Assessing the distribution and status of Britain's rarest freshwater fishes

Scottish Freshwater Group Meeting, 23rd April 2026, Stirling

Ruaidhri Forrester

Scottish Centre for Ecology and the Natural Environment, University of Glasgow

Email: 2602388f@student.gla.ac.uk

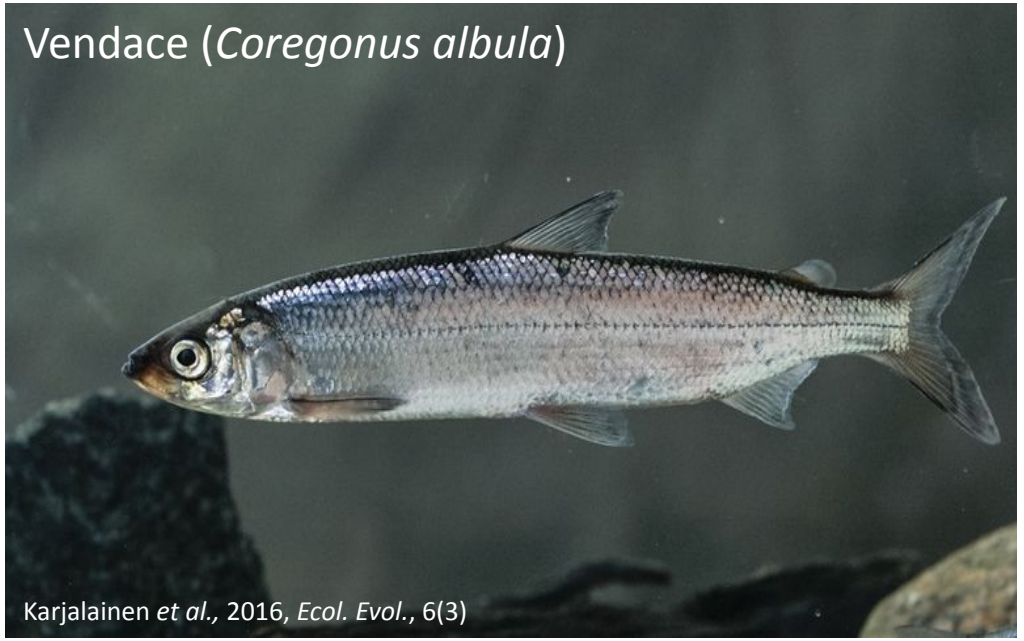
1) **Determining the contemporary distribution of vendace and European whitefish in the UK**

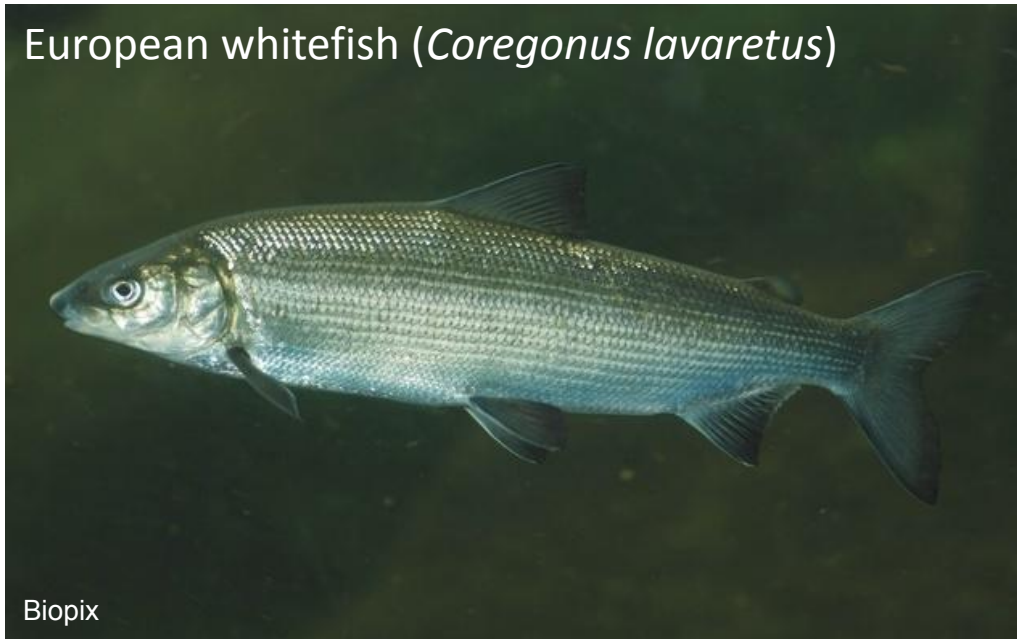
2) **Assessing the status of the UK's native populations of vendace**

3) **Investigating eDNA as a non-invasive method of locating the spawning grounds of *Coregonus* fishes**

Study Species

- Predominantly occupy lakes
- Commercially important in Europe

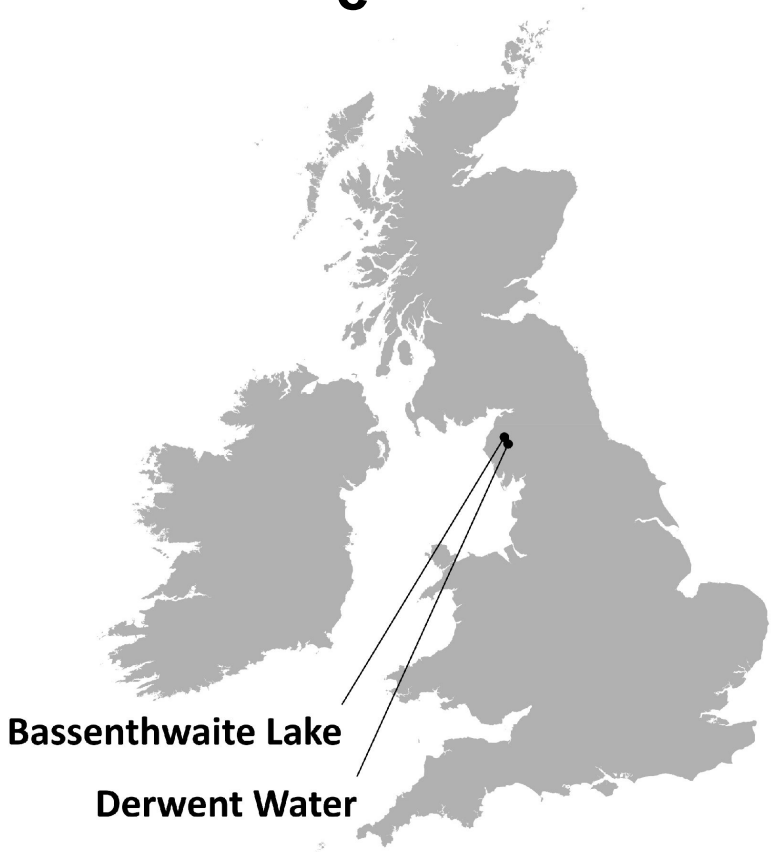




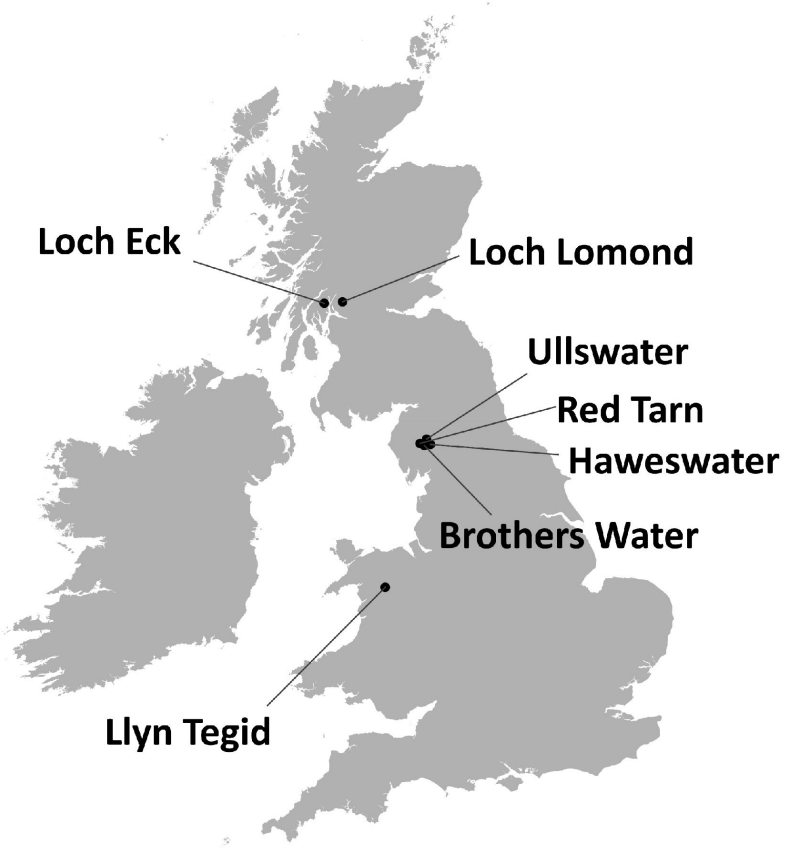
In the UK, vendace and European whitefish are at risk of extinction

(Nunn *et al.*, 2023, *Aquatic Conserv: Mar Freshw Ecosyst.*)

