UK Bycatch Monitoring Programme Report for 2021

Al Kingston, Len Thomas & Simon Northridge.

July 2024

The UK Bycatch Monitoring Programme is funded by the UK Department of Environment, Food and Rural Affairs and the Scottish Government.

Recommended format for the purpose of citation:

Kingston, A., Thomas, L. & Northridge, S. 2024. UK Bycatch Monitoring Programme Report for 2021. Report to DEFRA and the Scottish Government. 43pp.

Executive Summary

At-sea data collection during 2021 remained significantly impacted by the Covid-19 pandemic which led to further regional/national lockdowns and other significant restrictions on movement and social mixing to contain the spread of the virus. These measures meant that for significant parts of the year very limited at-sea data collection was undertaken.

In total 115 sea days (approximately 30% of normal levels) were monitored by at-sea observers for protected species bycatch in several net, longline and ring net fisheries during 2020.

609 specimens of species of conservation interest were recorded as bycaught, including one common dolphin, one grey seal, nine seabirds (great shearwater, guillemot, herring gull and northern gannet) and several elasmobranch and fish species including blue shark, common skate, undulate ray and shad.

A time-series of monitoring data were used, along with fishing effort data from 2020, to produce bycatch mortality estimates for harbour porpoise, common dolphin and seals in static net fisheries using a multi-annual ratio-based approach.

The point estimate for harbour porpoise bycatch in 2021, assuming full compliance by the relevant over 12m netting fleet with the ADD requirements of Regulation 2019/1241 was 865 animals (95% CL range 449-1578), and the point estimate, assuming no ADD use, was 1229 animals (95% CL range 682-2186). The point estimate for common dolphin bycatch in 2021 was 321 (95% CL range 181-728). The point estimate for seal bycatch in 2021 was 458 (95% CL range 356-836). The 2021 estimates are higher than estimates from 2020 but are similar to recent pre-covid estimates. The reduction in 2020 was driven largely by the effects of the Covid-19 pandemic which led to reduced static net fishing effort, rather than by changes in underlying bycatch rates. The presented mortality estimates include several assumptions and important caveats that are described and discussed in the report and annexes.

Official UK fishing effort statistics for 2021 show that two broad gear groups, pots and demersal trawl/seines make up the majority of total UK fishing effort in terms of days at sea, and both of these gear types showed a return to more normal effort levels following the significant drops seen in 2020. Dredges, lines and nets make up about a quarter of UK effort, and a small percentage of total UK effort is accounted for by a mix of hand gathering, pelagic trawls, purse seines/ring nets and miscellaneous gears. All these gears, except pelagic trawls which has shown stable effort levels over the mast few years, showed a return to more normal effort levels in 2021.

Contents **Page**

List of acronyms used in the report.

ADD	Acoustic Deterrent Device
AFBINI	Agri-Food and Biosciences Institute of Northern Ireland
ASCOBANS	Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas
BMP	UK Bycatch Monitoring Programme
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CL	Confidence Limit
DaS	Days at Sea
DEFRA	UK Department of Environment, Food and Rural Affairs
DCF	Data Collection Framework
DG MARE	Directorate-General for Maritime Affairs and Fisheries
EC	European Commission
EU	European Union
ICES	International Council for the Exploration of the Sea
ICRW	International Convention on the Regulation of Whaling
iFish	UK Integrated Fisheries System Holding
LCL	Lower Confidence Limit
MS	Marine Scotland
MMO	Marine Management Organisation
MPV	Marine Protection Vessel
NatureScot	Scotland Nature Agency
NE	Natural England
NGO	Non-Governmental Organisation
OSPAR	Oslo and Paris Conventions
PETS	Protected, Endangered and Threatened Species
PSG	Project Steering Group
SMRU	Sea Mammal Research Unit
SOI	Scottish Oceans Institute
ToR	Term of Reference
UCL	Upper Confidence Limit
VMS	Vessel Monitoring Systems
WG	Working Group
WGBYC	ICES Working Group on Bycatch of Protected Species
WKCOFIBYC	Workshop on Fish of Conservation and Bycatch Relevance
WKMOMA	Workshop on Estimation of Mortality of Marine Mammals due to Bycatch

1 Introduction.

The UK Bycatch Monitoring Programme (BMP) has been running since the mid 1990's and is a long-term broadscale at-sea fishery dependent data collection programme focussed on the bycatch of sensitive species including marine mammals, seabirds, marine reptiles and rare fish species. The programme is funded by the UK Department of Environment, Food and Rural Affairs (DEFRA) and the Scottish Government and has been operating in its current form since 2005 to meet the meet the requirements of European Union (EU) Regulation 812/2004 and the Habitats Directive (92/43/EEC). Prior to 2005 data collection efforts under the BMP were typically focussed on specific static net and midwater trawl fisheries with known or perceived interactions with small cetaceans. The BMP is managed by staff at the Sea Mammal Research Unit (SMRU) and Scottish Oceans Institute (SOI) at the University of St Andrews.

The UK officially left the EU on the 31st of January 2020 so work carried out under the BMP during 2021 addressed UK and other international monitoring obligations relevant to sensitive species bycatch including the UK Fisheries Act 2020, the UK Conservation of Offshore Marine Habitats and Species Regulations 2017, the UK Marine Strategy, the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the International Convention on the Regulation of Whaling (ICRW) and the Oslo and Paris Conventions (OSPAR).

This annual report provides an update on work undertaken within the BMP during the calendar year 2021. There are sections describing data collection activites and bycatch observations, UK fishing effort, marine mammal bycatch estimates, Acoustic Deterrent Device (ADD) compliance activities and relevant work undertaken by the International Council for the Exploration of the Sea (ICES) during 2021, to which BMP staff made significant contributions.

Details of the bycatch estimation procedure used in Section 4 of the report are provided in Annex 1, a summary of sampling and observed mammal and seabird bycatch from the English/Welsh at-sea catch sampling programme is provided in Annex 2, and a map showing the ICES Ecoregions and Divisions is provided in Annex 3.

1.1 Annual report format.

From 2010 to 2018 all BMP annual reports followed a standardised format which was developed by the European Commission under EU Regulation 812/2004. The standardised format was designed to ensure that bycatch monitoring data from all relevant EU member states were collated and published in a consistent and comparable way to facilitate analyses at spatial scales relevant to affected cetacean populations. The standardised reporting format is no longer necessary (see Kingston *et al*, 2021 for details). Consequently, a new

reporting format was developed for the 2019 UK annual report and the same format is used in this report covering data collection and analytical activities during 2021.

2 Bycatch Monitoring Programme Data.

2.1 Sampling designs and data collection protocols.

Sampling designs (i.e., which fisheries are sampled) within the BMP have evolved over time in response to changing legislative and policy needs. Initially the programme focussed mainly on cetacean bycatch (but bycatch of other taxa was also recorded) so most data collection activities were directed at specific fisheries considered high risk at that time, such as static net fisheries in the North Sea (ICES Subarea 4) and various midwater trawl fisheries in Subareas 4, 6 & 7 (North Sea, West of Scotland, Celtic Sea/English Channel).

Since 2005, phocids, seabirds, marine reptiles and fish species of conservation interest have been included in the programme's remit, and routine sampling efforts have expanded from static net and pelagic trawl gears and now include longline and ring net/purse seine fisheries. Sampling designs within the programme are based on existing legislative drivers and design alterations are agreed with the BMP Project Steering Group (PSG) before being implemented. Data from various demersal trawl fisheries and to a lesser extent some net and line fisheries are also provided to the BMP annually from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) at-sea observer programme.

Data collection protocols within the BMP are gear specific and are designed to ensure that all incidences of bycatch within monitored fishing operations are observed and accurately recorded. Operational and gear configuration data are also recorded and where feasible, biological samples from bycaught cetaceans are taken and added to existing sample collections for further analysis. Whole bycaught marine mammal and seabird samples are also sometimes returned to shore (under Marine Management Organisation (MMO) and Natural England (NE) licenses and with NatureScot permission) for more complete laboratory-based analysis and to supplement existing strandings based datasets. To date, over 30 whole marine mammal samples and 70 seabird samples have been collected.

2.2 Sampling during 2021.

At-sea data collection activities during 2021 remained significantly impacted by the effects of the Covid-19 pandemic. A similar pattern was observed in at-sea data collection programmes across Europe (ICES 2022).

Although less stringent than the severe restrictions in 2020, UK government measures in response to the continuing pandemic remained in place throughout 2021 and included regional/national lockdowns, limits on people mixing, non-essential business closures and reintroduction of compulsory facemasks. Normal fishing activity was permitted during 2021

and markets were less impacted than in 2020 but it was clear that many skippers and vessel owners had concerns about the risk of disruption to their operations by covid-19 transmission to crew members by observers joining a vessel. Despite developing robust pre-trip testing procedures and detailed covid-19 risk assessments for observers, access to vessels remained very limited throughout the year. This was particularly evident for larger vessels that undertake multi-day trips where there is no realistic possibility of observers and crew remaining a safe distance apart for the duration of the trip.

Consequently, most of the data collection achieved in 2021 was on smaller vessels using nets in Subarea 7 which coincides with the highest concentrations of netting effort in UK waters. Sampling of the offshore longline fishery that targets hake along the continental shelf break was achieved in the autumn of 2021 during a period when few Covid-19 measures were in place. Sampling of the ring net fishery that targets pilchard off the south coast of Cornwall was achieved in the late winter and autumn of 2021. No pelagic trawl sampling was conducted in 2021.

Table 1 provides a breakdown of sampling conducted during 2021 for nets, longlines and ring nets by vessel size and ICES Division.

Table 1: BMP sampling during 2021.

Metier level 4	Vessel size	ICES division	No of vessels	No of trips	Days at sea	No of hauls
Nets	<15m	4c	2	5	5	10
	<15m	7d	5	16	16	64
	<15m	7e	2	6	6	10
	<15m	7f	3	23	25	84
Longlines	>15m	7c	1	4	38	28
	>15m	7j	1	1	12	10
Ring nets	<15m	7f	3	8	13	14
Total			**17**	**63**	**115**	**220**

2.3 Observed bycatch.

Table 2 details observed bycatches in 2021 by ICES Division and broad gear type. Previously the species reported in this section of the report were based on a list of species of interest that was developed within the BMP and agreed with the BMP Steering Group in 2013. ICES have recently developed ecoregion specific lists for marine mammals, seabirds, turtles and fish of bycatch relevance, and these lists are now used as standard reference lists for bycatch data recording and reporting purposes throughout the Northeast Atlantic to provide consistency in national data collection programmes to facilitate more comprehensive bycatch assessments across the ICES area. The species lists for the Greater

North Sea and Celtic Seas ecoregions, where the majority of UK fishing effort occurs, are provided in Annex 4a and 4b.

In total, 609 specimens of species from the ICES reference lists for the Celtic Seas and Greater North Seas ecoregions were recorded: 3 marine mammals; 11 seabirds and 595 fish (elasmobranchs and teleosts).

