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# ASSESSMENT OF DEMERSAL REEF FISHERIES IN THE COMMONWEALTH OF DOMINICA

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ABSTRACT

The overall goal of this research paper was to assess demersal fish species landed in Dominica through (1) Analysing catch and effort trends of demersal fish species from 2008-2019 and (2) Mapping changes in catch composition, fishing grounds and effort of major demersal species. Landings records contained information on 189 species distributed among 47 families. The demersal fish families with the highest proportions included *Haemulidae* (35%), *Lutjanidae* (17%), *Balistidae* (15%), *Carangidae* (7%), *Serranidae*(4%), *Scorpaenidae* (3%), *Scaridae* (3%), *Sphyraenidae* (2%), *Scombridae* (2%), *Pomacentridae* (2%), *Palinuridae* (2%), *Mullidae* (2%), *Muraenidae* (1%), *Monacanthidae* (1%) and *Holocentridae* (1%). The CPUE trends for the four main families varied during the reporting period and averaged 21 kg per trip. Only CPUE for *Lutjanidae* showed a slightly positive trend, while values for *Balistidae, Haemulidae* and *Carangidae* showed a negative trend being most pronounced in *Haemulidae* (grunts). Further, catch landings have indicated a general decline in landing for demersal species. Exploration of spatial data has identified 115 catch locations and three sites which may require further management. The areas with the highest reported catches included two areas located near the shore on the west of Dominica and one site on the eastern coast. The understanding of the trends and spatial distribution of demersal species can help in planning and managing the development of this fishery. Collection of biostatistical data should be incorporated into routine data collection to determine the true impact of fishing pressure on demersal fish species in Dominica. Knowledge of geographic distribution and catch patterns over time is an important management factor that would ensure the long-term viability of the fishery.

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ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| CPUE | Catch Per Unit Effort |
| CRFM | Caribbean Regional Fisheries Mechanism |
| CMSY | Catch-maximum sustainable yield |
| FAD | Fish Aggregating Device |
| FAO | Food and Agriculture Organisation of the United Nations |
| FRP | Fibre-Reinforced Plastic |
| GDP | Gross Domestic Product |
| NOAA | National Oceanic and Atmospheric Administration |
| U.S.VI | United States Virgin Island |

1 INTRODUCTION

## 1.1 Country Overview

Dominica is an island in the eastern Caribbean Sea between the french islands of Guadeloupe to the north and Martinique to the south in an archipelago known as the Lesser Antilles. (Figure 1). Across the 750 km$^2$ of the country, some 72,000 people live generally along the shore or in low-lying areas, making them dependent on the marine environment for food security and economic gain (Andereck, 2007). Dominica's Exclusive Economic Zone (EEZ) has an area of 28,653 km2 and the Territorial Sea measures twelve nautical miles from land (IMIS, 2023). The continental shelf surrounding Dominica is narrow, with the 50 m depth contour at a maximum of 2.8 km from the coast. Therefore, much of the shallow-water benthic habitats of Dominican waters are near the coast and human populations (Steiner, 2015).

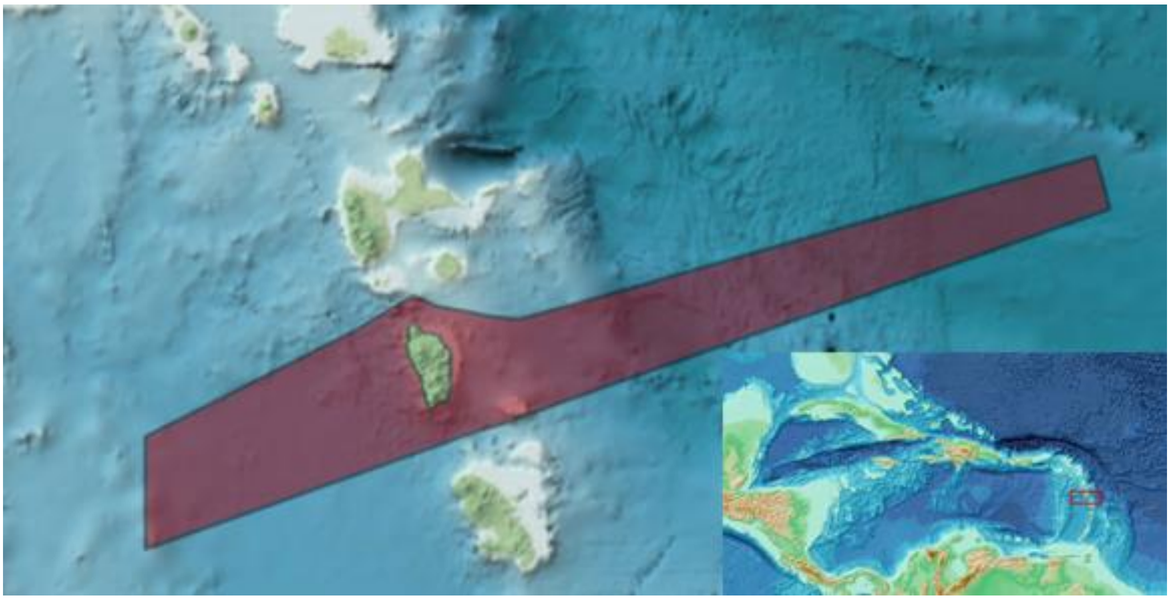

Figure 1. Map of the Commonwealth of Dominica showing range of Exclusive Economic Zone (EEZ) inset: Caribbean region with red box indicating location of Dominica. Source: IMIS, 2023.

## 1.2 Dominica Fisheries Sector

The Fisheries sector in Dominica plays a crucial role in food security, despite its relatively low economic output compared to other economic activities in the country (e.g. tourism) additionally, it offers a source of employment, support, and income to vulnerable families. The estimated contribution to gross domestic product (GDP) was 0.59% for 2020 (Eastern Caribbean Central Bank, 2022).

The Fisheries Sector in Dominica has been classified as small-scale and artisanal in nature, consisting of individual fishers or sometimes fisher groups, using small, open fishing vessels making short trips that last only a few hours each day. There is no industrial fleet segment. Fish exports are minimal, and all the landings are being consumed locally (Theophile, 2016). According to the 2011 Fisheries Industry Census, there were seven hundred and thirty-four (734) fishermen, the majority of which are part-time fishermen who use small, open vessels such as wooden keel boats, traditional canoes, and 434 fibreglass-reinforced plastic (FRP) pirogues which are under 25ft (see Table A7) (Dominica Fisheries Division, 2011). While demersal fish species are targeted across the island, pelagic fish species such as Yellowfin Tuna (*Thunnus albacares*) and Common Dolphin Fish (*Mahi mahi*) contribute to approximately 65% yearly to the overall landings. Being migratory species, these are targeted during the months of January to June.

The sector has its fair share of challenges, in particular the lack of enforcement to fisheries legislations. It must be emphasized that legal frameworks do exist to regulate the sector in Dominica, but the lack of successful management could be attributed to a lack of surveillance activities, strength of institutions, unclear legal management strategies, and limited involvement of fishers in the management process which is seen throughout the Caribbean (Salas, Chuenpagdee, Seijo, & Charles, 2007). There is a risk from numerous human activities that could affect vital habitats, biological and biophysical processes of coastal fishing supplies. Therefore, there is pressure on the nearshore marine environment and the potential for damage to marine habitats (Diamond, 2003).

### 1.3 Objectives

In recent years, several studies have been conducted on migratory pelagic species which include the dolphin, marlin, and tuna species. These species are primarily being targeted using moored fish aggregating devices. The introduction of moored fads was done primarily to increase fish landing and secondly to reduce fishing pressure on the country's demersal fish stock. However, it was noted in an Overview of the Fish Aggregating Device (FAD) Fishery in Dominica (Defoe, 2020) that fishing effort for demersal fishery was not reduced as planned. Therefore, an analysis of latest trends in demersal fish stock, landings, effort and their composition are warranted.

#### *1.3.1 Specific Objectives*

The overall goal of this study is to assess demersal fish species landed in Dominica. This was accomplished through the following:

1. Analysis of catch and effort trends of demersal fish species from 2008-2019.

2. Mapping changes in catch composition, fishing grounds and effort of major demersal species.

## 2 LITERATURE REVIEW

### 2.1 Demersal fish species

Demersal fish species have been defined as bottom-dwelling fish connected to environments like coral reefs, mangroves, and seagrass (Merrett & Haedrich, 1997). In the context of this paper, demersal species will refer to shallow shelf and reef finfish (Dominica Fisheries Division, 2011). Reef fish species have contributed to 12% of overall landings (Dominica Fisheries Division, 2011). In Dominica, major demersal fish categories include snappers (*Lutjanidae*), wrasses (*Labridae*), groupers (*Serranidae)*, parrotfishes (*Scaridae*), tangs (*Acanthuridae*) and grunts (*Haemulidae*) (Dominica Fisheries Division, 2011). The Caribbean Regional Fisheries Management (CRFM) has also identified and prepared a classification for demersal fish species (CRFM, 2020) (Table *1*). The species vary between regions and in the Caribbean are specifically targeted using gear methods such as line and fish pots (Theophile, 2016).

The maximum observed life span of snappers (*Lutjanidae*), wrasses (*Labridae*), groupers (*Serranidae)*, parrotfishes (*Scaridae*), surgeonfishes (*Acanthuridae*) and grunts (*Haemulidae*) varies from four (4) to one-hundred and fifty (150) years (Stevens, Smith, & Ault, 2019) with spawning happening throughout the year based on the species.

## 2.2 Nearshore Demersal (Reef Fishes)

Many nearshore demersal fishes in the Caribbean are associated with coral reefs. Fish traps are the main fishing gear for reef fish, catching many species simultaneously. Because the reef fishery is a multispecies fishery, it is difficult to apply conventional assessment and management methods to individual species. The trap fishery is probably the most economically important fishery in the region, employing the most fishermen and vendors and accounting for about 50% of the fish consumed (Chakalall, 1995). Most trap fishermen fish part-time and land their catch in a variety of locations, which facilitates distribution. It is widely recognised that nearshore groundfish stocks are overfished, although there is no documented evidence of this (Chakalall, 1995).

## 2.3 Deepwater Demersal Fishes

Deepwater Demersal Fishes in the Dominican fishery are primarily snapper (*Lutjanidae*) and grouper (*Serranidae)*, which are frequently found on deep banks or near the edge of the shelf. These species are caught using hand lines or fish traps, depending on the depth. Despite concerns about local depletion, it is generally assumed that these fisheries are not overfished (Chakalall, 1995). Fishing these species is challenging because of their preferred habitat, which includes cracks, pits, and steep rocky slopes.

## 2.4 Biology and ecology

### *2.4.1 Lutjanidae* – Snappers

Figure 2. Illustration of *Lutjanus campechanus* as an example of a typical snapper fished in Dominica

One of the most significant food fishes in tropical and subtropical waters are snappers (Figure *2*). Their morphology is unremarkable; they are generic, bottom-oriented predators, which may help to explain their success. There are 17 species from 5 genera in the greater Caribbean. The typical snapper has a thick body, a continuous dorsal fin, a tail that is slightly forked, a body that is completely covered in scales, and a triangular head with a huge mouth at the tip of the triangle. The mouth is long and wide, and it is filled with numerous teeth. Most have vivid colors, frequently with contrasting stripes and bars, ranging from vivid red to yellow to iridescent blue. Adults live in deeper waters with rocky or sandy bottoms, close to ledges and drop-offs. Juveniles are found in shallower water, frequently between 35 and 50 meters (Boyle & Cech, 2000).

Snapper species are caught in islands throughout the Caribbean chain, where they are targeted by fishermen during periods when migratory pelagics are not caught (Murray, Chinnery, & Moore, 1992). Commercial targeting of the queen snapper (*Etelis oculatus*) is only beginning in the French West Indies but is much more developed in Barbados and Puerto Rico (Prescod, Oxenford, & Taylor, 1996). The exploitation of snapper species in the Caribbean is poorly documented and there are very few detailed catch statistics. In all cases, the quantities landed in each country are small, but the potential production of these resources has never been estimated (Bertrand, et al., 2005).

### *2.4.2 Balistidae* - Triggerfish

Figure 3. Photo of *Balistes capriscus* (source: fishbase)

Most triggerfishes (Figure *3*) live on shallow coral reefs at depths of up to 50 meters in shallow tropical and subtropical waters. Members of this family are reef dwellers that move slowly, are solitary, and are frequently vividly coloured. They have compressed bodies, tiny mouths, and lack pelvic fins. Because the second spine can tightly lock the first dorsal spine into place, triggerfishes gain this name (Boyle & Cech, 2000). In 2021, 1.9 million pounds of grey trigger fish (*Balistes capriscus)* were harvested by fishermen in the Atlantic and Gulf of Mexico (NOAA Fisheries, 2023). Additionally, landings of queen triggerfish (*Balistes vetula*) including landings of unspecified triggerfish from 2000 to mid-2011, were approximately 30,000-95,000 pounds per year for U.S Caribbean countries. Reported commercial landings of queen triggerfish and the number of trips declined slightly from 2001-2019 (Rivera, Johnson, & McCarthy, 2022)

### 2.4.3 *Haemulidae* - Grunts

Figure 4. Photo of *Haemulon sciurus* (source: fishbase)

With approximately 150 species, grunts (Figure *4*) come in a wide variety of colours and patterns, including solid colours, stripes, bands, blotches, and spots. Most species' adult stages feature recognizable colour patterns. Early juveniles (2 to 5 cm) exhibit a caudal spot, along with dark dorsolateral and mid-lateral stripes. Fishes known as grunts are found in shallow, nearshore waters, exclusively in tropical and subtropical regions (Boyle & Cech, 2000). These species constitute an important fishery throughout the Caribbean and are targeted by artisanal fisherfolk (Harborne, Afzal, & Andrews, 2001). In one study conducted in the Mexico Central Pacific between 2002 – 2017 it was discovered that 10% of the overall catch for the artisanal fisheries belonged to *Haemulidae* (Gomez-Vanega, Espino-Barr, & López-Uriarte, 2021).

### 2.4.4 *Carangidae* – Jacks and Pompanos

Figure 5. Photo of *Alepes vari,* example of typical Carangidae species.

The family *Carangidae* is comprised of approximately 33 species from 16 genera in the Caribbean. Species are generally silvery in colour (Figure *5*), having size ranging from 30-170 cm in width (Boyle & Cech, 2000). Additionally, species are fast swimming predators of the waters above the reef and in the open sea. Species such as *Caranx caballus, Caranx sexfasciatus, Seriola lalandi* are part of catch composition of many Caribbean countries and Gulf of Mexico (Erisman, et al., 2010), seeing varied landings throughout the year.

### *2.4.5 Serranidae* – Sea Basses

Figure 6. Photo of *Epinephelus melanostigma* (Black spotted grouper)

Large, piscivorous sea basses (Figure 6), which include 450 species, are found inshore and on tropical and temperate reefs. Being hermaphrodite predominately, in some species, the male and female gonads develop at the same time. Hermaphrodites normally begin female and change to male at a larger body size (Brule, Colas-Marrufo, Perez-Díaz, & Déniel, 2023). They can be characterized by their operculum, which has three spines: a primary spine and two lateral spines. Complete and continuous lateral line that does not touch the caudal fin (lacking in one species). The dorsal fin may include a notch and 7–12 spines. *Serranidae* are distributed across temperate and tropical waters, some of which reach freshwater (Boyle & Cech, 2000). In the Western Atlantic, groupers are exploited commercially by industrial, artisanal, and recreational fisheries throughout the southeast coast of the United States, Bermuda, the Caribbean Sea and the entire Gulf of Mexico (Sadovy, 1994). During a 6-month study period in the Bahamas, landings for *Serranidae* accounted for 16%. In Belize the combined landings of *Lujanidae*, *Serranidae* and *Haemulidae* represented 74% of captured species (Cushion & Sullivan-Sealey, 2023). Existing data on the status of grouper stocks in the wider Caribbean provide indisputable evidence of the vulnerability of these fish even in the face of relatively low fishing pressure (Chiappone, Sluka, & Sullivan-Sealey, 2000).

### *2.4.6 Scaridae* – Parrot Fish

Figure 7. Photo of *Scarus taeniopterus*.

The more than 80 different types of parrot fish (Figure 7) resemble wrasses with their jaw teeth fused into a solid parrot-like beak. Moreover, they have massive pharyngeal teeth made of solid bone units. These features enable parrotfish to scrape algae and invertebrates from the reef's rugged surfaces before crushing the prey. During the day, they travel the reefs in small, noticeable schools, and at night, they hide in cracks and caves. The colour pattern of parrotfish, which varies significantly with age and sex and reflects complex mating systems, making them unique. The Atlantic, Indian, and Pacific oceans all have tropical waters where parrotfish can be found in large numbers. Several species do, however, live in subtropical seas.

In the Caribbean there has been a shift in harvesting of parrotfish, local regulations have been placed to reduce fishing pressure (Harms-Tuohy, 2021). More than 65% of the countries participating in a study conducted by the Food and Agriculture Organization (FAO) indicated that either a total fishing ban or fishing regulation exist to promote parrotfish conservation to some extent. Parrotfish are mainly caught with traps and spearfishing (Harms-Tuohy, 2021).

