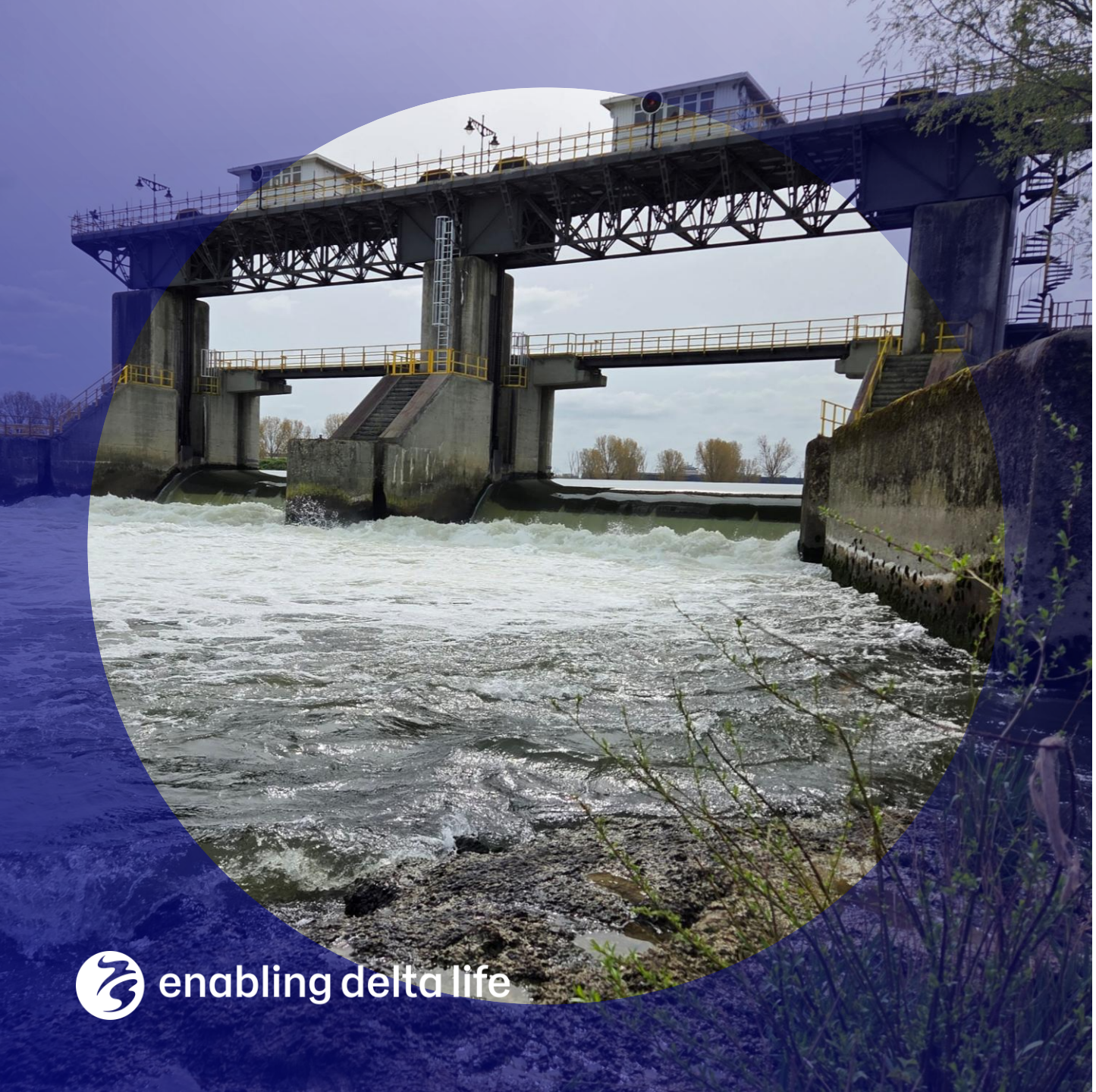


INTERNATIONAL MEUSE SYMPOSIUM

Deltares

Fish Friendly Weir Operation in the Dutch Meuse

Quantifying Fishway Findability & Predicting Arrival Times

Tom O'Mahoney

Nino Zuiderwijk

Sam Maijvis

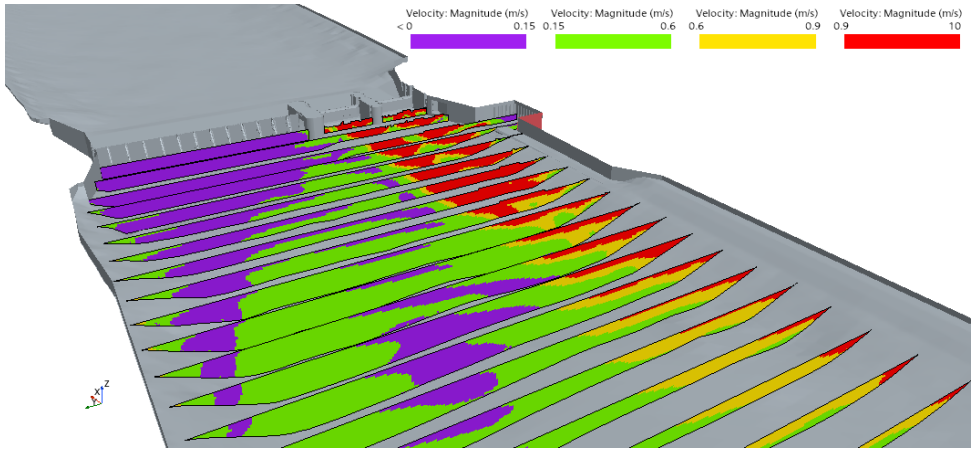
Natasha Flores

September 9th, 2026 – Liège

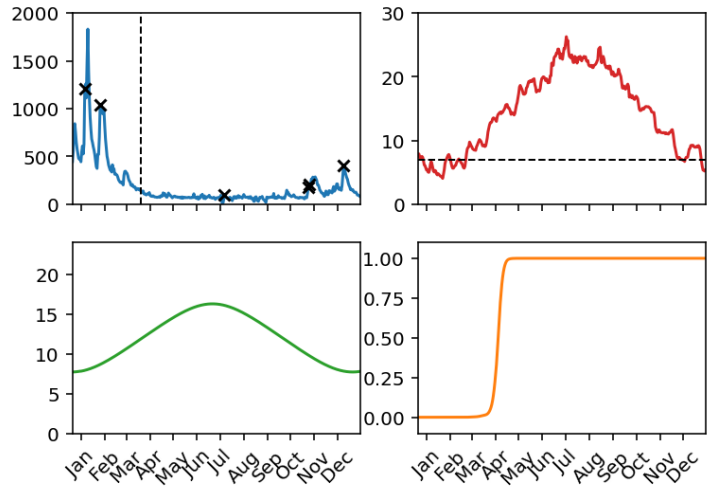
Current Fish Migration Projects

Hydraulic structures are one of the causes of the decline of migratory fish species. To try and mitigate this, the common goals of our two projects are:

