# CONTRIBUTION 3.3

# The Power of Data-driven Fisheries Governance

Vilhjálmur Hallgrímsson

*Fisheries Technologies ehf., Chief Executive Director,*
*Básbryggja 15, 110, Reykjavík, Iceland*
*vh@fishtech.is*

## Abstract

Fisheries management is a complex field with limited research and comprehensive data on techniques and costs. Many fisheries worldwide face challenges due to knowledge deficiencies, lack of standardized data management solutions, and high costs.

Iceland's experience demonstrates how data-driven fisheries management can revolutionize practices and contribute to long-term sustainability and success. This paper aims to identify key challenges affecting fisheries management data systems and answer what an optimal fisheries management system would look like.

Our goal is to research how to develop dynamic, adaptable data management solutions while reducing costs, enabling other nations to emulate Iceland's success in fisheries management.

The insights gained from Iceland's experience could offer valuable guidance and tools to other fishing communities aspiring to establish sustainable fisheries management techniques.

*KEYWORDS: Data-management for fisheries governance, Data-management costs, Data-management tools*

**CITATION:** Hallgrímsson, V., 2026. The Power of Data-driven Fisheries Governance. Contribution 3.3, p120-132 *IN* CRFM, 2026. Volume I: Technical Papers. Presented at the CRFM 20th Anniversary Scientific Conference, 28-31 August 2023. CRFM Special Publication No. 37, CRFM Secretariat https://www.crfm.int/index.php?option=com_k2&view=item&id=908

# 1. INTRODUCTION

In our world today, we confront a stark and undeniable reality where two formidable forces—fishing pressure and climate change—converge to threaten the very essence of our way of life. We find ourselves at a pivotal crossroads with an ever-growing consensus among those who truly comprehend the intricacies of our oceans. It's a consensus that leads us to one undeniable path forward, one guided by the principles of sustainable fisheries. For this, we must confer the responsibility of overseeing the fisheries sector to its custodians.

Utilizing living natural organisms, including fish, wildlife, and plants, for economic or other human purposes can yield significant advantages, such as food, fibres, and other valuable materials. However, this exploitation of natural resources, can also adversely affect the environment and the sustainability of these resources. Over exploitation, which involves using natural resources beyond their ability to regenerate sustainably, can result in reduced population sizes, habitat destruction, and even the extinction of certain species.

Fisheries are bustling hubs of activities, with thousands of vessels bringing in daily catches, igniting tens and hundreds of thousands of activities occurring throughout the entire fisheries value chain. How is it possible to obtain a holistic view of this complex sector? How do we bridge the gap between the frontlines of fishing activities and a comprehensive overview, equipped with all the statistical and management tools necessary for effective fisheries governance?

Generally, the core principles of sustainable fisheries management remain consistent across all fisheries, irrespective of their geographical location. The primary goal of fisheries management is to achieve the sustainable utilization of fishery resources while maximizing their long-term benefits. Evaluating these benefits involves considering various perspectives, including economic, ecological, and socio-economic factors. However, these viewpoints fundamentally rely on preserving robust fish populations that benefit present and future generations.

Nowadays, data touches almost every part of the fisheries sector. Compelling evidence highlights a strong correlation between proficient data management and sustainable fisheries. Countries that excel in data management have the capabilities to make informed decisions, develop effective strategies, and implement sustainable practices for their fisheries.

In contrast to many other industries, fisheries governance faces unique challenges as there are limited off-the-shelf data management solutions. Consequently, fishery data management solutions tend to be highly tailored. High costs associated with operating privately-owned information systems are widely recognized. On the other hand, when subscribing to cloud-based systems with larger user bases, economies of scale can lead to significantly reduced costs.

Similar to many other fisheries, Iceland has faced comparable challenges in the past. Nonetheless, Icelanders have achieved remarkable progress and implemented substantial reforms within their fisheries industry. Since the inception of the Icelandic quota system in 1992, the focus on data for fisheries governance has been consistently emphasized, and presently, data plays an integral role in all aspects of fisheries operations, making Iceland a leader in data-driven fisheries management.

