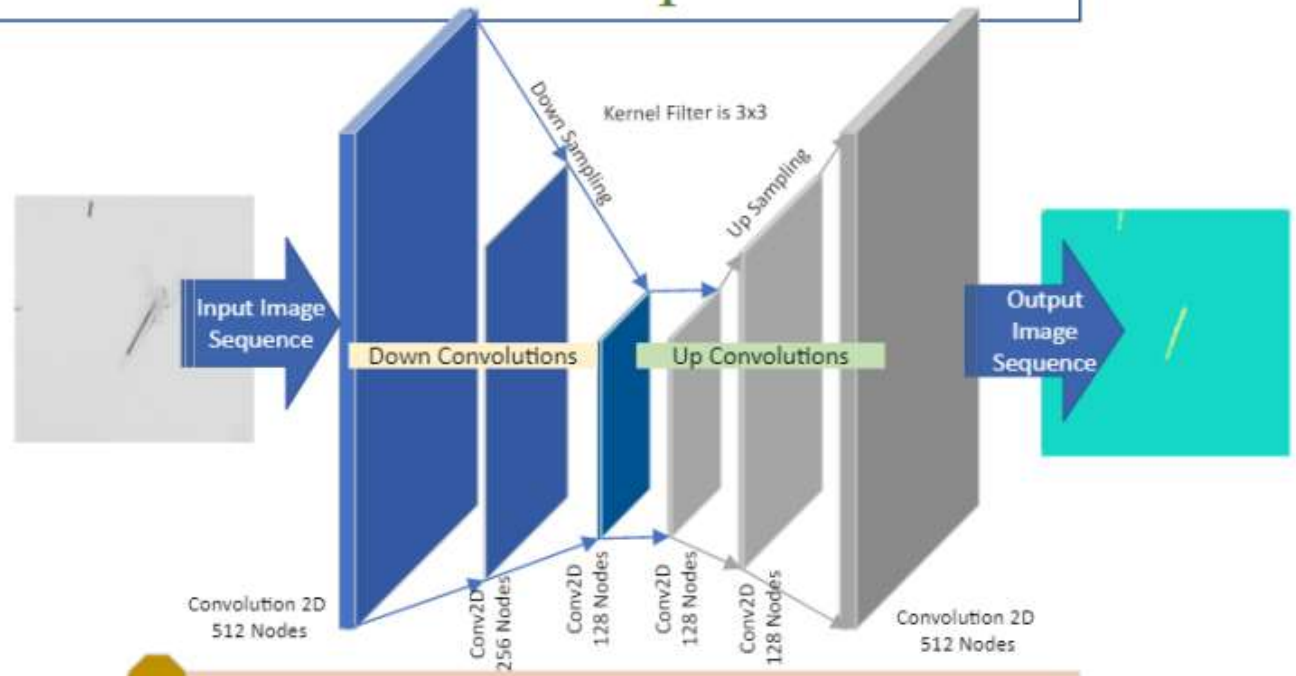
FEWS: Nano Particle Uptake Measurement with Computer Vision

Broader Implications of the Research

The ubiquity of plastics in the environment has an impact on the nanoscale and presents a new paradigm for research into climate change. This pollution of nanoparticles (NP) is of emerging concern as concentrations are found in commercial marine foods. Plastic nanoparticle pollution must be studied as it manifests in marine biology in order to anticipate the impact it will have on fisheries.

The *Research Tasks* for developing automated visual analysis and measurement capabilities of NP in living subjects are:

1. Preparing Training Dataset by Labeling
2. Training the Model Through a Supervised Learning Process
3. Applying the U-Net Model for Image Segmentation
4. Developing the Computer Vision for the Measurement of NP

