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AN APPRAISAL OF THE FISHERIES DATA COLLECTION SYSTEM IN SAINT LUCIA

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ABSTRACT

As a result of the changes that have occurred within the fishing sector of Saint Lucia over the last few years it has become necessary to review all of the mechanisms that are utilized for the management of the fishery. As part of the overall review process, a critical look needs to be taken of the current data collection management and analysis procedures within the Department of Fisheries. This study aims to examine the data management system of Saint Lucia with a view to determining its effectiveness and efficiency. Close attention was paid to the various processes and procedures with a view of addressing any weaknesses that may exist. Data from 1995-2010 were analysed during the study. It was then determined that the data management system of the Department of Fisheries in St. Lucia consists of all the basic elements that allows it to serve the purpose for which it was set up to perform. However, in order to strengthen the unit's capacity to carry out its mandate, the adoption of the recommendations made are recommended.

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1 INTRODUCTION

1.1 Country background

Saint Lucia is one of the islands within the archipelago of the Eastern Caribbean (Figure 1). It is located between latitude 13° and 14° north and longitude 60° and 61° west. Similar to other islands of the Lesser Antilles, two water bodies wash its shores, the Atlantic Ocean on the east and the Caribbean Sea on the west. The population of the island is 164,791 (Statistic Department 2005). The coastal shelf area of the island is narrow and measures 522 km^2 with a total Exclusive Economic Zone (EEZ) of 4700 km^{2,} which is 7.63 times the land mass area of the island (616 km²) (FAO 2012).

Figure 1. Map of the Caribbean (World Atlas 2012)

The western coast is characterized by a narrow, steep, insular shelf in contrast to the eastern coast, which has a fairly extensive, less steep, insular shelf, as seen in Figure 2. The southern coast has a wider shelf area extending southwards. Nearshore fishing on the island takes place along the coastline within 7 miles from shore, whilst reef and large pelagic fishing occurs within 10 miles. The length of the coastline extends for 158 km. Two important fishing banks with a total shelf area of 14 km^2 are located a few miles south and northeast of the island (National Country Report 2010).

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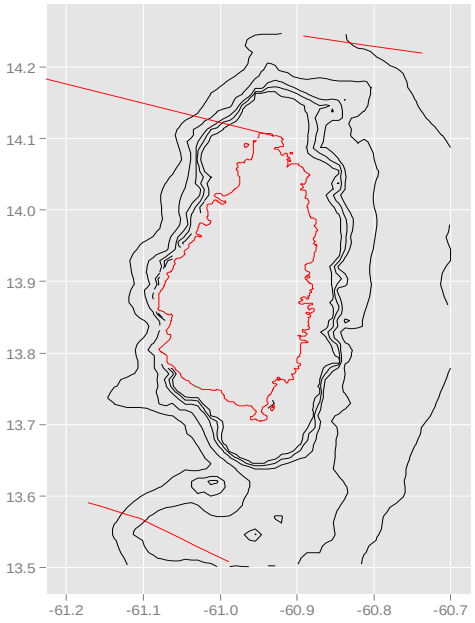

Figure 2. Bathymetry of Saint Lucia water. The depth contours are 50, 100, 200, 500 and 1000 m. The red lines mark the EEZ boundaries between adjacent countries.

The island marine ecosystems are comprised of a full range of tropical marine and coastal habitats including estuaries, mangroves, lagoons, sea grass beds, fringing, patch and barrier reefs, deep bank reefs and open oceans (National Country Report 2010). Shallow-shelf reef fishes are concentrated on fringing and patch reef systems located on the inner part of the island shelf but may be found within sea grass and mangroves areas during their juvenile stages (George 1999)

1.2 Overview of the fisheries sector

The fishing sector when compared to other leading fishing sectors like Iceland, Norway and Canada can be described as small scale. For the last three years, total fish landings for the island have been just over 1800 tonnes (DOF 2010a). The sector has contributed between 0.70-0.96% to the island's national GDP since 2000 (Statistic Department 2010). Although the sector employs a mere 1.2% of the labour force (Statistic Department 2005), it has been able to sustain the livelihood of many families especially in the rural communities.

The fishing fleet consists of 618 vessels operated by 2458 fishers; of whom 55% operate on a full-time basis (DOF 2010a). The fleet has a range of vessel classes but is dominated by open fibreglass pirogue and traditional dig out canoes. Vessel sizes range from 3-25 m. In addition, a small number of locally owned and operated long lining vessels have recently entered the fleet. Outboard engines ranging from 40 - 115 hp power majority of canoes and pirogues (FAO 2012). Because the of multi species nature of the fishery most fishing vessels are usually equipped with a combination of hand lines, trolling lines, nets and pots. Fishing trips are usually one-day trips ranging from 3-8 hours durations on average. All commercial vessels are required to be registered. And are inspected and licensed annually for safety and navigational equipment.

The island's fishery resources comprise of offshore pelagic, demersal and coastal pelagic. The offshore pelagic fishery contributed approximately 64% of the annual landings by weight in 2010 (DOF 2010a), which is made up of a number of migratory species including dolphin

fish (*Coryphaenahippurus)*; mackerel (*Stromberomorus*spp.*)*; Wahoo (*Acanthocybiumsolandri)*; blackfin tuna (*Thunnusatlanticus)*; yellow fin tuna (*Thunnusalbacares)*; and Skipjack tuna (*Katsuwonuspelamis)*. The remaining 36% of the annual landings was a combination of demersal and coastal pelagic. The coastal pelagic fishery comprises of an array of species including: ballyhoo (*Hemiramphidae spp*.); barracudas (*Sphyraenidae spp.*); herrings (*Clupeidae spp*.); jacks (*Carangidae spp*.); mackerels (*Decapterusmacarellus)*; and needlefishes (*Belonidae spp.*). The demersal fishery lands the most highly priced and valuable species for the local markets and tourism sectors, which includes: snappers (*Lutjanidae spp*.); groupers (*Serranidae spp*.); Caribbean spiny lobster (*Panulirusargus)*; and Caribbean queen conch (*Strombusgigas)* (DOF 2010b).

Currently, financial and manpower constraints limit national ability to assess and monitor the majority of fish populations and habitats to determine levels of exploitation or to estimate the appropriate MSY at the level of each stock. (George 1999).

According to the Fisheries Management Plan (DOF 2006) the Department of Fisheries is responsible for the management, implementation of policies and development of the fisheries sector. It has a staff of over 30 members with expertise in fisheries policy development, fisheries extension, marine and fisheries biology, coastal zone management, fishing gear technology and data management (DOF 2008).

Whilst the sector has continued to show potential and growth, the fishery landscape has seen several changes over the past years. These changes have resulted in improvements in the management. With reference to a Draft Fisheries Subsidies report (Charles 2005) the changes highlighted include:

- Government support to the sector.
- Improvement in fishing gear and fishing technology.
- Improvement in data collection and management.
- Changes in the marketing of fish and fish products.
- Improvement in the collaboration between major stakeholders in the sector.
- Changes in the regulatory framework that governs the sector.

Government Support to the sector

The government of St. Lucia is responsible for creating the environment within which the fisheries sector can grow. This has been created and sustained through various government initiatives.

The government has supported the growth of the fisheries department from a unit within the Ministry of Agriculture in 1972 with two staff members, to a fully-fledged department with a staff complement of over thirty persons in 2010. The department now comprises of four main units:

- Administration unit.
- Resource management unit.
- Aquaculture unit.
- Fisheries Extension unit.

To complement the growth in staff numbers, the fisheries department was moved to a modern and well-equipped office in 1997. The facility was built as part of a technical cooperation agreement between the Government of Japan and the Government of St. Lucia. This

expansion has improved the Department's capacity to develop policy, plan and implement programs to regulate the sector.

The government has remained committed to the sector and to this end, has continued to provide and seek training opportunities for staff both locally and internationally.

Further, government support has been enabled through incentives and subsidies that are provided to fishers and fisher organizations. These incentives are provided within the provisions of the Fisheries Incentives Act of 1972. One such incentive package includes duty free concessions on boats, engines, fishing equipment and other fishing related materials. Additionally, a rebate on the cost of fuel is also provided through the respective Co-operative Societies where members (fishers) are now entitled to 4500 gallons per year on fuel purchased for fishing expeditions.

