Fat chance: can *in situ* imagery and machine learning provide a clearer picture of Arctic zooplankton lipidscape ?

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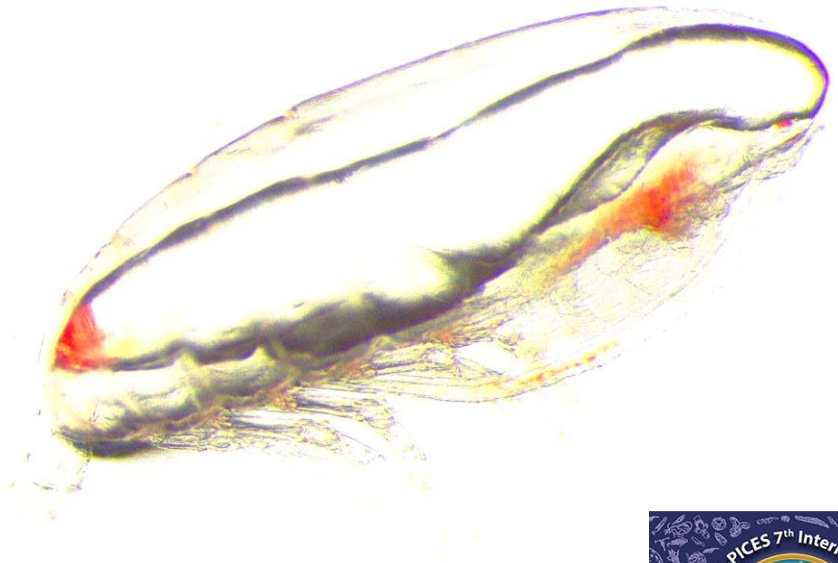


