EU request on the review of monitoring of bycatch of protected, endangered, and threatened species of mammals, birds, turtles and fish under the service of EC DG ENVIRONMENT

Service summary

This review has been carried out as part of a special advice request to ICES from DGENV with the aim to evaluate appropriate bycatch monitoring systems at Member State level and on regional coordination to comply with obligations under the Birds, Habitats and Marine Strategy Framework Directives. Three independent reviewers met online, reviewed relevant literature and summarized current practice on i) bycatch risk assessments of Protected, Endangered and Threatened Species (PETS), ii) bycatch monitoring programs and sampling protocols, iii) métiers and areas with reported PETS bycatch, iv) issues with sampling resolution for estimating total bycatch of PETS, and v) monitoring by Member States. Some conclusions and recommendations on best practice design for PETS bycatch sampling programs are included at the end of the report. The review is attached as Annex 1

Request

DGENV special request to ICES:

a) Inventory of Member States' bycatch monitoring programmes and of main data needs.

b) Advice on appropriate bycatch monitoring systems at Member State level and on regional coordination to comply with obligations under the Birds, Habitats and Marine Strategy Framework Directives.

This review service covers only aspects related to part a) of the request. Part b) of the request will be addressed at specific workshops and ICES advisory processes in 2023–2024.

Recommended citation: ICES. 2022. EU request on the review of monitoring bycatch of protected, endangered, and threatened species of mammals, birds, turtles and fish under the service of EC DG ENVIRONMENT. ***In*** Report of the ICES Advisory Committee, 2022. ICES Advice 2022, sr.2022.04, https://doi.org/10.17895/ices.advice.10096.

Annex 1

EXTERNAL REPORT ON THE REVIEW OF MONITORING PETS BYCATCH OF MAMMALS, BIRDS, TURTLES AND FISH FOR ICES UNDER THE SERVICE OF EC DG ENVIRONMENT

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Contents

i Executive summary

This review has been carried out as part of a special advice request to ICES from DGEnvironment with the aim to evaluate appropriate bycatch monitoring systems at Member State level and on regional coordination to comply with obligations under the Birds, Habitats and Marine Strategy Framework Directives. Three independent reviewers met online, reviewed relevant literature and summarized current practice on i) bycatch risk assessments of Protected, Endangered and Threatened Species (PETS), ii) bycatch monitoring programs and sampling protocols, iii) métiers and areas with reported PET species bycatch, iv) issues with sampling resolution for estimating total bycatch of PET species, and v) monitoring by Member States. Some conclusions and recommendations on best practice design for PETS bycatch sampling programs are included at the end of the report.

1 Introduction

ICES has been requested to provide advice on appropriate bycatch monitoring systems at Member State level and on regional coordination to comply with obligations under the Birds, Habitats and Marine Strategy Framework Directives. As part of this process a literature review was requested involving three external experts to jointly address key issues related to monitoring Protected, Endangered and Threatened Species (PETS) bycatch of i) mammals; ii) birds, iii) turtles and iv) fish. The experts were requested to:

1. Review current guidelines for best practices of PETS bycatch monitoring protocols in dedicated and non-dedicated (e.g. DCF) sampling schemes;
2. Identify métiers and areas with high bycatch risk and caveats in the methodology used;
3. Identification of key geographic areas (subregions of ICES ecoregions) where bycatch should be monitored;
4. Identification of key métiers where bycatch should be monitored;
5. If possible, identify the main gaps (e.g. areas, métiers…) in current monitoring efforts (by using the results of technical service under 1.) per subregion or ICES ecoregion;
6. Suggest adequate temporal resolution and "primary sampling units" (e.g. haul, fishing day, trip) for the different taxa;
7. Propose the use of relevant total effort units (e.g. fishing days vs. soak time) for different métiers.

Materials to be considered for review included:

a) RCG PET bycatch subgroup reports for 2019, 2020 and 2021;
b) FishPi 1 and 2, relevant Work Packages on PET bycatch sampling;
c) STREAM project, relevant Work Packages on PET bycatch sampling;
d) WKPETSAMP report;
e) Relevant sections of WGCATCH reports 2019 and 2020;
f) Relevant sections of WGBYC report 2020;
g) Report of the 1st ASCOBANS-ACCOBANS workshop on bycatch;
h) OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental bycatch of birds and marine mammals;
i) Review of the implementation of the EU regulation on the incidental catches of cetaceans (STECF-19-07);
j) Inventory of sampling programmes initiated by WKPETSAMP and updated at WGCATCH 2021;
k) Reports on MSFD monitoring programmes and results of Habitats Directive monitoring;
l) National DCF work plans and Member State information reported under ICES data calls;
m) Report of the EC contract "Risk Assessment of Bycatch of Protected Species in Fishing Activities".

This report addresses the seven points listed above.

1.1 Background information provided by the EC

As outlined in the EC request to ICES, appropriate monitoring of bycatch is essential to understand the magnitude of the problem and to help focus the identification and implementation of adequate conservation measures as required by EU legislation. Relevant EU legislation includes

Article 12(4) of the Habitats Directive[1] that requires Member States to establish a system to monitor the incidental capture and killing of the animal species that are in need of strict protection, listed in its Annex IV(a). In the light of the information gathered, Member States have to take further research or conservation measures as needed to ensure that incidental capture and killing does not have a significant negative impact on the species concerned. The same actions are needed to achieve the requirements under Article 2 of the Birds Directive[2] and to implement a general system of protection for seabirds as required by its Article 5.

The Marine Strategy Framework Directive (MSFD)[3], under its descriptor 1 requires that 'Biological diversity is maintained', and identifies 'mortality rate per species from incidental bycatch'[4] as one of the criteria defining good environmental status (GES). The species concerned include birds, mammals, reptiles and non-commercially-exploited species of fish and cephalopods, which are at risk from incidental bycatch. The MSFD also requires Member States to establish and implement coordinated monitoring programmes for the ongoing assessment of the environmental status of their marine waters.

For the management of EU fisheries under the common fisheries policy (CFP)[5], EU countries collect, manage and supply data under the data collection framework (DCF). The CFP has the objective to minimise negative impacts of fisheries and aquaculture activities on the marine environment through an ecosystem-based approach to fisheries management. The DCF contributes to these objectives though the collection and management of relevant data on commercial and recreational fisheries. In this context, data to assess the impact of Union fisheries on the marine ecosystem inside and outside Union waters are also to be collected, including data on bycatch, in particular species protected under Union or international law, data on impacts of fisheries on marine habitats, including vulnerable marine areas, and data on impacts of fisheries on food webs[6,7]. The data is collected on the basis of the national work plans in which the Member States indicate which and how data is collected, and the allocation of resources for the collection of data.

The CFP also includes provisions for the implementation of technical measures, i.e. the rules on where and how the fishers can fish. These measures shall in particular contribute to ensure that incidental catches of sensitive marine species, including those protected under the Habitats and

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[1] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

[2] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds

[3] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)

[4] D1C1 — Primary criterion: The mortality rate per species from incidental bycatch is below levels which threaten the species, such that its long-term viability is ensured.

[5] Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC

[6] Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008

[7] Commission Delegated Decision (EU) 2019/910 of 13 March 2019 establishing the multiannual Union programme for the collection and management of biological, environmental, technical and socioeconomic data in the fisheries and aquaculture sectors

Birds Directives, that are a result of fishing, are minimised and where possible eliminated so that they do not represent a threat to the conservation status of these species[8].

Finally, the recently adopted EU Biodiversity Strategy for 2030[9] commits to stepping up data collection on bycatch for all sensitive species in support of elimination, where possible, or minimizing bycatch so as not to threaten their conservation status.

Against this background, and despite the obligations stemming from the abovementioned policies and legislation, available information on bycatch of cetaceans and other protected species in fishing gear in EU waters is limited and, where it exists, it points to significant impact on several species.

1.2 Background information on PET species monitoring assessments

To improve estimates of bycatch, minimise bias and accurately estimate precision, best practice in sampling designs and protocols should be developed, which make the most efficient use of sampling resources and provide guidance on implementation, including common sources of estimation bias, and data analysis (ICES WKPETSAMP 2019, Moore *et al.*, 2021). For example, probability-based sampling with accurate control of the inclusion probabilities would be considered an example of best practice (ICES WKPETSAMP 2019). Where bias is unavoidable, best practice requires collection of information that allows the form and level of bias to be investigated. For example, recording all vessel refusals (and the reasons) to participate in PET species bycatch monitoring programmes, and the characteristics of those vessels and their activities, provides the potential to evaluate any biases (ICES WKPETSAMP 2019). Best practice protocols for monitoring PET species have been devised in the US (e.g. AFSC 2021), and recently for the Mediterranean Sea (FAO 2019), as examples. Whereas some best practice protocols have been developed for particular groups of species, such as marine mammals (e.g. Moore *et al.*, 2021; Wade *et al.*, 2021). Such protocols not only detail survey designs/sampling schemes, but also outline the objectives, sampling protocols, staff training, and data/sample collection and storage. In addition to this, Northridge (1996) reviewed bycatch observer schemes and provided best practice recommendations. This review is still largely pertinent but, given its date, does not include modern technological developments such as VMS or electronic monitoring.

The ICES Working Group on Bycatch of Protected Species (WGBYC) has been given the remit within ICES to collate and analyse data from across the North-east Atlantic and adjacent waters, including the Baltic, Mediterranean and Black Seas, related to the bycatch of marine mammals, and to a lesser extent other PET species. The WG was established partly to review Member States annual reporting under Regulation 812/2004, the 'bycatch' regulation, and as such the scope of the species and gear assessed was somewhat limited at times. Though in recent years, after the repeal of the bycatch regulation, and with activities related to bycatch observer programmes and

[8] Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) No 1967/2006, (EC) No 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) No 894/97, (EC) No 850/98, (EC) No 2549/2000, (EC) No 254/2002, (EC) No 812/2004 and (EC) No 2187/2005

[9] COM(2020) 380 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Biodiversity Strategy for 2030. Bringing nature back into our lives

mitigation subsumed within the Common Fisheries Policy, the work of the WG has become wider with less emphasis on small cetaceans.

As part of their work, ICES WGBYC has developed a bycatch database, incorporating information on fishing effort, at-sea monitoring effort and bycatch records, for the purposes of producing robust bycatch estimates. Data are primarily acquired annually through an ICES dedicated data call made to all ICES Member Countries. Currently the database holds information up to the end of 2020, acquired through data calls issued annually to all ICES member countries since 2017 and all non-ICES EU coastal states from 2021 (ICES WGBYC 2021). Since 2017, most of the data submitted to WGBYC came from national at-sea data collection efforts under the DCF, though data from dedicated bycatch monitoring programmes and bycatch focussed research projects were also obtained (ICES WGBYC 2021). As the initial focus within WGBYC was largely on cetaceans in relation to Regulation 812/2004, there is a need for a historical data call on bycatch for other taxa (and other gear types) (ICES WGCATCH 2019). The 'historical' data call would request information on fishing effort, monitoring effort as well as bycatch data, and such a call should obtain data in a form closely compatible with the new ICES Regional Database and Estimating System (RDBES).

Due to the initial focus of DCF monitoring, the consideration and experience of fisheries observers has been towards fish bycatch rather than that of protected species. However, with the implementation of EU Regulation 2017/1004 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy (EU-MAP), it is now a requirement that at-sea observations should be carried out for the purposes of collecting data on the 'bycatch of non-target species, in particular species protected under Union or international law' (ICES WGBYC 2020).

In 2012, the second Workshop on Practical Implementation of Statistical Sound Catch Sampling Programmes (WKPICS2 - ICES 2012) developed guidelines for best practice on the design and documentation of catch sampling programmes. Figure 1. outlines the stages in design and implementation of such a regional data collection scheme. However, these guidelines were somewhat generic, and as such work on improving reporting of PET species bycatch within such programmes has been undertaken within ICES working groups WGBYC and WGCATCH (Working Group on Commercial Catches), as well as the Joint NAMMCO-ICES Workshop on by-catch monitoring held in 2010 and the Joint WGBYC-WGCATCH Workshop on sampling of bycatch and PET species (WKPETSAMP) held in 2018. Currently, WGCATCH and WGBYC members are organising a Workshop on Estimation of Rare Events (WKRARE) that will be held in 2022 and led members of these two groups.

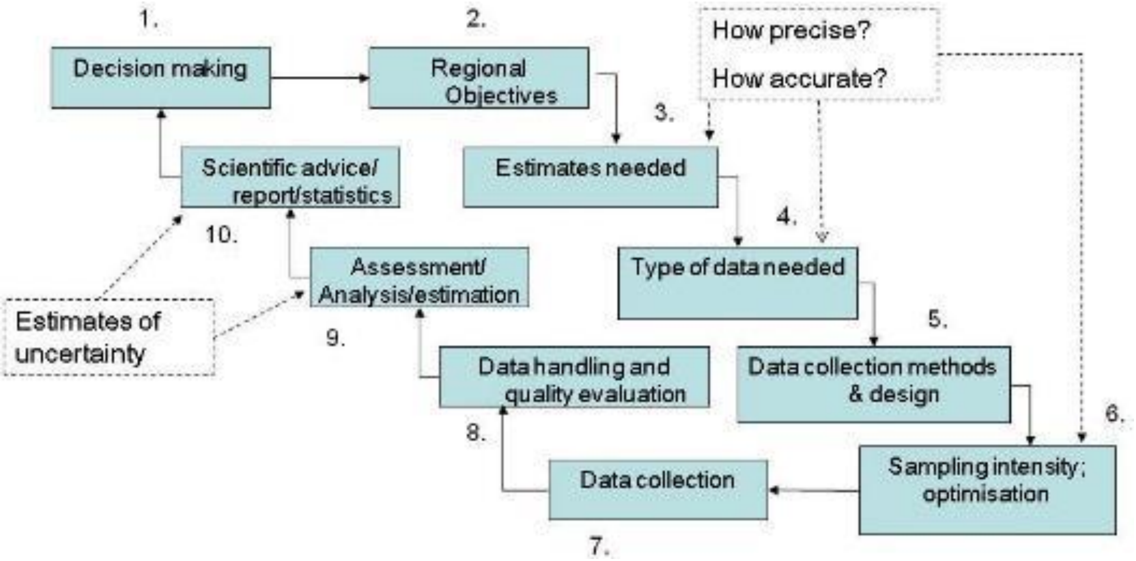

Figure 1. Stages in design and implementation of a data collection scheme providing data supporting assessments and management advice (from (ICES WGPICS 2012).

1.3 Background information on PET species bycatch indicators in development

To measure impact on PET species populations/management units/assessment units/stocks, total bycatch needs to be measured against a reference point/threshold for assessing their conservation status (Moore *et al.*, 2021, Wade *et al.*, 2021). Seen within the roadmap for ICES bycatch advice on PET species as one of its strategic developments: 'methodological work towards setting threshold values for incidental bycatch, derived based on the conservation/management objectives (when available), and testing to ascertain their ecological relevance'[10]. Within European waters, the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), aims 'to restore and/or maintain stocks/populations to 80% or more of the carrying capacity' (Resolution 3.3 of 2000 on Incidental Take of Small Cetaceans). ASCOBANS also proposed an 'unacceptable interactions' limit of 1.7% of the best available estimate of abundance for total anthropogenic removals (i.e. all anthropogenic removals and not just mortality from bycatch) in the case of harbour porpoise and a 'precautionary objective to reduce bycatch to less than 1% of the best available abundance estimate and the general aim to minimize bycatch (i.e. to ultimately reduce to zero)'[11]. It should be noted that, even for porpoises, the 1.7% limit is somewhat simplistic. It was derived using a simple deterministic population dynamics model, assumed an *R*MAX of 4% in a single stock with more-or-less independent dynamics, and did not incorporate very much biological information on the species, nor uncertainties in population estimates (ICES WGMME 2008, 2012, Murphy *et al.*, 2019). Following the introduction of Regulation 812/2004, the EU Scientific, Technical and Economic Committee for Fisheries tacitly adopted the 1.7% of best population estimate as the threshold against which bycatch would be assessed. However, 1.7% of best abundance does not enable an evaluation against which the population/

[10] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/Roadmap_ICES_Bycatch_Advice.pdf

[11] https://www.ascobans.org/en/species/threats/bycatch

unit can be monitored, as it is unknown if 'favourable conservation status' is in fact achieved and/ or will be maintained in the long-term.

In recent years, with the development of OSPAR's marine mammal bycatch biodiversity indicator (M6), contracting parties have adapted the ASCOBANS conservation objective for small cetaceans, where an 'assessment unit' should be able to recover to or be maintained at 80% of carrying capacity, with 80% probability, within a 100-year period. For grey seals (*Halichoerus grypus*), who exhibit a faster rate of increase and a 'favourable' conservation status in the marine Atlantic region[12], the conservation objective of the US Marine Mammal Protection Act (MMPA) is being employed where it aims to maintain or restore an 'assessment unit' to its maximum net productivity level MNPL (typically >50% of the population's carrying capacity), with 95% probability, within a 100-year period. To achieve such conservation objectives two management framework approaches are being employed. OSPAR's Marine Mammal Expert Group (OMMEG) have developed a Removals Limit Algorithm (RLA) framework based on the Catch Limit Algorithm developed under the Revised Management Procedure of the International Whaling Commission (Boyce 2000, Hammond *et al.*, 2019, Genu *et al.*, 2021). In addition to the RLA, OMMEG modified the US MMPA Potential Biological Removal (PBR) framework to the above stated conservation objective for small cetaceans (Genu *et al.*, 2021).

