Using Machine Learning/Computer Vision with RCA Imagery

Dr. Katie Bigham
Postdoctoral Research Fellow
University of Washington

My Background

- BSc in Oceanography from the University of Washington
- Worked for the OOI Regional Cabled Array team
- PhD in Marine Biology from Victoria University of Wellington with joint position at NIWA
- Currently NSF OCE Postdoctoral Fellowship using RCA imagery and machine learning

PRF Goals

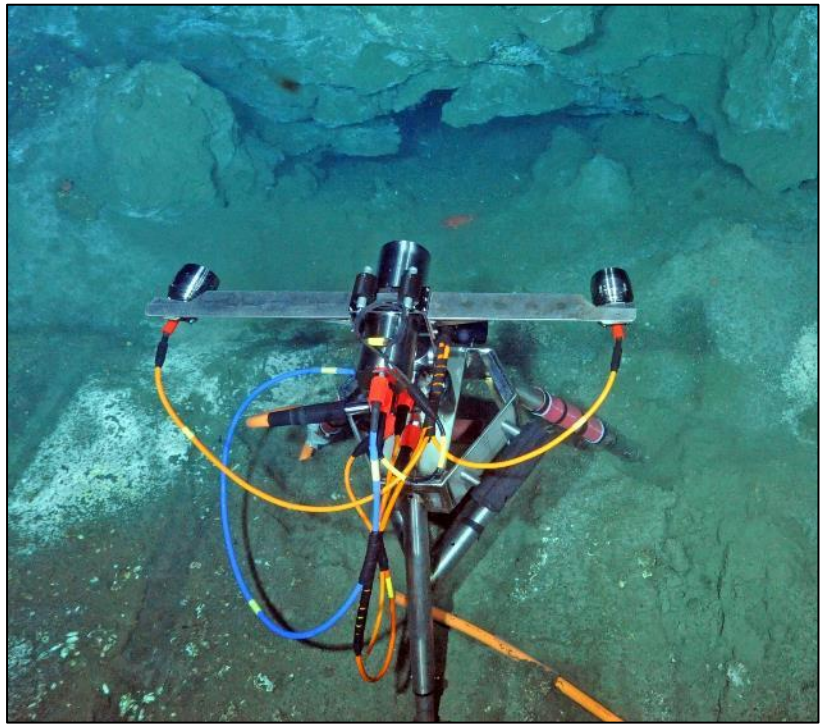
- OCE-PRF: Using machine learning to investigate temporal dynamics of methane seep fauna at the Ocean Observatories Initiative (OOI) Regional Cabled Array

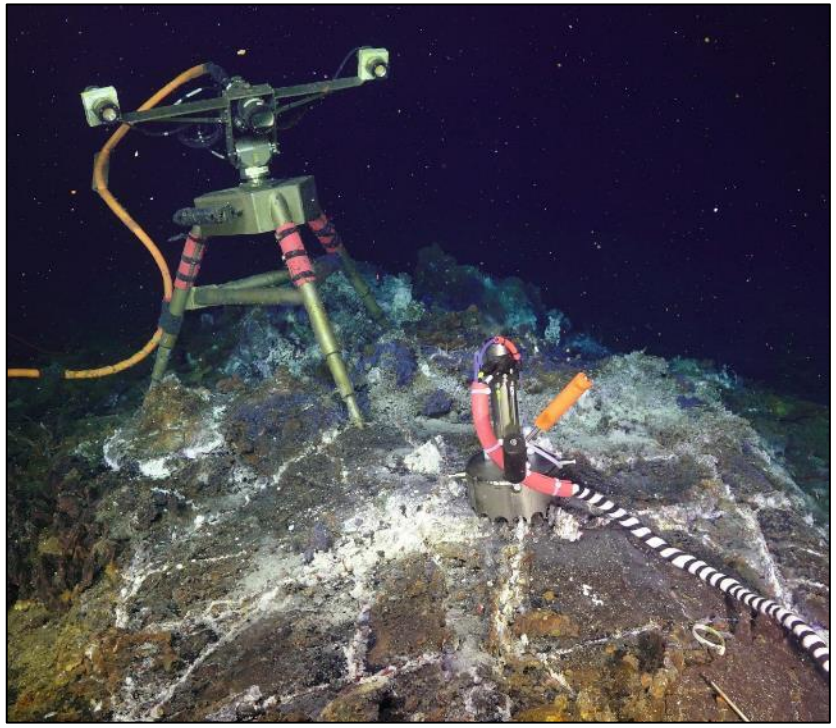
  - 1) Explore temporal dynamics of benthic fauna at a methane seep with over a decade of imagery (~37 TB in 2022)
    - Digital still images from a stationary camera that takes 3 picture every half hour (2014-present)
    - ROV imagery from annual construction/operation and maintenance cruise (2008-present)

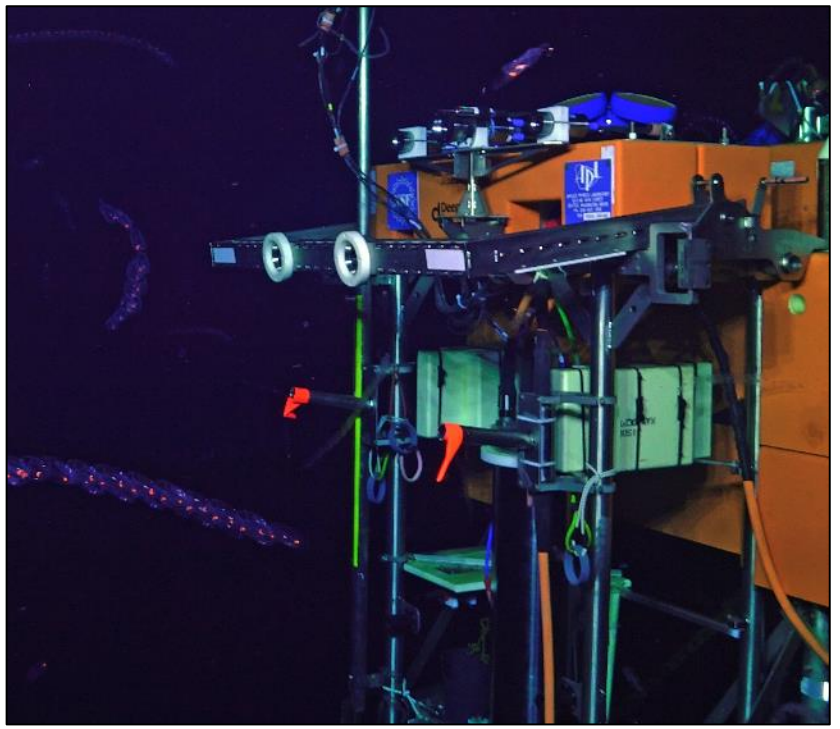
  - 2) Develop machine learning pipelines to assist with processing large volumes of imagery

RCA Digital Still Cameras

- 6 digital still cameras
  - 3 water column on 200 m platforms
  - 3 seafloor – Southern Hydrate Ridge, Axial Seamount, and Oregon Offshore

