A Prognostic Tool for Modeling the Optimal Environmental Conditions for Fish in the Gulf of Gdańsk – the Fish Module

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Introduction

The *Fish Module*, developed as part of the "*Knowledge Transfer Platform FindFISH – Numerical Forecasting System for the Marine Environment of the Gulf of Gdańsk for Fisheries*" project (Figure 1) (Dzierzbicka-Głowacka et al., 2024), is a tool designed to optimize fishing practices in the southern Baltic Sea, particularly in the Gulf of Gdańsk region.

The *Fish Module's* development was motivated by the urgent need to balance the economic necessities of the fishing industry with the imperative of environmental conservation. This tool represents a synergistic approach, melding traditional fishing expertise with cutting-edge scientific research and technological advancements, (Janecki & Dzierzbicka-Głowacka, 2023).

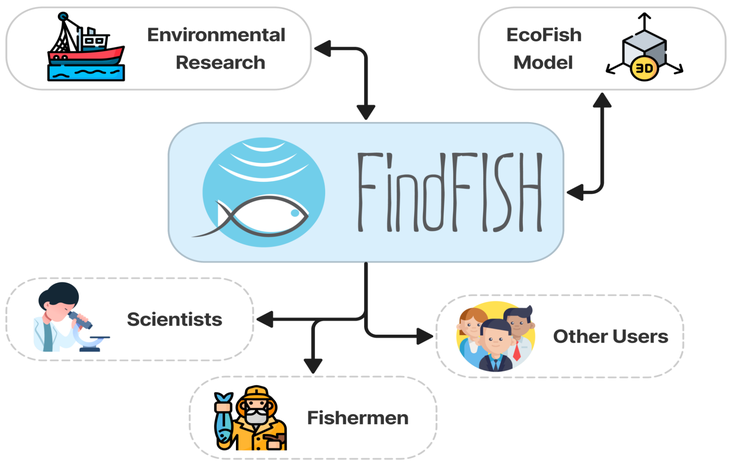


Figure 1. The general structure of the *FindFISH* platform.

Our approach

A distinguishing feature of our study lies in the active involvement of fishermen in the research process. Collaborative endeavors with local fishing communities allowed us to harness their experiential knowledge and expertise, creating a synergistic relationship between traditional ecological knowledge and contemporary scientific methodologies. This collaborative approach is not only unique in its depth of engagement but also enriches our research with insights that might be overlooked in more traditional, purely academic studies. The methodological innovation in our research extends to the data collection process. Leveraging regular commercial fishing expeditions, our team implemented a novel data collection strategy. An instrument, securely attached to the fishing gear, enabled the simultaneous acquisition of environmental data during routine fishing operations. This seamless integration of scientific data collection with commercial activities ensures a comprehensive and continuous stream of information, capturing the dynamic interplay between marine species and their environment in a real-world setting.

The Fish Module

The *Fish Module* is a tool designed for predicting optimal environmental conditions for fish species in the southern Baltic Sea, with a focus on the Gulf of Gdańsk (Figure 2). This tool integrates the *EcoFish* ecohydrodynamic model with fuzzy logic and extensive fish preference data to calculate the Habitat Suitability Index (HSI). The study meticulously analyzes data from 587 fishing expeditions, correlating physicochemical sea parameters with fishing success to establish HSI threshold values for sprat, herring, cod and flounder. The research findings provide actionable guidance for selecting efficient fishing routes and challenge traditional notions about the relationship between fishing duration and catch size.

In the *Fish Module* we focus on temperature, salinity, oxygen, and depth as key input parameters as they represent critical abiotic factors in aquatic ecosystems, playing pivotal roles in shaping fish behavior and influencing overall habitat suitability. Our research in the Gulf of Gdańsk focuses on four fish species, and the selection of these parameters is grounded in their significant impact on the ecological dynamics of the region.

