Development of a Bespoke Fisheries Information Platform for Barbados

Desarrollo de una plataforma de información pesquera personalizada para Barbados

Développement d'une plateforme d'information sur la pêche sur mesure pour la Barbade

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EXTENDED ABSTRACT

INTRODUCTION

Small-scale fisheries across the Caribbean suffer from data scarcity, hampering the development of effective fisheries policies and regulations (Gill et al 2019). Data driven solutions to inform decision making have been heralded as the strategic direction to address existing gaps in data collection mechanisms (Ainsworth et al. 2005, Bhavnah et al. 2020). Digital transformation of the fisheries sector in Barbados has been clearly articulated as a key policy directive in the Barbados Fisheries Policy (BFD 2023). The integration of digital technologies to shore up existing human resource limitations has led to an improved data collection program which has resulted in the generation of many datasets in several formats. This warrants the need for the design and development of a fisheries information platform tailored to the local context in Barbados to provide key data insights and support evidence-based decision making.

Fisheries landing statistics in Barbados have evolved significantly over the past several decades (King 2024). Initially, in the 1950s, data collection relied on paper-based records kept by shed keepers at landing sites, primarily focusing on total weight landed (Mahon et al. 1982). By the early 1980s, these records were expanded to include the total weight landed by a disaggregation of species. In the 1990s, the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) introduced the Licensing and Registration System (LRS) and Trip Interview Programme (TIP) to capture vessel registrations and landings data, respectively. These programs, implemented by the Barbados Fisheries Division, relied on information collected from fish landing shed keepers and data collectors at landing sites.

The early 2000s saw the introduction of digital platforms such as the Caribbean Fisheries Information System (CARIFIS) developed by the Caribbean Regional Fisheries Mechanism (CRFM) Secretariat, though its implementation was short-lived due to limitations reported such as: technical issues regarding software upgrades, lack of training on the CARIFIS platform and it wasn't user friendly (Masters, 2012). Subsequently, the Fisheries Information System for Barbados (FISBARB) was developed in 2003 and is currently used to manage vessel and fisherfolk registrations, while Microsoft Excel was used to capture landings data (Parker, 2007).

During this period, efforts were made to expand data collection to secondary and tertiary landing sites, including ex-vessel price information (Staskiewicz et al. 2008). This was successful for a couple of years, however, challenges of transportation to these sites, lack of timely data collection and a reduction in data collectors led to a halt in data collection efforts at secondary and tertiary landing sites between 2010 and 2015. The addition of a vessel monitoring system called Pelagic Data Systems under the programme DigiFish, provided additional insights for geospatial data of fishing trips. In 2023, a new survey was introduced on the platform called Kobo Toolbox which digitized the existing paper-based catch and effort data collection form (Figure 1).

From April 2024, efforts on modernizing existing data management began in earnest through a collaboration with Intergen Technology Inc. The database component of the platform was designed to be robust, secure, and capable of managing high-volume, multi-dimensional datasets. Requirements for the migration, architecture, data integrity, security, and management functionalities of the database were established from the onset to promote efficient operations including the real-time ingestion of data. A vital component of the platform, the dashboard, will serve as a visual interface, delivering real-time insights and analytics drawn from the system's comprehensive data repositories. It has been designed to cater to a wide range of stakeholders, including fisheries management officials, policy makers, researchers, fisherfolk, and the general public.

The overarching design and development of the platform must prioritize scalability, performance, reliability, and user support to ensure its long-term success and adaptability to evolving fisheries management needs. This paper highlights the process of creating a state-of-the-art bespoke Fisheries Information Platform for Barbados, aiming to address data scarcity in fisheries management. This system will consist of three main components: a database, Application Programming

