JOINT CIBBRINA-ICES-MARINE BEACON-REDUCE WORKSHOP ON MITIGATION MEASURES TO MINIMISE MARINE TURTLE BYCATCH (WKTURTLE)

VOLUME 8 | ISSUE 6

ICES SCIENTIFIC REPORTS

RAPPORTS
SCIENTIFIQUES DU CIEM



ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
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ISSN number: 2618-1371

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ICES Scientific Reports

Volume 8 | Issue 6

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Recommended format for purpose of citation:

ICES. 2026. Joint CIBBRiNA-ICES-Marine Beacon-REDUCE Workshop on Mitigation Measures to minimise Marine Turtle Bycatch (WKTURTLE).
ICES Scientific Reports. 8:6. 56 pp. https://doi.org/10.17895/ices.pub.31008598

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i Executive summary

Marine turtle bycatch remains a critical issue in European marine fisheries, particularly impacting loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles, in the Mediterranean and North Atlantic respectively. Bycatch threatens the survival of these species and may undermine conservation efforts. The Joint CIBBRiNA-ICES-Marine Beacon-REDUCE Workshop on Mitigation Measures to minimise Marine Turtle Bycatch (WKTURTLE) aimed to synthesise bycatch information (by compiling and assessing existing information on sea turtle bycatch in European fisheries) and review current mitigation techniques and their effectiveness to support policy development reducing turtle bycatch.

The workshop brought together experts in fisheries, conservation biology, and policy from across Europe and beyond. This report summarises key findings, methodological approaches and identified gaps; it also suggests actions for better management of sea turtle bycatch and a possible roadmap for developing assessments in the ICES framework.

Preliminary bycatch data were collated from national reports, scientific publications, and ICES WGBYC reports. Mitigation measures were evaluated based on existing experiences on experimental trials' success, observer programmes effectiveness, and fisheries-independent studies.

Key findings from the workshop included the following:

- data gaps exist due to inconsistent reporting and limited observer coverage;
- loggerhead turtles are the most affected species (this may simply reflect their high densities and wide distribution);
- mitigation measures, such as circle hooks, bait type alteration, and turtle excluder devices, are effective and show promise but are still not widely implemented and they cannot be applied indiscriminately (one size does not fit all).

The WKTURTLE main recommendations were:

- to increase observer coverage and standardise bycatch data reporting across EU Member States;
- to promote the use of proven mitigation techniques through regulatory incentives and training and within an assessment framework;
- to support further research on species distribution, gear modification, and post-release mortality;
- to enhance regional cooperation and data sharing frameworks.

In conclusion, reducing sea turtle bycatch requires coordinated efforts across scientific, regulatory, and fishing communities. This report provides a foundation for informed policy-making and highlights the urgency of management action (monitoring and mitigation) to protect vulnerable sea turtle populations in European waters.

Keywords: sea turtle bycatch, mitigation, Mediterranean, Northeast Atlantic, small-scale and industrial.

ii Expert group information

Expert group name	Workshop on Mitigation Measures to minimize Marine Turtle Bycatch (WKTURTLE)
Expert group cycle	Annual
Year cycle started	2025
Reporting year in cycle	1/1
Chair	Caterina M. Fortuna, Italy
Meeting venue(s) and dates	3-5 February 2025, online, (28 participants)

1 Context

Marine turtle bycatch represents a well-documented global conservation challenge (Wallace *et al.* 2010; Lewison *et al.* 2014). This is true of the Mediterranean Sea, the southern Northeast Atlantic, including the Macaronesian archipelagos and in the southern Northwest Atlantic specifically French Guiana. However, in these regions, persistent gaps in monitoring, data collection, and standardized reporting significantly constrain our understanding of bycatch impacts on local turtle populations. This lack of robust, region-specific data continues to hinder the development of effective management strategies, despite recent advances in conservation status assessments (Casale & Tucker 2017) and recent evidence highlighting potentially significant bycatch rates in the Northeast Atlantic (e.g., Parra *et al.* 2023a).

The Joint CIBBRiNA-ICES-MarineBeacon-REDUCE Workshop on Mitigation Measures to Minimise Marine Turtle Bycatch (WKTURTLE) was established as an initial step towards aligning and enhancing ongoing efforts in this field by the International Council for the exploration of the Sea (ICES) and the (then) three active European Union (EU)-funded projects. The primary objective of WKTURTLE was to consolidate current knowledge on marine turtle bycatch and associated mortality, with the aim of identifying the most effective and readily available mitigation methods and strategies. Specifically, WKTURTLE focused on reviewing:

- the nature and extent of interactions between marine turtles and fisheries in the Northeast Atlantic and Mediterranean Sea (ICES Science Plan code: 2.1);
- the factors influencing mortality rates of bycaught marine turtles, including consideration of direct mortality, handling practices, and post-release survival (ICES Science Plan code: 6.1); and
- the mitigation options available to reduce marine turtle bycatch and associated mortality (ICES Science Plan code: 2.1).

1.1 ICES work on bycatch

ICES provides annual scientific advice to the European Commission (EC) on bycatch of endangered, threatened and protected (ETP) species as outlined in a specific agreement between ICES and the EC's Directorate-General for Maritime Affairs and Fisheries (DG-MARE).[1] ICES also provides advice and information on the bycatch of ETP species to relevant stakeholders via the ICES fisheries overviews.[2]

The basis of such advice is the work of the ICES Working Group on Bycatch of Protected Species (WGBYC), which collates and assesses information on bycatch monitoring and assessment for protected species, including mammals, birds, turtles, and rare fish. The WGBYC also looks at relevant bycatch mitigation measures and helps coordinate relevant experimental work. See section 2.2 below for further details.

Since 2020, ICES has provided scientific advice on bycatch of ETP species in response to specific requests from DG-MARE (advice regarding common dolphin and harbour porpoise bycatch in

[1] https://www.ices.dk/about-ICES/global-cooperation/Pages/Cooperation-agreements.aspx

[2] https://www.ices.dk/advice/Fisheries-overviews/Pages/fisheries-overviews.aspx

2020, 2023, and 2024), the EC's Directorate-General for Environment (DG-ENV) (advice on suitable monitoring systems for ETP species bycatch in 2024), North-East Atlantic Fisheries Commission (NEAFC) (advice on seabird bycatch in 2023), and the OSPAR Commission (or OSPAR, so named because it is derived from the Oslo and Paris Conventions) (advice on marine mammal bycatch mortality in 2021). This type of "special advice" has been developed through dedicated workshops, where relevant knowledge was gathered and summarized.

Activities related to ETP species bycatch in ICES are coordinated in the framework of the ICES Roadmap for bycatch of endangered, threatened, and protected (ETP) species (ICES, 2024c). The overarching goal of the roadmap is to guide the development of robust bycatch assessments and advice for ETP species through improvements in data and methodology, in line with current and future management needs. The roadmap highlights eleven different expert groups contributing to ETP species bycatch activities and their roles.

Additional new expert groups that may be of relevance for WKTURTLE's aims and objectives are the Working Group on Stakeholder Engagement (WGENGAGE) and the Working Group on Innovative Gears (WGING).

ICES collaborates with several ongoing projects related to ETP species bycatch, including some of those described in section 1.2 below.

1.2 Brief description of EU-funded projects on this topic

This section provides a summary of several relevant national and European projects (including the three which collaborated in organising the workshop), as reported by the participants. It should be noted that three further large EU-funded projects addressing ETP species bycatch have started since the workshop was held (Marine Guardian, EcoCatch and Prometheus).

The project "**Coordinated Development and Implementation of Best Practice in Bycatch Reduction in the North Atlantic, Baltic and Mediterranean regions**" (CIBBRiNA) is funded under the EU LIFE programme (September 2023-August 2029), the mission of which is "Working together to minimise bycatch of Endangered, Threatened, and Protected species in the North-East Atlantic, Baltic, and Mediterranean". It involves 35 partner and 10 associated partner organizations. The work is built around seven case studies, examining ways to reduce bycatch of cetaceans, seabirds, turtles and elasmobranchs in gillnets, surface and deep-water longlines, and pelagic and bottom trawls. A particular focus is effective collaboration between relevant stakeholders to achieve the project goals, including the creation of a so-called safe-working environment to foster trust and cooperation. The human dimension of fishery bycatch is further emphasized through work packages dedicated to stakeholder engagement and socioeconomic aspects.

The Horizon Europe project **"Reducing Bycatch of Threatened Megafauna in the East Central Atlantic" (REDUCE)** (January 2024 – December 2027) aims to unify stakeholder efforts and utilize an interdisciplinary scientific approach to reduce bycatch of marine megafauna and inform sustainable management of European industrial fisheries in the Eastern Central Atlantic Ocean, from Spain and Portugal to Angola, with special emphasis on the Canary Current and the Gulf of Guinea Large Marine Ecosystem. This will involve:

- Expansion and improvement of observer programmes and use of electronic monitoring and automated machine learning systems to enable species-specific and high-resolution data on marine megafauna bycatch.
- Innovative and efficient data handling, sharing and publishing, including the assembly, integration and curation of data on sightings, fishery catches, GPS and GLS tracking data and capture-mark-recapture studies of selected megafauna species, along with AIS fishing effort data across all industrial European fleets in the region.

- Application of advanced predictive habitat mapping (e.g. using hierarchical Bayesian habitat models) and population viability analysis to better understand megafauna population status, abundance, distribution (including hotspots), post-release mortality, overlap with fisheries, by catch risk and bycatch impact, and the underlying key drivers, from local to basin-scales.
- The assessment and testing of mitigation measures to identify key approaches to significantly reduce bycatch in the region.
- Establishment of cooperation between science, the fishery industry, NGOs and policy-makers bordering Eastern Central Atlantic Ocean supported by by joint multi-disciplinary workshops, scientific training, capacity-building and monitoring events.
- Provision of input into policy including support for marine spatial planning.

The Horizon Europe project **"Monitoring and Elimination of Bycatch of Endangered & Conserved Species in the NE & High Seas Atlantic Region" (Marine Beacon)** is focused on the monitoring and elimination of bycatch of endangered and protected species in the NE and high seas Atlantic region. The project, which commenced on 1st January 2024, will run for four and half years until 30th June 2028. The main objectives of the project are to address the impact of bycatch on the decline of marine biodiversity by producing the knowledge and tools to effectively reduce the bycatch and subsequent mortality of ETP species within European waters and beyond. This will be achieved by 21 partner organisations across Europe who will produce state-of-the-art data products, tools and technologies, to reduce bycatch and mortality of ETP species across different fisheries and regions (seven case studies) including:

- Identify and overcome bycatch-related knowledge gaps.
- Evaluate risk of bycatch and spatio-temporal vulnerability status of ETP species.
- Develop next generation monitoring of ETP species through Artificial Intelligence (AI) and molecular approaches.
- Develop mitigation strategies to reduce bycatch and improve post-release survival.
- Quantify the effectiveness of bycatch mitigation measures and produce tools to inform policy and management.
- Collect and include stakeholder knowledge throughout the work program.

By working across diverse case studies, Marine Beacon will generate results that are broadly applicable to European fisheries and beyond. The project will engage scientists, industry experts, and stakeholders from fisheries, policy, and conservation sectors to co-develop and test innovative tools for monitoring key species and mitigating bycatch risks. This integration of diverse expertise will help ensure that outcomes are practical, scalable, and adopted beyond the project's lifetime, ultimately contributing to healthier marine ecosystems and more sustainable fisheries.

The *Analyse Risque Pêche* (**Fisheries Risk Analysis**) (ARP) is a French project funded under the European Maritime, Fisheries and Aquaculture Fund (EMFAF). It takes place within a sensitive legal and environmental context, shaped by European and national litigation concerning the bycatch of protected species in mainland waters of France. France has committed to completing all the fisheries risk analyses by the end of 2026 to meet the European Commission's requirements.

The project is coordinated by the *Office français de la biodiversité* (French Biodiversity Office) (OFB) in collaboration with national and regional fisheries committees, *Institut Français de Recherche pour l'Exploitation de la Mer* (IFREMER), the *Office de l'Environnement de la Corse* (Corsican Environment Office) (OEC), and *Association du Grand Littoral Atlantique* (AGLIA). Running for 3.5 years (2023–2027), it has a budget of €7.4 million, primarily funded through European contributions and ministerial grants.

The project's main objective is to finalize risk analyses for species and habitats of community interest and propose appropriate measures by the end of 2026. To achieve this goal, several actions are being implemented:

1. **Coordination and Consultation**: The development of ARPs relies on in-depth consultation at the level of different maritime regions and Natura 2000 sites. The project facilitates meetings and engages fishing professionals to actively participate in various stages of the process, including onboard observations, testing of measures, and collaborative discussions.
2. **Spatial Risk Analysis**: The project aims to map risks by integrating data on the distribution of non-geolocated fishing vessels (from databases) and the presence of relevant species. This analysis covers high-risk areas identified at biogeographical scale and 28 Natura 2000 sites.
3. **On-Site Qualification of Interactions**: To refine identified risk levels, surveys are conducted with professionals, and onboard observations are carried out. Data collection protocols, sampling plans, and data analysis are optimized to ensure reliable results.
4. **Testing of Bycatch Reduction Measures**: Bycatch reduction devices are tested according to identified risk areas and fishing gear. These tests align with those of the LIFE Marine Mobile Species project to ensure consistency in the suggested measures.
5. **Conclusions and Proposal of Measures**: Once risk levels are assessed, bycatch reduction measures are proposed to the relevant authorities. These recommendations are formulated at various scales: biogeographic, sectoral, and at the Natura 2000 site level.

This project helps meet French and European environmental and regulatory requirements for fisheries risk assessment while actively involving fishing industry stakeholders in the implementation of suitable and sustainable solutions.

The **LIFE Mobile Marine Species Project** (LIFE MMS project) is funded by the EU LIFE programme and the French government. Project partners include the French Biodiversity Office (coordinator), Cotentin Cetacean Study Group, Normandy Mammal Group, Ornithological and Naturalist Group, Ifremer, PIM Initiative, League for the Protection of Birds, Miraceti, National Museum of Natural History, Picardie Nature, Sathoan, Sensea, and the World Wildlife Fund (WWF) France. The bycatch reduction initiative is conducted in coordination with the EMFAF Fisheries Risk Assessment project. The LIFE MMS project aims to address the issue of bycatch of species with slow reproductive strategy, including seabirds, rays and sharks, turtles, and marine mammals, by testing simple methods to reduce bycatch and decrease mortality among the 23 protected species targeted by the project by 2030. In 2025, the LIFE MMS is trialling bycatch reduction devices in collaboration with shipowners and voluntary fishers operating gillnets, longlines, and trawlers. These include light emitting diode (LED) lights to illuminate the upper part of nets, deterrent kites, artificial lures, TEDs and more. Their effectiveness will be assessed based on data collected by fishers and onboard observers. The most effective devices will then be deployed on a larger scale.

1.3 The status of marine turtle populations in the ICES area and European seas

Extant sea turtle species present in the northeast Atlantic and/or the Mediterranean include green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), and olive ridley (*L. olivacea*). In addition, considering its adaptation to marine life, and feeding at sea, the African softshell turtle, *Trionyx triunguis* (Trionychidae), which occurs in the eastern Mediterranean as alien species may

also be considered to be a marine reptile (Taskavak *et al.* 1999, van Dijk *et al.* 2017). The International Union for the Conservation of Nature's Species Survival Commission (IUCN-SSC) Marine Turtle Specialist Group listed five major threats to sea turtles globally, without explicitly prioritise them, namely fisheries (including bycatch, entanglement in ghost gear, and effects on prey and habitat availability), coastal development, pollution (including pathogens and plastic), direct take and illegal trade, and climate change (Casale *et al.* 2020).

