CleanAtlantic

Tackling Marine Litter in the Atlantic Area

Characterization of seabed macrolitter and their impacts on flora/fauna observed during ROV operations

Testing methods and BIIGLE annotation software

WP 5.2: Monitoring the presence of ML in the Marine Environment
WP 5.3: Monitoring the interaction of marine litter with flora/fauna

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MSFD – Marine Strategy Framework Directive

OSPAR - International organisation to prevent pollution of the Northeast Atlantic (OSLO-PARIS)

Summary

This study is focused on advancing methods to monitor the distribution of seafloor litter and interactions with sessile organisms using ROV and underwater video annotation. It has been performed in the framework of the extension of CleanAtlantic project within tasks 5.2 and 5.3. Results of this study include a critical assessment of: i) video based surveys and monitoring, including considerations and limitations of ROV operations and data acquisition, and; ii) image processing and analysis using BIIGLE and common annotation referentials. Findings included in this report and outputs of this study (e.g. guidelines, future peer-reviewed publications) are also expected to contribute to improve seafloor litter monitoring and survey methods and in determining D10C4 MSFD indicator, currently under development.

Introduction

This study is focused on advancing methods to monitor the distribution of seafloor litter and interactions with sessile organisms using ROV and underwater video annotation. It has been performed in the framework of the extension of CleanAtlantic project within tasks 5.2 and 5.3. The study integrates video data from IFREMER and ARDITI/MARE-Madeira and assesses data acquisition and data processing, with a special focus on using harmonised annotation and testing collaborative video annotation using BIIGLE (Langenkämper et al, 2017).

During the first part of CleanAtlantic project, Ifremer produced a deliverable linked to MSFD D10C4 indicator on *« Strategy and constraints to support monitoring of Marine Litter Harm: Towards a protocol for the observation of marine organisms entangled/strangled/covered by marine litter during ROV operations »* (Gérigny, et al, 2020). This publicly available output was used as general guidelines for this study where IFREMER used ROV video data collected during Pacman and CheReef campaigns and ARDITI/MARE-Madeira conducted a specific campaign to assess litter pollution in the vicinity of Funchal harbour and Garaja MPA.

BIIGLE, a free image annotation online platform developed by the Center for Biotechnology (CeBiTec) & Bielefeld University, (https://biigle.de/) was selected to test : the use of a common referential on Litter categories, seafloor substrates and Interaction, and; the use of online collaborative annotation tools for image based seafloor litter surveys. These objectives are designed to facilitate and improve seafloor litter pollution assessments and monitoring. Currently, seafloor litter monitoring is greatly dependent on opportunistic sampling from bottom fishing (i.e. trawling), with recent advances pushing towards video-based surveys using different underwater platforms (e.g. ROVs, tow cameras, AUVs, divers). Despite these advances, there is still a lack of standardization and/or harmonization of data acquisition protocols and imagery analysis methods. Additionally, some of the technology and tools used are not widely available, making most efforts to map and monitor seafloor litter pollution spatially scarce and often with a negative impact on marine fauna and benthic habitats from destructive sampling with trawling. In addition to mapping litter pollution, standardized/harmonized video-based surveys and analysis can also provide assessment of the impact and interactions of litter-biota interactions, enabling to advance knowledge and understanding of litter items with higher impact to benthic organisms and on ranking taxa vulnerability to litter (i.e. which organisms are more likely to be negatively impacted by seafloor litter).

In this extension period of CleanAtlantic, IFREMER and ARDITI/MARE-Madeira teams have collaborated to test and improve methods using video-based surveys and annotation, using BIIGLE annotation tool and ROV surveys and data collected in campaigns in the Bay of Biscay and Madeira.

Results of this study include a critical assessment of: i) video based surveys and monitoring, including considerations and limitations of ROV operations and data acquisition, and; ii) image processing and analysis using BIIGLE and common annotation referentials. Findings included in this report and outputs of this study (e.g. guidelines, future peer-reviewed publications) are also expected to contribute to improve seafloor litter monitoring and survey methods and in determining D10C4 MSFD indicator, currently under development.

Materials and methods

ROV Operations & Data acquisition

For the purposes of this study both IFREMER and ARDITI/MARE-Madeira collected and/or included video data collected with ROV surveys.

French videos included and analyzed in this study come from two campaigns, PACMAN and ChEReef, which took place in the North Bay of Biscay in 2021. The H-ROV Ariane was deployed from the vessels. Marine Litter observations and their impact on organisms has been added in an opportunistic way. They have been realized onboard by chief scientists and also by Marine Litter thematic experts after the campaigns.

In Madeira a specific custom campaign for this study was designed to test and optimize methods for seafloor litter pollution assessments using a BLUE-Rov2 equipped with sonar and multiple cameras. ROV survey dives were conducted in 2022-2023 from small vessels.

H-ROV Ariane description

The hybrid ROV Ariane represents the next generation of remotely operated submersibles which carry their own energy source in the form of lithium-ion batteries. Its only link to the surface is a fibre-optic cable.

The hybrid ROV Ariane undertakes dives to 2,500 m for short missions requiring manipulation, sampling, inspection or optical and acoustic mapping.

Its propulsion system and navigation sensors enable it to work on any type of seabed, including very uneven ground such as canyons.

Fitted with HD video cameras and a pan and tilt digital camera, Ariane can undertake high-quality optical inspections and generate high-resolution photogrammetry (or 3D optical mapping).

Technical and operational characteristics are available on the Ifremer website: https://www.flotteoceanographique.fr/en/Facilities/Vessels-Deep-water-submersible-vehicles-and-Mobile-equipments/Deep-water-submersible-vehicles/Ariane/Main-features .

Figure 1: H-ROV Ariane – ©Ifremer.

BlueROV-2 HD description

Open source, modular observation class ROV with Heavy Duty configuration, altimeter, sonar, manipulator rated to operate at 300 meters depth.

The BlurROV-2 HD is battery powered and is equipped with additional camera systems with sensors for depth, temperature and conductivity. It can be equipped with multiple cameras (2.7k) for underwater photogrammetry and 3D mapping. Current configuration does not include underwater positioning systems, but ROV is compatible with both USBL and DVL.

Marine Litter protocol

The protocol of observation of the seafloor litter and their impacts take into account the feedback of the RAMOGE cruise which took place in Mediterranean, 2019. It comes from the deliverable produced during the first phase of the CleanAtlantic project by Gerigny et al, 2020.

It consists of collecting, during a dive, various elements coming from the observation of litter and their impacts captured and/or noted in the comments in order to optimize the viewing of videos during post-processing:

- Save a picture of the litter observation and interaction with biota (if any)
- Indicate the litter observed, *e.g.* Plastic (bottle, rope, food packaging,…), Cloth, Fishing net or line Metal (Boat anchor, pot,…), Glass ceramic…
- Indicate the type of interaction: covering, entanglement, strangling, etc. and the species impacted when it is possible

The complete protocol and the field sheet are available in appendix 1.

Macrolitter items, macrobenthic organisms and possible interactions between both, visible along each dive transect, were counted and classified at the lowest taxonomic level. Information on substrate was also determined when it was possible.

Survey operations are dependent on the ROV and payload (e.g. camera, video, battery vs surface powered, positioning and navigation systems). For ROVs with underwater positioning systems, tracking enables detailed mapping of observation, whereas in ROVs with no positioning systems, it is crucial to collect details on point of entry and depth, ideally maintaining a general heading to enable estimates of approximate positioning based on vessel GPS position, point of entry, depth, tether distance and heading.

French campaigns

PACMAN campaign took place on the oceanographic vessel “Côte de La Manche”, from June 2nd to 22, 2021. This campaign proposes to study the interactions between habitats, environment and pressures. Underwater video acquisition has been the main source of data as it is recognized as a non-extractive technique to study biodiversity. Nine videos (<400m depth) (Figure 2) have been collected (KOPP Dorothée, MEHAULT Sonia (2021) PACMAN cruise, RV Côtes De La Manche, https://doi.org/10.17600/18001472).

The Annotations from PACMAN campaign were based on pictures sent by the chief scientists.

The nine dives (Table 1) were annotated on board by the scientists. Then, they were sent to the thematic expert for verification and analysis.

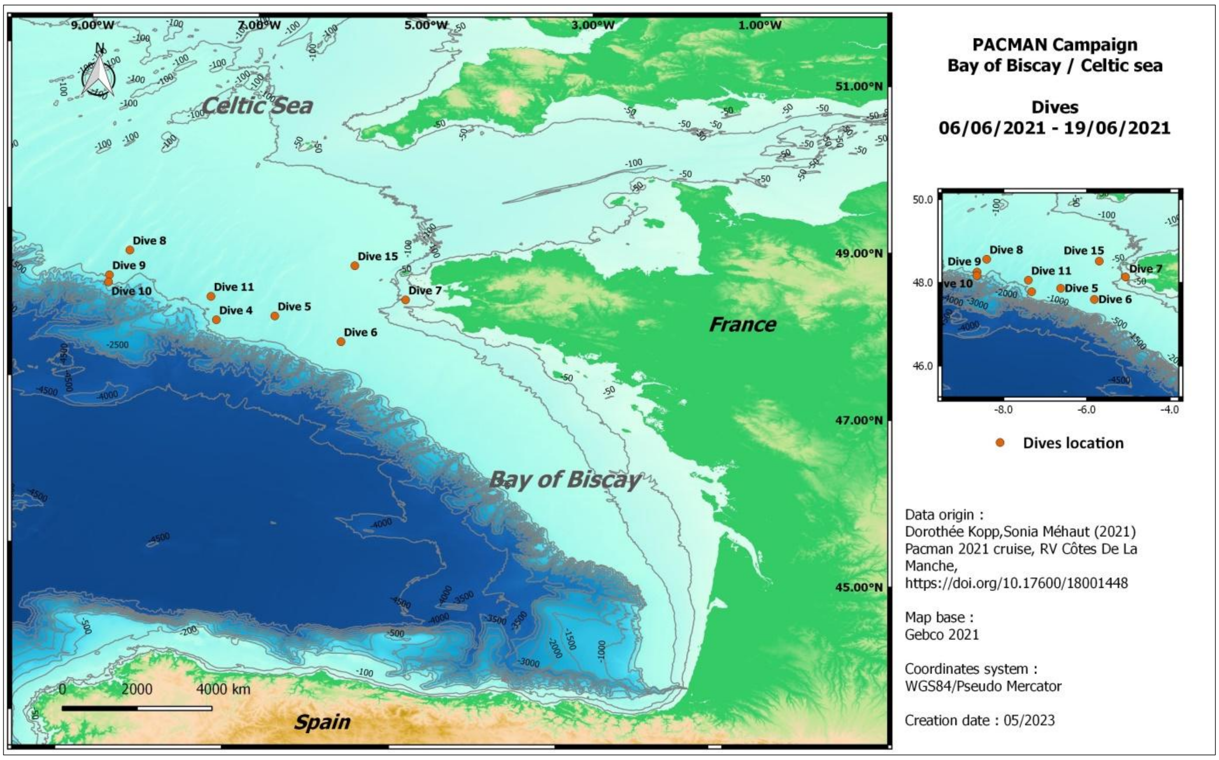

Figure 2: Dives location – Pacman ROV campaign, 2021.

Table 1: List of Pacman ROV dives analyzed, with geographical coordinates (start and end), depth range, and total length.

