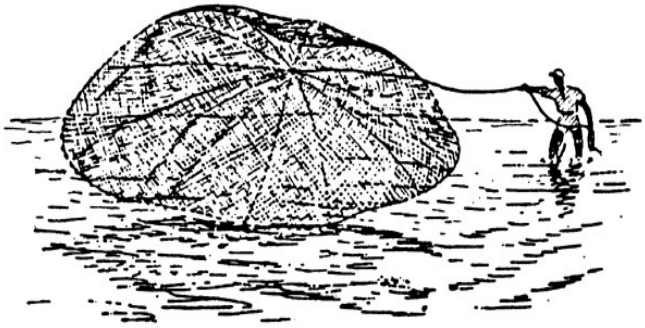
Description and analysis of the white shrimp (*Litopenaeus schmitti)* fisheries in Pearl Lagoon, Atlantic Coast of Nicaragua, with focus on the gear selectivity in the artesanal fleets



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Abstract

Fishing continues to be the main source of income in the Pearl Lagoon Basin in Nicaragua. Currently the fishermen in the area have expressed growing concern about the shrimps stocks. Over the past years it has become increasingly clear that the fish and shrimp stocks are being exhausted, severely over-fished and experiencing a serious decline.

This thesis examines the catch compositions (shrimps and by-catch) of three mesh sizes of the Cast net gear employed in the fishery through sampling during the months of July and August, as well as analyzes the current situation of the shrimp inside the lagoon through primary (interviews) and secondary (books, journals, articles, reports, etc.) data.

The data samples of the experiment with the different mesh sizes identified in the thesis were analyzed using standard software applying a trouser trawl method to determine the selectivity curve. Single factor ANOVA tests

were use to distinguish significant differences between lengths. Significant differences were also tested combining the three different mesh sizes applying the SPSS turkey multi comparison computer program model. The findings were discussed and compared with a previous selectivity study accomplished in the lagoon.

The thesis concludes that gears with ½ inch mesh size were vulnerable to the species during these months by retaining low weight and smaller length shrimp compositions (70% of the capture is between 5 and 8 cm total length). 1 inch and 1½ inch mesh sizes showed a general improvement in the selective performance of the gear (approximately 90% of the captured shrimps were between 11 and 14 cm).

The main secondary findings show that local people are employing small gear mesh sizes in the lagoon, especially those whose sustainability livelihoods are significantly threatened with very few opportunities of survival; most obvious those who live in the more remote areas.

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List of abbreviations

ADPESCA: National Administration of Fish and Aquiculture.

CAMPlab: Coastal Area Monitoring Project.

CIDCA: Centro de Investigación y Documentación de la Costa Atlántica (Center of Research and Documentation of the Atlantic Coast).

CPF: Common Pool Fishery.

DIPAL: Projecto de Desarrollo Integral de la Pesca Artesanal en Laguna de Perlas (Integrated Development of the Artesanal Fishery in Pearl Lagoon)

FAO: Food and Agriculture Organization.

WTO: World Trade Organization.

MARENA: Ministerio de Ambiente y Recursos Naturales (Ministry of Natural Resources and Environmental Development).

MIFIC: Ministerio de Fomento, Industria y Comercio (Ministry of Commerce and Industrial Foment).

NMFS: National Marine Fisheries Services.

RAAN: Región Autónoma Atlántico Norte (North Atlantic Autonomous Region).

RAAS: Región Autónoma Atlántico Sur (South Atlantic Autonomous Region).

UN: United Nations.

1. Introduction

1.1 Introduction

Fishing continues to be one of the main activities contributing to the economy of the inhabitants in the coastal zones of the developing countries. In Nicaragua, the fishing sector has grown significantly during the last decade being one of the most important economic segments in the country. It's the second largest commodity in exportation followed by the coffee. Thus, along with the lobster of the Caribbean (*Panalirus Argus*), it is the most important aquatic resource of the country, exploited both in industrial and artisan manner.

Today, shrimps constitute one of the most important economic fishing resources in the tropical regions of America, Africa, Australia and Asia. Considering the characteristics of the vital cycle of shrimps, they are object to a sequential fishing where the artisan fishermen capture them in lagoons, estuaries and matting ground and the industrial fleet fish the adult population in the sea (Sanchez, 2001). The production of shrimps in the region of the Nicaraguan Caribbean reach the maximum number of landing of 6×10^6 pounds of tails in 1973 and 1977, reporting a capture of 4,4 million pounds of tails approximately, which represents about 18 million US dollars in the export of the country (Sanchez, 2001). The artisan fishing in the whole lagoon system produces approximately 600 thousand reported pounds of shrimp tails in the year 2000 with a value of 1.5 million dollars in the export market (AdPesca, 2002). During the year 2004 the total volume of exportation of the white shrimps registered was 28,633 thousand pounds with an increase of 18% with respect to 2004 (Rivera and Tora, 2005).As far as the economical value it is estimated that about 90% of the export of shrimps come from the capture of the Penaeid white shrimps in the lagoon.

For 2004 the capture of shrimp tales and total shrimps from the Caribbean region was 3,127 and 776 thousands pounds, showing a reduction of 17% and 19% with respect to 2003, when the capture was 4,274 and 997 thousand pound. (Rivera and Tora 2005). The amount of capture in the lagoon environment was not registered during this period, but however, local fishermen have manifested a considerable reduction in the capture during the last 3 years.

The area of this study, Pearl Lagoon, is known as one of the biggest lagoons in the Caribbean and the biggest in Central America. It is the home of most abundant Penaeid shrimps in the lagoon environment in Nicaragua. There are 10 communities in the area, representing 7 different ethnic groups. For many years, these communities have dedicated themselves fundamentally to fishing activities as a means of subsistence and for sale outside the community. Currently the fishermen in the area have expressed growing concern about the shrimps stocks. Over the past years it has become increasingly clear that the fish and shrimp stocks are being exhausted, severely over fished and experiencing a serious decline. The once abundant shrimp's fisheries in the lagoon are disappearing.

1.2 Current situation

Fishing continues to be the main source of income in the Pearl Lagoon Basin in Nicaragua. During the last 5 years a drastic reduction in the biomass has occurred, emerging a great preoccupation among the surrounding communities and expressions of frustration in this vulnerable society.

As to the fishing equipments, the mosquito gear is considered as the most representative gear employed by the artisan fisheries in the local communities of Pearl Lagoon; a very traditional gear employed throughout the entire year. The dimensions of hand net vary from 1.5 to 2.5 meters of radius and the size of the mesh in the majority of cases is of 3/4 inches (20 mm) or smaller depending on the size of the shrimp to catch. The plummet or weight in the opening depends on the height of the opening.

There are as well a relatively small number of artisan trawler fleets (4 to 7 boats) functioning generally in The Bar Point area, with and average depth of 15 feet. The majority of these fleet trawlers are traditionally made of wood and fibreglass material, with relatively small size of approximately 10 to 17 m over all length; propelled with an outboard gasoline engine by 15-25 HP. The trawling method consists of single trawling, the net being horizontally opened by two wooden otter boards, with dimensions of about 30 foot wide and 26 long. The gears are retrieved manually, frequently by 3 crew members. The trawls are towed at 4 knot speed approximately, ranking 6 meters of distance. The legal framework of Nicaragua in terms of management stipulates a total

strict prohibition to drag within the lagoons and to use trawls with the mesh size of ¾ inches for small shrimps in the coastal zone (Gaceta, 2005).

However, it is evident that this regulation is implemented weakly or not at all; people are employing gears with a smaller mesh size, especially when using the hand net, since the regulation does not include the use of hand net and also practicing trawling in the lagoon and close to the coast. Regulation is carried out by output control, being prohibited the purchase and the export by the companies of the small size shrimps (smaller of 70/tail/pound), but unfortunately in many cases the control fails and the regulation is not being fulfilled.

In a selectivity study, it was found that hand net with these dimensions is not appropriate to use, because with the exception of the captures of June and October, 75% of the captures of this art are outside the allowed minimum category in the Ministerial Agreement of the Plan of Handling, that is 70 tails by pound (Sanchez, 2001).
Generally the artisan shrimps fisheries in the lagoon are considered as small scale or fisheries of subsistence, frequently operated by individual or familiar groups using traditional methods. It is of common belief that this type of fishing activity is not damaging the species. However, the fishermen in the communities of Pearl Lagoon are currently employing gears with many different mesh sizes in the shrimp's fisheries, not knowing the damage that it can cost the stock in the future. Unlike marine and continental waters, fisheries in the lagoons and estuarine have been object of little attention.

On the other hand, it is important to point out that the socioeconomic conditions such as poverty, corruption; unemployment and lack of other opportunities many times obligate the fishermen to respond to the needs without thinking of long term consequences (Christie et al., 2000). A common development in these communities is that every day more and more people get engaged in the fishing activity because of the immediate income that it brings, expecting an income that covers all their necessities. An additional problem is that during the same fishing operations a high percentage of none target species and of other species is caught in the fisheries (by-catch).

By-catch and non target fish are a severe problem in the shrimp's fisheries in Pearl Lagoon. Beside, many people are catching the small (noncommercial) shrimps for other

reasons, most obviously, to dry and sell in the outside market, or simply to sell at the local market. During my study, I also observed a great number of other small non target species which are discarded by the fishermen.

This situation is a big threat both for the fishermen and for the fish stock and measures are needed to ensure the selectivity of fishing gears in order to leave these fish in the sea and improve the economical benefit of the fishermen. However, reducing fishing effort and controlling the volume of catches cannot prevent the capture of small fish and fish which have no commercial value (Kapetsky, 1982). Moreover, the populations of Penaeid shrimps are inside the lagoon between the months of March and November and a fishing object during the recruitment around the months of June and July. In these months the lagoon waters are important areas of fishing (Tena, 1980).

The structure by size and weight of the captures during this period depends strongly on the use of different type of gears, among them the mosquito gear which is currently the most representative in the lagoon, employed with different mesh sizes. This way of fishing the species indicates the absence of a suitable way of managing the resource and constitutes one of the most powerful ways of overexploitation (Lluch, 1975).

The situation repels on the intensity of the recruitment towards the marine phase where the next generation can be seriously diminished as part of the consequences. This fluctuation is also heavily related to the variability of other environmental factors, such as temperature, currents, salinity, rain, natural mortality etc. The problem is invisible for many people and is not known as detrimental in the lagoon due to lack of accomplished scientific studies and other factors.

In order to take a closer look at the shrimp fisheries current problems, I will in this thesis identify and analyze the catch compositions using different gear mesh sizes employed in the fisheries of the Pearl Lagoon Basin with the means of samples taken during the period of July and August, comparing them with other studies. I will also apply the selectivity theory in the coastal shrimp's fisheries in Pearl Lagoon and see what recommendations could be given for further management.

The main research questions are:

- What is the overall current situation of the shrimp's fisheries in Pearl Lagoon?
- What is the size composition of the shrimps and by-catch using different mesh sizes?
- How can selectivity measures be introduced and made practical in this fishery?
- What type of management and legislation exists in the fishery (currently and before) and how does it work in practice?

1.3 Theoretical framework

In recent years there has been a growing focus on ecosystem effects of fisheries, addressing the impact of fishing operations not only on the target species, but also on by-catch or other effects on non-commercial species or habitats. Energy efficiency, reduced pollution and improved quality of the catch are also important aspects related to fishing gears and fishing operations (FAO, 1995[1]). From a situation where the development of fishing gears and methods only focused on the highest possible catching efficiency for the target species, now fisheries research, fisheries management and the fishing industry are challenged to develop gears, methods and regulations that meet the different considerations mentioned above. This is part of an emerging ecosystem approach to fisheries management (Cochrane, 2002).The theory of selective fisheries and the need of a suitable management to improve sustainability of the costal lagoon and estuarine shrimp's fishery will endow the theoretical framework on which I will focus this thesis on.

The tropical Penaeid shrimps species constitute a substantial portion of the total world shrimp and prawn catch. It is the most dominant benthic sea fishing, and probably the least selective fisheries (Baio, 1996). The mosquito gear in Pearl Lagoon is used to encircle shrimps as a target species in mid-water, close to the surface, using several mesh sizes. However, in this process there are several other species and especially small shrimps included in the catch, which usually are discarded in the case of other species; the small shrimps in most cases are put away to dry.

[1] FAO 1995. Code of Conduct for Responsible Fisheries, Article 7.2.2

The juveniles of the target species is now deemed as by-catch as they are also discarded or put to other use, a practice which threatens the maintenance of biodiversity and long term sustainability (FAO, 1995). The by-catch problem arises in the first place when different species with different sizes, body shapes and fleeing behavior occur on the same fishing ground (Cochrane, 2002).

Studies on selective shrimp's fishing of shrimps in coastal communities by the use of traditional methods (hand net) are poorly carried out around world. Most studies are focused on the industrial fishing, widely with the trawling process. Despite the lack of studies, it is attracting great awareness in many costal fisheries today. However, one of the few studies accomplished in this category, carried out in the coastal lagoon of Oaxaca in Chiapas, Mexico revealed that hand net gear contributed to the highest level of mortality of small shrimps (Tena, 1980). Selective fisheries are indeed a major concern in the world fisheries and certainly an anxiety in the Pearl Lagoon coastal shrimps fisheries. I will discuss in this thesis the importance of this theory and how it can be applied appropriately in the shrimp fisheries in the Pearl Lagoon Basin for a more successful management.

1.4 Data collection

The data collection for this thesis is based on both primary and secondary data through structured interviews, revision of archival data and an experiment carried out in the area. A field work was carried out linking three different communities, Pearl Lagoon, Haulover and Ratipura in the Pearl Lagoon Basin during a period of 14 days in July and a period of 10 days in August.

1.4.1 Interviews

Two sets of interviews were carried out to collect primary information. The first set was a rapid house-to-house survey with fishermen and captains to gather basic information including personal information, fishing activity including gear use, by-catch, fishing grounds, fishing depth, boat size, number and characteristics of crew, type and number of employed gears, dimensions of the gears, social influence, etc. reflecting the changes in the factors in time.

The other target group was the different authorities entailed in the fisheries in Pearl Lagoon area; representatives of fisheries affairs, members of the municipal council and the communal board in Pearl Lagoon in order to obtain information about the legal and political establishments, types and plans of fisheries management.

1.4.2 Archival data

During my stay in Nicaragua secondary data was collected from the archives of the Centre of Research and Documentation of the Atlantic Coast (CIDCA), DIPAL (*Proyecto para el Desarrollo Integral de la Pesca Artesanal en la Region Autónoma Atlantico Sur, Nicaragua*)[2] the University of the Autonomous Regions of the Nicaraguan Caribbean Coast (URACCAN) and the Bluefield's Indian and Caribbean University (BICU). Besides, articles, reports, journals and other scientific bibliography relevant to the study were revised in the internet sources to provide secondary data.

1.4.3 Experiment

Preliminary selective experiments were carried out in the lagoon during the months of July and August. It was carried out by employing the most representative gears with three different mesh sizes: 1 ½ inches mesh, 1 inch mesh and ½ inch mesh (equals approximately European sizes 40, 25 and 15 mm mesh). Hand nets (i.e. cast nest) with these mesh sizes were used to sample the area.The total composition of each sample by every mesh size was collected and measured, including target species and by-catch.

1.4.4 Limitations

The empiric data collected during the months of July and August is insufficient in order to make a full selectivity study in the lagoon. Time constraints in data collection were the main limitation and, in fact, an important constraint of this thesis. Pearl Lagoon is a poorly studied ecosystem, only one hydrographical and several commercial fisheries studies have been published in the past 10 years (Schegraf, 2004).

[2] *A Dutch development project that had been working in Pearl Lagoon for several years since 1995*

Another limitation was the lack of availability of studies made on the species in the lagoon. Besides, it was complicated to perceive and analyze the landing of the species from a more realistic point of view, since there were no data available on the species in the lagoon environment

2. Background information

This chapter on background information about the fisheries in Pearl Lagoon is regarded as relevant for the interpretations and recommendations to be drawn up in the end of the thesis. Without a deeper knowledge and understanding of the types of theoretical and practical problems the management of these areas is facing, it might be impossible to implement effective legislation for preserving a sustainable future of this fishery. Some of the information in chapter 2.3 is based on interviews of fishermen dealing with the problems and effects of a disputed management. More details are given in the appendix.

2.1 Nicaragua

The Republic of Nicaragua, described also as the land of lakes and volcanoes, borders Honduras in the north and Costa Rica in the South, to the east lies the Caribbean Sea and to the west the Pacific Ocean, occupying an area of 130,668 Km², with 410 km of coast line in the Pacific Ocean and 530 of coast in the Caribbean Sea. Nicaragua is the largest country in Central America (Nicaragua in the world fact book 2004[3]). The country has a population of 5 millions approximately, of which 50% live below the poverty line.

Nicaragua is divided into 15 departments and two Autonomous Regions: the Southern Atlantic Autonomous Region (RAAS) and the Northern Atlantic Autonomous Region (RAAN). More than 60% of the population is Mestizos (mixed Amerindian and white) located generally on the Pacific region, 32% are indigenous and Afro Caribbean peoples living in the Atlantic (Caribbean) region. The official language of the country is Spanish; in addition, the regional languages (Creole, Miskitu, Sumu-Mayangna, Rama and Garifuna) are official languages in the Autonomous Regions of the Atlantic Coast of Nicaragua (Rivera, 2000). Nicaragua's history has been characterized by instability and oppression. Dictatorships, wars and natural catastrophes such as earthquakes, volcanic eruptions and hurricanes have led to increased poverty and disaster.