Figure 1. Icelandic Fisheries

Profitable industries worldwide recognize the benefits of purposeful investments in data management to improve their competitiveness and return on investment. This is why Icelandic fisheries have invested significantly in data-driven fisheries management to sustain their high profitability. This data-driven approach helps governing bodies in Iceland make better decisions, optimize processes, innovate, and achieve more reliable and consistent outcomes by leveraging the power of data and analysis.

Iceland's experience is a compelling example of how data-driven fisheries management can revolutionize fisheries practices and contribute to long-term sustainability and overall success. By continuously monitoring and collecting data, Iceland can be responsive to changes in fish stocks, environmental conditions, and fishing activities, thereby facilitating sustainable and well-informed management outcomes.

The data-driven approach has also empowered Icelanders with real-time Monitoring, Control, and Surveillance capabilities and has enabled them to respond promptly to any situation. In the modern era, monitoring, control, and surveillance practices in fisheries heavily depend on data analysis, which facilitates the identification of trends and outliers. This data-driven approach provides valuable insights into the areas where control measures must be implemented. Moreover, it yields accurate and timely statistics derived from data which are essential for making informed stock assessments.

Fisheries management remains a field with limited research and a dearth of comprehensive data on techniques and related expenses. Consequently, to ascertain the status of data use in facilitating fisheries governance and the primary challenges facing other countries, we decided to undertake primary research that would inform the development of solutions.

We conducted interviews with fisheries managers from various fisheries across the globe. Our approach was methodical, involving the creation of a structured survey. Notably, participants were not required to possess extensive expertise in data management. Instead, they were invited to provide insights by describing key attributes that could shed light on the state of data management within their respective fisheries.

The query we aimed to address was: How can our team of experts develop dynamic, extendible, and highly adaptable data management solutions and simultaneously reduce costs to a degree that enables other nations to emulate the Icelandic trajectory and attain the recognized successes in their fisheries management?

## 2. METHOD

Drawing on the expertise and insights our team has gathered over the years, we set out to identify the key challenges affecting fisheries management data systems and answer the question, “in an ideal world, what would an optimal fisheries management system look like”? Furthermore, we needed to study different approaches employed by different fisheries worldwide and assimilate them into our newly devised framework.

Our group reimagined the Icelandic approach to enhance effectiveness, flexibility, and cost-efficiency. Should our efforts prove fruitful, the insights gained from Iceland's experience could offer valuable guidance and tools to other fishing communities aspiring to establish sustainable fisheries management techniques.

Our first primary challenge was to design a generic data system that is sufficiently flexible to be adapted to different fisheries policies without needing a redesign and complete overhaul.

Drawing from our expertise, fisheries management entails a range of significant challenges that can be categorized into three primary aspects i) instruments, ii) cost, and iii) access to data sources. Let's examine each of these in detail.

## 3. CHALLENGE 1 – INSTRUMENTS

Fisheries policies serve as instruments or tools to achieve specific objectives in fisheries management, such as sustainable resource utilization, conservation of fish stocks, and the promotion of responsible fishing practices. A fisheries policy is the primary determinant impacting the configuration and function of the data system. As input, the fisheries policy is pivotal in sculpting the data system's objectives and methodologies. However, a notable distinction exists between policy and data systems. The policy represents a profoundly political occurrence, dictating i) the allocation of resource quality among stakeholders and ii) sets the

Figure 2. Instruments

rules of engagement. Conversely, the data system operates as an impartial and scientific measurement tool, faithfully executing its functions in alignment with the policy.

Data management is not an isolated entity; instead, it forms an integral part of a much larger strategic framework. Iceland's effective approach to managing sustainable fisheries is built upon three fundamental pillars: policy, knowledge, and adequate funding. These pillars serve as the cornerstone for fostering innovation and, when coupled with strong leadership, constitute essential elements of Iceland's prosperous fisheries management strategy.

The Tricase Porto Algorithm

A: A good Fisheries Management
B: Knowledge and Data
C: Financial Resources
X: Leadership

A+B+C = Innivation + Leadership = Success

This comprehensive strategy can be distilled into a straightforward algorithm, sometimes referred to as the Tricase Porto Algorithm.