Date	Dive number	Lat (start)	Long (start)	Lat (end)	Long (end)	Depth range (m)	Transect length (m)
06/06/2021	Dive 4	47.7835020	-7.3283333	47.7865620	-7.3218150	169 - 183	4285
07/06/2021	Dive 5	47.8659650	-6.6303300	47.8531680	-6.6452400	120 - 122	2793
08/06/2021	Dive 6	47.5990920	-5.8197867	47.5977180	-5.8564083	143 - 145	4000
10/06/2021	Dive 7	48.1398250	-5.0723833	48.1520670	-5.0727167	93 - ?	3648
11/06/2021	Dive 8	48.5646830	-8.4083500	48.5470670	-8.4357333	152 - 154	3492
12/06/2021	Dive 9	48.2551030	-8.6383867	48.2367670	-8.6861500	?	4957
13/06/2021	Dive 10	48.1698500	-8.6449833	48.1485830	-8.6890333	230 - 440	4762
14/06/2021	Dive 11	48.0607000	-7.4072000	48.0574500	-7.4225500	179 - 182	2437
19/06/2021	Dive 15	48.5176850	-5.7018533	48.5003780	-5.7041017	117 - 120	3384

CheReef campaign took place on the oceanographic vessel “Thalassa”, from August 5 to September 5, 2021. The ChEReef project, implemented by the Biology and Ecology of Deep Sea Ecosystems Ifremer laboratory, is working on the assessment of the health status of deep-sea corals in the Lampaul submarine canyon. This canyon, located 200 km off the coast of Brittany, is included in a Natura 2000 site.

A total of six offshore oceanographic cruises are planned from 2021 to 2026 in order to explore, map and characterize the benthic habitats of the Lampaul canyon and its periphery, including trawled, untrawled and protected areas. Each year, the maintenance of the MARLEY observatory deployed in 2021 will also be carried out (MENOT Lenaick, TOUROLLE Julie (2021) ChEReef 2021 cruise, RV Thalassa, https://doi.org/10.17600/18001448).

All observations made during this campaign are available online, in the campaign catalog on the Ifremer website: https://campagnes.flotteoceanographique.fr/campaign?id=18001448 .

For this study, we’ve chosen to analyze dive 203-6 (Figure 3 and Table 2) with the BIIGLE annotation tool (see below) to use common referentials on items categories, interactions, species impacted with our partner ARDITI from Madeira.

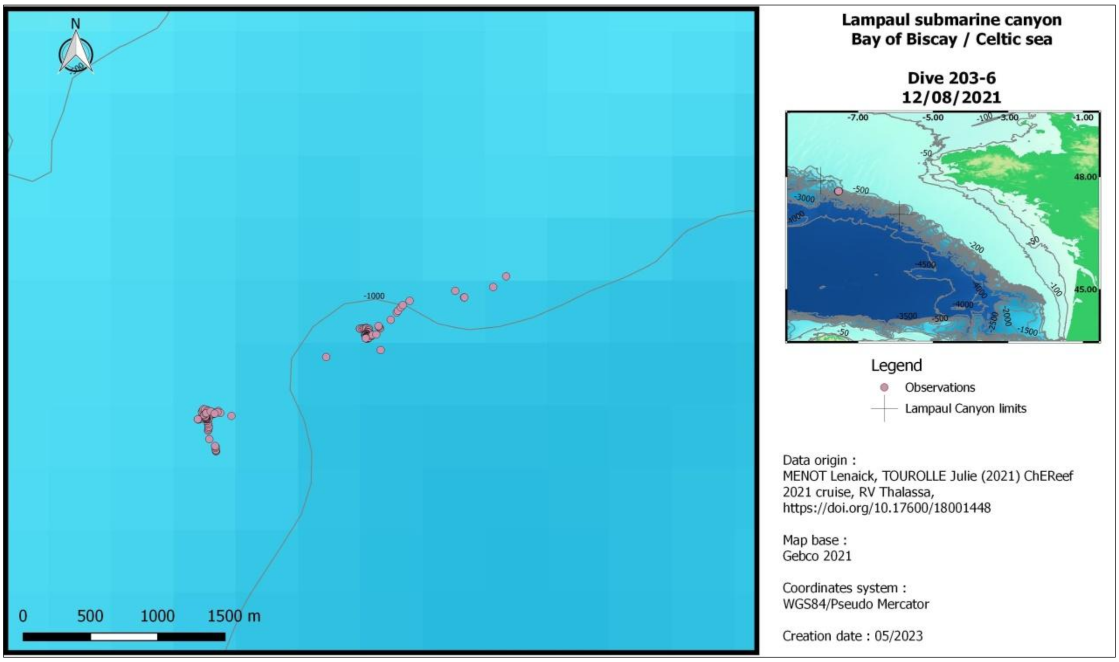

Figure 3: Lampaul submarine canyon location – CheReef Campaign, 2021.

Table 2: Dive analyzed from CheeReef campaign, with geographical coordinates (start and end), depth range, and total length.

Date	Dive number	Lat (start)	Long (start)	Lat (end)	Long (end)	Depth range (m)	Transect length (m)
12/08/2021	203-6	47.6094178	-7.5346251	47.6211201	-7.5152452	820 - 885	3 500

MADEIRA CAMPAIGN

For the purposes of this study, ARDITI/MARE-Madeira team planned a ROV campaign designed to test and optimize a workflow to assess seafloor litter pollution in a target area. The selected target area was in the vicinity of Funchal harbor (where a characterization of seafloor litter had been conducted during CleanAtlantic; Deliverable 5.2 “Overview of monitoring methods for marine litter in the Atlantic Area”) and Garajau Marine protected area (Figure 4).

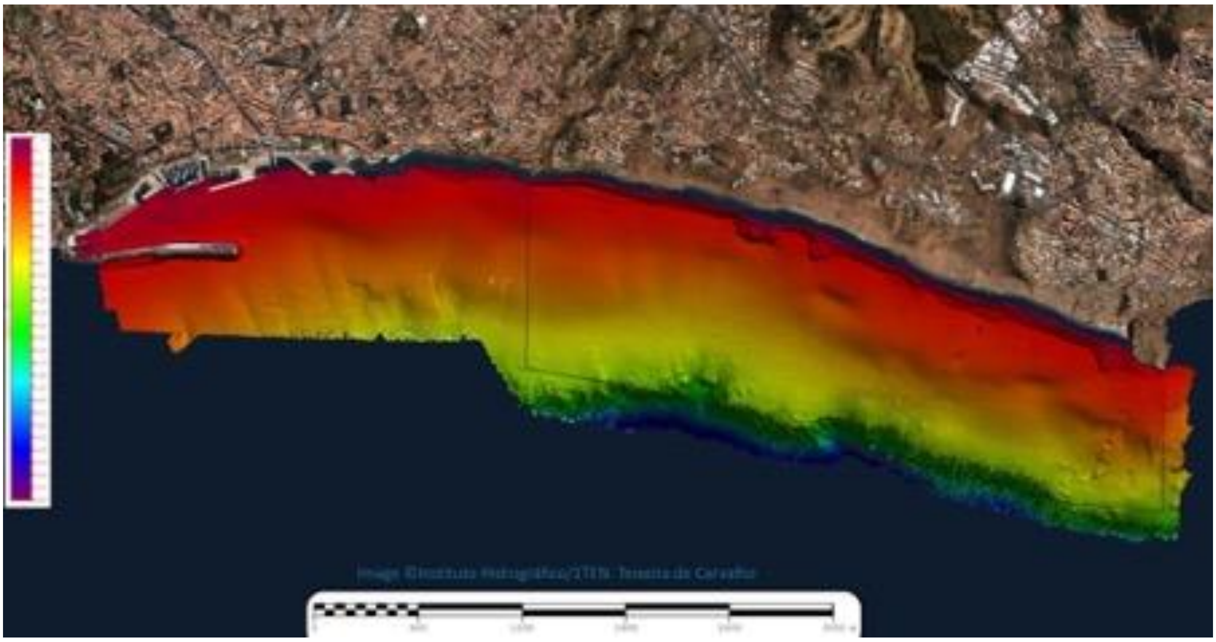

Figure 4: Map with depth and substrate features of the target area in Garajau (multibeam data collected by Instituto Hidrográfico in April 2022).

An inspection of the depth and substrate features of the target area enabled a selection of four "physiographic habitat" types: a shallow rocky reef (approx. < 30 m), a sandy plateau (approx. 30-90 m), a ridge (approx. 90-120 m) and a drop-off (approx. > 120 m). Based on this information, a sampling design was created to ensure ROV video surveys in the three physiographic habitats below 50 m depth (excluding the shallow rocky reef, where ROV operations are less adequate and SCUBA diving surveys are feasible, and excluding the sand plateau between 30-50 m, due to MPA restrictions in maritime activities and vessel operations). A total of six ROV drift surveys (Table 3) were conducted in the target area (June 2022 - January 2023), with two surveys targeting each of the three different habitats (established based on physiographic features): the sandy plateau (50-90 m depth), the ridge (90-120 m depth) and the slope (120-170 m depth). The target area had approx. 4 km², with each survey covering 800-1 200m distances (depending on current, waves and weather conditions).

Table 3 : ROV Dives in Madeira: date, coordinated, depth range and transect lengths.

Date	Dive Number	Lat (start)	Long (start)	Lat (end)	Long (end)	Depth range (m)	Transect length (m)
2022-06-22	1	32.632°	-16.883°	32.633°	-16.873°	158 – 123	1019
2022-06-23	2	32.633°	°-16.871	32.637°	-16.882°	123-88	1116
2022-06-23	3	32.631°	-16.858°	32.636°	-16.865°	93-46	811
2022-09-09	4	32.630°	-16.870°	32.630°	-16.857°	174-119	1195
2022-09-09	5	32.636°	-16.877°	32.637°	-16.868°	94-43	808
2022-11-30	6	32.633°	-16.863°	32.628°	-16.855°	88-121	910

IMAGE PROCESSING AND ANALYSIS - COMMON REFERENTIALS WITH BIIGLE ANNOTATION TOOL

During phase 1 of CleanAtlantic, the IEO and ARDITI partners inquired Ifremer on the tools used for annotating ROV videos. This request corresponded to the emergence of a new free online software for annotation of still images and videos developed by the Center for Biotechnology (CeBiTec) and Bielefeld University (Germany) (LangenkämperD, et al, 2017) and in deployment in Ifremer: BIIGLE.

Web based BIIGLE annotation tool allows users to develop, download and share hierarchical annotation trees and use them for picture and video annotation. With the capability of sharing video files and use the same annotation label trees, teams developed work test and assess feasibility of using BIIGLE to move towards an harmonized approach that can be leveraged by different users or institutions, with the added advantage of being able to share data and promote collaboration.

ARDITI and Ifremer agreed on content and created 3 annotation trees: i) Litter categories and sub-categories; ii) EUNIS Habitats (Marine), and iii) Litter-Biota interactions. The development of these trees and content was based on the TGML work on the revision of the Guidance on Monitoring of Marine Litter European Seas (Galgani et al, 2013) which includes a new chapter dealing with Litter in Biota (including a photo catalog to identify different types of litter interactions with benthic macro-biota). The Litter Categories label tree is based on the new Joint list 2021 (Fleet, D. et al, 2021) and Marine habitats come from the EUnis referential version 2022.

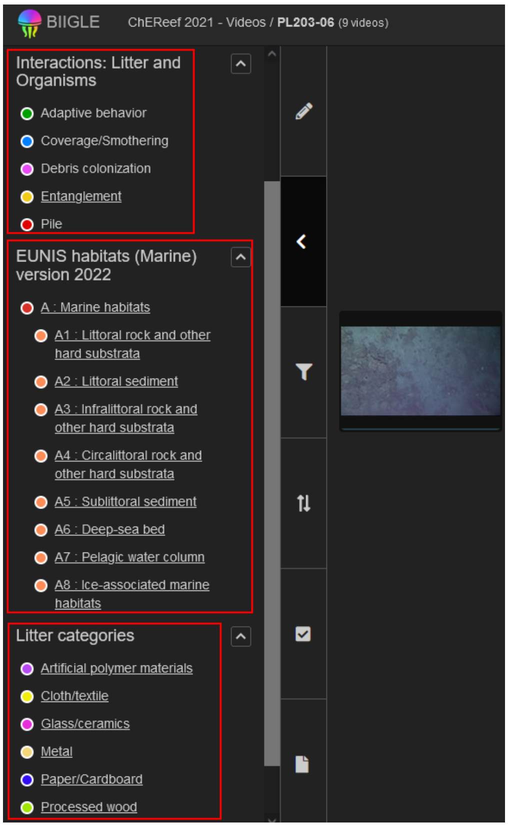

Figure 5: BIIGLE label trees shared by Ifremer and ARDITI.

