FISHERIES DATA MANAGEMENT, EXTRACTION, AND VISUALISATION IN ST. KITTS AND NEVIS TO FOSTER SUSTAINABLE MANAGEMENT.

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ABSTRACT

This study examined the fisheries departments of St. Kitts and Nevis and revealed comprehensive efforts to retrieve and standardise historical catch and effort sample data, ensuring its integration into the current database system (TFM) for future fisheries and stock assessment analyses. The research aimed to establish efficient methods for data collection and management, ensuring that stakeholders and policymakers have access to accurate information to make decisions about resource allocation and conservation measures. Accordingly, a thorough characterisation of target species, gear types, and seasonality in St. Kitts fisheries was conducted. There has been a general increase in sampling across the five major sites from 2014 to 2022, as there has been a consistent upward trend in the number of vessels sampled. With the use of historical data of sample records from 2014 to 2023 obtained from the Department of Marine Resources in St. Kitts and Nevis, data files were imported into R Studio and Excel, and selected variable names were standardised. The data illustrated varied trends in fishing gear usage across different methods, with the three most common being spearguns, traps, and handlines. The data also highlighted the distribution of fishing efforts across different sites, with some sites serving as focal points for fishing activities while others exhibited lower levels of engagement in fisheries. The findings revealed that a specific species, namely Queen Conch (*Strombus gigas*) and Spiny Lobster (*Panulirus argus*) possessed greater commercial value. Queen Conch and Spiny Lobster are the subjects of species-specific analyses, which emphasize their commercial importance and the varying trends in CPUE that occur when employing different fishing techniques. However, more research is needed to fully understand the trends. The development of a systematic approach for extracting data from the Fisheries Manager database, along with reporting templates, will facilitate efficient data handling and the presentation of key management metrics and trends.

Keywords: Fisheries data management, St Kitts and Nevis, catch and effort data, Queen conch, Spiny lobster, fishing gear usage.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ACROMYNS

API	Application Programming Interface
BAFC	Basseterre Fisheries Complex
BAIM	Basseterre West
CRFM	Caribbean Regional Fisheries Mechanism
CFRAMP	CARICOM Fisheries Resource Assessment and Management Program
CPUE	Catch-Per-Unit Effort
CHTN	Charlestown
CCTV	Closed Circuit Television
CSV	Comma Separated Values
CNGD	Cotton Ground
DIBA	Dieppe Bay
EEZ	Exclusive Economic Zone
FIS	Fisheries Information System
FAO	Food and Agriculture Organization
GLM	Generalized Linear Model
INCL	Indian Castle
JEUP	Jessup
JNBY	Jones Bay
LGHL	Long Haul
NWCL	New Castle
NEGU	New Guinea
OLRO	Old Road
PALP	Palmetto Point
REM	Remote Electronic Monitoring
SAPB	Sandy Point
SIDS	Small Island Developing States
TFM	The Fisheries Manager
IFIS	The Integrated Fisheries Information System
URL	Uniform Resource Locator
VMS	Vessel Monitoring Systems

1 INTRODUCTION

1.1 Background

Healthy marine and coastal ecosystems, as well as the biodiversity they sustain, are critical to the Caribbean economy and public health (Programme, 2005). Furthermore, because of the large number of significant endemic species found there, this region has been named one of the top five biodiversity hot areas in the world (Mittermeier, 2004). St Christopher and Nevis commonly called St Kitts and Nevis is part of the Eastern Caribbean's Leeward Island group, the twin island Federation is situated between latitudes 17º10'N and 17º25'N and longitudes 62ºW and 63ºW. The country's total area is 260 km^2, of which 170 km^2 is in St. Kitts and 90 km^2 is in Nevis (FAO, 2015). The islands are separated by a 3 km wide channel named 'The Narrows', and share an exclusive economic zone (EEZ) of approximately 10,200 km^2 (www.seaaroundus.org).

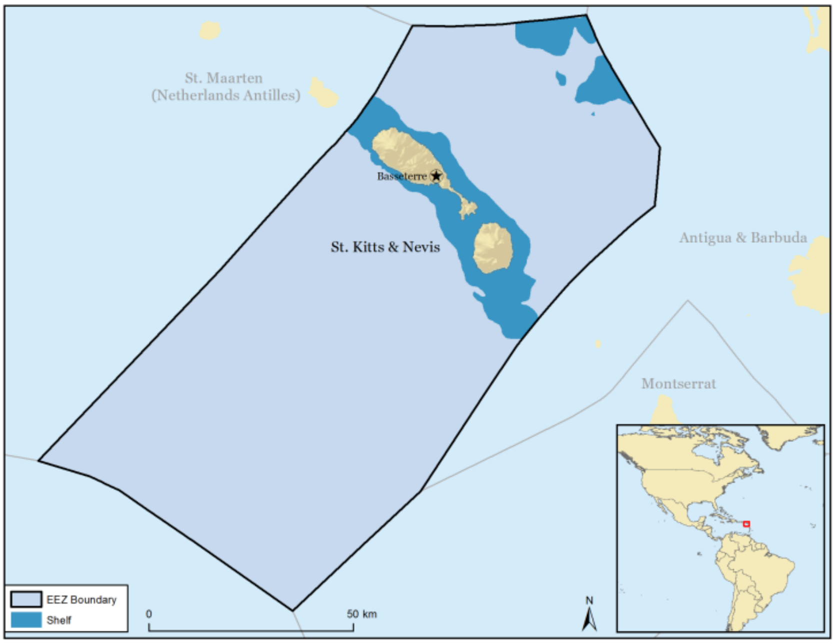

Figure 1. Map of St Kitts and Nevis showing the Exclusive Economic Zone (EEZ) and shelf area.

Maintaining the delicate balance between environmental preservation and economic growth in coastal regions relies significantly on sustainable fisheries management. The Caribbean island nation of St. Kitts and Nevis is dependent on its fishing industry for economic development, subsistence, and livelihood, with the fishery sector accounting for 0.5% of its Gross Domestic Product (Phillps, 2024). The estimated value of fish and fishery product exports in 2014 was USD 0.4 million, whereas the value of imports amounted to USD 3.8 million. Queen conch comprised the majority of exports; all other fish and fishery products were consumed locally and were vital to local food security. In 2013, per capita consumption of seafood was approximately 32.3 kilograms, according to estimates (FAO, Fishery and Aquaculture Country Profiles, 2016). Hence, it is necessary to conduct a thorough review of data collection management and description of the fishery to ensure the long-term sustainability of these resources.

1.2 Fisheries of St Kitts and Nevis

The fisheries departments on both St. Kitts and Nevis are covered by the Fisheries Aquaculture and Marine Resources Act (No. 1 of 2016) which is "[a]n Act to provide for the conservation, management, development, and sustainable use of fisheries, aquaculture and marine resources of Saint Christopher and Nevis, to monitor and control Saint Christopher and Nevis fishing vessels beyond the fisheries waters, to repeal the Fisheries Act 1984 and for related matters" (Fisheries, Aquaculture and Marine Act, 2019).

1.2.1 Short Fisheries Description

Catches are landed at five major landing sites on St. Kitts as seen in

Figure *2*: Basseterre East (BAEP), Basseterre West (BAIM), Old Road (OLRO), Sandy Point (SAPB), and Dieppe Bay (DIBA). However, there are two smaller areas where fishers also land: New Guinea (NEGU) and Palmetto Point (PALP) (Browne, 2024). On Nevis, there are seven landing sites: Charlestown (CHTN), Jessup (JEUP), Cotton Ground (CNGD), Jones Bay (JNBY), New Castle (NWCL), Long Haul (LGHL), and Indian Castle (INCL). There are two central fishing markets on the islands: Basseterre Fisheries Complex (BAFC), where a fisheries complex operates on St. Kitts, and a similar facility found in Charlestown on Nevis (Maynard, 2024). Nonetheless, fishers also engage in the direct processing and sale of their catches to customers at landing sites (Saddler, 2024).

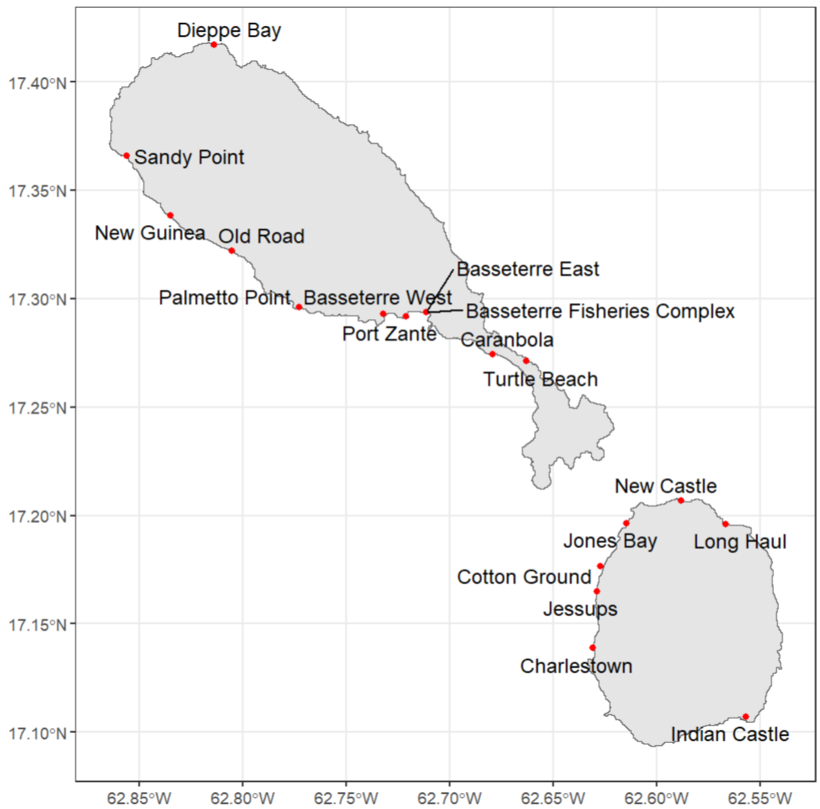

Figure 2. Map of St Kitts and Nevis showing the landing sites and Basseterre Fisheries Complex.

1.2.2 Database System

St Kitts and Nevis employ a uniform data collection method, inputting the collected data into the Google sheet, and also utilize Excel for visualization. Although St. Kitts and Nevis does not have an industrial fishery, it has an artisanal fishery (Saddler, 2024). Catch data collection is done on all species in the different fisheries; Spiny Lobster (*Panulirus argus*), Queen Conch *(Strombus gigas*), small coastal pelagic, large or ocean pelagic, reef/bank and slope fisheries. The fishing gear used ranges from different types of traps, longlines, spear guns, nets, hook-and-lines, to scuba diving. Catch data on St. Kitts and Nevis is gathered throughout the week, from Monday to Friday, at all landing sites, and adjustment factors are applied based on the number of fishing days and the type of gear used (Browne, 2024) to estimate the total catch for the month.

1.3 Rationale

The current fisheries management system in St. Kitts and Nevis faces several pressing challenges that hinder its effectiveness. The current description of the fisheries in St. Kitts and Nevis is limited, lacking a comprehensive analysis detailing gear usage and, landing by sites. Ineffective data-gathering techniques speak to the situation where data collectors collect data but delay submission for days, rendering the data unverifiable during the lapse between collection and submission, which jeopardizes the timeliness. Standardized coding is lacking in historical fishing data, which causes errors and makes trend analysis difficult to interpret. Historical fishing data may lack comprehensive metadata, such as information on fishing location, date, and vessel characteristics. Without a standardised system for recording data, it is difficult to aggregate and analyse a time series of data consistently.

Problems with database infrastructure and other data management systems make it problematic to guarantee data integrity and promote decision-making. The St. Kitts & Nevis Fisheries Data Collection Tool system that was previously used was unable to store and process data over a certain amount creating problems with backing up and generating reports. Hence, each month the previous data had to be deleted before new data could be entered into the system. Secondly, fisheries, vessel, and landing data were collected at different divisions and stored in different silos which caused problems with traceability. This led to exploring a different system that would be able to offer centralization of data. The Fisheries Manager (TFM) is a modularized and cloud-based fisheries data management tool, which is used to improve data and information management for evidence-based decision-making (Hallgrímsson, 2023). The implementation of the system took place in August 2022, enabling data collectors to gather, store, and report fisheries data to support the sustainable utilization and management of marine resources. It serves as a comprehensive central data source where users can then use third-party query tools to generate customized reports and perform statistical analysis to facilitate planning and decision-making. Nevertheless, there are certain challenges associated with it, such as the absence of a standardised method for extracting data, and the difficulty in importing historical data into TFM.

Currently, the analysis and reporting in fisheries management in St. Kitts and Nevis lack comprehensive insights into trends by landing sites. There is a notable absence of monthly estimates with uncertainty estimates, hindering the ability to accurately gauge the variability and reliability of the data. Without statistics to discern significant differences across time, area, and gear type, the efficacy of management decisions is compromised. Increasing the clarity of data analysis and reporting is imperative to address these deficiencies and to better inform fisheries management practices. The overall aim is to retrieve the historical catch sample records for St Kitts and Nevis. Retrieval of historical time series of data is of utmost importance in fisheries science because most methods used to make inferences about the status of the fisheries and the stocks are derived from time series trends.

Accurate, timely, and pertinent data are essential to the success of fisheries management. In the context of St. Kitts and Nevis, a thorough examination of data collection techniques, management systems, and main analytical procedures will offer insights into possible improvements, fill in current gaps, and promote sustainable practices. The project aims to establish efficient methods for data collection and management, ensuring that stakeholders and policymakers have access to accurate information to make decisions about resource allocation and conservation measures. The protection of local populations' livelihoods and long-term economic stability would be facilitated by the improvement of data collection, management, and analysis procedures.

This study aimed to offer practical solutions to these difficulties to improve the overall effectiveness of fisheries management methods. Therefore, there is a need for a thorough examination of data collection, management, and the depiction of fisheries to enhance fisheries management in St. Kitts and Nevis. Nevertheless, all further analysis is limited to St. Kitts. St. Kitts has historical and current data from 2014 to 2023, which is categorized by specific vessels and their catch. In contrast, Nevis' data from 2014 to 2022 is compiled monthly and categorised based on the kind of fishing gear used, rather than being organised by individual vessels and catches. In addition, the data from Nevis in 2023 was not included in TFM, making it impossible to analyse.

1.4 Research Objectives

The overall objective is to enhance the management and utilisation of fisheries catch and effort data by implementing standardised data coding procedures, describing the fishery, developing efficient data extraction methods, and creating visually appealing standardised reporting templates.

Specific Objectives

- Retrieval of historical catch sample data, including standardisation and correction in coding wherever possible, to enable their import into the current database system to ensure inclusion in future fisheries and stock assessment time series analyses.
- To thoroughly characterize the target species, gear types, seasonal patterns, and various aspects of the fishery in St. Kitts and Nevis, examine the cumulative landings across all species, categorizing them by gear type and site. Following this, conduct a detailed analysis specifically focusing on the main target species, conch, and spiny lobster. The analysis will cover 2014 – 2023. .

- Develop a systematic approach for extracting fisheries data from the Fisheries Manager database and employing efficient data handling procedures to maintain data integrity.
- Develop dynamic and visually appealing standardised templates for monthly, quarterly, and annual reports to present key fisheries management metrics, trends, and insights.

The anticipated outcome of the project

- Enhanced and standardised historical fisheries data coding procedures.
- Improved data extraction methods from the Fisheries Manager database.
- A detailed report providing a comprehensive characterisation of the fishery operating in St. Kitts, including thorough descriptions of the target species, gear types utilised, and seasonal variations in fishing activities.
- Development of dynamic and visually appealing standardised templates for reports.
- Overall positive impact on improved data management, analysis, and reporting in the fisheries sector.

2 FISHERIES STATISTICS

2.1 Data Collection Strategies, Traditional Fisheries Data Collection

2.1.1 Data Collection

Logbooks, landing surveys, and interviews with fishers are frequently the only appropriate fisheries monitoring instruments available in Small Island Developing States (SIDS), such as St. Kitts and Nevis. Fishermen's logbooks and fishing vessel locations, which are either manually entered by law enforcement or automatically gathered by automated vessel monitoring systems, are often available to more developed countries. However, several small-scale SIDS fisheries have challenges in implementing such monitoring devices due to their limited operations and the wide variety of species and fishing equipment used. In cases when there is a lack of official monitoring data, several interview techniques have been created to gather information about fisheries (Gill, 2019). Hence, an effective approach to gathering fisheries data entails the utilisation of logbooks, landing surveys, and fisher interviews.