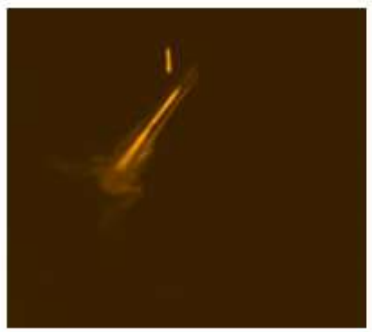


3 Unet Model Architecture and Input Output Images

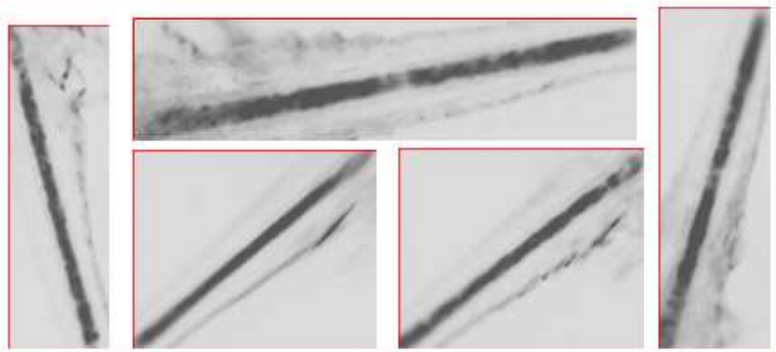
1 Manual labeling process of highlighting subject and background in image editing software.

Labeled Artemia for image segmentation as binary classification problem

2 Machine Learning process from dataset creation to model selection and supervised training



Input Frame



Cut Frames from CV Process

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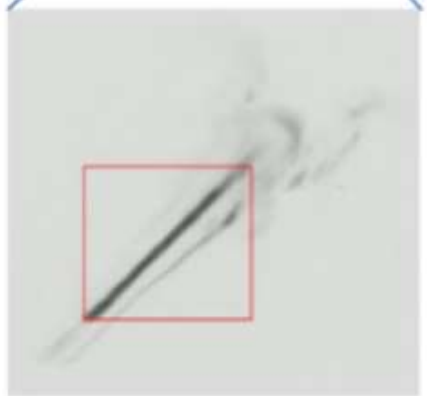
4 Computer Vision Algorithm for Measuring Nano Particle Buildup

Segmented Images by U-net

Input Image Sequence for measuring NP build up

Computer Vision - Countour Detect

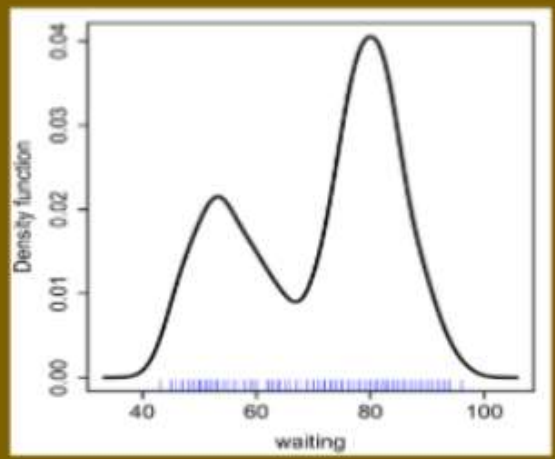
Computer Vision - Bounding Box



Snapshot of Process

Snapshot of Process

Computer Vision - Measure Pixel Density of Nano Particles



Determine NP accumulation as micro meter volume

Convert Surface Density to Nano Particle Density with ratio of 1.63 micro meters per pixel

- NP initial size= 300 nm
- NP Concentration= 0.5 mg/L
- Exposure period= 72h
- Waterborne exposure

