WORKSHOP ON ESTIMATION OF MORTALITY OF MARINE MAMMALS DUE TO BYCATCH (WKMOMA)

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WORKSHOP ON ESTIMATION OF MORTALITY OF MARINE MAMMALS DUE TO BYCATCH (WKMOMA)

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i Executive summary

The Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA) addressed a special request from OSPAR regarding the bycatch mortality of marine mammals (harbour porpoise *Phocoena phocoena*; common dolphin *Delphinus delphis*; and grey seal *Halichoerus grypus*) within the OSPAR maritime area. The objective of the workshop was to generate bycatch rates and associated confidence intervals for static and towed gears for relevant species within the three species assessment areas defined by OSPAR. Subsequently, the species-specific bycatch mortality estimates in the defined assessment area were requested. OSPAR provided thresholds for the relevant species/assessment units and ICES were tasked to compare the mortality estimates to the provided thresholds and identify any critical issues relevant for the comparison.

ICES issued an official data call requesting 18 of the 20 ICES countries with fisheries operating in the OSPAR area to provide data. Norway, the Faroes, and Russia did not submit bycatch monitoring and effort in response to the data call, and it was therefore not possible to estimate bycatch in these waters. The data call aimed to collect data describing total bycatch monitoring/sampling effort and grey seal, harbour porpoise and common dolphin bycatch incidents from the years 2005 until 2020 from fisheries operating in the OSPAR Region. Most of the contacted countries submitted data, but the quality and quantity of the data provided varied widely among nations. Regarding data on fishing effort, ICES asked all EU member states for permission to use fishing effort data held in the ICES Regional Database (RDB) which contains data on fishing effort data in various metrics by métier level, country, vessel size and ICES rectangle. When permission was granted, a data extraction was undertaken by the ICES data centre providing effort data from 2015 to 2020.

All submitted monitored effort data from 2005 until 2021 was summarized and resulted in a total of 884 common dolphins, 1221 harbour porpoises and 574 grey seals were observed bycaught from 2005 to 2021.

As recommended in ICES WGBYC 2020, a modelling procedure was carried out to generate bycatch rates. Before bycatch modelling occurred, statistical tests were run on the datasets of the three species to test how bycatch rates were affected by year, month, vessel size, ICES sub-area, and métier (level 4). Results varied between the three species, with all three species having higher bycatch rates the more recent years (2015-2020) and significant effects of sub-areas and métiers. Vessel size was significant factor for harbour porpoise with larger vessels (12-15m or larger) having higher bycatch rates, while the opposite was true for grey seals for which smaller vessels (up to 12 m) had higher bycatch rates. Thereby the monitored effort data sets were pooled from 2015 to 2020 for further analyses and for harbour porpoise and grey seal data was stratified by vessel size.

A Gamma Hurdle model was used to estimate bycatch rates per day at sea. This two-step process first estimates the probability of a bycatch occurring, and then their intensity (number of animals being caught). Multiplying those values together results in an overall bycatch rate for the observed days at sea.

For common dolphin, the highest frequencies bycatch events over 2015-2020 were recorded in PTM and OTM in ICES area 27.8 and OTM in ICES area 27.6. In ICES Subarea 27.7, highest frequencies were estimated in GTR, OTB and OTT. Bycatch event frequencies were also estimated for GNS and PS gears in ICES area 27.9 however these rates were below 0.01 events per day at sea.

The average number of common dolphins/bycatch event was close to one individual in most gears operating in ICES area 27.7 and static gears in 27.8. It ranged from 1.5 to 2 individuals in PS and GNS in ICES area 27.9. The numbers of common dolphins bycaught per haul was highest in PTM in 27.8 and OTM in 27.8 and 27.6 (3.58 common dolphins/bycatch event), and in PTB operating in 27.8 (4.09 common dolphins/bycatch event).

The bycatch rates extrapolated to the fishing effort gave the total number of common dolphins bycaught estimated to 6,404 individuals (95% CI 3,051-9,414) in 2020 for the entire assessment area. The highest bycatch estimate was calculated for PTM followed by GNS/GND and GTR. Bycatch estimates in 2020 are consistent with previous understanding of common dolphin bycatch and remain in the same order of magnitude as previous ICES bycatch estimates based on observer programs and strandings (ICES, 2020a). However, the 2020-point estimate is higher than that of the mean annual bycatch estimate across all métiers of 3973 (95% CI 1998–6599) dolphins for 2016-2018 for the Bay of Biscay and Iberian Coast.

Highest frequencies of harbour porpoise bycatch events were recorded in large vessels using GNS in ICES areas 27.3 and 27.4, when all data (2015-2020) are considered. However, sampling by one country in that area was unrepresentative due to non-random sampling and constitutes a very high proportion of the observed effort. Without that country, the rates are much lower for ICES Subarea 27.4. Small vessels using GNS also had relatively high rates in subareas 27.4 and in 27.3. Rate of bycatch events was also high in GNS within ICES subarea 27.5 and in Subarea 27.7 the highest bycatch rates were found in GNS/GTR/ for large vessels. In OTT and OTB there were few bycatch observations and therefore bycatch in all areas were grouped together to calculate the rate.

The average number of porpoises/bycatch event over 2015-2020 was generally between 1 and 1.5 individuals in most métiers and areas, apart from large vessels using GNS in ICES Subarea 27.4 where 2.5 individuals were observed on average per bycatch event if the non-random sampling observer effort is included. Removing that sampling lowers that estimate down to 1.33 individuals/bycatch event.

The mortality for harbour porpoise was estimated for all requested assessment areas except the Belt, the Faroes and the Iberian Peninsula. WKMOMA estimates that the bycatch in 2020 in the West Scotland and Ireland assessment unit to be 305 (134-686) harbour porpoises. In the Irish Sea's assessment unit 12 (6-27) porpoises were bycaught, of which 2 individuals were estimated to be caught in GNS/GND while 10 individuals were estimated to be caught in OTB/OTT. WKMOMA estimates bycatch in the Icelandic assessment unit to be 1712 (1123-1973) harbour porpoises, all caught in GNS. In the North Sea two estimates are presented, one higher estimate including submitted data from all countries, but heavily skewed due to very frequent bycatch observations from targeted few vessels and one estimate where the monitoring effort data from this country has been taken out. The two estimates for the North Sea are 5929 (95% CI 3176-10739) and 1627 (95% CI 922-3325; not including the unrepresentative data). Majority of the bycatch is estimated to be from GNS/GND in both cases (1306/5327 individuals), followed by GTR (198/479 individuals) and to lesser extent from OTB/OTT (123/123 individuals).

Highest frequencies of grey seal bycatch events were recorded in small vessels using GNS in ICES Subarea 27.7 and in small vessels using GNS in Subarea 27.5. Bycatch frequency in GND and GNS in ICES subareas 27.3 and 27.7 were around 50% lower than in the areas mentioned above and even slightly lower in GTR in subareas 27.7 and 27.8. Bycatch events were observed also in OTM in these areas, however fewer than in GNS/GTR. The average number of grey seals caught per bycatch event was between 1 and 1.5 individuals in most métiers and areas, besides small vessels using GNS in ICES area 27.5 where 3.5 individuals were observed on average.

The overall bycatch estimates for grey seals in the three assessment units were 3096[*] individuals (95% CI 2019–5042) based on bycatch events/frequency from 2015-2020 and raised with effort data from 2020. Broken up by assessment unit, WKMOMA estimates that 2229 individuals (95% CI 1598-3199) are caught annually in the Great North Sea assessment unit, 761 individuals (95% CI 333-1715) in the Iceland assessment unit and 108 individuals (95% CI 89-129) in the Ireland assessment unit. Gillnet métiers were the main gears with observed bycatch in all assessment units, but a small amount was also estimated to be caught in OTM in the Greater North Sea assessment unit.

[*] This estimate was corrected after ADGMOMA. By mistake, the total effort from a different métier was used for the estimation of the bycatch mortality for GTR in Ireland.

ii Expert group information

Expert group name	Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chairs	Sara Königson, Sweden
	Guðjón Már Sigurðsson, Iceland
Meeting venue(s) and dates	13-15 and 20-21 September 2021, by correspondence

1 Introduction

1.1 WKMOMA Terms of Reference

The Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA) chaired by Guðjón Már Sigurðsson, Iceland, and Sara Königson, Sweden, met remotely via Microsoft TEAMS on the afternoons of 13-15 and 20-21 September 2021. The workshop participants (24) addressed the special request from OSPAR regarding the mortality of marine mammals (harbour porpoise *Phocoena phocoena*; common dolphin *Delphinus delphis*; and grey seal *Halichoerus grypus*) due to bycatch within the OSPAR maritime area. ICES set the following Terms of Reference for the workshop:

ToR a) Generate bycatch rates (e.g. specimens per day at sea) and associated confidence intervals for static and towed gears (at least Métier Level 4) for relevant species and assessment units;

ToR b) Generate assessment unit and métier specific bycatch mortality estimates for each species and their associated confidence intervals. For harbour porpoise the assessment units will correspond to those defined in NAMMCO_NIMR (2019) report in OSPAR Regions II, III and IV. For common dolphin, assessment units are OSPAR Regions III and IV. For grey seal, assessment should be made for OSPAR Regions II and III.

ToR c) Compare the bycatch mortality estimates against thresholds for the relevant species/assessment units as provided by OSPAR and identify any critical issues (such as biases in the bycatch estimates) relevant for the comparison.

ToR d) Data available within OSPAR Region I will be evaluated and, if feasible, processed to generate bycatch rate and mortality estimates for harbour porpoise and grey seal using the relevant country/NAMMCO advised assessment units.

1.2 Background to the request

The vision set out under the OSPAR Convention is one of clean, healthy, and biologically diverse seas that are used sustainably. Contracting Parties (CP) to OSPAR are required to cooperate in the monitoring and assessment of the health of the Northeast Atlantic. Periodic assessments are undertaken to gauge the status of the marine environment, and these are published through the series of Quality Status Reports (QSR) (OSPAR 2000; OSPAR 2010). Assessments of biological diversity, including the status of marine mammals, are integral to the QSR process. The next QSR is due in 2023.

Indicators and targets have been developed for assessment purposes. For marine mammals, indicators relate to their abundance (cetaceans and seals) and productivity (seals), as well as marine mammal bycatch. The indicator and associated levels, or thresholds, against which the indicator is assessed have been developed through OSPAR's Marine Mammal Expert Group (OMMEG) for three species: common dolphin, harbour porpoise and grey seal. CPs have agreed to assessments for these species in OSPAR Regions II (Greater North Sea), III (Celtic Seas) and IV (Bay of Biscay and Iberian Coast). Additionally, a pilot assessment should be carried out for harbour porpoise and grey seal in Region I (Arctic).

To ensure that assessments are biologically meaningful to the species of interest, OMMEG reviewed and agreed Assessment Units (AUs) within the OSPAR Regions for the QSR2023. The AUs for each species are shown in **Error! Reference source not found.**.

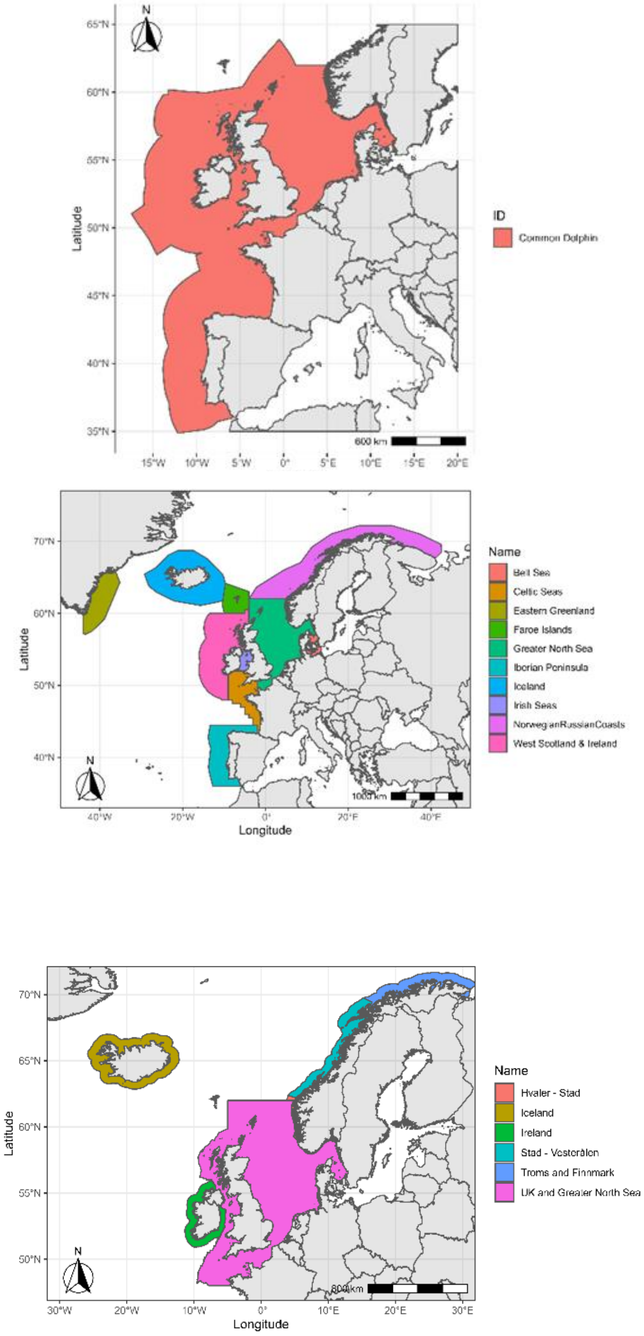

Figure 1. OSPAR Marine Mammal Expert Group defined Assessment Units for the QSR2023: common dolphin (top left); harbour porpoise (top right) and grey seal (bottom right)

Thresholds for harbour porpoise in Region II were developed using a Removals Limit Algorithm (RLA) Approach (Hammond *et al.*, 2019; Authier *et al. submitted*). For other regions and species such as the common dolphin, the approach is based on Potential Biological Removal (PBR) (Wade 1998) but the management objective of the procedure has, in most cases, been *modified* to align with European, rather than US, conservation objectives (henceforth *mPBR*). For grey seal, the (unmodified) PBR approach was used. The values of the thresholds supplied to WKMOMA from OMMEG are shown in Table 1. For more background information on the methods and conclusions from OMMEG see Annex 6[2].

Table 1. Summary of threshold information provided to WKMOMA from the OSPAR Marine Mammal Expert Group for use in ToR (c).

OSPAR Region	AU	Threshold setting approach	Provisional Threshold values (anthropogenic removal)
Harbour porpoise			
II	Greater North Sea	RLA	1622
III (IV)	Celtic Seas	mPBR	43
III	Irish Seas	mPBR	34
III (IV)	Celtic + Irish Seas	mPBR	82
III	West Scotland and Ireland	mPBR	78
IV	Iberian Peninsula	mPBR	0
I	Iceland	PBR	3500
I	Norwegian Coast	PBR	700
Common dolphin			
II, III, IV	NE Atlantic	mPBR	985
Grey seal			
II	Greater North Sea	PBR	7617
III	Western of UK	PBR	TBC
III	Ireland	PBR	TBC
I	?	PBR	Not provided

1.3 Common dolphin

1.3.1 Summary of existing knowledge

The common dolphin (*Delphinus delphis*) is one of the most abundant and widespread cetacean species in the northwest Atlantic, inhabiting both continental shelf and offshore waters (Murphy *et al.*, 2021). The abundance of common dolphin in northwest European Atlantic, excluding Irish waters, was estimated to be 473 461 (95% CI 286 094–783 539) individuals from data collected on the SCANS-III survey during summer 2016 (Hammond *et al.*, 2021). In Irish waters, data from

[2] Annex 6 was added before ADGMOMA but after the draft report was sent for peer review.

the ObSERVE survey was used to estimate common dolphin abundance for summer 2016 as 13 633 individuals (95% CI 5214 – 35 646) (Rogan *et al.,* 2018). These estimates combined are comparable to the estimate from the SCANS-II survey in July 2005 and CODA survey in July 2007 of 468 400 (CV = 0.33). If a proportion of sightings from the SCANS-III and ObSERVE surveys that were assigned as common/striped dolphins are also taken into account, then the most up-to-date (2016) estimate is 634 286 (CV = 0.31) common dolphins in the northeast Atlantic (ICES 2020).

The density of common dolphin is highest during summer in the southwestern region of the northeast Atlantic (Figure 2) and they occur on the shelf, shelf edge and oceanic waters. There is a marked seasonal change in distribution within the northeast Atlantic (Waggitt *et al.*, 2020). Although survey coverage in winter is limited, regional efforts show an increase in the abundance of common dolphins in the western Channel (Macleod and Walker, 2005; Brereton *et al.*, 2005), French Atlantic waters (Van Canneyt *et al.,* 2020) and potentially in Irish waters during winter (Rogan *et al.,* 2018). The seasonal redistribution of common dolphins, and higher densities of animals in continental shelf waters, coincides with peaks in bycatch documented on the UK's southwest coast and the French Biscay coast. The high level of bycatch occurring during the winter in these areas was particularly evident in the cetacean strandings records (Peltier *et al.*, 2014, 2016, 2020).

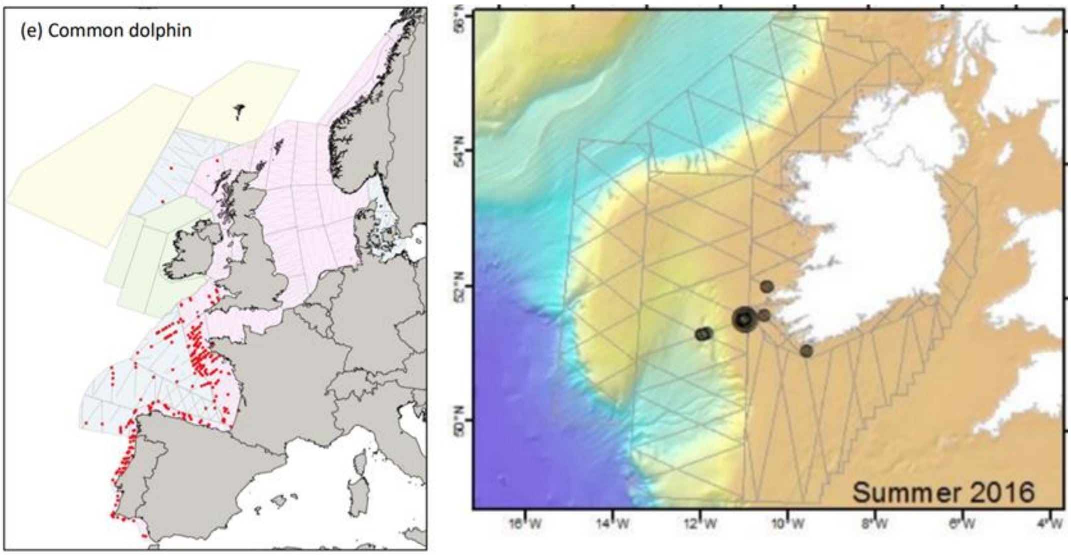

Figure 2. Survey areas, transect lines and common dolphin sightings during summer 2016 during i) SCANS-III (pink and pale blue areas), green and yellow are ObSERVE and NASS respectively and ii) ObSERVE (grey). Map (i) taken form Hammond et al. (2021) and (ii) from Rogan et al. (2018).

1.3.2 Overview of bycatch estimates

Over the period 2005 to 2020, bycatch of common dolphins has been reported in multiple different fisheries throughout the OSPAR Regions II - IV. Bycatch is thought to have been greatest in the Celtic Sea and Western Approaches to the English Channel (ICES Division 7.h), the western English Channel (ICES Division 7.e), Bay of Biscay (ICES Division 8.a), and along the shelf edge of Atlantic Spain and Portugal (ICES Divisions 8.c, 9.a) (Morizur *et al.*, 1999; ICES 2005; Fernández-Contreras *et al*., 2010; Marçalo *et al.*, 2015; ICES WGBYC, 2015, 2016; WKEMBYC, 2020).

OSPAR Region II: Greater North Sea

The highest levels of common dolphin bycatch and strandings in the UK, were attributable to the winter sea bass pelagic trawl fishery in the western Channel. Between 2000 and 2005, common dolphin bycatch in the UK sea bass pelagic pair trawl fishery in winter ranged from 38 (95% CI = 23-84 in winter 2001-2002) to 503 (95% CI = 491-592 in winter 2003-2004) (Northridge *et al.*, 2006). Measures to protect bass stocks were introduced in 2015 and the relevant fishery is no longer operational. Common dolphin bycatch continues to occur in the UKs netting fleet and the most recent estimate for 2019 was 278 (%95% CI 165–662) reported through the UK's dedicated PETS bycatch monitoring programme (Kingston *et al.,* 2021). Out of these 278 dolphins, estimated 36 dolphins (CI95% = 23–109) were bycaught in the Eastern Channel (ICES area 7.d), and 19 dolphins (CI95% = 13–39) in southern North Sea (ICES area 4.c) (Kingston e*t al.,* 2021), while the majority were observed in the Western Channel and Celtic Sea (see below).

In 2009, French pelagic pair trawl fishery targeting sea bass was estimated to have bycaught 40 common dolphins in the Channel (Demaneche *et al*., 2010; ICES WGBYC, 2011).

The French otter trawl fishery targeting various species in ICES Subarea 7 was estimated to have bycaught 216 and 214 common dolphins in 2011 and 2012, respectively (ICES, 2014).

OSPAR Region III: Celtic Seas

In the Celtic Sea, annual bycatch in 2006 and 2007 in Irish gill net fisheries targeting hake and cod was double what it had been in 1992-1994 (note that sampling period cannot be compared between both studies) (Tregenza *et al.,* 1997, Cosgrove & Browne, 2007).

In 2015-2016, 49 to 355 (95% CI) common dolphins were estimated bycaught in pelagic trawls (both OTM and PTM) and 104 to 549 (95% CI) in nets (GTR, GNS, GND) in the Bay of Biscay and Iberian coast (ICES WGBYC 2018).

In Celtic Seas and Channel, highest bycatch numbers were estimated in 2016-2018 in otter bottom trawls (276 CI95% = 151–427) and gillnets (192 CI95% = 85–299), both targeting demersal species (ICES WKEMBYC, 2020).

In the Western Channel and Celtic Seas in 2019, close to 200 common dolphins were estimated bycaught in UK net fisheries, highest in the ICES Divisions 7.e and 7.f (respectively 86 CI 95% = 61 – 143, and 61 CI95% = 45–85 common dolphins bycaught) (Kingston *et al.,* 2021).

OSPAR Region IV: Bay of Biscay and Iberian coast

In 2006 in the Bay of Biscay, English Channel and North Sea, French otter trawlers targeting various fish species, had an estimated bycatch of 57 common dolphins bycaught, compared with an estimate of 760 common dolphins in 2011.

In ICES areas 7 and 8 (Bay of Biscay, English Channel and Celtic Seas), bycatch in the French pelagic trawl fishery for sea bass was estimated at 489 common dolphins in 2003, and around 300 in 2007 and 2008 (ASCOBANS, 2009; ASCOBANS, 2010; Northridge *et al.,* 2006). In 2009, this fishery was estimated to have bycaught between 300 and 400 common dolphins in the Bay of Biscay alone, but 105 in the same area in 2010 (Demaneche *et al.,* 2010; ICES, 2011). In Bay of Biscay, English Channel and Celtic Seas, relatively low common dolphin bycatch was estimated on French pelagic pair trawlers for tuna: 60 in 2006, 13 in 2007 and 120 in 2008 (Demaneche *et al.,* 2010; ICES, 2010). But in 2009, around 900 common dolphins were estimated bycaught in this fishery (Demaneche *et al.,* 2010; ICES, 2011; ICES, 2010). Also, in 2009, Spanish set nets for hake in the northern Bay of Biscay had an estimated bycatch of 773 common dolphins (ICES WGBYC, 2011).

In 2015-2016, 924 to 2187 common dolphins were estimated bycaught in pelagic trawls (both OTM and PTM) and 683 to 2168 in nets (GTR, GNS, GND) in the Bay of Biscay and Iberian coast (ICES, 2018).

Finally, in 2016-2018, highest bycatch was estimated in trammel nets targeting demersal species and reached 2062 common dolphins (CI 95% = 1203–3092), 775 common dolphins (CI 95% = 388–1163) in pair bottom trawls (mixed pelagic and demersal species) and 481 in pelagic pair trawlers targeting demersal species (CI 95% = 408–555) in the Bay of Biscay (ICES WKEMBYC, 2020).

