



12 a 14 de dezembro de 2023

5.º ENCONTRO NACIONAL DE
LIMPEZA URBANA
& URBAN CLEANING EXPO

AUTÓDROMO DO ESTORIL, ESTORIL | CASCAIS

LIMPEZA URBANA AO SERVIÇO DAS PESSOAS E DOS TERRITÓRIOS

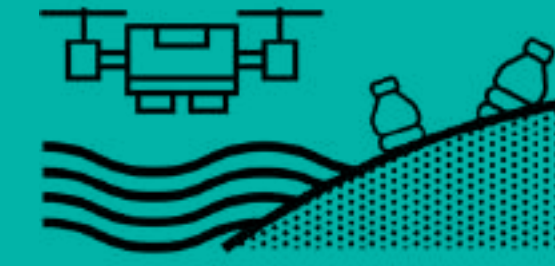


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CASCAIS
Tudo começa nas pessoas



UAS 4 Litter



Low-cost Unmanned
Aerial Systems for
marine litter coastal
mapping

Mapeamento de lixo marinho na zona costeira com drones: potencialidades para praias e dunas

mais limpas
Umberto Andriolo, INESC Coimbra
Gil Gonçalves, INESC Coimbra



INESC Coimbra
Instituto de Engenharia de Sistemas
e Computadores de Coimbra

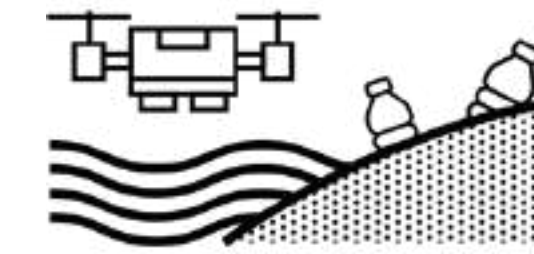


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Marine litter and traditional visual census

- Plastic and litter on coast, 80% is plastic
- Litter issue for human health, animals and ecosystems

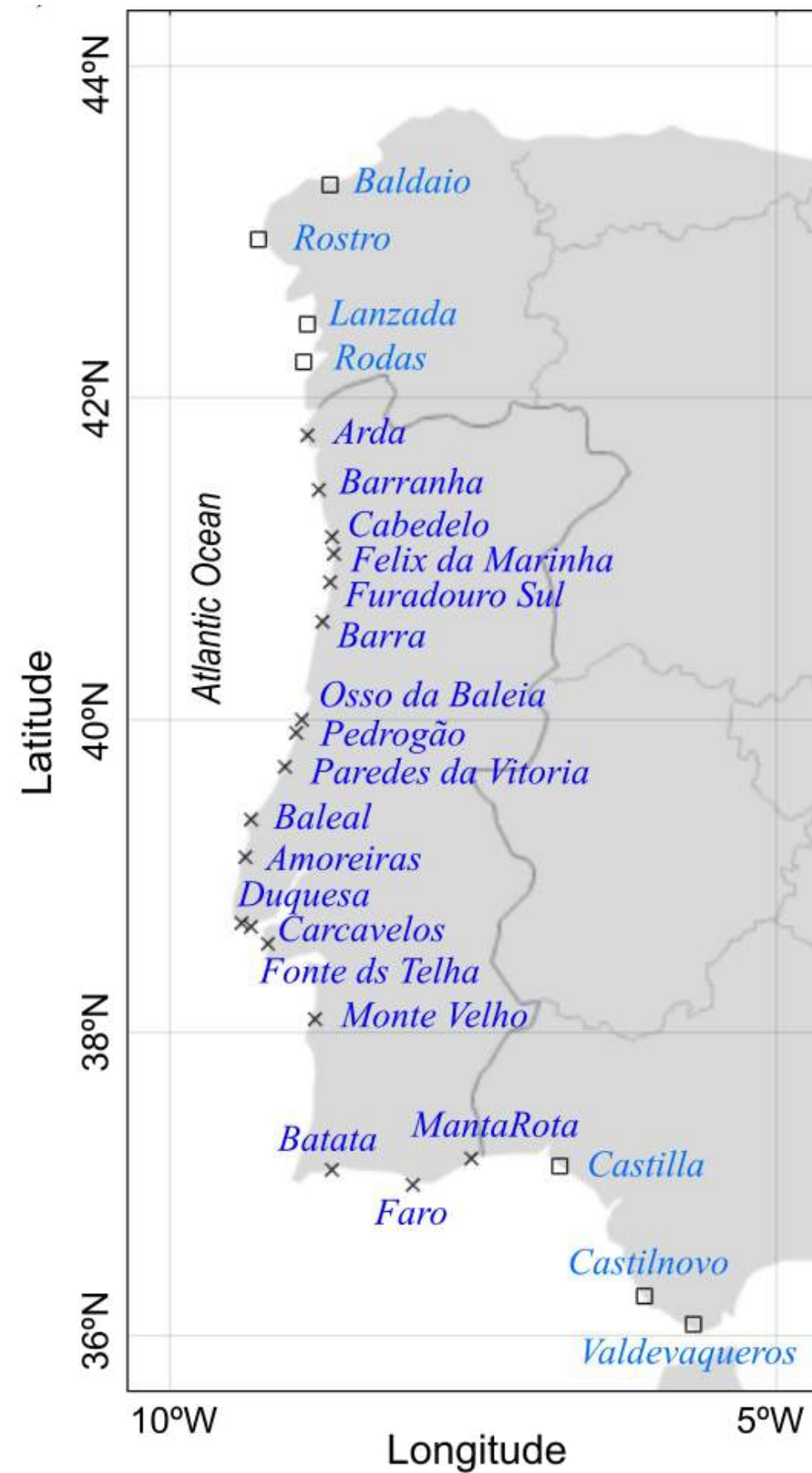
UAS 4 Litter



Low-cost Unmanned Aerial Systems for marine litter coastal mapping



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- OSPAR litter monitoring program
- Visual census
- 100 m sector
- 4 times a year (season) since 2010
- 18 beaches over about 950 km of coasts



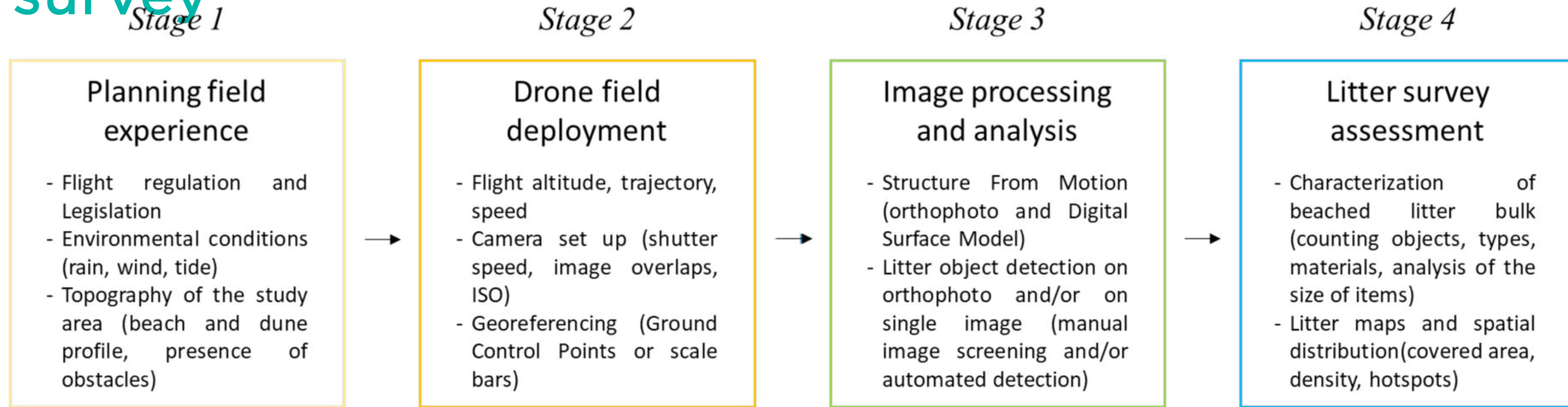
- Drone are relative low-cost
- Drones allow to collect high-resolution images
- Extensively used for multi-purpose in the marine environment
- Flights are fast and can cover a wide area
- The same flight path can be repeated with high frequency



Framework for drone-based litter survey



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Manual Image Screening



Machine Learning

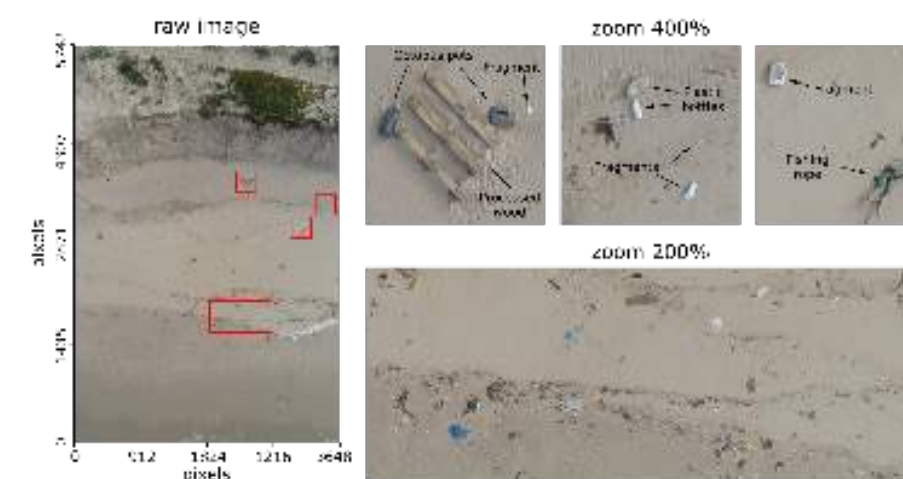
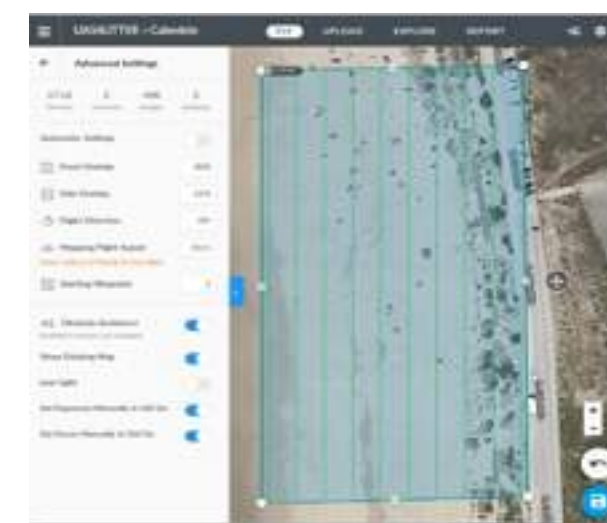
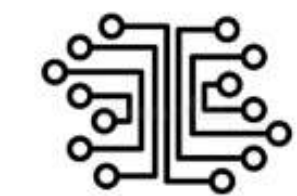
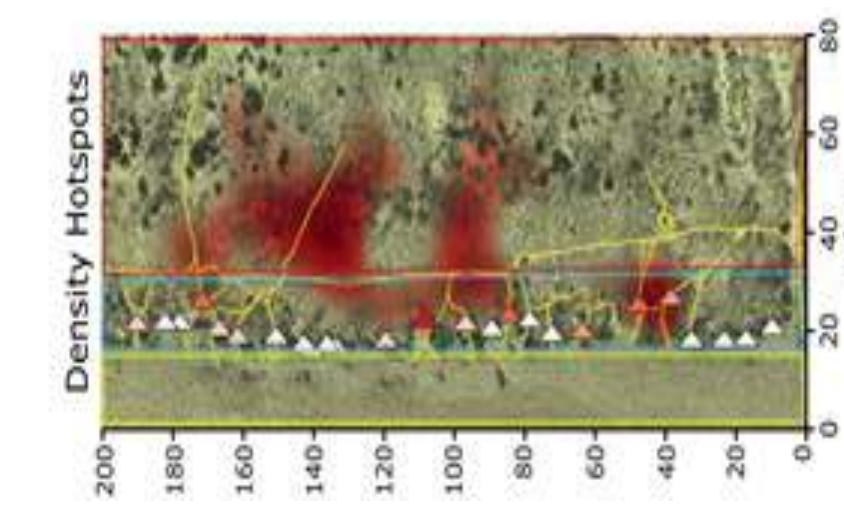


Table 1

Marine litter types, abundance and percentage for each flight (F1, F2 and F3).