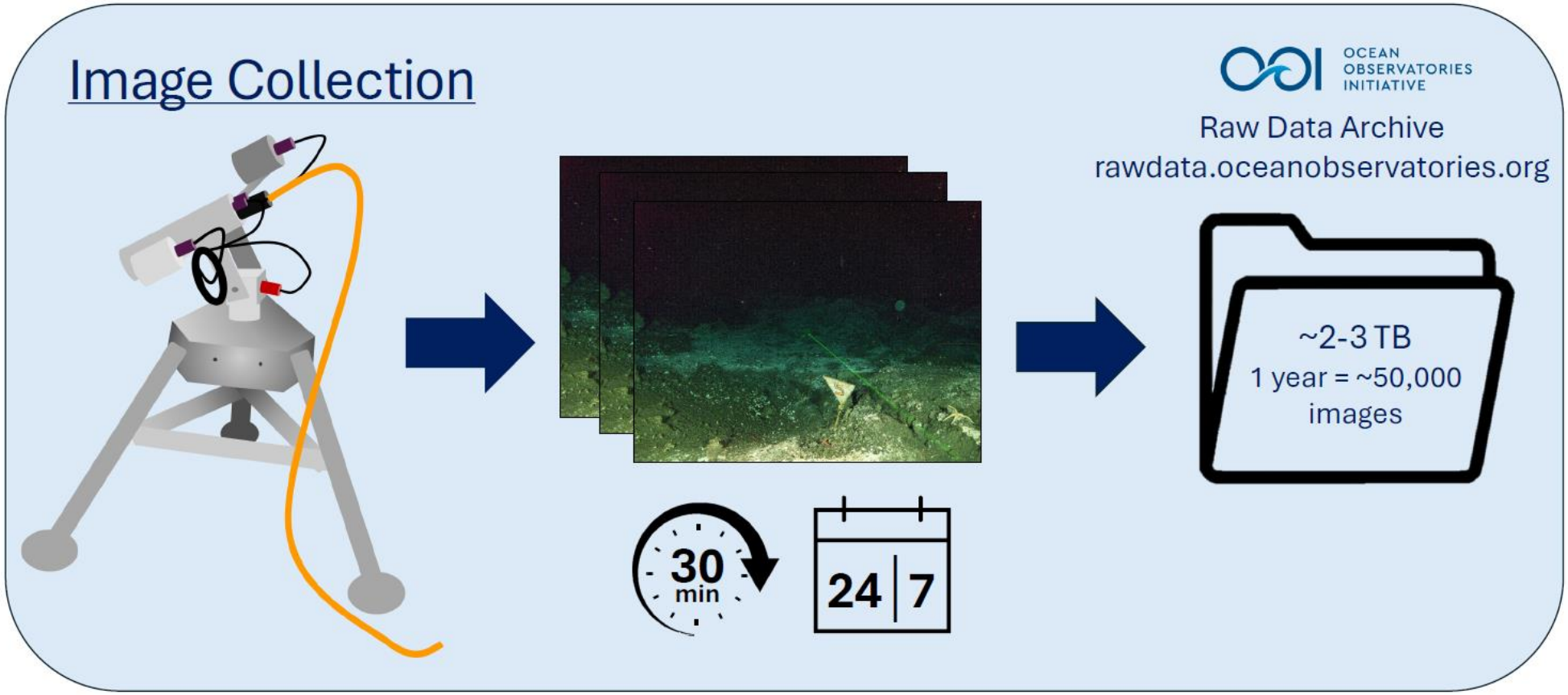




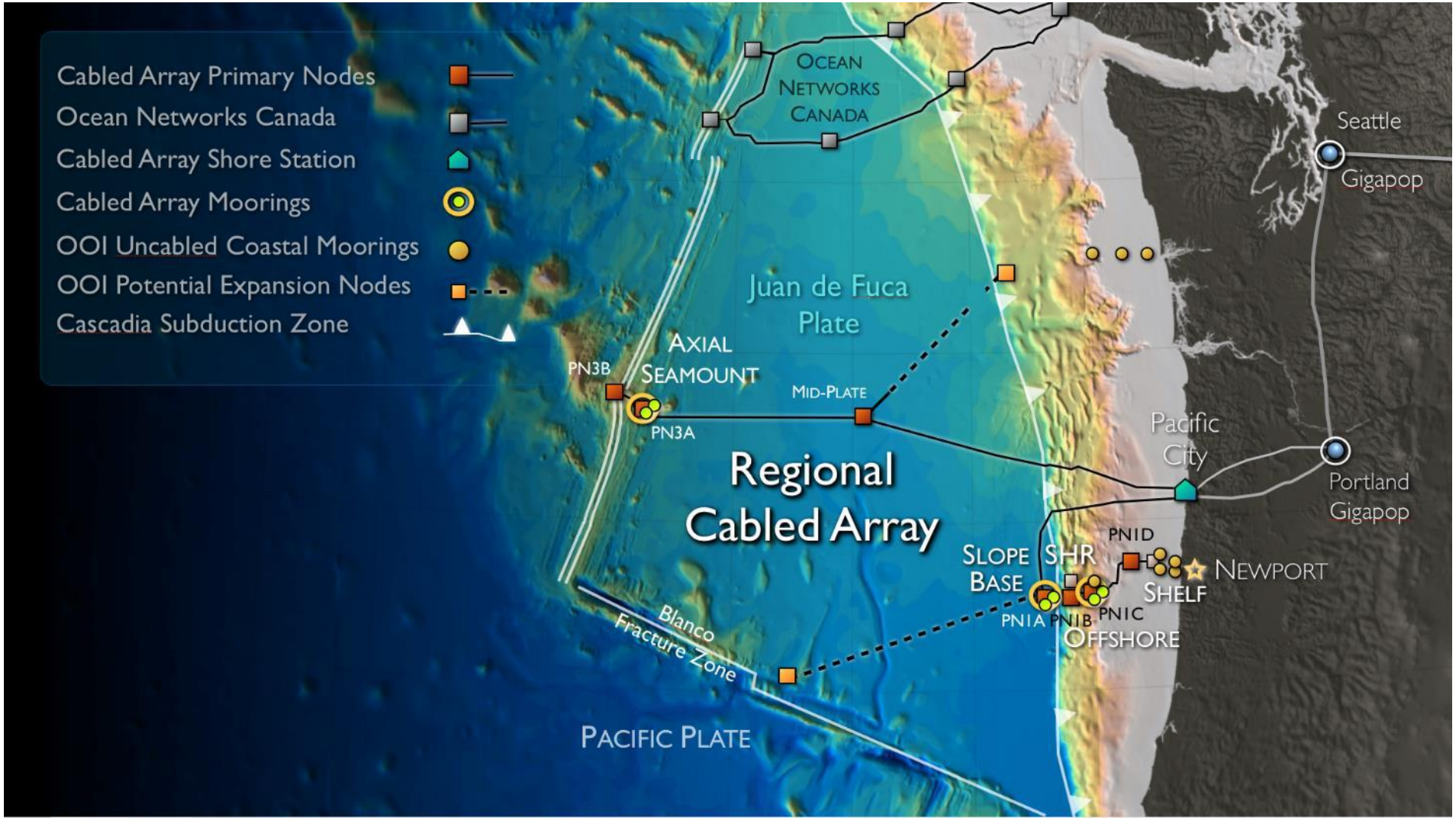


RCA Digital Still Cameras

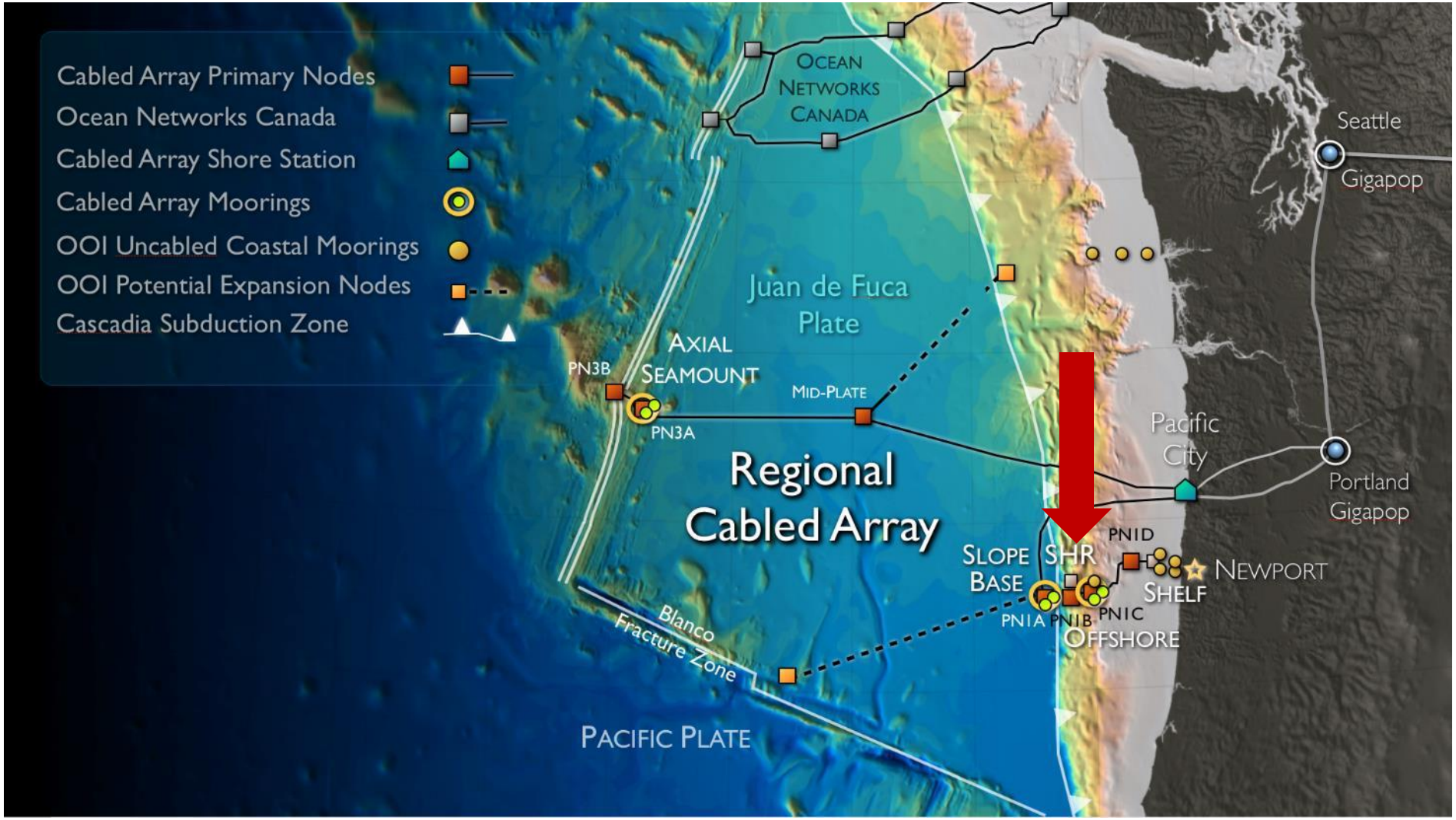
- Sampling scheme
  - Turns on every half hour and takes 3 pictures



