OVERVIEW OF FISHERIES DATA COLLECTION AND MANAGEMENT IN GRENADA

Olando K. Harvey
Grenada Fisheries Division
Melville Street, St. George's, Grenada
landokeri@yahoo.com

Supervisors:

Jón Sólmundsson, Jónas Páll Jónasson
Marine and Freshwater Research Institute, Iceland
jon.solmundsson@hafogvatn.is, jonas.jonasson@hafogvatn.is

ABSTRACT

There is a consistent upward trend in the total landing of fish in Grenada since the 1980s which may be as a result of improvement in fleet capacity (i.e. size and efficiency). The increase in fishing capacity is at its highest point in the history of Grenada; therefore, the risk to marine resources from the negative impacts of overharvesting is also at its highest. Consequently, it is critically important that the management of fisheries is based on empirical data on the status of the harvested resources to effectively manage against unsustainable harvest levels. This paper evaluates the current data collection and management system of the Grenada Fisheries Division in an effort to identify gaps that exist. It also provides practical recommendations which could be implemented in the short term (i.e. 1-3 years). Landing data are currently collected at every primary landing site, but with some inconsistencies in data entry. There has been a lack of biological and environmental data in the recent decade. With the implementation of the MPAs in Grenada, systematic visual reef surveys have been conducted. Given the unique differences of life history traits that can occur within and between a family or genus of fish, it is important not to implement a one size fits all approach to stock assessment; consequently, a suite of assessment methods appropriate for the available data must be employed. Given the data that is currently available and the suggested additions to the collection system, a combination of landing statistics, length-frequency and surplus production models would be the most appropriate assessment methods to determine the status of both demersal and pelagic stocks. In addition, visual surveys could be utilised to augment fisheries dependent assessment for shallow reef species especially for those un/underreported within the landing data.

This paper should be cited as:
Harvey, O. 2019. *Overview of fisheries data collection and management in Grenada*. United Nations University Fisheries Training Programme, Iceland. Final project. http://www.unuftp.is/static/fellows/document/Olando18prf.pdf.

CONTENTS

List of Figures

List of Tables

List of Abbreviations

AGRRA: Atlantic and Gulf Rapid Reef Assessment
BLIN: Bottom Longline
CCI: Caribbean Challenge Initiative
CCRF: Code of Conduct for Responsible Fisheries
CFRM: Caribbean Regional Fisheries Mechanism
CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE: Catch Per Unit Effort
DPMMFG: Draft Plan for Managing the Marine Fisheries of Grenada
EEZ: Exclusive Economic Zone
FAC: Fisheries Advisory Committee
FAD: Fish Aggregating Device
FAO: Food and Agricultural Organisation
FDIV: Free Diving
FMP: Fisheries Management Plan
GAMPA: Grand Anse Marine Protected Area
GCRF: Grenada Coral Reef Foundation
GDP: Gross Domestic Product
GFD: Grenada Fisheries Division
GMPA: Grenada Marine Protected Areas
GoG: Government of Grenada
GoMPA: Gouyave Marine Protected Area
GPASP: Grenada Protected Area System Plan
HACCP: Hazard Analysis and Critical Control Points
ICCAT: International Commission for the Conservation of Atlantic Tunas
IUCN: International Union for the Conservation of Nature
JICA: Japan International Cooperation Agency
LMPA: Levera Marine Protected Area
MPAs: Marine Protected Areas
NETS: Nets (i.e. Drift, Gill or Beach Seine)
OECS: Organisation of Eastern Caribbean States
POTS: Fish Pots/Traps
PSMA: Port State Measures Agreement
SCIMPA: South Carriacou Islands Marine Protected Area
SCUB: SCUBA Diving
SCUBA: Self-Contained Underwater Breathing Apparatus
SIOBMPA: Sandy Island Oyster Bed Marine Protected Area
SRO: Statutory Rules and Orders
TAC: Total Allowable Catch
TNC: The Nature Conservancy
UNFSA: United Nations Fish Stock Agreement

INTRODUCTION

1.1 Context

Grenada is a small archipelagic state located at the southern end of the Eastern Caribbean island chain (12°07'N & 61°40'W). Despite the relatively small (i.e. 348 km^2) landmass that comprise the islands of Grenada, it has an exclusive economic zone (EEZ) of 24,153 km^2, 1,595 km^2 of which constitutes the shelf (**Figure** *1*) (Mohammed and Rennie, 1998). Fishing has been an important activity for the survival of the inhabitants of Grenada since precolonial times. Fisheries continue to be of importance economically to Grenada representing approximately 1.5% of the national gross domestic product (GDP) (FAO, 2016). Additionally, fisheries resources constitute a significant source of dietary protein for Grenadians given that the annual per capita consumption of fish was 28.9 kg in 2011 (FAO, 2016). Grenada does not have any major bodies of freshwater (i.e. lakes or rivers) that can sustain commercial fishing; therefore, all capture fisheries are executed in the ocean.

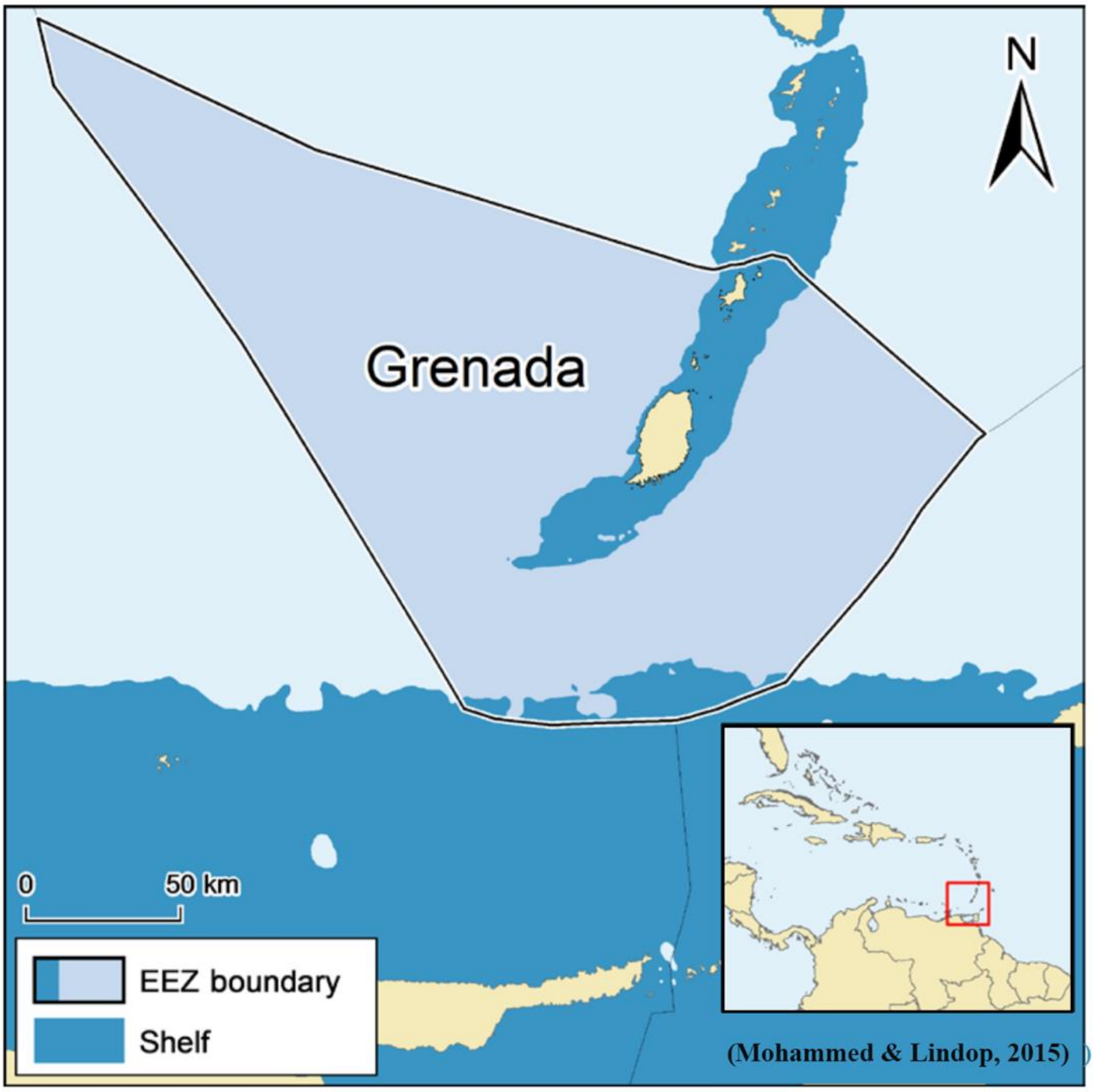


Figure 1: Grenada's Exclusive Economic Zone (EEZ) and shelf area (to 200 m depth).

1.2 Rationale

Currently the Grenada Fisheries Division (hereafter GFD) has a data collection and management system that was created decades ago and has not been updated or modified to meet current requirements. Despite the systematic collection of landing data at all formal landing sites, there is no mandate for the data collectors to record length frequency data which is important for conducting effective stock assessments. Additionally, there is no formal stock assessment currently being conducted to provide tactical management advice (e.g. fishing effort and fleet size) to facilitate the sustainability of fish stocks or fisheries in Grenada.

Consequently, this project aims to evaluate the current data collection and management system of the GFD in an effort to identify gaps and provide practical recommendations that could be implemented in the short to medium term (i.e. 1-3 years) to rectify identified gaps and facilitate the implementation of appropriate fisheries stock assessment methods in Grenada.

More specifically, this project will:

1. Develop an updated description of the Grenadian fisheries as it relates to characteristics of the fleet, gear, target species and catch rules.
2. Conduct a gap analysis of the current fisheries monitoring program (i.e. collection, handling, and storage of fisheries data).
3. Provide practical recommendations to address identified gaps to include, where appropriate, templates for data collection and storage database(s).
4. Provide recommendations on appropriate stock assessment methods given current human and financial capacity within the GFD.

2 LITERATURE REVIEW

2.1 Evolution of the Grenadian Fishery

There have been two distinct technological advancement periods in fisheries both of which have been facilitated by government of Grenada (GoG) subsidies in the form of duty-free loans to procure engines, gear and fishing equipment (Mohammed & Lindop, 2015). The first technological advancement occurred during the early 1960s and saw the equipping of locally built vessels with outboard engines which allowed for the first time the opportunity to quickly and reliably access fishing ground beyond the continental shelf (Mohammed & Rennie, 2003). This led to a transition in the fisheries from a near shore demersal fishery targeting groupers (e.g. *Epinephelus guttatus*) and other reef species to a pelagic fishery targeting large pelagics including blackfin tuna (*Thunnus atlanticus*), bonito (*Sarda sarda*) and billfish by trolling (Mohammed & Lindop, 2015).

The second major technological advancement in the Grenadian fishery began in the early 1980s. This period began with the deregulation of retail fish prices instituted in the 1940s to facilitate access to fish by the entire population and continued with the introduction of longline fishing technologies by Cuban experts (Mohammed & Lindop, 2015). There was slow uptake of the longline fishing method primarily due to the entry and operating costs. However, following a donation of eight semi-industrial vessels in 1991 by the Japan International Cooperation Agency (JICA) to the GoG, efforts were made to train fishers to effectively employ longlines targeting yellowfin tuna (*Thunnus albacares*) and swordfish (*Xiphias* *gladius*) for the export market (Mohammed & Lindop, 2015). The introduction of the longline fishing industry transformed fisheries in Grenada from a subsistence to an export-oriented activity (Mohammed & Lindop, 2015).

Today the fishery in Grenada is executed by approximately 3,250 fishers using 904 vessels, 90% of which are motorised (FAO, 2016). There are eight distinct fisheries in Grenada which are generally divided into two categories (i.e. pelagic and the demersal) defined by the target species (see Appendix 1) (GoG, 2009). There has been a consistent upward trend in total fish landing in Grenada since the early 1980s dominated by catches of large pelagic (Annex 1) (GFD, 2018). There was a five-year period from 2004 to 2009 where there was a significant drop in landings of small pelagic which has since shown signs of recovery (GFD, 2018). In 2002 there was also a significant increase in the total landings of demersal finfish; that is, a doubling of average landings prior to that point (GFD, 2018).

2.2 Demersal Fishery

The demersal fishery is executed primarily by artisanal fishers using small (i.e. 3-8 m) locally built vessels with outboard engines and limited electronics (Baldeo, 2018). The demersal fishery targets five main finfish families (i.e. snappers, groupers, grunts, parrotfish and jacks) as well as three species of invertebrates; Caribbean spiny lobster (*Panulirus argus)*, queen conch (*Lobatus gigas*) and white sea urchin (*Tripneustes ventricosus).* The primary fishing methods employed within the demersal fishery are fish traps/pots, bottom gillnets, bottom longlines, handlining and diving. The preferred fishing methods for demersal finfish are bottom longlines and handlining, while diving is preferred for conch and spiny lobsters.

2.2.1 Red Hind

Red hind (*Epinephelus guttatus*) is the most common species of its genus in the West Indies (Heemstra & Randall, 1993). It is a tropical western Atlantic species with a native range that includes Venezuela, The Caribbean Sea, The Gulf of Mexico, The Bahamas, North Carolina and Bermuda (Heemstra & Randall, 1993). The species typically inhabits shallow reefs and rocky bottoms at depths ranging from 2 to 100 m and feeds primarily on crustaceans, fish and cephalopods (Heemstra & Randall, 1993). The maximum length for red hind is 76 cm with a common length of 40 cm which is achieved within a lifespan of approximately 11 years (Heemstra & Randall, 1993; Potts & Manooch, 1995).

Red hind are protogynous hermaphrodites; all fish are born females and some individuals undergo sexual inversion to males at approximately 28 cm (most fish above 40 cm are males) (Heemstra & Randall, 1993). Red hind has a faster growth rate and shorter life span than most groupers with sexual maturity being achieved in approximately three years (Brule, 2018). It is typically a solitary and territorial species; however like most species of groupers, red hind forms aggregations for spawning which typically occurs during the full moon from December to April in the Caribbean (Heemstra & Randall, 1993; Brule, 2018; Froese & Pauly, 2018). During spawning buoyant eggs are released into the water where they are fertilised, with hatching occurring within 27 hours (Heemstra & Randall, 1993).

Red hind is highly priced and valued as an excellent food fish (Froese & Pauly, 2018). It is one of the most important commercial species in the Caribbean with regards to numbers and total weight landed despite the fact that it does not grow as large as some other species (Heemstra & Randall, 1993; Brule, 2018). Approximately 237 tonnes of red hind were landed in the western central Atlantic in 2014, about 53% of which were caught in Grenada (FAO, 2018). Red hind is typically caught using hook-and-line, traps and spears (Heemstra & Randall, 1993). Despite declines in localised populations, the red hind is classified as a species of "least concern" by the IUCN Red List of Threatened Species as overfishing is not currently considered to be a major threat to the species on a global level (Brule, 2018). There has been a general recommendation for improved fishery data collection and protection of spawning aggregations where red hind is highly susceptible to overharvesting (Brule, 2018).

2.2.2 Stoplight Parrotfish

Stoplight parrotfish (*Sparisoma viride*) is a subtropical species of the western Atlantic with a native range stretching from southern Florida, Bermuda, The Bahamas, throughout the Caribbean Sea to Northern coast of Brazil (Froese & Pauly, 2018). Adult parrotfish typically inhabit shallow (1 to 50 m) clear waters of coral reef areas, while juveniles are frequently observed in seagrass beds, mangroves and other heavily vegetated substrates (Cervigón, et al., 1993; Rocha, et al., 2012). They frequently form small groups as juveniles and become solitary as they age (Froese & Pauly, 2018). Stoplight parrotfish commonly reach a length of 38 cm and a maximum of 64 cm over the course of their lifespan of approximately 9 years (Cervigón, et al., 1993; Froese & Pauly, 2018). Like most other Scaridae, stoplight parrotfish are a strictly diurnal species that spend the night resting on the bottom (Froese & Pauly, Sparisoma viride (Stoplight Parrotfish), 2018).

Stoplight parrotfish are protogynous hermaphrodites that undergo sexual inversion to super-males via a hormone driven process and they reach sexual maturity at approximately 16 cm (Cardwell & Liley, 1991; Cervigón, et al., 1993; Froese & Pauly, 2018). The species depict three distinct body colourations associated with their developmental phases (i.e. juvenile, initial phase and terminal phase) (Cervigón, et al., 1993). Parrotfish feed by grazing on soft algae, detritus and live corals using specialised teeth that are fused at the base (Cervigón, et al., 1993). They are dependent on coral reef, seagrass and mangrove habitats for their food and shelter; therefore, the loss or degradation of these habitats may have profound adverse effect on the population health of the species (Rocha, et al., 2012).

Parrotfish are a high-priced species of minor commercial importance globally; however, there has been a steady increase in fishing of the species within the Caribbean (Rocha, et al., 2012; Froese & Pauly, 2018). Approximately 398 tonnes of parrotfish were caught in the western central Atlantic in 2014, about 23% of which were caught in Grenada (FAO, 2018). Caught mainly with traps and spears, stoplight parrotfish is one of the most commercially important parrotfish species because of its larger size and relative abundance throughout its range (Cervigón, et al., 1993). Stoplight parrotfish is listed as a species of "least concern" by the IUCN Red List of Threatened Species as it is common in the western north Atlantic and there is no indication of global population declines (Rocha, et al., 2012).

2.3 Pelagic Fishery

The pelagic fishery is conducted using larger (i.e. 9-15m) mostly imported vessels equipped with inboard engines and modern fishing electronics (R. Baldeo, personal communication, October 2, 2018). The pelagic fishery targets yellowfin, bigeye (*Thunnus obesus*) and blackfin, tuna-like species such as billfish and dolphinfish (*Coryphaena hippurus*) and to a lesser extent small pelagics such as flying fish (*Cheilopogon melanurus*) and scads (*Selar* spp.). The main fishing gear utilised within the pelagic fishery are longlines, drift gillnets and beach seines. Longlines are utilised to catch yellowfin tuna and billfish, drift gillnets are utilised to catch flying fish and beach seines to catch other small pelagics primarily to be used as live bait for the longlines (R. Baldeo, personal communication, October 2, 2018).

2.3.1 Yellowfin Tuna

Yellowfin tuna (*Thunnus albacares*) is an epipelagic species that occurs within the thermal boundaries of roughly 18° to 31°C and are present in tropical and subtropical seas worldwide with the exception of the Mediterranean Sea (Collette & Nauen, 1983). The vertical distribution of yellowfin tuna is determined by the thermal structure of the water column; however, they are usually confined to the upper 100 m (Collette & Nauen, 1983). They typically reach a common length of 150 cm (FL) and a maximum weight of 200 kg within an average lifespan of 9 years (Froese & Pauly, 2018). Smaller individuals (<15kg) frequently form schools while large individuals (>15kg) tend to be more solitary (Froese & Pauly, 2018). Schooling typically occurs near the surface in single or multispecies groups based on size and are frequently associated with floating debris or objects (Collette & Nauen, 1983). Yellowfin tuna feed both during the day and night in the tropical Atlantic region on a diet that consists of cephalopods, finfish and planktonic crustaceans (Froese & Pauly, 2018).

The average length at maturity for yellowfin tuna is 103 cm and they are considered to be open water egg scatterers that release their gametes into the water column where fertilisation occurs (Froese & Pauly, 2018). Spawning occurs in batches every few days over the spawning period throughout the year, peaking during the summer months in the southeastern Caribbean Sea (Collette & Nauen, 1983; ICCAT, 2016). Evidence from the Pacific suggests that yellowfin tuna do not undertake long-range adult migration supporting the hypothesis of subpopulations (Collette & Nauen, 1983). Although highly migratory the local subpopulation would move no more than a few hundred miles over several years (Froese & Pauly, 2018). Despite the distinct spawning locations (i.e. Gulf of Guinea, Gulf of Mexico, Southeastern Caribbean Sea & off Cape Verde) within the Atlantic region, heterogeneity within the distribution of the species suggest a single Atlantic stock (ICCAT, 2016). To facilitate management, yellowfin tuna has been divided into four stock management units globally with the Atlantic stocks considered to be fully exploited (IUCN, 2018).

Yellowfin tuna is highly valued on the international market for sashimi (Froese & Pauly, 2018). Approximately 13,310 tonnes of yellowfin tuna were landed within the western central Atlantic in 2014, about 10% of which were caught in Grenada (FAO, 2018). They are fished globally using three main gear types (i.e. longline, baitboats and purse seines); however, the most important fishing method for deep swimming individuals is surface longlining (Collette & Nauen, 1983; ICCAT, 2016). The IUCN Red List of Threatened Species classified the global population of yellowfin tuna to be "near threatened" (IUCN, 2018). An assessment in 2011 by IUCN indicated a downward population trend which is also reflected in the decline in annual catches in the Atlantic Ocean since the peak at approximately 139,300 tonnes in 1990 (IUCN, 2018; FAO, 2018). Despite this fact, the 2016 ICCAT stock assessment indicated that maintaining catch at the current total allowable catch (TAC) of 100,000 tonnes is expected to maintain a healthy stock status through 2024 (ICCAT, 2016). A major emerging threat that has been identified for the species is the high fishing mortality of juveniles around fish aggregating devices (FADs) due to their affinity for floating objects (ICCAT, 2016).

2.3.2 Common Dolphinfish

Common dolphinfish (*Coryphaena hippurus*) are a fast-swimming epipelagic species that typically inhabits the top 30 m of the open ocean but frequently approaches the coast and have been documented in estuaries and harbours (Palko, *et al.*, 1982). Dolphinfish are distributed worldwide in tropical and subtropical waters and are generally restricted by thermal boundaries of 21 to 30°C (Palko *et al.*, 1982; FAO, 2019). They are generally year-round residents over most of their range; however, there is pronounced seasonal variation in abundance and distribution in most areas (Palko *et al.*, 1982). Dolphinfish are top-level pelagic predators that are typically associated with floating objects (e.g. sargassum, flotsam and jetsam) (Palko *et al.*, 1982). They are not food selective and would prey on any living organism available; however, in the western Atlantic, they survive primarily on a diet of finfish, crustaceans and squids (Palko, Beardsley, & Richards, 1982; FAO, 2019). Common dolphinfish grow rapidly throughout their life and reach an average size of 100 cm during their lifespan of approximately 4 years (Palko, Beardsley, & Richards, 1982; FAO, 2019).

Common dolphinfish is a gonochoristic species and individuals within the Atlantic reach sexual maturity at approximately four months, with females reaching maturity slightly before their male counterparts (Palko *et al.*, 1982; Collette, et al., 2011). Studies of egg production show a sharp increase in fecundity with increases in size and batch spawning occurring three times per spawning period (Palko *et al.*, 1982; Collette, et al., 2011). Spawning occurs near the surface with individuals pairing to release their gametes for external fertilisation, hatching typically occurs within 60 hours (Palko *et al.*, 1982). Mitochondrional DNA indicated that there is a single genetic stock within the Western Atlantic region with two subunits (northeastern and southeastern Caribbean stocks) (Oxenford, 1999; Collette, et al., 2011). Common dolphinfish is abundant throughout the Caribbean Sea with the highest abundance occurring during the spring (i.e. February to May) as part of a pre-spawning migration (Palko *et al.*, 1982; Oxenford, 1999). The changes in distribution of dolphinfish have been attributed to variations in water temperatures with the highest abundance occurring at the highest temperatures (26-28°C) which corresponds with peak spawning (Palko *et al.*, 1982).

Common dolphinfish is marketed fresh or frozen as a high value food fish and has had a long tradition of seasonal importance to the commercial fisheries of many countries in the Eastern Caribbean that target the species during the months November to June at the edge of their continental shelf (Palko *et al.*, 1982; Oxenford, 1999; FAO, 2019). Approximately 4,280 tonnes of dolphinfish were landed within the western central Atlantic in 2014, about 2% of which were caught in Grenada (FAO, 2018).The fisheries in Grenada is executed on the southeastern Caribbean stock which has a home range from the north east coast of Brazil up to the Virgin Islands (Oxenford, 1999). The species tend to segregate into schools by sex and size which allows them to be easily caught by both commercial and recreational fishing gear (Palko *et al.*, 1982). The most common fishing gear utilised to catch dolphinfish globally are driftnets, purse seines, trolling and longline (FAO, 2019). The use of surface fish aggregating devices (FADs) within the dolphinfish fishery is now a widespread and growing practice (FAO, 1994; FAO, 2019).

The common dolphinfish is listed as a species of "Least Concern" by the IUCN Red List of Threatened Species as there are no indications that the species is undergoing significant population declines (Collette, et al., 2011). There has been a consistent increase in global landings primarily from the North Pacific (i.e. 60-70%) (FAO, 1994). There have been relatively few biological studies in the western central Atlantic despite the economic importance of the species (Oxenford, 1999). However, an assessment of the common dolphinfish fishery in the Caribbean concluded that there was no decline in catch per unit effort (CPUE) indices sustainable catch levels (CRFM, 2006). That same study highlighted the need for more data collection and sharing from countries within the stock area in order to enhance the robustness of future assessment (CRFM, 2006)

2.4 Policy Framework

2.4.1 National Legislation

The Grenada Fisheries Act (Act # 15 of 1986) and Fisheries Regulations (SRO # 9 of 1987) "provides for the promotion and management of fisheries in the fishery waters of Grenada, and for incidental and connected matters" (GoG, 2013). The Fisheries Act finds its principle underpinning in the Organisation of Eastern Caribbean States (OCES) Harmonised Fisheries Legislation which was developed in collaboration with the FAO Fisheries Law Advisory Programme (CRFM, 2008; OECS, 1992). The OECS Harmonised Fisheries Legislation is a model legislation that outlined a basic framework for the management and development of fisheries within member states of the OCES (OECS, 1992). There are also a number of national legislations not specific to fisheries that have implication for the management of fisheries resources (**Table 1**). Although Grenada does not currently have a national fisheries policy document, there is a "Draft Plan for Managing the Marine Fisheries of Grenada" (DPMMFG) as is mandated by the Fisheries Act outlines the primary management objectives and guidelines for all fisheries in Grenada (CRFM, 2008). The DPMMFG despite never being formally approved or endorsed by the Minister of Fisheries nor the Cabinet of Grenada has undergone several edits and revisions over the past few decades (GoG, 2009). The Caribbean Regional Fisheries Mechanism (CRFM) completed the most recent update to the DPMMFG in 2008 and submitted it to the GFD to undertake the process of conducting the required reviews and public consultations to facilitate its approval (Gibson, 2019).

