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DFO Phase IIB: Computer Vision Results

Review of Approach

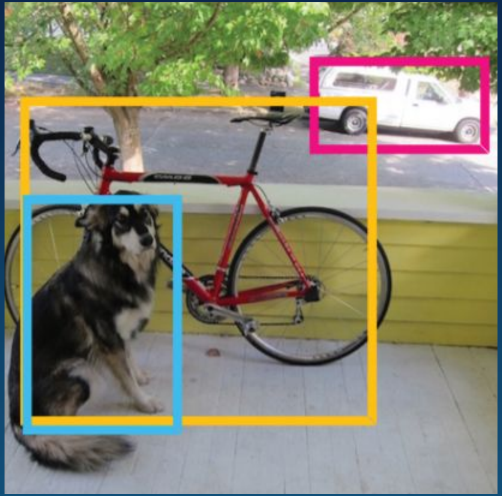
Goal: Predict species apportionment in an image

This involves:

- Localizing all fish in an image
  - 100s or 1000s or targets
- Classifying the species of all localized fish
- Computing proportions from these counts

Review of Approach

Existing computer vision algorithms inadequate.



Object detection

- Localization (boxes) + classification
- But **cannot handle dense scenes**

Crowd localization

- Localization in dense scenes
- But **cannot classify**

Review of Approach

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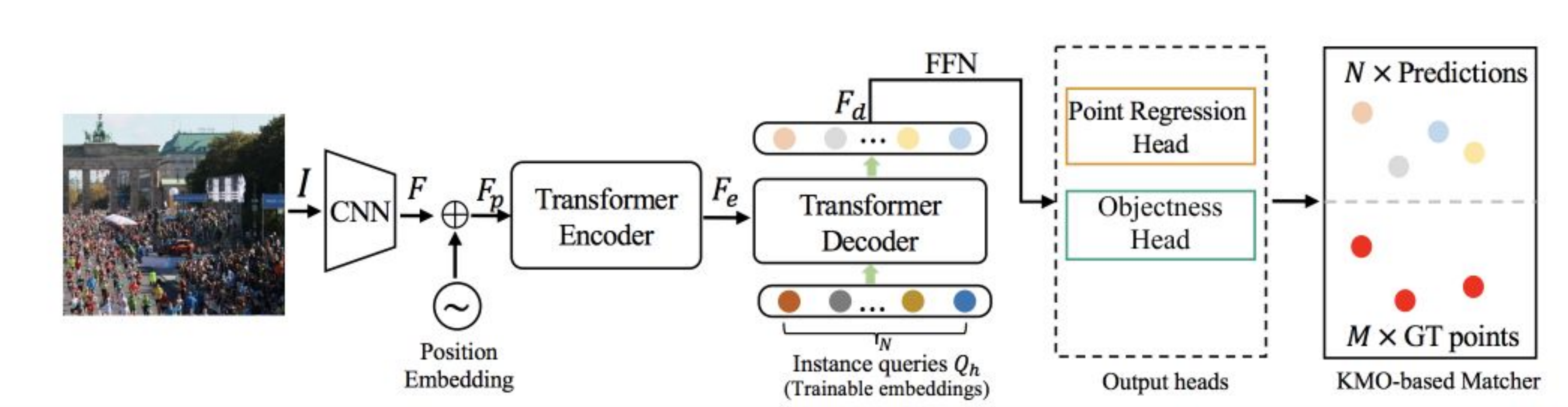
Goal: Dense localization and classification.

Dataset

- 9 vessels, 39 trips, 471 tows of raw data
- Three step annotation procedure:
    1. Localizations (“dots”)
    2. Expert species classifications
    3. Expert review
- Collected 477,889 annotations in 3,362 images

Algorithm Details

Starting point: Crowd Localization Transformer (CLTR)

