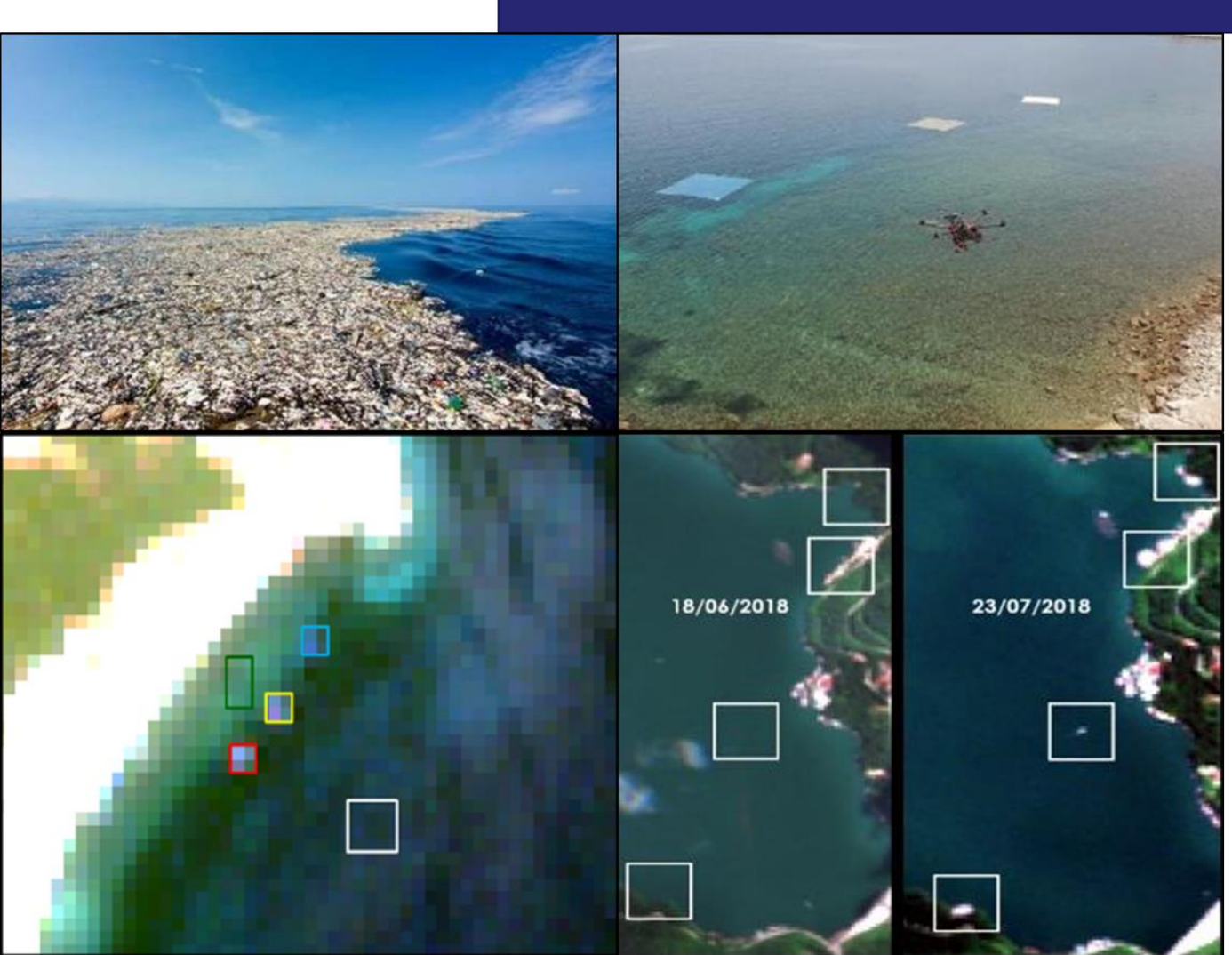
ESA, UKSA & Copernicus initiatives: Facing the Challenges of Marine Litter Tracking

Manuel Arias[1]

Anne Vallette[1], Stefano Alliani[2], Andres Cozar[3], Konstantinos Topouzelis[4], Shungu Garaba[5], Mark Hennen[6], Philippe Bryere[1], Francois-Regis Martin-Lauzer[7], Craig Jacobs[1], Antoine Mangin[1], Paolo Corradi[8]

[1]ARGANS France, [2]ISMAR-CNR, [3]University of Cadiz, [4]University of Aegean, [5]University of Oldenburg, [6]ARGANS Ltd, [7]ACRI, [8]European Space Agency



Technologies for Observing and Monitoring Plastics in the Oceans

IEEE Oceanic Engineering Society

26-27 November 2018
Brest (France)

Introduction

Marine Litter Programme

Remote Sensing for Marine Litter -RESMALI-

GeoInt Service for Marine Litter -SSGP Project-

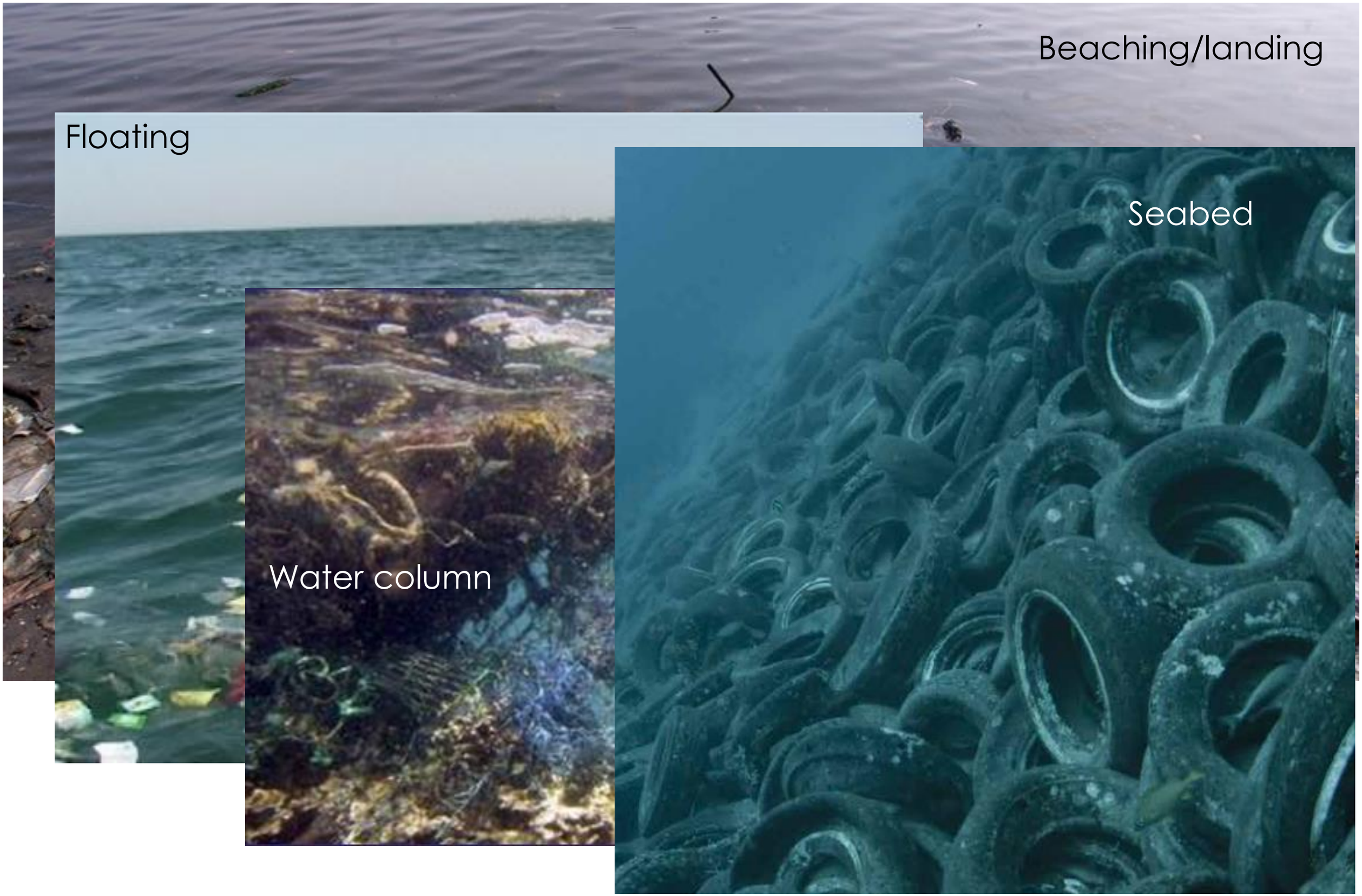
EO Tracking of Marine Litter in the Mediterranean Sea

Copernicus Service for Marine Litter (LitterTEP)

Marine Litter Programme

- Determine the capability of existing Earth Observation datasets to provide information about marine litter
- Increase the knowledge base about the physical characteristics, distribution and properties of both marine and riverine litter
- Develop products and services to support decision-making process with regard to marine litter prevention and management
- Identify the best technologies and remote sensing technologies for a possible dedicated Earth Observation mission for marine litter
- Engage with the research community and stake-holders with interest in the topic and develop synergies and collaborations

Introduction



Monitoring/observations general needs

Emission / release of macro-waste

- Earth Observation (Sentinel-2)
- Modelling (emission coefficient based on land use on watershed)
- Participative observation by public entities and other stackeholders

