University of Santo Tomas

Microplastic Detection in Water with YOLO v8

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Introduction

What are Microplastics?

Microplastics are tiny plastic particles (> 5 mm) that come from the breakdown of larger plastic waste or are intentionally produced as microbeads in cosmetics and other products.

They are found everywhere. In oceans, soil, air, and even drinking water, posing risks to marine life, ecosystems, and potentially human health through ingestion and chemical exposure.

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Introduction

Importance of this Study

This research tackles microplastic pollution in water through advanced AI detection, supporting SDGs 6, 14, and 12.

This technology can enable early intervention in contaminated areas, directly addressing this growing threat to ecosystems and potentially human health.

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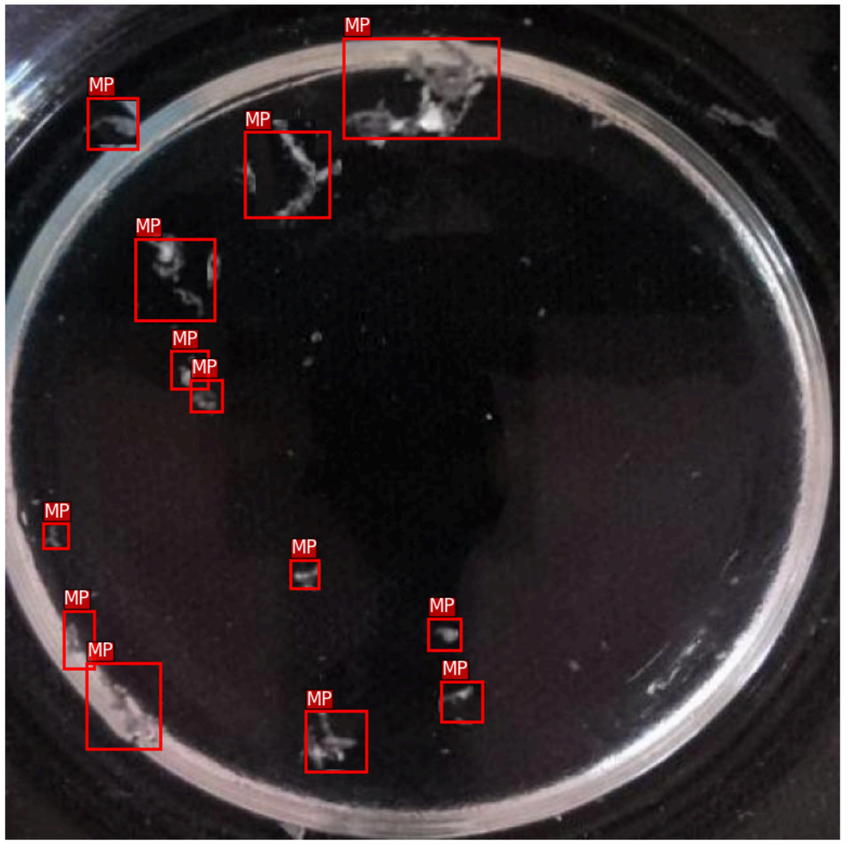
Details of the Dataset

