Impact of litter on sea turtles and marine fauna: an evaluation of ingestion and entanglement at the European and Regional Sea Convention scales.

Darmon G.[1*], Claro F. [2], Liria Loza A.[3], Matiddi M.[4], Miaud C.[1*], Attia El Hili H.[5], Bradai M.N.[5], Camedda A.[6], Chaieb O. [5], de Lucia G.A.[6], Kaberi H.[7], Kaska Y.[8], Novillo O. [9], Paramio L.[10], Pham C.K.[11], Silvestri C.[4], Sozbilen D.[8], Tomás J.[9], Tsangaris C.[7], Vale M.[10], Vandeperre F.[11] ; * coordination@indicit-europa.eu

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BACKGROUND

Marine litter affects marine species at all trophic levels, mainly through **ingestion or entanglement**. These interactions with marine litter often result in **fatal or sub-lethal effects** which decrease individuals' chances of survival and reproduction. **Sea turtles** are of particular concern, since they are prone to ingest marine debris. The **loggerhead turtle** *Caretta caretta* is proposed as a relevant **bio-indicator species of the marine litter impacts** on biota in the framework of **marine environmental policies** which have to monitor the efficiency of conservation and restoration measures.

In this perspective, a **global standardized methodological approach** and thresholds of marine ***Good Environmental Status*** (GES) are urgently needed. Besides, the relevance of **other indicators of litter impact on biota** need to be evaluated.

INDICIT CONSORTIUM

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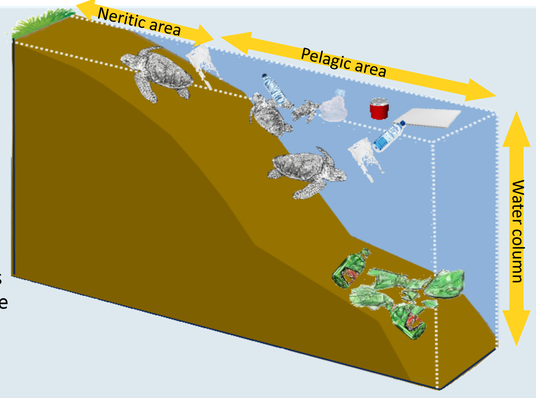

Figure 1: By using the surface and the water column of the neritic and the pelagic marine compartments, sea turtles can reflect litter abundance in numerous marine compartments.

WHY IS THE LOGGERHEAD CHOSEN AS A CANDIDATE BIOINDICATOR SPECIES?

The **loggerhead turtle** was identified as a **relevant indicator species** of anthropogenic debris in the Mediterranean Sea by the European community and the Barcelona convention (UNEP Mediterranean Action Plan) since 2013, because of:

- Its propensity to **ingest debris**;
- Its extended **distribution**;
- Its ability to use of various marine **compartments** (Fig. 1);
- The **abundance** of specimens and of existing **data**.

"Litter ingested by sea turtles" was also considered as a **new indicator** for the OSPAR Regional Sea Convention (RSC) (Fig. 2), in region IV (South: Bay of Biscay, Iberian Coast), since 2016. Other sea turtle species were also suggested to be considered.

OBJECTIVES AND METHODOLOGY

In order to support the **implementation of the indicator "Litter ingested by sea turtles"** and define the **feasibility** of the implementation of an **"Entanglement"** and **"micro-debris ingestion" indicators** in the **waters of the European Community and RSCs** (Fig. 2), the INDICIT consortium carried out:

1) a **literature review**, 2) an **evaluation of the GES** and criteria of the indicator "**Litter ingested by sea turtles**, 3) the calculation of the averaged **prevalence and quantities of ingested litter** and 4) the development of a **standardized procedure** for live and dead individuals, from the Marine Strategy Framework Directive (MSFD) guidelines.