For the purposes of this study, Ifremer and ARDITI teams used BIIGLE and the created label trees to inspect and annotate ROV survey videos independently, but also shared videos to test how annotations compared if analysis was performed by different users.

- 1 video from Dive 203-6 of CheReef campaign 2021:
  PL203-06 - CHEREEF_CHEREEF-203-06_210812085759_11
- 10 RAW videos from one dive of ARDITI campaign

The objective of this analysis of independent inspection and annotation of same video data to assess bias and how similar/different the results are when being annotated with the same platform and same labels. Ultimately, this pilot contributes to harmonizing seafloor litter assessments based on video annotation and evaluates if BIIGLE can contribute to analytical consistency.

Results

PACMAN Campaign

The videos from camera 11 of dive 203 were made available by the chief scientist on the BIIGLE application server. BIIGLE annotation and analysis produced the following results.

87 litters have been observed during the nine dives of this campaign. More than half (53%) are fishing related items (fishing lines, fishing net, rope). Glass represents 16% of the observations and Plastic 12% (Figure 6 and Figure 7). The other items are under 10% of the observations.

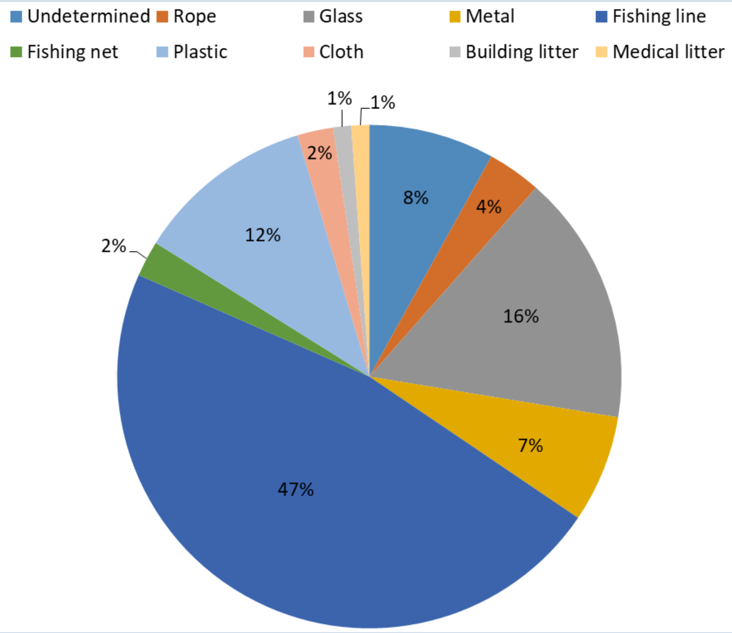

Figure 6: Percentage of Seafloor litter counted in Pacman Dives.

A maximum of 51 observations have been counted during the dive 10, one of the farthest dives from the coast and situated on the continental slope (see map, Figure 8).

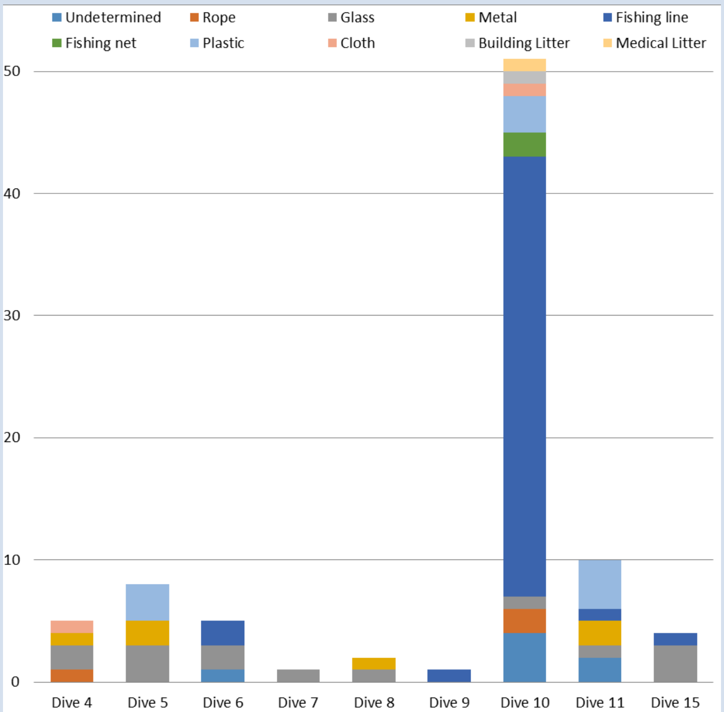

Figure 7: Number and characterization of litter per dives.

For each dive, results are shown in items per km (items/km) of observation because of technical reasons for evaluating surfaces with a submarine (Table 3).

Table 4 : Litter presence (items/km) per dives.

Dive Number	Date	Transect length (m)	Items number	Items / km
Dive 4	06/06/2021	4285	5	1.17
Dive 5	07/06/2021	2793	8	2.86
Dive 6	08/06/2021	4000	5	1.25
Dive 7	10/06/2021	3648	1	0.27
Dive 8	11/06/2021	3492	2	0.57
Dive 9	12/06/2021	4957	1	0.2
Dive 10	13/06/2021	4762	51	10.71
Dive 11	14/06/2021	2437	10	4.1
Dive 15	19/06/2021	3384	4	1.18

Unlike dive 10, which has the highest linear presence of seafloor litter (10,71 items/km) and is located on the continental slope, dives 11 and 5 with respective linear presence of 4.1 items/km and 2.86 items/km, are located on the continental shelf.

Seafloor litter observations were mainly made on shell sand substrate, colonized sometimes by living organisms. Few interactions could be identified: most covering and one colonization by a crinoid.

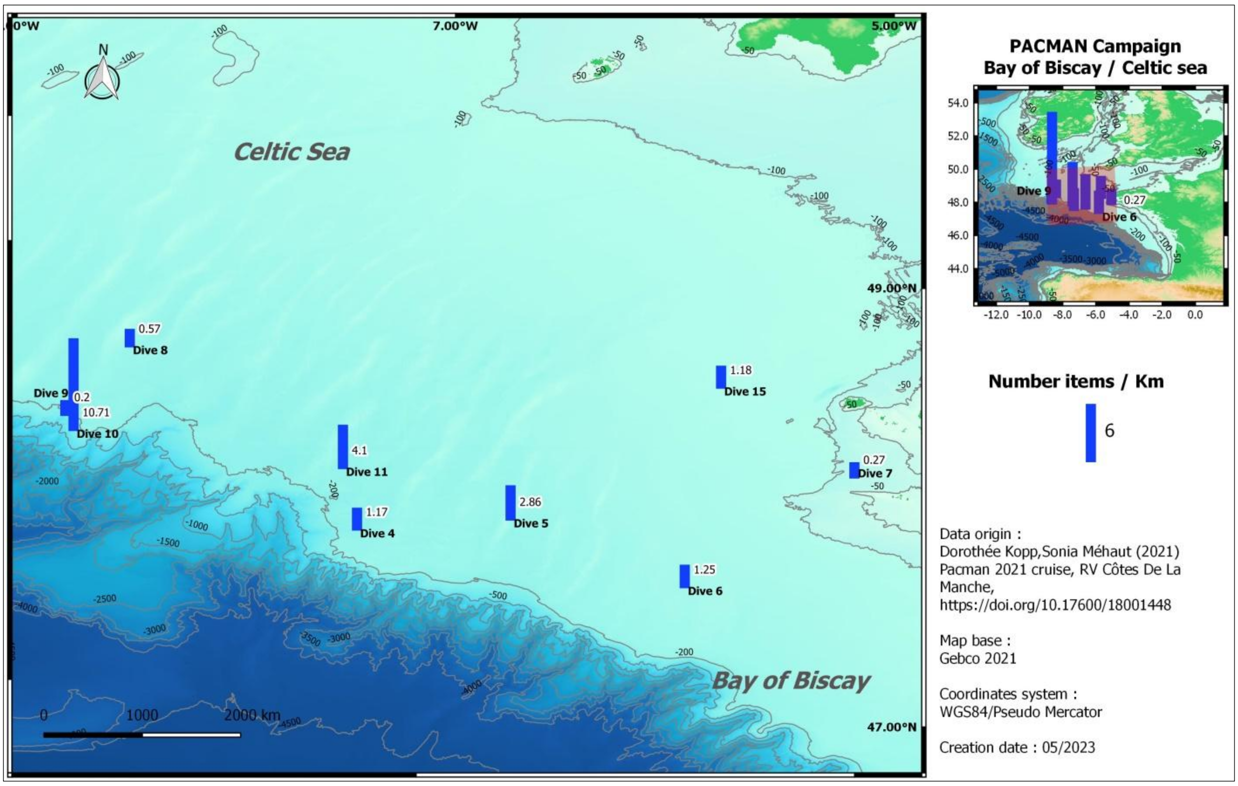

Figure 8: Representation of linear presence of seafloor litter for each dive (items / km) – Pacman campaign, 2021.

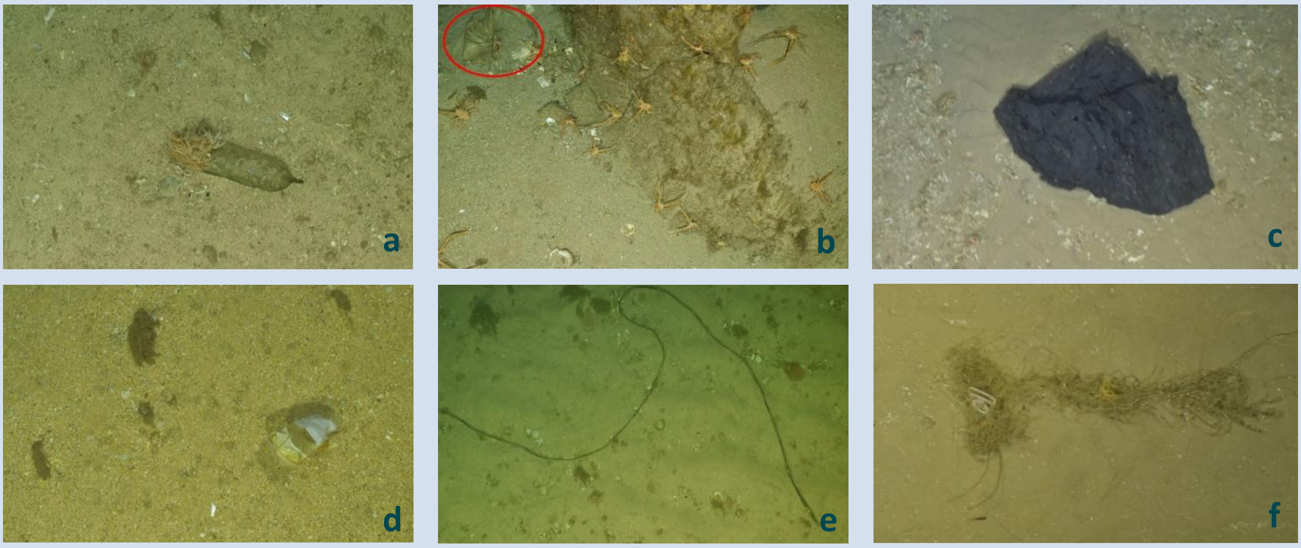

Figure 9: Seafloor litter examples : (a) Bottle colonized by crinoids, depth 141m, dive 6 ; (b) piece of cloth, depth 176m, dive 4 ; (c) Plastic bag, depth 305m, dive 10 ; (d) Plastic cup, depth 121m, dive 5 ; (e) Fishing line, depth 118m, dive15 ; (f) Fishing net, depth 428m, dive 10.

CheReef Campaign

Only one dive of CheReef cruise was analysed: CheReef Dive 203.

Six marine litter have been observed, for a distance of 3.5 linear kilometers of dive. The abundance of Marine Litter (items/km) for this dive is 1.71 items/km.

