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GHOST MED

METHODOLOGICAL GUIDE FOR ASSESSING THE IMPACTS OF DERELICT FISHING GEAR

2020

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1 INTRODUCTION

Marine pollution has been a global issue for decades. Of biological or chemical origin, this pollution has caused significant impacts on species and natural habitats that are already severely weakened by other human activities.

On land, over 300 million tonnes of plastic are produced each year, half of which is for single use items (Plastics Europe, 2008). Of these 300 million tonnes, 8 million tonnes end up directly in the world's seas and oceans. Waste found at sea are mainly originating from land-based activities, while proper marine waste come from marine transportation. Accidentally or intentionally abandoned, lost, or otherwise discarded fishing gear (ALDFG) or ghost fishing gear account for about 10% of the marine waste (Macfadyen *et al.,* 2009). A recent study estimates that 5.7% of nets, 8.6% of pots/traps and 29% of fishing lines are lost each year around the world (Richardson *et al.,* 2019). But the diversity of fishing practices and equipment used worldwide (Nedélec and Prado, 1990) leads to rare available estimates limited to one geographical area and one type of practice.

In the Mediterranean Sea, derelict fishing gear is an important issue due to the intensity of the artisanal fishery near the coast and the industrial one offshore using several types of gear including gillnets, trammels nets, lines as well as pots/traps. Recreational fishing also contributes to this input of waste the ocean in the form of fishing lines, lead fishing sinkers, lures, pots/traps, etc. One study (Golik, 1997 *in* Macfadyen *et al.,* 2009) estimated between 2,637 and 3,342 tonnes of fishing gear to be lost each year in the Mediterranean Sea, nevertheless there is still little information on the amount of derelict fishing gear worldwide.

It is important to note that professional fishing activities are under very strict regulations. Most professional fishermen abide to them because, on one hand, the significant cost of the gear, and on the other hand, a strong interest in having environmentally friendly practices that ensure a sustainable fishery (Scheld *et al.*, 2016). Fishing gear are often accidentally lost due to, for example, bad weather conditions, lack of knowledge of the terrain, conflicts of use, or drift of the gear with the current.

These gears have several impacts on the marine environment. The best documented is ghost fishing, i.e. involuntary trapping of mobile species. The phenomenon of ghost fishing is important for nets and lines recently lost. It decreases over time but can last for a long time if nettings remain deployed in the water column. It is also a cascading process because when a species is trapped, its carcass will attract scavengers who in turn can be trapped and so on. Abandoned fishing gear also cause significant physical damage to species attached to the substrate and alters the ecological functioning of the habitat. The introduction of synthetic materials also represents a risk of chemical pollution and therefore potential sources of contaminants for the marine food web. In addition, they pose a significant danger to sea users, such as sailors, swimmers, and scuba/freedivers.

In some very specific cases when the fishing gear has been submerged for a long time, it can have positive impacts on the environment by creating a complex structure to which several species can attach themselves or found shelter within. These positive effects for the environment must also be considered because the removal of this device would then be more damaging than beneficial.

The purpose of this methodological guide is to present the protocol used to assess the environmental impacts of derelict fishing gear and to provide a clue for decision-making assistance as to whether to remove it or not.

This guide is intended, first, for environmental managers who will have to undertake environmental impact assessments when a derelict fishing gear is reported. Attention the full implementation of such

a protocol is aimed at trained scientific scuba divers. This guide is also for recreational divers who, during their leisure dives, could encounter derelict fishing gear. In such case, we do not ask divers to implement the complete data collection. Having read this guide, these divers will know what to look for and what information will be important to report on the Ghostmed platform:
https://ghostmed.mio.osupytheas.fr/en/

2 DESCRIPTORS FOR THE EVALUATION OF DERELICT FISHING GEAR

2.1 Dimensions and characteristics of the derelict fishing gear

For any observations, the following information is necessary to accurately describe the derelict fishing gear:

- Date of the observation
- Depth (in meter)
- Identity of the observer:
  - Last name
  - First name
  - Address
  - Phone number
  - email
- GPS coordinates: latitudes and longitudes will be given in decimal degrees according to the WGS84 geodesic system
- Size and type of gear:
  - Length (L)
  - Width (w)
  - Height (h)
  - Surface (S)
  - Volume (V)
  - Type of gear (straight net, trammels net, trawl, trap, longline, wire, sinkers, hook, etc.)
- Additional information that can be noted
  - Mesh size
  - Number of layers
  - Number of hooks
  - Number of baits

Field data collection

The dimensions of the fishing gear can be estimated if the observer does not have the time or a way to measure them.

Estimating the surface of a derelict net can be difficult depending on the condition of the net itself. The method is based on cutting the net into several pieces to more easily calculate the total surface area of the net that is entangled. Divers will therefore have to try to measure the length and width of each of the different pieces. The surface occupied by the net, noted "S", is then assumed from the sum of all the pieces of net previously cutFigure 1,Figure 2). The total area is then defined as follows

$$S = \sum_{i=1}^{n} L_i * w_i$$

Where:

n: number of pieces cut

L_i: length of i piece of net

w_i: width of i piece of net

S: total surface of the derelict gear

The description of derelict fishing gear is a fundamental step in the decision making for its removal by acquiring as much useful information as possible *(e.g.* type of gear, its condition, the way it is hooked to the seafloor). This will allow a better anticipation of the material and human needed for the operation.

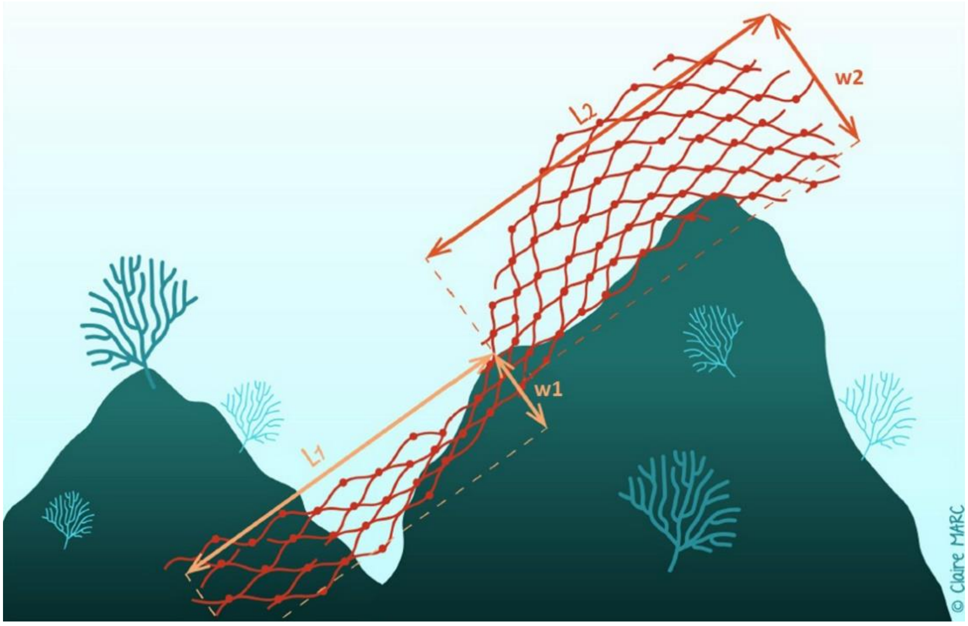


Figure 1 : Length and width measurements of the different pieces of the net.

If the derelict fishing gear is too large to be measured, the diver will estimate its dimensions and more specifically its length, for example by accounting the time necessary to swim from one end to the other. If it is impossible to do it during the dive because it is too large, then the diver will give, at minima, qualitative information such as: ">100 m".

Figure 2 : Estimating the length of a derelict fishing gear

2.2 Type of habitat affected by the derelict fishing gear

Among the habitats that may be affected by derelict fishing gear, we will describe the following:

The Posidonia meadow : *Posidonia oceanica* (L.) Delile beds represent a major ecosystem in the Mediterranean Sea, as they support a large part of the coastal waters diversity, and occupy very large areas (20 to 50% of the seafloor between 0 m and 40 m deep) and above all by their essential roles at ecological and physical levels in maintaining coastal balances and concomitant economic activities. *Posidonia oceanica* forms one of the Mediterranean climax communities.

The species *Posidonia oceanica* constituting of the structure of the habitat is a seagrass (Magnoliophyta, Archaeplastida kingdom) endemic to the Mediterranean. It develops in the sublittoral zone from the surface down to 30 to 40 m depth as a function of water transparency. The seagrass consists of stems called rhizomes, usually buried in the sediment and forming a matteFigure 3 The matte is actually the ensemble containing interlacing of living and dead rhizomes complemented by sediment filling the gaps. Rhizomes are either creeping (plagiotropic) or erected (orthotropic) (Figure 4). Figure 4

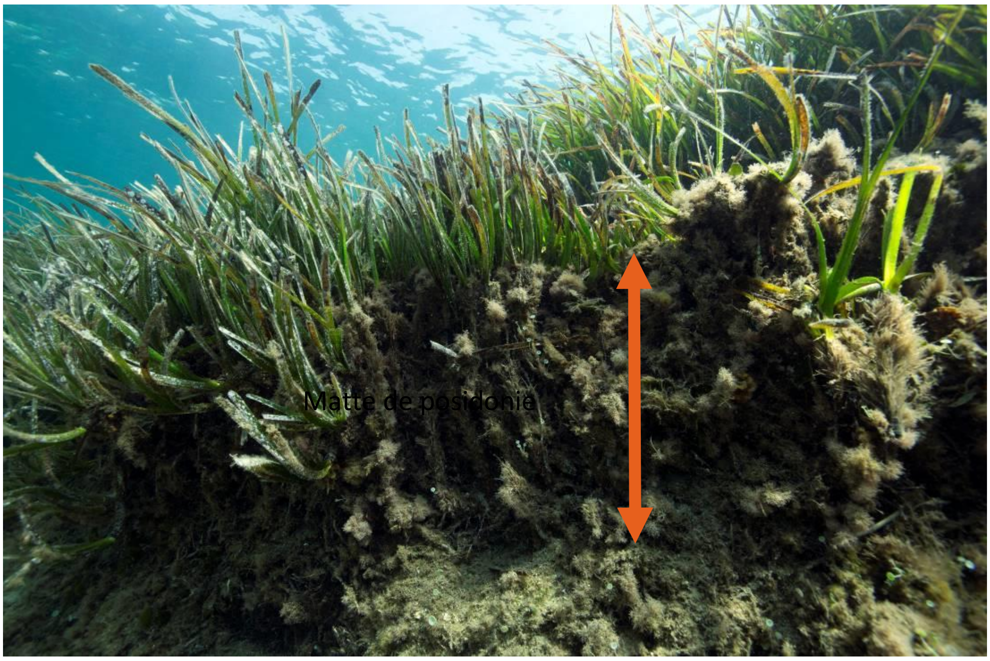


Figure 3 : Matte of Posidonia consisting of rhizomes, and roots with sediment trapped within. Leaves of Posidonia (photosynthetic compartment) develop above the mat.

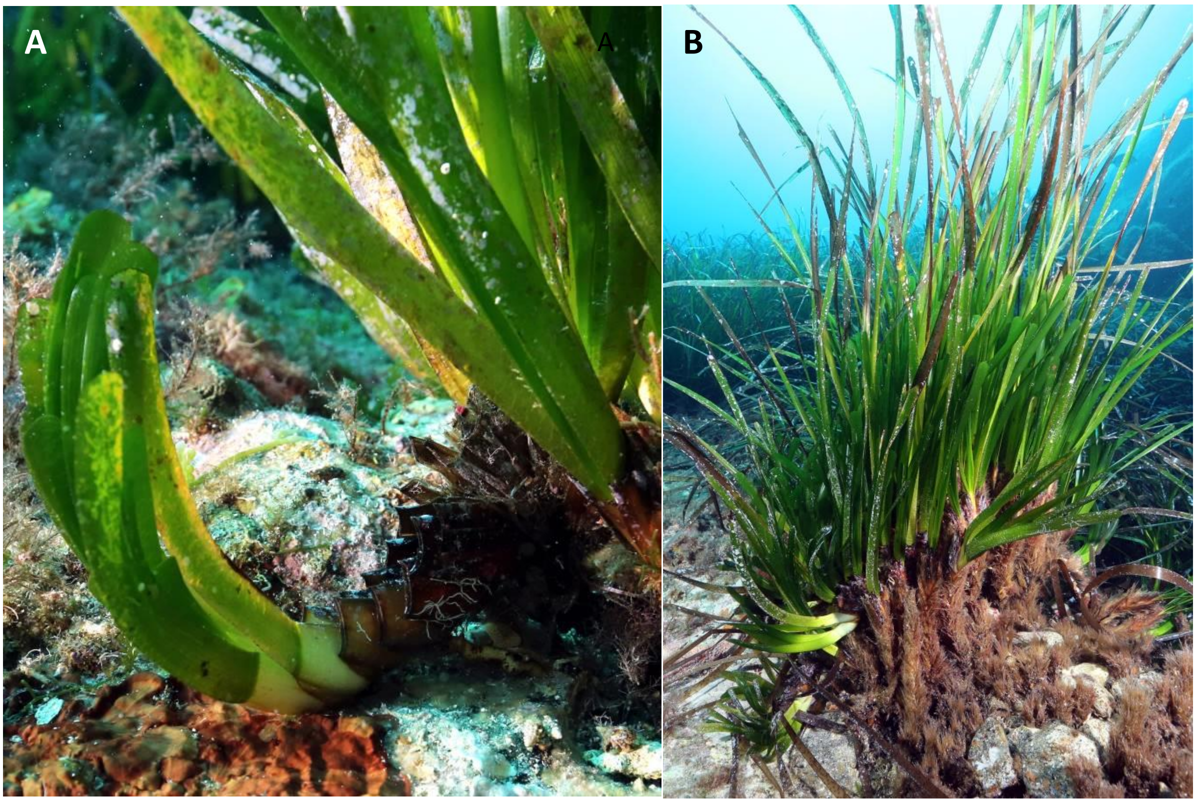


Figure 4 : Rhizomes of *Posidonia oceanica* creeping (A: plagiotropic rhizomes) or erected (B: orthotropic rhizomes).