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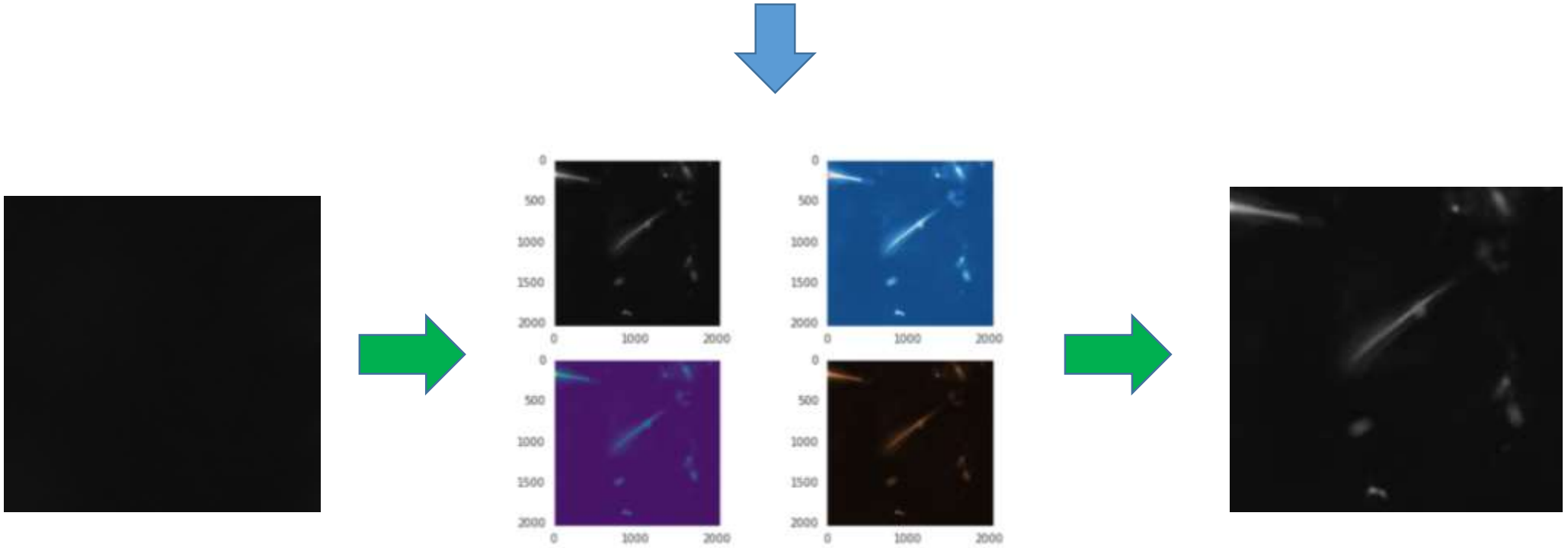
Converting the image files from TIF to PNG by applying colormaps to generate images with visible Artemia



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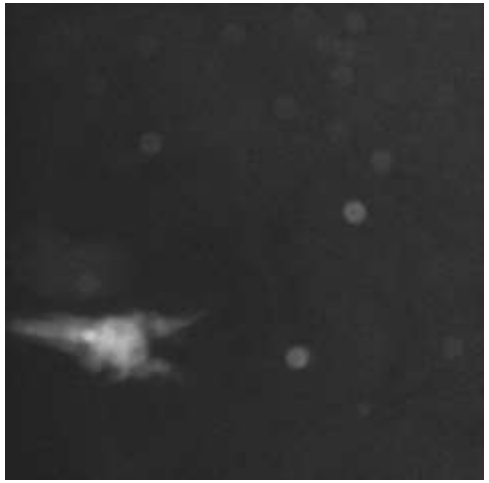
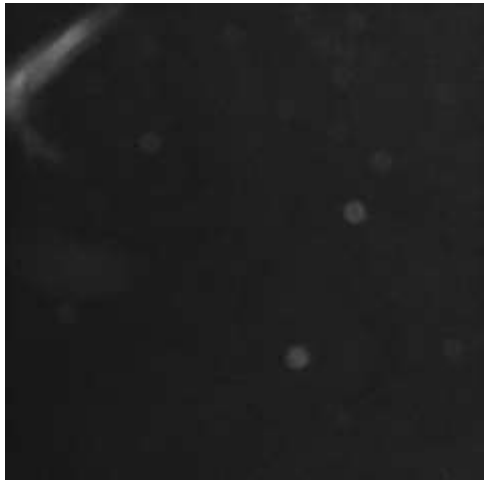
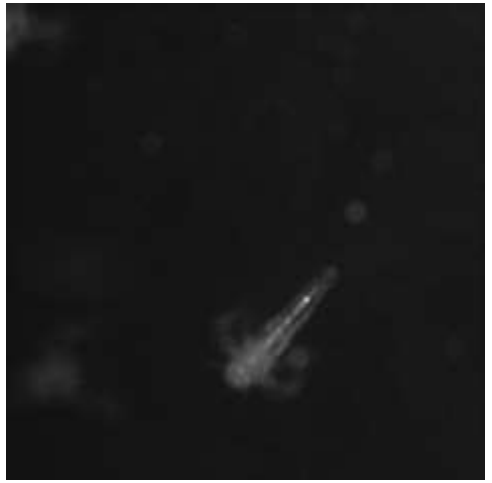
Discarding the images with out-of-focus or blurry Artemia

