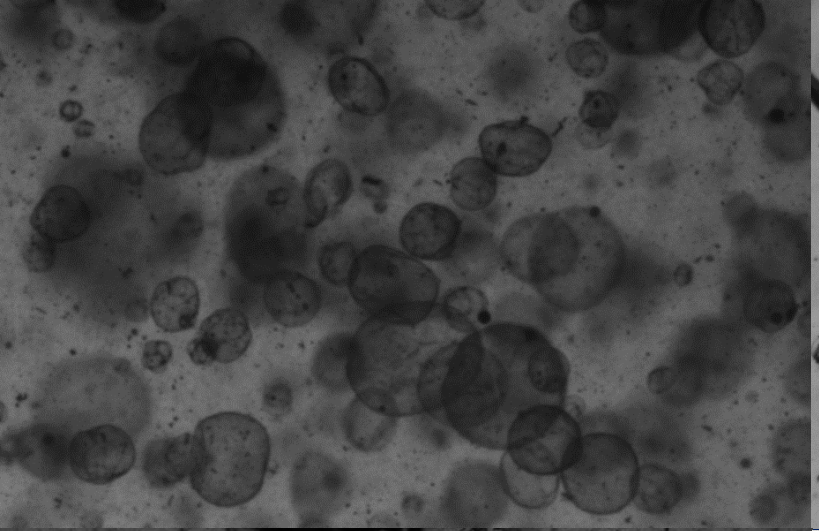
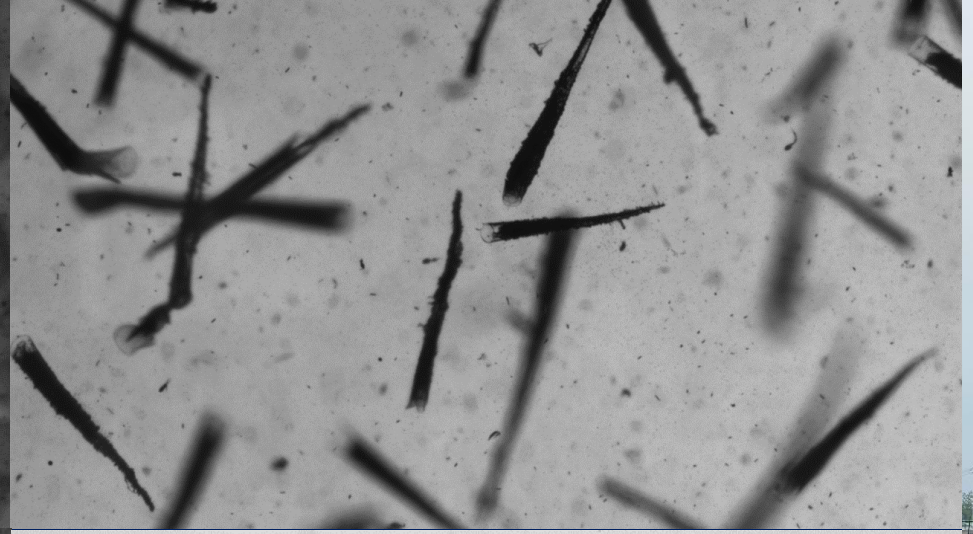
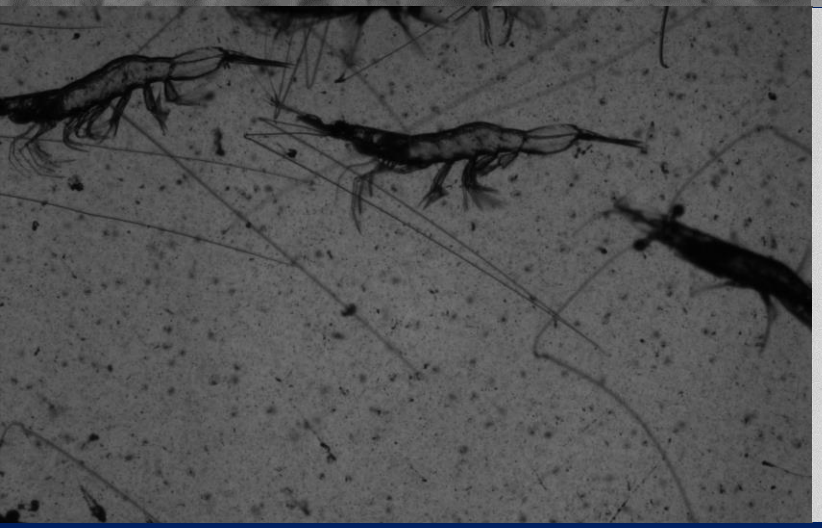




REAL TIME PLANKTON MONITORING IN CHESAPEAKE BAY: ADVANCED IMAGING AND DEEP LEARNING ILLUMINATE MESOPELAGIC IN SHALLOW WATER

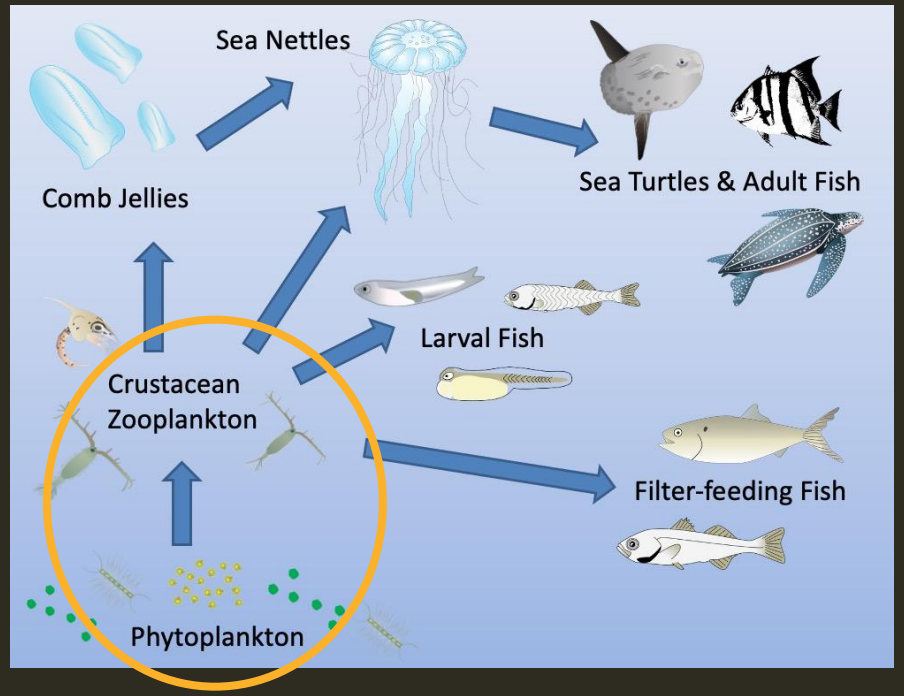
Hongsheng Bi, Jian Zhao, Wenjing Liu

University of Maryland
Center for Environmental Science

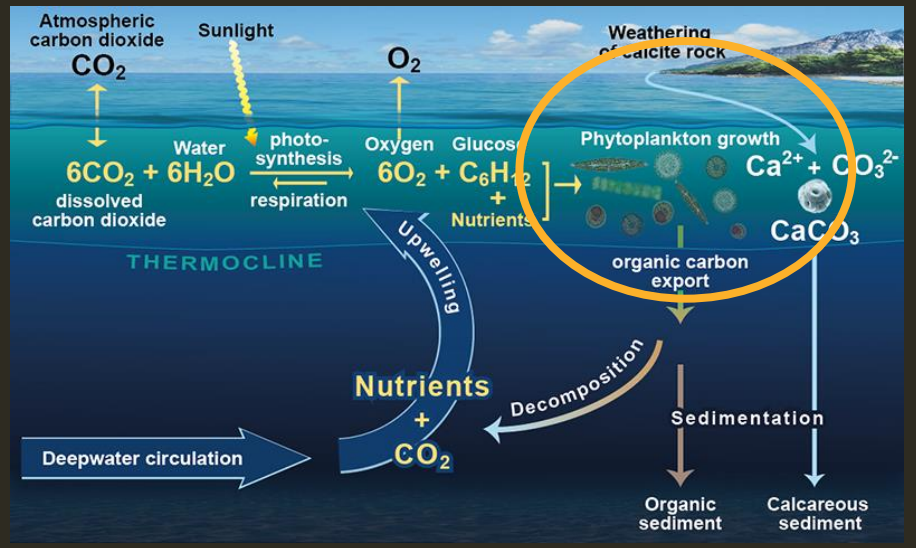
CONTENTS

IMPORTANCE OF PLANKTON

- Base for the marine food web
  - Ichthyoplankton & forage fish, e.g., critical period hypothesis
  - Affecting global fisheries
  - Ecosystem structure and functions, e.g., junk-food hypothesis
- Critical for ocean carbon pump and climate change
- Excellent indicators for integrated ecosystem and climate assessment