The roots grow into the sediment, while shoots of 6 to 10 leaves extend to up to 1.2 m long (Figure 5). Figure 5New leaves form year around from the center of the shoot and live between 5 and 8 months (sometimes up to 13 months). The growth area of the leaves is located at their base. When leaf growth is complete, a basal sheath appears: the leaf is then considered adult (as opposed to juvenile leaves that are less than 5 cm and intermediate leaves that do not have a sheath). The leaves shed throughout the year. When they die, the leaves come off, but their basal sheath, a few centimeters long, remain attached to the rhizome. They are then called scales (Figure 5). Scales, like rhizomes, are almost un-putrescible, and therefore can be preserved for several centuries or millennia in the thickness of the matte. As such, the meadow's matte sequester carbon and constitutes as such a very long-term carbon sink. When the meadow is alive, the plant's rhizomes counteract burial by vertical growth, but once dead, the matte maintain itself testifying the former presence of a live meadow. The matte is then called "dead matte" and persists throughout the very slow degradation of the rhizomes (Figure 3).

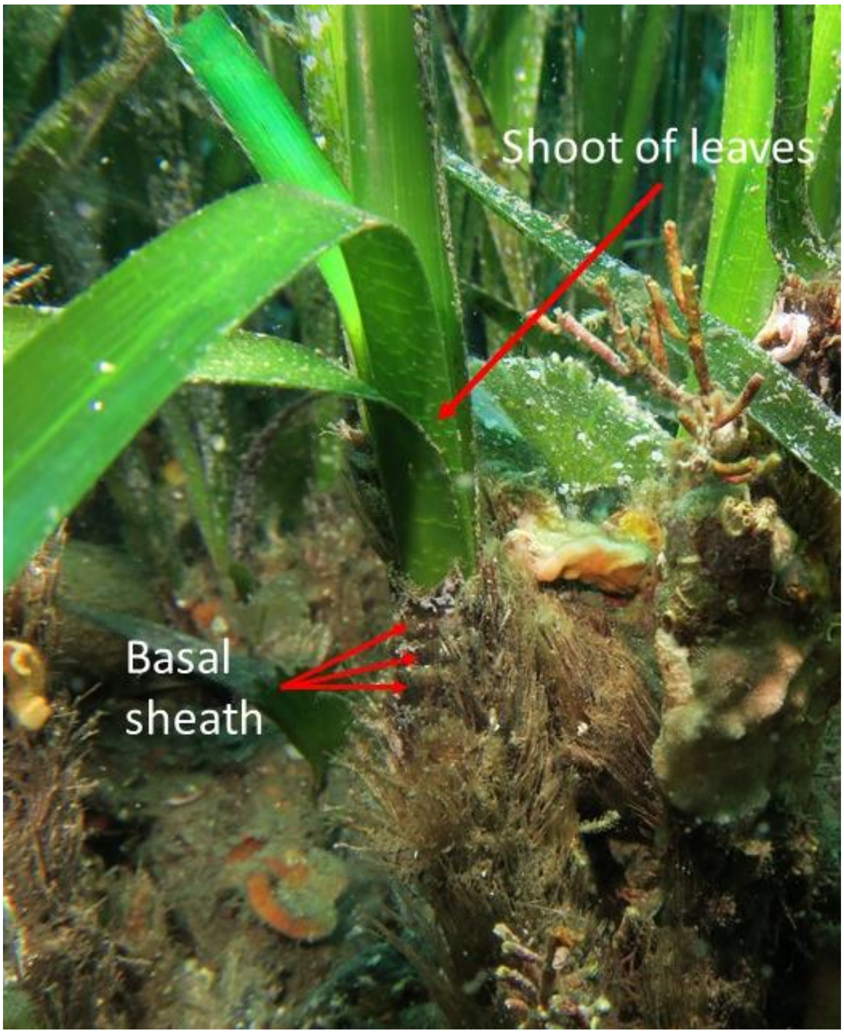


Figure 5 : *Posidonia oceanica* rhizomes ending with shoot of leaves. The basal sheath of the leaves remains attached to the rhizome and when the leaf falls turned into "scales"

Meadows of *Posidonia oceanica* first play a role in ecological balances by producing huge quantities of plant matter that participate in several food webs, but they also constitute a spawning, nursery, and permanent habitat for many species. This habitat is home to more than 400 different plant species and several thousand marine animal species, which make this habitat a unique biodiversity hub. The *Posidonia oceanica* meadows play a role in the physical characteristics of the coastal system by trapping sediments, resulting in increased transparency of coastal waters and also in protecting the coastline and beaches from scouring by reducing hydrodynamics. The roles played by Posidonia meadows in the ecological and physical characteristics of the coastal system also give them a considerable economic value *(e.g.* water quality, resource area).

Coralligenous: Ecosystem of biogenic origin, endemic to the Mediterranean. Mainly built from algal limestone concretions, it develops in low-light conditions. Depending on the biotic and abiotic factors of the environment, several assemblages can coexist or dominate within the coralligenous over a wide range of depth (20 to 120 m deep; Figure 6).Figure 6

Figure 6 : Coralligenous scenery with a school of fish typical of this habitat the marine goldfish (*Anthias anthias*) and red gorgonians (*Paramuricea clavata*)

These factors are mainly light, hydrodynamics, temperature, salinity, sediment deposition and biological interactions. Thus, the coralligenous appears as a complex habitat formed by a mosaic of several assemblages. Moreover, the juxtaposition of a wide variety of assemblages reinforces the seascape interest of this ecosystem. Coralligenous occurs on rugged and dimly lit rock walls as well as on more horizontal rocks where limestone algae can form large-scale biogenic constructions. In this case, due to the light sensitivity of the constructors' algae, the bathymetric extension of coral-like concretion is limited upwards by the strong illuminations and downwards by the amount of light energy required for algal photosynthesis. Seasonal variations in temperature observed for this habitat decrease with depth. While a certain tolerance to salinity fluctuations has been observed, fine particle sedimentation is particularly harmful.

Sublittoral reef formation: Sublittoral reef formation is a hard substrate habitat, usually covered by algae. Depending on the exposure to light, the slope, the currents but also the human impacts, the associations dominating these reefs can be very diverse. When light over the reefs are very strong, associations of photophilic algae are observed. When the reefs are shaded, the associations are composed of sciaphilic algae. One of the climaxes of the Mediterranean for sublittoral reef habitat are made of the association of brown algae of the genus *Cystoseira* (Fucales, this taxon will later be referred to as cystoseires). Cystoseires are species that structure the habitat of many rocky benthic assemblages (Figure 7).

Figure 7 : Photophilic algae sublittoral reef formation

Their bathymetric distribution is dependent on several environmental conditions such as light, temperature, hydrodynamics, and grazing. The decrease in cystoseires has been observed throughout the Mediterranean and is caused by habitat destruction, eutrophication, fishing nets and overgrazing by herbivores. This results in structural complexity losses of the habitat, such as the decline of the number of trees in a forest. The change in algal coverage leads to the appearance of low-vegetation levels such as grass, assemblages of filamentous or ephemeral algae, or "barren ground" assemblages in which sea urchin density drives the homogenization of the seascape. Link to this decline of the canopy throughout the Mediterranean, the photophilic algae communities of sublittoral reefs are often dominated by shrub or bush of algae *(e.g. Padina* spp., *Halopteris scoparia*, *Cladostephus spogiosum f. verticillatum*, *Dasycladus vermiculariss*, Dictyotales, *Corallina caespitosa),* or by "barren ground" with encrusting algae (e.g. *Lithophyllum incrustans, Neogoniolithon brassica-florida*, *Pseudolithoderma adriaticum, Cutleria* spp., *Peysonnelia rosa-marina)* and sea urchins (Figure 8).Figure 8

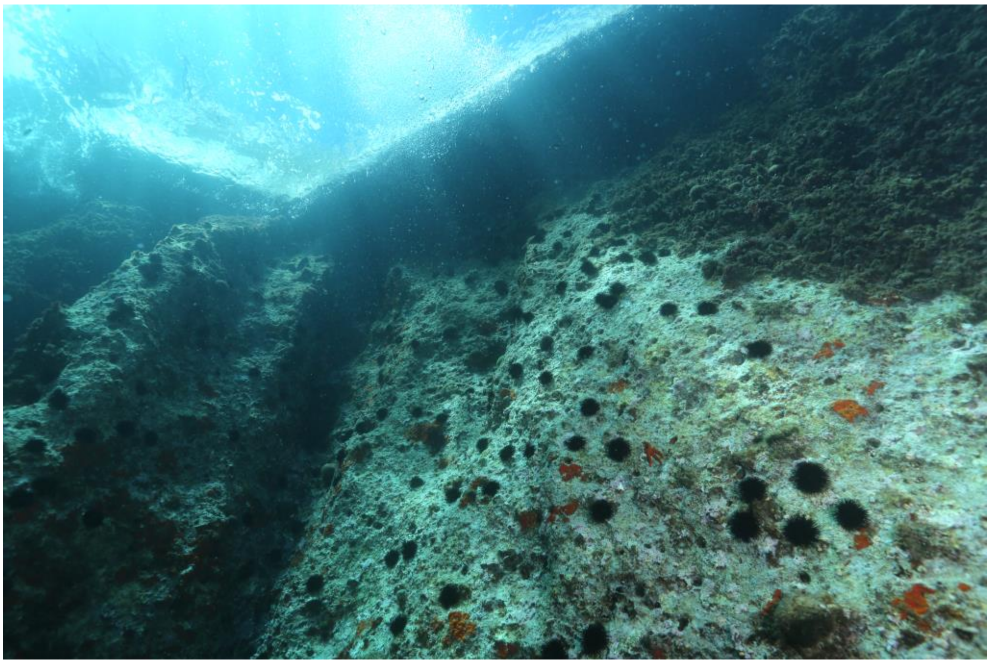


Figure 8 : Barren ground, bedrock dominated by sea urchins that cause overgrazing and the disappearance of erect algae.

Wrecks: Wrecks are not strictly speaking marine habitats defined by the nomenclature code of benthic habitats. We distinguish them here from other hard substrates because they constitute a distinct artificial structure, which did reach the seafloor accidentally and has been colonized by organisms over the years. These habitats are composed of ships, submarines, or aircraft, stranded, or sunk as a result generally of an accidental event and then abandoned on the seafloor. These artificial hard substrates represent preferred habitats for many mobile and marine fixed species and are targeted by fishermen. Shipwrecks often act as artificial reefs and it is not uncommon to note a high abundance of fish in their vicinity (Figure 9). Shipwrecks that have been submerged for more than a hundred years are part of the world's cultural heritage and are protected by the Convention on the Protection of Underwater Cultural Heritage.

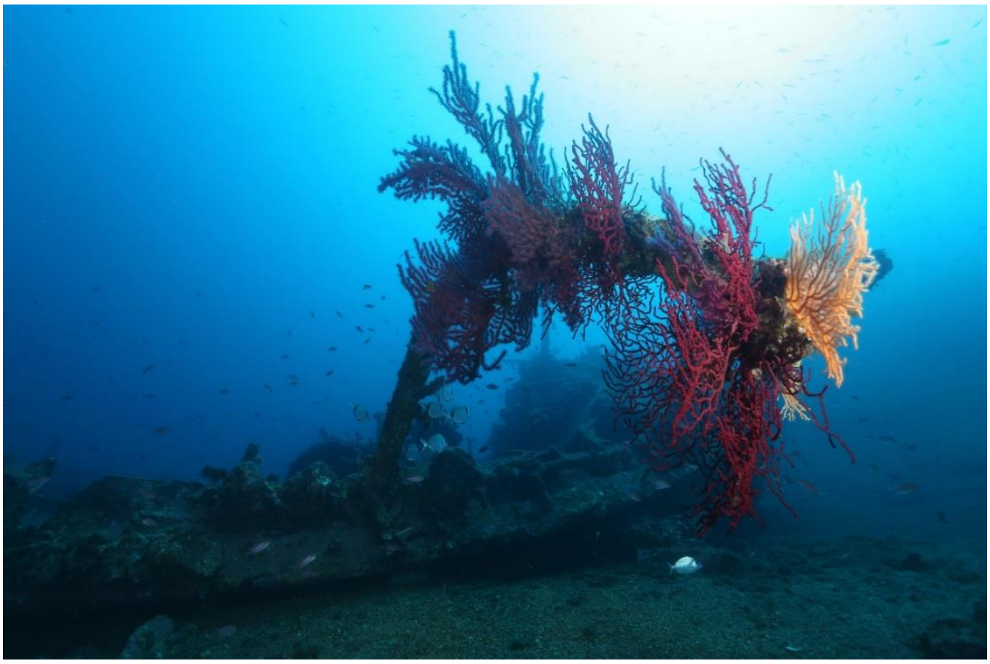


Figure 9 : Wreck of Liban on the island of Maïre in Marseille, France.