Sentinelle Nord

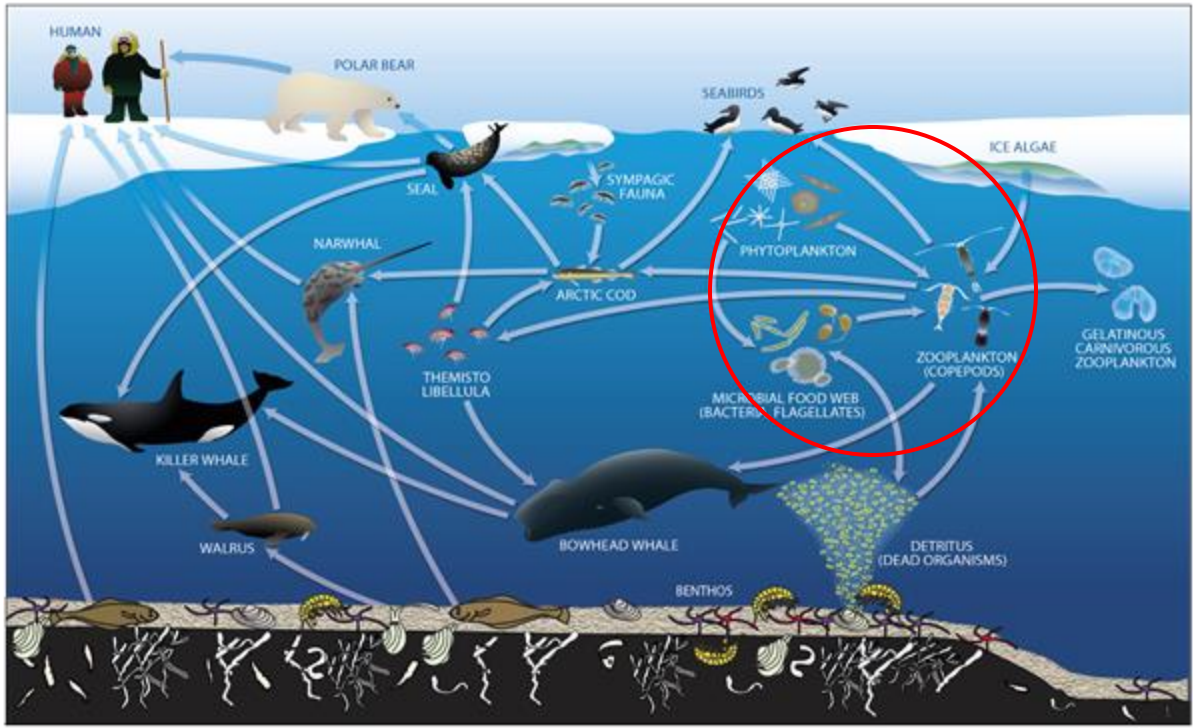
TAKUVIK

UNIVERSITÉ LAVAL

SORBONNE UNIVERSITÉ

ICES-PICES 7th International Zooplankton Production Symposium — NEW HORIZONS

Plankton : the beginning and the end of (almost) all marine things



Darnis et al. 2012 Fig. 1

The **classical** sampling approach…

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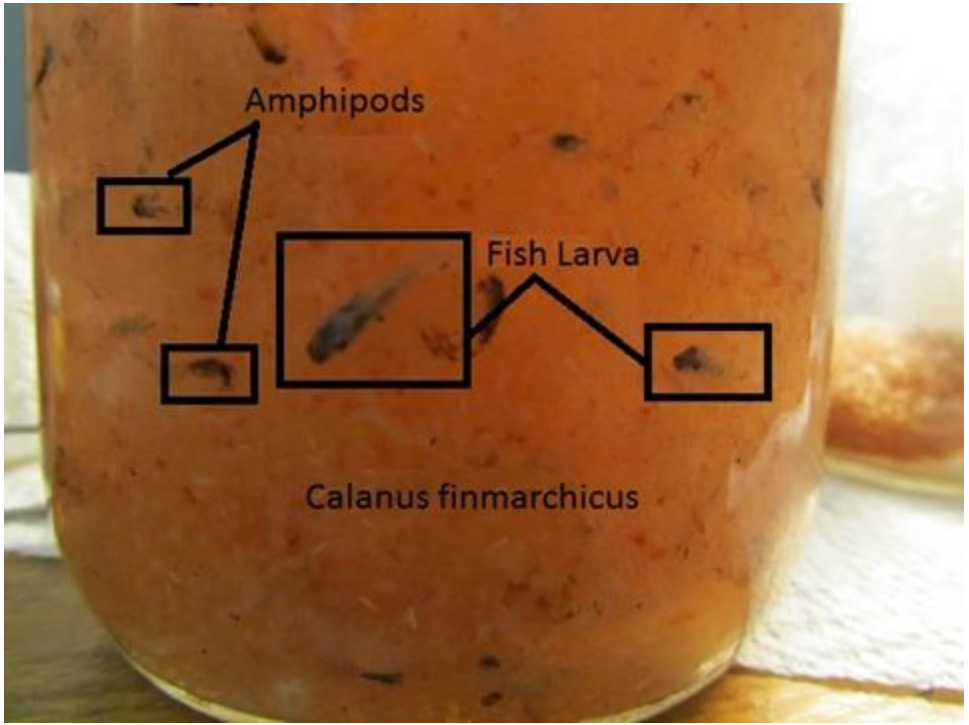
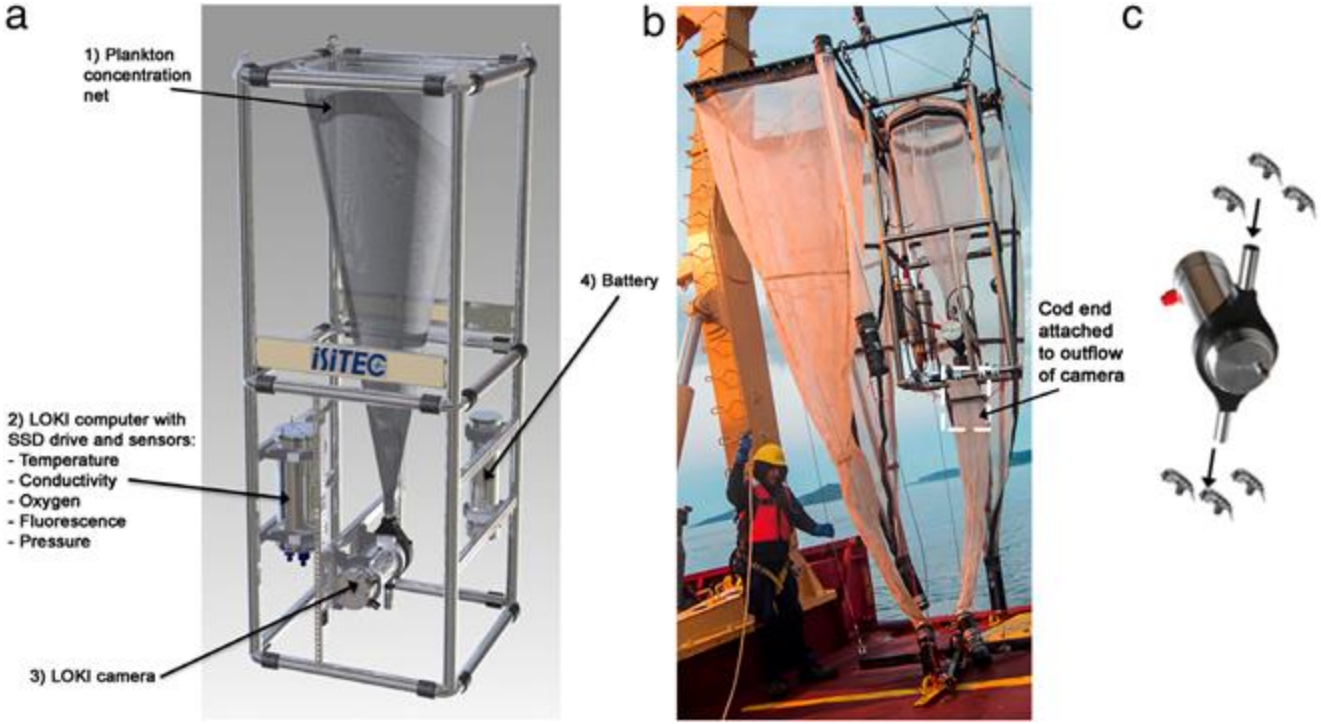
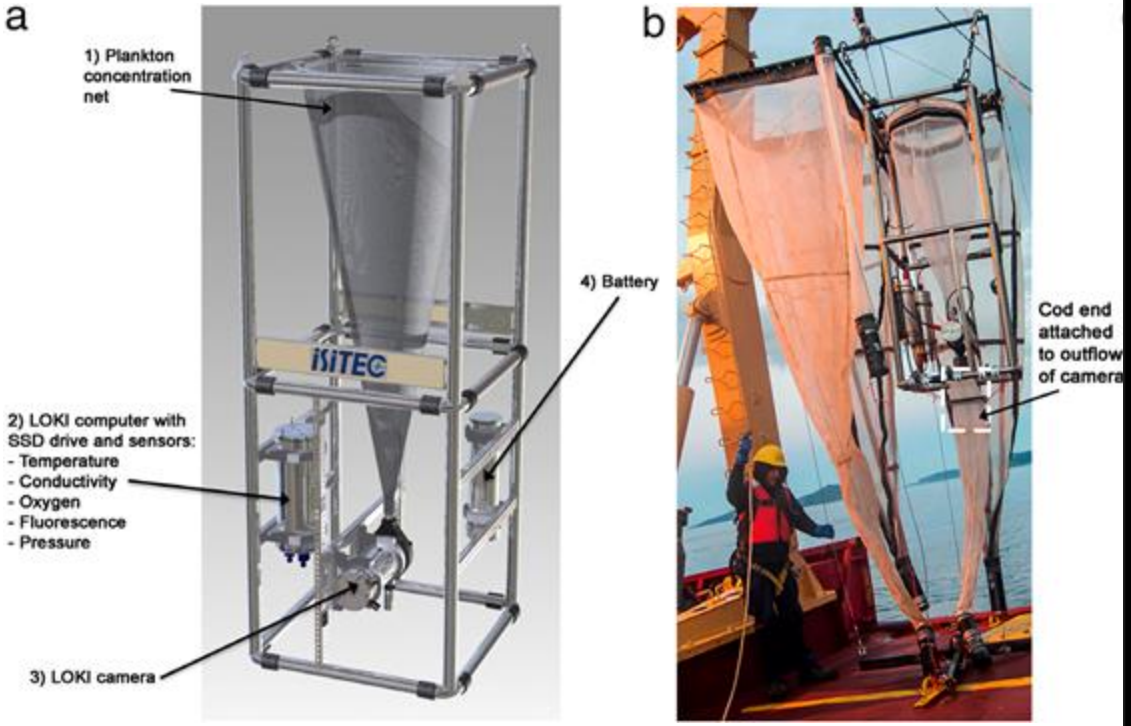