Regional Cabled Array

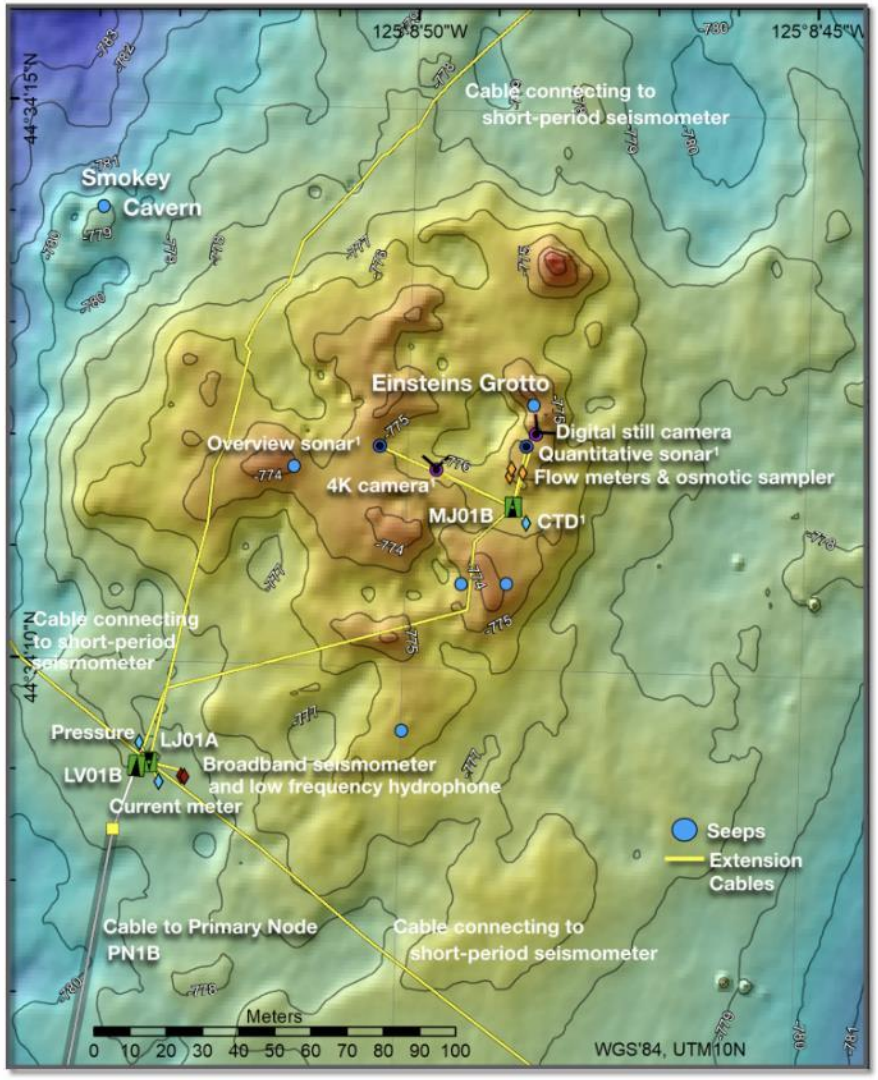


Regional Cabled Array



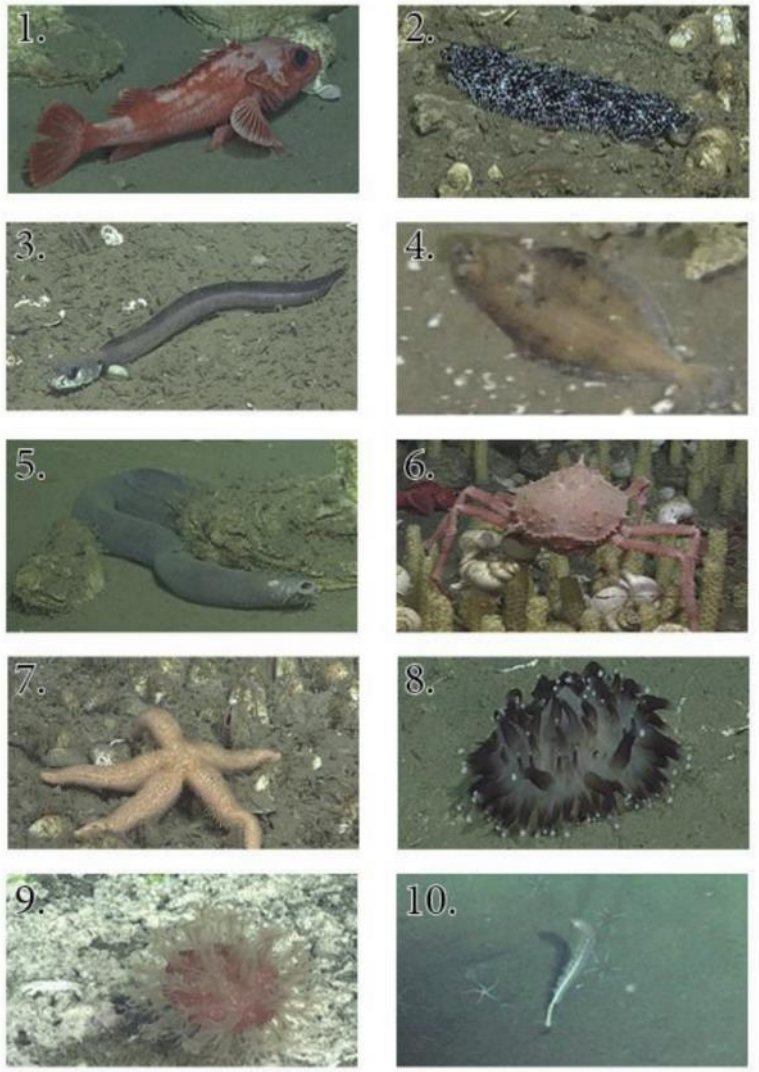
Southern Hydrate Ridge (SHR)

