

CORRECTION OF THE ESTIMATION OF THE VOLUME OF COPEPODS FROM 2-DIMENSIONAL IN SITU IMAGES

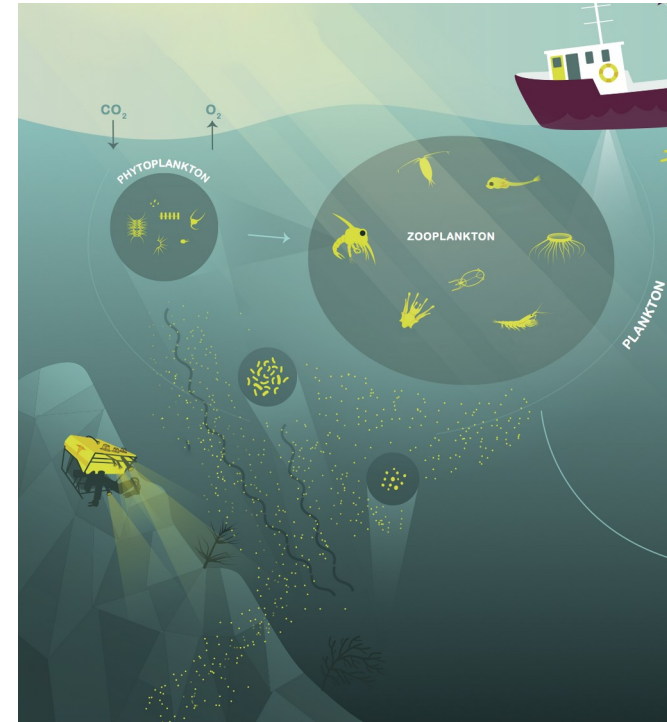


Session: SS29 1 - Zooplankton mediation of particle flux

Cédric Dubois, Jean-Olivier Irisson, Éric Debreuve

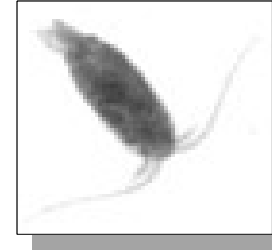
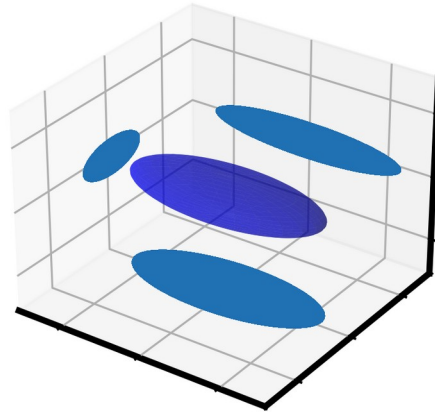
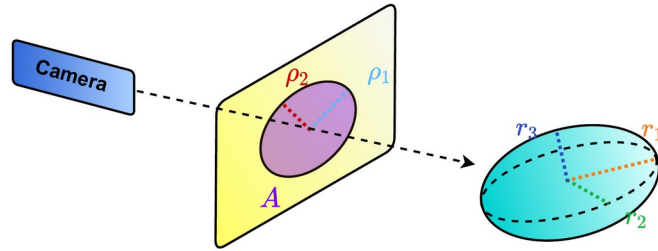
cedric.dubois@univ-cotedazur.fr

- Meso-plankton: major contributors to biogeochemical fluxes in the ocean [Buitenhuis E, 2006]
- Copepods: ~ 85% of meso-plankton organisms [Alan R. Longhurst, 2007]
- **Major impact on the “biological carbon pump”**
 - ➔ **Total Copepod volume estimation**





UVP camera
Source : Hydroptic



- 1- Equivalent Sphere Diameter (\mathcal{M}_{ESD}) :
- 2- Ellipse method (\mathcal{M}_{ELL}) :

- **ESD** & **ELL** → Volume estim. Errors
- $V_{TOTAL}(\text{copepods})$ → Total Error ?
 - ➔ **What is the trend for a large set of copepods ?**
 - ➔ **Possible** through simulation

$$\mathcal{T}_{ESD} = 122\%$$

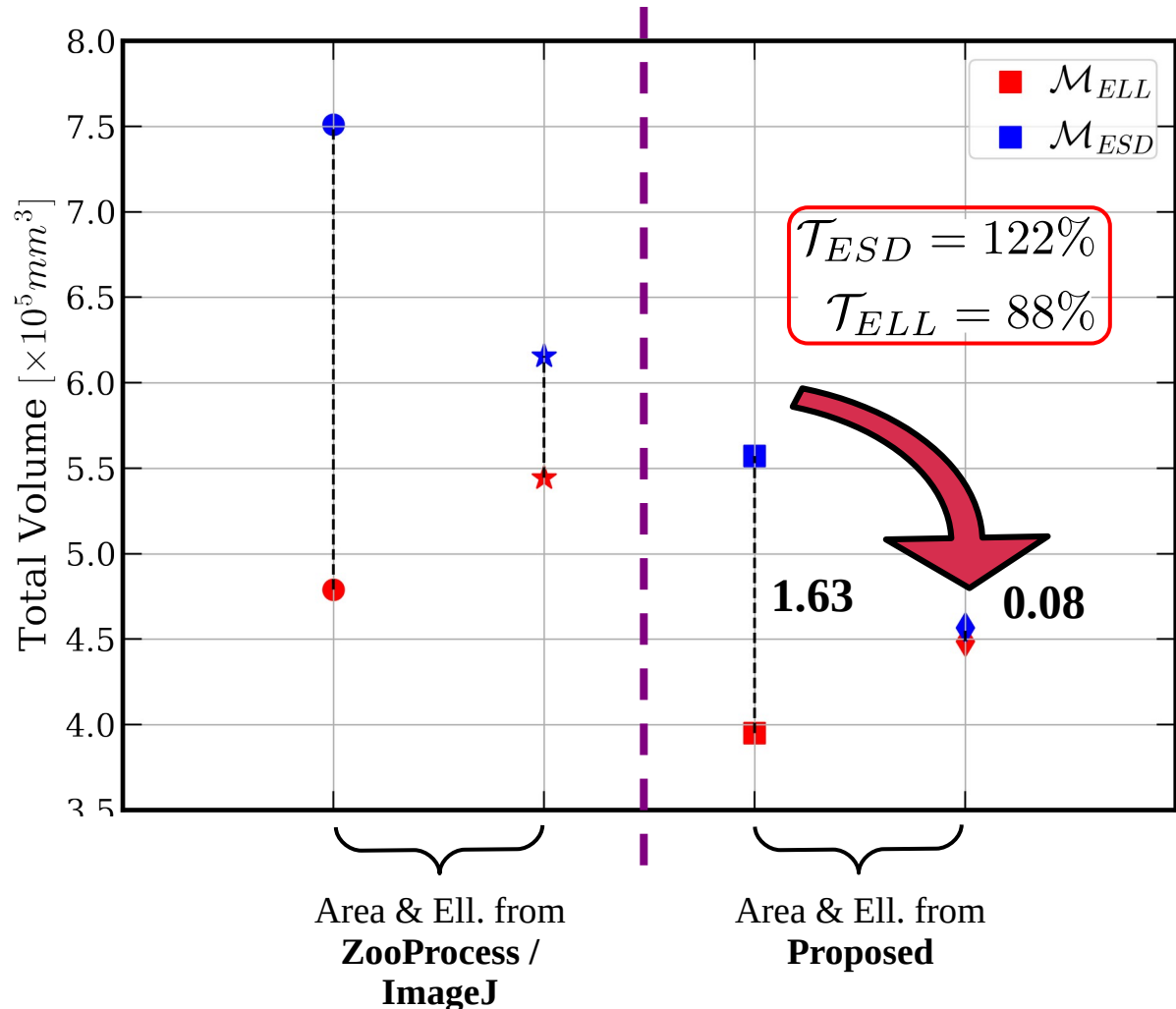
← Overestimate

$$\mathcal{T}_{ELL} = 88\%$$

← Underestimate



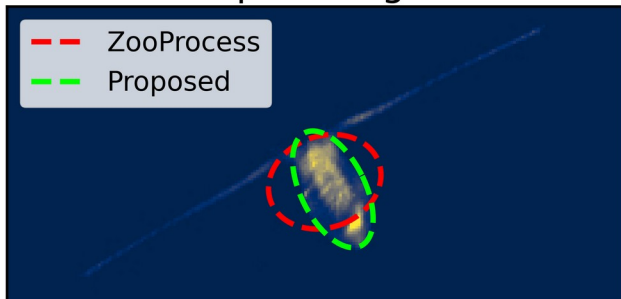
- Influence of the proposed method for **Area & Ell. Fit** :
 - Gap reduction **ELL** & **ESD**:
 - **Factor 2**
- Influence of **Total Volume Correction** :
 - Gap reduction **ELL** & **ESD**:
 - **Factor 4** (ZooProcess)
 - **Factor 20** (Proposed)
- Overall gap reduction
(**Area & Ell. Fit** + **Total Volume Correction**)
 - ✓ **factor 34**
 - ✗ Exact value not guaranteed
 - ➔ Corrected interval within initial interval



