TASK Quarterly 27 (4) 2023

Architecture of the FindFISH Platform - A Service for Fishermen and More

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https://doi.org/10.34808/0V8N-Z844

Abstract

The FindFISH Knowledge Transfer Platform represents a response to the primary issue diagnosed within the fisheries sector, namely the diminishing profitability of fishing endeavors. Additional challenges include escalating operational costs borne by fishermen, the necessity for fishermen to embark on longer and more distant voyages in search of fish, the capture of low-value or limited quantities of fish, the tenuous operation at the precipice of profitability due to escalating costs, and the imposition of fishing limits and concomitant difficulties thereof. The construction of the FindFISH Knowledge Transfer Platform through the employment of the Numerical Forecasting System for the Marine Environment of the Gulf of Gdańsk for Fisheries is predicated upon in-situ research, environmental data (physicochemical and hydrometeorological), quantitative and qualitative fishing data, as well as numerical modeling of hydrodynamic, physicochemical, and biological parameters within the Gulf of Gdańsk region. The visualization of data in the form of tables, charts, and maps has been executed and presented via the FindFISH platform, which was established under the auspices of the project.

This study presents a comprehensive depiction of the architecture of the system responsible for the dissemination of measurement and model data within the framework of the FindFISH Knowledge Transfer Platform. The principal tenets underpinning the architecture of the implemented system are the utilization of contemporary internet technologies within a complex, multi-module application grounded in solutions freely available under open-source licenses. The system has been realized in the form of several independently operable modules, each provided with distinct sets of requisite functionalities. The system modules are either founded upon existing solutions or have been wholly conceived and executed by the project team. The entirety of the system is accessible to users via a graphical user interface operative through a web browser (www.findfish.pl).

Keywords:

Numerical model, Fisheries, Gulf of Gdańsk

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1. Introduction

The establishment of the FindFISH Knowledge Transfer Platform through the implementation of the Numerical System for Forecasting Marine Environmental Conditions in the Gdańsk Bay for Fisheries is predicated upon a multifaceted approach encompassing in-situ investigations, environmental data analysis (physico-chemical and hydrometeorological), quantitative and qualitative fishing data, as well as the numerical modeling of hydrodynamic, physicochemical, and biological parameters within the Gdańsk Bay region.

Within the scope of the project, the undertaken efforts were compartmentalized into three distinct blocks [1, 2], Environmental Studies [3–7], Numerical Work [8–15], and Informatics Work – as presented within this article. In the realm of environmental studies, the following endeavors were undertaken: 1) an assessment of the chemical and ecological milieu of the Gulf of Gdańsk with a focus on ichthyofauna [4, 6, 7], 2) fishing expeditions aimed at gathering quantitative and qualitative catch data, along with physicochemical measurements employing specialized equipment/instruments such as the Midas CTD+ by Valeport [3], and 3) the determination of habitat preferences for select industrially harvested fish species within the Gulf of Gdańsk [5].

In the domain of numerical work, a three-dimensional prognostic ecohydrodynamic model for the Gulf of Gdańsk, named EcoFish, was formulated. EcoFish consists of three core modules: a hydrodynamic model, a biochemical model, and a Fish model, tailored for four specific industrially harvested fish species within the study area, all crafted to serve the operational needs of the FindFISH platform [8–15]. The EcoFish model, bolstered by the integrated Fish module, enables the continuous monitoring of marine environmental conditions, the tracking and projection of alterations transpiring therein, and the identification of optimal ecological circumstances conducive to the sustenance of the targeted industrially harvested fish species within the studied region.

Ultimately, within the scope of informatics endeavors, the visualization of measurement data obtained from probes, fishing expeditions, as well as the model-derived outputs from the EcoFish and Fish models, was accomplished. These visual representations were rendered in the form of tables, graphs, and maps, and were made accessible through the FindFISH platform (www.findfish.pl, referred to as the "FindFISH Service" in Fig. 1). The architecture of the FindFISH platform, a subject to be expounded upon in subsequent sections of this article, facilitated the data visualization process, contributing to a comprehensive understanding of the intricate interplay between measured and modeled variables in the context of the Gulf of Gdańsk ecosystem.