Globally all these species are threatened to varying degrees according to the IUCN Red List (Table 1.1), although some subpopulations are recognised as doing better, notably the Mediterranean subpopulations of the green and loggerheads turtle, with positive assessments reflecting increasing numbers of nesting turtles at monitored sites. In the case of the loggerhead, the IUCN Marine Turtle Specialist Group cautioned that the "Least Concern" status for this regional management unit is '*entirely conservation-dependent*' and that major threats (which include fishery bycatch) have not diminished. Hays *et al.* (2025) suggested that, in general, sea turtle populations are '*rebounding worldwide*', with nest numbers increasing at many nesting sites, reflecting extensive conservation efforts, while also acknowledging that some populations continue to decline dramatically and that threats posed by climate change and loss of nesting habitat continue to escalate. The Atlantic leatherback turtle (*Dermochelys coriacea*) exemplifies these latter critical situations, with the IUCN Red List describing its population as both fragmented and deteriorating. Notably, the Northwest Atlantic subpopulation was reclassified in 2019 from 'Least Concern' to 'Endangered' following precipitous nesting declines linked to bycatch mortality in small- and industrial-scale fisheries (Northwest Atlantic Leatherback Working Group 2019). Meanwhile, the Southwest Atlantic stock remains listed as 'Critically Endangered' (Tiwari *et al.* 2013) and the Southeast as 'Data Deficient'. Despite a global listing of 'Vulnerable' (Wallace *et al.* 2013), the overall trajectory in the Atlantic is negative, driven by persistent anthropogenic pressures including fisheries interactions, habitat loss, and pollution.

For the most recent IUCN assessments of each species, see Abreu-Grobois *et al.* (2008), Mortimer & Donnelly (2008), Wallace *et al.* (2013), Casale & Tucker (2017), van Dijk *et al.* (2017), Wibbels & Bevan (2019) and Wallace & Broderik (2025).

Table 1.1 Species status according to the IUCN Red List (https://www.iucnredlist.org/)

Key: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC). The year of the latest assessment is shown in brackets. The status globally is indicated also the status of relevant populations

Species	Global status	Mediterranean / Atlantic status
Green *Chelonia mydas*	LC (2025)	Mediterranean subpopulation NT (2022)
Hawksbill *Eretmochelys imbricata*	CR (2008)	
Leatherback *Dermochelys coriacea*	VU (2013)	NW Atlantic subpopulation: EN (2019) SW Atlantic subpopulation: CR (2013) SE Atlantic subpopulation: DD (2013)
Loggerhead *Caretta caretta*	VU (2017)	Mediterranean subpopulation: LC (2015); NE Atlantic subpopulation: EN (2015)
Kemp's ridley *Lepidochelys kempii*	CR (2019)	(Single population nesting in Gulf of Mexico)
Olive ridley *Lepidochelys olivacea*	VU (2008)	(Global distribution including E central + NE Atlantic nesting areas)

African softshell *Trionyx triunguis*	VU (2016)	(Range: Africa and E Mediterranean; many populations)

1.4 Regional Intergovernmental initiatives

Paolo Carpentieri (GFCM, Fishery Resources Monitoring Officer) provided an overview of the role of the **General Fisheries Commission for the Mediterranean (GFCM)** on actions in place to mitigate incidental catch of vulnerable species in the Mediterranean and Black Sea.

The GFCM aims to ensure the conservation and sustainable use of living marine resources, as well as the development of sustainable aquaculture in the Mediterranean and Black Seas. As fisheries, marine environments and ecosystems in this region face growing pressures from various anthropogenic sources, it is essential to take action to manage their long-term sustainability. The GFCM works to monitor and reduce negative impacts on biodiversity and ecosystems, particularly for vulnerable species and habitats. This includes improving data collection, testing mitigation measures, and reinforcing scientific foundations for adaptive conservation strategies. In response to these issues, the GFCM has issued several recommendations (https://www.fao.org/gfcm/decisions/en/) emphasizing the need for mitigation measures to limit the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries. Additionally, the recent adoption of Resolution GFCM/46/2023/4 outlines a regional plan of action (RPOA-VUL) to monitor and mitigate interactions—such as incidental captures and depredation—between fisheries and vulnerable species, including marine turtles. The plan emphasizes the development of effective monitoring programmes and the testing of mitigation measures by 2030, with specific goals to reduce both dolphin depredation and incidental captures and related fishing mortality.

In recent years, a significant effort has been made to develop standardized data collection and monitoring systems. Recent protocols and reviews (https://www.fao.org/gfcm/publications/en) have been published to report on historical and current trends related to the bycatch of marine turtles, alongside other vulnerable species (i.e. elasmobranchs, marine mammals and seabirds). These data are crucial for informing adaptive management strategies and improving conservation outcomes. The GFCM has also collaborated with different partner organizations to identify high-risk areas and the fishing gears most associated with interactions with marine turtles and other vulnerable species. These partnerships enable a comprehensive approach to addressing the conservation needs of vulnerable species within broader marine biodiversity initiatives. Ongoing pilot studies are testing the implementation of technical mitigation measures in some of the identified high-risk areas. The goal of these studies is to evaluate the effectiveness of different gear modifications and operational practices in minimizing interactions with marine turtles, and other group of vulnerable species, during fishing operations.

To further enhance the management and conservation of vulnerable species, the GFCM Commission stressed the continued implementation of mitigation measures and monitoring activities within the framework of the RPOA-VUL, underscoring the importance of exchanging information with other organizations. Such collaboration would support data gathering and the exploration of potential solutions to improve the conservation of these vulnerable species.

Verónica Caceres (IAC Secretary) introduced the efforts of the **Inter-American Convention for the Protection and Conservation of Sea turtles (IAC**; www.iacseaturtle.org**)** on addressing marine turtle incidental catch.

The IAC is an Intergovernmental Treaty that currently provides the legal framework for 16 countries in the American Continent (from North, South, and Central America, and the Caribbean) to take actions that benefit six species of sea turtles. Its main objective is to promote the protection, conservation, and recovery of the populations of marine turtles and their critical habitats (e.g.,

nesting and feeding grounds), based on the best available data and taking into consideration the environmental, socioeconomic and cultural characteristics of the Parties. These actions should cover both nesting beaches and the Parties' territorial waters. The IAC also facilitates dialogue among different government agencies (environment, fisheries, and foreign relations ministries) to collaborate and adopt resolutions to be implemented at national and regional levels. The IAC has two subsidiary bodies - the Scientific and Consultative Committees - and 12 working groups. The Committees support IAC Parties by drafting resolutions, preparing technical documents, as well as providing advice to Parties. Resolutions are implemented by countries through existing legislation or new national regulations. Countries report their progress via the IAC Annual Report. This includes information on sea turtle nesting abundance and fisheries, which is used by IAC Committees to prepare technical documents and assess sea turtle conservation status. The IAC collaborates with International Organizations like RAMSAR, ACAP, ICCAT, SSC, and SPAW, and regional sea turtle networks like LAUD OPO network. The partnerships facilitate dialogue and agreement on challenging topics, such as sea turtle bycatch.

During the discussion, several region-specific issues concerning the Mediterranean, Black Seas, and EU waters of the southern North-West Atlantic were brought to the attention of participants:

- For safety reasons, vessels under 12 m in length are not permitted to carry onboard observers. Consequently, data from these vessels are typically derived from questionnaires or self-reported logbooks, which may limit accuracy and consistency.
- Illegal, unreported, and unregulated (IUU) fishing is also present in the region. Evidently, by definition, such activities are not monitored by onboard observers.

Participants emphasized the potential value of enhancing collaboration between ICES, IAC and GFCM expert groups. It was noted that GFCM expert working group meetings are open to participation, and interested individuals may register to attend. Experts from WKTURTLE and WGBYC were specifically encouraged to participate in relevant forthcoming GFCM working group sessions.

It was generally recommended that the agendas of any future WK TURTLE meetings consider ongoing initiatives and outcomes from the GFCM and IAC frameworks, particularly those related to monitoring and mitigation efforts.

2 ToR A: Review the nature and extent of interactions between marine turtles and fisheries in the North-east Atlantic and Mediterranean Sea

2.1 Key considerations for monitoring marine turtle by-catch and for assessing bycatch impacts at the population level

When evaluating the nature and extent of negative interactions between marine turtles and fisheries in the Northeast Atlantic and Mediterranean Sea—particularly with the aim of assessing fishery-induced mortality at the population level—several key factors must be considered in the design of bycatch monitoring programmes. These include:

- **Geographic and temporal coverage** of monitoring efforts, ensuring that data adequately reflect the full spatial and seasonal extent and variability of fishing activities and turtle presence.
- **The suitability and limitations of available risk assessment methodologies**, which by influencing the monitoring programme design may influence the accuracy and reliability of bycatch estimates.
- **The availability of demographic data** for the affected species or populations, which are essential for translating bycatch levels into meaningful population-level impact assessments.

The geographic and temporal design of bycatch monitoring programmes must align with the biological ranges of affected populations or Management Units (MU). Ultimately, to accurately assess the cumulative impact of bycatch, mortality should be evaluated across the full distributional range of each (sub)population or MU. For example, 10 Regional MUs or subpopulations are recognised by the IUCN for loggerhead turtles (*Caretta caretta*), including the Mediterranean and Northeast Atlantic MUs. Loggerhead turtles bycaught in the northern Adriatic Sea are known to originate from multiple rookeries in the eastern and central Mediterranean (Tolve *et al.* 2018). Conversely, in the western Mediterranean, individuals are more likely to derive from Atlantic and central Mediterranean rookeries and thus include animals from two different MUs (e.g., Camiñas & de la Serna 1995; Monzón-Argüello *et al.* 2010; Carreras *et al.* 2011; Lescure *et al.* 2015; Casale *et al.* 2018). This highlights the importance of accounting for cross-regional connectivity in impact assessments: for instance, fisheries in the northern Adriatic may significantly contribute to mortality in eastern Mediterranean loggerhead populations and must therefore be included in cumulative impact evaluations. Likewise mark and recapture studies and telemetry studies exhibit that leatherbacks routinely travel long distances and are found in the North Atlantic, far from their tropical and subtropical nesting beaches (Hays *et al.* 2004).

Regarding risk assessment approaches, a variety of risk assessment frameworks - ranging from quantitative to semi-quantitative methods for data-poor contexts - are available to support bycatch management. Although these approaches are not equivalent in their ability to quantify population-level impacts, they are valuable for identifying high-risk fisheries and regions, particularly where direct estimates of bycatch rates are lacking. In such cases, proxy data (e.g., strandings or interviews) may indicate bycatch presence and justify prioritizing targeted monitoring, such as onboard observations in fisheries with high exposure to endangered, threatened,

and protected (ETP) species. Possible methodologies for data-poor situations include Bycatch Risk Assessment (ByRA: Hines *et al.* 2020) and Ecological Assessment of the Sustainable Impacts of Fisheries (EASI-Fish; Griffiths *et al.* 2019).

Regarding tools to assess population-level impact, several quantitative methods exist to estimate the impact of bycatch on marine species populations, ranging from relatively simple models like Potential Biological Removal (PBR) (Wade 1998) to more complex tools such as full Population Viability Analyses (PVAs). The Marine Mammal Protection Act of the United States of America introduced PBR. PBR as a benchmark for human-induced mortality in marine mammals. PBR is calculated as follows: $PBR = 0.5 \cdot Rmax \cdot F \cdot Nmin$. The idea is that annual anthropogenic mortality, as applied to a minimal population estimate (Nmin) should not exceed 50% of the population's maximum potential productivity rate (Rmax), adjusted by a recovery factor (F) that ranges from 0.1 to 1, depending on the population's conservation status. If anthropogenic mortality is below the PBR threshold, the population is expected to be able recover. The PBR approach is based on a logistic population growth model, in which maximum net productivity occurs at 50% of the maximum growth rate (Wade, 1998) and is thus related to fishery production models used to determine maximum sustainable yield from a fishery.

Given that sea turtles share several life history traits with marine mammals, such as low fecundity, slow development, delayed maturation, and long lifespans, PBR can theoretically be applied to turtles. The US Government's Turtle Expert Working Group (TEWG) first proposed applying PBR to sea turtles (Turtle Expert Working Group 2000). They noted that modifications would be necessary due to differences in life history between cetaceans and sea turtles. For instance, separate PBR calculations might be needed for different life stages, with abundance estimates based on nesting beach surveys rather than sightings at sea.

Casale and Heppell (2016) applied PBR to Mediterranean loggerhead and green turtles. Following the TEWG's approach, they estimated the population size using a model that included the number of nests and hatchlings. They then divided the population by age class. Rmax was computed based on existing data for both species, for loggerheads from Brazilian populations and for green turtles from Florida populations. They estimated bycatch mortality as the product of the reported number of bycatches and the expected mortality rate. Bycatch data indicated that turtles larger than 20 cm Curved Carapace Length (CCL) are at risk of being captured, with those over 40 cm CCL at a higher risk. Hence, the authors made separate PBR estimates for the age classes they considered to be (i) at risk of bycatch and (ii) at most risk of bycatch. They also considered three alternative values for the recovery factor (0.1, 0.5, and 1), reflecting different possible perceptions of population vulnerability and/or the reliability of the data. Loggerhead turtle bycatch in the Mediterranean is expected to include some Atlantic loggerheads, potentially resulting in an overestimation of bycatch and its impact for the Mediterranean loggerhead (sub)population. On the other hand, because Casale and Heppell (2016) used the best population size estimate and not a "minimum" value when computing PBRs, they might have overestimated the PBR and thus underestimated bycatch impact. Because they computed PBR for the entire Mediterranean region, they did not consider spatial variation in bycatch rate and impact.

Pierantonio *et al.* (2023) also applied PBR to Mediterranean loggerhead turtles, making separate calculations for different areas within the Mediterranean to account for spatial variation in bycatch. They found that the Western Mediterranean (Levantine, Aegean and Adriatic Sea) had higher loggerhead bycatch numbers. They estimated abundance based on aerial surveys over multiple seasons and years and did not attempt to separate different age classes. They calculated PBR based on several different abundance estimates, including "minimal" and "maximal" values, i.e. the lower and upper 95% confidence intervals, considering recovery factor values of 0.5 or 1 (but not 0.1).

In practice, application of even relatively simple methodologies like PBR require validation, which normally implies the use of simulations to explore future outcomes in relation to quantitative conservation objectives, accounting for uncertainty and the likely effects of proposed mitigation (e.g. Taylor *et al.* 2022). As such, the full procedure associated with PBR calculations may also be characterised as PVA or indeed as Management Strategy Evaluation (MSE). PVA models vary in complexity but share a common dependency on robust data on population status and dynamics (e.g., abundance, survival rate, reproductive rate) and estimates of anthropogenic mortality (e.g., bycatch levels). The utility and accuracy of these tools are thus inherently tied to the availability and quality of demographic data for the target species or population. Therefore, ongoing efforts to improve data collection on life history traits and population structure are critical to refining impact assessments and informing effective mitigation strategies (see Casale & Heppell 2016). Equally important is the availability of robust data on human-induced mortality, such as total bycatch and the associated mortality rate, to ensure accurate population-level evaluations.

2.2 ICES WGBYC data marine turtle bycatch: species, gear types, and estimates

The **ICES Working Group on Bycatch of Protected Species (WGBYC)** addresses bycatch of all ETP species across multiple taxonomic groups -including marine mammals, seabirds, sea turtles, elasmobranchs, and bony fishes - within ICES areas and adjacent regions, including EU waters of the Mediterranean and Black Seas. The group provides annual scientific advice to the European Commission on ETP bycatch issues in these regions.

WGBYC relies on an annual data call, through which ICES member countries and EU Member States submit information on observed bycatch events, monitoring effort, and fishing effort. These data are used to calculate bycatch rates and, more recently and whenever possible, to generate bycatch estimates using the Bycatch Evaluation and Assessment Matrix (BEAM) framework. Since 2022, ICES WGBYC has implemented the BEAM, a multi-criteria framework designed to integrate bycatch data, fishing effort, biological parameters, and conservation thresholds into standardized risk assessments across taxa and gear types (ICES 2023). BEAM supports both quantitative and expert-informed semi-quantitative assessments, making it particularly valuable in data-poor contexts. Outputs help identify high-risk species–gear–region combinations and prioritize monitoring efforts via the WKPETSAMP process. BEAM-derived mortality estimates underpin the annual bycatch advice provided to DG-MARE.

