living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

UNRAVELING THE SPATIAL HETEROGENEITY OF FLOATING MACROPLASTICS AT SEA USING UNMANNED AERIAL VEHICLES (UAVs)

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[1]The Ocean Cleanup

25 May 2022


MAERSK

METHODOLOGY

UAVS

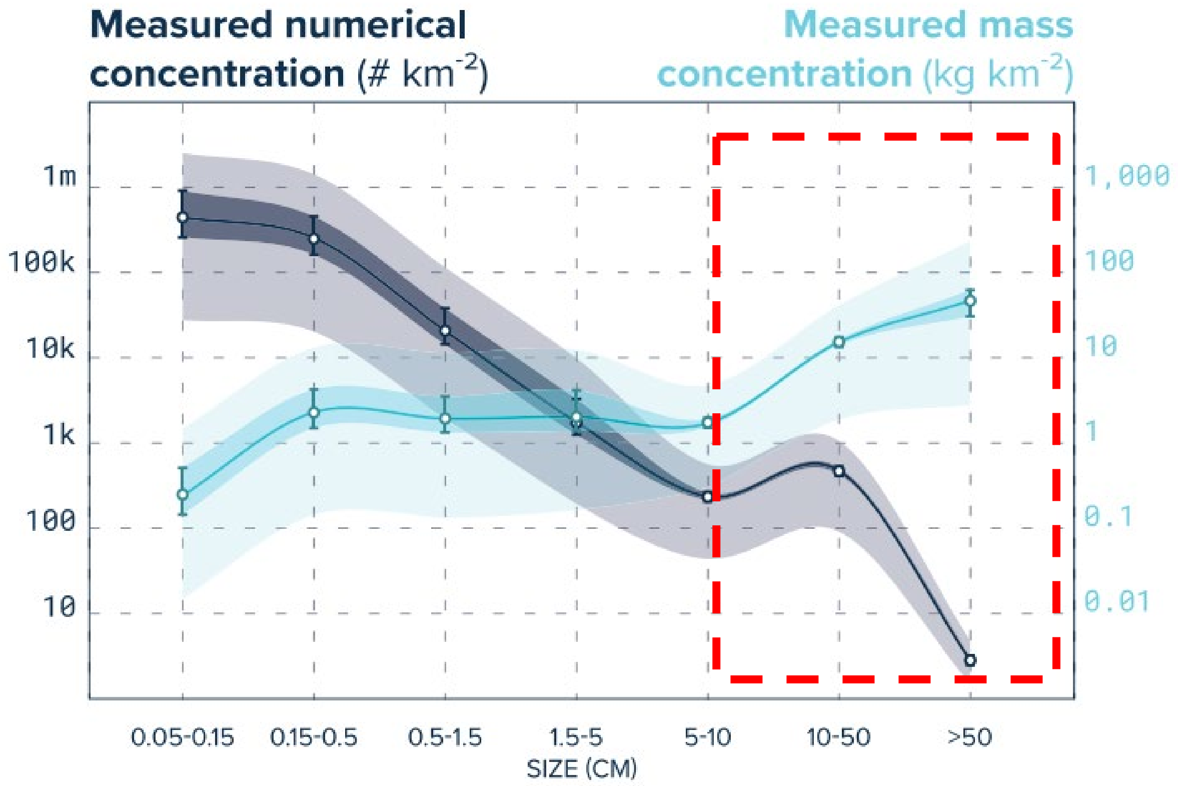
Timeframe:
July – August 2021

UAV:
Aeromapper Talon Amphibious

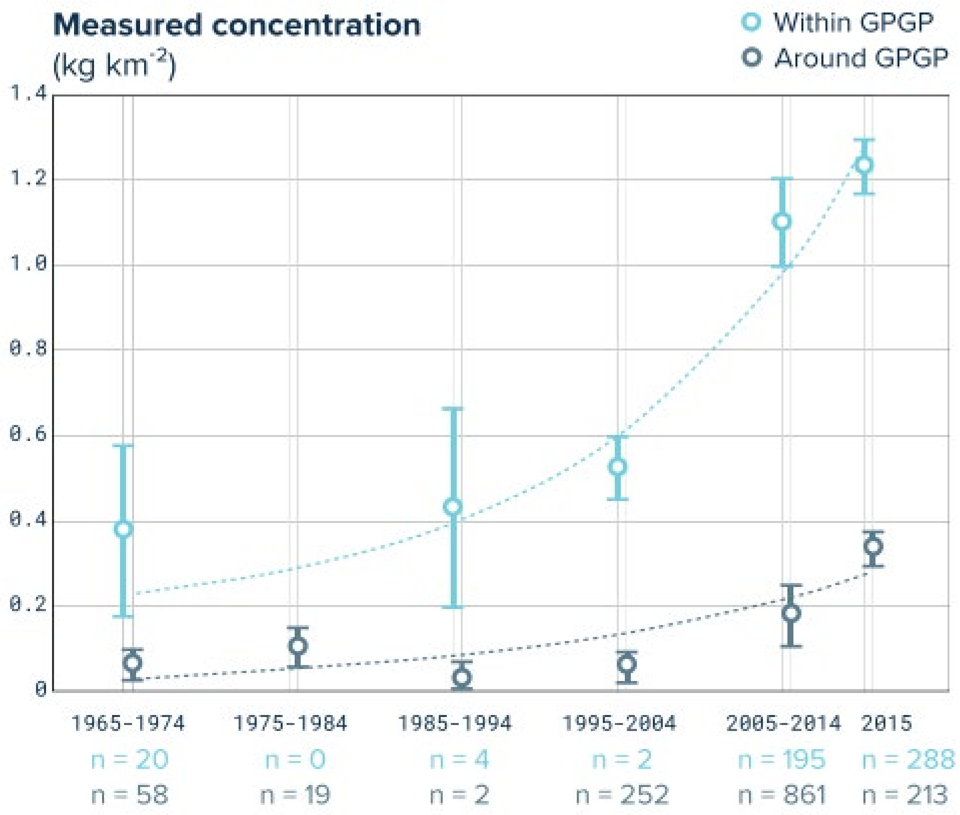
Operator:
Oceans Unmanned

Wingspan:	2m
Weight:	3600g
Cruise Speed:	62km/h
Maximum Speed:	85km/h
Range:	>30 km
Endurance:	Two hours
Maximum Altitude:	4,500m asl

REPETITIVE MEASUREMENTS ARE NECESSARY



Lebreton, L., Slat, B., Ferrari, F. et al. ***Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic.*** *Sci Rep* ***8,*** *4666 (2018). https://doi.org/10.1038/s41598-018-22939-w*



OCEAN PLASTICS AND INDIVIDUAL MACROPLASTICS (>50 CM)

Lebreton, L., Slat, B., Ferrari, F. et al. ***Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic.*** *Sci Rep* ***8****, 4666 (2018). https://doi.org/10.1038/s41598-018-22939-w*