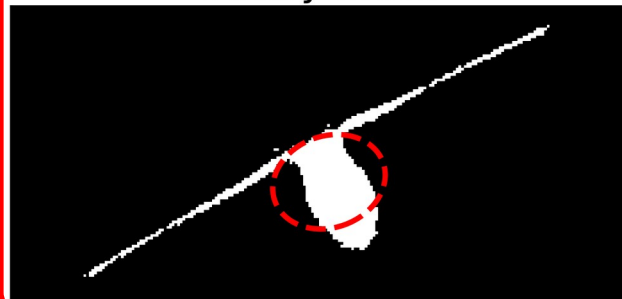
- Preliminary work on images

ZooProcess / ImageJ

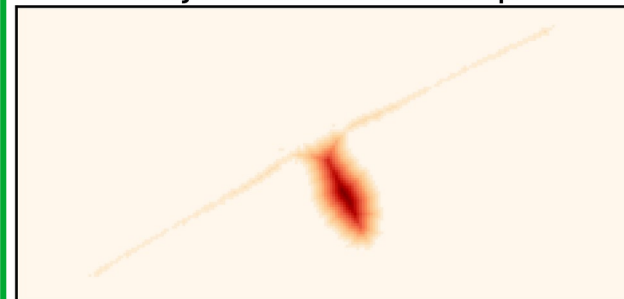
Input image



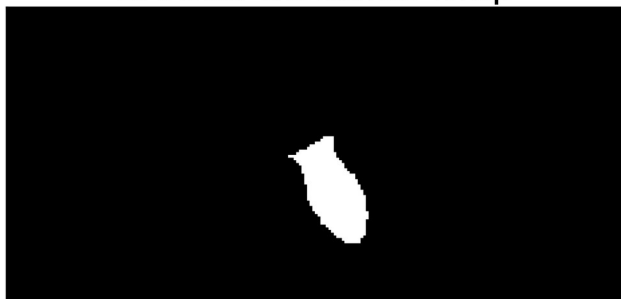
Binary mask



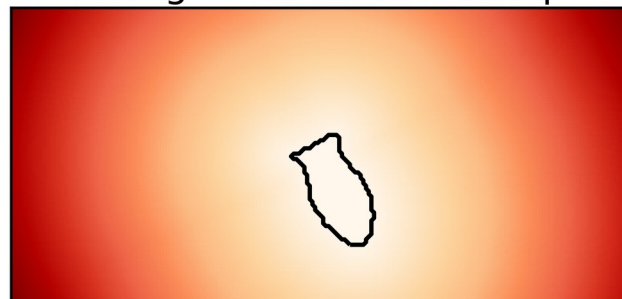
Object distance map



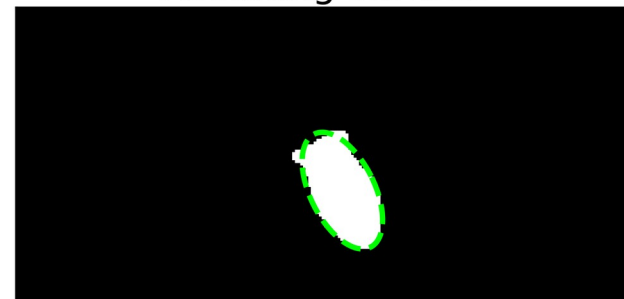
Eroded distance map



Background distance map



Resulting surface



Proposed

Remove antennas

body dilatation

Area estim.
& Ellipse fit

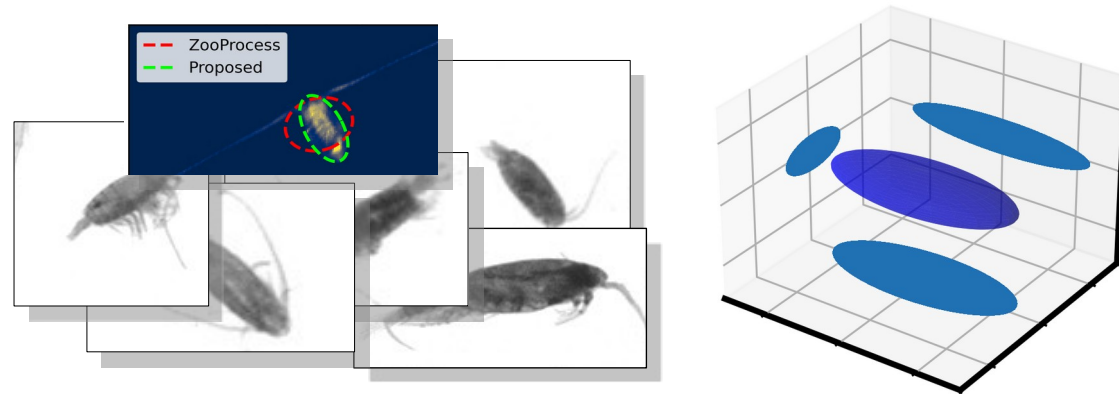
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Session: SS29 - Zooplankton mediation of particle flux