Improvement in gear and the adoption of new fishing practices

Between 1995 and 2010 there has been a sustained effort by the Department of Fisheries to modernize the fishing sector. To this end the Department has been engaged in the following:

- Encouraging fishers to move from the traditional open wooden canoes to more modern and safer craft (fiberglass pirogues).
- Providing incentives to fishers to purchase bigger and more powerful engines. Over the last few years there has been a shift to 75hp (horsepower) outboards engines. But more recently, fishers are moving to 85hp and 115hp engines.
- Intensifying the training of young fishers in all aspects of fishing inclusive of safety, drop line, drift line and troll line fishing.
- The deployment of several FADS (Fish Aggregating Devices) from 1999 to date. These devices have resulted in cost savings on fishing expedition, since fishers now have to travel shorter distances in search of pelagic species.
- Exploration of the Diamond Back squid fishing along with Japanese expertise.
- Construction of fish landing sites at strategic locations around the island from 1994-2008 with grant assistance from the Japanese government. These fisheries facilities allow for safer storage of fishing vessels and gear, better gear maintenance facilities, higher sanitary standards for fish handling and marketing areas.

Changes in the Marketing of Fish and Fish Products

With the financial assistance of the Japanese Government, a fish-marketing agency Saint Lucia Fish Marketing Corporation (SLFMC) was established in Castries in the year 1995. The facility is equipped with cold storage with 250 tons capacity, and nearly 5 tons of ice making capacity. Prior to the establishment of this facility, storage was inadequate to handle the fish supplied by local fishers. This new facility was timely and appropriate to meet the demand and production of fishers.

Other attempts have been made over the years to increase storage capacity by establishing other purchasing depots around the island. In 2000, another facility began operation in the southern town of Vieux Fort with similar storage capacity but even this has proven inadequate at times.

Even at this stage, the sector is in its infancy. The sole fish processing facility is still not European Union (EU) and Hazard Analysis and Critical Control Points (HACCP) certified. The local demand however has caused the price of most fish species to increase over years.

Improvement in collaboration between major stakeholders in the sector

The department of fisheries has recognized the importance of involving all stakeholders in the process of planning for and managing the fisheries resources of the country. Hence the Department has entered into strategic alliances with the following organizations that have an interest in the sustainable use and management of the fishery.

1. The St. Lucia Fish Marketing Corporation (SLFMC).
2. The Soufriere Marine Management Area (SMMA).
3. Nine Fishermen's Cooperatives.
4. Marine Police Unit.

Changes in the Regulatory Framework that governs the sector

The Department of Fisheries is mandated and regulated by law under the Fisheries Act No. 10 of 1984 and the Fisheries Regulations No. 9 of 1994. In addition to this the work program of the Department is guided by the Fisheries Management Plan (FMP), which was revised in 2006. These regulatory frameworks seek to facilitate the preservation of fragile ecosystems and habitats, sustainable use of fishery resources, and the restoration of depleted resources.

Some of the management measures currently supported by fisheries legislation to ensure the sustainability of the island's fishery resources include:

- License and permit systems (which regulate access to fishery resources).
- Marine reserves (no "extractive" activities permitted in these areas).
- Fishing priority areas (fishers have priority over all other user in these areas).
- Closed seasons for many fisheries, such as lobster and sea urchin (which protect species during vulnerable times such as breeding seasons).
- Size limits (these ensure the protection of juvenile/young species).
- Gear restrictions such as mesh size regulation (which allows juveniles to escape).
- Protection of breeding species (which ensures continued input of new stock into the fishery).

Between 1995 and 2010 there have been several amendments to the fisheries legislation to improve the capacity of the department to execute its mandate. Additionally, there have been several reviews of the Fisheries Management Plan and the Department engages consultants on a regular basis, to review its strategic direction.

Over the last few years St. Lucia has also signed onto a number of conventions and agreements whose objectives are to promote the sustainable use of fisheries resources. These conventions and agreements include the FAO Code of Conduct for responsible fishing, International Whaling Commission IWC and International Commission for the Conservation of Atlantic Tunas (ICCAT).

1.3 Purpose of the project

In light of the changes that have occurred within the fishing sector of Saint Lucia over the last few years, it has become necessary to review all of the mechanisms that are utilized for the management of the fishery.

One such mechanism is the data management system and its procedures, which has been in existence for more than a decade. Although the Department has grown and developed, some of the procedures of the data management system have remained the same. As part of the overall review process, a critical look will be taken at the current system and analysis procedures within the Department of Fisheries.

The system requires:

- The data collection and sampling strategy to be reviewed.
- The database efficiency and reliability to be exploded since the current system is old and is not compatible with current application software.
- The data analysis process to be revised and made simpler (too cumbersome)
- An improvement to the data integrity.

Therefore, this project seeks to examine the data management system of Saint Lucia with a view to determining its effectiveness and efficiency. The study will utilise data from 1995 to 2010. Close attention will be paid to the various processes and procedures with a view to sourcing ways to resolve any weaknesses that may exist.

One of the outputs from this project will be a set of recommendations for improving the overall management of the data collection system.

2 REVIEW OF THE DATA MANAGEMENT SYSTEM

2.1 Overview

The information available within this section was mainly acquired from unpublished reports, documents and other personal communications with staff within the Department of Fisheries in Saint Lucia. The system was also appraised based on internal and operational procedures and the author's own knowledge of the system.

2.2 Structure of the Data Management Unit

The data management unit is responsible for, amongst other tasks, to manage and monitor the collection of catch and effort data. At present, the unit employs nine data collectors to collect catch and effort data, one data manager with specific responsibility for the data analysis as well as the overall management of the unit; one fisheries assistant with responsibility for the licensing and registration system and one data entry clerk with responsibility for the entry of catch and effort data.

2.3 Saint Lucia Database Programs

The Saint Lucia data management system utilises two databases: Trip Interview Program (TIP) that captures catch and effort data and the Licensing and Registration System (LRS) that captures vessel and fisher data. Both databases are MS DOS based programs, which have been utilised by the Department from 1995. The databases were developed by a Canadian organization for CRFM to meet the data entry and management needs of the Caribbean region. Prior to 1995,the Department used other databases to store and manage its data.

More recently, an MS Access database program "CARIFIS" was developed and introduced to the Caribbean by Paul Medley who wrote the program for CRFM in an effort to merge and improve the two databases (TIP and LRS). To date this program is not being utilised due to some minor setbacks and administrative issues.

2.4 How the system has developed

The Saint Lucia fisheries data collection system dates back to 1979. At that time, catch and effort data was collected through a census-based survey where all returning vessels were sampled every day. Up until 1981, the Statistical Unit within the Ministry of Agriculture was responsible for processing collection and analysis of data. To arrive at total estimates, an arbitrary assumption that catches recorded by the data collectors represented 50% of the actual landings was used (Murray 1995).

In 1981, the responsibility for data collection and analysis was assigned to the Fisheries Unit. By 1983 the Fisheries Unit had revised the 50 % assumptions for estimating landings and adopted a 60% assumption based on the ratio of sampled days and total fishing days, however the actual formula to arrive at this is unknown (Murray 1995).

According to the data terminal report (Joseph 2000) from 1987, collected data was captured using a RBASE database program developed and distributed by the OECS Fisheries Desk. However, it is unclear what storage system or database was in used from 1979 to 1986.

In 1997, the Fisheries Unit became a Department. Since then several changes have been instituted to the data collection system, which included the introduction of the TIP database in 1995 for the capture of catch and effort data.

In 1999 a joint CRFM agreement led the way to the development of a sampling strategy plan for Saint Lucia. This plan outlined a sampling regime that was more suitable for the needs of the Department at that time. In addition to this sampling strategy an analytical procedure was developed and implemented which is still being utilized.

Table 1 provides a summary of these changes and developments that have taken place within the system overtime.

2.5 The Sampling Strategy

The current sampling strategy utilised by the Department of Fisheries is based on a stratified random sampling regime, which was implemented in 2000-2001. According to the sampling design, its main objective is to collect catch and effort data for the estimation of total landings.

The regime has three major strata, which are defined by primary, secondary and tertiary landing sites. This classification is based on the fishery type, the volume of fish being landed and the number of vessels operating at the site (National Fisheries Report, 2010). Although, the classification of the strata are stated it is not clearly defined or followed within the system.

Fish is landed at seventeen (17) landing sites as listed in Table 2. Catch and effort data are collected from ten sites, which are classified as sampled sites also listed in Table 2. The remaining seven sites are classified as non-sampled siteswhere no data are collected. The comparable sites listed in Table 2 are the sampled sites used to compare non-sampled sites based on similar fishing activities for the estimation of landings for non-sampled sites.

Data collectors are required to work fifteen (15) randomly selected days each month. The collector is required to capture information from every other returning vessel which includes: weight and price by species, species type, arrival and departure times, total vessels out and area fished among others. During sampling, the data collector is required to interview the captain or any crewmember of the sampling vessel for information and record the observed weights. Generally, fish is weighed on scales stationed at the site or owned by the fishers.

It is important to note that up until 2001, Savannes Bay and River Doree were sampled sites, and data was collected at both sites for ten days. Banannes and Anse La Raye were converted to sampled site in 2004 and 2008 respectively. All sites presently collect data for 15 days monthly. However, it is uncertainty, why data was collected for ten days in Savannes Bay and River Doree. Table 3 illustrates the sampled and non-sampled sites listing as of 2010.