Artificial reefs: Artificial reefs are artificial structures deliberately immersed in the marine environment to create new habitats (Figure 10). These reefs can have different roles, from physical protection of an area to fish production. They represent habitats, refuge areas and nurseries for local wildlife. It is common to find a high abundance of fish around artificial reefs.

Figure 10 : Prado artificial reef in Marseille, France.

Pebbles and gravel: This habitat is found in coves along the Mediterranean rocky coasts subject to strong hydrodynamics. It extends from the surface to a few meters deep (Costa and Picard, 1958; Picard, 1965; Ros *et al.,* 1984; Figure 11).Figure 11

Figure 11 : Pebble and gravel seafloor.

Sand: We chose to use the term "sand" to refer to all soft substrates habitats, with the exception of muds and coastal detritic, commonly extending into the sub- and circalittoral floors, i.e. the surface down to about 100 m deep. They sometimes occupy very large areas in large bays or along the coast, often subject to a strong local current (Figure 12). Generally, the mineral fraction of the sand is mixed with a more or less significant part of organism's debris. In the circalittoral stage (30 to 100 m deep), when the proportion of organism's debris becomes large and an important epigeous fauna and flora develop, these soft substrates are referred to coastal detritic. Soft substrates are the most common habitats in the Mediterranean in terms of surface areas. Fishing activities there usually target flat fish or fish such as red mullet or some crustaceans. Derelict fishing gear are less common there because the possibilities of hooking are lower than with rocks. However, nets, trawls or pots/traps that have encountered unpredictable obstacles such as small isolated rocks or shipwrecks can still be found.

Figure 12 : Sandy seafloor.

Coastal detritic: The coastal detritic is characteristic of the circalittoral stage (approximately 30 to 100 m deep). It is a soft substrate in which the proportion of debris from organisms is large and on which significant epigeous flora and fauna develop (Figure 13). This habitat is therefore home to a wide variety of species and play unique ecological roles for several species.

Figure 13 : Coastal detritic.

Mud: Mud seafloor is another category of soft substrate characterized by a high proportion of very fine particles that have sedimented. It is present either in protected areas of low hydrodynamics, such as creeks, in calm environments without current allowing sedimentation of fine suspended particles or in deep layers where currents are weak (Peres and Picard 1964; Peres, 1967; Bellan-Santini *et al.,* 1994; Figure 14).Figure 14

Figure 14 : Mud seafloor.

Underwater canyons: Underwater canyons are deep underwater valleys located off the coast with highly steep bathymetry carved into the continental slope. Canyons do not designate a single habitat but represent several habitats over the bathyal floor. Their formation is very old, as the results from the excavation by rivers during periods of emersion. These topographic features are comparable to gorges and land canyons that can be seen on continents nowadays. Underwater canyons generally display an important and original biodiversity. Their ecological role is major as they provide a transitional environment between the coast and the abyss (Figure 15).Figure 15

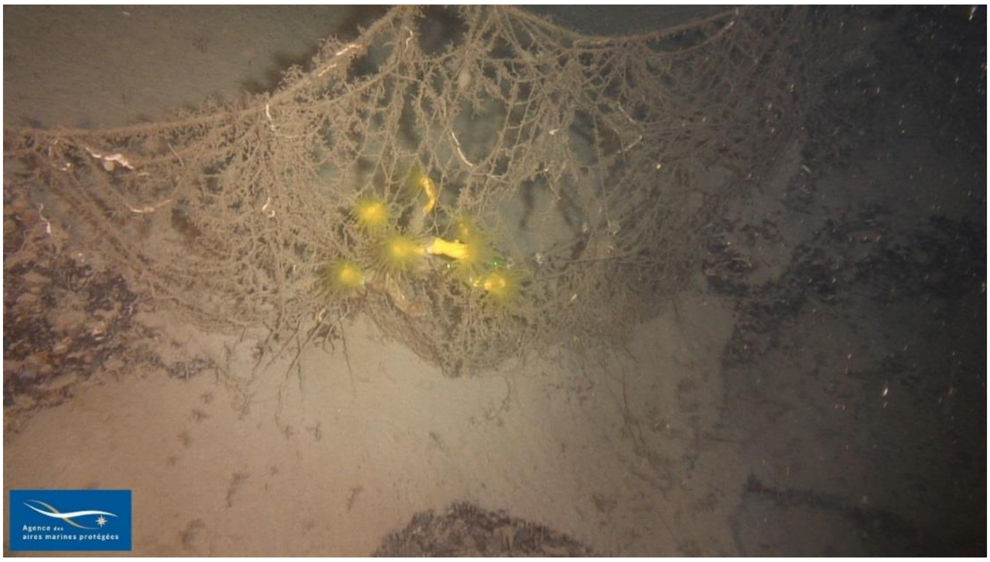


Figure 15 : Underwater canyon and derelict net encountered during Medseacan cruise (©AFB).

Field data collection

This data is acquired during the observation dive. The dominant habitat type will be noted. In the case of several habitats being significantly affected by the fishing gear, approximate percentage of each habitat should be note. Depending on the habitat involved, a rating is assigned based on the sensitivity of the habitat to the presence of a derelict fishing gear:

- Posidonia meadows: 2
- Coralligenous: 3
- Sublittoral reef formation: 2
- Wreck: 1
- Artificial reef: 2
- Pebbles: 1
- Sand: 0
- Coastal detritic: 1
- Mud: 0
- Underwater canyons: 2

2.3 Colonization of the derelict gear

Colonization stage: Colonization of a derelict fishing gear can be estimated by the composition and quantity of epibionts present. Colonization of nets varies a lot, depending mainly on the duration it has spent on the substratum. It also varies significantly with the type of material used as well as the physical-chemical and biological conditions of the environment *(e.g.* current, depth, nature of the seafloor, pollution, contribution of particulate organic matter). Generally, on a hard substrate colonization is represented by a succession of different organisms (schematized onFigure 16). The first species to settle are filamentous algae, then hydroids*(e.g. Aglaophenia pluma*) and finally, species with limestone skeletons such as bryozoans, polychaetae or algae (e.g. *Reteporella mediterranea, Filograna implexa, Mesophyllum* spp.), sponges and ascidians *(e.g. Crambe crambe*, Didemnidae; Linares *et al.* 2005;Figure 17Figure 16).

Depending on the epibionts present on the gear, four stages of colonization can be identified:

0. No colonization
1. Presence of filamentous algae
2. Presence of hydroids
3. Presence of bryozoans, sponges and/or polychaetae

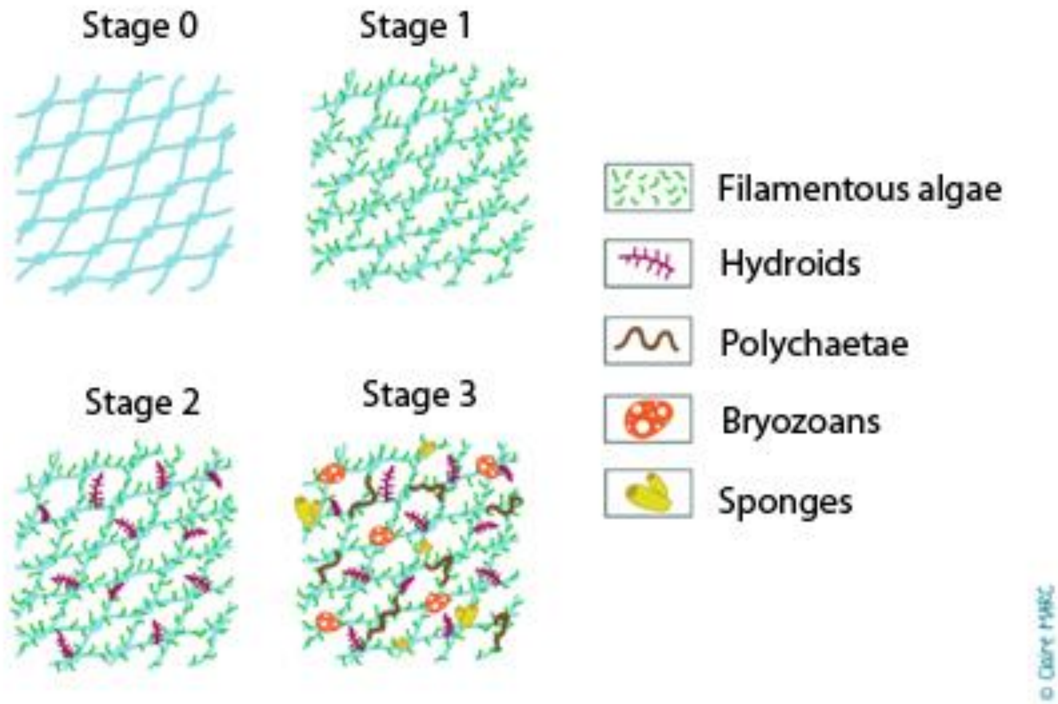


Figure 16 : The four stages of colonization of a derelict fishing gear.

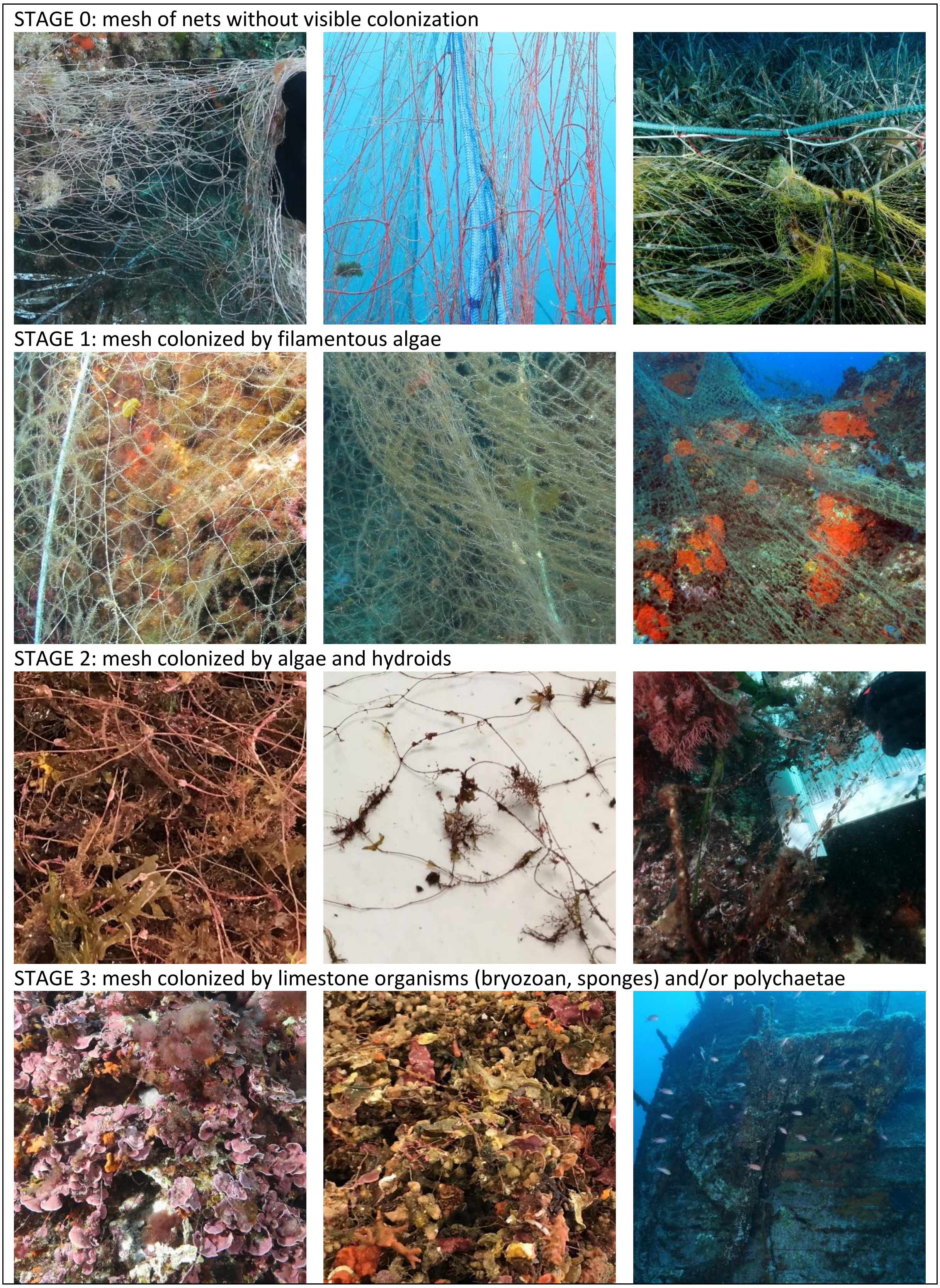


Figure 17 : Examples of net colonization and the four corresponding stages.

Field data collection

Colonization of the derelict fishing gear can be estimated visually by determining the stage of colonization according to the scale presented inFigure 16. If possible, a photographic survey will be carried out, colonization stage will then be done subsequently in the laboratory.

Fixed species colonizing the fishing gear: After a long period of immersion (equal to or greater than 1 year), fishing gear can be heavily colonized. This colonization may in some cases give a positive aspect to the presence of the gear, especially on a low-complex seafloor such as mud or sand. The gear will therefore create a structure allowing the establishment of new species. This aspect must be modulated according to the species considered and its status.

