "poços", and the main river channel
Habitat winter	"Beira da ilha" and "Saroba". This fish moves from the main river channel towards overflown islands and overflown vegetation to feed and lay eggs
Reproduction period (spawn and juvenils)	December - January
Reproduction habitat: eggs	"Beira da ilha". This fish spawns its egg in holes of decomposing wooden trunks which are located in the river. Sometimes the eggs are found under stones in "Corredeiras" and "poços".
Reproduction habitat: juvenile fish	"Beira da ilha". The juvenile fish remain in and around the decomposing trunks
Alimentation summer	Living algae on stones, the white fresh water sponge, and small crustaceans
Alimentation winter	Living algea on fallen trunks and decomposed wood
Current (1 = 'very strong'; 5 = 'stagnant')	2
Minimum depth (m) summer	0.5
Maximum depth (m) summer	20
Minimum depth (m) winter	1
Maximum depth (m) winter	20
Already noticed impact on this species	Half of the fishermen (50%) say this fish is already influenced the last years by the dam and that the occurrence has decreased. The fishermen noticed that the fish is weaker and dies easier after being captured, because of sediment and chemical pollution of the dam.
Future perspective for this species	All fishermen believe the dam will have a negative influence on this species. In the Big Bend downstream the dam (because of sediment, increased water temperature, lack of current and depth) the fish will decrease in quantity. In the reservoir at Altamira (stagnant water with chemical pollution of decomposing vegetation, oxygen poor water) the fish is likely to disappear. Next to this the fish needs a “beira da ilha” habitat for reproduction. Most fishermen (77%) think that this fish, at the impacted areas, will not adapt to the new situation, the moment the dam functions fully.

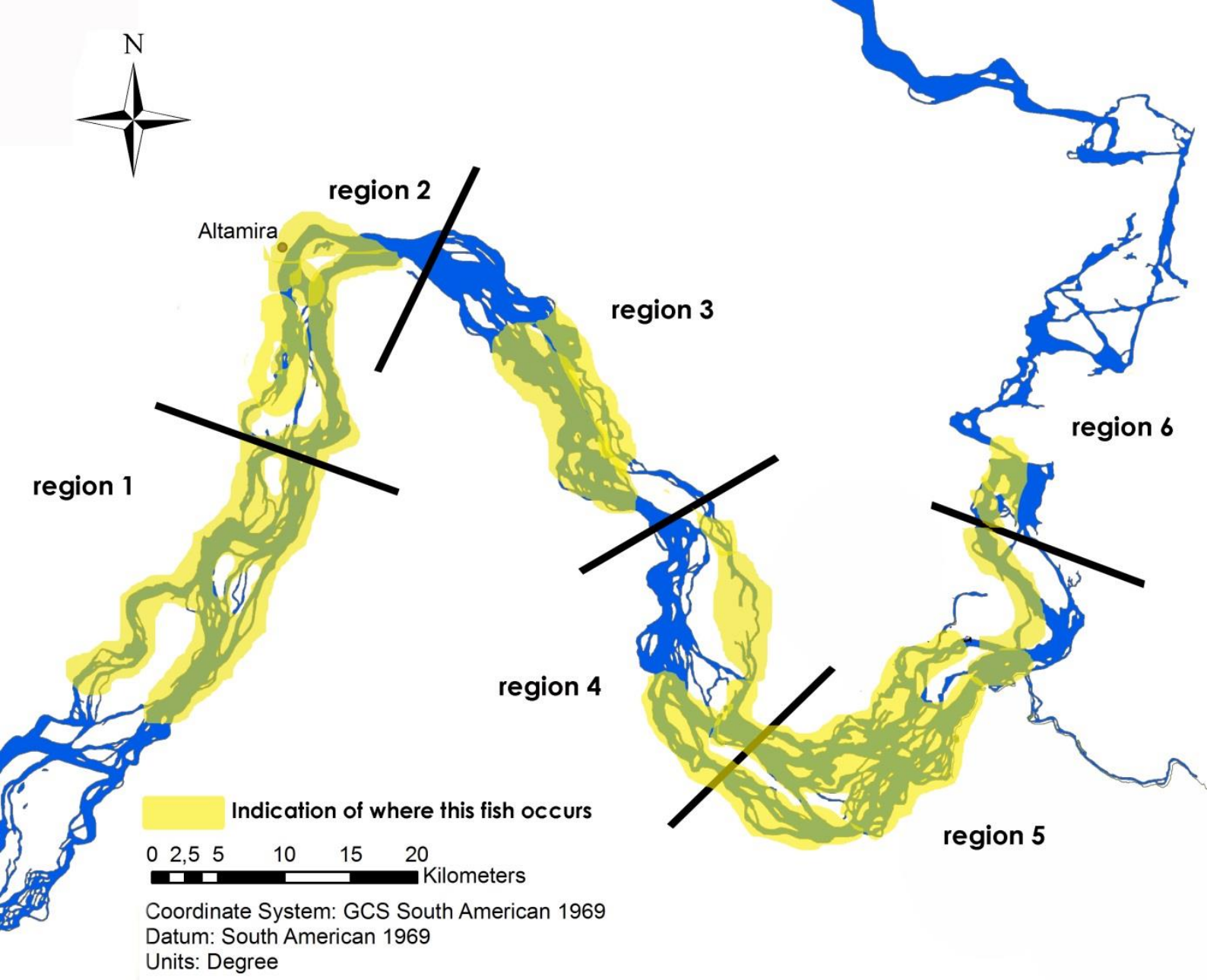


Figure 6. Fishing map, showing the regions where Acari Picota de Ouro (*Scobinancistrus aureatus*) occurs and is caught by local fishermen (n=11)

Looking at figure 6, the fishermen of Muratu only collect this species in the winter season, in region four and five. The fishermen of Altamira mostly use the fishing locations of region one, two, and three, also only in the winter season. One fisherman stated that he collects this species in region one in the summer season. Before the construction of the dam started region four was used by the fishermen to collect this fish. Nowadays the fishermen do not collect this fish here anymore. Catch pressure of this species is quite equally spread over the different locations.

Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri 'xingu'*)

Habitat summer	"Corredeiras", "lajems", "poços", and the main river channel
Habitat winter	"Beira da ilha" and "Saroba". This fish moves from the main river channel towards overflown islands and overflown vegetation to feed and lay eggs
Reproduction period (spawn and juvenils)	November - April
Reproduction habitat: eggs	"Beira da ilha" and "Saroba". This fish spawns it eggs in holes of trunks and between and under leaves, branches and trunks located in the river.
Reproduction habitat: juvenile fish	"Beira da ilha" and "Saroba". When the water level of the river drops when summer arrives the juveniles migrate to the summer habitat
Alimentation summer	Living algae on stones, the white fresh water sponge, and small crustaceans
Alimentation winter	Living algae on stones, the white fresh water sponge, small crustaceans and living algea on fallen trunks and decomposed wood
Current (1 = 'very strong'; 5 = 'stagnant')	2
Minimum depth (m) summer	0.1
Maximum depth (m) summer	30
Minimum depth (m) winter	0.1
Maximum depth (m) winter	20
Already noticed impact on this species	Half of the fishermen (50%) say that this fish is already influenced the last years by the dam. They mention that the occurrence of this fish decreased the past years, the individuas which are caught nowadays are smaller than before, which influences reproduction negatively. Next to this the living algae is currently covered with sediment, which also has a negative influence.
Future perspective for this species	All fishermen believe the dam will have a negative influence on this fish species. In the Big Bend (because of sediment, increased water temperature, lack of current ann depth) the fish is likely to disappear. Of the fishermen 44% think that the fish will remain in the reservoir at Altamira despite all environmental problems. The other 66% of fishermen think this fish will not remain here either. All fishermen agreed that this fish needs "beira da ilha" and "saroba" habitat for reproduction; the two habitats which will heavily decrease in number both in the reservoir as in the Big Bend