Vendace



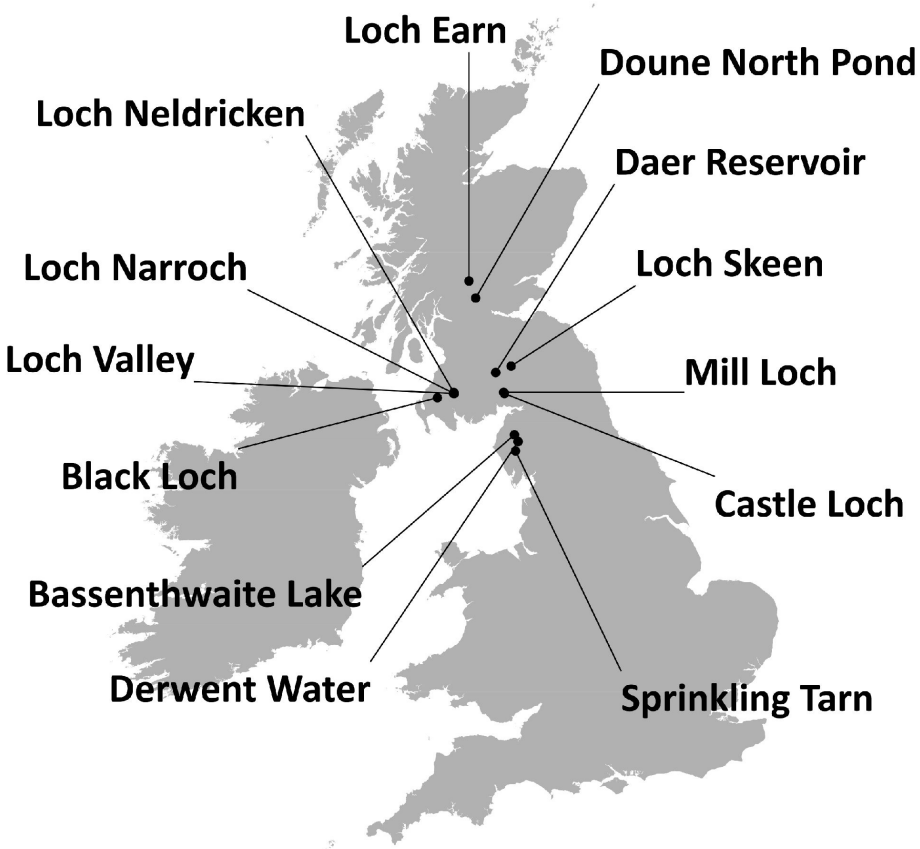
European whitefish



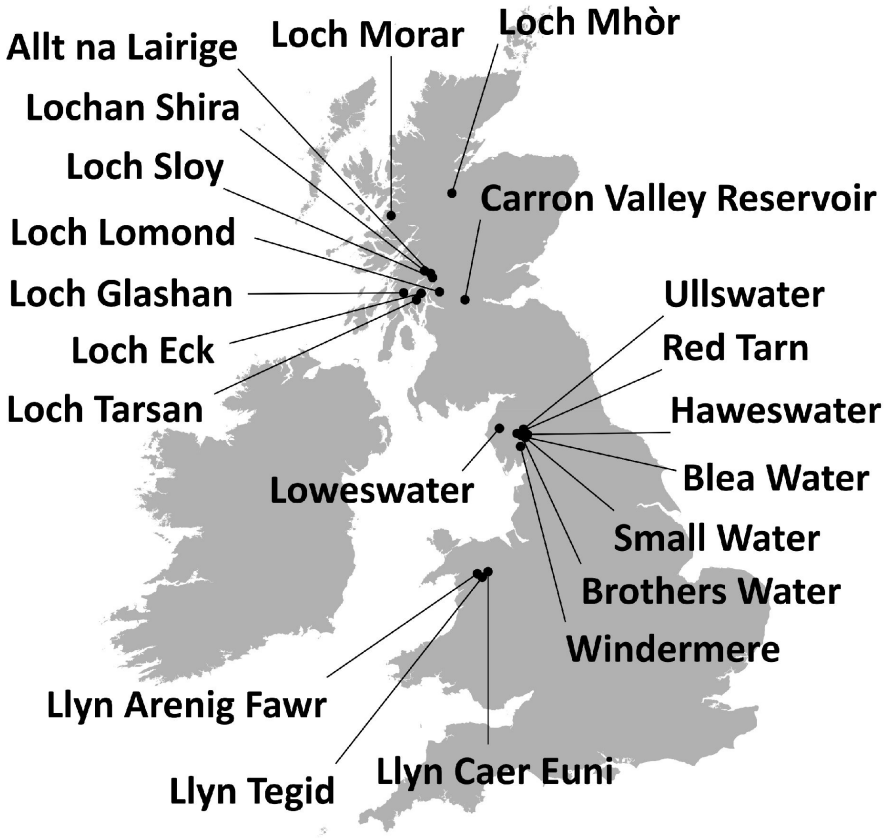
Native, extant populations

Few extant native populations…
…but a total of 34 lakes with records

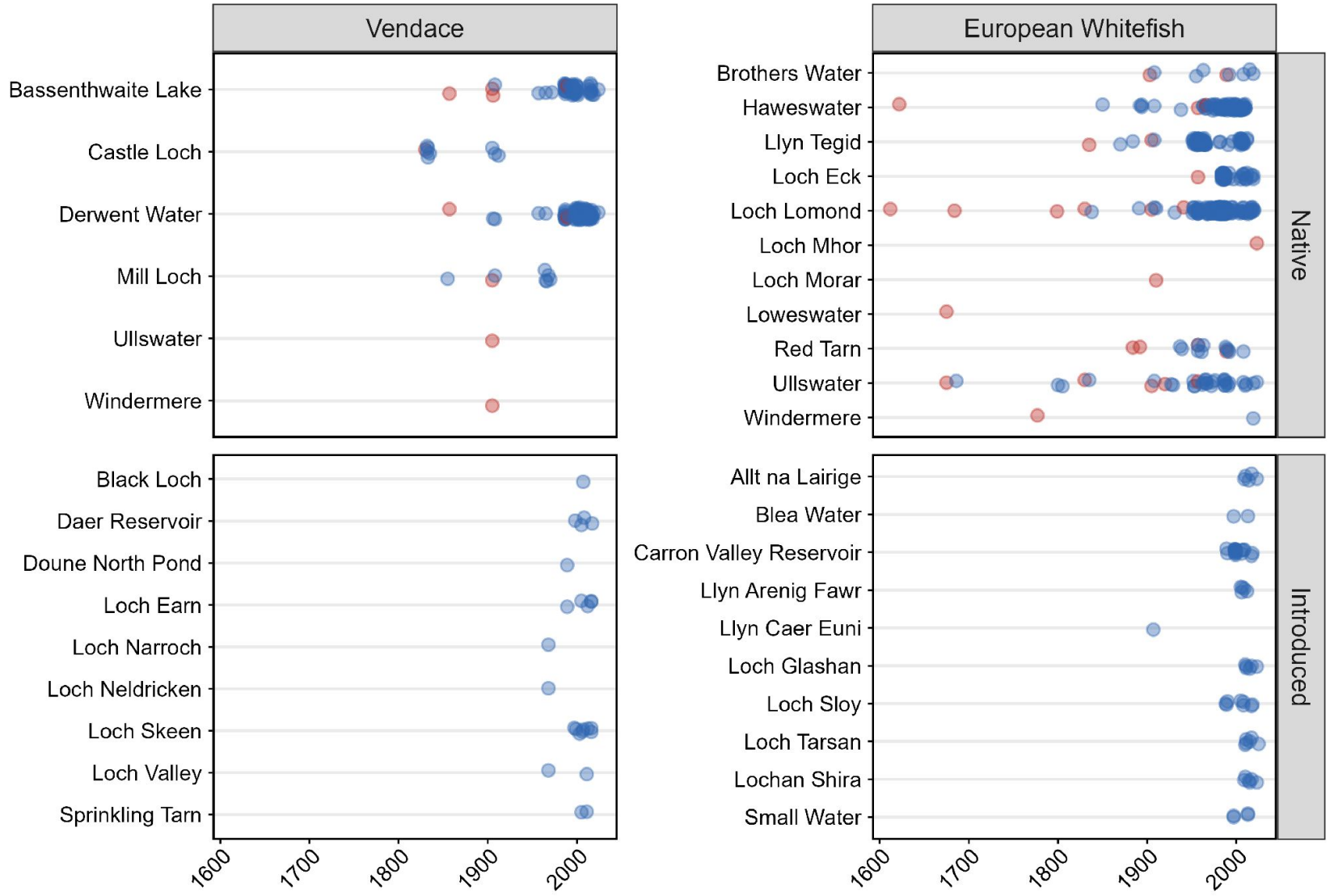
Vendac



European whitefish



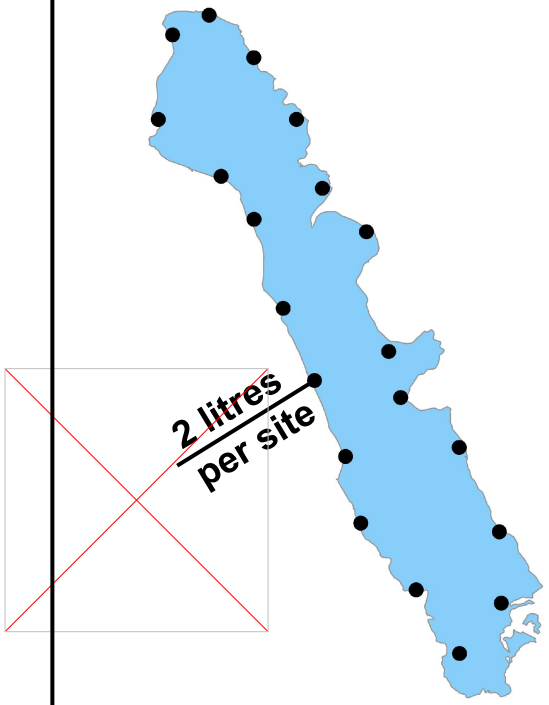
Many vendace and European whitefish records are historical



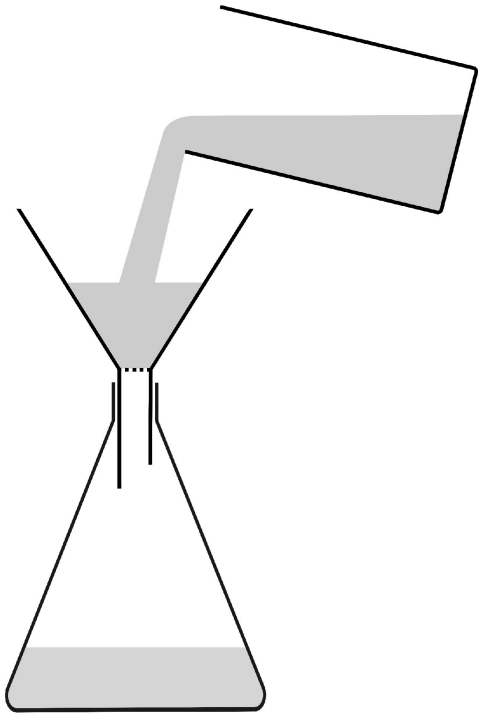
n = 783

eDNA metabarcoding conducted at all 34 lakes with a record of vendace or European whitefish

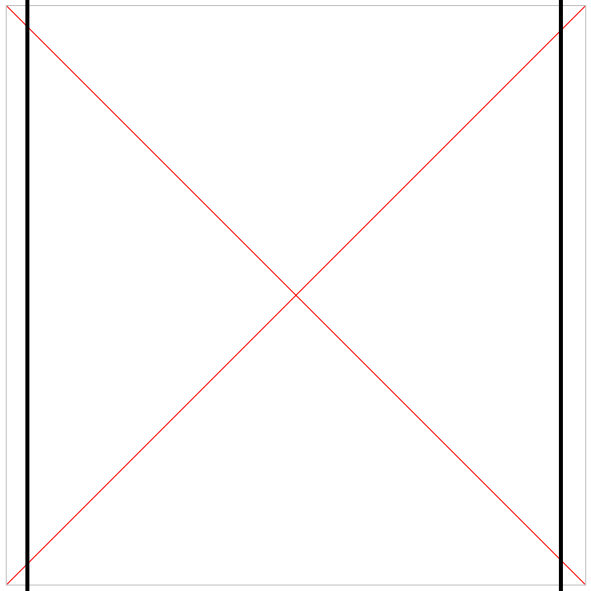
1. Collect 20 water samples



2. Filter each water sample

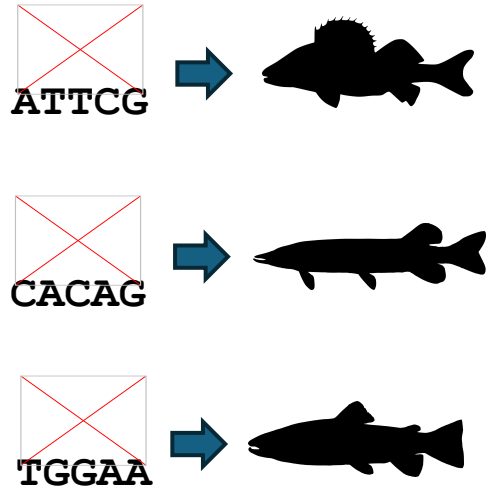


3. Extract, amplify and sequence DNA



12S-V5 Primers
(Riaz *et al.*, 2011, *Nucleic Acids Res.*)

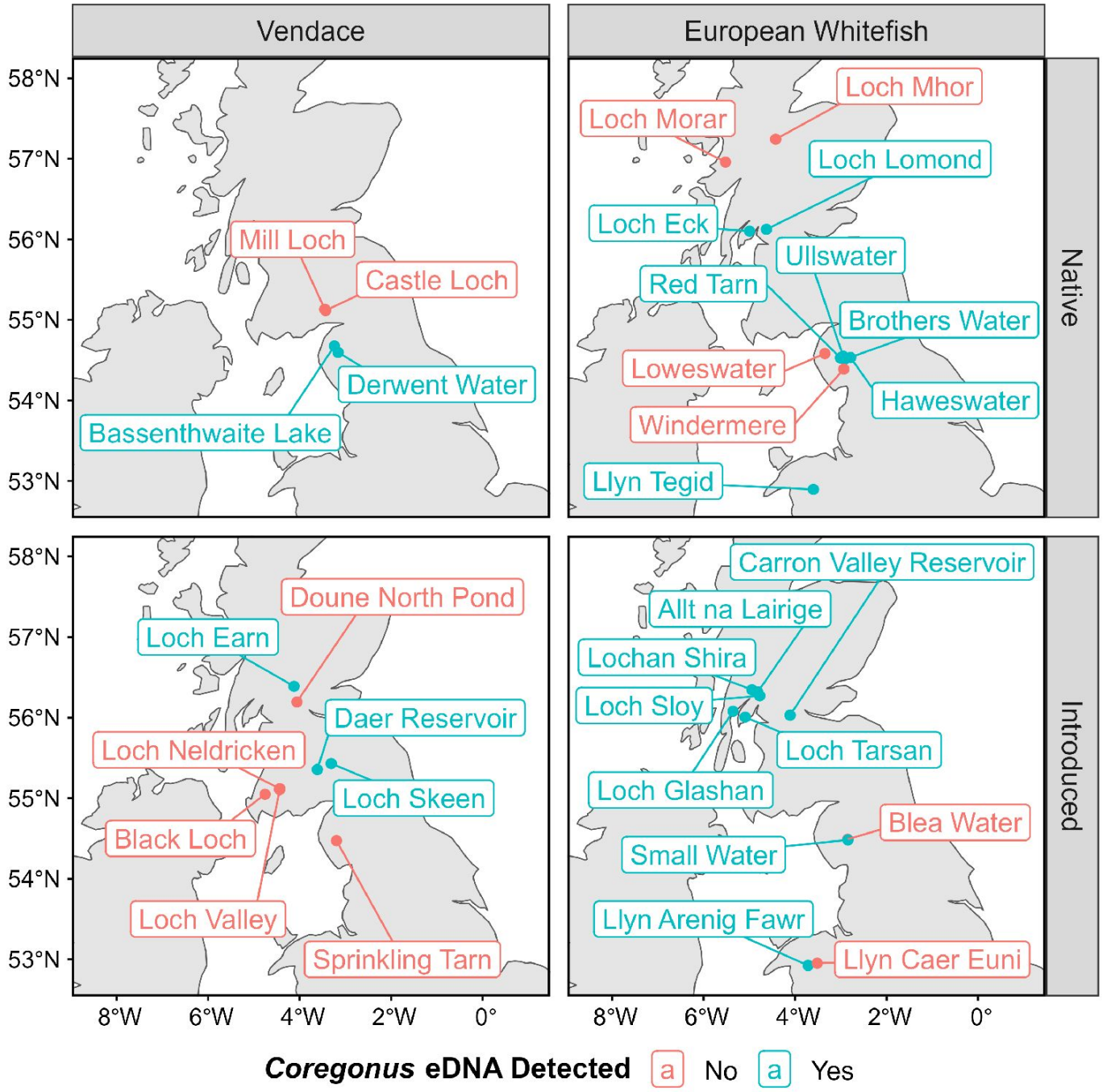
4. Assign sequences to taxa



Reference Database
(Hänfling *et al.*, 2016, *Mol. Ecol.*)

Provisional eDNA results (10 samples per lake)

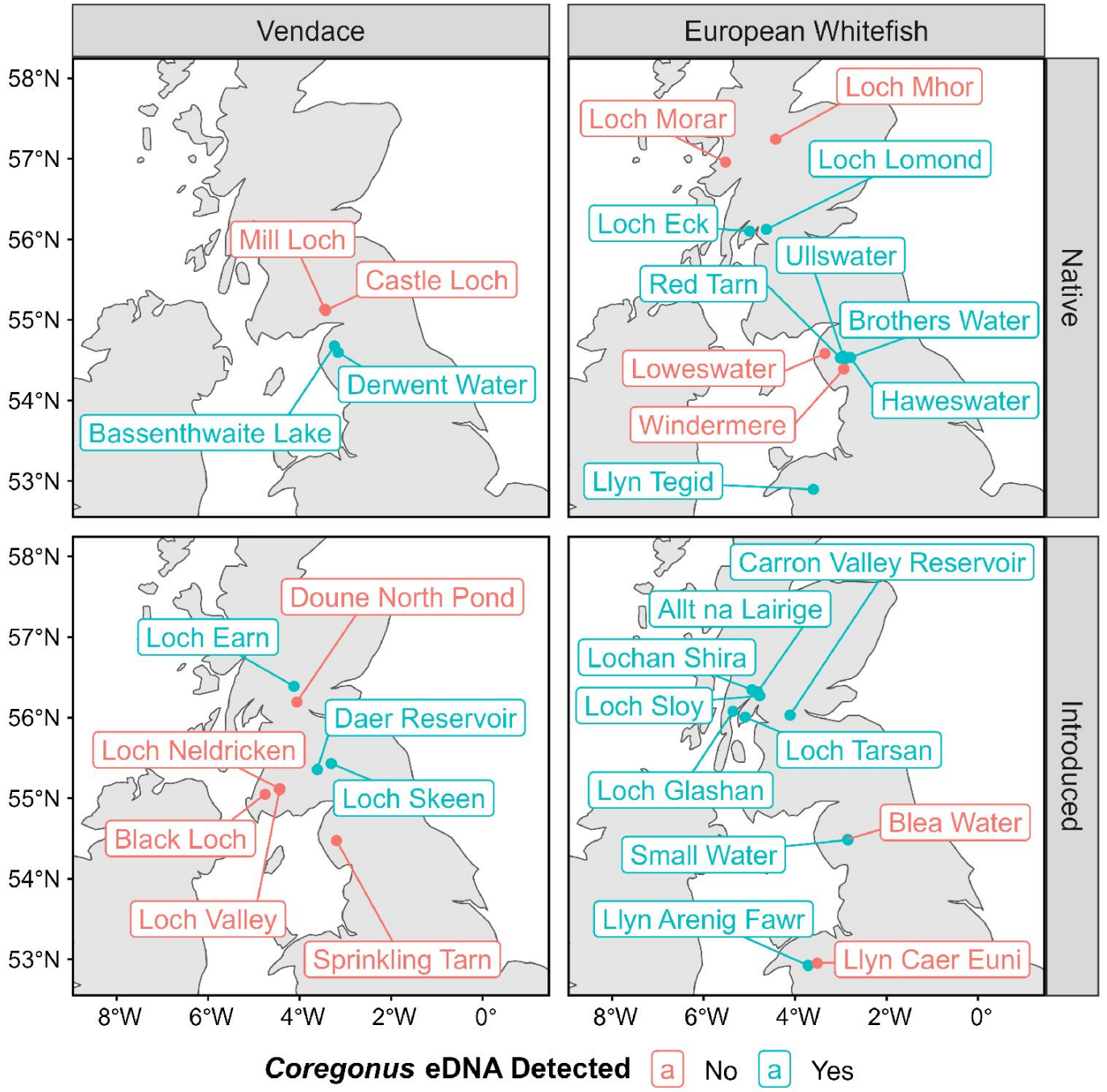
- Native populations remain extant
- Confirmation that at least 11 translocations were successful



Provisional eDNA results (10 samples per lake)

- Native populations remain extant
- Confirmation that at least 11 translocations were successful

