Improving eel downstream passage with machine learning

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Herting power plant

- Herting HPP at the river Ätran, Sweden
- 3 Km upstream river mouth
- Catchment area of 3,342 km^2
- Mean annual discharge of 57 m^3/s
- Migrating species, such as European eel, Atlantic salmon, Sea trout
- Major modifications in 2013

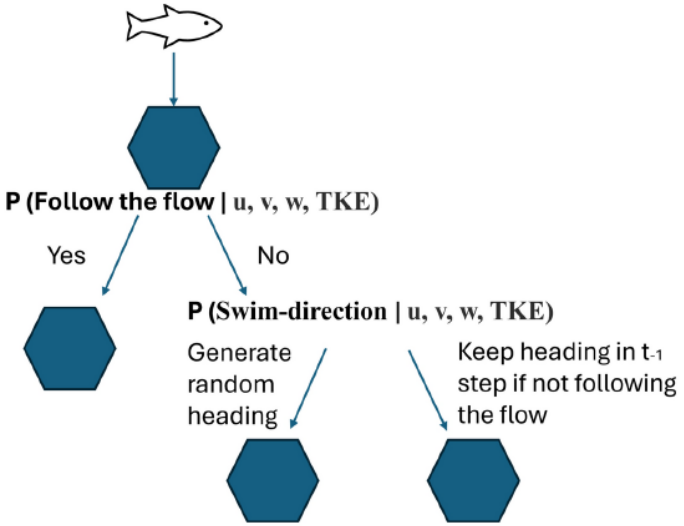
Kjærås et al. 2022

The problem

- Fish pass construction is expensive
- build-and-test approach

Can we develop a predictive tool that tells us how the fish will behave at given hydraulic conditions?

There are studies predicting the swimming behavior of fish



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Predicting fine-scale downstream migratory movement of Atlantic salmon smolt (*Salmo salar*) in front of a hydropower plant

Kim M. Bærum, Ana T. Silva, Henrik Baktoft, Karl Ø. Gjelland, Finn Økland & Torbjørn Forseth

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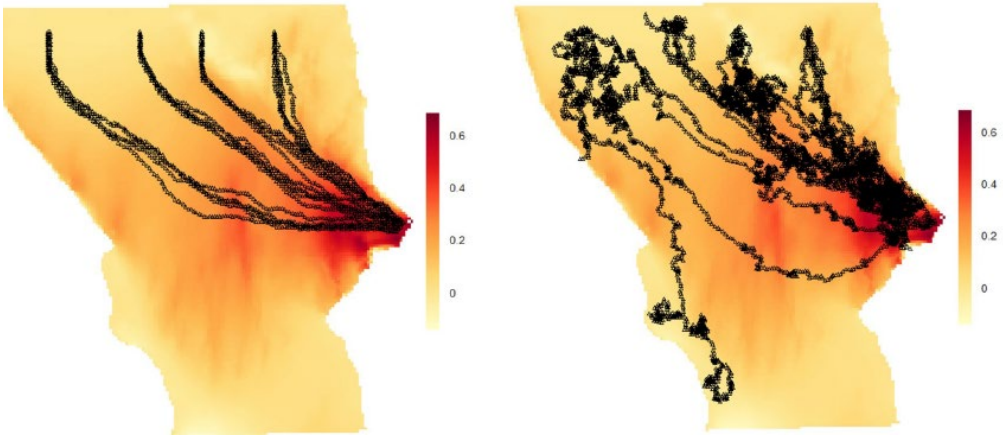


How does the water flow affect the swimming behavior?

