OSPAR
COMMISSION

Marine Bird Bycatch

Pilot Assessment

OSPAR

QUALITY STATUS REPORT 2023

2022

OSPAR's Quality Status Report 2023

Pilot Assessment of Marine Bird Bycatch

OSPAR Convention
The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR
La Convention pour la protection du milieu marin de l´Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d´Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l´Allemagne, la Belgique, le Danemark, l´Espagne, la Finlande, la France, l´Irlande, l´Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume- Uni de Grande Bretagne et d´Irlande du Nord, la Suède, la Suisse et l´Union européenne

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Contents

Key Message

By-catch of marine birds in fishing gear is an ongoing problem in the North-East Atlantic concerning a number of species. Though methods are developed, a considerable data paucity impairs a comprehensive assessment. In the few cases where an assessment was possible, the threshold value was either achieved or not achieved.

Background (brief)

Incidental by-catch in different types of fishing gear is among the most important pressures on marine birds worldwide. This problem has also been identified in the OSPAR Maritime Area and includes by-catch in gillnets, trawls, purse seines and on longlines. Birds by-caught belong to various taxonomic groups and include divers, fulmars, shearwaters, gannets, cormorants, sea ducks, gulls and auks.

The OSPAR North-East Atlantic Environment Strategy (NEAES) 2030 (the OSPAR Strategy – OSPAR Agreement 2021-01) includes the operational objective *S7.O6: 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 will work towards strengthening the evidence base concerning incidental by-catch by 2025*. The objective to "*minimise and where possible, eliminate by-catch*", is an adaptation from the EU Action Plan for reducing incidental catches of seabirds in fishing gears (COM (2012) 665) and the Regulation (EU) 2019 / 1241 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures..

This indicator addresses the predicted biological significance of marine bird by-catch mortality, which has to be used to advise on the level of mitigation measures required.

Background (extended)

In a worldwide assessment, marine birds were found to face three major threats: i) predation by invasive alien species, ii) by-catch in fisheries and iii) climate change / severe weather, with by-catch having the greatest average impact (Dias et al. 2019). Published evidence from the North-East Atlantic has shown that by-catch of marine birds in commercial fisheries such as longline and gillnet fisheries as well as from other fishing gears, is also a wide-ranging problem in the OSPAR Maritime Area (e.g., Anderson et al. 2011, Žydelis et al. 2013, Oliveira et al. 2015, Christensen-Dalsgaard et al. 2019, Glemarec et al. 2020, Northridge et al. 2020).

In view of by-catch being an important pressure in the North-East Atlantic, the NEAES 2030 includes the operational objective *S7.O6: 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 will work towards strengthening the evidence base concerning incidental by-catch by 2025*. This objective is an adaptation from the EU *Action Plan for reducing incidental catches of seabirds in fishing gears* (COM (2012) 665) and the Regulation (EU) 2019 / 1241 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures. The approach of this indicator is also based on the criterion D1C1 for assessing by-catch mortality of marine mobile species under the EU Marine Strategy Framework Directive (Commission Decision 2017 / 848 / EU): "*The long-term viability of marine bird populations is not threatened by deaths caused by incidental by-catch in mobile and static fishing gear*". The NEAES objective is potentially achievable because by-catch levels can be reduced by the implementation of adequate mitigation measures by commercial fishing fleets, as has been achieved in for instance some longline fisheries.

For this indicator, three assessment methods were developed, which address different parts of the NEAES and provide alternatives if a method is not applicable. The additional qualifier of the NEAES high level objective "*… so that it does not represent a threat to the protection and conservation of the …birds*" is reflected in the default assessment method (*Assessment Method 1*) which is based on a Population Viability Analysis (PVA) to be applied where data allow. The first part of the NEAES objective "*minimise and where possible eliminate incidental by-catches of …birds*" is reflected in a reference value of no by-catch in one of the three assessment methods proposed (*Assessment method 2*) which can be applied to species included in the *OSPAR List of Threatened and / or Declining Species and Habitats* (OSPAR Agreement 2008-06). In this approach, the value of a by-catch level amounting to 1% of total annual adult mortality is proposed as an approximation of zero by-catch, which acknowledges that small numbers of birds will probably still be caught even when the most effective mitigation measures are deployed. This will enable Contracting Parties to determine whether or not by-catch has been practically eliminated for a given species. The reference value of 1% of total adult mortality, which is used as an approximation of zero by-catch mortality is derived from legal interpretations in different European courts of 'small numbers' (Court of Justice of the European Union - Judgment of 18 May 2006 in the case no C-221 / 04) and was originally used in the *Guidance document on hunting under Council Directive 79 / 409 / EEC on the conservation of wild birds "The Birds Directive"* (European Commission 2008). *Assessment Method 3* identifies risk areas by investigating spatio-temporal overlap in distributions of threatened and / or declining marine bird species and fisheries causing by-catch.investigating spatio-temporal overlap in distributions of threatened and / or declining marine bird species and fisheries causing by-catch.

Species included in the Indicator Assessment

The approaches for assessing the candidate indicator on marine bird by-catch were proposed in anticipation of a potential pilot assessment of marine bird by-catch in the Quality Status Report (QSR) 2023. In principle, it is envisaged that the indicator will be applied to all seabirds. Currently, progress has been made on developing assessment methods, but the application to all species known to be by-caught is limited by a substantial lack of by-catch monitoring data. There are only a few programmes dedicated to the monitoring of marine bird by-catch in European waters. Data on bird by-catch available from some of those programmes are used to run this pilot assessment of by-catch mortality on a few selected species in order to test and demonstrate the proposed assessment methodologies (see COBAM proposals for biodiversity assessments), which go back to the outcome of the *OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental by-catch of birds and marine mammals* held in Copenhagen in 2019.

Assessment Method

Overview

The assessment is based on three components: i) observed by-catch rates as the number of by-caught birds per unit fishing effort, ii) fishing effort in the respective gears and iii) bird data (abundance, demographic data) entering population models. By-catch rates per observer effort (i) are scaled according to total fishing effort (ii) in order to assess the effect on population dynamics in the population models (iii). In the population models it is examined to which extent the by-catch mortality of a bird population is threatening the long-term viability of that population (***Assessment Method 1*** below).

For species included in the *OSPAR List of Threatened and / or Declining Species and Habitats* a precautionary approach is applied in case by-catch data and / or bird data for the approach mentioned before are not available. In this case, the number of by-caught individuals of a population is assessed against the threshold of 1% of annual adult mortality (***Assessment Method 2*** below). If even this is not possible, a population of a threatened and / or declining species from the above mentioned OSPAR List would be considered to be in the 'poor status' category if its distribution overlaps spatially and temporally with the exercise of a fishing method known to cause by-catch in that species (***Assessment Method 3*** below). The basic features of these assessment methods are illustrated in **Figure 1**.

