STUDY OF A Caranx caballus FISHERY IN LAS PERLAS ARCHIPIELAGO,PANAMA

by

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For

Mari Luz Dominguez

Without your unconditional love I could not have

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ABSTRACT

Las Perlas Cojinua (*C. caballus*) Fishery was studied from June 2005 to June 2006. The data available for this study was Biometric data and landing records from the Panama Shellfish Market. This data was completed with qualitative interviews with fishermen and local buyers. The data was statistically analyzed showing some interesting trends. The possible cycle for the *C. caballus* could be suggested as a spawning season in December following for the different maturity phases throughout the year. The Cojinua could reach the sex maturity after 9 months from the spawning, by September. It was found that 50% of the fish reaches the sexual maturity at about 35cm. From the landings records it has seen that the fishing activities removed almost 16tonnes of Cojinua per year. The data shows that the fishery has a lack of control of all the fishing activities being carried out. The control of the fishery should be enforced. The main fishing activities are Semi-Industrial fishing and *Artesanal* fishing and there is unregistered *Artesanal* fishing as well being carried out within Las Perlas Fishery. A high percentage of the fish (35.6%) is removed from the stock without a chance to reproduce. For this, a Minimum Landing Size (MLS) of 30cm (maybe an ideal MLS would be 35cm) has been suggested to be implemented as a good instrument of sustainable management of the fishery. A long-term study of C. caballus within Las Perlas Fishery in terms of landing records as well as biometric records should be developed to prove all the hypothesis that have been highlighted after this study.

Keywords: Cojinua, *C. caballus,* Las Perlas Fishery, Semi-Industrial, Artesanal.

1.0 INTRODUCTION

The general aim of this study is to provide for the first time a scientific understanding of the fishery of *Caranx caballus* (locally known as Cojinua) carried out in the area of Las Perlas Archipelago, Panama and to study the reproductive cycle of this fish. With the analysis of the collected data from catches from several boats that fish in the area it is anticipated that a better understanding of the effects of the fishing acti8vity will be obtained as well as the understanding possibly feeding into recommendations for good management practices in order to conserve the stock of the *C. caballus* in the area.

The Smithsonian Tropical Research Institute (STRI) (Panama City) made this study of *C. caballus* possible from the fishery in Las Perlas Archipelago by enabling the collection over 12 months of all the data from the fish market of the Panama City, where the fish are landed. The study has also been supported by the Darwin Initiative project collaboration between Heriot-Watt university and STRI since this project is aimed at developing the planning of a Special Management Zone around Las Perlas (Zona de Manejo Especial Archipielago de Las Perlas). This project is part of the conservation effort that the Darwin Initiative has developed in the area to create an effective long-term management plan for the region.

1.1 STUDY AREA- LAS PERLAS ARCHIPIELAGO

Las Perlas Aarchipelago is located on the Pacific side of Panama. This Archipelago is located 37 kilometers south from Panama City in the Gulf of Panama. The Archipelago is made up of around 255 islands and islets that comprise several marine environments like coral reefs and mangroves with a huge economic value for the sustainability of the Panama Gulf fishing productivity. The largest island of the group is Isla del Rey (in the south-eastern area), followed by the islands of San Jose and Pedro Gonzalez (Raab and Roche, 2005). There are 19 villages in the Archipelago with a range of populations from 10 to 700 (Campbell, 2005). Most of the islands within the Archipielago are unpopulated and some of them including the islets are completely uninhabited (Guzman, pers. comm.).

The tourism of the area is focused on Contadora island (in the northern part) where there is the only main airstrip within the Archipelago as well as accommodation and boat infrastructures such as hotels and a marina. Along with San Jose island they are the places in Las Perlas Archipelago where most of the tourism is currently occurring.

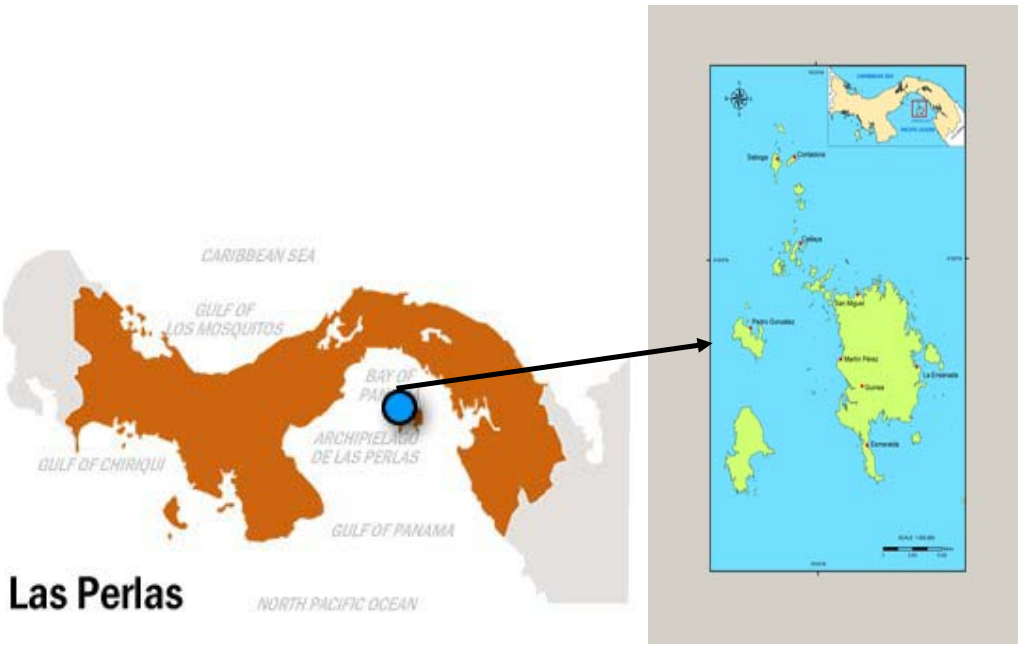

Figure 1.1 Las Perlas Archipielago within the Gulf of Panama [1] **Figure 1.2** Las Perlas Archipelago[2]

1.2 OCEANOGRAPHIC FEATURES OF LAS PERLAS ARCHIPIELAGO

The Gulf of Panama forms the eastern half of the Pacific coast of Panama. It is about 200 km wide (E-W direction) and 170 km long (N-S direction). There are two main groups of natural islands in the Gulf. The first group includes the islands of Taboga and Taboguilla, located 15 km. south of

[1] http://www.privateislandsonline.com/panamalasperlas.htm
[2] http://www.darwin.gov.uk/news/projects/las_perlas.html

Panama City. The second group, Archipielago de Las Perlas, is located in the middle of the Gulf at a distance of 90 km South East of the Canal Pacific entrance. The water depth range fluctuates from 50 to 100 meters in the middle of the Gulf. Most of the coast is flat with small river mouths, swamps and mangroves. The entrance of the Gulf located at an approximate Latitude of 7.5º N (East of Punta Mala, at the Azuero Peninsula) has depths in the order of 200 m. South of the entrance, depth increases very rapidly reaching values between 2000 to 3000 meters at a latitude of 6º N (Feasibility Study of Island Development at the Pacific Entrance of the Panama Canal, May 2004).

The tides in the Gulf of Panama are semidiurnal with two high waters and two low waters per day and with an approximate period of 12.25 hours. The average tidal range at the entrance of the Gulf of Panama is 1.5 m during neap tide and 3.4 m during spring tide. The tidal propagation along the Gulf follows a standing wave pattern. The tidal range amplifies from south to North due to the reflection of the tidal wave on the closed boundary at the North of Panama Bay (Feasibility Study of Island Development at the Pacific Entrance of the Panama Canal, May 2004).

There are two oceanographic occurrences in the Gulf of Panama which determine major variables in the marine environment: a wind-driven seasonal upwelling and the El Niño Southern Oscillation (ENSO) that produces an increase of the sea temperature with intervals of 4-9 years (Kwiecinski and Chial, 1987; D'Croz and Roberston, 1997).The Gulf of Panama lies within the Equatorial Low Pressure Trough, a low atmospheric pressure and is affected by the Intertropical Convergence Zone (ITCZ). The ITCZ is formed by the trade winds that converge to this area from both hemispheres. (D'Croz, 1998). The upwelling effect is affected by the ITCZ and its position within the Panama Isthmus during the two different seasons: dry season (from January to April) and rainy season (from May to December). During the dry season the ITCZ is located a slightly south of Panama and there is a predominance of northeast trade-winds (Forsbergh, 1969). These winds displace nutrient-poor coastal water and bring the nutrient-rich deep water to the surface resulting in large scale phytoplankton blooms (D'Croz *et al.*, 1991). During the rainy season a warm, low salinity and nutrient-poor water prevails in the Gulf of Panama (D'Croz *et al.*, 1991). At this time, the ITCZ is in the north of Panama and the winds are light and variable during the season (Forsbergh, 1969).

The temperature of the water varies during the two effects. During the upwelling the range of temperatures is 15º-20ºC and during the ENSO effect the water temperature increases until the range of 30º-31ºC (D'Croz *et al*., 2001; Medina, 2004; Baxter, 2004).

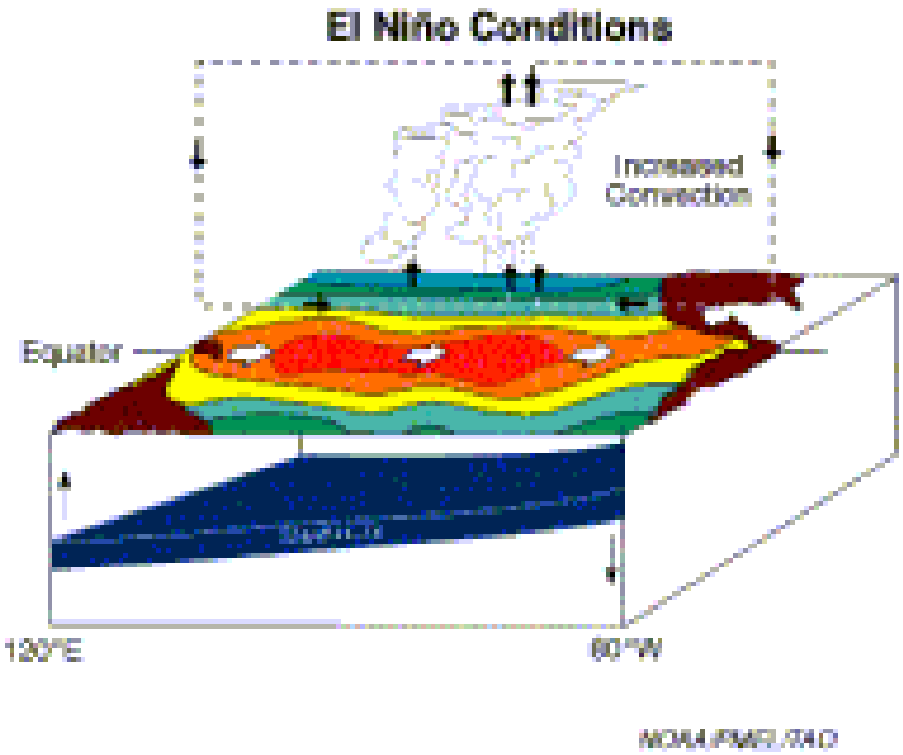

Figure 1.3 El Niño conditions[3]

1.3 THE COJINUA FISHERY

There is not much information available on *C. caballus*. On the basis of the work of Eschmeyer W. N., E. S. Herald and H. Hammann in 1983 gathered in the book, "A field guide to Pacific coast fishes of North America"; it is known that *C. caballus* or commonly named Cojinua is a fish wich belongs to the family Carangidae (Jacks and Pompanos) and the class Actinopterygii (ray-

[3]http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

finned fishes). Its maximum recorded size was 55.0cm and its maximum published weight of 2,810g. *C. caballus* is a pelagic fish wich lives in a depth range of 3-100m in subtropical climates. It has an important commercial value in the places where it occurs. It has a medium resilence, a minimum population doubling time of 1.4 to 4.4 years. The Cojinua is distributed along the Eastern Pacific. Its body is marked by 18-21 soft rays. It has 3 anal spines and 25 vertebras. It can be found on the continental shelf, generally near the coast but also in deeper waters, although it could also be found in stuaries. Juveniles are often found in estuarine waters. They feed on silver-colored fishes, but also takes squids, shrimps and other invertebrates.

The Cojinua occurs within Las Perlas Fishery, where other kind of fish with good economic value are located. There is a high fishing pressure on the Red Snapper mainly for exportation and processed plant (O. R. J. Anderson, 2005). There was an important shrimp fishery within Las Perlas archipielago that has begun to collapse and some of the vessels wich fished shrimp are being relocated on other type of fishing (O. R. J. Anderson, 1995). Another important fishing with a high economic value being carried in Las Perlas is the Lobster fishing. This activity is being regulated from 1981 throughout a *Decreto Ejecutivo* (Decree) No. 15. It gives several rules for the lobster fishing as a MLS of 6cm (total length of the head of the lobster) for the 2 different species of lobster that occur in Panama (*Panulirus gracilis* and *P. argus*). This Decree also ban the fishing of any lobster using nets, sharp instruments or oxygen tanks for diving. It is also banned the commercialization of lobsters with eggs that has to be released immediately.

1.3.1 Zona de Manejo Especial Archipielago de Las Perlas

Due to different threats of the marine environment of Las Perlas archipielago, Darwin Initiative Project in collaboration with the Smithsonian Research Institute (STRI) are working together to develop the Zona de Manejo Especial Archipielago de Las Perlas. This project is being developed in terms of protecting the area against the different threats that can harm the marine environment. The project pretends to control activities that can be a risk as overfishing, habitat degradation, pollution and ecological diversity loss; setting up a Marine Protected Area (MPA) (O. R. J. Anderson, 2005). Las Perlas archipielago has 737 fish species of the 780 fish species found on the Pacific coast of Panama

(Robertson and Allen, 2002). Such high biodiversity at upper trophic levels is indicative of a worthly site for the stablishment of an MPA (O. R. J. Anderson, 2005).

1.3.2 Relevant Fisheries Legislation within Panama

The Cojinua fishing activities within Panama are poorly controlled. The weight of the landings are controlled in the Panama Shellfish Market (*Mercado de Marisco*, where all the fish and shellfish commercial activities are carried out). Apart from these records, there is not any regulation or legislation developed. There are 9 licences for Cojinua fishing in Las Perlas archipielago for Semi-Industrial fishing vessels ("*bolicheritos*") but the rest of the fishing activities are not controlled. It exists *Artesanal* fishing in Las Perlas Fishery from wich there is no data even for the landings.

Other type of fishing as Snapper, Grouper and Shark is more regulated with the *Decreto Ejecutivo* (Decree) No. 49 of July 20th 1992. That Decree is a further step on legislation from the Cojinua regulation but it is still extremely limited (O. R. J. Anderson, 2005). This legislation ban the fishing of any of those fish (Snapper, Grouper and Shark) using gillnets or "*trasmallos*" (trammel nets) as well as a licence is required for the vessels with a capacity of greater than 10tonnes.

There is no studies about the state of the Cojinua stock within Las Perlas Fishery. Before the MPA consolidation is necessary to know the current sustainability of the fishery.

1.3.3 A Comparative Study of similar Carangid species in Belize

A study of courtship and spawning behaviours of carangid species in Belize conducted by Rachel T. Graham and Daniel W. Castellanos was a helpful source of knowledge of the sexual maturity and spawning behaviours of the carangid fish. The study was developed during 3 years. The conclusion of the study was that different species of carangids as Yellow Jack, Horse Eye Jack and Amber Jack, spawned close to sunset from February troughout October. The study also situated the spawning sites offshore at reef promontories. It describes many features of the reproductive cycle of these species of carangids. There is no much more information related to carangid species and nothing published on *C. caballus*.

1.4 AIMS OF THE STUDY

The specific objectives of this current study are to :

- Collect qualitative data on the cojinua fisheries throughout Las Perlas Archipelago through interviews with fishermen, local buyers and local officials.
- Quantify the scale of the cojinua fishery based in Las Perlas Archipelago, Panama.
- Quantify the minimum size of the cojinua with sexual maturity.
- Characterise the biometrics of the cojinua fishery in Las Perlas Archipelago, Panama.
- Characterise the reproductive cycle of the cojinua based on gonad maturity.
- Identify the sustainable yields of the Las Perlas cojinua fishery in order to improve the actual restrictions that may improve the long-term management of the fishery.

2.0 METHODOLOGY

2.1 FIELDWORK

The project involved two types of research: qualitative data collection and quantitative data collection**.** The qualitative data was collecting through interviews with local people like fishermen, buyers and officials. This data collection was conducted over three days. One day was using for collecting data from the buyers in the Shellfish Market of Panama City where three interviews were carried out with three different buyers. One day was used to talk to the fishermen, two interviews were carried out with two different captains of two "bolicheritos" boats. There are nine licences for cojinua fishing in Las Perlas Archipelago fishery for this type of boat (Guzman, pers. comm.). The third day was aimed at obtaining data from the Panama Shellfish Market official organisation. One day was not enough to get those data due to the data being not in the correct form. Subsequently Dr Hector Guzman (STRI) had to deal with other officials and after several weeks he obtained the data of the fish landings for the whole year.

The quantitative data collection involved recording biometric data directly from the fisheries. This collection was not directly taken as a measure of the fish population as a whole, it was taken as a sample from the Panama Shellfish Market. The fish which were sampled were known to be caught from Las Perlas Fishery (Guzman, pers. comm..). The data collected from the fishery can be assumed to be fairly representative of the actual population. There is also a small proportion of the population which is caught by non registered artisan fishermen (Guzman, pers. comm..). This amount of fish is a small section of the population and is not representative adequately purely by the fish catch data. The data from the Panama Shellfish Market has been complemented with the data collected from the official organisations about the landings during the whole year. Due to limits on the equipment and methodologies available for this study, there was no other way to carry out other type of population study of *Caranx caballus*.

2.2 QUALITATIVE RESEACH

The qualitative part of the project was taken from interviews with local fishermen, buyers and officials in the Panama Shellfish Market. There were two different formats of interviews. These formats are outlined below.