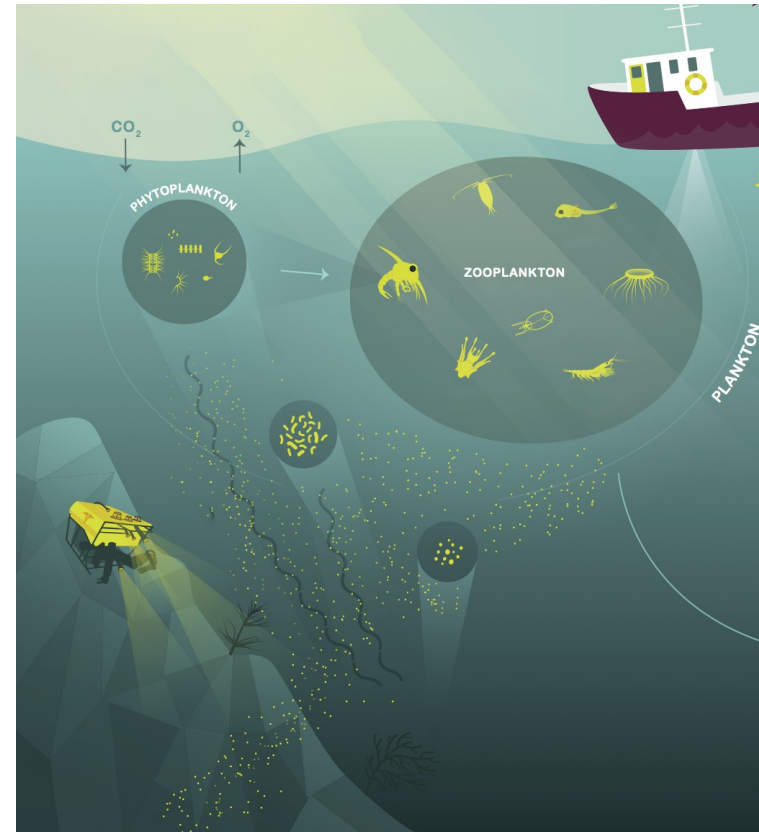
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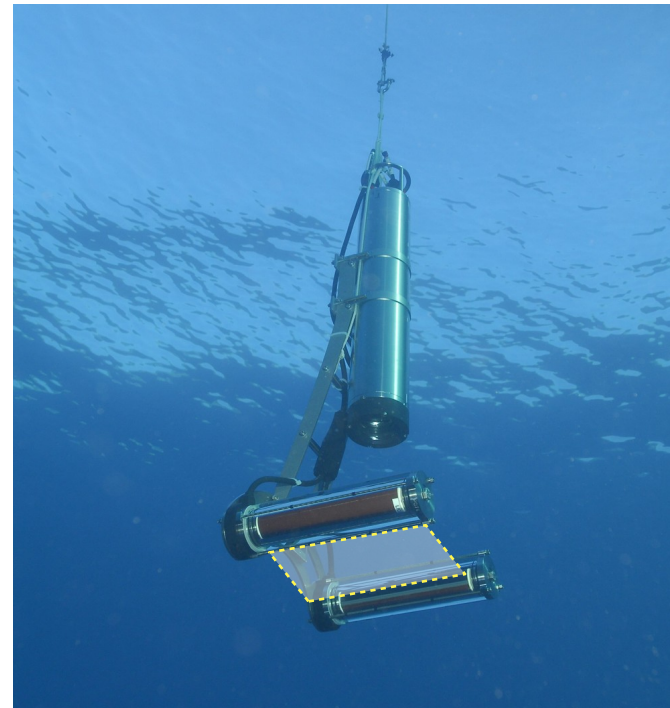
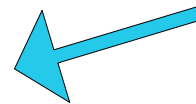
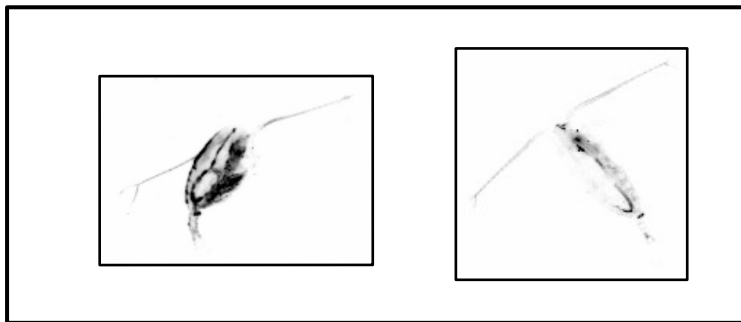
06/25/2021



- Meso-plankton: major contributors to biogeochemical fluxes in the ocean [Buitenhuis E, 2006]
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- **Major impact on the “biological carbon pump”**
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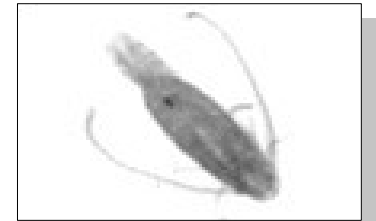
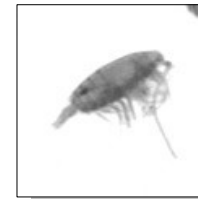
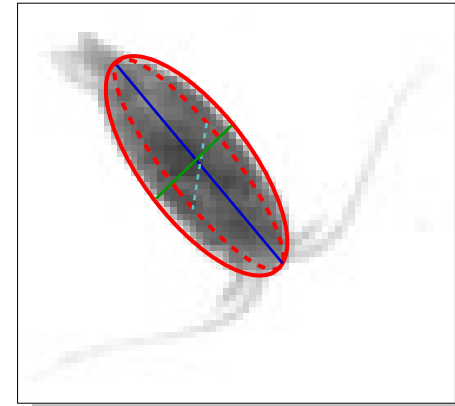
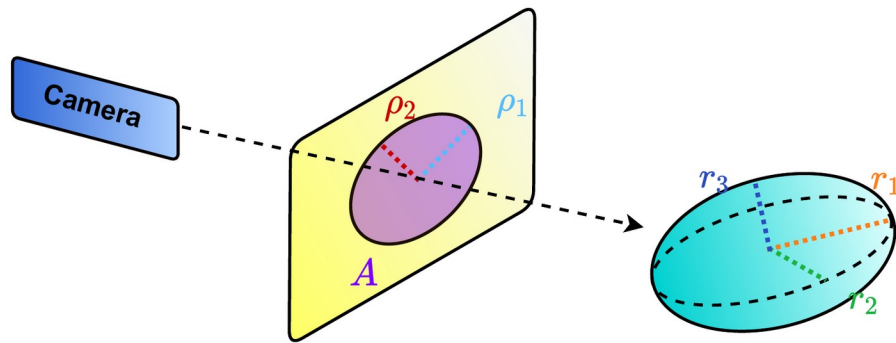
- biogeochemical fluxes → Biomass → **Volume**
- Nowadays, there exist multiple in situ instruments
- **Imagery** to quantify zooplankton volume
 - 2D projection of 3D organisms
- Acquisition → Individual volume estimation
 - Total volume



UVP camera
Source : Hydroptic



- Copepod antennas are neglected for volume estimation
- Copepod body \rightarrow modeled by an ellipsoid



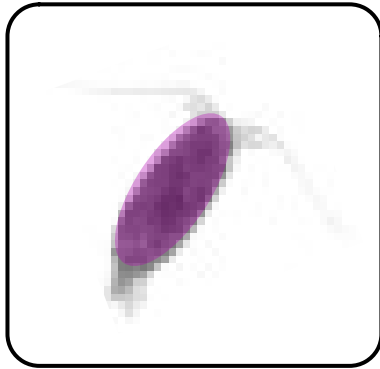
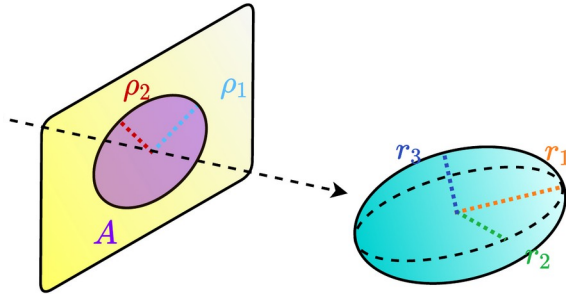
1- Equivalent Sphere Diameter (\mathcal{M}_{ESD}):

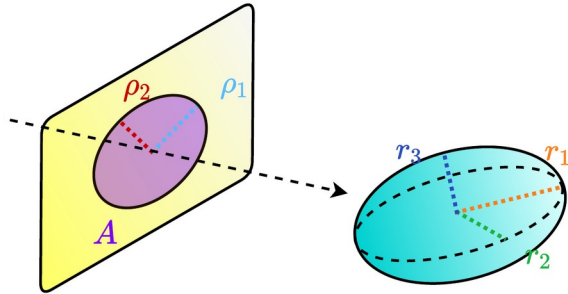
$A = \text{Area of object}$



$$ESD = 2\sqrt{\frac{A}{\pi}}$$

$$V_{ESD} = \frac{4}{3}\pi \left(\frac{ESD}{2}\right)^3$$





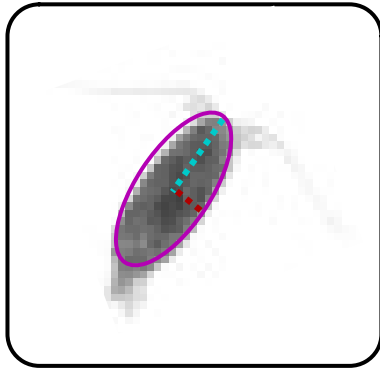
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2- Ellipse method (\mathcal{M}_{ELL}):