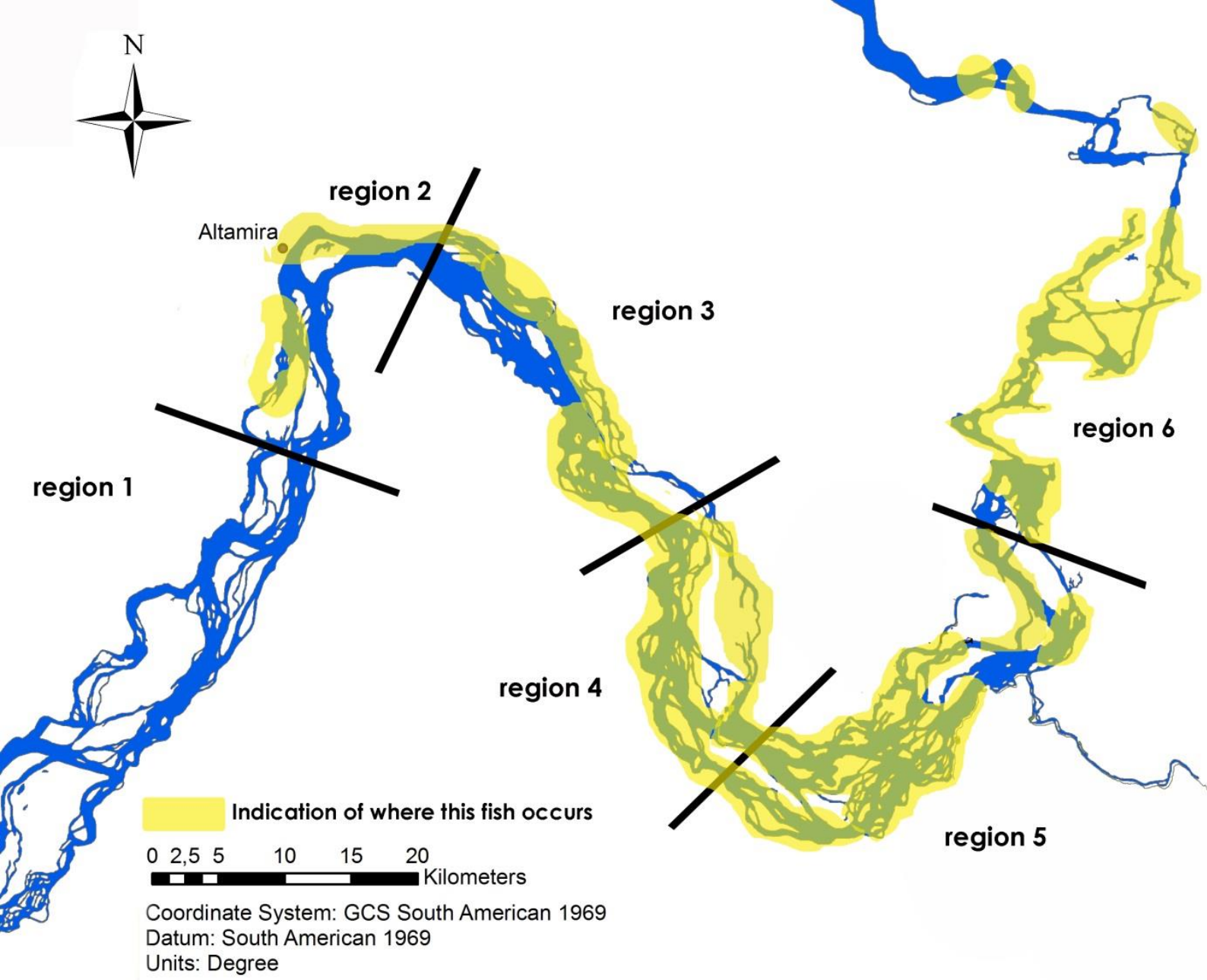
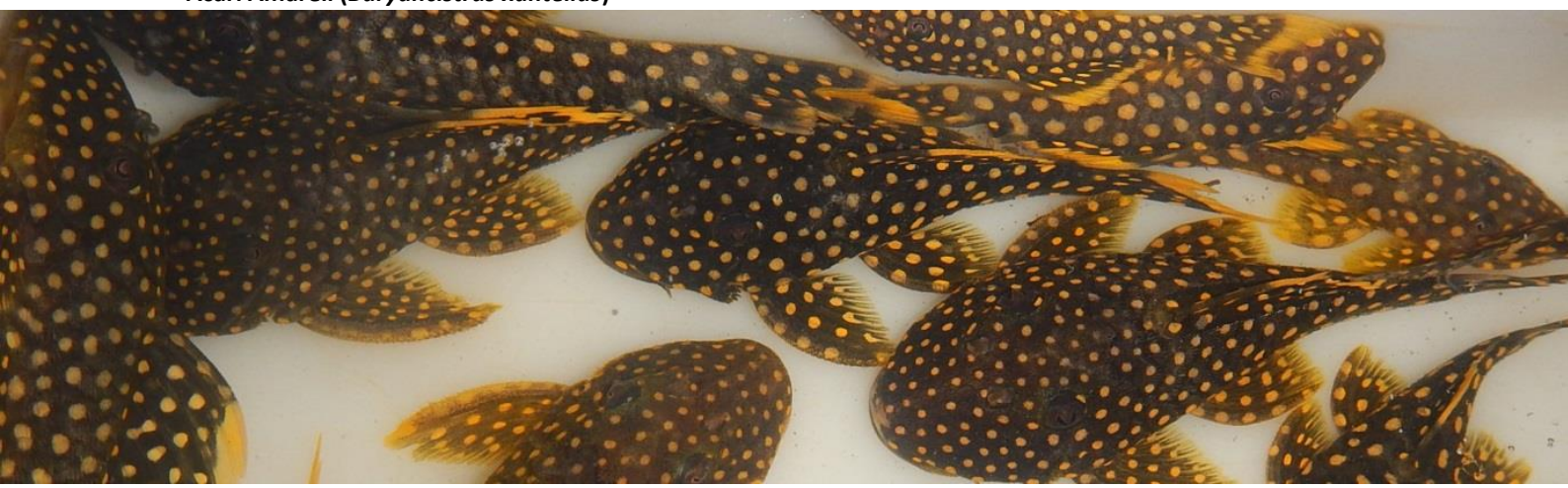


Figure 7. Fishing map, showing the regions where Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri 'xingu'*) occurs and is caught by local fishermen (n=13)

Most fishermen (8 of the 13) only collect this fish in the winter period. Before the construction of the dam started region four was used by the fishermen to collect this fish. Nowadays the fishermen do not collect this fish here anymore. The chief of Muratu explained that this species (and probably also the other four important species) disappeared from this region as the water volume in some channels here decreased significantly already. Some channels are even dry now. Catch pressure is concentrated in the region three, four, and five, as this fish species is very popular among fishermen of Muratu.

Acari Amareli (*Baryancistrus xantellus*)



Habitat summer	"Corredeiras" and "lajems"
Habitat winter	"Corredeiras" and "lajems". This fish has no movement or migration pattern
Reproduction period (spawn and juvenils)	August - September and November - January
Reproduction habitat: eggs	"Corredeiras" and "lajems". Here the eggs are spawn under rocks or in holes of the rock formation
Reproduction habitat: juvenile fish	"Corredeiras" and "lajems".
Alimentation summer	Living algae on stones, the white fresh water sponge, and a grey fresh water sponge with spines
Alimentation winter	Living algae on stones, the white fresh water sponge, and a grey fresh water sponge with spines
Current (1 = 'very strong'; 5 = 'stagnant')	2
Minimum depth (m) summer	1
Maximum depth (m) summer	10
Minimum depth (m) winter	1
Maximum depth (m) winter	10
Already noticed impact on this species	Most of the fishermen (60%) say that occurrence of this fish decreased the past years. This observation is not only related to the dam, according to two fishermen: Overexploitation occurs because of the high demand for this species for consuming purposes. Due to the population growth of the city of Altamira, less big individuals are found. Another fisherman mentioned that this fish disappeared at locations where there is sediment, caused by the construction activities at the dam. Downstream the dam this fish is weaker nowadays; individuals die faster, and the fishes are less fat, because of the sediment covering living algae, which is an important food source for the fish.
Future perspective for this species	All fishermen think the dam will have a negative influence on this species. All mentioned that the fish will remain (although reduced in quantity) downstream the dam (because this fish likes “corredeiras” habitats, which will remain). The water has to be clean an clear from sediment, though. This species will disappear at the reservoir of Altamira (because of the disappearance of current, chemical pollution of decomposing vegetation, and the high water level). Some fishermen mentioned that this species is quite common and widespread throughout the Xingu River and other rivers (Irirí River), so the impact of the dam will be less damaging for this species.

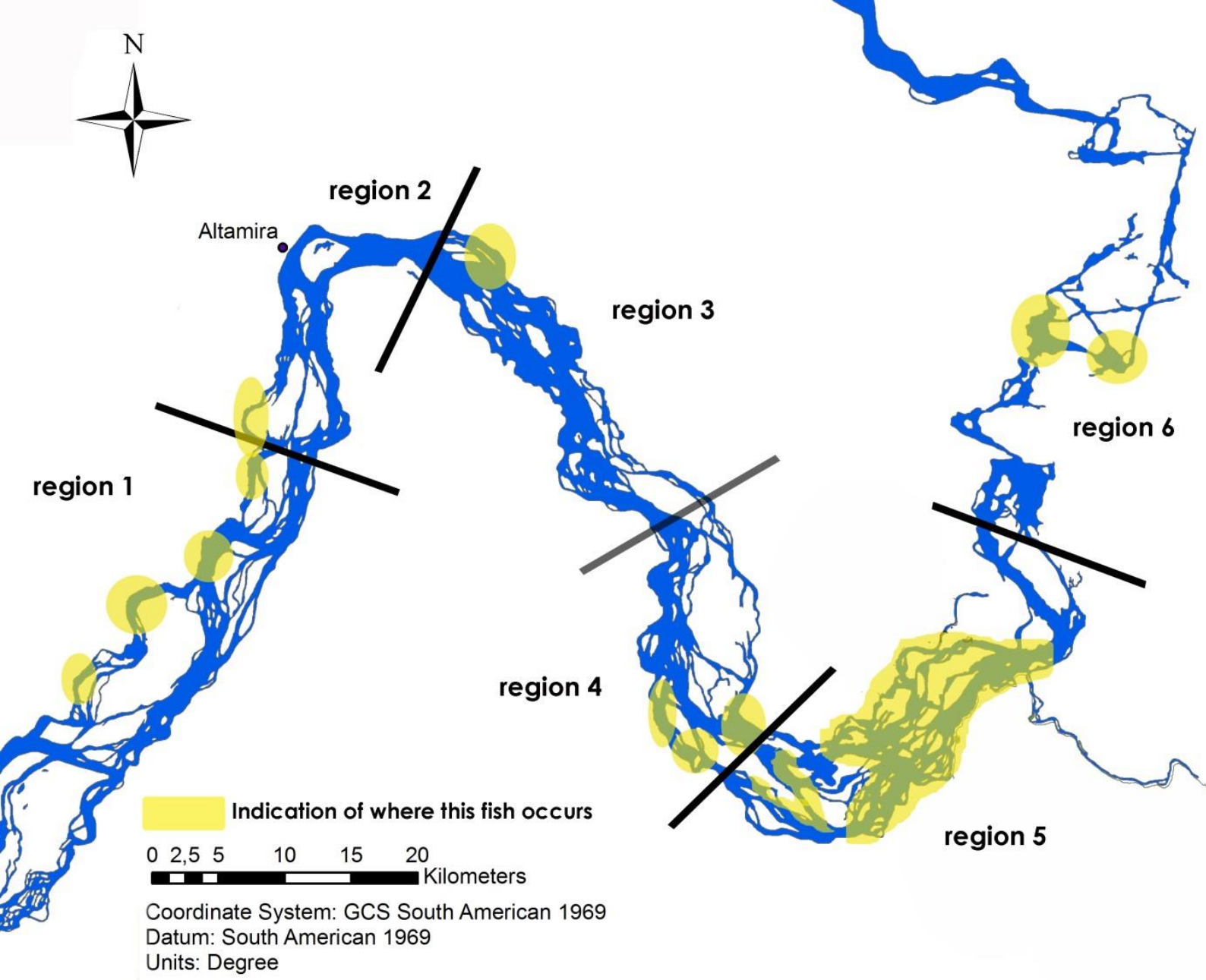


Figure 8. Fishing map, showing the regions where Acari Amareli (*Baryancistrus xantellus*) occurs and is caught by local fishermen (n=6)

The fishing locations of Acari Amareli (*Baryancistrus xantellus*) are the same for the summer and winter period. The fishermen did not change their catch location or moved to other spots because of the dam. Catch pressure is equally spread over the fishing location in the regions. Fishing locations for this fish are quite concentrated close to the residential areas. This is probably because this species is quite abundant throughout the whole course of the Xingu River, as shown on figure 8. This means that fishermen do not have to navigate far to collect this species.

