Settings methodologies for monitoring floating marine macro litter: the MEDSEALITTER effort

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MSFD and UNEP-MAP requirement on floating litter

COMMISSION DIRECTIVE (EU) 2017/845 of 17 May 2017 amending Directive 2008/56/EC of the European Parliament and of the Council as regards the indicative lists of elements to be taken into account for the preparation of marine strategies	**Theme: Substances, litter and energy** **Assessments of pressures** (Intensity and spatial and temporal variation of pressures on the marine environment and, if pertinent, at the source)
Guidance for assessments under Article 8 of the Marine Strategy Framework Directive Integration of assessment results February 2017	**Primary Criteria** Pressure: **D10C1** and D10C2 relate to the level of the pressure (litter and micro-litter) in the marine environment (coastline, **surface layer of the water column**, sea-floor and sea-floor sediment, as appropriate).
Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria UN Environment/MAP Athens, Greece (2017).	UN Environment/MAP will develop a specific Monitoring of floating litter protocol, on a regional basis. Common indicator**:** **Floating litter** (items/km2) Min value = 0; Max value = 195; mean value 3,9; Baseline 3-5.

Scope of FML monitoring

1) amount, distribution and composition of litter;

2) rates at which litter enters the environment (sources);

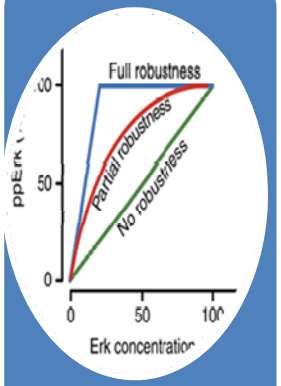
3) spatial and temporal variations;

4) impacts of litter.

...but which protocol??

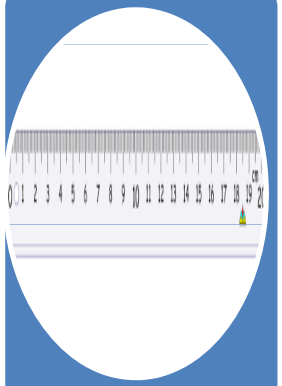
Scale of use:

- Geographical scale



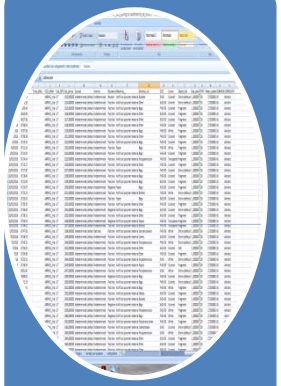
Scientific validity:

- Measurability
- Discriminatory power
- Reproducibility
- Comparability of the data
- Representativeness
- Sensitivity
- Complexity of information of the descriptor
- Early sign



Measurement method:

- There is a standard method
- Unit of measure
- Measurement method
- Elab method

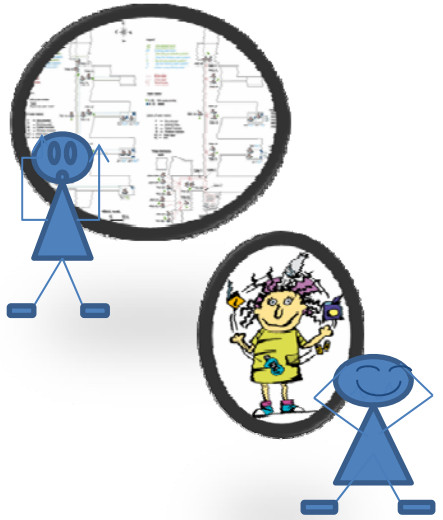


Previous data:

- Existence of previous data
- Existence of data validation systems
- Areas covered by the data
- Sampling start date
- Frequency of sampling
- Representation

Practical and programmatic considerations

- Complexity of application (level of specialization of the required professional skills)
- Application costs
- Understandable for the general public



MSFD:

- Pertinent and timeliness indicator to identify:
  - GES
  - Target
  - Effect of measures

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A priority issue is the development of widely agreed standardized monitoring protocols to be implemented under the Marine Strategy Framework Directive, supporting Marine Protected Areas (MPA).

MEDSEALITTER aims at networking MPAs, scientific organizations, NGOs for developing and testing efficient and cost-effective MEDiterranean-SpEcific protocols to monitor and manage litter impact on biodiversity.

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MEDSEALITTER timeplan

WP3-Studying
Gen. 2017 – Gen. 2018

WP4-Testing
Feb. 2018 – Apr. 2019

State of the art on existing monitoring methods of floating macro-litter and ingestio
WP3 – STUDYING
Deliverable 3.2.1 MEDSEALITTER

INTRODUCTION
Reduction of marine litter -any persistent, manufactured or processed solid material disposed of or abandoned in the marine and coastal environment- is globally acknowle major societal challenge of our times due to its significant environmental, economi political and cultural implications (Cheshire et al. 2009; Galgani et al. 2010). Marine litte the main causes for sea pollution and it is dominated by plastics (Barnes et al. 2009; Coe 1997; UNEP 2015)
First measures to tackle marine pollution were taken by the OSPAR 72/74 conventio International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), the main policy drivers of monitoring of coastal and offshore waters. More recently directives started to specifically target the reduction of waste and to monitor progres measures: the Waste Directive (2008/98/EC), the Packaging Directive (94/62/EC) and carrier bags Directive (2015/720/UE amending 94/62/EC) ask Member States to reduce average production of waste and consumption of plastic bags. Other European introducing the ecosystem-based approach have been largely integrated in the existing me enforced into State legislation. These directives, such as the Water Framework Directive (2000)and the UNEP/MAP Regional Plan for Marine litter Management in the Med (UNEP/MAP IG.21/9), highlight that policy drivers may change over time but maints overall purposes. In 2008, the European Commission adopted the Marine Strategy F Directive (European Commission, 2008/56/EC) whose objective is to achieve Good Envi Status (GES) by 2020, considering 11 qualitative Descriptors. Marine litter is Descriptor Directive and GES is reached when the *"properties and quantities of marine litter do harm to the coastal and marine environment"* (European Commission, 2008/56/EC; Gal 2010).
However, the lack of comparable data across all seas still presents a major obstacle for an marine assessments. Effective measures to tackle marine litter are in fact seriously hampe insufficient scientific data (Ryan 2013). To monitor effectiveness of measures, the nee accurate and coherent monitoring on marine litter is evident in order to set priorities protection actions in a cost-effective way (Cheshire et al. 2009; Galgani et al. 2013a; She UNEP 2015).

The Mediterranean context
Information on marine litter in the Mediterranean Sea, considered as one of the most aff by marine litter worldwide, is still limited, inconsistent and fragmented (Barnes et Jambeck et al. 2015). The Mediterranean Sea was designated as a Special Area under Annex V, that prohibited the disposal of garbage at sea and lead to the establishment o port reception facilities for garbage: nevertheless, the efficiency of the shoreside mana waste often remains in doubt. A pilot survey organised in 1988 by UNEP/MAP and assessments showed that the main sources of coastal litter in the basin are river run activities and coastal urban centers (MAP/UNEP, 2001; UNEP 2015). Additionally, at-se such as shipping and fishing grounds can heavily contribute to the inputs of litter contexts (Carić & Mackelworth 2014; Coe & Rogers 1997; Vlachogianni et al. 2016).

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Del. 3.3.2 - Shared monitoring protocols _ first draft

Shared monitoring protocols
first draft of shared protocols for marine litter monitoring

WP3 – STUDYING Deliverable 3.3.2 MEDSEALITTER

Compiled by:
- ISPRA- Italian National Institute for Environmental Protection and Research- ITALY
- Capo Carbonara MPA Comune di Villasimius - ITALY
- Cinque Terre National Park and Marine Protected Area- ITALY
- EcoOcéan Institut- FRANCE
- Hellenic Centre for Marine Research (HCMR) – GREECE
- Legambiente ONLUS - ITALY
- MEDASSET – GREECE
- The École Pratique des Hautes Études (EPHE) – FRANCE
- University of Barcelona - SPAIN
- University of Valencia- SPAIN

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Testing and experimenting the protocol

Final protocol for monitoring floating macro litter and litter ingested by biota at local and wide areas

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Variables and covariates influencing detectability and identification of litter items

Variables
• Number of items
• Size class
• Composition
• Geographical position

Covariates (observation parameters that could influence the sighting probability)	
a)	Sampling design and period
b)	Type of platforms (height and speed)
c)	Techniques
d)	Experience of the observers
e)	Weather and visibility conditions
f)	Strip width
g)	Size of items: lower size limit, classes
h)	Type and colour of items

Preview data for:

- *Site selection*
- *Frequency of sampling*
- *Sample unit*

New experiments using:

- *Ship based surveys:*
  - *-Inflatable;*
  - *-Sailing boat;*
  - *-Ferries.*
- *Aerial surveys:*
  - *-Drone;*
  - *-Aircraft.*