Questionnaire used for buyer's interview

1. **Where has the fish been caught?**
2. **What is the average of the price of the fish?**
3. **Why does the fish price vary?**
4. **What is the amount of fish sold per day?**
5. **During what time of the year is the largest amount of fish caught?**
6. **What is the average of fish landing per day?**
7. **What processing of the fish occurs before the costumer buys it?**
8. **Which type of businesses are interested on the *Caranx caballus* (Cojinua)?**
9. **What is the percentage of *Caranx caballus* (Cojinua) compared to other fish?**
10. **Which type of fish is sold?**

Questionnaire used for fishemen's interview

1. **Which types of fish are caught?**
2. **What is the way of fishing used?**
3. **What is the size of the net used?**
4. **How many months are spent fishing per year?**
5. **What is the size of the boat (length and weight)?**
6. **How is the processing way of the fish inside the boat?**
7. **How long does a working day last?**
8. **How many people are employed in the boat?**
9. **What is the maximum depth where the fishing is carried out?**
10. **What is the maximum weight that has been caught on a day?**
11. **What is the size of the mesh of the net?**
12. **In which season are the biggest catches?**
13. **Why does the fish price vary?**

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fishing businesses (local buyers or captains of the "bolicheritos". Dr Hector Guzman (STRI) provided the contact of the fishermen. The interviews with the local buyers were carried out at the same time as samples of fish were being purchased to process later on for the study. The people who were interviewed responded warmly and openly to all questions. The qualitative results also involve data collected from the Panama Shellfish Market. This data completes the qualitative results of this project, there is data for all the landings for the time of the project. The data comprises all the landings (Kg) made in the Market by the different boats with licence to fish *C. caballus.* There is no data enough to analyzed these landings as part of the quantitative results as a CPUE (Catch Per Unit Effort) analysis. It would be better for further studies to have all the data necessary (i.e. time spent fishing per trip, number

of people working in the boat per trip) to be able to make a CPUE analysis. However this data has been studied as part of the qualitative results.

It is noted that the answers of the local buyers are different in some aspects to the questions that were the same for all of them. This could be due to they are afraid of telling the truth in some questions just in case the given information is used to cause them troubles.

2.3 QUANTITATIVE BIOMETRIC DATA COLLECTIONS

The quantitative biometric data collection was carried every month for a whole year, from June in 2005 to June in 2006. There is no data for November 2005 due to it was impossible for the STRI to collect data during November, there was nobody to do the survey. The data are confined to the Las Perlas fishery. All the fish that have been processed, and later on analysed as statistical data; were caught in Las Perlas (Guzman, pers. comm.). The fishermen were fishing for *Caranx caballus* (Cojinua) at the same sites in Las Perlas during 4-5 days or even more (8-9 days) depending on the availability of the fish and other factors like season of the year and moon cycle. The fishermen return to Panama City when they consider the catches are enough and they sell the fish to local buyers. The local buyers sell the fish directly to their costumers in small posts in the Panama Shellfish Market. Whilst the boat is fishing the fish are conserve in cooler systems and the local buyers use ice to conserve them once the fish have been landed.

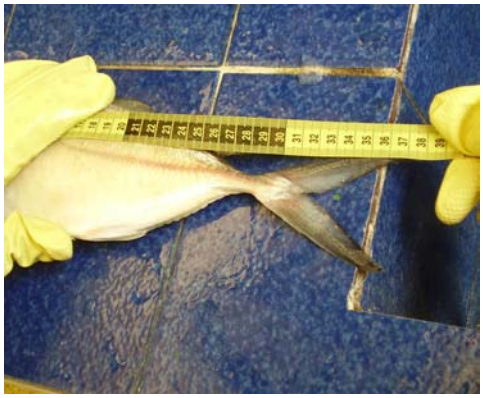


Figure 1.5: *Caranx Caballus* (Cojinua) in one of the small posts in Panama Shellfish Market.

Figure 1.6: Length measurement of the fish.

The samples of fish for this project were bought in the Panama Shellfish Market from local buyers and they were preserved on ice in small coolers until they were processed in the laboratory of the Smithsonian Tropical Research Institute (STRI). The samples were made up of 200 fish taken randomly twice a month (one in the first fortnight and the other in the second fortnight of the month) and each month 400 fish have been analysed. During May and the first fortnight of June the samples were double size (400 fish each sample) due to the size of the fish being smaller than the rest of the year. The double size of the last samples permitted a better search of the minimum size of the *Caranx caballus* (Cojinua) with sexual maturity. Taking two samples each month meant that the study can be done under different stages of the moon cycle and is possible to analyze the effect of the moon on the life cycle of *Caranx caballus* (Cojinua).

Measurements of the samples were taken for Total Length, Standard Length (i.e. base of the caudal fin where it meets the caudal peduncle), Total Weight, Sex, Gonad Maturity Phase (i.e. Immature, Premature, Incipient Maturity, Advanced Maturity and Spawned) and Gonad Weight.

Length measurements were taking using measuring tape and recorded to the nearest 0.5 cm.

Weight measurement of the fish were taking with a mechanical hanging scale that measured in pounds and ounces. To analyse the statistics of the data, the data has been translated into grams. Weight measurement of the gonads were taking with a better accuracy using a digital balance accurate to +/- 1.0g. The gonad weight was not the real weight due to they were weighed hours after they were inside the fish without preservation and with some water and weight loss. As all the eggs were under the same conditions and time the collected data are considered representative of the gonad weight. An improvement in this technique is necessary to make it more accurate for further studies. The gonads were taken from the fish using a standard dissection kit. Sex and gonad phase were determined by macroscopic examination of the gonads.

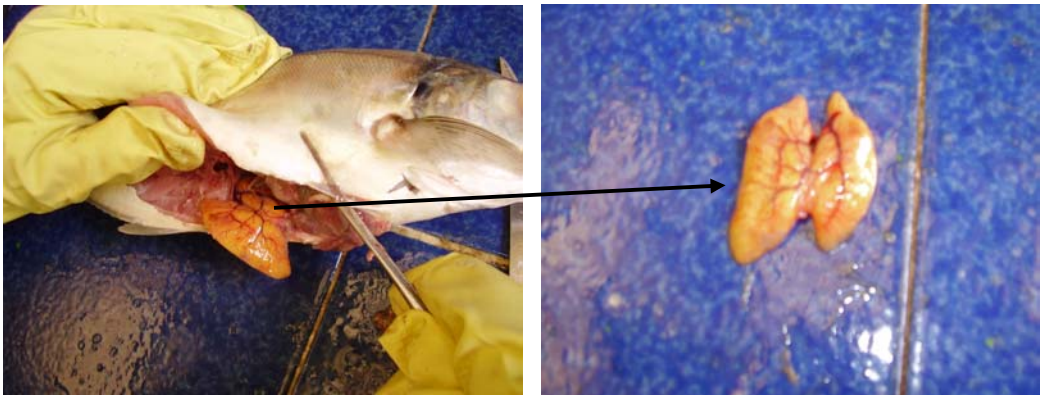


Figure 1.7: Dissection of *Caranx caballus* (Cojinua) to determine the Gonad Maturity Phase.

During the sampling period the data were collected by different members of the Smithsonian Tropical Research Institute (STRI) excluding the data collected during May, when the data were collected by the author.

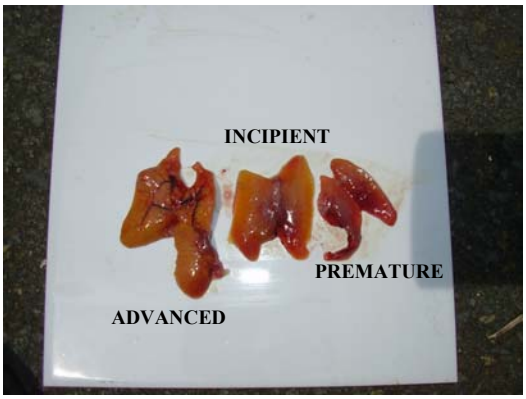


Figure 1.8: 3 different gonad stages of a female.

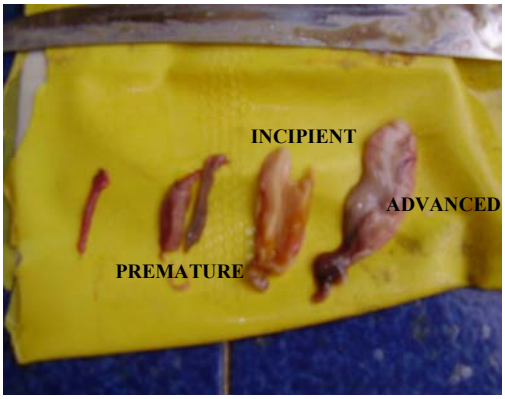


Figure 1.9: 4 different stages of a male.

2.4 BIOMETRIC DATA INTERPRETATION AND ANALYSIS

Biometric data interpretation and analysis was done using Microsoft Excel, SPSS AND Minitab statistical softwares. Length-weight analysis and Maturity analysis were developed under the methodologies of Sparre and Venema (1998) and Galluci *et al*. (1996).

3.0 RESULTS

3.1 QUALITATIVE RESULTS

3.1.1 Introduction

The qualitative data have been collected from interviews during 3 days in the Panama Shellfish Market in May 2006. The interviews were carrying out with two different groups of people who work in different stages of the Cojinua Market. The data involves three interviews with local buyers and two with fishermen. The local buyers buy the fish from the boats which arrive to the Shellfish Market after they have been fishing for some days. They sell the fish straight to the costumers. The fishermen make up the crew of the boats. These data cannot be treated as quantitative. This section is complemented by data of all the landings made in the Shellfish Market during the time of the project that has been analyzed as qualitative data due to there not being enough data to make a CPUE analysis within the quantitative results.

3.1.2 General Fishing Practices throughout the Archipielago.

The fishing practices throughout the Archipielago are focused on Cojinua, Grouper, Snapper, Sharks, *Camaron Rojo* (*Penaeus brevirostris*), Lobster and Octopus. For each of them there are different techniques of fishing but the fishing activities are mainly divided into four different groups:

- *"Artesanal*": small fibreglass or wooden boats of ca. 7-8m in length with ca. 40hp outboard engine (O. Anderson, 2005). They fish mainly for snapper not further than 20-25km from the small villages of Las Perlas Archipelago (Esmeralda and Pedro Gonzalez). The crew is made by 3-4 fishermen (O. Anderson, 2005).
- Semi-Industrial Fishing: wooden boats of ca. 15m in length. They fish mainly for cojinua but they also fish for other species as snapper or Spanish Mackeral. The crew is made by 10-15 fishermen.
- Industrial Fishing: wooden boats of ca.15-20m in length. They fish for several kinds of fish such as Shark and Dorado (Asamblea Nacional Panama, 2005).
- Skin-Diving: divers who fish mainly for lobster and octopus. This activity is mainly carried out from May onwards in the Archipelago (O. Andersen, 2005).

For each different activity there is a special regulation except for the "*Artesanal"* which is not registered at all. A regulation of this activity is needed to ensure a sustainable management of the fishery.

For the Cojinua fishing only types of practices are known: *Artesanal* (which is not registered) and Semi-Industrial. The Semi-Industrial Fishing of the Las Perlas Fishery is registered in the Panama Shellfish Market through the landings of the Cojinua from the fishing boats called "*bolicheritos*" ("*bolicherito artesanal*" or "*bolicherito semi-industrial*").

3.1.2.1 Interviews with the Fishermen

There are 9 permits for Cojinua fishing within Las Perlas Fishery. These permits are for Semi-Industrial "Bolicheritos" and only 8 names of these boats are known. These boats are*: Lina Cristina,*

Peregrina, Josefa, Francisco M, El Navegante, Don Jose, El Victorioso, Dona Gertrudis and *Emilio Munoz* (H. Guzman, pers. comm.).

There are other non-registered fishermen in the area of Las Perlas Fishery. These fishermen are mainly carrying out "*Artesanal*" fishing activities which appear not to harm the environment too much due to the small amount of fish that they remove from the stock; but they should be controlled to ensure a sustainable management of the fishery.

The "bolicheritos" are about 15m in length, 5m width and 1.67m height. They are made of wood. The crew is composed by 10-15 fishermen covering all the duties aboard. They fish with nets of 274m in length and 36.5m in height. The ,net mesh is 12.7mm. The duration of the fishing trips are about 4-5 days but, depending on the weather, they can be longer (8-9 days). They normally fish until the boat is full of fish and at that time, they go back to Panama Shellfish Market in Panama City to sell it to local buyers.

This special type of boat fishes for Cojinua in Las Perlas Fishery, mainly in San Miguel Island. They can catch 8T of Cojinua but the normal amount of catch landed in Panama Shellfish Market varies between 4T and 7T. The Cojinua is caught in depths between 27m maximum and 11-13m minimum, depending on the sites. The boats are fishing for the whole year except for a break of 10 days each month. That break starts 6 days before the full moon and finishes 4 days after the full moon.

Some of the "bolicheros" have permits for other species such as Snapper, Spanish Mackeral and Jurel (*Caranx sexfasciatus*).

Figure 3.1 "Bolicherito" called Francisco M (one with licence for fishing Cojinua in Las Perlas) with part of its crew having a rest in Archipielago Las Perlas next to San Miguel Island.

3.1.2.2 Interviews with the Local Buyers.

The fish landed by the "bolicheros" is bought by the local buyers who are owners of small business and they finally sell the fish to the costumer. The fish is sold in the Panama Shellfish Market in small posts equipped with coolers to maintain the fish in good conditions. The most popular fish within the Panama Shellfish Market is the Cojinua but other species such as Shark, Corvina (*Cynoscion praedatorius)*, Revoltura (base of fish made with different species) and Snapper (used for export after been processed in a fish factory). As the Cojinua is a great percentage of the fish sold in Panama Shellfish Market, good management throughout Las Perlas Fishery is considered necessary.

The Cojinua is caught in Las Perlas Archipielago, mainly in San Miguel Island. The best season for Cojinua fishing is from March to May when the Cojinua is present in high amount in the Market. The main buyers of Cojinua are the Panamanian citizens for home-cooking as well as the "fondas" (small restaurants that offer typical food to their customers). The "fondas" are the main buyers.

The "bolicheros" land the Cojinua in the Panama Shellfish Market and it is there where the local buyers buy the fish for their business. The fish is shared between all the buyers and due to this everyone has product to sell. The local buyers conserve the fish in big coolers and the product is offered to the costumer in large trays with the fish covered by ice.

Figure 3.2 Local buyer in a small business in Panama Shellfish Market.

The price of the Cojinua fluctuates throughout the year. The price is marked by the availability of the fish in the Panama Shellfish Market. This availability depends mainly on the moon cycle. During the full moon the fish tends to be far from the coast due to the increase of light and the shallow waters are not a safe place for them. During these days some fishermen make a break for some days and the availability of the Cojinua decreases and the price increases. The highest price is 1Dollar/Lb and it is reached during the full moon. The normal price for the Cojinua in Panama Shellfish Market oscillates between 50cent/Lb and 70cent/Lb.

Local buyers usually sell an amount of Cojinua of 300-500Lb per day.

3.1.3 Landings of Las Perlas Cojinua Fishery in Panama Shellfish Market

The data of Landigs has been collected after several weeks waiting. Hector Guzman was dealing with the "*Autoridad Maritima de Panama"* to get the data of the landings of all the boats wich have been fishing in Las Perlas and landing in the Shellfish Market of Panama during 2005 and also 2006. The original data submitted by the "*Autoridad de Panama*" is shown in the Appendix.

The analysis of the data could have been more accurate as a Catch Per Unit Effort (CPUE) but the data available is not enough for this analysis. However, the data has been interpreted as 3 different tables:

Table of the Landings for each type of fishing boats and the percentage of the total weight

	No BOATS SEMI INDUSTRIAL	No BOATS ARTESANAL	TOTAL TRIPS	TOTAL WEIGHT (Lb)	% TOTAL WEIGHT (Lb) SEMI INDUSTRIAL	%TOTAL WEIGHT (Lb) ARTESANAL
Jun-05	2	6	8	10,850	57.1	42.85
Jul-05	2	1	3	2,930	92.15	7.85
Aug-05	0	2	2	480	0	100
Sep-05	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Oct-05	0	2	2	400	0	100
Nov-05	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Dec-05	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Jan-06	1	7	9	6,760	74	26
Feb-06	0	19	20	7,652	0	100
Mar-06	2	10	26	13,815	43.1	56.9
Apr-06	0	9	9	5,155	0	100
May-06	2	1	3	4,760	96.6	3.4
Jun-06	2	1	3	11,040	95.1	4.9

Table 3.1 Table showing number of boats for the two different types of fishing developed in Las Perlas Fishery and the percentage of each type of the total weight.

The table shown above (Table 3.1) is the result of the analysis of the data of the landings in Panama Shellfish Market for the sampled year. The data has been agouped into two classes, artesanal and semi industrial, the only two fishing activities related to the cojinua, being carried out in Las Perlas Fishery. The percentage of the total weight for each activity shows that both activities contribute the same to the total weight.

Other analysis has been carried out in the table shown below. The 8 known boats wich have the licence for fishing Cojinua have been represented in relation to the fishing trips that they have done for each month.

Table of the fishing trips made by the boats with permits for fishing Cojinua in Las Perlas Fishery

	No FISHING TRIPS							
	LINA CRISTINA	PEREGRINA	JOSEFA	FRANCISCO M	EL NAVEGANTE	DON JOSE	EL VICTORIOSO	DONA GERTRUDIS
Jun-05	0	0	0	0	0	1	0	0
Jul-05	1	0	0	1	0	0	0	0
Aug-05	0	0	0	0	0	0	0	0
Sep-05	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Oct-05	0	0	0	0	0	0	0	0
Nov-05	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Dec-05	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA
Jan-06	0	0	0	0	0	1	0	0
Feb-06	0	0	0	0	0	0	0	0
Mar-06	0	0	0	0	2	0	0	0
Apr-06	0	0	0	0	0	0	0	0
May-06	1	0	0	0	0	0	0	1
Jun-06	1	0	0	0	0	0	0	1

Table 3.2 Table of the 8 known boats with permits for fishing Cojinua in Las Perlas showing the number of fishing trips for each month.

The Table 3.2 shows that all the boats with permit are not working each month, only some of them have been registered fishing in Las Perlas Fishery for the period of time of the study.

The last analysis of the data has been developed grouping the boats in relation to the type of the activity carried out (Semi Industrial or "*Artesanal"*)as well as in relation to the weight of their landings (>1000Lb or <1000

Table of the number of Semi Industrial or "*Artesanal*" boats in relation to the weight of their landings for each month.

