CleanAtlantic

Assessment of seabed litter data recorded by scientific observers onboard fishing vessels

Action 5.2: Monitoring the presence of ML in the Marine Environment

WP 5: Monitoring data and management

Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION
Clean Atlantic

WP	WP 5: MONITORING DATA AND MANAGEMENT
ACTION	5.2: MONITORING THE PRESENCE OF ML IN THE MARINE ENVIRONMENT
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PARTICIPANTS	

DISCLAIMER

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Overview

1. Aim

This report is the result of the research performed within CleanAtlantic, an Interreg Atlantic Area Programme funded project that aims to protect biodiversity and ecosystem services in the Atlantic Area by improving capabilities to monitor, prevent and remove (macro) marine litter. The project is also contributing to raise awareness and change attitudes among stakeholders and to improve marine litter managing systems.

One of the objectives of the CleanAtlantic project is to improve capabilities to monitor marine litter in different compartments: seafloor, beach, floating. For that purpose, current methods and technologies are being reviewed and tested and new technologies explored. This report aims to assess information sampled by scientific observers on board fishing vessels to monitor marine litter, predominantly seabed litter.

2. Data

The study is based on 1527 hauls carried out off the coasts of Spain and Portugal, and in the Irish Atlantic Ocean (Figure 1). Data come from the Spanish on board sampling program 2018-2019, which were recorded by scientific observers on the marine litter scoreboard included in Annex 1 and using different gears (Baca trawl, GOV trawl, Purse seine, Pair trawl, "*Rasco*" bottom set gillnet and *"Volanta"* bottom set gillnet) depending on the fishing fleet. We analyzed seabed litter data per haul. The Sampling program was distributed by trimesters (Figure 2) within the three fishing grounds: Cantabrian Sea-NW Spain (VIIIc ICES Division and IXa North ICES Subdivision), Gulf of Cadiz(IXa South ICES Subdivision), and Gran sol (VII c,g,h,k ICES Divisions).

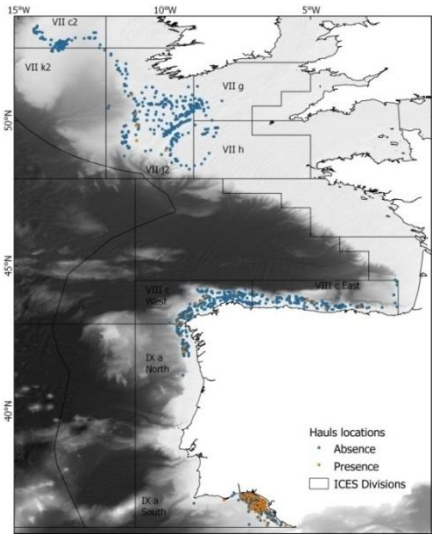

Figure 1. Map of the hauls locations (hauls without marine litter in blue and hauls with marine litter in orange),showing the bathymetry in grayscale.

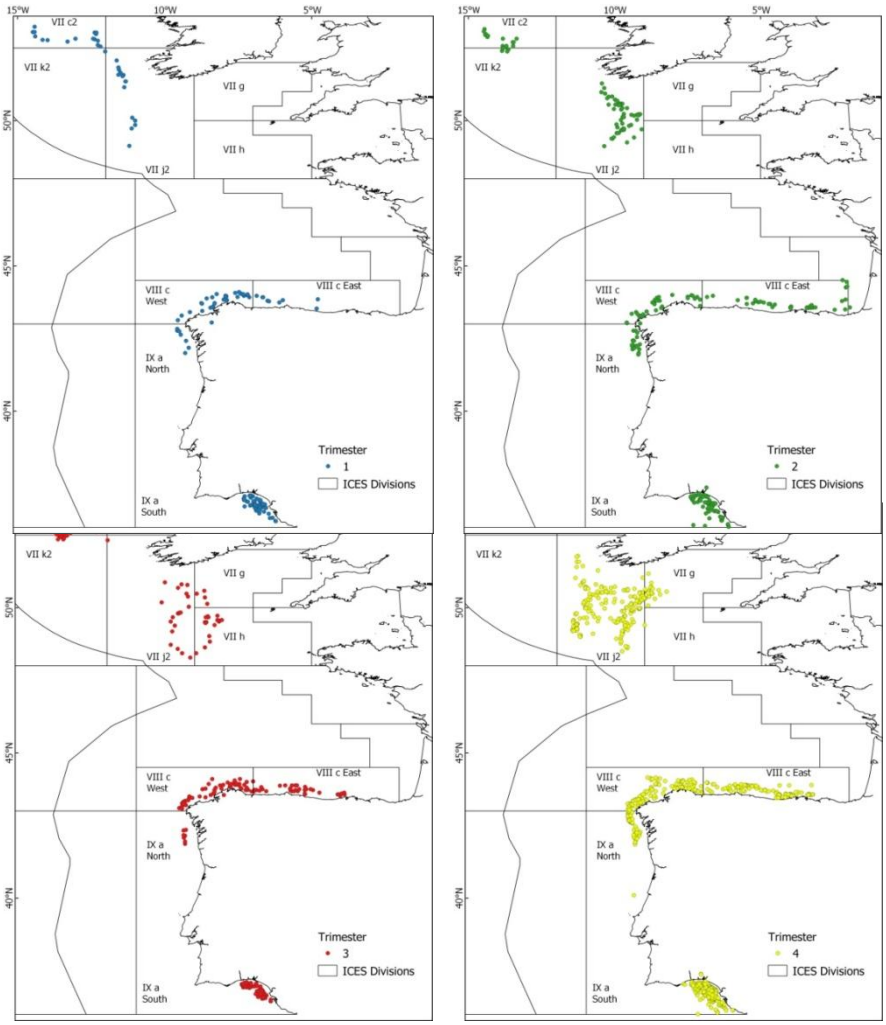

Figure 2. Maps of the hauls locations per trimester.