Table 1. Fishery category and the habitat to which the category is linked, description of the category and some of the main families or species of interest in the CRFM region (CRFM, 2020).

| **Habitat** | **Fishery category** | **Description** | **Species of interest for CRFM Region** |
|---|---|---|---|
| **Coral Reefs** | Shallow shelf and reef finfish fishery | Species living on or over coral reefs or associated with coral reef | Parrotfishes (*Scaridae*) Squirrelfishes (*Holocentridae*) Grunts (*Pamadosydae*), Surgeonfishes (*Acanthuridae*), Triggerfish (*Balistidae*) The *Serranidae* family (particularly hinds, sea-basses, and small groupers), Snappers (*Lutjanidae*) |
| **Shallow shelf** | Shallow shelf and reef lobster fishery | Lobsters are large marine crustaceans with hard exoskeletons. The species targeted in the region live in crevices on coral reefs and are specifically targeted or captured as a part of the reef fisheries | Caribbean spiny lobster (*Panulirus argus*) Spotted spiny lobster (*Panulirus guttatus*) Sculptured slipper lobster (*Parribacus antarcticus*) Spanish slipper lobster (*Scyllarides aequinoctialis*) |
| **Slope and Drop-off** | Deep slope fishery | Deep water fish from the outer reaches of the continental shelf to the drop-off (where the shelf descends in a steep slope or wall to the deep ocean floor) | (*Etelis oculatus*) Jewfish (*Epinephelus itajara*) Red hinds (*Epinephelus guttatus*) Nassau grouper (*Epinephelus striatus*) |

## 2.5 General Trends in Fisheries Sector

Specific landing trends over time are required to comprehend the possible vulnerability of harvested species. According to Froese and colleagues (2008), it has been hypothesized that the exploitation of multispecies communities alters the relative abundance of the various functional groups in the ecosystem that sustains these communities, which lends support to the need for exploring trends in landing data (Froese, Stern-Pirlot, Winker, & Gascuel, 2008).

Studies on the communities of deep-sea fishes have been conducted worldwide, mainly in the shelf and upper slope regions of the sea. However, most Caribbean countries are data limited with even less analysis being conducted on the information that is being collected. The Food and Agriculture Organization (Baisre, 2000) stated that despite the biases in national fishing statistics that are unavoidable and the lack of disaggregation for some species groups it is possible to determine trends based on national landings. In one study, landing data from 1935-1995 was used to analyse trends and fisheries potential in Cuba. The analysis for twenty-one key species revealed that a there were species still in the developing phase with the possibility of increased landings. Secondly, some species were in the process of decline and a third group were in the mature phase with a high exploitation level. One key recommendation from this study was the urgent need for implementation of fishery management measures to reduce or control fishing effort.

## 2.6 Trends in Catch Per Unit Effort (CPUE)

Catch per unit effort (CPUE) is a common index used in stock assessment, whether calculated from commercial, recreational fisheries data or research survey data. Trends in CPUE can be used to indicate the status of a fish stock where drops in CPUE could indicate that the fish population is unable to sustain the level of harvesting. A fish stock may be recovering if CPUE increases, which would allow for increased fishing activity. In cases where a correlation between the index and the stock size is assumed, CPUE can be utilized as a stock abundance index. Catch rates by boat and gear types, frequently combined with information on fish size at capture, allow for several analysis relating to gear selectivity, exploitation indices, and economic efficiency monitoring (Brander, 1975).

However, (CPUE) may be heavily skewed due to a phenomenon known as technological creep, where fishing technology improves over time. A study on the European lobster (*Homarus gammarus*) found that technological progress had masked a steady decline in stocks, especially in recent decades, mainly due to the switch from single-chamber to dual-chamber traps and the ability of newer trap designs to catch larger lobsters (Kleiven, et al., 2022). Technological development includes both significant investment in new technology on board individual vessels (GPS navigation systems) and incremental improvements to existing vessel technology or gear (fads and hook and longline designs) (Eigaard, Marchal, Gislason, & Rijnsdorp, 2014).

CPUE has been calculated for the common dolphinfish using landing data from Dominica and it has been recommended that this calculation should be performed for as many species captured as possible (Theophile, 2016). This method closely relates to the proposed method from the Guidelines for Collection and Compilation of Fishery Statistics (Brander, 1975). These methods have proven to provide a relatively accurate calculation of CPUE, however there is a need for scrutiny of the actual data collected to ensure that the calculations are accurate.

# 3 METHODOLOGY

## 3.1 Dominica Fisheries dataset

The data sets provided by the Fisheries Division of Dominica consist of sampled landings recorded at landing sites around the country. The data range from 2008-2019 and contain daily records of landings classified to the level of either species or species grouping.

At several of the island's fish landing sites, data on catch have been gathered by nine data collectors using a random sampling technique. This means that a data collector selects the vessel it samples at random from among all the vessels that went fishing from each landing site on a particular day. It is expected that one third of all activity at a landing site is captured and data collectors are expected to work at least three times weekly.

Once the catch has been landed, the captain or a crew member is interviewed to determine location fished, gear used, species caught, time spent at sea and price of fuel purchased before the initial trip. Visual confirmation and identification of fish would then take place as well as weight recorded using the standard data collection sheet (Figure A33). In cases where a weighing scale is not available, data collectors would make a visual estimate which would be indicated on the data sheet. This method is used with small coastal pelagic fish species and at sites where there are missing facilities. The information gathered in this process is highly reliable in terms of disaggregation since most trips involve the use of one gear type.

Data obtained in the field is then brought back to the Fisheries Division Office where a data entry clerk enters the data provided. If information is unclear data collector is contacted to reduce data entry error (Theophile, 2016) As part of their training, a data collector is instructed to record data from landings that they have personally observed. In few cases secondary catch records have been collected from a trusted source.

Most of the time collectors were given only one port to operate at, but in this data collection period there were four collectors who worked at two ports. Landing data was collected at 13 of the 29 permitted fish landing ports across the island. These sites contain storage facilities and have shown an increase in the number of fishers and vessels present, thus requiring the need for monitoring (Theophile, 2016).

The data set provided contains the following information collected by data collectors for each vessel sampled:

*Port:* identified by name or code where sampling took place

*Trips*: trips conducted in any given day

*Date*: the day sampling activity took place

*Species*: the code or species name landed

*Boat Number*: the boat identification

*Boat type*: the boat category

*Location fished*: an approximate area of where fish species was captured based on fishing grid (Figure *8*).

*Gear*: the code or name of gear used for each species caught

*Kg/lbs*: weight measurement used at the sampled port for landed species.

*Expenses*: Fuel consumption, price of food and bait

### *3.1.1 Data Storage*

During the 2008 – 2019 period, data was stored in two databases. The Trip Interview Programme (TIP) and Unified Fisheries Data base (UFD) in a MS Access database (Theophile, 2016). These two datasets were combined for analysis of the full period. Full use of MS access databases started from 2009 to 2019.

### *3.1.2 Data Preparation for Calculations*

To effectively perform calculations, the data had to be subset to look at the landings as it relates to demersal fish species. Trips with no fish caught were removed and calculation of total demersal fish species landed by year was performed by categorizing all fish species by a family category and summing. Standardization of a species class was achieved by reassigning all records related to coastal and ocean pelagic to category "pelagic", while demersal species were assigned to "demersal".

Time series for demersal fish landings was then plotted for families with the highest proportion to determine the impact of fishing pressure for 2008-2019. Commonly caught families were chosen for analysis by summing occurrences by family ranking them from highest to lowest and selecting families with the highest proportion of cumulative occurrence records.

### *3.1.3 Catch Location*

Determination of catch location was accomplished utilizing a grid system where one square represents a 5x5 miles within the marine space in Dominica (Figure *8*). These grids provide an approximate location of areas that have been fished on any given day. For the period 2008-2014, the fishing location in the dataset is unknown or was simply recorded using local area name. Catch locations which were entered had to be renamed to match the grid system based on the location collected by data collectors. Therefore, locations with local names were assigned to general grid number within which a fisher would have been active. In cases where these names were too ambiguous, they were assigned to best assumptions based on advice from data collectors working from that landing site. In situations where locations were difficult to identify they were assigned to unspecified. Distribution of general fish species have been determined to show geographical locations of fish species as well as changes in fishing locations based on landing sites.

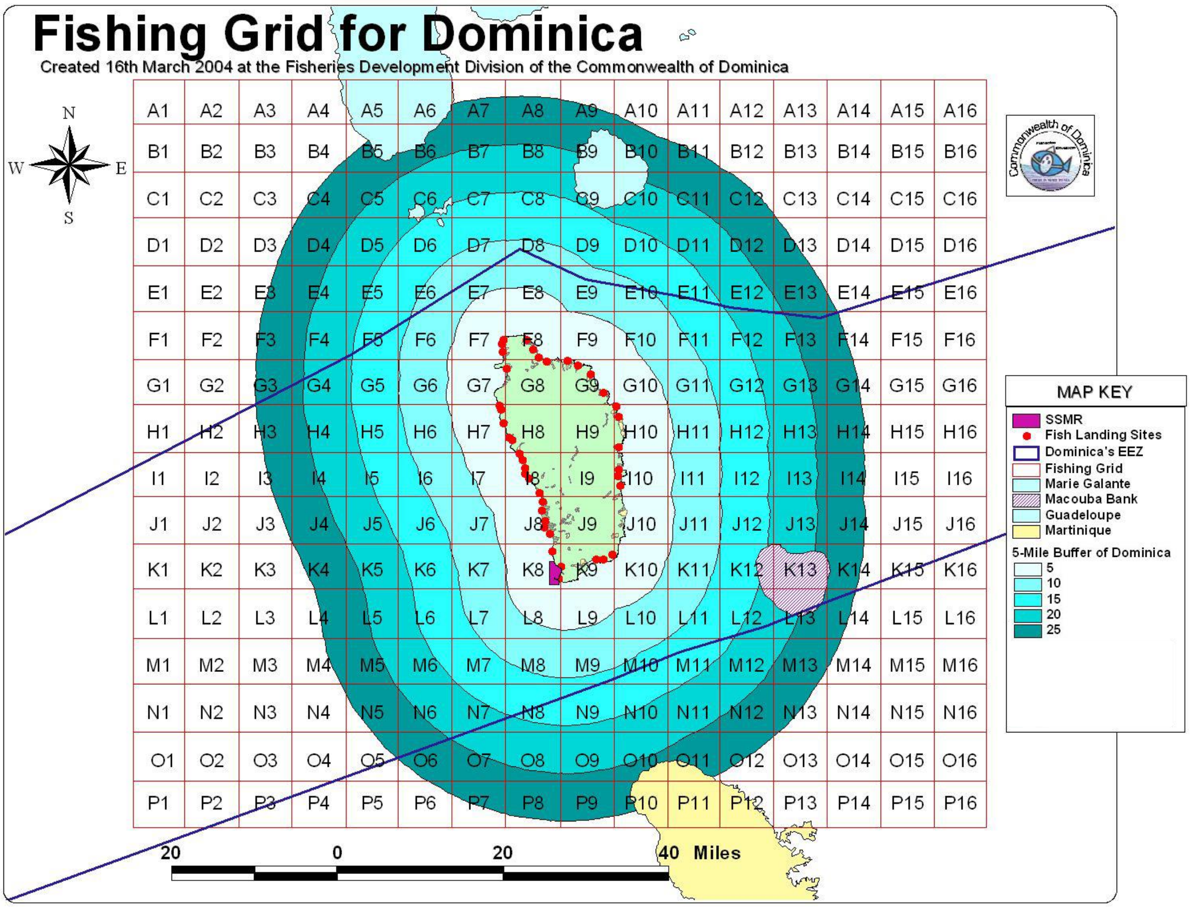


Figure 8. Fishing grid developed for Dominica. Map shows all landing sites (red) of the country and section of marine reserve (purple). The Exclusive economic zone (blue line) is also present indicating the boundaries between the two neighbouring French countries.

### *3.1.4 Catch Data and Estimation of Catch*

Catch data forms a key part of the data collection process at landing sites in Dominica. When determining the total sampled catch values, the necessary fields included a summary of the year caught, port of landing, and the total weight (kg) for that period of time. Discards and by-catch are not considered in this total value. Historically, all fish landed is consumed with minimal discards taking place at landing sites.

Since random sampling is done at landing sites, it was necessary to perform calculations to raise the sampled catch to determine the total estimated catch for the period of 2008-2019.

The table for boat activity contained the following:

*Date*: the day on which the sampling activity measured the catch.

*Port*: the name or code where the sampling was conducted.

*Boat type*: the category of boat which was sampled.

*n.active*: Number of boats that were active.

*n.sampled*: number of boats sampled.

### 3.1.5 Effort Data and Estimation of Effort

According to FAO (Brander, 1975), effort is an important measure for fishing activity. The unit of effort used for fishing was calculated by dividing the sum of catches against the sum of trips for each year. A trip here can be further defined as one day's vessel activity for a given vessel. In previous studies this unit has been identified as the most consistent unit for the measure of effort when considering the data available (Theophile, 2016).

Effort was calculated using the following parameters from the data recorded at landing sites.

*Date*: the day on which the sampling activity measured the catch.

*Port*: the name or code where the sampling was conducted.

*Boat type*: the category of boat which was sampled.

*Gear*: the name or code of the gear which was used to catch the species.

*Weight(kg):* the weight measurement (in kilograms) of the species landed at that sampled port on that sampled day.

*Trips*: the estimated trips (boats x days) calculated for the port for that year

### 3.1.6 Establishing Annual Estimates for Species

The total annual estimates were multiplied by the relative proportion of catch for each species found in the sampling catch and effort data for that year in a given port during a month or season, in order to determine the estimated annual value for a species.

### 3.1.7 Catch Per unit effort (CPUE)

The procedure follows the same principle as demonstrated in (Stamatopoulos, 2002).

The equation is:

$$\text{Catch} = \text{CPUE} \times \text{Effort}$$

In sample-based fishery, effort is calculated from a census-based frame survey providing the raising factor F that expresses the total number of crafts as counted during frame survey. In Dominica the number of boats active is estimated during all sampling trips and mean number of active boats for each port can be estimated.

An active days survey to determine the time raising factor A, expressing number of days with fishing activities for each month were calculated by removing non-working days such as public holidays.

A sample-based boat activity survey to determine the BAC (Boat Activity Coefficient) expressing the probability that any crafts will be active on any given day.

$$\text{Effort} = (\text{Boat Activity}) \times (\text{Total boats/mean number of boats}) \times (\text{Active days})$$

Or it can abbreviate as.

$$Effort = BAC \times F \times A$$

Overall CPUE is derived from using the generic formula to estimate catch as:

$$CPUE = Catch \times Effort$$

In this study these variables were firstly estimated by landing site.

## 3.2 Landing Site Selection

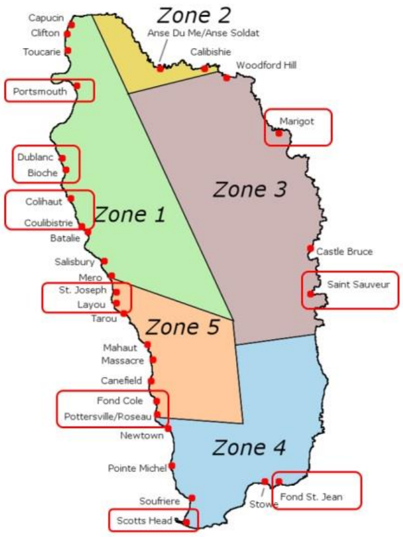


Figure 9. Map of Dominica showing all 31 fish landing points (red dots) and emphasizing the 13 locations where routine data collection on fisheries catch and effort takes place (within red outlined boxes) (Source: Fisheries Division)

Around the country thirty-one landing sites have been established according to regulations Dominica (Figure 9). These sites normally contain structures such as boat sheds, locker rooms or fisheries complexes fitted with weighing scales to assist weighing of fish landed. While there has been data collected from the period of 2008-2019 for up to twenty-two landing sites, some sites lack enough data to consider any trends (Figure A34). Eleven landing sites having consistent data were selected for analysis of demersal landings. These sites included Bioche, Colihaut, Dublanc, Fond Cole, Fond St. Jean, Layou, Marigot, Portsmouth, Pottersville, Scotts Head and San Sauveur.

# 4 RESULTS

## 4.1 Landings for demersal fish.

Overall, the combined annual catches on major landing sites for demersal species varied between 14 t and 127 t between 2008 and 2019. The year with the highest landings was 2009 with a total of 127 t. For the entire period, there were only 5 years with a total landing of more than 60 t. These occurred between 2008-2012. Landing values declined from 2012 (Figure *11*) with the lowest recorded value being in 2019 (Table *2*). A comparison between landings of demersal and pelagic species indicated a cumulative landing of 18% for demersal species when compared to 82% for Pelagic species (Figure *10*). Both however show annual fluctuations.

Table 2. Total landings for demersal species (2008-2019) for 11 landing sites.

| Year | Total landings t |
|---|---|
| **2008** | 124 |
| **2009** | 127 |
| **2010** | 86 |
| **2011** | 93 |
| **2012** | 86 |
| **2013** | 45 |
| **2014** | 39 |
| **2015** | 30 |
| **2016** | 33 |
| **2017** | 14 |
| **2018** | 14 |
| **2019** | 21 |

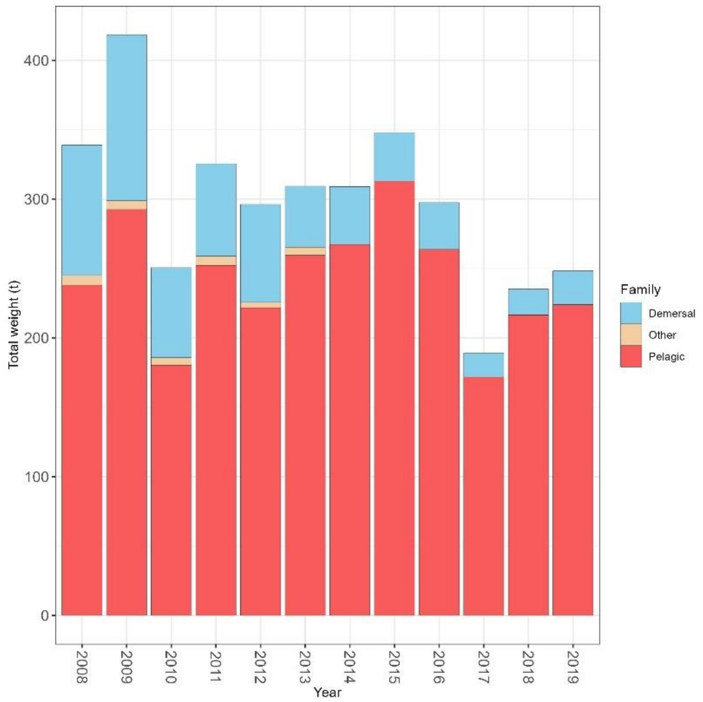

Figure 10. Comparison of landings between demersal (blue), pelagic (red) and others (brown) between 2008-2019 for all sites combined.