The Caribbean region is the most extensive zone being 47%f the surface of the country and containing only about 10% of the total population, with a density of 6 inhabitants by

[3] http://www.cia.gov/cia/publications/factbook/print/nu.html

km2. The region has very few urban centers barely interconnected. It is potentially very rich in marine resources, forest and mining.

2.2 Pearl Lagoon

The zone of this study is located in the Southern Atlantic Autonomous Region (RAAS) of Nicaragua. It includes the coastal strip from the mouth of the great river of Matagalpa to the Bay of Bluefield and is characterized in general to be a system of rivers, channels and smaller lagoons connected to the main lagoon (Christie, et al., 2000).

Pearl Lagoon is a large expanse of brackish water fed by four main rivers and various smaller creeks with a 200-m wide opening into the Caribbean Sea. The area of Pearl Lagoon is approximately 52 000 ha, making it the largest coastal lagoon on Nicaragua's Caribbean coast. The lagoon is shallow from 0.5 to 12 m deep. The salinity of the lagoon varies seasonally and spatially from almost fresh water to concentrations of 34‰ (34 parts salt per thousand of water) (Christie, et al., 2000).

The surface of Pearl Lagoon measures approximately 500 square km. It is characterized by having only one natural connection to the sea in the southeastern part known as the Bar Point (Barra), in front of the community of Pearl Lagoon (Sanchez, 2001). Some rivers end their waters on the west shore of the lagoon; also other 19 brooks and streams of smaller importance exist. In addition there are 14 adjacent lagoons around the main lagoon.

In the northern section of the lagoon, temperatures can range from 25˚C in November and December to 33˚C between May and September. PH varies from 6 to 7.5. The lagoon is generally turbid: surface disk measurements range from 0.3 to 1.8 m, with turbidity increasing during the wet season as rivers bring sediments from the surrounding region, likely the system's most important source of nutrients (Christie et al., 2000).

The vegetation is typical of humid tropical zone; it has a great variation with some characteristic species of estuary systems, e.g. mangrove. The marine surroundings are characterized by the formation of rocky and coralline keys. On the west shore there are 10 communities conformed by different ethnic groups which are dedicated fundamentally to fishing, especially of shrimps, for self consume and selling.

2.2.1 The Municipality of Pearl Lagoon

The Southern Autonomous Atlantic Region (RAAS) consists of seven (7) municipalities, among them the municipality of Pearl Lagoon, known among its inhabitants as Pearl Lagoon or the land of nature. There are twelve main communities in Pearl Lagoon: Awas, Brown Bank, Haulover, Orinoco, Raitipura, Kakabila, Saint Vincent, La Fe, Tasbapauni, Marshall Point, Pueblo Nuevo and Set Net Point. The largest population is concentrated in four communities: the town of Pearl Lagoon, Haulover, Tasbapauni and Orinoco (figure 1).

The population of the municipality consists of three different ethnic groups; approximately 50% is of Creole origin and the rest of Miskitu and Garífuna origin. The Garífunas live mainly in the communities of Orinoco, Brown Bank and La Fe. The Miskitus are based in the communities of Tasbapauni, Set Net Point, Raitipura, Kakabila and Haulover. However, more and more Mestizos are approaching the area from the Pacific side, constituting an ambient and cultural threat to the indigenous and ethnic communities.

Most of the population live a subsistence life situation. The region was considerably affected by the hurricanes Joan in 1988 and Mitch in 1998, in addition to the strong effects caused by the Contra war of the 1980ies. The vast majority of the income today in the communities emerges from the artisan fisheries and mostly from shrimp and lobster fishery.

The information I collected for this thesis through interviews is taken from three communities: Raitipura, Haulover and the community of Pearl Lagoon. However, despite their differences, they all play the same role in the lagoon fisheries.

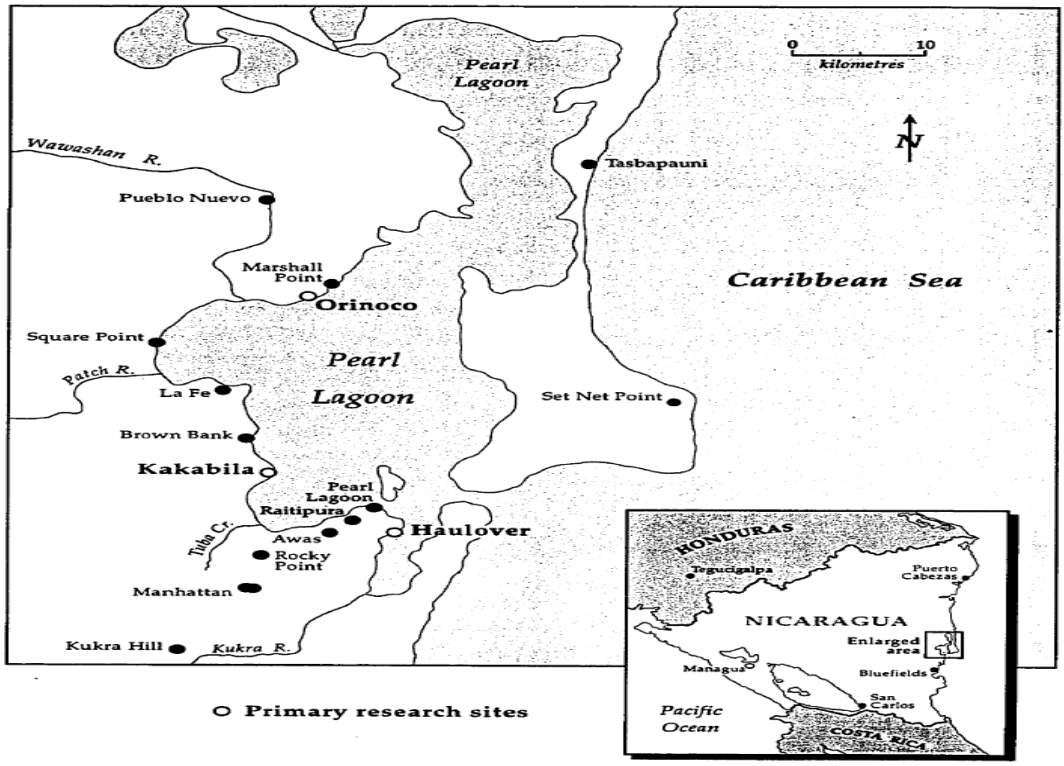

Figure 1: Map of Pearl Lagoon

Pearl Lagoon is the principal town and the center of the municipality of Pearl Lagoon, situated in the South of the Pearl Lagoon basin, about 40km North of Bluefields[4], with a population of 8000 persons approximately. Creole is the main language spoken by the inhabitants. Currently, about 60% of the population dedicates themselves to the fisheries activity, mainly in the shrimps and lobster catching.

[4] Bluefield's is known as the main town or capital of the Southern Atlantic Autonomous Region of Nicaragua.

Haulover is the neighboring community of Pearl Lagoon situated about one mile southeast of Pearl Lagoon Town. It is known as a Miskitu community with a considerable amount of Creoles, and people generally speak Creole. There are about 4000 thousand inhabitants living in the community, and similar to Pearl Lagoon, fishery is the main source of income today. A study carried out in Haulover points out that 60% of the productive activity in the early 80ies was from the fishery industry.

Kakabila is a smaller community than Haulover and Pearl Lagoon, located approximately 3 miles to the northwest of Pearl Lagoon Town. Kakabila has a population of 500 people approximately; it is a Miskitu village, and in fact, shows a clear cultural difference related to the other communities. Its inhabitants speak both Miskitu and Creole. Unlike the other communities, Kakabila is engaged more in the fishing commotion, practically all the inhabitants are appointed to this activity.

Since 1990, the economic development in the area has been based on the creation of a stable export market for the area's fish production. This stable market has taken the form of a permanent fish processing plant (*Mar Caribe*) near the town of Pearl Lagoon (Hostetler, 1998). In addition to providing an outlet for fish, the plant in partnership with the Dutch project for the Integrated Development of Artisanal Fishing in Pearl Lagoon (DIPAL) has leased motors and nets to a limited number of local people (28 for nets) in exchange for exclusive purchasing rights to the fish they catch until these debts are repaid. This has led in some cases to intensified fishing, and fishing in less productive times of the year in order to meet the requirements of lease agreements.

Today the stability of their subsistence economy is increasingly threatened by the deepening of commercial relations in the regiona1 fisheries. This consequently has significantly increased the pressure in the fishery and gives rise to several maltreatments in the fishery; frustration in these communities is increasing about the state of the fish stock and the unsteadiness of the market since the fishery operated under open access implies that people unconscientiously do what they like. Many people’s reactions to these changes today indicate a desire to protect the fisheries resources in the area that are the major component of their livelihoods, by better managing and controlling exploitation (Hostetler, 1998).

2.3. The fishery

As mentioned before, the lagoon fishery is a central component of the livelihoods of most people in the community. The vast majority of coastal fishers are artisan, usually with a small low-powered boat, estimated that approximately 3000 artisan fishers supply about 70% of the fish catch on the coast; a study estimates that, in Pearl Lagoon, more than 1,600 people are at least part-time fishers, and this number increases significantly when shrimps are present in the lagoon (Andreassen, 2004).

The harvesting of white shrimps is the most important income source in this community year-round and, as a result, the whole community becomes heavily involved (Hostetler, 1998). However, many of these fishers are also engaged in other activities, such as farming and hunting, depending on the season and the availability of fish and shrimp.

As a result, the continued use of the lagoon fisheries as the major part of the cash economy in these communities is unlikely to end. Many in the community, however, recognize the dangers inherent in over-exploiting this resource, and their inclination is to control and moderate exploitation in order to ensure its survival and protect their subsistence security (Schegraf, 2004). As for the fisheries in the lagoon in terms of value, shrimps contribute most to the economic return in the area and provide a substantial contribution to the national economy in form of export. In addition, it is a crucial factor for employment.

Today there is an increase in exploitation of the fisheries resources and a high number of fishermen engaged in the fishery; an obvious reason for this is the movement of the population from other productive activities to fishing. A typical example of these movements from agricultural and hunting activities beside, the incorporation of outsider moving into the fishery; a decisive issue is that the fisheries activities facilitate a quick access to money making, as for an open access fishery regulation are inadequately carried out, prudently technical measurement regarding mesh sizes.

Currently, apprehension of this situation is mounting between the user groups in the fisheries as a result of the government tending to forget the artisan fishermen and seeming to be on the side of the industrial - and largely foreign – fleets.

2.3.1 Assessment

Very few studies are carried out on this species in the lagoon environment. During the last 10 years only one scientific study was prepared through the above mentioned DIPAL Project in 2001. The biological parameters mentioned in this thesis are widely based on this individual study.

2.4 Management in Nicaraguan fisheries

2.4.1 Institutions

There are different institutions and non governmental organizations working on the management of the fishing resources. Among these are:

- ADPESCA : National Administration of Fish and Aquiculture
- MIFIC: Ministry of Commerce and Industrial Foment
- MARENA: Ministry of Natural Resources and Environmental Development
- Fuerza Naval
- The Regional Autonomous Government and SERENA: Secretary of Natural Resources and Environmental Development
- CAMP lab
- Communal Board
- The Municipal Government of Pearl Lagoon

2.4.2 Fisheries policy

The legal framework of Nicaragua stipulates a series of measures engaged to the fisheries. Among the most significant ones are the following:

> *Ministerial Agreement no. 043-98 of the Basic Regulation for the Control and Handling of the Hydro biological Resources in the area of Pearl Lagoon and the Mouth of the Rio Grande*

- *Articles 1 and 2 of Decree no. 56, March 1971*

Stipulates that it is totally prohibited to drag within the lagoons and to use trawls with the mesh size of ¾ inches for small shrimps in the coastal zone.

Law of Fish and Aquiculture, February 2005:

- *Article 38 of Degree no. 489*

Prohibits the capture, processing and commercialization of the minimum sizes of 71 to 80 tails by pound of shrimps in the lagoon environment.

- *Article 42 of the degree no. 489*

Prohibits the commercialization of the white shrimp juvenile and larva that come from the costal lagoon and estuarine zone from the Atlantic Coast of Nicaragua.

- *Article 78 of the degree no. 489*

For those engaged in the artisan fishing activity, it is required to obtain a fishing permission for a period of 5 years.

2.4.3 Monitoring, Control and Surveillance (MCS)

The regulations that exist from 1971 try to rationalize the fishing of shrimps in the lagoon, being prohibited the purchase and the export by the companies of the small size shrimps (smaller of 75/tail/pound). Unfortunately it is not being fulfilled at all, currently there is no fishing inspector monitoring that these regulations are carried out.

Hand-net (*Atarraya*) is the main tool of fishing that is used for the fishing of the shrimp, and it does not have any regulation. Hence, the fishermen construct them with relatively small mesh size. Hand-net with small dimensions is not appropriate to use, because with the exception of the captures of June and October, 75% of the captures are under the allowed minimum category according to the Ministerial Agreement, which is 70 tails by pound (Sanchez 2001).

Currently, there is a big amount of outsiders that appear to fish in the lagoon equipped with more detrimental and vulnerable gear. The Law of Fish and Aquiculture (Degree 49) stipulates that those who are executing artisan fisheries in the lagoon are required to

attain permission from the Municipal Government in coordination with MIFIC, but this regulation is inadequately carried out. Moreover, many people are employing small gear mesh sizes to catch small (non commercial) shrimps for supplementary reasons, most obviously to dry and sell to the outside market which is totally prohibited according to the Law of Fish and Aquiculture. However, the recognition of the regulations among local people is usually low.

The lack of the governmental institutions´ intervention in carrying out an efficient MCS in the fisheries is widely criticized by locals, according to them there were several periods when the governmental actions were totally unnoticed or absent. Hence, local fishermen were obligated to create their own pattern of alternative management, many times interdependently and with the support of non governmental organizations and projects that work for sustainable resources management on the Atlantic Coast of Nicaragua.

Since 1997, two main projects were heavily involved in the management of the fisheries resources in Pearl Lagoon, DIPAL and CAMPLAB. These two projects were working in coordination to development an institutional framework for a suitable management plan for the natural resources. According to local people, this plan was approved by the Autonomous Regional Council in the early 2000.

Both projects facilitated training to local people regarding the environmental issues and how to take care of and use their natural resources in a more sustainable way. Since then the demand of environmental protection by locals has increased.

In a broader outlook, the Monitoring Control and Surveillance of shrimp's fisheries of Pearl Lagoon is poorly carried out. Very few scientific studies have been accomplished over the last years and very few fishing inspectors are involved in the fisheries to enhance the regulations that exist today.

3. Selective fisheries and management

3.1 General challenges

Fishing gear is a name for all auxiliary tools that can be used for catching, trapping or getting any aquatic organism, animals or vegetal regales of the species and their size

composition (WTO, 1998). While fishing gear refers to the tools the fishing method is how the gear is used. Gear also includes harvesting organisms when no particular gear is involved (tool). As well the same fishing gear can be used in different ways (FAO, FIGIS)[5]. Since different species of different sizes are found together (so called multi species) it is hard to target only one of them of the same size, sharing the same habitat (Alverson et al., 1998). This attempt gives arise to one of the biggest problems in fisheries management called by-catch; to numerous authors, National Marine Fisheries Services (NMFS) and government agencies that manage fisheries, by-catch is today called "the problem of the 1990s", recent studies point out that 50% of the total catch of fisheries resources are not intended to catch or intentionally caught (Petruny et al., 2003).

The by-catch is defined as the part of the catch that is not the targeted species. A first attempt to address the issue at global level was made in the late 1990s by FAO (1997c) and was published by the organization. A recent review of the issue has been undertaken by Cook (2003). Over the last few years special focus has been set on the way by-catches have been discarded or dumped from the catches of target species. The estimated annual dumping of aquatic organisms has been calculated to exceed 27 million tons. This is close to 30% of the annual world-wide landings of fish and other organisms, which are believed to have reached a maximum of just above 100 million tons a year (Larsen, 2000). To reduce this problem several different studies need to be done, but essentially studies on the selectivity of the fishing gear.

Selective fishing refers to a fishing method that has the ability to target and capture organisms by size and species during the fishing operation allowing non-targets to be released unharmed (Valdemarsen, 2001). Good fisheries management requires that fishing gears retain large fish in the catch, while small juveniles are allowed to escape. If that is achieved, at least for one species, it can be said that the gear is highly selective (Armstrong et al., 1990). This implies that the capture efficiency of the gear should change with the ages or size of the fish. The capture efficiency of the gear is defined as

[5] FIGIS (http://www.fao.org/figis/servlet/static?dom=root&xml=index.xml) is the FAO fisheries global information system

the proposition of fish encountering the gear, retained in the catch. Thus, the gear should select the older fish from the population which is being exploited (Pope and Carter, 1975).

