GHOST

TECHNIQUES TO REDUCE THE IMPACT OF GHOST FISHING GEARS AND TO IMPROVE BIODIVERSITY IN NORTH ADRIATIC COASTAL AREAS

Hands-on Manual to prevent and reduce abandoned fishing gears at sea

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TECHNIQUES TO REDUCE THE IMPACTS OF GHOST FISHING GEARS AND TO IMPROVE BIODIVERSITY IN NORTH ADRIATIC COASTAL AREAS
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Contents

Acronyms

ALDFG = Abandoned, Lost or otherwise Discarded Fishing Gear
CBA = Cost-Benefit Analysis
CEA = Cost-Effectiveness Analysis
CV = Contingent Valuation
FAO = Food and Agriculture Organization of the United Nations
HRSS = High Resolution Scanning Sonar
UNEP = United Nations Environment Programme
UVC = Underwater Visual Census
VHF =Very High Frequency

Introduction

This manual is an operational guide targeting institutions, public and private bodies, sector operators and environmental associations, all contributing in various ways to marine ecosystem protection particularly through the adoption of appropriate measures for the management of fishing gears and aquaculture equipment abandoned at sea. Protocols and guidelines drawn up within the scope of the LIFE-GHOST project are the main contents of this manual. They have been designed in the conviction that their replicability will positively contribute to extending locally obtained benefits to other similar environmental contexts. Significantly, suggested methods are particularly suitable for use in shallow coastal areas of particular biological importance, owing to the (occasional) presence of seabeds characterised by rocky formations and high biodiversity. The abandoned fishing gear considered in this manual is mostly of small size, as fishing activities in these areas are mostly classified as small-scale coastal fishing.

The contents are divided into chapters dealing with the different technical aspects related to fishing gear management, following a specific order ideally reproducing the steps needed to prevent and mitigate their abandonment at sea, as well as to properly handle their recovery for recycling purposes.

Quantitative and qualitative project results are outlined in the introductory chapter, followed by a detailed description of the first phase of the process focusing on the procedures to remove fishing gears from the seabed with the relevant risks and opportunities. Guidelines are then provided on how to implement a management system of recovered fishing gear, by taking into consideration technical (identification of the most suitable recycling options) as well as logistical and organisational needs. The manual also describes a few approaches and operational strategies on how to manage dialogue among parties at stake, aimed at ensuring the active involvement of stakeholders from the fishing sector. Finally, the *Code of best practices to reduce lost and abandoned fishing gear at sea* and the *Operational recommendations for ALDFG effective management* are enclosed as annexes to this document.

THE LIFE-GHOST PROJECT: CONTEXT AND RESULTS

The LIFE-GHOST Project - *Techniques to reduce the impacts of ghost fishing gears and to improve biodiversity in north Adriatic coastal areas* – (2013-2016), is co-financed by the EU Programme "LIFE + Biodiversity", and has been promoted by the National Research Council CNR-ISMAR of Venice, with the participation of the Department of Design and Planning in Complex Environments of the Venice University IUAV, and of the Italian company Laguna Project snc. This initiative has been aimed at identifying measures to reduce the problem of abandoned, lost or otherwise discarded fishing gear (ALDFG) on the seabed, and promoting the protection of the marine environment and biodiversity.

The LIFE-GHOST project has been implemented at a time of increasing awareness of the ALDFG problem on seabeds: indeed, it is now universally recognised that ALDFG can cause serious problems to the environment as well as to the socio-economic context. Consequences from abandoning or losing fishing gears affect several levels. ALDFG seriously endangers the health and structure of habitats by depriving the seabed of vital surfaces ideal for reproduction, and it endangers species that may be trapped in them. For example, a survey has shown that in several fishing ports, especially off the Atlantic coasts of North America and in the North Sea, the loss of marine resources caused by ghost fishing may amount to approximately 10% of the available stock for commercial fishing (UNEP, 2005). Moreover, it has been recently assessed that plastic micro-fragments and micro-filaments produced in the long term through mechanic abrasion and degradation of plastic macro waste, including abandoned fishing nets, are ingested by marine organisms at several levels in the trophic chain, to the extent that they may potentially affect the health of human beings consuming fishing products.

The last decade has seen increasing acknowledgement at international level of the urging need to promote multilateral initiatives to effectively tackle problems caused by ALDFG. Several GOs and NGOs are actively taking action on this problem by means of research, prevention and recovery activities. Among them, the United Nations Environment Programme (UNEP) and the UN Food and Agriculture Organization (FAO) are worth mentioning as they have constantly published technical reports and recommendations on how to disseminate knowledge about the problem and reduce it (Macfadyen et al., 2009).

Within this scenario, the priority aim of the LIFE-GHOST project has been evaluating the extent of the problem in the typical rocky outcrops (the so-called *tegnùe*) located in the Northern Adriatic coastal area. These habitats are particularly important from a biological point of view and are the ideal substrate for the development of fish and zoobenthic communities rich in biodiversity.

By using these peculiar formations as test areas, LIFE-GHOST activities have mainly been implemented based on the following guidelines:

1. conduct a knowledge-based field analysis in order to assess the problem and its consequences in a specific environmental context, particularly by evaluating status, dissemination and biological impact. To this end, ALDFG has been located and mapped in a sample area along the coast of the Veneto region representing the rocky outcrop areas located off the Venetian coast;

2. implementation of an ALDFG removal campaign, with the two-fold aim of contributing to the qualitative improvement of the local marine environment, as well as drawing up removal protocols based on an objective evaluation of the relevant benefits;

3. define a management and technical program aimed at ensuring optimal land management of ALDFG recovered at sea and discarded fishing gears, by means of assessing the most effective options to make the most of the recycling procedure in terms of materials recovery;

4. promote concrete actions to prevent and restrict the voluntary abandonment or accidental loss at sea of fishing gears, by means of dissemination activities among fishing operators and regional policymakers to make them aware of the necessary recommendations;

5. estimate the economic value of ecosystem benefits in valuable marine environments - such as rocky outcrops - resulting from ALDFG removal.

Tegnùe (rocky outcrops): a valuable habitat to protect

The seabed off the Veneto coasts is basically sandy and muddy, sometimes interrupted by solid substrates creating areas abounding in ecological gradients and microenvironments increasing the specific diversity of the benthic community (i.e. organisms that live close to the seabed) and fish fauna. These rocky outcrops are locally called *tegnùe*, and they have been known by local fishermen since ancient times. This word derives from the local Venetian dialect (*tegnùa* means "withheld"), and it was used by fishermen in the old days meaning that their nets were often trapped in these outcrops.

The *tegnùe* are located along the coastal area stretching from the mouth of the river Brenta to the Grado lagoon. Though very unevenly scattered, they can be considered as roughly aligned along three parallel strips of seabed, respectively at a distance of 3-5 miles, 10-12 miles and 20 miles off the coast, at different depths ranging from 8 to 40 m (Stefanon & Boldrin, 1979; Mizzan, 1995). The exact number of these rocky outcrops is still unknown; however, it is estimated that they exceed 3,000 only in the stretch of sea belonging to the Veneto region. Their size varies considerably, from a few square metres up to several square kilometres, and their height from the seabed ranges from a few decimetres up to some metres: the deepest rocky outcrops are usually the highest ones (Mizzan, 2010).

The area where rocky outcrops are located is characterised by eutrophic shallow waters, thus favouring the development of a very large number of animal and plant species and a large amount of biomass, which is also favoured by the solid substrate providing ideal protection, the vertical gradient due to the height of the outcrops on the sandy seabed, and the great availability of suspended or sedimentary organic material providing food source.

An in-depth bibliographical research has been carried out in the LIFE-GHOST project to characterise outcrops biodiversity. Collected information has been organised in a database focusing on the lists of species accompanied by any available data on their abundance in a specific rocky outcrop and a specific time frame. The aim of this database is to update and systematise all information that can be retrieved in the scientific literature about fish and macrozoobenthic populations, thus contributing to an organised store of ecological knowledge about this habitat.

Research from scientific publications and technical reports surveyed 50 sites where 740 species were sighted over the years, mostly belonging (in terms of species number) to *Mollusca* (38%), *Crustacea* (16.4%) and *Anellida* (12.2%). Among them, 12 were included in protection lists, whereas 97 were species of commercial interest (Figure 1).

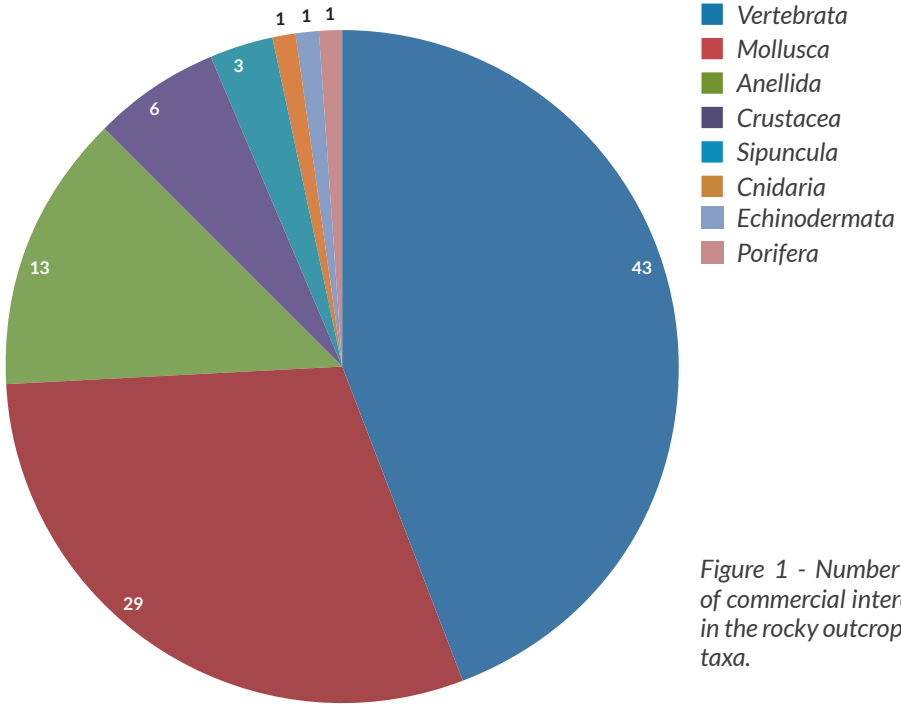


Figure 1 - Number of species of commercial interest located in the rocky outcrops sorted by taxa.

Data analysis highlighted a richer and more diversified number of fish species and macrozoobenthic populations in the rocky outcrops of the Northern Adriatic Sea, compared to those located in other similar Mediterranean habitats, in particular coralligenous ones (Ballesteros, 2006). The predominance of filtering organisms (particularly sponges and cnidarians), typical of these habitats, is likely to be associated with the large quantities of organic suspended matter and sediments, which favour their growth and expansion to the detriment of other functional groups, i.e. herbivores and carnivores (Casellato et al., 2007).

Measures implemented by the LIFE-GHOST project

The seabed was mapped on a total area of approximately 20 km² off the Venetian coast, by means of acoustic and visual underwater surveys mapping abandoned fishing gears located in approximately half of all rocky outcrop areas (Figure 2).

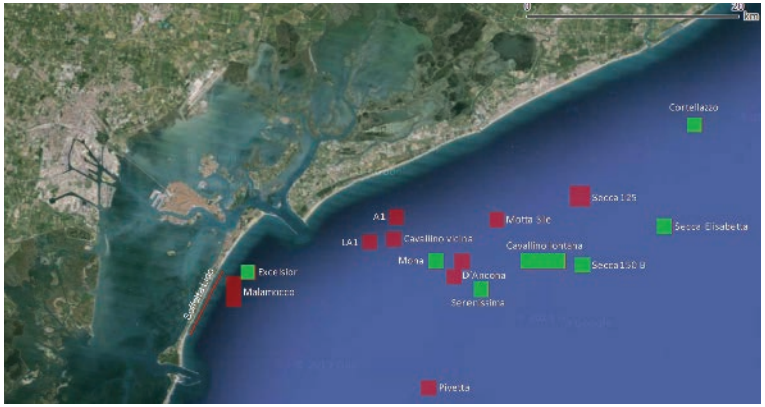


Figure 2 – Surveyed areas. The red spots show the areas where ALDFG has been detected.

Survey campaigns generally detected a larger number of fishing nets and gears abandoned in the rocky outcrops located near the busiest routes of fishing boats, in rocky outcrops within 3 miles from the coast or just beyond the three-mile limit. The morphology of rocky outcrops also favours the entanglement of fishing nets and gears, because their size is considerable in terms of height and surface.

The functional classification of fishing gears located on the seabed showed the larger presence of "active nets" (trawl nets, mid-water trawls, bottom trawl nets, etc.) and "fishing waste" (mainly ropes, also leaded ones, sheets, wire anchors, hoses for hydraulic dredges, elastic bands, mooring posts, metal frames etc.) compared to "passive nets" (gillnets, pots, trammel nets, etc.) or "aquaculture waste" (such as mussel socks and other equipment for sea mussel farming) (Figure 3).
Observations confirmed that "active nets" (often parts thereof) are rather widespread and evenly scattered on surveyed seabeds, both within 3 miles off the coast and beyond. Therefore, it was assumed that their presence might be due to accidental net entanglement during trawling activities caused by the rocky protrusions of unknown outcrops, or even by abandoned and unreported bulky waste. On the contrary, the higher density of materials classified as "fishing waste" in specific areas is likely to be ascribable to voluntary abandonment caused by the need to get rid of obsolete equipment. Finally, the detected presence of gillnets, pots and trammel nets on the seabed may have been caused by accidental loss following unfavourable weather conditions (storms), or breakage from the competition with other fishing gears.

Seabed cleaning operations performed after the mapping campaign led to the removal of 362 single objects classified as ALDFG, for a total dry weight of 513.54 kg (Figure 4). With reference to some *rapido* nets, i.e. equipment partly made of metal and partly of plastic materials, partial removal was used to recover the net bag and elastic bands. The metal frames of approx. 3 X 0.5 m were left on the seabed after realising that they were widely colonised by encrusting organisms. It was also considered that, once deprived of their bags, these nets would no longer be dangerous for the environment both with respect to seabed biological communities and recreational diving activities in the area.

There have only been sporadic sightings of organisms trapped in fishing nets and gears on the seabed, namely one pygmy cormorant (*Microcarbo pygmaeus*), in an advanced state of decomposition, and 7 warty crabs (*Eriphia verrucosa*), of which 4 alive (later released) and 3 dead.

Figure 3 – Some examples of ALDFG identified in the surveyed areas.

In 5 sample areas selected among those being the object of removal activities (the rocky outcrops of Cavallino vicino, D'Ancona, LA1, Secca 125 and Pivetta respectively), community changes were monitored over time in terms of biodiversity by means of observations of the macrobenthos and the fish fauna. Underwater observations were performed with a non-destructive photographic technique during seasonal diving campaigns over a period of 18 months. Photographs of the same benthic community taken in different survey periods were compared with one another, as well as with an area not affected by abandoned fishing nets. The fish fauna was also monitored with visual census at fixed points. Also in this case, survey data were compared with a reference area nearby.

An increase in biodiversity and coverage was observed in the benthic community living on the portions of ALDFG-free rocky surfaces, practically in all surveyed sites. Despite these very promising results, total recovery of pre-impact biodiversity conditions cannot be assumed, as further data are necessary and they will be obtained only through longer observation periods. Most significantly, statistically meaningful evaluations on the vertical growth of the encrusting community could not be made, owing to the limited monitoring period. Indeed, encrusting organisms spread significantly on the horizontal plane only. An increase in biodiversity and species abundance was also reported for the fish community, with particular reference to cryptic species which have occupied cracks and fractures of rocks previously obstructed by ghost nets.

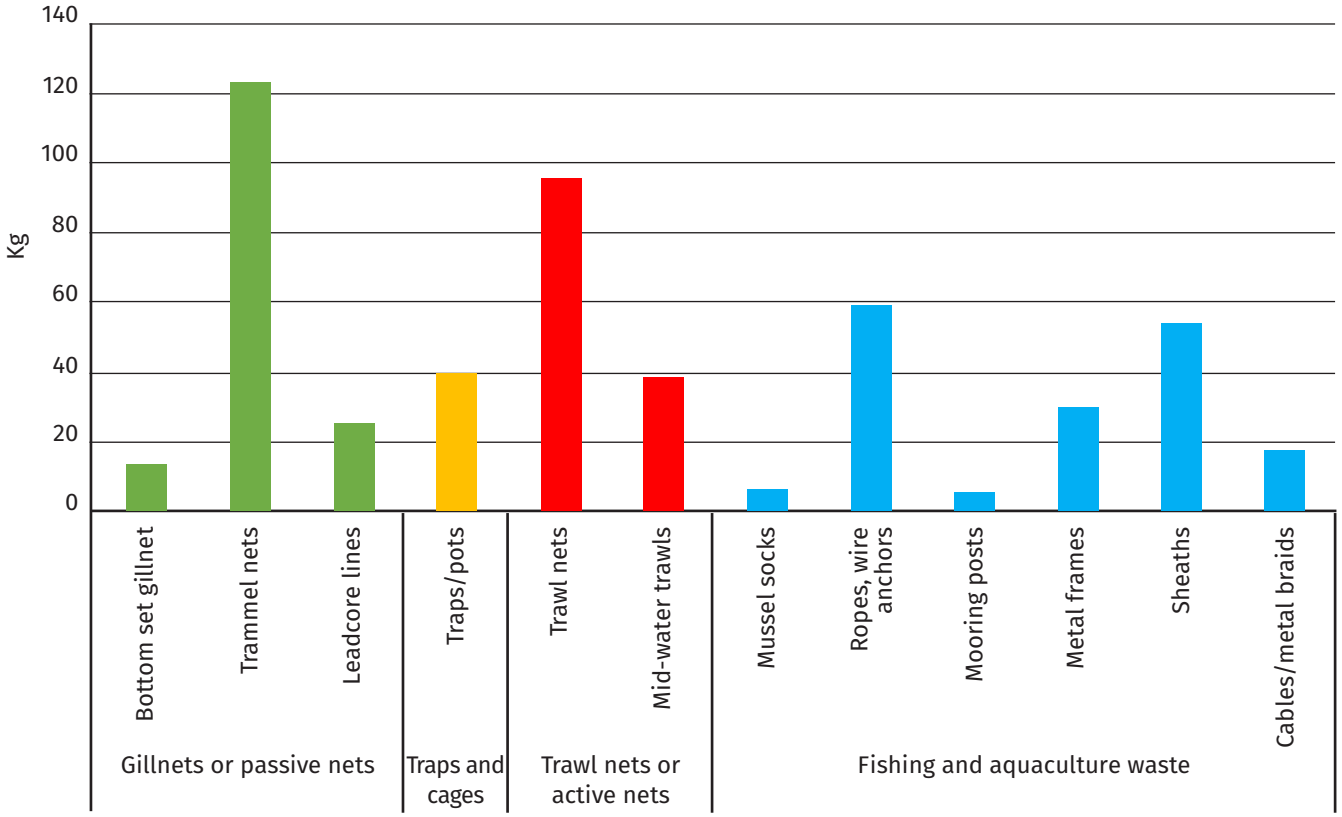


Figure 4 - ALDFG types and quantities recovered from the surveyed areas (in kg of dry weight).

