

**A NOVEL END-TO-END DEEP  
LEARNING SYSTEM FOR CLASSIFYING  
MARINE BIOLOGICAL AND ENVIRONMENTAL IMAGES**

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**2 An End-to-End Deep Learning System**

**3 Applications**

**4 Conclusions**

# 01 PART ONE

## Plankton Monitoring Image Processing

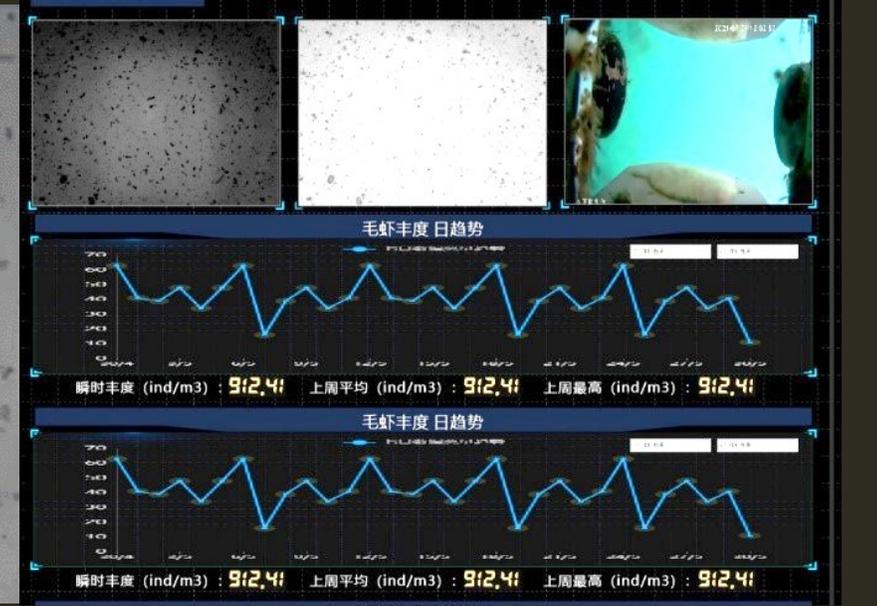
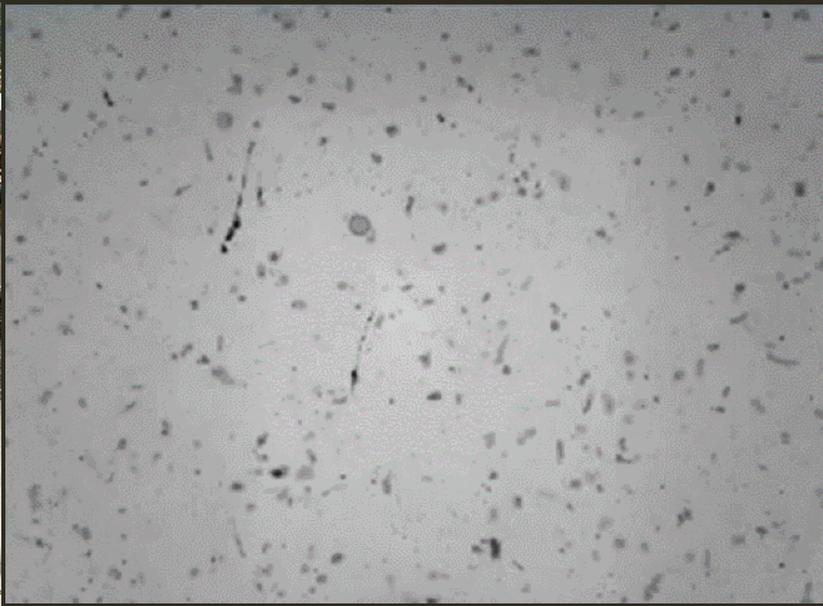
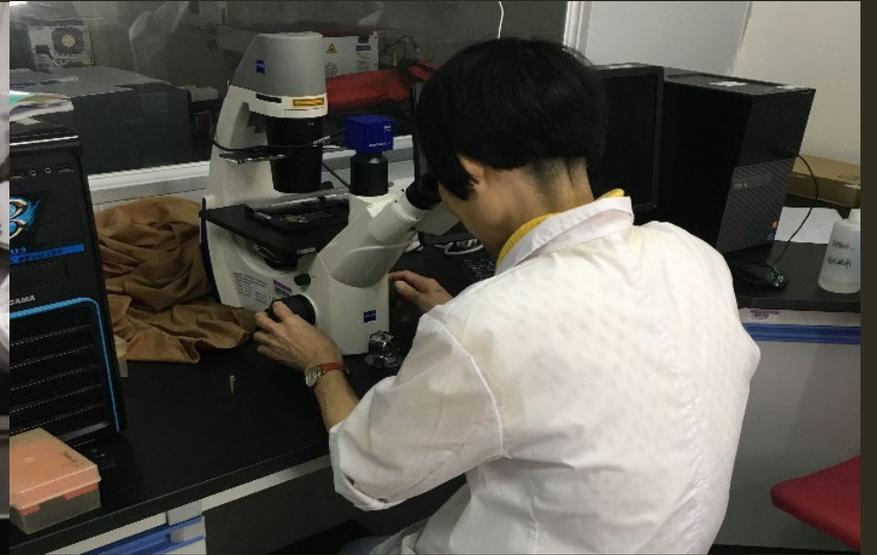
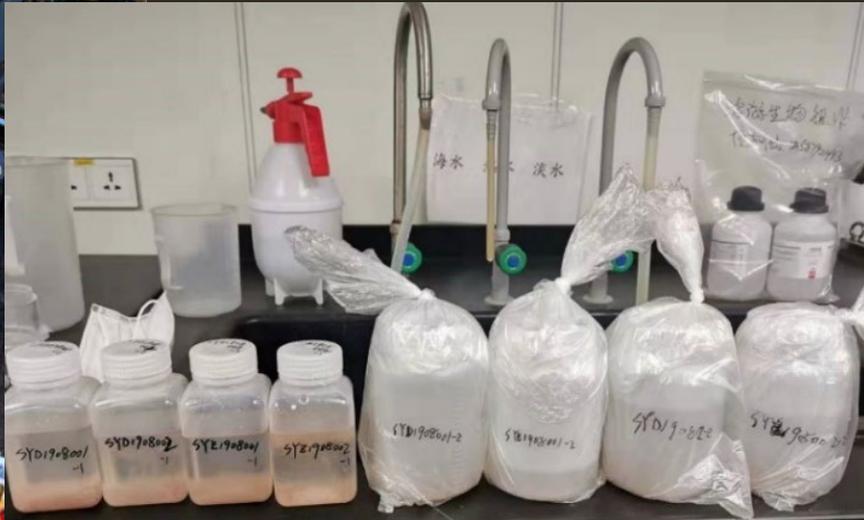