Table 2: *Recorded bycatches by ICES Division and broad gear type.*

Species of bycatch relevance	**4c**	**7b**	**7c**	**7d**	**7e**	**7f**	**Total**
Elasmobranchs							
Blue shark							
Longline			2				**2**
Blue skate							
Tangle net						1	**1**
Bull huss							
Gill net				1		1	**2**
Tangle net				4		1	**5**
Skate (spp ind)							
Trammel net				1			**1**
Small eyed ray							
Tangle net				2		5	**7**
Trammel net				6			**6**
Smoothhound							
Gill net						1	**1**
Trammel net				1			**1**
Starry smoothhound							
Drift Trammel	25			9			**34**
Gill net				54			**54**
Tangle net				91			**91**
Trammel net				21			**21**
Tope							
Gill net						1	**1**
Tangle net				1			**1**
Undulate ray							
Gill net				9			**9**
Tangle net				2			**2**
Trammel net				55			**55**
Fish							
Ballan wrasse							
Gill net						78	**78**
Blackbelly rosefish							
Longline		42	149				**191**
Brill							

Trammel net				14			**14**
Gilthead bream							
Gill net				4			**4**
John dory							
Gill net						1	**1**
Tangle net					2		**2**
Trammel net				4			**4**
Shad (spp ind)							
Gill net				3			**3**
Tub gurnard							
Drift Trammel	1			1			**2**
Gill net				1			**1**
Tangle net				1			**1**
Mammals							
Common dolphin							
Tangle net						2	**2**
Grey seal							
Tangle net						1	**1**
Seabirds							
Great shearwater							
Longline			2				**2**
Guillemot							
Gill net						2	**2**
Herring gull							
Ring net						5*	**5**
Northern gannet							
Longline			2				**2**
Total	**26**	**42**	**155**	**285**	**2**	**94**	**609**

* All specimens released alive.

Estimated total weights and counts of the number of individuals by species are generally recorded directly by observers. Sometimes when high numbers of fish or elasmobranchs were caught in a particular fishing operation, only an estimated total weight for that species was recorded. In those instances, the number of individuals is estimated using the mean weight for that species from haul records where both numbers and estimated weights were available.

Two common dolphins and a grey seal were observed bycaught in tangle nets in ICES Division 7f (Bristol Channel). Two great shearwaters and 2 northern gannets were observed bycaught in longlines in Division 7c (West of Ireland). Two guillemots were recorded as bycaught in gillnets in 7f. Five herring gulls were recorded bycaught in ring nets in 7f. All seabird specimens recorded in the ring net fishery were waterlogged and were allowed to dry onboard and subsequently released alive. No information is available on post-release mortality rates. Fish and elasmobranch bycatch was recorded from longline and net fisheries

in Divisions 4c (Southern North Sea) and 7b-f (West of Ireland; English Channel and Bristol Channel) and included several shark, skate and diadromous fish species.

3 Fishing Effort Data.

3.1 Fishing effort data collection.

In the UK, fishing effort data describing the scale and geographic distribution of fishing activity were collected by three main methods: 1 - Vessel Monitoring Systems (VMS) for vessels over 12m, 2 - official logbooks / e-logs for vessels over 10m, and 3 - sales notes for vessels under 10m.

Logbook and sales note records are held together in the UK Integrated Fisheries System Holding (iFish) database. iFish currently provides the most complete and useful fishing effort dataset for assessing patterns and trends in fishing activity and for compiling fishing effort data for use in the production of broadscale bycatch estimations.

3.2 Summary of UK fishing effort.

Figure 1 shows the annual UK fishing effort in terms of recorded Days at Sea (DaS) by broad gear type for 2018 to 2021. In 2021, fishing effort across gear types appeared to have largely recovered from the significant falls seen in 2020 that was associated with the effects of the Covid-19 pandemic on national and international markets for fisheries products. Total reported effort in 2021 was 350,000 DaS, just below the 375,000 DaS reported for the two years prior to the Covid pandemic.

Most UK fishing effort is carried out by demersal trawls/seines and pot fisheries. These two gear groups account for about 75% of total UK effort. Dredges, lines (handlines and longlines) and nets (static and drift) make up a further 23% of total effort. The remaining 1-2% of effort is accounted for by a mix of hand gathering, pelagic trawls, purse seines/ring nets and miscellaneous gears.

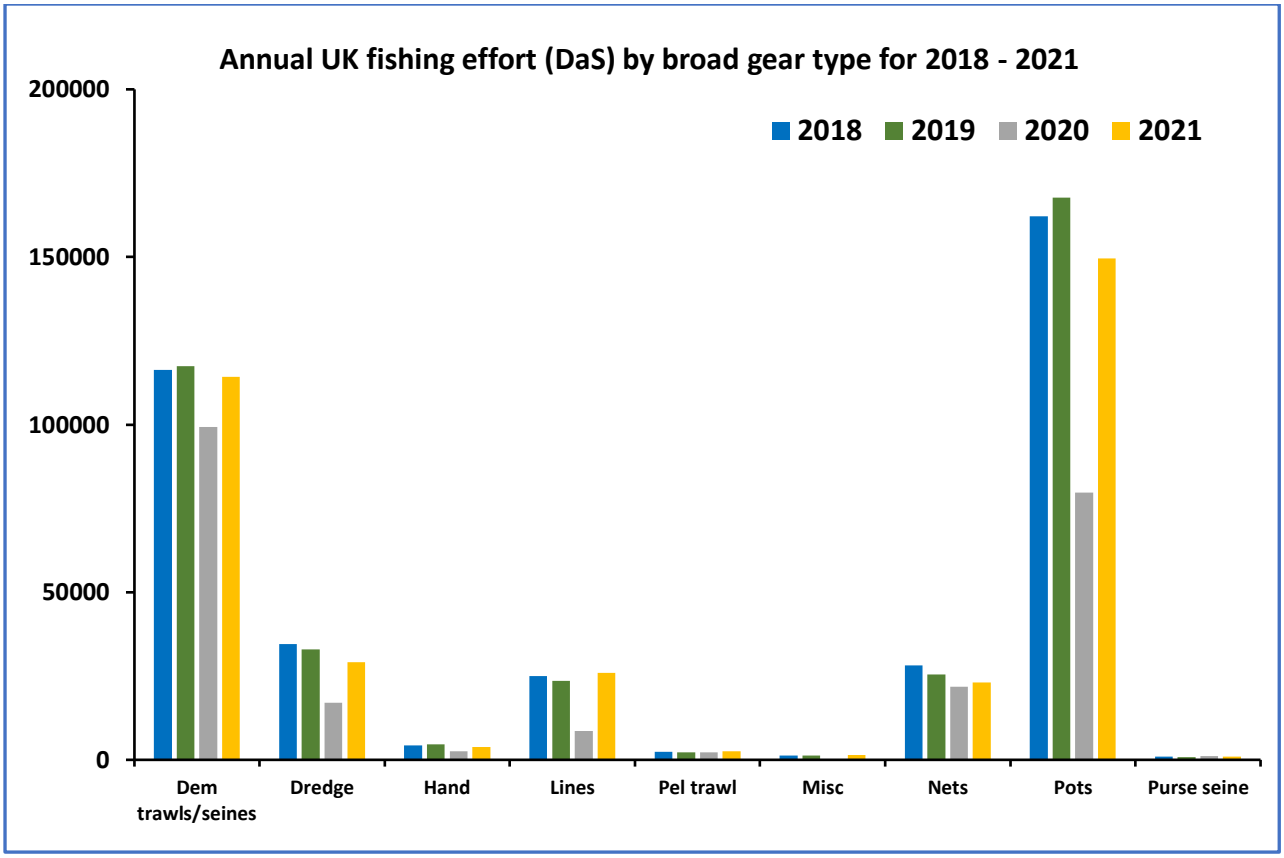


Figure 1: *UK fishing effort for 2018 - 2021 by broad gear type.*

Figure 2 provides a breakdown of 2021 UK fishing effort by ICES Division for the four main gear types sampled under the BMP.

Static net fisheries accounted for about 23,000 DaS in 2020 and are concentrated largely in ICES Subarea 7. According to the official data the highest netting effort typically occurs in Divisions 7de (Eastern and Western English Channel). However, the fleet operating in 7d is known to be highly polyvalent (i.e., many boats use a mix of gear types) and discussions with industry members in the area and unusual entries in the official effort and landings statistics, suggest that there may be some overestimation error contained in the netting statistics for that area. In 2021 the highest level of netting effort in DaS occurred in the Western English Channel (7e). Significant amounts of effort also occurred in 7f (Bristol Channel) and 4c (Southern North Sea), with lower levels in the Northern North Sea (4a), West of Scotland (6b), Irish Sea (7a) and Southwest Approaches (7g-k).

Pelagic trawl effort occurs mainly in the Northern North Sea (4a), West of Scotland (6a), Irish Sea (7a) with small amounts in other parts of Subarea 7.

Longline effort is concentrated in the Northern North Sea (4a) and West of Scotland (6a). This offshore fishery targets hake on the offshore shelf, shelf break and upper continental slope. Smaller amounts of offshore longline effort also occur to the west of Ireland (7c) and

the Great Sole Bank (Gran Sol) region in Divisions 7jk. Some longlining by smaller inshore vessels occurs in the Southern North Sea (4c) and Eastern English Channel (7d).

Ring net effort is largely confined to the Southwest UK and this fishery mostly targets pilchard off the south coast of Cornwall in Divisions 7ef. A short purse seine fishery is also undertaken targeting mackerel in Scottish waters (4a) during autumn.

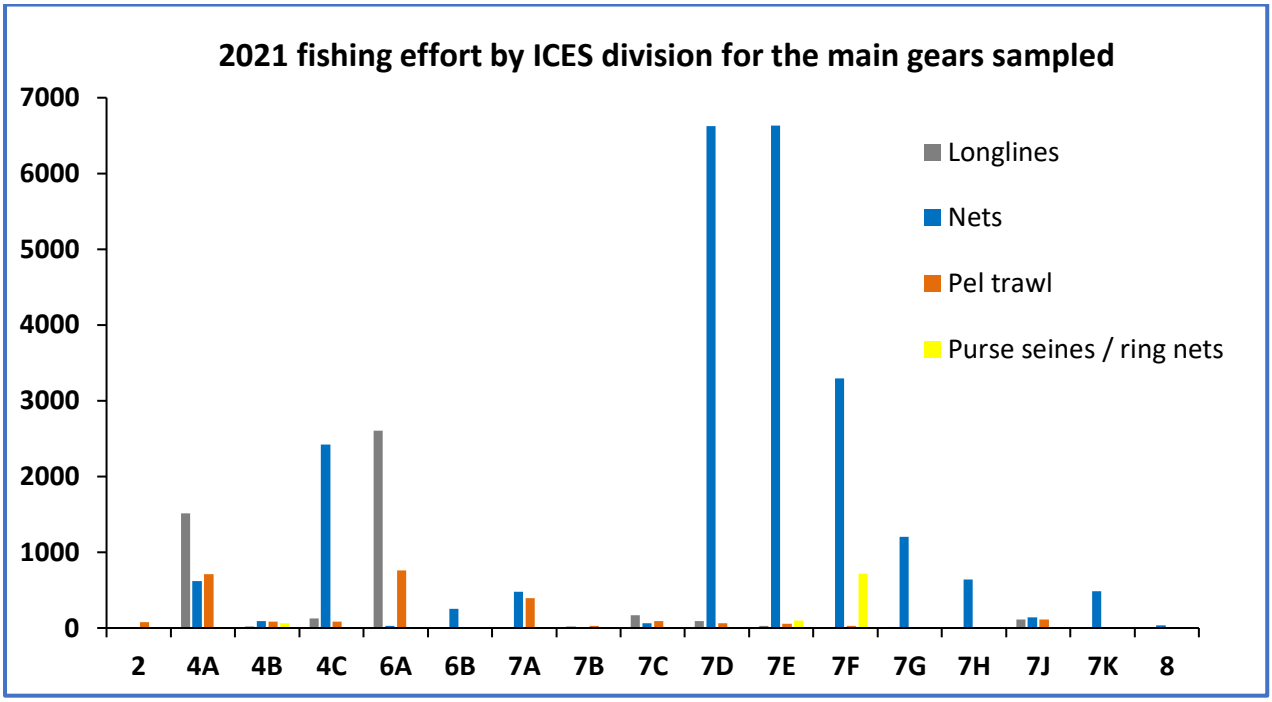


Figure 2: 2021 fishing effort by ICES Division for the main gears sampled within the BMP.