Proposals for the sustainable management of abandoned or discarded fishing gears and aquaculture equipment

To prevent fishing gears and waste from being abandoned at sea, environmental education and awareness-raising initiatives are necessary, as well as the organisation of effective waste collection and management services. The analysis of the local organisational context (landings, port waste collection and disposal plans) and interaction with the stakeholders involved in the fishing gear management process (fishing operators, municipally owned companies, harbour masters, private companies) clearly highlighted obstacles hampering the proper management of the "end-of-life" fishing gears, be they discarded, confiscated by port authorities and/or abandoned on the seabed. Firstly, the most critical point was the lack of adequate fishing gear delivery structures both in the port areas regulated by waste collection plans and in mooring areas not falling within port area regulations. Secondly, administrative difficulties were outlined in the implementation and subsequent management of any new waste collection centres. These difficulties were due to the need to supervise delivered waste materials and to control the area, bureaucratic red-tape envisaged by law, etc.

In order to meet local requests issuing from different parties and contexts, the project focused on drawing up a proposal for an efficient management system representing the model of a virtuous system that could be replicated in other national areas. To this end, possible options for the recovery / recycling of materials making up the fishing equipment were evaluated, bearing in mind the principles laid down by the Circular Economy model and by waste hierarchy, with a view to maximising environmental benefits. The scope of action was particularly focused on plastic materials making up the most significant component in terms of quantity and environmental impact.

The suggested management model can also be implemented in the plastic waste management of mussel farming activities. Indeed, a considerable part of marine litter very often consists of mussel socks, either abandoned or lost during operations at sea. Moreover, there is evidence that without local coordination among cooperatives to manage waste produced by production activities, mussel farmers complain of difficulties in the landfilling of waste materials, because of considerable waste volumes.

Recovery / recycling alternatives have been defined based on experimental activities and scientific literature. The most innovative experiences made at national and international level on the recycling of plastic components by means of mechanical, chemical and waste-to-energy plant processes have been studied. Preliminary experimentation has been carried out with the cooperation of local companies, in order to assess the potential use of mechanical recycling technologies for plastic materials making up the fishing equipment (PA6 - polyamide 6, HDPE – high-density polyethylene and PP – polypropylene). Results obtained pointed to the technical feasibility of mechanical recycling for all types of plastic materials, following cleansing operations for very dirty materials. However, it must be borne in mind that reusing them as second raw materials mainly depends on the type of polymer and on the building structure of materials (e.g. the use of several polymers, additives etc.). On top of that, it is vital to estimate the quantities of materials at stake and pre-treatment costs, at least when implementing a mechanical recycling chain.

Direct comparison with the situation in a few Italian enterprises also led to the identification of a possible alternative to mechanical recycling, consisting in the transformation of plastic materials into transport fuel (pyrolysis-based chemical recycling). The advantages of this type of solution lie in delivering plastic materials to the recycling plant without the need for treating them, thus reducing the relevant costs; on the other hand, at present there are no plants authorised for this type of treatment in Italy.

Figure 5 shows the decision-making process diagram for the management of fishing gears which was drawn up at the end of the project.

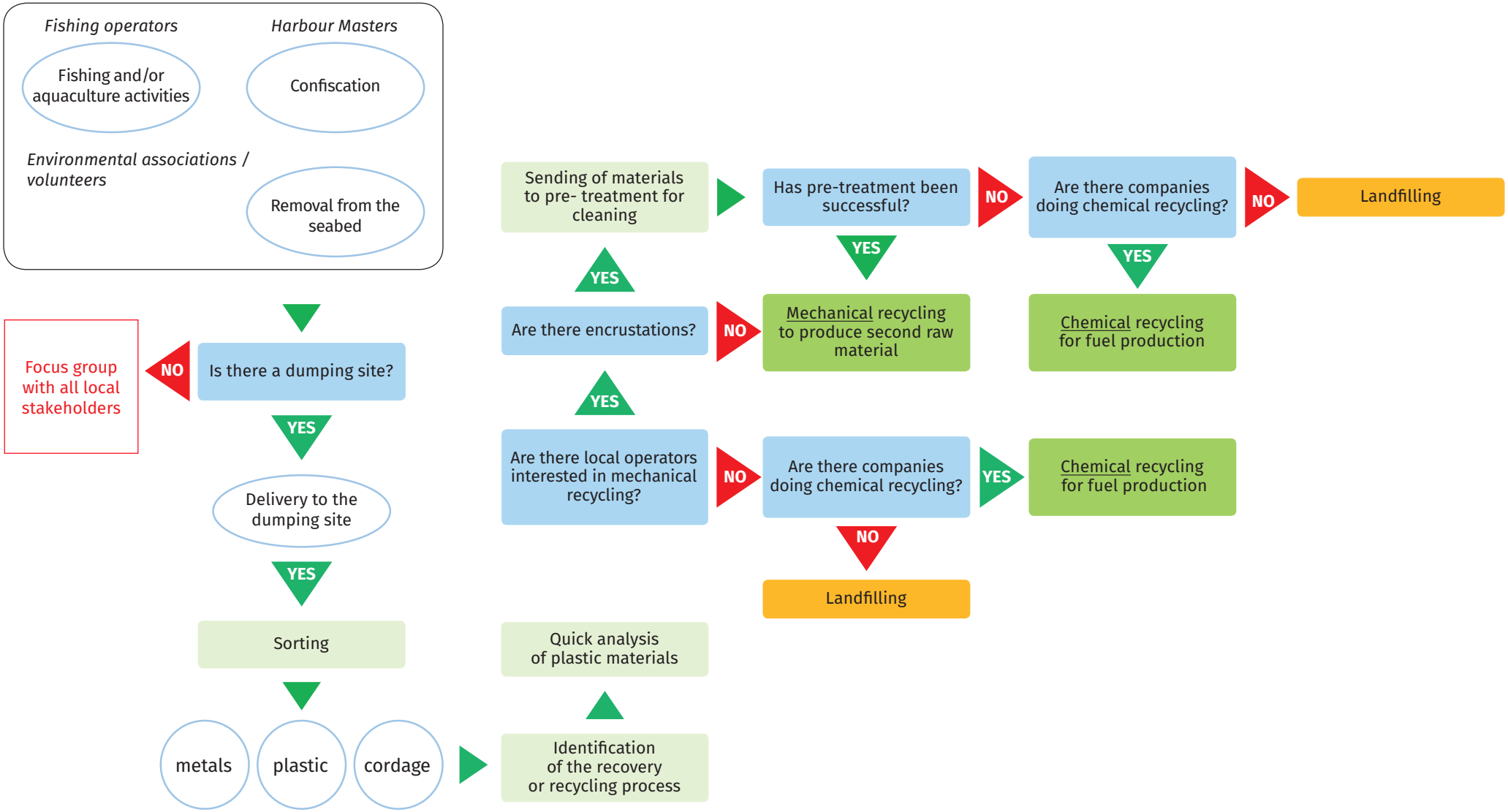


Figure 5 - Decision-making process diagram for the management of discarded and/or confiscated and/or recovered fishing gears.

Awareness-raising activities and stakeholders' involvement

Awareness-raising activities have been promoted within the LIFE-GHOST project and aimed at involving local stakeholders, in order to promote and disseminate the implementation of suitable methods and behaviours to prevent and/or reduce ALDFG. These activities have been targeted towards two main categories of stakeholders:

a. fishermen and aquaculture farmers, who are actually mainly responsible for the abandonment and accidental loss of fishing gears at sea;

b. policymakers, regional and local administrators.

Fishermen and aquaculture farmers have been involved in well-developed education and awareness-raising initiatives aimed at promoting sustainable fishing practices and behaviours, mainly concerning the proper management of waste generated by their activities, and implementing technical measures, conscious and responsible behaviour to prevent the loss of fishing gears at sea.

Exchanges with fishermen were promoted by public meetings organised with the support of opinion leaders from the fishing sector, in order to understand individual and collective needs and opinions. The needs jointly expressed by fishing vessel operators can be summarized in the request to set up (where lacking) or further develop (if already in place) a fishing waste delivery system based on real needs: the current shortage or insufficient development of such systems have been blamed as the main reason for voluntary abandonment of fishing equipment at sea. Measures to promote awareness have led to the publication of a shared *Code of best practices to reduce lost and abandoned fishing gear at sea* (see Annexes), which was welcomed by fishermen operating in the main fishing ports of Veneto.

At the same time, the LIFE-GHOST project took action within the institutional framework of the Veneto region, by defining some recommendations addressed to the Regional administration and outlined in the document entitled *Operational recommendations for ALDFG effective management* (see Annexes). These recommendations were submitted to the Veneto region with Motion No. 173 of the Regional Council. They contain prevention, mitigation and curative measures to reduce the negative effects of this type of waste, as well as to prevent this phenomenon in the long term.

Why is ALDFG removal necessary?

Undoubtedly, the removal of fishing nets and gears abandoned on the seabed has a positive impact on the healthy status of marine ecosystems. Despite its limited duration, the LIFE-GHOST project reported some environmental benefits obtained from removal activities, as mentioned in the previous paragraphs. However, this project also investigated human benefits deriving from "seabed cleaning" activities, such as increased well-being of local communities following improvement of biodiversity and related ecosystem services (increased production of food and raw materials, better habitats for protected and migratory species, recreational opportunities, nutrient regulation, etc.).

Biodiversity monitoring results have been used to assess the economic value of ecosystem benefits (i.e. the monetary value given by people to benefits resulting from ecosystems), following lower abandonment and ALDFG removal from rocky outcrops. In order to understand the value of removal activities in terms of collective benefits, and to evaluate the need for further removal activities, the LIFE-GHOST project has preliminarily analysed the population's willingness to invest in the "cleaning" of rocky outcrops, and subsequently compared results with removal costs.

From a methodological point of view, the economic value of improving marine biodiversity of rocky outcrops has been determined by using contingent valuation (CV, Mitchell & Carson, 1989). This technique is used in economic research to calculate the economic value of a specific good that is not usually traded on the market (like all natural resources). With specific reference to the LIFE-GHOST project, an estimate was made of the "willingness to pay" by a sample of individuals to contribute to removal activities improving and protecting marine biodiversity.

At a first stage, a CV questionnaire was drawn up and administered to a sample of 4,000 Italian people representing the national population (in terms of age, income, job and education), in order to evaluate the interviewees' Willingness To Pay (WTP) for specific biodiversity recovery and preservation measures such as the removal of fishing nets, several fishing gears and general fishing waste.

At the same time, a Cost-Effectiveness Analysis (CEA) was performed to evaluate the economic effectiveness of removing ALDFG from these areas. The CEA compares costs necessary for ALDFG removal with actual results achieved in terms of biodiversity improvement, which is measured by means of biological diversity indicators establishing the number of species living in that area and the relative percentage abundance (e.g. Shannon and Margalef indexes).

The third phase of the activity was the Cost-Benefit Analysis (CBA), a consolidated economic evaluation practice comparing the costs of ALDFG removal activities with economic benefits calculated in the first phase. In short, the CV results led to an estimated WTP among Veneto residents of about €20 per family, whereas this amount is slightly lower (around € 15 per family) if the national sample is taken as a reference. By multiplying such an amount by the number of Veneto resident families, the total value of estimated benefits deriving from improved biodiversity in the rocky outcrops equals about 41 million Euros.

By comparing this estimated amount - representing the willingness of the regional population to contribute to rocky outcrop recovery and protection operations - with costs borne to remove the fishing equipment, it is clear that activities implemented to improve rocky outcrop biodiversity are not only of interest for the community, but also economically sustainable.

This assessment process ultimately shows that biodiversity conservation initiatives suggested by LIFE-GHOST are effective and efficient from an environmental, economic and financial perspective. Benefits obtained from the removal of fishing nets and gears from the seabed not only contribute to the renewed delivery of some ecosystem services, but also to the improved well-being of a community considering a healthier rocky outcrop habitat as an asset to protect.

ALDFG REMOVAL TECHNIQUES AND PROTOCOLS

This chapter outlines the procedures for the identification and removal of ALDFG and nets in the coastal seawaters or whose depth does not exceed 40 metres. Generally speaking, three phases shall be envisaged in the planning of activities and they are briefly summarised as follows:

Phase 1. *Preliminary survey*: this phase includes preliminary field activities to identify the type of ALDFG to be removed (and possibly its product category).

Phase 2. *Analysis of removal criticalities:* this is the evaluation of field collected data concerning the degree of ALDFG cohesion with the seabed. This preliminary evaluation helps to take due account of the potential impact of removal on animal and plant species included in the protection lists according to specific European directives.

Phase 3. *Field activities for safe and cost-effective ALDFG removal.*

Figure 6 – An example of ALDFG removal from the seabed.

	Education	Competencies	Qualifications / Licenses	Expertise
Marine biology expert	· Master's degree in Marine Biology, Environmental sciences with a focus on marine issues, Natural sciences with a focus on marine issues	· Knowledge of EU directives for the protection of habitats and organisms · Competencies in taxonomy · Knowledge of fishing nets and gears	· Certified commercial diver qualification - recommended · Recreational diving qualification – Advanced level · Recreational boat licence within 12 miles · First aid course	· Knowledge of non-destructive underwater census techniques (UVC and photographic monitoring) · Problem-solving and decision skills
Diver	· Certified commercial diver qualification · Marine biology diver course	· Ability to distinguish fishing gears and marine organisms · Knowledge of underwater photographic techniques · Use of lifting balloons	· Registration in the Divers' Register at the Harbour Master office · Recreational boat licence within 12 miles · First aid course	· Problem-solving and decision skills during removal · Physical strength
Acoustic data acquisition operator	· Master's degree in Environmental sciences, Biology, Natural sciences, Geology, Engineering	· Skills at analysing echograms and sonograms	· Recreational boat licence within 12 miles	· Open-minded attitude to learn and use acoustic data acquisition systems
Navigation master		· Skills and experience in the management of diving campaigns · Knowledge of the territory (tides, evolution of weather conditions, currents, dangers, etc.)	· Certified Motor Boat Pilot at the Harbour Master office · Recreational boat licence · Recreational diving qualification – Advanced level · First aid course · Fire prevention course	

Table 1 - Specific requirements to be met by professional involved in ALDFG monitoring and removal activities.

ALDFG detection and removal activities (Figure 6) must be conducted by a team of professionals having the necessary technical qualifications (Table 1) and operating with the basic equipment described in Table 2. The number of professional divers can vary between 2 and 4, depending on the working depth and sea conditions.

The equipment listed in Table 2 and the relevant conditions of use have been selected on the basis of technical and economic considerations, always considering the need to take action and ensure maximum efficiency.

	Detection phase	Removal phase
Vessel	Type-approved for operations within 12 miles; type-approved for transport of at least 6 people; high cruising speed; 220/230V power supply; winch to drop or lift acoustic equipment; wide transom for handling acoustic equipment, divers' team and the relevant equipment; echo-sounder; GPS; VHF.	Type-approved for operations within 12 miles; type-approved for transport of at least 8 people; high cruising speed; 220/230V power supply; winch to lift ALDFG of bigger size; spaces available for divers' team and their equipment, for piling up ALDFG; echo-sounder; GPS; VHF.
Equipment	HRSS (sonar head, interface, cables); tripod for HRSS positioning; PC for HRSS data acquisition and processing; buoys to signal ALDFG of bigger size; net bags to collect ALDFG samples; ropes; digital cameras; action cam; full diving equipment.	HRSS (optional, to guide divers); lifting balloons; ropes; clippers/scissors; net bags to collect small ALDFG; maps of surveyed areas; mask with communicator; surface communicator for certified commercial divers; full diving equipment.

Table 2 – Necessary equipment for ALDFG monitoring and removal activities.

Phase 1: Preliminary survey

Like any other seabed cleaning operation to remove waste from fishing and human activities, ghost net removal activities must be preceded by a site survey. It should be noted that such cleaning activities do not fall within regular seabed cleaning activities scheduled in several European seas; rather, they are *ad hoc* activities undertaken following direct report from law enforcement authorities, fishermen, divers or citizens using the marine environment for recreational purposes. In this case, adequate and purpose-effective information must be supplied to the team of technicians entrusted with removal activities. Functionally relevant information for removal activities is, indeed, necessary to properly evaluate the extension of the affected area and the environmental conditions of the site.