Landing/beaching

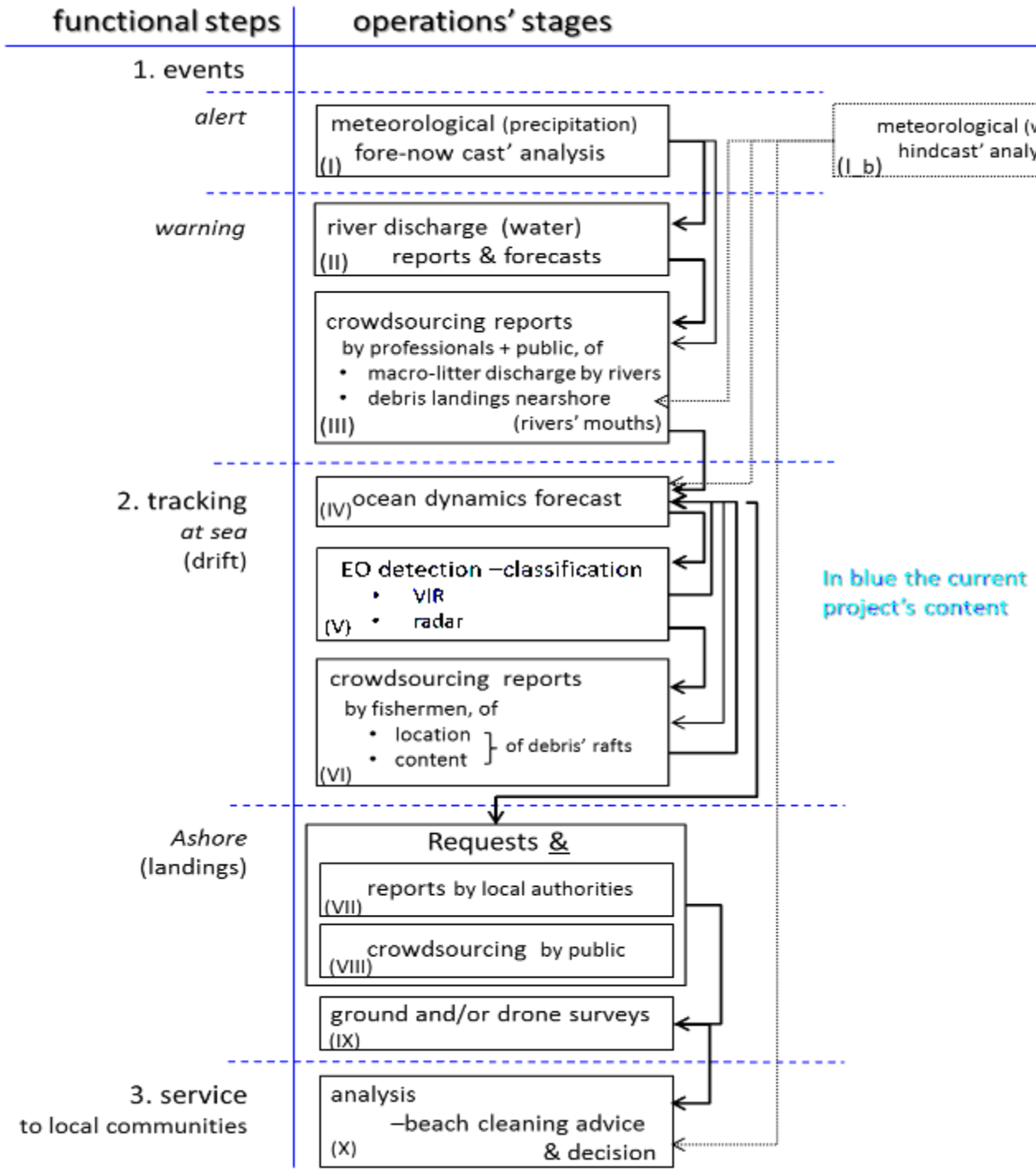
- Earth Observation (Sentinel-2, commercial satellites)
- Modelling (statistics)
- Participative observation by citizens and professional

Floating filaments and patches

- Earth Observation(Sentinel-2 / Sentinel-1)
- Participative observation by marine professions (fishermen, transportation…)

Objective is to merge efforts to demonstrate what is feasible/useful and could be operationaly deployed -> **consolidate a roadmap in addition to existing efforts.**

The Large Picture



1. Integration of ML by different agents:
   - Citizens (SIMPLEX mobile app)
   - NGOs
   - Fishermen
   - Proxies (e.g. flooding events)

2. Monitoring via remote sensing:
   - Public satellites
   - Drones
   - Commercial satellites

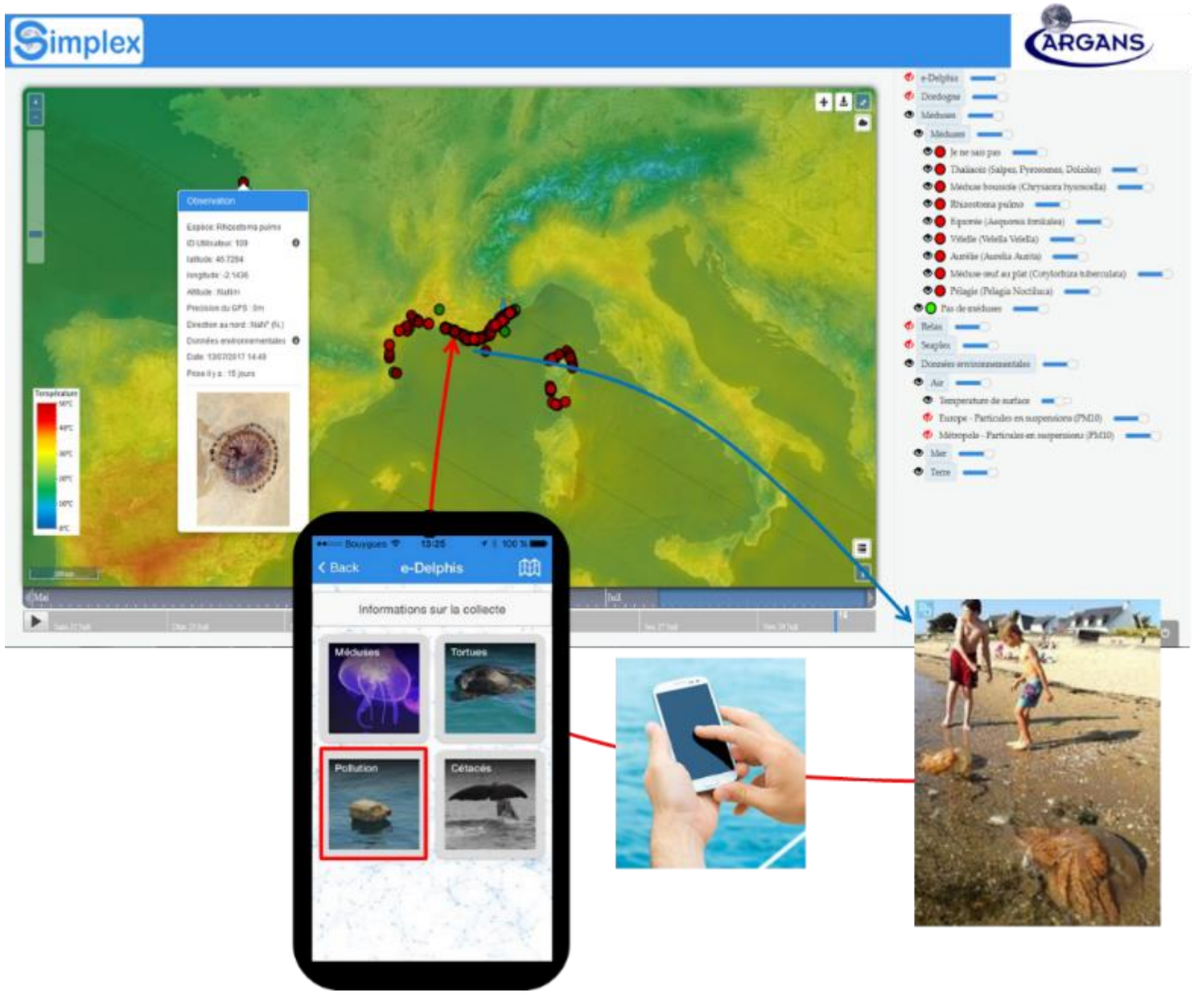
3. Litter hindcast/forecast through models
   1. Identification of sources
   2. Landing areas estimation
   3. Identification of risks levels

4. Automatic reporting and analysis

Contributions by ML agents

SIMPLEX Mobile App

ML data generator and reporting



-Pros-

Easy to use with potentially many contributors.

It provides fast warnings about litter presence at the coastal area.

It includes preliminary data classification and observations

-Cons-

Information only where people go

Lack of continuity by the user

Influenced by media

Contributions by ML agents

Fishermen's contributions

ML data generator

-Pros-

Identify litter at sea

Frequent and regular visits to the affected areas

They have economic interest

-Cons-

Usually require economic incentives to participate

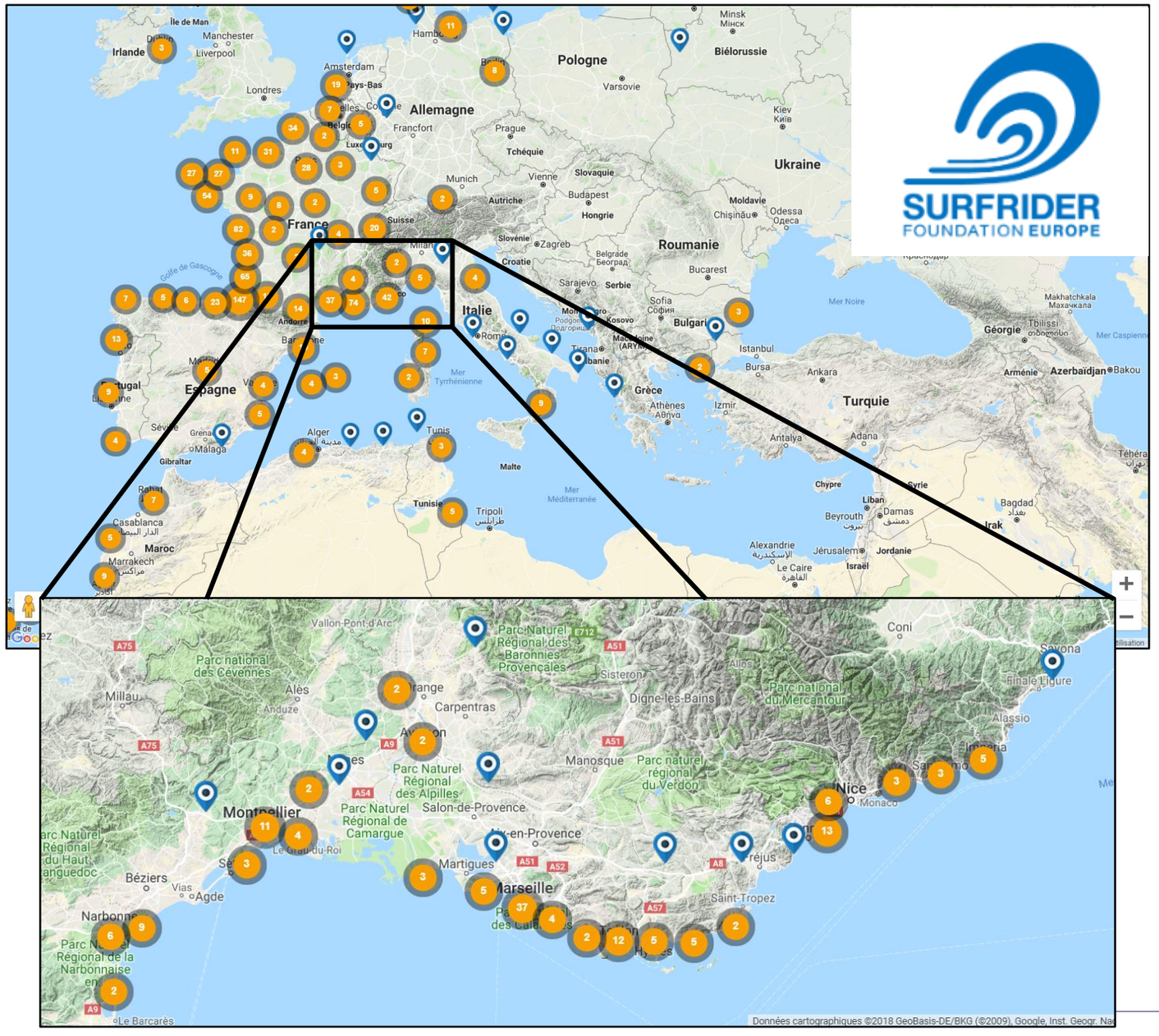
Not always will report about derelict fishing gear

Routine support could require legal regulations

Contributions by ML agents

NGOs contributions

ML data generator and reporting



-Pros-

Significant spatial coverage of data

Information about composition

Long records (in some cases)