Each method has its own advantages and disadvantages. Logbooks allow for methodical and reliable documentation of fishing effort, revealing valuable information about the effort and composition of catches over time. However, fishermen's precise and regular submissions are what make them reliable. Real-time information on species diversity and abundance is provided by landing surveys, which are conducted at the fish landing site. They are excellent at providing precise and timely information, although the frequency of their sampling may fluctuate. Fisherman interviews provide qualitative information by revealing subtle details about regional ecological expertise and fishing techniques. However, recollection biases and the information-sharing willingness of fishers may affect this approach. In contrast, a greater variety of methods and instruments are now available and have been used to track and gather catch information that may benefit the fishing sector. These include Remote Electronic Monitoring (REM) techniques like Closed Circuit Television (CCTV), which provides video surveillance of areas of the vessel where fish are handled for fish detection, identification, and measurement (McElderry et al. 2003); electronic log-books, which store catch and effort information along with other technical characteristics of the fishery (Gill et al., 2023); and Vessel Monitoring Systems (VMS), which record the location of the vessel in time and space (Aanes, 2011; Skaar, 2011). As observers can record a larger variety of data on more species than fishermen, using fisheries observers onboard vessels is another way to gather high-quality data at sea during fishing operations (Mangi et al., 2015). In contrast to comprehensive enumeration or logbooks, which may be more expensive to deploy, catch and effort data collected from small-scale fisheries usually work well with a questionnaire or interview-based sample survey approach (FAO, 1999). As logbooks are more difficult to instal within the small-scale fleet, most of the data obtained from that fishery come from the sample survey (FAO, 2024). Data collection is crucial to characterise relationships within the fishing industry, to help forecast how specific actions may impact future outcomes of those interactions, and to make well-informed and logical decisions on the management of various areas of the industry. More precisely, an estimate of the overall catch as well as the catch and effort for the main species that a country harvests must be made. Effort functions as a metric for evaluating the efficacy of the fleet and is a component in the catch-effort calculation.

To that end, since 1992, Eastern Caribbean island nations, including St. Kitts and Nevis have benefited from assistance from the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP), which served as a model for the Caribbean Regional Fisheries Mechanism (CRFM), in strengthening their capacity to gather data (CRFM, 2014). The features of the fishery, the social and economic significance of the area, and the personnel and resources available have a significant impact on the data-gathering techniques employed in fisheries (FAO, 1999). Some of the early approaches to gathering fishing data in the Eastern Caribbean were described by Mohan (1988). The approach followed the catch journey from the fisher to the final consumer using existing procedures, and local fisheries divisions could readily alter it as needed.

The difficulty and potential expense of accurately and consistently describing total effort data contribute to its complexity. The accuracy and precision of the sampling process dictate the quality of the data. However, the veracity of the sampled data determines how closely it corresponds to the population data. As the sample size of a population grows, accuracy improves. High accuracy may be obtained even with a small sample size if it is a representative sample. This is a crucial aspect because, after a given sample size, the accuracy achieved is no longer sufficiently substantial to justify allocating more financial and human resources to the endeavours. When processing the data, a sample size is considered representative if it accounts for at least 90% accuracy. Like accuracy, precision rises as sample size does as well. Stratification is an additional technique that enhances accuracy by decreasing variability. However, the cost-benefit ratio must also be considered, as more strata equate to greater expenses (Mouter, 2020). The efficacy of the data collectors and the degree of monitoring they receive throughout the gathering process determine the quality of the final data. Maintaining a data-gathering regimen costs money. To maximise the benefits of data collection, the current human resources (supervisors and data collectors) must work appropriate hours, be well-trained, have adequate resources, and generally operate successfully and efficiently. Hence the implementation of TFM.

The Fisheries Manager database system, which has been in operation in St. Kitts and Nevis since 2022, was filled with the following areas, as seen in Figures 4–6. It has been populated with two hundred and twenty-nine (229) licensed vessels for 2023. Vessels registered between 2005 and 2022 were included in the system for historical records. One thousand, seven hundred and seventy-eight (1778) fishers and an additional 100 contact persons, including staff members, have been added to the system. We are presently in the trial stage, and this project will enhance this system by merging all data into one central area. However, the challenges are in extracting data from The Fisheries Manager in a standardised and reusable procedure.

Subsequently, the question arises as to which of these can best be used for SIDS, such as St. Kitts and Nevis, to fulfil monitoring needs and how it may be implemented in fisheries with varying characteristics. Given the variety of aspects that make up fishing activities, including species, vessel sizes, gears, handling procedures, and other factors, any approach or strategy's applicability and relevance will depend on these dynamic variables.

2.2 Database Infrastructure and Management

2.2.1 Database Infrastructure

The term "digital fisheries data" is used broadly to describe any online data related to fisheries (Lennox, 2022). A comprehensive analysis of the database architecture currently in place for managing fisheries data indicates a foundation that is essential for storing data on fishing operations, environmental conditions, and fish populations (Lennox, 2022). The Food and Agriculture Organization (FAO) created the Fisheries Information System (FIS), a global platform for storing and sharing fisheries-related data, as one example of existing database architecture for fisheries data management (FAO, 1995). The Integrated Fisheries Information System (IFIS), designed to handle and analyse fisheries data (NOAA, 2023), incorporates modules for catch reporting, stock assessments, and compliance monitoring. This system ensures seamless data interchange and integration across platforms and applications, as emphasised in studies on database interoperability (NOAA, 2023). One important factor to consider is accessibility, which highlights the necessity of effective and user-friendly interfaces that enable stakeholders to easily acquire and submit information (Charles, 2002). Security precautions are assessed concurrently to protect private fishing information. According to (FAO, 1999), these systems should prioritise security, validation of input data, ease of access and analysis, and maintenance of standardised formats representative of field-collected data from illegal access and breaches. Nationally, many countries have established their databases, where each country maintains its databases for storing and managing fisheries data.

The evolving landscape of digital fisheries data management underscores the importance of vigorous database architectures, exemplified by systems such as the Fisheries Information System (FIS) and the Integrated Fisheries Information System (IFIS). These systems not only facilitate seamless data interchange and integration but also prioritise accessibility and security, in line with recommendations from the FAO and CRFM (2021). As nations continue to develop their databases for fisheries data management, ensuring standardised formats and effective security measures remains paramount for the sustainable stewardship of fisheries resources.

2.2.2 Stock Resource Assessment

Basic data within fisheries, including catch and effort, although rudimentary, can provide valuable insights into the biomass landed relative to the effort used (FAO, Sample-Based Fishery Surveys, 2002). One commonly used method is the catch-per-unit-effort (CPUE) methodology, which is based on catch and effort data obtained from fishers. The CPUE time series may provide a reasonably accurate image of a fishery stock if there is or assumes a proportional relationship between it and the size of the fish stock (Skalski, 2023). Regardless of whether they are utilised in analytical stock assessments or stock status estimations, CPUE time series are significant for describing the development of fisheries over time, which is important for fishermen and managers (Pauly, 2021).

Although population dynamics sometimes affect stock size, it would be wrong to assume that a decrease in the number of fish caught signifies a loss in the population, given that this is likely the case. However, over time, standardisation has increased the advantages of this strategy (Maunder and Punt, 2004). This relationship is often quantified as Catch Per Unit Effort (CPUE), serving as a proxy for abundance (Harley, 2001). Harley (2001) demonstrated that when catch and effort data are standardised over time, CPUE can serve as an index of abundance, particularly in small-scale fisheries. However, it is important to note that CPUE may not always accurately reflect stock size. Despite its limitations, catch and effort data remains valuable for informing management decisions when combined with analytical stock assessments and a precautionary approach. The process of standardising catch and effort data, or addressing annual variance not linked to abundance, can be approached through various methods (Maunder and Punt, 2013).

3 METHODOLOGY

3.1 Study Area and Data

3.1.1 Data Sampling Protocol

The sampling is currently done by fifteen (15) data collectors that are stationed at the landing sites on St. Kitts and Nevis (Browne, 2024). The data collectors work between the hours of 8 am and 6 pm, Monday to Friday each week. However, at the Basseterre Fisheries Complex data is collected on weekends. The data collectors use scales to record the weight of the landings, and if scales are not available, the collectors have been trained to make visual estimates (FAO, 2024). The weight estimates are usually based on the whole or gutted weight. Data collectors are provided with regular training in identifying fish species and most, if not all, can identify the fish down to a species level. The type of gear used during the fishing trip is also collected. The data collectors take note of the general area in which the boats operate (Figure *3*). Data is also collected from data books/sheets which the fishers directly complete and submit at the end of the week or month for those fishers who were not surveyed. Nevertheless, because some vessels would leave early in the morning and return beyond the planned working day, data collectors are unable to obtain data from every vessel. So, it is necessary to raise the sample to estimate the total catch.

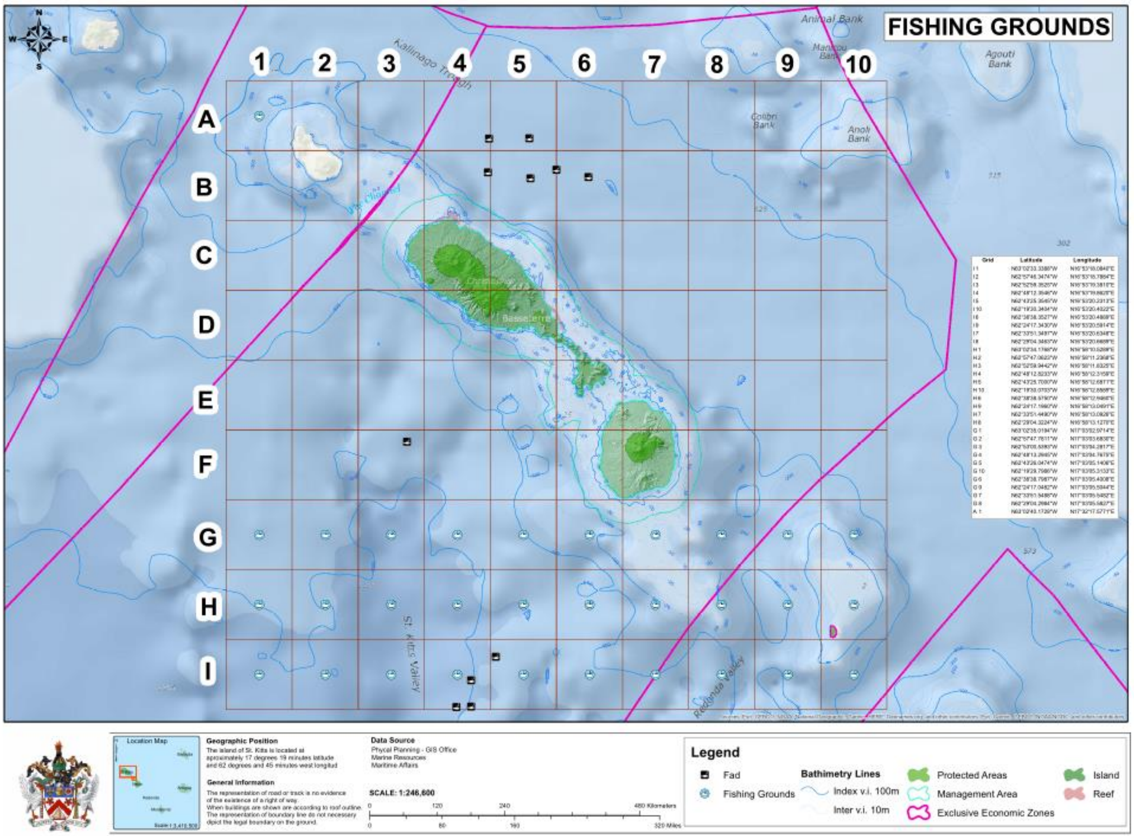

Figure 3. Map delineating regions where fishers engage in fishing activities in St. Kitts and Nevis.

Data collectors gather landing data from vessels upon their return. They collect details about the vessel, such as its identification, along with effort data like the gear used, number of traps deployed, and time of departure and arrival to port. Additionally, recording of the weight of each species caught, location, and catch specifics like the price per pound of fish are systematically collected. This data is typically acquired from the vessel's captain, owner, or crew members, and is sometimes initially documented in a notebook or form (Appendix 1) and subsequently transferred to a Google sheet or directly inputted into the TFM database via tablet. In the past, data collectors manually entered the completed paper forms into a comparable Google Form,which was created to digitally replicate the fields and structure of the paper forms. Before the implementation of the TFM system in August 2022, the data department used Google Sheets to input data. Prior to that, the CARICOM region data system, CARAFIS, was utilised (FAO, 2004). The fisheries officer (data cleaner) is responsible for the collection of data forms/books and performs an initial verification with the data collector to ensure that their entries are correct, and errors are highlighted and corrected before the final dataset is submitted. The Licencing and Registration System is also utilised for the capture and storage of vessel and fisher data.

3.1.2 Data Storage System

In this new database system, the TFM data collector enters the data into the system via tablets. A data flow chart is used to illustrate how data are inputted into the TFM (Figure 4).

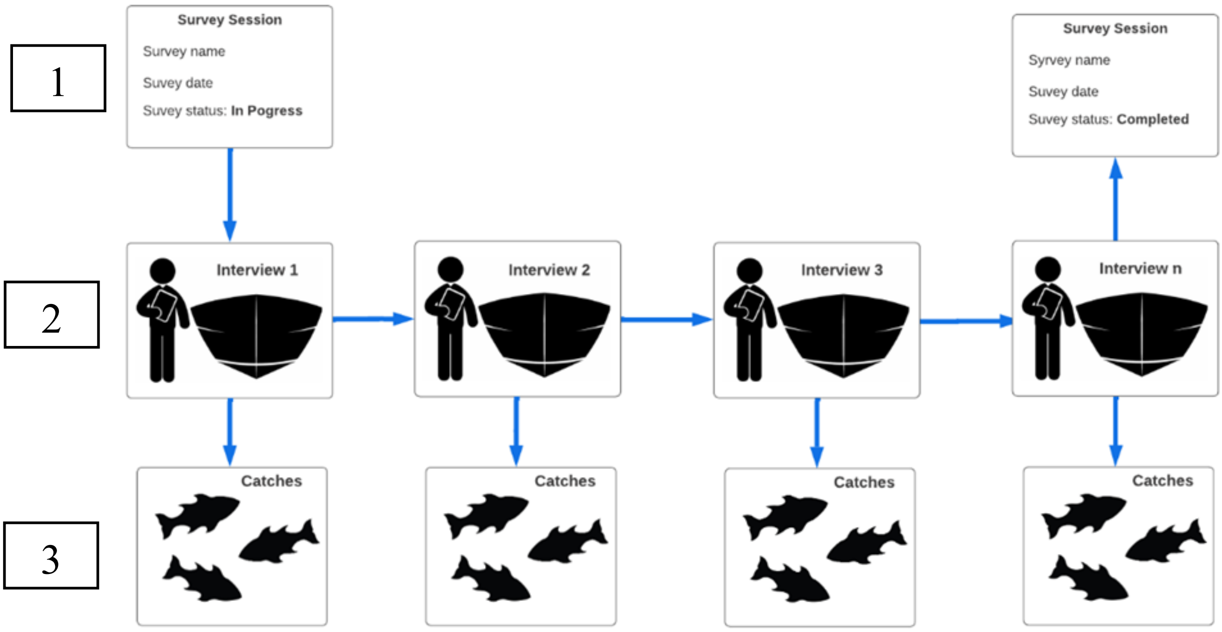

Figure 4. Flow Chart of how data is collected and inputted in The Fisheries Manager

<u>Level one</u> is the Landing Survey (Figure 5). This information is about the date the survey was conducted and the data collector. The surveyor´s name, survey data, and survey status, for example, data collector S went to Basseterre East on day, month, and year.