Type	F1 10/12/2019		F2 11/03/2020		F3 18/03/2020		Average		TOTAL n
	n	%	n	%	n	%	n	%	
Plastic	139	17.5	249	45.0	112	30.9	166.7	31.2	500
Plastic bottles	47	5.9	73	13.2	12	3.3	44.0	7.5	132
Fishing ropes	71	9.0	88	15.9	24	6.6	61.0	10.5	183
Octopus pots	20	2.5	88	15.9	76	20.9	61.3	13.1	184
Wood	24	3.0	49	8.8	15	4.1	29.3	5.3	88
Processed wood									
Fragments (undefined)	630	79.5	256	46.2	236	65.0	374.0	63.6	1122
	792	100	554	100	363	100	569.67	100	1709



Framework for drone-based litter survey – Field campaign

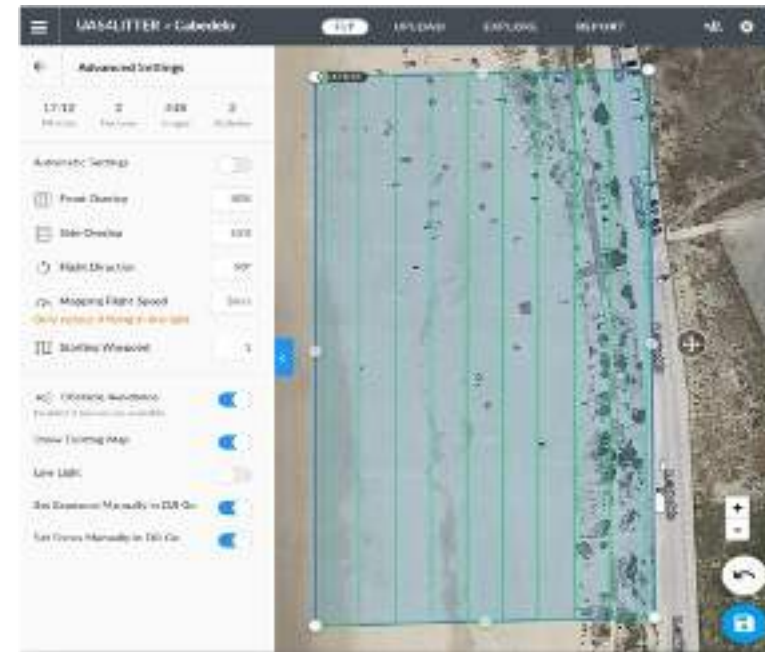


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Stage 1

Planning field experience

- Flight regulation and Legislation
- Environmental conditions (rain, wind, tide)
- Topography of the study area (beach and dune profile, presence of obstacles)



Ground Sampling Distance

$$GSD = \frac{H \cdot px}{f}$$

H = flight height
Px = pixel size (image)
f = focal length (camera)

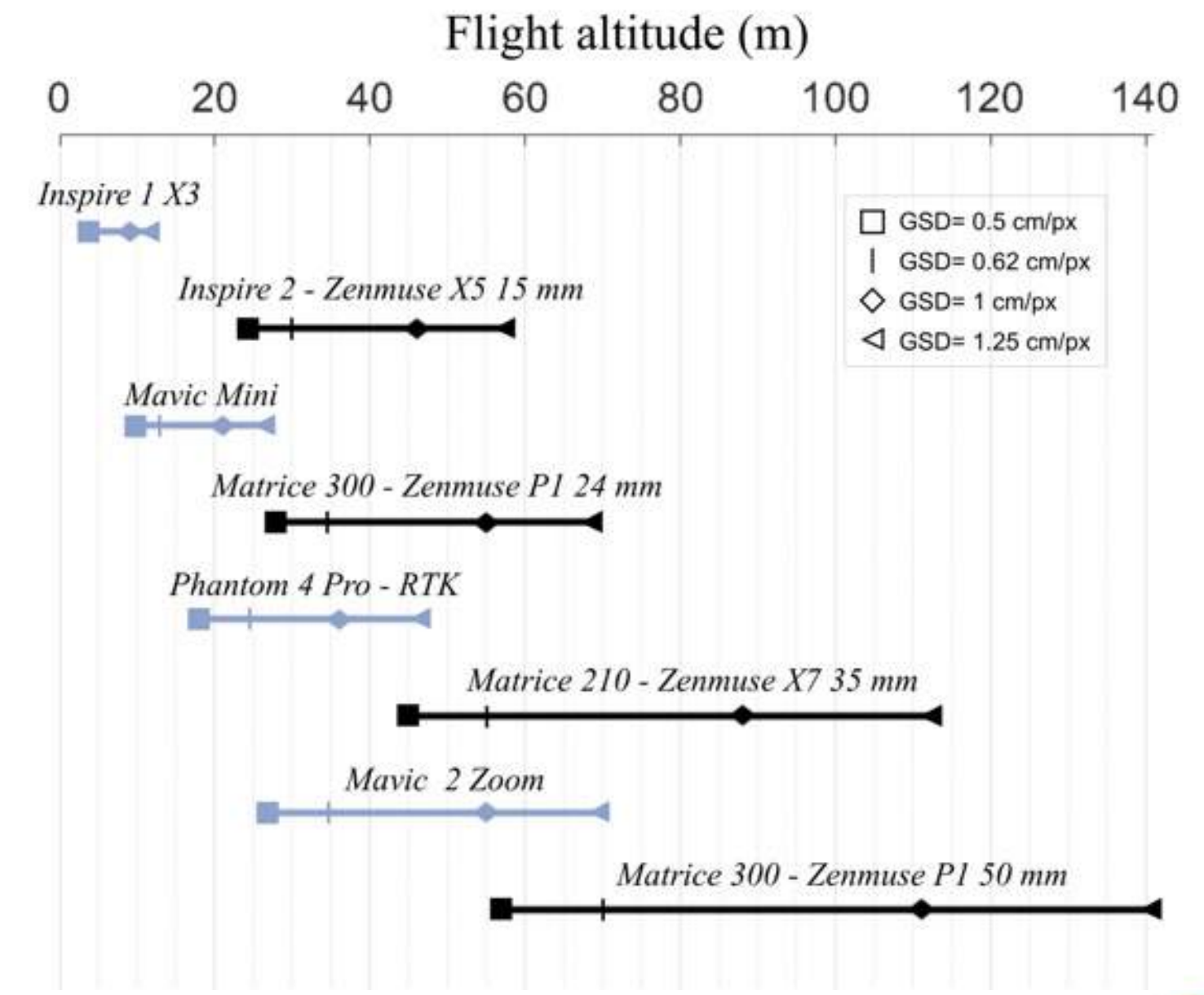
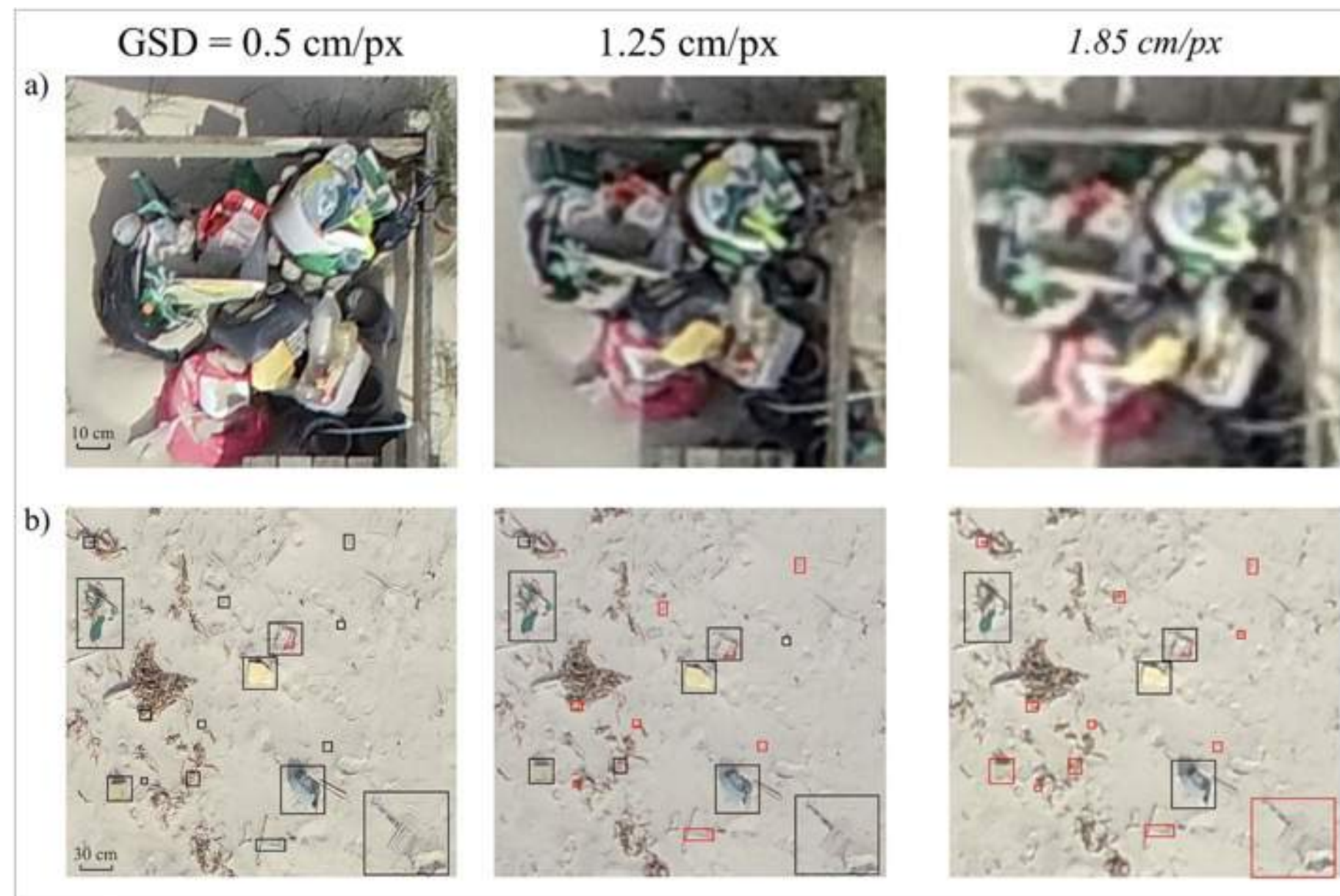
$0.5 \text{ cm/px} < GSD < 1.25 \text{ cm/px}$
for mapping marine
MACRO-LITTER (> 2,5 cm)



Stage 2

Drone field deployment

- Flight altitude, trajectory, speed
- Camera set up (shutter speed, image overlaps, ISO)
- Georeferencing (Ground Control Points or scale bars)



Framework for drone-based litter survey – Image analysis

Stage 3

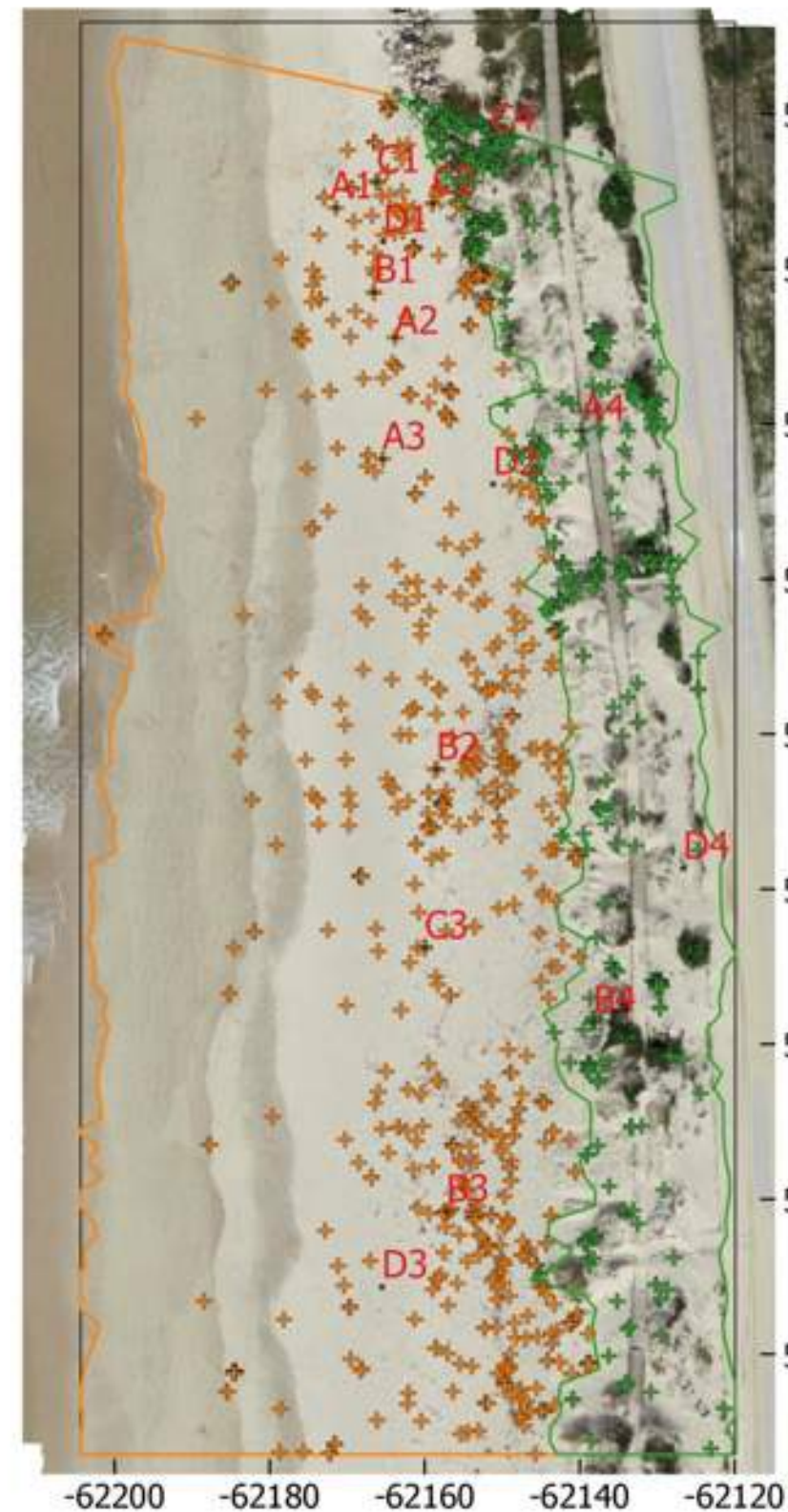
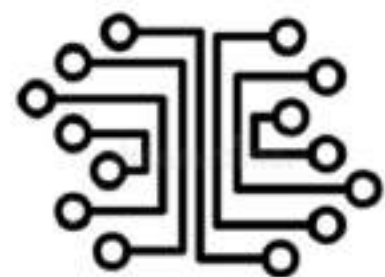
Image processing and analysis