The Fisheries Act and its subsidiary regulations articulate the management structure and capture rules that dictate how fisheries are to be executed within the jurisdiction of Grenada. The GFD is the competent authority under the law for the execution of the Fisheries Act, as such the division is responsible for the management of all living resources within the fisheries waters of Grenada. The primary function of the GFD as is outlined by the policy statement of the DPMMFG is "to facilitate fisheries development through the promotion of sustainable use of natural resources and the provision of quality products and services to enhance the quality of life of our people" (CRFM, 2008). The DPMMFG should be evaluated at least every five years and any updates to the FMP are to be approved by the process outlined in Figure *2* (CRFM, 2008).

2.4.2 Regional and International Agreements

Grenada is an active member of the Caribbean Regional Fisheries Mechanism (CRFM) which was established following an regional agreement in 2002 with the mandate "to promote and facilitate the responsible utilisation of the region's fisheries and other aquatic resources for the economic and social benefits of the current and future population of the region" (CRFM, 2008). Grenada is also party to a number of international conventions, agreement and instruments that affect the execution of fisheries and fisheries management. The United Nations Convention on the Law of the Sea (UNCLOS) is one of the most important international agreements that influences fisheries management in Grenada as it provides the conceptual underpinning of the Territorial Sea and Maritime Boundaries Act which defines its EEZ and by extension the fisheries waters (GoG, 2009; GoG, 2013). Other important agreements pertinent to fisheries include:

- FAO Code of Conduct for Responsible Fisheries (CCRF)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- FAO Compliance Agreement
- United Nations Fish Stock Agreement (UNFSA)
- FAO Port State Measures Agreement (PSMA)

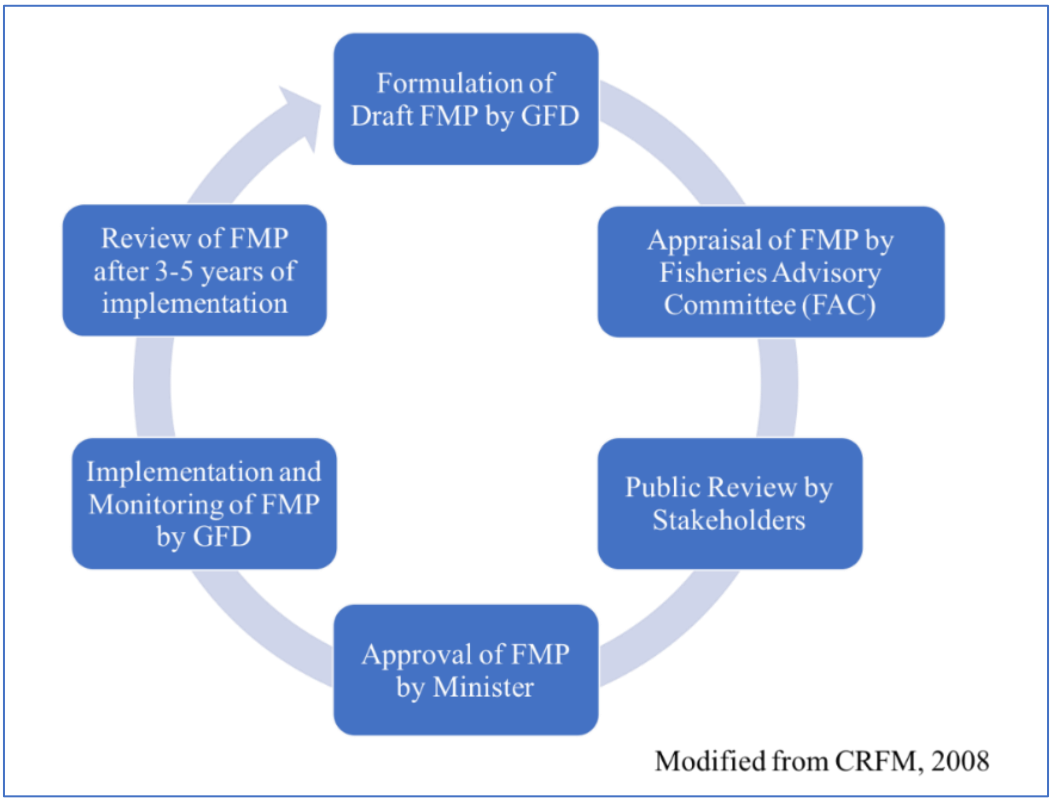


Figure 2: Diagram outlining the Fisheries Management Planning Process.

2.5 Fisheries Management

The primary basis for an individual to enter the Grenadian fishery is national citizenship; similarly, in the case of an association or organisation it requires that at least 51% of the voting shares to be held by citizen(s) of Grenada (GoG, 2013). The law also requires that all local fishing vessels must be legally licensed in order to participate in any fishing activities within Grenada waters (GoG, 2013). The requirement for licensing of all fishing vessels is not strictly enforced; however, it is mandatory in order to qualify for government subsidies (e.g. fuel rebate, tax and duty concessions) (GoG, 2009). The Fisheries Act does not outline any specific requirements for the registration or licenses for fishers; rather, it assigns the Minister of Fisheries the authority to make regulations for the management and development of the fishery including fishers (GoG, 2013).

Table 1: National legislation that impact the marine environment and fisheries.

Legislation Title	Year	Objective within the fisheries context
Beach Protection Act	1979	Prohibits the unauthorised harvesting of aggregate (e.g. sand, stone, shingle, or gravel) from the seashores
Power-Craft Act	1987	Outlines the rules for operating a motorised vessel with the territorial waters (i.e. within 12 nm) of Grenada
Grenada Territorial Waters and Marine Boundaries Act	1990	Defines Grenada's EEZ and by extension fisheries waters
Fisheries (Fishing Vessel Safety) Regulations*	1990	Outlines the minimum safety requirement for all vessels conducting fishing activities >3 miles from land
Physical Planning and Development Control Act.	1990	Manages development within the coastal zone so as minimise adverse impacts on the marine and coastal resources and habitats.
Fish and Fishery Product Regulations*	1999	Outlines all the rules governing the post capture handling, quality standards, import, export, and processing of fishery products.
Fisheries (Marine Protected Areas) Regulations*	2001	Outlines that various types of MPAs that could be established in Grenadian waters along with the management structure and rules to govern their use.

*Subsidiary Regulations to the Fisheries Act. Source: (GoG, 2013)

Grenada has an "open-access" fishery with no established catch limits or quotas; however, all vessels are required to obtain an annual fishing license to operate within Grenadian waters. The licensing requirement does not serve to regulate entry into the fishery; instead, it is intended to ensure that all vessels entering the fishery are seaworthy and meet the minimum safety standards outline by the GFD. In order to control the negative impacts of fishery on the marine resources, several catch rules are being implemented including a four-month closed season for Caribbean spiny lobster and sea turtles; minimum size limits for lobster, conch and turtles and minimum mesh sizes for nets (i.e. beach seine and gill nets) and traps. There are also prohibited fishing gear (e.g. trammel nets) and methods (e.g. blast or poison fishing) (GoG, 2013).

The fisheries regulations are enforced by specially designated fisheries officers as well as the Royal Grenada Police Force (RGPF) through regular constabulary force and the Coast Guard. The constabulary forces typically cover matters on-land while the Coast Guard cover all on-sea matters (e.g. vessel safety, patrolling the EEZ for infraction by both domestic and foreign vessels) (CRFM, 2008).

The co-management of Grenadian fisheries is underpinned in the traditional use rights and was enshrined in Grenada Fisheries Act through the requirement of a Fisheries Advisory Committee (FAC). The FAC has the mandate to provide industry specific advice to the Minister of Fisheries in order to drive the policy that governs fishing (GoG, 2013). The most recent FAC was appointed in 2009 by the cabinet of Grenada on the advice of the Minister of Fisheries; however, they only meet on an ad hoc basis as issues emerge (GoG, 2009; Cristina, 2016). There are also opportunities for the fishing community to actively participate in the management of marine protected areas (MPAs) through various co-management arrangements. There is a Stakeholder Advisory Committee for each established MPA which consists of representatives of each established fisher organisation and/or representatives of each gear type that has been historically utilised within the management area (Homer, 2016).

Similar to co-management, the Fisheries Act requires the development and implementation of species-specific fisheries management plans (FMP) (GoG, 2013). The Act outlines in specific detail what should be included into each FMP and the fact that these documents needed to be periodically reviewed and kept up-to-date (GoG, 2013). Amongst the components that must be included within the FMP is the status of stock as it relates to exploitation as well as any management measures that are required to maintain the sustainability of the fishery (e.g. catch limits, fleet size) (GoG, 2013).

2.6 Fishery Data Collection

The collection of fish landing data in Grenada dates back to the 1960s when it was hailed as being one of the better data collection systems in the Caribbean region (Mohammed & Lindop, 2015). Today data collectors at the ten formal landing sites record the weight of the total catch for all vessels that land at each facility. To record the total landing, the data collectors sort the entire landing from each vessel into species or family groupings (e.g. snappers, groupers, parrotfish) and record the total weight of each grouping separately. The level of data collection varies from site to site based on the capacity of the staff (i.e. training level and number of persons). In addition to total landing, a sample of fishers are surveyed to collect catch per unit effort (CPUE) data based on “fishing days” for the semi-industrial fleet or “fishing hours” within the artisanal fleet; however, these data are currently not digitised (i.e. they are stored on paper sheets) due to staffing constraints (C. Isaac, personal communication, November 15, 2018).

Landing data are only collected at the primary landing sites (Figure 3, Table 2); however, there are a number of secondary landing sites (i.e. beaches and bays) where fishers offload and sell their catch directly from their boat without ever going to a primary landing site (Baldeo, 2002). The GFD estimates that the current recordings of landing data accounts for approximately 80% of large pelagic, 70% of demersal, 60% of small/coastal pelagic and 25% of shellfish that are actually landed in Grenada (Baldeo, 2002). In order to rectify the missing data within the reported landings, Grenada has been applying an adjustment factor of 1.75 to the landings data for all species prior to 1998 (Mohammed & Lindop, 2015). Subsequently, an adjustment factor of 1.4 was used for tunas, dolphinfish and billfishes, while maintaining the 1.75 on all other species (Mohammed & Lindop, 2015)

Figure 3: Relative locations of the 10 primary landing sites on Carriacou and Grenada.

Table 2: Facilities of the primary fish landing sites in Grenada

Landing Site	Location	Facilities
Windward	Carriacou	Jetty, cold storage
Hillsborough	Carriacou	Fish market, cold storage, ice machine
Sauteurs	Grenada	Jetty, fish market, cold storage, ice machine
Duquense	Grenada	Fish market, cold storage
Waltham	Grenada	Cold storage, lockers
Victoria	Grenada	Fish market, cold storage, ice machine

Gouyave	Grenada	Jetty, fish market, cold storage, ice machine
Grand Mal	Grenada	Jetty, cold storage, ice machine
Melville Street	Grenada	Jetty, fish market, cold storage, ice machine, lockers
Grenville	Grenada	Jetty, fish market, cold storage, ice machine, lockers

2.7 Marine Protected Areas

Marine protected areas are implemented globally as a fisheries management tool that reduce fishing mortality on a stock by closing areas to fishing that are important for various ontogenetic stages of harvested species (FAO, 2007). Although the Grenada Fisheries Act of 1986 made provision for the establishment of ‘marine reserves”, it was not until 2001 that the first MPAs were declared in Grenada following the enactment subsidiary regulations specific to MPAs (GoG, 2013). In 2008, Grenada joined nine regional governments and pledged to protect 25% of its nearshore marine and coastal environment by 2020 as part of the Caribbean Challenge Initiative (CCI) (CCI, 2016). The GoG has decided to utilise the existing legislation and management framework of MPAs to fulfill the commitments made under the CCI. The Grenada Protected Area System Plan (GPASP) was created to come up with a strategy to systematically designate and manage all marine and terrestrial protected areas (Tuner, 2009).

The GPASP highlights a number of priority areas of interest for MPA with an intent of creating an MPA network that represented all the key marine and coastal habitats (Tuner, 2009). The Grenada Marine Protected Areas (GMPA) programme is managed from a unit within the GFD and has since 2010 systematically designated the priority areas of interest identified within the GPASP into MPAs (Figure *4*). The designated MPAs in Grenada prohibit the extraction of all demersal species form vessels by all gear types; however, allows hook-and-line fishing from the shoreline for traditional purposes and capture of small pelagic (e.g. scads and jacks) by beach seines in designated zones. The objectives of the GMPA program is to provide special protection to the flora and fauna as well as their natural breeding grounds and habitat in order to facilitate sustainable use of associated marine and coastal resources (GoG, 2013).

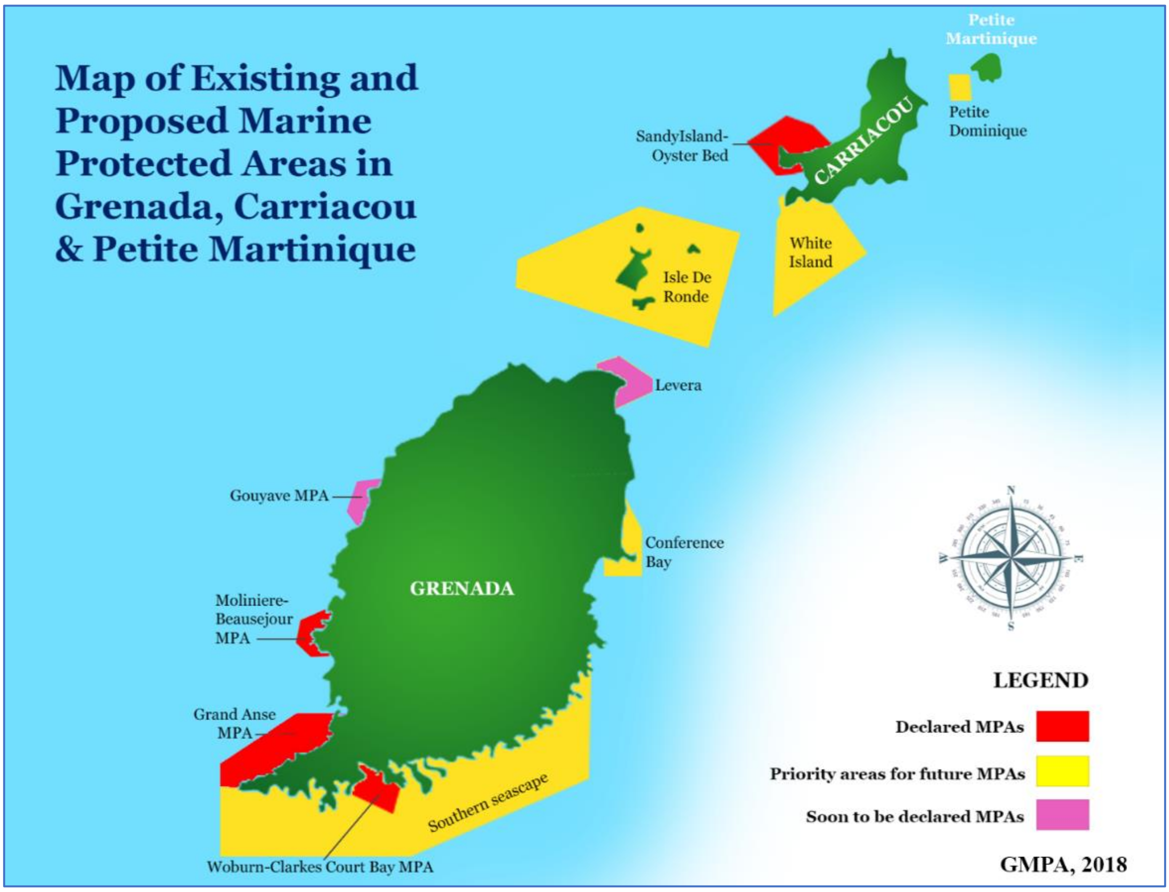


Figure 4: Locations and status of MPAs in Grenada as of December 2018.

2.7.1 Reef Fish Assessment within MPAs

The Grenada Marine Protected Areas (GMPA) programme aims to conduct routine assessments within the protected areas in order to determine the impact on management intervention on status of the marine resources within these areas. The focus is primarily on the health of coral reef and their associated organisms. In 2015, the GMPA programme selected the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol as the primary monitoring protocol for the network as it provides the requisite level of detail, scientific robustness and replicability. Since then, a total of 26 permanent AGRRA monitoring sites have been established within the GMPA network in addition to a number of control sites outside of MPAs (see Annex 2). AGRRA is a standardised coral reef monitoring protocol that was developed in 1997 by Dr. Robert Ginsburg (AGRRA, 2019). AGRRA utilises underwater visual censuses along a series of belt and point intercept transects to monitor the abundance and size of key indicator species of fish, benthos (e.g. corals, macroalgae) and mobile invertebrates (e.g. lobsters, urchins, sea cucumbers) as a means of determining the health of the coral reef ecosystem (OREF, 2019).

Typically, a baseline assessment is conducted at a number of permanent monitoring sites within each MPA prior to or during the legal designation process. Once the area is legally designated, monitoring is scheduled to be conducted at 3-5-year intervals based on the availability of resources and trained personnel. With the exception of the sites that were conducted in Carriacou in 2005, most sites are within the resurvey interval; therefore, the baseline is the only survey that has been done at these sites. The results from the subsequent rounds of surveys for each site are compared against the established baselines to assess changes in the resources within that protected area. The findings of these assessments are used to determine the impact/effect of management interventions on the resources within the protected areas. For example, if the assessment indicates that there is a decrease in coral cover within a specific area which can be attributed to physical damage (e.g. grounding, diver contact) then the management interventions to control damage to that area is ineffective; consequently, that area is closed to the public so as to reduce the level of impact.

3 METHODOLOGY

3.1 Review of Current Fisheries Data Management System

A review was conducted on the current fisheries data management of the GFD. The review focused on the structure and the content of the current system. The ease at which analysis could be conducted on the data, given its current layout and structure, was evaluated. Similarly, the review of the content of the data management system was geared towards identifying gaps in the data that is currently being collected. The gaps in the data were based on the types of data (e.g. CPUE, biological, environmental) that are utilised to conducted fisheries stock assessment. The review also identified key areas where the currently data collection and management program can be improved to enhance stock assessment and provide a scientific basis for underpinning management decisions.

3.1.1 Evaluation of Hillsborough Landing Data

The Hillsborough landing site on Carriacou was the only site with available data for an entire year (i.e. 2017) within the “Daily Log” workbook (GFD, 2018). Consequently, analysis was conducted on the 2017 fisheries landings data recorded at this landing site to demonstrate the variety of analyses that are currently possible given the available data.

Due to the incompleteness of the Hillsborough dataset; that is, missing data especially regarding effort parameters (e.g. length of trips, hours fished, size of crew) analysis was only conducted on the subsections of the data. This invariably means that is some cases the trends that emerged may not necessarily truly represent what actually occurred on the ground. This analysis was conducted only on the 2017 data; therefore, it is impossible to evaluate for annual trends and monthly variations observed may be anomalous to that year.

The data analysis was conducted using R statistical software (R Core Team, 2018) and Microsoft Excel (Microsoft, 2019). Prior to data analysis, the dataset was “cleaned” by removing errors in spelling, inconsistencies in date format and omitting blank cells. Fish species were divided into two categories (i.e. demersal or pelagic) based on where they spend most of their adult life.

3.2 Online Survey on the Grenada Fisheries

An anonymous online survey was developed and administered to key current and past GFD staff to explore the operations of the division and their perceptions on changes within the fishing industry during their tenure with the division. The objectives of the online survey were to highlight any divergence in management of fisheries from the stipulated policy and to provide insight into the fisheries managers' perceptions of the status of the resources given the limited use of empirical data in the management of the fisheries. The online survey included questions within the following thematic areas:

- Entry requirement (e.g. registration/licenses)
- Fleet composition (i.e. size, classification)
- Fisheries (i.e. target species, locations, gear)
- Fisheries management (i.e. management plans, interventions)

A total of fifteen direct emails were distributed containing the link to the online survey tool. Twelve responses were received which included four past and eight current employees with experience within the GFD ranging from two and a half years to 38 years (eight of the respondents had over 20 years of experience within the division). The primary responsibilities of the respondents included chief fisheries officer, fisheries extension, fishing technology, marine protected area management, fisheries biology, quality control and data management (Appendix 2).

3.3 Analysis of Reef Fish Abundance

An analysis was conducted on the changes in abundance of five commercially important reef fish families (i.e. groupers, snappers, grunts, parrotfishes and surgeon fishes) that occurred between the 2005 and 2015 surveys (i.e. 10 years) at the five monitoring stations. More specifically, the assessment was conducted on data that were collected from five permanent AGRRA coral reef monitoring stations on Carriacou, four of which (i.e. Lighthouse, Mabouya North, Mabouya South and Sandy Island) are within the Sandy Island Oyster Bed MPA (SIOBMPA) and one control site (i.e. Jack-A-Dan) outside the MPA. The monitoring stations were initially surveyed in 2005 and resurveyed in 2015 (Marks & Lang, 2018). The objectives were to examine potential changes in fish abundance that occurred between years and to examine the effect of protection on observed change in abundance. A typical AGRRA fish survey consisted of ten 30x2 m transects (AGRRA, 2016). Ten transects were conducted at each monitoring station each year with the exception of Jack-A-Dan where five transects were conducted in 2005 (Marks & Lang, 2018). The abundance of each species is determined by counting and estimating the size of each individual indicator fish species and placing them into 10 cm size categories (AGRRA, 2016). The analysis of the change in fish abundance was conducted using R statistical software (R Core Team, 2018).

4 RESULTS

4.1 Review of Current Fisheries Data Management System

4.1.1 Structure of Data Management System

The GFD stores its fisheries data in three distinct Microsoft Excel Workbooks (i.e. Daily Log, Fisher Registry & Vessel Registry) with a fixed template for each dataset. The data files are managed by the fisheries data clerk at the GFD headquarters at Melville Street, St. George's.

The “Daily Log” workbook consists of eleven sheets, one for each of the ten primary landing sites including the two processing facilities at the Grand Mall landing site. The “Daily Log” workbook is used to store the data collected during the fisher interview which includes data on fishing effort (e.g. hours/days fished, crew size, gear), landings (i.e. species & weight) and vessel information (e.g. boat owner, boat name and registration number). The “Daily Log” is structured in such a way that there is a separate entry for each species landed daily; that is, if the same boat lands three different species, three entries are made for that boat, one for every species.

The “Fisher Registry” database has both commercial and recreational fishers. Information on commercial fishers are entered into the database based on which of the seven parishes in Grenada they execute their fishing activities. There is also a single sheet where all exclusively recreational fishers are entered. The Fisher Registry stores data on the individual fishers including data on identity (e.g. name, alias, birth date, address, education), role in the fishery (e.g. crew, captain, boat owner), family (e.g. children, marital status), contact information (e.g. telephone number, emergency contact). The worksheet is arranged so that each row represents a different fisher.

The “Vessel Registry” workbook stores the information of all registered fishing vessels (i.e. local and foreign) in Grenada. The “Vessel Registry” includes information on the boat owner (e.g. name, address, crew), hull (e.g. material, length, beam), engine (e.g. make, size, quantity), registration status (e.g. registration number, expiration, inspection), ice storage (e.g. size) and fishing method (e.g. longline, trolling, diving). The “Vessel Registry” workbook has a total of fourteen sheets which include a master sheet, one sheet for each of the seven parishes and Isle de Rhonde, an archive, recreational, foreign, beach seine, and port of operation. The master sheet includes all the registered vessels in Grenada. The individual parish and Isle de Rhonde sheets include all the vessels registered in the respective parish or island. It is unclear what the vessels on the archive sheets represent. The foreign sheet includes the foreign vessels operating in Grenadian waters. The beach seine includes all vessels that are involved in the beach seine fishery (i.e. tour-boats and net-boats). The port of operation sheet has the abbreviation codes for all the ports of operations in Grenada. The worksheet is arranged with each row representing a single vessel.

4.2 Hillsborough Landing Data

4.2.1 Landings

4.2.1.1 Demersal Fish Frequency

The data indicated that in 2017, there were twelve categories of demersal finfish and one invertebrate species landed in Hillsborough, Carriacou. The five species/families that appeared most frequently were red hind (*Epinephelus guttatus*), coney (*Cephalopholis fulva*), snapper (*Lutjanidae* spp.), grunt (*Haemulidae* spp.) and squirrelfish (*Holocentridae* spp.) (Figure 5).