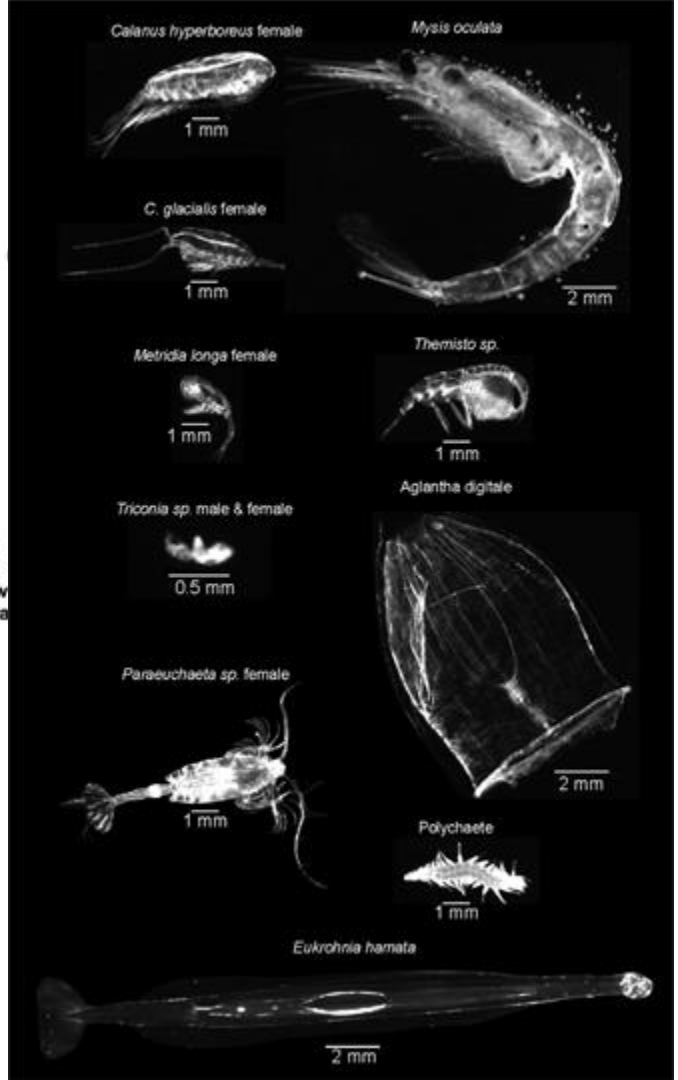
The modern **imaging** approach



Schmid et al. 2016 Fig.1 & Fig. 3

The modern **imaging** approach



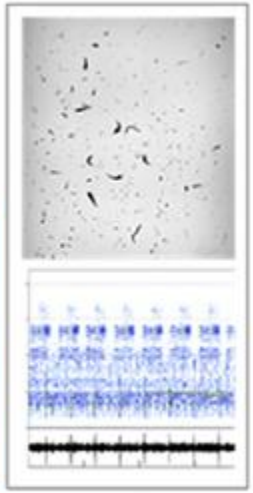


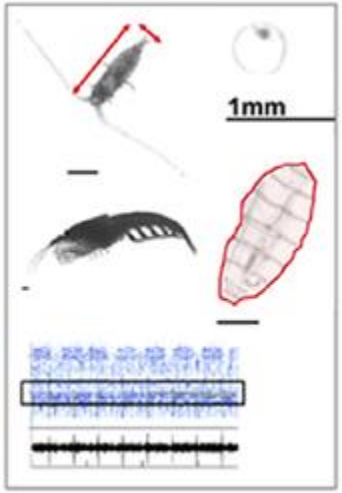
Schmid et al. 2016 Fig.1 & Fig. 3

The modern "**trait-based**" approach

Functional trait = any morphological, physiological or phenological feature measurable at the individual level that impacts the ***fitness*** of organisms and ***ecosystem functions***

