Fall 2006

One Fish, Two Fish, Red Fish, Blue Fish: The Economic and Environmental Impacts of Commercial Fishing

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SIT Study Abroad

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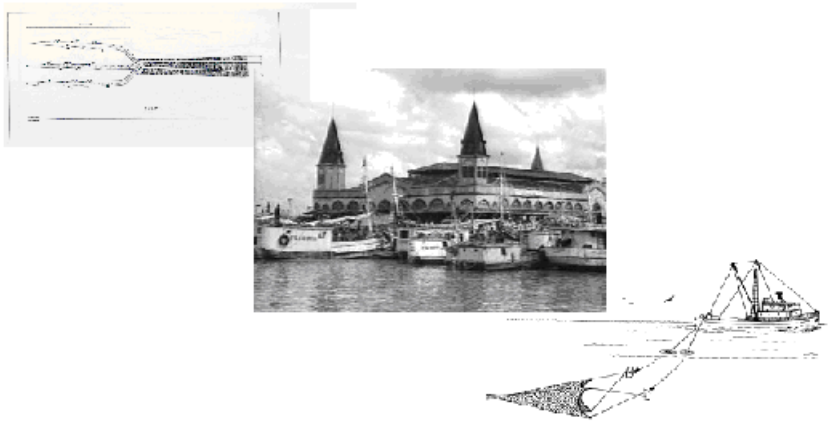

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11 December 2006
SIT Brazil: Amazon Resource Management and Human Ecology
Fall 2006

Abstract

Fish and fisheries play an important role in the Amazon River Basin. Fishing provides jobs to people of both urban and rural communities, and fish are a major source of protein in people's diets and a major part of the Amazon River ecosystem. In recent years commercial fishing has increased due to greater access to both domestic and international markets, and government incentives which have helped fishermen obtain better equipment and boats. The purpose of this study is to observe the Belém Ver-O-Peso fish market and interview fisherman about different aspects of commercial fishing (what species of fish were caught, how the fish were caught, the location where the fish was caught, and the price the fish is being sold for). This information was then compared to data from the years 1993-1996 and 2000-2004 and statistically analyzed to look at the effects of commercial fishing on the economy and the environment.

The data give evidence to support the idea that commercial fishing has led to an increase in fish prices, as well as a possible decrease in jobs of small local fisherman. Environmentally speaking, commercial fishing shows evidence of causing a loss of fish species biodiversity, as well as damage to the ecosystem as a whole because of over-fishing. Overall, this study gives evidence that commercial fishing has negative environmental and economic impacts.

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Resumo

Peixes e pescarias são muito importantes na bacia do Rio Amazonas. Peixes são uma grande fonte de proteína para pessoas e são importantes para o ecossistema do Rio Amazonas, e pescada proporciona trabalho para pessoas de ambas as comunidades, urbana e rural. Em anos recentes, a pesca comercial aumentou devido ao grande acesso para ambos mercados (doméstico e internacional), e incentivos para os governos, que devem ajudar os pescadores a terem melhores barcos e equipamentos. O propósito desse estudo é observar o mercado de peixes do Ver-O-Peso, em Belém, e entrevistar pescadores sobre os diferentes aspectos da pesca comercial (que espécies de peixes foram capturadas, como o peixe foi capturado, a localização na qual o peixe foi capturado, e o preço pelo qual os peixes estão sendo vendidos). Essa informação foi então comparada a dados de outros anos (1993-1996 e 2000-2004) e analizada estatísticamente para que se possa ver os efeitos da pesca comercial na economia e meio-ambiente.

Os dados deram evidência para suportar a idéia de que a pesca comercial leva a um aumento no preço dos peixes, assim como a possível diminuição no trabalho dos pequenos pescadores locais. Quanto ao meio-ambiente, a pesca comercial expõe evidências da perda da biodiversidade das espécies de peixes, assim como o estrago para o ecossistema total, em virtude da pesca desenfreada. No mais, esse estudo dá evidência de que a pesca comercial apresenta impactos negativos nos planos ambiental e econômico.

Introduction

Fish and fishing play an important role in the Amazon region. In riverine communities, fish are often the main source of protein in people's diets, and in both rural and urban settings selling fish can be an important source of income. Income from fishing is gained in one of two ways, either through small, local artisanal fishing, which employs approximately 70,000 people (30,000 of which are from "fishing colonies"), or through large industrial fishing, which employs less than 2,000 people (Barthem, 1999). In Santarém (Pará State), in what is considered an urban area, 84% of floodplain households engage in fishing for subsistence purposes. On average, fishing comprises 37% of a family's income, and the process of diversifying land use (e.g. fishing for part of the year instead of continually farming the land) has also been shown to help increase overall family income. The logistics change in an urban environment where people have more access to markets etc., but fishing can still be a major source of income for some. Commercial fishing generates R$ 389 million annually, and fishing in general, whether for commercial or subsistence purposes, is a major source of employment (Almeida, Lorenzen, McGrath, 2004)

Fish are also important environmentally speaking, as they play a crucial role in the ecosystem of the Amazon River. The fishes of the Amazon are still widely unstudied, but it is believed that there are more species of fishes within the Amazon River basin than in all of Europe. Estimates range from 2,000 to 3,000 freshwater species (Henderson, 1999) and up to 5,000 fish total if you include saltwater species ("Amazon Fish.", 2006). With so many species, the food web and ecosystem are highly specific, demonstrating the delicacy of the balance of the river structure.

Also, some fish of the Amazon, especially catfish, are highly migratory; a number of fish will migrate up and down the Amazon River, and at least two catfish species of the Amazon have the longest known migration within a river system in the world (Barthem and Goulding, 1997). That means that if a fish population is directly effected in one area of the river, other areas along the river will also be affected. This, combined with the already delicate ecosystem composition, demonstrates the potential to cause major changes within the Amazon River system. For example, Várzea farmland is highly productive because of the seasonal flooding that occurs, but when extensive areas are cleared for cattle ranching, logging, or agriculture, it ultimately affects the fish populations. Clearing land reduces habitat and food sources for fish, making some species more vulnerable to predation, starvations etc., which therefore also reduces fish species biodiversity. The

Várzea is a popular feeding ground for fish, so if fish can no longer have access to that area, their life cycle will be disrupted, causing a rippling effect throughout the Amazon.