In practice, the selection of the catch depends on the size rather than the age of the encountered fish, because the size (e.g. length or girth) determines the possibility of escape through the mesh or by swimming away from the gear (McLennan, 1992). However with the time, many types of selective fishing gears have been developed. More information about the selective performance of these gears is needed (Tokai, 2000).

3.2 Shrimp selectivity and by-catch

Today, shrimps constitute one of the most important economic fishing resources in the tropical regions of America, Africa, Australia and Asia. The shrimps enter zones where different kind of fisheries operate and finally arrive at the sea, where the populations of adults are operated totally by the industrial fleet and the juvenile by artisan fleet in the lagoon environment. During this process diverse assemblage of different species including very small fish, sea mammals and others, are exposed to be retained. This is a selection process where the fishing gears and their mesh size are the main component in the catch composition and size, including by-catch (Sanchez, 2001).

In the shrimp's fisheries various types of gears are used to catch the species; i.e. cast nets, haul seines, stationary butterfly nets, wing nets, skimmer nets, traps and trawlers.[6] Hand nets are the less dominant gear type in the shrimp fisheries (Watson, 1995).Very few studies have been carried out to know the selectivity properties of these gears; most scientific studies have been made on the trawl gear which is mainly utilized in the industrial fleet. However, in this study I will apply the selectivity theory on the mesh sizes of the shrimps gear.

By-catch in the shrimp's fisheries yields mainly large numbers of small sized fishes - individuals that have not yet reached maturity. However, fish harvesting is usually directed at individuals above a certain minimum size, to allow the animal to grow so that

[6] (http://ocean.floridamarine.org/efh_coral/pdfs/FMPs/appendices/APPENDIX%20N.pdf)

the yield from the fishery will be more productive (WTO, 1998).[7]

The selective properties of shrimp trawling are very poor. This is due to the small meshes that are used in shrimp trawls in order to retain this relatively small target species. Shrimp trawling does therefore produce relatively large amounts of by-catch and a high proportion of this is discarded. The development of sorting grids has, however, improved the species and size selectivity in many shrimp trawl fisheries, as most fish over a certain size are released from the trawl through the sorting grid. Reduction of the by-catch of the youngest fish groups (1-2 year olds), however, is still a problem because their size is overlapping with those of the shrimps (Cochrane, 2002).

Shrimp fishing is probably the least selective fishery (CFP, 2003) [8] and numerous countries are suffering of the same problem. In Nicaragua, for example, 53% of the catch in the shrimp fisheries in 1995 was registered as by-catch and therefore there was a very high amount of discards. In addition, it is a big threat for sea mammals and turtles (Cisneros, 2000).[9]

A serious problem is that also the juveniles of the target species (shrimps) are now deemed as by-catch as they are also discarded. This practice is a serious threat to the maintenance of biodiversity and long term sustainability (FAO, 1995).

3.3 Coastal and estuarine shrimp's fisheries

Shrimps are most abundant in coastal waters - especially in the tropics; fishing intensity for shrimps is greatest in inshore waters (WTO, 1998). According to its life cycle, it is object to two types of fisheries: by the artisan fishermen in the lagoon environment and by the industrial fleet in the marine waters.

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[7] http://www.sice.oas.org/DISPUTE/wto/58r00/shrus34e.asp

[8] The Common Fisheries Police,
Fisheries and Maritime Affairs; EU (European Union).
http://europa.eu.int/comm/fisheries/doc_et_publ/factsheets/facts/facts_en.htm#to

[9] http://www.fao.org/docrep/field/383551.htm#P547-34939

Unlike the other coastal fisheries in the lagoons or estuarine surroundings, the shrimp fishing is a crucial component for the subsistence of many inhabitants of the costal community and indigenous peoples operating on small and medium scale using an artisan approach (Spain, 2001).

Despite of the importance of the shrimp fisheries, very little attention has been paid on it today and in many cases it has lead to overexploitation. The fisheries in the lagoons and coastal areas are based frequently on multi species that move a lot according to the time and space; marine visitant species, residents and permanent species, visitants, migratory species, species that tolerate a wide range of temperature and other environmental factors. This complexity of populations makes it difficult to study and to evaluate the best management plan (Kapetsky, 1982).

A serious consequence of the problem in this type of fishery is related to selectivity of the gear and their mesh size. Many gears are used with a relatively small mesh size, this circumstance affects the productivity of these species, in the long run, since the lagoons and estuarine are residence of the juvenile and small shrimp's species.

However, many times it is difficult to limit the mesh sizes in the shrimp's fisheries through the lack of information on selectivity. Another difficulty is that previous attempts to limit the mesh size show that it will diminish the income of fishermen in such a way that their survival is threatened, especially of those who are permanently engaged in the fisheries. Hence, the acceptance of these regulations among fishermen is usually low. This may lead to various actions to circumvent the regulations and to compensate the catch losses (Tschernij et al., 2004).

In addition, in the majority of the fisheries in the lagoons and coastal estuarine of developing countries, the socio economic conditions - mainly the under employment or the lack of other opportunities for the fishermen – determine that the fisheries must be managed in a way that produces employment, even if this circumstance gives marginal results or undergo the total fishing production. On the other hand, this type of regulation is not used in many fisheries, especially where the fishermen have other opportunities of employment and survival.

Conflicts between actors in small-scale modernized/industrialized/motorized fisheries are

also a serious problem in the shrimp fisheries, especially among the trawlers. The problem exists in many countries, e.g., in Cameroon, Gambia, India, Indonesia, Malaysia, and Mexico. Considerable evidence exists that traditional fisheries are increasingly under threat from over exploitation, where prawn trawling is much to blame (WTO, 1998). The income derived from by-catch becomes proportionally more important to the small-scale operators; this is currently happening e.g. in India (WTO, 1998). A serious consequence of this problem is the use of gears with small mesh size, which can certainly reduce the fishing recruitment. Although, small-scale fishing are less threatening to the marine in many ecosystems than are large-scale fishing in many country, because it often uses low quantities (and greater diversity) of gear that are often passive.

The solutions in a coastal fishery can be very complex due to the multiplicity of resource users and the often difficult access to the resource and landing places. Finding the appropriate solution will need involvement with other managers in the coastal zone and possibly involve the consideration of creating zones for different users or fishing types. Such options may contribute significantly to decrease tensions and conflicts between the different fisheries or participants and often facilitate self-regulation (Cochrane, 2002).

J. M. Kapetsky (1982) points out that the problem in the coastal lagoon and estuarine areas is simple: it is being fished in excess, with the help of corruption, poverty and lack of protective laws. Shrimps fisheries today are harvested in both areas, the industrial fleet tending to catch a major portion of the resource.

Local communities manifest that the government management regime is only for the industrial fleet interest. In a situation like this government tends to remove their eyes off the local institutions, especially when there are no economical interests involved (Kooiman et al., 2005).

3.4 Mechanisms for Implementing Selective Fishing

Reducing fishing effort and controlling the volume of catches cannot prevent the capture of small fish and fish which have no commercial value. Additional measures are needed to ensure the selectivity of fishing gear in order to leave these fish in the sea. The basic

aim of improved selective fisheries is to avoid or limit the capture of:

- immature fish to allow them to contribute to stock renewal as adults;
- Unwanted fish because of their lack of commercial value or fish for which fishermen have no more quotas; Marine mammals, birds and other species such as turtles.

While the aim of technical measures is clear, their plan and implementation are extremely complex (CPF, 2003).

Selectivity in the fisheries can only be improved by the cooperation among the various parties enabling those involved to come an agreement by effective regulation and policy making, follow-up by a strong scientific research monitoring control and surveillance, both managers and fishers have a role to play and must work together. Managers can work to achieve selectivity by time and area of openings. Fishers must work to achieve selectivity by fishing gear and operations.

3.4.1 Conservation ethic and education training

All harvesters and managers must understand the need for conservation. Without the resource there is no fishery. Education is necessary to facilitate changes to more selective harvesting techniques. Education can be accomplished, in part, through dialogue among stakeholders. Politicians, in order to require a better understanding of the issues, must be part of the dialogue.

Training sessions could be made mandatory among guides, vessel owners and crew. Monitoring, assessment and partnership building are further areas where education is needed. It is most important that information be shared regarding what works fishermen can't realize as to the required levels of stock selective harvest by them (Gallaugher, 1998).

3.5 Technical measures for police making

These are generally defined by geographical areas and include:

- minimum net mesh sizes

- the use of other selective techniques
- closed areas and seasons
- minimum landing sizes
- limits on by- or incidental catches

Selectivity can be improved through obvious technical improvements such as, in the case of bottom trawling, increasing mesh size, using the so-called square mesh (which keeps the original mesh opening also during the fishing operation), as well as adopting grid escaping devices – which allow juveniles to escape from the net (Stewart, 2001).

Improved selectivity can be achieved by modifying the gear design and/or operation and by using alternative fishing gears. For mobile gears, like trawls and seines, improved selectivity can also be achieved by using square meshes in the codend and by inserting filtering grids in front of the codend, changing the mesh characteristics in the codend and inserting escape zones or other selective devices in the net (Valdemarsen, 2001).

However, as many species share the same fishing grounds and as stocks generally contains a wide range of ages and sizes of fish, most fisheries result in mixed catches. In addition to setting allowable catches, technical measures are needed to limit the capture of immature fish. Setting total allowable catches (TACs) involves the fixing of maximum quantities of fish that can be caught from a specific stock over a given period of time (CPF, 2003).

Selectivity devices can lead to short-term losses and can make the gear more difficult to handle. In addition, various devices can be used resulting in a increasing the effectiveness of selectivity measures for instances, reducing the mesh opening by using thick, knotted twine (type of string used to make nets); increasing the number of meshes around the codend or lengthening some parts of the net. Cooperation from fishermen is, therefore, crucial to the success of selectivity measures (CPF, 2003).

4. Resources and Shrimp Biology in Pearl Lagoon

The biological aspect of the species in this study is based widely on one study carried out by the DIPAL Project during 1995-1999. Very few biology assessments have been carried out in the lagoon and during the last 10 years only one was accomplished.

4.1 Abundance and distribution

Figure 2 below shows the eight predominant species[10] that have disembarked in the zone of the Lagoon, where the white penaied *shrimps* occupy the second and third place, respectively. Snuck has always occupied the first place with 35% of the total storing but, however, in the expression of revenue the shrimps constantly occupy the first place.

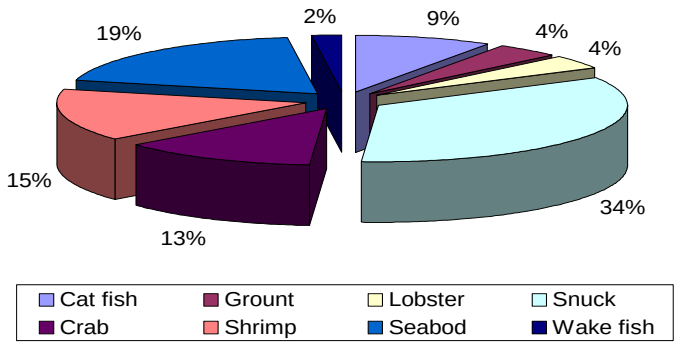


Figure 2: Percentages of the most important species in Pearl Lagoon; 1995-1999 (Sanchez, 2001)

According to Chavez (1997), there is three shrimp species that penetrate in the lagoon

[10] The name of the species presented in the figure1 are common name; Cat fish (Bagre marinus), Grount (Micropogon furnieri), Lobster (Panalirus argus), Snuck (Centropomus), Blue Crab(Callinectes sapidus) White shrimp (Litopenaeus Smitti), Camaroncillo (Penaeus Notiales),Wake fish (Cynoscion acoupa)

system by the proportions shown in table 1. The white penaied shrimp is a crustaceous decapods, which generally lives in inter tropical and subtropical zones, in estuaries or lagoons generally with bottoms of mud or mixed with sand, rich in organic material (Sanchez, 2001).

Previously, the coastal shrimps were defined to belong to the *Penaeus* genus; the white shrimps in the *Litopenaeus* subgenus and the red and brown shrimps in the *Farfantepenaeus* subgenus (synonymous to *Melicertus*). Recently, in the last published taxonomic revision in 1997, the *Litopenaeus* and the *Farfantepenaeus* subgenus were elevated to the category of genus (Sanchez, 2001).

Table 1: Percentages of the Penaeid shrimp species in Pearl Lagoon; 1995-1999 (Sanchez, 2001)

White shrimp (*Litopenaeus schmitti*)	64,8%
Brown shrimp (*Farfantepenaeus subtilis*)	19,6%
Red Shrimp (*F. notialis and F. brasiliensis*)	15,6%

Garcia and Le Reste, (1986) indicates that many authors have reflected on the factors that influence the distribution of the white shrimps, from the effect of the salinity to the feeding source, vegetation, nature of the sediment, currents etc. The distribution of the white shrimps in the estuary is very heterogeneous and presents phases of grouping or concentrations and massive migrations before events and climatic changes like temperature or, mainly the alterations in salinity (Sanchez, 2001).

The movements of the shrimps in the interior of the lagoon consist of forming concentrations or emigrating towards the sea. Once completed its formation, the shrimp is said to be pre adult and in conditions for undertaking the return to the sea, always depending on the environmental pattern and traffic relations (CIC[11], 2002).

[11] *Chemonics International Incorporated1133 20th Street, NW, Suite 600 Washington, DC 20036 (202) 955-3300*

Figure 3: White (Penaied) shrimp - *Litopenaeus schmitti*

4.2 Physiological aspects

The physiology of the shrimps varies throughout their development, particularly as to their faculties of osmo-regulation, in other words, the capacity of adapting to different surroundings with different grades of saline concentration (Garcia and Le Reste, 1981).

The shrimps live approximately two years, the reason why its presence in the fishing system is for a period of a little more than a year. They reach the sexual maturity in the age of 7 months, and the female can lay eggs several times in a year producing between 500.000 and 1.5 million eggs. They can adapt to diverse conditions of the aquatic surroundings and present great capacity of adaptation in the environment with ample margins of salinity. The young ones are able to live in environments of very low salinity and the adults inhabit marine environment (Sanchez, 2001).

4.3 Influence of the environmental and anthropogenic factors

In the recent past, physical aspects of the lagoon have been considerably altered. In addition to connecting the lagoon with other waterways, a deepwater passage through the lagoon was dredged to facilitate boat travel which can change the development of the shrimp tremendously.

Local fishermen have indicated that large areas of oyster reef and mangroves and other habitat especially for the shrimp's species have been killed in the swamps where the dredges deposited the sediments that they removed.

Mangroves play an important ecological role in the fisheries of the shrimps and a variety of valuable fish. Conversely, a study made in the lagoon point out that 98% of the people regularly cut down mangroves for several reasons. The durability of posts made of

mangrove wood is well known among local people. The bark is used for tannins, and the wood makes excellent firewood.

In addition to the negative effects of mangrove deforestation, large-scale operations might also result in overexploitation of shrimp larvae populations, overuse of freshwater sources, and contamination of the lagoon with excess nutrients (Christie et al., 2000). However, beside the selectivity dilemma and the increasing pressure of the fishing activity, there are several other factors that can play an important role in the development of the fisheries.

4.4 Mortality

In the white shrimps species the value of Z (mortality) is very rarely constant, because the fishing effort varies sensibly in the time, especially in the lagoon environment where the fishermen dedicate themselves to the fishing of shrimps based on the availability related to the dynamics of the environment, the biological cycle and the natural mortality (M) of this species. This means that the fishing effort fluctuates considerably (Sanchez, 2001).

In an experiment made in the lagoon, the values of natural mortality (M), calculated for two cohorts were of 0.65/month and 0.75/month which are considered high. They indicate that it is superior to the expected typical value of 0, 2. The high mortality also coincides with the general approaches of the species which stipulate that fast species always tolerate high mortality.

The values of K found in the study were 0.131/month and 0.232/month for the first and the second cohort, respectively.

The fishing mortality (F) of the first cohort in the majority of the months is below the value of the natural mortality (M), which is related to the unavailability of resources (Sanchez, 2001).

4.5 Predators

During the period 1995-1996, it was found that during the year 13 species consumed shrimps in average amounts of between 9 and 31% of the total of the ingested food. This indicates that the shrimps are consumed by the species of bony fish during most of the

year, which contributes to reduce the biomass before the migration towards the sea. To know about the predator the analysis were carried out evaluating the content that was found in the stomach of bony fresh water fish (Snuck, Jack etc.) by the DIPAL Project (Sanchez, 2001).

4.6 Growth

A work accomplished by Sanchez in 2001 shows the present of two cohorts of shrimps in the lagoon environment with different characteristics. The study indicates the present of the first cohort in June 1999, the length increased significantly during the month of June and July principally in the smaller shrimps. The second cohort appears exceptionally in March with the same characteristics. The shrimps will enter in the fisheries between 1.5 to 4 months of age of both cohorts. The fist cohort K value was 0.1313 and the second cohort K value was larger, 0.2323, the second cohort reaching the asymptotic length faster than the first cohort (Sanchez, 2001).

