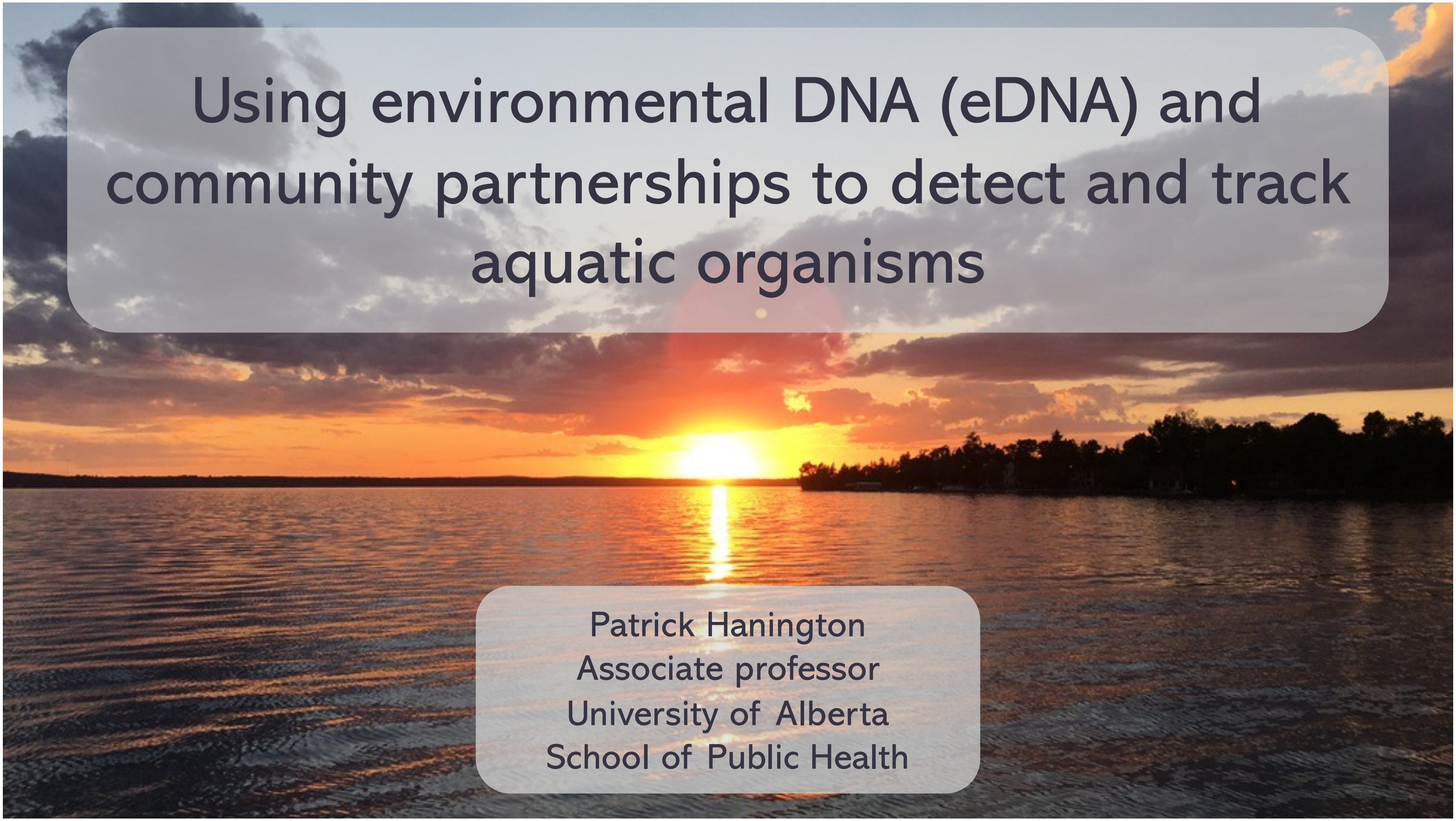

Using environmental DNA (eDNA) and community partnerships to detect and track aquatic organisms

Patrick Hanington
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University of Alberta
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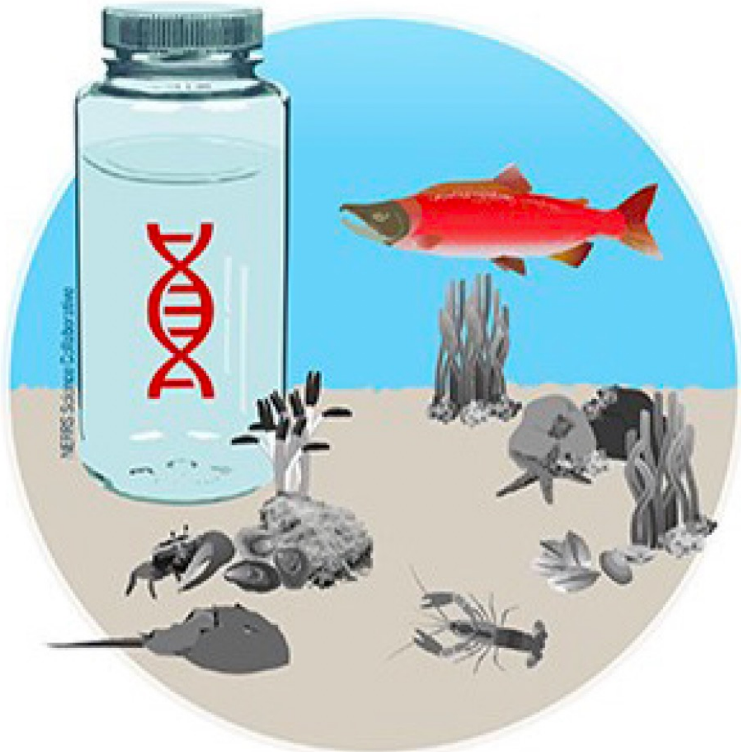
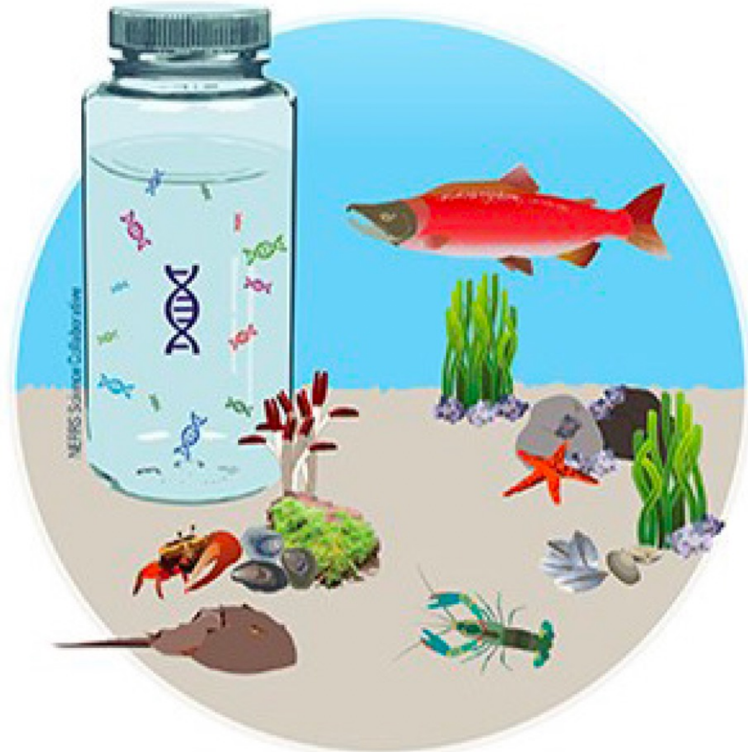
Environmental DNA

Organisms leave transient biological signatures in their environments. Feces, mucus, or tissues can be deposited into aquatic environments.

These signatures can be captured and using modern molecular techniques like DNA sequencing or qPCR, we can detect these transient signals and infer the presence of an array of species



Single Species PCR



Metabarcoding

Watts and Peter, 2020

eDNA-based monitoring can answer questions about the presence of invasive species or species at risk

Story 1: The Chinese Mystery Snail in McGregor Reservoir

Story 2: Community partners and swimmer's itch

Story 1: The Chinese Mystery Snail in McGregor Reservoir

Why these snails are a problem

Ecological

- Outcompete native snail species for food and space
- Can reproduce quickly and form very large populations
- Can bring invasive flatworm parasites to the ecosystem
- Can produce significant waste that can alter water chemistry

Health

- Can be infected by parasites which can infect humans if the snails are consumed

Economic

- Clogging screens of water intake pipes and irrigation infrastructure

Dailybulldog.com

History of the CMS invasion of North America

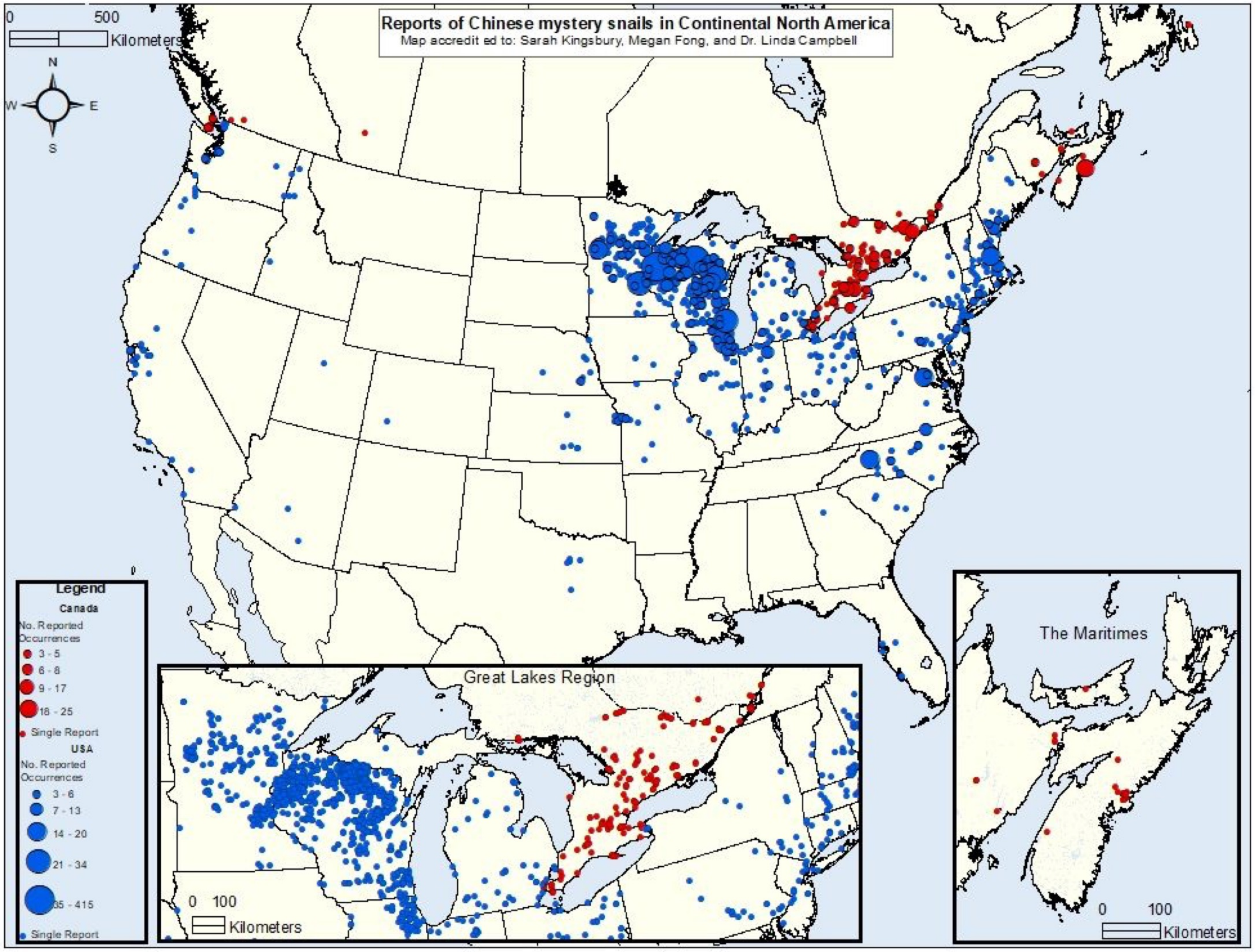
- The Chinese Mystery Snail goes by many names:
  - *Cipangopaludina chinensis*
  - *Bellamya chinensis*
  - *Paludina chinensis*
  - *Vivipara chinensis*
  - *Viviparus malleatus*

All of these names appear within the USGS invasive species database

- First reported occurrence in North America was in a food market in San Francisco in 1892 (Wood, 1892)

- Since this first report, it has spread to at least 32 US states, Quebec, Atlantic Canada, Southern Ontario, BC and now Alberta (Kingsbury et al, 2021)

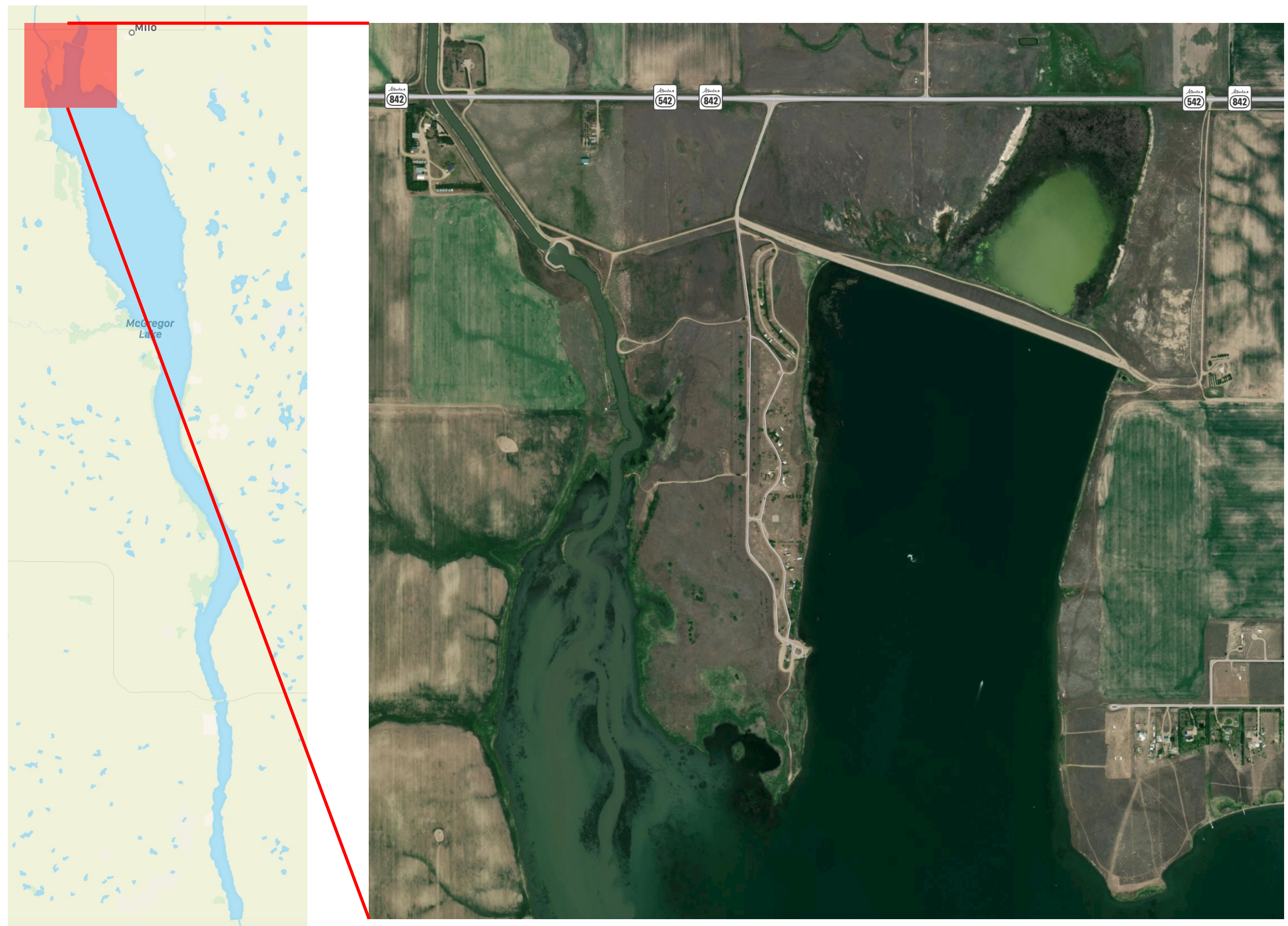
North American distribution of the CMS



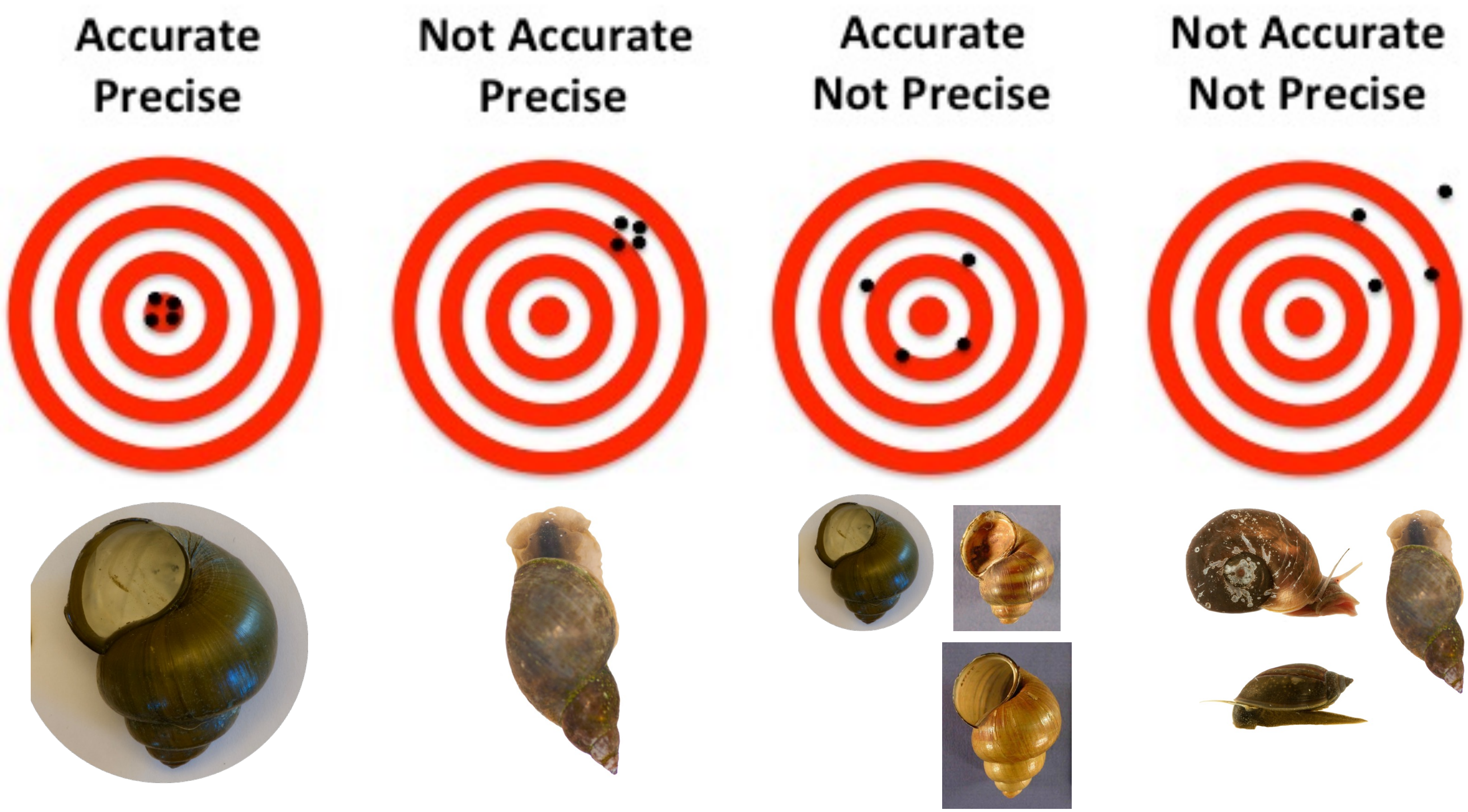
Kingsbury et al, 2021

Initial discovery at Lake McGregor in the fall of 2019

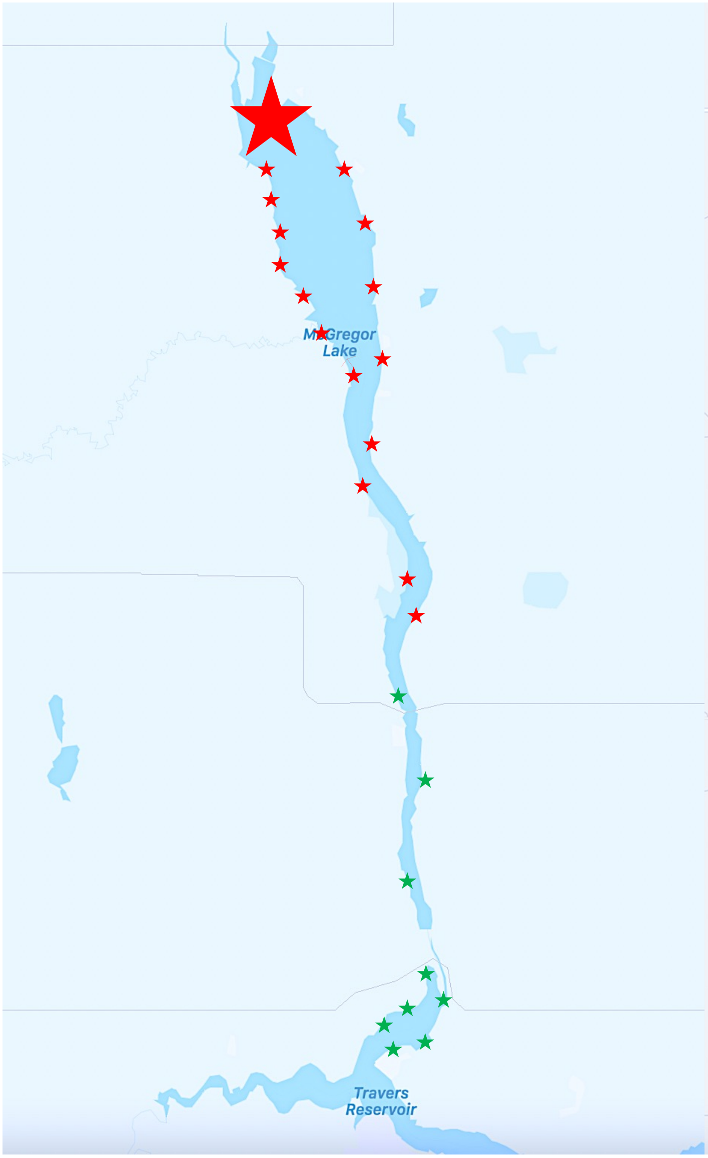
Fall 2019



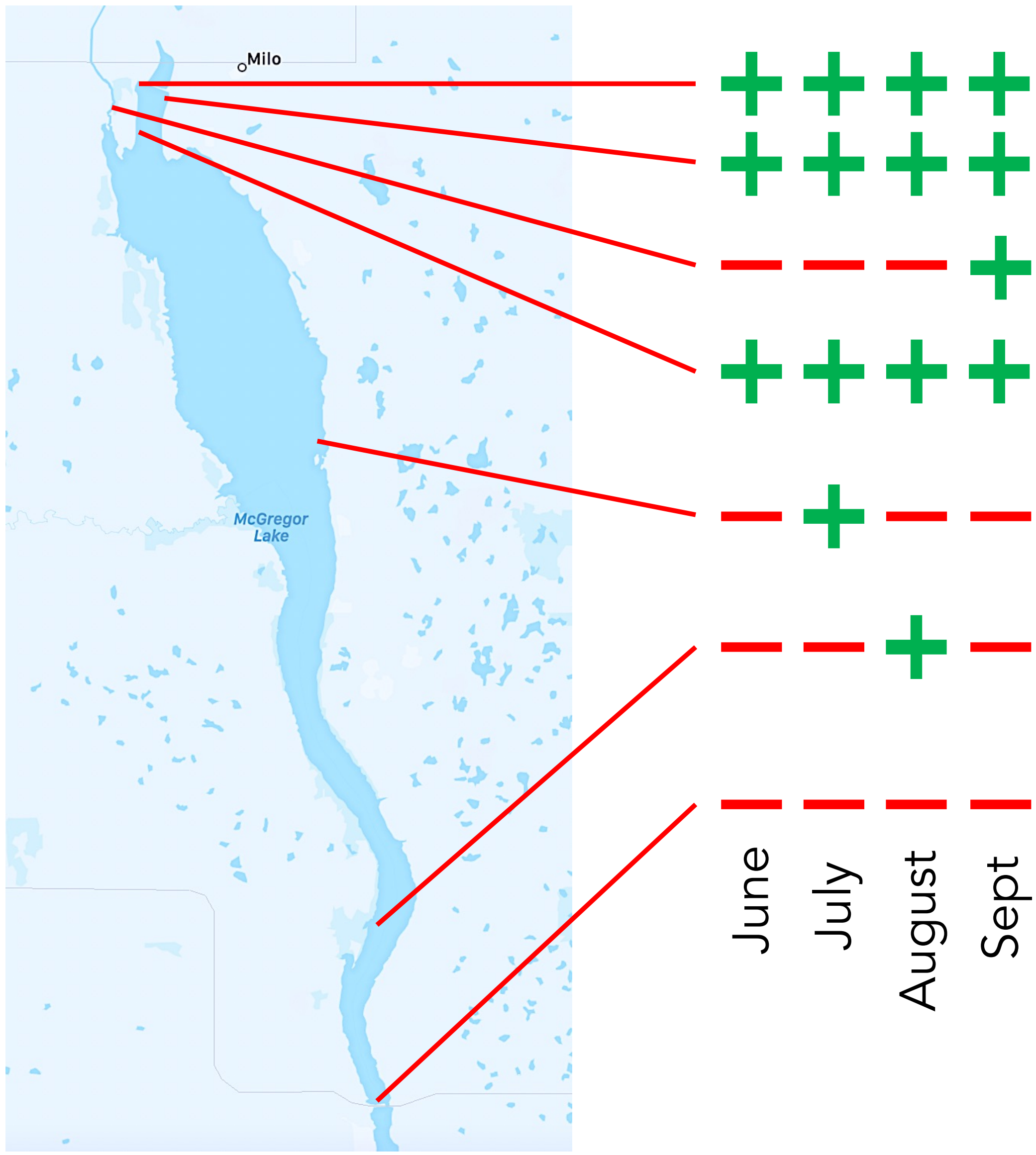
Designing a good eDNA test for the Chinese Mystery Snail



SUBSTRATE



WATER



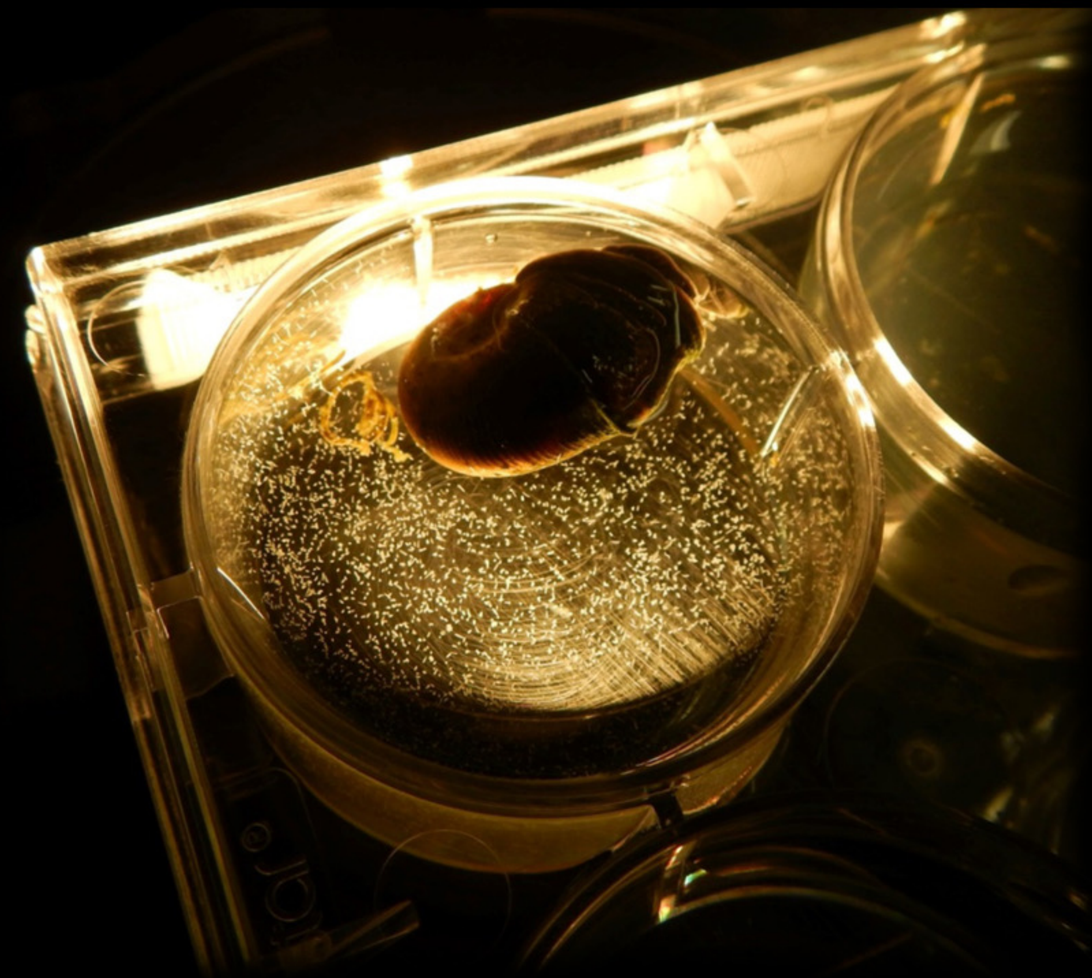
Summary

- The CMS invasion marks the first report of this species in Alberta – it will likely spread due to limited options for management

- The CMS has been a good species to target with an eDNA-based detection program – the CMS is large, easy to see, and leaves behind a substantial DNA signature

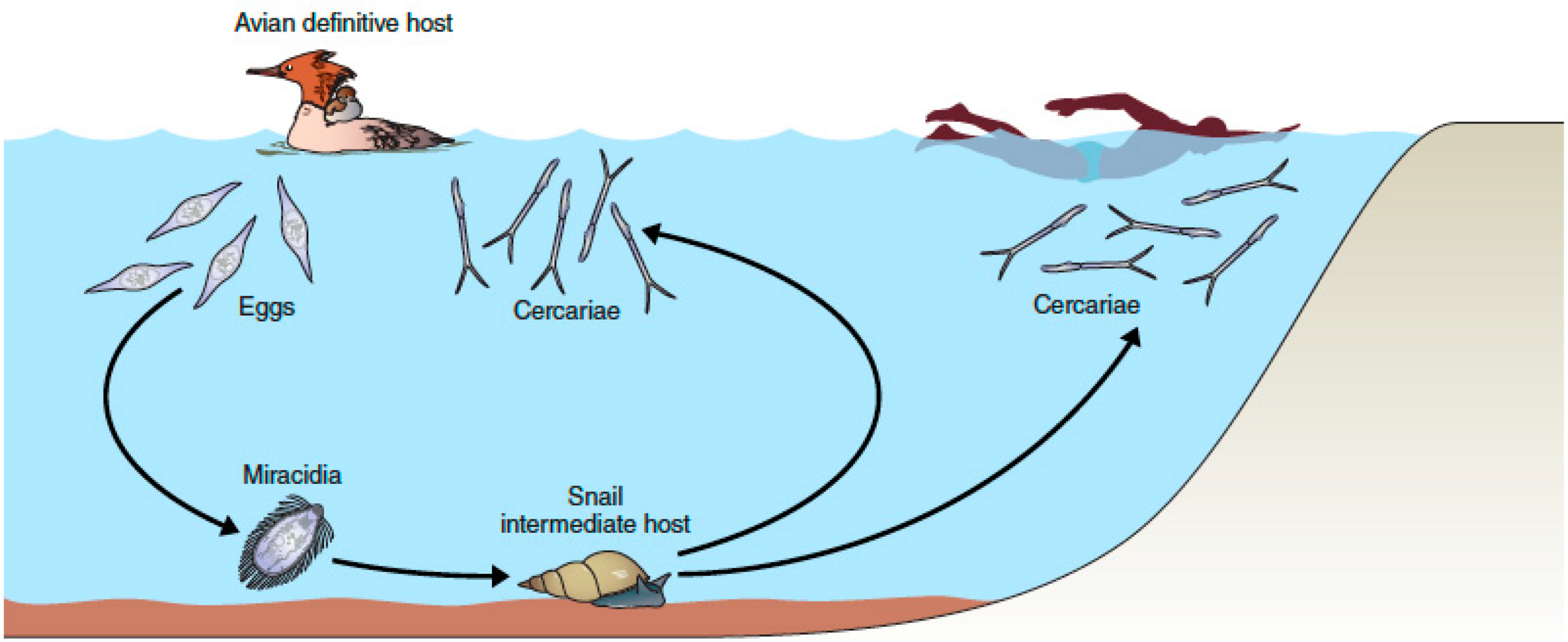
- eDNA-based monitoring for invasive species could be an appealing tool for aquatic invasive species programs – it is sensitive, and can be very specific

- We must use caution when interpreting eDNA data – it is only as reliable as the qPCR test, which can be impacted by many factors



Story 2: Community partners and swimmer’s itch

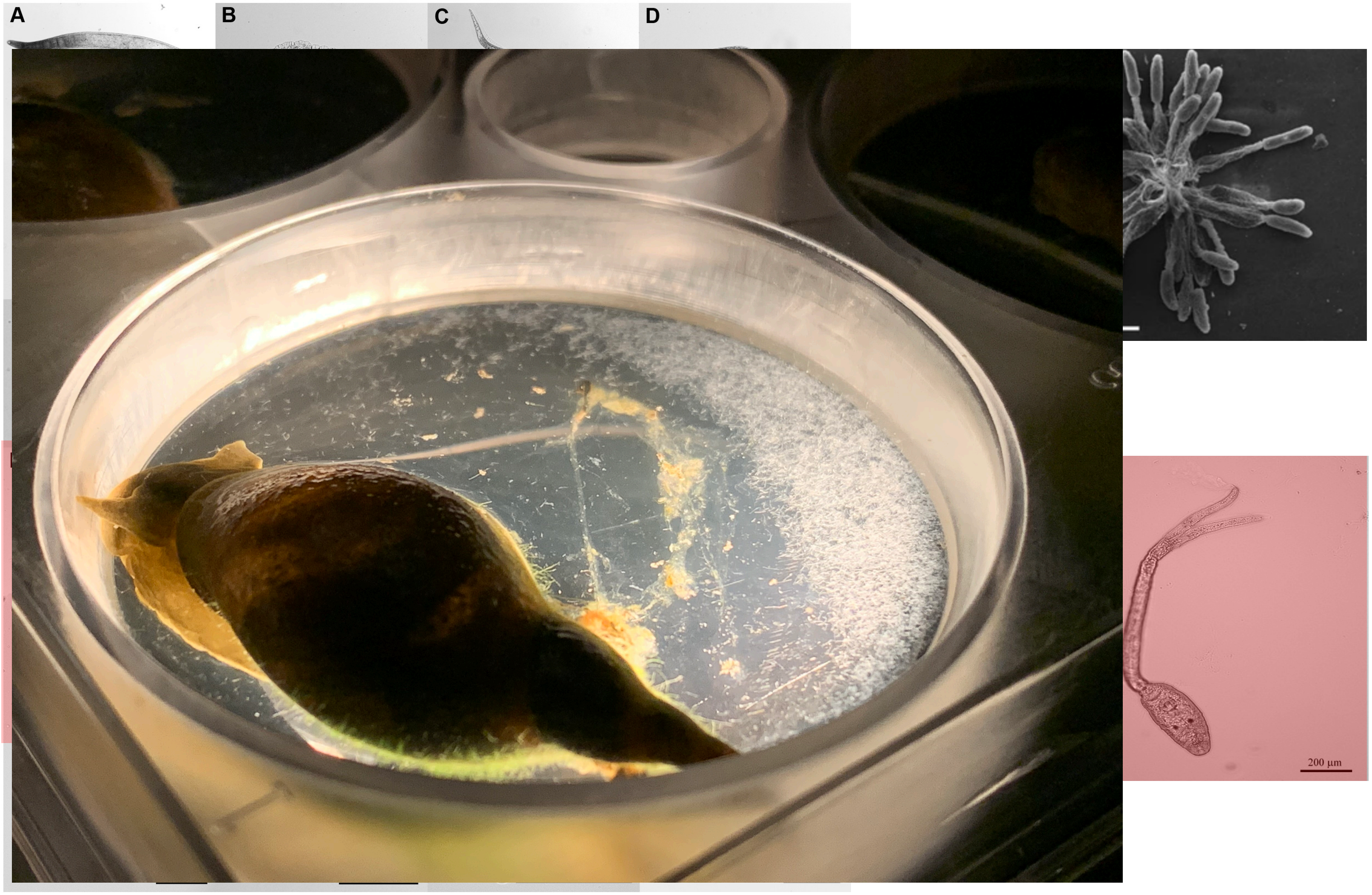
What is swimmer's itch?



Loker et al, 2022

The swimmer's itch rash: cercarial dermatitis

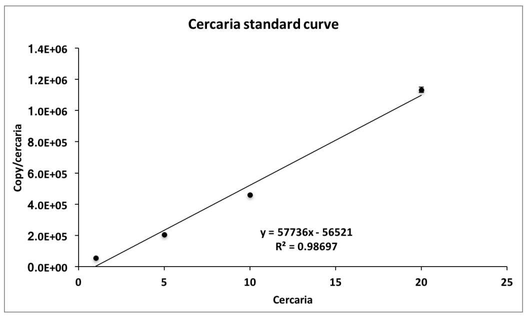
Severity dependent on the individual, history, and level of exposure



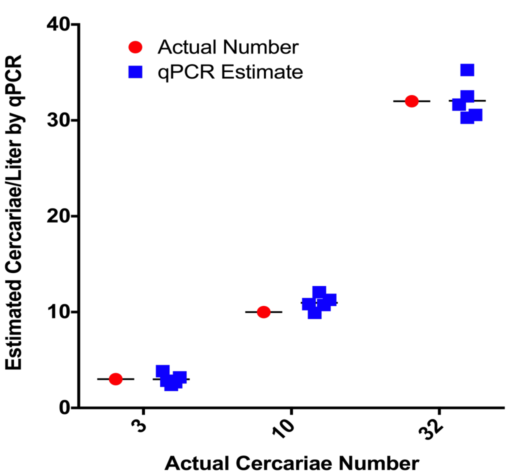
Gordy et al, 2016, Parasit Res; Gordy et al, 2017, Parasit Res; McPhail et al, 2021, JP

Swimmer’s itch qPCR: 18s rDNA

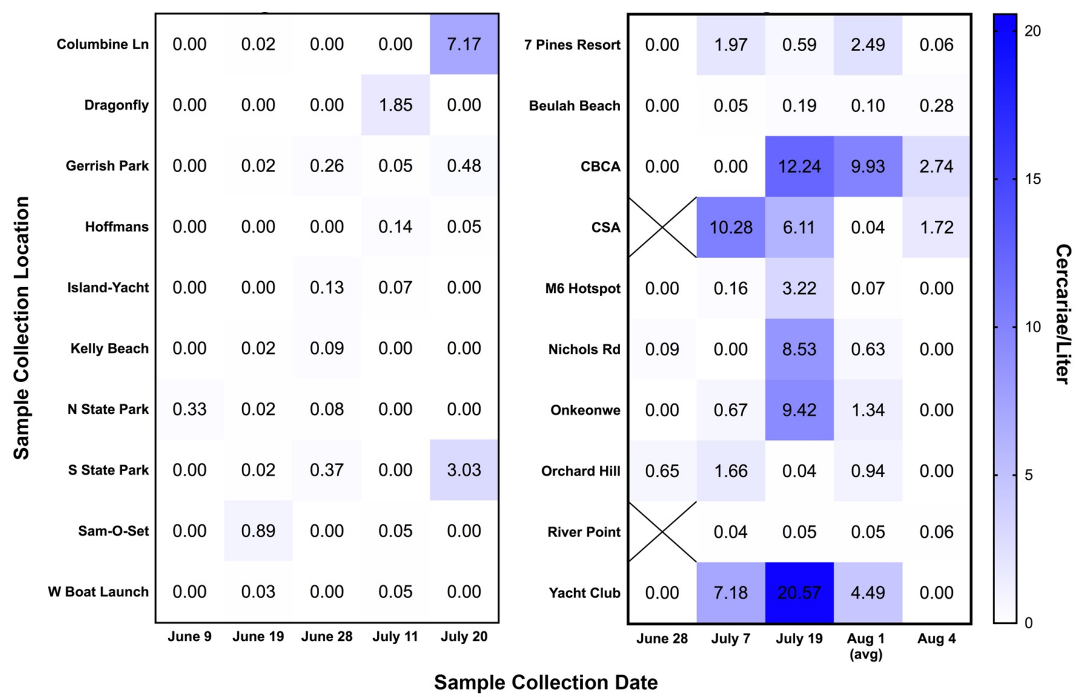
Confirm 18s gene copy number per cercariae



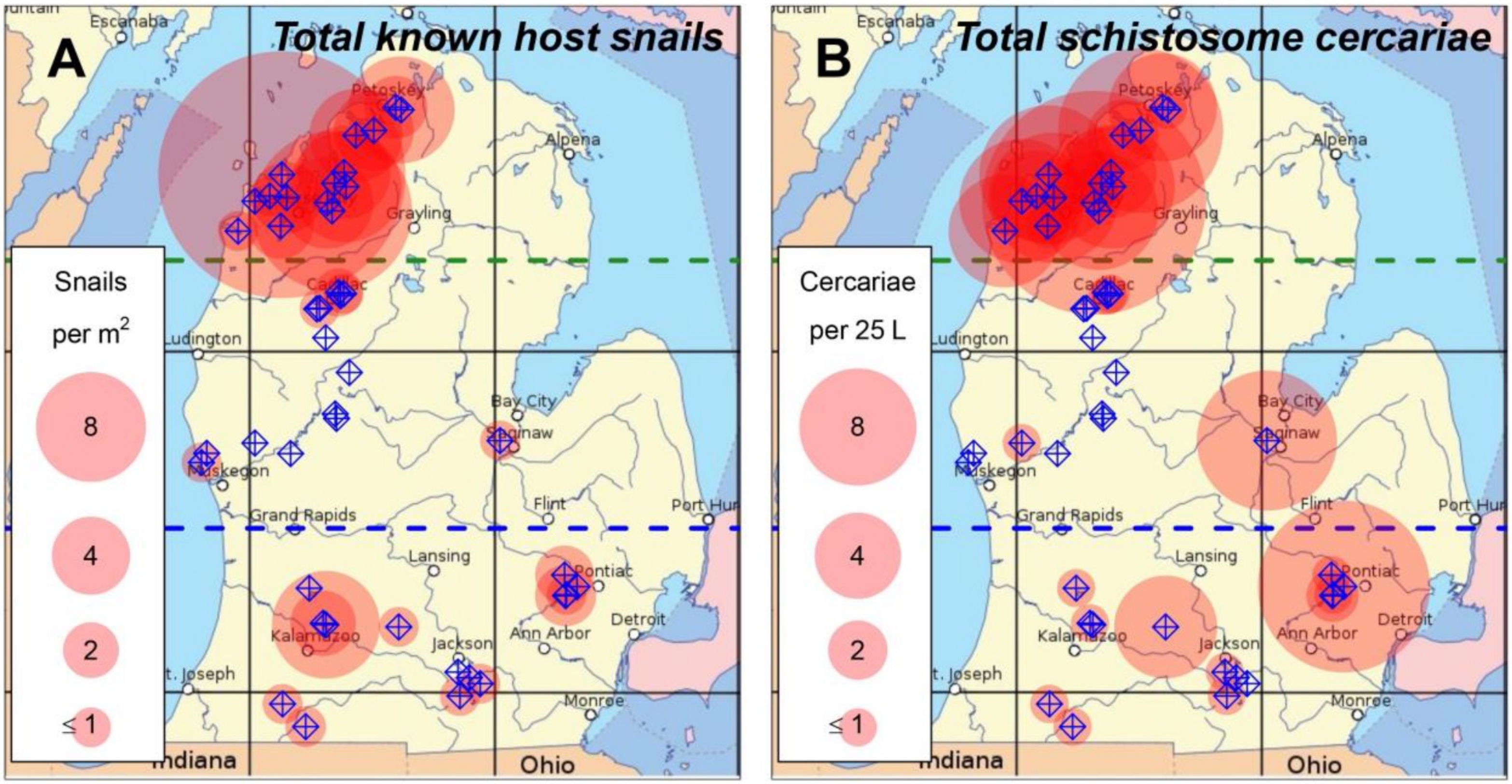
Blind study to confirm assay performance



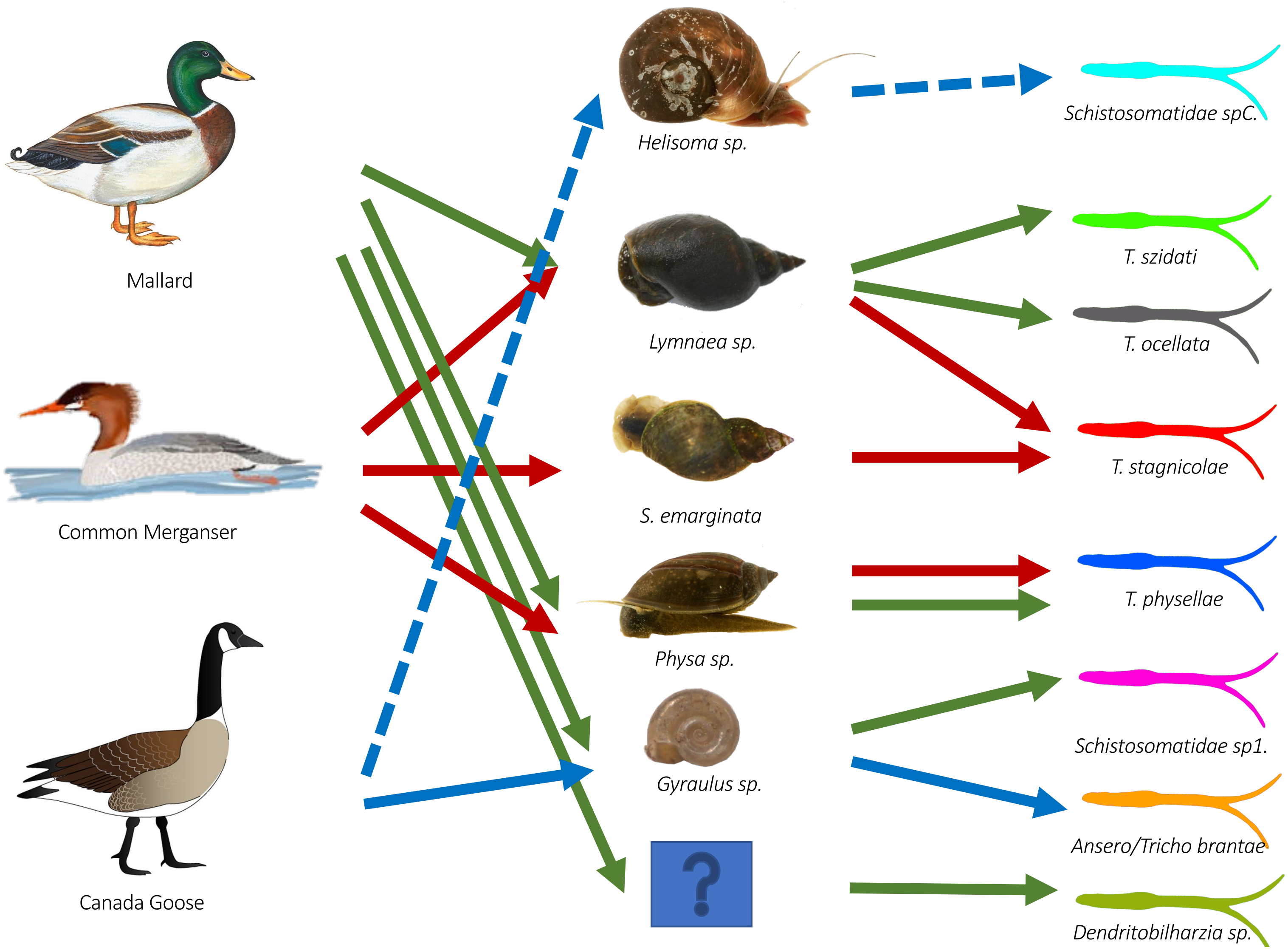
Example data corrected for cercariae per litre of water



Snail density correlates strongly with cercariae in water



Soper et al, 2022



Mallard
Common Merganser
Canada Goose
Helisoma sp.
Lymnaea sp.
S. emarginata
Physa sp.
Gyraulus sp.
?
Schistosomatidae spC.
T. szidati
T. ocellata
T. stagnicolae
T. physellae
Schistosomatidae sp1.
Ansero/Tricho brantae
Dendritobilharzia sp.

Facilitating projects that could not be accomplished without partnership

3 lakes

2 U of A coordinators

10 sites per lake

6 program managers

Sites sampled each week for 4 months

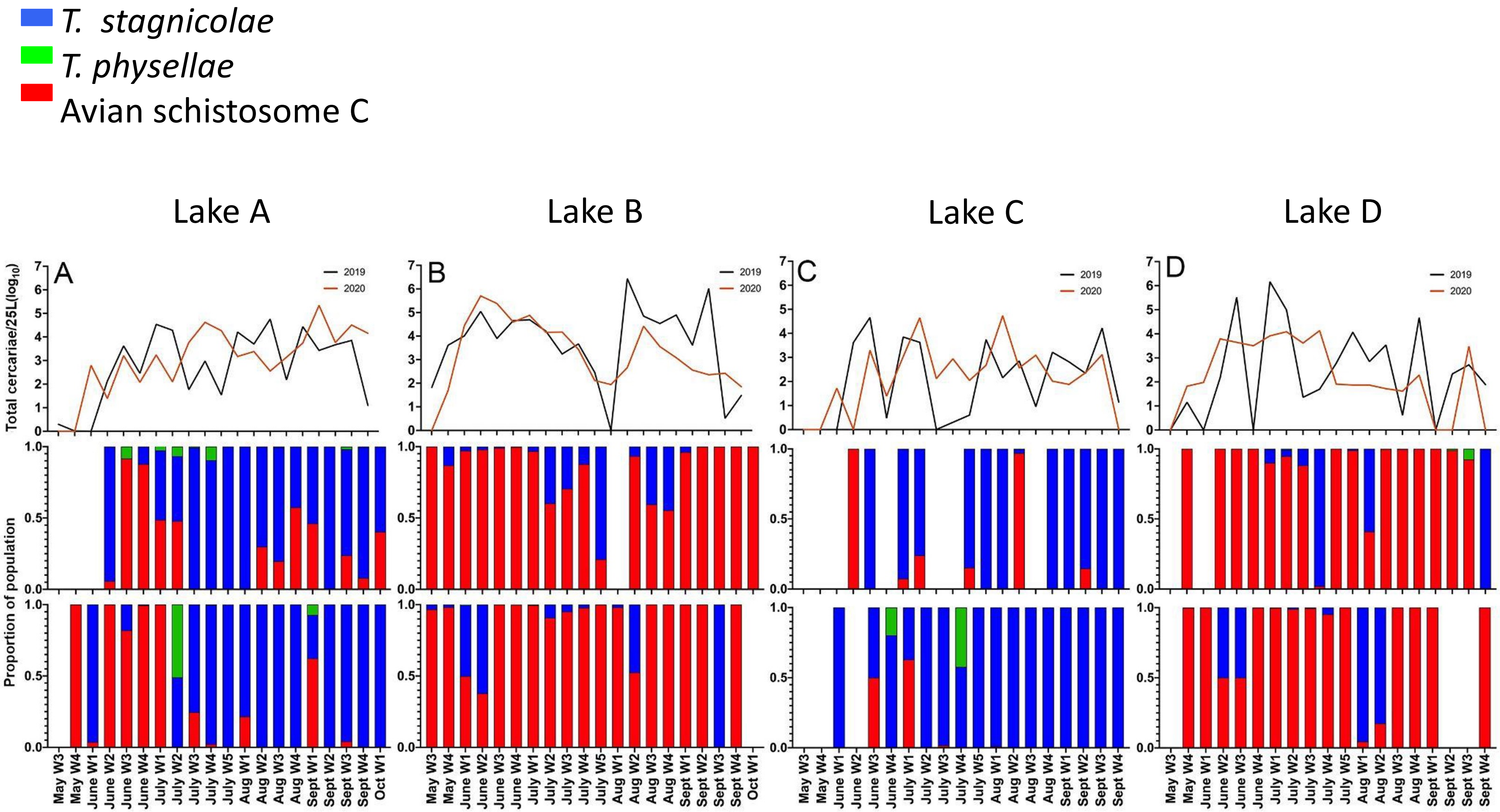
>25 community partners collecting samples

~1200 water samples collected from May – October (2019 and 2020)

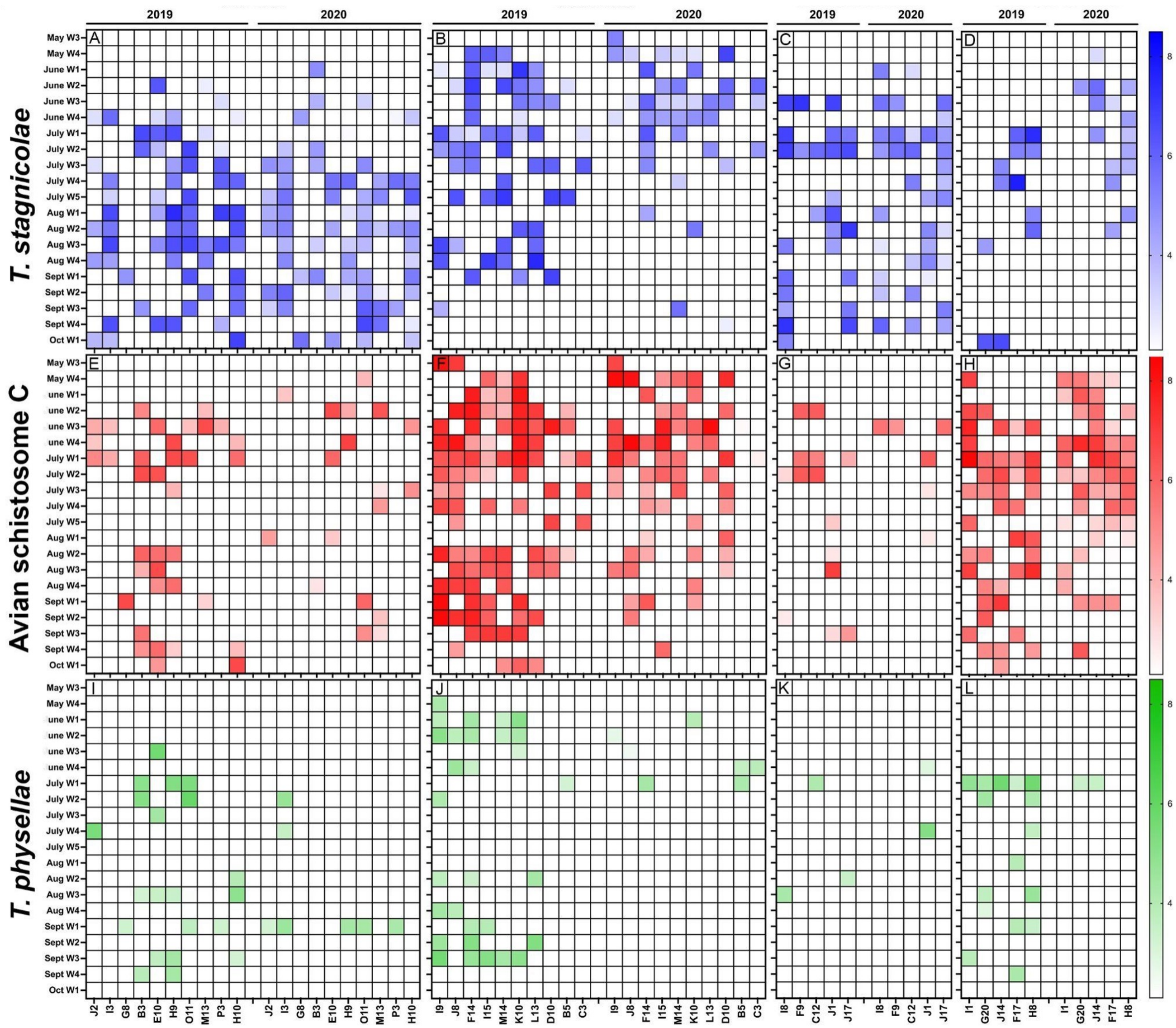
~1200 pan-swimmer's itch qPCR tests (run in a decentralized lab)