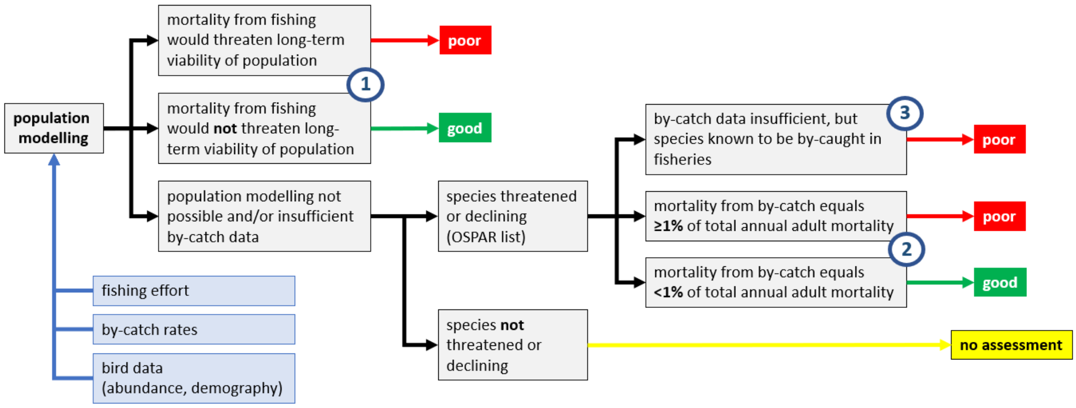

Figure 1: *Workflow for the candidate indicator B5 Marine Bird By-catch. Numbers indicate where the Assessment Methods 1, 2 and 3 are applied.*

Marine bird by-catch assessments can be undertaken in all OSPAR Regions provided data on bird by-catch and fishing effort are available in meaningful units. This pilot assessment addresses five populations: Cory's shearwater in the Bay of Biscay and Iberian Coast (Region IV), common guillemot in the Celtic Seas (Region III), Barolo shearwater (split from little shearwater and also known as Macaronesian shearwater) in the Wider Atlantic (Region V), roseate tern in Regions II, III and V, and Steller's eider in Arctic Waters (Region I), see **Figure 2**.

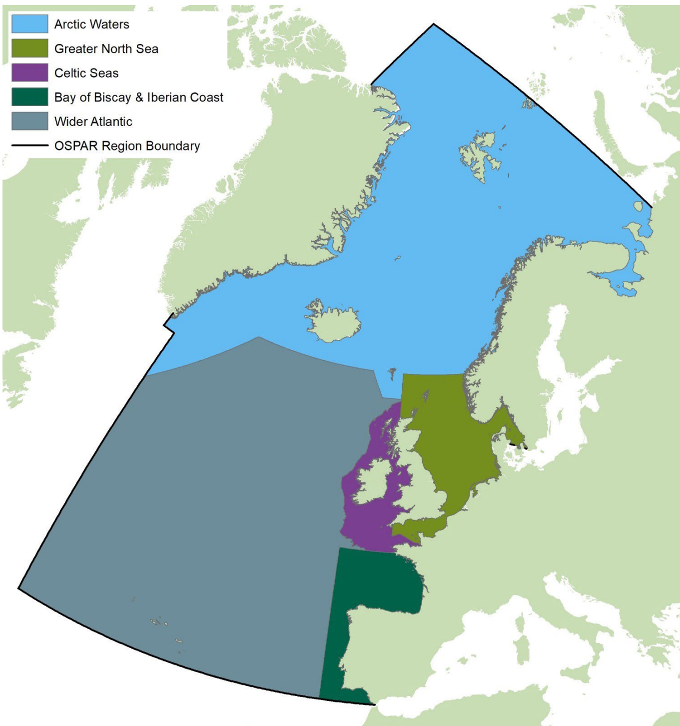

Figure 2: *The OSPAR Maritime Area and the five assessment units used in this pilot assessment (Arctic Waters – Region I, Greater North Sea – Region II, Celtic Seas – Region III, Bay of Biscay and Iberian coast – Region IV, Wider Atlantic – Region V.*

Species-specific assessment of by-catch mortality

Data acquisition and Data used in the assessment

By-catch data for marine birds are lacking considerably across the entire OSPAR Maritime Area, because very few dedicated monitoring programmes are carried out. Bird by-catch data are available from a few (academic) case studies, from a few national observer programmes and from the monitoring under the Data Collection Framework (DCF) (Council Regulation EC No 199 / 2008 with Commission implementing decisions 2016 / 1251 and 2016 / 1701). The latter is not dedicated to bird by-catch monitoring and has a number of limitations preventing or restricting the use for assessing the impact of by-catch mortality on bird populations. These restrictions include the concentration of DCF monitoring on gears not being in focus for bird by-catch (e.g. trawls instead of gillnets and longlines) and the use of inaccurate units for fishing effort like days at sea instead of net length * soak time or number of hooks.

This pilot assessment is not based on data acquired via a data call, but uses published and unpublished data and information, the latter made available as personal communication. Part of the analyses presented here was conducted under the JNCC contract *Preparatory work to assist in the delivery of a pilot OSPAR indicator: B5 Marine Bird Bycatch* (Oliveira 2021).

Baselines

This indicator has no fixed baseline values. Where population modelling is applied, the baseline is the predicted population trajectory in the absence of by-catch mortality.

Species selection and aggregation (functional groups)

Species were selected based on the availability of by-catch estimates and relevant demographic data which allows using one of the three assessment methods explained below. Emphasis was placed on species listed in the *OSPAR List of Threatened and / or Declining Species and Habitats*.

Assessment Method 1 (for all species if data are available)

Parameter / metric

In the default assessment method for all species, the focus is on the application of a population model to quantify the impact on population dynamics by estimated levels of by-catch mortality.

The metric here is the trajectory of the population size over a longer period (three generations time) in relation to the threshold defined (see under *Threshold values*). This approach needs to be applied on the level of an entire population, and Population Viability Analysis (PVA) appears to be a well-suited method to do this.

The PVA in this assessment used Leslie matrix analysis to model the demographic parameters of the study populations in order to test their response over a period of time to alterations in by-catch mortality. The stage-structured matrix model accommodated species-specific age at first breeding, productivity, and age-specific survival estimates. The initial number of females in each of the age-classes was modelled, assuming a stable age structure with mean demographic rates equal to the observed time series.

The baseline scenario considers a stochastic population model for K-selected marine bird populations following Cook & Robinson (2016). Stochasticity was incorporated as a random variation by sampling each demographic parameter from a normal distribution for each year of the model. The model was run 1 000 times in order to give an indicative trend for the study population and the correspondent uncertainty estimate. In scenarios where a positive trend was found, density-dependent effects were used to avoid generating falsely optimistic predictions about the potential for by-catch reduction to increase future seabird population sizes, following Miles et al. (2020).

Due to the lack of comprehensive by-catch data for all fisheries operating in any OSPAR Region, dummy scenarios were used as an alternative to real by-catch data. Three dummy scenarios were generated starting from each baseline scenario, in order to model the effect of different levels of by-catch mortality on the population demography. A 1%, 5% and 10% variation in mortality was added to the baseline scenario, if the mortality rate does not include by-catch mortality. In case the mortality rate already includes by-catch mortality, a 1%, 5% and 10% variation in mortality was subtracted from the baseline scenario. The results of the scenarios were then used to provide an indication of the possible impact of current by-catch levels, based on available information of by-catch in the respective population.

The 1% variation follows the concept of 'small numbers' (see Background section). The 5% and 10% values are used as an alternative to real by-catch mortalities, based on the evidence that even small changes in adult survival can significantly impact the population dynamic in long-lived marine birds and demography of marine birds is therefore highly sensitive to small variations in adult survival (Reiertsen et al. 2014).

The respective total number of birds that died following a variation in adult mortality (1%, 5% or 10%) was estimated for each scenario. The total number of birds that died due to by-catch was calculated in proportion to the age structure and assuming a sex ratio 1:1, using the 95% confidence interval reported for the size of each study population and following the equations:

(1) $M = (1 – S) * \Delta M$

(2) $Y = N/\Phi * M$

where adult mortality (M) is estimated from equation (1), as a function of adult survival (S) and the variation in adult mortality (ΔM = 1%, 5% or 10%). The total amount of birds that died due to by-catch (Y) is calculated in equation (2) with initial population size (N) and the proportion of females (Φ).