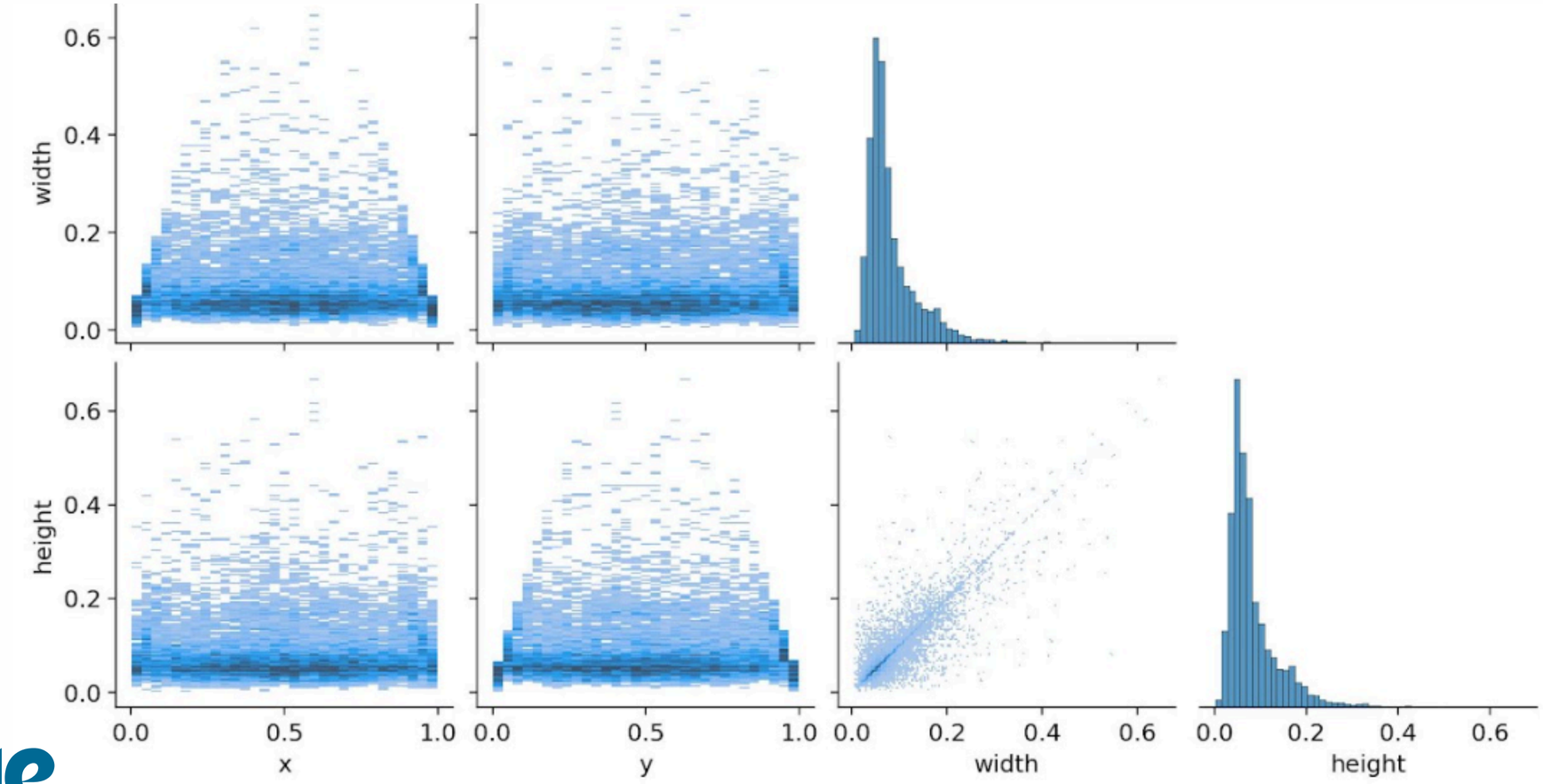
Data is provided by the user yolov8 (2024) on the platform **Roboflow**. Data consists of 4607 images of floating microplastics in water.

80% of images have labels for train and validation sets



Access the data set here!

