Caged fish experiment and hydrodynamic modelling to understand spatio-temporal dispersion of eDNA in the St. Lawrence River

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(Submitted to Env. DNA, Laporte et al. , 2019)

Quebec's Asian Carp Program

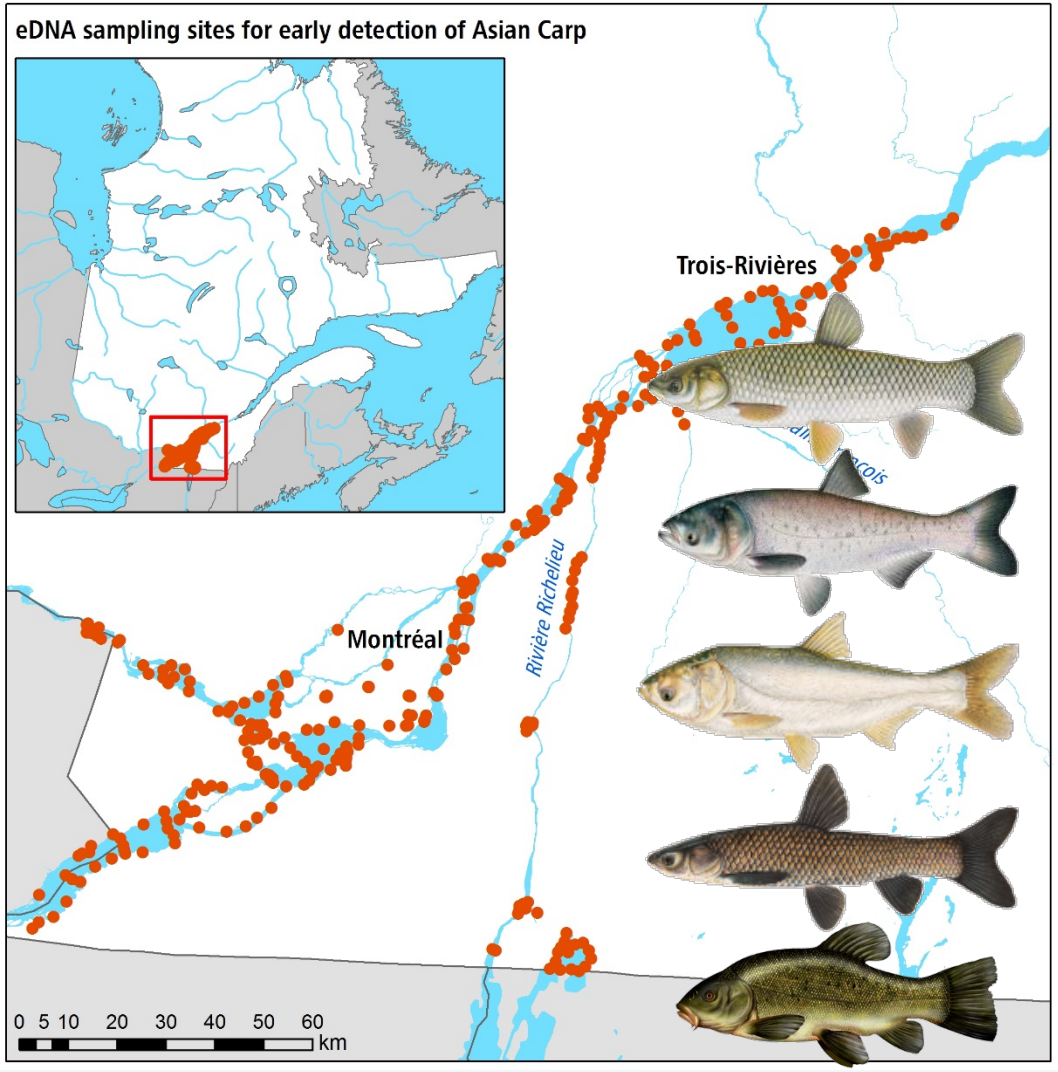
Initiated in 2016 (6.7 M$ until 2021, 2 phases)

Main objective: To increase the capacity to react and take actions in the face of AIS, notably Asian Carps, by creating this specific expertise.