Background Information

Commercial fishing was originally based solely on pirarucu *Arapaima gigas* (Schinz, 1822), a large bony tongued fish. The construction of the Amazonian highways however, opened up ways to the markets of the southern part of the country (particularly in the states of São Paulo and Paraná), which allowed trucks equipped with refrigeration capabilities to transport the catfish south (Moran, 1983). Additionally, in the 1960's the government offered incentives to fisherman to increase their fleet sizes and upgrade their equipment. Then in 1972 the government granted tax breaks and relaxed import regulations on equipment, and gave loans to fisherman to enable them to buy bigger fishing vessels (Barthem and Goulding, 1997). With that, the rise of the exploitation of catfish began, especially in Belém (Pará State)

Before the large market for catfish in Belém, fish were of little importance because people had more access to beef than other communities to the west, and therefore did not need fish in their diet. Additionally, Caboclo culture defines catfish and other scaleless fish as dangerous, so are generally avoided. Catfish are claimed to cause miscarriages, irritate inflammations, swell hemorrhoids, and discolor skin, among other things. At first, only one species of catfish was caught for commercial purposes. The gurijuba *Hexanematichthys parkeri* (Traill, 1832) was fished solely for its gas bladder, which could be used to make glue, but it was the only catfish that was fished for up until the 1960's (Moran, 1983). Once the foreign market for catfish was discovered however, the catfish industry took off and because Belém is the biggest city close to where the catfish live (brackish waters are the "nursery for large catfish" (Barthem and Goulding, 1997)), Belém is now a major exporter of catfish. Furthermore, fisherman can get higher prices for fish as the Ver-O-Peso market because fisherman haggle with buyers for the best price, often times selling their catch to more than one buyer, which is unusual compared to other markets. At most other markets, fisherman will sell their catch to just one buyer, and have less control over the price, which is why fisherman bring their fish from long distances to sell at Ver-O-Peso. People will even travel from very far south in the country (São Paulo State) to sell fish at the market in Belém. In 1981 alone, estuary fish and shrimp were the fifth most important of Para's exports, totaling 13 Million US Dollars. Also, 90% of the fish exported consisted solely of piramutaba

Brachyplathystoma vaillantii (Valenciennes, 1840), one of the most important catfish species, which were all sent to the United States. These external factors have all affected the fish market at Ver-O-Peso and lead to a more commercial focus (Moran, 1983).

Although there are many different species of fish that are caught and sold at Ver-O-Peso, the increase in commercial fishing has made some much more populous at the market than others, although the number of species at the market, may vary from what is initially observed due to the fact that fisherman have common names for fish species that do not necessarily correspond to the scientific name. For example, there are certain fish that are different colors during different periods of their lives, which could result in two different names for the same species. Also, sometimes fish are of the same family and look similar, and will therefore be given the same name, despite the fact the fish are two different species (Moran 1993). The most dominant fish species though are pescada-amarela *Cynoscion acoupa* Lacepède, 1801, pescada-branca *Plagioscion squamosissimus* (Heckel, 1840), pescadinha gó *Macrodon ancylodon* (Bloch & Schneider, 1801), pratiqueira *Mugil* spp. tucunaré *Cichla* spp., Xaréu *Carnax hippos* (Boulenger, 1898) and those of the catfish variety: Bagre *Bagre bagre* (Linnaeus, 1766), dourada *Brachyplathystoma rousseauxii* (Castelnau, 1855), filhote *Brachyplatystoma filamentosum* (Lichtenstein, 1819), gurijuba *Hexanematichthys parkeri* (Traill, 1832), piramutaba *Brachyplathystoma vaillantii*, and tamoatá *Hoplosternum litoralle* (Hancock, 1828). The fish (of market value) have various sizes, and size ranges. Some fish species can be as small as 63mm and grow into fish 673 mm long (*Macrodon ancylodon*), or start as large as 640mm and become as large as 1180mm (*Cynoscion acoupa*). Each individual species has a different range for what level of salinity it prefers to live in ranging from being a completely freshwater fish, to living in the brackish waters of the estuary, or the Atlantic Ocean. The Amazon estuary has one of the most productive fishing areas in Brazil with an estimated catch of 385,000-475,000 tons per year, comprising about 40% of the total fish production, demonstrating the significance of the brackish water region to the fishing industry (JICA, 1998).

Since large scale fishing has increased, instead of fishing with a small boat and a harpoon as it is done in small communities, fisherman use many other different fishing methods to capture more fish in less time. Close to the city smaller boats, such as canoes (canoas), are still used because they are located close enough to the market that the fish can be transported to the port within a few hours of being caught. For the most part however, large wooden commercial boats are what are most often used. Boats are equipped with hold areas that are filled with ice, making it

easier for fisherman to get fish to the market. With a 1:1 ratio of fish and ice (by weight), the fish catch can last up to twenty days, although the fish are better if sold within the first two weeks. Additionally, boats equipped with the hold areas for fish (barco com geleira comprador) will travel to highly exploited areas and buy fish directly from the fisherman, which frees up the hold area of the fishing boats, allowing fisherman to increase their catch sizes. For example: "During the main fishing season for Piramutaba [(*Brachyplatystoma vaillantii*)] in the Baía de Marajó…most fish are purchased by buyers with ice boats." Fisherman that sell their fish to the barco com geleira comprador can usually only get half the price they would at the markets, but the fisherman sell their fish in exchange for fuel and food, which prolongs their expedition, allowing them to catch more fish, increasing their total catch size (Barthem and Goulding, 1997).

There are four major methods of commercial fishing that take place in Northern Brazil and the most popular system is through the use of gill nets. Gill nets are nets constructed of twine .20 to .30mm in diameter with a length ranging from 50 to 3000 meters long. The nets were introduced in 1957 as both floating nets, used mostly for catching "sardinha" *(Characidae* or *Engraulididae*), and sinking nets, used for catching large fish (Sugunan, 1997). The sinking nets are of the most commercial significance and they are used both in estuary and inland waterways, although there are two different versions depending on the location. In the estuary the nets are extremely long (up to 3000 meters) used for catching large catfish. At low tide boats are turned off, and the area is surveyed to determine the best depth for the net. If it is a muddy region, the nets are generally lowered to just above the floor, where catfish tend to reside, but if it is open water, much of it depends on if there are other boats around. The nets are left in the water for 5-6 hours, and are pulled in with the rise in the tide (Barthem and Goulding, 1997).

The targeted fish (*Brachyplatystoma vaillantii*) are difficult to spot from the surface of the water, but there are other indicators that help fisherman to know where to release their nets. Amuré gobies (*Awaous* spp.) are a smaller fish that *B. vaillantii* kill and do not necessarily consume, so the presence of dead fish on the surface of the water, or swarming gulls, are a strong indication that *B. vaillantii* may be present nearby (Barthem and Goulding, 1997).

Fresh water gill nets, or malhadeiras, are drifting nets deployed from canoes that are designed to catch fish that are large in size. Nets are released into the river and are later pulled in and the fish are removed. The down side to this method of fishing is that smaller catfish will often attack the fish caught in the net, destroying the catch (Barthem and Goulding, 1997).

Another method of fishing is trawl fishing, or arrasto de parelha, which involves two boats. The two boats are about 100-meters apart and depending on the targeted fish drag a net between either 10 and 12 meters deep (Sugunan, 1997) or 20 and 40 meters deep. This method of fishing, which is most often used in the Amazon estuary, captures more than just the targeted fish, and often fisherman will throw back up to 80% of the catch. Unfortunately most fish are destroyed because they are attacked by flesh eating fish also caught within the net (Barthem and Goulding, 1997).

The method that is most primitive is fishing with zagalas. Zagalas are three pronged harpoons which are used to kill large fish such as pirarucu (*Arapaima gigas*). Zagalas are often used in rapids, where it would be too difficult to use a net. (Barthem and Goulding, 1997).