67% of the marine litter observed during the dive were artificial polymer materials. All of these items (plastics) belonged to the category “fishing gear”. As a result, litter from fishing gear also represents 67% of the total litter densities for this dive. 16% were ceramics and 16% “unsure” (both categories counting only one item).

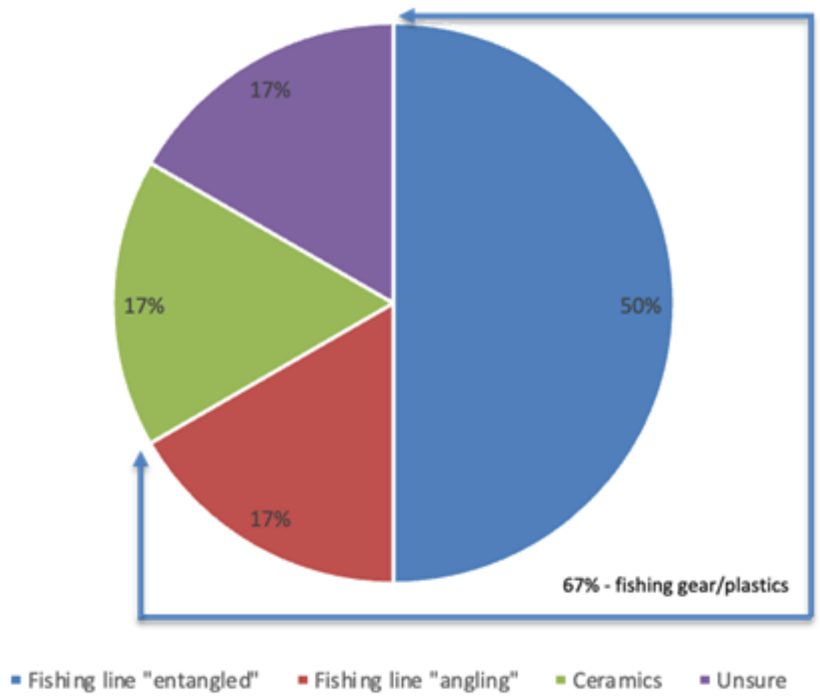

Figure 10: Percentage of seafloor litter categories counted in CheReef Dive number 203; 67 % correspond to artificial polymer materials and also to fishing gear litter.

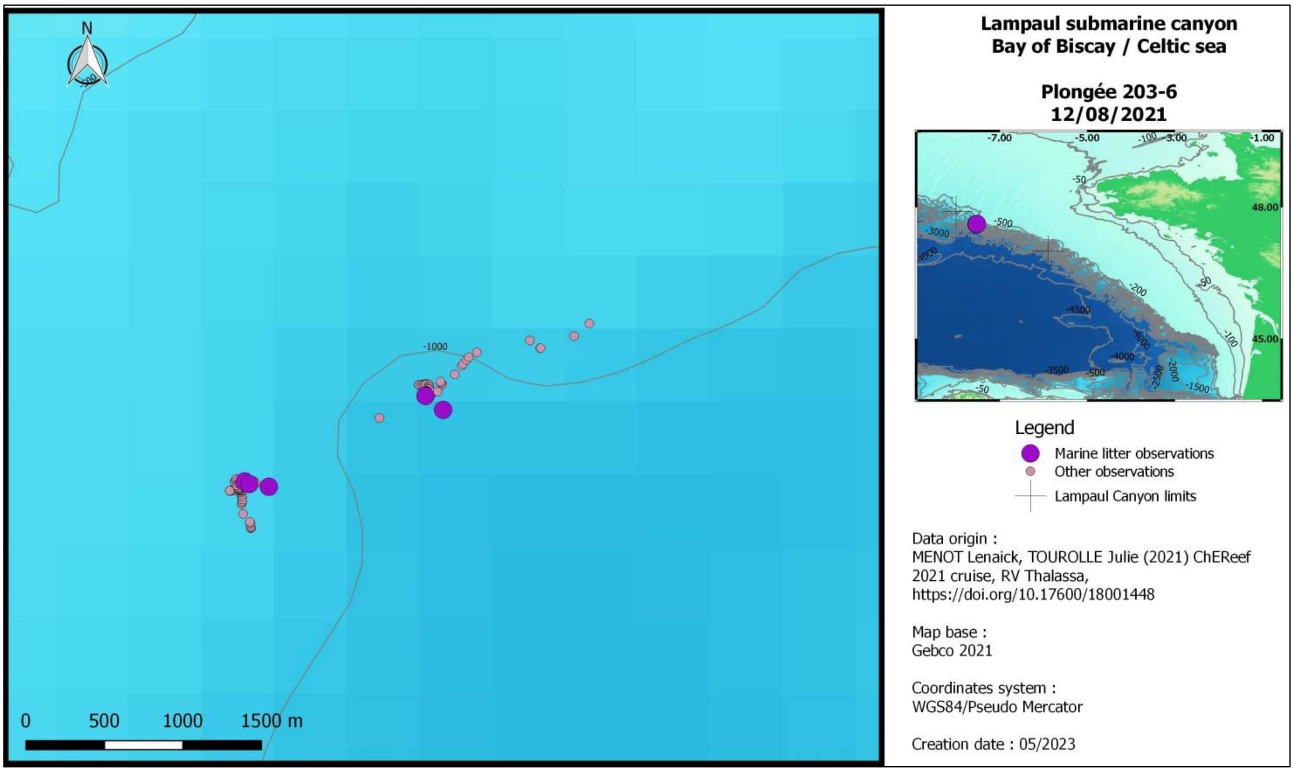

Figure 11: Representation of linear abundance for each dive (items / km) – CheReef campaign dive 203, 2021.

Only three interactions were observed on this dive, each time between fishing material and cnidarians (pictures a,c,d), giving 0.86 interaction/linear kilometer.

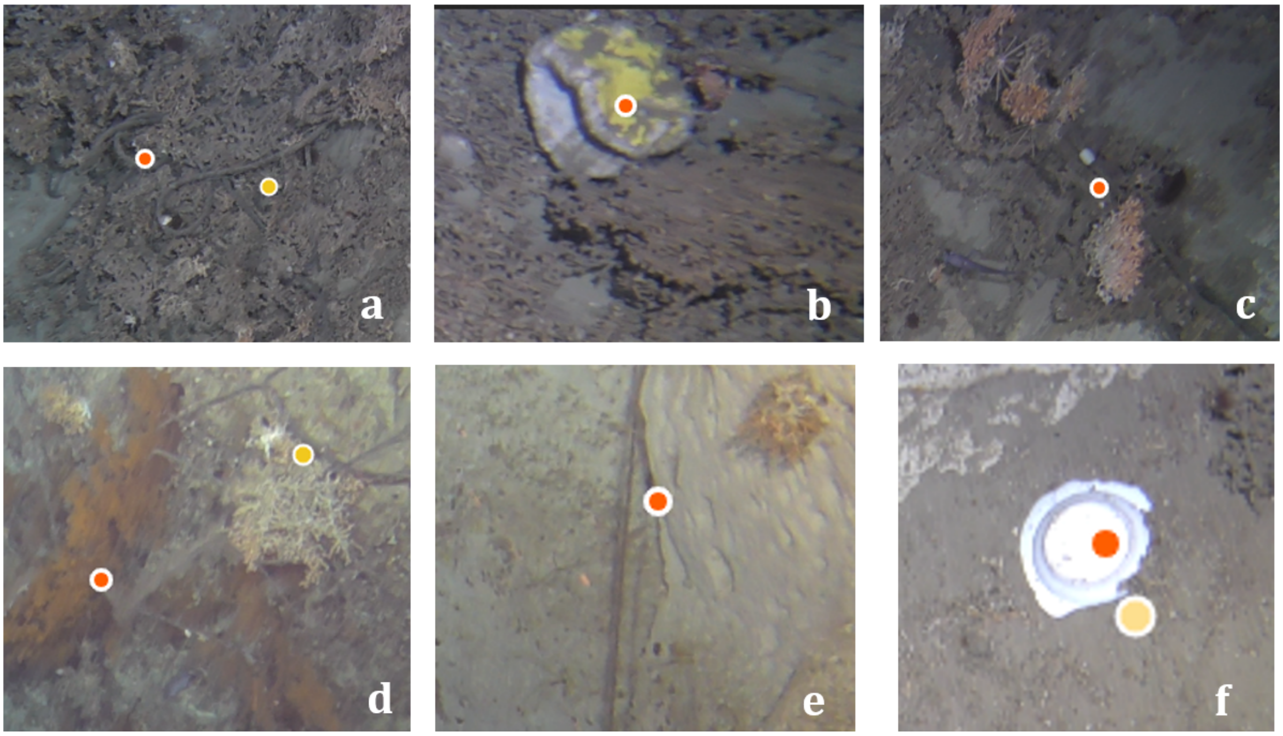

Figure 12: Marine litter items observed during CheReef campaign dive 203 extracted from BIIGLE annotation tool – a,c,d : fishing line entangled in cnidarians (with interactions) ; b : unsure category ; e : fishing line « angling » ; f : plate (ceramics category).

Madeira Seafloor Litter Campaigns

ROV surveys in Madeira targeted specific physiographic habitats identified from an inspection of multibeam data and maps (provided by Instituto Hidrográfico). This strategy resulted in a sampling design where two independent surveys were conducted to assess litter contamination of three different habitats (see above). The sampling design used enabled an independent data compilation and analysis for each of the targeted physiographic habitats. Litter characterization based on material and item classification (Figure 13 and 14) was compiled for each of the three target habitats: Sandy Plateau between 50-90 m depth, Ridge between 90-120 m depth and Slope below 120 m depth (Figure 14).

The Sandy Plateau had sparse whip corals between 70-90 meters that often increased in density along the depth gradient. These whip coral reach very high abundances and densities and often form a coral garden in the Ridge (90-120 m). Below 120 meters the slope had a mixed community of whip corals, gorgonians and scleractinian corals with frequent conspicuous sponges. Findings suggest differences in litter “abundance” with a total of 18 items detected during the two surveys conducted over the Sandy Plateau, 27 items detected on the Ridge habitat and 23 items on the Slope. Plastics and rubber were the most common, with rubber items, specifically tires, being most relevant in the shallower sandy plateau. In the Ridge and Slope, plastic items were more frequently detected, with fishing lines, bags and bottles being the most common items.

An analysis and classification of litter-biota interactions (Figure 14) showcased that 28% of the litter items detected were considered to be interacting with biota (Figure 15). The most commonly seen interactions were Debris colonization, when items serve as substrate or habitat for fouling and sessile organisms, and Entanglement of fishing lines and/or ropes with different biota. This latter interaction is noticeably the most damaging to biota as it often damages sessile organisms, especially when these have complex three-dimensional structures which provide niche habitat to associated fauna but are more prone to entanglement (e.g., gorgonians, colonial scleractinian corals, branching black corals). The interactions 'Coverage' (i.e., when litter items cover wide portions of the substrate) and 'Pile' (i.e., a cumulative point of litter which limits the identification and counting of single items and interactions) were very rare, comprising 2.5% and 1.2% respectively.

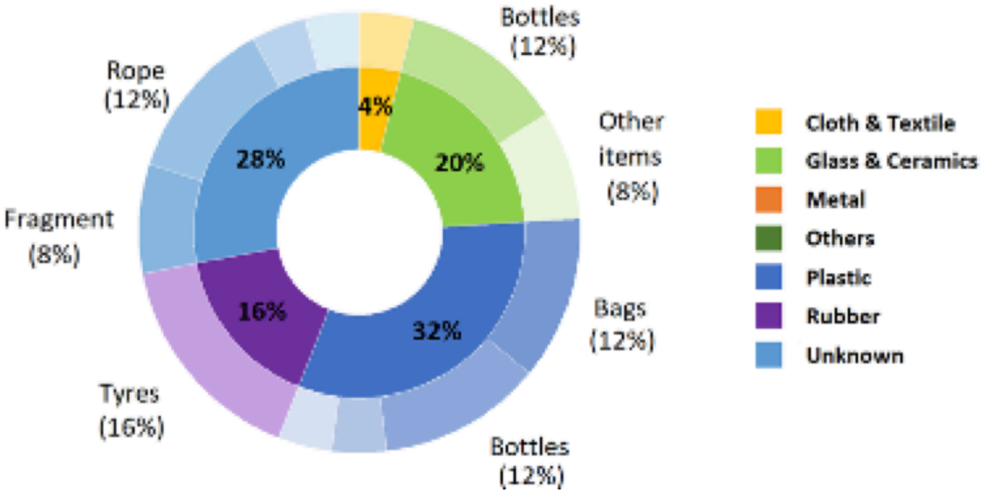

Figure 13: Materials and dominant types of all recorded litter items. Materials are presented as a percentage of the overall item count.