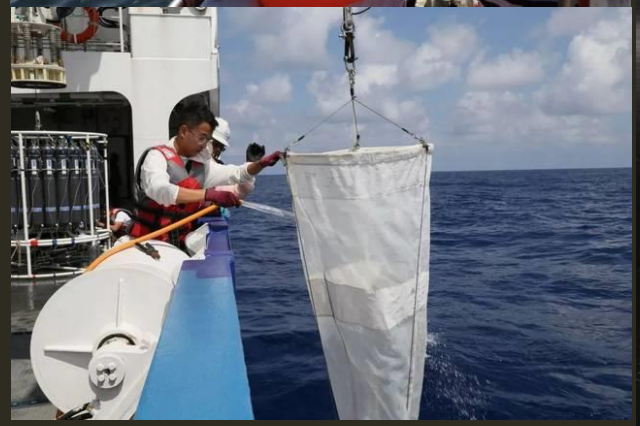


Source: IAN



https://rapid.ac.uk/abc/bg/bcp.php

Plankton Sampling



Net sampling

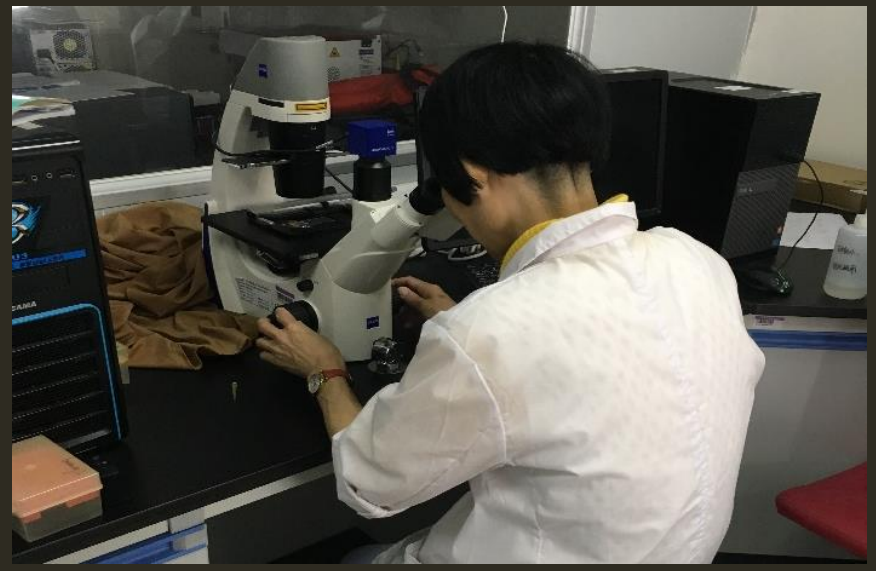
Discrete in time

Integrative in space

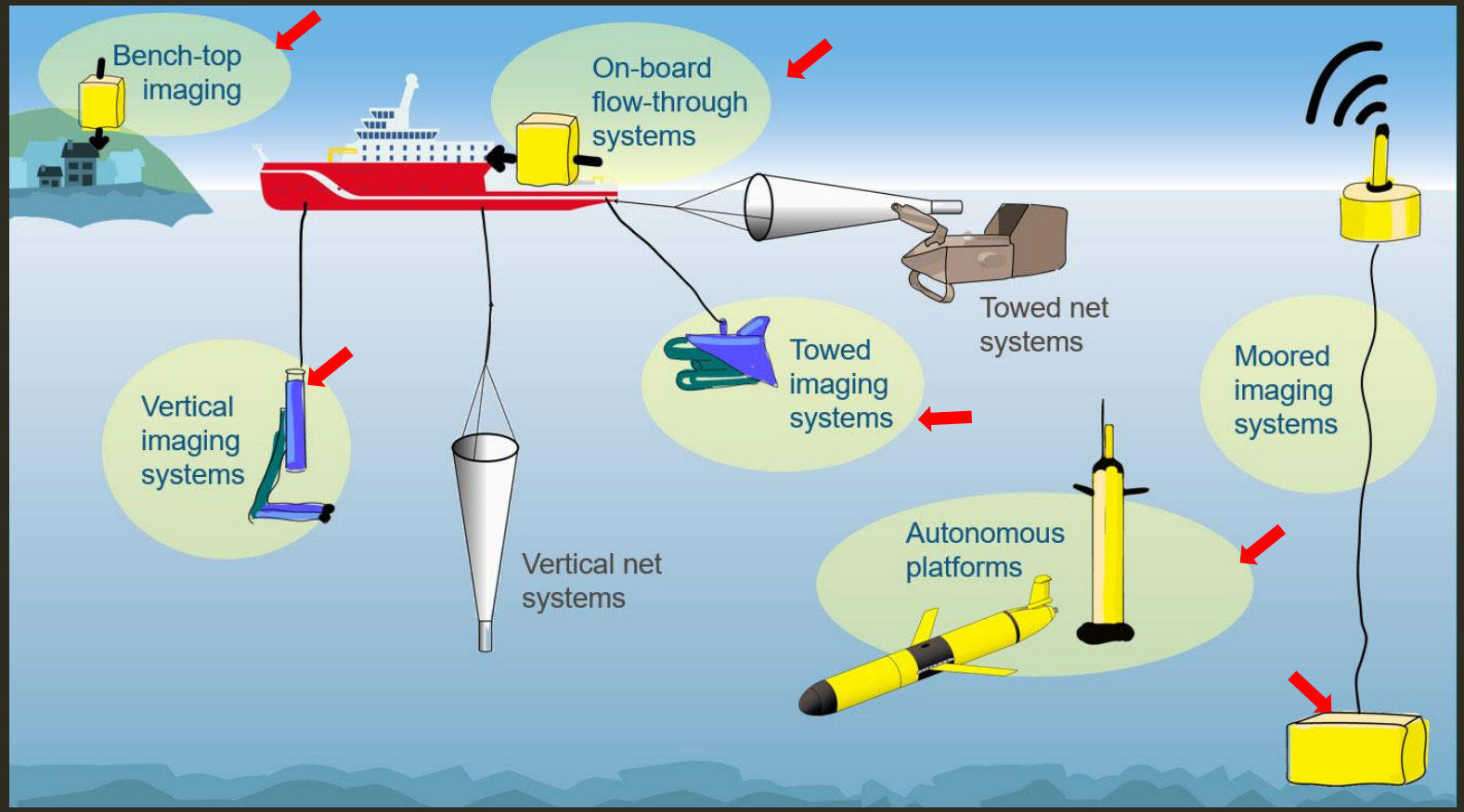
In situ imaging system

- No clogging or reduced filtering efficiency
- Nonintrusive, no damage to fragile organisms
- High spatial and temporal resolution
- Simultaneous measurements on a suite of plankton groups
- Size, behavior, bloom status etc.

Traditional Sampling – time lag



Giering et al. 2022, FMS



Net sampling

Discrete in time

Integrative in space

Traditional sample processing

Laborious

Time consuming

02

PART TWO

PlanktonScope

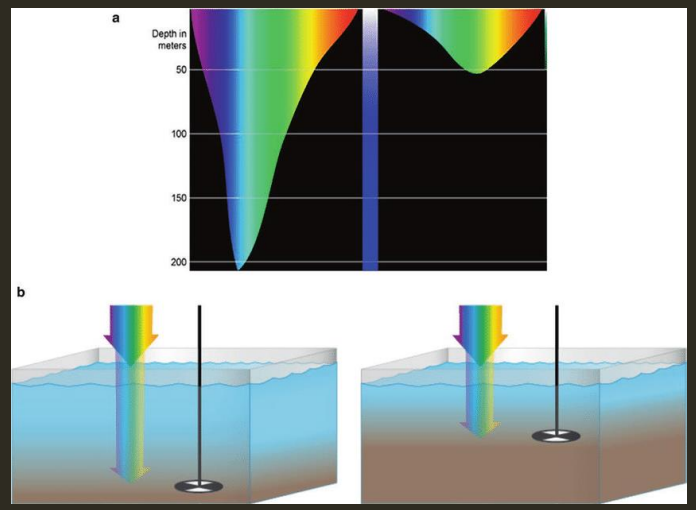
Image Analysis

PlanktonScope

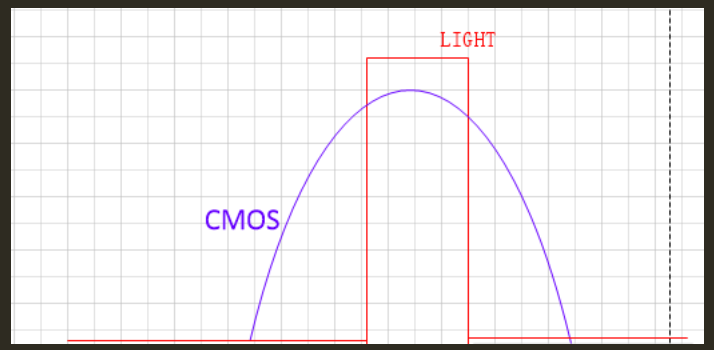
PLANKTONSCOPE

- A shadowgraph imaging system
  Self contained & battery powered
- Red LED pulse mode
  - High turbidity
  - Motion blurry

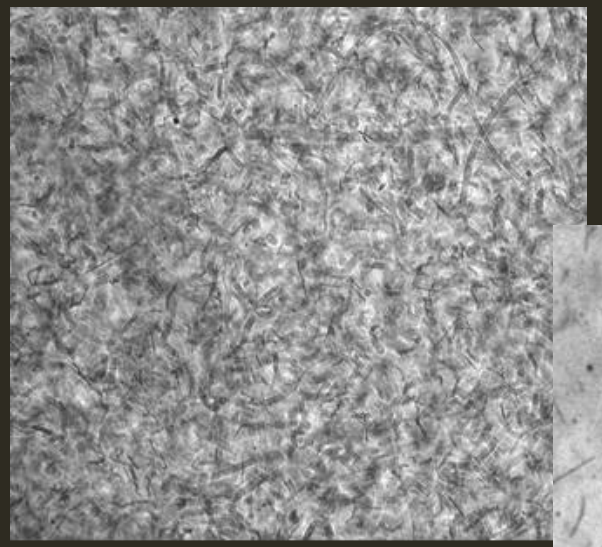
Bi et al. 2013 JPR
Song et. 2020 Ecol Ind
Liu et al. 2021 Limnol and Oceanol. sinica
Bi et al. 2022 JSR
Bi et al. 2024 LOM



Mascarenhas & Keck 2018

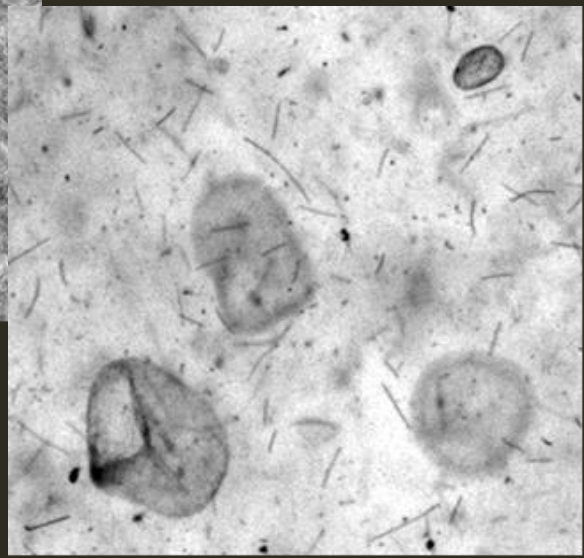


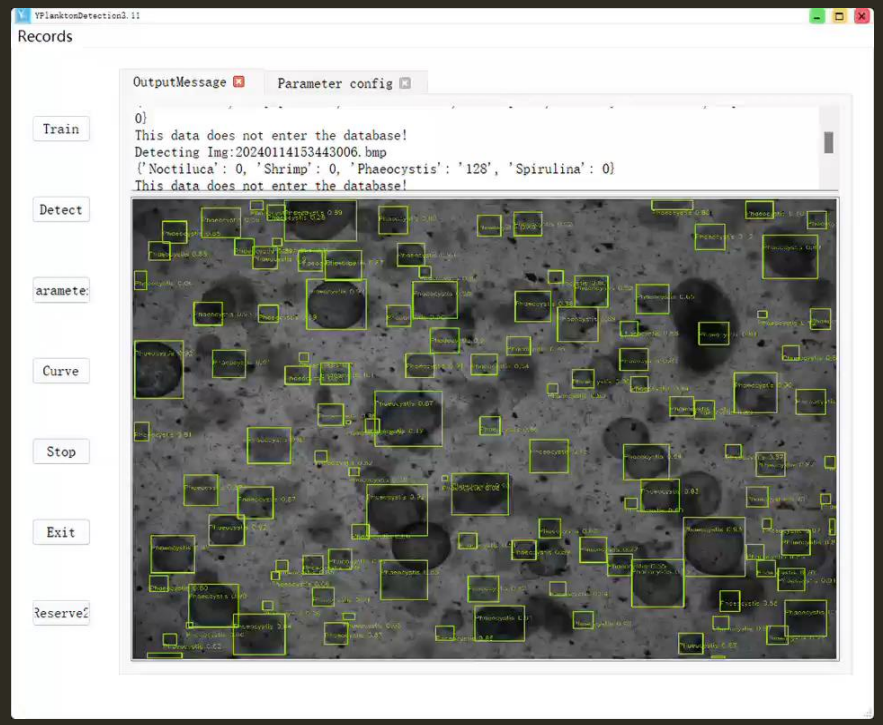
1. Pulse mode, high intensity
2. Fast exposure to overcome motion blurry