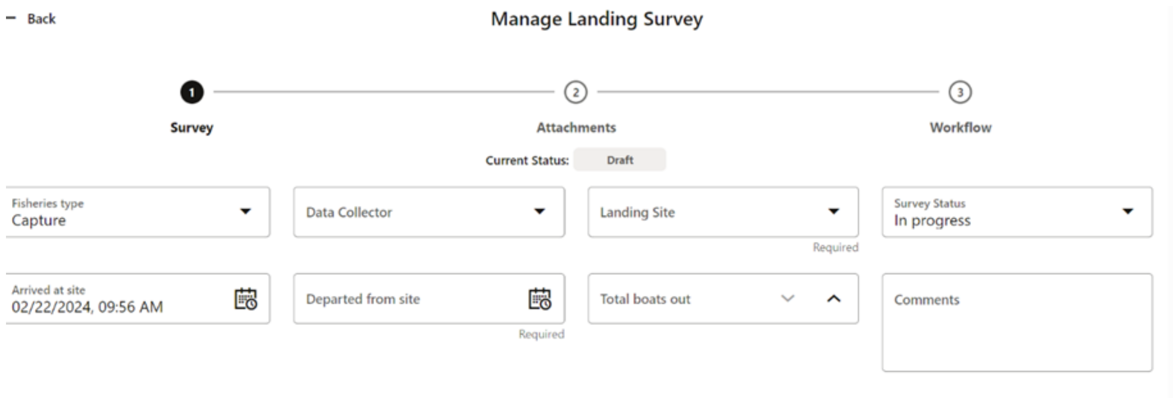

Figure 5. Landing survey from The Fisheries Manager

<u>Level two</u> recorded trip information (Figure *6*). This information describes the trips made by individual vessels. The data collected comprised the fisheries type, data collector, landing site, survey status, arrival and departure time and date, and the total number of boats. Although several vessels were at the site, the data collector worked on one trip (vessel) at a time. There are particular instances in which a vessel can have different trips for the same date; however, the times must differ. For example, Vessel 001FH went out three times on February 18, 2023. The first trip is 5 am – 7 am, the second trip is 9 am – 1 pm, and the third trip is 3 pm – 7 pm. All took place on the same day but at different times.

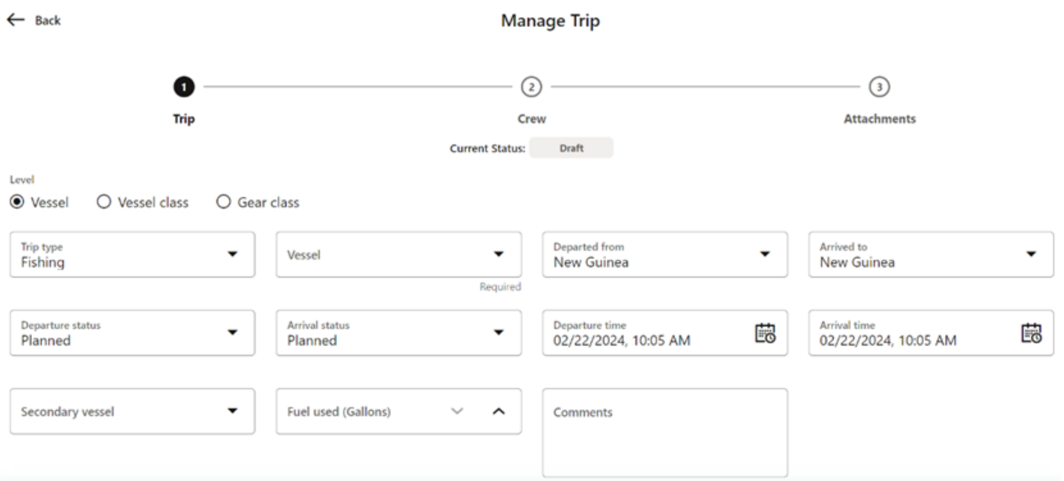

Figure 6. Trip survey from The Fisheries Manager

<u>Level three</u> is the catch survey (Figure *7*). This level is where all the species for a particular trip are entered. It can contain one or multiple species. The data recorded include species, weight in pounds, condition, measurement type, item count, price, gear, number of gears, gear size, number of sets, fishing zone, soak time in hours, batch number, and cooler number.

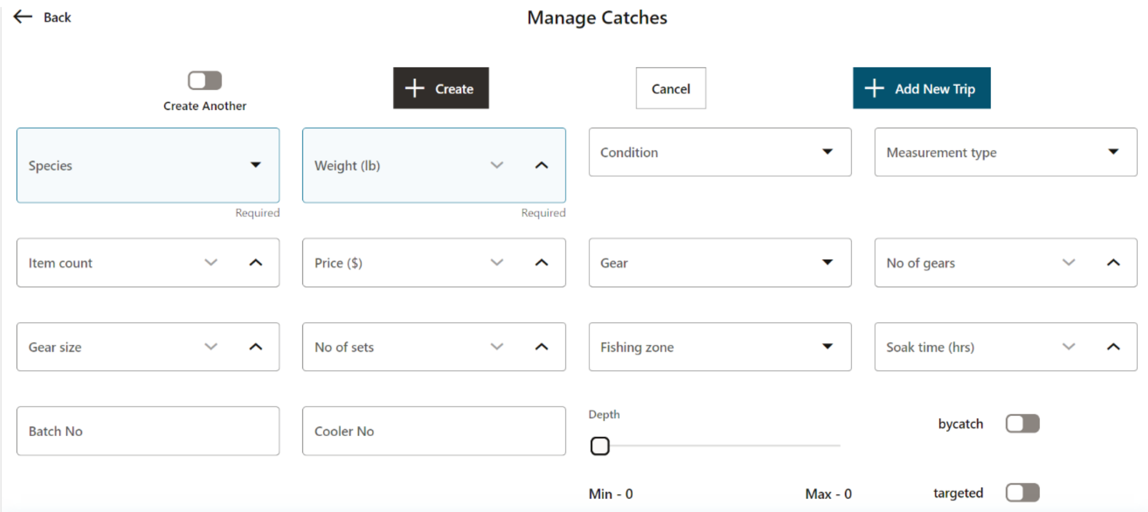

Figure 7. Catch survey from The Fisheries Manager

3.1.3 Retrieving Historical Records

Historical catch sample records from 2014 to 2023 were obtained from the Department of Marine Resources in St. Kitts and Nevis, with each year represented as a separate Excel or comma-delimited text (CSV) file. The original data contained the following common variables: vessel identifier, fishing date, landing site, gear type, area fished, species identifier, and catchweight. In some year files additional variables, e.g. trip departure and arrival time were available but these were not included in the present processing.

Each of the annual data files was imported into R, and the selected variable names were standardised; the annual data were then merged without any corrections into a single table. The merged data were then conceptually processed as follows, mostly within R:

- For each categorical variable (vessel identifier, landing site, gear type, and species identifier), a table containing a distinct version of the spelling in the original data was created, and a second column was generated containing the corrected spelling.
- Each of the corrected tables was joined with the original historical records, and a final clean table using only the corrected variable was generated and saved as a CSV file for downstream analysis.
- The vessel identifier was mostly in the form of a vessel registration number; however, if the original data was a vessel name, an attempt was made to find the corresponding registration number from the current vessel registration table in the FM database.
- The original species identifiers were of various origins, either native code names, CARIFIS species codes, or Latin names. For each record, an attempt was made to provide a corresponding latest FAO ASFIS Latin name as well as the current native code names.
- The date variable, originally imported as a character in one of three formats: Excel numerical date format, month-day-year, and day-month-year format. A hierarchical code was generated using the abovementioned order in an attempt to generate data in the ISO standard year-month-day format.

This approach ensured that the original data remained intact and that the process was documented and reproducible (see **Error! Reference source not found.**) thus allowing for potential amendments and improvements in the future. The process was also designed so that the cleaned data could be imported into the recently deployed FM database.

3.1.4 Description of the Fishery

Catch and effort were estimated by site and gear, while also examining trends and variations. The fishing industry is characterised as a multi-gear and multi-species capture fishery. Utilising techniques such as Catch Per Unit Effort (CPUE) enables statistical analysis to identify significant differences in catch and effort across various sites and gear types. Previously, sampling was limited to catch information only

Catch data

Catch denotes the fish brought ashore at a port, excluding any fish caught but subsequently discarded before landing. The datasets pertain to catch, which contains the sampled daily catch in the majority of instances. The sampled daily catch dataset encompassed the following variables.

- Date: the day on which the sampling activity measured the catch.
- Species: the name assigned to the species landed.
- Pounds (lbs): the weight measurement of the species landed at that sampled port on that sampled day.
- Port: the name or code where the sampling was conducted.
- Boat: the identification of the boat that was sampled.
- Boat type: the category of boat that was sampled.
- Gear: the name or code of the gear that was used to catch the species.

3.1.5 Extraction of Data from TFM

The data from The Fisheries Manager (TFM) for the year 2023 was imported using an interface that utilised the principal Uniform Resource Locator (URL) "https://datistica.is/datistica/api/v1.0/public/" to extract the data. The distinct table names, such as "siteD," and the corresponding unique key necessary for data retrieval were identified. The procedure entails the following:

1. Generate a token from TFM
2. Format the URL with a table name and individual token. https://dev.datistica.is/datistica/api/v1.0/public/<TABLENAME>?key=<TOKEN>
3. Retrieve and view your data in Google Sheets. This is done by
   Select Extensions → API Connector → Open: The API connector opens up
   Paste the URL into the Request URL
   Select the Destination sheet
   Press Run

Upon pasting this hyperlink into a web browser, the information is fetched. In the next step, "tidyverse" and "jsonlite" packages were employed, which are specifically designed for the R programming language, to generate a well-organised link. This link incorporates the table name, base URL, and key. The landing site table was successfully imported by collecting data from a well-organized URL and transforming it into a tibble for further analysis using the jsonlite::fromJSON approach.

A more efficient approach is to directly transfer data from TFM to R. This process entails first installing the necessary package using remotes::install_github("einarhjorleifsson/fmr"). Next, import the required libraries using the commands library (fmr) and library (tidyverse). Next, establish the specific key necessary for retrieving data by assigning it to a variable using the "<- "your_FM_API_key"" syntax.

3.1.6 Standardized Reporting

To guarantee clarity, uniformity, and aesthetic appeal, a thorough procedure must be followed while creating a standardised reporting template in R Studio and R Quarto. To create a clear framework for the data presentation, the first step was to identify the important metrics and insights that should be included in the weekly, monthly, quarterly, and annual reports to the Director, Ministry of Agriculture, and CRFM and Food and Agriculture Organization (FAO) reporting standards. The next step was to develop the template layout using R Markdown. To do this, R code chunks were used to easily combine data analysis (see

Appendix 5).

4 RESULTS

4.1 Retrieving Historical Records

A summary of the cleaning and standardisation of categorical variables (Table 1) shows a reduction in the different versions of site, gear, and species code between 76% and 80%, whereas for the vessel code, the reduction is 40%.

The original dataset indicates the number of different versions of a variable that appeared in the raw data in comparison with the number once cleaned and standardized and the percent reduction

The reduction in the gear code was surprisingly high, going from 38 different spelling versions to an expected number of eight. To give an example of the standardisation and cleaning process in general, Table Y provides an overview of the different original vs. standardised gear codes.

The reduction in the site code versions is surprisingly high; that can be mostly attributed to the original coding, which often contains the site code for the enumerator.

Table 1. Summary of the Categorical Cleaning Process

Variable	Original	Cleaned	Reduction
Vessel code	963	573	40
Site code	80	16	80
Gear code	34	8	76
Species code	639	136	79

The cleaning and standardisation of the vessel code, where the raw data was in most cases in the form of a registration code were mostly associated with the use of spaces instead of dashes between different elements of the native registration code (Table *2*).

Table 2. Overview of the Cleaned vs Original Version of Gear Codes

Cleaned	Original						
DIVE	DIVE	FREE DIVE	FREE DIVING	FREE DIVING	FREESTYLE		
	4	3	1	9	16		
BSNE	BSNE	NET	SEINE				
	1819	70	2				
HLIN	H/LINE	HLIN	HSLING	ROD			
	163	6471	1	1			
LLIN	L/LINE	LINE	LLIN	LLINE			
	39	35	429	21			
SCUBA	S-GUN	SCUB	SCUBA	SCUBALOOP	SGUB		
	36	16	4715	40	1		
SGUN	S.GUN	S/GUN	SGUN	SPARE GUN			
	85	867	28230	61			
TRAP	FISH POT	FISH TRAP	FISH TRAPS	POT	POTS	TRAP	TRAPS
	26	7	32	57	76	14117	1760
TROL	TROL	TROLL					
	87	1272					

Compiling the species list required significant effort. Achieving a comprehensive list involved amalgamating data from the CARIFIS, St. Kitts and Nevis (KN), and FAO lists. Throughout the years, there were discrepancies in names and codes used. After thorough cleaning and coding, the initial list comprising 639 different “species” was reduced to 136 species.

The cleaning process generated the clean and coded gears used in the historical data (Table *3*). The numbers represent the number of times a particular gear was observed in the dataset, and it is evident that the three most commonly used gears are spearguns, traps, and handlines. The data illustrate varied trends in fishing gear usage across different methods. Spearguns were the most frequently employed gear type, accounting for a significant proportion of fishing activities. Traps also demonstrated substantial usage, closely trailing spearguns in frequency. Handline fishing appears to be another prevalent method, with a considerable number of instances recorded. Scuba gear, though less common compared to other methods, still exhibits notable usage. Nets, trolls, and longlines contributed to fishing activities to varying degrees, with moderate to relatively lower frequencies observed. Miscellaneous methods and dive fishing represented smaller portions of the overall fishing gear usage.

Table 3. Clean and Coded Gear Table from Excel Historical Data, 2014 - 2023

Gear Code	Gear	Number
SGUN	Speargun	29265
TRAP	Traps	16097
HLIN	Handline	6648
SCUB	Scuba	4811
BSNE	Net	1891
TROL	Troll	1360
LLIN	Longline	530
<NA>	Miscellaneous	115
DIVE	Dive	34

Subsequently, similar procedures were used for the standardisation and rectification of the site (**Error! Reference source not found.**). Following the cleaning of the site list, the initial list containing 80 distinct naming conventions in Appendix 9 was condensed to 16 sites, as illustrated in Table *4*. The numbers in Table *4* represent the number of times a particular site was identified in the dataset. This reveals varying levels of fishing activity across different sites, with Basseterre East (BAEP) standing out as the site with the highest number of fisheries, boasting 30,636 instances. Basseterre West (BAIM) follows with 8,741 recorded instances, indicating a substantial but notably lower level of fishing compared to Basseterre East. Other sites, such as Old Road (OLRO), Dieppe Bay (DIBA), and Sandy Point (SAPB), also demonstrate significant fishing activities, with thousands of instances recorded at each site. However, sites such as Palmetto Point (PALP), Jessup (JEUP), and Charlestown (CHTN) show comparatively lower numbers, suggesting relatively lower fishing activity in those areas. The data highlight the distribution of fishing efforts across different sites, with some sites serving as focal points for fishing activities and others exhibiting lower levels of engagement in fisheries.

