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Modern Tools for Fisheries Data Collection and Data Management: Experiences From Suriname

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Abstract

Fisheries data and statistics are key to assess and monitor the status of exploited living marine resources and to inform evidence-based policy making for sustainable fisheries management. In the recent years, fisheries managers are faced with increasing data needs to meet reporting requirements, including biological, environment, social and economic information at national, regional and international level. The marine fishing sector in Suriname is relatively large and diverse, and collecting the required data is challenging. In revising the Suriname fisheries data collection system over the last three years, three modern tools and approaches were implemented to make the collection, processing and storage of fisheries data more efficient and reliable. (1) Digital forms were introduced to enter the data from landing samples collected by data enumerators at artisanal fishery landing sites. The forms were self-developed using KoboToolbox and eliminate the need to enter paper datasheets into large Excel spreadsheets, a tedious process prone to errors. (2) To process the large amounts of Excel spreadsheets containing raw data collected in the field (artisanal fleet) or self-reported by vessel operators (industrial fleet), data processing scripts written in Python were deployed to process and reformat the data, perform quality control and prepare the data for uploading in the database. (3) FAO's Calipseo platform was deployed as a central, web-based fisheries information system where all data are securely stored and statistics are computed. The introduction of these modern tools for fisheries data collection requires good internet connection, adequate data storage and back-up policies and, most critically, digital skills and expertise. Nevertheless, the tools are readily available and have the potential to make fisheries data collection more user friendly, more efficient and more accurate in many situations. Their adoption will therefore help to meet the increasing need for detailed fisheries statistics, in support of sustainable resource management and compliance with various reporting requirements.

KEYWORDS: Suriname, digital tools, fisheries data and statistics, marine resource management

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1. INTRODUCTION

Suriname's Exclusive Economic Zone (EEZ) features a wide continental shelf, transitioning from turbid brown waters near the coast to nutrient-poor blue oceanic waters further offshore (Artigas et al. 2003, Willems et al. 2015a). Such zoning affects the distribution of marine life, from estuarine catfishes to offshore pelagic species (Lowe-McConnell 1962, Willems et al. 2015b), resulting in a diverse landscape of marine fisheries. Estuarine activities are characterized by small wooden boats using an assortment of gears. The coastal fisheries, operating on the inner continental shelf, mainly utilize gillnets that drift with tidal movements. Offshore of the 10-fathom (18m) isobath, fisheries are predominantly (semi-)industrial, focusing on demersal fishes, shrimps, and large pelagic species using either bottom trawls or lines (LVV 2021).

Suriname's fisheries are economically pivotal. In 2022, the sector harvested 30,847 tons of fish and 2,117 tons of shrimp, contributing to 2.3% of the nation's GDP. A significant fraction of Suriname's working population, around 4,000 fishers and over 2,000 ancillary workers, relies on this industry (Smith and Burkhardt 2017, Vandorpe et al. 2020). Consequently, the stability of the fishing industry holds paramount importance for the nation's socioeconomic fabric.

The Fisheries Department of the Ministry of Agriculture, Animal Husbandry and Fisheries is responsible for managing, regulating and promoting the sustainable development of the nation's fishery resources for the benefit of the participants in the sector and the national economy (LVV 2021). One key aspect of sustainable management of fisheries is food security, i.e., to secure supply of seafood to local communities relying on fish as main source of protein (E.g., Stephenson et al. 2018). A second key element is economic development of the sector, balancing shared exploitation of resources by both the domestic-oriented small-scale fisheries and the export-focused industrial sector.

Fisheries data and statistics are critical for sustainable fisheries management. They are needed to assess the health and status of exploited resources and inform evidence-based policy making for sustainable development and management of fisheries (e.g., van Zwieten 2002). Secondly, data and statistics are needed to comply with national, regional and international mandatory documentation and reporting requirements. These include the European Union Catch Certification Scheme, Import Provisions under the USA Marine Mammal Protection Act, Sustainable Development Goal indicators, and catch statistics requested by various organizations including the Food and Agriculture Organization (FAO) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). Additional calls for data are requested on a voluntary basis to enrich the knowledge of the regional fishery, especially in the context of shared stock of the Northen Brazilian shelf by the Western Central Atlantic Fisheries Commission (WECAFC) and the Caribbean Regional Fisheries Mechanism (CRFM) . In recent years, the Suriname Fisheries Department has been facing a growing demand for high quality and detailed data and statistics to comply with the various reporting requirements. Increasingly, information requests include social, economic, gender and environmental aspects, which are traditionally not monitored.