Threshold values

The annual loss of individuals from by-catch in fisheries is to be assessed against the threshold that the long-term viability of a population is not threatened. The approach to do such an assessment is to examine the impact of by-catch-related additional mortality by the help of PVA. Possible definitions of the term threat to long-term viability include that

i) By-catch mortality shall not contribute to a decline in population growth rate resulting in an overall population decline of 30% or more within the next three generations, following the IUCN Red List criteria to classify a species as being "vulnerable" (IUCN 2012) and in line with the threshold used in the Common Indicator B3 *Marine Bird Productivity* or

ii) the ratio (R) between impacted (I) and unimpacted (U) populations (RI:UGL), i.e. the percentage variation in the population size of a baseline scenario when compared with a population experiencing alterations in survival due to by-catch mortality after three generations time (GL), is below a certain level with a certain probability (which both have not been defined yet).

Assessment Method 2 (only threatened and / or declining species from OSPAR List for which Assessment Method 1 not possible)

Parameter / metric

If a population cannot be assessed by the *Assessment Method 1* explained above, because bird demographic data and / or by-catch numbers are not available, any species not on the OSPAR *List of Threatened and Declining Species and Habitats* will be considered *'Not Assessed'.* However, a precautionary approach shall be applied to species included in the *OSPAR List of Threatened and / or Declining Species and Habitats*. The metric here is the number of by-caught individuals derived from by-catch rates and fishing effort.

Threshold values

In this method, the threshold is set at the number of individuals reflecting 1% of the annual adult mortality of a species (or population). Ideally, the threshold value would consider *natural* annual adult mortality. However, the natural level of adult mortality is unknown for most, if not all, seabird species (or populations), notably because studies on bird mortality (e.g., based on ring recoveries) necessarily include unknown proportions of anthropogenic mortality.

The value of 1% of the annual adult mortality of a species (or population) is derived from the interpretation of 'small numbers' (see Background section), provided that it is highly unlikely that by-catch can be completely eliminated, and small numbers will always be by-caught.

Annual adult mortality rates need to be taken from scientific literature, preferably from the same population. If not available, mortality rates from closely related species with similar population characteristics and lifestyle may be used as a proxy.

The threshold value of a certain population expressed as the number of birds can therefore be calculated as 1% of the product of the population size in the assessment unit and the corresponding annual adult mortality rate in that assessment unit. As the 1% value is not used in a population model but just intended to aid in generating an equivalent for 'small numbers', it is applied to the total population size, including immature birds.
Besides being a simple method, which can be applied in absence of demographic data, another advantage of this method is that the metric can be related to the birds in an assessment area instead of the entire population which is a prerequisite in *Assessment Method 1*. Thus, in this method by-catch data are not needed across the entire distributional range of the population in focus.

Assessment Method 3 (only threatened and / or declining species from OSPAR List, for which Assessment Methods 1 and 2 not possible)

Parameter / metric

If *Assessment Method 2* cannot be applied because either by-catch data or the population size of the assessment unit are not available, then the metric for species on the *OSPAR List of Threatened and / or Declining Species and Habitats* is the existence of spatial and temporal overlap of bird species distribution and exercise of the fishing method known to cause by-catch in that species.

The distribution of marine birds can be derived from national monitoring programmes, preferably including ship-based and / or aerial offshore surveys. In addition, the range of birds equipped with transmitters or data loggers can be used to assess the spatio-temporal distribution of the birds.

Information on the distribution of fishing activities using gears relevant for by-catch of the species in focus can be obtained from fishing effort data reported to e.g., ICES WGCATCH by analysing available geospatial data (e.g., Vessel Monitoring System (VMS), Automatic Identification System (AIS)). Problematically, in Europe, this information is often lacking for small scale fisheries and recreational fisheries in which the risk of by-catch of marine birds can be locally high.

Threshold values

The threshold value of this method is that the distribution of a bird population in a given assessment unit does not overlap spatially and temporally with the exercise of a fishing method which is known to cause by-catch in that species. This is a precautionary method only applied to OSPAR threatened and / or declining species to prevent further threatening of such species.

Integration of species-specific assessments

An integration of species assessments on the level of species groups is not intended in this pilot assessment, because only selected species are assessed.

Results

This pilot assessment has trialled an approach for assessing whether the NEAES operational objective was achieved. An attempt was made to assess the population impact of by-catch in fishing gear for species or populations for which a sufficient level of data and information was available. It turned out that only in very few cases both data on by-catch rates and fishing effort were available at such a sufficient level. The results are summarised in **Table 1**. There is however evidence that many more species of benthic feeders, water-column feeders, and surface feeders are susceptible to by-catch (see Results extended).

Assessment Method 1 was applied to the Cory's shearwater in the Bay of Biscay and Iberian coast (Region IV) and to common guillemot in the Celtic Seas (Region III). For Cory's shearwater off the Portuguese mainland coast, the by-catch mortality threshold was exceeded, because the observed number of individuals by-caught was already higher than that responsible for a strong decline of the population size as simulated in a Population Viability Analysis (PVA). The assessment for the common guillemot in the Celtic Seas could not be carried out successfully, because various populations of that species overlap in their wintering distribution. Common guillemots reported as by-catch in this pilot assessment could not be assigned to their breeding populations, hence the results of the PVA could not be used to determine the level of by-catch in the individual populations involved, and the species must remain unassessed.

Assessment Method 2 was applied to two species. The level of by-catch mortality equivalent to the threshold of 1% of annual adult mortality was compared to available information about estimated by-catch of the Barolo shearwater (Wider Atlantic, Region V) and the roseate tern (Greater North Sea, Celtic Seas and Wider Atlantic, Regions II, III and V). For both species there was no indication of by-catch happening in either the breeding area or in the wintering range. Therefore, the threshold was not exceeded, and the indicator was considered achieved.

Assessment Method 3 was applied to Steller's eider overwintering in the Arctic Waters (Region I). The assessment identified spatial and temporal overlap of bird species distribution and exercise of fishing activity known to cause by-catch of this species. The threshold of no overlap was therefore exceeded.

Table 1. Pilot assessments of by-catch mortality per species and OSPAR Region. n.a.: not assessed (failure to assign by-caught birds to populations).

Species	OSPAR Region	Assessment Method	Threshold
Steller's eider	I	3	Not achieved
Cory's shearwater	IV	1	Not achieved
Barolo shearwater	V	2	Achieved
Roseate tern	II	2	Achieved
Roseate tern	III	2	Achieved
Roseate tern	V	2	Achieved
Common guillemot	III	1	n.a.

Results (extended)

General Assessment

By-catch of marine birds in fishing gear occurs in most parts of the North-East Atlantic. **Table a** summarises the current knowledge on the bird species in fishing gears in the five OSPAR Regions. Note that the list of species per OSPAR Region is a minimal list since not all OSPAR Regions (and moreover many marine areas within OSPAR Regions) are covered adequately by monitoring programmes.

Fleet-wide marine bird by-catch estimates can be obtained by multiplying an estimate of the mean marine bird by-catch rate from a representative sample of the fleet with the total fishing effort of that fleet. Yet, in the OSPAR Maritime Area, only few case studies and monitoring programmes have come up with enough data from which by-catch rates can be derived (see Oliveira et al. 2015, Bærum et al. 2019 and Christensen-Dalsgaard et al. 2019). Moreover, knowledge on the fishing effort of small vessels is often too scarce to allow for meaningful estimates of the total effort in some by-catch-problematic fisheries.

Table a. Marine bird species reported as by-catch in fishing gear in the OSPAR Regions I toV. Species included in the *OSPAR List of Threatened and / or Declining Species and Habitats* are printed bold.