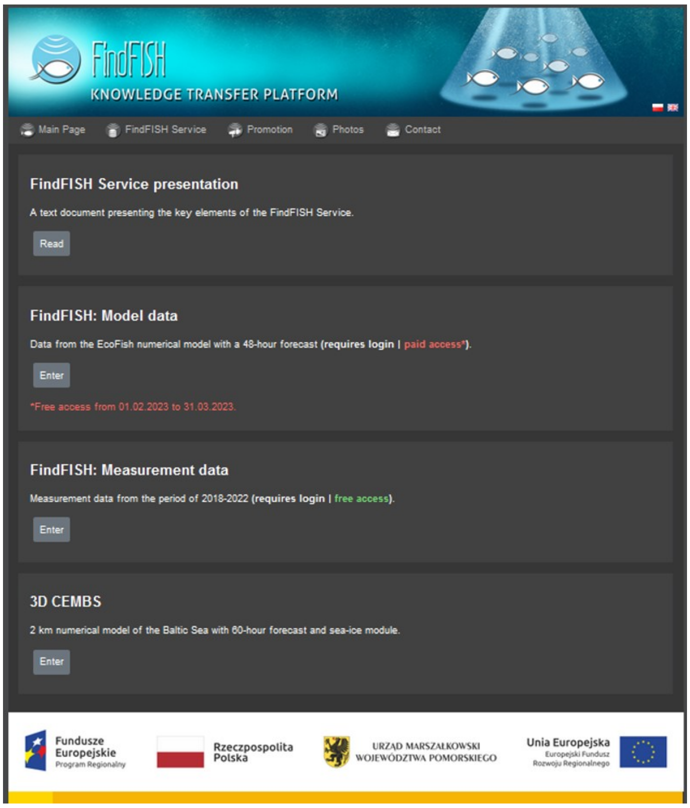

Figure 1: The FindFISH Project Website and Service Selection Interface.

Through the project's website (www.findfish.pl), a mechanism has been established to promote the FindFISH service and disseminate knowledge pertaining to the outcomes attained throughout the project. This dissemination is facilitated through dedicated sections encompassing materials such as Promotional Materials, Press Releases, Awards, Publications, Monographs, and Conference Highlights, each accessible through corresponding tabs. These curated sections serve as conduits for the propagation of the project's achievements, providing a comprehensive repository of information that serves to elucidate the significance and impact of the FindFISH initiative within the scientific and broader community.

2. System Components

The system for disseminating measurement and model data consists of independently executable components (modules) that communicate via designated network protocols, each responsible for a distinct set of logically connected functionalities. The technological stack was chosen deliberately, utilizing Java [16] for server-side business logic and TypeScript [17] for structured client-side development, compiled into

Figure 2: The FindFISH project website and tab selection interface: A – Main page, B – Promotion - Publications, C – Promotion - Results presentation conference 24.02.2023, and D – Promotion – Awards.

JavaScript [18] for web-based user interfaces. This combination ensures robust functionality, seamless interactions, and flexibility in development.

The second criterion for selecting the technological stack was the incorporation of both programming libraries and readily available solutions offered under open-source licenses, in accordance with the principles outlined in The Open Source Definition [19]. Embracing open-source software affords the flexibility to tailor the software to specific requirements (e.g., through source code modifications) without incurring additional costs within the project. Additionally, the choice of utilizing open-source solutions was made in order to reduce costs, as commercial alternatives often come with high licensing fees and require annual support contracts, significantly increasing long-term expenses. While open-source platforms may pose challenges in terms of long-term maintenance and security, this application was developed in-house, ensuring that employees responsible for its development are available for ongoing support and enhancements. Although team members may eventually vacate their roles, maintaining a dedicated development team is a fundamental responsibility, both for sustaining this project and for developing new initiatives. By