Table 4. Clean and Coded Site Table from Excel Historical Data, 2014 -2023

Site Code	Site	Number
BAEP	Basseterre East	30636
BAIM	Basseterre West	8741
OLRO	Old Road	7577
DIBA	Dieppe Bay	5498
SAPB	Sandy Point	4658
PALP	Palmetto Point	728
JEUP	Jessup	658
CHTN	Charlestown	606
BAFC	Basseterre Fisheries Complex	470
NEGU	New Guinea	403
NWCL	New Castle	395
LGHL	Long Haul	149
JNBY	Jones Bay	92
CNGD	Cotton Ground	1

In addition, standardisation of the date outlined in ***Error! Reference source not found.*** was critical for ensuring dataset consistency. The additional information in ***Error! Reference source not found.*** and

Appendix *12* regarding the number of unique dates (Figure 8) and the number of trips sampled (Figure 9. Number of Trips Sampled Each Month Based on the Achieved Historical Data, 2014 - 2023

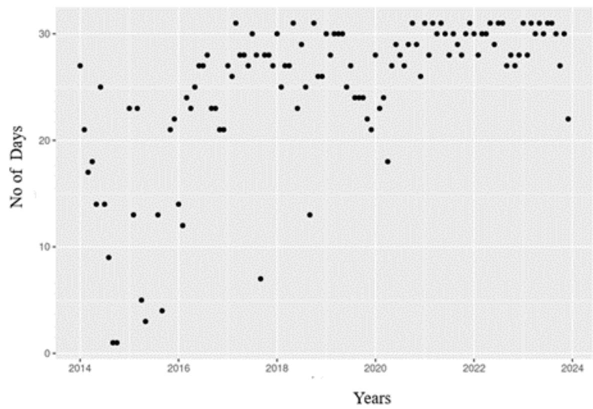

Figure 8. Number of distinct dates of Sampled Vessels from Excel Historical Data, 2014 – 2023

Initially, the total number of sampled trips each month was less than 100 between 2014 and 2016, but this figure steadily rose to a range of 150 to 175 trips from 2017 to 2019. Subsequently, from 2020 to 2023, the number of sampled trips consistently exceeded 300 each month (Figure 9. Number of Trips Sampled Each Month Based on the Achieved Historical Data, 2014 - 2023

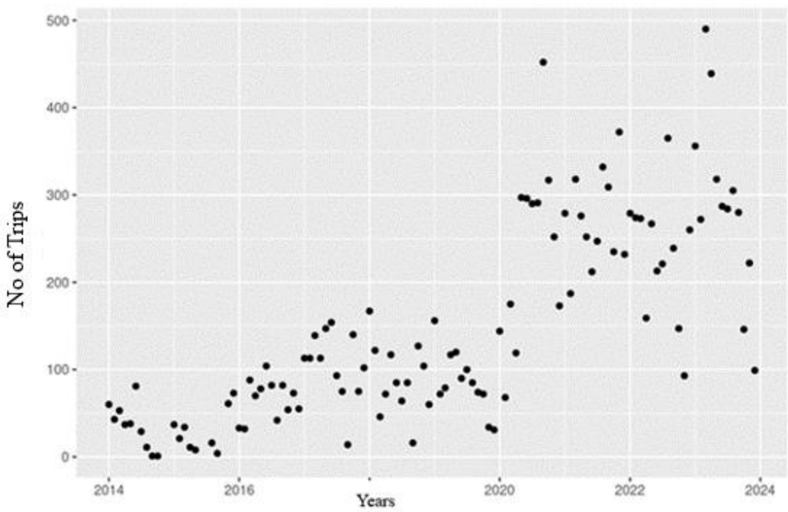

Figure 9. Number of Trips Sampled Each Month Based on the Achieved Historical Data, 2014 - 2023

From 2014 to 2023, there has been a significant rise and fall in the number of trips sampled for all locations (Figure *10*). A consistent increase in the number of trips was observed in

Basseterre East until 2018, when it saw a decrease, followed by a continuous growth that continued until 2022, after which there was a discernible decrease.

In Basseterre West, there was minimal activity between 2014 and 2016, followed by a small rise in trip sampling from 2017 to 2019. Between 2020 and 2021, there was a significant increase, followed by a steady decline in 2022. In 2023, there was a slight uptick and subsequent reduction.

Trip sampling in Dieppe Bay demonstrated a stable level from 2014 to 2020, after which there was an increase in 2021 and a slow and consistent reduction until 2023.

In Sandy Point, trip sampling data were limited from 2014 to 2016, with some years experiencing a complete absence of data. Trip sampling continued to fluctuate until 2020, when a notable increase occurred. From 2020 to 2022, consistent sampling efforts were observed.

The sampled trips on Old Road have fluctuated over the span of 10 years. Approximately 20 trips were recorded in 2014, followed by a decrease to less than five trips at some point in 2015. In 2016, over 60 trips were sampled before experiencing a dip. From 2017 to 2023, there has been a consistent pattern of rise and fall in the number of sampled vessels.

Data collection began in 2023 for Palmetto Point, New Guinea, and the Basseterre Fisheries Complex (BAFC). Throughout these areas, there was a noticeable increase in the number of trips recorded during the first three quarters of the year, followed by a slight decrease toward the end of the year.

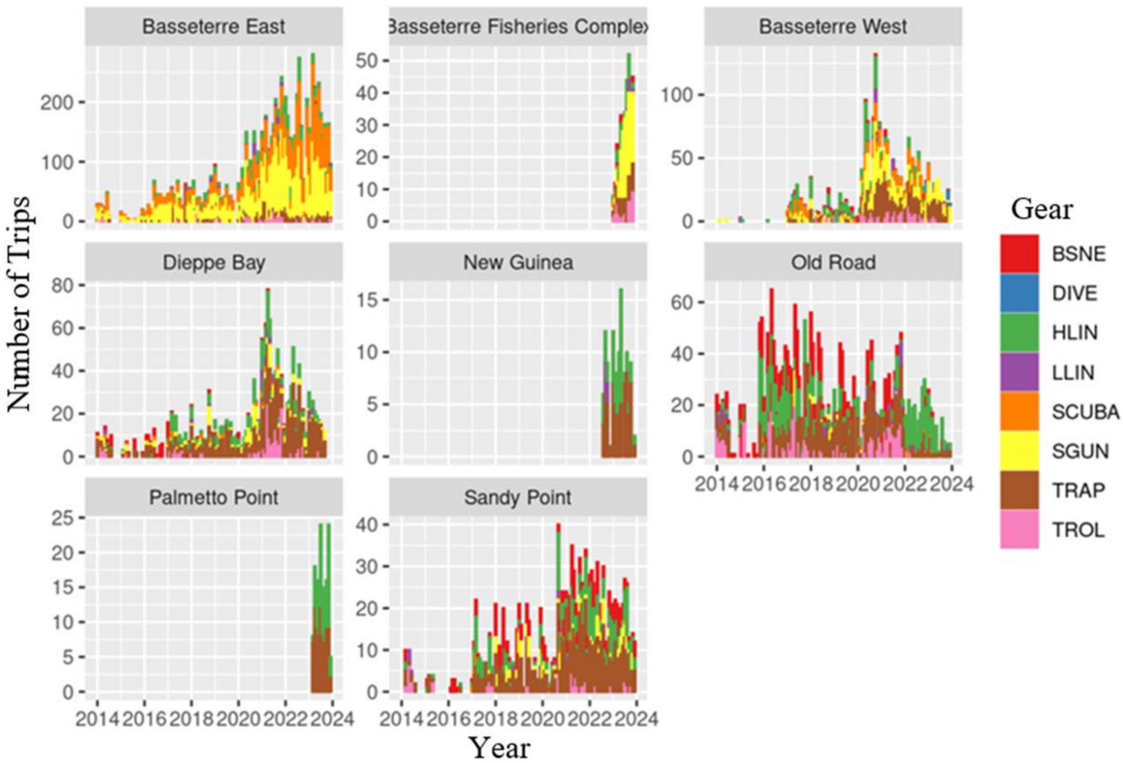

Figure 10. Number of Sampled Trips by Gear from the Excel System Historical Data 2014 – 2023.

4.2 Description of the Fishery

Figure 11 shows the distribution of fishing gear across various sites based on 2023 data. It illustrates distinct preferences and practices. Sandy Point, Palmetto Point, New Guinea, Dieppe Bay, and Basseterre West rely primarily on trap fishing methods. Meanwhile, scuba diving activities are concentrated in Basseterre East. Handline fishing is prevalent in Old Road, New Guinea, and Palmetto Point. Spear gun fishing landing is notably active in Basseterre West, Basseterre East, and the Basseterre Fisheries Complex. Additionally, spear gun catches are prominently accounted for at the Basseterre Fisheries Complex. These site-specific preferences highlight the diverse fishing practices and gear utilisation across different areas of St. Kitts. Trap, handline, and spear guns predominate in general at the other landing sites, except Basseterre East, where scuba is as significant as spear guns. Additionally, boat seine is prevalent in Sandy Point.

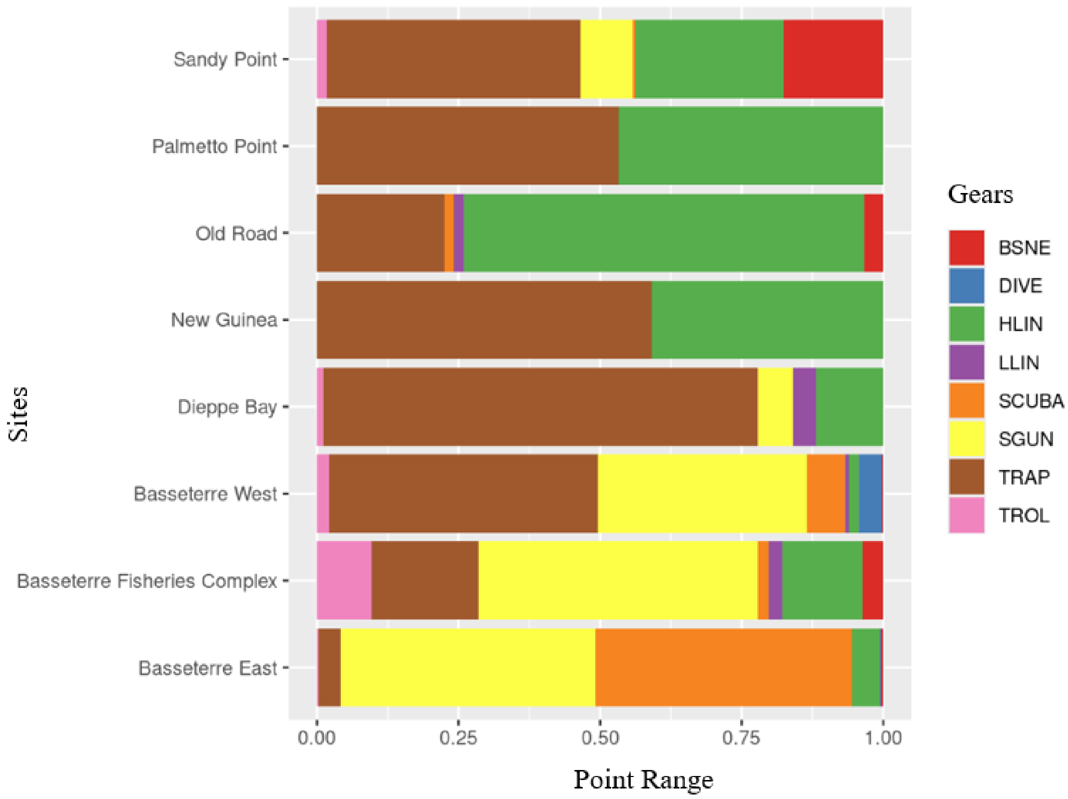

Figure 11. Relative Composition of Trips by Gear at Different Landing Sites in 2023 from TFM Database.

The gear composition has evolved over the course of the period 2014–2023 at the five main landing sites (
Figure *12*. Gear Composition at Main Landing Site, 2014 - 2023). Between the years 2014 and 2023, the area of Basseterre East has regularly had modest levels of activity in terms of boat seine, trolling, and free diving. Scuba and spear guns have become the main

gear used during this period. Significantly, the practice of spear gun fishing has decreased over time. On the other hand, there has been a notable increase in the use of scuba since 2020. The use of traps and trolls, although not prevalent, surged in 2020.

Handlines, spear guns, and traps were the main gear used at Basseterre West. Nevertheless, there was a substantial reduction in the utilisation of handlines in 2016, which experienced a further dip in 2020. However, in that same year, there was a significant surge in the primary use of spear guns and traps. Additionally, trolling, which had not been documented before 2020, was first recorded in that year. The utilisation of spear guns had a constant downward trend from 2014 to 2017, subsequently followed by a steady upward trajectory leading up to 2023. Furthermore, there has been an increase in the usage of traps and spear guns in the past year.

Gears such as boat seine, handline, traps, speargun, and trolling have been utilised to varying degrees throughout the study period. Between 2014 and 2019, every device that was previously named was recorded as sampled; however, no trolling data was collected from 2019 to 2020, However, between 2021 and 2023, trolling samples were collected. Traps have continuously been the most frequently used fishing gear in Dieppe Bay for the past nine years. There has been a gradual increase in their utilisation after a dip was detected in 2009. In contrast, the utilisation of handlines had a substantial surge in 2017, which was subsequently followed by a steady decrease. The boat seine catch rate was initially high and subsequently decreased until it reached zero in 2023.

Various fishing methods, including trolling, traps, handlines, scuba, and boat seines, have been routinely used at Old Road. Nevertheless, a consistent decrease was noted between 2014 and 2017. The decline in trips at Old Road commenced in 2016, and the gear composition shifted from trolling, traps, handlines, and boat seines to traps and handlines with limited documentation of boat seines in 2022. This represents a significant departure from the previous approach. Subsequently, there was an increase in the utilisation of traps, but with a significant decline in 2020. In 2021, there was a substantial surge in the utilisation of handlines. However, most of the gear showed a decrease in 2021, except for the handline gear, which saw a significant increase in 2022.

In Sandy Point, the utilisation of boat seine gear increased sharply in 2016, followed by a significant decline in 2017. There was a slight increase in 2018, with subsequent years showing consistency in usage. The utilisation of traps has increased continuously since 2017, accompanied by incremental increases until 2020. However, from 2020 onwards, there has been a consistent decrease in trap usage up to 2023. Additionally, there has been a slight upward trend in the use of spear guns, boat seine gear, and handlines over the last three years (2020–2023).

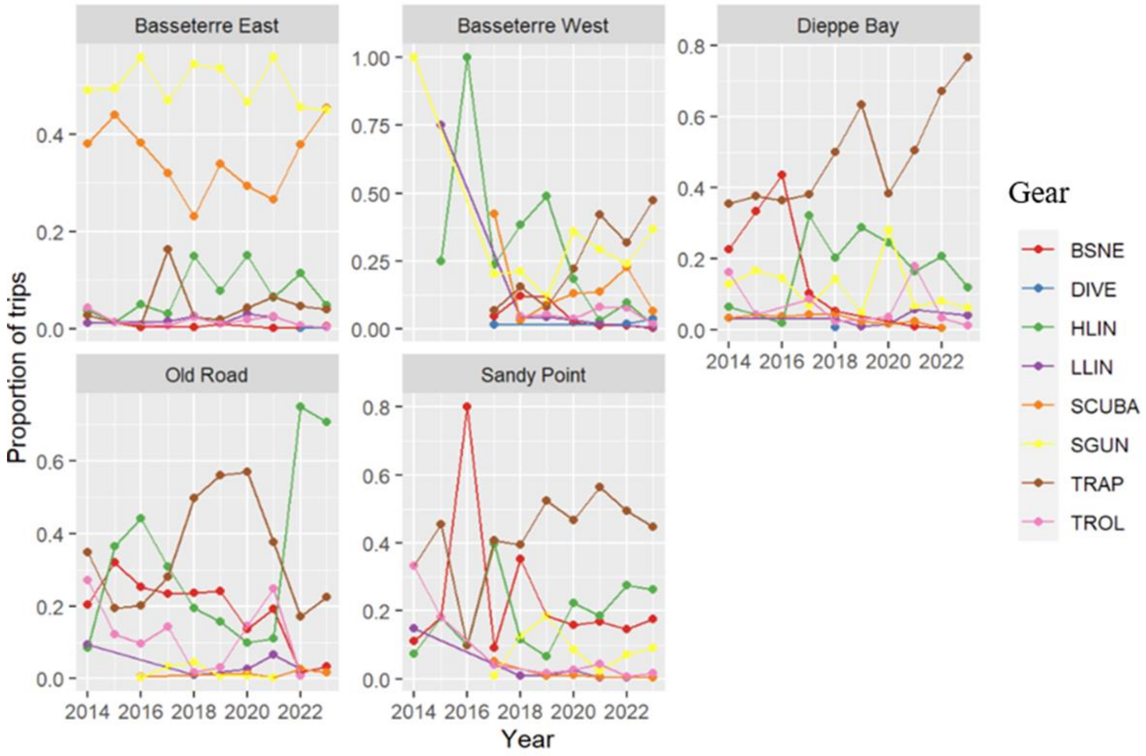

Figure 12. Gear Composition at Main Landing Site, 2014 - 2023

In 2023, the mean number of species per trip varied depending on the fishing gear used (Figure *13*). This measure provides insight into the diversity of species caught during fishing trips across different gear types. For example, gear such as traps, scuba, and spear guns exhibit a higher mean number of species per trip compared to gear like longline, trolling, boat seine, and handline due to its broader coverage and targeting of various species.