- To improve the passability of *current weirs* through fish friendlier weir operation
- To develop fish migration-based design criteria for *future weirs*



Quantifying the *upstream* 'findability' of the fishways through 3D numerical modelling



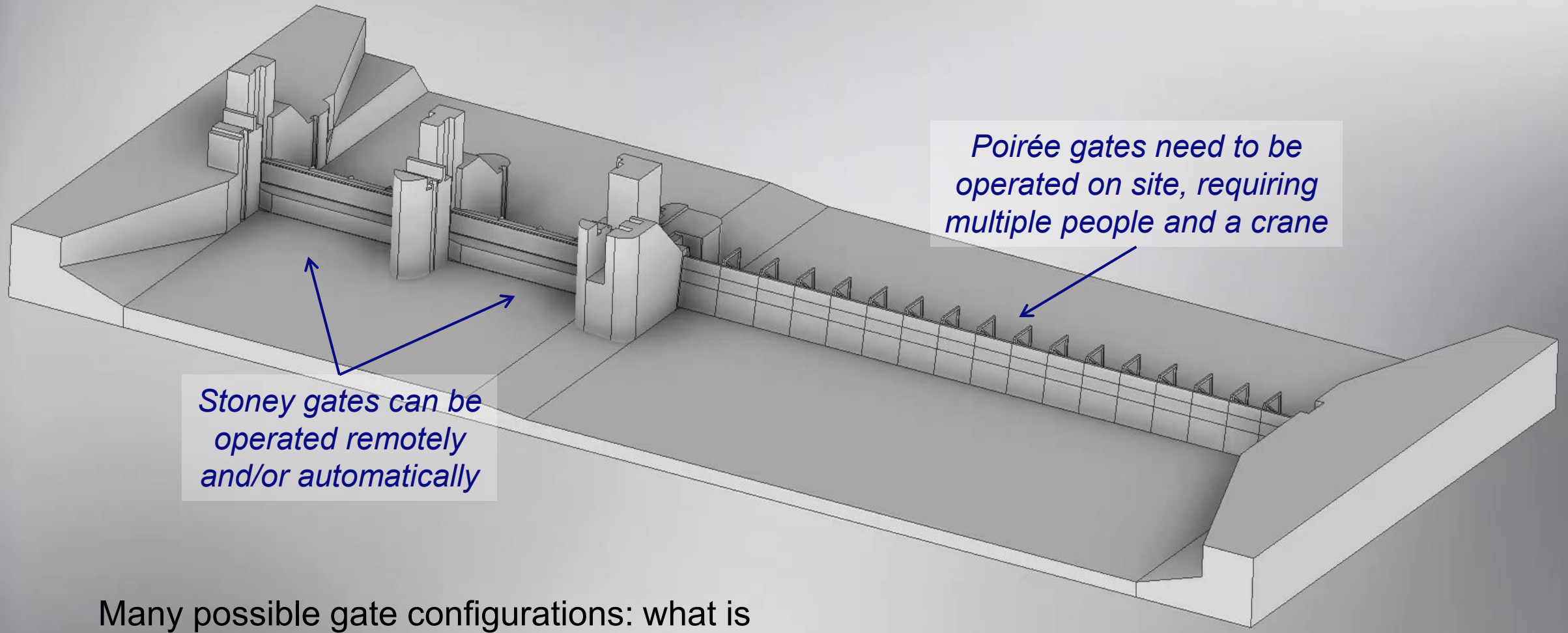
Predicting the timing of *downstream* migratory movement and arrivals

Weirs in the Dutch Meuse

Each of the seven weir complexes is a mostly unique combination of weir gates, navigation locks, a fishway and in some cases a hydropower plant

Weir Roermond (picture: © Rijkswaterstaat / Flying Eye)

