25 JUN 2025

NATUREFIRST

The Road Towards Predicting Sturgeon Migration

Anna Davison (WUR), Marian Mierla, Stefan Hont (DDNI) and Melanie Arp (Sensing Clues)

Field Expert Perspective

Researcher Perspective

Developer Perspective

12 JUN 2025

NATUREFIRST

The Road Towards Predicting Sturgeon Migration

Anna Davison (WUR), Marian Mierla (DDNI) and Melanie Arp (Sensing Clues)

SENSING CLUES

Groundstation OSPACE

WAGENINGEN UNIVERSITY & RESEARCH

3edata

WWF

Wildlife Forensic Academy

WWF

STAFFORDSHIRE UNIVERSITY

GRAPHWISE AI THRIVES ON WHOLE DATA

ИБЕИ

SUSTAINABLE SCALE-UP FOUNDATION

Nature FIRST

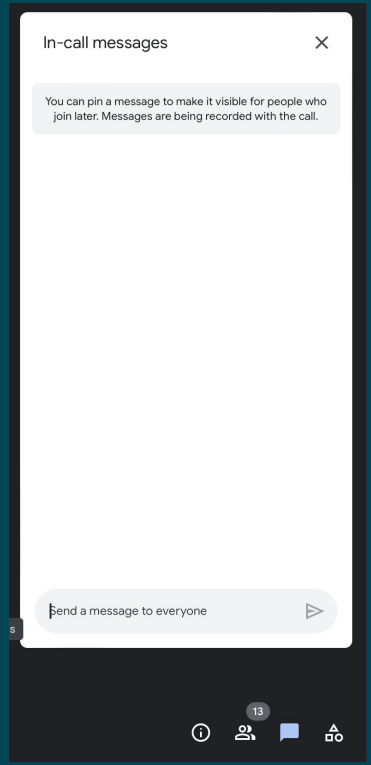
Horizon Europe Research & Innovation Programme

Before we start

🎥 Just so you know – we’re recording this session.

🎤 Please keep your mic off unless you're speaking.

❓ Got questions? Pop them into the chat anytime!



Webinar structure

Introduction - why predict sturgeon migration? (1 min)

Scientific approach through Agent-Based Model (Anna - 10 min)

Pivotal moments followed by a demo (videos) of application highlighting three/four elements (Marian & Melanie - 20 min)

Key: timeline in everyone's story

Three/four elements of the application

- Highlight the environment on the map (danube sectors etc.)
- Relevant hydrostation data makes the output closer to now-casting, so automated collection
- Simplify the model to define the output that should be on the map: sturgeon heat map (depending on state) and spawn/hatch/mig dates

Workshop structure

Expert perspective: practical side of monitoring and protecting sturgeon migration (Stefan - 10 min)

< audience questions > (5 min)

Research perspective: scientific approach through Agent-Based Model (Anna - 10 min)

< audience questions > (5 min)

Developer perspective: pivotal moments followed by a demo (live/video) of the application (Marian & Melanie - 15 min)

< audience questions > (5 min)

Why Predict Beluga Sturgeon Migration?

Agent-Based Model - An Integrated and Adaptive Approach for Complex Ecosystems

-**Simulates Sturgeon Migration Paths -** Uses **telemetry data** to model how individual sturgeons migrate, respond to environmental cues, and identifying spawning routes.

- **Environmentally Driven Behavior and Habitat Dynamics –** Incorporates Danube River water temperature and levels that trigger spawning events, informing the development of a spawning calendar that reflects natural migration timing and is used to monitor sturgeon larval movement and habitat use along the Lower Danube River, helping to identify critical zones.

- Connects with Spawning Success Data - Integrates data on the capture of young-of-the-year to validate model predictions and assess reproductive outcomes.

- Maps Human-Wildlife Conflict Zones - Combines biological modeling with spatial data from **Cluey Data Collector** to identify and mitigate **human-wildlife conflict hotspots** in the **Danube River**.

- Supports Conservation and Scenario Testing - Enables simulation of future river conditions, human pressures, and management strategies—vital for long-term sturgeon protection.

DANUBE DELTA NATIONAL INSTITUTE - TULCEA, ROMÂNIA

INCDDD TULCEA

Sturgeon of Lower Danube River - Monitoring and Conservation

Ștefan HONȚ, Marian IANI, Marian PARASCHIV, Daniela HOLOSTENCO, Alexandru DOROSENCU

Danube Delta National Institute- Tulcea, România



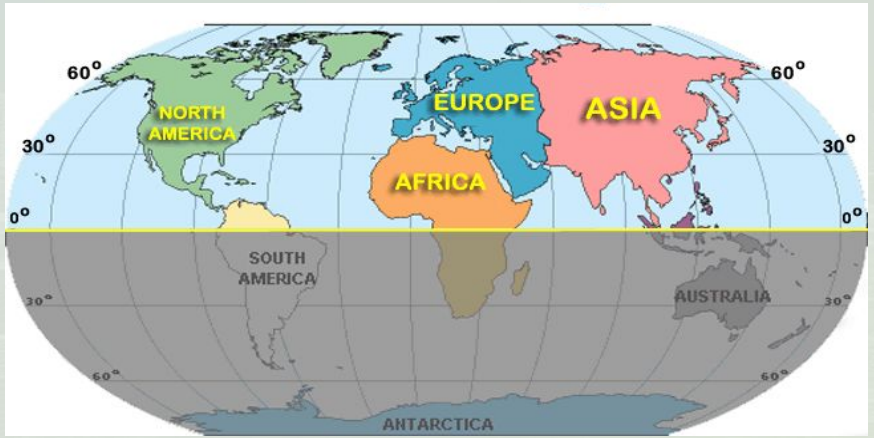

NATUREFIRST

Forensic Intelligence and Remote Sensing Technologies for Nature Conservation

NATUREFIRST

Sturgeons

Of the 27 species of sturgeon spread in the seas and tributary rivers of the Northern Hemisphere, 4 species of sturgeon are found in the Lower Danube



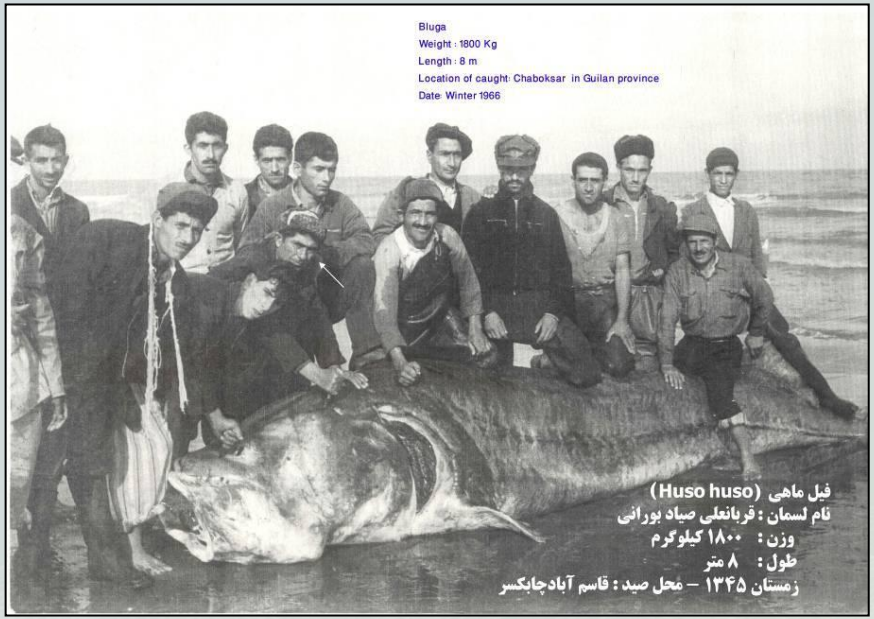
The sturgeon species from the Lower Danube River

Among the 6 sturgeon species that once lived in the Danube basin, we currently find three anadromous species:

- *Huso huso* – Beluga sturgeon
- *Acipenser gueldenstaedtii* – Russian sturgeon
- *A. stellatus* – Stellate sturgeon
- *A. ruthenus* – Sterlet sturgeon

Beltuga Sturgeon (*Huso huso*)

The most valuable fishery resource



Beluga sturgeon (*Huso huso*) captured durin the winter of 1966 in Caspian Sea, total length 8 m, total weight 1 800 kg

"Beluga sturgeon reaches the Black Sea in very large sizes. The usual specimens are **100-250 kg**, but much larger specimens are often caught, so a year ago a 560 kg Beluga was caught at the mouth of St. Gheorghe, which was kept in the Museum of Natural History. In **1890, an 882** kg Beluga was also caught at Sf. Gheorghe. which had 126 kg of caviar. The largest Beluga caught at St. Gheorge was recorded in fisherman's book, weighed almost 1161 kg." (*Greigore A. 1909*)

"The fact that a single Beluga sturgeon with roe can be worth as much as **five pairs of oxen shows** us how much interest we must have in conserving and breeding such a fish." G. A. 1909

NATUREFIRST

Status of sturgeon species from Lower Danube River, according International Union for Conservation of Nature (IUCN)

Species:	Status:	Population trend:
Huso huso (***Belguga sturgeon***)	critically endangered	decreasing
Acipenser gueldenstaedtii (***Russian Sturgeon)***	critically endangered	decreasing
Acipenser Stellatus (***Stellate Sturgeon***)	critically endangered	decreasing
Acipenser Ruthenus (***Sterlet sturgeon***)	Endangered	decreasing

The main threats:

I. Excessive fishing and illegal fishing driven by the price of caviar

II. Construction of dams

IUCN 2025. The IUCN Red List of Threatened Species. Version 2025-1. https://www.iucnredlist.org

Adults:
Migrate from the BlackSea in the Danube River for spawning in the various specific spawning sites. Currently they reach: Iron Gates II dam (~ 850 river km), in the past: Vienna ~1600 rKm, Regensburg ~2000 km. Some sub-populations start their migration in spring and others in autumn

Early life stages (larvae):

After hatching the larvae migrate downstream

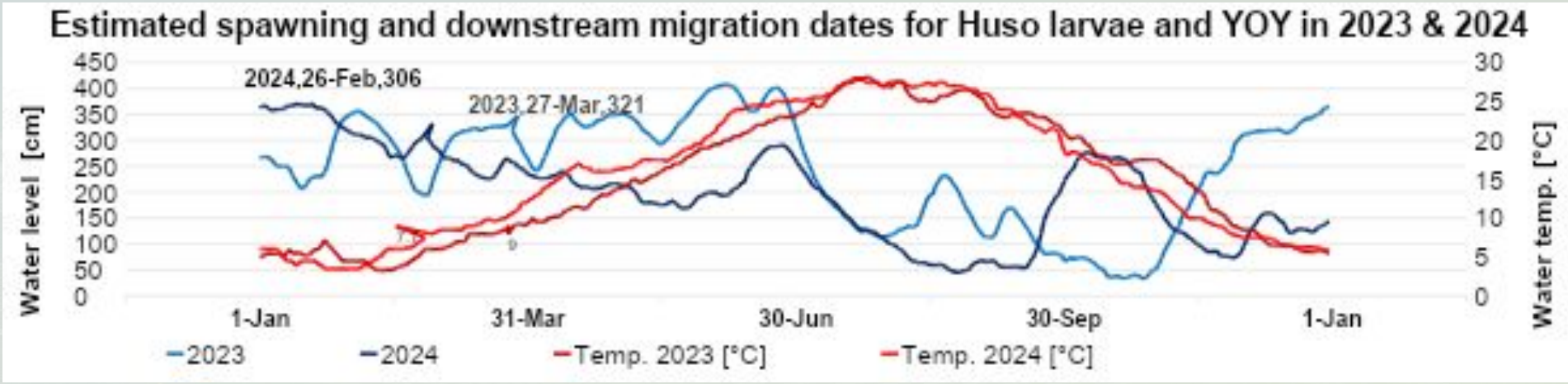
Juveniles:
Migrate downstream and feed in the river, and then juveniles and sub-adults feed in the BS.