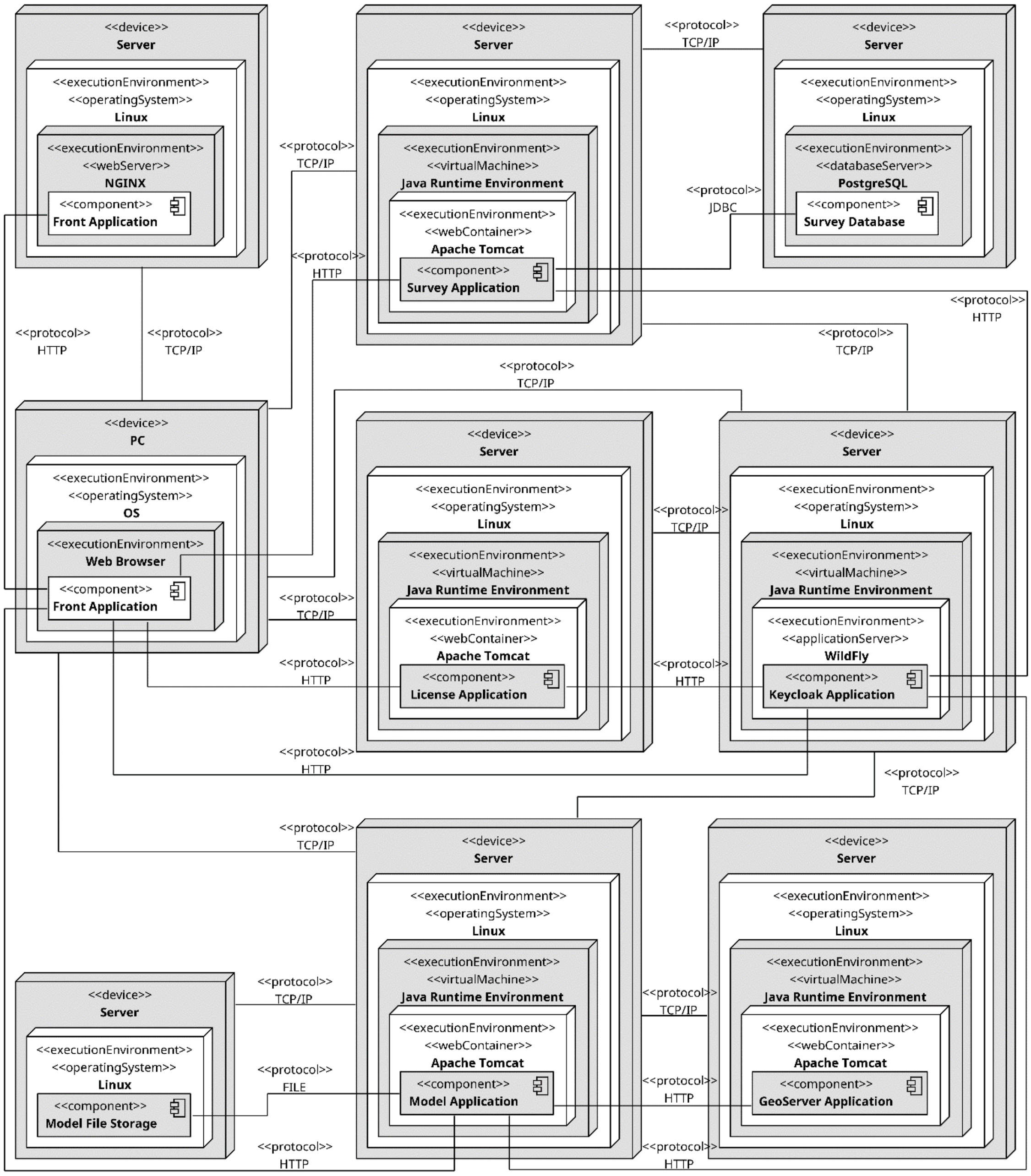

Figure 3: System Architecture Diagram. Source: Own work by IMUMG

fostering internal expertise, the organization ensures the system remains well-maintained and adaptable to future requirements.

Figure 3 depicts the system architecture through a deployment diagram, illustrating all components of the data dissemination system:

- Front application: Provides a graphical user interface accessible via web browsers,
- License application: Facilitates the management of access licenses to data,
- Survey application: Presents measurement data in chart and table formats. Measurement data are loaded from the database served in the requested format,
- Model application: Offers model data in the form of map layers and chart and table formats. Model data are precomputed by Fish Module and stored in the file storage from where they are loaded dynamically and served in the requested format,
- Survey Database: Houses the measurement data in a database,
- Model File Storage: Stores model data on disk,
- GeoServer application: Delivers map layers,
- Keycloak application: Serves as the central user authentication server.

By incorporating these components into the system's architecture, a holistic approach is achieved, enabling effective data presentation, management, and accessibility while adhering to the principles of open-source software utilization.