Martini et al. 2021, Fig. 2b

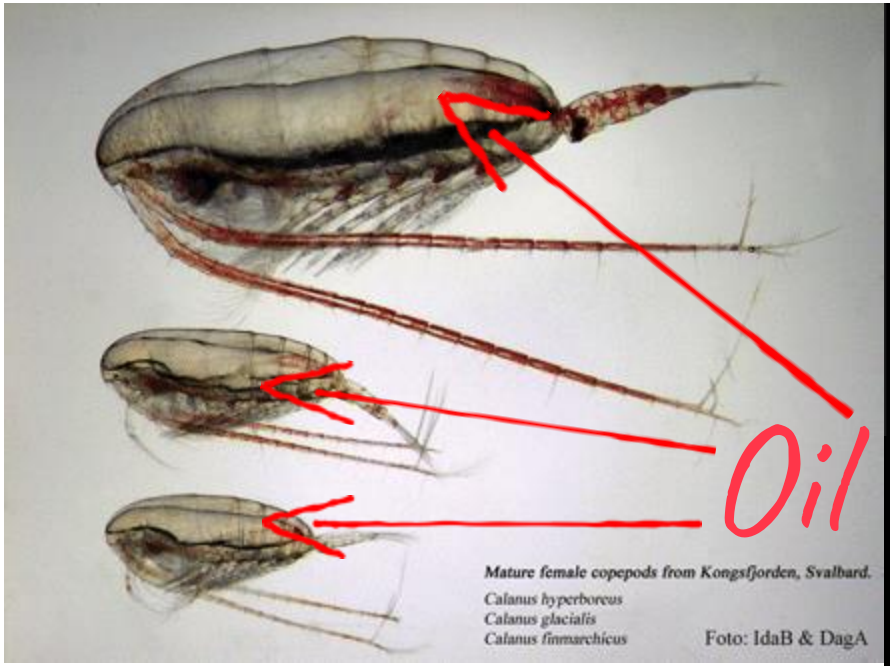


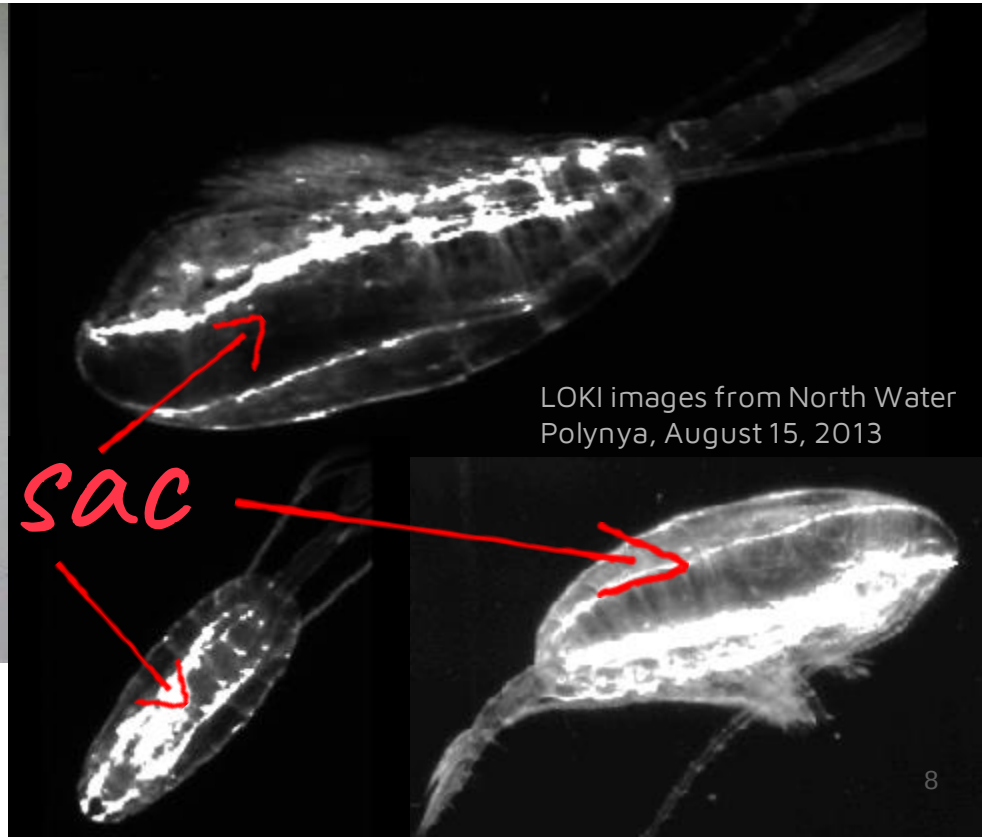


Taxa	Morphological traits	Behavioral traits	Life-History	Physiological
Copepoda - Calanidae	Size	Motility	Offspring size & number	Lipids reserve
	Shape	Migrations	...	...
	Transparency	Substrate relation		
	Bioluminescence	Escape response		
	...	Production of sound		

SAMPLING IMAGES/SOUNDS FEATURE EXTRACTION DATABASES

A closer look at **morphological traits**



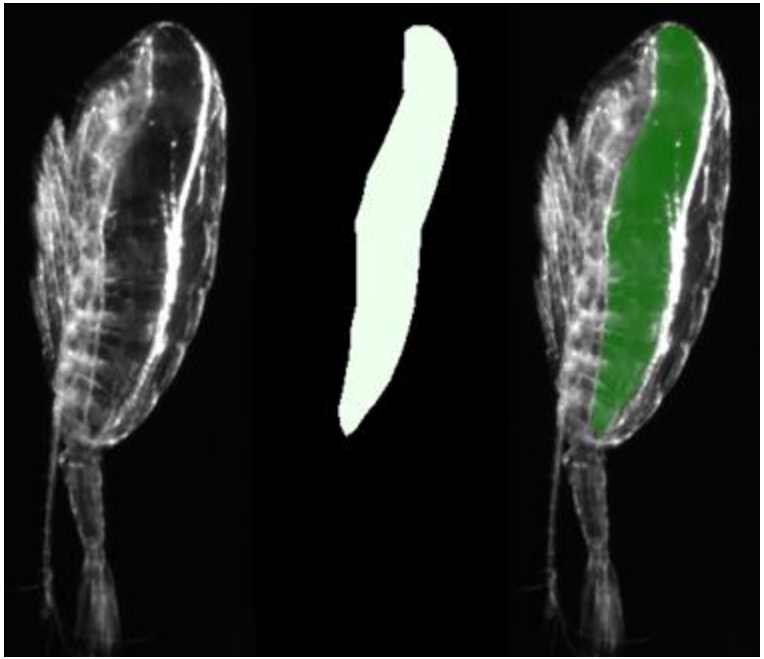


Berge et al. 2012, Fig. 1

Finding & measuring oil sacs

Oil sac identification:

1) Annotations by students with ImgLab
2) ResNet34 pretrained on ImageNet as backbone, with U-Net for segmentation.