**Net sampling: discrete and integrative**

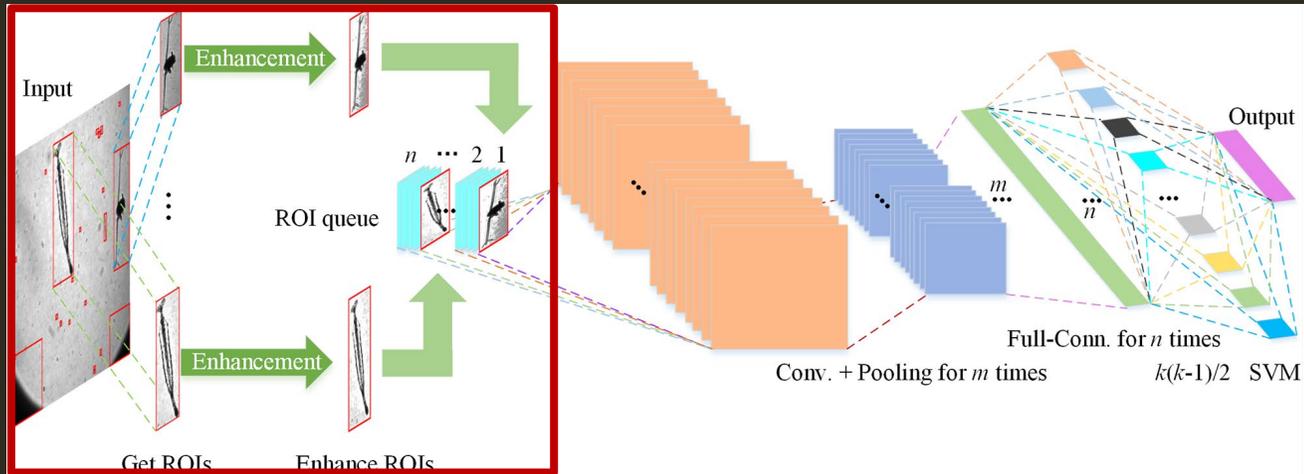


• In situ imaging system

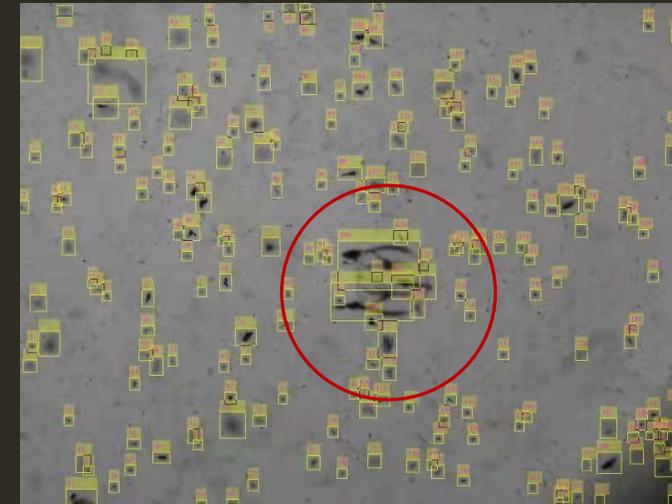
# Plankton Monitoring



# Common deep learning architecture for plankton recognition



Schematic Illustration



Oversegmentation



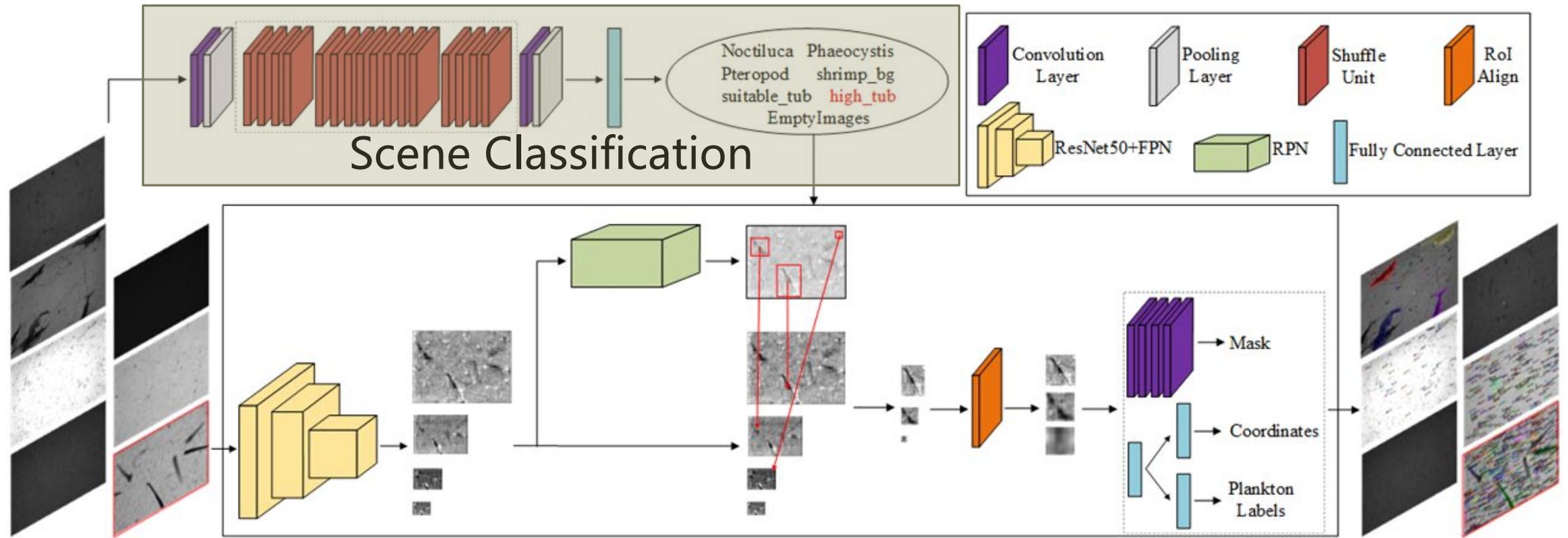
Missing targets

1. Large amounts of suspended particles
2. Marine organisms are patchily distributed
3. Large difference in abundance: copepod abundance high, shrimp abundances