More samples to be processed to decrease chance of false negatives

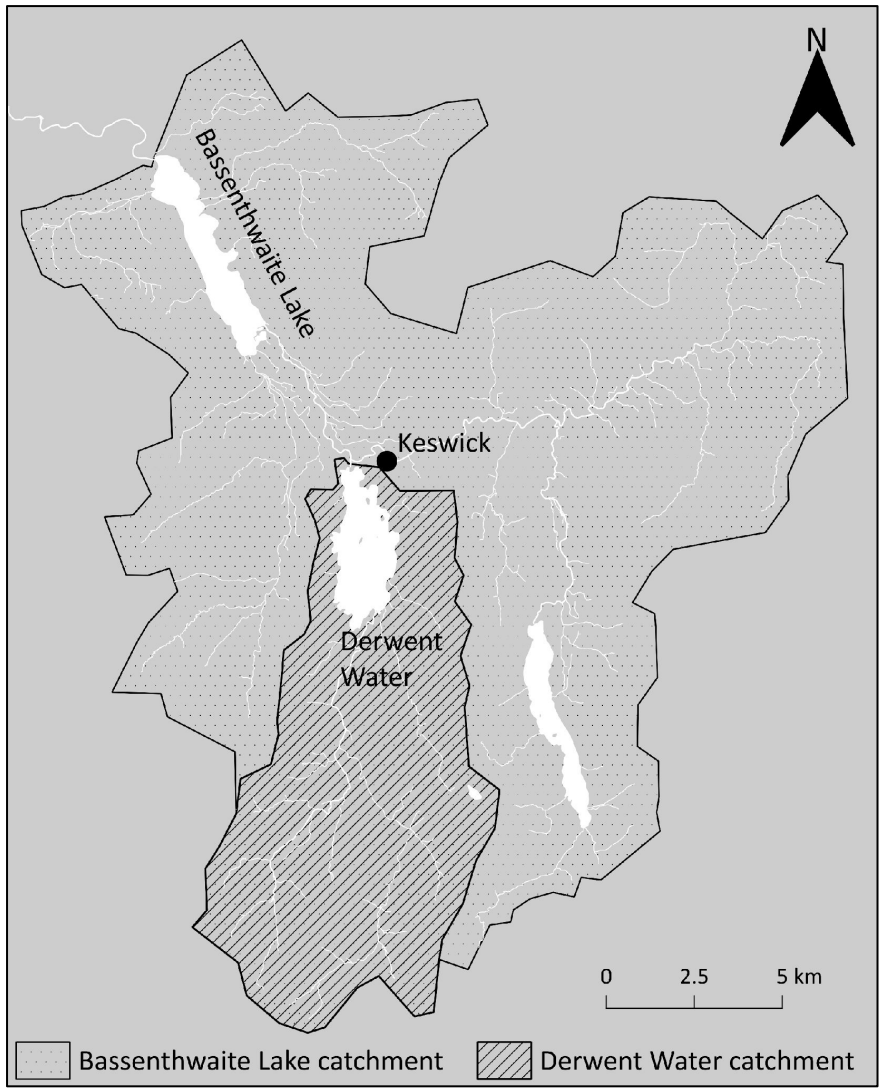


1) Determining the contemporary distribution of vendace and European whitefish in the UK

2) Assessing the status of the UK's native populations of vendace

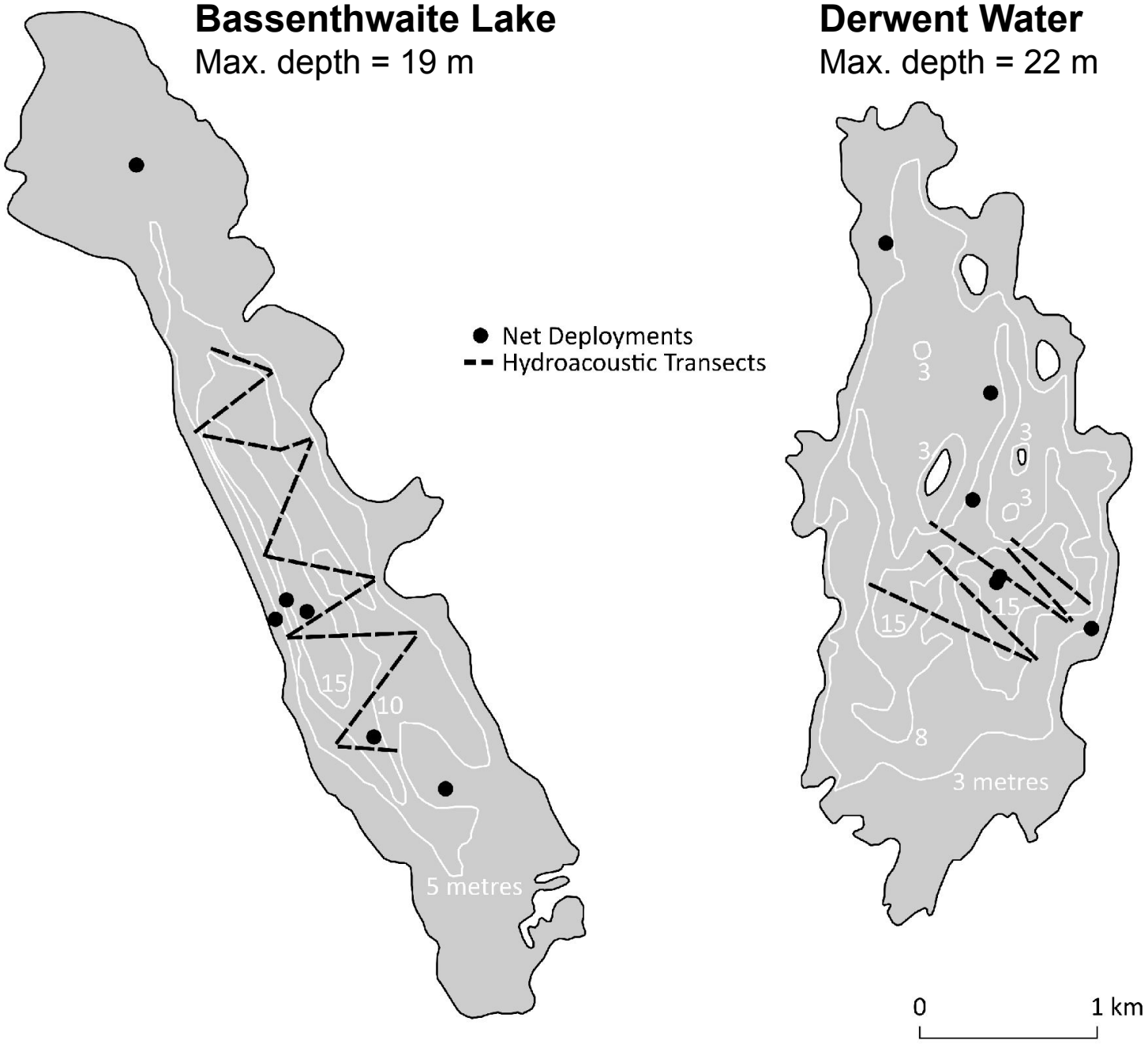
3) Investigating eDNA as a non-invasive method of locating the spawning grounds of *Coregonus* fishes

The UK's two native populations of vendace face a range of threats
(Winfield *et al.*, 2013, *Advanc. Limnol.*)



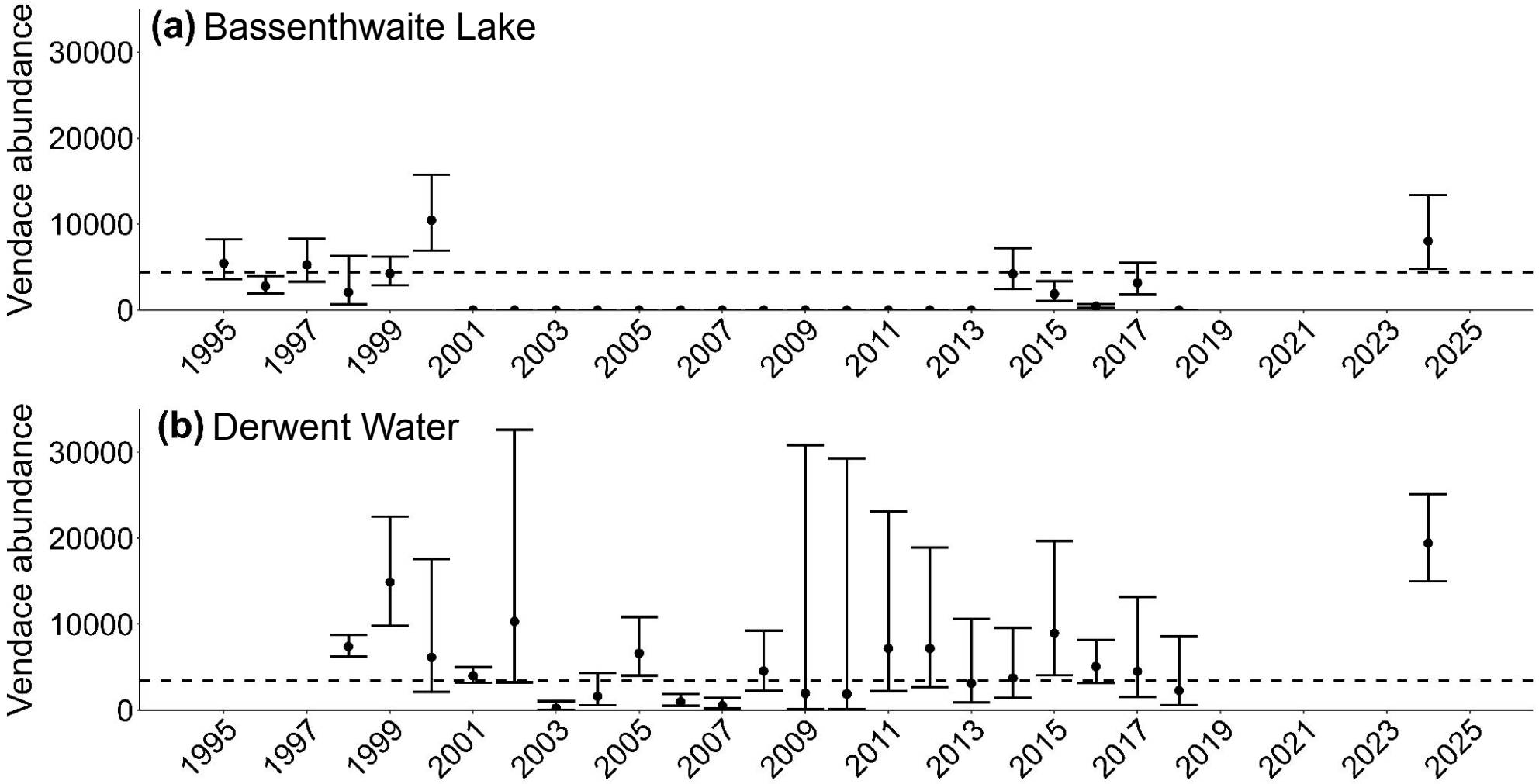
Aim:
To estimate the abundance of post-juvenile vendace

- Night-time surveys conducted 24-26 September 2024
- Hydroacoustic sampling with a Simrad EK80 echosounder
- Nordic multi-mesh gill netting



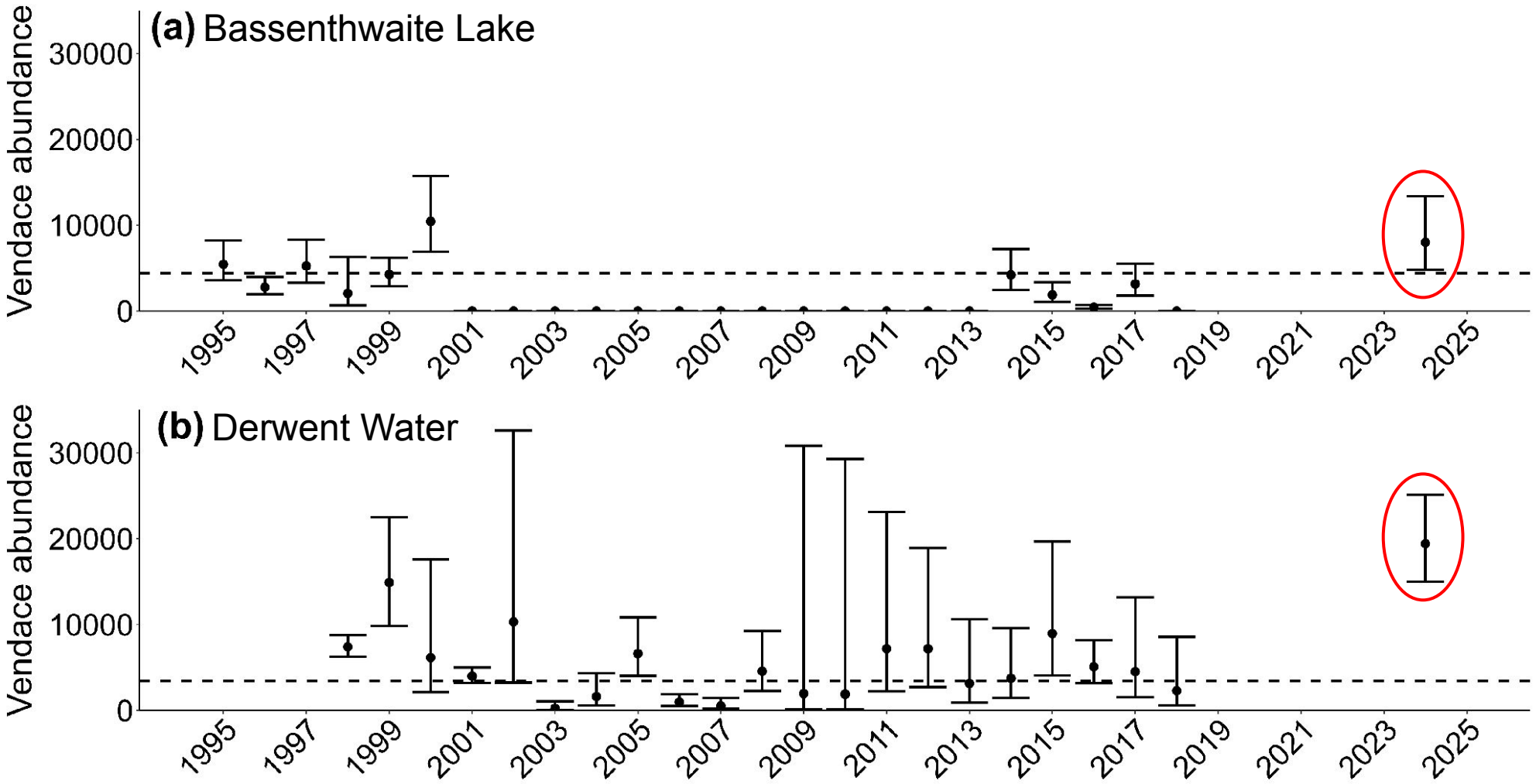
The 2024 surveys built on a time series of vendace abundance estimate