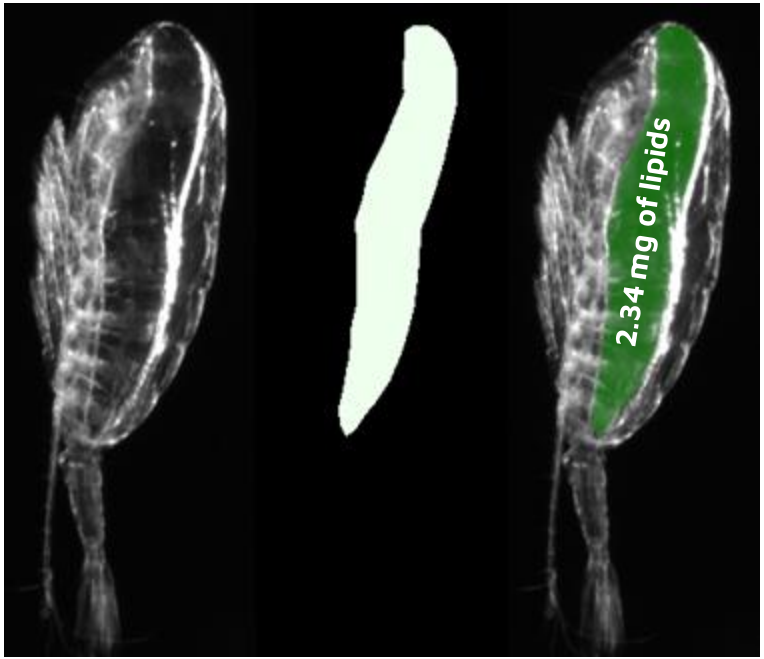
Maps et al. 2024 JPR (www.doi.org/10.1093/plankt/fbad048)

Finding & **measuring** oil sacs

Lipid mass estimation:

1) Each pixel in a LOKI image is 23 µm
2) Estimate the lateral area (A) in µm^2
3) Use the relationship of Vogedes et al. 2010

$$m = 0.197\ A^{1.38}$$



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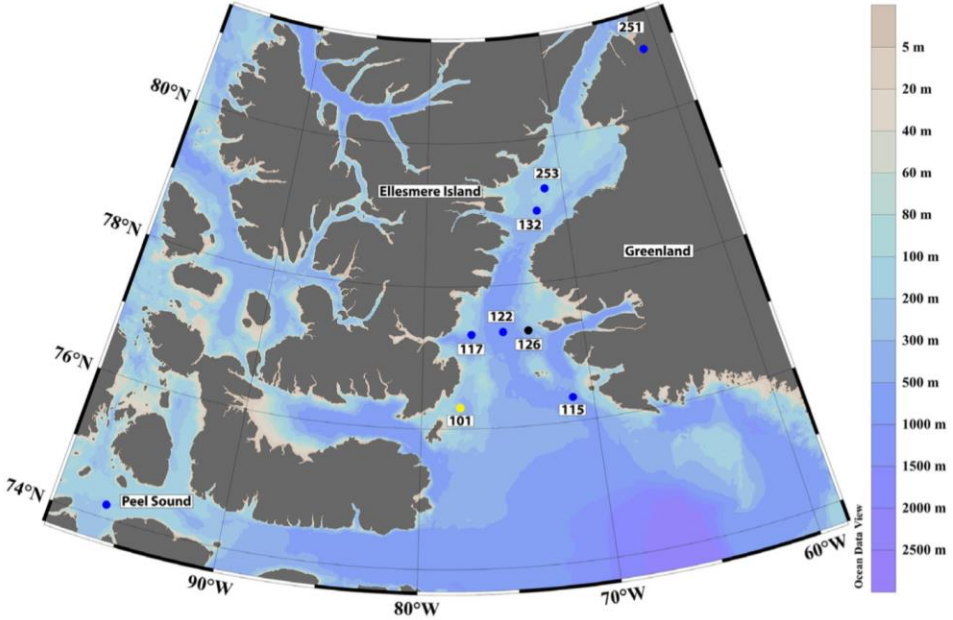
Case study in Pikialasorsuaq (North Water Polynya)



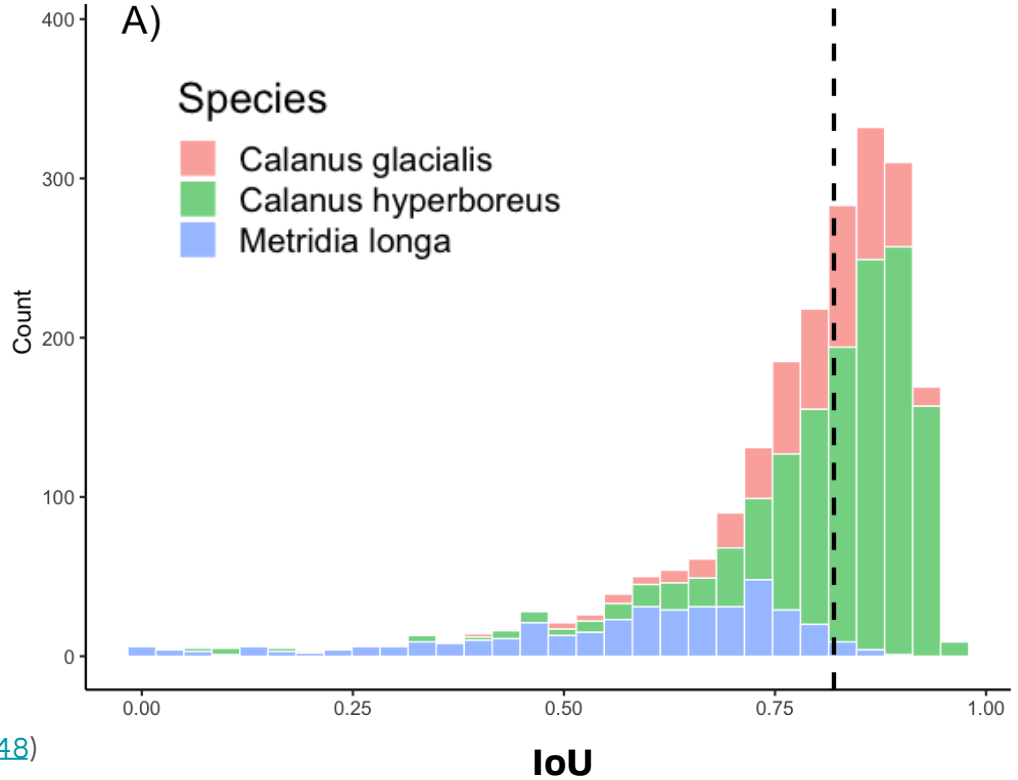
Maps et al. 2024 JPR (www.doi.org/10.1093/plankt/fbad048)