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2.1 Gears

Sampling data represented by gear are shown in figure 3. Baca gear´s data were represented in all the ICES divisions and therefore in the three fishing grounds, purse seine was sampled only in the Gulf of Cadiz and the other gears were sampled in the North of Spain and, mainly in the Cantabrian Sea.

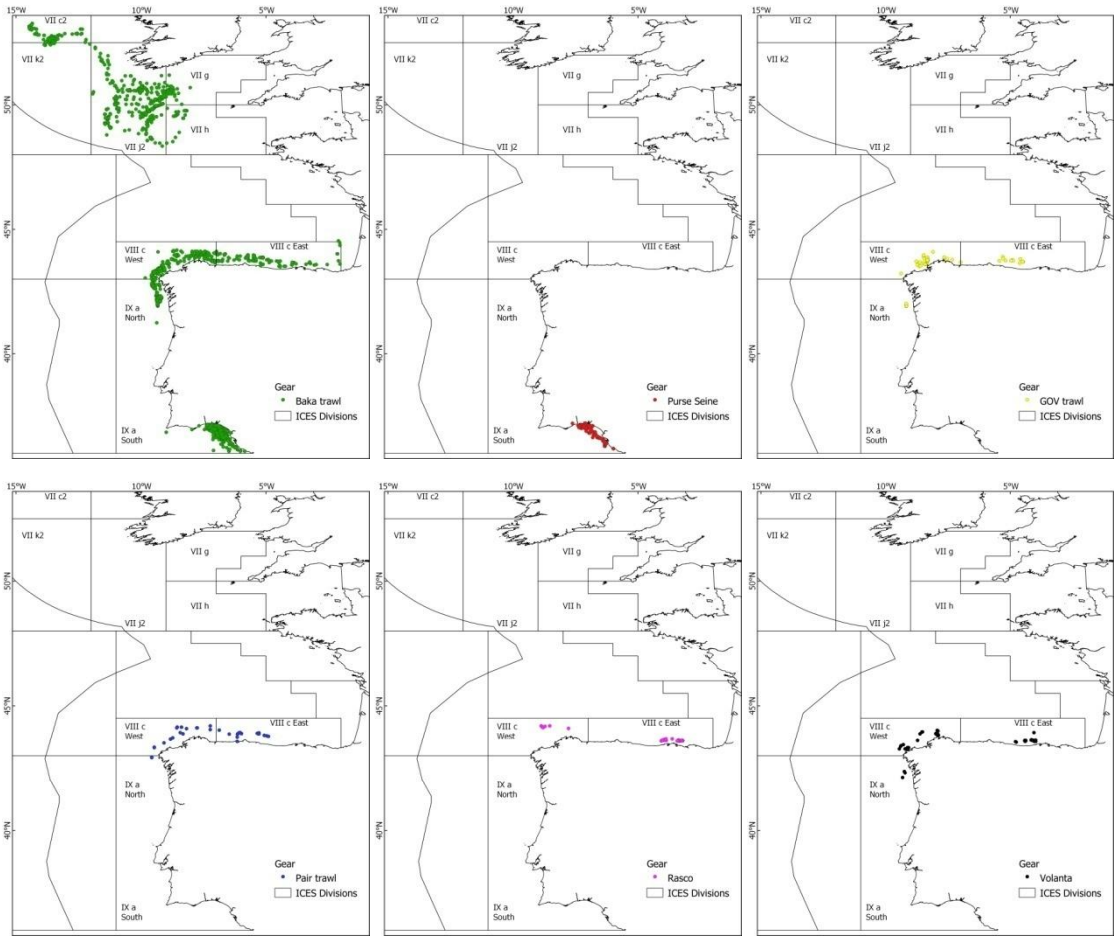

Figure 3. Maps of the hauls locations per gear.

We described here the gears used in this study, following the FAO´s definitions (Nédélec et al., 1990).

2.1.1. Bottom trawl: Baca, GOV and pair trawl

Bottom towed trawls are designed to work near the bottom, nets consisting of a cone-shaped body, closed by the cod end, and extended at the opening by wings.

The net in Baca and GOV is towed by one boat and in the case of pair trawl, is towed by two boats at the same time. The distance between the boats ensures the horizontal opening of the net.

Technical differences between Baca and GOV made their work at the bottom slightly different. The GOV, with its larger vertical opening, works on the 4 m of water from the bottom, which makes it more effective in capturing semi-pelagic species. On the other hand, the Baca works only on the 1.9 m of water from the bottom, but due to its heavy doors and sweeps, which hit the substrate, and its half-buried footrope, it is much more effective to sample species linked to the bottom(Sánchez et al., 1994).

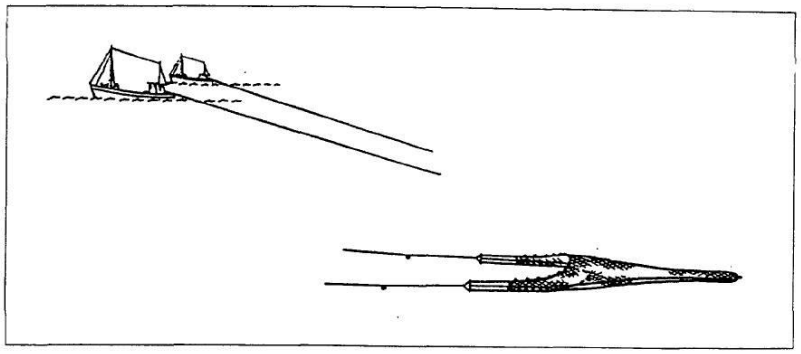

Figure 4. Scheme of a bottom towed trawl, towed by two boats (pair trawl) (image from FAO).