Visual observation
Automatic recording

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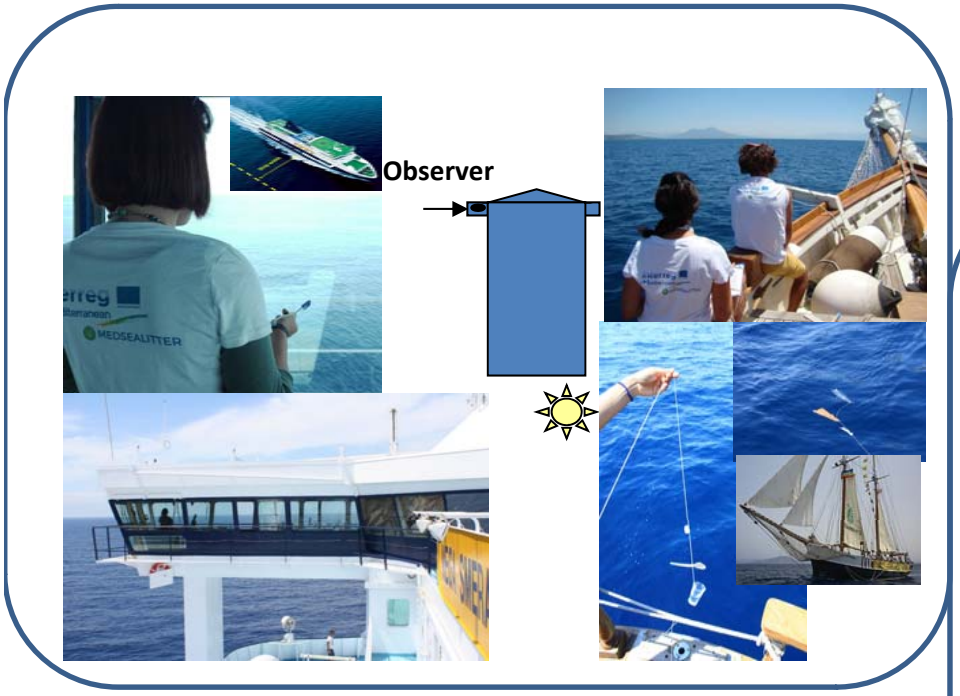
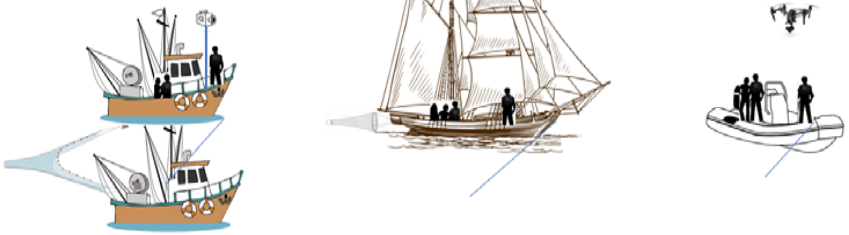
Experimental designs for protocol implementation

Pilot large basin-wide scale

surveys from *ferries* and *sailing vessel*.

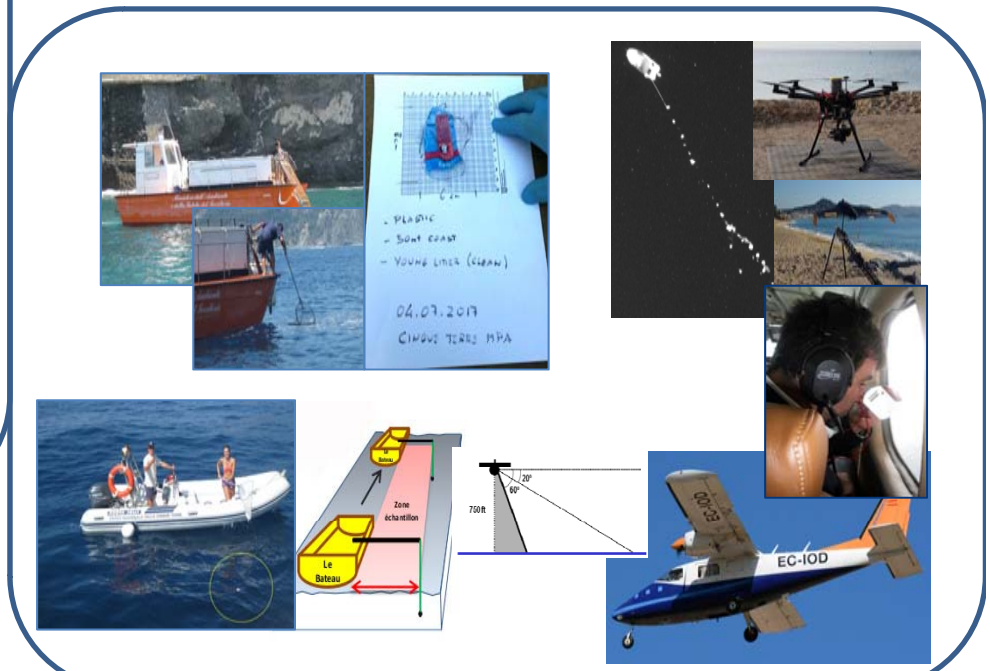




Local pilot MPAs

a) visual surveys conducted from *commercial vessels*, *sailing vessels* and *aircrafts*

b) analyses of automated photographs obtained from *aircrafts* and *drones* surveys.



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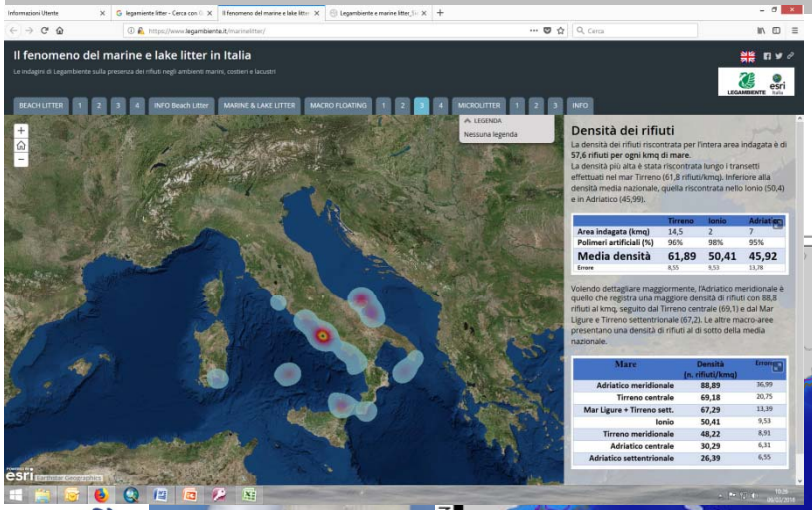
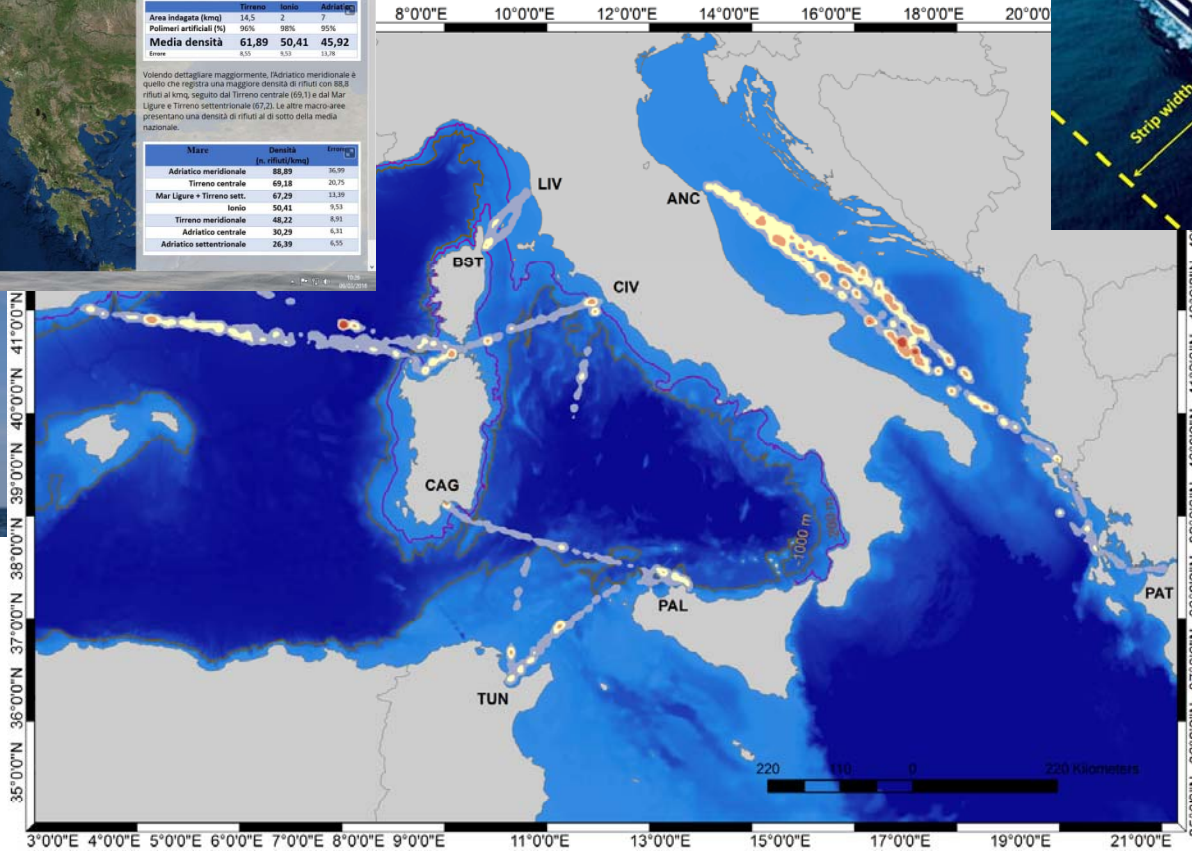
Sampling design: *Site selection*