Case study in Pikialasorsuaq (North Water Polynya)

Performance :

Median intersection over union (IoU) = **0.78**

Results are better for the large *Calanus* congeners (green and pink)



Maps et al. 2024 JPR (www.doi.org/10.1093/plankt/fbad048)

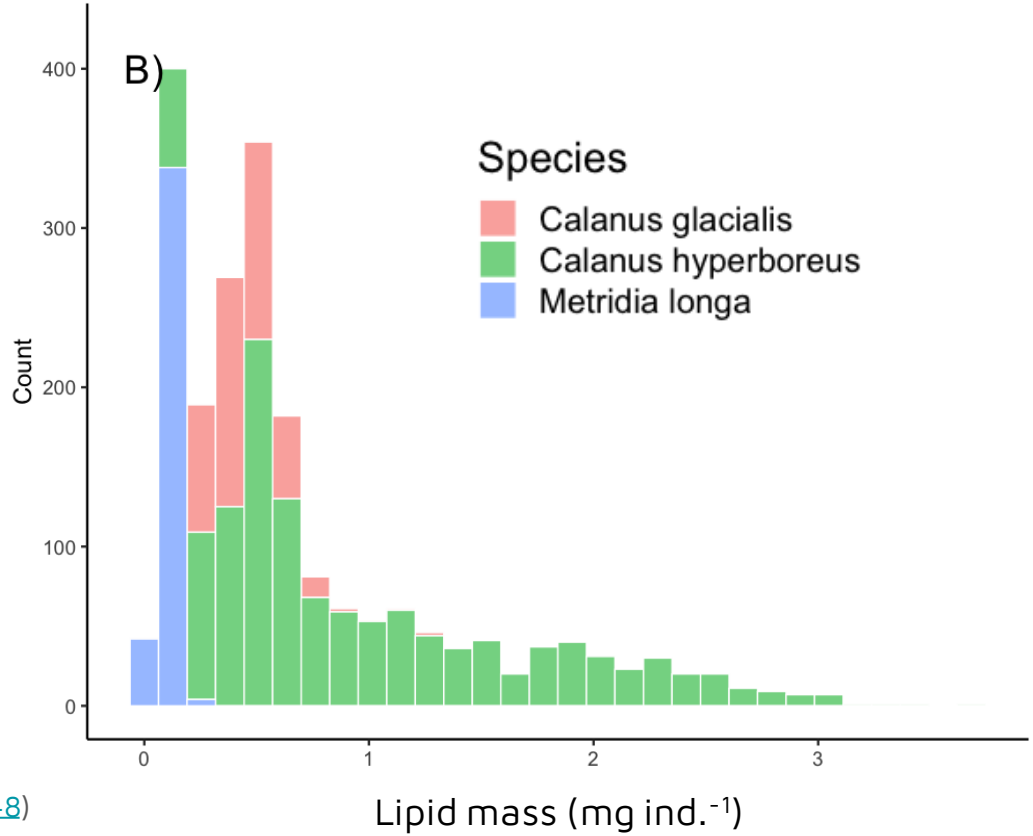
Case study in Pikialasorsuaq (North Water Polynya)

Estimation :

Mean lipid content **= 0.7 mg**

The large *Calanus* congeners (green & pink) contribute disproportionately to the lipid biomass of Arctic copepods.

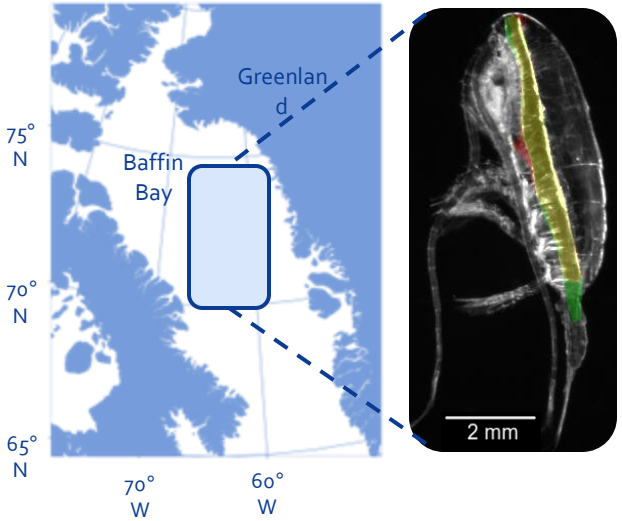
The median *error* in lipid estimation between the annotated area and the model is **0.7%**