2.6 The Data Management Stages

2.6.1 Stage 1 - Data Collection and monitoring

According to the data management system, the data collectors at their respective landing sites they are assigned to primarily collect data.

To ensure data integrity, a monitoring system is in place to monitor and assess the collectors at the landing sites on their workdays. All sampled sites are visited at least once a month by data unit staff. However, some sites are visited and monitored more frequently when necessary.

In addition, any fisheries officer collects data from time to time when significant catches are landed in the absence of a data collector. These landings are submitted by the officer to the data manager who records this data in the "data analysis issues to consider notebook". The data are then verified with the data collector's records to avoid duplication. Data are also collected of landings from fishing tournaments.

Data are recorded in a data booklet which compromises of field data sheets in which the data are captured (Appendix I). Data collectors are required to submit their completed data booklets monthly.

2.6.2 Stage 2 - Data Entry and verification

Upon submission of the completed data booklet, the entry clerk is required to review the submitted data with the data collector for inconsistencies. Thereafter the data are captured into the database program TIP. Each fishing trip recorded is allocated a sequence number generated by the program upon entry.

On a monthly basis the data manager is required to verify all data captured into the database. After verification, the entry clerk corrects all noted errors.

Data are also entered into an independent file created in excel referred to as the total vessel out file or TOT_VESS for purposes of analysis. This file is used to capture data on the total number of vessels and fishing days in a month. The data captured in this file comprises of landing site details, month information, and the sum of the total recorded vessels out on a sampled day and the total number of fishing days for each month. Since the possible number of fishing days for each month and site varies, this has to be calculated for each site and month separately. This is further explained in the data analysis section (2.6.3).

Only data captured by the data collector is entered into the database program TIP. However, all additional data collected is manually added to the final figures during data analysis.

2.6.3 Stage 3- Data Analysis

Data are analysed by the Department bi-annually and annually. Before the analysis, the data manager performs a further verification of the data until all errors are corrected. For analysis purposes seven data files are needed six of which are extracted from the database (TIP) by performing a series of queries and calculations and one is generated in excel. Each query performed and the resulting output creates one of the seven files needed. The process of generating these queries is guided by an internal document "Procedures for Analysing Fish Data".

The total vessel out file (TOT_VESS) is uploaded into TIP after it is generated and incorporated into the querying process. Listed below are the seven files required for the analysis and the calculations required for generating each file and its output. All files are sorted by landing site and month.

Listed below is the sequence of steps for estimating total fish landings.

1. TOT_VESS >> Generates - total vessels out and total fishing days per month
    a. FISH_DAYS = Total # of days in a month – (Total # of Sundays in month + # "0" zero boat out days + holidays).
    b. FISH_DAYS = Total # of days in a month – (Total # zero boat out days + holidays).

    **Calculation (a) applies to all sites except VIFO and DENN. Calculation (b) applies to VIFO and DENN.

2. A_SAMPDAY >> Generates – total sampled days and total sampled vessels.

3. R_FACT >> Uses the output of TOT_VESS and A_SAMPDAY files to generate the raising factor and total effort
    a. TOT_EFF =FISH_DAYS*TOT_VESS / DAYS_SAMP.
    b. RF = TOT_EFF / BOATSAMP.

4. A_LANDIN >> Generates - species caught, sampled (observe) weight, value, and average price.

5. TOT_LAND >> Uses the output of A_LANDIN file to generate - total raised weight by month by species and the total raised value by month by species
    a. SUM_WGT = OBS_WGT * RF.
    b. TOT_VALUE = VALUE * AVG_PRICE.

6. FAMILY >> Uses the output of the TOT_LAND file to generate species grouping by the official reported species groups.

7. ANALYSIS >> Uses the output of the FAMILY file to

    1. Calculate the landings for the non-sampled sites.
    2. Use the estimates from the previous year for sites where less than 8 days data was collected for a particular month and for months where no data was collected (missing months).
    3. Manually input additional data collected.
    4. Raise the estimates for conch and lobster figures (by an agreed percentage).

2.6.4 Summary of the estimation of landings

To arrive at the estimated landings for the sampled sites a raising factor is calculated for each month and site. The sampled landings are multiplied by the raising factor to account for vessels that are not sampled and days that are not sampled.

To arrive at the estimated landings for the non-sampled sites a different approach is used. A determination is made to establish comparable sites that are sampled sites and non-sampled sites that are similar based on fishing practices. A percentage of the number of registered vessels at the non-sampled site over the number of registered vessel at the sampled site is calculated (see equation below). This percentage is used to calculate non-sampled sites landings by taking a percentage of the comparable sampled site landings.

The sum of the landings for the non-sampled and sampled sites generates the total estimated landings for the island. It is important to note that additional manipulations are done for

missing months and less than 8 days data as stated in step 7 for the file listed as analysis above.

% = Total # of vessels at a non-sampled site/total # of vessels at a sampled site * 100

2.7 SWOT analysis of the Data Management System

This SWOT analysis provides a summary of the limitations and strengths encountered within the data management system during the review.

Strengths

1. The unit has experienced, knowledgeable and committed staff
2. The sampling plan is adequate

Weaknesses

1. The current database is not compatible with newer versions of application software.
2. In some cases data collectors do not adhere to the 15 sampling days
3. Some procedures are not clearly defined and not all are documented
4. The stratification of the sites are not defined in terms of site categories
5. All collected data is not captured in TIP
6. Non sampled sites are not monitored
7. The verification process does not follow stipulated checks
8. Codes, file names, file format and layout are not standardized
9. Data placed in storage contains errors
10. The procedure manual does not contain all the steps required to perform the data analysis
11. Significant occurrences within a year are not recorded
12. The data files and backups are not secured properly
13. Data are entered manually during analysis

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Opportunities

1. An upgraded database is available
2. There is regional support to help revise and strengthen our system

Threats

1. Financial constraints
2. Lack of adequate resources within the unit

3 REVIEW OF THE DATA ANALYSIS PROCEDURES

Although a review of the system was conducted and the limitations identified, it was important to further review one of the critical components of the data management system, the analysis procedures. The Department of Fisheries like other governmental agencies is dependent on the estimated landings produced by the data management unit.

To undertake this study, a 16-year data set (1995-2010) was used to review the data analysis procedures employed by the Department of Fisheries. The analysis procedure for that period was repeated using the statistical software program “R”.

Firstly, an understanding of how the estimated landings for 1995-2010 were obtained by the Department had to be established. Then the fish landings data for the period was imported into "R". All other supporting tables and Excel files relevant to the analysis and used by the Department were also imported into "R".

Subsequently, an "R" script was developed to replicate the procedure of estimating the total landings followed by the Department. Although the analysis process used from 1995-2000 was different from 2001-2010 all the data were imported and the two periods were dealt with separately. Once all the relevant tables were converted into data frames (a format used by "R" to describe tables), the data were ready for analysis.

In addition to that, a generic description of the internal document used to guide the analysis process was generated. This document describes in detail, the technical step-by-step instructions related to the specific software (TIP, Excel) in use by the department. The generic description paved the way for a better interpretation of the processes.

Further, a mathematical representation of the data analysis procedures was also developed for ease of use by any external or internal users accessing the system.

3.1 Mathematical explanation of the analysis

Estimation of total effort

The data collected on effort within a month within a sampling site is the number of days sampling took place and the sum of the number of boat trips over the sampling days. The estimates of the total number of fishing days within a month and the total number of trips in a given month from a given site are calculated as:

$$N^{T}_{m,l} = \frac{N^{S}_{m,l}}{D^{S}_{m,l}} D^{F}_{m,l}$$

where

$N^{S}_{m,l}$ is total number of fishing trips on the dates sampled in month m at site l

$D^{S}_{m,l}$ is number of days sampled in month m at site l

$D^{F}_{m,l}$ is number of fishing days in month m at site l

This equation can be expressed in words as the mean number of trips per fishing day multiplied by the number of fishing days in a month.

Estimates of landings

The monthly landings are estimated from:

$$\hat{C}_{m,l} = \frac{N^{T}_{m,l}}{n_{m,l}} \sum_{i=1}^{n} c_{m,l,i}$$

where

$\hat{C}_{m,l}$ is the estimated catch in month m at site l

$n_{m,l}$ is the number of boat trips sampled

$c_{m,l,i}$ is the estimated catch from the ith trip

This equation can be expressed in words as: The total catch is the mean catch per boat trip multiplied by the total number of boat trips in a month. By pooling the monthly landings estimates, that is, within and between sampling sites both monthly and yearly estimates of the landings can be obtained. Thus the annual landings within a site are:

$$\hat{C}_{l} = \sum_{m=1}^{12} \hat{C}_{m,l}$$

and the total annual yield is:

$$\hat{C} = \sum_{l=1}^{L} \sum_{m=1}^{12} \hat{C}_{m,l}$$

where L is the total number of sampled landings sites. Equivalent numbers can be calculated for each species or species group landed.