- Create a concerted provincial **action plan**
- Optimize and implement **early detection** and **surveillance** focusing on Asian Carps
- Identify and analyze **options** available to **control/restrict** invasion of inland waters
- Evaluate **options** available to **mitigate** impacts
- Develop and **adapt** Quebec's **expertise** on Asian Carps to deal with the St. Lawrence reality and **collaborate** with agencies and experts in US & Canada

eDNA survey: early detection and range expansion for AIS

Asian Carp and Tench



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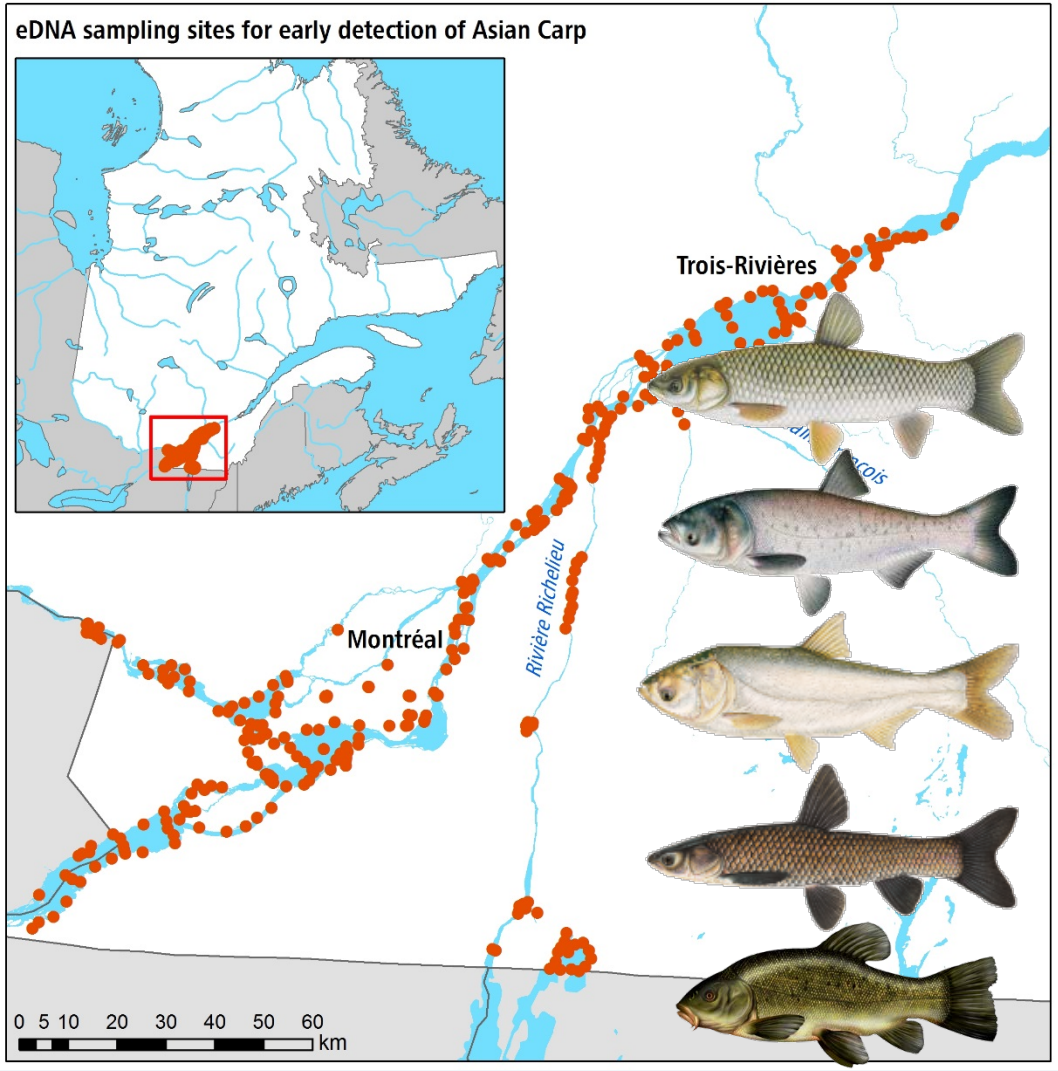
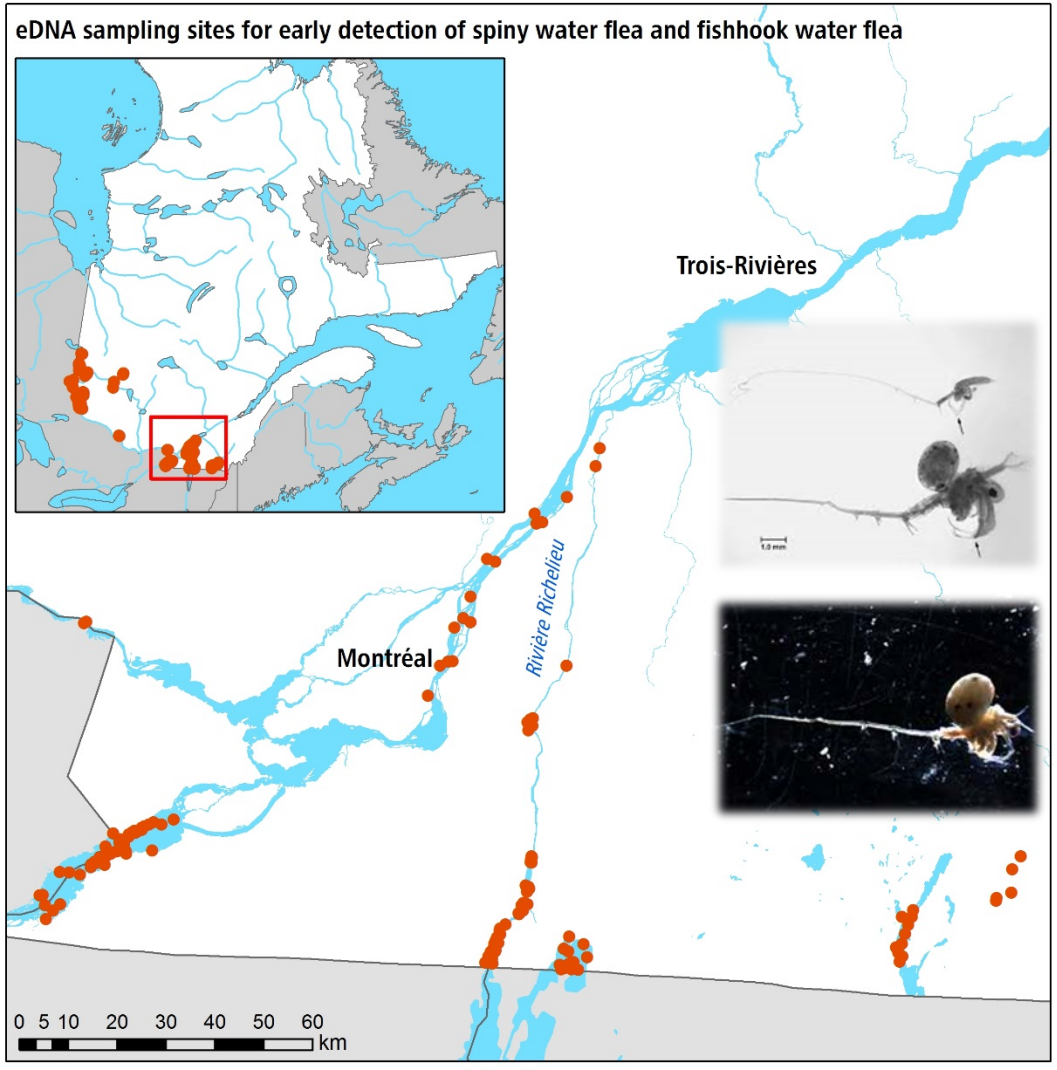
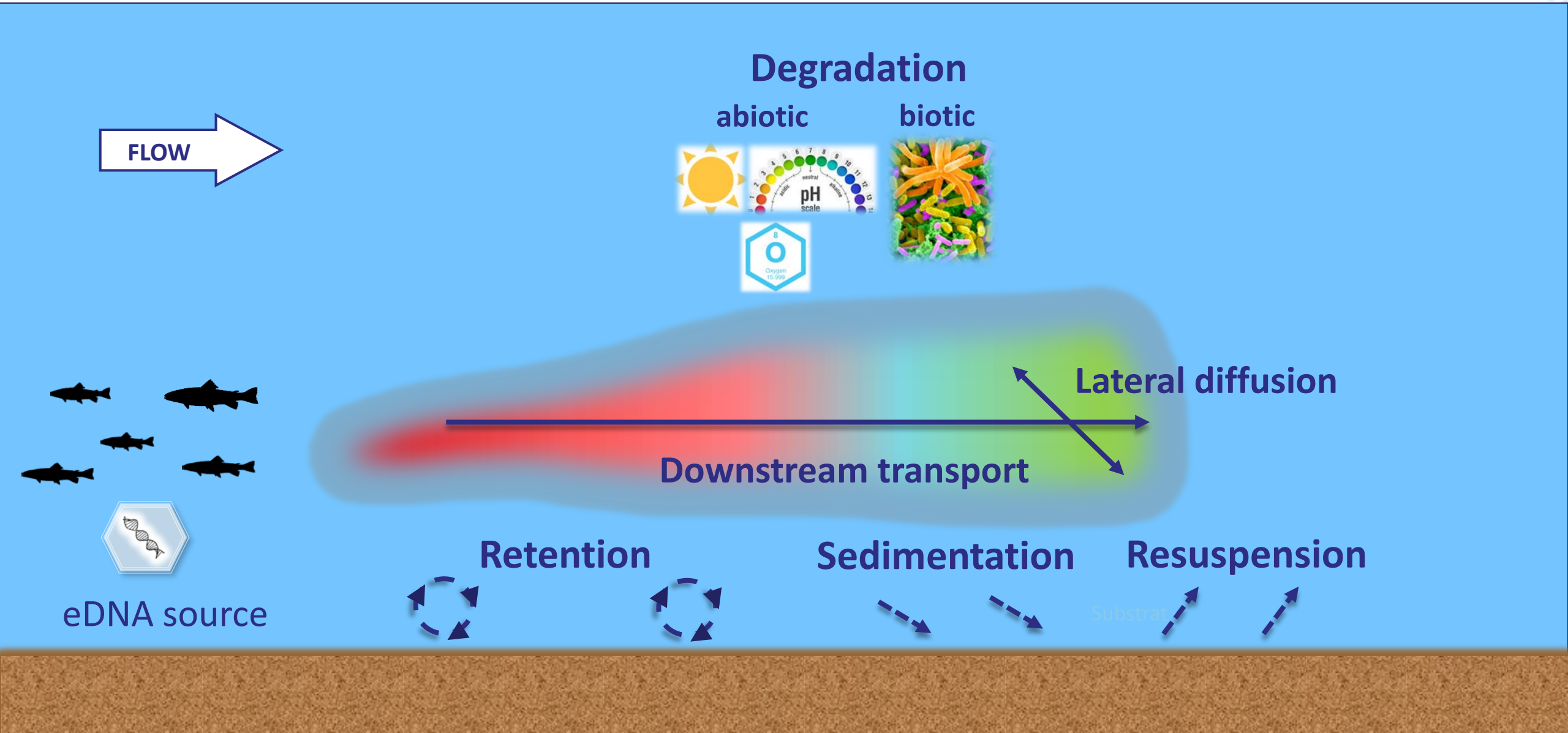