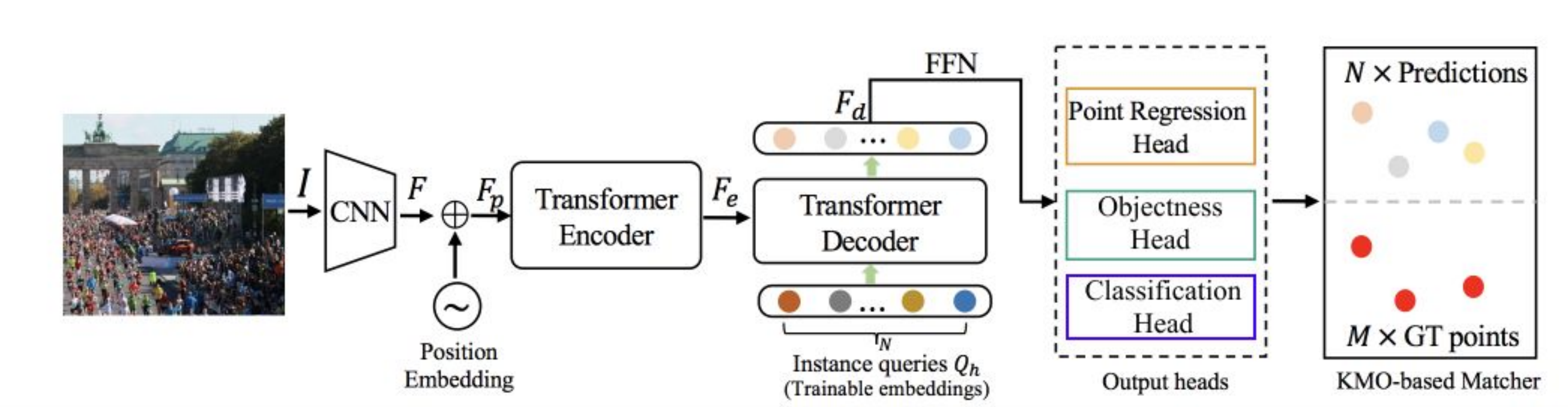


- State of the art for crowd localization
- But **cannot perform classification**

Liang, D., Xu, W. and Bai, X., 2022, October. An end-to-end transformer model for crowd localization. In European Conference on Computer Vision (pp. 38-54). Cham: Springer Nature Switzerland

Algorithm Details

Add a classification branch



- Additional neural network layers
- Additional classification loss during training (softmax + cross-entropy)
- Now **each point has a species classification**

Metrics

Two metrics were developed to evaluate our model in the context of the apportionment task:

1. **Dominant Species Accuracy**
2. **Weighted Classification Error**

We evaluated the model on its own (using our test dataset) as well as in comparison to trained reviewers.

Metrics

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Dominant Species Accuracy

Accuracy of predicting the most common class.

Typically an image is dominated by one species; predicting this species correctly will have the largest effect on overall accuracy.

This metric provides a simple "at a glance" measure of how well we do at identifying the majority class.

Metrics

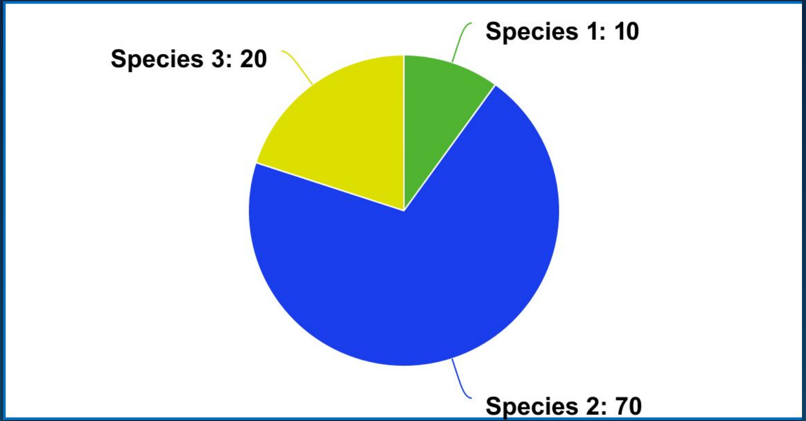
Weighted Classification Error

A more complex metric that takes into account all species present as well as the apportionment goal.