342 sampled transects
2700 Km^2 surveyed
7746 items recorded

Arcangeli et al., 2018. Amount, composition, and spatial distribution of floating macro litter along fixed trans-border transects in the Mediterranean basin. Marine Pollution Bulletin. ISSN 0025-326X,https://doi.org/10.1016/j.marpolbul.2017.10.028

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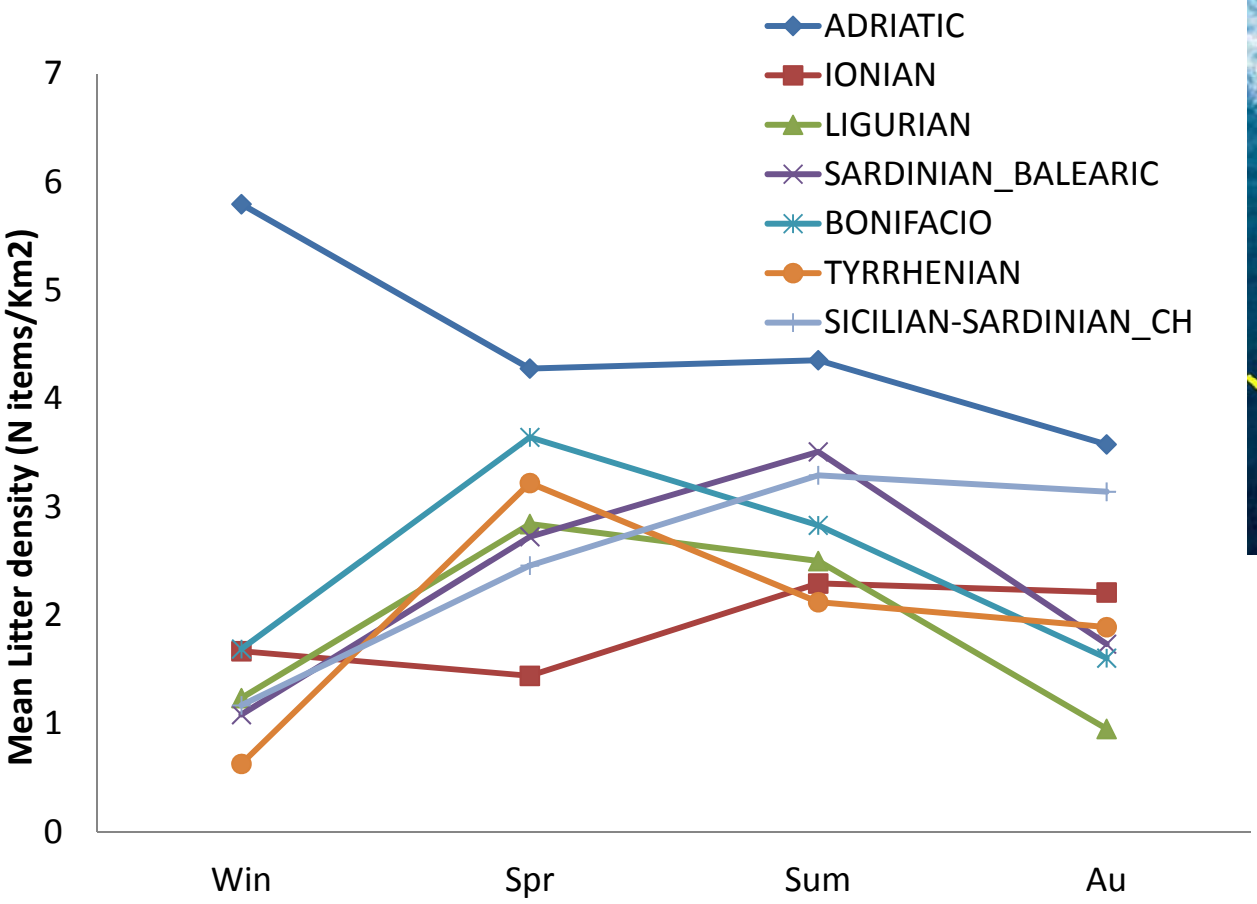
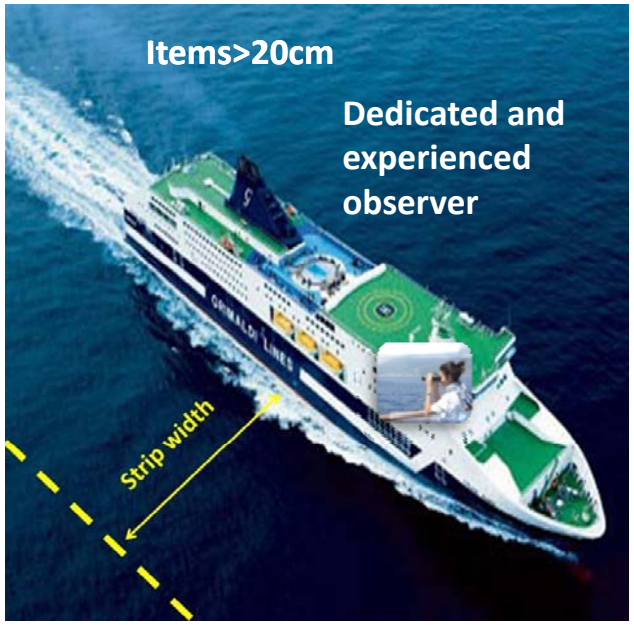
Sampling design: frequency of sampling





30.000 km surveyed
7746 items recorded

Arcangeli et al., 2018. Amount, composition, and spatial distribution of floating macro litter along fixed trans-border transects in the Mediterranean basin. Marine Pollution Bulletin. ISSN 0025-326X,https://doi.org/10.1016/j.marpolbul.2017.10.028

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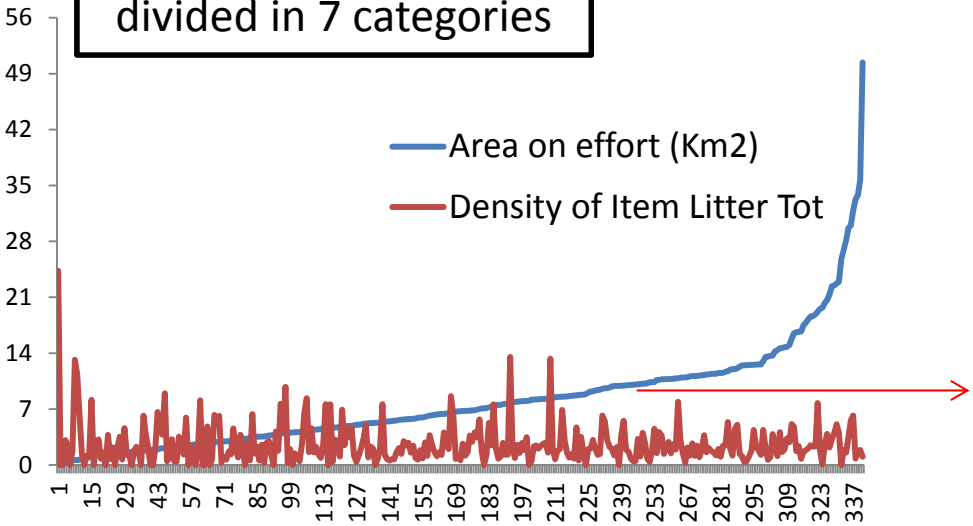
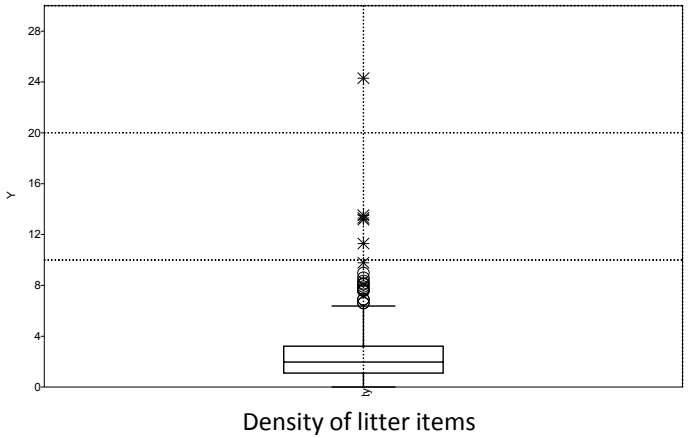
Sampling design: sampling unit