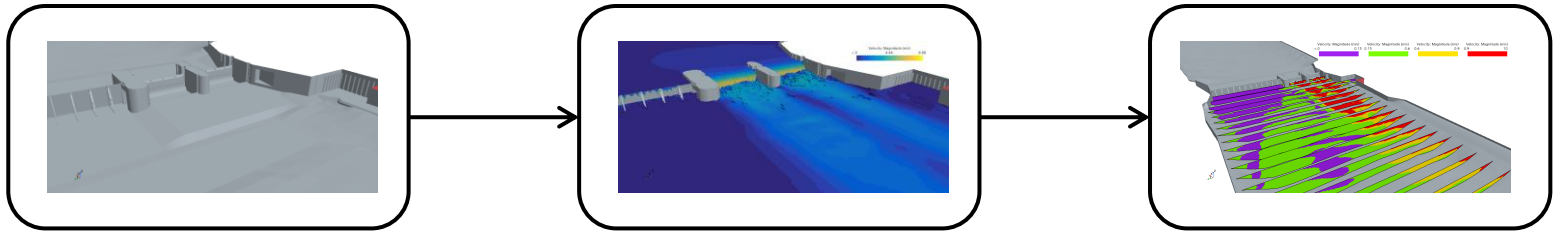
Weirs in the Dutch Meuse



Many possible gate configurations: what is *favourable for fish* (and *feasible for weir operators*)?

Quantifying the Fishway Findability

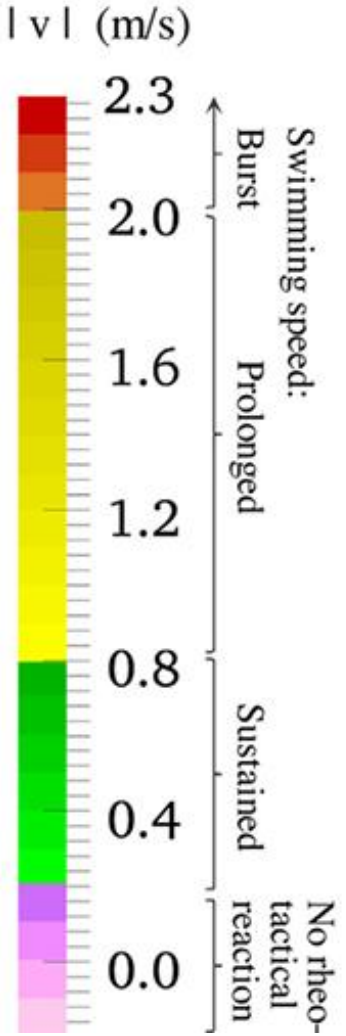
- The gate configuration has a big influence on flow velocity, turbulence and recirculation
- Focus on the easily operated Stoney gates (max. 200-300 m^3/s)
- Post-processing inspired by colourmap from Gisen et al. (2017)



3D CAD of the weir and bathymetry

3D flow simulations

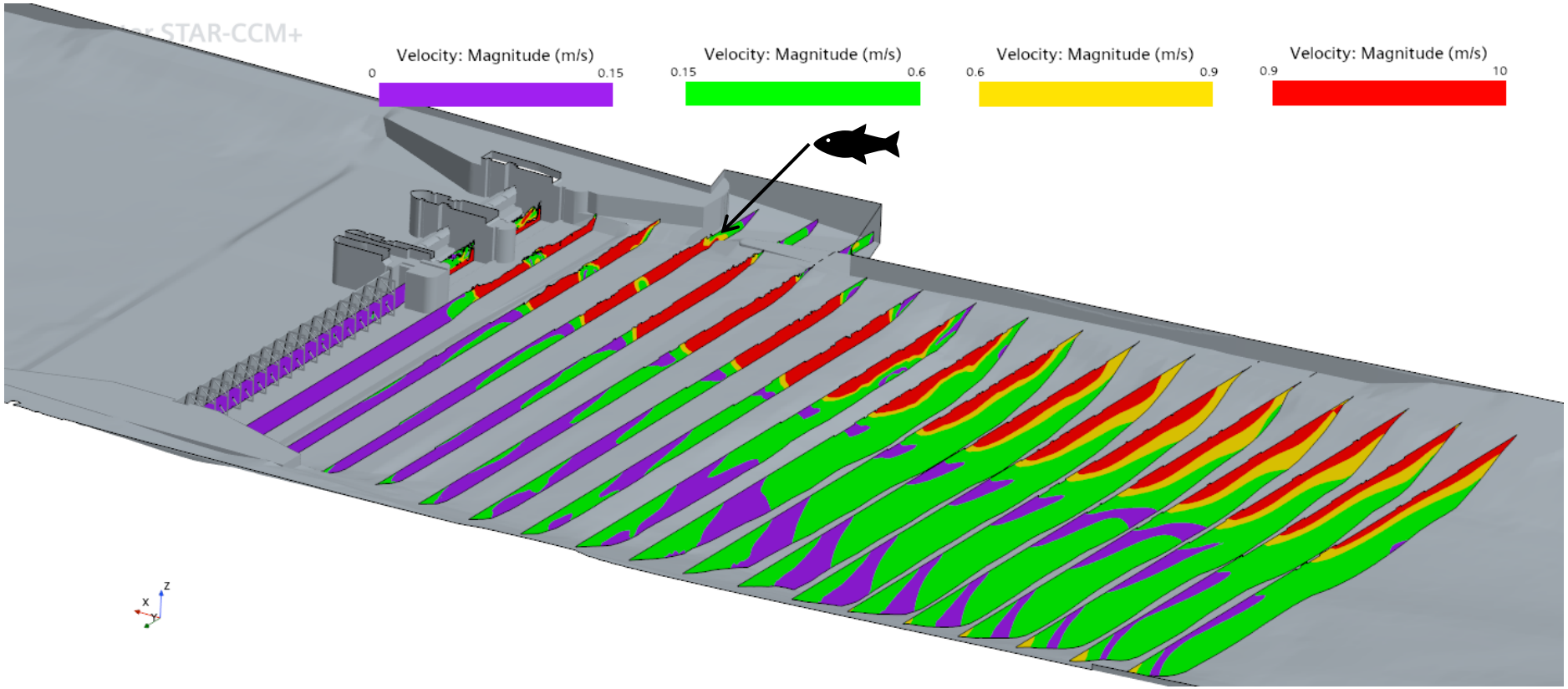
post-processing



Snippet from *Gisen et al. (2017). Optimizing attraction flow for upstream fish passage at a hydropower dam employing 3D Detached-Eddy Simulation. Ecological Engineering, 100, 344-353.*