NATUREFIRST

Conservation and recovery measures

Monitoring the feeding habitats of YOY sturgeon from the Danube River

Monitoring of sturgeon spawning habitats in the Danube (since 2000)



Conservation and recovery measures

Danube River sturgeon restocking Support Program with YOY obtained through controlled reproduction. - Started in 2005 - Over half a million YOY sturgeon released

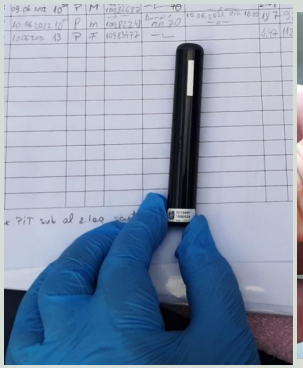
Capture of wild sturgeon broodstock from the Danube

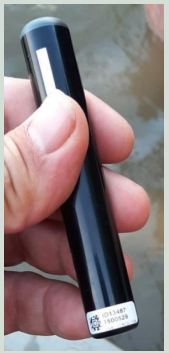
Artificial reproduction of wild broodstock on the farm

Raising sturgeon juveniles obtained from wild parents and tagging the sturgeon juveniles

Releasing sturgeon juveniles, raised from wild sturgeons

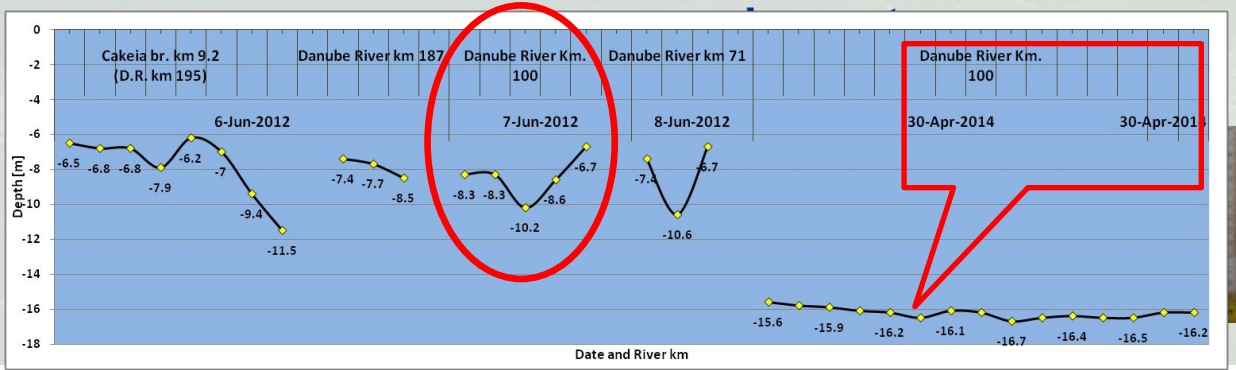
Monitoring Sturgeon migration using acoustic and satellite telemetry



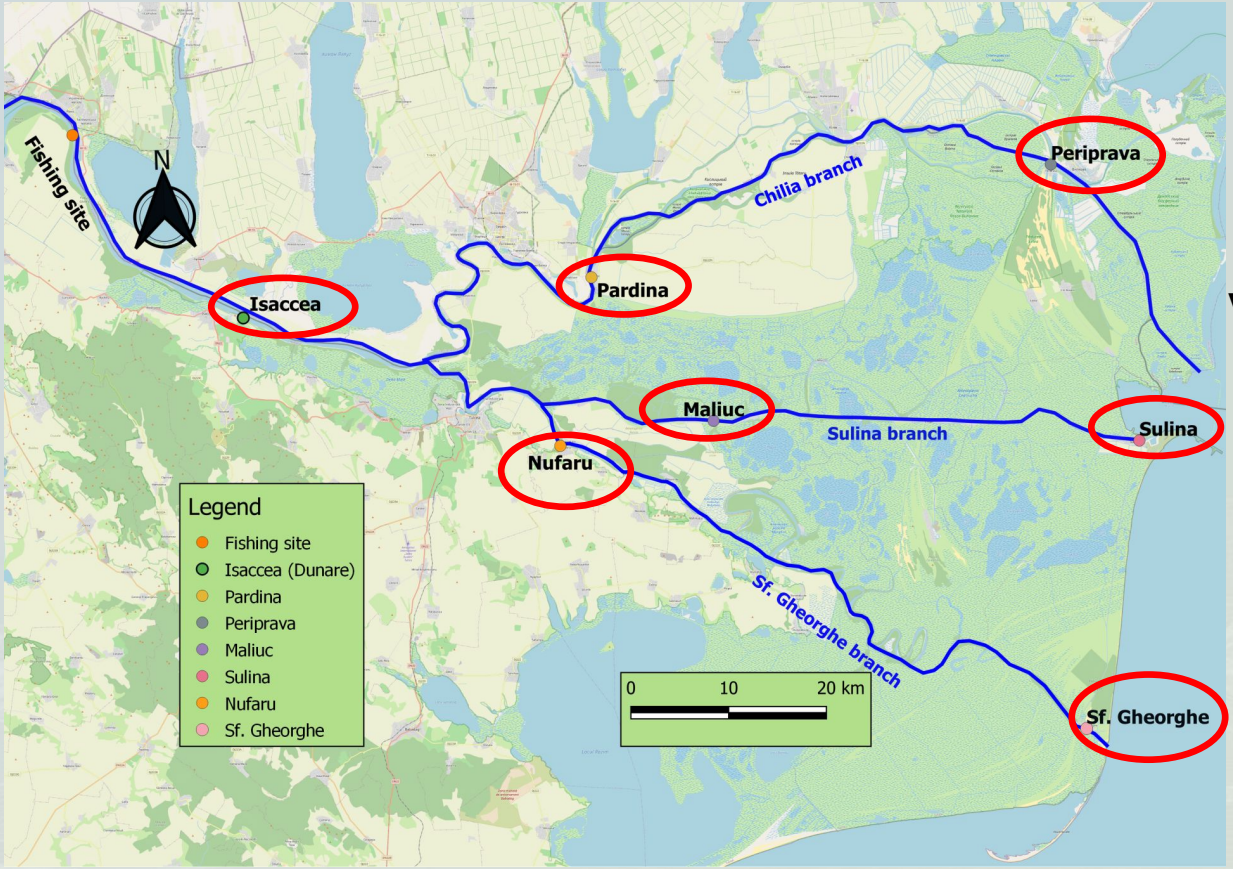


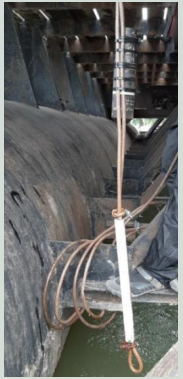
V16 Acoustic tags

Sturgeon monitoring using acoustic and satellite telemetry

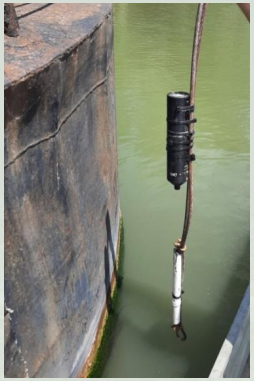


Material and methods



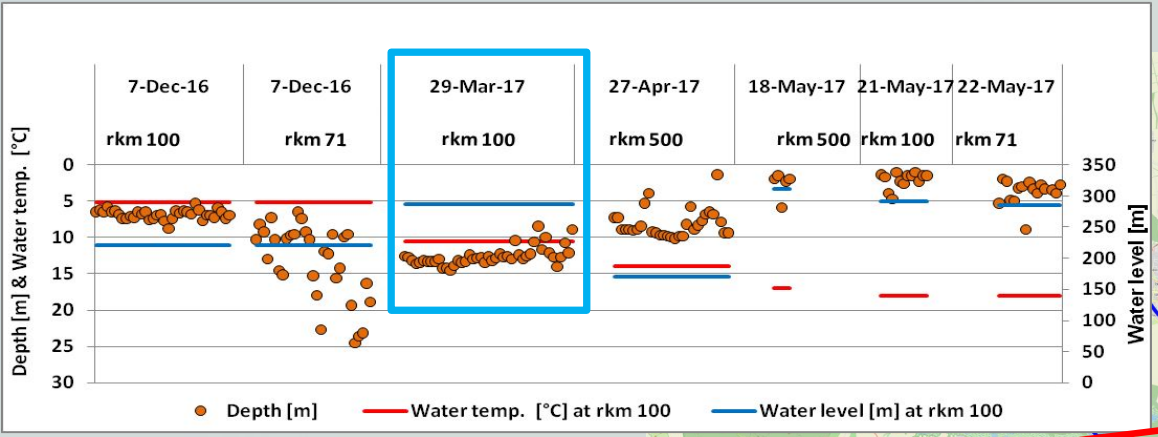


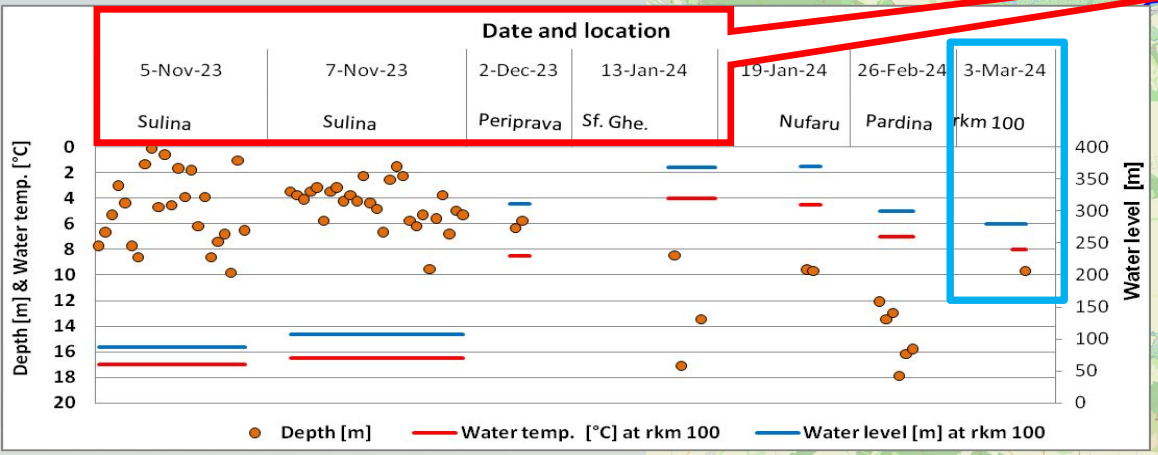
VR2W installed at Pardina (Chilia branch)

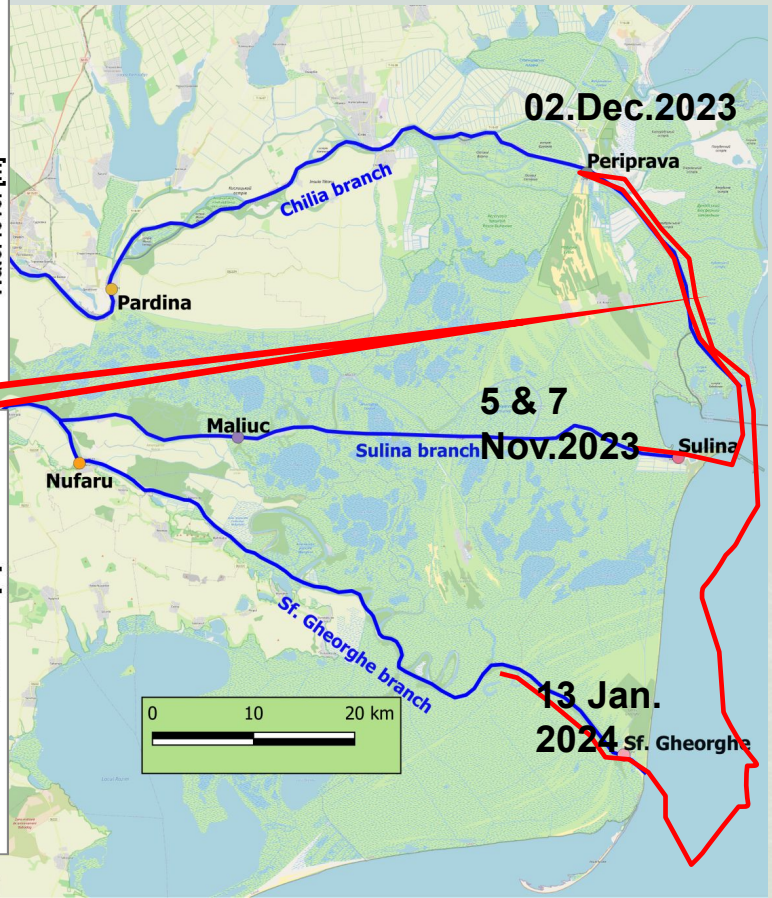


VR2W receiver (left), Receiver installed at Maliuc - Sulina branch(right)

Sturgeon (tag ID 12075) migration in Danube River up to km 500, recorded in 2016 and 2017 and 2023-2024