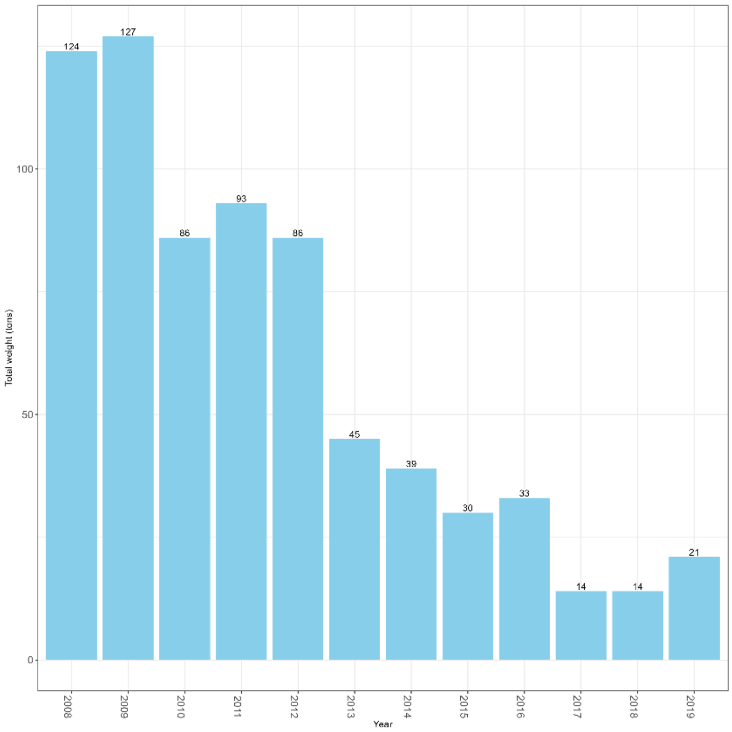


Figure 11. Annual landings for demersal species over time, for all landing sites combined.

Examination of data showed that the site with highest cumulative landings was Marigot with a total of 125 t and the second highest was Portsmouth with 119 t (Table A8, Figure *12*).

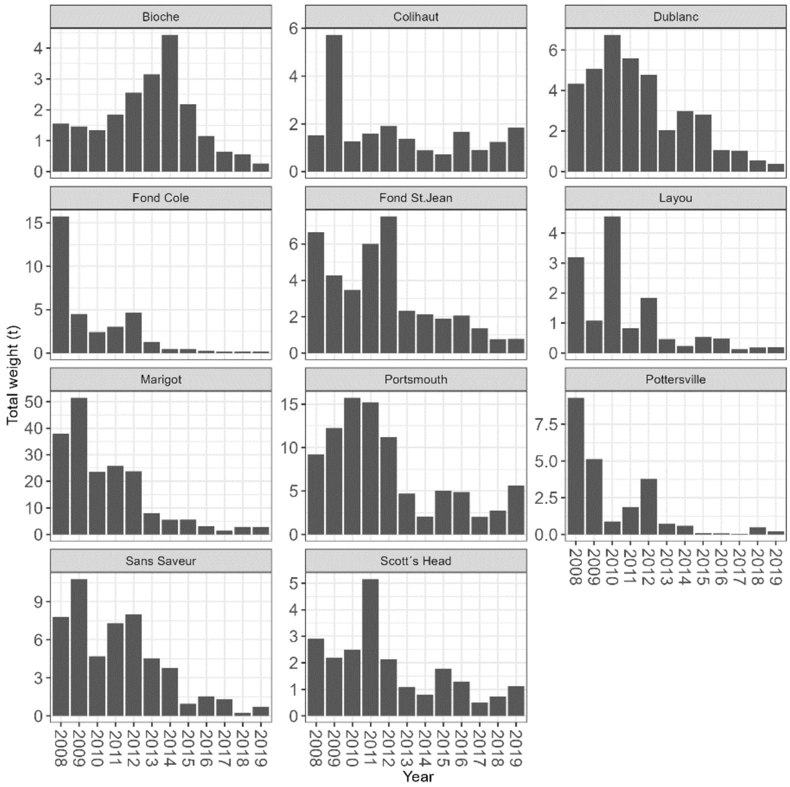

Figure 12. Summary of demersal fish capture over time, for each of 11 landing sites in Dominica between 2008-2019.

## 4.2 Catch Composition

The catch records contained catch records for 189 species, distributed among 47 families. A total of 15 main families formed the highest proportion of all catch landed throughout the period of observation (Table *3*), accounting for 97% of all landings. The most represented family, *Haemulidae* (grunts), accounted for 35% of the overall demersal catch with the second highest, *Lutjanidae* represented 17%. *Balistidae* and *Carangidae* came in next with 15% and 7% with a cumulative landings (value of 112 t and 56.5 t), respectively.

Table 3. Cumulative catch (2008 – 2019) based on family level of the 15 most abundant demersal fish species in Dominica.

| ***Family*** | ***Total weight t .*** | ***Proportion*** |
|---|---|---|
| *Haemulidae* | 264.8 | 35% |
| *Lutjanidae* | 127.2 | 17% |
| *Balistidae* | 112.0 | 15% |
| *Carangidae* | 56.5 | 7% |
| *Serranidae* | 28.1 | 4% |
| *Scorpaenidae* | 22.5 | 3% |
| *Scaridae* | 19.7 | 3% |
| *Sphyraenidae* | 17.7 | 2% |
| *Scombridae* | 14.7 | 2% |
| *Pomacentridae* | 11.5 | 2% |
| *Palinuridae* | 13.3 | 2% |
| *Mullidae* | 11.4 | 2% |
| *Muraenidae* | 10.2 | 1% |
| *Monacanthidae* | 5.9 | 1% |
| *Holocentridae* | 7.1 | 1% |

Landing data contained both fish species that were classified to species level as well as those that were only able to be classified to a categorical level. Species with the highest proportion landed included black margate (*Anisotremus surinamensis*), queen triggerfish (*Balistes vetula*), yellowtail snapper (*Ocyurus chrysurus*) and blue runner (*Caranx crysos*) (Figure *13*).

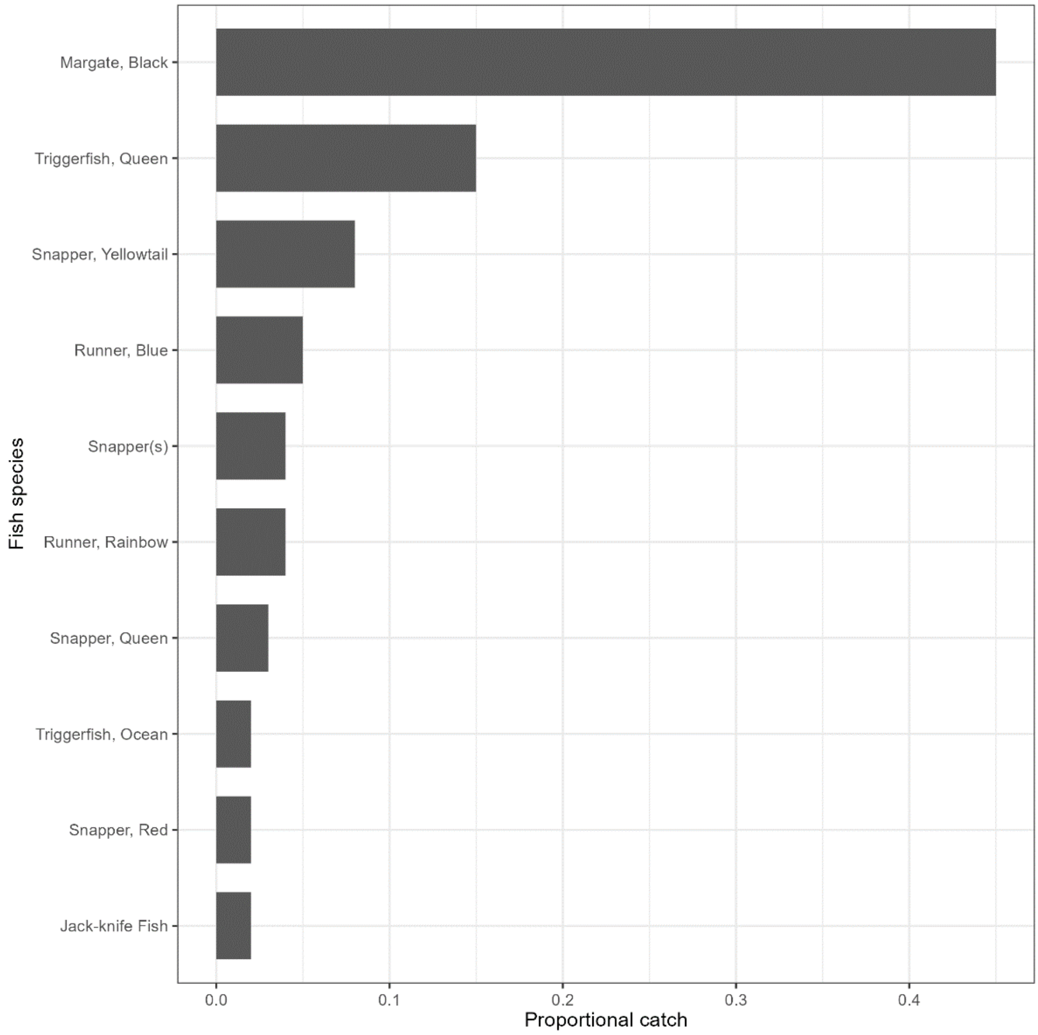


Figure 13. Demersal species cumulative proportions (2008-2019).

### *4.2.1 Catch Composition of Demersal Species*

From the 47 families identified, four families with the highest proportion landed were selected for analysis on a species level throughout the period (Figure *14*). These included *Lutjanidae* (snappers), *Haemulidae* (grunts), *Carangidae* (Jacks) and *Balistidae* (triggerfish). These families accounted for 73% of the overall landings. Two trends were noted in catch composition (1) There was decrease in landings for *Haemulidae* (grunts), *Balistidae* (Triggerfish), and *Lutjanidae* (snappers) from 2009. Landings increased from 2010 for *Caranigidae* (jacks) and this family showed greatest fluctuations in landings. (2) Catches for *Lutjanidae* has remained constant throughout the period with a decrease between 2015-2018.

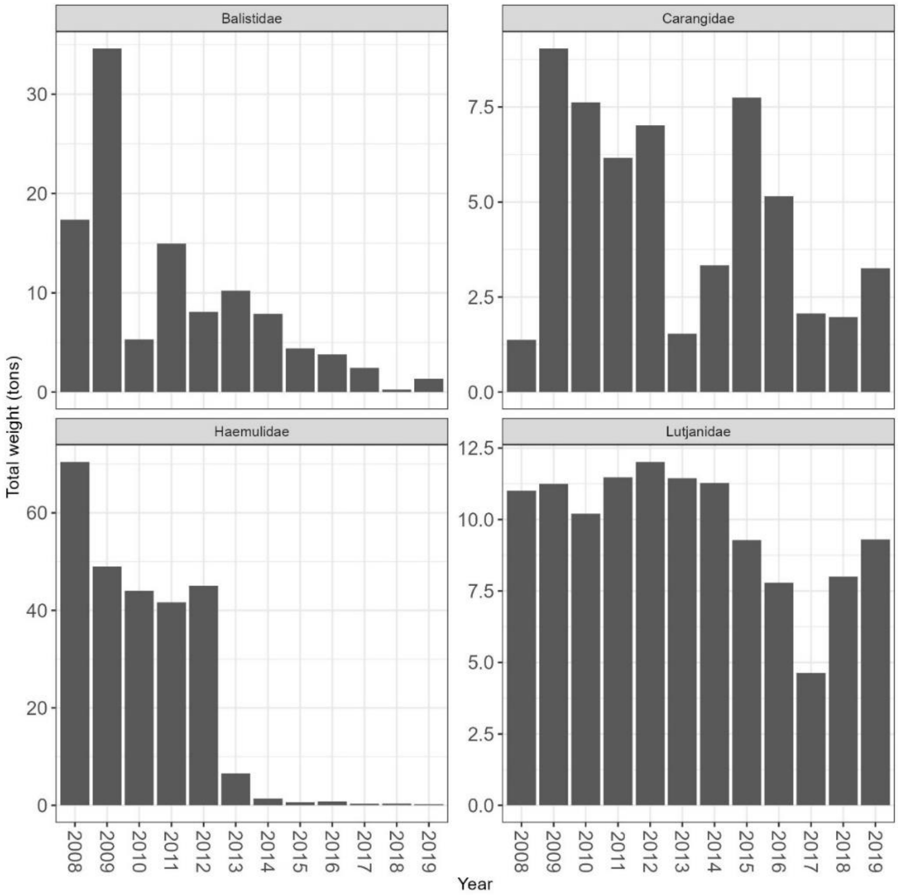


Figure 14.Landings of the families *Balistidae*, *Haemulidae*, *Carangidae* and *Lutjanidae* over time for all landing sites combined.

### 4.2.2 *Lutjanidae*

From the family *Lutjanidae*, 14 species were recorded, making it the most diverse family (Figure *15*). Yellow tail snappers (*Ocyurus chrysurus*) had the overall highest landings and accounted for 36% of snapper catches. Unclassified snappers contributed to 18% of the snapper landings.

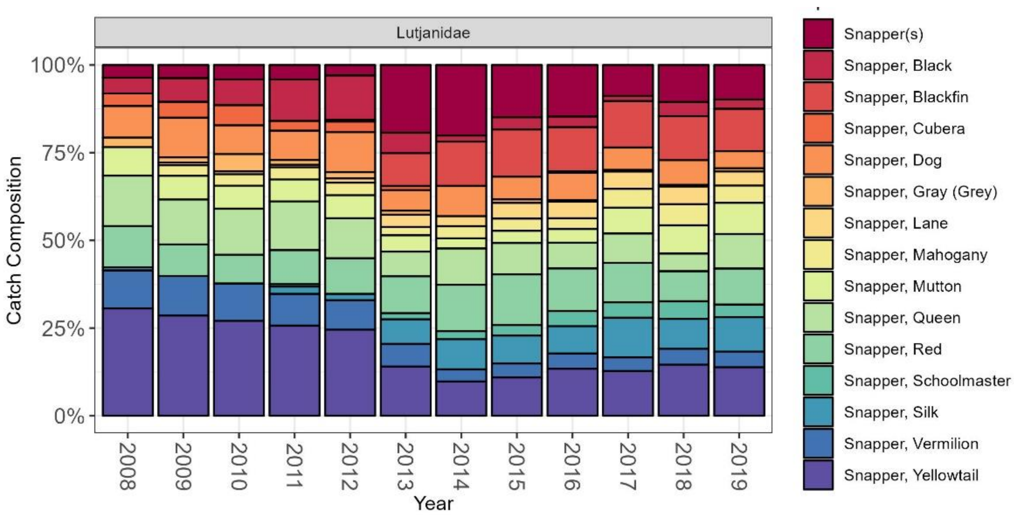


Figure 15. Catch composition of landings for *Lutjanidae* species.

### 4.2.3 Haemulidae

The family *Haemulidae* contains 12 unique species in the landings database (Figure *16*). Black Margate (*Anisotremus surinamensis*) dominated fish landing data, making up 94% of all landings for this family. Unclassified grunts were the second highest with 2.7 %. There is a clear drastic trend of decreased landings for Black Margate and White Grunts. These decreases were observed between 2013-2019 for both species. Overall, these results indicate a decrease in landings for the entire *Haemulidae* family from the year 2013.

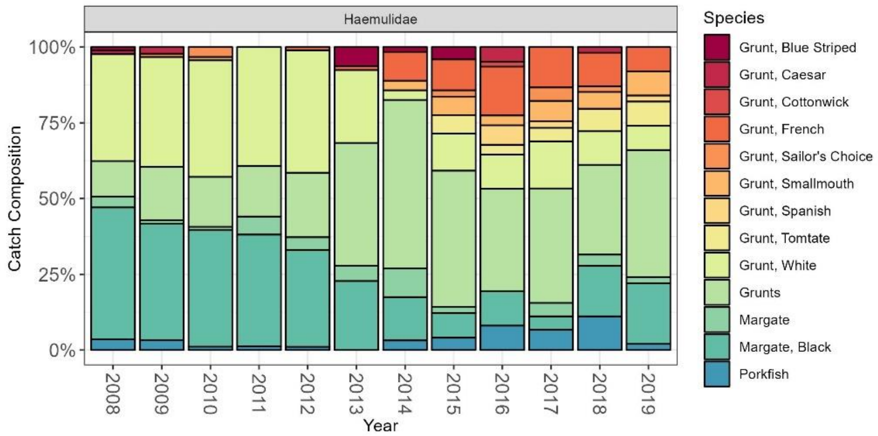


Figure 16. Catch composition of landings for Haemulidae species.

### 4.2.4 Carangidae

This family group includes five species (Figure *17*), of which two, the blue runner (*Caranx crysos*) and rainbow runner (*Elagatis bipinnulata*) together accounted for 80% of overall landings. Greater amberjack (*Seriola dumerili*) and spotfin hogfish (*Bodianus pulchellus*) contributed to less than 2% of landings.

### 4.2.5 Balistidae

Among the four species of family *Balistidae*, queen triggerfish (*Balistes vetula*) had a total of 73% of landings (82t ). This species had its highest landings in 2009 and has shown continued decrease moving into 2019. Landings for all other species have remained below 10t annually but unclassified triggerfish were 7.9% of total catches.