-Cons-

Non-systematic sampling

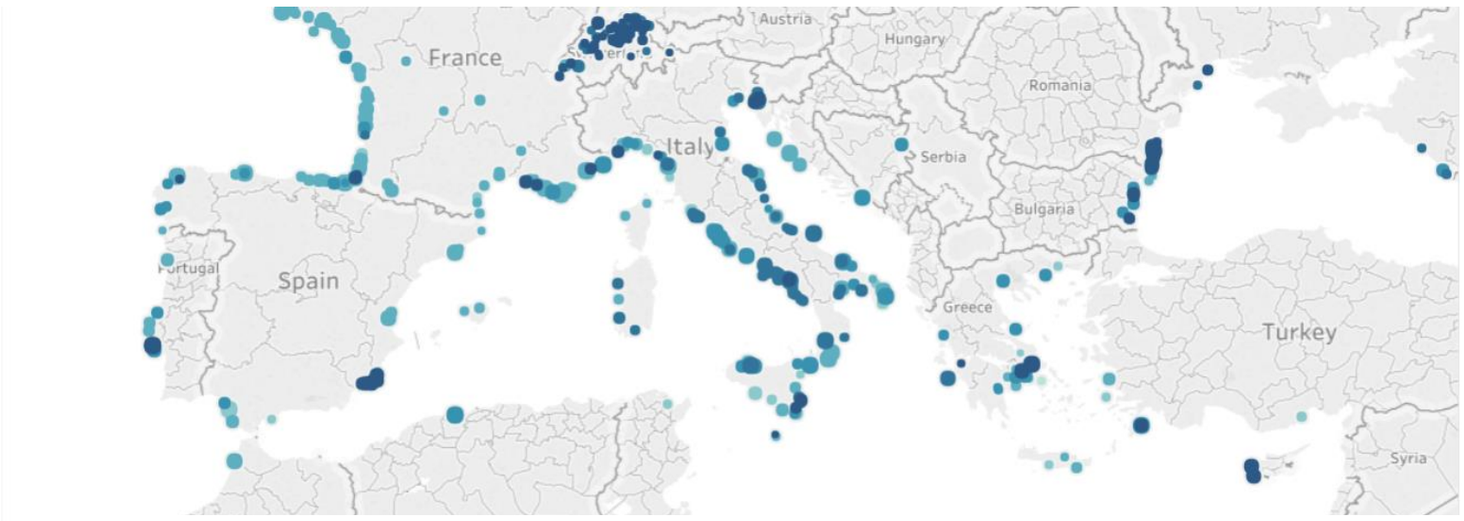
Not strict with the methodology

Collections focused in worst cases

Contributions by ML agents

Governmental contributions

ML data generator and reporting



Marine LitterWatch data viewer

Dashboard (Tableau) — **Prod-ID:** DAS-18-en — Published 01 Jun 2018 — 1 min read

The Marine LitterWatch (MLW) data viewer provides a map of beach litter data collection events organised by MLW communities. It collected and community engagement.

MapOfEvents | OverviewOfResults | CommunityOverview | CommunityActivity | TotalItemsSummary | Beach details

Beach details from map

Coccia di Morto beach, Legambiente Onlus, IT

Beach	Date	Material	Litter item	
Coccia di Morto beach	17/10/2016 09:00:00	Plastic	Cotton bud sticks	2,750
		Plastic	Cigarette butts and filters	350
		Plastic	Cups and cup lids	60
		Plastic	Plastic/polystyrene pieces 2.5 cm >< 50cm	60
		Plastic	Plastic pieces 2.5 >< 50 cm	45
		Plastic	Crisps packets/sweets wrappers	30
		Plastic	Cutlery and trays	28
		Glass/ceramics	Bottles incl. pieces	26
		Glass/ceramics	Jars incl. pieces	23
		Plastic	Cigarette lighters	22
		Plastic	Straws and stirrers	21