Ellipse fit



$$r_1 = \rho_1$$

$$r_2 = \rho_2$$

$$r_3 = \rho_2$$



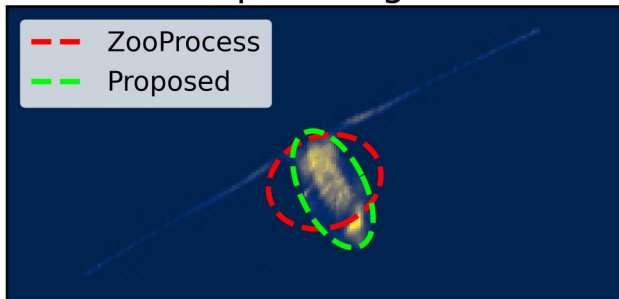
$$V_{ELL} = \frac{4}{3}\pi \rho_1 \rho_2^2$$



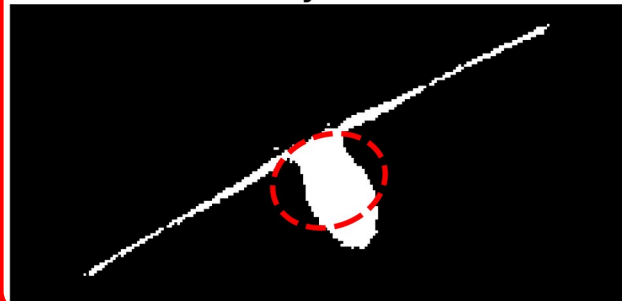
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ZooProcess / ImageJ

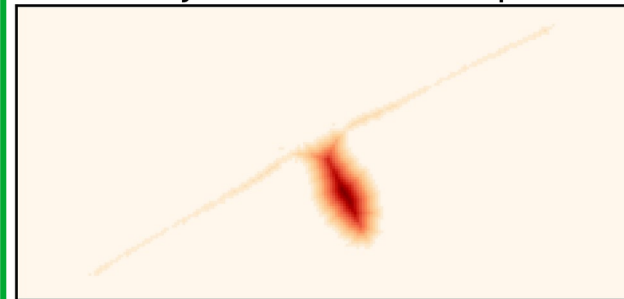
Input image



Binary mask



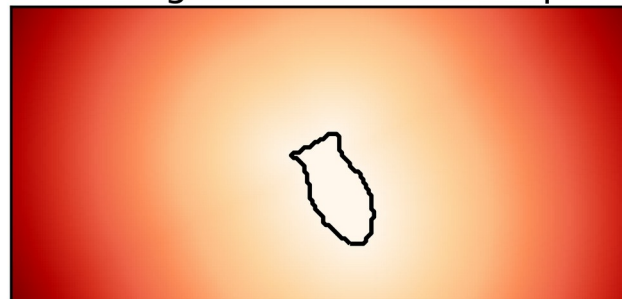
Object distance map



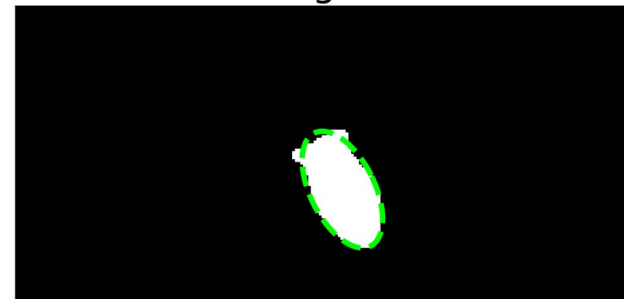
Eroded distance map



Background distance map



Resulting surface

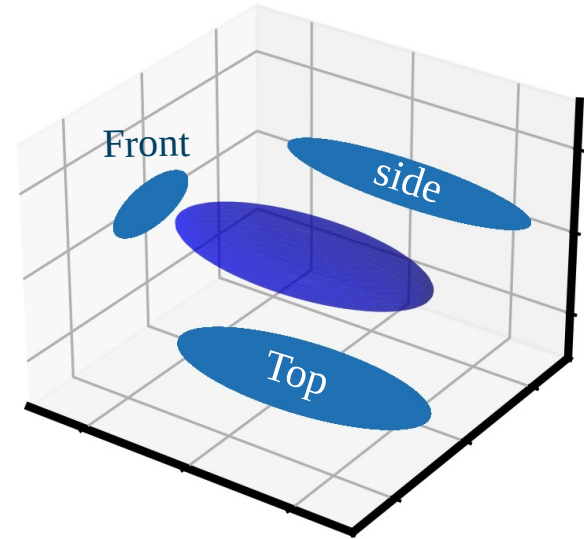
**Proposed**

Remove antennas

body dilatation

Area estim.
& Ellipse fit

- **ESD** & **ELL** → Volume estim. Errors
- Actually: **Impossible** to find the **true volume**
 - Projection 3-D → 2-D
- **Goal:** Estimate error on total volume
 - **What is the trend for a large set of copepods ?**
 - **Possible** through simulation



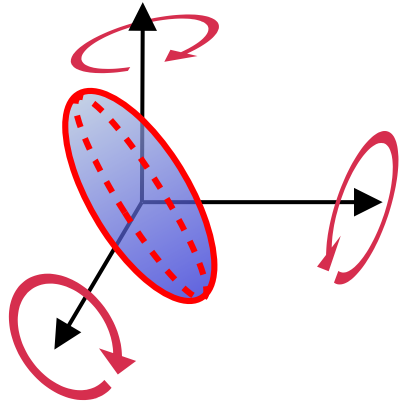
Method	Front	Side	Top
True		754	
\mathcal{M}_{ESD}	243 -68%	905 +20%	1947 +158%
\mathcal{M}_{ELL}	188 -75%	452 -40%	1257 +67%



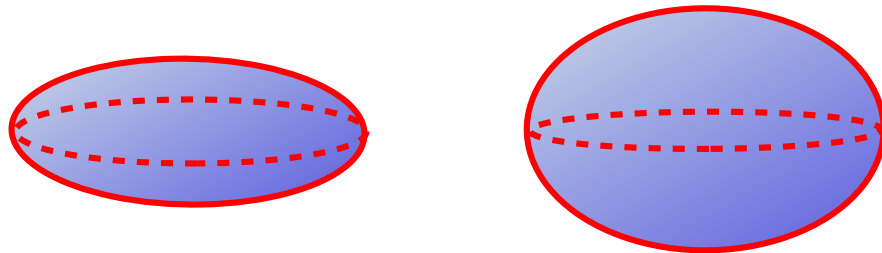
Calibration Data & Experts

Simulation parameters
(shape and orientation distributions)

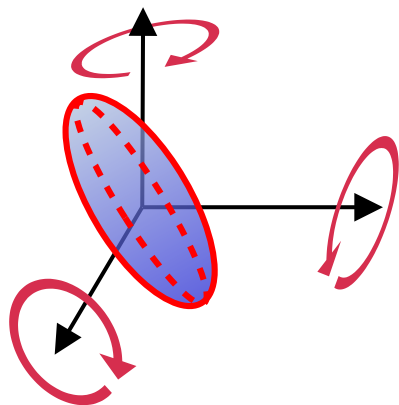
→ Orientation



→ Shape

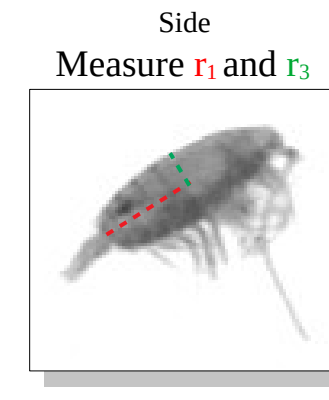
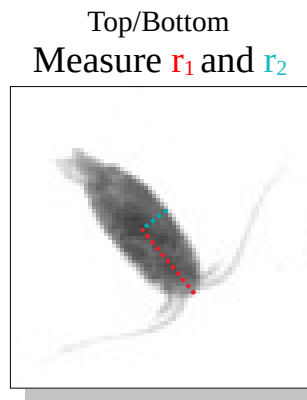
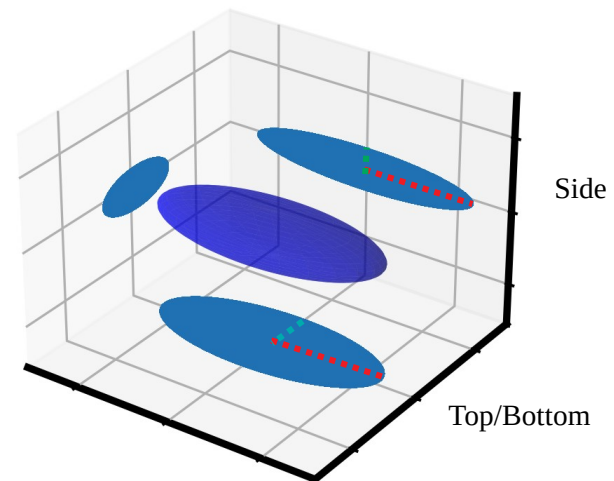