Table 1 provides an overview of the approaches for setting bycatch limits for marine mammals. OSPAR, as an end-user of bycatch monitoring data, now requires estimates of bycatch for all fisheries within the range of the marine mammal species assessment unit (for harbour porpoise *Phocoena phocoena*, common dolphin *Delphinus delphis*, and grey seal), with its associated uncertainly. However, issues exist with bycatch data availability, as monitoring of larger vessels and data collection using fisheries observers (i.e. as part of the DCF monitoring) dominate, and coverage using dedicated surveys monitoring bycatch in high risk métiers such as gillnets is relatively poor, so sampling is not representative (ICES WGCATCH 2020). This becomes an issue as data collected by dedicated monitoring differ from data collected with fisheries observers, for example in terms of the main métiers sampled (ICES WGCATCH 2020).

[12] https://www.eionet.europa.eu/article17/species/summary/?period=5&group=Mammals&subject=Halichoerus+grypus&region=MATL

Table 1. Approaches to setting bycatch limits for marine mammals. Taken from Murphy *et al.* (2019).

Approach	Pros	Cons
Percentage of abundance	● Easy to assess—Compared with maximum net productivity rate if known (and should be less than the maximum net productivity rate)	● Harbour porpoise '1.7% of best population estimate' assumes a single stock with more or less independent dynamics ● Assumed a maximum annual rate of increase of 4% ● Did not incorporate any biological information on the species ● Does not incorporate uncertainty in estimates of population size or bycatch ● Does not include natural mortality
US potential biological removal (PBR) level	● Incorporates uncertainty in estimates of population size ● Incorporates a recovery factor (if unknown status, a recovery factor of 0.5 is used)	● Uses only a single current value of absolute population size N_{min}; though in a model-based approach N_{min} is based on estimates of abundance from all previous surveys and Bayesian methods (Moore & Barlow, 2014) ● Does not incorporate estimates of bycatch ● Does not include natural mortality
Catch Limit Algorithm approach*	● Incorporates estimates of population size and bycatch ● Incorporates uncertainty in estimates of population size and bycatch ● Estimates relative population level (depletion) and allows implementation of a 'protection level' below which limits to removals can be set to zero. This can shorten recovery time to target population levels ● More conservative than PBR ● Safe bycatch limits can be calculated for multiple management units for a species	● If a time series of data on population size and bycatch rates are unavailable, it performs similar to the PBR ● Does not include natural mortality

*Developed as part of SCANS-II project and based on the framework for the International Whaling Commision's revised management procedure (Winship et al., 2009).

OSPAR and HELCOM are developing a common seabird bycatch indicator and it is anticipated that through the establishment of a threshold setting approach, assessments will be undertaken for those species that sufficient information are available (OSPAR-HELCOM 2019). Thresholds, which represent the upmost limit to anthropogenic mortality beyond which conservation objectives will not be met, are being based on Population Viability Analyses (PVA) that is currently being evaluated. As outlined in JWGBIRD (2020), the OSPAR-HELCOM workshop in 2019 proposed an assessment method related to the conservation objective to 'minimise and eliminate where possible incidental catches of marine birds', in line with the prohibition of deliberate killing or capture of birds according to Article 5 of EU Directive2009/147/EC (Birds Directive). It is also aligned with the conservation target of the EU-PoA, which requests Member States to 'minimize and, where possible, eliminate the incidental catches of seabirds'. The proposed threshold comprises a mortality rate from incidental bycatch equivalent to 1% of natural annual adult mortality of the species. The 1% level is an approximation of zero mortality (derived from legal interpretations in European courts of 'small numbers' stemming from the EU Birds Directive). It was recommended it shall be tested with PVA modelling, whether or not 1% of adult annual mortality would affect the population trajectory. It was further suggested that for data-poor species with known bycatch problems the assumption is that the species is not in GES unless the opposite is proven by monitoring data (ICES JWGBIRD 2020). If agreed by Contracting Parties of OSPAR, a pilot assessment of seabird bycatch will be produced for OSPAR's Quality Status Report in 2023.

2 What are PET species?

This review is based on the classification of PET species where bycatch is a concern as previously defined by ICES. This includes birds, mammals, PET fish species and reptiles (turtles) (ICES WKPETSAMP 2019). Draft species lists of bycatch concern were prepared by ICES to inform species sampling lists for observers-at-sea, and data-entry fields within the new ICES regional database and estimation System (RBDES) (ICES WGBYC 2020). ICES has prepared draft lists of marine mammal and bird species for ten ICES ecoregions (Barents Sea, Norwegian Sea, Faroes, Iceland Sea, Oceanic north-east Atlantic, Azores, Bay of Biscay and the Iberian Coast, Celtic Sea, Greater North Sea, and Baltic Sea) by assessing their relative status, i.e.vs their relative encounter rate (vagrant, rare, regular but uncommon, common) within that ecoregion (see Annex 1; ICES WGBYC 2020). Only some of these ecoregions are relevant to this request. The PET fish species list provided was compiled by the ICES Workshop on Fish of Conservation and Bycatch Relevance (WKCOFIBYC) held in 2020 and comprises a comprehensive list of bycatch species by region, including commercial species, elasmobranchs and deep-water species (ICES WKCOFIBYC 2021). Follow up work is required to produce such lists for mammals and birds for ecoregions in the Mediterranean and Black Seas, and for other protected species such as sea turtles.

As stated above, the PET fish species list provided includes a comprehensive list of bycatch species by region. However, as the list is so extensive, using it would preclude any sensitivity of this study. To avoid this, it was initially considered to reduce the WKCOFIBYC (2021) PET fish species list to a subset of the Regional Bycatch Lists (RBL) provided, but keeping the regional component and focusing on the species under so-called hard law protection, namely:

1. Species subject to strict protection under the Habitats Directive (Annex IV), and Appendix I of CMS and/or CITES;
2. IUCN Critically Endangered (CR) and Endangered (EN) red listed species.

However, other considerations taken from WKCOFIBYC such as very data poor species for which any data point is informative in itself e.g. *S. squatina*, not advised upon anywhere and listed as Data Deficient (DD) on any relevant red lists e.g. marbled stingray *Dasyatis marmorata*, or deep-water species could be considered. **Further work, which is outside the remit of this contract, is therefore needed to prioritize the PET fish species list in terms of monitoring objectives.**

3 Pre-monitoring - bycatch risk assessments of PET species

In absence of available data on bycatch rates in various métiers and to provide a rational basis for the prioritization of candidate high-risk métiers for increased monitoring of PET species bycatch, various bycatch risk assessment approaches have been devised. These include the ICES WKBYC risk-based approach (ICES WKBYC 2013), fishPi risk scoring index (MASTS 2016) and an EU-funded risk mapping project that developed risk categories (Evans *et al.*, 2021). Such approaches were reviewed by ICES WGBYC (2020; 2021), and all varied in their complexity and level of data requirements. Data that may not be available without the implementation of pilot studies, for example for defining 'bycatch risk'. Though while the focus of these approaches has been on the identification of high-risk métiers, it should be noted that a medium-risk métier can quickly develop into a high-risk métier due to changes in fishing effort and/or movements of PET species. Further, data resolution and spatial scale of such approaches should be considered, as in some cases a finer spatial scale may be required.

WKBYC risk-based approach combines species 'abundance', fishing effort and monitoring levels to identify areas and fishing gears in need of further monitoring. Such work was further developed by the fishPi project, where a risk index was calculated based on expert opinion on species/species group presence, as well as bycatch risk within métiers. Bycatch risk was defined for species/species group using three categories (1: low risk, 2: some risk, 3: high risk). Information on fishing effort of métiers (days at-sea) from DCF reporting was also included in the assessment (Mugerza *et al.*, 2017). Data were then included within a risk index matrix for each species and métier, based on fishing effort of each métier and presence in each different fishing ground, and risk indices were summed across either all species or all métiers for each fishing ground (see Figure 2). The higher the index, the greater the risk.

The third approach, the risk mapping exercise undertaken by Evans *et al.* (2021), aims to predict the degree of spatial and temporal overlap between fishing effort of 'high-risk' métiers and the density distributions of 25 cetacean and seabird species. As reported in ICES WGBYC (2021) fishing effort was calculated as the estimated number of hours of fishing per time-period by métier using AIS data and algorithms developed by Global Fishing Watch (GFW). A comparison of relative fishing effort was made with VMS maps produced by ICES for different gear types within three ecoregions and showed good correspondence. Specific maps were then prepared using the AIS fishing effort data by season, by year, and by EU member state for ten general gear types (pelagic trawls, pelagic seines, demersal trawls, demersal seines, driftnets, static gillnets, trammel nets, set longlines, drifting longlines, pots and traps). Maps of (cetacean and bird) species seasonal density distribution were created using environmental covariates, and data were then used to create maps of relative risk of bycatch. For such purposes, pelagic trawls and seines were combined, as were set gillnets, trammel nets and drift nets because of uncertainties in the fishing effort data and whether the gear type had been correctly ascribed across the entire region, due largely to the polyvalent nature of fishing gear registered in some areas (ICES WGBYC 2021). For both the fishPi and the risk mapping approaches, risk represents the likelihood of bycatch and does not signify the population level risk, and as such does not incorporate actual bycatch rates (ICES WGBYC 2021).

In order to assess how métier level sampling coverage relates to the fishPi risk scores, a comparison was undertaken between results of the fishPi approach and available data from the year 2019 on fishing and monitoring effort (days at-sea) by Métier Level 3, and ICES Division (ICES WGBYC 2021). Analysis revealed that several netting métiers (GNS / GTR) in subareas 8 and 9 may be initial candidate fisheries for increased monitoring, métiers considered to have a high PET species bycatch risk and are relatively large fisheries in terms of total effort (see Table 6.3 in ICES WGBYC 2021). Several métiers with higher monitoring coverage and lower risk scores of PET species bycatch were identified - higher monitoring likely due to the quantification of commercial species discard rates in those métiers (ICES WGBYC 2021).

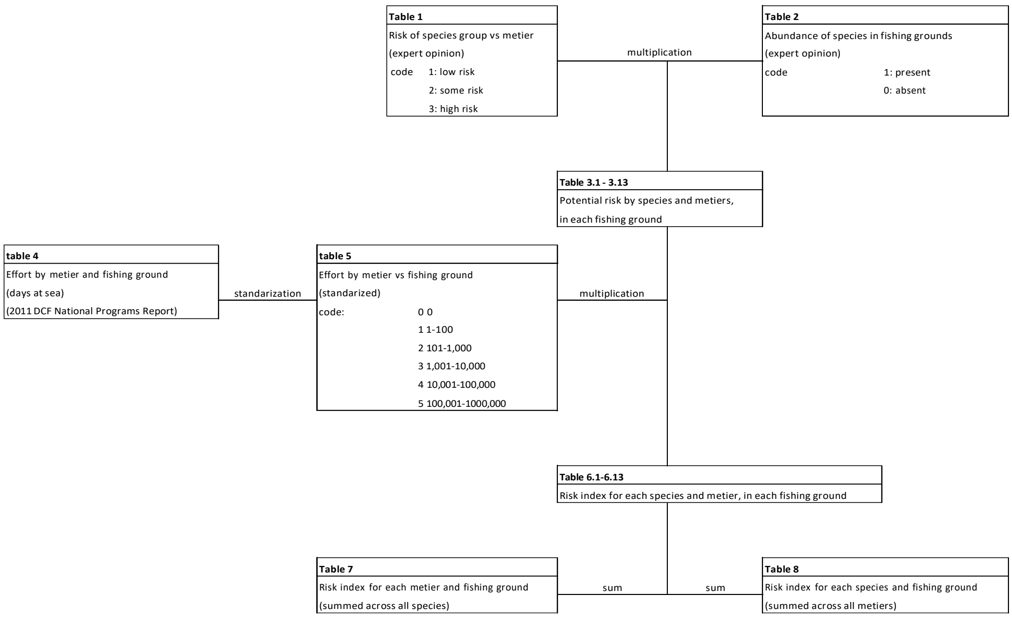

Figure 2. Risk based assessment methodology used in FishPi. Taken from Mugerza *et al.* (2017).

Several recommendations in terms of methodological improvements were made by ICES WGBYC (2021) after comparisons of the fishPi risk scores against fishing and monitoring coverage. A preliminary comparison was also undertaken of fishPi risk scores against 'risk', estimated using the overlap of fishing effort and species distribution created by the EU risk mapping project (Evans *et al.*, 2021). Some differences were observed between both approaches, most notably fishPi produce a high combined score for GND in ICES 8.a and 8.b, whereas the risk mapping approach did not, due to relatively low fishing effort recorded as days at-sea in those ICES Divisions. A similar result was reported for GNS and GTR in divisions 7.f, 7.g, and 7.h. In contrast, the risk mapping highlighted OTB in the western Channel (7.e) as high risk requiring increased monitoring due primarily to its high fishing effort, whereas the combined score from fishPi did not (ICES WGBYC 2021).

To improve such work, WGBYC recommended the incorporation of additional data such as spatial and temporal variations in fishing effort within ICES Divisions, as well as species composition and the overlap of fishing effort with collective seasonal density distributions of the higher risk species within the fishPi risk scoring approach. WGBYC also suggested that the approach could also be developed further to operate at a finer spatial scale. **WGBYC further recommended the incorporation of other PET species and métiers within the EU risk mapping study.** However, and as stated above, for PET fish species a prioritization needs to be made *a priori* to make the risk assessment sensitive. If the criteria to categorize a fish species as "PET" is determined by their possibility of being bycaught, then all fish species are PET species. Consequently, all fisheries are automatically high-risk fisheries for any given PET fish species bycatch and/or season/area, and need to be monitored accordingly, i.e. to high levels. Nevertheless, STECF 21-17 in its Evaluation of Work Plans for Data Collection 2022-2024[13], reports that several member states have carried out risk assessments of their fisheries regarding PET species bycatch. However, the results of those risk assessments, which are included in the member states national work plans (WPS) reports, are not publicly available.

It should be noted that while risk mapping work to date has largely focused on species such as cetaceans and seabirds, there are difficulties in developing some of these approaches for species such as pinnipeds and turtles. Pinniped abundance is estimated based on numbers at terrestrial pupping and/or haul-out sites and thus (satellite) telemetry data are required for the production of risk maps for the incorporate of at-sea usage (Cronin *et al.*, 2016), data that are not readily available in all countries EEZs/ICES Divisions/ecoregions. While estimates of abundance for turtles are also largely based on counts at nesting sites, as well capture–mark–recapture, tagging and in-water surveys, other platforms have been utilised internationally, including land, aerial and boat-based (Fuentes *et al.*, 2015). While such data are not available at the scale of ICES Divisions, efforts should be placed on collecting/ collating these data (OSPAR 2020). It should also be noted that for cetaceans, while efforts have been placed into collecting data on species occurrence outside the summertime (e.g. (Laran *et al.*, 2017, Rogan *et al.*, 2018), in many areas, sightings data from the wintertime are lacking, a period with increased fishing effort on continental shelf waters. While sightings data collected over longer-time periods can be used to improve data availability for risk assessment work, including inferring species occurrence for non-surveyed areas, it should be noted that many species show strong interannual variability in occurrence and abundance, for example common dolphins off the Irish coast, as reported by the Irish ObSERVE project (Rogan *et al.*, 2018).

Overall, when assessing a species relative risk to bycatch, there are a number of aspects that could be considered, as reported by OSPAR-HELCOM (2019):

- conservation status
- species sensitivities – characteristics that make them susceptible, length of time at-sea (birds), feeding mode (diver or surface feeder),
- density/abundance – biogeographic aspects
- life history aspects – feeding mode, productivity, longevity, breeding, consumption rates, time at surface, time beneath surface
- seasonality – migration events, seasonal local abundances, breading (and resultant feeding behavioural changes)
- habitat information and specialisation
- prey specificities
- environmental conditions and heterogeneity
- productivity
- oceanographic aspects – nutrients, upwelling events

[13] https://stecf.jrc.ec.europa.eu/reports/dcf-dcr; STECF 21-17 - Annexes.zip

4 Monitoring of PET bycatch

4.1 At-sea monitoring programmes

Fisheries monitoring and reporting programmes have historically relied upon independent fishery observers, vessel monitoring systems (VMS, real-time vessel position reporting), landings reports, and self-reported paper logbooks for a large majority of fishery-dependent data collection. However, constraining budgets and increasing demands for data are driving the need to improve existing programmes, while the COVID pandemic has shed a light on Electronic Technologies (ET) based programmes due the difficulty of observers to access vessels (ICES WGTIFD 2020). Table 2. provides an overview of the strengths and weaknesses of the different monitoring approaches, and ASCOBANS (2021) reviewed different monitoring approaches in light of their costs.

Observer programmes

In the EU, through the Data Collection Framework (Commission Regulation (EC) No. 665/2008), member states have to develop at-sea monitoring programmes (usually based on human observers) and fishing vessels targeted by the programme have to accept the presence of the observer, except in case of lack of space or for safety reasons. In 2017, of the 23 EU member states that have a sea border, the majority (20 MS) had running at-sea observers programmes (Ackermann *et al.*, 2018).

Other forms of at-sea observers programmes include dedicated bycatch monitoring programmes (UK) and directed bycatch studies. The 2019 Joint WGBYC-WGCATCH Workshop on sampling of bycatch and PET species (WKPETSAMP) report provides an inventory of these specific sampling schemes (see section 6). Directed studies are usually limited in space and time which make them unsuitable for extrapolating results to areas beyond the immediate fishery of focus. At-sea catch sampling (DCF programmes) and specific bycatch monitoring programmes have a larger spatial and temporal coverage meaning that extrapolation is appropriate, but may have high uncertainty due to monitoring intensity. At-sea catch sampling programmes tend to focus on fisheries with large volumes of catch and/or fisheries where discards are considered high. This often coincides with fisheries of relevance for bycatches of protected fish species and elasmobranchs, but with a lesser relevance for bycatches of birds, marine mammals and reptiles (ICES WKPETSAMP 2019).