Estimates of variance and confidence interval

The estimated variance of the monthly estimates ($\hat{C}_{m,l}$) is:

$$v\left(\hat{C}_{m,l}\right) = \frac{\left(N^{T}_{m,l}\right)^{2}}{n} v_{m,l}$$

where $v_{m,l}$ is an estimate of the stratum variance given by

$$v_{l,m} = \frac{\sum_{i=1}^{n} \left(c_{m,l,i} - \bar{c}_{m,l}\right)^{2}}{n_{m,l} - 1}$$

By pooling the stratified variance, that is, within and between sampling sites both monthly and yearly estimates of the variance can be obtained. Thus, the variance of the annual yield of a site is:

$$v\left(\hat{C}_l\right) = \sum_{m=1}^{12} v\left(\hat{C}_{m,l}\right)$$

and the variance in the annual yield for all sites is:

$$v\left(\hat{C}\right) = \sum_{l=1}^{L} \sum_{m=1}^{12} v\left(\hat{C}_{m,l}\right)$$

where L is the total number of sampled landings sites.

The standard errors of the estimate are simply

$$s\left(\hat{C}\right) = \sqrt{v\left(\hat{C}\right)}$$

and the 95% confidence interval of the estimated catch is:

$$\hat{C} \pm 1.96 s\left(\hat{C}\right)$$

Non-sampled landing sites

In St. Lucia there are a number of landings sites that are not sampled. In principle it is assumed that a certain sampled landing site is representative of a certain non-sampled landings site(s). This means that these sites belong to the same strata. It is assumed that the mean and the variance of the individual trips are the same for the landings sites within a given strata although the total effort (number of boat trips in a month) may be different. To account for total effort within a stratum one therefore needs the total number of trips within a month in the non-sampled landings stations. The number of boat trips used in the equations above would hence be modified by:

$$N_{m,l}^{T} = N_{m,l}^{Tsampled} + N_{m,l}^{Tnon-sampled}$$

In practice the mean number of trips at a non-sampled sites are not collected on a monthly basis but is based on an estimate that is derived by expressing the number of boats from a non-sampled site as a ratio of the number of boats at a sampled site with similar characteristics

From these estimates of effort at the non-sampled sites a ratio of the effort is calculated and subsequently used:

$$N_{m,l}^{T} = N_{m,l}^{Tsampled} + rN_{m,l}^{Tsampled} = N_{m,l}^{Tsampled}\left(1+r\right)$$

The ratio used for the various non-sampled sites and the associated sampled site for which this ratio is applied to is given in Table 4.

3.2 Analysis of total catch variations

Analysis of Variance (ANOVA)

Analysis of variance commonly known as ANOVA is a statistical method for making simultaneous comparisons between two or more means. The model assumes two hypotheses: zero hypotheses and an alternative hypothesis.

The model assumptions are:

1. $H_{0:}$ The zero hypothesis assumes all means are equal.
2. Ha: The alternative hypothesis assumes that the means are not equal or at least one pair is not equal.

Methodology

An analysis of variance (ANOVA) was performed to determine whether any significant differences existed between the estimated landings (total catch) for:

- Site.
- Year.
- Month.

Data

To fulfil the underlying assumption of ANOVA the dataset from 2005-2010 for nine landings sites (CASF, CAST, CHOI, DENN, GROS, LABO, MICO, SOUF, VIFO, OTHER) were used and a comparison among months, years and sites was justified. Log-transformed data were used to obtain a normal distribution with equal variance.

Results

	Df	Sum sq	Mean Sq	F value	Pr (>F)
Site	9	554.23	61.581	283.9564	<2.2e-16 ***
Factor (Month)	11	55.20	5.018	23.1401	<2.2e-16***
Site: (factor) month	99	50.51	0.510	2.3528	4.882e-10***
Residual	548	118.84	0.217		

*Indicates the level of significance of interaction

A two-factor model with interaction was applied to compare sites and months. The results indicate, based on the interaction model, that there are significant differences between months and sites. When year was tested no significant differences occurred between years.

4 FINDINGS

4.1 Sampling

4.1.1 Under sampling and over sampling

According to the sampling strategy currently in place data should be collected for 15 days. However, the analysis revealed that sampling takes place in excess of 15 days at some sites. This appears to be more prevalent at Gros Islet (Figure 3). On the other hand sampling at some sites are significantly less than the stipulated 15 days. This practice is relatively common at Anse La Raye, Castries, Micoud.

Although the raising factor may account for this irregularity the confidence interval among sites and months will be affected. It is obvious that if this practice of over sampling (> 15 days) and under sampling (<15 >8 days) is not addressed then it will create a bias in the estimates if the sampling strategy is not followed as prescribed.

4.1.2 Missing Months and less than 8 days data

According to the frequency sampling plot in Figure 3, the brown dots represent the total fishing days for each month and the orange dots represents the total sampling days for each month. The horizontal black line indicates when less than 8 days data were collected. Whereas the orange dots and lines that fall on zero indicates when no data was collected.

It is apparent that at many sites sampling takes place for less than 8 days in a month. When this happens, data for the same month of the previous year is substituted to account for landings for that month. The same procedures apply when no data are collected for a particular month. In both situations when this occurs estimates of landings are arrived at without any consideration of actual effort. This assumption that data from a previous year adequately reflects what happens in the current year can be flawed needs to be revised further.

4.1.3 Observed Changes

In 1995, sampling was based on a census survey where data was collected on every possible fishing day. Hence, Figure 3 shows from 1995, sampling was done for more than 15 days currently being sampled. It is evident however that between 1995 and 1999 there was some variation in the number of sampling days among sites. The figure also shows that after 1999, there was a transition in the number of sampling days from the census survey to the current sampling strategy. Despite the adoption of the new sampling strategy the inconsistencies remained because data collectors still do not follow the 15 stipulated sampling days.

The protocol for how the number of fishing days in a month is determined changed over time and it is uncertain why this happened. In Figure 3, Castries, Choiseul, Gros Islet, Laborie and Micoud appeared to have had a similar change in the total number fishing days between 2007 and 2008. It is believed that either fewer holidays were removed or all days in the months were considered as fishing day. This too can contribute to a bias in the estimated landings for the period.

Figure 4 points out the distribution of sampled vessels among sites. This figure attempts to explain the variations in total catch among sites based on the effort levels.

4.2 Landings

4.2.1 Comparison of estimated landings

Originally, data for 1995-2010 were to be used in the comparative analysis. However, it became extremely difficult and impossible to trace the procedures used to obtain the estimated landings from 1995 to 2000. That procedure was not clear. Apart from the 60% extrapolation, the data were subjected to further manipulation to arrive at the total estimated landings but these additional steps were not documented. The disparity between the calculation in this study and the official estimates was 67% on average (Table 5 and Figure 5). Due to that fact, further analysis was restricted to data for the period 2001 to 2010.

When the estimated landings from the official summaries were compared to the estimated landings derived from calculation in this study, an average difference of 3% was observed for 2001-2010 (Figure 6). This difference was an average of 55 tonnes, with a low of 8 tonnes in 2009 and a high of 128 tonnes in 2004 seen in Table 5. These differences can be attributed to the unavailability of the additional data that is manually entered during analysis, the manipulations made for missing months and less than 8 days data. Another factor, which may have contributed to these differences, are the unavailability of the period when the estimates for conch and lobster was raised.

4.2.2 Non sampled sites

Of major concern was the method used to establish comparable sites for the purpose of estimating landings at non-sampled sites and the use of different strata for this method. Sampled sites with similar fishing activities to non-sampled sites are used to determine the landings for that non-sampled site (Table 2). An assumption is made that a percentage of what was caught at a sampled site are caught at the non-sampled site. This practice can result in bias in the estimation of landings as the methodology only considers the similarity of fishing activities at the two sites and no consideration is given to the actual catch composition, sampling patterns overtime and actual effort level at those sites.

The percentage used for calculating non-sampled site landings for 2001-2010 shown in Table 3 does not reflect the correct percentages based on the formula, which is stated in the procedures. Table 4 illustrates the revised percentages and in some instances the percentages show wide variations and that could have impacted on the accuracy of the estimated landings for the period 2001-2010. The revised percentages were calculated based on the registered vessel figures in Table 6 and the formula according to the internal procedures.