- Structure From Motion (orthophoto and Digital Surface Model)
- Litter object detection on orthophoto and/or on single image (manual image screening and/or automated detection)

Manual Image Screening



Machine Learning



Legend

- + Litter on dune
- + Litter on beach
- Dune area
- Beach area
- Map Area



Framework for drone-based litter survey - Image analysis

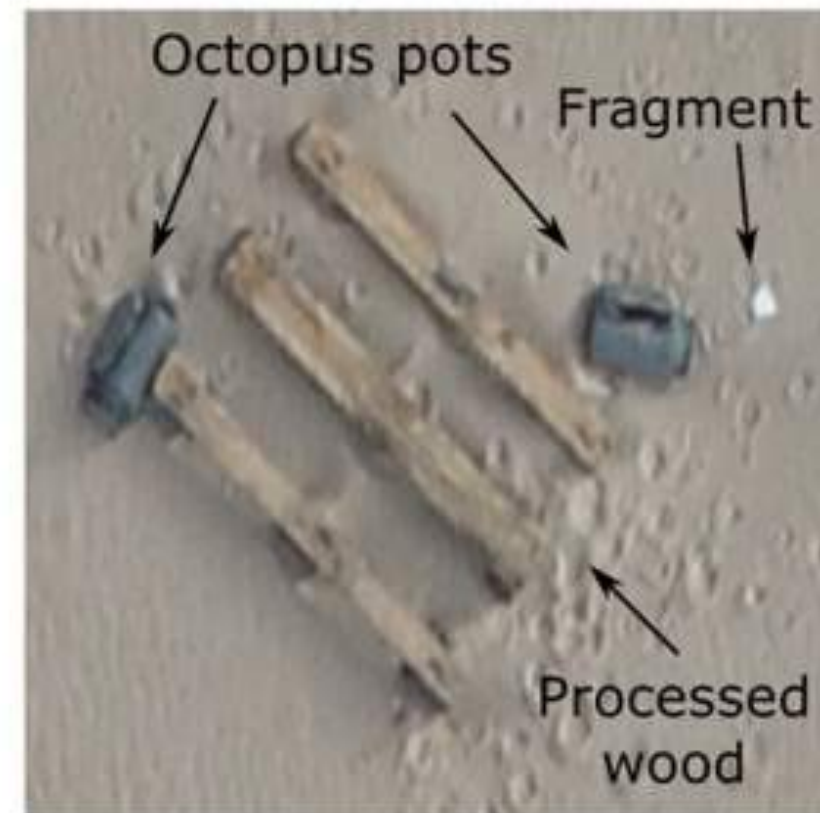


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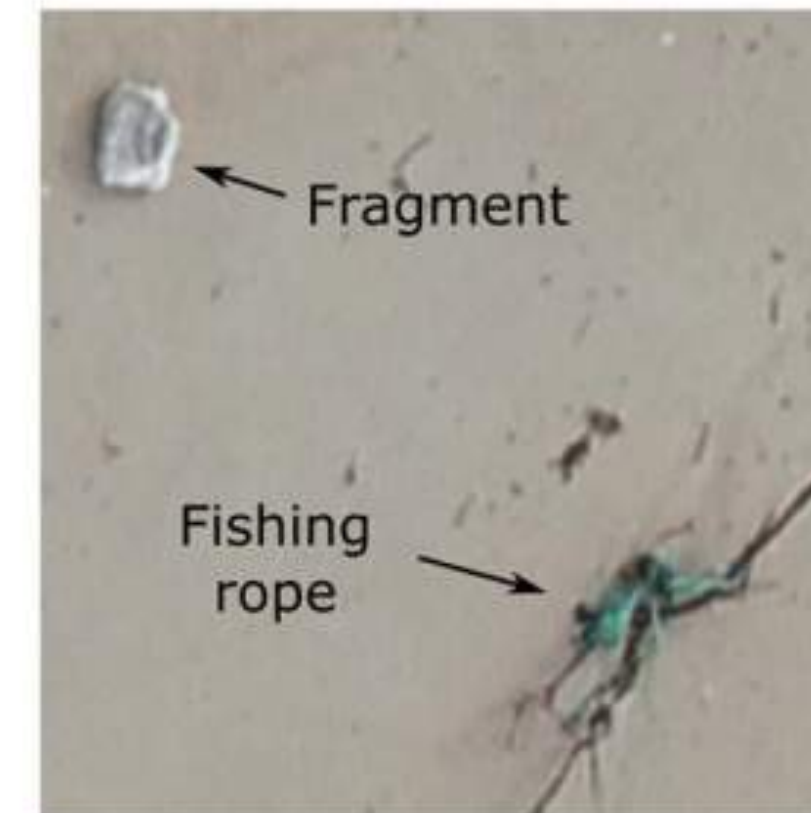
Stage 3

Image processing and analysis

- Structure From Motion (orthophoto and Digital Surface Model)
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zoom 400%



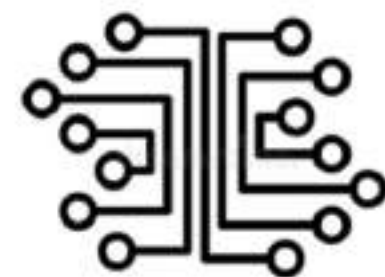
Manual Image Screening



zoom 200%



Machine Learning



Framework for drone-based litter survey - Image analysis

Stage 3

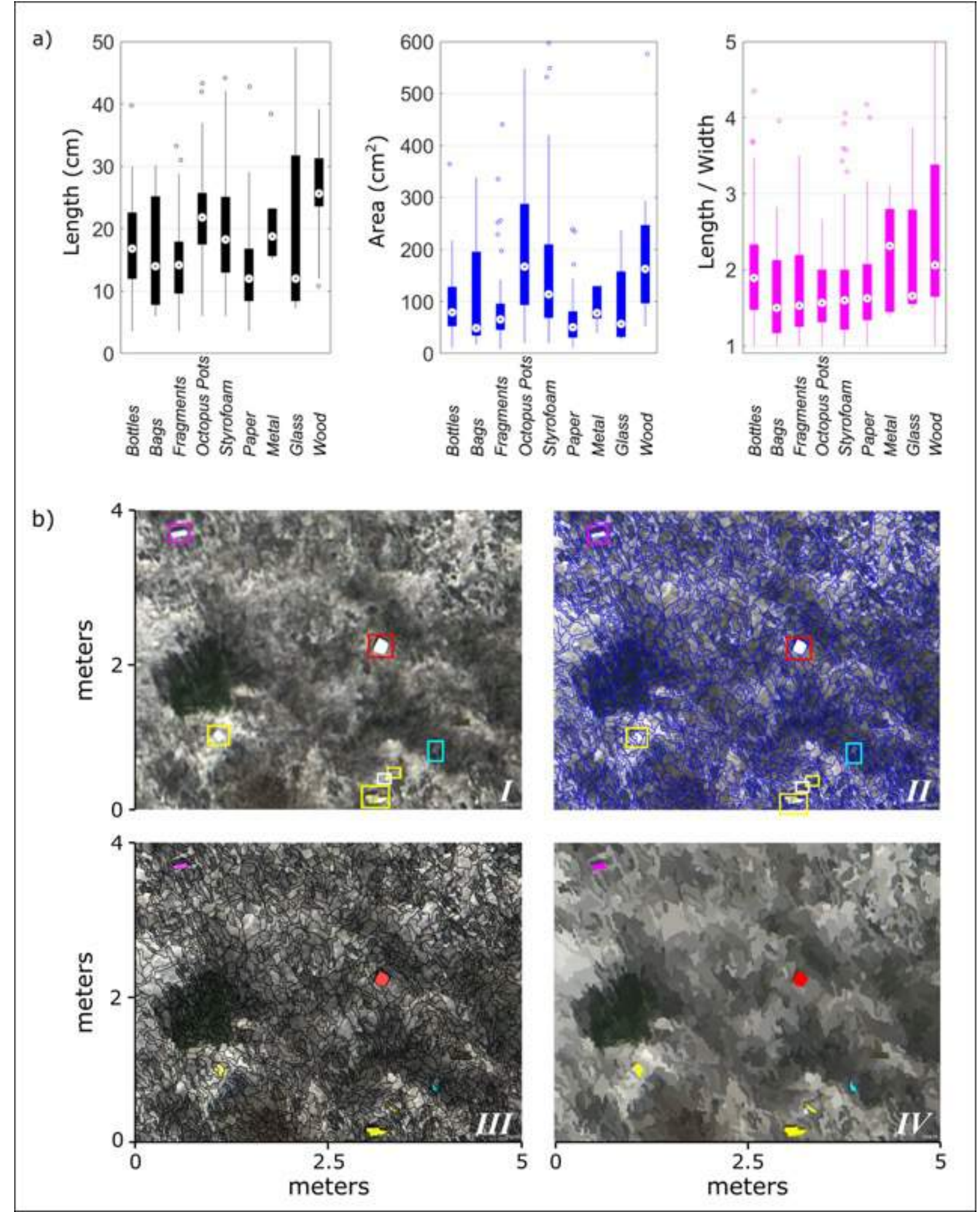
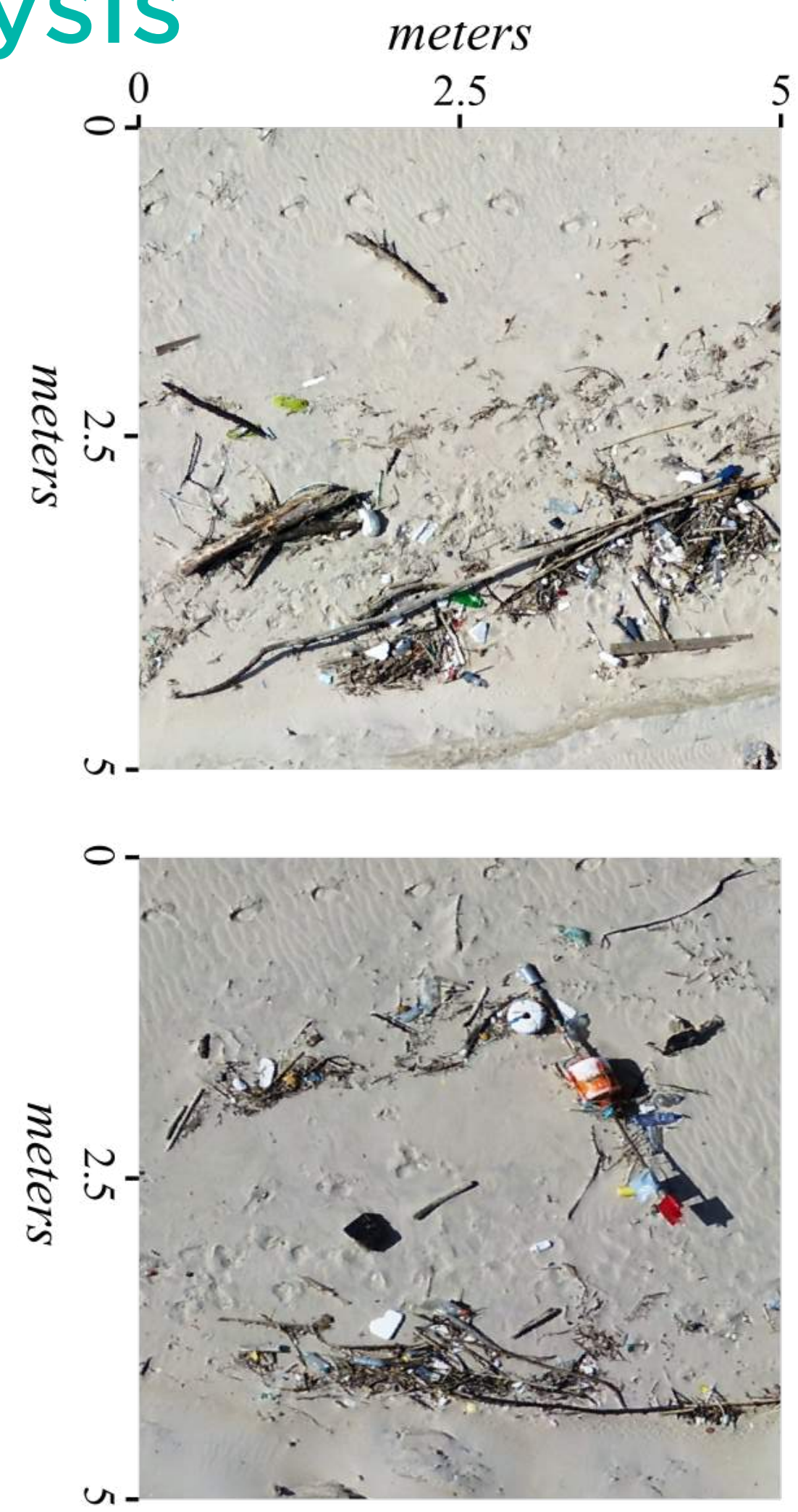
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Manual Image Screening