The analysis of strandings and use of drift models provided estimates of bycaught common dolphins from 1990 to 2019 (ICES, 2020a), following the methodology described in Peltier *et al.* (2016). This approach suggested 6090 common dolphins (CI 95% = 4430–9140) were bycaught annually between 2016 and 2019 in the Bay of Biscay and the Channel, all fisheries combined (Dars *et al.*, 2021)).

Along the Portuguese coast, Marçalo *et al*. (2015) estimated that 113 (3-264; 95% CI) common dolphins die annually in the purse seine fishery, but many more can be encircled and released alive injured with unknown post-capture survival rates. More recently, Vingada and Eira 2018, estimated for the most important fisheries on the coast an average annual bycatch of 287 common dolphins in purse seiners, 3318 in polyvalent boats using bottom-nets (gill or trammel), 414 in bottom-trawlers, 46 in long liners and 26 in beach seiners.

1.3.3 Assessment Unit (AU) for common dolphin

The estimate of 634 286 (CV = 0.31) best approximates the summer abundance of common dolphin in the Assessment Unit (AU) (**Error! Reference source not found.**) to be used in OSPAR's QSR 2023. There has been no survey effort in offshore waters to the west of Portugal within the AU where common dolphin are likely to occur. It is also worth noting that although the AU includes waters of the North Sea, common dolphins are rarely recorded there, and their distribution is primarily in Atlantic waters. The use of a single AU for this species is supported by genetic evidence of a single panmictic Northeast Atlantic population, which is separate from populations in the western North Atlantic and Mediterranean (Westgate, 2007; Evans and Teilmann, 2009). The western boundary of the AU aligns with the MSFD *Celtic Seas* and *Bay of Biscay and Iberian Coast* regions which contain OSPAR Regions III and IV. The North Sea area of the AU covers OSPAR Region II.

1.4 Harbour Porpoise

1.4.1 Summary of existing knowledge

Distribution and abundance in the OSPAR region

The harbour porpoise, *Phocoena phocoena,* is the most abundant cetacean species in eastern North Atlantic shelf waters (Boisseau *et al.*, 2007). It is typically a continental shelf species widespread throughout the cold and temperate waters of Europe, including OSPAR Areas I (Arctic waters), II (Greater North Sea), and III (Celtic Seas). Although present, porpoises occur less frequently in Area IV (Bay of Biscay and Iberian coast).

Harbour porpoise abundance for the OSPAR maritime area, based on the most recent SCANS III survey in 2016 was estimated as 424 245 (CV = 0.172) (Hammond *et al.*, 2021). However, neither Irish nor Icelandic waters were covered by this survey, so this number will likely be a significant underestimate of the total abundance across the area. A partial aerial survey for harbour porpoises in Icelandic waters conducted in 2007 resulted in an estimate of 43 179 (CV = 0.45) while close kin mark recapture genetics indicate an increase in the population since the survey was conducted (IMR/NAMMCO, 2019). The Observe programme conducted in Irish waters in 2015 and 2016 produced a best estimate of 39 118 individuals (CV: 0.22) (Rogan *et al.*, 2018)

Apart from the Kattegat / Belt Seas area and the North Sea, there are insufficient data available to assess changes in abundance or distribution across assessment units over time. Between 1994 and 2016, and based on three large scale surveys, the distribution of harbour porpoises in the North Sea shifted markedly from primarily in the north to primarily in the south, with more sightings made throughout the English Channel in 2016 than in previous surveys. Trends in abundance for both assessment unit areas (North Sea and Skagerrak/Kattegat/Belt Seas) were not significantly different from zero, thus there was no evidence of change in abundances over the period 1994–2016.

Harbour porpoises in Region IV, especially in the Iberian Coast, considered a distribution edge for the population, form a distinct, small and isolated lineage and possibly a subspecies, based on their distinctive ecology, morphology and genetic divergence (Chehida *et al.,* 2021, Carlén *et al.*, 2021). The Iberian harbour porpoise population inhabits the cold-water upwelling zone along the Atlantic coasts of Spain and Portugal (and possibly also southwards to north-west Africa), from the south Biscay coast to (at least) the Algarve coast of Portugal, bordering the Gulf of Cádiz (Sequeira, 1996; Castro, 2010; Pierce *et al.*, 2020). Records of porpoise observations are most numerous in the Galician region of Spain and in northern and central Portugal (Fontaine, 2016; Hammond *et al.,* 2021). The 2016 SCANS III survey generated an abundance estimate of 2715 individuals (CV = 0.31) from Cabo de São Vicente in Portugal northwards to Cape Finisterre in Galicia (Hammond *et al.,* 2021), an area which encompasses the core range of the Iberian population (Pierce *et al.*, 2020).

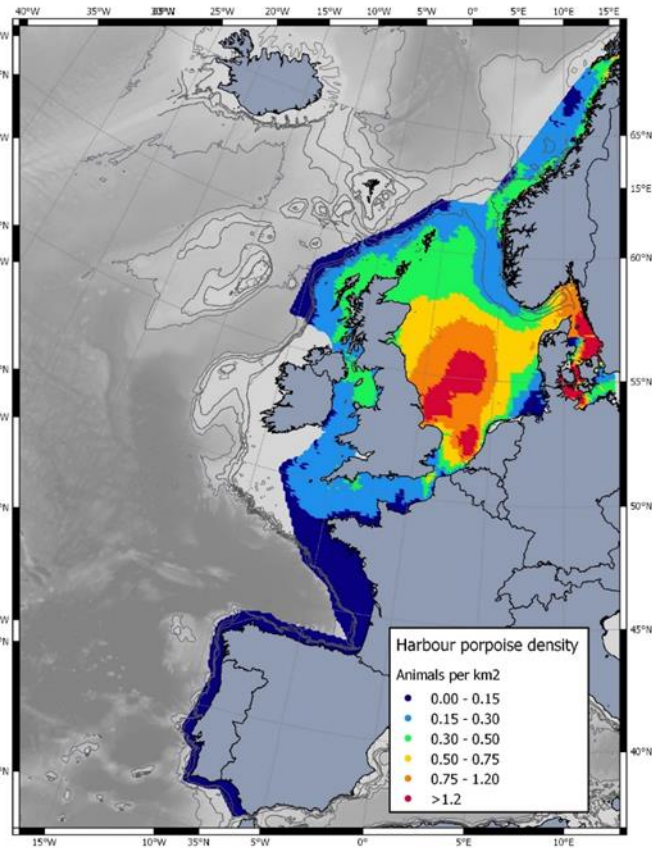

Figure 3. Predicted density surfaces for harbour porpoise in 2016 from SCANS-III. The colour scale is in units of animals per km²

1.4.2 Overview of bycatch estimates

Earlier analyses of monitoring data submitted to WGBYC (2005-2018) confirmed that the highest bycatch rates for harbour porpoise occurred in gillnet or trammel net fisheries (GNS or GTR) in the North Sea (ICES division 3.a, 4, 7.e and d), the Celtic Sea (ICES division 6 and 7), and the Bay of Biscay (ICES divisions 8.a and b). In the North Sea and the Celtic Seas the highest bycatch rates for harbour porpoise were observed in gillnet or trammel net fisheries (GNS or GTR) (ICES WKEMBYC, 2020). In the Bay of Biscay bycatch rates were highest in midwater pair trawls (PTM) in the time period 2016 to 2018. Harbour porpoises were also caught in bottom and midwater otter trawls (OTB, OTT and OTM). No harbour porpoises were observed bycaught in passive gears such as longlines and pots (LLS, LHM and FPO). For more details see Table 21 from Annex 7 of the WKEMBYC report (ICES, 2020a). Due to low monitoring coverage and summarizing data over a large area and time period, calculated bycatch rates come with large caveats and mainly provide an indication of which gears catch harbour porpoises rather than a robust comparison between gears (ICES, 2020a).

Harbour porpoises were reported as bycaught in ICES Division 5.a (Icelandic waters) in the years 2016 to 2018. Reported bycaught numbers per year were between 17 and 46 harbour porpoises and bycatch rates (individuals/days at sea monitored) ranged between 0.201 and 0.37.

In the Iberian coast (ICES Division 9.a), harbour porpoises are reported bycaught mainly in polyvalent boats operating bottom-set nets (gill or trammel nets) and beach seine. Overall, average numbers per year from the Portuguese fleet exceed 200 individuals which is considered concerning due to the low population estimates for the area and the additional pressure from the Spanish fleet in the region (Vingada and Eira, 2018). The low population density of porpoises in the Iberian population, coupled with a high level of gillnet fishing activity and frequent stranding records with signs of bycatch, suggests that the population is severely affected as a result of bycatch (Carlén *et al.*, 2021).

Assessment Units (AU) for harbour porpoise

The AUs for harbour porpoise are those defined in by the NAMMCO and Norwegian Marine Institute workshop in December 2019 (Figure 1). Assessments in WKMOMA generated estimates of harbour porpoise mortality for the majority of the relevant AUs.

1.5 Grey seal

1.5.1 Summary of existing knowledge

The OSPAR Marine Mammal Expert Group has identified the grey seal (*Haliochoerus grypus*) among the most commonly documented bycaught animals in the northeast Atlantic. OSPAR regions I (Arctic Waters), II (Greater North Sea) and III (Celtic Seas) (Figure 1) were identified by the OSPAR Marine Mammal Expert Group as regions containing grey seal population assessment units (AU) where bycatch estimates may be evaluated against anthropogenic removal thresholds (e.g. potential biological removal, removals limit algorithm).

The grey seal AUs contained within their respective OSPAR regions are adjacent to several European Union (EU) member states and non-EU countries with available data on grey seal population status and their observed interactions with commercial fisheries. They include non-EU countries Norway, Iceland and the UK, and the following EU member states: Ireland, Belgium, Netherlands, Germany, Denmark, Sweden, Spain, France and Portugal (**Error! Reference source not found.**).

Here we summarize the current state of knowledge on grey seal population estimates, trends, and biology relevant to the interpretation of grey seal AU bycatch estimate methodology and results (Table 1).

In the early 1900s grey seal populations started to recover in Europe after centuries of hunting, as they were afforded protection in the UK (under the Gray Seals Protection Act, 1914), a north-east Atlantic stronghold for the species. They had almost completely disappeared along the continental coasts of mainland Europe and only some small colonies had persisted in the less inhabited regions of northern UK. Throughout the first half of the twentieth century grey seals were only occasionally observed along the coasts of the southern North Sea but a significant recolonization of the area started in the 1980s (Brasseur *et al.*, 2015).

To circumvent generally broad dispersal and redistribution of pinnipeds after breeding, population estimates are most often based on counts of pups on the breeding sites. The Working Group on Marine Mammal Ecology (WGMME) identified four study areas where current grey seal population trends could be described (ICES, 2021, Table 1).

Table 1. overview of number of pups and where possible, population estimates for grey seals in the four study areas (summarised from ICES 2021).

Area	Subarea	Number of pups	Moult counts	Population estimate	Trend
Norway	Troms & Finnmark	271			Stable
	Mid Norway 62N-68N	439			Decrease
	Norway south of 62N	35			Stable
Norway	TOTAL	710		3850	Decrease
UK	Inner Hebrides	4541			Stable
	Outer Hebrides	15732			Stable
	NW Scotland	706			Decrease
	Scottish North Sea	33177			Increase
	English North Sea	9884			Increase
	SW England & Wales	2000			Stable
Other North Sea	Wadden Sea	1726	7649		Increase

	Dutch Delta	10	1593		Increase
	France	75	1558		Increase
North Sea and UK	TOTAL	67851		UK: population estimate (individuals of age 1+) in 2019 of 150 700 (approximate 95% CI 130 000–176 100; SCOS 2020). Other areas would potentially make up maximum ~3% more, based on pup production.	Increase in southern North Sea including Wadden Sea, Delta and France: varying 5-16% growth; levelling in most other areas
Iceland	TOTAL	1452		6269	Decrease
Ireland	TOTAL	2100		7284	Increase

Phenology and grey seal distribution

Though they display high breeding site fidelity grey seals may distribute widely outside the breeding season (Russell *et al.*, 2013; Brasseur 2017). This may result in some areas being used by large numbers of seals, with hardly any pups being born. In the Dutch Delta and Belgian coasts for example, over 1500 animals are counted on the haulouts, whilst only recently single pups were observed, this is similar to the French colonies and some colonies in Scotland (ICES, 2020b, 2021). Consequently, grey seal haulouts and adjacent waters are used throughout the year by a mixed group of animals breeding locally and animals breeding up to over a thousand kilometres away. Depending on the season, seals belonging to different breeding colonies might be present (Brasseur *et al*., 2015). Likewise, depending on the timing of fisheries, bycatch will affect different colonies; during breeding and moult, bycaught animals would be mostly the animals breeding or moulting locally, while in other periods seals from other colonies could have arrived and thus get bycaught. Recently two reports were drafted depicting the at sea distribution of grey seals in the southern North Sea (Carter *et al*., 2020; Aarts in prep). This type of work might be helpful when estimating potential overlap between fisheries and seals, or explain bycatch events. Ideally the temporal and spatial scale of both seal and bycatch data should be similar.

Grey seals breed on land with females arriving shortly before giving birth and suckling their pup for 19 days in average (Pomeroy *et al.*, 1999). After weaning females leave the haul out whereas pups may stay up to one month on land. Dominant males may stay on land during the breeding season, defending a single female or a harem, while other males gather around breeding sites attempting to fertilise females leaving. Within populations, there are marked differences in the timing of breeding. Breeding season ranges between September (western UK) and December (Wadden Sea). Around Iceland peak numbers occur in October (Hauksson, 2007). In Ireland peak numbers are observed in late September to mid-October (Ó Cadhla *et al*., 2013).

After a feeding period following breeding, grey seals return to land to finalise their moult. The total moulting process may last longer, visible moult lasts 2-3 weeks during which the seals haul out more frequently (Schop *et al.*, 2017). Moulting occurs in spring. In some but not all areas moulting animals are counted, this produces an indication of the number of animals visiting as opposed to breeding locally. Once the moult is complete the seals spend until the next breeding period feeding offshore, but returning regularly to haul out sites to rest.

1.5.2 Prior reporting on Grey Seal Bycatch/ Overview of bycatch estimates

In 2019 the ICES Working Group on Bycatch of Protected Species (WGBYC) completed a bycatch risk assessment (BRA) for grey seals in the Celtic Sea (Divisions 6.a, 6.b.2, 7.c.2, f, g , h, 7.j.2, 7.j.1 and 7.k.2.) and North Sea (Divisions 4 a b, c, 7d 7e and 3a20 and 21) ecoregions (ICES 2019, Figure 2). In 2017, with the exception of bottom trawl bycatch in the Celtic Sea reported by France that could not be verified, grey seal bycatch was highest in gillnets (set gillnets, trammel nets, and drift nets) in both Celtic and North Sea ecoregions ranging from 101-282 and 193-697 animals, respectively. No grey seal bycatch was reported for bottom and pelagic/midwater trawls in the North Sea. ICES (2019) reported that grey seal bycatch in 2017 did not exceed ACOBANS conservation threshold of 1.7% of the grey seal populations in the Celtic and North Sea ecoregions. However, it is important to note that the magnitude of potential bias in fishing effort and estimated bycatch numbers was unquantifiable for the BRA and consequently is not known.

The WKMOMA data call offers significant improvements in data quality and resolution to support a grey seal bycatch analysis for the OSPAR defined assessment units. Further details are described in the following sections of this report.

1.5.3 Assessment Unit (AU) for grey seal

OMMEG reviewed and agreed Assessment Units (AUs) within the OSPAR Regions for the QSR2023 as shown in **Error! Reference source not found.**.

2 Data used and methodology applied

2.1 ICES WKMOMA Data call

On, 22 June WKMOMA issued an official data call (link to the full data call text: https://www.ices.dk/sites/pub/Publication%20Reports/Data%20calls/WKMOMA_Data%20Call%202021.pdf) requesting 18 of the 20 ICES countries (all except USA and Canada) with fisheries operating in the OSPAR area to provide data. The data call aimed to collect data describing total bycatch monitoring/sampling effort and grey seal, harbour porpoise and common dolphin bycatch incidents from the calendar years 2005 until 2020 from fisheries operating in the OSPAR Region. Data on fishing effort were also requested from those member states not submitting data to the ICES Regional Database (RDB).

Most of the contacted countries submitted data, but the quality and quantity of the data provided varied widely among nations.

In the data call, WKMOMA requested data on:

- all fishing effort (for all gear types even if no at-sea monitoring has occurred in that gear type during the relevant period) for countries not submitting data to the RDB (Iceland, Norway and Russia);
- all at-sea monitoring/sampling effort (for all gear types whether or not incidental bycatch has been recorded during the relevant time period);
- all recorded incidental bycatches of the species listed above (data should be not raised (extrapolated)).

Data were requested from 2005 until 2020, with the rationale that reporting on bycatch of cetaceans was required due to EC Council Regulation 812/2004 since 2005 and, therefore data should be available from several countries. In addition, as bycatch of these species can be rare, there is a need to collect and pool data for a long period to ensure estimates are as reliable as possible.

When creating the WKMOMA data call template for submission, many factors were taken into account. Firstly, there was a desire to keep the data call template close to that of the ICES WGBYC template to ensure some compatibility between the datasets. Nonetheless, some fields present in the WGBYC template were excluded from the WKMOMA template to simplify the data submission. Results from earlier WGBYC work have shown that if data are submitted on trip or haul level (rather than as aggregated data, as has been done in previous WGBYC data calls) then it is possible to use statistical models to more accurately estimate bycatch rates. However, as fishing effort in the RDB is not recorded on a haul level, data on the number of hauls carried out during each day at sea within trips are also required. Therefore, the observed monitoring data were requested at per trip level, submitting effort in Days at Sea (DaS) and number of hauls per trip. Data presented on a trip level create challenges when fishing trips are conducted over several ICES divisions, ICES rectangles, with multiple gears, and/or over several months.

The data submission template includes fixed/mandatory vocabularies for several data fields, which facilitates efficient data collation across countries but can give rise to submission challenges, particularly for nations submitting data for the first time, for which tailored vocabularies may be needed.

2.2 Fishing effort

WKMOMA asked all EU member states for permission to use fishing effort data held in the ICES Regional Database (RDB). The RDB contains fishing effort data in various metrics by métier level, country, vessel size and ICES rectangle. When permission was granted, a data extraction was undertaken by the ICES data centre which provided effort data from 2015 to 2020 structured by:

Country; Year; Quarter; Month; ICES Division; ICES Rectangle; RCG Area; Métier Levels 4,5,6; Vessel Length; Trips; Hauls and Soak Time (where available); KW Days; GT Days and Days at Sea.

Although Days at Sea (DaS) is not a mandatory field in the RDB, most countries submit it routinely and it is the metric that most previous bycatch assessments by ICES have used, primarily due to reporting requirements under the recently repealed EU Regulation 812/2004, meaning a lot of historical bycatch monitoring data contained in the ICES WGBYC database are structured according to this metric. Thus, DaS was considered to be the most appropriate metric for the work of WKMOMA in the first instance, both for comparative checks against previous assessments, but also in case data gaps needed to be filled with data contained in the WGBYC database.

For ICES member countries (excluding USA and Canada) that do not report data to the RDB (Iceland, Norway and Russia) equivalent data on fishing effort (but only to ICES division and métier level 4) were requested through the WKMOMA data call. Of these countries, only Iceland submitted data in response to the data call.

Initial data checks were carried out during WKMOMA and it became evident that there were some errors and data gaps in the extracted RDB dataset:

- Existing French data we considered to be inaccurate and were totally replaced during the workshop with a new extraction from the French national database because France had recently implemented a new procedure with updated algorithms for calculating effort which was considered to be more accurate than previous effort calculation methods.
- None of the data from Ireland contained DaS data, so the Irish "days fished" data were transformed by staff at the Marine Institute in Ireland, and the updated data were resubmitted.
- Small boat effort from Germany may be significantly over-estimated because of the national effort recording system in place, which allocates a full month (30 days) effort to any vessel that has reported at least a single landing in that calendar month.
- Other countries did not submit DaS to the RDB for all years. Attempts were made to address this during the WKMOMA meeting, but the relevant data were not obtained in time for inclusion in the analyses.
- It became evident that the allocation of effort to months, areas and métiers is carried out differently by different countries, as there are no consistent rules on how these situations should be dealt with. For example, on fishing trips that span multiple months, métiers and ICES rectangles, effort may be split proportionally based on the number of trip days in each month/métier/rectangle combination, or effort may be assigned to the month/métier/rectangle combination where the majority of effort occurred, or in some cases the month was allocated based on the start date of the trip regardless of when most of the effort actually occurred.

Some of these issues were corrected during the workshop, for example significant time was spent adjusting the effort submitted differently by member states so that no effort was duplicated over area or métier in trips covering multiple areas and métiers. Others issues could not be resolved and were simply identified as possible biases in the effort dataset which could not be satisfactorily addressed within the available timescales.

When the final "cleaned" dataset was produced a number of subsequent steps were taken to prepare the RDB effort data for inclusion in the mortality estimations.

1. All German under 10 m effort was removed, because of concerns about the likely significant over-estimation of effort as described above.
2. All ICES rectangles were allocated to the common dolphin, harbour porpoise and grey seal OSPAR Assessment Units (AUs). ICES rectangles and the OSPAR AUs generally align well, with few exception with the grey seal assessment unites, so in these cases the criteria used for inclusion in an AU was that if any portion of the rectangle overlapped with the AU then effort from that full rectangle was considered part of the AU effort (the same approach was applied to the monitoring data).
3. The data were allocated to three vessel size categories (under 12 m, 12-18 m and over 18 m) to permit alignment with the modelling of bycatch rates from the monitoring data.

This final six-year dataset was then checked for completeness. Despite attempts to fix some of the initial problems it remained the case that some countries did not submit DaS data in some of the relevant years, and other countries appeared to have only submitted partial DaS data for other years so the full effort timeseries could not be used in the final analyses. The most complete years were 2019 and 2020, so a decision was made to use 2020 data as it was the most recent effort data available, but there is some indication that effort levels in 2020 are potentially lower than in the preceding years for some of the countries. It was considered by WKMOMA that these apparent reductions in effort in 2020 are likely to be associated with the effects of the Covid-19 pandemic. Mortality estimates calculated using the 2020 effort data are potentially biased low as a result. Due to this potential bias, mortality estimates are also provided based on the 2019 fishing effort in Annexz. A summary of 2020 fishing effort data from the RDB is provided in Annex 4.

2.3 Processing monitored fishing effort data from the data call

The monitoring effort was submitted per trip level and the bycatch events were submitted per haul. The data call was successful in that countries were able to successfully submit data on bycatch of the three species at haul level as well as more detailed observed effort data per trip. These detailed data provide the opportunity to estimate more reliable confidence intervals around both ratio and model-based estimates of bycatch rates.

On the other hand, the issues with the data call were evident with regards to submitting data on observed effort by trip level. In the data call we requested effort data be submitted per trip, métier, ICES division, ICES statistical rectangle and month, with information on the total number of days/hauls and observed hauls per trip. As a result, the same problems as those described in the section on fishing effort arose. When trips are carried out over multiple statistical rectangles, métiers and months, the observed effort was submitted using different approaches by different countries.

Each trip was given a unique trip identification number (tripID). In the bycatch event table, each bycatch event per haul had the same associated tripID as in the observed effort. This in theory meant that each individual bycatch record could be linked to a single trip. However, as highlighted earlier, many trips are carried out using multiple gears, or over multiple ICES statistical rectangles and months. In these cases, it was not possible to relate a bycatch event to the ICES rectangle or métier recorded in the observed trip. To mitigate this issue, more detailed information on bycatch events was submitted by countries concerned during the workshop.

Due to the issues highlighted, a summary of how data were submitted by each country was collated to better document how trips that were carried out over multiple areas, métiers, and months were submitted to the data call (Annex 2). There was a large variation in how countries report observed effort. Some countries adjusted effort to be proportional to the areas and métiers reported, other countries reported the total effort per trip for every métier and every ICES rectangle, while some countries report the effort in the areas and for the métiers where the majority of the fishing was carried out.

Before data could be utilised, duplicated effort data had to be adjusted (i.e. duplicated DaS or number of hauls in cases where total effort from one trip was reported in every ICES rectangle visited during the trip). This was done either by allocating all effort to a single ICES rectangle, or where possible, apportioning effort between rectangles and having all effort in all ICES rectangles for a trip add up to the total effort. The need for these adjustments was dependent on the species assessment areas. In most cases, information per ICES statistical rectangle is not required as the assessment areas are large and included all rectangles fished during a particular trip. If trips were carried out over several months and effort reported for each month, effort was allocated to a single month.

In future, more specific detail should be provided on how data should be submitted to a data call, particularly in cases where trip or haul level data are requested.