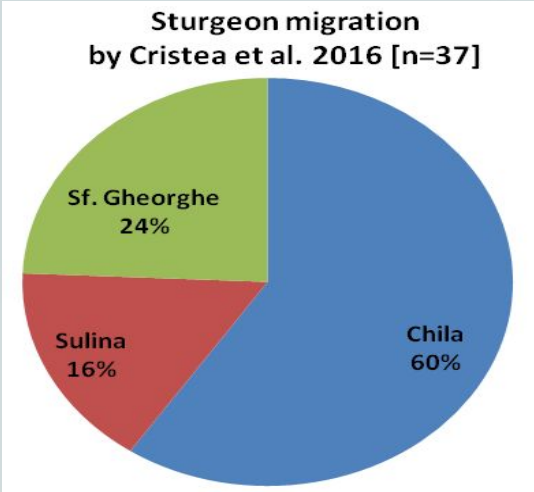


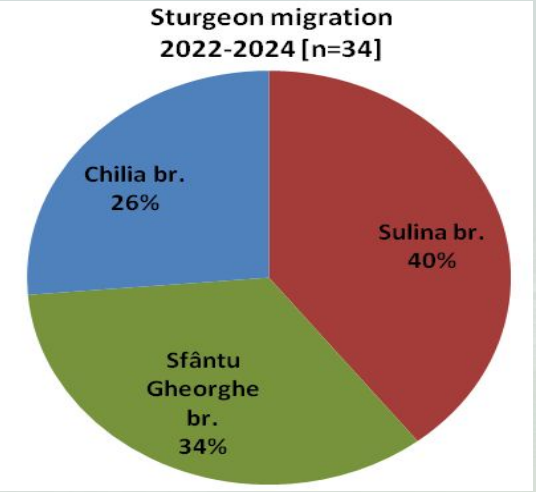




NATUREFIRST

Migration of sturgeons on Danube Delta branches recorded in 2022-2024 compared with sturgeons recorded before

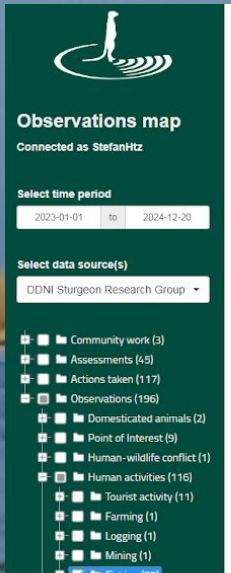


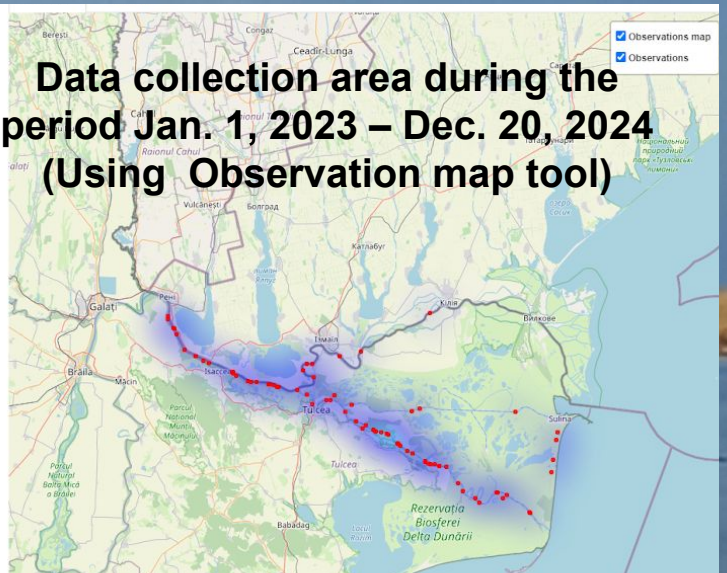


NATUREFIRST

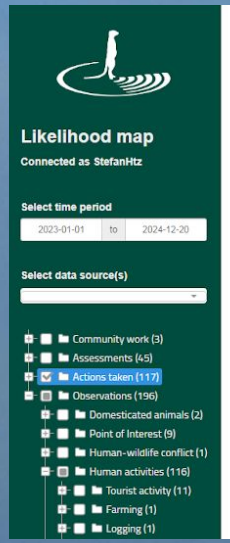
Mapping Human-Wildlife Conflict Hotspots in the Danube Delta Biosphere Reserve Using the Cluey Data Collector

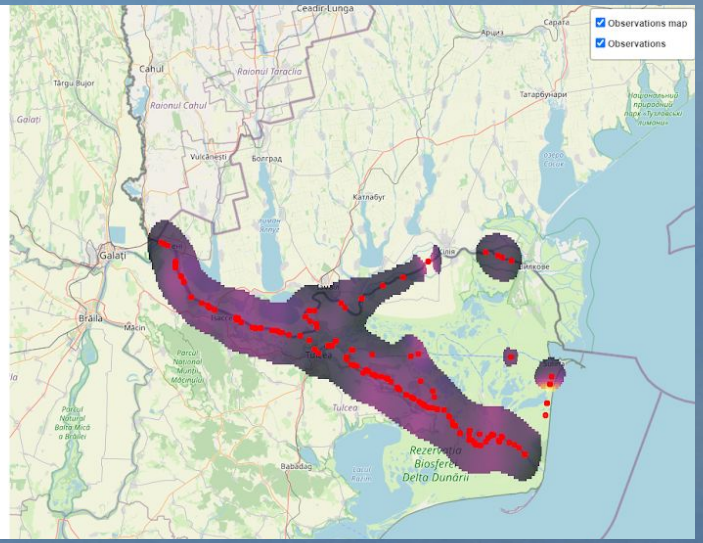
Data collection regarding fishing areas in the Danube sector located in the Danube Delta Biosphere Reserve





Data collection area during the period Jan. 1, 2023 – Dec. 20, 2024 (Using Observation map tool)





Data analysis result using analytical.sensingclues

HANDOVER

Questions for the field expert?

How do we leverage the information we have to aid monitoring and conservation?

June 2023

AGENT-BASED MODEL OF BELUGA STURGEON

- Population dynamics
- Migration patterns

What is an agent-based model?

Agent based models contain “agents” - in this case sturgeon

Agents have sets of rules to make decisions

Individual decisions create population level patterns

Should I migrate now?

- [x] **Am I an adult?**
- [x] **Is this my first time or has it been 2+ years since last time?**
- [ ] **Is the water over 6 degrees?**

Adult (10:15+)

Subadult (1-10:15)

Young of the Year (0-1)

Eggs (days)

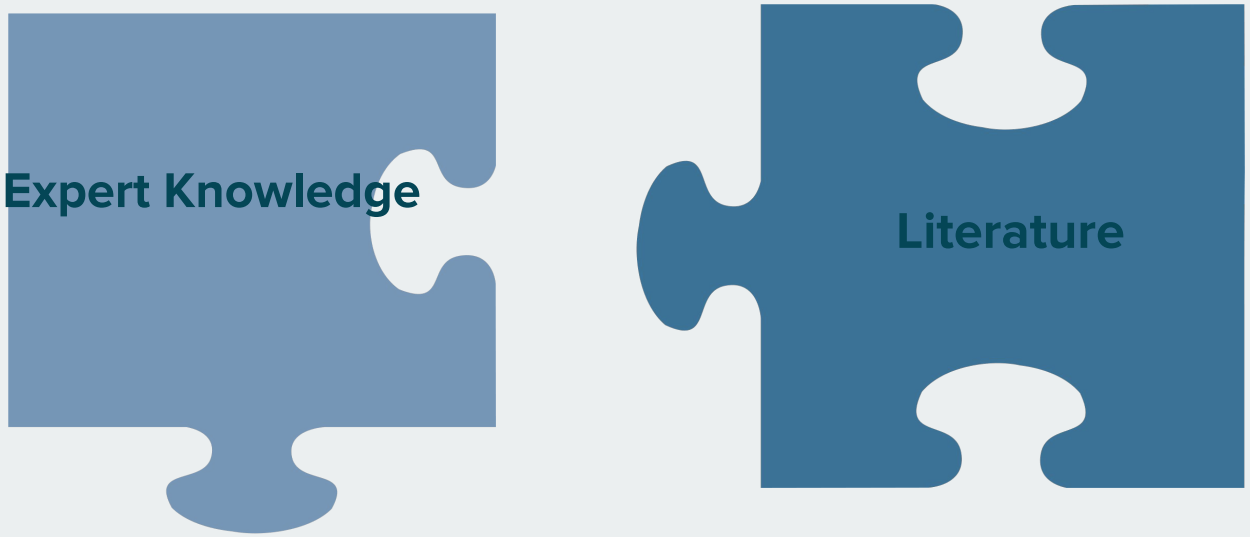
Environmental Data

Daily timesteps
2015 - 2023 (or present)

Water temperature

Water level

Piecing Together the Model

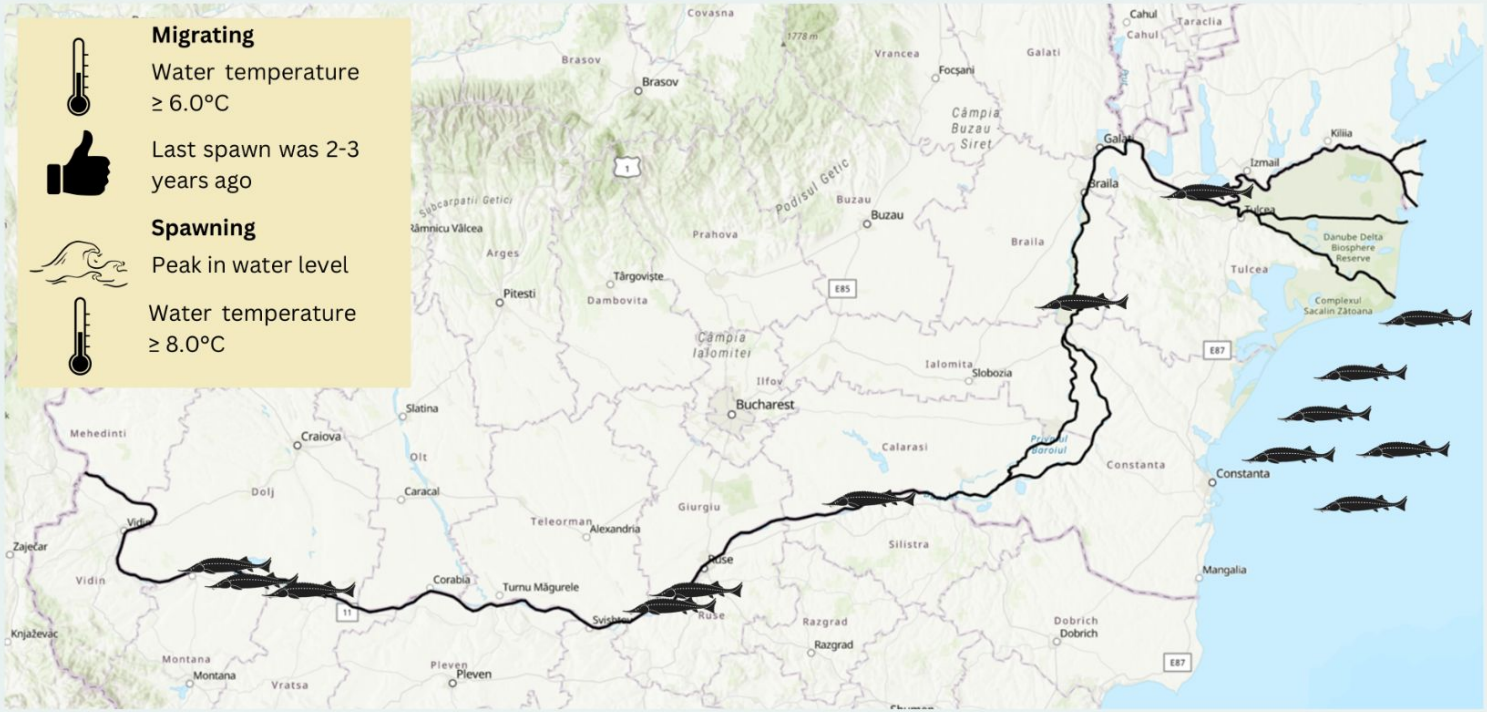


“Adult sturgeon migrate upstream in the spring to spawn triggered by a combination of temperature and a water level peak”

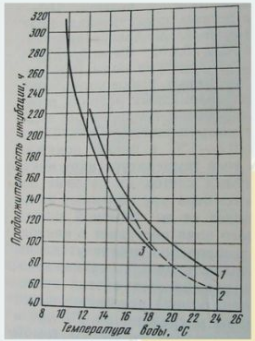
+

“Spring migration occurs at temperatures of 6-21°C”