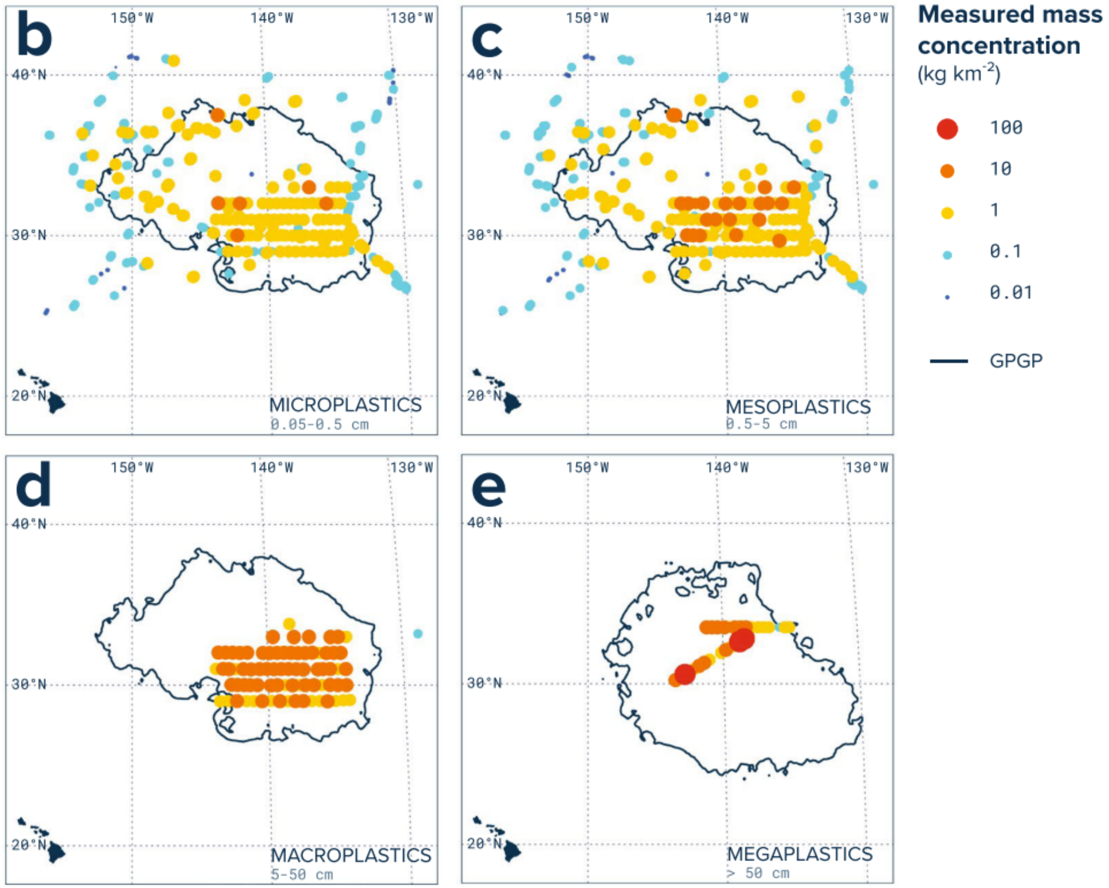
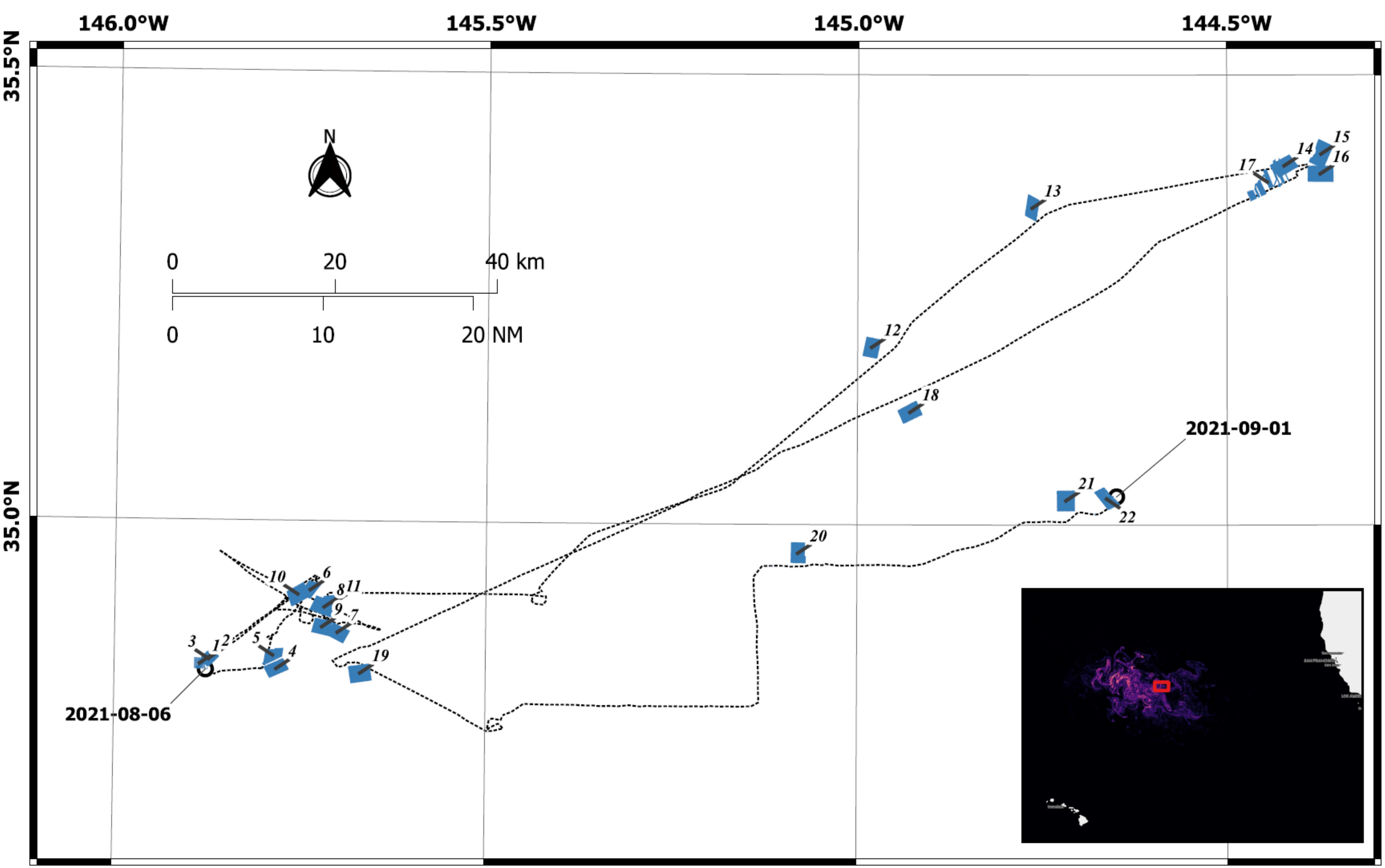


Figure 3. Modelled and measured mass concentration in the Great Pacific Garbage Patch (GPGP). (**a**) Ocean plastic mass concentrations for August 2015, as predicted by our data-calibrated model. The bold black line represents our established limit for the GPGP. (**b**) Microplastics (0.05–0.5 cm) mass concentrations as measured by Manta trawl ($n = 501$ net tows, 3.8 km^2 surveyed). (**c**) Mesoplastics (0.5–5 cm) mass concentrations as measured by Manta trawl; d) Macroplastics (5–50 cm) mass concentrations as measured by Mega trawl ($n = 151$ net tows, 13.6 km^2 surveyed); (**e**) Megaplastics (>50 cm) mass concentrations as estimated from aerial imagery ($n = 31$ mosaic segments, 311.0 km^2 surveyed). All observational maps are showing mid-point mass concentration estimates as well as the predicted GPGP boundaries for the corresponding sampling period: August 2015 for net tow samples, and October 2016 for aerial mosaics. Maps were created using QGIS version 2.18.1 (www.qgis.org).

METHODOLOGY

UAV CAMPAIGN SPATIAL OVERVIEW

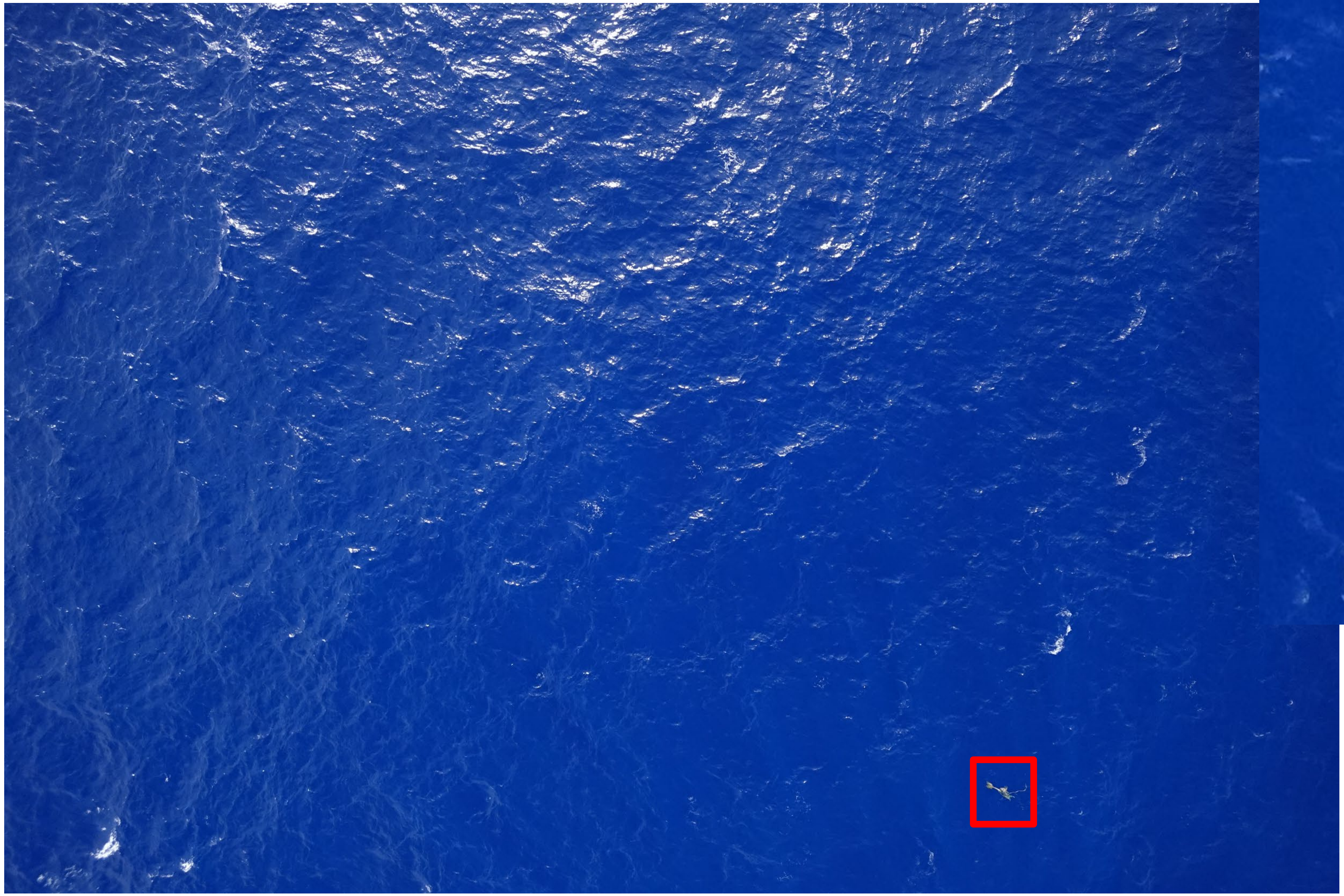


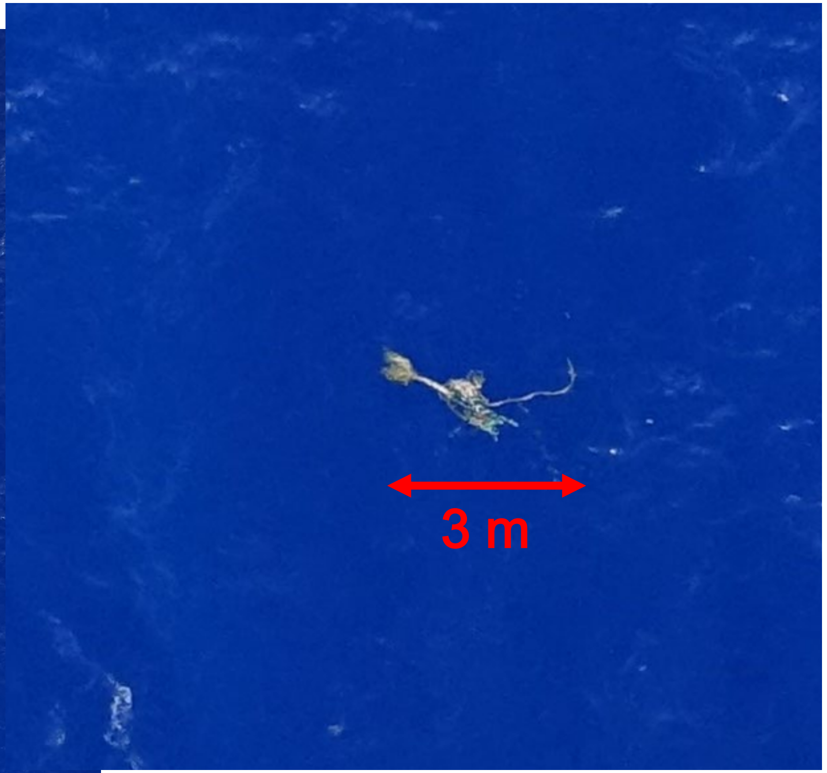
Legend
- Flights
- Start/End Point
- System Track