Field data collection

Species colonizing the fishing gear will be registered and quantified. Several parameters will be collected such as the number and size of the individuals, as well as weight estimate. It is also strongly advised to document these species by taking photographs. Not all these parameters are required to calculate the final impact index, but the maximum amount of information reported will allow for better subsequently analysis.

2.4 Impacts on habitats

When the fishing gear is found laid over the seafloor, it will, depending on its condition, cover the substrate and modify the impacted habitat. Its presence can have negative but also positive effects depending on how the gear is placed and the type of habitat covered.

Negative impacts on habitat: Within a complex habitat, the presence of a net will most often cause significant damage. For example, crevices can be obstructed, rendering them unreachable and trapping species within. In the longer term, this impact can even cause anoxia in areas located under the derelict gear, therefore killing all organisms present on the substrate. A second negative impact is the scouring of the substrate caused by the movement of the gear.

Field data collection

To assess the impact on the habitat, several parameters should be considered:

- The breadth of the impact of the derelict fishing gear;
- The fishing capacity;
- The scouring of the substrate near the gear;
- The crevices obstructed by the gear;
- The engagement on the seafloor.

The **breadth impact** represents the area occupied by the derelict fishing gear. To determine this area, an estimation of the dimensions of the gear is required (§2.1).

The **fishing capacity** of the gear depends on its level of colonization and its position in the water. If the gear is not colonized and is still in an upright position, with several floating sections, then its fishing capacity is very important. On the contrary, if it is already colonized, wrapped around itself and laid on the seafloor, then its fishing capacity will be very low. In calculating the index, estimation of the fishing capacity of the gear will be reported as zero, low or significant.

In order to define the **scouring extend** on the substrate in the vicinity of the gear, the distance from the gear to the first erected or un-damaged colony must be measured in several directions (Figure 18). The resulting area will indicate the breadth impact on the habitat and the seascape. To report on this index (chapter 3), it is necessary, at a minimum, to report the wear of the substrate by the net as absent, weak, or important.

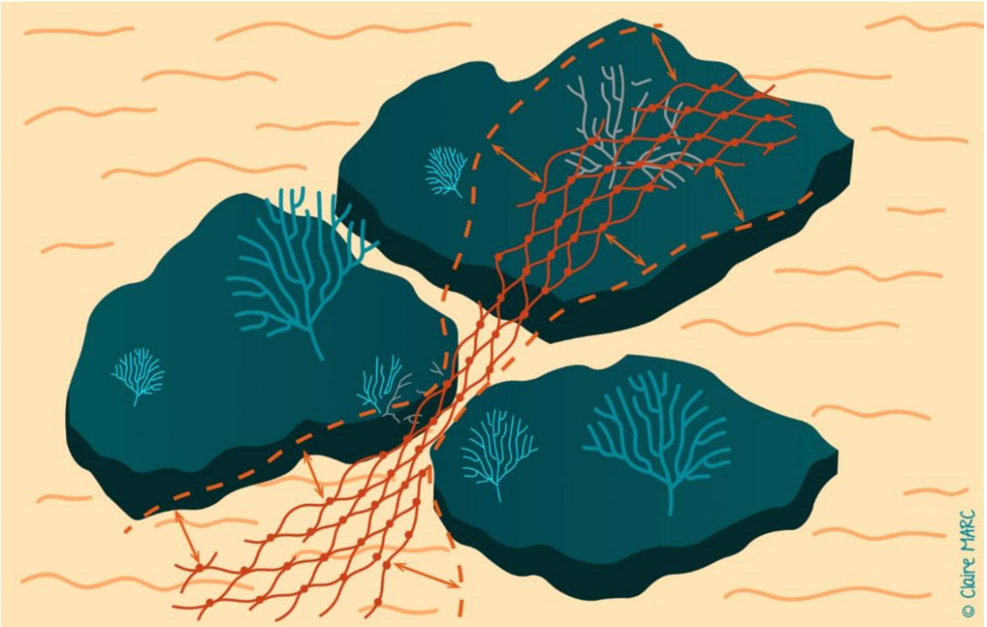


Figure 18 : Estimate of the substrate scoured area by a derelict fishing gear. The arrows indicate the distances to be measured to assess the surface impacted by the movements of the net.

At minima for the calculation of the index (chapter 3), number of obstructed crevices should be evaluated and placed within 3 classes (0; 1 to 10 and >10). Therefore beyond 10 obstructed crevices the impact is considered very important. When time allows, an accurate count of the crevices impacted should be done. Generally, distinguishing crevices under derelict fishing gear can be difficult, especially when the fishing gear is heavily colonized.

The engagement on the seafloor is illustrative to the surface of the gear laid over the substrate. These points of anchor can exist between the gear and rocks, gorgonians, and coralligenous for example. This criterion is considered in the technical difficulties when withdrawing of a derelict gear (§ 2.7).

Positive effects on the habitat: When the seabed is made up of simple substrates such as mud or sand, or in the case of a very old net, the gear may be considered as a new habitat. This newly created habitat will bring complexity, therefore representing a functional interest for the ecosystem. This may also apply to wrecks that have flat and homogeneous sections, as the derelict gear will change the three-dimensional structure of the habitat.

Field data collection

The formation of new habitat can be evaluated through the three-dimensional structure of the gear in relation to the topography of the seafloor. It will also be important to note if whether certain species use the fishing gear for shelter or to collect food. Habitat creation can also be reported when one can observe specific species or their absence, specific development stages (i.e. juveniles) or certain behaviors. To report on this index (chapter 3), it is necessary, at minima, to note whether or not there is habitat creation by the derelict fishing gear.

The "3D structure" parameter is an optional criterion, it will be quantified by taking 10 measurements of the height of the vertical structure of the gear and then 10 measurements near but outside the area of influence of the gear. These additional measures, which will not be included as part of the decision-making protocol for removal, will be used to estimate whether the gear has made the structure of the habitat more complex.

2.5 Impacts on the species

The impacts of derelict fishing gear are, in most cases, negative, in some cases positive, and sometimes both. These impacts can affect species, habitats, and seascape. In the long run, all information must be gathered to provide the necessary elements for assessing environmental risk and then for decision-making on whether or not to remove the derelict fishing gear.

Trapped mobile species: The most obvious but also the most talked about impact in the literature is the ghost fishing of mobile species (Erzini *et al.,* 1997; Ayaz *et al.,* 2006). These are unnecessary catches made by derelict fishing gear that will be doomed to decomposeFigure 19 These catches will be more or less large depending on the condition and position of the gear. They will be maximum if the net is deployed vertically and over a large area. If the net is folded or tangled on itself, this ghost fishing will be reduced but can still occur. In addition, the carcasses entangled in the gear will attract scavengers, which in turn might get caught in the gear, causing cascading fishing effect.

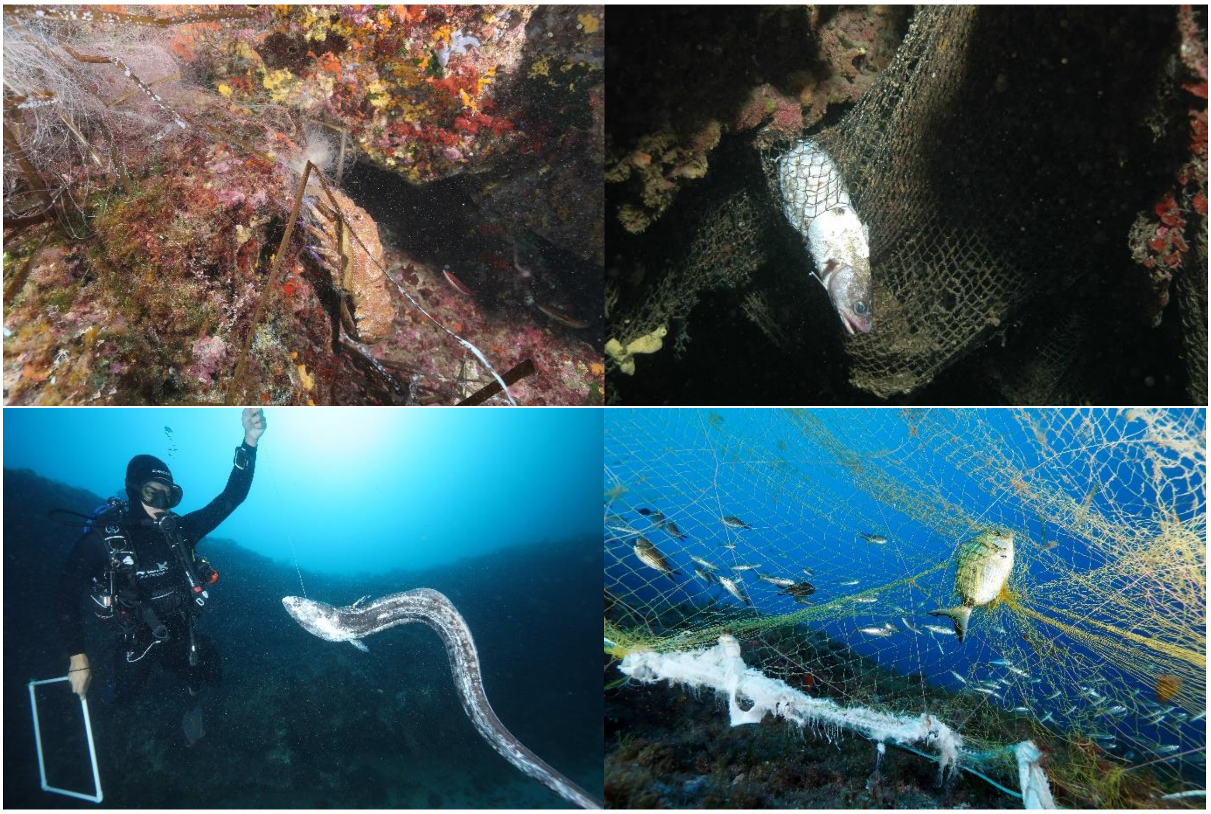


Figure 19. Species trapped in derelict fishing gear. A. Large slipper lobster *Scyllarides latus* in Port-Cros National Park. B. Forkbeard *Phycis phycis* in a net on the wreck of the Saint Dominic in Marseille © Dorian Guillemain. C. European conger *Conger conger* at the end of a longline lost along the Frioul archipelago, Marseille. D. While seabream *Diplodus sargus* and a decomposed fish in a derelict net in Calanques National Park.

Field data collection

Ghost fishing impact is estimated at the time of the observation dive. It is therefore largely underestimated compared to amount of total trapped organisms since the gear was lost. Trapped individuals, whether alive or dead, will be identified (down to species level when possible), counted, measured (and weighed if the removal of dead individuals is possible). For the calculation of the index (chapter 3), the assessment is done according to 4 classes based on the number of individuals trapped (0; 1 to 2 individuals; 3 to 5 individuals and >5 individuals). Indeed, the precise counting of trapped organisms can be lengthy, therefore the impact is considered to be already very important when more than 5 individuals are trapped. A precise count of the organisms should be performed if sufficient time is available. The state of decomposition of the captured organisms will be noted as it gives a clue to the time since they got trapped. This information can be used to calculate the average catch rate per day of the gear and ultimately the mortality rate per year (Northwest straits initiative and Natural resources consultants Inc., 2008).

The state of decomposition of captured individuals can fall into 5 categories:

1 Alive

2 Recent death

3 Partially decomposed

4 Apparent skeleton

5 Completely decomposed flesh

Fixed species torn off and/or damaged: The impact of fishing gear on the substrate can vary greatly depending on the habitat. It can be very limited on a soft seafloor, but very important on a more complex ecosystem such as coralligenous. These gears can scrape against the seafloor due to the weather and hydrological conditions of the environment *(e.g.* current, wind) resulting in damage to vulnerable organisms such as attached benthic species.

Field data collection

The impact on these fixed species will be estimated based on the following criteria:

1. The number of colonies or ripped off individuals found near or in the gear;
2. The number of broken colonies (in contact or in the area of influence of the fishing gear);
3. The rate of necrosis in invertebrate colonies (in the area of influence of the fishing gear; Figure 20).

As with trapped species, at minima for the calculation of the index (Chapter 3), the assessment is done according to 3 classes based on the number of individuals torn off or damaged (0; 1 to 10 individuals and >10 individuals). The impact is very significant when more than 10 individuals are torn off and damaged. A precise account of these organisms should be done if sufficient time allow.

For more information, an estimate of the necrosis age is possible based on biofouling present on necrotized branches (Harmelin and Marinopoulos, 1994;Figure 16 Figure 17). It will also be useful to note the rate of necrosis of gorgonians (Harmelin *et al.,* 1999; Figure 20).

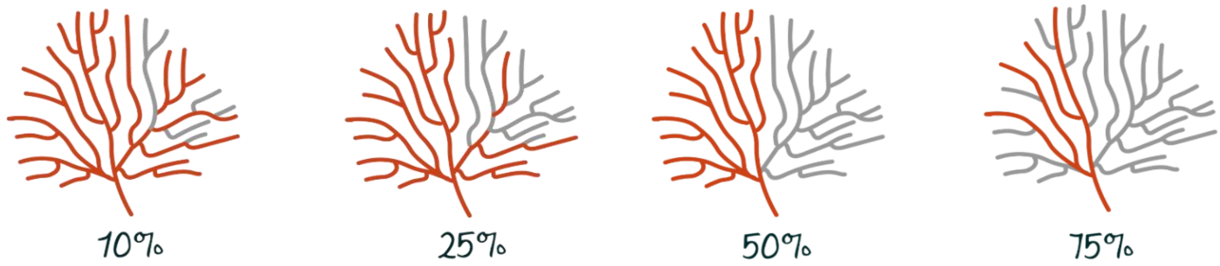


Figure 20: Estimated rate of gorgonian necrosis (modified from Harmelin *et al.,* 1999).