4.7 Biomass

The values of the monthly biomass are relatively higher in the second semester, as shown in figure 4 (from Sanchez in 2001). It is also illustrated that the second cohort appears exceptionally in the months in which first cohort biomass is somewhat low. It is well known that the fluctuations are considerable, but that is to be expected in the populations of adult shrimps with high mortalities in the lagoon environment and with massive migrations towards the sea.

In species like the Penaied shrimps, with short life span, the annual capture depends almost entirely or in its majority of a recruited annual class during that year. This is why a big fluctuation in the biomass was observed between the years. However, the influence of the environmental conditions and mortality in the lagoon also determines great fluctuation in the biomass. The table below (table 2) shows the trend in the shrimp biomass from 1997 to 1999.

Table 2: Estimation of the total Biomass of the white shrimp in Pearl Lagoon. Period of 1997 to 1999

Year	Biomass (t)
1997	713793
1998	517058
1999	977112

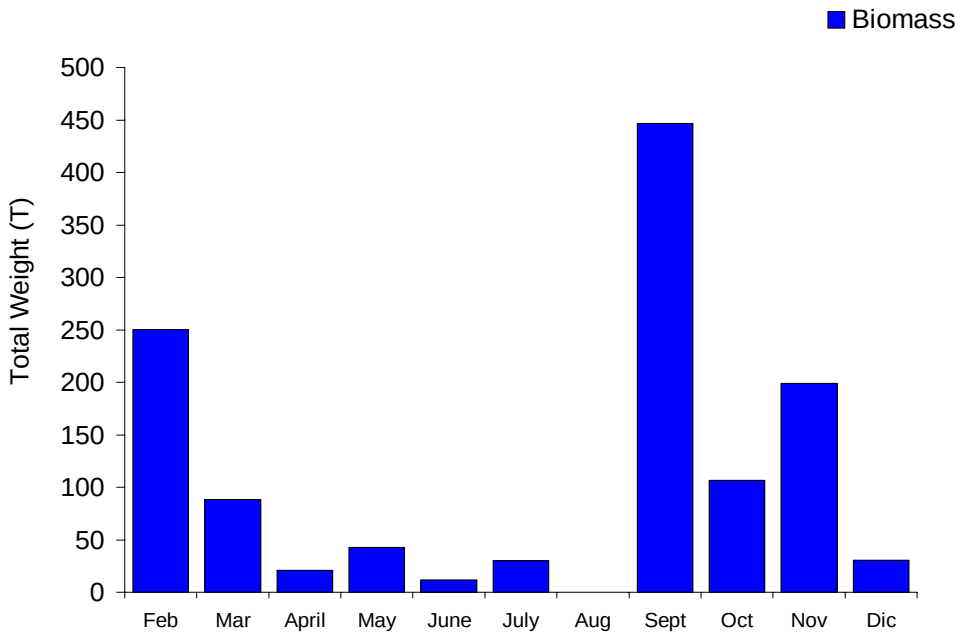


Figure 4: Monthly estimation of the Biomass during 1999 of two cohorts of white shrimp in Pearl Lagoon. From Sanchez (2001).

5. Materials and methods

The data collection for this thesis is based on primary and secondary through structured interviews, revision of archival data and an experiment carried out in the area. The field work was carried out linking three different communities, Pearl Lagoon, Haullover and Raitipura in the Pearl Lagoon Basin during a period of 14 days in July and a period of 10 days in August. The selective experiments were carried out in the lagoon during these same periods.

5.1 The layout of experiments

The selectivity experiment was carried out in the lagoon environment during the months of July and August. It was made by using the cast net fishing gears. Gears with three different mesh sizes were used for the study, and the samples were collected and analyzed separately. The experiment was done in two important fishing areas in the lagoon.

5.1.1. Fishing gear

The fishing gear used to carry out the experiment was the cast net or mosquito net (see figure 5 next page) with a netting material of monofilament nylon with twine thickness of 10 – 16 diameter and lengthwise of 8 feet radius. The gear was thrown by a person from inside the boat.

5.1.2. Mesh sizes

The catches of the experiment were obtained using three different mesh sizes of diamond shape: ½ inch, 1 inch 1½ inch mesh sizes. Each gear had the same measurement, approximately between 7 to 8 feet radius. The experimental catches were obtained during July-August, 2004, through two weeks of field work. Three sets of samples with each mesh size were attained from July 13th – 15th, and another set from August 14th to 15th. During the latter period only two samples were obtained.

The experiments were carried out during the mornings from around 6 to 12 o'clock nearby the other fishermen in the area.

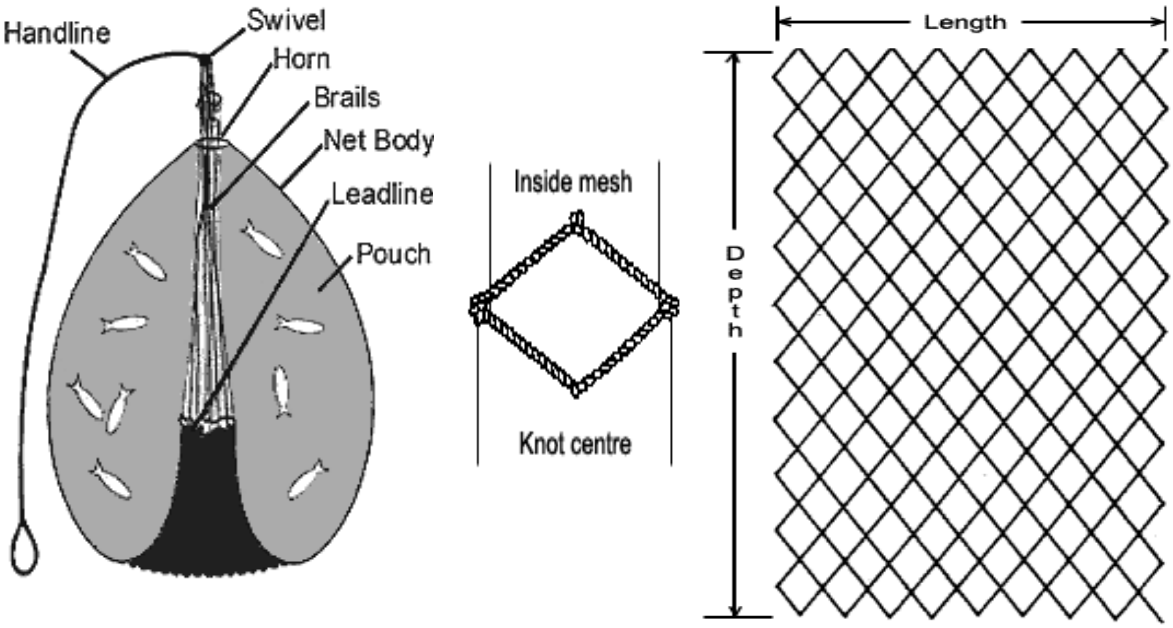


Figure 5: Characteristics of the Cast net (mosquito net) employed during the collection of the sample data for the selectivity experiment

5.1.3. Boat and fishing ground

A small fiberglass boat (local name: *Panga*) with an outboard motor was used to carry out the experiment inside the lagoon environment. The boat was 25 feet long and 5 feet wide and equipped with a 15 HP Yamaha engine. The boat facilitated good accommodation to accompany 4 crew members on board, including a student who was recording the data.

The selectivity experiments were done in two of the fishing grounds along the bank of Pearl Lagoon, close to the shore. The first area, Big Bay, has a great influence of the current which connects directly with the opening of the sea. The depth range was 5 to meter.

The Bar Point zone, located in the opening of the lagoon in the sea and its margins, samples were collected close to shore with a depth range between 2 and 4 meters. Both zones are very important traditional fishing grounds in the lagoon.

5.2 Additional data collection

5.2.1 Interviews

Two sets of interviews were carried out to collect primary information. The first set was a rapid house-to-house survey with fishermen and captains. The fishermen were selected randomly by meeting them at their homes, landing sites and socializing areas as well as following up recommendations by other fishermen with visits to individual homes.

A tape recorder was used during the during the secondary data collection, interview were carried out as a normal conversation among the local people.

Currently, the situation of the shrimp's fisheries in Pearl Lagoon is a very hot and polemic issue. During the interviews many fishermen tended to state there overall feelings about the circumstances in the fisheries, addressing in several occasions information that was irrelevant for the study. Such information is not included in this thesis. The other target group was the different authorities entailed in the fisheries in Pearl Lagoon area, the data obtained was analyzed and compared to the legal fishing framework of Nicaragua.

5.2.2 Archival data

During my stay in Nicaragua secondary data was collected from the archives of the Centre of Research and Documentation of the Atlantic Coast (CIDCA), DIPAL (*Desarrollo Integral de la Pesca Artesanal*, a Dutch development project in Pearl Lagoon), University of the Autonomous Regions of the Nicaraguan Caribbean Coast (URACCAN) and the Bluefield Indian and Caribbean University (BICU).

The majority of the background information was collected through these institutions, as a rich source of information about the state of the Pearl Lagoon. The personal at the universities and the other institutions were very collaborative. Additionally, university and high school students were willing to help me to gather the information. Besides, articles, reports, journals and other scientific bibliography relevant to the study, internet sources were revised.

5.3 Analysis

5.3.1 Experimental

After each sample 100 individuals of the total catch were removed and subsequently weighed, measured and classified according to the gear mesh size. Total catch and by-catch were also recorded separately. Overall length of the shrimps was measured in centimeters by an ordinary ruler and the weigh was measured in grams. The retained by-catch with each mesh size was identified and measured randomly by determining the average length of each species.

5.3.2 Length and weight statistical data analysis

The range of size and weight of the shrimps retained with each of the three mesh sizes was analyzed by using the descriptive statistic analysis histogram. Thus, analyze the frequency distribution pattern of each mesh size. Box plot, a descriptive statistic analysis (ANOVA) was also applied to determinate the means and averages retained by each of mesh size. An overall test with the three different mesh sizes was made by applying a single factor replica in ANOVA.

The turkey multi comparison model was employed to estimate the probability of significant deviation (P-values) between each mesh size using SPSS software. The levels of significance for the test were accepted as significant when the probability value<0.05 (95% CI).

5.3.3 Selectivity curve

The CC selectivity (2000 release) computer program was utilized to establish the selectivity curves in this study. The curves were determined according to the mesh sizes. The middle selection point (i.e. the length at which 50% are retained and 50% escape) of the shrimps and the corresponding selection ranges (75%-25% retention points) were calculated for the two test meshes.

The models supported by the software to determine the curves were the logistic or [12]Logit

[12] $r(1) = \frac{\exp(a + b1)}{1+\exp(a+ b1)}$, where a and b are the parameter to be estimated.

model, and the trouser trawl method was the only one that could be applied to the data. However, in the selectivity curve estimation only 1 and 1½ retained mesh sizes were illustrated. The ½ inch mesh is in my experiment regarded as non-selective and hence used as the control to the test the experimental mesh sizes of 1 and 1½ inch.

The selection curve itself is merely a graphical presentation of the probability for a given size of shrimp to be retained by the test mesh size given they are inside the gear (caught). Furthermore the selection curve is the cumulative function of a normal distribution (hence the name logit) and the raw data were fitted into the model according to this. The choice of proper models for sets of data like the ones I was able to retrieve from the Pearl Lagoon may therefore be very delicate and the output of the analyses should be treated carefully.

5.3.3 By catch analysis

Fish Base was visited to identify the species taxonomy of the retained by catch. Beside, local names were provided by people in the communities. The ANOVA single factor's option was used to test significant differences between average lengths of by-catch according to the mesh sizes. The analysis of the comparison between the total weight of by-catch and shrimps with two mesh sizes was done by calculating the percentages of each.

6. Results

6.1 Experimental data

6.1.1 Length and weigh data analysis

Rank and average results are displayed in figure 6, shown the range of length in centimeters of the capture of the white Penaeid shrimps obtained with different mesh sizes. It illustrates a big range of small length shrimps captured by ½ inch mesh size, where about 70% of the capture is "between" 5 to 8 cm. A range of bigger sizes was efficiently captured with mesh sizes of 1 inch and 1 ½ inches. A 90% of the captured shrimps lies between 11 to 14 cm approximately, although 1 inch and 1 ½ inches display almost the same catch.

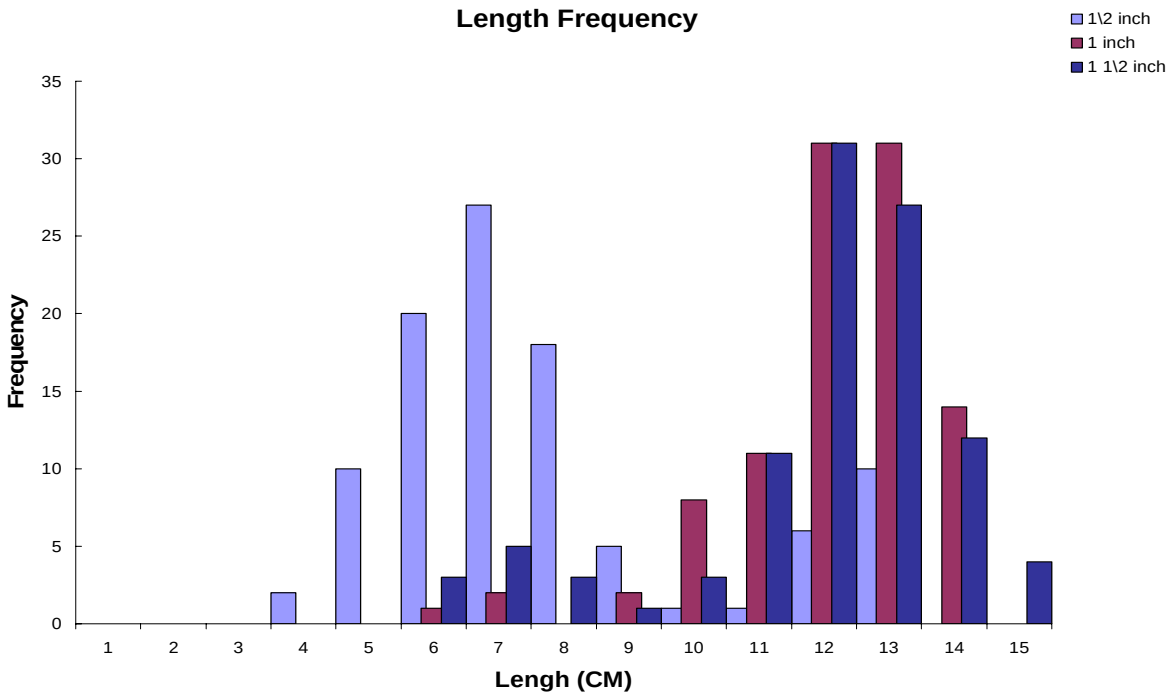


Figure 6: Range of length frequency of the white Penaeid shrimps obtained with the different mesh sizes during the month of July 2005

The results of the range of weight distribution in the study with the three mesh sizes are show in figure 7. The mesh size of ½ inch retained mainly small shrimps (1 – 6 grams). The table shows a roughly similarity between the weight of the 1 and 1 ½ inch catches, although 1 ½ inches retained heavier shrimps, varying between 14 and 17 grams approximately.

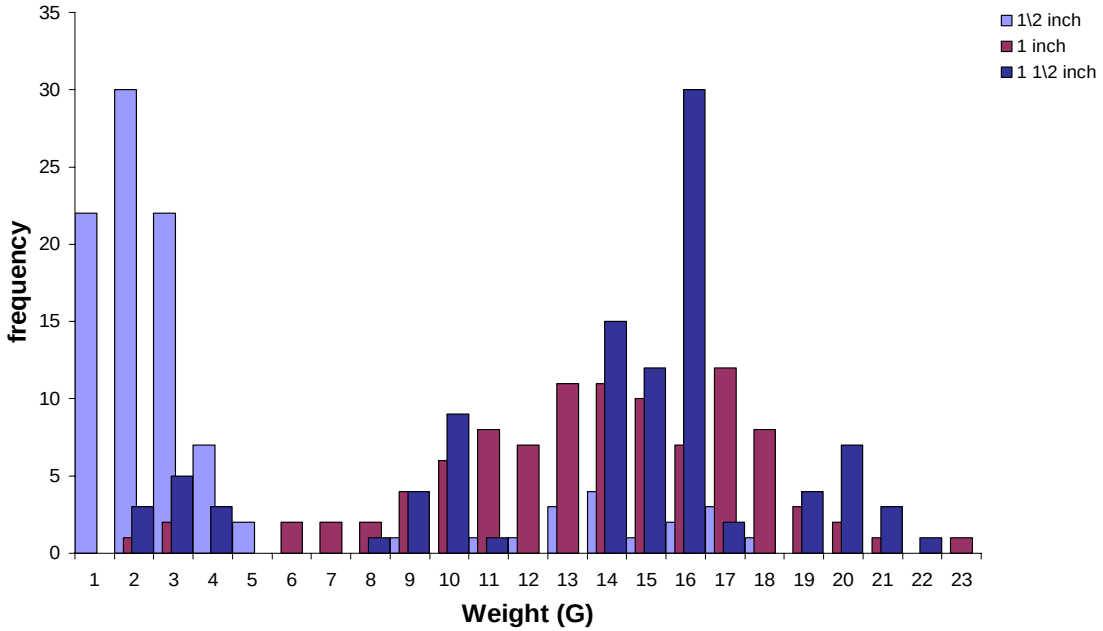


Figure 7: Range of weight frequency of the white Penaeid shrimps obtained with the different mesh sizes during the month of July 2005

The box plot in figure 8 illustrates the average and weight sample corresponding to each mesh size in this study. According to the figure ½ inch mesh size retained low weight shrimp composition, which range between 1 to 9 grams with an average catch of 4 grams. The catch range with greater weight responded to the 1 and 1 ½ inches mesh sizes. However, there were no considerable differences between the average weight catches with these two mesh sizes. They inclined to be similar to each other, although 1 ½ catch selection range is from 9 to 14 grams whereas 1 inch catch is from 10 to 13 grams.