- **Orientation:**
 - No data available to measure the orientation distribution
 - Approximation for worldwid data: **no preferred orientation**



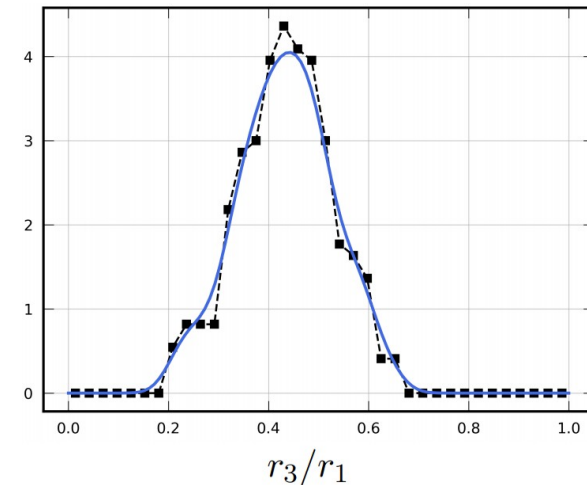
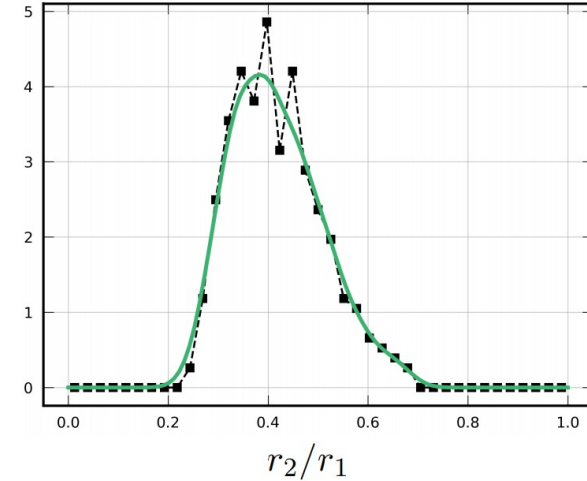
- **Shape:**

- Measures on data with **specific orientation**: top/bottom & side
 - Expert selection +600 copepods
- We show the total error do not depends on the scale
 - $r_1, r_2, r_3 \rightarrow r_2/r_1$ and r_3/r_1
 - Reduce dimension of simulation



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Calibration Data & experts

Simulation parameters
(shape and orientation distributions)

Simulator
(ellipsoid model, projection)



Simulator

1-

Generate ellipsoid
(shape & orientation)



Simulator

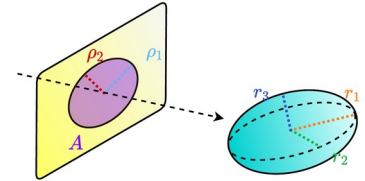
1-

Generate ellipsoid
(shape & orientation)



2-

Compute projection
(mathematically)



Simulator

Many ellipsoids

1-

Generate ellipsoid
(shape & orientation)



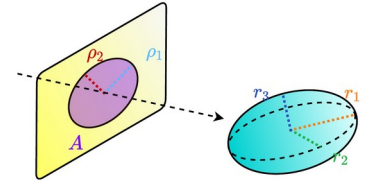
2-

Compute projection
(mathematically)