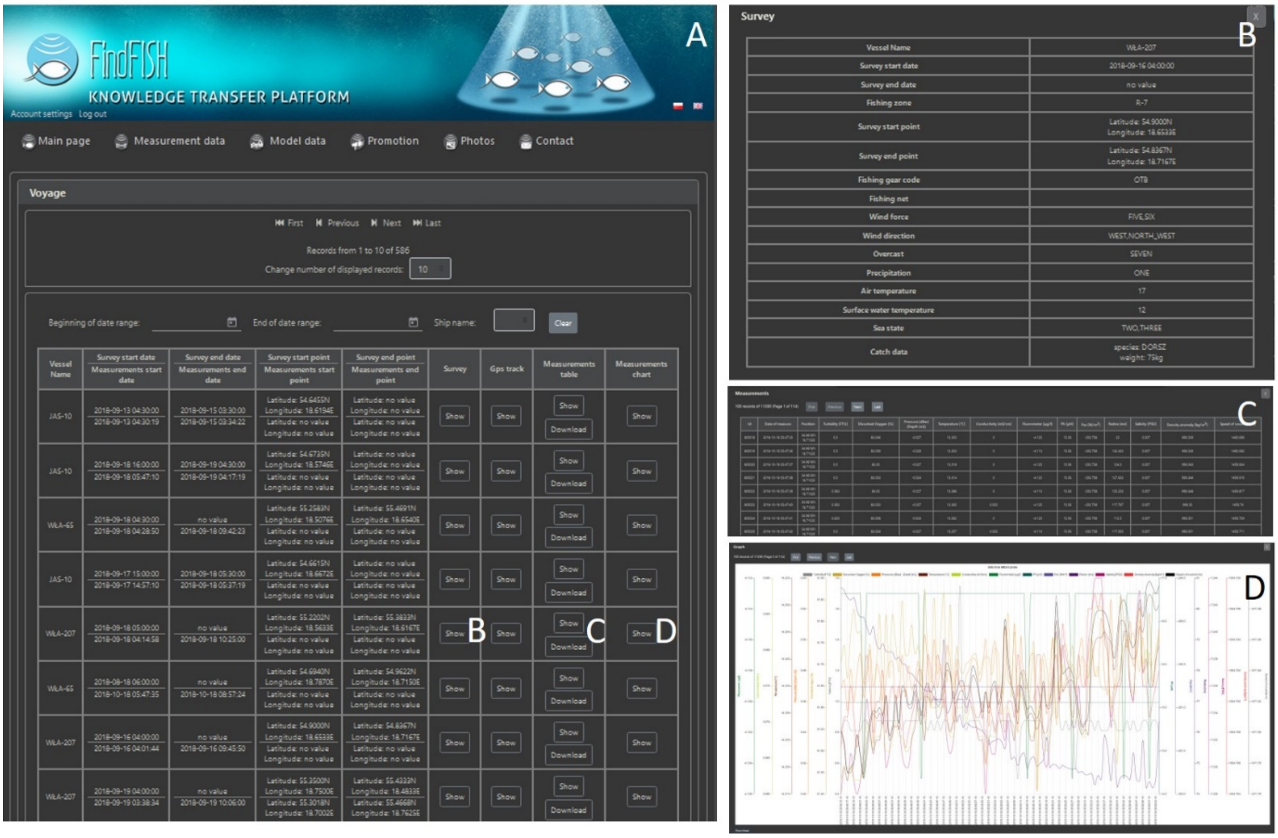

Figure 4: The FindFISH Project website and selection of the "Measurement data" views: A – selection of the fishing trip; B – quantitative and qualitative catch data; C – measurement data in the form of a table and D – measurement data in the form of a graph (D)

Table 1: Web services provided by the Survey application

Method	Resource	Desciption
GET	/voyages/count	Retrieve the total count of all fishing voyages.
GET	/voyages	Retrieve identifiers of fishing voyages. This resource supports pagination (request parameters: limit and offset).
GET	/voyages/id	Retrieve information about a specific fishing voyage, where id is the voyage identifier. The response includes the content of a completed fishing survey questionnaire, as well as dates and coordinates extracted from files submitted with the survey.
GET	/voyages/id/ surveys	Retrieve data collected by the CTD probe for a specific voyage.
GET	/voyages/id/ track	Retrieve the GPS track for a specific fishing voyage.
POST	/voyages	Upload new data in the form of source files from the CTD probe, XML file with GPS track, and DOCX file with the fishing survey questionnaire.

3. Data Sharing

The system for sharing model and measurement data realizes data dissemination through several means:

- User licenses: Managed via a designed RESTful service,
- Measurement data: Shared through a designed RESTful service,
- Model data: Disseminated via a designed RESTful service,
- Map layers: Provided through a Web Map service.

The utilization of RESTful web services conforming to the REST (Representational State Transfer) architectural style and accessible over the HTTP protocol obviates the necessity of relying solely on the graphical user interface offered by the Front application for data retrieval from the system. Following authentication within the Keycloak application using the OAuth 2.0 standard authentication protocol [20], users are empowered to leverage any network service furnished within the system. This enables users to devise their own scripts for data retrieval or to create personalized graphical interfaces, showcasing exclusively the forecast of interest for a particular model and variable, presented in the form of a map layer.

