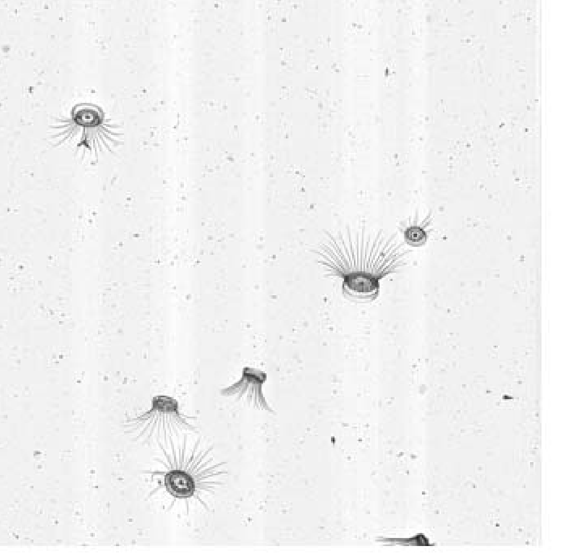
QuickTime™ and a
decompressor
are needed to see this picture.

In-Situ Plankton Imaging



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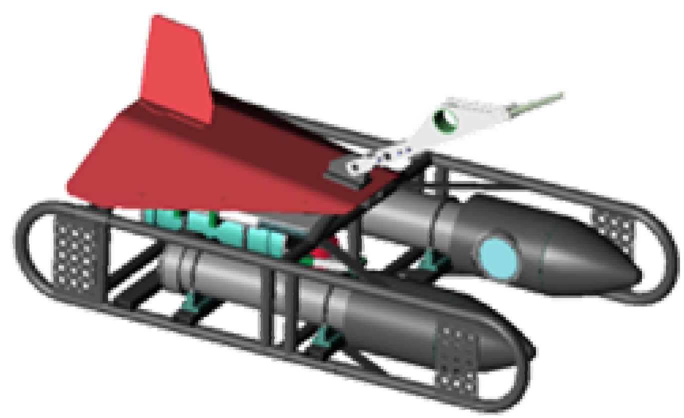
Founded in 2006 to provide engineering services to the **University of Miami** Marine Biology Department

The goal was to design/manufacture a:

"In-Situ Plankton Imaging System"



Already Two Major Achievements:

Innovative Imaging System & Innovative ROTVs

Future Developments - Need for **less expensive, smaller systems** -

Skids to Rosette CTD, Hand Deployable Tow Fish, Smaller ROTVs

The Need

Replace / Complement Net Systems

Hard work & lots of microscope time…

2 days at sea = 1 man-year of microscope work!

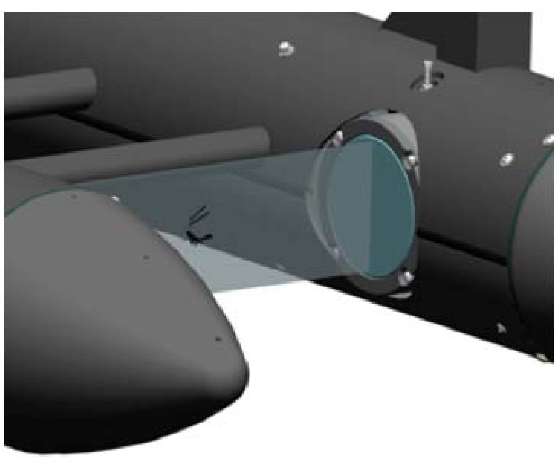
Our Solution

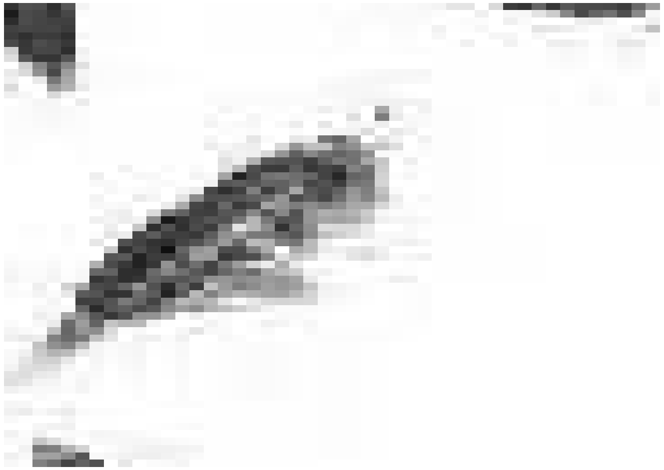
Imaging is a great solution

- Precise location position and time of each organism
- Inform about spatial and vertical distribution of critters (fine-scale distributions of plankton from centimeter- to basin- wide volumes)
- Environmental data of the organisms’ surroundings are sampled in sync.
- Imaging does not destroy organisms - easier to recognize!