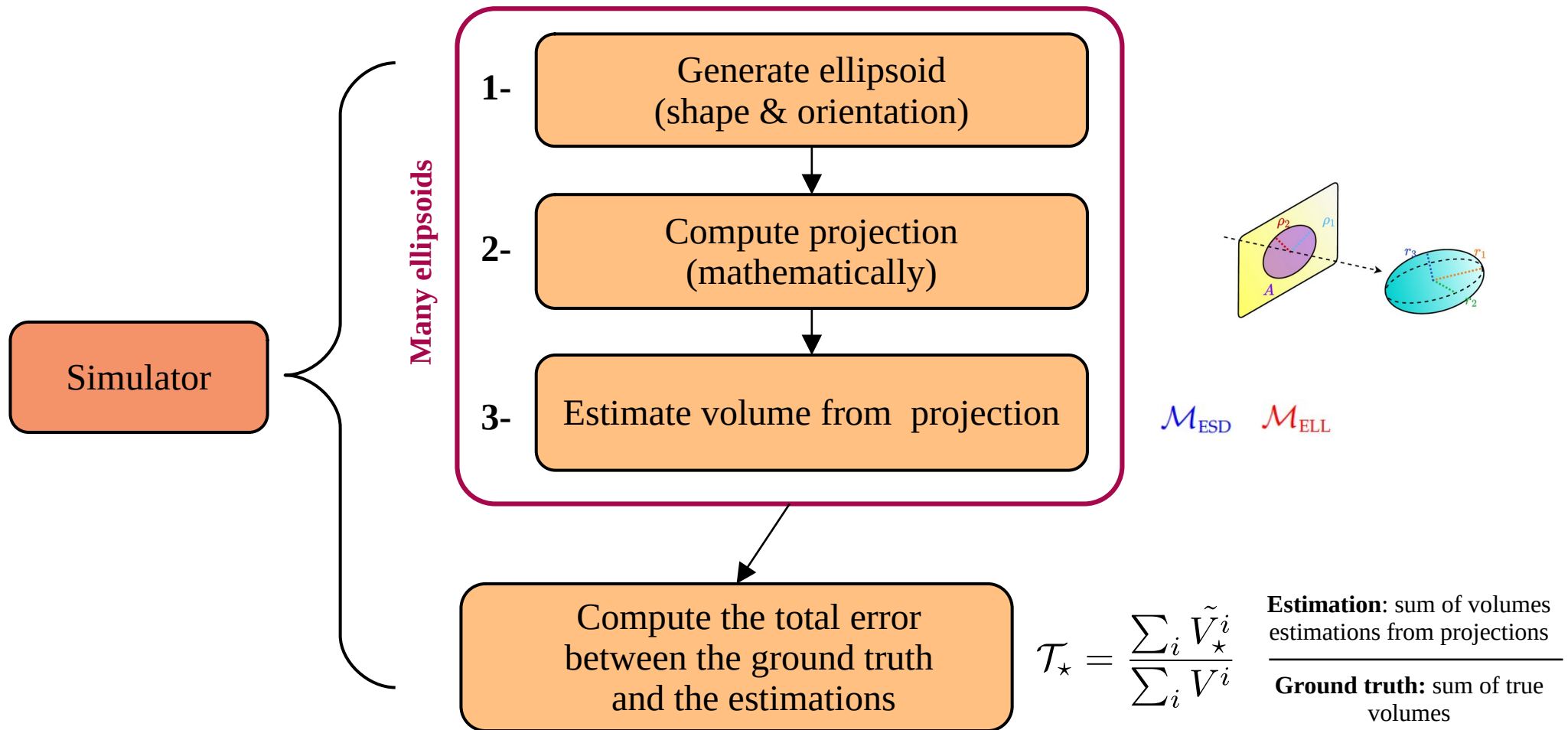
3-

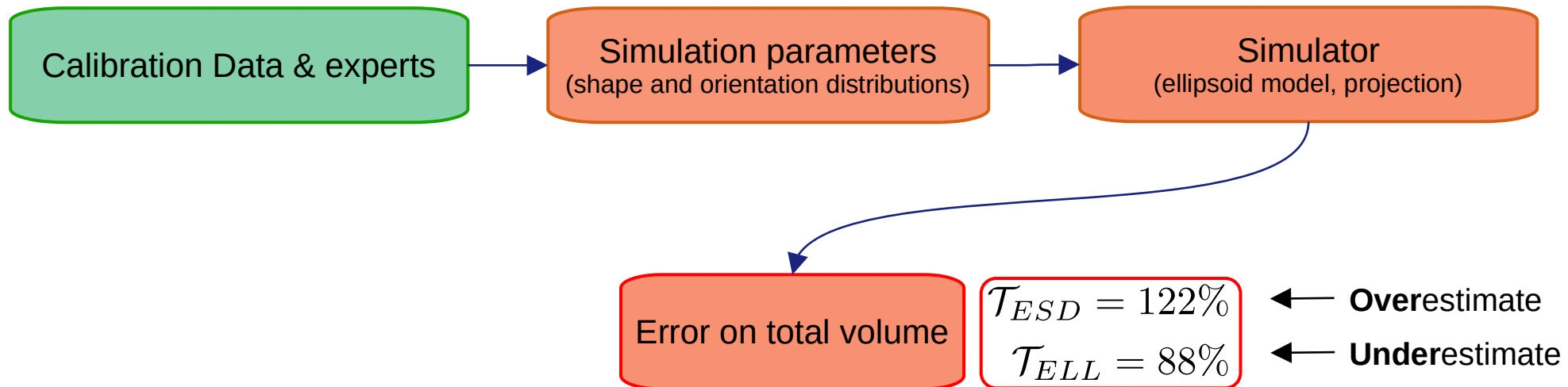
Estimate volume from projection

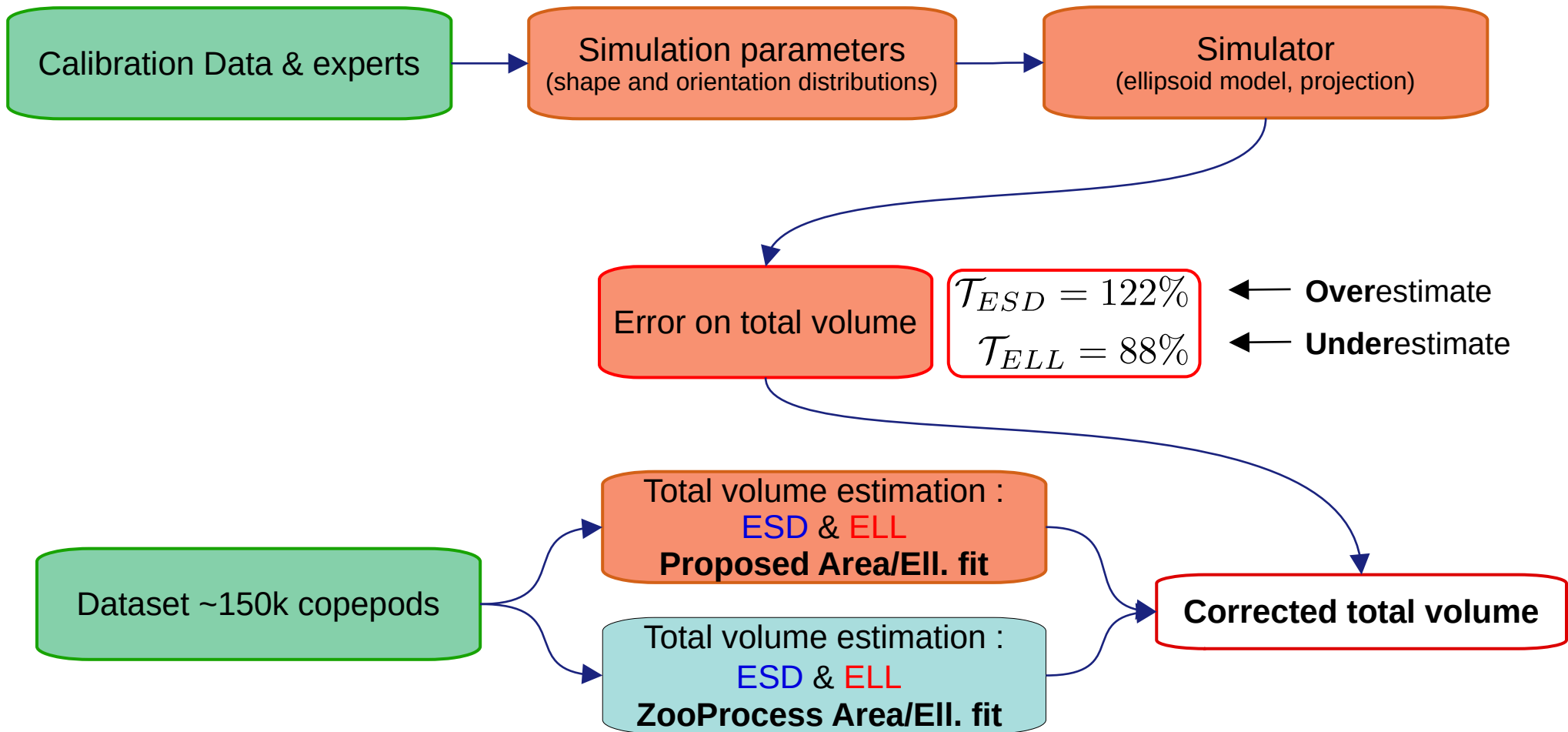


\mathcal{M}_{ESD} \mathcal{M}_{ELL}







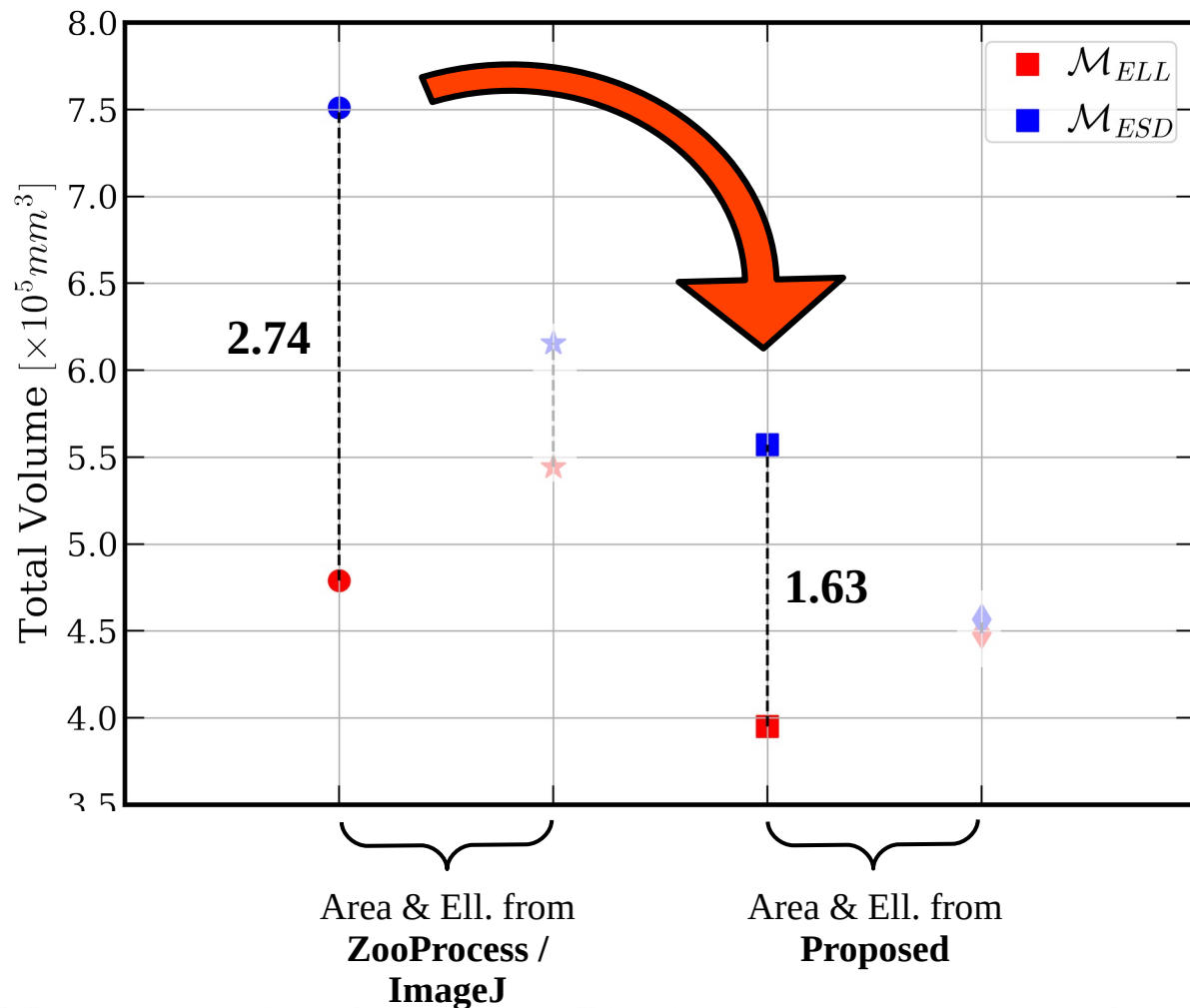
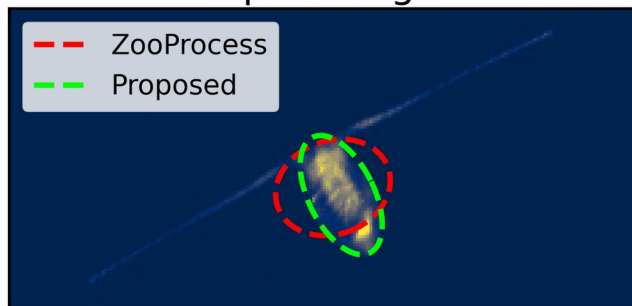