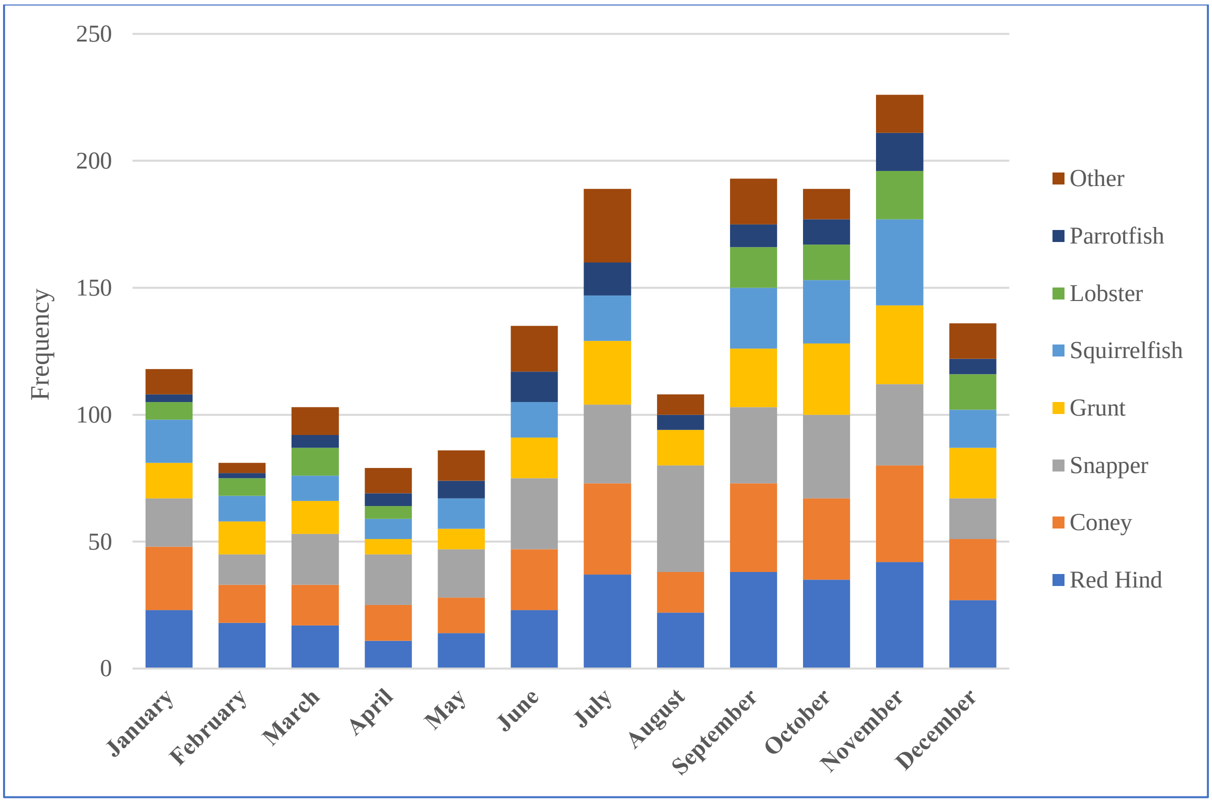


Figure 5: Number of entries of demersal fish by month during 2017 at Hillsborough.

4.2.1.2 Demersal Fish Weight

A total of 8,874 kg of demersal finfish was landed at Hillsborough in 2017. The top five most frequently landed species accounted for 91% of the demersal landings in 2017 (Annex 3). More specifically, snappers accounted for 42%, red hind for 1,735 kg (20%), coney for 17%, grunt for 7%, squirrelfish for 5% (Figure 6).

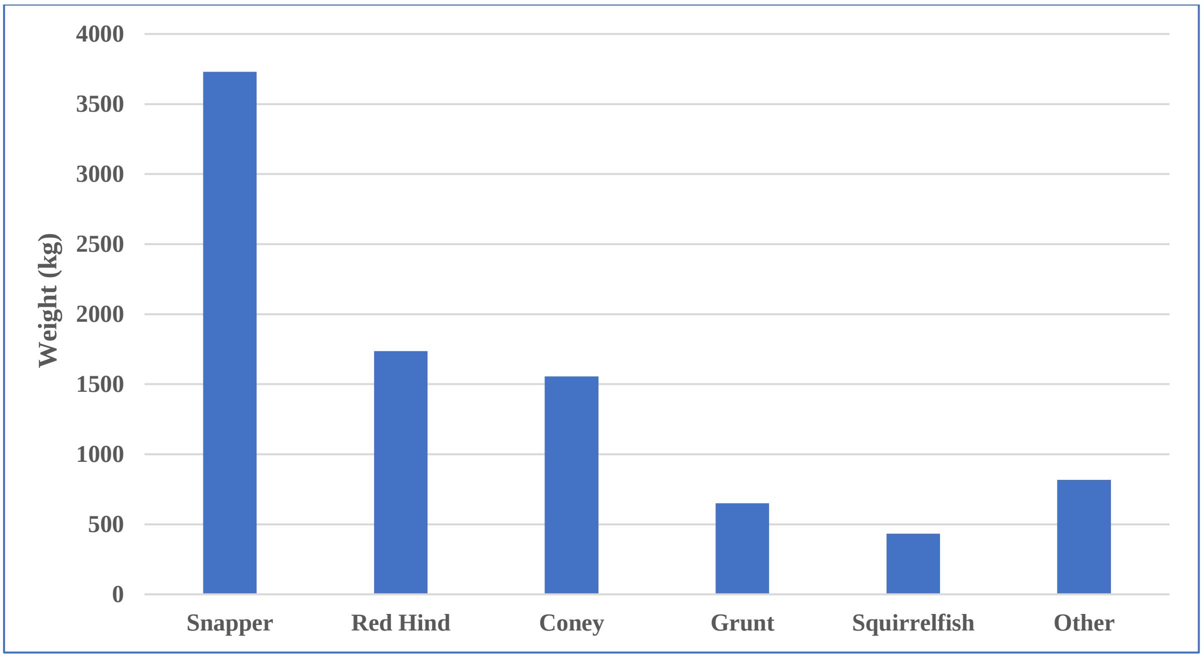


Figure 6: Landings of demersal finfish at Hillsborough, Carriacou in 2017.

4.2.1.3 *Pelagic Fish Frequency*

There were thirteen pelagic fish species landed at Hillsborough, Carriacou in 2017. The five most frequently landed pelagic species were crevalle (*Carangidae spp.)*, barracuda (*Sphyraena barracuda*), yellowfin tuna (*Thunnus albacares*), blackfin tuna (*Thunnus atlanticus*) and dolphinfish (*Coryphaena hippurus*) (Figure 7). Bigeye scad (*Selar crumenophthalmus*) was the only small pelagic species documented within the data with two entries in March and one in July.

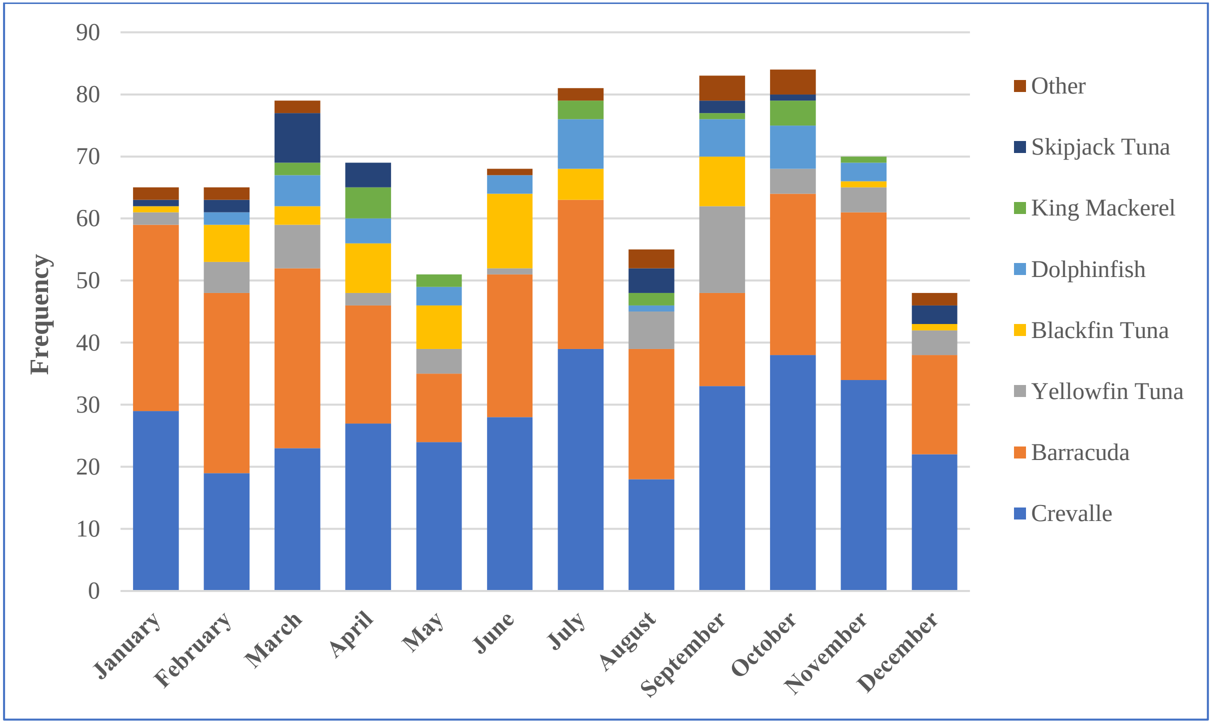


Figure 7: Number of entries of pelagic fish by months during 2017 at Hillsborough.

4.2.1.4 *Pelagic Landings*

A total of 7,873 kg of pelagic finfish was landed at Hillsborough in 2017. The top five most important species of pelagic fish accounted for 90% of the total pelagic fish landings in 2017 (Annex 4). More specifically, crevalle accounted for 34%, barracuda for 27%, yellowfin tuna for 19%, skipjack tuna for 5% and blackfin tuna for 5% (Figure 8).

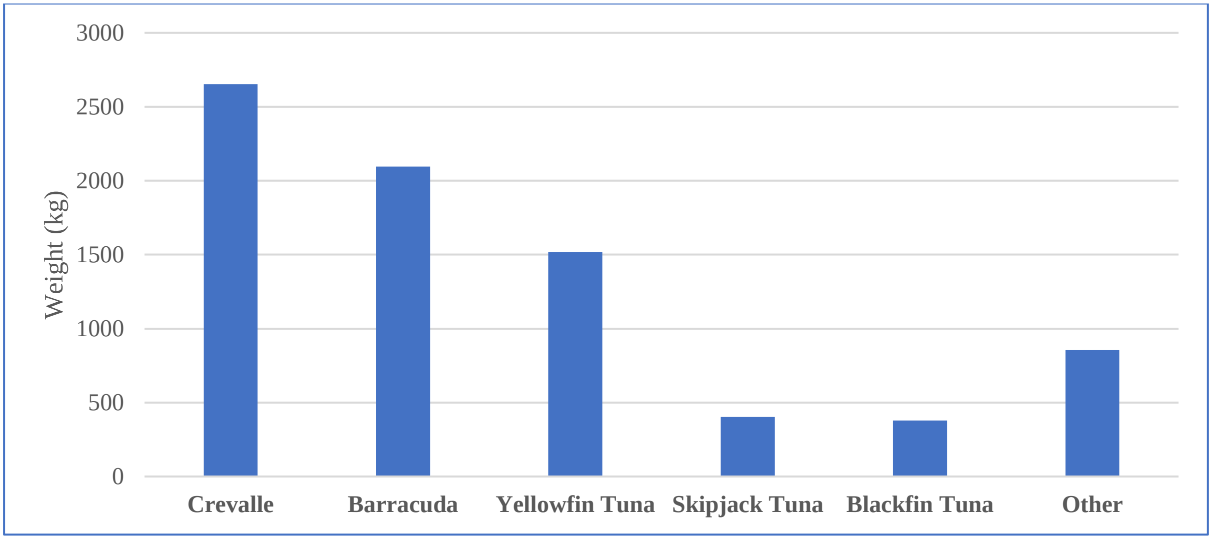


Figure 8: Total recorded landings of pelagic fish at Hillsborough, Carriacou in 2017

4.2.2 Fishing Activity

4.2.2.1 Number of Fishing Trips

Given that the dataset was incomplete with regards to the number of trips that were made, data was available for only five months of 2017. There were 51 vessels that landed fish at the Hillsborough Fish Market during 2017 (Appendix 3). During the five months, these 51 vessels made a total of 810 fishing trips, which ranged from 141-183 trips per month (Figure 9).

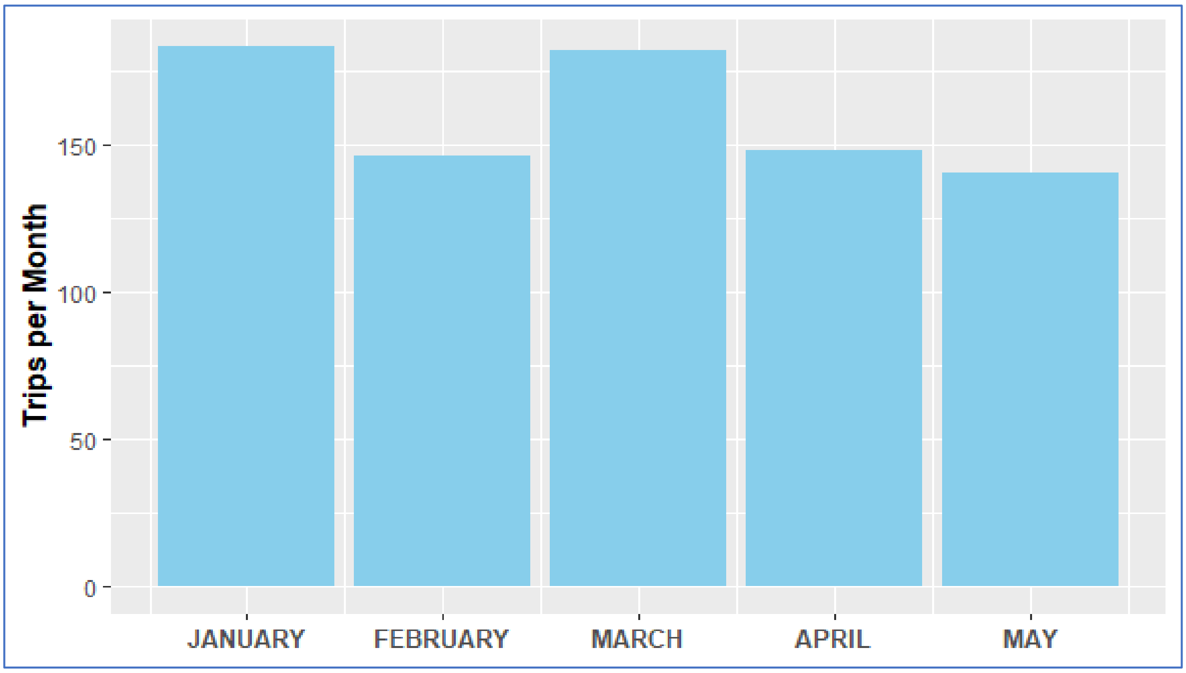


Figure 9: Fishing trips conducted that landed at Hillsborough in 2017

4.2.2.2 Types of Fishery

The fish that were landed at Hillsborough in 2017 were from four fishery categories (i.e. Coastal Pelagic Fishery, Ocean Pelagic Fishery, Shallow Reef and Deep Slope Fishery) based on the GFD classification. More specifically, landing frequency was highest for the "Shallow Reef" (62%) and lowest for the "Deep Slope" (4%) (Figure 10).

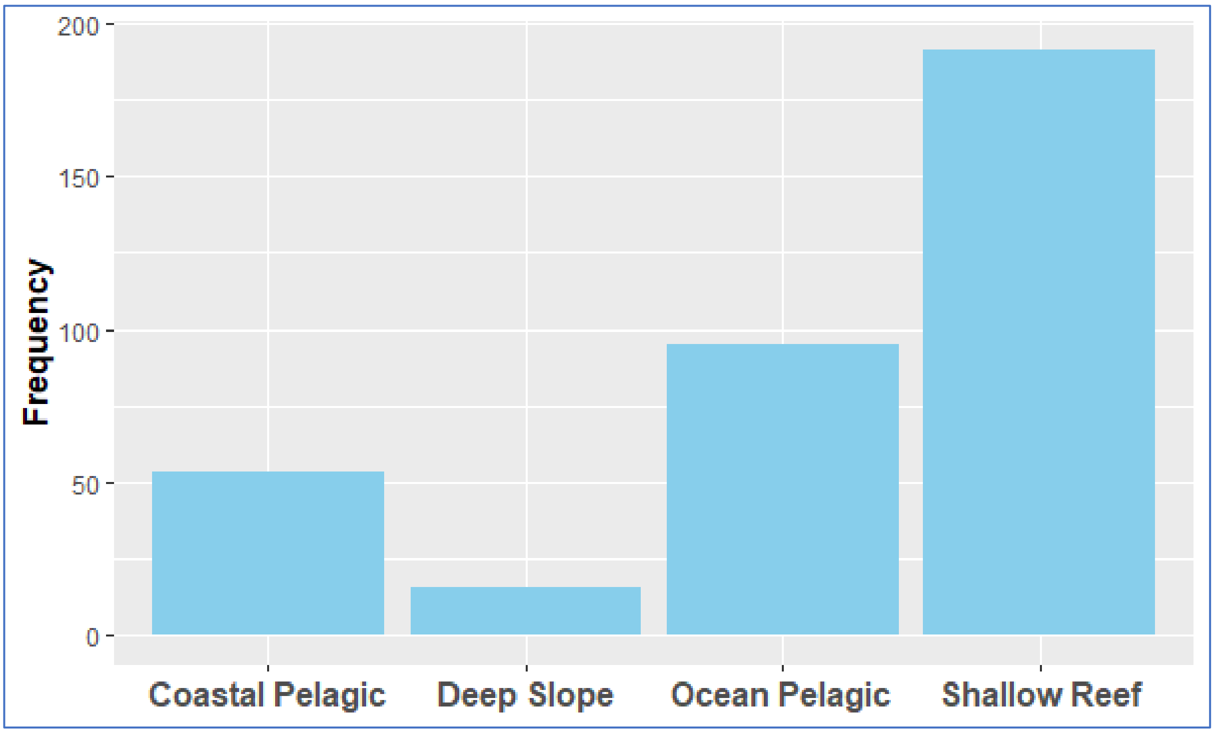


Figure 10: Type of fishery conducted at Hillsborough in 2017.

4.2.2.3 *Fishing Methods*

There were five distinct fishing methods utilised to catch the fish that were landed at Hillsborough in 2017; namely, bottom longlines (BLIN), gillnet or beach seine (NETS), fish pots/traps (POTS), SCUBA diving (SCUB) and free diving (FDIV). The most dominant fishing method was the bottom longline which accounted for approximately 88% of the fish that was recorded. Bottom longline was the dominant fishing method within the coastal pelagic, ocean pelagic and shallow reef fisheries, while SCUBA diving was the dominant fishing method within the deep slope fishery (Figure 11). The dominant fishing methods in several cases differ at the species level to that of the entire fishery both within demersal and pelagic species (Annex 5 and 6).

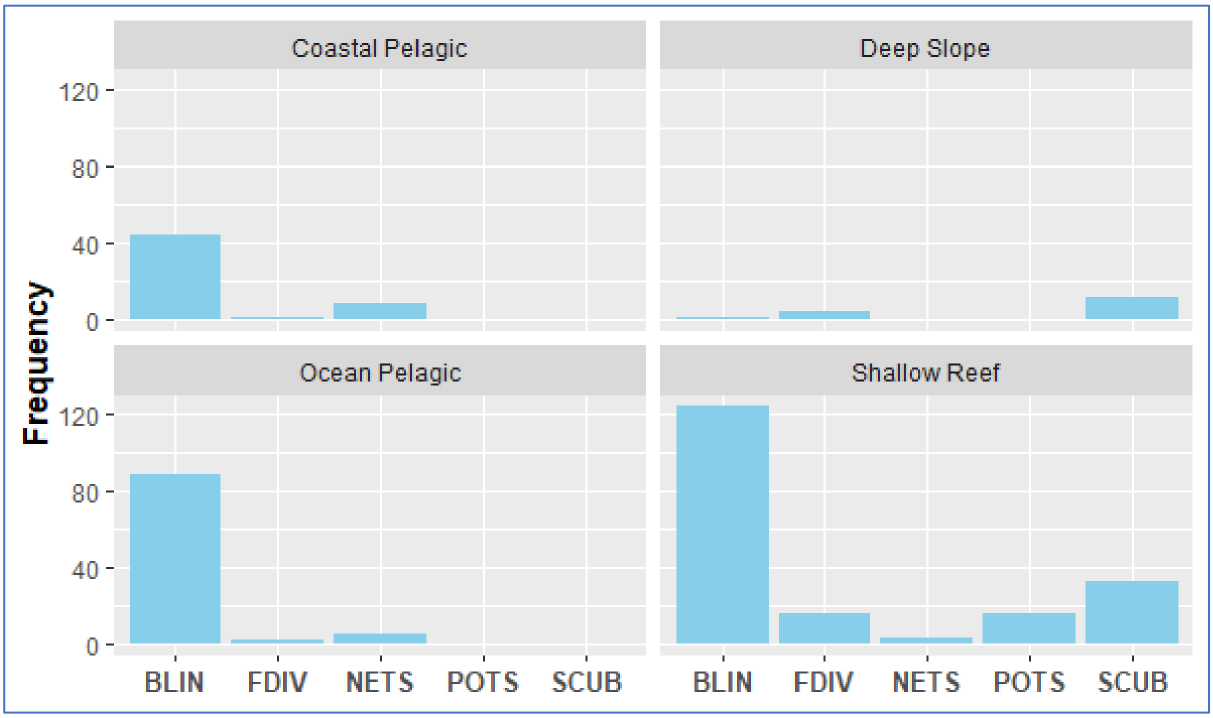


Figure 11: Fishing methods by fishery for fish landed at Hillsborough in 2017.

4.2.2.4 Location of Fishing Grounds

Grenada does not have defined fishing units with a unique identifier (e.g. code or name) to designate where fishing activities are executed, instead fishers indicate where they fished based on the eight cardinal points on a conventional compass (i.e. north, north east, east, south east, south, south west, west, north west). As such, the fisheries waters are divided into eight quadrants based on these cardinal points with the central point located on the island (i.e. Carriacou or Grenada) where the fishing trip originated. For Hillsborough, locations of fishing activities were available for 359 of the fishing trips conducted during the first three months of 2017 (Annex 7). Most of the fishing trips were made to the south and north of Carriacou but none to the east (Figure 12).

4.2.3 Duration of Fishing Trips

4.2.3.1 Demersal Fishing Trips

The mean duration of a demersal fishing trip at Hillsborough was ~ 4.5 hrs. The longest demersal fishing trips were those that landed snappers (*Lutjanidae* spp.); while the shortest trips were those that landed doctorfish (*Acanthurus chirurgus*) (Figure 13).

4.2.3.2 Pelagic Fishing Trips

The mean duration of a pelagic fishing trip at Hillsborough was ~ 6 hrs. The longest demersal fishing trips were those that landed wahoo (*Acanthocybium solandri*) or dolphinfish (*Coryphaena hippurus.)*; while the shortest trips were those that landed shark (*Carcharhinidae* sp.) (Figure 14).

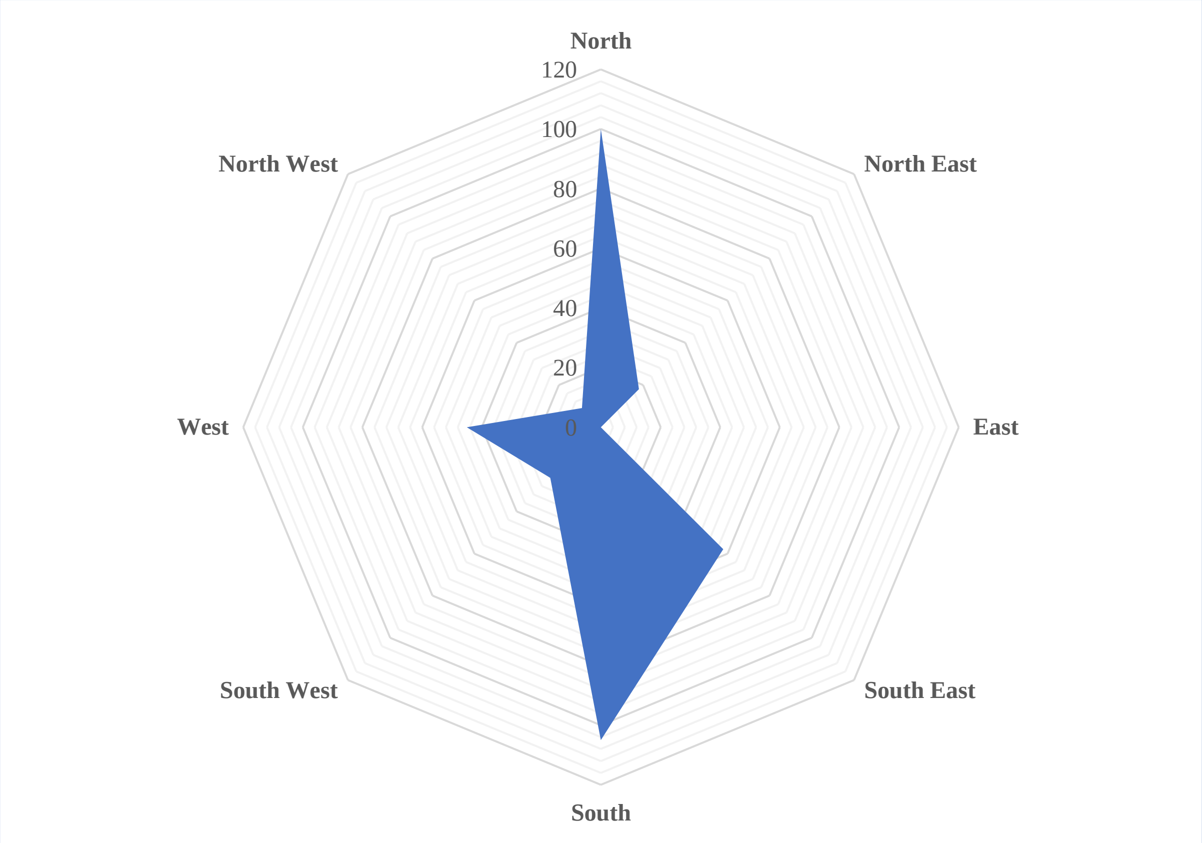


Figure 12: Areas where fishing occurred for fish landed at Hillsborough in 2017

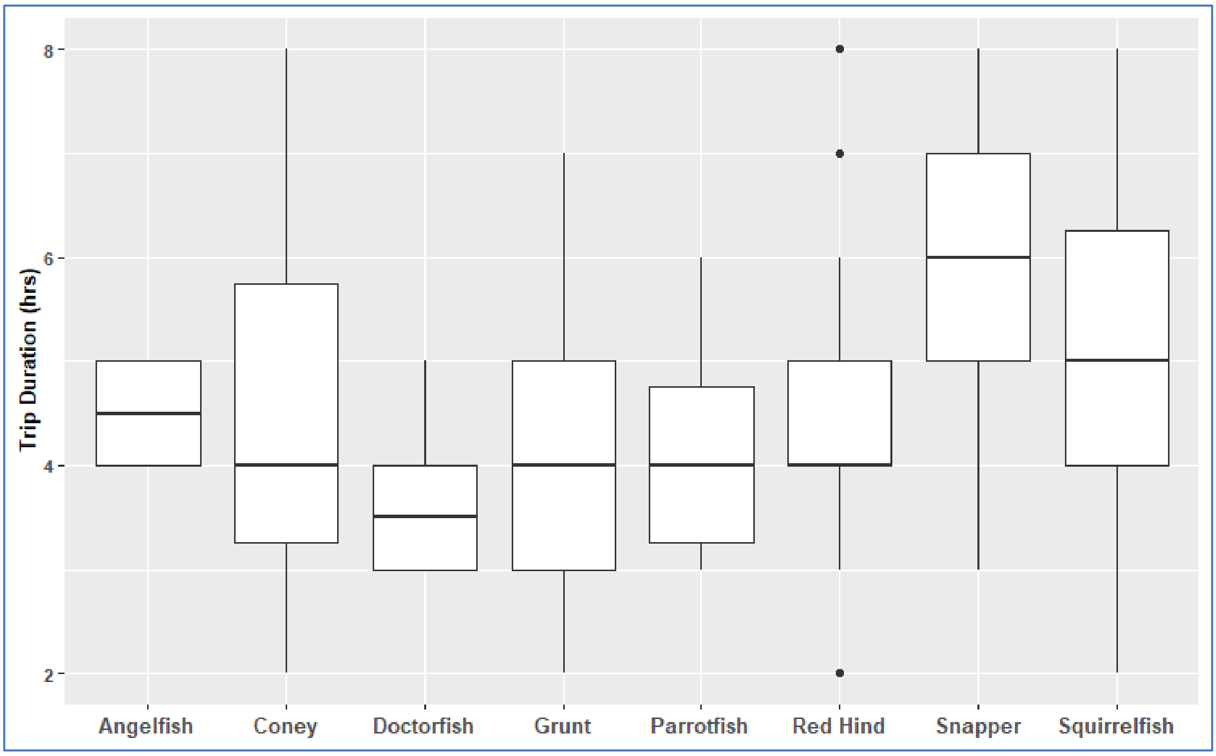


Figure 13: Duration of fishing trips for demersal finfish landed at Hillsborough in 2017.