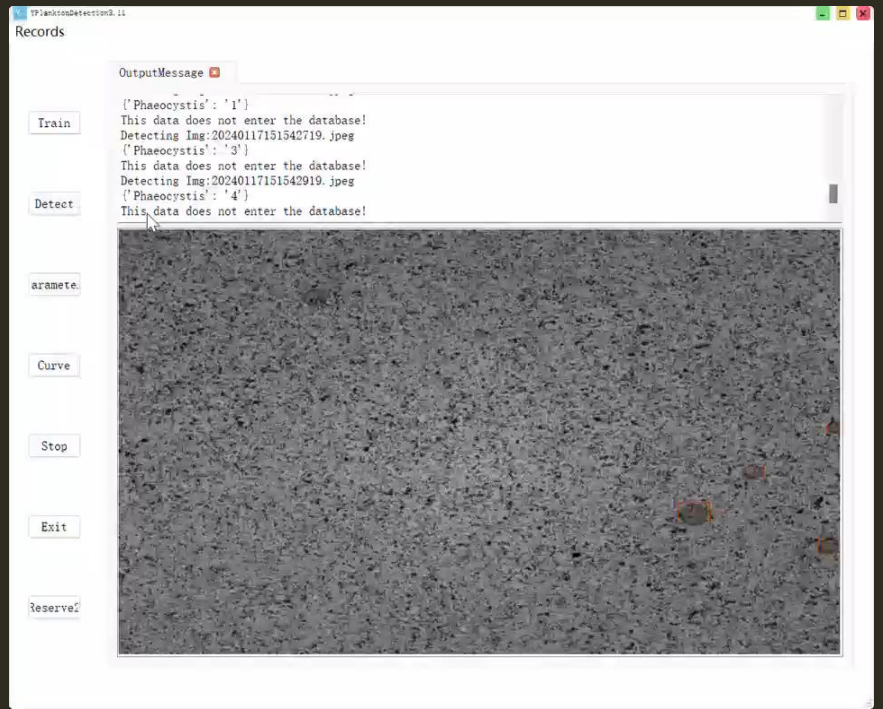


← 10μs

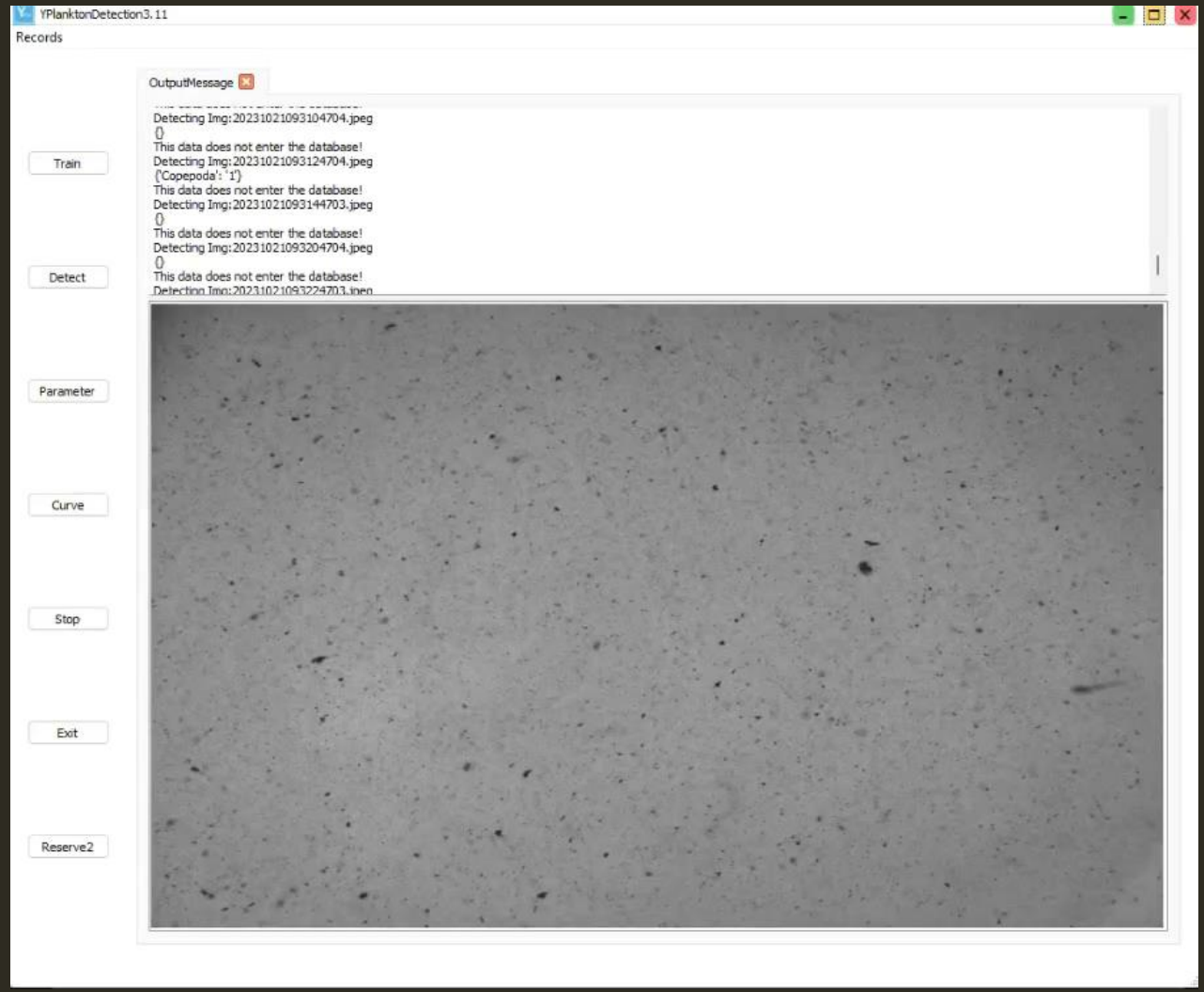
1μs →







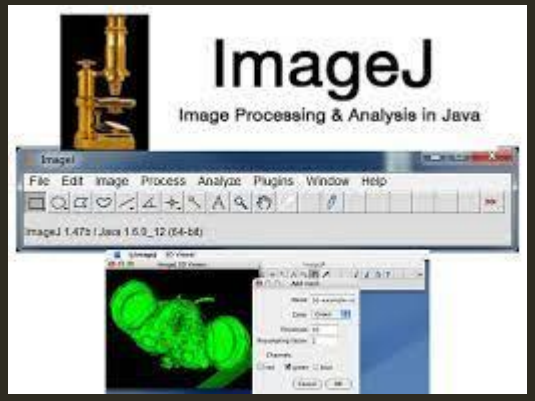
1. High turbidity imaging
2. Rapid image processing
   ~900,000 images in 24 hrs



Size measurement

Zhang et al. 2024 Front Mar Sci

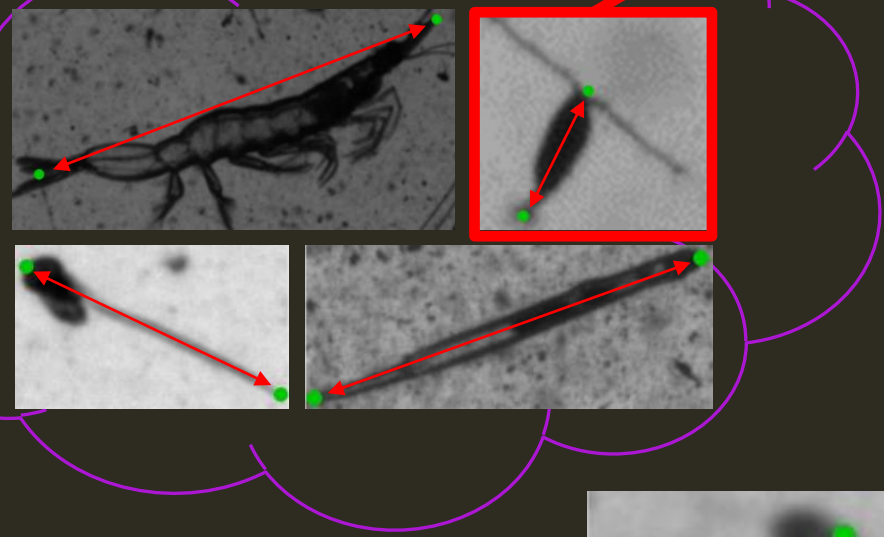
PlanktonScope

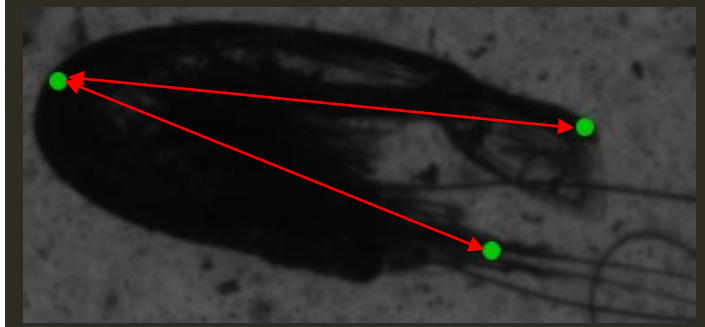


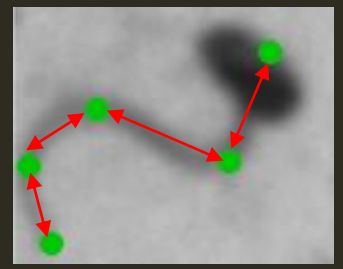
Animated biology with arpan

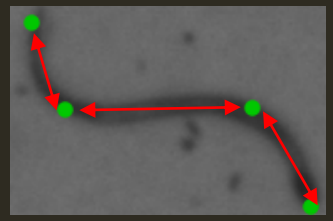
Human Key points Detection

Bounding box



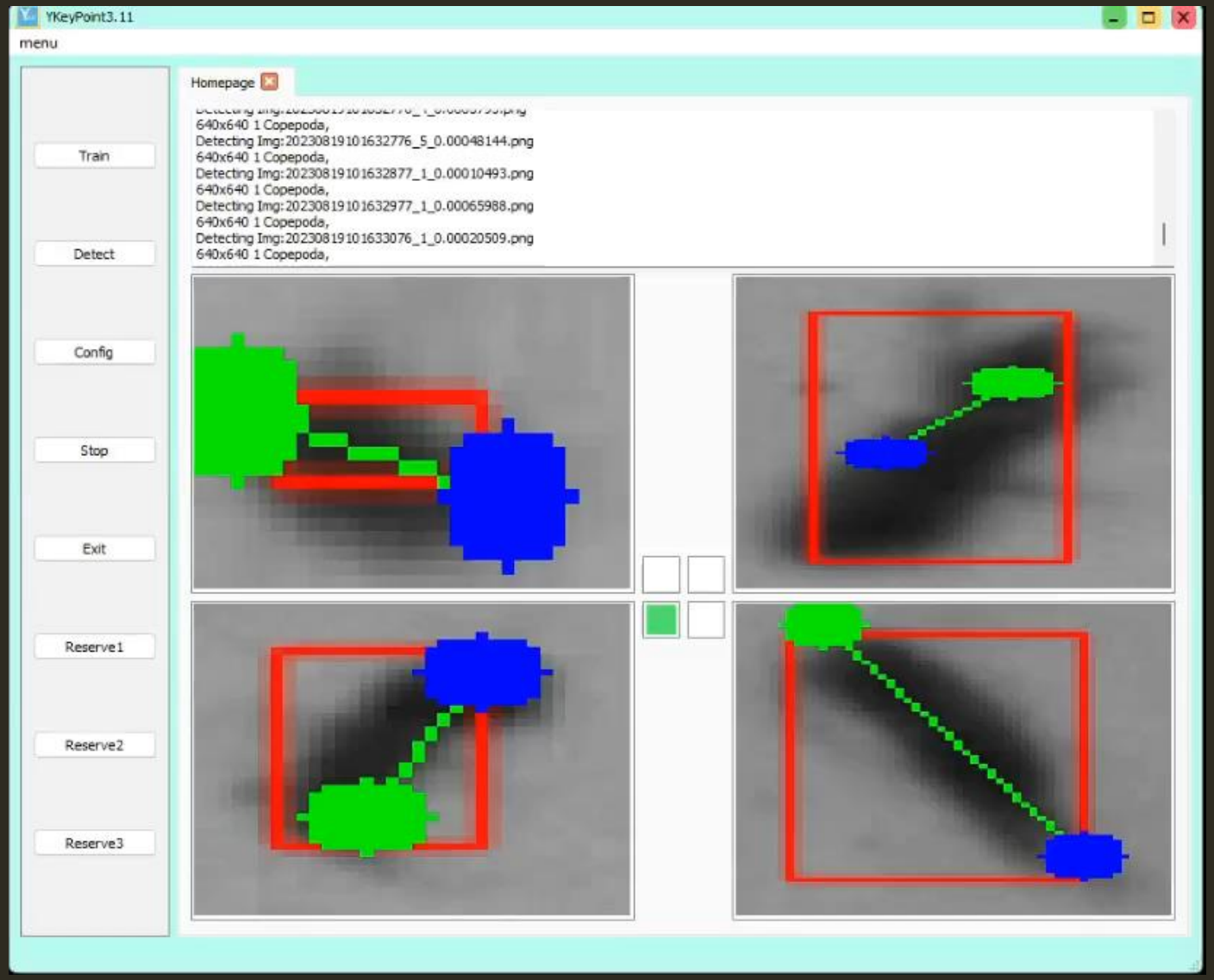






PlanktonScope

PlanktonScope



	True value (ImageJ)	Measured value (Key point)	Difference
	A	B	G
91	15.70211	16.17	0.029798
92	28.12548	28.71	0.020782
93	33.75	34	0.007407
94	22.94754	23.3	0.015359
95	28.18499	28.85	0.023594
96	32.60383	31.77	0.025575
97	22.1109	22.89	0.035236
98	33.38345	33.75	0.01098
99	23.4375	23.27	0.007147
100	23.44265	23.54	0.004153
101			0.023422

