OSPAR COMMISSION

Environmental Impacts of Human Activities

INTERIM REPORT: Entanglement of sea turtles in the Eastern Atlantic. State of play

2024

Entanglement of sea turtles in the Eastern Atlantic. State of play

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l'Allemagne, la Belgique, le Danemark, l'Espagne, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède, la Suisse et l'Union européenne.

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Abbreviations

ALDFG	Abandoned, lost or otherwise discarded fishing gear
BCI	Body condition index
DPS	Distinct population segment
EEC	European Economic Community
EIHA	Environmental Impact of Human Activities Committee
FAD	Fishing aggregating device
GES	Good environmental status
GPML	Global Partnership on Plastic Pollution and Marine Litter
ICCAT	International Commission for the Conservation of Atlantic Tunas
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre
MAP	Mediterranean Action Plan
MARLISCO	Marine Litter in Europe Seas: Social Awareness and Co-Responsibility
MPA	Marine protected area
MSFD	Marine Strategy Framework Directive
NEAES	North-East Atlantic Environment Strategy
NGO	Non-governmental organization
RAP	Regional Action Plan
RC	Rescue centre
RFMO	Regional fisheries management organization
RSC	Regional Sea Convention
TED	Turtle excluder device
TGML	Technical Group on Marine Litter
UNEP	United Nations Environment Programme

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Executive Summary

This document summarizes the available information on sea turtles entanglement in the OSPAR region, on the basis of the INDICIT II project results for this region. The main sea turtle species affected by entanglement in marine litter within the OSPAR region are the Loggerhead turtle (*Caretta caretta*) and the Leatherback turtle (*Dermochelys coriacea*), which are mainly entangled in fishing nets, ropes, strings and cords in the North-East (NE) Atlantic region. The document constitutes a review of the research carried out up to now on the problem of marine litter and its impact on marine turtles, with a focus on entanglement. It also includes other relevant studies and efforts conducted in the NE Atlantic region. The main issues identified by the INDICIT II project for the assessment of sea turtles entanglement are (i) the difficulty to distinguish entanglement from bycatch, (ii) the lack of standardized data and/or data collection methods, and (iii) the discrepancy in the classification of litter causing entanglement.

This document constitutes a first step in the implementation of the OSPAR action “To identify and understand the main sources of entanglement of sea turtles in the Eastern Atlantic and to develop adequate management measures”. Further work will be developed as part of the Second Regional Action Plan on Marine Litter (RAP-ML 2).

1. Introduction

1.1. The problem

Marine litter is defined by OSPAR[1] as "any solid material which has been deliberately discarded or unintentionally lost on beaches, on shores or at sea. The definition covers materials transported into the marine environment from land by rivers, draining or sewage systems or winds. It includes any persistent, manufactured or processed solid material". The UNEP defines marine litter (also known as marine debris) as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (UNEP, 2009).

Marine litter has increased drastically as a result of human activities on land and in coastal areas, with plastics being the type of litter most commonly found (Löhr *et al*., 2017). However, it wasn't until the early 1970s that the presence of plastics in the marine environment started to be reported (Bergmann, Gutow, & Klages, 2015), with litter being present in all of the world's oceans and seas, even in remote areas. According to Haarr *et al*. (2022), research on global distribution of marine litter over the past five years is highly skewed geographically: most studies are carried out in the North Atlantic Ocean and the Mediterranean Sea, and there is a lack of data from low-income countries. Furthermore, litter density seems to be highest on the coast, likely due to the fact that it is the area most intensively studied (Haarr *et al*., 2022).

In the OSPAR Maritime Area, there has been a statistically significant decrease in plastic litter on beaches in most OSPAR Regions and a decrease in floating litter in the North Sea. However, levels of marine litter remain elevated (OSPAR, 2023). OSPAR's 2014 Regional Action Plan for Marine Litter (RAP ML), which sets out commitments to promote waste prevention and management practices that have a significant impact on marine litter, to encourage recyclability and reuse of plastic products, to assess instruments to reduce single-use items and to reduce inputs of microplastics, has mostly been implemented. However, further actions are needed to prevent plastics from entering the marine environment, and this is considered in the second Regional Action Plan on Marine Litter, adopted in 2022 (OSPAR, 2023).

Marine litter is a threat for human health and safety, but it also has a substantial impact on marine ecosystems. Specifically, entanglement in marine litter and ingestion of plastic are the most common interactions (Barboza *et al*., 2019) with impact on marine animals (birds, turtles, mammals, fish and crabs).

Entanglement causes injuries and wounds and impairs an animal's swimming capacity. This leads to a reduction in feeding efficiency and makes difficult to escape from predators, which can ultimately result in death by drowning, suffocation, or strangulation (Laist, 1997; Moore, 2008). Discarded plastic lines and fishing gear, even if not directly drowning the animal, may cause complications in proper foraging or surfacing to breathe in the case of mammals and turtles (Wabnitz and Nichols 2010). Ingestion can cause physical and physiological effects. Physical effects include lacerations and lesions, blockages that produce a false sense of satiety, and retention in the digestive tract; these effects can lead to physiological effects (nutritional, developmental, immunological, and toxicological; *Barboza et al*., 2019). Plastic ingestion can also lead to bioaccumulation and trophic transfer of microplastics (Nelms *et al*., 2016, 2016b). Gall and Thompson (2015) reported that 693 different species around the globe were impacted by entanglement in or ingestion of marine litter, including all sea turtle species described to date. In this context, entanglement in plastic debris is recognized as a major risk for many marine species (Vegter *et al*., 2014), affecting mainly seabirds, fish, mammals and turtles.

In the case of sea turtles, entanglement has been found across all life stages and ocean basins, and the seven

[1] https://www.ospar.org/work-areas/eiha/marine-litter

described species have been reported to be affected by entanglement in marine litter (Bergmann *et al*., 2015). In addition, all species occurring in European waters are listed in the International Union for Conservation of Nature's (IUCN) Red List of threatened species (IUCN, 2020) and in the annexes of multiple European Directives (e.g., MSFD, Habitats Directive), global and Regional Sea Conventions (e.g., Bern and Bonn Conventions, Barcelona Convention, OSPAR Convention) (Palialexis *et al*., 2018). Entanglement may cause skin infections, flipper amputations and septic processes in these animals (Orós *et al*., 2005).

The OSPAR List of Threatened and/or Declining Species and Habitats includes two marine turtle species: the loggerhead turtle (*Caretta caretta*) and the leatherback turtle (*Dermochelys coriacea*). The loggerhead occurs mainly in the Azores and along the Atlantic coast of the Iberian Peninsula in the OSPAR Regions IV and V, while the leatherback turtle is considered to have a regular presence in the OSPAR Maritime Area.

The results of a questionnaire completed by 106 experts revealed that 90,6% of the turtles found entangled in marine litter across all ocean basins were dead, with the Atlantic represented by the 34,8% of the responses. These experts also suggested that pelagic juvenile life stages are particularly vulnerable (Duncan *et al.,* 2017).

In summary, it seems clear that entanglement in marine litter poses a risk for sea turtles. However, there is a lack of standardized data collection methods (i.e., that allows differentiation from bycatch). Besides, research on the subject and collaboration between stakeholders is scarce. These issues, make difficult to build up a robust database on sea turtle entanglement (Duncan *et al*., 2017) that allows to identify and better understand its main causes; and, thus, to develop adequate strategies and management plans.

1.2. OSPAR's marine litter objectives

The North-East Atlantic Environmental Strategy (NEAES) 2030 sets out collective objectives to tackle the triple challenge the ocean is currently facing: biodiversity loss, pollution (including marine litter), and climate change. Its implementation is part of OSPAR's contribution to the achievement of the United Nations 2030 Agenda for Sustainable Development and its Sustainable Development Goals.

The Strategy sets out OSPAR's vision, as well as strategic and operational objectives. The strategic objectives set out OSPAR's overarching goals on eutrophication, hazardous substances, radioactive substances, marine litter, protection, conservation and restoration of species and habitats, sustainable use of the marine environment, underwater noise, seabed protection, climate change and ocean acidification. The operational objectives set qualitative and quantitative targets to support the achievement of strategic objectives.

The Roadmap for the implementation of collective actions within the Recommendations for the protection and conservation of OSPAR listed Species and Habitats 2017-2025 (POSH Roadmap) has been developed in response to the need for a strategic approach to deliver the actions set out in the Recommendations for protection and conservation of the OSPAR listed species and habitats. The action 26 requires to develop and/or refine relevant measures and strategies for preventing and reducing impact on turtles of entanglement in and ingestion of marine litter (in particular plastic bags), pollution, collision and bycatch.

The second Regional Action Plan for Marine Litter (RAP ML 2) serves as the main instrument to deliver NEAES 2030 strategic objective 4: "Prevent inputs of and significantly reduce marine litter, including microplastics, to reach levels that do not cause adverse effects to the marine and coastal environment with the ultimate aim of eliminating inputs of litter".

To achieve this objective, the RAP ML 2 describes priority thematic areas and defines key actions, that will be taken forward collectively by OSPAR Contracting Parties within the framework of the OSPAR Commission. These include actions to reduce **land-based** and **sea-based** sources of marine litter, as well as cross cutting actions **to**

improve knowledge and understanding on marine litter. Regarding actions to reduce sea-based sources of marine litter further work on developing standardized data collection protocols and improving monitoring to identify and understand the main sources of entanglement of sea turtles to further develop adequate strategies and management plans in the North-East Atlantic was recommended (Baudouin M., Claro F. 2020) within OSPAR. Therefore, the following action was included within RAP ML 2 (B.4.6): "To identify and understand the main sources of entanglement of sea turtles in the Eastern Atlantic and to develop adequate management measures".

On the other hand, the OSPAR vision for a healthy and biodiverse sea considers strategic objective 5: "Protect and conserve marine biodiversity, ecosystems and their services to achieve good status of species and habitats, and thereby maintain and strengthen ecosystem resilience". In order to contribute to achieving strategic objective 5, the OSPAR Coordinated Environmental Monitoring Programme for marine litter has currently developed an indicator for "litter ingested by sea turtles" (BE8). Its monitoring is under the management of the Environmental Impact of Human Activities Committee (EIHA). This new OSPAR Common Indicator (S5.O5.) provides the basis not only for further monitoring and evaluating trends but also to assess the efficiency of reduction measures implemented by CPs. However, sea turtles entanglement is still not an indicator for marine litter assessment in the OSPAR region.