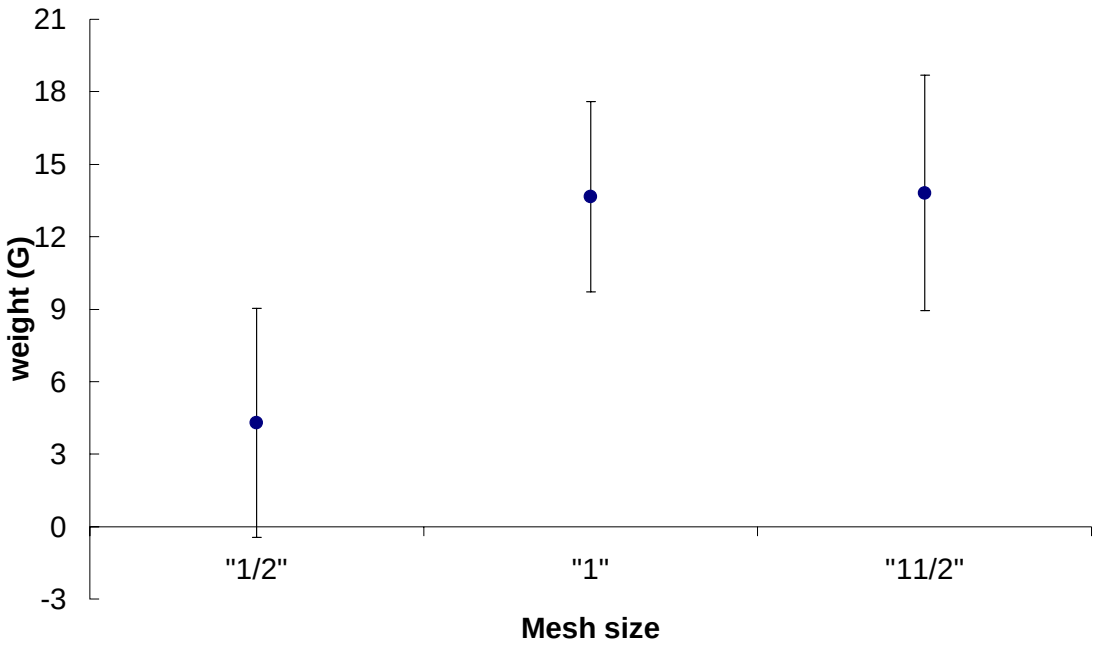


Figure 8: Rank of weight and average (total weight in grams) obtained during the month of July 2005

Conversely, a considerable difference was established in the range and average length composition with the mesh sizes in this study (figure 9). The range with lesser length is retained predominantly by the ½ inch mesh, with a range of 4 to 11 cm and an average of 8 cm. However, as seen in the figure, 1 inch and 1 ½ inches mainly select larger shrimps: 1 inch retained a range of 10 to 14 cm with an average of 12 cm, and 1 ½ inches selected a range of 10 to 15 cm approximately with an average of 12 cm.

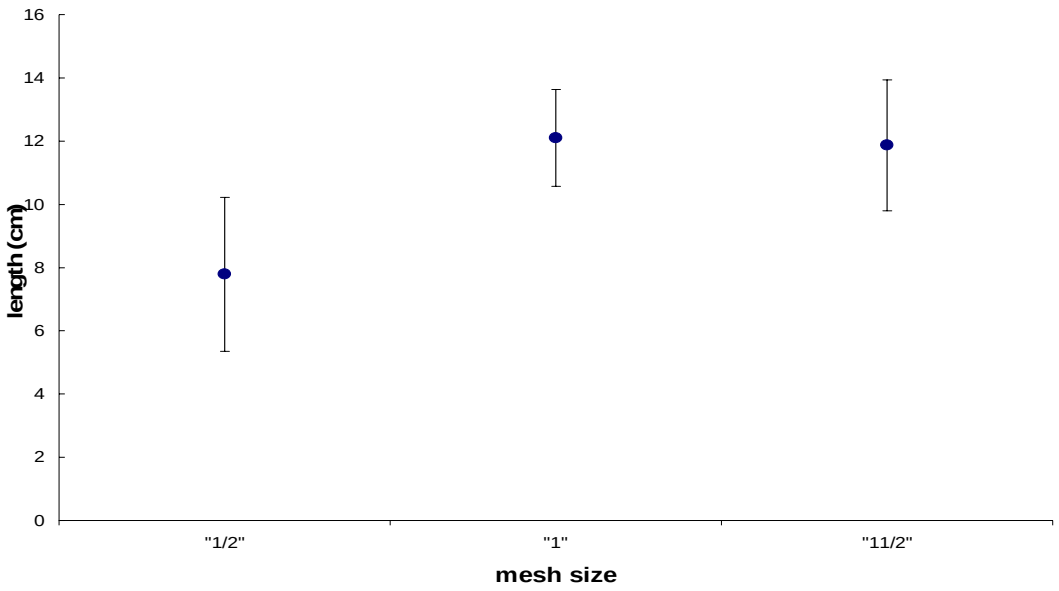


Figure 9: Rank of length and average (total length in cm) obtained during the month of July 2005

One way comparison using ANOVA test distinguished significant differences among the mesh sizes used. The levels of significance showed (p<0.001) between these group tested are low, which designated a relationship among the mesh size and length proportions of shrimps.

Turkey multi comparison of variance test shows significant difference (P<0.05) between ½ with respect to 1 and 1 ½ inches of the proportioned gear mesh sizes (table 3). It was found not significant differences (p=0.7) between 1 inch and 1 1/2 inches comparison (table 3).

Table 3: Multi comparison variance between the mesh sizes

Turkey HSD		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1/2 inch	***1 inch***	-4,3100(*)	0,2897	**<0.001**	-49,926	-36,274
	1 1/2 inches	-4,0787(*)	0,2905	**<0.001**	-47,630	-33,943
1 inch	***1/2 inch***	4,31000(*)	0,2897	**<0.001**	36,274	49,926
	1 1/2 inches	,23131	0,2905	**,706**	-,4530	,9157
1 1/2 inches	***1/2 Inch***	4,07869(*)	0,2905	**<0.001**	33,943	47,630
	1 inch	-,23131	0,2905	**,706**	-,9157	,4530

6.1.2 Selective estimation

The selective curve and output estimation are showed below in table 4 – 5 and figure 10 – 11. However, parameter L 50% in the goodness fit of both mesh sizes indicates a relatively low p – value that implies somewhat low fitness of the data in the model.

Figure 10 indicates a fairly flat top logistic length selection curve corresponding to the 1 inch mesh size: the parameter L 50% was 10,245 cm. The retaining probability was proportionally equivalent to bigger length shrimps p-value, which was however, low (0,054). 1 ½ inch mesh size probability retention length at 50% shown in figure 11was higher than the 1 inch, the estimation parameter assessment was of 12,063 cm; p- value was also low (0,165). Both estimations show a poor model fit and a close selection range.

Table 4: Selectivity output parameter for 1 inch gear

parameter	*estimation*	*S.e*	*t-value*	*p- value*
L50%	10,345	0,886	11,677	0,054
SR	1,478	0,516	2,866	0,214
confidence interval 0,95				

Deviance	*dof*	*p-value*
18, 72	8	0,0164

Table 5: Selectivity output parameter for 1 ½ inch gear

parameter	*estimation*	*S.e*	*t-value*	*p- value*
L50%	12,063	3,24	3,765	0,16
SR	2,827	1,134	2,494	0,24
confidence interval				

Deviance	**dof**	**p-value**
16,95	9	0,496

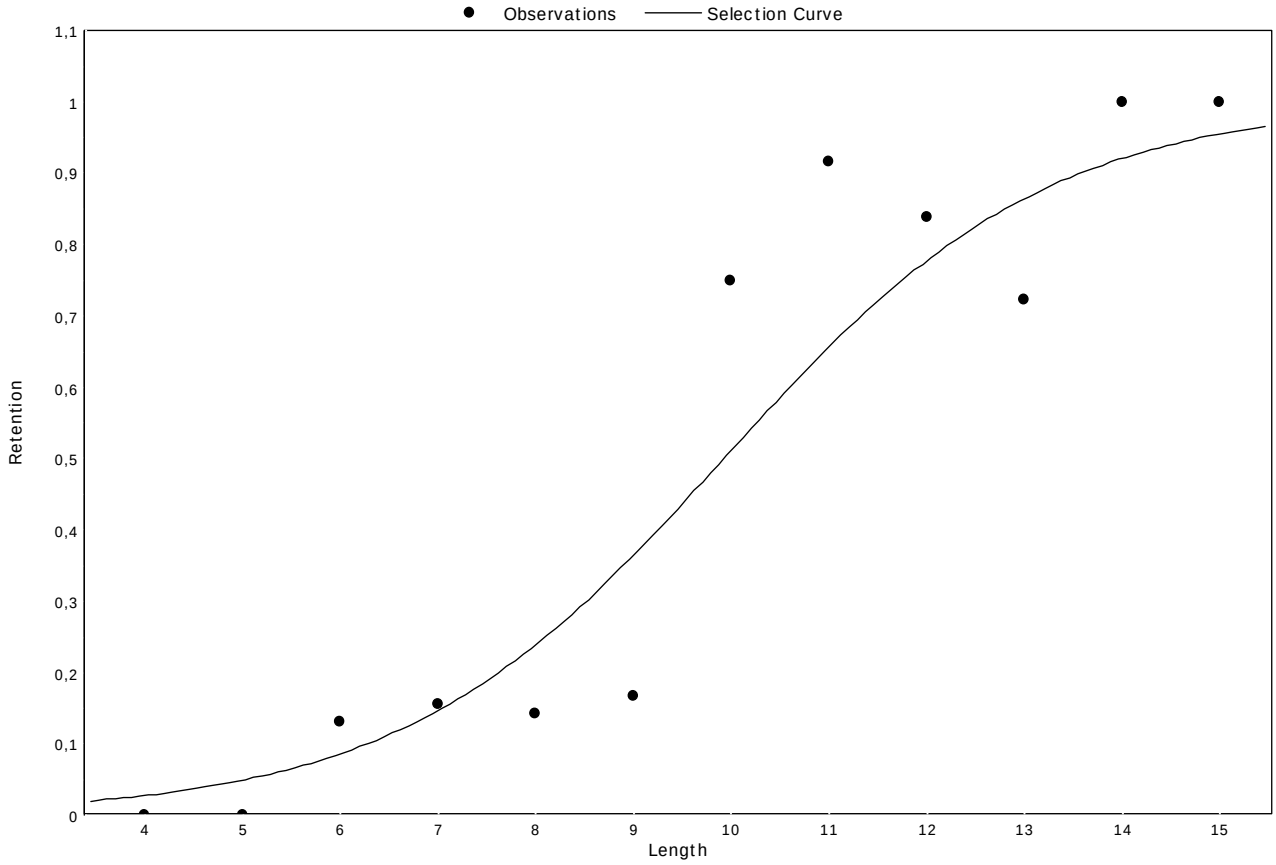


Figure 10: Selective curve calculated for the month of July in the shrimps fisheries with the hand net gear of 1 inch mesh size; Pearl Lagoon, 2005

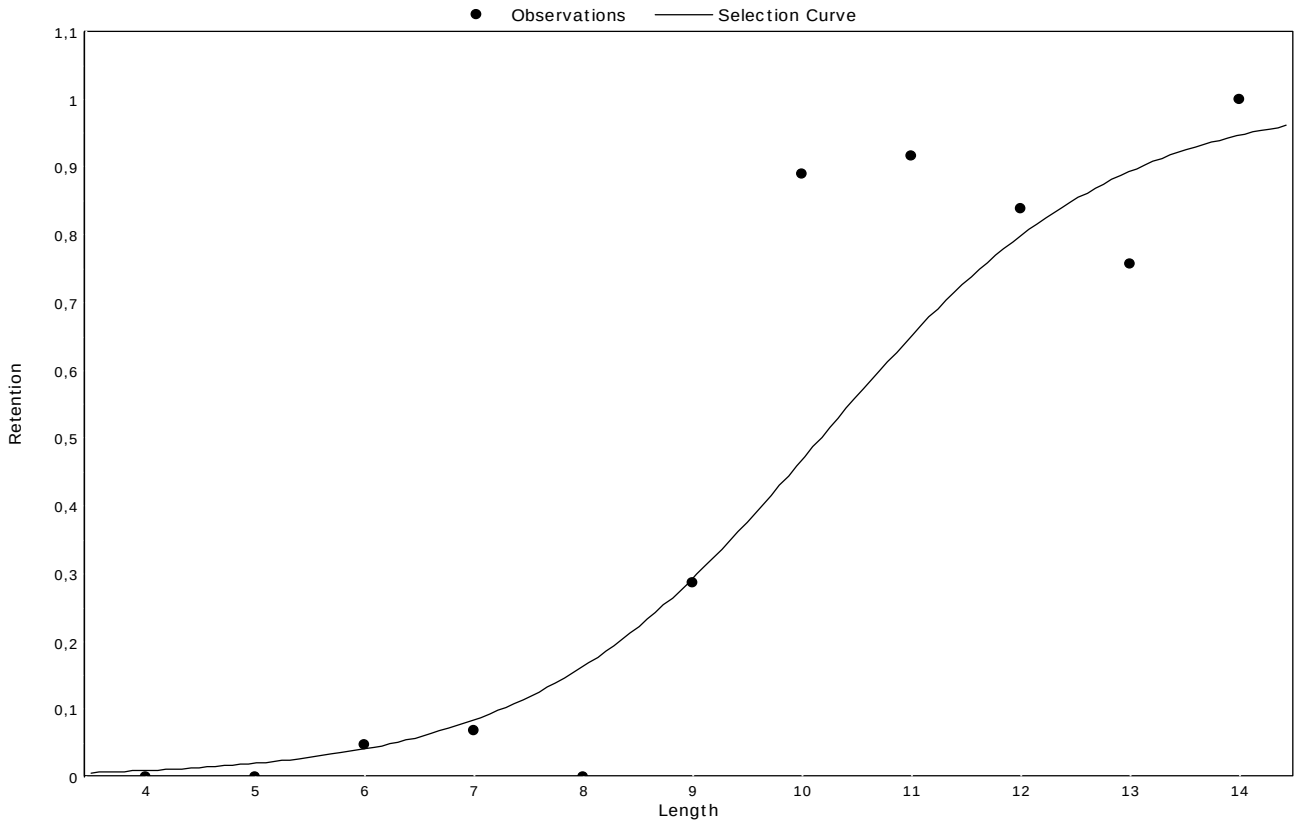


Figure 11: Selective curve calculated for the month of July in the shrimps fisheries with the hand net gear of 1 inch and haft mesh size; Pearl Lagoon, 2005

6.1.3 By-catch result

There was no significant difference of weight proportions between the by-catch and the shrimp catch using the two mesh sizes showed in figure 12. However, according to the figure, ½ inch mesh size shows a comparatively wider by-catch proportion (45% retained by-catch with 55% retained shrimps) than 1 inch (38% retained by-catch with 62% retained shrimps). The table 6 shows the scientific and common name of 6 principal species of by-catch obtained by the hand net with different mesh sizes in the shrimp fisheries. It also

illustrates the average length of each species.

ANOVA estimation distinguished no significance differences between the average lengths of by-catch by the hand net with the two mesh sizes (p-value was 0.53[13]).

The analysis shows that ½ inch mesh size retained smaller average length by-catch in the shrimp's fisheries (figure 13). Besides, the species of Sardine *(Neoopisthopterus tropicus)* is retained significantly by both gear mesh sizes, although ½ inch mesh size shows more incident of by-catch of the same species.

