Applying Image Recognition to Enhance Fisheries Management Capabilities

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Massachusetts Institute of Technology Sea Grant

How Many Herring?

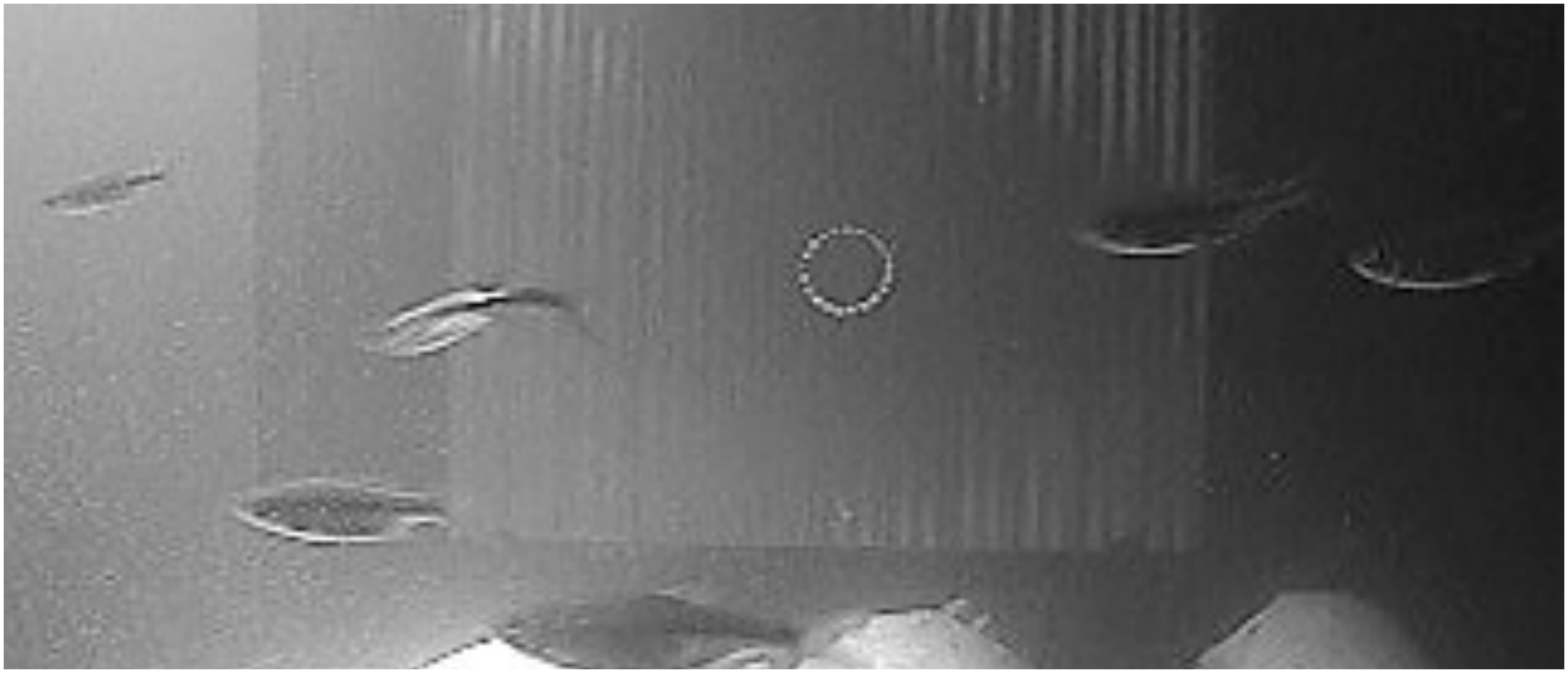
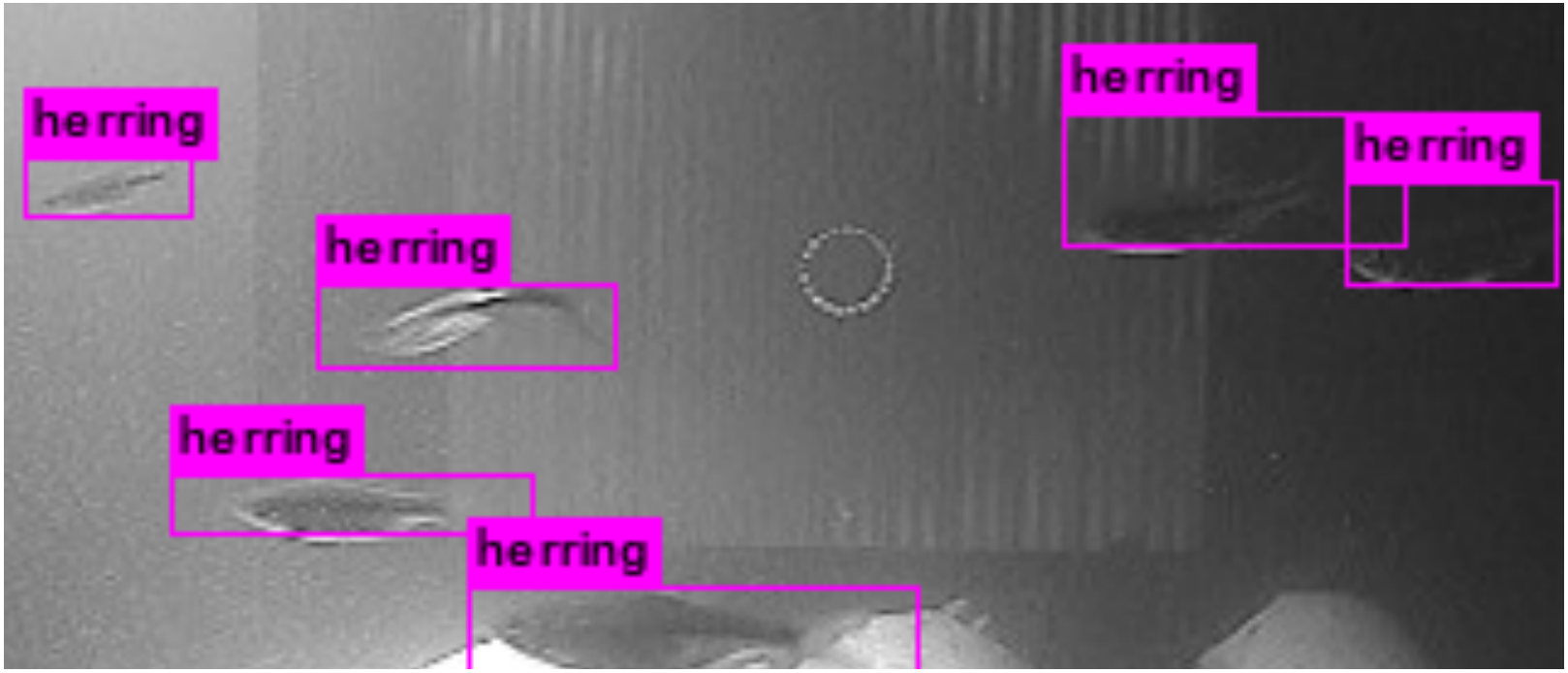