Table 3 briefly summarises the necessary information to be preliminarily collected. Figure 7 schematically represents the algorithm leading to the subsequent survey phase.

Basic questions to be answered
How, when and by whom has ALDFG been spotted?
Where is it located (GPS and DATUM exact position)?
What is the operational depth / Is the gear half protruding or visible from the surface?
Provide a summary description of the ALDFG type
What are the residual dangers (obstacles to navigation and diving activities)?
Is there regular maritime / recreational boat traffic?
Is the area populated by habitats or species included in protection lists?
Are there tide currents or other dangerous diving conditions?

Table 3 - Necessary information before undertaking ALDFG site survey activities.

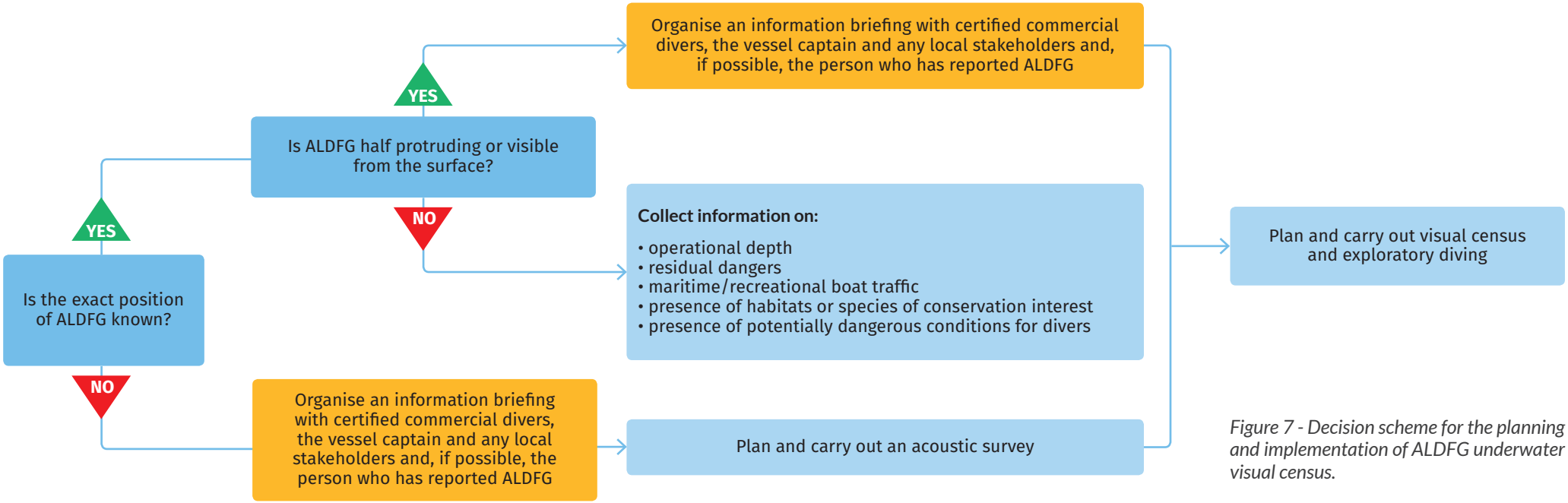


Figure 7 - Decision scheme for the planning and implementation of ALDFG underwater visual census.

Acoustic survey

It is advisable to carry out an acoustic survey before starting diving operations with qualified staff, should that be required by specific conditions (e.g. muddy or deep water, partial knowledge of seabed morphology, mapping for a new survey). The acoustic survey shall be carried out with a suitably equipped vessel having all the necessary equipment on board to provide a plan image of the removal area.
Modern side-imaging technology is currently available for a wide range of echo-sounders, including less expensive ones. These tools produce and save a digital copy of maps showing the seabed structure, and sometimes they can acoustically detect ALDFG to be removed. More sophisticated equipment like the HRSS (High Resolution Scanning Sonar) will further produce precise and detailed profiles of the survey sites and identify all variations resulting from anthropic structures (Figure 8).

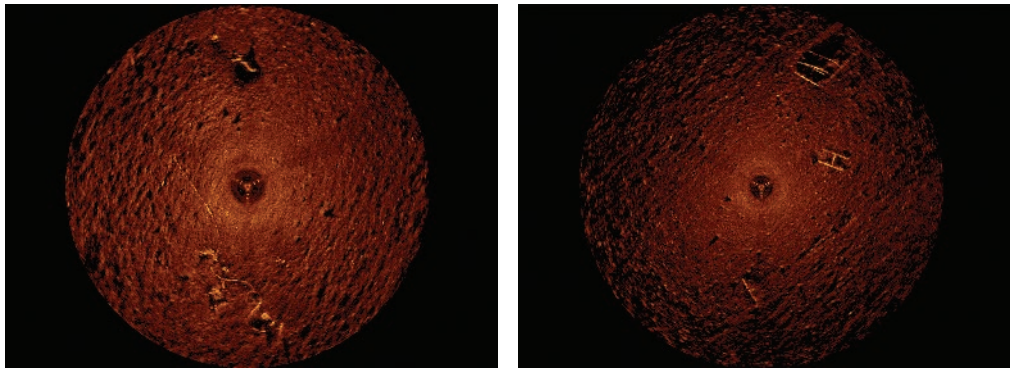


Figure 8 - Examples of HRSS data acquisitions to detect anthropic structures on the seabed.

The availability of a map locating "hotspots" (rocky tips, particularly clear bottom shapes, submerged phanerogam seagrass beds, anthropic objects etc.) provides a good starting point to the certified commercial diver charged with the removal during diving and subsequent operations, especially in conditions of reduced visibility.

The acoustic survey campaign must take place under stable sea and weather conditions. After reaching the approximate diving site, preliminary patrolling activities can be conducted with a side imaging/side view echo-sounder to minimise the duration of intervention. A rectangular or spiral-shaped grid patrolling scheme will be followed depending on craft manoeuvrability (Figure 9), so as to cover a wide surface of the area where ALDFG is presumably located, and to produce a low-definition map of the area itself. If HRSS equipment is also available, a grid of anchor points shall be prepared in advance from which acoustic surveys can be conducted. On each grid point, the sonar head shall be lowered with a winch, after being installed on a tripod ensuring proper emplacement on the seabed and shock protection. The modular tripod also maintains the sonar head perpendicularly against the seabed, while at the same time allowing the rotating head to spin around its axis and on a plane parallel to the seabed, thus delivering a plan image of a circular seabed area around the HRSS equipment.

Sonar setting modes and operational procedures implemented for field surveys shall remain unchanged for the whole sequence of plotting points on the survey grid, according to the following instructions:

- use an operational distance of 100 m in radius around the sonar position;
- if no outcrop / structure / ALDFG is detected within a 100 m radius, lift the equipment and place the vessel on the following spot to monitor;
- if an outcrop / structure / ALDFG is detected, lower the equipment several times at close distance (the distance between the lowering points shall not exceed 50-60 m between them) in the area surrounding the first surveyed spot, in order to "shed light" on the structure from all angles and subsequently facilitate its digital imaging.

For each surveyed point, at least one image acquisition shall be obtained corresponding to seabed scanning within a radius of 100 m from the sonar position. If the equipment has been placed near the outcrop / structure / ALDFG, images shall also be acquired with a lower radius (10 – 30 m), in order to scan the detected object with more details.

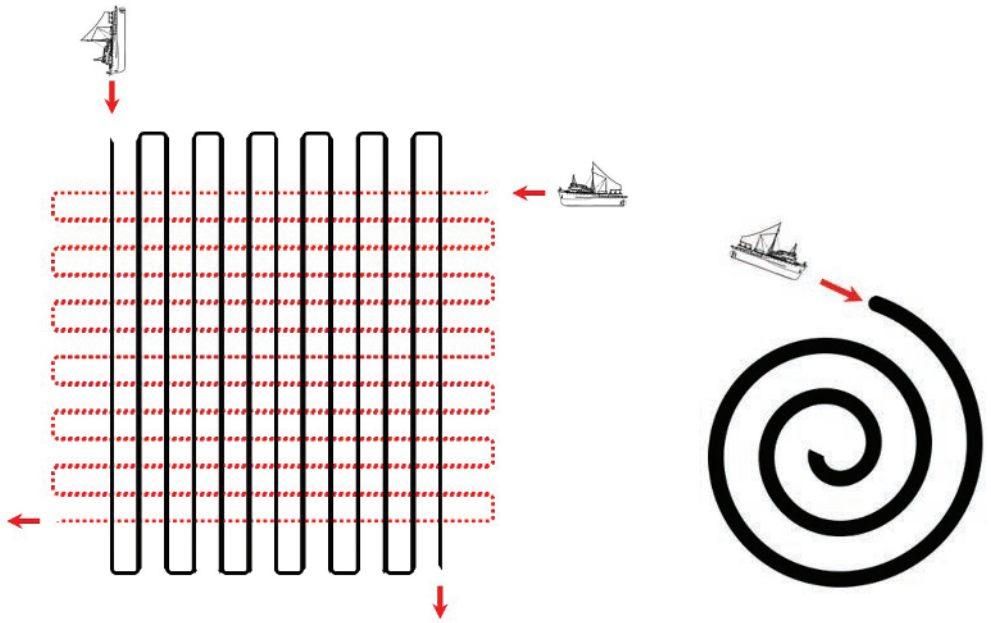


Figure 9 - Examples of directions to follow for the acquisition of acoustic images tracing the seabed plan.

Each acquisition must be associated with the GPS position of the craft during echo-sounding operations (preferably with WGS-84 datum). At the end of the acoustic survey, the team will be able to use a GIS plan image of the surveyed site, highlighting any existing anomalous or clearly anthropic structures (Figure 10). This map will be the starting point for the subsequent exploratory diving phase.

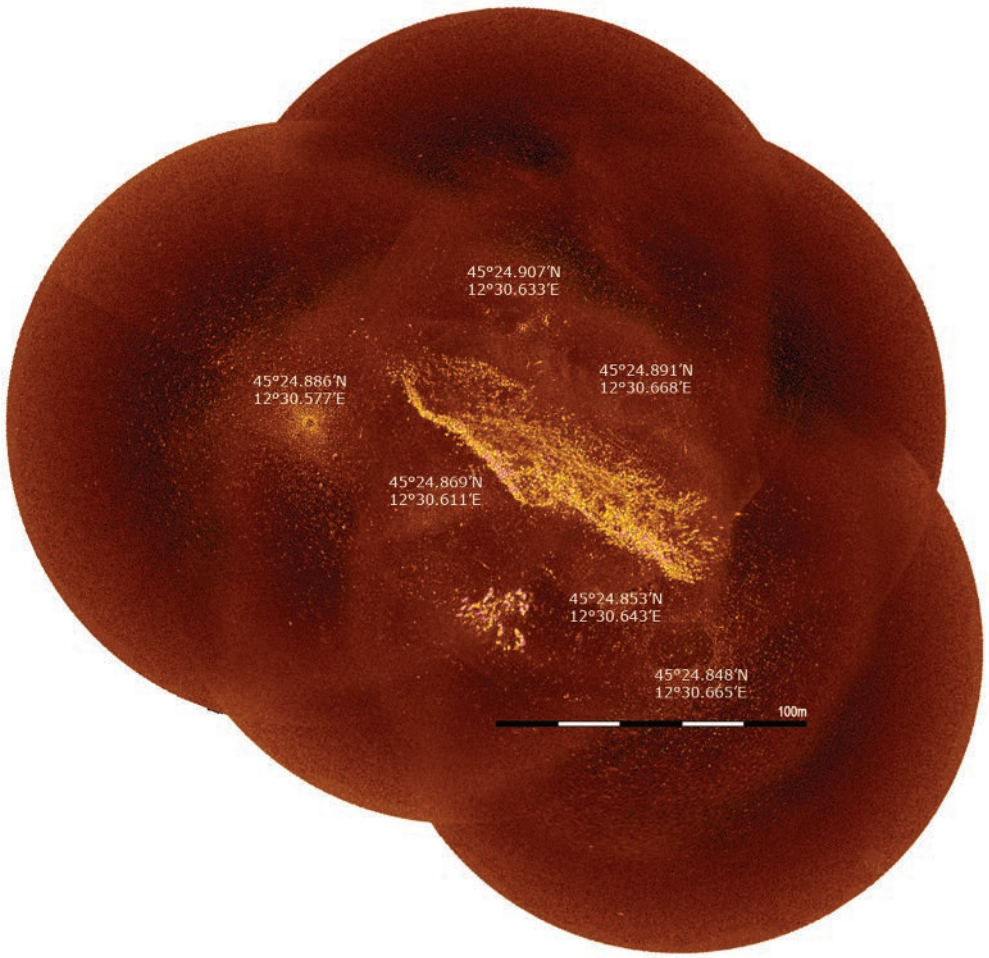


Figure 10 – Plan image of a surveyed area within the LIFE-GHOST project.

Visual survey

The dual aim of diving activities is to spot and identify existing ALDFG, assess their degree of entanglement and consequent removability, as well as make sure that removal will not entail risks for some species or habitats.

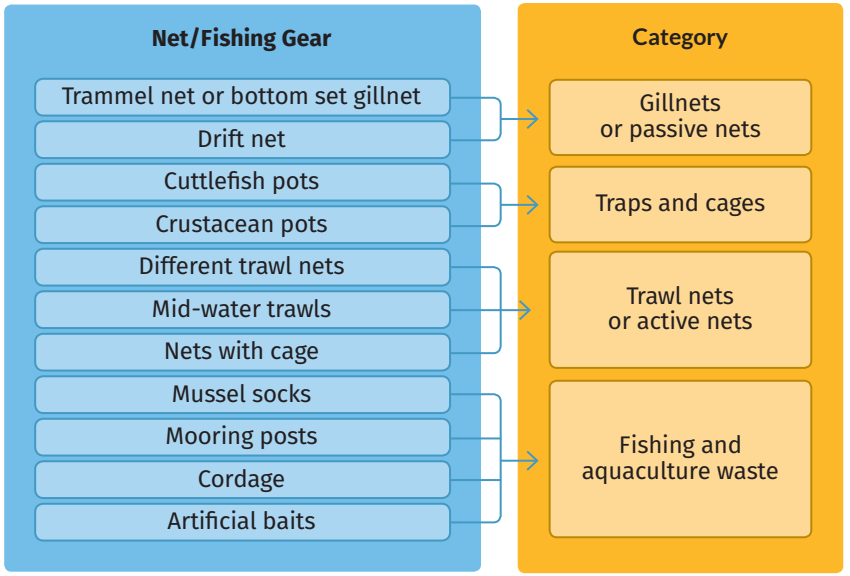
A marine biology expert shall assist the diving team and accompany certified commercial divers during diving activities, in order to contribute to a realistic assessment of any protected and/or particularly interesting habitats or species living in the area.

Diving activities shall be carried out in full compliance with the rules governing professional diving, as set forth in the decrees by the local harbour master operating in the surveyed territory.

The following schemes (Figure 11) can help operators properly evaluate the type of ALDFG to be removed and estimate technical difficulties during removal. Moreover, the identification of the specific type of fishing gear will provide valuable information on its construction materials.

In-situ identification can be subsequently confirmed by the analysis of any photographic and video material. ALDFG position shall be reported as precisely as possible on the maps previously drawn by means of echo sounding.

Certified commercial divers will also collect information on the predominant wildlife in the surveyed area. The presence of species or habitats included in protection directives will provide clues on the actual feasibility of removal. Table 4 lists a few relatively common species that can be spotted in the Mediterranean Sea related to the depth limits considered in this manual.



Net/Fishing Gear	Plastic materials	Lead/tin	Iron/ steel	Concrete
Trammel net or bottom set gillnet	X	X		
Drift net	X			
Cuttlefish pots	X			
Crustacean pots	X			
Trawl nets	X	X		
Mid-water trawls	X	X		
Nets with cage	X		X	
Mussel socks	X			
Mooring posts		X	X	X
Cordage	X			
Artificial baits	X	X		

Figure 11 – Visual survey. A scheme to identify the type of fishing gear / net, classification in four categories and identification of construction materials.

Scientific name	Common name	Protection directive
Hippospongia communis	Honey comb	Annex III ASPIM[a]; Bern app. III[b]
Hommarus gammarus	Common lobster	Annex II ASPIM[c]; Bern app. III;
Lithophaga lithophaga	Date shell	Annex II ASPIM; Bern app. II[d]; Habitat app IV[e]
Maja squinado	Spiny spider crab	Annex II ASPIM; Bern app. III
Paracentrotus lividus	Sea urchin	Annex III ASPIM
Pholas dactylus	Common piddock	Annex II ASPIM; Bern app. II
Pinna nobilis	Noble pen shell	Annex II ASPIM; Habitat app IV
Spongia officinalis	Bath sponge	Annex III ASPIM; Bern app. III
Tethya aurantium	Orange puffball sponge	Annex II ASPIM
Tethya citrina	Sea lemon	Annex II ASPIM

[a] *SPAMI Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean included in the Barcelona Convention. Appendix 3: "List of species whose exploitation is regulated".*

[b] *Bern Convention on the Conservation of European Wildlife and Natural Habitats. Annex III "Protected fauna species".*

[c] *SPAMI Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean included in the Barcelona Convention. Appendix 2 "List of endangered or threatened species".*

[d] *Bern Convention on the Conservation of European Wildlife and Natural Habitats. Annex II "Strictly protected fauna species".*

[e] *92/43/EEC Habitats Directive on the conservation of natural and semi-natural habitats of wild fauna and flora. Annex IV "Animal and plant species of community interest in need of strict protection".*

Table 4 - List of species included in protection directives and commonly found in the Mediterranean Sea at the depth of described actions.