System 002 Trip 1,
Overview of Trajectory and Fixed-Wing UAV campaign flights

12 October 2021
The Ocean Cleanup

THE VIEW FROM ABOVE (80 M)

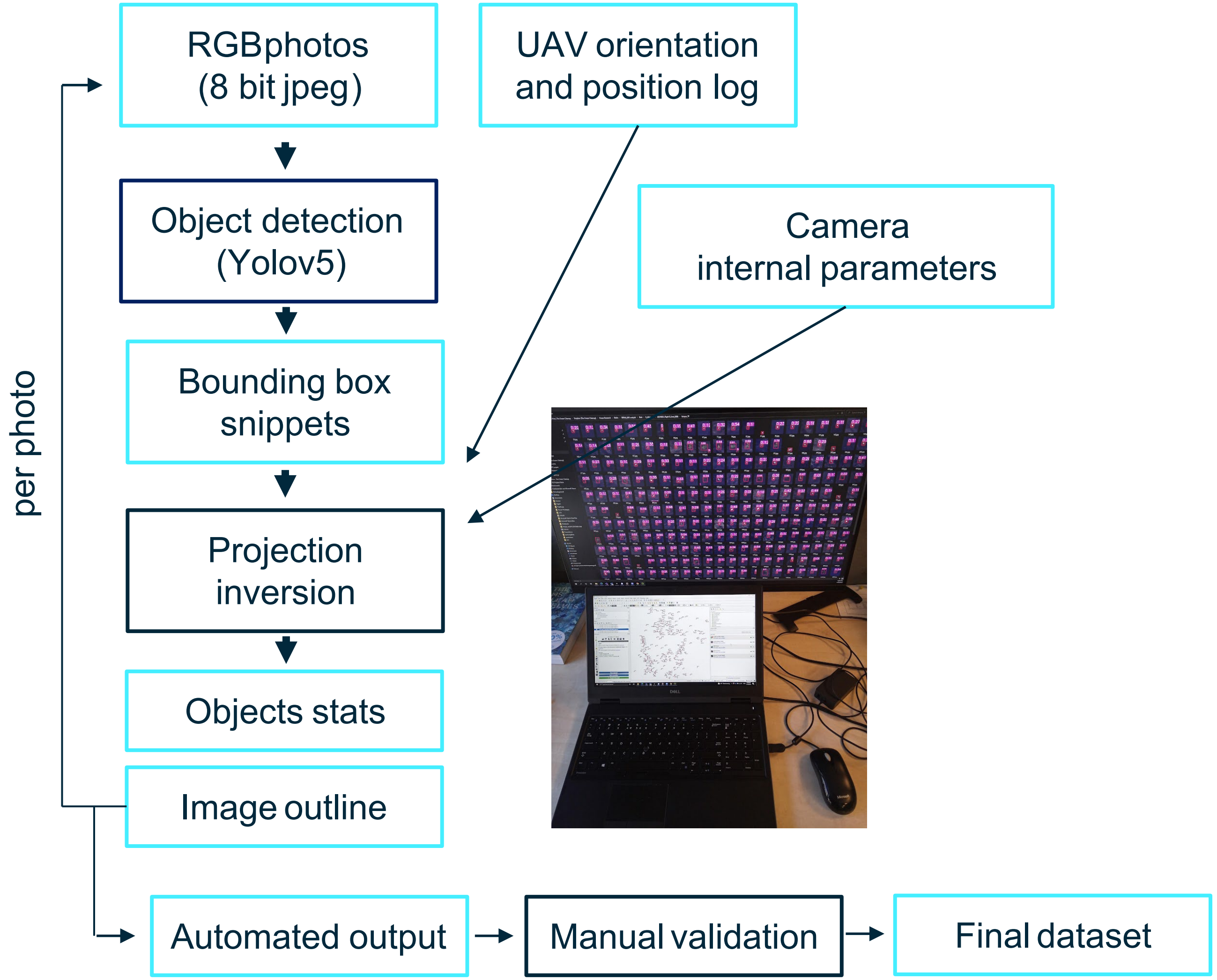




Sony RX0
4800 x 3200 pixels

PROCESSING

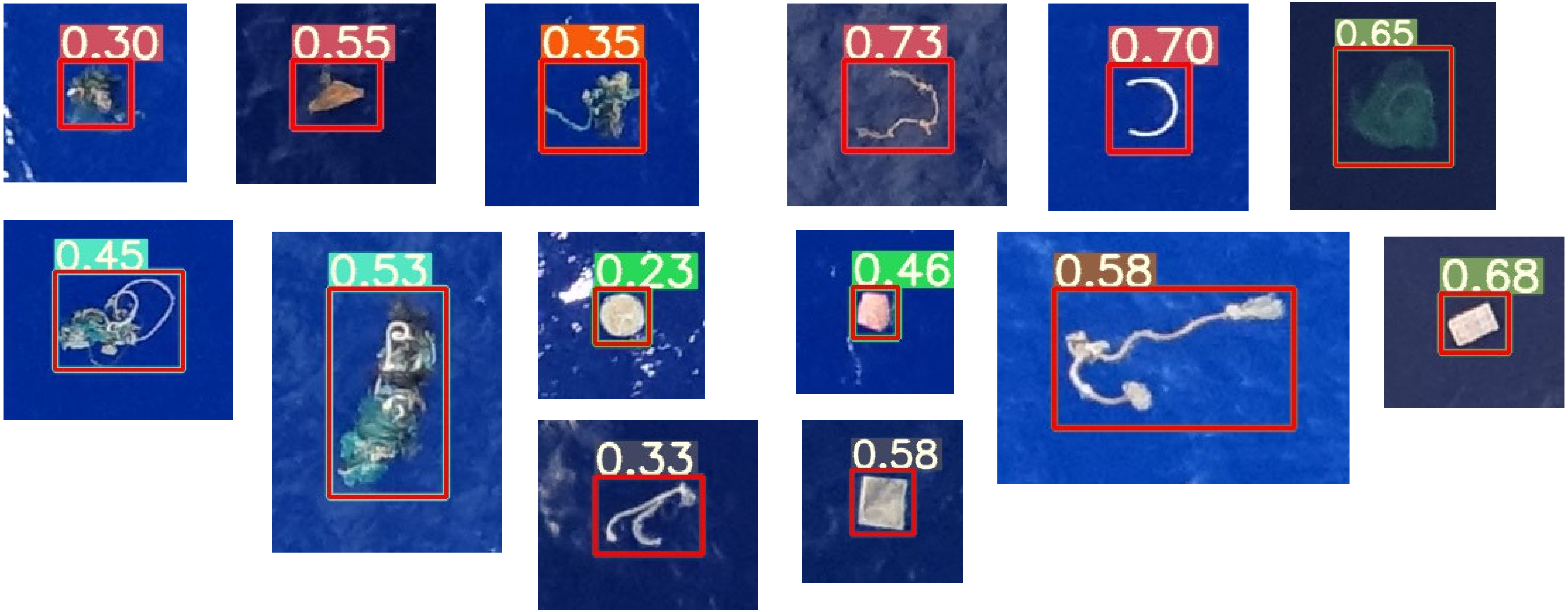
Real flightduration: 60 minutes



N

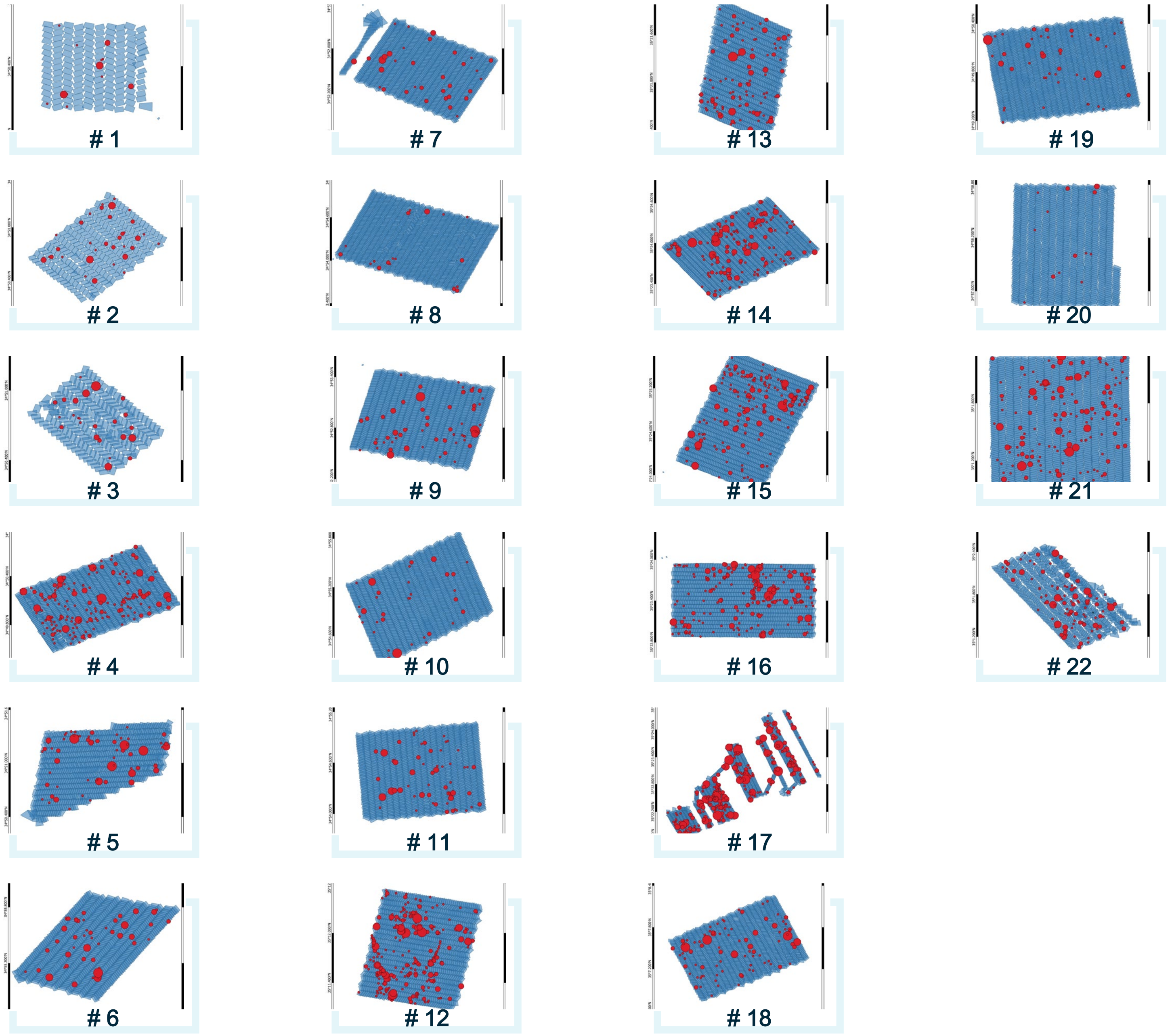
1 km

EXAMPLES OF OBJECTS

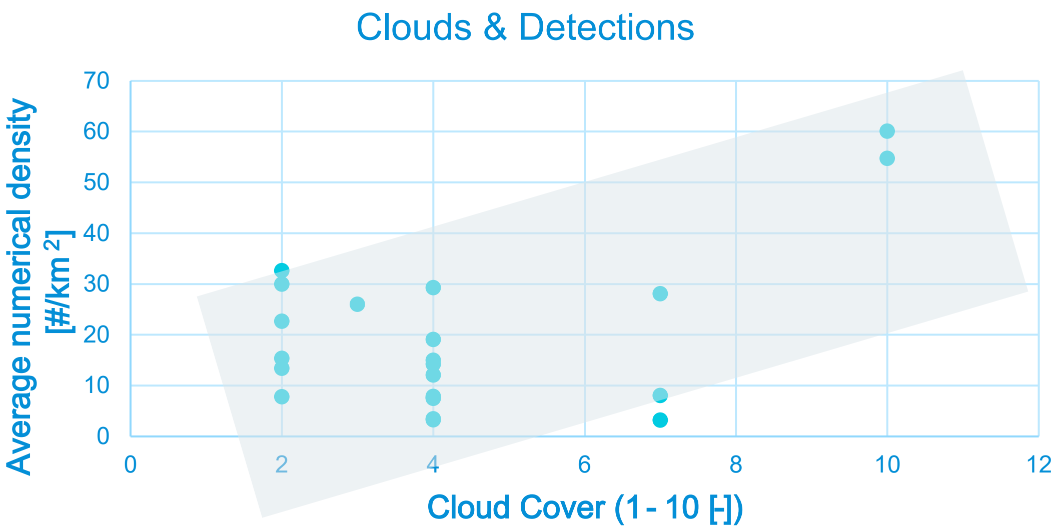


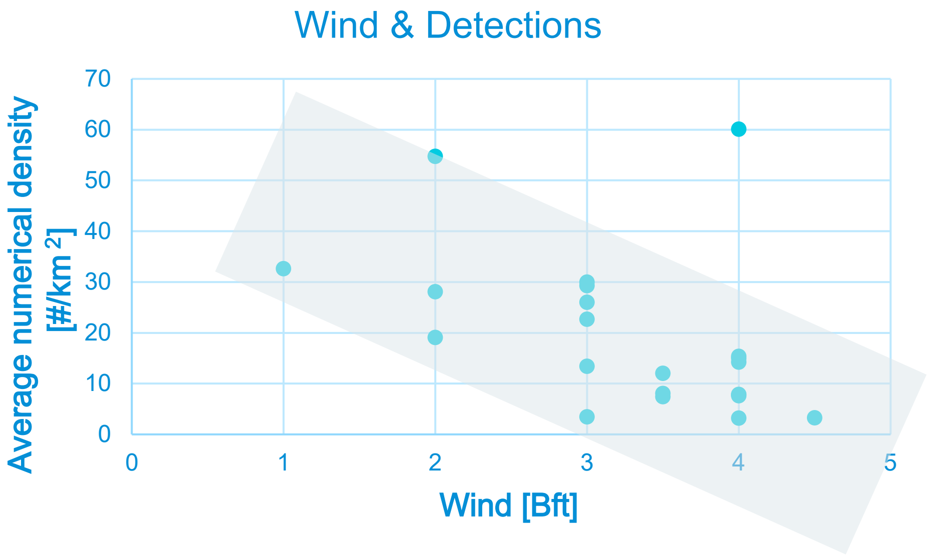
RESULTS