1.3. Other relevant Regional Sea Conventions and EU legislation

1.3.1. Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean – Barcelona Convention

The Barcelona Convention is the first regional agreement under the United Nation's Environment Programme (UNEP). It was signed in Barcelona in 1976 and constitutes the legal framework for the Action Plan for the Protection and Development of the Mediterranean (MAP).

Some lines of work undertaken by this Convention include the Regional Plan on Marine Litter Management in the Mediterranean, approved through Decision IG.21/7 (UNEP/MED, 2013). This plan includes actions that contracting parties are mandated to implement to reduce the amount of marine litter and its impact on the marine environment, as well as to increase the knowledge on their origin. This plan was approved through decision IG.22/10 at COP19, held in Athens (UNEP/MAP, 2016). At COP22, held in Antalya in 2021, the Regional Plan on Marine Litter Management in the Mediterranean was modified through amendments collected on Decision IG.25/9.

In the context of the Barcelona Convention, common indicators are used to summarize information into simple, standardized and communicable figures ideally applicable in the whole Mediterranean basin. Candidate indicators still have many outstanding issues regarding their monitoring and assessment. Therefore, they are recommended to be monitored in the initial phase of IMAP on a pilot and voluntary basis. Marine turtles are included in the candidate indicator 24 IMAP: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds and marine turtles (EO10). Marine turtles have been proposed as indicator species to study marine litter ingestion in biota in the Mediterranean through the major indicator "Litter ingested by sea turtles", where the loggerhead turtle has been adopted as the most appropriate species. However, as for the OSPAR region, sea turtles entanglement is still not an indicator for marine litter assessment in the Mediterranean basin.

1.3.2. European Union

European regulations made a specific reference to marine litter for the first time in 2008, through the Marine Strategy Framework Directive (Directive 2008/56/CE). This Directive aims to manage and protect marine environments across Europe. More specifically, it aims to achieve and maintain good environmental status (GES), defined as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". In practice, the GES is determined through the assessment of 11 qualitative Descriptors, and their associated criteria, related to ecosystems and human activities and pressures at the scales of pre-defined regions or sub-regions (European Commission, 2017). Marine litter is one of the 11 qualitative Descriptors (Descriptor 10).

In May 2017 the European Commission approved the Decision (EU) 2017/848 of 17 May 2017, which establishes the criteria and methodological standards applicable to GES of marine waters, as well as standardized specifications and methods for monitoring and assessment, and repeals Decision 2010/477/EC. Related to descriptor 10, secondary criteria D10C3 "The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned" and D10C4 "The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects", contribute to the assess of GES in sea turtles carried out mainly through the Biological Diversity descriptor (Descriptor 1). In this sense, in 2022, the Joint Research Centre (JRC) published an article entitled "Toward a common approach for assessing the conservation status of marine turtle species within the European MSFD", which aimed to develop indicators and a common assessment approach (consistent with other environmental policies) to be used by Member States to evaluate the status of marine turtle populations. This article is the outcome of a two-year study carried out in 2019, developed with the participation of international expert groups, which pointed towards leatherback, Kemp's ridley, green and loggerhead turtles as the focus of the assessment in the North-East Atlantic region, based on their frequency of occurrence. The criteria proposed to assess the status of marine turtle populations are (1) mortality rate from bycatch (D1C1), (2) population abundance (D1C2), (3) population demographic characteristics (D1C3), (4) population distributional range (D1C4) and (5) extent of suitable habitat (D1C5) (Girard *et al*., 2022).

1.4. Relevant studies and efforts carried out on the subject

There are several global efforts carried out for reducing litter production and mitigating its impacts on the marine environment. The Honolulu Strategy is an example of the prevention and management of marine debris at a global scale. Its goals include (i) to reduce the impact of land-based litter and solid waste introduced into marine environments; (ii) to reduce the impact of sea-based sources of marine debris (including solid waste, lost cargo, ALDFG, and abandoned vessels); and (iii) to reduce the impact of accumulated marine debris on shorelines, benthic habitats, and also in the water column (pelagic habitats).

There are also other worldwide initiatives, such as the Global Partnership on Plastic Pollution and Marine Litter (GPML), launched at the United Nations Conference on Sustainable Development (Rio+20) in June 2012. Its objectives are to reduce the leakage of plastics into the ocean through improving their design, applying the 3Rs principle (reduce, re-use, recycle), encouraging 'closed-loop' systems and more circular production cycles, maximizing resource efficiency and minimizing waste generation.

At the European level, initiatives such as CleanAtlantic, aimed to protect biodiversity and ecosystem services by improving capabilities to monitor, prevent and remove marine litter.

Although this is not the main objective of these projects, the result of reducing marine litter it will undoubtedly have a beneficial effect on the reduction of sea turtle entanglement in plastic.

Regarding entanglement and ingestion of marine litter, only few studies have been carried out at the national or international level. Of relevant importance, the European projects INDICIT (Implementation of the 'Impacts of marine litter on sea turtles and biota' indicator in RSC and MSFD areas) I and II, were committed to support the implementation of EU's MSFD and other international policies aiming at protecting the marine environment through the development of sea turtles as indicators of the impact of litter ingestion and litter entanglement (INDICIT II).

2. The INDICIT Project

The INDICIT project consisted of two parts: INDICIT I and II. The INDICIT I project ran from 1 February 2017 to 31 January 2019, while the INDICIT II project ran from 2 February 2019 to 1 February 2021 (extended to 2022 due to COVID19 pandemic situation).

The INDICIT I project "Implementation of indicators of marine litter impacts on sea turtles and biota in Regional Sea Conventions and Marine Strategy Framework Directive Areas" aimed to support the OSPAR, Barcelona and HELCOM (Baltic) RSCs and the MSFD in the implementation of indicators for litter impact on marine fauna, which are part of Criteria D10C3 and D10C4. INDICIT I addressed three indicators of litter impact: (1) litter ingested by sea turtles, (2) entanglement with debris by marine biota and (3) micro-plastic ingestion in fish and sea turtles. The INDICIT I consortium was composed of 10 partner institutions from public sector, belonging to 5 European countries (France, Greece, Italy, Portugal, Spain) and 2 non-European countries (Tunisia, Turkey), all Contracting Parties of Barcelona and/or OSPAR RSC.

The INDICIT II project is a follow-up of the INDICIT I project and involves 12 partners from the public sector, belonging to 6 European countries (France, Greece, Italy, Portugal, Spain and United Kingdom) and 2 non-European countries (Tunisia, Turkey), all Contracting Parties to the OSPAR (Atlantic) and/or Barcelona (Mediterranean) Conventions. The overarching aim of INDICIT II was to allow the standardized implementation of litter impact indicators in the framework of the MSFD and the OSPAR, Barcelona and HELCOM (Baltic) RSCs, using sea turtles, although other target taxa/species (marine mammals and seabirds) were also included in the evaluation for litter entanglement. The specific objective of this project was to develop a common approach for monitoring litter impacting sea turtles by:

a) Developing a set of standardized tools.
b) Creating a network of stakeholders and providing them with training sessions.
c) Collecting and analyzing data on living and dead turtles.
d) Analyzing the indicator's spatial and temporal limits, biological constraints and GES criteria.

As a *result of the INDICIT* projects, 3 different indicators were developed:

- Litter ingested by sea turtles.
- Entanglement with debris by marine biota.
- Micro-plastic ingestion in fish and sea turtles.

The INDICIT consortium considered the loggerhead turtle (*Caretta caretta*) as a target species due to its abundance in European waters, its wide distribution, the use of different marine habitats and its opportunistic feeding behavior. The leatherback turtle (*Dermochelys coriacea*) was also recommended as an indicator species, especially for OSPAR (Atlantic) zones III, IV and V, where it is regularly observed. In INDICIT II, other target taxa/species (marine mammals and seabirds) were included in the evaluation for litter entanglement.

It is important to note that although most Atlantic data in the INDICIT project comes from around the Canary Islands, these are of key importance, as many of the animals impacted in the OSPAR region are drifted by currents to the Atlantic archipelagos.

2.1. Difficulties and solutions identified by the INDICIT I and II projects

The indicator "*Entanglement with debris by marine biota*" belongs to MSFD criteria D10C4 "the number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects", with the unit of measurement being "the number of individuals affected (lethal; sub-lethal) per species".

INDICIT I project (2017-2019) conducted a feasibility study (El Hili et al., 2018) through the review of available grey and published literature, and responses to questionnaires disseminated to sea turtles, marine mammals, seabirds, fishes, or marine litter experts. All taxa were assessed to identify candidate indicator species, especially in the OSPAR-Macaronesia, HELCOM and Barcelona Convention regions. Regarding entanglement in marine litter, the main conclusion obtained were:

- Assessment of entanglement was not accurate because it was based on opportunistic data.
- It was difficult to distinguish between passive entanglement caused by litter and active entanglement due to bycatch in active fishing gears.
- Great discrepancy in the classification of litter causing entanglement was observed.
- Methodological constraints were identified on specimen collection and intrinsic species biological/ecological factors (behavior, life stages, etc.).

INDICIT II fought to solve all constraints identified during the feasibility study conducted during INDICIT I.

Regarding data collection an important source of data has been found on social media, where citizens, associations, or institutions shared videos/pictures of marine fauna found at sea or stranded. A deep analysis of images obtained from social media and opportunistic platforms was conducted to verify the proposals established by INDICIT consortium to solve the main difficulties found in INDICIT I.

A specific protocol ("Social media Protocol for entanglement") to conduct a deep search of images related to entanglement on social media and opportunistic platforms was developed and shared with partners for its application in their respective regions and countries. At the same time, and due to the COVID19 pandemic, the INDICIT II partners launched an online campaign on social media, the "INDICIT CHALLENGE", inviting any citizen (by then confined at homes) to search for images related to entanglement of marine fauna.