Exploratory Data Analysis



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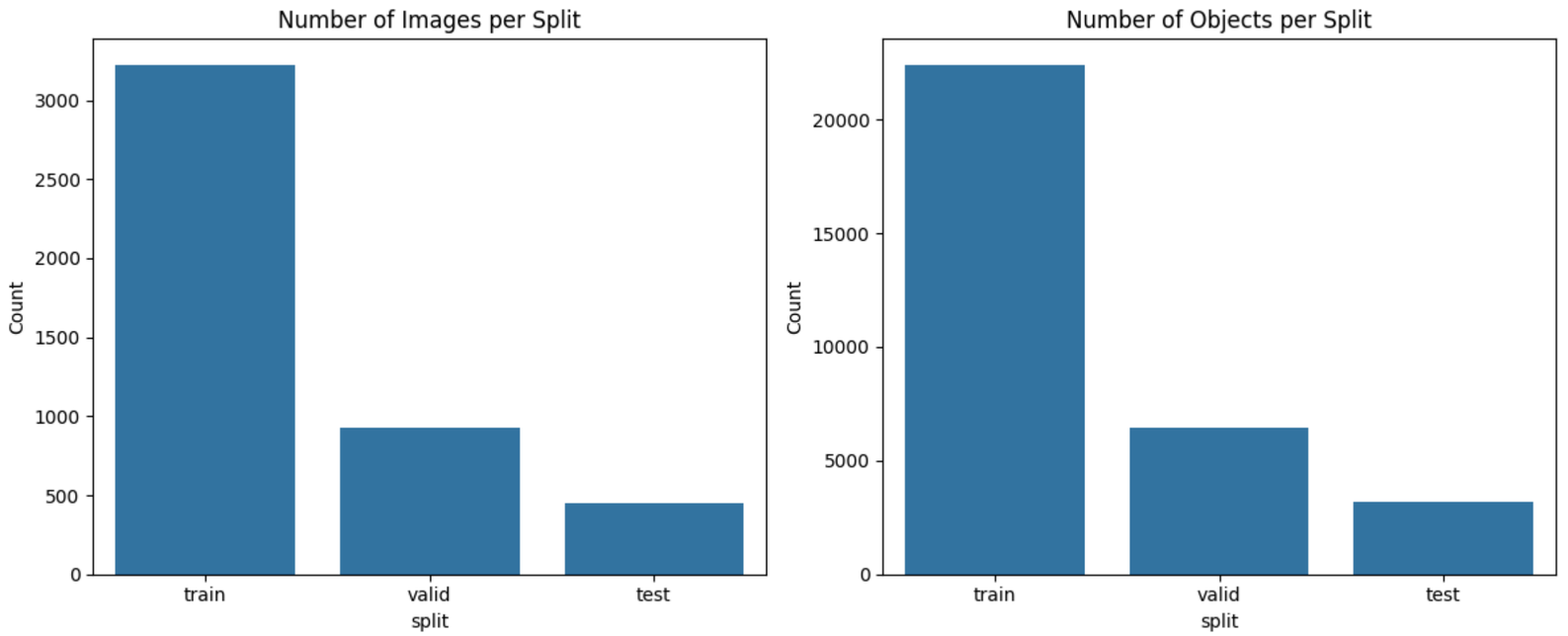
Exploratory Data Analysis



On average, there are approximately **7** objects per image (in train, validation, and test datasets)

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Methodology

Model Selection

ultralytics YOLO 8

We have utilized the **YOLOv8 Nano** (yolov8n), the smallest and fastest variant in the YOLOv8 model family, designed for resource-constrained environments with low-powered GPUs.

https://github.com/ultralytics/assets/releases/download/v8.1.0/yolov8n.pt

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Methodology

Instrument

OS: Microsoft Windows 11 Pro Version

CPU: AMD Ryzen 7 5800X3D

GPU: NVIDIA GeForce RTX 3070 Ti

RAM: 16.0 GB 3200mhz

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Methodology

Configurations

Epochs	300	For extensive training
Image Size	640×640 px	Standard YOLOv8 input resolution
Batch Size	16	Adjustable based on available GPU memory
Workers	8	Single-process mode to prevent DataLoader worker crashes

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Evaluation Metrics

Loss Functions

Box Loss

Measures how well the model predicts the location and size of bounding boxes around detected objects.

Class Loss

Quantifies the model's accuracy in classifying the detected objects.

Distribution Focal Loss (DFL)

A specialized loss function in YOLOv8 that improves bounding box regression, particularly for objects with varying scales. It helps with precise localization by focusing on hard-to-detect samples.