As reviewed by the WKPETSAMP (2019), different on-board sampling protocols carried out by dedicated PET species bycatch monitoring and DCF fish catch monitoring programmes led to a marine mammal bycatch rate that differed by more than a degree of magnitude between the two programmes, based on data from the same gear types (gillnets and tangle/trammel nets), areas and over the same time-period (see Annex 4 of WKPETSAMP 2019). As large animals can often fall out of nets as they are hauled, i.e. 'drop-outs', or are removed from nets before they are landed, if this is not properly checked by the at-sea observer at the time (by observing from an appropriate location onboard the vessel), it can lead to a significant difference in the estimated bycatch rate. Thus, it was recommended that adjustments were required to DCF sampling protocols, in addition to re-allocation of observer sampling effort to ensure that incidences of bycatch for larger PET species are not missed. Enhancing the overall sampling effort of the DCF programme would aid in this work, and the amount sampling effort required for a multi-purpose-at-sea sampling programme could be calculated from existing data (ICES WKPETSAMP 2019). Such an assessment should take into consideration the rarity of the PET species of interest, as the bycatch rate may be too low to be quantifiable by any realistic monitoring scheme (NAMMCO-ICES 2010).

Electronic Technologies

Worldwide, electronic technologies are increasingly being deployed to improve fisheries monitoring in all types of fisheries. Electronic technologies can complement traditional human onboard observer programmes, for example in assessing ‘drop-out’ rates, or in fisheries where vessels are unsuitable to place a human observer (too small, unsafe, remote or unpredictable location for placing and retrieving observers, high incidence of coercion/corruption of human observers), may offer an alternative method for scientific and/or compliance monitoring (Gilman *et al*., 2018) (Figure 3). However, while technology to support data collection for fisheries monitoring programmes continues to advance rapidly, there are still a number of challenges that remain: (1) costs, (2) privacy, (3) access and ownership of data, (4) lack of standards, coordination, and consistent applications, and (5) the correct balance of incentives and regulations (ICES WGTIFD 2019).

Electronic monitoring

Electronic monitoring systems installed on fishing vessels offer a cost effective and 24/7 monitoring alternative to independent fisheries observers to collect data, particularly in small-scale fisheries. Video-based high-resolution data makes it possible to estimate accurately e.g. compliance with the Landing Obligation, discard activities and incidental bycatch of PET species (Dalskov *et al*., 2021). Dalskov *et al*. (2021) recommends that in fisheries where there is a suspicion of high-risk of incidental captures of PET species, including marine mammals, birds, turtles, as well as non-commercial fish and elasmobranchs, at least a representative sample of the fishing vessels in the fleet carry a (video-based) electronic technology system.

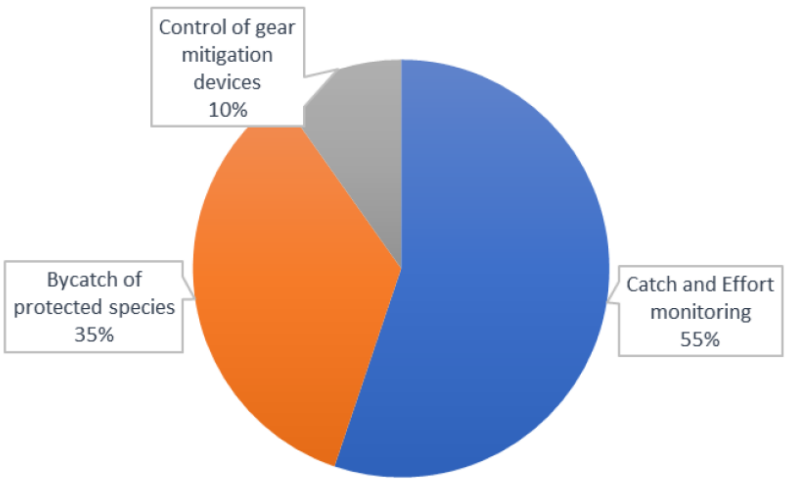

Figure 3. Relative proportion of the three main EM objectives in trials worldwide (Dalskov *et al*., 2021).

Depending on the monitoring objective of the electronic monitoring programme, different data fields need to be collected. For seabirds interactions related monitoring objectives for example, specific data fields on seabird catch, variables that significantly explain seabird catch and post-capture mortality risk (defined above), and fields that enable monitoring compliance with and assessing performance of seabird bycatch management measures, need to be collected (Gilman *et al*., 2021).

Hand-held devices

The global development of mobile technologies, and the portability of hand-held devices (smartphones and tablets), has led to a growing recognition of their potential for the collection of data for all fisheries sectors (several authors in Dalskov *et al.,* 2021). Specialised apps running on smartphones and tablets can be used to replace or enhance catch registration on paper (i.e. an electronic logbook), track and record the spatiotemporal distribution of the fishing effort of a vessel using GPS data, and report these data in real-time to the competent authorities, while in range of a mobile phone or Wi-Fi network.

Mobile technologies, due to their versability and portability, are particularly useful to monitor small-scale vessels. Smartphone/tablet apps are cost-effective tools to monitor fishing effort, while at the same improving data quality. Examples of such apps are Mofi (Germany), Abalobi (South Africa), mFISH(USA), VeriCatch (Canada), etc. (Dalskov *et al.,* 2021).

Self-sampling

Self-sampling, where fishers report, collect and sometimes process biological samples themselves, has been developed as a tool to obtain data in an affordable manner and often with a higher coverage (in time and space; Kraan *et al*., 2013). However, self-reported data collected for the purpose of compliance to management measures may be inherently biased and thus require independent verification, usually accomplished by an observer or electronic monitoring-based programmes.

Logbooks

Skippers in the EU are required under the DCF to self-declare the non-intentional capture or killing of any PET species, while discards above 50 kg and under all Landing Obligation exemptions are required by the Control regulation to be reported in logbooks. However, logbook reporting is widely considered unreliable and PET species catches are under-reported. It is known that fishers have little incentive to report and have concerns over negative repercussions to the industry over bycatch issues (Basran and Sigurðsson 2021). Furthermore, the set of skippers who choose to declare bycatch may differ markedly from those who do not. If this behaviour is correlated to other attributes, e.g. a more acute awareness of threats to PET species resulting in practices that tend to minimize impact on PET species, data collected from skippers reporting bycatch would not be representative (Authier *et al.,* 2021). Further, under the Common Fisheries Policy, only fishing vessels above 12 meters are required to use an electronic logbook; vessels above 10 meters length overall have to keep a logbook and need to submit landing and transhipment declarations (EC 2009). For vessels below 10 meters, no logbook is required, except for fisheries with a quota targeting Baltic Sea cod (EC 2016); though below 8 meters, no logbook is required anymore, which is the case for many recreational and part-time fishing vessels (OSPAR-HELCOM in prep.). Given that small-scale fisheries comprise approximately 80% of the European fleet[14], and that there is likely significant under-estimation of the extent of PET species bycatch in these types of fisheries (OSPAR-HELCOM in prep.), development of electronic logbooks for such vessels could be explored, at least in part to obtain information on fishing effort. In addition to developing single agreed data and monitoring standard for incidental bycatch related parameters, and a common logbook format for these parameters, within EU and between EU and non-EU countries (OSPAR-HELCOM 2019).

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[14] https://ec.europa.eu/oceans-and-fisheries/fisheries/rules/small-scale-fisheries_en

Reference fleets

Reference fleets are a sub-set of active fishing vessels with an enhanced data collection role requiring training and support (Mangi *et al.*, 2016) for a determined period of time. Reference fleets can be an extension of self-sampling programmes, where fishers from the subset of vessels report, collect samples or even process biological samples themselves. Reference fleets improve relationships with the fishing industry through participatory research and a two-way communication channel (Kraan *et al.*, 2013). Again, as with self-sampling programmes, reference fleets derived data needs to be audit to assert that there are no unknown bias, while making sure it is representative of the larger fishery.

Table 2. PET species bycatch monitoring methods (strength and weakness). Adapted from MASTS (2016).

Methodology	Strengths	Weakness
At-sea observers	1. Detailed bycatch information can be gathered 2. Biological information can be collected 3. Strengthens collaboration among scientist and fishers 4. Enables data collection on fishing practices	1. High cost 2. Lack of human resources available 3. Observer effect (change in fishers behaviour) is possible. 4. Personal safety risk for observers 5. Limitation to put observers on small scale vessels due to lack of space or safety reasons 6. In many cases impossible to monitor whole hauls. Subsamples are observed.
EM	1. Can record data and imagery from all hauls 2. Reviewers could analyse whole hauls and not subsamples 3. 100% coverage of the whole fleet, hauls is possible. 4. Enables data collection on fishing practices 5. Good alternative in the case of small scale fisheries monitoring 6. Data are available for subsequent quality assurance review 7. High speed data transfer 8. Opportunity to involve and motivate fishers in the process	1. Medium cost 2. Expertise needed to analyse images 3. High amount of data to analyse and storage 4. Not possible to collect biological data 5. Some limitation in the installation of the cameras due to logistic issues 6. Difficulties in the identification of some rare species (mainly fishes due to their small size, how the fish is sorted in the belt etc.)
Self-sampling	1. Low cost 2. All vessels could be monitored 3. Opportunity to involve and motivate fishers in the process 4. Enables data collection on fishing practices	1. Data quality and reliability not always the best 2. Requires auditing 3. Post-sampling data processing needed 4. Generates additional tasks for fishers 5. Incentives to fishers
Reference fleet	1. Detailed information 2. Data collected by trained crew 3. Opportunity to involve and motivate fishers in the process 4. Enables data collection on fishing practices	1. Low coverage 2. Incentives to fishers 3. Requires some level of auditing 4. Post-sampling data processing needed 5.
Fishers Interviews	1. Low cost 2. Possible high coverage	1. Data quality and level of resolution low 2. Underreporting is a known issue 3. Training for interviewers is needed
Logbook	1. Low cost 2. High coverage for larger vessels 3. High speed data transfer for e-logbooks	1. Data quality and reliability not always the best 2. Under/miss-reporting a known issue 3. Requires auditing 4. Excludes small-scale vessels

Such an approach has been employed in Norway, where a group of about twenty Norwegian fishing vessels (both high-seas and coastal vessels) contracted by the Institute of Marine Research (IMR) provide detailed information on their fishing activity, including bycatch of marine mammals and seabirds, to improve stock assessments and fisheries management[15]. Through this self-sampling programme, a long time series of bycatch data have been obtained that enabled the estimation of the total bycatch of seabirds (Bærum *et al.*, 2019) and harbour porpoises (Bjørge *et al.*, 2013) in the Norwegian small-vessel gillnet fishery operating along the Norwegian coast (OSPAR-HELCOM in prep.). IMR staff run quality checks on the data submitted, as well as providing training and onsite visits to vessels to provide support.

4.2 Port sampling programmes and indirect means of monitoring bycatch

Interviews/questionnaires

Fishers tend to have useful knowledge about when and where bycatches generally occur, particularly in their direct area of operation, and thus collectively can possess a significant amount of information over a much larger spatial scale. Questionnaires and interviews might be considered as a way to access and ultimately utilize this knowledge. The information might be difficult to use in quantitative assessments but could be incorporated as part of a screening procedure to highlight possible areas of particular interest when designing programmes or for validating outcomes from sampling programmes (ICES WKPETSAMP 2019). Namely, direct questioning of fishers and stakeholders could represent a useful and cost-effective approach that may be capable of providing sufficient data to estimate annual bycatch rates and identify high-risk gear/ location/ season combinations (Lucchetti *et al.*, 2017). One such study assessing sea turtle bycatch in Italian waters enabled the identification of bycatch hotspots in relation to area, season and to the main gear types, as well as minimum estimates of capture events and deaths (Lucchetti *et al.*, 2017). However, there are some limitations with interviews/ questionnaires, as they are based on the fishers' memory, or interpretation of events, their skills in species identification and wiliness to cooperate (NAMMCO-ICES 2010).

Strandings data

Strandings monitoring can in principle yield data on both bycatch rate and the absolute amount of bycatch mortality (Peltier et al., 2016, Peltier *et al.*, 2018), as well as the origin of the carcass/ fishery involved (Peltier *et al.*, 2020), provided that biases and confidence in the data are understood and can be quantified and compensated for; e.g. the catchment area for the strandings can be determined and some information is available on the distribution of cetaceans at-sea. Ideally, this requires consistent reporting of strandings, necropsy following protocols developed by trained veterinarians to provide adequate diagnosis of cause of death, plus recording of size, sex, maturity, age, condition and decomposition state and diet analysis, some knowledge of population distribution at-sea, and the application of drift models to establish carcase origin. Further, not all European coastlines are suitable to survey or collect carcasses. In practice such a combination of information is rarely available and strandings may, thus, provide only a minimum estimate of the number of bycatch mortality (CIBBRiNA proposal 2021). In 2018, the IWC Sub-Committee on non-deliberate Human-Induced Mortality of cetaceans (HIM) created an intersessional group to review the methodology, i.e. modelling the drift of carcasses, and bycatch

[15] https://www.hi.no/hi/nettrapporter/rapporwith t-fra-havforskningen-en-2020-8

estimates from strandings. Following which, the sub-committee provided recommendations on the following: (a) addressing uncertainties in bycatch estimates derived from strandings; (b) how bycatch estimates derived from strandings could be used; and (c) assessing if strandings can identify gaps in observer coverage (IWC 2018). Overall, strandings provide a cost-effective source of information that can often not be obtained by any other means (for example life history data which can be used for the construction of life tables) and represent a bycatch monitoring dataset complementary to the more conventional approaches such as at-sea monitoring programmes (CIBBRiNA proposal 2021). Further, as shown by the recent increased strandings of bycaught common dolphins along the French Atlantic coast, that led to an EC request to ICES to review the evidence for the implementation of emergency measures to prevent bycatch of said species, such an issue was not identified through observer or DCF monitoring programmes, due to low or inadequate sampling.

5 Sampling protocols for PET species

Work undertaken to date within ICES on best practice of PET species bycatch monitoring has led to many suggestions/recommendations, some of which are summarised herein. Such work has been heavily based on experience gained from independent PET species bycatch observer programmes, run by some member states. First and foremost, observers must be provided with proper instructions and training on PET species bycatch, including protocols for species identification and the recording of rare bycatch items (NAMMCO-ICES 2010, ICES WKPETSAMP 2019). Additionally, for supplying to industry, an easy-to-read folder or fact sheet should be created, describing why these data are collected and how they are useful, information that can be provided by the observer (ICES WGCATCH 2019). An overview of recruitment and training of observers in the US was provided during the ICES-NAMMCO workshop in 2010, as was observer training provided by some European member states. **Such information should be reviewed again, given the time period since the workshop, and as it was recommended to standardise training at a European level for those observers working on PET species bycatch monitoring programmes** (NAMMCO-ICES 2010).

It is assumed that within dedicated independent bycatch monitoring programmes or bycatch directed studies, observers dedicate close to 100% of their time in a way appropriate to quantifying bycatch (ICES WKPETSAMP 2019). However, for DCF at-sea monitoring, it is important to know whether all or part of the fishing operation and catch sorting process was observed, including information on what percentage was observed in each, to estimate the bycatch rate/ apply a subsample factor to any rare catch item (ICES WKPETSAMP 2019). WKPETSAMP (2019) suggested that the following fields be included in the new RDBES:

- Approximate % hauling operation actually observed (inc. bycatch);
- Approximate % sorting operation actually observed (inc. bycatch);
- Checkbox for slipped incidental bycatch;
- Checkbox to indicate whether megafauna <u>could</u> have been observed (was the observer in a position where he or she could observe for example, drop-outs, or the opening of the cod-end in trawl gear, etc.).

In routine programmes such as DCF, monitoring of 'drop-outs' or 'slipping' outside the vessel was not common (ICES WGBYC 2020). For instances where it was reported, all procedures were recorded as been visually monitored. While 'hauling' and 'sorting' may be effectively monitored in trawl fisheries, for net fisheries, for example, where gear retrieval and catch sorting/processing occur more or less simultaneously, there may be less scope (ICES WGBYC 2021). In such instances, hybrid type monitoring trips may be beneficial, where some fishing operations are sampled for commercial discards and others are primarily monitored for PET species bycatch, or alternatively providing observers with equipment (small cameras) that would permit both activities to be carried out (ICES WGBYC 2021). Such an approach is undertaken in the US, where observers undertake dedicated 'marine mammal haul watches' (and limit fish sampling) for some of their gill-net trips, to ensure that they do not miss porpoises getting dislodged from gill-net twine during haulback (NAMMCO-ICES 2010). In such cases, the results can be used to calibrate marine mammal watch hauls with fish sampling hauls.

In order to differentiate between catch/ bycatch that never came on board, from catch/ bycatch that was hauled onboard (i.e. the cod-end of a trawl), it was proposed to use the terminology 'slipped' and 'pre-sorted catch', respectively, instead of just 'hauling' when reporting 'Catch-Fractions' (ICES WKPETSAMP 2019). Further discussions among WGCATCH recommended separating 'slipping' into 'slipping' and 'drop-out' to highlight the importance between intentional and unintentional releases and agreed with the term 'pre-sorting' as an alternative to 'hauling' (ICES WGCATCH 2019). These new fields will enable a more accurate measure/ level of the visual coverage of each part of the fishing process (ICES WGBYC 2020).