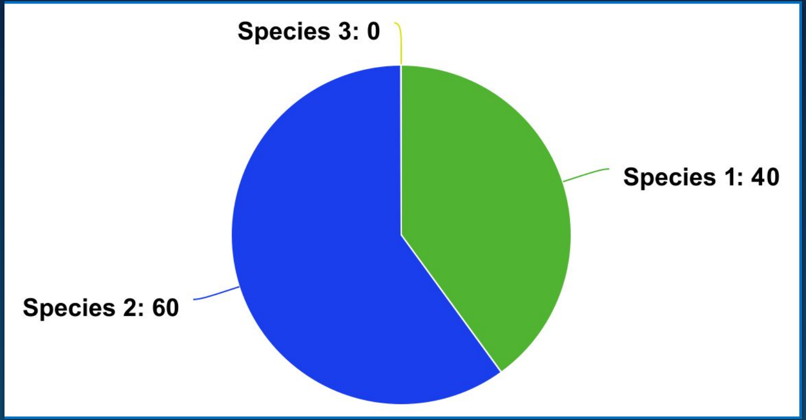
Metrics

Weighted Classification Error

Ground Truth



Predicted



Metrics

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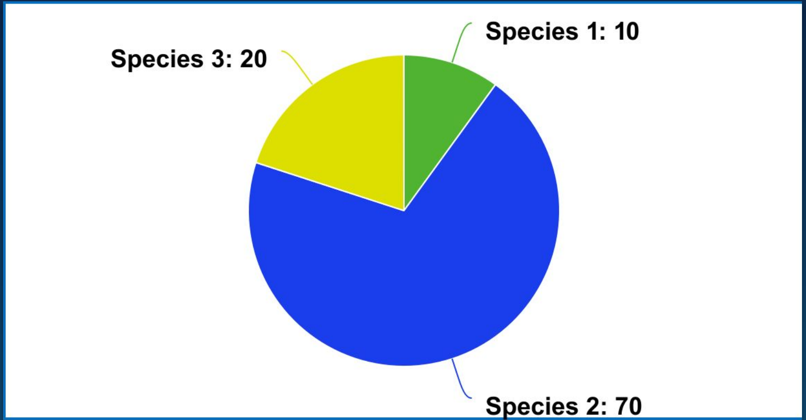
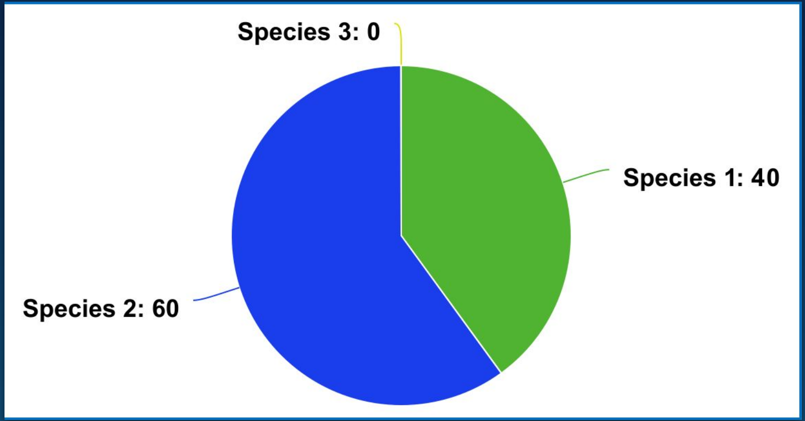
Weighted Classification Error