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Evaluation Metrics

Performance Metrics

Precision **Recall**

Accuracy **F1-Score**

mAP@50

Mean Average Precision with an IoU threshold of ≥0.5. A standard performance benchmark.

mAP@50-95

Mean Average Precision averaged over a range of IoU thresholds (from 0.5 to 0.95). A more comprehensive benchmark

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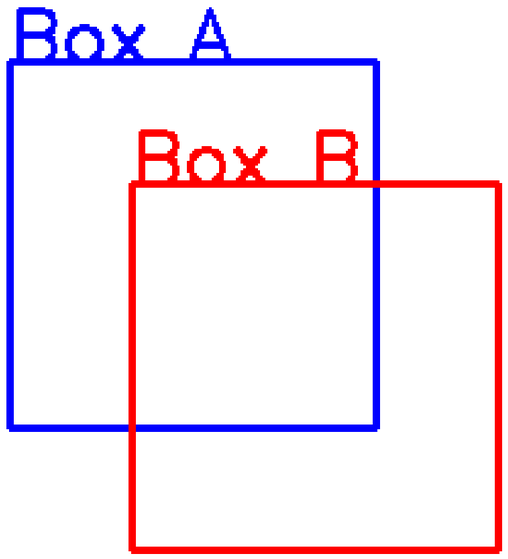
Evaluation Metrics

Detection Quality Metrics



Intersection over Union (IoU)

The overlap between predicted bounding boxes and ground truth boxes, ranging from 0 (no overlap) to 1 (perfect overlap).

Average/Min/Max IoU

Shows the overall, worst, and best spatial accuracy

Detections with IoU ≥ Threshold

Percentage of reliable detections

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Evaluation Metrics

Confidence Metrics

Confidence Score

The model's certainty about each detection, ranging from 0 to 1.

Average/Min/Max Confidence

Statistical measures of confidence across all detections.

Detections with Confidence ≥ Threshold

Percentage of high-confidence detections

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Results

The pretrained YOLOv8 is trained using the COCO dataset. Hence, it does not know the label for microplastics.

In 30 test images,

Total Ground-Truth Objects: 214
Total Predicted Objects: 6

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Results

In **453** test images, our fine-tuned YOLOv8 Nano model performed:

Precision	1.00
Accuracy	0.9845
Recall	0.9845
F1-Score	0.9922
MAP@50	0.831

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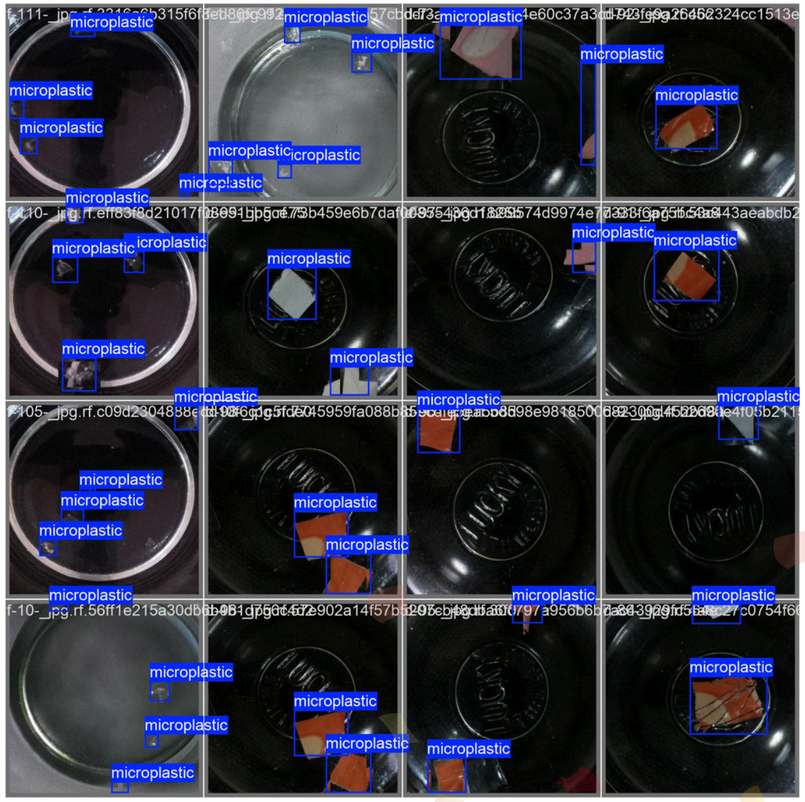
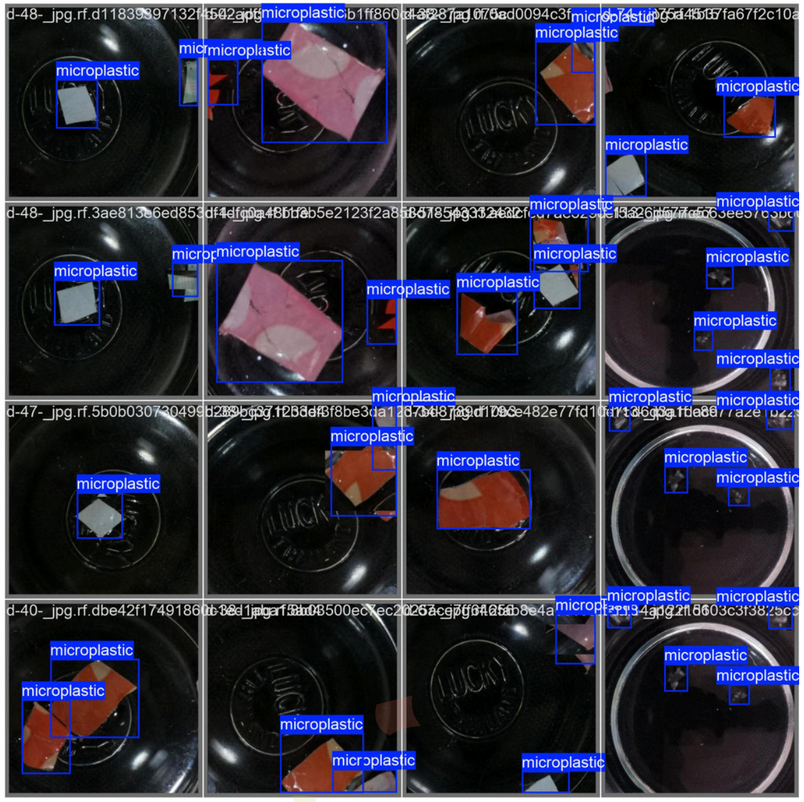
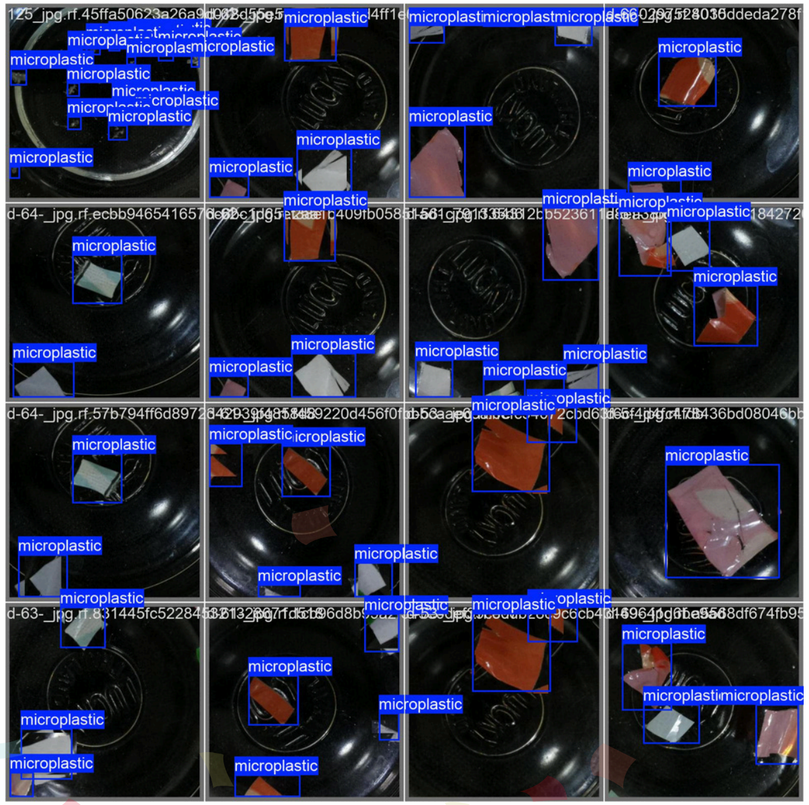
Results







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Conclusion

This study successfully implemented YOLOv8 for automated microplastic detection, achieving good performance with 100% precision, 98.45% accuracy, 98.45% recall, and 99.22% F1-score on 453 test images.