Trotlines (espinhels) are also a popular way to catch fish within the Amazon basin, and once again there are two different methods, depending on if one is in freshwater river channels, or if in the open waters of the estuary. In the river channels a line is attached to some point on shore, and the other end of the rope is either sunk to the bottom or the channel, or if narrow enough, attached to another point on the opposite shore. Baited hooks are dangled from line (using amuré gobies (*Awaous* spp) as the bait); if it is a short line 5-7 hooks are used, but if the line is long, or stretched across the river, many more hooks can be used.

In estuaries, a buoy with an anchored line is strategically placed. Attached to the bottom of the anchored line is another line with baited hooks attached (hooks are also baited with amuré gobies (*Awaous* spp)). Using espinhels in estuaries is more difficult though because of the possible interference with gill nets (Barthem and Goulding 1997). (See the Appendix A for diagrams of the four main fishing methods)

There are problems associated with each fishing method, each effecting the environment and economy. For instance, fish catches from arrasto de parelhas can capture huge amounts of fish, but fishermen will discard as much as four-fifths of their catch because the fish are not marketable, and/or have already been destroyed because of the consequences associated with this fishing method. This not only alters the ecosystem, but reduces the number of catchable/marketable fish as well (or fish that will soon grow into marketable fish). Fisherman have stated that they used to only keep *Brachyplatystoma vaillantii* greater than 1-kg, but since fisherman now rarely catch fish of that size, fisherman are forced to keep those fish instead. This is strong evidence of the problems associated with over-fishing. Not only does it hurt the ecosystem, it also has negative economic

impacts, as fisherman can no longer catch larger fish to sell to the market, which would in turn give them a higher income.

Furthermore, arrasto de parelhas, as well as malhadeiras, catch more than just the targeted fish, which could lead to a loss of biodiversity. Under current conditions, regulations for malhadeira mesh sizes do not permit anything smaller than 10cm (Barthem and Goulding, 1997), but there are many other forms of aquatic life that cannot pass through the small holes of the net, which can include dolphins or manatees. Instead of just taking in the fish that would be good for the market, all the fish caught in the net are killed, thus decreasing the population of fish that could potentially be marketable in the future, as well as damaging the ecosystem as a whole (altering the food web, lowering biodiversity etc.).

With the industrial use of arrasto de parelhas eliminating large amounts of fish from the pool of marketable fish, high levels of unemployment of small scale fisherman can occur (JICA, 1998). Fishing employs many more artisanal fishermen than commercial fisherman, so if commercial fishing increases, and more fish are removed from the Amazonian waterways, it could lead to a decrease in household incomes for many families due to the loss of fishing jobs. Likewise, reductions in fish populations also means a reduction in the surrounding community's protein/food supply.

Commercial fishing also has negative impacts on smaller communities, both local and upstream from the commercial fishing, in other ways. As mentioned previously, many fish are migratory, so reducing the number of migratory species in one site can have detrimental effects elsewhere. As stated by Ronaldo Barthem et. al. in *The Catfish Connection*: "Migratory species must be managed if present yields of relatively high value fish are to be maintained." For instance, gaff fishing is a method of fishing purely dependent on migratory species. Fisherman build perches that stretch from the shore to above the river rapids and then catch the fish they see migrating up the river (Barthem and Goulding, 1997). If the numbers of those species declined, that means of fishing would be severely reduced. Also, because of the malhadeira and arrasto de parelha methods of commercial fishing (which remove more fish from the watersheds than artisanal fishing methods would), there are fewer fish, if any at all, available for small fisherman. Small fisherman fish mostly in canoes or other small vessels using traditional methods such as hooks (anzols) or three pronged harpoons (zagalas) so with fewer fish populating the river, it is more difficult for small fisherman to get an income great enough for subsistence. Disrupting an area, whether it is

something as indirect as clearing a plot of land for a cattle ranch, or something that will obviously have an effect, such as over-fishing, will in the end cause changes in all parts of the river, which emphasizes the necessity of making educated choices about our actions.

Overall, commercial fishing can lead to potential problems throughout the Amazon basin environmentally, economically and socially speaking, and will continue to do so if no actions are taken to prevent it. One governmental organization that works for fishing regulations is the Instituto Brasileiro do Meio Ambiente (IBAMA), a government based environmental agency. IBAMA has a fishery and aquaculture section which sets the rules and regulations concerning the fishing industry. These include laws such as Portaria No. 2230/90, dated 7 November 1990 and Nos. 023/93 and 021/93 dated 9 March 1993 which regulate fishing in open water. Those laws set the regulations concerning fishing practices, the mesh size for the use of nets, and the size range that deems a fish allowable to be kept (Sugunan, 1997). Unfortunately there is very little enforcement of these laws and regulations, so although they were implemented to help reduce the impacts on the environment, are not helping as much as intended. Also, the regulations and laws are formed with the intent of being applied to many different regions, despite the fact that conditions are different in each place. What is beneficial in one area may not necessarily be beneficial in another, but government regulations do not take that into account when creating parameters for large regions. One method that has been used to curb these effects in other areas of the Amazon River basin is the application of management plans.

There are have been many successful management plans implemented in areas west of Belém (for example, the Mamirauá Sustainable Development Reserve in Tefé (Amazonas State), or the Projeto Várzea, based in Santarém Pará State)) which both concentrate on the flooded forests. Flooded areas are the focus of both abovementioned groups because flooded forests are of great importance concerning the balance of agriculture, fishing, and cattle ranching but, as discussed above, commercial fishing also affects urban areas, including Belém. A management plan would be deemed necessary if regulations were not being followed, and if problems were arising pertaining to the activities taking place in the area of concern. Before any action can be taken though, research needs to be done to understand the area so the most suitable management plan can be applied to the region.

As pointed out by Emilio F. Moran (1983), to create a sustainability management plan for a fishery, there are multiple factors that need to be taken into account, and can be placed into 4

categories. The first class of knowledge that needs to be known is related to the taxonomy, ecology and distribution of fish populations. In order to properly protect a species or group of species, there should be a through knowledge base, so that the organisms will be protected in the most adequate way. Secondly, reliable catch data needs to be known in order to be able to see what the trend in fish populations has been based on the current conditions. The role of fish in the economy and people's lives/diets also needs to be known so the management plan can be designed to fit the needs of the communities it will be affecting. For instance, if small scale fishing is important for subsistence, but commercial fishing is slowly hurting small fisherman, the management plan may involve a way to reduce or limit the amount of commercial fishing in the area to ensure the livelihoods of the small communities. The last thing that is needed for a management plan is an understanding of the current bureaucratic structure used to enforce the legislation concerning fisheries. Knowing about the current system and whether it is properly set up, or if it is being enforced and how, will serve as a guide to what needs to be changed, and what is already working. With that information, the best management plan possible can be constructed and applied to the area of interest. (Moran, 1983).