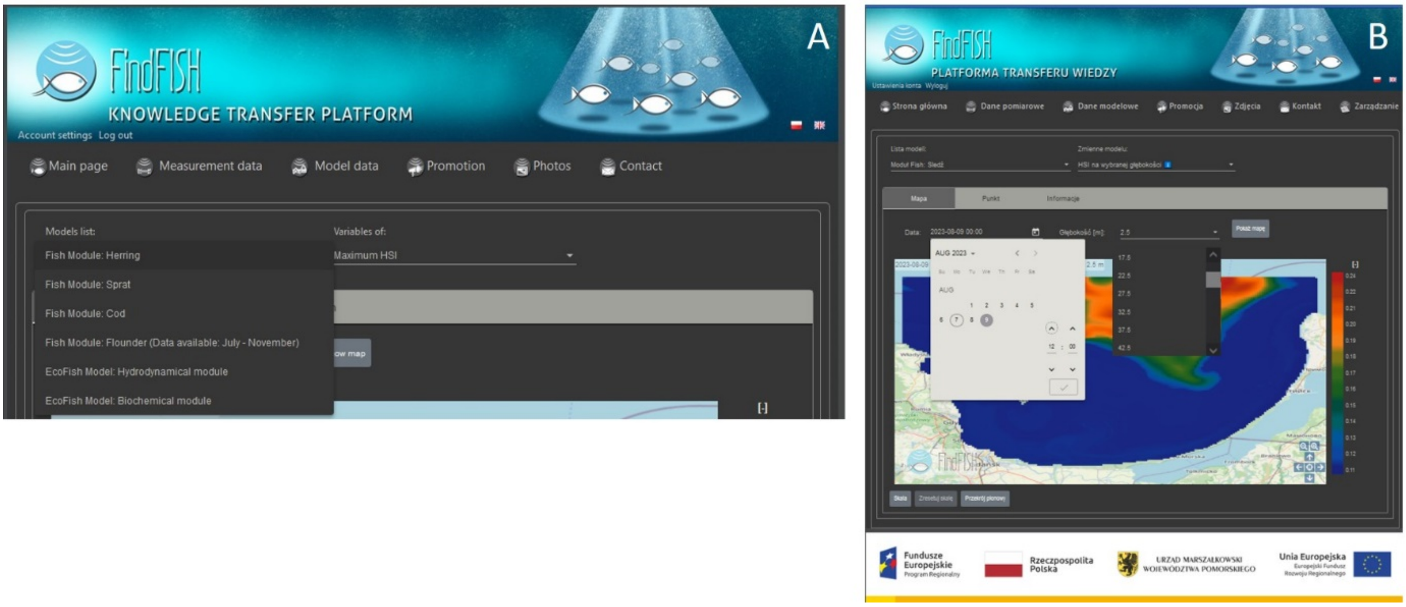

Figure 5: The FindFISH pro1ject website and selection of the "Model data" views: A - Chosen model from the list of all available models; B - Date and depth/layer of the model for result presentation.

Table 2: Web services provided by the Model application

Method	Resource	Description
GET	/models	Retrieve a list of all available models. The response includes information about the model's date range and temporal resolution.
GET	/models/model/variables	Retrieve a list of variables for the selected model, where model is the abbreviated model name. The response includes information about the variable's dimensions and unit.
GET	/models/model/variables/var/data	Retrieve values for the specified model parameter at the indicated point, where model is the abbreviated model name and var is the abbreviated variable name. Request parameters: lat, lon, from, to, elevation.
GET	/models/model/wms	Access the Web Map Service (WMS) address for the chosen model. Request parameters align with the documentation of the OGC WMS service. The model variable name is conveyed as the layer name.

The License application extends web services enabling the retrieval of all registered users within the system and individualized configuration of expiration dates for data access licenses. Data transmission to and from the web service is conducted in the JSON (JavaScript Object Notation) format [21].

The Survey application provides web services that facilitate the submission of new and retrieval of existing measurement data. A comprehensive description of the web services provided by the Survey application is detailed in Table 1. User interface views utilizing those services are visually presented in Fig. 4.

Please note that the provided endpoints allow for data retrieval and submission within the context of fishing voyages. The details of each endpoint's functionality and parameters are outlined for comprehensive reference.

The Model application provides web services that enable the retrieval of model data. A comprehensive description of the services provided by the Model application is detailed in Table 2. User interface views utilizing those services are visually presented in Figures 5 - 8.

These endpoints allow users to retrieve various aspects of model data, including information about available models, variable details, variable data at specific points, and access to the Web Map Service for visualizing model outputs. The parameters provided within the requests ensure accurate and tailored data retrieval.

The aforementioned web services delineate the data sharing capabilities of the model and measurement data dissemination system within the FindFISH platform (www.findfish.pl). This underscores the systematic adherence to a microservices architecture, where the entire system comprises a multitude of loosely interconnected, smaller services that can be developed independently of each other [22]. This design ethos facilitates the autonomous advancement of specific functionalities without impinging upon other elements of the system.