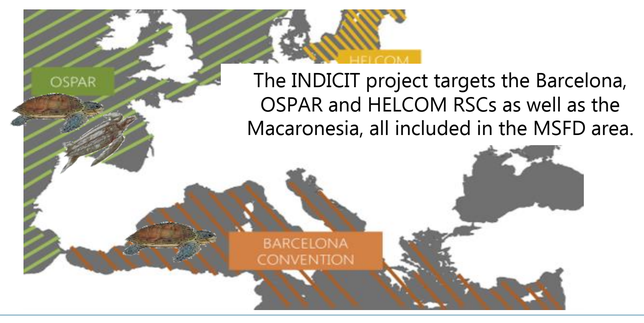

Figure 2: Besides *C. caretta*, *D.coriacea* which frequents the Northern Atlantic side of the area, was also considered. Other impact of litter on marine fauna (entanglement) and specifically on fish (micro-plastic (< 5 mm) ingestion) was evaluated at this area.

PREVALENCE AND VARIATION OF LITTER INGESTION

In the literature, the occurrence of **litter ingestion in *C. caretta*** varied from 5% (Turkey) to **100%** in several countries locally. In ***D. coriacea*, the occurrence** reached close to **90%** (Atlantic France) (Fig. 3). Spatial variations could indicate sub-regional differences in pollution levels (statistically non-significant up to date). **Plastics** were the most frequently **ingested litter** (Fig. 4). The mean dry mass of litter was respectively of 7.8 ± 12.3 g (grand mean from 11 studies) for loggerhead and 7.3 ± 9.1 g for leatherback (1 study). Studies used a ide range of protocols and were **barely comparable**.

Defining GES requires to define either **a target threshold** based on a minimum occurrence and quantity of ingested litter, or **a percent decrease** over time. This requires the **acquisition of a large standardized dataset**, which was undertaken by the INDICIT consortium. Our first results (Dec. 2017) showed a higher estimated occurrence in necropsied (**57.8 ±2.1** (st. er.)%, n=531) compared live individuals' faeces (19.6 ±2.2%, n=316) in *C. Caretta*. Considering necropsies, we found equivalent occurrence in both species (**52 ±5.1%** in 98 *D. coriacea*). In *C. caretta*, the occurrence was higher in the Mediterranean compared to the Atlantic (**63.1 ± 2.3%** and **37 ±4.7%** respectively). Mean dry mass of ingested plastics in this species was **0.52 ±0.07 g**.

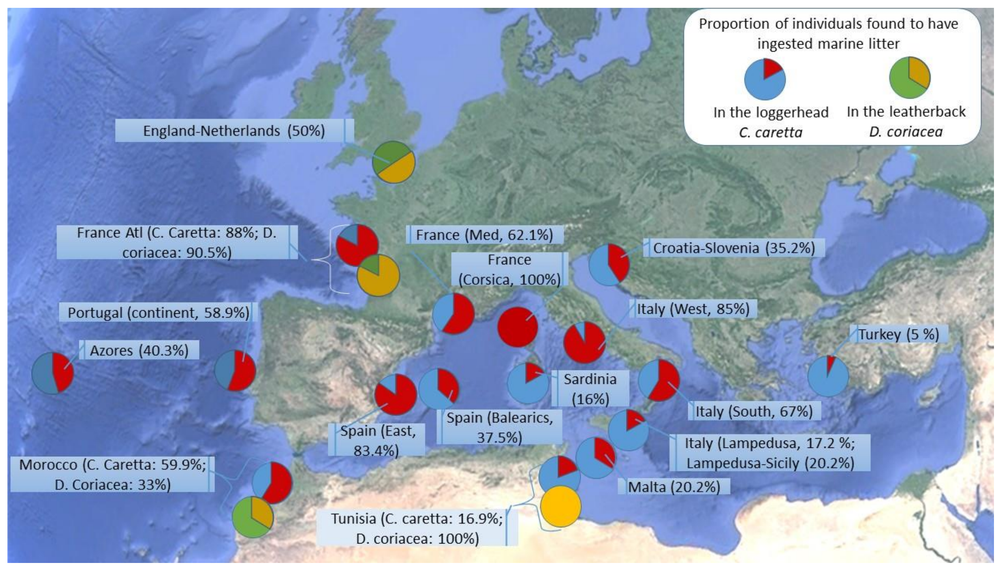

Figure 3: Averaged percentages of individuals having ingested litter in *C. caretta* (% in red, compared to 100% of the tested individuals, in blue) and *D. coriacea* (% in yellow compared to 100% in green) calculated from the literature between 1967 and 2016 (respectively N=30 and 6 records).