2.4 Models used to estimate bycatch rate and mortality estimates

Factors influencing bycatch rates

Before bycatch modelling occurred, statistical tests were run on the three datasets (harbour porpoise, common dolphin, and grey seal) to test the effect of various factors in the dataset on the bycatch rates. A generalized additive model with Poisson distribution and log-link function was run to see whether year, month, vessel size, ICES subarea, and métier (level 4) affected the observed bycatch rates. Results varied between the three species, with all three species having higher bycatch rates in more recent years (2015-2020) and significant effects of subareas and métiers, while month was rarely a significant factor. Vessel size was a significant factor for harbour porpoise, with larger vessels (12 m or larger in most cases, 15 m and larger in Iceland) having higher bycatch rates, while the opposite was true for grey seals for which smaller vessels (up to 12 m in most cases, up to 15 m in Iceland) had higher bycatch rates.

Model approach and data clean up

The data on observed effort were first divided into the species assessment units. Since data were submitted per ICES rectangle, data reported from an ICES rectangle that was within or crossing the border of the AUs were included in the data set. Figure 3 is an example and shows which ICES rectangles are included in the AUs for harbour porpoise in the North Sea. Several bycatch observations did not take place within one of the assessment units and were therefore excluded. Métiers and ICES areas that did not have bycatch events were removed from the dataset. In four métiers (LLS, SSC, TBB and OTM for dolphin), only one bycatch event was observed, and due to the rarity and lack of further data these were excluded from further analysis. As the preliminary analysis of the dataset indicated that the more recent years (2015-2020) were different from the rest of the time period, these years were used for the modelling.

Even though data at haul level were requested, the dataset used for the models was summarized per day at sea to make raising by effort as easy as possible and avoid estimating the number of hauls for the entire fleet, which is not reported in the RDB effort data.

Based on previous work done by the ICES WGBYC, gamma Hurdle models were used to estimate bycatch rates per day at sea. This type of models had been shown to outperform traditional ratio estimators previously used for bycatch advice (ICES 2020). This two-step process first estimates the probability of a bycatch occurring, and then their intensity (number of animals being caught) (Hilborn and Mangel, 1997). Multiplying those values together results in an overall bycatch rate for the observed day at sea.

Bycatch probability (i.e. probability of bycatch occurring) was estimated with a binomial generalized additive model with logit-link function. Similarly, the bycatch intensity (number of animals) was estimated with a gamma generalized additive model with log-link function.

The data were generally stratified by both métier level 4 and ICES sub-area, and bycatch rates generated for each métier/sub-area combination. In the case of grey seals and harbour porpoises, the data were further stratified by vessel size class (small vs large, with the cut-off being 12 m in most areas, but 15 m in Icelandic waters). In few cases, there were too few observations to allow the models to be run on a particular métier/sub-area combination. In those cases, several métiers or areas were joined together to allow the models to be run. This was the case for OTT and OTM in the dolphin assessment for these gears four sub-areas were joined together to get an estimate of bycatch rates (27.8, 27.7, 27.3 and 27.9). For harbour porpoise and grey seals, GND and GTR were generally grouped with GNS to get sub-area estimates for these rarer gillnet gears.

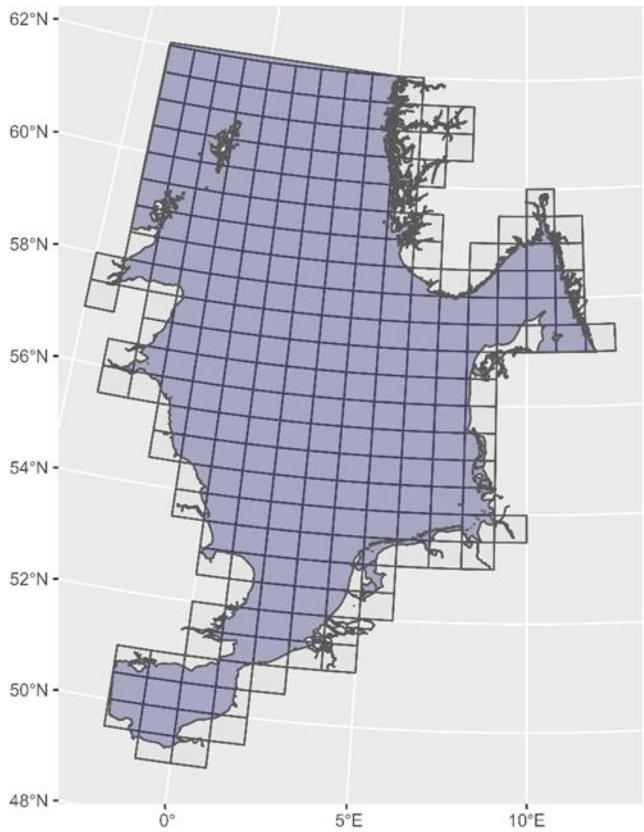

Figure 3. Data from ICES rectangles used in the harbour porpoise North Sea AU. All rectangles within or crossing the border of the AU are included in the assessment

3 Summary of data submitted to WKMOMA Data call

The total number of specimens of marine mammals, total fishing effort, and total observed effort extracted from the WKMOMA database are summarised in Table 3. Norway, the Faroes and Russia did not submit bycatch monitoring data through the datacal. Data are aggregated by gear type (métier levels 3, 4 and 5) and species-specific Assessment Unit (Figure 1). Totals of 884 common dolphins, 1221 harbour porpoises and 574 grey seals were observed bycaught from 2005 to 2021. This summary includes all métiers (to métier level 5) which had an observed bycatch of any of the three species. Data from métier level 5 where no bycatch has been reported are summarized in table 4.

Monitoring coverage per métier and vessel size was highly variable within each Assessment Unit, with some countries reporting only for larger vessel sizes and gear types identified as "general monitoring requirements" in the Reg. 812/2004 (>15 m for set-nets and pelagic trawls). The requirement for scientific data collection on bycatch in the <15m fleet was largely over looked; thus, sampling has been limited on smaller vessels, which make up the majority of the European fleet and likely account for a significant proportion of marine mammal bycatch.

When data were divided into AUs, it became apparent that some observed bycatch was not included in any AU. This observed bycatch is summarized in Table 5.

Bycatch of common dolphins was reported throughout the single AU for this species (see figure 1 for common dolphin assessment unit), from the Iberian coast in the south, northward into the North Seas. Bycatch was recorded in nets, purse and fly shooting seines, longlines and trawl gears (pelagic and bottom trawl).

Bycatch of harbour porpoises was observed in all AUs (see Figure 1 for Harbour porpoise assessment units) in nets, trawl gears (pelagic and bottom trawl) and anchored seines..

Bycatch of grey seals was observed in all AUs (see figure 1 for grey seal assessment units) in nets, trawl gears (pelagic and bottom trawl), traps and anchored seines.

Table 2. Summary of reported monitoring effort and bycatch incidents from 2005 until 2021 for common dolphin, harbour porpoise and grey seal.

Species	Ass Unit	Métier 3	Métier4	Métier level 5	Total Observed Effort (DaS)	Total No Specimens
Common dolphin	All	NETS	GND	GND_DEF	1353.64	1
			GNS	GNS_DEF	13940.04	61
				GNS_CRU	868.10	1
				GNS_SPF	25.00	2
			GTR	GTR_DEF	5782.41	62
		LONGLINES	LLS	LLS_DEF	1260.00	2
		PURSE SEINE	PS	PS_SPF	1658.50	32
		PELAGIC TRAWL	OTM	OTM_SPF	5640.36	19

Species	Ass Unit	Métier 3	Métier4	Métier level 5	Total Observed Effort (DaS)	Total No Specimens
				OTM_DEF	940.09	2
			PTM	PTM_DEF	1597.21	443
				PTM_LPF	1387.00	123
				PTM_SPF	1420.18	20
		BOTTOM TRAWL	OTT	OTT_DEF	7433.49	3
				OTT_CRU	3096.48	5
			PTB	PTB_DEF	1378.53	43
				PTB_MPD	588.00	11
			TBB	TBB_DEF	4110.39	1
			OTB	OTB_DEF	28055.58	49
				OTB_CRU	5105.40	2
		SEINES	SSC	SSC_DEF	414.95	2
	TOTAL				86055.33	884
Harbour porpoise	Baltic	NETS	GNS	GNS_DEF	5631	349
			GTR	GTR_DEF	36.00	12
		BOTTOM TRAWL	OTB	OTB_CRU	576	1
	Celtic	NETS	GND	GND_DEF	332.10	9
			GNS	GNS_DEF	5246.35	93
				GNS_SPF	25.00	1
			GTR	GTR_DEF	4320.36	82
				GTR_CRU	98.31	1
		BOTTOM TRAWL	OTB	OTB_DEF	11252.86	5
			OTT	OTT_DEF	5721.26	2
				OTT_CRU	1114.00	1
		PELAGIC TRAWL	PTM	PTM_DEF	1413.05	4
	Iberian coast	NETS	GNS	GNS_DEF	821.67	1
	Icelandic coast	NETS	GNS	GNS_DEF	995.00	199

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Ob-served Effort (DaS)	Total No Specimens
	Irish coast	NETS	GNS	GNS_DEF	58.77	1
	North Sea	NETS	GND	GND_DEF	986.74	6
			GNS	GNS_DEF	2668.88	422
			GTR	GTR_DEF	1313.05	22
		BOTTOM TRAWL	OTB	OTB_CRU	1973.20	1
				OTB_DEF	7689.10	1
			OTT	OTT_CRU	1379.88	1
			TBB	TBB_DEF	1537.21	1
		SEINES	SDN	SDN_CEP	26.00	1
	West Sco	NETS	GNS	GNS_DEF	641.33	2
			GTR	GTR_DEF	24.00	2
		BOTTOM TRAWL	OTB	OTB_DEF	7537.30	1
	TOTAL				63418.40	1221
Grey seal	Hvaler	NETS	GNS	GNS_DEF	1203.00	6
	Icelandic coast	NETS	GNS	GNS_DEF	995.00	109
		BOTTOM TRAWL	OTB	OTB_DEF	2255.00	2
		SEINES	SDN	SDN_DEF	97	1
	Irish coast	NETS	GND	GND_DEF	20.00	1
			GNS	GNS_CRU	444.00	200
			GTR	GTR_DEF	100.40	19
		PELAGIC TRAWL	OTM	OTM_SPF	1895.00	41
	North sea	NETS	GND	GND_DEF	1315.64	7
			GNS	GNS_DEF	8259.65	70
				GNS_CRU	417.10	4
			GTR	GTR_DEF	2984.01	42
				GTR_CRU	76.307692	2
		BOTTOM TRAWL	TBB	TBB_DEF	3906.39	1

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)	Total No Specimens
			OTB	OTB_DEF	18424.73	1
			OTT	OTT_DEF	5453.49	1
		PELAGIC TRAWL	OTM	OTM_SPF	5116.36	65
			PTM	PTM_DEF	1081.21	1
		POTS & TRAPS	FPO	FPO_CRU	252.87	1
	TOTAL				54297.16	574

Table 4. The observed fishing effort by AU for métiers where no bycatch of the three species has been observed.

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
Common dolphin	All	DREDGES	DRB	MOL	653.8667
		TRAPS	FPO	CEP	16
			FPO	CRU	317.8667
			FPO	DEF	8
			FPO	FIF	4
			FPO	MOL	103.1667
			FYK	DEF	10
		NETS	GND	ANA	10
			GND	SPF	44
			GNS	ANA	8
			GNS	LPF	54
			GTN	DEF	12
			GTR	CEP	96
			GTR	CRU	119.3077
		RODS AND LINES	LHM	DEF	56.5
			LHM	FIF	135.2
			LHM	SPF	9
			LHP	FIF	59

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			LHP	LPF	213
			LHP	SPF	1
			LLS	FIF	97.75
			LTL	DEF	11
			LTL	LPF	344
			LTL	SPF	1
		LONGLINES	LLD	DEF	4
			LLD	LPF	102
			LLD	SPF	1
			LLS	DWS	225
		OTHER GEAR	MIS	DEF	65
			MIS	MIS	10
		PELAGIC TRAWL	OTB	CEP	23.19048
			OTB	DEF	37.63333
			OTB	SPF	32
			OTM	CEP	25
			OTM	LPF	114
			OTM	SLP	6
			PS	DEF	5
			PS	SPF	32
			PTM	CRU	2
		SEINES	OTB	DEF	18.7
			OTB	MCD	1
			OTT	CRU	14.6
			PTB	DEF	7.4
			SDN	CEP	55
			SDN	DEF	694
			SDN	SPF	2

Species	Ass Unit	Métier 3	Métier4	Métier level 5	Total Observed Effort (DaS)
			SPR	DEF	1
		BOTTOM TRAWL	OTB	CAT	2
			OTB	CEP	930
			OTB	DWS	4097.5
			OTB	MCD	774.875
			OTB	MCF	196.5
			OTB	MDD	279
			OTB	MOL	8
			OTB	MPD	749
			OTB	SPF	225
			OTT	CEP	133
			OTT	DWS	140
			OTT	MCD	108
			PTB	CEP	5
			PTB	CRU	4
			PTB	DWS	87
			SSC	DEF	41.45
			TBB	CRU	794.9445
			TBB	MOL	7
		NULL	NULL	DWS	2.5
	TOTAL				
Harbour porpoise	Baltic	TRAPS	FPO	CRU	106
		LONGLINES	LLS	DEF	3
		PELAGIC TRAWL	OTM	DEF	2
			OTM	SPF	5
		SEINES	SDN	DEF	10
		BOTTOM TRAWL	OTB	DEF	506
			OTB	MCD	21

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			OTT	CRU	432
			OTT	DEF	89
			OTT	MCD	108
			PTB	CRU	3
	Celtic	DREDGES	DRB	MOL	384.2667
		TRAPS	FPO	CEP	12
			FPO	CRU	176.8667
			FPO	FIF	4
			FPO	MOL	3
		NETS	GND	SPF	30
			GNS	CRU	422.1
			GNS	LPF	54
			GTN	DEF	12
			GTR	CEP	89
		RODS AND LINES	LHM	FIF	125.2
			LHP	FIF	59
			LHP	LPF	112
			LHP	SPF	1
			LLS	FIF	25
			LTL	DEF	9
			LTL	LPF	132
		LONGLINES	LLD	DEF	4
			LLD	LPF	3
			LLD	SPF	1
			LLS	DEF	374
		OTHER GEAR	MIS	DEF	42
			MIS	MIS	9
		SURROUNDING NETS	PS	DEF	9

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			PS	LPF	1
			PS	SPF	303
		PELAGIC TRAWL	OTB	CEP	23.19048
			OTB	DEF	31.63333
			OTM	CEP	15
			OTM	DEF	184
			OTM	LPF	49
			OTM	SPF	1424.8
			PS	DEF	4
			PS	SPF	32
			PTM	LPF	270
			PTM	SPF	530.4101
		SEINES	SDN	CEP	29
			SDN	DEF	291
			SSC	DEF	169
		BOTTOM TRAWL	OTB	CAT	2
			OTB	CEP	512
			OTB	CRU	879
			OTB	MCD	7
			OTB	MCF	178
			OTB	MOL	8
			OTB	MPD	53
			OTB	SPF	20
			OTT	CEP	133
			OTT	DWS	14
			PTB	CEP	5
			PTB	DEF	477.5
			PTB	MPD	15

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			TBB	DEF	2441.379
	Eastgreen	PELAGIC TRAWL	OTM	DEF	1046.004
		BOTTOM TRAWL	OTB	DEF	1181.6
			OTT	DEF	16
	Faroe	NETS	GNS	DEF	2
		RODS AND LINES	LHM	DEF	5
		LONGLINES	LLS	DEF	82
		PELAGIC TRAWL	OTM	DEF	598.003
			OTM	SLP	21
			OTM	SPF	991.6667
			PTM	SPF	47
		SEINES	SDN	DEF	19
		BOTTOM TRAWL	OTB	CRU	2
			OTB	DEF	749.204
			OTB	DWS	94
			OTB	MDD	29
			OTT	DEF	191
			PTB	DEF	4
	Iberian coast	TRAPS	FPO	MOL	96.16667
		NETS	GTR	CRU	2
			GTR	DEF	42
		RODS AND LINES	LHM	DEF	32.5
			LHM	SPF	9
			LHP	LPF	155
			LTL	LPF	240
		LONGLINES	LLD	LPF	68
			LLS	DEF	147.6667
			LLS	DWS	225

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
		SURROUNDING NETS	PS	SPF	1400.5
		PELAGIC TRAWL	OTM	LPF	7
			PTM	LPF	354
			PTM	SPF	9
		BOTTOM TRAWL	OTB	CRU	421
			OTB	DEF	2315
			OTB	MCD	697
			OTB	MDD	1
			OTB	MPD	698
			PTB	DEF	30.5
			PTB	MPD	588
			TBB	CRU	24
		NULL	NULL	DWS	2.5
	Icelandic coast	RODS AND LINES	LHM	DEF	32
		LONGLINES	LLS	DEF	61
		PELAGIC TRAWL	OTM	DEF	1637.007
			OTM	SLP	454
			OTM	SPF	594
			PTM	SPF	8
		SEINES	SDN	DEF	98
		BOTTOM TRAWL	OTB	CRU	148
			OTB	DEF	3252.604
			OTT	DEF	207
			PTB	DEF	4
	Irish coast	DREDGES	DRB	MOL	156
		NETS	GND	DEF	31.8
			GNS	CRU	4
			GTR	DEF	66

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
		RODS AND LINES	LTL	LPF	16
		PELAGIC TRAWL	OTB	SPF	4
			OTM	SPF	4
			PTM	SPF	44
		SEINES	SDN	DEF	3
			SSC	DEF	1
		BOTTOM TRAWL	OTB	CRU	838.2
			OTB	DEF	266.8143
			OTT	CRU	23
			OTT	DEF	6
			TBB	DEF	138.8
	North Sea	DREDGES	DBR	DBR_MOL	113.6
		TRAPS	FPO	CEP	4
			FPO	CRU	141
			FPO	DEF	8
			FPO	MOL	4
			FYK	DEF	10
		NETS	GND	ANA	10
			GND	SPF	14
			GNS	ANA	8
			GNS	CRU	3
			GTR	CEP	7
			GTR	CRU	19
		RODS AND LINES	LHM	DEF	24
			LHM	FIF	10
			LLS	FIF	13
			LTL	DEF	2
			LTL	SPF	1

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
		LONGLINES	LLS	DEF	218.3649
		OTHER GEAR	MIS	DEF	23
			MIS	MIS	1
		SURROUNDING NETS	PS	DEF	2
		PELAGIC TRAWL	OTB	DEF	6
			OTM	CEP	10
			OTM	DEF	47
			OTM	SPF	3368.174
			PS	DEF	1
			PTM	DEF	180.5
			PTM	SPF	198.3333
		SEINES	OTB	DEF	13.7
			OTB	MCD	1
			OTT	CRU	8.4
			PTB	DEF	7.4
			SDN	DEF	383
			SDN	SPF	2
			SPR	DEF	1
			SSC	DEF	154.95
		BOTTOM TRAWL	OTB	CEP	418
			OTB	DWS	13
			OTB	MCD	69.875
			OTB	MCF	9.5
			OTB	SPF	205
			OTT	DEF	468.2286
			OTT	DWS	14
			OTT	MCD	108
			PTB	CRU	1

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			PTB	DEF	746.45
			SSC	DEF	41.45
			TBB	CRU	770.9445
			TBB	MOL	7
	Norway	PELAGIC TRAWL	OTM	DEF	601.003
			OTM	SLP	19
			OTM	SPF	706
			PTM	SPF	14
		SEINES	OTB	DEF	1
		BOTTOM TRAWL	OTB	CRU	1
			OTB	DEF	2052.504
			OTB	DWS	175.5
			OTT	DEF	227
			PTB	DEF	129
			PTB	DWS	67
	West Sco	NETS	GND	DEF	3.00
			GNS	CRU	439.00
		RODS AND LINES	LHP	LPF	42.00
			LLS	FIF	59.75
			LTL	LFP	132
		LONGLINES	LLS	DEF	452.9636
		PELAGIC TRAWL	OTB	SPF	28
			OTM	DEF	111.0833
			OTM	LPF	24
			OTM	SPF	2948.717
			PTM	CRU	2
			PTM	DEF	3.666667
			PTM	LPF	555

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			PTM	SPF	597.4333
		SEINES	OTB	DEF	4
			OTT	CRU	6.2
			SDN	DEF	90
			SDN	DEF	7
		BOTTOM TRAWL	OTB	CRU	608
			OTB	DEF	7537.3
			OTB	DWS	3815
			OTB	MCF	9
			OTB	MDD	278
			OTT	CRU	579.6009
			OTT	DEF	954
			OTT	DWS	112
			PTB	DEF	9.575
			PTB	DWS	20
	TOTAL				
Grey seal	Hvaler	TRAPS	FPO	CRU	106
		NETS	GTR	DEF	14
		PELAGIC TRAWL	OTM	DEF	601.003
			OTM	SPF	636
			PTM	SPF	8
		SEINES	SDN	DEF	10
			SSC	DEF	22
		BOTTOM TRAWL	OTB	CRU	366
			OTB	DEF	1636.006
			OTB	DWS	1
			OTB	MCD	21
			OTT	CRU	467

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			OTT	DEF	264
			OTT	MCD	108
			PTB	DEF	14
	Icelandic coast	RODS AND LINES	LHM	DEF	32
		LONGLINES	LLS	DEF	61
		PELAGIC TRAWL	OTM	SLP	428
		BOTTOM TRAWL	OTB	CRU	148
	Irish coast	DREDGES	DRB	MOL	99
		NETS	GNS	DEF	268.0744
		RODS AND LINES	LLS	FIF	15
		LONGLINES	LLS	DEF	1
		PELAGIC TRAWL	OTB	SPF	23
			OTM	DEF	26.75
			PTM	CRU	2
			PTM	DEF	3
			PTM	LPF	47
			PTM	SPF	392
		SEINES	SDN	DEF	35
			SSC	DEF	236
		BOTTOM TRAWL	OTB	CRU	652
			OTB	DEF	5275
			OTB	DWS	101
			OTB	MCD	7
			OTB	MDD	29
			OTT	CRU	115
			OTT	DEF	395
			OTT	DWS	26
			TBB	DEF	203

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
	North sea	DREDGES	DRB	MOL	554.8667
		TRAPS	FPO	CEP	8
			FPO	DEF	8
			FPO	FIF	3
			FPO	MOL	7
			FYK	DEF	10
		NETS	GND	ANA	10
			GND	SPF	44
			GNS	ANA	8
			GNS	SPF	18
			GTN	DEF	4
			GTR	CEP	8
		RODS AND LINES	LHM	DEF	24
			LHM	FIF	130.2
			LHP	FIF	41
			LHP	SPF	1
			LLS	FIF	61.03571
			LTL	DEF	8
			LTL	LPF	62
			LTL	SPF	1
		LONGLINES	LLS	DEF	779.9439
		OTHER GEAR	MIS	DEF	23
			MIS	MIS	4
		SURROUNDING NETS	PS	DEF	6
			PS	SPF	126
		PELAGIC TRAWL	OTB	CEP	23.19048
			OTB	DEF	37.63333
			OTM	CEP	24

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			OTM	DEF	831.6697
			OTM	SLP	6
			PS	DEF	5
			PS	SPF	32
			PTM	LPF	39
			PTM	SPF	517.8083
		SEINES	OTB	DEF	17.7
			OTB	MCD	1
			OTT	CRU	14.6
			PTB	DEF	7.4
			SDN	CEP	26
			SDN	DEF	509
			SDN	SPF	2
			SPR	DEF	1
			SSC	DEF	165.95
		BOTTOM TRAWL	OTB	CEP	645
			OTB	CRU	3362.4
			OTB	DWS	1334.5
			OTB	MCD	69.875
			OTB	MCF	9.5
			OTB	MDD	263
			OTB	MOL	7
			OTB	SPF	211
			OTT	CEP	55
			OTT	CRU	2633.477
			OTT	DWS	88
			OTT	MCD	108
			PTB	CRU	4

Species	Ass Unit	Métier 3	Mé-tier4	Métier level 5	Total Observed Effort (DaS)
			PTB	DEF	894.625
			PTB	DWS	87
			SSC	DEF	41.45
			TBB	CRU	770.9445
			TBB	MOL	7
	Stad	PELAGIC TRAWL	OTM	DEF	601.003
			OTM	SPF	565
			PTM	SPF	8
		BOTTOM TRAWL	OTB	DEF	1502.004
			OTT	DEF	226
			PTB	DEF	4
	Troms	PELAGIC TRAWL	OTM	DEF	598.003
			OTM	SPF	554
			PTM	SPF	8
		BOTTOM TRAWL	OTB	DEF	1417.004
			OTT	DEF	226
			PTB	DEF	4
	TOTAL				

Table 5. Observed bycatch of grey seals outside the species' AUs. Grey seals were observed outside of the designated grey seal assessment units but inside the common dolphin assessment unit and several harbour porpoise assessment units.