There is evidence that the fisheries surrounding Belém are experiencing a reduction in fish species biodiversity due to the fishing methods and exploitation of a few select species, as well as a change in the local economy. The intent of this study is to survey the fish market at Ver-O-Peso in Belém, Brazil, in order to compare the information gathered there with data from past years (1993-1996 and 2000-2004). Ver-O-Peso has been the residence of the city's fish market for over one-hundred years (Rivera, 2006), making Ver-O-Peso an excellent example of a fish market that has experienced the effects of commercial fishing. Having a better understanding of the economic and environmental impacts of commercial fishing in this location will be useful for further research concerning the protection of fisheries in the areas surrounding Belém.

Objectives:

The objectives of this study are to identify the composition of fish species being sold at Ver-O-Peso (both the common and scientific name), the price for the commercial fish, the method of fishing used, and the location the fish were caught. That information will then be used to evaluate the trend in fish composition/economic value during past years by comparing data

gathered in previous studies. After those conclusions are drawn it will be possible to look at the effects commercial fishing has had the economy and the environment.

Data concerning the type of fish sold at the market and the price of the fish will be useful information for determining if there is a possible decline in fish populations. For instance, if the market used to be dominated by a certain species, but is now less populous in the market and the price is higher, this indicates a low supply and a high demand, which could be an indicator of exploitation. To supplement this information, the location of where the fish was caught will also be useful. If the above pattern was noticed, and the species of fish was caught in the same location both in the past and currently, this will further support the idea that the area, and species of fish, are being exploited.

The method of fishing is also of importance. The fishing method can highlight a possible reason for why a certain population of fish are declining, or are still populous. It can also be used to help predict if a fish species is in danger of being over-fished, or if the fish will be relatively safe for the time being, based on if the fishing method requires a net (easy capture of all fish) or if a more sophisticated means of capture is necessary.

The interaction between the price of fish and the means of fishing also reveals some information. If the means of fishing is relatively difficult, then it can be expected that the price of the fish will be relatively high and a correlation between high price and exploitation cannot necessarily be drawn.

The intent of this study is to gather information from the Ver-O-Peso fish market and use it to make generalizations about the environmental and economic impacts of commercial fishing on the surrounding fisheries and the fish market itself.

Methods:

To gather the information needed for this study, data was collected at Ver-O-Peso in Belém. Ver-O-Peso was visited two times during the time period between the last three weeks of November and the first week of December. Each visit was at 7am, and consisted of getting information about the fish being sold through interviews and observation. Fisherman and vendors were interviewed to get the following information: the common name of the specimen, how much the fisherman is selling the fish for, the method of fishing (malhadeiras, arrastos de parelhas, etc.) and the location where the catch was obtained.

One individual of each species was purchased and brought back to the Ichthyology Department laboratory at the Museu Paraense Emilio Goeldi. At the laboratory fish were photographed, injected with formaldehyde for preservation purposes, and later scientifically identified (to eliminate the problem identified earlier concerning the match up of common names and the actual species).

After all the data was gathered for the present year (2006) it was compared to data collected by PróVárzea (MPEG/IBAMA) in the last three weeks of November and the first week in December (to resemble the current study) for the years 1993-1996 and 2000-2004. One date per week was chosen at random for the chosen time period, so as to further eliminate any external variables. The data was statistically analyzed with MINITAB, using a 95% confidence interval, for information pertaining to the following categories: market prices, means of fish transportation, fish species diversity/market composition, fishing sites, and method of fishing.

Results:

Market Prices: Prices were only available for the years 2000-2002 and 2006, but a statistical analysis was performed to determine if there was a difference in price between the years. Additionally, not all fish are as populous in the market, so only the most common species were assessed (those mentioned above). The data was first analyzed to determine if there was any variation in price between the days of the month of each particular year. After, an analysis of variance test (ANOVA) for a difference in prices was carried out to see if there was a change in prices over the years, and what the trend was.

The results from the ANOVA test (Table 1) all showed that there was no price difference between the days of the week for the month during the indicated time period. This gives evidence to show that there is very little fluxuation in prices from day to day at the Belém Ver-O-Peso fish market. The ANOVA tests for variation between the different years showed that the price of each individual species of fish either increased, or in a few cases, had no change. All species except *Macrodon ancylodon*, *Cichla* spp., and *Carnax hippos* experienced some sort of price increase, whereas those three species have no difference in prices between the various years.

The correlation tests further indicated a relationship between the price of a certain fish species and the year. (Table 2) *Mugil* spp. was the only species to have a negative correlation, indicating a price decrease. With the exception the three previously mentioned fish, all species had

Table 1 ANOVA test results (at a 95% significance level) for the test of variance between the price individual fish species per week and the price differences between the years

Fish Species (Scientific Name)	**ANOVA Results (p-value for diff b/t weeks)**	**Change Between Weeks?**	**ANOVA Results (p-value for diff b/t years)**	**Change Between Years?**	**What is the trend of the Change?**
Bagre (*Bagre bagre)*	2000 = 0.945 2001 = 0.819 2002 = 0.755 2006 = no data	No	0.000	Yes	Price increase
Dourada (*Brachyplathystoma rousseauxii)*	2000 = 0.408 2001 = 0.678 2002 = 0.735 2006 = no data	No	0.000	Yes	Price increase
Filhote (*Brachyplatystoma filamentosum)*	2000 = no var. 2001 = 0.615 2002 = 0.385 2006 = no data	No	0.002	Yes	Price increase
Gurijaba (*Hexanematichthys parkeri)*	2000 = no var. 2001 = 0.761 2002 = no var. 2006 = no data	No	0.009	Yes	Price increase
Pescada Amarela (*Cynoscion acoupa)*	2000 = no var. 2001 = 0.967 2002 = 0.138 2006 = no data	No	0.001	Yes	Price increase
Pescada Branca (*Plagioscion squamosissimus)*	2000 = .985 2001 = 0.555 2002 = 1.000 2006 = no var.	No	0.000	Yes	Increase between 2000 and 2001, after no price change
Pescadinha Gó (*Macrodon ancylodon)*	2000 = no data 2001 = 0.500 2002 = no var. 2006 = no data	No	0.178	No	N/A
Piramutaba (*Brachyplathystoma vaillantii)*	2000 = 0.346 2001 = 0.928 2002 = 0.500 2006 = no data	No	0.005	Yes	Price increase
Pratiqueira (*Mugil* spp.)	2000 = no data 2001 = 0.928 2002 = 0.426 2006 = no var.	No	0.000	Yes	Price increase for 2000-2002, sudden decrease with 2006
Tamoatá (*Hoplosternum litoralle*)	2000 = 0.233 2001 = 0.309 2002 = no var. 2006 = no var.	No	0.000	Yes	Price increase from 2000 to 2002, no change between 2002 and 2006
Tucunaré (*Cichla* spp.	2000 = no var. 2001 = 0.358 2002 = 0.676 2006 = no var.	No	0.227	No	N/A
Xaréu (*Carnax hippos*)	2000 = no var. 2001 = 0.294 2002 = no var. 2006 = no data	No	0.074	No	N/A