# 02

**PART TWO**

**New End-to-End  
Deep Learning System**



## NEW APPROACH

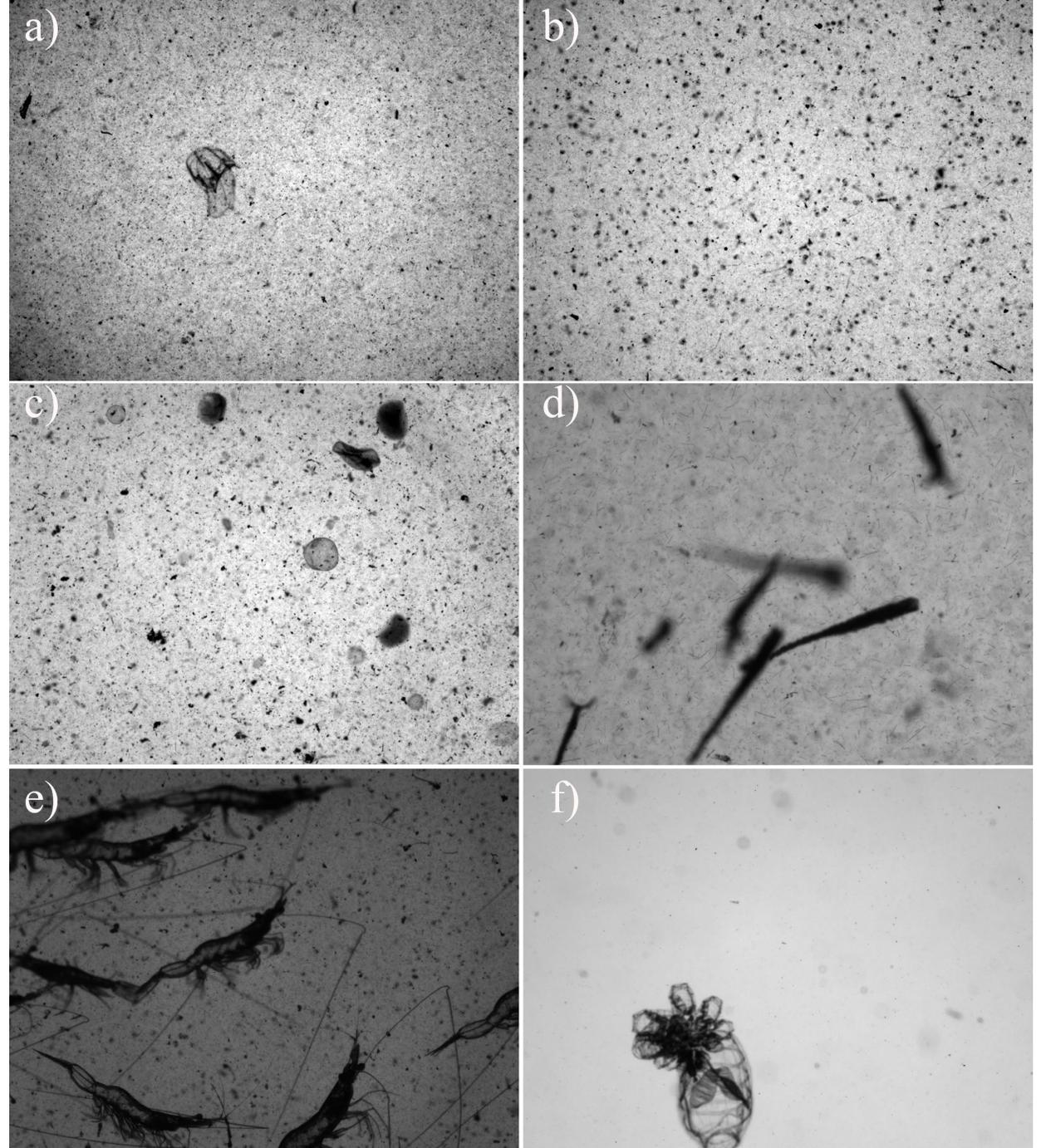
Use a scene classification as a primer, each scene has separate object detection & classification model

1. Different scene reflect image contents and layout
2. Improve the consistency between image and the model

# COMPARISON

1. Full model:
  - Mask R-CNN for all scene together
2. Scene Specific model
  - Separate Mask R-CNN for each scene

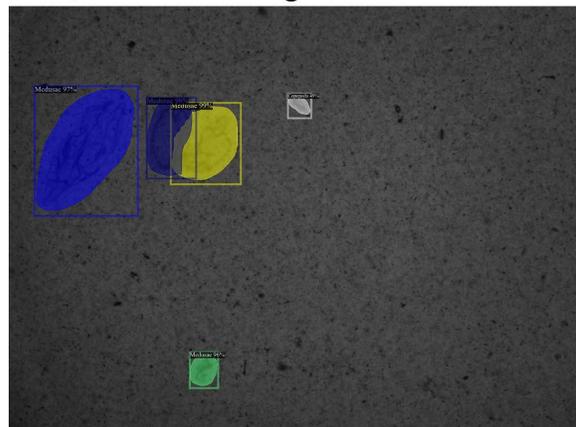
- 
- a) High Concentration
  - b) Nocticula
  - c) Phaeosystis
  - d) Petropod
  - e) Shrimp
  - f) Low Concentration