Porpoise Assessment Unit	AreaCode	MétierL3	MétierL4	MétierL5	Number of grey seals
Belt Sea	27.3.b.23	L3GN	GNS	DEF	1
Celtic Seas	27.8.a	L3GN	GTR	DEF	1
West Scotland & Ireland	27.7.j	L3GN	GND	DEF	4
West Scotland & Ireland	27.7.j	L3GN	GTR	DEF	1

4 ToR a) Bycatch rates and associated confidence intervals for static and towed gears

4.1 Common Dolphin

Highest frequencies of common dolphin bycatch events over 2015-2020 were recorded in PTM and OTM in the Bay of Biscay (ICES area 27.8) and OTM in the Celtic Seas, west of Scotland (ICES area 27.6) as 0.1462 bycatch events/day at sea (95% CI 0.105-0.201) in both gear types and subareas. The frequency of bycatch events in PTM and OTM was 3 times higher than recorded in PTB at 0.046 bycatch events/day at sea (95% CI 0.0256 -0.0814) and 6 times higher than frequencies estimated in GNS and GTR, both 0.0239 bycatch events/day at sea (95% CI 0.0172-0.0334).

In ICES Subarea 27.7, highest frequencies were estimated for GTR (0.009 bycatch event/day at sea 95% CI 0.0043- 0.0188) and OTB and OTT (0.0073 bycatch events/day at sea 95% CI 0.0045-0.0119)

Bycatch event frequencies were also estimated for GNS and PS gears operating off the Iberian Peninsula (ICES area 27.9). For both, the frequency of bycatch events was below 0.01 bycatch events/day at sea. The frequency of events in GNS, 0.0088 (95% CI 0.0028 – 0.0269) was lower than that recorded in 27.8 but higher than that estimated in the Celtic Seas.

The average number of common dolphins/bycatch event over 2015-2020 was close to one single individual in most gears operating in ICES area 27.7 and static gears in 27.8. It ranged from 1.5 (95% CI 0.81- 2.77) to 2 (95% CI 0.58 - 6.93) individuals in PS and GNS operating off the Iberian Peninsula (ICES area 27.9). The numbers of common dolphins per bycatch event was highest at 3.58 (95% CI 2.29-5.6) in PTM in 27.8 and OTM in 27.8 & 27.6, and 4.09 common dolphins/bycatch event (95% CI 2.49- 6.71) in PTB operating in the Bay of Biscay. The frequency of events in PTB was lower than for PTM in 28.8 which suggests the tendency for PTB events to consist of a greater number of animals per haul.

Table 6. The bycatch rate per ICES subarea and métier level 4 with data for the Common Dolphin AU from 2015 to 2020. Both the estimated frequency of bycatch events and the estimated number of individuals per bycatch event is shown.

			Bycatch event/DaS			Number of individuals/bycatch event		
ICES subarea	MétierL4	Observed DaS	mean	lower	upper	mean	lower	upper
27.3	OTB	26904	0.00	0.00	0.00	1.07	0.93	1.22
27.6	OTM	1062	0.15	0.11	0.20	3.58	2.29	5.60
27.7	GND	149	0.00	0.00	0.01	1.17	0.98	1.39
27.7	GNS	30306	0.00	0.00	0.01	1.17	0.98	1.39
27.7	GTR	12213	0.01	0.00	0.02	1.29	0.91	1.83
27.7	OTB	77087	0.01	0.00	0.01	1.07	0.94	1.20
27.7	OTT	8838	0.01	0.00	0.01	1.07	0.94	1.20
27.8	GNS	28714	0.02	0.02	0.03	1.18	1.05	1.32

			Bycatch event/DaS			Number of individuals/bycatch event		
ICES subarea	MétierL4	Observed DaS	mean	lower	upper	mean	lower	upper
27.8	GTR	27743	0.02	0.02	0.03	1.18	1.05	1.32
27.8	OTB	36483	0.00	0.00	0.00	1.07	0.93	1.22
27.8	OTM	806	0.15	0.11	0.20	3.58	2.29	5.60
27.8	PTB	3183	0.05	0.03	0.08	4.09	2.49	6.71
27.8	PTM	2948	0.15	0.11	0.20	3.58	2.29	5.60
27.9	GNS	11604	0.01	0.00	0.03	2.00	0.58	6.93
27.9	PS	31655	0.01	0.00	0.02	1.50	0.81	2.77

4.2 Harbour porpoise

Gillnet métiers generally had the highest bycatch rates of harbour porpoise. Highest frequencies of harbour porpoise bycatch events over 2015-2020 were recorded in large vessels using GNS in the North Sea (ICES areas 27.3 and 27.4) if all data are considered, with 0.404 (95% CI 0.272-0.552) events/day at sea observed in 27.3 and 0.369 (95% CI 0.281-0.467) events/day at sea observed in 27.4. However, as stated below in the estimates chapter, sampling by one country in that area was unrepresentative due to that nation selecting several large vessels with high bycatch rate to participate in a electronic monitoring trial and represents a very high proportion of the observed effort. Without that country, the rate is much lower for 27.4: 0.016 (95% CI 0.005-0.05). Small vessels using GNS in the North Sea also had relatively high rates: 0.18 (95% CI 0.14-0.23) in 27.4 and 0.053 (95% CI 0.047-0.06) in 27.3. The rate of bycatch events was also high in GNS in Iceland (ICES area 27.5): 0.259 (95% CI 0.224-0.299) for large vessels, and 0.98 (95% CI 0.069-0.137) for small vessels.

Bycatch event rates in ICES area 27.7 in GNS/GTR/GD were 0.029 (95% CI 0.016-0.05) for large vessels, but slightly lower for smaller vessels or 0.009 (95% CI 0.005-0.014). Due to few observations of bycatch all areas were grouped together to calculate a rate for OTT and OTB, which was 0.0011 (95% CI 0.00058-0.002) bycatch events/day at sea.

The average number of porpoises per bycatch event over 2015-2020 was generally between 1 and 1.5 individuals in most métiers and areas, apart from large vessels using GNS in ICES area 27.4 where 2.5 (1.68-3.79) individuals were observed on average if the non-random sampling is included. Removing that sampling reduces that estimate to 1.33 (95% CI 0.455-3.91) individuals/bycatch event.

Table 7. The bycatch rate per ICES subarea and métier level 4 for the Harbour porpoise in assessed AUs with data from 2015 to 2020. Both the estimated frequency of bycatch events and the estimated number of individuals per bycatch event is shown.

					Bycatch event/DaS			Number of individuals/bycatch event		
AU	Subarea	Métier L4	Vessel size	Observed DaS	mean	lower	upper	mean	lower	upper
CELTIC	27.7	GND	small	77	0.01	0.01	0.01	1.06	0.94	1.19

					Bycatch event/DaS			Number of individuals/bycatch event		
CELTIC	27.7	GNS	small	13448	0.01	0.01	0.01	1.06	0.94	1.19
CELTIC	27.7	GNS	large	4200	0.03	0.02	0.05	1.18	0.94	1.49
CELTIC	27.7	GTR	small	2784	0.01	0.01	0.01	1.06	0.94	1.19
CELTIC	27.7	GTR	large	3034	0.03	0.02	0.05	1.18	0.94	1.49
CELTIC	27.7	OTB	All	32895	0.00	0.00	0.00	1.10	0.90	1.35
CELTIC	27.7	OTT	All	6598	0.00	0.00	0.00	1.10	0.90	1.35
CELTIC	27.8	GND	small	2757	0.00	0.00	0.00	0.00	0.00	0.00
CELTIC	27.8	GNS	small	12211	0.00	0.00	0.00	0.00	0.00	0.00
CELTIC	27.8	GNS	large	6951	0.01	0.00	0.03	1.25	0.66	2.36
CELTIC	27.8	GTR	small	16170	0.00	0.00	0.00	0.00	0.00	0.00
CELTIC	27.8	GTR	large	8288	0.01	0.00	0.03	1.25	0.66	2.36
CELTIC	27.8	OTB	All	28099	0.00	0.00	0.00	1.10	0.90	1.35
CELTIC	27.8	OTT	All	22843	0.00	0.00	0.00	1.10	0.90	1.35
FAROE	27.5	OTB	All	385	0.00	0.00	0.00	1.10	0.90	1.35
FAROE	27.6	OTB	All	351	0.00	0.00	0.00	1.10	0.90	1.35
FAROE	27.6	OTT	All	31	0.00	0.00	0.00	1.10	0.90	1.35
ICELAND	27.5	GNS	large	3793	0.26	0.22	0.30	1.44	1.30	1.60
ICELAND	27.5	GNS	small	2215	0.10	0.07	0.14	1.38	0.12	0.52
IRISH	27.7	GND	small	4	0.01	0.01	0.01	1.06	0.94	1.19
IRISH	27.7	GND	large	0	0.03	0.02	0.05	1.18	0.94	1.49
IRISH	27.7	GNS	small	188	0.01	0.01	0.01	1.06	0.94	1.19
IRISH	27.7	GNS	large	0	0.03	0.02	0.05	1.18	0.94	1.49
IRISH	27.7	GTR	small	1	0.01	0.01	0.01	1.06	0.94	1.19
IRISH	27.7	GTR	large	0	0.03	0.02	0.05	1.18	0.94	1.49
IRISH	27.7	OTB	All	8557	0.00	0.00	0.00	1.10	0.90	1.35
IRISH	27.7	OTT	All	286	0.00	0.00	0.00	1.10	0.90	1.35
NORTHSEA	27.3	GNS	small	1647	0.05	0.05	0.06	1.19	1.04	1.37
NORTHSEA	27.3	GNS	large	1782	0.40	0.27	0.55	1.16	0.99	1.35
NORTHSEA	27.3	GTR	small	82	0.05	0.05	0.06	1.19	1.04	1.37

					Bycatch event/DaS			Number of individuals/bycatch event		
NORTHSEA	27.3	GTR	large	0	0.40	0.27	0.55	1.16	0.99	1.35
NORTHSEA	27.3	OTB	All	21907	0.00	0.00	0.00	1.10	0.90	1.35
NORTHSEA	27.3	OTT	All	7486	0.00	0.00	0.00	1.10	0.90	1.35
NORTHSEA	27.4	GND	small	288	0.08	0.06	0.11	1.38	1.16	1.64
NORTHSEA	27.4	GND	large	3.91	0.02	0.01	0.05	1.33	1.15	0.46
NORTHSEA	27.4	GNS	small	1747	0.08	0.06	0.11	1.38	1.16	1.64
NORTHSEA	27.4	GNS	large	3.91	0.02	0.01	0.05	1.33	1.15	0.46
NORTHSEA	27.4	GTR	small	1073	0.08	0.06	0.11	1.38	1.16	1.64
NORTHSEA	27.4	GTR	large	3.91	0.02	0.01	0.05	1.33	1.15	0.46
NORTHSEA	27.4	OTB	All	50951	0.00	0.00	0.00	1.10	0.90	1.35
NORTHSEA	27.4	OTT	All	6392	0.00	0.00	0.00	1.10	0.90	1.35
NORTHSEA	27.7	GND	small	67	0.01	0.01	0.01	1.06	0.94	1.19
NORTHSEA	27.7	GND	large	0	0.03	0.02	0.05	1.18	0.94	1.49
NORTHSEA	27.7	GNS	small	4789	0.01	0.01	0.01	1.06	0.94	1.19
NORTHSEA	27.7	GNS	large	0	0.03	0.02	0.05	1.18	0.94	1.49
NORTHSEA	27.7	GTR	small	6068	0.01	0.01	0.01	1.06	0.94	1.19
NORTHSEA	27.7	GTR	large	322	0.03	0.02	0.05	1.18	0.94	1.49
NORTHSEA	27.7	OTB	All	16842	0.00	0.00	0.00	1.10	0.90	1.35
NORTHSEA	27.7	OTT	All	567	0.00	0.00	0.00	1.10	0.90	1.35
WESTSCOT	27.6	OTB	All	17579	0.00	0.00	0.00	1.10	0.90	1.35
WESTSCOT	27.6	OTT	All	4135	0.00	0.00	0.00	1.10	0.90	1.35
WESTSCOT	27.7	GNS	small	229	0.01	0.01	0.01	1.06	0.94	1.19
WESTSCOT	27.7	GNS	large	7451	0.03	0.02	0.05	1.18	0.94	1.49
WESTSCOT	27.7	GTR	small	5	0.01	0.01	0.01	1.06	0.94	1.19
WESTSCOT	27.7	GTR	large	2	0.03	0.02	0.05	1.18	0.94	1.49
WESTSCOT	27.7	OTB	All	18793	0.00	0.00	0.00	1.10	0.90	1.35
WESTSCOT	27.7	OTT	All	1388	0.00	0.00	0.00	1.10	0.90	1.35
WESTSCOT	27.8	GNS	small	0	0.00	0.00	0.00	0.00	0.00	0.00
WESTSCOT	27.8	GNS	large	0.3	0.01	0.00	0.03	1.25	0.66	2.36

4.3 Grey seal

Highest frequencies of grey seal bycatch events over 2015-2020 were recorded in small vessels using GNS in Ireland (ICES area 27.7) where 0.139 (95% CI 0.122-0.159) bycatch events/day at sea were observed, and in small vessels using GNS in Iceland where 0.098 (95% CI 0.0686-0.137) bycatch events/day at sea were observed. Bycatch frequency in GND and GNS in the North Sea and Hvaler assessment unit (ICES areas 27.3, 27.7) was 0.048 (95% CI 0.042-0.054). The frequency of bycatch events in GTR in the North Sea and Irish seas (ICES areas 27.7 and 27.8) was slightly lower at 0.0168 (95% CI 0.0103-0.272). Bycatch events in OTM were much rarer, at 0.0038 (95% CI 0.0016-0.0092) in the North Sea (ICES areas 27.4 and 27.6).

The average number of grey seals/bycatch event over 2015-2020 was between 1 and 1.5 individuals in most métiers and areas, apart from small vessels using GNS in Icelandic waters (ICES area 27.5) where 3.5 (95% CI 2.19-5.65) individuals were observed on average

Table 8. The bycatch rate per ICES subarea and métier level 4 for grey seal in AUs with data from 2015 to 2020. Both the estimated frequency of bycatch events and the estimated number of individuals per bycatch event is shown.

					Bycatch event/DaS			Number of individuals/by-catch event		
AU	Sub-area	Métier L4	Vessel size	Ob-served DaS	mean	lower	upper	mean	lower	upper
HVALER	27.3	GNS	all	62	0.05	0.04	0.05	1.46	1.25	1.72
IRELAND	27.7	GTR	large	0	0.02	0.01	0.03	1.13	0.96	1.32
IRELAND	27.7	GNS	small	666	0.14	0.12	0.16	1.16	1.10	1.22
ICELAND	27.5	GNS	small	2215	0.10	0.07	0.14	3.52	2.19	5.65
NORTHSEA	27.3	GND	all	1	0.05	0.04	0.05	1.46	1.25	1.72
NORTHSEA	27.7	GND	all	149	0.05	0.04	0.05	1.46	1.25	1.72
NORTHSEA	27.3	GNS	all	4926	0.05	0.04	0.05	1.46	1.25	1.72
NORTHSEA	27.7	GNS	all	22241	0.05	0.04	0.05	1.46	1.25	1.72
NORTHSEA	27.7	GTR	all	12213	0.02	0.01	0.03	1.13	0.96	1.32
NORTHSEA	27.8	GTR	all	2726	0.02	0.01	0.03	1.13	0.96	1.32
NORTHSEA	27.4	OTM	all	4406	0.00	0.00	0.01	1.20	0.76	1.91
NORTHSEA	27.6	OTM	all	872	0.00	0.00	0.01	1.20	0.76	1.91

5 ToR b) Métier-specific bycatch mortality estimates for each species and assessment unit

This report section refers to bycatch mortality estimates for the year 2020. Additional estimates for 2019 were carried out in advance of ADGMOMA but after the WKMOMA draft report was sent for review. Results for 2019 can be found in Annex 7.

5.1 Common Dolphin

The total number of common dolphins bycaught was estimated as 6404 individuals (95% CI 3051-9414) in 2020 for the entire assessment area. In individual métiers, the highest bycatch estimate was calculated for PTM at 1543 common dolphins (95% CI 709-2414), followed by 1152 (95% CI 616-1780) for GNS/GND and 925 (95% CI 549-1080) for GTR.

Bycatch estimates in 2020 are consistent with previous understanding of common dolphin bycatch and remain in same order of magnitude as previous ICES bycatch estimates based on observer programs and strandings (ICES, 2020a). However, the 2020-point estimate is higher than that of the mean annual bycatch estimate across all métiers of 3973 (95% CI 1998–6599) dolphins for 2016-2018 for the Bay of Biscay and Iberian Coast. The previous estimates were based on data from 2016 to 2018 with reported highest bycatch estimates in the Bay of Biscay (27.8) in GTR at 2061 dolphins/year (95% CI 1203-3092) and with lower estimates of 481 common dolphins (95% CI 408-555) in PTM targeting demersal species and 8 dolphins (95% CI 0-23]) in PTM targeting large pelagic species. Estimates provided for the year 2020 in PTM are around 3 times higher than during the 2016-2018 period, even though 40 pelagic trawlers were equipped with DDD-03H pingers during winter 2020. Pingers were not used to the same extent during the winters of 2016-2018. France revised their fishing effort estimation between WKEMBYC and WKMOMA, and the revised numbers are considerably higher than those used in WKEMBYC, which likely explains part of the difference between the two estimates. It is also likely that increased monitoring in PTM has resulted in higher estimates.

Interactions between common dolphins and pelagic trawlers in the Bay of Biscay have been documented in the past 20 years through various EU-funded projects. They revealed high levels of bycatch while targeting sea bass, tuna and hakes. Bycatch has also been documented in bottom pair trawlers targeting a mix of demersal and pelagic fishes (but mostly hakes) in North-Western Spain (Fernández-Contreras *et al.*, 2010), and in GTR targeting demersal species (ICES, 2020a). Most of these predatory fishes have mutual prey species with common dolphins, including anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*) and sprat (*Sprattus sprattus*) (Quéro and Vayne, 1997; Mahe *et al.*, 2007; Murua, 2010; Spitz *et al.*, 2013). Schooling behaviour in small pelagic fishes can lead to high local densities of various predatory species due to possible mutualism and facilitation processes in aggregation of both prey and predator species (Astarloa *et al.*, 2019). The large overlap in prey species of predatory fish with common dolphin diet suggests likely ecological and spatial overlap between common dolphins and targeted species, that could explain their vulnerability to bycatch in these specific fisheries. Direct predation of common dolphins on small pelagic fishes targeted by purse seines in the Bay of Biscay and Iberian Peninsula can also generate high levels of bycatch while dolphins are actively feeding.

Table 9. Estimated bycatch of common dolphin by assessment unit and métier in 2020.

Assessment unit	Métier	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI
Common dolphin	GNS/GND	1152	616	1780
Common dolphin	GTR	925	549	1080
Common dolphin	OTB	771	414	871
Common dolphin	OTM	978	449	1530
Common dolphin	OTT	69	37	77
Common dolphin	PS	368	75	680
Common dolphin	PTB	599	203	982
Common dolphin	PTM	1544	709	2414
Total	All	6406	3052	9414

5.2 Harbour porpoise

The mortality for harbour porpoise was estimated for all requested assessment areas except the Belt sea, the Iberian Peninsula, and the Faroes. Additionally, Norway and Russia did not submit bycatch monitoring and effort to the WKMOMA data call, and it was therefore not possible to estimate bycatch in the Norwegian and Russian coast assessment units.

Most of the data submitted to WKMOMA on harbour porpoise bycatch in the Belt Sea was not provided down to métier level 4. High bycatch rates are commonly observed in trammel nets (GTR) in that area, but trammel nets have a low associated fishing effort so estimates were therefore raised using gillnet effort (GNS) which has a high effort in the Belt Sea. This gives mortality estimates that are biased upwards not reflecting the true numbers. The effort from small scale gillnet fisheries from Germany is also upwardly biased due to the nature of the German reporting system for small vessels, which reports a full month of fishing if a vessel reported at least one day of fishing that month. Understandably, including this effort will increase apparent effort significantly and thereby bias the estimates upwards to a large extent. Therefore, WKMOMA agreed that in place of showing unrealistic and biased estimates it would be better to refer to estimated numbers from recent work that estimated bycatch of harbour porpoise in the Swedish and Danish fisheries of this region. HELCOM Action (HELCOM, 2021) estimated the number of harbour porpoises bycaught in 2018 in the combined Danish and Swedish commercial gillnet fleets in ICES subdivisions 3a21, 3b23 and 3c22 (roughly the Belt Sea assessment unit) to be 601 (95%CI: 500-710). The German gillnet effort was not accounted for in these bycatch estimates either and this might affect the porpoise bycatches estimates in ICES subdivision 3c22.

As both fishing effort and bycatch monitoring data for the Faroe assessment unit was incomplete, it was not possible to estimate bycatch in that region. No porpoises were observed over the 2015-2020 period in Iberia, and therefore assessment.

Bycatches of harbour porpoises in their respective assessment areas by métier are shown in Table 10. WKMOMA estimates that the bycatch in the West Scotland and Ireland assessment unit to be 305 (134-686) harbour porpoises. Most of the bycatch is estimated to be in GNS, or 255 individuals, while 50 are estimated to be caught in OTB/OTT. Previous bycatch calculations for that region from the IMR/NAMMCO workshop on harbour porpoise populations (IMR/NAMMCO, 2019) estimated a bycatch of 907 animals in the West Scotland and Ireland assessment unit area.

WKMOMA estimates the bycatch of harbour porpoises in the Celtic seas to be 738 (284-2240) harbour porpoises. Majority of those were estimated to be caught in GNS/GND and GTR, 374 and 257 respectively, while 108 individuals were estimated to be caught in OTB/OTT. Harbour porpoise bycatch in this region was estimated by the IMR/NAMMCO workshop to be around 1143 animals, which is in a similar range to the WKMOMA estimate.

WKMOMA estimates bycatch in the Irish seas assessment unit to be 12 (6-27) porpoises, of which 2 individuals were estimated to be caught in GNS/GND while 10 individuals were estimated to be caught in OTB/OTT.

WKMOMA estimates bycatch in the Icelandic assessment unit to be 1712 (1123-1973) harbour porpoises, all caught in GNS. Previous estimates of bycatch in Icelandic waters (summarized in IMR/NAMMCO 2019) suggest an estimated bycatch of around 2000-2500 porpoises annually, or along the upper limit of the bycatch estimate from the WKMOMA dataset.

For the estimate in the North Sea, WKMOMA presents two estimates due to a potential bias in the dataset. The higher estimate includes all submitted data, but is heavily skewed due to very frequent electronic monitoring observations from few vessels from one nation. These vessels have high bycatch rates and were selected for monitoring trial due that fact, therefore making the observed effort unrepresentative for the whole North sea. Raising these bycatch rates to the full effort in the North Sea potentially results in biased mortality estimates. However, since the observed effort from this country is high, excluding these numbers in the North Sea assessment reduces the observer coverage significantly as well as the bycatch estimates. The true number is most likely somewhere in between the two estimates, especially considering that effort from Norwegian vessels and small German vessels was not available for the estimates produced by WKMOMA. The two estimates for the North Sea are 1627 (95% CI 922-3325) without the data explained above, and 5929 (95% CI 3176-10 739) including that unrepresentative data. A majority of the bycatch is estimated to be from GNS/GND in both cases (1306/5327 individuals), followed by GTR (198/479 individuals) and to lesser extent from OTB/OTT (123/123 individuals).

Table 10. Estimated bycatch of harbour porpoise by assessment unit and métier. Two values are provided for the North Sea, with and without the data from one country due to possible biases.

Assessment unit	Métier	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI
Belt Sea*	All	601	500	710
Iceland	GNS	1712	1123	1973
Celtic	GNS/GND	374	152	1079
Celtic	GTR	257	85	917
Celtic	OTB/OTT	108	47	244
Irish	GNS/GND	2	1	3
Irish	OTB/OTT	10	5	24
West Scotland	GNS	255	112	572
West Scotland	OTB/OTT	50	22	113
North Sea	GNS/GND	5327/1306	2845/747	9637/2698

Assessment unit	Métier	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI
North Sea	GTR	479/198	277/120	821/346
North Sea	OTB/OTT	123/123	54/54	281/281
Total	All	9298/4996	5223/2968	16376/8963

***From Helcom Action 2021**

5.3 Grey seal

The mortality for grey seal was estimated for the Greater North Sea, Ireland, and Iceland assessment units. Norway, the Faroes, and Russia did not submit bycatch monitoring and effort to the WKMOMA data call, and it was therefore not possible to estimate bycatch in the Hvaler, Stad and Troms assessment units.