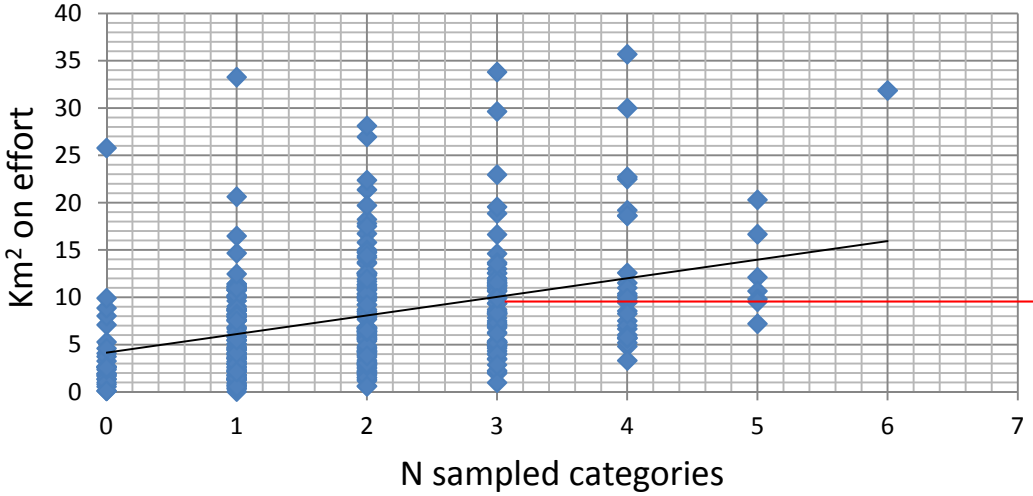
Based on a total population of 50 items, divided in 7 categories



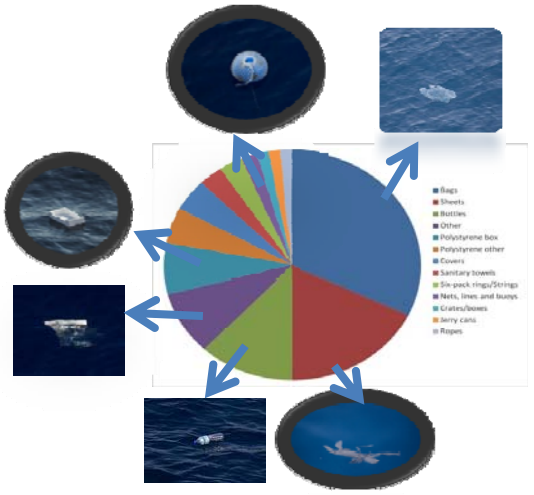


No outliers over 8 km² of effort

Variance: Z score±2, average effort ≥ 8 km²



≥ 10 km² of effort to detect 3 categories



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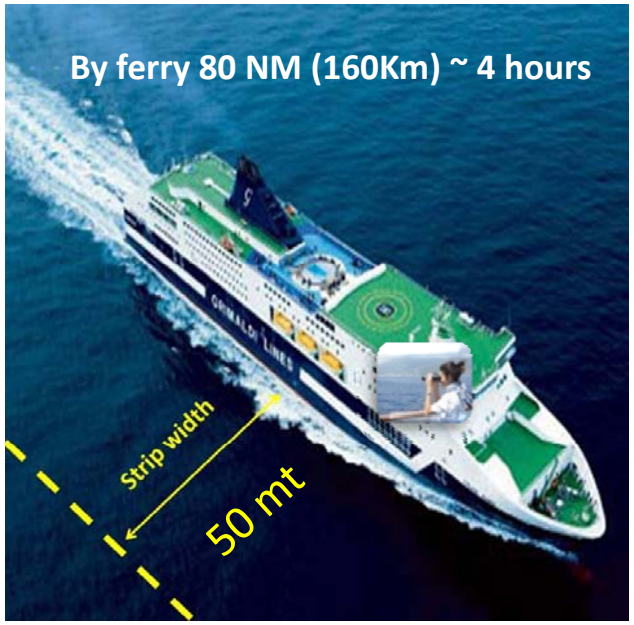
Sampling design: sampling unit

Based on a total population of 50 items, divided in 7 categories

Strip width	Km linear
100 m	80 Km
50 m	160 Km
10 m	800 Km

8 Km²

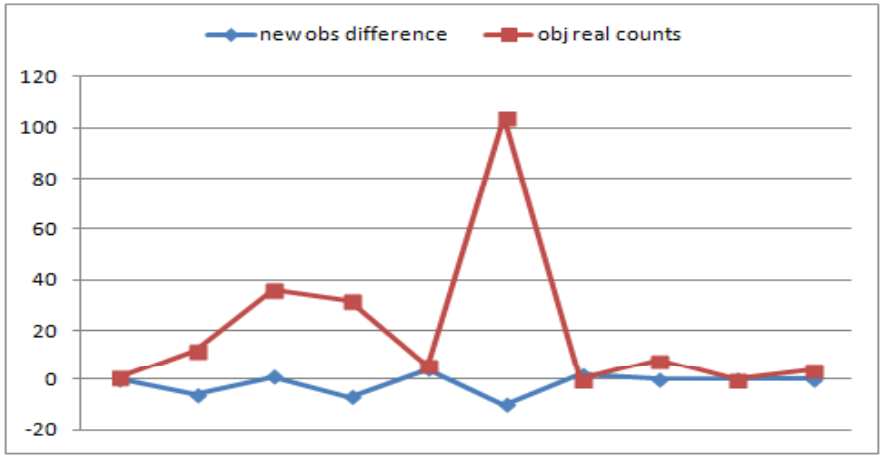


In high sea area, with lower density, is more efficient to use large vessel

Conversely in high density coastal areas, small vessels could be more suitable

Experience of observers

Double observers experiment



Difference in the number of objects detected by the two observers

The interobserver reliability test (Kappa coefficient) resulted in a Kappa coeff. = 0.08 so with a slight agreement between the two observers (range 0 -1).

NEXT: further experiments using an experienced observer and a camera recording the same strip, and with a direct collection and analysis of litter composition

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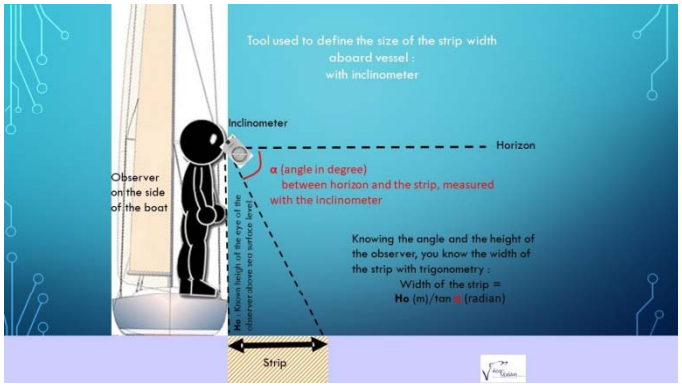
Strip width

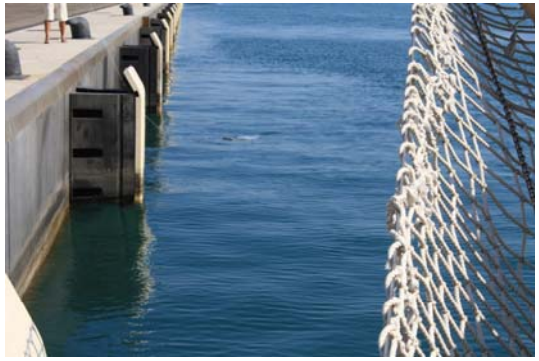
Measuring stick

Graduate pole

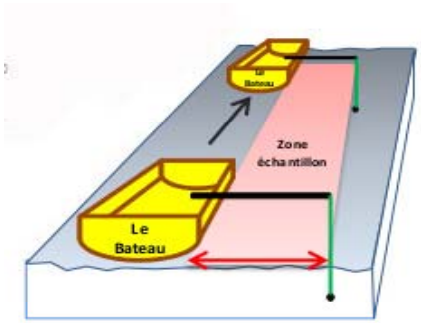


Inclinometer

Range finder



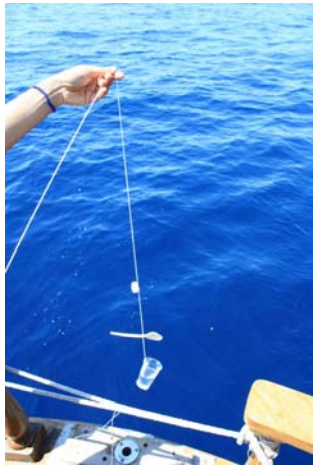
Training with known distance

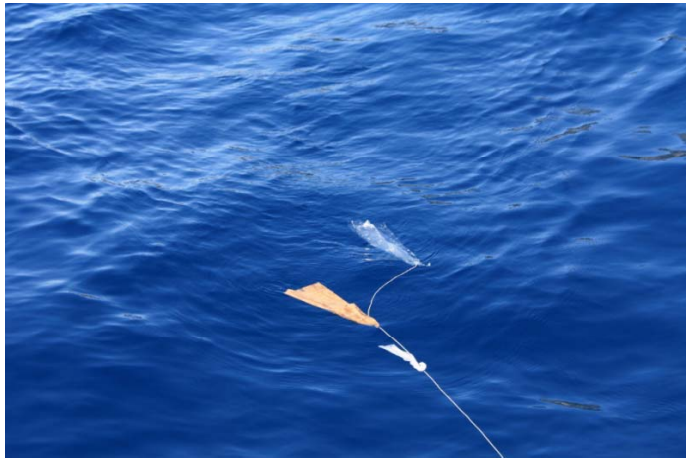


A pole to delimit the strip width

Strip width

Array with multiple items at different distance from the observation:

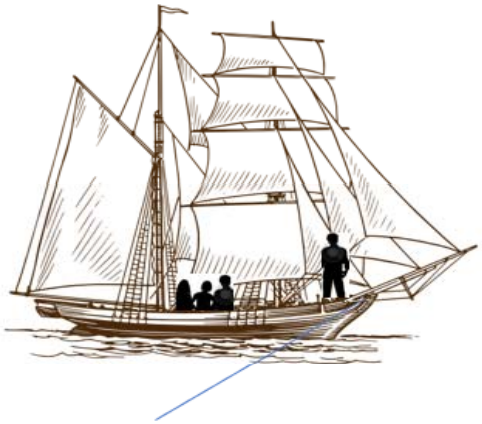


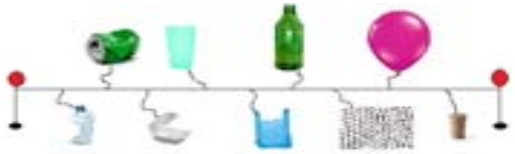


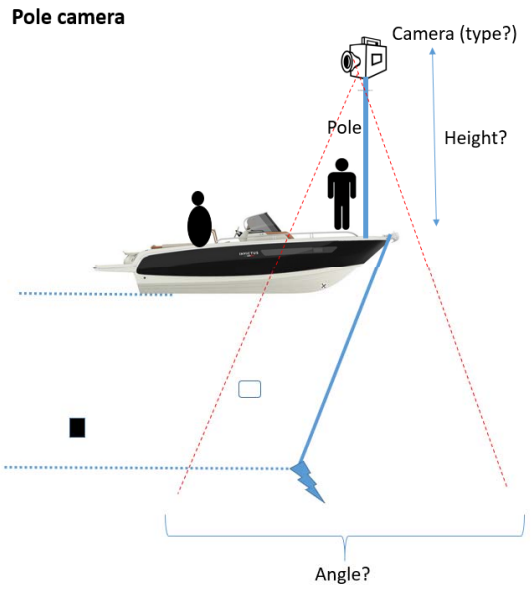
ITEM	COLOR	SIZE CLASS	MATERIAL	5 m	10 m	20 m
Plastic sheet	transparent	F	artificial polymer	ok	vis,no dist	NO
Paper bag	brown	F	paper	ok	ok	Ok
Bottle 1.5 l	transparent	F	artificial polymer	ok	ok	Ok
Bar tissues	white	D	paper	ok	ok	vis,no dist
Plastic cutlery	white	D	artificial polymer (bio)	ok	ok	vis,no dist
Drinking glass	transparent	C	artificial polymer(bio)	ok	vis,no dist	NO
Bottle cover	white	B	artificial polymer	ok	ok	vis,no dist

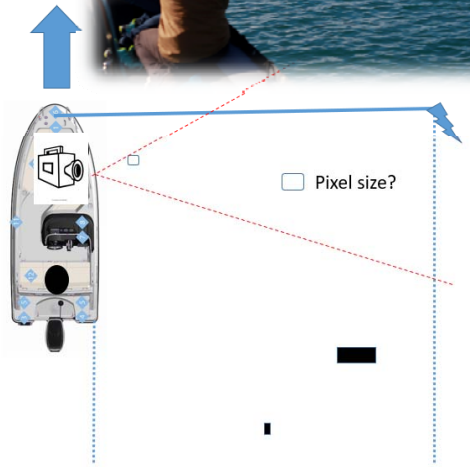
The experiment confirmed the maximum detection distance from this sailing vessel is 10 m, where all size of items are visible.

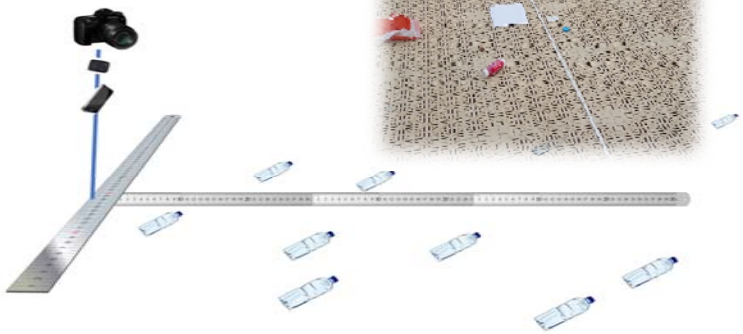
Strip width











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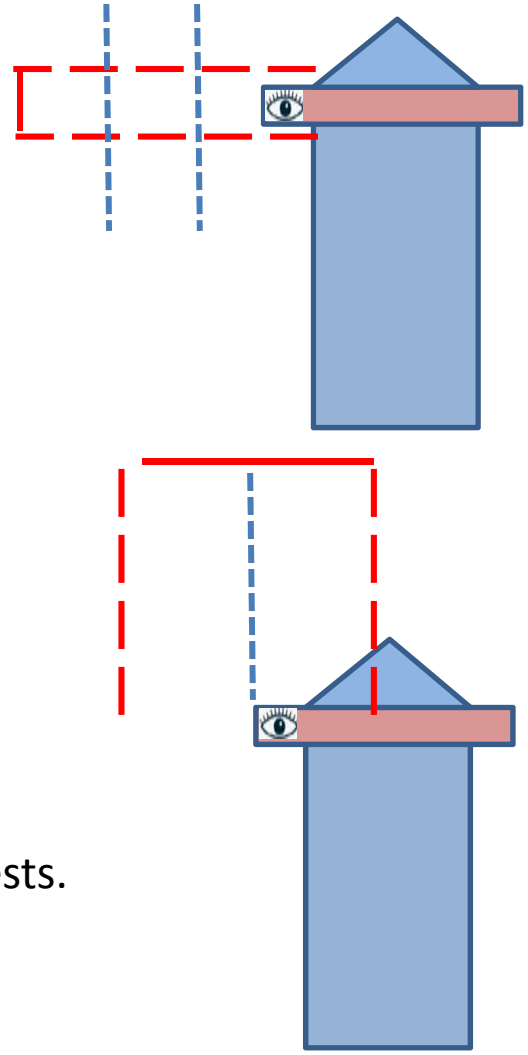
Strip width

*Experiment difference strip in the **front** and on the **side** is still ongoing*

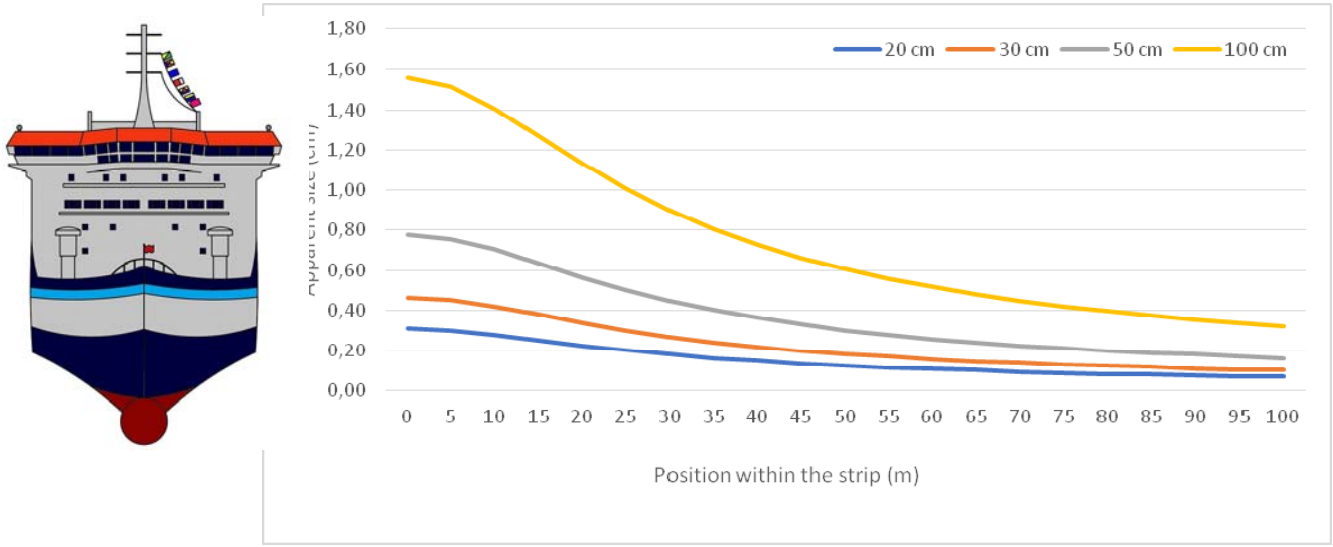


Experiment with strip in the front or on the side

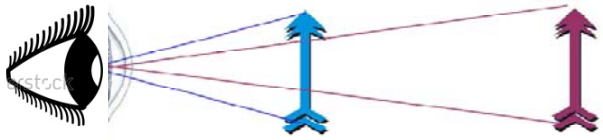
- 12 replicates, in total 1.500 travelled
- No significative difference with paired comparison statistical tests.