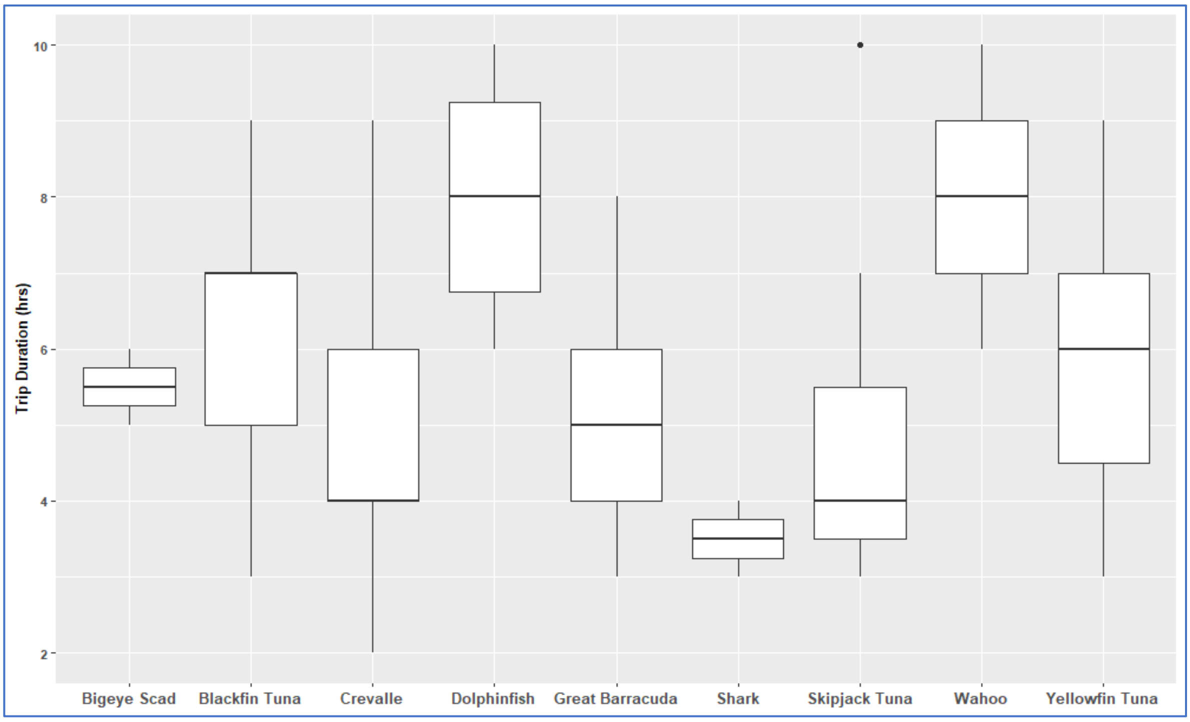


Figure 14: Duration of fishing trips for pelagic finfish landed at Hillsborough in 2017.

4.2.4 Catch Per Unit Effort

Catch per unit effort (CPUE) for the purposes of this document is the amount of landed fish (kg) caught per amount of time (hrs) spent fishing. The time spent fishing includes the entire fishing trip, from departure from the home port to arrival at the landing site.

4.2.4.1 CPUE by Target Species

The median CPUE for all demersal finfish landed at Hillsborough was 1.7 kg/hr (Figure 15), with the snapper having the highest and the squirrelfish the lowest for the demersal fish (Figure 16). The median CPUE for all pelagic finfish landed at Hillsborough was 3 kg/hr (Figure 15), with bigeye scads having the highest and sharks the lowest of the pelagic fish (Figure 17).

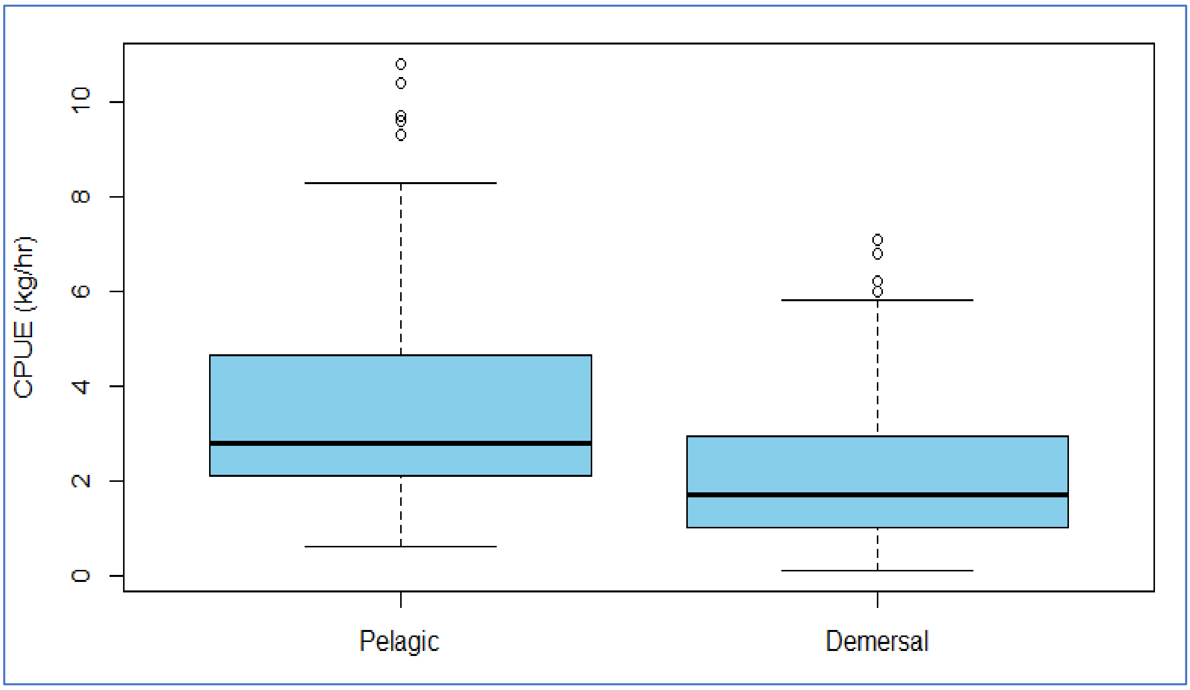


Figure 15: CPUE for all pelagic and demersal finfish at Hillsborough in 2017.

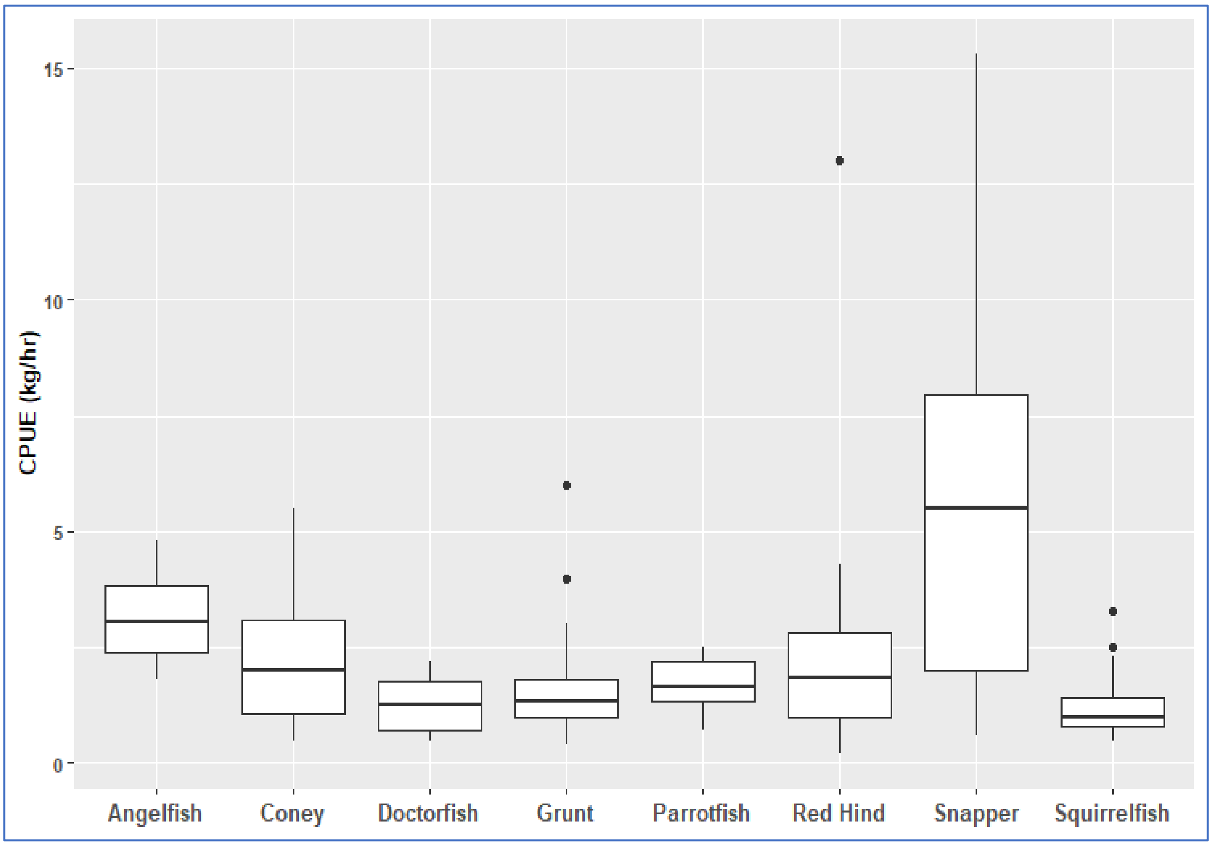


Figure 16: CPUE of eight most frequently landed demersal fish at Hillsborough in 2017.

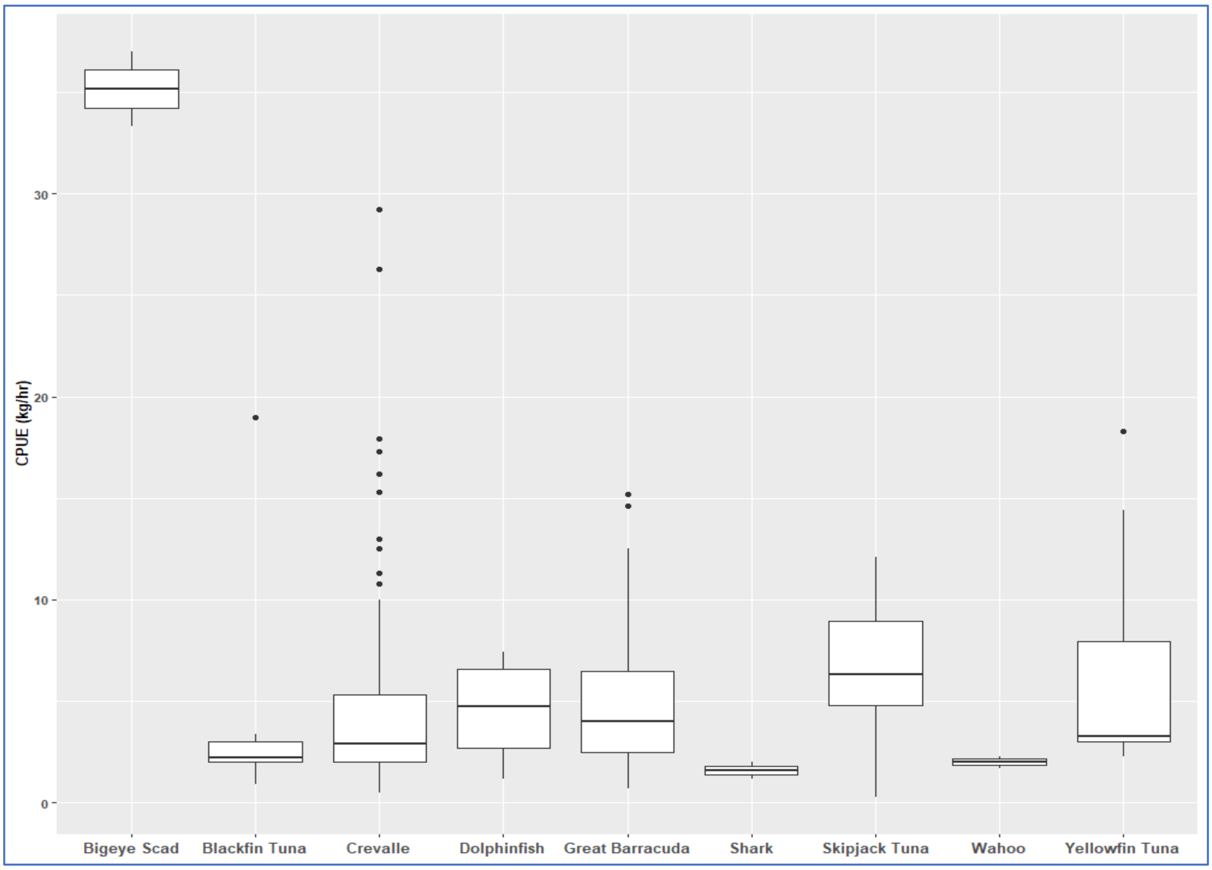


Figure 17: CPUE of nine most frequently landed pelagic fish at Hillsborough in 2017.

4.2.4.2 CPUE for Fishing Grounds

The mean CPUE for the seven areas were fishing occurred ranged from 3.5 kg/hr in the south east 1.5 kg/hr in the north east and north west (Figure 18).

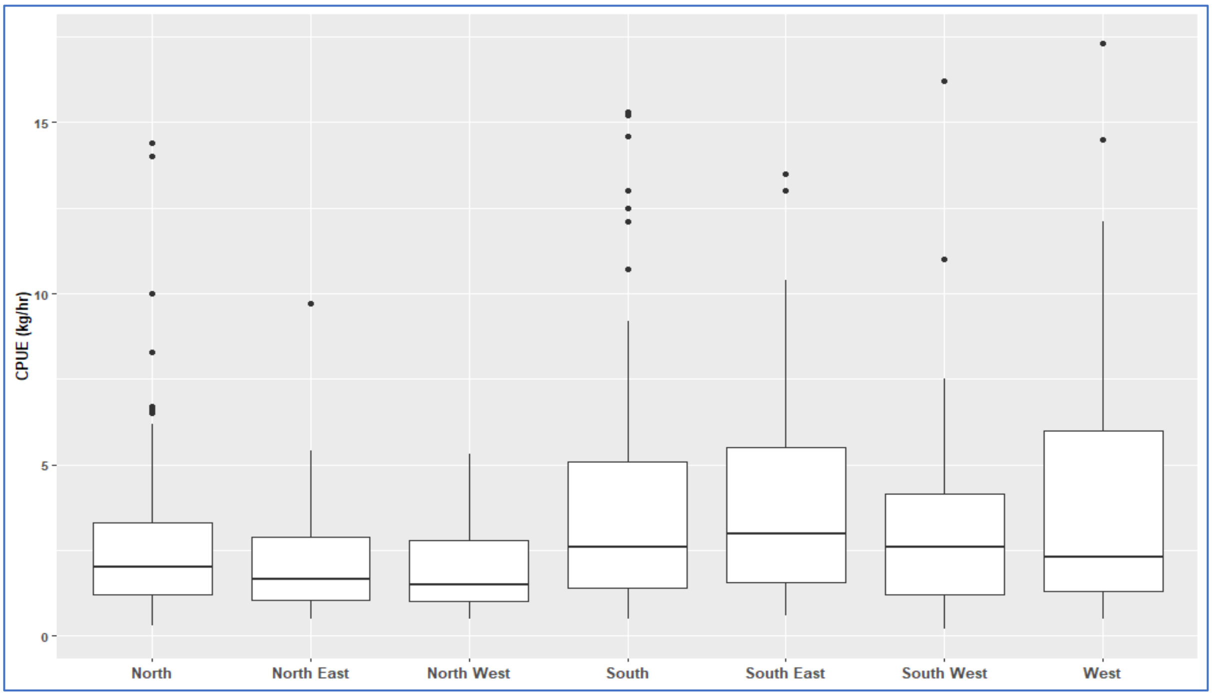


Figure 18: CPUE of fishing areas for the fish landed at Hillsborough in 2017.

4.3 Online Survey on the Grenada Fisheries

4.3.1 Fisheries Management

According to the online respondents, the only requirement for entry into the fishery in Grenada is Grenadian citizenship; however, there is a requirement for all local fishing vessels to be licensed by the GFD before commencing fishing operations. Marine protected areas (MPAs) were identified as a fisheries management tool intended to protect marine resources upon which the fishing industry is based. The major changes observed in the management of fisheries by the respondents included the introduction of MPAs, species-specific management plans and the co-management of fisheries between the GoG and stakeholders. The major shortcomings that were identified of the current fisheries management program is the lack of adequate number of trained personnel to fulfill the required functions and mandates of the division. In order to address this shortcoming, the respondents noted that there needs to be a commitment by the GoG to recruit appropriately qualified personnel to achieve the functions of the GFD.

4.3.2 Changes within the Grenadian Fisheries

The respondents cited four major changes within the Grenadian fisheries during their respective tenures within the GFD spanning from 1982 to present. These changes included the expansion of pelagic fishing, introduction of surface longlines, the use of fish aggregating devices (FADs), increase fisheries management control (e.g. MPAs, gear restrictions, size limits, enforcement), quality control (e.g. icing of fish, post-harvest HACCP guidelines) and the addition of modern infrastructure facilities (e.g. fish markets, cold storage).

4.3.3 Pelagic Fisheries

The respondents indicated that the five main pelagic species targeted in Grenada were yellowfin tuna, dolphinfish, Atlantic sailfish, blue marlin and blackfin tuna. In general, there was an impression amongst the respondents that the pelagic fish stocks were in "average" to "good" health (Figure 19). The respondents felt that the yellowfin tuna stocks were in "average" to "good" health. The dolphinfish stock was ranked generally as being in "fair" to "average" health.

Figure 19: Respondents perception on the current status of pelagic fish stocks.

There was a general perception of a minor decrease (i.e. <20%) in the average size of pelagic fish that has been landed over the past twenty years (Figure 20). There was less agreement among the respondents in the average amount of pelagic fish that had been landed over the past twenty years; however, most persons felt that there was generally an increase in the average amount of landings.

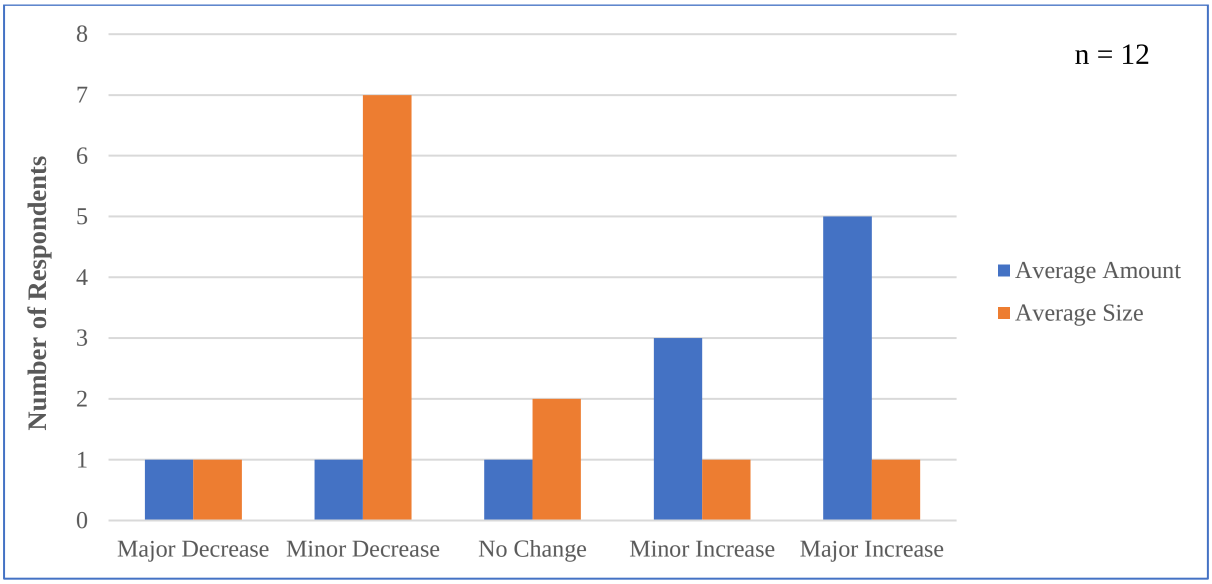


Figure 20: Respondents perceived changes in the average amount and size of pelagics landed in the past 20 years.

According to the respondents, the major changes in the pelagic fishing fleet over the past twenty years have been the increase in the number and size of vessels, vessels equipped with ice holds for multiday fishing and addition of more fuel-efficient engines (i.e. 4-stroke outboard & inboard diesel). The respondents suggested that the changes that have been observed within the pelagic fishing fleet may be attributed to the increased demand for yellowfin tuna, availability of financing to upgrade the fleet (e.g. loans, government subsidiaries), training of fishers in modern fishing technologies (i.e. gear, equipment and techniques) and overharvesting of historically important nearshore species (e.g. *Epinephelus* spp., *Lobatus gigas* and *Panulirus argus*).

4.3.4 Demersal Fisheries

The respondents noted that the five main species/groups of demersal fish that are targeted in Grenada are snapper (*Lutjanidae* spp.), red hind, parrotfish (*Scaridae* spp.), coney (*Cephalopholis fulva*) and groupers. There was a general sense amongst respondents that the stocks of demersal fish are generally in “fair” to “average” health. Parrotfish stocks were rated as being in “poor” to “average” health. Grouper stocks were ranked as being in “poor” to “fair” health (Figure 21).

There was a general consensus of a decrease in the average size of demersal fish landed over the past twenty years (Figure 22). There was more variability in the perceptions of respondents about the change in the average amount of demersal fish landed over the past twenty years; however, most respondents felt that there was a decrease (i.e. minor or major) in the average amount of demersal fish landed over the period.