324 sea turtle images were obtained for the Atlantic region, where 241 individuals (74,4%) were entangled animals. The highest number of entangled animals (sea turtles) were found around the Canary Islands.

Table 1. Number of total (N) and entangled individuals (n) obtained from social media and opportunistic platforms images, arranged by country in the Atlantic region.

		SEA TURTLES	
		N	*n entanglement (%)*
ATL	France	7	4 (57,1%)
	Portugal	29	18 (62,1%)
	Spain	288	219 (76,0%)
TOTAL		**324**	**241 (74,4%)**

2.1.1. Distinguishing entanglement from bycatch

The main constraint observed during INDICIT I was the difficulty found by partners and stakeholders to distinguish between entanglement on fishing gears (ghost nets) and bycatch in active fishing gears (i.e., animals escaped with a part of the gear after an accidental capture). To solve this problem, INDICIT II consortium, decided

to:

- Establish a clear definition of entanglement, bycatch and other situations of likely occurrence different to the aforementioned categories (e.g. doubtful cases, accidental catch in active structures; Fig. 1).
- Establish criteria to distinguish between the abovementioned concepts (entanglement, bycatch, doubtful cases, and accidental catch in active structures; Fig. 2).
- Verify the use of the established definitions and criteria with images obtained from social media: a deep review of images obtained from social media were conducted to verify the utility of definitions and criteria established by INDICIT consortium.

Figure 1. Definition/concepts established by the INDICIT II Consortium (images extracted from INDICIT II Standard Protocol)

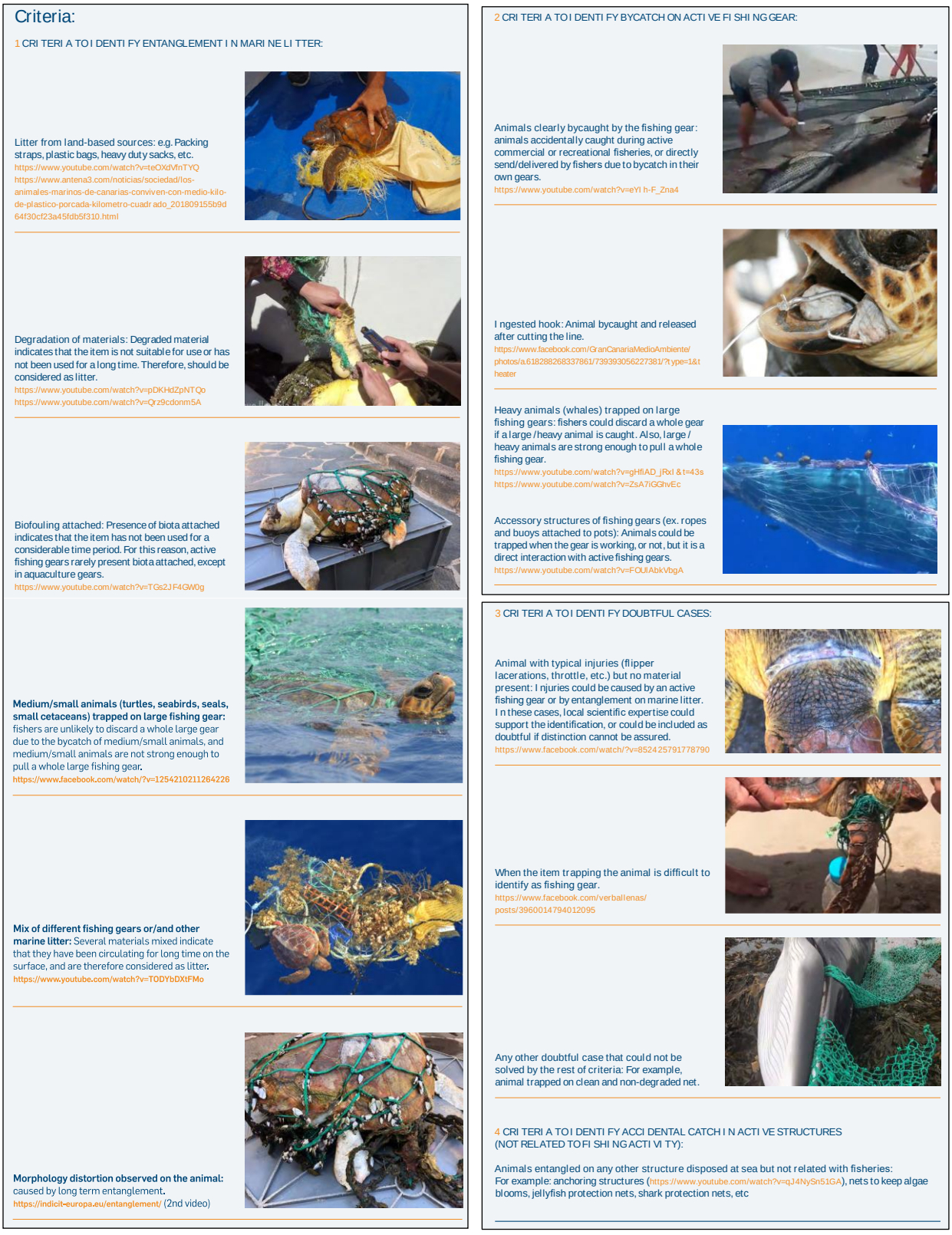

Figure 2. Criteria established by the INDICIT II consortium to distinguish between the proposed concepts (images extracted from INDICIT II Standard Protocol)

Verification of the difficulty to distinguish entanglement from bycatch

The large number of images obtained from social media were classified by INDICIT partners using the definitions and criteria developed by the INDICIT consortium. In general, criteria were useful to distinguish entanglement from bycatch, particularly when images were available. The greatest difficulty to distinguish entanglement from bycatch was found for the leatherback turtle, presenting the highest percentage of doubtful cases (18,2%). This difficulty resulted from:

- All the animals being affected by materials derived from fisheries and maritime sources (no land-based litter).
- The large size of the animals, which enables them to trawl active fishing gear.
- The animals are so heavy (around 300-500kg), that fishermen could cut the fishing gear to take them out of the gear.

On the other hand, no doubtful cases were found for green turtles and few were found for loggerhead turtles (1%).

In conclusion, it could be confirmed that the definitions and criteria stablished by the INDICIT II consortium are useful in distinguishing entanglement from bycatch, particularly when images are available.

Table 2. Number (n) and frequency (%) of individuals from images obtained from social media, classified based on definitions and criteria proposed by INDICIT II for Mediterranean and Atlantic regions.

	Entangled *n (%)*	**Bycatch** *n (%)*	**Doubtful** *n (%)*	**Other** *n (%)*	**No Data** *n (%)*
By animal taxa					
Sea turtles (N = 532)	344 (64,7%)	76 (14,3%)	9 (1,7%)	81 (15,2%)	22 (4,1%)
Sea turtle species					
Caretta caretta (N = 484)	327 (67,6%)	67 (13,8%)	5 (1,0%)	70 (14,5%)	15 (3,1%)
Chelonia mydas (N = 26)	11 (42,3%)	6 (23,1%)	0 (0,0%)	8 (30,8%)	1 (3,8%)
Dermochelys coriacea (N = 22)	6 (27,3%)	3 (13,6%)	4 (18,2%)	3 (13,6%)	6 (27,3%)

2.1.2. Standardizing the list of litter typologies involved in entanglement

The great variety of “names” given to litter typologies by partners and stakeholders, not only based on the lingual differences between countries, but also between stakeholders from the same country, constitutes another important constraint found by the INDICIT projects

Many difficulties were found to complete the list of litter typologies for entanglement, where the “entanglement” coordinators of INDICIT II developed a list of litter typologies based on the MSFD litter classification, extracting the items susceptible to be involved on entanglement (thread shaped materials).

The first draft was shared with:

- The MSFD Technical Group on Marine Litter (TGML). This group has been homogenizing litter classifications stablished by different projects, programmes, and conventions from the European Union (OSPAR, Barcelona, etc.).
- Stakeholders: who asked to reduce the list of litter typologies in order to be more practical and useful in the field.

To solve this problem, the INDICIT II consortium decided to:

- Establish litter typologies for entanglement based on the list of litter typologies stablished by the MSFD, updated by the TGML group (February 2020).
- Reduce the list of litter typologies in collaboration with stakeholders to facilitate data collectionin the field. Many stakeholders need to be involved in monitoring entanglement (stranding networks, rescue centres) in European waters, where many different people collect data from each stranding event. Reducing the list of litter typologies is important to support stakeholders on data collection.
- Include the CODES used by different litter programmes (floating litter, beach litter, etc.) in the list of litter typologies for entanglement, to facilitate comparisons.
- Validate the use of the list of litter typologies for entanglement proposed by INDICIT II with images obtained from social media.

Figure 3. List of litter typologies involved in entanglement stablished by the INDICIT II consortium (extracted from INDICIT II Standard Protocol)

Validating the use of the list of litter typologies for entanglement proposed by the INDICIT II consortium

The large number entangled animals images obtained from social media allowed to test whether the list proposed by the INDICIT II consortium included most items impacting marine fauna by entanglement in European waters.

Table 3. Number (n) and frequency (%) of entangled sea turtles obtained from social media images, classified by litter typologies established by the INDICIT consortium. (Red squares = litter typologies observed in frequencies < 1%). Data from the INDICIT II project (Mediterranean and Atlantic regions).