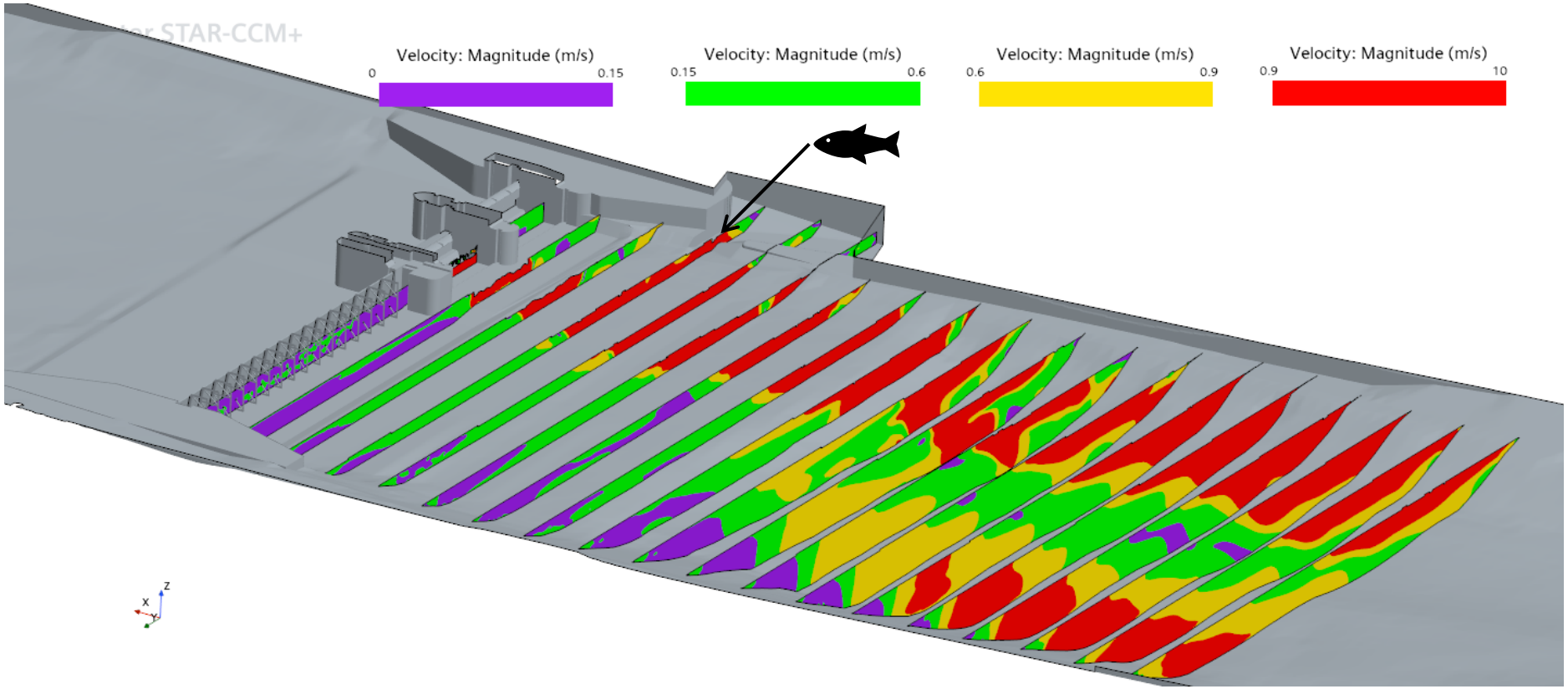
Quantifying the Fishway Findability: Examples

- 50 m^3/s over each Stoney gate (current protocol)
- Are there any continuous migration corridors (green-yellow)?



