Assessing Bay Scallop (*Argopecten irradians*) populations in Rhode Island using underwater image-based sampling and divers

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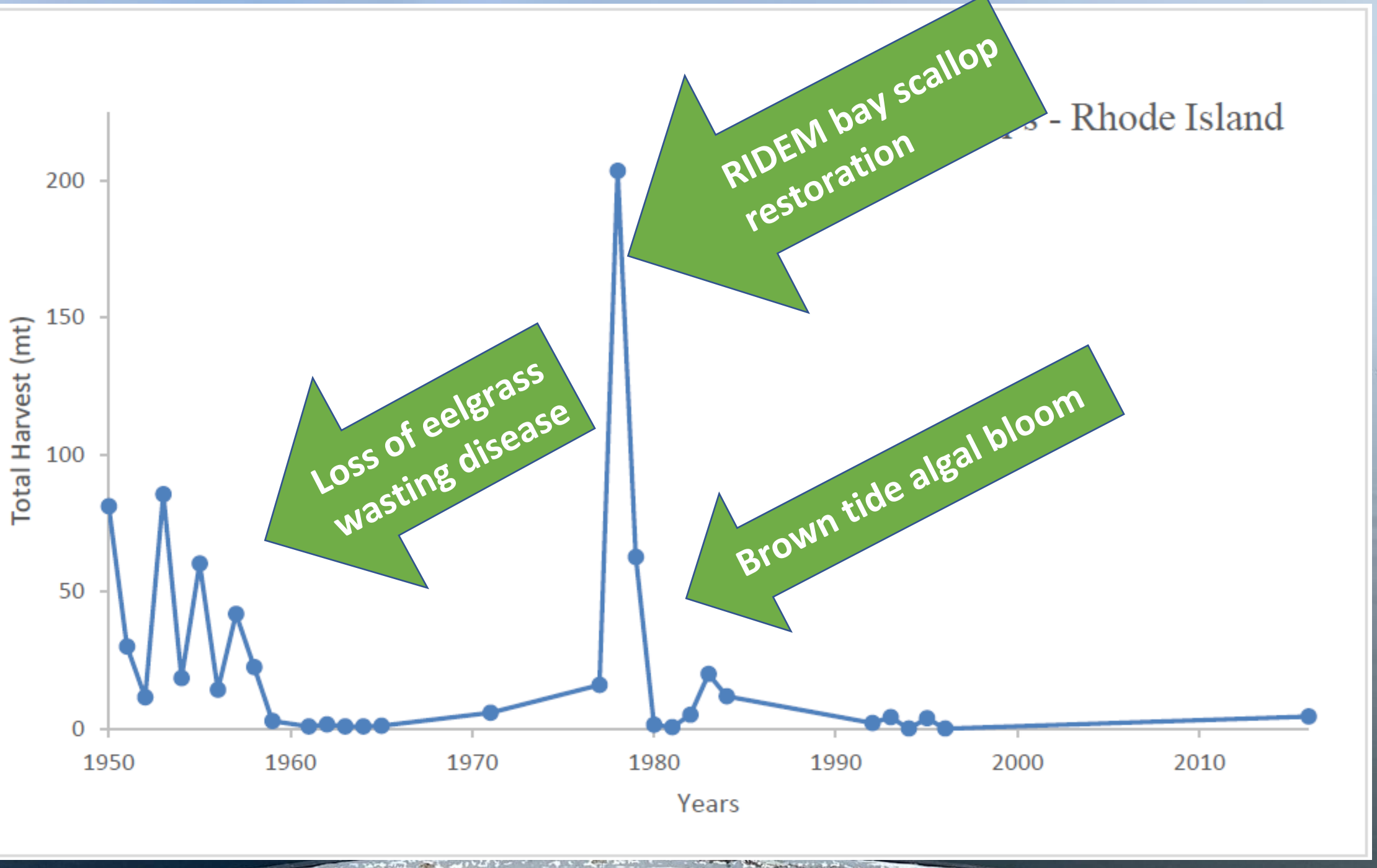
Background

1. *Environmentally sensitive*
   - *Water 20°C to 27°C*
   - *Salinity >24 ppt*
   - *SAV and bottom type*
   - *Predators*
2. Short life cycle - highly variable populations


- Rhode Island
RIDEM bay scallop restoration
Loss of eelgrass wasting disease
Brown tide algal bloom
Total Harvest (mt)
200
150
100
50
0
1950
1960
1970
1980
1990
2000
2010
Years

Restoration Efforts

Years	Lead organization	Location(s)	Restoration strategies used	Results	Source(s)
1969 to 1971	Rhode Island Department of Environmental Management	Narragansett Bay, unspecified coastal salt ponds	Transplanting wild scallops	Qualitative observations suggested acceptable growth and survival of seeded stock; unknown impact on population density or abundance	Sisson (1970) and Russell (1973)
1974 to 1976	Rhode Island Department of Environmental Management	Winnapaug Pond	Free release of hatchery-reared juvenile scallops	1974 trial release was unsuccessful; 1975 release initially considered successful; unknown impact on population density or abundance	Karlsson (1976)
1990 to 1991	Rhode Island Department of Environmental Management	Ninigret Pond, Point Judith Pond, Quonochontaug Pond, Winnapaug Pond	Caged spawner sanctuaries, free release of scallop seed	Growth and mortality rates quantified; unknown impact on population density or abundance	Dinsdale (1991)
2003 to 2008	North Cape Shellfish Restoration Program	Ninigret Pond, Potter Pond, Quonochontaug Pond, Green Hill Pond, Point Judith Pond	Free-planting seed, caged spawner sanctuaries	Quantified increases in bay scallop abundance and settlement in multiple ponds	Hancock et al. (2005, 2006, 2007) and DeAngelis et al. (2008, 2009)
2010 to 2014	Save the Bay	Point Judith Pond, Ninigret Pond	Caged spawner sanctuaries	Quantified increases in bay scallop density in Point Judith Pond and Ninigret Pond	STB (2013, 2014)

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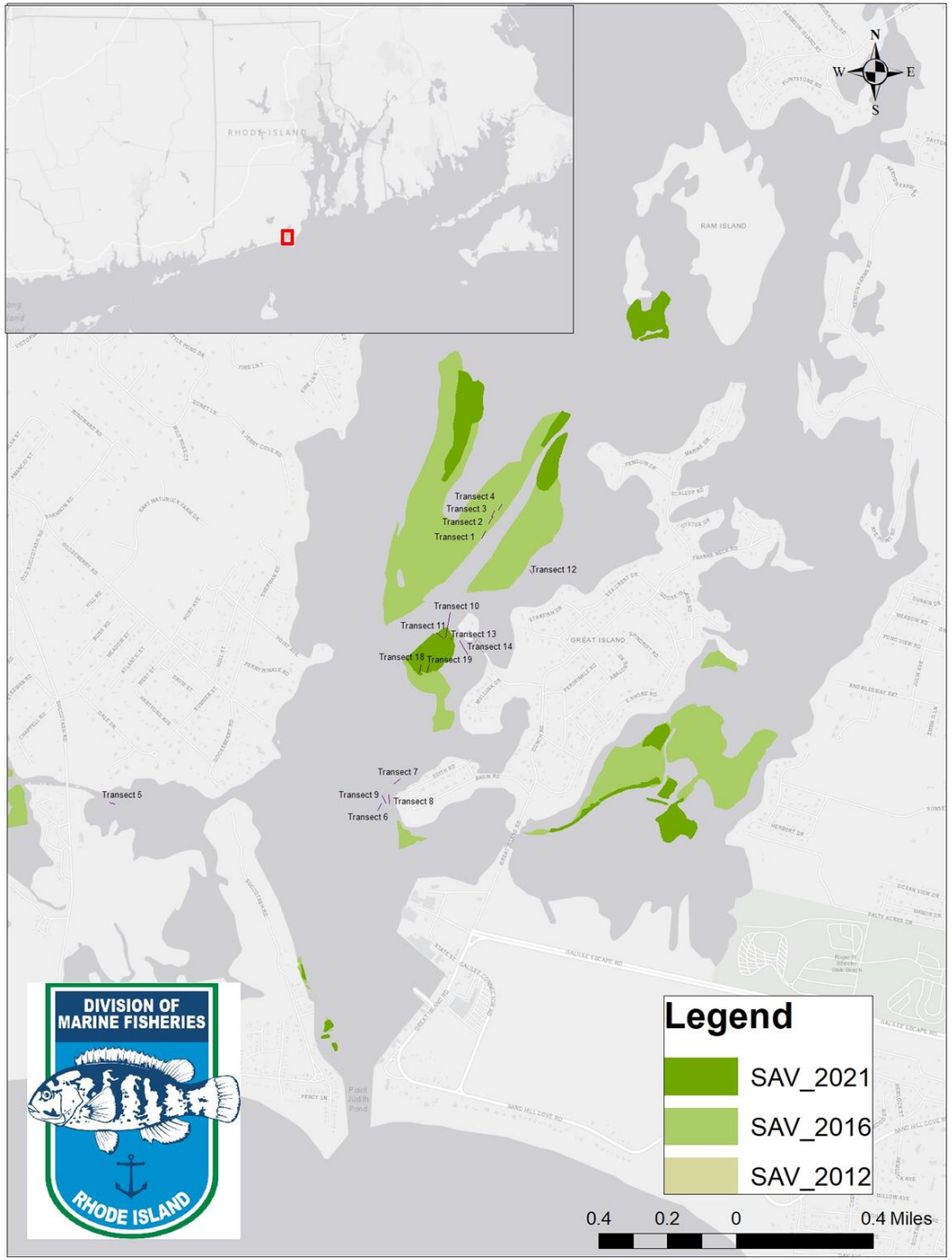
Objectives

1. **Assessment of bay scallop population dynamics within Point Judith Pond**

1. **The establishment of a long-term bay scallop monitoring program within Rhode Island to improve the management and regulation of the species and its associated habitat.**

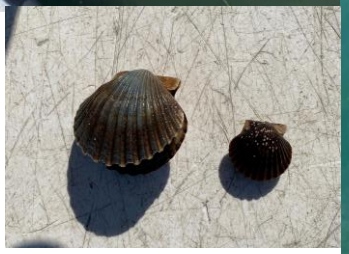
Methods - Divers

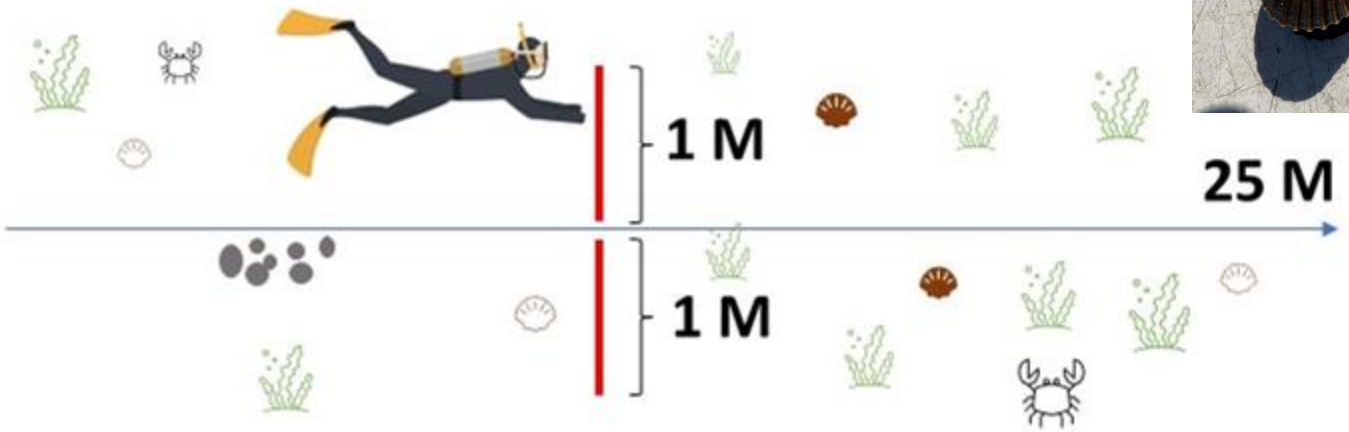
- **Site selection via adaptive sampling design**