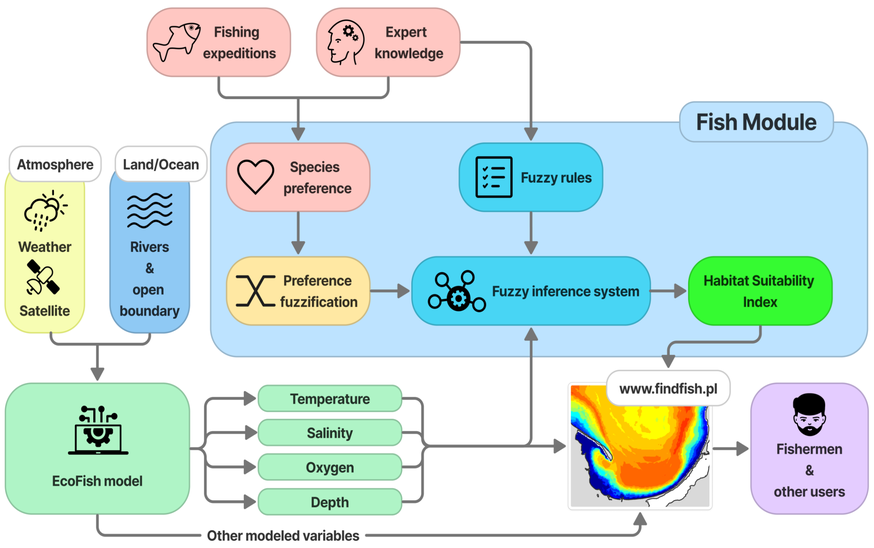


Figure 2. The general outline of the Fish Module algorithm along with the interdependencies between the elements implemented in the FindFISH project.

Habitat Suitability Index (HSI) maps

Using data from the *EcoFish* model for temperature, salinity, and oxygen saturation we analyzed a 2016-2020 period to identify locations that exhibit the most favorable environmental conditions for species investigated in the *FindFISH* project.
Here (Figure 3) we present an example HSI maps for sprat. The most favorable environmental conditions for this specie occur from December to April. From May to September, the environmental conditions exhibit a zonal pattern with a division into two sectors with distinct characteristics. The shallow coastal zone has noticeably worse environmental conditions compared to the deeper offshore areas. However, in November, the situation is reversed, and more favorable environmental conditions are observed in shallow waters.

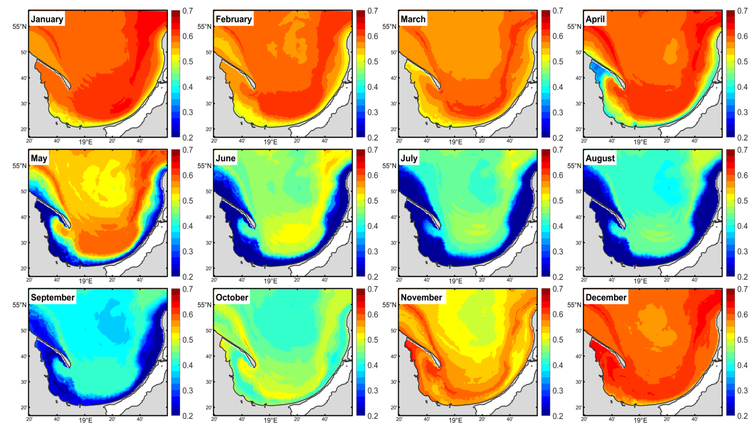
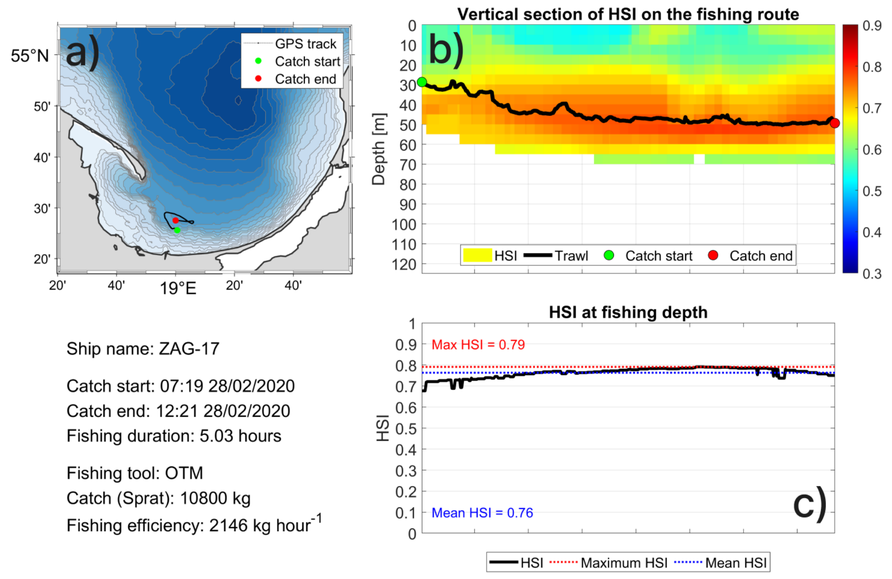


Figure 3. 2016-2020 monthly average median HSI values for sprat.