In some instances, sites from different strata were used as comparable sites as seen in Table 2. Figure 8 shows sampling patterns of two sites Soufriere (primary site) and Anse La Raye (secondary site). This figures illustrates the effort levels based on vessels sampled and the catch composition for each year. In figure 8, Soufriere sampling pattern is such that, an average of 5-10 vessels were sampled during the period 1995 to 1999and the catch composition was made up of ocean pelagics (OP), reef fish (RF) and coastal pelagics (CP). However, for the same period Anse la Raye's average number of vessels sampled was 3 and the catch composition was also made up of ocean pelagics (OP), reef fish (RF) and coastal

pelagics (CP). Notwithstanding, the similarity in fish caught (fishery type), the composition of the catch by month at Soufriere showed a lot of variability when compared to Anse La Raye by month for 1995 to 1999. Yet, for the years Anse la Rayewas not sampled 2000-2008, data from Soufriere was used to estimate landings for Anse la Raye. This indicates that the methodology of comparing sites without further monitoring and validating the assumptions over time can skew the estimated landings by catch composition. Another factor that can impact estimates is the use of different strata for comparisons. This is particularly so when effort is the only determining factor used to obtain these estimated figures. Similarly, the practice of using the ratio of the number of vessels registered at a non-sampled site to that of a sampled site to estimate landings at a non-sampled site can also result in bias estimates. This is because it does not consider the actual effort or the catch composition for the site. In theory this is not logical when these important factors are not considered. A more logical method would be to use the number of trips.

4.2.3 Other Findings

The seasonal trends for Saint Lucia reflected the reported high and low season within the fishery. These trends were similar throughout the period 2001 to 2010. This is presented in the box plot in Figure 7, which shows variation based on total catch by site, year and month.

5 DISCUSSION

The examination of the data management system of the Department of Fisheries in St. Lucia revealed that it contains all the basic elements that allow it to serve the purpose for which it was set up. However, because the department only collects catch and effort data the information has limited usage. It is useful for following trends, seasonality of catch, for predicting gluts and shortages in the supply of fish and for marketing policy including the setting of prices. However, since no biological data is being collected, the data has very limited use for stock assessment. In general nonetheless, the data collected at the landing sites provide the data that is required for estimating total fish landings. However, it has not yet been determined whether the total number of sites where the data are collected is adequate or insufficient.

The licensing system for fishing vessels differentiates between the vessel types. The catch data on the other hand does not make provisions for whether the catch came from a specific vessel types. Therefore, it may be impossible to make a determination of which vessel types contributes the most to fish landings.

The sampling analysis revealed that there is fairly wide variation in the collection of catch and effort data between sites. For Gros Islet, Micoud and Castries, data collection does not take place consistently for the required fifteen days. In comparison, the records indicate that the collector at Choiseul regularly worked the required fifteen days per month. This situation raises questions about the differences in the data being collected.

There are instances where less than eight days of data or no data are collected. Consequently, the system relies on data from previous years to estimate current year landings. Given that some of the previous year data may not have been validated and that the catch and effort for the two years in question may have been significantly different, it can be concluded that problems can arise in the analysis of the data.

According to the data in Figure 9 the total number of vessels engaged in the fishery decreased from 2001 to 2010. The data also indicate that the average catch per vessel has increased over the same period. One may assume from this that the greater the number of vessels engaged in fishing, the lower the financial returns per vessel. Whilst it may be beneficial to the sector to encourage investment in more vessels the average returns based on these trends may decrease per vessel.

There are also major issues with the method that is utilized to arrive at the estimate of landings at non–sampled sites. Firstly, the procedure that is used for utilizing data from a sampled site is prone to error as it does not consider whether any unusual situations may have taken place at the sites during the year, whether the effort level or catch composition was the same. Therefore, the assumptions made with regard to the actual landing of particular species may be incorrect. There is a need to validate these assumptions on a regular basis since the catch does not remain static from year to year.

Although verification takes place at two stages in the data analysis process, after entry and before analysis, during this study several errors were encountered. These errors ranged from omissions, typographical errors to coding inconsistencies. It is evident that further verification is required and more standardized verification checks must be made of the data at different data management stages. This would become even more necessary, before the data

are subjected to analysis and storage. The errors found in the stored data have the potential to further compromise the integrity of the data system. Therefore, a good data management system should have, as an integral component, documentation that provides explanations of the procedures as well as guidelines for all users of the system. All language, descriptions and processes should be standardized for ease of interpretation.

6 RECOMMENDATIONS

6.1 Sampling strategy

- To review and update the list of landing sites.
- To classify landing sites into strata and to set a criteria for each strata.
- To monitor non-sampled sites to assess effort levels and actual landings periodically.
- To closely monitor the data collectors' workdays to ensure the 15 stipulated workdays are followed.

6.2 Data analysis procedures

- To clearly document all analysis methods and steps.
- To ensure the analysis procedures are systematic. Any new changes to the analysis procedures are documented.
- To consider all possible factors in determining which sampled site is used to extrapolate for a non-sampled site.
- To ensure all DBF files are error free before placing in storage. Any subsequent cleaning or updating is made to all stored copies.
- To record electronically all notes from the "Data Analysis Issues to Consider Notebook" preferably within the final analysis worksheet.
- To use the annual vessel summary figures to calculate percentages for extrapolation of non-sampled sites.
- To standardize the verification checks for data analysis.
- To discontinue the manual data entries because of the potential for bias.

6.3 General

- To record electronically the "total boats out" data.
- To store all analysis files and data summaries for LRSin in one central storage folder that is password protected. A back up folder should also be kept.
- To implement a biological sampling plan within the collection system.
- To analyse and make use of the site visit information to monitor collectors performance.

7 CONCLUSION

One of the aims of the Department of Fisheries is to ensure a sustainable fishery for future generations. However, in order to achieve this, various management mechanisms and structures need to be put in place. One of those mechanisms is an effective and reliable data management system. To ensure reliability the system must be regularly appraised, reviewed and upgraded. Otherwise, it runs the risk of providing inaccurate information upon which major decisions about the fishery may be made.

The project focus was to evaluate the current system and make recommendations for adjustments where appropriate. The recommendations that came out of this project are meant to improve the overall data collection system, as well as strengthen the capacity of the data unit staff to carry out analysis in a more methodological and systematic way. This would ensure that the summaries and analysis obtained would provide some level of framework for implementing policies and changes for the management of the fishery.

Notwithstanding that a number of weaknesses were identified, overall with some minor improvements, the system can achieve the objective for which it was set up. What may be required is the adoption of the new database CARIFIS, adhering more closely to the sampling plan, improving the analysis procedures and the capacity of the data management unit.

TABLES

Table 1. Summary of developments in Data Management System.

Year	Developments within the system	Applied or used to date
1979	• Collection of catch and effort data commenced • A 50% extrapolation of the actual landings was used for the total estimation of the annual landings	✓ x
1981	• Statistical Unit process data	X
1983	• Fisheries Unit process data • A 60% extrapolation of the actual landings was used for the total estimation of the annual landings in addition to other unknown steps	X x
1987	• A "R-base" database was used to capture catch and effort data	X
1995	• TIP database was introduced and used to capture catch and effort data • An 11 sequence # format was generated by TIP • Data collection ceased in Banannes	✓ x x
1996	• Data collection ceased in Canaries	X
1997	• Fisheries Unit became a Department • Fisheries Department process data	✓ ✓
1999	• Sampling Strategy was introduced • Analysis procedure was developed • Data collection ceased in Anse La Raye	✓ ✓ x
2000	• A 13 sequence # format was generated by TIP	✓
2001	• Full analysis procedure was incorporated (7 files) • The collection of price data commenced • Data collection ceased in SABA & RIDO	✓ ✓ x
2004	• Data collection was resumed in Banannes	✓
2007*	• CARIFIS database was introduced	X
2008	• Data collection was resumed in Anse la Raye	✓
x – indicates this is not applied to date **✓ indicates this is still applied to date**		

Table 2. Landing sites and strata listings.

Site	Site Code	Site Category	Strata Category	Comparable site	Changes
ANSE LA RAYE	ANSE	Sampled	Secondary		2008*
BANANNES	CAST	Sampled	Tertiary		2004*
CASTRIES	CAST	Sampled	Primary		
CHOISEUL	CHOI	Sampled	Secondary		
DENNERY	DENN	Sampled	Primary		
GROS-ISLET	GRIS	Sampled	Primary		
LABORIE	LABO	Sampled	Secondary		
MICOUD	MICO	Sampled	Secondary		
SOUFRIERE	SOUF	Sampled	Primary		
VIEUX-FORT	VIFO	Sampled	Primary		
CANARIES	CANA	Non Sampled	Secondary	SOUF/ANSE	2009**
CUL DE SAC	CULD	Non Sampled	Tertiary	GRIS	
MARIGOT	MARI	Non Sampled	Tertiary	GRIS	
MARISULE	MASU	Non Sampled	Tertiary	GRIS	
PRASLIN	PRAS	Non Sampled	Secondary	MICO	
RIVER DOREE	RIDO	Non Sampled	Tertiary	MICO/GRIS	2005**
ROSEAU	ROSE	Non Sampled	Tertiary	GRIS	
SAVANNES BAY	SABA	Non Sampled	Secondary	MICO	

* Change in site category ** change in comparable site

Table 3. Percentages used to raise landings from sampled site estimates for non-sampled sites estimates.