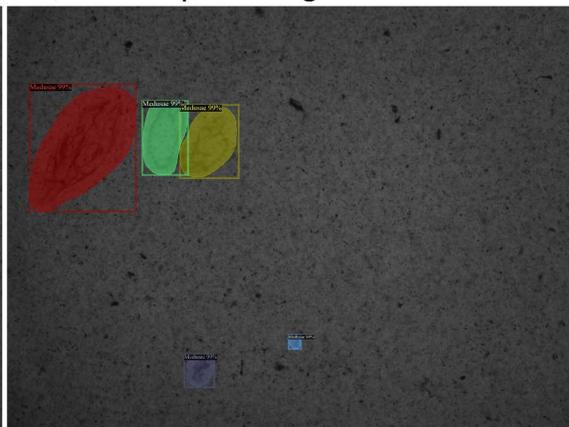


MODEL PERFORMANCE

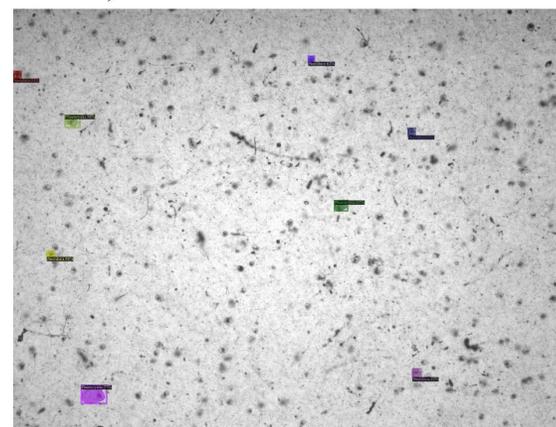
a) Full model: High concentration



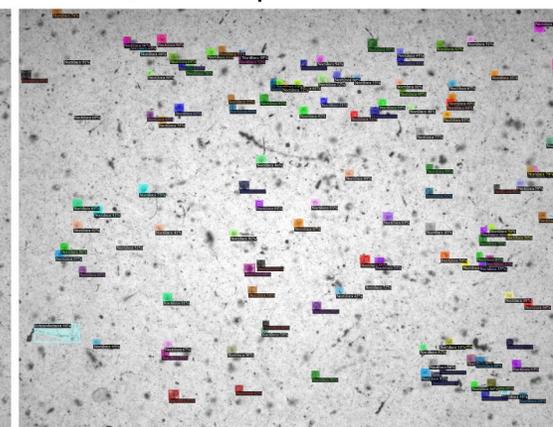
b) Scene-specific: High Concentration



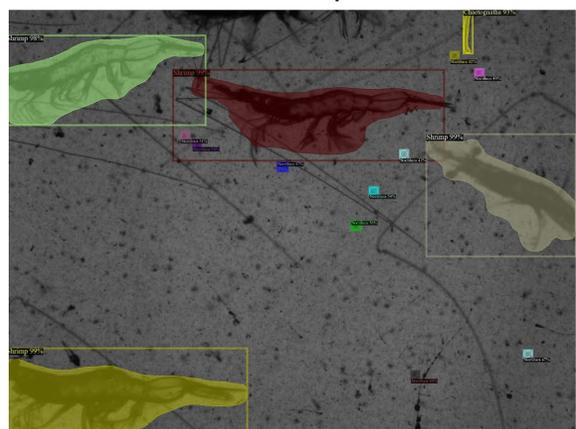
a) Full model: *Noctiluca*



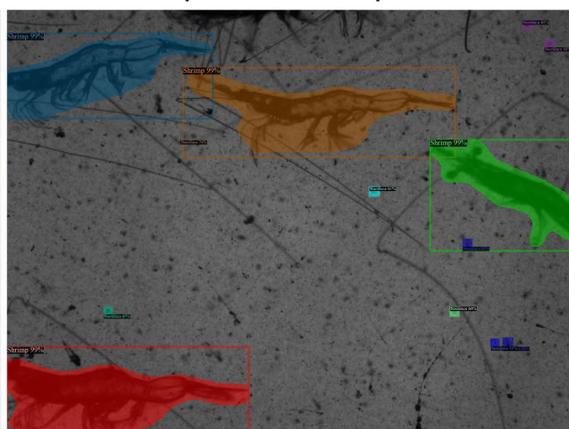
b) Scene-specific: *Noctiluca*



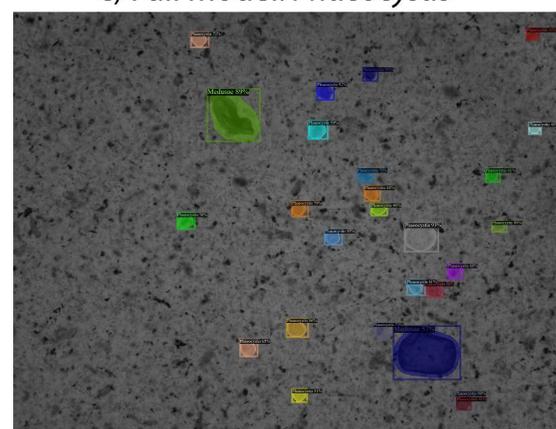
c) Full model: Shrimp



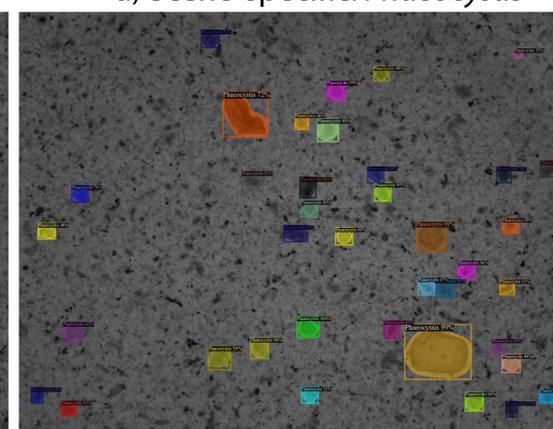
d) Scene-specific: Shrimp



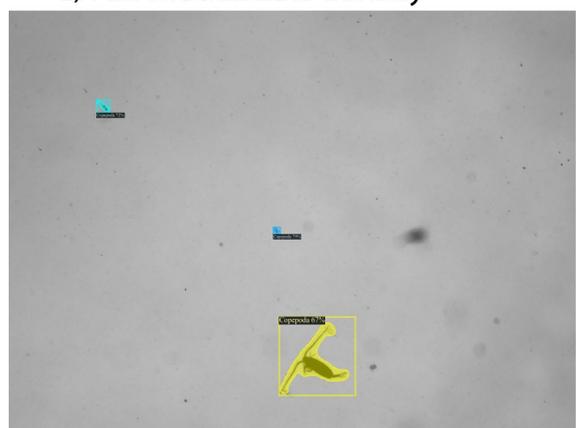
c) Full model: *Phaeocystis*



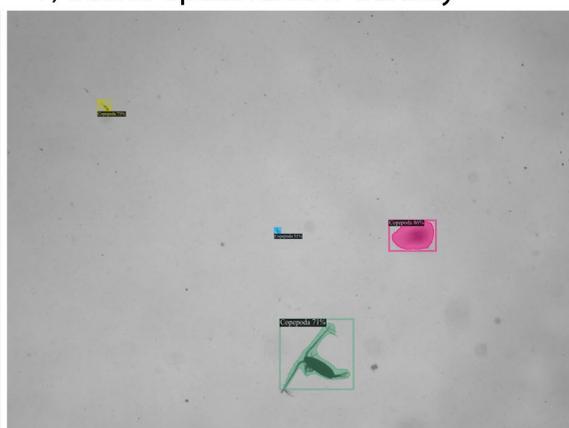