Machine Learning



Framework for drone-based litter survey – Outcomes



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Stage 4

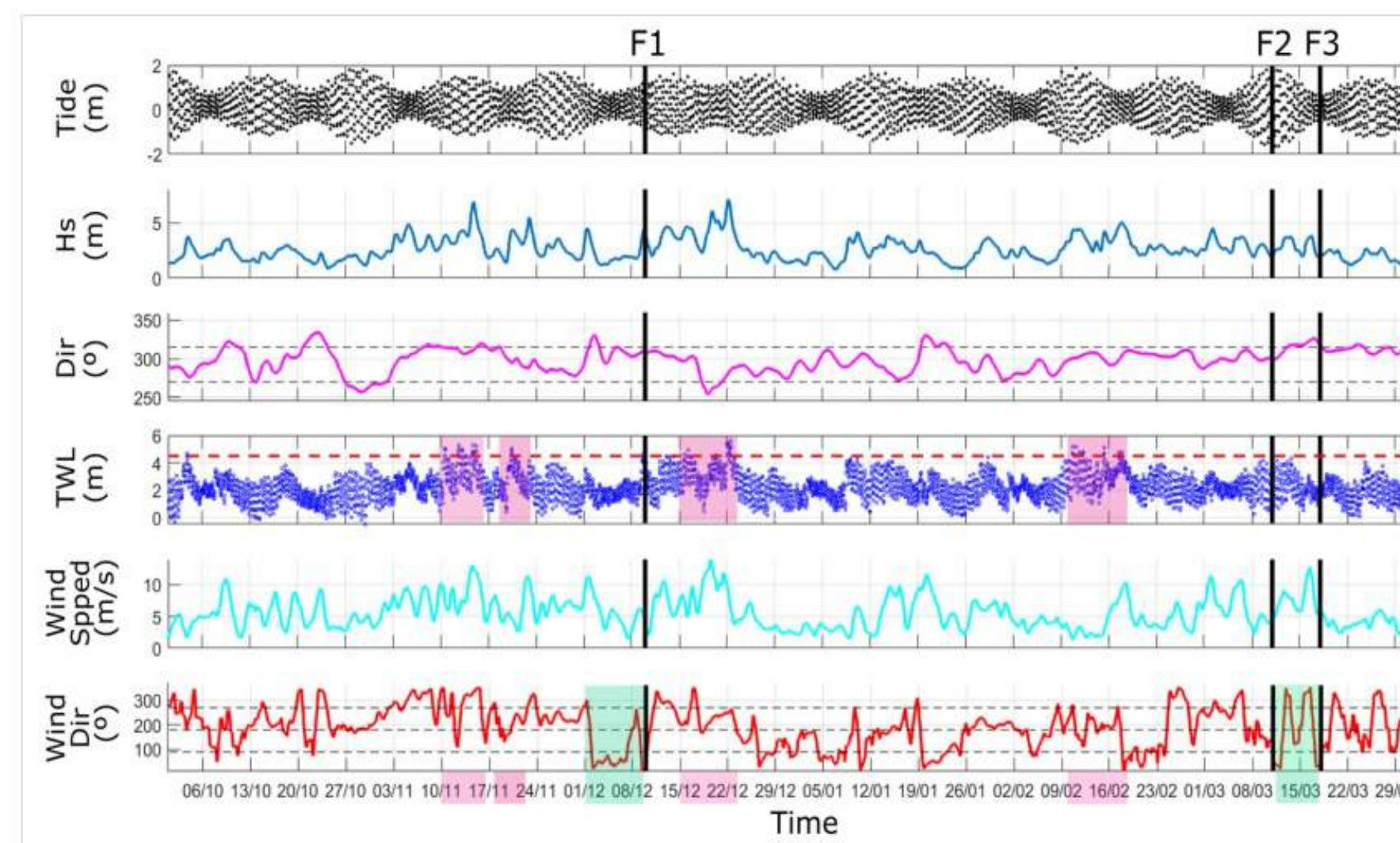
Litter survey assessment

- Characterization of beached litter bulk (counting objects, types, materials, analysis of the size of items)
- Litter maps and spatial distribution (covered area, density, hotspots)

	Number of items	%	Material	%	Total	
					n.	%
Bottles	54	13	Plastic	76	PLASTIC 304 75.6 Plastic bottles 82 20.4 Plastic bags 14 3.5 Plastic fragments 64 15.9 Octopus pots 51 12.7 Styrofoam (fragments) 93 23.1 PAPER 59 14.7 (paper napkins and tissues) METAL 8 2.0 (cans) GLASS 4 1.0 (bottles) WOOD 27 6.7 (processed, pieces) Total % 402	
Bottles >2 L	7	2				
Fishing strings	160	37				
Plastic (fragments, caps ecc.)	83	19				
Octopus pot	21	5				
Boots/shoes	3	1	Rubber	1		
Tyre	1	0				
Clothing	4	1		1		
Sheet/journals	9	2	Paper	2		
Wood pieces	23	5	Wood	5		
Cans (aerosol and food)	6	1	Metal	1		
Bottles	10	2	Glass	2		
Polystyrene pieces	48	11	Polystyrene	11		
	429					

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Framework for drone-based litter survey – Outcomes

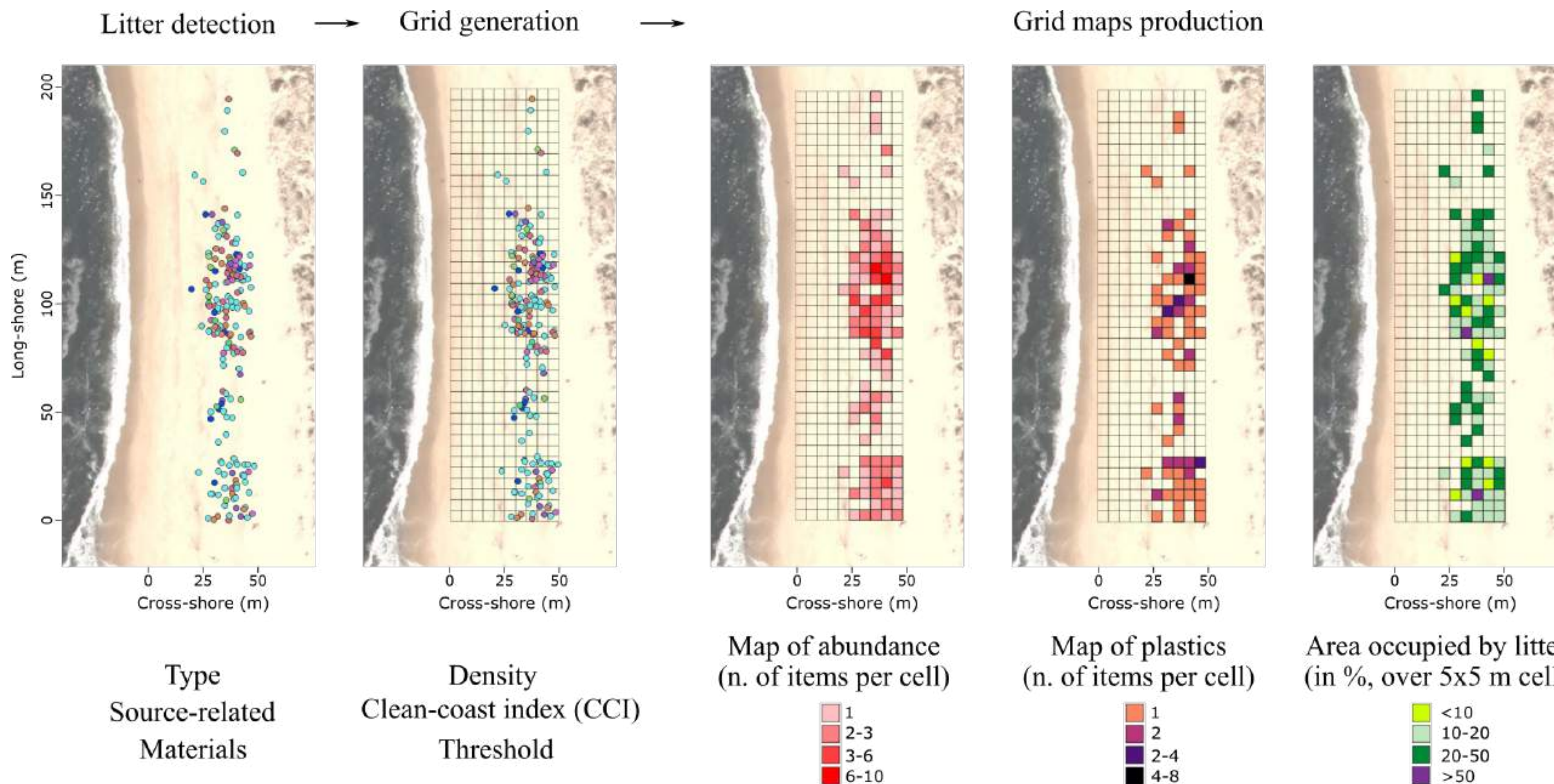


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Stage 4

Litter survey assessment

- Characterization of beached litter bulk (counting objects, types, materials, analysis of the size of items)
- Litter maps and spatial distribution (covered area, density, hotspots)



	Total	
	n.	%
PLASTIC	304	75.6
Plastic bottles	82	20.4
Plastic bags	14	3.5
Plastic fragments	64	15.9
Octopus pots	51	12.7
Styrofoam (fragments)	93	23.1
PAPER	59	14.7
(paper napkins and tissues)		
METAL	8	2.0
(cans)		
GLASS	4	1.0
(bottles)		
WOOD	27	6.7
(processed, pieces)		
Total %	402	