Comparable Sites	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
% of SOUF used for ALRA/CANA	67%	67%	67%	67%	67%	67%	67%	67%		
% of ALRA used for CANA									76%	76%
% of MICO used for PRAS/SABA/RIDO	154%	154%	154%							
% of MICO used for PRAS/SABA				154%	154%	154%	154%	154%	154%	154%
% of GRIS used for OTHER SITES	66%	66%	66%			100%	100%	100%	100%	100%
% of GRIS used for LOBSPT				12.24%						
% of GRIS used for RIDO/ROSE/MARIG					82%					
Total sampled sites	8	8	8	9	9	9	9	9	10	10
Total non-sampled	14	14	14	13	13	13	13	13	12	12
NS sites counted	14	14	14	5	7	13	13	13	12	12
NS uncounted	0	0	0	8	6	0	0	0	0	0
Total Landing Sites	22	22	22	22	22	22	22	22	22	22

Table 4. Revised percentages from Table 3 using vessel figures from Table 6.

Comparable Sites	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
% of SOUF used for ALRA/CANA	64	67	51	55	47	47	50	63		
% of ALRA used for CANA									150	130
% of MICO used for PRAS/SABA/RIDO	159	153	152							
% of MICO used for PRAS/SABA				115	120	96	111	150	120	136
% of GRIS used for OTHER SITES	130	127	125	141	27	60	61	29	33	34
% of GRIS used for RIDO/ROSE/MARIG					39					
Sampled	8	8	8	9	9	9	9	9	10	10
Non sampled	12	12	9	8	8	8	8	8	7	7
Total Landing Sites	20	20	17	17	17	17	17	17	17	17

NS – Non-sampled site

Table 5. Comparison of the estimated landings.

Year	**Total estimated landings**		**Differences in total**	**Percentage % difference**
	Official Data	**Present study**		
1995	982	1014	-33	-3
1996	1316	482	834	63
1997	1312	511	801	61
1998	1462	520	942	64
1999	1718	514	1204	70
2000	1860	482	1378	74
2001	1967	1873	94	5
2002	1607	1538	69	4
2003	1446	1412	34	2
2004	1519	1391	128	8
2005	1386	1357	29	2
2006	1440	1354	86	6
2007	1508	1482	26	2
2008	1809	1751	58	3
2009	1856	1848	8	0
2010	1800	1781	19	1

Table 6. Total registered vessel by landing site.

Landing Site	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
ANSE LA RAYE	47	51	25	31	25	24	28	20	18	20
BANANNES	53	59	36	35	37	39	39	34	34	34
CANARIES	37	40	30	30	30	30	32	25	27	26
CAS EN BAR	3	3								
CASTRIES	127	133	56	59	58	60	60	39	53	58
CHOISEUL	69	72	45	45	49	51	53	42	42	46
CUL DE SAC	3	3								
DENNERY	83	88	59	63	68	67	72	66	64	65
GROS-ISLET	84	93	48	49	51	52	51	45	46	47
LABORIE	67	70	31	39	36	34	35	36	38	37
MARIGOT	10	11	8	11	11	10	10	1	3	4
MARISULE	19	21	14	14	14	14	14	6	6	6
MICOUD	37	40	23	26	25	27	28	20	25	25
MONCHY	11	11								
PRASLIN	21	21	13	14	13	11	13	14	15	16
RIVER DOREE	19	20	7	7	7	5	5	5	5	5
ROSEAU	10	10	2	2	2	2	2	1	1	1
SAVANNES BAY	19	20	15	16	17	15	18	16	15	18
SOUFRIERE	131	135	107	111	117	116	119	71	74	71
VIEUX-FORT	158	177	150	117	120	133	142	133	134	139
Totals										
Vessels	1008	1078	669	669	680	690	721	574	600	618
Landing Sites	20	20	17	17	17	17	17	17	17	17
Sampled Sites	8	8	8	9	9	9	9	9	10	10
Non sampled Sites	12	12	9	8	8	8	8	8	7	7

FIGURES

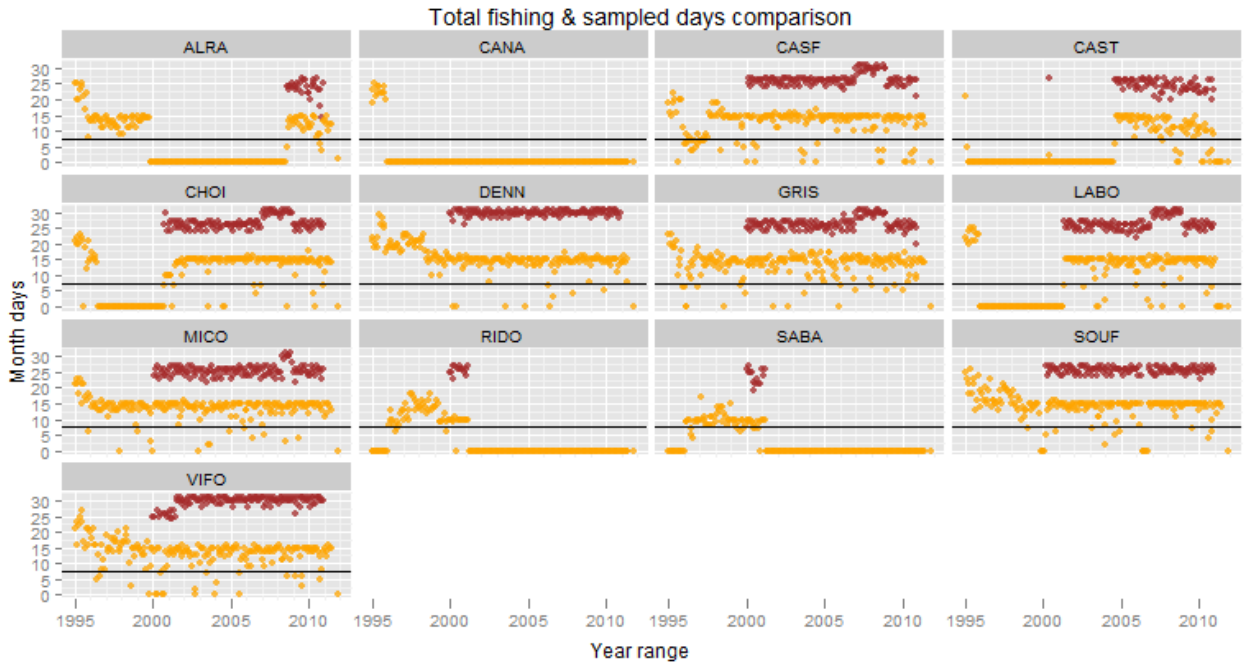


Figure 3. Comparison of sampling days (orange) and fishing days (brown) by landing sites from 1995-2010. The horizontal black line represents 8 days. The full name of each landing site is given in Table 2.

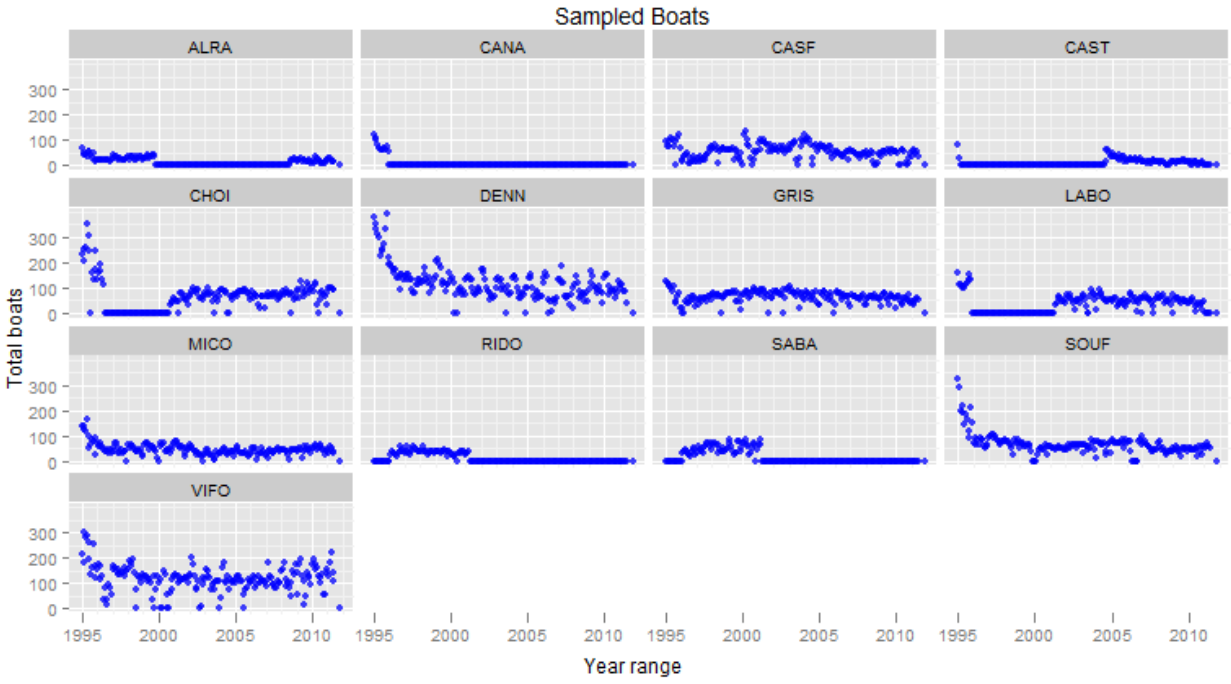


Figure 4. Number of vessels sampled each month by landing sites from 1995 – 2010. The full name of each landing site is given in Table 2.