-Pros-

Significant spatial coverage of data

Information about composition

Standardized data classification

-Cons-

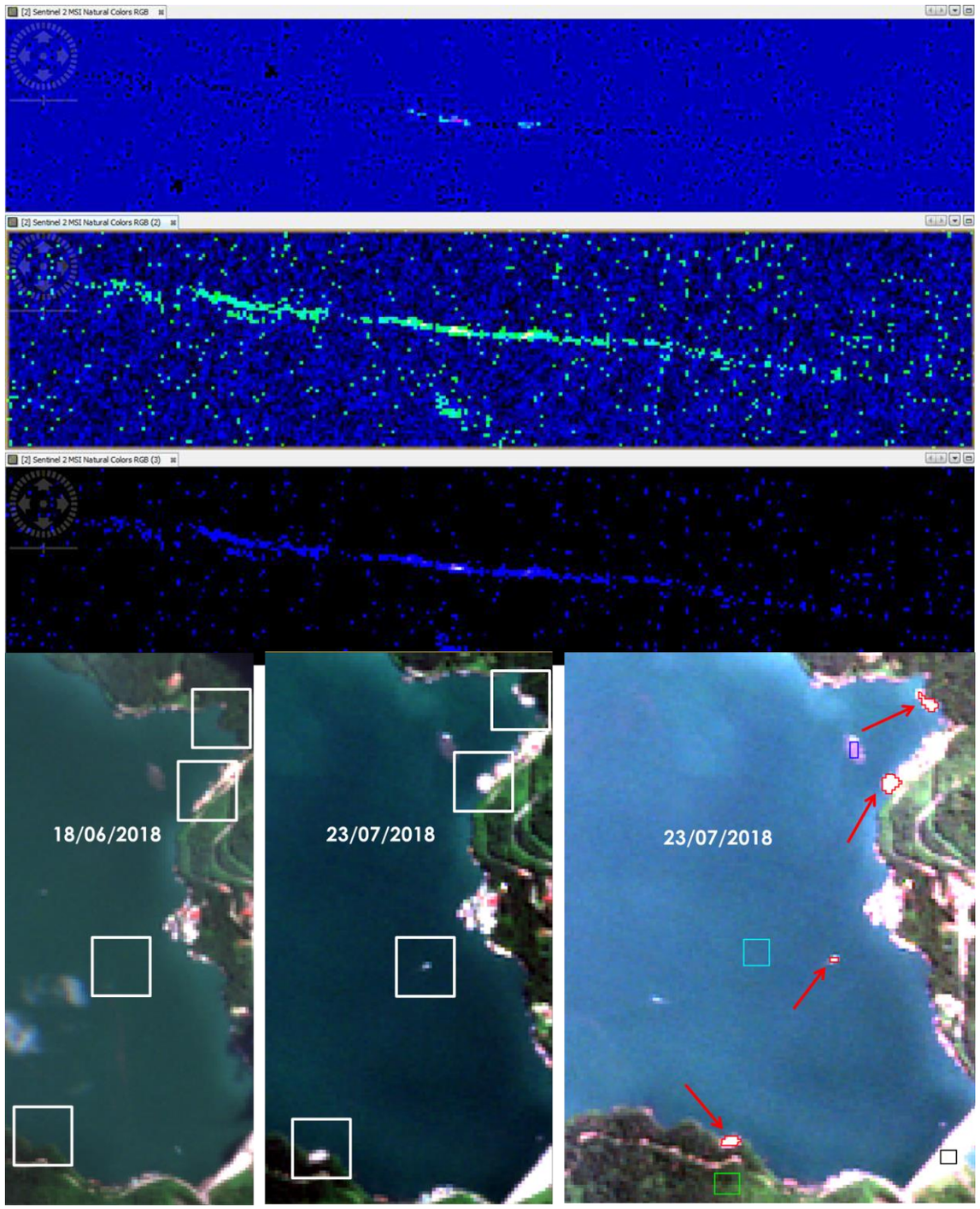
Non-systematic sampling

Shorter time series

Linked to public funding

Monitoring via remote sensing

Public satellites



-Pros-

Huge spatial and temporal coverage and free access

Enables EO techniques for detection

Long-term time series are possible

-Cons-

Not enough spatial resolution

Limited spectral information

Significant levels of noise and various contaminations into data

Monitoring via remote sensing

Drones

-Pros-

Very close to the target and allow for identification and quantification

Work well in areas where satellites performance is poor

Surveys under demand

-Cons-

Data collection and processing can be pricey

Limited range of action and pending on human operators

Non-systematic acquisition

Monitoring via remote sensing

Commercial satellites

-Pros-

High resolution that works well over beaches and rivers

High spatial and time coverage

Enable certain EO techniques for automatic processing

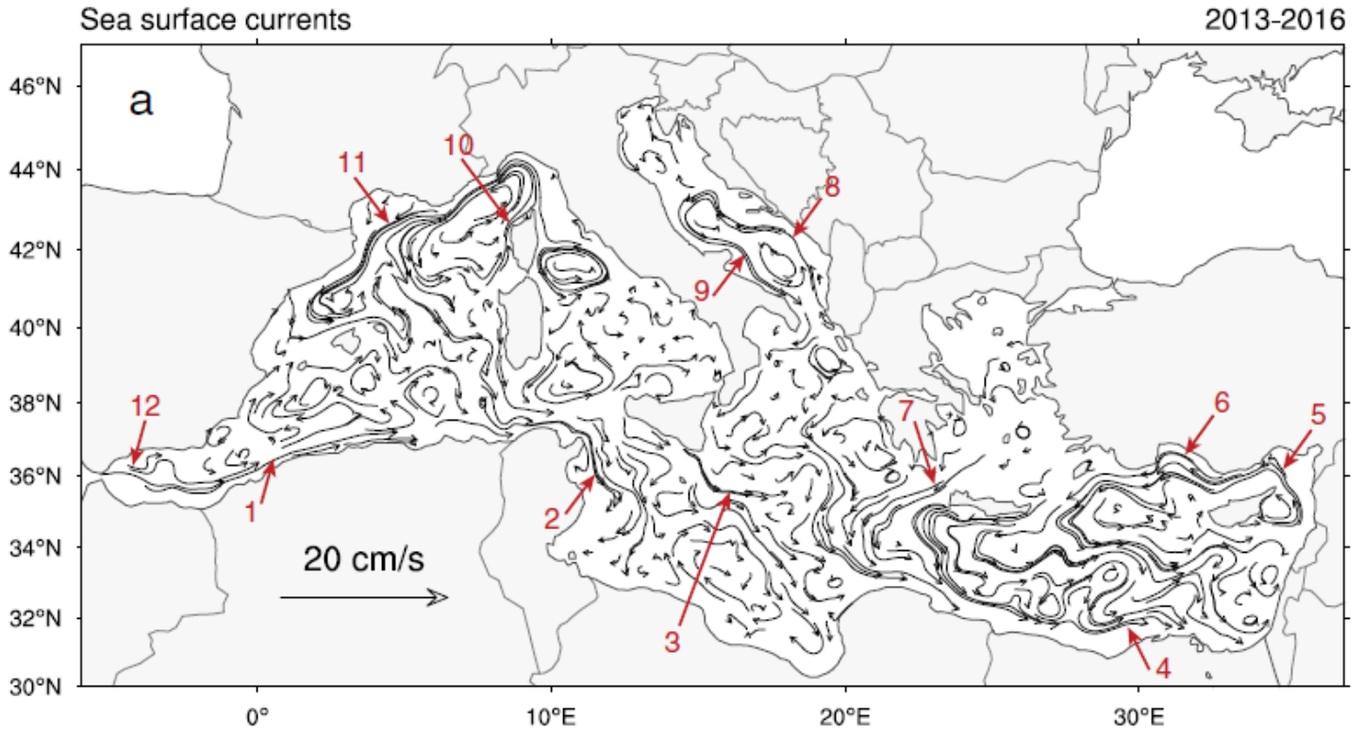
-Cons-

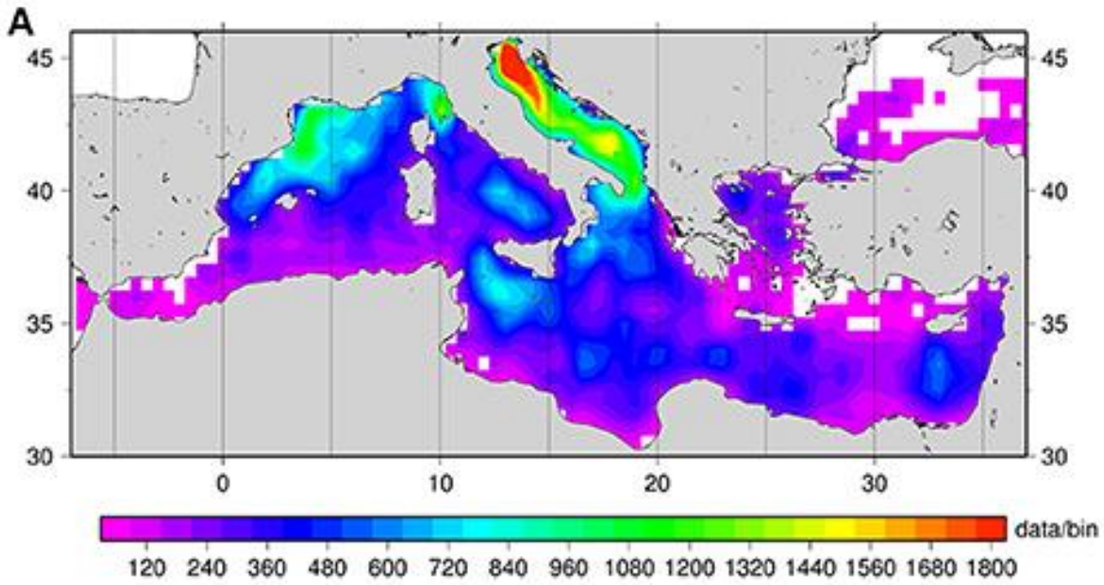
Really expensive data

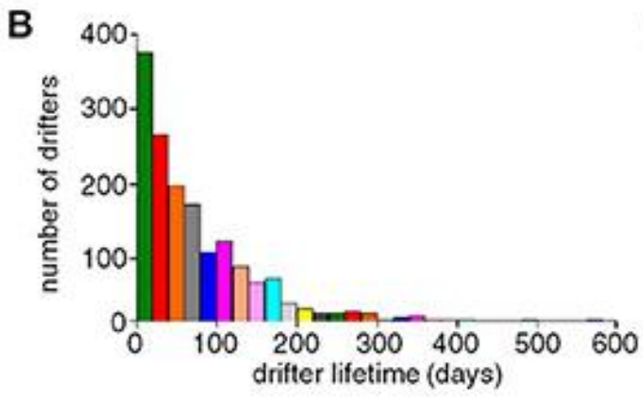
Time series cannot be granted

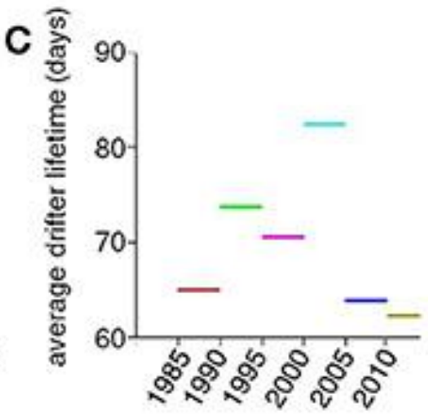
Systematic data processing requires huge IT capabilities

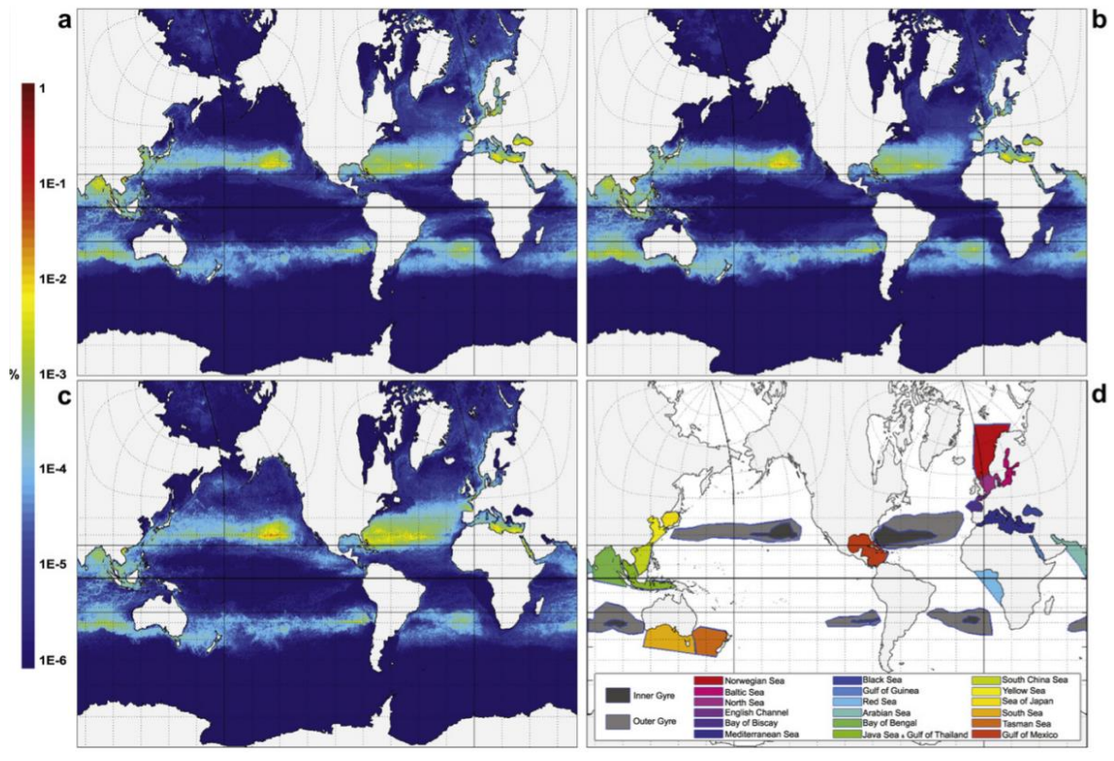
Litter hindcast/forecast through models











- Lagrangian transport
- Eularian transport
- Density maps / landing sites

Client requests on archive
Date : 20180101
Modelling period
Zone of study : Country name, river name

Data
CMEMS : -Northwest Shelf Analysis_Forecast_PHY &WAV,
-Wind_Glob_Wind_l4_Nrt_Obeservations
-Tidal
Download : by cron daily at 1am
From : nrt.cmems-du.eu
Storage : in C_Tep

Pre-process
Adjust CMEMS layers around the ROI to reach coasts
increase 7 times CMEMS layers resolution to integrate diffusion model

Grounding and refloating model
Inputs : Wave, Tidal
-Create a daily coefficient GRC at coasts
Test : (GRC(day2),GRC(day1) -> refloating

Wind and Sinking Model
Inputs : Litter type (plastic, woods,...), Wind
Test : (litterType, floating time, wind) -> sinking

Meteo Trigger
Download : Rain value by cron every 15 min
From : https://www.eumetsat.int
Test : (Rain Value, Threshold) -> activate trigger

Sources & Fluxes : Results from terrestrial model
Inputs : Rain value, population, trigger events , River Flow
Outputs : Litter data (positions, quantity, type,...)
Storage : in C_Tep

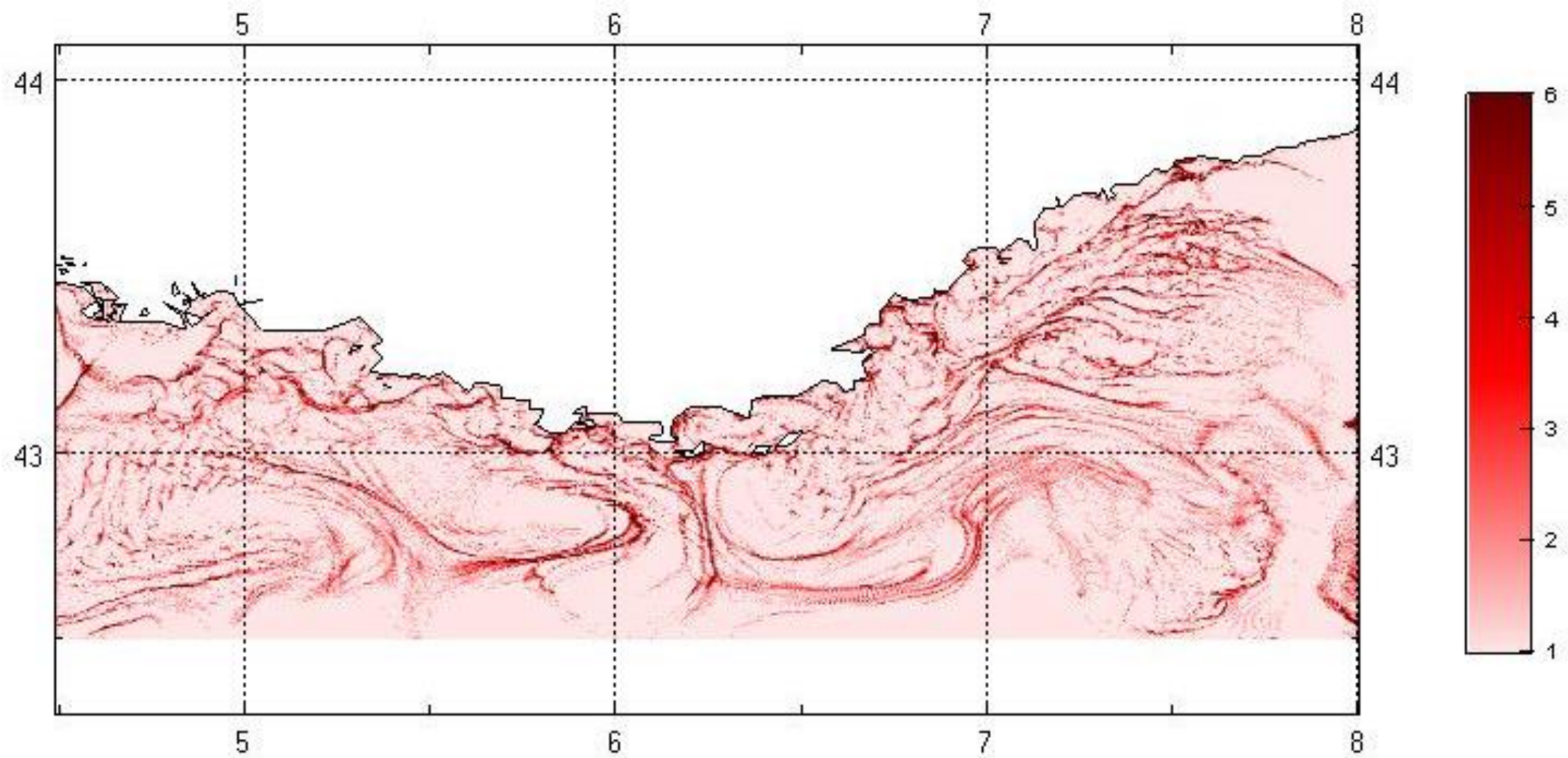
Eurelian Model
Inputs : Velocity , Wind, River flow, litter
Drift velocity : (velocity ,3%wind)
Diffusion : Random walk
Outputs : Litter spatial concentration