	No BOATS			
	SEMI INDUSTRIAL >1000Lb	ARTESANAL >1000Lb	SEMI INDUSTRIAL <1000Lb	ARTESANAL <1000
Jun-05	2	3	0	3
Jul-05	2	0	0	1
Aug-05	0	0	0	2
Sep-05	NO DATA	NO DATA	NO DATA	NO DATA
Oct-05	0	0	0	2
Nov-05	NO DATA	NO DATA	NO DATA	NO DATA
Dec-05	NO DATA	NO DATA	NO DATA	NO DATA
Jan-06	1	0	0	7
Feb-06	0	0	0	19
Mar-06	1	0	1	19
Apr-06	0	2	0	7
May-06	2	0	0	1
Jun-06	2	0	0	1

Table 3.3 Table of the number of the two different types of boats in relation to the weight of their landings

The Table 3.3 shows a trend of the size of the Landings for each type of the fishing activities carried out in Las Perlas Fisheries. The Semi-Industrial boats are normally more than 1000Lb and the *"Artesanal"* boats are normally less than 1000Lb.

3.2 QUANTITIVE RESULTS

3.2.1 Biometric Data

The biometric section of the results examines the biometric data collected from the local buyers of the Panama Shellfish Market. The fish that were analysed came from the Las Perlas Fishery between June 2005 and June 2006 except for November when there no data were available. The data collected was: total length, standard length, total weight, gonad maturation stage, sex and gonad weight.

The quantity of data available for *C. caballus* is 4976 records. The sample is sufficient for any sex, length or weight analysis to be performed with a high degree of confidence. The first analysis will be to examine the length-weight relationships of the cojinua (*C. caballus*) each month separately as well as for the whole year and for the whole year for each sex (females and males).

3.2.2 Length Weight Relationships

The weight of the fish increases in relation to the increase in volume. The relationship between length (L) and weight (W) can be described using a power function of the form:

$$W = aL^n \qquad (1)$$

The analysis used to find the relationships between Length (L) and Weight(W) has been a linear regression. Since the growth curve of a fish does not fit in a straight line, the data have been transformed to Ln. With this transformation the data can be adjusted to fit along the straight line of the linear regression.

If length and weight are transformed to Ln, the relationship between Length and Weight becomes:

$$\text{Ln } W = \text{Ln } a + b \text{ Ln } L \qquad (2)$$

The value of *a* and *b* have been calculated from a plot of Ln W (y) against Ln L (x) where Ln *a* is the intercept and *b* is the slope of the fitted linear relationship (Jennings *et al.,*2001).

3.2.2.1 *Logged Length-Weight Analysis for C. Caballus.*

The analysis has been performed for each month as well as for the whole year. The linear regressions for the relationship between Weight and Length for *C. caballus* are shown below in 12 graphics where the y axis is the Ln of Weight and the x axis is the Ln of Length:

Linear Regression Analysis for Length-Weight of Cojinua June 2005

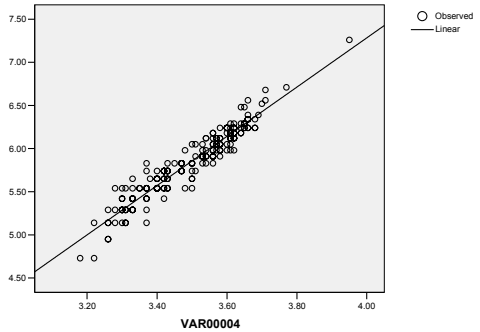


Fig 3.1 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.3211x + 1.6191, R^2= 0.911, p=<0.001, n=200).

Linear Regression Analysis for Length-Weight of Cojinua July 2005

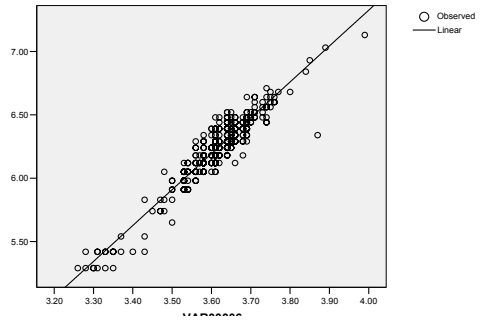


Fig 3.2 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.3161x + 1.6436, R^2= 0.891, p=<0.001, n=399).

Linear Regression Analysis for Length-Weight of Cojinua August 2005

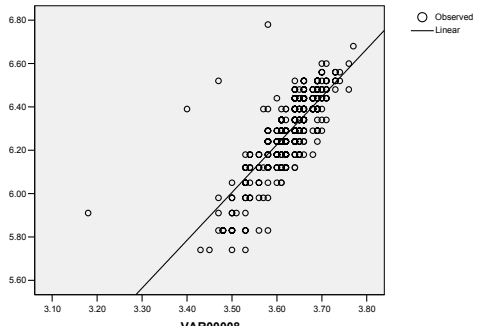


Fig 3.3 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.2688x + 1.937, R^2= 0.589, p=<0.001, n=400).

Linear Regression Analysis for Length-Weight of Cojinua September 2005

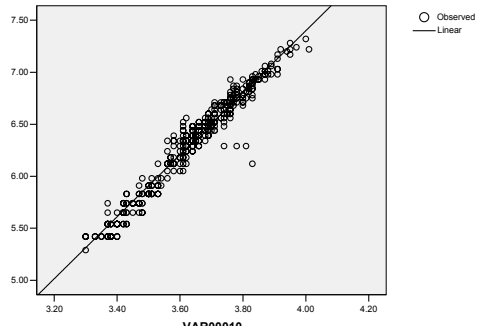


Fig 3.4 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.3183x + 1.6264, R^2= 0.976, p=<0.001, n=397).

Linear Regression Analysis for Length-Weight of Cojinua October 2005

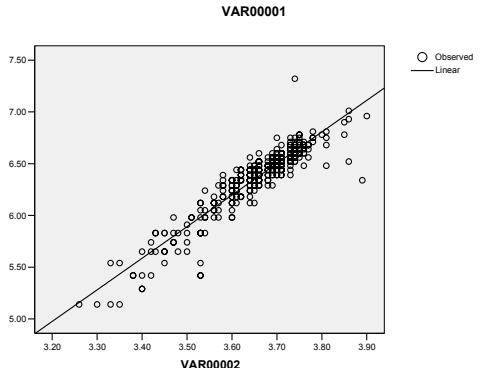


Fig 3.5 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.2824x + 1.8575, R^2= 0.860, p=<0.001, n=399).

Linear Regression Analysis for Length-Weight of Cojinua Decembre 2005

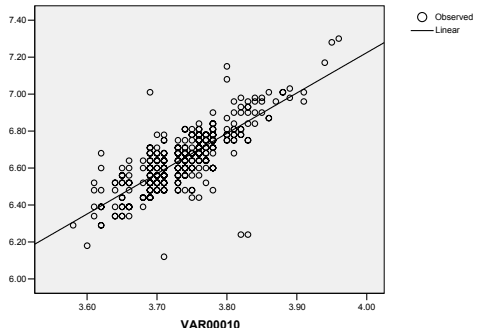


Fig 3.6 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.2837x + 1.8499, R^2= 0.620, p=<0.001, n=397).

Linear Regression Analysis for Length-Weight of Cojinua January 2006

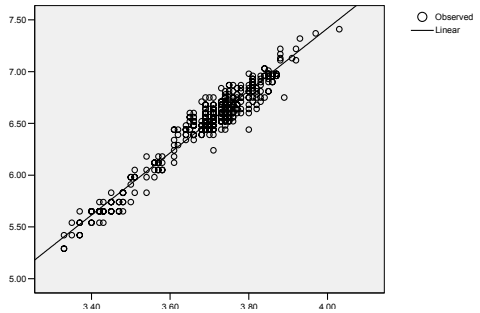


Fig 3.7 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.3119x + 1.6663, R^2= 0.938, p=<0.001, n=399).

Linear Regression Analysis for Length-Weight of Cojinua February 2006

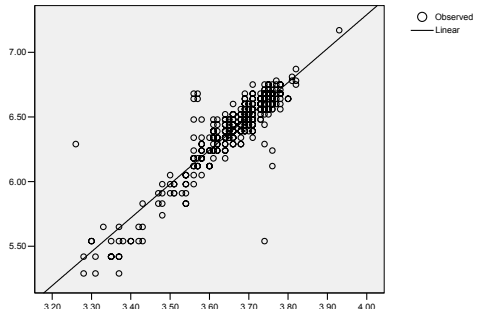


Fig 3.8 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.3134x + 1.6536, R^2= 0.818, p=<0.001, n=400).

Linear Regression Analysis for Length-Weight of Cojinua March 2006

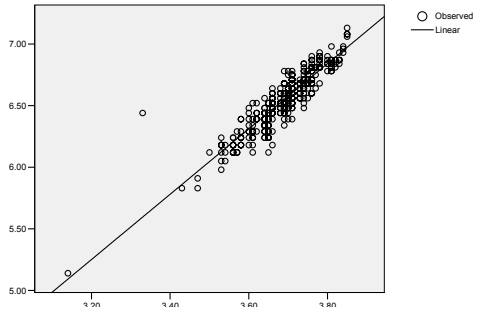


Fig 3.9 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.314x + 1.6339, R^2= 0.828, p=<0.001, n=399).

Linear Regression Analysis for Length-Weight of Cojinua April 2006

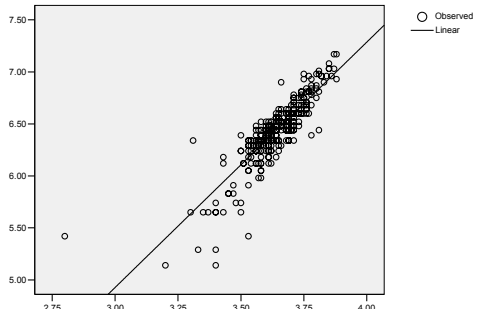


Fig 3.10 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.3126x + 1.6267, R^2= 0.738, p=<0.001, n=399).

Linear Regression Analysis for Length-Weight of Cojinua May 2006

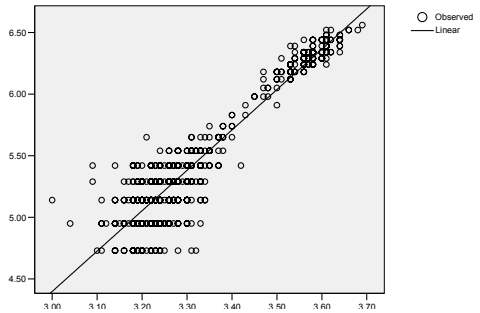


Fig 3.11 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.2738x + 1.8281, R^2= 0.894, p=<0.001, n=788).

Linear Regression Analysis for Length-Weight of Cojinua June 2006

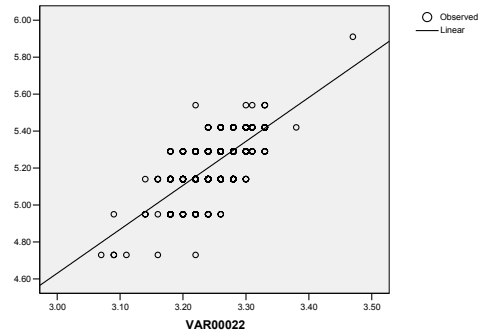


Fig 3.12 Linear regression analysis of logged length-weight relationship for C. caballus (y = 0.2154x + 2.1207, R^2= 0.513, p=<0.001, n=399).

In the graphics of the previous page (from Figure 3.1 to Figure 3.12) both sex of *C. caballus* have been included within the statistical analysis. With the standard linear equation being y = *b*x + *a* and using the formula above it is possible to quantify both a and b length-weight parameters. The table shown below shows the parameters *a* an *b* length-weight parameters for each month:

	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06
a	1.6191	1.6436	1.937	1.6264	1.8575	NO DATA	1.8499	1.6663	1.6536	1.6339	1.6267	1.8281	2.1207
b	0.3211	0.3161	0.2688	0.3183	0.2824	NO DATA	0.2837	0.3119	0.3134	0.314	0.3126	0.2738	0.2154

Table 3.4 Table of the *a* and *b* length-weight parameters for each month.

Another analysis has been performed for the data of the whole year including both sexes and also for the females and males separately. The graphics are shown below:

Linear Regression Analysis for Length Weight Relationship of both sexes of Cojinua for the whole year

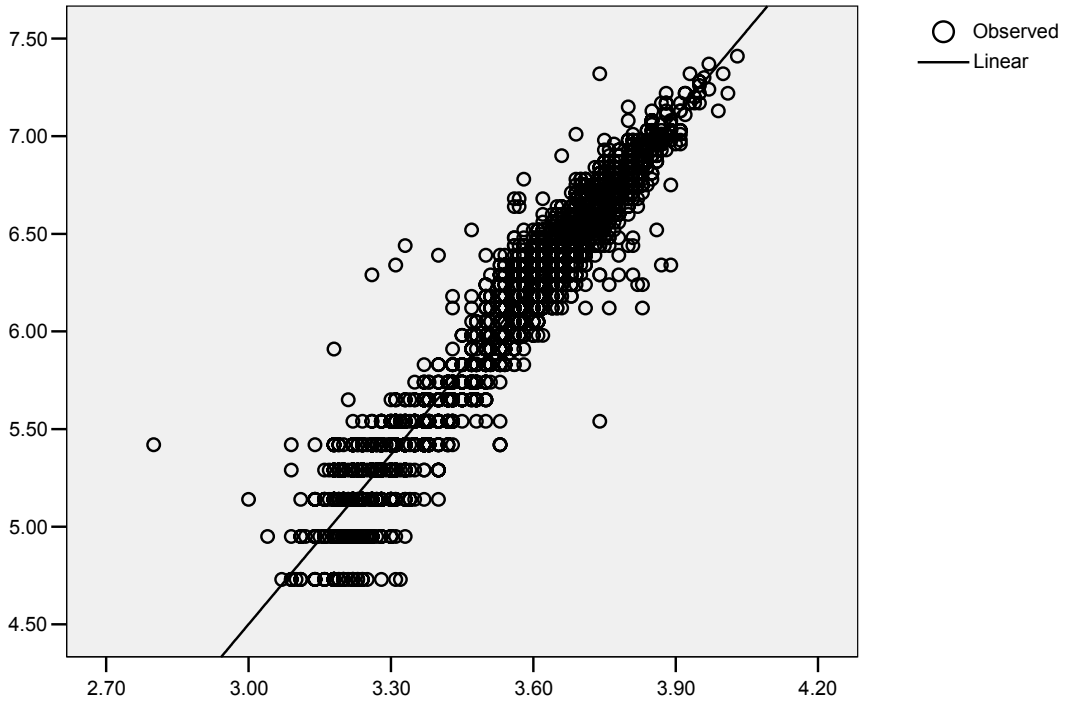


Fig 3.13 Linear regression analysis of logged length-weight relationship for both sexes of *C. caballus* (y =0.3275x + 1.5553, R^2 =0.945, n = 4976).

It is also possible to quantify *a* and *b* length-weight parameters from the graphic above, using the standard linear equation and the formula (2). These parameters are:

a = 1.5553

b = 0.3275

Linear Regression Analysis for Length Weight Relatioship of Cojinua Females for the whole year

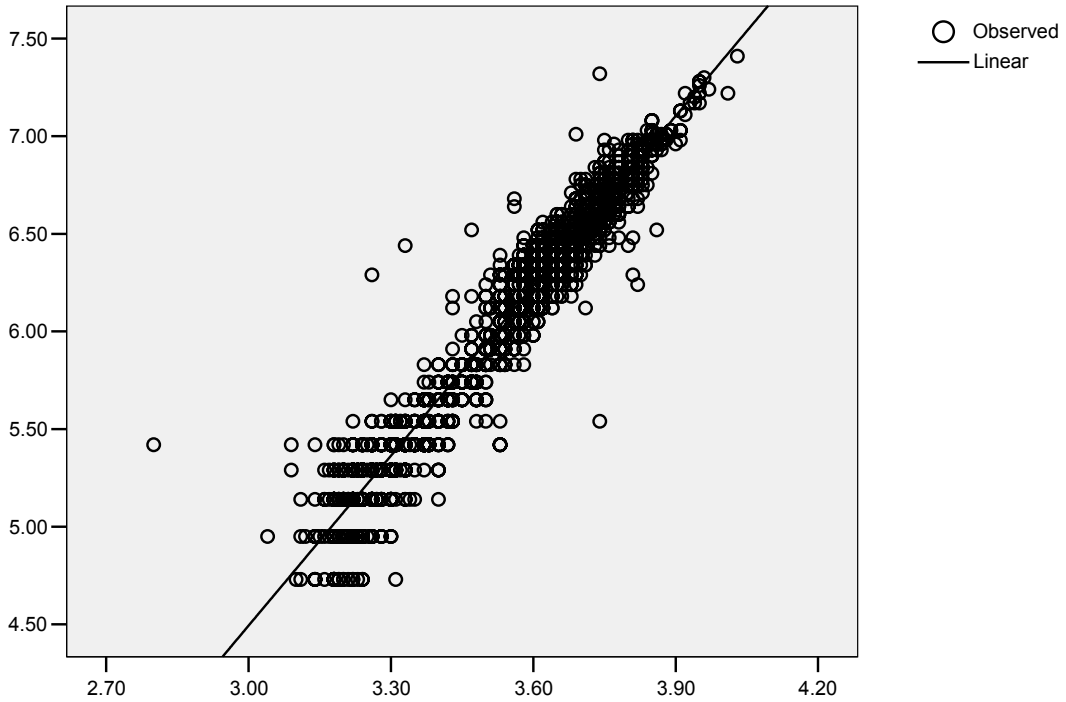


Fig 3.14 Linear regression analysis of logged length-weight relationship of *C. caballus* Females (y =0.3266x + 1.5616, R^2 =0.944, n = 2614).