Imaging “LARGE VOLUME OF WATER” **(comparable to net tows)**

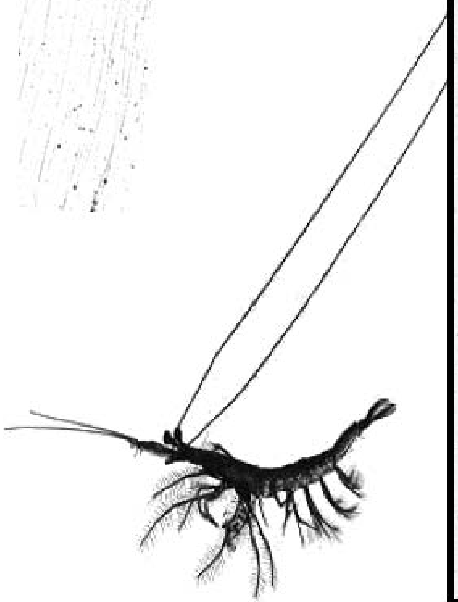
Less abundant taxa is missed when imaging too small of a volume

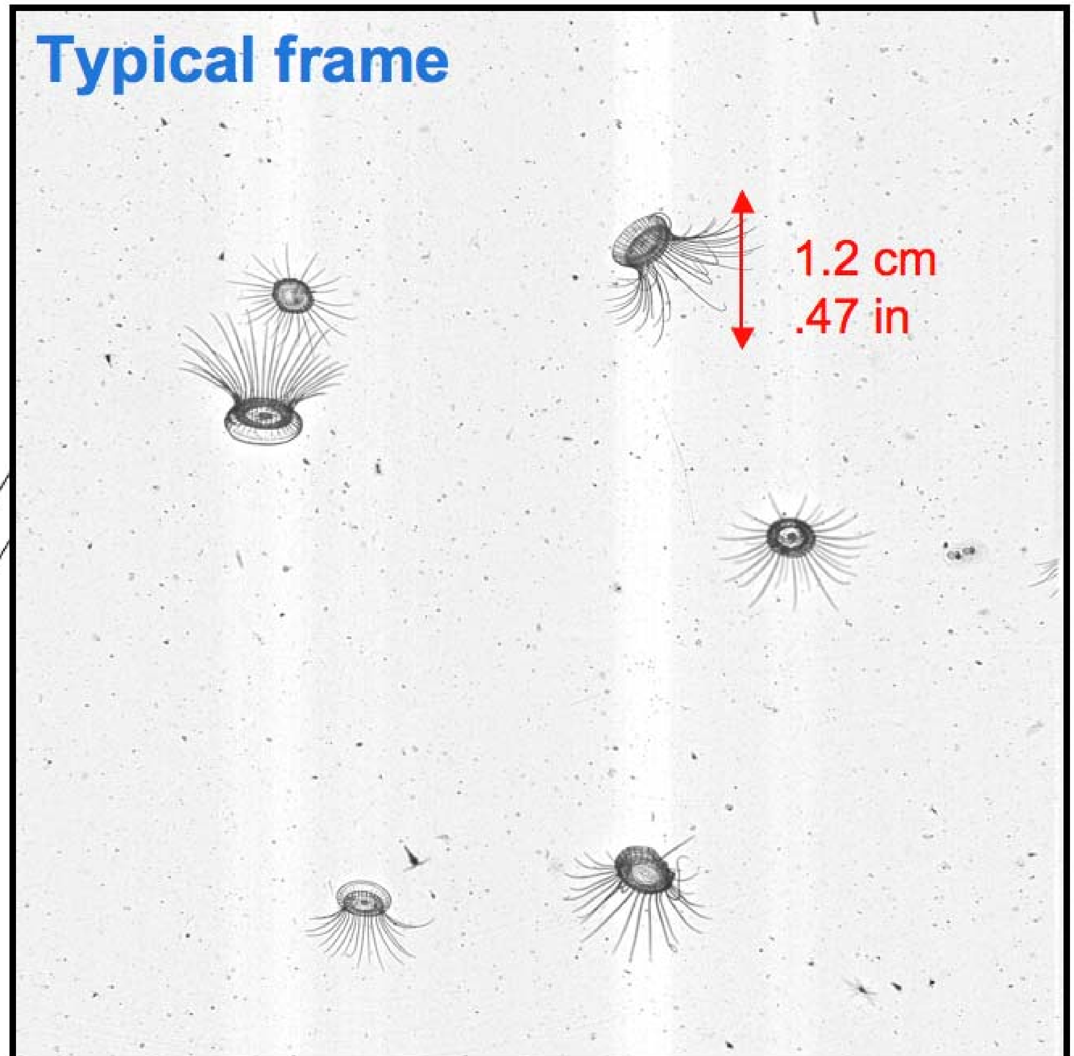


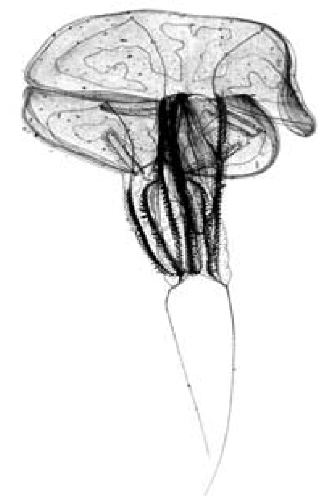


·Our Images

Imaging tiny organisms at 5 knots…

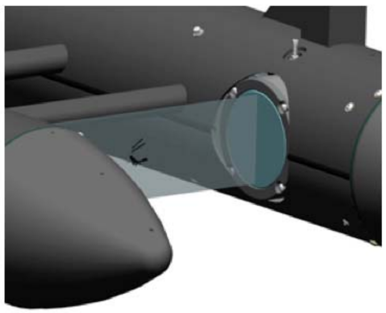


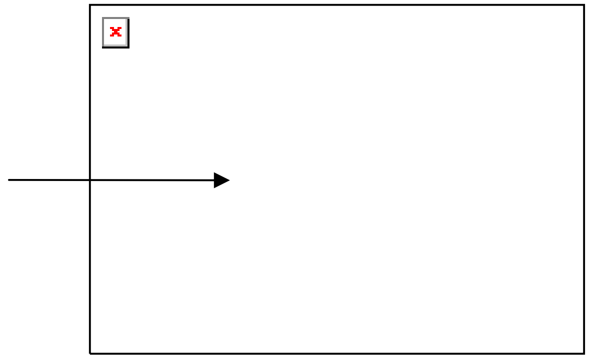




Our Images

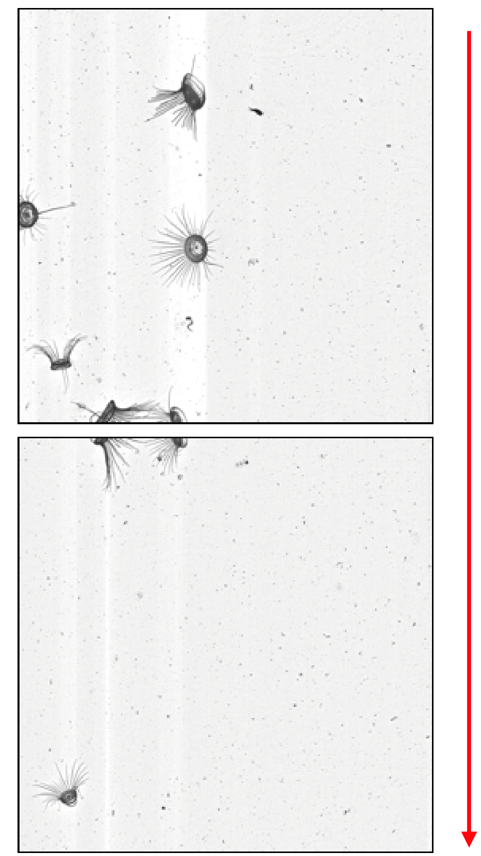
ISIIS uses a **line-scan** camera.





It creates one single **CONTINUOUS image** representing a real “slice” of the ocean.

When put end to end, images recorded represent one continuous image, several kilometers long, matching the mission profile.



Plankton! Why?