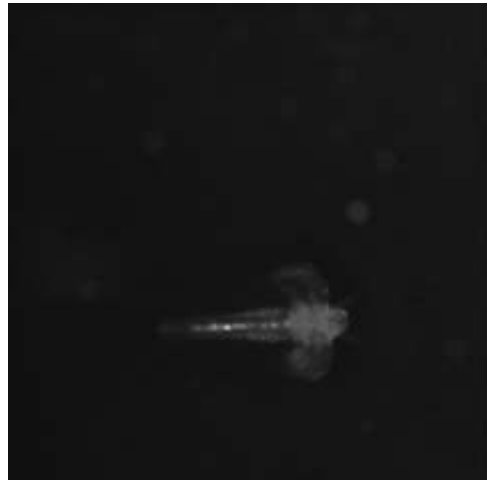
Out of focus





In focus





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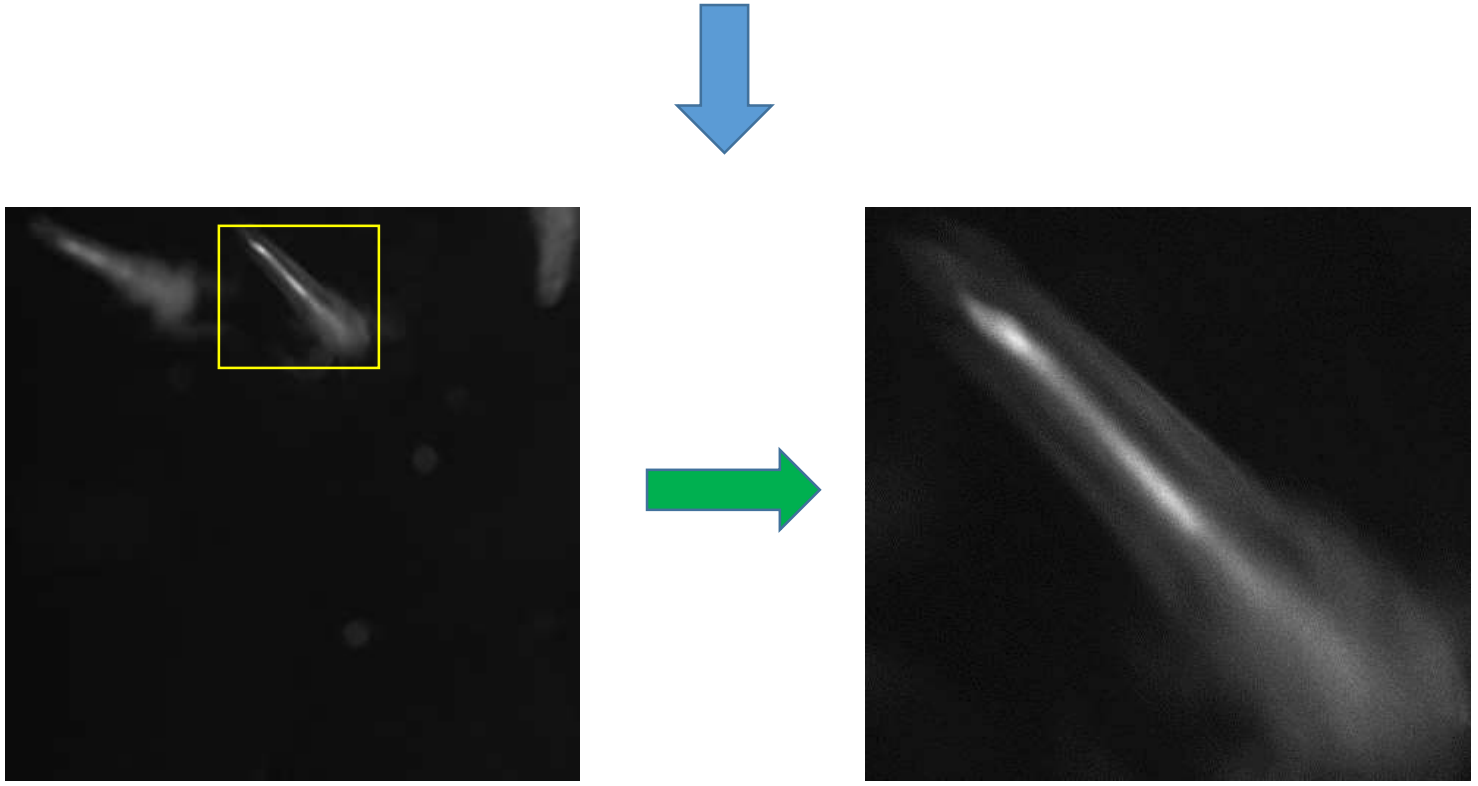
Cropping out the portion of the images that has Artemia on it