Presence of remarkable species: Remarkable species are species of interest due to their status *(e.g.* protected species) or their ecological role *(e.g.* engineer species, key species, importance in the seascape). The presence of remarkable species on the derelict fishing gear reinforces the positive aspect of the colonization. Indeed, if red coral begins to colonize the gear it can be considered that removing it will be unfavorable. Conversely, if we observe near the gear, species such as large noble pen shell or gorgonians likely to be damaged by the movement of the gear, its removal would be more appropriate. Indeed, species that could be present near a gear, let alone if it is moving or fishing, are likely to be damaged or even torn off, thus reinforcing the negative aspect of the presence of this gear. Remarkable species that meet the criteria below will be particularly reported:

- Protected species: species included in national and/or international protection regulations *(e.g. Pinna nobilis, Cystoseira spinosa*: Annex 1 of the Berne Convention; *Savalia savaglia*: Annex 2 of the Berne Convention);
- Rare species: species rarely seen in the geographic area;
- Species with seascape importance *(e.g.* red coral, fake black coral etc.);
- Species with a particular role: key species or engineer *(e.g.* large gorgonians);
- Heritage species: a species that scientists and curators consider important for ecological, scientific, or cultural reasons *(e.g.* groupers, corbs, etc.).

2.6 Impacts on the seascape

An underwater seascape can be defined as an "*identifiable mosaic of spatially organized biotopes and its associated biocenoses. It is observed and represented globally or in part according to variable perspective and depth conditions by following a reading grid whose level of objectivity and subjectivity depend on the culture of the observer*" (Musard 2003).
Criteria for assessing a seascape are generally aesthetic and subjective. It is common to define a seascape as beautiful or ugly, to argue about its exceptional character or its dullness. A seascape can thus be negatively altered by the presence of a derelict fishing gear in the same way as by the presence of macrowaste. On the contrary, sometimes derelict fishing gear can have a positive effect on the seascape. This is the case for some shipwrecks when several net sheets hung from, creating an interesting atmosphere. For example, some shipwrecks would not be so attractive without large nets over their hulls.

Field data collection

To assess the seascape impact, 3 criteria are proposed:

1. Modification of the seascape by the presence of the gear or not. A seascape may be altered by a net or other derelict fishing gear that easily seen. However, it is considered that it will not be modified if only a fishing wire is present, for example;
2. Use of an adjective to describe the seascape with the derelict gear (*e.g.* desolated, sinister, common, enjoyable, admirable, magnificent). This adjective will then be classified as negative, neutral or positive;
3. Topography modification which can be described as diminished, unaltered, or increased.

2.7 Technical difficulties

The removal of a derelict fishing gear must be carried out by professionals, as removing any object from the seafloor is a demanding task. The technical feasibility of the removal is a determining factor in the decision making to whether or not to remove the gear. Two techniques are generally used:

- From the surface, from a ship, the net is hooked with a grapple and hoisted on board. This grabbing technique is often used by fishermen themselves when they lose their nets (Figure 21);

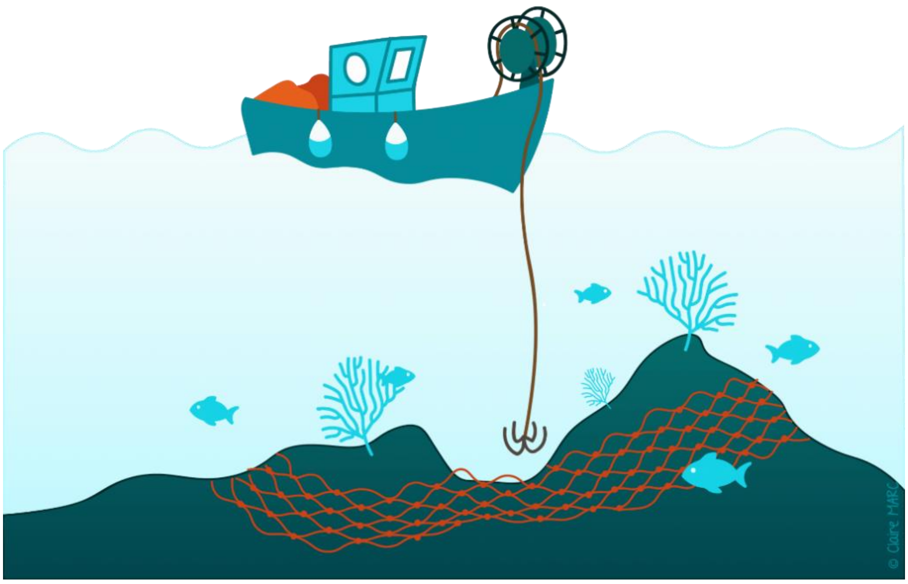


Figure 21 : Technique of grabbing a net abandoned on the seafloor.

- The second technique involves professional divers to locate the gear, collect it and bring it up to the surface using air lift bags (Figure 22).

Figure 22 : Removal of a derelict fishing gear by professional divers who will take it off the seafloor.

In addition to weather and hydrological conditions *(e.g.* wind and current speed, wave height, water temperature), the two main technical parameters to be considered for removal are the depth and engagement of the gear on the seabed. The engagement refers to the hooking of the net onto the substrate. The points of anchor can be on a rock, gorgonians, coralligenous

for example. These parameters are crucial because they will allow to determine the response time and therefore its cost and feasibility. In the case of gear located at a depth deeper than 50 m, the professional diving intervention requires an additional qualification in several countries. Local regulations should be check. Heavy means will then be needed to complete the removal. Therefore, beyond 50 m of depth, the cost of intervention and the risks involved are much greater than at depths shallower than 30 m.

The index presented in this methodological guide can be adapted to derelict fishing gear found in canyons and canyon heads, i.e. at great depths (below 100 m deep) knowing that means of observation will be different (ROV, submarines, …). These devices represent specific cases that reach beyond the limits of the protocol presented in this document. Technical difficulties are limiting factors making it often impossible to remove the gear. The costs of deep-range interventions that would allow the removal of a gear are very high, ~ 15,000 euros per day, mobilizing a ship with its crew and at minima a ROV and its pilots. It is therefore unlikely that missions will be carried out in these areas, although environmental and seascape impacts are present and just as significant as in shallower areas. Observations of fishing gear lost at great depths, however, make it possible to characterize fishing activity and eventually map areas dangerous to fishermen. They also highlight impacts such as ghost fishing or deep habitat recovery. Technical difficulties emphasized, in the context of this study, are meant for subtidal and coastal areas.

Field data collection

Technical risk is assessed, on one hand, by estimating the rate of engagement of the gear on the seafloor and on the other hand, the maximum depth at which the net is located In order to inform this criterion it will be asked to estimate the rate of engagement of the derelict fishing gear by choosing among 3 categories: low (< 10% of the gear is hooked); medium (10- 50% of the gear is engaged) and important (> 50% of the gear is hooked).

For the depth of engagement, even though the diver might not be able to reach the maximum depth of the derelict gear, it will be requested to note the maximum diving depth.

2.8 Uses on the site

Derelict fishing gear pose obvious risks to sea users. Sailors, swimmers, scuba/free divers, and fishermen themselves are most exposed to the dangers created by these macrowaste (Johnson, 2000).

First, they can compromise navigational safety. A fishing gear lost close to the surface may be caught in the propellers or rudders of ships (Figure 23) making it less operable or even not maneuverable at all in the event of engine failure. In some cases, scuba divers will be needed to free the parts hampered by the fishing gear. This work close to the ship's hull can become dangerous depending on the state of the sea.Figure 23

Figure 23 : Nylon fishing gear entangled around an outboard engine propeller. © NOAA.

Accidents can also occur when an anchor is caught in a derelict fishing gear located on the bottom of the ocean, making the recovery of the anchor very complicated if not impossible. Finally, a collision with a floating derelict fishing gear can cause significant damage to the hull or submerged parts of a vessel.

Scuba divers, spear fishermen and snorkelers are also highly exposed to fishing gear lost in their respective practices. They are often the first to identify and report them. Movements of a fishing gear in the water are difficult to predict and it is easy to entangle diving equipment in the mesh of a net or in fishing lines at the risk of becoming trapped making those derelict gear a real hazard for humans. Any derelict gear present in an area where one of these activities is undertaken, where floating sections in open water exist that can represent an obstacle to users and be dangerous will be noted. The same is true in swimming areas, in busy areas close to the coast and floating sections less than 2 m from the surface exist, a derelict fishing gear could quickly pose a hazard and cause accidents to humans.

A fishing gear lost in a fishing area can pose a high risk to fishermen. The deployment of an active fishing net over a derelict gear can lead to entanglement which can, in turn, lead to additional derelict fishing gear. In interviews with professional fishermen, loss of nets is often explained by entanglement over the seafloor with another older lost net.

All derelict fishing gear poses risks to users that are difficult to quantify and characterize because to do so properly and objectively, a good knowledge of practices in each geographical area concerned is required. Nevertheless, these criteria are considered in this evaluation (Chapter 3) as we take that managers are aware of the activities carried out within their territories. However, some limitations remain. Indeed, it is relatively easy to know if a site is a regular dive site, but what about occasional dive sites? Similarly, whether a site is a regular fishing spot or not is also complicated to quantify and beyond that, in coastal areas, potentially all sites can be fishing, mooring, or diving sites outside regulated areas. For all these reasons, in the evaluation, we will simply note the known usages on the site without pretending to make a true risk assessment for users.

2.9 Risks of chemical pollution

Most fishing gear are made from synthetic materials of plastic origin with the advantages of being very resistant, almost invisible to fish and very light. In some cases, release and accumulation of derelict fishing gear on the seafloor can reduce significantly the flow of water to the point of creating an anoxic zone underneath (Rundgren, 1992), resulting in the death of all living organisms over the impacted substrate.

The long-term chemical impacts of derelict fishing gear are poorly described. Nevertheless, modern plastics have a very long lifespan, up to 600 years in the marine environment, which will vary depending on hydrological conditions, UV penetration and the degree of abrasion to which the gear are subjected. As they are degraded, microplastics and chemical additives will be released into the environment. There is a string probability that these microplastics can enter the food chain. Studies provide information on the abilities of materials to adsorb, release or transport chemicals with their respective toxic effects (Teuten *et al.*, 2007; Rios *et al.* 2007).

Chemical pollution from derelict fishing gear is therefore real and comparable to the pollution of plastic waste at sea. We will not consider in this protocol the impact of pollution because it exists for all fishing gear lost and therefore does not constitute a discriminating factor in the prioritization of removal actions.

3 GEAR REMOVAL INDEX (GRI) OF DERELICT FISHING GEAR

Data collected during the dives to assess the impact of derelict fishing gear are standardized to allow comparison and prioritize removal actions of the gear.
We have identified four major parameters to consider (Figure 24):

- Environmental impacts (**I_E**)
- Seascape impacts (**I_L**)
- Risks to users (R_u)
- Technical difficulties (**D_T**)

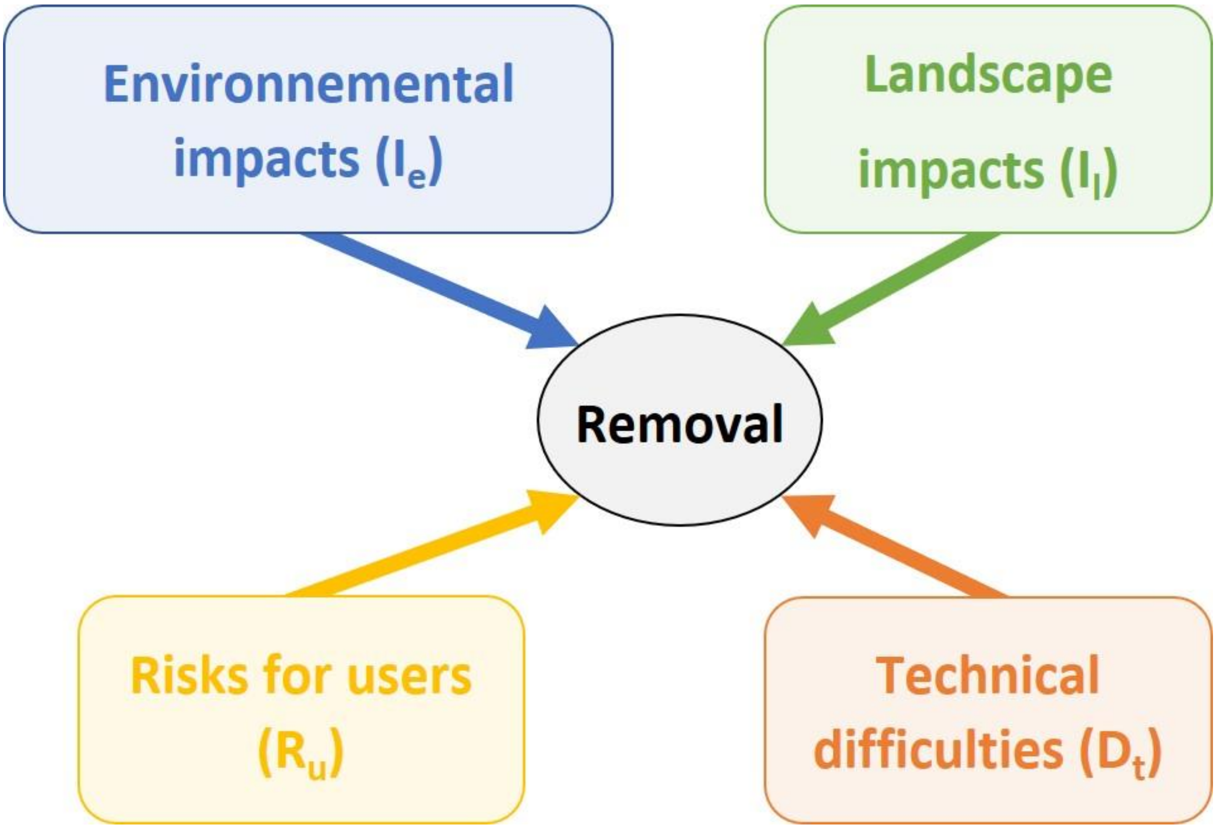


Figure 24. The four major parameters to consider to estimate the GRI.