ENTANGLEMENT, A NEW INDICATOR?

Our **literature analysis** and survey stressed the **emergency of improving the knowledge** about this harm (Table 1). **Four taxa** appeared relevant for an Entanglement indicator (Table 1). However, several factors influencing this impact of litter need to be further investigated, particularly in megafauna and invertebrates. The **main methodological constraint** is related to the difficulty **to determine the material responsible** for the entanglement due to a possible confusion between litter from fisheries and material from active bycatch (Fig. 5), especially for sea turtles and marine mammals. In birds, "entanglement in nest" overcomes this issue in certain species (*Phalacrocorax aristotelis* and *Morus bassanus*), where this interaction is clearly due to debris. At sea, **misdetection is also a key issue**, since entangled specimens floating at the surface or in the water column are uneasy to perceive, as well as the specimen sinking towards the sea floor or being predated. **Entanglement of corals on the sea floor is a promising indicator**, because the monitoring cannot miss specimens. However, this kind of monitoring requires heavy logistics (e.g. ROV and imaging means), which may be mutualized during oceanographic campaigns.

RELEVANCE OF A MICRO-DEBRIS INDICATOR

A **specific indicator for micro-litter ingestion** appeared **relevant**. In sea turtles, authors generally did not differentiate such items, preventing to define the criteria for such an indicator. However, **networks could be equipped** to collect **standardized data** specifically on the 1-5 mm ingested litter.

Figure 4: Sheet like plastics, fragments and threadlike plastics, generally white or transparent, are the most commonly debris items ingested by sea turtles, found either in digestive tract or in faeces (Photo: G. Darmon)

TAXA	PREVALENCE	OCEANIC COMPARTMENTS /SAMPLING DEVICES									CONSTRAINTS		
		coast			surface			water column		floor	method.	biol.	logist.
		RC	STN	NN	AES	RC	ASC	RC	ASC	ASC			
MAMMALS													
seals	0.25-6.5%												
cetaceans	0.1-30%												
BIRDS*	0-20%												
SEA TURTLES	0.1-58%												
INVERTEBRATE	1-23%												(ROV)

Table 1: Taxa possibly relevant for an Entanglement indicator in the INDICIT project area, and criteria for feasibility. **P. aristotelis, M. bassanus,C. diomedea ;* STN= stranding network ; NN= nesting monitoring networks ; ASC= at sea campaigns (fisheries, oceanographic, citizen science) ; RC= rescue centers ; AES= aerial surveys ; ROV= remote operated vehicles ; *method.*= methodological ; *biol.* = biological ; *logist.* = logistical.

Figure 5: Sea turtles are highly concerned by entanglement in litter. One of the main constraints in the use of an Entanglement indicator is the differentiation between "litter" and "active bycatch" (photos: HCMR; A. Liria Loza)

Figure 6: The use of a common protocol is necessary to collect standardized data and monitor the efficiency of restauration measures. (Photos: LDA30, G. Darmon)

PERSPECTIVES

This study confirmed the **importance of developing** and **disseminating a standardized procedure for monitoring litter impacts on sea turtles** and other biota. **Standardization** constitutes not only a key approach for improving the knowledge regarding the anthropogenic pressures on sea turtles and other biota at a global scale, but this is also a major challenge for **monitoring ocean conservation** and **efficiency of management measures**. In the perspective of a continuous monitoring program, t**he next steps** will be to assess the **existing permanent sampling device capacity** and to develop **networking with stakeholders** interested in this issue (Figs 6 and 7). The **INDICIT progress** are documented in https://indicit-europa.eu/.

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Figure 7: Stranding networks and rescue centres are key actors for the monitoring of litter impacts on sea turtles (Photo: CESTMed).