d) Scene-specific: *Phaeocystis*



e) Full model: Low density



f) Scene-specific: Low density



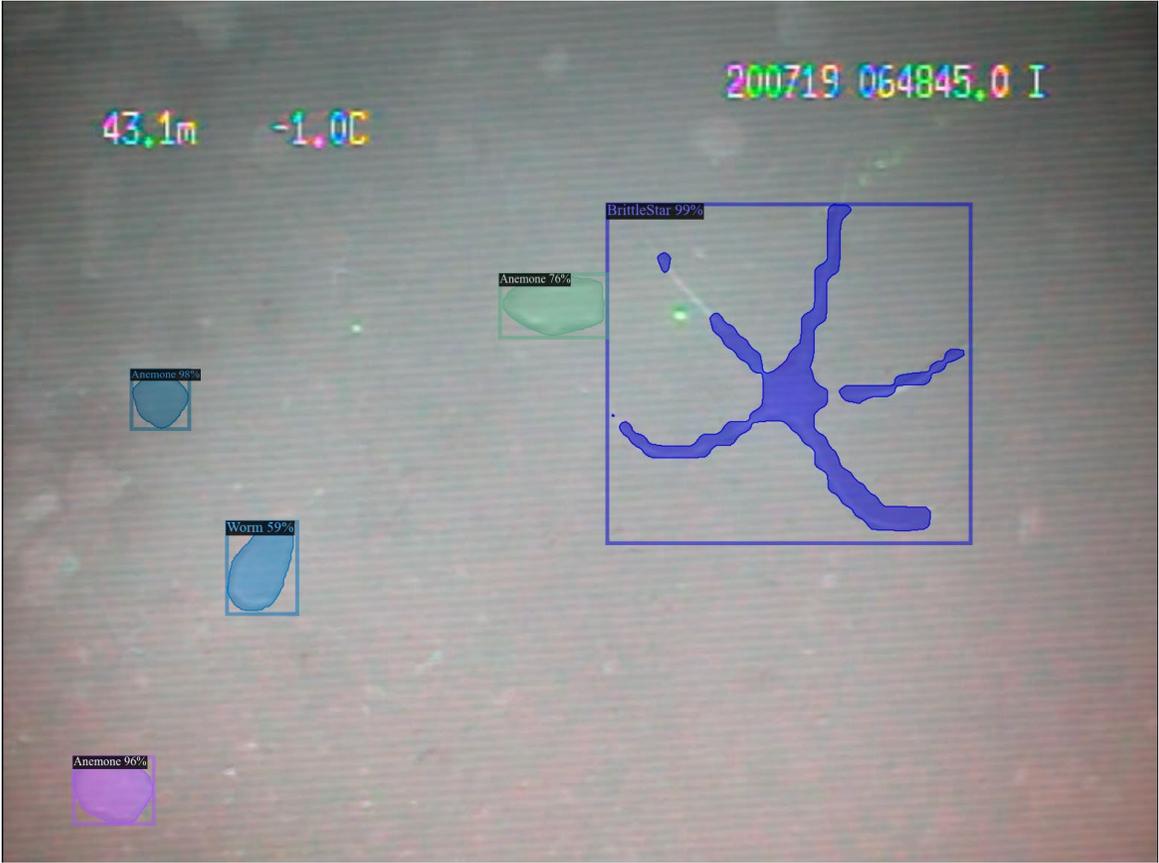
e) Full model: *Pteropoda*



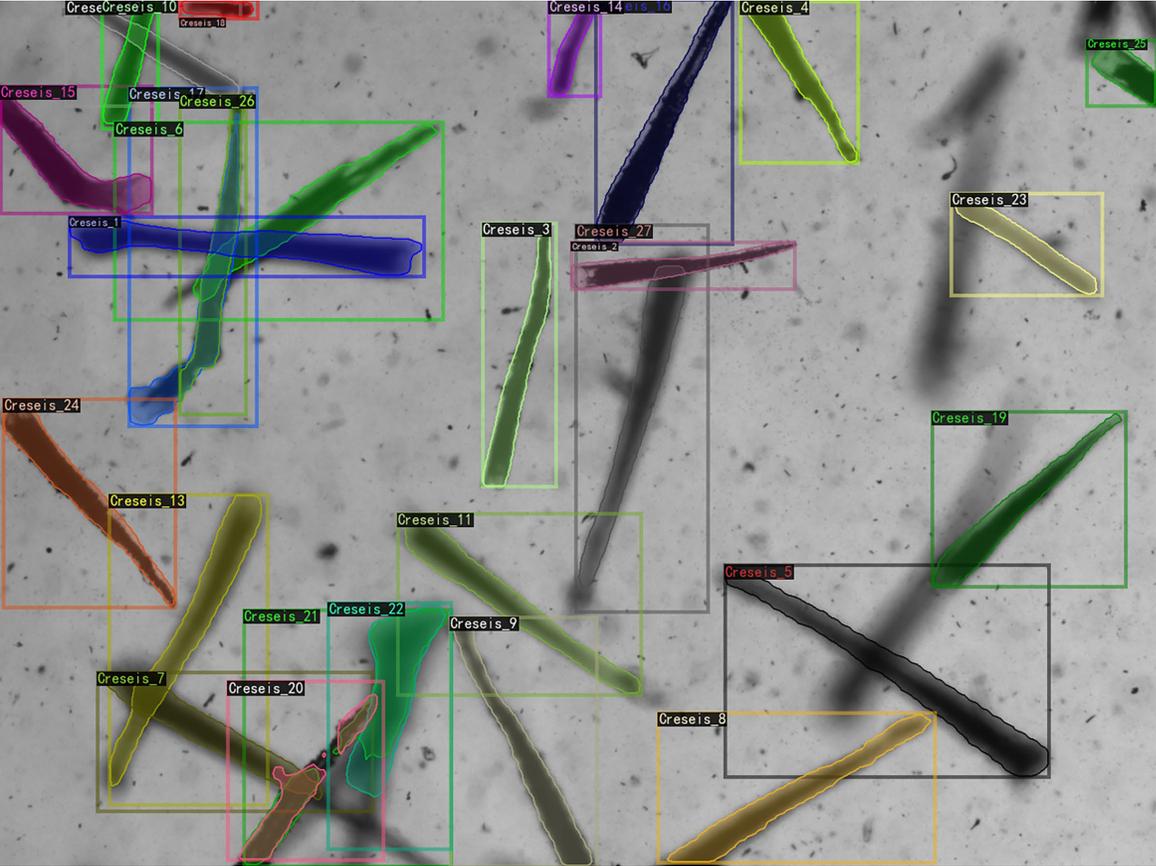
f) Scene-specific: *Pteropoda*



# OVERCOME OTHER ISSUES



Broken target



Overlapping targets

# 03

**PART THREE**

## Applications

Plankton Identification and Enumeration

Training

Scenes Training Evaluation Stop

Detection Training Evaluation Stop

Toolboxes

Split Frames Validation Plots

Clear

Evaluation

Parameters:

Contrast

Broken Protection

Display

Output:

Excel

Txt

Detection Setting:

Processor: cuda

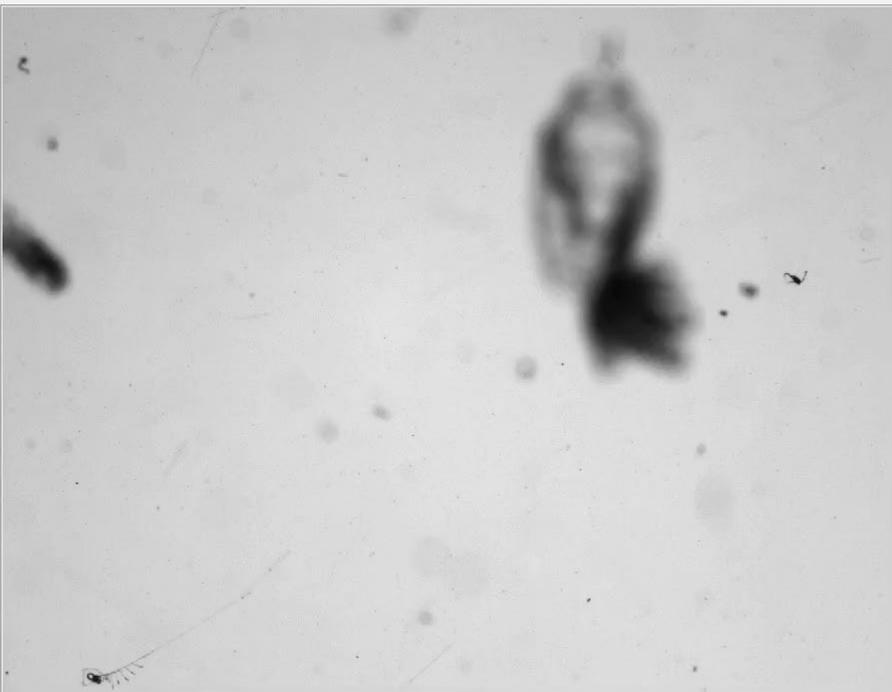
PRE\_NMS\_TOPK\_TEST: 10000

POST\_NMS\_TOPK\_TEST: 3000

Maximum Number of Targets: 900

Start Stop Quit

Image( 20190529092554159-20\_010-209717\_500-2067\_807.bmp ) is being processed!  
 Image was classified as: Shrimp  
 Image( 20190529092554159-20\_010-209717\_500-2067\_807.bmp ) is being processed!  
 Image was classified as: LowDensity



```
GPU IS AVAILABLE
[09/18 19:14:24 d2.data.datasets.coco]: Loaded 431 images in COCO format from D:/MaskRCNN/datasets/PS_MasterLib_2022Jan/ObjectClassification/labelme_subgroup_model_2021Nov/LowDensity_instances_train.json
[INFO ] checkpoint:load:150 - [Checkpointer] Loading from D:/MaskRCNN/datasets/PS_MasterLib_2022Jan/ObjectClassification/labelme_subgroup_model_2021Nov/LowDensity_16_model.pth ...
[WARNING] checkpoint:_log_incompatible_keys:355 - The checkpoint state_dict contains keys that are not used by the model:
  pixel_mean
  pixel_std
  Skeletonema:
```

Plankton Identification and Enumeration

Training

Scenes Training Evaluation Stop

Detection Training Evaluation Stop

Toolboxes

Split Frames Validation Plots

Clear

Evaluation

Parameters:

Contrast

Broken Protection

Display

Output:

Excel

Txt

Detection Setting:

Processor: cuda

PRE\_NMS\_TOPK\_TEST: 10000

POST\_NMS\_TOPK\_TEST: 3000

Maximum Number of Targets: 900

Start Quit

Warning, please restart the program if you encounter any problems:  
 Number of image file: 26  
 Image( 20210826041357753.bmp ) is being processed!  
 Image was classified as: HighConc



```
PlanktonID.exe - Shortcut
Image( 20210826041357753.bmp ) is being processed!
D:/MaskRCNN/datasets/PS_MasterLib_2022Jan/SceneClassification/scene_model_202202/best.pth
GPU IS AVAILABLE
[04/04 07:20:08 d2.data.datasets.coco]: Loaded 151 images in COCO format from D:/MaskRCNN/datasets/PS_MasterLib_2022Jan/ObjectClassification/labelme_subgroup_model_2021Nov/HighConc_instances_train.json
[INFO ] checkpoint:load:150 - [Checkpointer] Loading from D:/MaskRCNN/datasets/PS_MasterLib_2022Jan/ObjectClassification/labelme_subgroup_model_2021Nov/HighConc_13_model.pth ...
Chaetognatha: 0
Spiral_Diatom: 0
Medusae: 1
LarvalFish: 0
```

# Sonar image processing

# Benthic image processing

The screenshot shows the 'Plankton Identification and Enumeration' software interface. The 'Training' section has 'Training' selected under 'Scenes' and 'Training' under 'Detection'. The 'Toolboxes' section has 'Split Frames', 'Validation', and 'Plots' buttons. The 'Evaluation' section has 'Parameters' with 'Display' checked, and 'Output' with 'Txt' selected. The 'Detection Setting' section has 'Processor' set to 'cuda', 'PRE\_NMS\_TOPK\_TEST' set to 10000, 'POST\_NMS\_TOPK\_TEST' set to 3000, and 'Maximum Number of Targets' set to 900. The 'Start' button is highlighted. The main display area shows a sonar image of a fish floor. A status bar at the top right indicates: 'Number of image file: 20', 'Image (2016-06-15\_110951-03795.tif) is being processed!', and 'Image was classified as: FishNoFloor'.

```
PlanktonID.exe - Shortcut
Welcome to Plankton ID & Enumeration system!
[06/14 07:32:37 d2.data.datasets.coco]: Loaded 30 images in COCO format from D:/MaskRCNN/datasets/ARISImages/Labelme_subgroup_models_202109/EmptyFloor_instances_train.json
[06/14 07:32:37 d2.data.datasets.coco]: Loaded 29 images in COCO format from D:/MaskRCNN/datasets/ARISImages/Labelme_subgroup_models_202109/FishFloor_instances_train.json
[06/14 07:32:37 d2.data.datasets.coco]: Loaded 18 images in COCO format from D:/MaskRCNN/datasets/ARISImages/Labelme_subgroup_models_202109/FishNoFloor_instances_train.json
[06/14 07:32:37 d2.data.datasets.coco]: Loaded 30 images in COCO format from D:/MaskRCNN/datasets/ARISImages/Labelme_subgroup_models_202109/JellyfishFloor_instances_train.json
```