Phase 2: Analysis of removal criticalities

ALDFG removal must be carried out only if resulting environmental benefits exceed the disturbance or damage inevitably caused during removal operations, and only if operations can be performed in a safe and cost-effective way.

The first critical point to be considered is the degree of ALDFG cohesion with the seabed. Reference can be made to a useful five-level classification which is summarised in Figure 12:

- lying/resting on the seabed,
- entangled without encrusting organisms,
- entangled with encrusting organisms,
- partially silted up/covered with sand,
- fully silted up.

Along with the characteristics observed in Phase 1, this analysis will provide further valuable information on the opportunity of removal, whose convenience will be determined on the basis of additional considerations listed as follows:

Environmental benefits that can be obtained from removal can be verified at least from a qualitative point of view

The removal of synthetic materials of anthropic origin or inert materials from the natural environment produces at least two benefits for the ecosystem: it eliminates a pollution source and increases the available surface for habitats following removal activities on parts of the seabed. However, specific conditions such as

- protected species or habitats living and developing in areas close to or in contact with ALDFG,
- polluting substances that would be raised and remain suspended by ALDFG removal,
- critical conditions for the natural environment (port areas, shipwrecks, dumping sites),

might annul the benefits of ALDFG removal by making it useless or unrealistic. In such cases it is advisable to relinquish removal activities.

Removal activities do not jeopardise the protection of marine organisms and habitats

As previously mentioned parts of ALDFG, especially if they have been abandoned on the seabed for a long time, might have been colonised by several species of marine organisms, some of which could be included in protection lists (e.g. 92/43/EEC Habitats Directive, Bern Convention, SPAMI Protocol). Moreover, ALDFG could be strongly anchored to the rocky seabed depending on their type, permanence on the seabed and construction materials. Also in these cases it is better to relinquish removal activities.

Total safety conditions for divers

ALDFG removal, especially if they are big in size and entangled on the seabed, might become a very long and complicated operation for divers, even under the best environmental conditions (crystal clear waters, no fine sediments in the area concerned, acceptable water temperature). Divers' health protection is always a top priority, therefore ALDFG can only be removed if safety requirements are fully met.

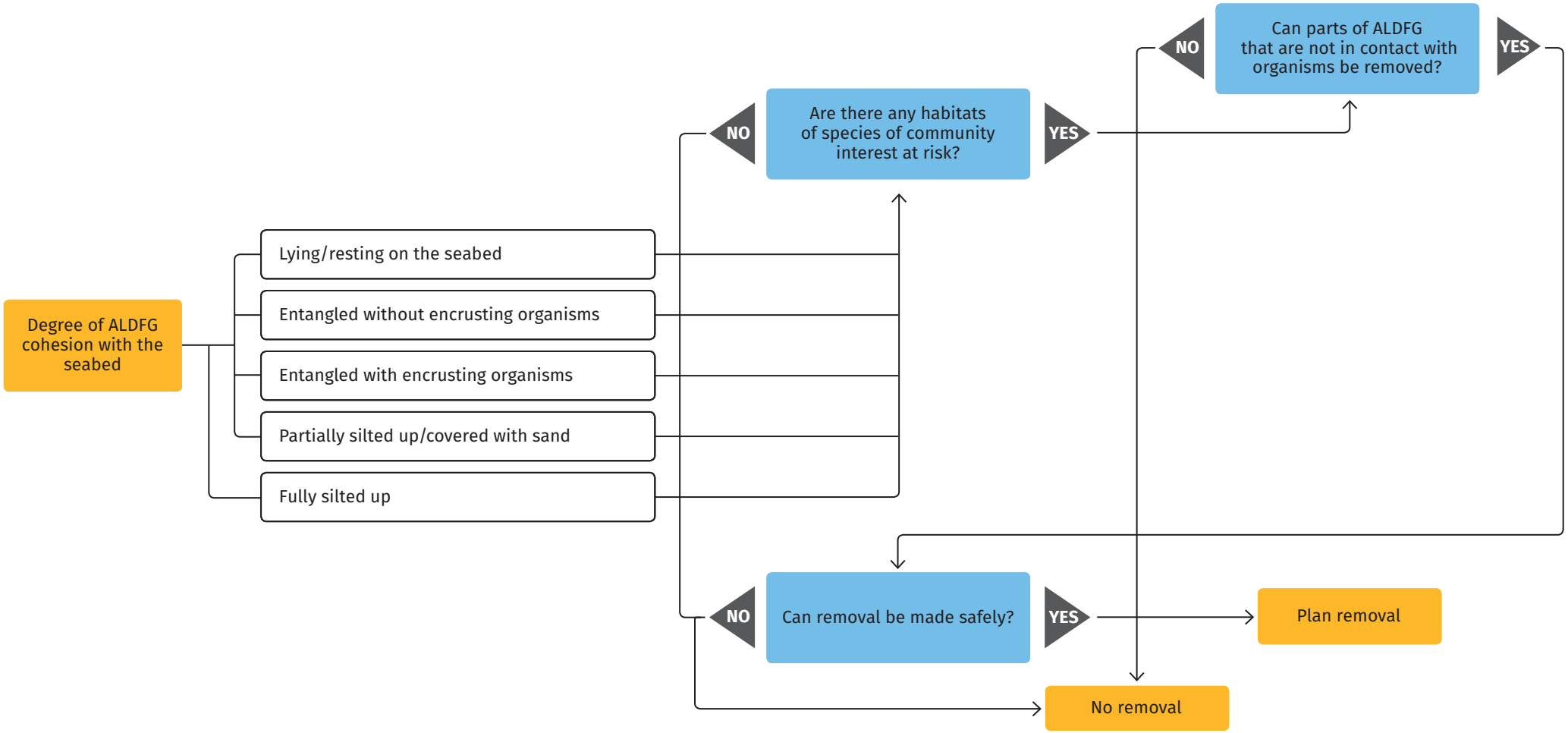


Figure 12 – Visual survey. Assessing the degree of entanglement of ALDFG detected on the seabed.

Phase 3: Field activities for ALDFG removal: case studies

Once all the preliminary detection phases have been completed as mentioned above, small ALDFG or parts thereof can be removed even by just a couple of professional divers, if sea and weather conditions permit. The team will operate in the best conditions, having already acquired all basic information on ALDFG to be removed and on the ecosystem, such as the type, size, location, degree of entanglement and the presence of species of particular interest.

A few practical examples of removal operations carried out within the LIFE-GHOST project are provided for further clarity and to give an overview of different operational strategies, always in full compliance with the general criteria above.

Case 1 - Figure 13 provides the example of an ALDFG to be removed, i.e. a mooring post which was probably used to anchor a bottom-set gillnet. The visual census established that it was an inert material made of concrete (cast into the bottom of a 1.5 l plastic bottle), into which an iron ring was plunged and used to tie a rope. The mooring post lay on the seabed, without encrusting organisms.

Removal operations were very easy and did not require any particular precautions. The mooring post was removed and placed into a special collecting bag to be delivered to the boat after diving.

Case 2 - Figure 14 provides a different example of a large part of bottom trawl to be removed, on which several encrusting organisms had grown. Due to the considerable net size, it was virtually impossible to handle and remove it in one single step or by just a couple of divers. Moreover, the site was populated with big-size organisms there were interesting for recreational diving.

In order to remove the bottom trawl, the diver had to cut the net into small portions of about 1 m^2 each so that it would be easier to remove. The net was cut precisely near the encrusting organisms to avoid any damage and to remove as much net as possible.

Case 3 - Figure 15 concerns the removal of a *rapido* net, i.e. a fishing gear of considerable size consisting of a rectangular metal structure about 3.5 metres long and weighing over 400 kg, on which a bag net is fixed.

Given the limited residual danger of the frame and the large number of encrusting organisms, only the net was removed as it was a source of plastic pollutants. Removal was made by cutting the net into small portions of about 1 m^2, which were subsequently brought back to the surface in special collecting bags.

At the end of diving, a data collection sheet should be filled in with the general information on the location and detailed information on the recovered ALDFG. Two different data collection sheets have been developed within the LIFE-GHOST project, as shown below: a more general one in the form of a questionnaire with photographic materials to help less-experienced divers recognise the type of ALDFG; and a "DATA COLLECTION SHEET on ghost nets and fishing gears" with all necessary information to use knowledge at a national level and internationally available databases. Initiatives and partnerships have been developed at international level to find a long-lasting solution to the problem of ALDFG, and to define the most sustainable and economically viable solutions. In this context, guidelines have been established to describe and quantify the problem more thoroughly, and to collect data on materials and equipment recovered from the seabed consistently by means of data sheets promoting the exchange of information about locally detected ALDFG.

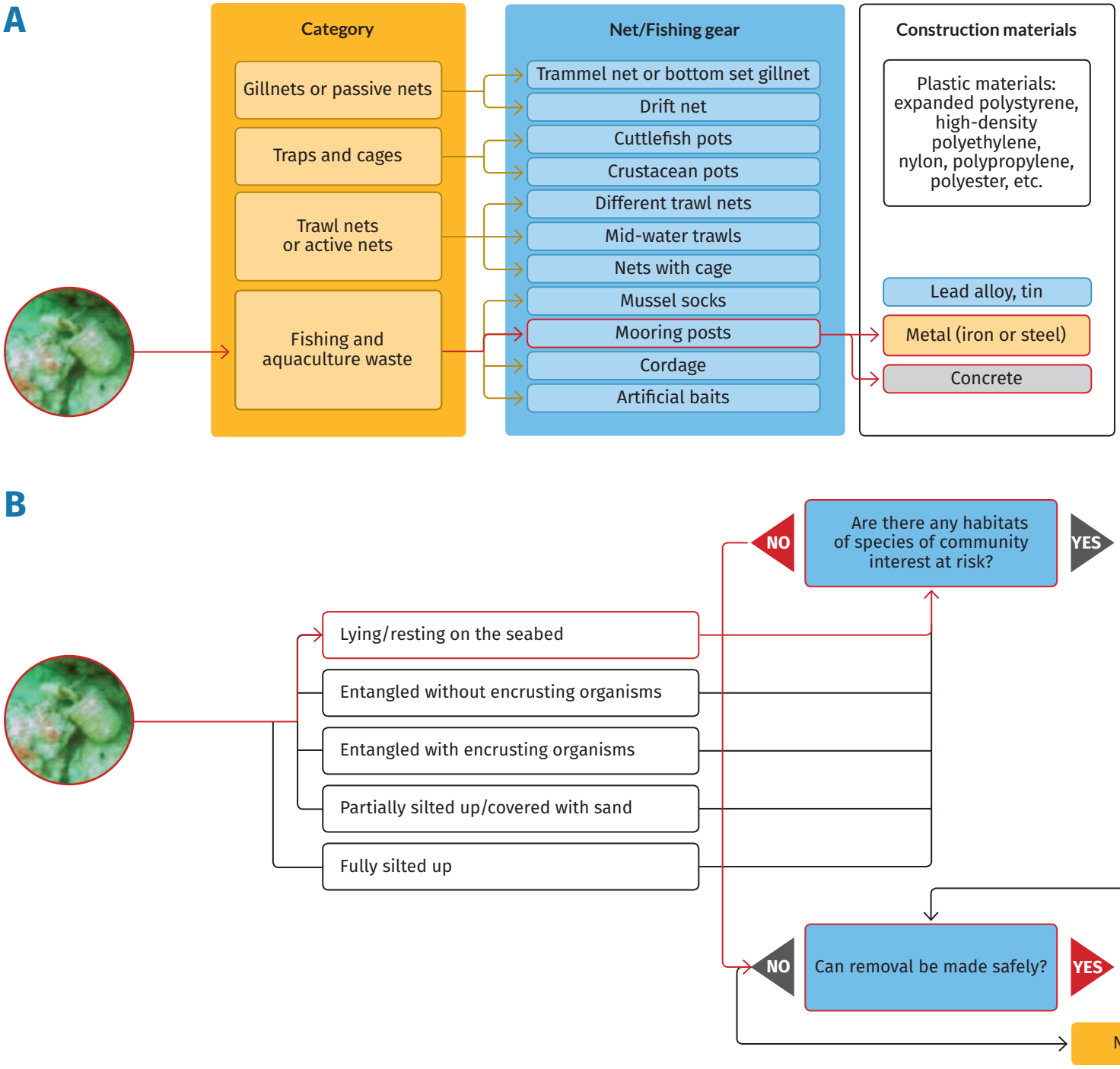


Figure 13 – Assessing the removability of a small ALDFG, i.e. a mooring post.
A) Type of construction materials;
B) Evaluation of the degree of entanglement.

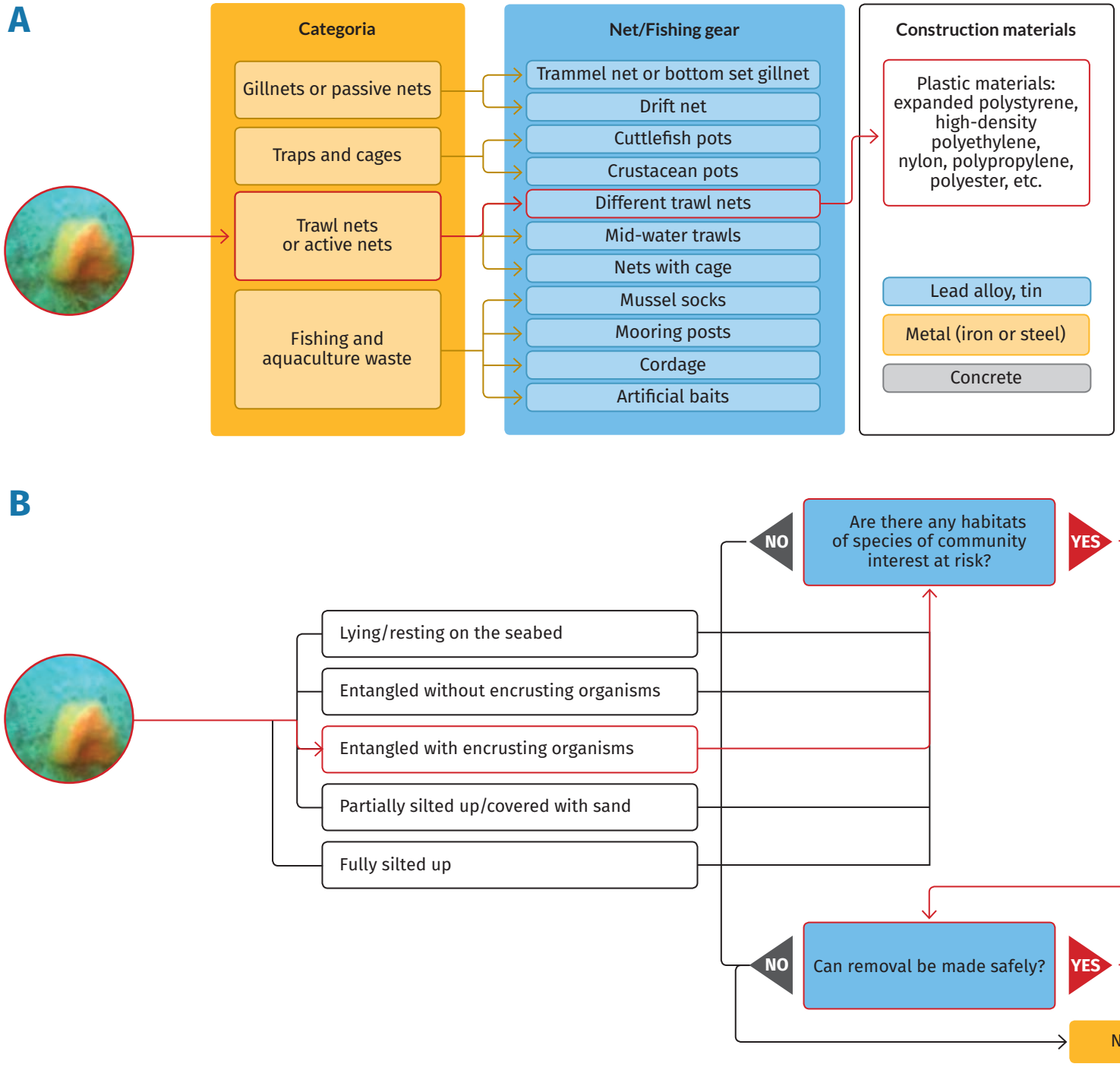


Figure 14 - Assessing the removability of a small ALDFG, i.e. part of a bottom trawl.
A) Type of construction materials;
B) Evaluation of the degree of entanglement.