4 Marine Mammal Bycatch Estimates.

4.1 Estimation methodology.

Broadscale bycatch mortality estimates for net fisheries for harbour porpoise and common dolphin (the two most frequently bycaught cetacean species in UK fisheries) have been produced annually since 2007 using data collected under the BMP. In 2011, bycatch estimates for seals (grey and harbour seal species combined but most bycatch observations are of grey seal) were also calculated and have also been produced annually since then. Occasional marine mammal bycatch is recorded from other gear types and for other species, but because of the limited number of records the data are insufficient to calculate reliable bycatch rates, so mortality estimates are not currently produced for those metier/species combinations.

For other taxa (seabirds, fish) bycatch estimates are not yet produced routinely, but preliminary seabird bycatch mortality estimates for a variety of gears/species were

produced using BMP data in 2019 (Northridge *et al*, 2020) and for the offshore longline fishery in 2023 (Kingston *et al*, 2023).

Currently bycatch estimates are produced using a modelled ratio-based approach. A brief description of the methodology is provided in this section, along with bycatch estimates for harbour porpoise, common dolphin and seals in 2020. A more detailed description of the estimation methodology is provided in Annex 1.

The estimation approach involves the calculation of bycatch rates (number bycaught per unit of fishing effort) and associated confidence intervals from sampling data which are then applied to the total fishing effort by metier (ICES Division/gear type combination) to produce extrapolated metier specific bycatch estimates and upper and lower confidence intervals. Metier specific estimates are then summed to provide a total mortality estimate. We also calculate and present the one-sided upper 90% confidence limit. This is useful if we are interested in how likely the estimate is to be above some pre-specified level, such as a mortality threshold.

The calculation of bycatch rates uses a multi-annual approach, whereby sampling efforts over multiple years are combined to calculate underlying rates. This approach has been developed to help produce more robust mortality estimates across metiers even when overall sampling levels might be considered low. The method is also used in some other countries (e.g., Iceland, USA) and by ICES. The method has the important benefit that bycatch rates can be calculated for metiers that may not have been sampled at all, or were sampled but no bycatch was recorded, in a particular calendar year. Consequently, more complete mortality estimates can be produced then would be the case if just a single year's sampling data was used in the calculation of annual estimates. The multi-annual approach is useful for species such as marine mammals and birds that do not normally exhibit large fluctuations in population abundance or bycatch rates over the short to medium term.

The stratification system used to produce bycatch estimates involves seven different gear metiers. This system has been specifically developed within the BMP for the UK netting situation where a wide variety of different net types are used to target many different species. The system is more detailed than the metier level 5 often used in ICES bycatch assessments and better reflects the heterogeneity of UK net fisheries.

The seven basic metiers used in the analysis are:

Drift Oth - bottom drift nets for demersal species.

Drift Pel - surface or midwater drift nets for small pelagic species.

Gill - heavy twine gillnets typically used for larger gadoids (cod, pollack etc).

Gill Hake - heavy twine gillnets designed specifically to target hake.

Gill Light - light twine gillnets typically used for smaller species (red mullet, bass, whiting etc).

Gill Light Flatfish - light twine nets designed to target small flatfish (sole, plaice etc).

TangTram - large mesh, heavy twine tangle and trammel nets designed to target large fish (anglerfish, turbot etc) and shellfish (spider crab, crayfish etc).

The time periods used in the calculation of bycatch rates vary by species and metier and the reasons for this are explained in Annex 1. Harbour porpoise rates are calculated using data from 2010 onwards, except for Gill Hake where data from 2005 onwards are used. Rates are also calculated separately for hauls where ADDs were used optimally and for hauls were ADD use was suboptimal or they were not used. This allows estimation of the likely bycatch reduction associated with ADD use in the over 12m netting fleet. For common dolphin and seals (for all metiers) data from 2005 onwards are used in the calculation of bycatch rates because of low bycatch records for both species in several metiers. Due to data limitations and no strong indication in the existing data that bycatch rates of either species are significantly influenced by the use of ADDs, no distinction is currently made between hauls with or without ADDs when calculating common dolphin and seal bycatch rates.

4.2 Harbour porpoise bycatch estimates.

Table 4: *Estimated number of harbour porpoises bycaught in UK net fisheries in 2021 by metier, assuming no ADD use. Estimates rounded to nearest integer.*

Metier	Estimated annual bycatch	Two-Sided 95% LCL	Two-Sided 95% UCL	One-sided 90% UCL
Drift Oth	10	1	37	27
Drift Pel	8	1	28	20
Gill	91	42	172	143
Gill Hake	280	154	462	398
Gill Light	402	162	823	673
Gill Light Flatfish	25	1	141	99
TangTram	413	321	523	485
Total	**1229**	**682**	**2186**	**1845**

Table 5: *Estimated number of harbour porpoises bycaught in UK net fisheries 2021 by ICES Division, assuming no ADD use. Estimates rounded to nearest integer.*

ICES Division	Estimated annual bycatch	Two-Sided 95% LCL	Two-Sided 95% UCL	One-sided 90% UCL
4a	82	64	104	96
4b	4	2	7	6

4c	98	67	150	134
6b	13	10	17	15
7a	22	10	42	35
7c	3	2	4	4
7d	166	103	284	246
7e	353	242	535	472
7f	230	163	335	300
7g	167	99	266	231
7h	76	48	118	103
7j	14	9	20	18
8a	1	1	1	1
Total	**1229**	**820**	**1883**	**1661**

Table 6: *Estimated number of harbour porpoises bycaught in UK net fisheries in 2021 by metier, assuming full ADD compliance. Estimates rounded to nearest integer.*

Metier	**Estimated annual bycatch**	**Two-Sided 95% LCL**	**Two-Sided 95% UCL**	**One-sided 90% UCL**
Drift Oth	10	0	10	7
Drift Pel	8	1	15	12
Gill	82	42	132	113
Gill Hake	39	7	248	160
Gill Light	402	188	638	545
Gill Light Flatfish	25	2	101	73
TangTram	299	209	434	380
Total	**865**	**449**	**1578**	**1290**

Table 7: *Estimated number of harbour porpoises bycaught in UK net fisheries 2021 by ICES Division, assuming full ADD compliance. Estimates rounded to nearest integer.*

ICES Division	**Estimated annual bycatch**	**Two-Sided 95% LCL**	**Two-Sided 95% UCL**	**One-sided 90% UCL**
4a	10	2	110	78
4b	4	2	7	6
4c	98	0	0	0
6b	1	0	18	12
7a	22	10	41	35
7c	0	0	3	2

7d	166	103	284	246
7e	329	221	510	450
7f	196	134	300	266
7g	27	7	144	96
7h	10	2	61	41
7j	1	0	9	6
8a	0	0	2	1
Total	**864**	**481**	**1489**	**1239**

Four metiers (Drift Oth, Drift Pel, Gill Light, Gill Light Flatfish) are not typically associated with over 12m vessels. ADD use is not mandated for vessels under 12m so there is little data showing how ADD use affects bycatch rates in these metiers. This means our normal estimation procedure produces very wide confidence intervals for the very limited occasions ADDs are used in those metiers. This is a statistical artifact associated with few observed hauls with ADDs in these metiers but creates a "false" impression of high uncertainty. Instead, we used a more conservative but plausible approach where we assume bycatch rates in hauls with and without ADDs in those four metiers are the same. This has the effect of significantly reducing the uncertainty associated with the overall estimate, but the estimate is likely to be biased slightly high because we know that ADD use reduces harbour porpoise bycatch in other metiers.

The total metier-based point estimate for harbour porpoise bycatch in 2020, assuming full compliance by the over 12m fleet with the ADD requirements under retained Regulation 2019/1241, was 865 (95% CL range 449-1578 (Table 6)), and the metier-based point estimate assuming no ADD use was 1229 (95% CL range 820-1883). This suggests that full ADD compliance in 2021 would have reduced total mortality in UK net fisheries by in the region of 360 harbour porpoises.

The largest metier specific reduction (280 to 39 porpoises or 86%) associated with ADD use was in the Gill Hake metier which mainly involves vessels over 12m operating in areas where ADDs are required.

The estimated bycatch reduction associated with fully compliant ADD use in the relevant fisheries was 30% of the total estimated mortality (for all metiers) if no ADDs were used in 2021.

The estimates for 2021 are higher than the 2020 estimates. The inter-annual increase is driven by a return to more typical levels of netting effort in 2021 following lower-than-normal levels in 2020 due to the effects of the Covid-19 pandemic, rather than by changes to underlying bycatch rates.

Approximately 95% of harbour porpoise bycatch was estimated to occur in four metiers: TangTram; Gill Hake (assuming no ADD use); Gill and Gill Light. The three other metiers (Drift Oth; Drift Pel and Gill Light Flatfish) had relatively low bycatch estimates and account for about 5% of total estimated mortality. There was little bycatch reduction effect associated with the currently mandated use of ADDs in these three metiers because they mainly involve vessels under 12m which are not required to use ADDs.

Spatially, about 95% of harbour porpoise bycatch was estimated to occur in ICES Divisions 7defgh (English Channel & Celtic Sea), 4a (Northern North Sea) and 4c (Southern North Sea).

4.3 Common dolphin bycatch estimates.

Table 8: *Estimated number of common dolphins bycaught in UK net fisheries in 2021 by metier. Estimates rounded to nearest integer.*

Metier	Estimated annual bycatch	Two-Sided 95% LCL	Two-Sided 95% UCL	One-sided 90% UCL
Drift Oth	0	0	14	9
Drift Pel	0	0	10	6
Gill	21	6	53	41
Gill Hake	101	55	169	145
Gill Light	36	1	199	139
Gill Light Flatfish	0	0	66	41
TangTram	163	119	217	198
Total	**321**	**181**	**728**	**579**

Table 9: *Estimated number of common dolphins bycaught in UK net fisheries 2021 by ICES Division. Estimates rounded to nearest integer.*

ICES Division	Estimated annual bycatch	Two-Sided 95% LCL	Two-Sided 95% UCL	One-sided 90% UCL
4a	32	23	43	39
4b	1	0	2	1
4c	20	13	42	36
6b	5	4	7	6
7a	3	1	10	8
7c	1	1	1	1
7d	30	19	85	68
7e	79	52	152	128

7f	58	40	99	85
7g	59	34	96	83
7h	27	17	43	37
7j	5	3	7	7
8a	0	0	1	1
Total	**320**	**207**	**588**	**500**

The total metier-based point estimate for common dolphin bycatch in 2021 was 321 (95% CL range 181-728). Most estimated bycatch (82%) occurred in two metiers (TangTram & Gill Hake) with the remaining 18% in the Gill and Gill Light metiers. Spatially, bycatch was mainly concentrated in ICES Divisions 7e-g (Western English Channel and Celtic Sea). The estimated bycatch of 20 individuals in 4c (southern North Sea) is likely overestimated (due to an analytical artefact) as this species in rarely found in that area. The same may apply to 7d but likely to a lesser extent.