2.1.2. Purse Seine

This fishing gear consists in surrounding nets with purse lines. Surrounding nets catch the fish by encircling them from the sides and from underneath. The purse seines nets are characterized by the use of a purse line at the bottom of the net, which enables the net to be closed like a purse and therefore retains all the caught.

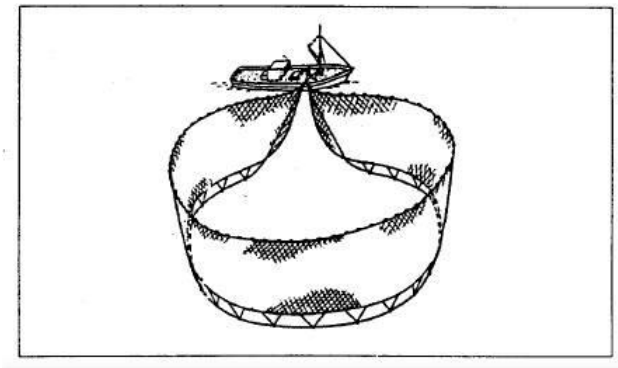

Figure 5. Scheme of a purse seine(image from FAO).

2.1.3. Bottom set gillnets: Rasco and Volanta

"Rasco" and *"Volanta"* are gill nets anchored to the seabed with sinkers, and floats on the upper end. Both are set transversely to the path of migrating fish to catch them. The *"Rasco"* differs from the "Volanta" by the total length (11 km versus 7km), having a larger mesh size (minimun length size of 280 versus 90mm)and also presents a lying position towards the seabed. Besides, the target species of the "Volanta" is the hake and from the *"Rasco" is* the anglerfish.

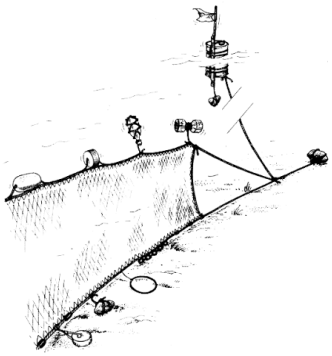

Figure 6. Scheme of a bottom set gillnet (image from FAO).

2.2 Data processing

The data could not be standardized because of the use of different gears and insufficient information regarding the effort of each haul. Therefore data was described by items/haul or by the percentage of hauls with presence of marine litter.

The mean, median, density histograms and percentage of each litter category were done for each gear in order to describe its behaviour in relation with the capture of seabed litter. The classification of the seabed litter data used was the CT-S-REV (Revised CEFAS Trawl Litter Survey parameters (2013).

Kruskal-Wallis test was applied to test for significant differences in the items/haul between years, trimesters, gears, and fishing grounds. Additionally, pairwise Wilcox rank sum tests were used to calculate pairwise comparisons with corrections for multiple testing when significant differences were found in the Kruskal-Wallis test.

3. Results

Marine litter was found in the 9.8% of the total hauls (149 from 1527 hauls), with mean densities of 0.34 ± 0.034 items/haul. Taking into account only the 149 hauls with marine litter, the mean values obtained is 3.5 ± 0.219 items/haul and the median is 3.0.

3.1 Marine litter categories

522 items were found in the 149 hauls with marine litter. Figures 7 and 8 summarize the percentage per category and type of these items, respectively. Plastic was the most abundant category and represented 41.4 % of the total items found. Then, metals and Glass/Ceramics were the next abundant categories with 24.7%, and 14.6% respectively. Moving on to the types of items found, cans (beverage) represented the 16.3 % followed in abundance by glass or ceramics pieces (8.6%), plastic bags (8.4%), and plastic sheets (6.9%).

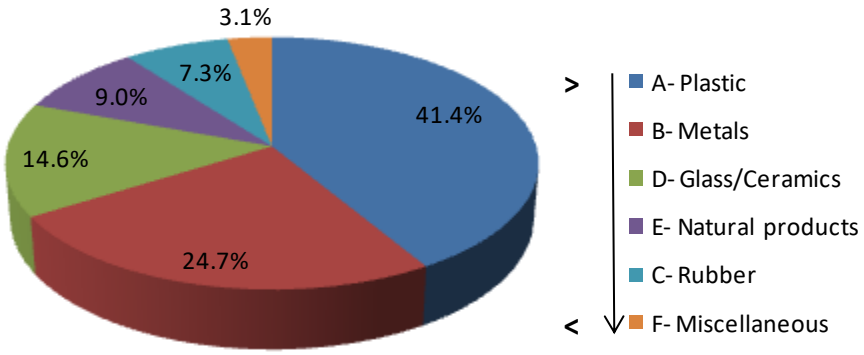

Figure 7. Pie chart showing the percentage of Items/haul into broader categories for the different types of seabed litter.