	OSPAR Region				
Species	**I Arctic Waters**	**II Greater North Sea**	**III Celtic Seas**	**IV Bay of Biscay and Iberian coast**	**V Wider Atlantic**
Common eider	x	x			
King eider	x				
Steller's eider	x				
Long-tailed duck	x				
Common scoter	x	x		x	
Red-throated diver	x	x			
Great northern diver	x	x			
Northern fulmar	x	x	x		
Balearic shearwater				x	
Sooty shearwater	x				
Great shearwater				x	
Cory's shearwater				x	x
Northern gannet	x	x	x	x	
Great cormorant	x	x		x	
Shag	x	x		x	
Great skua	x				
Black-legged kittiwake	x		x		
Black-headed gull				x	
Great black-backed gull	x		x		
Glaucous gull	x				
Herring gull	x	x			

Yellow-legged gull				x	
Lesser black-backed gull	x	x		x	
Atlantic puffin	x				
Razorbill	x	x			
Common guillemot	x	x	x	x	
Brünnich's guillemot (also known as thick-billed murre)	x				
Black guillemot	x				

Sources: Christensen-Dalsgaard et al. (2019), Cooper et al. (2003), Durinck et al. (1993), Fangel et al. (2015, 2017), Frantzen & Henriksen (1992), Lunneryd et al. (2004), Northridge et al. (2020), Ólafsson (2015), Oliveira et al. (2015, 2020b), Pálsson et al. (2015), Petersen (2002).

Species-specific assessments

The by-catch criterion was assessed for five populations in this pilot assessment.

Cory's shearwater Calonectris borealis in Bay of Biscay and Iberian Coast (Region IV)

In the Bay of Biscay and Iberian Coast (Region IV), the population of Cory's shearwater is mainly breeding in the Berlengas Archipelago off the Portuguese mainland coast. Smaller numbers from the Peniche coast (Portugal) and the Cies Islands (Galicia, Spain) are neglected here. As by-catch is unlikely to occur in the non-breeding season in the South Atlantic and the South Indian Ocean (Oliveira 2021), by-catch mortality can be exclusively addressed for the breeding season from March to October, when the Berlengas population uses the waters of this archipelago. Here, the trajectory of the population size over three generations (generation length 19,3 years, BirdLife International 2015) is predicted for different levels of by-catch mortality in this population.

The Population Viability Analysis (PVA) was conducted for two parts of the population, considering the different demographic data observed (**Table b**). The first part follows the demographic parameter estimates and size of Berlengas Archipelago breeding population, excluding Berlenga Island. This unimpacted scenario or any of the following impacted scenarios assuming 1%, 5% or 10% increase in mortality showed a decreasing population trend (**Figure a**). In the second part, demographic parameter estimates and size of only Berlenga Island population were used. This population shows a currently increasing trend in the unimpacted scenario, by assuming no by-catch and a high productivity due to conservation efforts at nesting areas. None of the simulated increments in mortality (1%, 5% or 10%) in the impacted scenarios resulted in a negative trend (**Figure b**). However, the ratio between impacted and unimpacted populations (RI:UGL) is slightly lower in the second part than in the first one, resulting in higher percentages of population reduction in the impacted scenarios when compared with the baseline (unimpacted) population after three generations (**Table c**). For example, if the population breeding on Berlenga Island faces a 10% increase in mortality due to by-catch it would show a reduction of 39,8% (i.e., 1 - 0,602) when compared to the same population with no by-catch mortality, after three generations.

Table b: Demographic parameters of Cory's shearwater used for the PVA of the Berlengas Archipelago population in this pilot assessment.

Part of the population	Population size (breeding pairs)	Productivity	Age at recruitment	Immature survival (0-7 y)	Adult survival (females)
Berlengas Archipelago,	520-675 [1]	0,397 (s.d. 0,016) [1]	9 years [2]	0,328 [2]	0,935 [2]

excluding Berlenga Island					
Berlenga Island	280-300 [1]	0,775 (s.d. 0,028) [1]			

Sources: [1] Oliveira et al. 2020a, [2] Mougin et al. 2000.

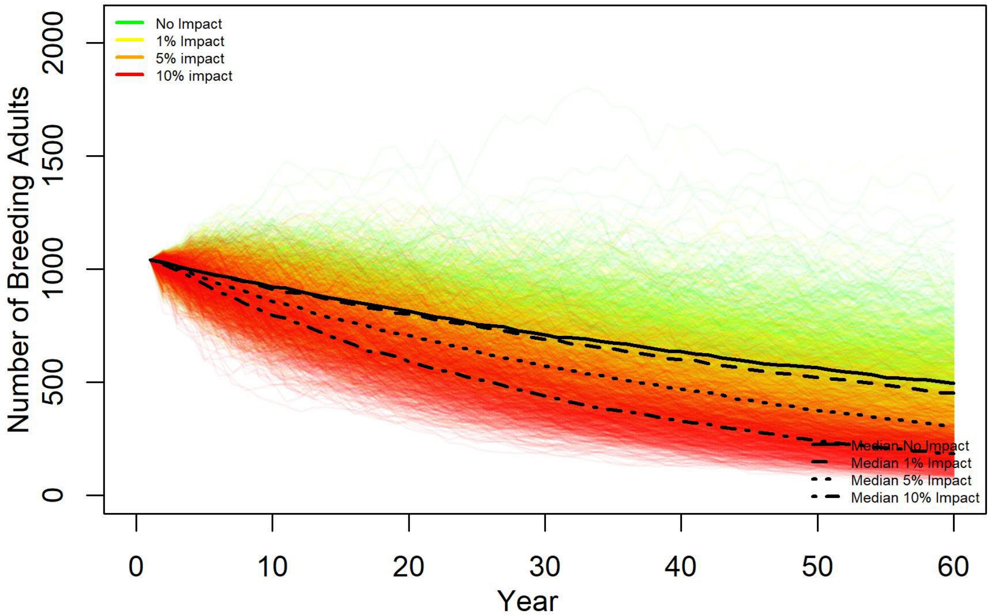

Figure a: *Stochastic population model (1 000 bootstraps) for Cory's shearwater breeding in Berlengas Archipelago, excluding Berlenga Island, assuming a density-independent productivity. The plot shows the baseline (i.e., no impact from by-catch scenario) as well as the impact of a 1%, 5% and 10% increase in mortality. The different colours represent estimates of uncertainty surrounding each scenario. Source: Oliveira 2021.*

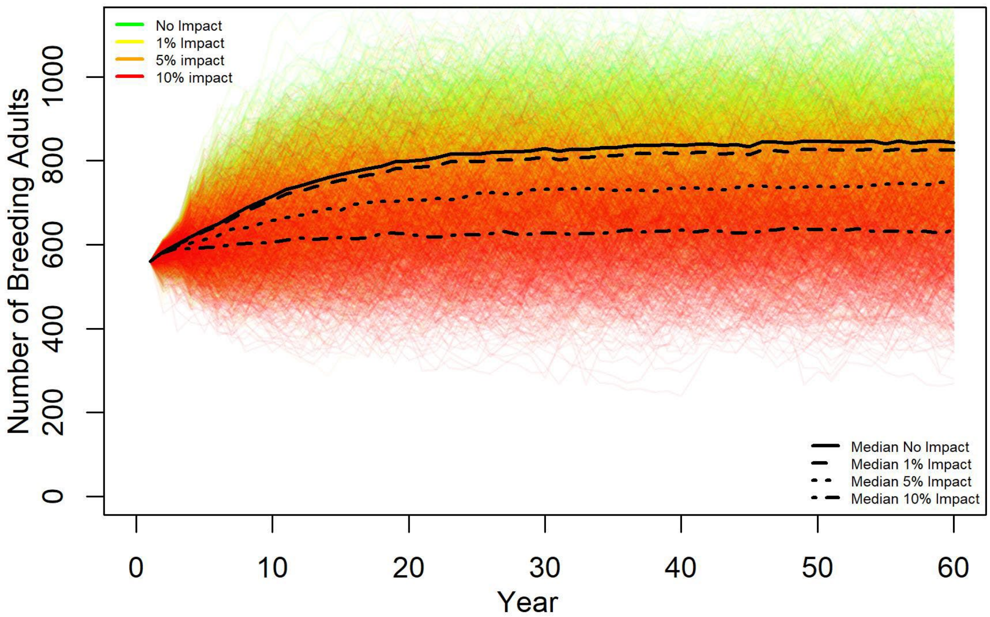

Figure b: *Stochastic population model (1 000 bootstraps) for Cory's shearwater breeding on Berlenga Island only, assuming density dependent productivity. The plot shows the baseline (i.e., no impact from by-catch scenario) as well as the impact of a 1%, 5% and 10% increase in mortality. The different colours represent estimates of uncertainty surrounding each scenario. Source: Oliveira 2021.*