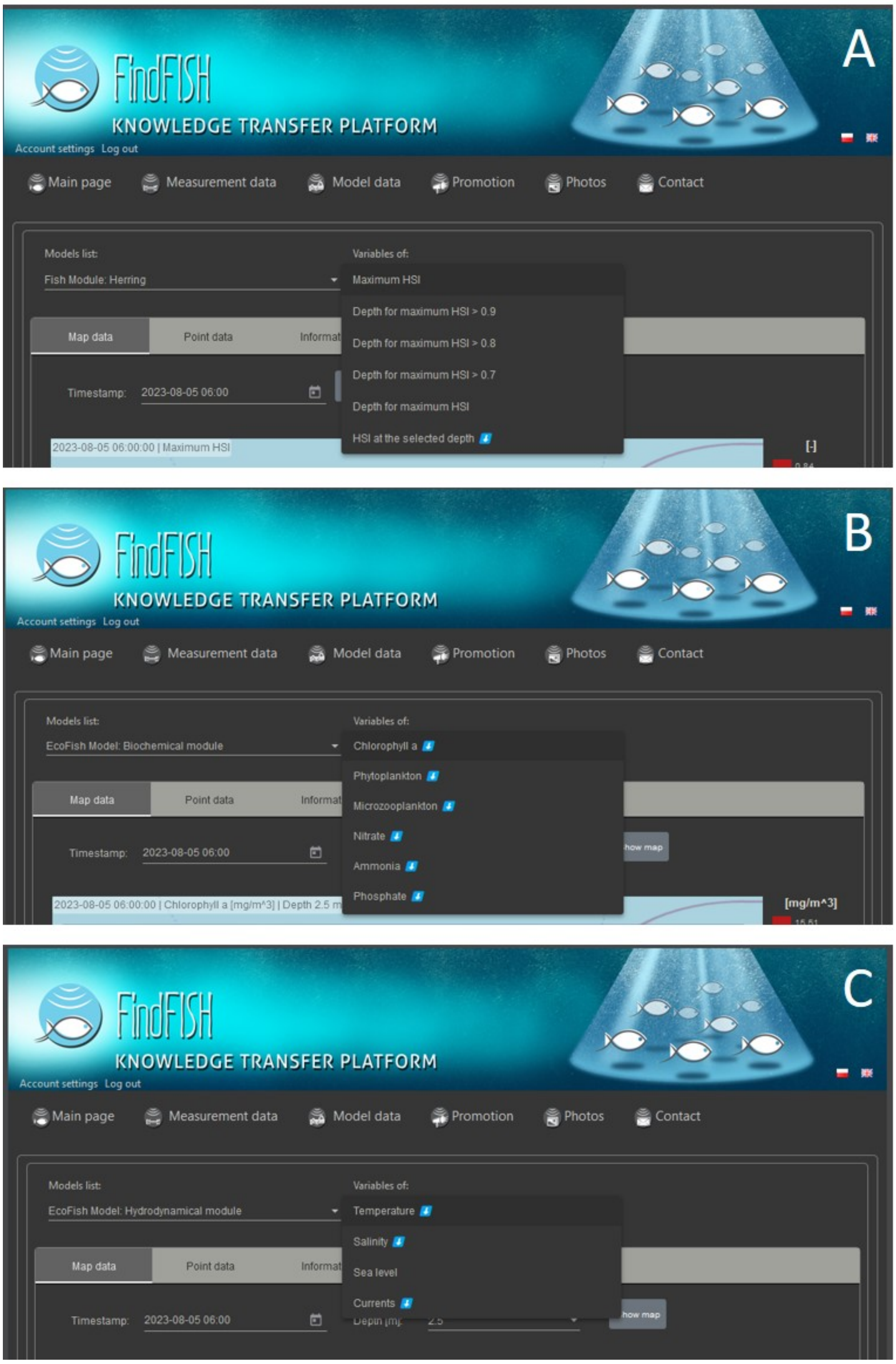

Figure 6: The FindFISH project website of the "Model data" views with variable selection: A - Chosen Fish model from the list of four available models; B - Hydrodynamic model; C - Biochemical model.

Furthermore, the incorporation of web services (both designed RESTful services and standard OGC WMS services) not only enables system integration with other platforms but also makes it possible for users to employ their own tools for data retrieval and presentation.

This architectural approach embodies flexibility and extensibility, fostering a modular and adaptable system that can seamlessly evolve and integrate with external systems, amplifying the overall utility and versatility of the FindFISH platform.