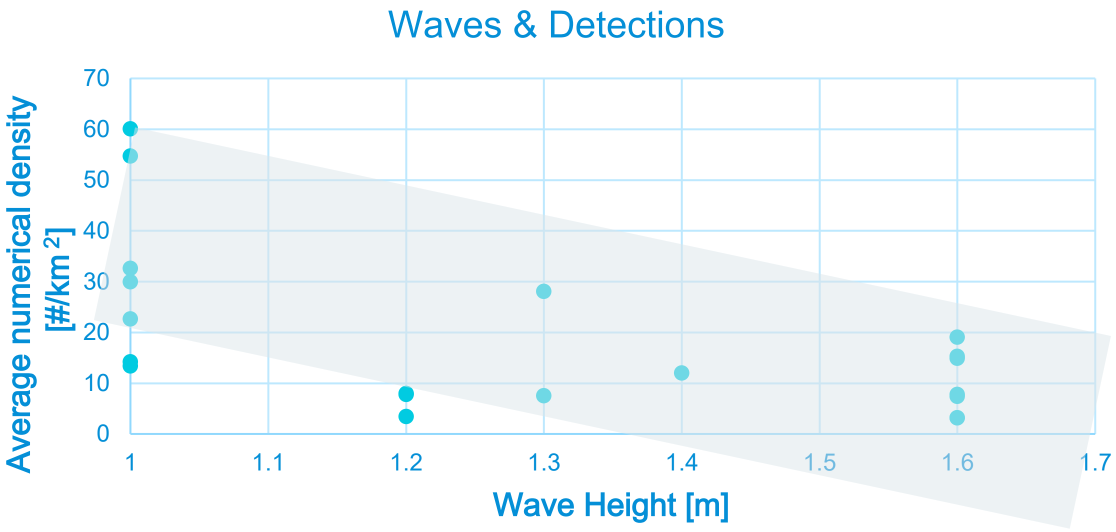
Number of flights	**22 flights**
Total airtime	**26.85 hours**
Photos taken	**21,185**
Total area scanned	**95 km^2**
# of plastic >50 cm	**1,839**
Minimum background Concentration	**3 #km^2**
Maximum background Concentration	**60 #/km^2**



WEATHER

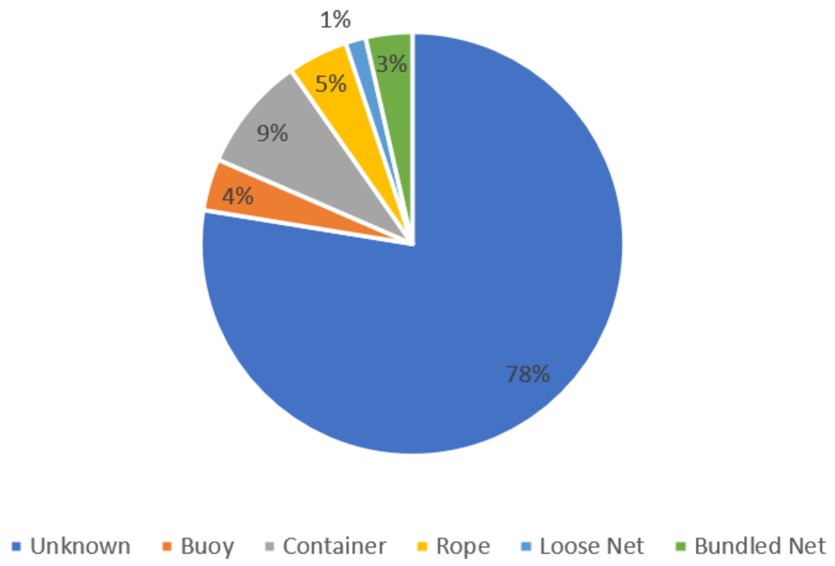

Clouds & Detections
Average numerical density [#/km 2]
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
Cloud Cover (1 - 10 [-])