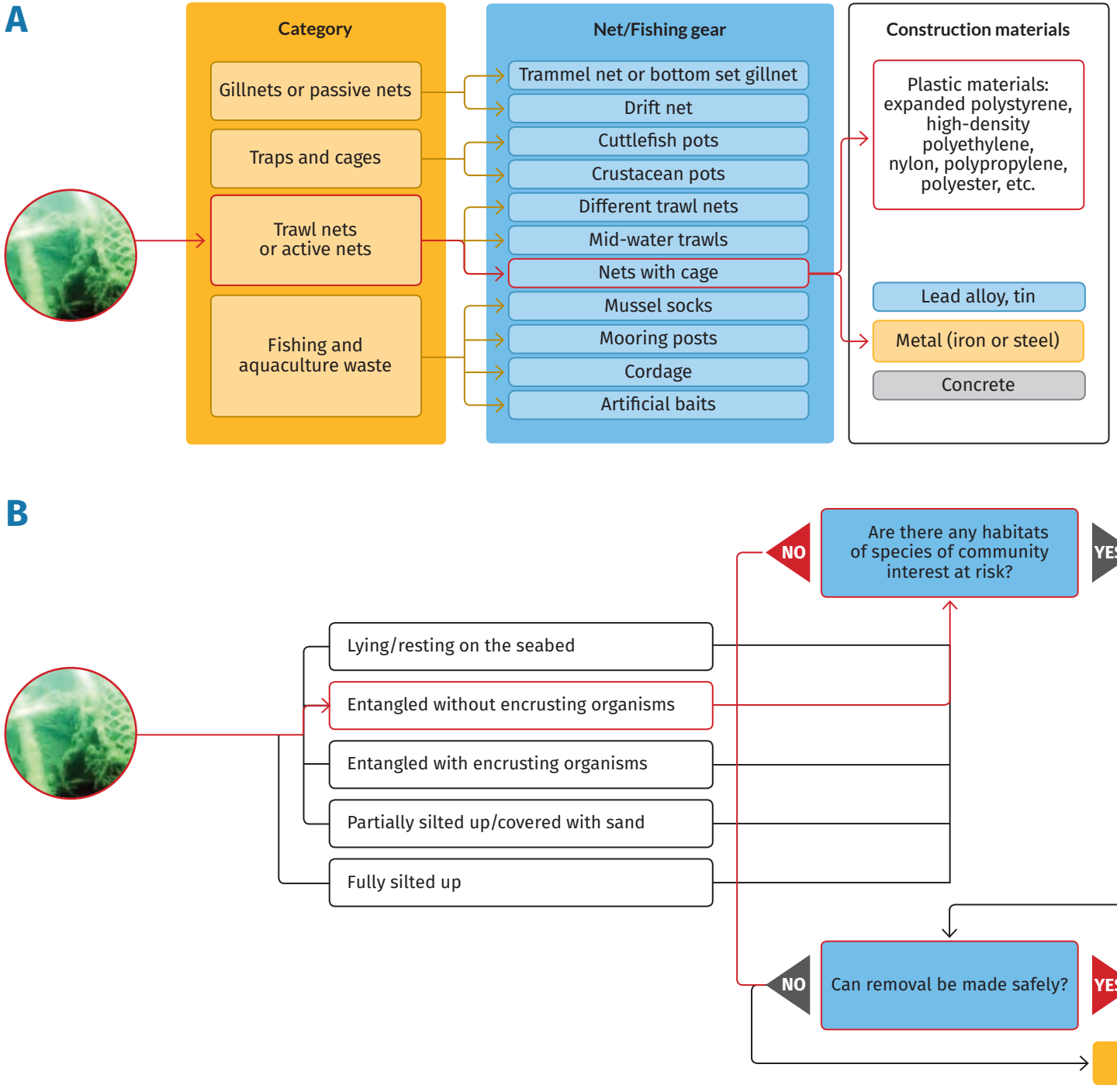
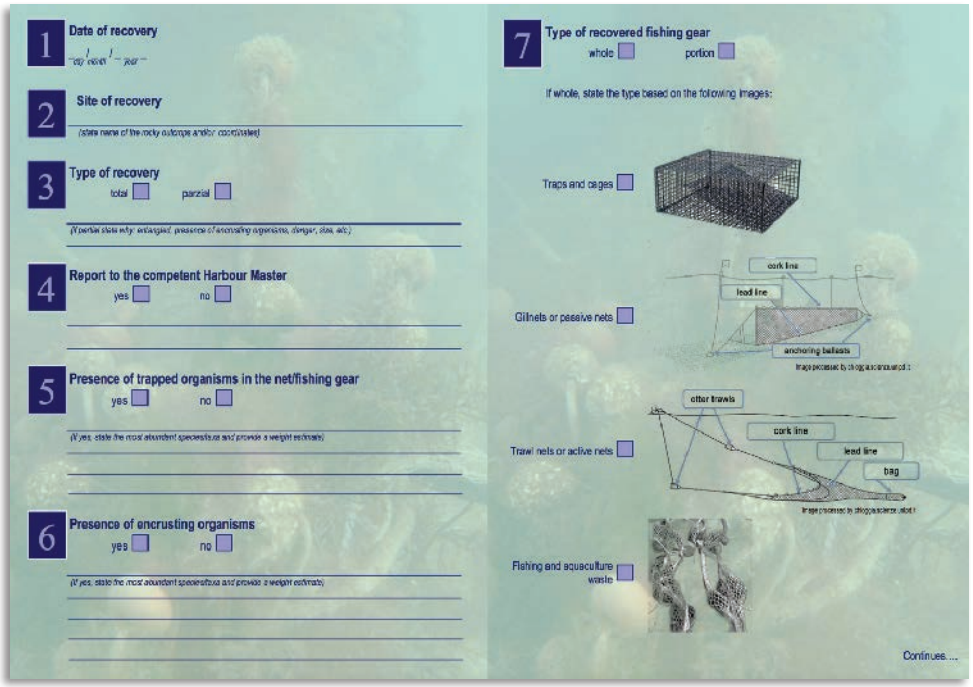


Figure 15 - Assessing the removability of a big-size ALDFG, i.e. an entangled rapido net.
A) Type of construction materials;
B) Evaluation of the degree of entanglement.



GHOST

TECHNIQUES TO REDUCE THE IMPACT OF GHOST FISHING GEARS AND TO IMPROVE BIODIVERSITY IN NORTH ADRIATIC COASTAL AREAS

DATA COLLECTION SHEET on ghost nets and fishing gears

General information

Name and surname	
Organisation/Association	
Email address or telephone	
Date of detection	
Site of detection	
Site coordinates	
Depth	
Type of site	

Specific information

Type of fishing gear		
Gillnets or passive nets	Bottom set gillnet	
	Trammel net	
	Leadcore line	
Traps and cages	Trap/pot	
Trawl nets or active nets	Trawl net	
	Mid-water trawl	
Fishing and aquaculture waste	Mussel sock	
	Rope or wire anchor	
	Mooring post	
	Metal frame	
	Sheath	
	Metal braid	

Degree of entanglement on the seabed

Lying/resting on the seabed	
Entangled without encrusting organisms	
Entangled with encrusting organisms	
Partially silted up/covered with sand	
Fully silted up	

Dry weight of the fishing gear/net _____

Size of the fishing gear/net _____

Other information

Fishing net colour _____

Are there any trapped animals? NO ☐ YES ☐

If so, how many and which ones (if recognisable) _____

Are there any photographs of the net/fishing gear? NO ☐ YES ☐

Other comments or information _____

_____

OPERATING INSTRUCTIONS TO MANAGE FISHING AND AQUACULTURE EQUIPMENT

This chapter provides operational instructions for the implementation of a management system for End-of-Life (EoL) fishing gears. EoL management is a delicate phase concerning both transition to a new product if possible, by reducing interruptions and service shortcomings as much as possible, and the elimination of the existing product through sustainable disposal operations complying with the existing regulations.

The new European Union guidelines are targeted towards promoting a circular approach to the product life-cycle, also known as "circular economy model" where the best available technologies are used in each phase of a product "life", from design up to the end of life. In this latter stage, attention is increasingly focused on the possibility of re-using and recycling materials. By abandoning the old traditional "take-make-waste" concept with all its negative connotations, materials are turned into new resources to be re-used in the production cycle. Therefore, waste management plays a fundamental role in this context as it decides how the EU waste hierarchy is implemented (Figure 16). By encouraging practices generating the best environmental-friendly results, waste hierarchy establishes an order of priority and ranks prevention first, followed by preparation for reuse, recycling, energy recovery and, last of all, disposal.

According to the European Commission, *a number of sectors face specific challenges in the context of the circular economy, because of the specificities of their products or value-chains, their environmental footprint or dependency on material from outside Europe. These sectors need to be addressed in a targeted way, to ensure that the interactions between the various*

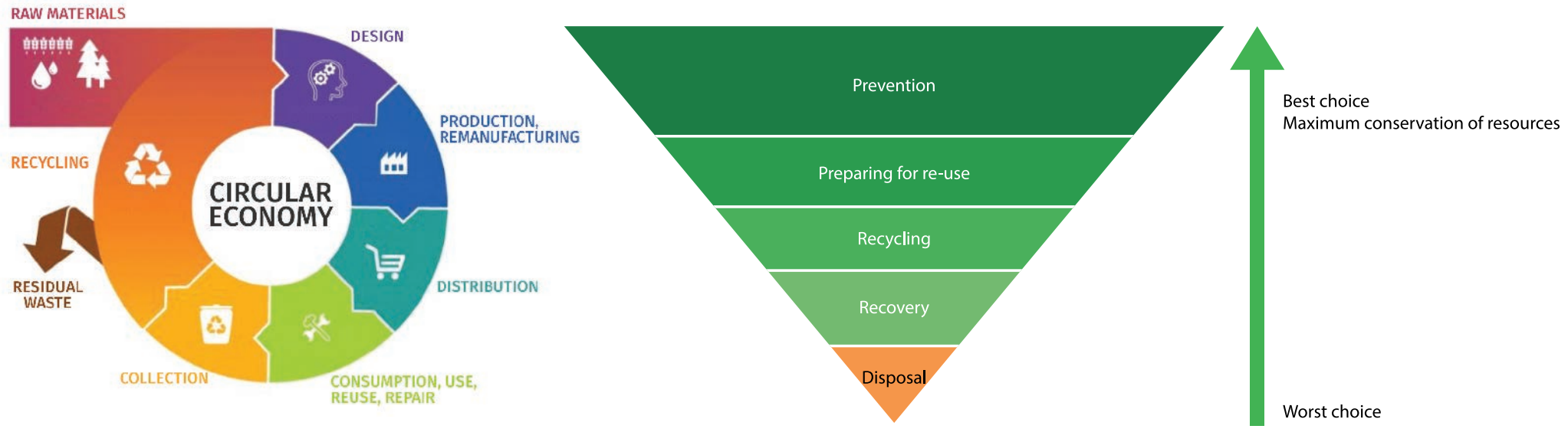


Figure 16 –Circular economy model (Source: European Parliament – Circular economy: how to use recycled products and materials) and waste hierarchy (Source: ENEA).

phases of the cycle are fully taken into account along the whole value chain (COM(2015) 614 final). Among these sectors, mention must be made of plastics constantly and increasingly used in the European Union, whereas plastic recycling still lies below 25%. *The Commission will prepare a strategy addressing the challenges posed by plastics throughout the value chain and taking into account their entire life-cycle. It will also take action to fulfil the objective of significantly reducing marine litter* (COM(2015) 614 final).

As already pointed out in the previous paragraphs, abandoned fishing gear represents a considerable percentage of marine litter. This practice is caused by the lack of infrastructures, the lack of a standard interpretation of the rules, improper attitudes or misconduct and the scarce knowledge of the available technological potential.
The following paragraphs provide a summary of the results obtained from literature and experimentation within the project and focus, in particular, on the rules governing the various steps of the management process, an overview of existing state-of-the-art technologies for plastic recovery and international best practices, as well as feedback from interaction with stakeholders of local fishing ports.

Activities carried out within the project have been aimed at identifying possible local alternatives to the current management (or non-management) model that could reduce landfilling practices or dumping at sea in line with waste hierarchy requirements. Please note that the following instructions identify management procedures only for the recovery of the plastic parts of fishing gears, i.e. the most significant and impacting portion within the wider category of fishing waste. Other materials making up the fishing gears are usually recovered by fishermen during routine maintenance activities.
As already stated in the previous chapters, the model developed for equipment abandoned on seabeds perfectly meets the requirements for dealing with equipment discarded by fishermen and aquaculture farmers or confiscated by law enforcement authorities.

[1] *This strategy will include a follow-up to the Green paper on a European strategy for plastic waste (COM/2013/0123 final).*

[2] *The European Commission, in its communication "Towards a circular economy, a zero waste programme for Europe" has proposed an aspirational target of "reducing marine litter by 30 % by 2020 for the ten most common types of litter found on beaches, as well as for fishing gear found at sea, with the list adapted to each of the four marine regions in the EU" (COM(2014)398).*

Criteria to define a management system of fishing gears and aquaculture equipment

When defining a system conceptual model, the following general information shall be collected in the preliminary phase in order to schedule all phases and optimise costs:

a) identify local fishermen and aquaculture farmers, organisational models (e.g. how many cooperatives and fishermen operate in the area), what fishing techniques are used and how fishing vessels are organised, with particular reference to landing sites in ports and/or urban areas;

b) define the type and quantity of fishing gears annually discarded by fishermen and how often fishing equipment is replaced with new equipment, by conducting interviews and privileged talks with operators using different fishing methods;

c) calculate the quantity of fishing gears annually abandoned at sea, identifying causes and areas most significantly affected by this problem;

d) analyse the type of port areas involved in the activity (i.e. if they are mainly used for commercial, fishing or recreational purposes) and identify the authority in charge of the management process.

In particular, the estimated volume and/or weight of nets annually produced in a fishing port is one of the most important aspects to be considered in developing a waste delivery system and management process. Italy has no official nor consistent estimates on the quantity generated over time; therefore, it is virtually impossible to calculate the market value of these products based on fishermen's purchase registers. This is also due to the fact that often times nets are not replaced entirely, but rather fixed by mending torn parts, thus generating hardly traceable small scrap.

This preliminary information can be collected directly from local operators by conducting interviews and privileged talks with operators using different fishing techniques, following the instructions provided in the next chapter.

The next phase implies the application of the following criteria for the implementation of a local management system:
1) general legislative framework;
2) logistics and administrative aspects;

3) origin and product category of materials;
4) available recycling technologies and pre-treatment systems, if applied.

General legislative framework

This is the main reference legislative framework:

a) Legislative Decree No. 182 of 24 June 2003, implementing Directive No. 2000/59/EC on port reception facilities for ship-generated waste and cargo residues;
b) Consolidated Law on the Environment: specific rule for waste management as amended and supplemented (Legislative Decree No. 152 of 3 April 2006 part IV and Legislative Decree No. 205/2010);
c) The "Regional waste management plan", where applicable.

Logistics and administrative aspects

If no suitable delivery systems are in place in the port area (or near fishing boat mooring facilities), a suitable place shall be identified in order for fishermen to deliver their discarded fishing gears, or any fishing equipment recovered at sea by fishermen themselves or following seabed cleaning campaigns. In this case, the relevant authority in the landing site (Port authority, Maritime authority, Municipality, private firms) shall be contacted in order to agree on delivery operations.

The following delivery and subsequent collection methods shall be used, either in combination or alternatively:

a) permanent collection sites with clearly marked cases and containers for sorting materials of different size and type based on waste characteristics, the available space, expected quantities and scheduled collection frequency;

b) temporary collection sites with the same characteristics as in a) and often set up at certain times of the year (to be defined on the basis of agreements with fishermen depending on the seasonality of fishing activities);

c) on-call waste collection.

Methods a) and b) may envisage surveillance and control systems, either with barriers and fences and/or container locking systems, or with staff assistance in order to improve the compliance of delivered material with delivery rules and characteristics.
Method c) can be organised by scheduling intervention periods at specific times of the year when calls can be scheduled (with this option, waste producers may store waste temporarily until it can be collected).

As to the cost-benefit ratio the most cost-effective collection method for this type of waste is probably type b), providing for specific collection campaigns over limited time periods, and the presence of an operator controlling containers during daytime and locking them at night. This method certainly maximises the quality of collected material, as it rules out any uncontrolled delivery of other waste types. The quantitative aspect is more critical, as consultation with fishermen is absolutely necessary as well as promoting targeted communication initiatives to identify the most suitable periods, frequencies and duration of waste collection campaigns.
When choosing the land delivery site, its location with respect to the mooring areas of fishing boats is one of the most important aspects to consider. Consultations with fishermen highlighted the need for them to have a delivery site close to the landing and/or mooring area, in order to avoid long distances that might deter proper delivery operations. At the same time, the delivery site location should not be in conflict with food health and safety rules, thus avoiding landing and storing fish and waste in the same site.

Moreover, the waste delivery system must be chosen considering the restrictions concerning the temporary storage of waste in the same place where it is produced, pursuant to art. 183, par. 1 bb) of Legislative Decree No. 152/2006, whereby *"Waste shall be collected and prepared for recovery or disposal according to one of the following alternative methods chosen by the waste producer: collection regardless of stored quantities on at least a quarterly basis; collection every time the stored waste quantity totals 30 m^3, of which at least 10 m^3 are hazardous waste. In all cases, if the waste quantity does not exceed said limits at year end, the temporary storage area shall not last more than one year"*.

As for obligations in the phases following temporary storage (i.e. transport and beginning of pre-treatment and treatment operations), compliance with the provisions of Legislative Decree No. 152/2006 is a must.

Origin and product category of materials

An important aspect concerning delivery site management and administrative authorisations is related to the possible sorting of different fishing gear materials depending on their final use, maximising any possible recovery and reducing treatment costs as much as possible. This phase shall possibly envisage disassembly operations before delivery, for example by sorting ropes, metal parts, floaters etc. It must be noted that fishermen often do it by themselves (without being forced by external rules), as by sorting materials they can recover and reuse components that are easy to separate and valuable (e.g. leads). However, the convenience of separating materials in the delivery site or sending them to a treatment plant for subsequent sorting activities remains to be established on a case-by-case basis.