Methods - Divers

- Count/measure
- Dead scallops
- SAV type & % cover
- Sediment type & %
- Predators
- Water quality

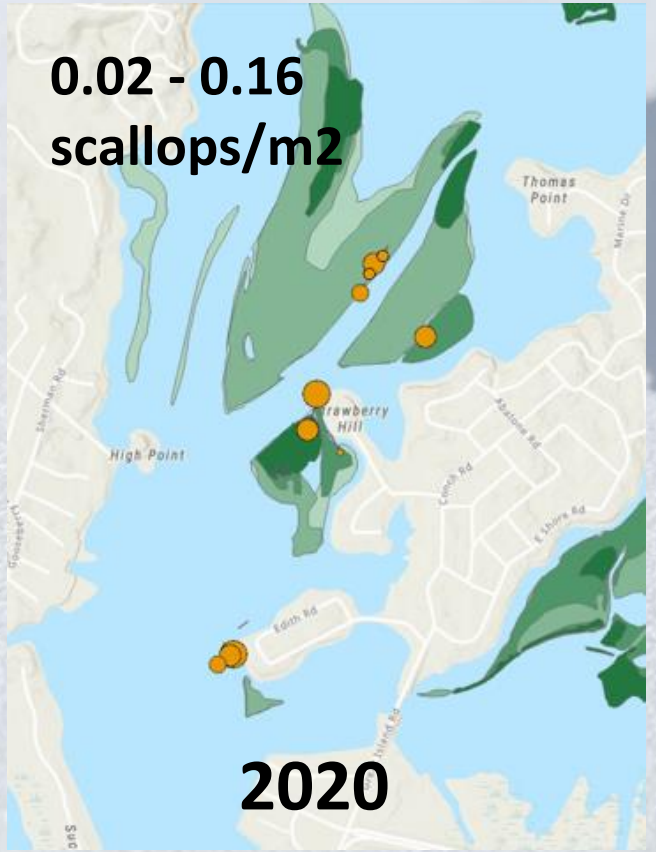


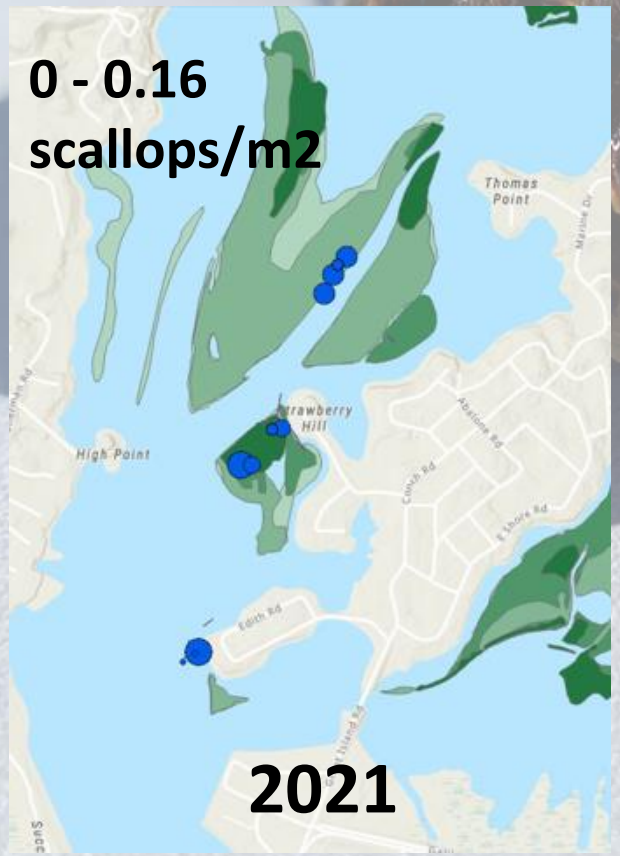


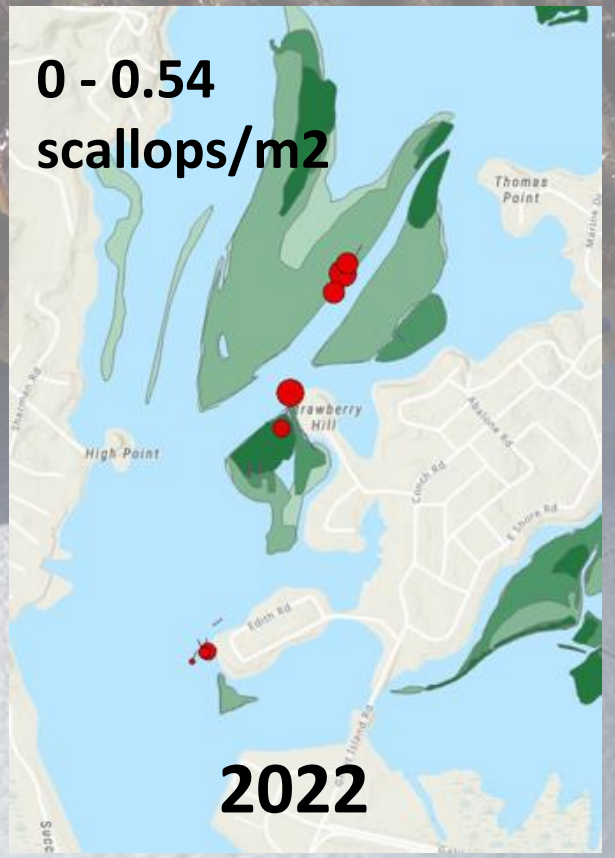
Diver Results

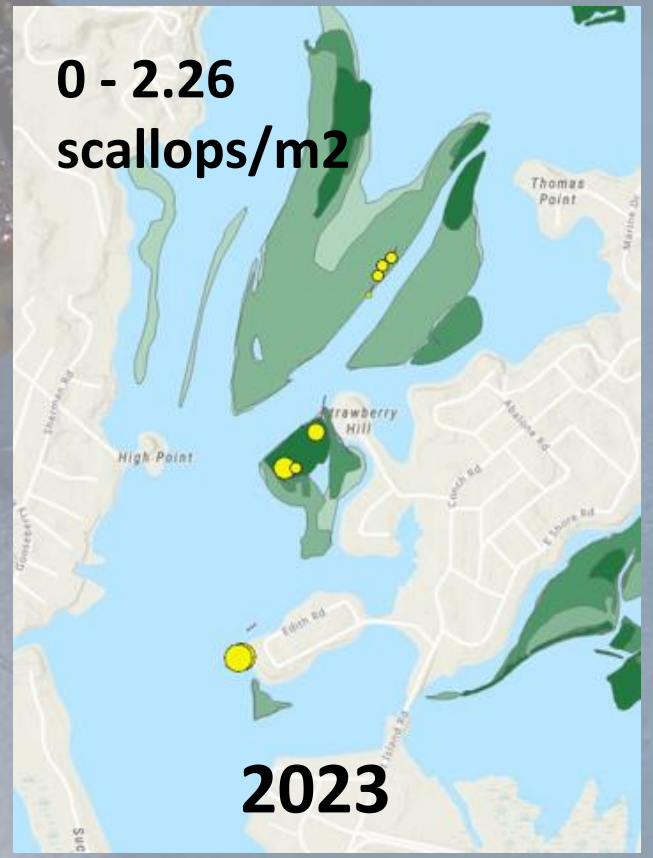
Scallop densities 2020 through 2023

- % SAV coverage and substrate important predictor for scallop abundance - “sweet spot”



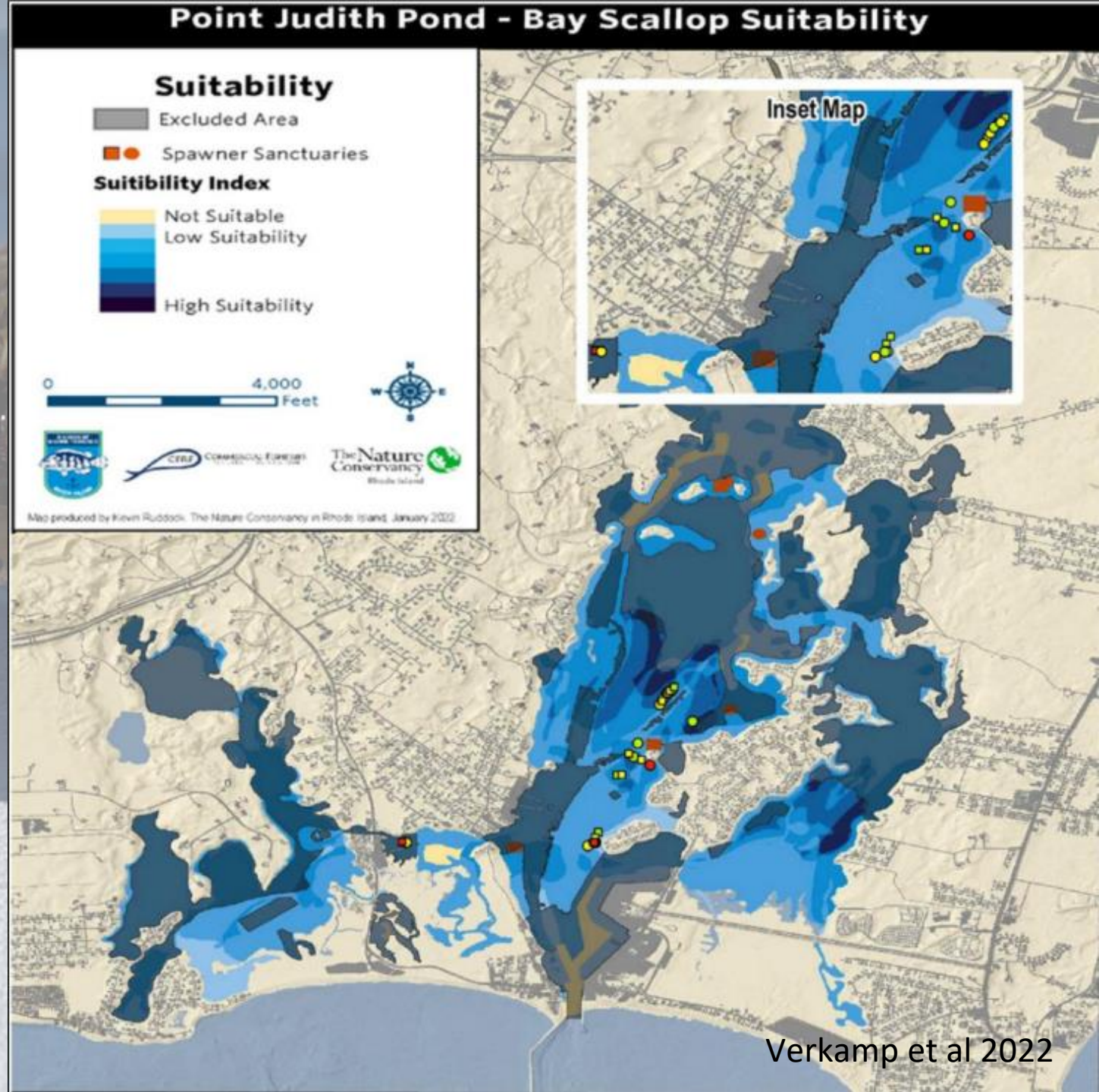






Next Steps

- Compare diver data and processed image data
- Incorporate into updated Habitat Suitability Index
- Continued monitoring
- Actively seeking funding to perform restoration work within PJP