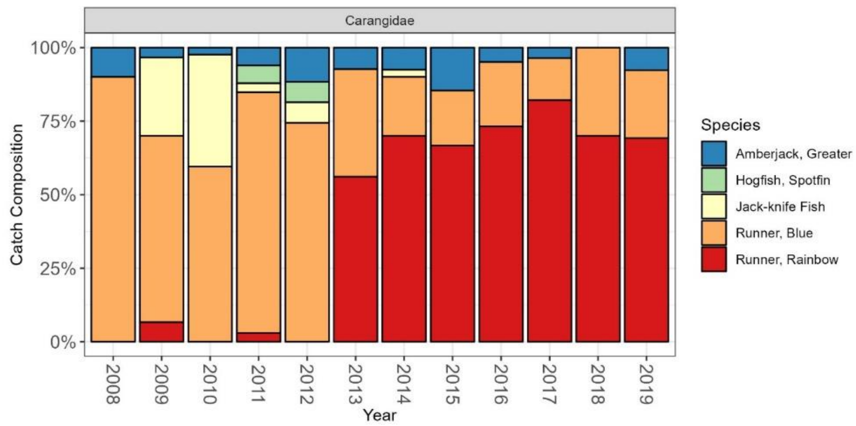


Figure 17. Catch composition of landings for *Caranigidae* species.

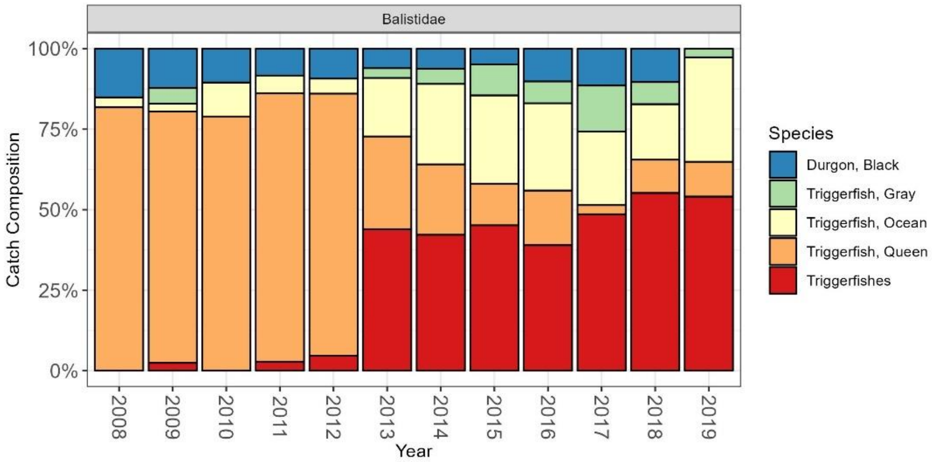


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Figure 18. Catch composition of landings for *Balistidae* species

## 4.3 Catch composition by landing site

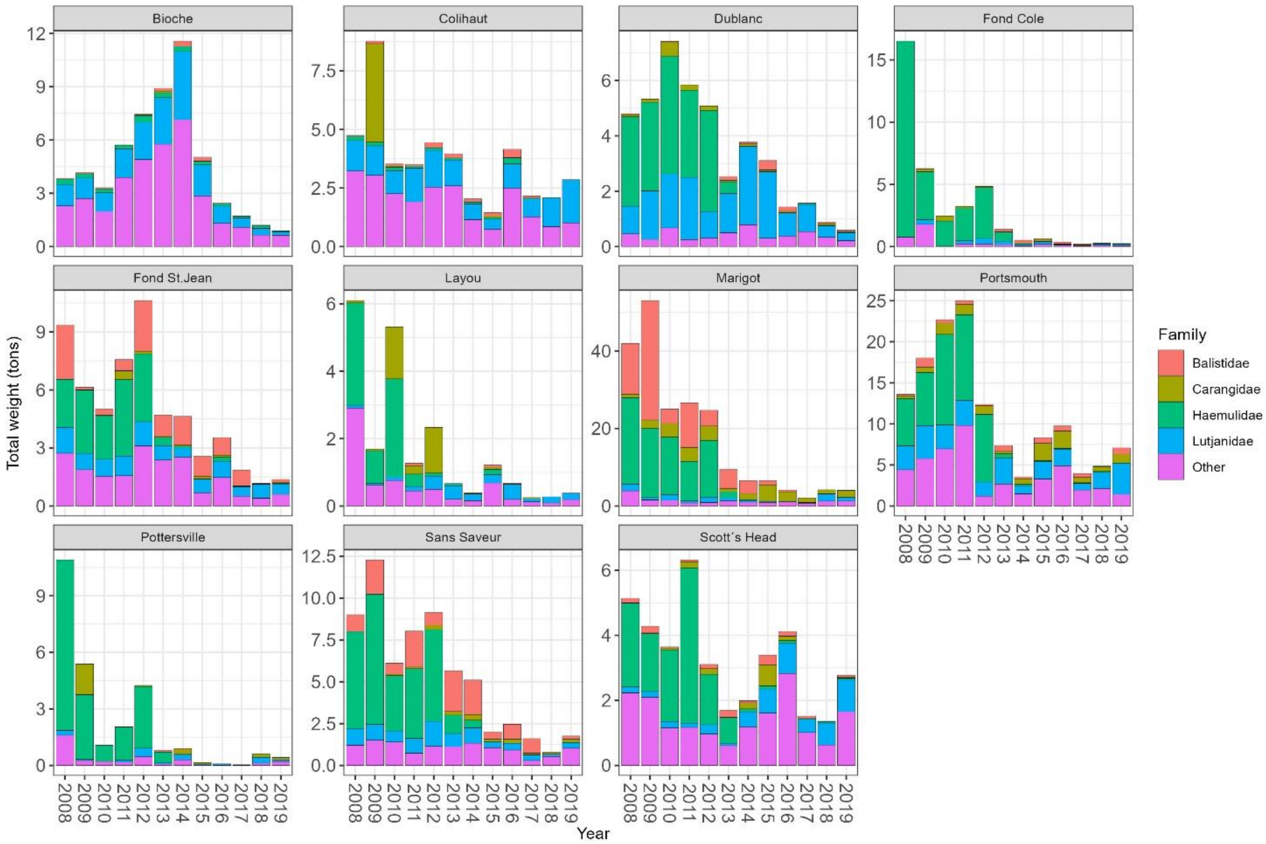



Figure 19. Distribution of demersal families landed at the 11 landing sites (Bioche, Colihaut, Dublanc, Fond Cole, Fond St. Jean, Layou, Marigot, Portsmouth, Pottersville, Scotts Head and San Sauveur) between 2008 to 2019.

The varying trends in catches at landing sites shows a shift in catch composition at various periods throughout the study. The contribution of *Haemulidae* (grunts) have declined for all sites by 2014. *Lutjanidae* however has remained present in varying in proportion. Landings for *Balistidae* (triggerfishes) have also shown changes in landing and is most abundant in composition for landing sites on the east of Dominica, Marigot, Fond St. Jean, and Sans Sauveur.

### 4.4 Geographical distribution of demersal fish.

The Dominica Fisheries Division developed a catch grid to better report on the distribution of species and to better quantify fishing grounds within the exclusive economic zone. It can be observed that the spatial distribution of catches for demersal species within the territorial waters and the contiguous zone is widespread, with distances of more than 25 nm on the west coast and 30 nm on the east coast (Figure *20*).

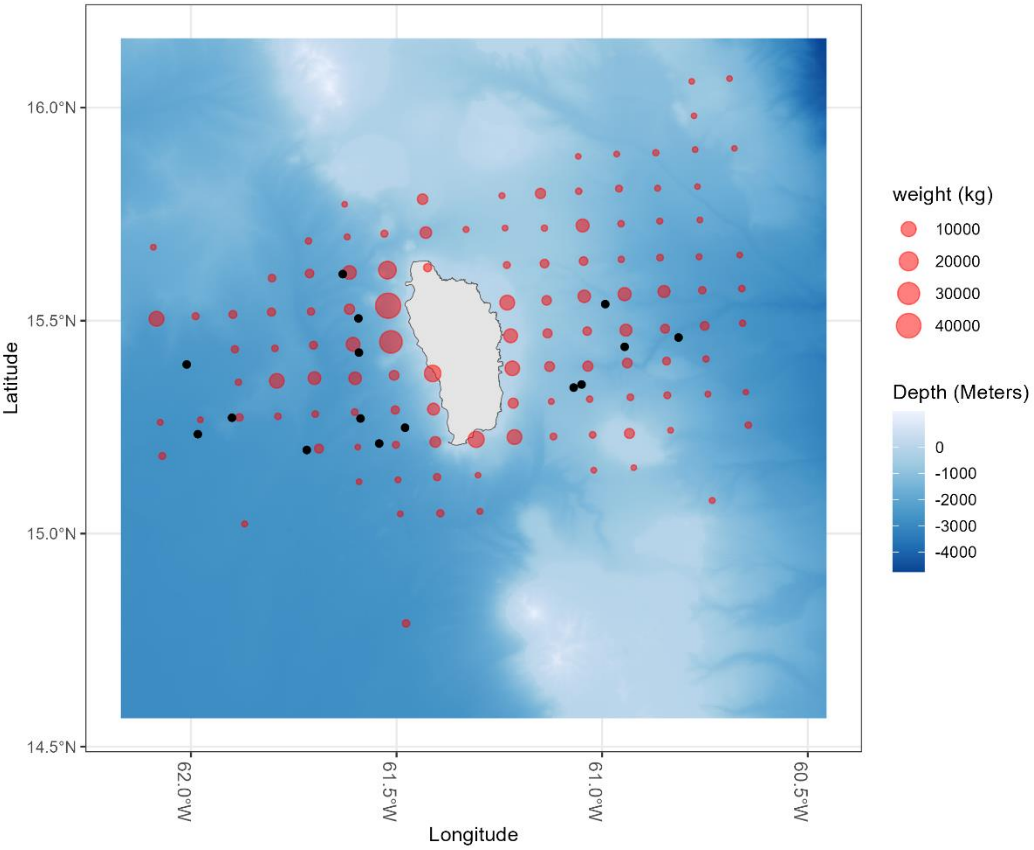



Figure 20. Map of demersal fish species catch locations between 2009-2019. Red dots indicate location and weight of fish captured. Black dots represent locations of fish aggregating devices.

Further examination of fishing locations revealed that of the 249 locations found in the fishing grid developed for Dominica, 115 locations were clearly fished (Figure *20*). The areas with the highest reported catches included two areas on the west of Dominica (G7, H7) and one area to the east (K10) (Table 4). These areas had the highest reported landings between 2013 and 2016. There is a noted decrease in reported catches along the west coast of the country after 2014, as well as the significant decrease in 2018. However, in 2019 catches increased in terms of both quantity and catch distance from shore. Looking at the catch locations along the east coast of Dominica, the distribution of catches remained constant from 2015-2017, with a similar decrease in 2018 as seen along the west coast (Figure 21)

Table 4. Catch locations showing highest fishing effort recorded and year.

| Year | Catch location | Frequency |
|---|---|---|
| **2014** | G7 | 3690 |
| **2013** | G7 | 1767 |
| **2014** | H7 | 1618 |
| **2014** | K10 | 1290 |
| **2016** | H7 | 1063 |

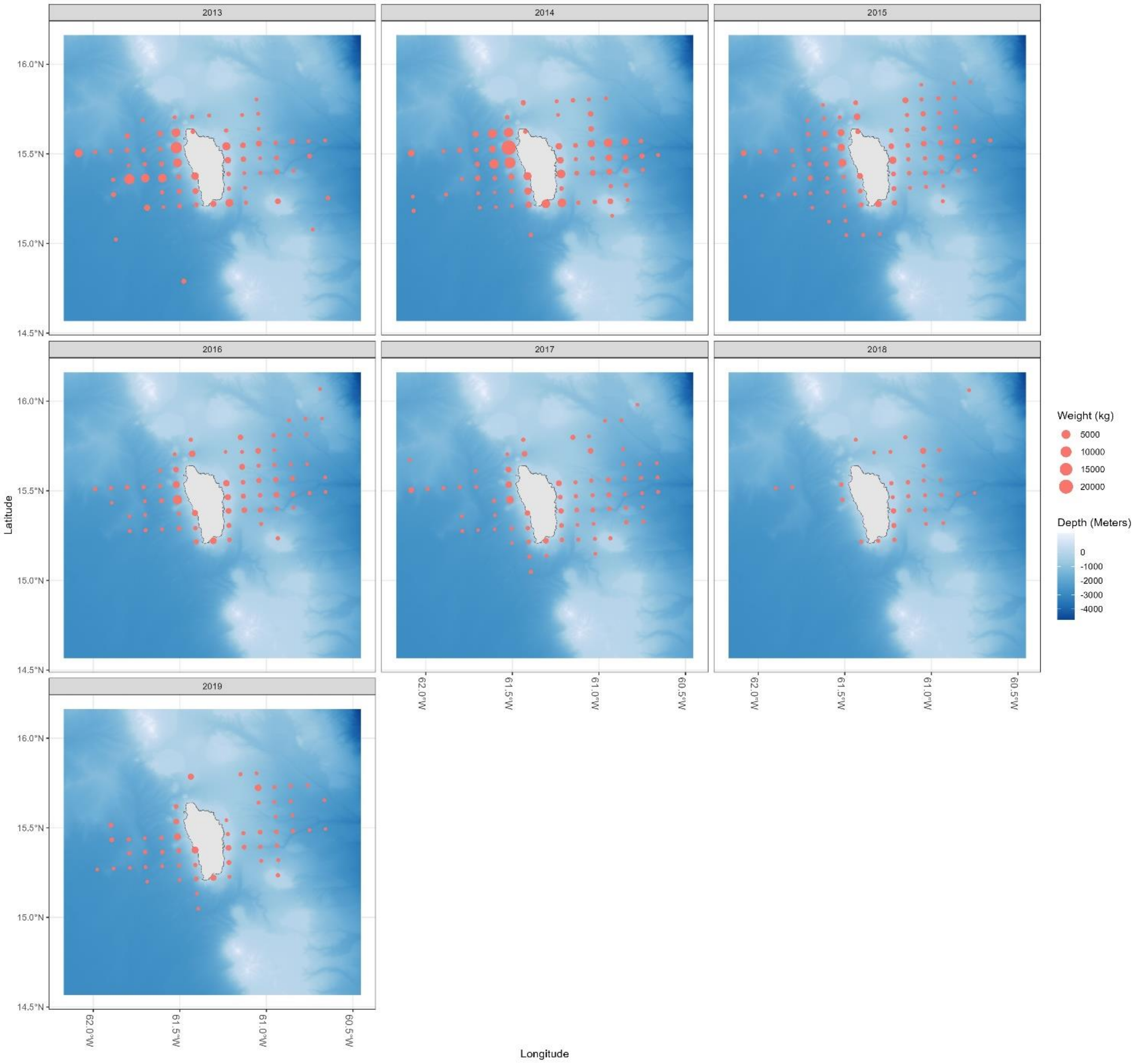



Figure 21. Summary of catch data by location for four main demersal fish families (combined) by year, showing changes in recorded weight and catch locations for demersal species over time.

### *4.4.1 Distribution of* Lutjanidae

The spatial distribution of *Lutjanidae* (snappers) was generally highest on the west coast, with hotspots at sites H7 (16.67%), G7 (16.28%) and I8 (7.96%) (Figure *22*, Table A*10*) and reported weights of 14, 528 kg, 14, 184 kg and 6938 kg, respectively. The average landed weight for *Lutjanidae* was 1281 kg per site.

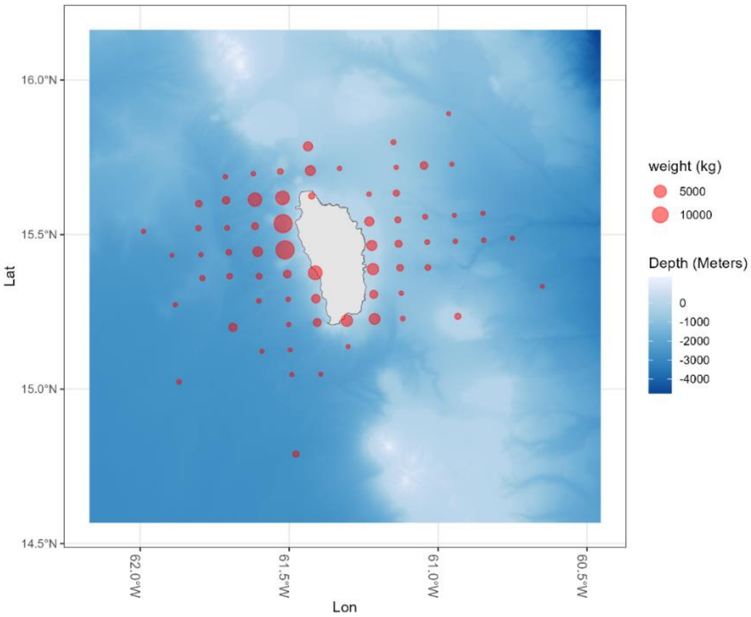



Figure 22. Map of *Lutjanidae* (Snappers) catch locations in Dominica between 2013-2019. Red dots indicate accumulated weight (kg) based on location.