The phase leading to the identification of the best management methods must envisage the following operational steps:

a) Sorting of materials and weighing. Nets delivered or recovered from the seabed are often equipped with specific accessories ensuring the best possible performance (cordage, leaded ropes, floaters, leads, cables or other entangled waste). This is why disassembly operations must be completed to obtain samples of homogeneous material: the specific materials are sorted by using specific tools (scissors, clippers, knives, etc.).

b) Visual analysis of the degree of wear and tear and encrustations on the nets. This phase is crucial for determining preliminary treatment before recycling operations. Indeed, the presence of organisms or parts thereof requires specific washing operations.

c) Identification of polymers making up plastic parts. Fishing nets are often produced with different polymers, sometimes with a single polymer filament, sometimes with a mixture of polymers. Nets are most commonly produced by using polyethylene (PE), polyamides (PA) and polypropylene (PP). The chemical composition analysis of nets is extremely important to identify the most suitable recycling process and all possible industrial stakeholders to be involved. Polymer characterisation can be quickly determined by using a portable spectrometer which determines the prevailing polymer, but does not provide information on the possible presence of other substances. This latter information can be obtained only by resorting to specialised laboratories.

d) Mechanical analysis to identify specific contaminants. The legislation requires that specific chemical and physical properties be investigated to identify the possible presence of contaminants such as heavy or organic metals. The need to perform further chemical in-depth analyses shall be assessed on a case-by-case basis, depending on the origin and destination of materials.

Available recycling technologies and pre-treatment systems, if applied

The last phase of the plastic material management process shall refer to the already mentioned waste hierarchy, thus giving priority to more effective environmentally-friendly methods and according to the following priority order: reuse, recycle and landfill.

The first option is mechanical recycling for second raw material production. The possibility to implement this treatment will depend on the following factors: a) the type of available materials (PP, PE, PA polymer, either monofilament or multifilament); b) available quantities; c) the degree of cleanliness; d) costs related to any necessary pre-treatment; e) the availability of local treatment plants. Should there be a considerable number of encrusting organisms preventing access to the mechanical recycling phase, further pre-treatment operations will be necessary with a preliminary cleaning of the nets. Experiments have been made during the project to define the most effective procedure, which can be summarized in the following treatments: 1) soaking in water; 2) first washing cycle with slightly acid detergent at a temperature of 40°C – 60°C; 3) second washing cycle with water and ultrasound.

The system developed during experiments minimises water consumption and waste to be disposed of (washing water), thanks to the filtering of organic residues removed from the nets and to a water recycling system; both factors are environmentally and economically important.

Several initiatives are implemented by companies and non-profit organisations at a global level aimed at recycling fishing nets to obtain new products of different types for human use. A Europe-wide well-consolidated production chain is the recycling of nylon (PA) nets; Aquafil (www.aquafil.com) is the European leading company in this sector. The Nofir group (http://nofir.no/#/home) and the company Plastix (www.plastixglobal.com) further provide other valuable examples. However, the decision to use these services should be carefully considered in the light of the economic and environmental efficiency of the whole process. From an environmental perspective, preference should always be given to using local companies operating in plastic recycling.

Should mechanical recycling result to be too costly and burdensome in terms of organisation, the second option would be chosen, i.e. chemical recycling such as pyrolysis. In the pyrolytic process, waste is heated in the total absence of oxygen. The treated material is not burnt or reduced to ash, but undergoes thermal degradation to be transformed into materials whose chemical and physical properties differ from the original substance and are consequently more desirable. A multitude of scientific publications is available on pyrolysis applied to plastics, as their hydrocarbon structure allows to obtain oils whose characteristics are very similar to those of fuels. In 2009, UNEP defined plastic waste as “one of the most promising resources for fuel production because of its high heat of combustion and due to the increasing availability in local communities” and referred to pyrolysis as a transformation process. This option totally eliminates landfilling or incineration and promotes recycling to produce fuel or feedstock for the chemical industry, with a lower environmental impact compared to the mere energy recovery in an incinerator.

Pyrolysis also has other advantages: on the one hand, no pre-treatment of materials is required, which could jeopardise recycling cost effectiveness; on the other, the reaction itself is “conveyed” towards desirable products by using catalysers or additives.

As far as plastics are concerned, the yield is maximised into liquid hydrocarbons which, all other things being equal, are a better energy vector than gas or solid hydrocarbons because they are easy to transport (pumping) and store (tanks).

Chemical recycling plants have extremely variable efficiency rates depending on the level of technology used. In the most modern plants, the net energy performance in fuel (considering plant self-consumption) is around 50%, which means that about 50% of the incoming plastic energy is transformed into energy as fuel for sale, after deducting self-consumption quantities. In terms of mass, about 70% of plastic becomes oil and the remainder consists of gas and solid residues. Gas is usually reused in the process itself, whereas solid residues are disposed of or used as fuel in furnaces. This yield rate is definitely good, considering the pyrolysis process in itself and the qualitative potential of the products.

The input of fishing nets in such a chemical recycling plant does not have any disadvantages. Technically speaking, fishing nets can be easier to process than, for example, unsorted plastics with a higher degree of heterogeneity.

The development of this technology and its implementation are not yet evenly distributed in European countries; some operating plants already exist in Spain and Britain. In Italy, the implementation of this technology has essentially administrative constraints. Two companies are currently advocating for the construction of waste treatment facilities for fuel production: Sintol (www.sintol.it) and DEMONT (http://www.demont.it/).

Landfilling is by no means a priority for end-of-life fishing nets. However, due to (mainly) administrative and (to a lesser extent) technical constraints, this method must be considered as a preventive measure against dumping at sea. To date, it already provides some improvement with respect to cases of mismanagement or non-management of waste from fishing and aquaculture activities, which unfortunately occurred in Veneto and in Italy and inevitably led to dumping at sea or on the quay.

GUIDELINES TO RAISE AWARENESS AND ENGAGE FISHERMEN AND AQUACULTURE FARMERS

Promoting the participation and active involvement of fishermen and aquaculture farmers in the ALDFG management process is a necessary step not only for the long-term prevention of ALDFG practices, but also for adjusting and ensuring good performance in the recovery of fishing gears and discarded fishing nets. After all, fish producers are the main users and final beneficiaries of the system, from which they can obtain advantages for their business.

The planning and implementation of fishermen's involvement must draw inspiration from social inclusion methods, as suggested by the well-known techniques of "Stakeholder Engagement". This practice aims not only at raising awareness on the issues and the environmental impacts, but also at stimulating stakeholders' participation in the decision-making process. In so doing, not only can they contribute to the definition of operational solutions, but they also become more willing to use the newly implemented systems.

Generally speaking, "Stakeholder Engagement" requires the following steps to be taken by the party advocating dialogue:

a) an interactive and two-way communication process;
b) ongoing and participatory interaction to verify expectations and to define or review system implementation strategies;
c) willingness to integrate stakeholders' expectations in the system implementation strategy;
d) commitment to implement initiatives aimed at providing practical answers to the stakeholders involved.

Engagement activities must be duly planned, by defining the area of intervention and resources to be invested. The planning process shall follow the steps below:

Phase 1. define objectives;

Phase 2. identify a preferred interface to fine-tune messages and engagement strategies;

Phase 3. identify a timeline for engagement based on stakeholders' specific needs;

Phase 4. identify stakeholder engagement strategies.

Phase 1: Define objectives

A "Stakeholder Engagement" campaign can have several objectives, depending on the different types of expected reactions. With reference to ALDFG issues, stakeholder engagement has the following aims:

- to inform: the information process is a prerequisite for engagement. It does not only aim at transferring information and knowledge, but also at raising stakeholders' awareness to issue opinions;
- to educate, outreach and raise awareness: this is a fundamental objective in promoting ALDFG prevention and management measures. This should foster changes in conduct and lead to the implementation of sustainable practices in the long term;
- to involve in the decision-making process: this is not only intended to obtain useful data and information from stakeholders with a view to defining the specific recovery system to be implemented, but also to gather specific requests and understand the needs expressed by some of the main system users. Moreover, the introduction of a participatory process aimed at solving conflicts between stakeholders increases ownership of the system by them, which is therefore used more extensively and constructively.

Phase 2: Identify a preferred interface to fine-tune messages and engagement strategies

In order for the process to provide useful results, dialogue strategies need to be identified to ensure stakeholders' inclusions and representativeness. Based on the experience acquired in the LIFE-GHOST project, the stakeholders' engagement process in the fishing sector is clearly more effective if opinion leaders are involved, i.e.

individuals or associations representing several operators and trusted by the people. Opinion leaders usually disseminate knowledge and information in the ports and they are the driving force of the sector. As far as local fishing is concerned, opinion leaders are the representatives of trade associations and/or leading representatives of fishing cooperatives or producer organisations.

Dialogue with the opinion leaders is particularly important for the success of the engagement campaign. In order to start the proper engagement process in a port area, understanding the needs and expectations of that area is of the utmost importance. Therefore, focused and dedicated meetings must be organised to exchange views with the opinion leaders on issues to be tackled with fishing vessel operators, in order to jointly prepare the essential and practical arguments against any remarks and objections that might be raised.

From a methodological point of view, individual talks are particularly effective when one or two opinion leaders are present. The meeting should be held in a "safe" venue, i.e. a place where the interlocutor can freely express his/her opinion, and the necessary information on engagement planning activities should be collected in addition to organisational suggestions (when and where meetings should be organised, who should be invited, how to start the discussion, etc.).

Phase 3: Identify a timeline for engagement based on stakeholders' specific needs

Regardless of the engagement strategy, stakeholders must be enabled to understand the process and get involved considering their constraints in terms of resources (for example the time they can devote to the process in terms of hours and weekdays) as well as specific requests. It is therefore advisable to organise engagement activities at certain times of the day and/or the week when fishermen are not working, and schedule meetings providing adequate time for questions and comments by participants.

Phase 4: Identify stakeholder engagement strategies

In order to focus on stakeholder engagement as much as possible, engagement tools and methodologies should pursue several objectives. Focus groups are an effective tool to inform, raise awareness and encourage stakeholders' participation in the decision-making process. This is why they have been widely used in the implementation of the LIFE-GHOST project.

This engagement technique is particularly suitable for a small group of interlocutors and to analyse specific issues, as it can obtain answers on how to deal with the issues at stake and helps understand the stakeholders' wide range of opinions. In particular, the presence of a facilitator can stimulate a debate on topics and unveil the opinions and personal points of view of the parties involved. In practical terms, focus groups are organised in the following way:

- definition of the working sessions: definition of the number of sessions, time schedule and venue. It is essential to define the specific topic of discussion and the list of questions to ask the participants. Questions prepared for the meetings shall be general and open-ended. Moreover, participants will not be asked direct questions about their personal situation, as the focus will be on their opinions;
- choice of participants: based on the previous activities, the number and type of participants will be defined. Make sure that groups are homogeneous (also in geographical terms), so that participants are not reluctant to talk about specific subjects. It is therefore advisable to organise a different focus group for each port with the participation of local fishermen;
- running of the focus group: this is the actual implementation phase based on instructions provided in the previous phases;
- discussion analysis: social methodology techniques will be used and produce summary tables and concept maps of the topics dealt with during the sessions. In particular, these summary reports will compare results obtained in the focus groups organised in different ports.

A wider information and awareness process shall be put in place following the focus group meeting. This is extremely important to show the focus group participants that their feedback has been considered and that provided information, as well as their comments and opinions, have been integrated into operational guidelines to define an ALDFG management system. To this end engagement strategies on a larger scale - such as public meetings - are preferable.

Like previous activities, public meetings shall be organised in no-fishing periods to increase fishermen's participation. They must be an educational and information opportunity, and ensure the dissemination and transfer of identified solutions to the whole stakeholder community. Public meetings shall therefore be used to raise awareness among fishermen on the need to act sustainably (i.e. by complying with the *Code of best practices to reduce lost and abandoned fishing gear at sea*) and to promote the adoption of good practices on a wide scale.

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Annexes

GHOST

TECHNIQUES TO REDUCE THE IMPACT OF GHOST FISHING GEARS AND TO IMPROVE BIODIVERSITY IN NORTH ADRIATIC COASTAL AREAS

CODE OF BEST PRACTICES TO REDUCE LOST AND ABANDONED FISHING GEAR AT SEA

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Venice, May 2016

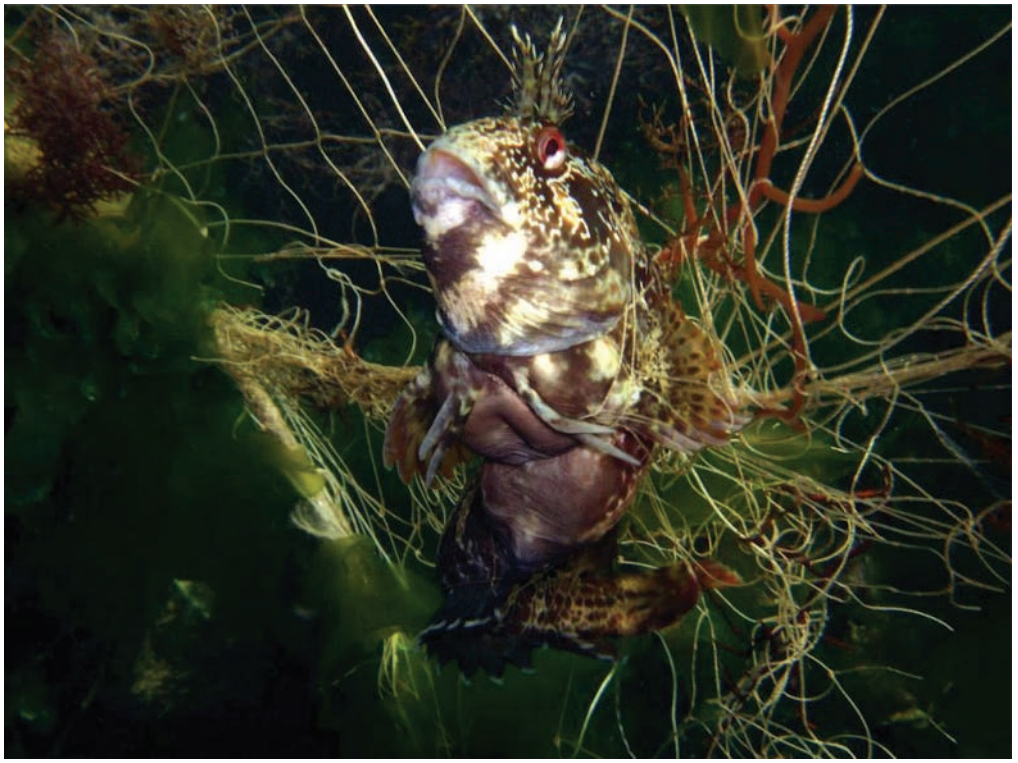
Cover photo courtesy of Piero Mescalchin,
Associazion "Tegnue di Chioggia" - ONLUS

Introduction

In the context of a sustainable development of fisheries activities, the present **CODE OF BEST PRACTICES TO REDUCE LOST AND ABANDONED FISHING GEAR AT SEA** promotes sustainable practices and individual behavior among fishery and aquaculture operators to reduce loss and voluntary abandonment of fishing gear, or parts of them, at sea. In particular, this Code aims not only at contributing to the **preservation of fish stocks**, reducing also the risk for commercially exploited species to be entangled into ghost nets, but also at **promoting more responsible and safer fisheries** activities, taking into account at the same time fishermen profits.

The Code has been discussed with local fishermen in the framework of technical meetings held at the main Venetian fishing fleet sites (Caorle, Chioggia and Porto Tolle), to share with them and their organizations the suggested good behavior practices, sometimes already partially applied locally.

The adoption of some of the proposed practices has been admitted, however, to be a complex matter, particularly in relation to the "proper management of the waste produced or retrieved during fishing activities, including fishing gear and mussel socks", due to the quite common local condition of lacking port reception facilities. Nevertheless, most of fishermen have stressed that the only one behavior practice not really easy to adopt is that related to the statement "the crew should have the expertise to dive for retrieving lost gear immediately, operating according to the law and in compliance with safety standards" since, although functional, this requires complex legal authorizations.



Butterfly blenny entrapped in a ghost net

Why is this issue to be faced?

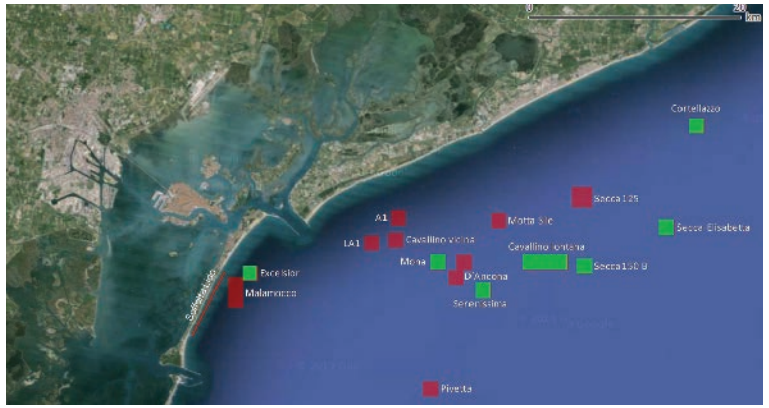
Abandoned, Lost or Discarded Fishing Gear (ALDFG) are known as one of the causes leading to the impairment of marine habitats and of the good condition of fish stocks. Once lost at sea, fishing gear and nets become "**ghost nets**" and continue catching fish indiscriminately and totally out of control ("**ghost fishing**") for different time span depending on type of fishing gear.

Quantifying the loss of marine resources due to "ghost fishing" is difficult, but several studies on static gears have shown it may be about 10% of the target population accessible for commercial exploitation.

Moreover, it should be stated that nets are mainly made of plastics and, once released at sea, they can last up to 600 years, being not only a source of pollutants but also a navigational hazard. Parts of nets and mussel socks, that before sinking continue floating almost invisible just below the water's surface, can interfere with the safety of navigation in different ways. For example, they can be entangled on vessel's propeller and rudder, ultimately causing considerable waste of working time.