4.2.2. Impact of the dam on the Big Bend area

The dam which blocks of the water course in the Big Bend will let running through a minimum of 700 m^3/s in the summer period and 4,000m^3/s in the winter period. The predicted maximum is just 8,000 m^3/s, which is not even a third of the maximum value of the full natural Xingu River. These flow rates are far below the natural pattern of around 23.000 m^3/s (at its peak), and withholds unforeseen natural irregularities. In a critical review on the by NorteEnergia S.A. written EIA (Environmental Impact Assessment), the authors mention that this water flow will be not sufficient to maintain the same fish communities as in the current situation. Later in the report they even mention that all fish species living in the Big Bend will not survive under the imposed flow regime (Santos, Barbosa, & Hernandez, 2009).

An immediate consequence of reducing the volume of water is a reduction of the physical available space for fish communities. According to the authors of the critical review on the EIA this leads to the disconnection of trees and vegetation of the habitats like 'saroba' and 'beira da ilha' from the water. Vegetation will not reach the water anymore and suffer from water stress. These habitats will probably disappear in a near future when the dam fully functions. Next to this, the remaining trees further from the river will also be impacted and the species composition will change, since the patterns of flow, river level and the hydrodynamic will change. Consequently, these changes are reflected on the fish communities that depend on these plants, especially those that live attached to their trunks, branches and roots (Santos, Barbosa, & Hernandez, 2009).
By the reduced volume of water the habitats 'remansos', 'poços' will decrease in number. The 'poço' habitat will remain as these are very deep parts of the river, but the quantity of water in it will be reduced. Probably the number of 'corredeiras' and 'lajems' will decrease as well, as these are shallow parts of the river. The current parts probably will remain without water and the deeper rock formations will be exposed at the surface.

4.2.3. Impact of the dam at the reservoirs in the region of Altamira

Fish communities which are benthic (living on the bottom of the river) and fish which are heavily restricted to rock formations and rapids will suffer a severe negative impact of the dam, especially in the reservoirs. The first problem will be the sedimentation and siltation which will influence the trophic relations between species, depending its chemical constitution and the dynamics of the water. It is expected that sediment will be quite harmful, because it will lead to increased turbidity and a reduced oxygen content of the water.
Also because of the reduction in speed of the current and the increased volume of water oxygen levels will drop in the reservoirs. Another problem will be the reduced production of algae (which live on the bottom of the river and are adapted to a strong current) by the decrease in light on the river floor (Santos, Barbosa, & Hernandez, 2009).

In the reservoir area lentic or species adapted to less current will be favored (Santos, Barbosa, & Hernandez, 2009). The five important species for local fishermen are not among these species, and are adapted to live on locations with a high current (fishermen indicated all species as needing a 'strong current', except for Acari Zebra (*Hypancistrus zebra*) which gets an intermediate indication for the current of its habitat). The five important species have as primary source of alimentation the algae growing on the river floor. All five important fish species need well-oxygenated waters to live in. The five species are accustomed to live at great depths, as the depths that will exist in the main reservoir.

4.3. Impact on local fishermen

Current problems with fishing

Almost all interviewees (92%) stated that the number of ornamental fish has decreased, due to the construction of the dam. In table 4, on next page, the main problems and their causes are discussed. The problems all have to do with the river environment, fish abundance and health of the fish, and local traders and the market. Not all problems are attributable to the dam, according one fisherman. He said that fish abundance also decreased because there are now more fishermen active. Another fisherman mentioned that especially the quantity of Acari Zebra (*Hypancistrus zebra*), Acari Boi de Bota *(Panaque nigrolineatus, Panaque armbrusteri 'xingu')*, and Acari Picota de Ouro (*Scobinancistrus aureatus*) decreased and that fishermen are now moving to locations close to Altamira, as the number of species decreased a lot in the Big Bend, beneath the dam. Only 8% of the interviewees did not notice any changes or has any problems with collecting ornamental fish compared with the time before the dam was built.

More than half of the interviewees (56%) noticed environmental changes of the river from the year 2011, the year that NorteEnergia S.A. started with the construction of HBM. A small number of fishermen (24%) noticed changes from 2012; 8% mentioned that the changes started in 2013, and the rest of the interviewees (12%) does not know when these changes started.

Table 4. Problems of fishermen related to the dam (n=25, multi response)

Kind of problem	Environmental changes (in the sense of river, fish and pollution) during the past 4 years	% (n=25)	Consequence	% (n=25)
River environment	The amount of sediment in the water increased	88	Fishermen bang their head now due to poor eyesight in the river	13
			On some important fishing spots there is a very bad view now, which made fishermen move to other fishing spots with a more clear view	8
			The living algae growing on on the rocks and stones, which is the main source of food for *Loricariidae* species, is buried under sediment	8
	On most parts of the river the current is stronger than four years ago, on other parts of the river the water remains stagnant or dries up	76	Fishermen are more exhausted after a day of work, because of more physical effort they have to deliver	33
			It is hard to cross the river near the dam, as currents are weird and strong there	13
			At some locations, like Ilha da Fazenda, algae grow very fast in which causes the disappearence of fish	4
	On some parts the water level rose more than it used to rise in the winter	56	Fishermen have to dive deeper which causes more pain because of pressure on the body	4
			Dissapearance of fishing spots because some spots of the river are to deep to dive for ornamental fish and some former fish locations are now impossible to reach	29
	Some species of aquatic flora are disappearing because of chemical pollution	16	No consequences	-
	The temperature of the river decreased	12	No consequences	-
	The waterquality in the river decreased. In 2012 people had skin rash (an itching and red skin). The doctor thought it was hepatitis	4	No consequences	-
Fish abundance and health	The quantity of ornamental fish decreased	92	It takes more time to catch the same amount of fish	75
			The expenses on fuel increased as the way to fishing locations is longer, fishermen have to move more often from location, and more terrain has to be navigated to provide a proper income	50
			Nowadays the catch deminished one third, compared to four years ago	21
	The changed chemical compostion of the water and pollution by the dam have impact on ornamental fish species	33	Fish are sick and weak, especially Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri 'xingu'*), and Acari Zebra (*Hypancistrus zebra*): they die faster after being captured, their skin gets red and the tail drops off	33
			Fish have problems with their gills	4
	Explosives used to built the dam have impact on ornamental fish species	13	Underwater rocks break more often. So if you are in a cave danger of collapse exist	4
			Fish are disturbed and leave their spots, which means fishermen find less fish on former fishing grounds	8
	Illumination of the dam at night has an impact on ornamental fish species	13	Fishermen used to catch ornamental fish species of the *Loricariidae* family at night as the fish come out from under stones and small caves to feed. Because of the lights the dam uses to work at night fish do not leave their hiding places anymore and are a lot more difficult to catch	13
Local traders and the market	Nowadays there are only four local traders in Altmira, where there were 25 in 2010 and the years before, so market possibilities for fishermen decreased	25	There are enough fishermen in the city to provide enough fishes for the four aqauriums, which makes it less necessary for local traders to navigate the Volta Grande, which provokes the exclusion of indigenous and riverbank communities from the ornamental fish market	25

Adapted fishing practices (n=24, multi response)

More than half of the interviewees (67%) did not make any adaptions in their fishing practices yet. All adaptions made by fishermen in fishing practices are related to the stronger current of the river. Fishermen (17%) now use more weights in the form of a weight belt. Before the construction of the dam started fishermen dived without or with weights up to 4 kg. Nowadays they use 8 kg. Some (13%) have to use a security hook to anchor themselves to their boat nowadays, to not be washed away with the strong current. Some fishermen (8%) need another type of boat and motor: Some need a stronger motor, others need a motorized boat and cannot use their wooden canoe anymore.

Loss of fishing locations (n=25, multi response)

A small amount of interviewees (32%) did not notice any changes in the fishing locations since the dam is being built. Most fishermen (68%) lost fishing grounds due to the prohibited area near the dam which will block off the Big Bend. The dam is built on the main habitat and most important fishing spot for fishermen to collect Acari Zebra (*Hypancistrus zebra*) and Acari Zebra Marrom (*Hypancistrus sp. 'marrom'*). A small number of fishermen (16%) mentioned that they lost fishing locations the last years because more territory was protected as indigenous or environmental reserve. This also happened in the Irirí River, which diminish the territory fishermen have to divert to other locations or rivers.

Advantages of the dam (n=24, multi response)

Most fishermen (88%) say that they have no profit from the dam, at this moment, in any possible way. Some do profit from the dam: One interviewee now works for LEME (the company Tractable Engineering) which is involved in the construction of the dam. Another fishermen mentioned that now the dam is built IBAMA pays less attention to the illegal trade in Acari Zebra (*Hypancistrus zebra*), which made the demand from clandestine local traders for this species rise. His income increased this way. Almost all interviewees (90%) do not think they will have profit from the dam in any possible way in the future. Some thought of potential benefits of the dam: One interviewee mentions it is practical that the river dries up downstream the dam, as there will be more camping spots available alongside the water for fishermen to sleep when they go out on fishing trips. Another states that the dam could function as a touristic attraction.

Income of fishermen (Altamira n=24, Muratu n=9)

In the summer, 87% of the total income (US$ 651.82 per month) of fishermen in Altamira comes from the of collecting ornamental fish. In winter, this is 86% of the total income (US$ 603.47). In Altamira 66% of the fishermen are 100% dependent for their income on the extractivism of ornamental fish. In Muratu 71% of the total summer income (US$ 763.74), and 77% of the total winter income (US$ 885.51) comes from collecting ornamental fish. In Muratu two of the six ornamental fishermen are 100% dependent for their income on the extractivism of ornamental fish. Fishermen who not only depend on extracting ornamental fish, complement their income with fishing fish for consumption, the crocheting fishing nets, work as agricultural contractor, and/or are salesmen of other NTFPs.

The average loss of income, compared with the period before the construction of the dam started, for fishermen in Altamira is, in the summer period, 61%, and 63% in winter period. The average loss of income for fishermen in Muratu is 59% in summer and 39% in winter period. Reasons for this loss, according all interviewees, are that before the dam was constructed the quantity of ornamental fish in the river was higher. Besides, it was easier to dive, because the current was less strong, and it did take less time to collect the same amount of fish in a certain period of time. Despite the lower prices of ornamental fish four years ago, the fishermen's income decreased in the period the dam is build. Another important problem is that the fishermen lost an important fishing spot, which is located on the location where the dam is constructed. 68% of the fishermen mentioned that this spot was crucial for the capture of ornamental fish. Now this territory is prohibited to use for any fishing activity. One fishermen in Altamira and all fishermen of Muratu mentioned that the fish die faster now after being captured, especially the fish coming from locations downstream the dam.