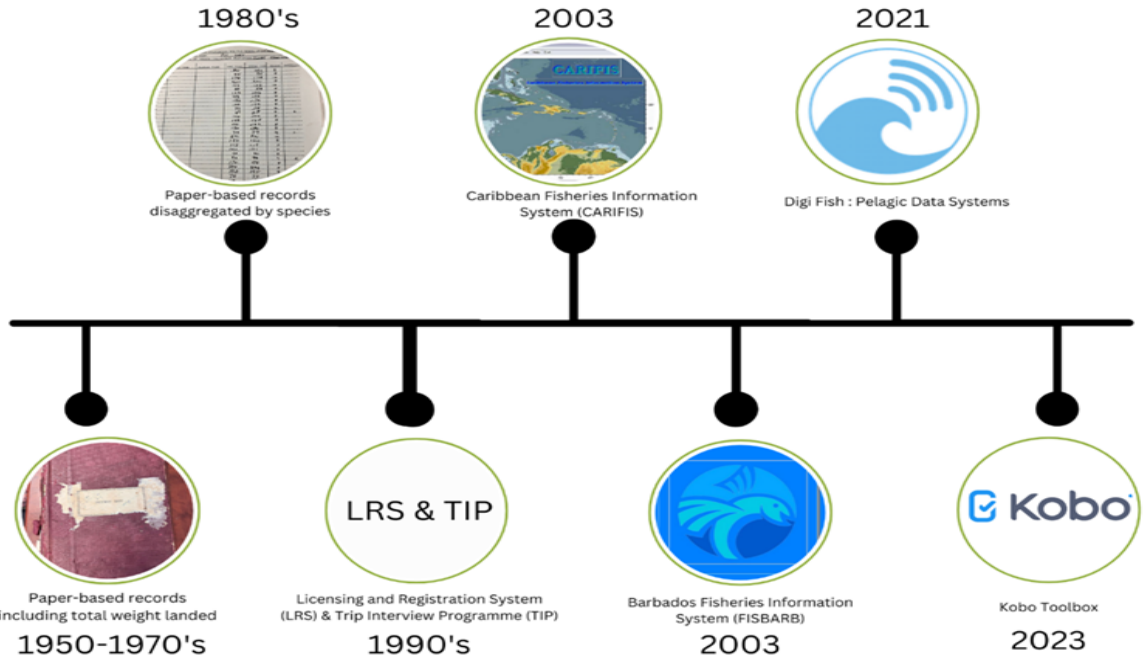

Figure 1. Fisheries Data Management Timeline (Source: Barbados Fisheries Division and King 2024)

Interfaces (APIs) for integration and interoperability, and a user-friendly dashboard. The paper ends with recommendations for future developments and the long-term vision for digital transformation of the fisheries sector in Barbados.

METHODS

System Requirements and Design

The development of the Barbados Fisheries Information Platform began with a thorough requirements elicitation process. Collaborations were held with the Barbados Fisheries Division (BFD) to identify data sources, legacy workflows, stakeholder roles, and desired enhancements over the existing systems. The project team conducted interviews, review sessions, and iterative discussions with fisheries officers, data collectors, policy makers, and information technology (IT) staff to clarify the scope and establish functional and non-functional requirements. Emphasis was placed on facilitating integrated data management, providing a seamless user experience for data collection, and enabling rapid analysis and reporting.

Using the collated requirements, a system architecture was conceptualized (Figure 2). The platform would be centered around a robust relational database, supported by secure Application Programming Interfaces (APIs) and a modular, web-based front-end interface. The design also incorporated role-based access controls (RBAC), ensuring that each category of user—fisheries staff, managers, policy makers, researchers, and selected external stakeholders—would have tailored access and permissions in accordance with data governance protocols.

Data Migration and Database Development

A key objective was to consolidate disparate data stores into a single, modern database system. Historical vessel and fisherfolk records existed in a legacy Microsoft Access database, while fisheries landings data were managed in spreadsheets and other siloed data stores. The Access database was first exported, transformed, and normalized to produce a coherent data schema in PostgreSQL. Data cleansing steps were undertaken to resolve inconsistent naming conventions, duplicate records, and missing values. Additional data integrity checks, such as referential constraints, were introduced to ensure long-term data quality.

PostgreSQL was selected as the principal database management system (DBMS) due to its scalability, robustness, and support for complex queries. The newly designed schema structured data around core entities—fisherfolk, vessels, fisheries landings, inspections, and related attributes—while accommodating future expansions. Detailed Entity-Relationship (ER) modeling guided the database schema to align with both current and anticipated data collection needs.