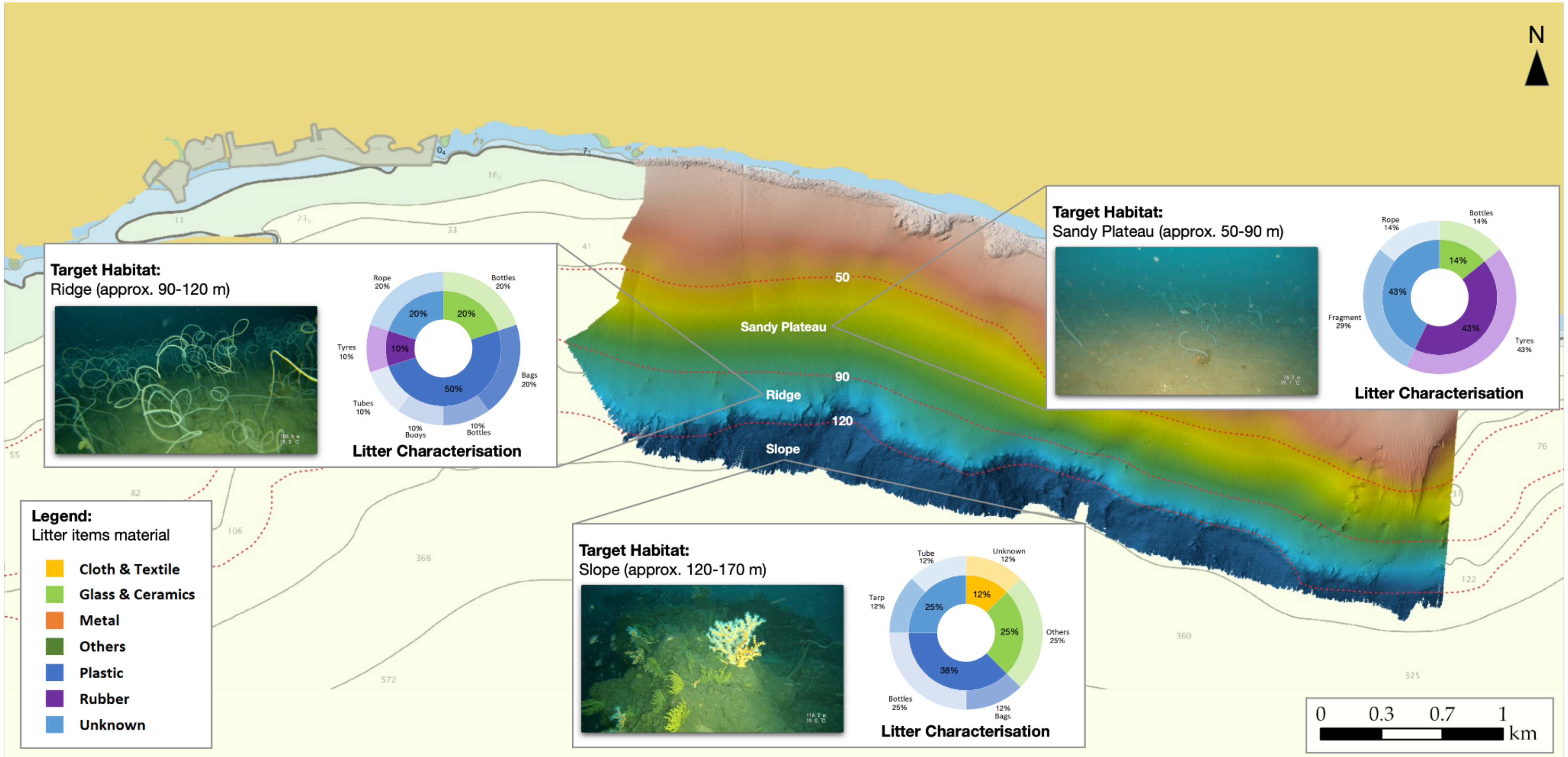

Figure 14: Seafloor litter assessment in three target habitats (Sandy Plateau between 50-90m, Ridge between 90-120m, and Slope between 120-170m) in Garajau. Pie charts include the total number of items identified within the two surveys conducted for each habitat and litter composition (%) with material in color and item in detail.

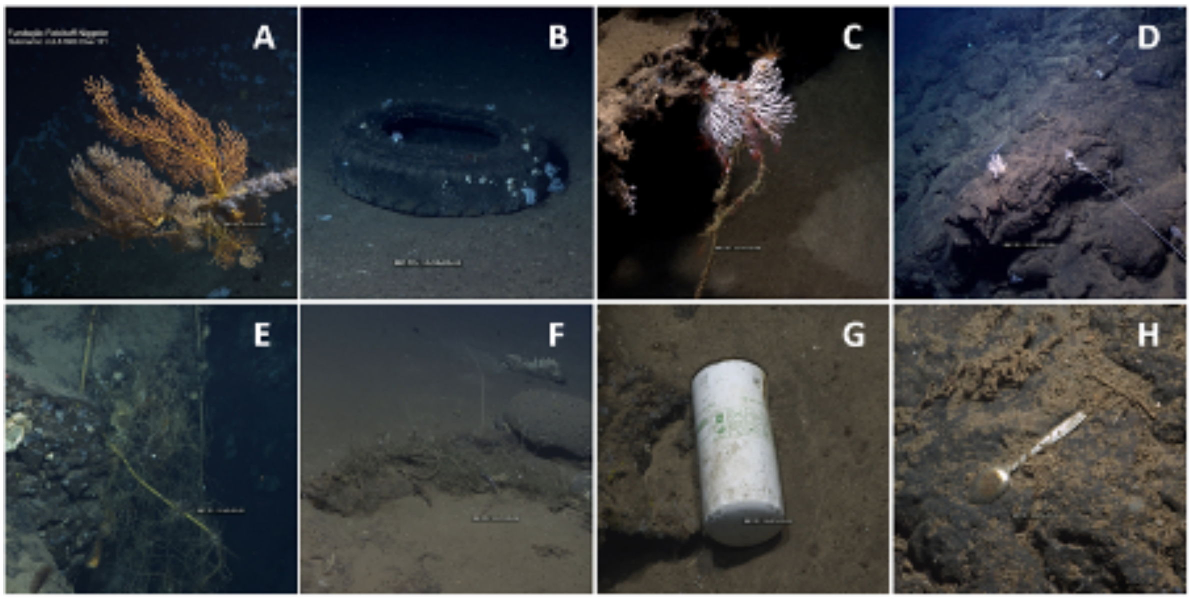

Figure 15: Types of interactions of species with litter items encountered at Madeira: (A, B) Debris colonization, (C, D) Entanglement, (E) Coverage, (F) Pile, and (G, H) None. (Imagery from LULA1000 ©Fundação Rebikoff-Niggeler).

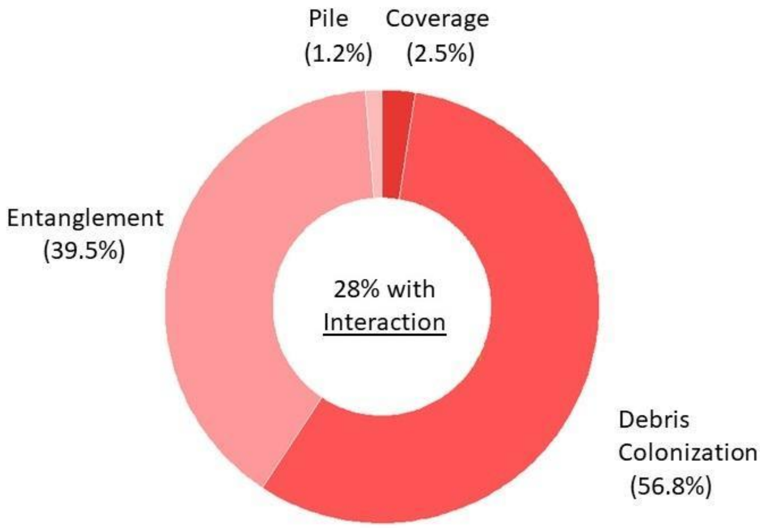

Figure 16: Types of litter-Biota interactions of all litter items recorded (total of 28% with interaction).

Intercomparison test on common videos

Monitoring strategies and methods need to provide consistency. Video transects and analysis are increasingly being used for seafloor litter assessments, as they can provide data and information on the type of items, on abundance and distribution and on visible impacts to marine biota. However, protocols and methods still require standardization and/or harmonisation to ensure results are robust. In this pilot we compared annotations by different BIIGLE users, sharing annotation labels and strategies, for one survey video from the Bay of Biscay (by Ifremer) and one set of videos from a survey dive in Madeira (by ARDITI).

An inspection of the annotation outputs (Figure 17 and 18) reveals illustrates that, despite using the same tool and annotation labels, different users provided different findings suggesting that user-bias cannot be solved by uniformization of the annotation tool and requires annotation training and strict protocols and/or a functional collaborative tool that effectively allows multiple users to annotate the same video files. Despite BIIGLE having these capabilities, stream based annotation does not work with high quality videos.

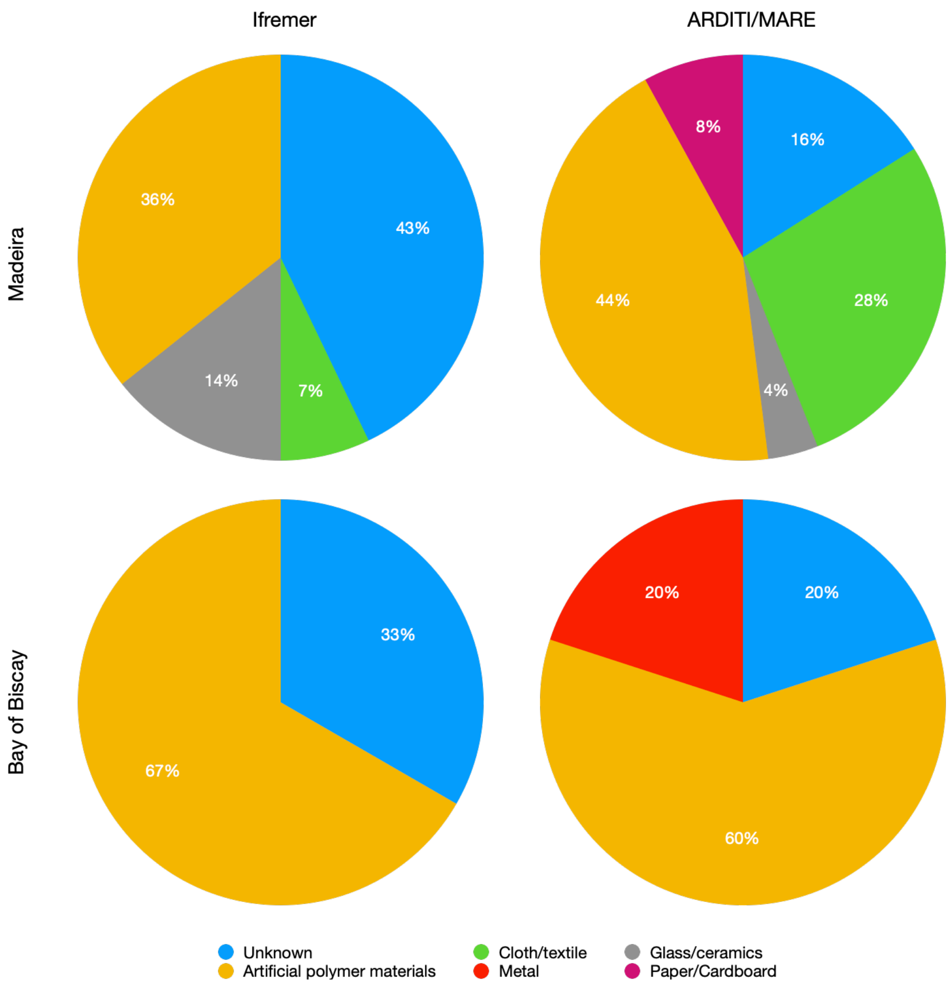

Figure 17: Comparison in composition analyses of survey videos from Madeira (top) and Bay of Biscay (bottom) by Ifremer (left) and ARDITI/MARE-Madeira (right).