- Methane seep
- 90 km west of Newport, Oregon
- ~780 m water depth

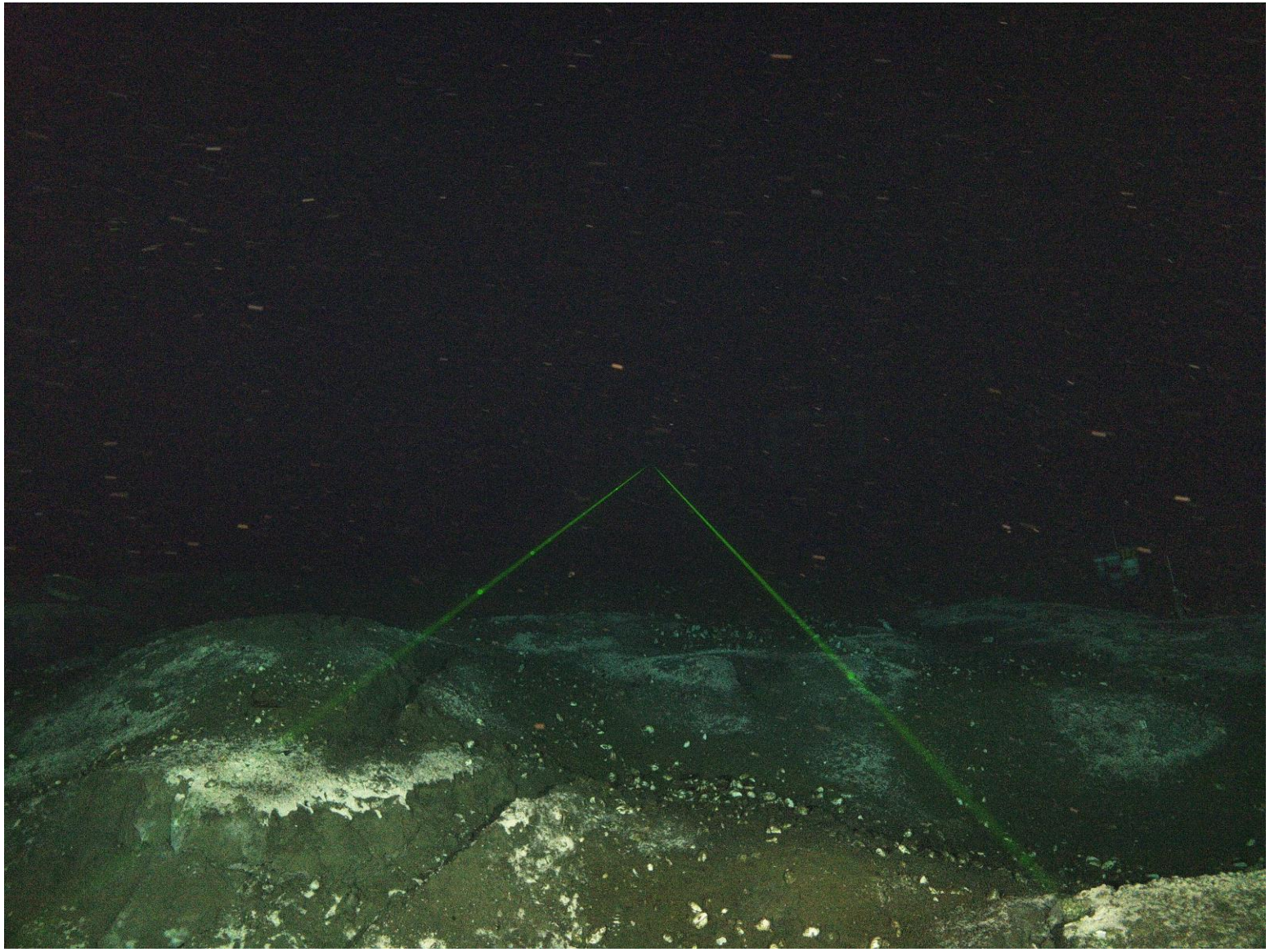


Southern Hydrate Ridge (SHR) - Biology

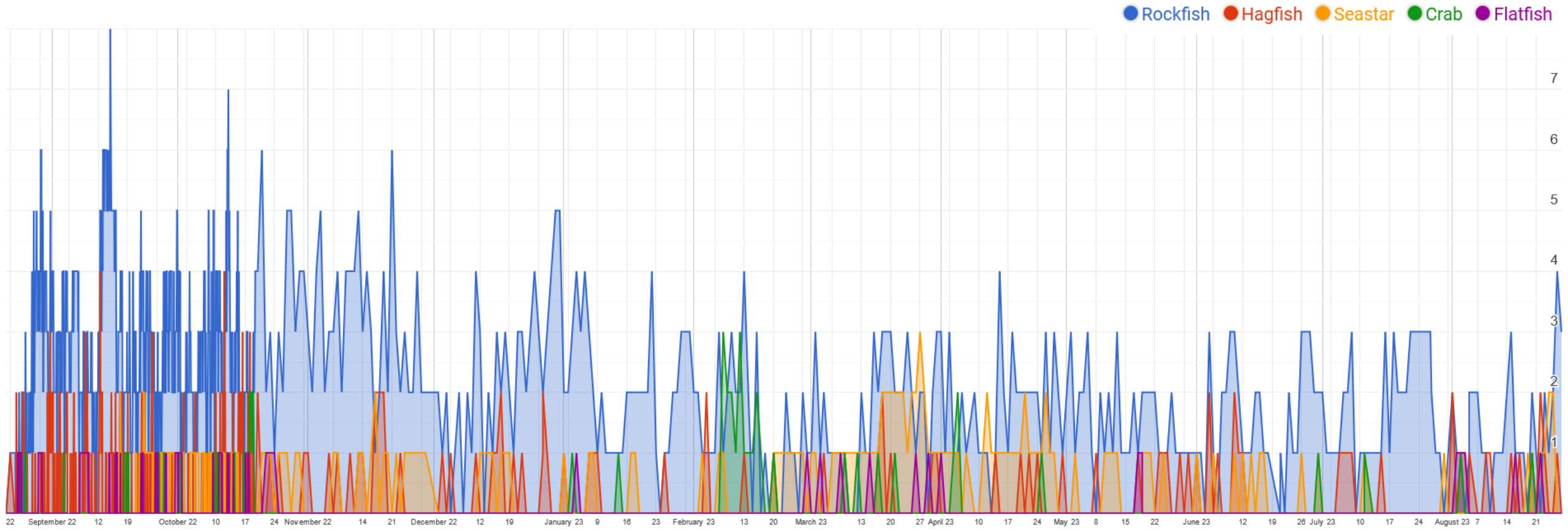
- Chemosynthetic environment
  - Bacterial mats
  - Symbiotic bacteria hosted by clams
- Hosts large community of megafauna including many commercially fished species
  - Rockfish (1)
  - Hagfish (5)
  - Halibut and other flatfish (2 & 4)
  - Crabs (6)



SHR Time Lapse Aug 2022 - Aug 2023

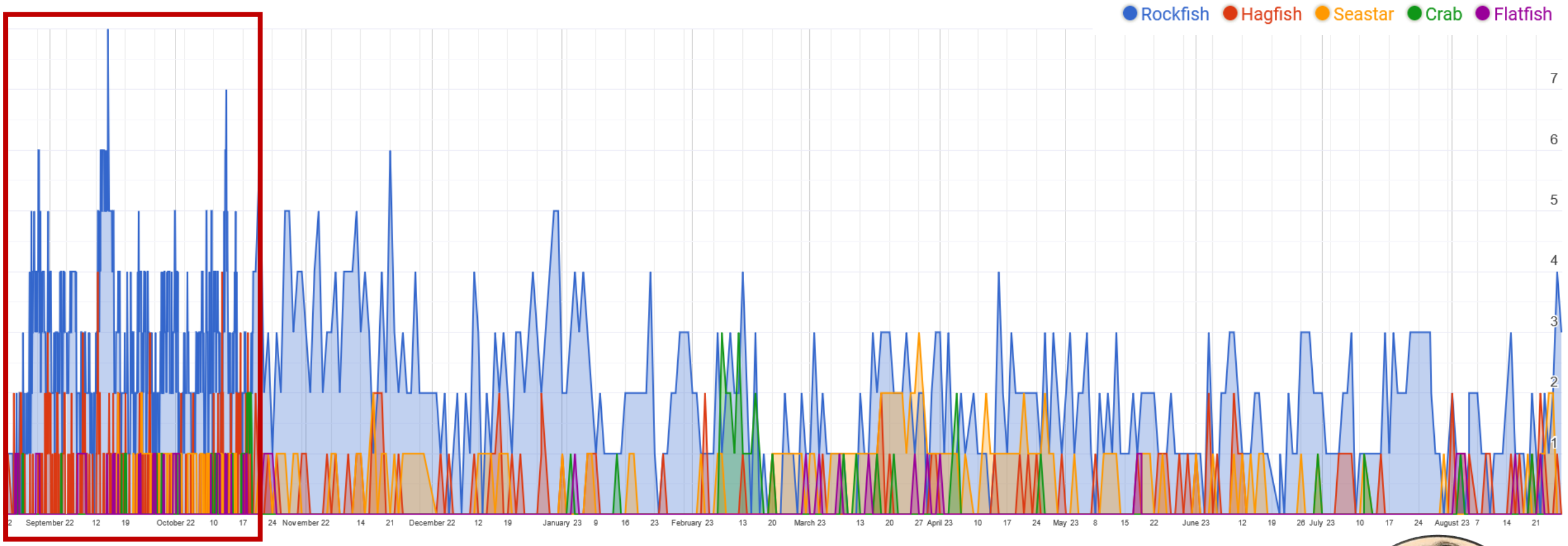


SHR Fauna Counts Aug 2022- Aug 2023



Chris Moon
UW Undergrad

SHR Fauna Counts Aug 2022- Aug 2023

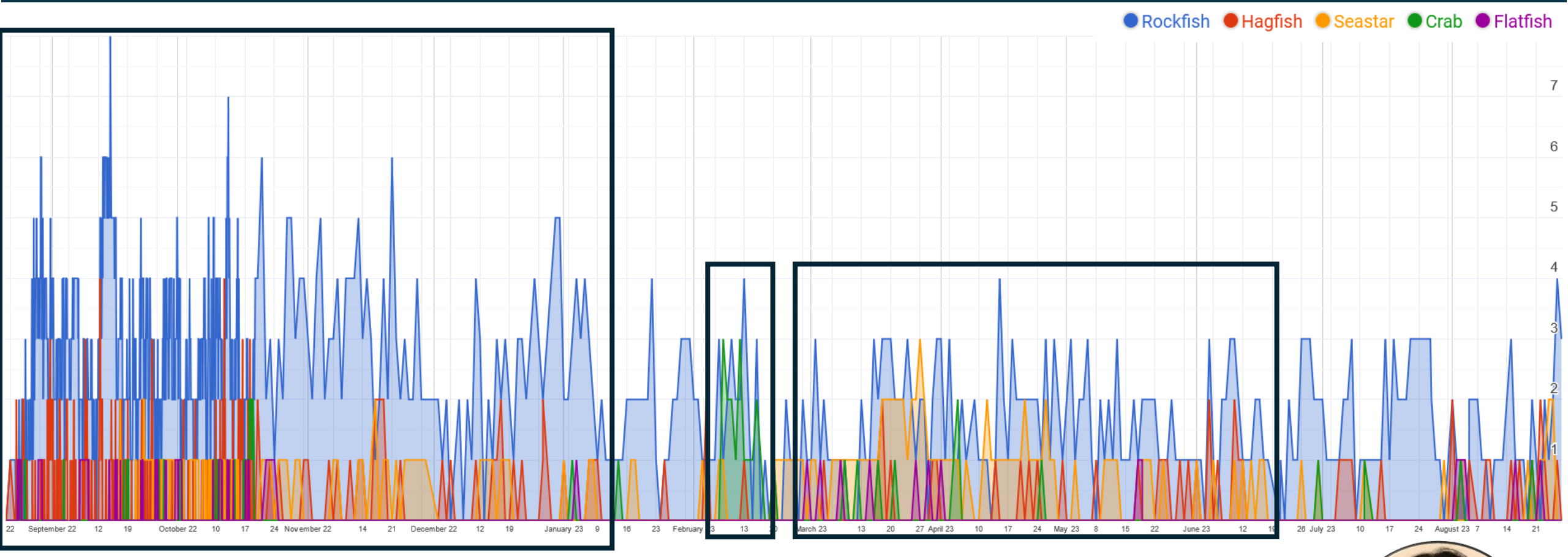


1 image every
2 hours

1 image every day

Chris Moon
UW Undergrad

SHR Fauna Counts Aug 2022- Aug 2023



More animals in 2022?