Income distribution over number of fish species

In summer, fishermen of Muratu are not significantly more dependent on a low number of species than fishermen of Altamira (T-test, p=0.4). In winter they are (T-test, p=0.02). Looking at table 5 we see that both

groups of fishermen are more vulnerable for abundance fluctuations in the winter period, as less species share part in their income.

Table 5. Dependency on number of fish species

Species (n)	Fishermen Altamira summer (n)	Fishermen Altamira winter (n)	Fishermen Muratu summer (n)	Fishermen Muratu winter (n)
1	0	0	1	2
2	1	0	2	1
3	0	1	2	2
4	0	1	0	2
5	1	2	0	0
6	4	3	0	0
7	0	1	0	0
8	0	2	0	1
9	0	1	0	1
> 10	6	2	4	0

Seasonality

Looking at the seasonal calendar (table 5) it becomes clear that in every month fish is available to provide the fishermen of income. Logical is that the expensive species are mostly caught in a particular season. The fish species which are caught year-round have the lowest price. The calendar shows the season in which the fish is easiest to collect due to the water level, current and location. In summer it is most easy to collect Acari Zebra (*Hypancistrus zebra*), Raia Pintada (*Potamotrygon leopoldi*), and Acari Zebra Marrom (*Hypancistrus sp. "marrom"*), as these species are located too deep in the winter period. In winter it is most easy to collect Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*), Acari Picota de Ouro (*Scobinancistrus aureatus*), and Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri '*xingu'). These are the typical winter species, as these species migrate to the "beira da ilha" habitat. All fishermen agreed that it is more difficult to collect the ornamental fish species in winter because of the high water level and strong current, which is an explanation for the opportunistic character of this job.

Table 6. Seasonal calendar of the most common fish species and the price indications (n=26)

Scientific name	Common name	January	February	March	April	May	June	July	August	September	October	November	December
Potamotrygon leopoldi	Raia Pintada	18	14	14	23	27	59	82	100	95	73	55	41
Leporacanthicus heterodon	Acari Onça	27	27	32	32	45	73	86	95	95	73	64	50
Hypancistrus zebra	Acari Zebra	4	0	4	4	33	79	96	83	83	54	25	17
Baryancistrus xantellus	Acari Amareli	38	38	42	42	54	69	92	96	92	65	62	54
Hypancistrus sp. "marrom"	Acari Zebra Marrom	6	0	13	25	44	75	81	94	94	75	44	31
Scobinancistrus aff. pariolispos	Acari Arábia or Tubarão	21	21	21	36	64	79	93	100	79	64	50	36
Baryancistrus chrysolomus	Acari Aba Laranja	38	42	58	58	63	75	83	92	88	75	58	46
Scobinancistrus pariolispos	Acari Cutia Preto	17	39	48	43	65	70	65	70	57	39	35	30
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	15	50	65	65	69	73	35	23	12	15	15	12
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	24	44	68	64	64	44	20	20	16	16	12	8
Scobinancistrus aureatus	Acari Picota Ouro	13	71	88	75	71	33	13	8	4	4	0	0
Peckoltia vittata	Acari Tigre Comun	57	78	87	87	87	83	70	65	52	52	43	39
Ancistrus sp., Pseudancistrus sp.	Acari Cara Chata	43	61	70	65	74	83	78	78	65	48	52	43
Oligancistrus punctatissimus	Acari Bola Azul	58	71	83	79	83	92	88	83	71	58	54	46
Ancistrus ranunculus	Acari Preto Velho	48	67	76	71	86	95	86	90	86	71	71	38
Oligancistrus sp.	Acari Bola Branca	64	82	95	91	100	100	86	86	73	68	64	50

Fishing intensity		**Price class (R$)**	
0-20		Price unknown	
21-40		0.01 - 0.50	
41-60		0.51 - 1.00	
61-80		1.01 - 2.00	
81-100		2.01 - 3.00	
		3.01 - 5.00	
		5.00 - 10.00	
		> 10.00	

Foreseen problems and future perspective

The fishermen had a clear idea on what will happen with them in the future. All of them had the opinion that the dam will have some kind of impact on their lives. In table 7 their ideas are shown. Most of the fishermen are convinced that their job and income from ornamental fishing practices will disappear in the future. Fishermen are convinced that their job and income highly depends on what will happen to the ornamental fish species, so in this table also an overview of their general opinion on the future of ornamental fish is given.

Table 7. Future perspective of local fishermen (n=23, multi response)

Kind of problem	Environmental changes (in the sense of river, fish and pollution) during the past 4 years	% (n=23)
Job and income	The job fishermen of ornamental fishes will not be possible anymore due of the environmental problems	74
	My income will decrease when the dam fully functions	17
	When the dam fully functions it will be prohibited to fish in resevoir at Altamira	4
Future of ornamental	Ornamental fish species will dissappear in Middle Xingu region	52
	The abundance of individuals of several species in the Middle Xingu region will decrease	22
	Some important ornamental fish species will loose their reproduction habitats	17
	In the Big Bend will appear more waterfalls because of damming the river. There for fish will be more concentrated, which will atrackt fishermen and contribute to the disappearance species. This is why after three years I will have to look for another job	13
	Upstream some ornamental fish species will adapt to the resevoir at Altamira. Downstream, under the dam the river will dry up and species will dissapear	13
	All Acari species eating living algae will dissapear in the Big Bend because their alimentation will be covered with sediment	4
	Indigenous tribes along the Xingu River will dissapear and move to the city because their survival depends on the river an aquatic fauna	4

Solutions

Most fishermen are already thinking about an solution for the time the dam will be fully functional, as they are convinced their current job as fishermen of ornamental fish has to be complementing with or replaced by another source of income. In table 8 their ideas on solutions are shown. Most solutions are related to antoher job in the city, financial compensation, education, producing agricultural products, and a breeding system for ornamental fish. Remarkable is that fishermen living in Muratu are not thinking about moving to the city of Altamira in search of a job. Five of the six fishermen prefer to stay in Muratu and gain their income with producing agricultural products. The sixth does not know what to do in the future.

Table 8. Solutions (Altamira: n=15; Muratu: n=7. Multi response)

Solution	% Altamira (n=15)	% Muratu (n=7)
I will search for a job in the city	53	-
Receiving financial compensation or in the form of assistence (for example for building a breeding system for ornamental fish and fish for consumption or a more intensive agricultural system) would be a solution. Untill this moment the company NorteEnergia did not yet respond to the protests of fishermen and indigenous people, altough it was promised in the past	33	29
The fishermen has no idea what to do: He does not know how to do agriculture, has no education or access to another job	13	14
The fishermen started a course to retrain himself	13	-
The fishermen already found a new job	13	14
Establish or buy a (larger) agricultural plot or plantation to gain an income out of cash crops like cocoa, cassave, and maize	7	71
The fishermen is thinking of following a new course to get another job	7	-
The fishermen preffers to live permanently with his wife in Muratu and conduct a job in this village, rather than finding a job in Altamira	7	-
The fishermen would like to built a breeding system in the deeper parts of the river (in wells), by placing a bomb (to provide oxigen and current to the water), so ornamental fish can remain as a source of income	-	29

4.4. Impact on local traders

Important ornamental fish for local traders

In both summer and winter the most important fish species for local traders of Altamira appears to be Acari Amareli (*Baryancistrus xantellus*). The fresh water stingray Raia Pintada (*Potamotrygon leopoldi*) also has a major share in the summer income of local traders, but is not always traded as local traders need a licence from IBAMA for it. In the winter season Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*) has quite a large share in the income for local traders. See table 9 for the rest of the species which contribute to the income of local traders.

Majority of the fish local traders buy from fishermen originate from the Xingu River. Sometimes a part of their stock comes from the Irirí and Tucuruí River, but this is quite exceptionally. Four of the five local traders are specialized in Acari or L-number Plecos and fresh water stingrays (only when they are in the possession of a quota licence). One local trader is specialised in scaled fish. This is why data on his income were not included in table 9. In the summer 37% and in winter 18% of his income is derived from scaled fish species, which makes his business exceptional.

Table 9. Share of common ornamental fish species in income of local traders (n=4)

Scientific name	Common name	Share (%) summer	Share (%) winter
Hypancistrus zebra	Acari Zebra	-	-
Hypancistrus sp. "marrom"	Acari Zebra Marrom	-	-
Baryancistrus xantellus	Acari Amareli	33	42
Potamotrygon leopoldi	Raia Pintada	21	-
Scobinancistrus aureatus	Acari Picota Ouro	8	18
Oligancistrus sp.	Acari Bola Branca	7	2
Peckoltia vittata	Acari Tigre Comun	5	4
Scobinancistrus pariolispos	Acari Cutia Preto	4	2
Leporacanthicus heterodon	Acari Onça	3	1
Ancistrus ranunculus	Acari Preto Velho	3	2
Ancistrus sp., Pseudancistrus sp.	Acari Cara Chata	3	2
Other species	-	3	2
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	2	13
Hypancistrus sp. "pao"	Acari Pão	2	2
Baryancistrus chrysolomus	Acari Aba Laranja	2	2
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	2	6
Oligancistrus punctatissimus	Acari Bola Azul	2	2

Impact of dam on income and businesses of traders

All local traders which still fully function noticed several changes, which they attribute to HBM. Most impacts they mentioned is have to do with the decrease in production by the river and the increased death rate of fish in their aquaria. The changes already had consequences for the business' turnover of the trader. Below a brief overview is given on the already noticed changes. Hereafter a forecast is made by the local traders on their future.