This graphic shows similar values of R^2 comparing with the graphic wich comprises both sexes. It also has similar values for a and b being these parameters for the females:

a = 1.5616

b = 0.326

Linear Regression Analysis for Length Weight Relatioship of Cojinua Males for the whole year

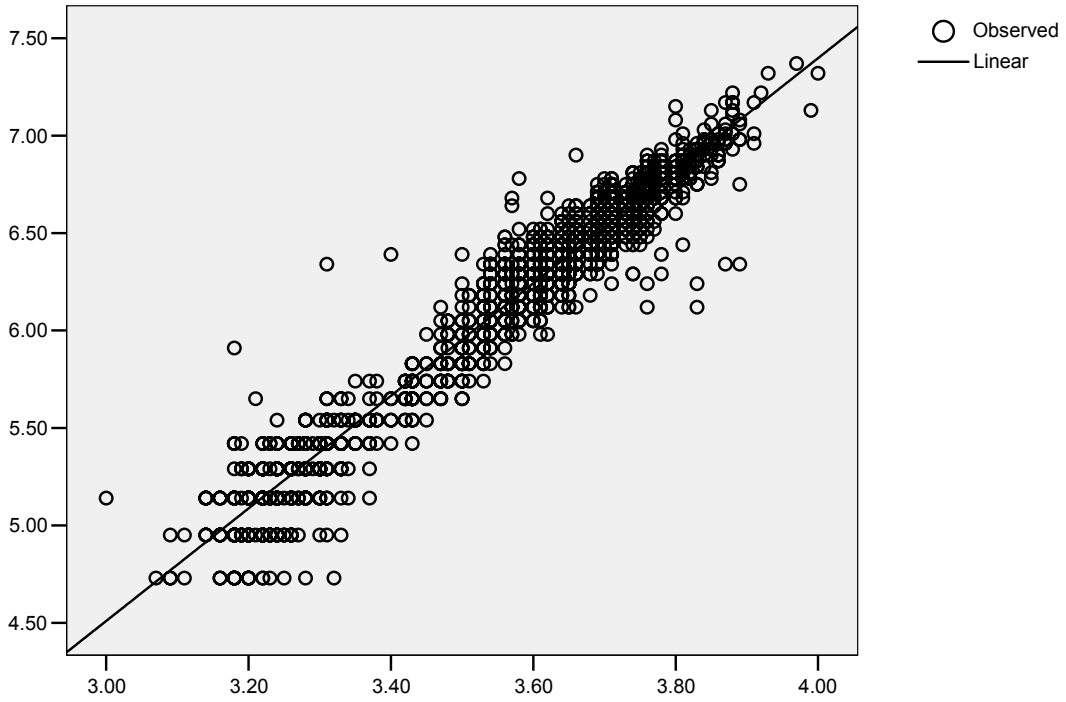


Fig 3.15 Linear regression analysis of logged length-weight relationship of *C. caballus* Males (y =0.3287x + 1.5466, R^2 =0.946, n = 2362).

This graphic also shows similar values of R^2 comparing with the graphic wich comprises both sexes as well as the graphic for the females. It also has similar values for a and b being these parameters for the males:

a = 1.5466

b = 0.3287

3.2.2.2 Statistical Analysis of Length-Weight Relationships for C.caballus

Using the Minitab software the data have been analyzed through an analysis of covariance (ANCOVA). This analysis has been performed to see if the L-W relationship differed significantly in relation to sex for the Cojinua.

Tests of Between-Subjects Effects

```
Analysis of Variance for Ln TW CO, using Adjusted SS for Tests

Source     DF     Seq SS     Adj SS     Adj MS       F      P
SEX (1=F    1      3.575      0.085      0.085    5.17  0.023
Ln TL      82   1530.556   1530.556     18.665 1133.39  0.000
Error    4892     80.564     80.564      0.016
Total    4975   1614.694

Term          Coef   SE Coef        T      P
Constant   6.03433   0.00849   710.37  0.000
SEX (1=F  0.008380  0.003684     2.27  0.023
```

Table 3.5 ANCOVA test using Minitab on Length-Weight relationship for *C. caballus*

Table 3.5 shows the significance of both the slope and the interception to be Not Significant (0.023) while the significance of the relationship between length and weight is highly significant (0.000) as might be expected. Due to the analysis it has been probed that there is no significant difference in Length-Weight relationship between the sexes of *C. caballus*.

3.2.3 Length Frequency Analysis

3.2.3.1 Length Frequency Analysis for C.caballus

In this analysis, the data collected from Las Perlas fishery for the period June 2005 to June 2006 (except for November when there is no data available), have been grouped into 1cm bins from the smallest caught fish to the largest one.

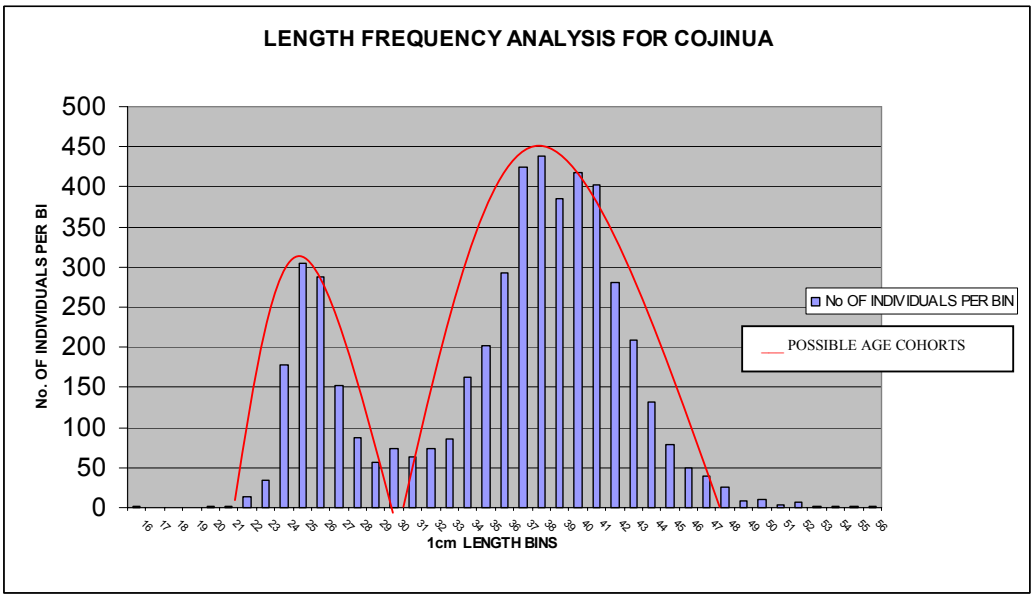


Fig 3.16 Length frequency distribution for *C.caballus* caught in Las Perlas fishery from June 2005 to June 2006 (n = 4976).

Figure 3.16 shows that fish are being removed from the stock at ca.20cm in length up to ca.50cm. The highest number of fish being removed within any one length class around 37-38cm length range. The graphic also shows possible age cohorts. There are two well differentiated cohorts showed by red lines within the graphic. The cohort groups can be further statistically analyzed by a density plot, as seen in Figure 3.17.

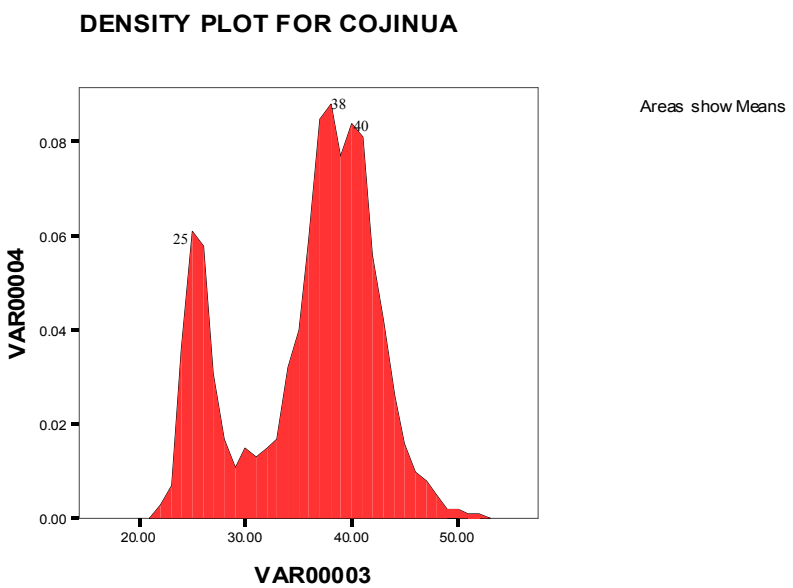


Fig 3.17 Density plot of length frequency data for *C.caballus* caught in Las Perlas fishery from June 2005 to June 2006 (n = 4976).

The density plot of the length frequency data for *C. caballus* shows peaks at 25cm, 38cm and 40cm. The peaks correspond well to the two possible age cohorts proposed on the histogram. This fact means that there can be two age cohorts within the sample. Further modelling as the von Bertalanffy growth curve is necessary to be sure. The data collected could have been more accurate and the density plot could have had more confidence. It is necessary to improve the equipment to enable a greater confidence. The length measurements could be taken to the nearest mm and the weight measurements could be taken to the nearest gram.

3.2.3.2 Length Frequency Analysis for C. caballus month by month

The data has been analyzed month by month in this section. It has been grouped using the same method as the previous analysis. The set of graphics shown below are graphics of the number of fish comprised into 1cm length bins.

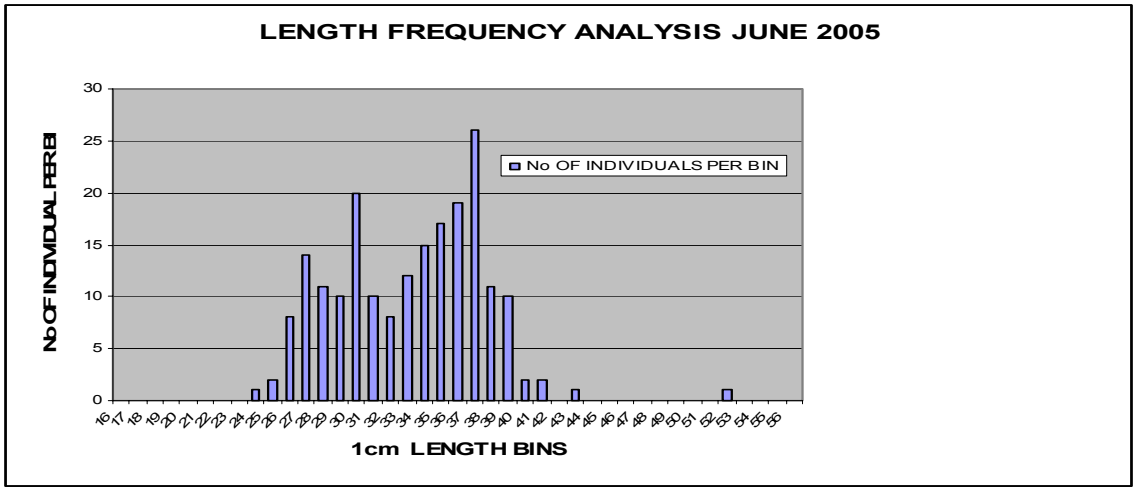


Fig 3.18 Length frequency distribution for *C.caballus* caught in Las Perlas fishery for June 2005 (n = 200).

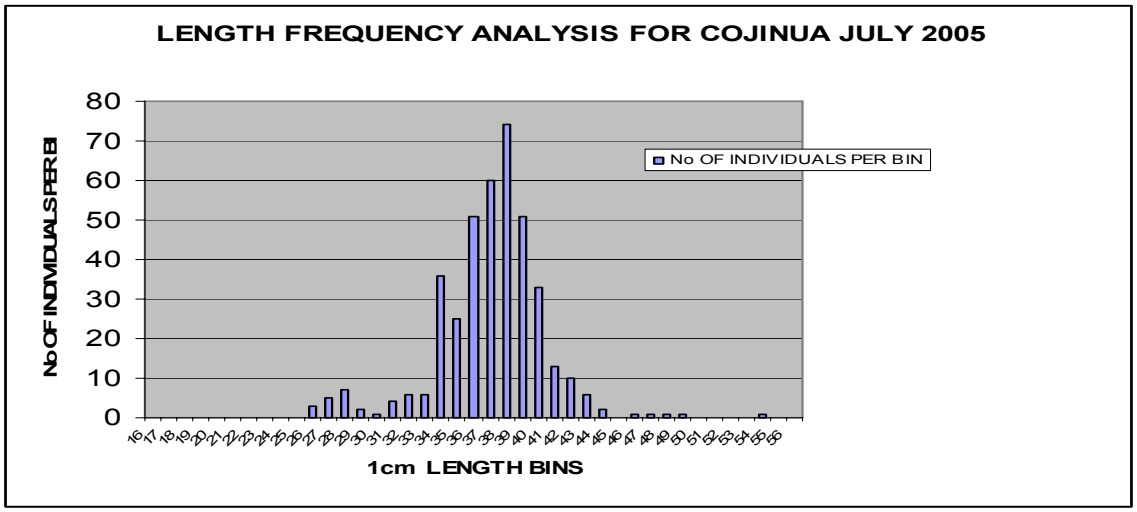


Fig 3.19 Length frequency distribution for *C.caballus* caught in Las Perlas fishery for July 2005 (n = 399).

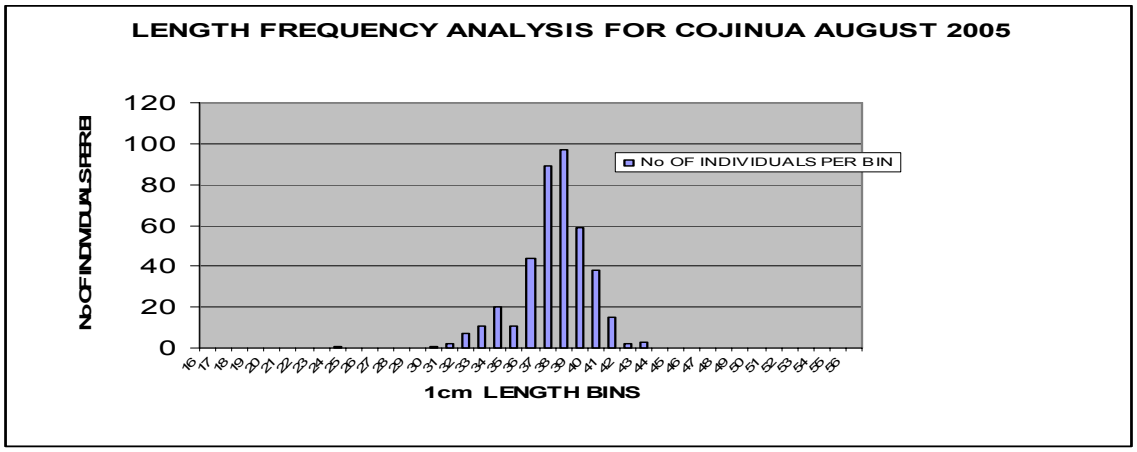


Fig 3.20 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in August 2005 (n = 400).

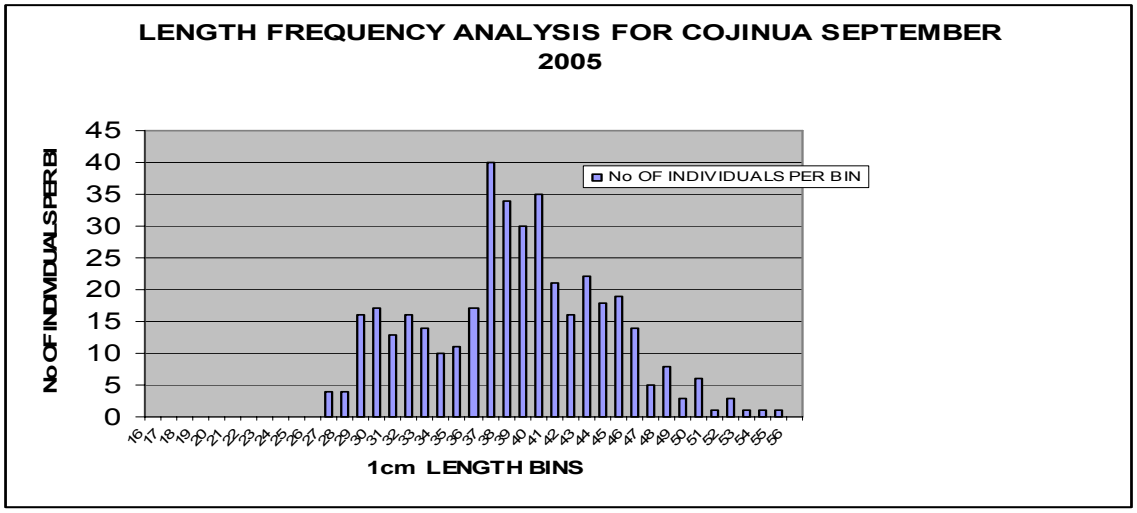


Fig 3.21 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in September 2005 (n = 398).

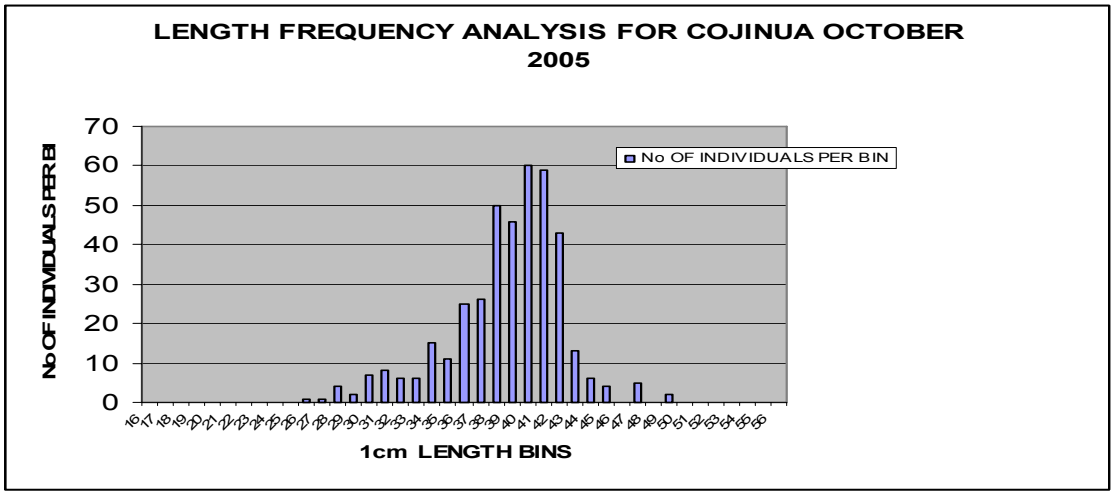


Fig 3.22 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in October 2005 (n = 399).