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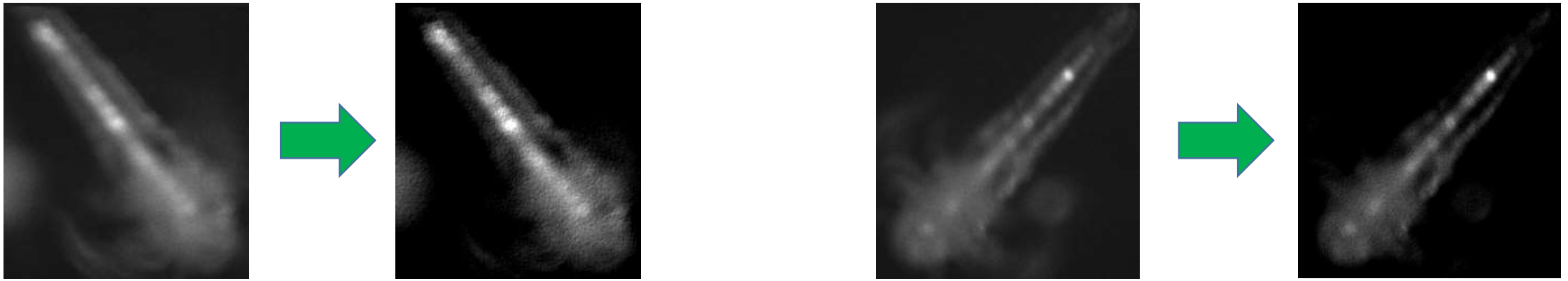
Sharpening the images by tweaking the gradient representations of them



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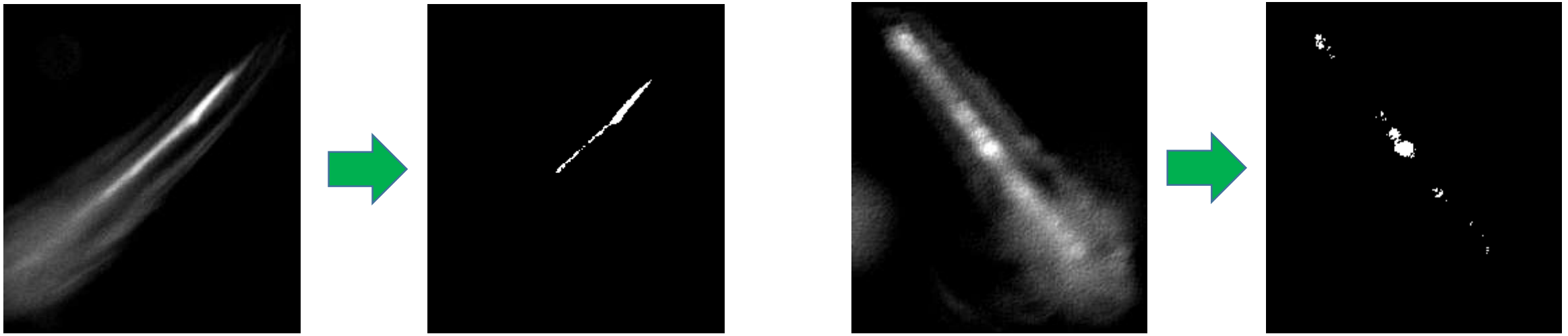
Applying a threshold value to the images