API Development and Interoperability

Following the database establishment, a suite of RESTful APIs was developed to facilitate controlled data interchange. These APIs were implemented using open-source frameworks and were configured with authentication and authorization layers to enforce RBAC. The APIs enabled secure integration with both internal and external systems, including survey instruments and existing regional

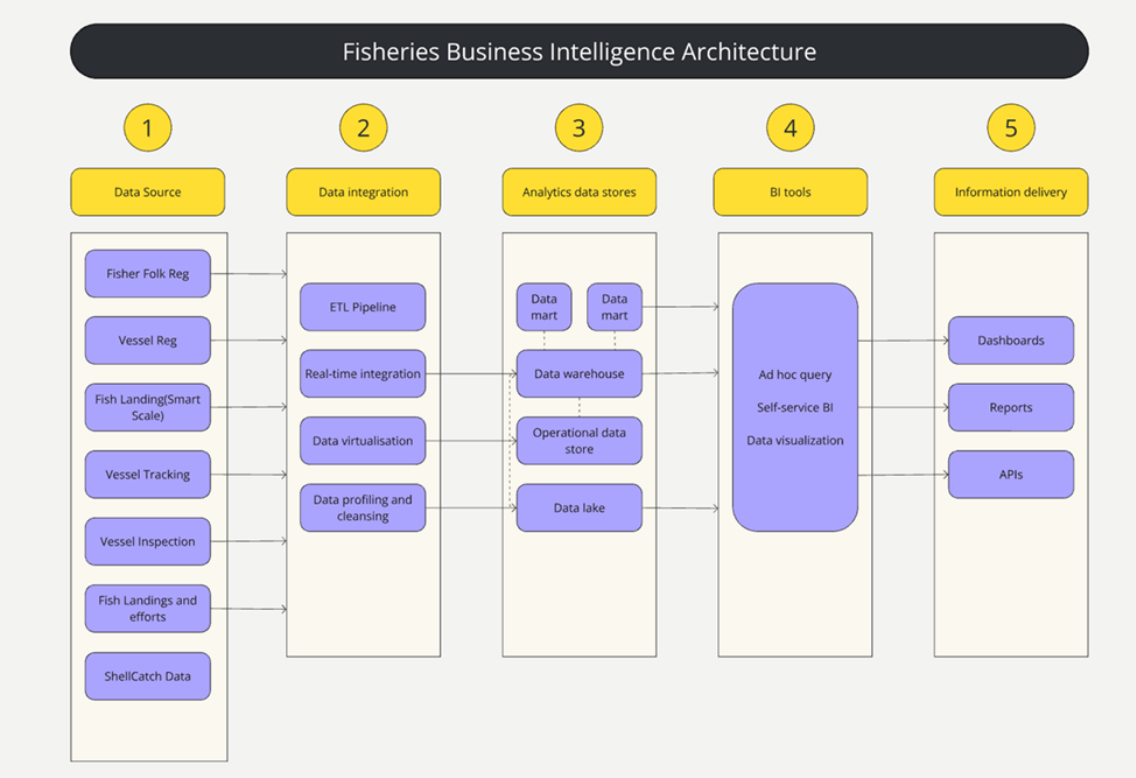

Figure 2. Schematic of Fisheries Business Intelligence Architecture.

fisheries monitoring tools. By adhering to standardized data exchange protocols, the platform ensures interoperability with third-party applications such as Pelagic Data Systems, Shell Catch, and Remora Fishing Traceability, thus supporting geospatial data ingestion and extended analytics.

Front-End Application and Data Collection Tool

A web-based front-end application was built using React, providing a responsive and user-friendly interface. This interface was designed to streamline data entry tasks, querying routines, and visualization dashboards. Existing paper-based and spreadsheet-driven workflows—such as vessel inspections, fisherfolk registrations, and fisheries landings surveys—were digitized through integrated survey instruments. The team leveraged Kobo Toolbox for survey creation and administration, embedding these instruments directly into the platform's interface. This eliminated the need for separate data entry portals and subsequent manual data cleaning.

The front-end design underwent iterative refinement through user testing sessions with fisheries officers and data collectors. These sessions focused on improving form layouts, error handling, and navigation flows. Feedback was incorporated through agile development cycles to ensure that the final interface was intuitive, reduced manual effort, and minimized training requirements.

Analytics, Business Intelligence, and Visualization

To facilitate real-time and historical data analysis, the platform integrated Cube.js, an open-source analytics framework connected directly to the PostgreSQL database. This integration allowed for dynamic querying of fisheries data and the generation of analytic dashboards tailored to various stakeholder groups. End-users could visualise key performance indicators, and historical landings trends. Built-in data filtering and grouping options enabled users to derive insights without requiring advanced technical skills. The dashboards were tested to ensure that all visual elements remained interpretable in both color and grayscale, in anticipation of diverse publishing and printing conditions.