Image Recognition Solution: 6 herring found in 0.01 seconds



Today's Presentation

- Objective
- Background
- Current Technique
- Applying Image Recognition
- Results
- Conclusion
- Future Work
- References

Objective

- To automate the detection and counting of relevant fisheries species in image and video data through image recognition
- Relevant fisheries species:

Alewife Herring /Blue Back Herring (*Alosa pseudoharengus / Alosa aestivalis)*

Atlantic Sea Scallops *(Placopecten magellanicus)*

Skates (Rajidae)

Flatfish, such as flounder (Pleuronectiformes)

Various round fish species

Background

"The world's finest wilderness lies beneath the waves …"
— Robert Wyland, Marine Life Artist

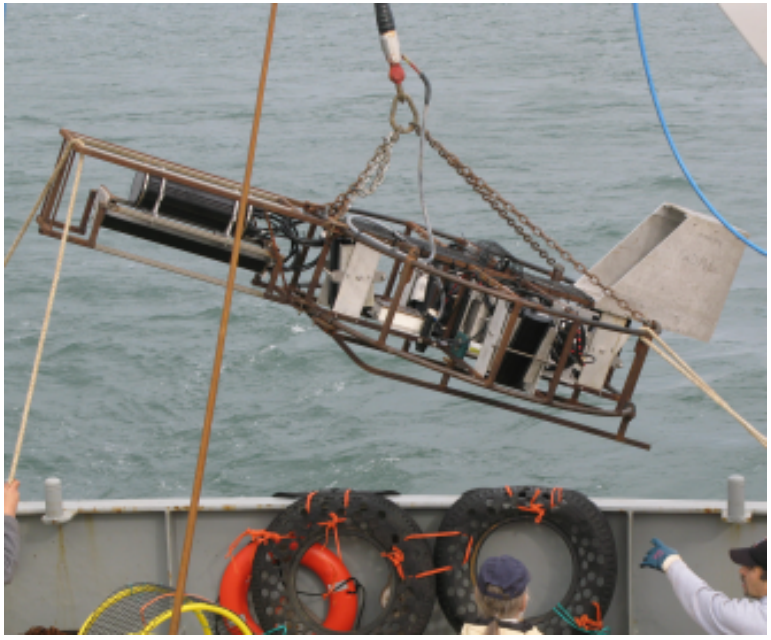
- Fisheries populations have a large impact on the U.S. economy
  - The U.S. fishing industry contributes about **$90 billion** and **1.5 million jobs** to the U.S. economy [4]
  - In 2014, 17% of the U.S. fisheries were classified as overfished [4]
- Therefore, NOAA Fisheries Management is interested in monitoring relevant species populations