- The sales of Acari Amareli (Baryancistrus xantellus) the past years decreased with a rate between 80 and 90%, as the occurrence of this fish in the river decreased
- The sales of other species also decreased the past years, due to the loss of fishing grounds for fishermen, the decrease in fish quantities in the river, and the lack of fishermen as lots of them found a job at NorteEnergia S.A.
- The death rate among fish in the aquarium has increased the past years
- Nowadays more villages along the river must be visited to pick up the same amount of fish as before 2011
- The sales of two businesses of the local trader has dropped with around 55% percent the last years
- One local trader did not noticed any change in the sales of his business yet, as he increased the effort to navigate the river to pick up fish at several riverbank and indigenous communities

- Several ornamental fish species will not adapt to the new situation in the Middle Xingu region. There for species have to be bought from fishermen who collect fish in other regions
- Fresh water stingray species can adapt to the new situation in the in the Middle Xingu region
- The business of the local trader in Altamira will not be profitable anymore when the dam fully functions
- I will have to navigate to further locations, other rivers and regions to remain profitable
- The local trader is planning on opening another aquarium business in another region where no plans to build a dam exist
- The composition of marketable species in the Middle Xingu region will change and the demand will adapt to this change. So the species composition of the stock in the local trader's aquarium will shift as well, and the local trader can stay profitable this way
- If the government continues its plans to legalize the purchasing of ornamental fish species in the RESEX (Reserva Extractivista) areas, the local trader's aquarium will remain profitable. If not, the local trader will suffer a loss of 30 to 40% in sales.

Altamira: the city of aquaria

From 2005 until 2013 the number of aquaria in Altamira decreased from 25 to four. Most of the businesses stopped functioning between 2012 and 2014. Local traders who stopped their businesses and local traders who still operate gave several explanations for this decline. The main reason they give is that most aquaria stopped functioning because of the 'lack of production'. This mains that the supply of fish declined due to environmental problems (mostly the decrease in quantity of fish), a lack of quotas, and a lack of fishermen. Some local traders moved to other regions where freshwater stingrays give a higher price and a larger number of quotas is distributed among traders. One former local trader stopped her aquarium because it was flooded by the exceptional high water level of the Xingu River in 2013. One local trader mentioned that former local traders did not put enough effort in the purchasing process and maintaining their fish healthy, so their business cannot handle one external problem, like a dam.

5. Conclusion, Discussion, and Recommendations

Important fish species

Acari Amareli (*Baryancistrus xantellus*), Acari Boi de Botas (*Panaque nigrolineatus, Panaque armbrusteri* 'xingu'), Acari Zebra (*Hypancistrus zebra*), Acari Picota de Ouro (*Scobinancistrus aureatus*), and Acari Assacú Pirarara (*Pseudacanthicus sp. "vermelho"*) are the five most important species for local fishermen. These are most frequently caught, have the preference of local fishermen, and appear the have the largest share in the fishermen's income.

There are a couple of leading factors of why these species are frequently caught and preferred by local fishermen: price, demand of the local trader (these are the two most important incentives), abundance and appearance of the species, and the effort needed to collect the species, which mostly depends on the season.

Acari Zebra (*Hypancistrus zebra*) does not have an equally large share in the income of fishermen in Altamira. In Muratu this is one of the most caught species by fishermen. It could be that the fishermen in the city are more conscious about regulations and prefer to collect fish they can sell to a legal trader. Muratu is located quite far from the city, so it could be that fishermen refuse to take notice of legislation. It could also be that the setting in which the interviews were done had influence on this topic. In Muratu the interviews took place at the homes of the fishermen, in which they could have felt more comfortable. In Altamira the interviews were hold in aquaria were fishermen sell their fish and were protected species cannot be sold.

This research was conducted in the winter season. This promoted that most interviews were conducted with fishermen who are active in summer and winter, and not only in summer, as most of Altamira's fishermen. This could mean that the typical winter fish species, which are quite important for the income of fishermen who are also active in winter, are not as important for the total group of ornamental fishermen, as a large part of the fishermen are only active in the summer season.

Impact on fish species

All five important ornamental fish species need (strong) current, oxygen-rich water. All species occur in both shallow and deep water. The food sources (living algae and fresh water sponges) are likely to disappear in the reservoir areas. Probably the three endemic species and the species with a reproduction habitat like 'beira da ilha' and 'saroba' will be most affected by the dam which blocks of the Big Bend area. These characteristics of the species probably will lead to high death rates in the reservoirs. Studies on the Tucuruí dam show that after two years the fish population recovers in the reservoirs. The question is if the five important species will be among the new species composition of the reservoirs.

Acari Boi de Botas (Panaque nigrolineatus, Panaque armbrusteri 'xingu') and Acari Picota de Ouro (Scobinancistrus aureatus) will be mainly impacted by the dam as they need the habitats 'saroba' and 'beira da ilha' (the roots, trunks and foliage of the overflown vegetation) for their reproduction and so survival. These habitats will disappear in the Big Bend and the reservoir areas. According to local fishermen and the critical review report on the EIA of NorteEnergia S.A. Acari Picota de Ouro (Scobinancistrus aureatus) is endemic for the Xingu River, which makes this species extra vulnerable for external disturbances. In the summer period these species need 'corredeiras' and 'lajems', which will decrease in number, both in reservoirs and the Big Bend. Probably these two species will drastically decrease in number in the Big Bend area and disappear in the reservoir areas, as these species need strong current. Acari Picota de Ouro (Scobinancistrus aureatus) probably will remain in the area of the Xingu River close to the Irirí River and Acari Boi de Botas (Panaque nigrolineatus, Panaque armbrusteri 'xingu') will remain in the Irirí River, as it also occurs in this river (Camargo, Gimenes Junior, Melo de Sousa, & Rapp Py-Daniel, 2013).

Acari Zebra (*Hypancistrus zebra*) is likely to go extinct when the dam fully functions. This forecast is based on the following arguments: this fish is endemic and only occurs on the parts of the Xingu River which will be heavily affected by the dam. Next to this fishermen state that this fish suffers already from the disturbances by

the construction and overfishing practices. Furthermore, the dam which withholds the water from flowing into the Big Bend is built on top of the principal location where this fish was most abundant. Next to this, the fish is quite fragile, sensitive to sediment, and the number of 'remansos' and 'poços', the main habitat of this fish, will decrease.

Acari Amareli (*Baryancistrus xantellus*) will probably decrease in abundance, but remain in the Big Bend area, due to the disappearing habitat locations. This fish is very sensitive to sediment and needs oxygen rich water, so will probably not remain in the reservoir areas. This fish will remain in the area of the Xingu River close to the Irirí River and in the Irirí River itself (Camargo, Gimenes Junior, Melo de Sousa, & Rapp Py-Daniel, 2013), as it also occurs here.

Acari Assacú Vermelho (*Pseudacanthicus sp. "vermelho"*) has a broad range of habitats where it reproduces or remains during its adult stage. It cannot be forecasted what will happen to the principal reproduction spot in front of the city of Altamira, where the reservoir will appear. If current is crucial for this spot and eggs and juvenile fish are sensitive to sediment and poor-oxygenated water, it is not likely that this reproduction spot will hold. Anyway, its abundance will decrease in the Big Bend (due to the decrease in habitat locations) and in the reservoir (due to sediment and the lack of oxygen). This fish is endemic to the Xingu River and occurs mostly in the heavily impacted areas of the dam (Camargo, Gimenes Junior, Melo de Sousa, & Rapp Py-Daniel, 2013). All these factors will make it quite difficult for this fish to survive and not go extinct when the dam fully functions.

Time will tell whether this prognosis is correct or not, but the information sources on which it is based are quite reliable: local fishermen, which are specialist in the ecology and habitat characteristics of the five important species, the EIA of NorteEnergia S.A., a critical review by experts on the EIA, and a subsequent examination on the impact of the Tucuruí dam.

Impact on fishermen

The fishermen mention they already experience a negative influence of the dam on fish and their fishing practices. Problems are related to the stronger current, more sediment, and the changed water level. All already made adaptions in fishing practices are the consequence of the stronger current. Fishermen mostly collect the ornamental species in the areas which will be impacted by the dam. Fishermen themselves are convinced that collecting fish in other regions will not be profitable, as they have to invest more time and fuel then.

The fishermen's perspective on the future is negative. Most think they have to find another source of income in order to survive when the dam fully functions. Fishermen living in TI's get increasingly dependent on governmental (financial) assistance, as the main source of income (out of ornamental fish collection) is disappearing. Many families in Muratu have recently changed their job as collector of ornamental fish into a 'community service' job, such as professor in the local school, cleaner in the school, a job at FUNAÏ, and football teacher. The government mainly pays these jobs. The general opinion of families in Muratu is that they want to be self-sustaining. The chief of the village states that, now they are losing ornamental fish species as an income, they want to shift to the produce and sell agricultural products (Juruna, A Batalha de Belo Monte: Giliarde Juruna, 2013). Fishermen in Altamira mostly think they will search for another kind of job in the city for which they do not need any specific education.

The EIA on hydroelectric dam Belo Monte state that collection of ornamental fish is considered the main income for 90% of the fishermen. Of these people, 41% have other activities that supplement the family income (NorteEnergia S.A., 2011). These numbers are equal to the results of this research; in the Middle Xingu region the collection of ornamental fish is an important job. This research did not involve the complete family income, so it is not clear whether or not the fishermen's wife contributes to the family's income. Income of relatives of the fishermen can put the result of that more than half of fishermen in Altamira depend completely on ornamental fish for their income, in a more complete perspective.

The average loss of income from the period before the dam constructions started, comparted to the current situation cannot be attributed to the construction of the dam. Fluctuations in income are quite common in the sector of extractivism of ornamental fish. This income of fishermen is influenced by a lot of factors: seasonality, production of the river, effort of the fishermen, demand from local traders, quotas, protected and so illegal

species to collect, and other regulations. Next to this, when interviewing people about the past, answers are often biased (Baarda, 2009). Thinking about a period of four years ago was often difficult for the fishermen. Furthermore, the average loss of income for fishermen in Altamira it is not representative, as just eleven of the total of interviewees were asked about this.

This research was conducted in the winter season. As already mentioned, this promoted that most interviews were conducted with fishermen who are active year-round. This influences the outcome of the numbers and figures about the impact of fishermen. It could be that the share of ornamental fish in the income of Altamira's fishermen is lower, when more fishermen who are only active in the summer would have been interviewed, as these people practice other jobs in the winter season. It could be that the fishermen of Altamira who mainly collect ornamental fish in the summer period is less impacted. They already have access to another professional sector, which they could extent to the summer period, when collecting ornamental fish would not be possible anymore.