User Access, Security, and Governance

Security and appropriate data governance were paramount considerations. RBAC was embedded at the database, API, and front-end layers. User roles were mapped to organizational responsibilities, ensuring that sensitive data—such as personally identifiable information (PII) of fisherfolk—remained accessible only to authorized personnel. Periodic internal reviews and audits were conducted to verify that access patterns adhered to established policies, and the system architecture was stress-tested for performance and reliability.

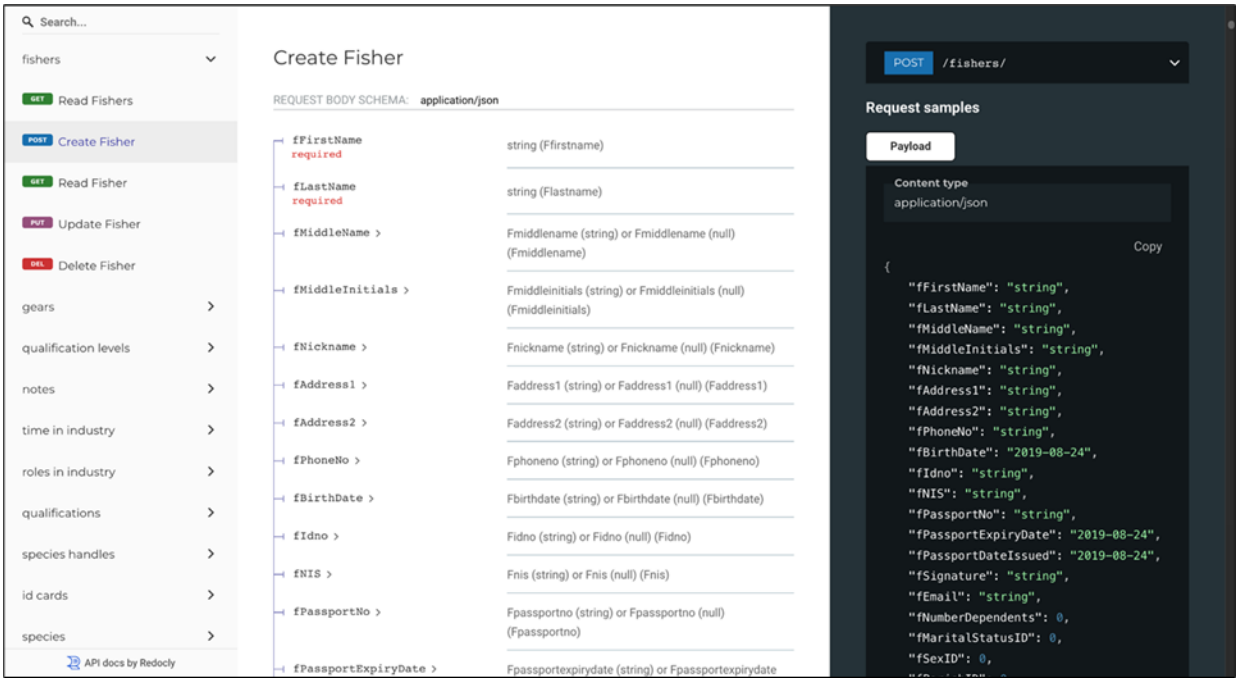

Figure 3. Data Migration Schematic.

Validation and Iteration

The final stages of development involved pilot testing and validation. A subset of fisheries staff was granted access to the platform to perform real-world tasks: registering new vessels, inputting updated fisherfolk credentials, completing landing surveys, and generating summary reports. Technical support was on standby to document issues and capture user feedback. Following this pilot phase, minor adjustments—such as refining data validations, updating help text, and optimizing certain API endpoints—were implemented. The iterative development approach ensured that the resultant Fisheries Information Platform accurately met the operational requirements, improved upon legacy processes, and was prepared for future enhancements.

RESULTS

The newly developed Fisheries Information Platform successfully integrated data from multiple legacy systems and external data sources into a centralized PostgreSQL database environment. This consolidation eliminated the need to maintain separate databases for vessel and fisherfolk registrations, inspections, and landings statistics. Following the data migration from Microsoft Access to PostgreSQL, historical records were harmonized and standardized, improving data consistency and integrity (Figure 3, Figure 4).