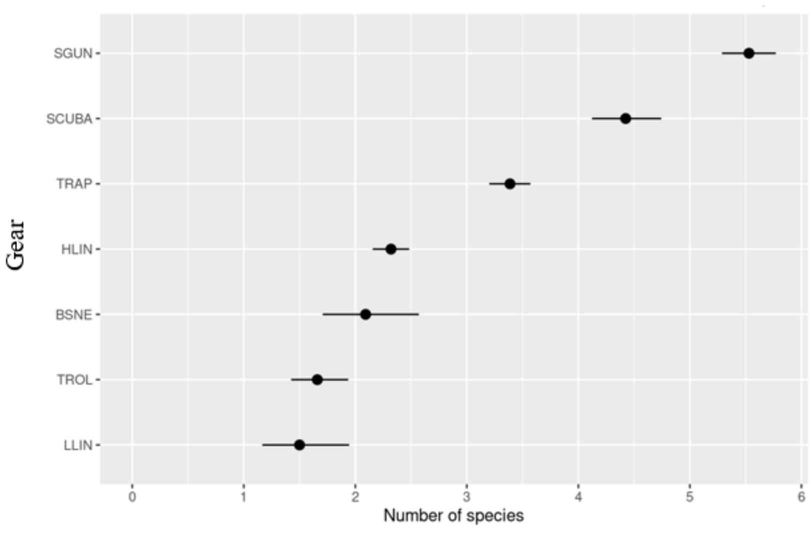

Figure 13. 2023 Mean and 95% Confidence Interval of Number of Species per Trip by Gear

The number of species caught using different fishing gear varied over time (Figure *14*). The number of species caught using trolling, boat seine, handline, and longline remained constant, with a slight increase observed in troll gear from 2020 to 2021, followed by a decrease. Spear guns and traps showed fluctuations over the same period but demonstrated an increasing trend in more recent years. Scuba diving remained consistent from 2014 to 2021 until a significant increase occurred in 2022.

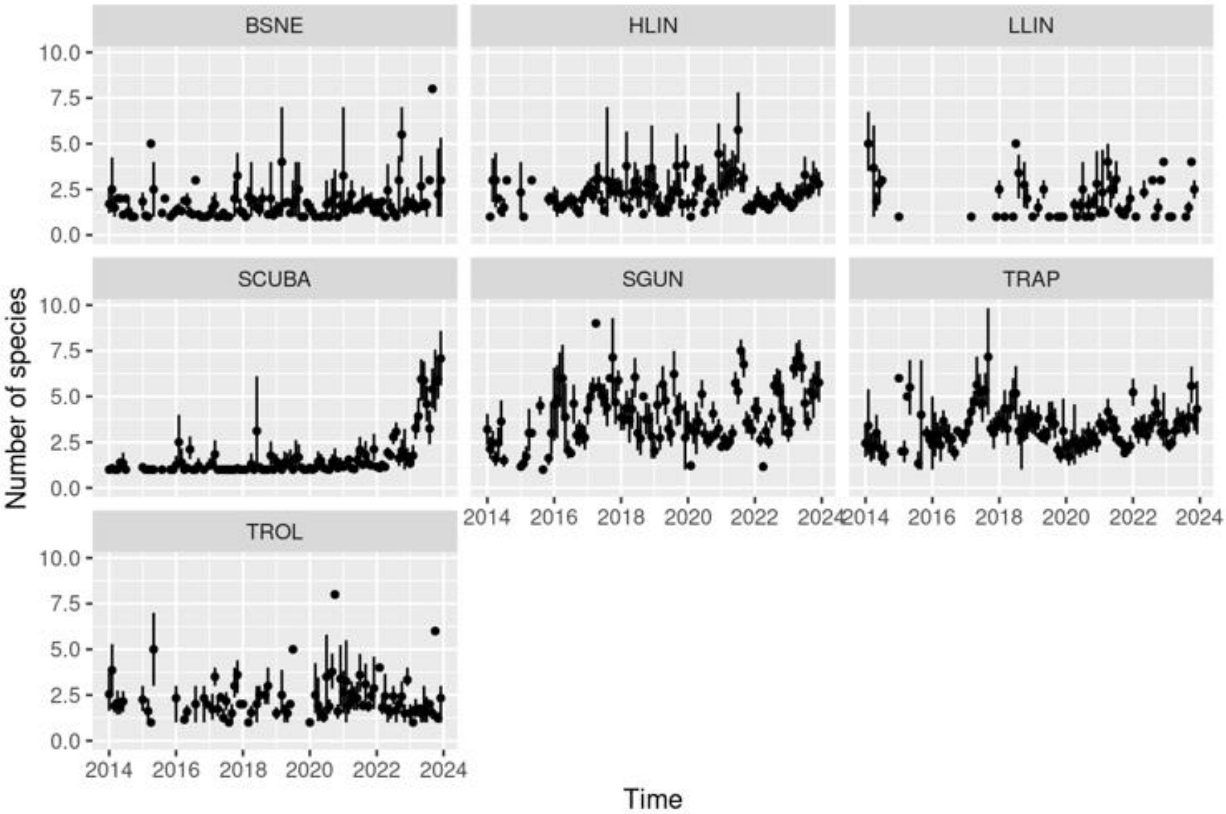

Figure 14. Number of Species by Gear for years 2014 – 2023.

The Catch Per Unit Effort (CPUE) by different gear types is shown in Figure 15. Outliers are indicated along with the median and interquartile range in the box plot. An important observation is the lack of overlap between the mean and median. This inconsistency indicates that the data distribution is asymmetric.

The measure of central tendency, denoted by the mean and the 95% confidence interval (CI), is computed by adding the values of the distribution and then dividing the result by the total number of observations. It is susceptible to extreme values or outliers in the data. In contrast, when organised in ascending order, the median (represented by the line in the box diagram) signifies the midpoint value of the set of data. It exhibits reduced susceptibility to outlier effects compared with the mean.

The absence of concurrence between the mean and median indicates that the catch-per-trip data follow a skewed distribution. There are numerous potential causes for this skewness, including the presence of outliers and the inherent characteristics of fishing activity. For instance, certain types of gear, such as BSNE, may occasionally produce considerably greater catches, resulting in a distribution that is positively skewed.

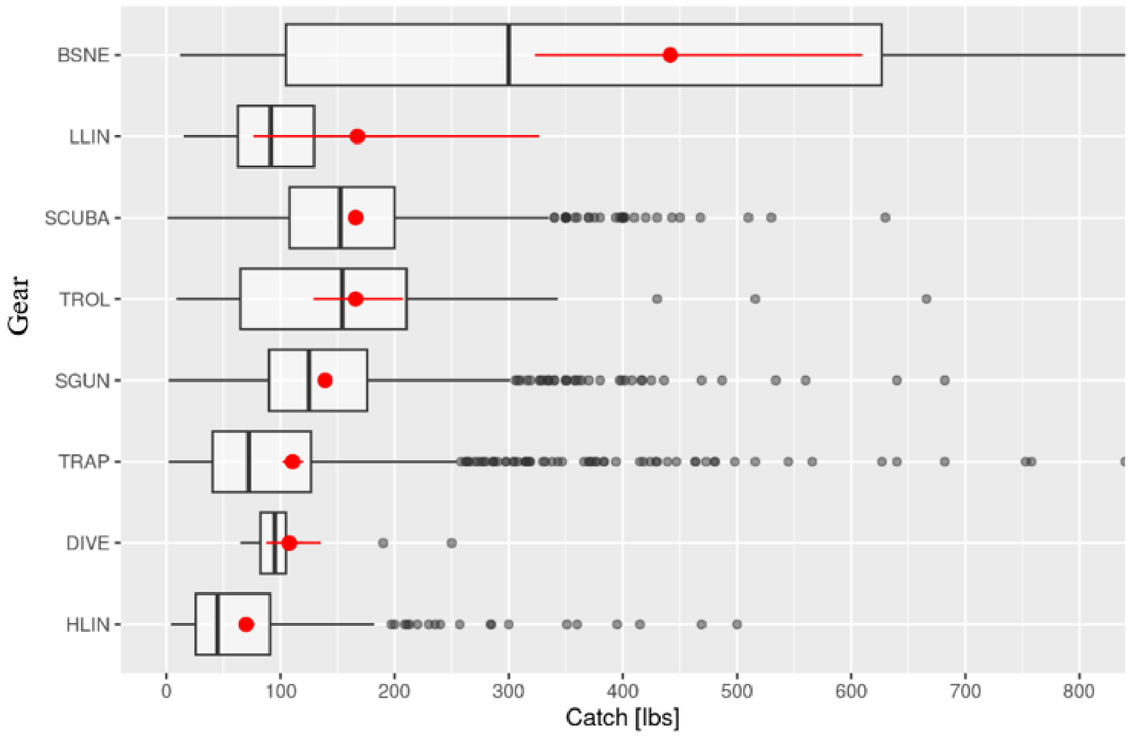

Figure 15. 2023 Mean and 95% Confident Interval of Catch per Trip.

CPUE per gear trends vary across different fishing methods (Figure *16*). Spear guns, traps, and scuba fishing methods exhibited a stable CPUE over time, suggesting consistent efficiency in catch rates. However, handline fishing showed a slight decline in CPUE, indicating a potential decrease in catch rates per unit of effort. In contrast, troll and longline fishing methods displayed high variability with no discernible trend over time, indicating fluctuations in catch rates that were not influenced by a consistent pattern or trend. These observations underscore the diverse dynamics within various fishing practices and highlight the need for nuanced management strategies to ensure sustainable fishing practices

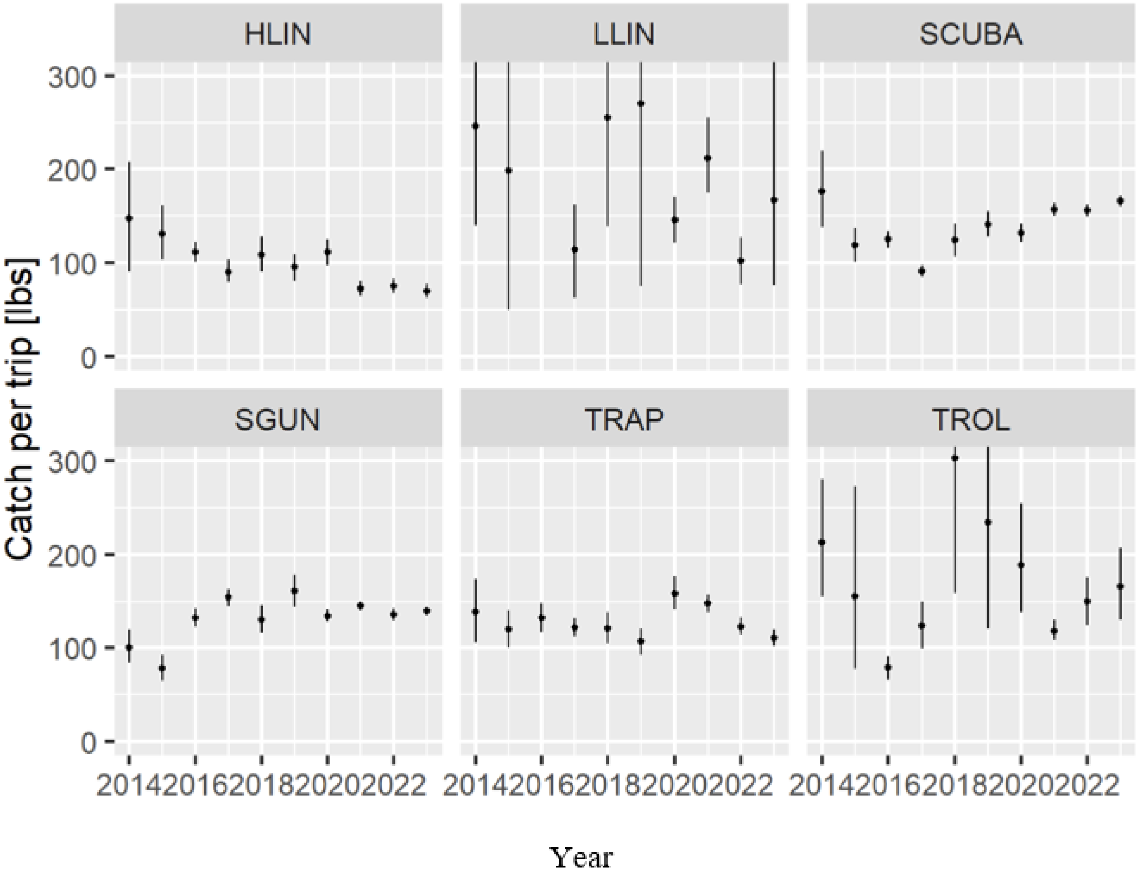

Figure 16. CPUE by Gear for Period 2014 – 2023.

4.2.1 *CPUE for Conch*

To conduct a more precise analysis, attention is now directed towards a specific species, namely Queen Conch (*Strombus gigas*) and Spiny Lobster (*Panulirus argus*) which possess greater commercial value. The annual landing of Queen Conch (*Strombus gigas*) exhibits significant variation ($p < 0.001$), indicating the statistical significance of this observation. Specifically, the notation ($p < 0.001$) suggests that the probability of obtaining the observed variation in the yearly number of Queen Conch landings, or more extreme results, purely by chance is less than 0.001, signifying a highly improbable occurrence. Consequently, this strong statistical significance implies that the variation in the yearly number of Queen Conch landings is not merely due to random fluctuations but likely stems from a meaningful underlying cause or trend. Despite a temporary decline in 2020, there has been a consistent upward trend since 2018, with continued growth observed until 2023, as depicted in Figure *17*.

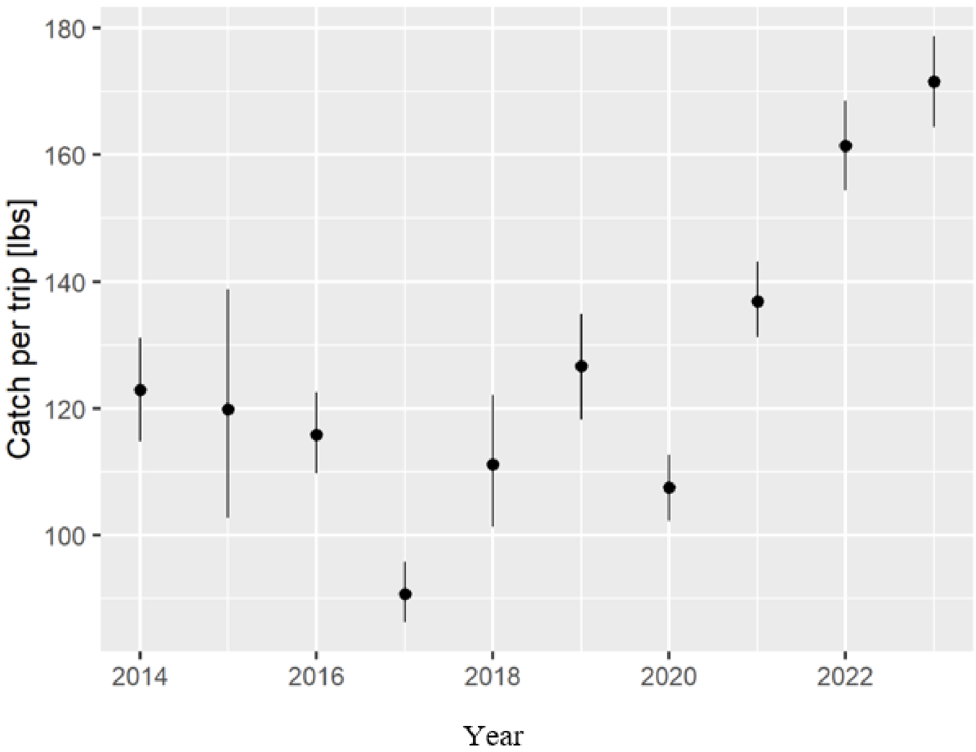

Figure 17. Conch Landing from 2014 – 2023.

The total landings from the landing sites in 2023 are illustrated in Figure 18. April through June saw a decline in conch captures that year, followed by a gradual increase; this indicates that the highest number of conch captures occurred between August and September 2023. Nevertheless, the conch landings demonstrated variety at different landing sites (Figure *19*). During the period when the overall conch was at its highest, from August to November, there was a noticeable decline in SAPB catches. However, landings are generally low throughout the month, with the conch reaching its peak in March. In contrast, a significant surge in DIBA was observed between July and September compared to the three months prior.