Depending on a small number of species for an income is more risky, than when gaining an income out of a broad range of species. This last pattern spreads the risk for when fluctuations in the abundance of certain species occur. The fishermen of Muratu (especially in the winter season) are more vulnerable than the fishermen of Altamira when abundance fluctuations among certain species occur. Looking at the ecologies of fish it is likely that the amount of fish Acari Boi de Botas (Panaque nigrolineatus, Panaque armbrusteri 'xingu'), Acari Zebra (*Hypancistrus zebra*) and Acari Picota de Ouro (*Scobinancistrus aureatus*) will decrease or disappear. These are exactly the fish that give income in the winter for this village. On the other hand, indigenous villages in the Middle Xingu region are less vulnerable than fishermen of the cities, as they are in the possession of a terrain with forest and a part of the Xingu River. They have access to natural resources which can be exploited for extractivism of a river or forest product, provided that a new market is encountered. Next to this, these groups have good contact with NGOs like ISA and governmental bodies, like FUNAI. Fishermen of Altamira do not have access to this kind of assistance.

The data of this research question is based on the opinions and information gained from local fishermen. Because of the continuing conflicts and negotiations with NorteEnergia S.A. it could be that fishermen used the interviews to complain about and exaggerate their current situation. By asking them to further explanations and justification of the numbers and statements, this was tried to alleviated. Next to this the interview questions, for example their income or changes in the river, were repeated in the form of informal conversations.

Impact on local traders

Acari Amareli (*Baryancistrus xantellus*) is most important in the income of local traders. This group of people already noticed a decrease in production of this species. When the dam fully functions this species is likely to decrease in number even more, which will have a negative influence on the local trader's income. Next to this, local traders attribute the increased death rates of fish species in the aquarium to the construction work of the dam.

For local fishermen it will be harder to make their business profitable if they have to navigate to region further away to pick up fish. Probably the number of fishermen collecting ornamental fish will decrease the coming years, which makes it necessary for local traders to navigate the river and visit indigenous or riverbank communities themselves.

Probably the traders that are still open at this moment had profit from the closure of other aquaria. Due to these bankruptcies the supply of fish is larger nowadays as is would have been if all 25 aquaria remained functioning. Perhaps, the supply of fish, as the production of the river decreased already according the fishermen and local traders themselves, would not have been sufficient to keep the aquaria profitable. The bankruptcies cannot be attributed completely to the dam. Factors like quotas, amount of active fishermen and market demand, also play large part in the productivity of an aquarium.

Overall reflections

Perhaps HBM means the end of trade in ornamental fish in the region Middle Xingu region, or at least will cause a reduction of jobs within this sector. This means that the culture and lifestyle of the fishermen and the traders and an important economic sector in this region will disappear or to a lesser extent passed on to future

generations. One could argue that it is a crime; a hydroelectric dam should not have such expanded impact on its surrounding. However, when looking at history we see that this region of Brazil has always had a turbulent movement of economic transition. The trade in ornamental fish in these regions begun in 1980. A couple of years ago collectors of ornamental fish were startled by the restrictions imposed by IBAMA to prevent overfishing of ornamental species (for example, Acari Zebra (for example, *Hypancistrus zebra* and fresh water stingrays, where prohibited from 2005 to trade). Before 1980 the ornamental fishermen were 'garimpeiros'; gold miners. Next to gold, the riverbank and indigenous communities provided jaguar skins to the international market. The parents and grandparents of the gold miners were 'seringueros'; rubber tappers. This activity came to an end when synthetic rubber was introduced on the international market. In short, fishermen of ornamental fish are opportunists from an economic point of view; within their own lifetime they switch job quite often, taking into account the costs and benefit and their preference for flexible and independent jobs. With a low level of education, they became accustomed to the itinerant life of extractive activities.
With other words, this social working class has a history of and is familiar with changing sources of income, always depending on the (international) demand for natural resources from the Amazon region. Nevertheless, the establishment of the hydroelectric dam will bring a difficult time for many families depending on ornamental fish species, but it fits history and the character of the collector of ornamental fish.

Recommendations

In the Middle Xingu region and in Brazil in general, there is little intellectual capital on captive breeding of ornamental fish species, as there are few experts in both scientific and commercial bodies to share the techniques (NorteEnergia S.A., 2011). It would be an opportunity for local fishermen and traders if a social program was implemented to establish captive breeding initiatives, so this economic sector of the region continues to supply the international market. By organizing this kind of trade, more regulations on sustainability and animal welfare can be implemented, as required looking at the current situation. It will also require a radical change in lifestyle of the fishermen, as the producer has to remain close to home. The job will lose its independent and opportunistic character. Training on genetics, reproductive biology, chemistry of water, and health are required. This recommendation could be conducted by NGOs which are involved in the region or governmental bodies which are currently occupied with the topic of compensation for fishermen. Another feasible option for fishermen is purchasing a small agricultural plot. For people whose house will be flooded by the main reservoir it is one of the four options of compensation offered by NorteEnergia S.A. The problem is that this is not correctly communicated towards fishermen. They often do not know this option exits (Silva, 2014).

Some species of the *Serrasalmidae* and *Cichlidae* family are caught (currently in small numbers in the Middle Xingu region) for ornamental purposes. In the main reservoir close to Altamira these species probably will be the leading candidates to succeed. Market acceptance will be a restraining factor in developing these species as successful trade products, but have the potential for the proliferation of ornamental fishing activity in this area. Therefor it is essential that companies and public institutions begin with raising awareness and reorganization of the local fishing industry for optimal use of this abundant resource of the future (Santos, Barbosa, & Hernandez, 2009).

It is recommendable that the ACEPOAT would become more active in these times of uncertainty. The association could play a large part by uniting and representing fishermen in negotiations with NorteEnergia S.A>. Besides, the association could contribute to the income of local fishermen by making price agreements, and strengthen the position of fishermen in the chain of custody, so fishermen receive a higher price per fish.

It would be interesting if a scientific study appears when the Belo Monte dam fully functions on all species (not only ornamental fish species, but also fish species which are consumed) which are important for local fishermen. These studies, including this research, should contribute to the deliberations of the Brazilian government to build 30 more dams in the Amazon region.

Another interesting research could be conducted on the impact of dams (of all continents) on international importers of ornamental fish species. For this research two aquarium stores were visited to see if what share fish species of the Xingu River have in the businesses' turnover and to what extend a dam affects the international market. Both aquarium stores did not suffer any noticeable impact of dams. Two of the three contacted owners of an aquarium store are worried about dams, as they think dams will have a negative impact on the reproduction of the L-number plecos. L-number plecos are important for aquarium stores as the

absolute values per individual fish are very high in comparison with other fish species, which are bought in groups or have a lower value per individual. Around 5% of the aquarium's turnover comes from wild caught fish species of the Xingu River.

Bibliography

Baarda, B. (2009). *Dit is onderzoek!* Nederland: Noordhoff Uitgevers B.V.

Baptista, F. M., & Thorkildsen, K. (2011). *The Belo Monte Dam: a camel in the tent?* Norway: NorLARNet.

Camargo, M., Giarrizzo, T., & Isaac, V. (2004). Review of the geographic distributation of fish fauna of the Xingu River basin, Brazil. *ECOTROPICA*, 123-147.

Camargo, M., Gimenes Junior, H., Melo de Sousa, L., & Rapp Py-Daniel, L. (2013). *Loricariids of the Middle Xingu.* Hannover: Panta Rhei.

Camargo, M., Júnior, J. C., & Estupiñan, R. A. (2012). PEIXES COMERCIAIS DA ECORREGIÃO AQUÁTICA XINGU-TAPAJÓS. In Z. C. Castilhos, & P. A. Buckup, *Ecorregiões Aquáticas Xingu-Tapajós* (pp. 175-192). Rio de Janeiro: Centro de Tecnologia Mineral.

Carvalho Junior, J. R., da Silva Carvalho, N. A., Gomes Nunes, J. L., Camoes, A., da Cunha Bezerra, M. F., de Santana, A. R., & Nakayama, L. (2009). *Sobre a pesca de peixes ornamentais por comunidades do Rio Xingu Pará – Brasil: Relato de Caso.* São Paulo: B. Inst. Pesca.

Eletrobras. (2010). *Belo Monte*. Retrieved from Eletrobras: http://www.eletrobras.com/elb/data/Pages/LUMIS46763BB8PTBRIE.htm

Fearnside, P. M. (2002). Greenhouse Gas Emissions from a Hydroelectric Reservoir (Brazil's Tucuruí Dam) and the Energy Policy Implications. *Water, Air, and Soil Pollution*(133), 69-96.

Folhapress. (2013). *A Batalha de Belo Monte - Capitulo 4: Povos Indigenas*. Retrieved from Folha de São Paulo: http://arte.folha.uol.com.br/especiais/2013/12/16/belo-monte/

Gonçalves, A., Camargo, M., Carneiro, C., Tambara, A., & de Paula, G. &. (2009). A pesca de peixes ornamentais. In M. &. Camargo, *Entre a terra as águas e os pescadores do médio rio Xingu – Uma abordagem ecológica* (p. 329). Belém: Eletronorte.

Hance, J. (2012, April 18). *Pictures: Destruction of the Amazon's Xingu River begins for Belo Monte Dam* . Retrieved from Mongabay: http://news.mongabay.com/2012/0418-hance_belomonte_photos.html

Instituto Ambiental. (2013). *De Olha em Belo Monte: 2013 no Pico do Contradição.* Sao Paulo, Brazil: Instituto Ambiental.

International Rivers. (2012). *Belo Monte.* Berkeley: International Rivers.

International Rivers. (2012). *Belo Monte - MASSIVE DAM PROJECT STRIKES AT THE HEART OF THE AMAZON.* Berkley: International Rivers.

Isaac, V. J., & Barthem, R. B. (2004). Os recursos pesqueiros da Amazonia Brasileira. In M. L. Ruffino, *A pesca e os recursos pesqueiros na Amazônia brasileira* (pp. 295-339). Manaus: Ibama & ProVárzea.

Juruna, G. (2013, 12 20). A Batalha de Belo Monte: Giliarde Juruna. (M. Leite, D. Amora, M. Kachani, L. de Almeida, R. Machado, & M. Kepp, Interviewers) Folha de São Paulo. Retrieved from http://arte.folha.uol.com.br/

Juruna, G. (2014, April). Informal conversations. (R. Diemont, M. de Boer, & C. Costa Carneiro, Interviewers) Muratu, Pará, Brasil.

Kricher, J. (2011). *Tropical Ecology.* New Jersey: Princeton University Press.

La Rovere, E., & Mendes, F. (2000). *Tucuruí Hydropower Complex Brazil.* Cape Town: World Commission on Dams.