Where observations of PET species bycatch are made, it is important to document if mitigation measures were employed at the time of capture (MASTS 2016, ICES WKPETSAMP 2019). Further, within sampling procedures, there needs to be clear indication where real zeros (no incidental bycatch) can be distinguished from zeros arising through non-sampling (ICES WKPETSAMP 2019). Additionally, where bycatch of rare species has been reported by other methodologies, such as self-sampling by crew, this should be clearly stated in any protocols / database so that these types of data can be placed in an appropriate context (ICES WKPETSAMP 2019). Largely as there may be some bias towards reporting of rare fish, for example. FishPi² (2019) outlines checklists of tasks for observers after the trip, including sending a cruise report to the skipper/ crew, and debriefing (evaluation of sampling protocol and interactions). Further information on such can be found in the US NOAA observer sampling guidelines, including information on personal and sampling equipment required for the tasks at hand (e.g. AFSC 2021).

Obtaining information on species/ individuals incidentally captured in hauls is invaluable, not only for estimating bycatch rates and assessing the population level impacts of those métiers, but also for implementation of mitigation measures. Such data enable assessments of bycatch selectively of age-sex classes by the métiers of concern (Murphy *et al.*, 2013, Murphy *et al.*, 2019). While initial work has been undertaken by fishPi (MASTS 2016) and fishPi² (MASTS 2019) on guidelines for sampling of PET species onboard fishing vessels, several additional parameters should be assessed and recorded. Many of these were addressed by WGCATCH (2019) and detailed within the US NOAA observer sampling manuals, for example the Alaska Fisheries Science Center (AFSC) 2022 Observer Sampling Manual. Most notably within the NOAA guidelines are their priorities to record not only marine mammal interaction data (including feeding on catch or discards as well as entanglement), but also to collect marine mammal specimen data and samples (e.g. deep tissue samples), as well as marine mammal sightings data.

Once finalised, use of the ICES PET species sampling lists should be employed, for which ICES species and individual entry codes should be devised. For every bycaught PET individual, information on trip/ haul should be recorded and associated with the PET individual identification number. It is important to note if the observer actually saw the bycaught animal, and any entanglement interactions observed - see section 14-6 - 14-7 of NOAA guidelines for examples of interaction codes, used for data entry (AFSC 2021). For each bycaught PET individual, it should be noted whether the animal was alive or dead during hauling/ pre-sorting, and if it was released alive. The observer may need training in how to recognise if an animal is alive or dead. In some cases, the animal may have died prior to encountering fishing gear, and thus the state of decomposition or condition code/ specimen state should also be recorded - see pages 14-3 to 14-5 of NOAA guidelines (AFSC 2021), and section 5.4 ICES WGCATCH (2019).

5.1 Marine Mammals

In regard to marine mammals, information on the number of bycaught specimens, species, sex, and body length, should be recorded whenever possible, and such data entry fields should be included on sampling sheets. This includes not only the number of marine mammal specimens reported as bycatch, but their position in the net when hauled. If not possible to identify to species level, higher taxonomic level should be recorded (group of species, genus, and family or order level), with photographs taken at different angles, for verifying species identification at a later stage. The NOAA guidelines detail requirements for taking pictures of dead marine mammals as outlined below. Such images are not just useful for species and sex identification but could also be used to assess evidence of net damage to the carcasses, valuable information for assessing evidence of bycatch in stranded (or beachcast) specimens. However, it should be noted that such photographs of bycatch events could potentially be accessed under Freedom of Information (ICES WGCATCH 2019). Diagrams for sex determination in both cetaceans and pinnipeds are provided in fishPi² and the NOAA guidelines, in addition to how to measure total body length for said species. In addition to these parameters, body weights could be taken where practical.

For any monitoring programme it is important to consider data requirements, and how frequently bycatch events are likely to occur. If there is a particular concern with bycatch in certain métiers, independent marine mammal observers may be required onboard a representative number of vessels, to accurately record bycatch events and collect important biological information on the bycaught species, as well as biological samples such as teeth (for age determination purposes) and skin (for genetics). Fishers may also be able to assist in the collection of such biological data where there is good industry engagement and cooperation (ASCOBANS 2021). Additionally, whole marine mammal carcass retrieval, for further sampling, should be explored where practical. As noted by WGCATCH (2019), there may be licencing requirements for landing of PET species, as well as sanitary issues that would need to be dealt with.

Table 3. Guidelines for taking pictures of dead marine mammals. Taken from AFSC (2021).

Pinnipeds	Cetaceans
Full body (dorsal, ventral, side view)	Full body (dorsal, ventral, side view)
Head straight-on (vibrissae visible)	Dorsal fin
Head in profile (ears/ear hole visible)	Saddle Patch
Fore flippers	Flukes (underside)
Hind flippers	Sex determination
Sex determination	

5.2 Seabird

AFSC (2021) is one of a set of fisheries observer protocols covering the waters around the USA. It is comprehensive, up-to-date and obviously adapted to the latest science. It includes all relevant PET species including seabirds for the area. It is though set in the societal and legal framework of the USA that mandates more independent inspection and monitoring of fisheries than is currently the case in the EU. It is an excellent example of what can be provided to guide seabird (and other bycatch) observers.

There appears to be no equivalent observer protocol in the EU, although fishPi and fishPi², relevant WP on PET bycatch sampling; Annex 4.2.3 in the fishPi² report on 'detailed sampling protocols for PET sampling' does contains some broad guidelines. This source, in relation to seabirds, is inaccurate in stating that-seabird specimens should be measured from beak to tail. It would be more important to get a photograph of each specimen (as is noted in the main part of the report), and measure wing chord – a much commoner measurement used in ornithology

There is some discussion but no guidance or advice in the relevant sections of the WGCATCH reports (2019 and 2020). There may be guidance and protocols in a French document referred to in the WGCATCH reports, but it was not available at the given URL: http://sih.ifremer.fr/Description-des-donnees/Module-Ressources-exploitees/Demographie-des-captures/Obsmer-Observation-sur-navires-de-peche/Manuels-formulaires/Manuels-et-protocole.

5.3 Turtle

The FAO (2019) report on 'monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries' reviewed those turtle species that are vulnerable to bycatch within those sea regions. A template for the recording of biological data from sea turtles can be found in Annex 4 of that report, and includes data such as curved carapace length, curved carapace width, three tail measurements, weight, sex and whether photographs were taken. Figures A6 and A7 in Annex 5 of the FAO (2019) report provide diagrams for species identification, as well diagrams or detailing measurements of sea turtles carapace and tails. Other European protocols include 'assessing marine turtle bycatch in European drifting longline and trawl fisheries for identifying fishing regulations' produced by the European Marine Turtle Project , which goes into further detail on methods of capture and recording the position of animals in the gear, as well as physical condition codes, the types of lesions that can occur from incidental capture and how to record such lesions (Camiñas *et al.,* 1999). A diagram on species identification was also included within the report. In addition to details for the crew on methodologies for hauling, handling and releasing (and tagging) longline-caught turtles. The FAO (2009) report on 'guidelines to reduce sea turtle mortality in fishing operations' provides further information on best practice for sea turtle handling and release.

Similar to marine mammals, strandings can provide a measure of incidental bycatch in the species, and necropsies can provide further information on the presence or absence of hooks or line in the gastro-intestinal tract of sea turtles (FAO 2019), as well as information on distribution/occurrence and life history. For example, a review of turtle strandings along the Portuguese coast revealed that loggerhead and leatherback turtles are present off the entire mainland coast year-round, though with aspects of seasonality, and most individuals recorded were juveniles-immatures, with interactions with fisheries accounting for 43% of deaths, largely in set gill or trammel net fisheries (Nicolau *et al.,* 2014). Similar work has been undertaken in Northern Cyprus, for example, and while necropsies were not undertaken on stranded animals, local fishers did complete questionaries on fishing activity and bycatch (Snape *et al.,* 2013). It was reported that strandings coincided with setting of trammel nets that targeted siganids, with the majority of bycatch registered by fishers caught in these gear types within the region.

OSPAR (2020) also reported a number of coordinated actions recommended by national turtle experts including:

- Share guidelines for fishers designed by each Contracting Party and design complementary medias in the whole OSPAR area;
- Encourage the deployment of observers aboard fishing vessels, particularly the surface longline fleet targeting tuna and swordfish, and encourage collaboration with artisanal fishers to report bycatch through interviews;
- Encourage knowledge acquisition on interaction of turtles with leisure fisheries;
- Facilitate the participation of OSPAR experts in the Subcommittee on ecosystems of ICCAT for the analysis of bycatch and mitigation measures of non-target species as marine turtles.

5.4 Fish

As stated above, information regarding PET fish species bycatch is usually collected through the DCF routine at-sea sampling programmes that prioritise catch sampling of commercial important fisheries. While multiple objective sampling programmes are usually more cost effective, their efficiency to gather information for specific tasks may be lower or even compromised, as a prioritization needs to be made between the different items to monitor. For example, while an observer is busy sampling the catch, he/she may not be able to register incoming incidental captures of PET species or other types of PET species/ gear interactions (CIBBRiNA proposal 2021). For the purpose of monitoring the interactions of PET species with fishing activity, it is important to know how the individuals interact with the fishery. The observation of the interaction depends on where it occurs and thus it is important to know if a specimen interacts during fishing operations (and may or may not be hauled to the vessel) or if the specimen is actually caught by the gear and hauled to the vessel deck. Consequently, the observation platform needs to be focusing on the fishing operation at-sea, the deck, the conveyer belt, etc. **The use of video cameras by observers** (e.g. to monitor for bycatch while they are undertaking sampling of commercial catches) is thus suggested by WGCATCH (2019). On the other hand, bycatch of protected species are typically rare events, and even within dedicated bycatch monitoring schemes with relatively high coverage and targeted protocols, the chance of observing bycatch occurrences of some types of PET species is generally low and may therefore not provide a complete picture (ICES WGCATCH 2019). To account for all possible rare bycatch events, **observers may have to sample the entirety of the fishing trip for that rare event**, while continue to follow the sampling protocol for catch data.

Existing monitoring programmes can also be optimised to improve bycatch rates **by collecting specific operational data.** For example, the WCPFC observer programme was amended to have longline observers record anatomical hooking position (mouth-hooked, deeply hooked, externally hooked), record what terminal tackle remained attached to PET species that were released alive, both of which affect survival rates, and record the number of “shark lines” deployed per set (Gilman *et al.*, 2017). As already stated above, WGCATCH (2019) recommends recording an accurate measure/level of the visual coverage of each part of the fishing operation rather than to describe the circumstances of individual bycatch incidents.

6 Métiers and areas with reported PET species bycatch

6.1 Marine Mammals

Within the OSPAR/HELCOM area, thirty-six species of cetaceans and eight pinnipeds have been recorded (OSPAR-HELCOM in prep.), and a summary of their relative status as per encounter rate, i.e. occurrence within the ICES ecoregions as define above by ICES WGBYC, can be found in Annex 1 (see Table 2).

Published bycatch estimates for marine mammals within ICES ecoregions were collated by the OSPAR-HELCOM workshop in prep. report and are shown in Annex 2 (see Table 1, Table 2). Five types of fishing gear have been particularly identified as having cetacean bycatch associated with them, these include (single or paired) pelagic trawls, and static gear including bottom set gillnets, driftnets, seine nets and pot lines (OSPAR-HELCOM in prep.). Using these data (including historical data), medium to high bycatch levels were reported for small cetaceans in bottom-set gill nets in all ICES ecoregions, and pelagic and/ or midwater trawls in the Celtic Seas and Bay of Biscay (mainly common dolphin). Other gears of concern include creel lines in the Celtic Seas and northern part of the Greater North Sea (minke whale (*Balaenoptera acutorostrata*) and humpback whale (*Megaptera novaeangliae*)), as well semi-drift nets in the Baltic (harbour porpoise) (summarised in OSPAR-HELCOM in prep.). Further, it was noted that other species, such as Risso's dolphins (*Grampus griseus*), may be prone to bycatch in long-line fisheries (as reported from the Mediterranean - (Macías *et al.*, 2012). For seals, there have been reports of incidental captured in set gillnets, demersal and midwater trawls, pots and traps, and ghost netting, and also fyke nets and longlines (OSPAR-HELCOM in prep.; and reference therein).

Table 4 is an overview of the marine mammal species observed as bycatch by ICES ecoregion and métier level 3 between 2016 and 2020, data reported to WGBYC (ICES WGBYC 2018, 2019, 2020, 2021). What is interesting is the reporting of incidences of marine mammal bycatch in bottom trawl fisheries in the majority of ICES ecoregions, a gear type not previously highlighted as a gear type of concern for abundant species such as common dolphins and harbour porpoises. For example, ICES advice in 2016 did not report any common dolphin bycatch in bottom pair trawls sampled between 2009 and 2013, due to a lack of sampling (ICES Advice 2016). As previously, marine mammal bycatch was reported in static gear and pelagic trawl gear in most ecoregions, with exception for nets in the Mediterranean Sea and Azores, though this may be due to low or inadequate sampling. For traps, incidences of bycatch were observed in the Baltic Sea and the Greater North Sea. Marine mammal bycatch was reported in seine nets and surrounding nets in the Bay Biscay and off the Iberian coast, as well as seine nets in the Greater North Sea. Within the Azores reported bycatch occurred in longlines, rod and lines and hooks and lines. Whereas within the Mediterranean Sea, bycatch was reported in bottom and pelagic trawls, as well as long lines.

In 2021, ICES reviewed new bycatch information on marine mammals for the years 2019 and 2020, data received through an ICES data call. The available monitoring data for 2017–2020 were used to highlight species, métiers, and ecoregions where bycatch may be of particular concern. A total of 609 bycatch incidents (fishing operations with bycatch) were reported from ten species (four seal species (grey seal, harbour seal, ringed seal and harp seal) and six cetaceans (common dolphins, harbour porpoise, bottlenose dolphin, pilot whale, white-beaked dolphin and humpback whale) across nine ecoregions (ICES Advice 2021a). Net métiers accounted for 80% of marine mammal bycatch incidents across ecoregions, including 79% of bycaught cetaceans and 74%

of bycaught seals. The average monitoring coverage in net métiers with marine mammals bycatch was equal to 3%. Traps and pelagic trawls accounted for 9% and 6% of marine mammal bycatch incidents, respectively. The average monitoring coverage was equal to 25% for traps and 1% for pelagic trawls. The average bycatch rate of marine mammals was 0.03 specimens per monitored day-at-sea. A high bycatch rate (0.6) of the common dolphin was observed in bottom pair trawl fisheries in the Bay of Biscay and Iberian Coast (ICES Advice 2021a).

Based on the information at hand, and the diversity of gear types that marine mammal bycatch is reported in, monitoring of all gear types at sufficient levels is required to accurately estimating bycatch rates, and truly identify each species 'bycatch risk' for planning future monitoring. While the average monitoring coverage for the net métiers was higher than some other gear types, as a gear type of high concern, at 3%, this is still too low. Further, as shown in the case of bottom pair trawls, bycatch was reported once monitoring commenced.

Table 4. Marine mammal bycatch data (2016-2020) reported to ICES WGBYC through ICES dedicated data calls (ICES WGBYC 2018; 2019; 2020; 2021).