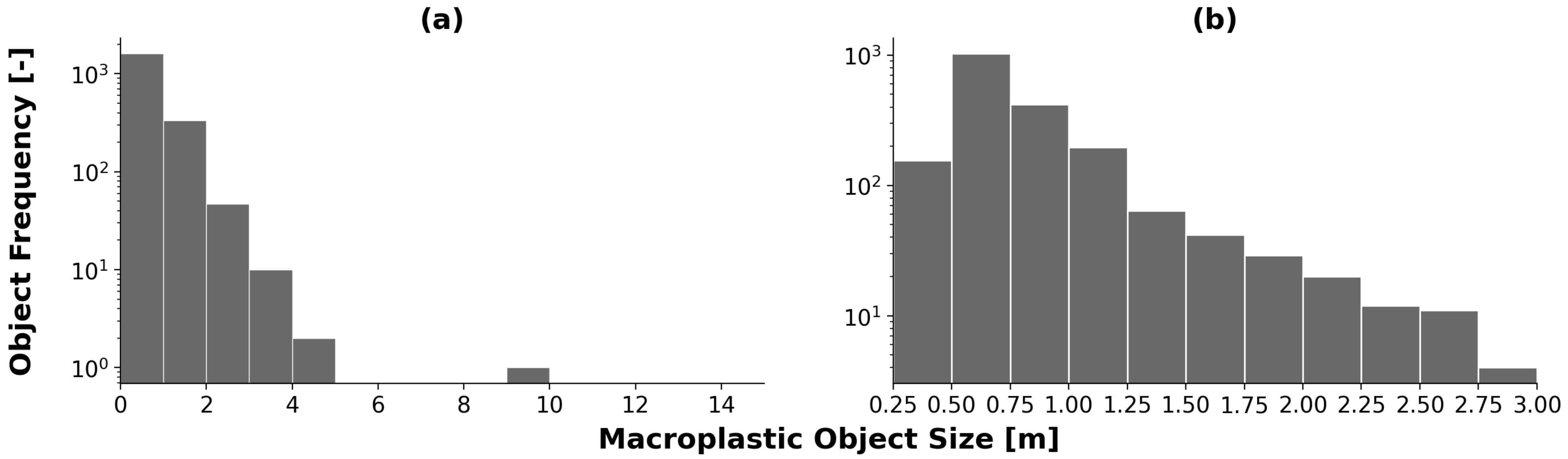

Wind & Detections
Average numerical density [#/km 2]
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Wind [Bft]


Waves & Detections
Average numerical density [#/km 2]
70
60
50
40
30
20
10
0
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
Wave Height [m]

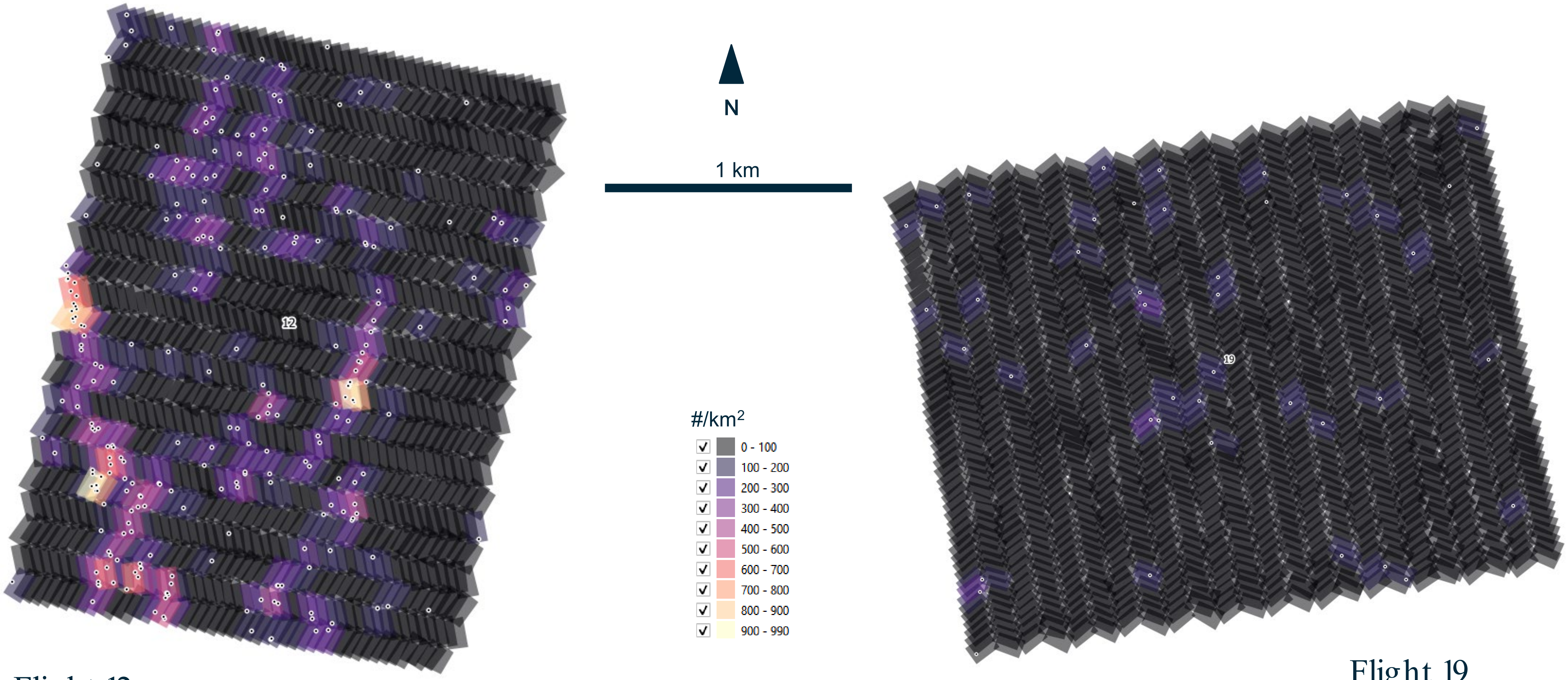
OBJECT SIZES AND CLASSES

Category	# [-]
Unknown	1549
Buoy	79
Container	175
Rope	92
Loose Net	31
Bundled Net	71





SPATIAL HETEROGENEITY (CLUSTERING)



Flight 12

Flight 19

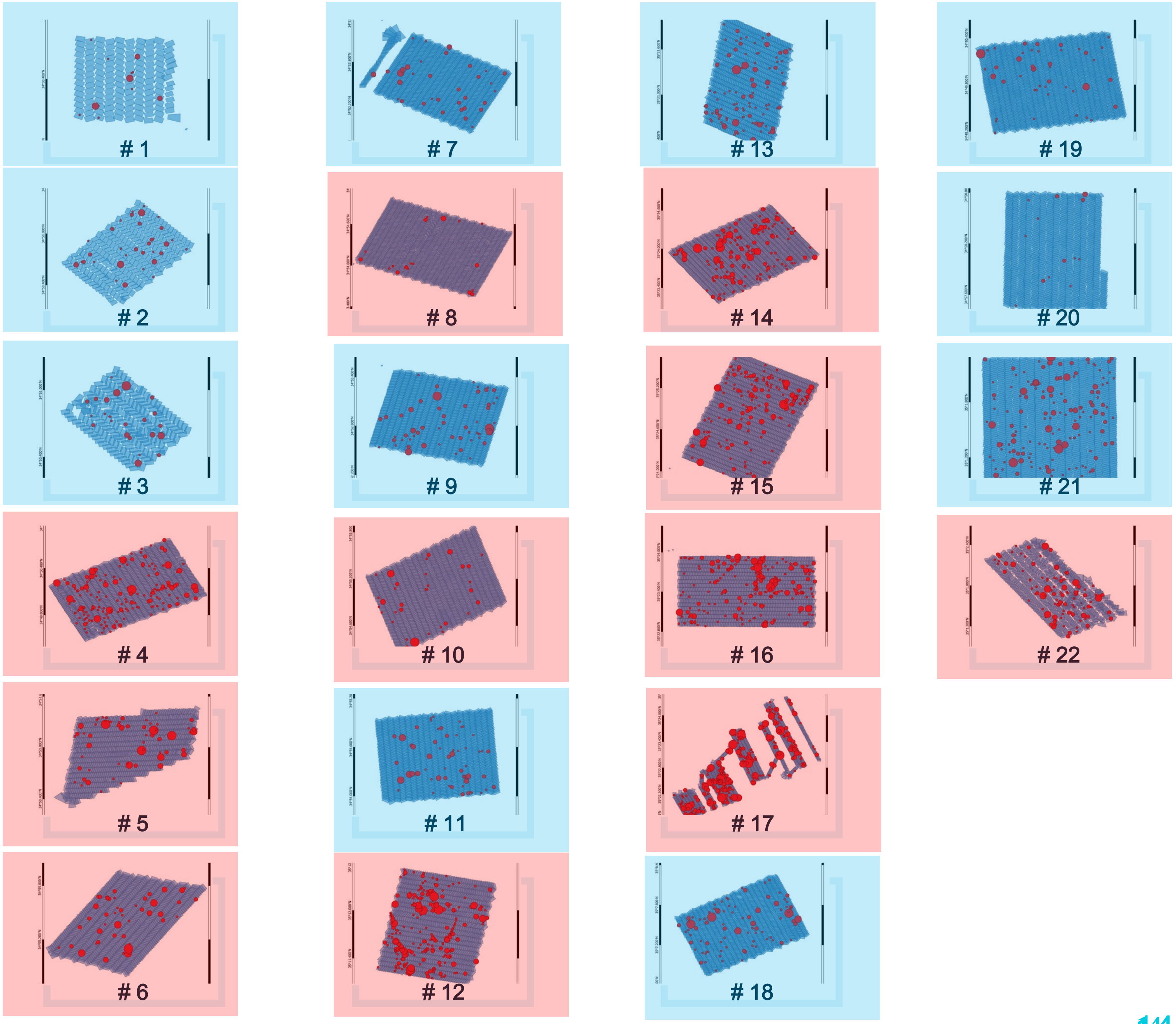
RESULTS

STATISTICAL TESTING FOR CLUSTERS

H_0: There is no cluster present in this flight. Objects are distributed randomly.