	TURTLES *(N = 356)*
Fisheries & maritime sources	209 (58,7%)
Fishing nets	105 (29,5%)
Fishing lines	62 (17,4%)
Rope, string, cord	104 (29,2%)
Floats, buoys, fenders	42 (11,8%)
Pots, tops, traps	1 (0,3%)
Aquaculture related	0 (0,0%)
Other fishing related	14 (3,9%)
Land-based sources	132 (37,1%)
Plastic bag	8 (2,2%)
Mesh bags	2 (0,6%)
Heavy-duty sacks	113 (31,7%)
Packing rings	0 (0,0%)
Packing strapping bands	7 (2,0%)
Plastic sheeting greenhouse	1 (0,3%)
Food packing	0 (0,0%)
Other packing	0 (0,0%)
Textile	0 (0,0%)
Medical and hygienic care	0 (0,0%)
Recreational related	3 (0,8%)
Other land-based	14 (3,9%)
Unknown / not identified	31 (8,7%)

The list of litter categories proposed by the INDICIT II consortium covered all litter typologies observed in the images obtained from social media and no new typologies were found. Items in “other fishing related” or “other land-based” categories included:

- Specific materials linked to other typology described on the list, such as hooks, lures and weight attached to “fishing lines”.
- Isolated cases (only 1 case) of very specific materials, such as a balloon, a deck chair or a bike wheel (included on “recreational related”).
- Cases described as “plastics” by people discovering the animals and the images do not show the material entangling the animal (included on “other land-based”).

The most frequent typologies in which sea turtles were entangled included: “fishing nets” (29,5%); “ropes, strings and cords” (29,2%) and “fishing lines” (17,4%) in the categories derived from fisheries and maritime uses, and “heavy-duty sacks” (31,7%) in land-based sources categories. Several typologies were found in less than 1% of the cases (red squares in Table 3) or not found: “Pots, tops and traps” and “Aquaculture related”, “Packing rings”, “Food packing”, “Plastic sheeting greenhouse”, “Textile” and “Medical and hygienic care”. Therefore, these litter typologies were removed from the final list. Crucially, when images were available, the undetermined cases

("unknown") decreased (only 8,7% of the cases were not possible to identify the litter category).

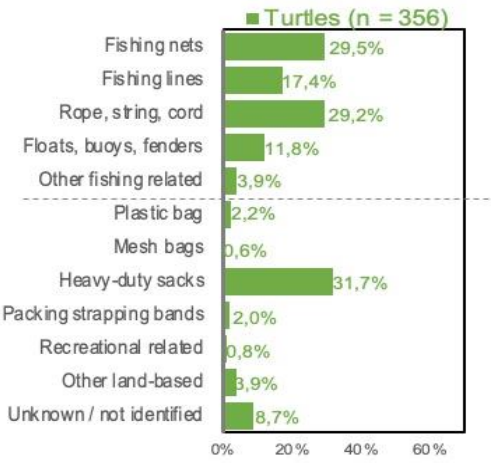

Figure 4. Frequency of litter typologies entangling individuals. Data from images obtained on social media (Mediterranean and Atlantic regions).

Loggerhead and green turtles were impacted by litter derived from fisheries and maritime sources but also from land-based sources, mainly "heavy-duty sacks" (33% and 27,3% for both species respectively) and by "plastic bags" (9,1%, green turtles only). Regarding sea-based sources, green turtles are more impacted by "fishing lines" (45,5%), probably due to their neritic behavior (inhabiting close to the shores). Loggerhead and leatherback turtles, which have an oceanic behaviour, are more impacted by "ropes, strings and cords" (28,2% and 80% respectively) and "fishing nets" (29,7% and 40% respectively).

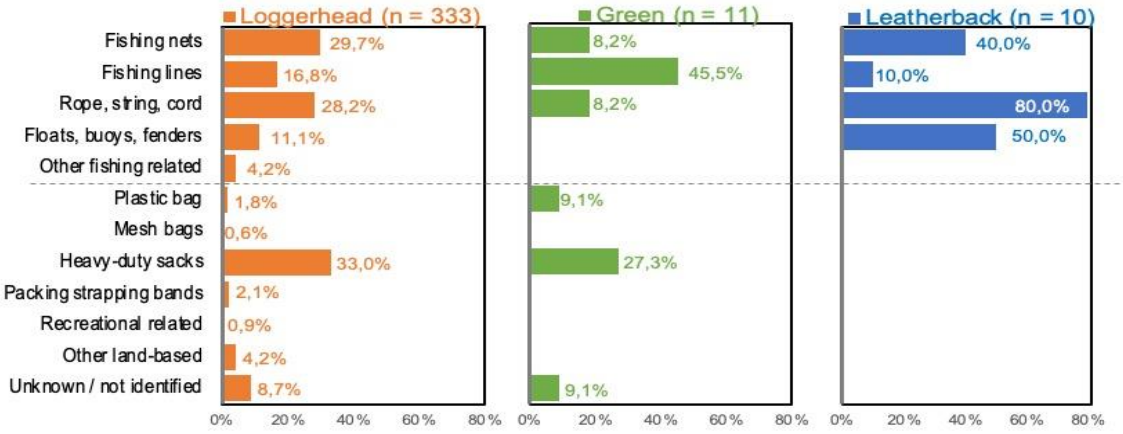

Figure 5. Frequency of litter typologies entangling different sea turtle species. Data from images obtained on social media (Mediterranean and Atlantic regions).

Even more, important regional differences were found on litter typologies impacting marine fauna in European waters. For regional analysis, only data loggerhead turtle data (N=230) were included to avoid variability between taxa and species, and 2 different Atlantic regions were established:

- Atlantic OSPAR region (ATL-OSPAR): including data from Atlantic France, Portugal (Azores, Madeira, mainland), and northern Spain.
- Atlantic Canary region (ATL-CAN): including data from the Canary Islands.

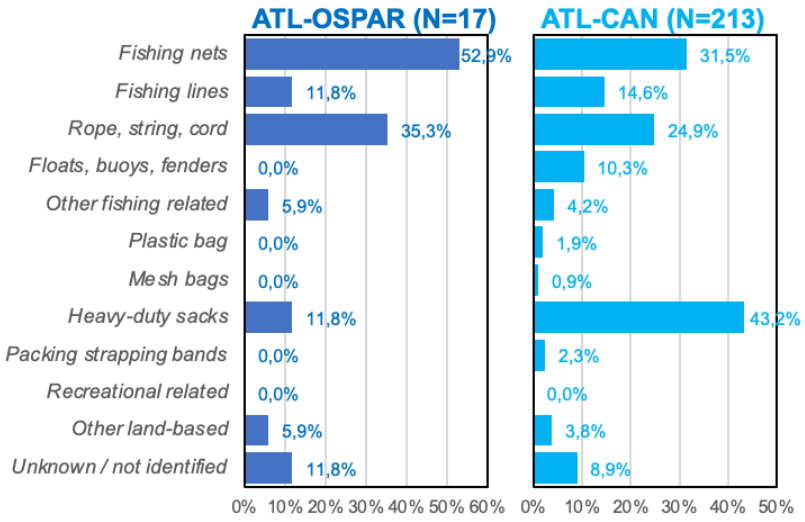

Figure 6. Frequency of litter typologies entangling loggerhead turtle per basin. Data from images obtained on social media & opportunistic platforms (Atlantic region).

Main results obtained on litter typologies impacting loggerhead turtles between these regions, from images obtained on social media, showed:

a) "Heavy-duty sacks" impact loggerhead turtles in the 2 regions. Moreover, it is most frequent on the Canary Islands (43,2% ATL-CAN), where is the most important litter category impacting loggerhead turtle.
b) "Fishing nets", "fishing lines" and "ropes, strings, cords" are frequently observed impacting loggerhead turtles in the 2 regions, with different frequencies.
c) "Mesh bags" were only observed in the Atlantic Canary Region.
d) The most important litter typologies observed by regions were:

- ATL-OSPAR: "fishing nets" (52,9%,) and "ropes, strings and cords" (35,3%).
- ATL-CAN: "heavy-duty sacks" (43,2%), "fishing nets" (31,5%) and "ropes, strings, cords" (24,9%).

2.1.3. Measuring the impact of entanglement on the animal's health

Entanglement may cause chronic or sub lethal effects that alter the biological and ecological performance of an individual over time, including reduced mobility, agility, or ability to ingest or digest food. All of these effects lead to reduced fitness, reproductive success and mobility. Tissue damage, such as skin lesions with ulceration or death of muscle tissue (necrotizing myositis) is a widespread result of entanglement (CMS, 2014; Orós *et al.*, 2005). Rope and line ligatures can cause amputations or wounds that leave sites exposed to infection, further reducing the likelihood of survival. For example, in turtles, entanglement usually results in flipper loss, where one flipper loss appears not to reduce their geographical range, whereas two flipper losses severely limit diving, feeding, and nesting abilities.

To solve this important constraint and try to measure the impact of entanglement on individual health, the INDICIT II consortium decided to:

- Create a new parameter called "Impact severity" based on the effect of injuries caused by entanglement on the animal's viability, with a scale of 5 degrees.

- Verify the utility of the new parameter with images obtained from social media and opportunistic platforms.

- **IMPACT SEVERITY:** based on the effect of injuries / lesions on animal viability.

Minor: Minor injuries that could heal quickly on their own. For example, mild skin abrasions or slightly cuts affecting only the epidermis (scratch).
Medium: Deeper injuries that will take longer to heal. For example, deep cuts crossing epidermis and dermis, throttle on the neck causing suffocation of the animal (no death), or dermatitis affecting a large area of animal body.
Severe: Serious injuries that alter the natural body condition of the animal. For example, amputations, bone fracture (flippers or carapace), eye loss or body deformations caused by the affection.
Extreme: Injuries that kill the animal (natural death or euthanasia in the rescue centre) or do not allows to reintroduce the animal on their natural habitat (unrecoverable animals).
Unknown: No data available about injuries

Figure 7. Impact severity scale (Extracted from the INDICIT II Standard Protocol)

Verification of the new parameter to measure the impact of entanglement on animal health ("impact severity")

The "impact severity" stablished by the INDICIT consortium (based on the effect of the injuries on the animal's viability), showed that the highest percentage (42,9%) of animals affected by entanglement in the Atlantic and Mediterranean regions presented a "medium" degree of impact, with typical injuries of deep cuts affecting epidermis and dermis, with different degree of infection, but not deriving in important alterations on the body condition or the viability of the animals. On the other hand, 10,5% suffered flipper amputation or body deformations (severe impact), and only on the 8,1% of the turtles the entanglement caused mortality (extreme impact).