Overall bycatch estimates for the three assessment units were 3143 individuals (95% CI 2044-5129) based on bycatch events/frequency from 2015-2020 and raised with effort data from 2020. Broken up by assessment unit, WKMOMA estimates that 2229 individuals (95% CI 1598-3199) are caught annually in the Great North Sea assessment unit, 761 individuals (95% CI 333-1715) in the Iceland assessment unit and 108 individuals (95% CI 89-129) in the Ireland assessment unit.

Gillnet métiers were the main gears with observed bycatch in all assessment units, but a small amount was also estimated to be caught in OTM in the Greater North Sea assessment unit (Table 11.).

Previous estimate in areas that roughly represent the Greater North Sea estimated the bycatch to be between 1689-3173 individuals per year, but these were based on data from 2015-2017 and fishing effort from 2017 (ICES WGBYC 2019). The current estimate is therefore very similar to this older estimate. Previous estimate for Iceland based on data from the lumpsucker fishery in 2014-2018 estimated 989 individuals (405-1573) taken annually, but noted high uncertainty around the estimate (MFRI, 2019). The current estimate of 761 individuals is well within the confidence intervals of this older estimate. A recent study estimated the bycatch of grey seals within the Irish EEZ, an area slightly larger than the Irish assessment unit, to be between 202 and 349 seals per annum based on data from 2011-2016, but high uncertainty around the estimates was noted (Luck *et al.* 2020). The current estimate of 108 is slightly lower than those estimates but given that the estimates from Luck *et al.* (2020) are based on larger spatial unit, they are largely comparable.

In many areas there are stranding records available for seals, that might provide additional data for comparison to monitored bycatch. Stranding data are currently under review with the WGMME (ICES 2021). In Scotland for example in 2019, 491 seals (307 grey and 95 harbour seals, 89 other/unknown) were reported stranded.

Table 11. Estimated bycatch of grey seal by assessment unit and métier.

Assessment unit	Métier	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI
Ireland	GNS	108	89	129
Iceland	GNS	760	333	1715
Greater North Sea	GNS/GND	1922	1444	2570

Greater North Sea	GTR	282	147	536
Greater North Sea	OTM	24	6	92

6 ToR c) Compare the bycatch mortality estimates against thresholds for species and assessment units and identify any critical issues

ToR c) Compare the bycatch mortality estimates against thresholds for the relevant species/assessment units as provided by OSPAR and identify any critical issues (such as biases in the bycatch estimates) relevant for the comparison.

6.1 Common dolphin

The mortality for common dolphin in the AU based on bycatch rates in 2015-2020 was estimated to be 6405 individuals (95% CI 3051 9414). OSPAR provided a threshold based on modified PBR (mPBR) of 985 common dolphins as the limit of annual anthropogenic mortality for this species in the AU. Therefore, the estimated level of common dolphin bycatch exceeds this threshold. The 95% confidence intervals around the bycatch estimate do not overlap the threshold value, which removes ambiguity in concluding whether the threshold is exceeded or not.

This outcome contrasts with that from previous work undertaken by ICES WKEMBYC (ICES 2020) where the confidence intervals around the estimated bycatch mortality overlapped with the threshold and precautionary approaches were taken to assess the likelihood of population consequences. We note that the estimated annual mortality here of 6405 is higher than that estimated in WKEMBYC of 4693 . The threshold value used in WKEMBYC was much higher than that supplied by OSPAR to WKMOMA. While the same algorithm was used to set the threshold values for WKEMBYC and for WKMOMA (via OSPAR) this edited approach is more conservative, and results in a low threshold. The choice of conservation objective is clearly critical, and comparison here demonstrates the significant differences in threshold values that arise under different objectives. Whilst it is not the task for WKMOMA to set the thresholds, the disparity is noteworthy and the threshold for WKMOMA represents an annual mortality of <0.2% of the best available abundance estimate of common dolphins in the AU.

Different bycatch reduction scenarios, based on various combinations of pingers and fishery closures, were tested during WKEMBYC in Bay of Biscay and Iberian Peninsula from 2016 to 2018. Most scenarios allowed bycatch to be reduced below PBR (based on at-sea monitoring: 3 between PBR and 50% of PBR, 10 between 50% of PBR and 10% of PBR and 2 below 10% PBR; based on stranding estimates: 6 between PBR and 50% of PBR and 7 between 50% PBR and 10% PBR) (ICES, 2020a). The mPBR threshold set by OSPAR represents 20% of the previously calculated PBR. Based on WKEMBYC scenarios, only those combining at least 2-month closures of all métiers and with pingers on PTM/PTB all year would reach WKMOMA conservation objectives.

As an emergency measure, WKEMBYC suggested implementation of a scenario that included a 4-month closure (3 months in winter (January-March) and 1 month in summer (mid-July–mid-August)) for PTM_DEF, PTM_LPF, PTB_MDP, GTR_DEF, OTM_DEF, PS_SPF and GNS_DEF and the use of pingers on PTM and PTB during the whole year. This scenario (called N) achieved the goal of bycatch reduction in Bay of Biscay and Iberian Peninsula below the WKMOMA threshold. Most métiers presenting high bycatch estimates in 2020 are included in scenario N, but WKMOMA also highlighted a high level of bycatch in OTB in 27.7 and OTM in 27.6 and 27.7, that could be included in this scenario.

The implementation of such scenarios at large spatial scale (ICES areas 27.6, 27.7, 27.8 and 27.9) would be the only strategy that may satisfy both OSPAR threshold and Article 12 of the Habitats Directive.

Table 12. The bycatch of common dolphin in the OSAR assessment area. The upper and lower limits represent 95 % confidence intervals. The mPBR threshold from OSPAR is also shown.

Assessment area	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI	OSPAR Threshold
Common Dolphin	6404	3051	9414	985

6.2 Harbour porpoise

The mortality for harbour porpoise was estimated for all requested assessment areas except the Belt sea, the Iberian peninsula. and the Faroes. Additionally, Norway and Russia did not submit bycatch monitoring and effort to the WKMOMA data call, and it was therefore not possible to estimate bycatch in the Norwegian and Russian coast assessment units.

Agreed thresholds with which to compare these bycatch estimates were provided by OSPAR for the Greater North Sea, Celtic Sea, Irish Seas, West Scotland and Ireland, Iberian Peninsula, Iceland and Norwegian and Russian coast assessment units.

WKMOMA estimates that the bycatch in the West Scotland and Ireland assessment unit to be 305 (134-686) harbour porpoises. The modified PBR threshold set by OSPAR for that assessment unit was 82 animals. Estimated bycatch is between 1.6 and 8.8 times higher than that set threshold.

WKMOMA estimates the bycatch of harbour porpoises in the Celtic seas to be 738 (284-2240) harbour porpoises. The mPBR set by OSPAR for that assessment unit was 43 animals, and estimated bycatch is therefore between 6.6 and 52 times higher than the threshold.

WKMOMA estimates bycatch in the Irish seas assessment unit to be 12 (6-27) porpoises. The modified PBR set for that assessment unit by OSPAR is 34 animals, and estimated bycatch is therefore 1.2-5.6 times lower than the threshold. However, if the small Irish assessment unit is grouped with the larger Celtic sea unit, estimated bycatch still exceeds the threshold considerably.

As for the North Sea, the provided threshold from OSPAR based on RLA population model is 1622 animals. The lower estimate of bycatch by WKMOMA in the North Sea, 1627 individuals (95% CI 921-3325) only slightly exceeds the threshold while the higher estimate, 5929 individuals (95% CI 3176-10739) exceeds the threshold significantly. An assessment carried out by the IMR/NAMMCO workshop (2019) estimated an average annual bycatch of around 4,500 animals. Their assessment model's outputs indicated that the population seems able to sustain a bycatch of around 4,500 animals a year, (which is around 1.1% of the estimated carrying capacity and around 1.3% of current abundance), while maintaining the population level at around 85-90% of carrying capacity.

WKMOMA estimates bycatch in the Icelandic assessment unit to be 1590 (1241-2039) harbour porpoises. The PBR threshold set by OSPAR is 3500 animals, and the estimated bycatch is therefore between 1.7 and 2.8 times lower than the threshold (Table 13).

Table 13. The bycatch of harbour porpoise in the OSAR assessment areas. The upper and lower limits represent 95 % confidens intervals.

Assessment area	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI	OSPAR Threshold
Celtic Sea	738	284	2240	43
Faroe+	1	0	2	NA
Iceland	1713	1123	21972	3500
Irish Sea	12	6	27	34
North Sea	5929	3176	10739	1622
North Sea *	1535*	911*	2499*	1622
West Scotland	305	134	686	78
Norwegian and Russian Coast	NA	NA	NA	NA

*Estimate with one country's bycatch observation data taken out due to possible biases.
+Incomplete effort and observation data available for this assessment unit

6.3 Grey seal

The only possible estimate comparison of an estimate to a is the Greater North Sea. The estimate from there, 2229 (95% CI 1598-3199) is considerably lower than the PBR threshold set by OSPAR of 7617 grey seals in the Great North Sea, or 2.4-4.8 times lower than the threshold (Table 13).

Table 14. The bycatch of grey seals in the OSAR assessment areas. The upper and lower limits represent 95 % confidence intervals.

Assessment area	Bycatch (number of animals)	Lower 95% CI	Upper 95% CI	OSPAR Threshold
Hvaler*	4	3	6	NA
Iceland	761	333	1715	NA
Ireland	108	89	129	NA
Greater North Sea	2229	1598	3199	7617
Stad	NA	NA	NA	NA
Troms	NA	NA	NA	NA

* Incomplete effort and observation data available for this assessment unit

7 ToR d) Bycatch rate and mortality estimates for harbour porpoise and grey seal in OSPAR Region I.

No data on bycatch was submitted to WKMOMA from OSPAR region I. However data were submitted to the ICES WGBYC data call from 2005 until 2020 from the area of concern. An assessment of that data will be carried out under ICES WGBYC.

8 Biases affecting WKMOMA assessments

The modeling approach used here allows us to produce estimates of bycatch rate stratified by factors such as vessel length, métier and area, and then raise the rate to the fleet level. However, even though the model approach is used in the WKMOMA assessment, important factors are still missing in the WKMOMA data set, as very few member states report their effort data on such a fine scale, as required under EU-MAP (Commission Delegated Decision (EU) 2021/1167). Mainly in gillnet fisheries two factors, soak time and net length are not often reported in logbooks but most likely they have a high influence on the bycatch (Northridge, *et al.* 2017). Net length can vary substantially, from a few hundred metres in e.g. wreck fisheries to over 10km in e.g. turbot fisheries. The net length is thus somewhat dependent on target species and area. Soak time can vary from a few hours to more than a week. The more net in the water and the longer the net stays in the water the higher chance there is for entanglement. Thus making extrapolations without knowledge of these factors will make the estimates more uncertain.

Other factors like time, area and distance to shore have also been shown to be important when modeling bycatch, especially for sea birds (Bærum et al. 2017). These factors are however reported to the WKMOMA to some extent. Area is reported by the ICES square, which also indicated the distance to shore on a large scale. However, several counties did not report the ICES square as it was not a mandatory field in the data call. Mesh size, nets height, actual fishing height, twine type and diameter and hanging ratio are also factors that may also influence the bycatch. Here only mesh size has been reported to some extent in the data call by those Member States that included métier level 6 information, as this field was optional in the WKMOMA data call. Other factors have also been identified like wind and fishing depth. Fishing depth especially has been shown to be important for certain bird species.

In addition to the factors related above concerning effort information, other components also need to be taken into account regarding the quality of the data provided on bycatch events . These components are related particularly to the potential level and impact of bias in the data. Bias can arise at three stages of the estimation process: the sampling scheme design, the implementation and in the analysis of the results.

Bias associated with sampling scheme designs is related to the sampling coverage and the methods for selecting the primary sampling units (e.g. trips, vessels etc.). This means for instance, whether the vessels monitored were selected randomly or not, the number of unique vessels monitored in the total population etc. Much emphasis is usually placed on the monitoring coverage effort of the different fisheries versus the total effort when considering the utilization of the data. However, regarding the quality of the data it could be more important to know how this coverage was realized. When collecting data on bycatch of protected species, the fisheries selected are not always selected randomly mainly because the likelihood of getting no results is large. Therefore métiers and areas where there is a high risk of bycatch are often selected and when extrapolating these number to the full effort, there will be a positive bias in the estimation.

Bias associated with the implementation phase relates to a failure to meet an intended survey design, leading to non-representative sampling of the population. In the case of PETS bycatch data, as these are very sensitive data, the rate of refusal to provide access for observers onboard increases. Knowledge of how this refusal rates affects getting a representative sampling population is essential. Most of the bycatch provided to WKMOMA are collected by scientific observers. There are other problems to take into account when trying to take observers on board such as safety concerns or availability of space in the smaller vessels. This may lead to some bias as most of the bycatch information collected is coming from the larger vessels although vessels of all sizes are considered as the same métier. Knowledge of the behavior of the skippers in the sampled trips compared to the rest of the trips could also provide relevant information about the quality of the data.

Finally, it is very important to know the objective of the sampling programmes in which the bycatch information was collected. The information provided to WKMOMA comes from different sampling programs. Some of them are specific for bycatch data collection but others have a wider range of objectives (e.g. biological data collection, discards etc.) because they are trips covered under the DCF. It could happen that the observers onboard the specific bycatch programs are better trained, the protocols are also more specific to collection of bycatch data etc., compared to other sampling programmes. This could have some impact in the quality of the data collected. This is relevant especially for data collected in the years prior to 2017, as until then it was not mandatory to collect bycatch data on trips sampled through the DCF. In those years, it is very likely that the quality of the data is more related to the way the protocols were implemented in terms of data collection for PETS species.

For a good part of the above-mentioned components related to the possible bias of the data, is not possible to analyse their effect based on the information provided in the data call. The data call provides information about what data are being collected (e.g. number of trips, métiers covered, monitoring coverage etc.) but not how these data were collected. Most of the components related to the data quality however, are associated with how the data are collected.

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Annex 2: Information on differences in provided data

Note that this annex was incorporated to the report after the draft report was sent for peer review.

	Days at Sea			**Number of Hauls**			**Number of Observed Hauls**		
Country	Trip conducted over multiple ICES rectangles	Trips conducted using several metiers	Trips conducted over several months	Trip conducted over multiple ICES rectangles	Trips conducted using several metiers	Trips conducted over several months	Trip conducted over multiple ICES rectangles	Trips conducted using several metiers	Trips conducted over several months
Sweden	Total DaS of trip reported on each rectangle ie duplicated DaS	DaS allocated to multiple metiers used during the trip ie duplicated DaS	DaS duplicated if trip is carried out over month	Number of hauls on trip reported on each rectangle ie duplicated effort	Number of hauls allocated to multiple metiers used during the trip ie duplicated effort	Number of hauls duplicated if trip is carried out over several month (only two occasions)	Number of OB hauls on trip reported on each rectangle ie duplicated effort	Number of OB hauls allocated to multiple metiers used during the trip ie duplicated effort	Number of OB hauls duplicated if trip is carried out over several month (only two occasions)
Ireland	DaS allocated in the ICES rectangle where the majority of fishing was carried out	DaS allocated to the metier used the most	DaS allocated one month	Number of hauls allocated in the ICES rectangle where the majority of fishing was carried out	Number of hauls allocated to the metier used the most	Number of hauls allocated to one month	Number of OB hauls allocated in the ICES rectangle where the majority of fishing was carried out	Number of OB hauls allocated to the metier used the most	Number of OB hauls allocated to one month

Netherlands	DaS reported per ICES rectangle, summarizing DaS from all areas give full trip DaS	Only one metier used during the trip	DaS divided proportional over month	Number of hauls reported per ICES rectangle ie no duplication	Only one metier used during the trip		Number of OB hauls reported per ICES rectangle ie no duplication	Only one metier used during the trip	
Poland	Total DaS of trip reported on each rectangle ie duplicated DaS	DaS allocated to multiple metiers used during the trip ie duplicated DaS	DaS duplicated if trip is carried out over month	Number of hauls on trip reported on each rectangle ie duplicated effort	Number of hauls reported per metier ie no duplication	Number of hauls duplicated if trip is carried out over several month	Number of OB hauls on trip reported on each rectangle ie duplicated effort	Number of OB hauls reported per metier ie no duplication	Number of OB hauls duplicated if trip is carried out over several month
Germany	DaS reported per ICES rectangle, summarizing DaS from all areas give full trip DaS	DaS allocated to multiple metiers used during the trip ie duplicated DaS	Trips are separated per month, and get a new tripID	Not available	Not available	Not available	Number of OB hauls reported per ICES rectangle ie no duplication	Number of OB hauls allocated to multiple metiers used during the trip ie duplicated effort	Trips are separated per month, and get a new tripID
Estonia	Total DaS of trip reported on each rectangle ie duplicated DaS	Only one metier used during the trip	DaS divided proportional over month	Number of hauls reported per ICES rectangle ie no duplication	Only one metier used during the trip	Number of hauls reported per month ie no duplication	Number of OB hauls reported per ICES rectangle ie no duplication	Only one metier used during the trip	Number of OB hauls divided proportional over months
France	DaS allocated in the ICES rectangle where the majority of fishing was carried out	DaS allocated to the metier used the most	DaS allocated one month with the highest fishing time	Number of hauls allocated in the ICES rectangle where the majority of fishing was carried out	Number of hauls allocated to the metier used the most	Number of hauls allocated to one month with the highest	Number of OB hauls allocated in the ICES rectangle where the majority	Number of OB hauls allocated to the metier used the most	Number of hauls allocated to one month with the highest fishing time

						fishing time	of fishing was carried out		
Spain	DaS reported per ICES rectangle or ICES division. Summarizing DaS from all areas give full trip DaS	DaS reported per metier, summarizing DaS from all metiers give full trip DaS	DaS reported per month, summarizing DaS from all months give full trip DaS	Number of hauls reported per ICES rectangle/ICES division ie no duplication	Number of hauls reported per metier ie no duplication	Number of hauls reported per month ie no duplication	Number of hauls reported per ICES rectangle/ICES division ie no duplication	Number of hauls reported per metier ie no duplication	Number of OB hauls reported per month ie no duplication
Portugal	Total DaS of trip reported on each rectangle ie duplicated DaS	DaS allocated to multiple metiers used during the trip ie duplicated DaS	Fishing occur on a daily basis	Number of hauls on trip reported on each rectangle ie duplicated effort	Number of hauls allocated to multiple metiers used during the trip ie duplicated effort	Fishing occur on a daily basis	Number of OB hauls on trip reported on each rectangle ie duplicated effort	Number of OB hauls allocated to multiple metiers used during the trip ie duplicated effort	Fishing occur on a daily basis
Iceland	DaS reported per ICES rectangle, summarizing DaS from all areas give full trip DaS	Only one metier used during the trip		Not available	Only one metier used during the trip	Not available	Number of hauls reported per ICES rectangle/ICES division ie no duplication	Only one metier used during the trip	Number of OB hauls reported per month ie no duplication

United Kingdom	DaS reported per ICES rectangle, summarizing DaS from all areas give full trip DaS	DaS reported in proportion to hauls in each metier, summarizing DaS from all metiers give full trip DaS	DaS allocated to month with most hauls	Number of hauls reported per ICES rectangle ie no duplication	Number of hauls reported per metier ie no duplication	Number of hauls allocated to one month with the highest fishing time	Number of observed hauls provided for each rectangle ie no duplication	Number of observed hauls provided for each metier ie no duplication	Number of OB hauls allocated to one month with the highest fishing time
Denmark	Reported monitored hauls, allocated in the ICES rectangle where the majority of fishing was carried out	Only one metier used during the trip		Number of hauls reported per ICES area ie no duplication	Only one metier used during the trip		Number of hauls reported per ICES area ie no duplication	Only one metier used during the trip	

Annex 3: Recommendations

None

Annex 4: Table of 2020 fishing effort from the RDB by AU at métier level 4 (data from Iceland not included).

Species	AU	Métier 4	Days at Sea
Common Dolphin	CD_AU	DIV	1390.86
	CD_AU	DRB	68737.61
	CD_AU	FOO	52.45
	CD_AU	FPN	191.00
	CD_AU	FPO	242702.47
	CD_AU	FYK	1619.02
	CD_AU	GNC	2631.64
	CD_AU	GND	2553.50
	CD_AU	GNS	85427.39
	CD_AU	GTN	510.43
	CD_AU	GTR	57320.29
	CD_AU	HMD	719.00
	CD_AU	LHM	5551.12
	CD_AU	LHP	21257.33
	CD_AU	LLD	5530.47
	CD_AU	LLS	52221.24
	CD_AU	LN_	178.93
	CD_AU	LTL	2114.33
	CD_AU	MIS	25735.64
	CD_AU	OTB	254951.65
	CD_AU	OTH	11227.65
	CD_AU	OTM	11309.28
	CD_AU	OTT	50853.84
	CD_AU	PS_	61742.41
	CD_AU	PTB	7820.80

Species	AU	Métier 4	Days at Sea
	CD_AU	PTM	4696.83
	CD_AU	SB_	73.00
	CD_AU	SDN	6506.91
	CD_AU	SPR	127.00
	CD_AU	SSC	9849.00
	CD_AU	TBB	84909.85
Grey Seal	HG_HVALER	FPO	722.00
	HG_HVALER	GNS	62.00
	HG_HVALER	GTR	5.00
	HG_HVALER	LHP	53.00
	HG_HVALER	MIS	5.00
	HG_HVALER	OTB	5273.93
	HG_HVALER	OTM	118.00
	HG_HVALER	OTT	1978.00
	HG_HVALER	PTB	5.79
	HG_HVALER	SDN	285.00
	HG_HVALER	SSC	35.00
	HG_HVALER	TBB	10.00
	HG_IRELAND	DRB	3169.00
	HG_IRELAND	FPO	12360.00
	HG_IRELAND	GNS	3077.67
	HG_IRELAND	GTR	1.00
	HG_IRELAND	LHP	363.00
	HG_IRELAND	LLD	25.00
	HG_IRELAND	LLS	3206.82
	HG_IRELAND	MIS	797.11
	HG_IRELAND	OTB	15677.58
	HG_IRELAND	OTM	499.26
	HG_IRELAND	OTT	725.99

Species	AU	Métier 4	Days at Sea
	HG_IRELAND	PTM	591.91
	HG_IRELAND	SSC	1387.00
	HG_IRELAND	TBB	1958.00
	HG_NORTHSEA	DIV	1344.23
	HG_NORTHSEA	DRB	57834.96
	HG_NORTHSEA	FOO	1.00
	HG_NORTHSEA	FPN	71.00
	HG_NORTHSEA	FPO	207879.75
	HG_NORTHSEA	FYK	1227.00
	HG_NORTHSEA	GNC	11.12
	HG_NORTHSEA	GND	439.73
	HG_NORTHSEA	GNS	36527.33
	HG_NORTHSEA	GTN	288.69
	HG_NORTHSEA	GTR	16756.86
	HG_NORTHSEA	HMD	719.00
	HG_NORTHSEA	LHM	5.95
	HG_NORTHSEA	LHP	18279.82
	HG_NORTHSEA	LLD	3108.66
	HG_NORTHSEA	LLS	10728.20
	HG_NORTHSEA	LN_	40.00
	HG_NORTHSEA	LTL	1528.32
	HG_NORTHSEA	MIS	21125.22
	HG_NORTHSEA	OTB	141675.64
	HG_NORTHSEA	OTH	401.89
	HG_NORTHSEA	OTM	8493.07
	HG_NORTHSEA	OTT	33926.27
	HG_NORTHSEA	PS_	3688.41
	HG_NORTHSEA	PTB	3237.03
	HG_NORTHSEA	PTM	986.55

Species	AU	Métier 4	Days at Sea
	HG_NORTHSEA	SB_	73.00
	HG_NORTHSEA	SDN	3698.96
	HG_NORTHSEA	SPR	127.00
	HG_NORTHSEA	SSC	8342.00
	HG_NORTHSEA	TBB	80666.85
	HG_STAD	OTB	105.00
	HG_STAD	OTM	48.00
	HG_STAD	OTT	7.07
	HG_STAD	PTM	2.00
	HG_TROMS	OTB	246.00
	HG_TROMS	OTM	9.00
	HG_TROMS	OTT	167.74
Harbour porpoise	HP_BELTSEA	DRB	1.00
	HP_BELTSEA	FPN	886.00
	HP_BELTSEA	FPO	670.00
	HP_BELTSEA	FYK	722.00
	HP_BELTSEA	GNS	12720.00
	HP_BELTSEA	GTR	2170.00
	HP_BELTSEA	LHP	100.00
	HP_BELTSEA	LLS	216.00
	HP_BELTSEA	MIS	59.00
	HP_BELTSEA	OTB	10029.00
	HP_BELTSEA	OTM	73.00
	HP_BELTSEA	OTT	860.00
	HP_BELTSEA	PTB	75.50
	HP_BELTSEA	PTM	139.50
	HP_BELTSEA	SDN	85.00
	HP_BELTSEA	SSC	53.00
	HP_BELTSEA	TBB	3.00