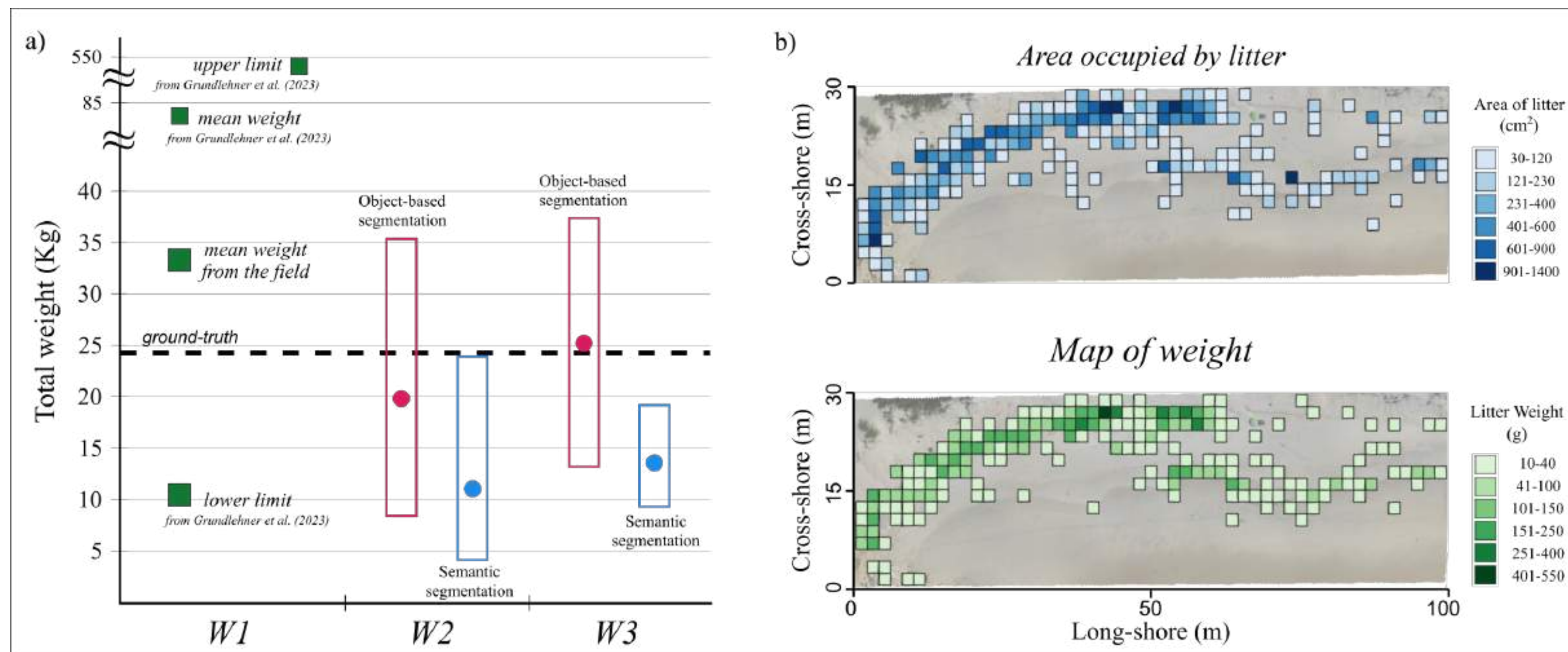
Framework for drone-based litter survey - Outcomes



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Litter survey assessment

- Characterization of beached litter bulk (counting objects, types, materials, analysis of the size of items)
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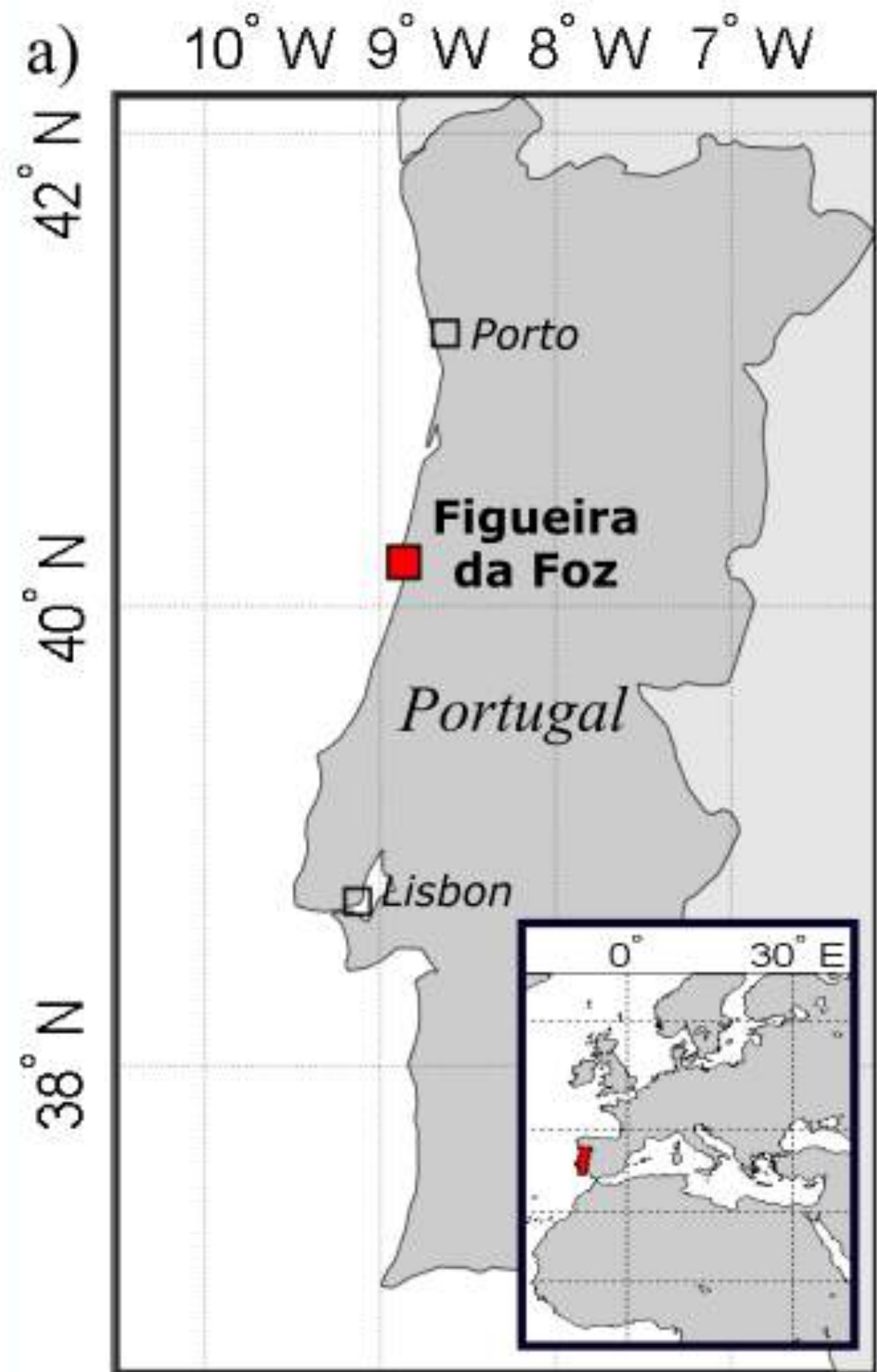
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METAL	8	2.0
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Total %	402	



Experiences



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Quiaios dunes



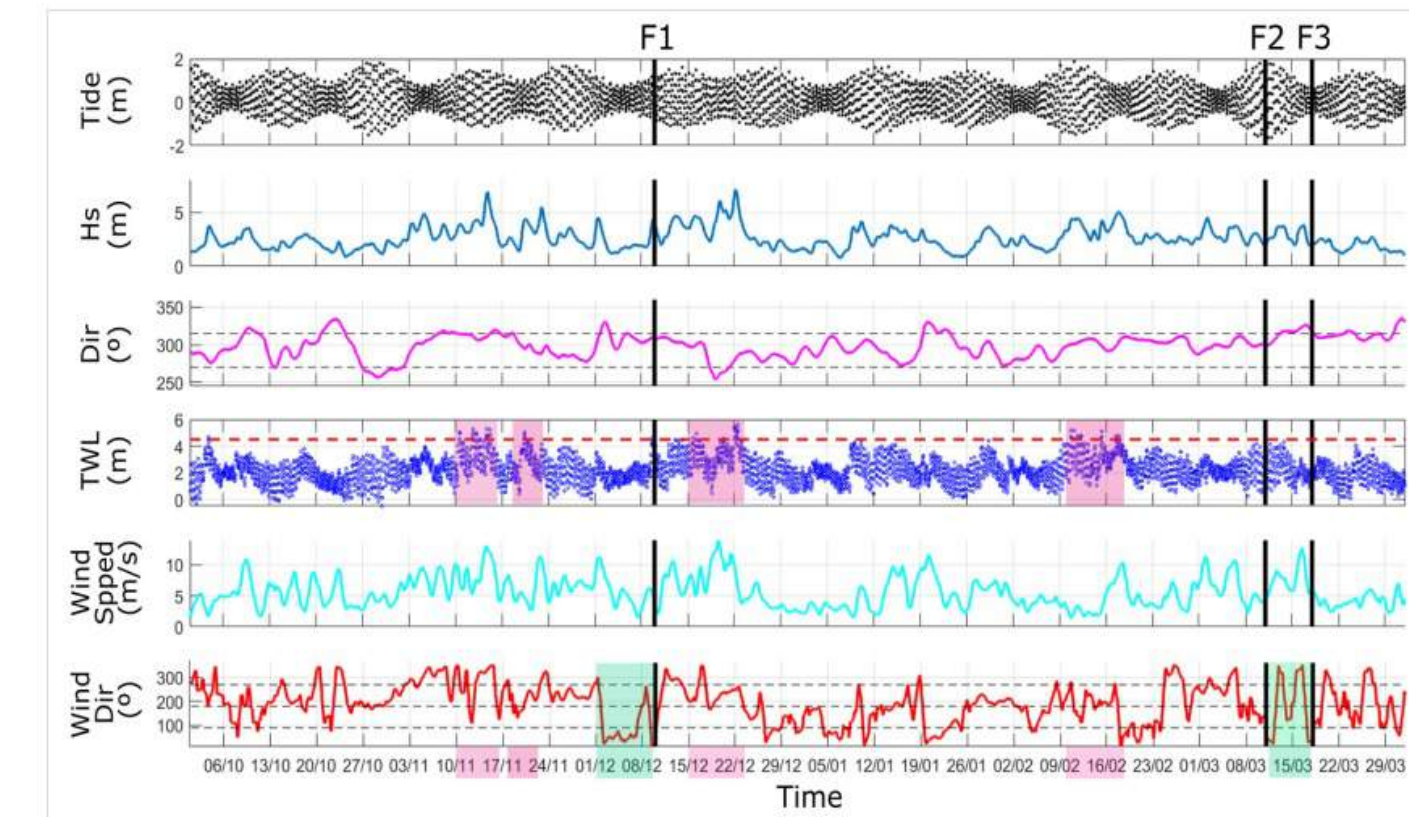
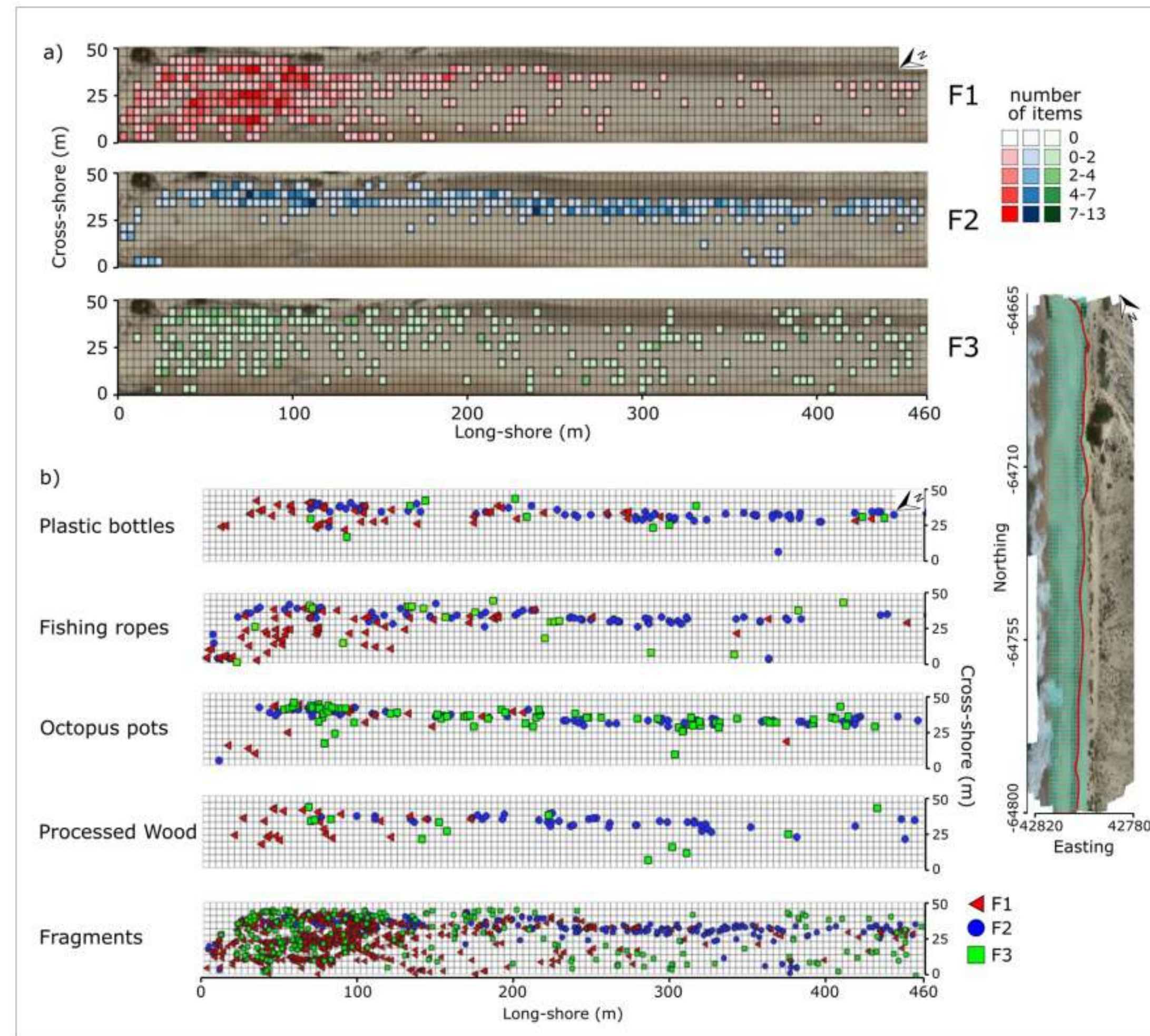
Leirosa beach