Current Technique:

Gather

1. *Gather [underwater photographs]*

- Habitat Mapping Camera System (HabCam)



Current Technique:

Manually Annotate

2. *Manually Annotate [underwater photographs]*

A	B	C	D
Image	Object_Id	Object_Name	Geometry_Text
201503.20150518.153633512.430500.png	1001	unidentified roundfish	"boundingBox": [[508.0037892659505, 22.670461018880207], [796.0037892659506, 240.00379435221353]]
201503.20150604.215648168.717650.png	524	unidentified skate	"boundingBox": [[277.3371225992839, 387.88257853190106], [722.6704559326172, 731.882578531901]]
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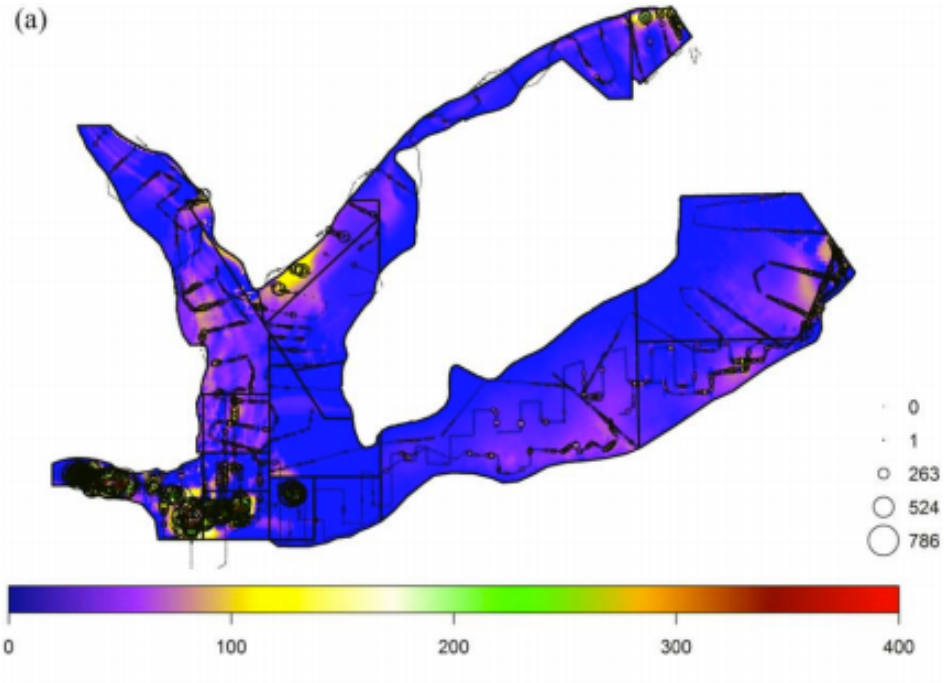
Current Technique:

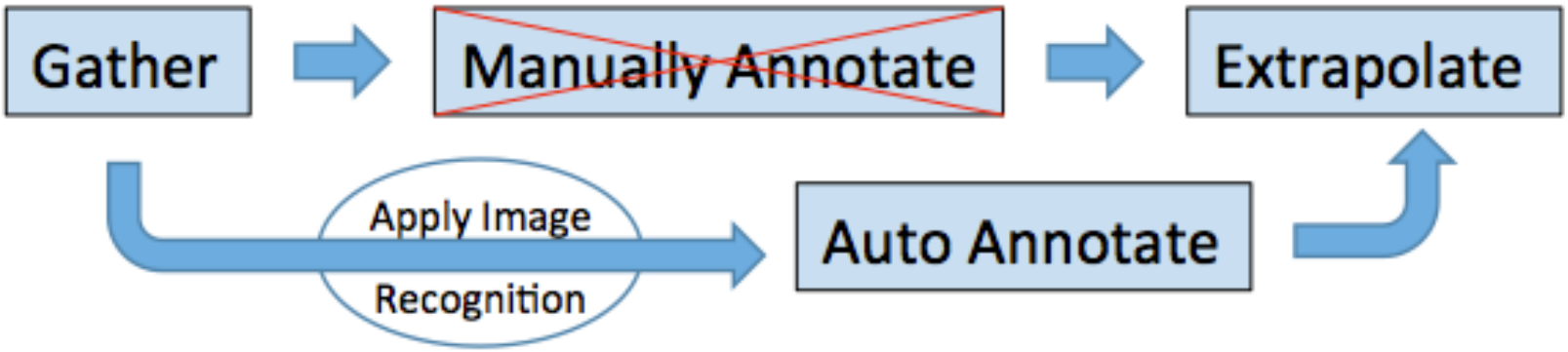
Extrapolate

3. Extrapolate [population estimates]



[1] Chang et al. 2017

Applying Image Recognition

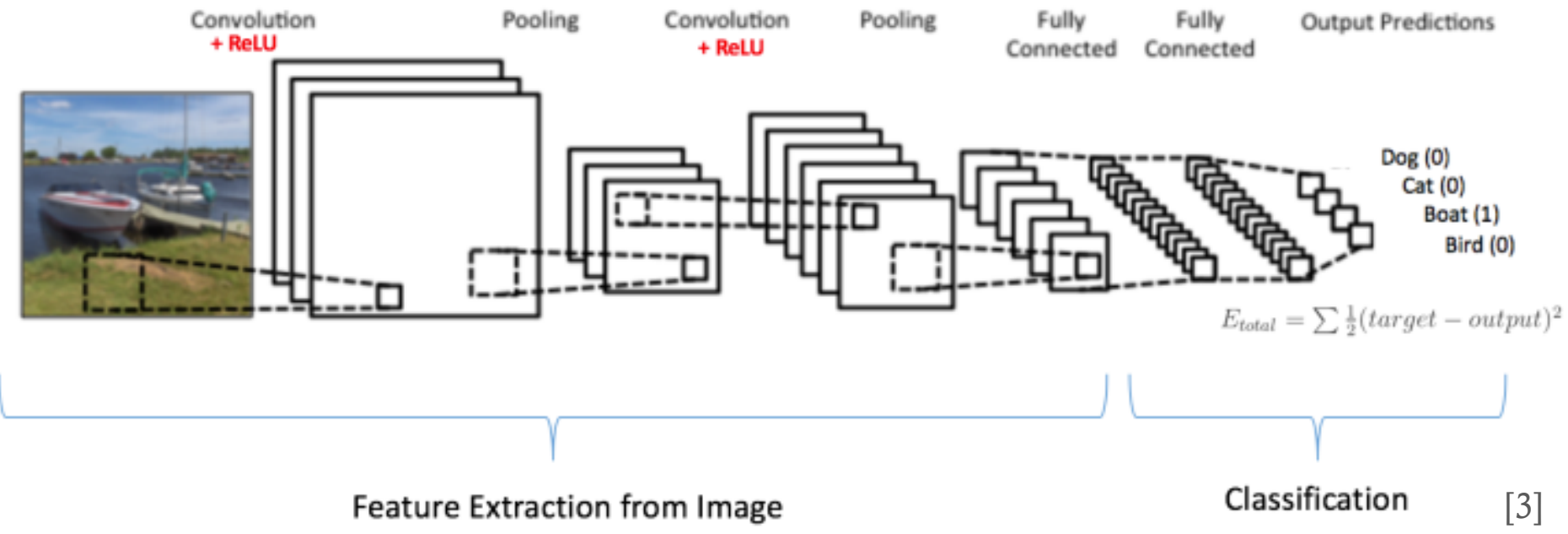


- Can image recognition be used to accurately detect and count fisheries species?
- How many iterations of training are needed to yield accurate results?
- How does the quality of annotations used in training impact accuracy?

Appling Image Recognition:

Convolutional Neural Networks

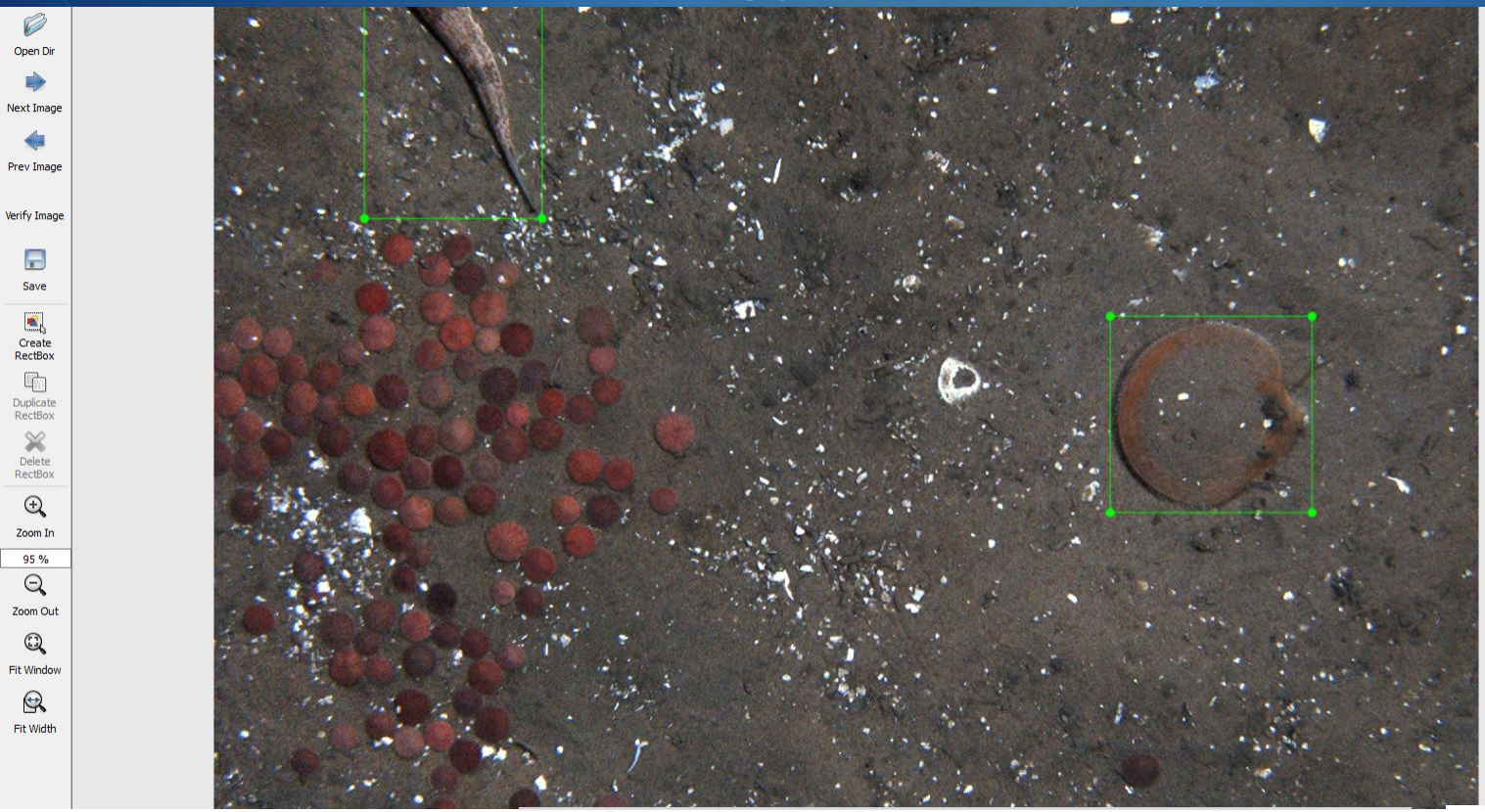
- Loosely based on biological neural networks

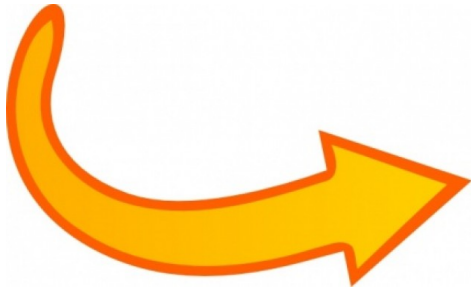


[3]

Applying Image Recognition:

Methodology – Gather & annotate





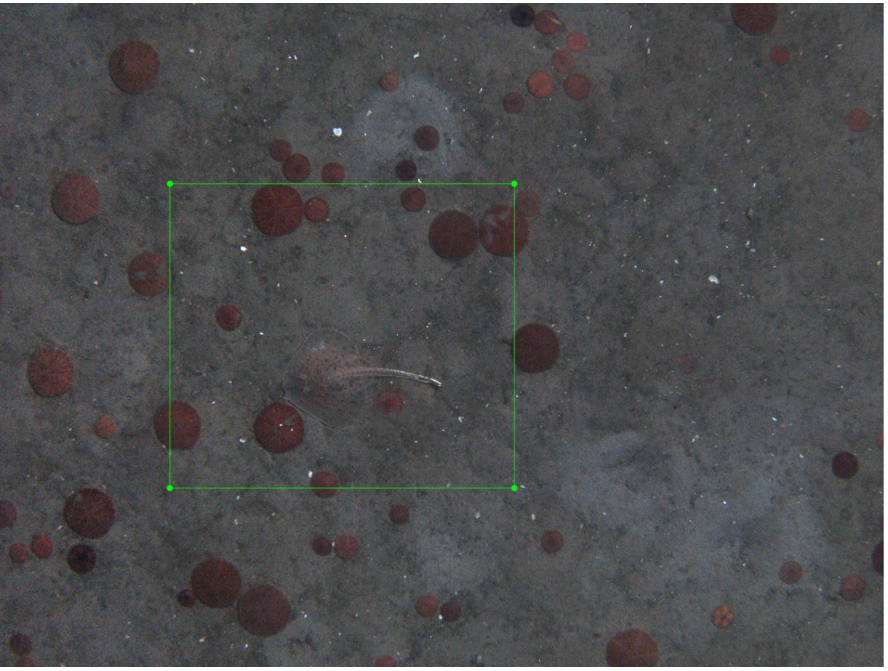
```
<?xml version="1.0" ?>
<annotation>
        <folder>FlatfishImages</folder>
        <filename>201303.20130615.135319375.19025
        </filename>
        <path>/Users/Tzofi/Dropbox (MIT)/Vincent/
        FlatfishImages/201303.20130615.135319375.
        19025.png</path>
        <source>
```

```
<object>
        <name>roundfish</name>
        <pose>Unspecified</pose>
        <truncated>0</truncated>
        <difficult>0</difficult>
        <bndbox>
                <xmin>627</xmin>
                <ymin>79</ymin>
                <xmax>772</xmax>
                <ymax>166</ymax>
        </bndbox>
</object>
```