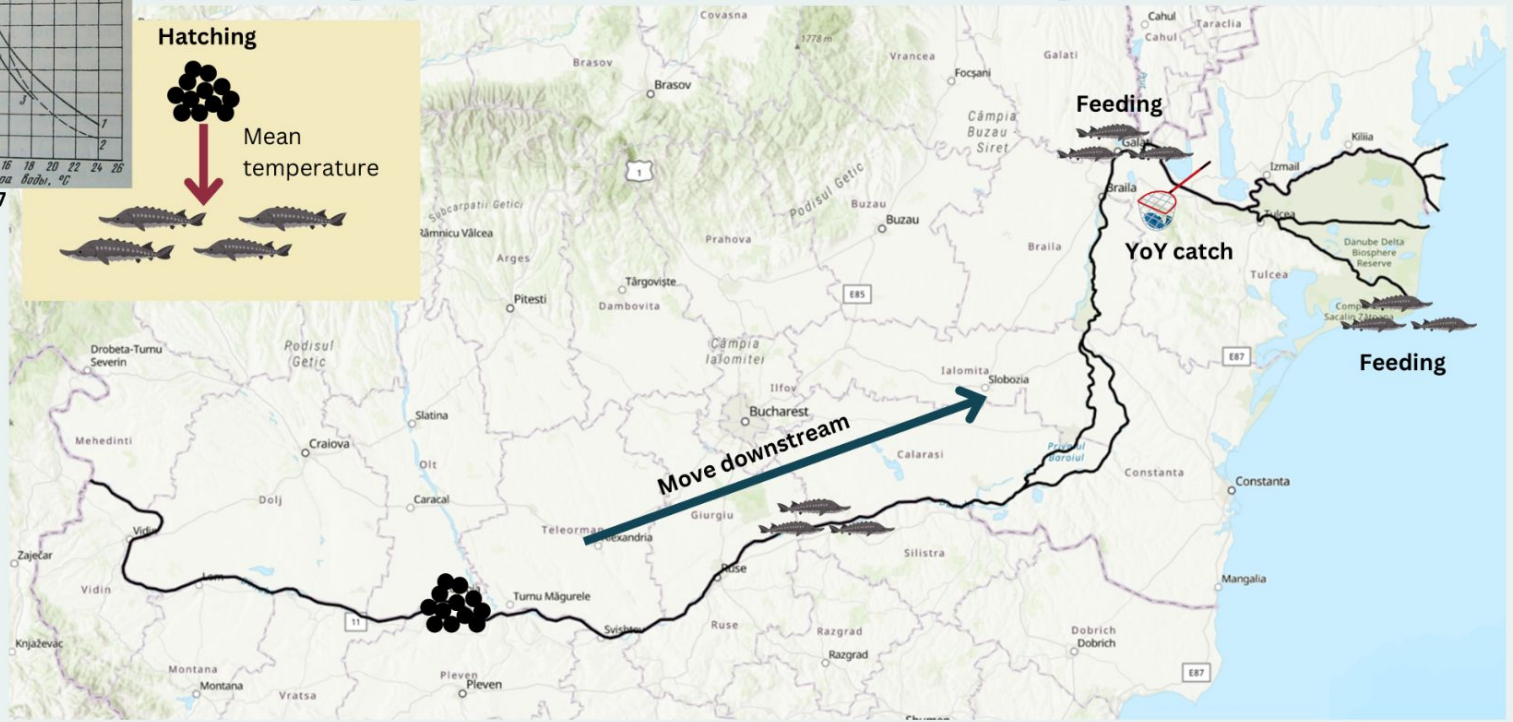
Adult Migration and Spawning



Eggs and YoY Migration



Ivanov, 1987



What did we FIND OUT?

Experiment Results

Spawning Temperature Threshold

The temperature at which sturgeon are triggered to spawn

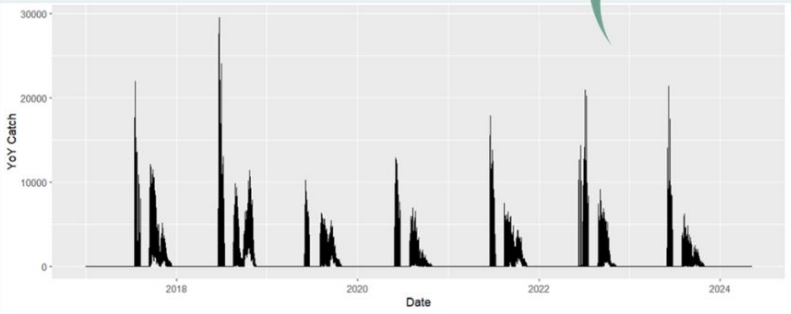
Environmental Dataset Location

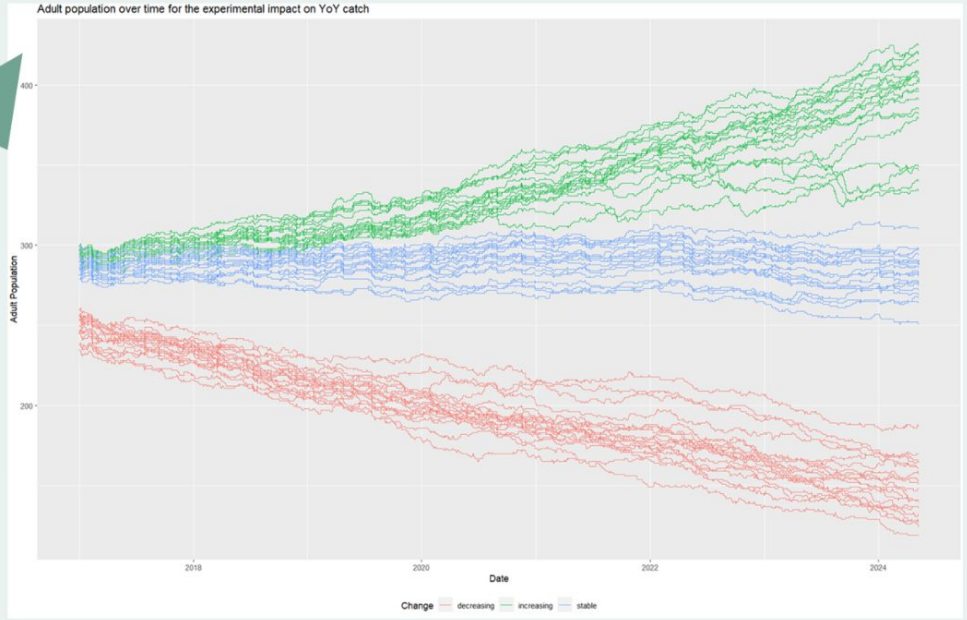
The selection of which environmental sensor along the river to use as input

Interaction

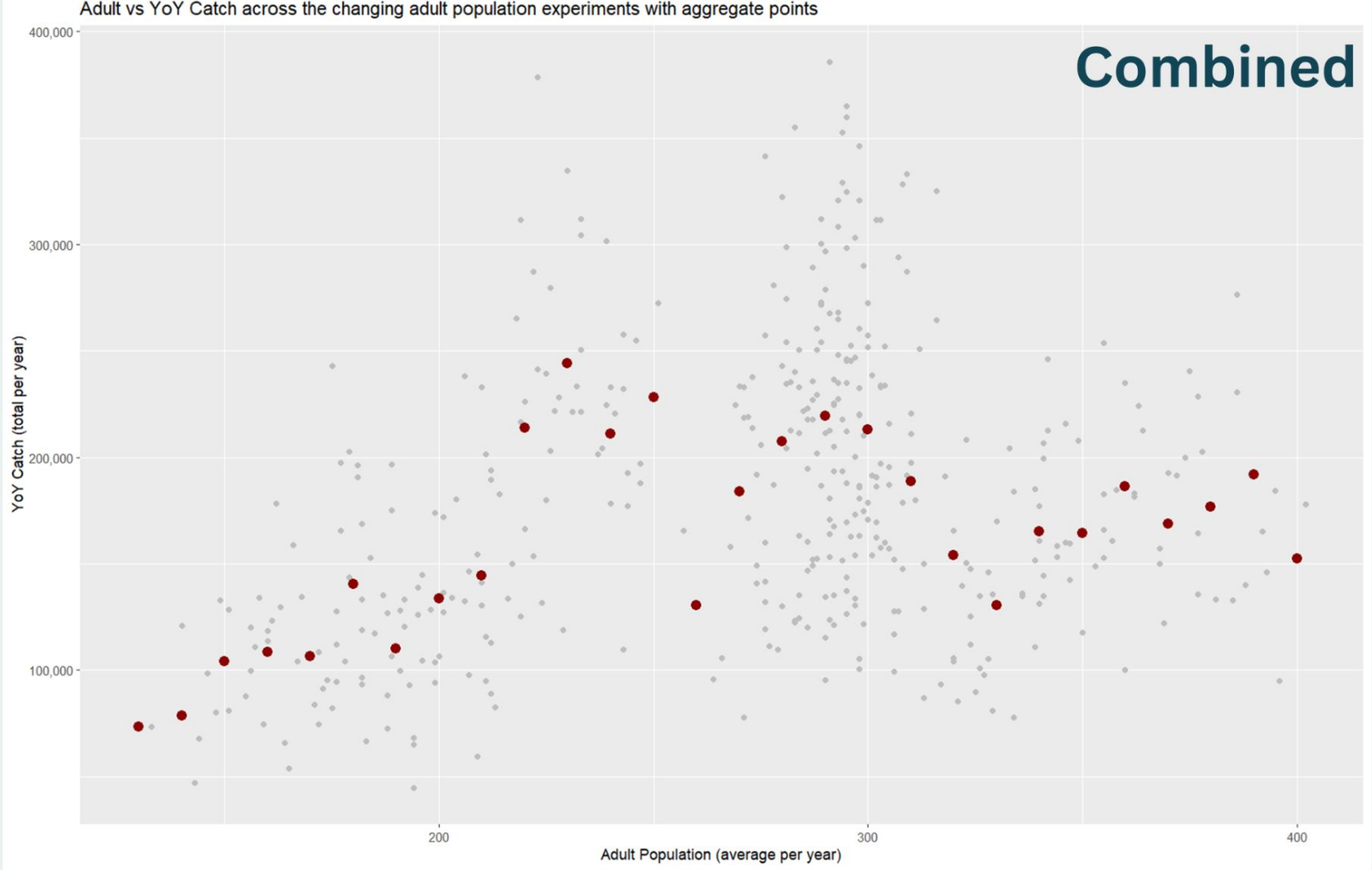
The impact of these two variables combined is amplified

Virtual Ecologist Approach





20 simulations of increasing, stable and decreasing adult populations


Adult vs YoY Catch across the changing adult population experiments with aggregate points
Combined
400,000
300,000
200,000
100,000
YoY Catch (total per year)
200
300
400
Adult Population (average per year)

MOVING FORWARD

GitHub

Coming soon...

Let’s make it useful in the field!

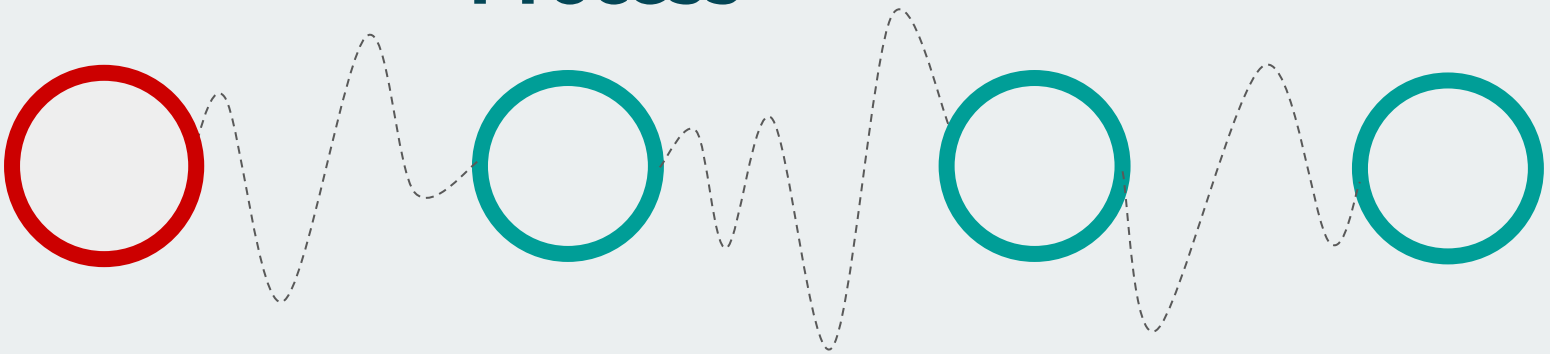
HANDOVER

From Science to a Tool

HANDOVER

Questions for the researcher?

Developer Process



Scientific handover

Transition from research to development.

First map

Visualizing the area of interest for the sturgeons.

Hydrostations

Zooming in on the input data.

Sturgeon heat map

Adding the modelling outputs to the tool.