Dr Ian Winfield



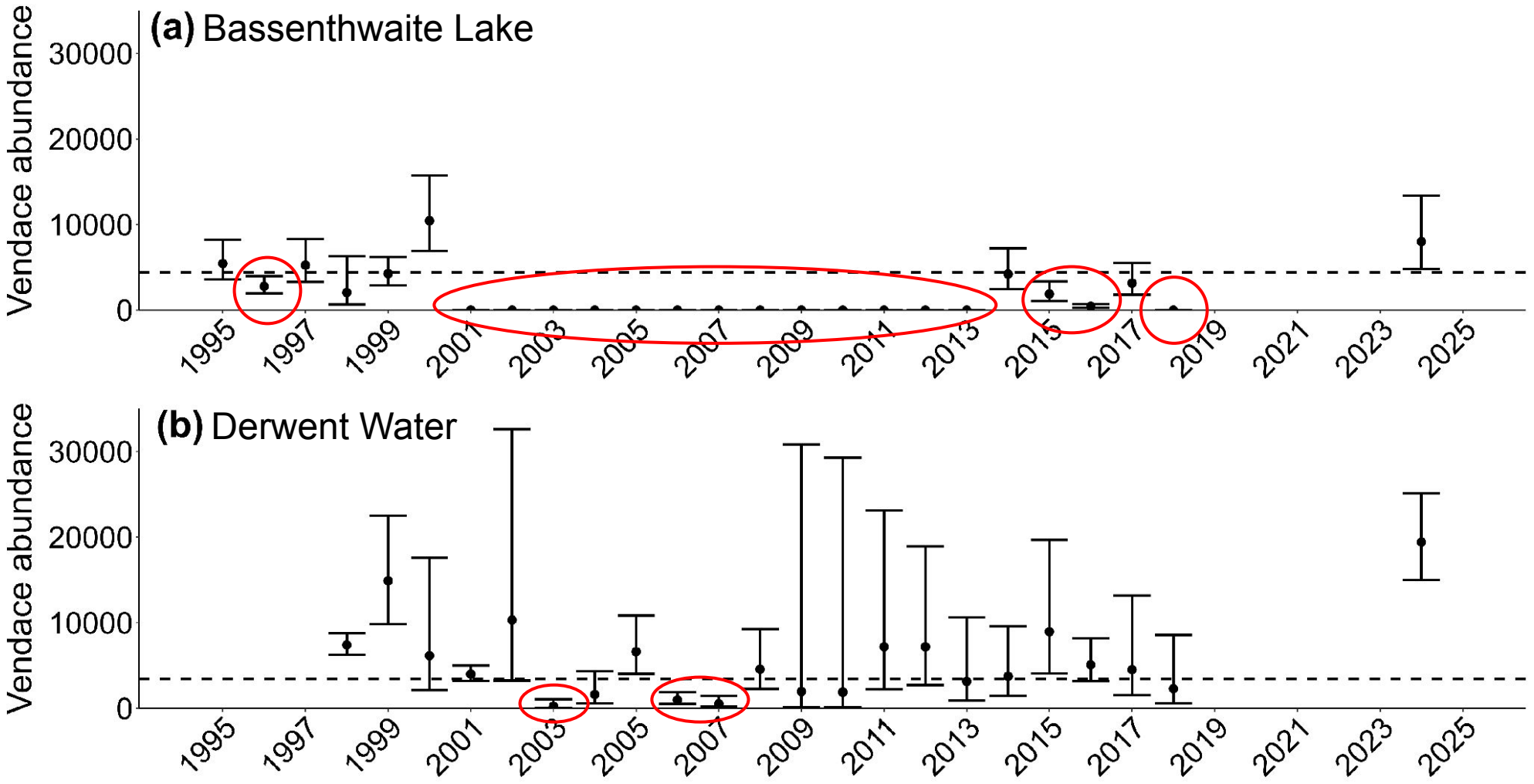
Brackets are 95% confidence intervals.
Dashed horizontal lines are baseline vendace abundances calculated from 1995 to 2000 in Bassenthwaite Lake and 1998 to 2018 in Derwent Water.

Post-juvenile vendace abundance in 2024 was higher than the reference baseline in both Bassenthwaite Lake (p = 0.028) and Derwent Water (p < 0.001).



Brackets are 95% confidence intervals.
Dashed horizontal lines are baseline vendace abundances calculated from 1995 to 2000 in Bassenthwaite Lake and 1998 to 2017 in Derwent Water.

Post-juvenile vendace abundance was markedly low in some years.



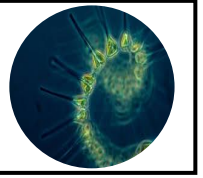
Brackets are 95% confidence intervals.
Dashed horizontal lines are baseline vendace abundances calculated from 1995 to 2000 in Bassenthwaite Lake and 1998 to 2017 in Derwent Water.

What factors might predict the occurrence of years with markedly low post-juvenile vendace abundance?

Post-juvenile mortality drivers

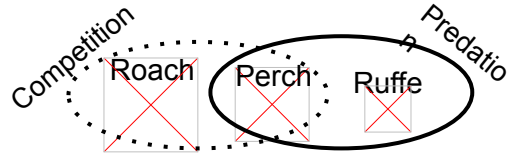
- *Effect takes place in same year as driver*

Water temperature

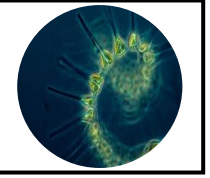
Chlorophyll *a* concentration 

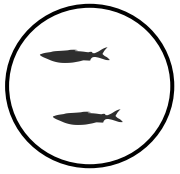
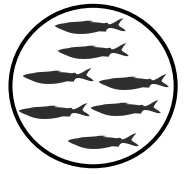
Recruitment drivers

- *Effect lags behind driver by 3 or 4 years*

Perch, roach and ruffe abundance 

Water temperature

Chlorophyll *a* concentration 

Abundance of spawners  **OR** 

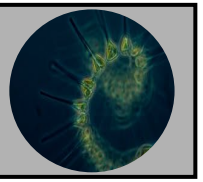
Perch - *Perca fluviatilis*, Roach - *Rutilus rutilus*, Ruffe - *Gymnocephalus cernuus*
Water temperature and chlorophyll *a* data supplied by UK Centre for Ecology &

What factors might predict the occurrence of years with markedly low post-juvenile vendace abundance?

Post-juvenile mortality drivers

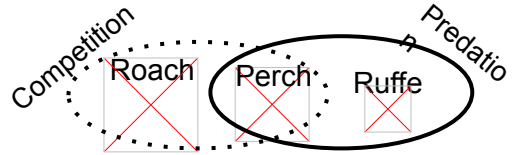
- *Effect takes place in same year as driver*

Water temperature

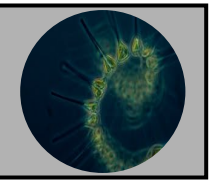
Chlorophyll *a* concentration 

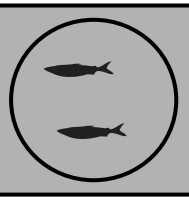
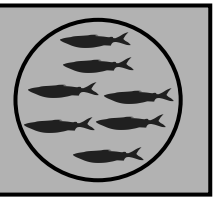
Recruitment drivers

- *Effect lags behind driver by 3 or 4 years*

Perch, roach and ruffe abundance 

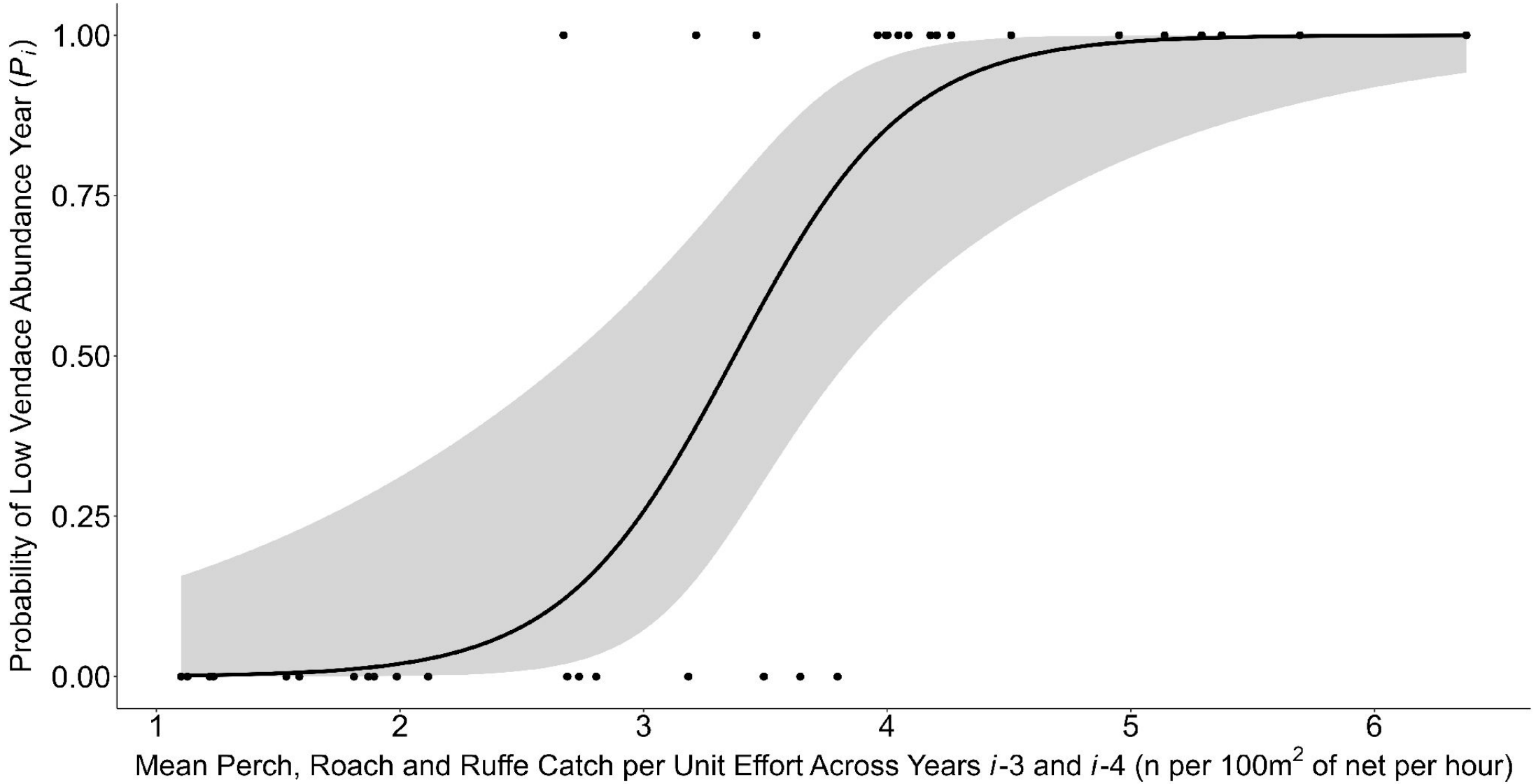
Water temperature

Chlorophyll *a* concentration 

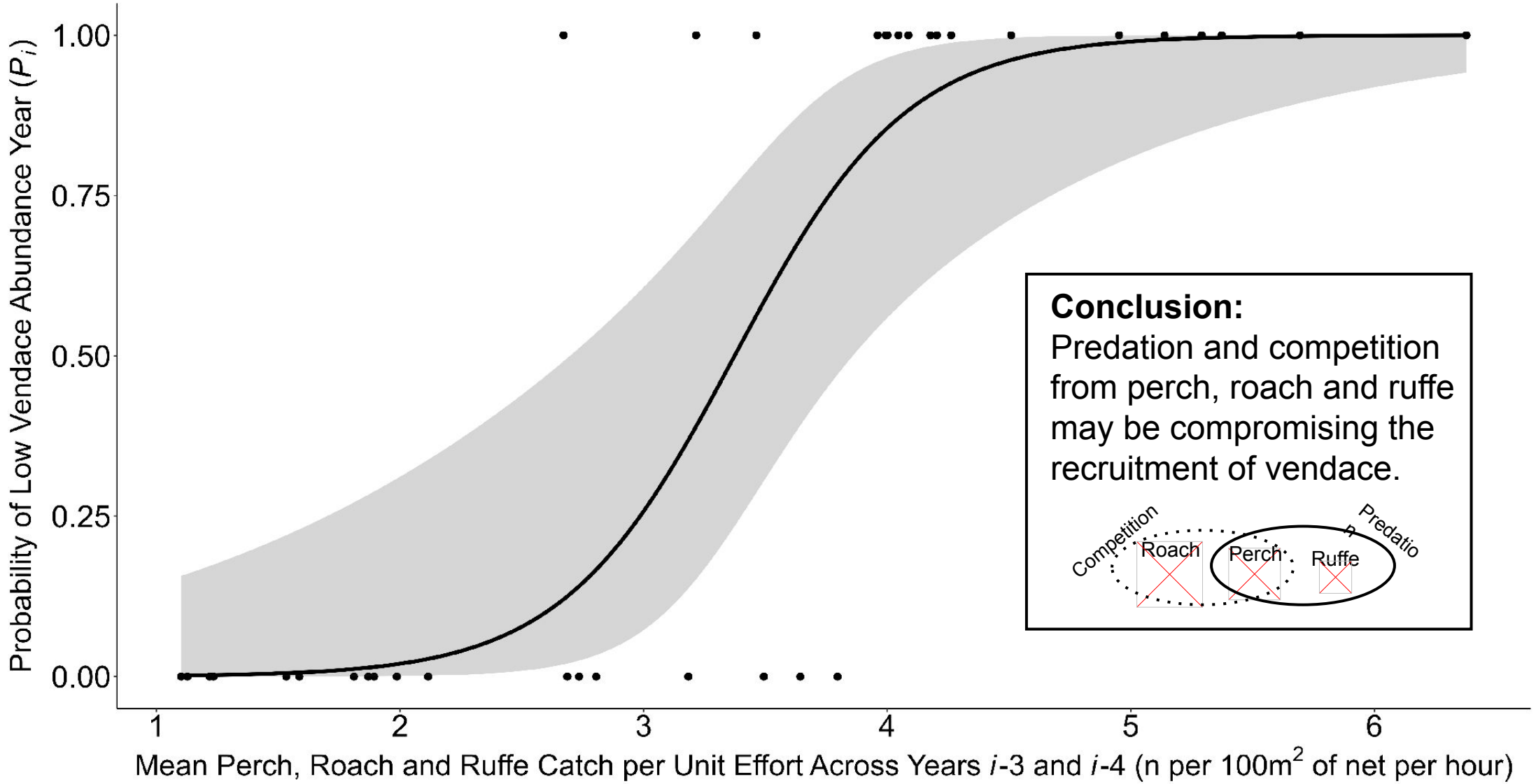
Abundance of spawners  **OR** 

Perch - *Perca fluviatilis*, Roach - *Rutilus rutilus*, Ruffe - *Gymnocephalus cernuus*
Water temperature and chlorophyll *a* data supplied by UK Centre for Ecology &