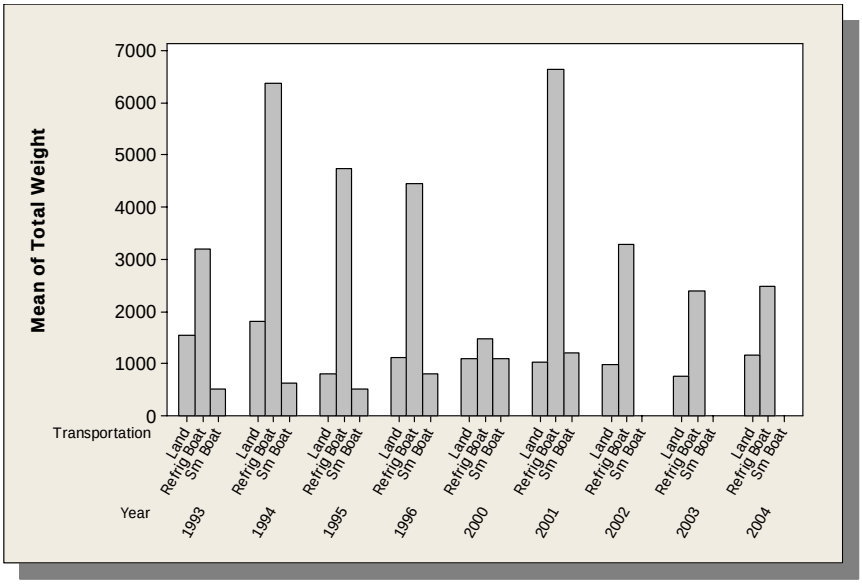
Table 2 Test results for correlation analysis of price of each fish species and the year

Fish Species (Scientific Name)	**Correlation Value**	**Strength**
Bagre (*Bagre bagre)*	0.868	Strong
Dourada (*Brachyplathystoma rousseauxii)*	0.836	Strong
Filhote (*Brachyplatystoma filamentosum)*	0.751	Medium-Strong
Gurijaba (*Hexanematichthys parkeri)*	0.838	Strong
Pescada Amarela (*Cynoscion acoupa)*	0.774	Medium-Strong
Pescada Branca (*Plagioscion squamosissimus)*	0.534	Medium
Pescadinha Gó (*Macrodon ancylodon)*	No correlation	N/A
Piramutaba (*Brachyplathystoma vaillantii)*	0.752	Medium-Strong
Pratiqueira (*Mugil* spp.)	-0.639	Medium/Medium-Strong
Tamoatá (*Hoplosternum litoralle*)	0.727	Medium-Strong
Tucunaré (*Cichla* spp.)	No correlation	N/A
Xaréu (*Carnax hippos*)	No correlation	N/A

a strong to medium-strong positive correlation between market price and the year, indicating that prices are increasing with each new year.

Modes of Fish Transportation: Modes of transportation were broken down into three groups: small motor boats, boats equipped with refrigeration, and land vehicles (trucks, kombis). A two-way analysis of variance test was conducted to see if the total catch weight varied for each year (with the exception of 2006, due to lack of data), based on the mode of transportation. The results indicated that there was a strong difference between the modes of transportation, and a slight difference between years. A graph of the data (Figure 1) shows that refrigerated boats provide the highest amount of fish to the market, and that over the years small motor boats have consistently been the smallest provider, but in recent years have not had any significant input into the market, whereas fish brought to the market by land vehicles have remained constant or increased.

Figure 1 Distribution of mean total catch weight per year for each mode of transportation



Fish Species Diversity/Market Composition: A correlation test was carried out to test for a relationship between the numbers of species at the market for each year (to look for an increasing, decreasing, or lack of trend for each increasing year). The r value for the correlation test was -0.705, indicating a relatively strong negative relationship. So with each new year, the number of different fish species at the market decreases (Table 3). The entire list of species available at least once during the time period studied is listed in Table 4.

Table 3 Average daily number of fish species available at Ver-O-Peso

Year	Species Number
1993	30
1994	35
1995	32
1996	41
2000	30
2001	34
2002	30
2003	28
2004	24
2006	16

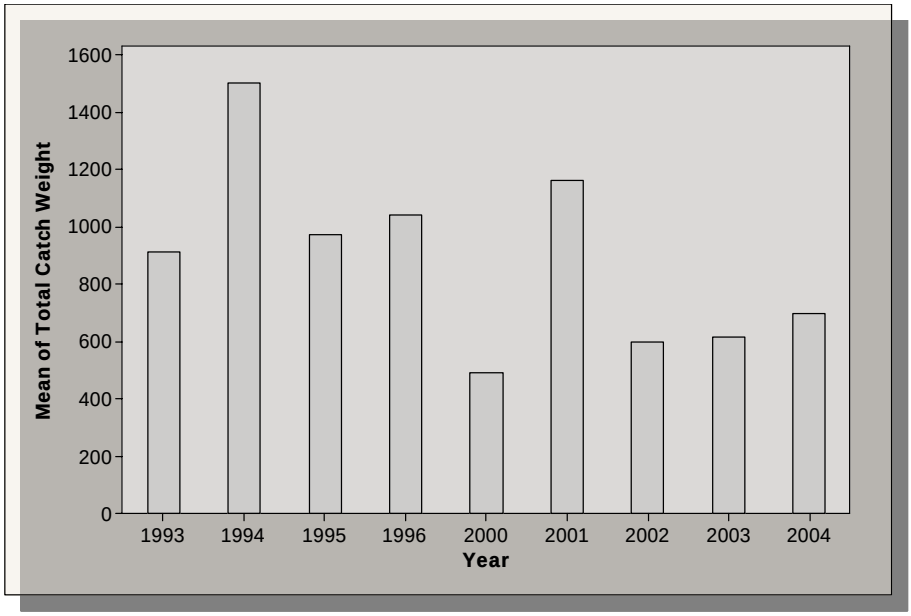
Table 4 A complete list of fish found at Ver-O-Peso at least once during 1993-1996, 2000-2004 and 2006. Note: some species do not have scientific names because the common name can be applied to many different species of fish.

Common Name	Scientific Name
Acará-Acu (doce)	*Astronotus* spp.
Acari	*Hypostominae*
Apaiari	*Astronotus* spp.
Aracú	*Anostomidae*
Arraia	*Rajiformes*
Bagre	*Bagre bagre*
Bandeirado	*Bagre bagre*
Cação	*Carcharinidae*
Cachorro de Padre	*Auchenipteridae*
Cambeua	*Arius grandicassis*
Camurim	*Centropomus* spp.
Cangata	*Arius quadriscutis*
Cará	*Cichlidae*
Cara Açu	*Astronotus* spp.
Cará Beré	Unknown
Carauaçu	*Astronotus* spp.
Cavala	*Scomberomus cavalla*
Cioba	Unknown
Coro	Unknown
Corvina	*Cynoscion virescens*
Curimã	*Mugil* spp.
Curimatã	*Prochilodus* spp.
Dourada	*Brachyplathystoma rousseauxii*
Filhote/Praiba	*Brachyplatystoma filamentosum*
Gurijaba	*Hexanematichthys parkeri*
Jeju	*Erythrinus erythrinus*
Jupi'ra'	*Arius rugispinis*
Mapará	*Hypopthalmus* spp.
Mero	*Epinephelus itajara*
Mistura	Unknown