Ecoregion	Métier 3	Species	Common Name	Year bycatch observed
Baltic Sea				
Baltic Sea	Nets	*Halichoerus grypus*	Grey seal	2016, 2017, 2019, 2020
		Phoca vitulina	Harbour seal	2019, 2020
		Phocoena phocoena	Harbour porpoise	2016, 2017, 2018, 2019, 2020
		Pusa hispida	Ringed seal	2020
	Bottom trawls	*Halichoerus grypus*	Grey seal	2019
	Pelagic trawls	*Halichoerus grypus*	Grey seal	2017
	Traps	*Halichoerus grypus*	Grey seal	2017, 2018, 2019, 2020
		Lutra lutra	Eurasian otter	2019, 2020
		Pusa hispida	Ringed seal	2018
	Longlines	*Halichoerus grypus*	Grey seal	2019
North-east Atlantic				
Azores	Longlines	*Globicephala melas*	Long-finned pilot whale	2017
	Rods and lines	*Delphinus delphis*	Common dolphin	2020
	Hooks and Lines	*Delphinus delphis*	Common dolphin	2017
Bay of Biscay and the Iberian Coast	Nets	*Delphinus delphis*	Common dolphin	2017, 2018, 2019, 2020
		Halichoerus grypus	Grey seal	2018,
		Phocoena phocoena	Harbour porpoise	2017, 2018, 2019

Ecoregion	Métier 3	Species	Common Name	Year bycatch observed
		Tursiops truncates	Bottlenose dolphin	2018, 2019
	Bottom trawls	*Delphinus delphis*	Common dolphin	2016, 2019, 2020
		Phocoena phocoena	Harbour porpoise	2017
	Pelagic trawls	*Delphinus delphis*	Common dolphin	2017, 2018, 2019, 2020
		Globicephala melas	Long-finned pilot whale	2017
		Phocoena phocoena	Harbour porpoise	2017
	Longlines	*Delphinus delphis*	Common dolphin	2020
	Seines	*Delphinus delphis*	Common dolphin	2017
	Surrounding nets	*Delphinus delphis*	Common dolphin	2019, 2020
Celtic Seas	Nets	*Delphinidae sp.*		2019
		Delphinus delphis	Common dolphin	2016, 2017, 2018, 2019
		Globicephala melas	long-finned pilot whale	2016
		Halichoerus grypus	Grey seal	2016, 2018, 2019, 2020
		Phocidae sp.		2017
		Phoca vitulina	Harbour seal	2020
		Phocoena phocoena	Harbour porpoise	2016, 2017, 2018, 2019
	Bottom trawls	*Delphinidae sp.*		2019
		Delphinus delphis	Common dolphin	2017, 2018, 2019
		Phocidae sp.		2017
		Phoca vitulina	Harbour seal	2018
		Phocoena phocoena	Harbour porpoise	2017, 2018, 2019
	Pelagic trawls	*Delphinus delphis*	Common dolphin	2016
		Halichoerus grypus	Grey seal	2017, 2018, 2019, 2020
		Globicephala melas	long-finned pilot whale	2020
Greater North Sea	Nets	*Delphinus delphis*	Common dolphin	2016, 2017,2019, 2020
		Halichoerus grypus	Grey seal	2016, 2017,2018, 2019, 2020
		Lagenorhynchus albirostris	White-beaked dolphin	2019, 2020
		Phoca vitulina	Harbour seal	2018, 2019, 2020

Ecoregion	**Métier 3**	**Species**	**Common Name**	**Year bycatch observed**
		Phocoena phocoena	Harbour porpoise	2016, 2017, 2018, 2019, 2020
		Pinnipedia sp.		2019, 2020
	Bottom Trawls	*Delphinus sp.*		2020
		Delphinus delphis	Common dolphin	2018, 2020
		Halichoerus grypus	Grey seal	2018, 2019
		Phocidae sp.		2017
		Phocoena phocoena	Harbour porpoise	2020
	Pelagic Trawls	*Halichoerus grypus*	Grey seal	2018, 2020
		Phoca vitulina	Harbour seal	2016
	Seines	*Phocoena phocoena*	Harbour porpoise	2019
	Traps	*Phoca vitulina*	Harbour seal	2019
Iceland	Nets	*Erignathus barbatus*	Bearded seal	2016
		Halichoerus grypus	Grey seal	2016, 2017, 2019, 2020
		Lagenorhynchus albirostris	White-beaked dolphin	2018
		Megaptera novaeangliae	Humpback whale	2020
		Pagophilus groenlandicus	Harp seal	2016, 2017, 2018, 2019, 2020
		Phoca vitulina	Harbour seal	2016, 2017, 2019, 2020
		Phocoena phocoena	Harbour porpoise	2016, 2017, 2019, 2020
		Pusa hispida	Ringed seal	2017, 2018
	Bottom trawls	*Pagophilus groenlandicus*	Harp seal	2017
		Halichoerus grypus	Grey seal	2016
Norwegian Sea	Nets	*Halichoerus grypus*	Grey seal	2019, 2020
		Phoca vitulina	Harbour seal	2019, 2020
		Phocoena phocoena	Harbour porpoise	2019, 2020
Mediterranean Sea				
Western Mediterranean Sea	Bottom trawls	*Delphinidae sp.*		2017

Ecoregion	Métier 3	Species	Common Name	Year bycatch observed
		Stenella coeruleoalba	Striped dolphin	2017
		Tursiops truncatus	Bottlenose dolphin	2020
	Pelagic trawls	*Stenella coeruleoalba*	Striped dolphin	2017
	Longlines	*Grampus griseus*	Risso's dolphin	2018
		Tursiops truncatus	Bottlenose dolphin	2017
Ionian Sea & the Central	Bottom trawls	*Tursiops truncatus*	Bottlenose dolphin	2018
Adriatic Sea	Bottom trawls	*Pagophilus groenland-icus* (mis-id?)	Harp seal	2018
	Pelagic trawls	*Tursiops truncates*	Bottlenose dolphin	2017, 2018, 2020

6.2 Seabirds

Annex 4 contains an assessment of seabird species versus the gear for which they are particularly at risk, and sea areas which they co-occur (ICES WGBYC 2019). Note that all regularly occurring species of migratory bird (and therefore all but a very few species of seabird) in the EU are subject to protection under the Birds Directive. Some species and some areas in Annex 4 are not in EU waters - this table could be edited back to EU waters only.

Annex 4 does not prioritise species/ métier/ area interactions for bycatch monitoring. ICES WGBYC has reviewed available evidence in compiling this table but have not placed any weighting on interactions based on available evidence. This is reasonable as evidence may be biased in where it has been collected versus where it has not been. Some interactions are though known to be serious to seabird populations and should be among the priorities for monitoring:

- Fixed net fisheries in the Baltic and North Sea in areas frequented by seaducks, divers, auks and cormorants
- Hook and line fisheries in the wider Atlantic (including Bay of Biscay and Celtic Seas) for interactions with fulmars and shearwaters
- Net fisheries in the western Mediterranean for interactions with the critically endangered Mediterranean shearwater

Based on this table, other fishery interactions or areas require some initial survey to gather evidence, these would include:

- All fishing gears in the wider Atlantic for interactions with storm-petrels and petrels. Such interactions are not known elsewhere in the world, but this may be due to insufficient study
- All gears in the eastern Mediterranean and Black Sea where there appears a dearth of any evidence.

ICES advice (2021a) reported a total of 749 bycatch incidents, involving 2596 specimens from at least 33 species across nine ecoregions for the years 2019 and 2020. The net métiers accounted for 77% of bycatch incidents involving seabirds across ecoregions during this period, with an average monitoring coverage of 10%. Longlines accounted for 10% of seabird bycatch incidents with an average monitoring coverage of 1% (ICES Advice 2021a). The average bycatch rate of seabirds was 0.1 with higher values being associated with nets and/or line fisheries and the highest bycatch rate (1.2) recorded for the northern fulmar *Fulmarus glacialis* in set longlines in the Greater North Sea. This was based on available monitoring data for 2017 to 2020 (ICES Advice 2021a).

6.3 Turtles

Pierpoint (2000) reviewed known bycatch of turtles in UK and Irish waters. The commonest species caught was Leatherback Turtle, with small numbers of Loggerhead, Kemp's Ridley, and Hawksbill Turtles. The commonest gear that entanglement occurred in was the ropes leading to crustacean traps (more than 50% of bycatch). Other gear were various static nets, trawl nets, drift nets, hook and line and even an anti-submarine net (Pierpoint 2000). There have been further bycaught turtles in these waters since 2000, but as far as can be found, these have not been aggregated or published in a single source.

Based on information presented to WGBYC since 2012, there is a bycatch risk to turtles primarily in ICES areas 12, 10, 7k, 8e, 8c, 9b and 9a, with bycatch more commonly reported in longlining and pelagic trawling in the open sea (ICES WGBYC 2020). In coastal regions, bycatch was common in gillnets and other gear of the polyvalent artisanal fleet of Portugal (ICES WGBYC 2013, 2015) and tuna pound nets of Ceuta, Barbate, and Tarifa (Cadiz, Spain) and Morocco (ICES WGYBC 2020). Pot ropes were also responsible for entanglement in France (areas 8a, 8b) as well as bottom otter trawls (ICES WGBYC 2014, 2020). Turtle mortalities have also been associated with dFADs (OSPAR 2020). The main current and historical threat to loggerhead turtles in the Western Mediterranean and adjacent Atlantic areas comes from entanglement in ghost gear and illegal pelagic driftnets still widely in use along the North African coast (ICES WGBYC 2020).

Table 5. Number of bycaught individuals per sea turtle species per métier. Taken from WGBYC (2021).

Species	GNS DEF	GTRDEF	LLDLPF	LLS DEF	OTBDEF	OTTDEF	PS SPF	PTMSPF	*Total*
Leatherback turtle			7						*7*
Loggerhead turtle	4	19	55	1	101	1	1	67	*248*
Green turtle		7							*7*
Chelonidae		1							*1*
TOTAL	*4*	*27*	*62*	*1*	*101*	*1*	*0*	*67*	*263*

STECF (2020) summarised estimates of turtle bycatch records for the period 2016 to 2018 for the Mediterranean Sea, but noted that the estimates were incomplete, with only a few fisheries with high percentage observer coverage and/or fisheries subject to studies on bycatch. For waters outside the Mediterranean for that period, bycatch of the loggerhead sea turtle was also observed in the Azores, at a batch rate of 0.003 (one mortality during 363 days effort), and also the leatherback sea turtle, at a bycatch rate of 0.006 (two mortalities out of 363 days of effort) (see ICES WGBYC 2020, Table 24). ICES WGBYC (2013) previously reported relatively high bycatch in the Portuguese polyvalent fleet with an estimated 838 marine turtles per year, and the pelagic longline fishery off the Azores with an annual estimate of 4190 turtles for the period May to December.

From analysis of data reported to WGBYC for the years 2017 to 2020, only three species were recorded as bycatch over the period: the loggerhead turtle (*Caretta caretta*), the leatherback turtle (*Dermochelys coriacea*) and the green turtle (*Chelonia mydas*) (ICES WGBYC 2021). The loggerhead turtle was the most frequently captured species in the widest range of métiers (eight different métiers), with the highest number of bycatches occurring in bottom otter trawls (Tables 5, 6). Trammel nets for demersal fish captured all three species. Leatherback turtles were caught only in pelagic longlines (ICES WGBYC 2021).

Table 6. Number of bycaught individuals in different ecoregions per sea turtle species per métiers (only reported métiers with events). Taken from WGBYC (2021).

RFMO	Ecoregion	Métiers	*Dermochelys coriacea*	*Caretta caretta*	*Chelonia mydas*	Cheloni-dae
ICES	Azores	LLD_ LPF	6	26		
	Bay of Biscay and theIberian Coast	GNS_DEF		2		
GFCM	Western Mediterranean Sea	LLD_LPF	1	13		
		OTB_DEF		15		
		OTT_DEF		1		
	Adriatic Sea	LLD_LPF		15		
		OTB_DEF		77		
		PTM_SPF		67		
	Ionian Sea & Central Mediterranean Sea	GTR_GTR		1		
		OTB_DEF		9		
		PS_SPF		1		
	Aegean-Levantine Sea	GNS_DEF		2		1
		GTR_DEF		18	7	
		LLS_DEF		1		

The average bycatch rate of sea turtles across métiers and ecoregions was 0.01 specimen per monitored day at-sea, using data collected between 2017 and 2020 (ICES Advice 2021a). Bycatch rates of the loggerhead sea turtle were higher in line fisheries in all ecoregions and highest in drifting longline fisheries in the Azores (0.1 turtles per monitored day at-sea) and in the Adriatic Sea (0.02). Drifting longline fisheries in the Azores also had a bycatch rate of 0.02 leatherback sea turtles per monitored day at-sea. The bycatch rate of loggerhead sea turtles in trawl fisheries was higher in bottom otter trawls in the Adriatic Sea (0.02) (ICES Advice 2021a).

Data available to ICES WGBYC is often incomplete, apart from a few well studied fisheries. Given the low observation coverage, it is unknown if zero bycatch events in some of the reported fisheries truly correspond to “no bycatch events”, hence “no risk”, or are simply a function of observer coverage levels and sampling design/protocol issues (ICES WGBYC 2021). Systematic monitoring of turtle bycatch at a regional scale in the Union is required, through the CFP.

6.4 Fish

For PET fish species, a prioritization of species is needed before the identification of métiers and areas with high PET fish species bycatch risk. Again, if the criteria to categorize a fish species as "PET" is determined by their possibility of being bycaught, then all fish species are PET species. Consequently, all fisheries are automatically high-risk fisheries for any given PET fish species bycatch and/or season/area, and need to be monitored accordingly, i.e. likely to high levels as a commonly caught species in one fishery may be rarely caught in another. A way forward would be to start with sensitive species due to their particular life cycle such as elasmobranchs and deep-water species. Nevertheless, several member states have already carried out risk assessments of sensitive species bycatch, which will inevitably include fish species, in the DCF work planning for 2022 and beyond. Unfortunately, these WPs are not available publicly.

7 Issues with sampling resolution for estimating total bycatch of PET species

ICES advice (2021a) reiterated, from previous years, that monitoring sampling design did not yet allow for robust and unbiased estimations of numbers of all sensitive species caught incidentally in fishing activities.

The amount of data collected is important for subsequent extrapolation: most protected species bycatch events are so rare that they can only be extrapolated in a statistically sound manner if the sampling is as extensive as possible (ICES WKPETSAMP 2019). The chance of observing bycatch occurrences of some types of PET species is generally low. Detailed spatial and temporal data on fishing effort provides information on possible areas and/or periods of high risk of incidental bycatch and is also needed for carrying out robust assessments of the impact of bycatch on PET species. For many Member States, there is no or very limited information on fishing effort from small fishing vessels, and is a major knowledge gap. Gear usage (number of hauls, length of nets or number of hooks/pots) per métier, as well as fishing durations (days at-sea and hours fished) for all vessel sizes is basic information needed for full scale bycatch (risk) estimates. Ideally, data would be aggregated by month because many PET species, for example some seabirds, exhibit significant seasonal distribution changes that are important to consider in bycatch mortality assessments, and PET species recorded to the lowest taxonomic level possible (WGCATCH 2019).

For the key métiers involved in PET species bycatch, effort units should preferably be the most detailed possible, as effort recorded at a finer scale can always be re-scaled to coarser units, whereas coarser data cannot be more finely resolved (Moore *et al.*, 2021). For hook and line fisheries, number of hooks set per haul allows the best scaling between observed effort to the whole fleet. Any less detail means that extrapolations will be less precise and may well be biased. For net fisheries, length of net/area swept and soak time is best. For both of these métiers, time of shooting and hauling may be very relevant as bycatch rates for many species can differ markedly by time of day. It is important to have data available for all key métiers, irrespective of vessel size (OSPAR-HELCOM 2019). One way of obtaining these data for small-scale and recreational fisheries could be the use of reference fleet, where use of gear type is reported appropriately. Additionally, though issues may exist with GDPR, Electronic Technologies, such as VMS or AIS or sensors on winches for such vessels could be considered, for provide information on fishing effort (OSPAR-HELCOM 2019).

In 2021, ICES Advice stated that robust confidence intervals around the estimates of bycatch rates could not be estimated based on current data provision and recommended the collection and provision of data at fishing operation level and that all monitoring effort should be reported for all métiers, regardless of whether there was recorded bycatch or not (ICES Advice 2021a). Currently, ICES WGBYC calculates effort based on days at-sea (see Table 7).

ICES WGBYC (2020) reviewed the choice of bycatch metric (e.g. trip, haul, days at-sea, km/hr) for marine mammals in static gear, which appears to be influence by the variable depth, though further analysis is required to fully understand how these and other covariates interact. The report also noted that for static nets, bycatch rates calculated using km/hr provided the most insightful outputs, which may alter the interpretation of broad scale patterns of bycatch. Though further statistical analysis is required to test the suitability of different effort metrics to complex statistical analysis, and their effects on assessments of total bycatch mortality, work that should be progressed by WGBYC.

Table 7. Fishing effort recorded for different data sources/end users. Taken from ICES WGBYC (2018).

Data SOURCE	EFFORT RECORDED AS	VESSEL POPULATION
ICES WGBYC database	Days at-sea	>15 m mandatory, <15 m often provided
VMS (Vessel Monitoring System)	Hours fished	>12 m only
Logbook	Days fished	>10 m all areas, >8 m in Baltic
ICES Regional Database	Fishing trips	All vessels

Following an ICES WGBYC data call for the 'OSPAR request to estimate bycatch mortality of marine mammals (harbour porpoise *Phocoena phocoena*, common dolphin *Delphinus delphis*, grey seal *Halichoerus grypus*) within the OSPAR maritime area', there were a number of issues pertaining to the assessment, and data provision. As detailed by ICES Advice (2021b), fishing effort, i.e. days at-sea, was not consistently available, and standardizations were required to address potential estimations bias. Further, data submissions were incomplete as some countries provided no data, and also imbalanced as some countries provided small vessel data (<15 m fleet) while others did not. No data were available on several additional factors that can affect bycatch estimates. These include fine-scale effort data (such as soak time and net length), fishing depth, time of day, distance from shore, and other gear configuration factors such as mesh size, net height, twine type, and diameter and hanging ratio (ICES Advice 2021b). Thus, data quality and quantity varied substantially among years and countries. As there was generally limited sampling on smaller vessels, which make up the majority of the European fleet and likely account for a significant proportion of marine mammal bycatch (ICES Advice 2021b), this would likely lead to a downward bias in recorded events/ bycatch estimate (ICES WGBYC 2015).

As further detailed by the ICES Advice (2021b), "bias associated with sampling design is related to sampling coverage and methods used for selecting the primary sampling units (e.g. trips, ves-sels). While emphasis is usually placed on achieving proportional monitoring across métiers and temporal and spatial ranges, it is also crucial to know whether the vessels monitored were se-lected randomly and what the proportion of unique vessels monitored was. In practice, high risk métiers and areas for bycatch may be selected for monitoring, which can result in positively bi-ased bycatch estimates. For example, in the Greater North Sea, data from several targeted large vessels with high bycatch rates of porpoises, submitted by one member country, increased by-catch rates by a factor of up to 5 in GNS/GND, and 3.5 in GTR. Bias can also arise from failure to meet an intended survey design (i.e. implementation constraints such as safety concerns, space availability or other reasons affecting onboard access for observers and monitoring), leading to non-representative sampling" (ICES Advice 2021b).