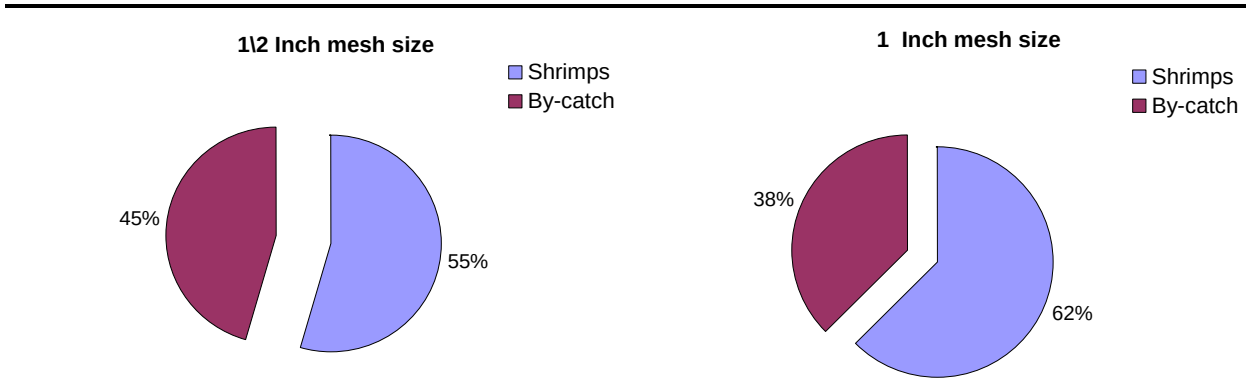


Figure 12: Comparison in percentages between by-catch and shrimps of the total weight with two different hand net gear mesh sizes calculated for the month of July in the shrimps fisheries; Pearl Lagoon 2005

[13] The mesh size has no effect on the average length of the by-catch

Table 6: Taxonomy identification and average length of the main species of by-catch in the shrimp fisheries with two different hand net gear mesh sizes during the month of July; Pearl lagoon 2005

	Neoopisthopterus tropicus	***Hexanematichthys seemanni***	***Bairdie ronchus***	***Callinectus sapidus***	***Micropogonias furnieri***	***Mugil curema***	
	Sardinas	**Tete catfish**	**Mojaras**	**Blue crabs**	**Curvina**	**White mullet**	**Others**
1/2 Inch	10 cm	15 cm	9 cm	9 cm	13 cm	17 cm	10 cm
1 Inch	12 cm	16 cm	12 cm	9 cm	15 cm	16 cm	15 cm

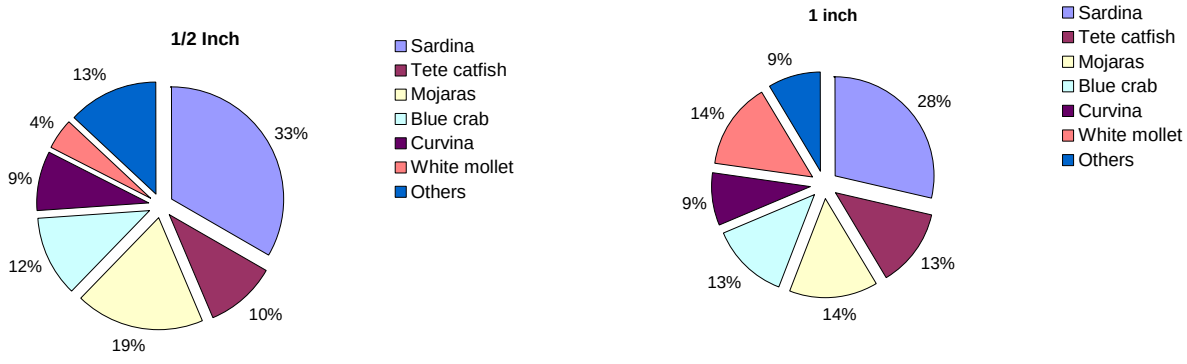


Figure 13: Comparison in percentages of by-catch between two hand net mesh sizes, calculated during the month of July in the shrimps fisheries; Pearl Lagoon 2005

6.2 Information from interviews

6.2.1 Shrimp fisheries in Pearl Lagoon – as seen by the community

*The shrimps and other aquatic species have been abundant in the Pearl Lagoon Area for a long time; many people believed that it would be impossible for it to get close to a critical point of overexploitation or depleting (*Morales, 2005)[14]. At the moment this is more like a dream that did not come through: the once abundant species is apparently diminishing rapidly.

According to the local people, the abundance of shrimps was due to the traditional management practices and peoples fishing on a very small scale mostly for the local consumption (Christie et al., 2000). The recent change from subsistence fisheries to commercial fisheries eventually increased the pressure on the shrimp's resources.

During the early 1990s, Pearl Lagoon Basin became one of the most popular areas for exploitation by private fisheries enterprises, creating centers of *acopio*[15] to store and process the catch, which were also known as *acopiadas*. Four storage facilities were built and guided for buying and processing (Christie et al., 2000).

Many local people indicated that prior to intensified commercialization of the fisheries; fish were commonly given away by returning fishers. The stable market for fish in the lagoon has changed this fish distribution pattern. It is clear that the movement from subsistent to commercial fishing subsequently has increased the pressure on the shrimp resource and eventually triggers reduction in the stock biomass as part of the consequences. Given access to modern gears and increased effort by fishers, the commercial part of the fisheries is flourishing. However, the ability of people to catch fish to supplement their diet is becoming more difficult, as this usually involves the use of more traditional methods (Hostetler, 1998).

Currently there are only two centre of *acopio* but none of them buys or purchases the product, circumstance that is distressing the local people today. For several years there was massive demand and several markets for the species and, unexpectedly, there were

[14] From interviews carried out for the thesis in June and August 2005

[15] A shrimp facilitating plant

no purchasers for the product. People are still wondering what triggered the outcome of this situation; local people believe that this can be a discrete political manoeuvre from the government and interest groups. This situation is creating a lot of tension in the lagoon and people seem very decisive to battle this crisis.

Gear selectivity is also a major concern in the shrimp's fishery in Pearl Lagoon. These concerns should be alleviated by a proper management and the selectivity should be increased through new compulsory measures. Employing small gear mesh sizes to catch small shrimps today is a common practice in several communities in Pearl Lagoon. However, during the migratory process inside the lagoon, the size allocation of the shrimps is presented differently between the communities within different periods of time and varied with sizes; in some communities the shrimps are still small but, however peoples still catch them.

A major social constraint in fisheries management is that human societies and behavior are not easily transformed and fishing families and communities may not be willing to move into other occupations or away from their normal homes when there is a surplus capacity in a fishery, even when their quality of life may be suffering as a result of depleted fish resources (Cochrane, 2002).

Short term advices regarding the effects of technical management measures typically do not include the short-term effects of a new measure (i.e. during the first months). So it can be expected that people under these conditions inside the communities, according to the above statements, are reluctant to this kind of management regime.

As for the biological features of the shrimps inside the lagoon, the shrimps reach their maximum size almost at the moment when they are immigrating to the marine environment, making it unreachable for several local people. In addition, small mesh sizes are also frequently utilizes by foreigner (most obvious from Bluefield's Rama and Big Lagoon) who come to fish in Pearl Lagoon, circumstances that need elucidation today according to local people.

6.2.2 Outsiders and the industrial fleets

Local people claim that peoples from the surrounding municipalities are coming now to

fish in their lagoon. Consequently, a large number of unreported fishermen are involved in the fishery today, since harvest regulations are accomplished only informally and enforcement is carried out rarely or not at all.

The situation is considered a threat to both the people of the basin and the resources. The fisher population of the Pearl Lagoon basin is already high (Christie, et al., 2000).

Silvio Pondler (from Haulover) argues that people coming from outside the lagoon area to fish their shrimps because they have already destroyed their own resources, and people from the lagoon on the contrary can't interfere with their resources and what they possess. He also states clearly a high desire to protect the resources (for themselves).

Local people believe that the outsiders are very reluctant to use illegal gears and disposed to mistreat the fishery, because the management is poorly carried out. Although many people indicated that they did not like people from Bluefields using the lagoon, some informants feel that everybody have a right to make a living and they can probably fish but under regulated conditions.

The decline in shrimp stocks is viewed by many in the communities as the result of the commercial exploitation by the industrial fleets.

Conflicts between small-scale fishers and modernized/industrialized/motorized fishers are notably also a big problem in the shrimp fisheries generally, in the Pearl Lagoon area. The conflict results of two important main issues mentioned by the local people: First, the retention of big quantity of by-catch, including immature shrimps. This consequence occurs due to the poor selective properties of gears (trawls) and the low level of management; according to the Common Pool Fishery (2003), shrimp fishing is probably the least selective fishery today. This statement is very rational and comprises a high level of reliability.

In addition, since 1995, of the overall catches by industrials fleets in Nicaragua 53% were by-catch. This can possibly trigger the decline in the stock biomass of the shrimp inside the lagoon.

The other conflict issue is the compression of the boundaries of the industrial and artesian fishing activity established by the Law of Fish and Agriculture of Nicaragua. It is obvious

that industrial fleet constantly fish in artisanal waters, of which the law states the total prohibition of industrial fleet to fish inside the 6 nautical miles of the coast which correspond to the artisan fishery.

Several local people blame the municipal government for this situation. During my stay in Pearl Lagoon I got the impression that the central government is familiar with this situation, but it appears that they are on the side of the industrial fleet.

6.2.3 By-catch

In this study I will focus by-catch as the untargeted species, although also the juveniles of the target species are now deemed as by-catch. Everyone who fishes, whether for a living or recreation, catches by-catch (Castro, 2003). In the shrimp's fisheries in Pearl Lagoon, by-catch yields mainly from the industrial and artisan trawlers catching mainly large numbers of small sized fishes - individuals that have not yet reached maturity.

The use of cast net gear inside the lagoon also yields a great number of by-catch but obviously not in such a great extent as compared with industrial fleets. Unwanted by-catch in the Pearl Lagoon shrimp fishery is usually thrown back into the water or discarded; sometimes it may be kept as proteins for domestic animals. The level of by-catch by local fishers is unknown due to the lack of accomplished work on this topic, although the intensity is low according to local knowledge. Local fishermen respond attentive when asked about the damage of catching small fish in the shrimp fisheries, and they are more concerned about by-catch produced by industrial trawlers and by-catch from the target species (immature shrimp).

On the other hand, a group of fishermen believe that by-catch is a detrimental factor and can possible threaten the maintenance of biodiversity inside the lagoon species. The respondents also raise the issue related to the green turtle *(Chelonia mydas)* as by-catch in the industrial shrimp fishery and claim for better management by improving selectivity practices.

To me there appears to be an obvious conflict between trawlers and cast net users inside the lagoon shrimp fishery, each group sustaining strongly their own rationality. Currently, tension is increasing significantly inside the lagoon on this issue.

Further background information and explanations on fishing vessels and the use of different fishing gears and mesh sizes, landing statistics and market situation, are given in appendix 2.

Neoopisthopterus Tropicus (Sardine)

Bairdie Ronchus (Mojara)

Figure 14: Principal species of by-catch in the Pearl Lagoon shrimp fishery during the period of June – July 2005

7. Discussion

7.1 General comments

Unlike to other brackish species from Pearl Lagoon, the shrimps-species (Panaeid) are

under fishing pressure in the lagoon and adjacent marine environment as well. During their stage of cycle-life inside the lagoon they are captured by artesanal methods. It constitutes the highest income, food security and sustainability way for the local communities. However, little knowledge exists about biological aspects and population dynamics of this species (Garcia and Le Reste, 1981). Also, several questions and uncertainties rise in fisheries management of these shrimp stocks, especially before new technical measures.

According to local information (*interviews*), few scientific research projects have been carried out into Pearl Lagoon with the objective to describe biological behavior of the shrimp species. It was developed only by the DIPAL's project five years ago (Sanchez, 2001). Data collected for this thesis were insufficient to make broad gear-selectivity studies in the lagoon. In spite of the limitations, it is possible to estimate and compare with the previous study made by DIPAL's project. They considered that throughout the year there are penaeus shrimp-species inside the lagoon. The fishery-season is between March and November months, with more enforcement during recruitment time (June and July). Mesh sizes analysis of the length and weight frequency distribution from shrimp captures revealed an integration of an ample interval of sizes, which denotes the use of different gear mesh sizes in the fisheries. This form of operation indicates the absence of a scheme of technical management adapted to the resource and constitutes one of the most eloquent indexes of overexploitation (Tena, 1980).

7.2 Importance of selective fishing practices

Selective fishing is one of the fundamental mechanisms of conservation-based management strategies in fisheries and an initiative that represents a fundamental and permanent change to the world fisheries. Improving this theory especially in multi species fisheries is important for fishing communities around the world.

Research in fishing gear selectivity is essential in the further development of technical measures and regulations designed to minimize mortality rates of juveniles and non-target species due to the practice of discarding. Discarding is a significant problem in the

world fisheries, many studies aim to improve selectivity of fishing gears and thus reduce by-catches and the level of discarding, resulting in lower environmental impacts of fishing and improved profitability (Tokai, 2000).

Past experience has shown that the reduction in the fishermen earnings due to greater selectivity is generally lower than initially feared. In some cases, better prices can compensate for lower production. Fishermen also adapt their activities to make the most of the available opportunities. In the medium term, selective fishing techniques benefit fishermen, consumers and fish stocks (CPF, 2003).

On the other hand, implementing the selectivity theory can raise great concern among actors if it's not done appropriately taking into consideration the welfare of all the actors involved. For instance many argue that the theory helps to identify the fisheries and reducing by-catch and discarding would mostly benefit the stocks. All reductions in fishing mortality are achieved at the cost of a loss of marketable catch and income to the fishermen (CPF, 2003).

However, fisheries selectivity is very important for the populations of Penaeid shrimps, as well as other species, that experiences two different phases of life: first, a phase inside the lagoon and second, a phase in the marine environment. Most of the Penaeid shrimps are heavily exploited by the artisan fishermen during their staying in the lagoon environment in a juvenile phase. This situation influences the intensity of the recruitment towards the marine phase (WTO, 1998). In this case improving selectivity fisheries can as well reduce conflicts among the small-scale fishers and modernized/industrialized fishers which is the situation of numerous countries, for instance in shrimps fisheries in Nicaragua and Cameroon (Njock, 2001).

Improving selective fisheries by reducing by-catch wastage and environmental damage can provide direct benefits to the fishermen also by the following point (WTO, 1998).

- Increasing the time and effort needed to sort the by-catch
- Increasing the value of the catch, by reducing damage from by-catch, and increasing efficiency in handling and quality and value of the primary product

for example, in Gambia

- Shrimp trawlers consider by-catch a problem because it may damage the shrimp, thus lowering the quality of the catch
- Increasing the efficiency of fishing by reducing distortion to the gear from the by-catch.

7.3 Moving toward selective fisheries

During the past 20 years, most of the concerns about by catch have been directed towards poor species selection by net-based fishing gears and the mortality of charismatic species like turtles and dolphins, as well as juveniles of commercially- and recreationally-important fish. In many cases, these concerns have been mitigated via quite simple modifications to fishing gears and practices designed to minimize the fishing mortality of key non-target species (Broadhurst et al., 2005).

It is of outmost importance to implement sustainable fisheries management and practices, in particular the Code of Conduct for Responsible Fisheries (FAO, 1995), to address a responsible and sustainable utilization and conservation of fisheries resources. Through a pertinent management system it is possible to optimize the long-term sustainable contribution of fisheries resources for food security, minimize wastes in fisheries, reduce excess fishing capacity and apply the precautionary approach in accordance with the UN agreement. One of the greatest challenges in modern fisheries is to develop and implement selective fishing (WTO, 1998)[16].

Recently, commercial and local fishermen and industry organizations have been working closely with various centers to improve this theory by maximizing selectivity for target species and target fish sizes; for example, the commercial fishermen and industry organizations including the Department of Fisheries and Oceans (DFO) in the Canadian fishery.

Research in fishing gear selectivity is essential in the further development of technical measures and regulations designed to minimize mortality rates of juveniles and non-

[16] http://www.sice.oas.org/DISPUTE/wto/58r00/shrus34e.asp

target species due to the practice of discarding. Discarding is a significant problem for instance in European fisheries. Many studies aim to improve selectivity of fishing gears and thus reduce by-catches and the level of discarding, resulting in lower environmental impacts of fishing, and improved profitability.

Conversely, fishing gears with their specific properties and potential for improvement are an important compartment in the fisheries management toolbox of the Code of Conduct for Responsible Fisheries. It addresses information of regulation on mesh size to improve the selective properties of fishing gear so that by-catches of juvenile fish are reduced in order to safeguard recruitment to the larger size groups of a fish stock including the spawning stock (Cochrane, 2002).

Some criteria for the improvement of selectivity fisheries are:

- The fishing gear should be highly selective for the target species and sizes, with negligible direct or indirect impact on non target species, sizes and habitats.
- Effective, giving high catches of target species at lowest possible cost; quality orientated, producing catches of high quality (Code of Conduct, Paragraph 8.4.4; Cochrane, 2002).
- A basic understanding of the properties, function and operation of the major fishing gears and methods is therefore fundamental for decision making in fisheries management, particularly when it comes to technical measures in fisheries regulations.
- The reorganization of the gear design as an important determination of selectivity had led to many experimental and theoretical studies over the past decade.
- Potential quality of selectivity computer programs has been improved and put in practice currently (Broadhurst et al., 2005). Moreover, there has been good international cooperation in this field promoted to large extent by the International Council for the Exploration of the Sea (ICES).

7.4 Experiments

7.4.1 Length and weight

According to the findings of this thesis it obvious that the gears with the ½ inch mesh size was inappropriate as to the length and weight of the shrimp (70% of the capture is ("between"5 to 8 cm) (Figure 6 and 7). Consequently, this undermines the regulation established by the government in the *Law of Fish and Aquiculture; Article 38 of Degree no. 489* which stipulates the rationalization of the fishing of shrimps in the lagoon, being prohibited the purchase and the export by the companies of the small size shrimps (smaller of 75/tail/pound) (average sizes of 8cm approximately).