The platform's Application Programming Interfaces (APIs) enabled seamless interoperability between the internal database and various external applications. This integration streamlined data collection efforts and facilitated the incorporation of real-time geospatial and trip information from third-party providers such as Pelagic Data Systems, Shell Catch, and Remora Fishing Traceability. As a result, stakeholders could now access and utilize a more comprehensive range of fisheries data sources within a unified system.

A key outcome was the successful digitization of survey instruments (Figure 5). Previously managed through separate applications or paper-based records, vessel inspection forms, fisherfolk registration forms, and landing surveys were incorporated directly into the platform using a React-based front-end. User testing confirmed that the new interface reduced administrative overhead, minimized data entry errors, and improved the timeliness of data submission.

The integration of Cube.js as a business intelligence layer enhanced the platform's analytical and reporting capabilities. Users at the Barbados Fisheries Division could dynamically query, visualize, and analyze data—such as landing trends, vessel activity distributions, and regulatory compliance metrics—through customizable dashboards (Figure 6). This immediate access to real-time data analytics will allow fisheries managers, policy makers, and researchers to make evidence-based decisions more efficiently.

Role-Based Access Control (RBAC) mechanisms improved data security and confidentiality by regulating user privileges according to defined roles and responsibilities. Internal Fisheries Division users, policy makers, and authorized external stakeholders (e.g., universities, law enforcement) were granted tailored access to relevant

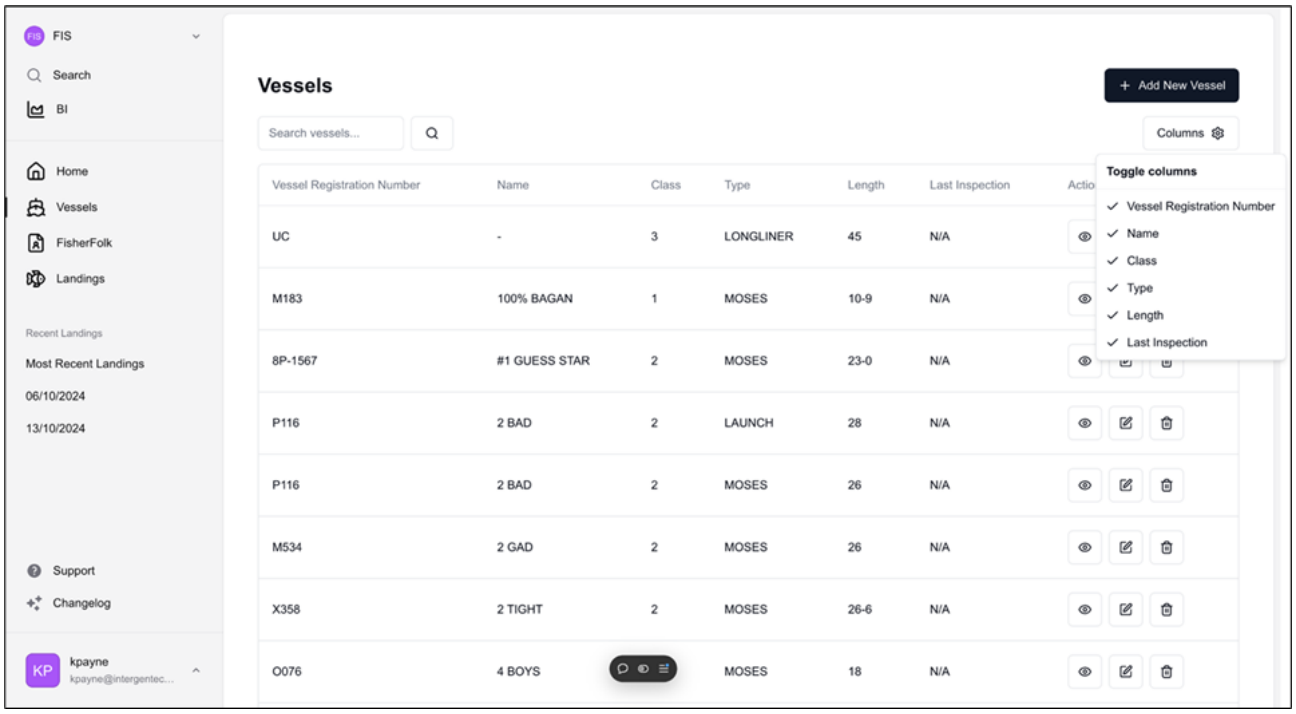

Figure 4. Vessels landing page .

datasets. Early user feedback indicated that these governance controls enhanced trust in the system and ensured data were shared appropriately.