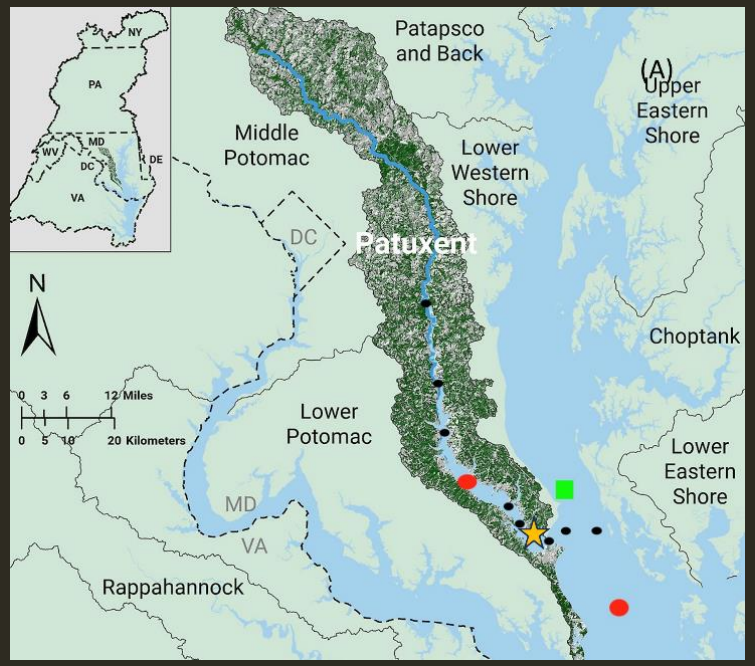
Mean error : **2.34%**

03

PART THREE

Deployment

Plankton dynamics



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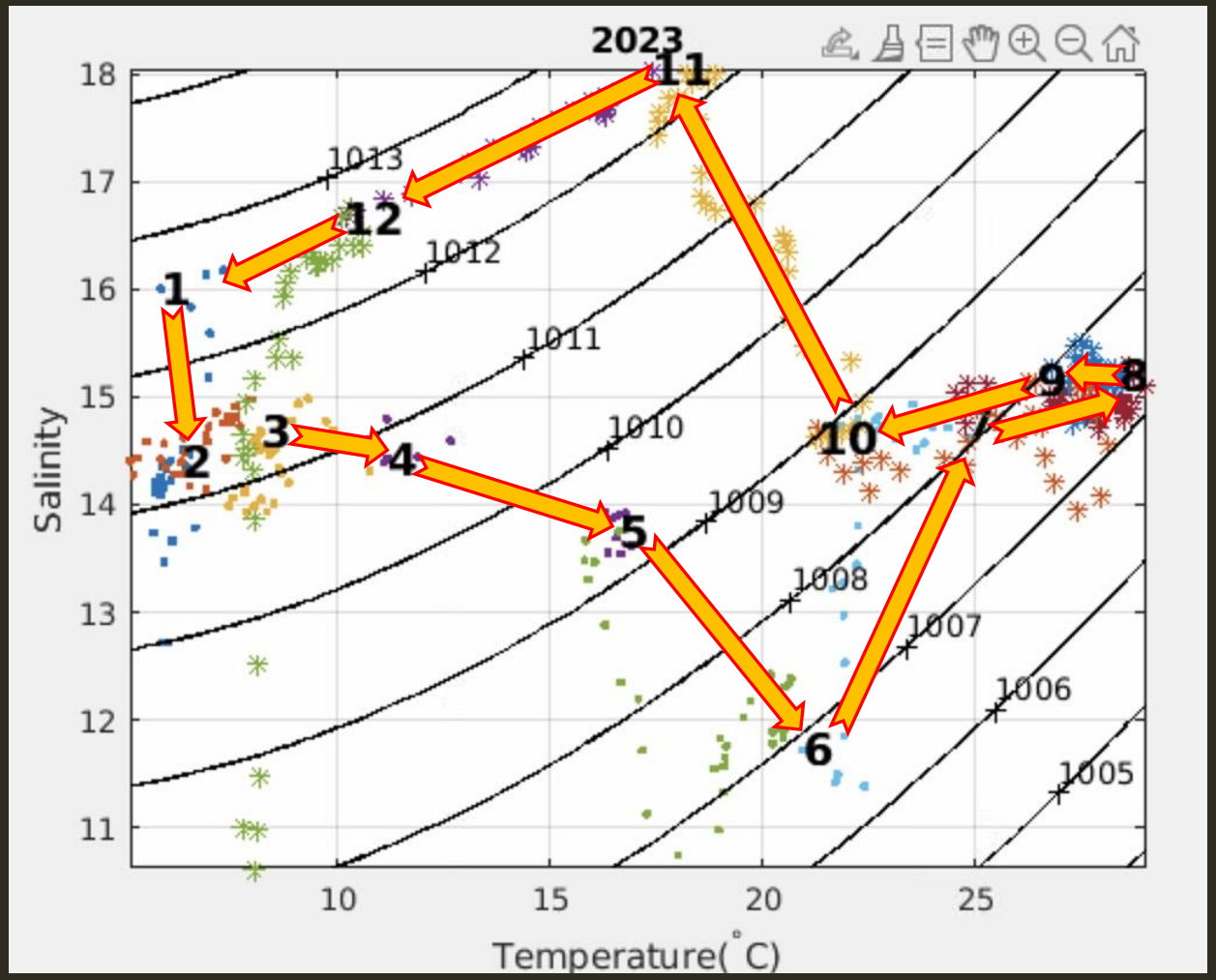
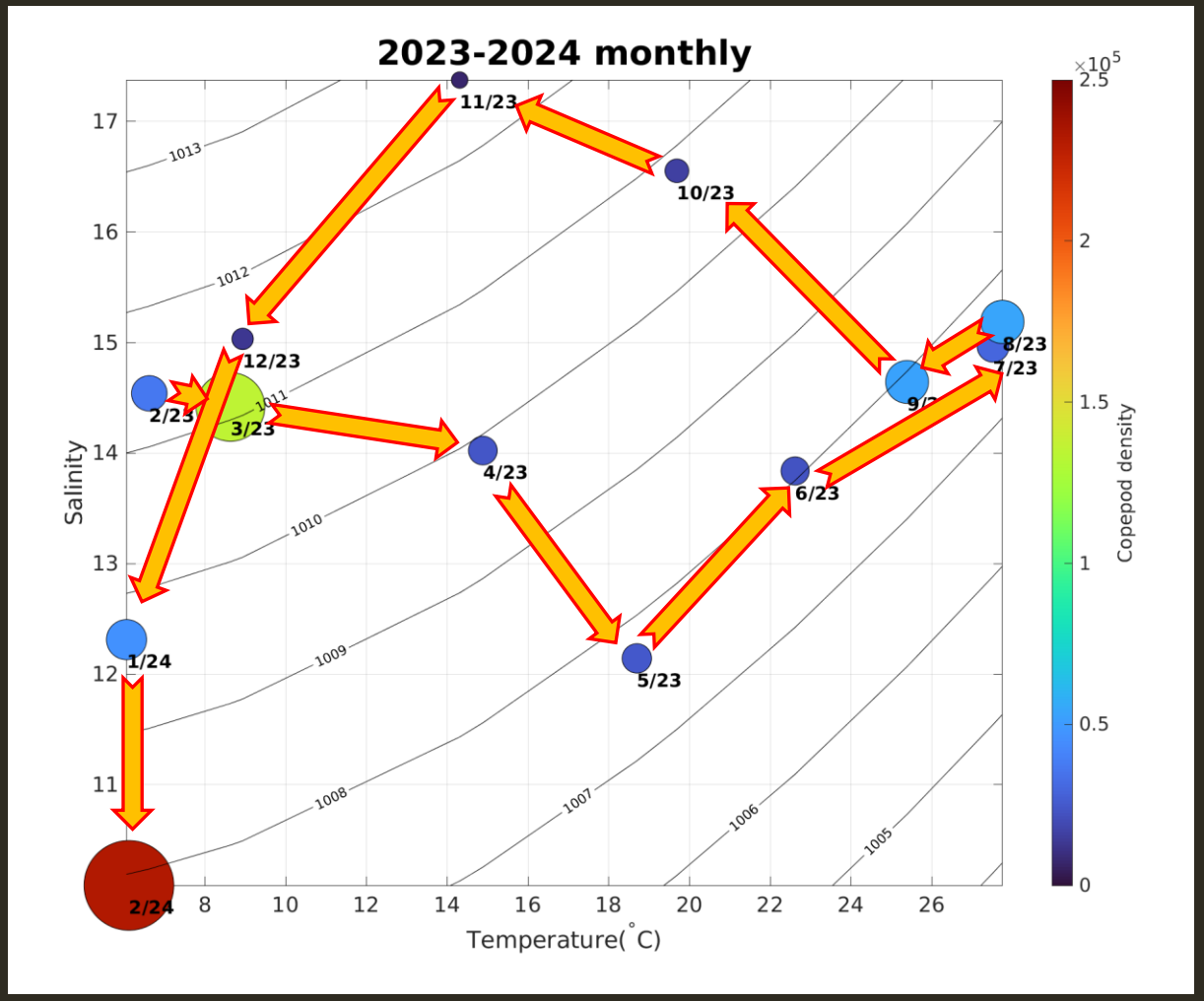
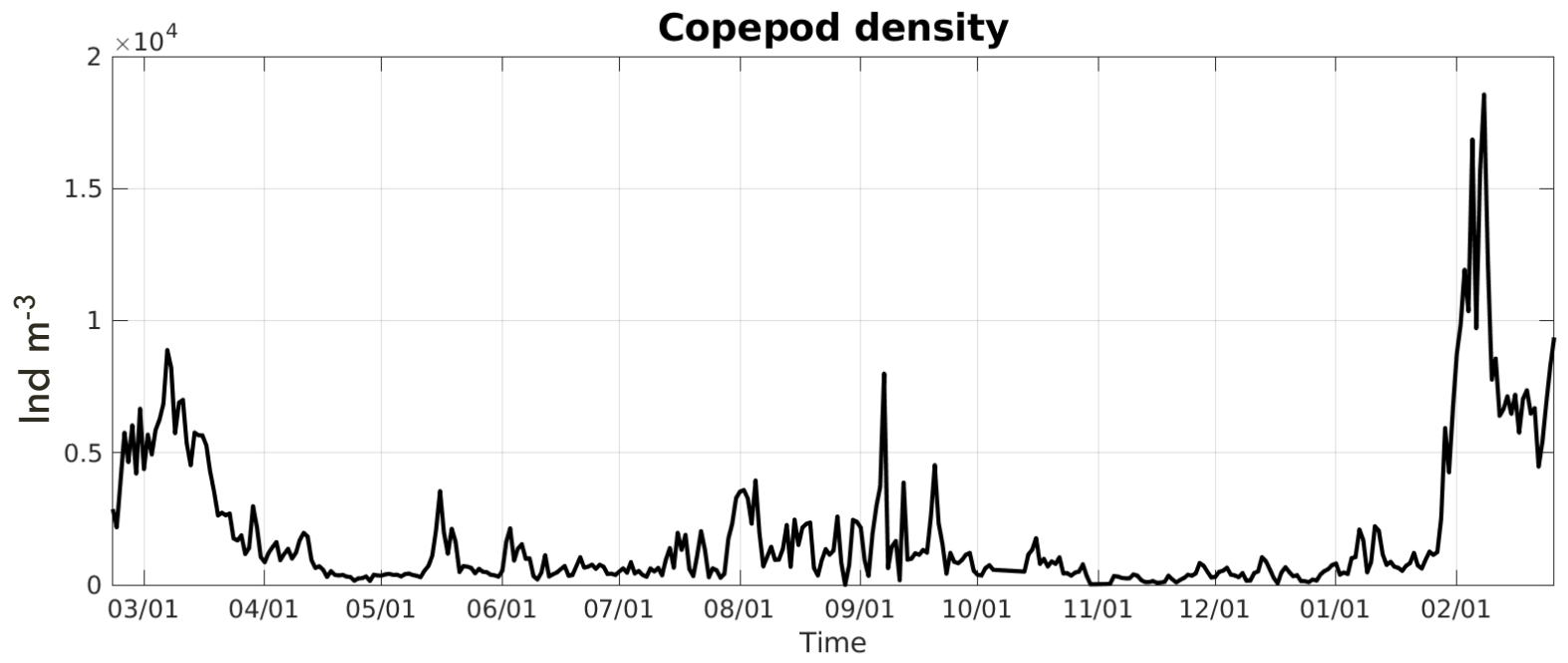
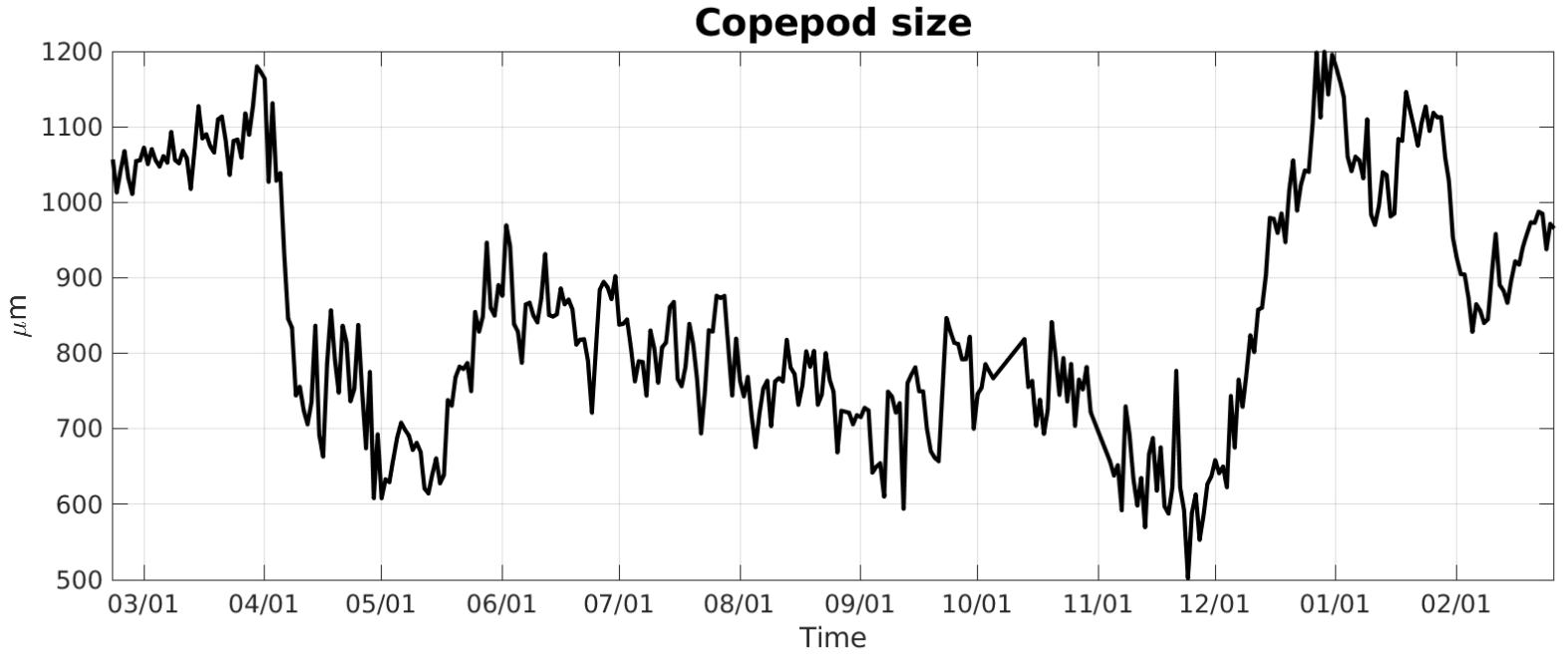
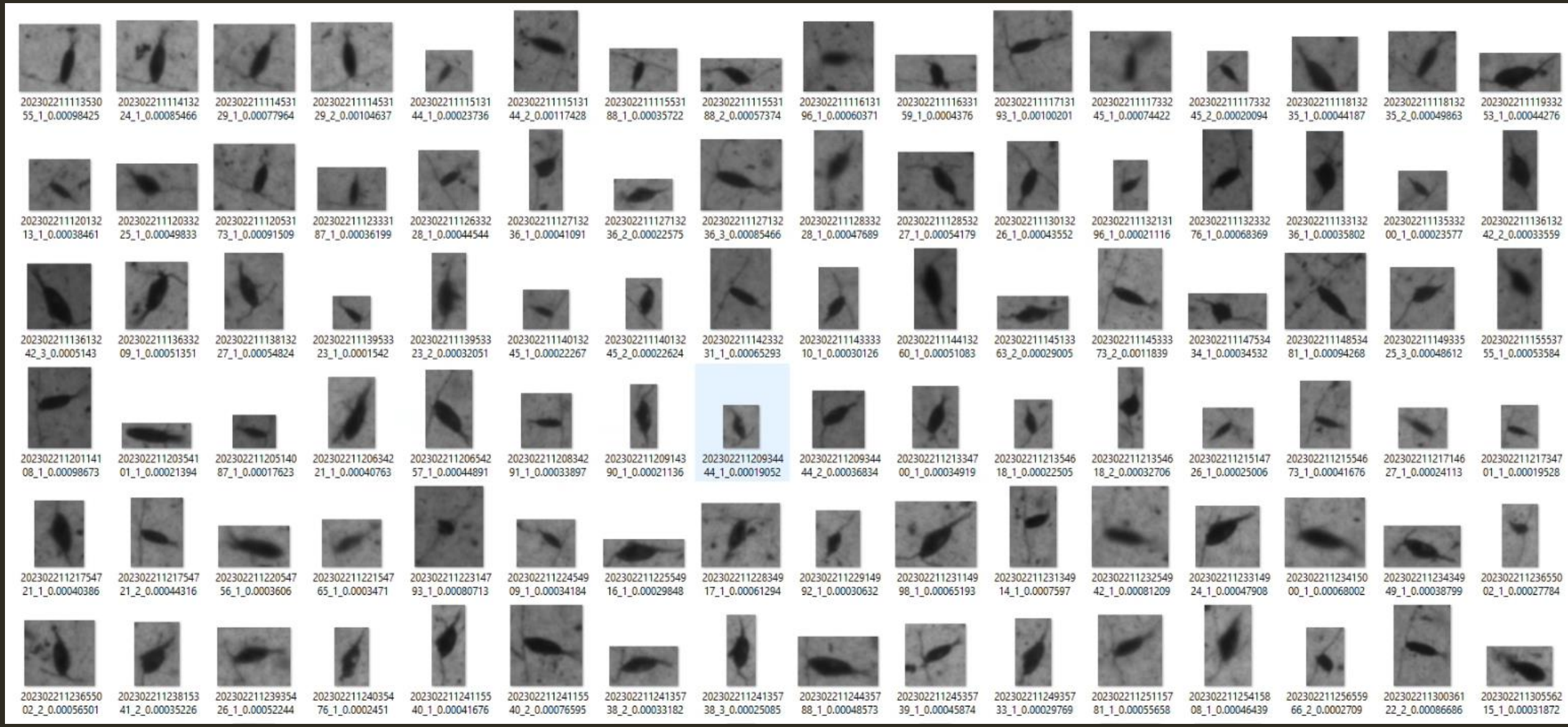
CHESAPEAKE BIOLOGICAL LABORATORY