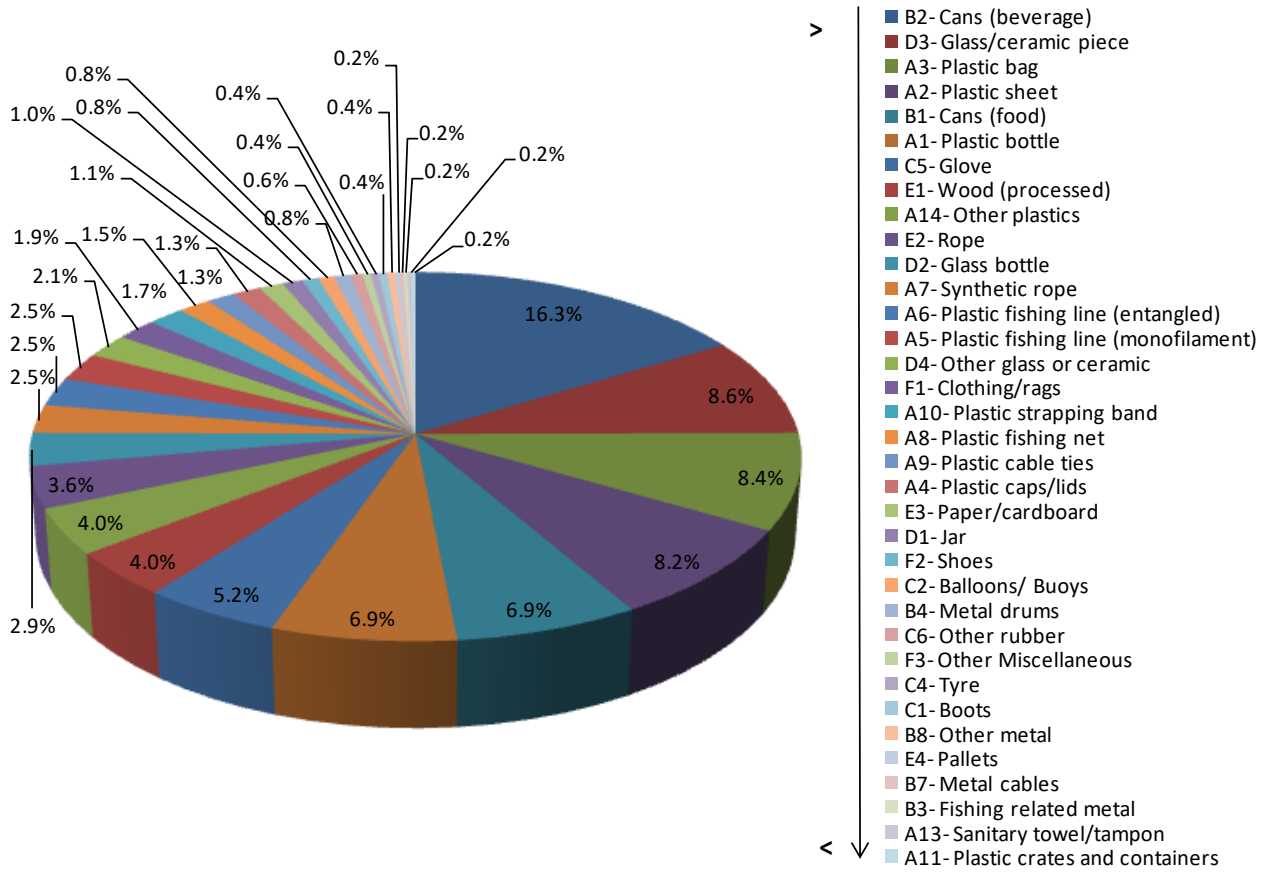

Figure 8. Pie chart showing the percentage of Items/haul for the different types of seabed litter.

3.2 Marine litter and year

There were no significant differences between years 2018 and 2019 (Kruskal-Wallis Items/haul – Year = 2.3124, 1df, P>0.5). Figure 9 and Table 1 show the mean values of densities by items/haul of marine litter grouped by year. Table 1 shows also the percentage of hauls with litter and the number of hauls performed.

Table 1 Mean values of marine litter densities calculated as the number of items/haul per year. % is the percentage of valid hauls with litter and N is the number of hauls performed.

	Mean	SE	%	N
2018	0.35	0.04	10.67	965
2019	0.33	0.06	8.19	562

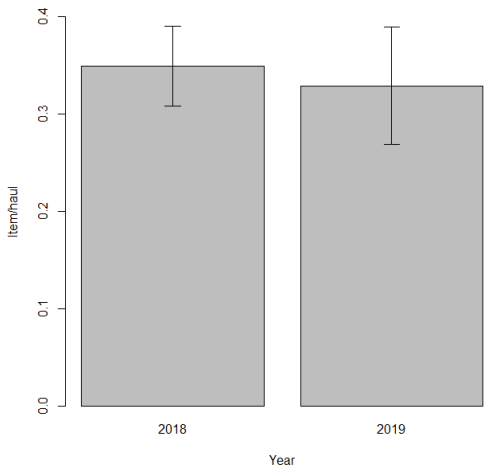

Figure 9. Mean values of marine litter densities calculated as the number of items/haul per year.

3.3 Marine litter and trimesters

Kruskal Wallis test confirmed significant differences by trimesters (Kruskal Wallis items/haul − Trimester = 61.40, 3df, P<0.05). Pairwise comparisons between trimesters show that there were significant differences between the different trimesters except between the second and third trimester (Annex 1a; in bold significant values with p value < 0.05). Figure 10 and Table 2 show the mean values of densities of marine litter by items/haul grouped by trimesters. Table 2 shows also the percentage of hauls with litter and the number of hauls performed. We can observe that there were substantial differences between trimesters, with low values in the second and third trimesters and with higher values in the fourth followed by the first trimester.

Table 2.*Mean values of marine litter densities calculated as the number of items/haul per trimester. % is the percentage of valid hauls with litter and N is number of hauls performed.*

	Mean	SE	%	N
1	0.43	0.08	10.93	375
2	0.24	0.05	5.96	436
3	0.25	0.07	4.01	399
4	0.5	0.07	20.82	317

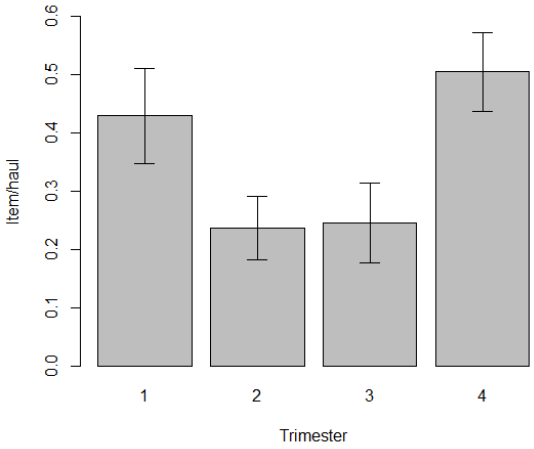

Figure 10. Mean values of marine litter densities calculated as the number of items/haul per trimester.