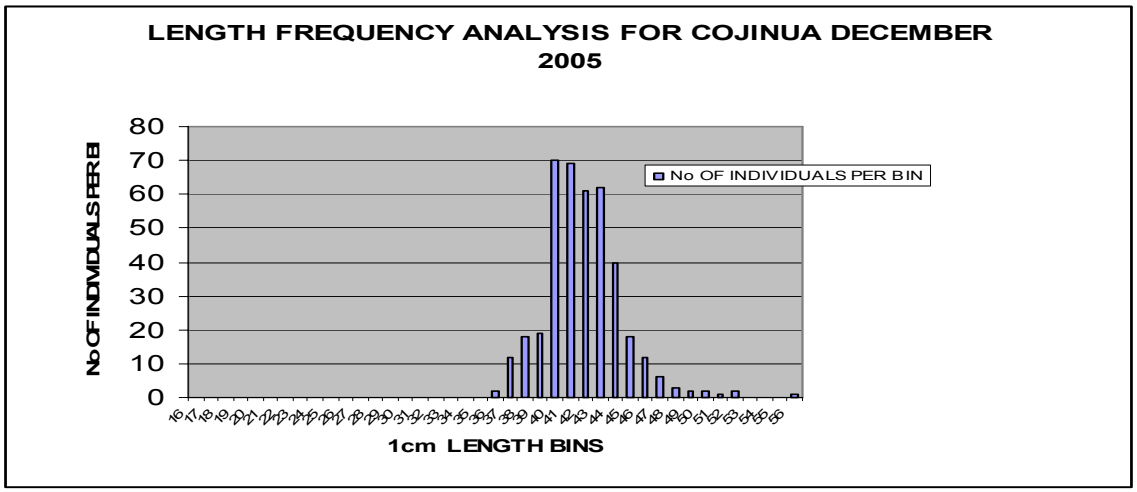


Fig 3.23 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in December 2005 (n = 398).

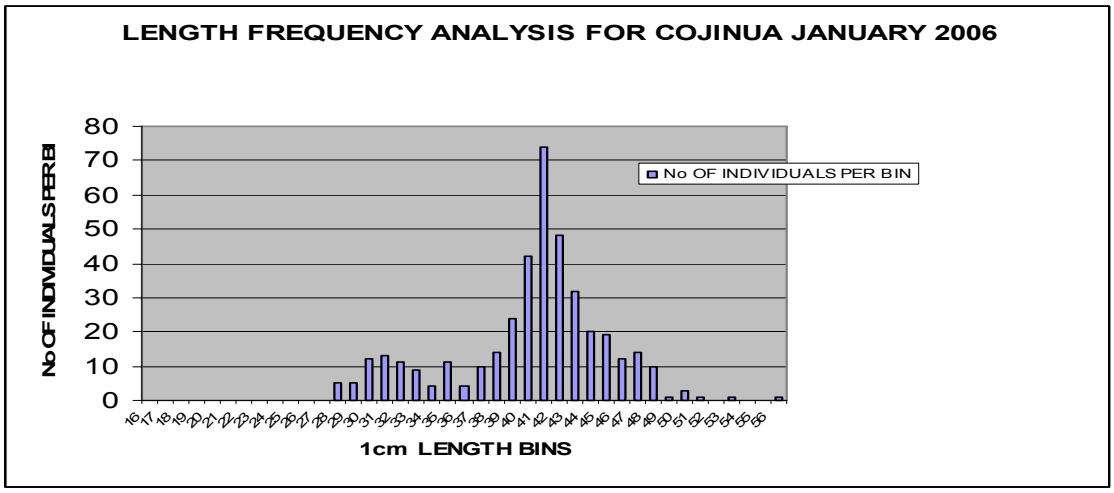


Fig 3.24 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in January 2006 (n = 399).

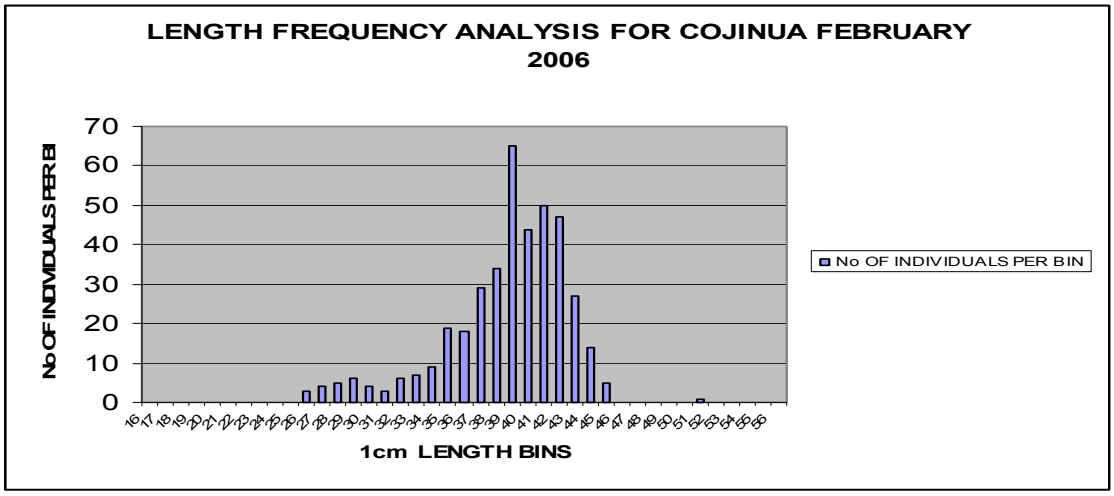


Fig 3.25 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in February 2006 (n = 400).

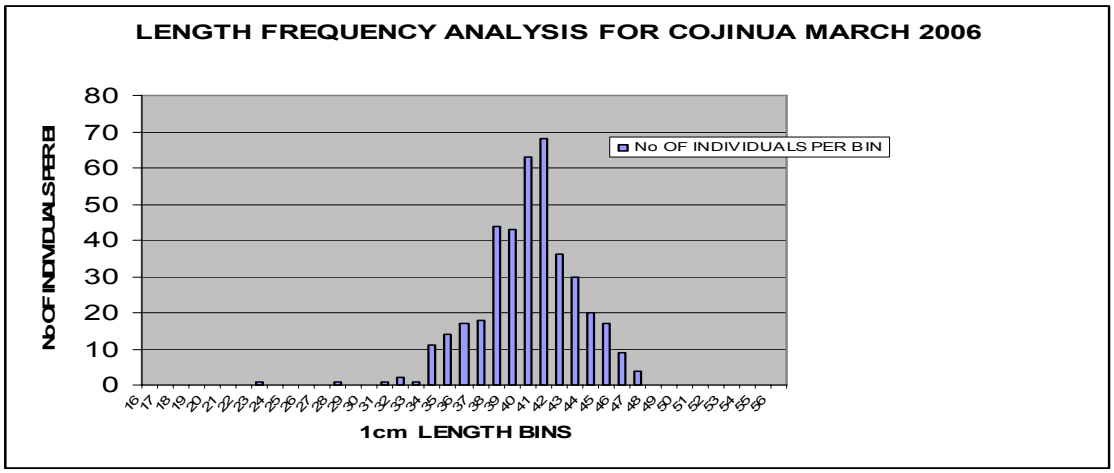


Fig 3.26 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in March 2006 (n = 399).

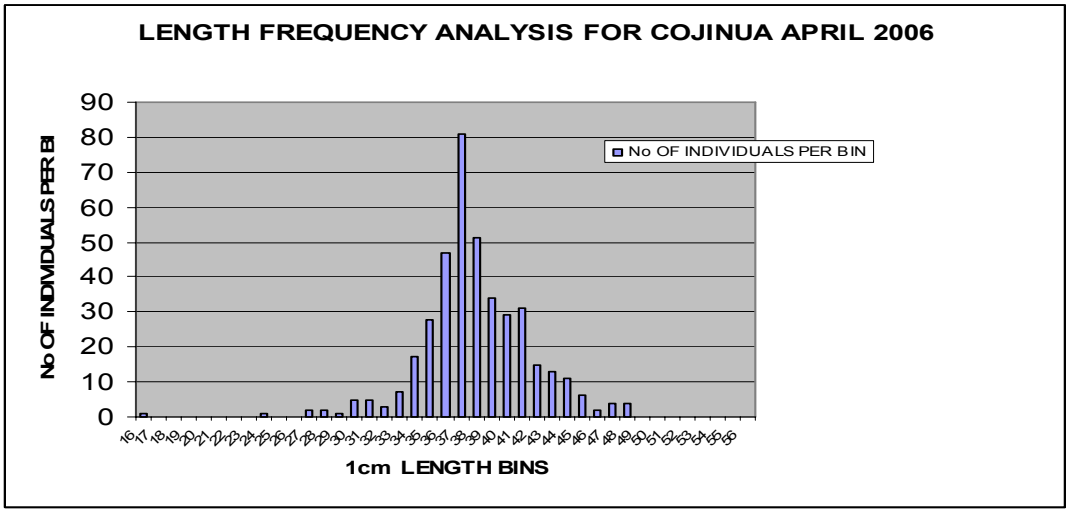


Fig 3.27 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in April 2006 (n = 399).

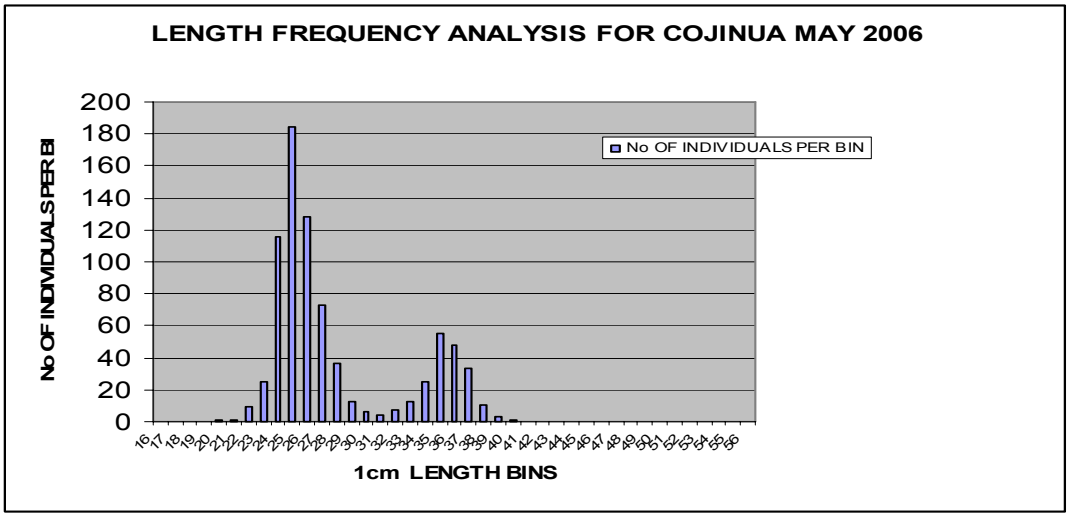


Fig 3.28 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in May 2006 (n = 788).

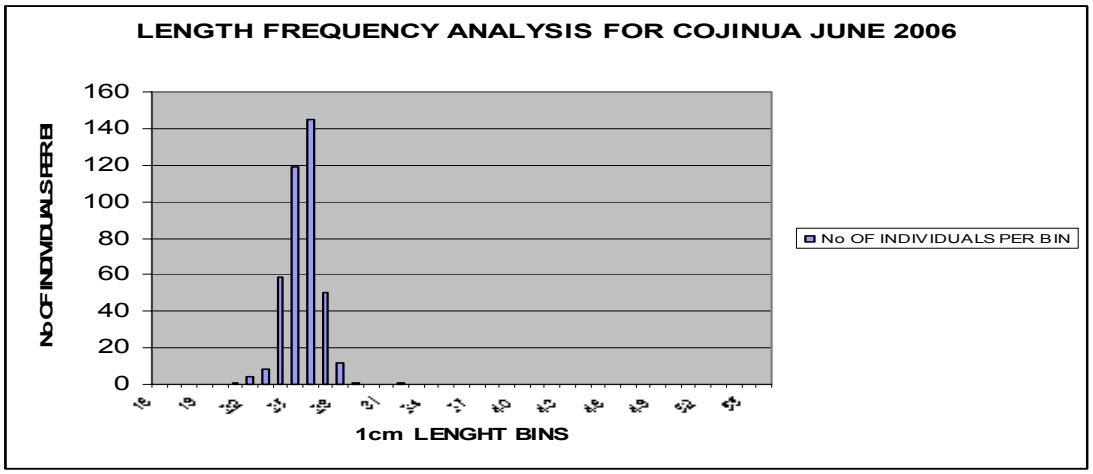


Fig 3.29 Length frequency distribution for *C.caballus* caught in Las Perlas fishery in June 2006 (n = 399).

The figures above show peaks at 38cm, 39cm, 41cm and 42cm from June 2005 to April 2006. May 2006 and June 2006 show differences and the peaks are at 26cm and 27cm, in June 2005 there is a peak at 31cm as well. During May and June the graphic shows that the fish caught are significantly smaller than the rest of the year and these months build the peak at 25cm seen in the density plot in the Figure 3.17. The other peak in the same figure is made by the rest of the months (from July to May). This analysis month by month shows a marked difference on size during May and June that could be due to the majority of the fish in the stock of the fishery is clearly not matured. An analysis of the maturity of the fish should be developed to ensure that during these months the fish is not matured.

The possible age cohorts proposed for the Figure 3.16 have been further analyzed throughout the figures of the Length Frequency Analysis developed for each month and showed above (from Fig. 3.18 to Fig 3.29). The possible cohorts can be seen in these graphics as different peaks. The table drawn below (Table 3.6) gives information of the percentage of the mature and immature individuals for each peak. This data amplifies the study due to knowing the gonad maturity phase for each possible cohort compared with the length, it is easier to distinguish the possible age of the cohort. The data of the year 2006 is more clear than the data for 2005 and shows a clear cohort of the same age of 41cm length. This cohort is also seen during the months of September, October and December of 2005.

Table of the percentage of matured and inmatured for each peak of the Length Frequency Analysis

	PEAKS OF LENGTH	%IMMATURED	%MATURED
Jun-05	27	21.42	78.58
	30	15	85
	37	7.76	92.24
Jul-05	28	0	100
	34	0	100
	38	0	100
Aug-05	34	0	100
	38	0	100
Sep-05	32	0	100
	37	0	100
	40	0	100
Oct-05	40	13.3	86.7
	41	5.1	94.9
Nov-05	NO DATA	NO DATA	NO DATA
Dec-05	40	0	100
	41	1.5	98.5
Jan-06	31	23.1	76.9
	41	0	100
Feb-06	39	0	100
	41	4	96
Mar-06	38	2.3	97.7
	41	3	97
Apr-06	37	7.4	92.6
May-06	25	96.2	3.8
	35	14.5	85.5

Jun-06	26	100	0

Table 3.6 Percentage of immature and matured individuals for each peak of the Length Frequency Analysis showed from the Figure 3.18 to 3.29.

3.2.4 Sexual Maturity in relation to Sex

3.2.4.1 Annual gonad Maturity Phase Analysis for C. caballus

The data of this section have been collected for a period of one year from June 2005 to June 2006, although there is no data available for November 2005. The data of sex and gonad maturity phase have been taken by visual analysis. It has been analyzed calculating the percentage of each maturity phase removed from the stock of the fishery Las Perlas, for each month. Graphics of the different gonad phases of the cojinua along the sampled year for both sex of the fish and also only for female individuals. Graphics for each gonad phase for the whole year have been drawn as well. The data haves been analyzed graphically for the different gonad maturity phase monthly. All the available graphics are shown below.

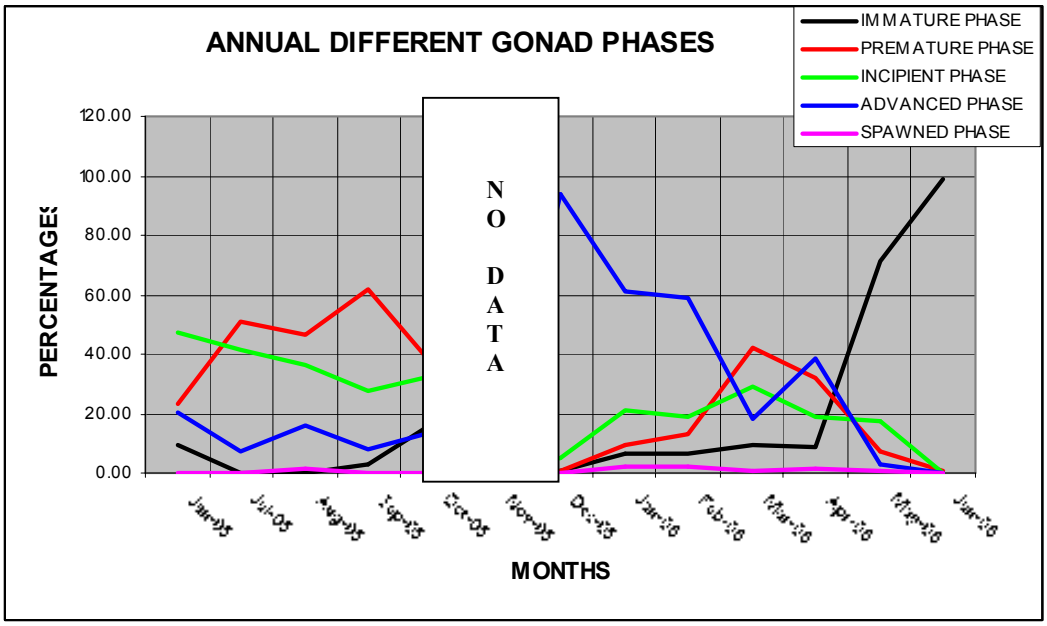


Fig 3.30 Graphic of the percentage of the different gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year for both sexes.

In the above graph there are different percentages of the different stages of gonad maturity along the year. There can be a cycle of the maturity of the fish. It is clearly visible that there is a peak of the Advanced maturity phase in December following by a peak of the Immature phase during May The graphic shows a peak for the Immature stage in September following for a peak of Incipient in October. There is another peak for Premature individuals (lower than the peak in September) in July and the period of time from the peak of June showing a majority of Immature fish and this peak in July, could be the needed time for the fish to reach the sexual maturity.

The data have also been analyzed only for the females of cojinua to see if there is differences between both sexes of the fish. The graphic is shown below.