In addition, the "Impact severity" in relation with litter typologies were also analyzed, where "fishing lines" and "heavy-duty sacks" presented the higher percentages of animals with severe impacts (15,5% and 10% respectively), where the viability of the animals were altered (amputations, bone fractures, eye loss, etc.), because these materials are the thinnest and very resistant, presenting a greater capacity to cut the skin, producing deeper wounds in a very short time.

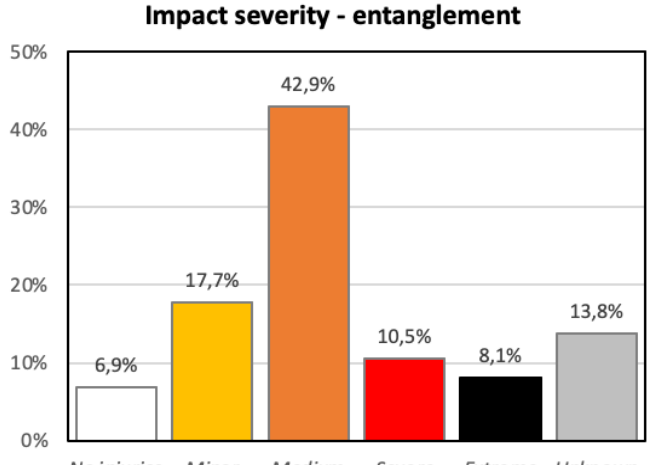

Figure 8. Impact severity of entanglement on loggerhead turtle. Data from images obtained on social media and opportunistic platforms (Atlantic and Mediterranean regions).

Litter typologies that caused the highest mortality were “fishing lines” (19%), “other land-based” (28,6%) and “plastic bags” (50%).

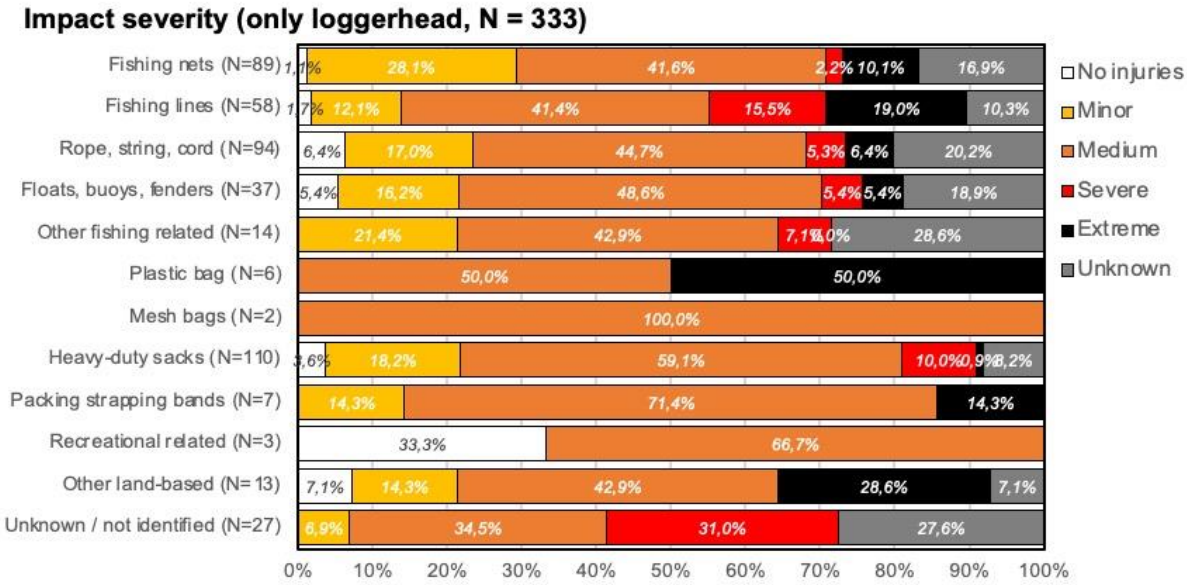

Figure 9. Frequency of Impact severity caused by litter typologies on entangled loggerheads. Data from images obtained on social media and opportunistic platforms (Atlantic and Mediterranean regions).

2.2 Standardization and harmonization of data collection

A review of historical databases from key stakeholders were conducted by INDICIT partners to better understand and identify the impact of entanglement in each specific region in the precedent years. In general, stranding networks and rescue centres aim to recover stranded animals, so they tend to focus on the health status and lesions observed on the animal, with little attention paid to other relevant data, such as the litter involved in entanglement events. For example, many entanglement cases are classified by stakeholders as “fisheries interaction”, which includes both bycatch of animals in active fishing gears and individuals entangled in marine litter (usually ghost nets). In many cases, extra data included in the datasets and databases could give indices to better identify and classify each stranding event.

One of the main constraints identified by INDICIT partners and stakeholders was the harmonization of data, mainly due to major differences in the criteria used to collect data on stranding events. In many cases, databases from stakeholders were not updated and homogenized, so many stakeholders did not arrive to share their databases with the INDICIT II project. Moreover, many stakeholders worked hard in their databases and included the standard data proposed to monitor entanglement in their protocols. Other stakeholders required a great deal of time and personal effort to update and homogenize their databases, such as the deep review of the 4429 data (2055 entangled animals) collected from sea turtles stranded in the Canary Islands (Spain) from 1989 to 2019 (9 stakeholders).

To solve this relevant constraint, the INDICIT II consortium created a Standard Protocol, which includes a variety of supporting materials (visual guide, full of images) to facilitate data collection. Many stakeholders started data collection based on the Standard Protocol in 2020.

2.2.1. Data sources

The external examination of live and dead specimens of marine fauna found at sea or on shore could be used to describe the impact of marine litter on biota, particularly caused by entanglement, in the perspective of defining an indicator for the D10C4 criteria of the MSFD. Different data sources could be used to collect data on marine litter entanglement.

Table 4. Main characteristics of different data sources to monitor litter entanglement of sea turtles in European waters.

	OPPORTUNISTIC DATA *(Social media images)*	**STANDARDIZED DATA** *(Stranding network + RC)*
Description:	Simple protocol for citizen science	Detailed protocol for trained personnel
Addressed to:	General public (citizen science)	Stranding network + Rescue Centres (RCs)
Data collected:	- Image (photo/video) - Date - Location	- Images (photos) - Date - Location - Biometry (stage) - Litter typology - Injuries generated (impact) - Mortality rate - Frequency (FO%)
Use of information:	To help understand information gaps or verify methodologies	Scientific analysis: allows to measure frequency, impact, trends, etc.
Advantages:	- Reach large audiences - Increase the volume of data - Disseminate educational information	**- Homogeneous effort** **- Data quality** (standardized) - Allows identification of new impacts
Disadvantages:	- Effort NOT homogeneous (depends on public participation in each region) - Requires a group of experts analyzing the images to homogenize criteria	- Requires the continuous collaboration of partners from different regions. - Only for partners with the capacity to collect detailed information.

All European countries have arranged organizational structures or systems to manage stranded or injured animals found at sea or on shores (stranding networks), with animals found alive generally being taken to appropriate facilities for rehabilitation (RCs), and dead animals being taken to authorized facilities (RCs, veterinary facilities, research institutions, etc.) to conduct protocolized necropsies.

In general, stranding networks conduct a continuous effort in specific areas/regions/countries, constituting an important source of data to monitor threats and impacts to marine fauna over time. A great variety of experts are involved in stranding networks (veterinarians, biologists, environmental authorities, etc.) and different parameters are collected to describe each stranding event. In most cases, rescue centres are coordinated with stranding networks where more data about the animals is collected.

The INDICIT II project involved these key stakeholders (stranding networks and RCs) to monitor entanglement in the European waters through standardized data collection based on the Standard Protocol developed by the INDICIT II consortium and described below.

2.2.2. Protocols developed by INDICIT project

In general, the most useful data to monitor entanglement are: the frequency of occurrence, the type of litter involved in the entanglement and the severity of the impact caused by the interaction. Other information is useful during the development stage of the D10C4 criteria, and to evaluate the biological constraints of the indicator.

INDICIT Project developed 2 Protocols:

- **Social Media Protocol**: to obtain images from social media to improve methodologies.
- **Standard Protocol**: to collect data on the indicator "entanglement on sea turtles".

Figure 10. Standard Protocol and Social Media Protocol.

The Standard Protocol contains two types of data:

a) **General data:** to obtain the frequency of occurrence (FO%) of entanglement per region and per year. Data to be collected are:
   - Area covered by the stakeholder.
   - Number of total animal stranded/registered by the stakeholder per year.
   - Number of animals affected by entanglement per year.

b) **Individual data**: to obtain accurate data on the impact of entanglement on marine fauna (focus on loggerhead sea turtle). Several parameters from each entangled animal were proposed, included in 4 different sections:
   - Stranding event characterization: date, location, circumstance, etc.
   - Individual characteristics: size, sex, conservation status (if dead), etc.
   - Litter characterization: to classify and characterize litter involved.
   - Litter impact: "Impact severity" parameter developed by INDICIT II.

All data is described in the Standard Protocol.

Once the Standard Protocol was finished, it was shared with stakeholders to obtain data and update the common database on entanglement.

Looking at the final database of the INDICIT II project, several data were easily collected by stakeholders from almost all the individuals (>70%). Moreover, some data were difficult (50-70%, highlighted in yellow in Table 5), or very difficult to be collected (<50%, highlighted in orange in Table 5).

Table 5. Standard data shared by the stakeholders with the INDICIT project.