Of relevance to this workshop are data related to marine turtle bycatch. For instance, the 2024 data call indicated that bycatch events were reported primarily in the southernmost ecoregions of the ICES area and throughout the Mediterranean Sea (Figure 2.1).

In terms of species, loggerhead turtles (*Caretta caretta*) were reported as bycaught in all ecoregions where bycatch of marine turtles (as a taxonomic group) was recorded (Figure 2.1). Leatherback turtles (*Dermochelys coriacea*) bycatches were reported only in the Azores, the Oceanic Northeast Atlantic, the Bay of Biscay and Iberian Coast, and the Western Mediterranean Sea and in French Guiana notably in the Maroni estuary. Green turtles (*Chelonia mydas*) bycatches were reported exclusively in the Azores and the Aegean–Levantine Sea.

Marine turtles have been reported as bycaught across a variety of fishing gears. Loggerhead turtles were recorded in gillnets and trammel nets, demersal and drifting longlines, handlines, bottom and midwater trawls, purse seines, and pots and traps. Leatherback turtles were observed in gillnets, trammel nets, and drifting longlines, while green turtles were recorded in bottom and midwater trawls, trammel nets, and drifting longlines.

As part of the BEAM implementation, bycatch estimates for marine turtles were generated for multiple species–ecoregion–metier combinations. These estimates are based exclusively on onboard observer data, which are filtered and processed through a standardized methodology (for details, see ToR C in the ICES WGBYC 2024). Table 2.1 presents the total bycatch estimates that could be calculated using the BEAM framework in 2024 (ICES, 2024a).

In addition to the estimates shown in Table 2.1, bycatch rates are available for a broader set of species, ecoregions, and metiers. Although, these additional values did not meet the quality criteria required by BEAM for generating robust bycatch estimates and therefore should be used with caution, they could be used in other preliminary phases of some semi-quantitative risk assessment approach.

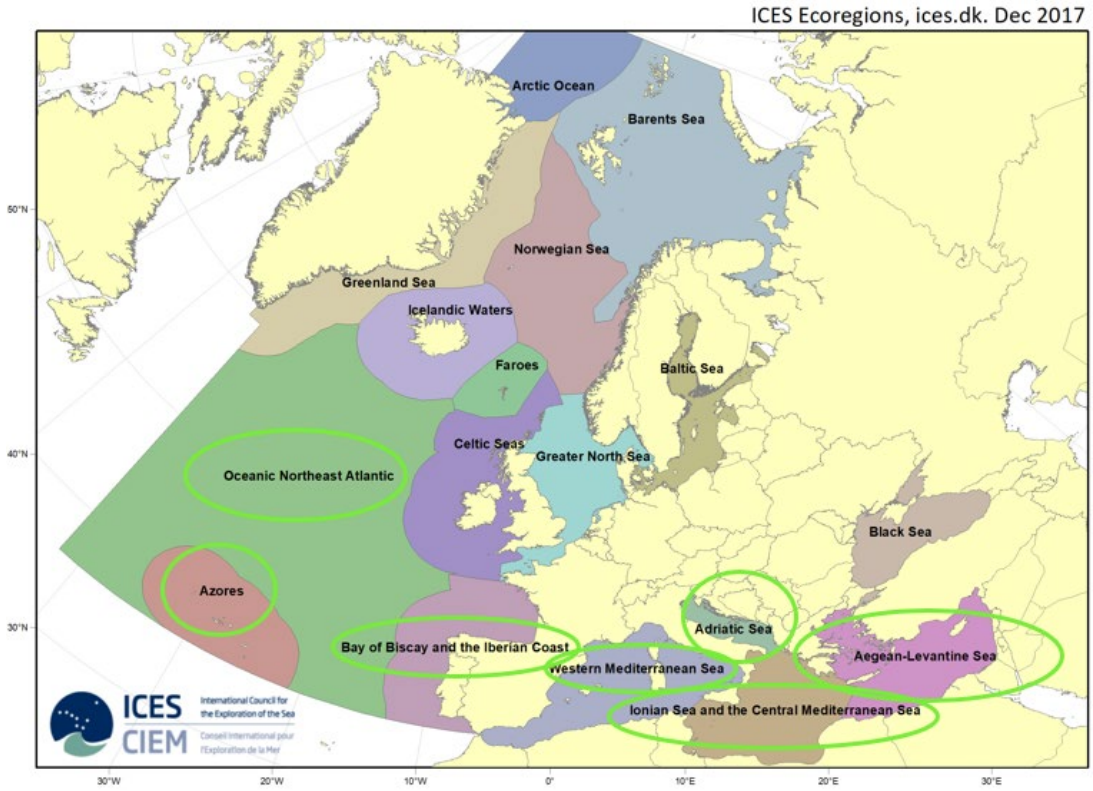


Figure 2.1 ICES Ecoregions. Ecoregions where marine turtle bycatch has been reported since 2017 are highlighted with green circles (ICES, 2024a).

Table 2.1 Bycatch estimates derived from the BEAM approach for turtles from the ICES WGBYC 2024 report (ICES, 2024a).

Ecoregion		Species	Gear	Total bycatch
Mediterranean Sea	Western Mediterranean Sea	Loggerhead turtle	Drifting longlines (LLD)	14 (2-102)
	Adriatic	Loggerhead turtle	Bottom trawl (OTB)	2887 (530-15825)
			Midwater trawl (PTM)	491 (338-712)
	Aegean-Levantine Sea	Loggerhead turtle	Drifting longlines (LLD)	16 (2-113)
			Bottom trawl (OTB)	333 (155-712)
		Green turtle	Drifting longlines (LLD)	125 (20-774)
Northeast Atlantic	Azores	Loggerhead turtle	Drifting longlines (LLD)	124 (28-549)
			Gillnets (GNS)	74 (24-229)
		Leatherback turtle	Drifting longlines (LLD)	30 (11-83)
		Green turtle	Gillnets (GNS)	25 (4-175)
	Oceanic Northeast Atlantic	Loggerhead turtle	Drifting longlines (LLD)	302 (95-963)
	Bay of Biscay and Iberian Coast	Loggerhead turtle	Gillnets (GNS)	90 (9-854)
			Drifting longlines (LLD)	166 (25-1090)
			Bottom trawl (OTB)	208 (92-473)
			Twin bottom trawl (OTT)	17 (6-46)

According to Table 2.1, approximately 79% of the estimated total bycatch of turtles reported by ICES WGBYC in 2024 occurred in the Mediterranean. Tables 2.2-2.4 summarise data on reported marine turtle bycatch in the Mediterranean Sea, as submitted by EU Member States through ICES WGBYC reports since 2011. Table 2.2 provides annual bycatch figures by species, Table 3 by GFCM Geographical Sub-Area (GSA), and Table 4 by gear type. In some cases, the observed fluctuations in bycatch over time do not necessarily reflect a true rise or decrease in marine turtle–fishery interactions but may instead result from variable levels of monitoring efforts or reporting driven by stricter policy requirements. Many of the area-year-gear type combinations in the Mediterranean have very low levels of observer coverage (<1% of reported fishing effort) and as such much of the data will not have entered BEAM calculations.

Table 2.2 Marine turtle bycatch in Mediterranean Sea as reported by European Union Member States: number of individuals by species (ICES, 2023)

Species	2011	2012	2014	2016	2017	2018	2019	2020	2021	2022	Total
Cheloniidae						1				2	3
Green				1			1	6	3	6	17
Leatherback					1						1
Loggerhead	14	36	7	12	14	154	44	32	75	194	582

Total	14	36	7	13	15	155	45	38	78	202	603

Table 2.3 Marine turtle bycatch in Mediterranean Sea as reported by European Union Member States: number of individuals by GFCM GSA and year (source: ICES WGBYC reports)

Area	2011	2012	2014	2016	2017	2018	2019	2020	2021	2022	Total
1+5+6					11						11
5										30	30
6						2			32	1	35
7		2						1	1		4
9						5				1	6
11.2						8	3			4	15
15							1				1
16						7					7
17	14	34	7	5	3	52	25	10	29	150	329
18						54	15			2	71
19						1				1	2
22					1	25			1	4	31
25				7		1	1	27	15	9	60
24+25+26				1							1
Total	14	36	7	13	15	155	45	38	78	202	603

Table 2.4 Marine turtle bycatch in Mediterranean Sea as reported by European Union Member States: number of individuals by gear and year (source: ICES WGBYC reports)

Gear	2011	2012	2014	2016	2017	2018	2019	2020	2021	2022	Total
Bottom trawls		2		1		125		1	5	101	235
Longlines				1	11		18	1	32	46	109
Nets				7	1	1	1	26	13	6	55
Pelagic trawls	14	34	7	4	3	29	25	10	8	39	173
Rod and lines										2	2
Seines									20	8	28
Surrounding nets							1				1
Total	14	36	7	13	15	155	45	38	78	202	603

Although monitoring of fishing effort in the Mediterranean has historically ranged from limited to extremely low (or none - particularly in relation to small-scale fisheries (SSFs), which are often unmonitored), these data clearly indicate the occurrence of marine turtle bycatch across multiple years, regions, and gear types. Loggerhead turtles (*Caretta caretta*) are consistently prominent in the reported bycatch. The figures suggest that bycatch levels may be significant, despite the limited observation coverage. These findings underscore the urgency to enhance monitoring under the EU Data Collection Framework (DCF), with a focus on increasing spatial and gear-specific coverage, especially in metiers known or suspected to pose high bycatch risks. In addition, there is a pressing need to initiate dedicated monitoring and mitigation programmes targeting underrepresented SSF segments. A coordinated, EU-wide marine turtle bycatch mitigation strategy is strongly recommended.

In 2024, WGBYC developed a simplified risk assessment framework under ToR D for use in data-poor contexts. As part of this effort, a preliminary table was produced to reflect perceived or known species bycatch risk levels across different metiers in two regions. WKTURTLE participants - experts familiar with the Northeast Atlantic and Mediterranean contexts - were invited to review and validate this species bycatch risk table. A revised version, incorporating their feedback, is presented in Table 2.5, and highlight the perceived high risk of bycatch of loggerhead turtle in pelagic and bottom trawls, gillnets and longlines, and moderate risk in purse seines, in both the Northeast Atlantic and Mediterranean, albeit generally with higher confidence in the Mediterranean.

Table 2.5 Bycatch risk scores for loggerhead turtle in the Atlantic and Mediterranean, in various fishing gears, based on an expert consultation to update a table from ICES WGBYC (2024).

Gear / metier	Pelagic Trawl		Bottm Trawl		Boat dredge	Bottom Seine		Purse Seine	Gill Nets		Long Lines	Hand & Pole Lines	Pots & Traps	Fyke & Pound Nets
Area and Species	PTM	OTM	PTB OTB OTT	TBB	DRB	SDN SPR SSC	SVB	PS LA	GNS GTR GNC GTN	GND	LLS LLD	LHM LHP LTL	FPO	FYK FPN
Atlantic *Caretta caretta*	3**	3**	3**	ns	1*	0*	1*	2**	3**	3*	3***	1*	1**	ns
Mediterranean *Caretta caretta*	3***	3***	3***	ns	1*	n/a	n/a	2***	3***	3**	3***	1*	1**	ns

Notes: ns = not scored; n/a = not applicable (because gear is absent); * = low confidence; ** = medium confidence; *** = high confidence; 0 = negligible risk (gear poses no threat); 1 = low evidence of risk; 2 = moderate evidence of risk; 3 = high evidence of risk.

2.3 The case of marine turtle bycatch in the Northeast Atlantic Portuguese pelagic longline fishery

Frederic Vandeperre (OKEANOS, University of Azores) presented the case of marine turtle bycatch in the Northeast Atlantic Portuguese pelagic longline fishery. The Portuguese surface longline fishery is a largely industrial fishery, targeting swordfish (*Xiphias gladius*) and blue shark

(*Prionace glauca*), that operates from the Iberian Peninsula (Spain and Portugal) and the Azores. To tackle the known issue of bycatch of protected marine turtles in this fishery, the COSTA project (COnsolidating Sea Turtle conservation in the Azores, costaproject.org), which began in 2015, set up a fishery observer programme with the objective to obtain current bycatch rates, define high bycatch areas and seasons, propose measures and promote best-handling practises. Between 2015 and 2024, 2386 days at sea (1498 sets and 1457512 hooks) were monitored on 20 vessels. The total numbers of bycaught loggerhead and leatherback turtles were 158 and 46, respectively.

The fishery has a pronounced seasonal and spatial dynamic in which the catches of the target species alternate (Parra *et al.* 2023b). Bycatch of loggerhead and leatherback marine turtles is higher during summer and autumn and is mostly recorded in association with fishing sets targeting swordfish. Model-based estimates indicated catches of 1439 (552-3069 BCI) loggerhead and 604 (262-1129) leatherback marine turtles by the Portuguese fleet in the period 2015-2020. Direct (at-haulback) mortality for loggerhead marine turtles was estimated at 26%, while for leatherback marine turtles the estimate was zero (Parra *et al.* 2023a). No recent estimates exist for post-release mortality.

Currently, no specific regulations exist to minimize the bycatch of marine turtles in these fisheries besides ICCAT recommendation 22-12 (EU 14/3/2024). However, since the bycatch of marine turtles is strongly influenced by the spatio-temporal dynamics of the fleet, regulations that influence this, such as, catch limits for target species or gear and area restrictions, are listed in Table 2.6 because of their potential direct or indirect influence on the observed bycatch patterns.

Table 2.6 Relevant Portuguese legislation and policies on measures to reduce sea turtle bycatch in the pelagic longline fishery.

Level	Regulation / Measure	Jurisdiction / Scope	Key Provisions	Source
International	ICCAT Recommendation 22-12	ICCAT contracting parties	Measures to reduce sea turtle bycatch; referenced in EU Regulation update	ICCAT, 2022
EU	EU Regulation 2017/2107 (as amended by EU 14/3/2024)	All EU waters	Implements ICCAT Recommendation 22-12, includes sea turtle protection provisions	Official Journal of the EU
EU / Global	CITES Appendix II	Global	Inclusion of blue shark and shortfin mako; indirectly affects gear use and target species in turtle habitats	CITES
Portugal (mainland)	DGRM 17/DG/2024	Portuguese mainland surface longline fleet	Mandatory seasonal closure (45 days) between 15 June and 15 September 2024	Direção-Geral de Recursos Naturais (DGRM)
Azores + Mainland + Spanish Fleets	Portaria n.º 165/2020	30–100 NM (Pt mainland, Azores, Spain); 30–200 NM (Azores)	Prohibits use of wire leaders	Portuguese Government Gazette
Azores only	Portaria n.º 113/2020	30–200 NM (Azorean fleet)	Prohibits directed fishing for blue shark; introduces restrictive quotas	Portuguese Government Gazette

Azores only	Portaria n.º 116/2018	Azorean longline fleet	Mandates the use of circle hooks	Portuguese Government Gazette
Portugal (national)	Plano de Ação – Decree nº 12140/2023	National (still under development)	Draft action plan to reduce bycatch of birds, marine mammals, and turtles; includes: minimum branch line length, fisher training on handling	Portuguese Government Gazette

These regulations reflect a multi-tiered approach adopted by several countries to reduce bycatch, combining international obligations with national and regional measures. However, their effectiveness remains contingent upon consistent enforcement and integration with robust monitoring programmes.

Beyond regulatory frameworks, a number of initiatives and projects have contributed to mitigating the adverse effects of bycatch in the Portuguese pelagic longline fishery. One of the earliest large-scale fishing experiments (2000–2004) evaluated the effects of different hook types on marine turtle interactions, yielding results consistent with similar studies conducted elsewhere (Lima *et al.*, 2023). More recently, the COSTA project has played a central role in promoting best-handling practices for marine turtles, delivering both training and equipment to fishers in line with internationally recognised standards (e.g. FAO, NOAA). Nonetheless, as noted during the workshop discussion, quantifying the effectiveness of such interventions remains a challenge.