Preliminary assessments of platform performance showed stable operation under test conditions, including simultaneous data entry sessions and complex analytical queries. The digital transformation of data handling—previously split among spreadsheets, Access databases, and manual forms—resulted in more streamlined workflows, reduced redundancy, and an overall improvement in data quality and accessibility. Together, these results demonstrate the platform's effectiveness in supporting integrated fisheries data management, real-time analytics, and policy-driven decision-making in Barbados.

DISCUSSION

he new Fisheries Information System embodies the key policy directive of digitally transforming the fisheries sector (Pita et al. 2019), capable of combining crucial pieces of information such as vessel information and associated owners and crew, trip information, and landing site statistics, alleviating the issue of integrated data management. In its remit to ensure its interoperability with other platforms, it has the ability to incorporate vessel monitoring system information from applications such as Pelagic Data Systems and Shell Catch, and Remora Fishing Traceability, collating catch and effort data, data which improves the traceability and transparency of the industry, and aids in efforts to reduce bycatch with the traditionally collected information.

Improvements in information sharing both internally for the Fisheries Division and externally are an added advantage of the new platform. It combines a wealth of information not only beneficial to the Fisheries Division, but the fisherfolk, academics, policy makers and law enforcement, increasing transparency and promoting communication.

The platform would provide data necessary to make informed sustainable management decisions. This is key for processes such as the Marine Spatial Plan that Barbados is currently undertaking, with information such as the visual representation of catch per unit effort and areas of heavy traffic being easily identified.

Previous systems also made it difficult to find data or share with others due to issues in functionality. Recent incidents, such as the aftermath of Hurricane Beryl, highlighted the need for readily available and easily shareable information to improve response times when data requests are made (Tilley et al. 2020).

Following the development of the platform, reports for landing statistics, vessel inspections and duty-free concessions will be automated. The platform will also have the ability to issue licenses and certificates for fisherfolk, aquaculturists, and seafood markets and businesses. This also applies to law enforcement agents out in the field who need quick access to information. Agencies such as the Barbados Coast Guard and the Marine Police will be able to automatically generate reports in a timely manner on matters which concern Illegal, Unreported, and Unregulated fishing for example. The increase in data further improves monthly reporting, enhancing economic studies