Data name		Data class
Basin (ATL, MED)		mandatory
Country		mandatory
Region		mandatory
Stakeholder name		mandatory
INDICIT Partner		mandatory
Taxa (turtle, seabird, cetacean, seal, other)		mandatory
Species		mandatory
Animal tags *(metal tags, PIT tag)*		optional
Date of discovery		mandatory
Location at finding	***Location name***	mandatory
	Latitude / Longitude	optional
Circumstance *(stranded, at sea, other)*		mandatory
Status *(alive, dead, unknown)*		mandatory
Conservation status *(1, 2, 3, 4 ,5, unk)*		optional
Animal size reference (*)		mandatory
Biometric data	*CCLst*	mandatory
	CCLmin	optional
	CCLmax	optional
	SCLst	mandatory
	SCLmin	optional
	SCLmax	optional
Weight		mandatory
Sex (male, female, unknown)		optional
Pictures collected (yes, no, unknown)		mandatory
Litter typology *(multiple choice)*		mandatory
Litter size reference*: hand, elbow, arm, 1p, 2p, 3-6p, >6p.*		mandatory
Impact severity		mandatory
Main injuries (multiple choice)		optional
Affected body part (multiple choice)		optional
Litter characteristics	Color	optional
	Net material	optional
	Mesh size	optional
	Twine1 (knots)	optional
	Twine2 (D, S)	optional
	Twine3 (M, T, B)	optional
	Twine4 (thickness)	optional
Fishing gear (longline, trawler, serne)		optional
Observations		optional

To improve future data calls on sea turtle entanglement from stakeholders the following is required:

a) Understanding why some data is more difficult to collect:
   - Location at time of finding: the great majority of stakeholders collected the location name (92,2%), but almost none collected the coordinates (1,9%). The majority of stakeholders indicated that they do not use GPS devices to locate the stranding site.
   - Animal size reference: present in 66,7% of the data obtained, but many of them were translated from biometric data. This is a new parameter proposed by the INDICIT consortium and many stakeholders do not have the habit of collecting it.

b) Strengthening collection of relevant data:
   - Circumstance: only 44,2% of the data indicated whether the animal was stranded on shore, found at sea or bycaught in active fishing gears (not entanglement). These data are important to better distinguish entanglement from bycatch, or to identify if the animal was still not stranded.
   - Biometrics: reduced amount of data was collected (<15%), except for CCLmin/SCLmin, collected by the Canary Islands stakeholders (major proportion of data in the database). The mandatory biometric proposed by the INDICIT consortium was CCLst/SCLst that presented scarce data in the database (14,1%/10,2%). Biometric data requires to be reinforced as it indicates individual life stages and could be used together with weight to calculate the Body Condition Index (BCI), which is very important to measure the impact of entanglement on animal health.
   - Weight: collected in the 59,1% of cases, but strengthening this data collection could be relevant to obtain BCI to measure the impact of entanglement on animal health.
   - Litter typologies: only in 33,6% of the data obtained, and it is one of the most important data to be collected for the indicator and therefore needs to be reinforced. Many stakeholders indicated that often animals do not have the litter on them when they arrive at the stranding site.
   - Litter size reference: only on 7,3% of the data obtained. This is a new parameter proposed by the INDICIT consortium and many stakeholders do not have the habit of collecting it, and many stakeholders indicated that the animals often do not have the litter on them when they arrive at the stranding site.

c) Identifying data that could be modified, not collected, or collected in a different way:
   - Litter characteristics and fishing gear: almost all data proposed to describe litter derived from fisheries (color, net material, mesh size, twine), and/or to identify fishing gear, were collected in less than 10% of the data.

An important tool proposed by the INDICIT consortium to improve data collection was the inclusion of image collection in the Stranding Networks Protocols. Taking pictures of each stranding event is an important source of data that could be used to improve the description of each event or, in the future, to collect relevant information that was not registered at the time of stranding. The inclusion of pictures in the general stranding protocols of each organization is the first step to improve data collection.

In the specific case of entanglement, images will be essential to better identify litter typologies (and even litter characteristics), obtain litter and individual size, and even the impact severity of the entanglement (main injuries, animal status, etc.).

The INDICIT II consortium includes several recommendations in the Standard Protocol to collect pictures from each stranding event:

a) The pictures should be as clear as possible and taken from several angles:
   - General picture of the stranded animal and all the elements involved.
   - Details of litter entangling the animal.

- Detail of main external injuries.

b) The picture should include reference elements (rule, metric tape, pen, etc.) that allow to estimate size.
c) To request pictures of the animal to the people who found it: in many cases people's first reaction is to remove the debris from an entangled animal. Thus, by the time the official staff arrives, the material has already been removed.
d) The pictures should be carefully codified and stored: for this reason, the use of "Image storage applications" (Image App) is highly recommended as an important tool on the stranding networks to better identify each stranding event. Generally, these apps collect:
   - Date.
   - Location (coordinates).
   - Images, which are the most relevant data to describe each stranding event (other data could be extracted later from the image: species, relative size, animal status, main injuries, etc.).

To monitor entanglement, the inclusion of "Image storage applications" in the official stranding protocols could be very useful on data collection and harmonization (e.g. the App REDPROMAR (Canary Islands Government) for the Atlantic).

2.3. Results in the Atlantic region

By the end of the INDICIT II project, a standard database with data from 2203 entangled sea turtles in the Atlantic region was available (Table 6).

Table 6. Number of entangled sea turtles in the Atlantic region obtained from INDICIT stakeholders (stranding networks, rescue centres; Historic data: before 2013; Data from 2013 to 2020).

COUNTRY (region)		Period covered	SEA TURTLES		
			N total	*Historic data*	*Data 2013-2020*
ATL	**France**	No data	No data	No data	No data
	Portugal (Azores)	(2010 – 2020)	13	2	11
	Spain (Canary Is.)	(1989 – 2019)	2190	1724	464
TOTAL		**(1989 – 2020)**	**2203**	**1726**	**475**

Looking at sea turtle species, the loggerhead turtle represents the great majority of data. For this reason, main analysis on entanglement focusses on loggerhead sea turtles.

In general, the database is clearly influenced by the huge quantity of data obtained from the Canary Islands (99,2% of the total), which can introduce significant errors in the data analysis, and only shows the impact observed in this region.

From a temporal point of view, 78,3% of the data was historical data collected by stakeholders before 2013 in Portugal (Azores) and Spain (mainly Canary Islands). It should be noted that historical data is less accurate, due to the time elapsed since it was collected. In the period from 2013 to 2020, the database is still strongly influenced by data from the Canary Islands (97,5% of the data).

INDICIT II showed important gaps in data collection:

- There is a lack of data in the OSPAR region.
- Some stakeholders do not distinguish between entanglement and bycatch, where all data are classified as "interaction with fishing gears".

- Some stakeholders needed to harmonize their databases before sharing data, so these data could not be included in the INDICIT II database.

Looking at the entanglement Frequency of Occurrence (FO%, number of entangled individuals in relation to the total number of animals registered per year in one specific area), stakeholders shared the number of total individuals (Ntot) and entangled individuals (Nent) registered per year.

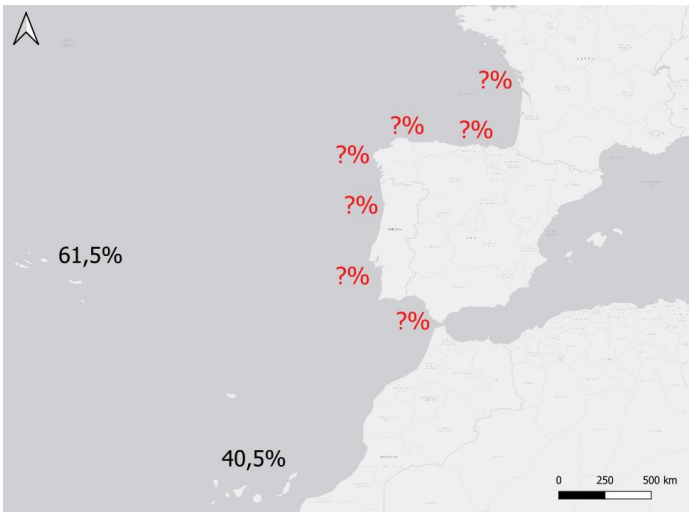

Figure 11. Entanglement FO% obtained with standard data on the OSPAR region (Data: from 2013 to 2020).

In the Atlantic basin, only data from the Macaronesian archipelagos were obtained, where the highest FO% was obtained in the Azores (61,5%, OSPAR region), even though the total number of individuals affected by entanglement is much higher in the Canary Island region (Nent = 435), due to the large number of sea turtle strandings registered.

Considering all data collected from all stakeholders (historical and data from 2013 to 2020) in the Atlantic region, in a high percentage of cases the litter typology involved in the entanglement was not identified.

A regional analysis of litter typologies involved in loggerhead turtle entanglements revealed important differences between the Atlantic and Mediterranean basins. A high percentage of cases in the Atlantic (56,1%) were associated with unidentified litter, compared to 16,9% in the Mediterranean.

In the Atlantic, the FO% of litter derived from fisheries and maritime sources (26,7%) is very close to the FO% of litter derived from land-based sources (20,9%), instead of the large difference observed in the Mediterranean where the FO% of litter derived from fisheries and maritime sources (66,9%) was more than three times higher than the FO% of litter derived from land-based sources (20,3%).

When looking at the specific litter typologies involved in the entanglement on loggerhead turtles, “fishing nets” and “heavy duty-sacks” were the most commonly observed litter typologies entangling the animals in the Atlantic region (this analysis is strongly influenced by the large amount of data collected from the Canary Islands).

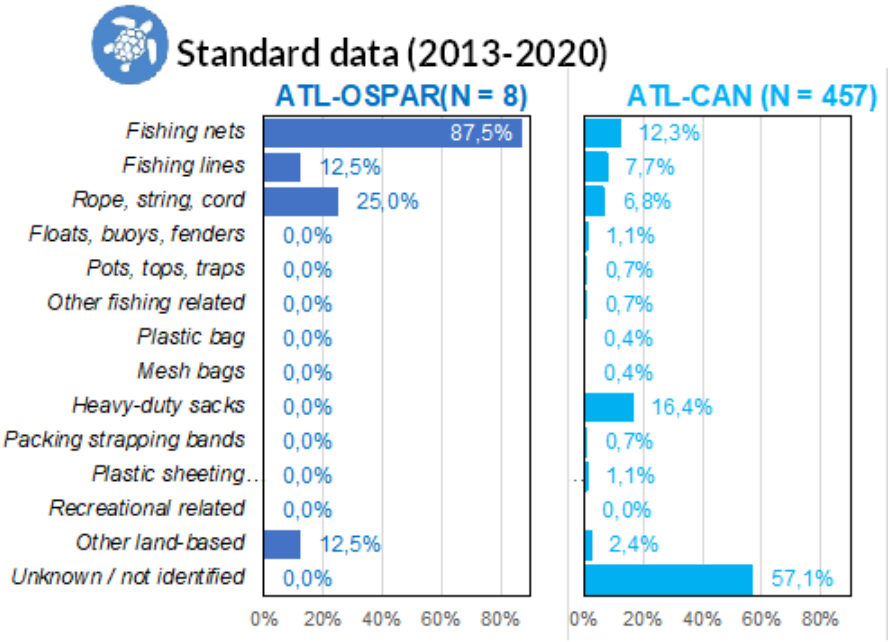

Figure 12. Frequency of litter typologies involved in sea turtle entanglement in the Atlantic waters, based on standard data (stranding networks, rescue centres).