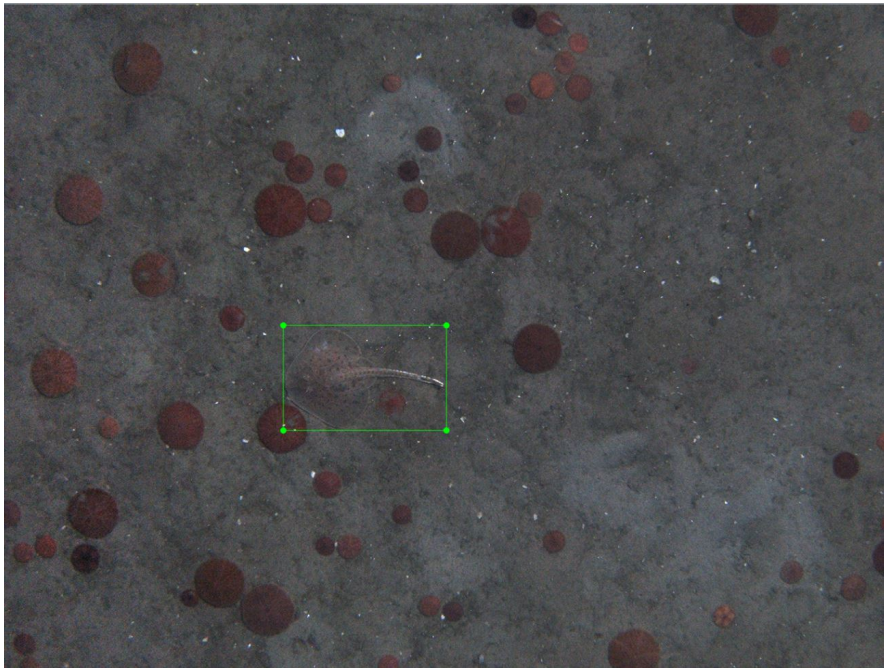
Applying Image Recognition:

Methodology – Train

Train YOLOv2 Real-Time Object Detection algorithm:



Original training set: 5,063 images



Adjusted training set: 5,063 images

Applying Image Recognition:

Methodology – Test

Run trained YOLOv2 algorithm on 300 test images

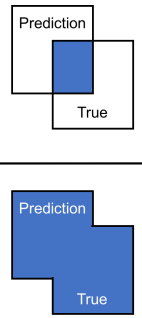
- False positives?
- False negatives?

Results:

Metrics

- Intersection Over Union (IOU) (%)

$$IOU = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$



- Recall (%)