The major changes within the demersal fishing fleet over the past twenty years have been the increase in the number of vessels, the addition of outboard motors and the use of bottom longlines. The changes within the demersal fleet over the past twenty years have been attributed to the increase in the number of persons entering fishing, the increase availability of modern technologies (e.g. outboard motors) and the increase in demand for demersal species (e.g. conch, lobsters, snapper and parrotfish) for the export markets

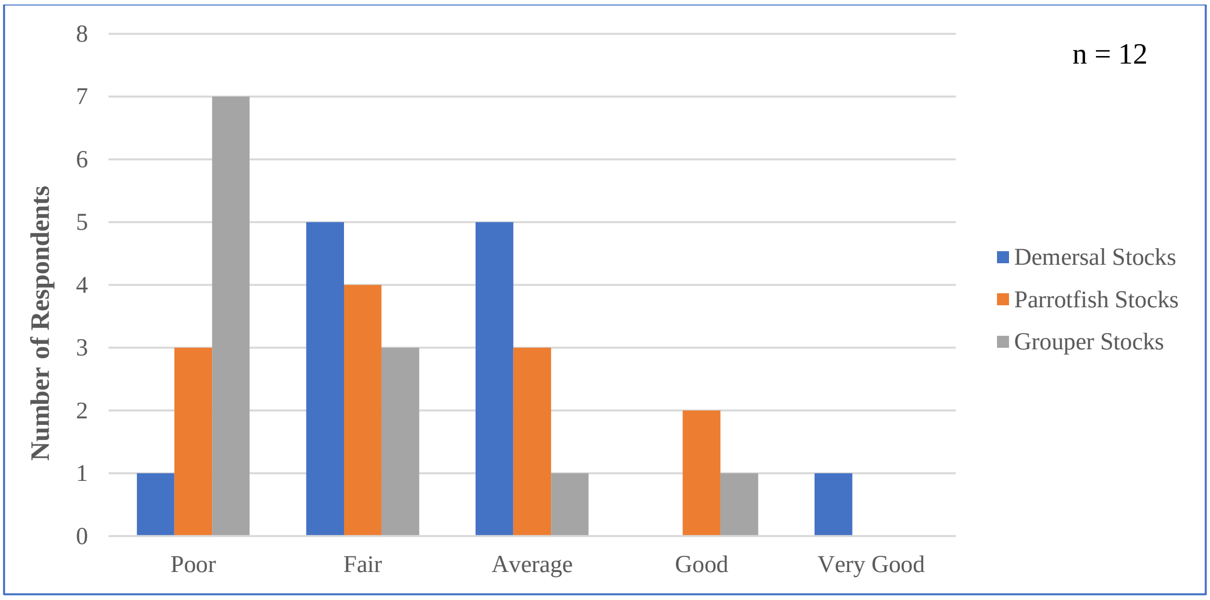


Figure 21: Respondents perception on the current status of demersal fish stocks.

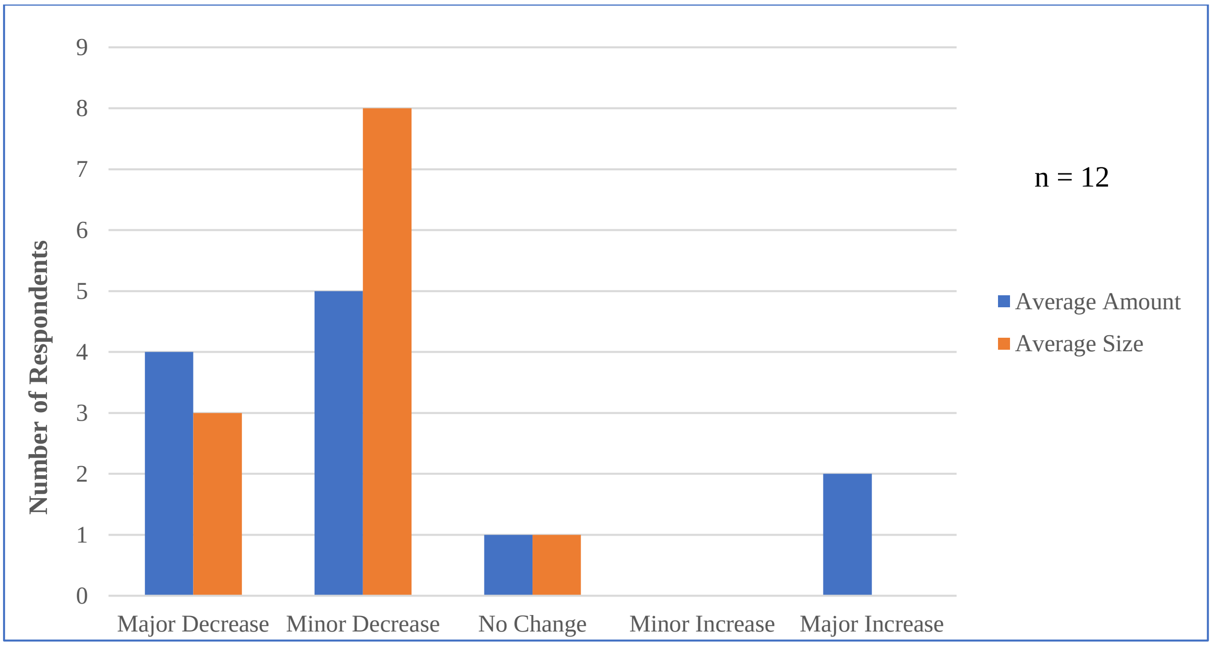


Figure 22: Respondents perceived changes in average amount and size of demersal fish landed over the past 20 years.

4.3.5 Data Collection and Management

According to the respondents, the objectives of the GFD fisheries data collection program are to monitor the status of fished stocks, to guide management policy and fulfill external reporting obligations to regional (e.g. CRFM) and international (e.g. FAO) organisations as well as donors (e.g. JICA). Fisheries data are collected at all primary landing sites (i.e. fish markets) and tertiary landing sites (i.e. exporters) by GFD staff (i.e. market/data clerks) and exporters using a fixed template on paper data sheets, logbooks and computer. The data collected include fish landings, biological data (e.g. length frequency), fishing effort, exports, and value. There was uncertainty on whether the fisheries data are validated before they are entered into electronic files (i.e. Microsoft Excel); however, there are indications that the fisheries extension officer in each fishing district quality checks the raw data from their district before submitting for entry into the storage system. There was a general consensus amongst the respondents that the current data collection programme does not adequately address the data needs of the division. The respondents also identified three major shortcomings of the current data collection and management system. Firstly, there is insufficient properly trained personnel to collect the data. Secondly, there is no collection of biological or environmental data. Thirdly there is no comprehensive computerised system that connects all landing sites and facilitates the collection and management of data as well as analysis and generation of reports. There was general agreement that these shortcomings could best be addressed by training existing and hiring additional qualified personnel, expanding the data collection to secondary landing sites, collecting biological and environmental data, and instituting a comprehensive computerised data management system.

4.3.6 Stock Assessment

The majority of respondents indicated that they “Don’t Know” or said that “No” stock assessment has been conducted in Grenada. However, most respondents indicated that stock assessment would typically be conducted by the GFD and more specifically by the marine biology or resource management unit. The major shortcoming of the current stock assessment programme was identified as lack of financing and appropriate datasets as well as trained personnel. The options identified for improving the current deficiencies within the stock assessment program included assigning a dedicated budget line for assessment, collection of appropriate data, training of existing and hiring of additional qualified personnel.

4.4 Reef Fish Assessment within MPAs

The Sandy Island Oyster Bed Marine Protected Area (SIOBMPA) was officially established in 2010 and is the only MPA on the Island of Carriacou (TNC and GoG, 2007). The sites were initially surveyed in 2005, prior to establishment then in 2015, five years after establishment. Overall, there were little changes in median abundance between the two surveys (2005 and 2015), apart from the parrotfishes which had an increase in abundance in 2015 ($p<0.05$), within the stations, there was difference on a few occasions. There was a decrease in the median abundance of groupers at three of the protected sites within SIOBMPA while there was no change at the control site (Figure 23). Two of the stations showed no change and the other two sites showed an increase and a decrease in median abundance of snappers (Figure 24). There was a decrease in the median abundance of grunts at three of the monitoring stations while one site showed an increase in abundance (Figure 25). There was an increase in median abundance of parrotfishes at all monitoring stations including the control station outside the SIOBMPA

(Figure 26). There was an increase in the mean abundance of surgeonfish at one of the stations, while a decrease was observed at the other three stations (Figure 27).

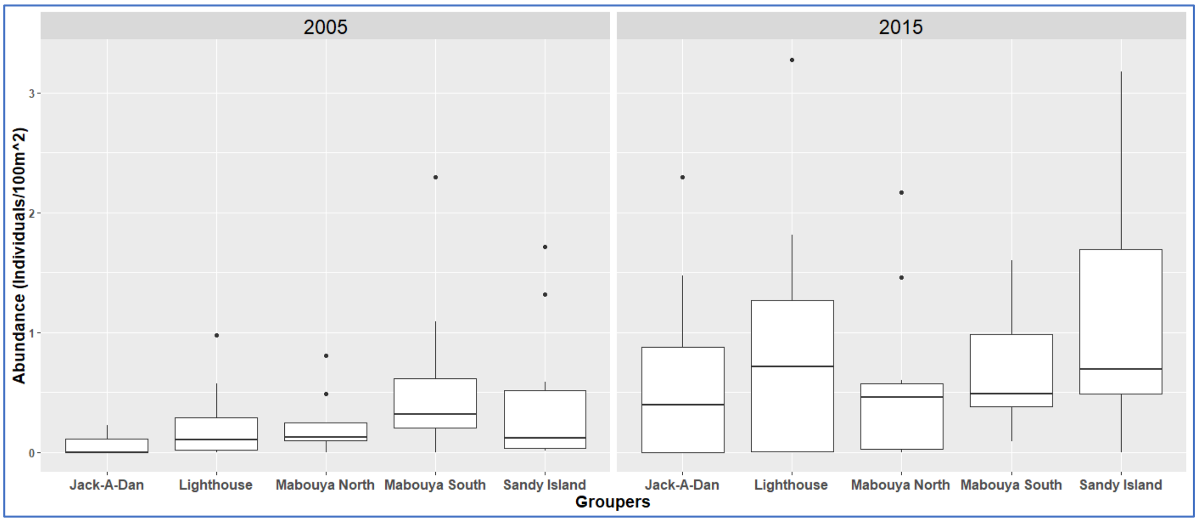


Figure 23: Abundance of groupers at AGRRA stations in Carriacou in 2005 and 2015.

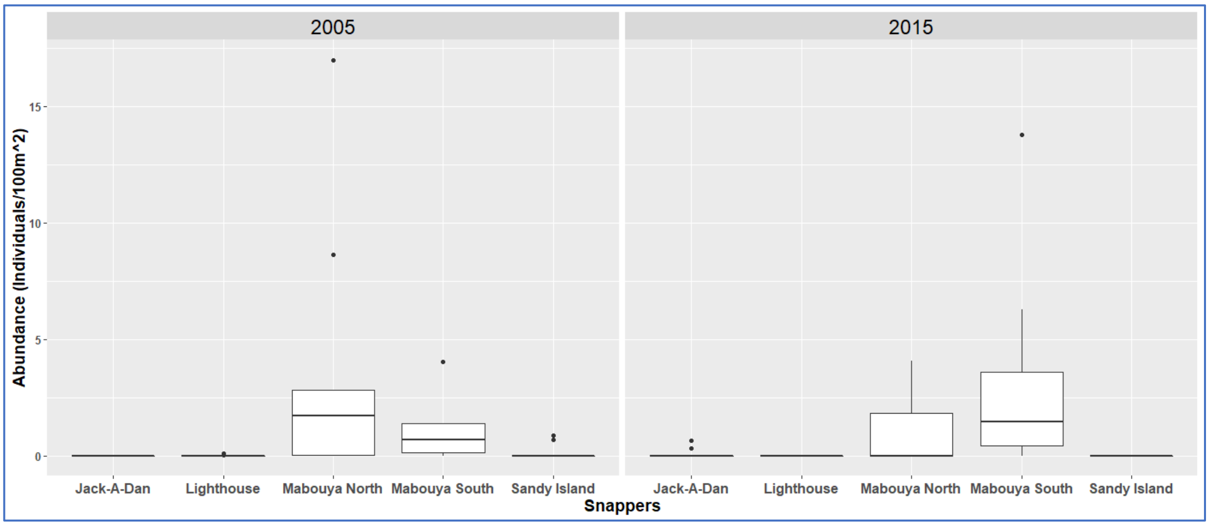


Figure 24: Abundance of snappers at AGRRA stations in Carriacou in 2005 and 2015.

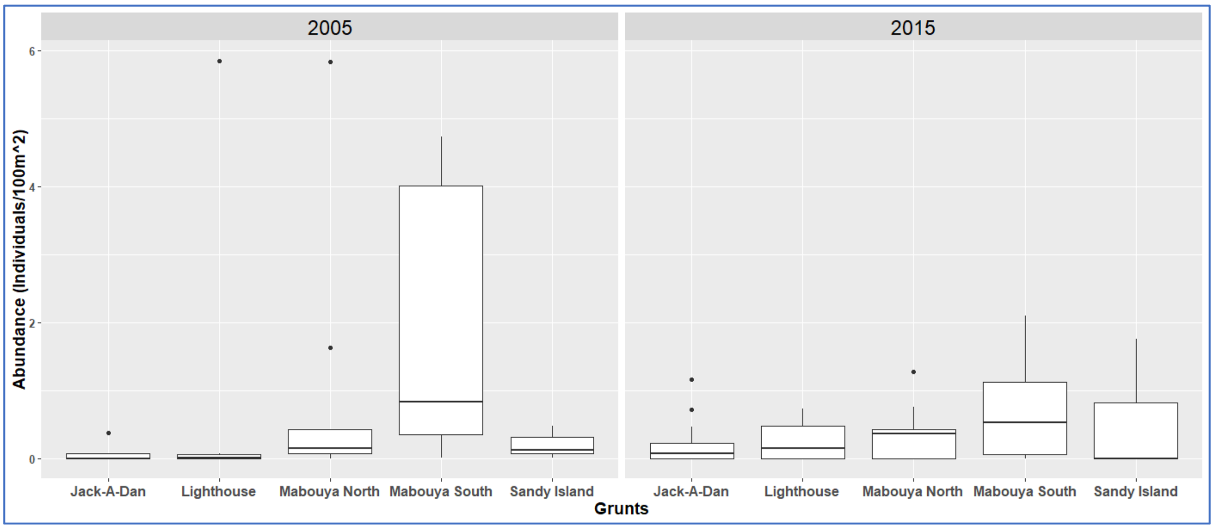


Figure 25: Abundance of grunts at AGRRA stations in Carriacou in 2005 and 2015.

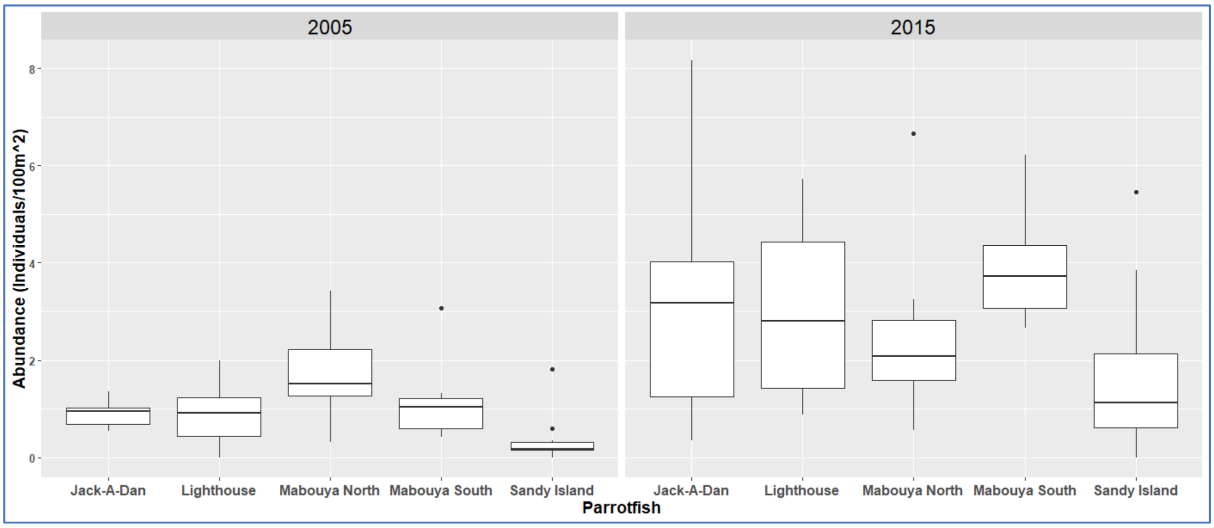


Figure 26: Abundance of parrotfish at AGRRA stations in Carriacou in 2005 and 2015.

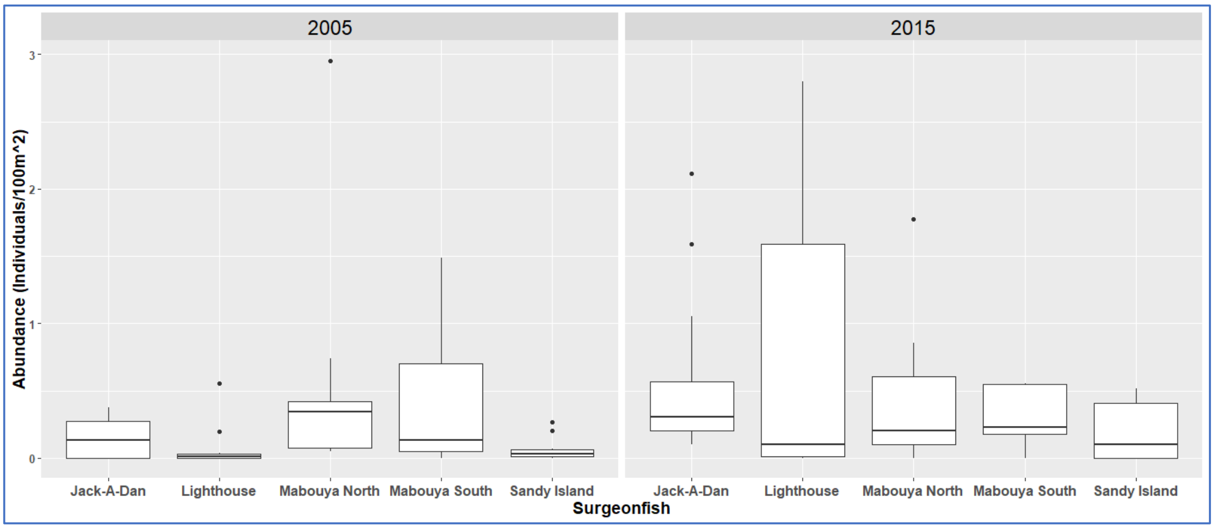


Figure 27: Abundance of surgeonfish at AGRRA stations in Carriacou in 2005 and 2015.

5 DISCUSSION

5.1 Review of Current Fisheries Data Management System

The use of Microsoft Excel workbooks which are stored on a desktop computer as the primary database for the storage of all fisheries data is grossly inadequate. This current system is insecure and susceptible to error or loss. In general, based on the data fields within the various worksheet, the GFD collects a significant amount of data. What appears to be lacking is adequate supervision to ensure that the protocols for data collection and management are strictly adhered to. There are a few areas of concern within the dataset which if adequately addressed, would significantly enhance the utility and robustness of the dataset.

In most cases, the datasets are broken into several worksheets within a workbook based on a number of parameters (e.g. landing site, parish, commercial/recreation) that may be convenient for categorising the data; however, this is unnecessary and makes it more challenging to run analyses that compare between categories that are divided between different worksheets. All of the worksheets have a significant number of empty fields. It is not clear if these empty fields are because the data were not collected, if they were collected but not entered, or if an empty field represents a "zero" value. This can cause a lot of confusion and would require significant manipulation in order to facilitate analysis. Most of the worksheets are cumbersome and congested, because of the use of long names (e.g. boat name, species name, boat owner). It may have been convenient to use the long names within the database because only direct visual interpretation of the data was conducted which was easiest with complete names. Conversely, there is also a significant use of abbreviations (e.g. fishing gear, species code) within the database that is not explained within a metadata or explanation sheet. This makes it difficult to interpret what the data are supposed to express. The use of abbreviations is very useful within the database to streamline analysis; however, it is necessary for these abbreviations to be fully explained so as to ensure accurate interpretation of said analysis.

There are a number of inconsistencies or errors in the spelling of various parameters (e.g. species names, boat name, home port). These errors would most likely have occurred during the collection of the data or while it was being entered into the database. Either way, these errors would introduce complications during data analysis as the different spelling variations would be interpreted by the analysis software as different entities. These errors should have been eliminated by the proper vetting and validation of the data during data entry or subsequent quality checks by the database manager. Within several of the worksheets, there is inconsistency with the formatting of the date; with at least two variations in the date format on the same sheet. The variation in the date format includes the position of the day in the sequence (e.g. dd mm yyyy vs. mm dd yyyy) as well as variations in the separator between the element of the date (e.g. dd/mm/yyyy vs. dd-mm-yyyy). The different variations in the date format within the same sheet cause complications in conducting any analysis related to date.

5.2 Hillsborough Landing Data

There is significant variation in the landing frequency of demersal fish between months; however, there is little variation in species composition of the landings. The lack of variation in the composition of the landings between the months for the demersal fish, may be attributed to two main factors. Firstly, most of the harvested demersal species that are harvested are permanently resident in the Grenada Bank as adults based on size of their typical home range (Farmer & Ault, 2011). Secondly, there is no legally specified fishing season in Grenada with the exception of the lobster fishery which legally occurs from September 1st to April 30th. Snapper was by far the most important demersal family based on landed weight for Carriacou followed by groupers (i.e. red hind, coney), then grunts and squirrelfish. Parrotfish was the fifth most important family by landed weight; however, this may not accurately represent the importance of the family as the majority of parrotfish caught on Carriacou are marketed directly to exporters that ship them to Martinique (GoG, 2009).

There is more variation in the landing frequency of the pelagic species within the months of 2017, which may be a result of the fact that most of the pelagic species are highly migratory and are present within the fisheries waters of Grenada only within specific months. This is demonstrated with the dolphinfish which is most frequently reported during the warmer months (i.e. March to October) and absent from January and December. This is consistent with the fact that the dolphinfish is typically most abundant in the Eastern Caribbean during the summer months when the water is warmest (Oxenford, 1999). Coastal pelagic (i.e. crevalle and barracuda) are the most important pelagic species based on landed weight in Carriacou followed by the tuna species; yellowfin, skipjack and blackfin, respectively. Although there is not a targeted fishery for sharks in Grenada, it was the 8th most frequently landed pelagic species group at Hillsborough in 2017.

The species category within the dataset includes information at both the species and family levels as is illustrated by the fact that red hind and coney are two of the most frequently reported "species". Conversely, squirrelfish, snapper and grunts which are a family level grouping were within the top five most frequently reported "species". It is not clear if this is done due to the inability of the data collectors to identify specimens to the species level. However, the current classification scheme makes it impossible to get a true comparison of species frequency as single species (e.g. red hind or coney) are compared to a family (e.g. snapper or grunt) which consist of several species grouped into a single category.

The lobster (*Panulirus argus*) was the only invertebrate species identified within the landing data, although other species such as conch (*Lobatus gigas*) and sea urchin (*Tripneustes ventricosus*) are commercially harvested on Carriacou (J. McDonald, personal communication, January 9, 2019). This indicates that these species do not make their way to the primary landing site and are as such not reported in the landing data. This is an area that must be addressed especially for the two species indicated above as their regional populations have undergone major declines. More specifically, the conch was added to Appendix II of the Convention on International Trade in Endangered Species (CITES) in 1992 due to concerns regarding decline in its population within its native range (CITES, 2019). Similarly, the Grenadian sea urchin fishery was reopened in 2015 following a 10-year moratorium intended to allow stocks to recover following a drastic decline (C. Isaac, personal communication, November 15, 2018).

The bigeye scad was present only on three occasions within the landing data at Hillsborough in 2017 (i.e. March and July). The underreporting of the landing of bigeye scad at Hillsborough given the importance of the species as a bait and food fish may be attributed to two factors. Bigeye scad is the primary bait for the longline (i.e. surface and bottom), trap and trolling fishing methods in Grenada with most fishers preferring the scad alive; therefore, fish destined for bait are seldom taken to a landing site. Secondly, given the small population of Carriacou (~ 6,100), most of the scad caught for food are sent directly to Grenada or other neighbouring islands in the Grenadines (e.g. Union Island or Canouan) to be sold (J. McDonald, personal communication, January 9, 2019).

Bottom longline was the most important fishing gear based on landed weight; however, there are a number of anomalies with regard to the gear type used for the fishery type and species captured (Figure 11; Annex 6). For example, bottom longline is registered as the most important fishing gear for catching ocean pelagic and more specifically, it is the only gear recorded for catching yellowfin tuna, blackfin tuna, and dolphinfish. Although it is not unheard of to catch large pelagic on bottom longline; it is suspicious that it was the dominant method and, in some cases, the only method documented. It is even more alarming that trolling does not appear in the database as a fishing method for any of the fish landed in Carriacou in 2017, given the fact that trolling has historically been the preferred fishing method for targeting ocean pelagics on Carriacou.

Snappers had the highest CPUE of the demersal fishes but also the highest variance. That may be attributed to the higher tendency of snappers to form large schools which increases their catchability as opposed to species like the doctor fish which had lower CPUE. The bigeye scad had the highest CPUE of the pelagic species which may be attributed to the fact that the species forms large schools that are captured by nets typically beach seines (R. Baldeo, personal communication, October 2, 2018). Consequently, a relatively large biomass of fish can be removed in a single catch. Conversely, the low CPUE for sharks may be attributed to the lack of a targeted fishery for sharks meaning that all sharks that are captured are considered by-catch. In fact, there have been changes to the design of longline and hooks to minimise the capture of sharks; therefore, the low CPUE is an expected outcome of these measures (R. Baldeo, personal communication, October 2, 2018).

The value in landing data lies in the ability to compare changes in the CPUE for the various species as a proxy for stock status; however, this requires a robust time series which was not available for this study. The fact that commercially important species (e.g. lobster, conch, bigeye scad) are absent or underreported in the landing data, highlights the importance of utilising multiple metrics (e.g. quantity landed, economic value, cultural significance) to evaluate the importance of a species to the fishery sector. A multiparametric analysis would provide a more comprehensive understanding of the dynamic and importance of a species to the socioeconomic importance of a species within the Grenadian context.

5.3 Online Survey of Grenada Fisheries

Contrary to the opinion of most of the respondents, the GFD landing data indicated that there has been a “major increase” (i.e. >20%) in the total recorded landing of demersal finfish over the past twenty years (GFD, 2018). The increase in the total recorded landings may be as a result of a corresponding increase in the demersal fishing fleet over the same timeframe (R. Baldeo, personal communication, October 2, 2018). More specifically, the increase in total recorded landings of demersal fish may be a function of an increase in the number of vessels fishing; where the average landings per vessel over the period may actually be decreasing (R. Baldeo, personal communication, October 2, 2018). However, it is not possible to confirm this hypothesis as data on the annual demersal fleet size over the period are not currently available. The data indicate an almost 6-fold increase (i.e. from 120 to 701 tonnes) in landings for demersal fish between 1996 and 2006 then a slow decline to 2016 catch levels approximately 30% higher than the 1996 landings (Annex 8). Similarly, there was more fluctuations within the landings of pelagic fish over the same period; however, there was approximately 27% increase in landings over the same period (Annex 9) (GFD, 2018).