The model demonstrated strong localization capabilities with an IoU of 94.5%, indicating accurate bounding box predictions for the majority of detected microplastics. However, further model selection and training would provide a better overall mAP@50. This framework provides a highly reliable solution for AI-assisted microplastic detection in environmental monitoring applications.

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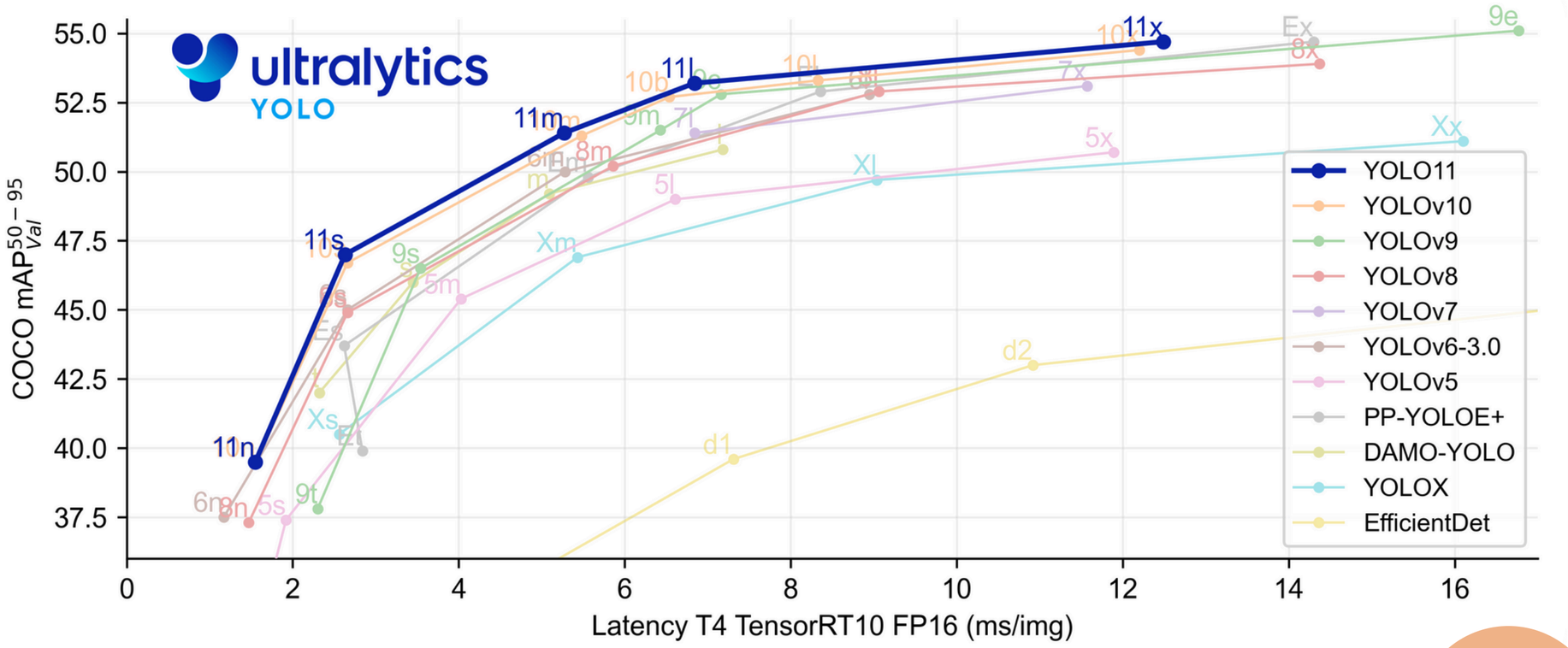
Room for Impovement?



https://docs.ultralytics.com/models/

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Room for Impovement?