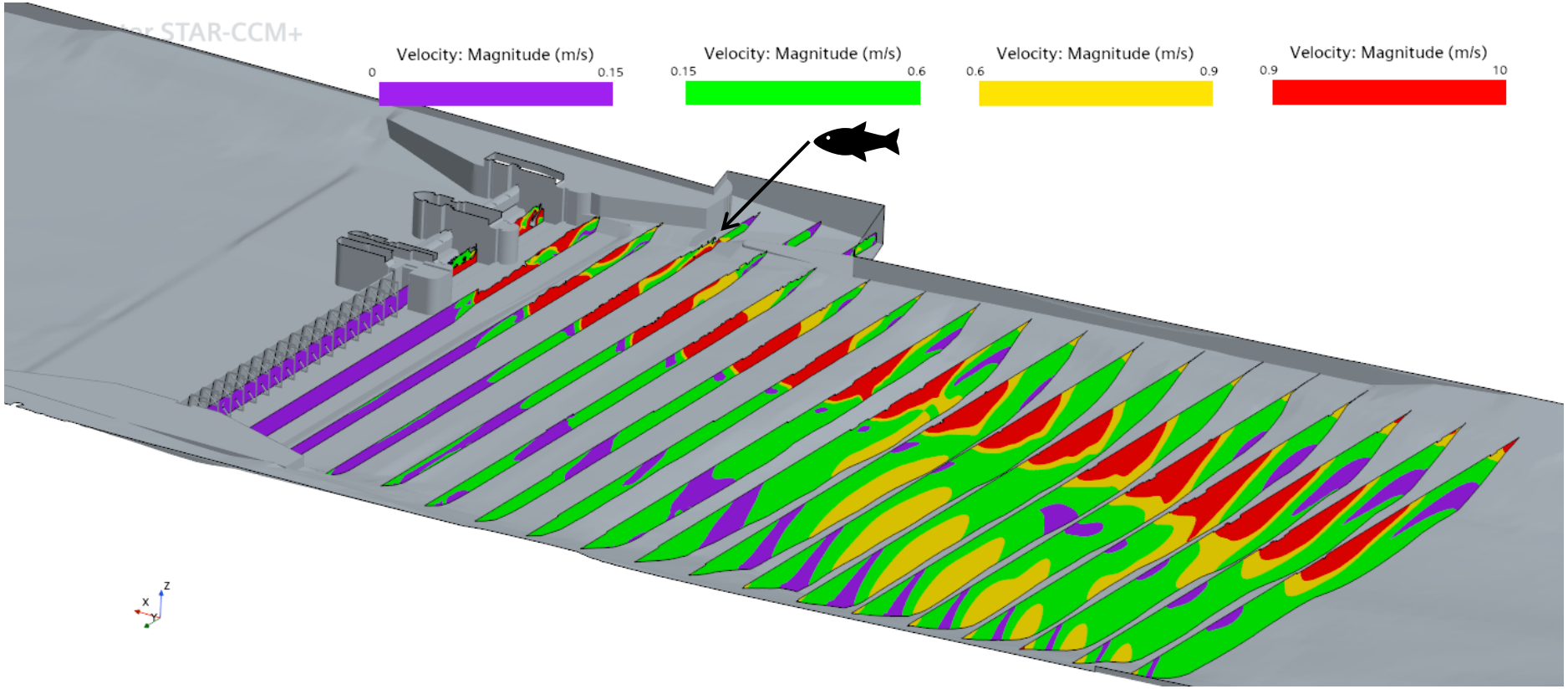
Quantifying the Fishway Findability: Examples

- 100 m^3/s over a single Stoney gate
- Are there any continuous migration corridors (green-yellow)?



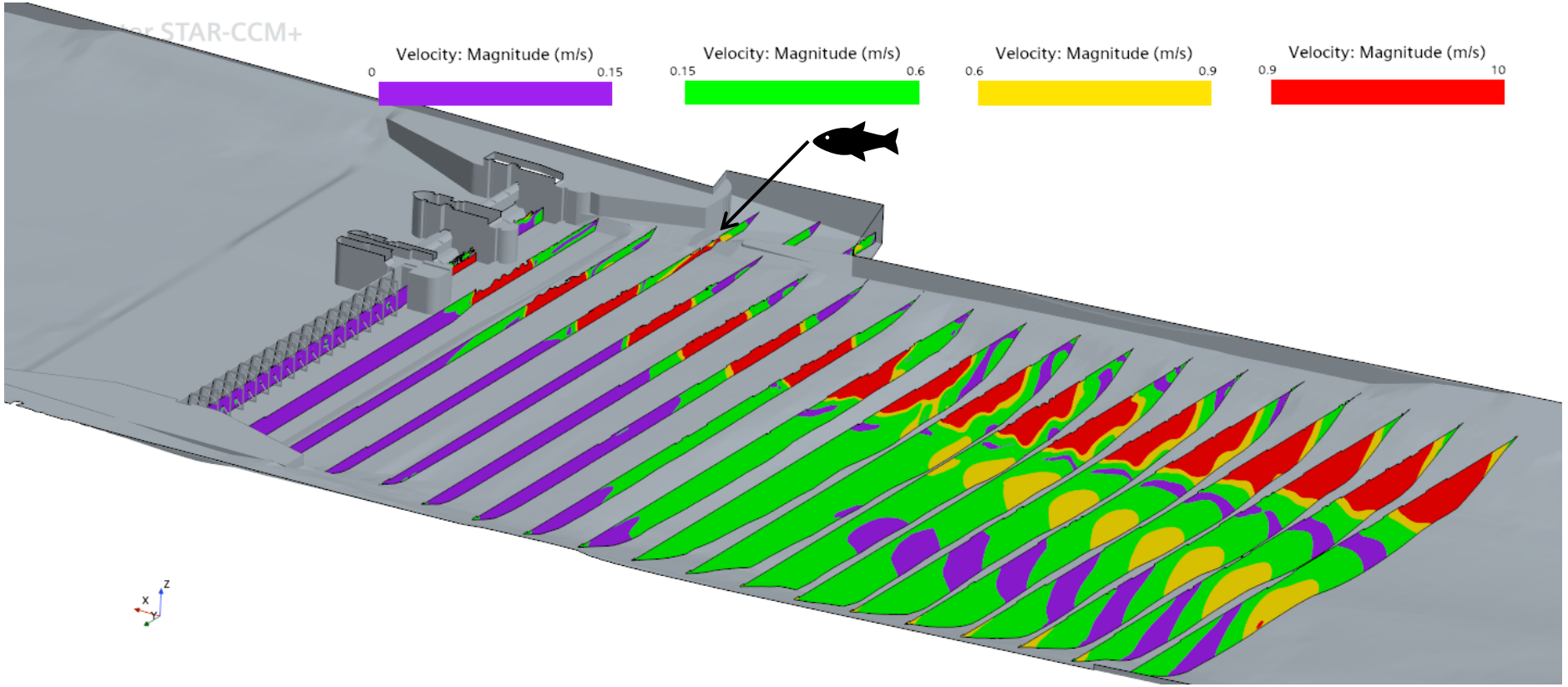
Quantifying the Fishway Findability: Examples

- 75 m^3/s and 25 m^3/s over the Stoney gates
- Are there any continuous migration corridors (green-yellow)?