### *4.4.2 Distribution of* Haemulidae

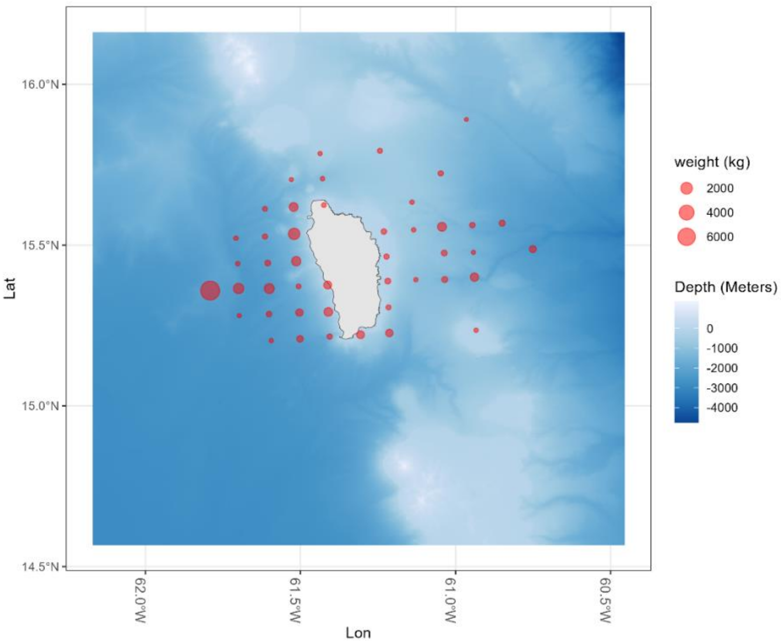



Figure 23. Map of *Haemulidae* (grunts) catch locations in Dominica between 2013-2019. Red dots indicate accumulated weight (kg) based on location.

Recorded catches of family *Haemulidae* (grunts) has varied both geographically and with depth (Figure *23*). Compared with the east of Dominica, landings are higher for the west with 24 reported locations as opposed to 21 on the east. Three locations I4 (38.66%), I5 (6.91%), I6 (6.21%) and G7 (9.39%) (Table A10) located on the west had the highest reported catches by weight (Table *5*). Based on depth, these species have been captured at depths between ranges of 1000-3000 meters depth.

Table 5. Catch locations with highest fishing effort reported for Haemulidae (grunts).

| Catch Location | Total Weight (Kg) |
|---|---|
| I4 | 7,475 |
| G7 | 1,816 |
| I5 | 1,337 |
| I6 | 1,201 |

### *4.4.3 Distribution of* Carangidae

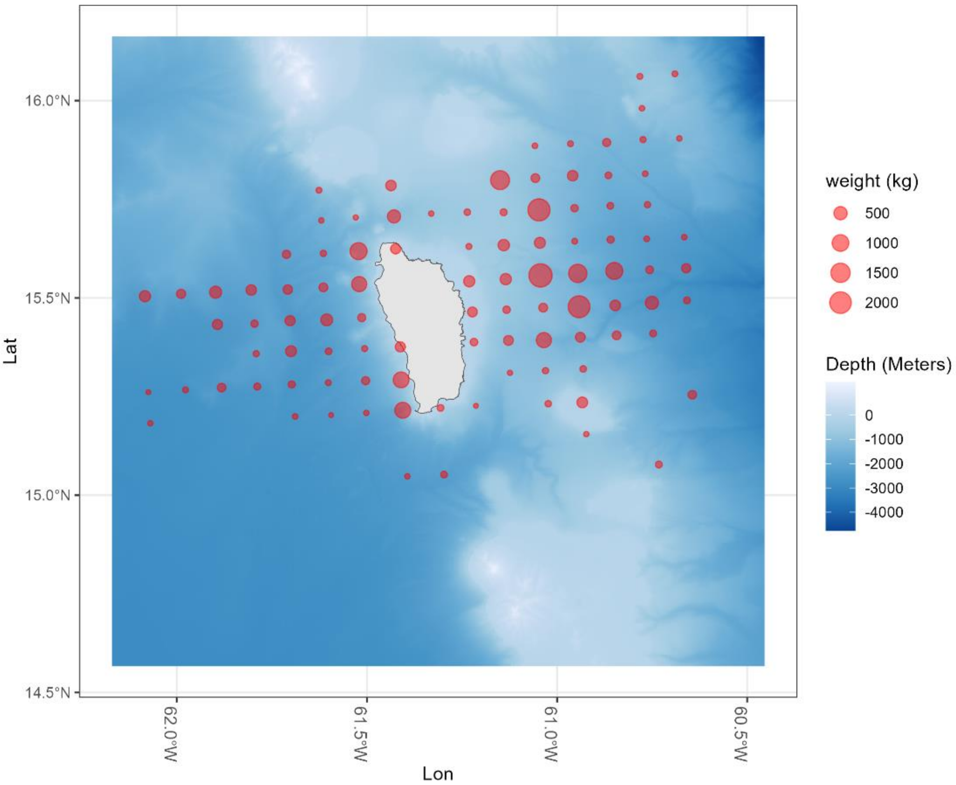



Figure 24. Map of *Carangidae* (Jacks) catch locations in Dominica between 2013-2019. Red dots indicate accumulated weight (kg) based on location.

A total of 97 catch locations (Figure *24*) were identified when conducting analysis of *Carangidae* (Jacks). Location G12 accounted for 11% of overall catch landed for this family. Additional key areas included E12, H13, D11 and G13 accounting for 31% weight landed (Table A10). The east coast of Dominica accounts for more than 60% of reported catches.

### *4.4.4 Distribution of* Balistidae

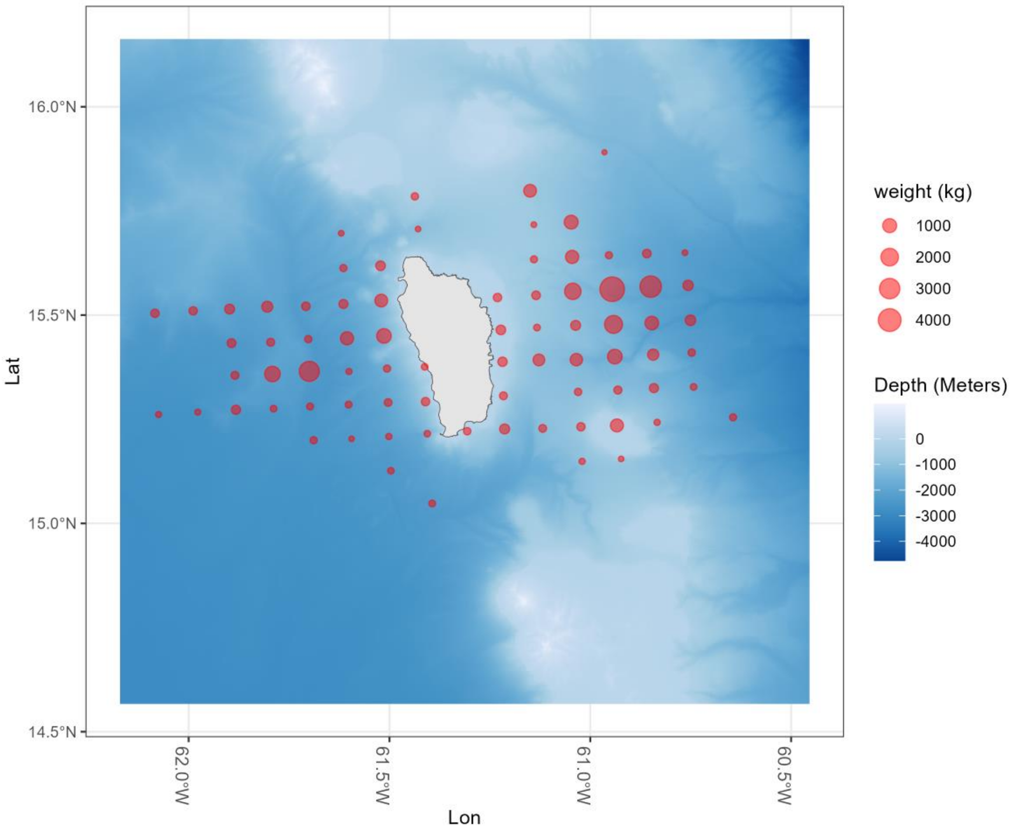
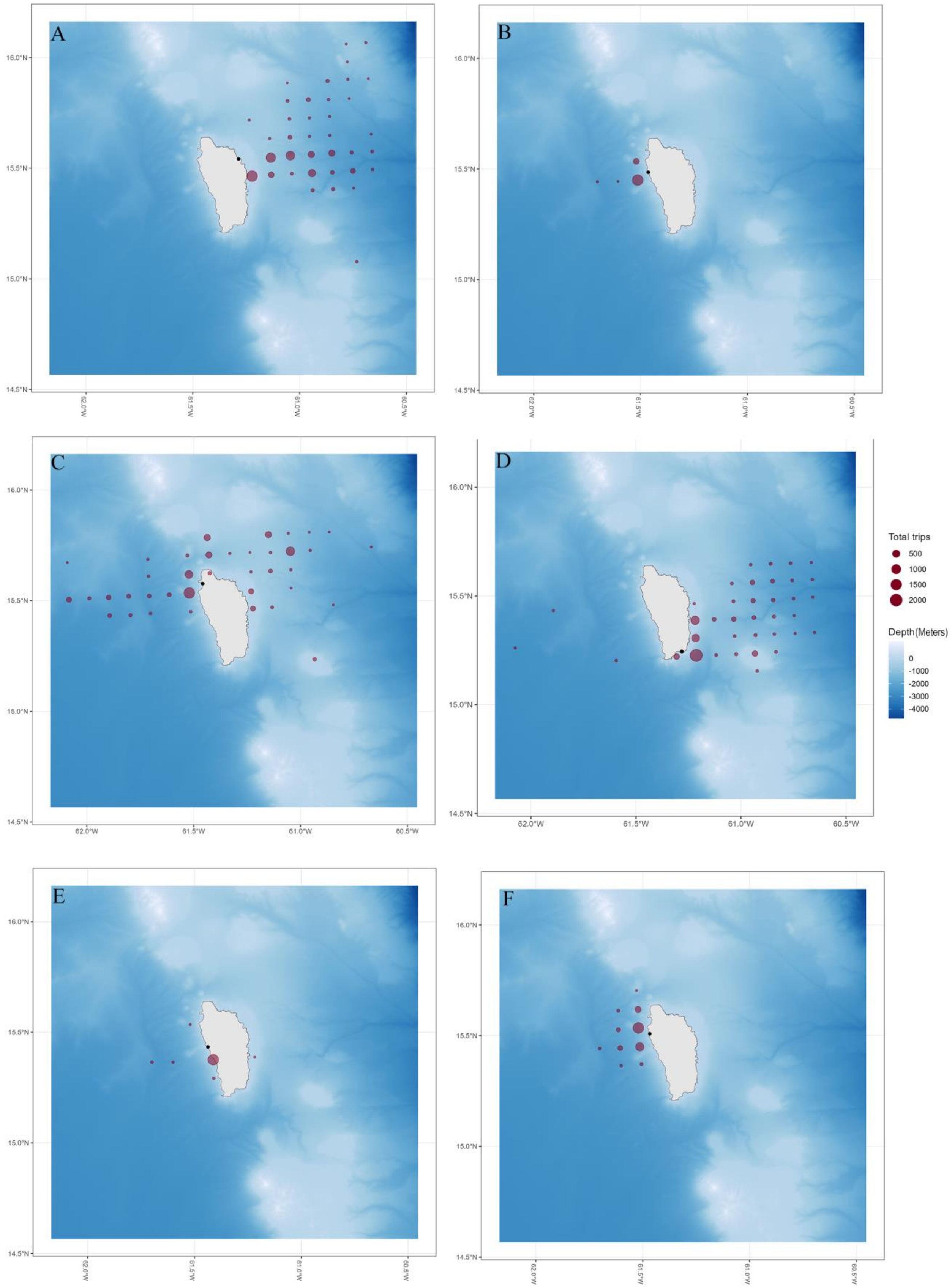



Figure 25. Map of *Balistidae* (triggerfish) catch locations in Dominica between 2013-2019. Red dots indicate accumulated weight (kg) based on location.

Four *Balistidae* species were reported from capture sites around Dominica. Sites G12, G13 and G14 accounted for 31% of the weight landed (Table A10). This family is geographically most widespread with 77 fishing sites identified (Figure *25*).

## 4.5 Trends in demersal fish catch locations by landing site

Catch landings were mapped based on landing sites having records where spatial data was present. This provided identification of landing sites with reported engagement in capture of demersal fish species which include Fond St-Jean, Portsmouth, Dublanc, Marigot, Scotts Head, San Sauveur, St. Joseph, Bioche, Colihaut, and Salisbury. A summary of catch location recorded between 2013-2019 showing differences in catch location (Figure 27) indicates that few sites remain confined to a particular region with sites located on the north such as Portsmouth (C) having reported catch greater than 25 m from the landing site. While there has been a clear increase for distance travelled, no indication can be seen for decrease in capture of demersal for many sites through-out the period. For all sites the highest proportion of trips were within a 5m grid of the landing site. Further, the data indicates an overlap in fishing grounds for neighbouring landing sites. On the west coast this occurs between sites Portsmouth (C), Dublanc (H), St. Joseph (J), Bioche (F) and Colihaut (B). Similarly, on the east coast landing sites Marigot (A), San Sauveur (I) and Portsmouth (C) have commonality between their fishing grounds.


A
B
C
D
E
F
16.0°N
15.5°N
15.0°N
14.5°N
62.0°W
61.5°W
61.0°W
60.5°W
Total trips
500
1000
1500
2000
Depth(Meters)
0
-1000
-2000
-3000
-4000

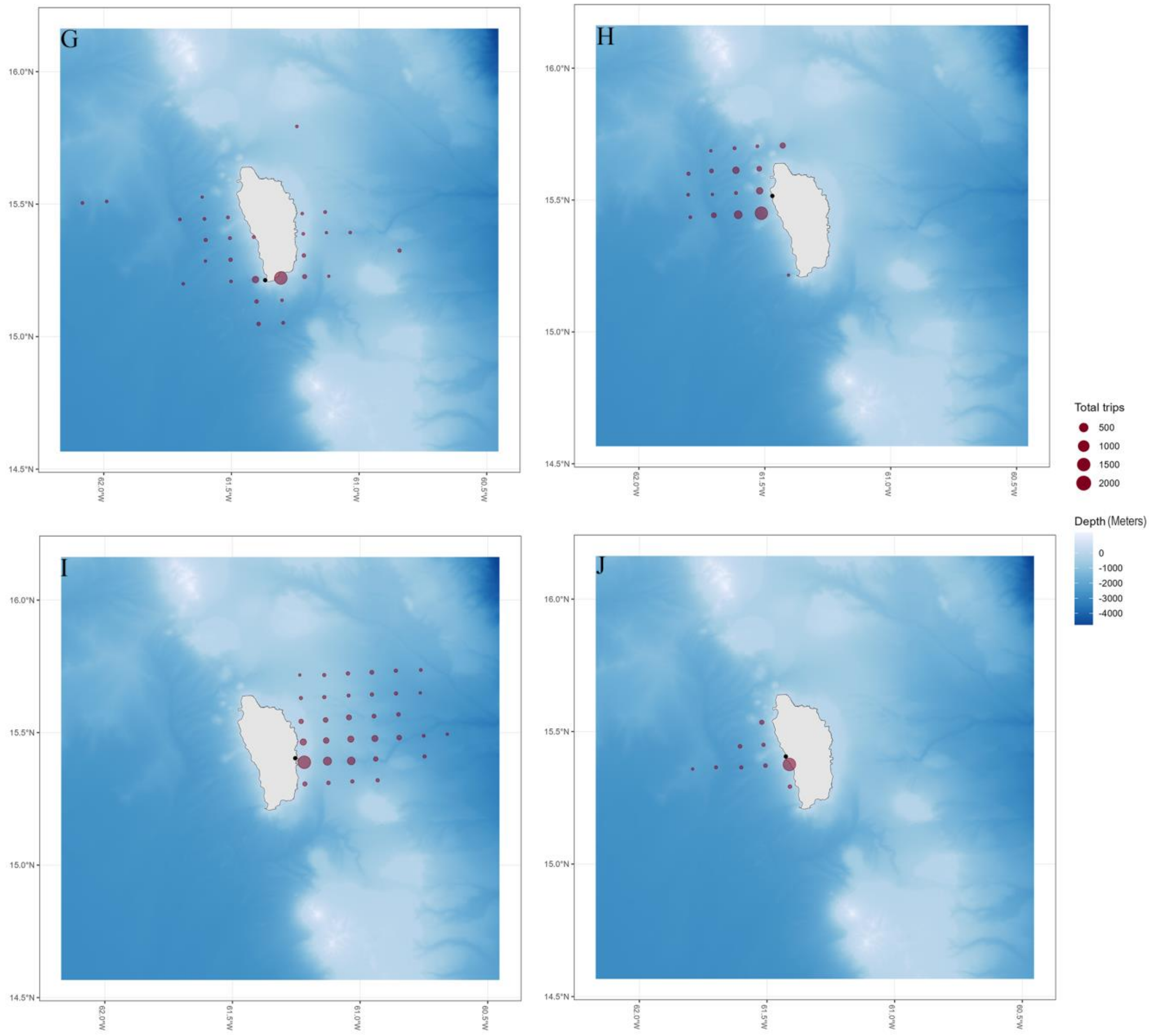



Figure 26. Maps showing geographical distribution of fishing effort between landing sites (black dots) between 2013-2019. (A) Marigot (B) Colihaut (C) Portsmouth (D) Fond St-Jean (E) Salisbury (F) Bioche (G) Scotts Head (H) Dublanc (I) San Sauveur (J) St. Joseph.

### *4.5.1 Portsmouth*

A total of 119 fishing locations were recorded for the Portsmouth landing site from 2013 to 2019. A comparison of the number of trips over the years shows clear changes in the fishing areas for demersal species (Figure *27*). The changes after 2014 indicate a reduction in trips near the coast and further exploration away from the main landing site, while the frequency of trips west of the island increased in 2015. At both G7 and F7 fishing sites, 95% fewer trips were reported between 2013 and 2019. Both sites are less than 5 miles from the landing site.

### *4.5.2 Marigot*

A total of 107 catch sites were mapped for the Marigot landing site from 2013 to 2018. From the mapped changes in fishing locations (Figure *28*), the number of trips near the landing site, which was highest in 2014, has decreased. For one site H10, which is within a 5-mile buffer, there was a 95% decrease in reported catches.