Handover From Science To A Tool

Code Blame 1184 lines (1105 loc) · 55.5 KB Code 55% faster with GitHub Copilot Raw

```
############ BELUGA STURGEON ABM ##############################################
# The following is an agent based model built to examine the factors which
# influence beluga sturgeon (Huso huso) migration and population in the Danube
# River up to the Iron Gates dams. The parameters included in this model are
# accumulated as far as possible from a mixture of literature review and
# consultation with experts. The sampling of the YoY simulated in this model
# reflects the sampling conducted by DDNI each year.

# Agents are individual adult and subadult sturgeon as well as groups of eggs
# and YoY from the same mother. Spatial information was created using ArcGIS Pro
# using real spawning, wintering and feeding sites.

# The output is several csv files which record key dates in migration and
# spawning, the sturgeon present in the model, overall population numbers and
# the simulation of YoY sampling.

################################################################################

# First load in the packages used
library(lubridate)
library(tidyverse)
library(dplyr)
library(leaflet)
library(magrittr)
library(sf)
library(ggplot2)
library(TrackReconstruction)
library(stringr)
```

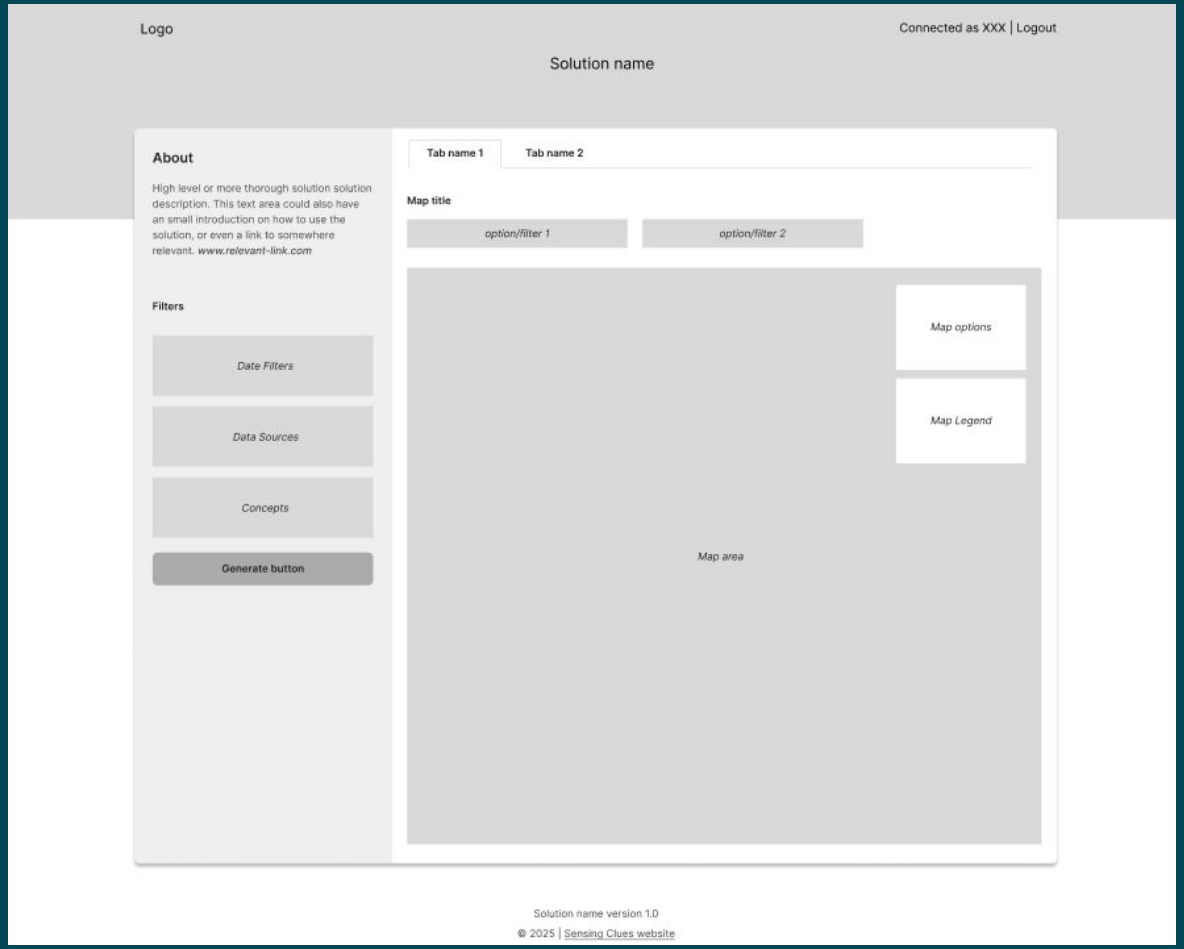
Code Blame 1184 lines (1105 loc) · 55.5 KB

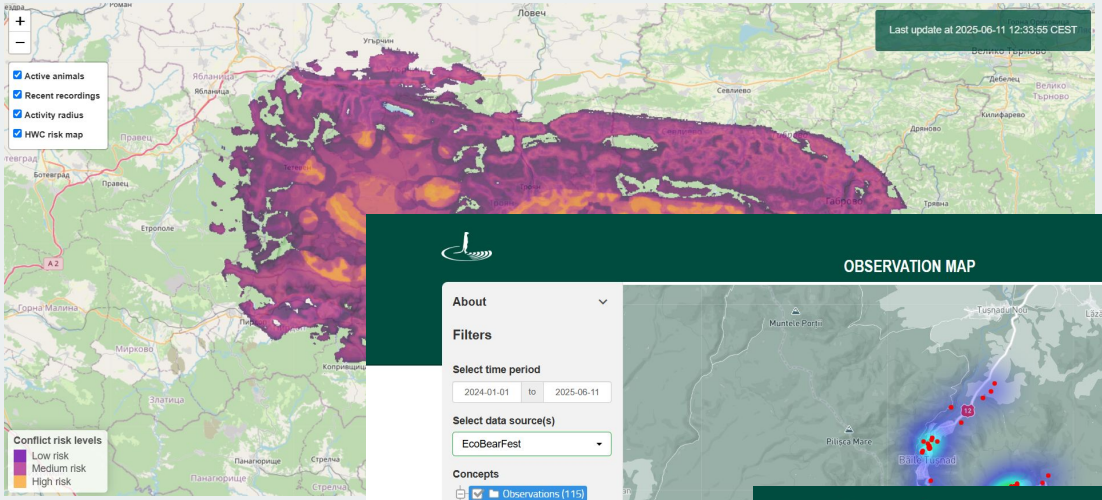
```
##### Load in agents #####
# Load in the pre-made, standard sturgeon
# population.

# Use this for the baseline
sturgeon <- read.csv("baseline_sturpop.cs
spawningtrack <- read.csv("baseline_stand

# Convert to sf data frame
sturgeon_sf <-
  st_as_sf(
    sturgeon,
    coords = c("X_Coord", "Y_Coord"),
    crs = 4326,
    na.fail = FALSE
  )
sturgeon_sf$Spawnsite <- as.numeric(sturg

spawningtrack$Date_left <- as.POSIXct(spa
spawningtrack$Date_spawned <- as.POSIXct(
########################################
# Load in the data frame for the existing
younggroups <- read.csv("Start_younggroup
colnames(younggroups) <- c("ID", "Class",
younggroups$X <- str_replace_all(younggroups$X, "([c(X = ])", "")
younggroups$Y <- str_replace_all(younggroups$Y, "([Y = )])", "")
younggroups <- st_as_sf(younggroups, coords = c("X", "Y"), crs = 4326)

```

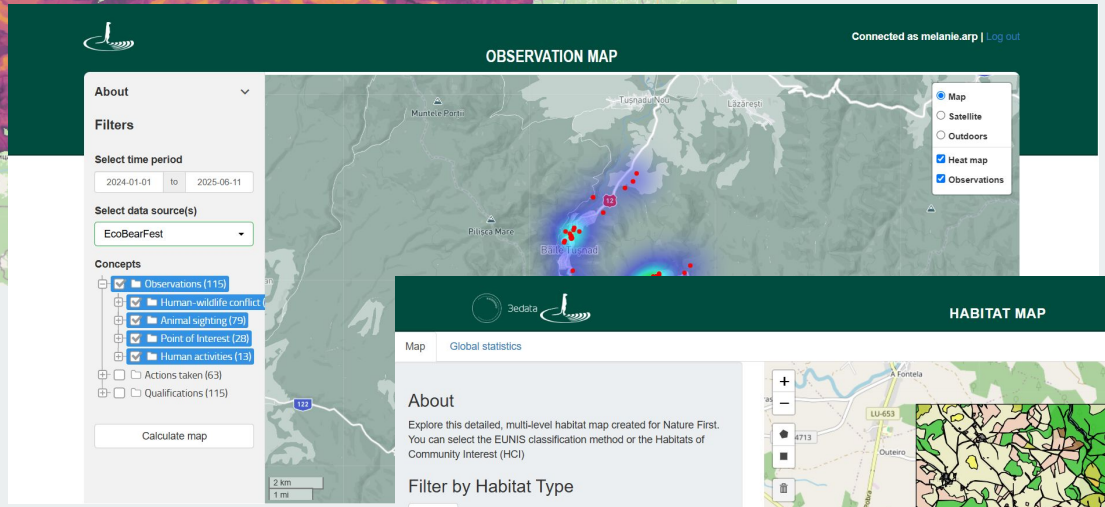
Code Blame 1184 lines (116

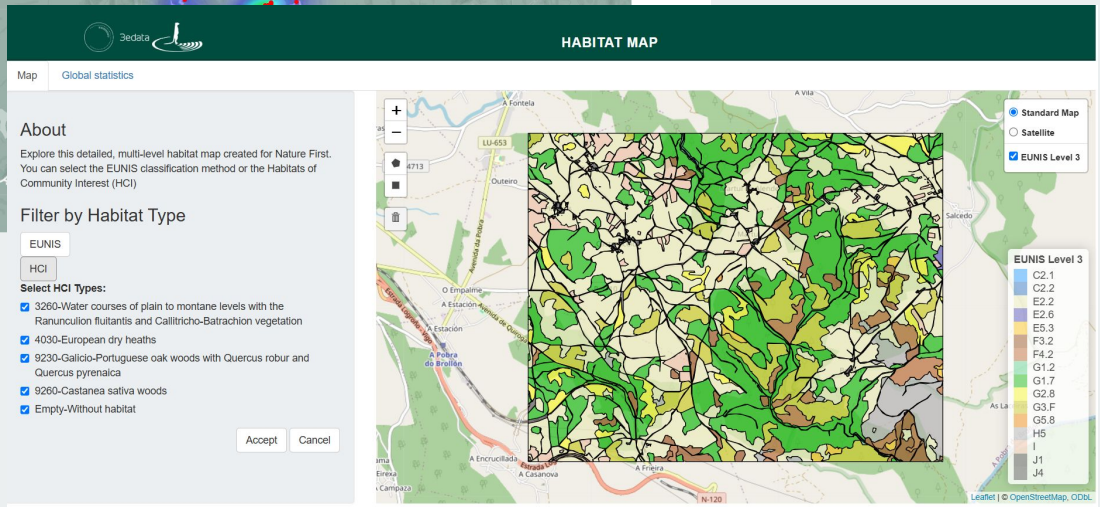
```
##### For Loop - Mod
# Establish the time
start_time <- Sys.ti

# The model runs for
for (day in 1:nrow(E
  print(EnvVarHist$D
  # Firstly mortalit
  # For each of the
  if (nrow(younggrou
    for (group in 1:
      ##############
      # First comes
      # the day to t
      # Mortality is
      # first year i
      # starting wit

      # Mortality is
      # function whi
      # annual morta
      survivingYoung <- survivingYoY(younggroups$Number[group], asYoYnum)
      # Replace the number with the new number of living individuals
      younggroups$Number[group] <- survivingYoung
      # Add a day to their age
      younggroups$Age[group] <- younggroups$Age[group] + 1
```

Designing the Interactive Tool

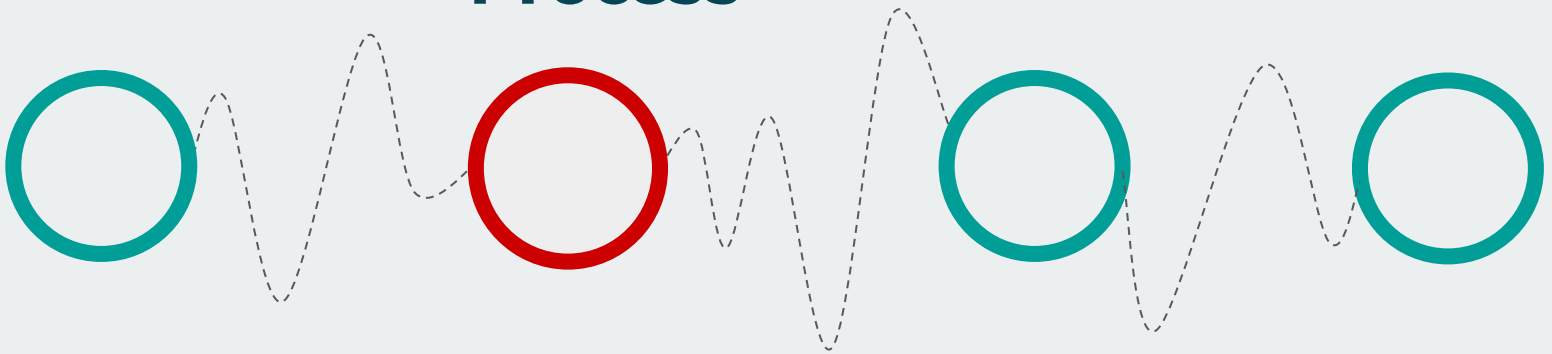



Last update at 2025-06-11 12:33:55 CEST
Active animals
Recent recordings
Activity radius
HWC risk map
Conflict risk levels
Low risk
Medium risk
High risk


OBSERVATION MAP
Connected as melanie.arp | Log out
About
Filters
Select time period
2024-01-01
to
2025-06-11
Select data source(s)
EcoBearFest
Concepts
Observations (115)
Human-wildlife conflict (
Animal sighting (79)
Point of Interest (28)
Human activities (13)
Actions taken (63)
Qualifications (115)
Calculate map
Map
Satellite
Outdoors
Heat map
Observations


3edata
HABITAT MAP
Map
Global statistics
About
Explore this detailed, multi-level habitat map created for Nature First. You can select the EUNIS classification method or the Habitats of Community Interest (HCI)
Filter by Habitat Type
EUNIS
HCI
Select HCI Types:
3260-Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation
4030-European dry heaths
9230-Galicio-Portuguese oak woods with Quercus robur and Quercus pyrenaica
9260-Castanea sativa woods
Empty-Without habitat
Accept
Cancel
Standard Map
Satellite
EUNIS Level 3
EUNIS Level 3
C2.1
C2.2
E2.2
E2.6
E5.3
F3.2
F4.2
G1.2
G1.7
G2.8
G3.F
G5.8
H5
I
J1
J4
Leaflet | © OpenStreetMap, ODbL

Developer Process



Scientific handover

Transition from research to development.