In the Atlantic region, several typologies were observed only in the ATL-CAN ("floats, buoys and fenders"; "pots, tops and traps", "other fishing related", "plastic bags", "mesh bags", "packing strapping bands", "plastic sheeting greenhouse"), although this could be caused by the low number of entangled animals observed in the ATL-OSPAR (n=8) compared to the ATL-CAN (n=457). In the ATL-OSPAR, entanglement is clearly dominated by "fishing nets" (87,5%), followed far behind by "ropes, strings, cords" (25%). On the other hand, in the ATL-CAN region, the most frequently litter typology entangling loggerheads is "heavy-duty sacks" (16,4%), followed by "fishing nets" (12,3%).

2.4. Key stakeholders for collection of standard data

During the INDICIT I-II projects (2017 - 2022), key stakeholders were contacted by INDICIT partners to involve them in data collection, firstly on "litter ingestion by sea turtles", and secondly on "litter entanglement". Contact was made individually (email/phone, etc.) or during specific events such as conferences (e.g., ISTS in February 2019 in South Carolina, EE. UU), or thanks to the facilitation by EAB and national representatives. The INDICIT partners participated in national and international workshops related to marine litter and co-organized some of them (MICRO 2020). These events provided an opportunity not only to share INDICIT outputs and protocols, but also to expand the network.

During the projects, a Google map was updated to show the spatial distribution of the network, referencing all the stakeholders involved. At the same time, a stakeholders list was created containing the coordinates, characteristics and contact details of each stakeholder. The map and the list were shared with DG Environment (EU) and national representatives.

By the end of the INDICIT projects, 44 stakeholders in the Atlantic region had been contacted and involved in sharing data on marine litter entanglement of sea turtles, including:

- Stranding networks.

- Rescue centres.
- Transit centres: recovering specimens temporarily, to be transferred to rescue centres.
- Veterinarian institutions: in charge of necropsies and evaluation of health status.
- Research institutions: in charge of collecting data and analyzing samples. The focus is on gaining knowledge, particularly about sea turtles and the litter effects.
- Regional or national authorities.
- Institutions responsible for networking experts and exchanging information.

The structure of the stakeholder network for the collection of standard data varies greatly from country to country, with some countries having national or regional coordination. For example, in France, the Atlantic strandings are coordinated by the La Rochelle Aquarium and the Mediterranean strandings by the Montpellier Aquarium, both in coordination with the national authority (French Ministry of the Environment) and the national research institute.

In other countries there is no official stranding network, but there are regional organizations responsible for strandings. For example, in Spain different organizations (e.g., regional authorities, research institutions, RC, aquariums, NGOs) are involved in each province or island (in the Canaries regions), and the Ministry for the Ecological Transition and the Demographic Challenge has a national protocol for stranded sea turtles.

Networking recommendations

- In certain areas/countries, the network will need to be better developed, e.g. by creating/reinforcing stranding networks and rescue centres, ensuring constant means and training referents or coordinators at the local/regional level.
- The engagement of stakeholders in certain areas is necessary to provide accurate assessments of litter impacts and GES in European waters. This is particularly the case in the Atlantic basin, where important data gaps have been identified (France, mainland Portugal and Atlantic Spain).
- Specifically for entanglement, the inclusion of pictures in stranding protocols is the best way to obtain accurate databases that could be reviewed by experts on marine litter to harmonize litter classification. Some tools can support data collection, such as the Image App REDPROMAR, developed by the Canary Islands Government, or ObsEnMer, a collaborative platform managed by Cybelle Planete (France), which allows citizens or institutions (NGOs, RC, stranding networks) to post pictures with date and GPS coordinates.
- Key-stakeholders, such as fishermen, who are key to recovering sea turtles in certain areas, should be involved in monitoring litter.
- Organizing regional/national or international workshops between stakeholders, together with other experts and representatives, could facilitate the involvement of new stakeholders. These workshops should propose training sessions and exchange of experiences.

3. Other potential data in the OSPAR region

Several studies have been undertaken in the OSPAR region to understand the anthropogenic impacts on marine ecosystems, where sea turtles are reported to be a great indicator. In this sense, the first milestone was the inclusion of two marine turtle species (*C. Caretta* and *Dermochelys coriacea*) in the OSPAR List of Threatened and/or Declining Species and Habitats in 2003, on the basis of an evaluation of their status according to the Criteria for the Identification of Species and Habitats in need of Protection and their Method of Application (the Texel-Faial Criteria; OSPAR 2003).

In the following years, the OSPAR Commission conducted two studies on this topic; a background document for leatherback turtles (2009) and a background document for loggerhead turtles (2015). In 2020, the OSPAR Commission published the scooping study "An overview of anthropogenic impacts on loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles; measures and strategies for prevention in the OSPAR area" for the Biodiversity and Ecosystem series.

In the follow up to the OSPAR List of Threatened and/or Declining Species and Habitats, the last status assessments for both marine turtle species were published in 2022. The status of both species is set as poor, for the loggerhead in the OSPAR Regions IV and V, where it is observed, and for the leatherback turtle in all OSPAR regions. Furthermore, both species are assessed as significantly threatened or impacted in the aforementioned regions.

The last milestone is the Quality Status Report 2023 – the QSR 2023 – for the evaluation of the North-East Atlantic quality status and for taking forward OSPAR's vision of a clean, healthy and biologically diverse sea. It follows up on the previous QSRs – the QSR 2010 and QRS 2000 – as well as earlier QSRs specific to the North Sea. The QSR 2023 reflects the collective effort made by contracting parties over the period 2009 to 2019 to manage, monitor and assess the many pressures on the diverse ecosystems of the North-East Atlantic and the impacts that they bring.

The efforts carried out in the OSPAR region show that loggerheads breed in North-West Atlantic, Gulf of Mexico and Caribbean coasts. Apparently, the limit of distribution is waters of about 10°C. The majority of loggerhead turtles found in the OSPAR maritime area are thought to originate from North-West Atlantic and Cape Verdean populations (Monzón-Arguello *et al*., 2012) This species is known to occur in large numbers around the Azores and in waters north of these islands, as well as along the Atlantic coast of the Iberian Peninsula. While detailed information on population sizes and trends is difficult to obtain and interpret (the main source of uncertainty being the limited information on nesting activity along the coast of North-West Africa according to Casale and Marco (2015)), the analyses carried out in 2009 showed that data from the past 10-23 years from different sites within the North-West Atlantic Distinct Population Segment (DPS) did show a severe decline overall.

The Loggerhead turtle is recorded regularly in the Bay of Biscay and Iberian Coast (Region IV) and the Wider Atlantic (Region V). In fact, Region V comprises important oceanic developmental habitats for juveniles originating primarily from South-Eastern United States rookeries, especially in the Azores. In terms of conservation, Regional Management Units (RMU) have been defined for all marine turtle species globally, including *Caretta caretta* (Wallace et al., 2020, 2023). It is important to note that part of the OSPAR maritime area (mainly regions IV and V, but also region III) is included in the North East Atlantic and North West Atlantic RMUs for this species and that the Cape Verde Archipelago constitutes the most important nesting site within the North-East Atlantic RMU (Casale and Marco, 2015).

On the other hand, leatherback is the only marine turtle considered a regular and normal member of North American and European Atlantic waters (Martin, 2003), and hence the OSPAR Maritime Area is within the natural foraging range of this species, but there are no nesting beaches in the OSPAR Maritime Area. The North Atlantic is considered a stronghold for sub-adult to mature leatherback sea turtles (Doyle *et al*., 2008) due to food

abundance.

The Status Assessment (2022) on leatherback turtles stablished that they are predominantly recorded in Regions II, III and IV in the summer months, coincident with abundant jellyfish on which they prey. However, the Scottish Entanglement Alliance affirms that leatherback turtle entanglements are distributed in autumn and early winter, corresponding to changing prey foraging patterns for this species in the OSPAR Regions II and III. From a conservation point of view, it is highlighted that part of the OSPAR maritime area (regions III, IV, V and part of region II) is included in the North West Atlantic RMU for this species.

Using data from nesting beaches, the global population of adult female leatherback turtles was estimated to be around 115.000 individuals in the early 1980's and the population as a whole was considered to be endangered (Pritchard, 1982). A figure of around 34.500 individuals was estimated by Spotila *et al.* in 1996, suggesting a decline of around 60% for that period. Most recently, the 2019 IUCN Assessment for North-West Atlantic Ocean subpopulation of *Dermochelys coriacea* sets the number of mature individuals at 20.000. The NWA Leatherback Working Group summarized trend analyses from intermediate, and long-term temporal windows using existing time series datasets of annual nest counts from beaches throughout the Wider Caribbean region, with results showing negative long-term trends at site, genetic stock, and regionwide scales (NWA Leatherback Working Group 2018). There are no estimates of the likely population size in the OSPAR Maritime Area (OSPAR 2006) and it has not been possible to determine trends due to the limited data available (Leatherback turtle - Status Assessment, 2022).

Regarding long term abundance trends, the loggerhead turtle appears to be stable in Region V (2001 to 2015) according to its status assessment 2022. In contrast, the North-West Atlantic leatherback population is in decline and listed as "critically endangered" (IUCN red list), and continues to be significantly impacted by bycatch and marine litter. Both conclusions have been conducted with limited data, both spatially and temporary. Therefore, trends in distribution and population remain unknown for all the five regions for both leatherback and loggerhead turtles.