Spiny and Fishhook water flea



eDNA challenge: how to interpret a positive detection



eDNA challenge: transport

- eDNA transport in river

  Detected in river systems at variable scales and up to 60 km away from its sources (Deiner and Altermatt 2014; Jane et al. 2015; Pont et al. 2018)

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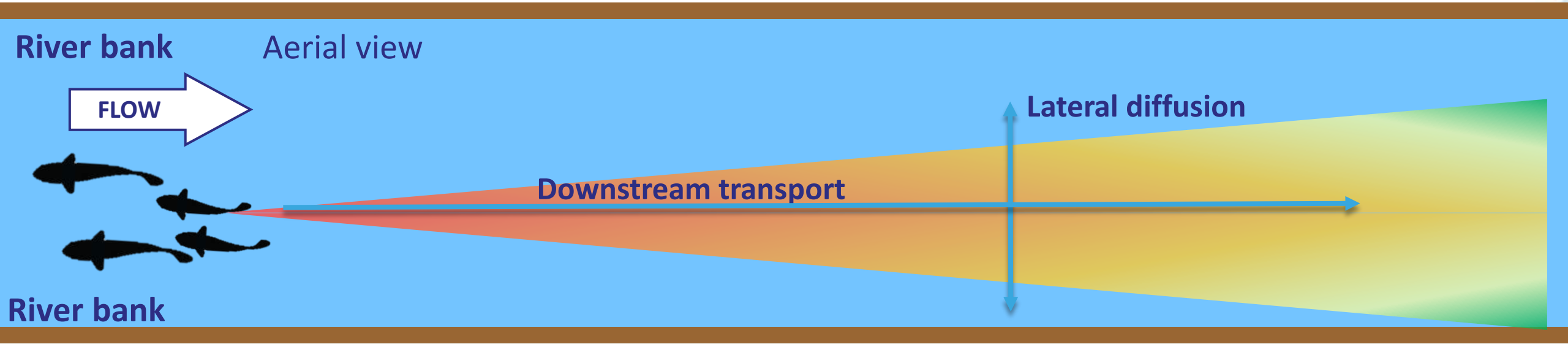
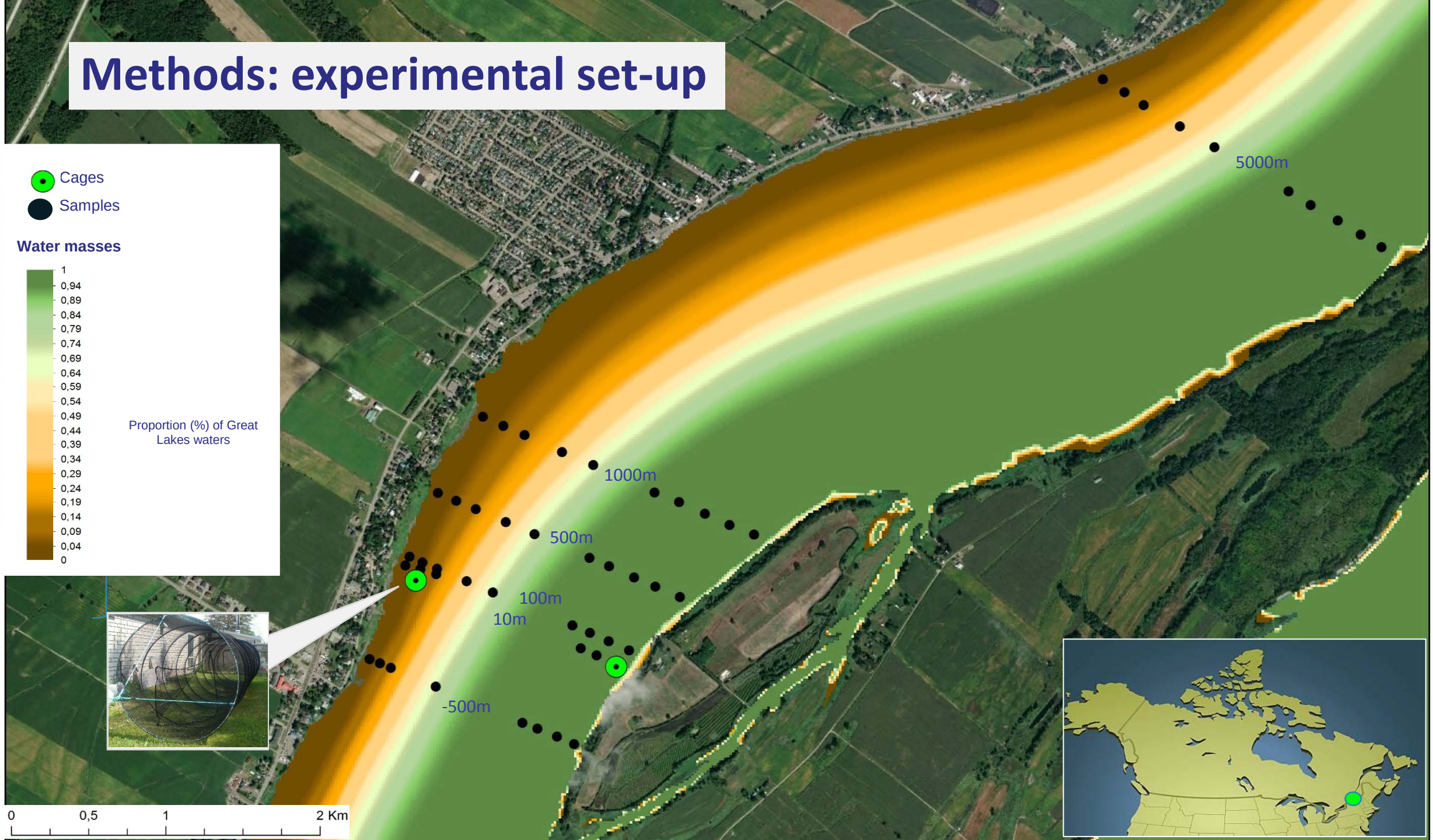
  Detected in river systems at variable scales and up to 60 km away from its sources (Deiner and Altermatt 2014; Jane et al. 2015; Pont et al. 2018)