Ground Truth



Predicted

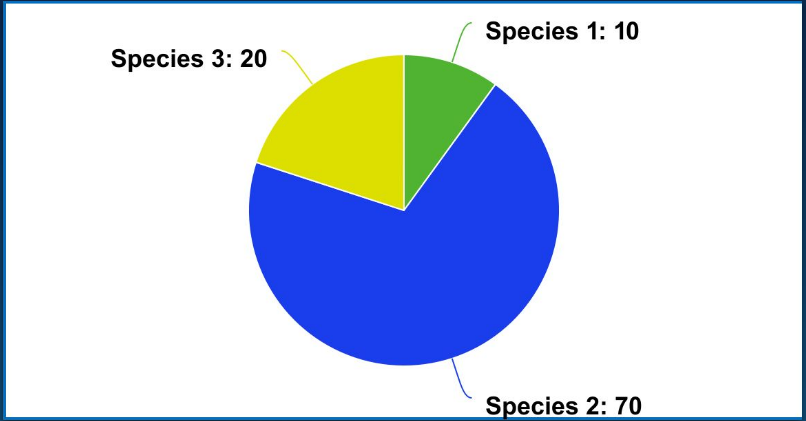


- **Mean absolute error:** (|40 - 10| + |60 - 70| + |0 - 20|) ÷ 3 = 20%

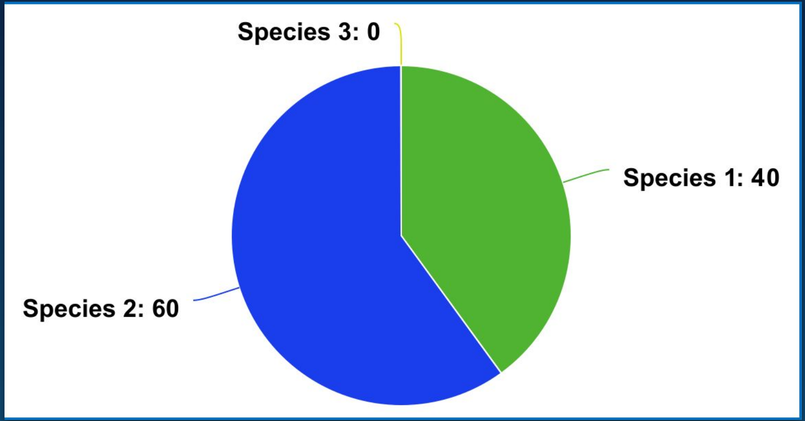
Metrics

Weighted Classification Error

Ground Truth



Predicted

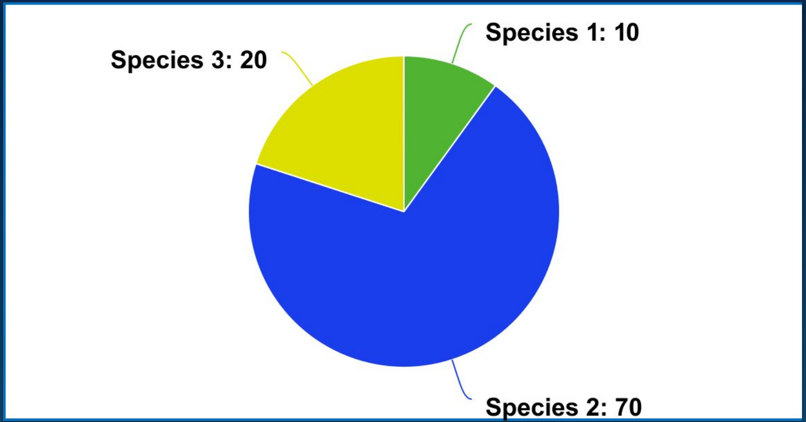


- **Mean absolute error:** (|40 - 10| + |60 - 70| + |0 - 20|) ÷ 3 = 20%
- But this gives equal weight to all classes, which might not be appropriate.
  - E.g. there are 5 classes total, but only 3 present; now divisor is 5, so error is artificially reduced