Relationship between fishing efficiency and HSI

Figure 4 presents an example of a successful fishing expedition by the ZAG-17 vessel. The effective fishing time during this expedition lasted just over 5 hours and the vessel used pelagic trawl, resulting in a catch of 10,800 kg of sprat with a fishing efficiency of 2,146 kg h^{-1}. The vertical HSI profile along the fishing route (Figure 4b) clearly shows that the pelagic trawl operated at depths between 30 and 50 meters, corresponding to the maximum HSI values along this route. The average HSI was 0.76 with a maximum of 0.79 (Figure 4c). This indicates a well-chosen location and fishing depth by the skipper, resulting in an efficient catch. The area north of the Vistula mouth has exceptionally good environmental conditions for sprat in February, which can be seen in Figure 3 (February).



Ship name: ZAG-17

Catch start: 07:19 28/02/2020
Catch end: 12:21 28/02/2020
Fishing duration: 5.03 hours

Fishing tool: OTM
Catch (Sprat): 10800 kg
Fishing efficiency: 2146 kg $hour^{-1}$

Figure 4. The details of successful fishing expedition of ZAG-17 on February 28, 2020; a) GPS track, b) vertical HSI section along the route, and c) HSI values during this expedition.

Web portal

The results from the EcoFish model and the Fish Module are available through the FindFISH project website www.findfish.pl (Figure 5). This platform integrates all the results of the project. It involves free access to the data collected during the fishing expeditions (surveys, catch data and physicochemical data recorded by the MIDAS CTD+ instrument). Archived modeled results of hydrodynamic and biochemical parameters and maps of environmental conditions (HSI) for sprat, herring, cod, and flounder with the 48-hour forecasts are available upon registering and subscribing to the service. Forecasts are updated four times a day. For all model products and variables, it is possible to generate raster maps for individual depths, representing the vertical layers of the model. Additionally, it is possible to create temporal and spatial series for specified periods in a selected location (after specifying or indicating the desired latitude and longitude) as well as data tables for selected model parameters. Regarding the Fish Module, there are several parameters available: Maximum HSI, HSI at the selected depth, Depth for maximum HSI > 0.9/0.8/0.7 and Depth for maximum HSI column.

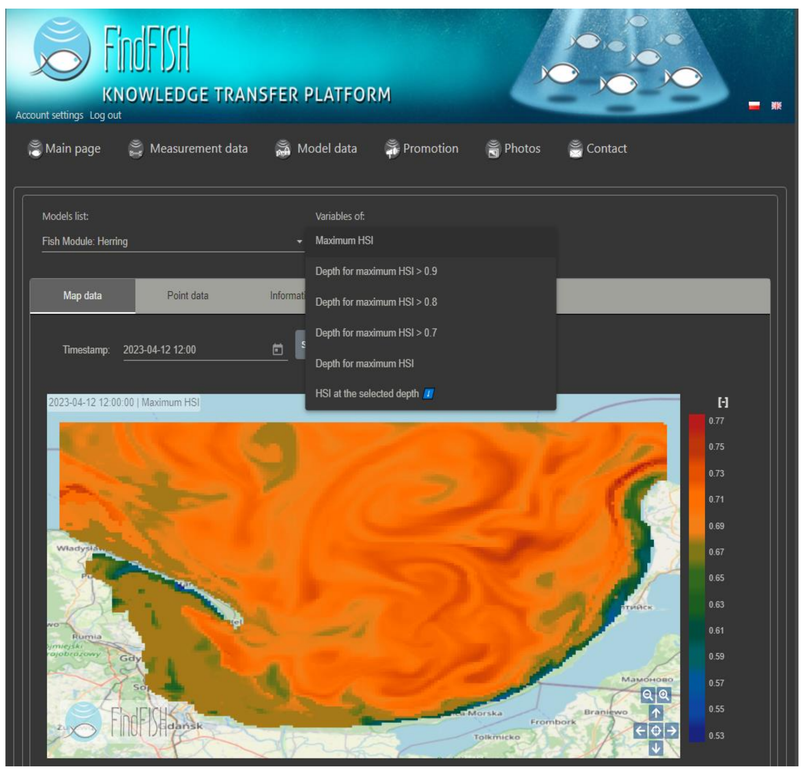


Figure 5. FindFISH project website. List of available parameters of the Fish Module, and the map of the Maximum HSI for herring on April 12, 2023.

Summary

The *FindFISH Platform*, designed for fishermen, aims to enhance fishing efficiency and reduce environmental impact. This tool, a first of its kind, uses a numerical method to forecast marine conditions in the Gulf of Gdańsk, aiding in locating optimal fishing grounds. Targeting a diverse market, *FindFISH* promises profitability and reduced operational costs for the fishing industry, while ensuring sustainability and environmental protection. The platform is developed through a collaboration between scientific institutes and a fishermens, integrating real-time data and models.

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