4. Containerization

To enhance both the development and deployment processes of the system, a containerization mechanism was employed. Containers refer to executable software units. The application, along with its dependencies (programming libraries), is encapsulated within a container, enabling its execution in any environment (PC, server, cloud, etc.) [23]. The Docker CE [24], an open-source tool released under a permissive license, was utilized for

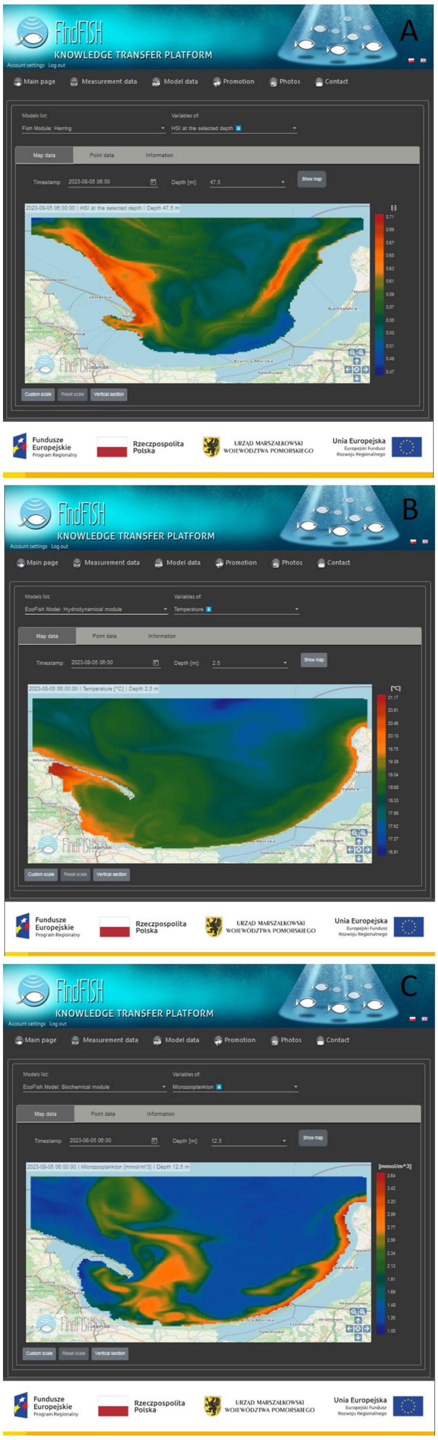

Figure 7: The FindFISH project website of the "Model data" views with results presentation in the form of maps for variable: A - HSI (Habitat Suitability Index) for the selected depth z = 47.5 cm in the Fish module - Herring; B - Temperature for the selected depth z = 2.5 m in the EcoFish model - Hydrodynamical module;
C -Microzooplankton for the selected depth z = 12.5 m in the EcoFish model - Biochemical module.

creating and running containers. For each component of the system (Front application, License application, Survey application, Model application, Keycloak application, GeoServer application, and Survey Database), a container image is crafted and subsequently stored in an image repository. Nexus [25] was employed as the image repository. To launch a specific module, one merely needs to use Docker CE commands to retrieve the appropriate image from the repository and initiate the container.

In addition to containers, a deployment configuration for the entire system was devised using a YAML (YAML Ain't Markup Language) [26] file, utilizing the syntax of Docker Compose [24]. This approach encapsulates the configuration of all system-constituting applications and their interdependencies within a singular configuration file that governs the entire deployment. Such a configuration is applicable in both developmental and production environments, streamlining the process and ensuring consistency across different operational settings.

5. Conclusion

This article has presented a detailed description of the system architecture responsible for sharing measurement and model data within the FindFISH Knowledge Transfer Platform (www.findfish.pl). Specifically, all system components have been described, both those entirely implemented by the project team and those based on existing solutions. For each component, the utilized programming languages, pre-existing applications, and essential programming libraries have been provided.

While the system primarily offers access through web browsers, data can also be automatically retrieved using pertinent web services. The chapter has elucidated the utilization of standard OGC services, as well as the comprehensive structure of services developed by the project team for the system's specific needs.

The application of pre-existing solutions and freely available open-source software libraries facilitates the future expansion of the system without the necessity of financial investment in software licenses. Moreover, the adoption of a microservices-based architecture permits independent development of distinct components and the seamless addition of new ones. Furthermore, the utilization of containerization mechanisms ensures the system can be easily deployed across varied IT infrastructures.

While FindFISH demonstrates significant innovation in fisheries management, further improvements could enhance its accessibility and scalability. The reliance on advanced numerical models and in-situ data may require technical expertise, potentially limiting its usability for smaller fishing operations. To address this, future development will focus on refining the user interface, providing comprehensive documentation, and offering training programs to facilitate adoption by a broader user base.