## 4. CHALLENGE 2 –COSTS OF DATA MANAGEMENT

One certainty in business is that every asset a company operates comes with associated costs. When discussing costs, it is of paramount importance to differentiate between the primary components that constitute the expenses associated with data management, namely acquisition costs and operational costs.

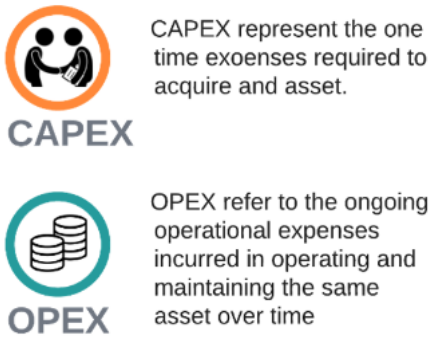


Figure 3. CAPEX - OPEX

However, conducting systematic data collection for fisheries, on national, or regional levels, is a costly endeavor, requiring leadership, infrastructure, appropriate tools, and financial resources to be successful.

In contrast to many other industries, fisheries governance faces unique challenges as there are limited readily available solutions. The range of available solutions varies greatly with respect to features and costs, spanning from, zero to millions of dollars.

We However, we found that the solutions with lower upfront costs often tend to be overly generic and lacking in their ability to accommodate the complex fisheries requirements of individual states. Consequently, efforts to reduce initial data management expenses may also manifest as increased operational costs elsewhere.

The limited accessibility of off-the-shelf solutions and the substantial costs associated with custom development have posed significant obstacles, hindering numerous states from adopting efficient data management practices and attaining their management objectives.

As a result, it has been typical for governing bodies to run their own IT infrastructure and custom solutions in-house. This often results in the system owner having to shoulder the “Total Cost of Ownership” (TCO) alone, with limited or no opportunity for cost sharing.

Fisheries data systems face well-known challenges affecting any data system during their life cycles. The first main challenge is that data systems become obsolete and become progressively less efficient, leading to higher operating costs. This is due to the swiftly evolving technological landscape, gradually leaving the current design behind, making it harder to align existing systems with contemporary business demands. This demands a resilient and adaptable infrastructure capable of addressing data processing, storage, and security requirements, along with proficient personnel responsible for upholding data precision, confidentiality, and the uninterrupted flow of operations.

One can reasonably hypothesize that OPEX generally falls within the range of 10-25% of the total CAPEX. Striking this balance between CAPEX and OPEX holds significance for seamless operations, implying that the system lifecycle could span 10 to 15 years. This implies that for every 1 million USD invested in software, there would be an annual operational expense of 100,000 to 250,000 USD.

I like to use the analogy of an iceberg to explain the components that generate costs in the data management perspective. Above the surface, you have a wealth of secure data that ideally generates all the necessary statistical reports and management tools on time. This section deals with one-time costs that are usually well-known and visible.

However, to maintain this level of data management over time, numerous tasks must be performed beneath the surface, and this is where we enter the realm of OPEX or operational expenditure.