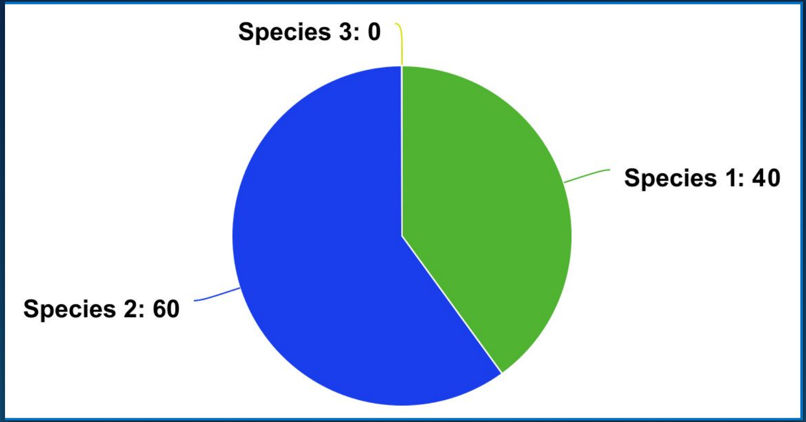
Metrics

Weighted Classification Error

Ground Truth



Predicted



- **Weight by ground truth:** 0.1*|40 - 10| + 0.7*|60 - 70| + 0.2*|0 - 20| = 14%

Metrics

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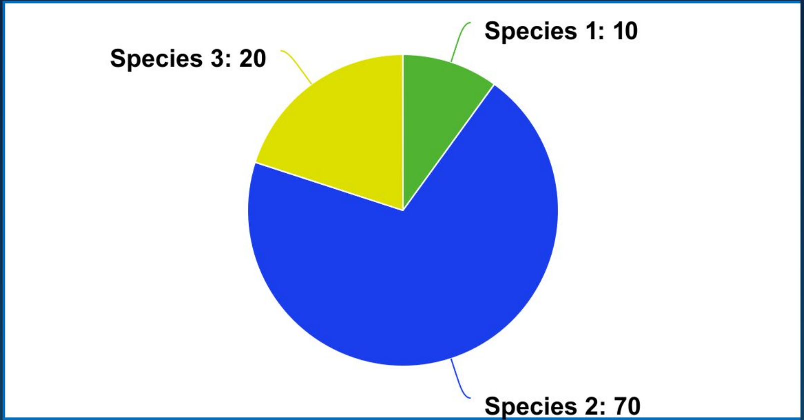
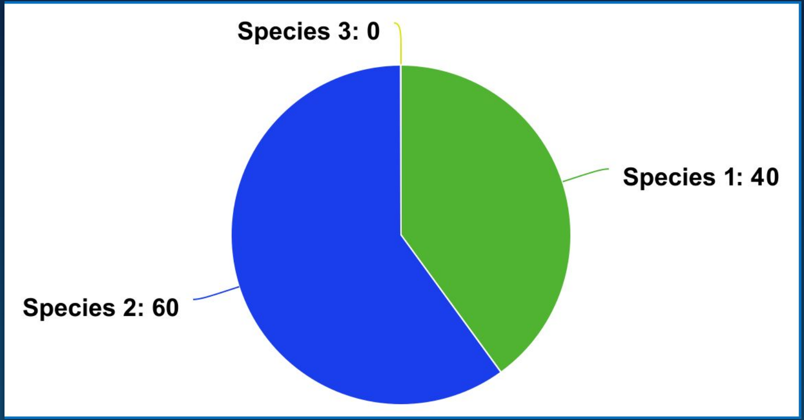
Weighted Classification Error

Ground Truth



Predicted

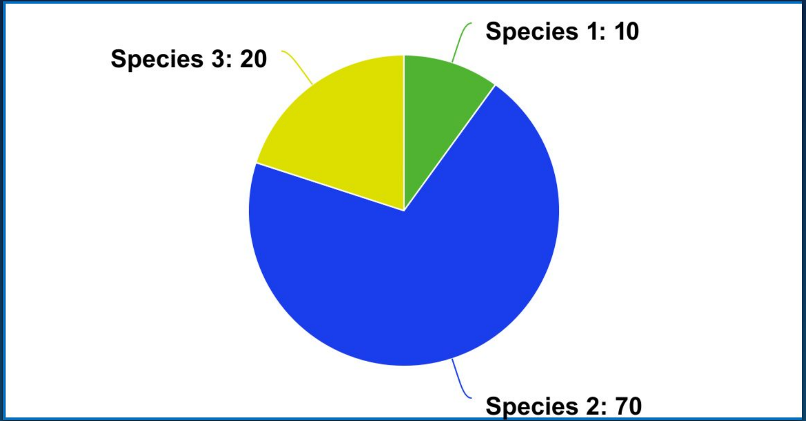


- **Weight by ground truth:** 0.1*|40 - 10| + 0.7*|60 - 70| + 0.2*|0 - 20| = 14%
- But what if a ground truth class is not present, but you predict it? Error for that class would be 0.