Quantifying the Fishway Findability: Examples

- 90 m^3/s and 10 m^3/s over the Stoney gates
- Are there any continuous migration corridors (green-yellow)?

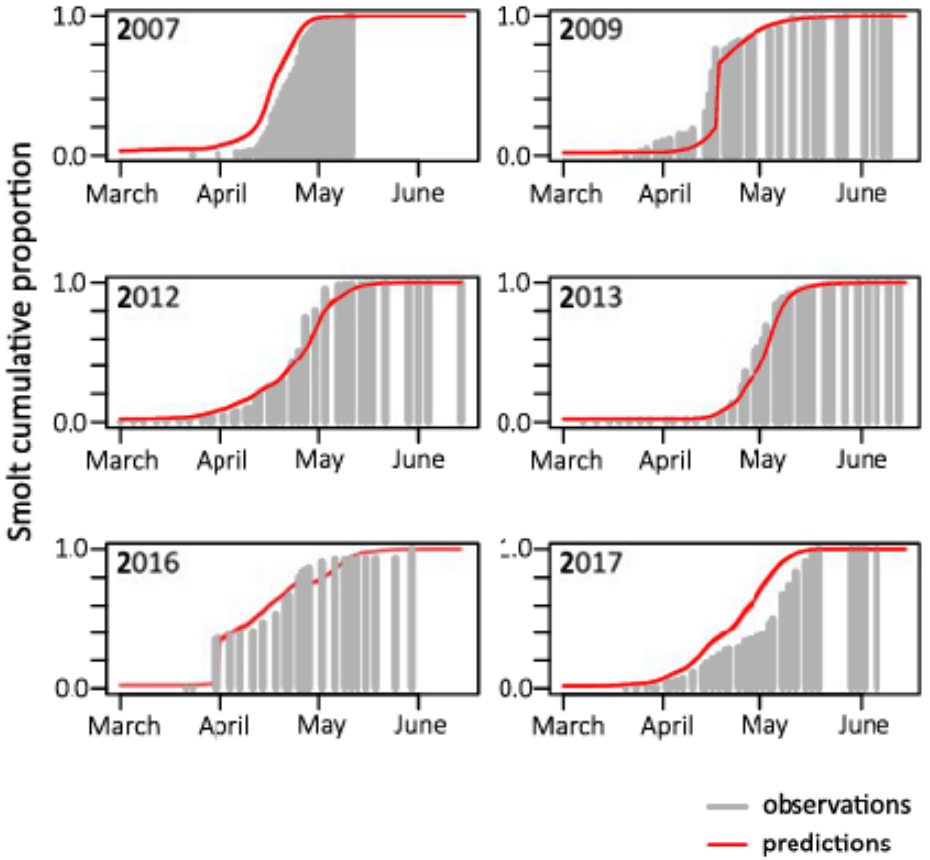


Predicting Arrival Times

- Teichert et al. (2020) developed a model that can accurately predict the onset of downstream smolt migration in Ourthe River, BE
  - Based on water temperature, day length and the occurrence of discharge peaks

- Teichert later also calibrated the model for the Linne (NL) hydropower plant in the Meuse at request of Rijkswaterstaat
  - Used in practice to determine the period during which the HPP should be switched off at night

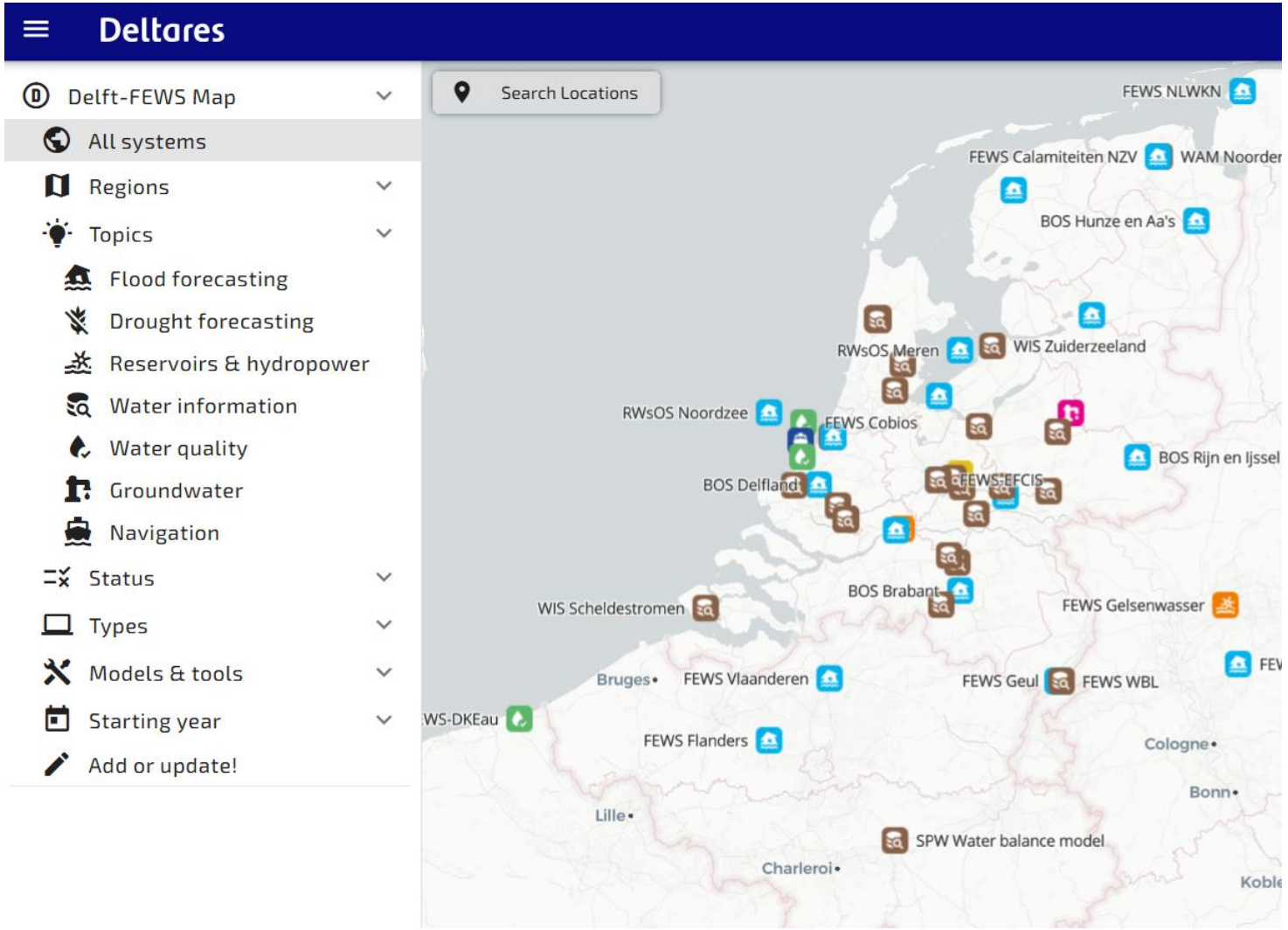
- This inspired us to create a *proof-of-concept for an operational model*