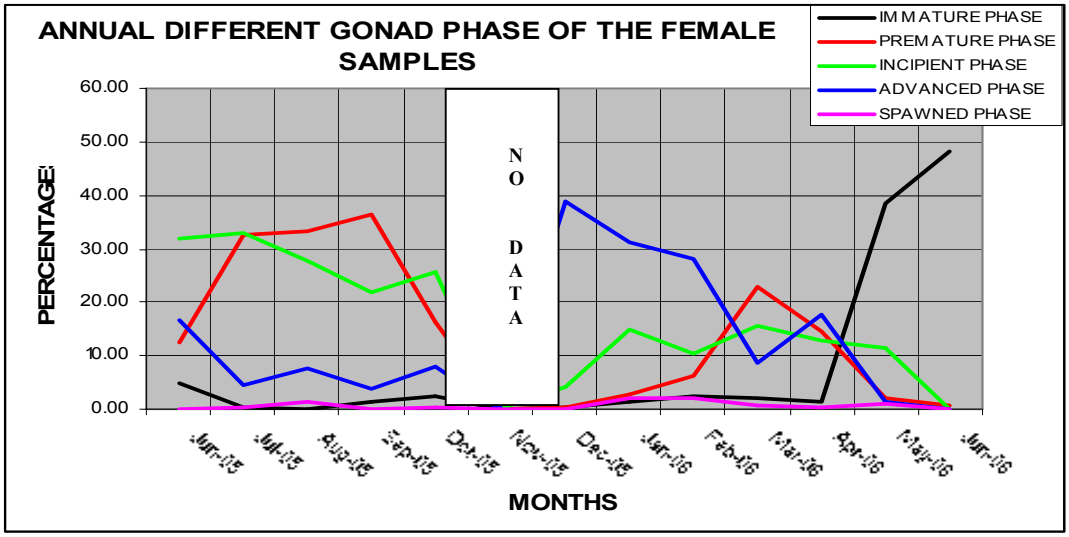


Fig 3.31 Graphic of the percentage of the different gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year, only for the females.

The graphic shown in the Figure 3.31 is very similar to the graphic showing both sexes. In this graphic the two peaks for the Premature phase are almost the same drawing a slightly difference between the percentage of the both peaks

The data has been analyzed as well separately for each gonad phase throughout the year. The graphics are shown below.

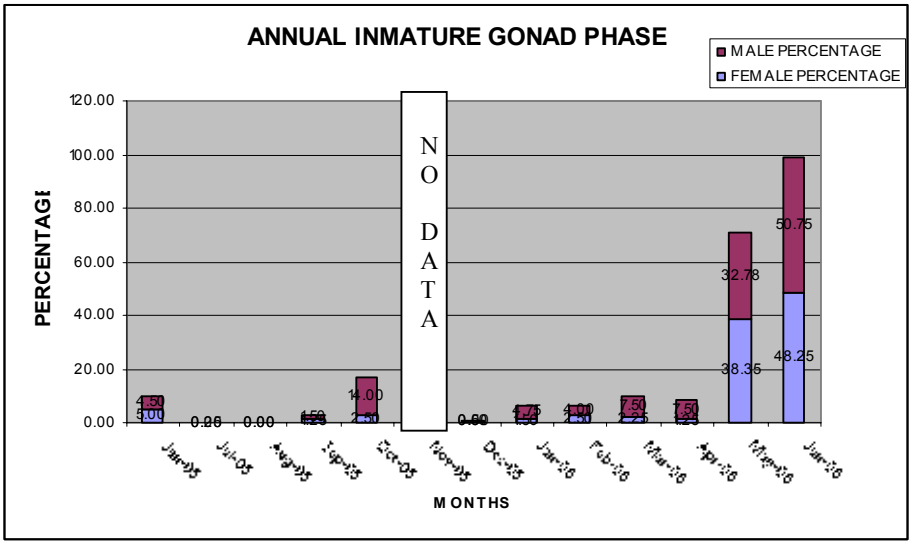


Fig 3.32 Graphic of the percentage of the Immature gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year, for both sexes.

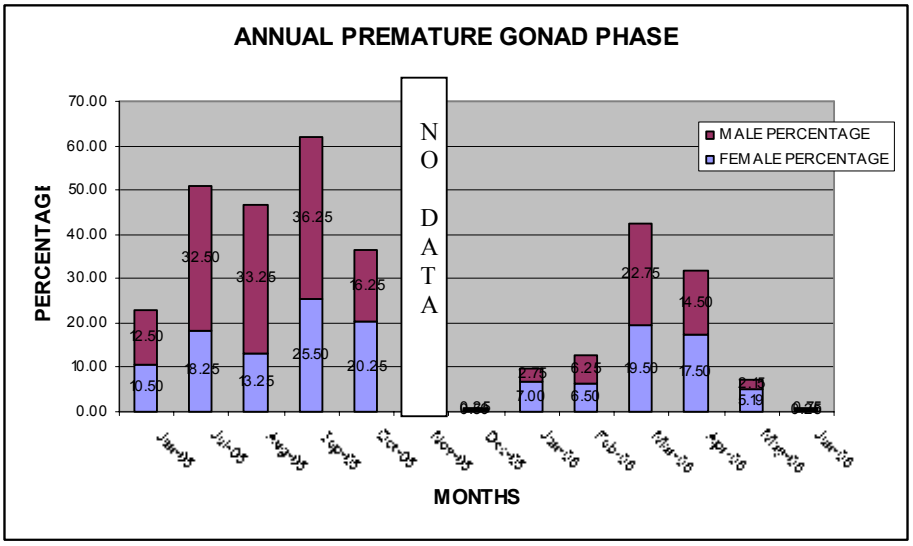


Fig 3.33 Graphic of the percentage of the Premature gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year, for both sexes.

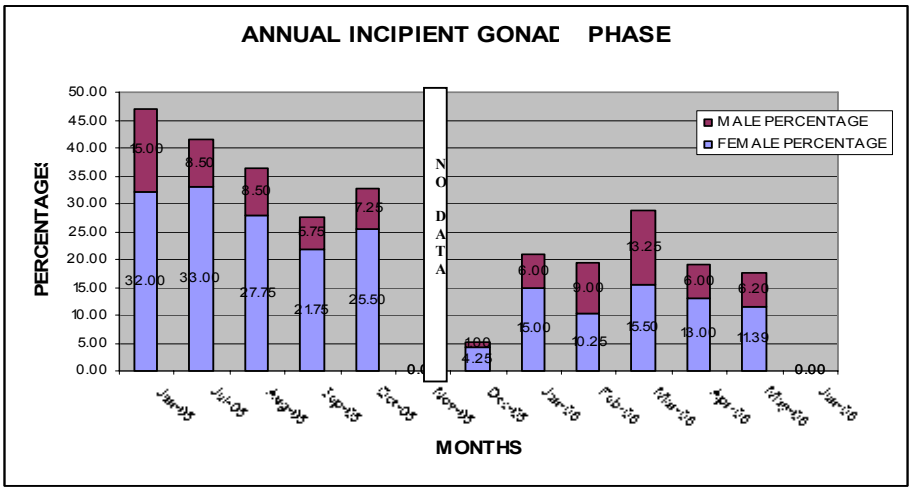


Fig 3.34 Graphic of the percentage of the Incipient gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year, for both sexes.

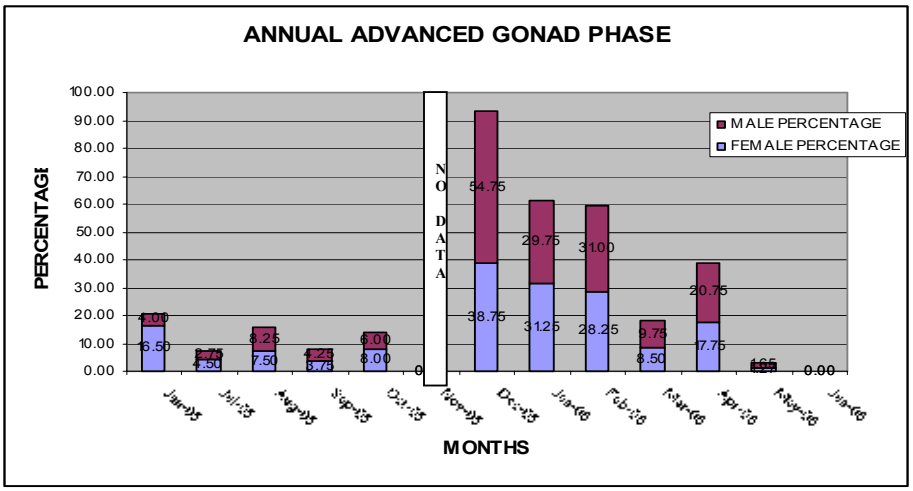


Fig 3.35 Graphic of the percentage of the Advanced gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year, for both sexes.

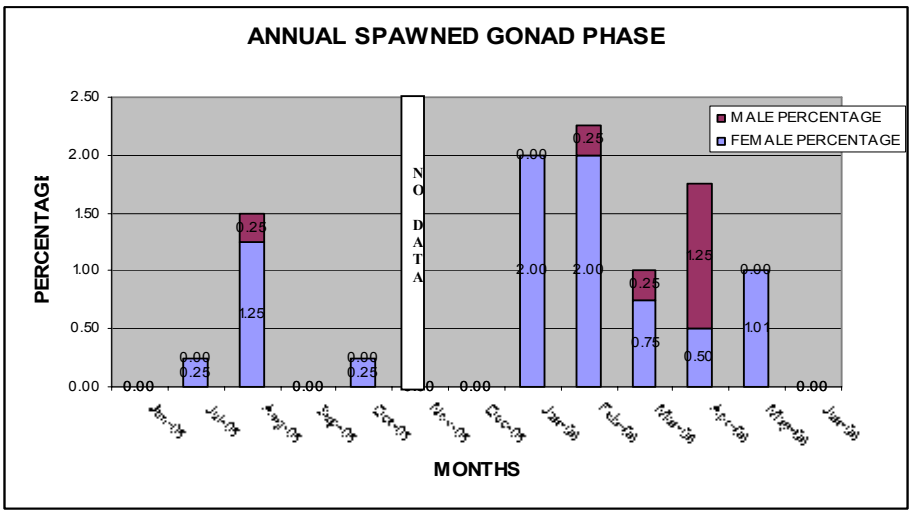


Fig 3.36 Graphic of the percentage of the Spawned gonad maturity phase of the caught fish within Las Perlas fishery, Panama, for the whole year, for both sexes.

The graphics for each gonad maturity phase confirm what is shown in the figures 3.30 and 3.31. The Immature phase has peaks in May and June, the Advanced phase in December and the Spawned phase in February. The Premature phase shows a peak in September with a high rate during July, Augut and September. The highest rates for the Advanced phase are in June, July and August with similar percentage and a peak in September.

3.2.4.2 Gonad Maturity Phase Analysis for C. caballus month by month

Other analysis of the data has been performed comparing all the gonad maturity phases for each month. The graphics are shown below.

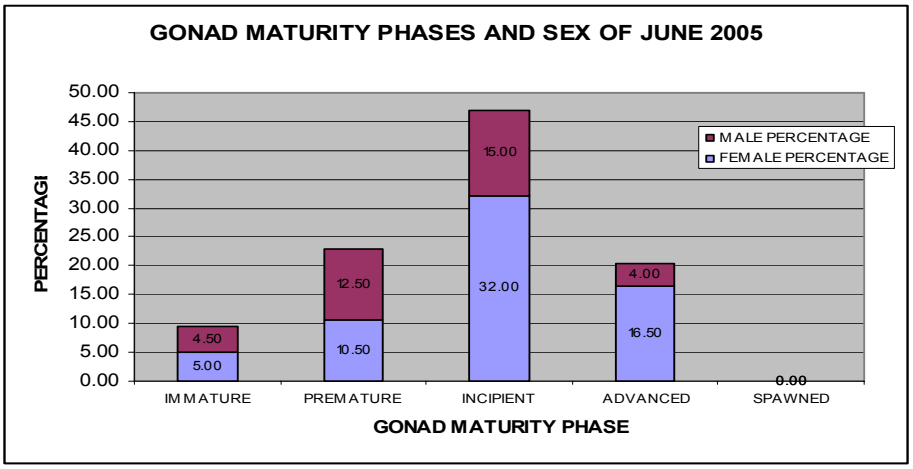
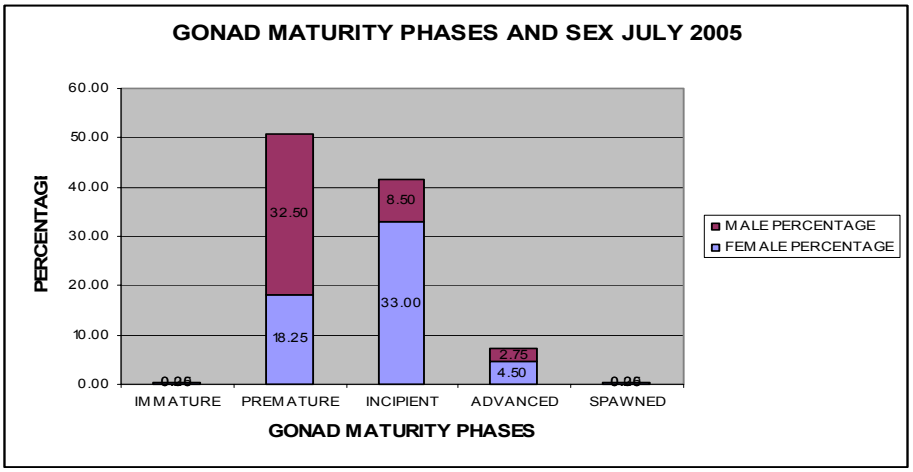
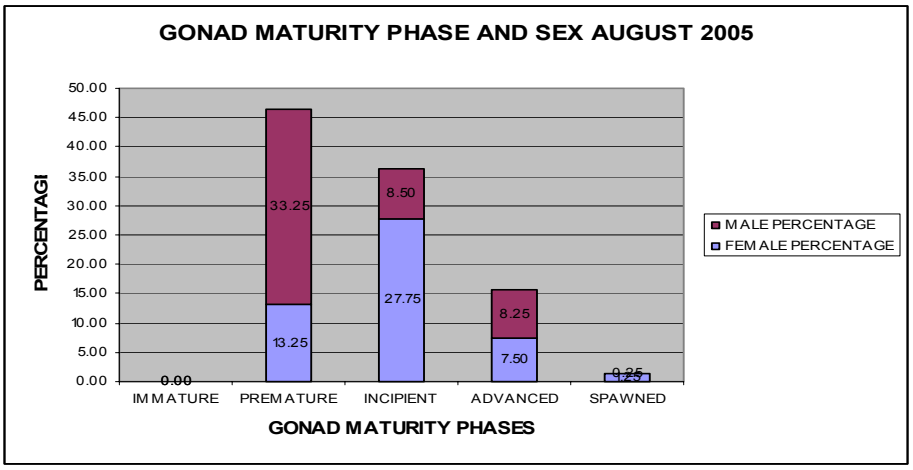


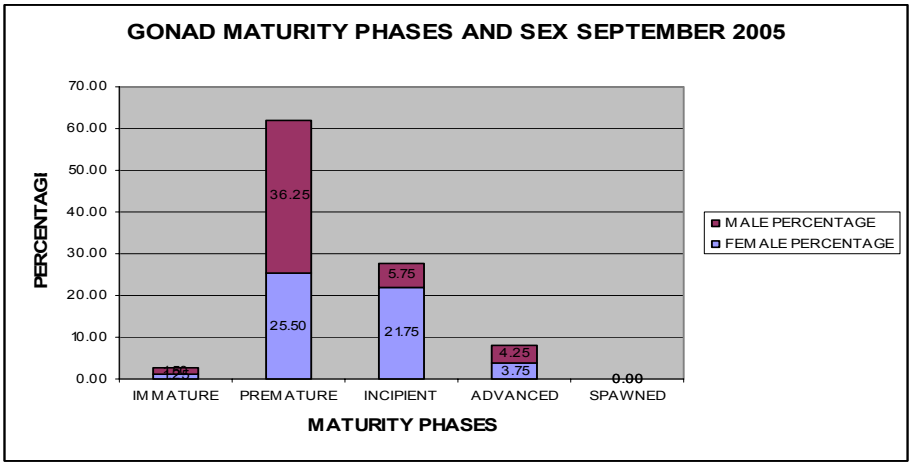
Fig 3.37 Graphic of the percentage of the gonad maturity phases during June 2005.



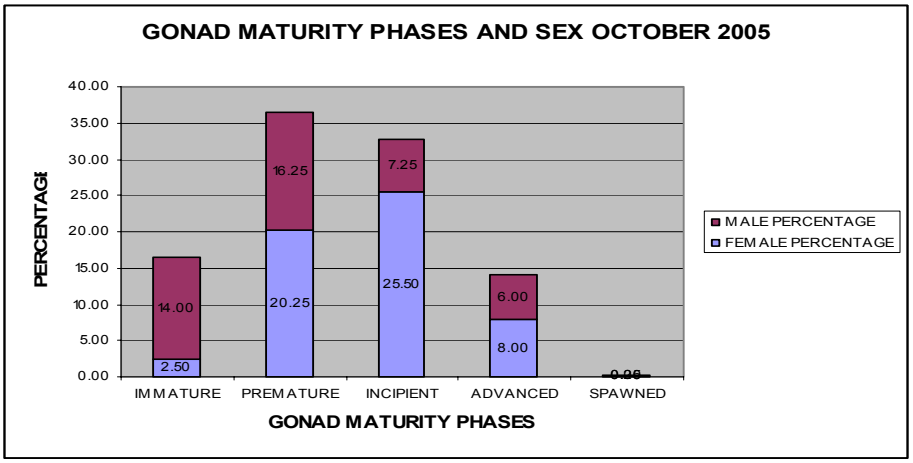
3.38 Graphic of the percentage of the gonad maturity phases during July 2005.



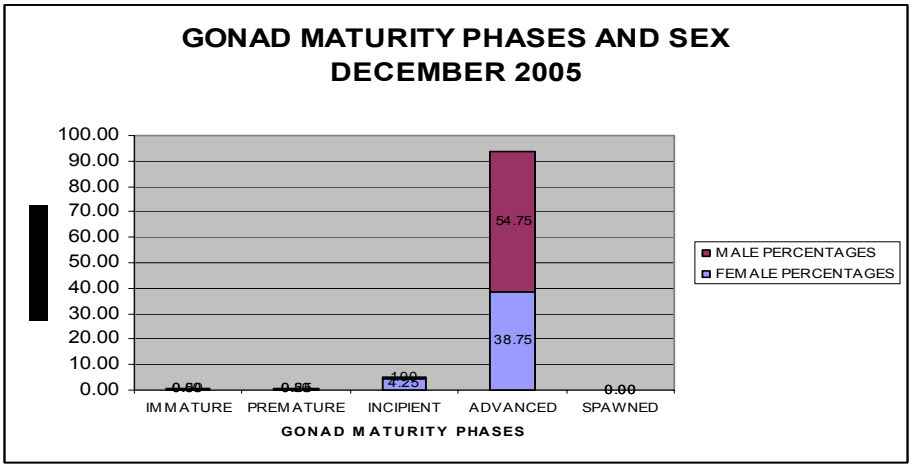
3.39 Graphic of the percentage of the gonad maturity phases during August 2005.