How significant is this issue along the venetian coasts?

To estimate the presence of ALDFG along the Venetian coasts, an intensive monitoring survey has been performed in the framework of the LIFE-GHOST project to evaluate the distribution and localization of ghost nets and gear in the study areas, the so-called *tegnùe* (sub-tidal rocky outcrops widespread along the Veneto coastline). Given to their nature, these rocky areas are zones in which fishing nets frequently get entangled and lost, or are here accumulated by the sea currents, such as for the lightest mussel socks. The monitoring survey, performed in a total area of about 20 km^2, showed that more than 50% of the *tegnùe* located in the study area were impacted by the presence of ALDFG. As a whole, about 350 items were identified in situ by using scanning methods at sea, including fishing gear, parts of them or other waste originating from fishing activities. In particular, the most abundant ALDFG types were parts of trawl nets and floating trawls (36%), then ropes, sheets, stays, mooring posts, sheaths, metallic frames and other waste from fishing activities (31%), then trammel nets and gillnets (23%) and lastly mussel socks (10%).
The commercially exploited species mostly at risk to be entrapped in the ghost nets located on the rocky bottom of the Venetian *tegnùe* are: soles, scorpion-fishes, warty crabs, sea breams, common pandoras, lobsters, squids, smooth hounds and brown meagers.
The LIFE-GHOST project carried out recovery activities of ALDFG from the study areas. On the whole, about 5 tons of ALDFG and other waste deriving from fisheries and aquaculture activities were collected at various degradation stages.



Surveyed areas. The red spots show the areas where ALDFG has been detected.

What does the law say?

Both European and national legislation aim to preserve fish resources and marine environment from risks related to ghost nets and to promote management of waste generated from fishery activities. The main purposes of the legislation is: to make the identification of the areas where gear are lost clear-cut, to promote the rapid retrieval of lost gear aiming also at their proper disposal as special waste.

Regulation (EC) No. 1224/2009 Article 8 Marking of the fishing gear.
1. The master of a fishing vessel shall respect conditions and restrictions relating to the marking and identification of fishing vessels and their gear. 2. Detailed rules for the marking and identification of fishing vessels and their gear shall be adopted in accordance with the procedure referred to in Article 119.

Regulation (EC) No. 1224/2009 Article 48 Retrieval of lost gear.
1. A Community fishing vessel shall have the equipment on board to retrieve lost gear. 2. The master of a Community fishing vessel that has lost gear or part of it shall attempt to retrieve it as soon as possible 3. If the lost gear cannot be retrieved, the master of the vessel shall inform the competent authority of its flag Member State, which shall then inform the competent authority of the coastal Member State, within 24 hours of the following: a) the external identification number and the name of the fishing vessel; b) the type of lost gear; c) the time when the gear was lost; d) the position where the gear was lost; e) the measures undertaken to retrieve the gear.

4. If the gear that is retrieved by the competent authorities of the Member States has not been reported as lost, these authorities may recover the cost from the master of the fishing vessel that lost the gear. 5. A Member State may exempt Community fishing vessels of less than 12 metres' length overall flying its flag from the requirement set out in paragraph 1 if they: a) operate exclusively within the territorial seas of the flag Member State; or b) never spend more than 24 hours at sea from the time of departure to the return to port.

Regulation (EC) No. 1967/2006 (Mediterranean Regulation) Article 13 Minimum distances and depths for the use of fishing gears. *1. The use of towed gears shall be prohibited within 3 nautical miles of the coast or within the 50 m isobath where that depth is reached at a shorter distance from the coast. By way of derogation from the first subparagraph, the use of dredges shall be authorized within 3 nautical miles irrespective of the depth provided that the catch of species other than shellfish does not exceed 10 % of the total live weight of the catch. 2. The use of trawl nets shall be prohibited within 1,5 nautical miles of the coast. The use of boat dredges and of hydraulic dredges shall be prohibited within 0,3 nautical miles of the coast. 3. The use of purse seines shall be prohibited within 300 meters of the coast or within the 50 meters isobath where that depth is reached at a shorter distance from the coast. A purse seine shall not be deployed at depths less than 70 % of the overall drop of the purse seine itself as measured in Annex II of this Regulation.*

(Italian) Legislative Decree 3 April 2006 n. 152 Code on the Environment. Article 188 Responsability of the producers and holders (of the waste). *1. The burdens related to waste disposal are borne by the holder who shall transfer the waste to a licensed waste collector or to a dealer who carries out the disposal operations, as well as by the previous holders or producers of the waste. 2. The producer or the holder of hazardous waste shall fulfil his obligations applying the following priority order: a) self disposal of waste; b) waste disposal to licensed dealer under the current rules; c) waste disposal to public collector of urban waste, with which a special agreement has been signed.*

HOW TO ACT CONCRETELY…

… BEST PRACTICES FOR FISHERY AND AQUACULTURE OPERATORS

Trawl net found in the surveyed area.

Correctly mark and identify fishing gear

1. Make sure that fishing gears are positioned in such a way as to not interfere with activities of other fishermen or vessels passing through the fishing ground.
2. Correctly mark the position of gear to avoid as much as possible their damage by other vessels and the possible resulting loss.
3. Ensure that passive gears are marked with two end buoys.
4. Make sure that the marker buoys are in accordance with the law: check the height of the mast, the size and color of the flags, the position and the functioning of the lights.
5. Make sure that the marker buoys of passive gear are always correctly working throughout the fishing phase.
6. Ensure that when required the fishing gears are marked with the external registration letters and numbers of the fishing vessel which they belong to. In particular, the marking shall be reported as following: directly placed on the beam of each beam trawl assembly, on a label attached to the upper first row for nets, on a label at the point of contact with the mooring buoy for lines and long lines, on a label attached to the ground rope for pots and traps.
7. Make sure that the labels with the external registration letters and numbers of the fishing vessel are made of durable material, securely fitted to the gear and at least 65 mm broad and 75 mm long.
8. Ensure that for passive gear extending more than 1 nautical mile, the labels are attached at regular intervals not exceeding 1 nautical mile.

Do not fish in areas at high risk of gear loss and in case of adverse marine weather conditions

1. Have onboard echosounders to identify the type of seabed and the possible presence of any obstacles lying at the sea bottom (outcrops, set fishing gear or ALDFG) that could determine the snagging (or "hooking") of the nets during the fishing activities.

2. Inform other fishermen operating in the same fishing ground about the location of any obstacles lying at the sea bottom.

3. Avoid as much as possible fishing gear conflicts, in particular do not fish using bottom trawl nets in areas where gillnets are already set.

4. Avoid undertaking fishing activities when adverse marine weather conditions are foreseen as the risk of losing or damaging fishing gear is higher.

5. Haul gillnets and other passive gear as soon as possible when adverse marine weather conditions or sea storm are foreseen.

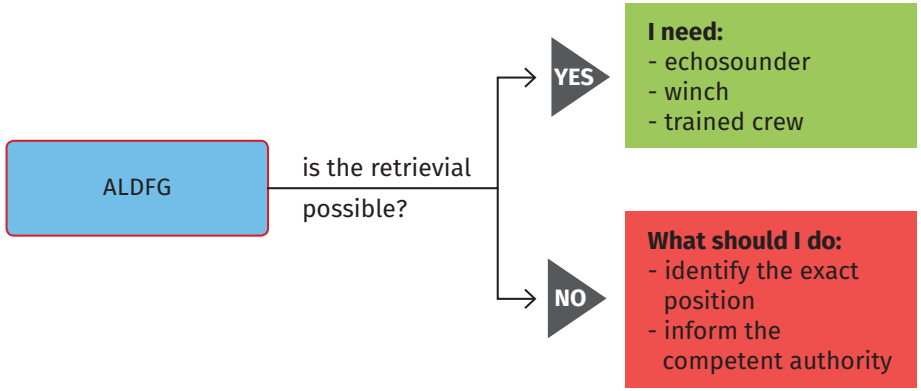
Gillnet found in the surveyed area.

Always retrieve lost gear

1. Always try to retrieve lost gear as soon as possible.

2. Fishing vessel shall have the equipment onboard to retrieve lost gear: GPS and echosounder to identify the exact position where the gear was lost, winch for the retrieval.

3. If the lost gear cannot be retrieved, inform the Coast Guard of the exact position where the gear was lost, the type of lost gear, the size and the external identification number of the lost gear.



Properly manage the waste produced or retrieved during fishing activities, including fishing gear and mussel socks

1. Do not discard at sea any type of fishing gear and consumables used during the working phases carried out at sea and lagoon (as for example fishing gear or nets, parts of them, mussel socks, styrofoam fish boxes, etc.).

2. Arrange a specific zone of the boat to the storage of discarded gear and of other consumables used during the working phases.

3. Fishing gear, damaged and discarded nets, mussel socks and other consumables from fisheries and aquaculture activities must be disposed as "special waste" being originated from an economic activity. Costs of the proper special waste disposal shall be borne by the producers. It is important to know that some components of the damaged and/or discarded gear and nets can be recovered, re-used and recycled.

4. Discarded gear and consumables from fishing activities produced at sea must be always brought back onshore and disposed in adequate waste collection points.

To be known

Any type of waste accidentally recovered during fishing activities shall always be brought back on-shore and never discarded at sea, including fishing gear or parts of them. The Italian law (Legislative Decree n. 182/2003) foresees that the on-shore delivery of any waste accidentally recovered at sea during fishing activities is free.

GHOST

TECHNIQUES TO REDUCE THE IMPACT OF GHOST FISHING GEARS AND TO IMPROVE BIODIVERSITY IN NORTH ADRIATIC COASTAL AREAS

GHOST PROJECT
Operational recommendations for ALDFG effective management

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Laguna Project snc

www.life-ghost.eu

Contents

Introduction

Marine ecosystem contamination due to waste of human origin is a complex problem originating from several sources, both on land and at sea, creating negative impacts on society, the economy and the environment. Globally speaking, it is estimated that abandoned, lost or discarded fishing gears (commonly referred to as ALDFG) represent approximately 10% (i.e. over 600,000 tons per year, Macfadyen, 2009) of the total plastic waste ending up into the sea every year. Precise data are not available for the Mediterranean Sea, or more specifically for the Adriatic Sea. However, EU-funded studies have recently been performed in the Northern Adriatic Sea to assess the quantity of fishing gears lying on the seabed and their impacts on biota and to suggest prevention and mitigation solutions; for the first time, they have calculated the extent of the problem in the Veneto coastal area. The LIFE-GHOST Project called “Techniques to reduce the impacts of ghost fishing gears and to improve biodiversity in North Adriatic coastal areas” is one of them.

LIFE-GHOST was financed by the European Commission's LIFE+ programme at the end of a multi-year research period analysing the local problem and focusing on an area particularly rich in biodiversity hosting *Tegnùe* (rocky outcrops) off the Venetian coasts of Pellestrina, Lido and Cavallino. LIFE-GHOST assessed the quantity of fishing nets and gears abandoned on the seabed, implemented targeted removal activities and evaluated their cost-benefit ratio. The project also considered the need and urgency to reduce abandonment of such waste at sea due to its negative impact on biodiversity and the physical/chemical quality of the environment. In this context, thanks to targeted stakeholder awareness-raising initiatives, the project highlighted technical, administrative and regulatory obstacles hampering the implementation of effective prevention, mitigation and curative measures.

This document is targeted to public administrators and decision-makers of the Veneto region and provides some information on the extent of the ALDFG problem and specific recommendations, in order to support policy and implementation decisions on the management of ALDFG and - in more general terms - of fishing and aquaculture waste in the ports of Veneto.

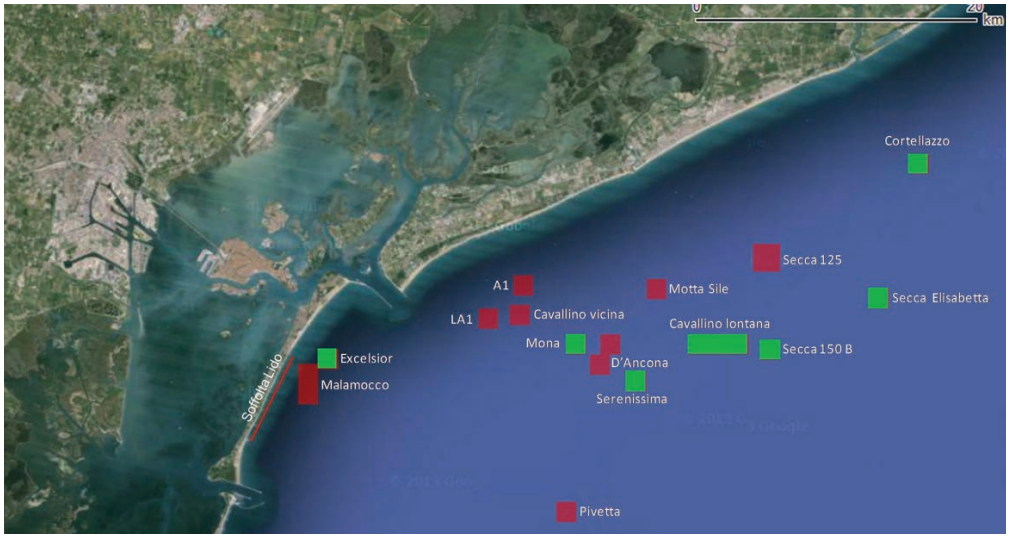
Ghost nets in Veneto: extent, causes and management at a local level

"Ghost nets" usually refer not only to nets but also to other fishing equipment which, for several reasons, is entangled on the seabed or drifting in the water column, thus threatening the whole marine ecosystem. Indeed, ALDFG endanger not only the life of animal and plant species living on the seabed by covering areas which are vital for reproduction, but also pelagic species that can be trapped in them. Although it is difficult to make realistic estimates, it was considered that in several fishing ports - especially off the Atlantic coasts of North America and in the North Sea - the loss of marine resources caused by ghost fishing may amount to approximately 10% of the available commercial fishing stock (UNEP, Regional Seas Programme. Marine Litter and Abandoned Fishing Gear.2005). Moreover, the negative impacts of plastic micro-fragments and micro-filaments produced through mechanic abrasion and degradation of plastic macro-waste at sea have recently been assessed: their consequences affect marine organisms ingesting them and all the subsequent levels of the trophic chain, with negative repercussions on human beings as consumers of fish products.

In the framework of the LIFE-GHOST Project, surveys were conducted at a local level to map the seabed of the Northern Adriatic Sea: results highlighted the presence of ALDFG in nearly half of the surveyed areas. In particular, a total surface of approximately 20 km^2 was surveyed by monitoring the status of 15 rocky outcrops scattered off the Venetian coasts of Pellestrina, Lido and Cavallino. Survey campaigns detected a larger number of ALDFG in the rocky outcrops located near the busiest routes of fishing boats (as emerged from the analysis of their Blue box tracking system), as well as in the rocky outcrops mostly affected by the main currents transporting nets and gears to areas that are far away from the place where they have been lost or abandoned. The most affected rocky outcrops are usually located within 3 miles from the coast, or just beyond the three-mile limit, and their morphology favours the entanglement of fishing nets and gears because their size is considerable in terms of height and surface.

The functional classification of fishing gears located on the seabed showed the larger presence of "active nets" (trawl nets, mid-water trawls, bottom trawl nets, etc.) and "fishing waste" (mainly ropes, also leaded ones, sheets, wire anchors, hoses for hydraulic dredges, elastic bands, mooring posts and metal frames), accounting for 36% and 31% of total detected ALDFG respectively, compared to "passive nets" (gillnets, pots, trammel nets, etc.) or "aquaculture waste" (such as mussel socks and other equipment for sea mussel farming), with 23% and 10% respectively.

Observations confirmed that "active nets" (often parts thereof) are rather widespread and evenly scattered on surveyed seabeds, both within 3 miles off the coast and beyond. Deep entanglement with the rocky outcrops and serious degradation were also evident, thus suggesting that their presence might be due to accidental entanglement during trawling activities too close to the rocky outcrops. On the contrary, observations on "fishing waste" and its higher density in specific areas is likely to be ascribable to voluntary abandonment of obsolete equipment. Finally, the detected presence of gillnets, pots and trammel nets may be caused by accidental loss following unfavourable weather conditions (storms), or breakage from the competition with other fishing gears.



Surveyed areas. The red spots show the areas where ALDFG has been detected.

No specific regulation on ALDFG is currently envisaged by law. Provisions on ALDFG management (both in terms of prevention and of removal) are contained in a set of rules governing the protection of the sea as a natural resource and waste management, with specific reference to fishing and aquaculture waste in port areas. In general, legislation on waste management (reference is made to the Consolidated Law on the Environment) classifies fishing waste as "hazardous waste", as it results from a production process. In the Veneto region, Legislative Decree No. 182/2003 led to the drawing up of "waste management plans in port areas", although results in fishing and aquaculture waste management have not always been effective. In Venice and Chioggia, for example, waste collection plans in the port area have proved to be ineffective though regularly implemented and despite all regulatory aspects have been considered. In practical terms, they do not manage fishing waste nor could they do it as fishing boats are not moored at the port quays. In the port areas of Caorle and Jesolo, "Collection plans for ship-generated waste and cargo residues" classify fishing waste as garbage (i.e. a type of waste comparable to urban waste, food waste and other non-hazardous waste), and

the waste delivery system based on containers is totally inadequate in terms of waste quantities and types. The most effective systems are in place in Polesine (southern Veneto), in the ports of Pila and Scardovari: local regulations approved by the town council classify waste as hazardous, make specific reference to waste management in the mooring areas and provide the latter with dedicated collection systems based on waste disposal.