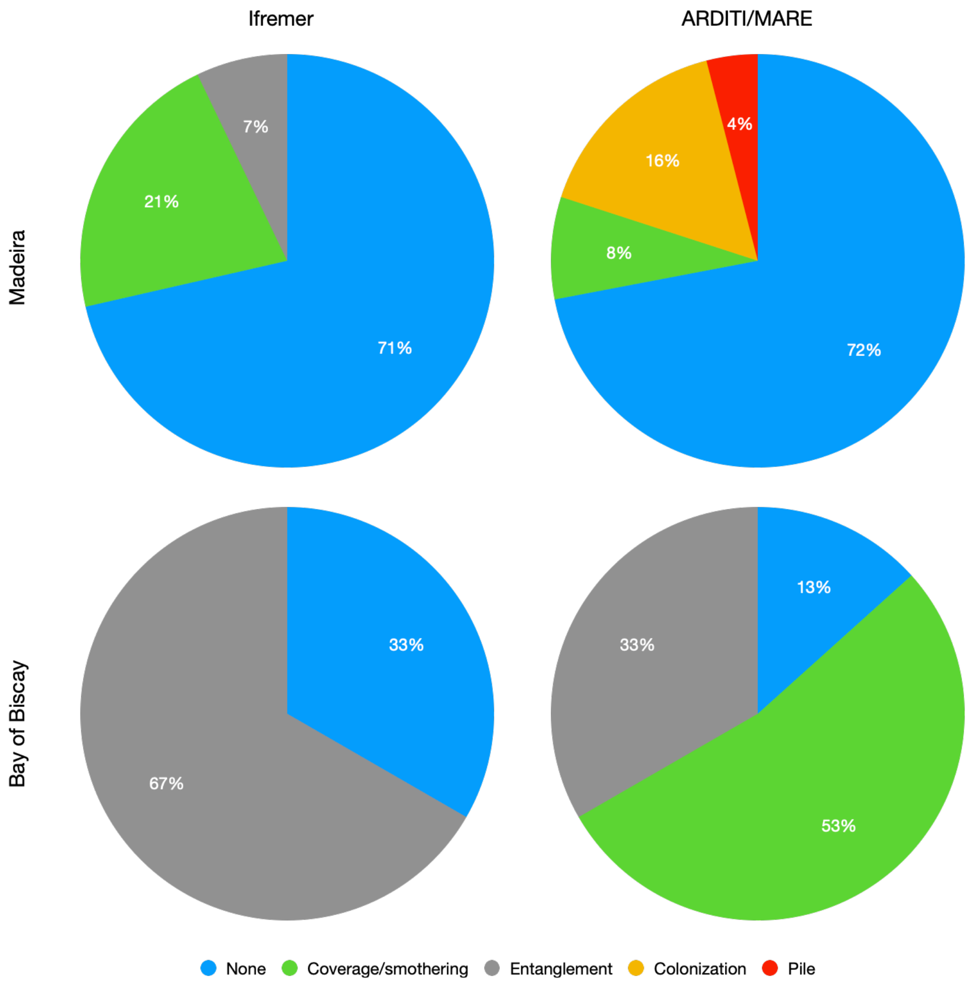

Figure 18: Comparison in litter-biota interaction analyses of survey videos from Madeira (top) and Bay of Biscay (bottom) by Ifremer (left) and ARDITI/MARE-Madeira (right).

Feedback on BIIGLE use

Despite the potential of BIIGLE software and design, this study revealed the difficulties in using BIIGLE as a common annotation tool as the media to be analyzed is videos. Indeed, the size of the files didn't allow ARDITI-MARE Institute to load them into a common platform, mainly due to the quality of the Internet connection and the lag in loading videos and during annotation. In fact, ARDITI-MARE team had to create a local set-up of BIIGLE using a dedicated computer to run analysis in locally stored video files. When using the BIIGLE web-based interface to annotate files stored remotely and streaming via the internet, the video image would lag behind the annotation timer, rendering all annotations useless or impossible. One way to circumvent this limitation would be to send video files to different institutes and run analysis locally, but this makes joint analysis and remote collaboration in the annotation impossible.

In addition to this inconvenience, table 4 below shows the other Pros and cons for BIIGLE that have been noted by the observers of this study.

Table 5 : Pros and cons for BIIGLE.

BIIGLE Advantages	**BIIGLE Disadvantages**
Ergonomic software	Slow display when video size is too large. Video lags behind annotation timer
Easy to understand even without training	Data reports are hardly directly exploitable (csv, no column...), and the file requires reformatting to allow visibility of the data.
Annotations easy to do	Lack of the title or the number of the video on the dives menu
Multiple ways to focus on the objects (points, shapes,…)	
Label trees easy to create, to modify and to share	

Based on the disadvantages column, technical improvements of the software could be suggested to make BIIGLE more efficient. Meanwhile, not all BIIGLE limitations in video annotation extend picture analysis and annotation, especially the difficulty in remote video analysis, which lags behind annotation timer. As such, one solution to this problem is to use frame extraction tools and use frames as still images for the analysis. Frame extraction can be tailored in terms of how many frames per minute or second are sampled. When paired with underwater positioning, frames can be embedded with GPS coordinates, facilitating spatial analysis. Image annotation can also be more easily used for AI and deep learning training than with video, as AI needs to track moving objects when dealing with video. One other advantage is that each frame will be used as a single sample, when estimating pollution levels, making harmonization and statistics easier to handle. However, there are also caveats in using frames: if frame rate is low, a lot of items can be lost and, depending on camera and ROV speed, frames often have drag marks making object recognition harder than the video.

Considering label trees that have been created based on MSFD joint list for item categories, EUNIS referential for Marine habitats and on the elements of the D10 revised guideline (ongoing) for the characterization of the impacts, their use highlights their complexity especially for the first two.

One other consideration is the ease of leveraging BIIGLE annotations for AI and deep learning training. Recent advances in AI assisted imagery analysis are promising, however, there is a need of training data sets to be made widely available as to make them accessible for widespread use. BIIGLE as the potential for it, but still needs improvements and refinements in the data outputs and in how these can be made widely available for AI training while not compromising privacy of the data and without disclosing detailed data.

Discussion

Observations from ROVs images and videos have been used for almost 30 years to characterize deep-sea pollution by marine litter and its impact on marine organisms (Galgani et al, 1995 a and b; Galgani et al, 2000; Miyake et al, 2011; Loakeimidis C. et al, 2015; Van den Beld et al, 2016; Chiba et al, 2018; Gérigny et al, 2018)

Within the framework of the MSFD, the data for the indicator seafloor litter mainly comes from data from trawling campaigns. Due to the environmental impact of trawls, the scientific community of marine litter experts tend to find an alternative to trawling. The observation of marine litter by ROVs has the advantage of being non-deteriorating for the environment, of being able to associate the observations of litter with their impact, but also of prospecting in larger areas than that targeted by trawls (other than the continental tray). These arguments have prompted the members of the MSFD Technical Group of Marine Litter to propose a new indicator D10C4 that would enable a common protocol to be adopted across Europe.

As in most locations around the world, the seafloor litter surveys conducted within the CleanAtlantic project are insufficient to establish major spatial patterns and model litter distribution in the study area. However, findings clearly demonstrate that there are spatial differences in litter composition (and sources). This information is relevant in assessing potential sources when considering reduction and mitigation measures. Abandoned, Lost and Discarded Fishing Gear, which are particularly concerning due to the higher probability of impacting organisms through entanglement, cover and ghost fishing, has obvious sources and measures that can be considered and implemented to reduce and mitigate the amount of these items that pollute the marine environment. Glass and ceramics, for example, are harder to pinpoint the sources, as they may come from shore or vessels and they may have been discarded (e.g., glass bottles thrown to the ocean from beachgoers, fisherman or pleasure vessels) or not (e.g., accidentally lost). In Funchal, for example, the high abundance of tiles and other construction materials may have originated from shore (e.g., storm or river outflows) or from a vessel (e.g., container loss, illegal disposal or sunken vessel). In contrast, there are multiple actions and measures that can reduce ALDFG, ranging from stricter regulations and enforcement to providing incentives for adequate disposal and better maintenance of fishing gear.

On top of being easier to detect the source (i.e., fishing activities), mitigating and reducing ALDFG is also particularly relevant as these litter items have a much greater negative impact than others. Litter Entanglement is known to mechanically damage corals and other branching organisms by abrasion causing colony loss and in more severe cases mortality. Most cases of entanglements encountered at Madeira Island were due to fishing lines/ropes/strings getting caught in branching corals. In this context, fishing lines, nets and other fishing gear are not only amongst the most common litter on the seafloor but also those most damaging to habitat constructors such as gorgonians, corals and sponges by covering them or getting entangled, which often damages these slow-growing organisms and can ultimately destroy the habitat they provide. As such, biotopes where these habitat-building organisms are abundant and/or dominant, are particularly vulnerable, as it is corroborated by the data and findings included in this report (see above). Within the framework of this report, biotopes were identified based on most abundant taxa and relevant biological and functional traits. Additional and follow up research can be conducted to further identify taxa diversity and describe biotopes in greater detail.

Similarly, despite the pioneering nature and even though it establishes important baselines and provides insight into litter contamination of deep and mesophotic marine habitats in Madeira, survey methods and experimental design can be improved in future monitoring efforts. The absence of accurate underwater location and scaling reference such as lasers limits the ability to collect accurate measurements and calculate densities for taxa and litter). The use of underwater laser scales and the adoption of a standardized protocol for speed, time and/or distance of the video transect would greatly enhance the quality of the data and information that could be extracted from the videos. Similarly, the use of high resolution multibeam data and maps (Figure 4) can be used for directing monitoring efforts based on an experimental design that targets physiographic habitats based on depth, substrate and slope. This strategy, coupled with statistical analysis, spatial analysis and predictive modeling strategies can be used to better extrapolate ecological niches, the distribution of relevant biotopes and even predict contamination levels.

Considering all the findings and these considerations, it is clear that assessing the good environmental status of deep and mesophotic habitats in Madeira, as well as the contamination and impact of marine litter in the marine environment (in compliance with the Marine Strategy Framework Directive and in line with UN Sustainable Development Goals 6, 12 and 14), will certainly require periodic systematic monitoring of these habitats. It is therefore highly recommended to plan for the design and establishment of long term periodic monitoring and mapping of litter contamination and impacts in mesophotic and deep sea habitats. Finally, the relevance of ALDFG pollution requires actions by decision makers towards decreasing their impacts (through regulations, incentives, surveillance and scrutiny of fishing activities).

This study also presents a first result on the bias of the analysis between several observers from two European institutes, Madeira ARDITI-MARE from Portugal and IFREMER from France. Findings indicate that the use of a common tool, annotation labels and guidelines is insufficient to mitigate user related bias. Strict protocols, annotation and video analysis training and live collaborative tools.

It would be important to push the study and do the same work on a larger number of videos, in order to carry out a robust statistical study on what the "observer bias" can generate in the results. Indeed, two different people watching and annotating the videos would be really relevant as the results showed that after a first watch on videos, a second one enables them to identify more items.

To improve common annotations, it should be relevant to agree on the counting of items and particularly considering fishing lines which usually appear during a long time on videos or may appear many times pending on ROV movement. It would be important to statute how to count these elements: should each observation be considered, or should the element be counted only once, when it's obvious that it is the same?