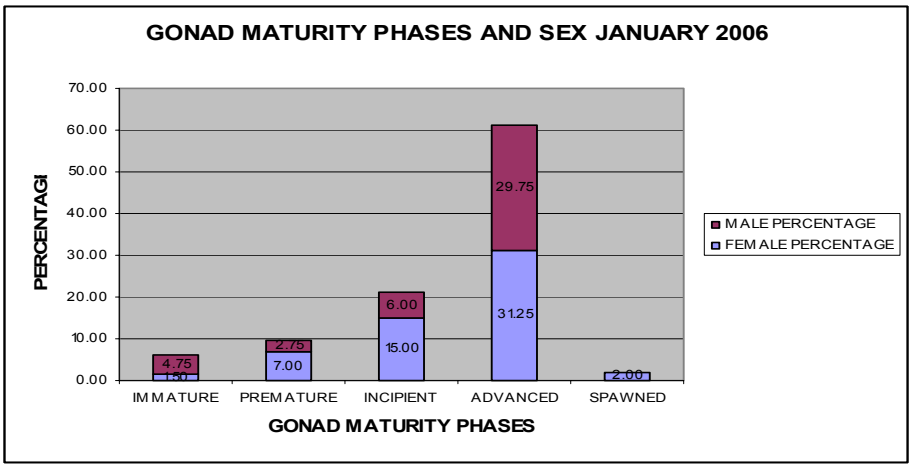
3.40 Graphic of the percentage of the gonad maturity phases during September 2005.



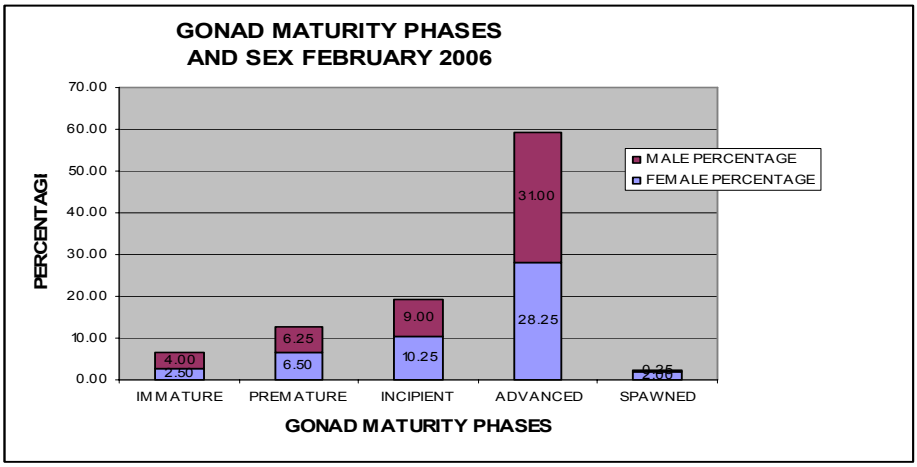
3.41 Graphic of the percentage of the gonad maturity phases during October 2005.



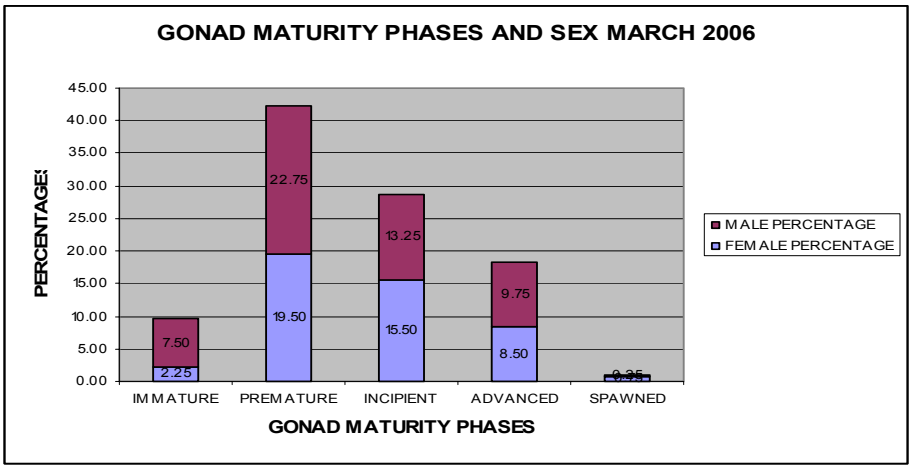
3.42 Graphic of the percentage of the gonad maturity phases during December 2005.



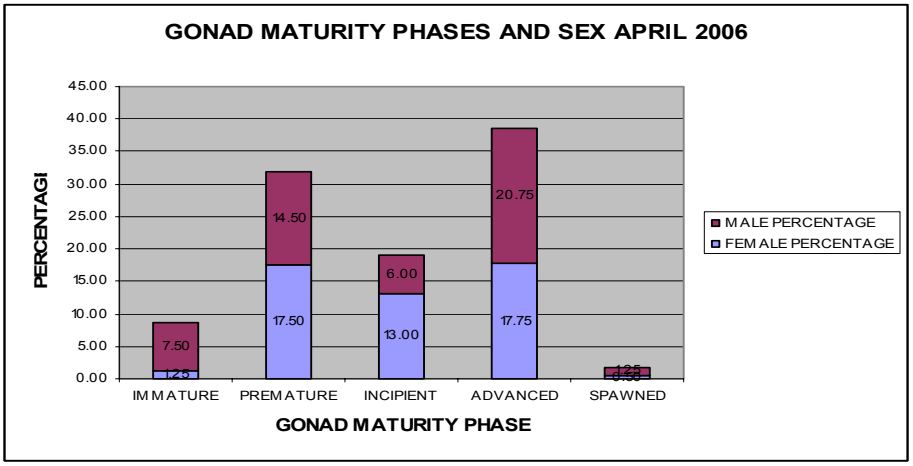
3.43 Graphic of the percentage of the gonad maturity phases during January 2006.



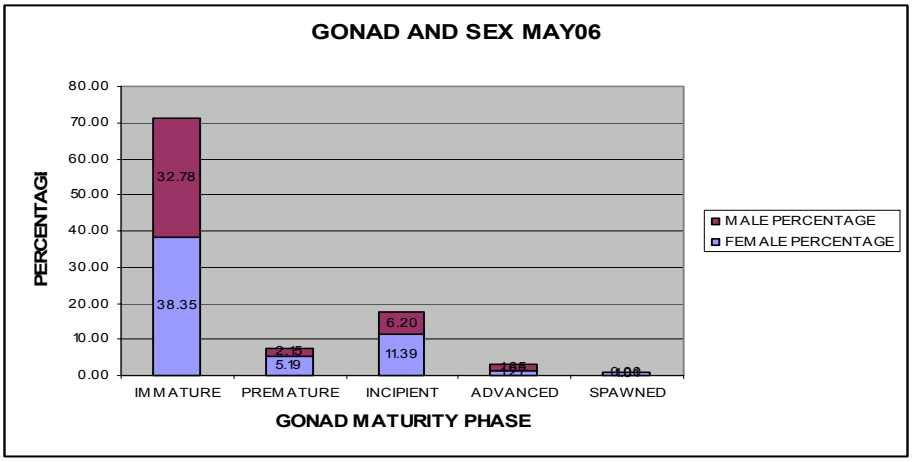
3.44 Graphic of the percentage of the gonad maturity phases during February 2006.



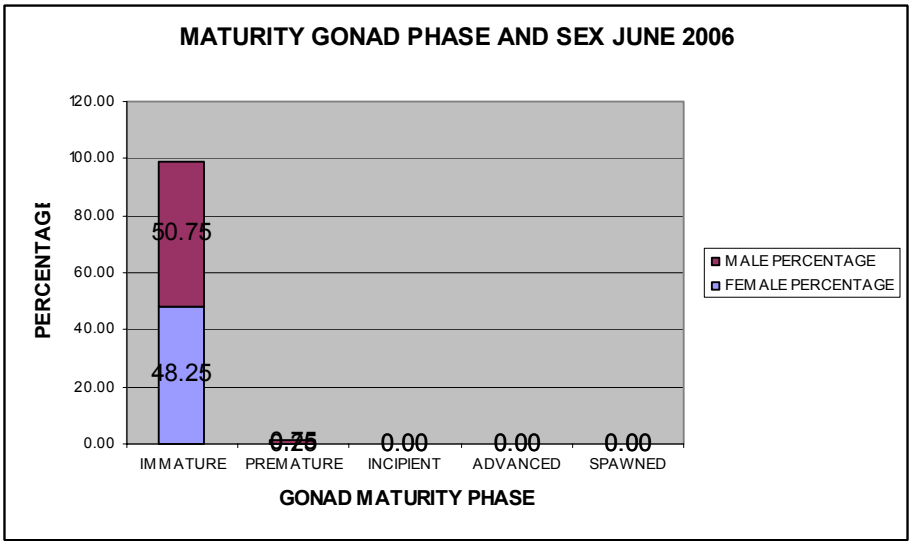
3.45 Graphic of the percentage of the gonad maturity phases during March 2006.



3.46 Graphic of the percentage of the gonad maturity phases during April 2006.



3.47 Graphic of the percentage of the gonad maturity phases during May 2006.



3.48 Graphic of the percentage of the gonad maturity phases during June 2006.

The graphics show the different gonad maturity phase for each month divided in males and females. In this analysis the differences between males and females throughout the months can be seen with more confidence. The percentage of each maturity phase has the same value for females and males except for Incipient phase that the females are clearly higher than the males along the year

3.2.5 Sexual Maturity in relation to Length

In this section the data have been examined to find the relationship between length of individuals and the point at which sexual maturity is reached. It was not possible to analyze all the fish landed and the assessment was focused in a sample of the fish landed, the relationship of the two parameters give us a confident idea about the proportion of catch landed before sexual maturity.

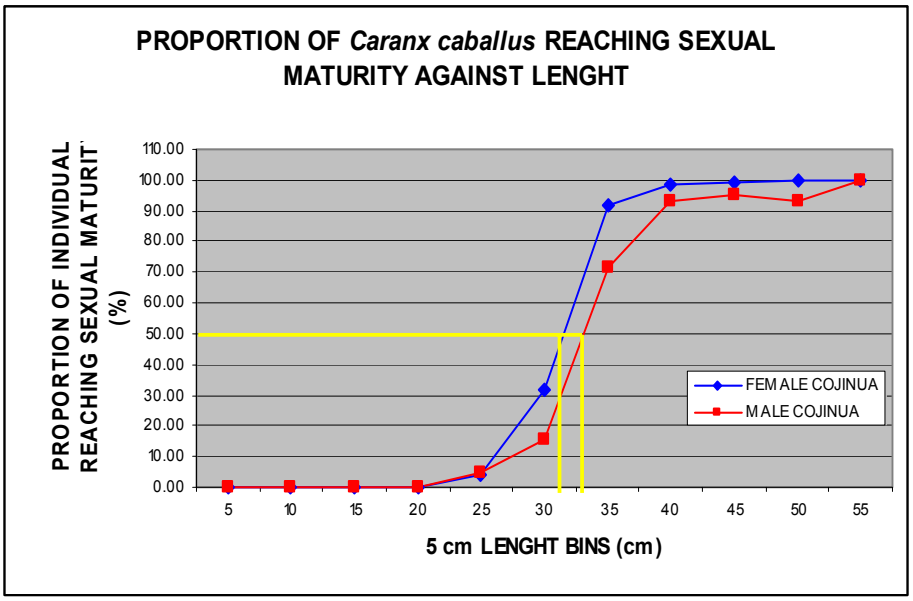


Figure 3.49 Proportion of *C. caballus* calculated using 5cm bins from biometric data of Las Perlas from June 2005 to June 2006 (n = 4976).

The figure 3.49 shows the point of at which 50% sexual maturity is reached . For *C. caballus* this point is different for males and females, being 34.90 for females and 35.05 for males. There is a slightly difference between both values. Comparing this graphic with the graphic of the length frequency analysis (Fig 3.16) where the first peak of the length frequency analysis, which occurred at 25cm, a large number of individuals are being landed before the length at which 50% sexual maturity is reached (L_{50}) (34.90 for females and 35.05 for males).35.6% of the total catch is made up of fish that are 35cm or less, below L_{50}. It is not known if the length class of 26cm reflects a first or second year cohort.

There is other peak within the length frequency analysis graphic at 38cm and if this one corresponds to a second age cohort, there is a higher percentage of 70-80% of individuals would have reached sexual maturity at this length.

4.0 DISCUSSION

4.1 CHARACTERISTICS OF LAS PERLAS COJINUA FISHERY

The Cojinua *C. caballus* is an important product of the overall Las Perlas Fishery in terms of its socio-economical value and the aspect of its ecological conservation as. This fish is mainly caught in Las Perlas Fishery and it is consumed only in Panama, there is no exportation of Cojinua. However, the Cojinua is famous in most of the panamanian homes as a typical meal as well as being cooked in every *fonda* (small local restaurants). The Cojinua fishing activity is significant within Las Perlas Fishery, generating employment for the people of the archipelago and people from Panama City also. Those reasons are enough to warrant measures to ensure the sustainability of the stock and the Fishery with appropriate management.

This study could be useful to realize the relationship between the fishermen, local buyers and the customers of the *C. caballus*, and amongst all the users of this fish. The project also attempts to quantify the extent of the fishery and searches patterns throughout the available records.

The control of the Cojinua fishing within Las Perlas Fishery appears to be very poor. The only restriction is the size of the mesh of the nets used for its fishing. There is no control over the size at which Cojinua are caught nor over the number of fish that can be caught at any one time. Information taken from the fishermen and the local buyers shows that the fishing activities appear not to harm the amount of fish of the stock of the Fishery, there is no variability in terms of landings. The small variability of the Cojinua fishing appears to be related to natural causes (ENSO and seasonal oscillation in temperature due to the upwelling) and not from excessive fishing. However, here are no accurate data on these aspects and it would be interesting to investigate these relationships in further studies.

4.2 LENGTH WEIGHT RELATIONSHIPS FOR *C.caballus*

. With the large amount of data collected from the Panama Shellfish Market a study of the L-W relationship was performed. The study was done first of all, for each month with linear regression of

the data on Length (L) and Weight (W). The similarity of the linear regressions of each month and the parameters *a* and *b*, show a significant relationship between Length and Weight. The *a* parameter varies between 1.6 and 2.1, being 2.1 for June 2006. The rest of the analyzed months are almost the same (1.6-1.8) except for a slight increase during May 2006, August 2005 and October 2005. The b parameter varies from 0.2 to 0.3 being 0.3 the normal value for all the months except for June 2006 which is 0.2. The variation of these parameters is focused on June 2006 and this fact is also seen in the linear regression of this month. In this graph (Fig. 3.12) the straight line does not fix too much with the points. This could be due to the fish for this month was clearly smaller than for the rest of the months. An hypothesis for this difference could be that during the early stages of the *C. caballus*, the L-W relationship does not behave in the same way as it does for older stages. A further study developed for the maturity gonad phase of the fish also shows differences during this month from the rest of the months (further explained in the Population Dynamic Findings from Biometric Analysis section).

Another analysis of these parameters (L and W) was performed for the whole term of the study (June 2005 to June 2006 except for November when there was no data available). The study was carried out to find differences of this relationship between both sexes of Cojinua. The graphic for both sexes (Fig. 3.13) are similar to the graphics for each sex separately (Fig. 3.14 and 3.15). The a and b parameters have the same value for these graphics (a = 1.5 and b = 0.32) aswell. A further statistical analysis of ANCOVA has been performed to ensure the relationships findings on the previous analysis. The ANCOVA shows that the L-W relationships do not differ significantly between the sexes.

4.3 POPULATION DYNAMIC FINDINGS FROM BIOMETRIC ANALYSIS

4.3.1 Length Frequency Analysis

The Length Frequency Analysis performed for the *C. caballus* for the whole year (June 2005 to June 2006) shows interesting trends in population dynamics that occurs within the Cojinua stock of Las Perlas Fishery. The fish is mainly removed from the stock at ca. 22cm up to 52cm, with the highest numbers of individual being caught around 37-38cm. Another peak was seen at 20cm in the Length

Frequency Analysis with lower value of number of individuals (Fig. 3.16). The same peaks are seen in the Density Plot (Fig.17). The two peaks could appear due to possible age cohorts occur within the fishery. These two graphics appear to have two cohorts, a main one marked by the peak at 37-38cm and another around 20cm.

Another Length Frequency Analysis has been developed for each month. This study shows similar peaks as the Length Frequency Analysis for the whole year. The difference in length of the two differentiated peak of each month is similar along the year. However, due to different values having been found for some months (especially in 2005, 2006 shows more regular values), the existence of two cohorts within the Fishery cannot be demonstrated. The two peaks could be, then, due to a movement of fish into the Fishery under study. During May 2006 and June 2006 it is shown a main peak for 25-26cm. This fact could be for a recruitment of young fish that have been using a different environment to grow and at this stage of length migrate to other places, where they are caught. The data for June 2005 are different than for June 2006 but they still show a peak at 27cm with less quantity of number of individuals removed from the Fishery. More data are needed to locate the exact time of the possible recruitment. A long term analysis could be useful to allocate the recruitment. This possible recruitment is also demonstrated with high percentage of immature individuals for May 2006 (96.2%) and June 2006 (100%).A high percentage also occurs for June 2005 (21.42%) compared to the rest of the year for the same Length. The combination between the Length Frequency Analysis and the percentage of the immature individuals is a good data to analyze a Fishery in terms of migrations, escaping, recruitment (Alastair R. Lyndon, pers.comm.).

4.3.2 Sexual Maturity in relation to Sex

The analysis of the percentage of the fish for each Maturity Gonad Phase throughout the sampled year was performed on annual and monthly data as well as related to the sex. Possible trends were found from the different plots of this analysis.