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Methods – Image Collection

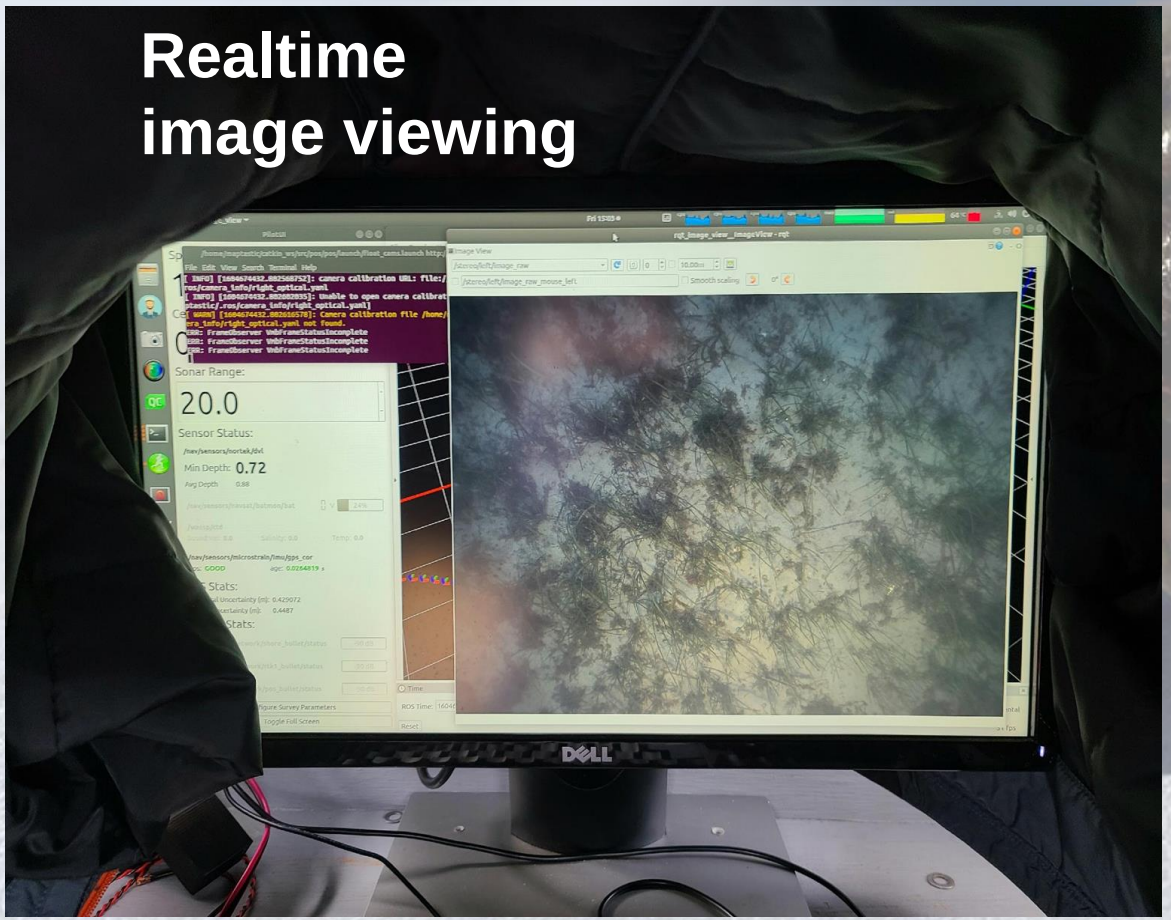
LED strobe (2 msec flash)

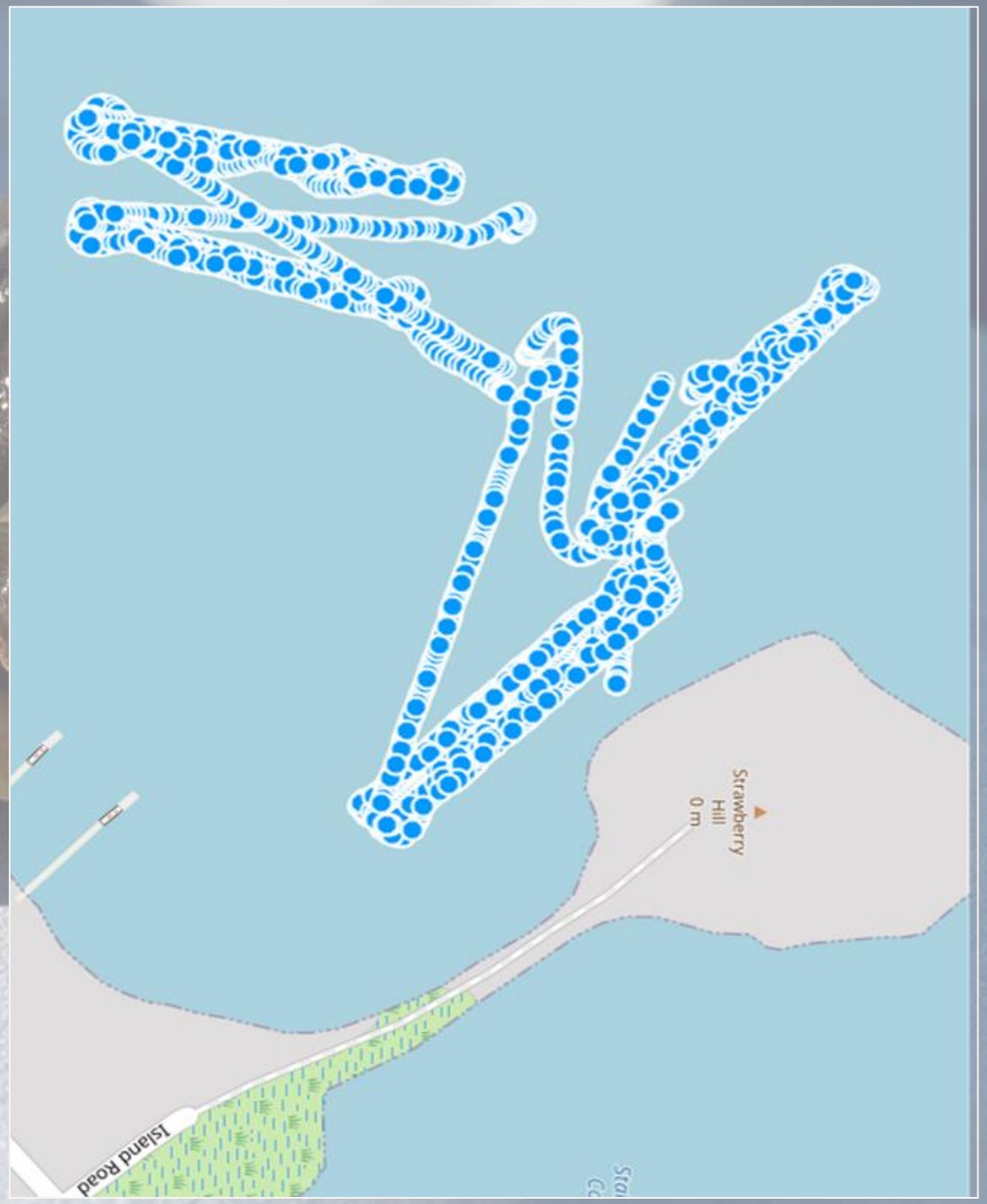
Cameras

Doppler Velocity Log (DVL)
Velocity over the bottom, altitude (not really necessary for this application)