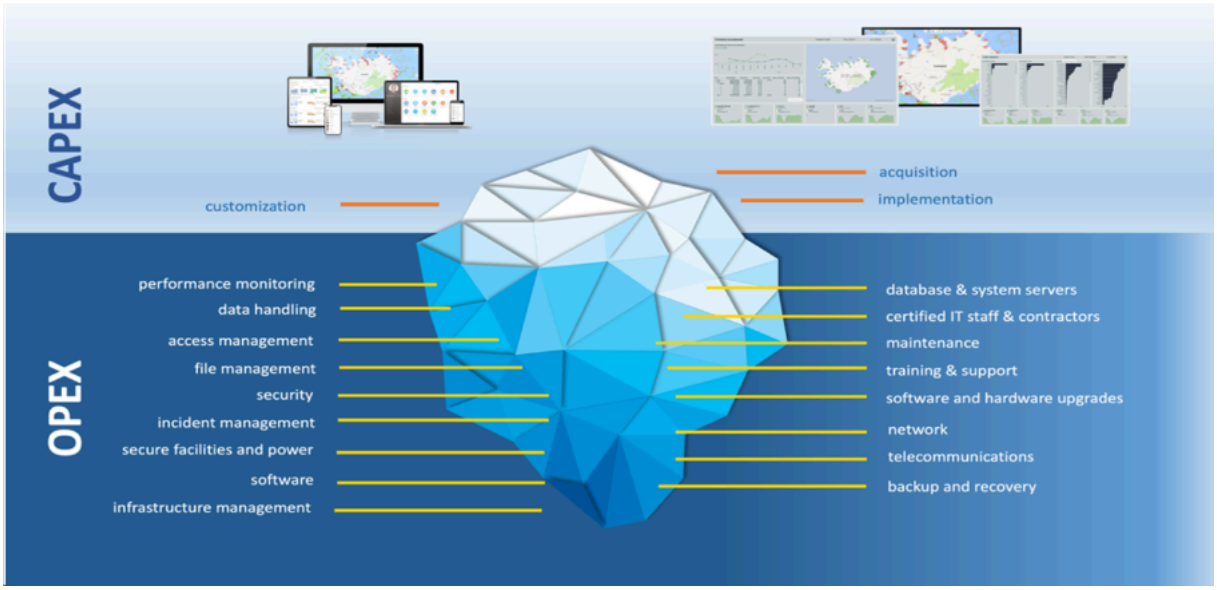


Figure 4. The components of data management

When breaking down the operational expenditures (OPEX) of data management into its primary components they give us greater insight into how these costs are generated. This section tends to be less visible and includes IT personnel and data specialists' salaries, electricity and cooling costs for running the equipment, software licensing fees, security measures, regular maintenance, and other operational expenses.

Despite being frequently overlooked and hidden from plain view, these crucial components play a vital role in the seamless functioning of the data management system. Based on empirical

evidence, it is evident that when data management tasks hidden under the surface become weak, it can have a ripple effect and derail the entire fisheries management infrastructure, preventing the retrieval of the benefits the fisheries can generate.

This paper focuses on the explicit expenditures linked to investments and the ongoing operational costs of resources tied to data management systems. Notably, this excludes the costs incurred by the end users and stakeholders who utilize the technology to collect or consume the data such as salaries of data collectors, travel costs, etc.

## 5. CAPEX AND OPEX REAL-WORLD EXAMPLES

Data costs for fisheries management remains a field with limited research, and there is a scarcity of comprehensive data regarding techniques and their associated costs. Nevertheless, we have managed to gather extensive data from multiple sources, enabling us to conduct an in-depth analysis of the expenditures linked to data management and what organizations are currently investing in fisheries data management. It should also be noted that although it is possible to identify the costs incurred by different entities in fisheries data management, this does not necessarily indicate that they are achieving satisfactory outcomes.