A similar effect was found by Sanchez (2001) study when applying 2/3 mesh sizes (20mm). The conclusion of the study (Sanchez, 2001) revealed that it is inappropriate to use these mesh sizes in the entire lagoon, especially between the months of June and October due to the recruitment process, although the incidence of the biological parameters are still to question.

It is important to mention also that the 2/3 inch mesh size selectivity experiment that Sanchez carried out was one quarter more than ½ inch. This gives us comprehensible evidence of the negative effect of the ½ inch mesh size on the resources, although there are still uncertainties on the data and other parameter considerations.

On the other hand, compared to the 1 inch and 1 ½ inches, both mesh sizes showed a general improvement in performance due to the retention of larger number of individuals with greater length.

The average weight results from the experiments indicate a parallel outcome as to the weight frequencies when applying ½ inch, 1 inch and 1 ½ inch mesh sizes. The ½ inch meshes size retained low weight shrimp compositions (an average of 4 grams), while the 1 and 1½ inch mesh showed higher weight retention. The findings show that the ½ inch mesh size is vulnerable to the species during these periods by being non-selective and that the use of 1 and 1½ inch mesh sizes is greatly healthier.

The findings with 1 and 1 ½ inch mesh sizes show similarities in average retention although local fishermen suggested that this is probably a result of the more uniform

shrimp size distribution during this period (the average was 8 cm approximately). It was therefore expected that the gears with 1 and 1½ inch mesh sizes caught the same shrimp sizes, so that fishing with both mesh sizes will eventually reveal catches with more or less the same sizes.

However, a significant difference for those between ½ inches with respect to 1 and 1 ½ inch mesh sizes was also showed in the finding of ANOVA and Turkey estimation. This relationship was very much to be expected since the interplay between 1 and 1/2 inches in the previous analysis shows a great difference.

7.4. 2 Selection curves

Generally, smaller mesh sizes will retain smaller shrimp. The selectivity results detected that both 1 inch and 1½ inch mesh sizes were significantly efficient by retaining bigger shrimps while most juveniles escaped. According to the hypothesis of this study, the 1½ inch middle selection point was higher (12,063 cm) than the 1 inch (10,345 cm).

The finding of Sanchez shows that it is totally inappropriate to use ¾ inch mesh size during the months of June and October. This finding gives us evidence to say that mesh sizes inferior to 3/4 are totally inappropriate during this period, according to the *Law of Fish and Aquiculture; Article 38 of Degree no. 489.*

The results denote the utility of a simple change from ½ inch to 1 inch or 1 ½ inch mesh size, improving the selectivity performance of the gear due to the escape of small shrimp individuals.

The trouser trawl method was the only experiment to show improvement in the estimates of selection parameters and gives the only precise estimates. The ½ inch mesh size catches were according to their size compositions regarded as appropriate for the assumption that this mesh size could be regarded as non-selective and hence the data formed the control.

Regarding to the variations shown in the length and weight statures throughout this experiment, it was confirmed that such fluctuations are mainly due to the mesh sizes of the gear. As a matter of fact, such variation can be affected by recruitment, growth, mortality of the organisms and, environmental parameters.

The major hypothesis confirmed by these findings of this work was that smaller mesh sizes retained smaller shrimps and bigger mesh sizes retained bigger shrimps increasing the possibility for the juveniles to escape. This was revealed according to the outcome when comparing with Sanchez work (2001).

7.5 By catch

By catch occurs because most fishing gears and practices are not perfectly selective for the species and sizes being targeted and because target species exist in habitats occupied by a wide range of other species (Valdemansen 2000).

There is a large number of different species on the same ground with shrimp in tropical waters (Baio, 1996).

The experiment reveled that the overall shrimp to the by-catch ratio was significant similar in the retained weigh percentage by mesh sizes. Although, the quantity of shrimps was essentially greater that those to the by-catch; which was possible due to the greater weight of the by-catch. An additional factor that also could contribute to the existence of this effect is the body shape from by-catch species that may have influenced some individuals, preventing them from escaping.

A shrimp fishery in tropical areas has most fish by-catches that comprise small specimens of by catch about the same size as the target shrimp species (Brewer et al., 1998). Thus is correlated with the finding of this work showed in the by catch analysis (table 6). Differences could be influenced by the gear mesh sizes, and other parameter, but, this experiment reveled very little. An explanation can be the small samples sizes used during the experiment, taking into account that by-catch depend on the year, season, composition and location (Pinto, 2001).

On the other hand, this thesis provide evidence that local community are aware of the damage that by-catch can produce in the lagoon. Nevertheless, they still consider that is not an immediate problem, since mainly low quantity species are retained with low or no economical value. Being Sardine and Mojaras the main species as by catch into Lagoon (figure 13).

7.6 Current situation

In addition to information provided by this experimental survey on gear-selectivity, another important analysis of this work was to examine the current situation of the species parallels to the need of improving selectivity practice in the Pearl Lagoon shrimp fishery. The findings of the secondary data (interviews) show that the mainstream of those who employ small mesh sizes gear to catch shrimps inside Pearl Lagoon are those whose sustainability livelihoods are significantly threatened with very few opportunities of survival; most obvious those who live in the more remote areas. Information about the species´ biology related to fishing overcapacity is lacking. The political decision to reduce capacity and improve the mesh size regulation in the fishery can be an extremely unattractive option to local people.

According to Tschernij et al. (2004), however, there are three major questions that the fisheries managers should ask before new technical measures are implemented:

1: How large short-term catch losses a fishing fleet and individual fishermen can tolerate.

2: How much additional effort fishermen are capable to produce to compensate those losses, and

3: How easily the selectivity properties of gears can be manipulated.

Additionally, it was impossible to make a clear analysis about the landing trends in time due to the lack of available historical data, essentially during the last 6 years. However, according to the secondary information (interviews) currently the stock biomasses stress a significant reduction.

The recent change from subsistence fisheries to commercial fisheries eventually increased the pressure on the shrimp's resources since the early 1990s, when Pearl Lagoon Basin became one of the most popular areas for exploitation by private fisheries enterprises (Christie et al., 2000). However, the available data on landing during the last recorded year (1999) show a considerable reduction from the previous years (Appendix 2).

The commercial demand of shrimp is attracts by outsiders; like people from Bluefield's and the Pacific area. They are more disposed to carry out illegal fishing practice by catching small immature shrimps accompanied by considerable amount of by-catch.

On the other hand, for the local people the consequences of reduction in the biomass imply a greater effort to catch shrimps, which creates a straightforward condition to employ small mesh sizes as well. The industrial fleet gears (trawls) participating in the same fishery along the coastline are unselective, and their owners are very reluctant to overall management of the resource disputed by locals. Conversely, the local fishermen are very aware of this situation and compelling the government to find an unbiased solution. Hence, future work should be carried out in this respect and management should prudently reflect over this fact when trying to improve selective fisheries.

The findings of this study detect that there are serious defects in the shrimp's fisheries in Pearl Lagoon today. Possible explanations to the problematic situation would be the lack of information on selectivity and overall management in the shrimp-fishery.

7.6.1 Limit access to the fishery

Limited access to the fishery will give more or better outcome (economic returns) for those who share the resources. If each fisher can increase income it might be to meet management goal of selectivity fishery and some short time losses in revenue.
States should prevent over-fishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization (Cochrane, 2002)
Limited access to the shrimp fishery in Pear Lagoon can be accomplished by output control, by the fallowing way.

- Limit licenses and permission for fisher
- Close season fishery for specific period of the year
- Introduce tax for outsiders

7.6.2 Cooperatives action for effective management

The devolution of authority to manage the fisheries away from the fisheries administration to user groups is said to be one of the most difficult tasks in fishery management (Raanjaer, J. 1997).

Fisheries development plans often fail because they are directed mostly towards capital production technologies, giving inadequate attention to resource limitation or social context in which development take place (Jentoft et al., 2004).

The form a new and effective management in Pearl Lagoon is it very important that everybody who shares the resource should work close together. All management responsibilities should formally shared between government management agencies and user organizations as well as other stakeholders groups, such as the scientific community. Norway and Australia are good examples in the way the selective by-catch reducing trawl were developed and introduced in the fisheries legislation. Department of Fisheries and Oceans (DFO) in Canada did for many years run workshops together with the industry (sea and land) with science in other to improve the responsible fishing practice.

7.6.3 Education

The evidence suggests that local communities can be successful for management planning and their voices should also be heard in the implementation of fisheries management process.

The availability of current information about the actual impacts of by-catch, and the progress being made in controlling the problem, should help clarify the issues and encourage cooperation in developing solutions. Conferences and other forums for public discussion enhance prospects for solutions (Petreuny et al., 2003).

Educational programs to increase understanding for proper means to preserve the stocks and safe the future for the communities. It is vital to include the local community for poin 0; the very beginning of management process.

Education and training are required in areas such as fish stress factors and ways to minimize stress in all fisheries. Training sessions, videos and television (e.g. Knowledge

Network) could be used to provide education on topics such as brailing and fish handling techniques and to introduce a conservation ethics among fishers, sports guides and customers.

The legitimacy of the system is to be enhanced by involvement of user groups and community members, which may result in people being more willing to comply voluntarily with and even exceed the requirements placed upon them (Kooiman et al., 2005).

7.6.4 Technical measurement

These technical fisheries management measures play a potentially important role in the management of many fisheries around the world, for instance in the Baltic cod trawl fishery where the management is working very hard to improve the selective performance of the gear (Tschernij et al. 2005).

The introduction of more selective fishing techniques (minimum mesh, this can be done temporary or forever, by area and season) and establish more selectivity experiment in the future are important input for effective management in the shrimps fishery in Pearl Lagoon. This should be done in co-operation with the fishers to establish better understanding by them of the aim of the regulations and to hear and consider their advice on the regulations and their implementation (Gallaugher, 1998).

8. Conclusion and recommendation

On the basis of the results found, the apparent fishing overcapacity is indeed a serious problem in the Pearl Lagoon shrimps fishery, although its level is yet to be determined. Landings are declining and attention given to this problem by the management is significantly poor. This study gives us evidence to state that the constant maltreatment of mesh size regulations, time and fishing season in the shrimp's fisheries today may certainly contribute to the outcome of this situation.

A ½ inch mesh size gear is absolutely vulnerable to the resource, especially during the months of June and July when the recruitment occurs. The management should adopt the strategy of selective fisheries by increasing the mesh sizes at least from ½ to 1 or 1½ inch to protect immature shrimp and reduce by-catches and the level of discarding, resulting in lower environmental impacts of fishing and improved profitability for the fishermen in the long run.

Selectivity is not an exclusive remedy to the detected fishing overcapacity in the Pearl Lagoon shrimps fisheries. In this case, improving selectivity alone is no longer a viable solution; it should be accompanied by a drastic reduction of fishing capacity that would allow the shrimp population to rebuild. In this case, I would recommend the management to limit the entry of outsiders in the fishery and apply mesh size regulations in combination with other regulation strategies, more obvious by input control; closed fishing areas and license or permission. An important question is what is the proper month (season) to close the fishing areas or when to change the mesh sizes regulation in time; hence future investigation should be carried out to study these facts.

The attempt to limit the mesh sizes in the shrimp fisheries in Pearl Lagoon can possibly diminish the income of fishermen in such a way that their survival is threatened, especially for those who are permanently engaged in the fisheries. The acceptance of these regulations among fishermen would frequently be low. It should therefore be recommended that the management look into this situation before a new mesh size regulation is established.

Improving selectivity fisheries by mesh size regulation in the shrimp's fisheries in Pearl

Lagoon Basin will possibly be a hard task due to the lack of MCS and the unawareness of those involved in the fishery. Therefore, all harvesters and managers must understand the need for conservation. Education is necessary to facilitate changes to more selective harvesting techniques and sustainable, responsible fishing practices. Without the resource there is no fishery.

9. References

AdPesca, (2002). Anuario Pesquero y Acuicola de Nicaragua 2004. Centro de Investigaciones Pesqueras y Acuicola (CIPA) de la Administracion Nacional de Pesca y Acuicola (AdPesca). Managua, Nicaragua. P.7- 47.

Alverson, D., M. Freedberg,, S. Murawski, & J. Pope. 1994. A global assessment of fisheries bycatch and discards. FAO Technical Paper No. 339. Rome, Italy, 233 p.

Andreassen, C. (2004). Coping with Resources Crisis. Peoples struggle for sustainable livelihoods in Pearl Lagoon, Nicaragua. Master Thesis. Department of Social Science and Marketing, Norwegian College of fishery Science. University of Tromsø, 143 p.

Armstrong, D. W., R. S. T. Ferro, D.N McLennan, and S.A Reeves. (1990). Gear selectivity and the conservation of fish. Journal of Fish Biology, 37: 261-262.

Baio, A. (1996). By-catch and selectivity studies in the shallow water shrimp trawl fisheries off Freetown, Sierra Leone. - MPhil Thesis. - Department of Fisheries and Marine Biology, University of Bergen, 70 p.

Brewer, D., Rawlinson. N., Eayrs, S., B.C. 1998. An assessment of by-catch reduction devices in a tropical Australian prawn trawl fishery. Fish. Res. 36: 195–215.

Broadhurst, M. K., W. G. Macbeth, M.E.L. Wooden. (2005). Reducing the discarding of small prawns in NSW's commercial and recreational prawn fisheries. NSW Department of Primary Industries (now incorporating NSW Fisheries). FRDC Project No. 2001/031, 41:205.

Christie, P., Bradford, D., Garth, R., Gonzalez, B., Hostetler, M., Morales, O., Rigby, R., Simmons, B., Thinkam, E., Vega, G., Vernooy, R. and White, N. (2000). Taking care of what we have: Participatory natural resource management of the Caribbean Coast of Nicaragua. Center for Research and documentation of the Atlantic Coast AP A-186 Managua, Nicaragua and the International Development Research Centre, Ottawa, ON, Canada. K1G 3H9.

Cisnero, R. (2000). Informe sobre la utilización de la fauna acompañamiento del camarón (FAC) y de otras pesquerías en Nicaragua. Managua, Nicaragua. MEDEPESCA, 7 p.

Cochrane, K.L. (2002). A Fishery Manager Guide book. Management measures and their application. FAO, Italy, Rome. Fishery Technical Paper, No. 428:231.

FAO 1995. Code of Conduct for Responsible Fisheries. Rome, FAO. 41 pp.

García, S y L. Le Reste. 1981. Ciclos vitales, dinámica, explotación y ordenación de las poblaciones de camarones peneidos costeros. FAO .Doc.Tec. Pesca, 20: 180 p.

Gallaugher, P. (1998). Stock Selectivity Salmon harvesting. Speaking For Salmon. Workshop Record. Harbour Centre, Vancouver. Simon Fraser University. P. 8-10.

Hostetler, M. (1998). Local reaction to the capitalist change in the fisheries of the Pearl Lagoon on the Atlantic Coast of Nicaragua. Master Thesis. Department of Arts in the Program of Latin American. Simmon Frasser University, National Library, Canada, P. 25-135.

Jentoft, S.H.B.a.D.P. Fisheries development the institutional challenge. Marine Policy, 2004 Eburon publish Amsterdam Netherlands: p. 73121.

Kapetsky, J.M. (1982). Consideraciones para la ordenación de las pesquerías de lagunas y esteros pesqueros. FAO. Doc. Tec. Pesca, 218 p.

Kooiman, J., S. Jentoft, R. Pullin, and M. Bavinck (2005), editors, Fish for Life: Interactive Governance for Fisheries. 6-1/4 x 9-1/4 2005 Series: (A-MARE) Amsterdam University Press - MARE Publication Series, 400 p.

La Gaceta, (2004).Sumario de la Ley de Pesca y Acuicultura No.489. Asamblea Nacional de la Republica de Nicaragua. Managua Nicaragua, DIARIO OFICIAL, p.7-20.

Larsen, R.B. (2000). A short Review of the Development of Modern Trawling and By-Catch Reduction Devices in the North - Atlantic Shrimp Fisheries. The Norwegian College of Fishery Science, the University of Tromsø. 7 p.

Lluch, D.B. (1975). Selectividad de las redes de arrastre camaroneras en el Pacifico de Mexico. Inst. Nal. de Pesca de Mexico. Sria. de Comercio.15 p.

McLennan, D.N. (1992). Fishing Gear Selectivity - an Overview. Fisheries Research, 13(3): 201-204.

Njock, J. C. (2001). The Tropical Shrimps Fisheries. Cameroon National Report on reduce the Impact of Tropical Shrimp trawling Fisheries on living marine resources through the adopting of the environmentally friendly techniques and practices in Cameroon. Socio-Economist. IRAD, Limbé, 317 pp.

Petruny, M.E., Parker, K.M. Castro, M.L. Schwartz, L.G. Skrobe, and B. Somers (eds.) 2003. Proceedings of the New England By catch Workshops. Rhode Island Sea Grant, Narragansett, R.I. 52pp.

Pinto, M. A. (2001) Gear selectivity for three by-catch species in the shallow-water shrimp trawl fishery at the Sofala Bank, Mozambique. Maputo, Mozambique. Institute for Fisheries Research. P. 1-12.