Common Name	Scientific Name
Pacu	*Serrasalminae*
Pargo	Unknown
Pedra	*Lithodoras dorsalis*
Pescada Amarela	*Cynoscion acoupa*
Pescada Branca	*Plagioscion squamosissimus*
Pescadinha Gó	*Macrodon ancylodon*
Piaba	Unknown
Pinambu	Unknown
Piramutaba	*Brachyplathystoma vaillantii*
Piranha	*Serrasalminae.*
Pirapema	*Tarpon atlanticus*
Pirarucu	*Arapaima gigas*
Pratiqueira	*Mugil* spp.
Sarda/Apapá	*Pellona* spp.
Sardinha	*Characidae ou Engraulidae*
Sardinha	*Characidae ou Engraulididae*
Serra	*Pristis* spp.
Suru	Unknown
Surubim	*Sorubimichthys planiceps*
Tainha	*Mugil spp.*
Tambaqui	*Colossoma macropomum*
Tamoatá	*Hoplosternum litoralle*
Timbira	*Oligoplites saurus*
Timbira/Pratiuira	*Oligoplites palometa*
Traíra	*Hoplias malabaricus*
Tucunaré	*Cichla* spp.
Uritinga	*Ariidae*
Xaréu	*Carnax hippos*
Xaréu Poca	Unknown

The total weight of the catch was also tested to determine if there was a variance in the amount of fish caught per year. It was discovered that there was a difference in total catch weights between the years, and a low negative correlation between the two variables, indicating there is a

Figure 2 Mean daily total catch weight per year



general trend toward a decreasing total catch weight. The output also shows a pattern of fish weight totals increasing for a year or two, and then decreasing dramatically, possibly indicating the amount of fish extracted from the river one year could effect the fish populations for the following year(s) (Figure 2)

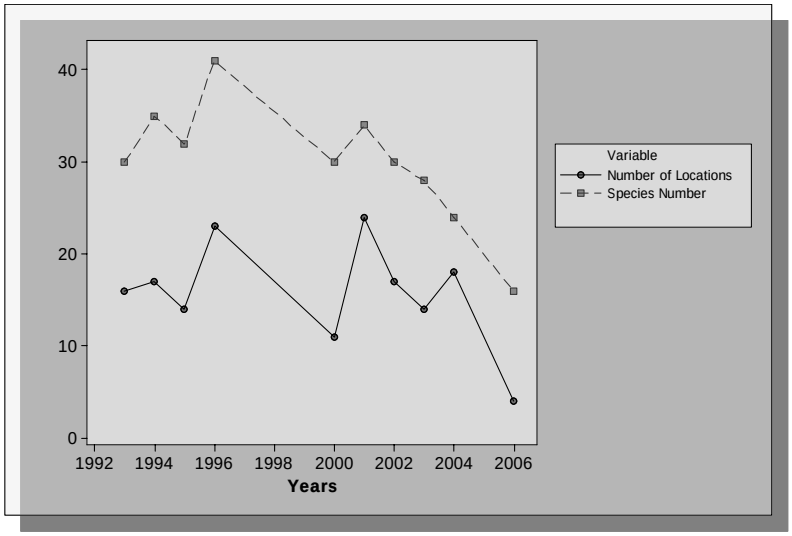
Fishing Sites: A correlation test was run to examine if there is a relationship that exists between the fishing location, and the species of fish caught. (See Appendix B for all fishing locations). There was no supporting evidence of a correlation between the average daily number of locations represented at Ver-O-Peso and the year. It was determined however, that there is a strong correlation between the average daily number of different locations per year (Table 5), and the average daily number of fish species per year (Table 3) available at the market (see Figure 3).

Method of Fishing: A correlation test was run to see if one method of fishing results in higher total catch weights than another, although the results showed there was no correlation. An analysis of variance also tested the same thing; to see if there was a difference between each year, and it was determined that a difference exists between the different fishing methods. The use of malhadeiras remained the dominant method of fishing, but the arrasto do parelha method of fishing resulted in

Table 5 Average daily number of different fishing sites

Years	Number of Locations
1993	16
1994	17
1995	14
1996	23
2000	11
2001	24
2002	17
2003	14
2004	18
2006	4

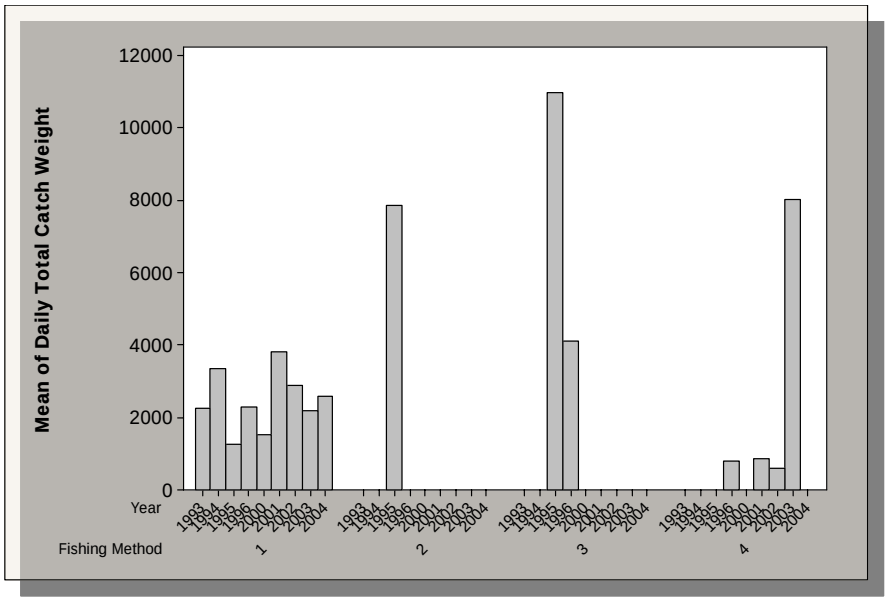
Figure 3 Scatterplot showing the similarities between the average daily number of fish species and fishing sites represented at Ver-O-Peso.



much higher total catch weights. Also, in an ANOVA test of daily total catch weight and year it was found that there was no significant difference in the mean of the total daily catch weight between the years, indicating that the method of fishing generally captures the same amount of fish each time. (Figure 4)

Figure 4 Bar chart showing variation of daily total catch weight for each year based on the method of fishing

1 = Malhadeira 2 = Arrastão do parelha 3 = Zagalas 4 = Espinhel



Discussion

Based on the results from the study, the theory that commercial fishing has effects on the environment and economy of the fishing industry is supported. The results give implications surrounding the future of the fishing industry with reference to jobs and fish availability, fish species biodiversity, and the possibility of over-fishing.