Leite, M., Amora, D., Kachani, M., de Almeida, L., Machado, R., & Kepp, M. (2014, August 25). *A Batalha de Belo Monte*. Retrieved from Folha de S. Paulo: http://arte.folha.uol.com.br/especiais/2013/12/16/belo-monte/

LEME Engenharia. (2008). *Environmental Impact Assesment - Diagnnóstico Ictiofauna.* Brazil: LEME Engenharia.

Macedo, E. (2014). *O garimpo hidrelétrico: Impactos de Belo Monte na cidade de Altamira.* Altamira: unpublished.

Melo de Sousa, L. (2014, May 5). Conversation on ornamental fish species and fishermen. (R. Diemont, Interviewer, & R. Diemont, Translator) Altamira, Pará, Brazil.

NorteEnergia S.A. (2011). *SUMÁRIO – 13.3.3 PROJETO DE AQUICULTURA DE PEIXES ORNAMENTAIS.* Brazil: NorteEnergia S.A.

Pedrosa Gonçalves, A. (2008). *Aspectos Etnoecológicos é caracterizasão da Pesca de peixes ornamentais no médio rio Xingy, Altmira, Pará.* Altamira: Universidade Federal do Pará.

Pedrosa Gonçalves, A. (2011). *Ecologia e etnoecologia de Hypancistrus zebra (Siluriformes: Loricariidae) no rio Xingu, Amazônia brasileira.* Altamira: Universidade Federal do Pará.

Ros-Tonen, M. A., & Freerk Wiersum, K. (2003). *The importance of non-timber forest products for forest-based rural livelihoods: an evolving research agenda.* Bonn: CIFOR.

Santos, M., Barbosa, S. M., & Hernandez, F. d. (2009). *PAINEL DE ESPECIALISTAS - Análise Crítica do Estudo de Impacto Ambiental do Aproveitamento Hidrelétrico de Belo Monte.* Belém.

Silva, C. A. (2014, 5 21). Informal interview. (M. de Boer, Interviewer)

The Economist. (2013 , May 4). *The rights and wrongs of Belo Monte*. Retrieved from The Economist: http://www.economist.com/news/americas/21577073-having-spent-heavily-make-worlds-third-biggest-hydroelectric-project-greener-brazil

The Rainforest Foundation. (2009). *Belo Monte factsheet.* United Kingdom: The Rainforest Foundation.

Wohl, E. (2012). *A World of Rivers - Environmental Change on Ten of the World's Great Rivers.* London: The University of Chicago Press.

Appendices

I. Interview on income, fishing practices, and preferred and most caught fish species

Name:

Sources of income:

Age:

Date of the interview:

Residential area:

1.
2. Total income in summer:
3. Total income in winter:
4. Why do these numbers differ?
5. Total income out of ornamental fish summer:
6. Total income out of ornamental fish winter:
7. Why do these numbers differ?
8. With how many persons you go collect ornamental fish?
9. Which object do you use? (compressor, a snorkel or both)
10. Which kind of boat do you use? (barcomotor de centro, rabeta, canoa de rema, vaodeira)
11. To which local trader you sell your fish?
12. What is the telephone number of this trader of where does he/she has a aquarium?
13. Which species do you caught mostly? Why?
14. Which species do you prefer to catch? Why?
15. What is the price you receive for the above mentioned species?

II. Interview on the impact of the Belo Monte dam on the Xingu River, the water of the river and ornamental fish, fishing practices, and the lifestyle of the fishermen

1. Did you notice any changes in the Xingu River lately?
2. (colour, current, aquatic vegetation, temperature, quality, depth)
3. When did these changes started?
4. What are the factors causing these changes?
5. Which problems do you encounter nowadays with the collection of ornamental fish?
6. Did you changed your effort to catch ornamental fish recently? (for example by using other objects, routes, time spend)
7. Did the territories where you used to catch ornamental fish changes recently?
8. Do you experience benefits of the dam?
9. What will happen to your fishing practice when the Belo Monte dam fully functions?
10. Which problems will you encounter?
11. How are you going to resolve these problems?
12. Will you experience some benefits caused by the construction of the dam?

III. Interview on ecology and environment of the five important fish species

Name of the fish species:

1. Alimentation in summer (options: fruits, algae, bait, small shellfish, detritus, insect larvae)
2. Alimentation in winter (options: fruits, algae, bait, small shellfish, detritus, insect larvae)
3. Feeding habitat summer (options: main channel, 'remansos', 'corredeiras', 'poços', overflown territory, lakes, beaches)
4. Feeding habitat winter (options: main channel, 'remansos', 'corredeiras', 'poços', overflown territory, lakes, beaches)
5. Does this fish live in school, pair, or alone?
6. Main habitat summer (options: main channel, 'remansos', 'corredeiras', 'poços', overflown territory, lakes, beaches)
7. Main habitat winter (options: main channel, 'remansos', 'corredeiras', 'poços', overflown territory, lakes, beaches)
8. Of what kind of material exists the bottom of the habitat where this fish remains?
9. In which month this fish is spawning?
10. In which month the juveniles appear?
11. In which habitat the fish spawns? (options: main channel, 'remansos', 'corredeiras', 'poços', overflown territory, lakes, beaches)
12. In which habitat the juveniles stay? (options: main channel, 'remansos', 'corredeiras', 'poços', overflown territory, lakes, beaches)
13. How many juveniles are present in a brood?
14. Do the parents stay with the juveniles? How many time?
15. How many time does it take for a juvenile to start reproducing?
16. What are the predators of the adults and/or juveniles?

17. Is this fish already influenced by the Belo Monte dam? How?
18. Which other factors cause problems for this fish?
19. What will happen to this fish when the dam fully functions in the Big Bend, reservoir areas, other Why?
20. Will this fish adapt to the new situations? How?

IV. Interview on the impact of the dam on local traders

Name:

Sources of income:

Age:

Date of the interview:

Residential area:

Since when do you have the aquarium?

1. Total turnover of the aquarium in summer:
2. Total turnover of the aquarium in winter
3. Why do these numbers differ?
4. Total income (all sources of income, including the aquarium) in summer:
5. Total income (all sources of income, including the aquarium) in winter
6. Why do these numbers differ?
7. How many fishermen sell their catch to you?
8. Do these fishermen all catch their fish in the Xingu River or also in other rivers?
9. Which are the largest risks for your business?

10. Did you notice any changes in the Xingu River lately?
11. (colour, current, aquatic vegetation, temperature, quality, depth)
12. When did these changes started?
13. What are the factors causing these changes?

14. Did you noticed any changes among fish species, lately?
15. Which species are most impacted? How?
16. What are the factors causing these impacts?
17. Which species can adapt themselves to the new situation when the dam fully functions?

18. Did you noticed any changes in the turnover of your aquarium lately?
19. What are the factors causing these changes?
20. What will happen to your turnover and aquarium when the Belo Monte dam fully functions?
21. How are you going to resolve possible problems?
22. Will you experience some benefits caused by the construction of the dam?

23. Did you noticed that most aquaria of Altamira closed the last years?
24. Why did this happen?
25. What is the name of these aquaria and their owners?
26. When did the aquarium close?

V. Complete tables on most caught and preferred species

Most caught ornamental fish species in Altamira (n=21, multi response)

Scientific name	Common name	%
Scobinancistrus aureatus	Acari Picota Ouro	90
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	76
Baryancistrus xantellus	Acari Amareli	67
Peckoltia vittata	Acari Tigre Comun	57
Oligancistrus punctatissimus	Acari Bola Azul	52
Baryancistrus chrysolomus	Acari Aba Laranja	43
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	38
Oligancistrus sp.	Acari Bola Branca	29
Scobinancistrus pariolispos	Acari Cutia Preto	29
Ancistrus ranunculus	Acari Preto Velho	29
Hypancistrus sp. "pao"	Acari Pão	14
Hypancistrus zebra	Acari Zebra	14
Hemiancistrus sabaji	Acari Tigre de Poço	10
Potamotrygon leopoldi	Raia Pintada	10
Scobinancistrus aff. pariolispos	Acari Arábia or Tubarão	5
Ancistrus sp., Pseudancistrus sp.	Acari Cara Chata	5
Leporacanthicus heterodon	Acari Onça	5
Hypancistrus sp. "marrom"	Acari Zebra Marrom	5

Preferred ornamental fish species in Altamira (n=20, multi response)

Scientific name	Common name	%
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	85
Scobinancistrus aureatus	Acari Picota Ouro	60
Hypancistrus zebra	Acari Zebra	50
Baryancistrus chrysolomus	Acari Aba Laranja	30
Baryancistrus xantellus	Acari Amareli	25
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	25
Scobinancistrus aff. pariolispos	Acari Arábia or Tubarão	10
Hypancistrus sp. "pao"	Acari Pão	10
Oligancistrus punctatissimus	Acari Bola Azul	5
Hypancistrus sp. "marrom"	Acari Zebra Marrom	5
Potamotrygon leopoldi	Raia Pintada	5

Most caught ornamental fish species in Muratu (n=10, multi response)

Scientific name	Common name	%
Baryancistrus xantellus	Acari Amareli	80
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	50
Hypancistrus zebra	Acari Zebra	50
Baryancistrus chrysolomus	Acari Aba Laranja	30
Oligancistrus punctatissimus	Acari Bola Azul	30
Oligancistrus sp.	Acari Bola Branca	30
Scobinancistrus pariolispos	Acari Cutia Preto	30
Pseudacanthicus sp. "vermelho"	Acari Assacú Pirarara	20
Ancistrus sp., Pseudancistrus sp.	Acari Cara Chata	20
Leporacanthicus heterodon	Acari Onça	20
Scobinancistrus aureatus	Acari Picota Ouro	20
Ancistrus ranunculus	Acari Preto Velho	20
Peckoltia vittata	Acari Tigre Comun	20
Scobinancistrus aff. pariolispos	Acari Arábia or Tubarão	10
Hypancistrus sp. "marrom"	Acari Zebra Marrom	10
Potamotrygon leopoldi	Raia Pintada	10

Preferred ornamental fish species in Muratu (n=8, multi response)

Scientific name	Common name	%
Hypancistrus zebra	Acari Zebra	88
Panaque nigrolineatus, Panaque armbrusteri 'xingu'	Acari Boi de Botas	63
Baryancistrus xantellus	Acari Amareli	38
Scobinancistrus aureatus	Acari Picota Ouro	25
Leporacanthicus heterodon	Acari Onça	13

VI. Local names for river habitats, elements and organisms

“Remanso”
Calm and shallow water (<5 m) located close to the river shore. The location, size and number depends on the time of year, being less numerous in the rainy season and usually located in flooded areas of islands and shore covered with rainforest. In the dry season, ‘remansos’ are more numerous and found close to beaches and rock formations close to the riverbank.