- Downstream transport and continuous lateral diffusion in large river systems with high discharge is not well documented

➡ This knowledge would be useful to locate eDNA sources



Methods: experimental set-up



Methods: experimental set-up

Cages
Samples

Water masses

1
0,94
0,89
0,84
0,79
0,74
0,69
0,64
0,59
0,54
0,49
0,44
0,39
0,34
0,29
0,24
0,19
0,14
0,09
0,04
0

Proportion (%) of Great Lakes waters

	nb	Mean weight (g)	Total biomass (kg)
Brown water cage	50	557	27,9
Green water cage	49	571	28,0

5000m
1000m
500m
100m
10m
-500m

0 0,5 1 2 Km

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qPCR with specific brown trout assay

0 0,5 1 2 Km

Methods: statistical analysis

- High-resolution 2D hydrodynamic model for the St. Lawrence River

  Hydrodynamic modeling based on topography, substratum and water discharge

  ➡ Model predicts particules transport and lateral diffusion

- Model predictions for eDNA detection

  Probabilities of detection (presence/absence) tested using logistic regressions and eDNA quantification from qPCR analysis and tested using an ANOVA

  Fixed variables:

  i) 'predicted eDNA concentration' (obtained from the 2D hydrodynamic model)
  ii) 'downstream distance' from its source (10, 50, 100, 1000 and 5000 meters).