- Plankton is the bottom of the ocean's **Food Chain** (No plankton, no fish, no whales….). It is also a very important part of the **Carbon Cycle.**

- **Climate Change / Pollution**: since plankton is not harvested or exploited by humans, adjustments in distribution and abundance can be attributed to changing environmental factors.

- **Fish Stocks**: the abundance of eggs and larvae is a scientific indicator of population abundance of adults.

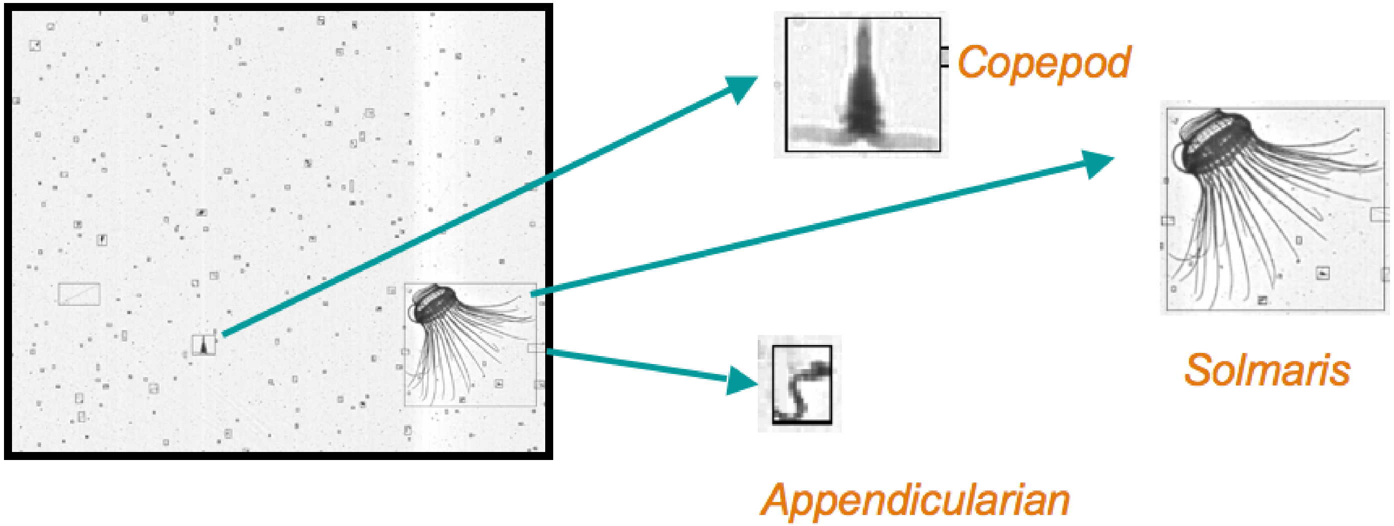
Applications

Fundamental Science

High Frequency Monitoring of Fish Population

Coastal Construction Permitting / Environmental Monitoring

*If high **data analysis** of collected images is **feasible**, we can **increase sampling frequency** which leads to **better monitoring** and leads to a greater capacity for **improved scientific inquiries**.*