Table c: Impact of 1%, 5% and 10% increase in mortality on the ratio of the population size after three generations for the impacted and unimpacted (RI:UGL) population of Cory's shearwater breeding in Berlengas Archipelago derived from stochastic models. Further, the ranges of total annual by-catch are given for each scenario as number of birds, assuming 1%, 5% and 10% of by-catch mortality. Source: Oliveira (2021).

Baseline population	Actual trend	RI:UGL			Total annual by-catch (number of birds, from simulations)		
		1%	5%	10%	1%	5%	10%
Berlengas Archipelago, excluding Berlenga Island	decreasing	0,962 (0,956-0,967)	0,821 (0,794–0,844)	0,672 (0,628–0,714)	1	4-5	8-10
Berlenga Island	increasing	0,952 (0,943–0,960)	0,778 (0,739–0,811)	0,602 (0,539–0,657)	0	2	5

The total number of birds estimated in simulations to have died due to by-catch, considering the different levels of impact in mortality (**Table c**), represented a very low proportion of the current breeding populations from Berlengas Archipelago (estimated at 800 to 975 pairs, **Table b**). Assuming a 1% increase in mortality due to by-catch resulted in only one bird, while a 10% increase would represent a 13 to 15 birds removed every year from Berlengas Archipelago population due to by-catch, corresponding to approximately five birds from Berlenga Island plus eight to ten birds from the remaining population.

In the case of the Cory's shearwater population of the Berlengas Archipelago, extrapolations from observed by-catch rates to total numbers of birds by-caught are probably an overestimate (Oliveira et al. 2020b). However, sampling of demersal longline fishery in waters surrounding Berlengas Archipelago resulted in a minimum of eight individuals by-caught within a three-year study during observed trips only (Oliveira et al. 2020). Given that only 1% of fishing trips were observed it is highly likely that more than 15 individuals are by-caught annually, i.e. annual mortality would increase by more than 10% and after three generations the population would be more than 33 to 40% below the level of a scenario without by-catch mortality (see **Table c**). Thus, the PVA results presented here indicate that the Berlengas population of Cory's shearwater is sensitive to small amounts of additional mortality due to by-catch. As already the low number of 13 to 15 adult birds removed every year causes a strong decline of the population, the population failed in the by-catch criterion, because it can be assumed to exceed one of the proposed threshold values (though this has not been defined yet, see *Assessment Method 1* above).

Barolo shearwater Puffinus baroli in Wider Atlantic (Region V)

The Barolo shearwater, formerly known as little shearwater, or Macaronesian shearwater, is included in the *OSPAR List of Threatened and / or Declining Species and Habitats*. Therefore, if a PVA cannot be conducted, *Assessment Method 2* can be applied.

As the annual adult survival rate of Barolo shearwater is unknown, it is assumed that it is close to the survival rate for the closely related and similar-sized Audubon's shearwater *Puffinus lherminieri* (0,94, Precheur et al. 2016). From the population estimate of Barolo shearwater for the Azores of 840 to 1 530 breeding pairs (Monteiro et al. 1999) the number of adult individuals would be 1 680 to3 060, and including immature non-breeders the population size is estimated at 3 500 individuals. The multiplication of that population size with the annual mortality rate of 0,06 results in approximately 210 individuals dying per year. Therefore, the threshold value of 1% of annual adult mortality for this species would be 2,1 birds per year.
There is no by-catch of this species reported in the Azores region (Cooper et al. 2003, Saavedra et al. 2018). As this part of the Wider Atlantic is characterised by zero or minor megafauna by-catch in general (Afonso et al. 2020) and the Barolo shearwater as a non-migratory species largely stays in this area (Neves et al. 2012,

Ramos et al. 2021), it is assumed that no by-catch occurred also in the assessment period. Thus, the species is supposed to achieve the proposed threshold value.

Common guillemot Uria aalge in Celtic Seas (Region III)

In the Celtic Seas, common guillemots occur in a mixture of populations. There is the breeding population of OSPAR Region III, which according to ring recoveries (Wernham et al. 2002) and tracking data (SEAPOP 2021) is supplemented by birds from Greater North Sea (Region II) and Arctic Waters (Region I) in the non-breeding season. As the latter probably has only a smaller share, this assessment is addressing only the Celtic Seas breeding population and the visitors from the Greater North Sea. The common guillemot is not listed as threatened and / or declining by OSPAR (except for the Iberian population, which is not occurring in the Celtic Seas), so *Assessment Method 1* needs to be applied.

The PVA is based on the demographic data shown in **Table d**. Due to the differences in productivity between the breeding populations of the Celtic Seas and the Greater North Sea, two baseline scenarios were used to show the trajectory of the population size over three generations (generation length 15,1 years, BirdLife International 2015) for different levels of by-catch mortality.

First, a baseline scenario considered the population that breed in Celtic Seas, showing a high productivity (**Table d**) and a stable trend derived from the recent history of monitoring at the breeding sites (**Figure c**). Another baseline scenario was modelled using the smaller productivity found in colonies in the United Kingdom belonging to the Greater North Sea Region (**Figure d**). Other than in Cory's shearwater (see above) both baseline scenarios assume that current mortality includes some unknown proportion of anthropogenic mortality (i.e., by-catch). The 1%, 5% and 10% reduction in impact of mortality assumed to be related with by-catch were removed from the estimated survival on each baseline scenario. Starting with each baseline scenario, both dummy scenarios showed a strong effect of mortality impact on population trends. This is obvious from the ratio between impacted and unimpacted populations (RI:UGL), which for a 10% decrease of by-catch mortality would mean a 36% and 34,1% higher population size after three generations for the populations of the Celtic Seas and Greater North Sea, respectively (**Table e**).

Table d: Demographic parameters of common guillemots used for the PVA in this pilot assessment.

Population	Population size (breeding pairs)	Productivity	Age at recruitment	Immature survival (0-7 y)	Adult survival (females)
Celtic Seas (United Kingdom and Ireland)	456 264 [1]	0,823 (s.d. 0,056) [3]	6 years [3]	0,560 (0-1 y) [3] 0,792 (1-2 y) [3] 0,917 (2-3 y) [3]	0,939 [3]
Greater North Sea (United Kingdom only)	631 905 [2]	0,629 (s.d. 0,174) [3]			

Sources: [1] Miles et al. 2020, [2] Mitchell et al. 2004, [3] Horswill & Robinson 2015.