2023
Salinity
Temperature(°C)
1
2
3
4
5
6
8
9
10
11
12
1013
1012
1011
1010
1009
1008
1007
1006
1005


2023-2024 monthly
Salinity
Temperature(°C)
Copepod density
×10^5
11/23
10/23
12/23
2/23
3/23
4/23
6/23
8/23
7/23
1/24
5/23
2/24
1013
1012
1011
1010
1009
1008
1007
1006
1005


Copepod density
×10^4
2
1.5
1
0.5
0
Ind m^-3
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01
11/01
12/01
01/01
02/01
Time


Copepod size
1200
1100
1000
900
800
700
600
500
μm
03/01
04/01
05/01
06/01
07/01
08/01
09/01
10/01
11/01
12/01
01/01
02/01
Time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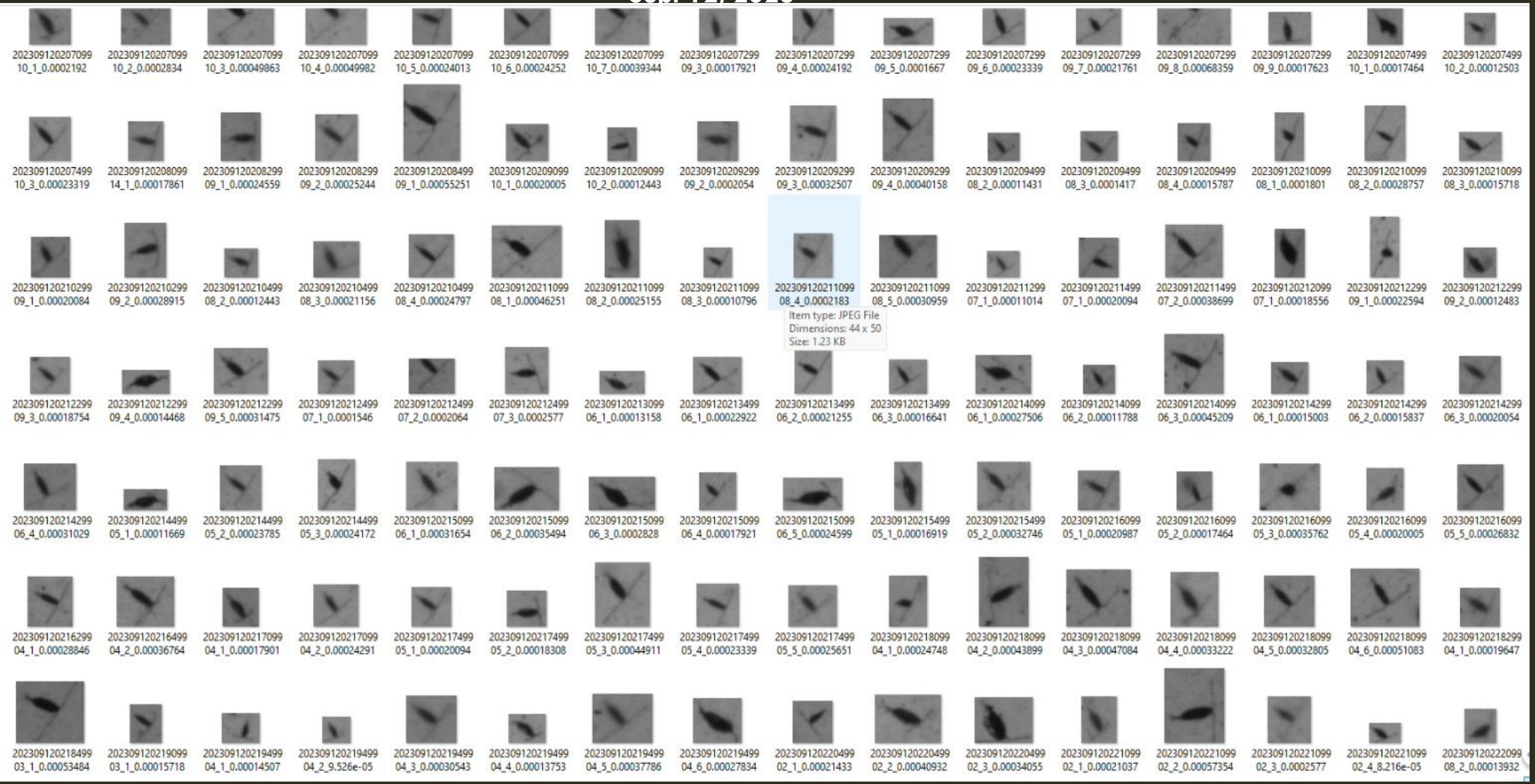
Feb 21, 2023