Workshop participants were also informed that the Marine Beacon project will conduct a spatially explicit risk assessment and evaluate the potential of area-based mitigation strategies. In parallel, the Portuguese government is currently developing a national action plan aimed at reducing the incidental capture of cetaceans, seabirds, and marine reptiles.

In relation to observed differences in bycatch rates among marine turtle and shark species, it was clarified that hooks targeting swordfish are typically set shallow, near the surface, while those for blue sharks are deployed deeper. Despite the shallow hook depth, marine turtles still exhibit relatively high bycatch rates. When mortality occurs, the specific cause is often uncertain; however, drowning is considered more likely than hook injury. Interestingly, a recent decline in loggerhead turtle bycatch has been linked to reduced autumn fishing effort and a shift in bait type—from squid (now more expensive) to mackerel. This may be related to a reduced likelihood of hook ingestion: turtles tend to take small bites out of fish bait but ingest squid bait whole (e.g. Cambiè *et al.* 2012, Swimmer *et al.* 2014, Gilman and Huang 2017).

Given the relatively high number of loggerhead and leatherback turtles observed as bycaught in this fishery - figures that do not appear in ICES WGBYC reports, which rely on official Member State submissions - the workshop emphasised the importance of identifying complementary data sources. This includes data generated by independent observer programmes, which are currently excluded from official reporting streams.

During the discussion, it was clarified that while ICES WGBYC can combine datasets from different sources, there is no formal obligation for data owners to share such information with ICES. Furthermore, expanding the range of data contributors to the ICES data call would require broadening beyond the current contacts under the EU Data Collection Framework (DCF). For instance, in the Azores, bycatch data are managed by the regional government and passed on to national authorities, but some of this information may not reach the designated national DCF contact points.

It was also highlighted that numerous small-scale or local monitoring efforts - such as past LIFE projects - may contain valuable bycatch data that could contribute to more accurate mortality

estimates. Exploring mechanisms for aggregating and integrating such information into regional assessments was strongly recommended. Recommendations from this workshop are listed down in Section 5 of this report.

2.4 Evaluating Interactions Between Mainland Portugal Fisheries and Marine turtles: Insights from strandings

Ana Marçalo (CCMAR) presented an evaluation of interactions between mainland Portugal fisheries and marine turtles: insights from strandings. Up to 2010, information on marine turtles along the Portuguese mainland coast was scarce, primarily limited to occasional sightings or unstandardized stranding records. The lack of systematic data collection made it difficult to assess species presence, key habitats, and interactions with fisheries. However, from 2010 onward, the upgrading of local stranding networks, particularly along the southern coast (Algarve), significantly improved knowledge on marine turtle occurrence, distribution, and threats, providing a more comprehensive dataset for conservation and management efforts. Currently, Currently, the Centro de Ciências do Mar (CCMAR) coordinates the Algarve stranding network, one of four regional networks that together cover the entire country and form part of the National Stranding Network, centrally coordinated by Instituto da Conservação da Natureza e Florestas (ICNF). All the networks ensure standardized data collection and facilitating research on marine turtle interactions with fisheries. Additionally, CCMAR has been involved in observer-based studies aimed at better understanding bycatch in small-scale fisheries, complementing stranding data.

Stranding data has emerged as a crucial tool for understanding the interactions between fisheries and marine turtles along the Portuguese mainland coast. This study analysed long-term stranding records to assess species presence, identify high-risk areas, and evaluate fisheries' impact, particularly from small-scale fisheries (SSF), which often lack observer coverage (Nicolau *et al.* 2016). Results confirm that the Portuguese mainland coast serves as an important foraging area for loggerhead turtles and leatherback turtles, with the Algarve region identified as a hotspot for loggerheads. Both species are present year-round, but loggerhead strandings peak from spring until late summer. This seasonal pattern suggests an influx of juveniles using the region as a key foraging ground. The Algarve's warmer waters and the narrow continental shelf increase spatial overlap between SSF operations and marine turtle habitats, heightening the risk of incidental capture, particularly in set nets.

Stranding data plays a fundamental role in enhancing fisheries monitoring, particularly in SSF, where direct observation efforts remain minimal. By analysing stranded turtles, researchers can obtain essential information on species presence, size distribution, and maturity stages, offering insights that traditional fisheries-dependent monitoring fails to capture. This is particularly relevant for identifying mortality hotspots, understanding fisheries interactions, and detecting rare mortality events that may otherwise go unnoticed. The integration of stranding data into fisheries assessments has been instrumental in identifying key areas of concern and recognizing the prevalence of anthropogenic mortality, particularly from fisheries interactions.

Despite these advances, challenges remain in obtaining robust bycatch estimates, mainly due to limited spatial and temporal monitoring and the scarcity of observer programs in SSF and other fisheries. Furthermore, no mitigation measures to reduce marine turtle bycatch have been implemented in Portuguese mainland waters to date, highlighting an urgent need for targeted action. Moving forward, improving monitoring efforts, incorporating stranding data into fisheries management frameworks, and implementing effective bycatch mitigation strategies are critical to ensuring the long-term conservation of marine turtles along the Portuguese coast. Addressing this gap requires collaborative efforts between researchers, policymakers, and fishers to implement

science-based solutions, ensuring the long-term survival of marine turtles in this ecologically significant region.

2.5 Marine turtle bycatch and mitigation measures in Cyprus (Eastern Mediterranean)

Marios Papageorgiou (Enalia Physis Environmental Research Centre) summarised the information on a project carried out in Cyprus (Eastern Mediterranean) on marine turtle bycatch, which appears to be a serious issue in Cypriot fisheries, often leading to death by drowning. Two species of marine turtles are found in Cypriot waters, and both are known to interact with fisheries, the loggerhead turtle and the green turtle. Cyprus is a major nesting site for both species, especially for the green turtle. These species are legally protected in Cyprus by national and European legislations since 1971. Due to the long-term conservation efforts, the abundance and nesting activity of the two species has significantly increased over the past few years on the island, consequently leading to more frequent interactions with Cypriot fisheries. Following standardised methods (FAO, 2019), a recent fieldwork study conducted between 2018 - 2019 estimated an annual marine turtle bycatch rate of approximately 3,500 individuals in Cypriot fisheries (Papageorgiou *et al.*, 2020). However, the reliability of this estimated bycatch rate is affected by several limitations in relation to the sampling effort and the representativeness of the fishers who participated in the study, and further long-term efforts are required to produce more accurate estimates.

The inshore small-scale fishery represents more than 90% of the entire Cypriot fishing fleet. In 2023, the total numbers of active small-scale (vessels with length 0-< 12m using Polyvalent passive gears), large pelagic (vessels 12-<18m using Polyvalent 'passive' gears), demersal trawl (24-<40m) and purse seine (18-<24m) vessels were 739 (95.4%), 32 (4.1%), 3 (0.4%) and 1 (0.1%), respectively (DFMR, 2024). Considering these numbers, the inshore small-scale (SSF) and offshore large pelagic (LPF) fisheries are the two most important fisheries on the island. The SSF targets demersal species using mainly set nets and set longlines whereas the LPF is engaged in two fisheries, the large pelagic fishery using drifting pelagic longlines and the inshore demersal fishery using set nets and set longlines.

Preliminary data analysis showed significant bycatch of loggerhead and green turtles in both SSF and LPF. For SSF, the main factors affecting turtle bycatch are soak time, net length and gear type. Longer soak times and greater net lengths, as well as the use of set nets (trammel nets and gillnets) rather than set longlines, are responsible for higher bycatch and mortality rates. For the LPF, there is significant turtle bycatch and mortality on the drifting pelagic longline during the albacore tuna fishing period which normally lasts between June and August. Given that all vessels employing drifting pelagic longlines use similar/identical gear specifications and fishing methods, variations in bycatch rates may be influenced more by environmental factors than by fishing practices, which requires further investigation. In both LPF and SSF, bycaught individuals of loggerhead turtles were generally larger (curved carapace length [CCL]: 60 – 95 cm) than green turtles (CCL: 24 – 58 cm), which appears to contribute to the higher mortality rates observed among green turtles (Marios Papageorgiou, unpublished data).

2.6 Emerging challenges: introduction of new unregulated Trap Line Gear

The workshop was also informed of a new and emerging challenge in the management of bycatch: the introduction and increasing use of a novel fishing gear by segments of the pelagic

longline industry, referred to as the "trap line" (Garibaldi *et al.*, 2024). This gear is currently being deployed experimentally across various parts of the Atlantic and Mediterranean Seas.

The use of this gear raises several regulatory and environmental concerns. Firstly, the trap line does not conform to the legal definition of a surface longline under existing EU or national frameworks. Its configurations vary widely, with no standardized technical specifications or official classification. As such, its use often falls outside established licensing and monitoring systems, complicating efforts to evaluate its legality, the associated fishing effort, and its compliance with conservation measures. At present, there is no scientific information available on the gear's operational performance, catch composition, or selectivity. Preliminary anecdotal observations, however, indicate several potential environmental risks. Notably, the gear often uses synthetic leader material and plastic squid-shaped lures, which may contribute to marine plastic pollution—particularly if lost or discarded at sea. In addition, using fish as bait instead of squid on longlines has been found to reduce deep hooking because, as previously mentioned, turtles tend to take small bites out of fish bait but ingest squid bait whole (e.g. Cambiè *et al.* 2012, Swimmer *et al.* 2014, Gilman and Huang 2017).

In Cyprus, where this gear has gained popularity over the past two years, fishers have reported modifying the lures by inserting sardines to increase attractiveness, further complicating assessments of bait selectivity and ecological impact. Field observations from Cyprus and other locations have also recorded bycatch of sharks and marine turtles associated with trap line deployments, along with incidents of dolphin depredation. These interactions raise concerns about the potential for unintended impacts on protected or vulnerable species, especially in the absence of observer coverage or mandatory reporting requirements.

Given that the trap line is currently being tested in multiple fisheries across different EU Member States, workshop participants highlighted the need for coordinated international cooperation. Establishing a formal, harmonized legal definition of the gear - alongside standard protocols for its construction, deployment, and monitoring - was seen as a critical first step. Such cooperation would help ensure that management frameworks remain effective and responsive to emerging gear technologies, while preventing regulatory loopholes that could undermine bycatch mitigation efforts.

2.7 Importance of monitoring via strandings

Stranding events provide valuable supplementary data to highlight some aspects of the pervasive issue of bycatch, particularly in regions lacking systematic onboard observer programmes (e.g. Tómas *et al.* 2008, Snape *et al.* 2013). When documented systematically by trained teams, strandings can reveal spatial and temporal patterns of bycatch mortality, offering indirect evidence of fisheries interactions. In some cases, stranded turtles are found entangled or with fishing gear remains, directly indicating the fisheries involved - including small-scale and illegal operation - and the nature of the interaction, whether through active fishing (i.e., bycatch) or ghost gear.

Beyond fisheries interactions, strandings help identify other causes of mortality, such as vessel strikes, disease, and pollution, providing essential context for assessing threats to marine turtle populations. Standardized data collection - including necropsies, species identification, and cause-of-death analysis - ensures reliability and enables comparisons across regions and time periods. The adoption of regionally harmonised protocols enhances data compatibility for multinational assessments. In such frameworks, stranded animals may also contribute key life-history data, such as age, growth rates, and reproductive status, which inform population health assessments and conservation priorities.

Therefore, in regions where onboard observer coverage is absent or limited, strandings remain a critical tool for assessing bycatch impacts, identifying fisheries interactions, and detecting spatio-temporal trends that would otherwise go undocumented. Their true value emerges when integrated with complementary sources such as satellite tracking, allowing for a more comprehensive understanding of fisheries-related threats and supporting targeted mitigation efforts.

However, strandings alone cannot quantify bycatch rates, as numerous factors influence the arrival and detection of bycaught individuals (dead or alive) on the shore (e.g., carcass drift, decomposition, scavenging, and beach accessibility). Many bycaught turtles never wash ashore, making observer programmes and electronic monitoring irreplaceable for direct, quantifiable bycatch metrics. Integrating stranding data with electronic monitoring (e.g., onboard cameras) in small-scale fisheries, where observer coverage is logistically challenging, could provide a more robust approach to assessing bycatch impacts in data-limited regions. Recent advances in drift and reverse-drift modelling have improved estimates of strandings due to bycatch and helped identify fisheries operating regionally in overlap with turtle distributions. Collaborative efforts to validate these models with local oceanographic data could refine bycatch hotspot predictions, further enhancing their applicability for management.

Nevertheless, in regions where onboard observer coverage is absent or limited, strandings remain a critical tool for assessing bycatch impacts, identifying fisheries interactions, and detecting spatio-temporal trends that would otherwise go undocumented. However, the utility of these data is maximised when integrated with complementary sources such as fisher surveys and satellite tracking, enabling a more comprehensive understanding of fisheries-related threats and informing targeted mitigation efforts.

Mustapha Aksissou presented the results of a long-term study on marine turtle strandings conducted along a 324 km stretch of the northwestern Moroccan coastline over a 24-year period (1998–2022). During this time, a total of 208 stranded turtles were recorded. Of these, 184 (88%) were loggerhead turtles (*Caretta caretta*), 21 (10%) were leatherback turtles (*Dermochelys coriacea*), and 3 (1%) were unidentified specimens.

Strandings were most frequent during the summer and early spring, periods that coincide with the peak fishing activity of trawlers, purse seiners, and longliners operating near the Moroccan coast. Among the measured loggerhead turtles, 81% were subadult individuals, indicating the importance of these coastal waters as developmental or foraging habitat. Stranded leatherback turtles included both subadult and adult specimens.

These findings suggest that Moroccan coastal waters serve as critical foraging, developmental, and migratory habitat for both loggerhead and leatherback turtles. The temporal overlap between peak strandings and intensive fishing activity implies that fisheries bycatch and vessel strikes are likely among the primary threats to sea turtles in the region. This study provides a valuable baseline dataset for the design and implementation of targeted conservation and management strategies in Moroccan nearshore and Mediterranean waters.

3 ToR B: Review the evidence available on factors affecting the mortality rate of bycaught marine turtles, considering both direct mortality and post-release mortality, and including onboard handling

Although it depends on gear type and many other factors, a high proportion of bycaught turtles may arrive on deck alive, yet direct mortality of bycaught animals is often poorly recorded and the post-release mortality remains largely unknown. Hence, monitoring direct mortality rate and evaluating post-release survival are fundamental components of assessing the impact of fisheries bycatch on sea turtle populations.

The post-release mortality rate depends on the condition of the animals (e.g. if they are injured or unconscious) and the on-deck handling procedures, so it is important to record how many of the bycaught animals were released alive, their apparent condition and what interventions were undertaken (e.g. removal of hooks, placement of unconscious animas in the recovery position for a certain period of time) (Alvarez de Quevedo *et al.* 2013, Swimmer *et al.* 2014, Baez *et al.* 2019, Parga *et al.* 2020).

Application of best practice in handling, recording of the condition of animals that are released, and greater efforts to quantify post-release mortality, are also needed. It is essential that the status of bycaught animals on deck (i.e., dead, unconscious, conscious, etc.) is recorded, also what steps were taken to maximize the post-release survival of animals which were released alive.

Understanding post-release survival can be enhanced by tagging of released animals. Evidently, tagging every single released turtle would be impractical but further tagging studies would be valuable.

3.1 Direct mortality

An overview on data on direct mortality and post-release mortality was provided, with a focus on the Mediterranean Sea.