Finally, for green turtles (*Chelonia mydas*), Rodríguez *et al.* (2022) analyzed stranding events in the Azores archipelago to investigate interactions with marine litter. The stranding network in the Azores collected data between 2000 and 2020 from a total of 21 green turtles. Entanglement in marine litter was detected in three stranded green turtles (14% FO), all of which were entangled in plastic items related with fishing activities, specifically in ALDFG. This study demonstrated that the Azores archipelago is the northernmost foraging habitat for juvenile green turtles in the NE Atlantic, and further revealed their vulnerability to marine litter. However, green turtles are mainly reported in the Mediterranean basin and are not included in the OSPAR List.

The lack of information on population size and their distribution range is the main difficulty in sea turtles conservation, which is generally extrapolated from the number of turtles that are reported stranded or bycaught. New indicators including abundance trends, have been proposed to OSPAR by the Sea Turtle Expert Group.

3.1. Threats identified

In the scoping study on anthropogenic impacts on loggerhead and leatherback turtles by the OSPAR Commission (2020) the threats identified for both marine turtle species were bycatch, being the most impacting pressure, especially in Spain and Portugal, followed by litter (ingestion and entanglement), collisions and contaminants.

The status assessment (2022) carried out for both marine turtle species identified the same threats as the scooping study, with bycatch in the surface longline fishery and marine debris ingestion being the main threads for loggerhead turtles, and bycatch and marine litter (ingestion and entanglement) the main impacts for

leatherback turtles. Bycatch and debris ingestion are considered to be the most important anthropogenic mortality factors known within the OSPAR maritime area (Angel *et al.,* 2013; Bellido *et al*., 2010).

For loggerheads, current monitoring programmes are insufficient to measure the impact, and long time series are still lacking. Likewise, monitoring of entanglement and distinguishing it from bycatch is still under development, although in the OSPAR area, entanglement has been reported in loggerhead and leatherback turtles in UK, France and Macaronesia since 1998 (Barreiros & Raykov, 2014; Calabuig Miranda & Liria Loza, 2007; Alves, Liria-Loza, Santos & RTMAE CESTM, pers. comm.; Claro & Hubert, 2011; Dellinger, 2007; Duguy *et al*., 1998; Nicolau *et al*., 2016).

In terms of marine litter impacts, two types of macro-debris pose a threat to sea turtles: plastic debris (see OSPAR Commission, 2015 for definition), which is mainly ingested, and ghost nets (ALDFG at sea by fishermen), which often entangle turtles (Duncan *et al*., 2017).

All the studies carried out by the OSPAR Commission show agreement in the lack of data available to assess the impact of litter on marine turtles. Additionally, when the focus is on entanglement, the problem of data scarcity is greater, and therefore, there is a need to standardize and conduct monitoring. Claro *et al.* (2019) state of the art approach and feasibility study identifies gaps of knowledge for potential megafauna indicator species, particularly on spatio-temporal variability of entanglement and factors of sensitivity. The study underlines the need for standard methodologies and provides recommendations for the development of an entanglement indicator and a long-term monitoring programme.

3.2. Conservation efforts

One of the most promising advances in marine conservation is the development of marine protected areas (MPAs) on an ecosystem scale. Studies have confirmed the efficacy of MPAs for these ecological goals, but they do not fully address the needs of migratory species. Of the two species of turtle listed by OSPAR as threatened and/or declining, *Caretta caretta* is considered to be adequately represented and replicated within the OSPAR MPA network, but protection for *Dermochelys coriacea* is lacking in OSPAR Regions I, II and III. For migratory species, the solution is not ecosystem protection alone, but taxon-specific protection of vulnerable life stages (Bowen & Roman, 2005).

Besides the Habitat Directive and the Marine Strategy Framework Directive implemented by all EU Member States, some Contracting Parties have put national regulation into force to protect sea turtles: France, Portugal and Spain have national decrees for the protection of sea turtles (the Ministerial Order of October 14, 2005 (FR); the Decree-laws 140/99 and 49/2005 (POR); Royal Decree 139/2011 of February 4, 2011 and law 42/2007 on Natural Heritage and Biodiversity (SP) respectively). Furthermore, some measures are being implemented by Contracting Parties, such as Spain, which has already promoted the setting of deeper longlines (Báez *et al.,* 2006) and is also implementing the replacement of baits and hooks by surface longlining. Spain is also testing lightsticks in gillnets (Mangel *et al*., 2018; Martin & Crawford, 2015).

In the OSPAR region, other projects have been developed to improve the conservation status of marine turtles in addition to the INDICIT projects.

The Scottish Entanglement Alliance (SEA) undertook a two-year long project sought to assess the extent, scale and impact of marine animal entanglements in creel fishing gear from an animal welfare, conservation and industry perspective (NatureScot Research Report 1268, 2021). In this report they notified that some species, especially basking sharks and marine turtles, are hardly ever reported to the national strandings networks, despite being cited by fishers as common victims of entanglements.

The Scottish Marine Animal Stranding Scheme (SMASS) aims to provide a systematic and coordinated approach to the surveillance of Scotland's marine species by collating, analyzing and reporting data of all cetaceans, seals, marine turtles and basking sharks that strand on the Scottish coastline. Regarding the type of entanglement, they noticed that marine turtles are mostly found with evidence of entanglement marks consistent with ropes used in creel fishing, although cases involving trawl and monofilament netting have also been recorded. The majority of leatherback turtles (*Dermochelys coriacea*) were found entangled in endlines.

On the other hand, the COSTA project (COnsolidating Sea Turtle conservation in the Azores) aims to conserve sea turtles in the Azores and their marine habitat in the North Atlantic through monitoring, research and technical training. It is carried out by the Institute of Marine Research (IMAR) and the Azores Fisheries Observer Program (POPA) in collaboration with the Sea Observatory of the Azores (OMA), the Regional Directorate of Sea Affairs (DRAM) and the Polytechnic Institute of Leiria (IPL). This is an important project for collecting data on incidental catches of sea turtles in the Azores, as well as collecting biological and demographic data.

3.3. Recommended actions

The scoping study on anthropogenic impacts on loggerhead and leatherback turtles by the OSPAR Commission (2020) includes several actions recommended by experts to reduce the impact of marine litter (ingestion and entanglement) on sea turtles:

- Developing standardized data collection protocols and improving monitoring to identify and understand the main sources of entanglement in the Eastern Atlantic and to develop adequate strategies and management plans.
- In the framework of the revision of the RAP-ML, supporting and developing programmes and measures to reduce the quantity of litter reaching the marine environment.
- Supporting and improving stranding networks and recovery centres facilities and logistics means to ensure an adequate control and data collection of all impacted individuals, as well as the conservation of important individuals for the population dynamics.

More general recommended OSPAR actions and measures are included in the background documents for leatherback (2009) and loggerhead (2015) turtles:

- By the OSPAR Commission:
    - Ensuring policy coordination across agencies/authorities.
    - Encouraging Contracting Parties that are also EU Member States to place observers aboard fishing vessels as required by EC Regulation 812/2004 for the purposes of monitoring cetacean bycatch, and to include loggerhead turtles in their reporting work in partnership with Regional Fisheries Management Organizations.
    - Working with Contracting Parties and the European Commission to clarify conservation objectives and the links to management actions in MPAs particularly in relation to measures that aim to regulate effects of fishing that compromise conservation objectives (ICES, 2008).
    - Supporting a regional sightings database.
    - Increasing the number of MPAs focused on the conservation of loggerhead turtles, which could also provide protection and encompass a number of other OSPAR-listed species (sharks in particular) and the seamount habitat.
    - Continuing to work in partnership with NGOs striving to reduce marine litter.
    - Working in partnership with RFMOs.
- By Contracting Parties:
    - Including loggerhead and leatherback turtles in existing stranding systems.
    - Increasing collaboration between national Sea Turtle Stranding Networks.
    - Supporting efforts to decrease plastic marine debris.
    - Supporting marine turtle satellite-tracking research programmes.
    - Strengthening port-state control to reduce oil pollution from ships.
    - Encouraging voluntary reporting of turtle bycatch.
- By the responsible authorities to whom the OSPAR Commission can make its concerns known:
    - Recommending mitigation measures (e.g., reduced daylight soak time for longline gear) to appropriate fishing authorities.
    - Recording information provided by fishermen on routine fisheries inspection visits.
    - Encouraging voluntary reporting of turtle bycatch.
    - Encouraging public availability of fishing boat, gear type and VMS data in order to correctly evaluate and situate accidental Catch Per Unit Effort.
    - Encouraging common standards for data recorded in order to facilitate wider-scale analysis.

Some of these recommended actions have been implemented by Contracting Parties. The Overview Assessment

of Implementation of OSPAR POSH Recommendations, as part of the QSR 2023, identifies that the Contracting Parties reporting indicates good engagement for the implementation of these Recommendations by the Contracting Parties for which the species are relevant (predominantly in Regions III, IV and V). In most cases, Contracting Parties who are implementing the Recommendation indicated this is being done through a combination of legislative, administrative and negotiated actions.

All reporting Contracting Parties indicated that national legislation was in place to protect both the Loggerhead and Leatherback turtles. Two Contracting Parties noted that these species are covered by the EU MSFD, EU Habitats Directive Annex IV, Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention).

Monitoring actions are in place in all reporting Contracting Parties. Two Contracting Parties reported the inclusion of turtles in the monitoring by fisheries observers and three included mechanisms for recording incidence of stranded animals. One Contracting Party reported using regular aerial surveys to monitor the distribution and abundance of sea turtles. Two Contracting Parties have MPAs designated in areas where turtles are observed, and where turtles were a designated feature for one of the Contracting Parties.

However, efforts throughout the OSPAR region are mainly focused on reducing bycatch or interaction with marine litter by ingestion, while entanglement is still not as well assessed as other interactions, hence the need to develop an indicator for entanglement and distinguish it from bycatch.

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