Examples of some of the types of microplastic that are proliferating our oceans

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https://www.boomerangalliance.org.au/mpp-blog-02-microplastics

Thank You So Much!

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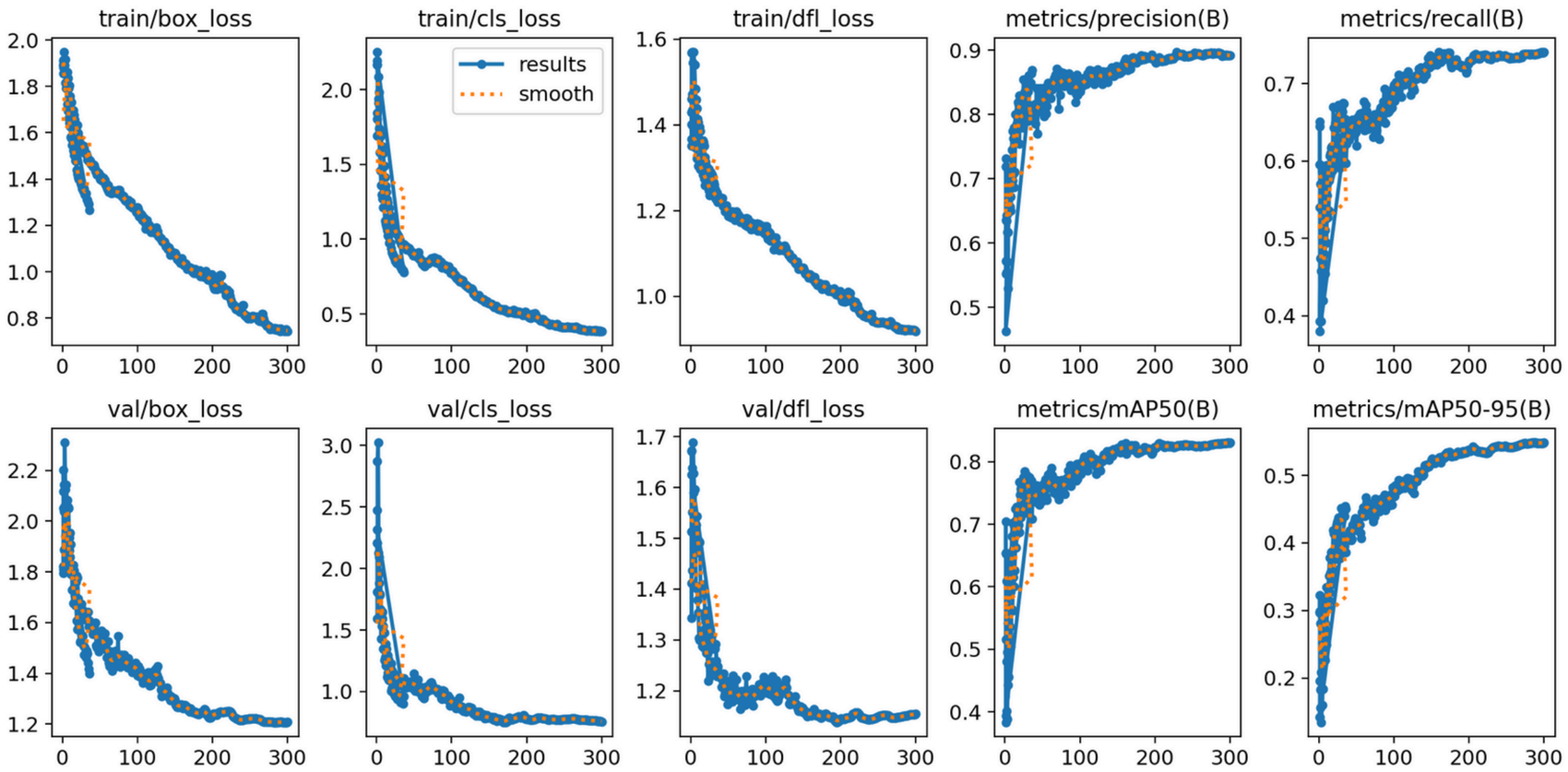
Evaluation Metrics (Appendix)