The respondents reinforced the fact that fisheries data are collected only at primary landing sites across the country. However, it is important to note that there are approximately 36 secondary landing sites (i.e. beaches or bays with no infrastructure) where no data are collected (GoG, 2009). Consequently, some species especially demersal species that are primarily consumed locally (e.g. sea urchin) are grossly underreported in the landings data. Landing data for species such as lobsters and conch which are typically landed at secondary sites in the south of Grenada (i.e. Calliste and Woburn) and in the Grenadines (i.e. L'Esterre and Sanchez Bays) are also grossly underreported in landing (C. Isaac, personal communication, November 15, 2018). The higher value species (e.g. conch, lobster, parrotfish, snapper) that are landed at secondary sites are subsequently reported in the export data as permits are required from shipment of all marine products (C. Isaac, personal communication, November 15, 2018).

Three main shortcomings were identified for the current fisheries data collection and management program. The first issue was a shortage of trained personnel within the division to collect and manage the data. The issue of shortage of trained staff emerged within several areas of the survey and is an issue of major concern. More specifically, the position of data manager is highly specialised; therefore, anyone hired to fill that position must already possess the skillsets/training required for that position. The second shortcoming was the lack of collection of biological and environmental data. Although there is a data manual for the GFD, it is not strictly adhered to; consequently, each landing site collects data based on the technical expertise of the data collector and the facilities available at the sites (e.g. scales, datasheets, computers). The third issue with the current data collection and management program, according to the respondents, is the lack of a comprehensive computerised system that integrates all landing sites. This is a fairly straight forward issue to resolve as all the technology and systems required to address this problem already exists. All that is required is the commitment by the relevant ministry and the GFD to designate a modest amount or resources (i.e. financial and personnel) to develop a network that integrates all the landing sites using an interactive portal. Such a system would illuminate several redundant tasks and streamline the flow of information.

There was a general lack of awareness amongst the respondents on the issue of fisheries stock assessment. The findings of the literature review fisheries stock assessments conducted in Grenada have been limited to the GMPA program. Generally, the marine assessments that have been conducted in Grenada, are limited to baseline assessment using underwater visual censuses of near-shore coral reef ecosystem associated with the establishment of MPAs (Nimrod, 2015; GCRF, 2018a; GCRF, 2018b). The lack of adequate number of trained personnel and financial resources have been cited as the primary reasons for the general lack of fisheries stock assessment by the GFD by the respondents. The 2008 National Fisheries Report for Grenada cited the fact that there was only one assistant biologist on staff at the GFD (GoG, 2009). Given this fact, the perception on the respondents that the division lacks the technical capacity to execute stock assessment is well founded. This is an issue of grave concern and warrants immediate action to rectify as two fundamental components of a successful and sustainable fisheries management program are an accurate knowledge of stock status and adequate, trained personnel to manage the harvesting of the stock.

The staff of the GFD despite limited stock assessment and production of formal stock reports have a good understanding of the most important commercially important fishery species and harvest rates. They are also cognizant of the changes that are occurring within the fisheries regarding fleet and technology. However, despite a legally established mechanism for the management of fisheries in Grenada, there is currently no formally approved management plan for fisheries. Instead, it appears that fisheries are managed based on perceptions of the status of the fisheries resources by the managers; given, the lack of assessment for most harvested species. Similarly, there are provisions with the fisheries legislations for the co-management of the fishery between the GFD and fishery stakeholders; however, there has been limited utilisation of this mechanism within recent years.

5.4 Reef Fish Assessment within MPAs

The SIOBMPA was designated to protect critical habitats and enhance marine resource abundance. Consequently, enforcement officers have been active within the MPA ensuring that the relevant no-take rules are complied with (TNC and GoG, 2007). Generally, there had been an increase at most of the monitoring stations within the SIOBMPA with regard to species abundance; however, the only significant increase has been in parrotfish. There stations have been protected for only five years; however, commercially important reef fish abundance was highest within the SIOBMPA of the three MPAs existing in 2015, it is also the highest of the 6 sub-regions in Grenada (Kramer, et al., 2016). The mean abundance of five commercially important coral reef fish species was higher than the eastern Caribbean mean for each species with the exception of snapper at Sandy Island and grunt at Mabouya North monitoring stations (Marks & Lang, 2018). Despite the relatively high abundance of these species, the data available for this study do not yet provide statistical evidence to suggest that the protection given to the monitoring stations within the SIOBMPA has positively impacted on the abundance of all key commercially important reef fish. However, there are studies that suggest that given the size of the SIOMPA (~ 6.6 km^2) and the average home range of these reef fish, that the MPA has the potential to positively impact on reef fish abundance by protecting key habitats important to ontogenetic development of these species (Farmer & Ault, 2011; Harasti, Lee, Gallen, & Steward, 2015).

Due to the diversity and dynamic nature of coral reef ecosystems, the results of the current reef assessments method (i.e. AGRRA) are reef specific; that is, conclusions of the findings for the SIOBMPA cannot be generalised to all MPAs within the GMPA system. Consequently, developing a holistic perspective on the status of coral reefs across the country, requires establishing a large network of monitoring stations across all major reef systems. The current visual survey methodology is resource intensive, requiring significant investment in equipment, gear, time, and staff training. The 10 year survey interval within this study is sufficient to capture changes in benthic composition of the reef (i.e. live coral cover) as they are relatively slow growing organisms; however, it is not ideal for motile organisms (e.g. fish, lobster, conch) that have a more dynamic population structure which can undergo significant changes (i.e. collapse or recovery) within the monitoring interval.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Fisheries Management

There should be an immediate move to update the current draft of Plan for Management of Marine Fisheries in Grenada and have it approved and endorsed for implementation by the relevant authorities (i.e. Minister or Cabinet). The approved plan should be reviewed and updated every five years. A workshop should also be conducted with all technical fisheries management staff (i.e. market managers, extension officers) to ensure that they are fully knowledgeable of their respective roles in the management of the fisheries management plan. The Grenada Fisheries Division should move as soon as practical to implement a vessel log system for all registered fishing vessels. The template, format or level of detail of this log would have to be finalised in consultation with the fishers but as a minimum it should include information on fishing effort (i.e. hours fished, crew size, soak time, location fished, gear type), landings (i.e. species, weight, quantity) and environmental conditions (e.g. sea state, precipitation, wind and current). The environmental parameters could be gathered from the local metrological office.

6.2 Fisheries Data Collection and Handling

A fisheries data collection and management procedures manual should be created for the GFD. Such a document would stipulate what data should be collected, when, how, by whom and using what equipment. Strict adherence to such a document is the only way to ensure that all relevant data are consistently collected, handled, and stored to provide robust scientific advice to direct fisheries management. To facilitate the accurate identification of fish landed at Grenadian landing sites, there should be mandatory biennial training of data collectors in sampling protocols and species identification. Additionally, every landing site should be furnished with copies of species identification guides appropriate for the region (i.e. Caribbean or Western Atlantic). Effort should be made to identify all fish to the species level; however, if a fish cannot be identified to the species level, the species column within the database should be populated with the word “unknown” and the family column populated with the appropriate family.

The data manual should be accompanied by properly structured formal relational database (e.g. Microsoft Access) (Appendix 5). The data table should be structured such that each row is a single observation (i.e. species, fisher, or vessel) with columns describing that observation. There should not be any empty cells within the dataset as this provides confusion on whether the data was collected or just omitted from the database. The database should also include a comprehensive metadata document that outlines all critical information that is not included within the data itself (e.g. measurement units, currency, abbreviations, data sources). The inclusion of such data would ensure that all the particulars about the data are preserved so that it can be accurately interpreted or analysed in the future even if the person who developed or entered the data is no longer available. In order to manage the inconsistency in format and errors in spelling within the database, drop-down lists, or abbreviations (e.g. OECS species codes) should be utilised for data entry. Additionally, conditional formatting should also be included into the data entry forms which would verify that the data entered meets the specified format for each field.

In order to address the issue of non-reporting or underreporting of landings, a program of systematic sampling of high-volume secondary landing sites (e.g. SGU Campus, Woburn Bay, L' Esterre Bay) should be implemented especially for shellfish (i.e. conch, lobster) and reef fish (e.g. parrotfish, surgeonfish). These secondary landing sites could be sampled at least twice per month to provide the GFD with a proxy for the amount of marine resources that are landed at these sites. This proxy would help to accurately adjust the 'lifting factor" for total landings. It is critically important to ensure that all data are verified and validated before they are submitted or entered into the database. It is also important that the person entering the data is familiar with the database and data categories especially when abbreviation or codes are utilised to enter the data. Validation of data should be done no more than 48 hours after it was initially collected so as to ensure that minor errors such as gear type can be corrected while it is still fresh in the data collectors' or fishers' minds.

Given the limited staff that is currently available for data entry and management, it would be more efficient to phase out the current paper-based data sheets and transition to an electronic (e.g. smartphone or table) data collection system. Entering the data directly into an electronic database using the same predesigned data template helps to solve three major drawbacks of the current paper-based system. Firstly, it would illuminate the need for a second person to collate datasheets and enter into the databases. Secondly, it would reduce the number transcription errors that would typically occur during data entry from datasheets. Thirdly, controls could be automatically included into the database to check/cross-reference the data that is inputted to minimise errors with size, weight, or misidentification.

6.3 Stock Assessment

The assessment via visual survey methods of population dynamics within shallow reef stocks (e.g. reef fish and invertebrates), should be conducted on a more frequent basis (i.e. at least every three years). The in-situ monitoring data could be augmented by annual changes in CPUE from fisheries landings data. Species that are commercially harvested but are underreported or absent for the landing data (e.g. bigeye scad, conch, sea urchin) would require fisheries independent assessment methods to evaluate the status of their stocks. In the case of the bigeye scad, this may require the in-situ monitoring of beach seine operations to include sampling of catch; whereas, the commercially important invertebrates (e.g. conch, lobster, urchin), could be monitored using underwater visual censuses by diving in shallow water (i.e. <25m) and video transects at deeper depths (>25 m). Environmental parameters such as currents, water temperature and water quality (e.g. pH, salinity, dissolved oxygen, nutrients), should also be monitored within and outside of MPAs in order to be able to determine the causative links with changes observed in species abundance.

Given the unique differences of life history traits that can occur with a family or genus of fish, it is important not to implement a one size fits all approach to stock assessment. There are a number of assessment methods employed to determine the stock status of pelagic (e.g. dolphinfish, yellowfin tuna) and demersal (stoplight parrotfish, red hind) species given their life history traits (e.g. migration, reproduction mechanism, stock units) (Appendix 4). There are also a number of assumptions that must be inputted into the various stock assessment methods/models which inherently introduce uncertainty into the output. Consequently, a suite of assessment methods appropriate for the available data must be employed to address the uncertainty and employ a precautionary approach.

Some of the large pelagic stock such as the yellowfin tuna and common dolphinfish undergo routine stock assessment at the regional level (ICCAT, 2016; Parker *et al.*, 2000). The landing data collected in Grenada should be provided to the relevent regional fisheries management organisations (e.g. ICCAT, CRFM) as input parameters for those assessment models. Length frequency and size data are easily acquired and are suitable input data for species like red hind and stoplight parrotfish (Sustainable Fisheries Group, 2016; Valles & Oxenford, 2014). In light of the data that is currently available and the suggested addition to the collection system, a combination of landing statistics, length/size-based and surplus production models should be utilised to assess the status of both demersal and pelagic stocks in Grenada.

7 ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to the United Nation University-Fisheries Training Program (UNU-FTP) and the Caribbean Regional Fisheries Mechanism (CRFM) for affording me the opportunity to participate in the six-month training fellowship for which this report is the final project. Participation in the UNU-FTP has provided me with a tremendous opportunity to understand Grenadian Fisheries through the lens of evolving global fisheries.

To the staff of UNU-FTP: Tumi Tómasson, Þór Ásgeirsson, Mary Frances Davidson, Julie Ingram and Stefán Úlfarsson, thank you for your hospitality and guidance throughout the entire fellowship process.

I would like to thank the Government of Grenada through the Fisheries Division for affording me the opportunity to participate in the UNU-FTP Fellowship. I would also like to thank the Fisheries Division staff that participated in the online survey and provided me with data and insight into the Fisheries Division.

Finally, I express sincere gratitude to my supervisors Jónas Páll Jónasson and Jón Sólmundsson for the dedication, guidance and expertise they so generously shared with me in the development and execution of this research project.

8 REFERENCES

AGRRA. (2016). *AGRRA Detailed Fish Protocol Instructions for Use.* Ocean Research and Education.

AGRRA. (2019). *About Us: Our Story*. Retrieved from AGRRA: Atlantic and Gulf Rapid Reef Assessment: http://www.agrra.org/about-us/

Baldeo, R. (2002). National Report of Grenada. *National reports and technical papers presented at the First Meeting of the WECAFC Ad Hoc Working Group on the Development of Sustainable Moored Fish Aggregating Device Fishing in the Lesser Antilles.* (p. 292). FAO Western Central Atlantic Fishery Commission.

Brule, T. (2018). *Epinephelus guttatus. The IUCN Red List of Threatend Species.* IUCN.

Cardwell, J., & Liley, N. (1991). Hormonal Control of Sex and Color Change in the Stoplight Parrotfish, Sparisoma viride. *General and Comparative Endocrinology, 81*(1), 7-20.

CCI. (2016). *CCI Governments: Grenada*. Retrieved from Caribbean Challenge Initiative.org: https://www.caribbeanchallengeinitiative.org/get-involved/governments/446-grenada

Cervigón, F., Cipriani, R., Fischer, W., Garibaldi, L., Hendrickx, M., Lemus, A., . . . Rodriquez, B. (1993). *Field Guide to the Commercial Marine and Brackish-water Resources of the Northern Coast of South America.* Rome: FAO.

Choat, J., Robertson, D., Ackerman, J., & Posada, J. (2003). An age-based demographic analysis of the Caribbean stoplight parrotfish Sparisoma viride. *Marine Ecology Progress Series, 246*, 265-277.

CITES. (2019). *Queen Conch Introduction* . Retrieved from Convention on International Trade of Endnagered Species of Wild Fauna and Flora: https://cites.org/eng/prog/queen_conch/introduction

Collette, B., & Nauen, C. (1983). *FAO Species Catalogue Vol. 2. Scombrids of the World: An annotated and illustrated Catalogue of tunas, mackerels, bonitos and related species known to date.* Rome: FAO.

Collette, B., Acero, A., Amorim, A., Boustany, A., Canales-Ramirez, C., Cardenas, G., . . . Schaef. (2011). *Coryphaena hippurus. The Iucn Redlist of threatend Species.* IUCN.

CRFM. (2006). *Report of the Second Annual Scientific Meeting - Port of Spain, Trinidad and Tobago, 13-22 March 2006.* Kinsgtown: CRFM.

CRFM. (2008). *Draft Plan for Managing the Marine Fisheries of Grenada.* CRFM.

Cristina, L. (2016). *Caribben Fisheries Legal and Institutional Study: Findings of the Comparative Assessment and Country Reports.* Bridgetown: FAO.

FAO. (1994). *World Review of Highly Migrator Species and Straddling Stocks.* FAO, Fisheries. Rome: FAo.

FAO. (2007). *Marine Protected as a Tool for Fisheries Management.* Retrieved from FI Project Website: http://www.fao.org/fishery/mpas/en

FAO. (2016). *Grenada.* Fishery and Aquaculture Country Profiles, Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture , Rome.

FAO. (2018). Fishery and Aquaculture Statistics. Global Capture Production 1950-2016 (FishstatJ). *FAO Fisheries and Aquaculture Department*. Rome.

FAO. (2019). *Species Fact Sheets: Corypaena hippurus*. Retrieved from FAO Fish Finder: http://www.fao.org/fishery/species/3130/en

Farmer, N., & Ault, J. (2011). Grouper and Snapper Movement and Habitat Use in Dry Tortugas, Florida. *Marine Ecology Progress Series, 433,* 169-184.

Froese, R., & Pauly, D. (2018). *Epinephelus guttatus (Red Hind)*. Retrieved from Fishbase.org: http://www.fishbase.us/summary/SpeciesSummary.php?ID=15&AT=grouper

Froese, R., & Pauly, D. (2018). *Sparisoma viride (Stoplight Parrotfish)*. Retrieved from Fishbase.org: http://www.fishbase.us/summary/SpeciesSummary.php?ID=1161&AT=stoplight+parrotfish

Froese, R., & Pauly, D. (2018). *Yellowfin Tuna (Thunnus albacares)*. Retrieved from Fishbase.org: http://fishbase.org/Summary/SpeciesSummary.php?ID=143&AT=yellowfin+tuna

GCRF. (2018a). *Coral Reef Composition and Status within the Coastal Areas of the Proposed Gouyave MPA.* St. George's: Grenada Coral Reef Foundation.

GCRF. (2018b). *Baseline Assessment of Coral Reef Condition within the Coastal Areas of Levera.* St. George's: Grenada Coral Reef Foundation.

GFD. (2018). Daily Log 2017 (Fish Landings): Hillsborough Fish Market.

GFD. (2018). Historical Total Fish Catch Data for Grenada: 1978 to 2016. *Fisheries Landing Database*. Grenada.

Gibson, P. (2019, January 17). personal communications.

GoG. (2009). *Final Country Report for Grenada: Formulation of a Master Plan on Sustainable Use of Fisheries Resources for Coastal Community Development.* JICA.

GoG. (2013). *Chapter 108: Fisheries Act*. Retrieved from Legislation: Laws of Grenada: http://laws.gov.gd/

GoG. (2013). *Legislation: Laws of Grenada*. Retrieved from Laws of Grenada: http://laws.gov.gd/

Hampton, J., Kleiber, P., Langley, A., Takeuchi, Y., & Ichinokawa, M. (2005). *Stock assessment of yellowfin tuna in the western and central Pacific Ocean.* Western and Central Pacific Fisheries Commision.

Harasti, D., Lee, K., Gallen, C. H., & Steward, J. (2015). Movement, Home Range and Site Fidelity of Snapper (Chrysophrys auratus) within a Tempertue Marine Protected Area. *PLoS ONE, 10*(11), 1-20.

Heemstra, P., & Randall, J. (1993). *FAO Species Catalogue Vol. 16 Groupers of the World (Family Serranidae, Subfamily Epinephelinae): An Annotated and Illustrated catalogue of the Grouper, Rockcod, Hind, Coral Grouper and Lytetail Specis Known to Date.* . Rome: FAO.

Homer, F. (2016). *Grand Anse marine Protected Area Management Plan 2016 - 2020.* Eastern Caribbean Program. St. George's: TNC.

ICCAT. (2016). *Executive Summary of the 2016 ICCAT Yellowfin Tuna Stock Assessment Session.* Madrid: Internation Commission for the Conservation of Atlantic Tunas.

ICCAT. (2016). *Report of the 2016 ICCAT Yellowfin Tuna Stock Assessment Meeting.* Assessment Meeting Report, Internation Commission for the Conservation of Atlantic Tunas, Standing Committee on Research and Statistics.

IUCN. (2018). *Yellowfin Tuna*. Retrieved from The IUCN Red List of Threatened Species. Version 2018-2. : https://www.iucnredlist.org/species/21857/9327139

Kadison, E., Nemeth, R., & Blondeau, J. (2009). Assessment of an Unprotected Red Hind (Epinephelus guttatus) Apawning Aggregation on Saba Bank in the Netherlands Antilles . *Bulitin of Marine Sciences, 85*(1), 101-118.

Kramer, P., Roth, L., Constantine, S., Knowles, J., Cross, L., Kramer, P., . . . Phillips, M. (2016). *Grenada's Coral Reef Report Card 2016.* The Nature Conservancy.

Lang, J., & Marks, K. (2007). *Release of the AGRRA (Atlantic and Gulf Rapid Reef Assessment) Database and Summary Products for 1997-2004 V1.5.* AGRRA.

Mahon, R., & Oxenford, H. (1999). Precautionary assessment and management of dolphinfish in the Caribbean. *Scientia Marine, 63*(3-4), 429-438.

Marks, K., & Lang, J. (2018). *"AGRRA Summary Products, version (2018-03)"*. Retrieved from AGRRA.org: http:www.agrra.org/data-explorer/explore-summary-products/

Marks, K., & Lang, J. (2018). *AGRRA Database and Summary Products*. Retrieved from agrra.org: http://www.agrra.org/data-explorer/explore-summary-products/

Microsoft. (2019). Microsoft Excel for Mac (version 16.22).

Mohammed, E., & Lindop, A. (2015). *Grenada: Reconstructed Fisheries Catches, 1950-2010.* Working Paper # 2015 - 40, Fisheries Centre, The University of British Columbia.

Mohammed, E., & Rennie, J. (2003). Grenada and the Grenadines: Reconstructed Fisheries Catches and Fishing Effort, 1942-2001. *Fisheries Centre Research Reports, 11*(6), pp. 67-94.

Nimrod, S. (2015). *Grenada's Grand Anse Bay Coral Reefs: A Baseline Assessment of Benthic Conditions and Fish Population.* Eastern Caribbean Office. St. George's: The Nature Conservancy.

OECS. (1992). *the Implementation of Harmonized Fisheries Legislation in the OECS Region.* FAO, isheries Management and Law Advisory Programme . Rome: FAO.

OREF. (2019). *Coral Reef Monitroing*. Retrieved from Atlantic and Gulf Rapid Reef Assessment: http://www.agrra.org/coral-reef-monitoring/

Oxenford, H. (1999). Biology of the Dolphinfish (Coryphaena hippurus) in the Western Cantral Atlatic: A Review. *Scientia Marina, 3*(4), 277-301.

Paddack, M., Sponaugle, S., & Cowen, R. (2009). Small-scale demographic variation in the stoplight parrotfish Sparisoma viride. *Journal of Fish Biology, 75*, 2509-2526.

Palko, B., Beardsley, G., & Richards, W. (1982). *Synopsis of the biological data on dolphin-fishes, Coryphaena hippurus Linnaeus and Coryphaena equiselis Linnaeus.* NOAA. NOAA Technical Report NMFS Circular.

Parker, '. S.-R., Hackett, A., & Lauckner, F. (2000). *Assessment of Dolphinfish (Coryphaena hippurus) Fishery Using Eastern Caribbean Data.* Working document CFRAMP.

Parker, C., Singh-Renton, S., Hackett, A., & Lauckner, F. (2000). *Assessment of dolphinfish (Coryphaena hippurus) fishery using eastern Caribbean data.* CFRAMP Working document, CARICOM Fisheries Unit.

Potts, J., & Manooch, C. (1995). Age and Growth of Red Hind and Rock Hind Collected from North Carolina Through the Dry Tortugas, Clorida. *Bulletin of Marine Science, 56*(3), 784-794.

R Core Team. (2018). R: A Language and environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing.

Rocha, L., Choat, J., Clements, K., Russell, B., Myers, R., Lazuardi, M., . . . Rahardjo, P. (2012). *Sparisoma viride. The IUCN Red List of Threatened Species* . IUCN.

SEDAR. (2014). *U.S. Caribbean Red Hind.* Southeast Data, Assessment and Review.

Straker, L., Singh-Renton, & Lauckner, B. (2000). *Assessment of red hind (Epinephelus guttatus) fishery using Eastern Caribbean Data.* CFRAMP Working Document, CARICOM Fisheries Unit.

Sustainable Fisheries Group. (2016). *An Assessment of Montserrat's Fisheries.* Assessment Report.

TNC and GoG. (2007). Sandy Island/Oyster Bed Marine Protected Area Management Plan. UVSI: TNC.

Tuner, M. (2009). *Grenada Protected Area System Plan Part 2: Legistaltion, Instutional Organization, Managemnet Planning, Financing, capacity Development and Training.* Organization of eastern Caribbean States, Environmental and Sustainable Development Unit. OECS.

Valles, H., & Oxenford, H. (2014). Parrotfish Size: A Simple yet Useful Alternative Indicatorof Fishing Effects on Caribbean Reefs? *PLoS ONE, 9*(1), 1-15.

9 APPENDICES

Appendix 1: Key Features of the Eight Major Fisheries in Grenada

Fishery	Main Target Species	Fishing Method	Management Unit	Stock Status
Large Oceanic Pelagic	Large Tunas, Mackerel, Billfishes & Dolphinfish	Longline Trolling	Eastern Caribbean	Unknown
Small Oceanic Pelagic	Skipjack tuna and Blackfin tuna	Trolling	Eastern Caribbean	Unknown
Small Coastal Pelagic	Scads (bigeye & Round)	Beach Seine	Island Shelf * Eastern Caribbean**	Unknown
Shallow Reef, Bank/Deep Slope	Groupers, Red hind, Parrotfishes & Snappers	Handlines, vertical & bottom longlines	Island Shelf * Eastern Caribbean**	Overexploited (anecdotal)
Lobster	Spiny lobster	Loop on SCUBA Traps Nets	Island Shelf * Eastern Caribbean**	Unknown
Conch	Queen Conch	Free diving SCUBA	Island Shelf * Eastern Caribbean**	Overexploited in the nearshore
Seamoss (Macroalgae)	Red Algae (*Rhodophyta*)	Harvested by free diving	Island Shelf	Overexploited at some locations
Sea Urchin	White sea urchin	Harvested by free diving	Island Shelf * Eastern Caribbean**	Unknown
* Juvenile and Adult stages ** Planktonic Larvae			**Source: CRFM, 2008**	

Appendix 1: Description of fisheries in Grenada (CRFM, 2008)

Appendix 2: Online Survey

Grenada Fisheries Survey

Welcome

The survey was designed to collect critically important information from both current and past employees of the Grenada Fisheries Division in order to help improve the data collection and management program in order to facilitate effective stock assessment for harvested species.