Lagrangian Model :
Inputs : Velocity, River flow Previous test, litter
Process & Storage : C_Tep
Advection : RK4, RK5
Outputs : Litter updated position,
Show : Animation of litter trajectories, images of litter positions

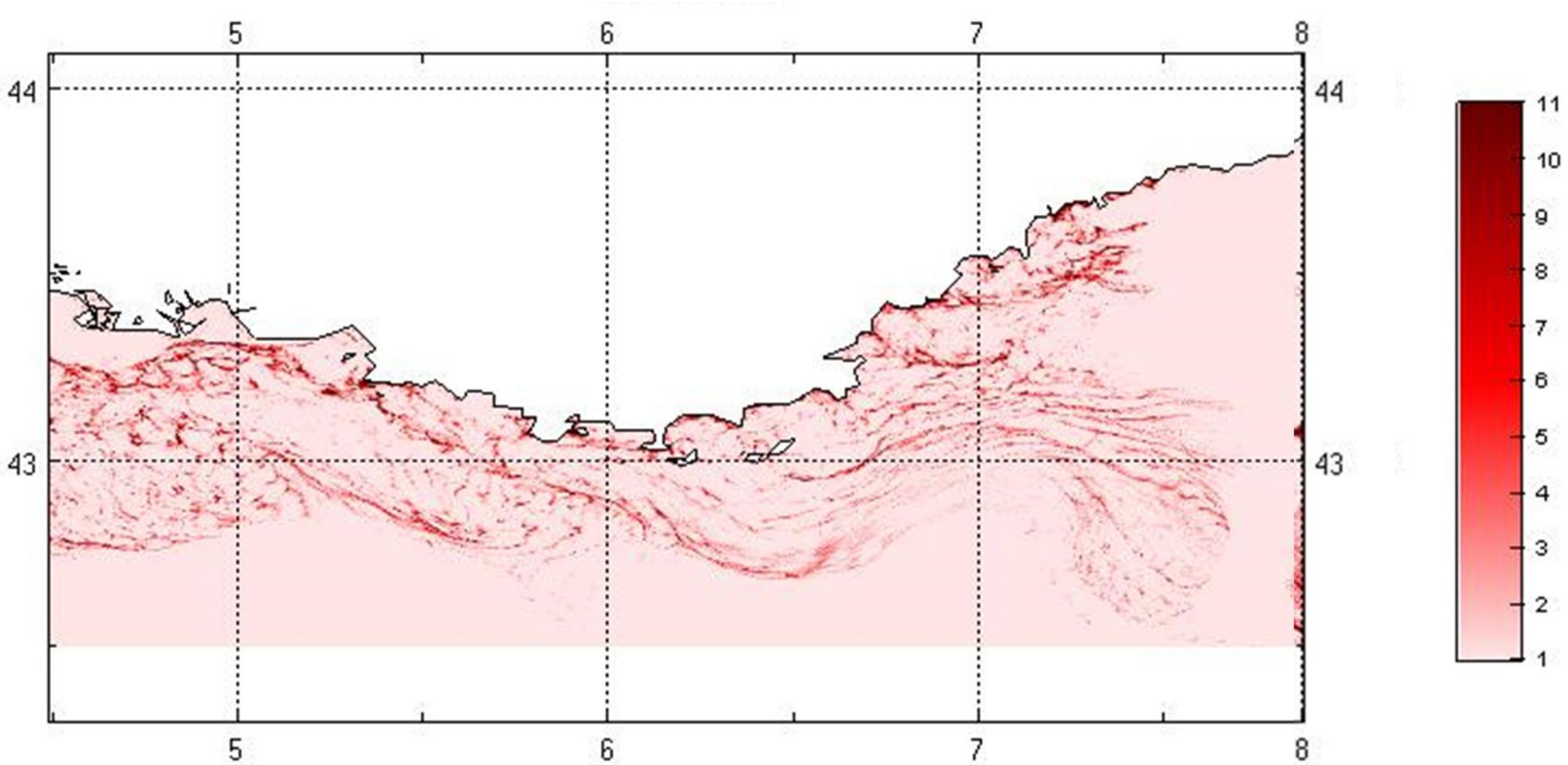
Stranding cartography
Products : Map of daily litter beaching in term of quantity
Real time* Hindcast * Forecast at 5 days
Share : Download available