- Influence of the proposed method for **Area & Ell. Fit** :

→ Gap reduction **ELL** & **ESD**:

> **Factor 2**

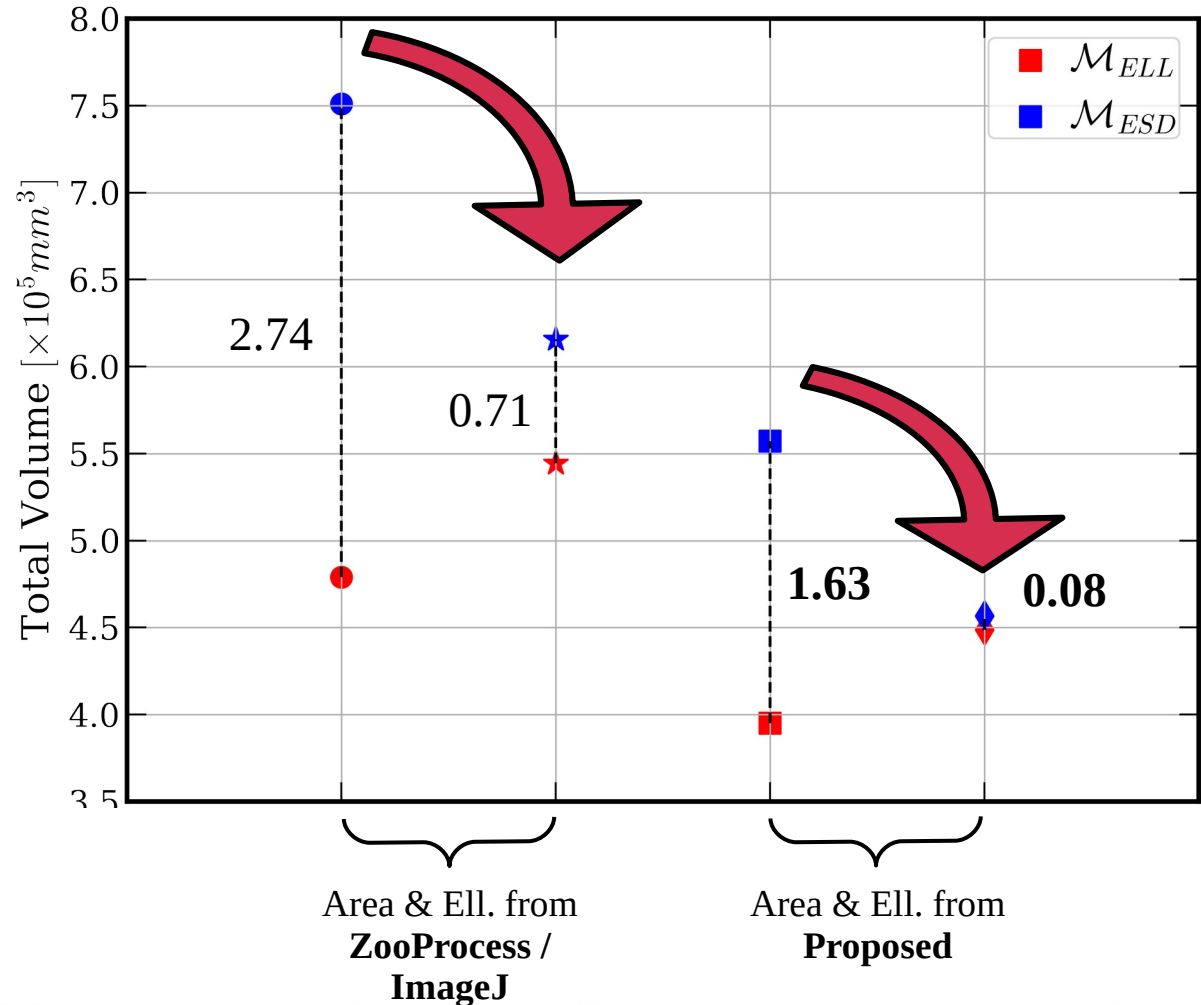
Input image



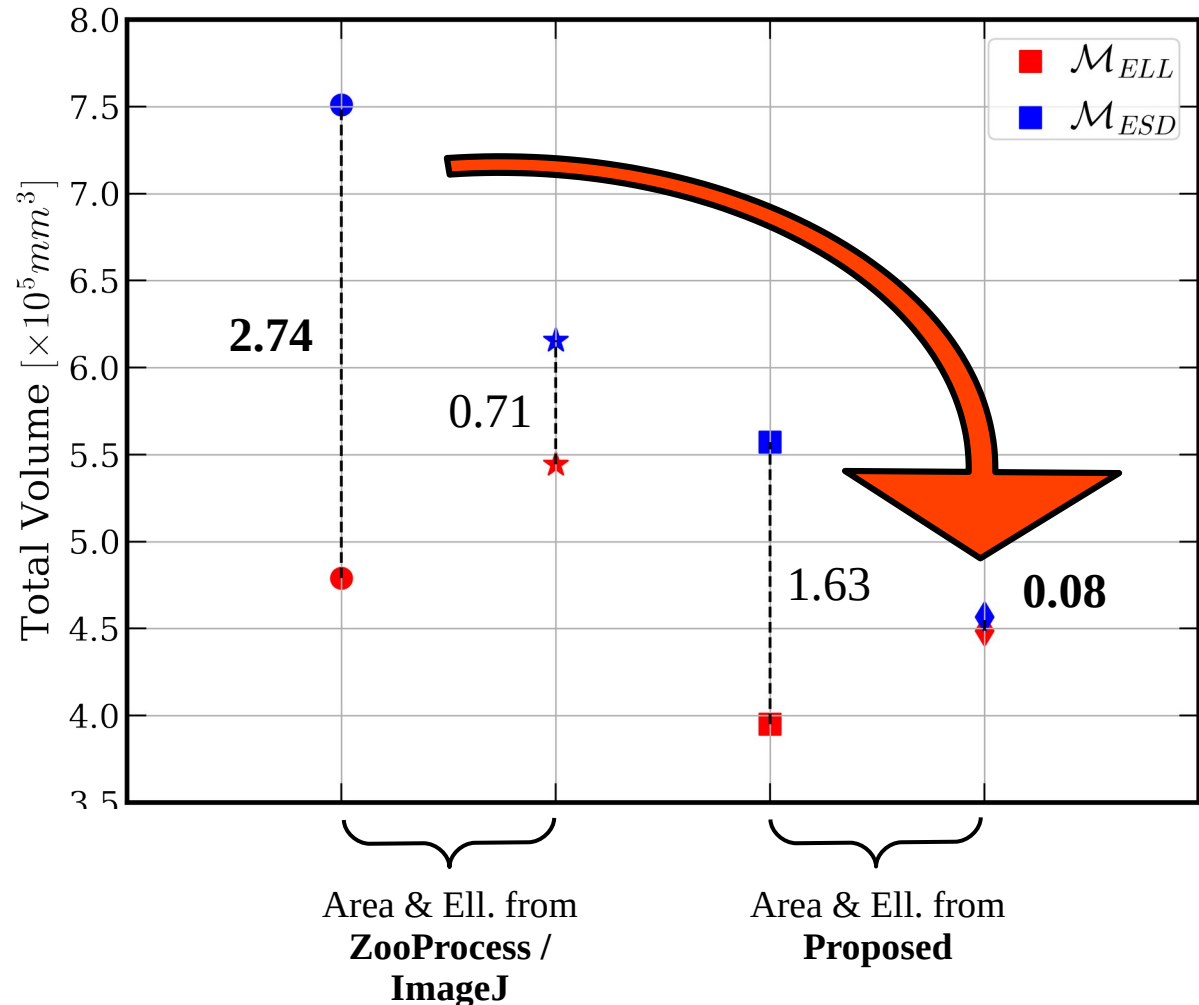
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 - **Factor 20** (Proposed)