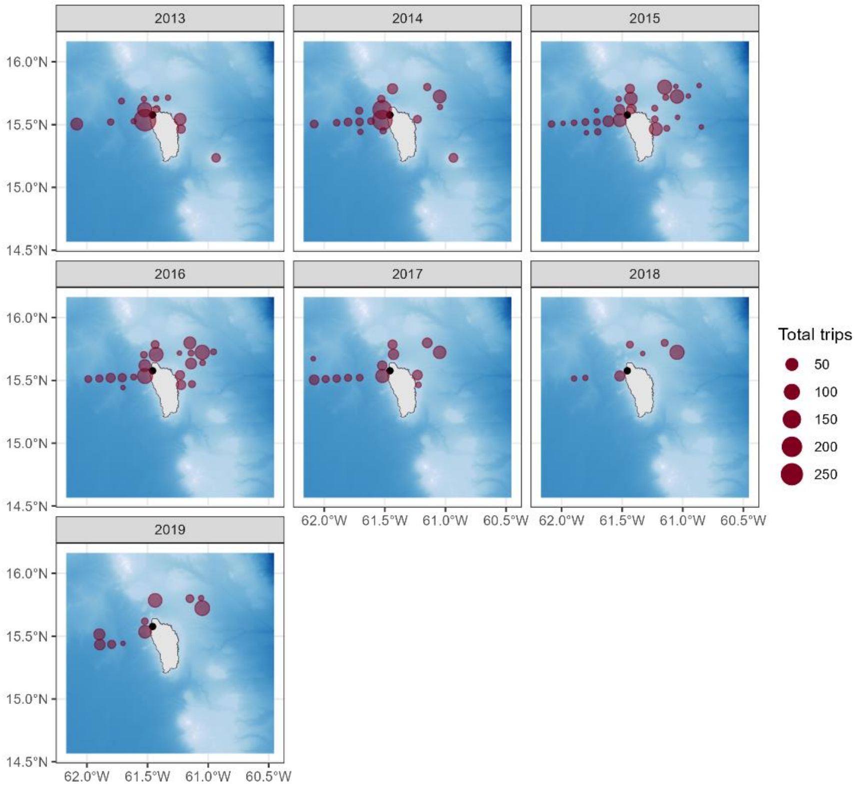



Figure 27. Maps of fishing effort over time for Portsmouth landing site. Red dots indicate number of trips to fishing locations determined from fishing grid system for Dominica. Black dot indicates location of landing site.

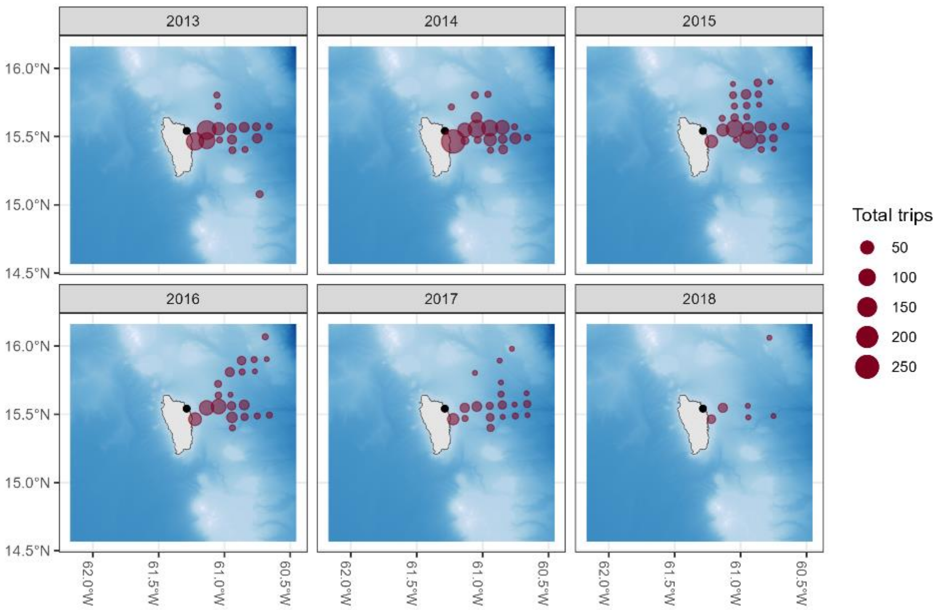



Figure 28. Maps of fishing effort over time for Marigot landing site. Red dots indicate number of trips to fishing locations determined from fishing grid system for Dominica. Black dot indicates location of landing site.

### *4.5.3 Scott's Head*

Mapping of fishing locations for the Scott's Head landing site indicates that reported fishing trips have decreased. This can be seen most distinctly between 2014 and 2018 (Figure *29*). In 2014, a total of 764 fishing trips were recorded for fishing site K9. This represented 77% of the recorded fishing trips in that year.

### *4.5.4 Fond St. Jean*

This landing site in the south of Dominica recorded the highest number of trips for site K10 in 2014 (*Figure 30*). Trips to this site accounted for 65% of all activity. However, in 2015, reported trips decreased by 60%, while trips to neighboring sites increased. There is also evidence that trips started increasing in 2017 and decreased significantly in 2018.

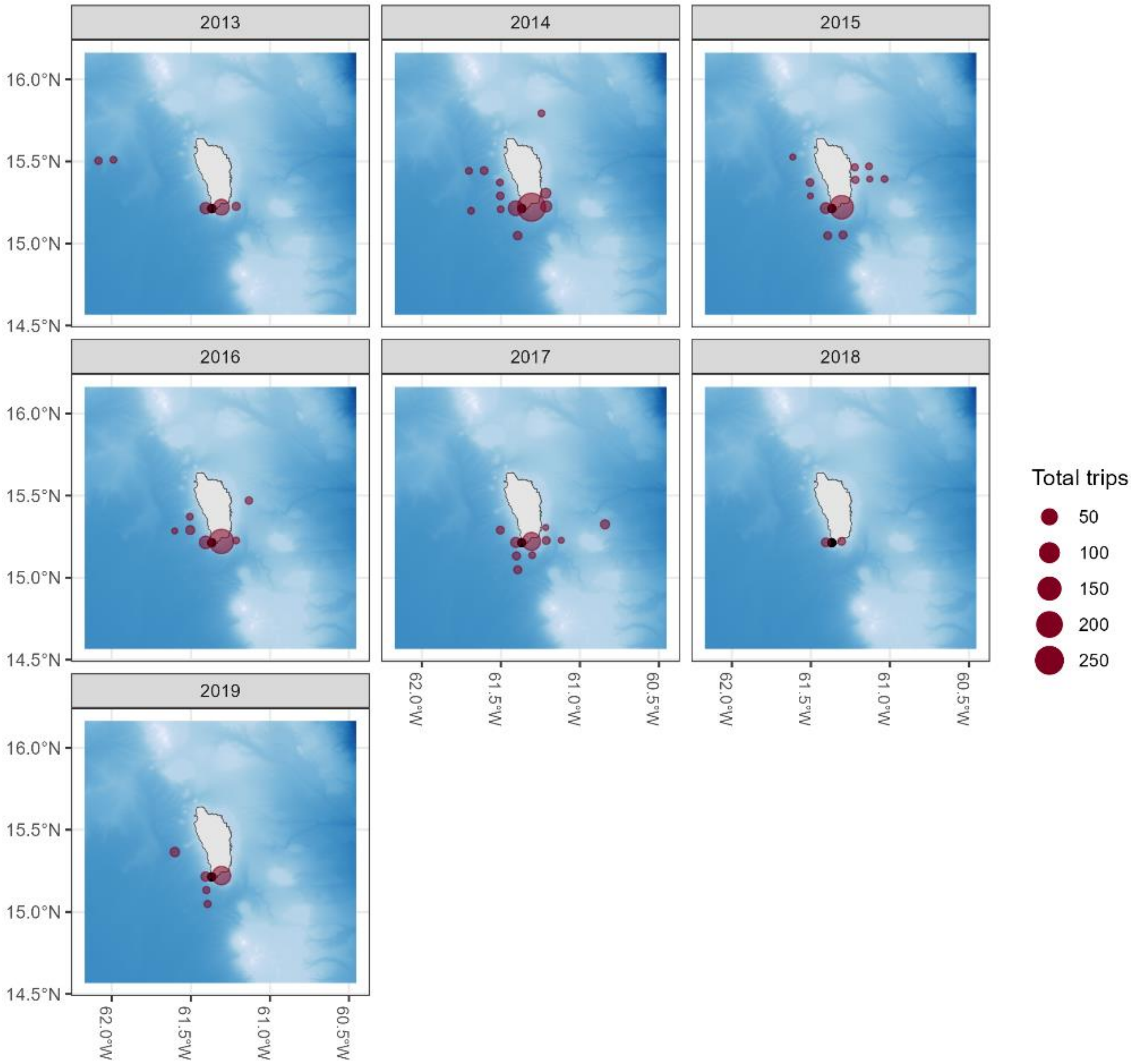



Figure 29. Maps of fishing effort over time for Scott's Head landing site. Red dots indicate number of trips to fishing locations determined from fishing grid system for Dominica. Black dot indicates location of landing site.

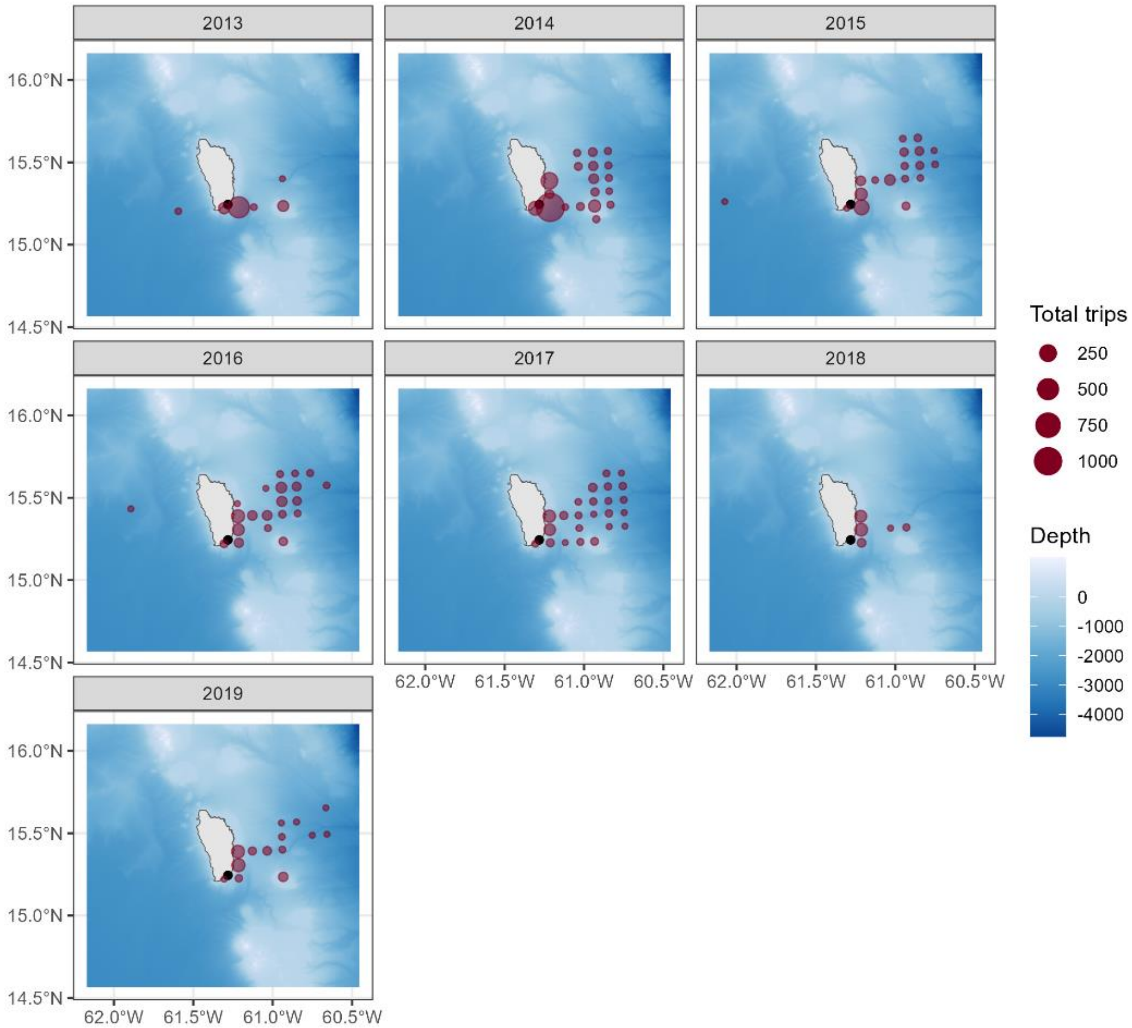



Figure 30. Maps of fishing effort over time for Fond St. Jean landing site. Red dots indicate number of trips to fishing locations determined from fishing grid system for Dominica. Black dot indicates location of landing site.

## 4.6 Trends in Catch per unit effort.

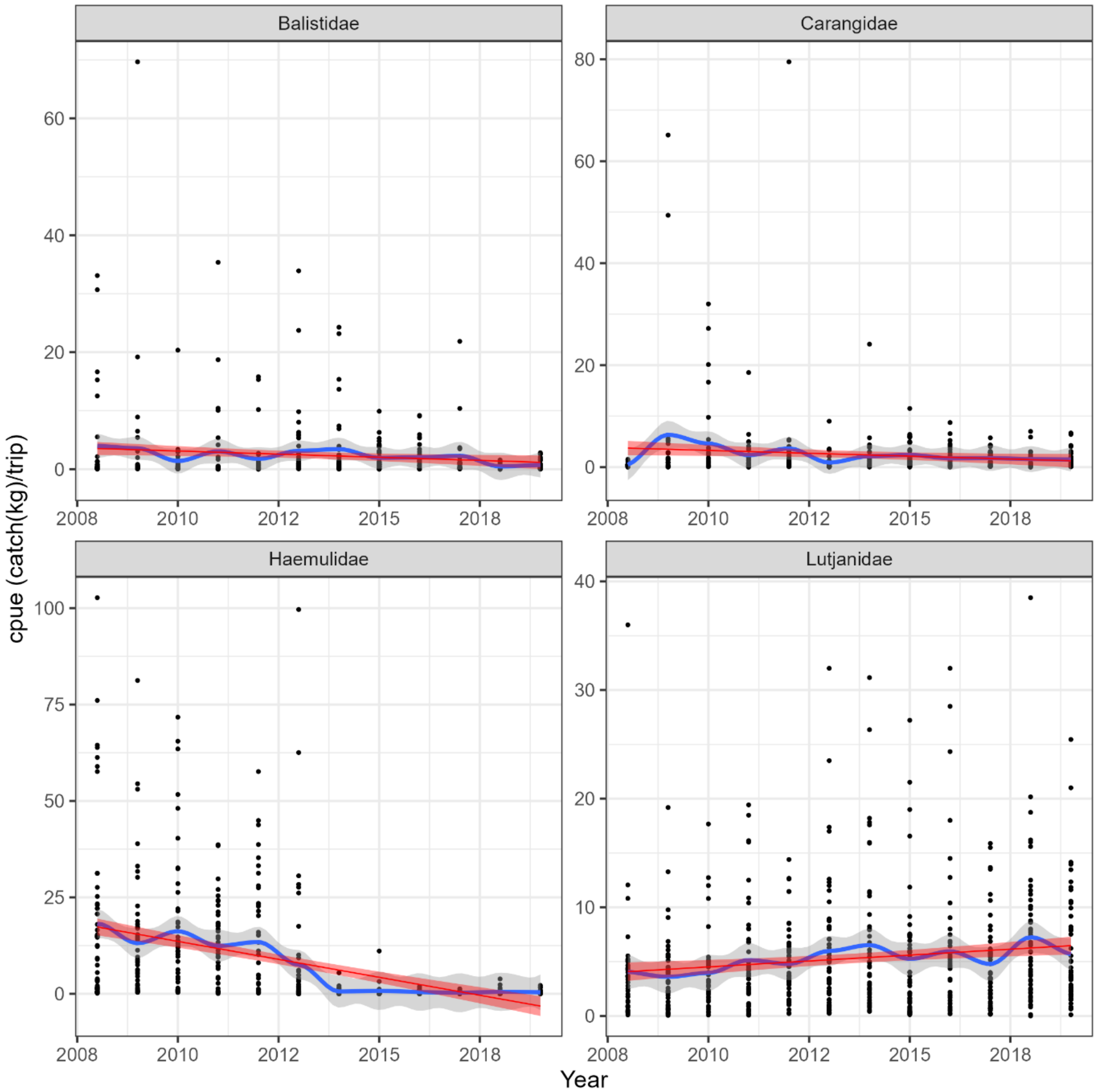



Figure 31. Plots showing catch per unit effort by year (2008-2014) for four demersal fish families (A)*Lutjanidae* (B)*Haemulidae*, (C)*Serranidae*, (D)*Balistidae*. Red line fitted to gam linear model. Blue line fitted with loess smoothing with a span of 0.2.

CPUE for the four major families varied over time, having an average CPUE of 21kg per trip. Only CPUE for *Lutjanidae* showed a slight positive trend, while the CPUE for *Balistidae*, *Haemulidae* and *Carangidae* exhibited negative trends (Figure *31*). The CPUE trend was most pronounced for *Haemulidae* (grunts), which was the most abundant category based on proportions landed, indicating a decline in availability of fish stock.

## 5 DISCUSSION

In this study, data from the Dominica Fisheries Division was used to determine the spatial distribution of demersal fish species as well as the overall estimated landings between 2008-2019. The data available for demersal fish species was well documented to include species level information where possible, with a total of 189 species belonging to 47 families identified in the landings data for the period.