As with harbour porpoise, the estimates for 2021 are higher than the 2020 estimates. This increase in estimated total mortality is driven largely by a return to more normal netting effort levels following the significant impact on fishing effort of the Covid-19 pandemic during 2020.

The 2021 estimates do not incorporate possible effects of ADDs on common dolphin bycatch rates because these have not been fully quantified yet.

4.4 Seal bycatch estimates.

Table 10: *Estimated number of seals bycaught in UK net fisheries in 2021 by metier. Estimates rounded to nearest integer.*

Metier	**Estimated annual bycatch**	**Two-Sided 95% LCL**	**Two-Sided 95% UCL**	**One-sided 90% UCL**
Drift Oth	0	0	14	9
Drift Pel	0	0	10	6
Gill	15	3	45	34
Gill Hake	0	0	27	17
Gill Light	0	0	132	82
Gill Light Flatfish	18	0	100	70
TangTram	425	353	508	479
Total	**458**	**356**	**836**	**697**

Table 11: *Estimated number of seals bycaught in UK net fisheries 2021 by ICES Division. Estimates rounded to nearest integer.*

ICES Division	Estimated annual bycatch	Two-Sided 95% LCL	Two-Sided 95% UCL	One-sided 90% UCL
4a	84	70	101	95
4b	1	0	1	1
4c	42	35	63	58
6b	13	11	16	15
7a	2	2	9	6
7c	2	2	3	3
7d	67	49	129	109
7e	140	114	202	183
7f	82	68	117	106
7g	11	9	26	21
7h	11	9	17	15
7j	1	1	2	2
8a	1	1	1	1
Total	**457**	**371**	**687**	**615**

The metier-based point estimate for seal bycatch in 2021 was 458 (95% CL range 356-836). The latest estimates indicate that over 90% of seal bycatch occurs in the TangTram metier. Spatially, bycatch is mainly concentrated in ICES Divisions 7d-f (English Channel and Bristol Channel) with lower levels in the northern and southern North Sea (4ac). The same pattern was evident in previous assessments.

The 2021 estimates do not consider possible effects of ADDs on seal bycatch rates.

4.5 Trends in bycatch estimates.

The estimates presented in Tables 4-11 are based on data collected by bycatch observers from approximately 15,000 monitored hauls since 2005 (common dolphin, seals, harbour porpoise “Gill Hake” metier) and from 9,000 monitored hauls since 2010 (harbour porpoise all other metiers). This large dataset, combined with the analytical approach used, provides the most complete broadscale bycatch mortality estimates available for these three species for UK net fisheries.

The multi-annual approach means that any inter-annual differences in recorded bycatch are essentially smoothed out and so trends in mortality estimates over time are driven mainly

by changes in reported fishing effort levels rather than by random changes in observed bycatch rates, though both elements will influence the annual estimates to some degree.

In Figures 3-5, the bycatch estimates and confidence intervals from 2012 to 2021 are plotted to provide an indication of the likely trajectory of total bycatch mortality for each species over that period. The reducing uncertainty through the time series is due to the cumulative increase in the number of monitored hauls used in the calculations, and from 2018 onwards also from the use of a new method (see Annex 1 for details) for calculating confidence intervals.

The annual mortality estimates for harbour porpoise (assuming full ADD compliance) have been falling since 2012 (Figure 3) and this is likely, at least partly, to reflect the general pattern of gradually decreasing netting effort over this period. However, it is possible that the underlying bycatch rates are also falling, which could indicate reduced abundance, regional distribution shifts, behavioural changes or fishing gear/operational factors including changes in the relative proportions of effort by metiers with different bycatch rates. The roles of fishing effort levels and bycatch rates in the resulting estimates warrants further attention.

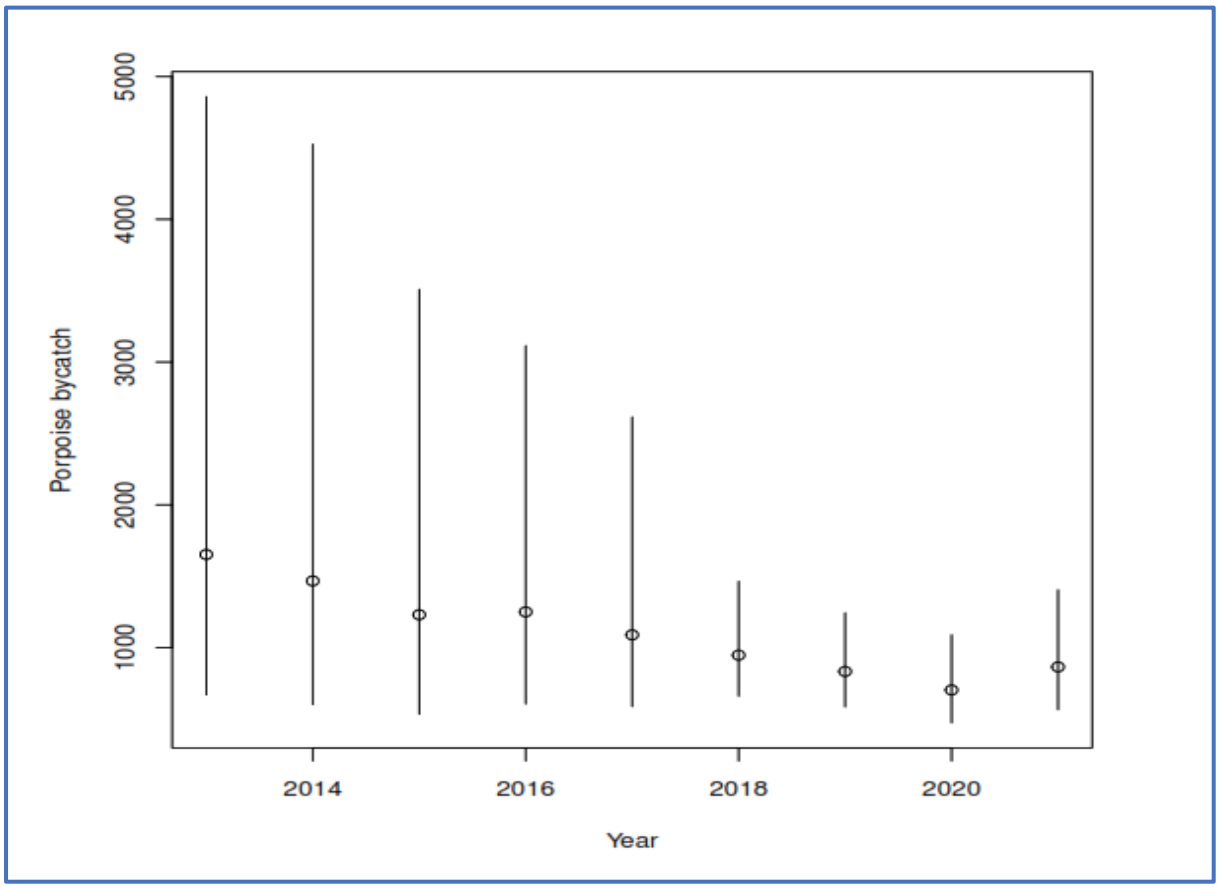


Figure 3: Harbour porpoise bycatch estimates from 2012 – 2021 (note: the reduced uncertainty evident since 2018 is related to a new method (see Annex 1) for calculating the confidence intervals).

The annual bycatch estimates for common dolphin since 2012 in Figure 4 show no clear trend. When considered against the decreasing pattern in UK netting effort this might represent a gradual increase in underlying bycatch rates for this species.

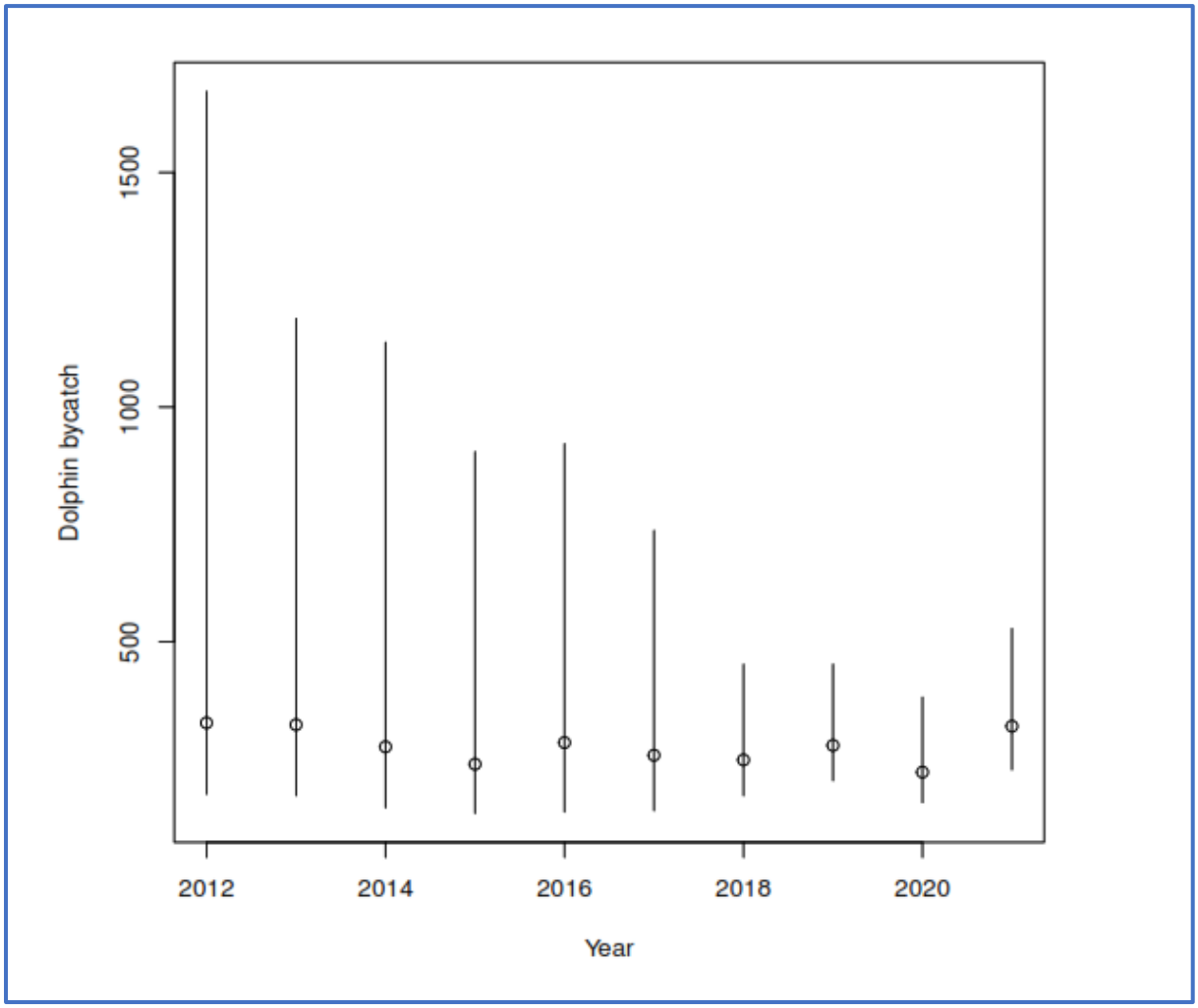


Figure 4: Common dolphin bycatch estimates from 2012 – 2021 (note: the reduced uncertainty evident since 2018 is related to a new method (see Annex 1) for calculating the confidence intervals).