Thank you for participating in our survey.

Grenada Fisheries Survey

Background and Context

* 1. When did you start working with the Fisheries Division?

* 2. Are you currently employed with the division?

- ◯ YES
- ◯ NO

* 3. How long have/did you work with the division?

* 4. What is/was your primary responsibility at the division?

* 5. What are the requirement for entering the fishing industry?

* 6. What has been the single largest changes in fishing over the course of your tenure with the division?

Grenada Fisheries Survey

Pelagic Fisheries

* 7. What are the five main pelagic (ocean) species?

Species 1:

Species 2:

Species 3:

Species 4:

Species 5:

* 8. In your opinion what is the status of pelagic (ocean) fish stocks in Grenada?

Poor	Fair	Average	Good	Very Good
○	○	○	○	○

* 9. In your opinion what is the status of Yellowfin Tuna stocks in Grenada?

Poor	Fair	Average	Good	Very Good
○	○	○	○	○

* 10. In your opinion what is the status of Dolphinfish stocks in Grenada?

Poor	Fair	Average	Good	Very Good
○	○	○	○	○

* 11. How has the average size of pelagic (ocean) fish that are caught changed over past 20 years? (Minor: < 20%; Major: > 20%)

Major Decrease	Minor Decrease	No Change	Minor Increase	Major Increase
○	○	○	○	○

2

12. How has the average amount of pelagic (ocean) fish that are caught changed over past 20 years? (Minor: < 20%; Major: > 20%)

Major Decrease	Minor Decrease	No Change	Minor Increase	Major Increase
○	○	○	○	○

13. How has the pelagic (ocean) fishing fleet changed over the past 20 years?

14. In your opinion what was the main reasons/cause for the change?

Grenada Fisheries Survey

Demersal Fisheries

* 15. What are the five main demersal (bottom) species fished in Grenada?

Species 1:

Species 2:

Species 3:

Species 4:

Species 5:

* 16. In your opinion what is the status of demersal (bottom) fish stocks in Grenada?

Poor	Fair	Average	Good	Very Good
○	○	○	○	○

* 17. In your opinion what is the status of Parrotfish stocks in Grenada?

Poor	Fair	Average	Good	Very Good
○	○	○	○	○

3

* 18. In your opinion what is the status of Grouper stocks in Grenada?

Poor	Fair	Average	Good	Very Good
○	○	○	○	○

* 19. How has the average size of demersal (bottom) fish that are caught changed over past 20 years? (Minor: < 20%; Major: > 20%)

Major Decrease	Minor Decrease	No Change	Minor Increase	Major Increase
○	○	○	○	○

* 20. How has the average amount of demersal (bottom) fish that are caught changed over past 20 years? (Minor: < 20%; Major: > 20%)

Major Decrease	Minor Decrease	No Change	Minor Increase	Major Increase
○	○	○	○	○

21. How has the demersal fishing fleet changed over the past 20 years?

22. In your opinion what was the main reasons/cause for the change?

Grenada Fisheries Survey

Fisheries Data

* 23. What is the object of the fisheries data collection program?

* 24. Where are fisheries data collected?

* 25. Who collects the fisheries data?

4

* 26. What fisheries data is collected?

* 27. Are there fixed templates for collecting the data?

- YES
- NO

* 28. What medium is used to record the data at the source?

- Mobile Device (eg. Tablet, Smart phone)
- Computer
- Logbook
- Datasheet

* 29. Is the fisheries data validated before entry into the database?

- YES
- NO
- Don't Know

30. If yes, by what means?

* 31. What is the fisheries data used for?

* 32. Does the current data collection program adequately address the data needs of the Fisheries Division?

- YES
- NO
- Don't Know

33. In you opinion, what are the major shortcomings of the current data collection and management System?

34. In your opinion how could this be improved?

5

Grenada Fisheries Survey

Fisheries Stock Assessment

* 35. Has stock assessment been conducted in Grenada?

- ◯ YES
- ◯ NO
- ◯ Don't Know

36. If YES, for what species?

Species 1: ______

Species 2: ______

Species 3: ______

* 37. Who typically conducts the stock assessment?

______

38. What method was utilized for the stock assessment(s) that have been conducted?

______

* 39. What are the major shortcomings of the present stock assessments?

______

40. In your opinion how could this be improved?

______

Grenada Fisheries Survey

Fisheries Management

6

41. What is the role of Marine Protected Areas (MPAs) in fisheries management?

42. What has been to most significant change in the management of fisheries that you have observed?

43. What are the major shortcomings of the present fisheries management program?

44. In your opinion how could this be improved?

7

Appendix 2: Copy of the online survey (Survey Monkey) administered to fisheries staff (past and present)

Appendix 3: Vessels That Landed Fish at Hillsborough in 2017

Boat Owner	Boat Owner	Registration #	Length (m)	Crew Size
Otis Benjamin	Acha	Unregistered	5	2
George Lowel	Angella	J3-352-LE	5	3
Joseph Enoe	Black Egil 4	J3-249-BO	6	3
Boniface Mc Lawrence	Blue Dolphin	J3-1882-WW	9	-
Clyde Frank	Celestine	J3-1929-PM	10	-
Martin Thomas	Cisco Kedi	J3-571-LE	5	-
Alvin Ollivierre	Cool Runnings	Unregistered	6	-
Bertrand Calliste	Dealian	J3-2002-LE	5	1
Wendell Stafford	Faith	Unregistered	6	2
Thomas Joseph	Fearless Child	J3-1604-LE	5	
Timothy Galley	Free Star	Unregistered	8	2
Emerold Telesford	Ghost	J3-2020-WW	5	3
Albert Mitchell	God Bless	J3-533-LE	6	3
Allan Clement	God Fearing	J3-345-LE	5	2
Junior Stapleton	Good Over Evil	J3-2073-LE	6	2
Joshua Clement	Good Question	J3-1928-LE	4	1
Dane Lewis	Hustler	J3-1527-BL	7	2
Jerry Felix	Jackie Boy	J3-1993-WW	12	2
Howard Mitchell	Jeezee	J3-1448-PM	8	3
Terry Enoe	Keep Rolling	J3-1657-WW	6	2
Che Prime	Kio Jah	Unregistered	9	2
Anthony Mc Intyre	Let Them Talk	J3-2007-HV	6	3
Augustus Williams	Mad Max	J3-1513-GV	14	3
Michael St Hillaire	Magito	Unregistered	-	-
Joseph Modeste	Mr Kim	J3-1408-HL	6	-
Rawston Weeks	Mr Weeks	J3-023-HL	10	2
Leroy Bethel	No Question	J3-156-GV	-	
Desmond De Coteau	Ocean Reaper	J3-1902-PM	13	3
Jaral Mc Neil	Online	J3-1978-LE	4	1
Amon Cudjoe	Over Come	Unregistered	6	2
Timothy Cudjoe	Pussy Bum	J3-1112-HV	8	-
Kenville Kydd	Rample Dazzle	J3-1910-WW	-	-
Joshua Clement	Ray Ray	J3-1939-LE	6	3
Kenville Kydd	Renek	Unregistered	-	-
Lashley John	Sea Angel	J3-812-GV	7	2
Kent Charles	Sea Queen	J3-1038-CA	-	-
Leroy Bethel	Sea Train	Unregistered	-	-
Sebastian Stiell	Shenima	J3-1254-LE	-	-
Aaron Malcolm	Soul of a shark	Unregistered	4	-
Emmanuel Gilbert	Still Talk	Unregistered	-	-
Gregory C Alexis	Take A Mark	J3-2083-HV	9	2
Jayson Bethel	Tempted	J3-1755-PM	7	
Scotty Frank	Theon	J3-625-CA	12	
Rolik Joseph	Trim	J3-1982-PM	10	2

Boat Owner	**Boat Owner**	**Registration #**	**Length (m)**	**Crew Size**
Austin Federick	Triumph	J3-1429-GV	12	2
Daniel Noel	Undefeated	J3-1976-HL	6	2
Denzel Adams	Rogue	Unregistered	5	-
Thomas	Unknown	Unregistered	-	-
Ronold Comton	Upset	J3-967-WW	7	2
Alister Douglas	Wisdom	J3-1925-WW	6	2
Herbert Placid	Yellow Bird	J3-549-LE	6	1
- : Unspecified/Unknown		Source: (GFD, 2018)		

Appendix 3: List of fishing vessels that landed fish at the Hillsborough landing site in 2017

Appendix 4: Methods Utilised for Conducting Assessment of Demonstration Species

Species	Location	Assessment Model/Method	Year	Citation
Dolphinfish	Eastern Caribbean	Stock Production (CPUE) Yield per Recruit	2000	(Parker *et al*., 2000)
Dolphinfish	Caribbean	Stock Production (CPUE) Yield Per Recruit	1999	(Mahon & Oxenford, 1999)
Yellowfin Tuna	Atlantic Ocean	Stock Production (CPUE) Stock Synthesis Virtual Population Analysis	2016	(ICCAT, 2016)
Yellowfin Tuna	Pacific Ocean	Stock Production (CPUE) Age-based & Size-based	2005	(Hampton *et al*., 2005)
Red Hind	U.S. Caribbean	Yield per Recruit	2014	(SEDAR, 2014)
Red Hind	Saba Bank, Caribbean	Stock Production (CPUE) Visual survey	2006	(Kadison *et al*., 2009)
Red Hind	Montserrat, Caribbean	Length-based	2016	(Sustainable Fisheries Group, 2016)
Red Hind	Eastern Caribbean	Stock Production (CPUE) Yield Per Recruit	2000	(Straker *et al*., 2000)
Stoplight Parrotfish	Caribbean	Visual Survey	2003	(Choat *et al*., 2003)
Stoplight Parrotfish	Florida Keys	Visual Survey Age-based	2005	(Paddack *et al*., 2009)
Stoplight Parrotfish	Caribbean	Visual Survey Size-based	2014	(Valles & Oxenford, 2014)

Appendix 4: Methods utilised for conducting assessment of demonstration species

Appendix 5: Proposed Daily Fish Landings Form within Microsoft Access Relational Database

Appendix 5: Screenshot of the proposed Daily Fish Landings form within Microsoft Access relational database

Appendix 6: Mean Abundance of Key Commercial Reef Fish Species.

Site Name	Island	Location	Status	Year	Grouper	Parrotfish	Snapper	Jack	Grunt
Sandy Island	Carriacou	SIOBMPA	Protected	2005	**5.8** (± 4.5)	**10.2** (± 7.6)	**3.7** (± 8.3)	**0.2** (± 0.5)	**5** (± 4.5)
Sandy Is. (Shallow)	Carriacou	SIOBMPA	Protected	2005	**3.7** (± 3.6	**15.2** (± 12.5)	**5.8** (± 7.5)	**0.2** (± 0.5)	**25.5** (±25.9)
Lighthouse	Carriacou	SIOBMPA	Protected	2005	**3.7** (± 3.7)	**21.5** (± 14.7)	**0.5** (± 1.1)	**0.5** (± 1.1)	**4.5** (±11.3)
Sister Rocks	Carriacou	SIOBMPA	Protected	2005	**2.9** (±1.7)	**13.6** (± 5.9)	**13.6** (± 11.6)	**2.7** (± 5.2)	**9.6** (±8.6)
Mabouya Garden	Carriacou	SIOBMPA	Protected	2005	**3.3** (± 3)	**22.6** (± 7.1)	**12.2** (± 13.7)	**0**	**9.1** (±13.1)
Point Cistern	Carriacou	SIOBMPA	Protected	2005	**6.8** (± 5)	**16.1** (± 10.6)	**3** (± 4.9)	**1.1** (± 3.3)	**2.4** (± 4.2)
Mabouya South	Carriacou	SIOBMPA	Protected	2005	**5.9** (± 3)	**20** (± 6.2)	**8.3** (± 11.1)	**0.9** (± 2.8)	**23.2** (± 27.6
White Is. Shallow	Carriacou	SCIMPA	unprotected	2005	**1.1** (± 1.7)	**36.9** (± 23.9)	**1.9** (± 2.9)	**0.2** (± 0.6)	**22.6** (± 37.6)
Saline Is. Channel	Carriacou	SCIMPA	unprotected	2005	**6.9** (±6.4)	**24.4** (± 7.8)	**0**	**0**	**5.8** (± 8.3)
Frigate Island	Carriacou	SCIMPA	unprotected	2005	**11.5** (± 7.4)	**14.1** (± 8.4)	**0.6** (± 0.9)	**0.9** (± 1.7)	**6.5** (± 6.8)
Casada Bay	Carriacou	SCIMPA	unprotected	2005	**0.4** (± 1.1)	**12.2** (± 8.9)	**5.7** (± 6.9)	**3.3** (± 4.9)	**20** (± 15.6)
Jack-a-Dan	Carriacou	Outside MPA	unprotected	2005	**1** (±1.5)	**14.7** (± 4)	**0**	**0**	**2** (± 3.6)
Thibault Reef	Carriacou	Outside MPA	unprotected	2005	**4.4** (± 5)	**3.1** (± 3.7)	**1.2** (± 1.9)	**0**	**13.7** (± 11.4)
Windward Reef	Carriacou	Outside MPA	unprotected	2005	**0**	**13.8** (± 9)	**10.4** (± 18.2)	**0**	**48.8** (± 60.2)
P-nez Reef	Carriacou	Outside MPA	unprotected	2005	**4.2** (± 4.1)	**34.2** (± 23.1)	**4** (± 4.7)	**0**	**37.9** (± 81.7)
Grand Anse Inshore	Grenada	GAMPA	Protected	2015	**0.2** (± 0.5)	**14.8** (± 11.8)	**0**	**0**	**9.2** (± 21.5)
Kahonae	Grenada	GAMPA	Protected	2015	**1.2** (± 1.4)	**16.5** (± 10.3)	**0**	**0.5** (± 1.6)	**3.4** (± 6)
Lower Boss	Grenada	GAMPA	Protected	2015	**0.3** (± 0.7)	**19.2** (± 10.4)	**0**	**0**	**0.8** (± 1.2)
Mid Boss	Grenada	GAMPA	Protected	2015	**1.1** (± 1.3)	**16.5** (± 8.9)	**0**	**0**	**4.7** (± 5.2)
Northern Exposure	Grenada	GAMPA	Protected	2015	**1.2** (± 1.4)	**20.5** (± 7)	**0**	**0**	**17.7** (± 29.3)
Quarter Wreck	Grenada	GAMPA	Protected	2015	**1.5** (± 1.9)	**15.2** (± 6.4)	**0**	**0**	**2.4** (± 2.7)
Red Buoy	Grenada	GAMPA	Protected	2015	**1.2** (± 1.8)	**16.5** (± 11.2)	**0**	**0**	**4.5** (± 12.5)
Upper Boss	Grenada	GAMPA	Protected	2015	**0.5** (± 0.8)	**25** (± 9.7)	**0.3** (± 1)	**0**	**2** (± 1.9)

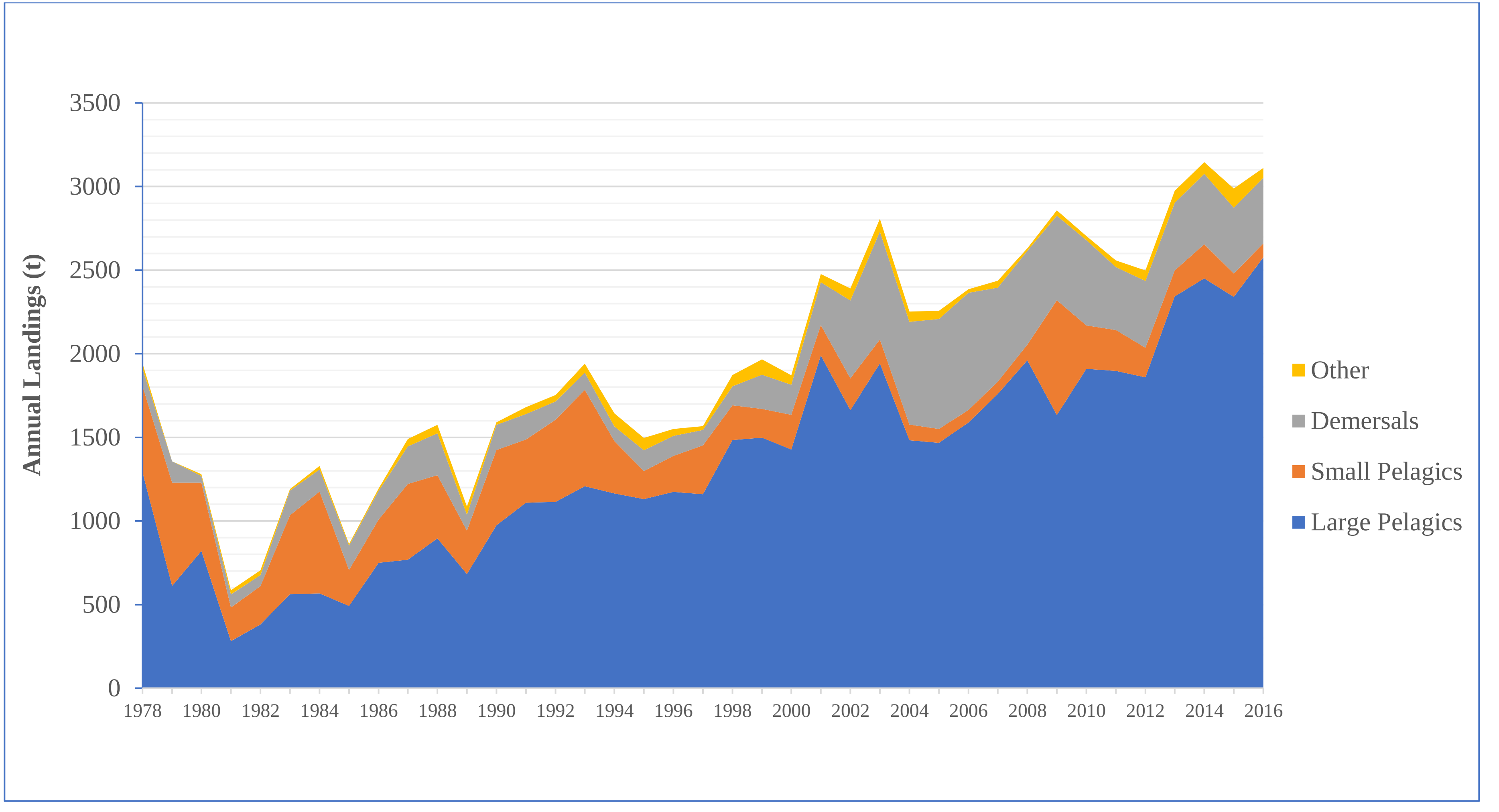
Unit: (individuals/100m^2 ± standard deviation) **Source:** (Marks & Lang, AGRRA Database and Summary Products, 2018)

Site Name	Island	Location	Status	Year	Grouper	Parrotfish	Snapper	Jack	Grunt
L'Esterre Bay	Carriacou	SIOBMPA	Protected	2015	**8.3** (± 8.6)	**2.7** (± 4.1)	**1.3** (± 4.2)	**0**	**0**
Mabouya South	Carriacou	SIOBMPA	Protected	2015	**3.5** (± 2.4)	**49.2** (± 27.3)	**18.5** (± 26.3)	**2.7** (± 8.4)	**149** (± 365.9)
Lighthouse	Carriacou	SIOBMPA	Protected	2015	**4.3** (± 4.5)	**49.2** (± 25.8)	**5.5** (± 17.4)	**0.2** (± 0.5)	**30** (± 83.2)
Mabouya North	Carriacou	SIOBMPA	Protected	2015	**2.8** (± 3.3)	**34.5** (± 14.4)	**1.7** (± 2.5)	**0**	**2.2** (± 2.4)
Sandy Island	Carriacou	SIOBMPA	Protected	2015	**4.3** (± 3.7)	**26.5** (± 19.7)	**0**	**0**	**8.5** (± 12.2)
Jack-A-Dan	Carriacou	Outside MPA	unprotected	2015	**4.3** (± 4)	**78.5** (± 37.1)	**0**	**1.3** (± 4.2)	**1.3** (± 2.2)
Sparrow Bay North	Carriacou	Outside MPA	unprotected	2015	**7.5** (± 4)	**37.5** (± 24)	**0**	**0**	**6.8** (± 16)
Sparrow Bay Central	Carriacou	Outside MPA	unprotected	2015	**1.8** (± 2.4)	**3.5** (± 3.6)	**0**	**0.8** (± 2.6)	**0**
Jack-A-Dan North	Carriacou	Outside MPA	unprotected	2015	**5.7** (± 3.4)	**76.3** (± 30.5)	**3.2** (± 8.9)	**0**	**0.2** (±0.5)
Jack-A-Dan South	Carriacou	Outside MPA	unprotected	2015	**2.3** (± 3.1)	**37.2** (± 21.9)	**0.5** (± 1.1)	**0**	**1.8** (± 1.4)
Palmiste 1	Grenada	GoMPA	Protected	2018	**1.2** (± 1.8)	**11.7** (± 7.2)	**0.8** (± 1.8)	**0.7** (± 1.4)	**7.3** (± 11.3)
Palmiste 2	Grenada	GoMPA	Protected	2018	**1.5** (± 2.0)	**13.3** (± 6.1)	**6.1** (± 10.3)	**0**	**8.1** (± 6.9)
Benago	Grenada	GoMPA	Protected	2018	**0**	**5.2** (± 4)	**0.5** (± 1.6)	**0**	**4.5** (± 2.7)
Maran Point	Grenada	GoMPA	Protected	2018	**1** (± 1.8)	**5.2** (± 3.9)	**1.5** (± 2.2)	**0**	**1.5** (± 1.6)
La Resource	Grenada	GoMPA	Protected	2018	**3.5** (± 2.9)	**4.7** (± 3.8)	**1.7** (± 2.5)	**0**	**1.5** (± 2.1)
Sugar Loaf	Grenada	LMPA	unprotected	2018	**2** (± 2.8)	**8.5** (± 9.2)	**1** (± 3.2)	**3.5** (± 7.9)	**11.7** (± 11.3)
Green Island	Grenada	LMPA	unprotected	2018	**10.7** (± 2.2)	**8.2** (± 7.3)	**0.2** (± 0.5)	**0**	**2.2** (± 6.9)
Nine Hole	Grenada	LMPA	unprotected	2018	**8.3** (± 5)	**4.7** (± 4.4)	**0**	**0**	**3.5** (± 5.2)
Unit: (individuals/100m^2 ± standard deviation) **Source:** (Marks & Lang, AGRRA Database and Summary Products, 2018)									

Appendix 6: Mean abundance (individuals/100m^2 ± standard deviation) of key commercial important reef fish species from AGRRA surveys in 2005 and 2015.