Sept 12, 2023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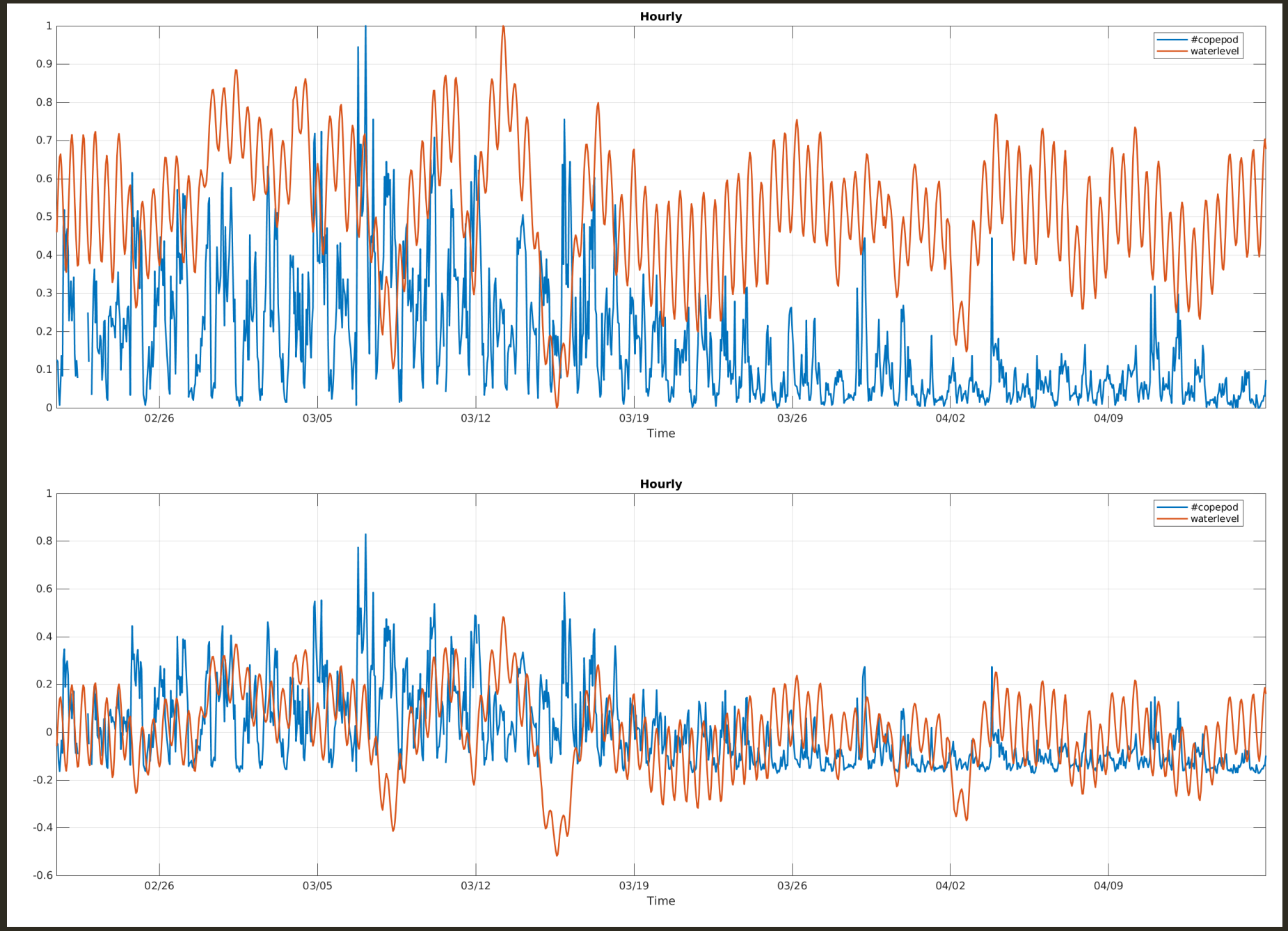
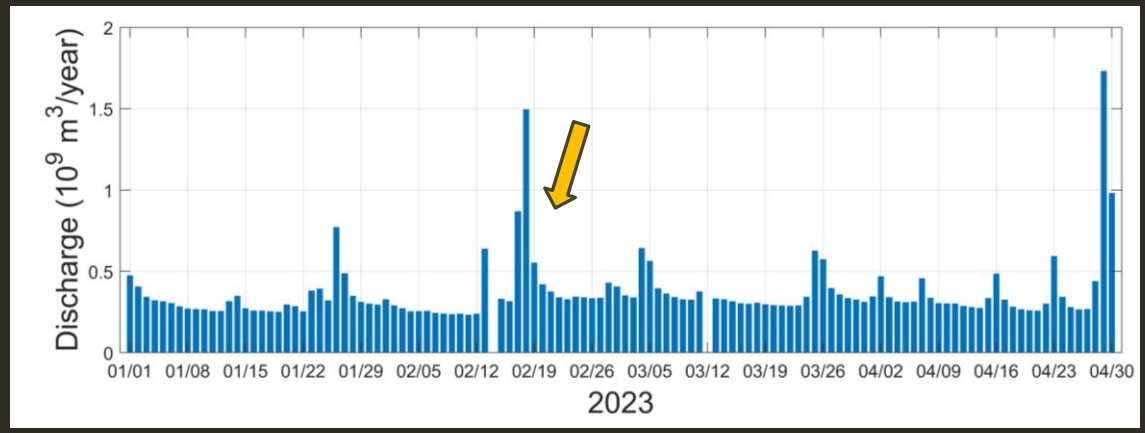
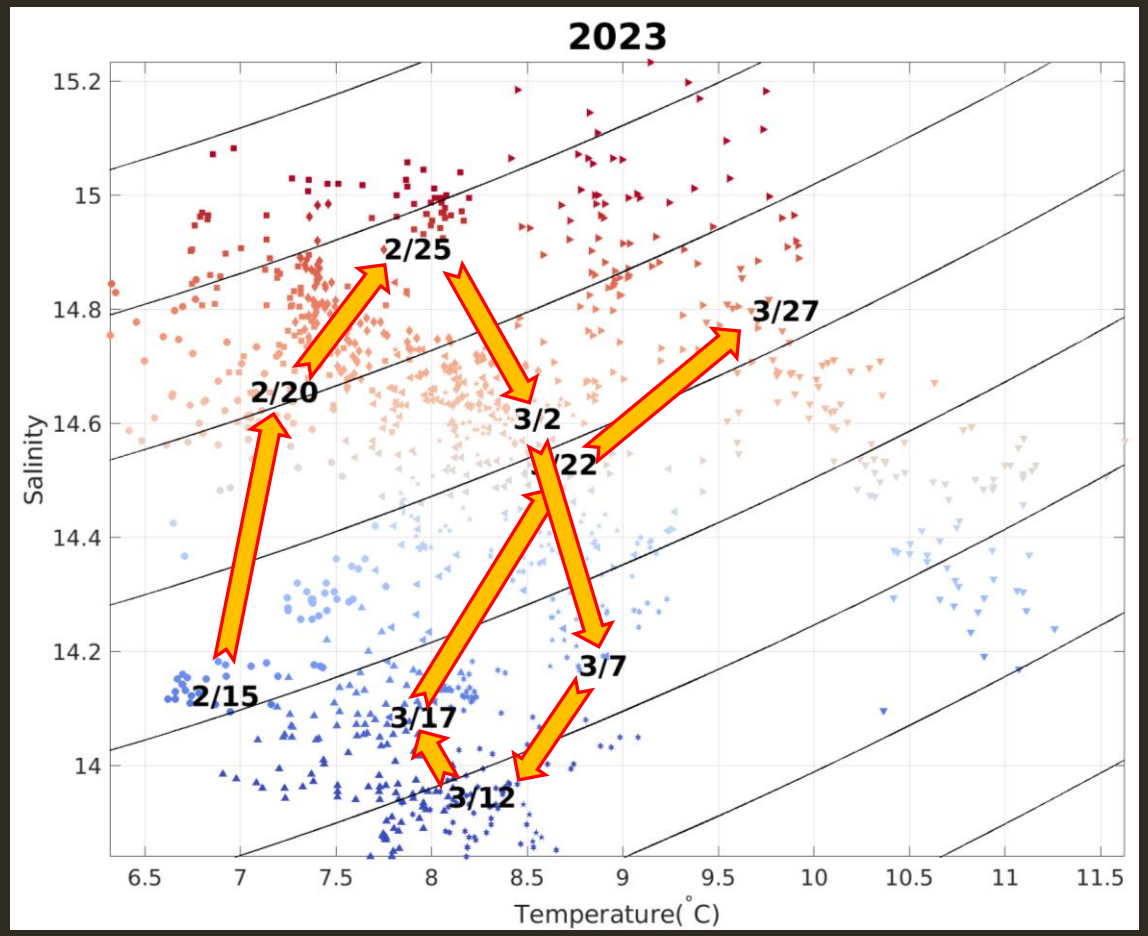
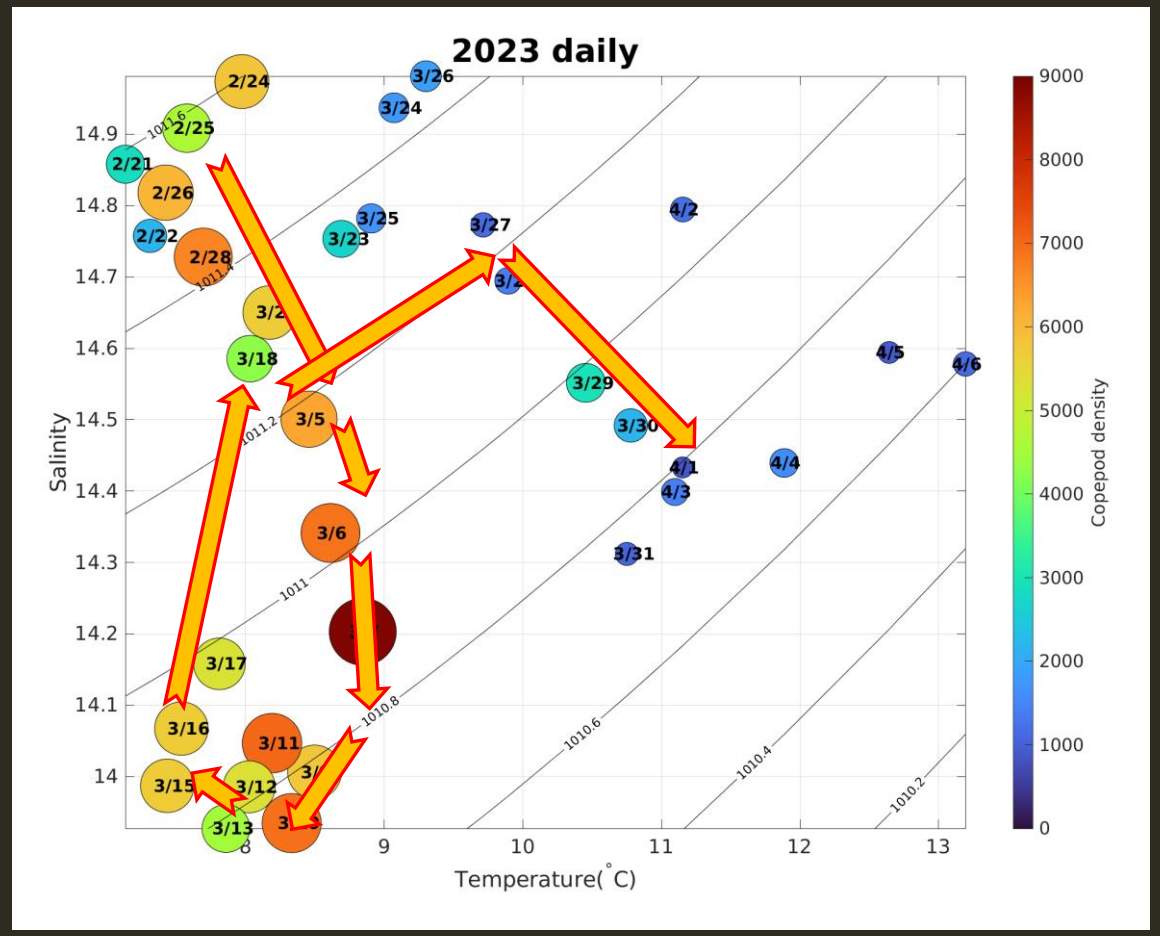
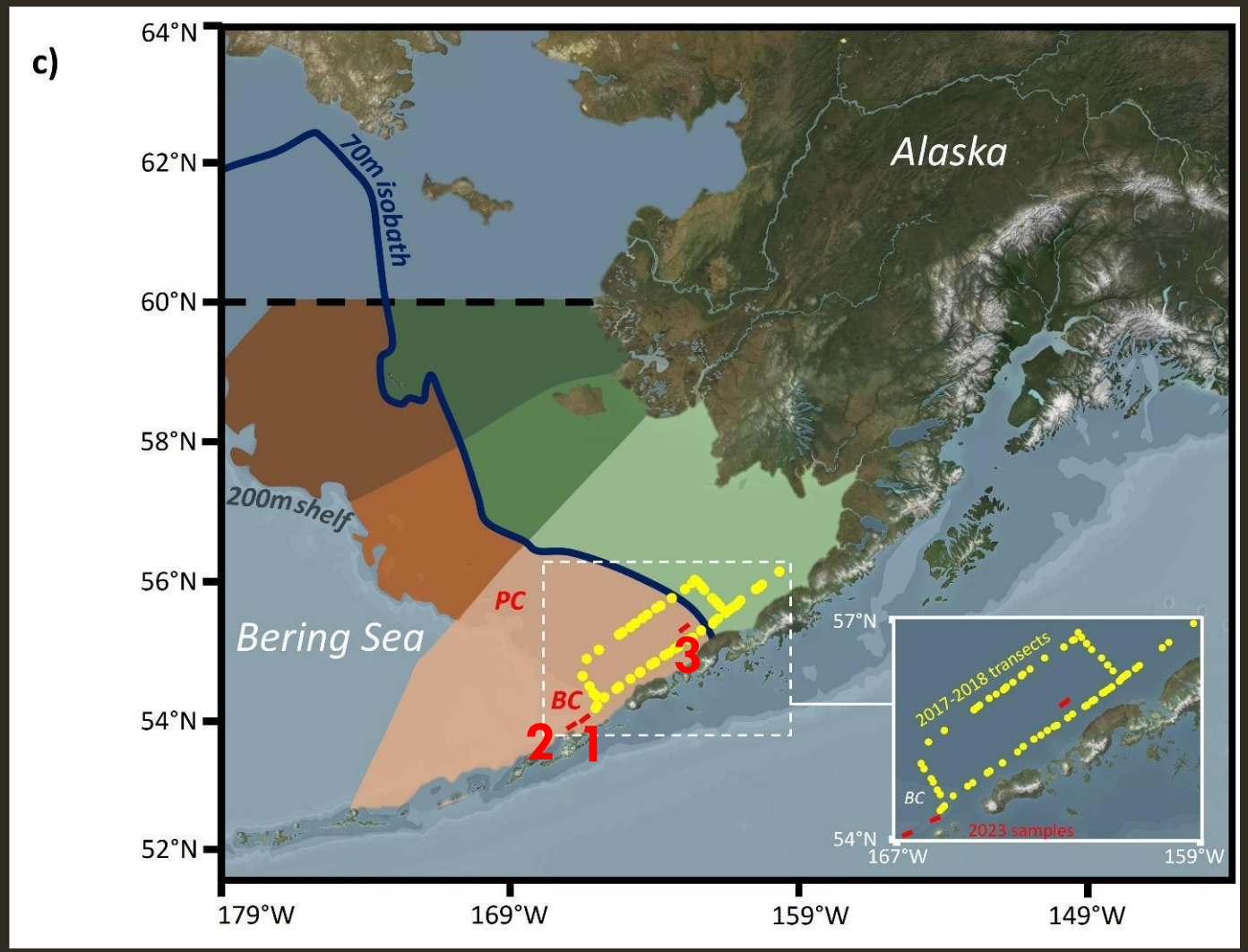

Hourly
#copepod
waterlevel
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
02/26
03/05
03/12
03/19
03/26
04/02
04/09
Time
Hourly
#copepod
waterlevel
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
02/26
03/05
03/12
03/19
03/26
04/02
04/09
Time


Discharge (10^9 m^3/year)
2
1.5
1
0.5
0
01/01 01/08 01/15 01/22 01/29 02/05 02/12 02/19 02/26 03/05 03/12 03/19 03/26 04/02 04/09 04/16 04/23 04/30
2023


2023
Salinity
Temperature(˚C)
2/15
2/20
2/25
3/2
3/7
3/12
3/17
3/27


2023 daily
Salinity
Temperature(˚C)
Copepod density
2/24
2/25
2/21
2/26
2/22
2/28
3/2
3/18
3/5
3/6
3/17
3/16
3/15
3/12
3/13
3/11
3/26
3/24
3/25
3/23
3/27
3/4
3/29
3/30
3/31
4/1
4/3
4/2
4/4
4/5
4/6