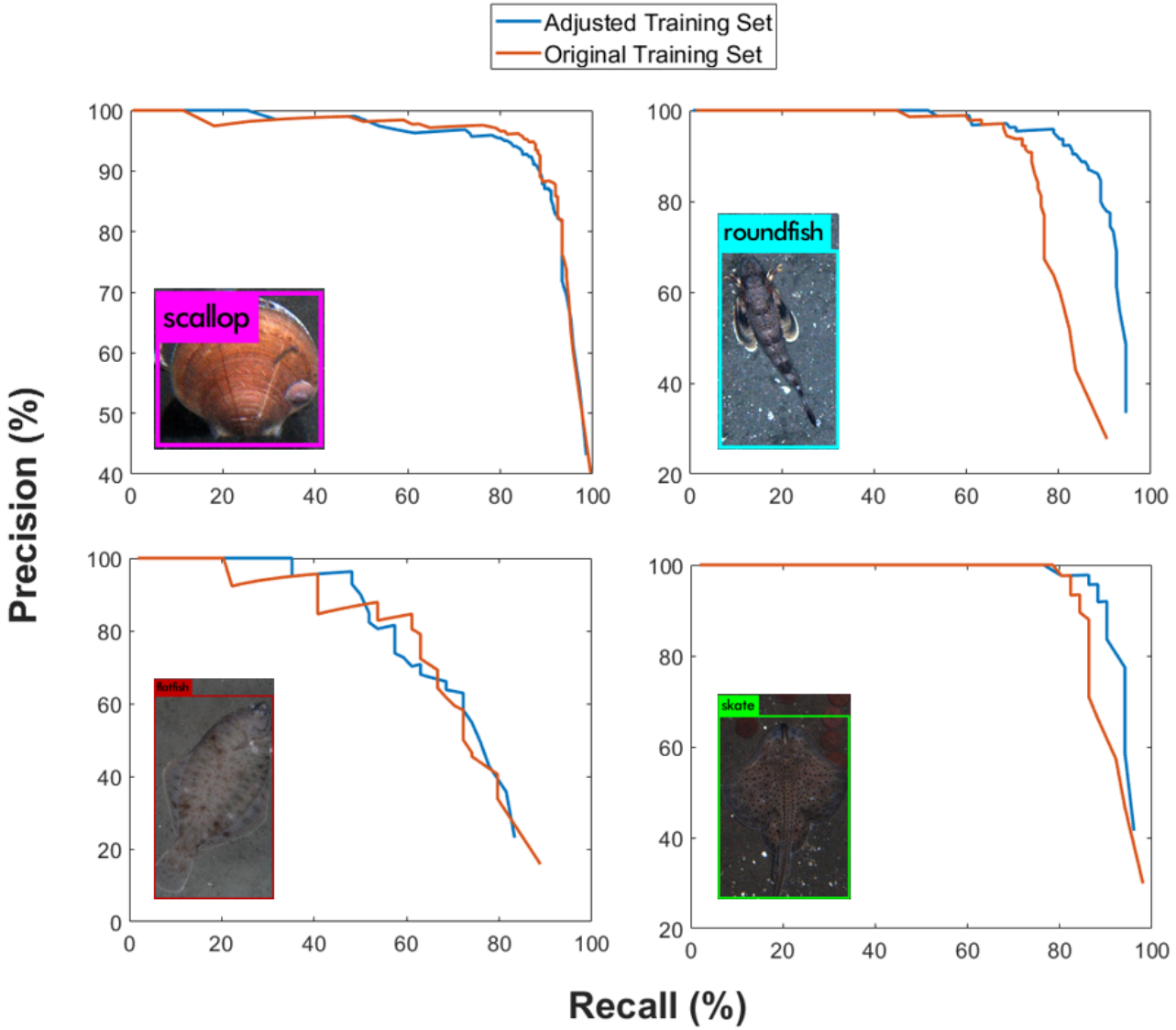
$$\text{recall} = tp/tp + fn$$

- Precision (%)

$$\text{precision} = tp/tp + fp = tp/n$$

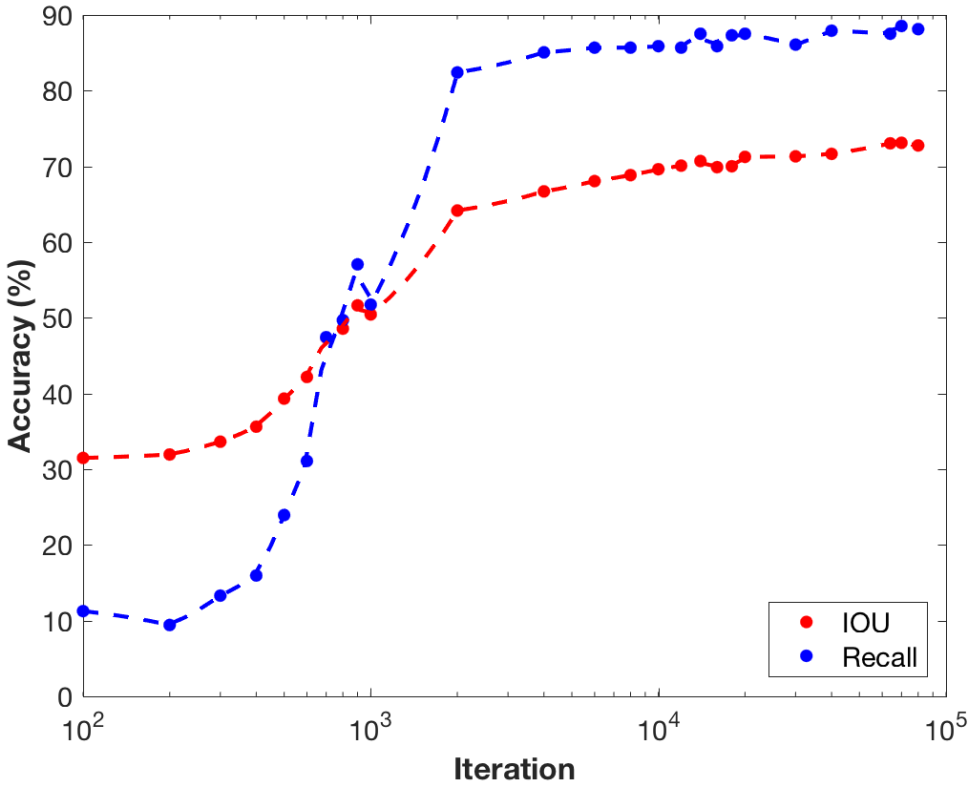
Results

- Can image recognition be used to accurately detect and count marine species?