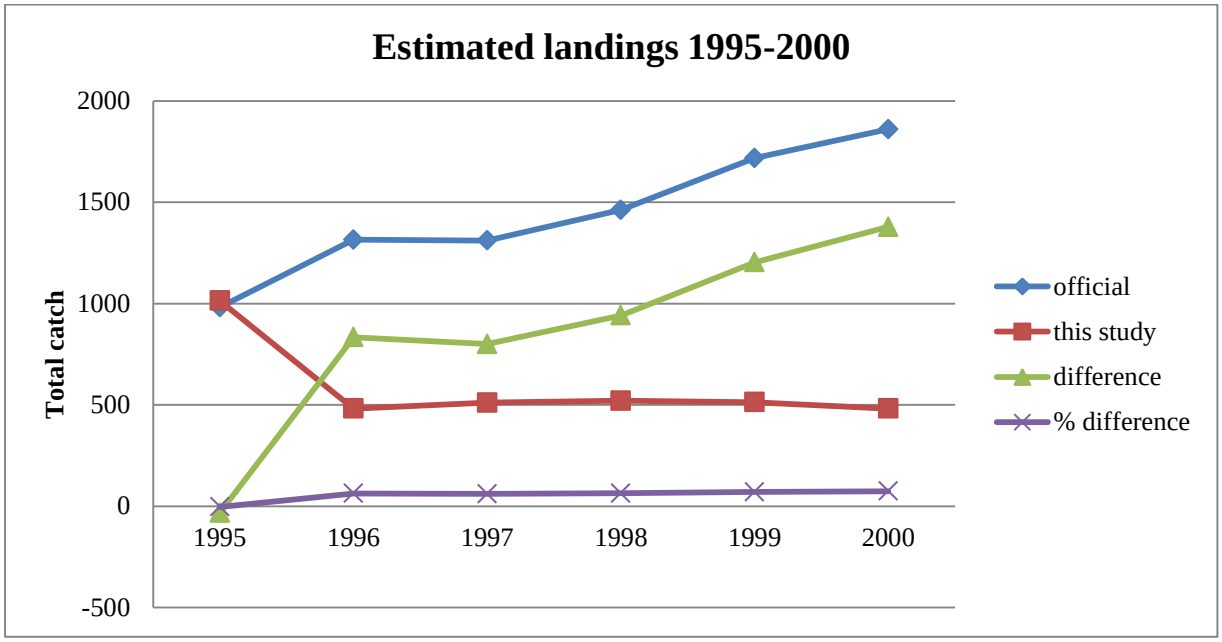


Figure 5. Comparison of the official and this study estimated landing for .1995-2000 indicating differences and percentages differences.

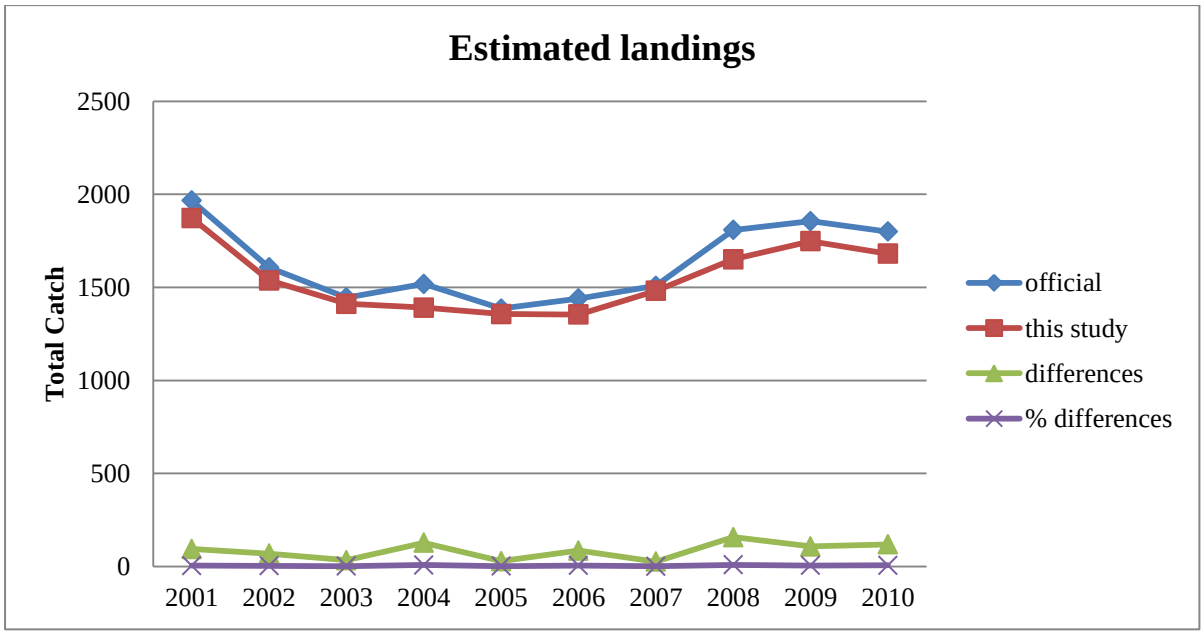


Figure 6. Comparison of the official and this study estimated landing for 2001-2010 indicating differences and percentages differences.