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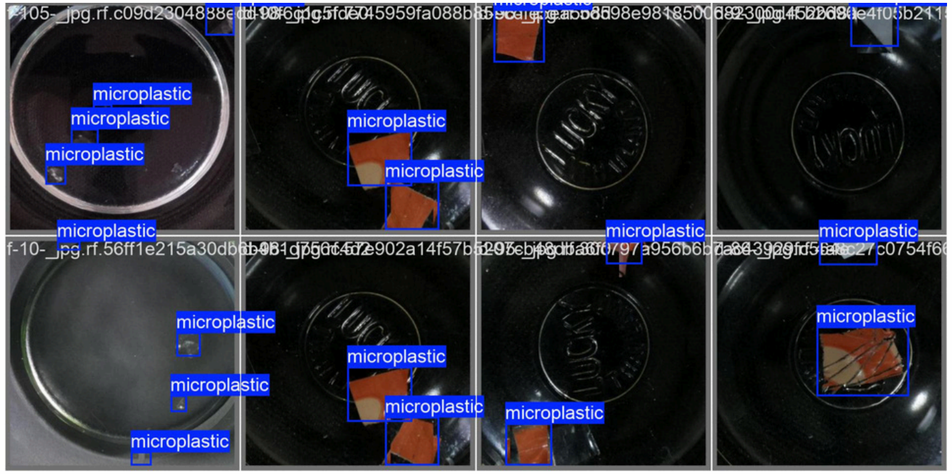
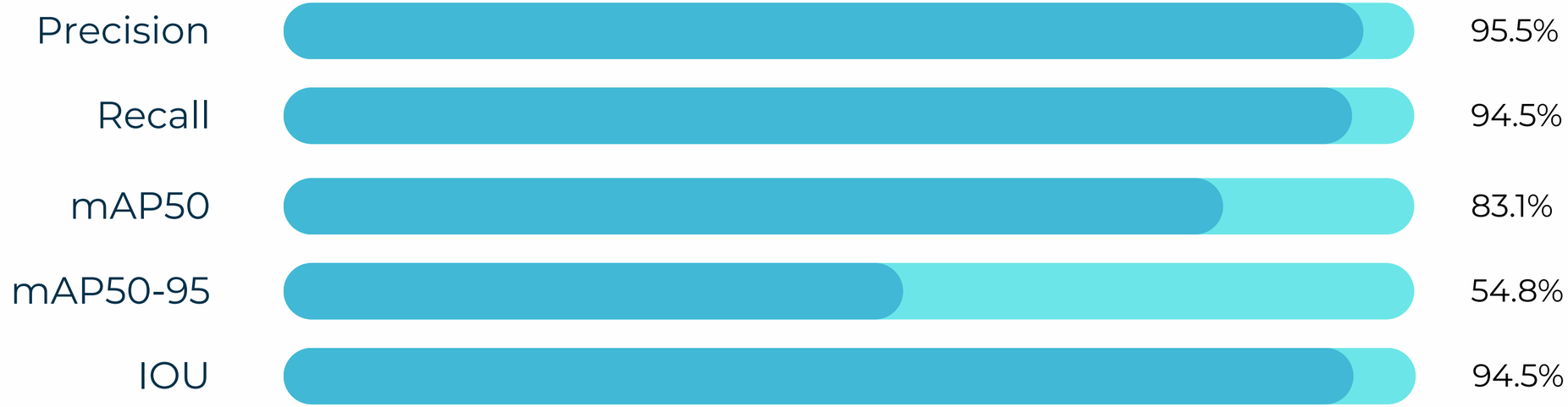
Indicates that the training went well



Result

Fine-tuned YOLOv8 (Validation)



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