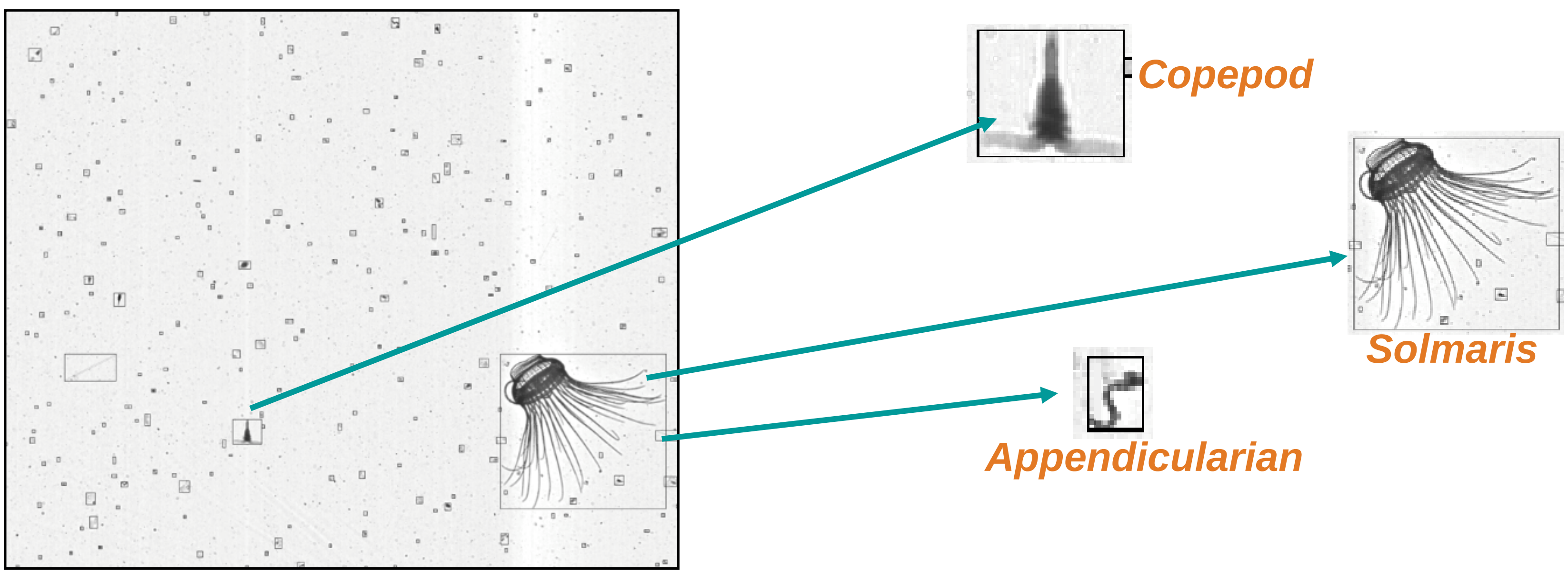
Automated Analysis is a Must!

QuickTime™ and a
decompressor
are needed to see this picture.

Generally, there are 2 necessary steps for pattern recognition:

Step 1. Segmentation :
find regions/objects of interest (ROI-s) versus background.

Step 2. Recognition :
identify objects of interest as belonging to certain classes.



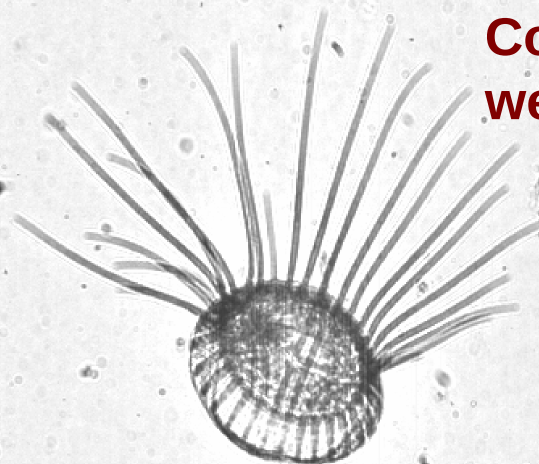
Step 1. Segmentation
for In-Situ High-Volume Imaging

Challenges:

Compared to Lab Imaging scanners (net tows → "*Zooscan*"), the <u>background</u> is real ocean water:

typical
zooscan image

- **Non-uniform intensity distribution**
- **Bubbles**
- **Unrelated objects.**

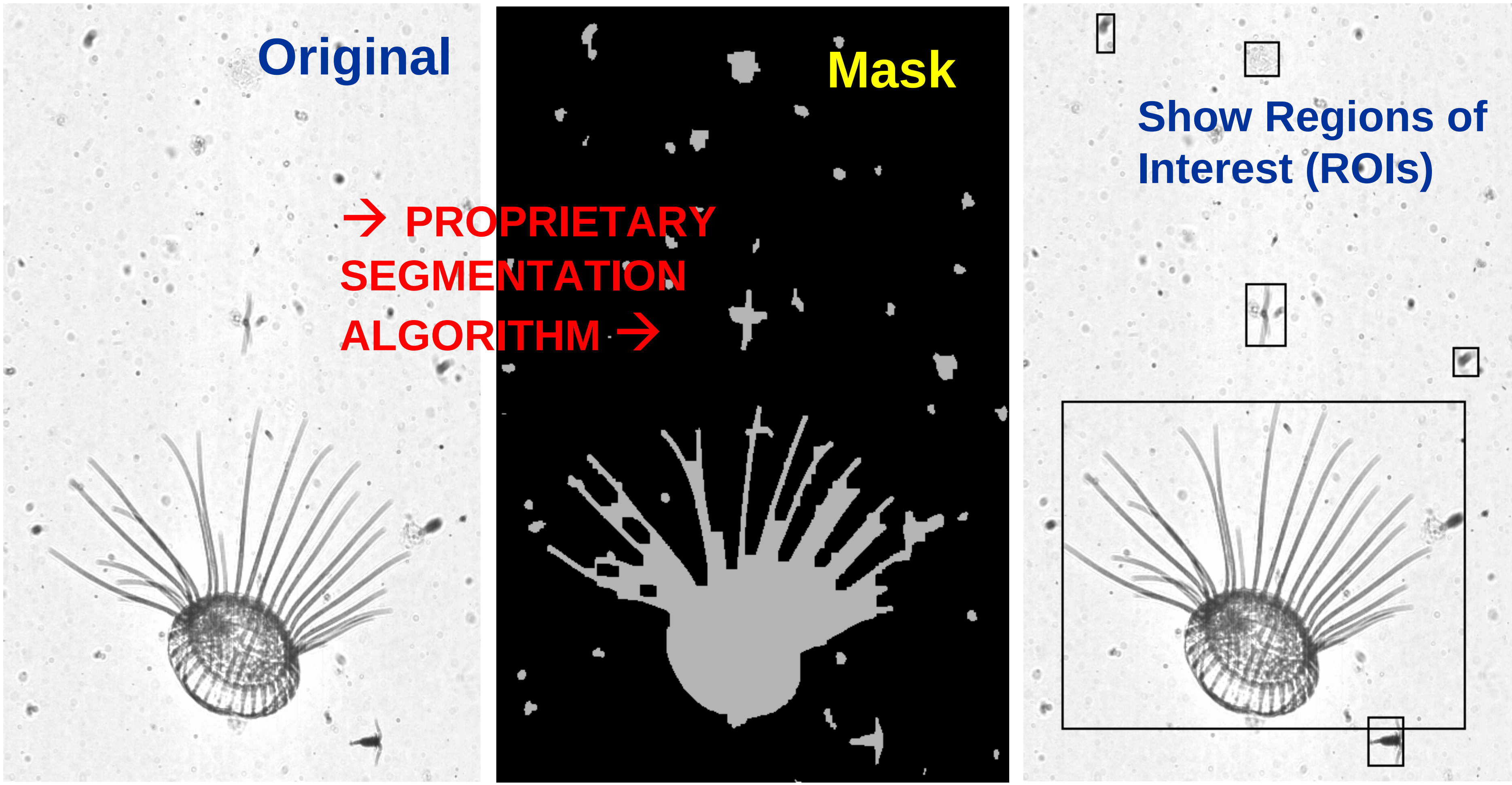


Compared to other In-Situ Imagers, we look at BIG water VOLUMES:

- **Focus quality will vary!**

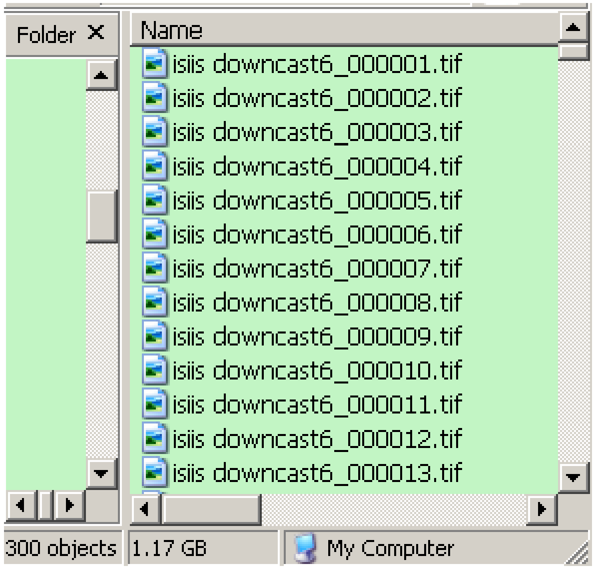
Step 1. Segmentation

…Continued



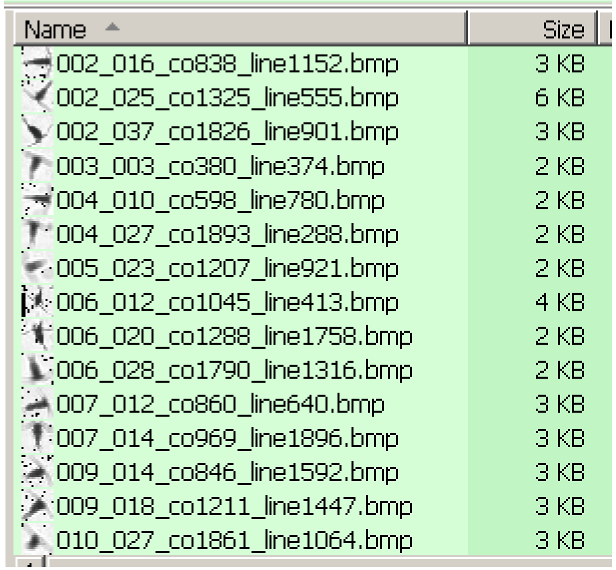
"Segmentator"
A Powerful Tool in Itself

1. Data Reduction > 20 times.
2. Can be implemented on parallel hardware for real-time, on board, processing.
3. Number of ROIs and their distribution, by size, are already very informative!