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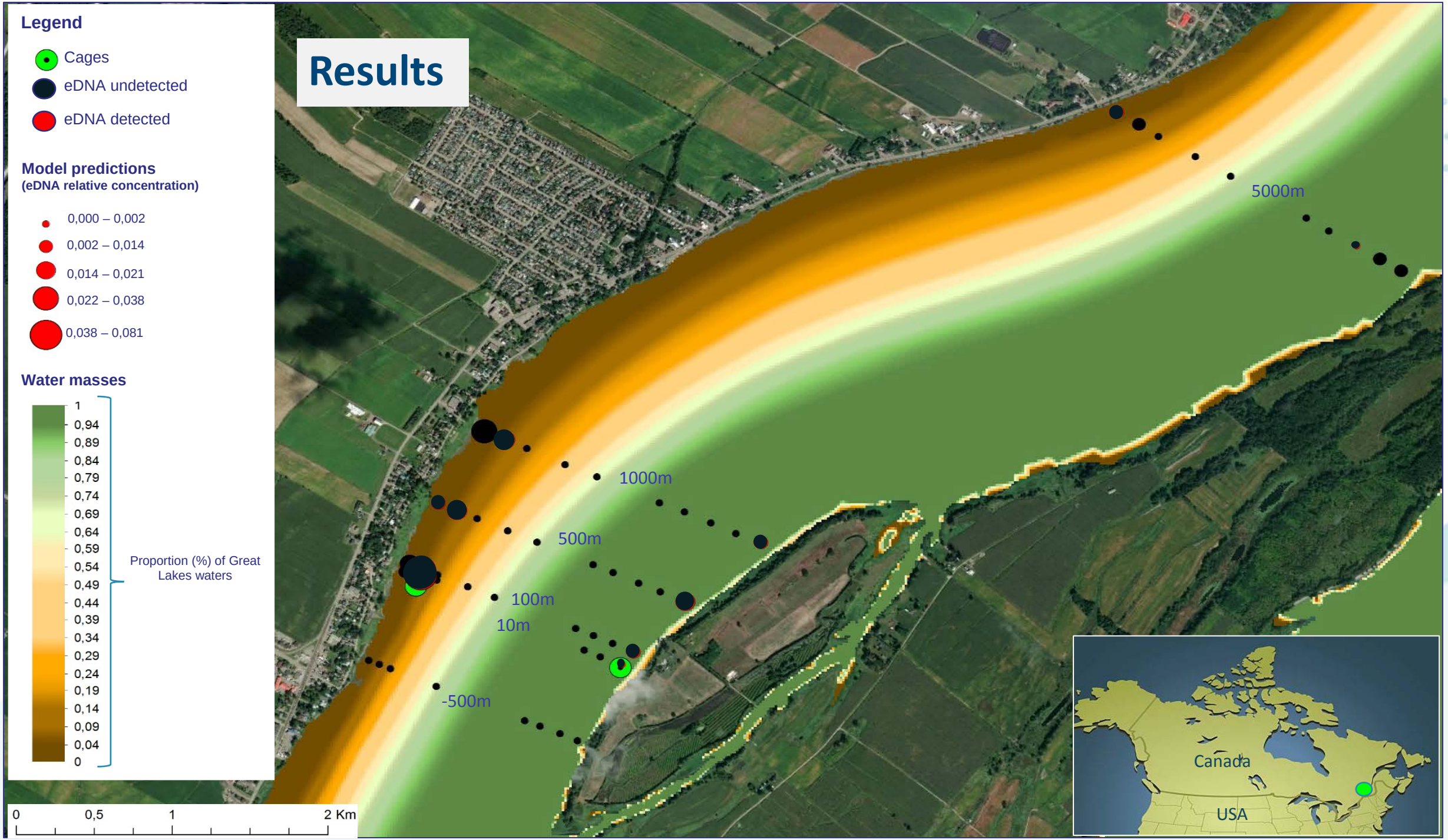
Results