One other solution is to use frame extraction and standardize by time (e.g. 1 frame per 20 seconds) or even by distance (e.g. 1 frame every 10 meters). This solves issues related to the annotation and enables standardization by sampling effort. To the best of our knowledge there is no readily available tool for frame extraction, requiring coding to enable it (see Annex 3 for Python code for extracting frames per second).

Conclusion

These results will make it possible to detail the test protocol from phase 1 of CLEANATLANTIC project. Indeed, it will be possible to specify the way to make annotations when there is a doubt about a multiple observation of a piece of litter, in particular in the case of fishing nets or monofilament. The recommendation of a double check on videos could also be added not to miss items. A reduction of the items present in the label trees could be proposed in order to facilitate annotations.

One other suggestion is to reduce file size being used for annotation in BIIGLE, including the use of frames extracted from videos. This would enable standardization of sampling effort, easier annotation and AI training and tackling current limitations in web-based annotation in video streaming over an internet connection.

This protocol modification could be carried out in a future work and could be brought to the attention of OSPAR and MSFD working groups.

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ANNEX 1 – Observation sheet

Observation Sheet on Entanglement/Strangling/covering of the species by Marine Litter during ROV dives

Survey name / Vessel / Gear	
Diving Number	
Diving Area	
Diving duration	

Observation N°	Dive Time	Latitude	Longitude	Entangled species	Recovery %	Litter Material[1]	Litter Types[2]	Comments/Impacts

ANNEX 2 – BIIGLE label trees

Items Categories

id	name	parent_id	color	label_tree_id	source_id
199366	Food containers incl. fast food containers - G10	199410	b749f2	1062	
199367	Other plastic/polystyrene items (identifiable) - G124	199410	ccff66	1062	
199368	Crates and containers / baskets - G18	199410	59e639	1062	
199369	Bags - G2	199410	2451f2	1062	
199370	Plastic caps and lids - G20	199410	bd66ff	1062	
199371	Cigarette butts and filters - G27 --- tobacco products with filters (cigarette butts with filters) - J27	199410	457de6	1062	
199372	Gloves - G39	199410	f20049	1062	
199373	Synthetic rope - G48	199410	e60b1e	1062	
199374	Fishing net - G51	199410	4dd5ff	1062	
199375	Fishing line (entangled) - G55 ---- plastic fishing line - J59	199410	ff19c9	1062	
199376	Fishing line/monofilament (angling) - G59 --- plastic fishing line - J59	199410	e6d62e	1062	
199377	Bottles - G6	199410	4500f2	1062	
199378	Other fishing related - G61	199410	49a9f2	1062	
199379	Strapping bands - G66 --- plastic strapping bands - J66	199410	fff700	1062	
199380	Cans (food) - G176 --- metal food cans - J176	199407	f2d679	1062	
199381	Cans (beverage) - G175 --- metal drinks cans - J175	199407	ff0d49	1062	
199382	Appliances (refrigerators, washers, etc.) - G180 --- metal appliances (refrigerators, washers, etc.) - J180	199407	f2558c	1062	
199383	Fishing related (weights, sinkers, lures, hooks) - G182 --- metal fisheries related weights/sinkers, and lures - J182	199407	ff4da3	1062	
199384	Middle size containers - G185 --- other metal pieces 2.5cm â‰¥ â‰¤ 50cm - J198	199407	e62284	1062	
199385	Drums,e.g.oil - G187 --- metal drums & barrels - J187	199407	8830f2	1062	
199386	Car parts / batteries - G193 --- metal vehicle parts / batteries - J193	199407	f2780c	1062	
199387	Cables - G194 --- metal cables - J194	199407	f24324	1062	
199388	Pallets - G160 --- wooden pallets - J160	199409	a1e600	1062	
199389	Wood (processed) - G170 --- N/A	199409	f26163	1062	
199390	Other (specify) - G173	199409	79f299	1062	
199393	Bottles incl. pieces - G200 --- glass bottles - J200	199406	e62ed9	1062	
199394	Jars incl. pieces - G201 --- glass jars - J201	199406	5233ff	1062	
199395	Glass or ceramic fragments >2.5cm - G208 --- pieces of glass/ceramic (glass or ceramic fragments â‰¥ 2.5 cm) - J208	199406	e63f39	1062	

199396	Large glass objects (specify) - G209 --- pieces of glass/ceramic (glass or ceramic fragments â‰¥ 2.5 cm) - J208	199406	550dff	1062	
199397	Clothing / rags (clothing, hats, towels) - G137 --- clothing - J137	199405	f2ee0c	1062	
199398	Shoes - G136 --- shoes & sandals made of leather and/or textile - J138	199405	ff334e	1062	
199399	Carpet & Furnishing - G141 --- cloth textile carpet & furnishing - J141	199405	30c8f2	1062	
199400	Paper/Cardboard - G146 --- other paper items - J158	199408	320cf2	1062	
199401	Cardboard (boxes & fragments) - G148	199408	3df24f	1062	
199402	Other paper items - G158	199408	3db3f2	1062	
199405	Cloth/textile		f2ee0c	1062	
199406	Glass/ceramics		e62ed9	1062	
199407	Metal		f2d679	1062	
199408	Paper/Cardboard		320cf2	1062	
199409	Processed wood		a1e600	1062	
199410	Artificial polymer materials		b749f2	1062	
199411	Rubber		5b3df2	1062	
199412	Unsure		e66781	1062	
203898	Sheets, industrial packaging, plastic sheeting - G67	199410	b749f2	1062	
205949	Cable ties - G93 --- plastic cable ties - J93	199410	b749f2	1062	
205950	Cotton bud sticks - G95 --- plastic cotton bud sticks - J95	199410	7e00e6	1062	
205951	Sanitary towels/panty liners/backing strips - G96	199410	5ce6b1	1062	
205952	Syringes/needles - G99 --- plastic syringes/needles - J99	199410	f28a61	1062	
205953	plastic single-use face-mask - N/A - J253	199410	24f292	1062	
205954	Fragments - N/A	199410	f28a6d	1062	
205955	Diapers/nappies - G98 --- plastic diapers/nappies - J98	199410	b749f2	1062	
205956	Rope, string and nets - G142	199405	f2ee0c	1062	
205957	Other textiles (incl. rags) - G145	199405	cf6df2	1062	
205958	Other glass items - G210	199406	e62ed9	1062	
205959	Large metallic objects - G196 --- other metal pieces > 50cm - J199	199407	f2d679	1062	
205960	Other (metal) - G197	199407	00ff84	1062	
205961	Balloons and balloon sticks - G125 --- -rubber balloons - J125	199411	5b3df2	1062	
205962	Rubber boots - G127 --- rubber boots - J127	199411	ff8e59	1062	
205963	Tyres and belts - G128	199411	f20800	1062	
205964	Bobbins (fishing)- G132 --- N/A	199411	f2e824	1062	
205965	Condoms (incl. packaging) - G133 --- rubber condoms (incl. packaging) - J133	199411	e67d2e	1062	
205966	Other rubber pieces - G134	199411	ff4f19	1062	
205967	plastic dog/pet faeces bag - J1010	199369	2451f2	1062	
205968	plastic mesh bags for vegetable, fruit and other products - J238	199369	0be6c1	1062	
205969	plastic shopping/carrier/grocery bags - J3	199369	4d8bff	1062	

205970	other plastic heavy-duty sacks - J36	199369	1d0dff	1062	
205971	small plastic bags - J4	199369	0c3af2	1062	
205972	the part that remains from tear-off plastic bags - J5	199369	6ae60b	1062	
205973	plastic beach use related body care and cosmetic bottles and containers - J11	199377	4500f2	1062	
205974	plastic non-beach use related body care and cosmetic bottles and containers - J12	199377	4500f2	1062	
205975	other plastic bottles & containers (drums) - J13	199377	c855f2	1062	
205976	plastic engine oil bottles & containers 2.5 cm â‰¥ â‰¤ 50 cm - J14	199377	3700ff	1062	
205977	plastic engine oil bottles & containers >50cm - J15	199377	0db2ff	1062	
205978	plastic jerry cans - J16	199377	0c64f2	1062	
205979	plastic drink bottles â‰¤ 0.5 l - J7	199377	458de6	1062	
205980	plastic drink bottles >0.5 l - J8	199377	c80cf2	1062	
205981	plastic bottles and containers of cleaning products - J9	199377	39e695	1062	
205982	plastic crates, boxes, baskets - J18	199368	59e639	1062	
205983	plastic buckets - J65	199368	9.35E+09	1062	
205984	plastic string and filaments exclusively from dolly ropes - J232	199374	4dd5ff	1062	
205985	plastic tangled nets and rope without dolly rope or mixed with dolly rope - J234	199374	ff4d8b	1062	
205986	plastic tangled dolly rope - J235	199374	6c50e6	1062	
205987	plastic nets and pieces of net 2.5 cm â‰¥ â‰¤ 50 cm - J53	199374	f27c61	1062	
205988	plastic nets and pieces of net > 50cm - J54	199374	3deff2	1062	
205989	plastic 4/6-pack yokes & six-pack rings - J1	199366	b749f2	1062	
205990	plastic food containers made of foamed polystyrene - J224	199366	73ffc2	1062	
205991	plastic food containers made of hard non-foamed plastic - J225	199366	e62e3a	1062	
205992	plastic cutlery - J228	199366	e14dff	1062	
205993	plastic plates and trays - J229	199366	ffb073	1062	
205994	plastic stirrers - J230	199366	00e6da	1062	
205995	plastic straws - J231	199366	e6677a	1062	
205996	plastic crisps packets/sweets wrappers - J30	199366	335fff	1062	
205997	plastic lolly & ice-cream sticks - J31	199366	f2bf24	1062	
205998	fragments of non-foamed plastic 2.5cm â‰¥ â‰¤ 50cm - J79	205954	f28a6d	1062	
205999	fragments of non-foamed plastic > 50cm - J80	205954	e60b6a	1062	
206000	fragments of foamed polystyrene 2.5 cm â‰¥ â‰¤ 50 cm - J82	205954	b9e650	1062	
206001	fragments of foamed polystyrene > 50cm - J83	205954	e60be6	1062	
206002	single-use plastic gloves - J252	199372	f20049	1062	
206003	plastic gloves (household/dishwashing, gardening) - J40	199372	ff9173	1062	
206004	plastic gloves (industrial/professional applications) - J41	199372	89e617	1062	
206005	other plastic string and filaments exclusively from fishery - J233	199378	49a9f2	1062	