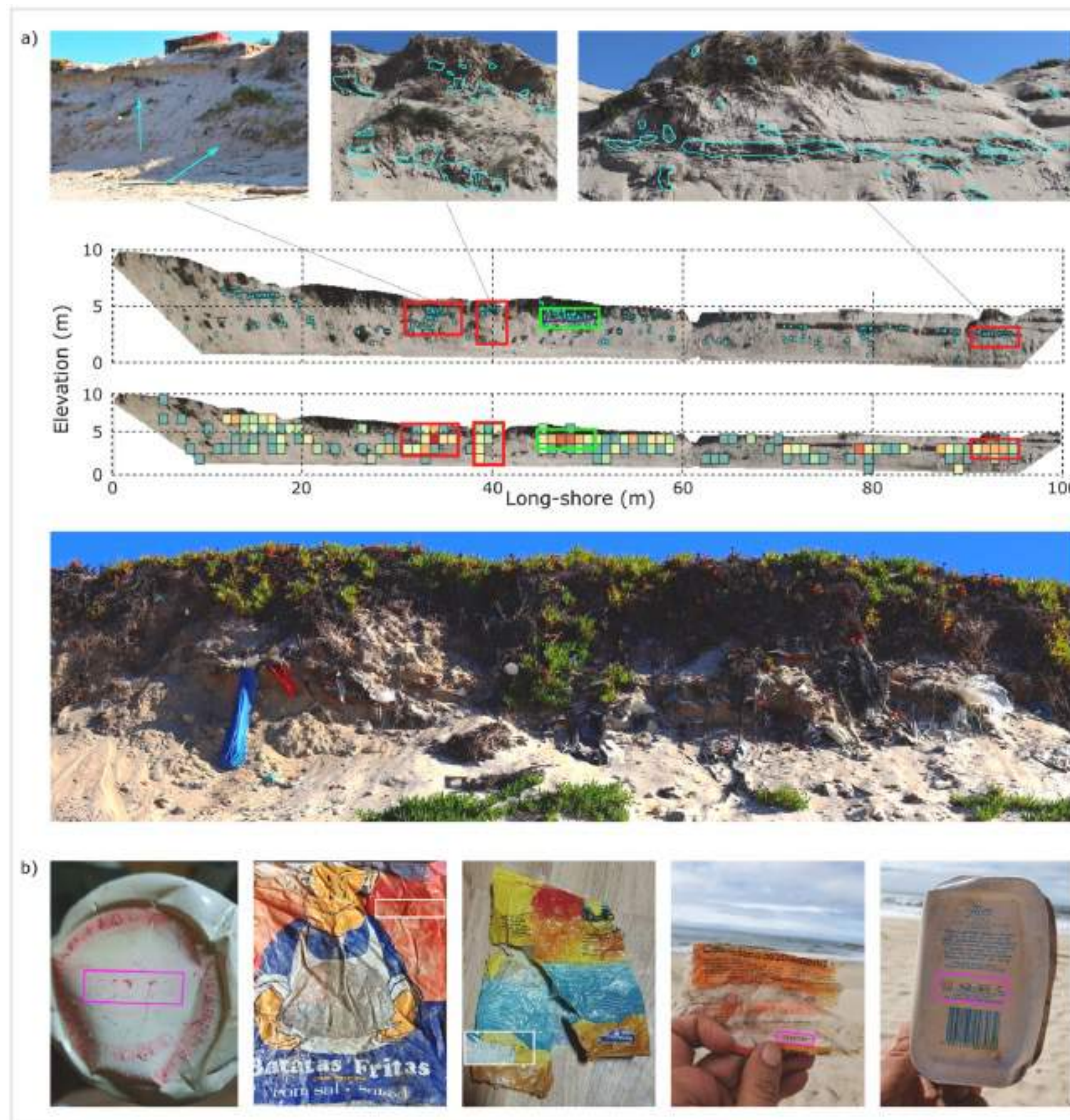
Assessments – Leirosa beach



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Assessments – Leirosa dunes



Mapeamento de lixo marinho
na zona costeira com drones

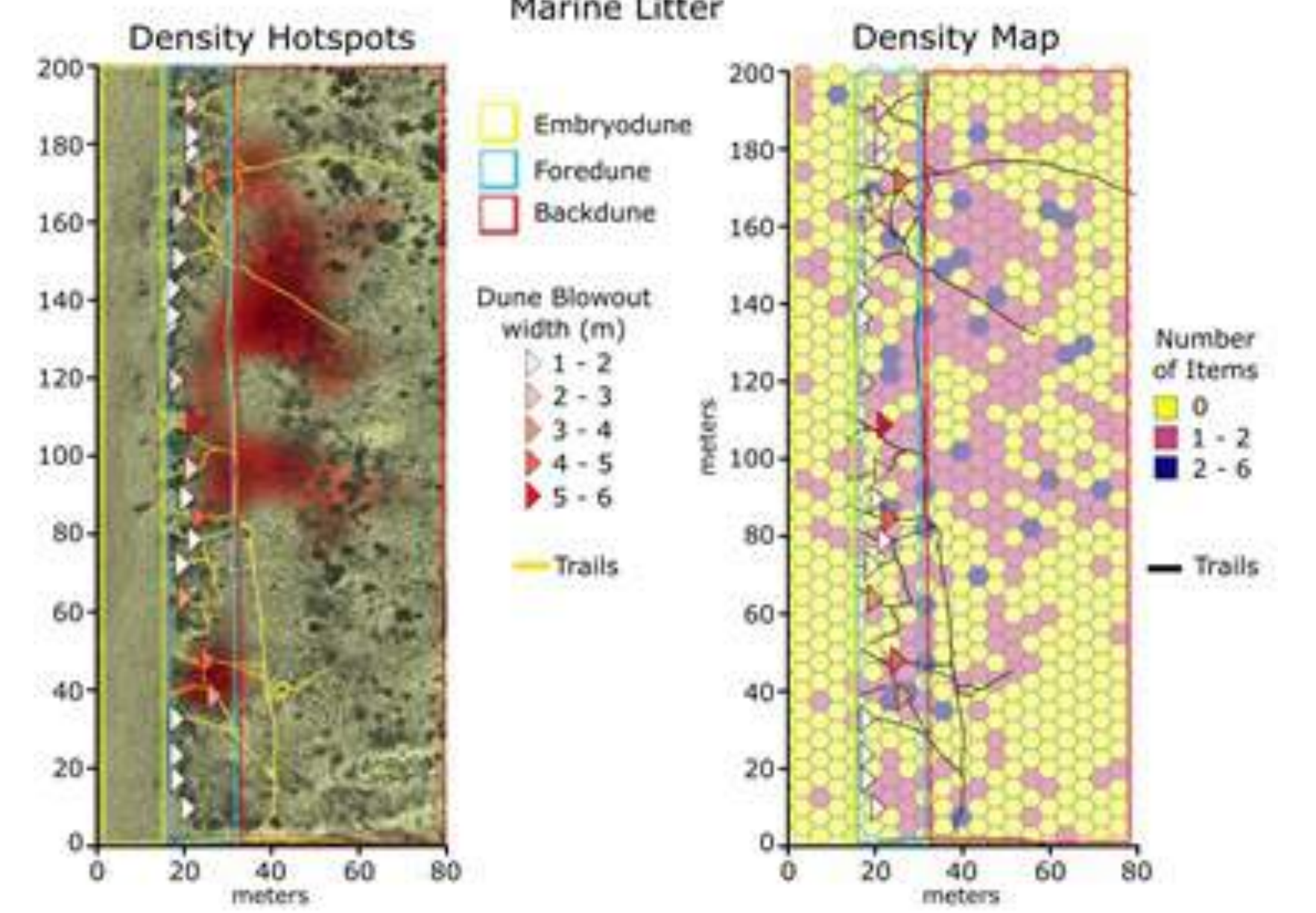
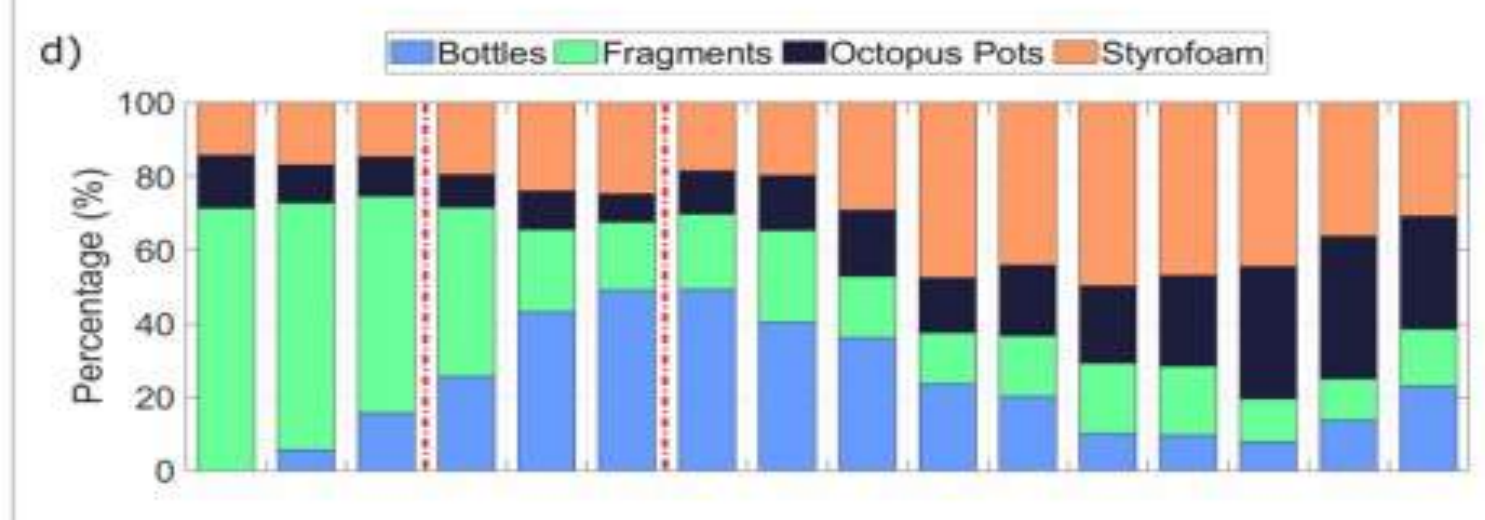
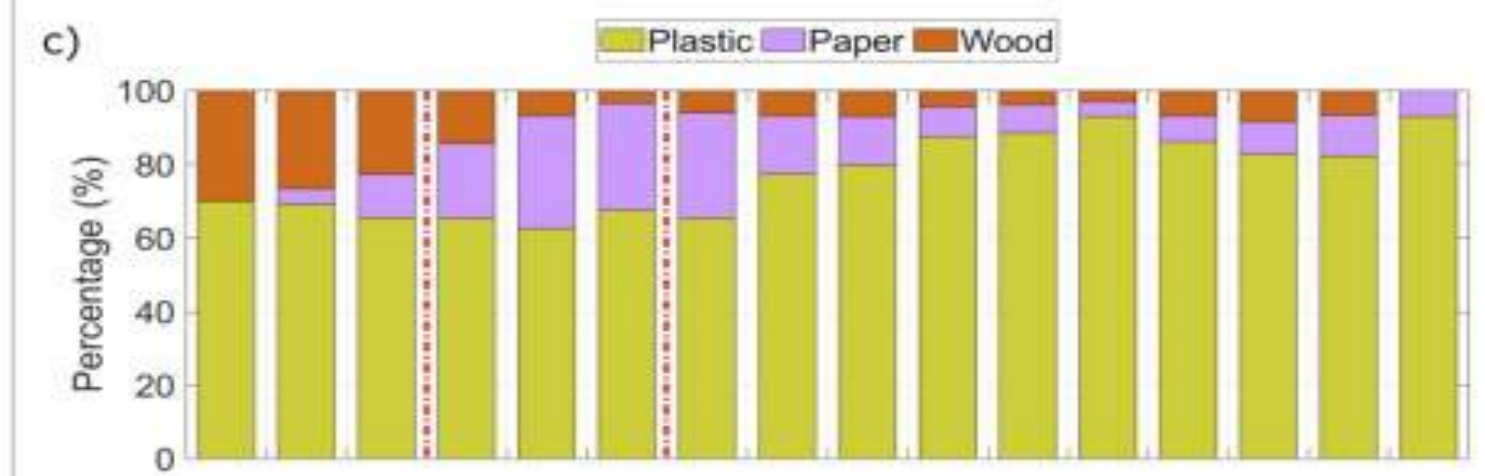
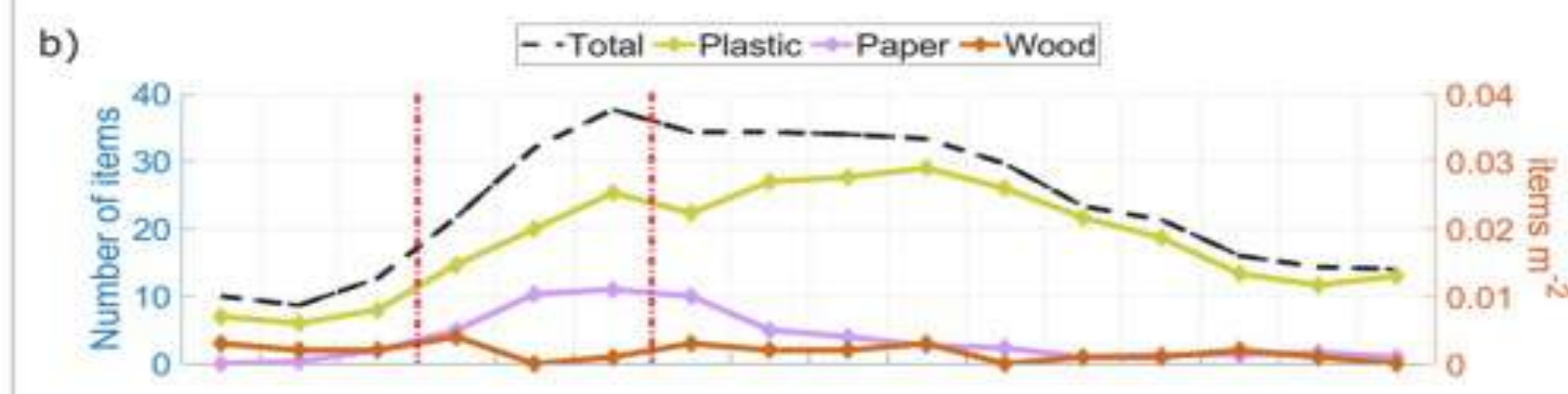
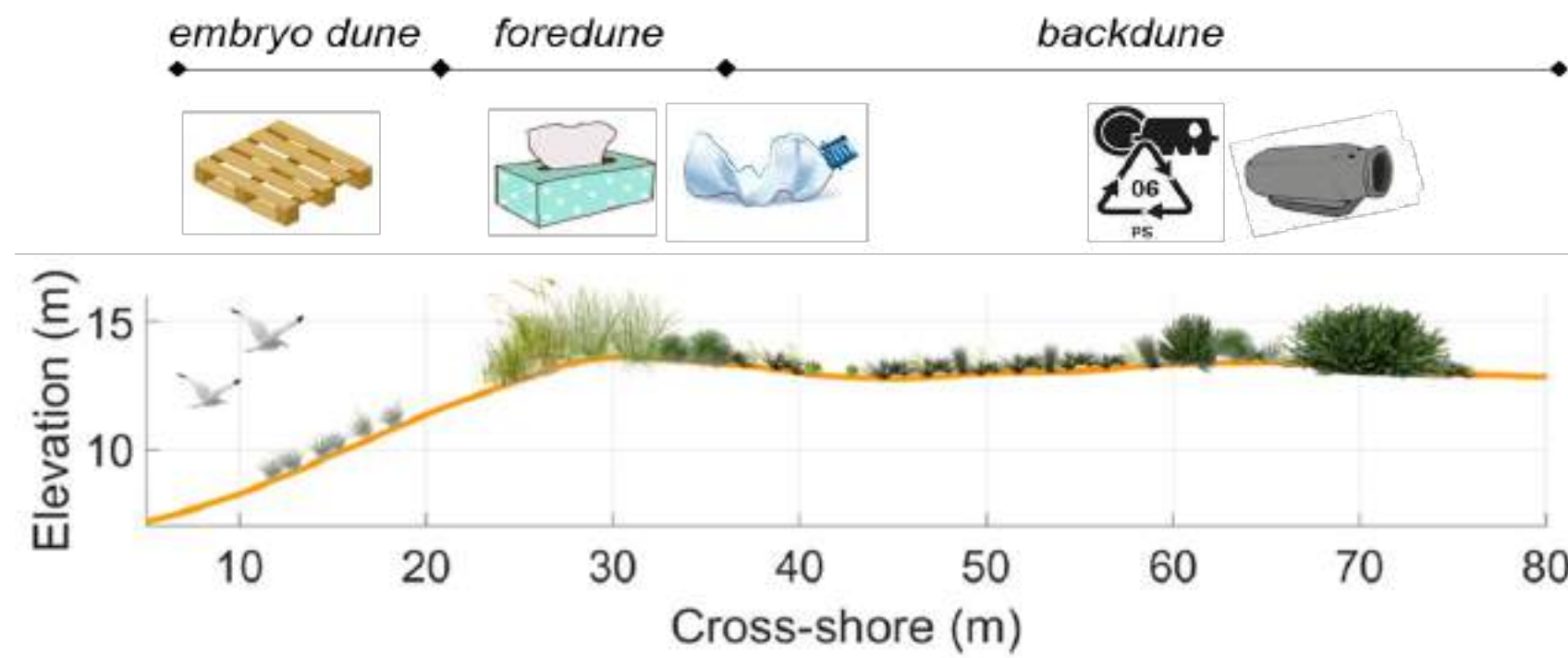
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Assessments – Quiaios dunes