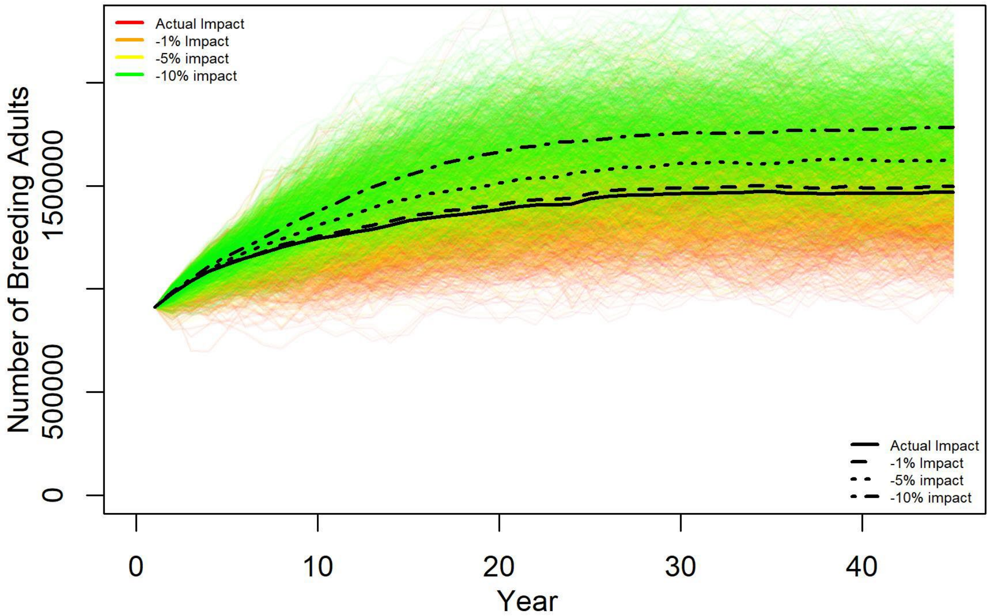

Figure c: *Stochastic population model (1 000 bootstraps) for common guillemots breeding in Celtic Seas colonies, including United Kingdom and Ireland, assuming density dependent productivity. These populations currently show a stable trend. The plot shows the baseline scenario (considering survival estimates including mortality due to by-catch) as well as the impact of a 1%, 5% and 10% decrease in mortality. The different colours represent estimates of uncertainty surrounding each scenario. Source: Oliveira 2021.*

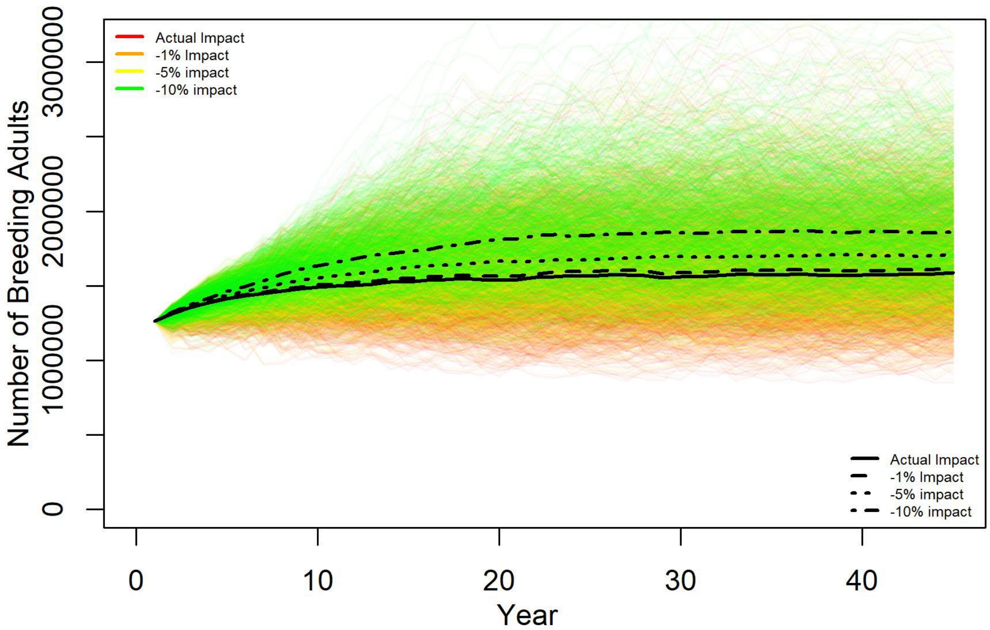

Figure d: *Stochastic population model (1 000 bootstraps) for common guillemots breeding in North Sea colonies of United Kingdom only, assuming density dependent productivity. This population currently shows a decreasing trend derived from the recent history of monitoring at the breeding sites. The plot shows the baseline scenario (considering survival estimates including mortality due to by-catch) as well as the impact of a 1%, 5% and 10% decrease in mortality. The different colours represent estimates of uncertainty surrounding each scenario. Source: Oliveira 2021.*

Table e: Impact of 1%, 5% and 10% decrease in mortality on the ratio of the population size after three generations for the impacted and unimpacted (RI:UGL) populations of common guillemot breeding in the Celtic Seas and Greater North Sea derived from stochastic models. Further, the ranges of total annual by-catch are given for each scenario as number of birds, assuming 1%, 5% and 10% of by-catch mortality. Source: Oliveira 2021.

Baseline population	Actual trend	RI:UGL			Total annual by-catch (number of birds, based on simulations)		
		1%	5%	10%	1%	5%	10%
Celtic Seas (United Kingdom and Ireland)	stable	1,031 (1,027-1,036)	1,167 (1,140–1,196)	1,360 (1,298 –1,432)	472	2 517	4 724
Greater North Sea (United Kingdom only)	decreasing	1,030 (1,026–1,035)	1,159 (1,136–1,186)	1,341 (1,287–1,400)	771	4 487	7 709

The total number of birds that were modelled to have died due to by-catch considering the different levels of impact in mortality (**Table e**) represented a low proportion of the current breeding populations from the two source areas. A level of 1% decrease in mortality due to by-catch would translate to 472 birds in the Celtic Seas population and 771 birds in the UK North Sea population. Annual by-catch of common guillemots in the Celtic Seas was estimated at 1 033 (739 to 1 351) and 885 (636 to 1 167) birds in 2016 and 2017, respectively (Northridge et al. 2020). These figures fall between the modelled scenarios of 1 and 5% reduction in total annual by-catch.

The application of *Assessment Method 1* to the common guillemot in the Celtic Seas faces several deficiencies in the basic data, which obscure the relations between the numbers of birds by-caught and the populations included:

- The by-catch numbers aggregated by Northridge et al. (2020) only consider UK waters and UK fleets, so the birds by-caught by foreign fleets and in Irish waters would increase these numbers.
- The birds by-caught cannot be assigned to either population, but it is expected that they are not by-caught in similar proportions given the very likely differences in temporal and spatial occurrence.
- Birds from the UK North Sea are not only by-caught in the Celtic Seas, but also in the North Sea itself (Northridge et al. 2020).
- More populations do probably occur in the Celtic Seas during the non-breeding season (e.g. breeders from Jan Mayen and Faroe Islands in OSPAR Region I, SEAPOP 2021) and would make up a share of the by-catch of this species.

These considerations show that the application of an assessment method based on population models reaches its limits when several populations or sub-populations partially overlap in their occurrence in time and space. Owing to this, an assessment for common guillemots cannot be done yet. Thus, the indicator status in this case remains unknown.

Roseate tern Sterna dougallii in Greater North Sea (Region II), Celtic Seas (Region III) and Wider Atlantic (Region V)

Based on literature data, a by-catch assessment is possible for the European population of roseate tern. The most recent estimate of population size is 2 679 breeding pairs in 2019, of which 58% are breeding in only one colony in Ireland (Piec & Dunn 2021). Including immature birds, a population size of 7 500 to 9 200 individuals is given by Wetlands International (2021). The species is on the *OSPAR List of Threatened and / or Declining Species and Habitats*. Therefore, for the demonstration of this method, the population can be assessed using *Assessment Method 2*.