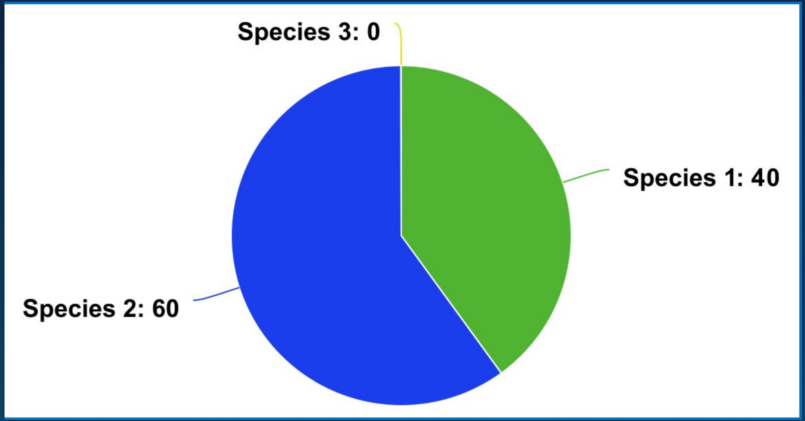
Metrics

Weighted Classification Error

Ground Truth



Predicted

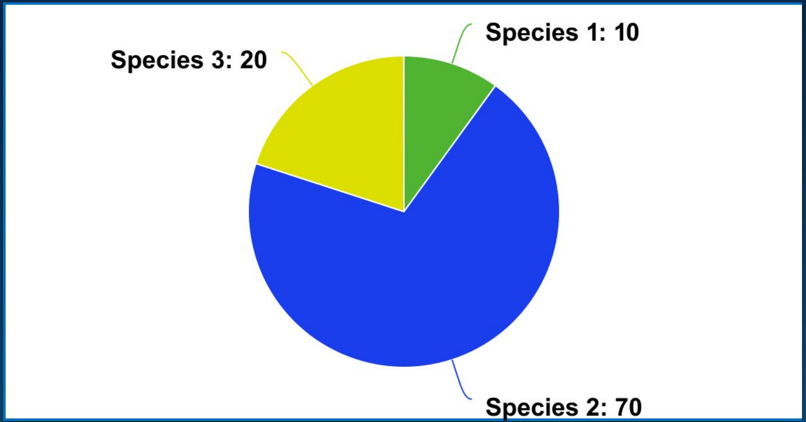


- **Weight by avg of GT + predicted:** 0.25*|40 - 10| + 0.65*|60 - 70| + 0.1*|0 - 20| = 19.2%

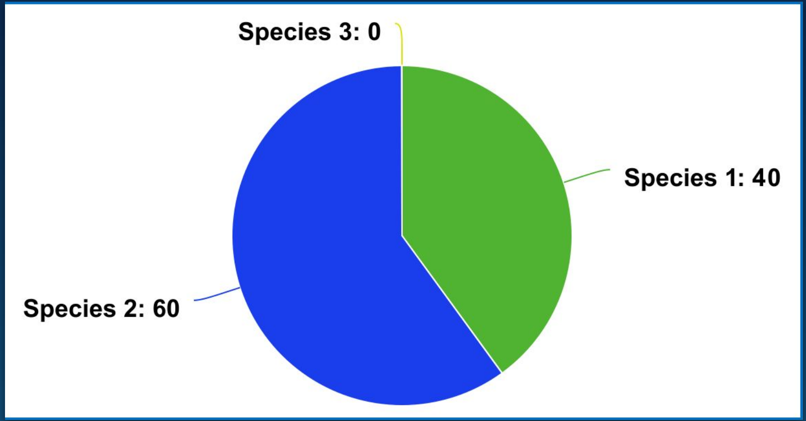
Metrics

Weighted Classification Error

Ground Truth



Predicted



- **Weight by avg of GT + predicted:** 0.25*|40 - 10| + 0.65*|60 - 70| + 0.1*|0 - 20| = 19.2%
- Bonus: Now the measure is symmetric, so neither needs to be considered the "ground truth": we can compare the discrepancy of human reviewers, for example.