Bering Canyon and jellyfish, krill distribution



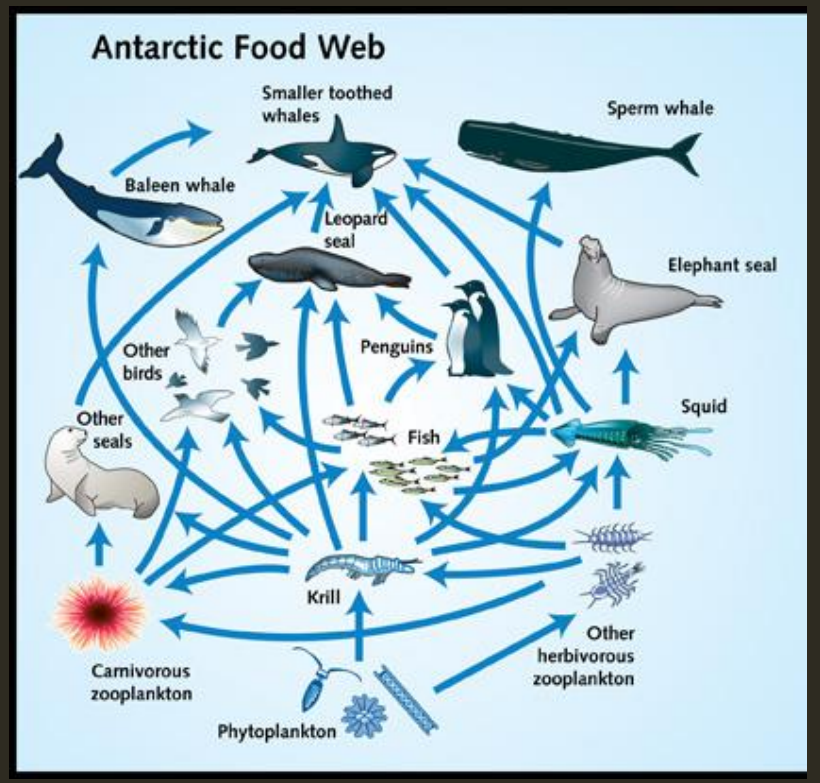
KRILL AND BERING CANYON

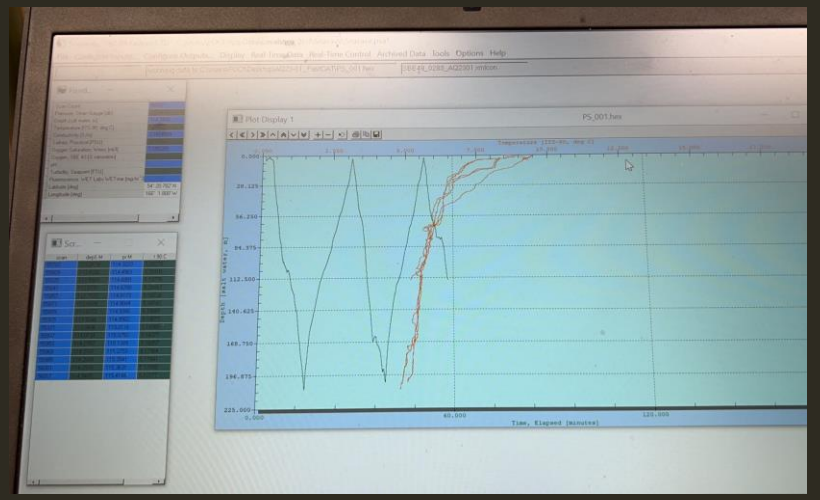
Three 5 hour tow
(180,000 ×3 = 540,000)

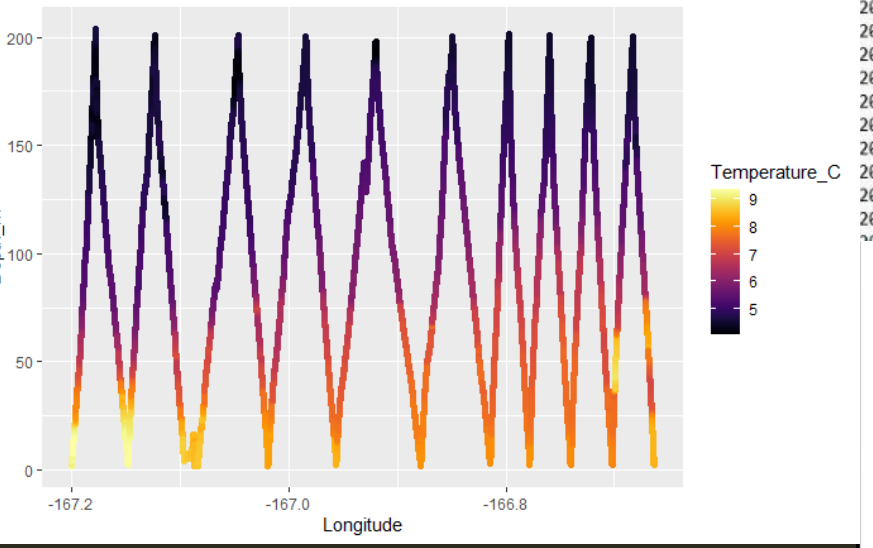
Canyon heads (High)

Inside canyon
(Intermediate)

Shelf (70m isobath, low)







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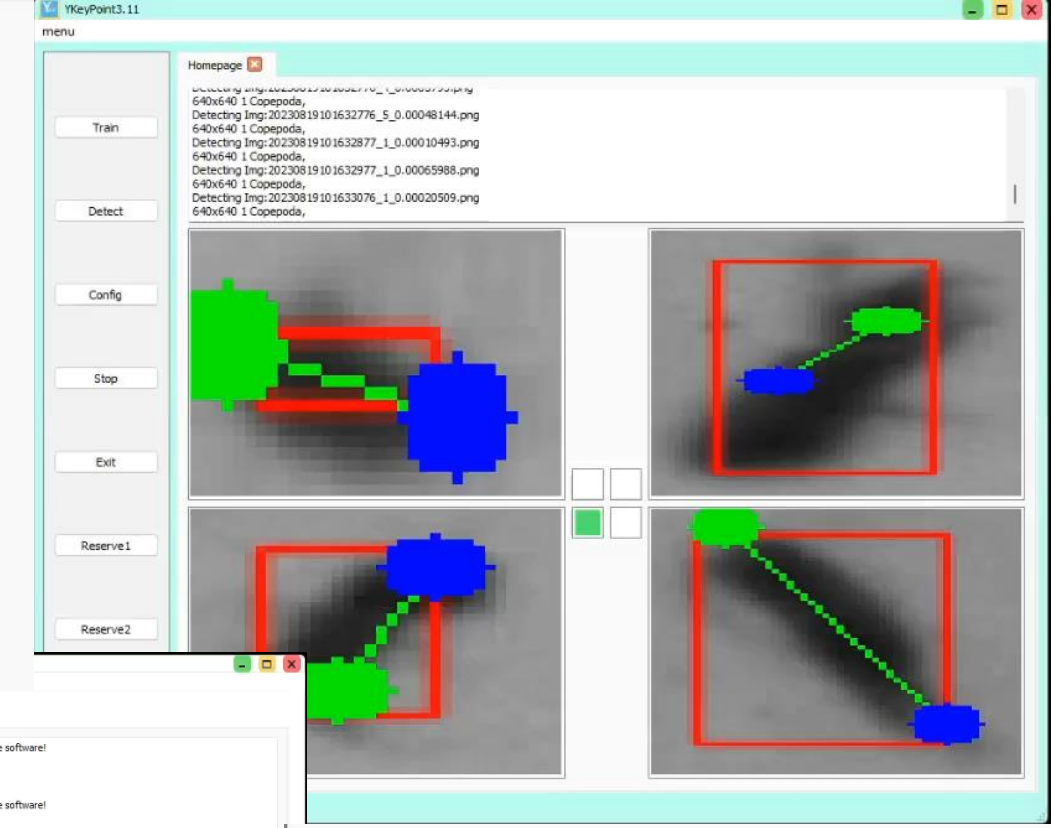