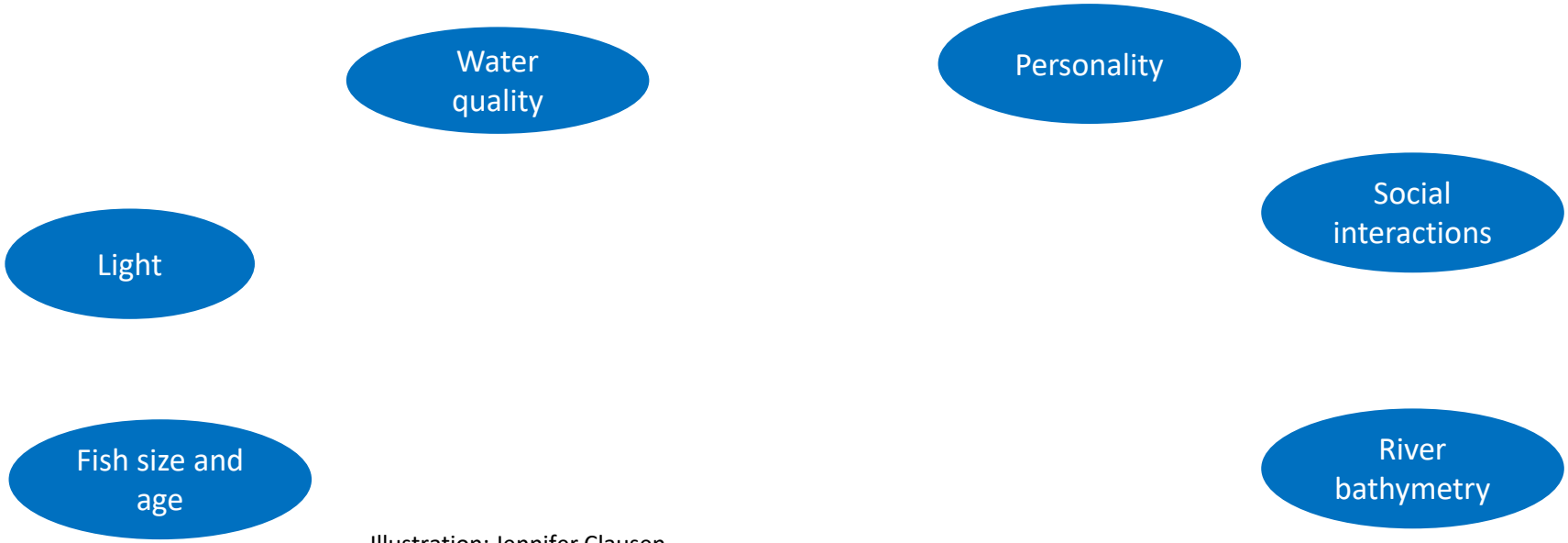


Illustration: Jennifer Clausen

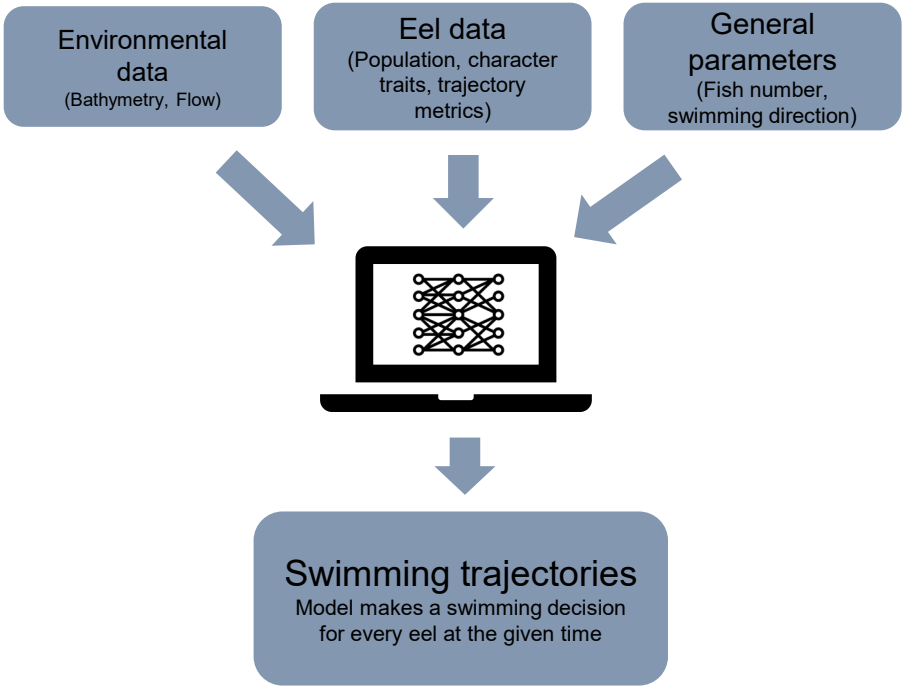
Artificial Neural Networks can use complex patterns