To address the increasing reporting needs, and obtain more reliable and timely data and statistics in support of sustainable fisheries management, the Suriname Fisheries Department engaged in an improvement process of its fisheries data and statistics supply chain, starting in 2020. Key aspects of this process have been the implementation of revised data collection methodologies and strategies for both the industrial and artisanal fleet, improved data processing and quality control practices, and the deployment of a central, web-based database to store, access and analyse fisheries data. In each step of the improved data flow, modern tools have been implemented that were, until recently, new to fisheries data collection in Suriname.

These are presented and discussed in the current paper, as we believe it is worth sharing what these tools can do, how they can be used to improve fisheries data collection and what some of the considerations are when planning to implement them.

2. METHODS

Suriname's current, improved fisheries data and statistics supply chain is visualized in Figure 1. Industrial fishery operators are required (by license condition) to self-report catch and effort data in an Excel format provided by the Fisheries Department, resulting in a total count (census) of industrial fisheries data. Catches from the artisanal fleet, on the other hand, are estimated based on the raising of catch and effort samples, collected by data enumerators of the Fisheries Department, following a stratified random sampling design.

The modern tools that are part of the revised data collection strategy in Suriname fit in at various stages of the data collection process. Digital data entry forms (developed in KoboToolbox) are introduced to improve field data collection in the artisanal fishery. A second 'tool' is the use of Python scrips to process data from both the artisanal fishery (received through the digital forms) and the (semi-)industrial fishery (received in Excel format). Finally, all data are entered into a web-based application based on FAO's Calipseo platform[1] (Figure 1).

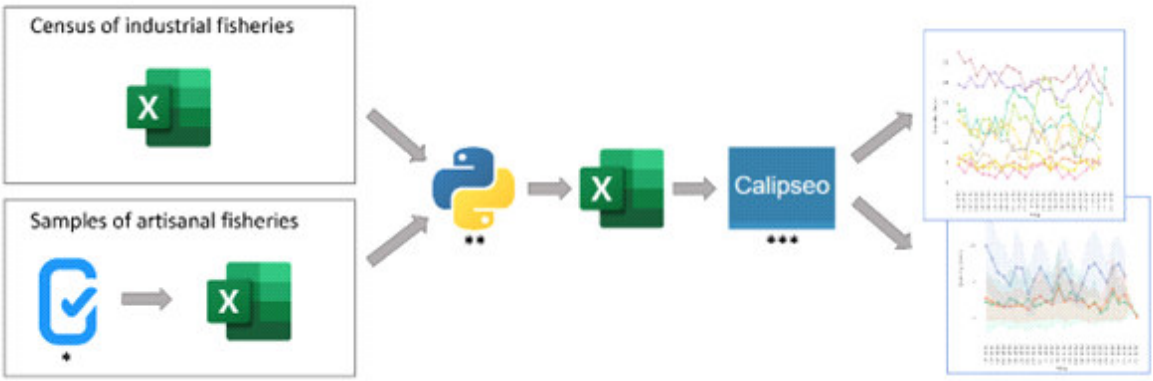

Figure 1. Schematic representation of Suriname's improved data and statistics supply chain. The modern tools that are part of the data flow include digital data entry forms developed in KoboToolbox (*), data processing scripts written in Python (**) and Calipseo as a central, web-based database (***).

2.1 Digital data entry forms

Catch and effort data from the artisanal fleet used to be collected on paper forms by data enumerators, entered into Excel spreadsheets and sent to the Fisheries Department by email. This two-step process of data entry (first on paper, then in Excel) has now been replaced by digital data entry forms developed in KoboToolbox. KoboToolbox is an open-source platform for the collection, management, and visualization of data[2]. The platform allows users to build and deploy XLSForms. Once forms have been deployed, data can be collected via KoboToolbox in two ways: through Enketo webforms (accessed via a browser) or through the KoboCollect application for Android.

In the field, data enumerators complete the digital forms using a mobile Android device. Forms can be completed offline. When the device is connected to the internet, completed forms are uploaded to the KoboToolbox server. Every data enumerator has his or her own KoboToolbox account where data can be reviewed and visualized.

[1] https://www.fao.org/fishery/en/statistics/software/calipseo
[2] https://www.kobotoolbox.org/about-us/

Data collected using the digital forms are uploaded by the data enumerators on a daily basis. At the Fisheries Department, all data are reviewed using the KoboToolbox web interface. In a first phase of quality control, the data are manually checked by Fisheries Department staff for completeness and accuracy. If needed, the data enumerators are contacted and corrections are made. The web interface contains a feature for record validation which allows Fisheries Department staff to assign a validation status to each submission. This is used to mark forms as completed and verified. Data are downloaded from the KoboToolbox server as Excel files on a monthly basis and stored for further processing (Figure 1).