Dispersion of a generalized, uniform and unitary pollution of floating objects

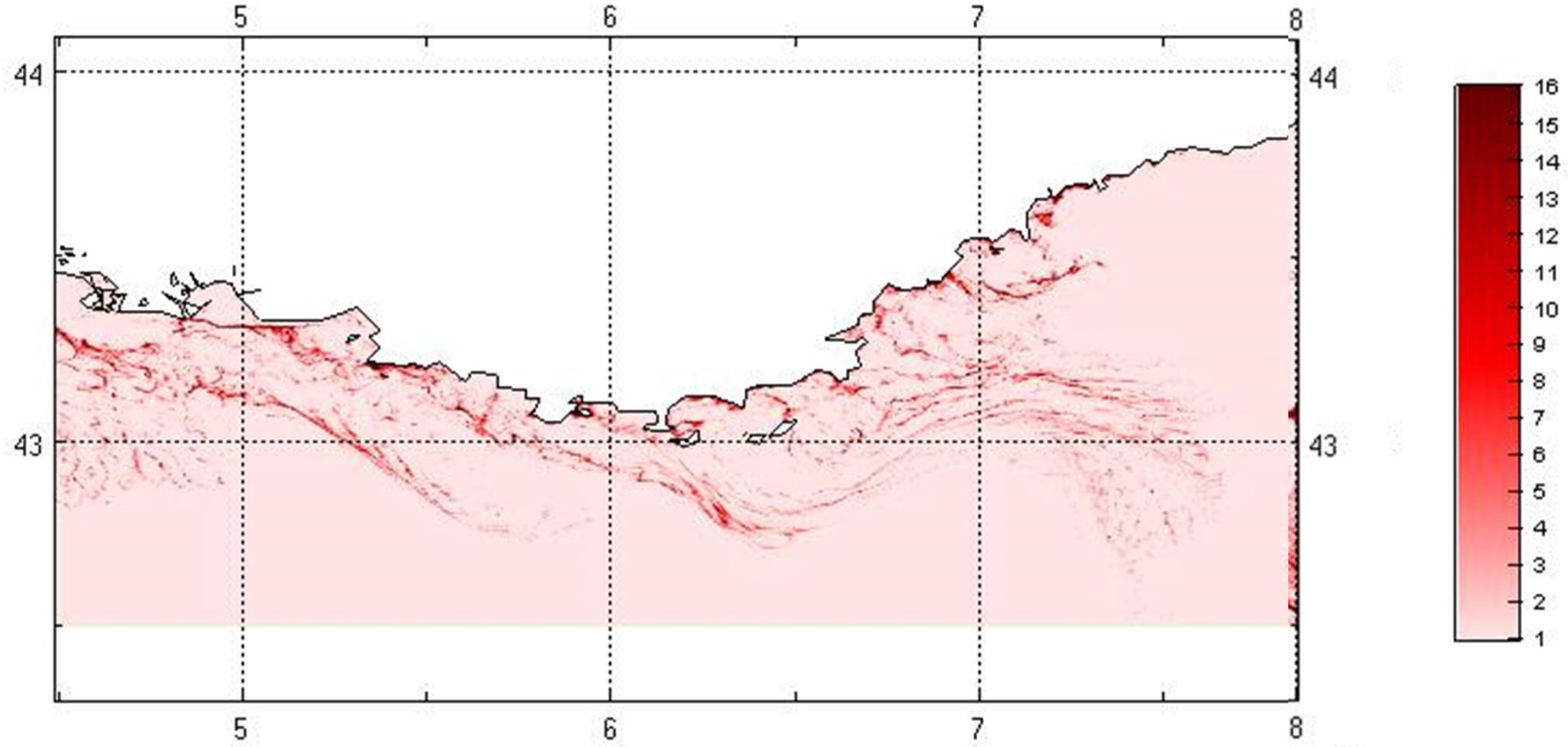
After 12 hours of drift



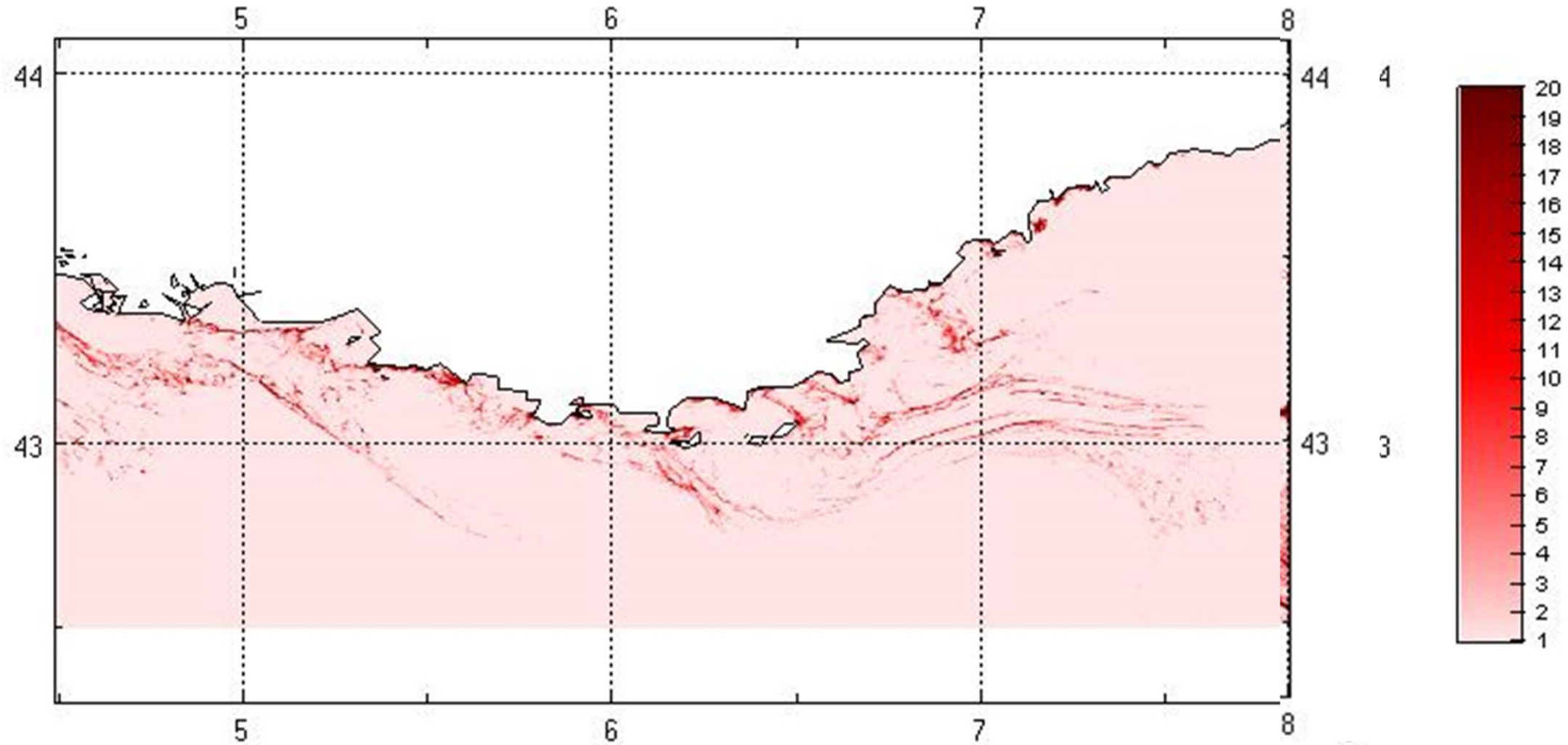
After 24 hours



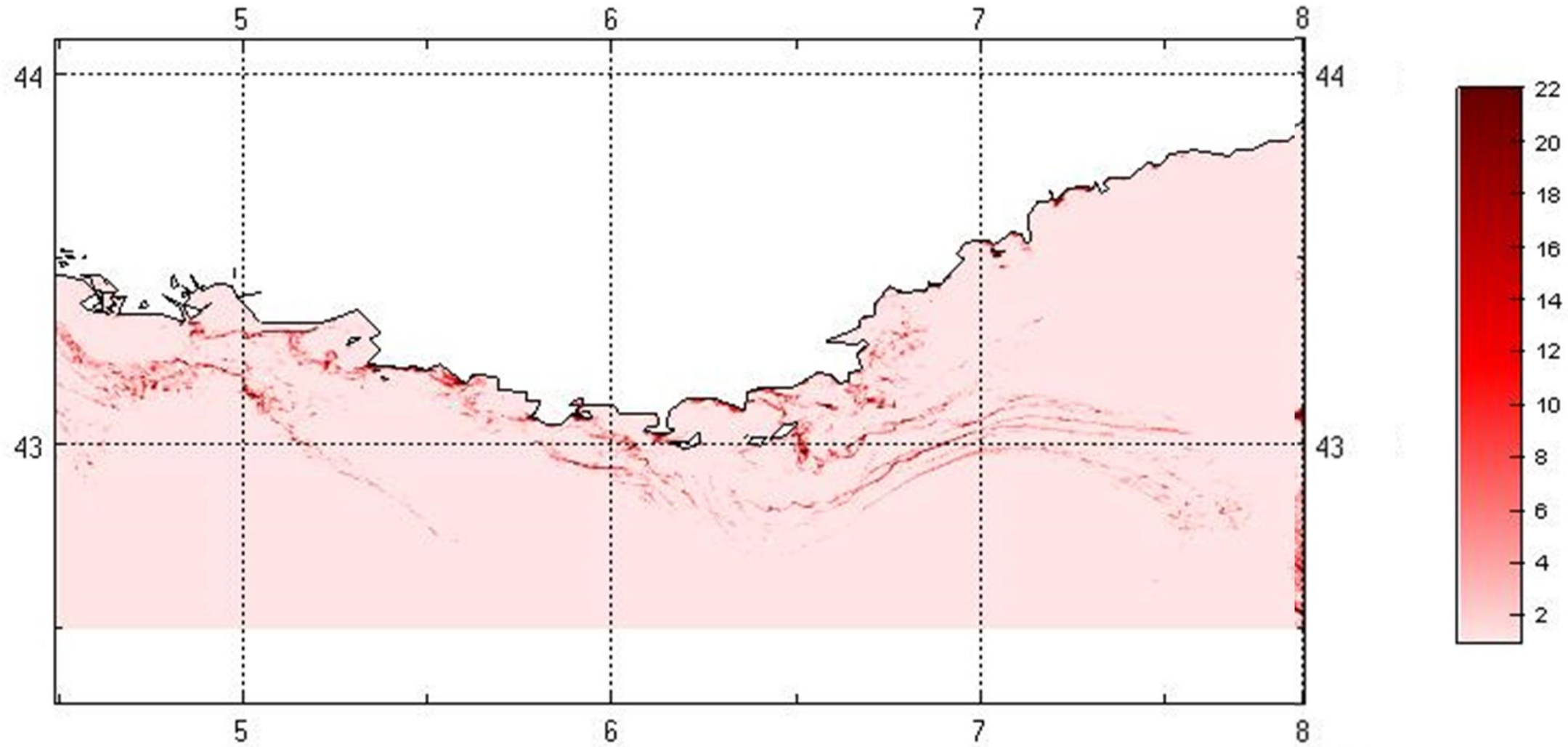
After 36 hours



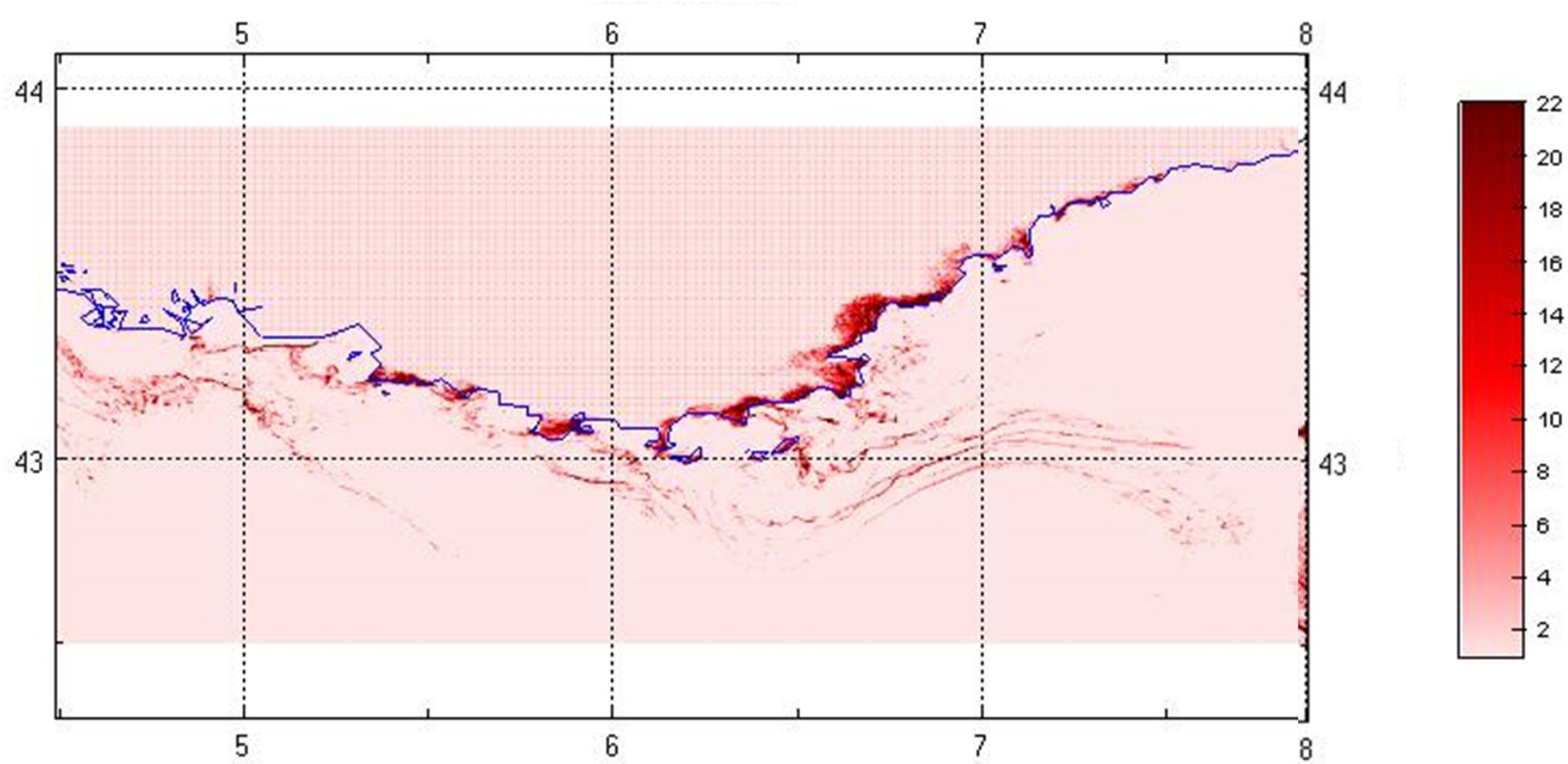
After 48 hours



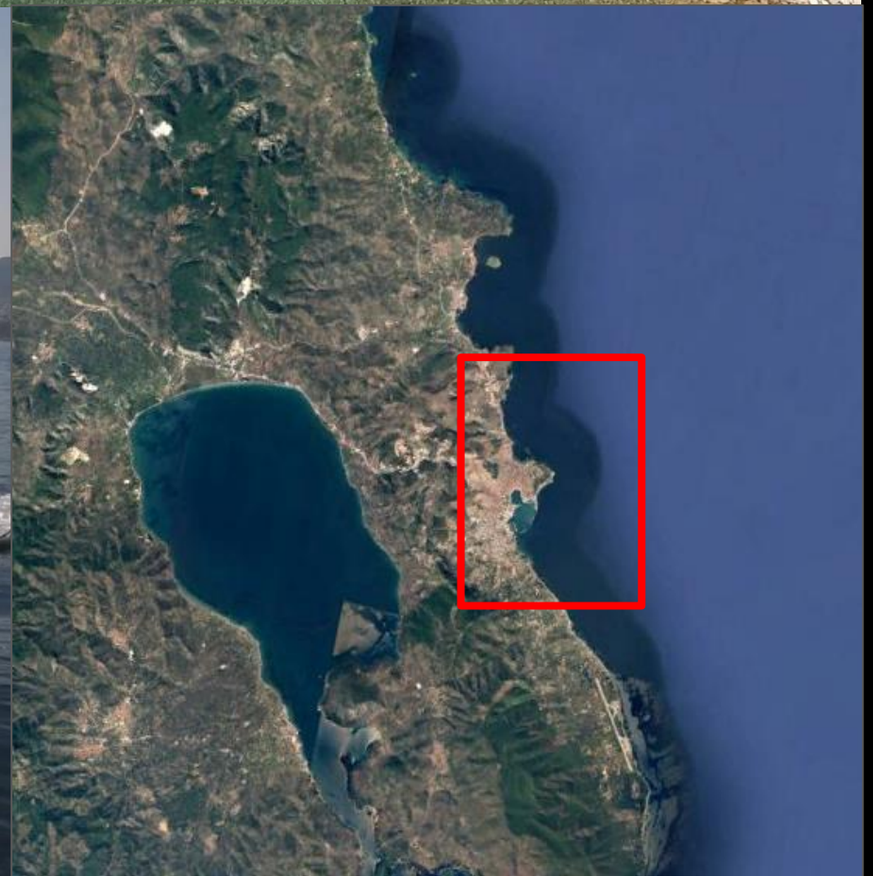
After 60 hours



Beaching/Landing



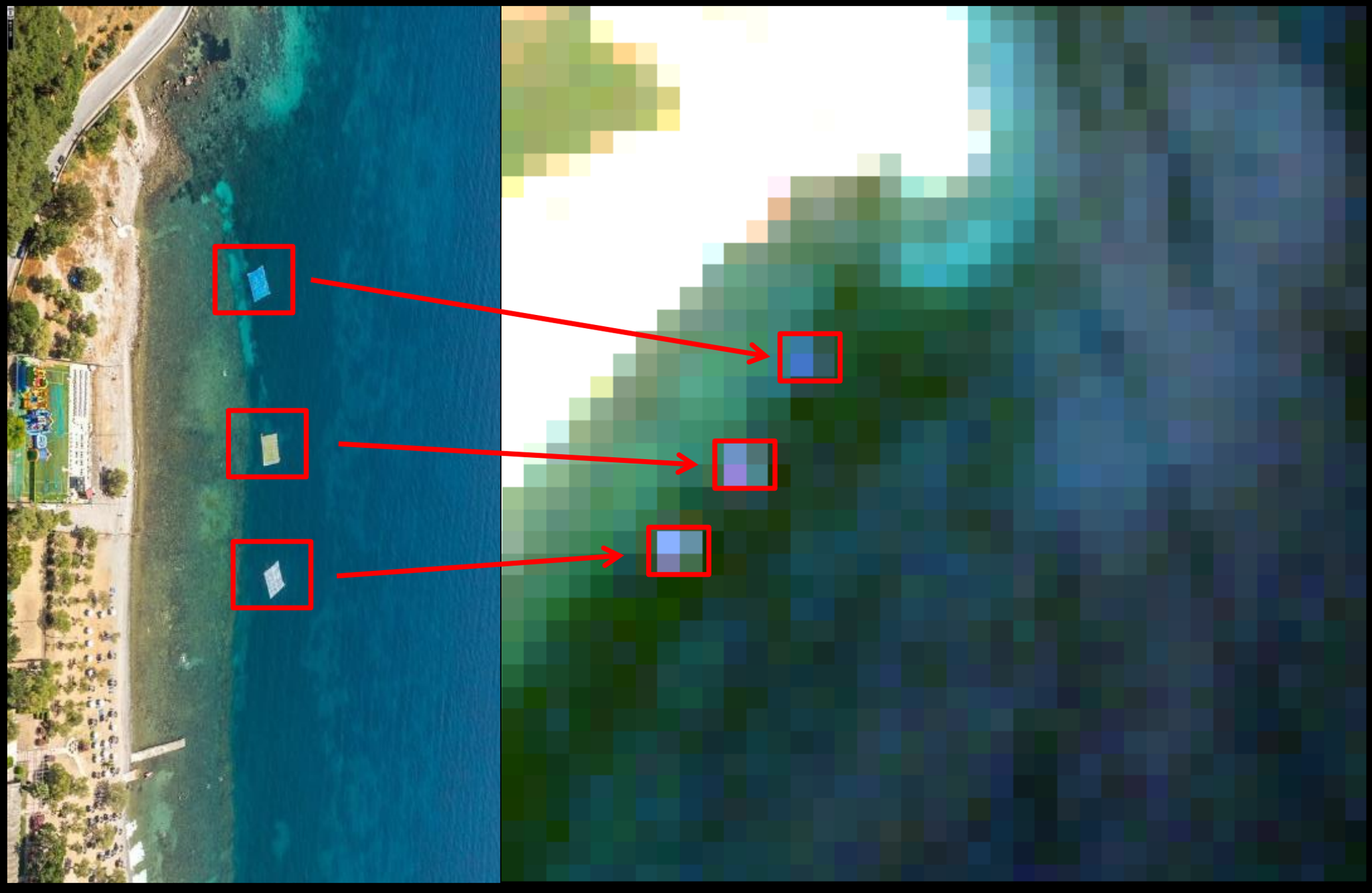
Deployment of 10x10m patches of plastic materials in Lesvos Island. Source: K. Topouzelis



ESA Project: EO Tracking of Marine Debris in the Mediterranean Sea