Building an IBM that learns to predict the next position of an eel from multiple variables
Predictor variables:

- Acoustic Telemetry Tracking data of 98 silver eels
- River Bathymetry
- CFD modelled water flow
- Temperature

Advantage:

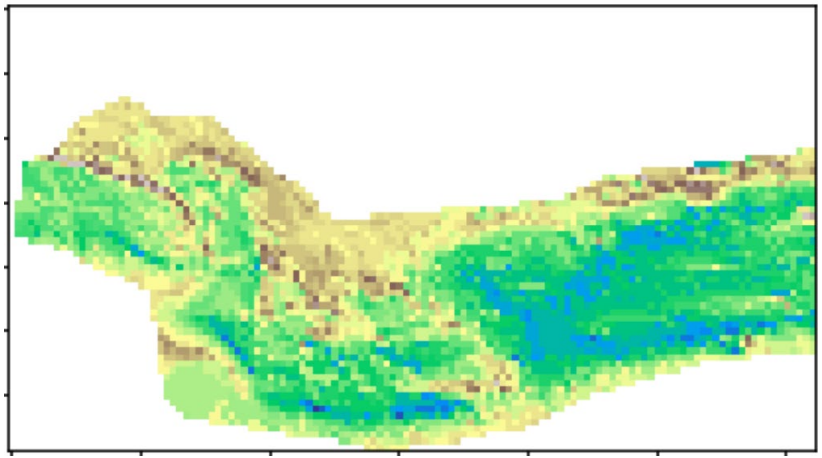
- Account even for fish population and character traits
- Parameter importance revealed from variable exclusion
- Output are swimming trajectories