3.4 Marine litter and gears

Mean values of marine litter densities by items/haul grouped by gear are shown in Figure 11 and Table 3. Table 3 shows also the percentage of hauls with litter and the number of hauls performed. Differences between gears were found, being the Baca trawl the one with the highest value, which was followed by far by Rasco. Kruskal Wallis test confirmed significant differences by gears (Kruskal Wallis items/haul – Gears = 29.368, 5df, P<0.05). Pairwise comparisons between gears show that there were only significant differences between Baca and two other gears, namely Purse Seine and Volanta. The fact that significant differences were not found between the other 3gears may be due to the lower number of hauls performed (Annex 2b; in bold significant values with p value < 0.05).

Table 3 Mean values of marine litter densities calculated as the number of items/haul per gear. % is the percentage of valid hauls with litter and N is number of hauls performed.

	Mean	SE	%	N
Bacatrawl	0.42	0.04	11.77	1223
PurseSeine	0.03	0.03	1.08	93
GOV trawl	0.02	0.02	2.33	43
Pairtrawl	0.05	0.05	2.56	39
Rasco bottom set gillnet	0.15	0.11	5.13	39
Volanta bottom set gillnet	0	0	0	90

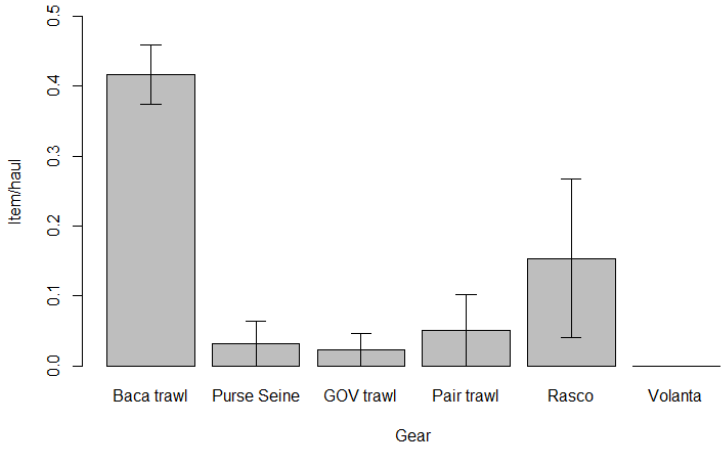

Figure 11. Mean values of marine litter densities calculated as the number of items/haul pergear.

3.5 Marine litter and fishing grounds

Mean values of marine litter densities by items/haul grouped by fishing groundsare shown in Figure 12 and Table 4, and hauls locations are represented in Figure 13. Table 3 shows also the percentage of hauls with litter and the number of hauls performed. According to the data, there were differences between fishing grounds, with higher values in the Gulf of Cadiz followed by far by the Cantabrian Sea-NW Spain fishing ground. Kruskal Wallis test confirmed significant differences by fishing grounds (Kruskal Wallis items/haul− Divisions = 191.26, 2df, P<0.05). Then, pairwise comparisons show that there were significant differences between the three fishing grounds (Annex 2c; indicated in bold significant values with p value < 0.05).

Table 4. Mean values of marine litter densities calculated as the number of items/haul per ICES Division/Subdivision. % is the percentage of valid hauls with litter and N is number of hauls performed.

	Mean	SE	%	N
Cantabrian Sea - NW Spain	0,18	0,04	4,33	578
Gulf of Cadiz	0,85	0,09	25,76	458
Gran sol	0,06	0,03	1,22	491

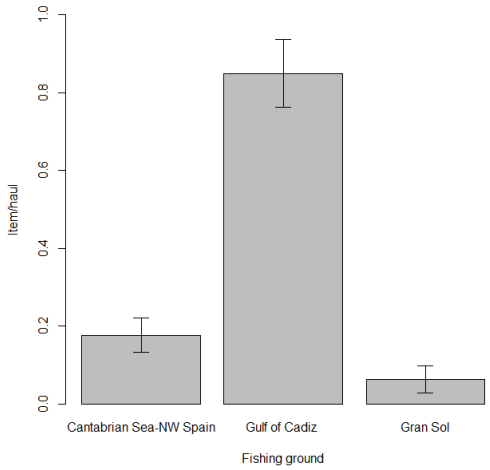

Figure 12. Mean values of marine litter densities calculated as the number of items/haul per ICES Division/Subdivision.