206006	plastic crab/lobster traps (pots) and tops - J42	199378	96ff40	1062	
206007	plastic octopus pots - J44	199378	30cbf2	1062	
206008	plastic mussels/oyster mesh bags, net sack, socks - J45	199378	6d8ef2	1062	
206009	plastic oyster trays - J46	199378	f21865	1062	
206010	plastic sheeting from mussel culture (Tahitians) - J47	199378	d280ff	1062	
206011	fish boxes - hard plastic - J57	199378	00f2ea	1062	
206012	fish boxes - foamed polystyrene - J58	199378	f2618f	1062	
206013	plastic fishing light sticks / fishing glow sticks incl. packaging - J60	199378	00f2b2	1062	
206014	other plastic fisheries related items not covered by other categories - J61	199378	87f249	1062	
206015	plastic floats for fishing nets - J62	199378	f21827	1062	
206016	plastic commercial salt packaging - J85	199378	a7f224	1062	
206017	plastic bait containers/packaging - J92	199378	f20c2b	1062	
206018	plastic medical/ pharmaceuticals containers/tubes/ packaging - J100	199367	ccff66	1062	
206019	plastic flip-flops - J102	199367	f2b824	1062	
206020	footwear made of plastic - not flip flops - J136	199367	ffc273	1062	
206021	plastic paint brushes - J166	199367	f2f26d	1062	
206022	plastic injection gun containers/cartridges - J17	199367	4dff58	1062	
206023	plastic vehicle parts - J19	199367	ff19b3	1062	
206024	other plastic medical items (swabs, bandaging, adhesive plasters etc.) - J211	199367	9940ff	1062	
206025	plastic irrigation pipes - J221	199367	755ce6	1062	
206026	other plastic items from agriculture - J222	199367	e93df2	1062	
206027	trays for seedlings of foamed plastic - J22	199367	c53df2	1062	
206028	other plastic personal hygiene and care items - J236	199367	4.84E+09	1062	
206029	plastic wet wipes - J237	199367	8f73e6	1062	
206030	other foamed plastic items and fragments not made of foamed polystyrene - J239	199367	44f218	1062	
206031	other identifiable foamed plastic items - J240	199367	8179f2	1062	
206032	other identifiable non-foamed plastic items - J241	199367	3dadf2	1062	
206033	plastic remains of fireworks - J243	199367	f23d8b	1062	
206034	plastic tobacco pouches / plastic cigarette packet packaging - J25	199367	9ce65c	1062	
206035	foamed plastic insulation including spray foam - J256	199367	33ffe4	1062	
206036	foamed plastic packaging - J257	199367	e622e6	1062	
206037	plastic cigarette lighters - J26	199367	ccff66	1062	
206038	plastic pens and pen lids - J28	199367	69ff40	1062	
206039	plastic combs/hair brushes/sunglasses - J29	199367	daf224	1062	
206040	plastic toys and party poppers - J32	199367	5.05E+09	1062	
206041	plastic tags (fishing, shipping, farming and industry) - J43	199367	92f249	1062	
206042	plastic floats/buoys other source than fishing or not known - J63	199367	737cff	1062	
206043	plastic fenders - J64	199367	67ff59	1062	

206044	fibre glass items - J68	199367	6168f2	1062	
206045	plastic hard hats/helmets - J69	199367	f28955	1062	
206046	plastic shotgun cartridges - J70	199367	61f28a	1062	
206047	plastic traffic cones - J72	199367	d8f255	1062	
206048	plastic CDs & DVDs - J84	199367	cf66ff	1062	
206049	plastic fin trees (from fins for scuba diving) - J86	199367	49f257	1062	
206050	plastic masking/duct/packing tape - J87	199367	8f55f2	1062	
206051	telephone - J88	199367	61f26f	1062	
206052	plastic construction waste (not foamed insulation) - J89	199367	f29661	1062	
206053	plastic flower pots - J90	199367	b5e667	1062	
206054	plastic biomass holder from sewage treatment plants and aquaculture - J91	199367	f20c68	1062	
206055	plastic toilet fresheners - J97	199367	19ffdd	1062	
206056	plastic caps/lids drinks - J21	199370	bd66ff	1062	
206057	plastic caps/lids chemicals, detergents (non-food) - J22	199370	f261cb	1062	
206058	cups and cup lids of foamed polystyrene - J226	199370	184ff2	1062	
206059	cups and lids of hard plastic - J227	199370	e6cc5c	1062	
206060	plastic caps/lids unidentified - J23	199370	f2d600	1062	
206061	plastic rings from bottle caps/lids - J24	199370	f2ef49	1062	
206062	plastic tampons and tampon applicators - J144	205951	5ce6b1	1062	
206063	plastic sanitary towels/panty liners/backing strips - J96	205951	a400e6	1062	
206064	plastic sheeting from greenhouses - J220	203898	b749f2	1062	
206065	plastic sheets, industrial packaging, sheeting - J67	203898	75ff66	1062	
206066	plastic string and cord (diameter less than 1cm) not from dolly ropes or unidentified - J242	199373	e60b1e	1062	
206067	plastic rope (diameter more than 1cm) - J49	199373	660be6	1062	
206068	cloth textile backpacks & textile bags - J139	205957	cf6df2	1062	
206069	hessian sacks/packaging - J140	205957	7.42E+09	1062	
206070	sails, canvas - J143	205957	0cf223	1062	
206071	other textiles - J145	205957	18f27a	1062	
206072	glass light bulbs - J202	205958	e62ed9	1062	
206073	glass and ceramic tableware (plates/cups/glasses) - J203	205958	ffbc40	1062	
206074	glass ceramic construction materials (bricks, tiles, cement) - J204	205958	50e693	1062	
206075	glass fluorescent light tube - J205	205958	3355ff	1062	
206076	ceramic or glass octopus pots - J207	205958	ff73d0	1062	
206077	other glass items - J210	205958	334bff	1062	
206078	other ceramic items - J219	205958	ff7519	1062	
206079	wheels with metal hub - J130	205960	00ff84	1062	
206080	metal aerosol/spray cans - J174	205960	e6e045	1062	
206081	metal foil wrappers, aluminium foil - J177	205960	e6177e	1062	
206082	metal bottle caps, lids & pull tabs from cans - J178	205960	ff008c	1062	
206083	metal disposable BBQs - J179	205960	61d5f2	1062	

206084	metal tableware (e.g. plates, cups & cutlery) - J181	205960	0ca6f2	1062	
206085	metal lobster/crab pots - J184	205960	b2f26d	1062	
206086	metal industrial scrap - J186	205960	b9ff73	1062	
206087	other metal cans - J188	205960	b818f2	1062	
206088	metal paint tins - J190	205960	6a59ff	1062	
206089	wire, wire mesh, barbed wire - J191	205960	f230a8	1062	
206090	metal household batteries - J195	205960	30f2ae	1062	
206091	cardboard boxes - J148	199401	3df24f	1062	
206092	paper cartons/Tetrapak milk - J150	199401	ff7d19	1062	
206093	paper cartons/Tetrapak (non-milk) - J151	199401	33fff1	1062	
206094	paper bags - J147	199402	3db3f2	1062	
206095	paper cigarette packets - J152	199402	e6c639	1062	
206096	paper newspapers & magazines - J154	199402	96ff66	1062	
206097	paper tubes and other pieces of fireworks - J155	199402	0c46f2	1062	
206098	paper fragments - J156	199402	00e6f2	1062	
206099	other paper items - J158	199402	189ff2	1062	
206100	paper cups - J244	199402	e639a6	1062	
206101	paper food trays, food wrappers, drink containers - J245	199402	e4ff4d	1062	
206102	paper cotton bud sticks - J246	199402	0cf26c	1062	
206103	other paper containers - J247	199402	0be699	1062	
206104	wooden corks - J159	199390	79f299	1062	
206105	wooden crates, boxes, baskets for packaging - J162	199390	f29e0c	1062	
206106	wooden crab/lobster pots - J163	199390	e65ce3	1062	
206107	wooden fish boxes - J164	199390	33ff8f	1062	
206108	wooden ice-cream sticks, chip forks, chopsticks, toothpicks - J165	199390	f20cd7	1062	
206109	wooden fireworks & matches - J167	199390	40f224	1062	
206110	other processed wooden items 2.5 cm â‰¥ â‰¤ 50 cm - J171	199390	f20095	1062	
206111	other processed wooden items > 50cm - J172	199390	24f258	1062	
206112	rubber belts - J249	205963	f20800	1062	
206113	rubber tyres - J251	205963	f20800	1062	
206114	rubber balls - J126	205966	ff4f19	1062	
206115	rubber band (small, for kitchen/household/post use) - J131	205966	b973ff	1062	
206116	other rubber pieces - J134	205966	3034f2	1062	
206117	rubber sheet - J248	205966	4af230	1062	
206118	rubber inner-tubes - J250	205966	bee65c	1062	

Interactions

id	name	parent_id	color	label_tree_id	source_id
209238	Coverage/Smothering		0080ff	1134	
209239	Entanglement		f2ca18	1134	
209240	Ghost fishing	209239	ff8040	1134	
209241	Debris colonization		e749f2	1134	

209242	Adaptive behavior		009f00	1134	
209243	Pile		e10000	1134	

Marine species

id	name	parent_id	color	label_tree_id	source_id
199414	Plant		8040	1063	
199415	Seagrass	199414	00ae00	1063	
199419	Algae	199414	408080	1063	
199420	Chlorophyta	199419	099f41	1063	
199421	Phaeophyceae	199419	804000	1063	
199422	Rhodophyta	199419	b30000	1063	
199423	Animalia		80	1063	
199424	Crustaceans	199423	ff8080	1063	
199425	Crabs	199424	ff4040	1063	
199426	Hermit	199424	bd0000	1063	
199427	Shrimp	199424	ff0080	1063	
199428	Porifera	199423	ff8000	1063	
199429	Cnidaria	199423	0080ff	1063	
199430	Hydrozoa	199429	0080ff	1063	
199431	Scyphozoa	199429	06aeff	1063	
199432	Anthozoa	199429	9.18E+05	1063	
199433	Cubozoa	199429	0cf2d7	1063	
199434	Hexacorallia	199432	ffff9f	1063	
199435	Actiniaria - Anemone	199434	8080ff	1063	
199436	Corals	199434	800080	1063	
199437	Ceriantharia - Tube-Dwelling Anemones	199432	dbdb00	1063	
199439	Octocorallia	199432	ffff51	1063	
199440	Ctenophora	199423	80ffff	1063	
199441	Chordata	199423	4080	1063	
199442	Tunicates	199441	408080	1063	
199443	Vertebrata	199441	ff0000	1063	
199444	Chondrichthyes	199443	bf0000	1063	
199445	Actinopterygii	199443	dd0042	1063	
199446	Shark	199444	770000	1063	
199447	Ray	199444	c80000	1063	
199448	Chimaeras	199444	bf0000	1063	
199449	Echinodermata	199423	ffff1a	1063	
199450	Asteroidea - Starfish	199449	ff0080	1063	
199451	Ophiuroidea - Brittle Stars	199449	8080ff	1063	
199452	Holothuroidea - Sea Cucumbers	199449	4000	1063	
199453	Echinoidea - Sea Urchins	199449	22c5e6	1063	
199454	Crinoidea - Feather Stars	199449	6df2ca	1063	
199455	Pennatulacea - Sea Pens	199439	39e664	1063	
199456	Cyclostomi - jawless fish	199443	d21309	1063	
199457	Mollusca	199423	c0c0c0	1063	

199458	Cephalopoda	199457	00ffff	1063	
199459	Bivalvia	199457	8080ff	1063	
199460	Gastropoda	199457	800080	1063	
199461	Octopus	199458	0080c0	1063	
199462	Sepia	199458	3ec0ff	1063	
199463	Squid	199458	0061c1	1063	

ANNEX 3 – Frame extraction code

```
import cv2
import os

output_dir = "frames"
current_frame = 0
counter = 0

input_dir = input("Enter the folder name with videos: ")
each_n_sec = int(input('Enter number indicating how many seconds you want to take each frame: '))


if not os.path.exists(output_dir):
   os.makedirs(output_dir)

for root, dirs, files in os.walk(input_dir):
   for filename in files:
      print(filename)
      if filename[0] != '.':

         video = os.path.join(root, filename)
         cap = cv2.VideoCapture(video)

         if not cap.isOpened():
            print("could not open :",video)

         width       = int(cap.get(cv2.CAP_PROP_FRAME_WIDTH))
         height      = int(cap.get(cv2.CAP_PROP_FRAME_HEIGHT))
         frame_count = int(cap.get(cv2.CAP_PROP_FRAME_COUNT))
         fps         = round(float(cap.get(cv2.CAP_PROP_FPS)))
         duration    = frame_count / fps
         frame_counter = fps * each_n_sec

         minutes = int(duration/60)
         seconds = duration%60
         print('duration (M:S) = ' + str(minutes) + ':' + str(seconds))
         print('fps = ' + str(fps))
         print('frame_counter', int(frame_counter))
         print('tot frames', frame_count)
         print('width', width)
         print('height', height)

         while cap.isOpened():
```

```
        ret, frame = cap.read()

        if(current_frame%frame_counter == 0):
          print("extracting frame",current_frame)
          if ret:
            cv2.imwrite(
              str(output_dir) + "/" + str(counter) + "_" + filename + "_" + "%d.jpg" % current_frame,
frame)

        current_frame += 1
        counter += 1

        if current_frame == frame_count:
          print("done")
          break

      cap.release()
      current_frame = 0
```