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Mapeamento de lixo marinho na zona costeira com drones

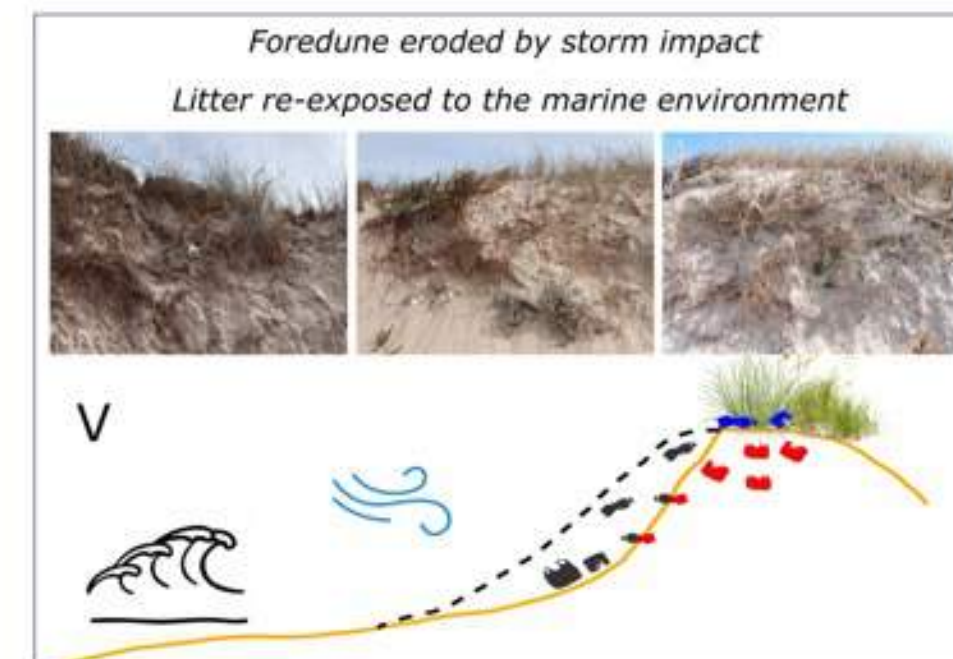
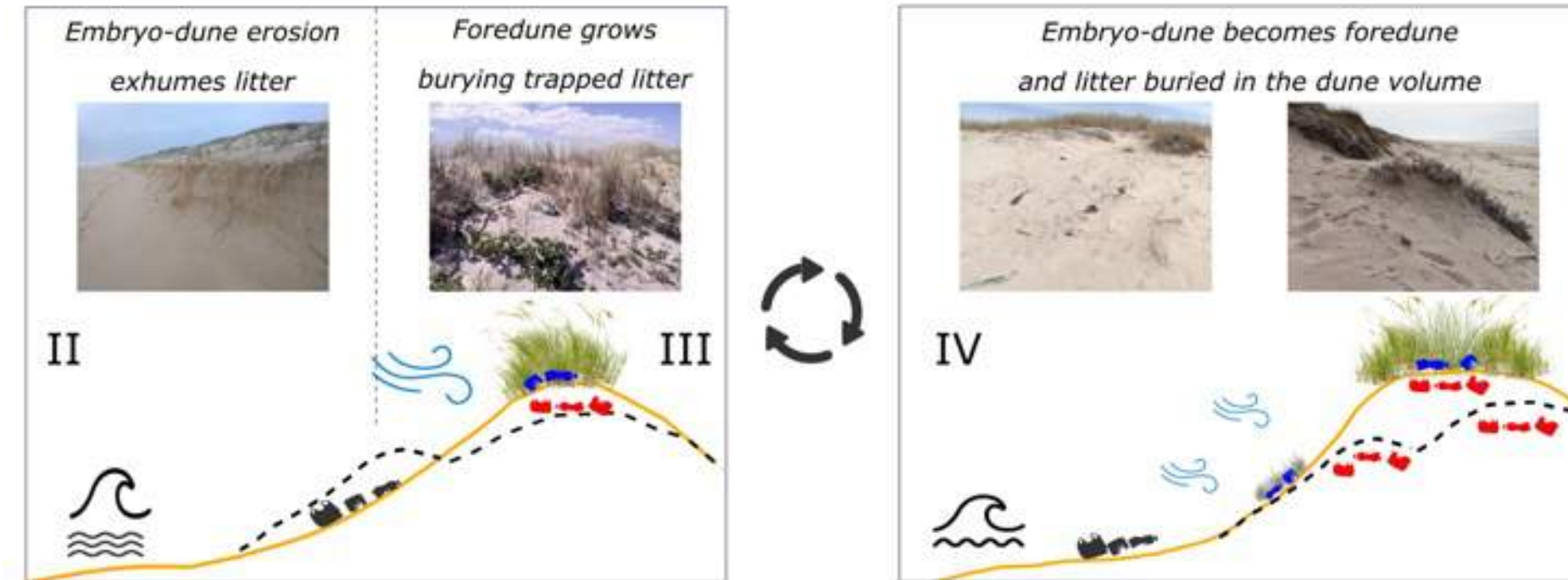
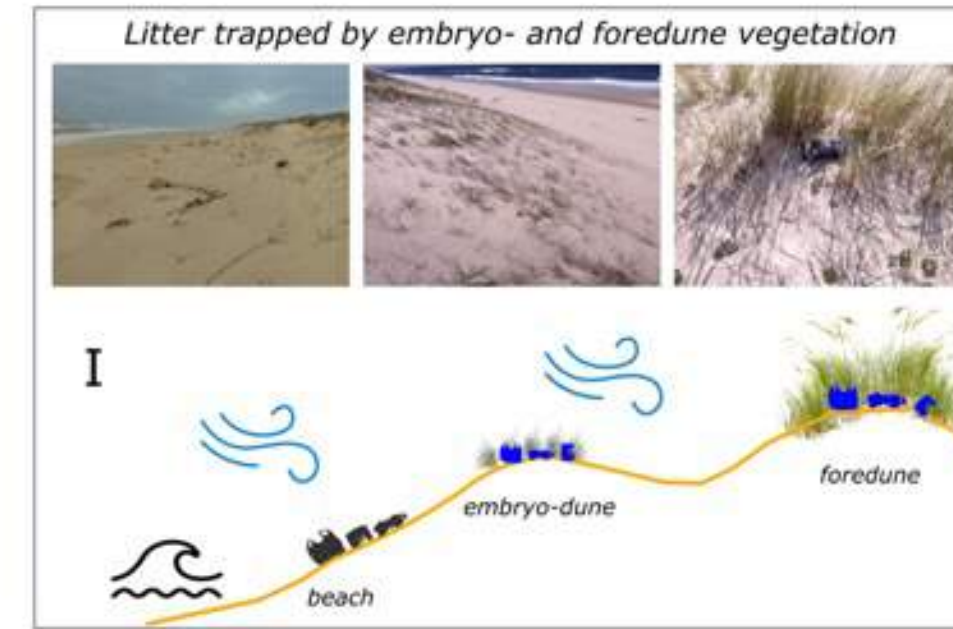
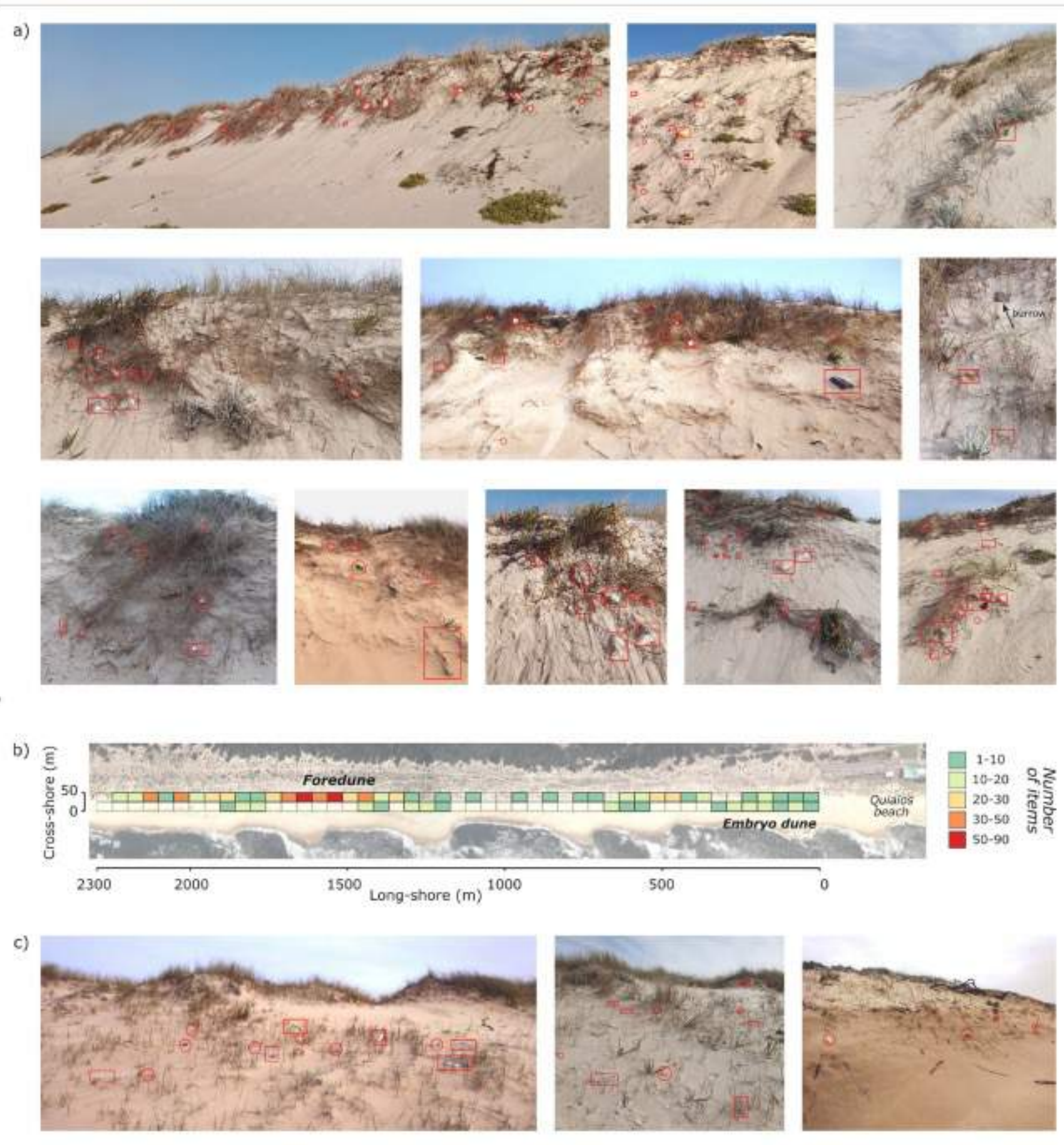
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Assessments – Quiaios dunes