Results

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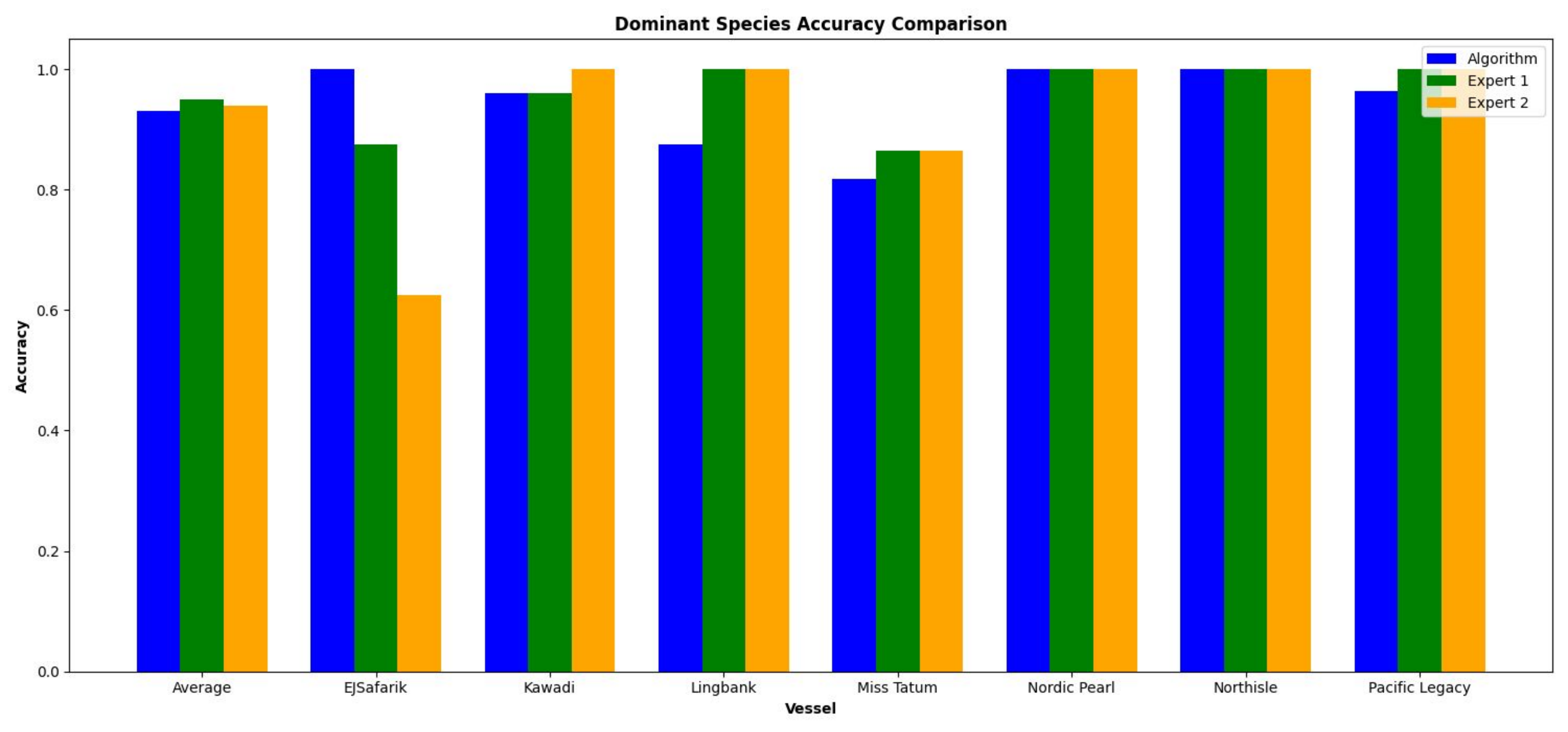
Evaluate:

- Model performance
- Human expert performance

Using:

- Test set of 100 held-out examples
  - Sampled from *tows not present in training data*

Results



Dominant Species Accuracy Comparison
Accuracy
1.0
0.8
0.6
0.4
0.2
0.0
Algorithm
Expert 1
Expert 2
Average
EJSafarik
Kawadi
Lingbank
Miss Tatum
Nordic Pearl
Northisle
Pacific Legacy
Vessel