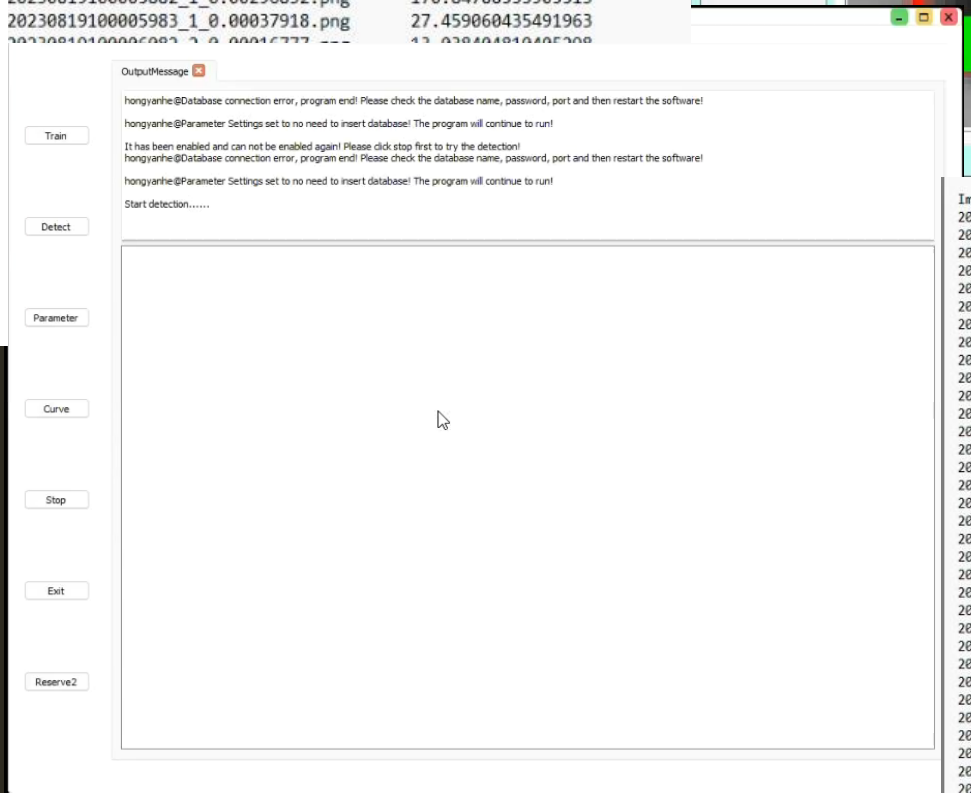

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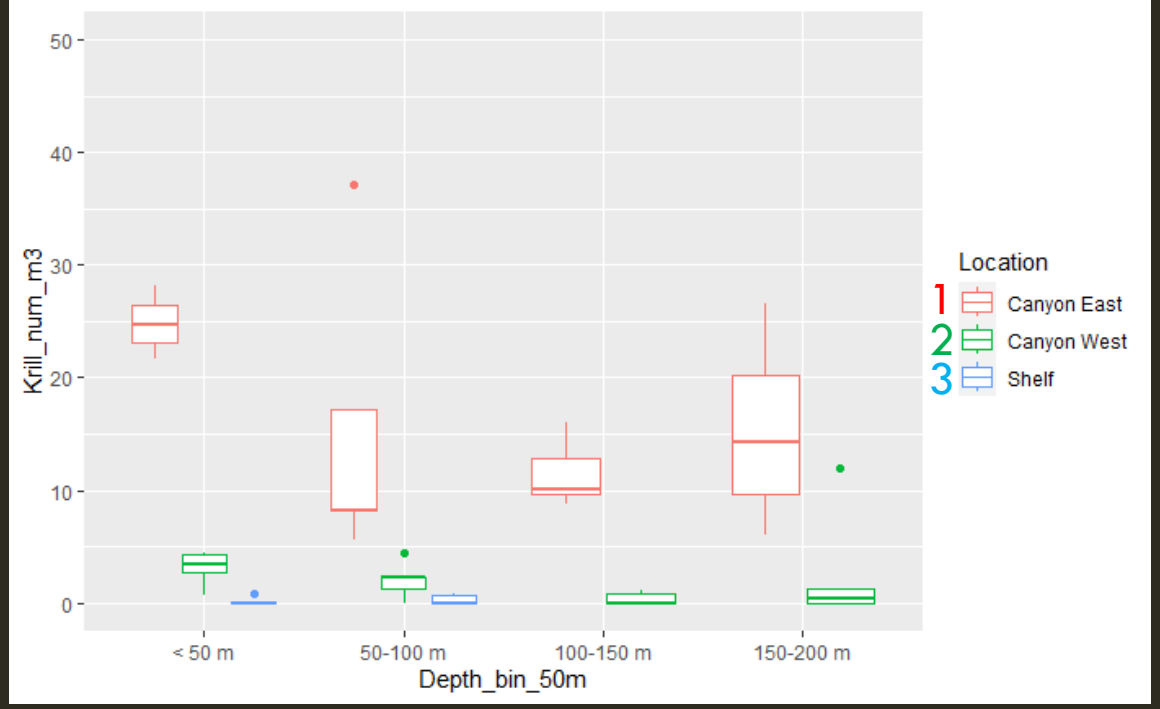
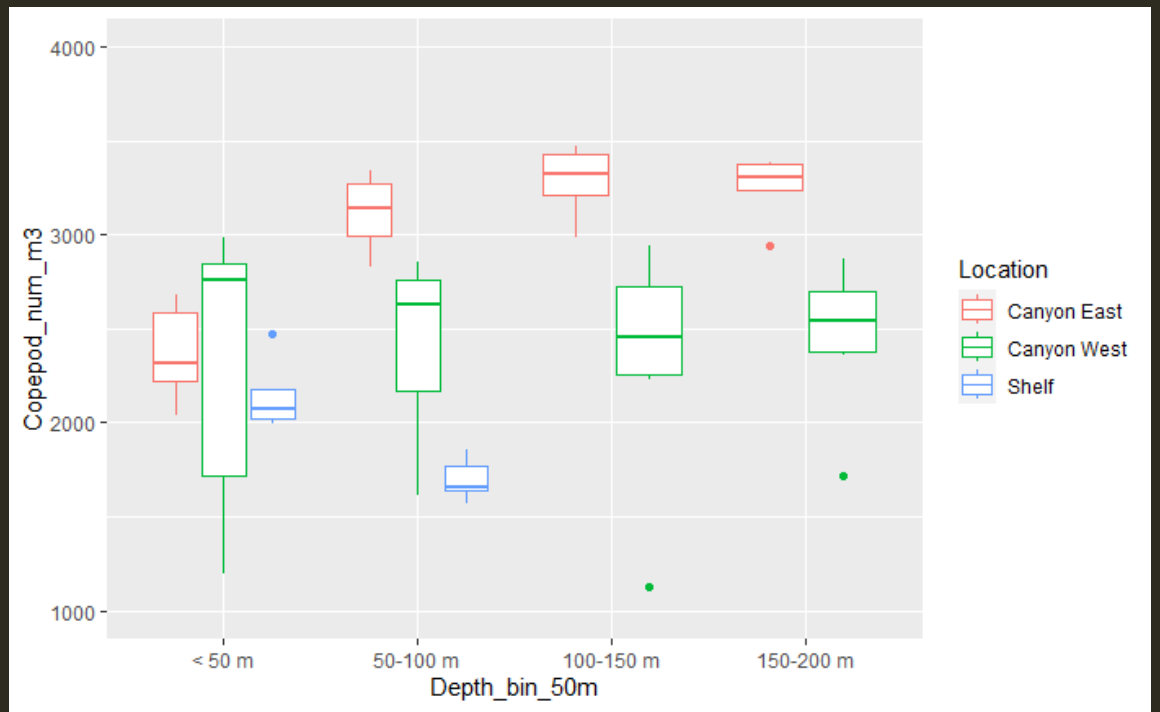
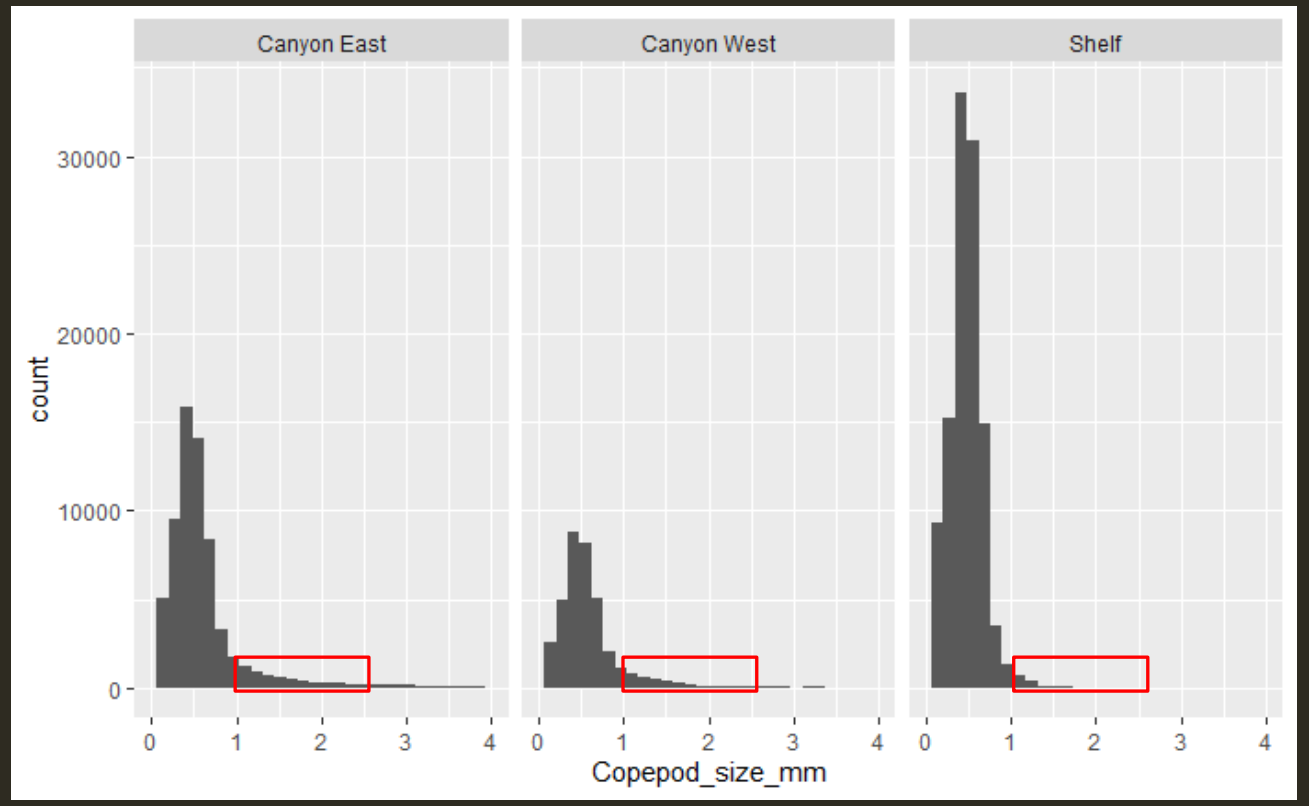
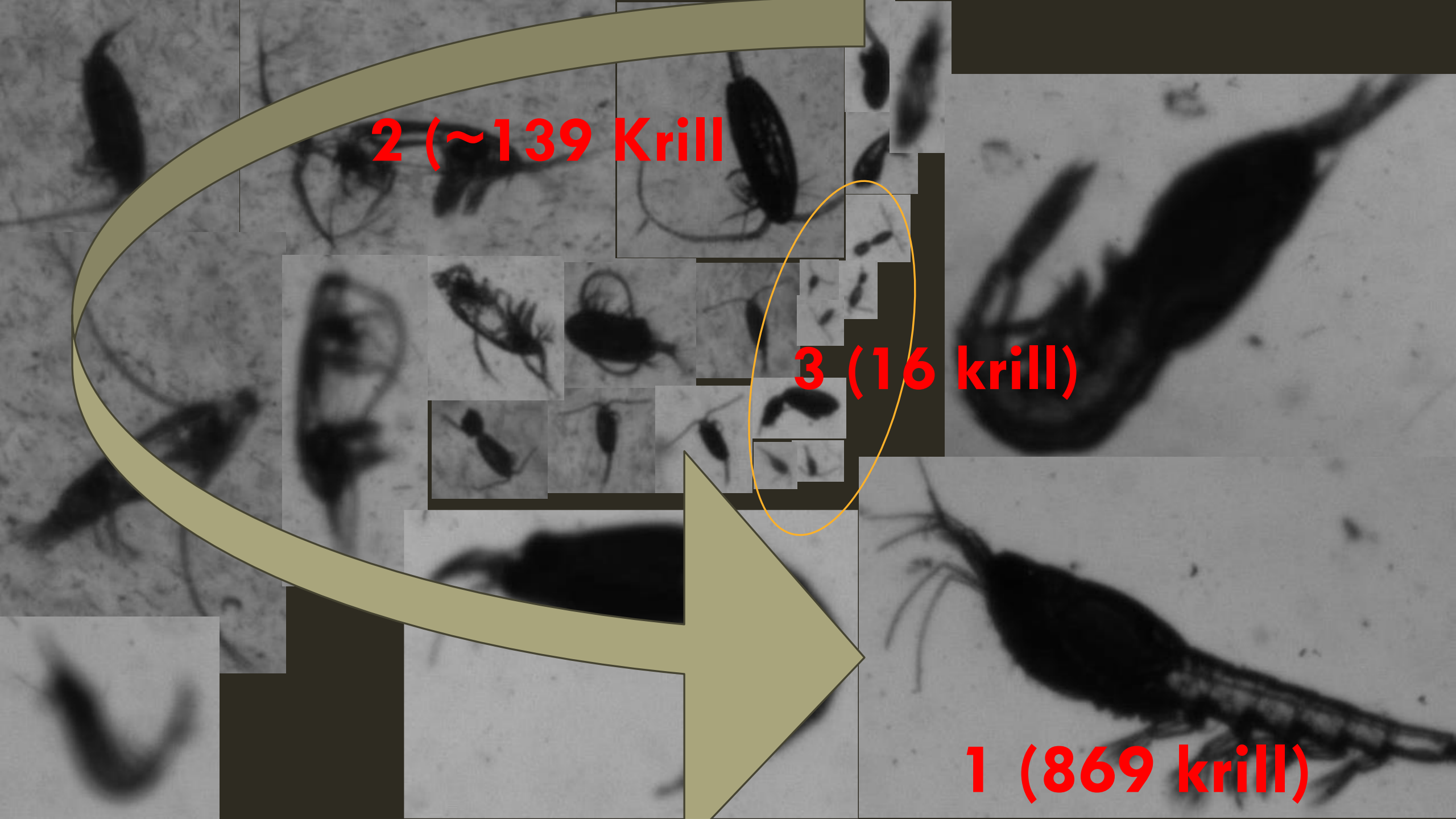

Krill_num_m3
50
40
30
20
10
0
< 50 m
50-100 m
100-150 m
150-200 m
Depth_bin_50m
Location
1 Canyon East
2 Canyon West
3 Shelf


Copepod_num_m3
4000
3000
2000
1000
< 50 m
50-100 m
100-150 m
150-200 m
Depth_bin_50m
Location
Canyon East
Canyon West
Shelf


Canyon East
Canyon West
Shelf
count
30000
20000
10000
0
0
1
2
3
4
Copepod_size_mm

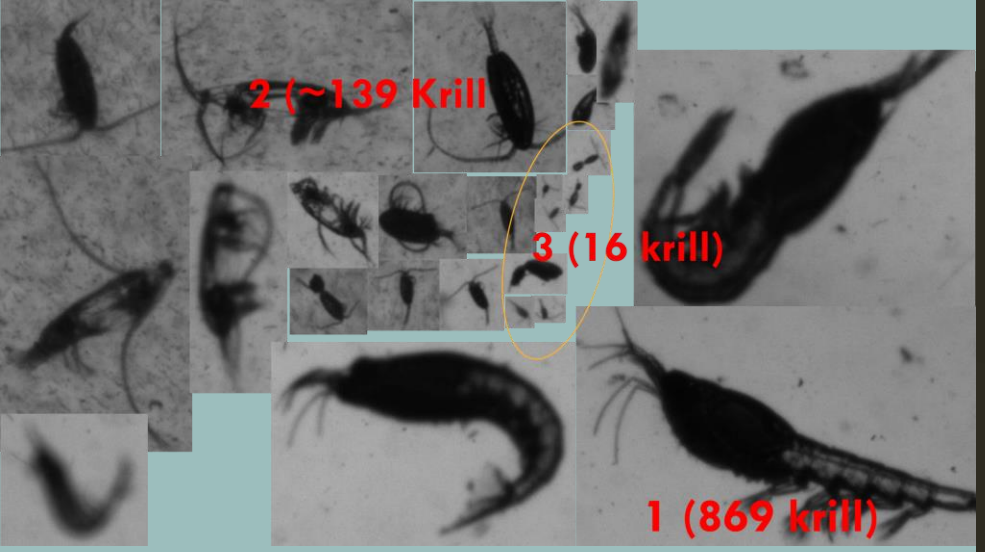

2 (~139 Krill
3 (16 krill)
1 (869 krill)

04

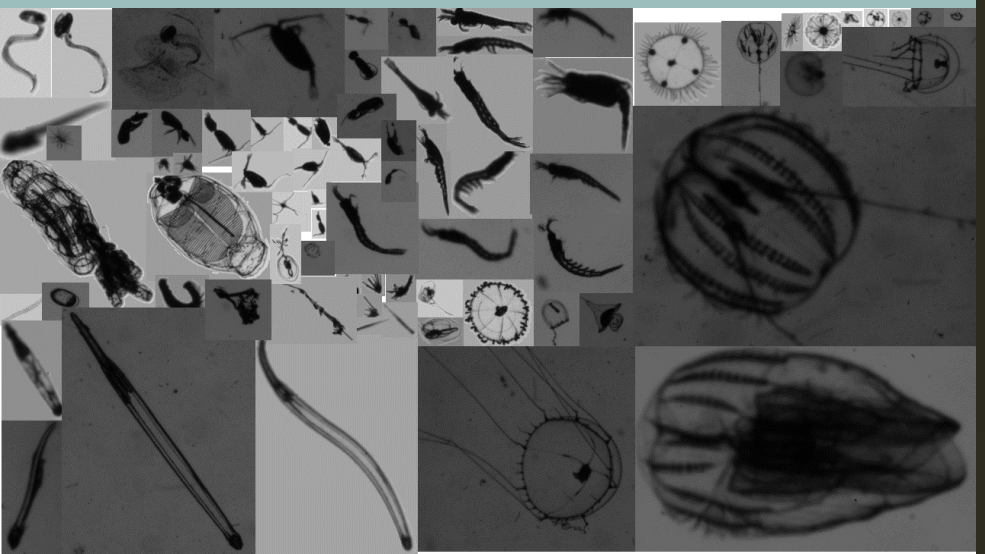
PART FOUR

Conclusion

Future work



CONCLUSIONS



Real time plankton monitoring fills in the gap for biology in observing system: wintertime

Provide evidence for top-down control of phytoplankton, higher density and larger size

High resolution data provided unprecedent information on plankton and underlying processes

Microscopic version will be deployed in this summer!

Thanks & questions!