The results showed that there is an increase in the amount of fish transported by land vehicles, and a decrease in small motor boats bringing fish to the market, indicating a possible change in the job market. Small motor boats, operated mostly by artisanal fisherman, have always been the smallest provider of fish to the market, mainly because of a limited capacity for fish storage and the fact that smaller boats cannot travel long distances (in comparison to refrigerated boats or land vehicles). But, if the market is becoming more and more flooded with fish brought in by land vehicles from other areas of Brazil, it will make it even more difficult for small scale fisherman to compete for prices. One of the main economic concerns with commercial fishing is the potential negative impacts on the livelihoods of smaller fisherman. As mentioned above, fishing is a large source of jobs, and often the main source of income for a family, thus showing the importance of small fishing boats in the economy.

Prices have also changed dramatically (within the small range of years studied) indicating another economic change associated with commercial fishing. With the exception of a few fish species, each increasing year shows a significant increase in price for each individual fish species. This could be due to multiple reasons: an increase in market demand (McGrath et. al. 1999), or over-fishing. As indicated by the yearly decrease in the number of species available at the market, the fish market at Ver-O-Peso is narrowing, which is a possible cause for the increase in prices. A reduction of diversity at the fish market, economically speaking, can indicate that some species are more popular than others, and an increase in demand would be cause for an increase in price. The increase in demand however, could also be due to fish becoming sparser, therefore creating an increase in demand by default. The results of this study give support to that theory, as the total catch weight shows evidence of a decrease with each year. Overall, the evidence is high that over-fishing is the reason behind the increase in prices at the market.

The economic changes seen in this study are also strong indicators of the environmental impacts of commercial fishing. The data gathered gives strong evidence of a decrease in fish biodiversity, and the sensitivity of the ecosystem to over-fishing.

The decrease in the number of fish species available at Ver-O-Peso is a possible indicator of a loss of fish species biodiversity. Results showed that there was no change between the years for the mean total catch weights in relation to the method of fishing. If there have been no changes in how the fish are caught, but the number of species has significantly declined, the most likely reason is that there are not as many species of fish available. Commercial fishing removes more fish from the waters than are marketable and since everything caught by the net is killed, the result is that there are fewer fish species available at the market.

The fish market is also a good indicator of how sensitive the ecosystem is to heavy amounts of fishing. When an area is heavily fished in one year, it generally means that the large, and many of the medium sized fish, are removed from the ecosystem. This means that the following year the only fish available will be small fish and those that have grown into medium sized fish. When the fish that have the potential to grow into large fish are extracted by fisherman, at least a year of recovery is required before large fish will be available again. So, if fish populations are smaller, and few large fish are available, the total catch weights the year following heavy exploitation will be significantly lower, which is exactly the trend seen in Figure 2. The relationship between when the total catch weight significantly increases in one year (or remains relatively high for multiple years), and the following year shows a significant decrease in total catch weight, demonstrates the sensitivity of the ecosystem (as represented by the fish market) to over-fishing.

It was also discovered that there is a strong relationship between the number of species at the market, and the number of locations where the fish were captured (Figure 3). As the number of locations being fished decreases, so too does the number of fish species available at the market. This gives evidence that there are some fishing areas that are being exploited. Fish catch totals and fish biodiversity are decreasing, and that combined with a decrease in the number of places being fished gives strong evidence that over-fishing is occurring, and that it is having negative impacts on the environment.

The data gathered at Ver-O-Peso has given strong indications that commercial fishing is causing detrimental economic and environmental impacts. Small fisherman are slowly being edged out of the market, and prices are drastically increasing. At the same time, fish species biodiversity is decreasing, and certain species of fish are being exploited, which in turn affects the market. The economy and environment surrounding the fishing industry are closely tied, and are greatly affected by commercial fishing.

Conclusions

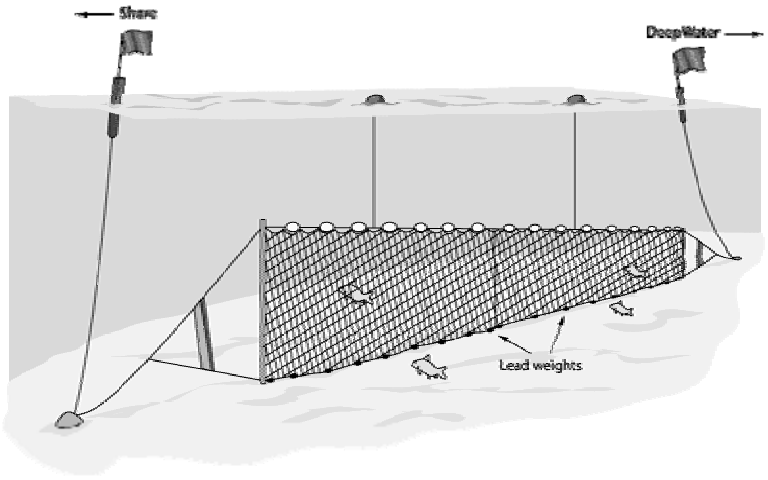
The impacts of commercial fishing at Ver-O-Peso are clear, and are representative of the effects of commercial fishing in other areas as well. Economically, there is the potential for a loss of jobs, and prices are increasing. Although the increase in prices could be beneficial to fisherman, the social impacts are less optimistic. Many people depend on fish as the main source of protein in their diet, and if prices continue to increase, could eventually put buying fish out of reach. Environmentally speaking there is a loss of species diversity and the potential for other changes within the ecosystem due to the exploitation of a few select fish species (causing alterations of the food web, increased loss of species due to an increase in predators etc.).

This study is part of a larger study that is continually monitoring the fish market at Ver-O-Peso in order to observe changes in the market. As this study demonstrates, the economic changes in the market are representative of the changes occurring in the environment. The results of this study have shown that the commercial fishing industry is, or has a strong potential, to negatively impact the economy and the environment. If the trends continue, it may call need to an environmental management plan, similar to those in the western sections of the Amazon Basin, in order to preserve people's livelihoods, and the ecosystems of the area.

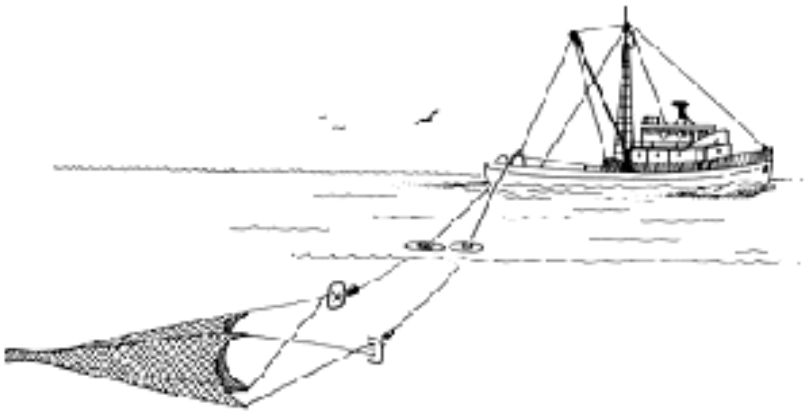
Appendix A

Figures Demonstrating the Four Main Fishing Methods

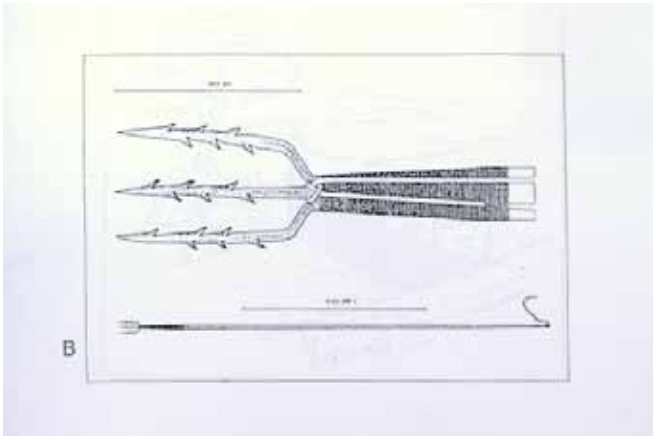
Gill Net or Malhadeira ("Know your Nets", 2006), ("www.zsee.seplan" (first listed), 2006)