The annual survival in birds from the largest colony (Rockabill, Ireland) is on average 0,84 for adult birds at least four years old (Seward et al. 2019). Applying this to the total number of individuals in the population, between 1 200 and 1 472 birds would die each year. The threshold of 1% of annual adult mortality according to *Assessment Method 2* then would be 12 to 15 birds per year.

There is no indication of roseate terns getting by-caught in fisheries in the OSPAR Regions II and III (Northridge et al. 2020) as well as OSPAR Region V (Saavedra et al. 2018). This is supported by the fact that by-catch is not mentioned as a threat for roseate terns in conservation driven overviews (BirdLife International 2015, Piec & Dunn 2021). Further, the species-specific sensitivity for getting by-caught is ranked very low (Bradbury et al. 2019). However, by-catch cannot be excluded in principle, because by-catch of roseate terns at longlines is listed by Gochfeld et al. (2018) for the Seychelles, i.e., outside the range of the European population. Based on the information available, it appears reasonable to assume that close to zero by-catch mortality is occurring in the European population. Therefore, the roseate tern is passing the indicator for the OSPAR Regions II, III and V.

Steller's eider Polysticta stelleri in Arctic Waters (Region I)

The Steller's eider is an Arctic species breeding along the Arctic coast of Siberia and Alaska. In winter they migrate to near-Arctic waters in Alaska, East Asia and northern Europe (Bustnes & Systad 2001). Prolonged declines in the number of Steller's eider wintering in Europe have raised concerns about the conservation status of the Western Palearctic population (Aarvak et al. 2013), with by-catch in commercial fisheries having been identified as one of the threats to this species (Žydelis et al. 2006, Øien & Aarvak 2007). In northern Norway there is, however, no by-catch data available for the species, though the evidence of by-catch exists (Fox et al. 1997, Øien & Aarvak 2007). It is therefore not possible to carry out *Assessment Method 1* or *2* for this species in this region. Nonetheless, as Steller's eider is on the *OSPAR List of Threatened and / or Declining Species and Habitats*, the population can be assessed using *Assessment Method 3*, considering the existence of spatial and temporal overlap of bird species distribution and exercise of the fishing method known to cause by-catch in that species.

In Europe, the largest winter populations are found in Russia and northern Norway, with the Norwegian range largely being confined to the northern coastline of the Varangerfjord in eastern Finnmark (Aarvak et al. 2013, Heggøy et al. 2019). In the 1990s up to 13 200 Steller's eiders were counted in the Varangerfjord (Žydelis et al. 2006), however, during the last decades there has been a shift in distribution with birds now primarily residing in Russia (Žydelis et al. 2006, Aarvak et al. 2013). In 2017, the Norwegian wintering population of Steller's eiders counted approximately 1 750 individuals (Heggøy et al. 2019). Steller's eiders arrive in Finnmark, Norway in October and usually depart during May (Henriksen & Lund 1994, Petersen et al. 2006). Preferred feeding areas of Steller's eiders in the area are almost exclusively in shallow nearshore habitats (Bustnes & Systad 2001, Heggøy et al. 2019).

Steller's eiders are vulnerable to by-catch in gillnets (Fox et al. 1997, Žydelis et al. 2006), especially those placed close to shore and in shallow habitats. There is an extensive gillnet fishery in the area, targeting cod, saithe and haddock in the period where Steller's eiders are present in the area. If the nets are set close to shore this might pose a risk to Steller's eiders. A gillnet fishery of special concern is that targeting lumpsuckers, as nets are often placed in shallow waters close to the shoreline. Previous work has shown that lumpsucker fishery can pose a risk to a range of diving seabird species (Christensen-Dalsgaard et al. 2019).
To assess the potential overlap of Steller's eiders and gillnet fishery, information on fishing activity was downloaded from The Norwegian Directorate of Fisheries (www.fiskeridirektoratet.no). The Norwegian Directorate of Fisheries registers catches from all fishing trips made in the entire Norwegian fishing fleet (i.e., all vessels that participate in commercial fishing). Only a limited number of parameters are recorded by the Directorate of Fisheries, such as the number of trips, area and catch. This was however sufficient to get an overview of number of fishing trips undertaken in the different regions in eastern Finnmark, what fishing gear was used and what the target species were**.** For the assessment, trips were selected where gillnets had been used, which were carried out during the period November-May when Steller's eiders are present in the area. The number of fishing trips were summarised per fishing areas as defined by the Directorate of Fisheries. The fishery in the area is mainly carried out by small boats and it is assumed that each trip

represents a day at sea. Information on the distribution of Steller's eiders was derived from the Norwegian National Monitoring Programme for Seabirds (www.seapop.no), which carries out counts of Steller's eiders during February or March every year. It has been shown that the number of Steller's eiders in the region are fairly consistent in the period February-April (Heggøy et al. 2019). It is therefore assumed that the counts from the Norwegian National Monitoring Programme are representative of the distribution throughout the whole period. The fishing information was overlaid with the yearly counts of Steller's eiders to assess the overlap (**Figure e**).

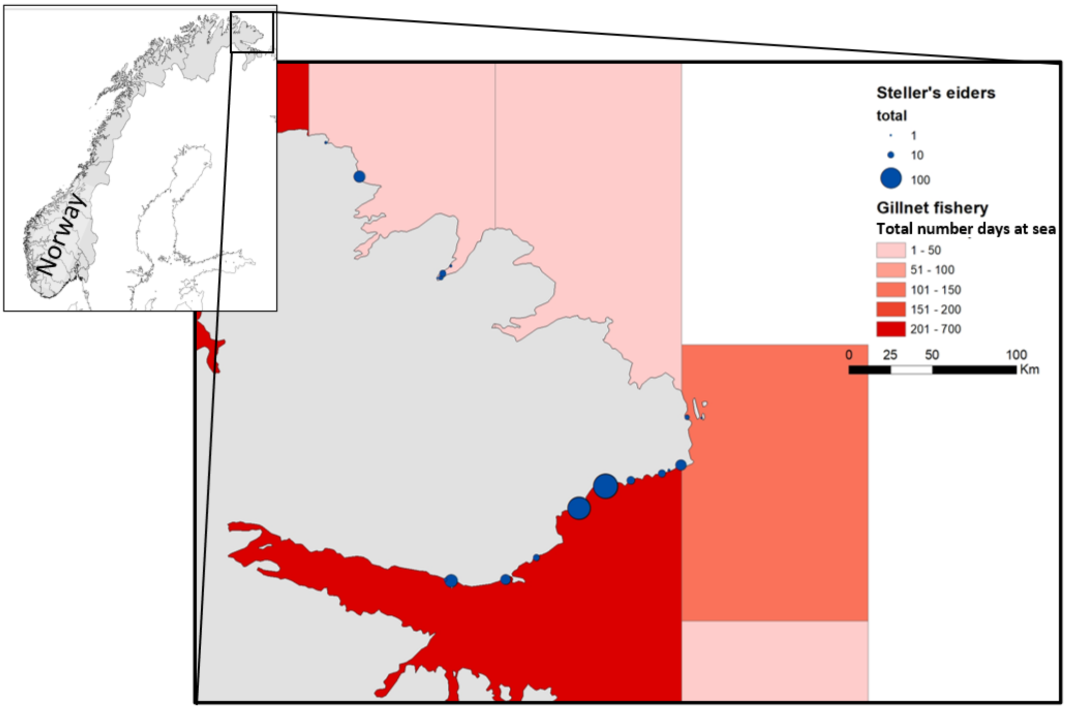

Figure e: *Example of gillnet fishing activity in eastern Finnmark. Fishing intensity is given as number of days at sea and shown for the fishing areas as defined by Directorate of Fisheries. Information on fishery activity is from April 2020 and counts of Steller's eider from February 2020.*

The resulting maps show that there is a clear overlap in the winter distribution of Steller's eiders and fishing activity using gillnets in eastern Finnmark. The fishing intensity in the area is higher during March and April, than the winter months. The example shown (**Figure e**) therefore depicts April, which is the month with the highest intensity of fishery while the Steller's eiders are in the area, and therefore the month with the potential largest conflict.