Direct mortality refers the number of sea turtles found dead upon gear retrieval (Jribi *et al.* 2008). The literature on mortality rate does not always clearly separate the direct and post-release mortality rates, although most studies are based on what was seen onboard and as such refer only to direct mortality. The mortality rate varies among fishing gears due to factors such as the submerged time and the likelihood and severity of injuries arising during capture and release. In bottom trawls, the velocity at which nets are dragged can contribute to the likelihood of injury and exhaustion, the latter ultimately resulting in a comatose state and a reduced chance of survival. Exhaustion and coma are also seen in turtles caught in set nets and on demersal longlines. Even if the injured animals are alive when brought onboard, they could still die post-release (Oruç 2001, Casale 2011, García-Párraga *et al.* 2014, Lucchetti *et al.* 2016).

In general, set nets (gillnets, trammel nets and similar gear completely submerged below the water surface for an extended period) result in the highest direct mortality rate in bycaught turtles, followed by demersal longlines, reflecting the long soak time and submergence below the surface of these gears. Bottom trawls tend to have somewhat lower mortality rates, presumably because they remain underwater for less time than set nets and demersal longlines. Pelagic longlines also tend to have lower mortality rates because although soak time tends to be long, the

gear floats at the water surface which often allows the bycaught turtles to breathe. The most important factors contributing to these differences appeared to be the depth of deployment and the soak time/tow duration.

A review of Mediterranean turtle bycatch by Casale (2011) indicated the highest percentage mortality in set nets: the average direct mortality rate was 55.4%, with overall mortality rate estimated to be 60%. Most other gears have lower associated direct mortality rates, but total mortality rate may still be quite high. For demersal longlines, the average direct mortality rate was 12.5% but the overall mortality rate was 40%. For demersal trawls, direct mortality was estimated at 12% on average with an overall mortality of 20%. For pelagic longlines, direct mortality was low (in the range 0 to 7.7%) but overall mortality was thought to be considerably higher (30%). Set nets tend to be left submerged for an extended period, so that the entangled turtles drown before the gear is hauled by fishers. Lucchetti (2021; in Carpentieri *et al.* 2021) estimated turtle bycatch and mortality rates in the Mediterranean during 2008-2019: mean mortality rates were 51% for small-scale fisheries (which typically deploy a range of gear types), 24% for set longlines, 20% for drifting longlines and 18% for bottom trawls. Bourjea *et al.* (2014) reported on (direct) mortality in 557 individual turtles bycaught in the Atlantic and Indian Oceans. Based on the data they present and depending on whether the "unknown" category is assumed to comprise live or dead animals or is excluded from calculations, mortality rate was between 5% and 9.4% in the Atlantic and between 11% and 23.1% in the Indian Ocean (6.9% to 13.6% overall) with an overall best estimate of 7.4%.

3.2 Post-release mortality

The importance of post-release mortality remains poorly understood. When individuals are released alive, they may die hours or days later due to injuries sustained and/or physiological effects of bycatch such as decompression sickness (Maxwell *et al.* 2018). One component of post-release mortality, which can be reduced or eliminated by appropriate handling on deck, is the drowning of animals released into the sea while still comatose. While their ultimate viability might remain in doubt if they are conscious when released, animals that are still comatose will almost certainly drown immediately.

Inferences can sometimes be made based on the severity of the injuries sustained in animals brought on deck alive and the immediate fate of released animals (at least, any immediate deaths) can be determined by direct observation of the release process but otherwise it is almost impossible to directly confirm post-release mortality in the field. One option to estimate post-release mortality is to take bycaught turtles to a recovery centre to observe their subsequent mortality rate, although survival in captivity and in the wild may differ for several reasons. Another approach is to attach satellite tags to bycaught turtles prior to release, to follow their subsequent fate. This is unlikely to be feasible on a regular basis and there have been relatively few of them to date. Such studies are costly and there are many challenges associated with tracking animals at sea (Swimmer *et al.* 2014).

For set nets such as gillnets, little information is available on post-release mortality but, given the longer soak time and greater depth compared to other gears, overall survival is likely to be very low. García-Párraga *et al.* (2014) referred to 6 turtles captured in gillnets, of which 4 were found dead (direct mortality) and both the other two died subsequently: one received no treatment and died and the other received treatment but died anyway.

For pelagic longlines, various studies have reported post-release mortality rates, although often based on very different methodologies, making it difficult to compare the reported rates. Aguilar (1995) reported a post-release mortality of 20-30% in bycaught loggerhead turtles after they were taken into captivity in Spain. Swimmer *et al.* (2014) reported a post-release mortality rate of 28% (95% CI: 16% – 52%) based on satellite tracking of released loggerhead turtles and taking account of whether turtles were shallow-hooked (in the flipper, jaw or mouth such that the hook could be removed) or deep-hooked (if the hook was ingested). Álvarez de Quevedo *et al.* (2013) also satellite tagged hooked loggerhead turtles, but left the hooks in the body along with 40 cm of line. They reported a subsequent mortality rate of 30.8% - 36.5%. In general, although the direct mortality due to pelagic longlines is distinctly lower than for the other main gears mentioned below, the post-release mortality can be high, due to injuries caused by both ingested hooks and lengths of line left attached to hooks. The location of the hooks in the digestive tract is an important factor because it affects the prospect of removing the hooks without causing further injury, e.g. if the hooks are lodged the upper oesophagus removal prior to release is feasible, and removing the hooks increases the chance of survival (Casale *et al.* 2008). The post-release mortality of turtles with hooks deeply embedded in their digestive tract (which cannot not be removed) is high. Casale *et al.* (2008) reported a mortality rate of 65% in loggerhead turtles, with hooks in the lower oesophagus or deeper, that were observed in captivity at a rescue centre. The7se authors concluded that "turtles with a hook in the lower oesophagus/stomach has a very low chance of surviving the combined effect of hook and branchline". Based on an expert consultation exercise, Ryder *et al.* (2006) suggested mortality rates of up to 85% and 95% in deep-hooked hardshell and leatherback turtles respectively, the highest mortality rates being associated with turtles already entangled in the line and lower rates with trailing line (although longer lengths of trailing line resent a higher risk than shorter lengths). The authors noted that "any significant amount of trailing line can always present the risk of later effects", including strangulation of limbs and subsequent infection or amputation. Indeed, in general, if not removed (or unless very short), the line represents a greater hazard than the embedded hook.

In trawls, injuries and death can result from high velocity contact with the gear or the contents of the net, as well as through gas embolisms arising from decompression sickness and the animals may also drown. Poiner and Harris (1996) estimated direct and post-release mortality of five species of turtles bycaught in bottom trawls on the Australian northern coast in 1989 and 1990. They estimated that over 5000 turtles were bycaught in each year. They estimated the overall direct mortality (drowning) rates to be 10% in 1989 and 16% in 1990, although the rate varied between species. Overall, 21% of captured turtles were comatose when removed from the net and 4% were injured. Fishermen commented that around half of the comatose animals regained consciousness after 30 minutes on-board and that many injuries were superficial. Thus, immediate post-release mortality of could be reduced to around 10.5% if turtles were returned to the sea after 30+ minutes of recovery time.

Several more recent studies have generated estimates of post-release mortality of turtle caught in bottom trawls but were mainly based on small sample sizes and, again, varying circumstances make comparisons difficult. García-Párraga *et al.* (2014) reported that of 19 turtles found alive in trawls and diagnosed with gas embolism, 16 survived after medical treatment. Maxwell *et al.* (2018) reported that 1 out of 3 comatose olive ridley turtles that were resuscitated, tagged and released, died post-release - although the cause of death in this individual could have been predation. Parga *et al.* (2020) reported on the fate of 28 live turtles (27 loggerheads and one olive ridley) brought onboard in trawl nets. Of these animals, 20 were confirmed as suffering from gas embolism based on ultrasound or post-mortem examination. Twelve animals died on-board. Fifteen animals were satellite-tagged and released of which 3 (20%) died within six days. Franchini *et al.* (2021) reported the fate of 482 live loggerhead turtles bycaught by a trawler. Of these, 204 showed signs of gas embolism and the other 278 were released. Of the former subgroup, 40 died

(8.3% of the animals originally caught alive): 21 were dead on arrival at the Sea Turtle Clinic and a further 19 died within 12 hours. Baldi *et al.* (2022) reported a minimum post-release mortality of 8.2%: of 1131 turtles taken alive by bottom trawlers and transferred to a rescue centre, 93 died within 30 days. Jančič *et al.* (2022) reported the survival of at least 9 out of 10 loggerhead turtles released after following an on-board recovery protocol and attaching satellite transmitters.

4 ToR C: Review and propose options for mitigation of marine turtle bycatch and associated mortality in European fisheries

Barry Baker introduced the Terms of Reference C by reporting on a literature review undertaken with Louisa Breimann (Convention on Migratory Species – CMS) on proven approaches to mitigate marine turtle bycatch in artisanal & commercial fisheries. The review sought to evaluate improvements in management of turtle bycatch since the publication, by the FAO 15 years ago, of guidelines to reduce marine turtle mortality in fishing operations (FAO 2009) and identify current best mitigation practices.

Most research on technical mitigation measures since the publication of the FAO guidelines has focused on gillnets and pelagic longline gears:

- for gillnets, via increasing gear visibility to turtles but not target species, principally through illumination via light emitting diodes (LEDs), which has proven effective in many, but not all, fisheries.
- for pelagic longlines, replacement of J and tuna hooks with wider circle hooks, use of fish instead of squid baits, and encouraging deeper setting of gear. Development of hook-shielding devices show potential to reduce bycatch but these have not been tested extensively to warrant consideration as best-practice.

Little recent research has been directed toward purse seine gear and none to demersal longline gear. For purse seine, this is probably due to the low impact reported on marine turtles. Drifting fish aggregating devices (FADs) play a key role in aggregating juvenile turtles and there has been considerable progress toward developing non-entangling designs constructed of biodegradable materials. While FADs are associated with fishing gear, their impact could be more correctly described as ghost fishing than bycatch. ***

Present knowledge suggests that the most effective technical measures are the following:

- **Gillnets / setnets** - Increasing gear visibility to turtles but not target species through illumination of gillnets via LEDs has been shown to be effective in some but not all fisheries. Deep setting of gear beyond depths usually occupied by turtles, keeping nets taught by eliminating the use of tie downs to reduce slack webbing that 'entangles' rather 'gill catches' fish, and using small meshes, will all be beneficial to turtles.
- **Pelagic longline** - use of large circle hooks and fish baits reduce bycatch. Capture probabilities are lowest when using a combination of both these measures (Swimmer *et al.* 2014).
- **Trawls** - Turtle Excluder Devices (TED) are effective in minimising turtle bycatch and have wide acceptance by fishers, particularly in prawn fisheries due to improvements in product quality. Hard grids are more effective than flexible grids although the latter offer improved handling efficiency, particularly on smaller vessels.
- **Purse seine** - Purse seine bycatch levels of turtles are very low and with vigilance most animals can be released alive. Not setting on FADs can further benefit turtles and other non-target taxa such as sharks and marine mammals. Recent work and commitment by most of the tuna RFMOs has led to significant improvements in FAD design, particularly using biodegradable materials and non-entangling constructions.

- **Demersal longline** - no effective mitigation measure has been identified.

In addition, loggerhead turtles are more likely to be caught in sea surface temperatures above 22.2°C, and leatherbacks above 20°C. on the other hand, target species such as swordfish are more abundant in temperatures below 20°C. Therefore, directing fishing efforts to cooler waters below 20°C can both decrease sea turtle interactions and enhance the efficiency of fisheries (FAO 2009).

As previously identified in bycatch mitigation studies for other taxa (seabirds, sharks, marine mammals — Baker & Robertson 2018, Drynan and Baker 2024, Hamilton & Baker 2019, respectively), solutions to turtle bycatch problems are often fishery-specific and what works well in many fisheries may not always be effective in others.

Operational mitigation strategies such as spatio/temporal closures, and post-capture practices to improve the survival prospects of marine turtles after release, will reduce the impact of fisheries on marine turtles but were not discussed in this presentation.

4.1 Reducing mortality in bycaught turtles

Fishing operations that set hooks deeper than 100 m and are conducted during daytime can reduce interactions with sea turtles, which tend to inhabit surface waters for feeding and thermoregulation (Secretariat of the Pacific Community, 2004). Furthermore, sea turtles that are caught in deeper waters are less likely to be deeply hooked (they tend to bite less aggressively at these depths), so the survival rates after release are higher (Polovina *et al.* 2003, Beverly and Park 2009).

Shorter duration deployments of gear can decrease the opportunity for sea turtles and other vulnerable taxa to encounter and become entangled or captured by fishing gear. In addition, reducing the time spent in gear can lower stress levels and physical harm to sea turtles, reducing direct mortality and improving their chances of post-release survival (FAO 2009, Ferreira *et al.* 2011, Epperly *et al.* 2012, Northridge *et al.* 2017).

Appropriate handling and release practices are crucial for reducing post-release mortality of incidentally caught sea turtles. Fishers are advised to cut the fishing line as close to the hook as possible and, when feasible, bring the turtle on board to facilitate recovery (WWF, 2007). Minimizing time outside the water, and associated stress and injury during handling and release, improves the immediate survival of released sea turtles and other vulnerable taxa (Poisson *et al.* 2014a and b; ISSF 2016, 2023; Ruiz *et al.* 2023; Murua *et al.* 2024). When hook removal is necessary to enhance the turtle's survival chances, it should be performed with extreme caution to avoid inflicting further injury (WWF, 2007). In addition, best practice guides need to take account of the characteristics of different types of hooks. An exception to the desirability of rapid release is when a turtle is unconscious and requires a period of recovery onboard to reduce the likelihood of it drowning when released (see Gerosa and Aureggi 2001, ACCOBAMS, FAO and GFCM 2018).

Continuation and expansion of training programs for fishers in all fisheries are needed to ensure they receive training on the benefits and application of bycatch mitigation measures including best practices in handling and releasing sea turtles for reducing post-release mortality. As noted above, for apparently drowned or comatose bycaught turtles, training fishers in the application of recovery techniques before release may help turtles survive. Gerosa and Aureggi (2001) wrote a guidebook which provides instructions for handling turtles caught in longlines, trawls and gillnets. The protocol for handling an inactive (comatose) turtle is the same in all cases: 1) place it in a shady and out-of-the-way place, 2) raise the hindquarters of the turtle about 20 cm off the deck, 3) keep it damp using a water-soaked towel, 4) repeat every two hours, or until the turtle

responds, for up to 24 hours. The guidebook also includes a section on assessment of a turtle's condition. Jančič *et al.* (2022) reports on how fishers were instructed based on this guidebook. Fishers had to leave the turtles on-board in a sheltered location, in a slightly head-down position, until the animals became active and recovered their mobility. Turtles that seemed weak or were dead were not released into the water. Various other handling guides exist (e.g. Nastasi *et al.* 2018).

Post-release mortality from longlines can be decreased by removing hooks and fishing lines. Swimmer *et al.* (2014) described how observers removed the hook if it was lodged in the flipper, mouth, or jaw of a turtle. Based on veterinary observations, lines could be the most hazardous part of the longline gear, causing the hooks to become more deeply embedded or leading to more extensive lesions (Parga 2012). If not removed, the line could also cause entanglement and necrosis on the turtle body. Fishers should not pull hooked turtles on board using the line but instead use a net. In accordance with veterinarian recommendations, if the hook is deep in the mouth and/or has been ingested, it is left in place and as much as possible of the trailing line should be removed (Balazs *et al.* 1995, Ryder *et al.* 2006). Since a high proportion of turtles are caught with a hook embedded in the lower oesophagus or deeper (which is associated with high mortality), even though awareness campaigns, handling best practices and provision of dehooking devices to fishers are useful for ensuring the removal of shallowly lodged hooks, they cannot entirely solve the problem and a reduction in the number of turtles captured in the first place should be prioritised (Casale *et al.* 2008).