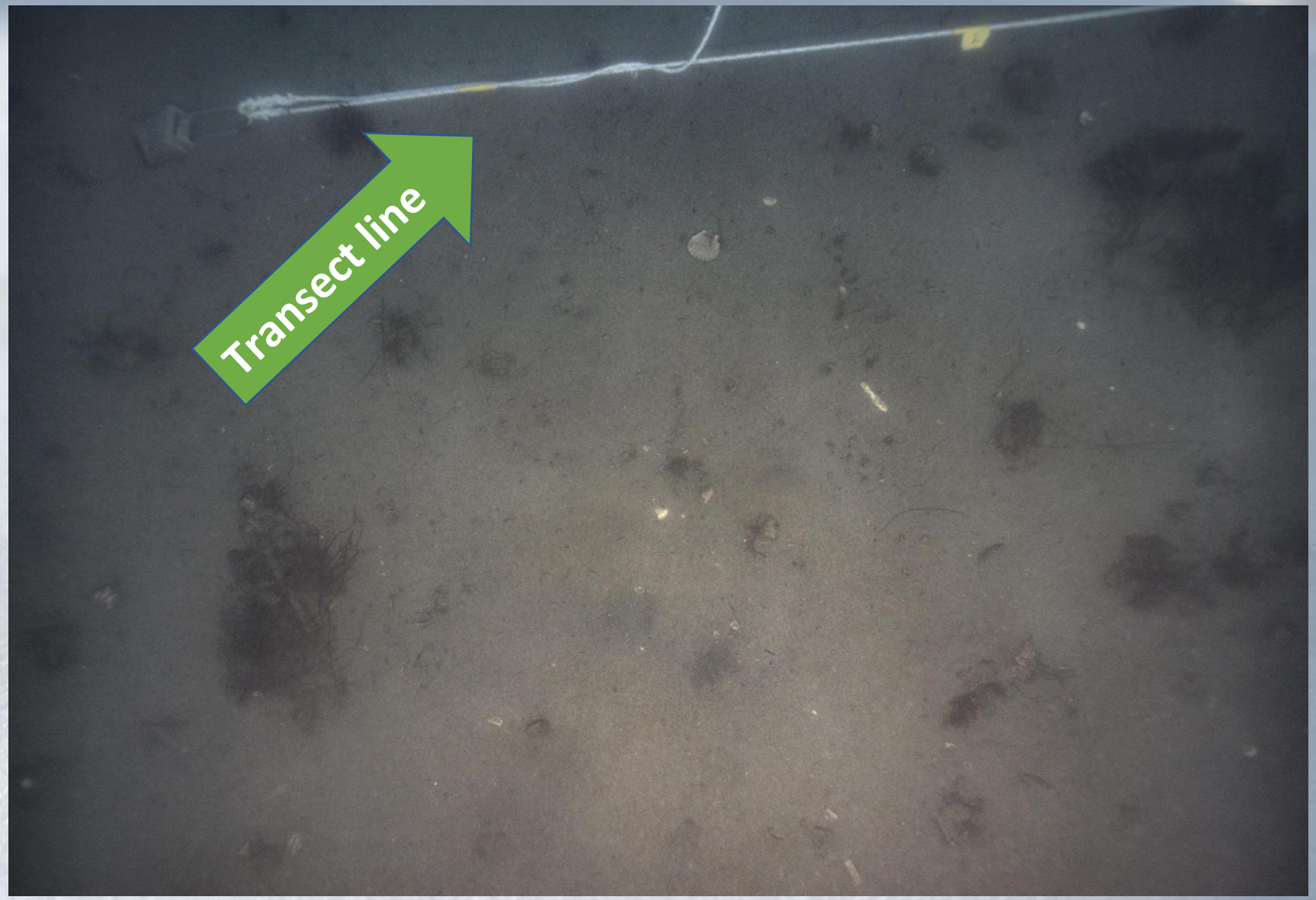
Methods – Image Collection

Methods – Image Collection

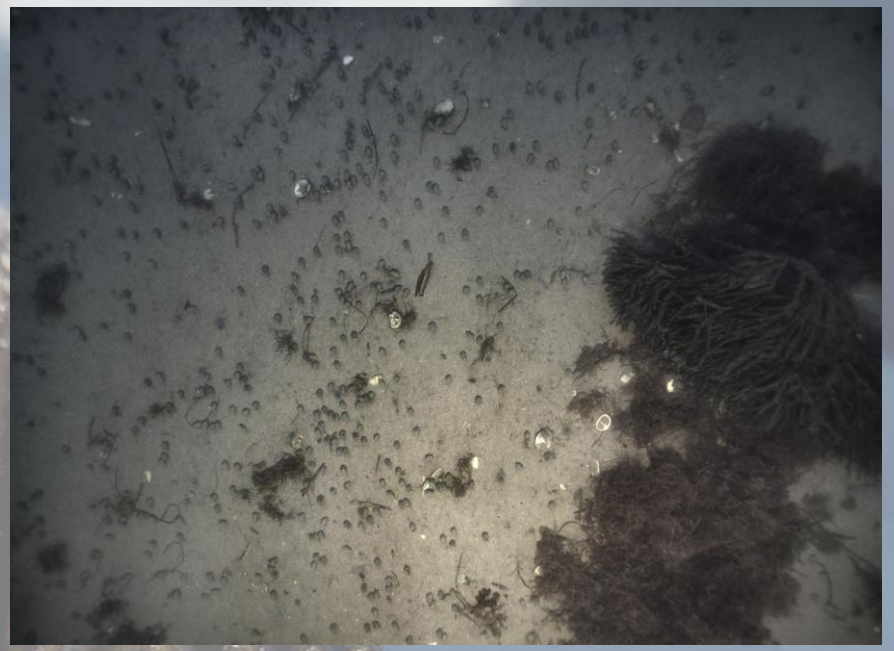


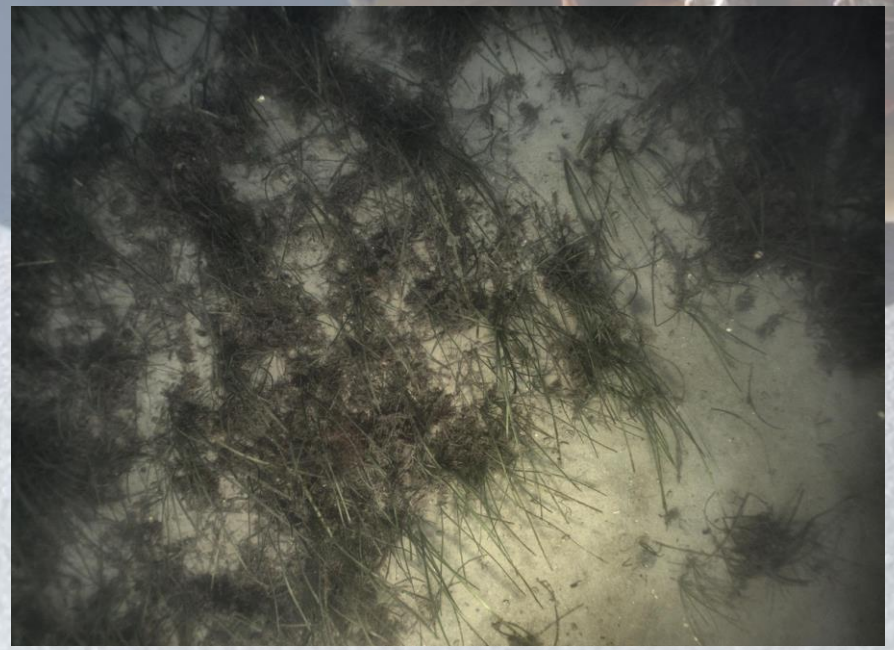


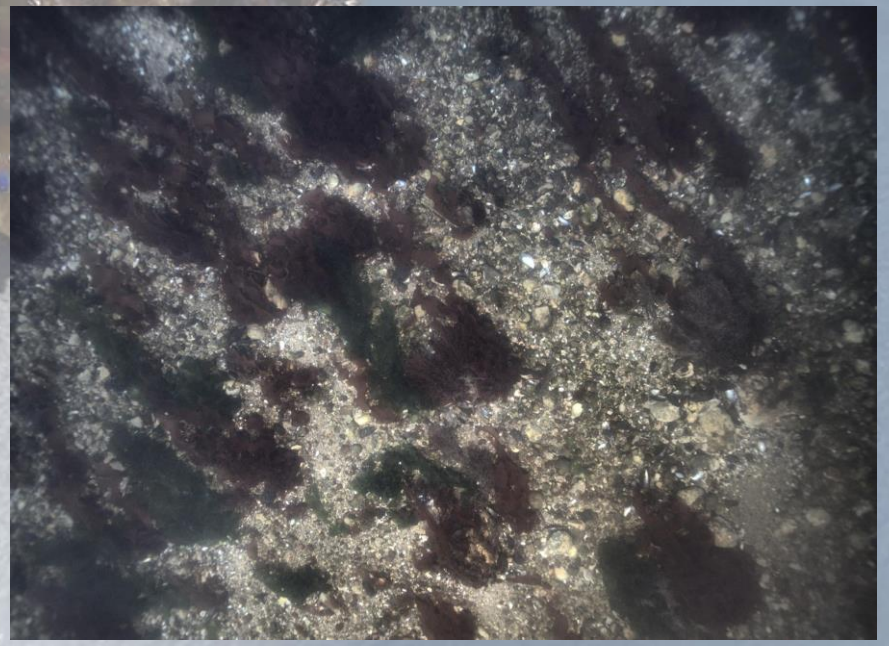
Methods – Image Collection



Methods – Image Collection

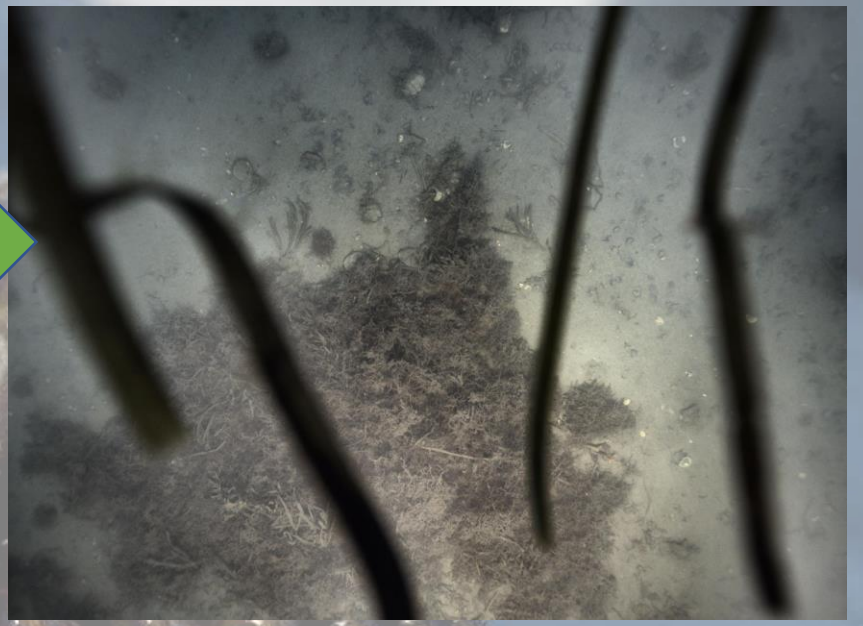






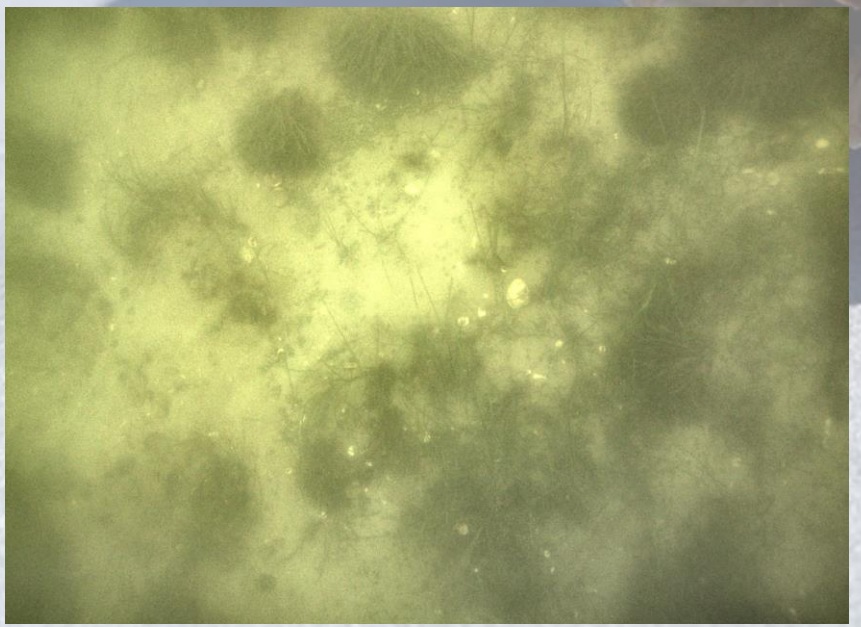
Methods – Image Collection

Weed



Too deep

No strobe



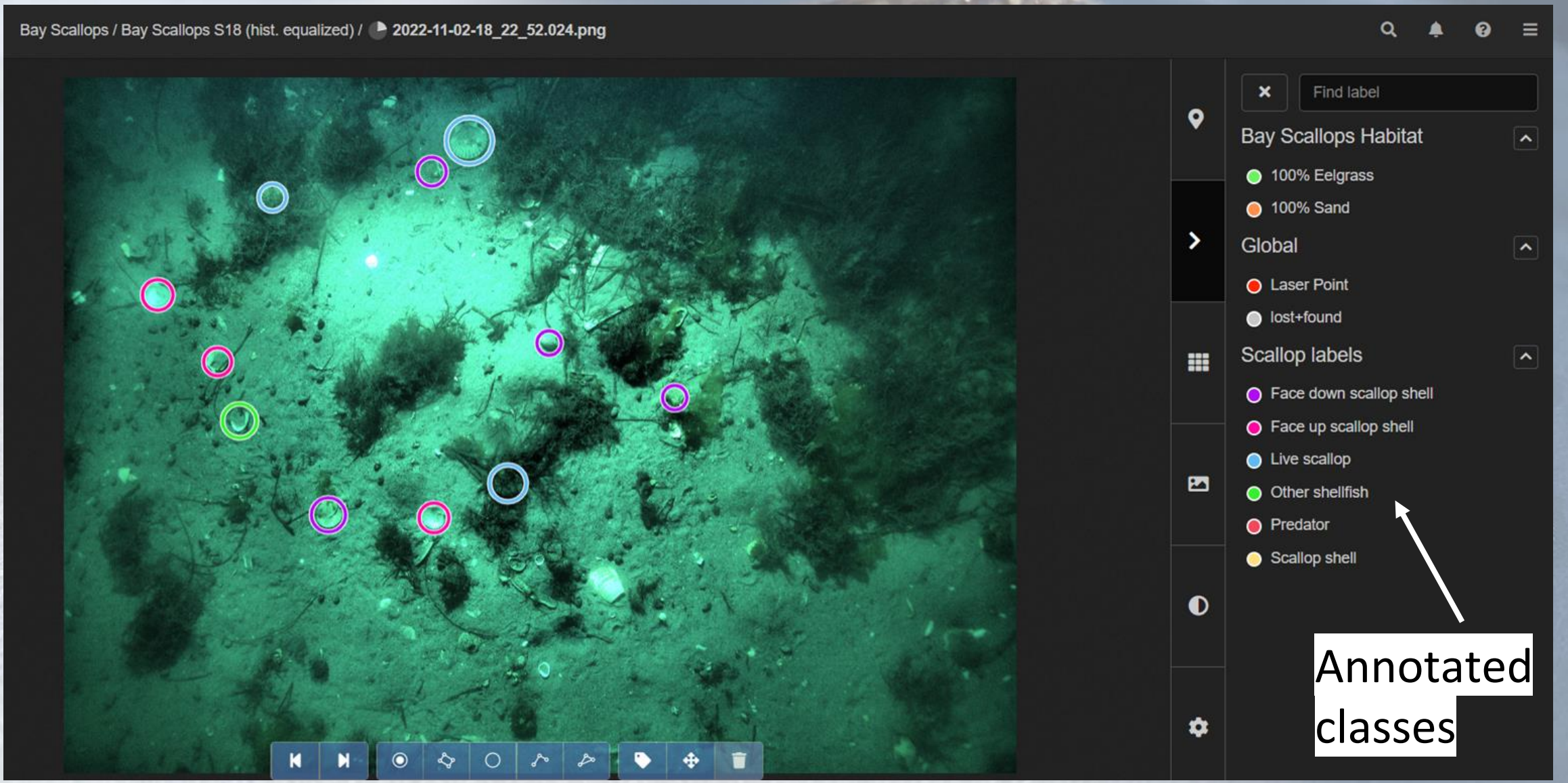
MATLAB Processing