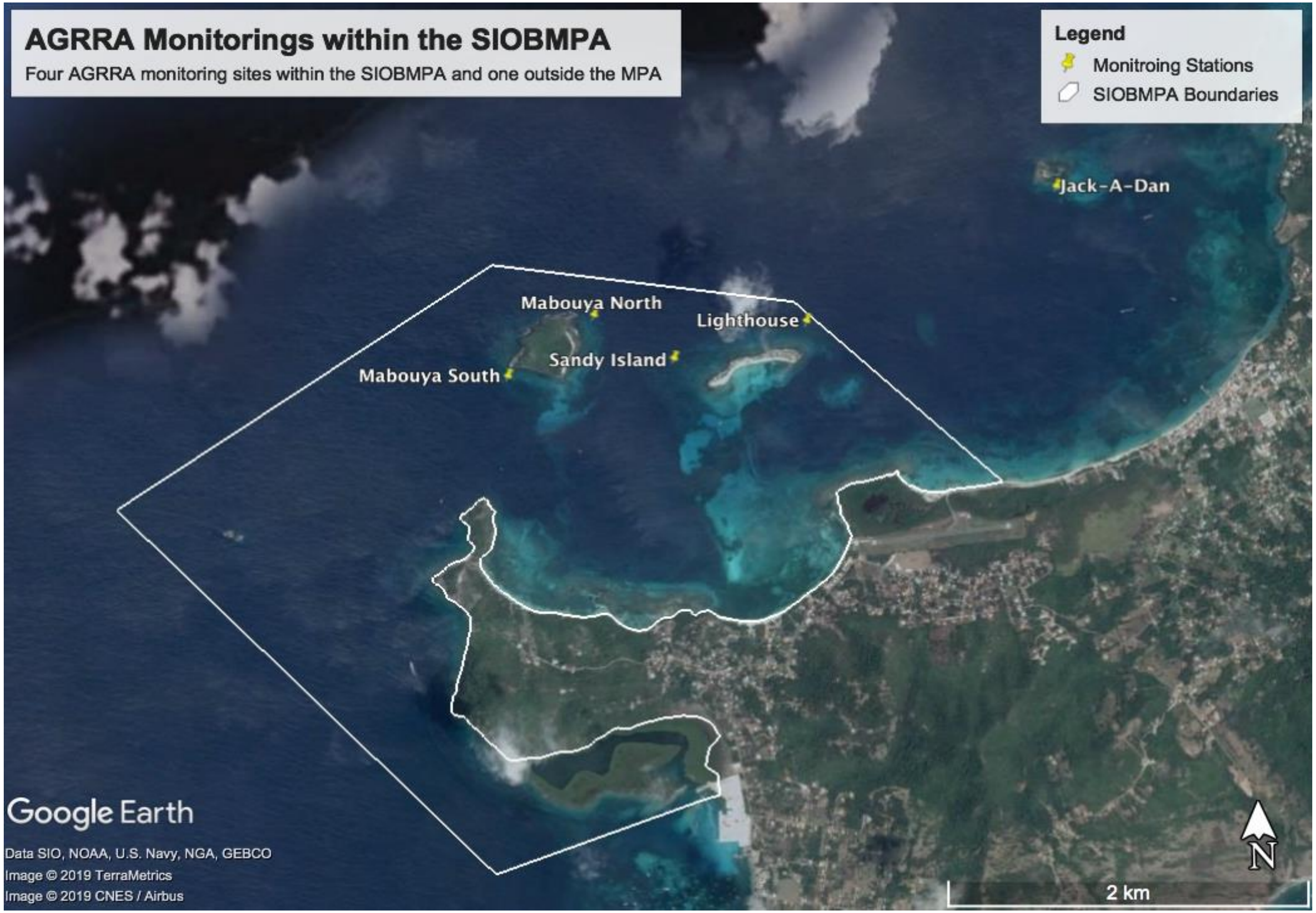
10 ANNEXES

Annex 1: Total Recorded Fisheries Landings in Grenada



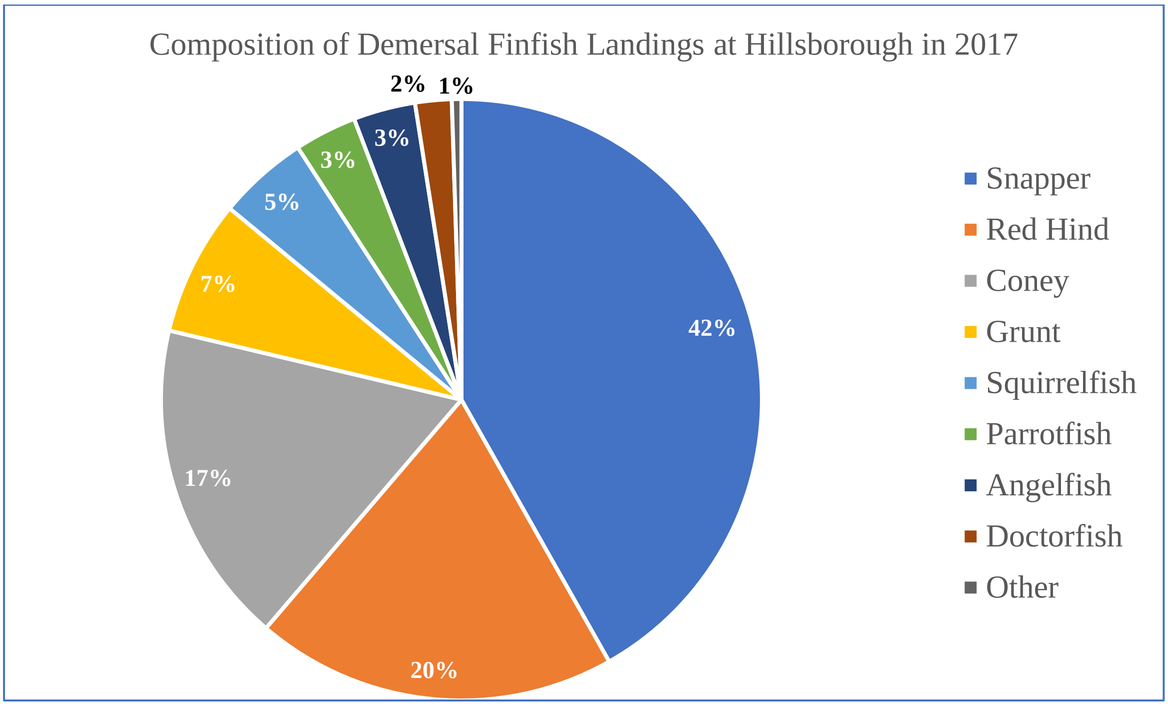
Annex 1: Total recorded fisheries landings in Grenada for the period 1978 to 2016.

Annex 2: Map of the five AGRRA Monitoring Stations at the SIOBMPA in Carriacou



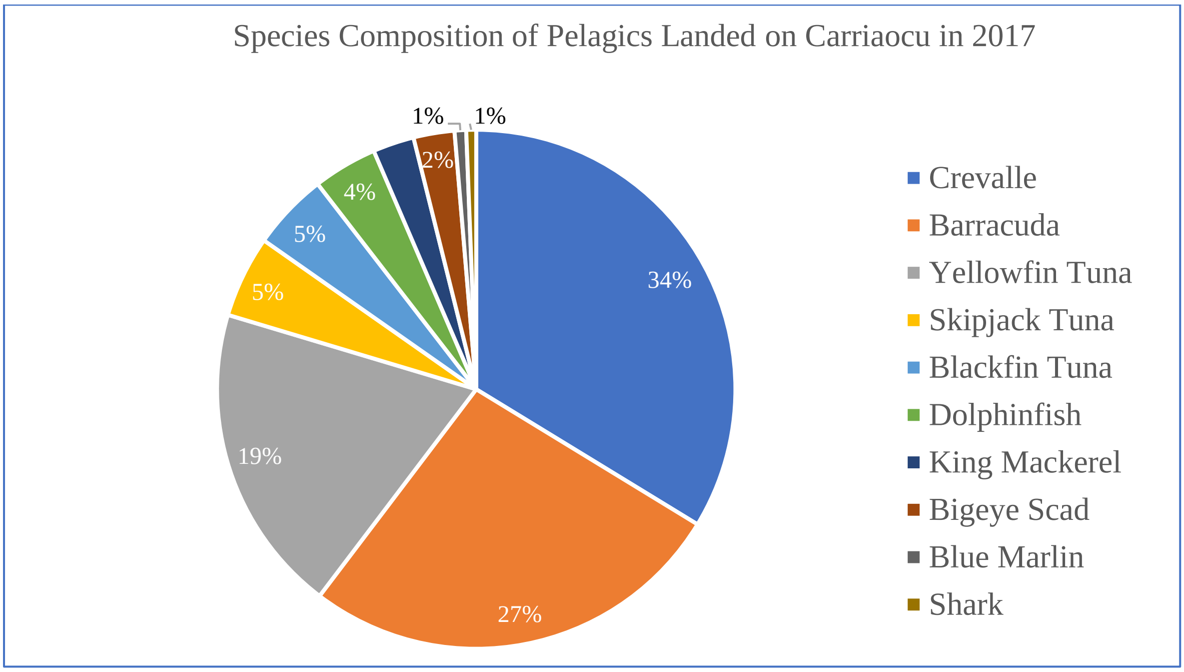
Annex 2: Map of the five AGRRA monitoring stations at the SIOBMPA in Carriacou

Annex 3: Composition of Demersal Finfish



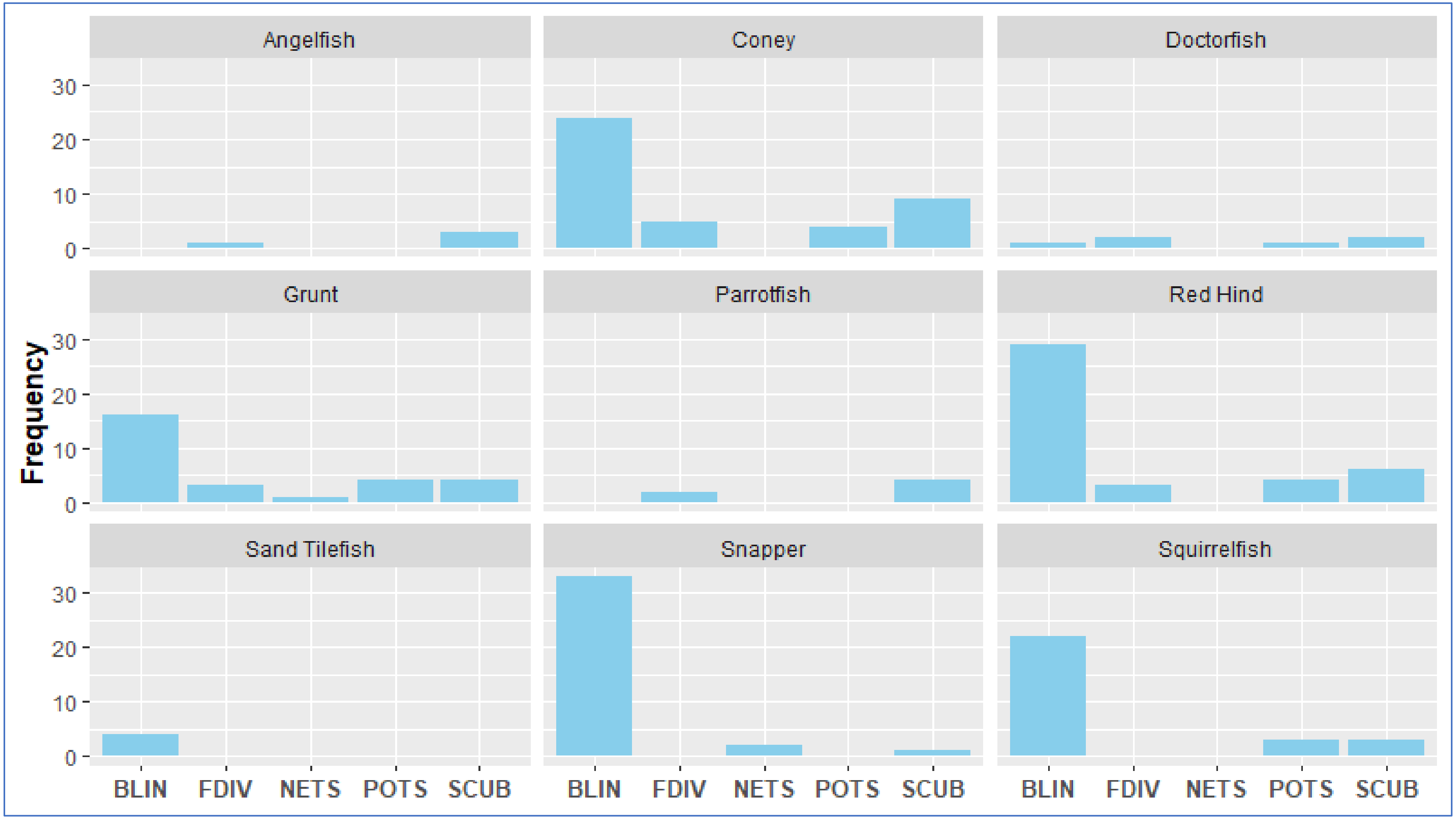
Annex 3: Species contribution to total landings of demersal finfish at the Hillsborough landing site in 2017

Annex 4: Composition of Pelagic Species



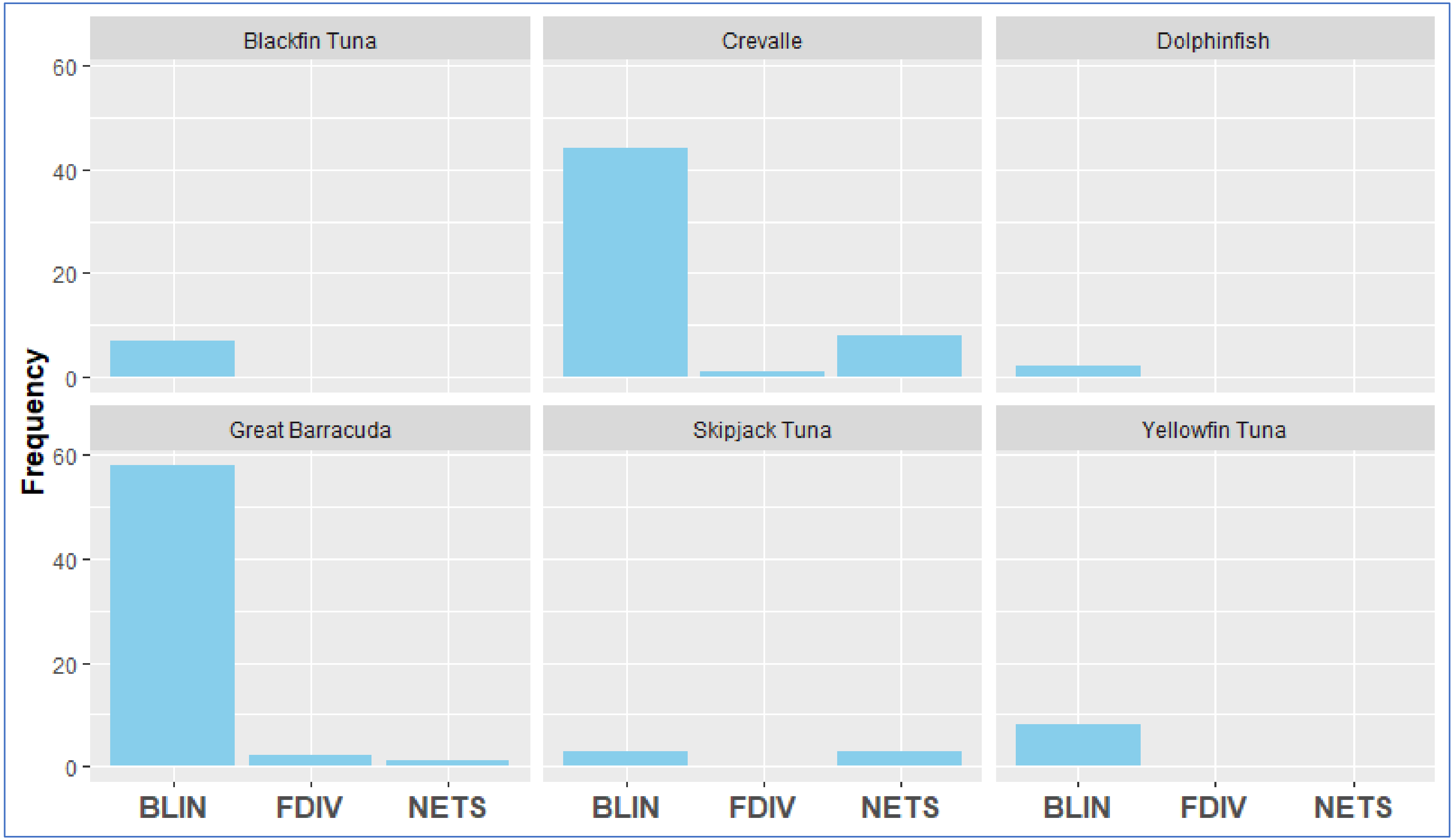
Annex 4: Species contribution to total landings of pelagics fish at the Hillsborough landing site in 2017

Annex 5: Fishing Gear Utilised to Catch Demersal Finfish



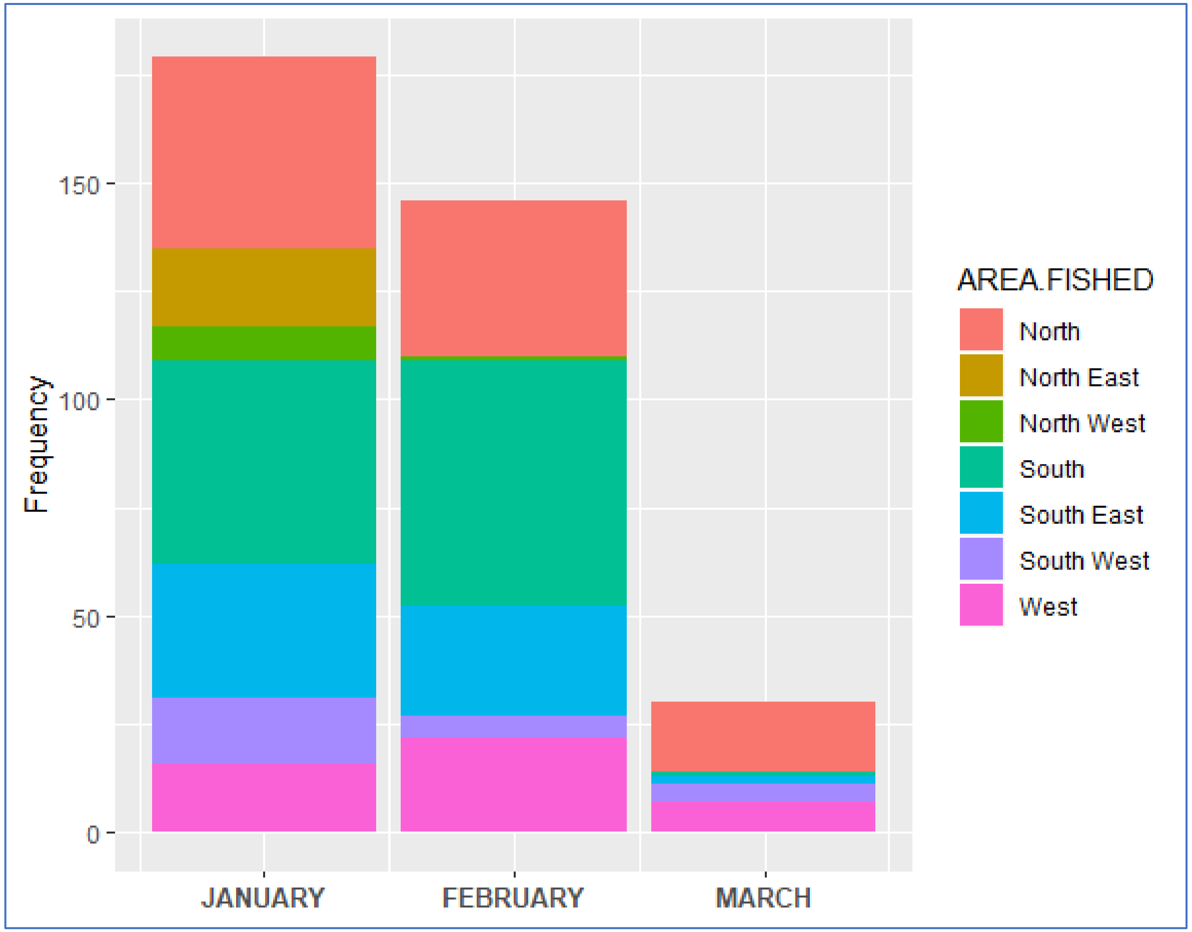
Annex 5: Fishing gear utilised to catch demersal finfish landed at Hillsborough in 2017 .

Annex 6: Fishing Gear Utilised to Catch Pelagic Finfish



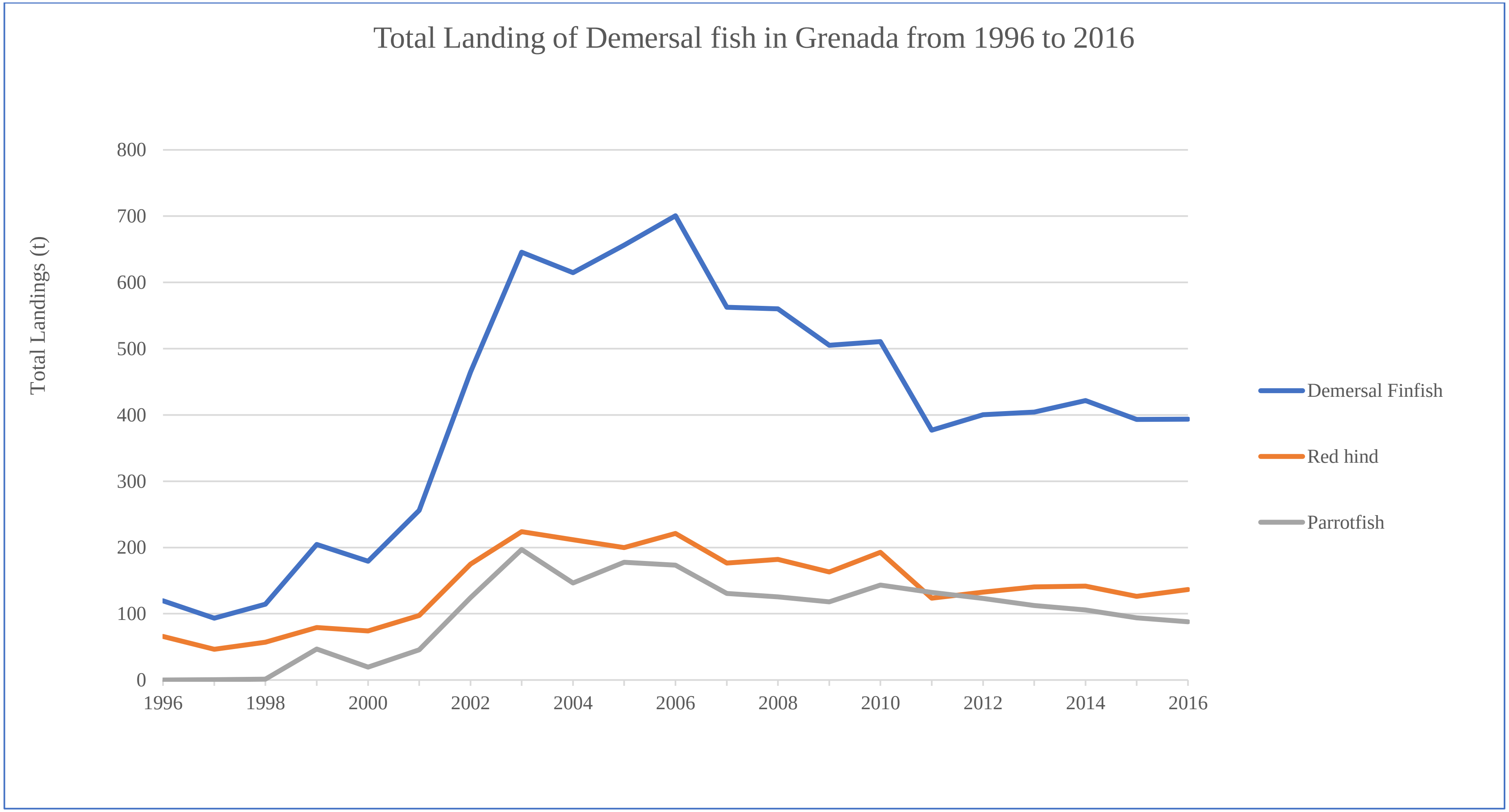
Annex 6: Fishing gear utilised to catch pelagic finfish landed at Hillsborough in 2017.

Annex 7: Location of Fishing Activities.



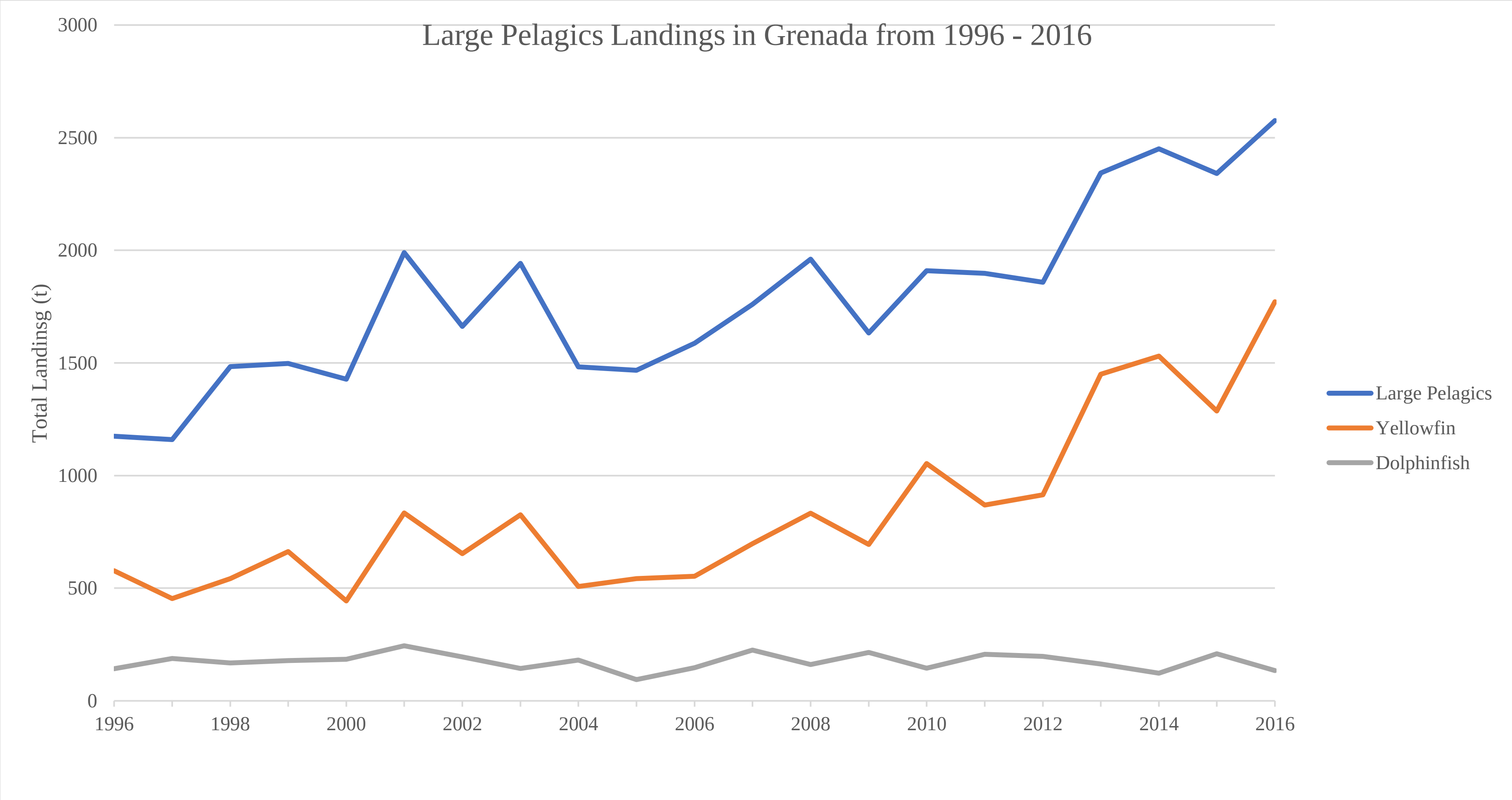
Annex 7: Location of fishing activities for the fish landed at Hillsborough in 2017 for which data is available .

Annex 8: Total Recorded Landing of Demersal Fish in Grenada



Annex 8: Total recorded landing of demersal fish including the contribution of red hind and parrotfish from 1996 to 2016.

Annex 9: Total Recorded Landing of Large Pelagic in Grenada



Annex 9: Total recorded landing of large pelagic including the contribution of yellowfin tuna and common dolphinfish in Grenada from 1996 to 2016.