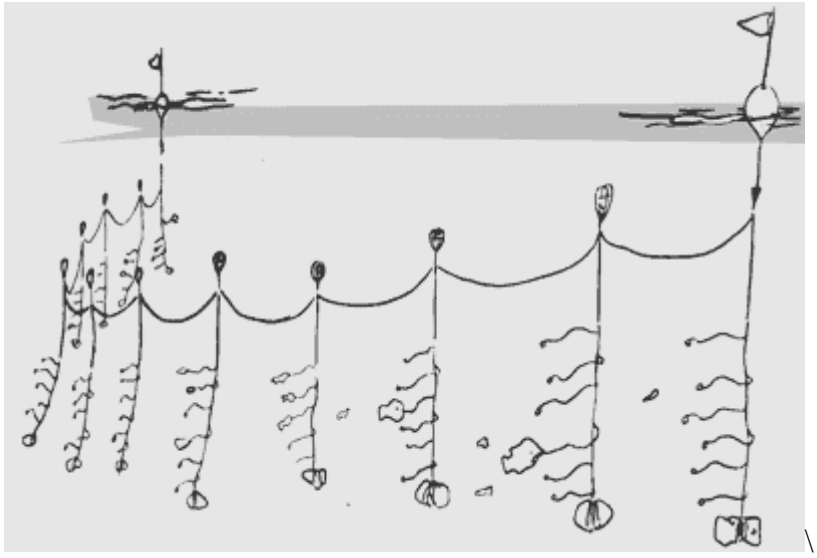
Trawl or Arrasto de Parelha ("http//www.alaska", 2006)



Three pronged Harpoon or Zagala ("www.zsee.seplan" (second listed), 2006)



Trotline of Espinhel ("Espinhel.", 2006)



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Appendix B

The Location is the name given by the fisherman, the region was determined by the researcher
1 = Marine Coast 2 = Delta Region 3 = Amazonas Region 4 = South (truck site)

Location	Region
Abaetetube	2
Altamira	4
Amapá	1
Amazonas	3
Augusto Corrêa	1
Bailique	2
Baixo Amazonas	3
Barcarena	2
São Sebastião do Boa Vista	2
Boca Do Amazonas	1
Bragança	1
C. Arari	1
Cacíporé (AP)	1
Calcoene (AP)	1
Canal do Curuá	3
Canal do Corva	3
Caro do Norte	3
Cacidoré	1
Chaves (PA)	2
Curralinho	2
Curuçá	1
Fonte Boa (AM)	3
Frigorifico	4
Icoaraci	2
Imperatroz (MA)	4
Itupiranga	4
Jacundá	4

Location	Region
Marabá	4
Macapá (AP)	2
Marajó	2
Maeriá (AP)	2
Maranhão	4
Marapanim (PA)	1
Marudá	1
Mosqueiro	2
Norte	4
Obidos	3
Porto Novo	4
S.C. de Odivelas	4
São Joáo do Pirabas	1
Salvaterra (PA)	2
Salinas	1
Santa Cruz do Arari (PA)	1
Santa Helena (MA)	*3*
Santa Izabel	4
São Caetano	4
Soure	2
Sucuri Ju (AP)	1
Tefé (AM)	3
Treme	4
Tucurui	4
Vigia	2
Vizeu	1

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Synopsis

Fish and fishing play an important role in the Amazon region. In riverine communities, fish are often the main source of protein in people's diets, and in both rural and urban settings selling fish can be an important source of income. Income from fishing is gained in one of two ways, either through small, local artisanal fishing, which employs approximately 70,000 people (30,000 of which are from "fishing colonies"), or through large industrial fishing, which employs less than 2000 people.

Fish are also important environmentally speaking, as they play a crucial role in the ecosystem of the Amazon River. The fishes of the Amazon are still widely unstudied, but it is believed that there are more species of fishes within the Amazon River basin than in all of Europe. Estimates range from 2000 to 3000 freshwater species and up to 5000 fish total if you include saltwater species. With so many species, the food web, and ecosystem in general, is highly specific, demonstrating just how delicate the balance of the river structure.

In the last 50 years commercial fishing has drastically increased due to the increased market for catfish and government incentives that have allowed fishermen to improve their fishing equipment. With the increase in large scale fishing more industrial methods of fishing have increased. The most popular methods of fishing are those that use gill nets (or malhadeirs), trawls (arrastos de parelhas), or trotlines, all of which involve non-selective fishing, meaning more than just the targeted fish is captured killed.

The objectives of this study are to determine the composition of fish being sold at the fish market at Ver-O-Peso, Belém as well as the price the fish are being sole for, and method and location of capture. The information was then compared to data from past years (1993-1996 and 2000-2004) to look at the effects commercial fishing has had the economy and the environment.

It was determined that there was an increase in the amount of transportation from trucks, and a decline in small motor boat transportation indicating a possible shift in the job market. Fishing serves as a large source of income for many families and a decrease in this source of employment could be detrimental to the livelihoods of many families. It was also discovered that there is strong evidence showing the price of fish is dramatically increasing. Fish is the cheapest source of protein, and the rising prices could eventually put this source out of reach, causing many problems. Overall, the evidence shows that the effects of commercial fishing on the economy are having negative impacts.

The results also give evidence of negative environmental effects. The number of fish species available at the market declined with each increasing year, indicating a loss of biodiversity. The data also shows that the ecosystem is highly sensitive to over-fishing. If one year there are high total catch weights (the total weight of all fish in one boat), the following year generally has significantly lower total catch weights. The total catch weights showed a decreasing trend overall, signifying that over-fishing is occurring, and it is resulting in a loss of biodiversity and has the potential to cause other changes within the ecosystem as well, due to the exploitation of a few select fish species (causing alterations of the food web, increased loss of species due to an increase in predators etc.).

The results of this study have shown that the commercial fishing industry is, or has a strong potential, to negatively impact the economy and the environment. If the trends continue, it may call need to an environmental management plan, similar to those in the western sections of the Amazon Basin, in order to preserve people's livelihoods, and the ecosystems of the area.