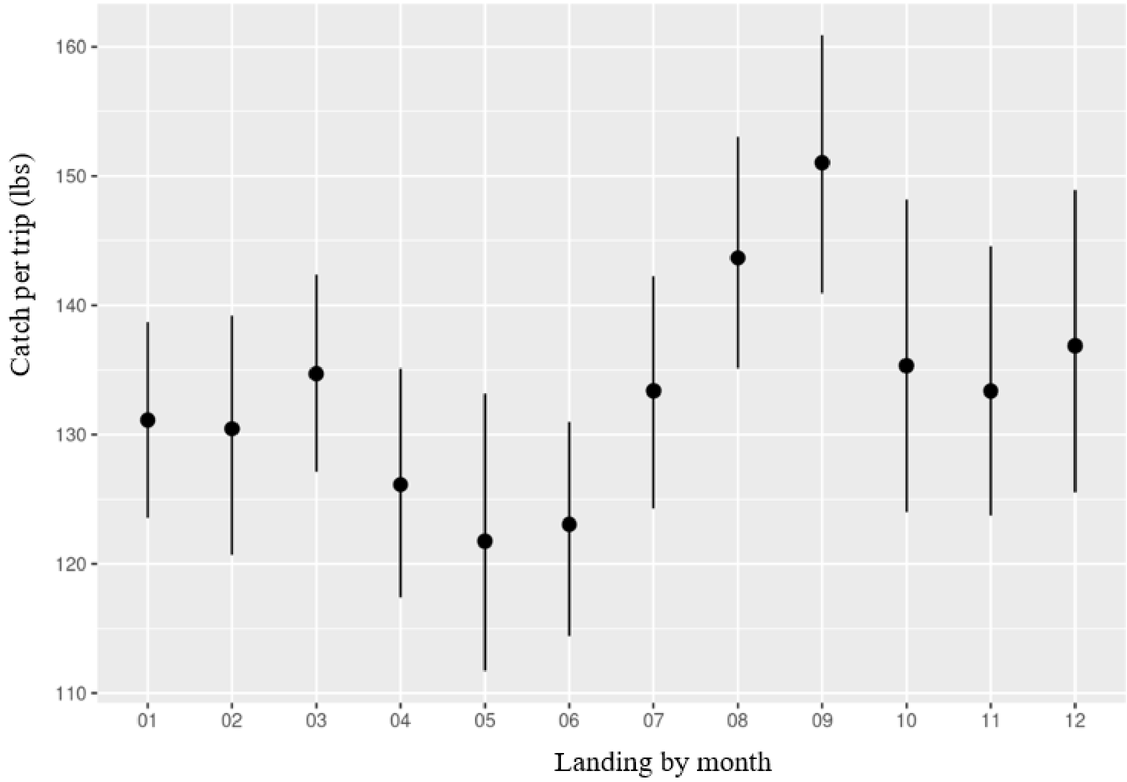

Figure 18. Overall Landing for Conch for 2023.

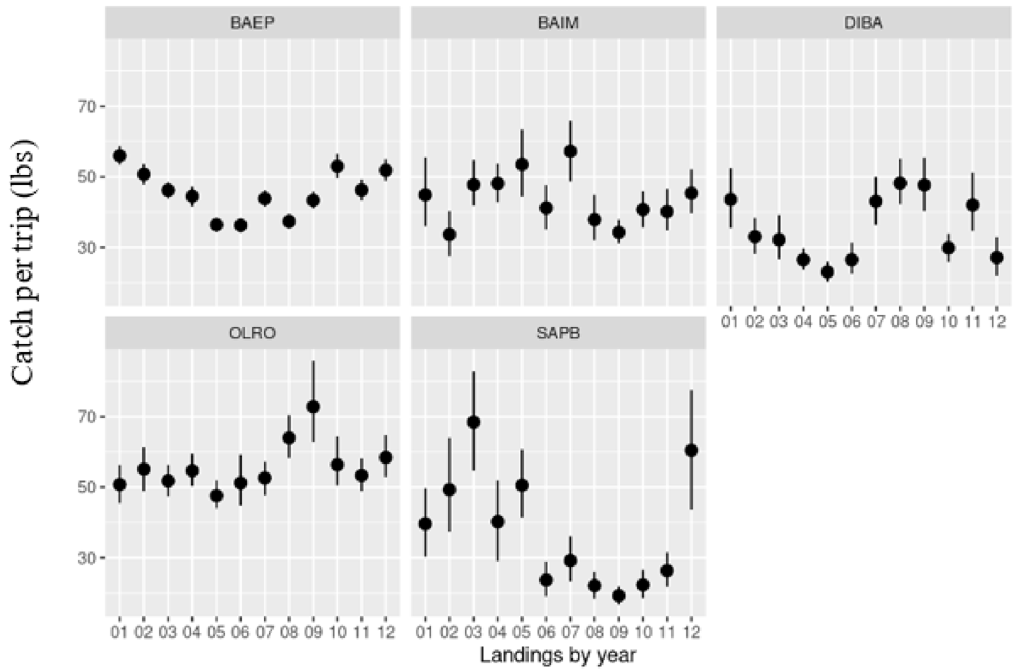

Figure 19. Conch Landings by Sites from Historical Data 2023.

4.2.2 CPUE for Spiny Lobster

The CPUE for Spiny Lobster demonstrates varying trends across different fishing methods over the period from 2014 to 2023 in Figure *20*. Both scuba and spear gun fishing methods exhibited consistency, maintaining a steady CPUE throughout the entire timeframe. In contrast, traps experienced a decline in 2015; however, from 2017 onwards, there has been a continuous increase in trap CPUE, culminating in the present year, 2023. Despite these fluctuations, there is no strong indication of overall change in the CPUE for Spiny Lobster across the observed period, suggesting relative stability in catch rates despite some fluctuations in specific fishing methods.

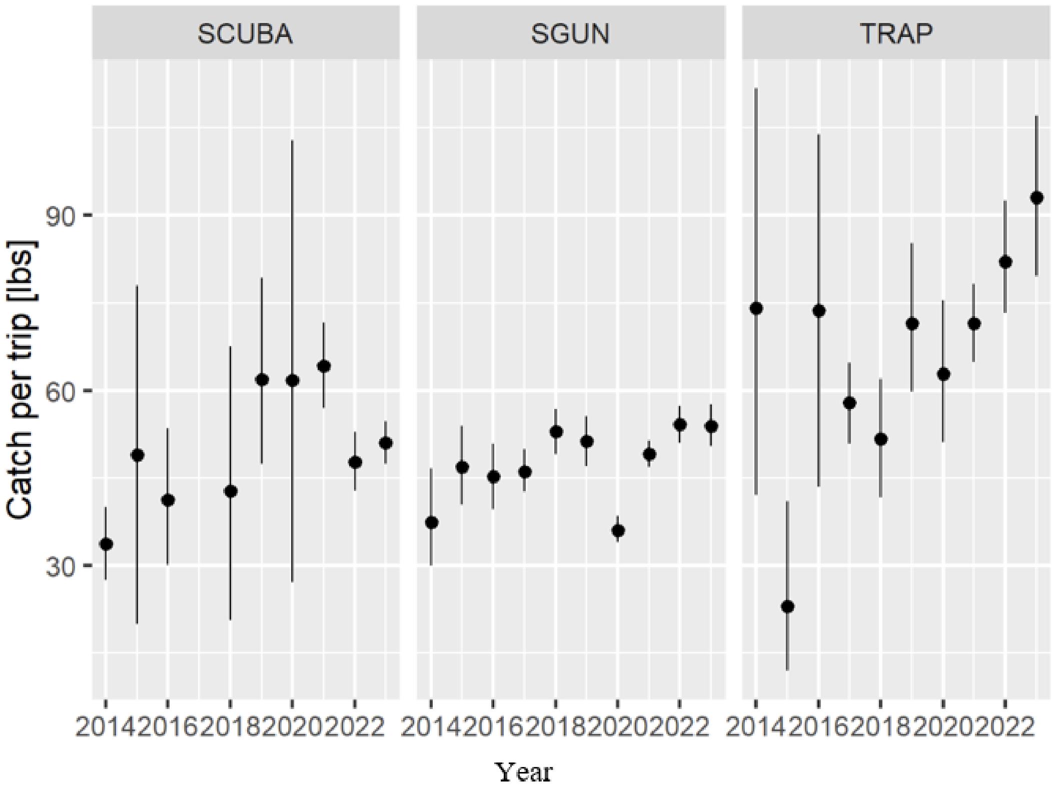

Figure 20. CPUE for Spiny Lobster, 2014 – 2023.

4.3 Extraction of Data from TFM

The previous method of using the Application Programming Interface (API) to produce data from the specific Uniform Resource Locator (URL) was challenging and several steps must be followed. First, generate a token as in Figure 21. Format the URL, and then manipulate the API connector (Figure *22*) which then produces a wide spreadsheet of data (Figure *23*). However, with the current procedure, it is a smoother and quicker way of successfully retrieving data using R (Figure *24*) to produce data (Figure *25*). While assessing the data, it became evident that certain data collectors were inaccurately inputting information into the system. Consequently, a quality control report (Figure *26*) was devised and implemented to address this issue. This pertains specifically to data collection regarding the date of the survey, ensuring accuracy in recording when the survey was conducted.

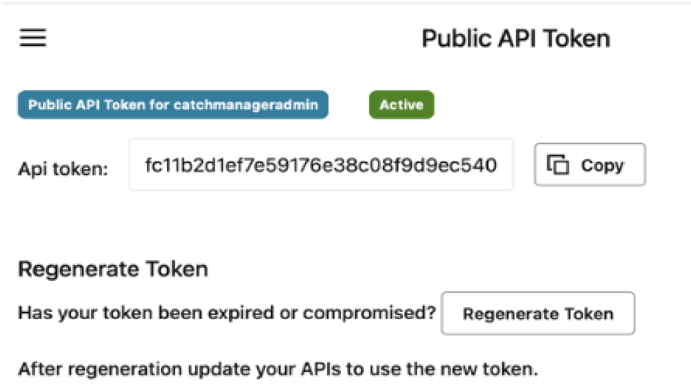

Figure 21. Token Generated from TFM.

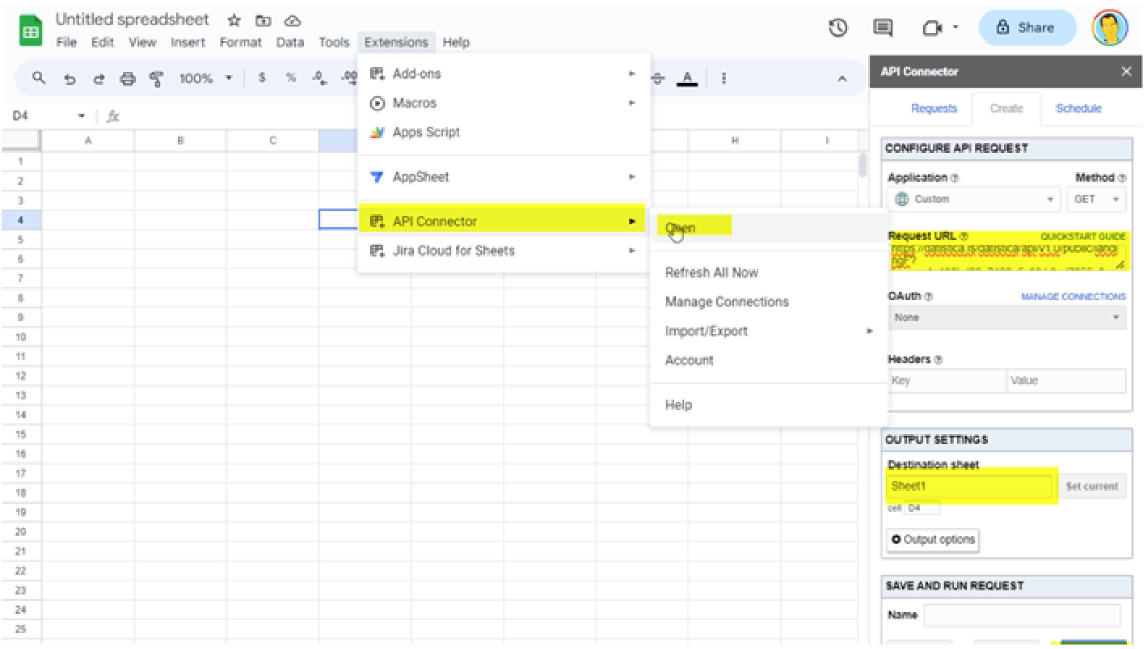

Figure 22: Application Programming Interface Connector.

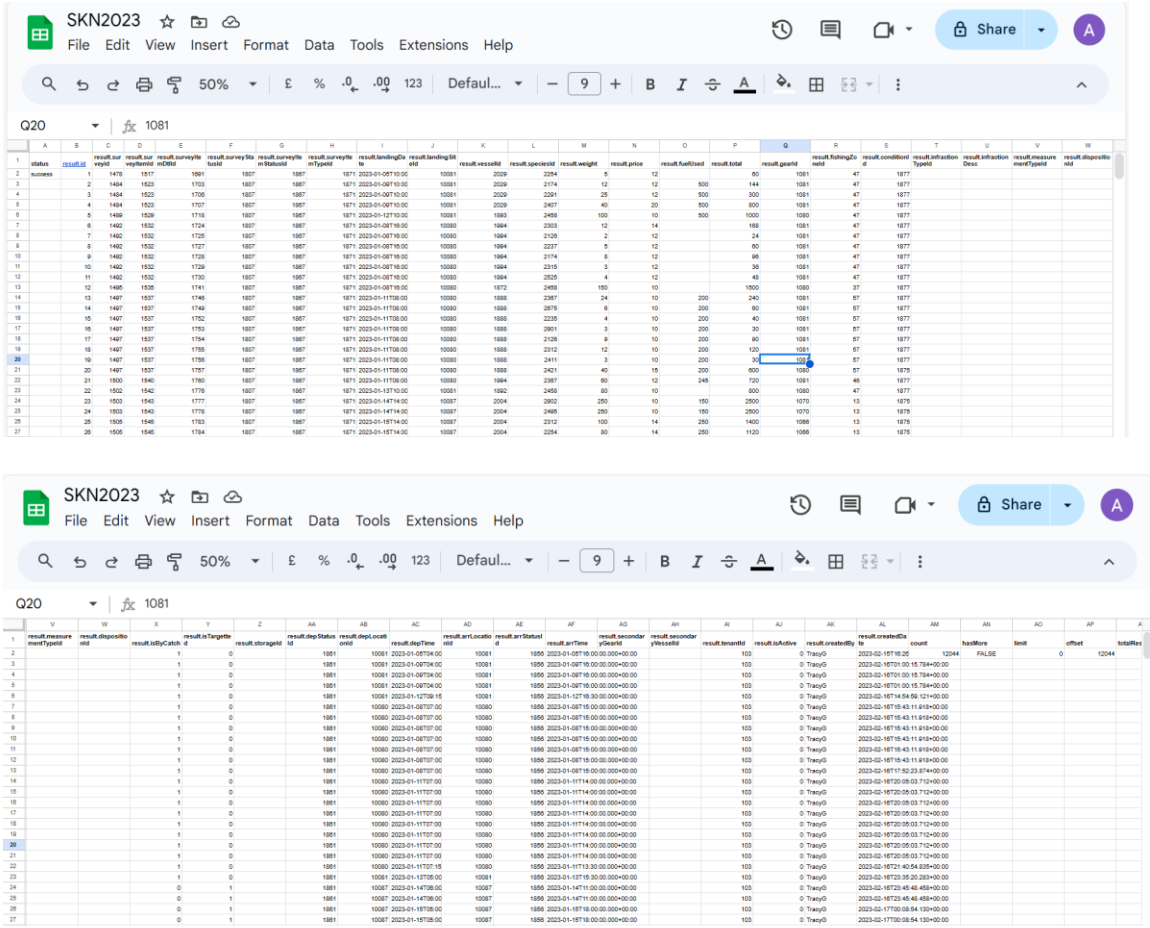

Figure 23. Wide Spreadsheet with 2023 Data from TFM.

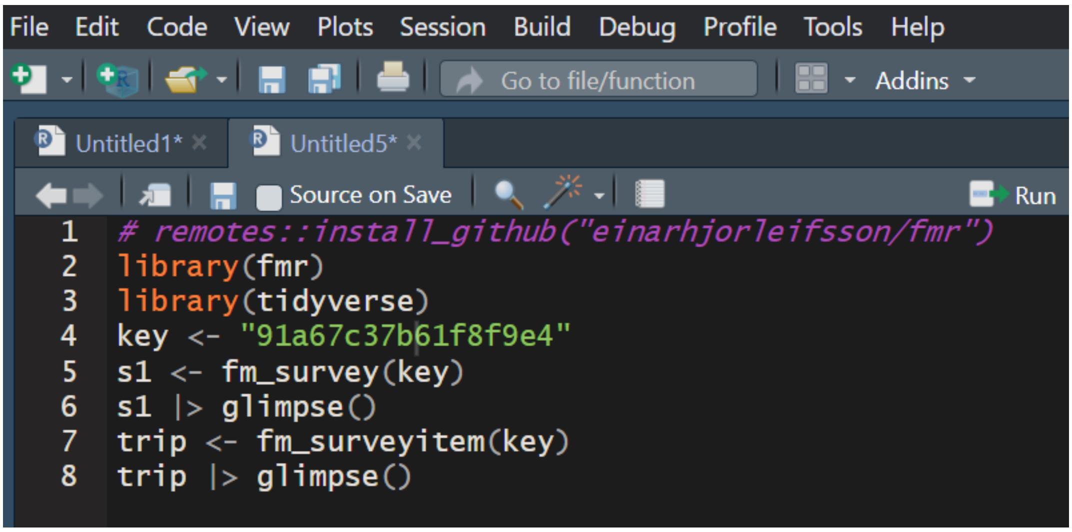

Figure 24. New Procedures for Extracting Data from TFM.