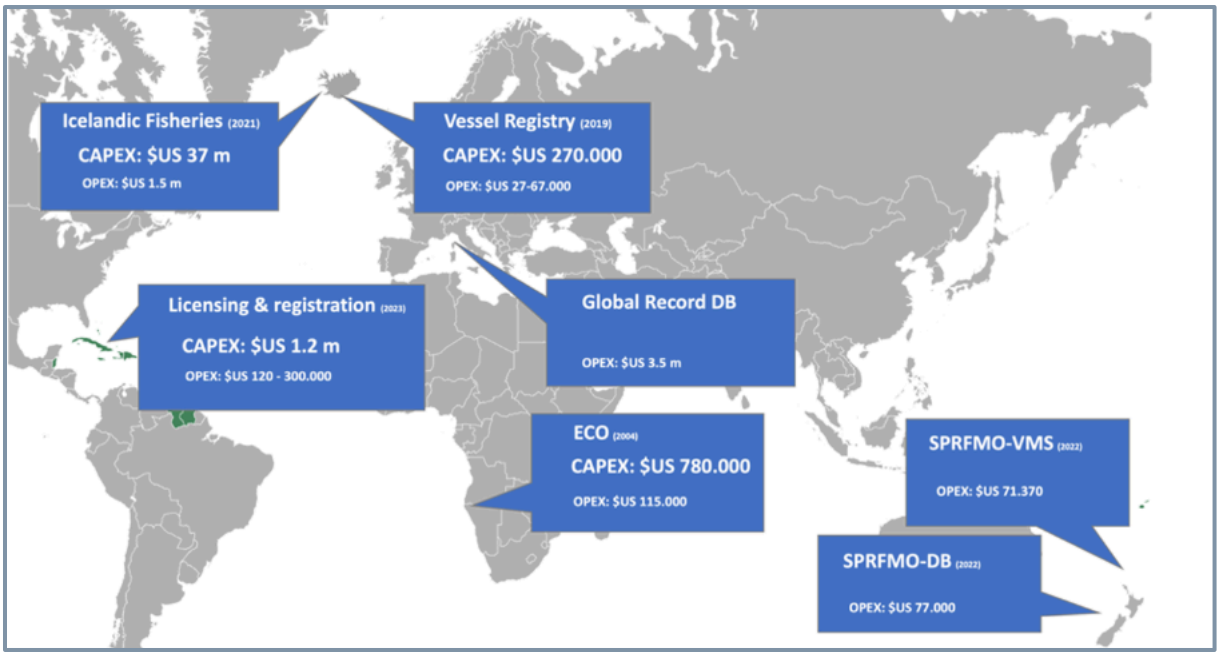


Figure 5. Cost examples

- Example 1 - A relatively simple regional database designed to retrieve and store data from member states in the South Pacific incurs annual operational costs of seventy-seven thousand dollars.

- Example 2 - The annual expense, of storing and processing data for Vessel Monitoring within the same region, amounts to 72 thousand dollars.

- Example 3 - Implementing a fisheries licensing and registration system in the Caribbean, requires a capital investment of 1.2 million dollars. The projected annual operational cost of the same, is anticipated to fall within the range of one hundred thousand, and two hundred and fifty thousand dollars.

- Example 4 - In 2019, an Icelandic vessel registration system was developed with a capital cost of two hundred and seventy thousand dollars. The annual operating cost is estimated to be 50 thousand dollars.

- Example 5 - From 2002 to 2004, a Fisheries Economic Database Project, supported by Iceland and conducted for the Namibian government, incurred capital expenditures totaling 780 thousand dollars. The projected yearly operating expenses range from 80 to 200 thousand dollars.

- Example 6 - In 2021, the operational expense for managing data related to Icelandic fisheries was 1.5 million dollars.

- Apart from the essentials, purchasing this amount also provides Iceland with a comprehensive data management system, Monitoring, control, and surveillance, along with all the necessary tools to cater to all sectors. Though this might appear to be a significant expenditure, it may not be so in the context that Iceland is handling and safeguarding its $1.2 billion asset.

- Example 7 - The annual operation cost of the Global Record system at the Food and Agriculture Organization of the United Nations is $3.5 million.

From this, it can be inferred that on average the cost for each system unit is nearly 600,000 USD, and for basic operations, a fishery requires a minimum of three of these units. Given this perspective, it is reasonable to infer the CAPEX for an entry-level data system tailored for fisheries management is approximately $1.7 million, with an annual OPEX of around $325,000.

Given this perspective, it is reasonable to infer the CAPEX for an entry-level data system tailored for fisheries management is approximately $1.7 million, with an annual OPEX of around $325,000.

It should also be noted that although it is possible to identify the costs incurred by different entities in the field of fisheries data management, this does not necessarily indicate that they are achieving satisfactory outcomes.

| Average cost per feature | | |
|---|---|---|
| Feature | CAPEX | OPEX |
| Vessel registry | US$588K | US$108K |
| Central DB/RFMO | US$588K | US$108K |
| Licensing and registration | US$588K | US$108K |
| Total | US$1.7mn | US$324K |

Figure 6. Average costs

## 6. CHALLENGE 3 – DATA SOURCES, PROCESSING, AND REPORTING

The fisheries sector is a bustling hub of activities where thousands of vessels may be bringing in catches of the day, igniting countless fisheries-related activities and processes throughout the value chain. How can regulatory authorities effectively attain a comprehensive and resilient understanding to oversee the sector on national or regional levels? The answer for Iceland is data-driven fisheries management.