Legend
Cages
eDNA undetected
eDNA detected
Model predictions
(eDNA relative concentration)
0,000 – 0,002
0,002 – 0,014
0,014 – 0,021
0,022 – 0,038
0,038 – 0,081
Water masses
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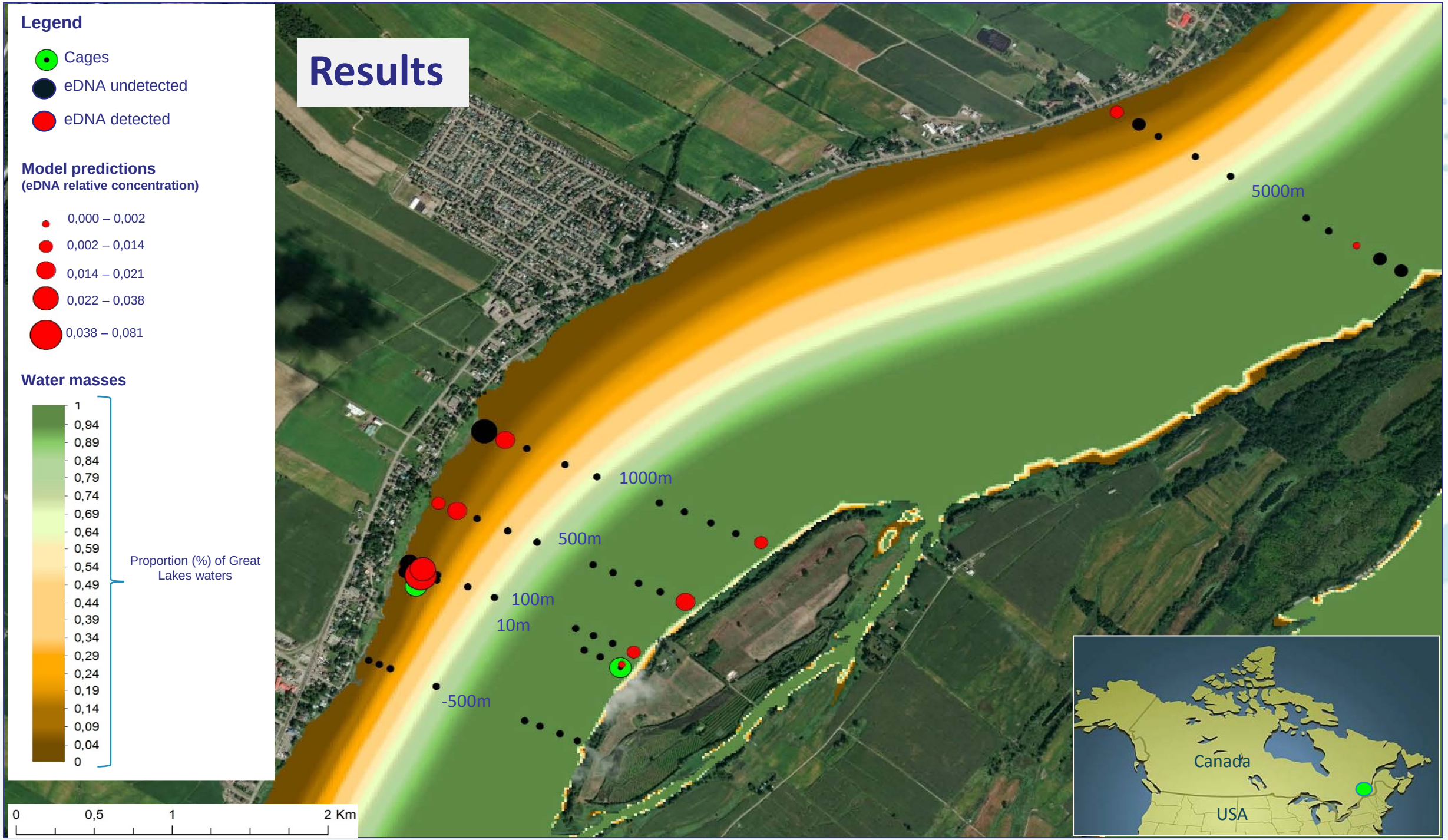
0,09
0,04
0
Proportion (%) of Great Lakes waters
5000m
1000m
500m
100m
10m
-500m
Canada
USA
0
0,5
1
2 Km

Results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Proportion (%) of Great Lakes waters
5000m
1000m
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100m
10m
-500m
Canada
USA
0
0,5
1
2 Km

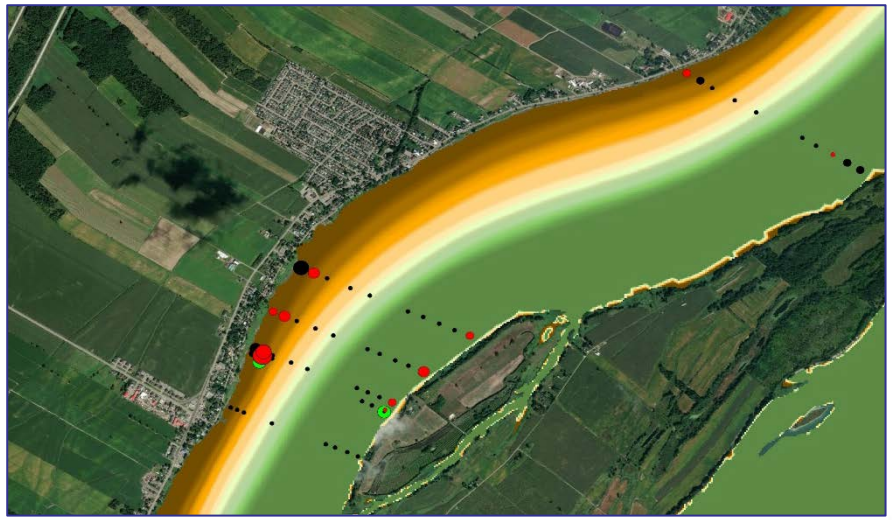
Results

Presence/absence of brown trout eDNA at sampling site

i) ‘predicted eDNA concentration’, $P < 0.05$
ii) ‘downstream distance’ from its source), $P > 0.05$

Quantity of brown trout eDNA at sampling site

i) ‘predicted eDNA concentration’, $P < 0.05$
ii) ‘downstream distance’ from its source), $P > 0.05$