Traditional, design-based, ratio estimates are biased if sampling is biased; imprecise if observer coverage is low (as is the usual case in the North East Atlantic); and volatile if bycatch events are only observed occasionally (several authors in Authier *et al.*, 2021). Clegg *et al.* (2021) obtained excessively large overestimations of catches of a number of rare or non-commercial bycatch species. Clegg *et al.* (2021) suggest that alternative estimators should also be considered for individual species where assumptions of the ratio estimator are violated such as with rare species where the delta lognormal estimator may be more appropriate. The authors also concluded that vessel selection for sampling has more impact on bias of the catch estimates than hauls sampled. The goal for survey design is to obtain observer data from a representative sample of the fishery, with respect to the suite of attributes that characterize fishing effort, such as the geographic distribution of effort, temporal distribution on diurnal and seasonal timescales, vessel and gear characteristics, and types of effort (e.g. sets, hooks, etc.) (Moore *et al.*, 2021). A stratified random sampling approach is optimum for statistical valid estimates, whereby fishing effort is subdivided into relatively homogenous subgroups with respect to a particular variable, for example, area or season (Moore *et al.,* 2021, and references therein). Where fishing effort is well characterised, but observed fishing effort is not representative, statistical approaches to eliminate bias in bycatch estimates can be employed (Moore *et al.*, 2021). An observer coverage calculator ObsCovgTools in R (R Core Teams, 2019) has been developed in the US to assess the coverage required to document and estimate rare bycatch events (Curtis and Carretta, 2020). See FAO (2021) and AFSC (2021) for further discussion on designing an observer programme for PET Species.

The financial and logistical feasibility of achieving even 5% coverage, for example, of all métiers of concern needs to be considered where fishing effort is high, in excess 30 000 days at-sea for some métiers (ICES Advice (2020), for example), and further work is required to determine what coverage is sufficient to produce robust estimates of bycatch, as noted above. As outlined in ASCOBANS (2020), within the UK, due to generally low achievable monitoring coverage across métiers, a method was developed whereby bycatch rates were calculated using multiple years' monitoring data and were applied to a single year's fishing effort data to give an annual estimate for that year. By using this approach, estimates could still be produced for métiers that might not have been sampled in a particular year and so provided a fuller mortality assessment and broad-scale mortality estimates to judge conservation status than simply using monitoring data from a single monitoring year. Alternatively, for those fisheries where information is scarce, indirect and low-cost monitoring methods could be the best options as an initial approach to assessing their impact on PET species (see Table 2). Whereas for those well-known and medium-to-high-risk fisheries, a combination of direct methods could be the best option, such as a combination of scientific observers and EM (MASTS 2016).

8 Monitoring by Member States

WKPETSAMP created an inventory of sampling programmes conducted on PET species bycatch, describing different programmes/ surveys being employed and what year they commenced, what kind of monitoring is undertaken (e.g. direct study, DCF sea sampling programme), what the main objective of the programme is, where it takes place (ecoregion and division), what fishery/ métier it covers (including size of vessel), the sampling design of the programme, sampling intensity, temporal stratification of sampling, observation method (e.g. onboard observer, electronic monitoring), PET species groups identified, and how data are stored, along with some expert judgement on the perceived importance of these fisheries compared to other fisheries in relation to the bycatch of birds, mammals, PET fish species, elasmobranchs and reptiles. These programmes include regular DCF at-sea sampling programmes as well as other national monitoring programmes and directed studies that focus on PET species bycatch. The inventory provides an overview to end users, such as ICES WGBYC, of all programmes and studies collecting information on protected species bycatch, to enable assessment of what data should be available and to identify gaps to help further improve data collection efforts (ICES WGBYC 2021), when used in collaboration with bycatch risk assessments. Information contained within the inventory can potentially be used to inform expert judgment within the fishPi risk scoring approach (see Section 3), though currently data is only incorporated at the order level, i.e. mammals, birds – and as noted earlier for bycatch indicator assessments undertaken for OSPAR/MSFD, assessments are undertaken at the species/population/assessment unit level. Further, the inventory may inform expectations on where, for example, bycatch rates can be appropriately generated (ICES WGCATCH 2020). Thought it should be noted that the inventory only presents information on sampling intensity, i.e. proportion of trips covered by sampling, and not days at-sea, the current fishing effort metric used by WGBYC. Further, as shown by the WKMOMA (2021), for many monitoring programmes listed in the inventory, only until data are fully assessed/ reviewed for estimating bycatch at a métiers/ regional level will one know if they were collected appropriately, the data gaps that may exist in sampling/ reporting, and if bycatch rates can indeed be appropriately generated. WGCATCH has assumed the responsibility to manage and update the inventory, with assistance from WGBYC.

According to STECF 21-17, most member states are routinely recording incidental bycatch in the DCF on-board (catch) monitoring programmes. However, within the DCF, member states can prioritise certain activities such as sampling of discard data from the most important fleets/stocks. Hence, fleets of less importance might not be sampled. Only a few member states have dedicated PET species bycatch monitoring programmes in place, e.g. Estonia, Denmark and Spain. For most, if not all member states, STECF concluded that current (low) effort results in an unreliable basis for a comprehensive assessment for bycatch rates of PET species in commercial fishing fleets (low number of planned sampling compared to total effort in the 2022-2024 WPs), while data collection from recreational fisheries does not include any data on bycatch. A general comment was made to all member states, where it is expected that they undertake efforts to improve bycatch monitoring on PET species.

ICES has suggested that the Regional Coordination Groups (RCG) ensure that fisheries monitoring programmes are designed and implemented to minimize bias in the estimation of bycatch rates (ICES Advice 2021a). Work has commenced within RCG North Atlantic, North Sea and Eastern Arctic (NANSEA) and RCG Baltic (BAL) with the production of risk based assessments for different PET groups or species and identifying the sampling coverage of the high-risk fisheries with scientific observers at-sea under the DCF sampling programmes (RCG 2021). As there is a need to know the effort allocated to monitor fisheries with at-sea observer programmes, the

RCGs are working with ICES WGBYC on such work. Through the use of case studies, their generic regional sampling programme will be reviewed and adapted to the specific issues related to PET species bycatch data collection; with one of the current case studies being the 'common dolphin in the Bay of Biscay and the harbour porpoise in the Baltic' (RCG 2021). Under these case studies several tasks will be covered including:

- Fisheries/ métiers characterization at the right resolution considering bycatch impact;
- Sampling coverage of these fisheries/ métiers;
- Align observers' protocols between countries;
- Standardize effort calculation methodologies and identify relevant variables needed to collect under the transversal data to improve bycatch estimates (e.g. number of nets, soak time etc. in the case of passive gears).

The other tasks to be covered are more focused on the need to increase the fisheries monitoring effort:

- Identify minimum sampling coverage per fishery/ métier.
- Ensure minimum sampling coverage for fisheries that currently have no/ low coverage.
- Methodologies to collect bycatch data considering different fleet segments:
    - Scientific observers
    - New technologies (e.g. EM)
    - Fishers collaboration

Mindfully Wired (2021) summarises the results of a workshop addressing seabird bycatch for the UK. The report has many good ideas and discussions, but no concrete outcomes (yet) that could be used as a template for future member state monitoring.

9 Conclusions: Best practice design of PET bycatch sampling programmes

The design of any sampling scheme needs to take account of a number of elements. These include the objective of any scheme, financial and personnel resources, the precision required of the monitoring, the willingness to allow bias, the ability to access fishing vessels, health and safety. The nature of bycatch events is also important, in many cases bycatch can be statistically very clumped and zero inflated (i.e. there will be many observations of no bycatch, but then much bycatch in one place or time). It is easier to design a monitoring scheme for statistically normally-distributed bycatch. These elements need to be balanced, for example there is no point in requiring a very precise and unbiased assessment of bycatch in a scheme that is not well resourced (FAO 2019). The literature review has not found any one document within the materials to be considered for review that considers all of these elements together.

9.1 Objectives

High-level objectives may be derived from European legislation, but these are not detailed enough to allow the design of a co-ordinated monitoring programme. For small cetaceans, ASCOBANS has considered further detailed objectives that define levels of harbour porpoise bycatch deemed unacceptable and more recently has OSPAR and HELCOM, partly to meet the requirements of monitoring for the EU Marine Strategy Framework Directive. ASCOBANS objectives have been available for many years so that Contracting Parties to that Agreement can design and implement national monitoring programmes. Despite this not all Contracting Parties have monitoring programmes that adequately observe PET species bycatch, and several have run a series of research projects instead. **For seabirds, OSPAR-HELCOM (2019) has suggested a target of bycatch to be less than 1% of natural mortality for the species under consideration, based on an interpretation of the legal requirements under the Birds Directive**. The workshop suggested that this be tested 'biologically' to determine how populations might respond from such levels of bycatch. The workshop did not address the definition of 'natural mortality' however, this is difficult, especially for species that have sporadic and episodic 'die-offs'. The ability to monitor to meet this target does not appear to have been addressed yet either. The objectives adopted by HELCOM and OSPAR include some definitions of precision, however no assessment seems yet to have been made as to whether it is practically possible to monitor to this level of precision in an unbiased fashion, unless adequate resources are made available.

No targets/objectives for monitoring turtle bycatch in European waters have been found in the literature search.

No monitoring objectives are specified for PET fish bycatch specifically, except for the ones included in the DCF for commercial species, and the requirement in the CFP and the Technical Measures regulations to minimise and if possible eliminate bycatch.

9.2 How much monitoring is required?

This is a commonly asked question, but one that has no standard answer. Information is needed on the statistical properties of the bycatch and of the precision needed for the estimate of bycatch. As noted above, other factors such as availability of resources affect the answer also. In general, with a very few exceptions, **current bycatch monitoring in EU waters is insufficient to answer any of the policy questions that are being asked**. Elsewhere in the world (e.g. CCAMLR waters around Antarctica, certain fisheries off Alaska (AFSC 2021; ICES WGCATCH 2019; ICES WGCATCH 2020; ICES WKPETSAMP 2019; NAMMCO-ICES 2010)), high levels of bycatch monitoring have been achieved. **Bycatch monitoring will need to increase in EU waters.**

One approach is to develop adaptive monitoring programmes. Under this, a scheme might commence monitoring ~5% of métiers fishing effort (below which is regarded by NAMMCO-ICES (2010) as 'low') with a set of monitoring targets for levels of bias and precision. If these **targets cannot be met, then the targets might be amended, monitoring might be increased (usually involving an increase in funding), or a different approach to monitoring (e.g. combining electronic technologies with self-sampling) adopted. If the objective is to monitor rare events, then it is likely that the monitoring may be needed for 100% of fishing activity.** Within the ICES bycatch survey inventory dataset, for those sampling programmes where sampling intensity (proportion of trips covered by sampling) was reported, only 16% (19 out of 122) had a coverage of 5% or more, and 66% had a sampling intensity of ≤1%.

Under-sampling may distort the perception of bycatch as a very rare event when it can, in fact, be widespread. This is a catch-22 situation whereby PET bycatch is described as a rare event because it is rarely reported, and this perceived rarity may serve to argue against ambitious dedicated monitoring programmes out of cost-effectiveness considerations, thereby reinforcing the initial misconception (Authier *et al.,* 2021).

Follow-up work **should review and provide recommendations for improvement of monitoring systems per Member State**, and at regional level where appropriate, to ensure that collection of data is adequate to assess population level bycatch issues and link to métiers operating at regional scale, by identifying in particular the areas, métiers, gears and vessel types where improvements are needed in view of fulfilling the Birds and Habitats Directives and MSFD obligations. Such work could be undertaken by ICES WGBYC, following a 'historical' data call. Further, information on **sampling survey design** would be required from member states, to understand any bias that may exist with the available data, and forthcoming workshops could be used to discuss **designing appropriate PET species bycatch sampling programmes**, and how to sample a representative proportion of the fishery/ métier **Bycatch is not a function of vessel length** (Murphy *et al.*, 2013; 2019) and as outlined within the report, the disparity of information arising from different requirements depending on vessel size must be addressed.

Within DCF monitoring programmes, issues around comprised efficiency in sampling were discussed, and a way forward might be to design robust multipurpose catch/bycatch sampling programmes in which observers focus on **fish catch sampling on some hauls and on bycatch monitoring on others**, depending on the gear type in question. Additionally, **standardised training of observers at a European level** (and reviewing current approaches undertaken by member states) has also been suggested to improve present monitoring programmes, and by providing specifically designed **manuals for observers, incorporating PET species identification guides**. Collection of specific operational data such as information on 'slipping' and 'drop-outs', 'hauling/pre-sorting' and 'sorting', would enable **a more accurate assessment of the visual coverage of each part of the fishing process**. Further, the **inclusion of real-zeros**, where bycatch was not observed, needs to be clearly distinguished from zeros arising through non-sampling, on reporting. Finally, WGBYC should continue work to identify the most **appropriate fishing effort metric for calculating bycatch rates** across gear métiers, and testing the suitability of different effort metrics to complex statistical analysis, including their effects on assessments of total bycatch mortality. Monitoring programmes may also employ different monitoring methods (EM, DCF observers, self-sampling etc.), even within a country, and how best these data should be collated and assessed requires further consideration, as different monitoring methods will have different levels of uncertainty.

If strandings data are to be employed to estimate bycatch rates, as per ICES Advice (2020), **further review of the methodologies employed is required by an independent review group**, following the approach, and continuing the work, undertaken by the International Whaling Commission.

9.3 Resolving conflicting objectives and building a monitoring programme

As noted above there is a need to balance apparently conflicting objectives with available resources. If programmes are to be international to cover EU fisheries then a number of negotiations will be needed. At the high level, discussions will need to involve DG Environment, DGMARE, STECF, ICES, GFCM, OSPAR, HELCOM, Mediterranean and the Black Sea commissions (these last four as part of Member States' obligations under MSFD) and industry/NGO representatives, possibly through the various CFP Advisory Councils, to understand each others objectives. Objectives of sampling programmes should be cost effective, and coordinated. At the operational level scientists and specialists will be needed from Member States to discuss practicalities. An understanding between these two groups will be needed too.

An onboard monitoring scheme needs to be representative of all fishing activity and not biased by inability to access some fleet segments. In the USA (and elsewhere), fishing licences include a mandate to carry fisheries observers when requested. This has not occurred in EU waters, but the issue needs to be addressed. Further options for incentivising and certifying fisheries should be explored. The ability to monitor the small vessel fleets in EU waters (in many places the dominant part of fleets) has proved particularly challenging. Some data protection issues may also need to be resolved.

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Annex 1: Bird and Marine Mammal Species by ICES ecoregion and relative encounter rate

Table 1. List of Bird Species by ICES ecoregion and relative encounter rate

	Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay and Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
benthic feeding ducks	Common Pochard	*Aythya ferina*	VAG	RAR	VAG	RAR			VAG?	VAG	RAR	RAR	RAR	REG*
	Tufted Duck	*Aythya fuligula*	RAR	REG*	RAR	REG*			VAG?	RAR	RAR	RAR	REG*	COM*
	Greater Scaup	*Aythya marila*	REG*	REG*	RAR	REG*			VAG?	VAG	RAR	RAR	RAR	COM*
	Steller's Eider	*Polysticta stelleri*	REG*	REG*	VAG	RAR			VAG?	VAG	VAG	VAG	VAG	REG*
	King Eider	*Somateria spectabilis*	REG*	REG*	VAG	VAG	REG*	REG*	VAG?	VAG	VAG	VAG	RAR	RAR
	Common Eider	*Somateria mollissima*	COM*	COM*	COM*	COM*	REG*	REG*	VAG?	RAR	VAG	REG*	REG*	COM*
	Velvet Scoter	*Melanitta fusca*	REG*	REG*	VAG	VAG					VAG	VAG	RAR*	COM*
	Common Scoter	*Melanitta nigra*	REG*	COM*	VAG	REG*			VAG?	RAR	REG*	REG*	REG*	COM*
	Long-tailed Duck	*Clangula hyemalis*	REG*	REG*	RAR	REG*	REG*	REG*	VAG?	VAG	VAG	RAR	RAR	COM*
	Common Goldeneye	*Bucephala clangula*	REG*	REG*	RAR	RAR			VAG?	VAG	RAR	RAR	REG*	COM*
mergansers	Smew	*Mergellus albellus*	RAR	RAR	VAG	RAR					VAG	RAR	RAR*	REG*
	Goosander	*Mergus merganser*	REG*	REG*	VAG	RAR			VAG?	VAG	VAG	RAR*	RAR*	COM*
	Red-breasted Merganser	*Mergus serrator*	REG*	REG*	RAR	COM*	REG*		VAG?	VAG	REG*	REG*	REG*	COM*

	Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay and Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
divers	Red-throated Diver	*Gavia stellata*	REG*	REG*	REG*	REG*	REG*	REG*	VAG?	VAG	RAR	REG	REG*	COM*
	Black-throated Diver	*Gavia arctica*	REG*	REG*	VAG				VAG?	VAG	RAR	RAR	REG*	COM*
	Great Northern Diver	*Gavia immer*	REG*	REG*	RAR*	REG*	REG*		VAG?	RAR	RAR	RAR*	RAR*	RAR*
	White-billed Diver	*Gavia adamsii*	REG*	REG*	RAR*						VAG	VAG	VAG	RAR*
albatross	Black-browed Albatross	*Thalassarche melanophris*	VAG	VAG	VAG	VAG			VAG	VAG	VAG	VAG	VAG	

	Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay and Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
petrels and storm petrels	Wilson's Storm Petrel	*Oceanites oceanicus*		VAG	VAG	VAG			COM	COM	RAR	VAG	VAG	
	European Storm Petrel	*Hydrobates pelagicus*	REG	REG	COM	COM			REG	REG	COM	COM	REG	VAG
	Band-rumped Storm Petrel	*Hydrobates castro*							REG	REG	REG			
	Monteiro's Storm Petrel	*Hydrobates monteiroi*							RAR	REG				
	Swinhoe's Petrel	*Hydrobates monorhis*		VAG					VAG	VAG	VAG	VAG	VAG	
	Leach's Storm Petrel	*Hydrobates leucorhous*	VAG	REG	COM	COM	RAR		REG	REG	RAR	REG	VAG	VAG
	White-faced Storm Petrel	*Pelagodroma marina*							VAG	VAG				
	Desertas Petrel	*Pterodroma deserta*							RAR	RAR	VAG			
	Zino's Petrel	*Pterodroma madeira*							RAR	RAR	VAG	VAG		
	Bulwer's Petrel	*Bulweria bulwerii*							RAR	REG				
Fulmar and shearwaters	Northern Fulmar	*Fulmarus glacialis*	COM	COM	COM	COM	COM	COM	REG	RAR	REG	COM	COM	VAG
	Scopoli's Shearwater	*Calonectris diomedea*							RAR	RAR	RAR	VAG		
	Cory's Shearwater	*Calonectris borealis*		VAG	VAG				COM	COM	COM	REG	RAR	VAG
	Sooty Shearwater	*Ardenna grisea*	VAG	REG	REG	REG	REG		RAR	RAR	REG	REG	RAR	VAG
	Great Shearwater	*Ardenna gravis*	VAG	RAR	REG	REG	REG		REG	REG	REG	REG	RAR	
	Manx Shearwater	*Puffinus puffinus*	VAG	RAR	COM	REG	VAG		REG	REG	COM	COM	REG	VAG
	Balearic Shearwater	*Puffinus mauretanicus*		VAG	VAG				RAR	RAR	REG	RAR	VAG	VAG

Species	**Scientific Name**	**Barents Sea**	**Norwegian Sea**	**Faroes**	**Icelandic Waters**	**Greenland Sea**	**Arctic Ocean**	**Oceanic North-East Atlantic**	**Azores**	**Bay of Biscay and Iberian Coast**	**Celtic Seas**	**Greater North Sea**	**Baltic Sea**
Yelkouan Shearwater	*Puffinus yelkouan*							VAG		VAG	VAG		
Barolo Shearwater	*Puffinus baroli*							REG	REG	RAR	RAR	VAG	

	Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay and Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
grebes	Red-necked Grebe	*Podiceps grisegena*	RAR	REG	VAG	VAG			VAG?	VAG	RAR*	RAR	RAR	REG
	Great Crested Grebe	*Podiceps cristatus*		RAR	VAG	VAG			VAG?	VAG	RAR*	RAR	REG*	COM
	Horned Grebe	*Podiceps auritus*	VAG	RAR	RAR	RAR			VAG?	VAG	RAR*	RAR	RAR	REG
	Black-necked Grebe	*Podiceps nigricollis*							VAG?	VAG	RAR*	RAR	RAR	REG
gannets	Northern Gannet	*Morus bassanus*	REG	REG	REG	COM	REG		RAR	REG	COM	COM	COM*	RAR*
cormorants	European Shag	*Phalacrocorax aristotelis*	COM*	COM*	REG	COM*					REG*	REG*	REG*	RAR
	Double-crested Cormorant	*Phalacrocorax auritus*								VAG		VAG	VAG	
	Great Cormorant	*Phalacrocorax carbo*	COM*	COM*	REG	COM*	REG*		VAG?	VAG	REG*	REG*	REG*	COM*
rails	Eurasian Coot	*Fulica atra*	VAG	RAR	VAG	VAG			VAG?	RAR	RAR*	RAR*	REG*	COM*
gulls	Black-legged Kittiwake	*Rissa tridactyla*	COM	COM	COM	COM	COM	COM	REG	RAR	REG	COM	COM*	RAR*
	Ross's Gull	*Rhodostethia rosea*	RAR	VAG	VAG	VAG	RAR	COM			VAG	VAG	VAG	VAG
	Ivory Gull	*Pagophilae burnea*	RAR	VAG	VAG	VAG	REG	COM			VAG	VAG	VAG	VAG
	Sabine's Gull	*Xema sabini*	RAR	VAG	VAG	VAG	REG*	REG	VAG	VAG	RAR	VAG	VAG	VAG
	Slender-billed Gull	*Chroicocephalus genei*									REG	VAG	VAG	VAG
	Black-headed Gull	*Chroicocephalus ridibundus*	RAR	COM*	RAR	COM*			VAG	REG	REG*	REG*	REG*	COM*
	Little Gull	*Hydrocoloeus minutus*	VAG	VAG	VAG	VAG					REG	RAR	REG*	REG
	Laughing Gull	*Leucophaeus atricilla*							VAG?	RAR	VAG	VAG	VAG	VAG
	Audouin's Gull	*Ichthyaetus audouinii*									RAR[1]			

	Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay and Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
	Mediterranean Gull	*Ichthyaetus melanocephalus*							VAG	VAG	REG	RAR	RAR*	RAR*
	Common Gull	*Larus canus*	COM*	COM*	RAR	REG*			VAG?	VAG	REG	REG*	REG*	REG
	Ring-billed Gull	*Larus delawarensis*			VAG				RAR	REG	VAG	VAG	VAG	
	Great Black-backed Gull	*Larus marinus*	COM*	COM*	REG	COM*	REG*		VAG?	REG	COM	COM*	COM*	COM*
	Glaucous Gull	*Larus hyperboreus*	COM	REG	RAR	COM	COM*	REG	VAG?	RAR	VAG	RAR	COM*	VAG
	Iceland Gull	*Larus glaucoides*	REG	REG	RAR	COM*	COM*		VAG?	RAR	VAG	RAR	RAR	VAG
	Herring Gull	*Larus argentatus*	COM*	COM*	REG*	COM*			VAG?	VAG	COM[2]	COM*	COM*	COM*
	Yellow-legged Gull	*Larus michahellis*							RAR	REG	REG[3]	VAG	VAG	RAR*
	Lesser Black-backed Gull	*Larus fuscus*	REG	COM	REG	COM	REG*		VAG	RAR	COM	COM*	COM*	REG
terns	Caspian Tern	*Hydroprogne caspia*			VAG				VAG?	VAG	VAG	VAG	RAR*	RAR*
terns	Sandwich Tern	*Thalasseus sandvicensis*	VAG	VAG	VAG	VAG			VAG?	VAG	COM	REG	REG*	RAR*
terns	Little Tern	*Sternula albifrons*		VAG	VAG				VAG?	VAG	REG*	RAR	RAR	RAR
terns	Roseate Tern	*Sterna dougallii*		VAG					VAG	REG	RAR*	RAR*	VAG	VAG
terns	Common Tern	*Sterna hirundo*	REG*	COM*	VAG	VAG			RAR	COM	REG	COM	COM*	REG
terns	Arctic Tern	*Sterna paradisaea*	COM*	COM*	REG	COM	COM	REG*	RAR	VAG	RAR	REG*	REG*	REG*
terns	Black Tern	*Chlidonias niger*	VAG	VAG	VAG	VAG			VAG?	VAG	RAR	RAR*	RAR*	RAR*
skuas	Great Skua	*Stercorarius skua*	REG	REG	REG	COM*	REG	RAR	RAR	REG	REG	REG*	REG*	VAG
skuas	Pomarine Skua	*Stercorarius pomarinus*	REG	REG	RAR	REG	COM	REG	RAR	RAR	REG*	RAR	VAG	VAG
skuas	Arctic Skua	*Stercorarius parasiticus*	REG	REG	REG	COM*	REG	REG	RAR	RAR	RAR	REG*	REG*	RAR*

	Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay and Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
	Long-tailed Skua	*Stercorarius longicaudus*	REG	REG	RAR	REG	REG	REG	RAR	VAG	RAR	RAR	VAG	VAG
auks	Little Auk	*Alle alle*	COM*	COM*	RAR	COM*	COM	COM	RAR	VAG	VAG	RAR	REG	VAG
auks	Brünnich's Guillemot	*Uria lomvia*	COM	RAR	RAR	COM*	COM	COM	VAG	VAG	VAG	VAG	RAR*	VAG
auks	Common Guillemot	*Uria aalge*	COM	COM	COM	COM	REG		REG	VAG	COM	COM	COM*	COM*
auks	Razorbill	*Alca torda*	COM	COM	REG	COM	REG		RAR	VAG	REG	COM	COM*	COM*
auks	Black Guillemot	*Cepphus grylle*	COM*	COM*	REG*	COM*	COM*	COM			VAG	RAR	RAR*	REG
auks	Atlantic Puffin	*Fratercula arctica*	COM*	COM*	COM*	COM*	REG	VAG	RAR	VAG	REG	COM	COM*	VAG

NOTES

Status was assessed in terms of the relative encounter rate between species at sea within that region. Four categories of status were used:

VAG – Vagrant, defined as a very low probability of being encountered at sea;

RAR – Rare, defined as a low probability of being encountered at sea;

REG – Regular but uncommon, defined as likely to be encountered at sea in small numbers;

COM – Common, defined as likely to be encountered at sea in relatively large numbers

* Marked variation in status within region (generally less common offshore)

1 VAG in French Biscay, RAR in Atlantic Iberiia 2 COM in French Biscay, REG in Atlantic Iberia 3 REG in French Biscay, COM in Atlantic Iberia

DATA SOURCES

Mehlum (1989), Nygard *et al.* (1988), Snow & Perrins (1998), Skov *et al*. (2011), Cadioui *et al.* (2015), Fauchald *et al.* (2015). Norwegian SEAPOP Programme (SEAPOP, 2020), Gabrielsen *et al.* (2008), Skov *et al.* (2011), Fauchald *et al*. (2015), Rogan *et al*. (2017), HELCOM (2018, b), tagging data, Marine Ecosystems Research Programme (Waggitt *et al*., 2020), Joiris & Hert (2020)

The lists and status assessments have been reviewed by the following:

Birds: Volker Dierschke, Adam Wozniczka (Baltic Sea), Tycho Anker-Nilsson (Barents Sea & Norwegian Sea), Aevar Petersen (Icelandic Waters), David Boertmann (Greenland Sea, Arctic Ocean), Antoine Chabrolle (Bay of Biscay), Peter Alfrey, Mark Bolton, Luis Barcelos, Joel Bried (Azores and Oceanic North-east Atlantic).

Table 2. List of Marine Mammal Species by ICES ecoregion and relative encounter rate

Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay & Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
Harbour Porpoise	*Phocoena phocoena*	COM*	COM*	COM*	COM*	REG***		REG*	VAG	REG	COM	COM*	REG*
Rough-toothed Dolphin	*Steno bredansensis*							REG	VAG	VAG			
Common Bottlenose Dolphin	*Tursiops truncatus*	VAG	RAR	REG	VAG			REG	COM	COM	COM	COM	RAR
Atlantic Spotted Dolphin	*Stenella frontalis*							REG	COM	VAG			
Striped Dolphin	*Stenella coeruleoalba*		VAG	VAG	VAG			COM	COM	COM	RAR	RAR	VAG
Common Dolphin	*Delphinus delphis*	VAG	VAG	VAG	VAG			COM	COM	COM	COM	REG*	RAR
Fraser's Dolphin	*Lagenodelphis hosei*							VAG	VAG	VAG	VAG		
White-beaked Dolphin	*Lagenorhynchus albirostris*	COM	RAR	REG	COM	COM***		VAG		RAR	COM	COM	RAR
Atlantic White-sided. Dolphin	*Lagenorhynchus acutus*	RAR	COM	COM	REG**	RAR***		REG		VAG	COM	REG*	VAG
Risso's Dolphin	*Grampus griseus*		VAG	RAR				REG	COM	REG	REG	REG*	
Melon-headed Whale	*Peponocephala electra*							REG		VAG	VAG		
Pygmy Killer Whale	*Feresa attenuata*							VAG		VAG			
False Killer Whale	*Pseudorca crassidens*							REG	REG	RAR	VAG	VAG	VAG
Killer Whale	*Orcinus orca*	REG	REG	REG	REG	REG***	RAR	RAR	RAR	RAR	RAR	RAR	VAG

Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay & Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
Long-finned Pilot Whale	*Globicephala melas*	REG	COM	COM	COM**	REG***		COM	RAR	COM	COM	REG*	
Short-finned Pilot Whale	*Globicephala macrorhynchus*								REG	VAG			
Narwhal	*Monodon monoceros*	REG	VAG	VAG	VAG	REG	REG				VAG	VAG	
Beluga	*Delphinapterus leucas*	RAR*	VAG	VAG	VAG	VAG	VAG				VAG	VAG	VAG
Cuvier's beaked Whale	*Ziphius cavirostris*	VAG	VAG	VAG	VAG			REG	REG	REG	RAR	VAG	
Northern Bottlenose Whale	*Hyperoodon ampullatus*	REG	REG	REG	REG**	REG***		REG	REG	REG	REG	RAR	VAG
True's beaked Whale	*Mesoplodon mirus*							RAR	VAG	VAG	VAG		
Gervais' beaked Whale	*Mesoplodon europaeus*				VAG			RAR			VAG		
Sowerby's beaked Whale	*Mesoplodon bidens*	VAG	RAR	REG	VAG			REG	REG	REG	RAR	RAR	VAG
Gray's beaked Whale	*Mesoplodon grayi*											VAG	
Blainville's beaked Whale	*Mesoplodon densirostris*				VAG			RAR	REG	VAG	VAG		
Pygmy Sperm Whale	*Kogia breviceps*							RAR	RAR	RAR	VAG	VAG	
Dwarf Sperm Whale	*Kogia sima*							VAG	VAG	VAG	VAG		
Sperm Whale	*Physeter macrocephaluis*	REG	REG	REG	REG	REG		REG	COM	REG	REG	RAR	
North Atlantic Right Whale	*Eubalaena glacialis*	VAG	VAG	VAG	VAG	VAG		VAG	VAG	VAG	VAG	VAG	

Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay & Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
Bowhead Whale	*Balaena mysticetus*	RAR	RAR	VAG	VAG	REG	REG			VAG	VAG	VAG	
Humpback Whale	*Megaptera novaeangliae*	REG	REG	REG	COM*	COM		RAR	RAR	RAR	RAR	RAR	RAR
Common Minke Whale	*Balaenoptera acutorostratra*	COM	COM	COM	COM	COM		RAR	REG	RAR	COM	COM*	RAR
Antarctic Minke Whale	*Balaeenoptera bonaerensis*	VAG											
Sei Whale	*Balaenoptera borealis*	RAR	REG	RAR	REG**	RAR***		REG	REG	RAR	RAR	RAR	
Bryde's Whale	*Balaenoptera brydei*							RAR	RAR			VAG	
Fin Whale	*Balaenoptera physalus*	REG	REG	REG	COM**	COM	RAR†	REG	REG	COM	REG	RAR	RAR
Blue Whale	*Balaenoptera musculus*	REG	REG	RAR	REG	REG	RAR†	REG	REG	RAR	RAR		
Walrus	*Odobenus rosmarus*	REG*	RAR	VAG	VAG	REG	REG				VAG	VAG	
Hooded Seal	*Cystophora cristata*	COM*	REG*	REG*	RAR	COM	REG†		VAG			VAG	
Bearded Seal	*Erignathus barbatus*	REG*	RAR	RAR	RAR	COM	REG			VAG		VAG	
Grey Seal	*Halichoerus grypus*	RAR	REG*	REG*	REG*	VAG			VAG	RAR	COM*	COM*	REG*
Mediterranean Monk Seal	*Monachus monachus*								VAG	VAG			
Harp Seal	*Pagophilus groenlandicus*	COM*	RAR	VAG	RAR	COM	REG†		VAG			VAG	
Harbour Seal	*Phoca vitulina*	REG*	COM*	VAG	COM*	RAR*			VAG	VAG	COM*	COM*	REG*

Species	Scientific Name	Barents Sea	Norwegian Sea	Faroes	Icelandic Waters	Greenland Sea	Arctic Ocean	Oceanic North-East Atlantic	Azores	Bay of Biscay & Iberian Coast	Celtic Seas	Greater North Sea	Baltic Sea
Ringed Seal	*Pusa hispida*	COM*	REG*	VAG	RAR	COM	REG		VAG	VAG	VAG	VAG	REG*
Polar Bear	*Ursus maritimus*	REG	RAR		VAG	REG	REG						

NOTES

Assessment is made in terms of the relative encounter rate between species at sea within that region. Four categories were used:

VAG – Vagrant, defined as a very low probability of being encountered at sea;

RAR – Rare, defined as a low probability of being encountered at sea;

REG – Regular but uncommon, defined as likely to be encountered at sea in small numbers;

COM – Common, defined as likely to be encountered at sea in relatively large numbers

* Marked variation in encounter rate within region (generally less common offshore

** Marked variation in encounter rate within region (generally less common inshore)

*** Marked variation in encounter rate within region (less common in the north)

† Occurs only in the margin of the Arctic Ocean

DATA SOURCES

Hammond *et* al. (1995, 2003, 2017), Rogan *et al.* (2017), Lockyer & Pike (2009); Jefferson *et al.* (2015), Vacquié-Garcia *et al*. (2017), Desportes *et al*. (2019), tagging data, Marine Ecosystems Research Programme (Waggitt *et al*., 2020)

The lists and status assessments have also been reviewed by the following:

Mammals: Gisli Vikingsson, Marianne Rasmussen, Aevar Petersen (Icelandic Waters, Greenland Sea). David Boertmann (Greenland Sea, Arctic Ocean), Kit Kovacs (Norwegian Sea, Barents Sea, Arctic Ocean), Rui Prieto, Monica Silva (Azores and Oceanic North-east Atlantic), Carl Kinze (Baltic Sea).

Annex 2: Species-gear interaction and bycatch information for cetaceans in North-western Europe

Table 1. Species / Gear Interactions - fishing gear known to cause accidental entanglement for major European cetacean species. From OSPAR-HELCOM draft technical report on bycatch indicators for seabirds and marine mammals (in prep.) which see also for source references.