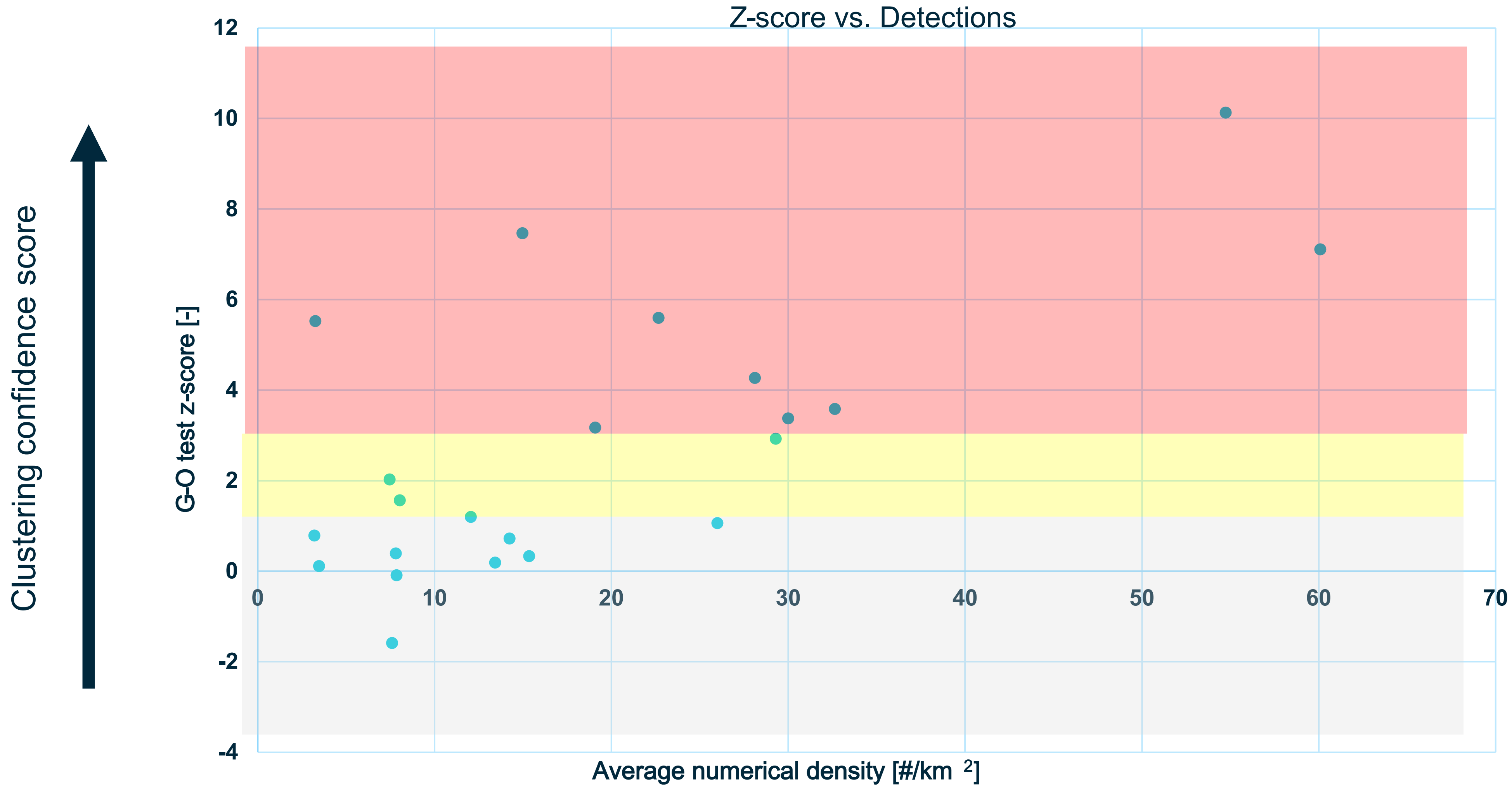
H_0 not rejected

H_0 rejected ($p < 0.05$)



Getis, Arthur, and J. K. Ord. "The Analysis of Spatial Association by Use of Distance Statistics." *Geographical Analysis* 24, no. 3. 1992.
Mitchell, Andy. *The ESRI Guide to GIS Analysis*, Volume 2. ESRI Press, 2005.

PER FLIGHT: TEST SCORES



CONCLUSIONS & PERSPECTIVE

Conclusions

- Successful tests of amphibious fixed-wing UAVs in the North Pacific Ocean.
- Revealing microscale spatial variability of megaplastic (>50 cm).
- New local extremes of megaplastic (>50 cm)numerical concentration.
- High concentrations coincide with presence of spatial clusters.

Perspective

- Refinement of method: object sizes, false positives, processing speed.
- Deeper study of accumulation patterns and comparison to other.
- Renewed applications for studying microscale accumulation of marine plastic litter.

THE OCEAN™ CLEANUP

Feel free to reach out if you have any tips or further questions!

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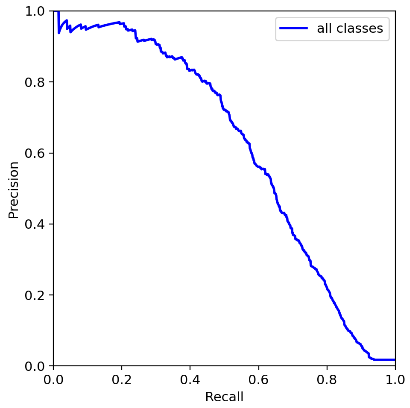
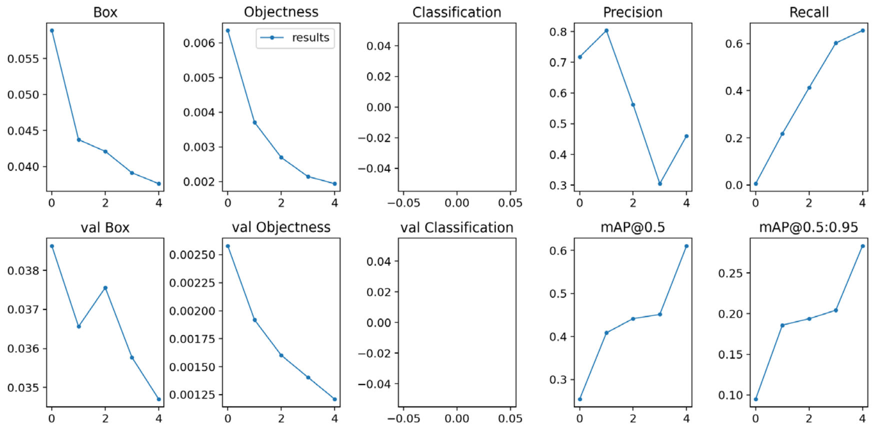
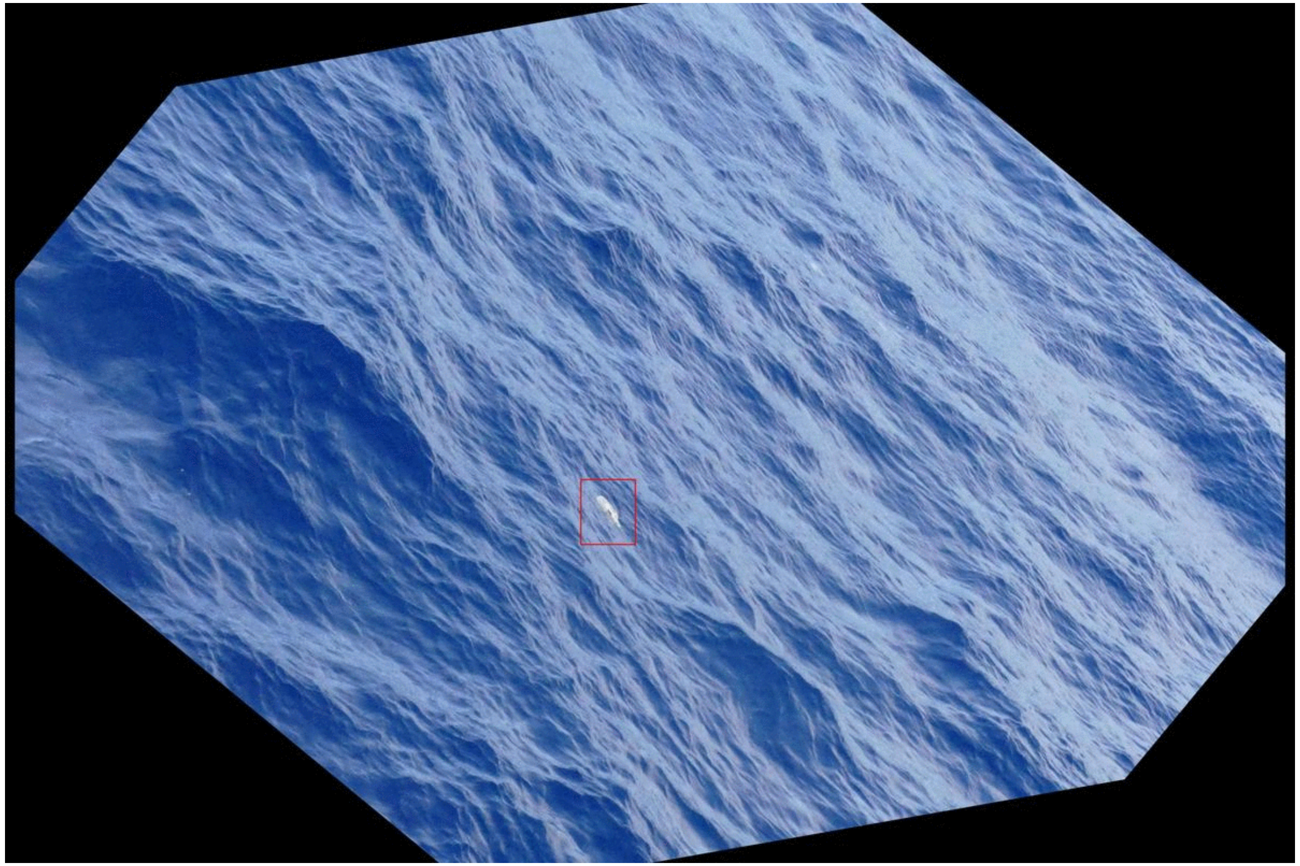
theoceancleanup.com

YOLOV5 OBJECT DETECTION: TRAINING AND PERFORMANCE







Data augmentation: generating synthetic data by rotating, skewing, shifting, etc.