Size of items

Real size (s) = Height of the observation x size measured with the ruler / distance between eye and ruler



Influence of the position of the litter within the strip, on its apparent size, for 4 different real sizes (20, 30, 50 and 100 cm).



Rule of thumb: doubling the distance, halve the apparent size of the object

Optimal capacity to detect object size is based on known item

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Size of items

Top 20 categories from boat based survey

Reference for size classes

Common marine species size from aerial survey

ITEM	SIZE (cm)	SIZE CLASS	MATERIAL
Plastic bag standard	30-50	F	artificial polymer
Crates standard	50	F	processed wood
Polystyrene box	45-50	F	artificial polymer
Paper bag	30-40	F	paper
Maritime buoy medium	32-45	F	artificial polymer
Bottle 1.5 l	33	F	artificial polymer
Cover, bucket top	30	E	artificial polymer
Bucket standard	29	E	artificial polymer
Jerry can	27	E	artificial polymer
Sanitary towel	24	E	artificial polymer
Six-pack rings	22	E	artificial polymer
Plastic tableware	22-23	E	artificial polymer
Bottles 0.5 l	22	E	artificial polymer
Plastic cutlery	20	D	artificial polymer
Bar tissues	15-17	D	paper
Drink cans	11	D	metal
Drinking glass	9	C	artificial pol/paper
Cigarette box pack	9	C	paper
Tetrapack small brick	8,5	C	paper
Cotton bud stick	8	C	artificial polymer
Small coffee cup	5	B	artificial pol/paper
Bottle cover	3	B	artificial polymer
Cigarette butt/filter	2,5	B	artificial polymer

Size category

Small = 30cm – 1m

Medium = 1m – 2m

Large = >2m

Loggerhead turtle juv. ≈ 30cm

Striped dolphin adults ≈ 2m

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Type and colour of items

Recorder		Date	Area
Transect nº		Glare area:	
Sun position (horizontal):		Sun position (Vertical):	
Start	Coordinates	Stop	Coordinates
	Time		Time

Observer		Lon	Lat	angle	COMPOSITION																														Class	Size	Buoyancy	Source	Likely use	Color	Foto
Left	Right				Natural Marine Litter			Antropomorphic Marine Litter																																	
					Vegetable		Animal	Plastic					Polystyrene			Glass		Paper/Cardb				Rubber			Procesed wood			Textile				Metal		Oil							
					Seaweed/Sea plant	Trunk/branch/Cane	Animal remains	Bag	Bottle	Rope	Fish box	Plastic Fragments	Polystyrene boxes	Polystyrene others	Polystyrene fragments	Bottles	Others	Cardboard	Paper bag	Paper packaging	Others	Tyre	Ballons	Others	Crate	Pallet	Wood boards	Clothing	Live best	Hard hat	Carpet/Furnishing	Cans food/drinks	Drums/Barrels	Oil slick	(**I**)Individual item, **P)** Patch		(+) Positive, (0) Neutral,(-)Negative	**OS**= Ocean, **LS**= land, **I**=Indef			Y (Yes), N (No)

Environmental data

Natural organic

Transect information

Anthropogenic marine litter classified by the type of material

Characteristics:
Size and class (individual or patched); Buoyancy; Source; Likely use; Color; Photos

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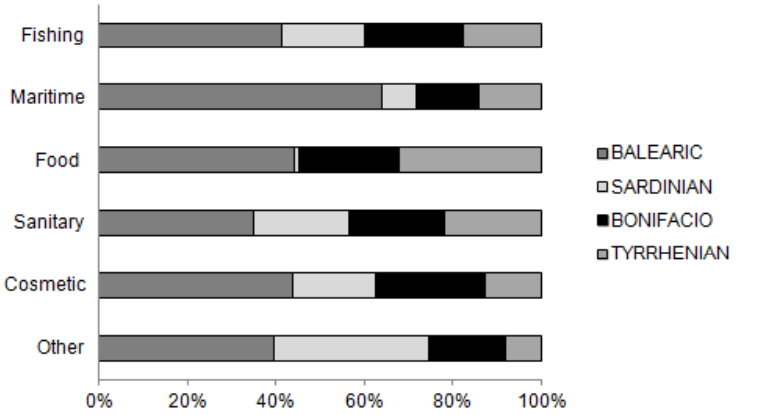
Type and colour of items

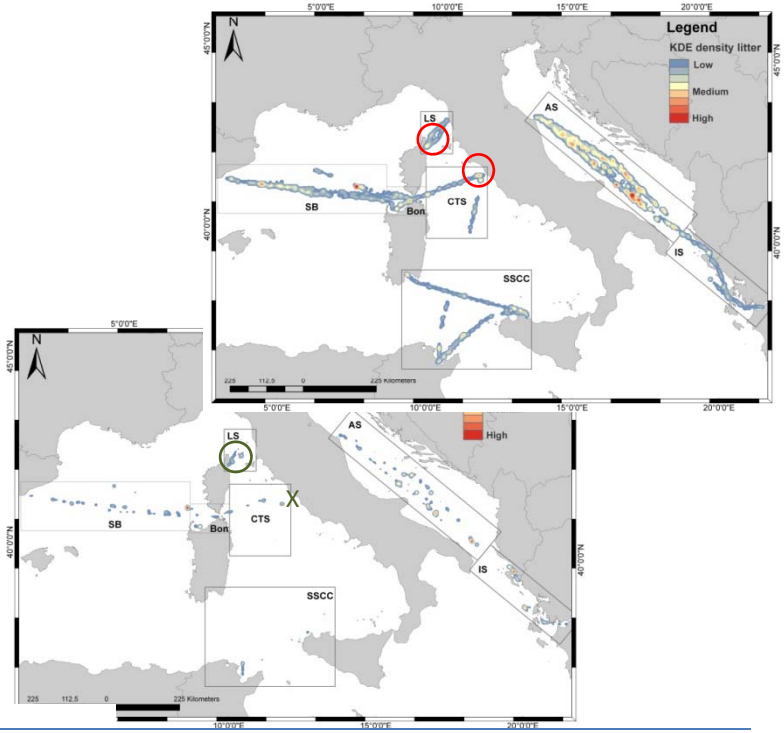
Data scheet MEDSEALITTER (in progress)		Modification respect to JRC Masterlist on floating	JRC Code	UNEP-MAP Code
Artificial polymer materials	Sheets		G67	PL16
	Bags		G2	PL07
	Polystyrene boxes	not all are fishing related	G58	PL17
	Plastic boxes	not all are fishing related	G57	PL17
	Bottles		G6	PL02
	Buoys		G63	PL14
	Buckets	+	G65	PL03
	Gloves	Aggregated	G39, G40, G41	PL09, RB03
	Beach-coastal amenities	++		
	Crates containers/baskets		G18	PL13
	Ropes		G48	-
	….	…..	….	…..
Glass	Bottles	+	G200	GC02
	Other	+	G210	GC08
Pr. Wood	Boards/Beams	Aggregated	G168, G159	-
	Pallets/Crates	Aggregated	G160, G162	WD04, WD04
	Other		G173	WD06
Metal	Spray cans		G174	-
	Drums/barrels	Aggregated	G187, G192	ME05

Type and colour of items

Data scheet MEDSEALITTER (in progress)	Modification respect to JRC Masterlist on floating
M: from sea T: from land I: indef.	
F=fishing; OF=other Food; S=sanitary; C=cosmetics; M=marittime; A=other; I=indeterm.	++
+ positive; ' 0 neutral; '- negative	++



Data scheet MEDSEALITTER		Modification respect to JRC Masterlist on floating
Natural Organic	Seaweed/marine plant	++
	Logs/plants parts	++
	Other	++



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Type and colour of items

EcoOcean experience. *"The sheet appears to have too many categories and is not quickly "fillable", especially when the speed is over 20 knots, which poses problems when the density of macro-litter is high"*

MPA Capo Carbonara experience. *"It is not easy to fill the data on the sheet when the density of macro-litter is high; it is suggested to modify the sheet as the example in annex."*

GOLETTA and ISPRA. *"Given the frequency of some items commonly seen during the first monitoring sessions, it is suggested to add new categories from the MSFD Masterlist in the data collection sheet, such as cigarette butt, cotton bud, paper tissue, and to separate "covers and packaging" and "tableware" indicating if dish, glass, cutlery or straw"*

ISPRA and Accademia. *"The datasheet is easy and quick to fill in after an initial training phase"*

Aerial surveys: automatic detection

Field experiments were done using different platforms:

MULTI-ROTOR DRONE

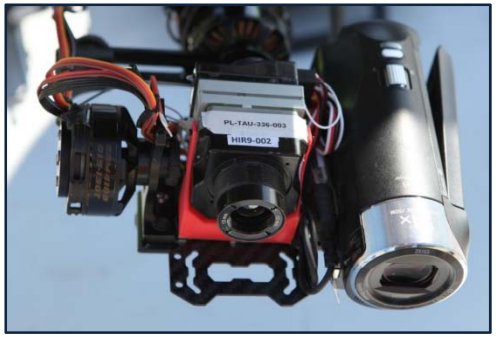
FIXED-WING DRONE

SMALL AIRCRAFT (PARTENAVIA)

… And different sensors:

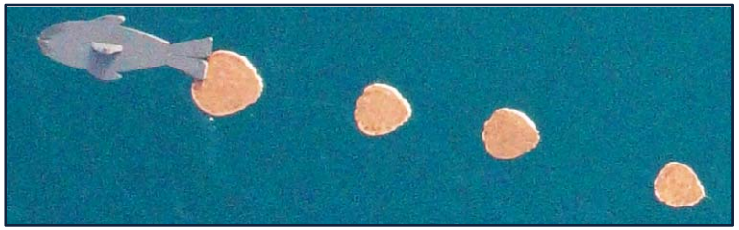
'TRADITIONAL' RGB CAMERA

MULTI-SPECTRAL CAMERA



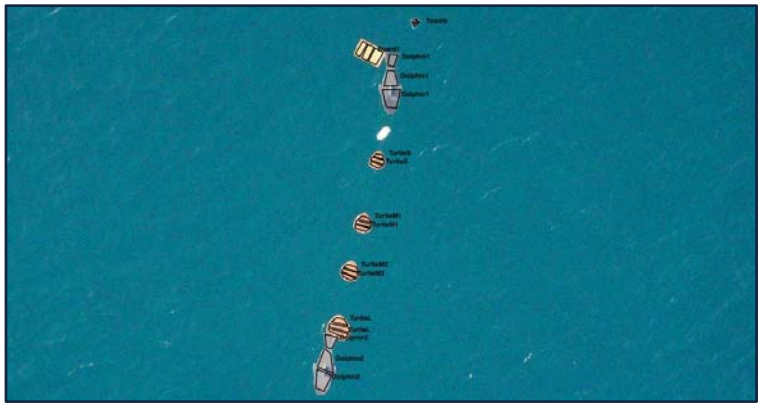
THERMIC CAMERA

… To take aerial images of a fixed set of objects varying flight height and angle.

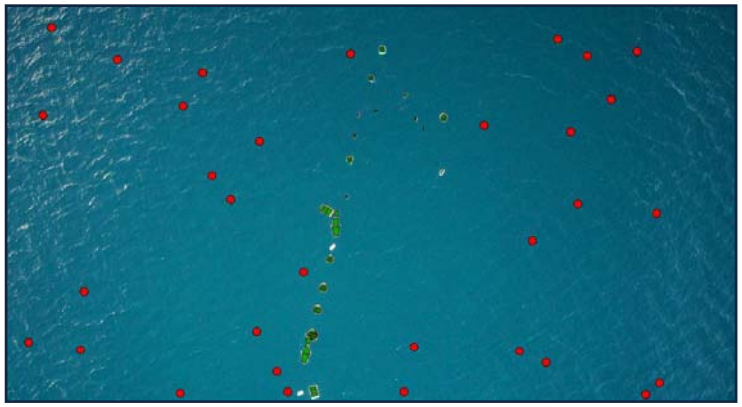


Aerial surveys: automatic detection

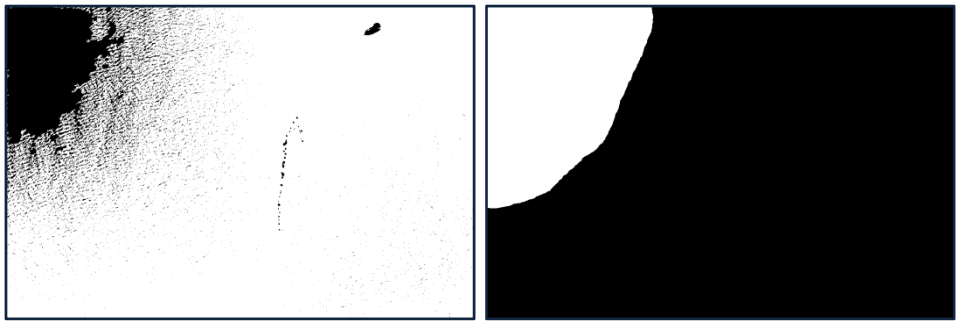
Image analysis included:



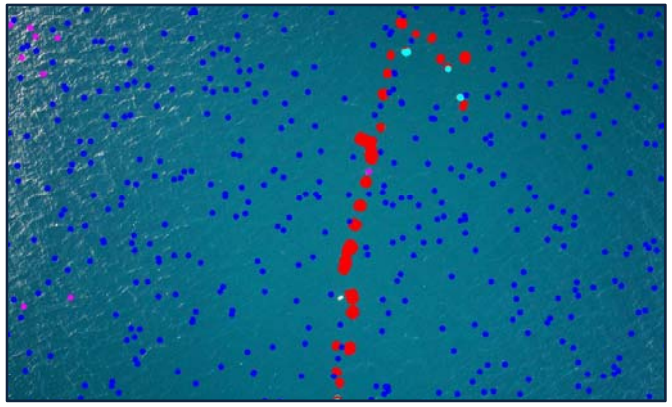
1. Creation of vectors of polygons representing the various floating items



2. Pixel characterization (water vs floating items)



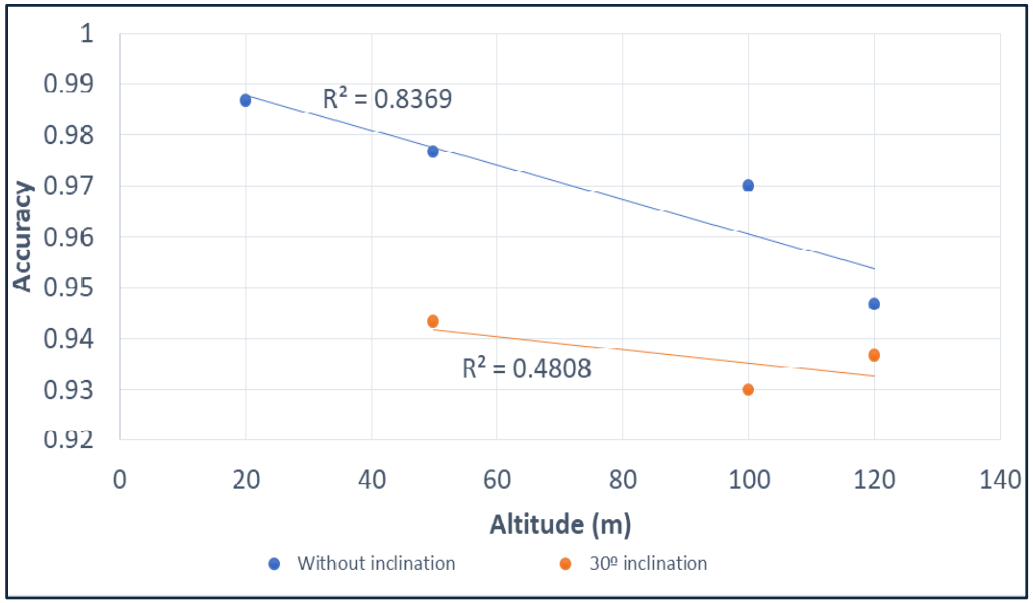
3. Masking areas of sun glare



4. Evaluation of items discriminability (Linear Discriminant Analysis)

Aerial surveys: automatic detection

Detection accuracy was calculated for each set of photos and related to flight parameters:



- probability to correctly classify floating objects decreases with:
  - **increasing flight height**
  - **photos are not taken perpendicularly** to the water (pixel distortion)
  - **increasing sun glare**
- **!** **sensors** with a proper resolution according to the planned flight height
  - **thermic and multi-spectral sensors** normally provide lower-resolution images than RGB cameras, but they can help to differentiate materials and/or identify living organisms.