Crab week?

More diversity in spring?

Chris Moon
UW Undergrad

ML and CV and AI, Oh My

- Do I really have to count all those animals?
  - 1 year of images from SHR is >50,000 images
  - 1 image every 2 hours for 365 days = 4,380 images
  - For 1 PhD chapter I annotated 5,795 images
- Can’t the computer count them for me?

ML and CV and AI - some definitions

- Artificial Intelligence (AI): ability of a machine to mimic human intelligence, learning, reasoning, and problem solving
- Machine Learning (ML): a subset of AI, uses algorithms and statistical models to perform complex tasks without explicit instruction
- Computer Vision (CV): a type of AI that uses ML to teach computers to understand visual data

ML and CV and AI, Oh My

MEPS 615:15-30 (2019) - DOI: https://doi.org/10.3354/meps12925

Automated identification of benthic epifauna with computer vision

Nils Piechaud[1,*], Christopher Hunt[2], Phil F. Culverhouse[3], Nicola L. Foster[1], Kerry L

[1]School of Biologica
[2]Controlled Frenzy
[3]School of Computi

*Corresponding aut

JOURNAL ARTICLE

Unlocking the potential of deep le ecology: overview, applications, a

Morten Goodwin, Kim Tallaksen Halvorsen, Lei Jiao, Krist
Angela Helen Martin, Marta Moyano, Rebekah A Oomen, Jeppe
Tonje Knutsen Sørdalen, Susanna Huneide Thorbjørnsen

ICES Journal of Marine Science, Volume 79, Issue 2, March 2022, P

JOURNAL ARTICLE

Machine learning in marine ecology: an overview of techniques and applications

Peter Rubbens, Stephanie Brodie, Tristan Cordier, Diogo Destro Barcellos, Paul Devos,

Computer vision and deep learning for fish classification in underwater habitats: A survey

Alzayat Saleh, Marcus Sheaves, Mostafa Rahimi Azghadi

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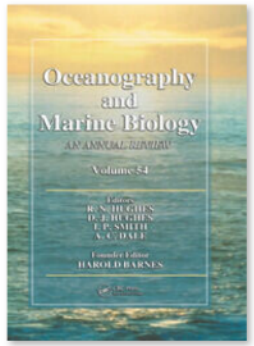


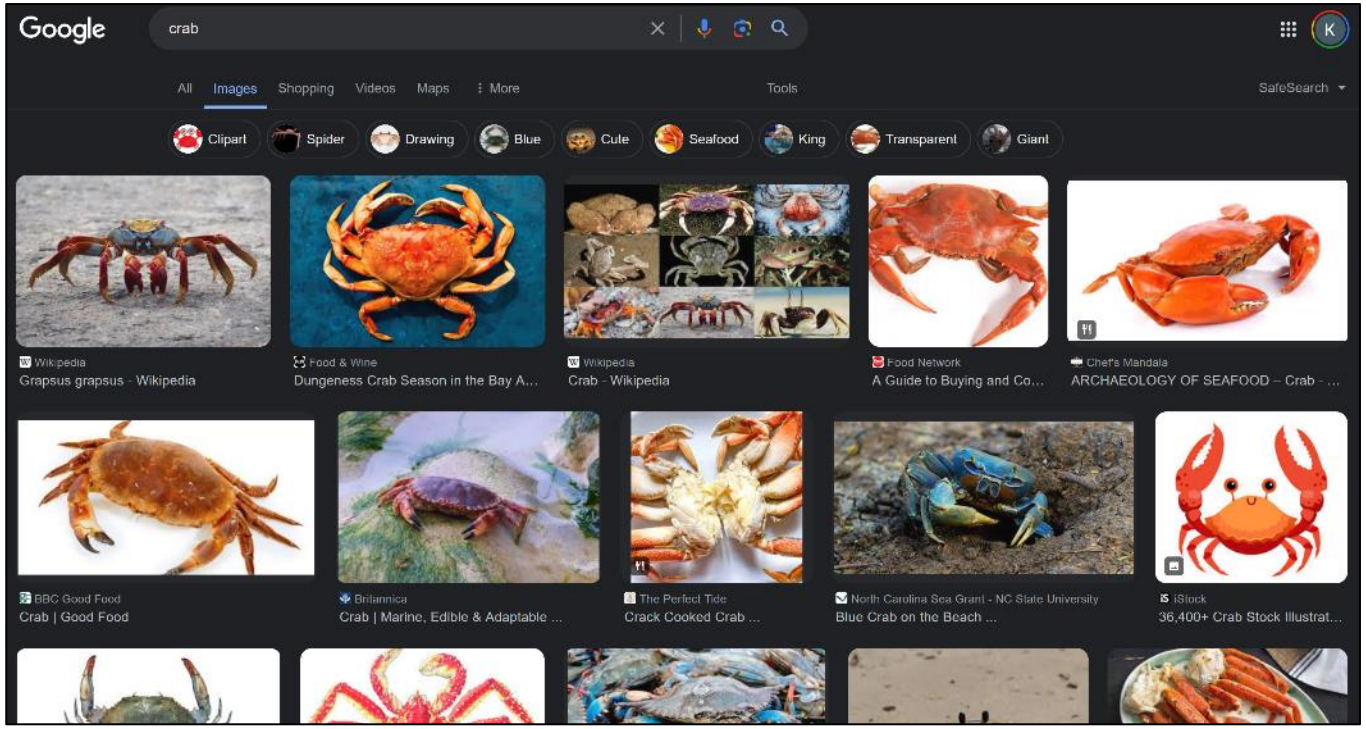
Chapter

Perspect Marine B Acquisiti

By Jennifer M. D
Friedman, Rafa
Jacobsen Stout,
Kevin Köser, Lir
W. Nattkemper,
Maggie Tran & Brian J. Bett

ML and CV and AI, Oh My

- Why is it so challenging?
  - Lack of images to train from
  - Unique challenges posed by the marine environment
    - Water makes things weird



ML and CV and AI, Oh My

- Solutions?
  - Individual researchers and groups are developing bespoke models

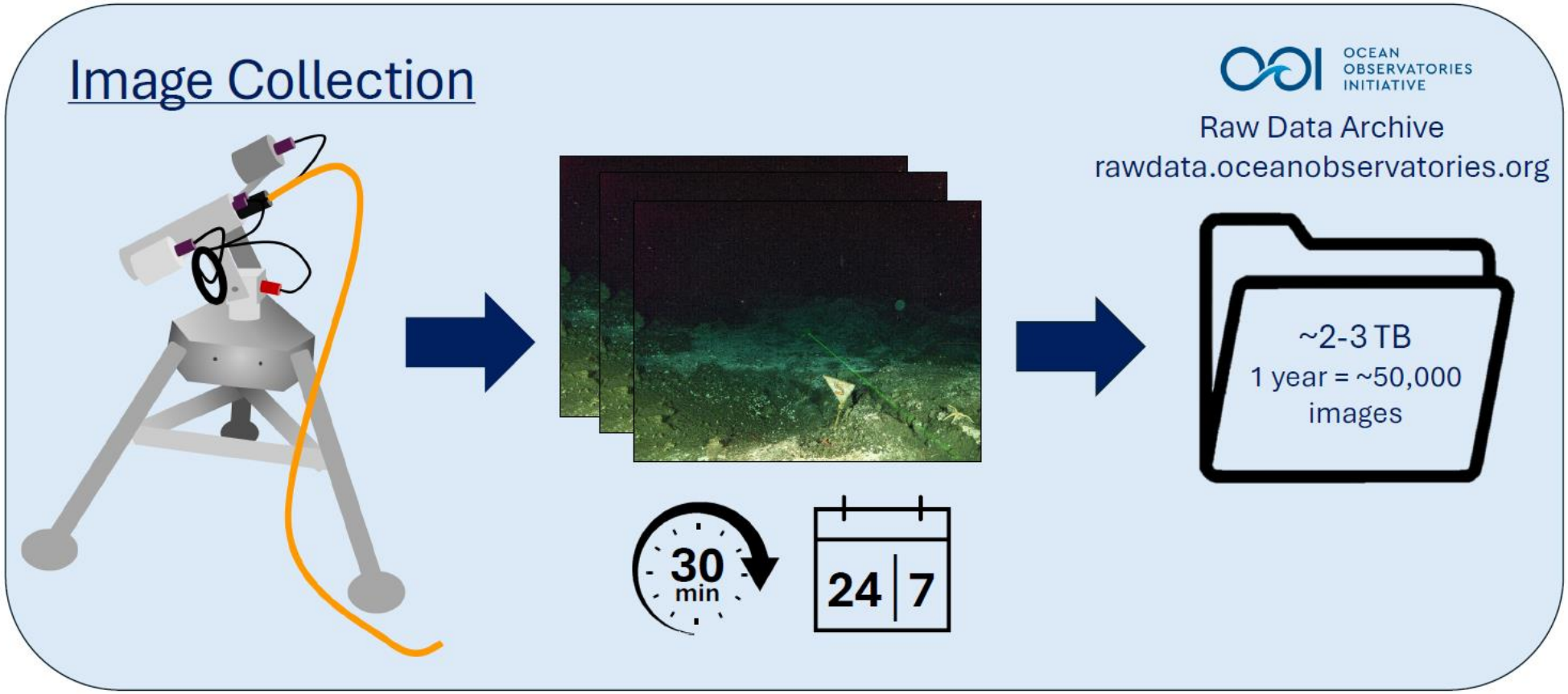
ML and CV and AI, Oh My

- Solutions?
  - Individual researchers and groups are developing bespoke models
  - As a community we are building shared resources of training sets and models