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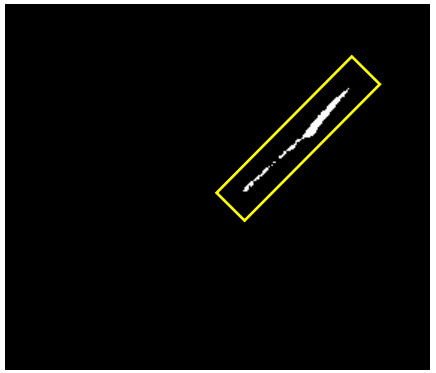
Counting the number of pixels that each Artemia has (50mg)



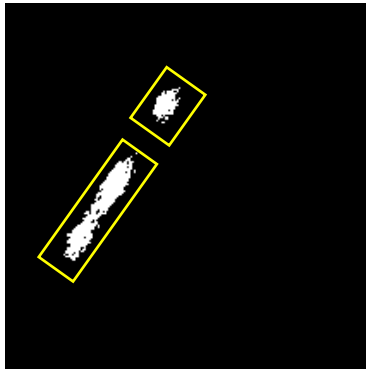


Image: 50mg (20).PNG, Number of pixels: 684
Image: 50mg (21).PNG, Number of pixels: 285
Image: 50mg (22).PNG, Number of pixels: 225
Image: 50mg (23).PNG, Number of pixels: 1055
Image: 50mg (24).PNG, Number of pixels: 529
Image: 50mg (25).PNG, Number of pixels: 279
Image: 50mg (26).PNG, Number of pixels: 132
Image: 50mg (27).PNG, Number of pixels: 106
Image: 50mg (28).PNG, Number of pixels: 20

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Counting the number of pixels that each Artemia has (100mg)

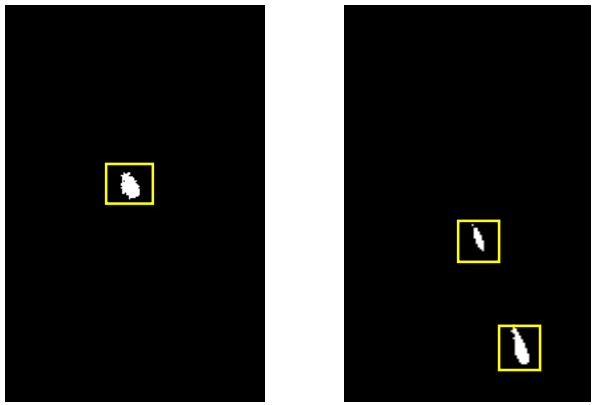

Image: 100mg (10).PNG, Number of pixels: 97
Image: 100mg (11).PNG, Number of pixels: 425
Image: 100mg (12).PNG, Number of pixels: 146
Image: 100mg (13).PNG, Number of pixels: 131
Image: 100mg (14).PNG, Number of pixels: 152
Image: 100mg (15).PNG, Number of pixels: 196
Image: 100mg (16).PNG, Number of pixels: 545
Image: 100mg (17).PNG, Number of pixels: 362
Image: 100mg (18).PNG, Number of pixels: 206
Image: 100mg (19).PNG, Number of pixels: 426

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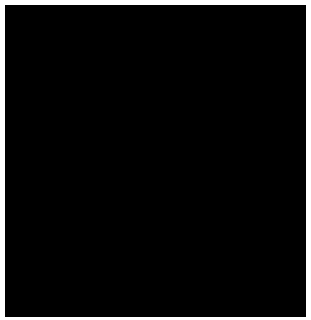
Counting the number of pixels that each Artemia has (Controlled)