2.2 Data processing scripts

All Excel files originating either from self-reporting (industrial fishery) or downloaded from the KoboToolbox server (artisanal fishery) (Figure 1) are processed using scripts. The scripts are written in Python (Van Rossum and Drake 1995), a general-purpose computer programming language often used to build websites and software, automate tasks, and analyze data. The Python scripts perform various tasks, which can be grouped into *quality control*, *cleaning & compiling* and finally preparation for *uploading to Calipseo*.

2.2.1 Quality Control

When the received landing data are complete for a quarter (in case of industrial data) or a month (in case of artisanal data), a second phase of quality control takes place. This phase of quality control is largely automated through the use of Python scripts. The scripts are used to (1) extract the data from the individual forms (industrial data) or the KoboToolbox exports (artisanal data), (2) compile the data and (3) automatically perform a series of checks on it. These checks consist of both *validity checks* (data type, format and acceptable value range) and *accuracy checks* (accurate or reasonable values).

Validity checks mainly relate to the type and format of the data, e.g., the way vessel registration numbers, dates, times, etc. are entered. When the validity checks are completed, *accuracy checks* are performed. These checks relate to the actual values of the data, rather than the type and format. For example, while the validity check verifies whether a species is entered correctly as a 3-letter code (FAO ASFIS code[3]), the accuracy check will compare the species code to a list of species that are expected in the fishery. In cases where comparison with an exact value is not possible, the accuracy check is done by manually comparing summary statistics of the data (calculated by the script) with pre-defined ranges of acceptable values (e.g., trip duration for a certain vessel-gear type should be between X and Y days). An overview of the parameters included in the accuracy checks can be found in Table 1 and Table 2.

Table 1. Overview of the parameters included in the automated part of the accuracy check and the corresponding reference data that they are checked against

Parameter	Checked against
Vessel registration number	Vessel registry
Vessel name*	Vessel registry
Vessel flag	Vessel registry
License type	Vessel registration number
License holder	List of issued licenses
Species code (ASFIS)	Reference list of species
Fishery product**	Reference list of fishery products
Trip number sequence	Chronological sequence
File name	Protocol for storing forms
File path	Protocol for storing forms

*Based on vessel registration number.
**The combination of species and processing.

[3] https://www.fao.org/fishery/en/collection/asfis/en

Table 2. Overview of the parameters included in the manual part of the accuracy check and the corresponding set of statistics calculated by the script.

Parameter	Statistics
Departure date, arrival date	Min, max
Trip duration, landed weight per trip	Min, max, mean per fishery type
Landing site	Unique values per fishery type
Number of fishers	Min, max per fishery type
Ice bought	Min, max per fishery type
Fuel spent	Min, max per day at sea, per fishery type
Food costs	Min, max per person, per day at sea
Ice price, fuel price	Min, max, mean
Catch price	Min, max, mean per species

2.2.2 Cleaning & Compiling

After ensuring the data are valid and accurate, a script is used to clean and compile the data, in preparation for upload to the Calipseo database. During this process the data are extracted from the forms or exports, cleaned (removal of excess spaces, harmonisation of case and spelling) and translated from Dutch to English. Furthermore, additional data necessary for the upload to Calipseo (e.g., fishery product code, fishing gear code, fishing zone code), are derived from the form input. The final output of the script is a table of a specific format, ready for upload in Calipseo as an Excel file.

2.2.3 Uploading to Calipseo

The Excel file containing the validated, cleaned and compiled data is uploaded to a *data validation tool,* which is an R Shiny application within Calipseo. The tool outputs an SQL script, which is then applied on the production database using MySQL Workbench to upload all the data in the Excel file. Currently, only industrial ('logbook') data can be uploaded in this manner. The bulk upload to Calipseo is done per quarter and the compilation includes data from all industrial fishery types.

2.3 Web-based database

FAO's Calipseo platform was deployed as a central, web-based fisheries information system where all data are securely stored and statistics are computed. A full deployment of the Calipseo tool was done in Suriname, including registries of fishers, vessels, companies and licenses, as well as modules to enter and process all fishery dependent data originating from these vessels, collected either by data enumerators in the field (samples of artisanal fisheries) or self-reported (census of industrial fisheries). The tool also includes reporting components and associated monitoring dashboards for the key indicators needed to manage fisheries, such as catch, effort, number of vessels, number of fishers, etc. In order to facilitate harmonized reporting, it implements standards classifications (ASFIS species list for instance) and is based on standard methodologies such as "Artfish" developed for small-scale fisheries statistics for the last 30 years by FAO (Stamatopoulos 2002).