First map

Visualizing the area of interest for the sturgeons.

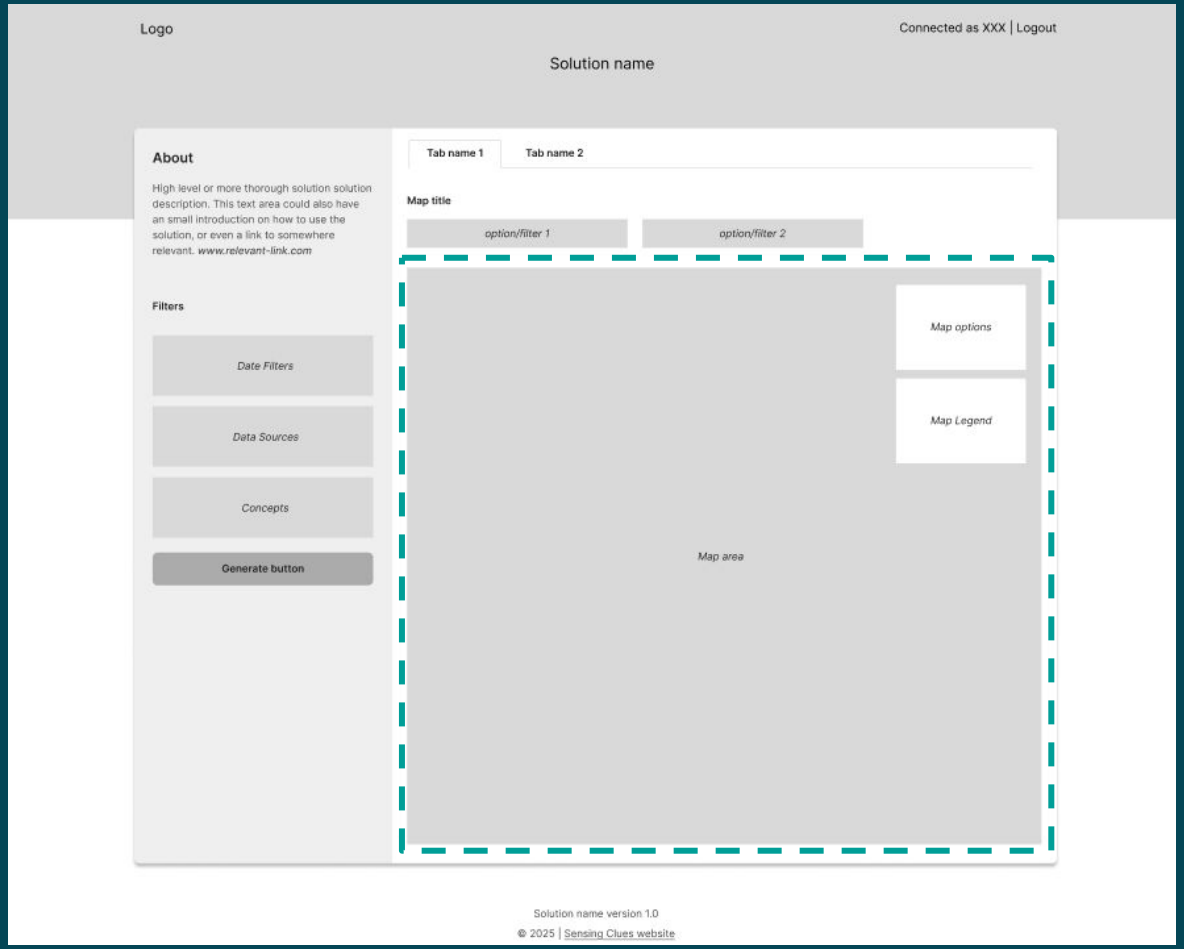
Hydrostations

Zooming in on the input data.

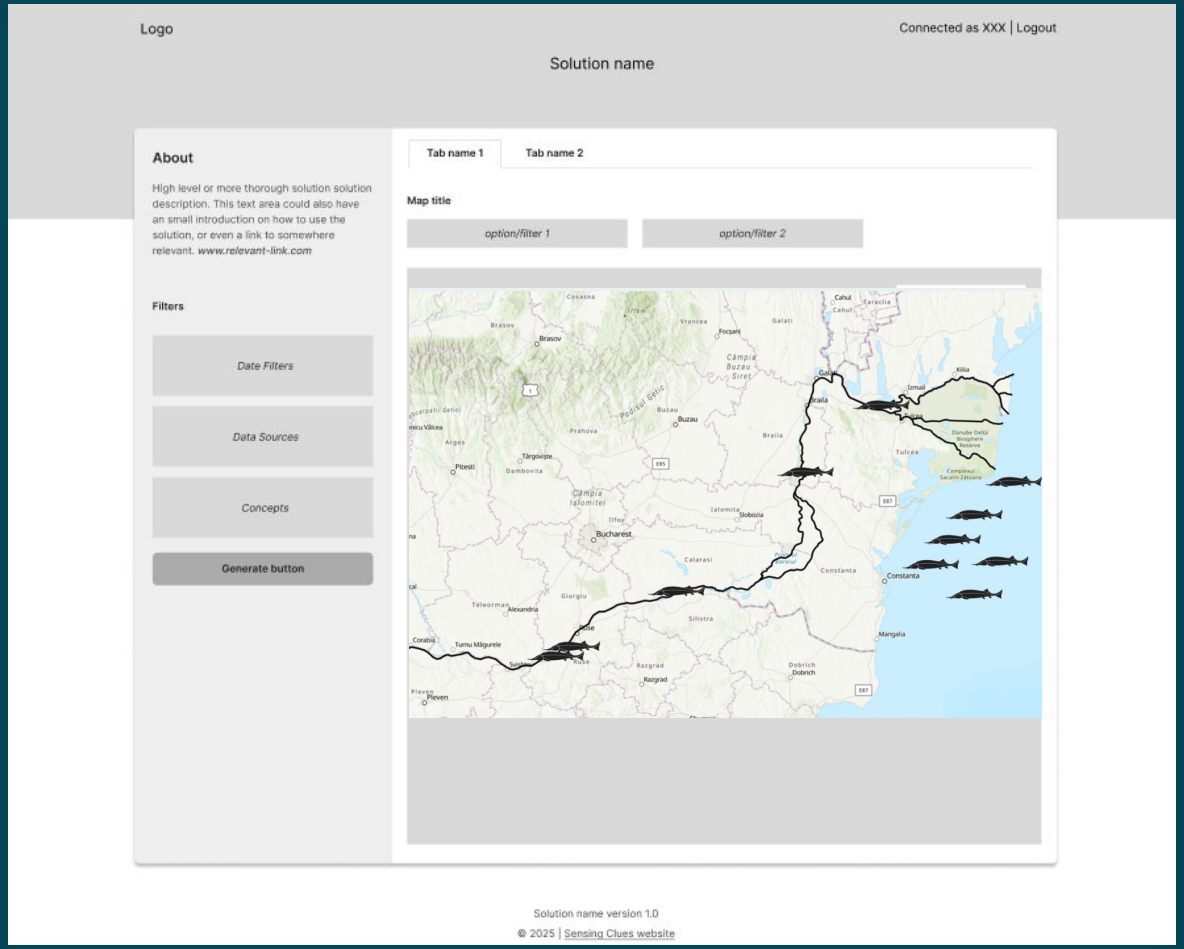
Sturgeon heat map

Adding the modelling outputs to the tool.

Starting Point
The Map



- The Landscape
- The Danube River
- Key Sites for Sturgeons



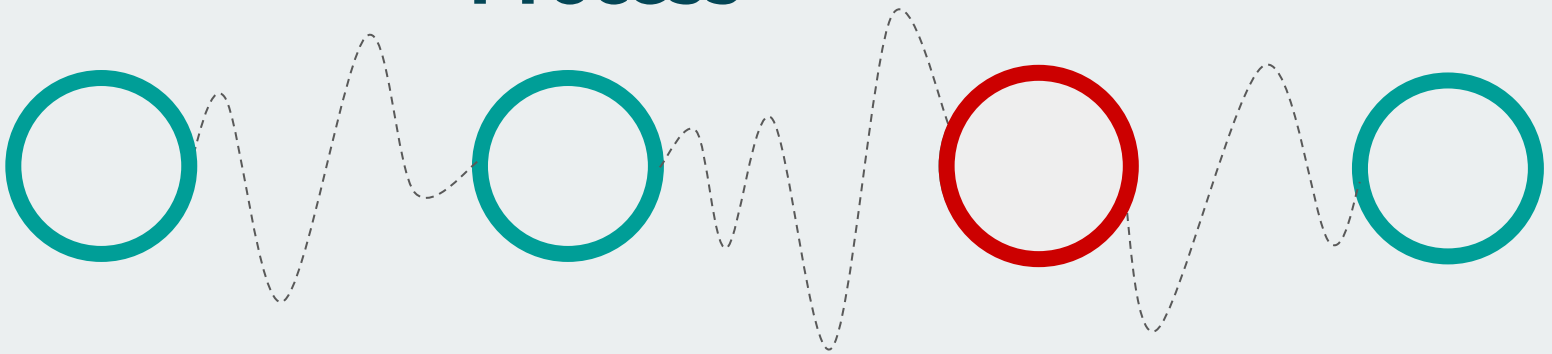
Study the sturgeon's homeground

Highlight the environment on the map

- **Zoom in to study area: Europe-Romania-Danube-Delta**
- **Basemap toggle**
- **Show Danube river sectors**
- **Show spawning/wintering sites**
- **Show potential/proved spawning sites**
- Comparison of Anna's scientific map with the live version

<Live Demo>

Developer Process



Scientific handover

Transition from research to development.

First map

Visualizing the area of interest for the sturgeons.

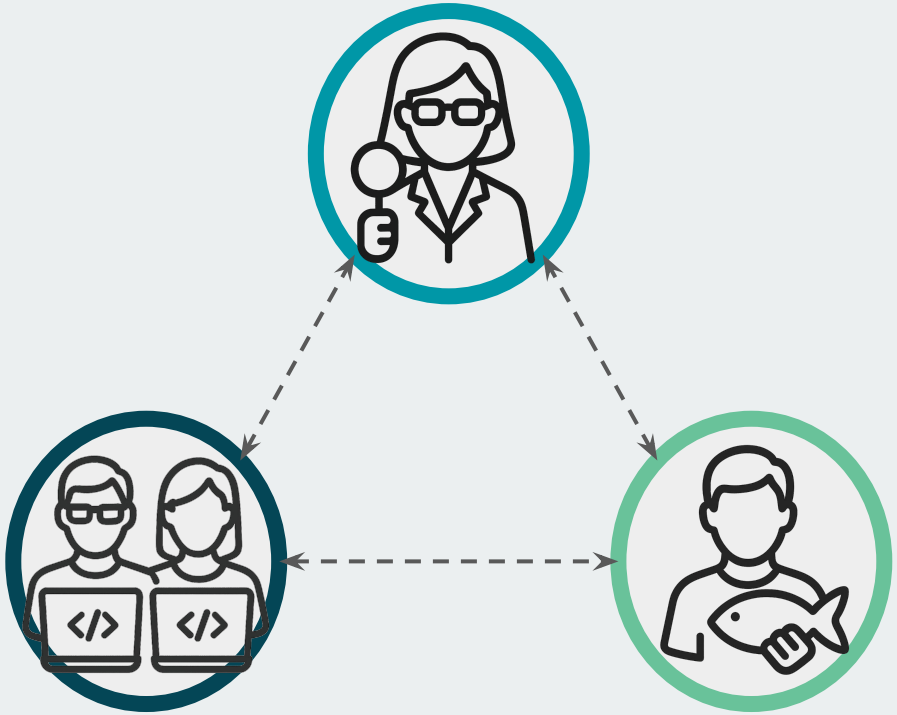
Hydrostations

Zooming in on the input data.