~4000 species-specific qPCR tests (run in our lab at U of A)

- Over 1000 hours of community partner volunteer time
- Over 100 hours of qPCR run-time and ~1000 hours of processing and sample collection
- 640 hours Summer Student time
- Over 200 hours qPCR validation at U of A lab
- Equivalent to collecting ~720,000 snails for traditional SI parasite assessment



T. stagnicolae
T. physellae
Avian schistosome C
Lake A
Lake B
Lake C
Lake D
A
B
C
D
2019
2020
Total cercariae/25L(log10)
Proportion of population
May W3
May W4
June W1
June W2
June W3
June W4
July W1
July W2
July W3
July W4
July W5
Aug W1
Aug W2
Aug W3
Aug W4
Sept W1
Sept W2
Sept W3
Sept W4
Oct W1



Observations:

- Timing of cercarial emergence in spring varies between lakes
- Some species are more abundant than others
- Variability between sites on a lake as to whether species are found
- Metadata collected alongside eDNA samples can provide insight into organism biology/ecology

Effect of temperature

Temperature is a “hurdle”

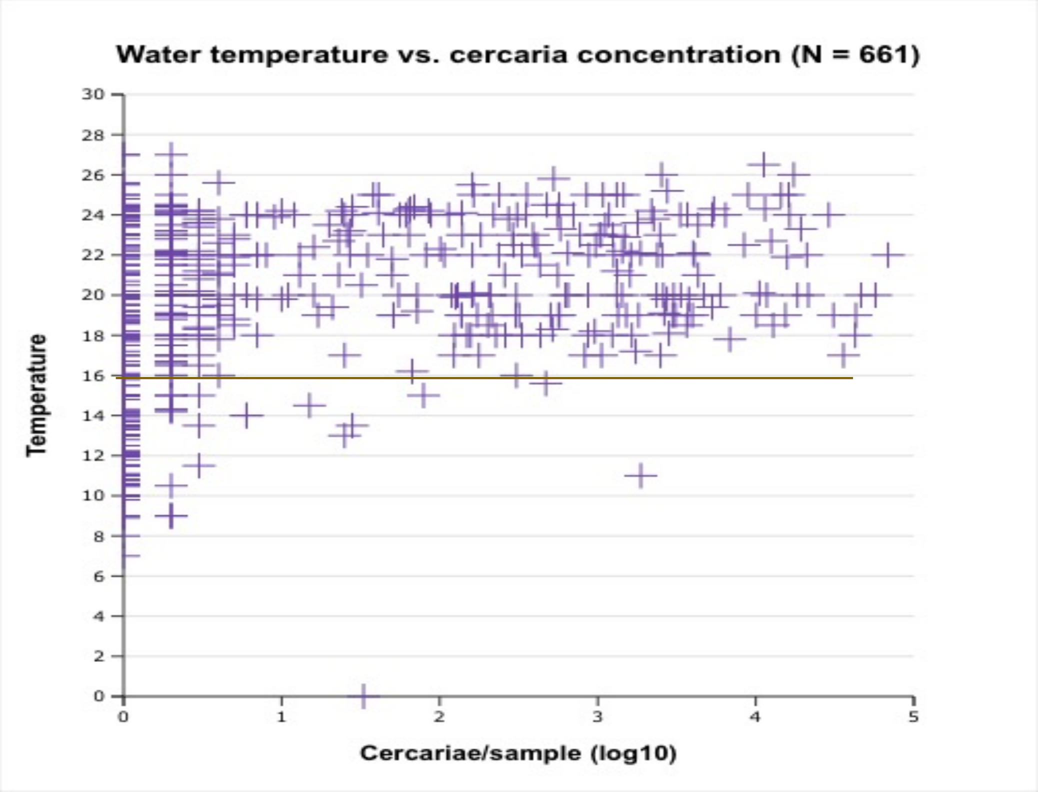
Every 1 degree increase in temperature increases the odds of having greater than 0 cercariae by 1.73 (+/- 0.33, $p < 0.001$)

$Y\ (cerc) = B_0 + B_1(x_{temp}) + B_2(x_{windspeed})$

At what temperature can we expect to see greater than 0 cercariae in the water?

Set wind speed to 0, solve for x_{temp}

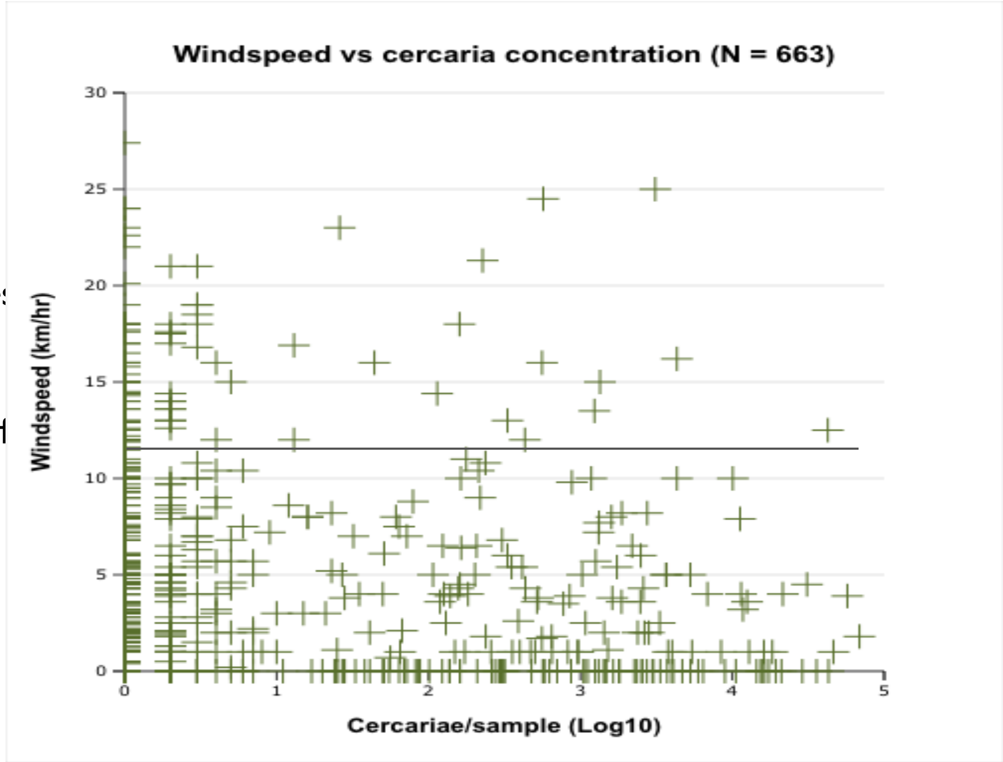
$x_{temp} = 15.76$ C.



Effect of wind speed/direction

Wind speed is a “hurdle” but also is a predictor of decrease
in cercariae concentration in water samples.

Every 1 km/hr increase in wind speed decreases the odds o
having greater than 0 cercariae by 0.9 (+/- 0.09)



Ways in which we integrate community partnerships into qPCR-based monitoring

Acknowledgements

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