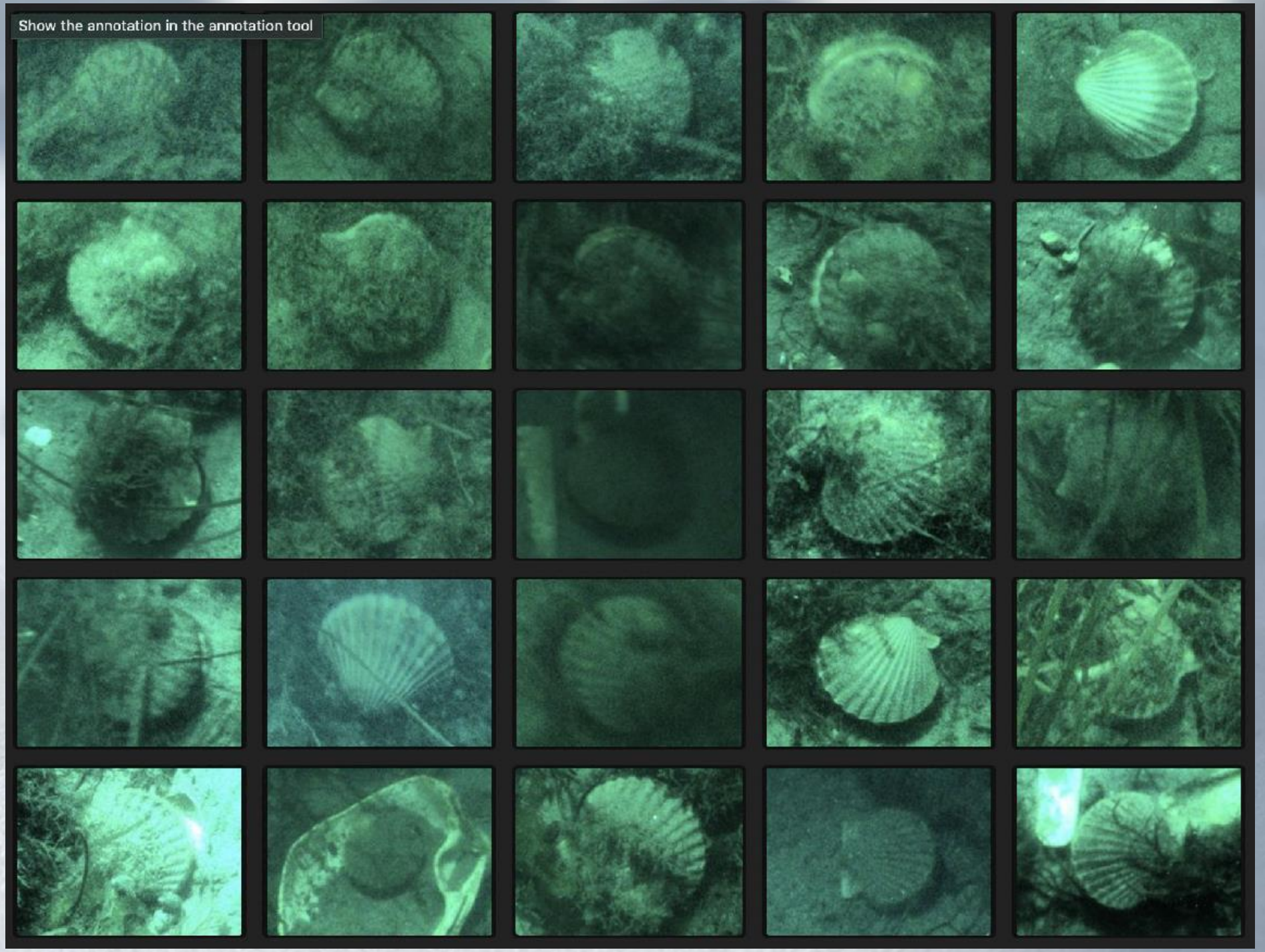
Extracted navigation data from the robot, organized it, saved it to a file

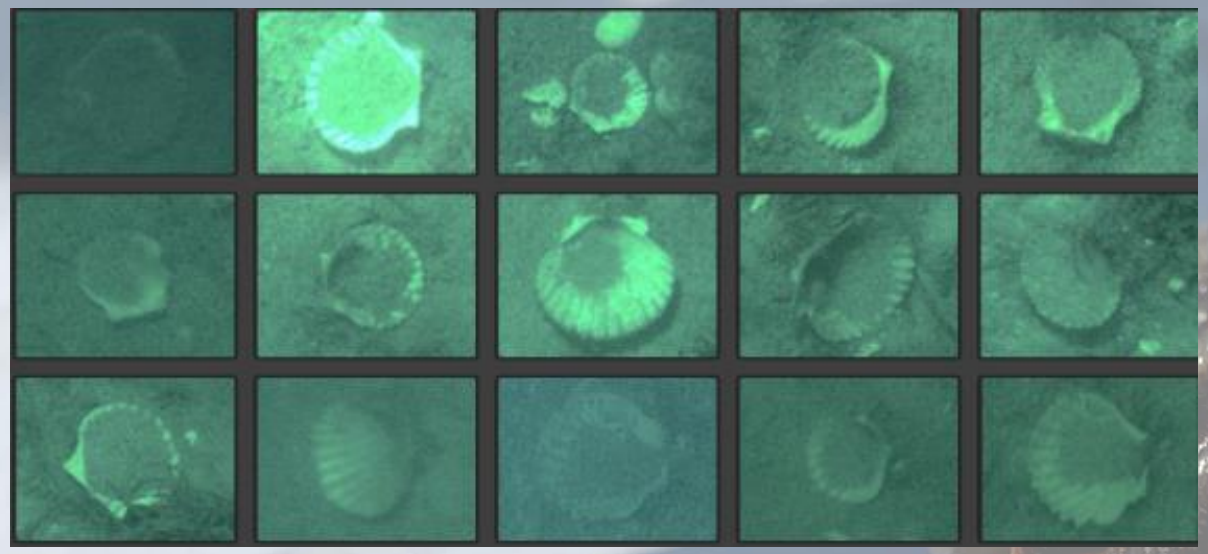
Extracted images from the robot, made them clearer, renamed them

Matches the image names with the nav data, only selecting images with corresponding nav data, compiles into a CSV (excel sheet)

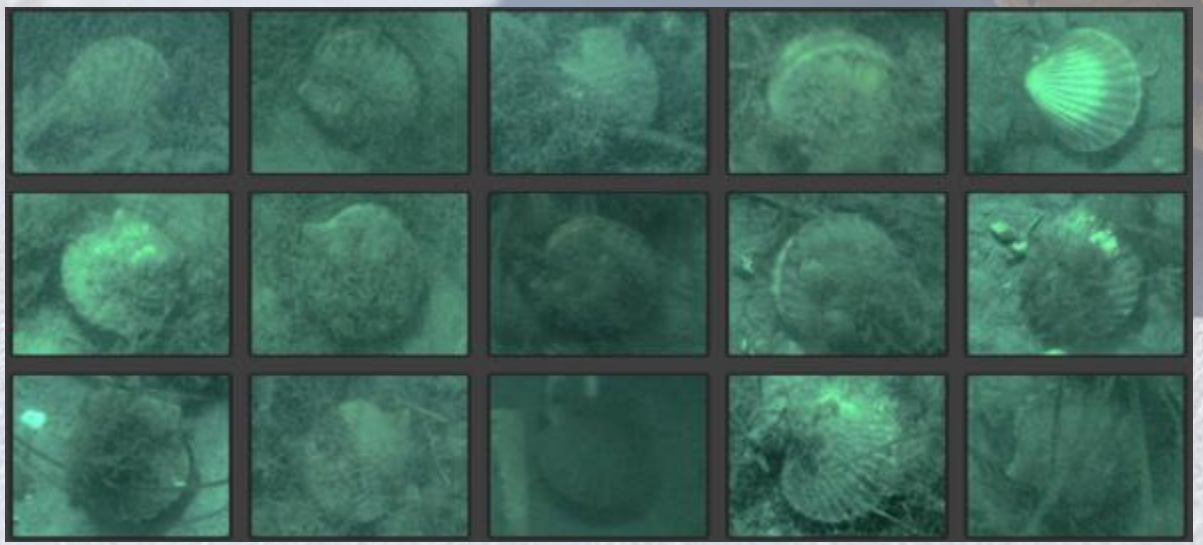
Image Annotation Using BIIGLE – BioImage Indexing, Graphical Labeling and Exploration