- FathomNet
  - Database of annotated images
- FathomVerse
  - Community science
  - Phone based app
  - Currently has ~270 RCA images

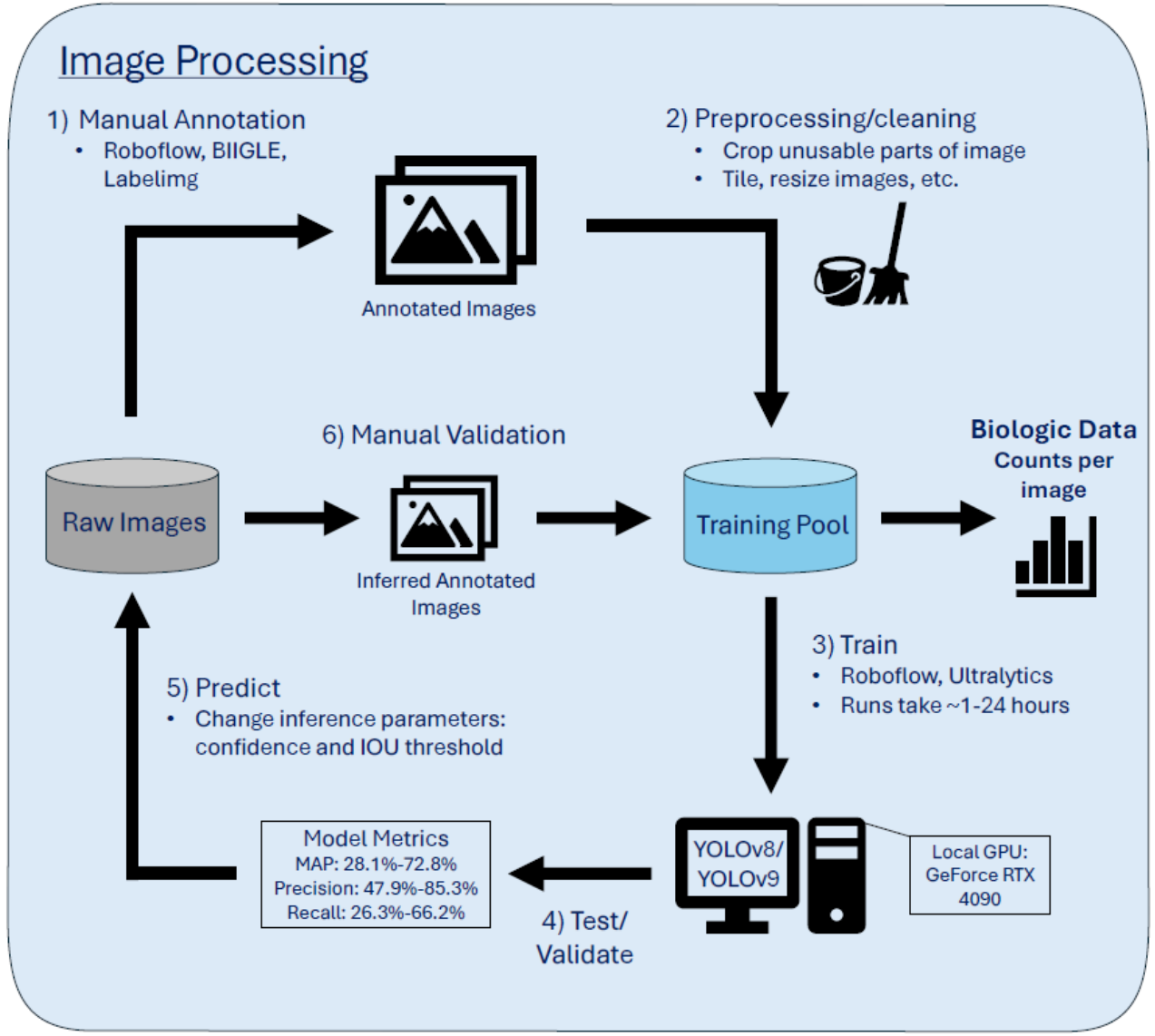
Accelerating RCA annotations with CV

- Developing machine learning pipelines to assist with processing large volumes of imagery



Accelerating RCA annotations with CV

- Machine assisted annotations
- Pseudo-active training style
- Dataset agnostic – being used on multiple sets of images at the moment by my students



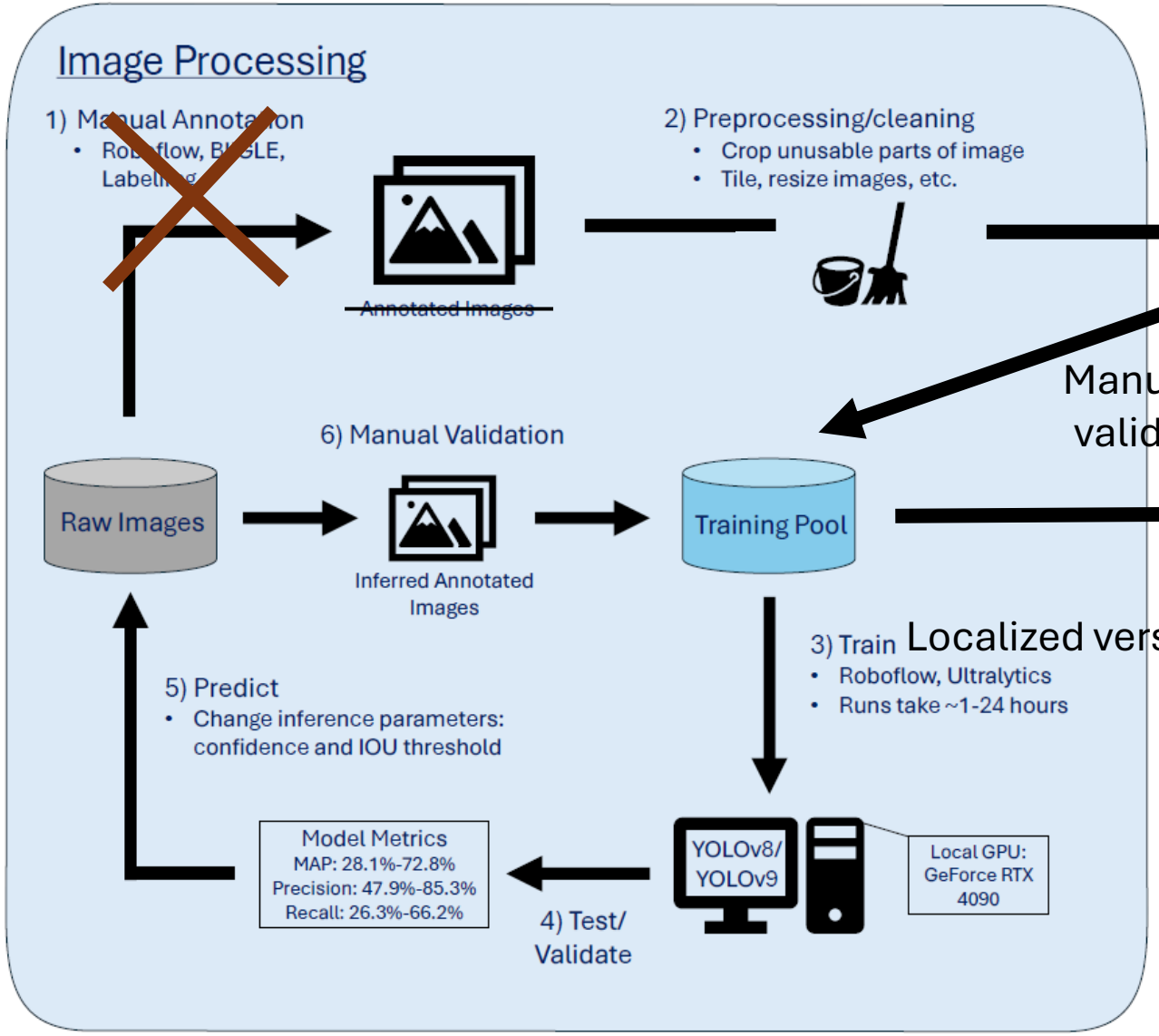
Machine Assisted Annotation Example

Nikola Jenkins
Smith College - Senior

- How have fine scale habitats at SHR changed through time?
- Using ROV imagery collected in 2011 and 2022 during RCA construction and maintenance cruises

- Fully manual
  - 2-3 weeks to annotate ~100 images
- Machine assisted
  - 1 week to annotate ~100 images