The shape and size of the hooks, and bait types, may affect the survivability (Cambiè *et al.* 2012, Clarke *et al.* 2014, Gilman and Huang 2017, Gilman *et al.* 2016, 2020, Lima *et al.* 2023, Lucchetti and Sala 2010; Sales *et al.* 2010, Stokes *et al.* 2011, Sumpton *et al.* 2011, Swimmer *et al.* 2014, WWF 2007): circle hooks were found to be more likely to lodge in the jaws or upper part of the digestive tract while J hooks were more likely to be ingested deeper inside the body, although this finding is not conclusive, and more evidence is needed. Larger hooks are less likely to be deeply ingested into the body. As previously mentioned, using fish as bait instead of squid has been found to reduce deep hooking, as turtles tend to take small bites out of fish bait but ingest squid bait whole.

The severity of gas embolisms and subsequent mortality is correlated with gear ascent rate. Turtles ascending ≥ 3.5 m/min have a 3.22 times greater risk of death than those with an ascent speed < 2.5 m/min (Franchini *et al.* 2021). Decreasing ascent velocity could help reduce mortality from gas embolisms. Hyperbaric chambers were shown to be an effective treatment for gas embolisms, but this is expensive and requires specialized equipment and expertise (Franchini *et al.* 2021, Portugues *et al.* 2018). García-Párraga *et al.* (2014), described how turtles were medically evaluated and received supportive therapy including injections of normal saline solution, additional drugs and, if necessary, recompression with hyperbaric oxygen.

Gear modification measures can further help reduce incidental capture and mortality. Obligation to use baitlines that are 10% longer than the length of the floatlines (<100 m) have been implemented in US longline fisheries since early 2000s (HMS Compliance Guide: Recreational Fishing, 2025). This was implemented after observations showed that most turtles which were hooked on the hooks closest to the buoys drowned because they were unable to reach the surface to breathe. This measure is currently under discussion for the Portuguese fishery as part of the Action Plan as mentioned in Table 2.6 of this report.

Michel Nalovic presented the Trans-Atlantic Conservation Initiative (TALCIN), an international initiative that aimed to reduce bycatch of leatherback turtle. This is a highly migratory species found throughout the Atlantic Ocean vulnerable to bycatch from artisanal and industrial fisher-

ies. There are two Atlantic management units (northern and southern Atlantic). The project estimated potential bycatch areas for nesting turtles by overlapping trans-oceanic movements of 106 leatherbacks (1995-2010) and ICCAT fisheries fishing effort data (1995-2009).

4.2 IAC Manual for handling and release of marine turtles incidentally caught in fisheries operations

IAC resolution CIT-COP10-2022-R7 (Resolution on mitigation the adverse impact of fisheries on sea turtles) focuses on mitigating the adverse impact of fisheries on sea turtles, promoting data collection, bycatch mitigation measures, and best practices. The IAC Technical document **"**Manual for handling and release of sea turtles incidentally caught in fishing operations" was prepared by the IAC Scientific Committee Fisheries Working Group together with the CPPS sea turtle expert group to support implementation of the IAC Resolution on fisheries. It is a compilation of information applicable to IAC region fisheries based on numerous published manuals and guidelines. The objective of the manual is to be used together as supplemental information with hands on training on best practices for fishers.

The framework of IAC – IATTC MoU also addresses sea turtle bycatch, and has resulted in two publications "*Vulnerability of the Critically Endangered leatherback turtle to fisheries bycatch in the eastern Pacific Ocean. I. A machine-learning species distribution model*" and "*Vulnerability of the Critically Endangered leatherback turtle to fisheries bycatch in the eastern Pacific Ocean. II. Assessment of mitigation measures*". This effort involved sharing from IAC and IATTC countries and collaboration with a multidisciplinary team of experts.

The IAC Marine turtle Convention Text Annex III includes extensive detail about the use of TEDs and the exceptions to this.

4.3 Various case studies

4.3.1 Illuminating fishing nets (LEDs) in artisanal fisheries in Peru and elsewhere

Jeffrey Mangel and Joanna Alfaro Shigueto (ProDelphinus) offered an overview on their achievements and scientific results on artisanal fisheries in Peru, in particular providing an update on illuminating fishing nets (LEDs).

Small-scale fisheries in Peru, particularly those using gillnets (driftnets and bottom-set nets), are characterised by opportunistic targeting of species such as sharks, rays, tuna, dolphinfish, among others These fisheries cover more than 100,000 km per year and unfortunately result in significant bycatch of non-target species, including sea turtles, cetaceans, and seabirds (Alfaro-Shigueto *et al.*, 2011; Mangel *et al.*, 2010).

To address this issue, researchers have investigated the use of light-emitting diodes (LEDs) to illuminate gillnets. The principle is grounded in visual physiology studies showing that certain species, like sea turtles, can detect illuminated nets and avoid entanglement. In addition, the LED colour should not be visible to the target species. Green or UV-LEDs (outside most fish visual ranges) are particularly preferred for marine turtle bycatch reduction as they remain visible to them but less conspicuous to fish (Horodysky *et al.* 2010). Results demonstrated significant reductions in bycatch: green turtle bycatch decreased by 63.9% (Ortiz *et al.*, 2016) and guanay cormorant bycatch decreased by 85.1% (Mangel *et al.* 2018). Building upon those results, experimental deployments from 2015 to 2018 further tested net illumination under real-world conditions across 864 fishing sets in vessels from three ports along the Peru coast (Bielli *et al.* 2020).

This study reported bycatch probability reductions of 74% for sea turtles and 71% for small cetaceans when nets were illuminated (Bielli *et al.* 2020). Similar 'experimental' successes have been observed in other global contexts (Wang *et al.* 2010; Virgili *et al.* 2018). Importantly, net illumination did not negatively affect the catch-per-unit-effort (CPUE) for sharks and bony fish, meaning fishers' incomes were not reduced. Reduce of small cetaceans' bycatch was also observed. Moreover, target species such as rays increased with illuminated nets - by about 67% in bottom-set and 60% in driftnets - possibly due to altered behaviour or attraction to light. See Table 8 for some key aspect of these studies.

The integration of LEDs as a multitaxon Bycatch Reduction Technology (BRT) shows promise, but implementation challenges remain, including cost, scaling, and maintenance. Complementary efforts include the use of vessel monitoring systems (VMS) and cameras for observing fishing practices as well as target catch and bycatch, and training over 3,000 fishers in safe handling and release techniques for protected species.

Net illumination represents a viable and scalable solution for reducing bycatch in small-scale gillnet fisheries, with minimal disruption to target catch (see Table 4.1).

Virgili *et al.* (2018) - focusing on loggerhead turtle (*Caretta caretta*) bycatch in Italian Mediterranean gillnet fisheries - specifically highlighted water turbidity and transparency as key environmental considerations for UV-LED effectiveness. These authors noted that dredging activities typically decrease water transparency in the Mediterranean, increasing turbidity. As a result, they recommended UV-LEDs, which "have increased ability to penetrate through turbid conditions" compared to visible-light LEDs and chemical light-sticks. Although absolute turbidity values were not reported, this study refers to moderately to highly turbid coastal and nearshore waters, conditions under which UV illumination remains effective.

Table 4.1 Key aspects of mitigation trials deploying lights to reduce bycatch of marine turtles and other ETP species.

Study	Location	Gear Type & FAO Code	Target Species	Bycaught Turtle Species	Water Depth & Turbidity	Mitigation Tested	Key Findings
Wang *et al.* (2013)	Baja California (Mexico)	Gillnets (GND/GNS)	Coastal demersal and semi-pelagic species	Green turtles	Turbidity unspecified; likely clear enough for UV effect	UV LEDs on nets	UV light visible to turtles; reduced turtle interactions
Ortiz *et al.* (2016)	Sechura Bay, northern Peru	Bottom-set gillnets (GNS – "Set gillnets/anchored")	Commercial fish & rays (mainly flounder and guitarfish)	Green turtle (*Chelonia mydas*)	Deployed at coastal depths (~10–30 m); turbidity not quantitatively provided	Green LED floats on net's floatline	LED nets reduced green turtle bycatch by ~64%; no effect on fish CPUE
Mangel *et al.* (2018)	Sechura Bay, northern Peru	Bottom-set gillnets (GNS – "Set gillnets/anchored")	Commercial fish & (mainly flounder and guitarfish)	Seabirds (e.g., guanay cormorant)	Deployed at coastal depths (~10–30 m); turbidity not quantitatively provided	Green LED-illuminated nets	Seabird bycatch ↓85%; shark/bony fish CPUE unaffected
Virgili *et al.* (2018)	Mediterranean set-net fisheries	Anchored set gillnets (GNS)	Local commercial fish	Loggerhead turtles (*Caretta caretta*)	Measured water transparency, turbidity recorded during testing	UV LEDs	UV nets reduced turtle bycatch; specific % not provided
Bielli *et al.* 2020	Peru small-scale fleet	Driftnets (GND – "Driftnets") & bottom-set gillnets (GNS)	Sharks, tunas	Primarily green turtles	Coastal and offshore waters, turbidity not measured.	Green LED-illuminated nets	Sea turtle bycatch probability reduced by 74% when nets illuminated, small cetacean bycatch probability declined 71%.

4.3.2 French Guiana shrimp trawlers and coastal gillnet fisheries

Michel Nalovic outlined the development of the "Trash and Turtle Excluder Device" (TTED) by the French Guiana Fisheries Committee (CRPMG). Initiated in 2006 through collaborative research with WWF and NOAA to address high bycatch rates, the TTED modified the standard "super-shooter" design by utilizing flat bars (6mm) with reduced spacing (5cm). This configuration was designed to improve hydrodynamic efficiency and exclude smaller bycatch; trials indicated a 20–30% reduction in total bycatch without loss of target shrimp (Nalovic *et al.* 2010). The fleet voluntarily adopted the TTED in 2009, followed by US certification (2011) and mandatory implementation via Prefectoral decree (2021). Although the fleet eventually reverted to standard TEDs to allow for the commercial retention of finfish, the reduced bar-spacing concept has since been tested in US and Suriname fisheries with promising gains in shrimp production and bycatch reduction.

Audrey Chevalier (WWF) summarised the results of two projects (*Pêcheries Actives pour la Limitation des Interactions et des Captures Accidentelles* - Fisheries working towards the Limitation of Bycatch) (PALICA) 2 and 3) on turtle bycatch mitigation in French Guiana coastal gillnet fleet. Since the late 2010's, WWF and the Fisheries Committee have jointly launched the PALICA projects, which aim at evaluating and developing the technical, technological and logistical capacities of artisanal coastal gillnet fisheries in order to reduce the bycatch of protected species such as marine turtles, dolphins and sawfish Together they are testing different modifications of the gear and its deployment to try and reduce the bycatch of large vertebrates. These projects are accompanied by an onboard observation programme using both cameras and observers. The modifications tested are:

- Changing the colour of the floats.
- The use of a floating line OR of integrated floats in the superior rope of the net.
- Reducing the vertical profile.
- The use of acoustic signallers.

Other than modifying the nets, WWF and the fisheries committee of French Guiana are also helping the professional fishermen move to more sustainable practices by:

- Changing their gear to hooks and lines.
- Adapting their fishing zones and times depending on the reproduction season of the olive ridleys, creating voluntary no fishing zones where the animals regroup.

While reducing bycatch in the legal local fishing fleet is importance, it is crucial to acknowledge that in French Guianan waters legal vessels account for a small proportion of the fishing effort. Preliminary findings from a forthcoming joint study by IFREMER, CRPMEM Guyane, and WWF highlight the alarming volume of IUU fishing, estimating illegal catch at 0.7 to 4 times that of legal vessels. These figures suggest a potential doubling of fishing effort compared to 2009-2011 levels. Illegal fleets from Suriname, Guyana and Brazil are reported to deploy hundreds of kilometres of gillnets in French Guiana daily, inflicting severe damage on the marine ecosystem, including marine turtles, marine mammals, elasmobranchs, and key fisheries resources (Pers. Comm., S. Leforestier).

4.3.3 A Mediterranean case study

One of the primary goals of TartaLife project (LIFE12 NAT/IT/000937) was to reduce the bycatch of marine turtles - a critical threat to these endangered species, particularly *Caretta caretta*, the loggerhead turtle. The project focused on testing and implementing innovative mitigation measures across various fisheries in the Mediterranean, including bottom trawling, longlines, and static nets. See https://www.tartalife.eu/sites/default/files/galleria/final_report_short.pdf for the final report of this project.

4.3.3.1 The TartaLife Project on Bottom trawls and TEDs

Marine turtles often come into contact with bottom trawl nets, particularly in areas with soft seabeds where they forage, such as the northern Adriatic Sea. To mitigate bycatch in this sector, the TartaLife project introduced and tested TEDs. These grid-like structures fitted within trawl nets allow smaller target species to pass through while preventing the capture of larger animals like marine turtles. During trials conducted with local fishers, TEDs demonstrated their effectiveness in reducing turtle bycatch without significantly affecting the catch of commercial species. 34 campaigns on 33 commercial fishing vessels (136 total fishing days) were monitored. The results showed that the average fish catch with traditional trawl and TEDs are comparable, confirming optimal capture efficiency levels with the flexible and hard (supershooter) grids.

4.3.3.2 Drifting longlines: the use of circle hooks

In pelagic longline fisheries, turtles are frequently attracted to baited hooks. The project tested the use of circle hooks. Particular attention was given to the selection of hooks for comparison, basing the J *versus* Circle hook comparison on the "gape" size of each hook type. Results from these trials indicated a notable decrease in direct mortality of turtles with minimal impact on the catch rates of target fish species, such as swordfish. A total of 250 trials was held, involving 53 boats and 239 fishermen. The bycatch reduction with circular hooks was high (more than 30%). Furthermore, in cases of turtles captured with a circular hook, they were always released in apparently good health. The swordfish specimens caught with circle hooks were larger in size, although the overall number caught was lower compared to traditional hooks. Circle hooks also caused less physical damage to other taxonomic groups, such as elasmobranchs.

4.3.3.3 Set nets: LED-UV and collapsible pots

Set nets pose a significant threat to marine turtles, which can become entangled and drown. Marine turtle bycatch reduction involved the use of visual deterrents (LED-UV) and a new type of foldable pot. The results showed that visual deterrents do not involve changes in fishing performance, while reducing marine turtle by catch by 100%. However, the use of lights required significant additional work to install them, turn them off after use, and recharge them after a few weeks, including changing the batteries (an extra expense). Therefore, the conclusion was that the use of lights is effective in reducing bycatch, but for the future, it is necessary to explore more cost-effective technical solutions that do not involve significant changes to standard onboard practices.

The results of tests with collapsible pots were satisfactory: catches of cuttlefish and other species such as sand steenbras *Lithognathus mormyrus*, other sea breams and brown meagre *Sciaena umbra* were similar or, as for cephalopods, even higher, compared with those obtained with traditional nets, proving that this new type of trap is a good alternative to traditional gears, at least in certain areas and periods. The objective of this action was not to radically replace traditional nets but to provide a good alternative during periods of greater interaction with marine turtles. In recent years, very affordable traps have been introduced for catching mantis shrimp (*Squilla mantis*).

During the spring-summer period, a significant part of the small-scale fishing fleet has been using these traps, resulting in a reduction in bycatch of turtles and interactions with dolphins.

4.3.3.4 Capacity Building and Stakeholder Engagement

A key strength of the TartaLife project was its collaborative approach, working closely with local fishers to ensure the practical adoption of mitigation measures. Training sessions and workshops provided fishers with the knowledge and tools necessary to implement these bycatch reduction strategies effectively. Moreover, awareness campaigns highlighted the ecological and economic importance of protecting marine turtles, fostering a conservation-oriented culture within the fishing community. The TartaLife project successfully demonstrated that reducing marine turtle bycatch is achievable through a combination of technological innovation and stakeholder engagement. The implementation of TEDs, circle hooks, lamps and alternative gears (such as pots) has proven to be both practical and effective.

In discussion, it was clarified that UV-LEDs are expensive (≥€20 per unit), while green lamps (Fishteks NetLights) were cheaper (a few euros on the Chinese market). The LEDs are time-consuming in terms of attachment to the gear, while Fishtek's NetLights are efficient and can be attached easily and save battery life as they turn off out of the water.