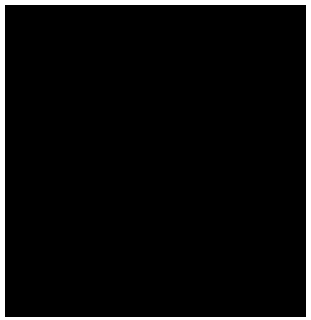


Image: 5dph (30).PNG, Number of pixels: 0
Image: 5dph (31).PNG, Number of pixels: 0
Image: 5dph (32).PNG, Number of pixels: 0
Image: 5dph (33).PNG, Number of pixels: 0
Image: 5dph (34).PNG, Number of pixels: 0
Image: 5dph (35).PNG, Number of pixels: 0
Image: 5dph (36).PNG, Number of pixels: 0
Image: 5dph (37).PNG, Number of pixels: 0

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No	Name	Year	Novelty	Link
1	Aquatic Microplastic Research - A Critique and Suggestions for the Future	2020	What proportion of contaminants are removed in the digestive system vs. staying bound tightly to the mps	https://www.mdpi.com/2073-4441/12/5/1475
2	Correction of out-of-focus microscopic images by deep learning	2022	Correcting out-of-focus images using Cycle Generative Adversarial Network (CycleGAN) based model and a multi-component weighted loss function	https://www.sciencedirect.com/science/article/pii/S2001037022001192
3	Simplifying Microplastic via Continuous Probability Distributions for Size, Shape, and Density	2019	Fully defining mps through a three-dimensional (3D) probability distribution, with size, shape, and density as dimensions	https://pubs.acs.org/doi/10.1021/acs.estlett.9b00379
4	Advanced tracking system of multiple Artemia and various behavioral endpoints for ecotoxicological analysis	2020	Optimization of frame per second (fps) to solve the problem about the jerky movements of artemia	https://doi.org/10.1016/j.ecolind.2020.106503
5	Review on Nanoparticles and Nanostructured Materials: Bioimaging, Biosensing, Drug Delivery, Tissue Engineering, Antimicrobial, and Agro-Food Applications	2022	Discussed different nanoparticles and nanostructured material synthesis approaches and presents some emerging biomedical, healthcare, and agro-food applications	https://doi.org/10.3390/nano12030457
6	Toxicity Effect of Silver Nanoparticles in Brine Shrimp Artemia	2014	When the concentration of silver NPs increased, the mortality rate, aggregation in gut region, apoptotic cells, and DNA damage increased in nauplii but the percentage of hatching in Artemia cysts decreased	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3910122/
7	Comparative evaluation of impact of Zn and ZnO nanoparticles on brine shrimp (Artemia salina) larvae: effects of particle size and solubility on toxicity	2013	Smaller Zn NPs (40-60 nm) were relatively more toxic than larger Zn NPs (80-100 nm)	https://doi.org/10.1039/C2EM30540B
8	Mortality and Effect on Growth of Artemia franciscana Exposed to Two Common Organic Pollutants	2019	Acute toxicity and inhibition on growth of Artemia franciscana nauplii (Instar I-II) after exposure to the reference toxicants bisphenol a (BPA) and sodium dodecyl sulfate (SDS) were studied after 24, 48, and 72 h of exposure to the toxicants	https://doi.org/10.3390/w11081614
9	Effects of nanoparticles in species of aquaculture interest	2017	Toxicity data cannot be easily used to infer on aquaculture mainly considering short-term exposure scenarios, underestimating the potential exposure of aquacultured species	https://link.springer.com/article/10.1007/s11356-017-9360-3
10	Effects of enriched artemia with selenium nanoparticles on growth, survival and biochemical factors of guppy (Poecilia reticulata)	2019	In terms of growth indices, significant differences were observed among treatments in length increment, weight gain, specific growth rate and survival rate	https://jifro.ir/article-1-4170-fa.pdf

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