The peaks of the Figure 3.31 shows a possible cycle of the development of the Cojinua. It is clearly visible that there is a peak of the Advanced maturity phase in December following by a peak of the Immature phase during May. This could be due to there being a high spawning rate as well as high growth from the spawned eggs to the stage of Immature gonad maturity phase during the period

between the two peaks (from December to June). The fish could be maturing from the Immature stage to a Premature stage from June to September, as one peak for Immature phase is seen in June 2006 and other peak for Premature phase occurs in September 2005. There is another peak for Premature individuals (lower than the peak in September) in July. The period of time from the peak of June showing a majority of Immature fish and this peak in July could be the required time for the fish to reach the sexual maturity. The time for reaching the sexual maturity could also be the period of time between June and September. Further analysis has to be done to confirm this. Another step from Premature to Incipient stages could be suggested from September to October (there were no data for November so there is not enough information to have confidence on in this hypothesis). The step from an Incipient stage to an Advanced phase cannot be suggested due to there is no data available in November.

The same analysis has been developed only for the females and it has shown that the two peaks for the Premature phase are almost the same, drawing a slight difference between the percentage of the both peaks. It could be due to during these two months the fish is maturing to a Premature fish. The time required to reach the sexual maturity could be from June (peak for Immature) to September when all the spawned eggs in December (as the peak for advanced phase shows), have reached the sexual maturity. This was the only difference between the analysis for both sexes and the graph only for females.

Another study of the each Gonad Maturity Phase throughout the analyzed year was developed as well as compared to the percentage of each sex that made up the values of each month. The results show the same as the study developed for the whole year. The percentage of each maturity phase has the same value for females and males along the year, except for Incipient phase and Spawned phase where the percentage of the females are clearly higher than the percentage of the males. This could mean that the time spent in those maturity phase for the males is shorter than for the females.

4.3.3 Sexual Maturity in relation to Length

The Sexual Maturity compared to Length is a good analysis to find trends within a fishery. The graph (Fig. 3.49) shows that the point of at which 50% sexual maturity is reached. For *C. caballus* this point is slightly different for males and females, being 34.90 for females and 35.05 for males.

Comparing this study with the Length Frequency Analysis, it is seen that a large number of individuals are being landed before the length at which 50% sexual maturity is reached (L_{50}) (34.90 for females and 35.05 for males).35.6% of the total catch is made up of fish that are 35cm or less, below L_{50}.This length class appears to be corresponded approximately to the length at which the fish are recruited into the Fishery from the breeding sites. A significant proportion of the population at this stage is being caught without a chance to reproduce.

There is other peak within the length frequency analysis graph at 38cm and if this one corresponds to a main age cohort, there is a higher percentage of 70-80% of individuals would have reached sexual maturity at this length. This value may not be sufficient to ensure sustainable recruitment for the fishery (O. R. J. Anderson, 2005).

4.5 MINIMUM LANDING SIZES (MLS)

The benefits of a Minimum Landing Size (MLS) for any fishery has been proved in many places where has became a strategy of its management. A study conducted by Manooch III *et al.* (1998) into a snapper fishery in the southeast of United States where the MLS was introduced as a regulation of the fishery. The size of the snapper landed was bigger than the size without this regulation at the same time as the landings of snapper declined. The conclusion was that the spawning potential ratio could be improved with a decrease in fishing mortality or an increase in age at entry to the fishery (O. Anderson, 2005). This regulation appears to be the key of an actual sustainable management.

The statistical study of the data of the Las Perlas Cojinua Fishery shows that a great amount of fish are caught with 35cm or less, below L_{50} without the chance to reproduce. This is not a good sustainable strategy of the management of the Fishery and could harm the stock of the Fishery. At least, the young fish need to have a chance to spawn before being caught from the Fishery. For this, a Minimum Landing Size has to be introduced as a strategy to ensure the sustainability of the stock. The MLS for Las Perlas Fishery for *C. caballus* would be above the length at which 50% of the fish reach sexual maturity, that is approximately 30cm. Even a larger MLS would be better for ensuring a healthy

stock, at the length which 70% of the fish has reached the sexual maturity. For Las Perlas Fishery for *C. caballus*, the ideal MLS would be 35cm.

4.6 FINDINGS FROM ANALYSIS OF THE PANAMA SHELLFISH MARKET CATCH DATA

The available data were not full enough to perform a detailed CPUE analysis. The available data were only the weight of the landings during 2005 and 2006. It is necessary to have more information for example, on time spent fishing or number of fishermen per trip to develop a CPUE analysis. For this reason therefore the data have been treated as qualitative data. There was no pattern found during the analysis due to the data available for the study was only for 2005 and 2006 and longer term of data collection is necessary to show any regular annual fluctuations. During these years the volume of catch has similar value, both years was nearly 16tonnes. 52.7% of the catch are made up by Semi Industrial activity and 47.3% by "*Artesanal*" fishing. As a big percentage of the annual landings is made up by "*Artesanal*" fishing activities, a better control of this activity would be necessary to ensure a sustainable management of the Las Perlas Fishery.

All the months the major percentage of total weight is made up by Semi Industrial fishing, except for the months of August 2005, September 2005, February 2006 and April 2006 when all the fish have been caught by "*Artesanal*" fishermen. There are not enough accurate background data to find a reason for this lack of Semi Industrial activity during those months. It could be for several reasons, for example that the Semi Industrial activity is focused on other type of fishing. If the price of any fish different than Cojinua is higher during those months, the fishermen probably prefer to fish for it and get more money. A further study on the different fish that occur within Las Perlas Fishery and the economic value of them throughout the seasons is needed to ensure where the effort of the fishermen is being developed throughout the year.

There are 9 licences for the Cojinua fishing in Las Perlas Fishery. 8 names of those 9 registered "*bolicheritos*" are known. 3 of these boats have not had any activity during 2005 and during 2006 neither. The rest of the boats show an irregular activity throughout 2005 and 2006 with an

average of 2 trips during the studied time. This is a very low fishing activity of the known registered boats ("bolicheritos"). It could be due to the fishing effort is focusing on other fish or in other fishery.

5.0 CONCLUSIONS AND SUGGESTIONS

5.1 CONCLUSIONS

There was found a significant relationship of length-weight (L-W) throughout the months of the study with a slight difference during May 2006 and June 2006. This difference could be due to different behaviour during the early stages of *C. caballus*. A further study focused only on immature individuals is needed to prove the hypothesis. There was found to be no significant difference on the L-W relationships between the sexes of *C. caballus*.

There was found that the population of *C. caballus* in Las Perlas Fishery could be formed by a principal cohort of mainly 36-37cm in length individuals. This cohort could be increased due to a recruitment of small immature fish of mainly 25-26cm in length during May and June. This hypothesis needs a long-term study of the Cojinua *(C. caballus)* stock of Las Perlas Fishery to be proved.

On the basis of the Sexual Maturity Analysis of the *C. caballus* performed for the whole year without available data in November 2005, a possible trend of the maturation cycle of the fish could be discerned. There could be a spawning during December with a high growth from the eggs to an Immature stage from December to June. The maturation from an Immature stage to a Premature stage could be from June to September. The step from Premature to Incipient could be from September to October. Due to there is no data for November, it is impossible to know the duration of this step. The maturation from an Incipient phase to an Advanced phase could be from October to December but the lack of data during November does not permit any suggestion. On the basis of these hypothesis the eggs spawned on December could be mature fish by September. The time spent for the fish to reach the sex maturity from the egg could be 9 month. There was found to be no significant difference of the suggested maturity cycle for *C. caballus* between both sexes. Both sexes have been found to be in similar percentages throughout the different maturity phases except for Incipient and Spawned phases,

where there is a majority of females individuals. This could be due to the period of time that the females spent on those stages is longer than the period of time that the males spent.

There was found that 50% of the fish reaches the sexual maturity (L_{50}) at about 35cm length with a slight difference between males and females. It has seen that 35.6% of the total catch is made up of fish below L_{50}. A significant proportion of the population of the fish is being caught without a chance to reproduce. For this, a Minimum Landing Size (MLS) of 30cm or even larger, 35cm, has been proposed to be implemented as a strategy of management of Las Perlas Cojinua Fishery.

The landing data from the Shellfish Market were not complete enough for a Catch Per Unit Effort (CPUE) analysis. There was found a regular annual weight of the landings during 2005 and 2006 (the only data available) of nearly 16tonnes. The Semi-Industrial activity made up 52.7% of the total annual weight being 47.3% the percentage made up by the "*Artesanal*" activity. It has seen a lack of Semi-Industrial during August 2005, September 2005, February 2006 and April 2006 when all the landings were done by "*Artesanal*" fishermen. A possible cause of this would be that the Semi-Industrial activity is focused on other fish of more economic value. A more accurate background data is needed to explain all the trends on the fishing activities being carried out within Las Perlas Fishery. A long term collection of records of landings would be helpful to clarify where the efforts of the different fishing activities wich occur within Las Perlas Fishery, are focused on.

5.1 PROTECTION OF COJINUA STOCK AROUND LAS PERLAS

Due to the results of this study, a MLS is needed for *C. caballus* on the Las Perlas Fishery to control the stock in a sustainable way. Other further control would be to set up a Marine Protected Area around the archipielago. This plan has already set up for Las Perlas Archipielago. Further studies of the distribution of *C. caballus* throughout Las Perlas Archipielago should be performed to ensure that the boundaries of the proposed MPA involved the fishing grounds as well as the spawning grounds of *C. caballus*. The benefits of a spatial approach to fisheries protection have already been covered but it is an important point to highlight once again. (O. R. J. Anderson, 1995). The current proposed boundary is 3km offshore for the majority of the area. The fishing grounds of *C. caballus* appears to be located near the coast as the interviews with the fishermen show. Then, the Cojinua fishing grounds could be

covered by the MPA boundaries and the MPA could have beneficial effects on the Cojinua stock within Las Perlas Archipielago.

5.2 OTHER THREATS TO THE FISHERY

The control of the fishing activities of *C. caballus* within Las Perlas Archipielago appears to be very poor. It would be helpful for further studies to have more accurate official data of landings in the Panama Shellfish Market. It is also needed more control on the extent of the fishing pressure of unregistered "*Artesanal*" fishing activities due to a high percentage of the annual total weight of the landings is made up by this activity.

The imposition of MLS within Las Perlas Fishery could be a crucial instrument of management of the fishery. It could bring benefits to the fishery if all the fishing boats respect it. Otherwise the Cojinua users (fishermen and local buyers) could be affected in terms of incomes as well as the stock of *C. caballus* could decrease dramatically and in a long-term period of time could collapse.

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APPENDIX 1- Official data of landings in the Panama Shellfish Market (2005 and 2006)

DESEMBARQUE DE COJINUA EN EL MERCADO DEL MARISCO
AÑO: 2005
EN LIBRAS

Fecha	Nave	Especies	Libras
01/01/2005	Información no disponible	Cojinua	11,500
09/01/2005	Información no disponible	Cojinua	3,400
Total			**14,900**
02/02/2005	Navegante	Cojinua	1,200
14/02/2005	Don Gayo	Cojinua	700
15/02/2005	Mana	Cojinua	2,300
16/02/2005	Doña Carmen	Cojinua	1,300
17/02/2005	El Delfin	Cojinua	75
18/02/2005	Nuevo Milenio	Cojinua	200
21/02/2005	Bendición	Cojinua	300
22/02/2005	Danielín	Cojinua	126
23/02/2005	Mi Lindo Niño	Cojinua	1,000
24/02/2005	Niña Mitzila	Cojinua	600
25/02/2005	Don Basilio	Cojinua	300
Total			**8,101**
04/03/2005	Gustavo	Cojinua	400
08/03/2005	Don Dagoberto	Cojinua	2,000
10/03/2005	Pan de los Pobres	Cojinua	1,600
14/03/2005	Mil Amores	Cojinua	400
15/03/2005	Divino Niño	Cojinua	500
16/03/2005	El Peregrino	Cojinua	750
18/03/2005	Niña Yauri	Cojinua	350
22/03/2005	La Chichi	Cojinua	1,206
23/03/2005	Don Basilio	Cojinua	1,000
24/03/2005	Pelegrino	Cojinua	1,500
Total			**9,706**
08/04/2005	Momo	Cojinua	399
15/04/2005	Buen Amigo	Cojjinua	400
15/04/2005	Delfin	Cojjinua	200
15/04/2005	Doña Josefina	Cojjinua	500
16/04/2005	Don Dignio	Cojjinua	200
21/04/2005	Pan de los Pobres	Cojjinua	100
26/04/2005	Mis & Nietas	Cojjinua	100
26/04/2005	Niña Maryuli	Cojjinua	100
26/04/2005	Doña Tomasa	Cojinua	300
Total			**2,299**
01/05/2005	Información no disponible	Cojinua	3,380
Total			**3,380**
07/06/2005	Navengante	Cojinua	3,000
18/06/2005	Doña Edigna	Cojinua	2,000
02/06/2005	El Halcòn del Mar	Cojinua	1,200
04/06/2005	Don Josè	Cojinua	1,650
08/06/2005	Doña Edilma	Cojinua	1,800
08/06/2005	Don Dagoberto	Cojinua	600
13/06/2005	Doña Ceci	Cojinua	300
18/06/2005	Don Basilio	Cojinua	300
Total			**10,850**

09/07/2005	Francisco M	Cojinua	1,200
10/07/2005	Lina Cristina	Cojinua	1,500
12/07/2005	Sektra	Cojinua	230
Total			**2,930**
13/08/2005	Niño Eymar	Cojinua	280
23/08/2005	Información no disponible	Cojinua	200
24/08/2005	Luz Marina	Cojinua	200
Total			**680**
08/10/2005	Don Dagoberto	Cojinua	200
12/10/2005	Niño Abel	Cojinua	200
Total			**400**

9

AUTORIDAD MARITIMA DE PANAMA
DIRECCIÓN GENERAL DE RECURSOS MARINOS Y COSTEROS
MERCADO DEL MARISCO

Nota: DMM-208-2006

PARA: ***Licdo. George Novey***
Director General de Recursos Marinos y Costeros

DE: ***Sr. Armando Torres***
Jefe - Encargado de la Oficina de Recursos Marinos del Mercado del Marisco

ASUNTO: *Movimiento de Cojinúa de las Embarcaciones que Pescan en El Archipiélago de las Perlas de enero a junio del 2006.*

FECHA: *viernes 14 de julio del 2006.*

Mediante la presente le detallo la información solicitada por Usted a nuestra Oficina.

Mes de Enero del 2006.

Nombres de Embarcaciones	**fecha**	**Cantidad en Libras**
Doña Mariana (Artesanal)	02	260
Con la Ayuda de Dios (Artesanal)	20	135
Don Jose I (Semi-Industrial)	25	5,000
Delfin V (Artesanal)	25	200
La Nave del Placer (Artesanal)	26	165
Cinco Hermanos (Artesanal)	28	320
" " "	30	320
El Brujo (Artesanal)	31	180
Mi Lindo Niño (Aretesanal)	31	180
Total de Libras		**6,760**

AUTORIDAD MARITIMA DE PANAMA
DIRECCION DE RECURSOS MARINOS Y COSTEROS
17/7/06
Recibido hoy:
FIRMA

Mes de Febrero del 2006.

El Lival (Artesanal)	01	240
Doña Cesira (Artesanal)	02	185
Don Dagoberto (Artesanal)	03	210
Doña Tomasa (Artesanal)	09	760
Don Cecilia (Artesanal)	09	290
Genesis (Artesanal)	09	430
El Sol (Artesanal)	16	562
Doña Zaila (Artesanal)	16	410
Don Nicho (Artesanal)	16	530
Niña Mitzila (Artesanal)	16	400
Niño Ediel (Artesanal)	16	475
Doña Hermelinda (Artesanal)	17	510
Delfín IV (Artesanal)	18	360
Doña Sarita II (Artesanal)	17	370
" " " " "	18	370
La Esperanza (Artesanal)	18	235
Puerto Piña (Artesanal)	22	200
Yaribeth (Artesanal)	22	260
Zapallo (Artesanal)	22	300
Delfín IV (Artesanal)	25	315
Total en Libras		**7,652**

Mes Marzo del 2006.

Doña Nuvia (Artesanal)	02	280
La Lenguita (Artesanal)	02	340
Bendición (Artesanal)	02	340
	07	700
	09	250
	10	400
Doña Sarita II	03	360
Claudia (Artesanal)	03	250
Pan de los Pobres (Artesanal)	03	320
Mis Lindos Niños (Artesanal)	07	300
Don Vacilio (Artesanal)	08	200
El Sol (Artesanal)	09	250
" " " "	25	300
Don Kiko (Artesanal)	09	300
" " " " "	11	350
Virgen del Carmen (Artesanal)	02	350
" " "	11	350
" " "	17	300
Navegante (Semi-Industrial)	10	4,500
El Gato (Artesanal)	10	500
El Pupy (Artesanal)	10	300
La Nave del Placer (Artesanal)	10	350
Niña Yiliana (Artesanal)	11	250
Mis Lindos Niños (Artesanal)	16	200
El Rastrillo (Artesanal)	16	200
La Esperanza (Artesanal)	16	100
" " " "	28	300
Doña Cesira (Artesanal)	25	300
Navegante (Semi-Industrial)	25	875
Total de Libras		**13,815**

Mes de Abril del 2006.

Dios Fiel (Artesanal)	02	540
Juan Alvenis (Artesanal)	11	100
Picsis (Artesanal)	14	2,000
Rosa E. (Artesanal)	14	1,500
Sentra (Artesanal)	14	200
Niña Tania (Artesanal)	14	275
Diez Hermanos (Artesanal)	26	200
El Taliban (Artesanal)	26	180
Cintya (Artesanal)	27	160
Total en Libras		**5,155**

Mes de Mayo del 2006.

Eduardo Jr. (Artesanal)	10	160
Doña Gertrudis (Semi-Industrial)	29	1,600
Lina Cristina (Semi-Industrial)	29	3,000
Total de Libras		**4,760**

Mes de Junio del 2006.

Doña Gertrudis (Semi-Industrial)	01	3,500
Dios Fiel (Artesanal)	02	540
Lina Cristina (Semi-Industrial)	04	7,000
Total de Libras		**11,040**

Se recaudo un total de 49,182 libras de COJINUA de enero a junio del año en curso.

Sin otro particular, queda de usted.

Atentamente,

c.c Licda. Leyka Martínez – Sub-Directora de Recursos Marinos y Costeros