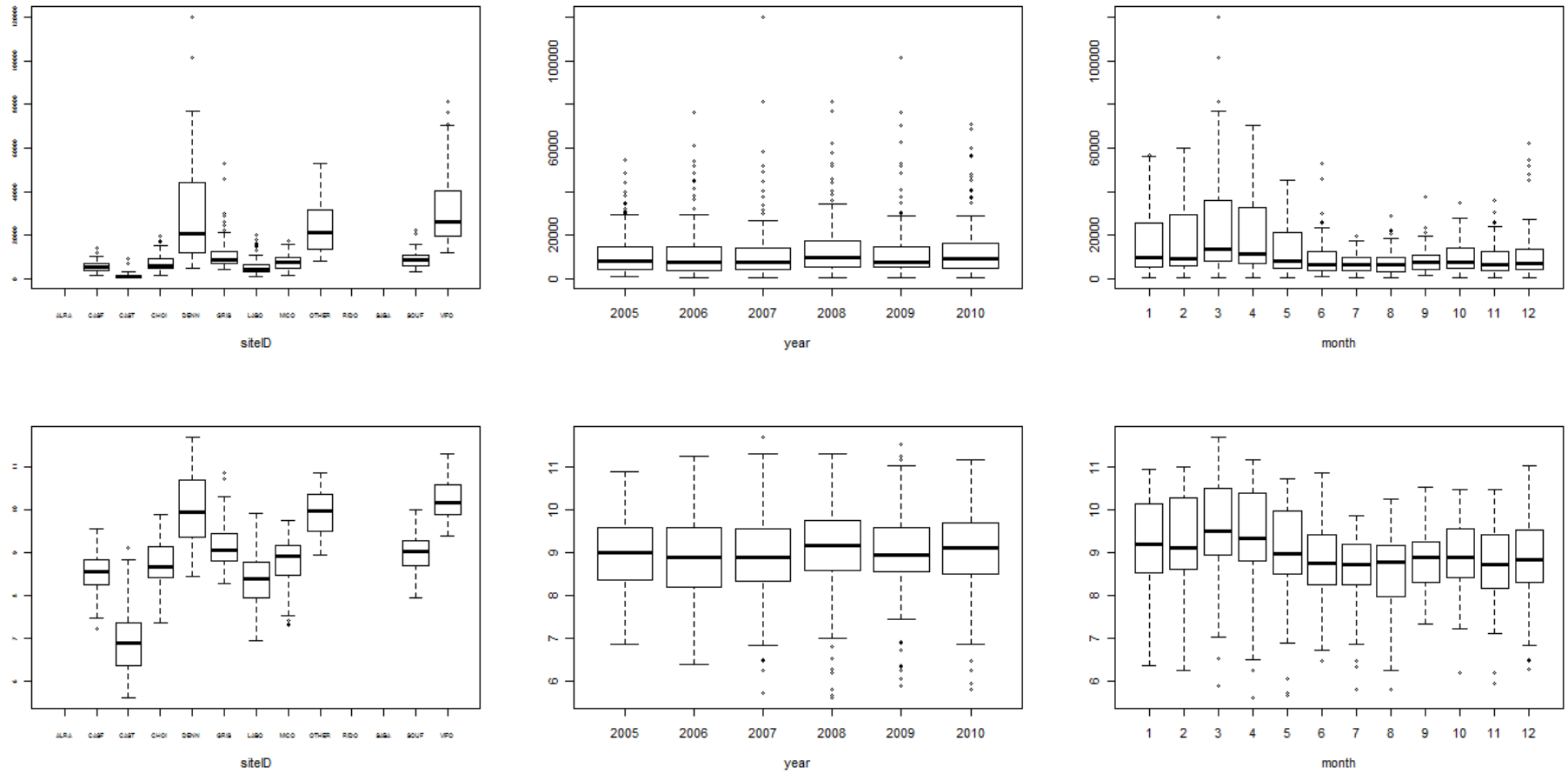


Figure 7. Box and whisker plot showing variance in total catch between site, year and month.

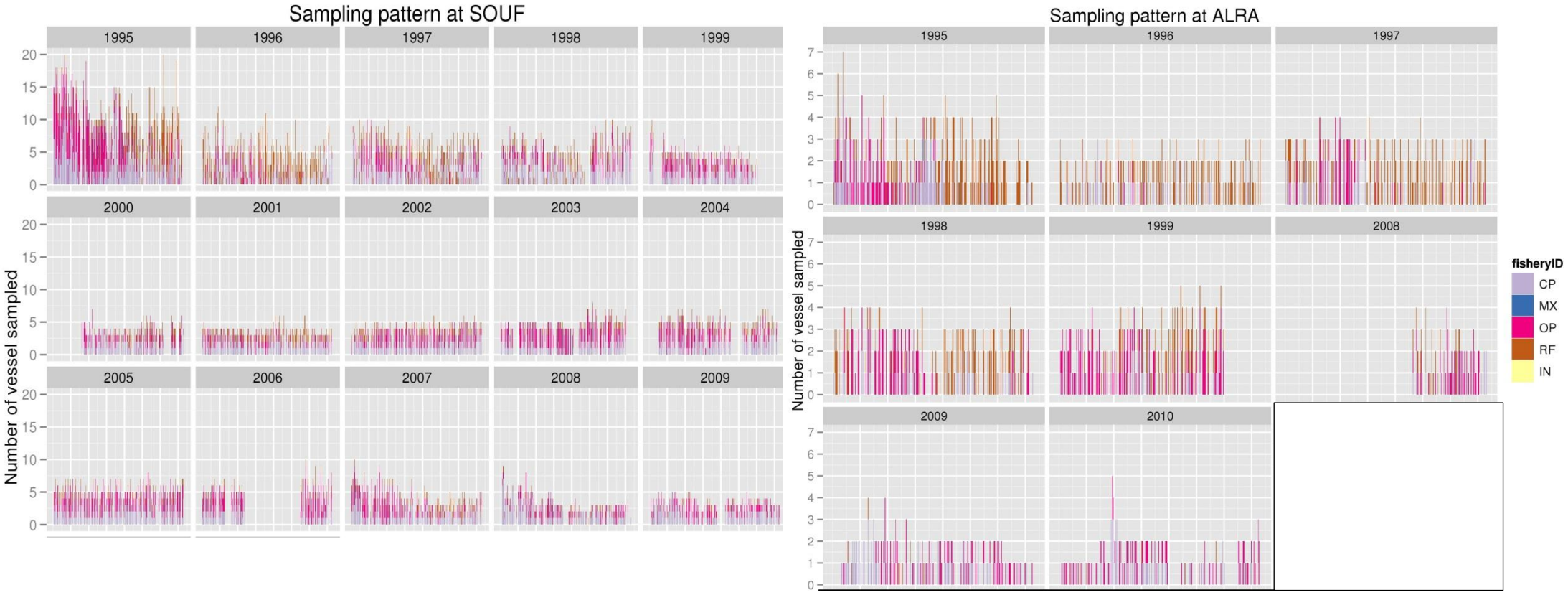
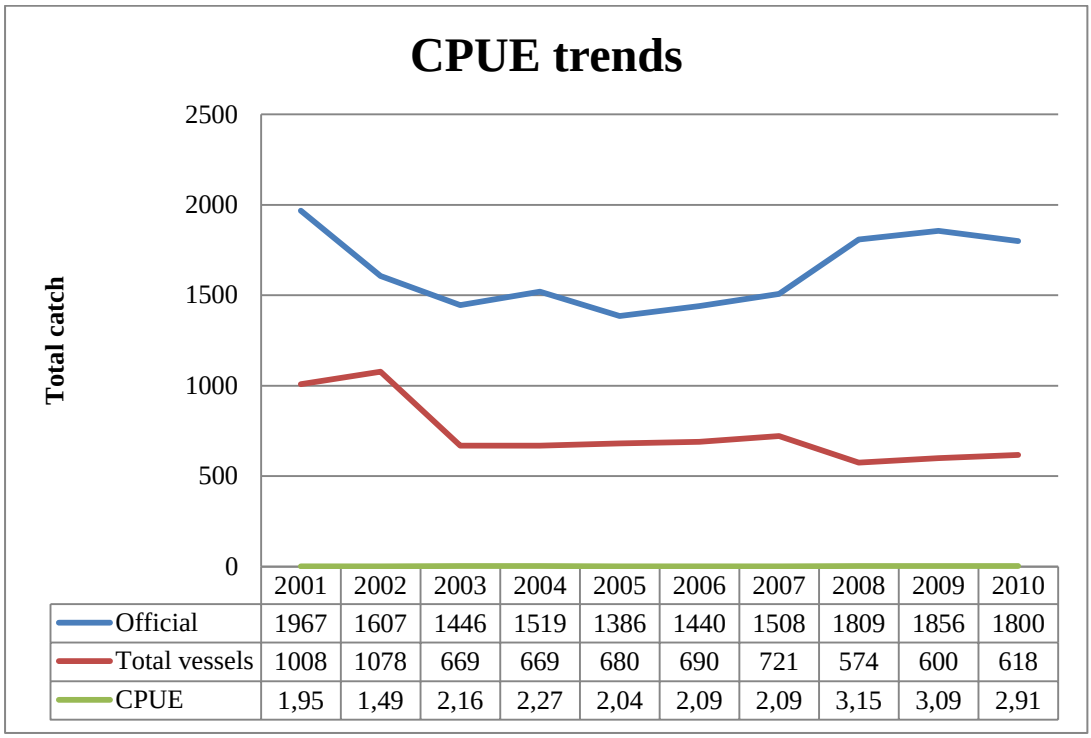


Figure 8. Soufriere &Anse la Raye landing site sampling patterns. Showing the frequency of sampled fishing trips by fishery type from 1995-2010. Fishery ID: CP-coastal pelagic, MX-mixed fish, OP-ocean pelagic, RF-reef fish, IN-invertebrate, EG.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Official	1967	1607	1446	1519	1386	1440	1508	1809	1856	1800
Total vessels	1008	1078	669	669	680	690	721	574	600	618
CPUE	1,95	1,49	2,16	2,27	2,04	2,09	2,09	3,15	3,09	2,91

Figure 9. CPUE figures based on the official estimated landings.

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APPENDIX

Appendix I: Saint Lucia Data Collection Form

ST. LUCIA DATA MANAGEMENT PROGRAMME
FIELD DATA SHEET

Landing Site	Weather	Date	Checked
Date	Sea State	Name of collector	Total Vessels Out

*VE-Visual estimate, FE-Fishermen estimate, WT-Weight measurement, GP-Gutted Weight

Crew Size				
Landing Order				
Boat ID Number				
Time-Departure				
Time Returned				
Area Fished/Zone				
Fuel Used(Gal.)				
Gear Primary				
Gear Secondary				
Number of gear used (Trol, Pots, Nets, L-ling)				
Number of Sets (Nets, L.lines)				
Range of depth Pots, Nets, L-lines)				
Nets & Pots (mesh size)				
Nets & Pots Soak time time)				
Total Number of Hooks				
Weight Type (VE, FE, WT)				
SPECIES NAME				
Trip Interview Program Sequence number				

*No. Sharks Caught*_____ *No. Tunas Caught*_____ *No. Wahoo Caught*_____

*No. Dolphin Caught*_____ *YFT more than 20lbs*_____ *YFT more than 60lbs*_____

Comment on low & no catch, early return, weather condition & currents: