Applications of Computer Vision in Underwater Ecology: A Case Study from the Northeast Pacific

Rimmer, T*.[1], Mcintosh, D.[2], Bates, C.[3], Zhang, T.[1], Branzan Albu, A., Juanes, F.[1]

1. Department of Biology, University of Victoria, Victoria, BC, Canada
2. Electrical and Computer Engineering, University of Victoria, Victoria, BC, Canada
3. Cascadia Seaweed Corp., Sidney, BC, Canada

Talen Rimmer | @talen.r | rimmertalen@gmail.com

Goal of this presentation

1. Discuss applications of Computer Vision (CV) for *novel / exploratory long-term* underwater monitoring (particularly image data)

- **How do we capture the data we want, and remove things we don't care about, *efficiently*?**
- **How do you validate a CV training dataset (from an ecologist's perspective)?**

2. Outline case study from B.C.

- **Targeted for non-CV experts (high-level)**

Background: Seaweed Farming

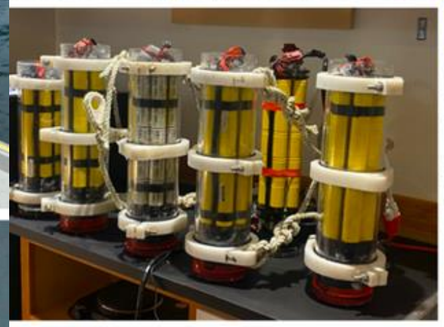
- **Commercially recent in B.C. (1980s), but rapid expansion in recent years**

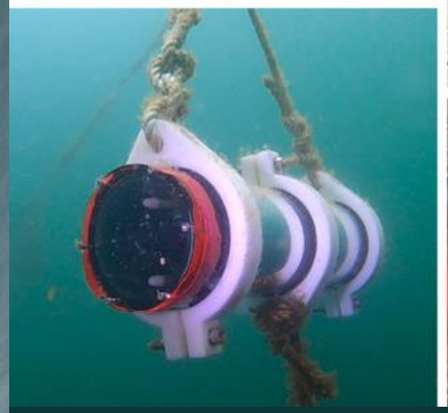
- **Of particular interest for many reasons..**
  - **Potential as habitat**
  - **Lots of unknowns (and opinions)**

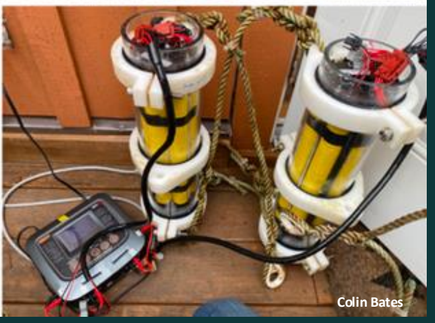
  - **How can we monitor these spaces efficiently as the industry expands?**

Credit: AMLObservations.com, 2022

Credit: Aria Willis







"Assess the presence of salmonids and their prey through space and time"

Challenges

- **~9000 hours of video data collected**
- **Novel monitoring environment (epipelagic)**
- **Novel recording device & deployment type**
- **“Won’t know how many annotations we need *until we have enough*“**

~~Challenges~~

- ~9000 hours of video data collected
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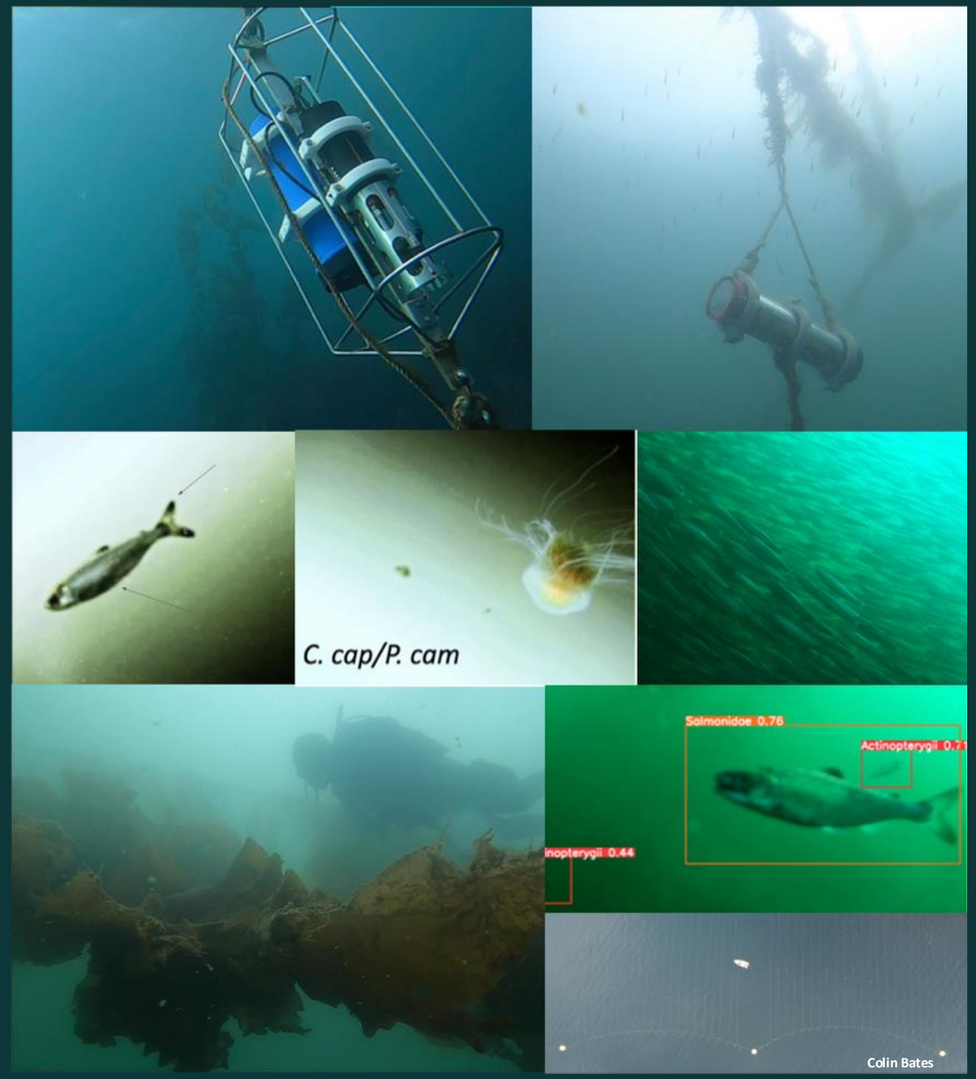
Objectives

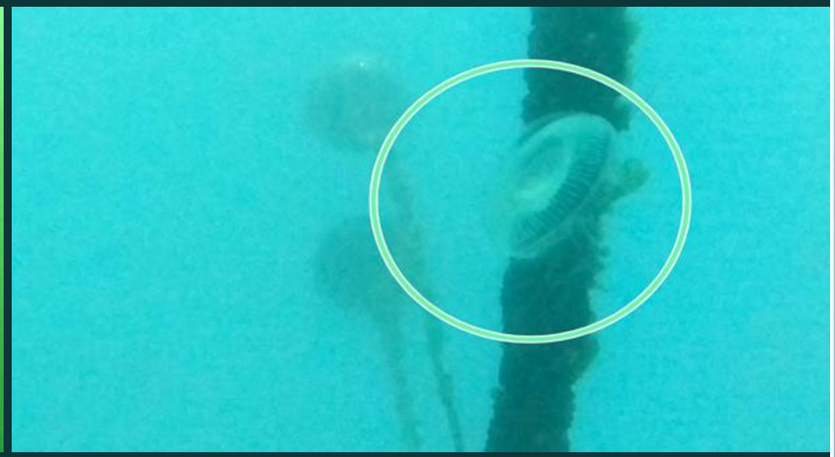
1. How do you sort through empty (open water) footage *efficiently and reliably*?
2. How do you create repeatable, standardized methods when making a training dataset (e.g. identifying & quantifying taxa)?
3. How many annotations do you need of each taxa *to train a well-performing model*?
4. How do you ground-truth a large dataset with limited resources?

Method

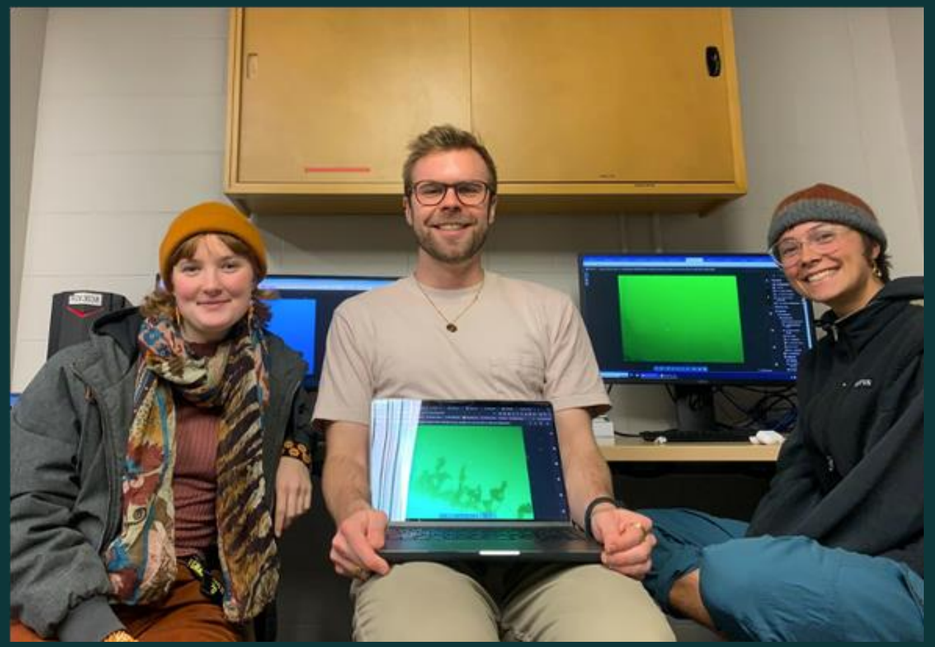
1. Data Collection + Exploration
2. Salient Motion Filter
3. ResNet-18 Classifier
4. Adjacency Filter
5. QAQC + VOLOv8 Model



1 Data Collection + Exploration

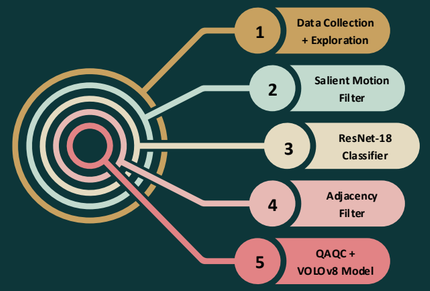


FishCams (Muoy *et al.* 2020)



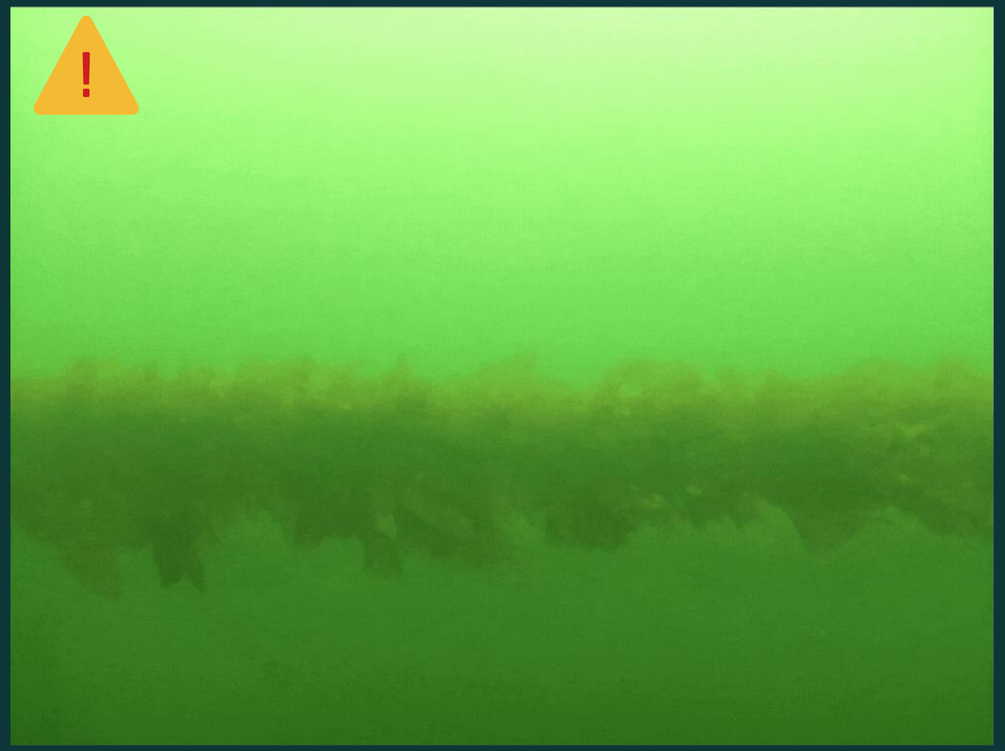
1. “How do you sort through empty (open water) footage...”

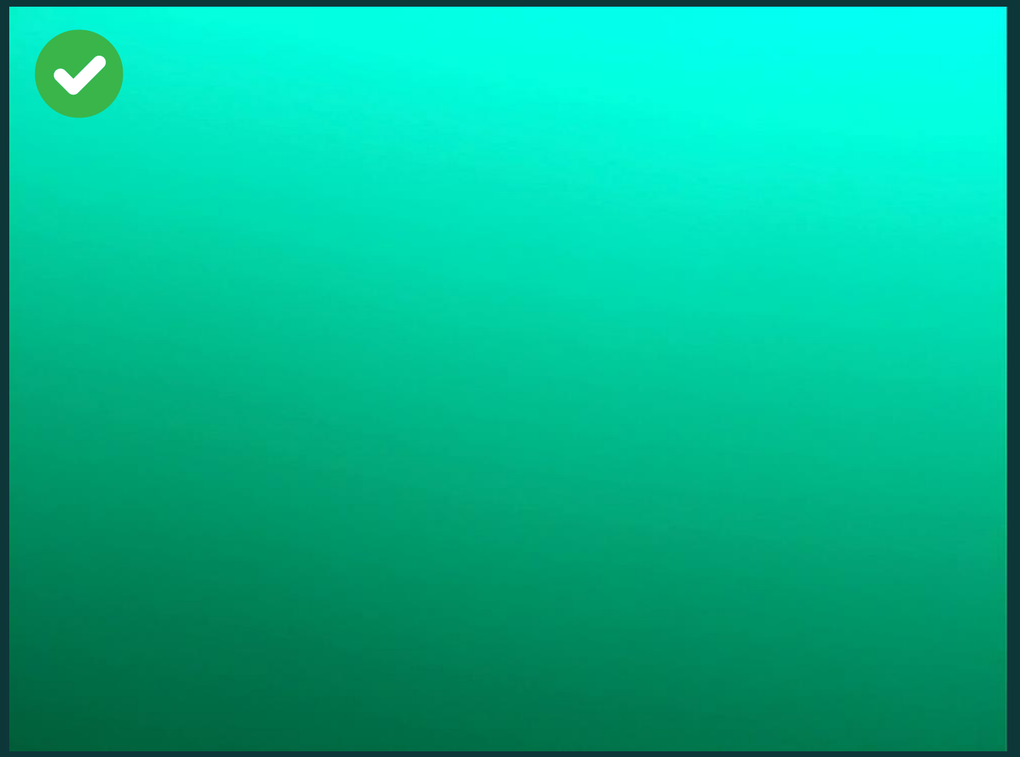
<u>When empty water is 99.5% of your data</u>



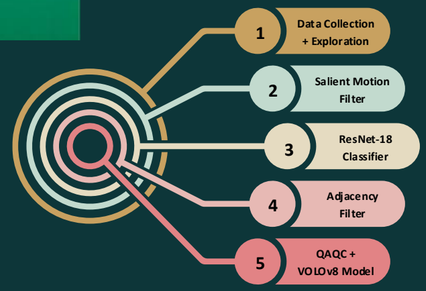
2 Salient Motion Filter

- *Motion* - difference in object location across multiple images
- *Saliency* - quantitative info from pixels in image
- Highly iterative process





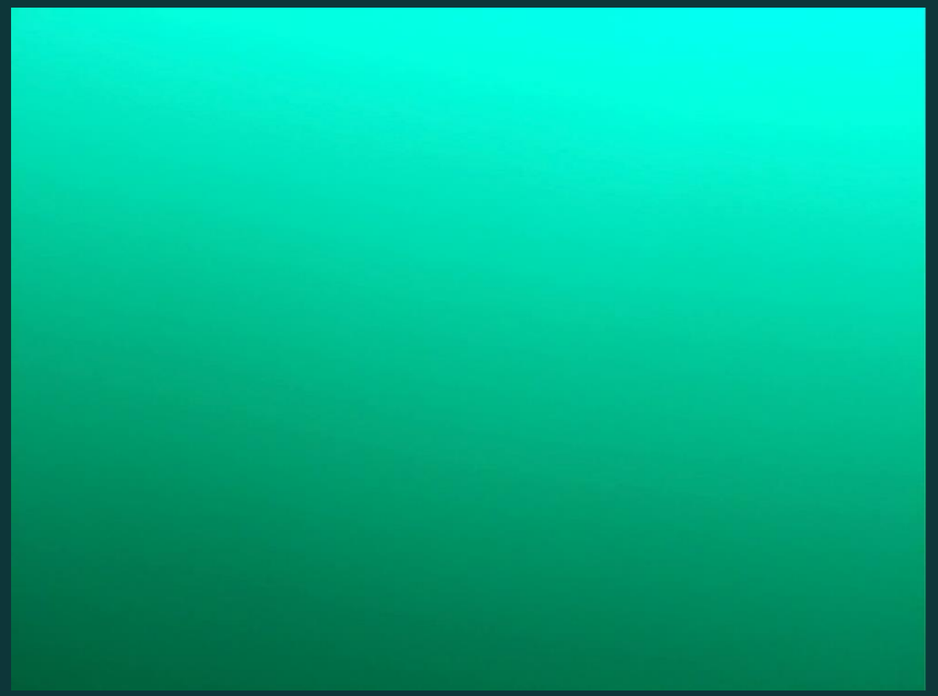
"You should see *this*"

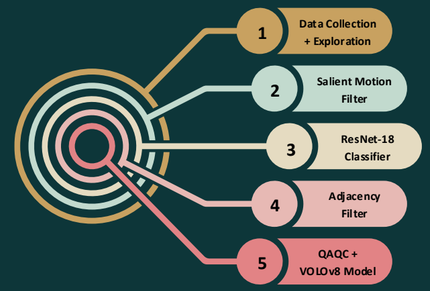


3 ResNet-18 Classifier

> “There’s *something* in this image”

- **ResNet = Residual Network**
- **Deep-learning model (*binary classifier*)**
- **Designed to ‘skip’ over unnecessary steps through pixel pattern recognition**
- **Like a ‘first pass’ observer**





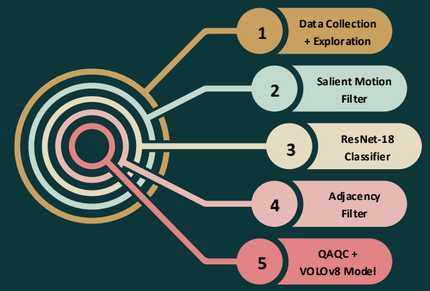
4 Adjacency Filter

Adjacent Frames within video

?

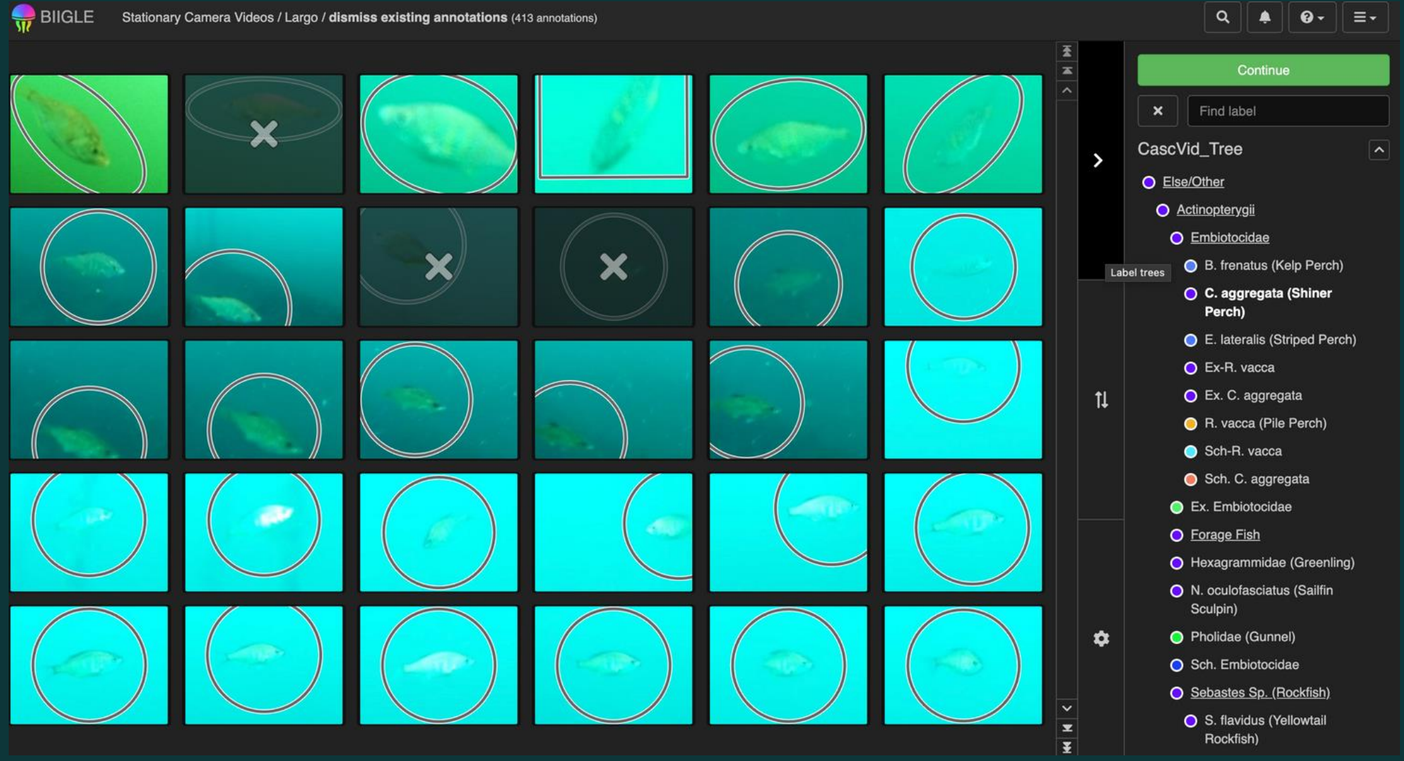
Rare taxa

?

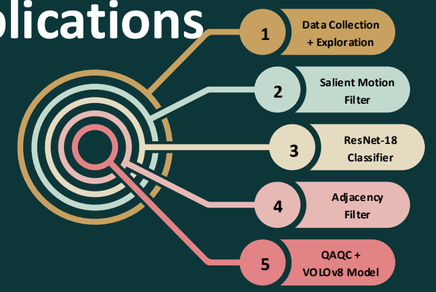


5 QAQC & Validation

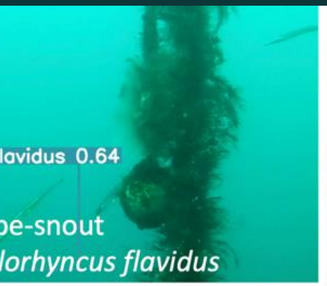
- **Iterative ID guide**
  - Marine ID guides
  - Expert ID sessions
  - Recorded morphological features for each taxa
- **Accounting for inter-annotator bias**
  - All annotations reviewed (BIIGLE)
  - Regular team meetings
- **How do you create trust that the dataset represents the system? (when to stop?)**
  - Unsupervised anomaly detection ‘explorer’ filter
  - Multiple methods of validation

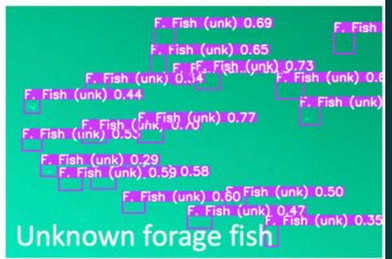


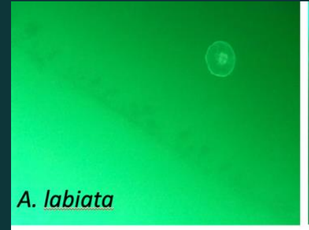
- **Explore large temporal ranges based on anomalies**
- **Detect rare taxa**
- **Behavioural ecology applications**

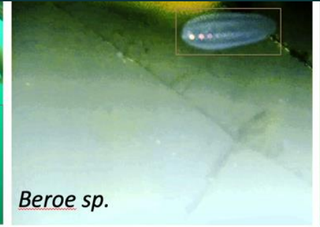


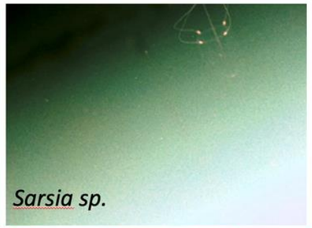
5 QAQC & Validation

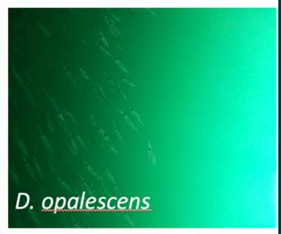


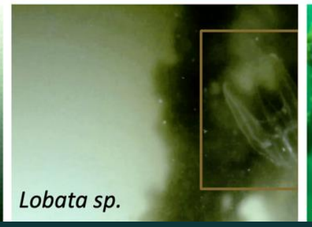


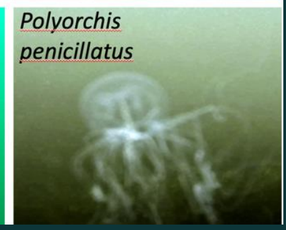






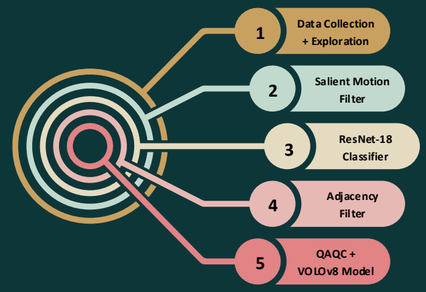






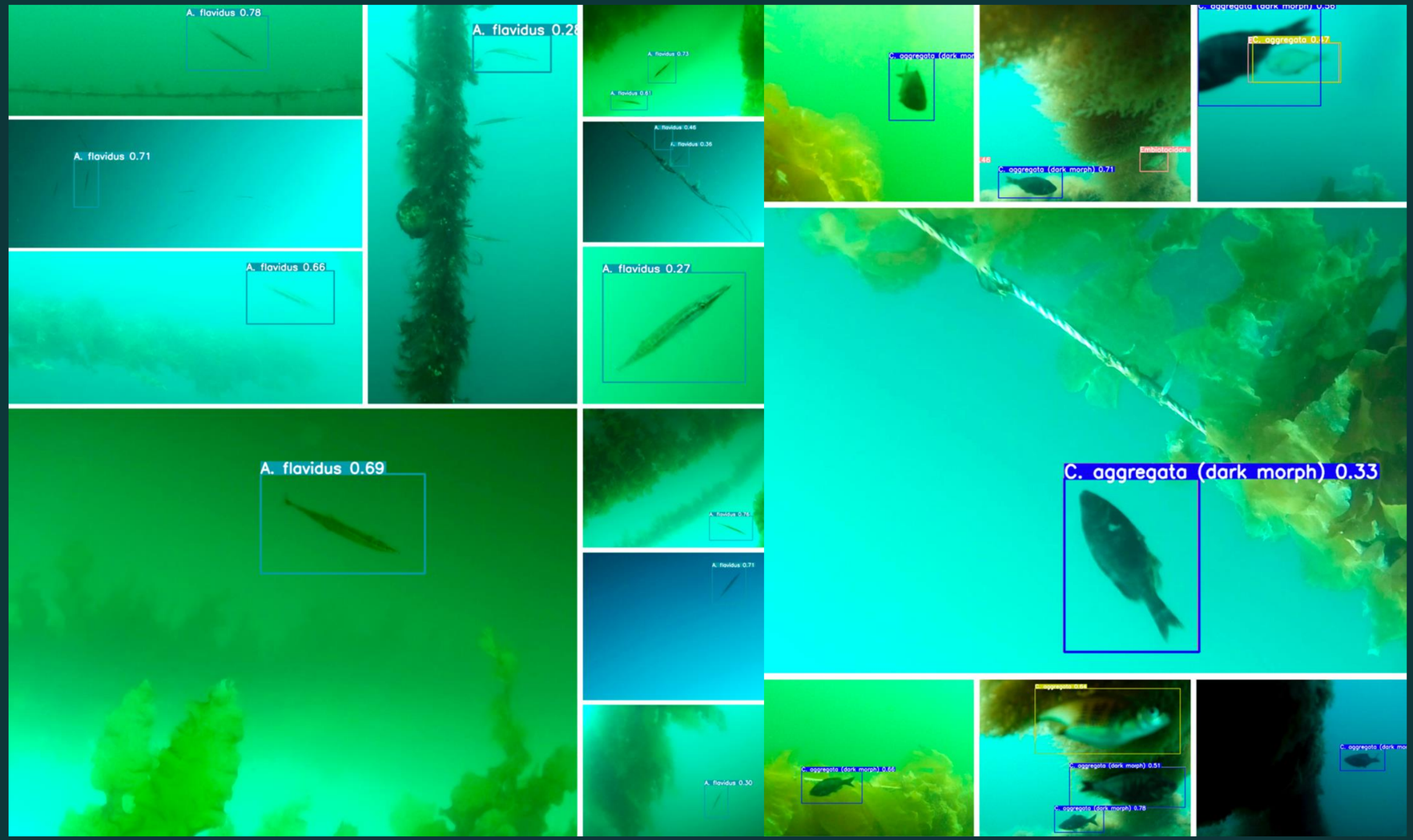
Colin Bates

>240,000 images annotated (>500,000 images reviewed)

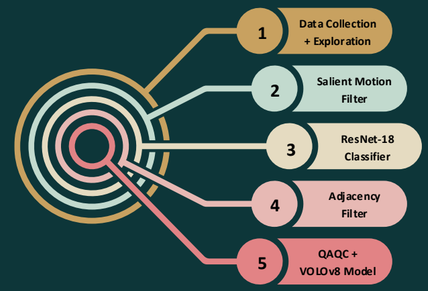


5 VOLOv8 Model

- R-CNN Classifier
- Mimics Human Observer
- Identified >2 million fish from 9 taxa (March 2022 – June 2023)



> “There’s a shiner perch *here*“



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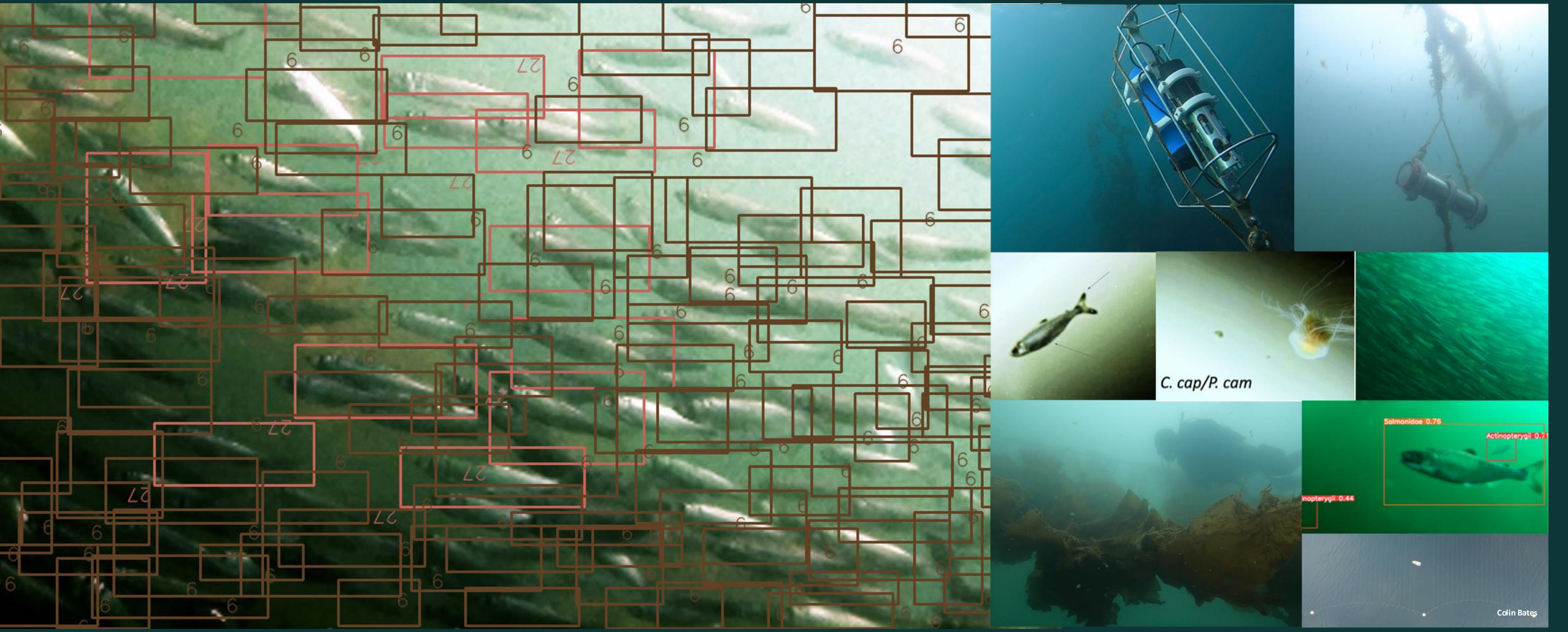
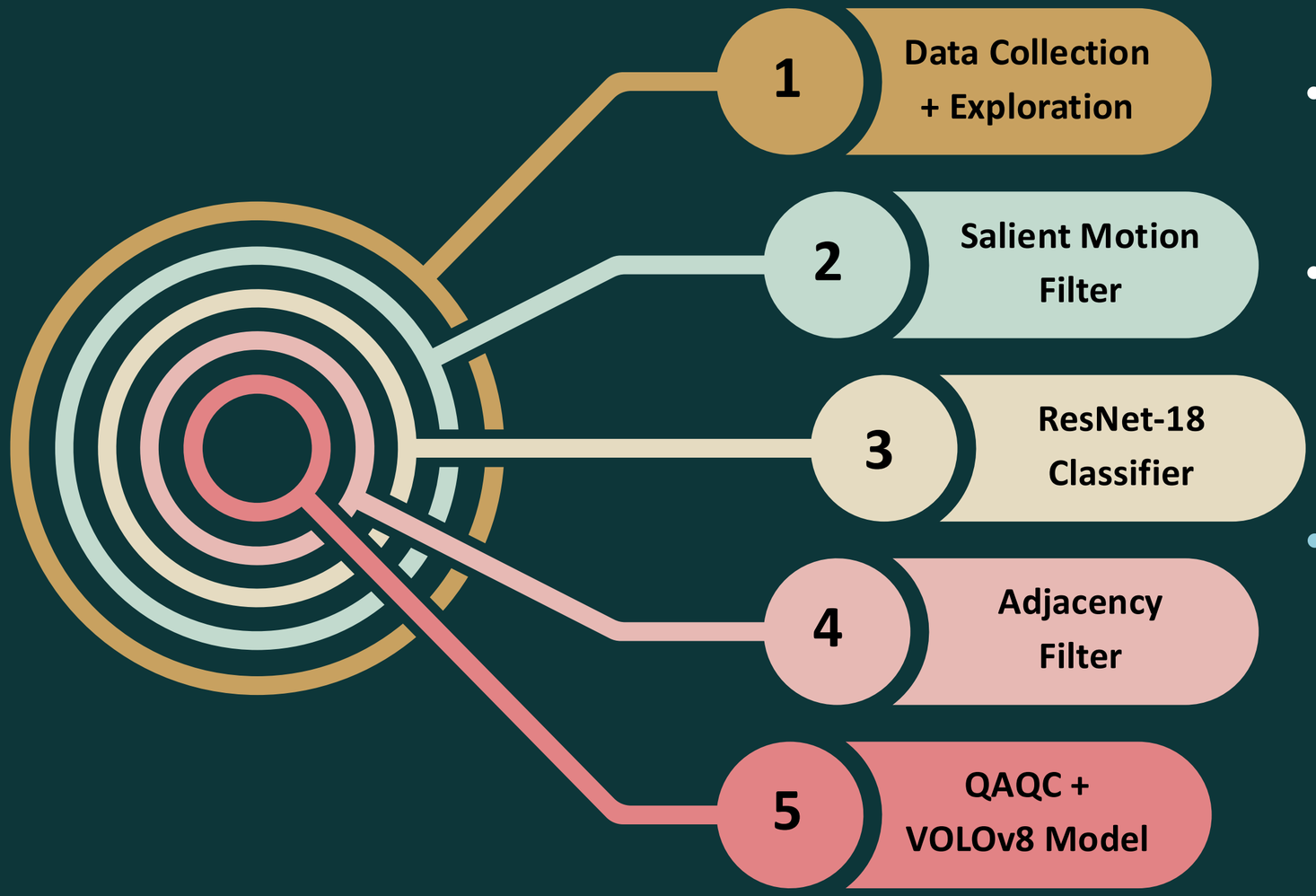
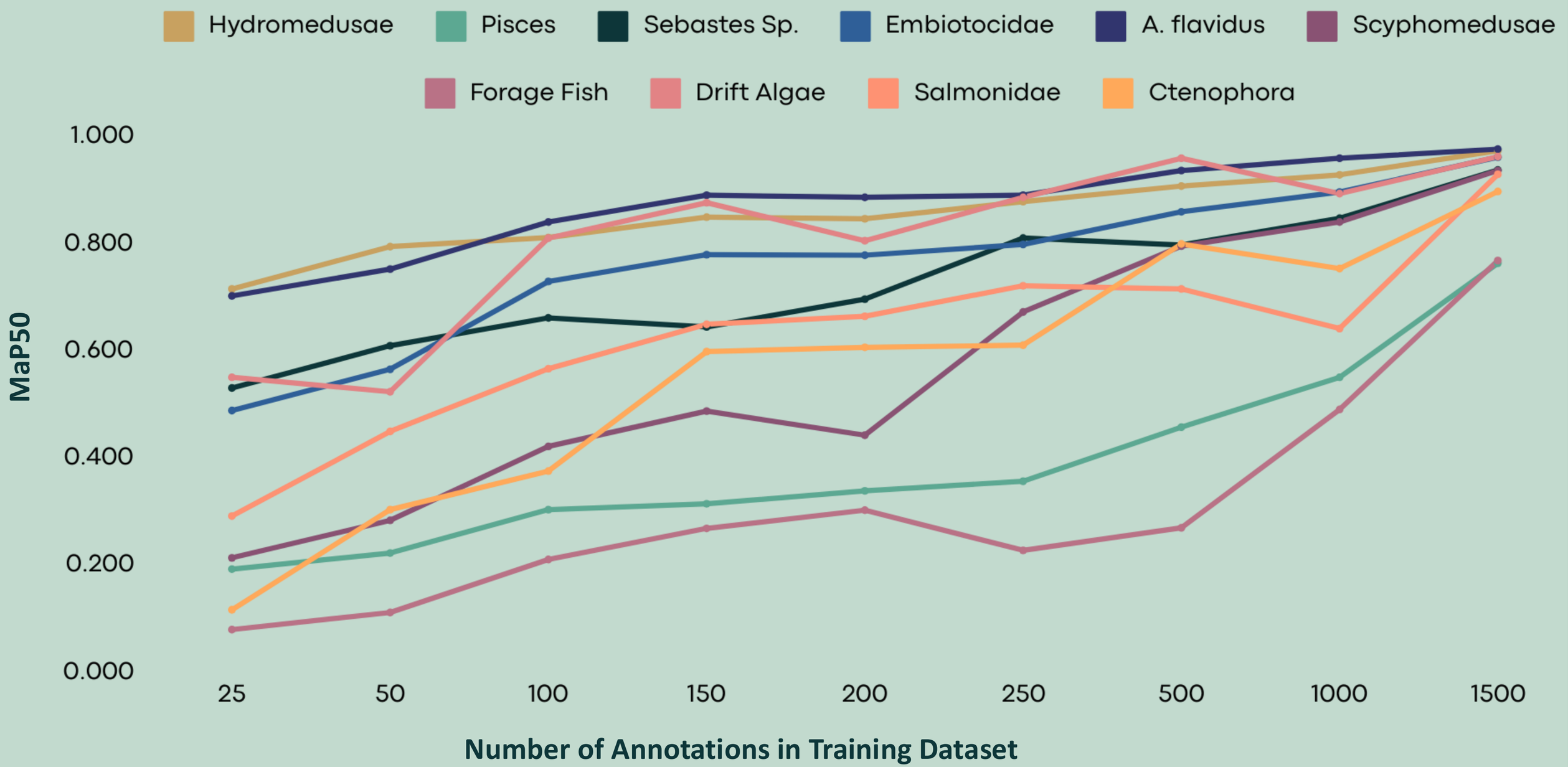


Result



- **>240,000 images annotated (>500,000 images reviewed)**
- **Model that identifies 9 epipelagic fish taxa, 8 gelatinous zooplankton taxa**

- **How many annotations do you need of each taxa to train a *well-performing model*?**


Hydromedusae
Pisces
Sebastes Sp.
Embiotocidae
A. flavidus
Scyphomedusae
Forage Fish
Drift Algae
Salmonidae
Ctenophora
1.000
0.800
0.600
0.400
0.200
0.000
MaP50
25
50
100
150
200
250
500
1000
1500
Number of Annotations in Training Dataset

What’s next:

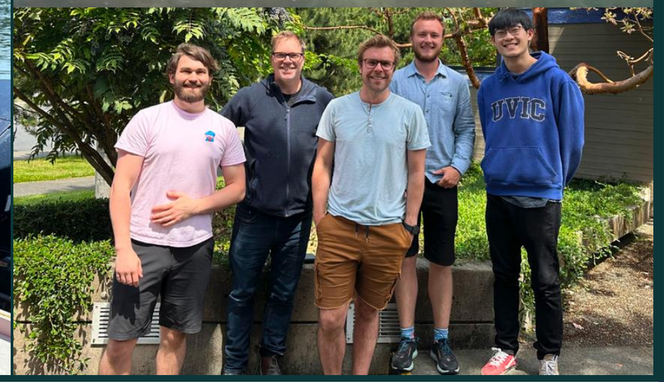
- **Results from abundance and diversity of pelagic taxa are currently in prep (Bates et al., 2024)**
- **Finalize thesis and publication – resource for ecologists considering CV for long-term underwater image monitoring**

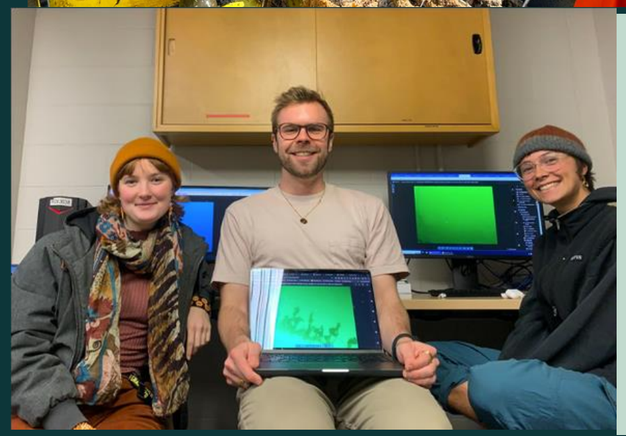
Thank you! Questions?

PHOTO DIARY

Cameras, Computers, and Collaboration: Cutting Edge Approaches to Marine Fish Monitoring

Colin Bates | Cascadia Seaweed Corp., Sidney, BC, Canada | Department of Botany, University of British Columbia, Vancouver, BC, Canada. E-mail: cbates@cascadiaseaweed.com
Declan McIntosh | Electrical and Computer Engineering, University of Victoria, Victoria, BC, Canada
Talen Rimmer | Department of Biology, University of Victoria, Victoria, BC, Canada
Daniel Pedde | Cascadia Seaweed Corp., Sidney, BC, Canada
Jennifer Clark | Cascadia Seaweed Corp., Sidney, BC, Canada
Gemma Macfarlane | Maaqutusiis Hahoulthee Stewardship Society, Ahousaht Nation, Tofino, BC, Canada
Ryan Anaka | Uchucklesaht Tribe Government, Port Alberni, BC, Canada
Alexandra Branzan Albu | Electrical and Computer Engineering, University of Victoria, Victoria, BC, Canada
Francis Juanes | Department of Biology, University of Victoria, Victoria, BC, Canada





BC Salmon Restoration and Innovation Fund
Fonds de restauration et d'innovation pour le saumon de la C-B
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Mitacs
Ocean Networks Canada
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DEEP TREKKER
bmsc Bamfield Marine Sciences Centre
Rendezvous
Bamfield Mercantile & Marina

Juanes Lab

Talen Rimmer | @talen.r | rimmertalen@gmail.com