Results

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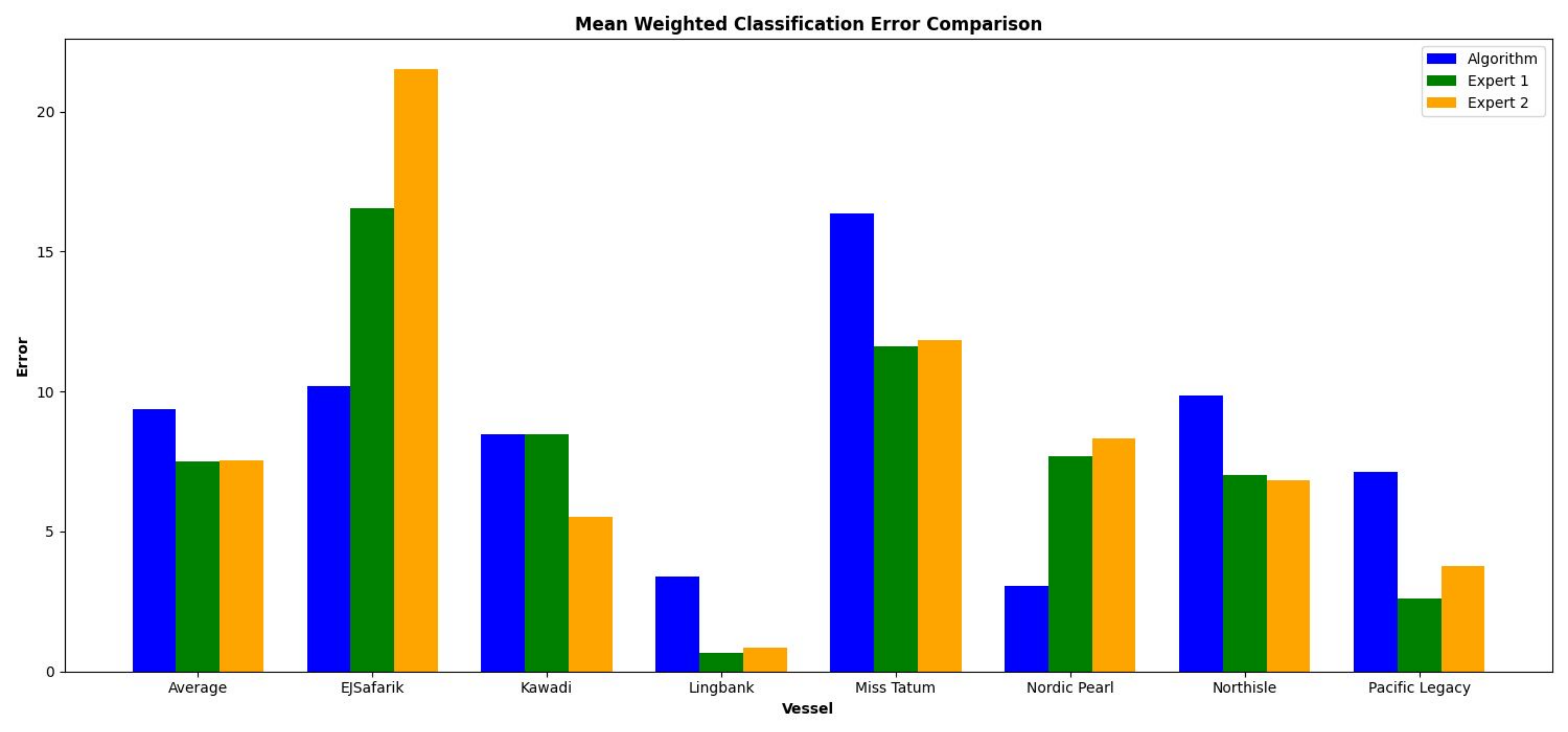

Results

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Metric	Algorithm	Expert 1	Expert 2
Dominant Species Accuracy	94%	95%	94%
Mean Weighted Classification Error	9.4%	7.5%	7.5%

- Algorithm achieves human expert-level performance on dominant species classification
- Algorithm is within 2% of human expert performance when considering mean weighted classification error
- Demonstrates the **feasibility of our approach** for producing **accurate automated apportionment estimates**


Next Steps
Proof of Value Proposal Outline

Access to Data

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- Work with Archipelago to obtain access to at least 20 boats to participate in the Proof of Value phase

- NOTE: Data will not be streamed from the vessels but will be analyzed as part of the typical Program flow alongside all standard review that is normally conducted

POV Analysis

- Reviewers will follow their usual routine
- During review clips from relevant tows on participating boats will be extracted from footage loaded into FishVue Interpret and loaded into the POC solution
- The reviewer will select at least 3 - 5 images from each tow for catch apportionment analysis
- The reviewer will review catch apportionment results and then utilize these results to inform catch estimates.
- A sample of tows will have full manual review performed so that we can assess the impact on accuracy of catch estimates

Timeline

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- The POV phase will be conducted in 2 iterations to facilitate an opportunity for incorporation of feedback on either algorithm or user interface performance
- The first iteration will run from **Oct 16 - Dec 29, 2023**
- The second iteration will run from **Jan 15 - Feb 29, 2024**
- Time prior to Oct 16, 2023 will be used to line up permissions with vessel owners and to finalize the software implementation to operate at scale.
- Aim to present results to DFO team by **March 15, 2024**.

KPIs for POV Phase

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- Number of catch apportionment results rejected by reviewers (single images)
- Number of total catch apportionment results rejected by reviewers (tows)
- Accuracy of catch apportionment (deviation compared with manual review)
- Delta in results between first and second iterations
- Change in administrative user feedback between iterations if any UI/UX adjustments are made