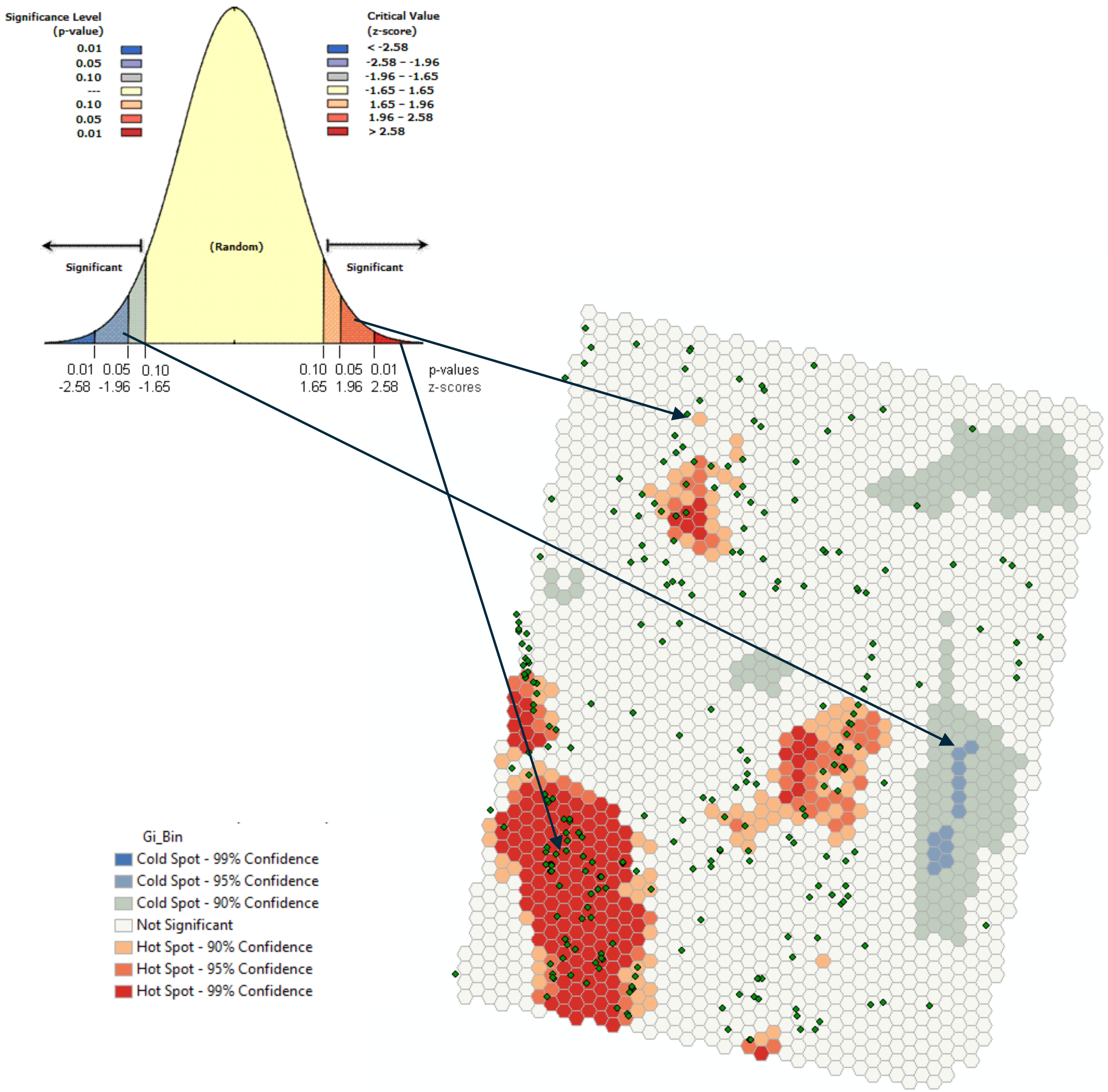
Training set: **18,589 images**

Training: prevent overfitting by limiting the number of training steps

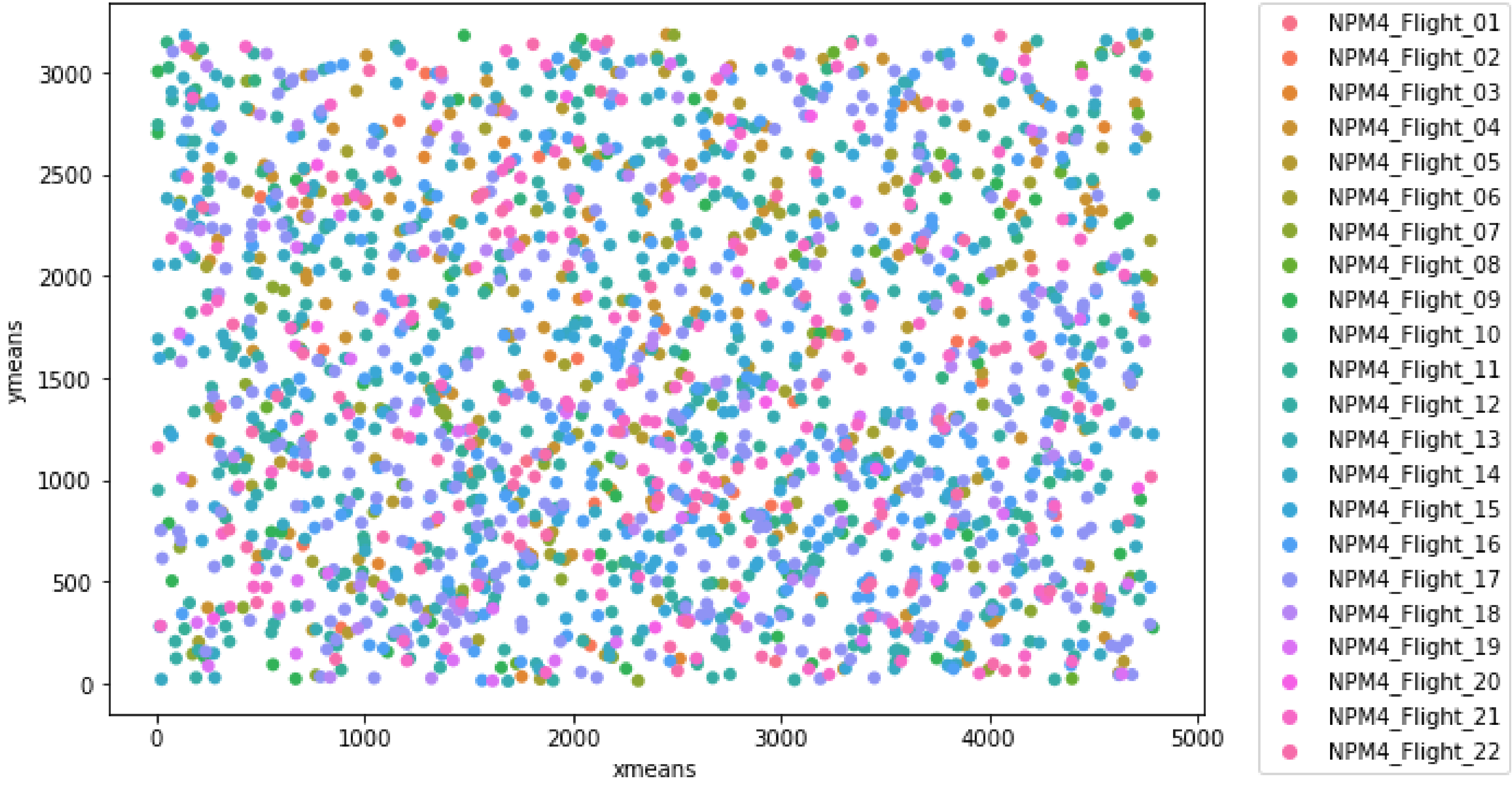
CLUSTERS
ANALYSIS

Hex bins, 50 m cell size, 250 m search window.

308 cells with 99% hotspot confidence.