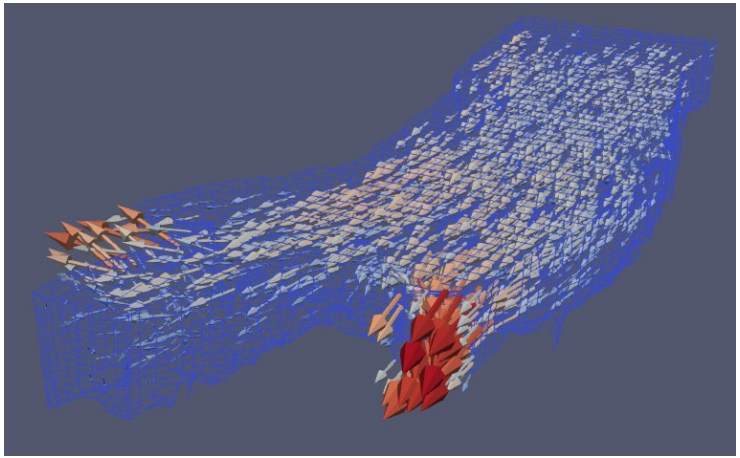
The eel data set

The Bathymetry and water flow

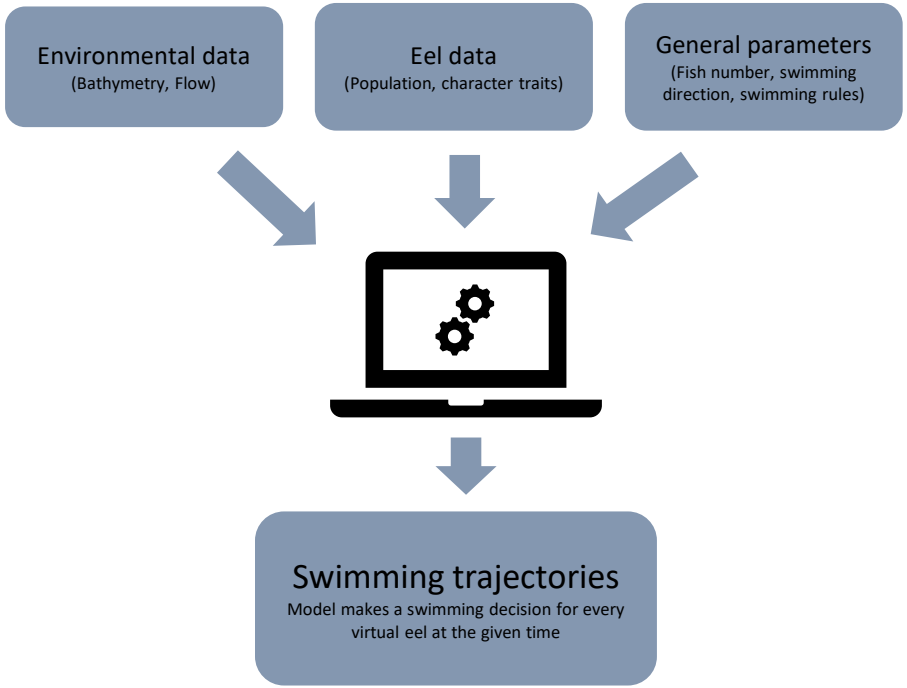
River Bathymetry



CFD modelled water flow vectors



Testing the approach



Virtual eel in futuristic aquatic setting created by ChatGPT

IBM creates a virtual data set

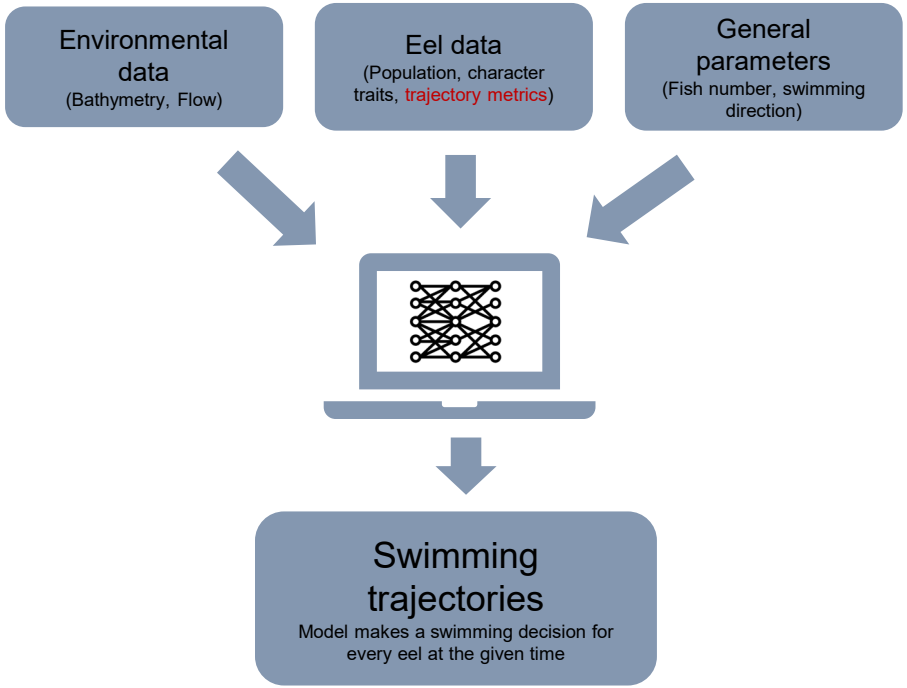
Can we train a Deep Neural Network to predict the next swimming step on the information perceived by the fish?

30 eels over 2000 time steps

Example data set with known patterns:

- Environmental factors (Bathymetry)
- Individual eel characteristics

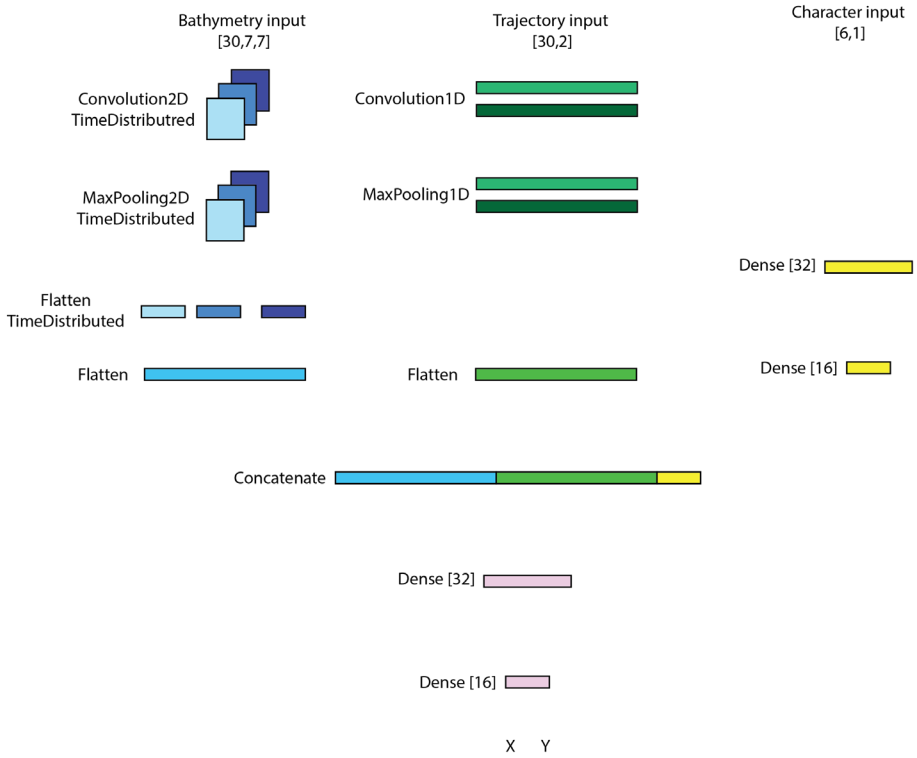
Training an AI model on the swimming data



Virtual eel in futuristic aquatic setting created by ChatGPT

The CNN architecture

- Convolutional Neural Network with three inputs
- Prediction of the next position
- Eel have memory of 30 frames
- Model accounts for bathymetry around eel positions
- Model accounts for eel characteristic traits

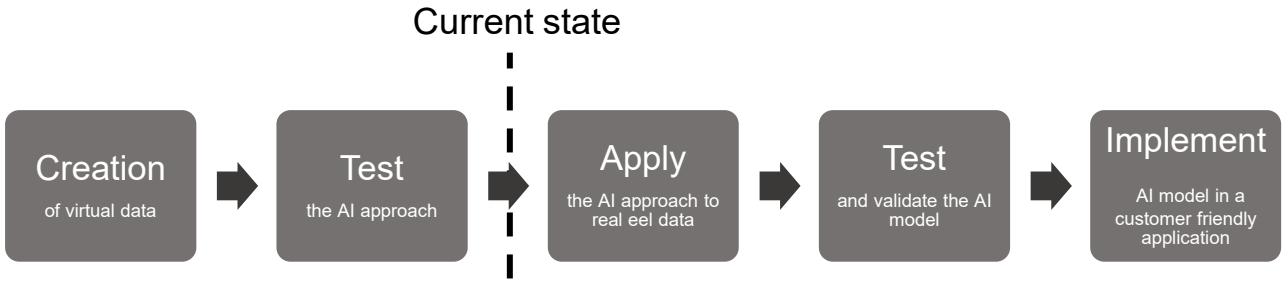


Fitting the model to virtual tracks

Implementing the AI model in the IBM

- IBM rules replaced by the CNN
- The eels have the same characteristic traits as the training eels

Conclusion



Outcome:

- A **predictive tool** for eel behaviour
- Predicition of behaviour in eel populations with different **characteristic traits**
- **Parameter importance** by manupulation of the model input

My turbulent journey

Expertise

Fish behavior ecology
Ethohydraulics
Machine learning
Data Science
Python
R

Postdoc
Predicting eel downstream migration at hydropower plants
Karlstad, Sweden