Deployment of 10x10m patches of plastic materials in Lesbos Island

Sentinel-2/MSI Image Natural colour RGB (Band 4 / 665 nm, Band 3 / 560 nm, Band 2 / 490 nm)

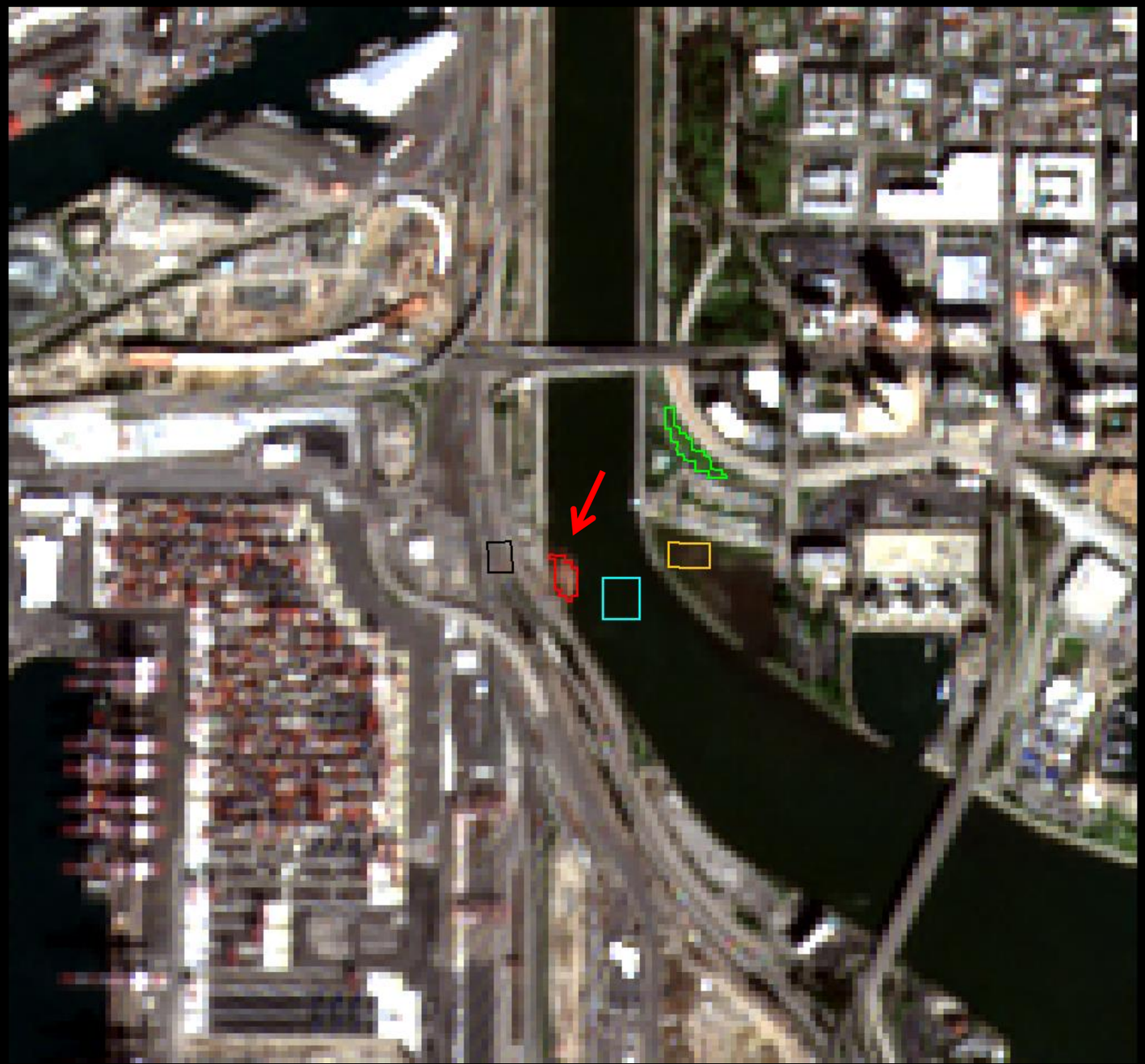


02/02/2018

Proof of Sentinel-2/MSI has capability to observe sub-pixel marine litter

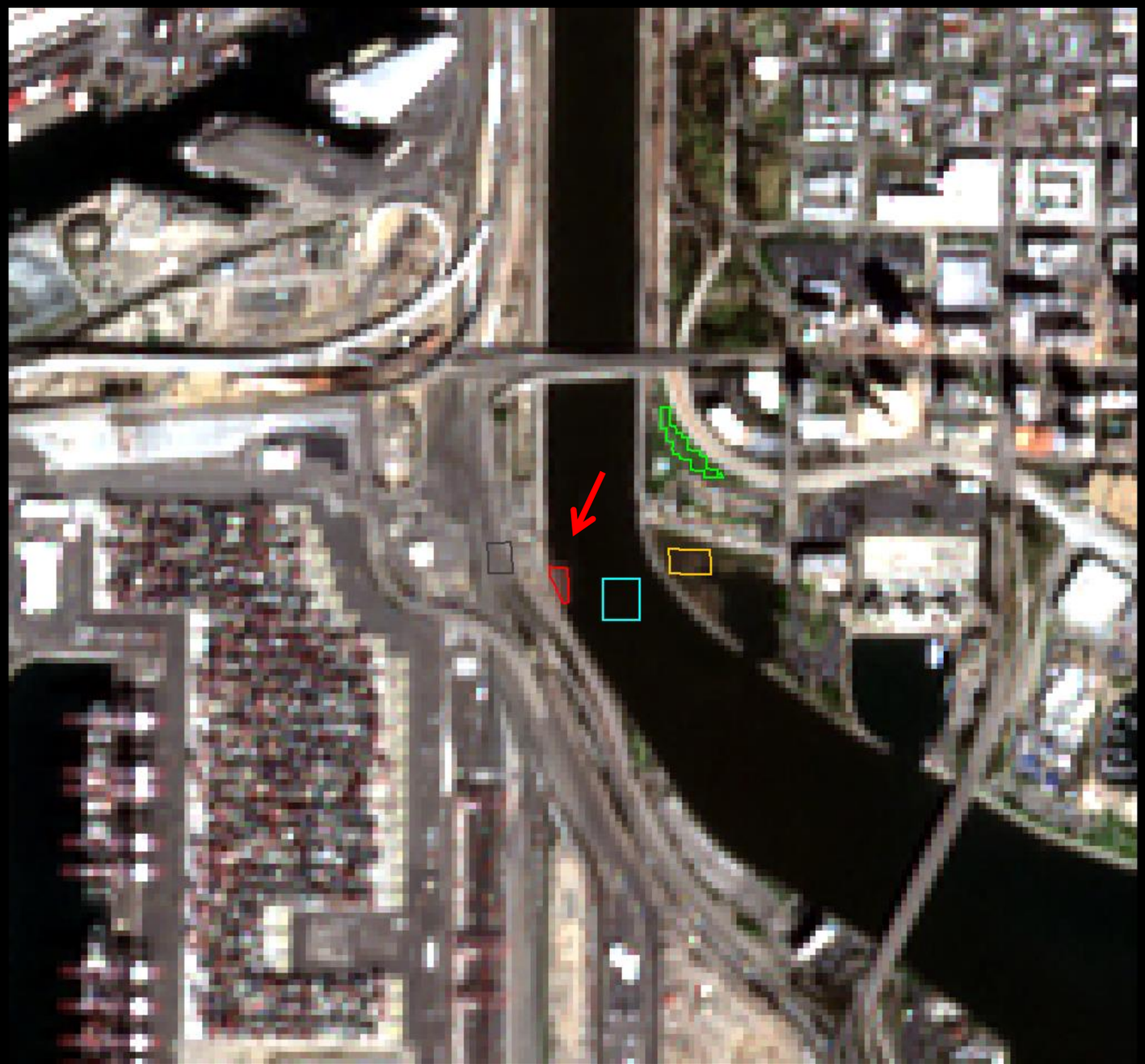
Los Angeles River (U.S.) garbage boom

Source: Google Earth. (Top right) View from the western river bank looking east over the garbage boom during dredging (Unknown date / source). (Bottom right) View from the eastern river bank over the lagoon (Golden Shore Marine Biological Reserve). Source: Google Earth Street view.