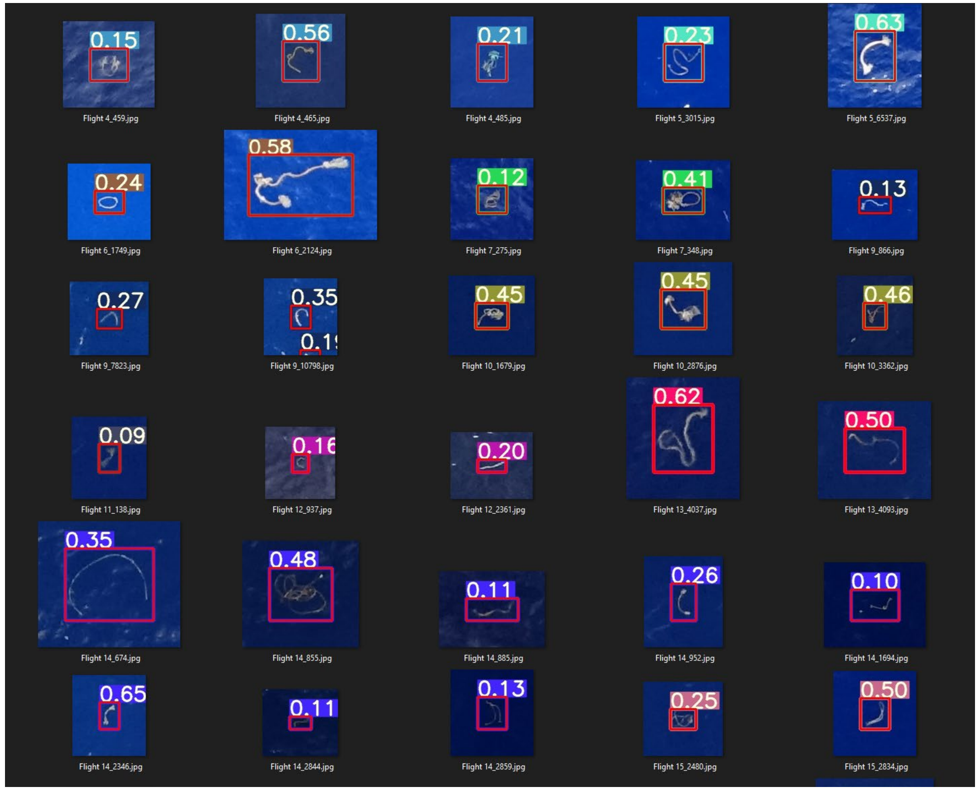


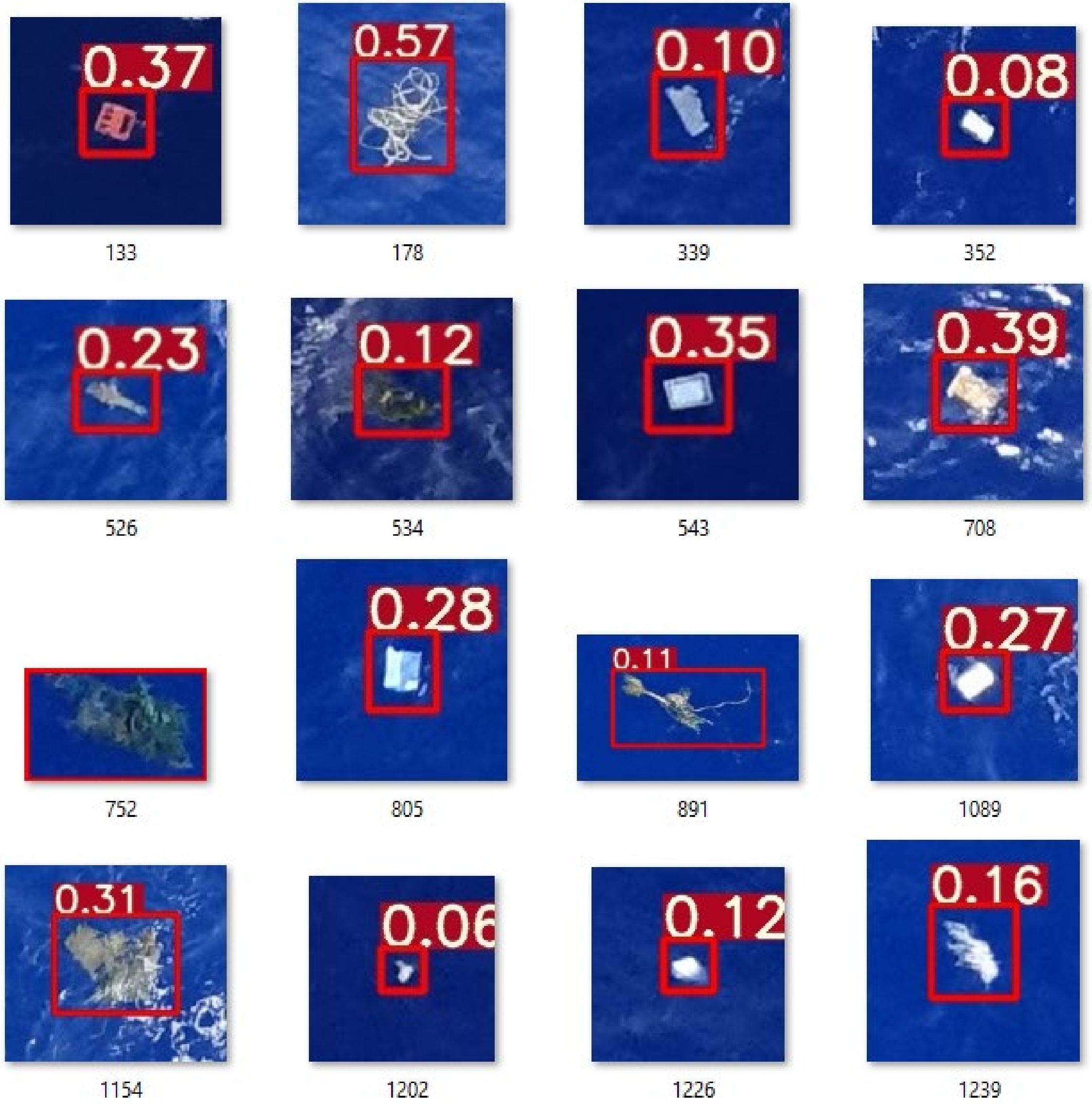
OBJECT DETECTION POSITIONS WITHIN IMAGE FRAME



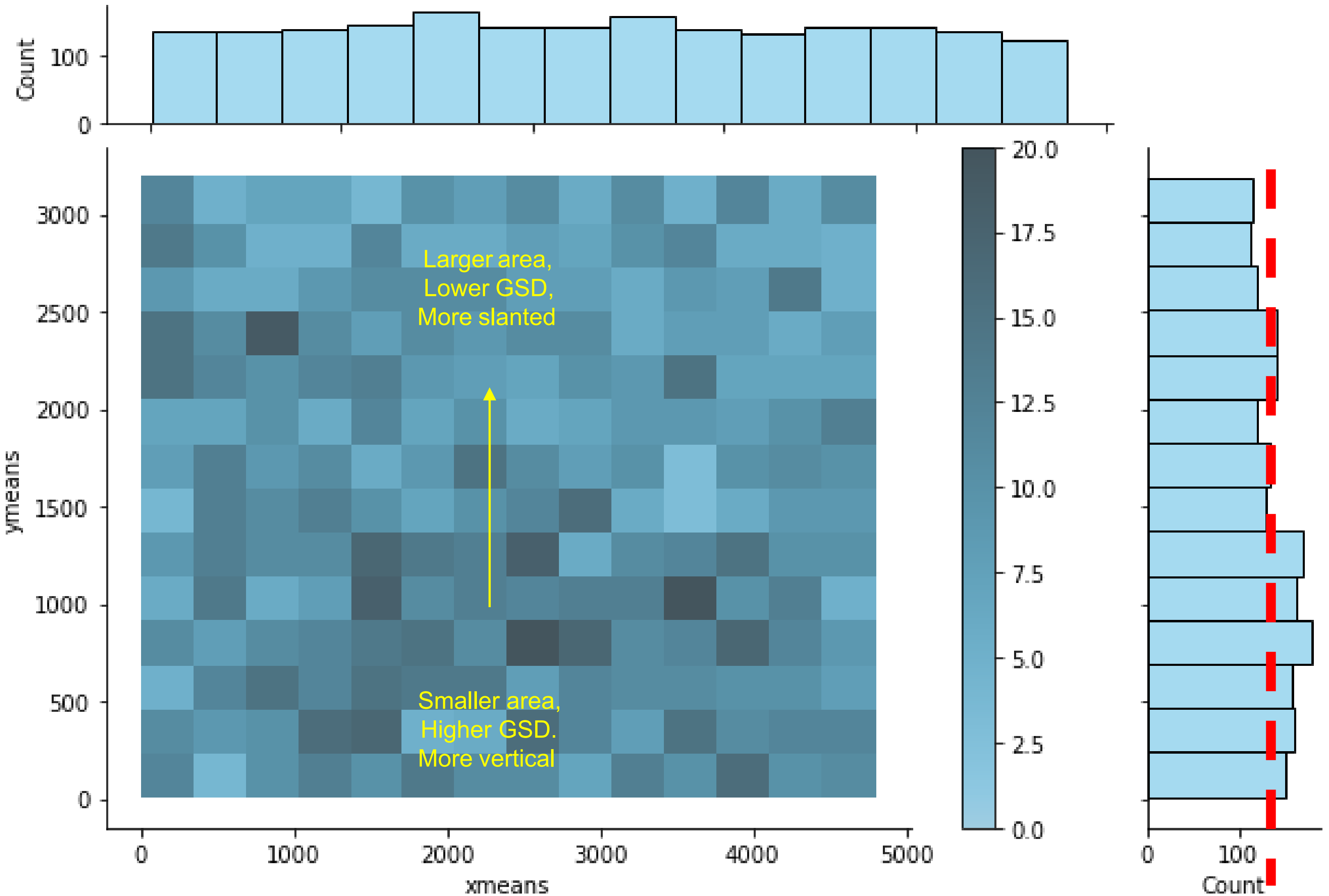
AI FOR MASS-PROCESSING

Robin de Vries, Matthias Egger, Thomas Mani, and Laurent Lebreton. 2021. ***Quantifying Floating Plastic Debris at Sea Using Vessel-Based Optical Data and Artificial Intelligence"*** *Remote Sensing13, no. 17: 3401. https://doi.org/10.3390/rs13173401*





IMAGEBLUR, DOES IT AFFECT DETECTIONS AROUND CORNERS?



OBJECT DETECTION POSITIONS WITHIN IMAGE FRAME VARY BY ~10%