TEDs used for turtles can be the same as those used for cetaceans. The appropriate design will depend on the type of net and its dimensions (TEDs need to be adjusted for smaller nets). Costs also depend on where the product is obtained. Danish producers are expensive, while Turkey produced its own TEDs from cheaper materials for a much lower price. In the Mediterranean TEDs have had a 10-year trial period; however, while they are currently being used in Turkey, there is no mandatory use of TEDs in Mediterranean. In French Guiana TEDs have been implemented by industry successfully since 2010. In general, the introduction of TEDs can increase the quality of catch and there has not been much opposition from fishers outside the Mediterranean to use them. In the Mediterranean region TEDs could be used in some high-risk areas. Note that the ICES/FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) has done a considerable amount of work on TEDs.

4.3.4 Best handling and release practices

Mariluz Parga (SUBMON) provided an overview of best practices for turtle bycatch in surface longline gear based on her extensive experience as a veterinarian.

Marine turtle bycatch mitigation techniques have been developed for some fisheries, but adoption of these techniques uniformly across fishing sectors is often precluded by variation in gear configurations, vessel designs, operational characteristics, fishing methods or fisher cultures and customs across fleets. While more effective and fishery-specific mitigation techniques are under development, it is imperative and urgent to introduce fishers to handling and release methods to improve the survival of captured individuals after release. This is particularly critical in drifting longline fisheries, where the use of Best Handling and Release Practices (BHRP) have been shown to significantly reduce post-release mortality. Many initiatives have already taken place in different countries, including in the Mediterranean Sea, to develop and implement general BHRP of marine turtles, and several countries (mainly in America) and fishery bodies have adopted regulations requiring fishers to complete training on BHRP, and to carry a set of release tools (dehooker, bolt catcher, dip net) on board.

Although generic best practices for surface longline fisheries do exist and are commonly applied, they need to be adapted according to the specific situation, since if used unmodified, the recommended practices or tools can be detrimental to marine turtle post-release mortality (e.g., recommending the use of long-handled line-cutters in a fishery that uses a metal wire leader) or may

simply be not applicable in the conditions of a specific fishery (e.g., obligatory use of a dipnet for small boats). There is no "one-size-fits-all" recipe. Instead, BHRP and national and regional policies should be practical and tailored and adapted to the singularities of each fleet and fishery, or even community, based on factors such as fishing gear, vessels used, socio-economic situation of the community, and availability of tools in the domestic market or fishing operations. Local ecological or traditional knowledge and co-design of the BHRP with fishers and authorities have proven to be a win-win solution for fisheries and conservation of marine turtles. At the same time, institutionalizing the training and capacity building for whole fleets is also essential for the long-term success of BHRP.

4.3.4.1 Are circle hooks effective?

The use of large circle hooks (>C16) has been shown to reduce the impact of longline fishing on marine turtles, significantly decreasing the number of marine turtles captured, especially when used in combination with finfish bait. However, depending on their target species, some longline fleets cannot use large circle hooks without an important negative economic impact in their activity. The mahi-mahi fishery along the Eastern Pacific Ocean is a good example, as are probably many of the more artisanal drifting longline fleets of the Mediterranean Basin. For these fisheries, researchers and fishery managers tend to recommend the use of smaller circle hooks. In fact, little is known about the true post-release mortality of captured turtles in relation to hook location and associated injuries, so we lack essential information to adequately determine gear impacts, and mitigation technique impacts. The help of specialized marine turtle veterinarians is here essential, as well as to help define BHRP according to other specifics of the fishing gear.

Due to their shape, circle hooks of any size tend to result in hookings in the mouth, as opposed to being swallowed like J hooks. Traditionally, this has been deemed a better option for improving post-release mortality. However, this is not so clear if we look at the anatomy and physiology of marine turtles. The oesophagus of these animals has a strong, thick muscular wall covered with *queratinous papillae*, making it rather resistant to injuries and infections: unless the hook lodges close to the heart or large blood vessels, and as long as handling practices are correct, a marine turtle can live with several hooks lodged here (something commonly seen in the Mediterranean). However, the mouth has several rather sensitive and fragile structures which should be carefully considered, such as the glottis (entrance to the respiratory system), the tongue (easily broken and infected) and the mandibular joint. A hook lodged in the mouth, therefore, is only beneficial if fishers remove it (after bringing the animal on board in an appropriate way (i.e. not pulling it in using the line)). On the other hand, due to their shape, circle hooks are much more difficult to remove than J hooks, causing further damage due to their large barb. A further consideration is that on many occasions the problem of marine turtle bycatch is not so much the hook, but the way fishers handle the situation: for example, if the problem of a given fishery is that fishers do not cut the line short when releasing turtles, changing J hooks for small circle hooks will not solve the problem – bycatch rates will remain similar, as will post-release mortality due to the line. For this reason, Mariluz Parga asked for cautious consideration before adopting a "mitigation" measure in a specific fishery without good understanding of that fishery, and without conducting previous studies. She also requested that more weight is given to veterinarians' expert opinions when dealing with anything related to post-release mortality.

4.4 Marine turtle bycatch mitigation measures in Cyprus (Eastern Mediterranean)

Marios Papageorgiou (Enalia Physis Environmental Research Centre) summarised his work on turtle bycatch on Cypriot fishing boats. Turtle mitigations measures have been tested in SSF and LPF in Cyprus aiming to mitigate bycatch as well as post-release mortality. In SSF, LED green

illuminating lights were trialled on set nets following standardized methodologies, with trained onboard observers monitoring the results. However, these trials found no significant difference in the catch or bycatch rates of marine turtles between control nets (without LEDs) and experimental nets (with LEDs), suggesting that LED lights are ineffective in reducing turtle bycatch (Papageorgiou, *in prep*.). Despite these inconclusive results, continuous efforts have been made since 2018 to raise awareness and train professional fishers in the safe handling and release of marine turtles, yielding positive outcomes. Over the years, an increasing number of fishers have participated in these workshops, indicating a gradual shift in attitudes toward marine megafauna conservation. This approach, which does not require additional effort or resources from fishers and has no adverse impact on catch rates, is likely the most effective strategy for reducing post-release mortality of marine turtles. However, its success is contingent upon fishers' willingness to implement safe handling and release protocols at sea. This underscores the importance of fostering strong collaboration and trust between fishers and scientists, as well as maintaining ongoing awareness campaigns and training initiatives.

4.5 Other gears

Entanglement in buoy ropes can be an important source of turtle mortality in pot fisheries (Hays *et al.* 2023). Reducing the soak time may increase the chances that incidentally caught turtles can be released alive. Another proposed mitigation method is the use of "ropeless" fishing, whereby the marker buoys stay near the seabed and are only released, with the buoy rope unfurling, just before retrieval (Dodge *et al.* 2022).

4.6 Import regulations

Legislation prohibiting the import of shrimp harvested in a manner which may adversely affect marine turtles was adopted in the U.S.A. in 1989 (Public Law 10-162, 1989). U.S. fishing fleets and foreign countries wishing to export wild-caught shrimp to the U.S. are required to use TEDs or to prove they are not impacting marine turtles. More than 40 shrimp-exporting countries now meet this requirement. However, the EU - the largest importer of shrimp in the world - does not yet mandate the use of TEDs for imported products, thereby providing an alternative market for countries that do not utilize these devices. To address this disparity and curb marine turtle bycatch globally, the CRPMEM Guyane launched the EU TED initiative in 2017. Building on the successful implementation of TEDs in French Guiana, the initiative aims to raise awareness of the fact that the EU continues to import shrimp from third countries that lack effective bycatch mitigation measures (Davies 2016).

5 Conclusions and recommendations

5.1 General conclusions

There appears to be an increasing inclination to prioritise the implementation of bycatch mitigation measures over the continued investment in monitoring programmes, under the assumption that this represents the most effective pathway to conserve Endangered, Threatened, and Protected (ETP) species. However, monitoring and mitigation should not be seen as competing priorities but rather as interdependent components of an integrated bycatch management and species conservation strategy. In short, with no monitoring, both the scale of the problem and the efficacy of mitigation are difficult to verify.

A comprehensive understanding of the operational dynamics and ecological contexts in which ETP species interact with fisheries is essential for the identification, selection, and refinement of effective mitigation tools, as exemplified by the complex issues associated with the choice of hooks used on pelagic longlines and the procedures used to remove them from live bycaught turtles. In this regard, onboard observer programmes remain indispensable. They not only provide robust data for assessing the actual impacts of fishing activities on ETP species but also offer critical insights to guide the adaptation and effectiveness of mitigation measures in real-world conditions.

To achieve a balanced and sustainable management approach, the development and deployment of mitigation strategies must be accompanied by rigorous economic assessments. Understanding the financial implications of mitigation - both in terms of initial investment and operational costs (which may include not only maintenance but also potentially negative impacts on target species catches and ease of handling the gear) - will support the design of practical, acceptable, and scalable solutions, particularly for small-scale and resource-constrained fisheries.

Despite increased reporting and monitoring efforts, data on turtle bycatch remains inconsistent and limited- particularly for small-scale fisheries, vessels under 12m. Many interactions go unreported due to lack of observers, low trust, or fisher hesitance. In addition, IUU fishing operations are suspected to contribute significantly to turtle bycatch, which is the case in EU waters of French Guiana. Observational biases and inconsistent methodologies still contribute to poor population and risk assessments, especially in high-interaction zones like the southern Mediterranean. For small-scale and artisanal fleets, interviews and community-based monitoring were highlighted as critical supplementary data sources and strandings monitoring may also contribute relevant data. Even where bycatch numbers are adequately recorded, data on associated mortality rates – and indeed on visible sub-lethal effects on bycaught individuals - are often lacking.

Technological mitigation, such as Turtle Excluder Devices (TEDs) have been implemented successfully in a broad range of countries for over 40 years. LED illumination shows promise. In European waters TEDs have been readily adopted since 2010 only in French Guiana and are in an early adoption phase in Turkey, with limited opposition from fishers and added benefits like debris exclusion and improved catch quality. TEDs have been tested in fisheries operating in specific areas of the Adriatic by Italian trawl operation and will be tested for the first time aboard a French Mediterranean trawler in 2026. LED illumination technologies significantly reduce bycatch of turtles and other megafauna in some settings, but high costs, limited battery life, and logistical impracticalities hinder widespread use. UV-LEDs, while effective under controlled conditions, were found to be impractical during field trials.

Behavioural and operational measures such as shortening soak times, avoiding turtle hotspots, and reducing fishing effort were also discussed.

Marine turtle bycatch remains a concern across European waters due to the wide distribution and migratory behaviour of species such as the loggerhead and leatherback. These species navigate multiple maritime regions during their life cycles, and as such, bycatch risks often span national boundaries. Effective bycatch mitigation, therefore, requires coordinated, range-aware strategies that consider species-specific movements and the diverse fisheries or IUU activities operating across these areas.

Mitigation strategies should be informed by data on fishing effort, gear type, and turtle distribution, incorporating tools such as electronic monitoring, observer programmes, and community-based data collection. Species-specific approaches are particularly important. For instance, loggerheads nesting in the Mediterranean may face bycatch risk in both Mediterranean and Atlantic waters, while leatherbacks require protections along extensive trans-Atlantic migratory routes. While the apparently good conservation status of Mediterranean subpopulations of green and loggerhead turtles is a testament to successful conservation actions, it should not be interpreted as a reason for complacency in the face of ongoing threats.

One significant challenge in trawl fisheries is the occurrence of gas embolism in turtles, regardless of depth or trawl duration. Clinical studies in both Brazil and the Adriatic Sea have documented high rates of gas embolism in bycaught turtles, with post-release mortality reaching up to 25%. These findings suggest that handling and release best practices may not be sufficient in trawl fisheries (given that the routine use of hyperbaric chambers is impractical), although experimental work on slower retrieval of gear may be appropriate so that decompression can occur naturally and accumulation of nitrogen bubbles in tissues avoided. Nevertheless, arguably the most effective strategy is to reduce bycatch incidence altogether. In this context, the use of **Turtle Excluder Devices (TEDs)** is strongly recommended, as they allow turtles to escape before being brought on board, minimizing physiological trauma.

In addition, the use of **collaborative fisheries research (CFR)** approaches can enhance the development and adoption of mitigation measures. By involving fishers directly in research and technology testing, CFR increases the relevance, practicality, and uptake of bycatch reduction tools. Local ecological knowledge, when combined with scientific expertise, has proven valuable for refining gear modifications and informing adaptive management strategies.

Efforts to reduce bycatch should also consider imported seafood supply chains, particularly where wild-caught tropical shrimp harvested using bottom trawls are concerned. Where possible, incentives for the use of selective fishing technologies, such as TEDs, could be extended through certification programmes and market-based tools.

In conclusion, an effective approach to marine turtle bycatch reduction requires:

- Species- and region-specific mitigation strategies.
- Wider use of selective gear such as TEDs in trawl fisheries.
- Recognition of gas embolism risks and limits of post-capture handling.
- Expansion of collaborative research models.
- Coordinated data-sharing across jurisdictions and fleets.

Such measures would contribute to more effective, practical, and evidence-based conservation outcomes for marine turtles in European and adjacent waters.

Following presentations on best handling practices for bycaught turtles and the use of circle hooks, participants engaged in a focused discussion on practical and biological considerations.

The need to tailor mitigation guidelines - such as hook type and handling protocols - to specific fisheries, countries, and gear configurations was strongly emphasised. It was noted that larger circle hooks (>C16) can significantly reduce turtle bycatch, while smaller hooks tend to embed deeply and cause more injuries. To reduce deep injuries specialized removal tools and handling protocols are required.

Circle hooks were recommended if they demonstrably reduce bycatch, but the long-term fate of injured turtles is uncertain and expected to vary between fisheries according to details of fishing practices. As such further investigation is needed. For example, even though circle hooks tend to lodge in the mouth, rather than being swallowed like J-hooks, if the attached line on J-hooks is not removed (or at least cut as close to the beak as possible) before the animal is released, it is likely to die from the line left instead of a lodged hook. Thus, making the advantage of J-hooks over circle hooks ineffective.

Finally, the workshop warned against unnecessarily holding trawl-caught turtles onboard. Drawing from fieldwork in Italy and Brazil, it was reported that this can exacerbate the negative impact of gas embolisms caused by forced submerge and rapid ascent. As such, active and apparently uninjured individuals should be released into the sea immediately. The workshop proposed the development of a visual flowchart for fishers to improve outreach efforts, including descriptions of low-cost multi-purpose cutting tools (e.g., that developed in Costa Rica from an originally box opening tool).

The workshop also agreed that it would be useful to produce as an output an exhaustive table summarising the pros and cons of each mitigation measure, acknowledging the gaps in practical implementation. Such a table should specify at least the following information to provide necessary context: fishing gears, fishery target species, type of used bait, marine turtle bycaught species, and water quality (e.g., turbidity, depth, temperature, etc.).

Lastly, participants emphasised the need for co-designing mitigation with fishers, harmonising bycatch assessments with the relevant RFMOs, and creating tailored, enforceable solutions backed by regional trials and socioeconomic feasibility studies.

Regarding the case of the Mediterranean Sea - which is a recognised biodiversity hotspot and a key habitat for marine turtle species, particularly the loggerhead and green turtle - despite ongoing conservation efforts, interactions with various fishing activities continue to present a significant threat to these vulnerable populations. The workshop agreed that a risk-based analytical approach would offer a structured and pragmatic method to assess and address bycatch interactions, enabling more targeted and effective management responses.

The Workshop acknowledged that, while official fisheries data collection by EU Member States in the Mediterranean (and the North Atlantic) has improved in recent years, notable limitations and discrepancies remain across countries. These differences affect the consistency and completeness of available data. However, a substantial body of peer-reviewed literature and regional studies provides valuable insight into turtle bycatch associated with specific fishing gears and geographic areas. This broader knowledge base - such as, for example, the recent review conducted by the GFCM (Carpentieri *et al.* 2021) should be revised, updated and integrated into future bycatch risk analyses. In addition, data from north African fisheries (and small-scale fisheries generally) are lacking.