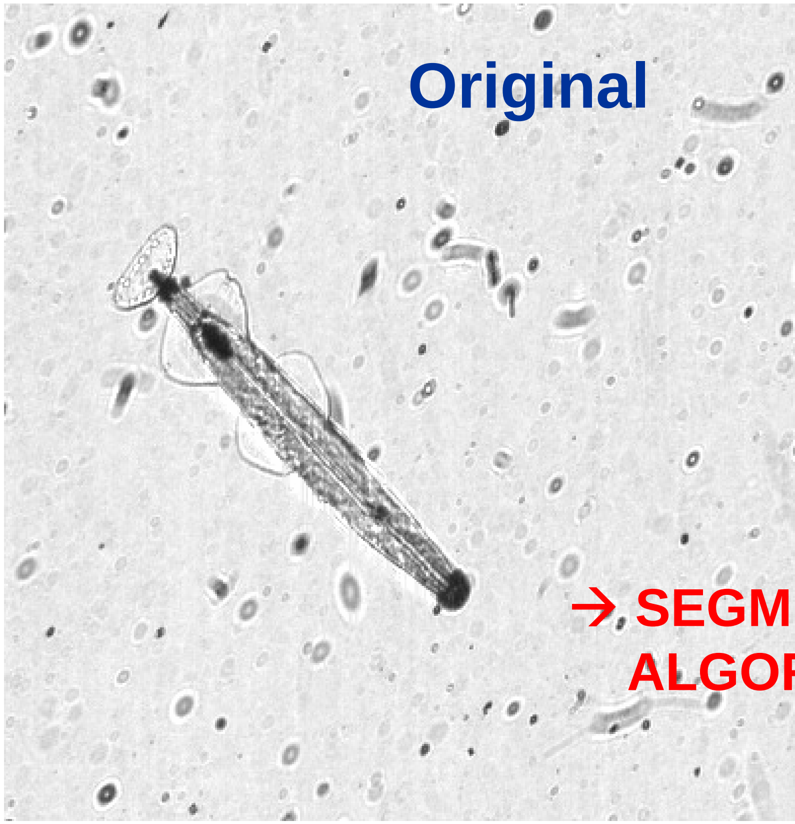
original 300 Frames:
1.17 GB Total

segmentation

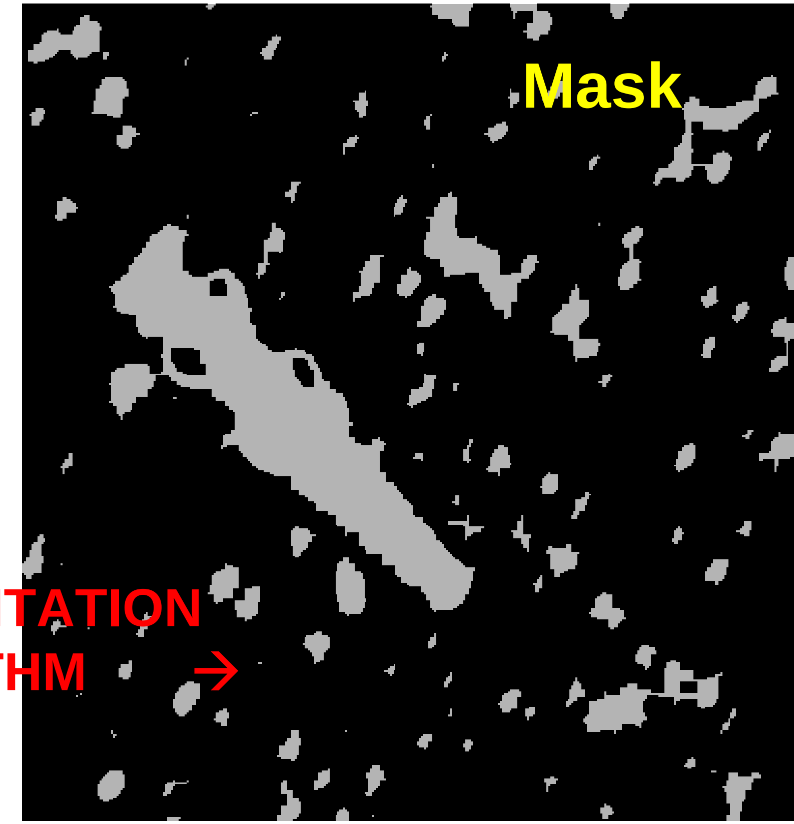


Regions of Interest:
57 MB Total

Another
Segmentation Example



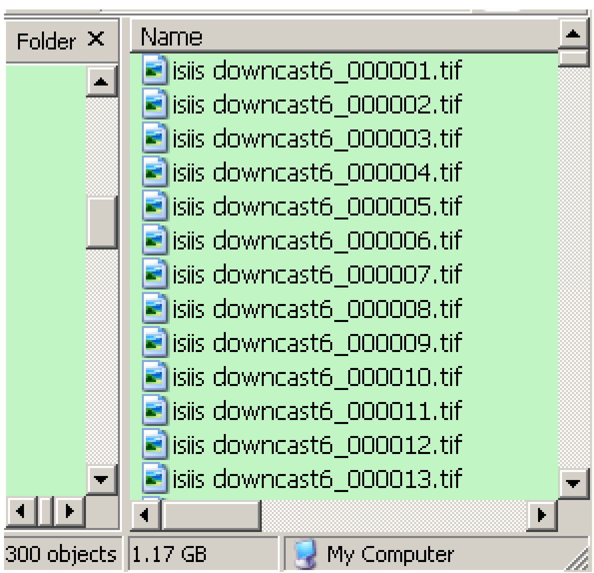
→ SEGMENTATION
ALGORITHM →

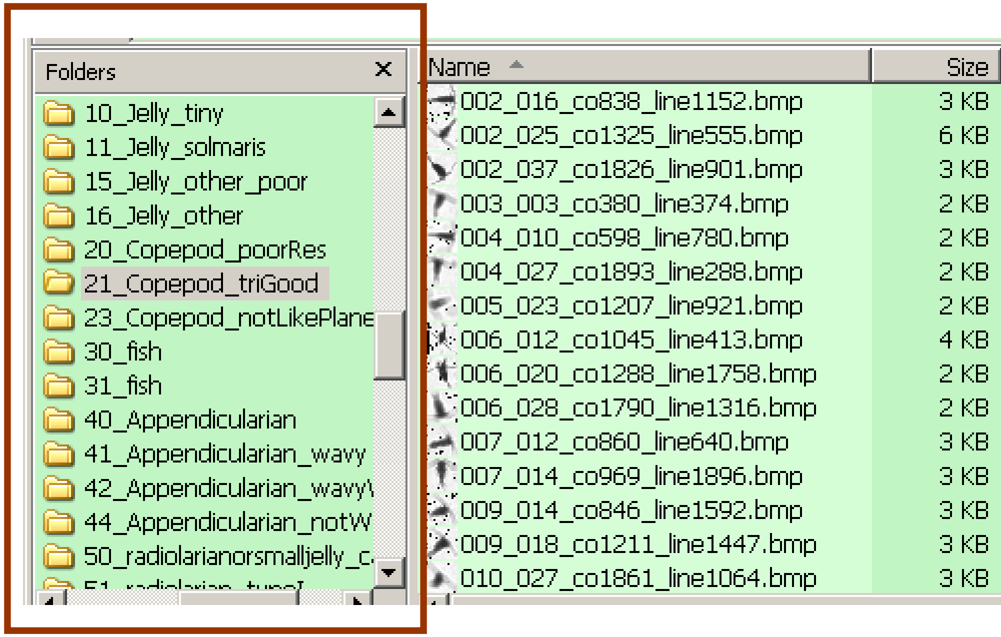


**Further recognition must be adapted
to non-perfect ROIs such as “group portraits” .**

Step 2. Recognition
Manual training

<u>Recognition</u>
Done manually, here, for “Training” purposes





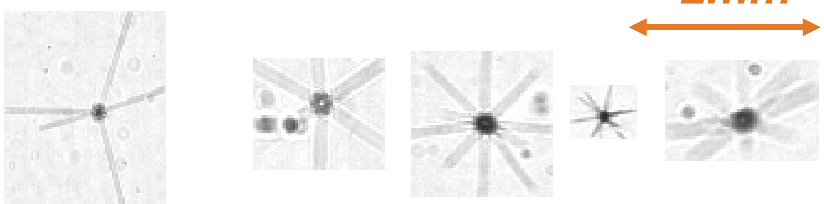
Step 2. Recognition

Ambiguities can be numerous…

Need to adapt Recognition to the imaging system's resolution: Smaller, more abundant taxa should be imaged with a secondary system to avoid ambiguities.