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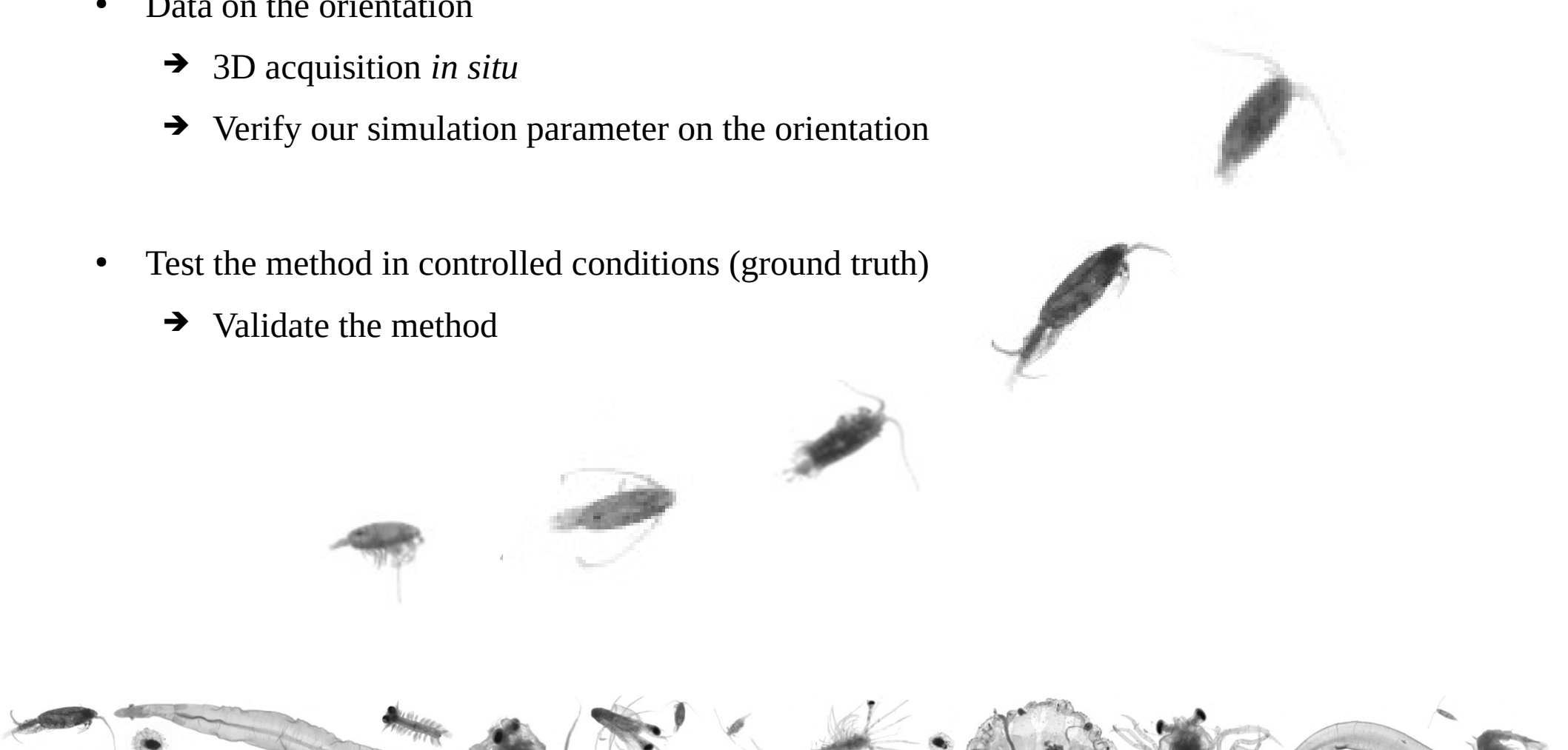
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 - ✓ **factor 34**
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- Data on the orientation
 - 3D acquisition *in situ*
 - Verify our simulation parameter on the orientation
- Test the method in controlled conditions (ground truth)
 - Validate the method



ASLO 2021 AQUATIC SCIENCES MEETING

- Thank you for listening



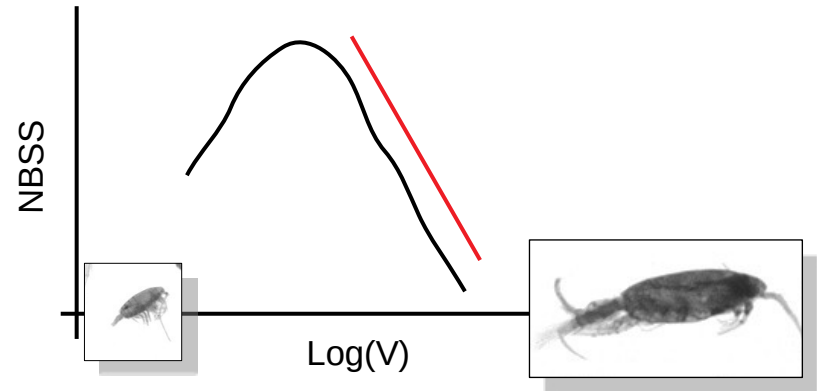
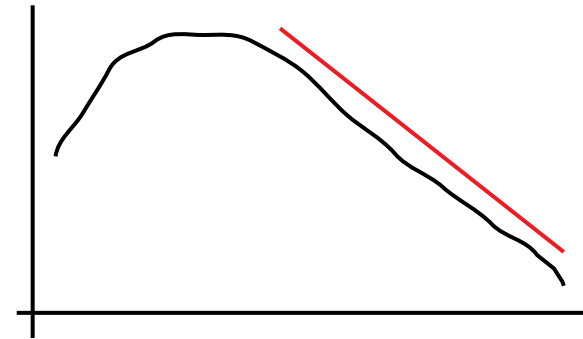
Experiments : Energetic transfer

Use the simulation for different purpose.

Measuring accuracy for the energetic transfer estimation :

Measured as **the slope of the decreasing part** of the bio-volume (or bio-mass) spectrum.

Is it affected by vol. estim bias (ESD / ELL) ?



Experiments : Energetic transfer

1- Compute the volume spectrum (GT and estim.)

2- Measure the energetic transfer for GT and estim.

~10% of error → low compare to the typical variations of the energetic transfer ~130% (between arctic and equator)