Show the annotation in the annotation tool

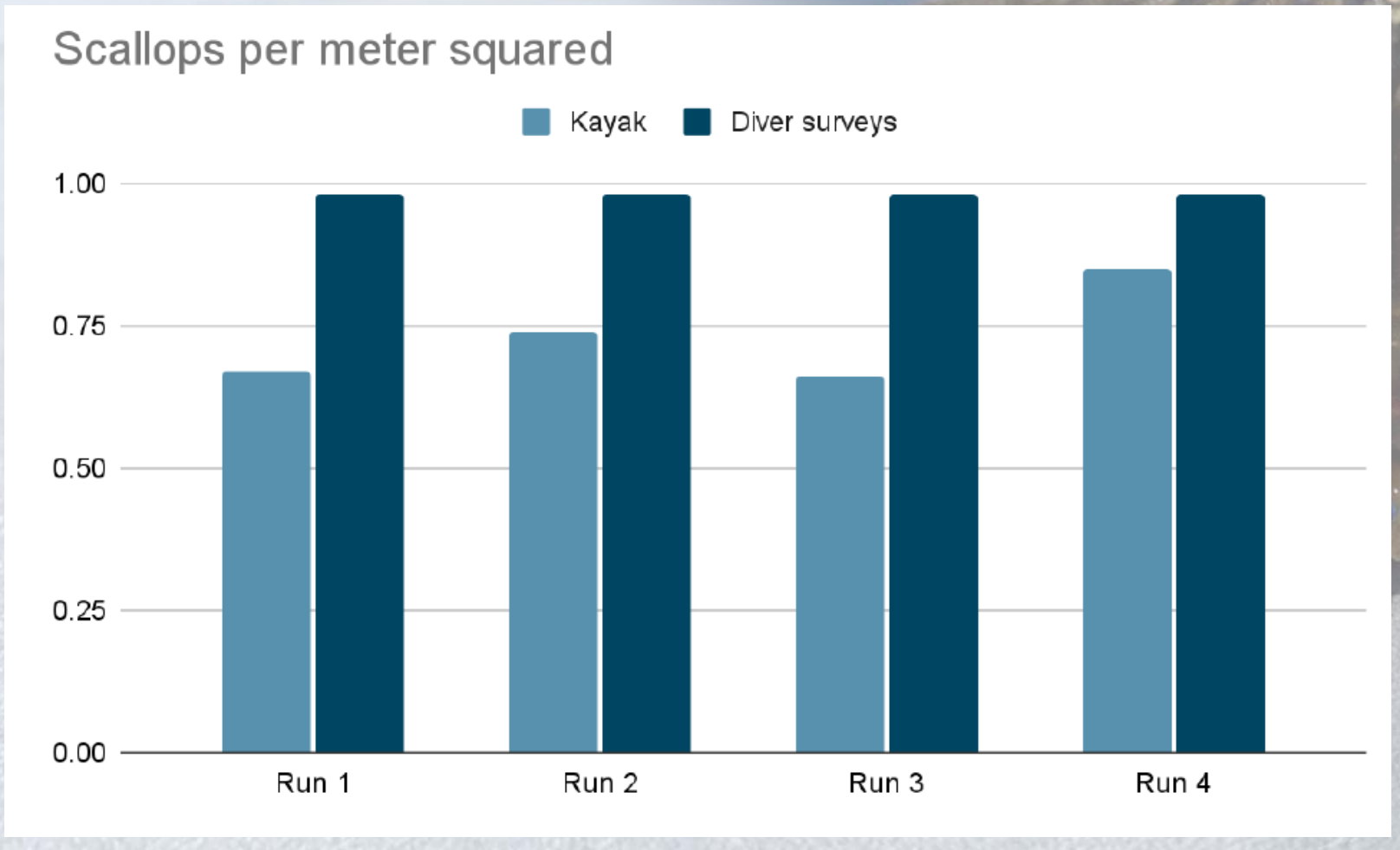


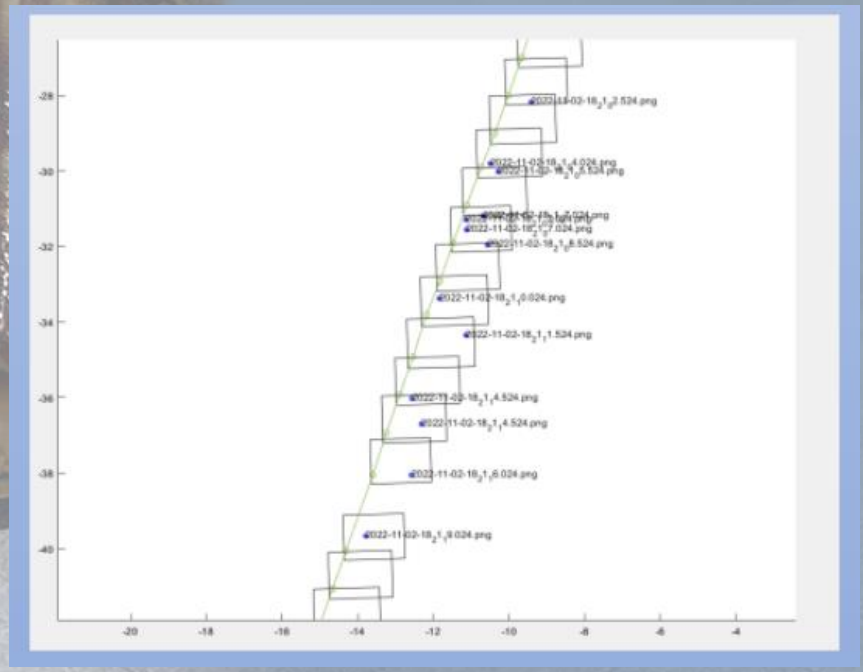
Face up scallop



Live scallop

70% accuracy of the autonomous vehicle





YOLOv5 (You Only Look Once)

- Machine Learning image recognition program
- User manually labels some images for training
- YOLO then identifies similar targets in other images

Precision - Fraction of positive predictions that actually belong to the positive class.

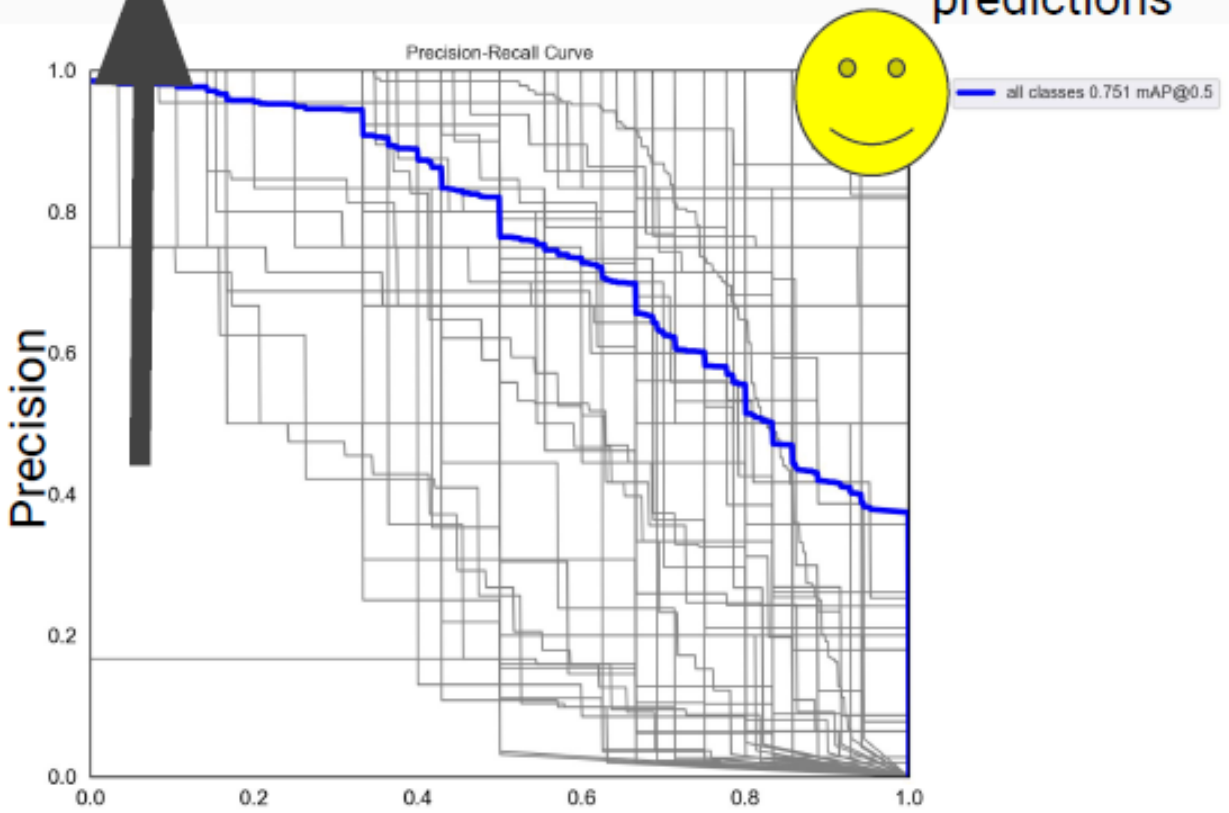
$$precision = PPV = \frac{TP}{TP+FP}$$

Recall -Fraction of positive predictions out of all positive instances in the data set.

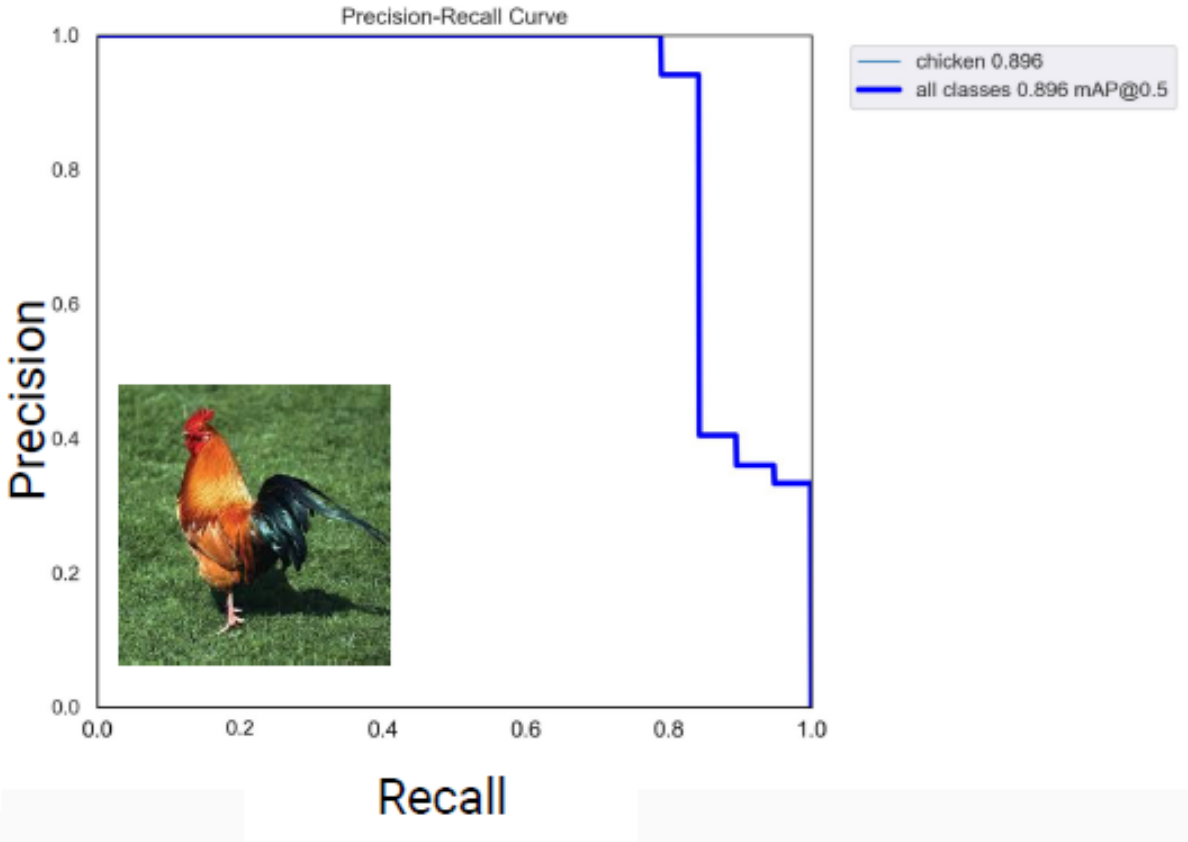
$$recall = sensitivity = \frac{TP}{TP+FN}$$

Making no false positives

This corner is perfect predictions

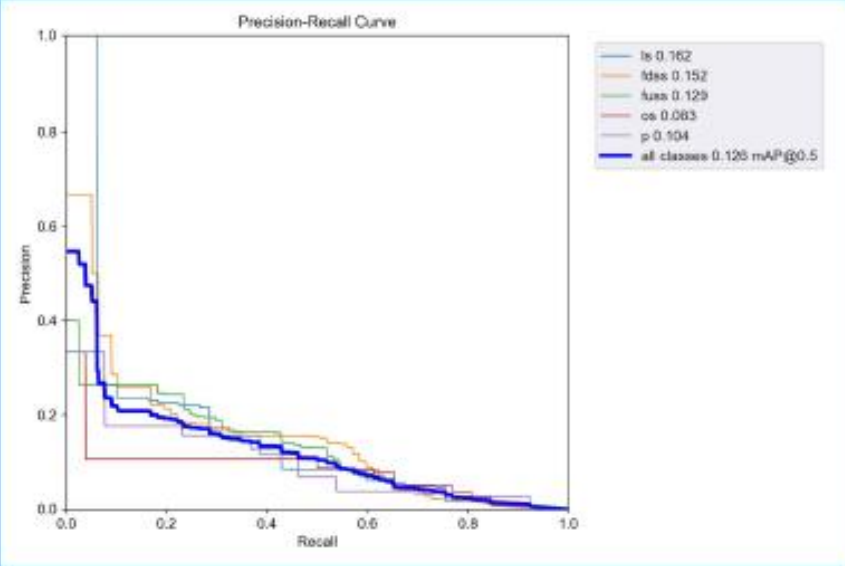


Not missing any positives

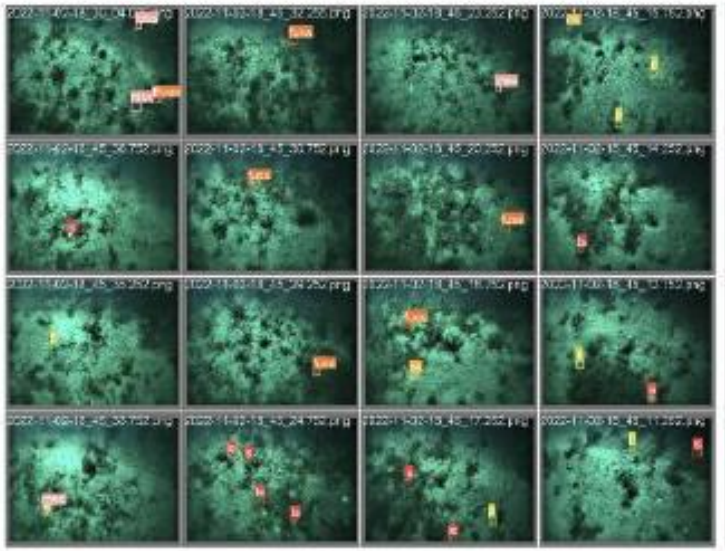


Five Label Test

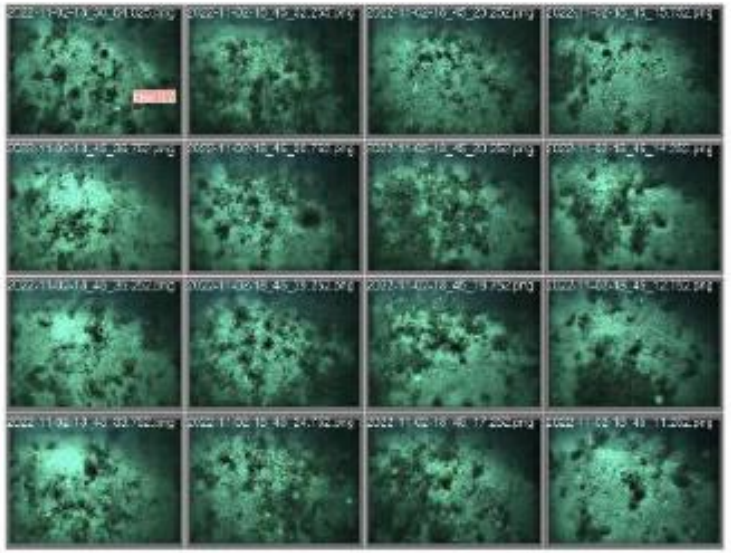
- With two major datasets complete (~500 images) tried to test
- Very poor results