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Mapeamento de lixo marinho
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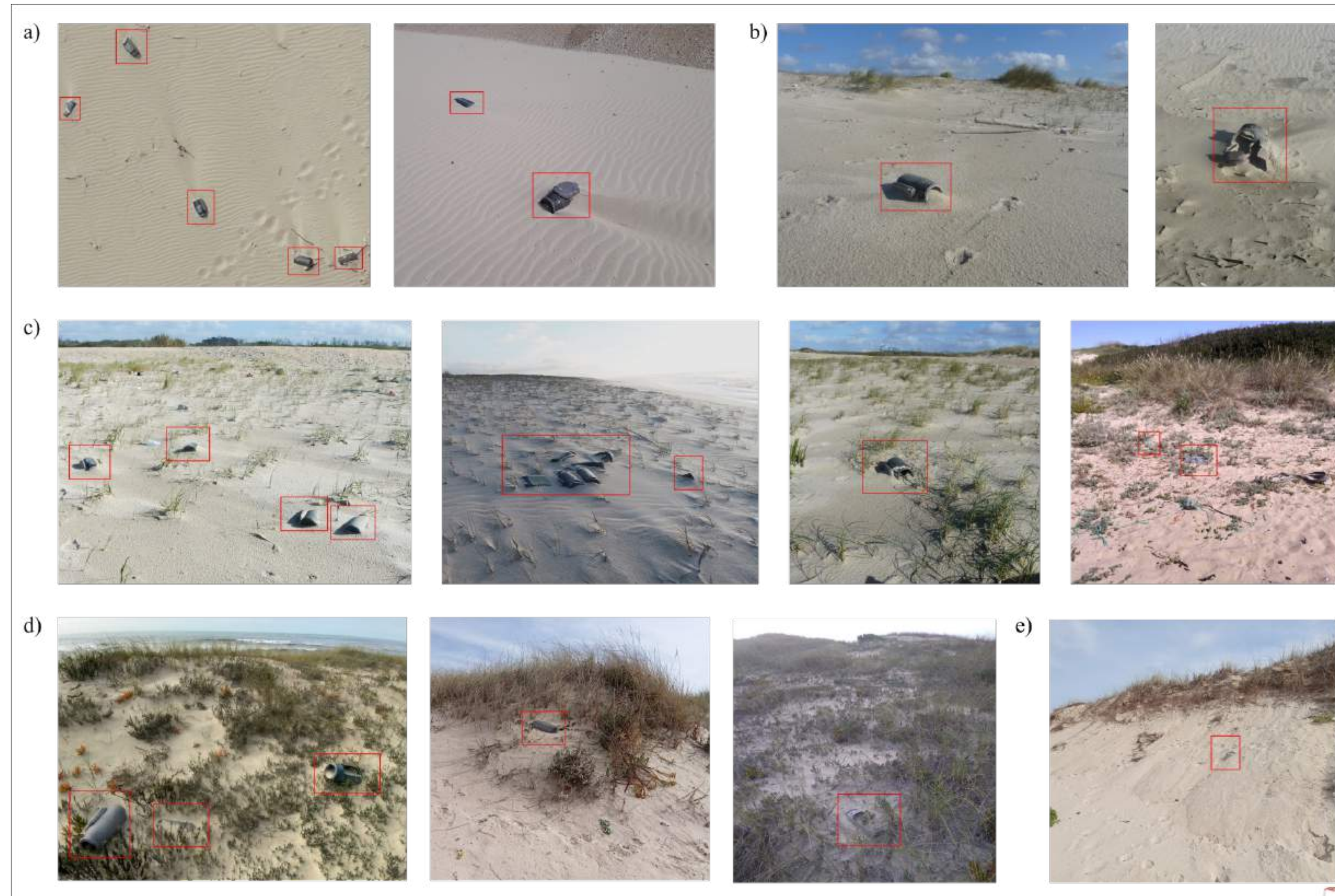
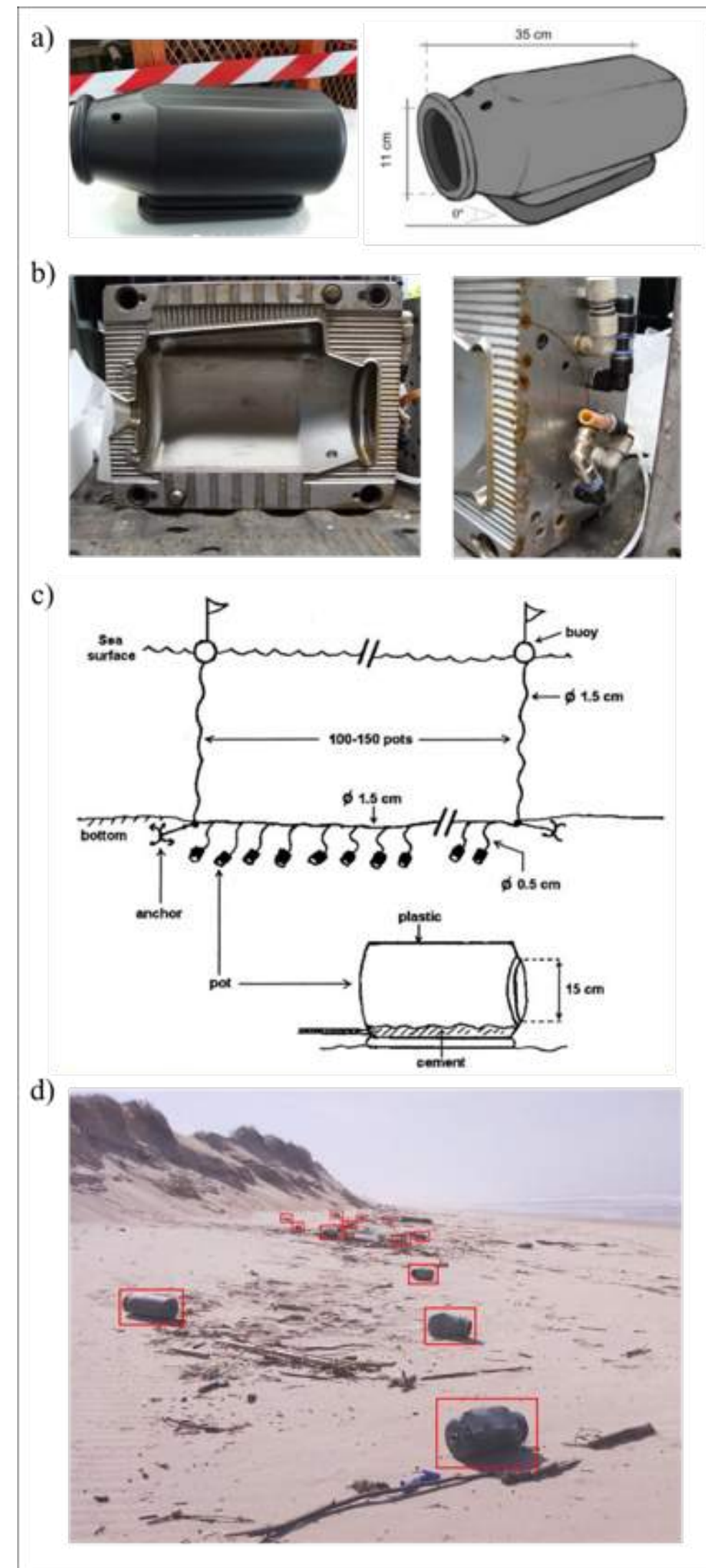
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Fishing-related



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Fishing-related



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a)



Mar à Deriva



BrigadaDoMar

b)



BrigadaDoMar



Conclusions

- Plastics ~75%
- Fishing-related items ~40%
- Drone-based surveys can
 - Increase the frequency of surveys, as it requires less human effort
 - Provide litter census over a major number of beaches, over wider and also remote areas
- Drone-based surveys can provide new information
 - Litter items size and weight
 - Litter dynamic in stranding, moving on the beach or towards dunes, resuspension etc.
 - Location of hotspots
- Drone-based surveys can
 - provide maps of litter to support and optimize clean-up operations
 - involve citizens in collecting and analyzing the data



Acknowledgments

Filipa Bessa, Paula Sobral, Luisa Gonçalves, Diogo Duarte and Luis Pinto, and all colleagues of international universities and governmental institutions from Italy (CNR, Pisa), Colombia, Greece, Netherlands, Japan and Spain (Barcelona, Vigo), who collaborated in the project.

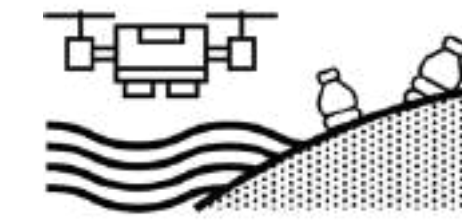
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UAS 4 Litter



Low-cost Unmanned
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Publications List



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12 a 14 de dezembro de 2023

5.º ENCONTRO NACIONAL DE
LIMPEZA URBANA
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AUTÓDROMO DO ESTORIL, ESTORIL | CASCAIS

Limpeza urbana ao serviço das pessoas e dos territórios



CASCAIS
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