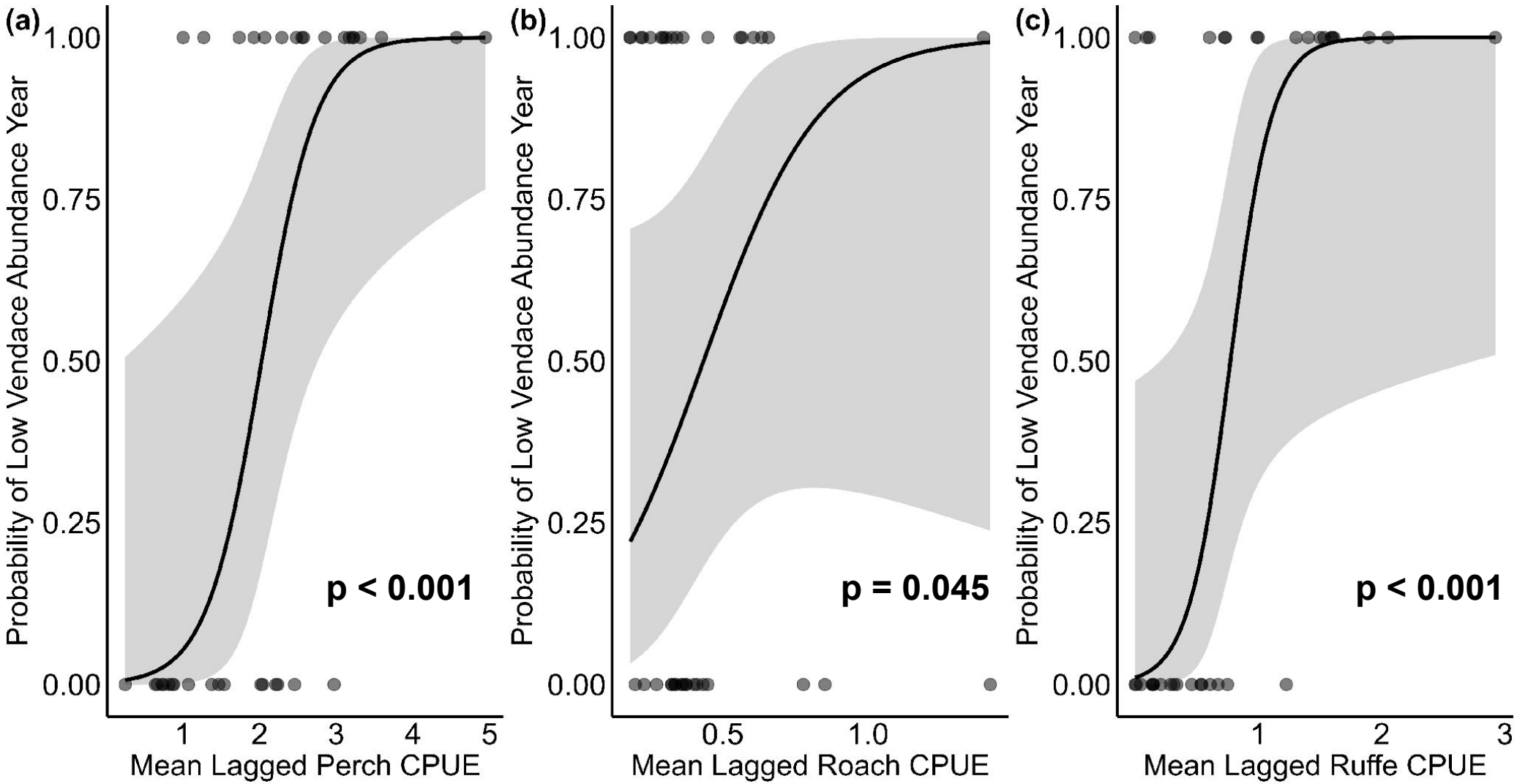
The probability of a low post-juvenile vendace abundance year increases with the lagged abundance of perch, roach and ruffe ($p < 0.001$).



The probability of a low post-juvenile vendace abundance year increases with the lagged abundance of perch, roach and ruffe ($p < 0.001$).



High lagged abundances of perch and ruffe are significantly associated with low vendace abundances. Relatively equivocal evidence of a roach effect.

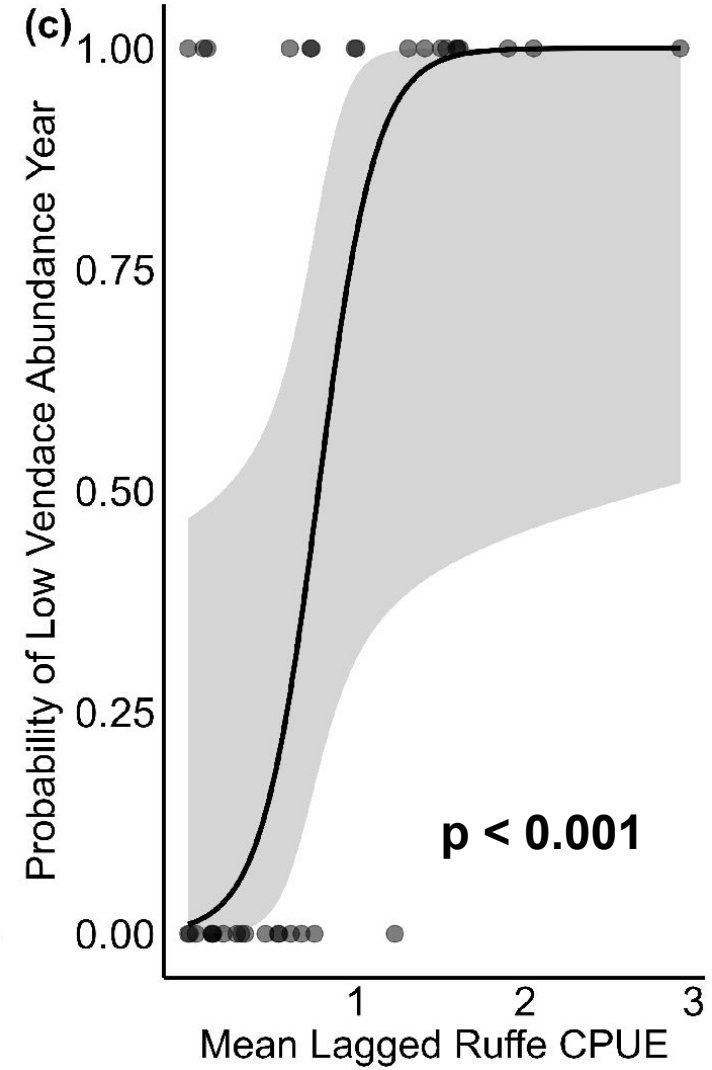


This demonstrates one of the risks associated with the translocation of fish species.

First records of ruffe:

- Bassenthwaite Lake - 1991
- Derwent Water - 2001

(Winfield *et al.*, 2007, *Adv. Limnol.*)



1) Determining the contemporary distribution of vendace and European whitefish in the UK

2) Assessing the status of the UK's native populations of vendace

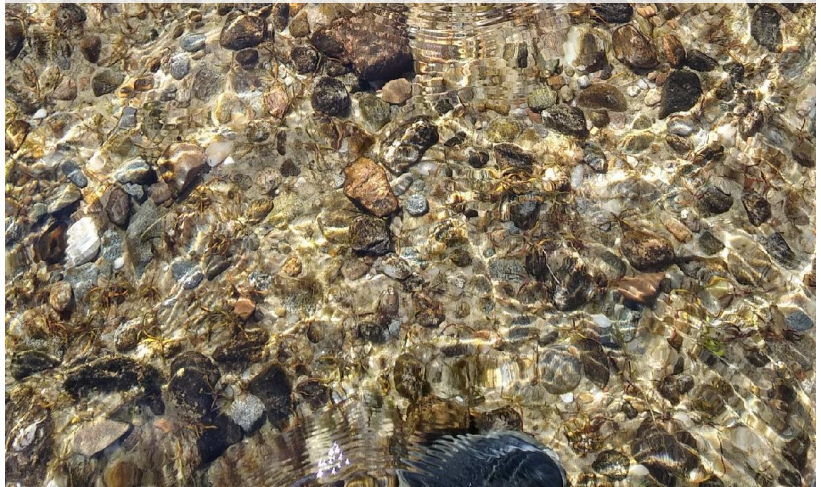
3) Investigating eDNA as a non-invasive method of locating the spawning grounds of *Coregonus* fishes

In the UK, both vendace and European whitefish aggregate in winter to spawn

Broadcast spawning

In water < 10 m deep

Over gravel and stone substrates



Żuromska (1982) *Pol. Arch. Hydrobiol.*

Existing methods of locating *Coregonus* spawning grounds are invasive

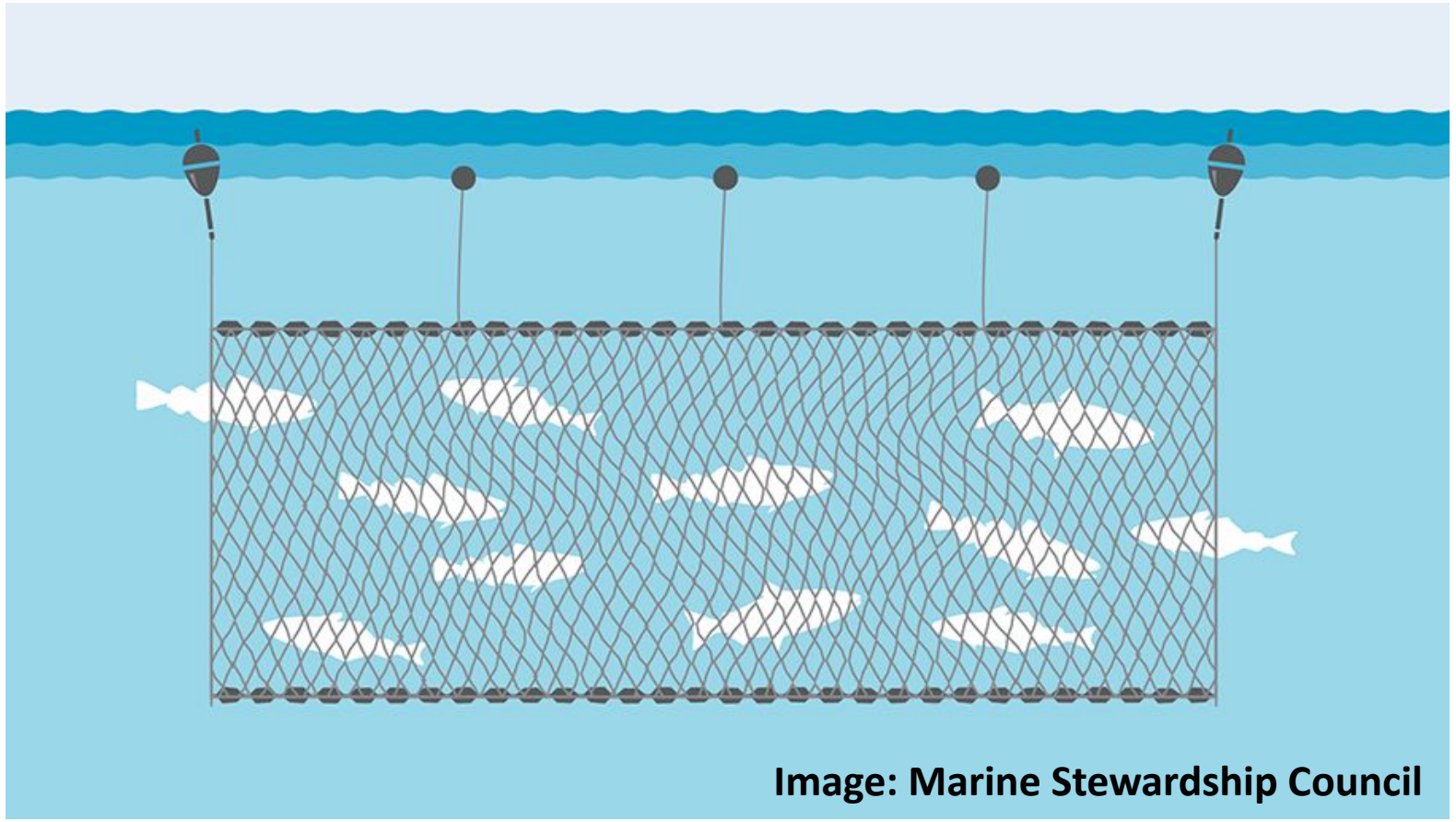


Image: Marine Stewardship Council

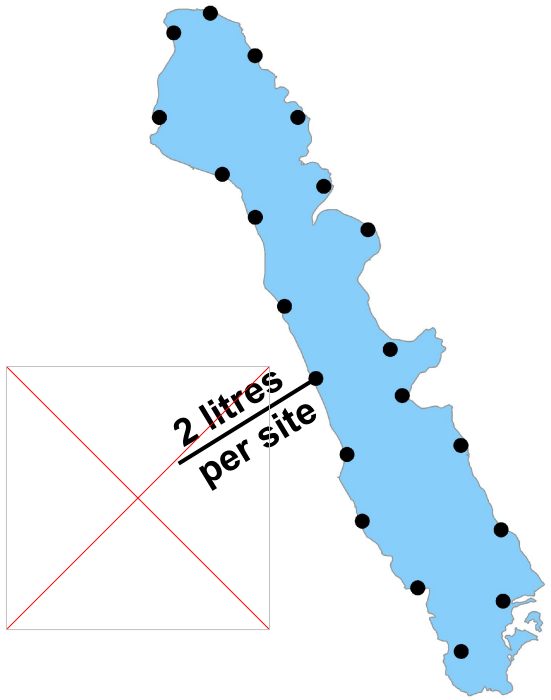
Aim

Assess the utility of eDNA as non-invasive method of locating the spawning grounds of vendace and European whitefish

Aim

Assess the utility of eDNA as non-invasive method of locating the spawning grounds of vendace and European whitefish

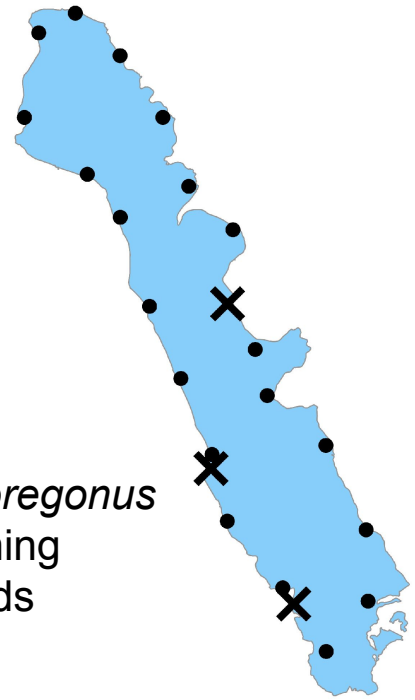
1. Sample water at spawning time



2. eDNA metabarcoding

- Water Filtration (0.45 µm pores)
- Spin Column DNA Extraction
- 12S Mitochondrial Marker
- Reads Assigned to Fish Taxa
- Field, Extraction and PCR Negative Controls