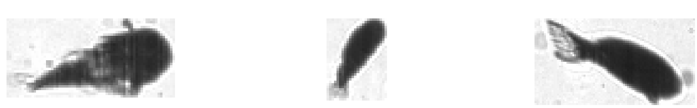
Radiolarian type II

1mm

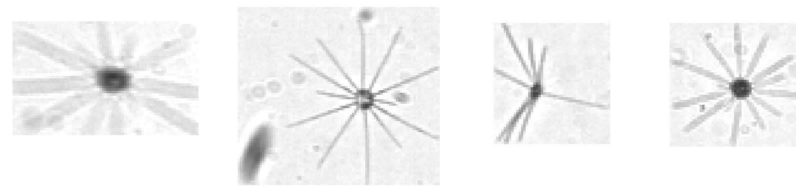


Chaetognath

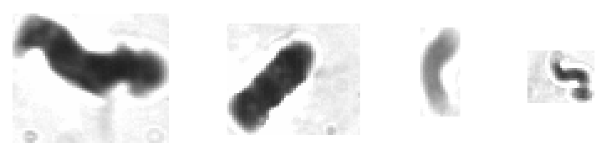
Fish



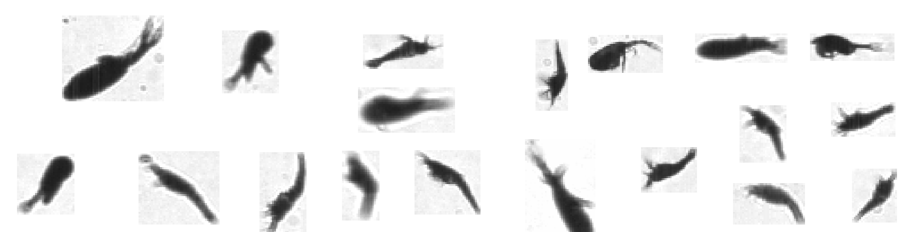
Jelly tiny



Appendicularian



Shrimps



Step 2. Recognition

Known efforts…

Known Plankton Recognition Approaches

- G. Tsechpenakis, C. Guigand, and R. Cowen, "Image analysis techniques to accompany a new In Situ Ichthyoplankton Imaging System (ISIIS)", 2007.
- Q.Hu, C. Davis, “Accurate automatic quantification of taxa-specific plankton abundance using dual classification with correction”, Marine Ecology Progress Series, 306: 51–61, 2006

Calculate 30+ features!!

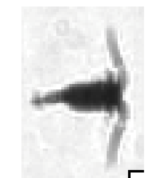
size, aspect ratio, Hu moments, Fourier Coeffs for contour Radius(Angle), texture-based values (mean and range of co-occurrence matrices from different angles, energy, contrast, entropy, etc.) and a support vector machine classifier.

With extensive variety of plankton shapes, and potentially non-perfect ROIs (segmentation), generalization methods of recognition face a big challenge.

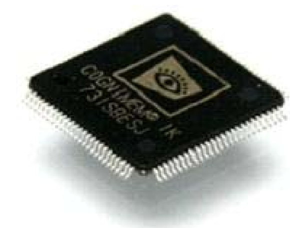
Our Approach is different…

Step 2. Recognition
Our Vision

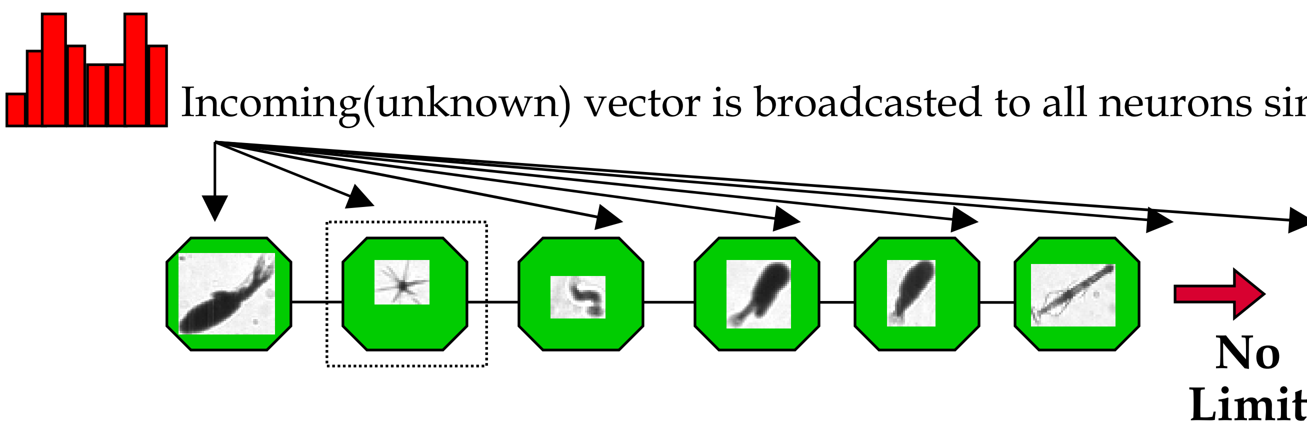
Our Approach combines:



1) **Proprietary analytical methods** whenever there is a distinct recognition principle, like “triangular” copepods.
(includes integrating logical reasoning into distance equation in clustering space as logical polynomials)



2) CogniMem: **dedicated hardware** NN non-linear classifier: learn and recognize a 256-bytes vector < 11 μ sec @27MHz.



Publication on these results is coming...


Thank You!