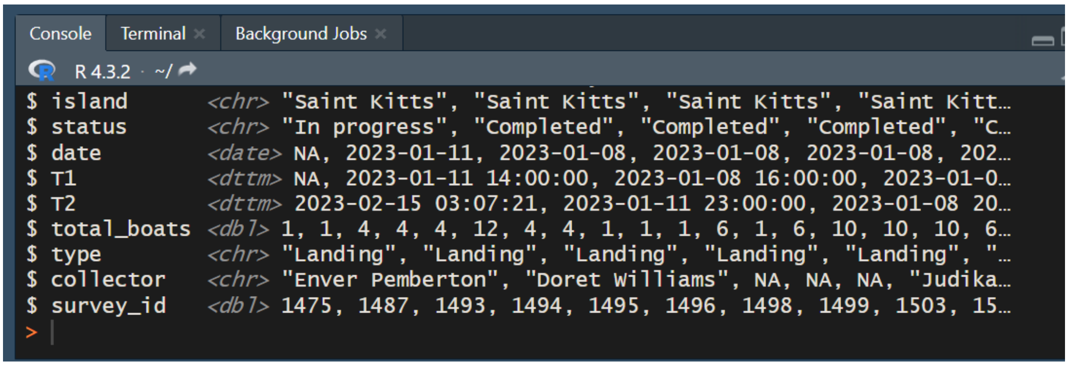

Figure 25. Data Displayed from TFM using New Procedure via R.

Quality Control Verification Sheet

Name: Jane Doe
Date: 15 February 2024

survey _id	site	T1	T2	Vessel _name	dep_time	arr_time
6233	Old Road	2024-02-15 12:00:00	2024-02-15 14:00:00	Survival 2	2024-02-15 06:00:00	2024-02-15 13:30:00
6260	Palmetto Point	2024-02-15 12:00:00	2024-02-15 15:00:00	Lucera	2024-02-15 07:00:00	2024-02-15 15:00:00
6281	Old Road	2024-02-15 12:00:00	2024-02-15 15:00:00	Biggers	2024-02-15 08:10:00	2024-02-15 16:45:00

Comments: All these vessels have 15 February 2024 as the survey date.

1. Should they have one survey ID? ____________________________
2. Did you collect/survey the vessels on the same date? ____________________

If the answer to question 2 is **NO** then it is correct with the different Survey ID.
If your answer to question 2 is **YES,** then all of them should have one survey ID.
Explain____

____

3. Vessel - The first time was entered twice. See details below:

Survey ID	**Departure date and time**	**Arrival date and time**	**Vessel Name**	**Vessel Number**	**Species**	**Weight**
6267	2024-02-11 08:45:00	2024-02-11 14:30:00	First Time	039BE	Conch	120
6269	2024-02-10 09:00:00	2024-02-10 15:15:00	First Time	039BE	Conch	40

Please verify. It could be that the vessel had two trips on 2024-02-20, but it can't be at the same time or overlapping times.
Explanation: ____

Secondly, if it is that you entered the same vessel twice, we then have a different problem because the weight is different.
Explanation: ____
Please verify.

Andrea Browne
Data and Statistics Department
28 February 2024

______________________________ ________________________
Data collector Signature and date Verifier Signature and date

Figure 26. Quality Control Verification Form.

4.4 Standardised Reporting

The monthly standard report (Figure *27*) to the Director and Ministry presents a comprehensive overview of marine fishery activities, including landing site activity, fishers' data, gear utilization, fish catch summaries, and species breakdowns. The report detailed specific locations and corresponding activities, such as vessel sampling days, fisher counts, and types of gear used. Additionally, it provided a detailed breakdown of fish catch quantities and values across various fisheries and species, facilitating a thorough understanding of monthly fisheries data status.

MONTHLY REPORT - Director and Ministry

To: Randel Thompson (Mr)
Director

From: Andrea Browne (Mrs)
Data and Statistics Division Head

Date: *End of month*

Subject: Monthly Fisheries Data Status Report - Description of Fisheries

<u>MARINE FISHERY</u>

LANDING SITE ACTIVITY
Describe what transpired at both levels of strata (St Kitts and Nevis).
State the number of vessels per sampled day.

<u>St Kitts</u>
Basseterre East
Basseterre West
Old Road
Sandy Point
Dieppe Bay
New Guinea
Palmetto Point
Basseterre Fisheries Complex

<u>Nevis</u>
Charlestown
Jessups
Cotton Ground
Jones Bay
New Castle
Long Haul
Indian Castle

<u>FISHERS</u>
(The number of fishers recorded for St Kitts and Nevis)

<u>St. Kitts</u>

<u>Nevis</u>

<u>GEAR USED</u>
(What gears were used according to the site)

FISH CATCH
(Aggregated quantity and value of fish catch according to fisheries.)

Coastal Pelagic Fishery
In-Shore Pelagic Fishery
Reef Fishery
Lobster Fishery
Conch Fishery

SUMMATION OF SPECIES (*An itemized list of species catch–raised.)*

Common Name of Species	**Scientific Name /Group**	**Quantity (lbs)**	***Value $EC***
Angelfish	Pomacanthidae spp		
Angelfish Blue	Genicanthus bellus		

Example of what should be included, but a comprehensive list of all species

AQUACULTURE

St Kitts

Species

Name of Establishment	Number of fishers	Quantity of fish (lbs)	Value $EC

Seamoss

Name of Establishment	Quantity (lbs)	Value $EC

Nevis

Species

Name of Establishment	Number of fishers	Quantity of fish (lbs)	Value $EC

Seamoss

Name of Establishment	Quantity (lbs)	Value $EC

Figure 27. Standard Monthly/Quarterly/Annual Report.

The Fisher´s Bank form (see Figure *28*) was another standardised document that can be reproduced for any lending institution that displays total catch (weight) and time the fisher fished and submitted data. This was done by utilisation of the R programming language and R Markdown.

Date: 2024-01-26

Bank Name: XXXX

Bank Address: XXX

Subject: Request for Loan Consideration for Name of Vessel Fishing Operation.

Dear Sir/Madam

I write one behalf of 1888, a dedicated and hardworking fisher who operates the fishing vessel named Indigo. 1888 has been an integral part of the fishing community, contributing significantly to the local economy through sustainable fishing practices.

Enclosed, please find a summary table detailing recent fishing activities for the period 2023-07-01 to 2023-12-31:

date	weight
2023-07-06	105
2023-07-12	240
2023-07-13	264
2023-07-18	1456
2023-07-19	320
2023-07-24	64
2023-07-26	93
2023-08-08	36
2023-10-31	420
2023-11-09	1680
2023-11-13	300
2023-11-14	1248
2023-11-16	96
2023-11-21	64
2023-11-28	525
2023-11-29	58
2023-12-06	145
2023-12-19	78

Thank you for considering this request. We look forward to the possibility of working together to support Owner's Name in continuing their valuable contribution to the fishing community.

Yours faithfully

Randel Thompson Director

Figure 28. Fisher's Bank Form.

5 DISCUSSION

5.1 Fishing Effort and Vessel Composition

Over the years, the total fishing effort has fluctuated as fishers have adjusted the frequency of their trips. St. Kitts fishers face vulnerability to natural disasters such as hurricanes and tropical storms, which can result in the loss of vessels and fishing gear, thereby impacting the number of vessels at fishing sites. Despite these challenges, there has been a consistent upward trend in the number of vessels sampled. This increase in sampling efforts reflects proactive measures to collect data more frequently and extensively. The increase or introduction of technological and methodological advancements has facilitated more efficient and cost-effective data collection processes. Additionally, growing recognition of the importance of comprehensive data for decision-making and research may have motivated government stakeholders to allocate increased resources to sampling activities. Although there has been a general increase in sampling across the five major sites from 2014 to 2022, the decline observed in Old Road (OLRO) can be explained by the fact that data from New Guinea (NEGU) and Palmetto Point (PALP) was previously combined with OLRO until 2023.

Between 2014 and 2023, St. Kitts experienced nine hurricanes and tropical storms, potentially impacting the distribution of vessels at different landing sites. Additionally, many fishermen engage in part-time fishing activities alongside other forms of employment. With the growth of the tourism sector over the years, providing increased job opportunities for locals, some fishermen may have transitioned to more stable employment options. Consequently, it is plausible that a decrease in the number of vessels and fishing efforts could be attributed to this shift in employment dynamics.

Throughout the study period, a decrease in the number of fishing vessels at certain landing sites, namely, Dieppie and Old Road, was observed. This decline may be attributed to several factors. First, fishermen have transitioned from traditional smaller boats to stronger fibreglass pirogues, capable of accommodating larger crews. Consequently, some fishermen may have opted to pool resources and share the operating costs of a single boat instead of maintaining multiple vessels, leading to a reduction in the number of vessels at certain sites. Additionally, some fishermen may have temporarily joined other vessels if their boats were undergoing maintenance or repairs. However, confirming these trends would require access to vessel registration data from the Licencing and Registration System, which was unavailable for this study. Nonetheless, the introduction of The Fisheries Manager aims to address the issue of fragmented databases within the organisation, thereby eliminating data silos. By consolidating all data into a unified centralised database, information accessibility and integration across different divisions would be significantly improved.

Furthermore, the distance of landing sites from consumers could influence the number of vessels recorded at each location. Fishermen might opt to relocate their landing sites, moving from areas with smaller populations to those offering greater economic prospects. For instance, fishermen may shift to landing sites closer to hotels and restaurants to minimise operational costs and take advantage of increased market accessibility.

Additionally, the introduction of measures, such as tax exemptions on engines and fishing gear, may have impacted fishing efforts. With access to more powerful engines, fishermen can extend their reach to pursue higher-value fish species. However, these subsidy programs may pose challenges to sustainable stock management. While they may incentivise increased participation in the sector, the lack of corresponding investments in enhancing fishing technologies, such as mesh and hook size adjustments, could lead to the overexploitation of stocks.

5.2 Sampling Scheme

Currently, the method used to record the total number of boats on a given day within the system does not serve as a dependable indicator of the overall fishing effort throughout a sampling date. If this process were executed accurately, it could significantly contribute to the calculation of Catch Per Unit Effort (CPUE), a key metric for assessing fishery productivity. Therefore, there is a pressing need to introduce supplementary measures or appoint a harbour master to aid in the collection of this data. Such a role would be instrumental in ensuring the precise monitoring of vessels departing from and arriving at landing areas. Moreover, beyond enhancing data accuracy, the presence of a harbour master would strengthen the safety of fishermen navigating the seas, thereby addressing broader concerns related to maritime security.

While evaluating the data from the Fisheries Manager, discrepancies were identified in how certain data collectors inputted survey dates into the system, leading to inaccuracies. In response, a quality control report was formulated and implemented to address this issue. Specifically, this pertains to the recording of the date on which the survey was conducted. Ensuring accuracy in recording survey dates is crucial for maintaining the integrity of the dataset and facilitating proper temporal analysis. The implementation of the quality control report aimed to rectify these mistakes.

Moreover, the most recent frame survey, which produced information on the utilisation of particular fishing gear by landing site and vessel, was conducted in 2021. Nevertheless, an important gap in the presented information is the lack of crucial supporting materials, such as the survey protocol or methodology document. This document functions as a manual, providing a critical analysis of the survey's structure, methods of sampling, protocols for data collection, and standards for quality control. The absence of this documentation results in evaluators lacking a comprehensive understanding of the survey's methodology and the precautions implemented to guarantee the accuracy and reliability of the data. The incorporation of the survey protocol or methodology document would have increased confidence and transparency in the survey methodology.

5.3 Catch

The process of recording species data presented several obstacles that substantially hindered the attainment of exhaustive and precise records. Notwithstanding these challenges, this study signifies the initial effort to delineate patterns in catches, providing significant perspectives on the dynamics of landing sites. An examination of the usage and gear utilisation in landing areas unveils fluctuations in fishing patterns and the accessibility of resources throughout St. Kitts. A noticeable inclination towards specialized equipment such as scuba and spearguns becomes apparent in Basseterre East, whereas variations in equipment utilization in other areas may suggest adjustments to evolving environmental conditions. The continued use of traditional fishing gear, including handlines and traps, in Dieppe Bay is indicative of well-established fishing practices. In contrast, the fishing methods observed at Sandy Point and Old Road appear to be adapting to changing conditions.

An examination of Catch Per Unit Effort (CPUE) reveals a multitude of dynamics inherent in different fishing methods. Stable CPUE over time is observed for spear gun, trap, and scuba fishing techniques, indicating consistent efficacy in capture rates. Conversely, handline fishing experiences a marginal decline in CPUE, which may indicate potential challenges or alterations in fish availability. On the other hand, troll and longline fishing exhibit considerable variability, which may be attributed to individual fishing techniques.

Queen Conch and Spiny Lobster are the subjects of species-specific analyses, which emphasize their commercial importance and the varying trends in CPUE that occur when employing different fishing techniques. Localised responses to changing conditions and seasonal fluctuations in conch captures highlight the complexity of fisheries dynamics, which necessitates flexible management strategies for resource conservation and sustainability.

6 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the comprehensive efforts undertaken include the retrieval and standardisation of historical catch sample data and ensuring its integration into the current database system for future fisheries and stock assessment analyses. Additionally, a thorough characterisation of target species, gear types, and seasonality in St. Kitts fisheries was conducted. More research is needed to fully understand the trends. Moving forward, the development of a systematic approach for extracting data from the Fisheries Manager database, along with reporting templates, will facilitate efficient data handling and the presentation of key management metrics and trends.

In general, there is little evidence of a deterioration in fisheries, indicating that it has not had a large deterrent effect. The stock used in dive gear is currently not decreasing. This indicates a steady or improving condition of the stock.

Overall, addressing these challenges is crucial to ensure the reliability and usability of fisheries data for informed decision-making in fisheries management and conservation efforts. To enhance data accuracy and effectiveness, the following recommendations are proposed:

6.1 Retrieving Historical Records

Recommendations include:

1. Restrictions on the gears, sites, and species codes that can be selected in any database, Excel, or Google sheet.
2. Increase training programs for data collectors to ensure understanding and adherence to coding protocols.
3. Regular quality control checks and validation processes should be implemented to identify and correct discrepancies or errors in the coded data.

4. Nevis data must be in the same format and also 2023 and onward must be inserted into The Fisheries Manager

6.2 Description of the Fishery

Recommendations include the need to:

1. Evaluate whether the sampling design is adequate or oversampling is being conducted. For example, established for documenting catches on weekends.
2. Evaluate what happens at each site; for example, how many vessels go out and return per day? What gear is being used?
3. Improve the accuracy of the total number of vessels on a sampling day; hence, the need for the implementation of a harbour master.
4. Provide regular quality control checks and spell-checking procedures should also be integrated into data collection processes.
5. Implement standardised protocols for data collection to ensure consistency among data collectors. This includes a uniform classification of fish species, standardisation of species coding systems, and guidelines for recording fishing gear types.
6. Provide comprehensive training to data collectors on species identification, classification, and data entry procedures.
7. Establish regular quality control checks should be conducted to identify and rectify any inconsistencies or errors in the collected data.
8. Establish unified terminology for describing fishing gear types to avoid confusion and discrepancies in historical records.
9. Incorporate additional variables, such as weather conditions, fishing intensity, biological measurements, Fishing Aggregating Device (FAD), and Geographic Information Systems (GIS) Data to refine the estimation process. FAD information.
10. Explore the use of technology, such as digital data collection tools or databases, to streamline data management processes and reduce the likelihood of errors associated with manual data entry. For example, Vessel Monitoring Systems (VMS).
11. Establish the landing site with workstations and measurement equipment/instruments.