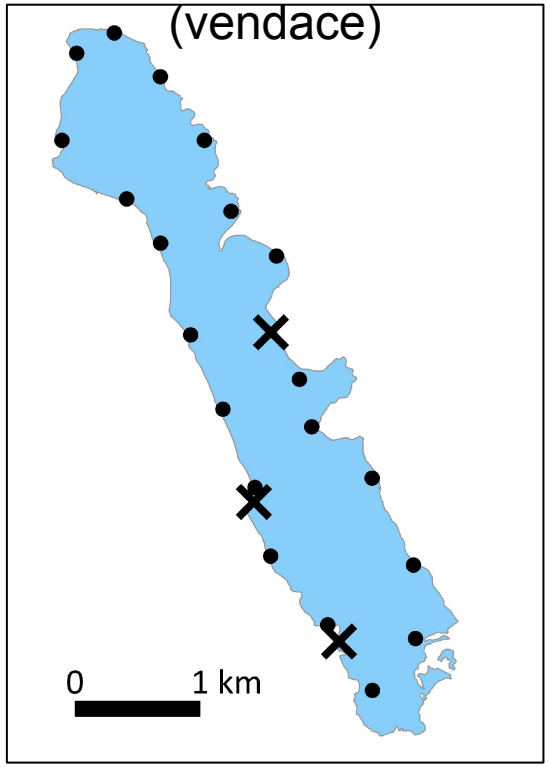
3. Link eDNA to spawning grounds



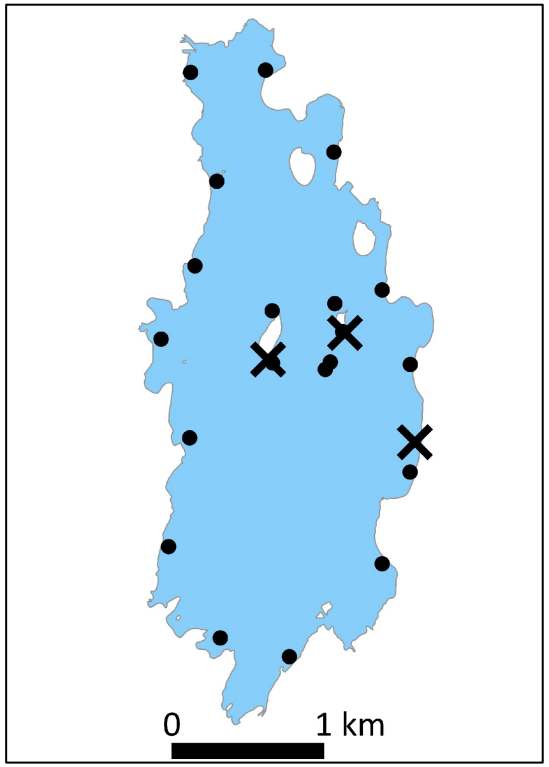
X - *Coregonus* spawning grounds

Methodology replicated in four lakes

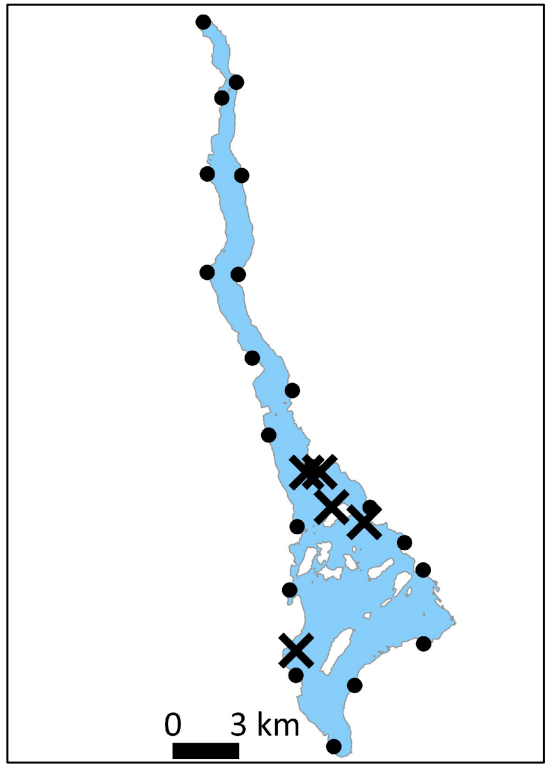
Bassenthwaite Lake
(vendace)



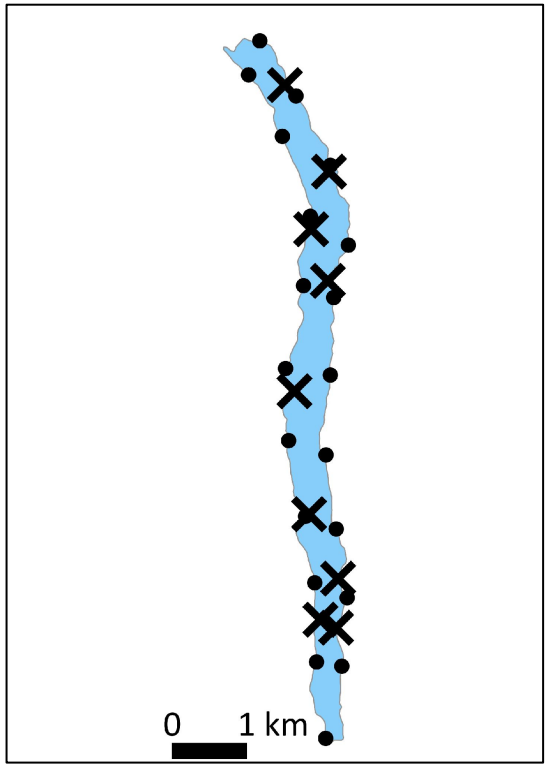
Derwent Water
(vendace)



Loch Lomond
(European whitefish)



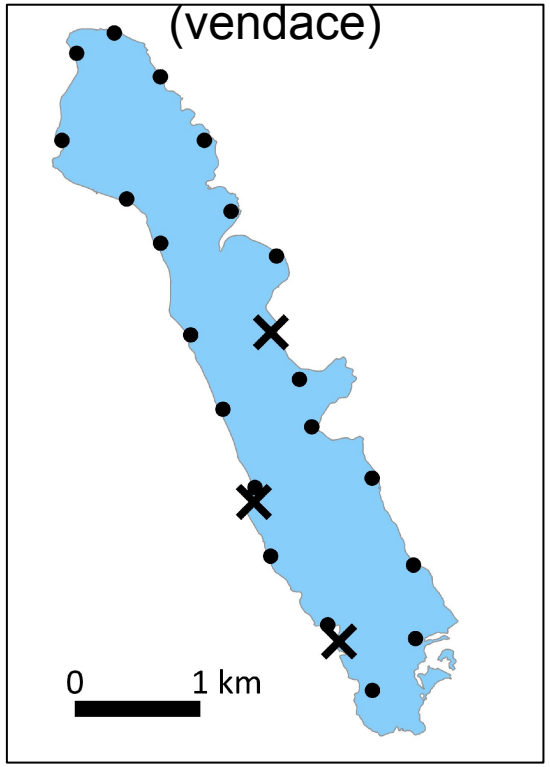
Loch Eck
(European whitefish)



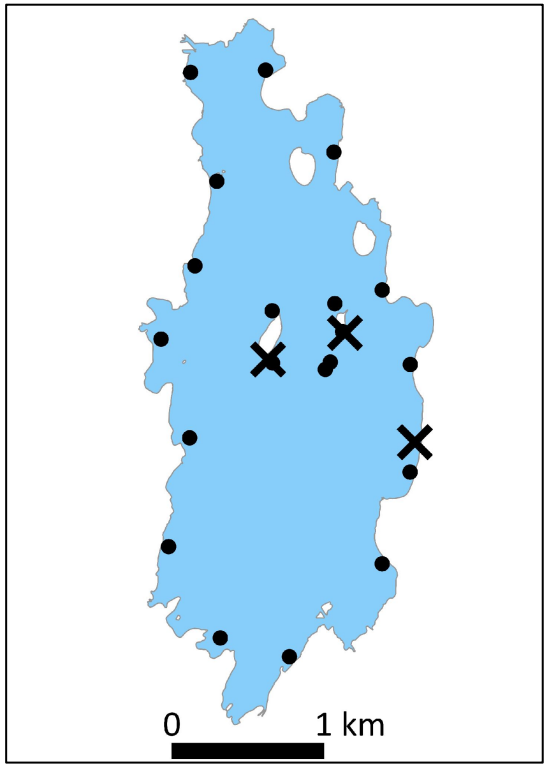
X - *Coregonus* spawning grounds, ● - eDNA sampling sites

Methodology replicated in four lakes

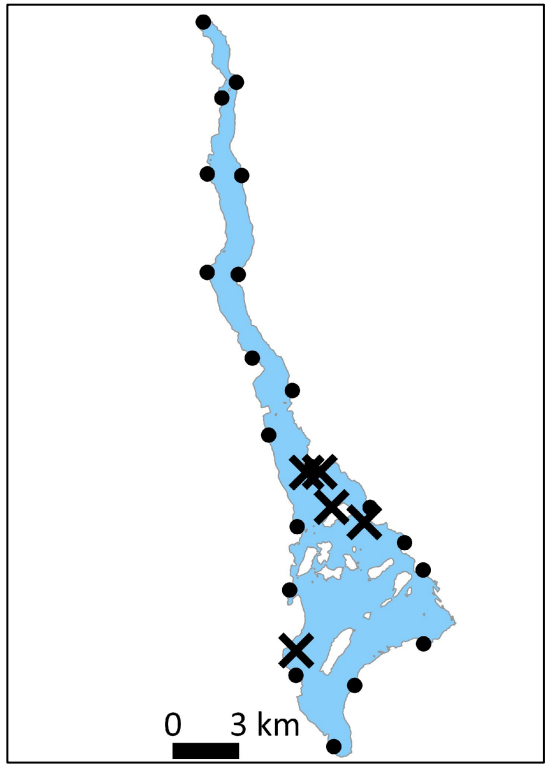
Bassenthwaite Lake
(vendace)



Derwent Water
(vendace)

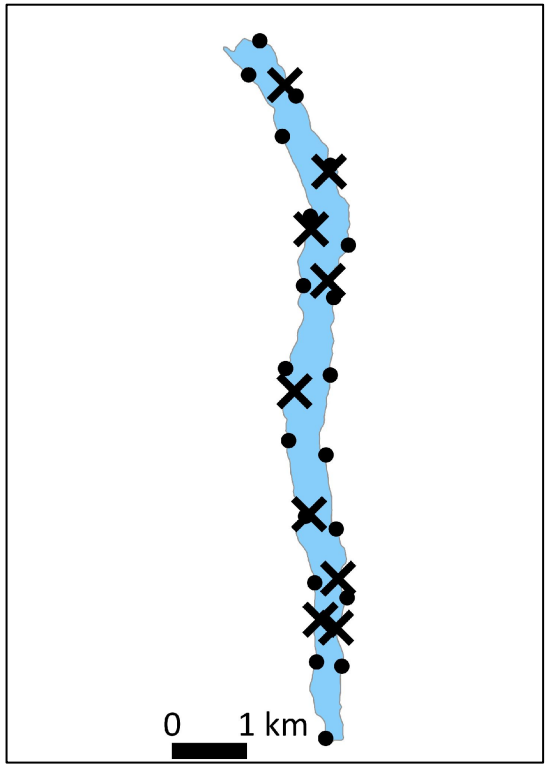


Loch Lomond
(European whitefish)



Clustered Spawning Grounds

Loch Eck
(European whitefish)