Species	AU	Métier 4	Days at Sea
	HP_CELTIC	DIV	1390.86
	HP_CELTIC	DRB	24601.25
	HP_CELTIC	FOO	52.45
	HP_CELTIC	FPO	53784.42
	HP_CELTIC	FYK	166.02
	HP_CELTIC	GNC	2644.48
	HP_CELTIC	GND	2834.29
	HP_CELTIC	GNS	36811.08
	HP_CELTIC	GTN	570.69
	HP_CELTIC	GTR	30278.87
	HP_CELTIC	LHM	148.62
	HP_CELTIC	LHP	15786.27
	HP_CELTIC	LLD	2064.15
	HP_CELTIC	LLS	23701.94
	HP_CELTIC	LN_	226.93
	HP_CELTIC	LNP	6.28
	HP_CELTIC	LTL	1721.93
	HP_CELTIC	MIS	5776.89
	HP_CELTIC	OTB	60994.36
	HP_CELTIC	OTH	12539.78
	HP_CELTIC	OTM	1317.69
	HP_CELTIC	OTT	29441.20
	HP_CELTIC	PS_	6911.96
	HP_CELTIC	PTB	371.98
	HP_CELTIC	PTM	2363.84
	HP_CELTIC	SDN	1883.12
	HP_CELTIC	SPR	1.05
	HP_CELTIC	SSC	1276.00
	HP_CELTIC	TBB	14169.62

Species	AU	Métier 4	Days at Sea
	HP_EASTGREEN	OTB	497.00
	HP_FAROE	FPO	17.00
	HP_FAROE	GNS	62.00
	HP_FAROE	LLD	586.00
	HP_FAROE	LLS	423.67
	HP_FAROE	MIS	0.00
	HP_FAROE	OTB	736.29
	HP_FAROE	OTM	47.26
	HP_FAROE	OTT	31.63
	HP_FAROE	PTB	66.49
	HP_FAROE	PTM	0.50
	HP_IBERIAN	DRB	3678.00
	HP_IBERIAN	FPO	11168.00
	HP_IBERIAN	GNC	6.00
	HP_IBERIAN	GND	347.00
	HP_IBERIAN	GNS	20818.00
	HP_IBERIAN	GTR	18312.83
	HP_IBERIAN	LHM	5400.00
	HP_IBERIAN	LHP	44.16
	HP_IBERIAN	LLD	1577.87
	HP_IBERIAN	LLS	12485.16
	HP_IBERIAN	LTL	4.72
	HP_IBERIAN	MIS	3122.40
	HP_IBERIAN	OTB	53775.42
	HP_IBERIAN	OTM	8.10
	HP_IBERIAN	OTT	2.02
	HP_IBERIAN	PS_	54765.00
	HP_IBERIAN	PTB	4121.00
	HP_IBERIAN	PTM	607.72

Species	AU	Métier 4	Days at Sea
	HP_IBERIAN	SDN	644.00
	HP_IBERIAN	TBB	1751.00
	HP_ICELAND	OTB	20.00
	HP_IRISH	DRB	7310.00
	HP_IRISH	FPO	30791.00
	HP_IRISH	GND	4.00
	HP_IRISH	GNS	188.00
	HP_IRISH	GTR	1.00
	HP_IRISH	HMD	26.00
	HP_IRISH	LHP	50.00
	HP_IRISH	LLD	291.00
	HP_IRISH	LLS	9.00
	HP_IRISH	LTL	1.00
	HP_IRISH	MIS	391.00
	HP_IRISH	OTB	8557.00
	HP_IRISH	OTM	258.00
	HP_IRISH	OTT	286.00
	HP_IRISH	PTM	214.50
	HP_IRISH	SSC	72.00
	HP_IRISH	TBB	1326.00
	HP_NORTHSEA	DRB	29896.95
	HP_NORTHSEA	FPN	16.00
	HP_NORTHSEA	FPO	100417.57
	HP_NORTHSEA	FYK	1081.00
	HP_NORTHSEA	GND	356.93
	HP_NORTHSEA	GNS	13984.62
	HP_NORTHSEA	GTN	61.17
	HP_NORTHSEA	GTR	7691.22
	HP_NORTHSEA	HMD	579.00

Species	AU	Métier 4	Days at Sea
	HP_NORTHSEA	LHM	2.50
	HP_NORTHSEA	LHP	4879.60
	HP_NORTHSEA	LLD	1.00
	HP_NORTHSEA	LLS	1354.34
	HP_NORTHSEA	LTL	382.99
	HP_NORTHSEA	MIS	13472.60
	HP_NORTHSEA	OTB	89700.46
	HP_NORTHSEA	OTH	69.00
	HP_NORTHSEA	OTM	7014.79
	HP_NORTHSEA	OTT	14445.42
	HP_NORTHSEA	PS_	59.00
	HP_NORTHSEA	PTB	3027.66
	HP_NORTHSEA	PTM	395.68
	HP_NORTHSEA	SB_	73.00
	HP_NORTHSEA	SDN	3950.25
	HP_NORTHSEA	SPR	125.95
	HP_NORTHSEA	SSC	7869.00
	HP_NORTHSEA	TBB	67590.24
	HP_NORWAY	FPO	0.67
	HP_NORWAY	OTB	400.16
	HP_NORWAY	OTM	185.01
	HP_NORWAY	OTT	189.78
	HP_NORWAY	PTB	23.89
	HP_NORWAY	PTM	8.50
	HP_NORWAY	SDN	3.00
	HP_WESTSCOT	DRB	3269.90
	HP_WESTSCOT	FPO	46331.59
	HP_WESTSCOT	GNS	8273.41
	HP_WESTSCOT	GTR	5.00

Species	**AU**	**Métier 4**	**Days at Sea**
	HP_WESTSCOT	HMD	114.00
	HP_WESTSCOT	LHP	412.41
	HP_WESTSCOT	LLD	957.00
	HP_WESTSCOT	LLS	13379.58
	HP_WESTSCOT	MIS	2904.97
	HP_WESTSCOT	OTB	36371.87
	HP_WESTSCOT	OTM	2561.99
	HP_WESTSCOT	OTT	5523.23
	HP_WESTSCOT	PTB	206.29
	HP_WESTSCOT	PTM	932.55
	HP_WESTSCOT	SDN	0.00
	HP_WESTSCOT	SSC	631.00
	HP_WESTSCOT	TBB	70.00

Annex 5: ICES WKMOMA data call

The data call text is available in the ICES library following this link:

https://www.ices.dk/sites/pub/Publication%20Reports/Data%20calls/WKMOMA_Data%20Call%202021.pdf

Annex 6: Thresholds for anthropogenic removals on marine mammals (OSPAR marine mammal expert group)

Note that this annex was incorporated to the report before ADGMOMA but after the draft report was sent for peer review.

Prepared by the OSPAR Marine Mammal Expert Group

Context

Assessments of bycatch will only be made for harbour porpoise (*Phocoena phocoena)*, common dolphin (*Delphinus delphis)* and grey seal (*Halichoerus grypus*). These species are the most commonly documented bycaught marine mammals in the northeast Atlantic (e.g. ICES, 2019) and therefore, the species most likely to have sufficient data available to support an assessment.

Thresholds represent the upmost limit to anthropogenic mortality beyond which conservation objectives will not be met. The threshold values derived are entirely dependent on the conservation objective to be achieved. Model-based threshold setting procedures (including the Removals Limit Algorithm and Potential Biological Removal) require a quantitative objective. OSPAR has yet to agree a conservation objective that is suitable for model-based threshold setting procedures for marine mammals. However, in OSPAR's draft North East Atlantic Environment Strategy (NEAES) 2030 Part II, the following high-level objective has been proposed: OSPAR will work with relevant competent authorities and other stakeholders to minimise, and where possible eliminate, incidental by-catch of marine mammals, birds, turtles and fish so that it does not represent a threat to the protection and conservation of these species, and to work towards strengthening the evidence base concerning this interaction by 2025.

Assessment units are being finalized. For the harbour porpoise, several assessment units have been defined during the joint NAMMCO/IRM workshop that took place in 2018 in Tromsø, Norway. These assessment units are usually smaller than an OSPAR region or a MSFD sub-regions: hence several harbour porpoise assessment units may be encompassed within a single OSPAR region or MSFD subregion (Figure 1).

OSPAR BDC agreed in 2021 on the following thresholds for marine mammals (pending further work from OMMEG completed in September 2021; see appendices for mPBR and RLA).

<table>
<tr><th colspan="3">Harbour porpoise: model-based

Conservation Objective: A population should be able to recover to or be maintained at 80% of carrying capacity[3], with 80% probability, within a 100-year period</th></tr>
<tr><td>OSPAR Region II
RLA

Removals Limit Algorithm

(<u>indicative annual anthropogenic removals limit</u> of 0.5% of the latest best abundance survey estimate. The exact figure will depends on the most up-to-date abundance estimates, and removal estimates in the North Sea)</td><td>OSPAR Region III
mPBR

Modified[4] Potential Biological Removal</td><td>OSPAR Region IV
mPBR

Modified[5] Potential Biological Removal

(<u>indicative annual anthropogenic removals limit</u> of 0 for the Iberian Peninsula assessment unit; see appendix on mPBR)</td></tr>
</table>

<table>
<tr><th colspan="3">Common dolphin: model-based

Conservation Objective: A population should be able to recover to or be maintained at 80% of carrying capacity[6], with 80% probability, within a 100-year period</th></tr>
<tr><td>OSPAR Region II
mPBR

Modified[7] Potential Biological Removal</td><td>OSPAR Region III
mPBR

Modified[8] Potential Biological Removal</td><td>OSPAR Region IV
mPBR

Modified[9] Potential Biological Removal</td></tr>
<tr><td colspan="3"><u>indicative annual anthropogenic removals limit</u> of 985 animals for the North East Atlantic (see appendix on mPBR)</td></tr>
</table>

[3] Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas. https://www.ascobans.org/

[4] Modified in the sense of having been tuned to the CO. PBR is by default tuned to the US Marine Mammal Protection Act (MMPA). See ICES (2020) pages 26-27.

[5] See footnote 2

[6] See footnote 1

[7] See footnote 2

[8] See footnote 2

[9] See footnote 2

<table>
<tr><th colspan="2">Grey seal

Conservation Objective: a population will remain at, or recover to, its maximum net productivity level MNPL (typically 50% of the populations carrying capacity), with 95% probability, within a 100-year period[10]</th></tr>
<tr><td>Region II
PBR

Potential Biological Removal

(<u>indicative anthropogenic mortality limit</u> of 7,617 individuals: see Appendix on PBR)</td><td>Region III
PBR

Potential Biological Removal</td></tr>
</table>

<u>Pilot assessment (Region I)</u>

The planned assessments for M6 in the QSR2023 will be for the harbour porpoise, common dolphin and grey seal in Regions II (Greater North Sea), III (Celtic Seas) and IV (Bay of Biscay).

The indicator measures the total mortality due to bycatch of each of the marine mammal species against thresholds. The indicator assessment will allow us to determine whether bycatch prevents achievement of the conservation objectives for the species within the assessment region. The range of harbour porpoise and grey seal extends into Region I (Iceland and Norway) and potential extension of the indicator into this region will allow a more complete understanding of any population level impacts to these species. The range of common dolphins does not extend into Region I and is therefore not a consideration for the pilot.

The amount and quality of bycatch monitoring by different countries is variable; the data received through the ICES data call from Iceland and Norway will be assessed as part of the pilot. Data may have been collected through dedicated studies/programmes, non-dedicated observers, and/or camera (Remote Electronic Monitoring, REM). The assessment areas for the pilot of Region I will correspond to those identified for the harbour porpoise during the Joint IMR/NAMMCO workshop (Figure 1).

[10] Conservation objective of the US MMPA (Wade 1998)

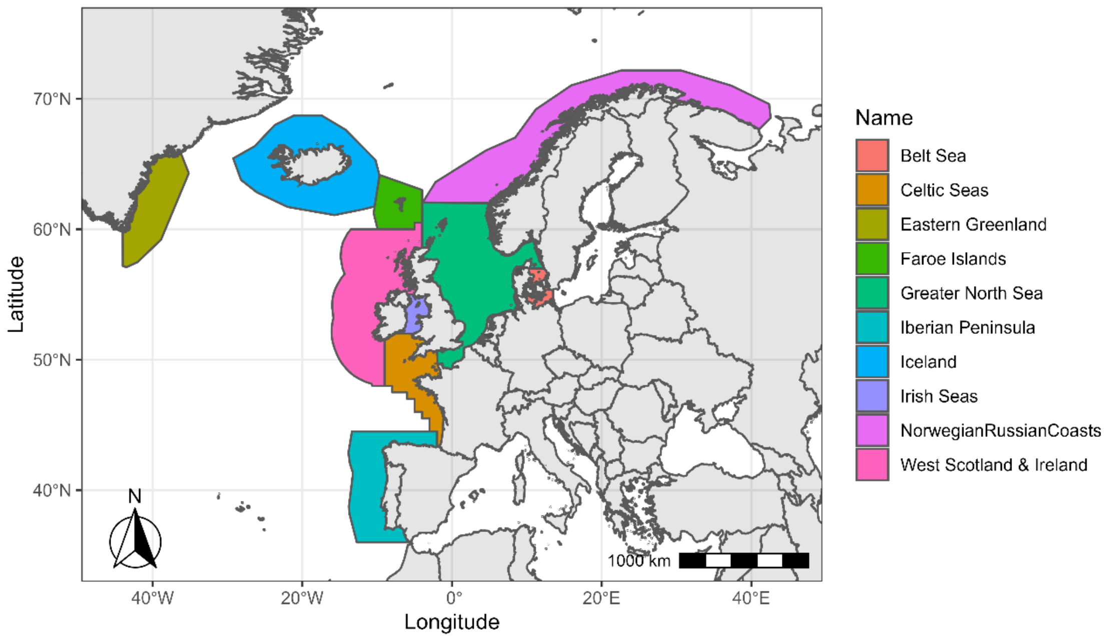

Figure 1: Assessment units for the harbour porpoise defined during the Joint IMR/NAMMCO workshop. Note that the Irish Seas AU is an area of genetic transition between the admixed porpoises located in the Celtic Sea, Bay of Biscay and and Western Channel. The Irish Seas AU may be joined to the Celtic Seas or West Scotland and Ireland AU following OMMEG meeting in September.

For the grey seal (Figure 3), the same unit defined for harbour porpoise can be used to define the Icelandic Assessment Unit. Off Norway, the single AU for harbour porpoise (NAMMCO, 2019; Figure 1) and initially, the three "management areas" (Lista – Stad; Stad – Lofoten; Vesterålen – Varanger) identified for grey seals will be used. Whether the Norwegian grey seal data will support assessments by these relatively "small-scale" units can only be determined once the data are received; a decision will be made as to whether data will need to be pooled for generating the bycatch estimates.

For the pilot assessment, the proposal is for a Potential Biological Removal (PBR) approach be explored for setting the threshold. The management objective for implementing the PBR procedure will be reviewed and a decision as to the appropriateness of the US MMMPA objective will need to be taken before an assessment can be made. It is also understood that there is already an agreed management objective for grey seals in Iceland which aims to maintain the population above or at 4100 animals.

In 2018, PBR for Icelandic harbour porpoises was estimated around 3500 porpoises (NAMMCO 2019, page 34).

In 2017, the Icelandic population size was larger than the governmental management objective for the size of the grey seal population of 4100 animals. However, according to the Icelandic red list for threatened populations, which is based on criteria put forward by IUCN, the grey seal population should, at its current level, be considered as "Vulnerable".

The PBR for Norwegian waters is about 700 harbour porpoises (NAMMCO 2019, page 37).

References

Granquist S. M. and Hauksson E. 2019. Aerial census of the Icelandic grey seal (Halichoerus grypus) population in 2017: Pup production, population estimate, trends and current status. https://www.hafogvatn.is/static/extras/images/1549015805-hv2019-02pdf1125515.pdf

ICES. 2019. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 1:51. 163 pp. http://doi.org/10.17895/ices.pub.5563

ICES. 2020. Workshop on fisheries Emergency Measures to minimize BYCatch of short-beaked common dolphins in the Bay of Biscay and harbour porpoise in the Baltic Sea (WKEMBYC). ICES Scientific Reports. 2:43. 354 pp. http://doi.org/10.17895/ices.pub.7472

North Atlantic Marine Mammal Commission and the Norwegian Institute of Marine Research (NAMMCO). 2019. Report of Joint IMR/NAMMCO International Workshop on the Status of Harbour Porpoises in the North Atlantic. Tromsø, Norway. https://nammco.no/wp-content/uploads/2020/03/final-report_hpws_2018_rev2020.pdf

Wade, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science, 14: 1-37. https://doi.org/10.1111/j.1748-7692.1998.tb00688.x

Assessment unit for the Common Dolphin

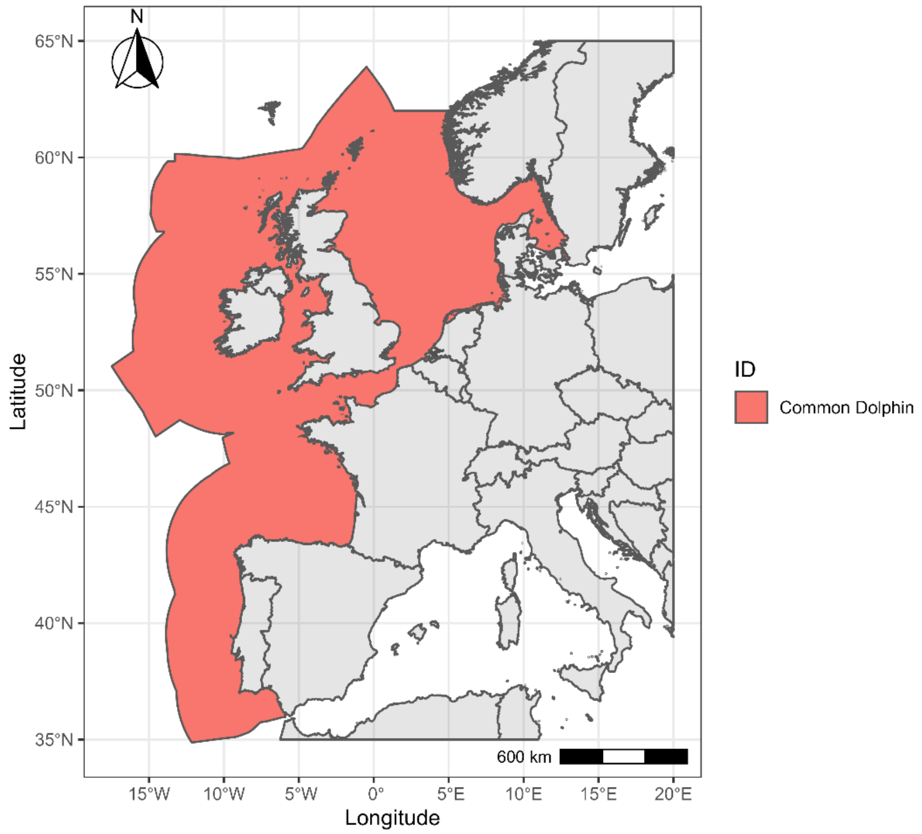

Figure 2: Assessment units for the common dolphin. Note that common dolphins are rarely observed in the North Sea. Source: OMMEG

<u>Assessment unit for Grey Seals</u>

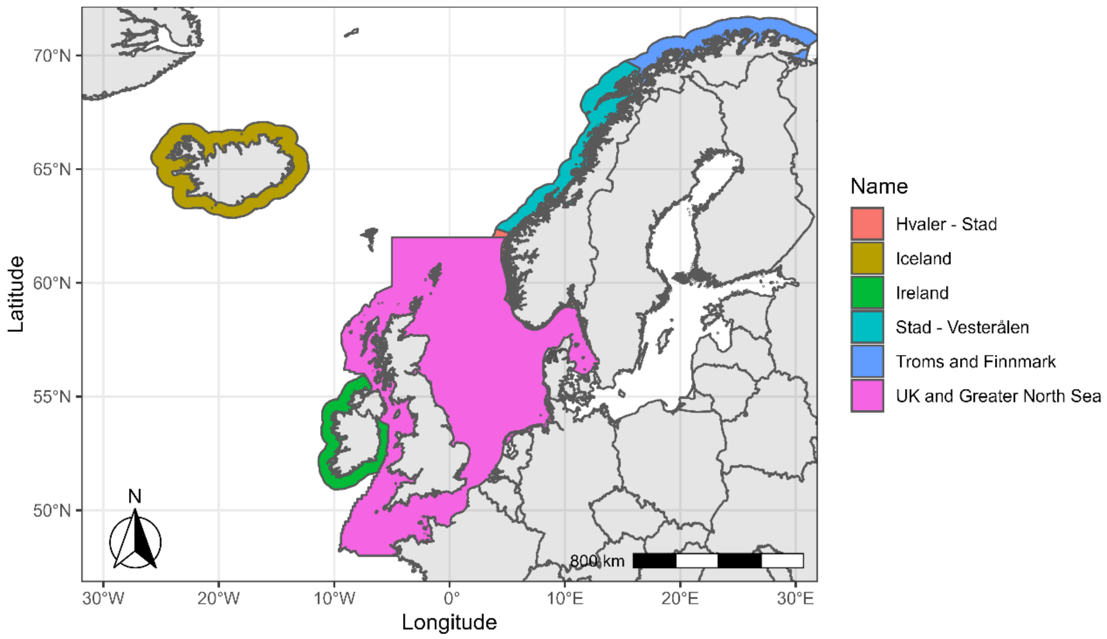

Figure 3: Assessment units for grey seals. Source: https://odims.ospar.org/en/submissions/ospar_assessment_areas_2021_02_001/

Update on development of a modified PBR (mPBR) for small cetaceans

Prepared by Matthieu Authier on behalf of the OSPAR Marine Mammal Expert Group

Context

The procedure known as the Potential Biological Removal (PBR) aims to set limits to anthropogenic mortality of small cetacean populations that allow specified conservation objectives (CO) to be met. The formula for PBR is empirically determined, using a Management Strategy Evaluation (MSE) approach whereby simulations of population dynamics under different management scenarios are used to determine, on well-defined criteria, the best values for some unknown parameters to be used to achieve COs. PBR was developed in the United States (US), and is a pragmatic approach: its data requirements are as miminal as possible in order to be applicable for 'data-needy' species, and yet is robust against several bias and uncertainties that are common in marine mammal data (Wade 1998). The PBR formula is calibrated to a given CO using simulations of population dynamics from an age-aggregated model (a.k.a. the operating model; Wade 1998). Wade (1998) calibrated PBR to the CO of the US Marine Mammal Protection Act: "*a population will remain at, or recover to, its maximum net productivity level MNPL (typically* 50% *of the populations carrying capacity), with* 95% *probability, within a* 100*-year period*".

The formula of the PBR is:

$$\text{PBR} = N_{\min} \times 0.5 \times R_{\max} \times F_{\text{R}} \quad (1)$$

where $N_{\min}$ is the minimum population estimate (i.e., the 20^{th} percentile of the best available abundance estimate, usually the most recent one, assuming a lognormal distribution), $R_{\max}$ is the maximum theoretical or estimated productivity rate of the population and F_{R} is a recovery factor between 0.1 and 1.0. For small cetaceans, the maximum theoretical or estimated productivity rate $R_{\max}$, is very difficult to estimate in practice but the value 4% is the consensus one[11] (Wade 1998). The recovery factor F_{R} is most often chosen to be between 0.1 and 0.5 and allows accounting for (i) the current depletion level of the population (the more depleted, the lower F_{R}), and (ii) for some protection against bias and uncertainties in the data. The use of $F_{\mathrm{R}} < 1.0$ buffers against uncertainties that might prevent population recovery, such as biases in the estimation of $N_{\min}$ and $R_{\max}$. Within the PBR context, the choice of $F_{\mathrm{R}} = 0.5$ as a default was determined by tuning, with simulations (see below; Wade 1998). This value is used as a default for populations that are depleted, threatened, or of unknown status, with the value allowed to be increased up to 1.0 when populations are well studied and biases in estimation of $N_{\min}$ and other parameters are thought to be negligible (Punt *et al.*, 2020).