Moving towards fully automated annotations

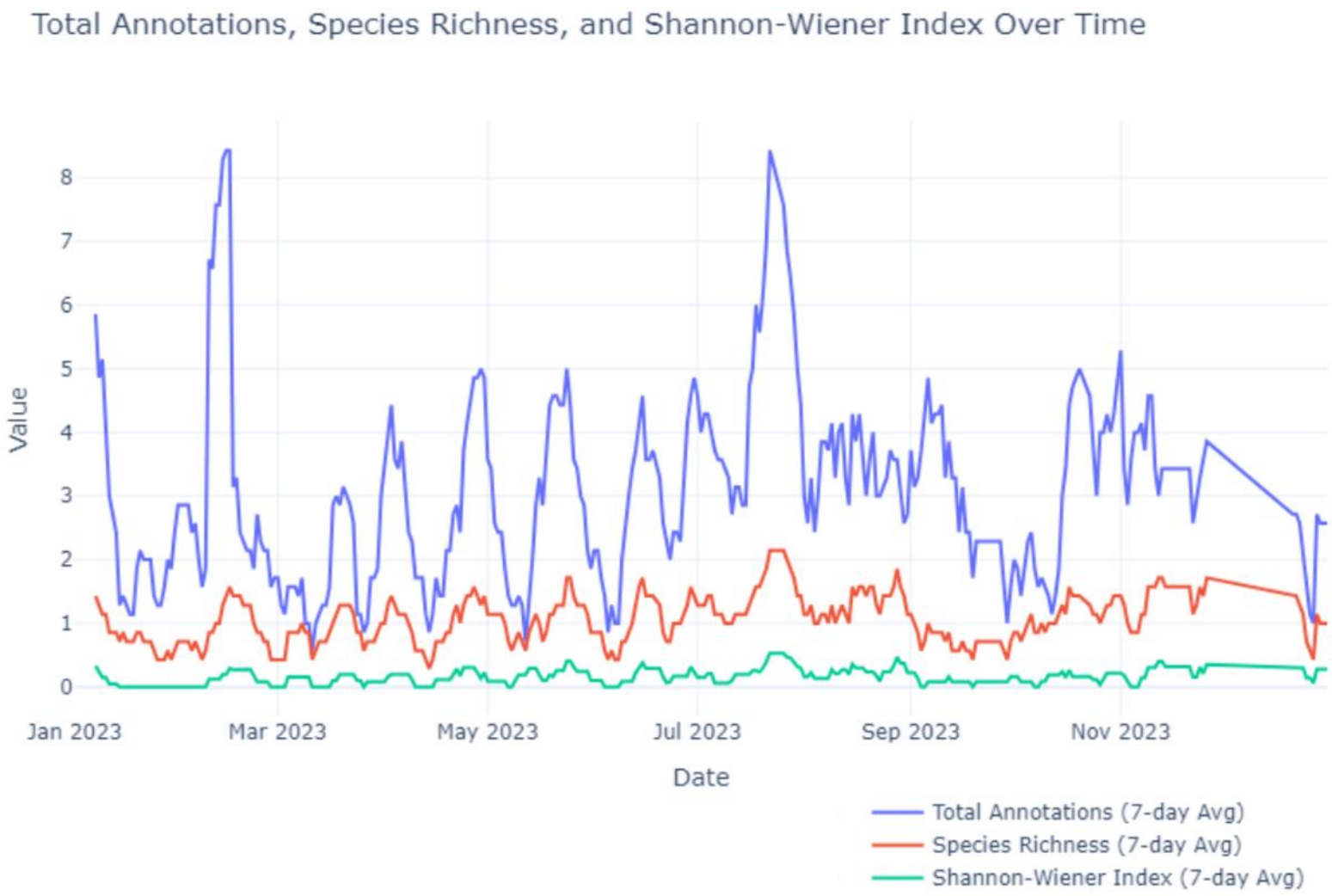


Atticus Carter
UW Ocean - Junior

SHR Fauna Counts Jan 2023- Dec 2023

- 1 year of imagery (~50,000 images)
- 2-3 hours to produce
- Still a lot of room for improvement in this model
  - Training a new version right now

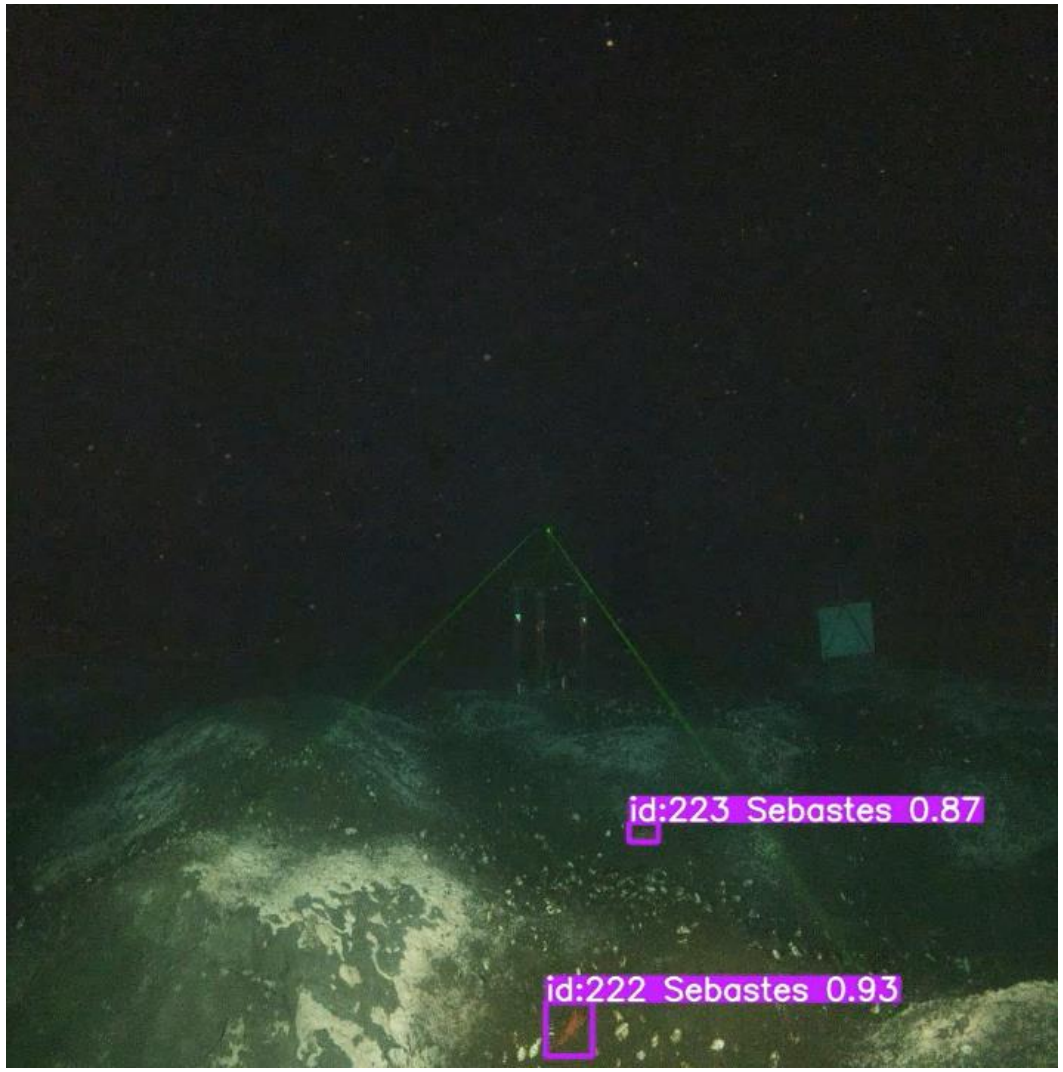
Atticus Carter
UW Ocean



Expanding RCA annotations with CV

- Track individuals
  - Total counts of individuals along with instances
  - Path tracking – where do animals go and how long do they stay