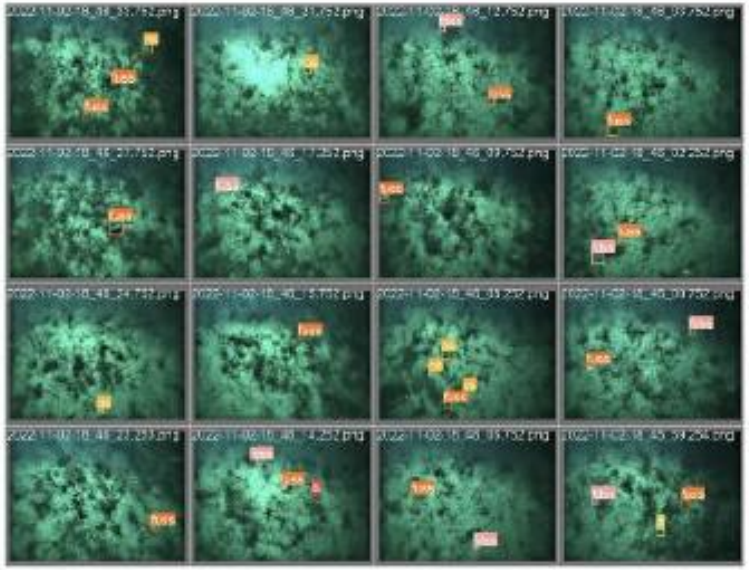


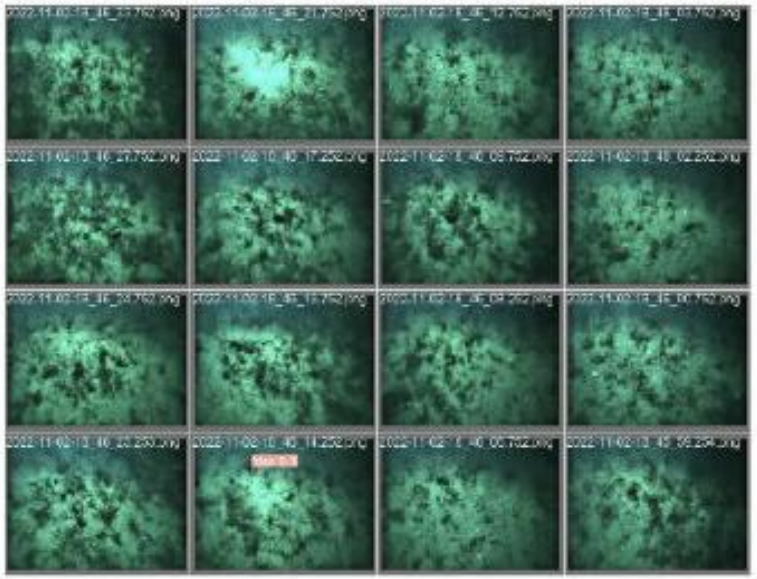
Manually Labeled Data



YOLO's results

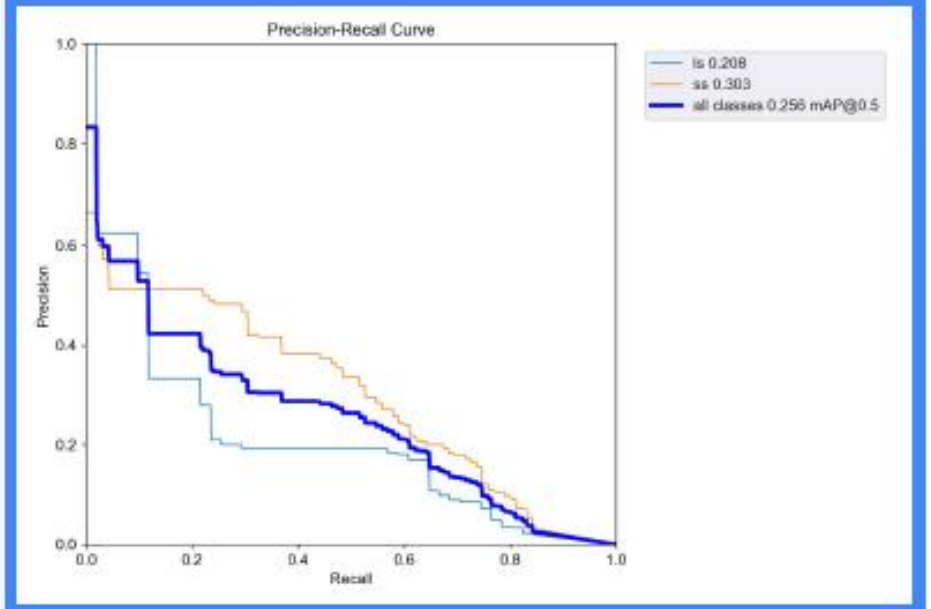




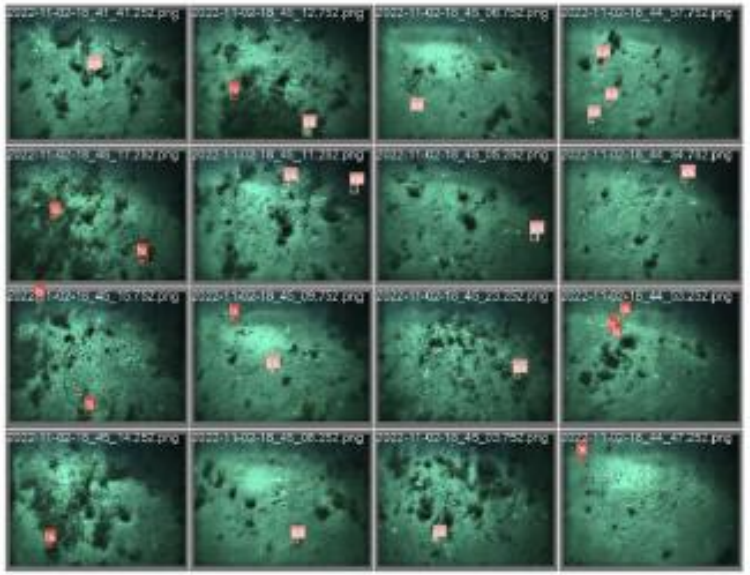


Two Label Test

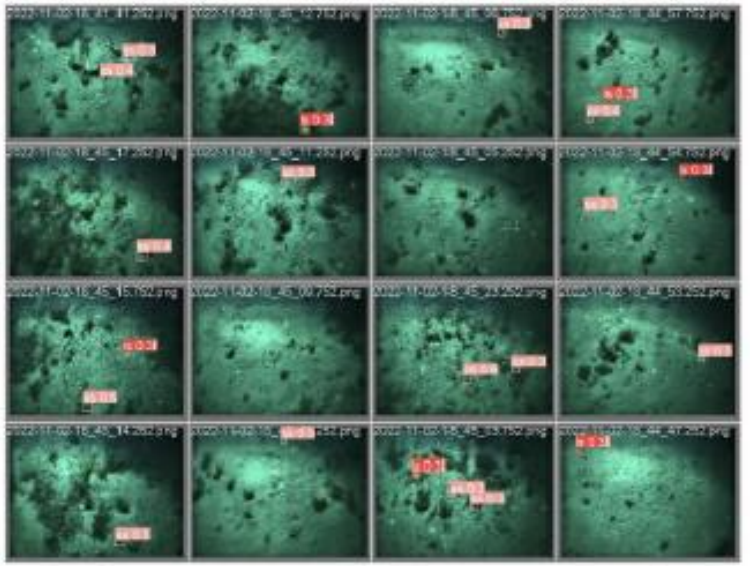
- Could number of classes be an issue?
- Tried with just “live scallop” and “scallop shell”
- Twice the precision and recall as the previous test, still sub 80