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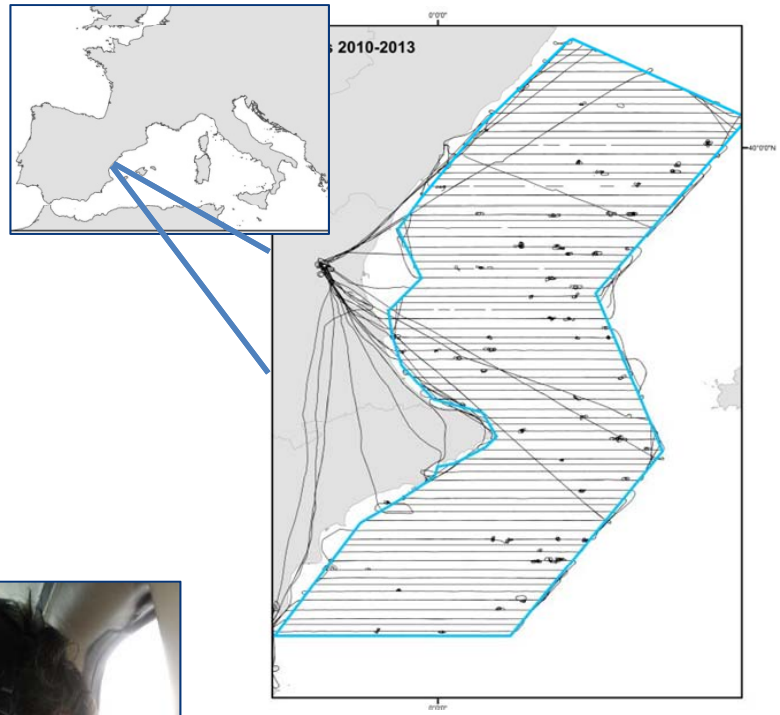
Aerial surveys: visual detection

- ✓ **Working protocol**
- ✓ Criteria for floating litter detection
- ✓ Tools for data collection



Sampling design

Platform and crew

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Aerial surveys: visual detection

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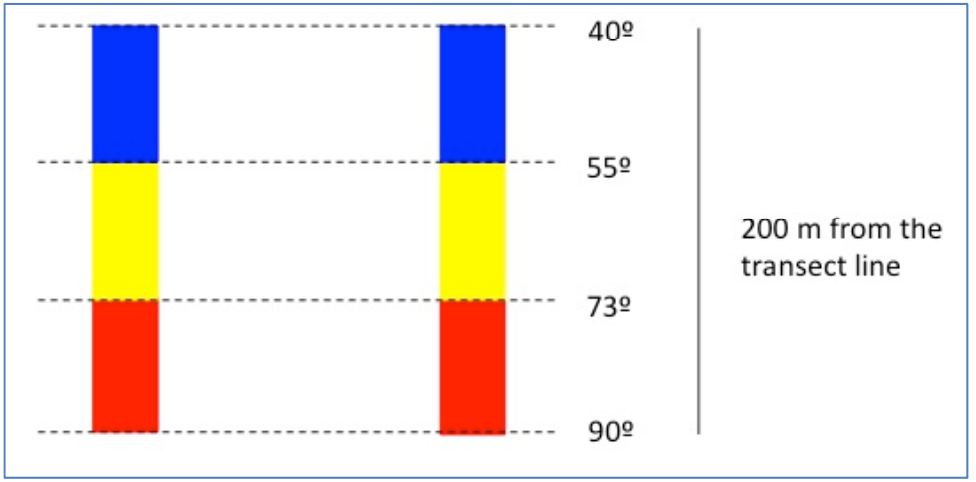

Distance from transect line

Size of marine litter

- ✓ Small: 30-100 cm
- ✓ Medium: 100-200 cm
- ✓ Large > 200 cm

Plastic, Polystyrene, Polyurethane	Bags Boxes Buoys Buckets Ropes (plastic) Foam Fishing nets Fish box	Textile	Clothing Ropes
		Rubber	Balloons Balls Tyres
		Liquids	Oil slick Dirty wake of ships Isolated foam
Glass	Bottles	Vegetable	Seaweed/marine plant
Paper/Cardboard	Wood boards Paper bag	Animal	Logs/plants parts Animal carcases
Procesed wood	Pallets Crates		
Metal	Drums/Barrels Cans		
Textile			

Type and composition

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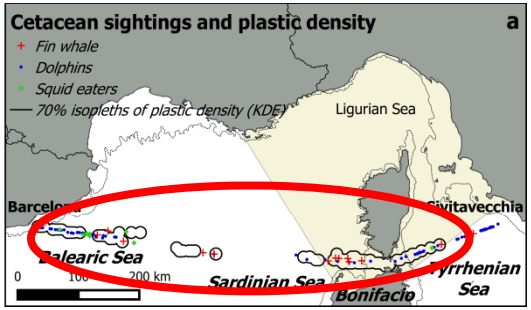
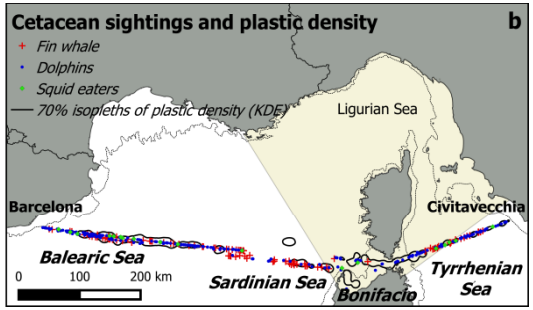
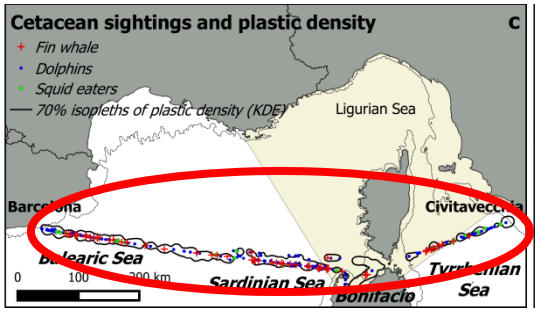
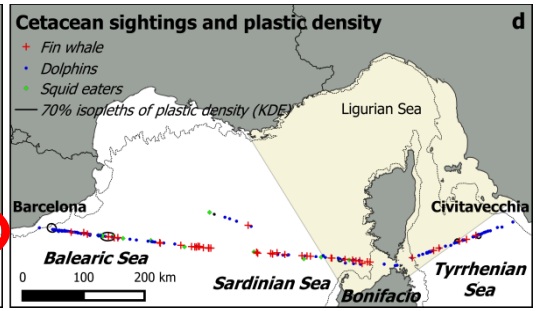
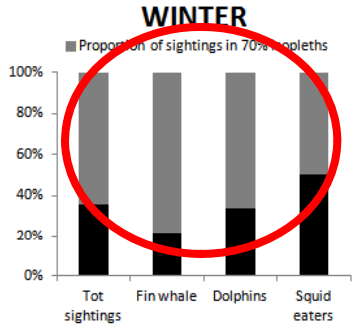
Impact on biota: risk areas/seasons

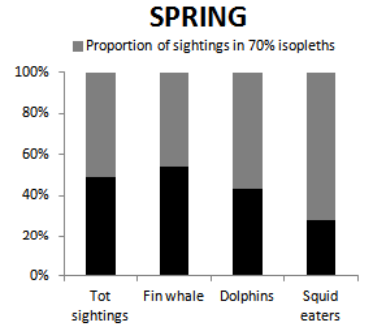


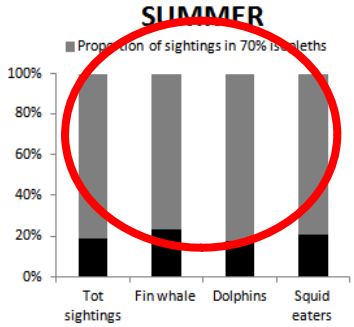


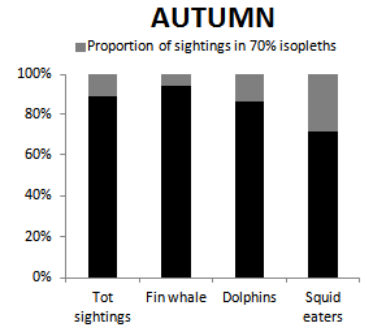












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Key messages on sampling design

*Setting appropriate methodology for collecting data to feed a **pertinent** and **timeliness indicator**: find the best compromise among scale of use, scientific validity, measurement method, previous data, practical and programmatic considerations (e.g complexity of application, application costs)*

- Considering stratify for coastal and open sea water when planning the sampling design as the conditions are different: higher densities along coastal water likely influenced by local inputs (river mouth/estuary, ports..); lower densities in high sea areas mainly determined by stream/prevalent wind regimes.
- Considering the effect of seasonality for planning time of surveys: results can be very different if we compare data collected during different seasons. More replicates per season or at least for two periods of the year (autumn+winter; spring+summer)
- Considering the sampling unit: first results for open sea water reported a sampling unit of almost 8Km2 (i.e. sample length of transect of 160 km with a strip width of 50m) to record accurate data with low dispersion.
- Considering setting the best width of the strip and minimum/maximum size of object for each platform type or technique
- Considering find a balance among the need to have a narrow strip width (to improve the probability of item detection) and the sampling unit needed in order to have representative and accurate data: the narrower is the strip width, the longer must be the length of the sampled transect.

In high sea area, with lower density, could be more efficient to use large vessel; conversely in high density coastal areas, small vessels could be more suitable

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Key messages on datasheet

- Review of the master list on the basis of the common sighted items, items that can be pertinent and timeliness indicators of: a specific sector (e.g. fish box linked to fishery) or a specific policy measure (plastic shopping bags linked to a ban; single use items).
- List of common items with indication of the correct size class
- Insert information to improve identification of source: industry sector, natural items
- Synoptically collect also data on marine macro/mega fauna to help identification of areas/seasons of highest risk (overlapping areas).

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Thank you for the attention...

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