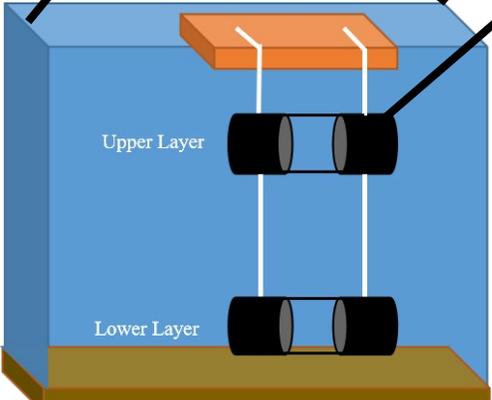
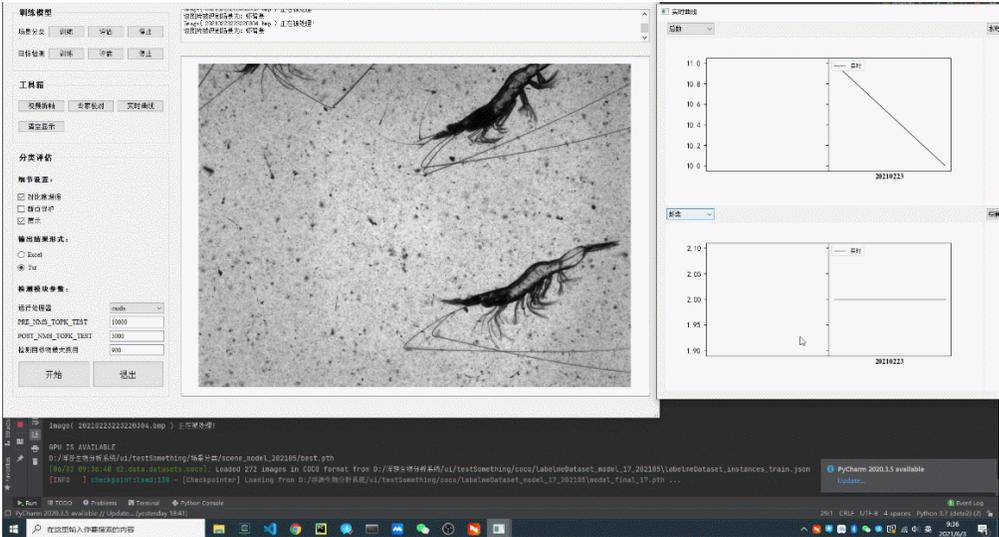
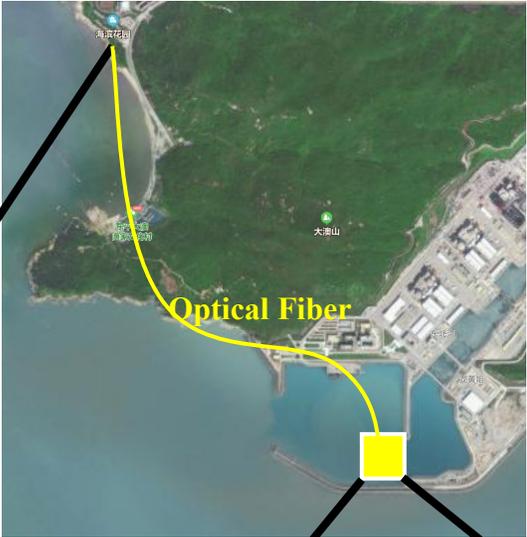
The screenshot shows the 'Plankton Identification and Enumeration' software interface. The 'Training' section has 'Training' selected under 'Scenes' and 'Training' under 'Detection'. The 'Toolboxes' section has 'Split Frames', 'Validation', and 'Plots' buttons. The 'Evaluation' section has 'Parameters' with 'Display' checked, and 'Output' with 'Txt' selected. The 'Detection Setting' section has 'Processor' set to 'cuda', 'PRE\_NMS\_TOPK\_TEST' set to 10000, 'POST\_NMS\_TOPK\_TEST' set to 3000, and 'Maximum Number of Targets' set to 900. The 'Start' button is highlighted. The main display area shows a benthic image with overlaid text: '34.2m', '4.6C', and '170717 051402.0-I'. A status bar at the top right indicates: 'Number of image file: 20', 'Image (20210624195957049.png) is being processed!', and 'Image was classified as: Aggregated'.

```
PlanktonID.exe - Shortcut
Welcome to Plankton ID & Enumeration system!
[06/14 07:35:56 d2.data.datasets.coco]: Loaded 6 images in COCO format from D:/MaskRCNN/datasets/BenthicImages/Benthic_Library_Models/Benthic_Objects/Object_Submodels_202107/Aggregated_instances_train.json
[06/14 07:35:56 d2.data.datasets.coco]: Loaded 10 images in COCO format from D:/MaskRCNN/datasets/BenthicImages/Benthic_Library_Models/Benthic_Objects/Object_Submodels_202107/ComplexBackground_instances_train.json
[06/14 07:35:56 d2.data.datasets.coco]: Loaded 15 images in COCO format from D:/MaskRCNN/datasets/BenthicImages/Benthic_Library_Models/Benthic_Objects/Object_Submodels_202107/Isolatedorganisms_instances_train.json
Number of image file: 20
Image( 20210624195957049.png ) is being processed!
```