Snippet from *Teichert et al. (2020). Development of an accurate model to predict the phenology of Atlantic salmon smolt spring migration. Aquatic Conserv: Mar Freshw Ecosyst. 2020;1–14.*

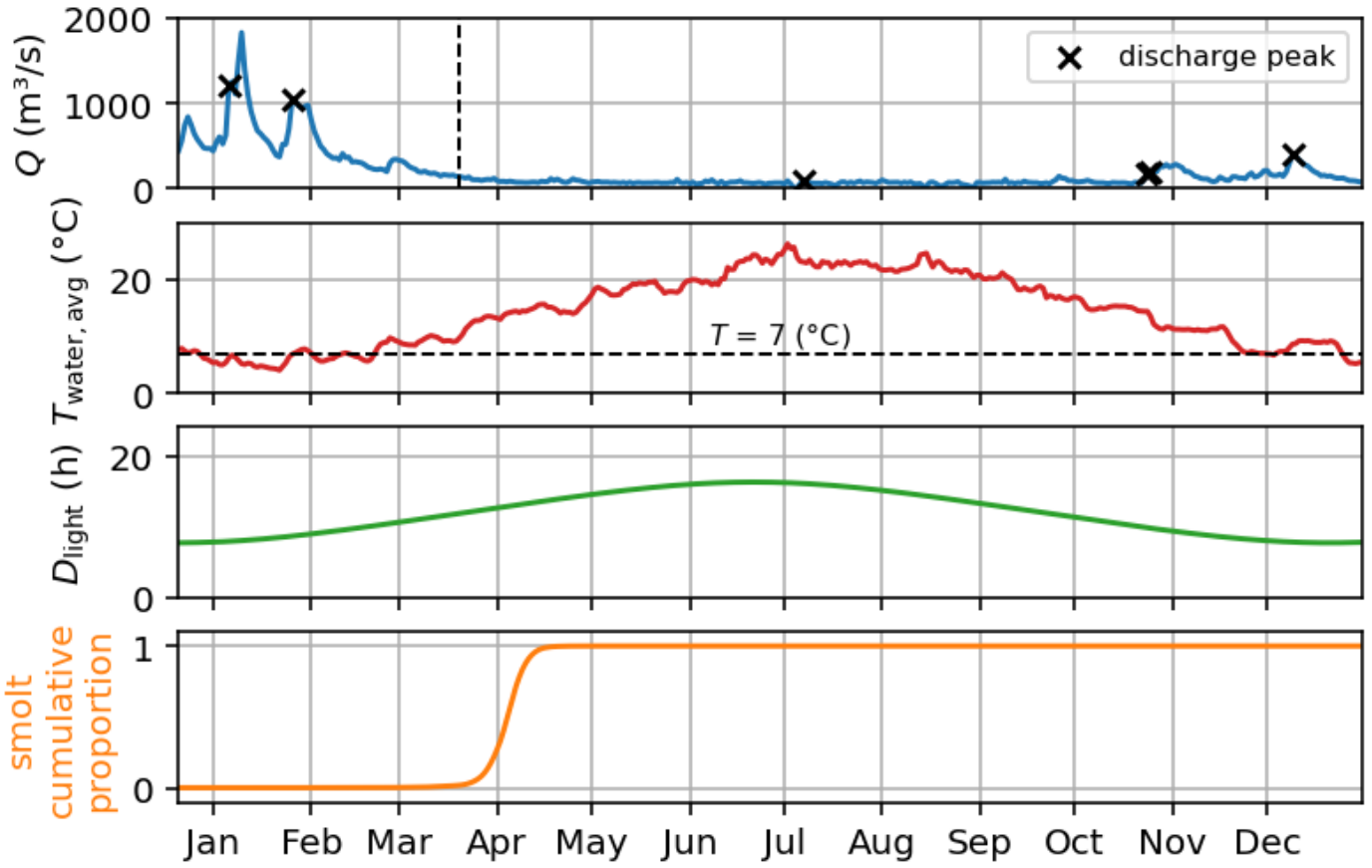
Delft FEWS

- System for managing forecasting processes and handling time series data
- Modular and highly configurable
- Used worldwide and in many contexts
- Functionality ranges from data storage and retrieval, to simple forecasting systems, to complex configurations that integrate a full range of modelling techniques