6.3 Extraction of Data from TFM

Recommendations include the need to:

1. Create a procedural manual that details all the steps and procedures for establishing data quality standards and metrics aligned with organizational objectives.
2. Provide training and capacity-building programs for staff across divisions.
3. Implement data-profiling techniques to assess the quality of existing data.
4. Develop data cleansing procedures to identify and rectify inaccuracies, duplicates, and inconsistencies.
5. Implement data validation checks to ensure data accuracy, completeness, and consistency.
6. Continuously monitor data quality through automated tools and manual audits and promptly address any issues.

6.4 Standardised Reporting

Recommendations include the need to:

1. Integrate Geographic Information Systems (GIS) capabilities into the reporting templates to visually represent spatial data such as fishing grounds, landing sites, and marine habitats.
2. Design user-friendly dashboards that provide a snapshot of key fisheries metrics and trends at a glance, thereby allowing decision-makers to quickly identify areas of concern or opportunities for improvement.
3. Implement automated data retrieval and updates from relevant sources into reporting templates to ensure that information is always up to date and reduce manual data entry and save time for report generation.

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I sincerely appreciate my supervisors, Dr. Einar Hjorleifsson and Dr. Warsha Singh, for their invaluable guidance and assistance throughout the development of this project and its successful culmination.

To my friends and family, who continue to support and believe in me and my aspirations. I consider myself fortunate to have each and every one of you in my life, as you have made even the most challenging situations, bearable. I express my sincere gratitude for your unwavering support in all that I undertake.

Finally, I would like to extend my gratitude to the 2023-2024 GRÓ-FTP fellows for their invaluable contributions towards creating a lasting memory of this fellowship. Many thanks!

APPENDICES

Appendix 1: Fisher Capture Form

Depart of Marine Resources Field Data Sheet
St Kitts and Nevis

Date (Today) ____________________ Data Collector: __________________________

A	
Landing Site	
Vessel Marking (*Name/No.)*	
Capt. Name	
Crew Names	
Time Departed	
Time Arrived	
Area fished	
Depth fished	
Gear used	
No. of Gear (Traps/Longline)	
No. of Set (Traps/Longline)	
Soak Time (Traps/Longline)	
FAD	
Amt Fuel used *(Gallon)*	
Ice Used	
Measurement Type *(weight (WT)/Fisherman Estimate (FE)/ Visual Estimate (VE)*	
Condition *(Torn (T)/ whole (W) Gutted (G)*	
Targeted *(T)* **/By Catch** *(BC)*	

Name of Species	Weight	Price $

	Signature	Date
New System		
Old System		
Trip ID No.	**(A)** ______________	
Landing ID No.		
Entered by		
Checked by		

Appendix 2: Code for Importing Historical Data

```
library(tidyverse)
library(janitor)
library(readxl)
library(datefixR)
library(here)
options(knitr.kable.NA = '')

d2023 <-
  read_csv(here("data-raw/historcial-data/Raw Itemised data  2023
St Kitts.csv"),
           col_types = cols(.default = col_character()))  |> # no
guessing, everything as a character
  clean_names() |>
  janitor::remove_empty(which = c("rows", "cols")) |>
  select(vid = vessel_number,
         site = landing_site,
         date_raw = date_mm_dd_yyyy,
         gid = gear,
         sid = species,
         w = weight,
         n_traps = traps_pull,
         soak_time = soak_time_hrs,
         sq = area_fished) |>
  mutate(.rid = 1:n(),
         year = 2023)

d2022 <-
  read_excel(here("data-raw/historcial-data/Raw itemised data
2022 St Kitts.xlsx"),
```

```
                 col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  janitor::remove_empty(which = c("rows", "cols")) |>
  select(vid = vessel_number,
         site = landing_site,
         date_raw = date,
         gid = gear,
         sid = species,
         w = weight_6,
         n_traps = traps_pull,
         soak_time = soak_time_hrs,
         sq = area_fished)  |>
  mutate(.rid = 1:n(),
         year = 2022)

d2021 <-
  read_csv(here("data-raw/historcial-data/Raw Itemised data 2021
St Kitts.csv"),
           col_types = cols(.default = col_character()))  |> # no
guessing, everything as a character
  clean_names() |>
  janitor::remove_empty(which = c("rows", "cols")) |>
  select(vid = vessel_no,
         site = landing_site,
         date_raw = date,
         gid = gear,
         sid = species,
         w = weight_6,
         n_traps = traps_pull,
         soak_time,
         sq = area_fished) |>
  mutate(.rid = 1:n(),
         year = 2021)
d2020a <-
  read_excel(here("data-raw/historcial-data/data 2020.xlsx"),
                 col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  janitor::remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = lansite,
         date_raw = date,
         gid = gear,
         sid = species,
         w = weight,
         n_traps = traps_pull,
         soak_time) |>
  mutate(.rid = 1:n(),
```

```
         year = 2020)
d2020b <-
  read_csv(here("data-raw/historcial-data/data 2020.xlsx - 
Sheet1.csv"),
           col_types = cols(.default = col_character())) |>  # no 
guessing, everything as a character
  clean_names() |>
  janitor::remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = lansite,
         date_raw = date,
         gid = gear,
         sid = species,
         w = weight,
         n_traps = traps_pull,
         soak_time)  |>
  mutate(.rid = 1:n(),
         year = 2020)

d2019 <-
  read_excel(here("data-raw/historcial-data/2019 raw data 
best.xlsx"),
             col_types = "text") |>  # no guessing, everything as 
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = lansite,
         crew = crew_size,
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight,
         dep = time_dep,
         arr = time_ar,
         fuel = fuel_cost,
         n_traps = traps_pull,
         soak_time,
         total)  |> # This is a derived value
  mutate(.rid = 1:n(),
         year = 2019)
d2018a <-
  read_excel(here("data-raw/historcial-data/2018 RAW DATA 
best.xlsx"),
             col_types = "text") |>  # no guessing, everything as 
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
```

```
  select(vid = vessid,
         site = lansite,
         crew = crew_size,
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight,
         dep = time_dep,
         arr = time_ar,
         fuel = fuel_cost,
         n_traps = traps_pull,
         soak_time,
         total) |>  # This is a derived value
  mutate(.rid = 1:n(),
         year = 2018)
d2018b <-
  read_excel(here("data-raw/historcial-data/2018 RAW DATA
(version 1).xlsx"),
             col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = lansite,
         crew = crew_size,
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight,
         dep = time_dep,
         arr = time_ar,         fuel = fuel_cost,

         n_traps = traps_pull,
         soak_time,
         total)  |> # This is a derived value
  mutate(.rid = 1:n(),
         year = 2018)
d2017 <-
  read_excel(here("data-raw/historcial-data/2017 Raw Data
best.xlsx"),
             col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = lansite,
         crew = crew_size,
```

```
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight,
         dep = time_dep,
         arr = time_ar,
         fuel = fuel_cost,
         n_traps = traps_pull,
         soak_time,
         total) |>   # This is a derived value
  mutate(.rid = 1:n(),
         year = 2017)
d2016 <-
  read_excel(here("data-raw/historcial-data/Fish landings jan
2016 best.xlsx"),
             col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = landsite,
         crew = crew_size,
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight) |>
  mutate(.rid = 1:n(),
         year = 2016)
d2015 <-
  read_excel(here("data-raw/historcial-data/FISH LANDINGS
2015.xlsx"),
             col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = landsite,
         crew,
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight) |>
  mutate(.rid = 1:n(),
         year = 2015)

d2014 <-
```

```
  read_excel(here("data-raw/historcial-data/Fish Landing 2014
(Autosave)dishon.xlsx"),
             col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessid,
         site = landsite,
         crew,
         date_raw = date,
         sq = area_fished,
         gid = gear,
         sid = species,
         w = weight) |>
  mutate(.rid = 1:n(),
         year = 2014)

d1999 <-
  read_excel(here("data-raw/historcial-data/Raw data
1999.xlsb.xlsx"),
             col_types = "text") |>  # no guessing, everything as
a character
  clean_names() |>
  remove_empty(which = c("rows", "cols")) |>
  select(vid = vessel,
         date_raw = date,
         gid = gear,
         sid = species,
         w = weight,
         crew,
         lis = landing_site) |>
  mutate(.rid = 1:n(),
         year = 1991)

d <-
  bind_rows(d2023, d2022, d2021, d2020b, d2020a, d2019,
            d2018b, d2018a, d2017, d2016, d2015, d2014) |>
  mutate(gid = str_squish(gid),
         gid = str_to_upper(gid),
         site = str_squish(site),
         site = str_to_upper(site),
         sid = str_squish(sid))
```

Appendix 3: Code for Gear Correction and Standardisation

```
gear.correction <-
  d |>
  count(gid)
gear.correction |>
  knitr::kable()

#gear.correction |>
#  write_csv(here("data-raw/AB_correct-gear.csv"))
# read in the table that has the corrected values
gear.correction <-
  read_csv(here("data-raw/AB_correct-gear_CORRECTED.csv"))
d <-
  d |>
  left_join(gear.correction |>
              select(gid, Correct)) |>
  # overwrite the original with the correct value & then remove
the column
  mutate(gid = Correct) |>
  select(-Correct)
d |> count(gid)
```

Appendix 4: Fisher´s Bank Form (letter)

Date: 2024-01-26

Bank Name: XXXX

Bank Address: XXX

Subject: Request for Loan Consideration for Name of Vessel Fishing Operation.

Dear Sir/Madam

I write one behalf of 1888, a dedicated and hardworking fisher who operates the fishing vessel named Indigo. 1888 has been an integral part of the fishing community, contributing significantly to the local economy through sustainable fishing practices.

Enclosed, please find a summary table detailing recent fishing activities for the period 2023-07-01 to 2023-12-31:

date	weight
2023-07-06	105
2023-07-12	240
2023-07-13	264
2023-07-18	1456
2023-07-19	320
2023-07-24	64
2023-07-26	93
2023-08-08	36
2023-10-31	420
2023-11-09	1680
2023-11-13	300
2023-11-14	1248
2023-11-16	96
2023-11-21	64
2023-11-28	525
2023-11-29	58
2023-12-06	145
2023-12-19	78

Thank you for considering this request. We look forward to the possibility of working together to support Owner's Name in continuing their valuable contribution to the fishing community.

Yours faithfully

Randel Thompson Director

Appendix 5: Code for Fisher´s Bank Report

~~~~
```{r}
library(tidyverse)
library(jsonlite)
library(here)
source(here("R", "fm_api.R"))
key <- "AAAAAAA55ab288f47b890a4"
d <-
  fm_landings(key) |>
  dplyr::mutate(date = lubridate::as_date(landing_date)) |>
  dplyr::filter(vessel_id == params$VESSEL_ID,
         dplyr::between(date,
                        lubridate::ymd(params$PERIOD_FROM),
                        lubridate::ymd(params$PERIOD_TO)))
vessel <- d$vessel |> unique()
```
~~~~

Appendix 6: Code for Fisher´s Bank Report (letter)

~~~~
**Date**: `r lubridate::today()`

**Bank Name**: XXXX

**Bank Address**: XXX


Subject: Request for Loan Consideration for Name of Vessel
Fishing Operation.

Dear Sir/Madam

I write one behalf of `r params$VESSEL_ID`, a dedicated and
hardworking fisher who operates the fishing vessel named `r
vessel`. `r params$VESSEL_ID` has been an integral part of the
fishing community, contributing significantly to the local
economy through sustainable fishing practices.


Enclosed, please find a summary table detailing recent fishing
activities  for the period `r params$PERIOD_FROM` to  `r
params$PERIOD_TO`:
~~~~

Appendix 7: Unclean Gear List from Excel Historical Data, 2014- 2023

gidR	**n**
BAIM	1
BSNE	1819
DIVE	4
FISH POT	26
FISH TRAP	7
FISH TRAPS	32
FREE DIVE	3
FREE DIVING	1
FREE STYLE	9
FREESTYLE	17
H/LINE	163
HLIN	6483
HSLING	1
L/LINE	39
LINE	35
LLIN	435
LLINE	21
MACHINE	2
NET	70
POT	57
POTS	76
ROD	1
S-GUN	36
S.GUN	85

gidR	n
S/GUN	867
SCUB	16
SCUBA	4718
SCUBALOOP	40
SEINE	2
SGUB	1
SGUN	28252
SPARE GUN	61
TRAP	14121
TRAPS	1778
TROL	88
TROLL	1272
VLLN	16
	96

Appendix 8: Code for Site Correction and Standardization from Excel Historical Data, 2014 - 2023

```
#site.correction |>
#  write_csv(here("data-raw/AB_correct-site.csv"))

# want to get the island for each site
library(fmr)
key <- Sys.getenv("fm_key")
fm.site <- fm_site(key)
site.correction <-
  read_csv(here("data-raw/AB_correct-site_CORRECTED.csv")) |>
  select(1:4) |>
  janitor::clean_names() |>
  left_join(fm.site |>
              select(correct_code_fm = site,
                     island))
```

```
d <-
  d |>
  left_join(site.correction |>
              select(site, corrected = correct_column_skn,
                     island)) |>
  mutate(site = corrected) |>
  select(-corrected)
```

Appendix 9: Unclean and Uncoded List of Sites from Excel Historical Data, 2014 - 2023

siteR	n
BAAEP	2
BAEB	8
BAEP	21639
BAEP1	1373
BAEP10	32
BAEP2	1724
BAEP3	5284
BAEP4	3
BAEP5	3
BAEP6	92
BAFC	68
BAFC10	71
BAFC2	57
BAFC3	132
BAFC4	122
BAFC7	91
BAIM	8172
BAIM1	31
BAIM10	175
BAIM2	3
BAIM3	60
BAIM4	4
BAIM5	4
BAIM6	5
BASSETERRE	395
BEAP	73
BIAM	57
CARAMBOLA	3
CASTLE	11

siteR	**n**
CHTN	582
CHTN2	13
CNGD	1
DAEP	3
DIAB	2
DIBA	5081
DIBA1	13
DIBA10	135
DIBA2	6
DIBA4	64
DIBA7	90
DIEPPE BAY	107
FBAY	1
FBAY7	1
JEUP	649
JEUP11	3
JEUP12	6
JNBY	92
LGHL	149
NEGU	63
NEGU2	162
NEGU4	176
NEW GUINEA	2
NEWCASTLE	14
NWCL	288
NWCL10	83
NWCL5	10
OLD ROAD	36
OLR01	1
OLRO	7389
OLRO1	37
OLRO10	53
OLRO3	12
OLRO4	9
ORLO1	15
ORLO10	4
ORLO4	21

siteR	n
PALP	378
PALP2	10
PALP4	147
PALP6	109
PALP7	84
POZA	230
RANDOM	1
SANDY POINT	59
SAPB	4336
SAPB10	3
SAPB3	74
SAPB4	77
SAPD	109
	67

Appendix 10: Date Standardisation, Excel Historical Data 2014 - 2023

```
d <-
  d |>
  mutate(date_raw = str_replace_all(date_raw, "//", "/")) |>
  mutate(is.a.number = !is.na(as.numeric(date_raw))) |>
  mutate(# if value is numeric assume it is an excel numeric date
value else MDY-form
    date = case_when(is.a.number ~
janitor::excel_numeric_to_date(as.numeric(date_raw)),
                     .default = mdy(date_raw))) |>
  mutate(# if above still gives NA, try DMY-format
    date = case_when(is.na(date) ~ dmy(date_raw),
                     .default = date))
d |>
  filter(is.na(date)) |>
  knitr::kable(caption = "Records where date can not be converted
to proper date")
```

Appendix 11: Number of Distinct Dates from Excel Historical Data 2014 - 2023

```
d.sum <-d |>
  filter(!is.na(date),
         !is.na(gid),
         !is.na(site)) |>
  arrange(date, site, island, vid) |>
  mutate(trip_id = dplyr::consecutive_id(date, site, vid)) |>
  mutate(datem = floor_date(date, "month")) |>
  group_by(datem) |>
  summarise(n_measured = n(),
            n_dates = n_distinct(date),
            n_trips = n_distinct(trip_id),
            .groups = "drop") |>
  filter(year(datem) >= 2014,
         year(datem) <= 2023)
d.sum |>
  ggplot(aes(datem, n_dates)) +
  geom_point() +
  labs(title = "Number of distinct dates")
```

Appendix 12: Number of Trips Sampled from Excel Historical Data, 2014 - 2023

```
d.sum |>
  ggplot(aes(datem, n_trips)) +
  geom_point() +
  labs(title = "Number of trips sampled")
```