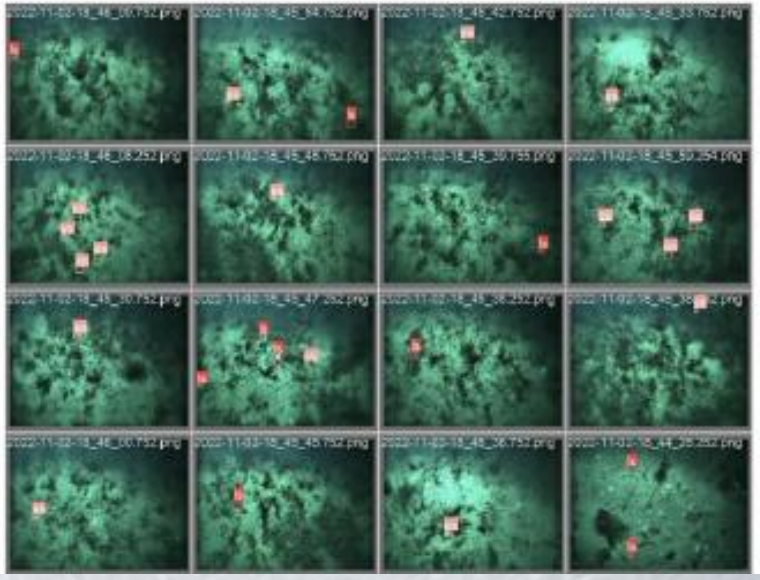


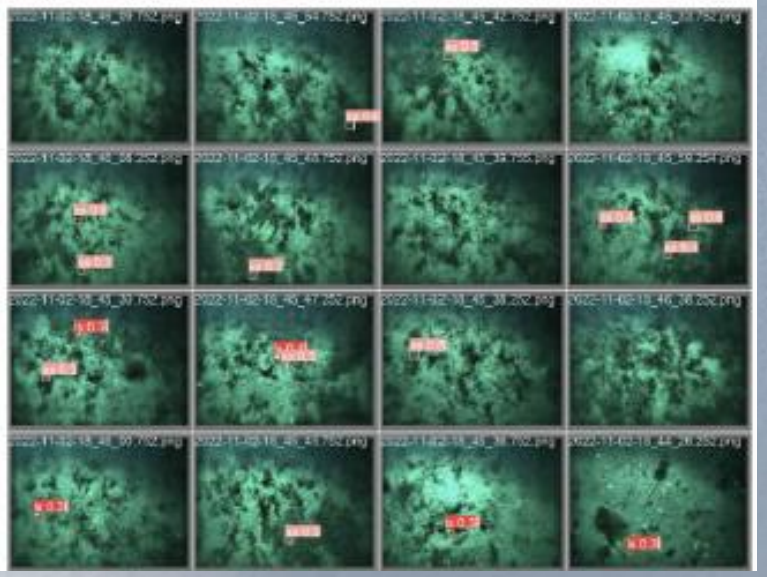
Manually Labeled Data



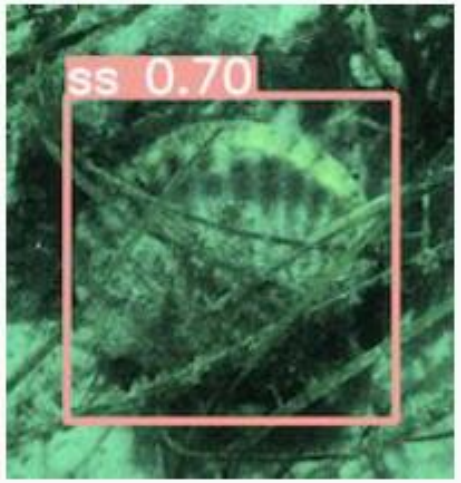
YOLO’s results

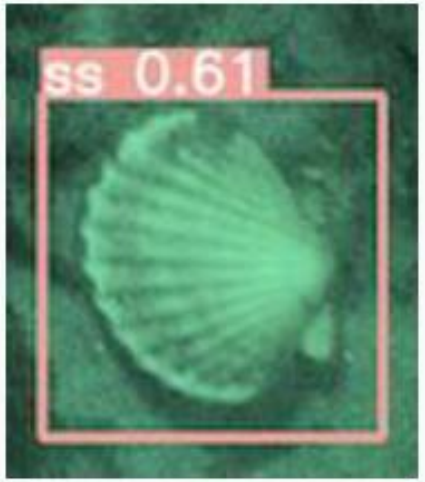


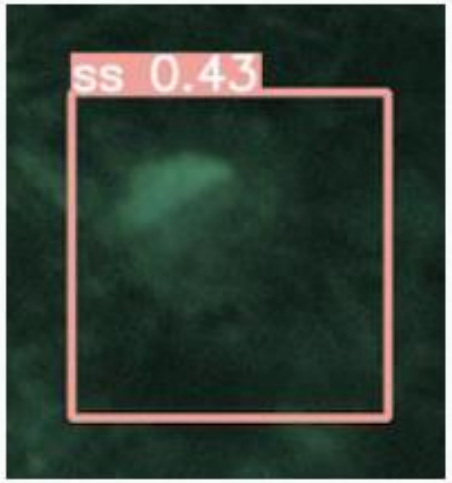




Examples Of YOLO Identifications On New Dataset

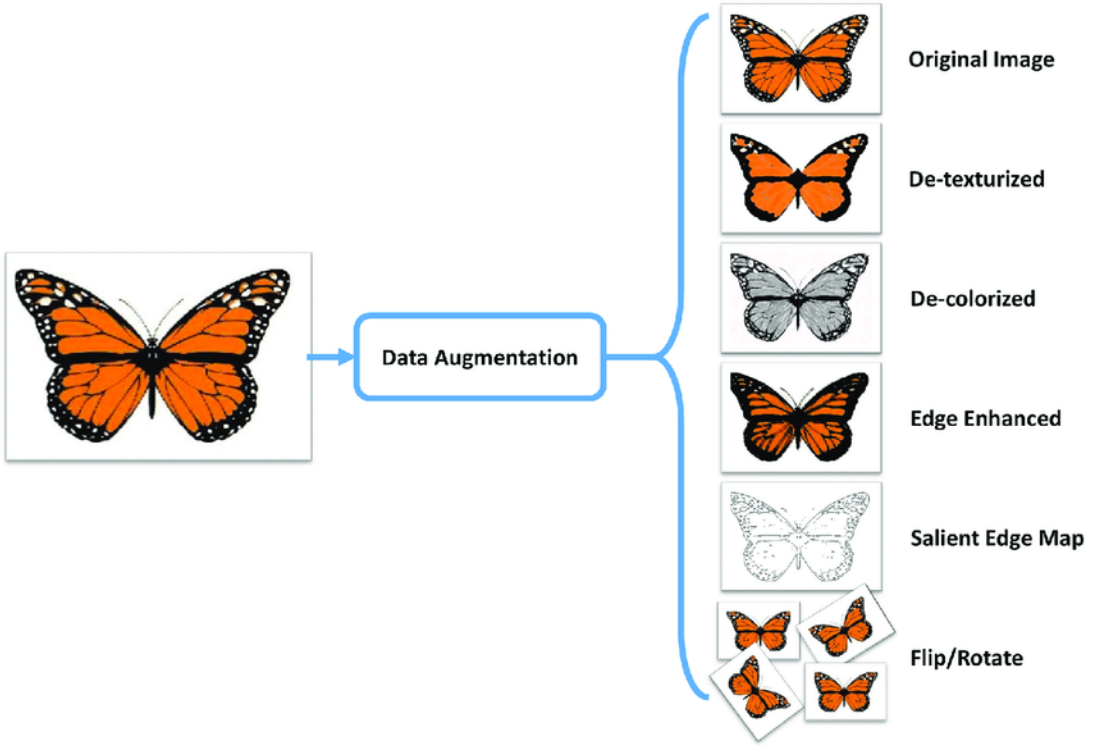






Data and Augmentation

- With limited training data, can use augmentation to create more
- Common tool



- **Type 1**: creates 1.5 and 0.5 contrasts of each image and then generates three separate color spaces (i.e. ycrcb, lab and hsv)

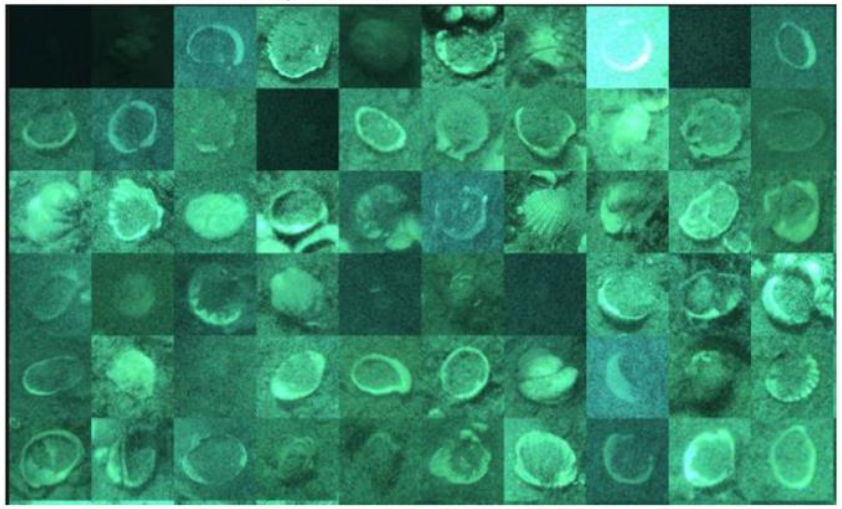
- **Type 2**: applying an CLAHE adaptive thresholding and generate an image with hsv color space
- **Type 3**: applies type 2 augmentation and generates rotations of the image in 45, 90 and 135 degrees

Experiment Results Overview

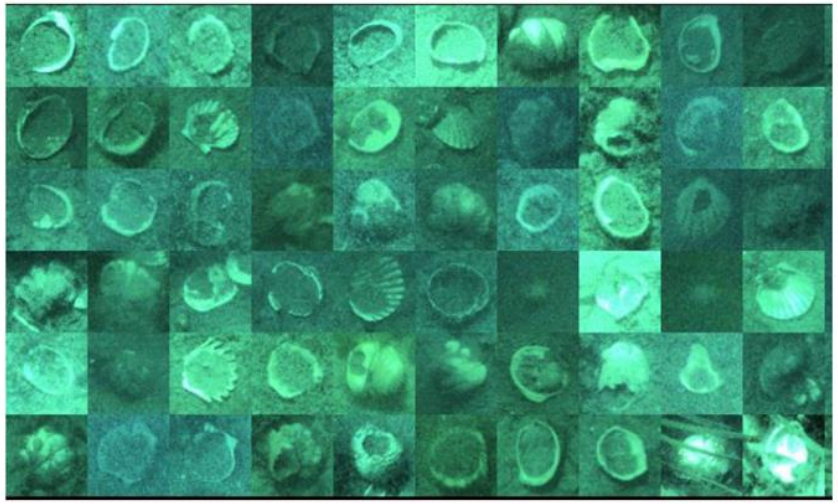
Exp	Class Group	Augmentation Type	Number Of Images	Precision	Recall	mAP
1	All Classes	1	2385	0.34	0.114	0.093
2	All Classes	2	795	0.13	0.355	0.18
3	Scallop Variants	2	795	0.259	0.405	0.235
4	Live scallop	1	1152	0.61	0.327	0.403
5	Live scallop	2	384	0.713	0.449	0.481
6	Live scallop	3	1094	0.6	0.449	0.443
7	Live scallop	3	1152	0.625	0.482	0.482

Sample Detections

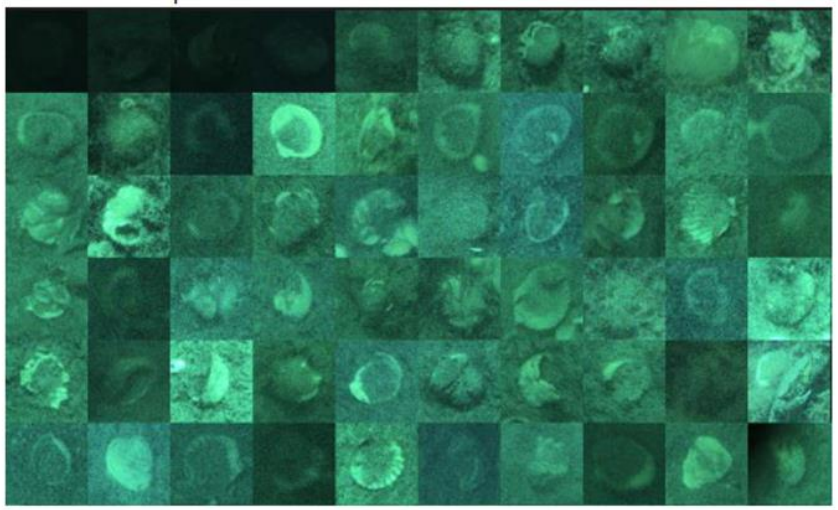
Face down scallop shell



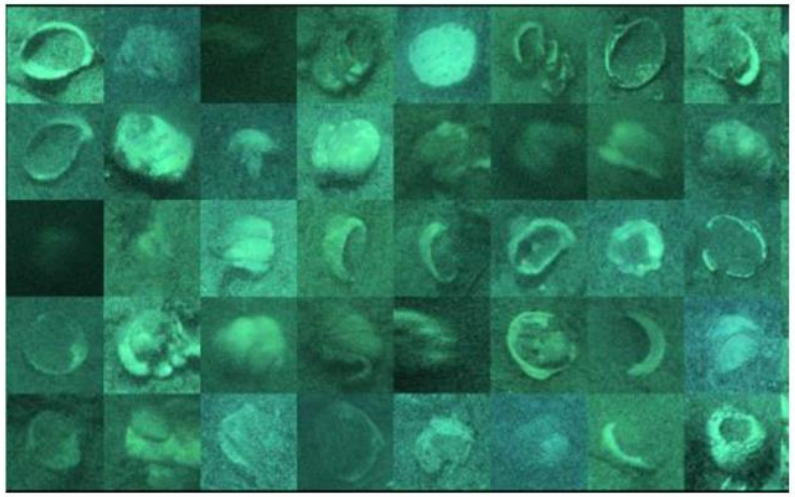
Face up scallop shell



Live scallop



Other Shellfish



Discussion

- Data augmentation and class reduction improved results.
- Best performing model focused only on 'Live scallop' class.
- Improvements highlight the impact of clean, balanced data.

Conclusion

- YOLOv5 effectively detects live bay scallops.
- Precision improved from 20% to 65% with tuning.
- Demonstrates potential for automated ecosystem monitoring.
- Future work:
  - more balanced datasets, better raw images, more training data
  - looking at habitat identification

Questions?

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