Our results best fit the model with low diffusion and downstream laminar flow of eDNA

Discussion

- Our results underline the importance of quantifying both downstream transport and lateral diffusion in large river systems in eDNA studies

- 2D hydrodynamic model seems efficient to predict the probabilities of detection and estimation of quantity of eDNA

- Low diffusion between and within water masses will be advantageous to study species habitat preference such as littoral versus pelagic habitats

This eDNA dispersion model could be used to locate AIS present in this river system and would facilitate the actions to facilitate the monitoring of these species

Next steps

- Integration of decay and setlling rates to the present model should allow a better estimation of downstream localization of eDNA sources, as previously shown in smaller rivers (Sansom and Sassoubre 2017; Shogren et al. 2017; Carraro et al. 2018)

- Complete the analysis of same type of experiment in Richelieu river
  - Similar set-up: different species in each cage, sample up to 20 km
  - 2D hydrodynamic model for this river is on the way

Acknowledgement

Laval University

Louis Bernatchez
Martin Laporte
Bérénice Bougas
Noémie Leduc
Éric Normandeau

MFFP

Yves Paradis
William Cayer-Blais
Sarah Aubé

Environment and Climate Change Canada

Jean Morin
Olivier Champoux
Guillaume Guénard

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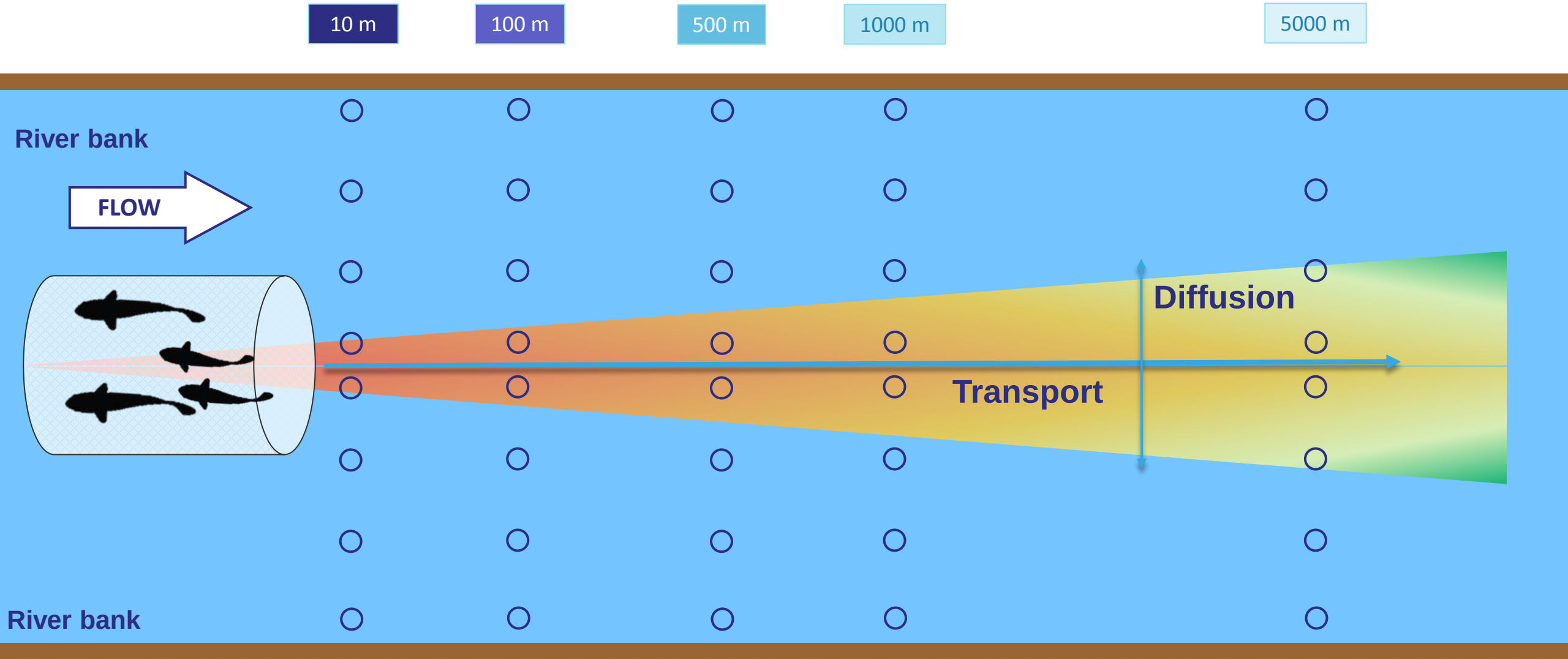
10 m
100 m
500 m
1000 m
5000 m
River bank
FLOW
Diffusion
Transport
River bank