The Calipseo platform is hosted by a governmental data center in Suriname, and can be accessed from anywhere using login credentials. All users have specific access rights, depending on their role they can only access certain sections of the database, or have 'view only' access.

3. RESULTS

Digital data entry forms, scripts and the web-based database all play key roles in the revised data collection strategy in Suriname. It is worth reviewing the specific functions these tools perform, and compare the situation before and after their deployment.

Key advantages of the use of digital data entry forms include the fact that data only needs to be entered once and that digital entry is faster and less prone to errors due to the use of dropdown lists and data validation restrictions. Quality control of the data submitted through digital forms is easier due to the user-friendly KoboToolbox web-interface to review and correct data. Since digital forms can easily be submitted on a daily basis, the process of reviewing the incoming data is spread-out and not concentrated at the end of the month as it used to be. Finally, while digital forms do require a one-time investment in a mobile device, there is no need for continuous copying, distribution and submission of paper forms (Table 3).

Data processing scripts play a central role in the improved fisheries data flow in Suriname. They execute various operations on the data that were previously not performed, including data cleaning and compilation of larger monthly or quarterly datasets for storage and further analysis. The most important feature of the scripts, however, is their ability to perform automatic quality control, checking the entries for both validity and accuracy.

The deployment of Calipseo as a central web-based database has dramatically changed storage, access and analysis of fisheries data in Suriname. While data were previously scattered in numerous files, on various devices, they are now securely stored in a central location, accessible through the web by anyone with valid user-rights and credentials. Since the database holds data from registries (vessels, fishers, licenses, etc.) as well as catch data, these two data sources can be verified against each other, which can help in tracing Illegal, Unregulated and Unreported (IUU) fisheries (e.g., catch data is collected by enumerators from vessels without a valid fishing license). Finally, Calipseo includes an RShiny application for automatic calculation and visualization of key fisheries statistics, which formerly had to be calculated manually.

Table 3. Comparing the situation before and after the deployment of modern tools for fisheries data collection in Suriname

Digital data entry forms	
Before	*After*
Data entered twice: paper and then Excel	Data only entered once
Any value can be entered into the forms	Input restrictions in digital form
Manual quality control of large Excel files difficult	User-friendly quality control in KoboToolbox web interface
Data submitted monthly: staff overwhelmed at end of the month	Data submitted on daily basis: workload spread out over the month
Need to copy and distribute paper forms	No need for paper forms
Data processing scrips	
Before	*After*
Manual and limited quality control of data	Automated data quality control
No automated data cleaning	Automated data cleaning
No compilation of data in monthly/quarterly datasets	Data compiled into monthly/quarterly datasets
Web-based database	
Before	*After*
No central storage of data	All data, including registries and catch data, stored centrally
No secure storage of data	Data stored a served with redundancy and back-ups
Data not easily accessible due to scattered nature of data files	Easy access to web-based database using login credentials
No cross checks between catch data and registries of vessels	Catch data verified against registry of licensed vessels
Manual calculation and visualization of key statistics	Automatic calculation and visualization of key statistics

4. DISCUSSION

It is clear that the modern tools presented here, all play a critical role in the improved fisheries data and statistics supply chain in Suriname, and their implementation can be called successful. An important key to the success of these tools is the fact that they are readily available. KoboToolbox is an open-source platform, where users can have a free plan that includes 10,000 submissions per month and 5 GB free data storage[4]. While users can get a paid account that includes more monthly submissions, unlimited data storage and some other options, the free plan is largely sufficient for the fisheries data collection needs in Suriname, and probably in many other countries. To ensure the 5 GB storage is not exceeded, data can be downloaded from the KoboToolbox server at regular intervals and stored elsewhere, freeing up space for new submissions. Python as well is free to use and so are various integrated development environments (IDEs) that can be used with it, e.g., Jupyter and PyCharm. Calipseo is currently deployed by FAO, upon requests by countries. However, the application is to become available as open-source software in the near future (Taconet and Laurent 2023), which means that installation and maintenance of the application can entirely be done locally, without the strict need for support by FAO experts.