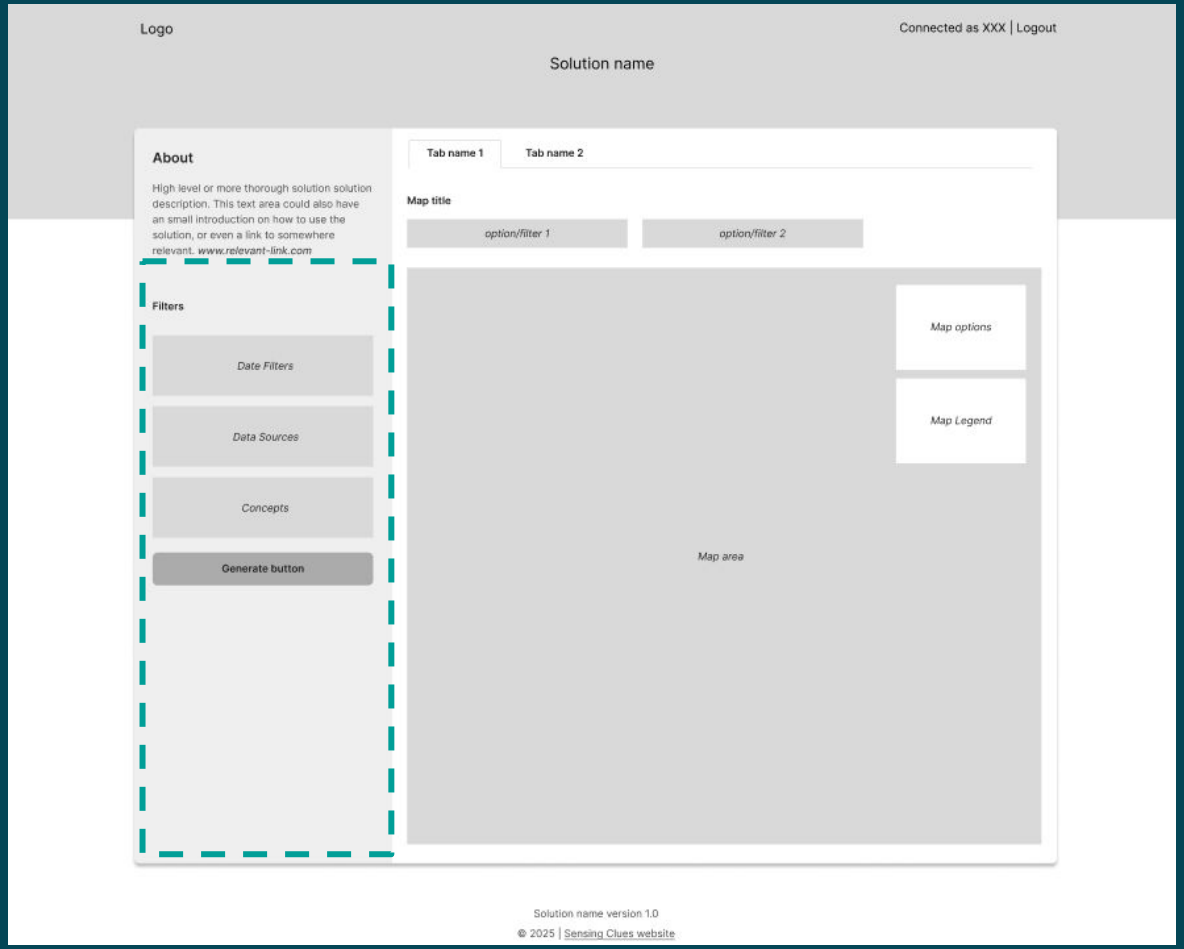
Sturgeon heat map

Adding the modelling outputs to the tool.

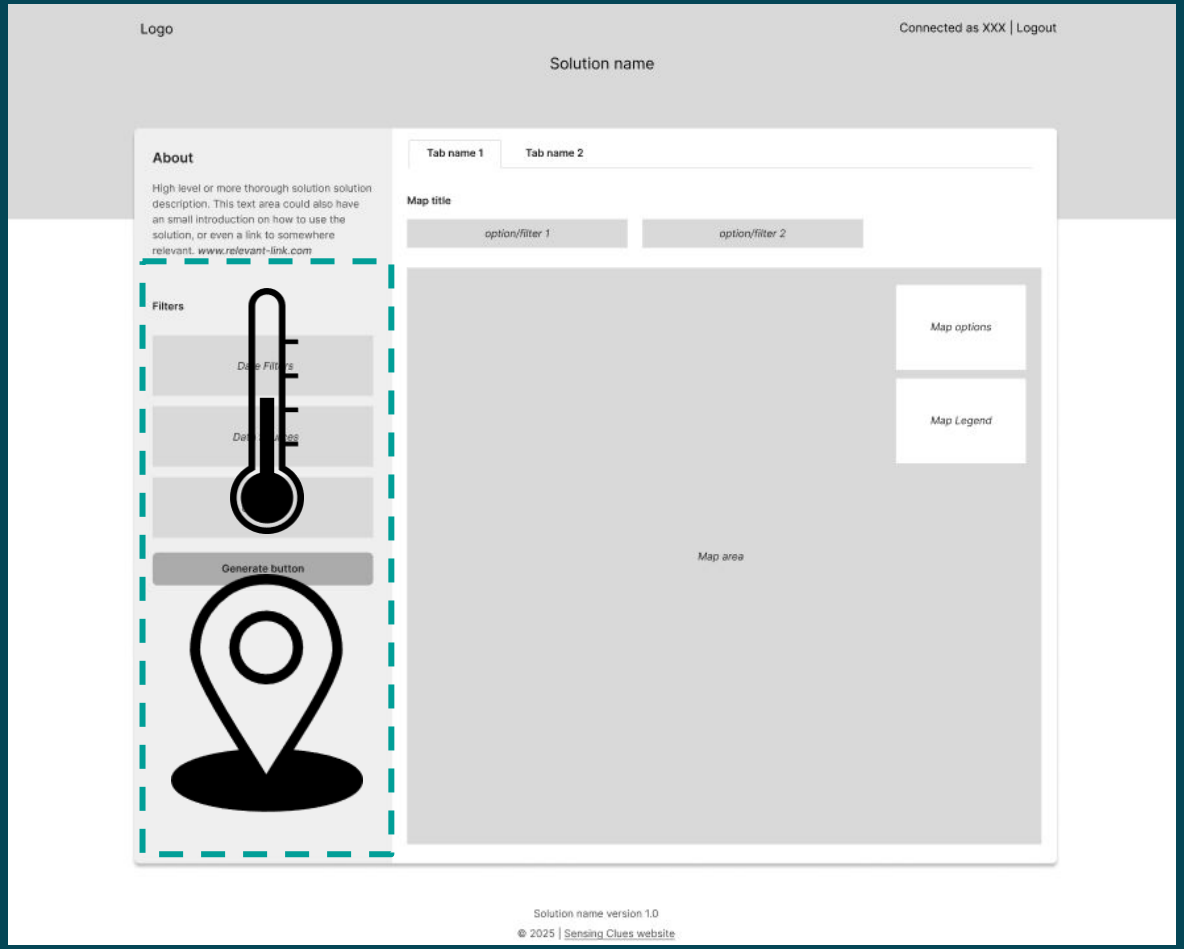
Informed Development



Focus On
The Inputs



Focus On
The Inputs



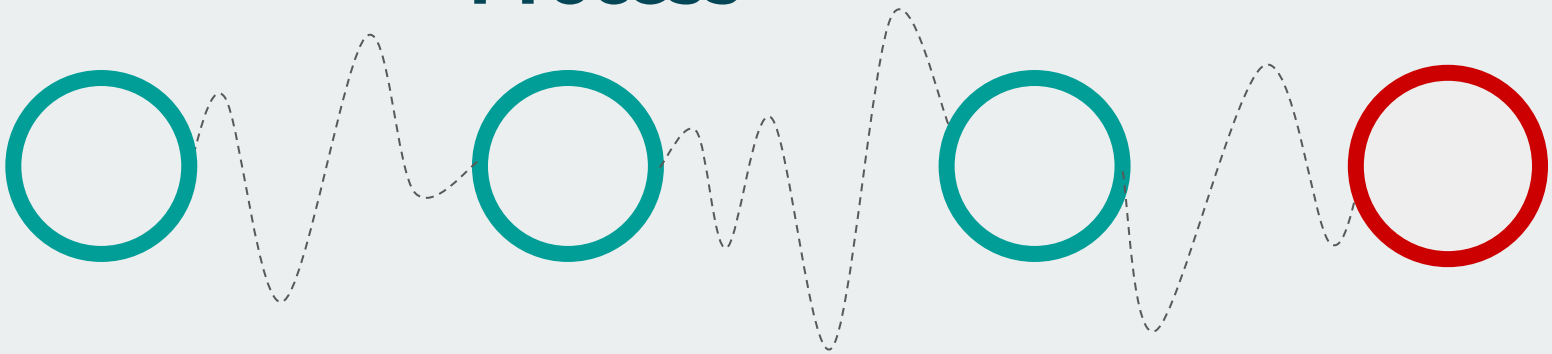
Hydrostations into the mix

Relevant hydrostation data makes the output closer to now-casting, so automated collection

- Show https://www.cotele-dunarii.ro/
- Show collection of recent data
- Show recent station data in the application

<Live Demo>

Developer Process



Scientific handover

Transition from research to development.

First map

Visualizing the area of interest for the sturgeons.

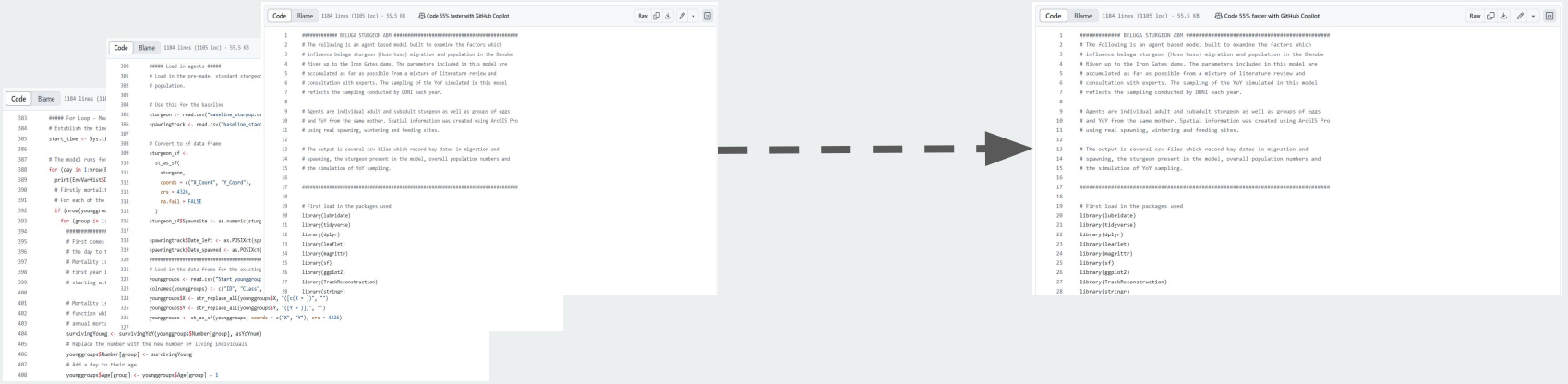
Hydrostations

Zooming in on the input data.