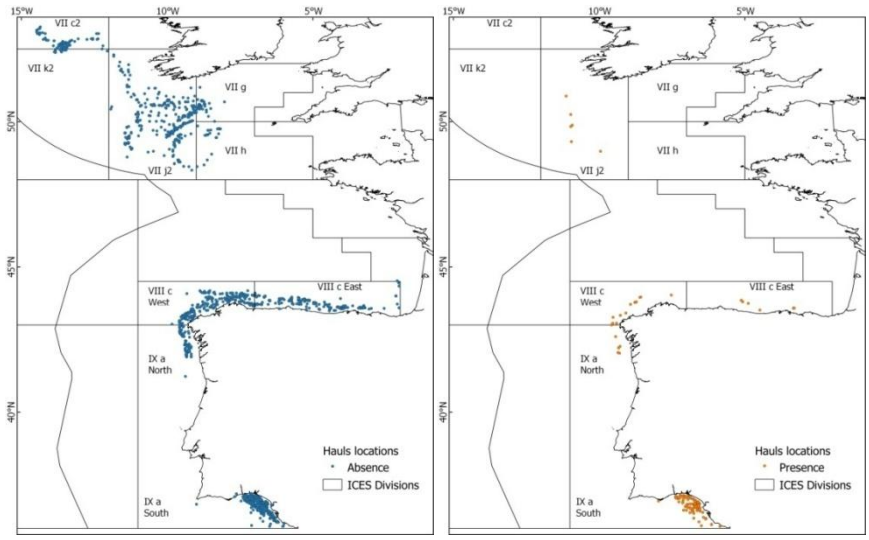

Figure 13. Maps of the hauls locations (hauls without marine litter in blue and hauls with marine litter in orange) and the ICES Divisions.

3.6 Marine litter and Baca gear

Baca was the only gear that was used in the three fishing grounds and throughout the 4 trimesters considered in this study. Besides, it obtained higher values of marine litter. Therefore, it seems to be the most appropriate gear to sample seabed marine litter among the six considered -or at least the one that deserves more attention when aiming to compare data both spatially and temporally. The Baca data constitute 80% of the entire data (all gears), and they will be analyzed in this section separately. Marine litter was found in 11.8% of the total Bacahauls with mean densities of 0.42 ± 0.04 items/haul.

3.6.1 Baca marine litter and year

There were significant differences between years 2018 and 2019 (Kruskal-Wallis Items/hauls − Year = 4.5517, 1df, p value <0.05). Figure 14 and Table 5 show the mean values of densities by items/haul of marine litter grouped by year. Table 5 shows also the percentage of hauls with litter and the number of hauls performed.

Table 5. *Mean values of marine litter densities calculated as the number of items/haul per year. % is the percentage of valid trawls with litter and N is number of hauls performed.*

	Mean	SE	%	N
2018	0,44	0,05	13,34	772
2019	0,38	0,07	9,09	451

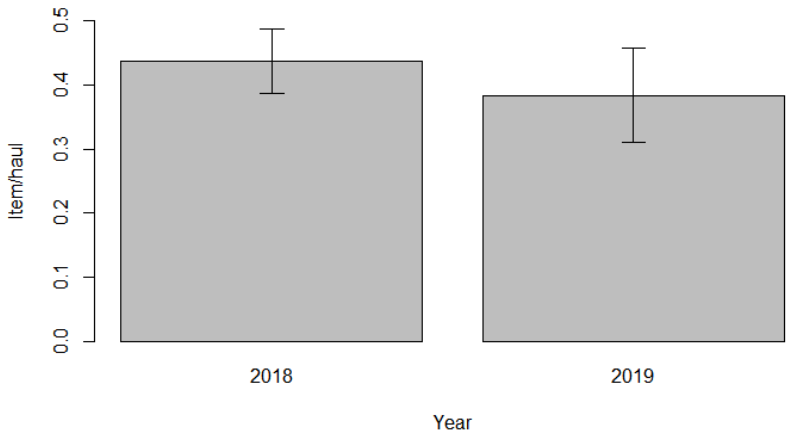

Figure 14. Mean values of marine litter densities calculated as the number of items/haul per year.

3.6.2 Baca marine litter and trimesters

Mean values of marine litter densities as items/haul grouped by trimester were presented in Figure 15 and Table 6 and spatially represented in Figure 16. Table 6 shows also the percentage of hauls with litter and the number of hauls performed. We can observe that there were differences between trimesters with a similar pattern with the entire data (all gears), but with less marked differences. Kruskal Wallis test confirmed significant differences by trimester(Kruskal Wallis items /hauls − Trimester = 50.09, 3df, P<0.05). Pairwise comparisons between trimesters confirmed that there were

significant differences between the fourth trimester and the rest and between the first and the third trimester (Annex 2d; indicated in bold significant values with p value < 0.05).

Table 6. *Mean values of marine litter densities calculated as the number of items/haul per trimester. % is the percentage of valid hauls with litter and N is number of hauls performed.*

	Mean	SE	%	N
1	0.47	0.09	11.55	329
2	0.33	0.08	8.08	297
3	0.31	0.09	5.02	319
4	0.58	0.08	23.74	278

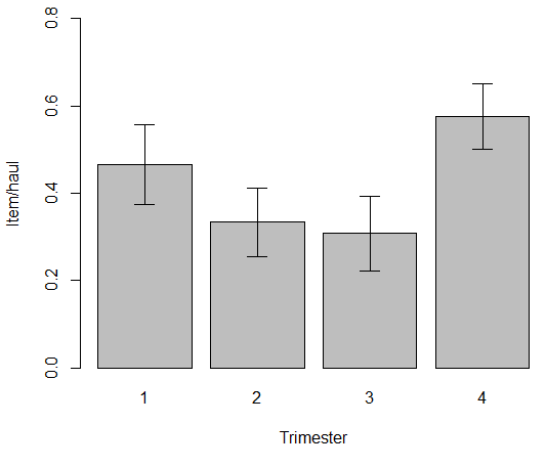

Figure 15. Mean values of marine litter densities calculated as the number of items/haul per trimester.