We have observed on multiple occasions that government authorities face challenges in securing cooperation from fishermen to obtain essential information from them. In contrast, Iceland has achieved success by incorporating a provision into its fishing policy that mandates fishermen to adhere to specific requirements, including holding a valid fishing license, to access fisheries resources. To maintain the validity of their licenses, compliance with regulations is essential. Some of these regulations may pertain to the provision of information concerning fishing trips and catch rates. In such instances, the establishment and oversight of an infrastructure for issuing and monitoring fishing permits become imperative.

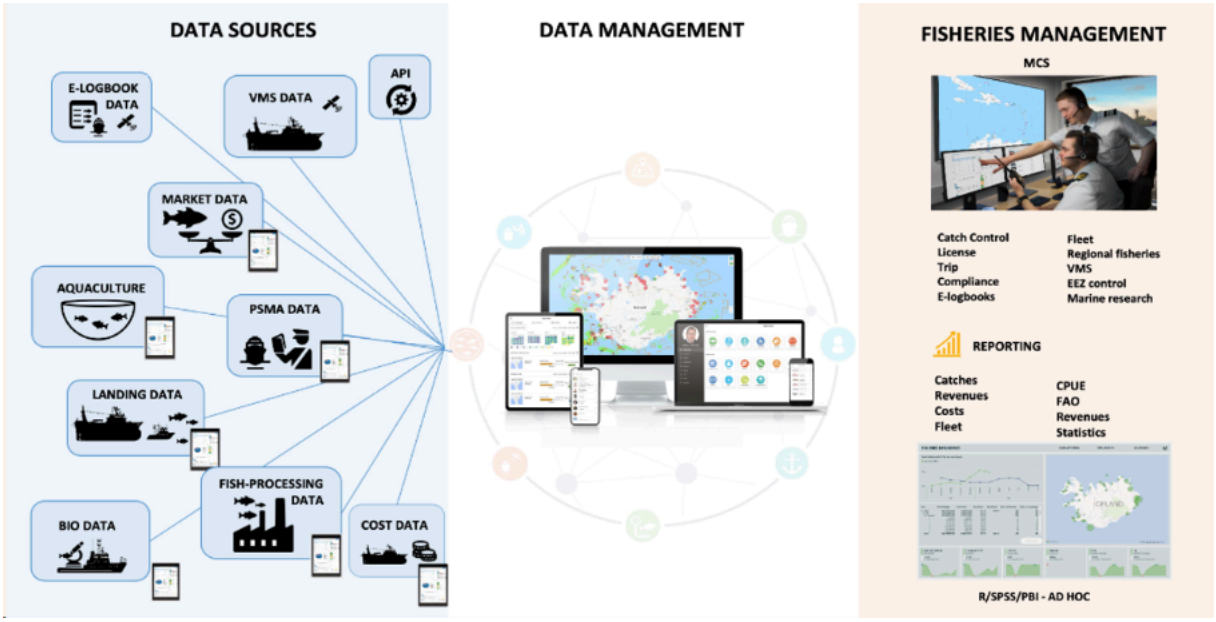


Figure 7. Data Sources

Which data to collect, process, and report depends on the level of fisheries management desired. It is imperative to collect evidence-based data from fish landings to generate fundamental statistics.

At a minimum, it is essential to include what we refer to as the five W's:
(i) What species are being harvested?
(ii) Where is the fishing taking place?
(iii) Where is the harvest being offloaded?
(iv) Who is the owner of the catch?
(v) When did the fishing take place?

Employing the five W's enables managers to gain a deeper comprehension of the target fisheries. As data accumulate over time, the capacity to conduct annual contrasts, evaluate

Figure 8. Example of 5W output

CPUE (Catch Per Unit Effort), discern patterns, and formulate questions emerges, thereby facilitating the path to informed decision-making. Moreover, to obtain a comprehensive understanding of the economic aspects, it is essential to gather data encompassing both revenues and operational costs. This may help to reveal the overall performance of the fisheries, as a business. To delve into even more sophisticated fisheries analysis, it might be necessary to incorporate supplementary data from Marine Research and Monitoring Control and Surveillance data sources.