The fact that the tools presented here are, or will become, open-source software (OSS) is not only key to their current success, but also to ensure their continuity. The use of software that is subject to monthly or yearly subscription fees or paid updates is likely to be discontinued when external project funding runs out. Furthermore, OSS is typically supported by a user-community, ensuring further development and de-bugging by users. This is in contrast to applications that are dependent on proprietary IT solutions, which might become obsolete once they are discontinued by the supporting company. This is exactly what happened to CARIFIS, a data storage software developed and promoted by the CARICOM Fisheries Unit in the early 2000's (FAO 2004).

One could argue that there are still vulnerabilities in the tools presented here, notably KoboToolbox, which is a 'foreign' platform with no guarantee that the application will remain (freely) available in the future. The use of digital surveys for data collection, however, is clearly on the rise (Lakshminarasimhappa 2022), and it is therefore likely that a suitable alternative will be found should KoboToolbox be unavailable or deemed unsuitable in the future. Already, several alternatives currently exist such as CognitoForms, Typform, Microsoft Forms, etc. The future of Calipseo could be questioned as well: FAO is developing a strategy for long term maintenance of the system (Taconet and Laurent 2023) but its publication as open source will enable the development of a broader community of developers and users which will be key for its long-term sustainability. Further, it is possible that other web-based applications based on the same OSS approach to serve as a central fisheries information system will emerge in the coming years. Finally, while our data processing and quality control scripts are written in Python, other OSS languages are available that are equally effective, notably R (R Core Team 2023). While specific software solutions are presented and discussed in the current paper (KoboToolbox, Python, Calipseo), we mainly want to convey what these tools can do to help improve the fisheries data and statistics supply chain, i.e., digital, mobile data collection, automatic data processing and quality control and central, web-based storage of data. These tasks might be performed by different software applications and choosing which ones to use might depend on various factors, including characteristics of the fishery, experience and skills of staff responsible for data collection and data processing and available financial resources.

The introduction of modern tools for fisheries data collection in Suriname has brought mainly advantages and the overall experience so far is a positive one. There are, however, some

[4] https://www.kobotoolbox.org/pricing/

considerations and conditions associated with the introduction of these tools. First, in comparison to the former data collection strategy in Suriname, the internet plays a much more important role. Internet connection is needed to submit completed KoboToolbox forms, to access and download data from the KoboToolbox server and to access Calipseo. A stable internet connection is therefore needed for both the data enumerators (although forms can be completed in the field offline) and the staff at the office responsible for data processing, storage and analysis. A second condition accompanying the switch to digital tools is the need for an adequate back-up policy to protect against any catastrophic los of IT hardware. In Suriname, Calipseo is hosted in the governmental data centre, on servers with built-in redundancy storage. In addition, data are backed-up on a daily basis to a PC located at the Fisheries Department. Finally, compared to 'traditional' fisheries data collection, the use of these digital tools requires new technical capacity and skills. While both KoboToolbox and Calipseo have a user-friendly interface (front-end), the use of scripts (in either Python, R or another language) requires skills in programming. Training and capacity building, as well as exchanging experience and knowledge in the use of these tools is critical (and currently catalysed by the CRFM by organizing R trainings and stimulating and R-user community in the region[5]).

Despite these conditions, the modern tools presented in this paper have clearly improved fisheries data collection and statistics in Suriname. The improvement process is ongoing, and new functionalities will be introduced as they become available (e.g., an Application Programming Interface (API) between KoboToolbox and Calipseo has been successfully tested in some countries). In conclusion, we believe that modern, freely available digital tools have the potential to make fisheries data collection more user friendly, more efficient and more accurate in many situations. Their adoption will therefore help to meet the increasing need for detailed fisheries statistics, in support of sustainable resource management and compliance with various reporting requirements.

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[5] https://www.crfm.int/index.php?option=com_k2&view=item&id=761:18-fisheries-professionals-equipped-with-new-skills-through-the-crfm-gro-ftp-fisheries-assessment-and-data-modelling-course&Itemid=179

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List of Table Captions

Table 1. Overview of the parameters included in the automated part of the accuracy check and the corresponding reference data that they are checked against.

Table 2. Overview of the parameters included in the manual part of the accuracy check and the corresponding set of statistics calculated by the script.

Table 3. Comparing the situation before and after the deployment of modern tools for fisheries data collection in Suriname

List of Figure Captions

Figure 1. Schematic representation of Suriname's improved data and statistics supply chain. The modern tools that are part of the data flow include digital data entry forms developed in KoboToolbox (*), data processing scripts written in Python (**) and Calipseo as a central, web-based database (***).