Annual seal bycatch estimates since 2012 are quite variable, though there is some indication of increasing mortality up to 2016 and decreasing total mortality since then.

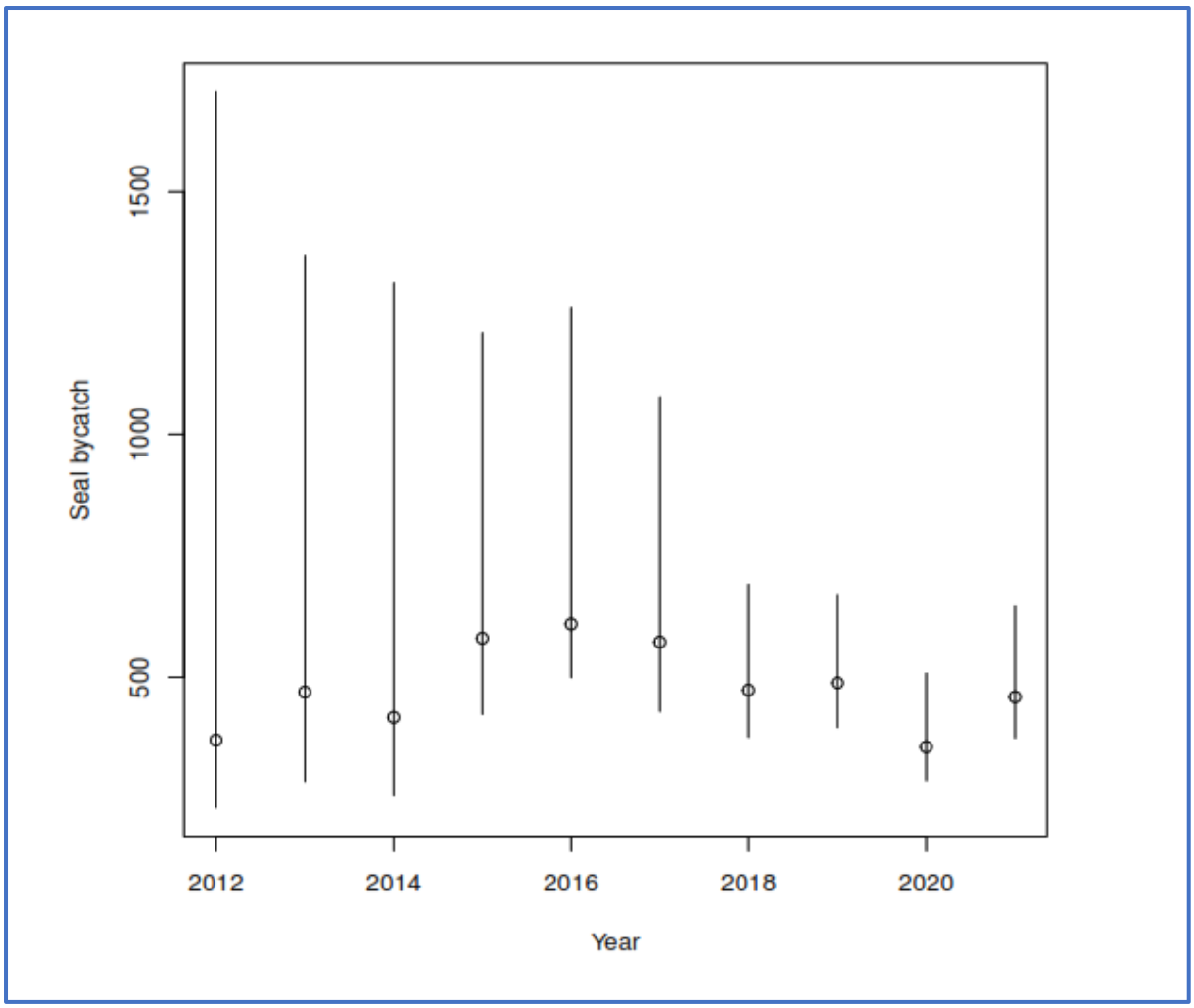


Figure 5: Seal bycatch estimates from 2012 – 2021 (note: the reduced uncertainty evident since 2018 is related to a new method (see Annex 1) for calculating the confidence intervals).

5 Acoustic Deterrent Devices.

5.1 Acoustic deterrent device legislation.

The use of ADDs in some specific net fisheries was mandated under Regulation 812/2004 from 2004 until July 2019 when Regulation 812/2004 was repealed. The ADD requirements were then moved into the new Technical Conservation Measures Regulation (2019/1241) which was transposed into UK law prior to the UK withdrawing from the EU on the 31st January 2020. The areas and fisheries covered by the relevant regulations remained the same throughout these changes and are shown in Table 12 and only apply to vessels over 12m.

Table 12: *Fisheries in which use of ADDs is mandatory under 2019/1241 (Annex XIII).*

Area	Gear
Baltic Sea Area delimited by a line running from the Swedish coast at the point at longitude 13° E, thence	Any bottom-set gill net or entangling net

due south to latitude 55° N, thence due east to longitude 14° E, thence due north to the coast of Sweden; and, Area delimited by a line running from the eastern coast of Sweden at the point at latitude 55°30′ N, thence due east to longitude 15° E, thence due north to latitude 56° N, thence due east to longitude 16° E thence due north to the coast of Sweden	
Baltic Sea sub-division 24 (except for the area covered above)	Any bottom-set gill net or entangling net
ICES subarea 4 and ICES division 3a (only from 1 August to 31 October)	Any bottom-set gill net or entangling net, or combination of these nets, the total length of which does not exceed 400 m Any bottom-set gillnet or entangling net ≥ 220 mm
ICES divisions 7e, 7f, 7g, 7h and 7j	Any bottom-set gill net or entangling net
ICES division 7d	Any bottom-set gill net or entangling net

5.2 Vessels required to use ADDs.

Based on official logbook records for 2021, twenty UK registered vessels over 12m worked in areas and seasons where the use of ADDs is required. Sixteen of these vessels worked in relevant ICES Divisions within Subarea 7 and six vessels worked in Subarea 4 with relevant net mesh sizes. Two vessels worked in Subareas 4 and 7.

5.3 Monitoring ADD efficacy.

During 2021 ongoing monitoring of ADD effectiveness in bycatch reduction terms was required under EU Regulation 2019/1241 (Annex XIII, Part A, (1.3)) which was transposed into UK law post Brexit. This monitoring is carried out under the BMP where a portion of overall netting targets are directed at fisheries where ADD use is mandatory. In addition to standard bycatch monitoring an additional element of this sampling is to collect data to support periodic assessments to see if ADDs are maintaining previously observed bycatch reduction rates for harbour porpoise and to assess effects on other species as data permits. Additional data fields are recorded in relevant fisheries on a haul-by-haul basis, including the ADD type/model, functionality, and attachment position. The exact position (latitude/longitude) and estimated distance from bycatch events to the nearest ADD is also recorded.

In 2021 no monitoring of over 12m netters was carried out in fisheries where ADD use is mandatory due to the continued impact of Covid-19 on sampling activities which restricted access to vessels carrying out multi-day trips.

5.4 ADD compliance activities.

Fishing vessel compliance with the ADD requirements of Regulation 2019/1241 are carried out by the Marine Management Organisation (MMO) in English and Welsh waters and by Marine Scotland (MS) in Scottish waters. ADDs are not required in Northern Irish waters.

Although not a formal part of the BMP contract here we provide short summaries from the MMO and MS on ADD compliance activities carried out during 2021.

The MMO carried out three shore-side inspections of over 12m netting vessels during 2021. All vessels were UK registered. No mention of ADDs was provided in the port inspection reports. Nine at-sea inspections were carried out on over 12m netting vessels involving seven French and two UK registered vessels. Seven inspections involved assessment of ADD compliance. One French vessel was questioned about their use and type of ADDs but no checks were made as the gear was not on board at the time of inspection. Five French vessels were checked for compliance of their ADDs, all of which were compliant. One British vessel was checked for compliance and issued a Written Warning for failure to use ADDs.

In Scottish waters, Marine Scotland's Marine Protection Vessels (MPVs) completed 6 at-sea inspections on gill netters, 5 in ICES Division 4a (Northern North Sea) and 1 in Division 6b (West of Scotland). Three infringements were detected during these boardings but did not relate to ADD use. ADD's (model STM DDD03L) were noted to be in use during one inspection.

There were no reports of any cetaceans being caught during the inspections, which included periods aboard the fishing vessel while nets were being hauled.

The main concentration of gillnet effort in Scottish waters continues to be along the continental shelf edge west of the Shetland Isles, with increasing netting activity taking place on the continental shelf and up to the 6-mile limit west of Shetland Isles.

Compliance operational priorities during 2021 did not focus on the netting sector and Marine Scotland will continue to base the majority of at sea inspection activities on a risk assessed basis.

6 Other significant work using BMP data and input.

6.1 ICES Working Group on Bycatch of Protected Species (WGBYC).

WGBYC was established in 2007 and collates and analyses data from the Northeast Atlantic, Baltic, Mediterranean and Black Sea on fishing effort, bycatch monitoring and mitigation

efforts, and undertakes regular bycatch mortality and risk assessments for protected and sensitive species including marine mammals, seabirds, turtles and rare fish. The BMP has contributed data to WGBYC annually since 2007 and BMP staff have been active members and/or working group chairs throughout WGBYC's existence.

Since 2017 ICES/WGBYC has issued an annual data call requesting data on fishing effort, bycatch monitoring and recorded bycatch from all ICES Member States and EU Mediterranean/Black Sea countries.

In 2021, the BMP, the UK national at-sea Data Collection Framework (DCF) programmes for England, Wales and Scotland (managed by CEFAS & Marine Scotland) and the Marine Management Organisation all provided data relating to fishing effort, sampling effort and bycatch events during 2019 and 2020 in response to the WGBYC data call. The UK data call submission is coordinated by BMP staff and consisted of approximately 4000 metier-based fishing effort records for multiple gears (totalling over 738,000 DaS), 370 metier-based monitoring records (totalling over 2,000 monitored DaS) and almost 300 metier-based bycatch records (totalling over 170 marine mammal and seabird bycatch specimens). Fish species were not included in the 2021 data call because ICES was in the process of finalising ecoregion reference lists for fish taxa (see Section 6.3).

The international scale of the data acquired by WGBYC means that bycatch issues can be considered at geographic scales that are demographically appropriate, because many protected and sensitive species populations are highly mobile and/or have wide distributions.

WGBYC meets annually for approximately one week, and works inter-sessionally, to carry out various tasks related to its Terms of Reference (ToRs). In 2021, the Working Group (WG) met online which was ICES policy at the time due to the Covid-19 pandemic. The meeting was attended by 31 scientists from multiple ICES member countries and chair-invited experts from non-ICES countries. In 2020 the WG addressed eight ToRs:

a) Review and summarise data submitted through the annual data call and other means, and other data assembled by ICES WGs to collate protected species bycatch rates and mortality estimates;

b) Collate and review information from WGFTB national reports, other WGs and other recent published documents relating to the implementation of protected species bycatch mitigation measures and ongoing bycatch mitigation trials;

c) Evaluate the range of (minimum/maximum) impacts of bycatch on protected species populations, where possible, to assess likely conservation level threats, including feed-back to the results from the Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA);

d) Review ongoing monitoring of different taxonomic groups in relation to spatial bycatch risk and fishing effort to inform coordinated sampling plans;

e) Coordinate with other ICES WGs to ensure complete compilation of data on protected species bycatch and to develop and improve on methods for bycatch monitoring, re-search and assessment;

f) Identify data requirements on fishing effort, monitoring effort, and bycatch incidents, by considering spatial, temporal and gear type aspects, for the special request advice on bird bycatch in the NEAFC Regulatory Area;

g) Identify potential research projects and funding opportunities to further understand PETS bycatch and its mitigation;

h) Continue, in cooperation with the ICES Data Centre, to develop, improve, populate through formal Data Call, and maintain the database on bycatch monitoring and relevant fishing effort in ICES and Mediterranean waters (Intersessional).