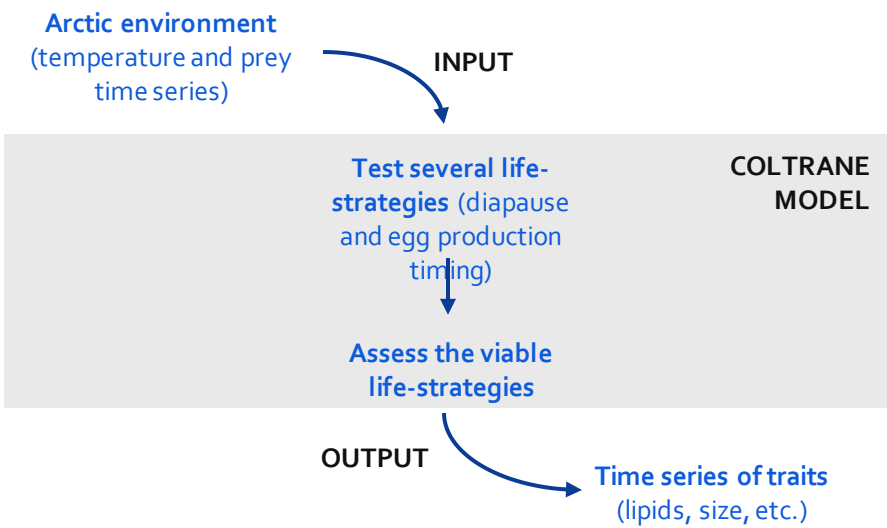
Maps et al. 2024 JPR (www.doi.org/10.1093/plankt/fbad048)

Imaging, ML & **IBM modelling** to study the composition and functions of arctic copepod communities (Lucie Bourreau)

Copepod traits from **images**

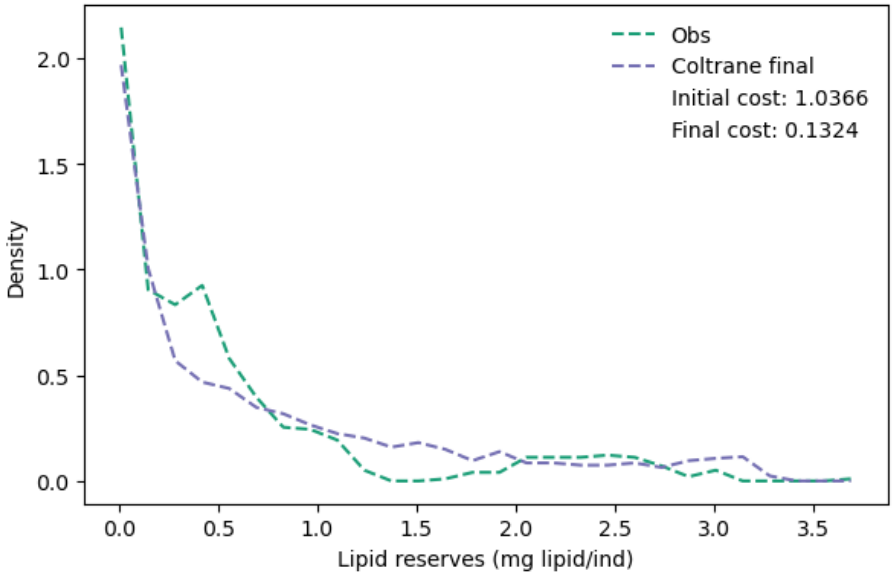


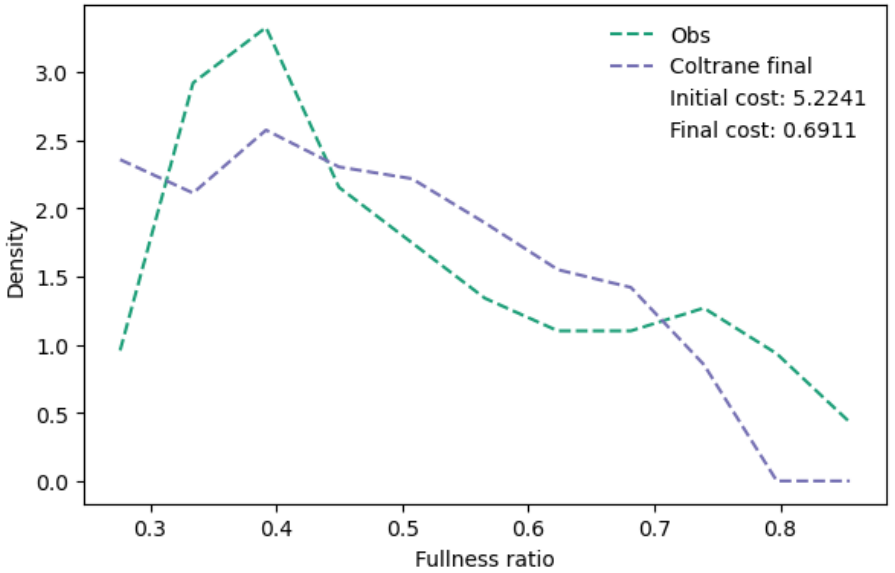
Copepod traits from **a model**



Imaging, ML & **IBM modelling** to study the composition and functions of arctic copepod communities (Lucie Bourreau)