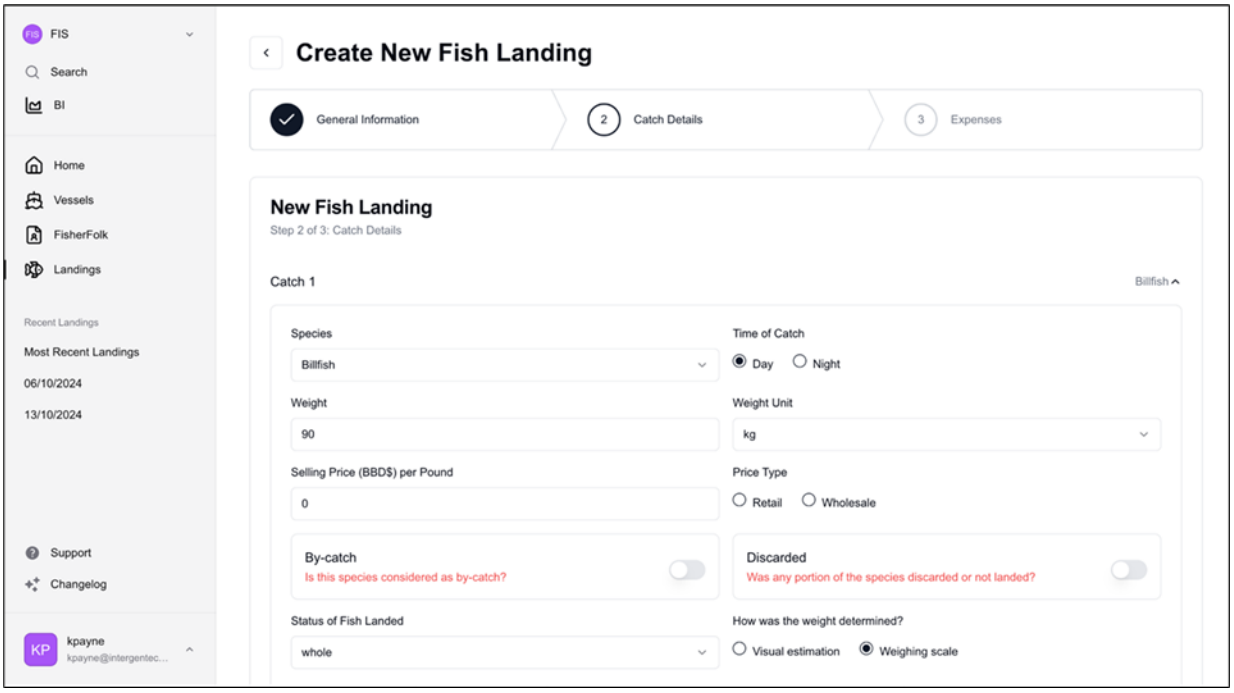

Figure 5. Catch and effort Data E– form.

which determine the sector's contribution to the island's Gross Domestic Product (GDP).

Finally, the long-term vision for the platform is the potential to support a financial model where data requests including the production of customized visualizations will be monetized. It is envisaged that API keys can be sold on established API marketplaces to support hardware acquisitions for data collection and the overall sustainability of the platform. This innovative model will ensure the platform's long-term success and adaptability to evolving fisheries management needs.

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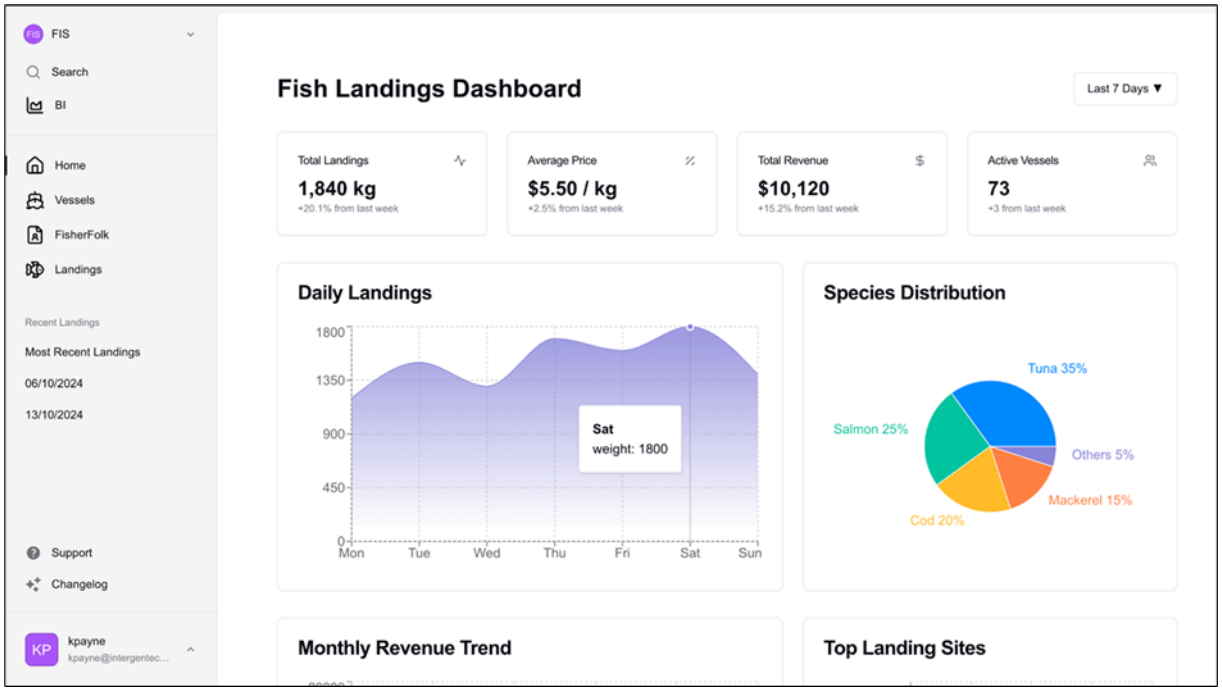

Figure 6. Mockup of Customizable Dashboard.

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