Since 09/2024

M.Sc. Aquaculture and Sea Ranching
Invasive round goby food web
Rostock, Germany

2015 - 2017

B.Sc. Biology

Düsseldorf, Germany

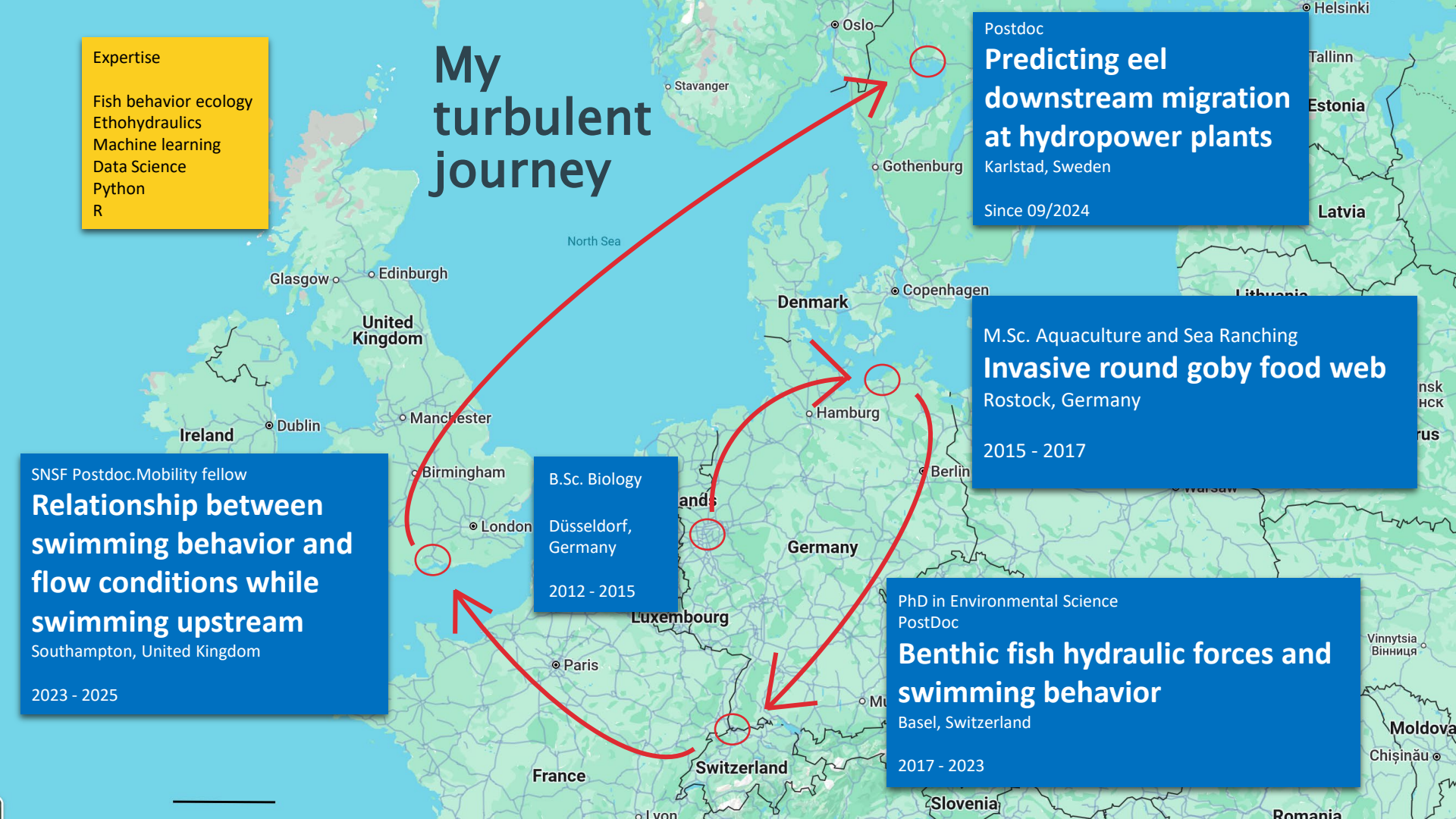
2012 - 2015

SNSF Postdoc.Mobility fellow
Relationship between swimming behavior and flow conditions while swimming upstream
Southampton, United Kingdom

2023 - 2025

PhD in Environmental Science
PostDoc
Benthic fish hydraulic forces and swimming behavior
Basel, Switzerland

2017 - 2023



Thank you for your attention