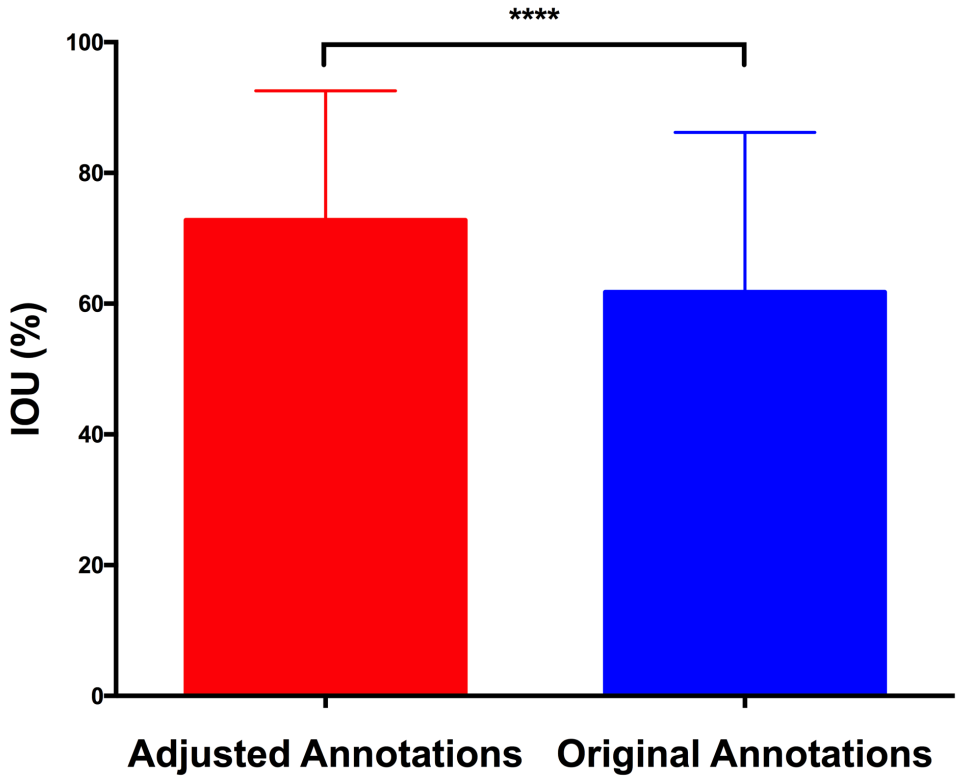
Results

- How many iterations of training are needed to yield accurate results? ~**2000**



Results

- How does the quality of annotations used in training impact accuracy?



IOU values averaged across all objects (N = 489) in both the adjusted and original training sets.

Conclusion

- Image recognition is a viable solution to detecting and counting fisheries species in photographic data
- You Only Look Once (YOLO) v2: Real-Time Object Detection software can obtain as high as 93% average recall
  - According to [2] Chang et al. 2016, imperfect automated annotation can be combined with human annotation
- We recommend annotation guidelines be strictly followed
- Deliverables: training sets, trained weights, programs for counting fisheries species

Implications:

- NOAA Fisheries can use these techniques to optimize time and resource allocation

Future Work

- Continue applying image recognition to herring
  - Of interest to: NOAA Fisheries, state agencies, as well as regional fisheries councils and local municipalities
  - Image recognition is a novel approach
- Develop graphical user interface for end users
- Test other image recognition algorithms, such as Faster R-CNN and Mask R-CNN

References

- [1] Chang, Jui-Han, Burton V. Shank, and Deborah R. Hart. "A comparison of methods to estimate abundance and biomass from belt transect surveys." Limnology and Oceanography: Methods 15.5 (2017): 480-494.
- [2] Chang, Jui-Han, et al. "Combining imperfect automated annotations of underwater images with human annotations to obtain precise and unbiased population estimates." Methods in Oceanography 17 (2016): 169-186.
- [3] Karpathy A. Convolutional Neural Networks (CNNs / ConvNets). In: Stanford University [Internet]. [cited 21 Jul 2017]. Available: http://cs231n.github.io/convolutional-networks/
- [4] Kearney, Melissa S., Benjamin H. Harris, and Brad Hershbein. "Economic Contributions of the U.S. Fishing Industry." *Brookings*. Brookings, 28 July 2016. Web. 25 July 2017.
- [5] Redmon, Joseph, and Ali Farhadi. "YOLO9000: better, faster, stronger." *arXiv preprint arXiv:1612.08242 (2016)*. APA