6.1.1 Summary of work within relevant WGBYC ToRs:

Of most relevance to this annual report was the work carried out by WGBYC under ToRs C (Points 1-5 below) and D (point 6 below). Several analyses were undertaken. A short summary is provided below (full details are presented in ICES 2021):

1. The group presented fishing effort, monitoring effort, monitoring coverage, bycatch numbers and calculated bycatch rates by species, ecoregion and ICES Division for marine mammals, seabirds and turtles using data from 2017 to 2020 from the WGBYC database.
2. The group produced seabird mortality estimates by species, gear type and ICES Division and presented those combinations where mortality estimates exceeded 300. The group cautioned that these estimates are only indicative because the variation around the mean cannot be fully quantified with the aggregated data currently available to WGBYC. It is expected that when the RDBES database becomes fully operational that more disaggregated data will be available to support the calculation of more reliable minimum and maximum estimates.
3. The group provided a review of turtle bycatch based on data contained in the WGBYC database. Three species: loggerhead, leatherback and green turtle were recorded as bycatch. Loggerheads were reported from the widest variety of metiers (n=8) and Ecoregions (Azores; Bay of Biscay and Iberian Coast; Western Mediterranean Sea; Adriatic Sea; Ionian Sea & Central Mediterranean Sea; Aegean-Levantine Sea) with the highest reported number of bycatches occurring in bottom and midwater trawls in the Adriatic. Leatherback turtle bycatch was reported from drifting longlines in the Azores and Western Mediterranean Sea Ecoregions, and

green turtle bycatch was reported from trammel nets in the Aegean-Levantine Sea Ecoregion.

4. The group calculated bycatch rates and confidence intervals for harbour seal in the Greater North Sea (gill and trammel nets) and Baltic Sea (gill nets) Ecoregions using data from 2017 – 2020 from the WGBYC database. The group highlighted that harbour seal abundance has increased quite significantly in the southern and eastern parts of the Greater North Sea Ecoregion.
5. The group summarised bycatch rates for harbour porpoise, grey seal and harbour seal in the Barents Sea, Norwegian Sea and Greater North Sea Ecoregions from a longer-term dataset from 2006 to 2020.
6. The group further developed a risk-based approach for highlighting metiers which might be considered under-sampled with respect to PETs bycatch. The methodology uses fishing effort, monitoring effort and species functional group risk scores to indicate those gear types and areas which are perceived to be high risk across a range of taxa, but which currently experience low or no monitoring effort. This is a broadscale approach which provides useful insights into where the risk of "not knowing" is likely to be greatest and which is being used to inform the development of coordinated regional sampling plans in the EU.

6.2 Workshop on Estimation of Mortality of Marine Mammals due to Bycatch (WKMOMA).

WKMOMA addressed a special request from OSPAR regarding bycatch mortality of harbour porpoise, common dolphin and grey seal within the OSPAR area. The main objective of the workshop was to estimate bycatch rates with CI's for static and towed gears and to extrapolate those rates to available fishing effort data to produce bycatch mortality estimates which could be compared against available mortality thresholds.

The workshop issued a specific data call to 18 of the 20 ICES countries with fisheries operating in the OSPAR area. 15 countries submitted monitoring effort and bycatch data for the period 2005 to 2020. Three countries did not submit data, so it was not possible to estimate bycatch for those areas. Fishing effort data were obtained from the ICES Regional Database (RDB). The bycatch data obtained resulted in records of 1221 harbour porpoises, 884 common dolphins and 574 grey seals.

Initial modelling of the data indicated that bycatch rates were influenced by several variables including year, month, vessel size, area and gear type. For all three species bycatch rates were higher in the more recent years of the time series (possibly indicating improved bycatch monitoring) and significant effects of area and gear type as would be expected. For harbour porpoise larger vessels showed higher bycatch rates while the opposite was true for grey seal.

Following initial data explorations, a Gamma Hurdle model was used to estimate bycatch rates per day at sea. Gamma hurdle models first estimate the probability of bycatch occurring and then estimates the intensity (number of animals per event). Combining these elements results in an overall bycatch rate per day at sea.

The total estimate for common dolphin in the entire assessment area was 6404 (CI 3051 – 9414). The highest rates were recorded in midwater trawls in ICES Subareas 6 (West of Scotland) and 8 (Bay of Biscay).

For harbour porpoise, estimates were calculated by assessment unit and were 305 (CI 134-686) for West of Scotland and Ireland, 12 (CI 6-27) in the Irish Sea and 1712 (CI 1123-1973) in Icelandic Waters. For the North Sea two estimates were produced, one higher estimate of 5929 (CI 3176-10739) included likely highly biased data that included non-representative REM coverage, and a lower estimate of 1627 (CI 922-3325) where the non-representative data had been removed. The highest bycatch rates were recorded in net fisheries by large boats in Subareas 3 and 4.

For grey seal, estimates were calculated by assessment unit and were 2229 (CI 1598-3199) in the Greater North Sea, 761 (CI 333-1715) in Icelandic Waters and 108 (CI 89-129) in the Ireland assessment unit. The highest rates were recorded by net fisheries by small boats in Subareas 5 and 7.

6.3 Workshop on Fish of Conservation and Bycatch Relevance (WKCOFIBYC).

WKCOFIBYC was convened to develop a list of fish species of conservation and/or bycatch interest to help prioritise and plan for future work within ICES.

The workshop compiled an initial Comprehensive Species List (CSL) of species of conservation concern including commercial and non-commercial species by referring to national and international legislation, red listings and other academic exercises to identify sensitive and/or protected species. The workshop initially identified 597 species from the Northeast Atlantic and Mediterranean. 193 of these were not considered relevant due to not being representative of the main fish fauna of the region.

Regional assessment lists (RALs) of priority candidate species for conservation/biodiversity-concern assessments were then developed from the CSL. The group also compiled ecoregion lists of fish species of bycatch concern or relevance (Regional Bycatch Lists (RBLs), which can be used for future planning, including informing national data collection activities and streamlining data acquisition by relevant ICES working groups (e.g., WGBYC).

The RBLs provide a comprehensive and consistent basis to inform data collection activities within national fisheries data collection programmes and have now been adopted as the working reference lists within the UK Bycatch Monitoring Programme.

The current RBLs for fish, mammals and seabirds can be found at https://ices-library.figshare.com/articles/report/ICES_Roadmap_for_bycatch_advice_on_protected_endangered_and_threatened_species_2022_/19657167

7 References

ICES. 2021. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 3:107. 168 pp. https://doi.org/10.17895/ices.pub.9256

ICES. 2021. Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA). ICES Scientific Reports. 3:106. 95 pp. https://doi.org/10.17895/ices.pub.9257

ICES. 2021. Workshop on Fish of Conservation and Bycatch Relevance (WKCOFIBYC). ICES Scientific Reports. 3:57. 125 pp. https://doi.org/10.17895/ices.pub.8194

ICES. 2022. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 4:91. 265 pp. https://doi.org/10.17895/ices.pub.21602322

Kingston, A., Thomas, L. & Northridge, S. 2021. UK Bycatch Monitoring Programme Report for 2019. Final report to DEFRA and Marine Scotland.

Kingston, A., Northridge, S., Paxton,C.G.M. & Forti Buratti, J.P. 2023. *Improving understanding of seabird bycatch in Scottish longline fisheries and exploring potential solutions.* Report to the Scottish Government.

Newcombe, R.G. 2011. Propagating imprecision: combining confidence intervals from independent sources. Communications in Statistics – Theory and Methods. 40: 3154-3180.

Northridge, S., Kingston, A. & Coram, A. 2020. Preliminary estimates of seabird bycatch by UK vessels in UK and adjacent waters. Final report to JNCC.

8 Annexes

Annex 1: Bycatch estimation procedure

Observations of marine mammal, seabird and sensitive fish species bycatch made during 2020 were added to an annual data series that began in 2000. These incremental annual observations help to refine our understanding of the bycatch process by improving sampling coverage in the various net fisheries, seasons and areas fished by UK vessels. The precision of bycatch estimates is thereby improved, while trends and changes in bycatch rates over time can be examined. The pooled observations made over several years are used to provide a best estimate of the bycatch rate (number of animals bycaught per haul) and associated confidence intervals by fishery stratum (metiers). We then use official logbook and landings data from the most recent year (2020) to estimate fishing effort for the same metiers. Finally, we apply the calculated multi-annual bycatch rate by metier to the fishing effort estimate for that metier to generate mortality estimates for the most recent year. The production of regular estimates of total annual bycatch have so far been confined to three species/groups of mammals (harbour porpoise, common dolphin and seals), pending a more in-depth analysis of data quantity and the statistical distribution of bycatch events for other species/taxa.

Preliminary data exploration and preparation

As in previous years, an initial analysis was conducted on observations from about 15,000 sampled static net hauls since 2000, over 2000 of which had one or more ADDs in place. Observations of 'pingered' hauls (mostly using the ADD model DDD-03L) began in 2008, but it is important to note that not all "pingered" hauls observed since then were equipped in accordance with current operating guidelines, whereby any part of a net should be no more than 2 km from a DDD-03 pinger.

Analyses have suggested that there may have been higher porpoise bycatch rates, over a range of net fleet lengths, prior to 2010 so we have only used the more recent years' data (from 2010) to calculate porpoise bycatch estimates for all metiers, except for hake netting where recent data with net fleets without pingers are limited, and the full dataset (from 2005) therefore provides a more robust estimate of bycatch rates in fleets without ADDs.

Ideally, we would use net fleet length as an explanatory variable in predicting the overall bycatch per metier per year, as this variable has previously been shown to have a significant effect on bycatch rates. However, net fleet length is not a mandatory field in the official logbook and landings data collection process, and we therefore use a metier approach (based on general net type and most landed species), along with ICES Division as the two primary strata for bycatch estimation.

To estimate total bycatch we need to extrapolate the number of animals bycaught per haul from our observations to the entire fleet, so we use the observer data to estimate the mean

number of hauls per day for unobserved vessel trips. This is done by trip length category and metier as there are significant differences in the operational characteristics between metiers, and because a statistical analysis of the number of hauls per day by metier suggests that there is also significant difference in the number of hauls per day between single day trips and multiday trips. Multi-day trips tend to result in fewer hauls per day because more time is generally spent steaming to and from fishing grounds and because net fleet lengths are generally substantially longer in most offshore metiers than in inshore fisheries where single day trips are typical.

Further modelling by vessel and landing characteristics would be required to incorporate net fleet length into our bycatch estimation. For this analysis we effectively assume that net fleet lengths are the same within a metier regardless of vessel size category. *A strong caveat here is that subsequent bycatch estimates will likely underestimate bycatch from larger offshore vessels and overestimate it for smaller inshore vessels.*

Calculation of rates and estimates

Bycatch rates are calculated for all species using the observed bycatch per haul rates by metier, by ADD presence (for harbour porpoise only), and by vessel size category (over 12 m and under 12 m). Binomial confidence limits were calculated using the F-distribution (exact or Clopper-Pearson) method in R. This method is known to be conservative (i.e., it produces intervals that may be wider than necessary), but other less conservative methods produce confidence intervals with zero width when no bycaught animals are observed.