PBR is a pragmatic approach to setting limits to anthropogenic removals when a recent abundance estimate (with its associated uncertainty in the form of a coefficient of variation) is available. In that sense, its data requirements are few: computing PBR requires only information on a species abundance in a management/assessment unit. PBR computation does not require any estimates of bycatch: default values can be assigned to $R_{\max}$ and F_{R} (Wade 1998). These default values have been tuned to the CO of the US Marine Mammal Protection Act, and will thus provide some guarantee that the CO can be reached even for 'data-needy' species. Although they are not needed to set the threshold, estimates of bycatch will nevertheless be needed at some point to assess whether the threshold is exceeded, in which case mitigation actions or emergency measures will be required.

The CO "*a population should [be able to] recover to or be maintained at* 80% *of carrying capacity, with probability* 0.8*, within a* 100*-year period*" is different from the US Marine Mammal Protection Act CO. This objective is a quantitative interpretation from OMMEG of the ASCOBANS[12] interim objective "to restore and/or maintain stocks/populations to 80% or more of the carrying capacity" (IWC 2000). No probability were associated with the ASCOBANS interim objective and OMMEG considered an 0.8 probability. Calibrating a PBR procedure to a different CO than that of the MMPA required to re-run the original simulations and scenarios of Wade (1998). In the European context, this means *e.g.* assuming a SCANS-like survey of European waters every 6 years as per MSFD aspirational requirements. This calibration can result in new default values in Equation (1), and the resulting formula will correspond to a modified PBR, or mPBR. Running simulations will allow to determine new default values for parameters $N_{\min}$ and F_{R} in the mPBR formula. These default values will be chosen so that the ASCOBANS CO can be reached with probability 0.8 across simulations despite uncertainties and bias in data for most species of cetaceans, as long as an abundance estimate of population abundance is available. Other values than the default ones may be chosen for "data-rich" species, since by definition, for these species, additional piece of information may be mobilized to obtain a more accurate mortality limit. For "data needy" species, default values are to be used.

The use of formula (1) will always result in a non-nil limit to anthropogenic removal except in the case of population extinction. Special consideration needs to be given to small populations: a small population size intrinsically increases extinction risk. The operating model behind PBR

[11] $R_{\max}$ is difficult to estimate in practice. In the original PBR, Wade (1998) reviewed the available evidence for odontocetes and found "that 4% is probably a suitable default value for odontocetes, and that 2% represents a worst-case scenario" (page 34).

[12] https://www.ascobans.org/

or mPBR is deterministic, and thus it cannot accommodate demographic stochasticity which is important when populations are small. Special provisions for small populations are thus required to remedy this shortcomings. A small population is thereafter defined as a population with less than 2 500 mature individuals (Red List criterion C of the International Union for the Conservation of Nature for an endangered population[13], *i.e.* small population size[14]). This case was considered to align OSPAR common indicator M6 thresholds with the ones for OSPAR common indicator M4 (Abundance and distribution of cetaceans, agreed at OSPAR BDC in March 2021) whereby "no further population decline should be allowed for endangered, critically endangered or vulnerable populations", due to small population size, restricted geographic distribution, and/or a known high level of pressure. In the case of small populations, because of the intrinsically heightened risk of extinction, no anthropogenic mortality should be allowed: for population with a minimal population size estimated to be less than 2 500 mature individuals, mPBR is set to 0. While a zero anthropogenic mortality limit is neither sufficient nor necessary to prevent further decline, it does increase the likelihood of no further decline compared to the alternative, and is further justified per the precautionary principle or per European Directives such as the Habitat Directive which lists all cetacean species on its Annex IV.

Method

The PBR procedure was recoded in software R (v. 4.0.5, R Core Team 2021) and is available at https://gitlab.univ-lr.fr/pelaverse/rla [15]. The conservation objective used by OMMEG for the procedure was that an initially depleted population should recover to or be maintained at 80% of carrying capacity, with probability 0.8, within a 100-year period. A depleted population means an assumed depletion level of 30% of carrying capacity (K, Wade 1998)[16].

The mPBR was re-run on the same base scenario as Wade (1998), except that survey frequency to collect new abundance information was assumed to be every 6 years instead of the original 4 years in Wade (1998). Wade (1998) was concerned about "providing quantitative definitions for N_{min}, R_{max}, and F_{R} that can be used to calculate a mortality limit which can be used to evaluate the impact of known levels of human-caused mortality of marine mammals" (page 6). In order to do so, Wade (1998) considered several scenarios about the data and their possible uncertainties or bias. As in Wade (1998) each scenario considered precise (cv = 0.2) as well as imprecise (cv = 0.8) abundance estimates. The first step of calibrating mPBR to the CO *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8, *within a 100-year period"* was to set the parameter F_{R} to its maximum value of 1, and to find a value of N_{min} (*i.e.* a quantile from a log-normal distribution) that would allow a stock initially depleted at 30% of carrying capacity (Wade 1998) to recover to 80% of K after 100 years (Figure 1). If no suitable value could

[13] https://nc.iucnredlist.org/redlist/content/attachment_files/summary_sheet_en_web.pdf

[14] The IUCN considers 5 criteria to assign a taxon to a Red List Category. These criteria are related to change in abundance (A), geographic range (B), small population size (C), very small or geographically restricted population (D), and quantitative extinction risk (E). A taxon is categorized as critically endangered, endangered or vulnerable if the best available evidence indicates that it meets any of the criteria A to E for that category.

[15] Code for reproducibility is available upon request at mauthier@univ-lr.fr

To install the library in R: remotes::install_gitlab(repo = "pelaverse/RLA", host = "https://gitlab.univ-lr.fr")

[16] Because (i) the US MMPA defines an 'Optimal Sustainable Population' as the number of animals which will result in the Maximum Net Productivity Level (MNPL) of the population or species; and (ii) the operating population model assumes the said MNPL to occur at 50% of K; a depleted population must by definition be below 50% of K.

be found, the original definition[17] of N_{min} was retained (the 20th percentile of the log normal distribution; Wade 1998, Figure 1).

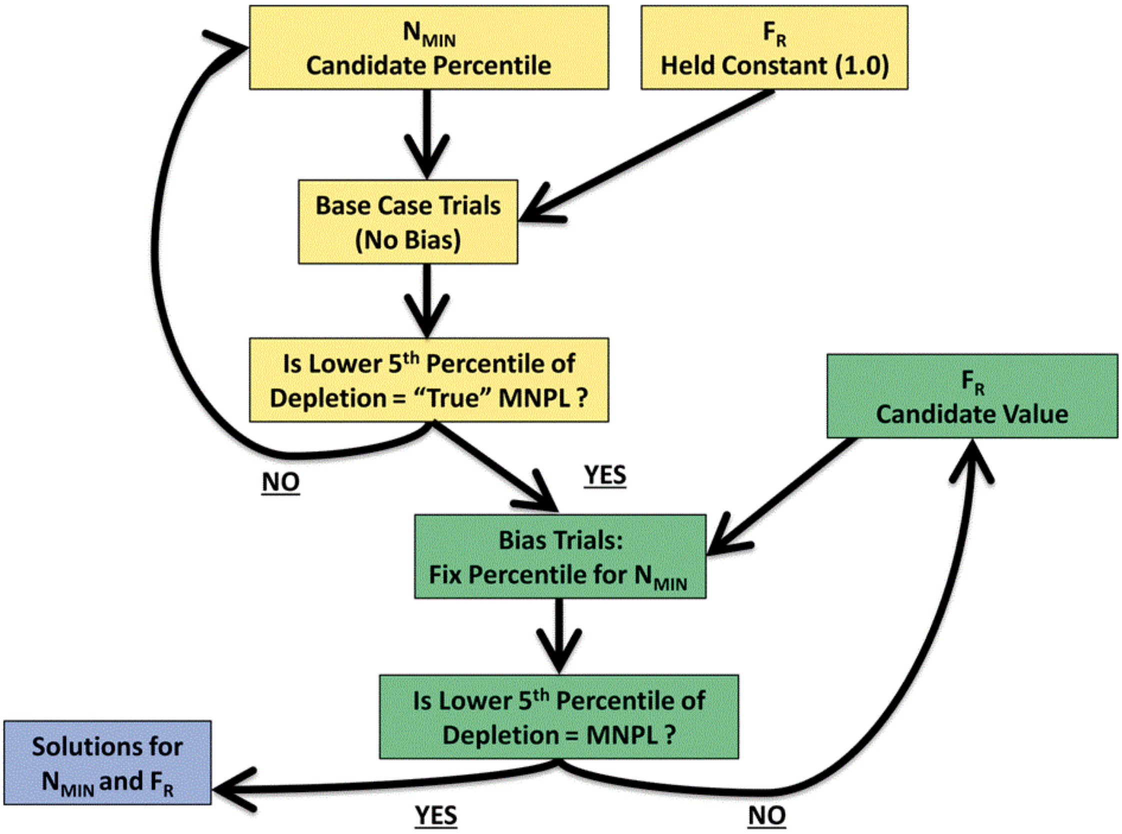

Figure 1: Flow diagram of Wade's (1998) procedure for solving for values of N_{min} and F_R that meet the MMPA CO (taken from Brandon et al. 2017, © International Council for the Exploration of the Sea 2016). Note that the ASCOBANS CO is different from the MMPA CO and this new values of N_{min} and F_R need to be determined.

Our second step to calibrate *m*PBR was to test different values of F_R between 0.1 and 1.0, eventually choosing the smallest one that would allow to reach the CO *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8*, within a 100-year period"* across all scenarios below (see also Table 1):

Scenario 0: base case

Scenario 1: bycatch underestimated by half;

Scenario 2: biased abundance estimate;

Scenario 3: biased R_{max};

Scenario 4: increased coefficient of variation in survey estimates;

Scenario 5: increased coefficient of variation in bycatch estimates;

Scenario 6: new abundance survey every 10 years;

[17] N_{min} was chosen in Wade (1998, page 8) to satisfy two criteria: (a) any population in the base case of an absence of significant biases in the data will be above the Maximum Net Productivity Level (MNPL) with probability 0.95 after 100 years, under mortality equal to PBR calculated with $F_R = 1$, and (b) a population starting at MNPL will still be at or above MNPL in 20 years with probability 0.95.

Scenario 7: true Maximum Net Productivity Level (MNPL)= 45% of K instead of the assumed 50%;

Scenario 8: true MNPL = 70% of K instead of the assumed 50%, but bycatch underestimated by half;

Scenario 9: one catastrophic mortality event of 10% in the course of the next 100 years; and

Scenario 10: K decreases by half within 100 years.

Scenarios 0-8 are the same as in Wade (1998, Figure 1) who called them "bias trials" whereby the magnitude of the assumed biases were set to a level that was considered a plausible 'worst-case scenario' (page 10). Scenarios 9 and 10 were added to assess the robustness of mPBR against a (punctual) catastrophic mortality event or a decrease in carrying capacity due for example to environmental degradation. The idea of these trials is to provide a quantitative definition for F_{R} that would still guarantee to reach a desired CO despite biases and uncertainties in the data. It is the consideration of these scenarios that allows to define the default value of F_{R} to be used in mPBR.

To calibrate mPBR, 1 000 simulations[18] were carried for each scenario and two performance metrics were assessed:

1. The probability that the population starting at a depletion level of 30% will reach 80% of K within 100 years of the mPBR implementation; and

2. The average depletion level at year 100 after implementation of the mPBR.

Results

All results can be accessed and visualized with the free statistical software R (R Core Team 2021) by typing the following lines of code[19] in an R console[20]:

```
remotes::install_gitlab(repo = "pelaverse/pbrFrTuning", host = "https://gitlab.univ-lr.fr")
library(pbrFrTuning)
run_app()
```

After examination of the performance metrics, it was evident that, for a base case scenario (*i.e.*, with cv = 0.2), no value of $N_{\min}$ allowed to reach the CO *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8, *within a 100-year period"* with the recovery factor F_{R} set to its theoretically maximum value of 1 (Figure 2).

The definition of $\boldsymbol{N_{\min}}$ for $\boldsymbol{m}$**PBR** was thus chosen to be the same as that of **PBR**, *i.e.* the **20**th percentile of the log normal distribution (Wade 1998). This choice ensures that, with probability

[18] Jade Paillé carried out these simulations as part of her MSc Thesis. Simulations were independently re-run by Mathieu Genu to confirm results.

[19] The libraries 'remotes', 'shiny' and 'golem' are required and need to be installed prior to running the app.

[20] We are indebted to Mathieu Genu for creating the Shiny app.

0.95, the population reaches the Maximum Net Productivity Level (here assumed to be 50% of K) after 100 years (Wade 1998).

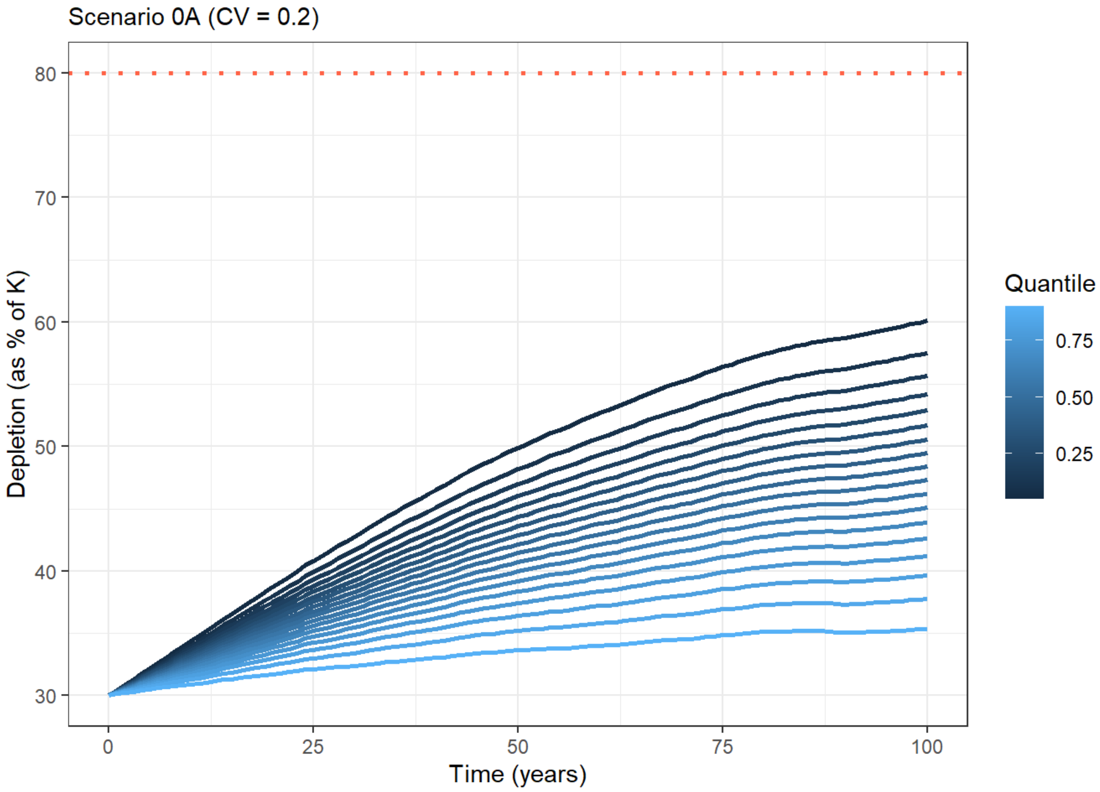

Figure 2: Tuning mPBR (step 1). The x-axis shows time, starting at 0 (years of implementation of the mPBR) up to 100 years in the future. The y-axis shows the population depletion, starting at 30% of K. Each line shows the average value across $1\ 000$ simulations for a chosen quantile (color-coded) for $N_{\min}$. The red dotted line shows the 80% of carrying capacity (K) needed to be attained under the conservation objective.

Table 1: Results of calibrating the recovery factor F_R in mPBR across the different scenarios. The letters 'A' and 'B' refer, respectively, to a precise (cv = 0.2) and imprecise (cv = 0.8) coefficient of variation of the best available abundance estimate. Yellow cells highlight scenarios wherein a parameter was changed from the base case to address uncertainty or bias in the data. Scenarios in which the CO "a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability 0.8, within a 100-year period" could be reached are color-coded in green, and in red otherwise.

Scenario	R_{max}	quantile for N_{min}	F_R	MNPL (as % of K)	K after 100 years (in % of initial K)	Survey frequency (years)	CV of abundance estimate	biased bycatch	biased abun-dance	biased R_{max}	CV of by-catch esti-mates	catastrophic mortality event
0A	4%	20%	**0.35**	50%	100%	6	20%	none	none	none	30%	0%
0B	4%	20%	**0.60**	50%	100%	6	80%	none	none	none	30%	0%
1A	4%	20%	**0.15**	50%	100%	6	20%	underestimation	none	none	30%	0%
1B	4%	20%	**0.30**	50%	100%	6	80%	underestimation	none	none	30%	0%
2A	4%	20%	**0.15**	50%	100%	6	20%	none	overestimation	none	30%	0%
2B	4%	20%	**1.00**	50%	100%	6	80%	none	underestimation	none	30%	0%
3A	4%	20%	**0.70**	50%	100%	6	20%	none	none	underestimation	30%	0%
3B	4%	20%	**1.00**	50%	100%	6	80%	none	none	underestimation	30%	0%
4A	4%	20%	**0.60**	50%	100%	6	80%	none	none	none	30%	0%
4B	4%	20%	**1.00**	50%	100%	6	160%	none	none	none	30%	0%
5A	4%	20%	**0.25**	50%	100%	6	20%	none	none	none	120%	0%
5B	4%	20%	**0.50**	50%	100%	6	80%	none	none	none	120%	0%
6A	4%	20%	**0.35**	50%	100%	10	20%	none	none	none	30%	0%
6B	4%	20%	**0.55**	50%	100%	10	80%	none	none	none	30%	0%
7A	4%	20%	**X**	45%	100%	6	20%	none	none	none	30%	0%
7B	4%	20%	**X**	45%	100%	6	80%	none	none	none	30%	0%
8A	4%	20%	**0.70**	70%	100%	6	20%	underestimation	none	none	30%	0%
8B	4%	20%	**1.00**	70%	100%	6	80%	underestimation	none	none	30%	0%
9A	4%	20%	**0.25**	50%	100%	6	20%	none	none	none	30%	10%
9B	4%	20%	**0.45**	50%	100%	6	80%	none	none	none	30%	10%
10A	4%	20%	**0.30**	50%	50%	6	20%	none	none	none	30%	0%
10B	4%	20%	**0.60**	50%	50%	6	80%	none	none	none	30%	0%

For the base case scenario (scenarios 0A and 0B in Table 1, Figure 3), the value of the recovery factor F_R allowing for the CO "a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability 0.8, within a 100-year period" to be reached was 0.35. **The maximum theoretically possible values for F_R to be used in mPBR is $F_R = 0.35$**. In other words, a difference between PBR and mPBR is that for the latter, possible values for F_R are constrained between 0.1 and 0.35. The value $F_R = 0.35$ may be justified in the case of a population or species of small cetacean for which, for example, there is reasonable scientific evidence that abundance and bycatch estimates are unbiased.

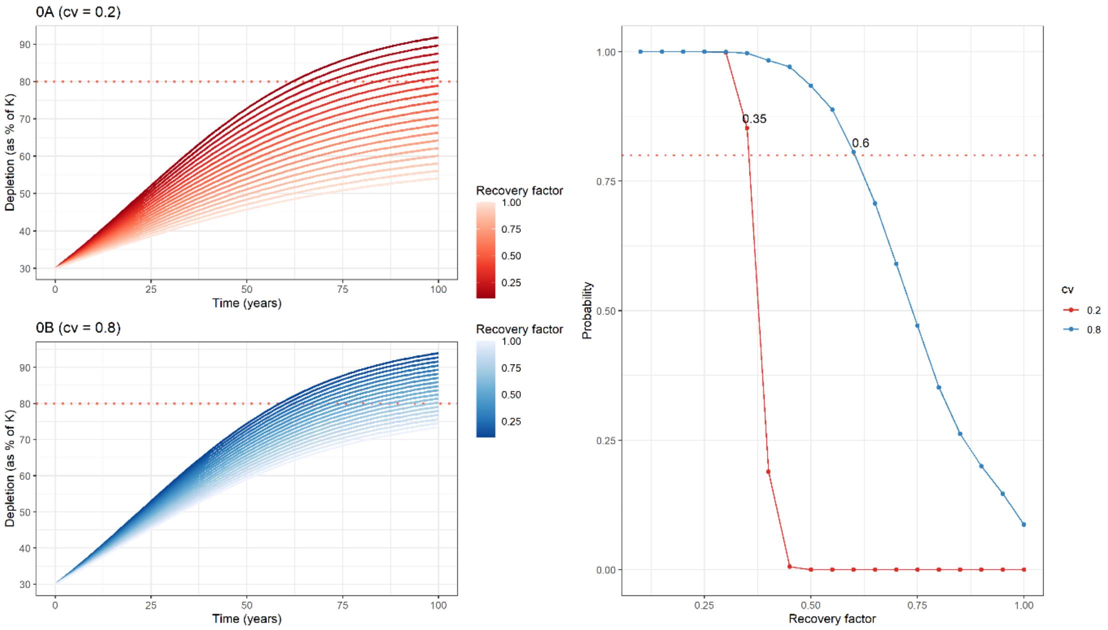

Figure 3: Tuning mPBR (step 2): scenarios 0A and 0B. Left panels: the x-axis shows time, starting at 0 (years of implementation of the mPBR) up to 100 years in the future. The y-axis shows the population depletion, starting at 30% of K. Each line shows the average value across 1 000 simulations for a chosen quantile (color-coded) for N_{min}. The red dotted lines show the 80% of carrying capacity (K) needed to be attained under the conservation objective. Right: Probability of reaching the 80% of K after 100 years as a function of the recovery factor F_r. The red dotted line show the probability 0.8.

For all 'bias trials', a value for F_R that allowed to reach the conservation objective could be found, except for scenario 7 (Table 1, Figure 4). For scenarios 1 and 2 in which abundance and bycatch are biased respectively the value of F_R that allowed to reach the CO "a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability 0.8, within a 100-year period" was $F_R = 0.15$ (Table 1).

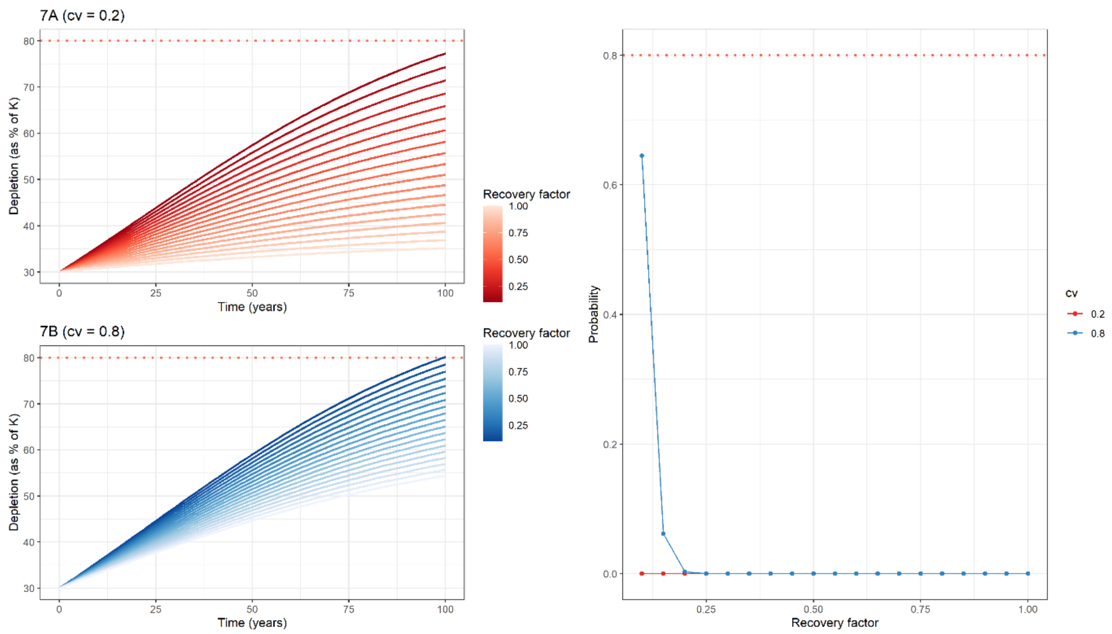

Figure 4: Tuning mPBR (step 2): scenarios 7A and 7B. Left panels: the x-axis shows time, starting at 0 (years of implementation of the mPBR) up to 100 years in the future. The y-axis shows the population depletion, starting at 30% of K. Each line shows the average value across 1 000 simulations for a chosen quantile (color-coded) for $N_{\min}$. The red dotted lines show the 80% of carrying capacity (K) needed to be attained under the conservation objective. Right: Probability of reaching the 80% of K after 100 years as a function of the recovery factor F_r. The red dotted line show the probability 0.8.