Recommendations

The LIFE-GHOST project has issued some **recommendations for the management of ghost nets**, which are outlined in the following section and aim not only at "curing" and mitigating the impacts of this problem, but also at limiting its duration. Suggested measures include **horizontal recommendations** inspired by international consolidated guiding principles, as well as **local recommendations** resulting from studies and analyses on ghost net management in the Veneto area conducted by the LIFE-GHOST Project.

As far as horizontal recommendations are concerned, the LIFE-GHOST Project shares and has taken inspiration from FAO recommendations (*FAO Fisheries and Aquaculture Technical Paper No. 523, UNEP Regional Seas Reports and Studies No. 185, "Abandoned, lost or otherwise discarded fishing gear"*) based on widely shared guiding principles in line with the following values:

- ✓ the precautionary principle, with special attention to human health protection and the prevention of damage caused by microplastics;
- ✓ biodiversity conservation, by means of actions to prevent biodiversity loss and reduce the negative impacts of human activities;
- ✓ the principle of social inclusion in making choices and implementing policies on the management and protection of resources and the environment;
- ✓ the principles of efficiency and cost-effectiveness in defining and implementing policies and guidelines for human activities.

By approving local recommendations, these principles have been applied to the real context of Veneto and Northern Adriatic coasts, by adopting an *ad hoc* pragmatic approach in the implementation of medium and long-term prevention, mitigation and curative measures.

Horizontal recommendations

ALDFG extent, impacts and causes are widely known and reported in several international studies. Nevertheless, it is difficult to draw global conclusions without acknowledging the importance of local peculiarities, which often lack detailed available information. A precautionary approach suggests that the lack of complete information should not be reason for non-action. Indeed, several examples show that the level and impact of ALDFG is sufficiently high to give reason for concern and urge for action.

Recommendation 1
It is necessary to take prompt action to reduce ALDFG, although knowledge of various aspects related to ALDFG impacts has not yet been fully developed.

Actions can be undertaken to prevent, mitigate or cure the problem of ALDFG. Curative measures generally remove ALDFG only after it has been in the marine environment for some time and has caused negative impacts, whereas prevention measures are probably more effective in reducing ALDFG and its consequences.

Recommendation 2
It is necessary to take proactive measures to reduce the problem of ALDFG, possibly by adopting preventive solutions. Mitigation and curative measures are not sufficient to reduce marine contamination.

There is no widespread awareness of ALDFG environmental impacts. Fishing operators should not be excessively blamed for this as a) fishing waste only accounts for a small percentage of total marine litter; b) ALDFG is inevitably a small portion of fishing waste in several ports. All the stakeholders should contribute to raising awareness of the problem. Education can lead to positive actions and improve measure effectiveness.

Recommendation 3
It is necessary to raise stakeholders' awareness by introducing - among other things - educational measures.

Like other environmental problems, ALDFG can be studied and monitored by means of a multi-sectoral approach based on the implementation of education and awareness programmes, the development of specific rules and policies, the collaboration of public and private bodies, and adequate infrastructure support. The development of effective policies to reduce this problem requires a general understanding of ALDFG sources and impact, as well as awareness of human behaviour and of the way it is affected by economic policies. Economic incentives are potentially important in solving the problem, provided they are used in the framework of an integrated strategy.

Recommendation 4
It is necessary to design, develop and implement measures based on efficiency and cost effectiveness to promote the reporting of lost equipment and the landfilling of equipment to be discarded.

Local recommendations

Prevention measures

Education and awareness-raising activities for fishing operators and aquaculture farmers are one of the most effective prevention measures to avoid ALDFG not only at a global, but especially at a local level. In this context, the LIFE-GHOST project has drawn up a *Code of best practices to reduce lost and abandoned fishing gear at sea* and has promoted its compliance by fishing operators. This Code is a compendium of virtuous behaviours going beyond compliance with the rules, urging fishermen not to abandon fishing gears at sea and providing suggestions to prevent accidental loss due to unfavourable sea/weather conditions or competition with other fishing gears. The Code has been shared with the vast majority of Veneto fishermen. However, its daily and systematic implementation in ports can be made possible only by ongoing and long-term education and training activities, in order to change fishermen's behaviours and promote the use of an organised delivery system for discarded equipment.

Recommendation 5
It is necessary to promote regular and long-term education and training activities for fishermen and aquaculture farmers in order to raise awareness and to change behaviours and attitudes, with a view to promoting the landfilling of equipment to be discarded.

The LIFE-GHOST project has highlighted regional and national discrepancies in the classification of discarded fishing gears or equipment recovered from the seabed. As a matter of fact, in some places this type of waste is classified as urban solid waste, whereas in others it is classified as hazardous waste resulting from a production process. Waste classification is a fundamental step to identify all management phases in terms of authorisation procedures, costs related to each phase and the identification of cost-bearing parties.

Recommendation 6
It is necessary to identify a clear and standard definition of the EWC classification of fishing gears throughout the region, in order to promote shared management practices for recovery/recycling purposes.

Once they have been delivered, recovered ALDFG must be managed in compliance with efficiency and cost-effectiveness principles. Although disposal is better than abandonment at sea, recovery and recycling are always the best option, as they contribute to circular economy. A delivery and management system for recovered ALDFG and must be organised based on a regionally coordinated approach, that can ensure the critical mass required for the system to work. In this context, stakeholder consultation and engagement activities must be launched to identify the best technical and operational solutions.

Recommendation 7
It is necessary to define and implement a regional management plan for discarded fishing gear or equipment recovered from the seabed, in order to promote recovery and recycling following consultation with all the stakeholders.

Based on the survey of ghost nets in the rocky outcrops, LIFE-GHOST has increasingly shown that ALDFG originates from a wider and more complex topic, i.e. the management of fishing and aquaculture waste. The review of the enforcement of local rules and regulations has highlighted shortcomings, which can be summarized as follows:

a) Proper classification of fishing and aquaculture waste has not been agreed upon either locally or at a higher administrative level: "waste management plans in port areas" in the ports of Caorle and Jesolo classify this type of waste as unsorted urban waste, but this does not comply with the origin of waste (from the production process) nor - sometimes - with its degree of hazardousness (hazardous waste can be found among discarded fishing gears and aquaculture equipment).

Recommendation 8
It is necessary to review waste collection plans for ship-generated waste and cargo residues for Veneto port facilities by introducing more appropriate measures on fishing and aquaculture waste, based on a better classification and quantification of this type of waste.

b) In the ports of Venice and Chioggia, "waste management plans in port areas" do not set any rules for fishing vessels mooring in areas that are not classified as port areas but as urban areas. This context does not fall within the scope of the national regulatory framework and sees the coexistence of several competent authorities intervening in the administrative process on fishing and aquaculture waste management. Consultation among stakeholders is therefore necessary to allocate specific roles and responsibilities, in order to define and set up a delivery and collection system for hazardous waste deriving from fishing and aquaculture activities.

Recommendation 9
It is necessary to foster consultation among stakeholders for the local management of fishing and aquaculture waste, in order to define operational steps to provide mooring areas not falling within the scope of Legislative Decree No. 183/2003 with adequate waste delivery facilities.

Criticalities emerge in the management of fishing and aquaculture waste not only locally, but also at a national level. Hence the need to coordinate actions among stakeholders involved. Since 2007, the statutory Italian Consortium for the recycling of polyethylene-based waste (PoliEco) has been actively involved in activities to promote the recovery of fishing nets and gears. Among them, a national consultation round table has been set up, to which the LIFE-GHOST project is actively contributing. The round table is open to stakeholders interested in this issue, and its current members include national administrations (the Italian Ministry of the Environment, the Ministry of Health, the General Command of the Port Authorities), public and private research institutes (including CNR - Italian National Research Council, ISPRA - Italian National Institute for Environmental Protection and Research, several universities dealing with waste management, the Mediterranean Consortium etc.), the main fishing sector associations and technical bodies (PoliEco). Consultations in the round table are aimed at identifying regulatory, technical and operational solutions to improve the management of discarded fishing gear and aquaculture equipment.

Recommendation 10
It is necessary to participate in supra-regional coordination activities, including the initiative promoted by PoliEco (Italian National Consortium), in order to identify common regulatory, technical and operational solutions at a national level agreed upon with the stakeholders.

Mitigation measures

Fishing gear marking is compulsory for passive equipment and *rapido* nets. On the contrary, no identification system is mandatory for nets and other equipment used in other fishing techniques, e.g. trawl nets and mid-water trawls. Moreover, current statutory marking methods do not always identify the owners of lost or abandoned equipment, as the frequency and characteristics of labelling cannot identify every single part of the equipment. The implementation of a more effective and specific marking system for all fishing nets and gears, either on a voluntary or compulsory basis, could significantly contribute to ALDFG reduction and deter fishermen from abandoning them.

Recommendation 11
It is necessary to adopt an effective marking system for fishing equipment to be applied to all types of fishing nets and gears used for different fishing methods.

Immediate removal of fishing gears lost during a fishing trip is often impossible for the following reasons: 1) fishing operators often lack the necessary diving authorisations; 2) they need to have adequate instruments and equipment to recover ALDFG (especially of considerable size); 3) removal is a dangerous activity. Although it is compulsory to report the loss of fishing gear to the competent authority (Coast Guard), this is rarely done due to the complexity of monitoring activities and bureaucracy. A fast reporting system like a toll-free telephone number or other system managed by the relevant authority (Coast Guard) is desirable: such a system may record calls (even anonymous calls) to report lost equipment, identify its type and record coordinates for future recovery.

Recommendation 12
Fishermen should adopt a fast and simple communication/recording system to report the loss of fishing equipment at sea to the competent authorities when recovery is not possible during fishing operations.

Direct control of fishing gear abandoned at sea by the relevant authorities (Coast Guard) is not only difficult to implement, but also very expensive. Control activities should rather be carried out indirectly and ex-post, by checking and authorising the purchase of new equipment (or parts thereof) only if evidence is provided of accidental loss, or of discarding and properly delivering old equipment. This is why collaboration with the fishing equipment production and distribution chain is necessary, also by introducing suitable rules and conformity checks on sales and purchases.

Recommendation 13
It is necessary to implement an ex-post control system on lost or discarded fishing gear by introducing restrictions on the purchase of new fishing equipment.

Professional fishing is not the only source of ALDFG: recreational fishing also causes voluntary or accidental abandonment of fishing equipment at sea. Stricter controls and regulations are also necessary for recreational fishermen, using the same methods already in place for professional fishing (e.g. equipment marking, direct and indirect control).

Recommendation 14
It is necessary to implement a regulatory and monitoring system to reduce the abandonment of fishing gear by recreational fishermen.

The use of alternative and biocompatible materials to produce fishing equipment can provide a good alternative to the use of plastic equipment, and it would contribute to reducing the release of plastic pollutants at sea. However, the structural and functional limits of such an alternative have been highlighted on several occasions.

Recommendation 15
It is necessary to conduct further research and tests on alternative and biocompatible materials to produce fishing gear meeting both production and environmental sustainability needs.

Curative measures

Although ALDFG systematic removal is not effective in the long term, it is viable in terms of economic and environmental sustainability (priority is given to prevention and mitigation measures) to: 1) recover equipment lost during fishing activities when immediate removal is not possible; 2) recover equipment accidentally lost following unfavourable weather conditions (often used for gillnetting). Removal actions must be carried out following a preliminary assessment of the need for removal and on condition that divers can operate in total safety. The LIFE-GHOST project has developed protocols assessing the feasibility of removal (both with respect to operators' safety and changed habitat conditions following deposition of materials on the seabed) and providing operational instructions.

Recommendation 16
It is necessary to resort to ALDFG ex-post removal only in justified and specific cases, by implementing removal protocols taking into account operators' safety and the changed habitat conditions following deposition of materials on the seabed.

In addition to the above-mentioned prerequisites, systematic removal activities must be organised through close cooperation between the relevant authorities (Veneto region, Harbour master office, etc.) and fishing operators, leading to targeted and justified removal campaigns. Poorly efficient and single removal initiatives should be avoided. To fishermen, removal campaigns may represent an alternative to fishing, to be carried out when fishing activities are temporarily stopped. In this respect, a rewarding system for fishermen contributing to the organisation of ALDFG removal campaigns can be developed either directly (e.g. payment for delivered environmental services) or indirectly (additional fishing days granted based on delivered environmental services). However, removal by fishing operators must be preceded by suitable training activities and cannot be made without prior assessment of the safety and adequacy of the tools and procedures used.

Recommendation 17
It is necessary to carry out systematic ALDFG removal in the framework of targeted and justified removal campaigns. They must be jointly approved by the competent authorities and fishing operators, who can consider removal activities as an alternative to fishing. Removal can be rewarded directly or indirectly with prizes and incentives.

Conclusions

This document has been written in the framework of the LIFE-GHOST project in order to provide information and recommendations to policy decision-makers on the problem of ALDFG (Abandoned, Lost or Discarded Fishing Gear – ghost nets and fishing equipment) and its management along the coasts of Veneto and, more generally, of the Northern Adriatic Sea.

The recommendations included in this document and summarised in the table below are aimed at tackling the problem of ALDFG and consist of actions to cure, mitigate or prevent its occurrence. Mitigation and curative recommendations contribute to reducing the problem and its local impacts in the medium term. Therefore, they must be considered as a valuable, prompt and easier to implement tool for action.

However, only prevention measures can ensure a constant, more effective and long-term reduction of ALDFG at sea, and mitigate its impacts on man and the environment. It is therefore extremely important to undertake a multifaceted approach based on the best available scientific knowledge and strong stakeholder engagement, in order to define and implement operational solutions that are sustainable from an economic and environmental perspective. The aim is to manage and - if possible - reduce the problem of ghost nets in the future.

With this objective clearly in mind, among prevention recommendations suggested by this document, the definition and implementation of a management system for discarded fishing gear or aquaculture equipment recovered from the seabed is particularly important, as well as the subsequent implementation of operational solutions. Both strategies are aimed at promoting recovery and recycling activities. As a matter of fact, the results obtained from the LIFE-GHOST project may support the identification of ALDFG waste management chains as an alternative to landfilling. This would open up new opportunities to recover and recycle the raw materials it is made of, and it would ultimately contribute to reducing the impact of human activities on natural resources, in line with the recent circular economy principles.

The development of a waste delivery and management system for ALDFG must be coordinated at a regional level, in synergy with national initiatives launched to overcome criticalities reported in fishing waste management. Intensive talks are therefore necessary to reach agreement through consultation with all stakeholders at different levels, in order to identify the best technical and operational solutions for the implementation of an effective ALDFG management system.

HORIZONTAL RECOMMENDATIONS		Recommendation 1: It is necessary to take prompt action to reduce ALDFG, although knowledge of various aspects related to ALDFG impacts has not yet been fully developed.
		Recommendation 2: It is necessary to take proactive measures to reduce the problem of ALDFG, possibly by adopting preventive solutions. Mitigation and curative measures are not sufficient to reduce marine contamination.
		Recommendation 3: It is necessary to raise stakeholders' awareness by introducing - among other things - educational measures.
		Recommendation 4: It is necessary to design, develop and implement measures based on efficiency and cost effectiveness to promote the reporting of lost equipment and the landfilling of equipment to be discarded.
LOCAL RECOMMENDATIONS	PREVENTION MEASURES	Recommendation 5: It is necessary to promote regular and long-term education and training activities for fishermen and aquaculture farmers in order to raise awareness and to change behaviours and attitudes, with a view to promoting the landfilling of equipment to be discarded.
		Recommendation 6: It is necessary to identify a clear and standard definition of the EWC classification of fishing gears throughout the region, in order to promote shared management practices for recovery/recycling purposes.
		Recommendation 7: It is necessary to define and implement a regional management plan for discarded fishing gear or equipment recovered from the seabed, in order to promote recovery and recycling following consultation with all the stakeholders.
		Recommendation 8: It is necessary to review waste collection plans for ship-generated waste and cargo residues for Veneto port facilities by introducing more appropriate measures on fishing and aquaculture waste, based on a better classification and quantification of this type of waste.
		Recommendation 9: It is necessary to foster consultation among stakeholders for the local management of fishing and aquaculture waste, in order to define operational steps to provide mooring areas not falling within the scope of Legislative Decree No. 183/2003 with adequate waste delivery facilities.
		Recommendation 10: It is necessary to participate in supra-regional coordination activities, including the initiative promoted by PoliEco (Italian National Consortium), in order to identify common regulatory, technical and operational solutions at a national level agreed upon with the stakeholders.
	MITIGATION MEASURES	Recommendation 11: It is necessary to adopt an effective marking system for fishing equipment to be applied to all types of fishing nets and gears used for different fishing methods.
		Recommendation 12: Fishermen should adopt a fast and simple communication/recording system to report the loss of fishing equipment at sea to the competent authorities when recovery is not possible during fishing operations.
		Recommendation 13: It is necessary to implement an ex-post control system on lost or discarded fishing gear by introducing restrictions on the purchase of new fishing equipment.
		Recommendation 14: It is necessary to implement a regulatory and monitoring system to reduce the abandonment of fishing gear by recreational fishermen.
		Recommendation 15: It is necessary to conduct further research and tests on alternative and biocompatible materials to produce fishing gear meeting both production and environmental sustainability needs.
	CURATIVE MEASURES	Recommendation 16: It is necessary to resort to ALDFG ex-post removal only in justified and specific cases, by implementing removal protocols taking into account operators' safety and the changed habitat conditions following deposition of materials on the seabed.
		Recommendation 17: It is necessary to carry out systematic ALDFG removal in the framework of targeted and justified removal campaigns. They must be jointly approved by the competent authorities and fishing operators, who can consider removal activities as an alternative to fishing. Removal can be rewarded directly or indirectly with prizes and incentives.

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