Overall, the data collected through the 5W‘s can inform a range of management tools, including catch quotas, fishing licenses, and incentives, for sustainable practices. By continually collecting and analyzing this data, fisheries can ensure the long-term sustainability of the resources they depend on.

Effective and structured data collection and statistical programs must be established for a data-driven fisheries approach. These programs incorporate well-defined key performance indicators derived from fisheries policy to assess the fishery's performance. This approach enables regulatory systems to attain their management goals successfully.

The key aspects of the Icelandic data-driven approach:

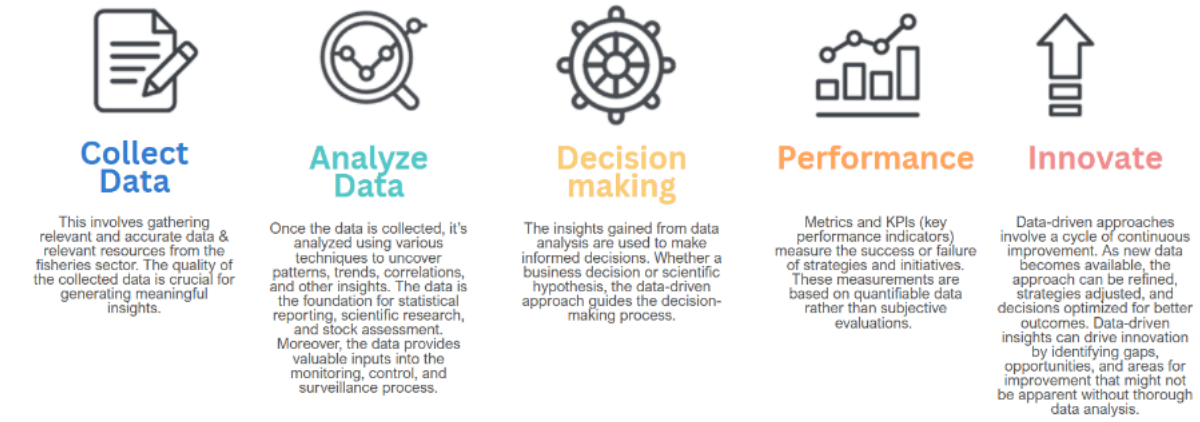


Figure 9. Data collection cycle

## 7. RESULT - THE FISHERIES MANAGER CLOUD SERVICE

When considering data management tools, we pinpointed two primary challenges. Our foremost challenge revolves around devising a versatile data system capable of seamlessly adjusting to various fisheries policies, accommodating modifications without necessitating a comprehensive redesign. The second challenge involves the imperative to reduce operational expenditures.

Data-driven fisheries management is fuelled by harnessing vast volumes of fisheries data at the national or regional scale. This pivotal approach empowers organizations to shape strategic choices and operational pathways by extracting insights from a comprehensive analysis of substantial, empirically grounded data spanning all sectors of the fisheries domain.

Covering the entire spectrum of the fisheries value chain – from the frontline operations of beach management units (BMUs) to the realm of Monitoring Control and Surveillance (MCS), marine research, and economic analyses - the Fisheries Manager emerges as an all-encompassing fortified cloud service designed to oversee sustainability of the fisheries.

Figure 10. The Fisheries Manager cloud service

The wealth of invaluable data collated through the Fisheries Manager cloud service plays a transformative role in evaluating the state of fish stocks, thoroughly observing fishing operations, and is the foundation of informed decision-making processes of fisheries management. Manifesting as a next-generation secure cloud service, the Fisheries Manager introduces a host of nearly real-time functionalities that facilitate vigilant oversight of adherence to fisheries regulations and has a pivotal role in combatting illegal, unreported, and unregulated (IUU) fishing practices.