L.A. River garbage boom Sentinel-2/MSI Natural color RGB image (Nature Comms, in prep.)

Litter patch observed in the expected location (red polygon)

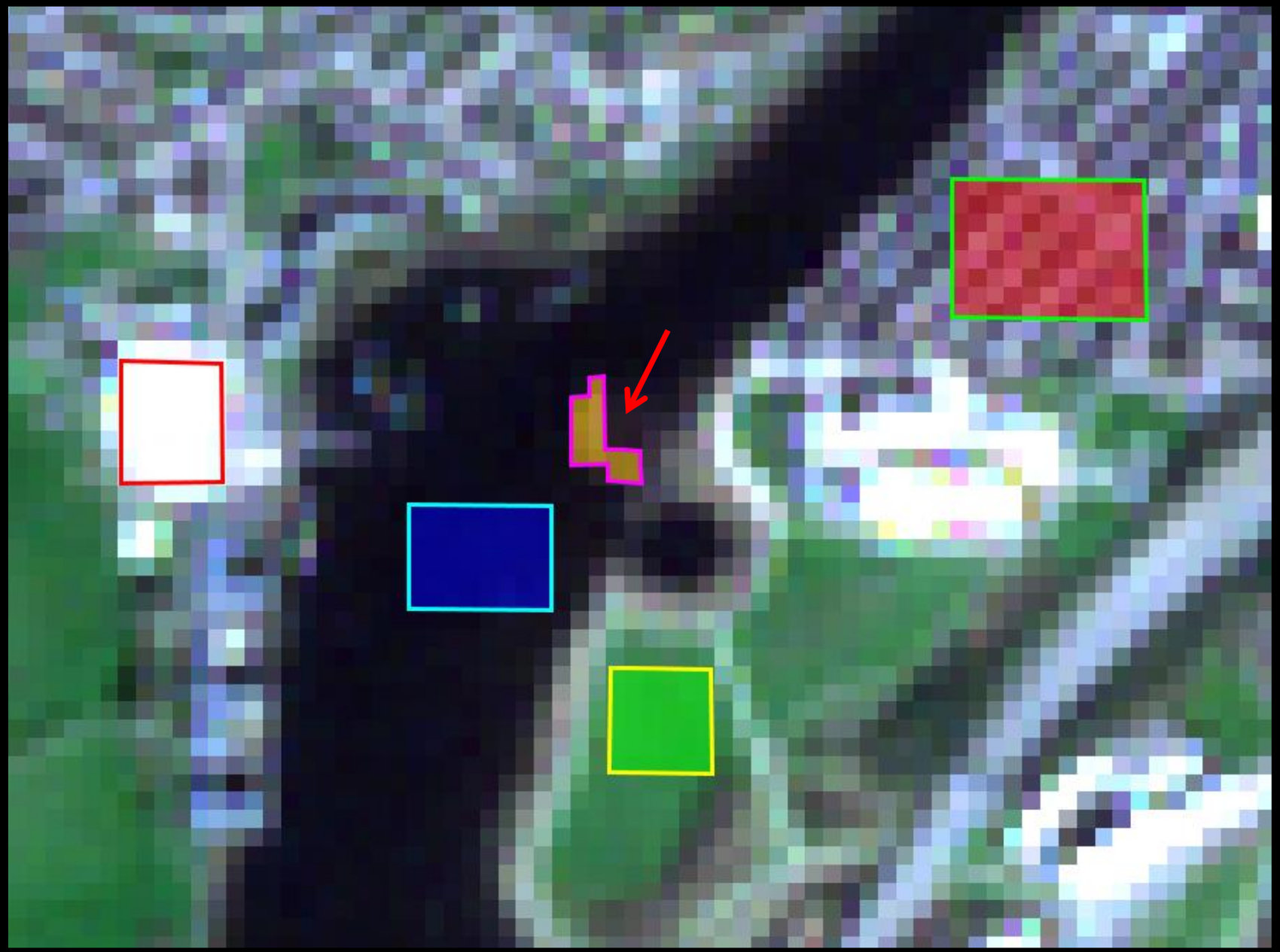


L.A. River garbage boom Sentinel-2/MSI Natural color RGB image (Nature Comm, in prep.)

Litter patch observed in the expected location (red polygon)

Cardiff Bay (U.K.) (Nature Comms, in prep.)

Cardiff bay plastic boom as seen in Google Earth (bottom right) (The litter boom was built as a way to clean the river and Bay area for the upcoming 2018 Volvo Ocean Race (top). Source: BBC News.



UKSA ProjectSSGP – GeoInt Service for Marine Litter

Cardiff Bay (U.K.) garbage patch by Sentinel-2/MSI Natural color RGB image

Litter patch observed in the expected location (purple polygon)

ESA EO Track / UKSA SSGP

Bicaz lake, Romania

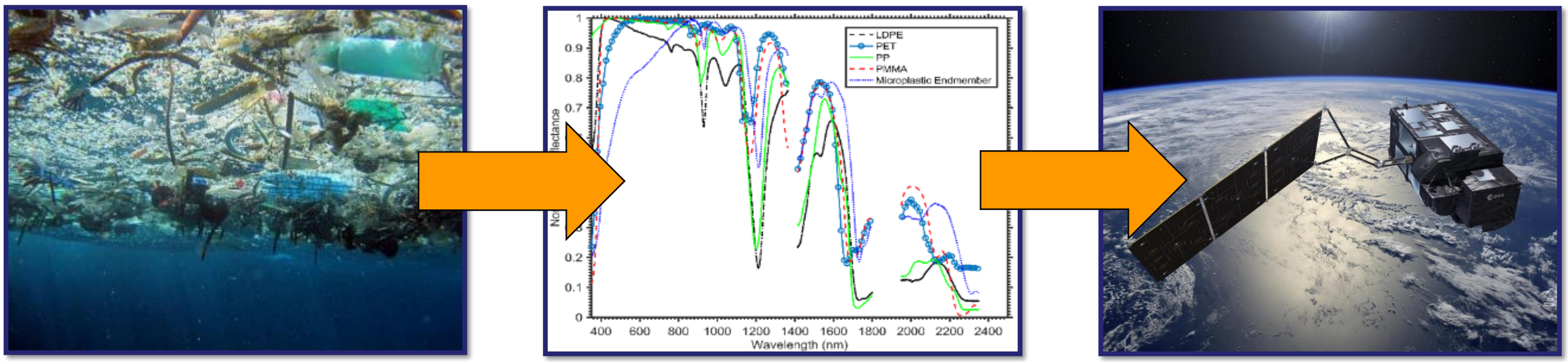
Top Left: Image of plastic bottles and debris littering the waters of the lake. Top right: Google Maps image showing the are affected. Bottom left: BR Business review news about the event. Bottom right: Google maps image of the place.

Bicaz lake by Sentinel-2/MSI Natural color RGB image

Litter (red lines, right figure) could be easier to detect with anomaly detection algorithms

Goals of the RESMALI project

- Characterization of physical properties and meaningful spatial and time scales for marine litter.
- Definition of remote sensing observational requirements of data acquisition for scientific and downstream applications.
- Identification of best potential technologies and instrument ensemble that could compose an EO mission for marine litter.



Characterization of marine litter

- Based on the **marine domain** under consideration

Beaches

Shallow waters

Open Ocean

- Based on the **marine litter fraction** under observation

Large Items

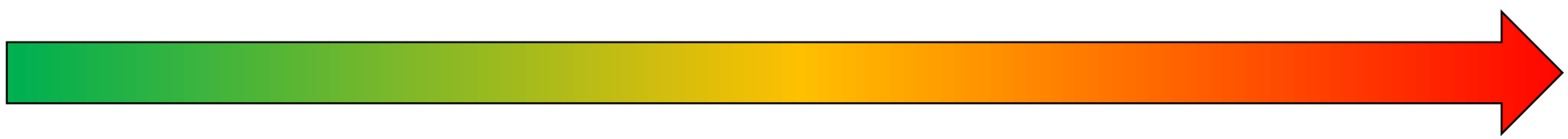
Small pieces and fragments

Microplastics

Characterization of marine litter

ML Characteristic	Domain			
	Open Ocean	Continental Shelf	Coastal Area	Shores & Beaches
Variability	Low (months to years)	Medium (months to weeks)	Medium to High (weeks to days)	Very high (days to hours)
Residence time	Long	Medium to short	Short	Long to short
Origin	Plastics (PP, PE)	Plastics (PP, PE, PS, PET) Organic	Plastics (PP, PE, PS, PET) Organic, Rubber, Paper	Plastics (PP, PE, PS, PET) Organic, Rubber, Paper, Metal
Accumulation factor	Global currents	Wind/currents transport, human activity	River mouths, run-offs, dumping, human activity	Tidal/storm stranding, dumping, human activity

Complexity



Remote Sensing of Environment (in prep.)

Characterization of marine litter

Characteristic	ML fraction			
	> 200mm	200-5mm	5-1mm	<1mm
Abundance	Very low	Low to medium	Very high	?
Total mass	Very high	High to medium	Medium to very low	?
Vertical zoning	0-5m	0-5m	0-5m	?
Main composition	PE, PP, PET, PS	PE, PP, PET, PS	PE, PP	PE, PP

Large items accumulate most of mass but are the less abundant

Smallest fractions are composed by fewer materials

Most of observable ML is found at the surface of the oceans

Remote Sensing of Environment (in prep.)

Observational requirements

MR	Domain			
	Open Ocean	Continental Shelf	Coastal Areas	Shores & Beaches
Spatial Resolution	1000-5000m	20-250m	50-250m	1-50m
Time Resolution	2w – 2m	1-2w	3-7d	<1-7d
Coverage	Global	Global	Regional	Regional
Water penetration	Not essential	Added value	Desirable	N/A

MR	ML fraction			
	> 200mm	200-5mm	5-1mm	<1mm
Spatial Resolution	0.2-1m	20-250m	1-5km	1-5km
Time Resolution	<3d-4w	1-2w	2w – 2m	2w – 2m
Coverage	Global	Global	Global	Global
Water penetration	Not essential	Desirable	Added value	?

Remote Sensing of Environment (in prep.)

Potential applications of interest

- Detection and monitoring of large ML items (> 200mm) at ocean
- Global quantification of concentrations of ML
- Monitoring of hot spots and accumulation zones
- Monitoring of river mouths as main input flow for ML at the oceans
- Detection, monitoring and quantification of ML at shores and beaches

Thank you!