Picture 11. A remanso at the riverbank (LEME Engenharia, 2008)

“Poço”
A well or a part of the river which is very deep. Especially in winter it is hard or even not possible for fishermen to dive for ornamental fish in poços as the fish are located too deep and the current is too strong.

“Corredeira”
A rapid is a section where the river bed has a relatively steep gradient, causing an increase in water velocity and turbulence. The current of rapids gets stronger in the dry period (LEME Engenharia, 2008).

Picture 12. Corredeira near Muratu (Diemont, 2014)

“Beira da ilha”
This habitat is only formed in winter when the river expands and overflows the vegetation at the immediate border of the river or of small islands which are covered with pioneer vegetation. In summer this habitat is not reachable for fish as the river is a lot smaller in this period.

Picture 13. Beira da ilha near Muratu (Diemont, 2014)

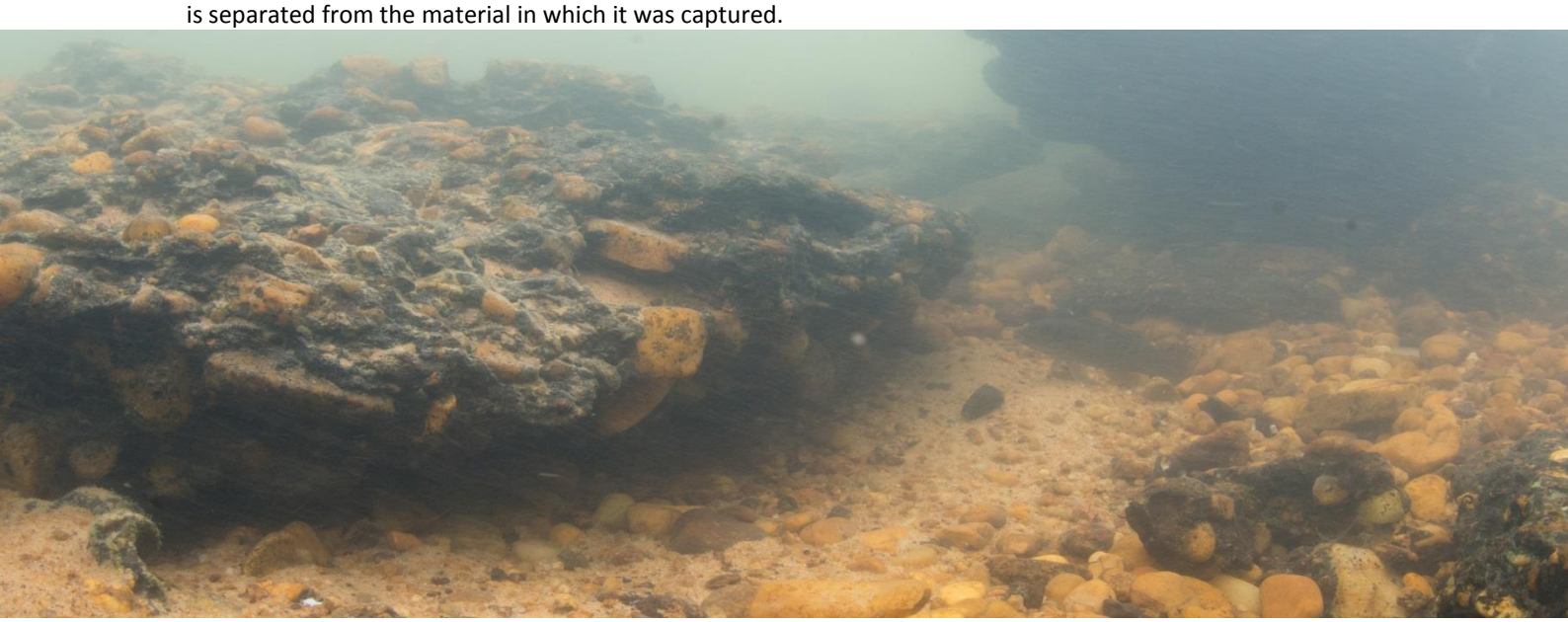
“Lajem” or “Pedrais”
Large and flat rock formations or plateaus. Lajems and pedrais are numerous in the summer period.

Picture 14. Lajems near Muratu (Diemont, 2014)

“Saroba”
Vegetation growing on a ”lajem” in the river. The plants here grow within the cracks and fissures of the rocks where river sediments accumulate.

Picture 15. Saroba vegetation near Muratu (Diemont, 2014)

“Mocororo”
“Mocororo” is a type of rock which exits out of layers of gravels of lateritic concretion (Villas Bôas, Beinhoff, & Rogério da Silva, 2001). Its material is vulnerable, as it crumbles or erodes easily. When this happens the gravel is separated from the material in which it was captured.

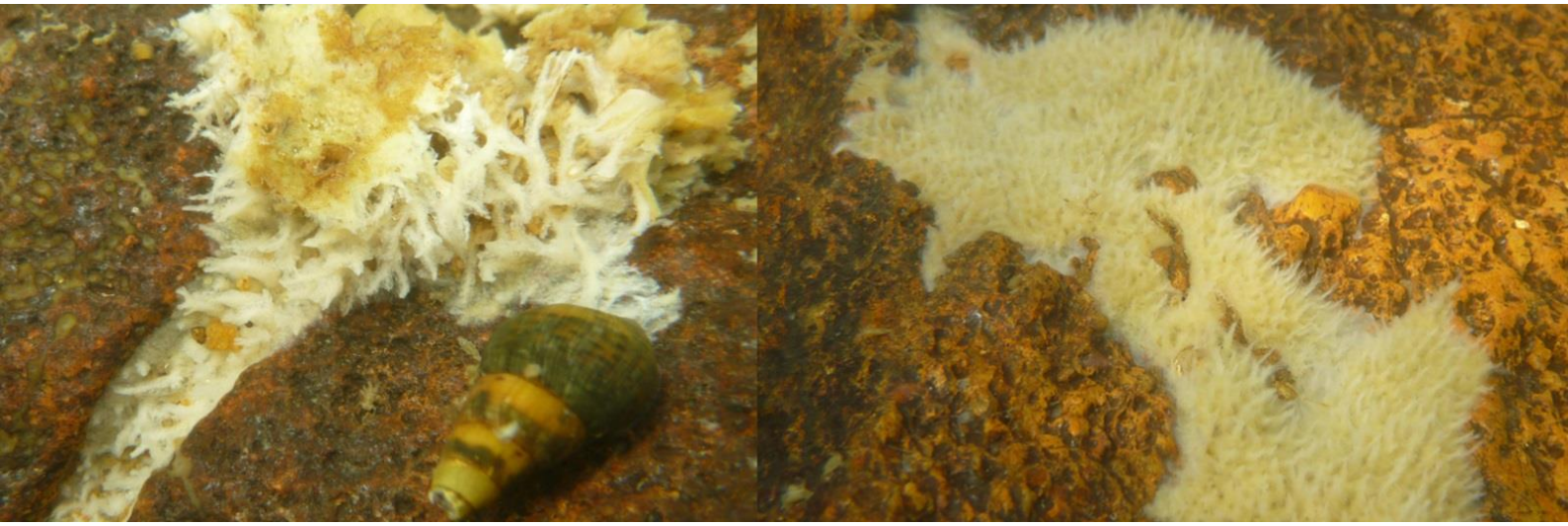


Picture 16. Mocororo (Melo de Sousa, 2013)

Grey fresh water sponge with spines (Order *Haplosclerida*)
Fishermen mentioned this grey fresh water sponge with spines several times during the interviews as a source of alimentation for the important fish species.

Picture 17. Grey fresh water sponge (Melo de Sousa, 2013)

White fresh water sponge with microorganisms living on it (Order *Haplosclerida*)
This white water sponge is fruequenlty used as source of alimentation by the five important fish species. Fishermen mentioned that the fish eat the sponge itself and the microorganisms, like larvae of insects, leeches, and freshwater snails, feeding or living on the sponge, this is confirmed by scientific researches (Pedrosa Gonçalves, 2011). Fishermen also mentioned that this sponge is found under rocks In the winter period, which makes it more difficult for ornamental fish to feed on it than in the summer period, when the sponge is found on top of rocks and in fractures.



Picture 18. White fresh water sponge (Melo de Sousa, 2011 and 2012)

Preface

This research tells the story of the 'Acarizeiros' of the Big Bend of the Xingu River in Brazil. Acarizeiro is the local name for a fisherman who collects and sells ornamental fresh water fish as a source of income. According to the perception of local people operating in the production chain of the trade in ornamental fish, the impact of hydroelectric dam Belo Monte on ornamental fish species, the income and fishing practices of fishermen is measured. This document is the final product for my bachelor study Forestry and Nature Conservation at the University of Applied Sciences Van Hall-Larenstein in Velp, The Netherlands and a great addition to my previous studies conducted in South America.

I would like to use this section of the paper to thank a number of people who contributed significantly to this research and the research period.

First of all I would like to thank dr. prof. Juarez Carlos Brito Pezzuti of Universidade Federal do Pará, and his wife Danièla Felix, who offered me the opportunity to conduct this research and who were always present in the background for questions and suggestions. Next to this I would like to thank Cristiane Costa Carneiro, PhD student Aquatic Ecology and Fisheries at Universidade Federal do Pará and her mother Lucia for substantive issues and for always being around to assist in all kind of practical matters.

Secondly, I also thank Ir. Erika van Duijl, lecturer Tropical Forestry at University of Applied sciences Van Hall Larenstein for her content and counselling during this research period.

Most important, I very much would like to thank all interviewed fishermen and local traders, who spent their time on collaborating, while giving me the opportunity to get to know their practices. I sincerely hope for all that the impact study with the least damaging prognoses becomes your reality. May your future be bright.

Furthermore, I thank dr. prof. Leandro Melo de Sousa, expert on ornamental fish species of the Middle Xingu region for his additions to the interviews, his photographs, videos, and background information. I also thank Erik Macedo for sharing his information, research experiences, and his presence during field visits.

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Rosa Diemont

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