The overall findings indicated that for demersal fish species, landings have declined during the study period. Further the overall results of the cpue trend agrees with previous studies by Theophile (2016) and Defoe (2020) in that there has been a noted decline in the landings from the demersal sector. A decrease in landing of demersal species in Dominica, though tempting to link to overfishing, can be gauged by the level of technology that has increased surrounding overall fish capture in the Caribbean. The techniques and gears used have seen no new advancement especially in relation to selectivity. When compared to the pelagic fish sector, moored FADs have been deployed clearly showing the increased capture efficiency of vessels using FADs, compared with those fishing in open water (Defoe, 2020).

While there was a high diversity of families caught, family *Haemulidae* (grunts) (35%) dominated the landings for the reported period. The other families included *Balistidae* (triggerfish), *Lutjanidae* (snappers), and *Carangidae* (jacks) based on proportion. Historically, *Balistidae* (triggerfish), *Haemulidae* (grunts) and *Carangidae* (jacks) have been a part of the demersal catch composition in Dominica contributing at least 3% to the overall catch landings from estimated from studies as early as 1991 (Guiste, Bertrand, & Gilles, 1996). Their contributions to overall landings have since significantly increased. The *Balistidae* family became part of an effort to increase the exploitation of underutilized species in the 1990s by the Fisheries Division increasing the overall landings. Triggerfishes were then landed in high quantities with great receptance from the local market. However, CPUE indicates a decline in landings starting in 2015. This trend of increased exploitation has been observed in neighbouring regions which made triggerfish an important demersal species (Erisman, et al., 2010). However, in many reported cases this species has declined leading to the need for management. An assessment conducted by Gulf of Mexico Fishery Management Council and National Oceanic and Atmospheric Administration indicated that grey triggerfish (*Balistes capriscus*) was overfished in previous years but as of 2017 with management was no longer undergoing overfishing. It was however considered overfished in the Gulf of Mexico (Gulf of Mexico Fishery Management Council, 2017). Regardless, *Balistidae* has seen significant decline in landings matching patterns of a steep increase and rapid decline (Aggrey-Fynn, 2007) and signals the need for implementation of management strategies and further study in Dominica.

The pattern of annual reduction in black margate (*Anisotremus surinamensis*) has been a key factor in the evident decline in CPUE for the family *Haemulidae* and the general decline of demersal landings in Dominica. Within the Caribbean this species is of moderate economic importance, however literature is limited on reduced landing signaling the need for further investigation.

The family *Lutjanidae* in particular is an economically and ecologically important species in the Caribbean (Pinnegar, Engelhard, Norris, Theophille, & Sebastien, 2019), and other regions of the world, where it often dominates the reef fish community in shallow to mid-water depths along the continental shelf (Powers, et al., 2018). Negative trends have been observed in the Bahamas, Belize (Murray & Aiken, 2006) and regions of the lesser Antilles (Gobert, 2000). A decrease in landings of these long-lived families could signal a shift (Gobert, et al., 2005) to low value species within the families *Scaride*, *Sparidae*, *Labridae*, *Mullidae*, *Holocentridae* and *Acanthuridae* (Koslow, Aiken, Auil, & Clementson, 1994). The *Lutjanidae* landings were however rather stable in Dominica and CPUE trends positive. Further there has not been a marked increase in landings of low value species.

The impact of storms and hurricanes must also be considered when assessing the status of this fishery. Dominica's fishing communities are believed to be particularly vulnerable to long-term climate change and occasional catastrophic hurricanes (Pinnegar, Engelhard, Norris, Theophille, & Sebastien, 2019). The country lies in a hurricane zone due to its geographical location in the middle of the Lesser Antilles Island arc. Hurricanes form in the Atlantic Ocean and move in a north-westerly direction occurring between 1 June to 30$^{th}$ November. While the impact over land is visible in terms of gear and vessel losses, the impact of sedimentation (Diamond, 2003) should be seen as affecting the natural habitat for demersal fish which has been seen in Dominica (Caricom Today, 2022). Caroline (1990) lends support to this mentioning that one of the largest possible sources of reef degradation due to human activity in the Caribbean is sedimentation from dredging and runoff. For landing sites that have had marked changes in catch location it may well be the impact of sedimentation from storms and hurricanes. Further, the marked changes in distribution between 2017-2018 can be directly related to the impact of Hurricane Maria which caused significant destruction to the fisheries sector (Dominica Fisheries Division, 2019), and may have an extended impact into the future of the sector resulting in a reduction of landings due to loss of vessels at multiple landing sites and destruction of the Roseau fisheries complex with ice production capabilities of an estimated 25 tons and 8 tons daily ice production (Defoe, 2020).

The spatial distribution of marine fish populations is vital for the creation of appropriate management measures, such as the determination of essential fish habitats and the further formation of marine protected areas. This is particularly true for reef fish populations, which can be characterised at multiple scales as they typically occupy different patchy habitats throughout their lives and are exposed to spatially heterogeneous predatory threats and environmental conditions (Saul, Walter, Die, Naar, & Donahue, 2013). Landing sites located on the west coast of Dominica such as Portsmouth, Salisbury and Scotts Head all have reef structures (Steiner, 2015) and calmer waters when compared to the east coast which can explain the number of trips and overall landed weights of demersal species. Portsmouth for example has an 18.5 km length of reef that is fished (Guiste, Bertrand, & Gilles, 1996). Historically, these locations have recorded higher landings of demersal based on the fishery type since they are able to utilise gears which include fish pots, a primary method for demersal capture. When considering range of exploitation, sites along the west coast also tend to exhibit a wider range of exploitation of the marine space (Guiste, Bertrand, & Gilles, 1996). The findings here match some of the patterns discovered by Guiste et al (1996) with most noted changes seen in distribution for Portsmouth into the east coast of the country.

The findings of these studies raise intriguing questions about demersal fisheries and the extent to which resources have been extracted from ocean space. The results in this study should be interpreted with caution particularly with the decreasing trend in reported landings for demersal fish species (Gobert, 2000). Without the available data on present stock, it is difficult to decide whether too much pressure is being applied. The dangers of using catch and effort solely as a means presents itself due to the inconsistencies in how catches are recorded at landing sites around the country. The same can be said for conducting analysis using for example CMSY method for individual species data sets with limited data (Bouch, Minto, & Reid, 2020), where possible species are either misidentified or placed in broader categories. Further, while these can supply an estimate, they are not dependable, but in some cases are still used as a basis for stock assessment (Salas, Chuenpagdee, Seijo, & Charles, 2007).

To create management strategies for resource use, information on the precise impacts of regional consumption, economic growth, tourism, and environmental degradation on fishery resources is required to make a definite conclusion (Jeffrey, 2000). Tourism is quickly becoming a major economic contributor to the sector and has the potential to shift the targeting habits of fishers. Each of these factors have a significant input on whether fishers continue to target demersal or focus on pelagic species which in some cases fetch a higher market price.

# 6 CONCLUSION

Geographical distribution of demersal and fishing effort showed a widespread distribution around the island indicating three major sites, which can be considered as hot spots for demersal fish species in Dominica. Fishing activity has changed throughout the years being influenced by storms and hurricanes but remains most concentrated on the west of the island. These findings are important because the locations where marine species live may be affected by fishing and/or climate change. In addition, the ocean is under increasing pressure from new sectors seeking to participate in the blue economy, potentially affecting productive fishing areas. In managing the oceans, it is therefore important to consider the dynamics of marine species distribution.

In terms of further studies, it is recommended that studies be conducted for each landing site, considering socio-economic impacts, to better examine changes in landings for both pelagic and demersal fisheries.

In addition, the following recommendations can be made to improve the analysis for the fisheries sector:

(1) Biostatistical data collection for the main families identified. This would allow simple evaluations to be made to determine whether the average catch length is generally increasing, decreasing, or remaining relatively stable. This can be included in the development of a sampling manual for Dominica ensuring that it is part of data collectors workplan.

(2) There should also be improvement on classification of species to reduce uncertainty in analysis. Data collectors and staff members should be trained in fish identification with the intention of reducing possible misidentification and placing of species in broad categories. While it may not be a solve all problem, it would lead to clearer understanding of fishing pressure at a species level.

(3) The spatial data used in this study was sufficient to provide a snapshot of fishing activities in the marine sector. However, many sites lacked spatial data which would have provided a clearer representation and collection of this data should be encouraged at all sites. Further, exploration of measures to gather precise location of landings should be explored to understand

trends in the fisheries. Stakeholders of the sector also need to be introduced to spatial data collection and its importance.

(4) In addition, staff should receive regular training on how to maintain the correct data structure, including how to record information, use the correct data entry format and interpret data. This would be important to reduce errors found during data cleaning and improve the department's human resources.

(5) Conduct a frame survey to get a clearer representation of stakeholders in the fisheries sector. A time frame should also be established between surveys. There is a possibility that an annual survey may not be necessary, but an updated frame survey would assist in the estimation of overall landings for the country.

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APPENDIX

Table A6. List of Landing sites names and port code used for data collection.

| *Port Code* | **Port Name** | *Port Code* | **Port Name** |
|---|---|---|---|
| **ADI** | Anse De Mai | **MGT** | Marigot |
| **BAT** | Batalie | **MHT** | Mahaut |
| **BOE** | Bioche | **MRO** | Mero |
| **CBH** | Calibishie | **MSC** | Massacre |
| **CBT** | Coulibistrie | **NTN** | Newtown |
| **CHT** | Colihaut | **PMH** | Portsmouth |
| **CLF** | Clifton | **PTM** | Pointe Mitchel |
| **CPN** | Capuchin | **PTV** | Pottersville |
| **DBL** | Dublanc | **RFC** | Roseau |
| **FDC** | Fond Cole | **SBY** | Salisbury |
| **FSJ** | Fond St. Jean | **SFE** | Soufriere |
| **JIM** | Jimmit | **SHD** | Scotts Head |
| **LYU** | Layou | **SSR** | Saint Sauveur |
| | | **STE** | Stowe |
| | | **STJ** | St. Joseph |
| | | **TAN** | Tan Tan |
| | | **TCE** | Toucarie |
| | | **TRU** | Tarou |
| | | **WFH** | Woodford Hill |

Table A7. Characteristics of fishing boats from 2011 Fisheries Industry Census

| **Characteristics** | **Canoe** | **Keel** | **FRP or Pirogue** |
|---|---|---|---|
| **Length range** | 10 to 20 feet | 15-25 feet | 20-25 feet |
| **Construction /description** | Dugout gommier trunk | Wooden-planked open vessel on a skeleton frame with a keel | Fiberglass Reinforced Plastic open boat |
| **Propulsion methods** | Oars and engines 15 HP or smaller. | Outboard engines 30-85 HP. Oars carried as a backup in some cases | Outboard engines 30-85 HP. Some of the larger FRP vessels can carry dual 150 HP four stroke outboards. |
| **Gear used** | Mainly use net-type gear such as beach seines. Fish pots are also used | Hook and line gear is most popular, although the boats are known to carry fish pots as well. | Hook and line, fish pots and nets. However, hook and line gear is most popular, especially when used for fishing operations around FADs. |

| | | | |
|---|---|---|---|
| **Species fished** | Small coastal pelagic such as ballyhoo, jacks and sardines. Reef fish such as parrotfish, groupers and snapper | Migratory pelagic such as tunas, dolphinfish, marlin, flyingfish and wahoo, among others. Reef species include snappers and groupers | Migratory pelagic such as tunas, dolphinfish, marlin, flyingfish and wahoo, among others. Reef species include snappers and groupers. |

Table A8. Total demersal landings for 11 selected landing sites in tons for 2008-2019.

| *Year* | *BOE* | *CHT* | *DBL* | *FDC* | *FSJ* | *LYU* | *MGT* | *PMH* | *PTV* | *SHD* | *SSR* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2008** | 3.85 | 4.75 | 4.80 | 16.51 | 9.37 | 6.10 | 11.04 | 13.62 | 9.60 | 5.14 | 9.01 |
| **2009** | 4.16 | 8.77 | 5.33 | 6.28 | 6.14 | 1.69 | 52.99 | 13.84 | 3.69 | 4.28 | 12.28 |
| **2010** | 3.32 | 3.53 | 7.42 | 2.46 | 4.50 | 5.32 | 6.24 | 22.69 | 1.09 | 2.75 | 4.96 |
| **2011** | 5.73 | 3.52 | 5.84 | 3.24 | 7.57 | 1.27 | 13.40 | 11.88 | 2.05 | 4.86 | 6.82 |
| **2012** | 7.46 | 4.45 | 3.81 | 4.86 | 10.62 | 2.33 | 11.16 | 12.39 | 4.24 | 3.10 | 5.50 |
| **2013** | 8.91 | 3.97 | 2.54 | 1.42 | 4.71 | 0.66 | 9.42 | 7.38 | 0.80 | 1.69 | 1.91 |
| **2014** | 11.57 | 2.04 | 3.78 | 0.51 | 4.64 | 0.39 | 6.54 | 3.55 | 0.89 | 1.99 | 5.11 |
| **2015** | 5.04 | 1.46 | 3.11 | 0.64 | 2.58 | 1.22 | 6.53 | 8.33 | 0.15 | 3.39 | 2.01 |
| **2016** | 2.46 | 4.16 | 1.43 | 0.37 | 3.54 | 0.68 | 4.13 | 9.77 | 0.09 | 4.12 | 2.46 |
| **2017** | 1.73 | 2.17 | 1.57 | 0.22 | 1.86 | 0.25 | 2.08 | 3.97 | 0.03 | 1.52 | 1.61 |
| **2018** | 1.21 | 2.09 | 0.89 | 0.30 | 1.17 | 0.26 | 4.18 | 4.87 | 0.60 | 1.36 | 0.79 |
| **2019** | 0.90 | 2.86 | 0.60 | 0.25 | 1.38 | 0.38 | 4.06 | 7.08 | 0.43 | 2.77 | 1.76 |

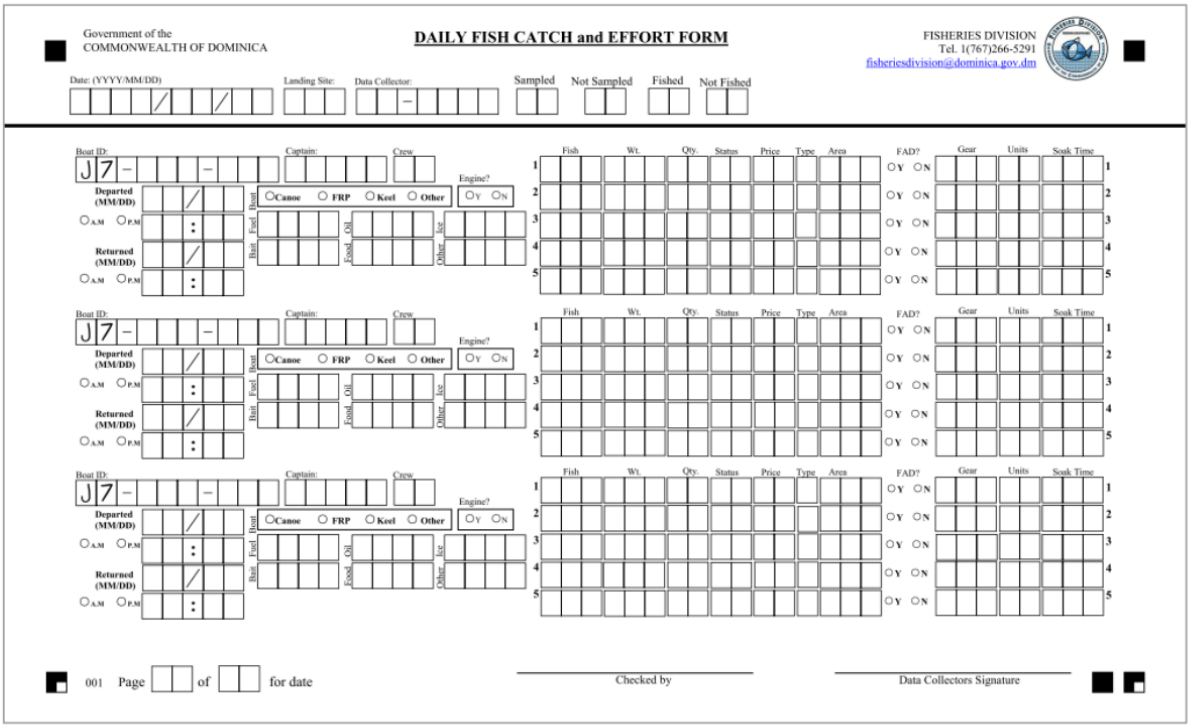


Figure A32. Standard fish catch and effort data collection form used by the data collectors in Dominica


Figure A33. Total sampled landings data collected from 21 landing sites indicating gaps in periods of data collection.