Pope, G.F. and Carter, J.C. (1975). Crustacean Plankton Communities of Madame River System and Their Variation with Predation. Journal of the Fisheries Research, Canada, 32(12): 2530-2535.
RaankJaer, J. (1997).Danish cases with fisheries Co -management. Marine Policy (1997): p. 1-11.

RaankJaer J. (1997). Danish cases with fisheries Co -management. Marine Policy.(1997): p.1-11.

Rivera, C. (2000). Guía informativo: Nicaragua y el sector pesquero. Admisnitracion Nacional de la Pesca. publicado por (ADPESCA), 19 p.

Rivera, C. and Tora, N. (2004). Anuarios Pesquero y Acuícola de Nicaragua 2004. Managua Nicaragua - Centro de Investigaciones Pesqueras y Acuícolas (CIPA) de la Administración Nacional de Pesca y Acuicultura (AdPesca), p.7-11.

Sanchez B.R. (2001). Biología Pesquera de Camarón Costeros del Gen. Litopenaeus y del Camaroncillo Xiphopenaes kroyeri en las Lagunas Costeras de la Región Autónoma Atlántico Sur: Proyecto para en Desarrollo Integral para la Pesca Artesanal de las Regiones Atlántico Sur, de Nicaragua (DIPAL). CONVENIO PAÍSES BAJOS/NICARAGUA Nº. NI-007604. 83 p.

Schegraf, J.M. (2004). Establishment of Sea grass Decline and Causative Mechanisms in Pearl Lagoon Nicaragua, through the use of Traditional Ecological Knowledge, Sediment Coring and Direct Virtual Census. Environmental Studies. Toronto Ontario, York University.8: 25-80.

Spain, G. (2001). The Pacific Coast Federation of Fishermen Association. The 10th Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET), Oregon State University. 9 p.

Stewart, P.A. (2001). A review of the studies of fishing gear selectivity in the Mediterranean. Aberdeen, Scotland, COPEMED. p.1-15.

Tena, V. F. 1980. La disponibilidad de postlarvas de camarón para la actividad acuacultural de la costa de Chiapas. Depto. de Acuac. Sría. de Pesca. Deleg. Fed. Pesca, Chiapas, México.16pp.

Tokai, T. (2000). Trawls with separator-panel for by-catch reduction and evaluation Methodology of Their Selective Performance. Department of Marine Science and Technology, Tokyo University of Fisheries, Konan, Minatoku, Tokyo 108, and Japan. 8 p.

Tschernij, V., Suuronen, P., Jounel P. (2004). A modeling approach for assessing short-term catch losses as a consequence of a mesh size increase. Fisheries Research 69(3): 399-406.

Valdemarsen, J.W. (2001). Principles involved in reducing species by catch. Fishery Technology Service. The State of World Fisheries and Aquaculture. http://www.oceansatlas.com/world_fisheries_and_aquaculture/html/issues/ecosys/selectgear/reduction_of_bycatch.htm#bottomrefsources.

Watson, J. W. (1995). Summary Report on the status of by catch reduction device development. Presented to the South Atlantic, Fishery Marine Council, and April 1992.

WTO (1998). United States - Import Prohibition of Certain Shrimp and Shrimp Products. World Trade Organization, 11:98-1710.

Appendix 1.

Life cycle of the shrimps

The life cycle of the shrimp can be represented through several phases such as: the process of egg-laying; the embryonic and larval development until the pelagic post-larvae reach drifting to the coastal zones and estuaries.

The post larvae enter the lagoons at the size of 4-12 millimeters, managing to enter to the lagoon system with the aid of the tides, which push them to colonize the entire estuary zone mangrove swamps on rich river-borne sediments.

They remain in this area of low salinity and high productivity for several months, while staying in the lagoon the juvenile consume of any type of organic material they come across on the sea floor.[17] Once completed its formation, the shrimp is said to be pre adult and in conditions for undertaking the return to the sea, always depending on the environmental pattern and traffic relations ready to breed again.

The post larvae enter the lagoons at the size of 4-12 millimeters, managing to enter to the lagoon system with the aid of the tides, which push them to colonize the entire estuary zone. They remain in this area of low salinity and high productivity during several months until reaching the maturity (Sanchez, 2001).

While staying in the lagoon the juvenile consume of any type of organic material they come across on the sea floor. Diet varies as shrimps grow, with larger individuals becoming more predatory and consuming animals such as marine worms, larvae of other crustaceans, small fishes, and even other white shrimps.[18]

Once completed its formation, the shrimp is said to be pre adult and in conditions for undertaking the return to the sea, always depending on the environmental pattern and traffic relations.

[17] (www.ucs.louisiana.edu/~rtb6933/shrimp

[18] (www.ucs.louisiana.edu/~rtb6933/shrimp/)

Appendix 2.

A 2.1 Boats

In Pearl Lagoon, the fishing of shrimps is merely artisan; the fishermen use small canoes (*dories)* that are approximately 6 m long and 2 m wide and operated with paddle and sail. The crew on board consists of 2, 3 or 4 persons, depending on the magnitude of the canoes. They also use canoes with outboard motor from 15 to 50 horse power, although they are infrequently used due to the high cost of operation. There are as well a relatively small number of semi industrial trawl fleets (4 to 7 boats), better known as hand trawlers, functioning generally in the Bar Point area inside the most profound area of the lagoon. The majority of the fleet is traditionally made of wood, with small size of approximately 10 to 17 m and working with a small Yamaha motor between 15 and 45 horse powers approximately. However, this type of fisheries is mainly carried out when fish stock is abundant due to the high cost of operation. Also the price of an engine is very high for people within the community.

Conversely, this type of fishing is waking apprehension inside the community with complaints and demands from different groups. The situation has even reached to an extent of emerging violence among the local communities.

Most people in these communities are attentive of the damages that trawling produces (most obvious, by-catch and immature shrimps species), including poor environmental sustainability. In addition, as mentioned before, the capability to fish with trawl is low through the high cost of operation.

People in the community of Raitipura express more awareness about the actual situation of the trawling since they cannot afford to maneuver on this level, according to them. Nobody trawls in Raitipura,, shrimps trawlers are regularly from Haulover and Pearl Lagoon. Local fishermen suggest two main negative effects of trawling: first, the non-selectivity of the gear combined with a huge amount of by-catch; second, the quarrels and conflicts among fishermen, essentially between trawlers and cast net users.

A 2.2 Gear and mesh size

The hand-net or cast net is a small-scale fishing gear. It is the most used type of gear to

capture shrimps inside the lagoon and the environment. They are nets thrown from the shore or from a boat that catch the shrimps by falling and closing in on them.

It is a simple round net, usually made out of monofilament nylon (transparent) or cotton mesh, with a lot of weights attached to the outer perimeter of the mesh. A line runs through the center of the net, called the lead line and also known as the stoking line according to local people. It is attached to another group of lines connected to the outer weights lead, normally called the foot line. When the net is thrown, the mesh form a circle, flattening out like a plate which sinks to the bottom still flattened out, trapping whatever is under the net. After pulling the net from the water, the opening lead line will cause the catch to fall out.

The majority of the nets are made by hand, but also fabricated ones are used. The use of cast net is usually restricted to shallow waters. The dimensions of hand net vary from 1.5 to 2.5 meters of radius and the size of the mesh in the majority of cases is of 1 inch or smaller depending on the size of the shrimps. The size of the plummet or weight in the opening depends on the height of the opening. This type of fishing techniques is not a threat to the marine ecosystems apparently; according to local fishermen the problem lies in the mesh size, most obviously in the use of small mesh size.

Local cast net (in nylon)

The fishermen also operate with small traditional (hand used) trawl gears, no more than 100 m long, which is a very fast and active gear to control. These trawl gears mostly manoeuvre in the South-eastern area (Bar Point) where the shrimps are about to

immigrate toward the marine environments. The mesh size of the gear is relatively small, mostly only a 1/2 inch. According to the fish law of Nicaragua it is totally illegal to operate this type of gear in the lagoon environment, but at the moment the law is poorly carried out.

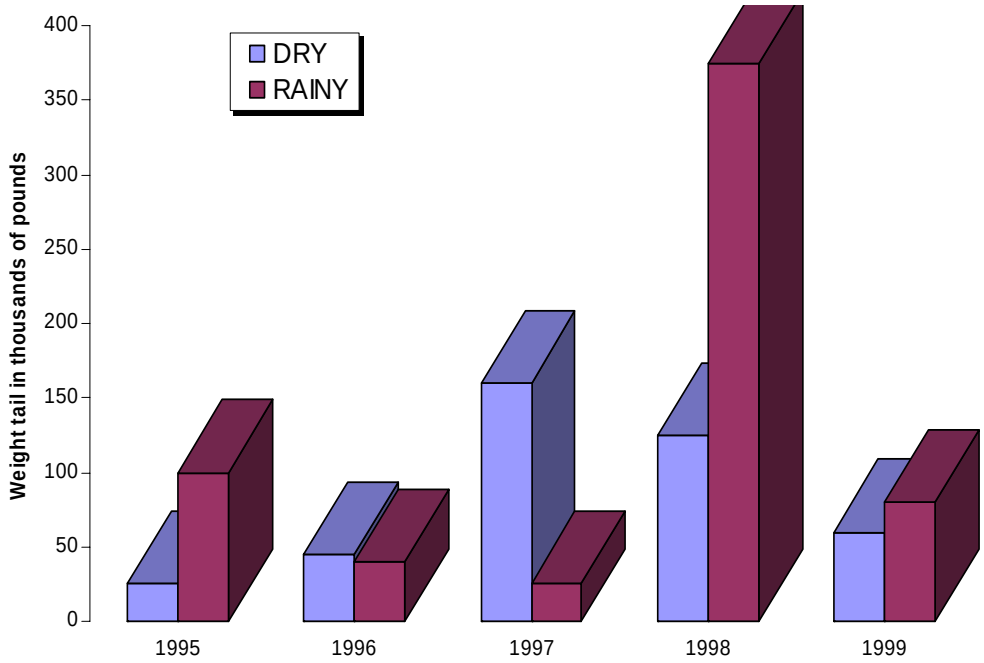
As already mentioned, people in the community are concerned about using this type of fishing gear, with complaints and demands in the more vulnerable areas.

A 2.3 Landing

To know about the shrimp captures made in the lagoon, I took as base the volume of disembarked shrimps in Pearl Lagoon by Mar Caribe S.A[19]. In fact, it is the only company in the area that receives shrimps both in the dry and rainy season (Figure 21).

The figure shows that the years 1996 and 1997 were exceptional, considering that the shrimps in the lagoon environment are most vulnerable to fishing in the second half of the year starting in June. However, the years 1995, 1998 and 1999 are typical years, disembarking greater volumes in the months of the second semester.

[19] Mar Caribe is the first and only storing company (*acopio)* in Pearl Lagoon.



Disembarkations of shrimp (weight tail in pounds) by station in the Caribbean Sea Company during two catch season in Pearl Lagoon (Sanchez, 2001)

The study of Sanchez (2001) shows clearly that the population of shrimps inside the lagoon is usually captured approximately between 1.5 and 3 months of age and in the size between 73.3 and 91.1 millimetres in total length. The biggest population inside the lagoon had an approximated age of 4 months with an average size of between 89.9 and 144.7 millimetres in total length. The maximum age of the captured shrimps reaches approximately to 13 months with a size of between 167,9 and 199.5 millimetres in total length. The graph also illustrates a significant reduction in the landings between the periods of 1998 to 1999: this had been reducing eventually from 1998.

There is a relative quantity of unreported catch of the shrimps, allocated between the local market and by individual buyers that purchase the product and sell them elsewhere. A study in the lagoon stipulates that about 30% of the total catch of shrimps is not sold to the company.

However, one limitation of my study is the lack of available data concerning the landing

of the species during the last 5 years. It is extremely hard to get hold of these data inside the lagoon. This missing scopes of data difficult the observation of the state of the fishery, although local fishermen assert a reduction in biomass.

A 2.4 Market

There are only two *Acopios* that purchase the shrimps in the lagoon: the Fishermen Union Stock Centre which is functioning with some financial and organizational constraints, and the Mar Caribe (Caribbean Sea S.A.) which is the biggest and most successful company. In the majority of cases the fishermen sell their product to this company.

Beside, small private boats from other places have begun to come up to the Pearl Lagoon Basin to buy the white shrimp (Christies et al., 2000)

The price of the shrimps paid to the fishermen has stayed between USD 1.47 in 1995 and USD 2.02 by pound of tails, depending on the size and quality of the product (Sanchez, 2001).

However, shrimps are also purchased among the local people for a lower price, essentially when the processing plant is not operating or buying the product.

The companies that buy the product commercialize only frozen shrimp tails, classified in commercial categories. Most of the artisan shrimp production is exported to the international market.

Conversely, today there is an obvious paradox in the shrimp marketing. Shrimps are considered to have continuously a high demand, but the only company that purchased the shrimps in Pearl Lagoon suddenly stops buying, compelling the fishermen to purchase at local market for a relatively low price. This circumstance is raising huge frustration among the local people at this moment.

Appendix 3.

Questioner during the interview

Date: _____
Time: _____
Name of the interviewee: _____
Position: _____

Interview

1. What are the representative gears employed in the shrimps fisheries and name the most important one, and why?

Note:

Gear	**More important**	**Important**	**Less important**
Hand net			
trawl			
others			

2. How are the gears operated now and before? (Currently, 10 years ago, in the past)

	Currently	**10 years ago**	**Past**
Number of crew			
Fishing depth			
Number of gears			
Types of gears			
Size and lengths			
Height and width			
Boat size			

Note:

How were the catches? (Currently, 10 years ago and in the past)

Catches	Currently	10 years ago	Past
Very good			
Good			
Bad			

Comment:

1. How are the gears made now (material) and before? What caused the change of the material?
2. What kind of impacts (negatives and positives) takes place through the changing of the gears and mesh size?
3. What are the physical and chemical parameters (weather, change of moon, place etc) that change the type of gears and mesh size in the shrimps fisheries?
4. What are the weakness and strengths in using the different type of gears and mesh size in the shrimp's fisheries?
5. What type of management is used in the fishery? (Currently, for 10 years ago and in the past)

Types of management	Currently	10 years ago
Co-management		
Community-based management		
Cooperative		
Others		

1. Explain how the management works now and in the past
2. How well does this benefit you (economically) now and in the past? Why?
3. Explain why this type of gears are used in the community (social aspect)
4. Does there exist any law or regulations regarding the type of gears and the mesh size now and in the past? What type of law or regulations?
5. How well these laws and regulations answer to the needs of the people and of the sustainability of the shrimps resource?
6. Who in your opinion should look for the welfare of the resource and to see that these laws and regulations work in the best manner?
7. What is in your opinion the biggest problem facing the shrimps

8. Fisheries today*?*

9. How do you think this research work about the gears and mesh sizes will benefit the shrimp's fisheries now and in the future?

Appendix 4.

Respond from the interview

KAKABILA	HALOUVER	PEARL LAGOON
Alfred Lopez	Arnoldo Beckford	Alberto Morales
Carlos Allen	Elvis Rigby	Danilo Sambola
David Pichi	Henry Burton	Ensward Fox
Graniso	Horace Rigby	Winfred McCoy
Olish Archivold	Joel Lopez	
Marlon Imgram	Steve Thinkam	
Mark Brown	Silvio Pondler	
Karl Imgram	Youstes Tatum	
Rene		

Appendix 5.

By catch output parameter for ½ and 1 inch mesh sizes (ANOVA test)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.083333	1	4.083333	0.42461	0,053	4.964591
Within Groups	96.16667	10	9.616667			
Total	100.25	11				

One way comparison between mesh sizes (ANOVA test)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1182.534	2	591.2671	141.7768	**<0.001**	3.026893
Within Groups	1209.418	290	4.170407			
Total	2391.952	292				

Appendix 6.

Sample of the shrimp length retention data base, obtained during the field work in Pearl Lagoon in July 2005

1/2 inch		1 inch		1 ½ inches	
Length (cm)	***Unit***	***Length (cm)***	***Total***	***Length (cm)***	***Total***
4	2	6	1	6	3
5	10	7	2	7	5
6	20	9	2	8	3
7	27	10	8	9	1
8	18	11	11	10	3
9	5	12	31	11	11
10	1	13	31	12	31
11	1	14	14	13	27
12	6			14	12
13	10			15	4
Total	***100***		***100***		***100***

Sample of the shrimp' weight retention data base, obtained during the field work in Pearl lagoon in July 2005

1/2 inch		1 inch		1 ½ inches	
Weight (K)	***Unit***	***Weight (K)***	***Total***	***Weight (K)***	***Total***
1	22	2	1	2	3
2	30	3	2	3	5
3	22	6	2	4	3
4	7	7	2	8	1
5	2	8	2	9	4
9	1	9	4	10	9
11	1	10	6	11	1
12	1	11	8	14	15
13	3	12	7	15	12
14	4	13	11	16	30
15	1	14	11	17	2
16	2	15	10	19	4
17	3	16	7	20	7
18	1	17	12	21	3
		18	8	22	1
		19	3		
		20	2		
		21	1		
		23	1		
Total	***100***		***100***		***100***