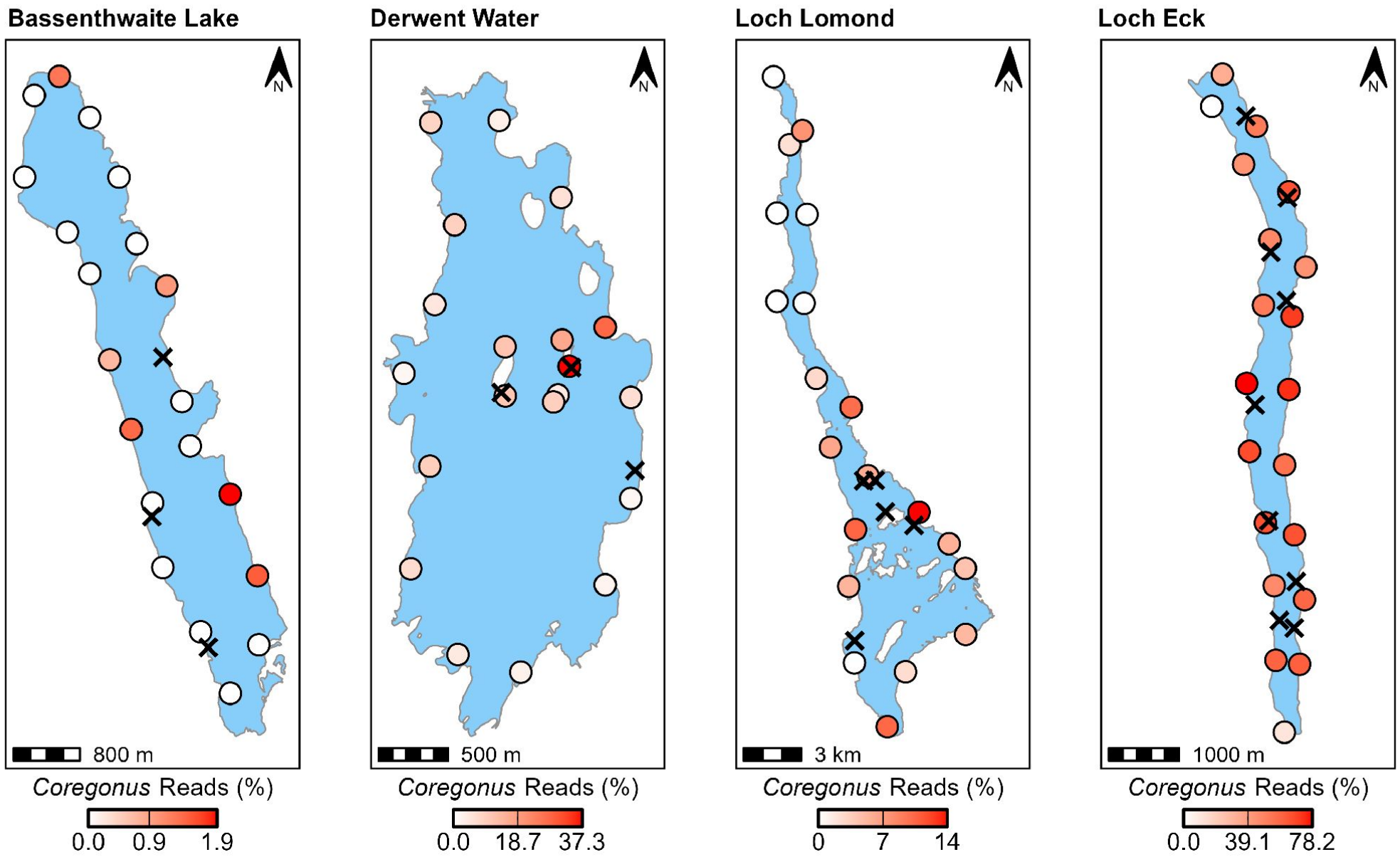


Evenly Distributed Spawning Grounds

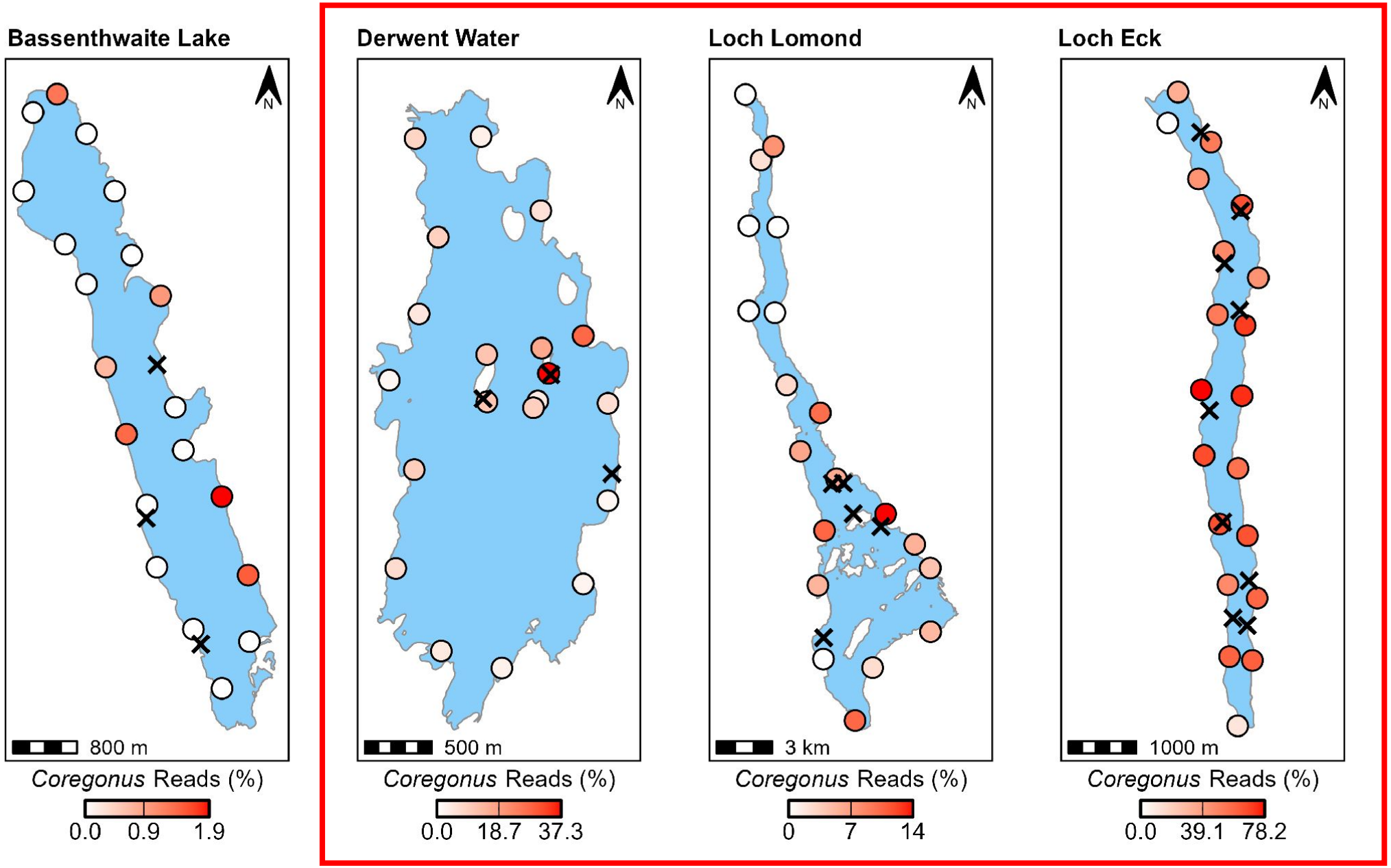
X - *Coregonus* spawning grounds, ● - eDNA sampling sites

Hypothesis

Higher proportions of *Coregonus* reads in eDNA samples collected near known spawning grounds

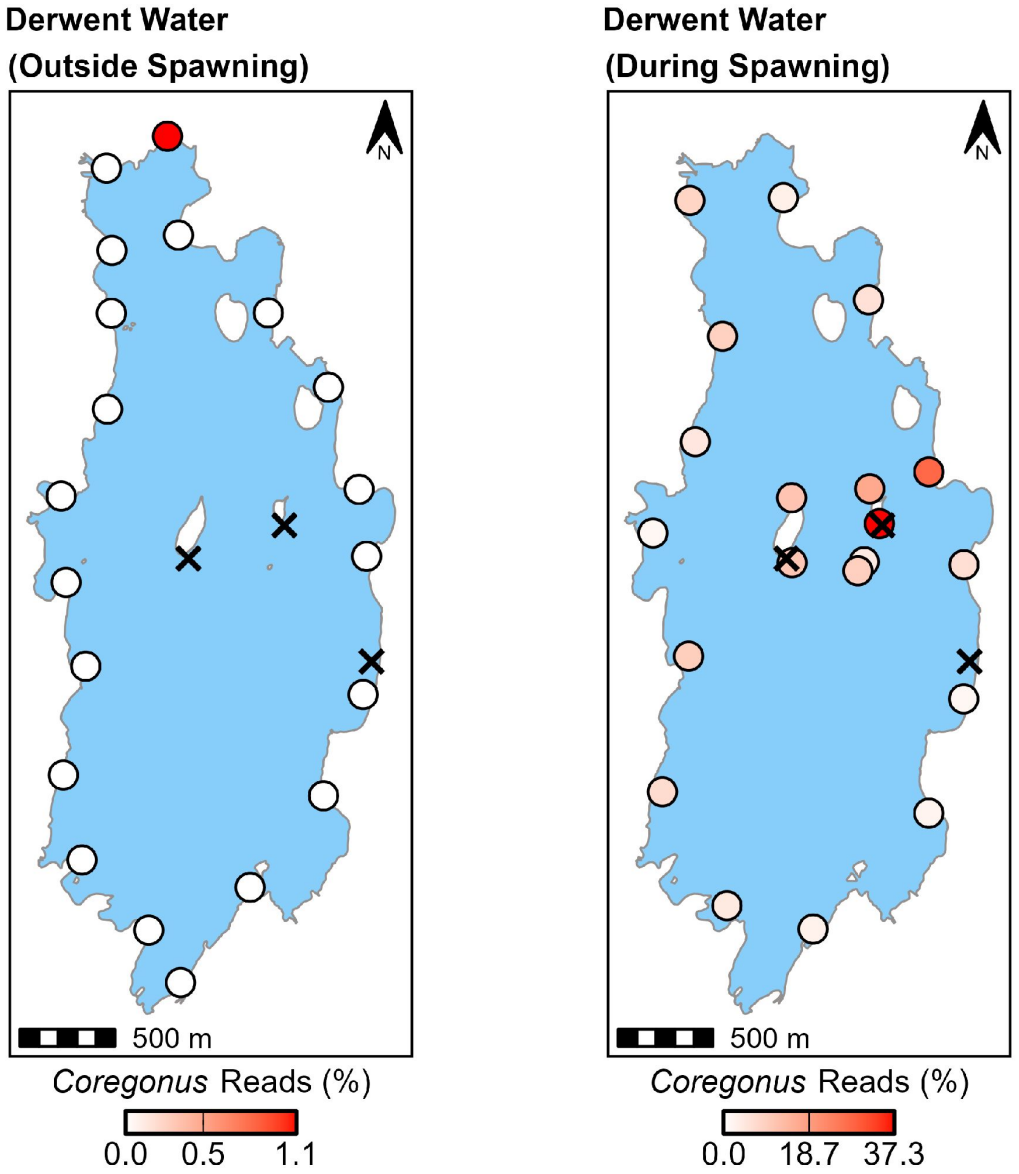


X - *Coregonus* spawning grounds - eDNA sampling sites

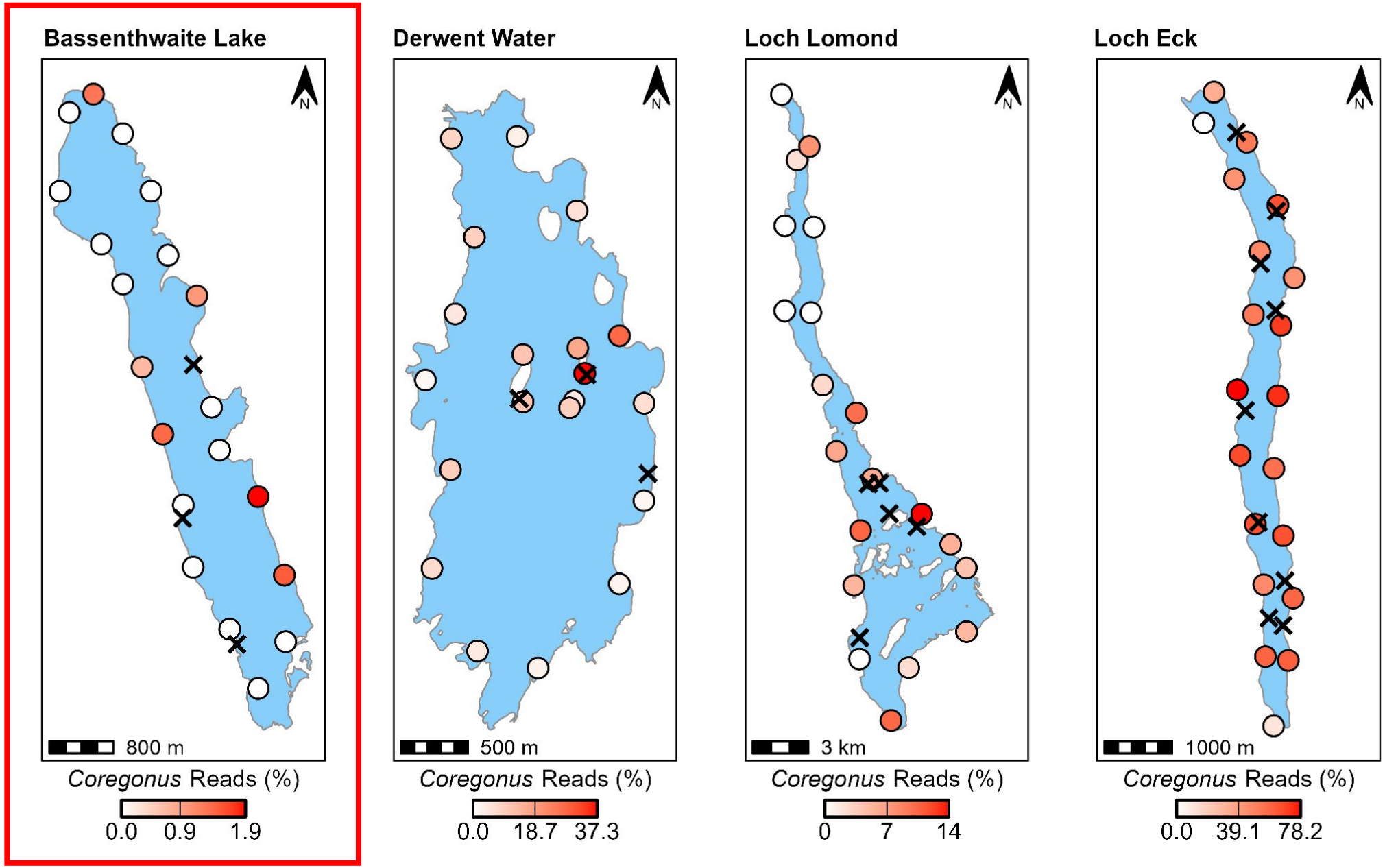


X - *Coregonus* spawning grounds ○ - eDNA sampling sites

Association only evident during the spawning season

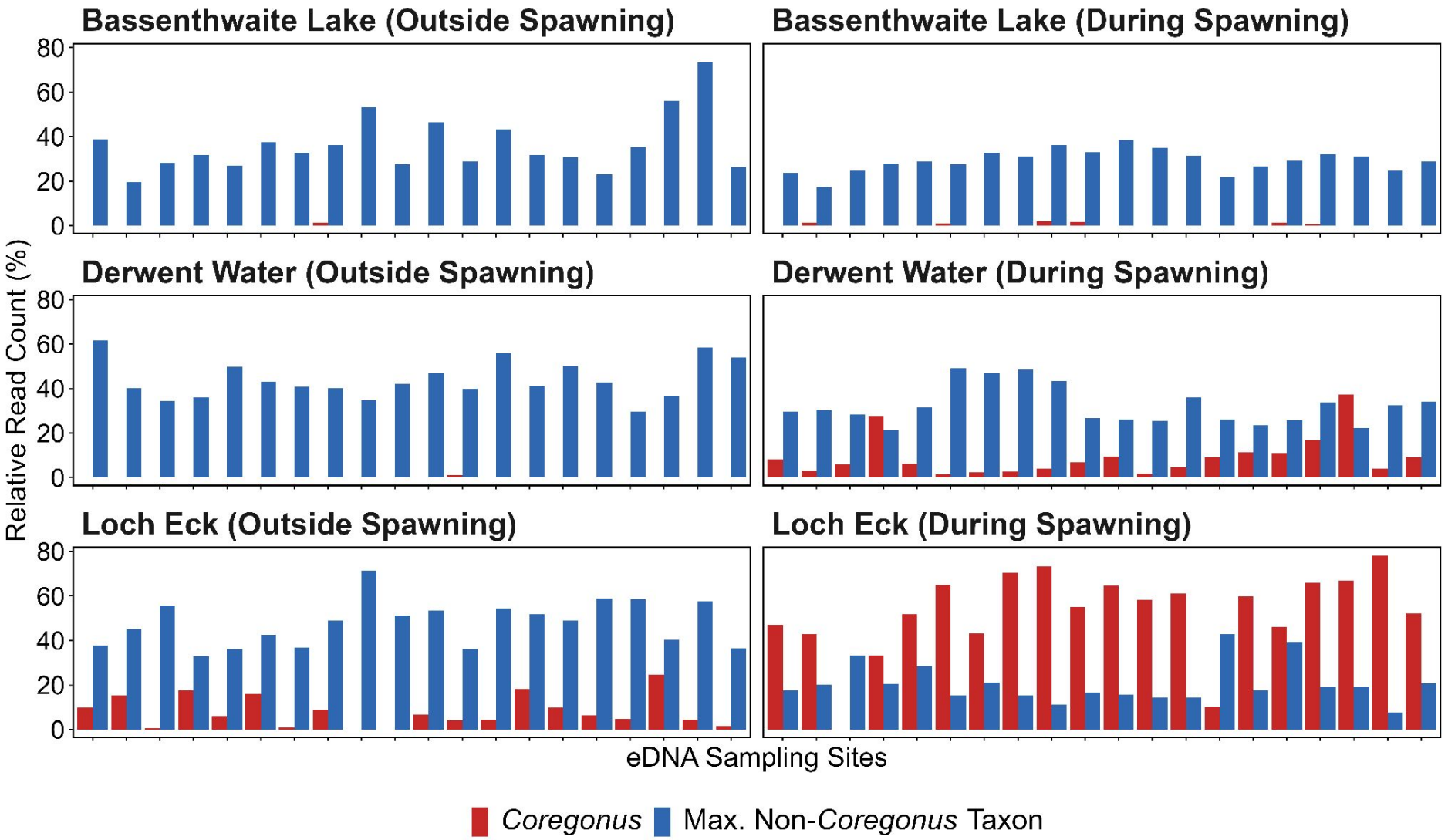


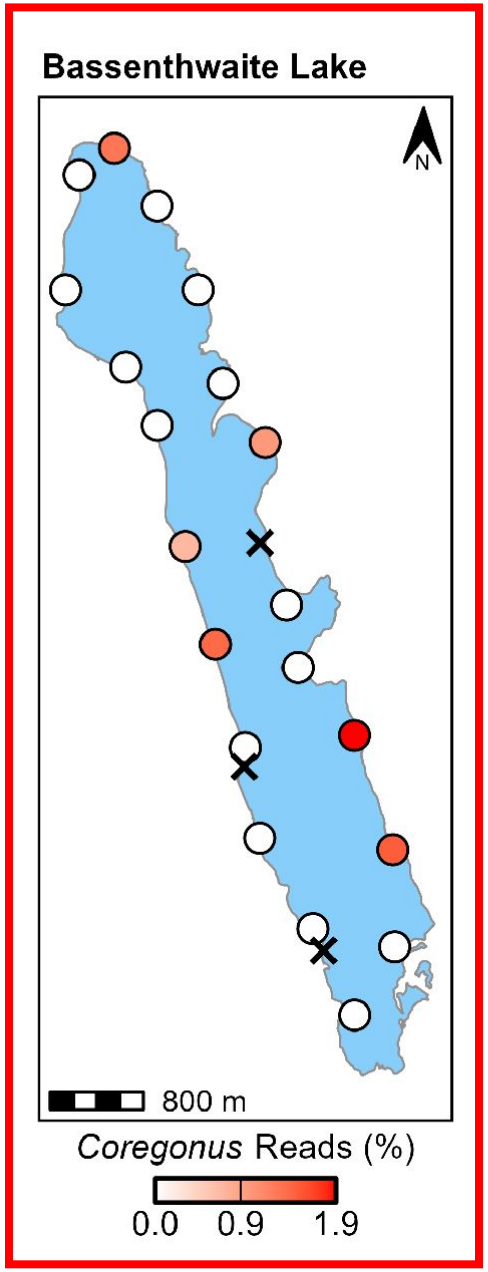
X - *Coregonus* spawning grounds - eDNA sampling sites