Harbour porpoise rates are estimated under two scenarios, first on the assumption that no boats were using ADDs in 2020 (the baseline scenario) by using only observations made on observed hauls without ADDs, and secondly, assuming all vessels over 12 m in length were using ADDs (regardless of mesh size or net length). The second scenario is the 'best case' assumption that all vessels have fully complied with ADD use requirements and the calculated rate is based on observations on vessels over 12 m in length where ADDs were used correctly. For four metiers (Drift Oth, Drift Pel, Gill Light and Gill Light Flatfish) the no ADD rate is used for both elements because the number of observed hauls with ADDs in these metiers is very low because they are mostly prosecuted by under 12m vessels, and this leads to very wide confidence intervals for these metiers when assuming ADD presence.

The standard error (a measure of the precision of the estimate) and the upper and lower 95% 2-sided confidence limits for the rates are calculated. We also calculate and present the one-sided upper 90% confidence limit which is useful if we ask the question how likely the rate is to be above some pre-specified level.

The bycatch rates for each metier are then applied to the fleet estimates of the number of hauls per day to estimate the total bycatch by metier and area, assuming no ADDs are in use. This is done separately for each ICES division, and the area values are then summed across divisions to obtain an estimate of overall bycatch by metier. Confidence intervals are

derived by multiplying the confidence limits around the bycatch rates by the estimated number of hauls that were not observed in each metier and adding on any observed bycatch. This approach does not account for uncertainty in estimating the number of hauls per metier.

To produce the total bycatch estimate, the estimates for each metier are simply summed. Two measures of uncertainty are calculated. Firstly, the coefficient of variation (CV) which is the standard error divided by the estimate. The standard error is derived by summing the squared metier specific standard errors and taking the square root of the sum. Secondly, the 95% confidence interval is obtained from the metier-specific confidence intervals using the PropImp method of Newcombe (2011). This method for calculating confidence intervals was also used in the 2018 and 2019 estimates and leads to less uncertainty. We have not recalculated the uncertainty around the 2012 – 2017 estimates using the new method.

Bycatch estimates by ICES Division are also calculated and presented but these are based on stratified observations by metier and vessel size alone, and not by incorporating division level bycatch rates, because in several area/metier combinations there are too few observations to calculate robust rates.

Another important caveat is therefore that these estimates make assumptions about bycatch rates across areas that are likely to be biased. For example, if bycatch rates in 7d, where sampling has been limited, are systematically higher or lower than in other parts of Subarea 7, this will not be reflected in the extrapolated totals. In the absence of precise estimates of bycatch in several areas, we have estimated bycatch totals based on the best *available* data, while recognising that there are likely to be biases associated with these estimates.

Annex 2: Other Non-dedicated sampling

Table 13 (overleaf) details sampling coverage during 2021 under the English/Welsh DCF discard programme which is managed by CEFAS. As with the BMP at-sea sampling continued to be curtailed during 2021 by the Covid-19 pandemic with approximately 50 sampling days achieved. Due to the ongoing effects on at-sea sampling activities CEFAS implemented a fisher self-sampling programme where vessels were compensated for bringing discard samples ashore, but this did not include PET species.

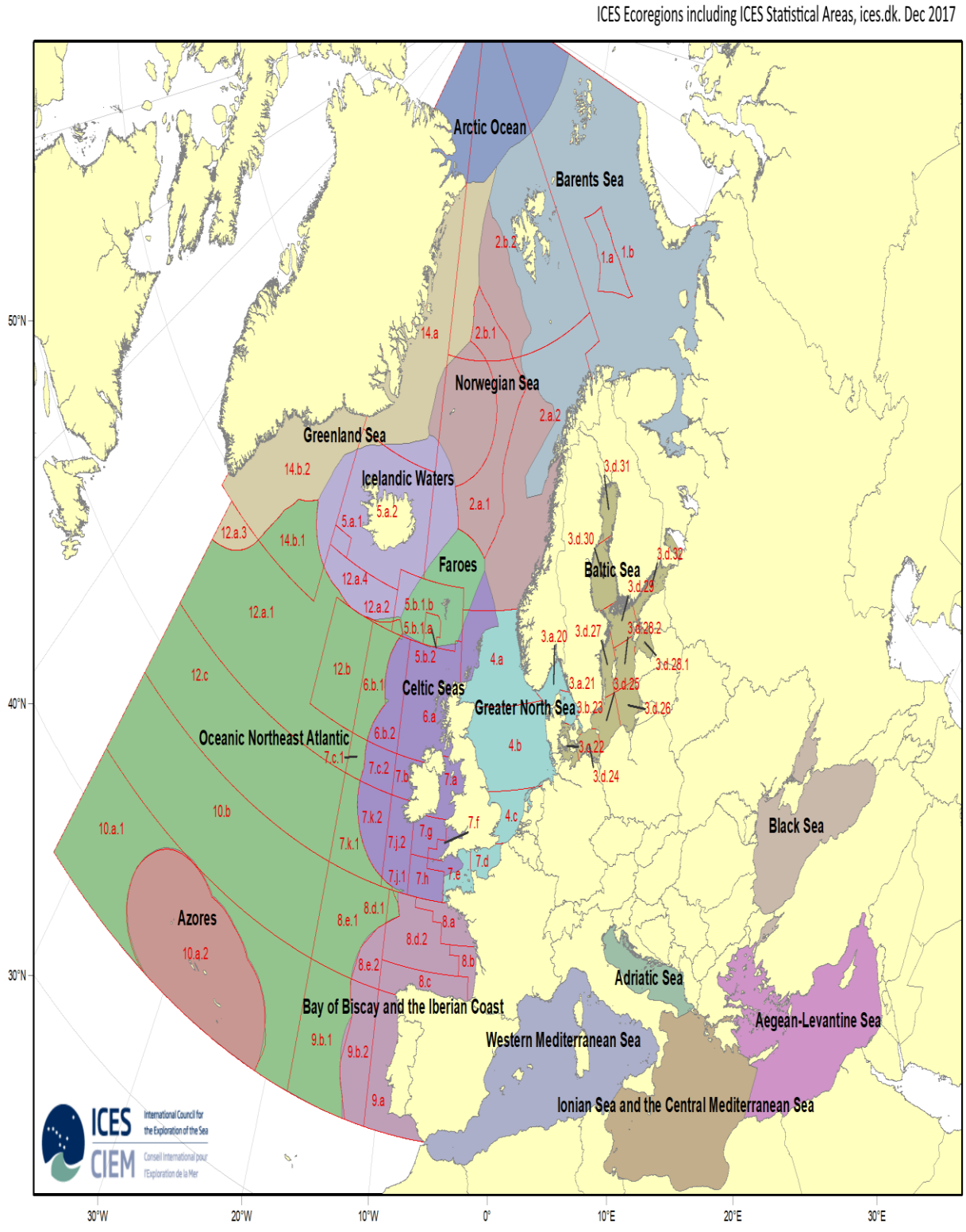
At-sea discard sampling is focussed mainly on demersal trawl gears because they are known to be a significant contributor to overall commercial species discard levels but are generally considered to be less significant for some protected species bycatch, particularly marine mammals and seabirds. This perception is supported by the presented summary data where no bycatch records of those taxa were recorded in demersal trawl gears, although data collection protocols are not specifically optimised for all PETs recording. Unraised elasmobranch (n=174) and teleost (n=1) bycatch data for relevant species are presented and are recorded more frequently from demersal trawls.

In other gears (e.g., nets and midwater trawls) which are generally considered higher risk for mammal, seabird and potentially some elasmobranch and teleost bycatch, but which are sampled less intensively under the discard programme, a single seal bycatch was recorded in a net fishery in Subarea 7.

Table 13: *Sampling during 2021 under the English/Welsh DCF programme.*

Gear	Gear Type	Area	Main Target	Days	Hauls	Dolphin	Porpoise	Seal	Seabird	Elasmobranch	Teleost	Contractor
Demersal Trawl	Beam	4c	Shrimp	2	6	0	0	0	0	0	0	CEFAS
	Dredge	7d	Scallop	2	7	0	0	0	0	0	0	CEFAS
	Otter	7d	Dover sole	1	2	0	0	0	0	4	0	CEFAS
		7d	N/A	3	6	0	0	0	0	10	0	CEFAS
		7d	Squid	1	2	0	0	0	0	5	0	CEFAS
		7e	John Dory	1	3	0	0	0	0	2	0	CEFAS
		7e	Lemon sole	1	2	0	0	0	0	83	0	CEFAS
		7e	Mixed	2	7	0	0	0	0	31	0	CEFAS
		7e	N/A	2	5	0	0	0	0	10	0	CEFAS
		7e	Ray	1	3	0	0	0	0	14	0	CEFAS
		7e	Ray, Anglerfish	1	2	0	0	0	0	0	0	CEFAS
		7e	Squid	1	2	0	0	0	0	0	0	CEFAS
		7e	Whiting	1	1	0	0	0	0	1	0	CEFAS
	Single Nephrops	4b	Nephrops	1	2	0	0	0	0	0	0	CEFAS
	Twin Otter	4b	Nephrops	1	2	0	0	0	0	0	0	CEFAS
		7e	Cuttlefish	1	2	0	0	0	0	0	1	CEFAS
	Triple Otter	7d	Dover sole	2	2	0	0	0	0	0	0	CEFAS
		7e	Dover sole	2	3	0	0	0	0	1	0	CEFAS
Lines	Handline	7e	Bass	4	27	0	0	0	0	0	0	CEFAS
Nets	Gill	7e	Anglerfish	2	8	0	0	0	0	0	0	CEFAS
		7e	Mackerel	1	3	0	0	0	0	0	0	CEFAS
		7e	N/A	1	3	0	0	0	0	0	0	CEFAS
		7e	Pollack	1	8	0	0	0	0	2	0	CEFAS
		7e	Spurdog	1	3	0	0	0	0	0	0	CEFAS
		7f	Crayfish	1	5	0	0	1	0	2	0	CEFAS
	Tangle / Trammel	7e	Anglerfish	2	5	0	0	0	0	1	0	CEFAS
		7e	N/A	1	2	0	0	0	0	0	0	CEFAS
		7f	Crayfish	2	8	0	0	0	0	8	0	CEFAS
		7f	Turbot	1	4	0	0	0	0	0	0	CEFAS
Pots	Pots	7f	Lobster	1	9	0	0	0	0	0	0	CEFAS

Annex 3 – Map of ICES Ecoregions and ICES Divisions in the Northeast Atlantic.



Annex 4. ICES species reference lists for the Greater North Sea and Celtic Seas eoregions.

4a: Greater North Sea.