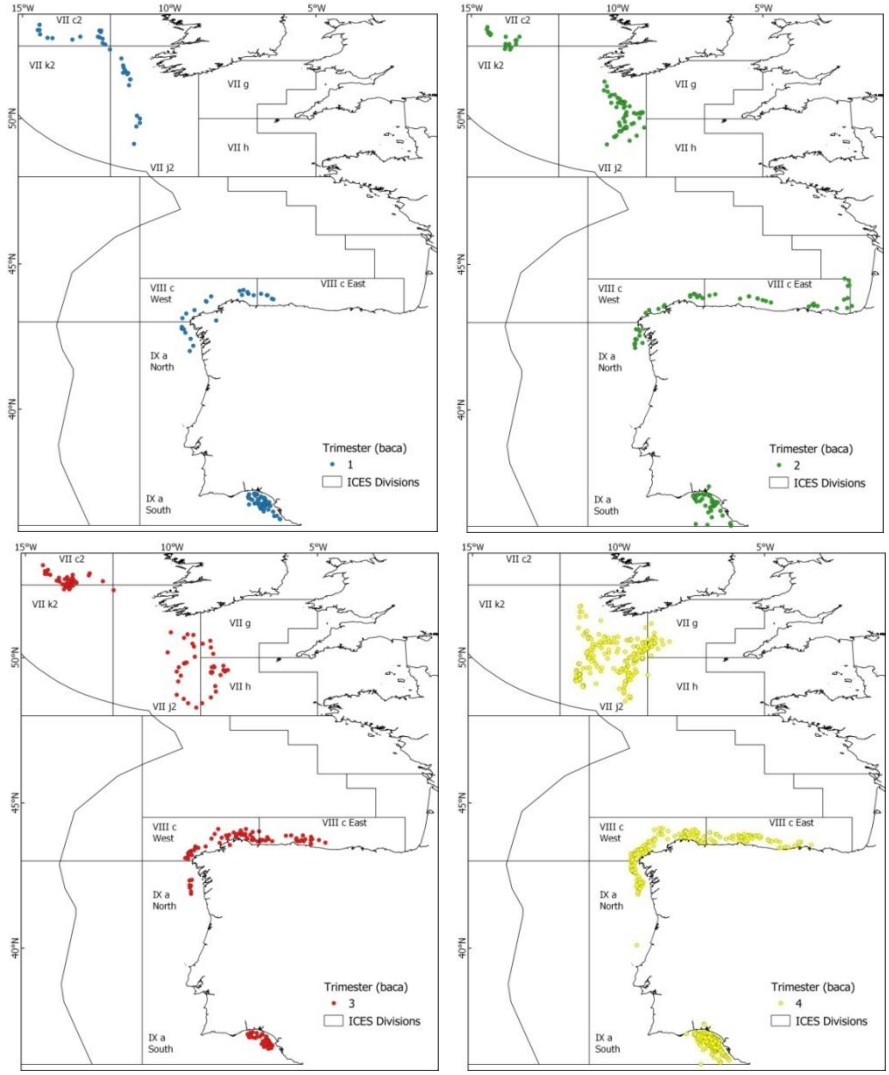

Figure 16. Maps of the hauls locations per trimester.

3.6.3 Baca marine litter and fishing ground

Mean values of marine litter densities expressed as items/haul and grouped by fishing ground are shown in Figure 17 and Table 7, and hauls locations represented in Figure 18. Table 7 shows also the percentage of hauls with litter and the number of hauls performed. We can observe that there were differences between fishing grounds following the same pattern of the entire data (all gears), with higher values in the Gulf of Cadiz followed by far by the Cantabrian Sea-NW Spain fishing ground.Kruskal Wallis test confirmed significant differences between fishing grounds (Kruskal Wallis items/haul− Fishing ground = 206.78, 2df, $P<0.05$) and Pairwise comparisons set that there were significant differences between the three fishing grounds(Annex 2e; significant values with p value < 0.05indicated in bold).

Table 7. *Mean values of marine litter densities calculated as the number of items/haul per Ices Division/Subdivision. % is the percentage of valid hauls with litter and N is number of hauls performed.*

	Mean	SE	%	N
Cantabrian Sea - NW Spain	0.25	0.07	5.72	367
Gulf of Cadiz	1.06	0.11	32.05	365
Gran sol	0.06	0.03	1.22	491

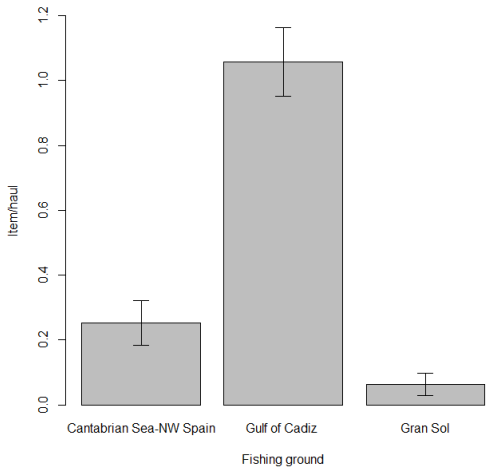

Figure 17. Mean values of marine litter densities calculated as the number of items/haul per ICES Division/Subdivision.

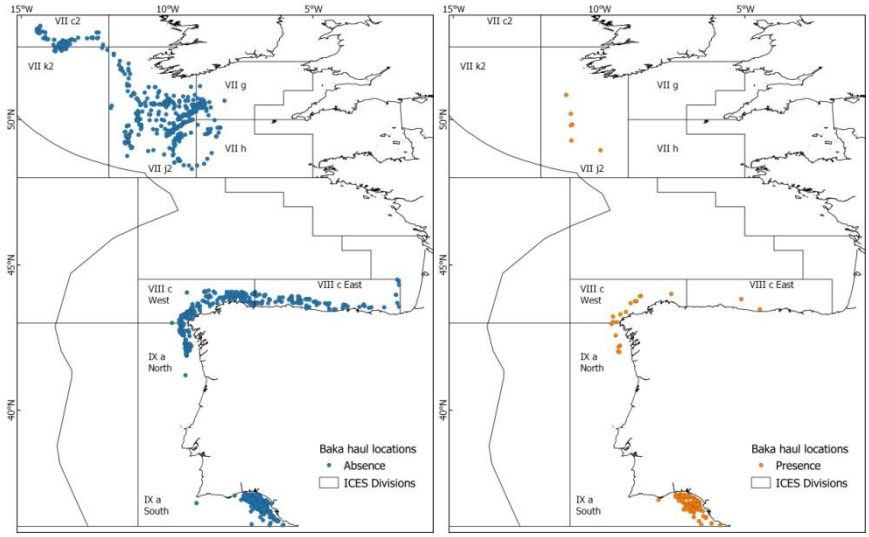

Figure 18. Maps of the Baca hauls locations (hauls without marine litter in blue and hauls with marine litter in orange) and the ICES Divisions.