Another avenue for future enhancement involves incorporating data from acoustic surveys routinely

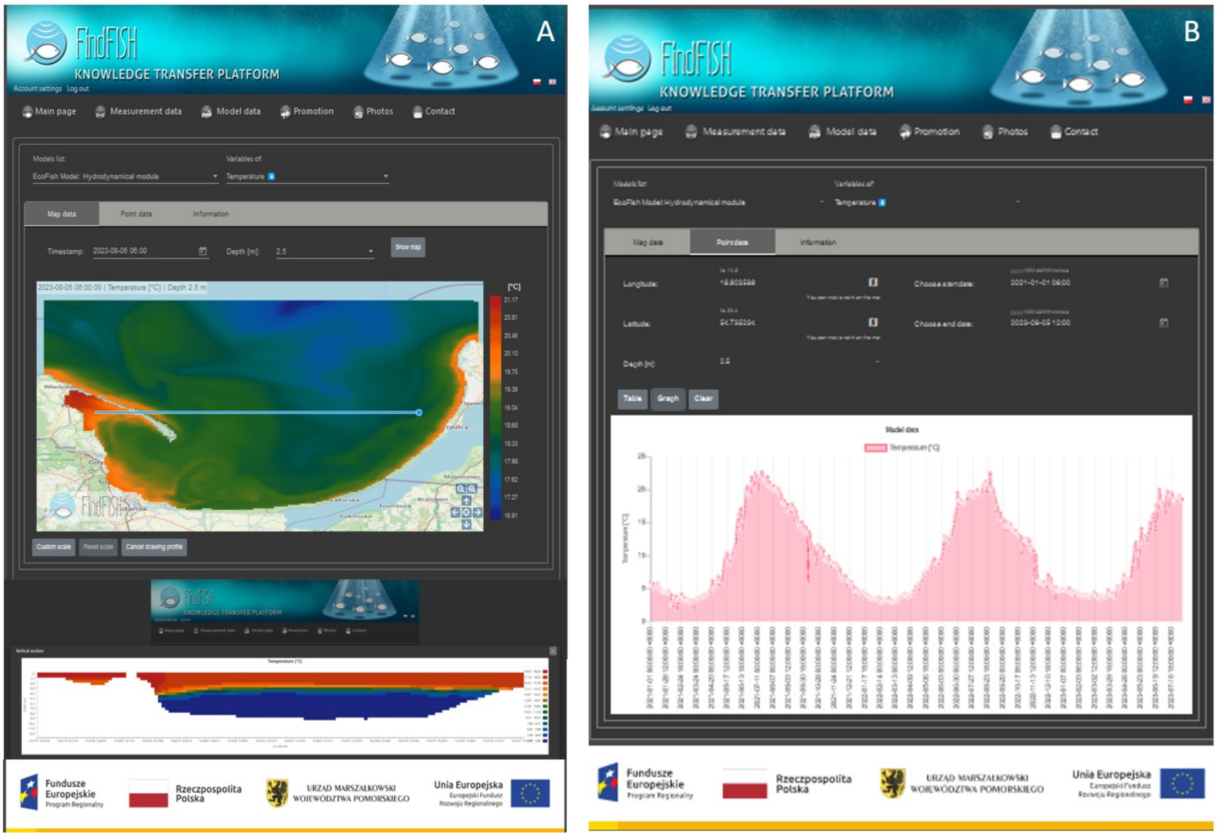

Figure 8: The FindFISH project website of the "Model data" views with results presentation in the form of: A - Vertical cross-section for the selected variable between two chosen points on the map; B - Chart for the selected variable and chosen point on the map.

conducted by governmental and research institutions worldwide. Integrating such data could further improve the predictive capabilities of the system and enhance its applicability to fisheries management.

Although the platform has been developed with a primary focus on the Gulf of Gdańsk, the underlying modeling approach has the potential to be adapted to other regions of the Baltic Sea. However, achieving this would require expanding the project's scope to cover the entire Polish marine area, necessitating collaboration with additional research institutions and regional fishing communities. Extending the model domain and incorporating artificial intelligence methods, such as neural networks, could help process larger datasets and account for ecological differences across different parts of the Baltic.

Lastly, while open-source solutions offer cost efficiency, the long-term maintenance and security of the platform require dedicated resources. Future efforts will focus on establishing strategic partnerships and exploring funding opportunities to ensure the system's sustainability. Addressing these aspects will further strengthen FindFISH's impact and usability, broadening its adoption within the fisheries sector.

6. Acknowledgments

The project "Knowledge transfer platform FindFISH - Numerical Forecasting System for the Marine Environment of the Gulf of Gdańsk for Fisheries" (no. RPPM.01.01.01-22-0025/16-00) is co-financed from the European Regional Development Fund (ERDF) under the Regional Operational Program for the Pomeranian Voivodeship for 2014-2020, Priority Axis 01. Commercialization of knowledge, Measure 01.01. Expansion through innovation, Sub-measure 01.01.01. Expansion through innovation. Calculations are carried out at the Centre of Informatics Tricity Academic Supercomputer and Network in Gdańsk.

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