Scientific name	Common name
Aythya ferina	Common pochard
Aythya fuligula	Tufted duck
Aythya marila	Greater scaup
Somateria spectabilis	King eider
Somateria mollissima	Common eider
Melanitta fusca	Velvet scoter
Melanitta nigra	Common scoter
Clangula hyemalis	Long-tailed duck
Bucephala clangula	Common goldeneye
Mergellus albellus	Smew
Mergus merganser	Goosander
Mergus serrator	Red-breasted merganser
Gavia stellata	Red-throated diver
Gavia arctica	Black-throated diver
Gavia immer	Great northern diver
Fulmarus glacialis	Northern fulmar
Puffinus griseus	Sooty shearwater
Puffinus gravis	Great shearwater
Puffinus puffinus	Manx shearwater
Podiceps grisegena	Red-necked grebe
Podiceps cristatus	Great crested grebe
Podiceps auritus	Horned grebe
Podiceps nigricollis	Black-necked grebe
Morus bassanus	Northern gannet
Phalacrocorax aristotelis	European shag
Phalacrocorax carbo	Great cormorant
Fulica atra	Eurasian coot
Rissa tridactyla	Black-legged kittiwake
Larus ridibundus	Black-headed gull
Hydrocoloeus minutus	Little gull
Ichthyaetus melanocephalus	Mediterranean gull
Larus canus	Common gull
Larus marinus	Great black-backed gull
Larus hyperboreus	Glaucous gull
Larus glaucoides	Iceland gull
Larus argentatus	Herring gull
Larus fuscus	Lesser black-backed gull
Stercorarius skua	Great skua
Stercorarius parasiticus	Arctic skua
Alle alle	Little auk

Uria lomvia	Brünnich's guillemot
Uria aalge	Common guillemot
Alca torda	Razorbill
Cepphus grylle	Black guillemot
Fratercula arctica	Atlantic puffin
Phocoena phocoena	Harbour porpoise
Tursiops truncatus	Common bottlenose dolphin
Stenella coeruleoalba	Striped dolphin
Delphinus delphis	Common dolphin
Lagenorhynchus albirostris	White-beaked dolphin
Leucopleurus acutus	Atlantic white-sided dolphin
Grampus griseus	Risso's dolphin
Orcinus orca	Killer whale
Globicephala melas	Long-finned pilot whale
Hyperoodon ampullatus	Northern bottlenose whale
Mesoplodon bidens	Sowerby’s beaked whale
Physeter macrocephalus	Sperm whale
Megaptera novaeangliae	Humpback whale
Balaenoptera acutorostrata	Common minke whale
Balaenoptera borealis	Sei whale
Balaenoptera physalus	Fin whale
Halichoerus grypus	Grey seal
Phoca vitulina	Harbour seal
Lampetra fluviatilis	River lamprey
Petromyzon marinus	Sea lamprey
Hexanchus griseus	Bluntnose sixgill shark
Galeus melastomus	Blackmouth catshark
Scyliorhinus stellaris	Greater-spotted dogfish
Centroscyllium fabricii	Black dogfish
Etmopterus princeps	Great lanternshark
Etmopterus spinax	Velvet belly lanternshark
Scymnodon ringens	Knifetooth dogfish
Somniosus microcephalus	Greenland shark
Oxynotus paradoxus	Sailfin roughshark
Deania calcea	Birdbeak dogfish
Tetronarce nobiliana	Atlantic torpedo ray
Torpedo marmorata	Marbled electric ray
Dipturus intermedius	Flapper skate
Dipturus nidarosiensis	Norwegian skate
Dipturus oxyrinchus	Long-nosed skate
Leucoraja circularis	Sandy ray
Leucoraja fullonica	Shagreen ray
Raja microocellata	Small-eyed ray
Raja undulata	Undulate ray
Rajella fyllae	Round skate

Rajella lintea	Sailray
Dasyatis pastinaca	Common stingray
Myliobatis aquila	Common eagle ray
Chimaera monstrosa	Rabbitfish
Acipenser sturio	Atlantic sturgeon
Conger conger	Conger eel
Alosa alosa	Allis shad
Alosa fallax	Twaite shad
Coregonus spp. (incl. maraena and oxyrhinchus)	Whitefish
Salmo trutta	Sea trout
Brama brama	Atlantic pomfret
Hippocampus guttulatus	Long-snouted seahorse
Hippocampus hippocampus	Short-snouted seahorse
Pomatoschistus microps	Common goby
Pomatoschistus minutus	Sand goby
Hippoglossus hippoglossus	Atlantic halibut
Mola mola	Ocean sunfish
Sparus aurata	Gilthead seabream
Sciaena umbra	Brown meagre
Umbrina cirrosa	Shi drum
Labrus bergylta	Ballan wrasse
Lycodes esmarkii	Esmark's eelpout
Zoarces viviparus	Eelpout
Anarhichas lupus	Atlantic wolffish
Anarhichas minor	Spotted wolffish
Helicolenus dactylopterus	Blackbelly rosefish
Sebastes mentella	Beaked redfish
Sebastes norvegicus	Golden redfish
Sebastes viviparus	Norway redfish
Chelidonichthys lucerna	Tub gurnard
Cyclopterus lumpus	Lumpfish
Zeus faber	John Dory
Cetorhinus maximus	Basking shark
Squatina squatina	Angel shark
Dermochelys coriacea	Leatherback turtle
Caretta caretta	Loggerhead turtle
Lepidochelys olivacea	Olive ridley turtle
Lepidochelys kempii	Kemp's ridley turtle
Chelonia mydas	Green sea turtle
Eretmochelys imbricata	Hawksbill turtle

4b: Celtic Seas

Scientific name	Common name
Aythya ferina	Common pochard
Aythya fuligula	Tufted duck
Aythya marila	Greater scaup
Somateria mollissima	Common eider
Melanitta fusca	Velvet scoter
Melanitta nigra	Common scoter
Clangula hyemalis	Long-tailed duck
Bucephala clangula	Common goldeneye
Mergus serrator	Red-breasted merganser
Gavia stellata	Red-throated diver
Gavia arctica	Black-throated diver
Gavia immer	Great northern diver
Fulmarus glacialis	Northern fulmar
Calonectris borealis	Cory's shearwater
Puffinus griseus	Sooty shearwater
Puffinus gravis	Great shearwater
Puffinus puffinus	Manx shearwater
Puffinus mauretanicus	Balearic shearwater
Podiceps grisegena	Red-necked grebe
Podiceps cristatus	Great crested grebe
Podiceps auritus	Horned grebe
Podiceps nigricollis	Black-necked grebe
Morus bassanus	Northern gannet
Phalacrocorax aristotelis	European shag
Phalacrocorax carbo	Great cormorant
Fulica atra	Eurasian coot
Rissa tridactyla	Black-legged kittiwake
Xema sabini	Sabine's gull
Larus ridibundus	Black-headed gull
Hydrocoloeus minutus	Little gull
Ichthyaetus melanocephalus	Mediterranean gull
Larus canus	Common gull
Larus marinus	Great black-backed gull
Larus hyperboreus	Glaucous gull
Larus glaucoides	Iceland gull
Larus argentatus	Herring gull
Larus michahellis	Yellow-legged gull
Larus fuscus	Lesser black-backed gull
Stercorarius skua	Great skua
Stercorarius pomarinus	Pomarine skua
Stercorarius parasiticus	Arctic skua
Stercorarius longicaudus	Long-tailed kua

Alle alle	Little auk
Uria aalge	Common guillemot
Alca torda	Razorbill
Cepphus grylle	Black guillemot
Fratercula arctica	Atlantic puffin
Phocoena phocoena	Harbour porpoise
Tursiops truncatus	Common bottlenose dolphin
Stenella coeruleoalba	Striped dolphin
Delphinus delphis	Common dolphin
Lagenorhynchus albirostris	White-beaked dolphin
Leucopleurus acutus	Atlantic white-sided dolphin
Grampus griseus	Risso's dolphin
Orcinus orca	Killer whale
Globicephala melas	Long-finned pilot whale
Ziphius cavirostris	Cuvier's beaked whale
Hyperoodon ampullatus	Northern bottlenose whale
Mesoplodon bidens	Sowerby's beaked whale
Physeter macrocephalus	Sperm whale
Megaptera novaeangliae	Humpback whale
Balaenoptera acutorostrata	Common minke whale
Balaenoptera borealis	Sei whale
Balaenoptera physalus	Fin whale
Balaenoptera musculus	Blue whale
Halichoerus grypus	Grey seal
Phoca vitulina	Harbour seal
Lampetra fluviatilis	River lamprey
Petromyzon marinus	Sea lamprey
Hexanchus griseus	Bluntnose sixgill shark
Chlamydoselachus anguineus	Frilled shark
Galeus murinus	Mouse catshark
Apristurus laurussonii	Iceland catshark
Apristurus spp.	Deep-water catshark
Sphyrna zygaena	Smooth hammerhead
Sphyrnidae	Hammerhead sharks
Centroscyllium fabricii	Black dogfish
Etmopterus princeps	Great lanternshark
Etmopterus spinax	Velvet belly lanternshark
Centroscymnus crepidater	Longnose velvet dogfish
Scymnodon ringens	Knifetooth dogfish
Somniosus microcephalus	Greenland shark
Oxynotus paradoxus	Sailfin roughshark
Deania calcea	Birdbeak dogfish
Tetronarce nobiliana	Atlantic torpedo ray
Torpedo marmorata	Marbled electric ray
Amblyraja radiata	Starry ray

Dipturus intermedius	Flapper skate
Dipturus nidarosiensis	Norwegian skate
Dipturus oxyrinchus	Long-nosed skate
Rajella bathyphila	Deep-water ray
Rajella fyllae	Round skate
Rajella lintea	Sailray
Dasyatis pastinaca	Common stingray
Myliobatis aquila	Common eagle ray
Chimaera monstrosa	Rabbitfish
Hydrolagus mirabilis	Large-eyed rabbitfish
Rhinochimaera atlantica	Atlantic longnose chimaera
Acipenser sturio	Atlantic sturgeon
Synaphobranchus kaupii	Kaup's arrowtooth eel
Conger conger	Conger eel
Alosa alosa	Allis shad
Alosa fallax	Twaite shad
Coregonus spp. (excluding C. oxy- rhinchus)	Whitefish
Salmo trutta	Sea trout
Mora moro	Common mora
Molva macrophthalma	Spanish ling
Brama brama	Atlantic pomfret
Hippocampus guttulatus	Long-snouted seahorse
Hippocampus hippocampus	Short-snouted seahorse
Gobius cobitis	Giant goby
Gobius couchi	Couch's goby
Pomatoschistus microps	Common goby
Pomatoschistus minutus	Sand goby
Scophthalmus maximus	Turbot
Scophthalmus rhombus	Brill
Hippoglossus hippoglossus	Atlantic halibut
Mola mola	Ocean sunfish
Polyprion americanus	Wreckfish
Epigonus telescopus	Black cardinal fish
Dicentrarchus punctatus	Spotted seabass
Sparus aurata	Gilt-head seabream
Sciaena umbra	Brown meagre
Labrus bergylta	Ballan wrasse
Zoarces viviparus	Eelpout
Anarhichas lupus	Atlantic wolffish
Anarhichas minor	Spotted wolffish
Helicolenus dactylopterus	Blackbelly rosefish
Sebastes mentella	Beaked redfish
Sebastes viviparus	Norway redfish
Scorpaena scrofa	Red scorpionfish
Chelidonichthys lucerna	Tub gurnard

Cyclopterus lumpus	Lumpfish
Alepocephalus bairdii	Baird's slickhead
Zeus faber	John Dory
Cetorhinus maximus	Basking shark
Squatina squatina	Angel shark
Dermochelys coriacea	Leatherback turtle
Caretta caretta	Loggerhead turtle
Lepidochelys olivacea	Olive ridley turtle
Lepidochelys kempii	Kemp's ridley turtle
Chelonia mydas	Green sea turtle
Eretmochelys imbricata	Hawksbill turtle