The evaluation of these parameters should be used to calculate a **Gear Removal Index (GRI)**.

3.1 Environmental Impact Assessment

The environmental impact assessment is carried out using 12 criteria and is the sum of the scores of each criterion, with a total score between -7 and 28. The lower the score higher the positive effect on the environment will be. On the contrary, a high score will reveal a strong negative impact. The grades were awarded based on the importance of the criteria from an environmental point of view. Notes for the different criteria for assessing the environmental impact are presented in Table 1.Table 1

Table 1: Criteria for assessing the "environmental impact".

Criteria	Assessments	Scores
Habitat	Posidonia meadow Coralligenous Sublittoral reef formation Wreck Artificial reef Pebbles Sand Coastal detritic Mud Underwater canyon	2 3 2 1 2 1 0 1 0 2
Gear colonization	Stade 0 Stade 1 Stade 2 Stade 3	0 -1 -3 -5
Trapped mobile species	0 individual 1 à 2 individuals 3 à 5 individuals > 5 individuals	0 2 4 6
Species fixed torn off	0 individual 1 à 10 individuals > 10 individuals	0 1 2
Damaged fixed species	0 individual 1 à 10 individuals > 10 individuals	0 1 2
Presence of remarkable species colonizing the gear	Yes No	-1 0
Remarkable species in the vicinity of the gear	Yes No	1 0
Engagement of the impact	0 m² to 5 m² 5 m² to 20 m² > 20 m²	1 3 5
Fishing capacity	Nil Small Large	0 2 4
Substrate abrasion	Nil Small Large	0 1 2
Obstructed crevices	0 crevice 1 to 10 crevices > 10 crevices	0 1 2
Habitat creation	Yes No	-1 1
Total		**-7 to 28**

3.2 Assessing seascape impact

Seascape impact (§2.4) is assessed by 3 criteria with scores between -2 and 1 (Table 2). The maximum score that can be obtained is 4, it represents a very strong seascape impact (Table 2). The minimum score is -3, in this case it corresponds to a positive effect on the underwater seascape. The "seascape modification" criteria are based on the identification of a change in the seascape by the presence of a derelict gear. The perception of this change may be different depending on the nature of the gear itself. Indeed, a large net will be very visible, easily noticed and the seascape will inevitably be altered by its presence. On the other hand, since the program studies all fishing gear, a simple fishing line is more complicated to notice, much less visible and therefore less impactful with regard to one's perception of a seascape.

Table 2: Criteria for assessing the "seascape impact".

Criteria	Assessment	Scores
Seascape modification	No Yes	0 1
Adjective qualifying the gear	Neutral Negative Positive	0 1 -1
Topography	No changes Decrease of topography Increased of topography	0 2 -2
Total		**-3 to 4**

3.3 Site Usages

The risk to users is assessed according to 4 criteria which represents the main activities carried out off the coast: swimming, diving/snorkeling/spearfishing, sailing/mooring; and fishing. Scores for the first two criteria (swimming and scuba diving/snorkeling/ spearfishing) range from 0 if no activity to 3 if activity undertaken as there is a significant danger to humans (Table 3). The following two criteria (sailing/mooring and fishing) have scores ranging from 0 no activity to 1 activity occurs. The scores are lower for these activities because human life is not directly endangered. The "Site usages" will therefore get a score ranging from 0 to 8. A low score will indicate that there is no known usage where the derelict fishing gear is present. On the contrary, a high score will correspond to a site with multiple usages.

Table 3 : Evaluation criteria for the "site usages".

Criteria	Assessment	Scores
Swimming	No Yes	0 3
Scuba diving/snorkeling/ spearfishing	No Yes	0 3
Sailing/mooring	No Yes	0 1
Fishing	No Yes	0 1
Total		**0 to 8**

3.4 Technical difficulties

Technical difficulties are assessed through two criteria, with a minimum score of 0 and a maximum of 5 (Table 4). If the gear is shallow and not engaged, its rating will be minimal. Otherwise, if the craft is engaged at a depth deeper than 50 m, the technical difficulties will be maximum. It should be noted that the cost of removing fishing gear depends heavily on the time it takes professional divers to complete the task. Therefore, the deeper and more engaged the gear, the more costly the intervention will be due to the dangerousness and time spent underwater. The decision not to put actually "cost" as an evaluation criterion was made considering than technical difficulties is taken as proxy to the cost of the intervention.

Table 4 : Criteria for evaluating the "technical difficulties".

Criteria	Assessment	Scores
Depth	0 – 15 m 15 - 30 m 30 – 50 m > 50 m	0 1 2 3
Engagement	Low (0-10%) Medium (10-50%) Important (>50%)	0 1 2
Total		0 to 5

3.5 Calculating the Gear Removal Index (GRI) of derelict fishing gear

The derelict fishing gear removal Index **(GRI)** is calculated using the following formula:

$$GRI = I_e + I_l + R_u - D_t$$

with I_e : Environmental impact (ranking from -7 to 28)
I_l : Seascape impact (ranking from -3 to 4)
R_u : Risk to users (ranking from 0 to 8)
D_t : Technical difficulties (ranking from 0 to 5)

GRI therefore corresponds to a theoretical value between -15 and 40. The higher the value, the more advisable it will be to remove the fishing gear. This index is an aid to the decision making and is in no way intended to replace the final choice made by local managers. It is also important to visualize which criteria have mostly influenced the index's score to make a thoughtful decision that is in line with the situation encountered. The GRI allows to classify the various fishing gear lost, thus allowing managers to decide on priorities keeping in line with funding available to carry out such operations. Decision making classes can be defined as follows:

- 30 < GRI < 40 removal of the gear **absolutely advised, priority 1**
- 20 < GRI < 30 removal of the gear **very highly advised, priority 2**
- 10 < GRI < 20 removal of the gear **highly advised, priority 3**
- 0 < GRI < 10 removal of the gear **advised, priority 4**
- -15 < GRI < 0 removal of the gear **not recommended, priority 5**

Situations where removal is not recommended mainly apply to long-lost fishing gear, which are heavily colonized and thus constitute now a complex structure well integrated into the environment. Low scores can also be obtained if the technical risks are high, i.e. whether the gear is at significant depths and if it is fully engaged over the rock.

Gear classified as "removal advised" have mostly average environmental and seascape impacts with variable technical risks, or strong environmental and seascape impacts associated with strong technical risks. The removal of these gear is therefore advisable, but they do not represent a priority for managers.

Finally, gear whose removal is “absolutely advised” are as a rule very impactful, both from an environmental and a seascape point of view. The technical risks are low as the sites are often in the top 30 meters of the ocean and the gear are not engaged. These gears, which are therefore easily recoverable but have strong negative impacts, are considered a priority in the context of an action to remove derelict fishing gear.

4 FIELD SHEET

A field sheet to be completed during the dive and containing all the necessary information to be collected *in situ* has been developed (Annex 1).

This fact sheet (Figure 25, Annex 1) is primarily intended for scientists and managers but also for all observers who would like to provide additional information to the sighting of derelict fishing gear. Filling the form is easy, and its use does not require extensive knowledge in marine biology. Only familiarity with the identification of certain marine species will be needed, to properly recognize individuals who may be trapped in the gear or those which might colonize it. The sheet is organized in several sections in order to be able to address the metrics as effectively as possible.
Figure 25

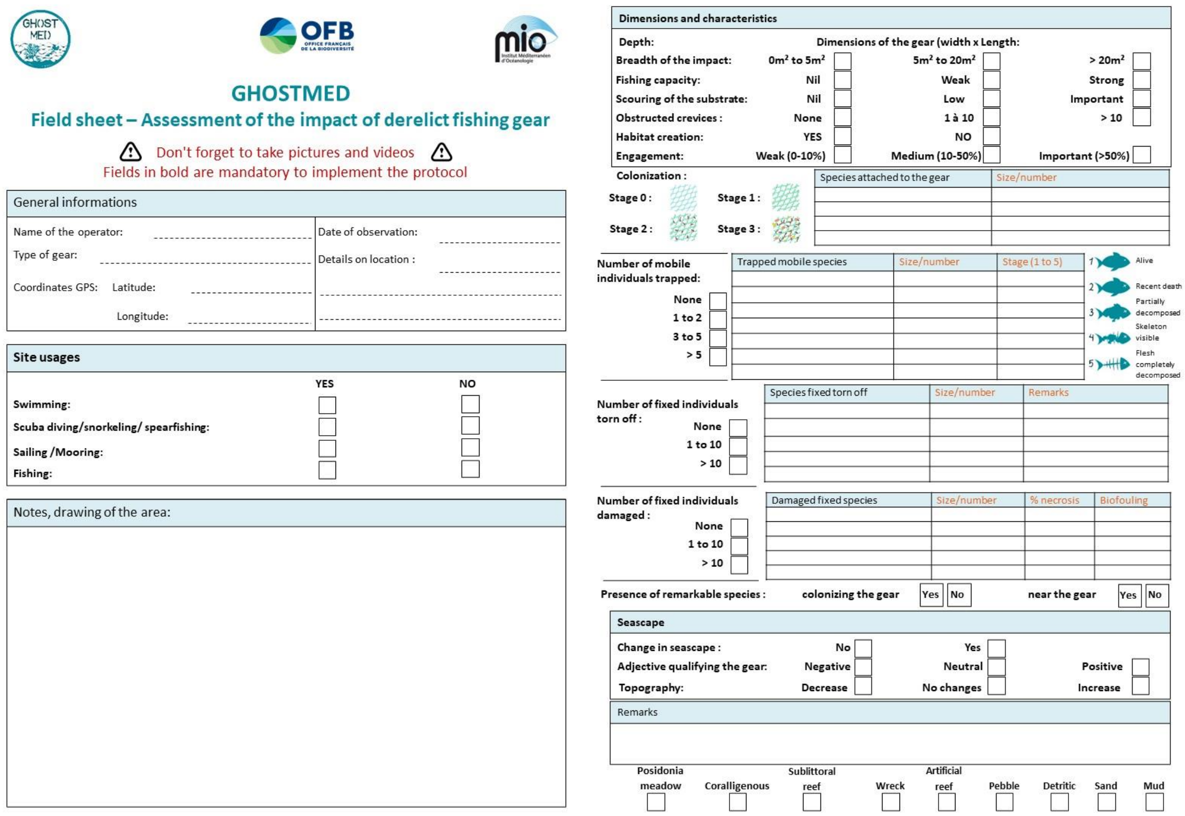


Figure 25: Field sheet to obtain the information needed to implement the GRI.

The field sheet is organized so to keep all the necessary information on one page during the underwater evaluation. The front of the sheet is therefore composed of fields that can be filled before or after the dive. Under the General information is regrouped information, such as the name of the observer, the date of the observation, the type of gear and details on the location of the gear. Under "site usages" fields can also be filled before or after immersion. But it is mandatory to answer whether or not activities proposed in the sheet are carried out in the area. Finally, a large blank section is intended for collection of any other remarks, comments, or even to draw a schematic of the area.

The back of the sheet is kept for observations made *in situ* during the dive. Criteria for implementing the protocol are in bold and their information is mandatory. Additional parameters may also be noted, the operator wishing to go further in assessing the impact. These parameters are not in bold to differentiate them from the mandatory criteria for calculating the GRI.

The first insert aims to provide information about the characteristics of the gear, i.e. depth, dimensions of the gear (length, width), surface estimate, fishing capacity, abrasion on the substrate, number of crevices it clogs, if it constitutes a new habitat and finally its engagement.

The second insert concerns the colonization of the gear as well as the species that could be attached to it. The stage of colonization must be indicated by choosing from the 4 different choices. It is also possible to list the species attached to the gear by indicating their number of individuals as well as their size

The third insert concerns mobile species that could be found trapped in the fishing gear. Number of mobile individuals trapped in the gear must be indicated. To go further, species observed, number of individuals, size, and finally their state of decomposition can be provided. Vignettes symbolizing the different states of decomposition are presented on the right to assist in the assessment.

The fourth and fifth inserts concern the fixed benthic species torn off and damaged by the fishing gear. It is necessary to fill up one of the metrics for the fixed individuals torn off by the gear. To further the assessment, it is possible to note the species torn off, their size and the number. A "comments" field can be filled up by adding useful information to the description of the sessile species torn off. The last criterion is to indicate the number of fixed individuals damaged by the gear by choosing from the three proposed answers. A section is available to record fixed species damaged due to the derelict fishing gear. Their size as well as their percentage of necrosis and the stage of biofouling should be also provided. Figures 17 and 20 of this guide represent an aid on how to fill up these fields. It is also asked to report if remarkable species are either colonizing the gear or found in the vicinity of the gear.