The platform fosters cross-institutional collaboration, enabling multiple organizations to join forces and pursue shared objectives. It lays the groundwork for the stewardship of fish populations across geographic boundaries, orchestrating multinational, and regional fisheries management endeavours.

Organizations can leverage this service as a centralized data storage and management repository, introducing automation to diverse processes, and seamlessly integrating information spanning various organizational domains. This holistic integration markedly enhances overall efficiency and amplifies the quality of decision-making within the complex realm of fisheries management.

## 8. REDUCING COSTS WHILE BOOSTING PERFORMANCE

What level of reduction in OPEX costs can we expect? In the realm of cloud-based solutions, customers jointly share the burden of development and operational expenditures. When new customers opt for such services, they inherit the previously invested development efforts and costs. Consequently, it's plausible that customers may need to make an initial (higher) investment in the first year and then transition to the standard (lower) rate in subsequent years. However, it's essential to acknowledge that this approach may vary depending on the specific manufacturer or service provider.

Furthermore, it's reasonable to deduce that cloud subscription services offer a more extensive array of features compared to the Total Cost of Ownership (TCO) model. Moreover, over time, new features and services are likely to be incorporated at no additional cost.

The Fisheries Manager's flexible cloud service can be tailored to match every organization's distinct requirement and preference. This empowers organizations to harness the power of the best tools available for effective fisheries governance, thereby expediting the digital revolution and transformation, creating a data-driven future workplace.

Implementing the service and initiating data-driven fisheries management is a straightforward process. Customers do not need to worry about setting up a local technical infrastructure, as the service encompasses all the essential components for secure and reliable operation through the Internet. Integrating the Fisheries Manager cloud service into pre-existing fisheries management systems is also seamless. This presents a unique opportunity to reimagine organizational structures, streamline workflows, consolidate isolated data repositories, and cultivate a dynamic and contemporary work environment.

The forward-looking service continuously evolves and undergoes regular upgrades and additions of new features, while customer service and training programs ensure uninterrupted business continuity.

## 9. DISCUSSION

We pondered the current state of fisheries management across the globe and the key challenges it faces.

As stewards of our fisheries, how can we instigate improvements to yield more favourable outcomes within this sector?

Figure 11. Data Collection in progress

We concluded that a combination of political determination and bravery is vital to addressing this task successfully. Once these foundational elements are in place, the necessary components for implementation, such as infrastructure, knowledge, tools, equipment, and capital, become imperative.

Furthermore, our exploration has revealed that the fundamental principles of fisheries management remain consistent worldwide. Consequently, it is feasible and cost-effective to standardize the tools and equipment employed in these operations. Now we possess a well-defined blueprint for best practices in fisheries management, and the opportunity exists to reduce associated costs by adopting standardized tools and methodologies.

Data collection is a fundamental cornerstone for states planning to initiate fisheries management in the upcoming years.

Figure 12. Fisheries Reports

Even though the roadmap for establishing a fisheries management program might span several years, there is a compelling rationale for instituting a data collection system and commencing data gathering without delay. The immediate commencement of data collection offers a crucial advantage, expediting the achievement of effective fisheries management and all its associated benefits, including sustainable fisheries, access to valuable fish markets, bolstering fishing communities, and preserving the natural environment.

The prospect of bringing order to the global fishing industry, replacing chaos with organization, and elevating its administrative standards to be on par with other global business sectors is attainable and within our grasp.

Figure 13. Sustainable Development Goals (SDG)

## List of figures

*Figure 1.* Icelandic Fisheries
*Figure 2.* Instruments
*Figure 3.* CAPEX - OPEX
*Figure 4.* The components of data management
*Figure 5.* Cost examples
*Figure 6.* Average costs
*Figure 7.* Data Sources
*Figure 8.* Example of 5W output
*Figure 9.* Data collection cycle
*Figure 10.* The Fisheries Manager cloud service
*Figure 11.* Data Collection in progress
*Figure 12.* Fisheries Reports
*Figure 13.* Sustainable Development Goals (SDG)
*Figure 14.* The Survey Results

## List of tables

*Table 1.* The Survey Questions