4. Conclusions

Marine litter was found in 9.8% of the 1527 hauls included in this study, with mean densities of 0.34 ± 0.034 items/haul. Plastic was the most abundant category found, which accounted for41.4 % of the total items, followed by metals and Glass/Ceramics with 24.7%, and 14.6% respectively.

Spatial, seasonal, and between gears significant differences were found. The Gulf of Cadiz was the area with higher values of marine litter followed by far by the Cantabrian Sea-NW Spain fishing ground. The highest marine litter densities were recorded inthe fourth trimester followed by the first trimester. The lowest values were registered between April and September.

Data sampled by scientific observers on board fishing vessels provided valuable information on marine litter due to the quantity and broad spatial and temporal coverage of the data. Considering the 6 fishing gears included in this study, the Baca´s data seem to be the most appropriate for marine litter assessment for two main reasons: (i) the sampling program is more complete (Baca´s data represents 80 %of the data and it is spatially and temporally better distributed, covering the three fishing grounds);(ii) and this gear obtained the highest marine litter yields.

5. References

- Litter reference list (CT-S and CT-S Revised): CEFAS Trawl litter survey parameters (IBTS) and Revised CEFAS Trawl litter survey parameters (2013). Available at:https://vocab.ices.dk/?ref=1381
- Maugeri, S. "Fishing with bottom gillnets." 1980. FAO.
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- Sánchez, F., Poulard, J.C., de la Gándara, F. 1994. Experiencia de calibración entre los artes de arrastre BACA 44/66 y GOV 36/47 utilizado por los B/O Cornide de Saavedra y Thalassa. Inf.Téc. Inst. Esp. Oceanogr. 156.
- Spanish on board sampling program 2018-2019. Spanish multiannual program for the collection, management and use of data in the fisheries and aquaculture sectors.

6. Annex 1

Annex1. Scoreboard marine litter.

SCOREBOARD MARINE LITTER

Code Fishing Trip: Nº Haul: Date:

Code	Type	Description	Quantity	Size							
A.	**Plastic**										
A.1		Bottle	I I I	B	B	A					
A.2		Sheet									
A.3		Bag									
A.4		Caps/lids									
A.5		Fishing line (monofilament)									
A.6		Fishing line (entangled)									
A.7		Synthetic rope									
A.8		Fishing net									
A.9		Cable ties									
A.10		Plastic strapping band									
A.11		Crates and containers									
A.12		Diapers									
A.13		Sanitary towel/tampon									
A.14		Other									
B.	**Metals**										
B.1		Cans (food)									
B.2		Cans (beverage)									
B.3		Fishing related metal									
B.4		Drums									
B.5		Appliances									
B.6		Car parts									
B.7		Cables									
B.8		Other									
C.	**Rubber**										
C.1		Boots									
C.2		Balloons/Buoys									
C.3		Bobbins (fishing)									
C.4		Tyre									
C.5		Glove									
C.6		Other									
D.	**Glass/Ceramics**										
D.1		Jar									
D.2		Bottle									
D.3		Piece									
D.4		Other									
E.	**Natural products**										
E.1		Wood (processed)									
E.2		Rope									
E.3		Paper/cardboard									
E.4		Pallets									
E.5		Other									
F.	**Miscellaneous**										
F.1		Clothing/rags									
F.2		Shoes									
F.3		Other									

Size	**Observations:**
A: <5*5 cm=25 cm^2	
B: <10*10 cm=100 cm^2	
C: <20*20 cm=400 cm^2	
D: <50*50 cm=2500 cm^2	
E: <100*100 cm=10 000 cm^2= 1 m^2	
F: >100*100 cm=10 000 cm^2= 1 m^2	

7. Annex 2

Annex2. Pairwise comparisons using Wilcoxon rank sum test.

a) Trimesters

```
  1       2       3
2 0.01350 -       -
3 0.00071 0.22190 -
4 0.00138 9.9e-09 1.0e-10

P value adjustment method: BH
```

b) Gears

```
Baca   Purse Seine  GOV    Pair trawl Rasco
Purse Seine            0.0116 -            -      -          -
GOV                    0.1916 0.6322       -      -          -
Pair trawl             0.2202 0.6322       0.9446 -          -
Rasco                  0.3393 0.2971       0.6322 0.6322     -
Volanta0.0087 0.4960       0.2971 0.2971     0.1599

P value adjustment method: BH
```

c) Fishing grounds

```
Cantabrian Sea - NW Spain   Gulfof Cadiz
Gulfof Cadiz <2e-16-
Gran sol       0.0026              <2e-16

P value adjustment method: BH
```

d) Baca and trimesters

```
  1       2       3
2 0.15811 -       -
3 0.00584 0.15811 -
4 0.000493.7e-06 2.0e-09

P value adjustment method: BH
```

e) Baca and fishing grounds

```
Cantabrian Sea - NW Spain   Gulfof Cadiz
Gulfof Cadiz <2e-16-
Gran sol       0.00019<2e-16

P value adjustment method: BH
```