Predicting Arrival Times

- Delft-FEWS can bring together measurements and predictions of temperatures and discharges, calculated daylength
- The collected data forms the input for Teichert et al.'s model, resulting in predictions of the onset of migration of smolts near the Linne HPP (Meuse) and Méry HPP (Ourthe)

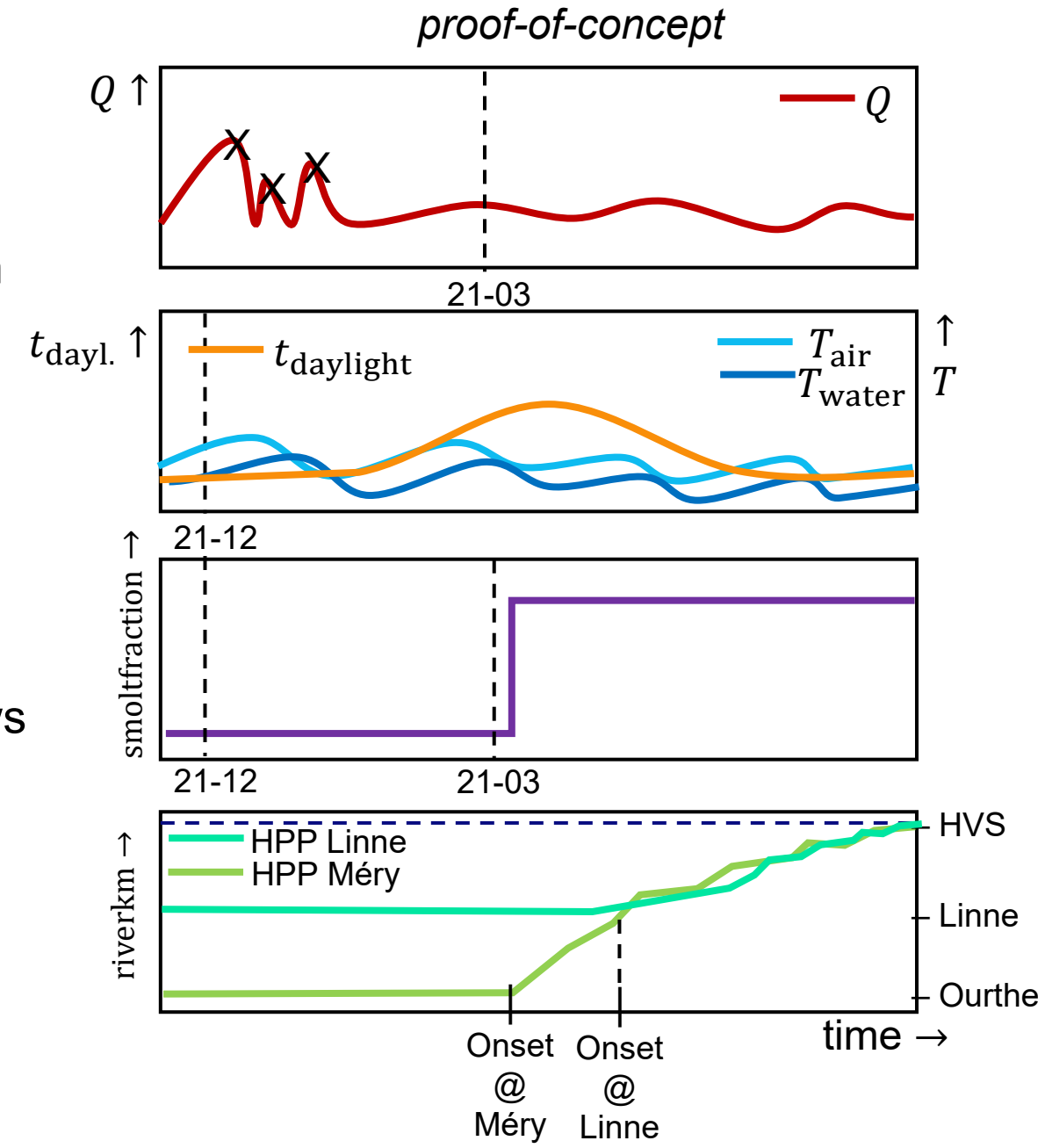


Predicting Arrival Times

- From the predicted onset, we would like to predict the approximate arrival times at other structures on the route to the North Sea
  - Adding modelled flow velocities to the Delft-FEWS configuration to estimate swim speeds
  - Include a ‘delay’ at each encountered hydraulic structure (based on telemetry data)

- Knowing when fish will arrive (approximately) allows additional measures to be taken to ensure a safe route to the sea

- Next steps: what can we do to make downstream migration easier at the Haringvliet Sluices (HVS)?



Conclusions

- There are fish friendlier alternatives to current weir protocols;
- Future weirs should have enough gates to steer the flow in a favourable pattern;
- Future weirs need to be able to ‘destroy’ the turbulence close to the weir;
- We can benefit from predicting fish arrival in advance so that hydropower plant, weir or sluice gate operation can be planned accordingly;

Collaboration between hydraulic engineers, ecologists and weir operators is essential for a fish friendlier Meuse.

Questions?
Or ideas for fish friendlier weirs?

also feel free to contact any of us later:

tom.omahoney@deltares.nl *nino.zuiderwijk@deltares.nl* *sam.maijvis@deltares.nl*