The workshop agreed on the need for a coordinated strategy that could be implemented through a series of thematic workshops. ICES could lead on the planning of a series of follow-up workshops co-organized with relevant RFMOs and MEAs, such as the GFCM, and IAC, focused on: (i) bycatch risk assessment, (ii) mitigation technology evaluation, and (iii) bycatch impact assessments.

5.2 Recommendations on the nature and extent of interactions between marine turtles and fisheries in the Northeast Atlantic and Mediterranean Sea (ToR A)

Regarding the assessment of the nature and extent of interactions between marine turtles and fisheries in the Northeast Atlantic and Mediterranean Sea (ToR A), the Workshop recommended the following:

- **The strengthening of monitoring frameworks:**
  Establish and/or enhance fishery monitoring programmes that include onboard observer schemes and/or remote electronic monitoring (REM) systems, particularly in high-risk or data-poor fisheries. Where onboard observer monitoring is unfeasible (such as on vessels <12 m) and for data-poor situations, test REM feasibility and use alternative data collection methods (e.g., fisher self-reporting, logbooks, community-based surveys). Interview surveys of fishers may provide both additional monitoring data and insights into mitigation options to reduce megafauna bycatch (e.g. Potts and Berggren 2024) and the use of stranding data to provide complementary information (as already done for cetaceans) should be explored.
- **The identification of high-risk fisheries and regions:**
  Compile and analyse existing data to identify specific fisheries, gear types (e.g., small-scale gillnets), and regions with significant turtle interactions, especially in unmonitored or under-reported sectors. This includes better inclusion of IUU fishing impacts and revisiting, for example, the potential risk to leatherback turtles in the Azores.
- **The fostering of collaborative monitoring and assessment:**
  Support co-management approaches and Collaborative Fisheries Research (CFR) with industry and fishers to build trust and improve data quality. Encourage participation in ongoing initiatives (e.g., CleanCatch UK, CRFS, ICES-GFCM-IAC collaborations) and future inclusion in ICES WGs of expertise from groups like the OSPAR Sea Turtle Expert Group.
- **To supplement data through port and community surveys:**
  Implement or expand port-based and community-level surveys to supplement official data. These approaches can be particularly valuable for small-scale and artisanal fisheries and should be coupled with targeted capacity-building initiatives for data collectors.
- **Systematically incorporate stranding data:**
  Collect and integrate data on stranded marine turtles as a supplementary source of information on mortality causes and spatial risk patterns. While stranding data cannot replace direct monitoring, they can enhance spatial understanding of threats and should be used in coordination with fishery data.
- **Carry out a bycatch risk assessment at appropriate geographic scales:**
  Conduct a risk-based analysis - e.g., ByRA, SEFRA, Productivity and Susceptibility Analysis (PSA), etc. - to assess the potential bycatch risks posed by different fisheries to marine turtles, which could inform targeted mitigation strategies in the Mediterranean Sea. This assessment should consider key factors including gear type, fishing effort, and the spatial and temporal overlap with marine turtle habitats. Such initiative should be carried out in connection with all relevant RFMOs (e.g., GFCM, ICCAT, etc.) to ensure methodological consistency, enhance data sharing, and incorporate region-specific expertise.

5.3 Recommendations on factors influencing mortality rates of bycaught marine turtles, including direct mortality, handling practices, and post-release survival (ToR B)

Regarding factors influencing mortality rates of bycaught marine turtles, including direct mortality, handling practices, and post-release survival (ToR B), the Workshop recommended the following:

- **Improved handling protocols and training:**
  Develop, disseminate, and enforce handling guides tailored to different gear types and vessel operations. These should include clear procedures for minimising onboard stress, addressing hook injuries (e.g., with appropriate cutting tools), and reducing post-release mortality.
- **The monitor of post-release survival:**
  Support studies evaluating the long-term fate of released turtles, especially those caught with gear known to cause internal injuries (e.g., circle hooks, bottom trawlers). Satellite tagging or veterinary follow-ups could improve understanding of delayed mortality.
- **The assessment of the role of operational variables:**
  Promote risk-based assessments to understand how operational factors such as soak time, gear depth, and area-specific turtle presence influence bycatch outcomes. This information is critical for defining high-risk conditions and adapting mitigation effort accordingly.
- **The investigation and validation of alternative mortality indicators:**
  While stranding data alone are not sufficient for estimating bycatch mortality, they can serve as complementary indicators when interpreted alongside fishery and environmental data, especially for artisanal and small-scale fleets.
- **The exploration of the integration of crew-based monitoring:**
  Encourage the testing of use of trained crew members as onboard data providers where formal observer programmes are not feasible, following examples from Norway, Portugal, and Ireland. These data can support mortality assessments and improve compliance with best practices.

5.4 Recommendations on mitigation options available to reduce marine turtle bycatch and associated mortality (ToR C)

Regarding mitigation options available to reduce marine turtle bycatch and associated mortality (ToR C), the Workshop recommended the following:

- **No "one-size-fits-all" approach:**
  Acknowledge that mitigation must be context-specific. Best practices must be adapted to local gear, species, environmental conditions, and fishery types. Standardisation should be accompanied by flexibility, with follow-up and fisher engagement as essential components.
- **Promote the use of proven mitigation tools:**

- **Turtle Excluder Devices (TEDs):** use TEDs wherever feasible, particularly in trawl fisheries, emphasising their dual benefit in reducing bycatch and debris. Their promotion should be backed by local implementation activities, such as at sea evaluations, feeding into cost-benefit analyses to aid managerial uptake.
- **Circle hooks:** adopt large circle hooks (e.g., >C16) in longline fisheries to reduce deep hooking, considering that their effectiveness depends on hook design and leader length, where long leaders reduce the benefits.
- **Gear modifications:**
  - avoid the use of non-biodegradable monofilament to prevent ghost fishing;
  - promote trials with alternative gear types (e.g., lasso traps, buoy-less ropes);
  - develop cost-effective innovations (e.g., solar powered, neutral buoyancy LED systems with auto-off features);
  - adapt mesh sizes where appropriate.

- **Improve handling & post-release survival:**
  - standardise handling protocols, distribute appropriate tools, and ensure at least one trained fisher per vessel;
  - track post-release mortality through tagging where possible.
- **Spatial and temporal effort controls (risk-based area & gear management):**
  Encourage use of dynamic management tools such as spatial/temporal closures in marine turtle hotspots, soak time limitations, and avoidance of high-abundance areas during peak turtle activity.
- **Support collaborative research and innovation:**
  Foster the co-development of mitigation technologies and their deployment with fishers, through positive communication of ecological and economic benefits, incorporation of local ecological knowledge (LEK), and sustained logistical support (e.g., "afterlife resources") are key to long-term uptake.

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Annex 1: List of participants

Name	Institute	Country (of institute)
Caterina M. Fortuna (chair)	Institute for Environmental Protection and Research (ISPRA)	Italy
Alessandro Lucchetti	Institute of Marine Sciences	Italy
Ana Marçalo	Algarve Centre of Marine Sciences (CCMAR)	Portugal
Andrea Fariñas	Department of Ecology and Marine Resources, Institute of Marine Research	Spain
Angela Mastrogiacomo	Unaffiliated	NA
Anis Zarrouk	FAO Fisheries Division	Italy
Audrey Chevalier	World Wildlife Fund France	France
Barry Baker	COP appointed Scientific Councillor, Bycatch, Convention on Migratory Species (CMS)	Australia
Bianca Wiles	European Commission Directorate-General for Maritime Affairs and Fisheries	International
Carmen Mifsud	Unaffiliated	NA
Desislava Chaparova	European Commission Directorate-General for Maritime Affairs and Fisheries	International
Dunja Jusufovski	Marine and Freshwater Research Institute	Iceland
Frederic Vandeperre	Institute of Marine Sciences, Okeanos University of the Azores	Portugal
Graham Pierce	Department of Ecology and Marine Resources, Institute of Marine Research	Spain
Guðjón Sigurðsson	Marine and Freshwater Research Institute	Iceland
Jeffrey Mangel	ProDelphinus	Peru
Joanna A. Shigueto	ProDelphinus	Peru
Jose Carlos Báez	Centro Oceanografico de Málaga	Spain
Jose Luis Crespo-Picazo	The Oceanographic Foundation	Spain
Lotte Kindt-Larsen	DTU Aqua, National Institute of Aquatic Resources	Denmark
Mariluz Parga	Submon	Spain
Marios Papageorgiou	Enalia Physis Environmental Research Centre	Cyprus
Michel Nalovic	IUCN-SSC Marine Turtle Specialist Group	International
Mustapha Aksissou	Abdelmalek Essadi University	Morocco

Paolo Carpentieri	The Food and Agriculture Organization of the United Nations	International
Pilar Santidrian Tomillo	Spanish Institute of Oceanography	Spain
Ruth Fernandez	International Council for the Exploration of the Sea	International
Sara Cerqueira	Unaffiliated	NA
Verónica Cáceres Chamorro	Inter-American Convention for the Protection and Conservation of Sea Turtles	United States

Annex 2: Resolutions

Joint ICES-CIBBRiNA[3]-REDUCE[4]-MarineBeacon[5] Workshop on Mitigation Measures to minimise Marine Turtle Bycatch (WKTURTLE), chaired by Catarina Fortuna, Italy, will be established and will meet online, 3–5 February 2025 to:

- Review the evidence available on the nature and extent of interactions between marine turtles and fisheries in the Northeast Atlantic and Mediterranean Sea, together with quantifying the fisheries impact on marine turtles (Science Plan code: 2.1);
- Review the evidence available on factors affecting the mortality rate of bycaught marine turtles, considering both direct mortality and post-release mortality, and including onboard handling (Science Plan code: 6.1);
- Review and propose options for mitigation of marine turtle bycatch and associated mortality in European fisheries (Science Plan code: 2.1)

Supporting information

Priority	The workshop will review our current understanding on sea turtle bycatch and associated mortality. It will contribute to the ICES Roadmap for Bycatch on Endangered, Threatened, and Protected (ETP) Species and support the work of ICE WGBYC, addressing a gap in the expert matter expertise in marine turtles, as noted in the Roadmap as a short-term priority. The work is relevant to the provision of ICES advice on ETP species bycatch, covering a taxon which is not specifically addressed by current ICES groups and thus with critical linkages to WGBYC.
Scientific justification	Sea turtle bycatch is a recognised issue in the Mediterranean and some parts of the Northeast Atlantic (e.g. Macaronesia) but knowledge and monitoring gaps limit the extent to which the impact of this bycatch in the populations can be assessed and managed. ToR C encompasses the main tasks of the workshop and aims to review and synthesise information on the success of current mitigation approaches in a range of different metiers (e.g. bottom and pelagic trawls, set nets, longlines, and surrounding nets) as well as reviewing available alternatives. Note that this will include methods to reduce bycatch and to reduce direct and post-release mortality in bycaught turtles. ToRs A and B provide necessary context for discussions of mitigation and it is suggested that these reviews are undertaken prior to the workshop, including a summary based on WGBYC records, and the results briefly summarised at the workshop. Particular issues include methods for estimating spatial and seasonal variation in bycatch rate, the current reporting of turtle byatch, and understanding and quantifying the survival rate of bycaught turtles in different fishing gears.
Resource requirements	It is expected that several large ongoing EU projects on ETP species bycatch will support and facilitate expert attendance to the Workshop.
Participants	The Workshop is expected to attract appr. 25 participants. The intent is to gather relevant expertise from all relevant stakeholder sectors, e.g. science, policy, fishing industry, NGOs. The chairs of WGBYC, or a designated representative of the WGBYC, will be invited to participate in the workshop.

[3] https://cibbrina.eu/

[4] https://www.ciimar.up.pt/projects/reduce/

[5] https://marinebeacon.eu/

Secretariat facilities	None besides Teams and SharePoint access and assistance with report production.
Financial	No financial implications.
Linkages to advisory committees	ACOM
Linkages to other committees or groups	WGBYC, WGING, OSPAR
Linkages to other organizations	The work of this group is closely aligned with that of several large EU projects (e.g. CIBBRiNA, REDUCE, MarineBeacon).

Annex 3: List of abbreviations and acronyms

ACAP	Agreement on the Conservation of Albatrosses and Petrels
AGLIA	Association du Grand Littoral Atlantique (Grand Littoral Atlantic Association)
AI	Artificial Intelligence
ARP	Analyse Risque Pêche (Fisheries Risk Analysis)
BEAM	Bycatch Evaluation and Assessment Matrix
BHRP	Best handling and release practices
CCL	Curved carapace length
CIBBRiNA	Coordinated Development and Implementation of Best Practice in Bycatch Reduction in the North Atlantic, Baltic and Mediterranean regions
CMS	Convention on Migratory Species
CPPS	Permanent Commission for the South Pacific
CPUE	Catch per unit effort
CRPMEM	Comité Régional des Pêches Maritimes & des Élevages Marins (Regional Committee for Maritime Fisheries and Marine Farming)
DG-ENV	European Commission's Directorate-General for Environment
DG-MARE	European Commission's Directorate-General for Maritime Affairs and Fisheries
EMFAF	European Maritime, Fisheries and Aquaculture Fund
ETP species	Endangered, Threatened and Protected species
EC	European Commission
EU	European Union
FADs	Fish Aggregating Devices
FAO	Food and Agriculture Organization of the United Nations
GFCM	General Fisheries Commission for the Mediterranean
IAC	Inter-American Convention for the Protection and Conservation of Sea turtles
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission on the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer (French Institute for Ocean Science)
IUCN	International Union for the Conservation of Nature
IUCN SSC	International Union for the Conservation of Nature Species Survival Commission
IUU	Illegal, Unreported, and Unregulated fishing

LAUD OPO	Eastern Pacific Leatherback Turtle Conservation Network
LED	Light emitting diode
LIFE MMS	LIFE Mobile Marine Species Project
LPF	Large Pelagic Fisheries
Marine Beacon	Monitoring and Elimination of Bycatch of Endangered & Conserved Species in the NE & High Seas Atlantic Region
MEA	Multilateral Environmental Agreement
NEAFC	North East Atlantic Fisheries Commission
OEC	Office de l'Environnement de la Corse (Corsican Environment Office)
OFB	Office français de la biodiversité (French Biodiversity Office)
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (derived from the Oslo and Paris Conventions)
PALICA	Pêcheries Actives pour la Limitation des Interactions et des Captures Accidentelles (Fisheries working towards the limitation of Bycatch)
RAMSAR	Convention on Wetlands of International Importance especially as Waterfowl Habitat (signed in Ramsar, Iran)
REDUCE	Reducing Bycatch of Threatened Megafauna in the East Central Atlantic
REM	Remote Electronic Monitoring
RFMO	Regional Fishery Management Organization
RPOA-VUL	The GFCM's Regional Plan of Action for VULnerable species
SEFRA	Spatially Explicit Fisheries Risk Assessment
SPAW	Specially Protected Areas and Wildlife Protocol under the United Nations Environment Programme
SSC	Species Survival Commission
SSF	Small-scale fisheries
TALCIN	Trans-Atlantic Conservation Initiative, an international initiative to reduce bycatch of leatherback turtles
TED	Turtle Exclusion Device
TTED	Trash and Turtle Excluder Device
UV-LED	Ultra violet light emitting diode
VMS	vessel monitoring systems
WGBYC	ICES Working Group on Bycatch of Protected Species
WGENGAGE	ICES Working Group on Stakeholder Engagement
WGFTFB	ICES/FAO Working Group on Fishing Technology and Fish Behaviour
WGING	ICES Working Group on Innovative Gears
WKPETSAMP	ICES Workshop on Appropriate Sampling Schemes for Protected Endangered and Threatened Species Bycatch
WWF	World Wildlife Fund