Sturgeon heat map

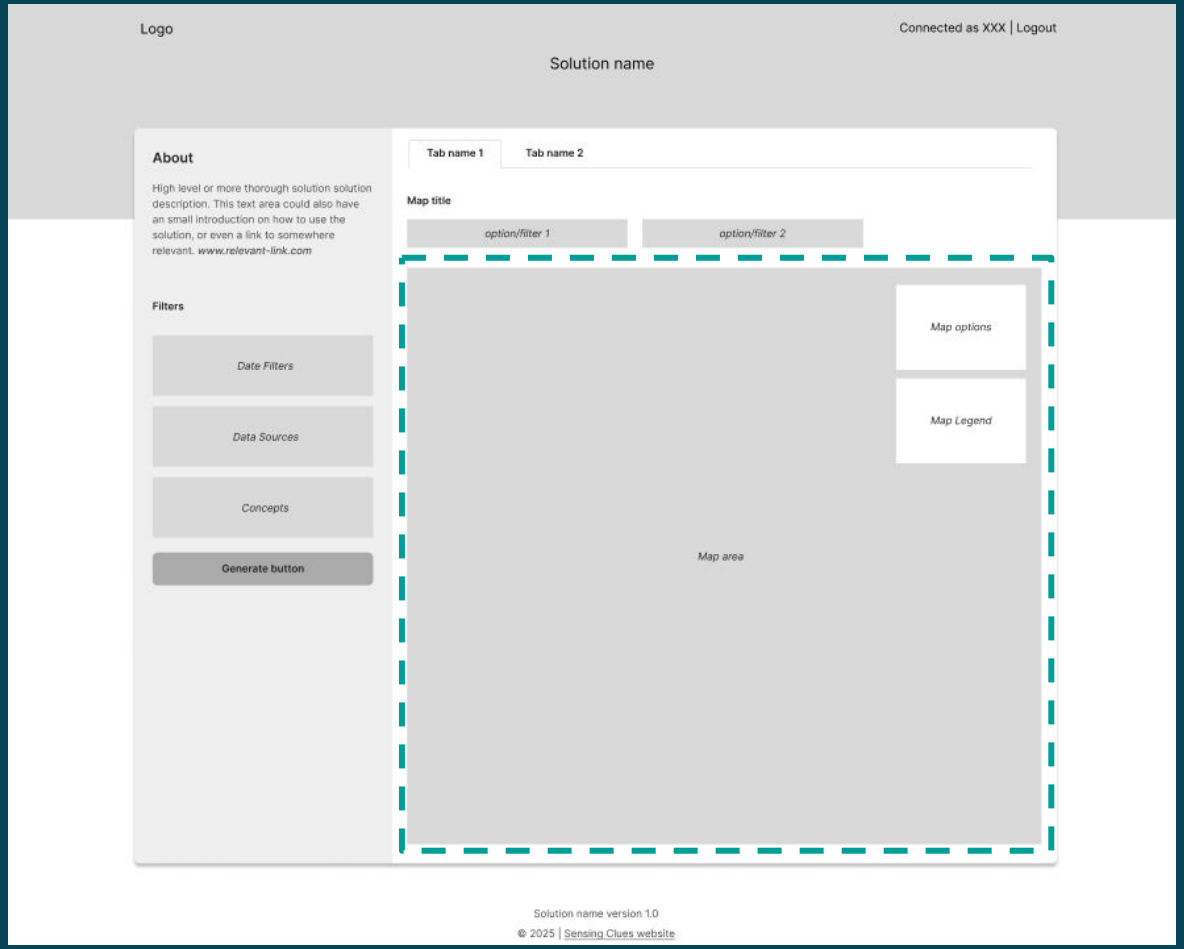
Adding the modelling outputs to the tool.

Simplifying The Model

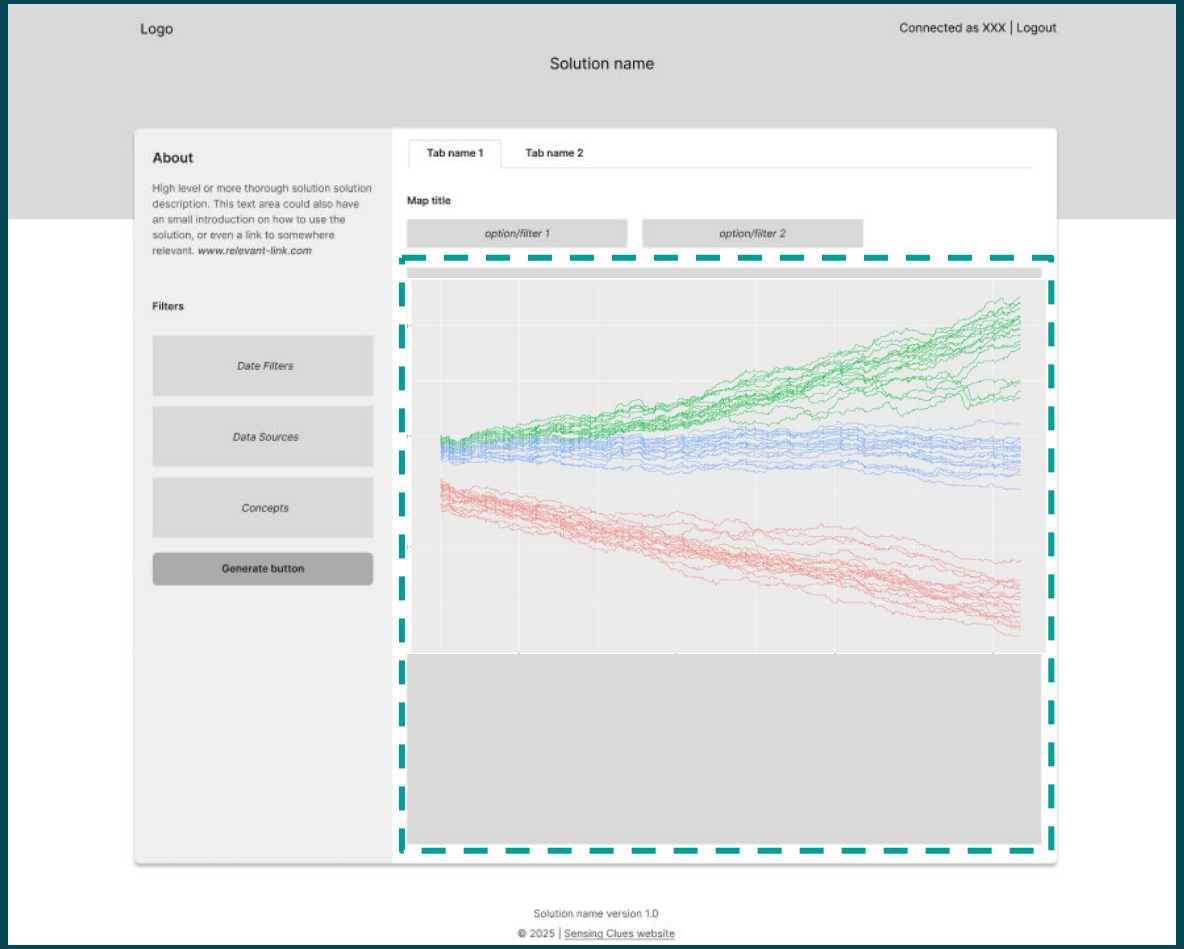


End User In The Picture

Modelling
Outputs



Modelling Outputs



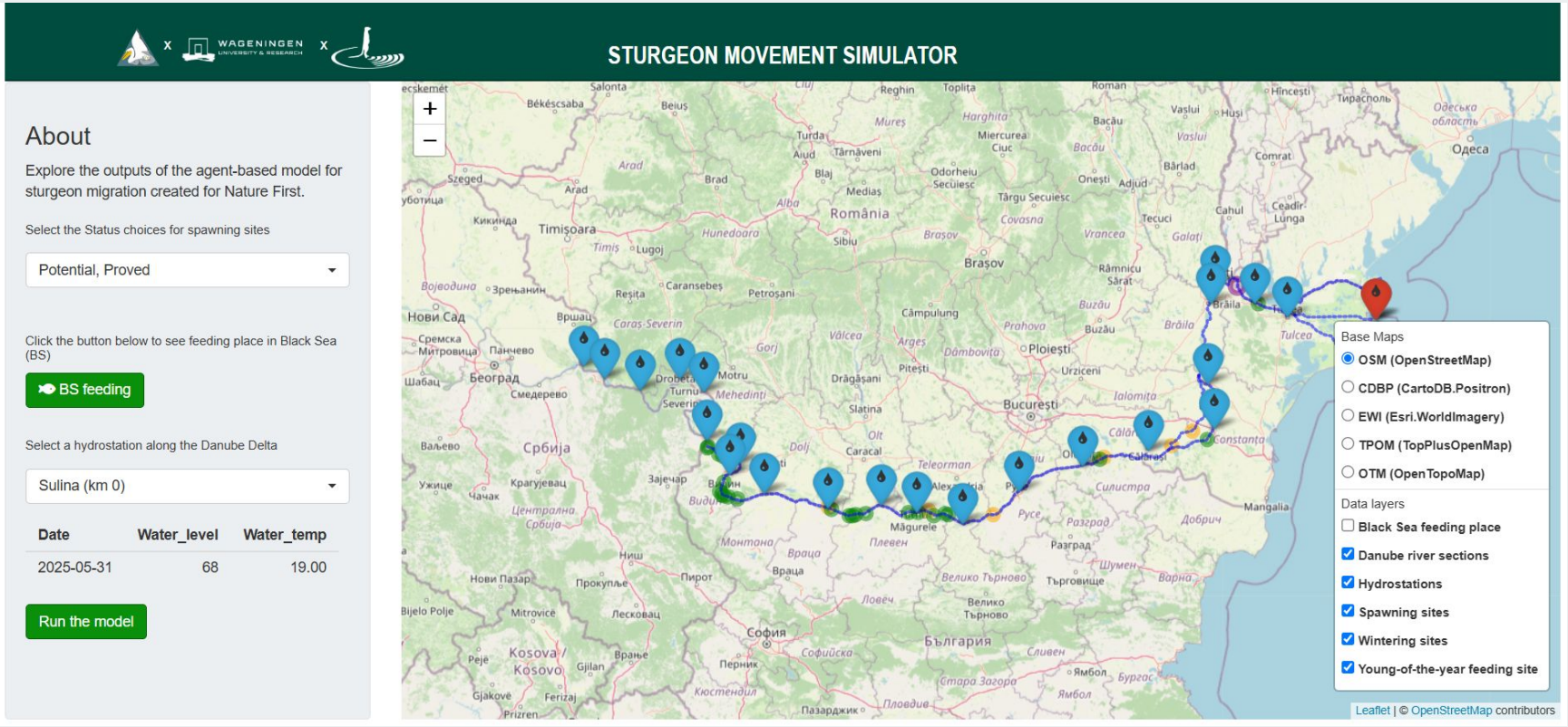
Running the model

Simplify the model to define the output that should be on the map: sturgeon heat map (depending on state) and spawn/hatch/migration dates

- Show a model run, short version
- Show the sturgeon heat map after a model run, switching between state

<Live Demo>

Tool Under Development



HANDOVER

Questions for the developer?

Thanks for Listening!

Over to you:
Questions? Thoughts? Reflections?

Conclusions:

Why Predicting Beluga Sturgeon Migration for Sturgeon Conservation?

Agent-Based Model - An Integrated and Adaptive Approach for Complex Ecosystems

-**Simulates Sturgeon Migration Paths** - Uses telemetry data to model how individual sturgeons migrate, respond to environmental cues, and identifying spawning routes.

-**Environmentally Driven Behavior and Habitat Dynamics** – Incorporates Danube River water temperature and levels that trigger spawning events, informing the development of a spawning calendar that reflects natural migration timing and is used to monitor sturgeon larval movement and habitat use along the Lower Danube River, helping to identify critical zones.

NATUREFIRST

Conclusions:

- **Connects with Spawning Success Data** - Integrates data on the capture of young-of-the-year to validate model predictions and assess reproductive outcomes.
- **Maps Human-Wildlife Conflict Zones** - Combines biological modeling with spatial data from Cluey Data Collector to identify and mitigate human-wildlife conflict hotspots in the Danube River.
- **Supports Conservation and Scenario Testing** - Enables simulation of future river conditions, human pressures, and management strategies—vital for long-term sturgeon protection.

NATUREFIRST

Thank You!

NATUREFIRST

Field Expert Perspective

Researcher Perspective

Developer Perspective

More info?

NATUREFIRST

naturefirst.info

SENSING CLUES

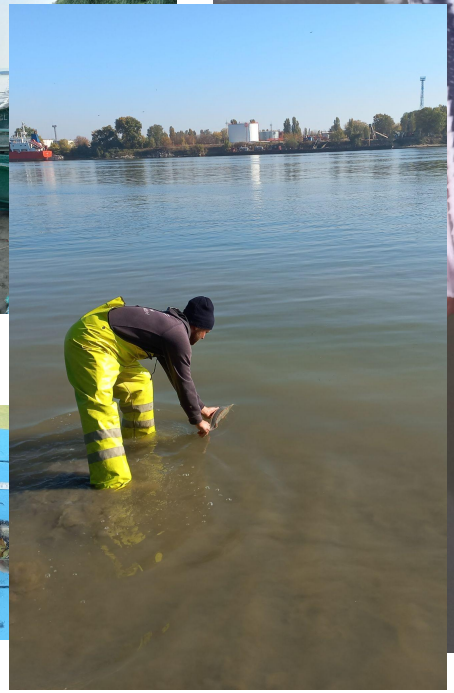
sensingclues.org

SINCE 1970 DDNI TULCEA 50

ddni.ro

Stefan Hont - stefan.hont@ddni.ro
Anna Davison - anna.davison@wur.nl
Marian Mierla - marian.mierla@ddni.ro
Melanie Arp - melanie.arp@sensingclues.org

EXTRA IMAGES



EXTRA IMAGES