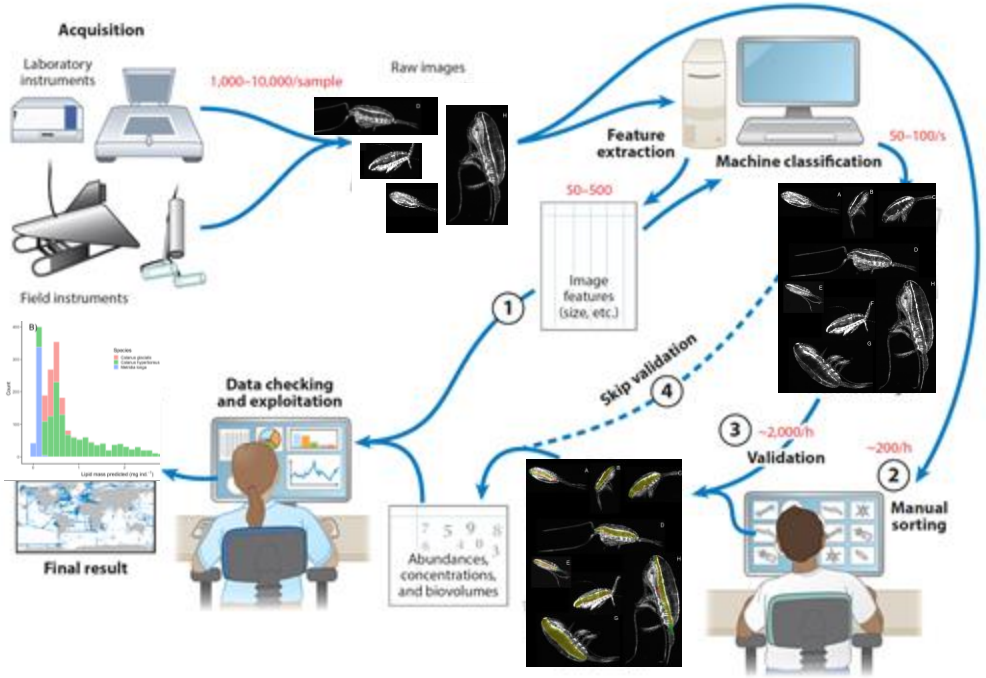
- Minimize a cost function on **lipid content** & **lipid fullness** ratio distribution
- Critical to calibrate on *several traits at the same time*





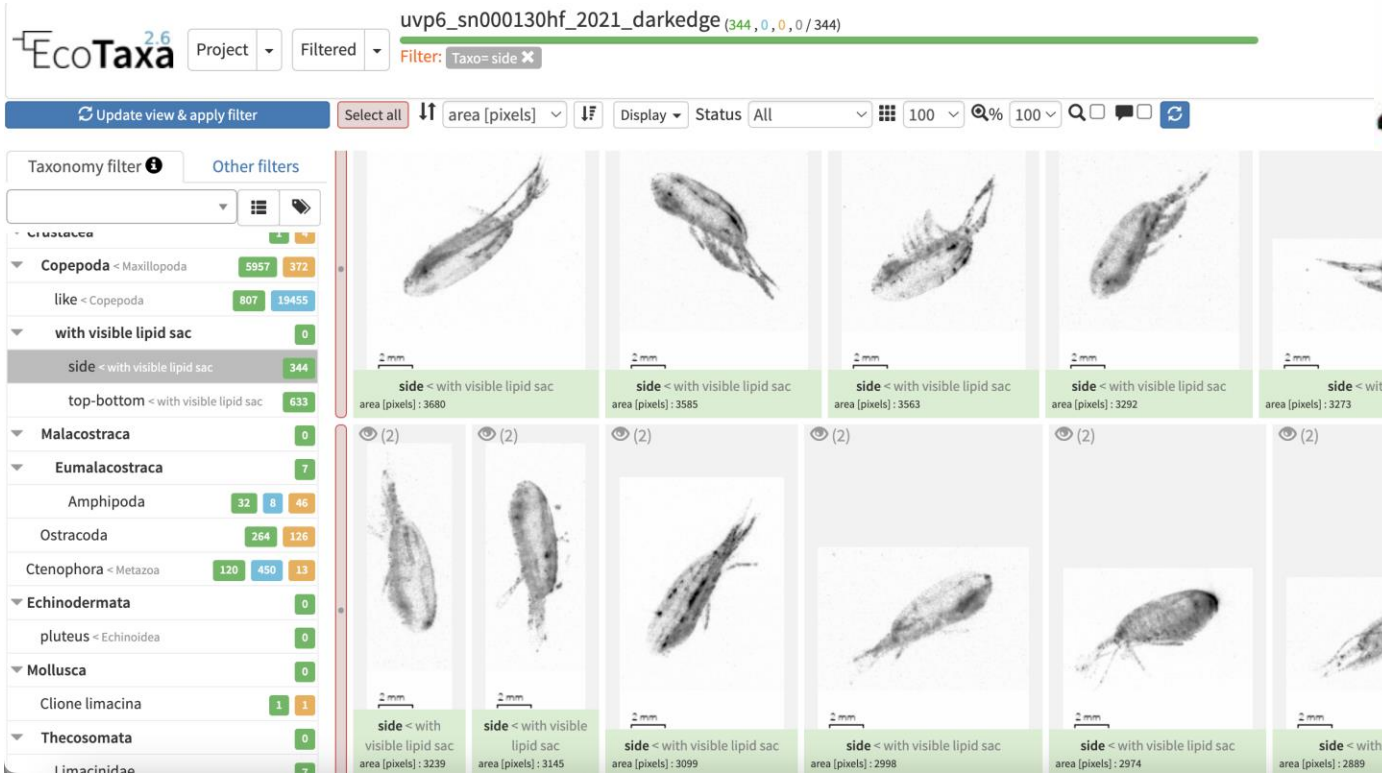
Conclusion

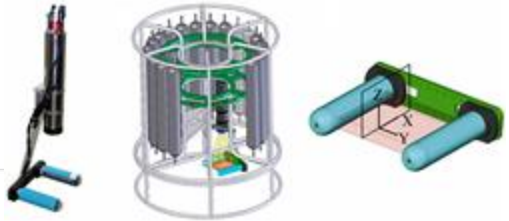
- In situ imaging provides new kind of data at individual level
- The potential for ecological application is very large : 10^6 of archive images and much more to come !
- Projects integrating *from the start* imagery, ML & modelling open a new era in producing rapid quantitative estimates relevant for research & management



Modified from Irisson et al. 2022, Fig. 2

Thank you !





Datasets of **UVP5 & 6** will be annotated for oil sacs & new models trained.

Collab. with JO Irisson

Machine learning tools : an expert partner

Appsilon

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