Atticus Carter
UW Ocean



Expanding RCA annotations with CV

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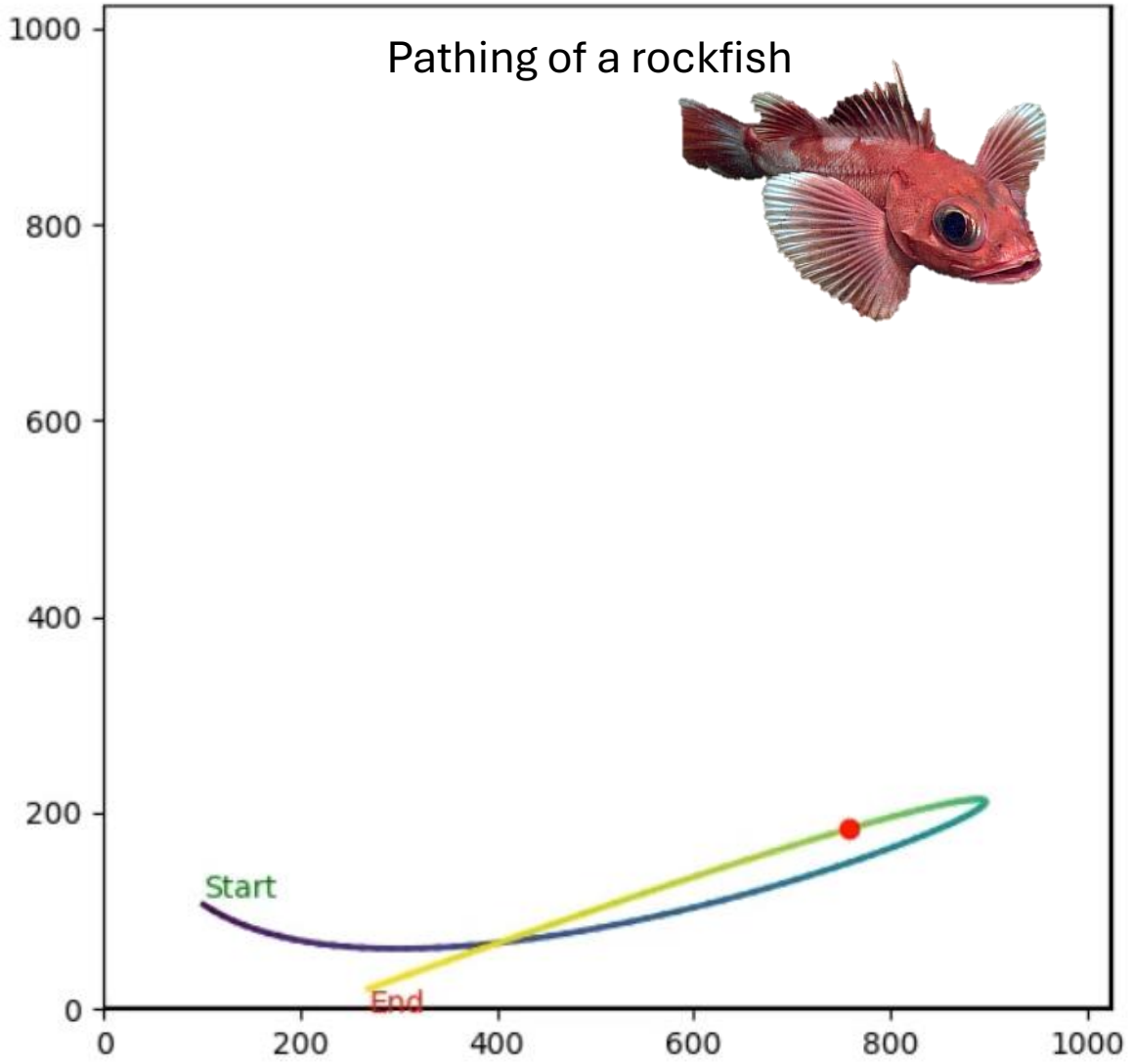
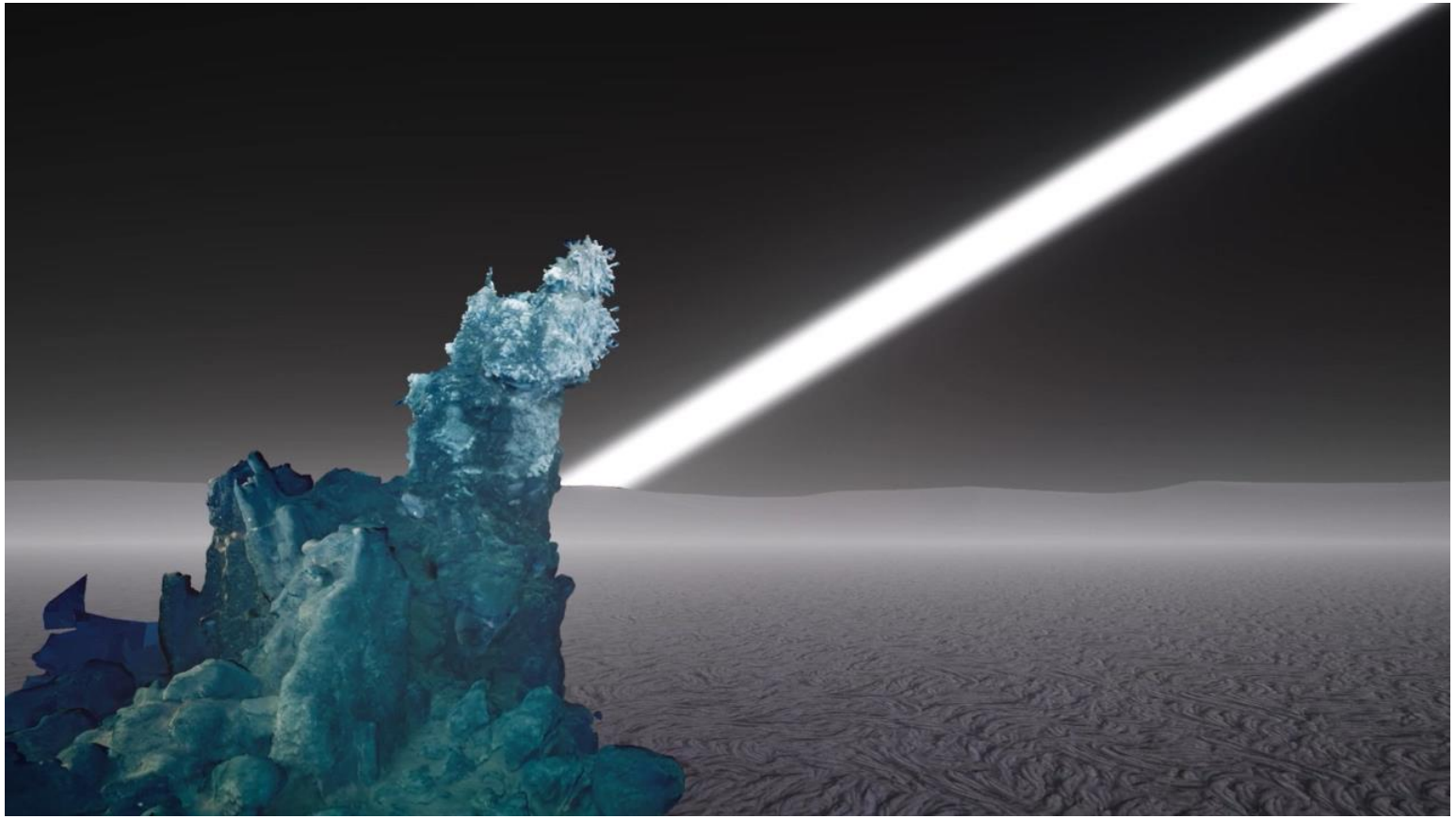


3D Axial Hydrothermal Vents

- Goal: explore biologic communities on hydrothermal vents
  - Changes in space and time
  - Driving abiotic factors
- Using ROV imagery from RCA cruises
- 3D models allow for fine scale mapping and volume estimates



Atticus Carter
UW Ocean

Computer Vision Tutorials

- Ocean CV - Jupyter Binder
  - A full suite of computer vision tutorials with tailor made marine example sets
- Soft launch January 2025
  - Teaching 10 undergrads in winter quarter
  - Soliciting feedback and improving the course and notebooks

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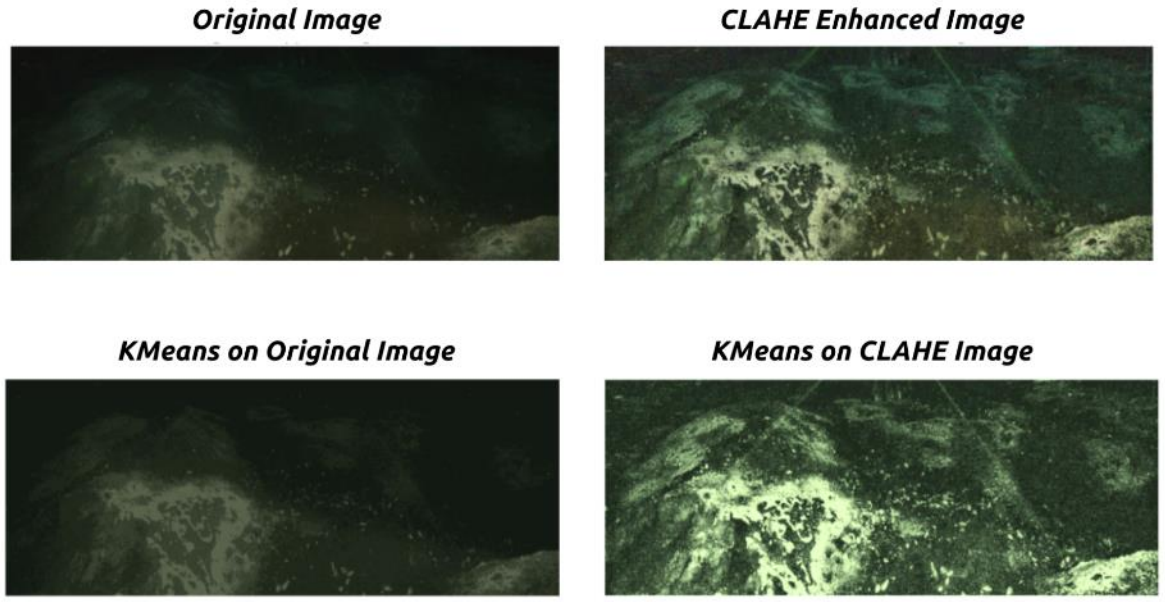
UW Ocean

Computer Vision
Across the Marine Sciences



RCA video and imagery used extensively throughout as examples

Thank you

Dr. Katie Bigham

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