The sixth insert provides information on the seascape impact of the derelict fishing gear. All criteria have pre-filled choices to simplify the operator's task. It will therefore be necessary to check the choice in accord with the situation encountered on site.

The last insert of this field sheet is a wide field available to add any additional information about the fishing gear.

Finally, the type of habitat where the derelict fishing gear is located is to be informed by checking one of the choices proposed at the bottom of the page.

5 EXAMPLES OF GRI IMPLEMENTATION

The GRI assessment protocol was tested on 13 real-life situations of derelict fishing gear in the field. Scores for each criterion are outlined in Table 5. It contains all the criteria to be provided by the scores presented previously in this document. The sum of the environmental, seascape impacts, risks to users as well as technical difficulties are calculated to provide the GRI for each situation. The final score is used to indicate the priority of removal of the machine. The results are presented in Figure 26.Table 5Figure 26

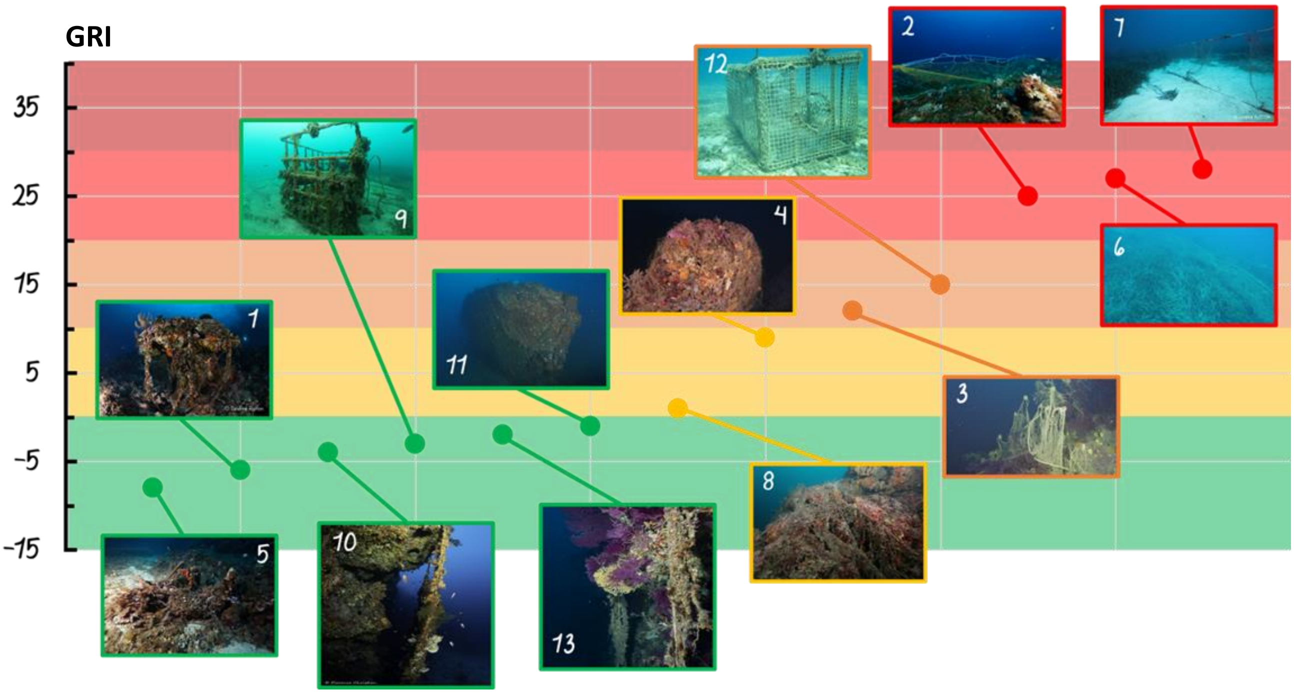
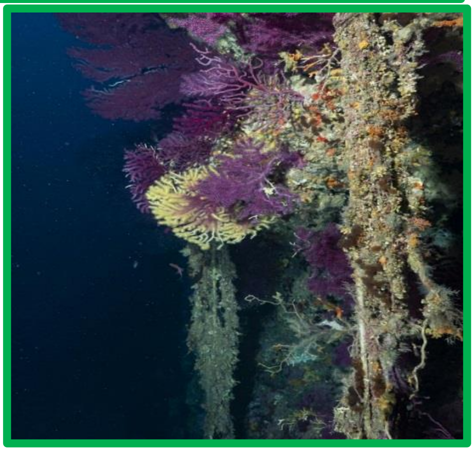


Figure 26 : GRI results for 13 derelict fishing gear tested.

Removal not advised, priority 5



Derelict fishing gear classified as **"removal non advised, priority 5"** are highly colonized and highly engaged. They are totally immobile and no longer have any fishing capacity, so they no longer pose any danger to both marine flora and fauna but also to sea actors such as swimmers, divers, sailors, fishermen, etc. These gears often create new three-dimensional structures on the seafloor allowing certain species to take refuge there.

Removal recommended, priority 4

The category **"removal advised, priority 4"** includes partially colonized and engaged gear. Their environmental impact is small and the dangers they pose to sea users are limited. Their fishing capacity is often reduced due to their advanced colonization status.

Removal highly recommended, priority 3

Gear classified as priority 3, i.e. **"removal highly advised"** are weakly colonized and moderately engaged. They often have floating sections that pose a clear danger to divers, snorkelers, spearfishermen but also to wildlife that could become trapped. These gears are partly mobile, resulting in potential damage to the substrate and to the attached benthic species.

Removal very strongly advised, priority 2

The category **"removal very strongly recommended, priority 2"** includes gear that are very little colonized and engaged. In most cases, they are in an upright position, providing them with a very high fishing capacity. They also pose a significant danger to fixed wildlife because their mobility allows for abrasion of the substrate and tear off benthic species. Finally, their fishing vertical positions also present a potential danger to sea users who may find themselves entangled in them.

Removal absolutely advised, priority 1

In this work, no derelict fishing gear was classified in this category. Nevertheless, it includes all extremely dangerous gear both for local fauna and flora but also for all sea users. Gear concerned here are usually large, in shallow area, and recently lost. They would therefore not be colonized, little engaged, still in an upright position, with a great fishing capacity. The impact of these gear on the environment, the seascape, and users would therefore be very important, and their removals would not present great difficulties.

Table 5 : Examples of GRI calculation

Net ID	E nvironmental impact													Seascape impact				Risks for users					technical risks			
	Gear colonization	Sp mobile trapped	Sp fixed torn off	Sp fixed damaged	Sp remarkable colonising the gear	Sp remarkable near the gear	Obstructed crevices	Subtrate scouring	Habitat creation	Fishing capacity	Habitat	Impact breadth	**TOTAL**	Modification seascape	Adjectif qualificative	Topogra phy	**TOTAL**	Swimming	Diving / Snorkeling / Spearfishing	Sailing / Mooring	Fishing	**TOTAL**	Depth	Engament	**TOTAL**	**GRI**
1	-5	0	0	0	-1	0	0	0	-1	0	3	1	**-3**	1	-1	-2	**-2**	**0**	**3**	**0**	**0**	**3**	2	2	**4**	**-6**
2	0	6	0	1	0	0	0	2	1	4	2	5	**21**	1	1	0	**2**	**0**	**3**	**0**	**0**	**3**	1	0	**1**	**25**
3	-3	2	0	2	0	0	1	1	1	2	3	3	**12**	1	1	0	**2**	**0**	**3**	**0**	**0**	**3**	3	2	**5**	**12**
4	0	0	0	1	-1	0	1	1	1	2	3	1	**9**	1	1	0	**2**	**0**	**0**	**0**	**0**	**0**	1	1	**2**	**9**
5	-5	0	0	0	-1	0	0	0	-1	0	0	1	**-6**	1	1	-2	**0**	**0**	**0**	**0**	**0**	**0**	2	0	**2**	**-8**
6	0	6	1	1	0	1	0	0	1	4	2	5	**21**	1	1	0	**2**	**0**	**3**	**0**	**1**	**4**	0	0	**0**	**27**
7	0	6	1	1	0	1	0	0	1	4	2	5	**21**	1	1	0	**2**	**0**	**3**	**1**	**1**	**5**	0	0	**0**	**28**
8	-5	0	0	0	0	0	2	0	1	0	3	3	**4**	1	0	0	**1**	**0**	**0**	**0**	**0**	**0**	2	2	**4**	**1**
9	-3	0	0	0	0	0	0	0	-1	0	0	1	**-3**	1	1	-2	**0**	**0**	**0**	**0**	**0**	**0**	0	0	**0**	**-3**
10	-5	0	0	0	-1	0	0	0	-1	0	3	1	**-3**	1	1	-2	**0**	**0**	**3**	**0**	**0**	**3**	2	2	**4**	**-4**
11	-5	0	0	0	-1	0	0	0	-1	2	1	5	**1**	1	-1	-2	**-2**	**0**	**3**	**0**	**0**	**3**	1	2	**3**	**-1**
12	-1	6	0	0	0	0	0	0	1	4	0	1	**11**	1	1	0	**2**	**0**	**0**	**1**	**1**	**2**	0	0	**0**	**15**
13	-5	0	0	0	-1	0	1	0	-1	0	3	1	**-2**	1	1	-2	**0**	**0**	**3**	**0**	**0**	**3**	2	1	**3**	**-2**

6 FISHING GEAR LOST BY RECREATIONAL FISHING

Recreational fishing is very important along the French coast and is quite diverse: angling from the shore or on-board vessel, longlining, spearfishing, etc. Most significant loss of equipment are linked to angling and the laying of longlines. For example, in sites where these practices are common, plenty of fishing threads, hooks, lures and sinkers are found on the seafloor (Figure 27). The quantification and impacts of this material, although not insignificant, are rarely reported precisely because it is ubiquitous and trivialized along the French coast and observers no longer pay attention to their presence. The magnitude of the impact of this small derelict fishing gear is certainly less than that of a net or trawl, but in some areas it can be substantial.Figure 27

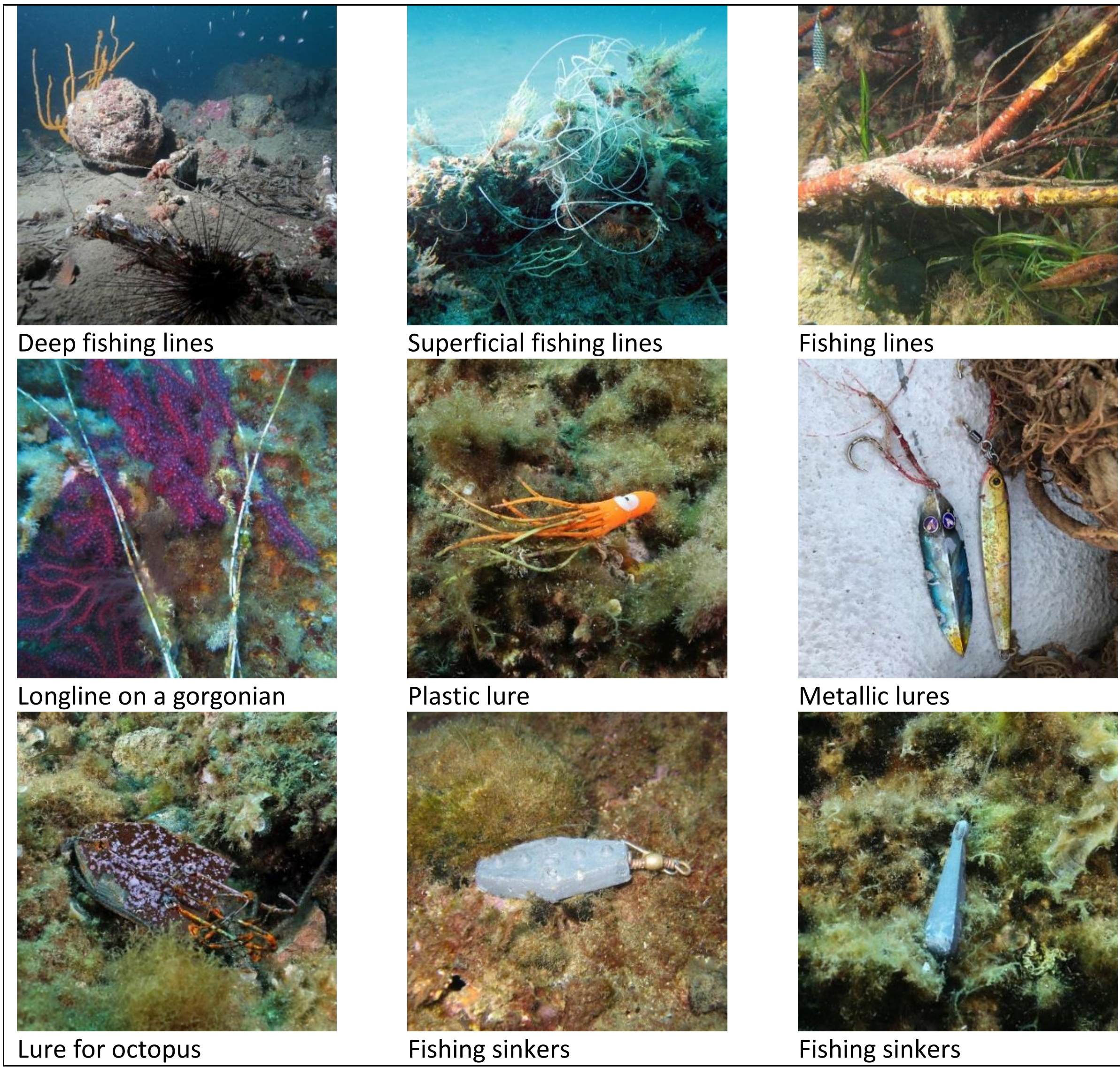


Figure 27 : Example of small fishing equipment found on the seafloor.