Species/Gear category	Gill nets	Pelagic trawls	Demersal trawls	Long lines	Drift nets	Seine nets	Pot lines
Harbour porpoise	√		√		√		
Bottlenose dolphin	√	√	√				√
Atlantic white-sided dolphin	√	√			√		
White-beaked dolphin	√	√					
Short-beaked common dolphin	√	√	√		√	√	
Striped dolphin	√	√	√		√	√	
Risso’s dolphin				√			
Killer whale				√			
Long-finned pilot whale	√	√	√	√			
Minke whale	√	√					√
Fin whale							√
Humpback whale							√

NOTE: Current sampling based on frequency of records, not necessarily the significance of possible impact

Table 2. Summary of Fisheries and Bycatch Information for Cetaceans in North West Europe. From OSPAR-HELCOM draft technical report on bycatch indicators for seabirds and marine mammals (in prep.) which see also for source references.

Area (and ICES area if known)	Gear type	Target species	Year	Species	Bycatch levels	Estimated Mean Annual Bycatch	Source	Bycatch Investigation approach and Comments
Irish Sea 8.a-e, 7.h,j,k	Driftnet	Albacore Tuna	1995	CD, SD	Medium	Low 100s	CEC, 2002b	Monitoring scheme Bycatch decline with low effort, fishery terminated by EC regs. in 2002
North Sea (offshore) 2.a, 4.a, 4.b, 4.c	Static	Cod, skate, turbot, sole, monkfish, dogfish	1995-1999	HP	High	100s	CEC 2002a,b: Defra, 2001; Northridge & Hammond, 1999; SFPA / SFI, 2001	Monitoring scheme By catch estimate without freezer-netter fleet
North Sea (inshore) 2.a, 4.a, 4.b, 4.c	Static	Cod	1995-1999	HP	Medium	100s	CEC, 2002a, b; Defra, 2001; Northridge & Hammond, 1999; SFPA/SFI, 2001	Monitoring scheme Bycatch estimate without freezer-netter fleet
West of Scotland 6.a	Static	Dogfish, crayfish, skate	1995-1999	HP, CD	Medium	Low 100s	Northridge, in CEC, 2002a	Monitoring scheme Drastic decline due to collapse of crayfish fishery
Channel 7.d, 7.e	Static	Cod, monkfish, flatfish	-	HP	Low?	-	ASCOBANS, 2003a; CEC, 2002a,b	Opportunistic records
Celtic Sea 7.f-j	Static	Hake, cod, pollack, saithe, ling	1992-1994	HP, CD	Medium-high	100s	CEC 2002a,b: Tregenza *et al.*,	Monitoring scheme

Area (and ICES area if known)	Gear type	Target species	Year	Species	Bycatch levels	Estimated Mean Annual Bycatch	Source	Bycatch Investigation approach and Comments
							1997; Tregenza & Collet, 1998	
Bay of Biscay, Celtic Shelf 7.g-k	Pelagic pair trawl	Albacore tuna	2000-2010	Mainly CD, also SD, AWSD, WBD, LFPW	High?	10s to 100s	CEC, 2002b; ICES, 2008; Y.Morizur *pers. comm.*	Monitoring scheme
North Sea and West of Ireland 4.a-c, 6.a,b	Pelagic trawl	Herring, mackerel	1995-1996 and 2000-2001	LFPW, potentially other species	Low?	-	ASCOBANS, 2003a;CEC, 2002a,b; Morizur *et al.,* 1999	Monitoring scheme
Western Channel 7.d, 7.e	Pelagic pair trawl	Mackerel, bass, pilchard, blue whiting, and anchovy	1995-1996 and 2000-2001	CD, SD, AWSD, WBD, LFPW	High, mainly CD	-	CEC, 2002b; Morizur *et al.,* 1999	Monitoring scheme
North Sea and potentially others 4.b, 4.c and potentially others	Demersal trawl	Cod and others?	-	HP	Very low?	-	CEC, 2002b	NONE
Northern North Sea 2.a, 4.a (parts)	Purse seine	Herring, mackerel	-	Small cetaceans	Low?	-	CEC, 2002b	Opportunistic records
North Sea 4.a, 4.b, 4.c	Fish trap	Salmonids	-	HP	Low?	-	CEC, 2002b	NONE
North Sea 4	Set nets	Cod, skate, turbot, sole, monkfish	1995-2002	HP	Medium	439 [371-640]	ASCOBANS, 2004	NONE

Area (and ICES area if known)	Gear type	Target species	Year	Species	Bycatch levels	Estimated Mean Annual Bycatch	Source	Bycatch Investigation approach and Comments
North Sea 4	Set nets	Cod, turbot, sole, other demersal fish	2002-2003	HP		25-30	Flores & Kock, 2003	Independent observer scheme
North Sea 4, 7.d, 3.a	Set nets		2012-2014	HP		27-29/1000 days at-sea	ICES WGBYC, 2015	Remote Electronic Monitoring
North Sea including 7.d and 3.a	Set nets		2013-2014	HP	High	1235-1990	ICES WGBYC, 2015	Independent observer scheme
English Channel, Celtic Sea and North Sea	Gill nets and trammel nets		2013	HP	High	1600-1900	ICES WGBYC, 2015	Independent observer scheme
English Channel, Celtic Sea and North Sea	Gill nets and trammel nets		2014	HP	High	1400-1700	ICES WGBYC, 2016	Independent observer scheme
Channel and Bay of Biscay 7.d,e,f, 8.a,b and some in 4.c	Fixed	Sole, anglerfish, cod, hake, turbot	1995-1996	HP	Low?	<1	ASCOBANS, 2003c; Morizur *et al.,* 1996; CEC, 2002b	
Channel 7.d, 7.e	Fixed	?	-	HP	Medium?	>10	Morizur *et al.,* 1996; Swarbrick et *al.*, 1994	1 HP per boat per year (potentially up to 30 boats)
Celtic Sea 7.e-j	Fixed	Hake and anglerfish	?	HP and other species	High?	-	Morizur *pers. comm.,* in CEC, 2002b	
North Sea 6.a, 6.b	Pelagic single or pair trawl	Herring, mackerel and horse mackerel	-	HP, LFPW and small cetaceans	Very low?	-	ASCOBANS, 2003c; CEC, 2002b	NONE

Area (and ICES area if known)	Gear type	Target species	Year	Species	Bycatch levels	Estimated Mean Annual Bycatch	Source	Bycatch Investigation approach and Comments
Celtic and Irish Seas			2012-2014	HP	High	1137-1472	ICES WGBYC, 2015	Independent Observer Scheme
Western Channel and potentially Celtic Seas	Pelagic single or pair trawl	Blue whiting, mackerel and horse mackerel, herring, sea bass, black sea bream	1994-1995	CD, AWSD, and other species	High for all species but mainly CD	100s	ASCOBANS, 2003c; CEC, 2002a,b; Morizur *et al.,* 1996, 1999	Independent Observer Scheme
Celtic Shelf and Bay of Biscay 8.a, 8.b, 8.d	Pelagic single or pair trawl	Hake, tuna, sardine, anchovy, horse mackerel, sea bass	1994-1995	CD, BND	High for all species but mainly CD	100s	ASCOBANS, 2003c; CEC, 2002a,b; Morizur *et al.,* 1996, 1999	Independent Observer Scheme
Celtic Shelf and Bay of Biscay 8.a, 8.b, 8.d	Pelagic single or pair trawl	Manly sea bass	2000-2010	Mainly CD	High	Up to 1,000 (2009)	ICES, 2008; Y. Moriizur *pers. comm.*.	Independent Observer Scheme
English Channel and Bay of Biscay	Set nets, mainly trammel nets	Monkfish, turbot and sole	2008-2013	HP	High	600	Morizur *et al.*, 2014; ICES WGBYC, 2015	Independent Observer Scheme
Celtic Shelf and Bay of Biscay 8.a, 8.b, 8.d	Pelagic single or pair trawl, set net, and purse seine		2008-2013	CD	High	2509	ICES WGBYC, 2015, ICES, 2016	Independent Observer Scheme

Annual Bycatch levels

Rare	**Very low**
<10/year	Low
10-500 animals/year	Medium
>500 animals/year	High
Several 1000 animals/year	Very high
Potential bycatch levels for fisheries not yet monitored using independent observer programs but alternative sources of information available.	?

Key to species

Harbour porpoise	**HP**
Common dolphin	CD
Bottlenose dolphin	BND
Striped dolphin	SD
Atlantic white-sided dolphin	AWSD
Minke whale	MW
White-beaked dolphin	WBD
Long-finned pilot whale	LFPW

Annex 3: Relevant fishing gears contributing to bycatch of Seabird species

List of seabird species of the NE Atlantic, the Mediterranean Sea and the Baltic Sea with relevant fishing métiers concerning bycatch, regions of sea with occurrence and status of various Red Lists IUCN criteria given below; note that UK and Ireland use a slightly different system). From ICES WGBYC (2019) which see also for source references.

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
with benthic feeding ducks	Common Pochard				x				x	x	x		x	x	VU	VU	VU				x	*Aythya ferina*
	Tufted Duck				x			x	x	x	x		x	x				NT			x	*Aythya fuligula*
	Greater Scaup				x			x	x	x	x		x	x		VU	VU	VU			x	*Aythya marila*
	Steller's Eider				x			x						x	VU		EN	EN	x	x	x	*Polysticta stelleri*
	King Eider				x			x						x							x	*Somateria spectabilis*
	Common Eider				x			x	x	x	x		x	x	NT	VU	EN	EN			x	*Somateria mollissima*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
	Velvet Scoter				x			x	x	x	x		x	x	VU	VU	VU	EN			x	*Melanitta fusca*
	Common Scoter				x			x	x	x	x		x	x				EN			x	*Melanitta nigra*
	Long-tailed Duck				x	x		x	x	x				x	VU	VU	VU	EN			x	*Clangula hyemalis*
	Common Goldeneye				x			x	x	x	x		x	x							x	*Bucephala clangula*
mergan-sers	Smew				x	x			x				x	x						x	x	*Mergellus albellus*
	Goosander				x	x		x	x	x				x							x	*Mergus merganser*
	Red-breasted Mergan-ser				x	x		x	x	x	x		x	x		NT	VU	VU			x	*Mergus serrator*
divers	Red-throated Diver				x	x		x	x	x	x		x	x				CR		x	x	*Gavia stellata*
	Black-throated Diver				x	x		x	x	x	x		x	x				CR		x	x	*Gavia arctica*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
	Great Northern Diver				x	x		x	x	x	x					VU	VU			x	x	*Gavia immer*
	White-billed Diver				x	x		x	x					x	NT	VU					x	*Gavia adamsii*
petrels and storm petrels	European Storm Petrel		x		x	x		x	x	x	x	x	x							x	x	*Hydrobates pelagicus*
	Band-rumped Storm Petrel		x		x	x					x	x									x	*Hydrobates castro*
	Monteiro's Storm Pet-rel		x		x	x						x			VU	VU	VU				x	*Hydrobates monteiroi*
	Leach's Storm Petrel		x		x	x		x	x	x	x	x			VU		VU			x	x	*Hydrobates leucorhoa*
	White-faced StormPet-rel		x		x	x						x				EN	EN			x	x	*Pelagodroma marina*
	Desertas Petrel		x		x	x						x			VU	VU	VU			x	x	*Pterodroma deserta*
	Zino's Petrel		x		x	x						x			EN	EN	EN			x	x	*Pterodroma madeira*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
	Bulwer's Petrel		x		x	x						x								x	x	*Bulweria bulwerii*
	Northern Fulmar		x		x	x		x	x	x						EN	VU				x	*Fulmarus glacialis*
	Scopoli's Shearwater	x	x		x	x					x	x	x							x	x	*Calonectris diomedea*
Fulmar	Cory's Shearwater	x	x		x	x					x	x	x							x	x	*Calonectris borealis*
	Sooty Shearwater	x	x		x	x		x	x	x	x	x			NT						x	*Ardenna grisea*
	Great Shearwater	x	x		x	x		x	x	x	x	x									x	*Ardenna gravis*
	Manx Shearwater	x	x		x	x		x	x	x	x	x							x		x	*Puffinus puffinus*
	Balearic Shearwater	x	x		x	x			x	x	x		x		CR	CR	CR			x	x	*Puffinus mauretanicus*
	Yelkouan Shearwater		x		x	x							x		VU					x	x	*Puffinus yelkouan*
	Barolo Shearwater		x		x	x					x	x				NT	NT		x	x	x	*Puffinus baroli*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
grebes	Red-necked Grebe				x	x			x		x		x	x				EN			x	*Podiceps grisegena*
	Great Crested Grebe				x	x			x	x	x		x	x							x	*Podiceps cristatus*
	Horned Grebe				x	x		x	x	x	x		x	x	VU	NT	VU	VU		x	x	*Podiceps auritus*
gan-nets	Northern Gannet	x	x	x	x	x		x	x	x	x	x	x	x							x	*Morus bassanus*
cormorants	European Shag*	x		x	x	x	x	x	x	x	x		x				NT			x	x	*Phalacrocorax aristotelis*
	Great Cormorant	x		x	x	x	x	x	x	x	x		x	x							x	*Phalacrocorax carbo*
rails	Eurasian Coot				x			x	x	x	x		x	x		NT					x	*Fulica atra*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
gulls	Black-legged Kittiwake	x		x	x	x		x	x	x	x	x		x	VU	VU	EN	EN	x		x	*Rissa tridactyla*
	Sabine's Gull	x		x	x	x		x	x	x	x	x									x	*Xema sabini*
	Slender-billed Gull	x		x	x	x							x							x	x	*Chroicocephalus genei*
	Black-headed Gull	x		x	x	x		x	x	x	x	x	x	x							x	*Chroicocephalus ridi-bundus*
	Little Gull					x			x	x	x		x	x		NT		NT		x	x	*Hydrocoloeus minutus*
	Audouin's Gull	x		x	x	x					x		x							x	x	*Ichthyaetus audouinii*
	Mediterranean Gull	x		x	x	x			x	x	x		x	x				EN		x	x	*Ichthyaetus melano-cephalus*
	Common Gull	x		x	x	x		x	x	x	x		x	x							x	*Larus canus*
	Great Black-backedGull	x		x	x	x		x	x	x	x			x							x	*Larus marinus*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
	Glaucous Gull	x		x	x	x		x	x	x	x			x							x	*Larus hyperboreus*
	Iceland Gull	x		x	x	x		x	x	x											x	*Larus glaucoides*
	Herring Gull	x		x	x	x		x	x	x	x			x		NT	VU				x	*Larus argentatus*
	Yellow-legged Gull	x		x	x	x			x		x		x	x							x	*Larus michahellis*
	Lesser Black-backed Gull*	x		x	x	x		x	x	x	x		x	x				VU	x		x	*Larus fuscus*
terns	Caspian Tern					x							x	x			NT	VU		x	x	*Hydroprogne caspia*
terns	Sandwich Tern					x			x	x	x		x	x						x	x	*Thalasseus sandvicensis*
terns	Little Tern					x			x	x	x		x	x						x	x	*Sternula albifrons*
terns	Roseate Tern					x			x	x	x	x							x	x	x	*Sterna dougallii*

	species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
	Common Tern					x		x	x	x	x	x	x	x						x	x	*Sterna hirundo*
	Arctic Tern					x		x	x	x	x	x		x						x	x	*Sterna paradisaea*
	Black Tern								x		x		x	x						x	x	*Chlidonias niger*
skuas	Great Skua					x		x	x	x	x	x									x	*Stercorarius skua*
skuas	Pomarine Skua					x		x	x	x	x	x	x								x	*Stercorarius pomarinus*
skuas	Arctic Skua					x		x	x	x	x	x	x	x			EN				x	*Stercorarius parasiticus*
skuas	Long-tailed Skua					x		x	x	x	x	x									x	*Stercorarius longicaudus*
auks	Little Auk	x	x	x	x	x		x	x	x											x	*Alle alle*
auks	Brünnich's Guillemot	x	x	x	x	x		x											x		x	*Uria lomvia*

species	Purse seine (PS)	Pelagic trawls OTM, PTM)	Bottom trawls (TBB, OTB, OTT, PTB)	Nets (GNS, GTR, GND)	Hooks and longlines (LLS, LLD)	Pots and traps (FPO)	NE Atl.: Arctic Waters (OSPAR I)	NE Atl.: Greater North Seas (OSPAR II)	NE Atl.: Celtic Seas (OSPAR III)	NE-Atl.: Bay of Biscay, Iberian Coats (OSPAR IV)	NE Atl.: Wider Atlantic (OSPAR V)	Mediterranean Sea	Baltic Sea	Red List World (IUCN 2018)	Red List Europe (BirdLife International 2015)	Red List EU27 (BirdLife International 2015)	Red List Baltic Sea (HELCOM 2013)	OSPAR List of Threatened and/or Declining Species and Habi-	Bird Directive Annex I	Bird Directive migratory species	scientific name
Common Guillemot*	x	x	x	x	x		x	x	x	x			x		NT			x	x	x	*Uria aalge*
Razorbill	x	x	x	x	x		x	x	x	x		x	x	NT	NT					x	*Alca torda*
Black Guillemot*	x	x	x	x	x		x	x	x				x			VU	VU			x	*Cepphus grylle*
Atlantic Puffin	x	x	x	x	x		x	x	x	x		x		VU	EN	NT				x	*Fratercula arctica*

* Part of information refers to a subspecies only.

RE	IUCN: regionally extinct	NT	IUCN: near threatened
CR	IUCN: critically endangered	R	UK/IE: red list
EN	IUCN: endangered	A	UK/IE: amber list
VU	IUCN: vulnerable		