Table A9. General list of Demersal groupings found in fisheries database.

| *Family* | *Species* | *Classification* |
|---|---|---|
| Carangidae | Amberjack, Greater | Demersal |
| Pomacanthidae | Angelfish, Blue | Demersal |
| Pomacanthidae | Angelfish, French | Demersal |
| Pomacanthidae | Angelfish, Gray | Demersal |
| Pomacanthidae | Angelfish, Queen | Demersal |
| Pomacanthidae | Angelfishes | Demersal |
| Diodontidae | Balloonfish | Demersal |
| Sphyraenidae | Barracudas | Demersal |
| Grammatidae | Basslet, Fairy | Demersal |
| Ogcocephalidae | Batfishes | Demersal |
| Priacanthidae | Big Eye, Atlantic | Demersal |
| Albulidae | Bonefish | Demersal |
| Albulidae | Bonefishes | Demersal |
| Scombridae | Bonito, Atlantic | Demersal |
| Ostraciidae | Boxfishes | Demersal |
| Stromateidae | Butterfish | Demersal |
| Stromateidae | Butterfishes | Demersal |
| Chaetodontidae | Butterflyfish, Banded | Demersal |
| Apogonidae | Cardinalfishes | Demersal |
| Pomacentridae | Chromis, Blue | Demersal |
| Pomacentridae | Chromis, Yellowedge (Brown) | Demersal |
| Strombidae | Conch, Queen | Demersal |
| Ostraciidae | Cowfish, Scrawled | Demersal |
| Ostraciidae | Cowfish,Honeycomb | Demersal |
| Portunidae | Crab, Speckled Swimming | Demersal |
| Serranidae | Creole Fish | Demersal |
| Sparidae | Crimson Seabream | Demersal |
| Sciaenidae | Cubbyu | Demersal |
| Pomacentridae | Damselfish, Yellowtail | Demersal |
| Pomacentridae | Damselfishes | Demersal |
| Acanthuridae | Doctorfish | Demersal |
| Sciaenidae | Drum, Spotted | Demersal |
| Balistidae | Durgon, Black | Demersal |
| Myliobatidae | Eagle Ray,Spotted | Demersal |
| Congridae | Eel, Conger | Demersal |

| | | |
|---|---|---|
| Ophichthidae | Eel, Palespotted | Demersal |
| Ophichthidae | Eel, Snake | Demersal |
| Congridae | Eels, Conger | Demersal |
| Monacanthidae | Filefish, American Whitespotted | Demersal |
| Monacanthidae | Filefish, Orange | Demersal |
| Monacanthidae | Filefish,Orangespot | Demersal |
| Monacanthidae | Filefish,Scrawled | Demersal |
| Bothidae | Flounder, Peacock | Demersal |
| Pomacanthidae | Flying Gurnards | Demersal |
| Mullidae | Goatfish, Red | Demersal |
| Mullidae | Goatfish, Spotted | Demersal |
| Mullidae | Goatfish, Yellow | Demersal |
| Mullidae | Goatfish,Spotted | Demersal |
| Mullidae | Goatfishes | Demersal |
| Serranidae | Graysby | Demersal |
| Serranidae | Grouper, Black | Demersal |
| Serranidae | Grouper, Nassau | Demersal |
| Serranidae | Grouper, Red | Demersal |
| Serranidae | Grouper, Tiger | Demersal |
| Serranidae | Grouper, Yellowedge | Demersal |
| Serranidae | Grouper, Yellowfin | Demersal |
| Serranidae | Grouper, Yellowmouth | Demersal |
| Serranidae | Groupers | Demersal |
| Serranidae | Groupers G:Dermatolep | Demersal |
| Serranidae | Groupers,G:Epin. | Demersal |
| Serranidae | Groupers,G:Mycteroper | Demersal |
| Haemulidae | Grunt, Blue Striped | Demersal |
| Haemulidae | Grunt, Caesar | Demersal |
| Haemulidae | Grunt, Cottonwick | Demersal |
| Haemulidae | Grunt, French | Demersal |
| Haemulidae | Grunt, Sailor's | Demersal |
| Haemulidae | Grunt, Sailor's Choice | Demersal |
| Haemulidae | Grunt, Smallmouth | Demersal |
| Haemulidae | Grunt, Spanish | Demersal |
| Haemulidae | Grunt, Tomtate | Demersal |
| Haemulidae | Grunt, White | Demersal |
| Haemulidae | Grunt,Striped | Demersal |
| Haemulidae | Grunts | Demersal |
| Dactylopteridae | Gurnard, Flying | Demersal |
| Serranidae | Hamlet, Barred | Demersal |
| Dorosomatidae | Herring, Redear | Demersal |
| Serranidae | Hind, Red | Demersal |
| Serranidae | Hind, Rock | Demersal |
| Labridae | Hogfish | Demersal |
| Labridae | Hogfish, Spanish | Demersal |
| Carangidae | Hogfish, Spotfin | Demersal |
| Carangidae | Jack-knife Fish | Demersal |
| Serranidae | Jewfish | Demersal |
| Sciaenidae | Kingfish, Gulf | Demersal |
| Scorpaenidae | Lionfish | Demersal |
| Synodontidae | Lizardfish,Sand Diver | Demersal |
| Palinuridae | Lobster, Caribbean Spiny | Demersal |
| Palinuridae | Lobster, Smoothtail Spiny | Demersal |
| Palinuridae | Lobster, Spotted Spiny | Demersal |
| Scyllaridae | Lobsters, Slipper | Demersal |
| Palinuridae | Lobsters, Spiny | Demersal |
| Haemulidae | Margate | Demersal |
| Haemulidae | Margate, Black | Demersal |
| Muraenidae | Moray, Green | Demersal |
| Muraenidae | Moray, Reticulate | Demersal |
| Muraenidae | Moray, Spotted | Demersal |
| Muraenidae | Moray, Staut | Demersal |
| Muraenidae | Moray, Viper | Demersal |
| - | Morays | Demersal |

| | | |
|---|---|---|
| Mugilidae | Mullet, White | Demersal |
| Mugilidae | Mullets | Demersal |
| Octopodidae | Octopus, Caribbean Reef | Demersal |
| Octopodidae | Octopus, Common | Demersal |
| Scaridae | Parrotfish, Blue | Demersal |
| Scaridae | Parrotfish, Midnight | Demersal |
| Scaridae | Parrotfish, Princess | Demersal |
| Scaridae | Parrotfish, Redband | Demersal |
| Scaridae | Parrotfish, Spotlight | Demersal |
| Scaridae | Parrotfish,Queen | Demersal |
| Scaridae | Parrotfishes | Demersal |
| Diodontidae | Porcupinefish | Demersal |
| Sparidae | Porgy, Knobbed | Demersal |
| Sparidae | Porgy, Littlehead | Demersal |
| Sparidae | Porgy, Saucereye | Demersal |
| Sparidae | Porgy, Spotfin | Demersal |
| Haemulidae | Porkfish | Demersal |
| Tetraodontidae | Puffers | Demersal |
| Scorpaenidae | Rock Beauty | Demersal |
| Scorpaenidae | Rockfish, Yelloweye | Demersal |
| Carangidae | Runner, Blue | Demersal |
| Carangidae | Runner, Rainbow | Demersal |
| Scorpaenidae | Scorpionfish, Hunchback | Demersal |
| Scorpaenidae | Scorpionfish, Longsnout | Demersal |
| Scorpaenidae | Scorpionfish, Reef | Demersal |
| Serranidae | Sea Bass, Rock | Demersal |
| Kyphosidae | Sea Chub, Bermuda | Demersal |
| Kyphosidae | Sea Chub, Yellow | Demersal |
| Kyphosidae | Sea Chubs | Demersal |
| Serranidae | Seabass, Coney | Demersal |
| Serranidae | Seabass, Grasby | Demersal |
| Pomacentridae | Sergeant Major | Demersal |
| Carcharhinidae | Shark, Caribbean Reef | Demersal |
| Eleotridae | Sleepers | Demersal |
| Lutjanidae | Snapper(s) | Demersal |
| Lutjanidae | Snapper, Black | Demersal |
| Lutjanidae | Snapper, Blackfin | Demersal |
| Lutjanidae | Snapper, Cubera | Demersal |
| Lutjanidae | Snapper, Dog | Demersal |
| Priacanthidae | Snapper, Glasseye | Demersal |
| Lutjanidae | Snapper, Gray (Grey) | Demersal |
| Lutjanidae | Snapper, Lane | Demersal |
| Lutjanidae | Snapper, Mahogany | Demersal |
| Lutjanidae | Snapper, Mutton | Demersal |
| Lutjanidae | Snapper, Queen | Demersal |
| Lutjanidae | Snapper, Red | Demersal |
| Lutjanidae | Snapper, Schoolmaster | Demersal |
| Lutjanidae | Snapper, Silk | Demersal |
| Lutjanidae | Snapper, Vermilion | Demersal |
| Lutjanidae | Snapper, Yellowtail | Demersal |
| Lutjanidae | Snapper,Two-Spot | Demersal |
| Lutjanidae | Snappers | Demersal |
| Centropomidae | Snook, Common | Demersal |
| Centropomidae | Snooks | Demersal |
| Serranidae | Soapfish, Freckled | Demersal |
| Serranidae | Soapfish, Greater | Demersal |
| Serranidae | Soapfish,Greater | Demersal |
| Serranidae | Soapfishes | Demersal |
| Holocentridae | Soldierfish, Blackbar | Demersal |
| Ephippidae | Spadefish, Atlantic | Demersal |
| Ephippidae | Spadefishes | Demersal |
| Sciaenidae | Spotted Drum | Demersal |
| Loliginidae | Squid, Common | Demersal |
| Thysanoteuthidae | Squid, Diamondback | Demersal |

| | | |
|---|---|---|
| Holocentridae | Squirrelfish | Demersal |
| Holocentridae | Squirrelfish, Longspine | Demersal |
| Dasyatidae | Stingray, Bluntnose | Demersal |
| Dasyatidae | Stingray, Southern | Demersal |
| Dasyatidae | Stingrays | Demersal |
| Acanthuridae | Surgeonfish, Blue Tang | Demersal |
| Acanthuridae | Surgeonfish, Ocean | Demersal |
| Acanthuridae | Surgeonfishes | Demersal |
| Malacanthidae | Tilefish, Blackline | Demersal |
| Malacanthidae | Tilefish, Sand | Demersal |
| Branchiostegidae | Tilefishes | Demersal |
| Balistidae | Triggerfish, Gray | Demersal |
| Balistidae | Triggerfish, Ocean | Demersal |
| Balistidae | Triggerfish, Queen | Demersal |
| Balistidae | Triggerfishes | Demersal |
| Lobotidae | Tripletail, Atlantic | Demersal |
| Lobotidae | Tripletails | Demersal |
| Latridae | Trumpetfish | Demersal |
| Ostraciidae | Trunkfish | Demersal |
| Ostraciidae | Trunkfish,Smooth | Demersal |
| Ostraciidae | Trunkfish,Spotted | Demersal |
| Lutjanidae | Wenchman | Demersal |
| Labridae | Wrasse, Clown | Demersal |
| Labridae | Wrasse, Creole | Demersal |
| Labridae | Wrasse, Yellowhead | Demersal |
| Labridae | Wrasses | Demersal |

Table A10. Proportion of demersal families reported for catch location for period of 2008-2019.

| ***Location*** | ***Haemulidae*** | ***Balistidae*** | ***Lutjanidae*** | ***Carangidae*** |
|---|---|---|---|---|
| **A15** | 0% | 0% | 0% | 0.04% |
| **A16** | 0% | 0% | 0% | 0.04% |
| **B15** | 0% | 0% | 0% | 0.02% |
| **C12** | 0% | 0% | 0% | 0.02% |
| **C13** | 0.01% | 0.00% | 0.00% | 0.04% |
| **C14** | 0% | 0% | 0% | 0.34% |
| **C15** | 0% | 0% | 0% | 0.05% |
| **C16** | 0% | 0% | 0% | 0.01% |
| **D10** | 0.20% | 0% | 0% | 0% |
| **D11** | 0% | 2.27% | 0.12% | 6.32% |
| **D12** | 0% | 0% | 0% | 0.49% |
| **D13** | 0% | 0% | 0% | 1.02% |
| **D14** | 0% | 0% | 0% | 0.11% |
| **D15** | 0% | 0% | 0% | 0.02% |
| **D6** | 0% | 0% | 0% | 0.04% |
| **D8** | 0.03% | 0.20% | 2.32% | 1.03% |
| **E10** | 0% | 0% | 0% | 0.09% |
| **E11** | 0% | 0.02% | 0.02% | 0.15% |
| **E12** | 0.33% | 3.03% | 1.16% | 9.47% |
| **E13** | 0% | 0% | 0.01% | 0.20% |
| **E14** | 0% | 0% | 0% | 0.11% |
| **E15** | 0% | 0% | 0% | 0.07% |
| **E5** | 0% | 0% | 0.04% | 0% |
| **E6** | 0% | 0.02% | 0.04% | 0.01% |
| **E7** | 0.02% | 0% | 0.28% | 0.01% |
| **E8** | 0.05% | 0.01% | 3.06% | 2.15% |
| **E9** | 0% | 0% | 0.04% | 0.01% |
| **F10** | 0% | 0% | 0.04% | 0.04% |
| **F11** | 0.03% | 0.15% | 0.44% | 1.35% |
| **F12** | 0% | 2.57% | 0% | 1.16% |
| **F13** | 0% | 0.16% | 0% | 0.04% |
| **F14** | 0% | 0.49% | 0% | 0.17% |
| **F15** | 0% | 0.02% | 0% | 0.03% |

| | | | | |
|---|---|---|---|---|
| **F16** | 0% | 0% | 0% | 0.02% |
| **F4** | 0% | 0% | 0.62% | 0% |
| **F5** | 0% | 0% | 1.10% | 0.37% |
| **F6** | 0.11% | 0.17% | 7.51% | 0.07% |
| **F7** | 3.92% | 0.81% | 7.70% | 4.73% |
| **F8** | 0.08% | 0% | 0.42% | 0.86% |
| **G10** | 0.39% | 0.43% | 2.30% | 1.26% |
| **G11** | 0.05% | 0.48% | 0.39% | 1.30% |
| **G12** | 4.11% | 5.02% | 0.11% | 10.75% |
| **G13** | 0.39% | 15.00% | 0.00% | 5.73% |
| **G14** | 0.76% | 10.61% | 0.02% | 4.70% |
| **G15** | 0% | 1.07% | 0% | 0.27% |
| **G16** | 0% | 0% | 0% | 0.59% |
| **G2** | 0% | 0.42% | 0.02% | 0.58% |
| **G3** | 0% | 0.89% | 0% | 1.66% |
| **G4** | 0% | 1.35% | 0.20% | 1.01% |
| **G5** | 0.06% | 0.47% | 0.06% | 0.67% |
| **G6** | 0.27% | 0.60% | 0.79% | 0.50% |
| **G7** | 9.39% | 2.28% | 16.28% | 3.32% |
| **H10** | 0.31% | 0.81% | 3.11% | 0.80% |
| **H11** | 0% | 0.10% | 0.82% | 0.21% |
| **H12** | 0.63% | 0.88% | 0.09% | 0.50% |
| **H13** | 0.02% | 6.50% | 0.04% | 9.18% |
| **H14** | 0% | 2.83% | 0.05% | 1.05% |
| **H15** | 1.53% | 1.16% | 0.01% | 2.14% |
| **H16** | 0% | 0% | 0% | 0.12% |
| **H3** | 0% | 0.55% | 0.00% | 0.88% |
| **H4** | 0% | 0.32% | 0.01% | 0.19% |
| **H5** | 0.05% | 0.19% | 0.23% | 0.89% |
| **H6** | 0.58% | 2.55% | 2.84% | 1.57% |
| **H7** | 4.89% | 3.56% | 16.67% | 0.33% |
| **I10** | 0.59% | 0.72% | 4.45% | 0.24% |
| **I11** | 0.03% | 1.72% | 0.61% | 0.78% |
| **I12** | 0.76% | 2.07% | 0.29% | 3.31% |
| **I13** | 3.23% | 3.63% | 0% | 0.76% |
| **I14** | 0% | 1.45% | 0% | 0.47% |
| **I15** | 0% | 0.20% | 0% | 0.12% |
| **I3** | 0% | 0.32% | 0% | 0% |
| **I4** | 38.66% | 4.32% | 0.16% | 0.06% |
| **I5** | 6.91% | 8.93% | 0.23% | 1.18% |
| **I6** | 6.21% | 0.04% | 0.35% | 0.12% |
| **I7** | 0.14% | 0.18% | 1.20% | 0.04% |
| **I8** | 2.70% | 0.11% | 7.96% | 0.90% |
| **J1** | 0% | 0.04% | 0% | 0.00% |
| **J10** | 0.17% | 0.30% | 1.46% | 0% |
| **J11** | 0% | 0% | 0.03% | 0.01% |
| **J12** | 0% | 0.20% | 0% | 0.07% |
| **J13** | 0% | 0.34% | 0% | 0.09% |
| **J14** | 0% | 0.61% | 0% | 0% |
| **J15** | 0% | 0.10% | 0% | 0% |
| **J16** | 0% | 0% | 0.00% | 0% |
| **J2** | 0% | 0.03% | 0% | 0.04% |
| **J3** | 0% | 0.64% | 0.01% | 0.46% |
| **J4** | 0% | 0.10% | 0% | 0.14% |
| **J5** | 0.01% | 0.13% | 0% | 0.16% |
| **J6** | 0.39% | 0.13% | 0.03% | 0.03% |
| **J7** | 1.93% | 0.28% | 0.06% | 0.34% |
| **J8** | 3.86% | 0.43% | 1.72% | 3.82% |
| **K10** | 2.03% | 0.92% | 3.98% | 0.00% |
| **K11** | 0% | 0.27% | 0.06% | 0.01% |
| **K12** | 0% | 0.41% | 0% | 0.08% |
| **K13** | 0.03% | 2.43% | 0.44% | 1.10% |
| **K14** | 0% | 0.05% | 0% | 0% |
| **K16** | 0% | 0.16% | 0% | 0.44% |

| | | | | |
|---|---|---|---|---|
| **K5** | 0% | 0.18% | 1.54% | 0.02% |
| **K6** | 0.03% | 0.01% | 0% | 0.00% |
| **K7** | 1.16% | 0.05% | 0.02% | 0.01% |
| **K8** | 0.32% | 0.08% | 1.30% | 3.88% |
| **K9** | 2.65% | 0.22% | 4.61% | 0.12% |
| **L12** | 0% | 0.05% | 0% | 0% |
| **L13** | 0% | 0.01% | 0% | 0.01% |
| **L6** | 0% | 0% | 0.01% | 0% |
| **L7** | 0% | 0.08% | 0.00% | 0% |
| **L8** | 0% | 0.11% | 0.01% | 0.01% |
| **L9** | 0% | 0% | 0.01% | 0% |
| **M15** | 0% | 0% | 0% | 0.13% |
| **M3** | 0% | 0% | 0.04% | 0% |
| **M7** | 0% | 0% | 0.01% | 0% |
| **M9** | 0% | 0% | 0% | 0.12% |
| **P7** | 0% | 0% | 0.45% | 0% |