# POWERPLANT COOLING WATER INTAKE



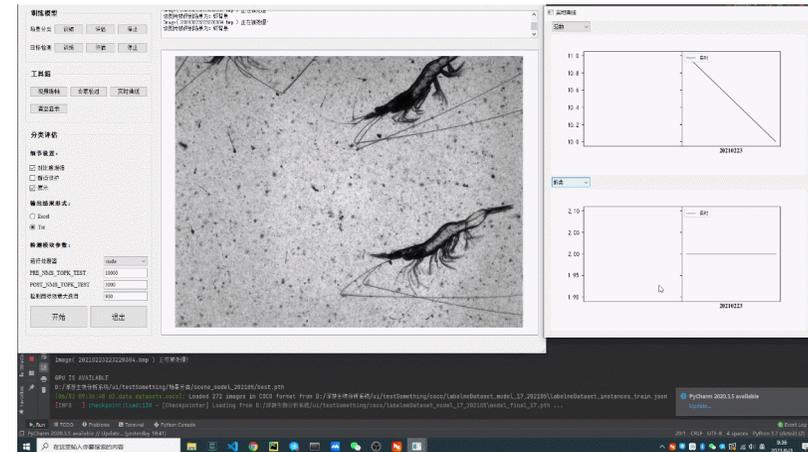
Data Center



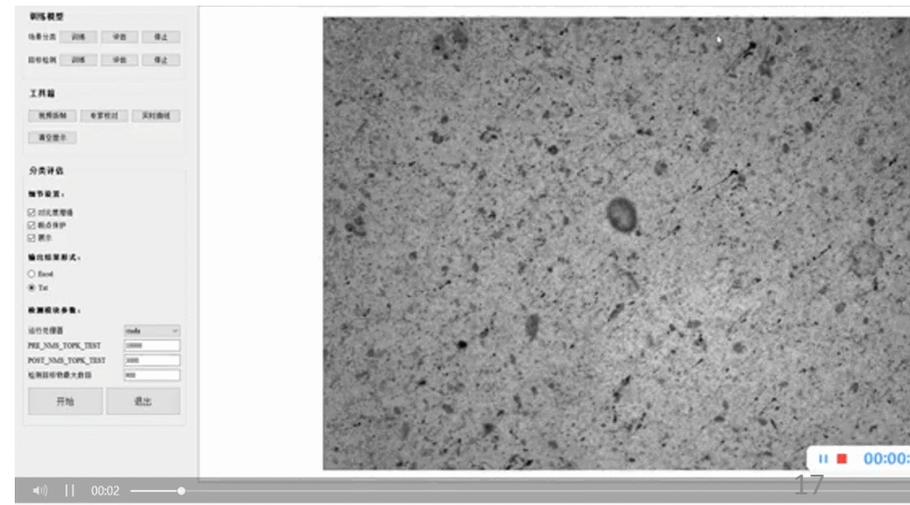
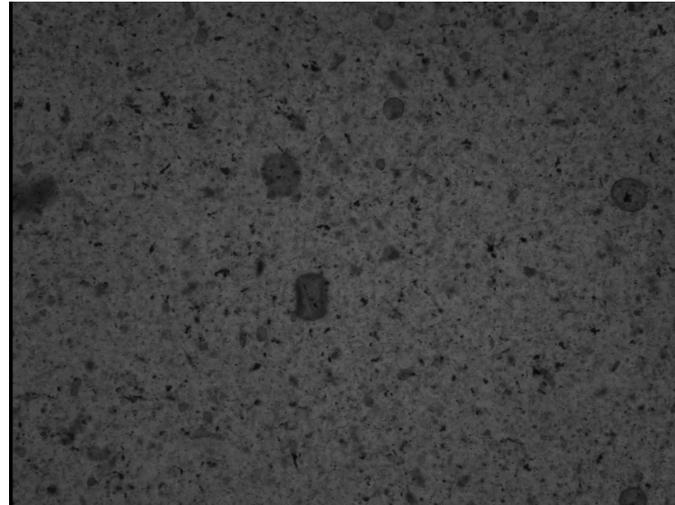
- 1. Upper for meduase
- 2. Lower for mysid shrimps

# In Situ Plankton Monitoring

## Mysid shrimp

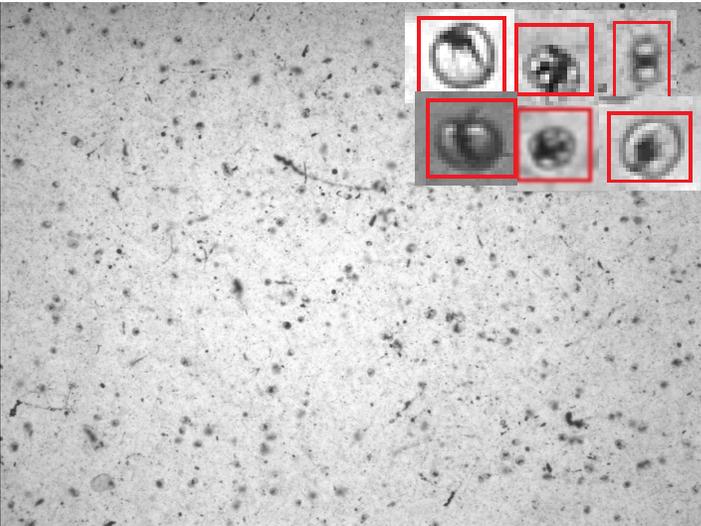


## Phaeocystis

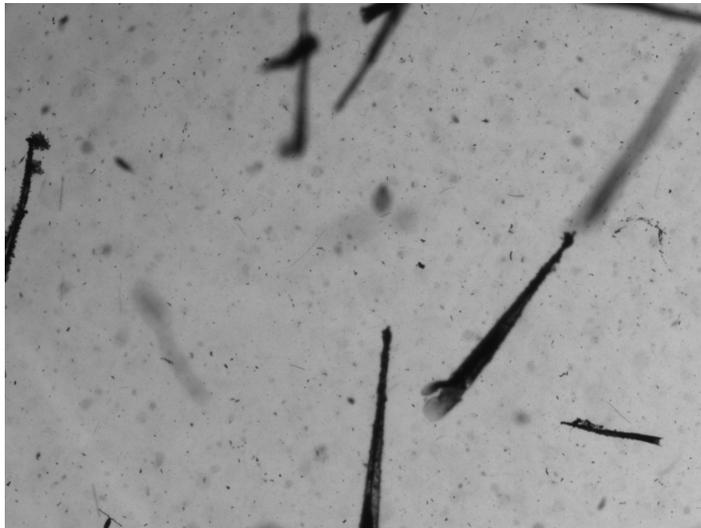


# Other blooms

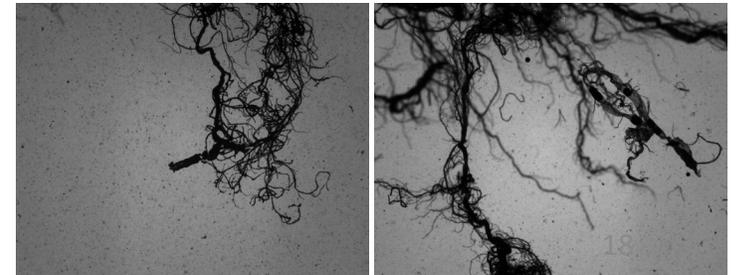
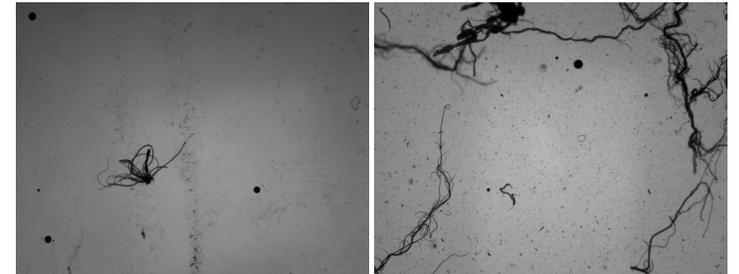
■ Noctiluca



■ Creseis



■ Enteromorpha



# CONCLUSIONS

- Plankton imaging systems readily available for monitoring work
- Deep learning systems make near real time image processing feasible
- Real time monitoring for plankton blooms or swarms is possible
- Imaging systems are useful tools for ecological process studies and ecosystem-based management