For scenario 7, in which the true Maximum Net Productivity Level (MNPL) is lower than assumed, no value of $\boldsymbol{F_R}$ between $\mathbf{0.1}$ and $\mathbf{1.0}$ allowed to reach the CO. Using the smallest possible value, i.e., $\mathbf{0.1}$, allowed to be close to, but not quite at or above, **80**% of **K** after **100** years. $\boldsymbol{m}$**PBR** is thus not robust to a downward bias in MNPL.

Results from these robustness checks (or 'bias trials', Wade 1998) suggest that the default value for the recovery factor $\boldsymbol{F_R}$ should be $\mathbf{0.1}$ for $\boldsymbol{m}$**PBR** to be robust against a wide array of potential uncertainties or biases in the data needed for its computation. In order to achieve the CO, *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* $\mathbf{0.8}$*, within a 100-year period"* (or be at least very close to it), the formula for $\boldsymbol{m}$**PBR** should be:

$$m\text{PBR} = N_{\min} \times 0.5 \times R_{\max} \times F_R$$

where $N_{\min}$ is the minimum population estimate (set as the 20th percentile of the best available abundance estimate, assuming a log normal distribution). A default value for $R_{\max}$ is 4% for small cetaceans. F_R is set to 0.1 by default but may be increased up to 0.35 when populations are well studied and biases in estimation of $N_{\min}$ and other parameters are thought to be negligible.

The mPBR sets a non-nil limit to anthropogenic removals for populations of small cetacean with more than 2,500 mature individuals. However, for small populations, *i.e.* with less than 2 500 mature individuals, no population decline should be allowed and thus mPBR is set to 0.

Examples

<u>Common dolphins (*Delphinus delphis*) in the Northeast Atlantic</u>

ICES (2020) estimated PBR = 4926 for the common dolphin in the Northeast Atlantic from $N_{\min} =$ 492 582. Implicit in the use of PBR is the MMPA CO. The CO for mPBR is: *"a population* *should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8, *within a 100-year period"*. From the minimum abundance estimate $N_{\min} = 492\,582$ (ICES 2020), mPBR can be calculated:

$$m\text{PBR} = N_{\min} \times 0.5 \times R_{\max} \times F_{\text{R}} = N_{\min} \times 0.5 \times 0.04 \times 0.1 = 492\,582 \times 0.002 = 985$$

In order to reach the CO *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8, *within a 100-year period"* **for the common dolphin in the Northeast Atlantic, anthropogenic removals should not exceed 985 individuals per year.**

Iberian harbour porpoises (*Phocoena phocoena*)

Hammond *et al.* (2021) estimated the population size of the endangered population of Iberian harbour porpoises to 2 898 (cv = 32%). The minimum population size[21] is $N_{\min} = 2122$, which is smaller than 2 500 mature individuals. Note also that the minimum population size also includes calves and juveniles, and it is thus certain that there are fewer than 2 500 mature individuals of Iberian harbour porpoises. In that case, no population decline should be allowed and mPBR is set to 0.

Summary

1 – Compute $N_{\min}$ from the best available abundance estimate N and its coefficient of variation cv

➔ if $N_{\min} < 2500$, $m\text{PBR} = 0$

➔ if $N_{\min} \geq 2500$, $m\text{PBR} = N_{\min} \times 0.5 \times R_{\max} \times F_r$

Go to step 2

2 – Values for $R_{\max}$ and F_r

➔ If no information on the target small cetacean population

$$\begin{cases} R_{\max} = 0.04 \\ F_r = 0.1 \end{cases}$$

➔ If the population is well studied and biases in parameters are thought to be negligible

$$\begin{cases} R_{\max} = 0.04 \\ F_r = 0.35 \end{cases}$$

Plug-in the values of $N_{\min}$, $R_{\max}$ and F_r to compute $m\text{PBR} = N_{\min} \times 0.5 \times R_{\max} \times F_r$

[21] Minimum population size is computed as the 20% quantile of a lognormal distribution using the command line in R : RLA::PBR(N = 2898, cv = 0.32, Fr = 0.1)

➔ If $R_{\max}$ is thought or estimated to be lower than 4%, further simulation work is required as mPBR is not currently not robust against values of $R_{\max}$ lower than the default 4%. To be conservative and align with a precautionary approach, mPBR should be set to 0 because the CO *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8*, within a 100-year period"* is not met with $R_{\max}$ lower than 4% (Figure 4, Table 1).

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An example of the estimation of an anthropogenic removal limit for grey seals in the Greater North Sea (OSPAR Region II) using Potential Biological Removal

Prepared by Kelly Macleod on behalf of the OSPAR Marine Mammal Expert Group

Background

The Potential Biological Removal (PBR) (option 1) was developed in the U.S. for the purposes of implementing the 1994 Marine Mammal Protection Act (MMPA). The PBR is an upper limit to the level of mortality that would allow a stock to achieve abundance equal to or greater than the Maximum Net Productivity Level (MNPL). A "stock" that is at at/above the MNPL is referred to as being at "optimum sustainable population". The algorithm developed for the PBR is based on the quantitative interpretation of attaining the Optimum Sustainable Population: *a population will remain at, or recover to, its maximum net productivity level MNPL (typically 50% of the populations carrying capacity), with 95% probability, within a 100-year period.* The PBR requires only information on species abundance and does not incorporate estimates of bycatch. When the abundance of the affected population is known, then the PBR approach has been shown to be robust to several sources of uncertainty (Punt et al. 2020).

The PBR is calculated as:

$$PBR = N_{min} \cdot \frac{1}{2} R_{max} \cdot F_R$$

where N_{min} is the minimum population estimate (usually the 20th percentile of the log normal distribution), R_{max} is the maximum theoretical or estimated productivity rate of the population and F_R is a recovery factor between 0.1 and 1.0.

Application to grey seals in Greater North Sea (OSPAR Region II)

To calculate the PBR for grey seals in the Greater North Sea, values of R_{max} and F_R need to be determined. The default value of R_{max} for pinnipeds is 0.12 (Wade, 1998; Taylor et al. 2003) and was applied in this example. An F_R of 1 was chosen because grey seals in the Greater North Sea are increasing throughout the region (OSPAR IA, 2017). An F_R of 1 has also been used in the UK for setting PBR limits (Thompson et al. 2021) and is justified when populations are well studied and biases in estimation of N_{min} are negligible. The US Stock Assessment Guidelines (Taylor et al. 2003) set default recovery factors as: 0.1-0.3 for endangered species or populations known to be declining; 0.4-0.5 for threatened or depleted species and for stocks of unknown status; and up to 1.0. for stocks known to be at optimum levels or of unknown status but known to be increasing.

Grey seals are not monitored in a consistent way throughout the North Sea which means deriving N_{min} based on the 20th percentile of the best abundance estimate was not feasible. The following approach to calculate N_{min} was therefore taken, using a combination of count data:

1) August counts multiplied by a "scalar" from the UK (2016-2019)

2) Moult counts from France, Netherlands and Wadden Sea (2019/2020)

The scalar applied to the UK data was based on analysis of telemetry data from 107 grey seals tagged between 1998 – 2016. The scalar is the 20th percentile of the distribution of multipliers from counts to abundances implied by that data and is 3.86 (Russell et al. 2016; Thompson et al. 2018). Counts from Belgium, Sweden and Norway were not included in this example; but there are very few seals within the OSPAR region II in these countries. This approach resulted in an N_{min} of 126,956 animals (ICES, *in prep*).

These parameters result in an anthropogenic removal limit of 7,617 grey seals in the Greater North Sea relevant to this QSR2023 assessment period. The value of the PBR should be recalculated for future assessment/uses based on the most up-to-date count data to estimate N_{min}. The value of the F_R should also be reviewed and a value chosen appropriate to the population being assessed.

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Update on development of an RLA for Harbour Porpoises in the North Sea

Prepared by Matthieu Authier on behalf of the OSPAR Marine Mammal Expert Group

Context

The procedure known as the Removals Limit Algorithm (RLA) aims to set limits to anthropogenic mortality of small cetacean populations that allow specified conservation objectives to be met. The RLA comprises a population model to simulate population dynamics and a control rule to estimate the mortality limit from estimates of absolute abundance and bycatch (or other incidental anthropogenic mortality). Hammond *et al.* (2019) developed an RLA to set limits to anthropogenic mortality of harbour porpoise (*Phocoena phocoena*) in the North Sea. This work on harbour porpoises in the North Sea came with a considerable number of assumptions and caveats and called for further developments. OMMEG undertook further developments of the procedure in 2021 with a view to improving the approach and deriving an anthropogenic mortality limit (or threshold) for harbour porpoise in the Greater North Sea harbour porpoise assessment unit.

Method

The RLA was recoded in software **R** (v. 4.0.1), https://www.R-project.org/) and **Stan** (Stan Development Team 2020) to allow testing of the RLA for the Greater North Sea harbour porpoises in the North Sea assessment unit (ICES, 2013). The conservation objective used by OMMEG for the procedure was that "a population should [be able to] recover to or be maintained at 80% of carrying capacity, with 80% probability, within a 100-year period". This objective is a quantitative interpretation of the ASCOBANS[22] "short-term practical sub-objective" "to restore and/or maintain stocks/populations to 80% or more of the carrying capacity". The RLA estimates two parameters: population growth rate (r, which was called μ in Hammond *et al.* 2019) and depletion. The latter parameter corresponds to the depletion level at the time of the best available survey estimate. For the population of harbour porpoises in the North Sea, there are three survey estimates available (SCANS surveys 1994, 2005, 2016; Hammond *et al.* 2002; 2013; 2017) to estimate these parameters. Once these two parameters have been estimated, the anthropogenic mortality limit is computed as:

$$\text{Antropogenic mortality limit} = \hat{N} \times r \times \max(0, \ depletion - \text{IPL}) \qquad (1)$$

[22] https://www.ascobans.org/

where $\hat{N}$ is the best available abundance estimate and IPL is the internal protection level set to 0.54 (*i.e.* 54% of carrying capacity K). If the estimated depletion level of the population is below the IPL, then the bycatch limit is set to 0. The bycatch limit can be expressed as a fraction of the best available abundance estimate:

$$\frac{\text{Anthropogenic mortality limit}}{\hat{N}} = r \times \max(0, depletion - \text{IPL}) \quad (2)$$

Recoding the RLA highlighted some historical choices that were a consequence of the procedures' origins as the International Whaling Commission's (IWC) Catch Limit Algorithm which was developed for depleted stock of whales (*e.g.* the default value for the IPL). One such choice was how "tuning" was achieved; this ensures the RLA limit allows the population to meet the conservation objective. In Hammond *et al.* (2019) tuning is achieved by first taking the posterior median of the anthropogenic mortality limit, and then multiplying this summary statistic by a factor γ. OMMEG decided to achieve tuning by considering different quantiles of a anthropogenic mortality limit as suggested in Hammond *et al.* (2019, page 7) or as done in Wade (1998). Tuning by choosing a quantile allows us to better take account of estimation uncertainty in parameters r and depletion.

The RLA was re-run on the same base scenario as Hammond et al. (2019), except that Maximum Net Productivity (MNP) was set to 4% instead of 2%. This value is considered a more likely value for harbour porpoise (Woodley & Read 1991; Caswell *et al.* 1998). Estimation of parameters in the RLA is achieved in a Bayesian framework, which requires to specify priors on parameters. Those priors reflect current knowledge on the possible range for population growth rate and depletion. The upper bound for the prior on population growth rate (parameter r) for the species was increased to 10% to reflect results from U.S. studies on the maximum population growth rate of harbour porpoises (Forney *et al.* 2020; Woodley and Read 1991; Caswell *et al.* 1998; Lockyer 2003). Though it should be noted, harbour porpoises in the North-east Atlantic and adjacent waters exhibit reduced reproductive rates compared to U.S. populations, possibly due to exposure to anthropogenic pollutants and/or other factors, and this maximum reproductive rate is used as an upper bound to the possible values of the population growth rate. All other inputs were identical.

To make a choice of quantile for tuning the RLA, two performance metrics were reviewed for different quantiles:

1. The probability that the population will reach 80% of K within 100 years of the RLA implementation; and

2. The average depletion level at year 100 after implementation of the RLA.

Robustness trials were also considered to address issues with respect to bias in abundance estimates, bias in bycatch estimates, changing the time horizon in the conservation objective, catastrophic mortality events and decrease in carrying capacity.

Results

All results can be accessed and visualized with the free statistical software R (R Core Team 2021) by typing the following lines of code[23] in an R console[24]:

```
remotes::install_gitlab(repo = "pelaverse/ rlaScenarioViz", host = "https://gitlab.univ-lr.fr")
```

---

[23] The libraries 'remotes', 'shiny' and 'golem' are required and need to be installed prior to running the app.

[24] We are indebted to Mathieu Genu for creating the Shiny app.

```
library(rlaScenarioViz)
run_app()
```

Base case scenario

After examination of the performance metrics, it was evident that, for a base case scenario, the conservation objective is reached with tuning set to the 55% quantile of the anthropogenic mortality limit estimated by the RLA (Figure 1). Tuning is the process of selecting a quantile in the posterior distribution of the quantity described in Equation (2) to use as the limit. The selection is done by testing several quantiles and choosing the one that meets the conservation objective as defined for this work (Figure 1).

Tuning the RLA to the conservation objective with probability 0.8 corresponds to using the 55^{th} quantile of the posterior distribution of the quantity in Equation (2) to set the anthropogenic mortality limit. Applied to the harbour porpoise in the North Sea assessment unit, this corresponds, on average across simulations, to 1.3% of the best available abundance estimate. The precise figure for the harbour porpoise in the North Sea assessment unit is currently unavailable as bycatch estimates used in Hammond et al. (2019) should no longer be used as they are being updated (Larsen and Kindt-Larsen, personal communication).

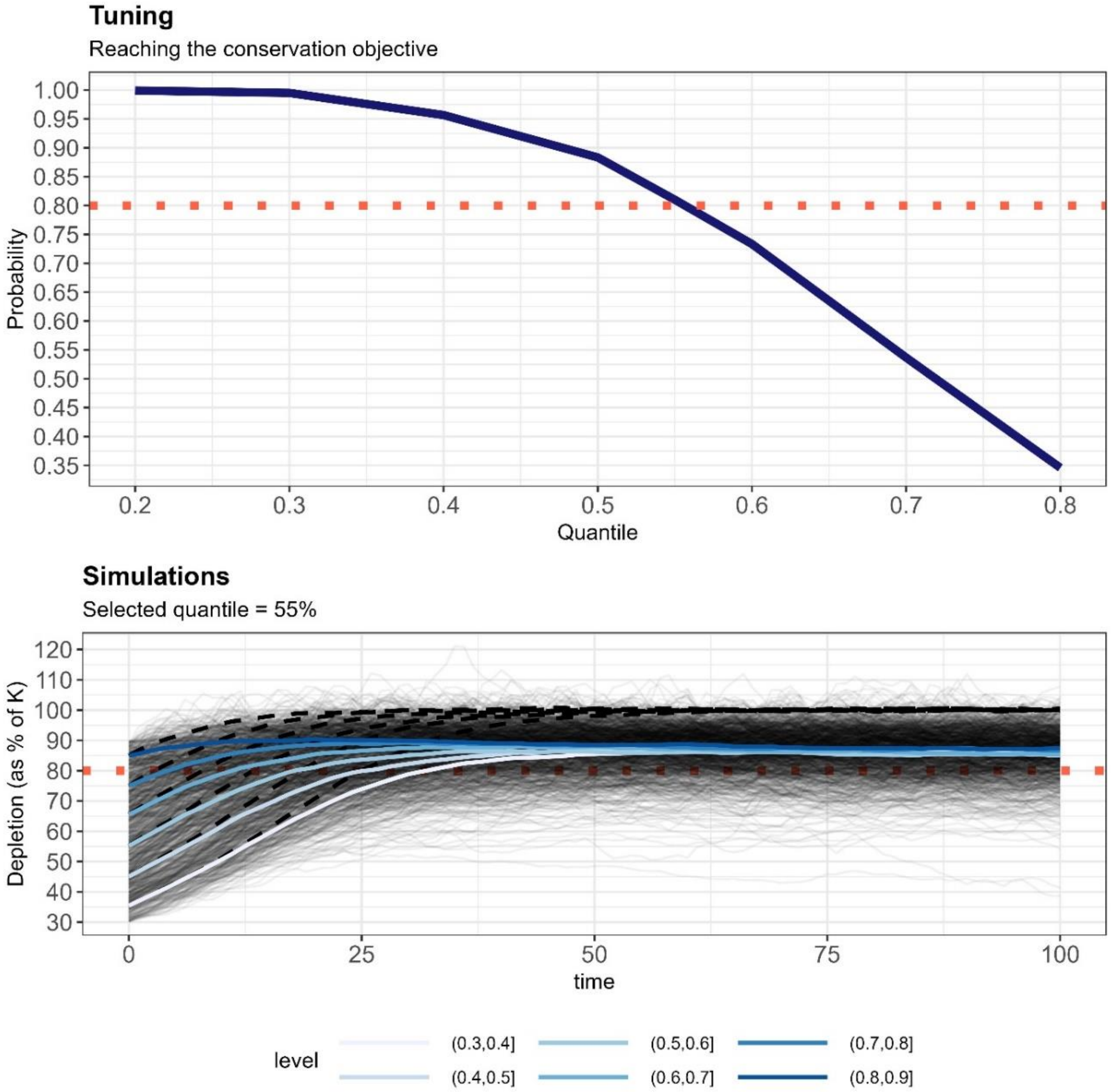

Figure 3: Tuning the RLA for the Greater North Sea harbour porpoise population in the North Sea assessment unit. Top panel: Probability to reach the conservation objective for setting the removals limit as a quantile of the posterior distribution of Eq. 2. The 55th quantile is the largest one that allows to reach the conservation objective with probability 0:8 after 100 years. Lower panel: All 1; 200 simulations (thick lines: average stratified by initial depletion level) after the implementation of the RLA and removals limit set by using the 55th quantile. The red dotted line shows the 80% of carrying capacity (K). Black hashed line shows the average population trajectory if anthropogenic removals were eliminated.

Robustness Trials

The selected quantile could vary from the 30th to the 80th across the different robustness trials (see shiny application). Trials corresponding to scenarios in which removals are underestimated by a factor 2, or abundance is overestimated and removals are underestimated both by a factor 1:5; were the most challenging ones to reach the conservation objective. The choice of the 30th quantile corresponded to an average (across all simulations) removals limit set to 0.5% of the best available abundance estimate. The precise figure for the harbour porpoise in the North Sea assessment unit is currently unavailable as bycatch estimates used in Hammond et al. (2019) should no longer be used as they are being updated (Larsen and Kindt-Larsen, personal communication).

Results from these robustness trials (Wade 1998) suggest that the 30th quantile of the posterior distribution of Eq. 2 should be used for RLA to be robust against a wide array of potential uncertainties or biases in the data needed for its computation. In order to achieve the conservation objective, *"a population should [be able to] recover to or be maintained at 80% of carrying capacity, with probability* 0.8, *within a 100-year period"*, the 30th quantile of the posterior distribution of Eq. 2 should be used.

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Annex 7: Bycatch estimates based on 2019 fishing effort

Note that this annex was incorporated to the report before ADGMOMA but after the draft report was sent for peer review.

Concerns were raised by the reviewers that fishing effort in 2020 might be unrepresentative due to the ongoing covid-19 pandemic. To address those concerns estimates based on the 2020 and 2019 fishing effort are provided here below:

Table 1. Estimated bycatch of common dolphin by OSPAR assessment unit and métier level 4 in 2019 and 2020. Numbers of individuals bycaught are obtained by multiplying the average bycatch rates (animals bycaught per day at sea) by the annual fishing effort. Lower and upper values represent 95% confidence intervals.

OSPAR Assessment unit	Métier level 4	Estimated bycatch rate 2015-2020 (95% CI)	Number of individuals bycaught 2019 (95% CI)	Number of individuals bycaught 2020 (95% CI)
Common dolphin	GNS/GND	0.014 (0.006-0.050)	1315 (703-2034)	1152 (616-1780)
Common dolphin	GTR	0.020 (0.010-0.041)	1058 (623-1241)	925 (549-1080)
Common dolphin	OTB	0.003 (0.001-0.005)	896 (481-1012)	771 (414-871)
Common dolphin	OTM	0.524 (0.240-1.126)	944 (434-1476)	978 (449-1530)
Common dolphin	OTT	0.008 (0.004-0.014)	93 (50-105)	69 (37-77)
Common dolphin	PS	0.012 (0.002-0.057)	390 (79-720)	368 (75-680)
Common dolphin	PTB	0.188 (0.064-0.546)	726 (246-1191)	599 (203-982)
Common dolphin	PTM	0.524 (0.241-1.126)	1893 (869-2960)	1544 (709-2414)
Common dolphin	All		7315 (3485-10739)	6406 (3052-9414)

Table 2. Estimated bycatch of harbor porpoise by OSPAR assessment unit and métier level 4 in 2019 and 2020. Except for the Belt Sea assessment unit, numbers of individuals bycaught are obtained by multiplying the average bycatch rates (animals bycaught per day at sea) by the annual fishing effort. Lower and upper values represent 95% confidence intervals.

OSPAR assessment unit	Métier level 4	Estimated bycatch rate 2015-2020 (95% CI)	Number of individuals bycaught 2019 (95% CI)	Number of individuals bycaught 2020 (95% CI)
Belt Sea*	GNS/GTR		601 (500-710)*	601 (500-710)*
Iceland	GNS	0.251 (0.177-0.340)	1863 (1374-2490)	1713 (1274-2276)
Celtic Seas	GNS/GND	0.007 (0.003-0.019)	407 (167-1159)	374 (152-1079)
Celtic Seas	GTR	0.011 (0.004-0.031)	287 (95-1021)	257 (85-917)
Celtic Seas	OTB/OTT	0.001 (0.0005-0.003)	125 (55-284)	108 (47-244)
Irish Seas	GNS/GND	0.021 (0.010-0.044)	2 (1-3)	2 (1-3)

OSPAR assessment unit	Métier level 4	Estimated bycatch rate 2015-2020 (95% CI)	Number of individuals bycaught 2019 (95% CI)	Number of individuals bycaught 2020 (95% CI)
Irish Seas	OTB/OTT	0.001 (0.0005-0.003)	14 (6-32)	10 (5/24)
West Scotland & Ireland	GNS	0.011 (0.004-0.031)	214 (94-481)	255 (112/572)
West Scotland & Ireland	OTB/OTT	0.001 (0.0005-0.003)	52 (23-118)	50 (22/113)
Greater North Sea**	GNS/GND	0.240 (0.137-0.409)	5696 (3021/10391)	5327 (2845/9637)
Greter North Sea**	GTR	0.247 (0.142-0.418)	690 (399/1178)	479 (277/821)
Greater North Sea	OTB/OTT	0.001 (0.0005-0.003)	145 (64/331)	123 (54/281)
Total	All		10096 (5799/18198)	9299 (5374/16677)

* From Helcom Action 2021

** Evidence of non-random sampling

Table 3. Estimated bycatch grey seals by OSPAR assessment unit and métier level 4 in 2019 and 2020. Numbers of individuals bycaught are obtained by multiplying the average bycatch rates (animals bycaught per day at sea) by the annual fishing effort. Lower and upper values represent 95% confidence intervals.

OSPAR assessment unit	Métier level 4	Estimated bycatch rate 2015-2020 (95% CI)	Number of individuals bycaught 2019 (95% CI)	Number of individuals bycaught 2020 (95% CI)
Hvaler-Stad	GNS	0.070 (0.053-0.094)	NA*	NA*
Ireland	GNS	0.041 (0.034-0.049)	82 (67-97)	108 (89-129)
Ireland	GTR	0.005 (0.002-0.009)	2 (1-4)	0
Iceland	GNS	0.086 (0.038-0.194)	971 (425-2187)	760 (333-1715)
UK and Greater North Sea	GNS/GND	0.070 (0.053-0.094)	2171 (1632-2903)	1922 (1444-2570)
UK and Greater North Sea	GTR	0.019 (0.099-0.036)	342 (179-650)	282 (147-536)
UK and Greater North Sea	OTM	0.005 (0.001-0.018)	19 (5-72)	24 (6-92)
Total			3587 (2309-5913)	3142 (2043-5129)

*Fishing effort data were incomplete for this OSPAR assessment unit and for this reason it was not possible to calculate the number of individuals bycaught.