Under the GHOSTMED program, small fishing equipment are also considered and will be reported in the same way as other gear.

Field data collection

The quantification of small fishing equipment is carried out by scuba diving. In each site, all recreational fishing waste is collected in quadrats of 5 m wide materialized by pentameters arranged on the bottom. 12 quadrats are then analyzed by site to quantify fishing wires (length and mass), lures (number and mass), hooks (number and mass), fishing sinkers (number and mass) and other materials (fishing rods, swivels, etc.) (Figure 28).Figure 28

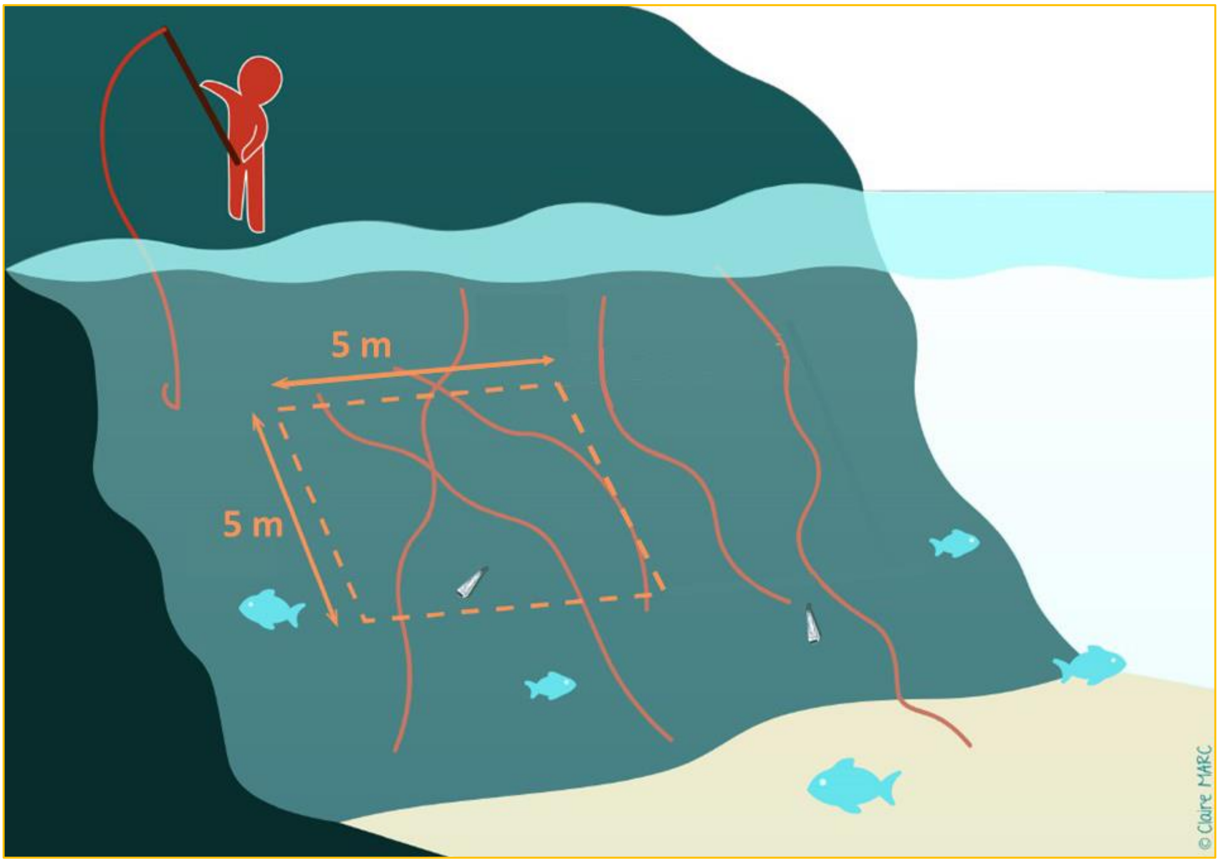


Figure 28 : Fishing line and sinkers quantification technique in the sublittoral zone.

The impacts of these small derelict fishing equipment are noted. Derelict fishing lines are likely to damage or remove fixed species such as gorgonians. They can cause necrosis and sometimes even continue to fish on the seafloor if a lure, a bait, or a catch is present on the hook. Lead and plastic are materials that can contaminate the environment.

7 GLOSSARY

Adsorb: to undergo or cause to undergo a process in which gas or nutrients, accumulates on the surface of a solid

Artisanal fishing: Fishing activity over short distance and often in coastal areas conducted from small fishing boats. This fishery uses traditional techniques, without technological development. It is also called small trades fishing.

Barren ground: In an ecosystem, a disturbance can tip the system from one climax to another. Barren ground is the result of intensive grazing by sea urchins or other herbivores on a habitat composed of macroalgae. The habitat is then stripped of any standing macroalgae and will eventually be covered by encrusting limestone algae.

Benthic: Qualifies organisms and communities that live on or in close relationship with the substance the seafloor. Opposite to pelagic.

Biogenic: Material from biological origin. For example, concretions that form the coralligenous are biogenic because they come from limestone organisms such as limestone macrophytes (corallinaceae) but also animal such as bryozoans. They are called bio-builders.

Carbon sink: A carbon sink refers to a biological or physical system that can capture and store atmospheric carbon for a certain period.

Circalittoral: Marine zone that lies under the subtidal zone, where photophilic algae are becoming scarce. Its lower limit is set when sciaphilic organisms, *i.e.* requiring very little light, disappear. The upper and lower limits of this zone therefore is function of the turbidity of the seawater.

Climax: In ecology, climax refers to the relatively stable state to which an ecosystem evolves, in the absence of major disturbances. This stable state can be destroyed by natural or anthropogenic environmental disturbances.

Concretion: Clusters of solid particles found on rocks or soils resulting from the successive formation and agglomeration of new particles under the action of physical or chemical agents. When it comes to biological concretions, they are called bio-concretions. This is the case with coralligenous.

Disturbance: In a given ecosystem, a disturbance is the result of an unpredictable and short-lived modification of a physical-chemical and/or possibly biological parameter, with a magnitude of such an amplitude that it is greater than the capabilities of one or more key species or a functional compartment to maintain itself in a good ecological state.

Endemic: A species that is naturally present only in a given geographical area and not elsewhere.

Engineer species: A species that by its physical presence or activity contributes to the creation of habitat or significantly shapes habitat. Examples include forest trees and reef-building corals, or beavers that change the riverbed and the current speed through their activity.

Epibiont: Epibionts are organisms that live fixed to other ones. When they are found on “vegetal”, they are called epiphytes.

Fishhook: Metal hook that is placed at the end of a line, and on which one attaches a bait to catch fish.

Fishing net: Meshed device, consisting of a net made of natural or synthetic fibres to capture, confine or handle aquatic organisms, especially fish.

Hydrodynamics: Hydrodynamics at sea characterize the movements of water masses, mainly generated by wind, tides and ocean currents.

Industrial fishing: Fishing activity aimed at collecting a large number of captures. It requires large vessels and requires appropriate port infrastructure to disembark and distribute fish.

Sub-tidal: Zone of the ocean defined between the surface (biological zero) and the lower limit of the Posidonia herbarium. The lower limit depth is therefore variable depending on the clarity of the water.

Key species: A species that by its behavior will significantly modulate the availability of other resources. Top predators are often key species, which by controlling the stock of species at a lower trophic level will influence the state of the whole ecosystem.

Longline: Long line carry many fishhooks, and is usually deployed horizontally in the water column by a longliner. Used in artisanal fishing, the longline rests on the seabed. The pelagic longline floats on the surface adrift in the ocean.

Lure: Artificial bait used to catch fish in angling.

Magnoliophytes: Magnoliophytes are a group of organisms that includes flowering and seed vascular plants (also called angiosperms). Among the marine Magnoliophytes are posidonia *Posidonia oceanica,* eelgrass *Zostera noltei* or cymodoce *Cymodocea nodosa.*

Matte: The surface of the interlacing of the living and dead posidonia rhizomes added by the sediment filling the gaps is called "matte"." When the meadow dies, the matte stays in place and testifies to the past presence of the meadow. It is then called "dead matte."

Mesh of a net: The mesh of a net is limited by four sides and four knots. The size of the mesh of a net can be given in several ways but by convention it is the length of the side of the mesh that is most common.

Photophilous: A photophilous organism requires light to live and grow, only developing in areas well exposed to light.

Photosynthesis: An energetic biochemical reaction that takes place in plants with the aim of creating from the sunlight energy in forms of carbohydrates.

Pots/traps: Fishing instrument that lands on the bottom of the ocean, in the shape of an oblong or rectangular cylindrical basket, made of wicker, net or wire, with a gully through which the fish can enter but not come out.

Professional fishing: Professional activity of capturing aquatic organisms, allowing the fisherman to earn income. He works on a boat that has obtained a license to commence operations and is registered to the Multiannual Guidance Program for Fishing Fleets. It operates near the coast, in the open ocean, or further offshore. There are different types of professional fishing, small-scale fishing, and industrial fishing.

Recreational fishing: Non-commercial fishing activity whose species collected are intended exclusively for the consumption of the fisherman and his family and cannot be sold. This fishery is also subject to rules to protect the resource.

Rhizomes: Perennial stem, more or less elongated, branched or not, with leaves reduced to very small scales, producing each year adventive roots and an apical bud that gives rise to an aerial stem, slightly buried in the soil in which it grows horizontally (plagiotrope) or vertically (orthotropic).

ROV (Remotely Operated underwater Vehicle): Small controlled underwater vehicle controlled remotely.

Sediment: Any deposit of insoluble material, primarily rock and soil particles, transported from land areas to the ocean by wind, ice, and rivers, as well as the remains of marine organisms, products of submarine volcanism, chemical precipitates from seawater, and materials from outer space (e.g., meteorites) that accumulate on the seafloor. They are deposited in successive layers by gravity. The sedimentation process importance depends upon climatic, ecological, geomorphological and hydrological factors.

Spawning ground: Place where animal species reproduce.

Trammel net: Vertically set net, consisting of three sheets, with two wide-mesh exteriors and a much smaller mesh inside, which form a trap in which the fish remains imprisoned.

Vegetation zonation: Vertical distribution of a plant community, each characterized by a specific fauna. These different zones may not be all present at once in the environment. In the marine environment, 4 zones can be identified: encrusting, filamentous, shrubbery and arborescent.

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9 ANNEXE 1: FIELD SHEET

GHOSTMED

Field sheet – Assessment of the impact of derelict fishing gear

⚠ Don't forget to take pictures and videos ⚠

Fields in bold are mandatory to implement the protocol

General informations	
Name of the operator: ______________________________	Date of observation: ______________________
Type of gear: ____	Details on location : ______________________
Coordinates GPS: Latitude: ______________________	____
Longitude: ______________________	____

Site usages	**YES**	**NO**
Swimming:	☐	☐
Scuba diving/snorkeling/ spearfishing:	☐	☐
Sailing /Mooring:	☐	☐
Fishing:	☐	☐

Notes, drawing of the area:

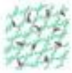
Dimensions and characteristics

Depth: **Dimensions of the gear (width x Length:**

Breadth of the impact:	**0m² to 5m²** ☐	**5m² to 20m²** ☐	**> 20m²** ☐
Fishing capacity:	**Nil** ☐	**Weak** ☐	**Strong** ☐
Scouring of the substrate:	**Nil** ☐	**Low** ☐	**Important** ☐
Obstructed crevices :	**None** ☐	**1 à 10** ☐	**> 10** ☐
Habitat creation:	**YES** ☐	**NO** ☐	
Engagement:	**Weak (0-10%)** ☐	**Medium (10-50%)** ☐	**Important (>50%)** ☐

Colonization :

Stage 0 :  **Stage 1 :** 

Stage 2 :  **Stage 3 :** 

Species attached to the gear	Size/number

Number of mobile individuals trapped:

None ☐
1 to 2 ☐
3 to 5 ☐
> 5 ☐

Trapped mobile species	Size/number	Stage (1 to 5)

Number of fixed individuals torn off :

None ☐
1 to 10 ☐
> 10 ☐

Species fixed torn off	Size/number	Remarks

Number of fixed individuals damaged :

None ☐
1 to 10 ☐
> 10 ☐

Damaged fixed species	Size/number	% necrosis	Biofouling

Presence of remarkable species : **colonizing the gear** Yes ☐ No ☐ **near the gear** Yes ☐ No ☐

Seascape

Change in seascape :	**No** ☐	**Yes** ☐	
Adjective qualifying the gear:	**Negative** ☐	**Neutral** ☐	**Positive** ☐
Topography:	**Decrease** ☐	**No changes** ☐	**Increase** ☐

Remarks

Posidonia meadow	Coralligenous	Sublittoral reef	Wreck	Artificial reef	Pebble	Detritic	Sand	Mud
☐	☐	☐	☐	☐	☐	☐	☐	☐