Non-Invasive Monitoring of Brook Trout to Support Adaptive Management in River Corridors

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Overview

Brook Trout from 12 Mile Creek, Niagara Region.
Sampled July 31, 2025

I Why biological monitoring matters for natural channels

II How mark-recapture estimates population abundance

III Why Brook Trout are useful indicators of stream health

IV Current photo-ID tools and the manual bottle necks

V Automated image analysis as a scalable monitoring workflow

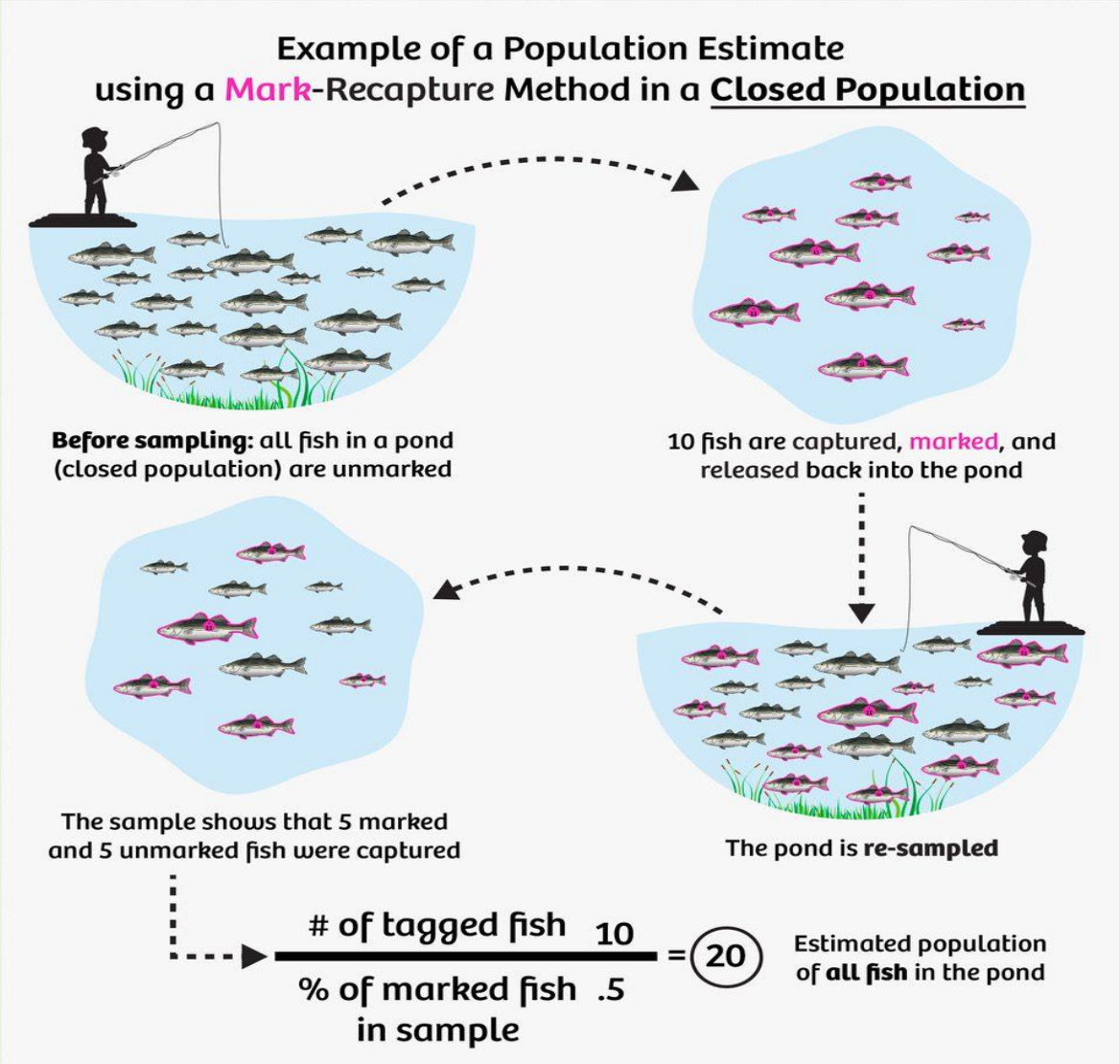
Motivation

To manage natural channels effectively, we need to measure the biota they support

Smallmouth Bass Caught in the Grand River, Waterloo

Grand River in rural Waterloo, Ontario

Estimating Population



Retrieved From Fishbio.com

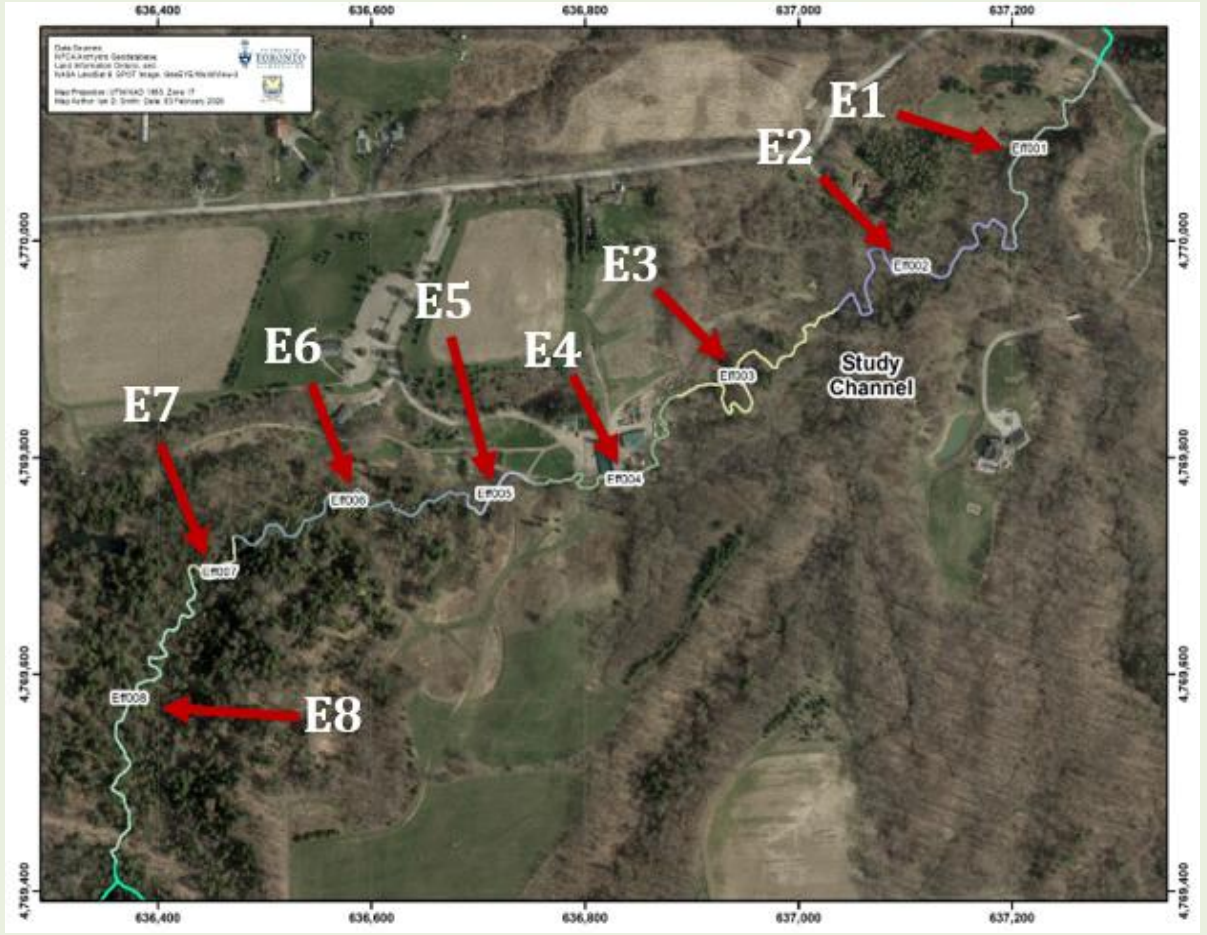
Why Brook Trout?

- B.T are pressured by warming + urbanization + habitat fragmentation
- Conservation estimates achieved by mark–recapture studies are invasive
- Can image analysis provide a non-invasive, scalable way to estimate Brook Trout abundance?

Tagged Rainbow Trout. *arkansasonline.com*

Study Site

- One of the Southern-most populations of Brook Trout in Canada, close to urban areas
- Serve as a baseline/comparison for Brook Trout Restoration Projects?



Upper 12 Mile Creek Watershed and the Effingham Branch study area where Brook Trout were sampled in 2025, Niagara Region

Field Sampling + Dataset

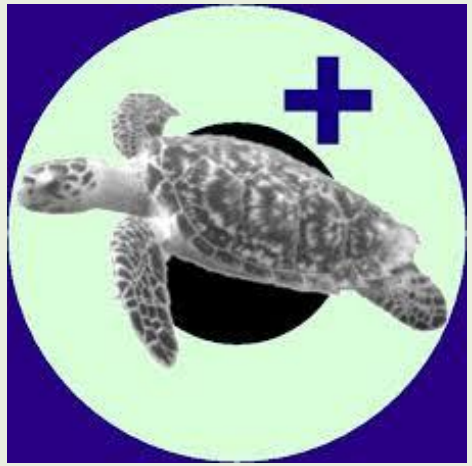
- Two-pass backpack electrofishing survey (Between May and September 2025)
- Fish weighed + measured, + swabbed, and photographed on the left flank twice
- 1,494 total flank-images were processed; YOY were later excluded from the analysis

Smith-Root LR-24 backpack electrofishing unit

Current Technology

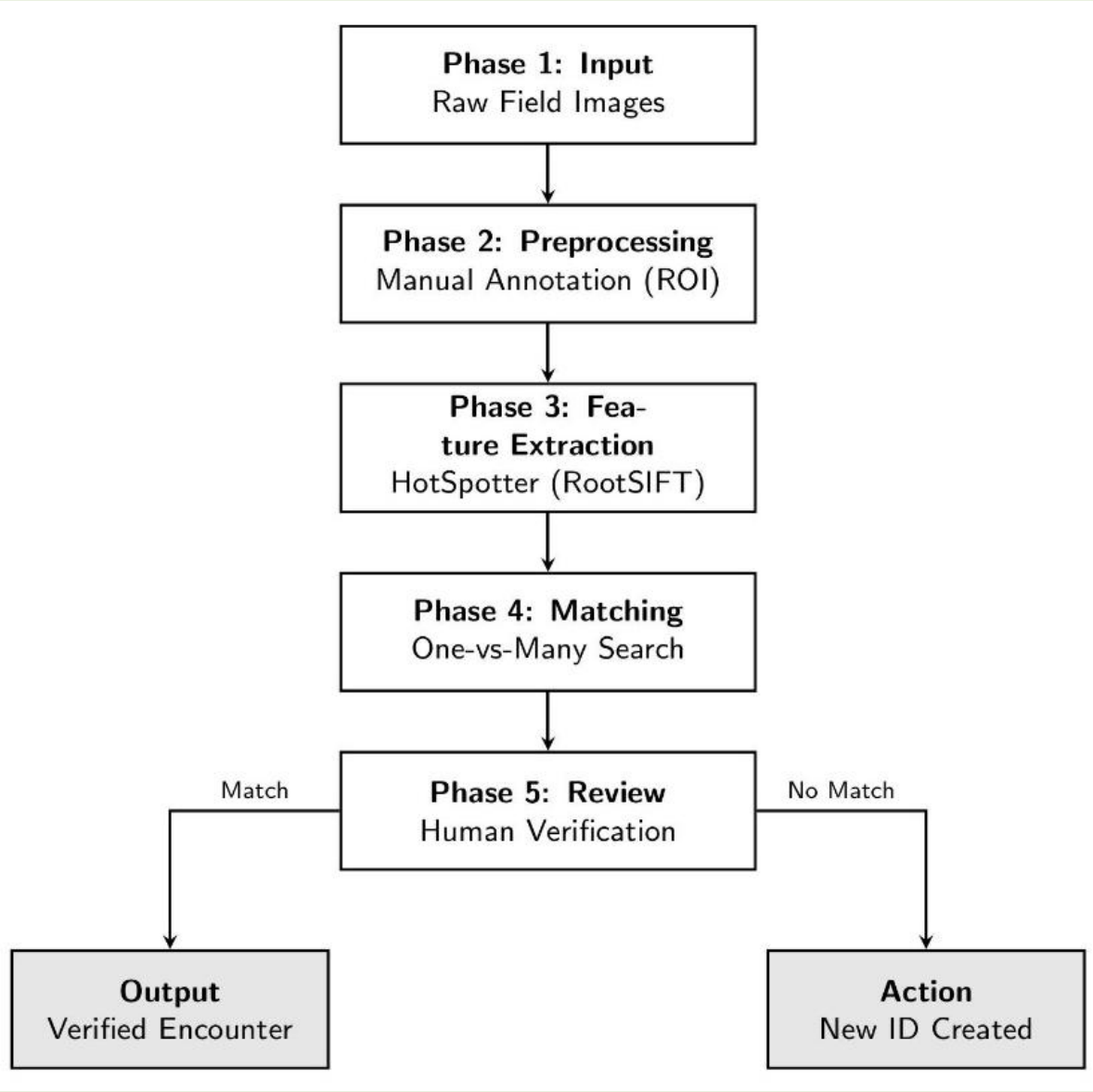
Current Popular Non-Invasive Technology involves the use of image analysis, but are time-consuming

TROUTSPOTTER



Interactive Individual Identification System (I3S).

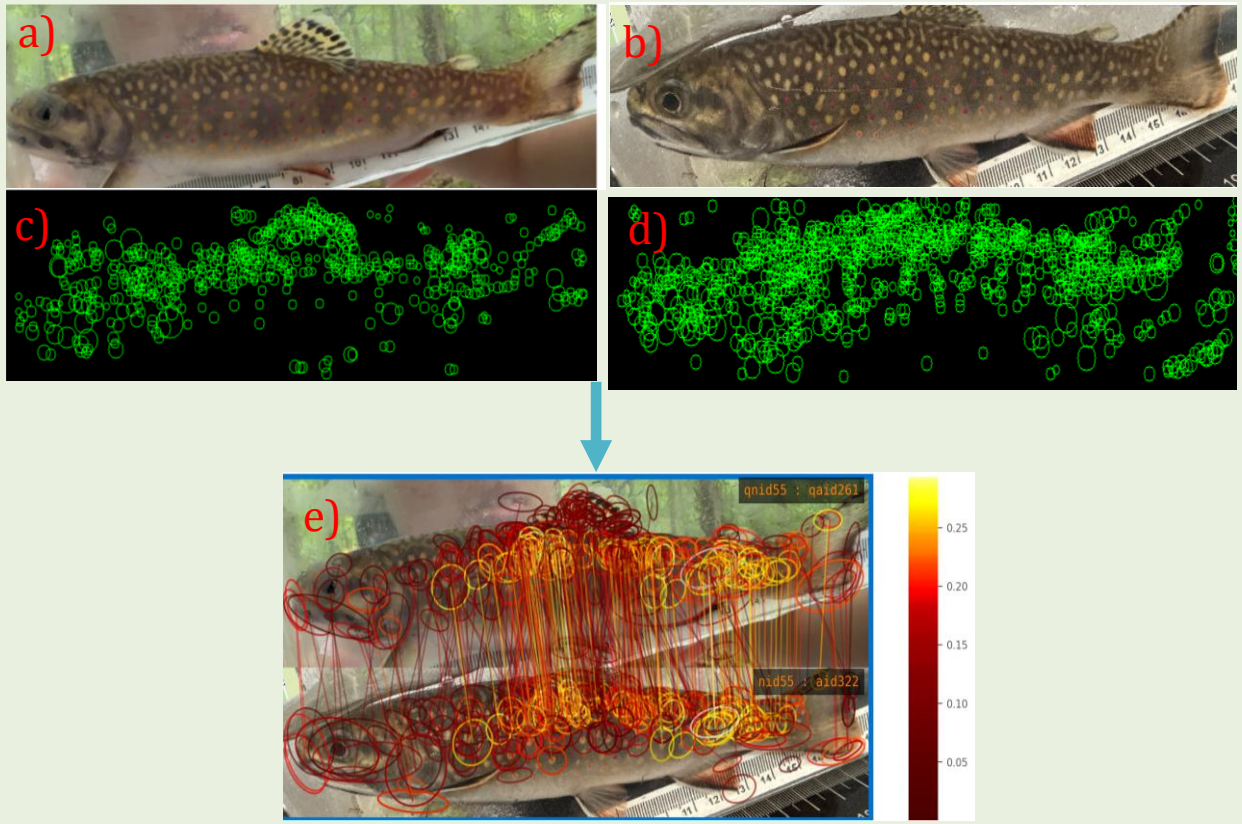
IBEIS (Image Analysis for Biological Surveys)



- Open-source computer vision system designed for the individual identification of wildlife
- These verified recaptures formed the ground-truth dataset for Bayesian population estimation and for evaluating the automated model

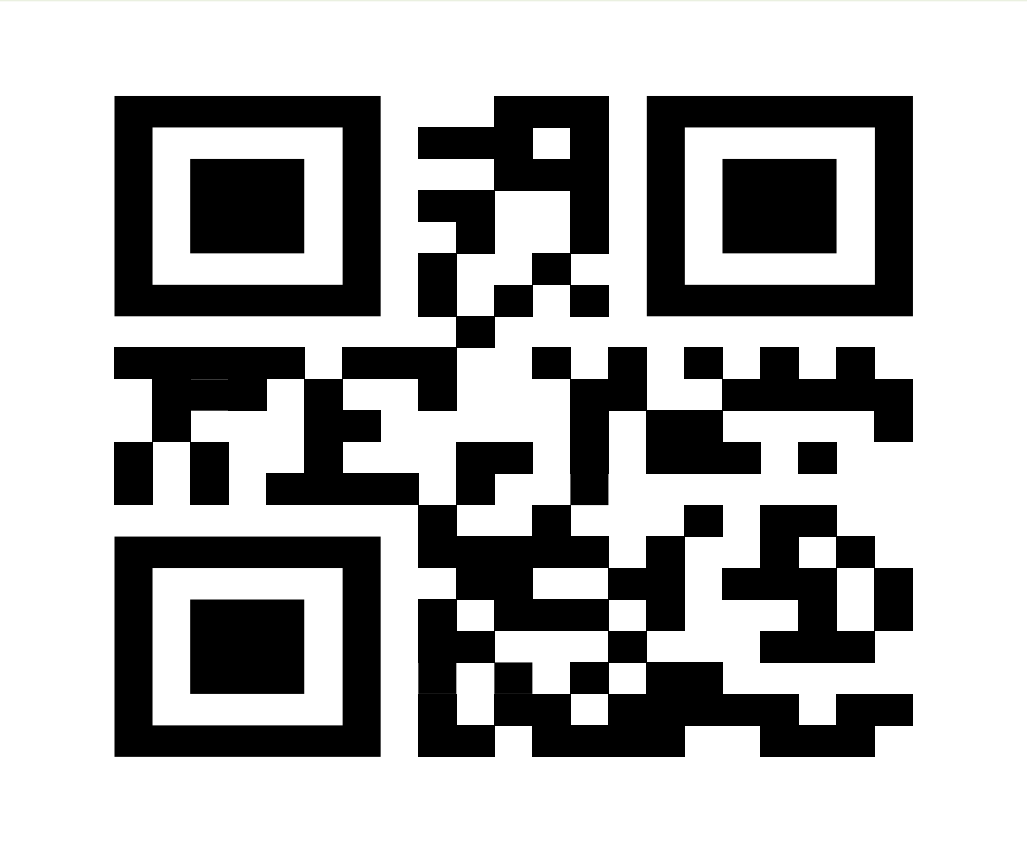
IBEIS example: ROI annotation & Feature Matching

Manual flank ROI annotation



a–b) flank images for comparison; c–d) local invariant keypoints extracted from each image; e) matched feature correspondences visualized by HotSpotter during review.

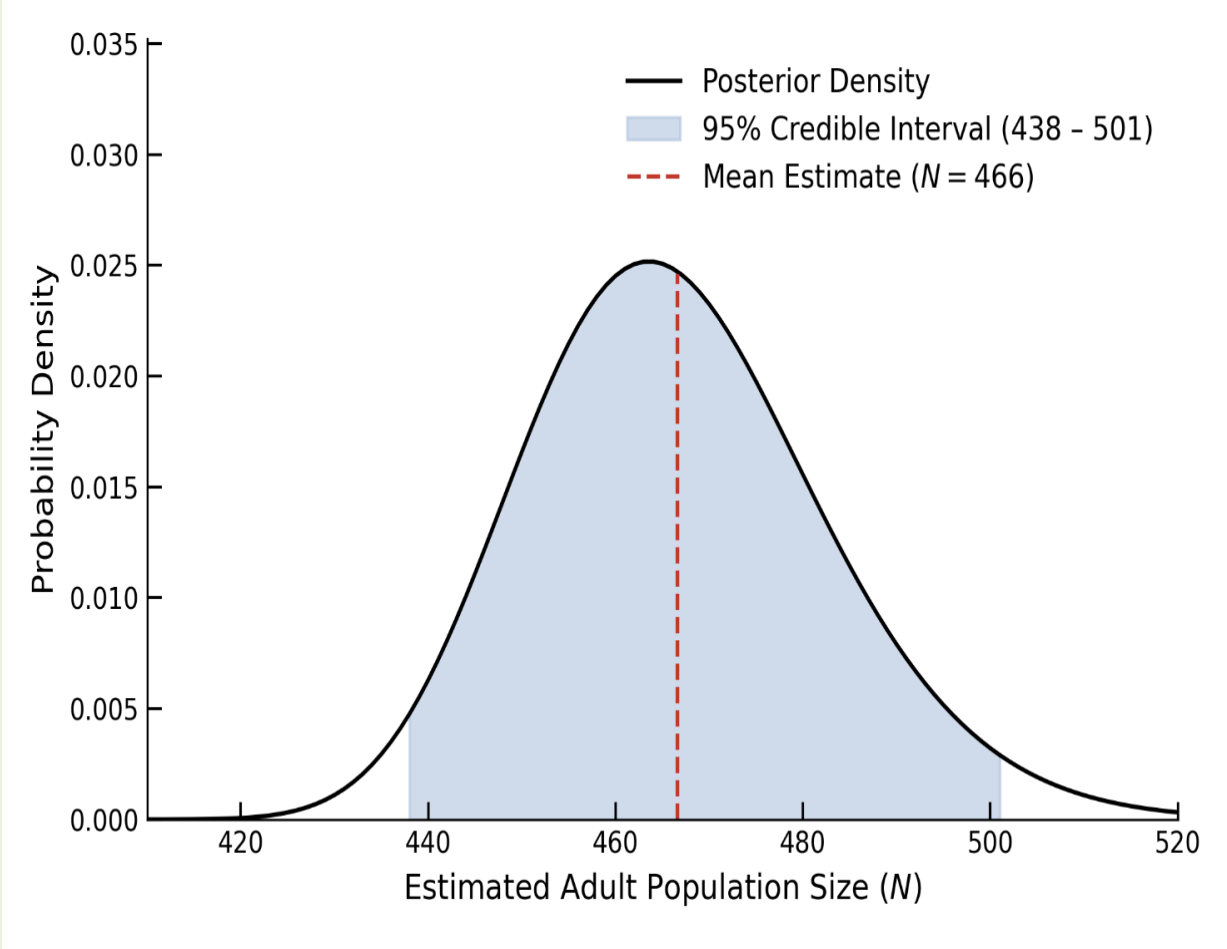
Can You Verify the Matches?



https://btmatch.org/

IBEIS Result (Population Estimation)

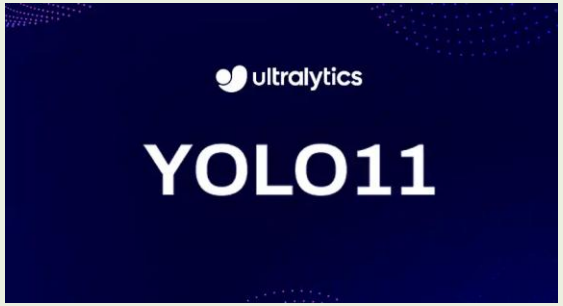
- Processed **1,494** encounter events, **105** adult recaptures
- A pooled Bayesian Lincoln-Petersen model estimated an adult superpopulation of **466** individuals (95% HDI: 438–501)
- Manual annotation and human match verification remained major bottlenecks for larger datasets

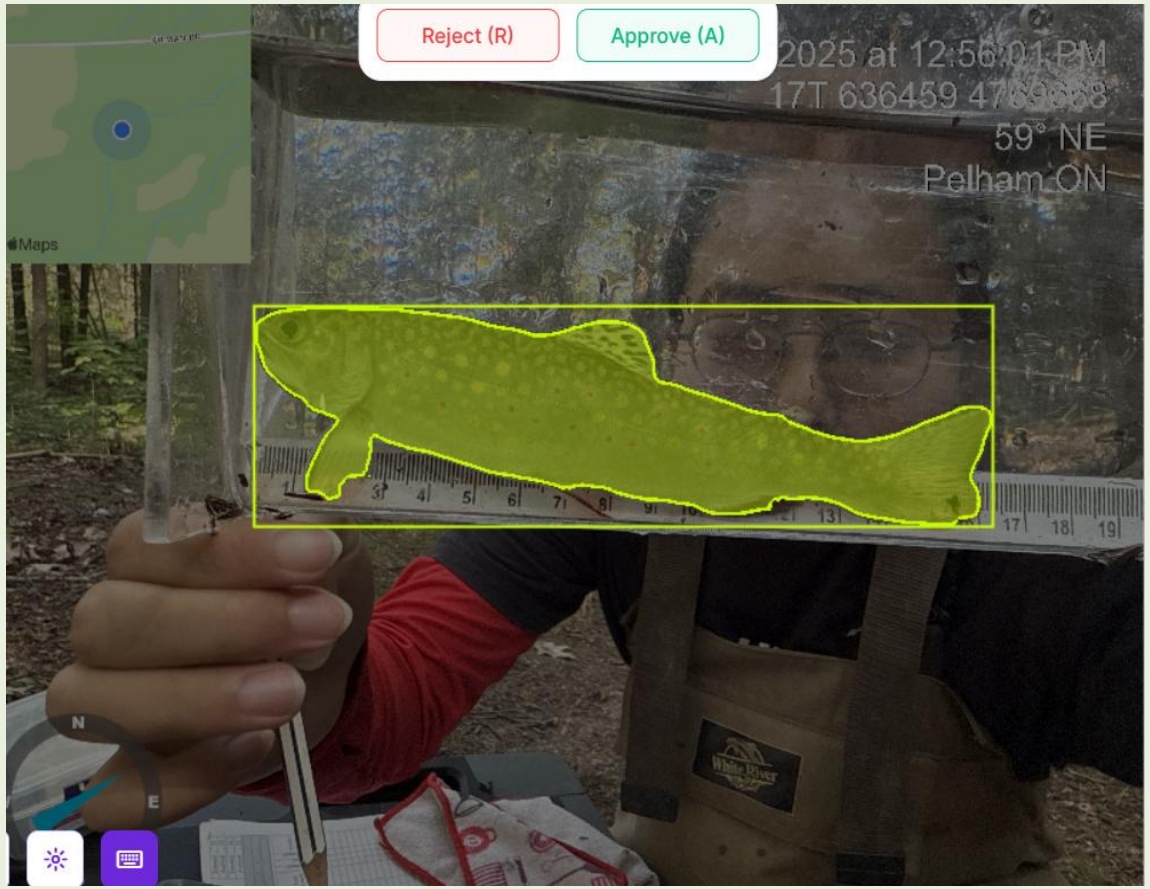


Posterior density from the Bayesian Lincoln-Petersen model

YOLO Processing

- Goal: replace manual flank annotation with automated segmentation
- 165 field images were manually annotated to train a YOLOv11 segmentation model
- Automated cropping reduced background noise(ruler, hands, etc.)

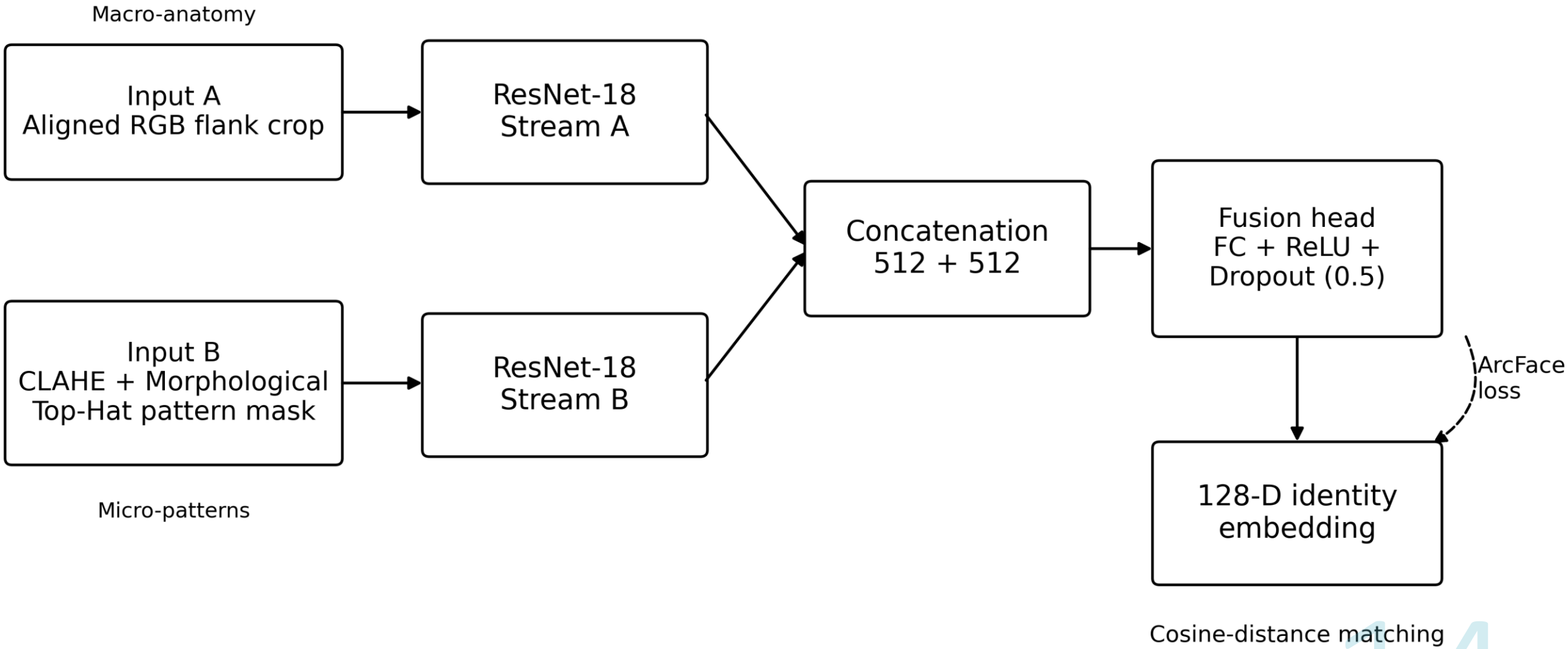




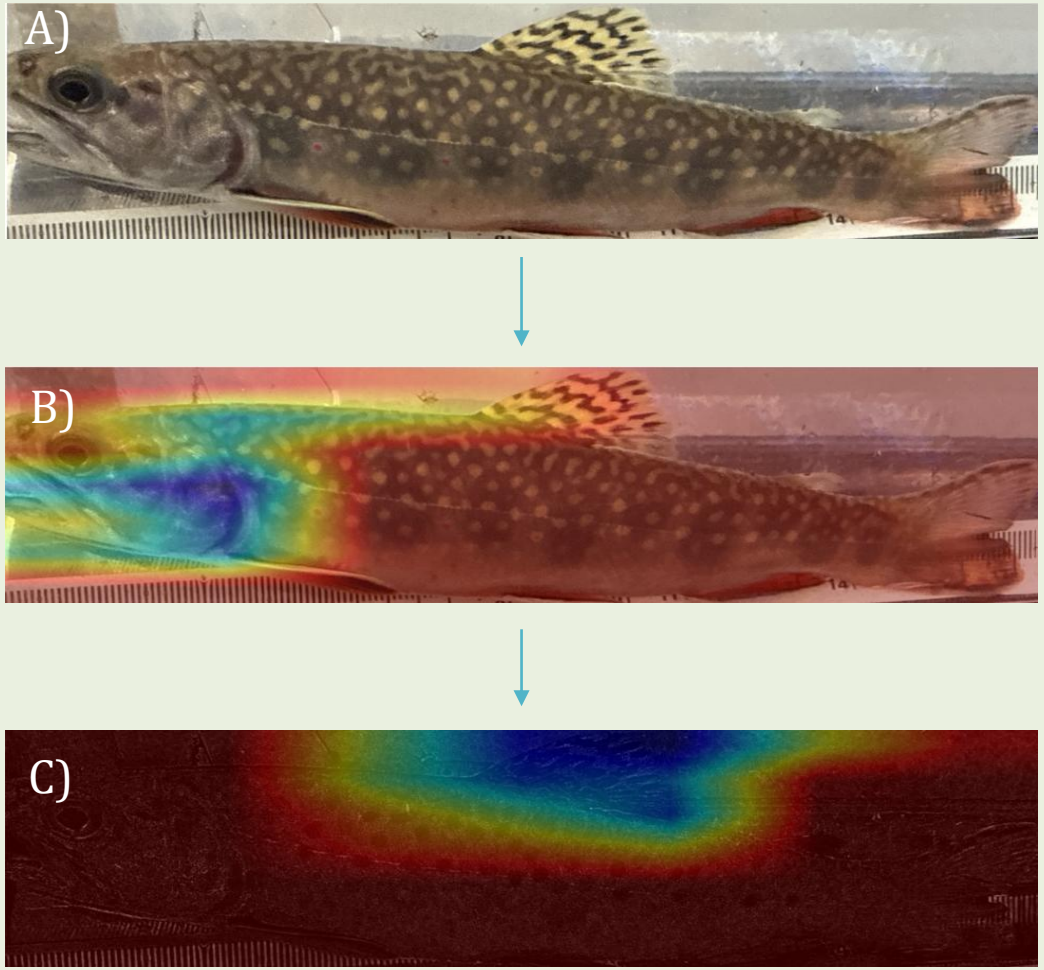
YOLOv11 segmentation output used to isolate the trout flank

Two-Stream architecture and feature fusion

Combines body-level structure with fine-scale pigmentation for individual re-identification



Two-Stream Multi-Modal network



A) Original aligned flank image
B) Stream A (RGB) activation heatmap
C) Stream B (Morphological Top-Hat) activation heatmap

On a blind adult holdout, the model achieved 92.9% identification accuracy against the IBEIS matches and produced no false-positive cryptic matches at the selected threshold

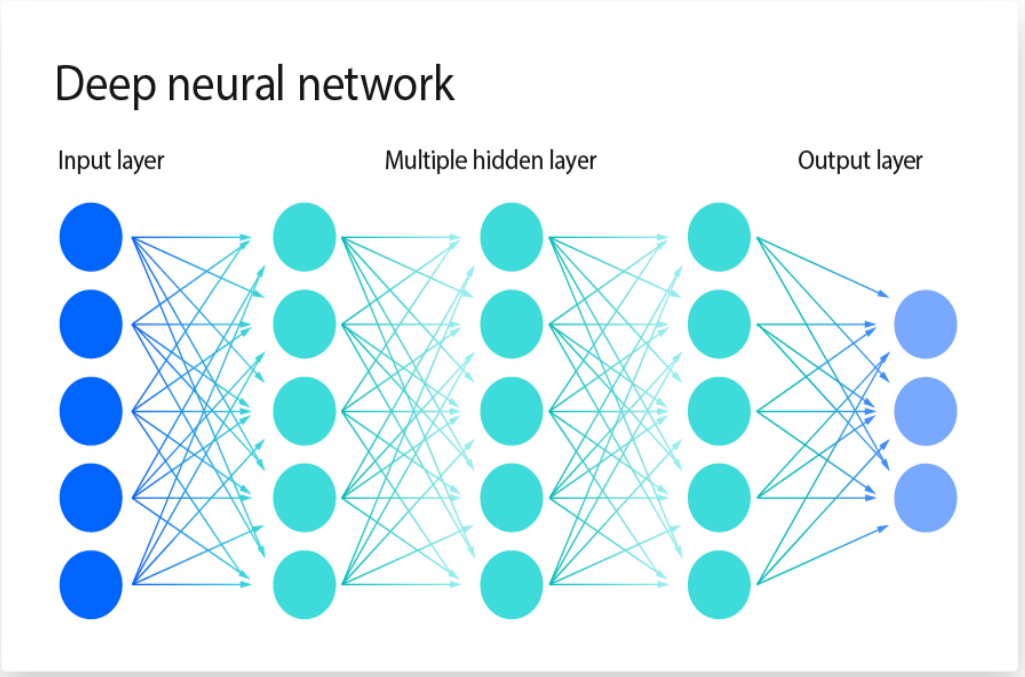
Takeaways

- IBEIS-assisted photo-ID identified 105 verified adult recaptures and supported an adult abundance estimate of 466 Brook Trout (95% HDI: 438–501)
- The two-stream model is a promising proof of concept
- **Image analysis can reduce manual bottlenecks**

Next Steps

- Expand the verified dataset across more years, streams, and image conditions, and evaluate other metric-learning variants such as true Siamese or triplet-loss re-identification

- This non-invasive workflow could be adaptable to other naturally marked species



Acknowledgments

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Questions?

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