X - *Coregonus* spawning grounds - eDNA sampling sites

No evidence of elevated *Coregonus* relative read count at spawning time in Bassenthwaite Lake

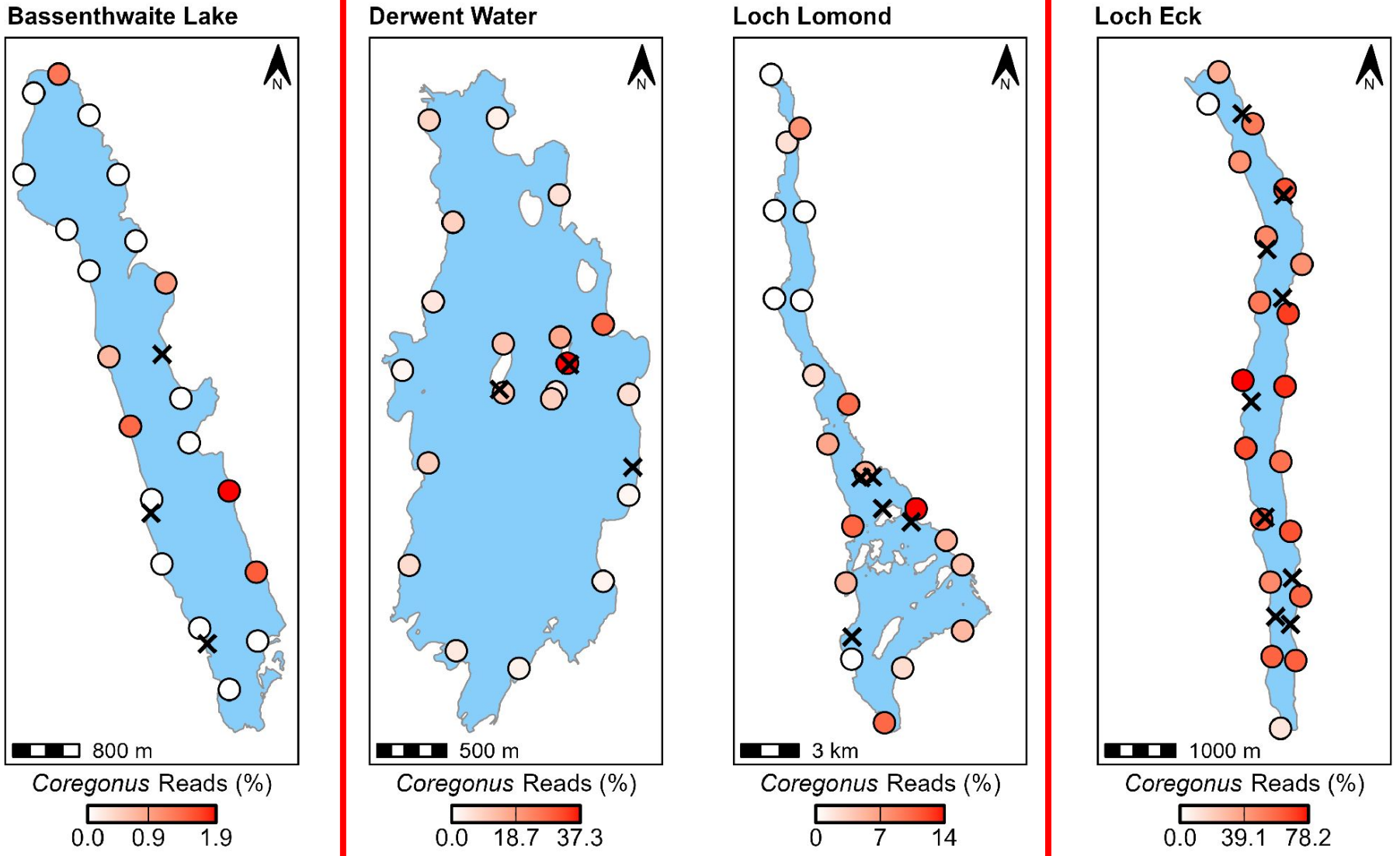




Spawning may not have been detected in Bassenthwaite Lake

X - *Coregonus* spawning grounds - eDNA sampling sites

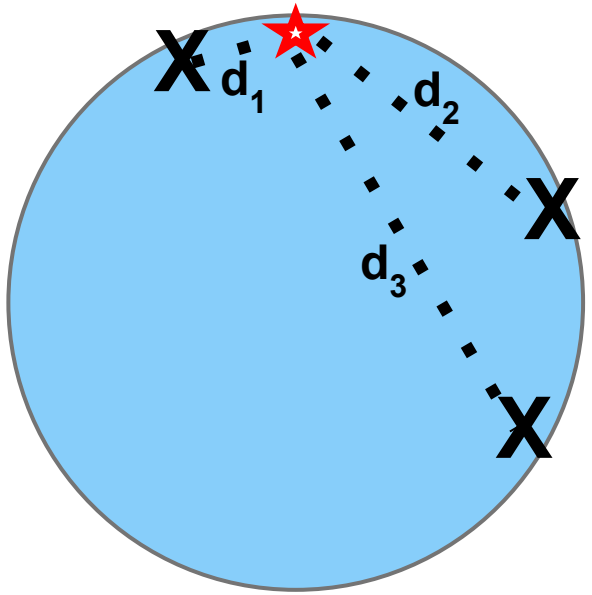
Can spatially clustered spawning grounds be located using the eDNA sampling site with the highest proportion of *Coregonus* reads?



X - *Coregonus* spawning grounds - eDNA sampling sites

Can spatially clustered spawning grounds be located using the eDNA sampling site with the highest proportion of *Coregonus* reads?

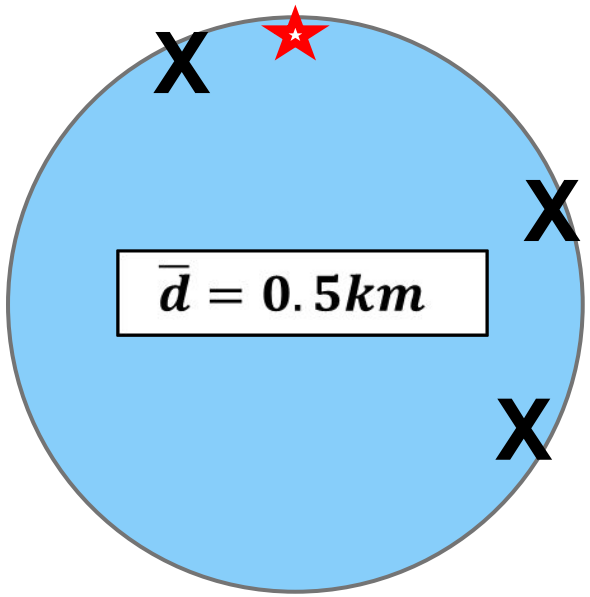
$$\overline{d} = \frac{d_1 + d_2 + \cdots + d_n}{n}$$



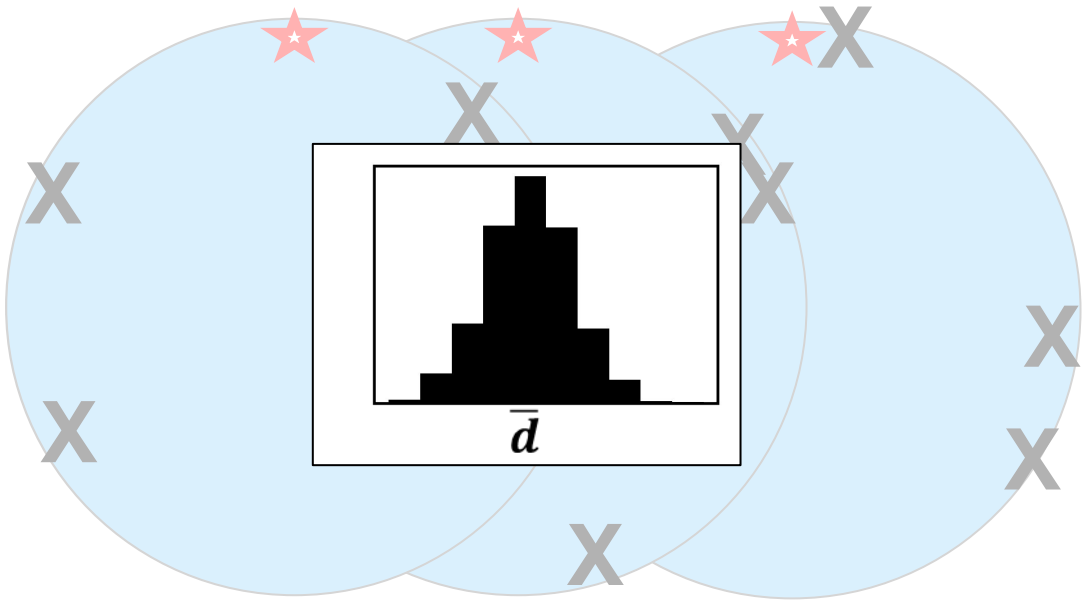
X - *Coregonus* spawning grounds; ★ - eDNA sampling site with the highest proportion of *Coregonus*

Can spatially clustered spawning grounds be located using the eDNA sampling site with the highest proportion of *Coregonus* reads?

Observed Data



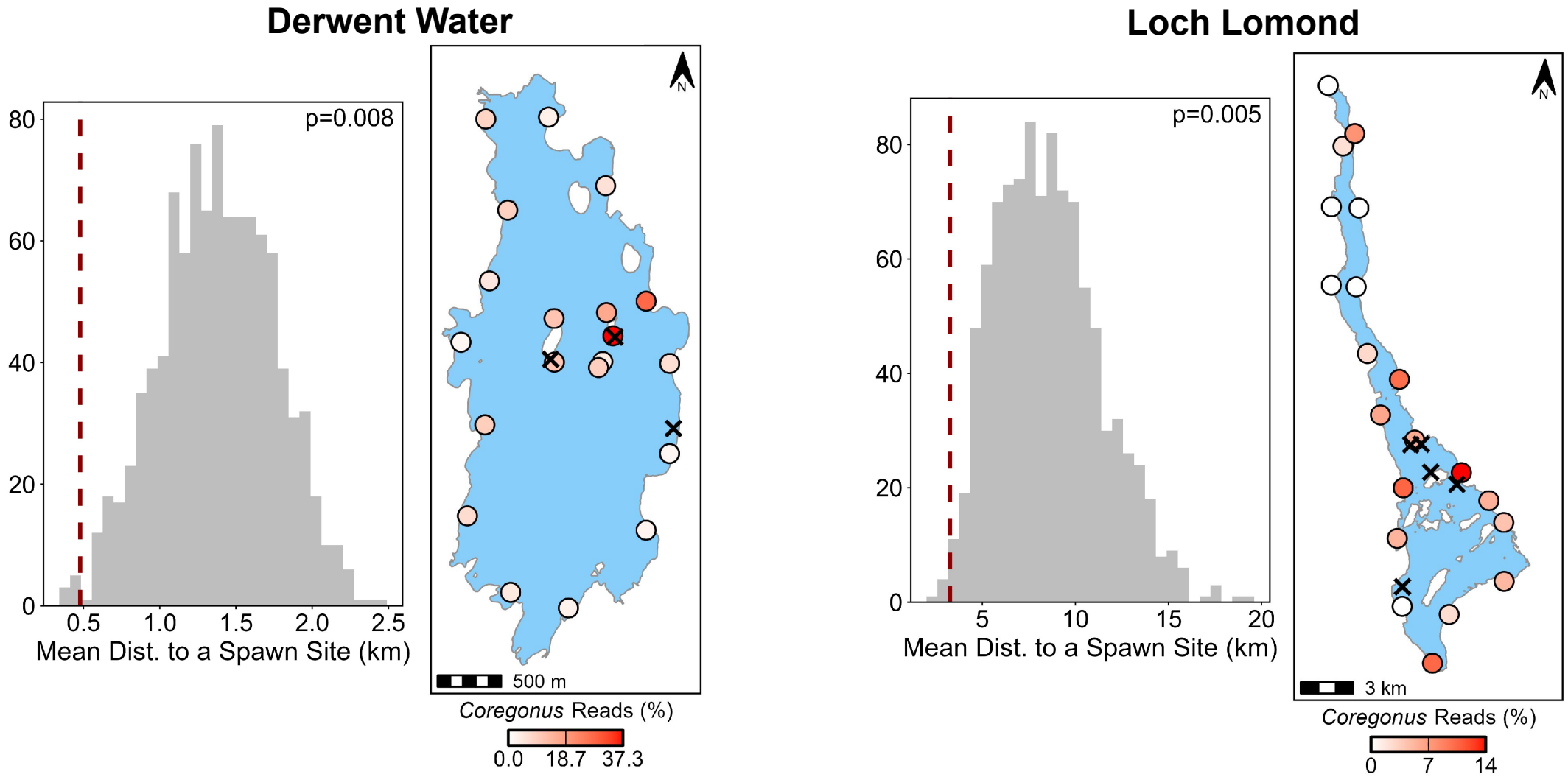
Randomised spawning grounds (1000 iterations)



X - *Coregonus* spawning grounds ★ - eDNA sampling site with the highest proportion of *Coregonus* reads

- Possible alternative spawning ground locations

The sample with the highest proportion of *Coregonus* reads was closer to the spawning grounds than would be expected by chance



X - *Coregonus* spawning grounds ○ - eDNA sampling sites

Summary

- eDNA metabarcoding identifies 5 UK lakes with populations of vendace and 15 with European whitefish.
- Both native populations of vendace were abundant in 2024, but the size of these populations appears to be modulated by native and introduced percid fishes.
- Strong *Coregonus* eDNA signals co-occur with the locations of known spawning grounds.

Acknowledgements

Colin E. Adams
Colin W. Bean
Melanie Fletcher
Nathan P. Griffiths
Jemma Guthrie
Bernd Hänfling
Chris Harrod
Hannele M. Honkanen
Phoebe Kaiser-Wilks
Alex A. Lyle
Jim Lyons
James A. Macarthur
Dave Ottewell
Philip Ramsden
Dasha Svobodova
Ian J. Winfield

Funding

Email: 2602388f@student.gla.ac.uk