As lumpsucker fishery is thought to have the largest potential of taking Steller's eiders as by-catch, also data on fishery was extracted targeting this species. Due to the format of data, information was used on what municipality the catch was delivered, to summarize the fishing intensity (**Figure f**). As lumpsuckers are fished from small fishing boats (Christensen-Dalsgaard et al. 2019), it was assumed that the landing municipality represents the general area where the lumpsuckers were fished.

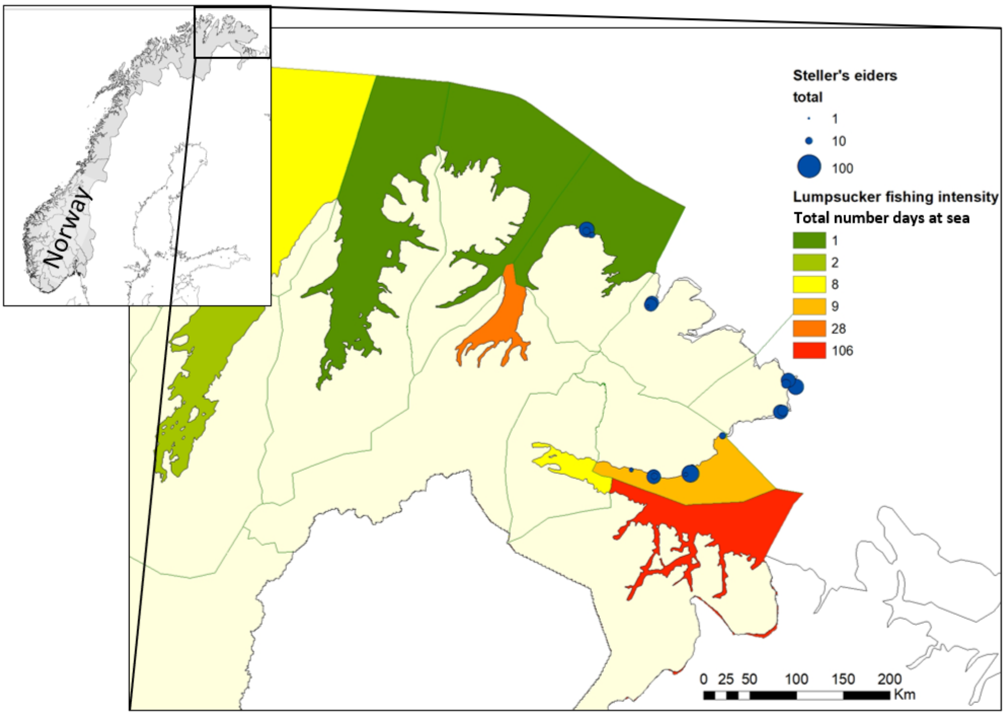

Figure f: *Example of overlap of fishing activity targeting lumpfish in eastern Finnmark, shown as the municipality where the catch was delivered. Information on fishery activity shows the summarized number of days at sea of all fishing boats targeting lumpsucker during spring 2021 and counts of Steller's eider from March 2021.*

The results show that there is an overlap between wintering area of Steller's eiders and key fishing areas for the lumpsucker fishery (Varangerfjord, **Figure f**). In 2021, a total of 143 days at sea were registered for boats targeting lumpsuckers within this area. The intensity of the lumpsucker fishery varies, however, between years depending on market prices and demand. Since 2000 the landings have declined due to market conditions. In 2018, the fishery was MSC-certified leading the numbers of active boats to increase (Christensen-Dalsgaard et al. 2019).

In conclusion, the assessment identified spatial and temporal overlap of bird species distribution and exercise of fishing activity known to cause by-catch of this species. The by-catch mortality threshold was therefore exceeded.

Confidence Assessment

In this assessment, significant gaps were identified concerning limited data and overall poor spatial coverage. Therefore, the confidence in data coverage is **low**. The assessment methods have been developed specifically for this assessment, have not been used in a previously published assessment and require further development. Therefore, the confidence in the methodology is **low**.

Conclusion (brief)

For the first time, an assessment of marine bird by-catch can contribute to an OSPAR Quality Status Report (QSR). Though the assessment methods tested were found to be applicable in principle, it turned out that the one based on Population Viability Analysis (PVA, *Assessment Method 1*) faces considerable obstacles regarding lack of data currently available for assessment. This is owing to the difficulties to obtain by-catch rates from all over the distributional range of populations and mixing of breeding populations in overwintering areas. Therefore, it is recommended to consider using *Assessment Method 2* for more than just the species included on the *OSPAR List of Threatened and / or Declining Species and Habitats*. This would be justified by the fact that beyond that list all European marine bird species are protected under various international conventions and agreements, including the EU Birds Directive, the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA). Furthermore, more marine bird species occurring in the OSPAR Regions and being prone to by-catch are globally threatened according to the IUCN Red List, i.e., species not currently classified as threatened and / or declining by OSPAR.

Conclusion (extended)

Since the Intermediate Assessment 2017, considerable progress has been made in the development of Indicator Assessment methods for the incidental by-catch of marine birds in fishing gear. Unfortunately, the availability of by-catch data could not keep pace, leading to a significant data deficiency regarding the application of assessment methods. Therefore, only a small number of species pilot assessments could be conducted for the Quality Status Report (QSR) 2023. While the originally preferred assessment method based on Population Viability Analysis (PVA, *Assessment Method 1*) fit with the preconditions presented by a small, localised population of the Cory's shearwater, problems became apparent when looking at a much more widely distributed species, namely the common guillemot.

From the example of the common guillemot in the Celtic Seas, it was demonstrated that the assessment method using PVA faces considerable limitations when several populations overlap spatially and / or birds from a population spend a part of the year outside the assessment area (i.e., in areas for which no by-catch data exist). An alternative assessment method for such complex population dynamics could be a PVA for multiple occurrences and metapopulations through a multi-site extinction analysis (Morris et al. 1999). However, such a method is data-hungry and more complex than a single population PVA, so it is unlikely to be developed for all the species/populations listed on the *OSPAR List of Threatened and/or Declining Species and Habitats* in the foreseeable future. Further, the PVA method does not match the first part of the North-East Atlantic Environment Strategy (NEAES) 2030 operational objective S7.O6 which is also the conservation objective in the *EU Action Plan for reducing incidental catches of seabirds in fishing gears*: …*minimise and where possible eliminate incidental by-catches of marine … birds* but only with the additional qualifier… *so that it does not represent a threat to the protection and conservation of these species*.

Therefore, at the time being, it is worth considering the application of the more comprehensive *Assessment Method 2*, which uses 1% of annual adult mortality as a threshold. Besides being much easier to apply, this method could be used for many more species taken as by-catch, including species not listed on the *OSPAR List of Threatened and / or Declining Species and Habitats.* However, the most important prerequisite for any by-catch assessment is to overcome current data deficiencies by qualitatively and quantitatively establishing appropriate monitoring programmes to assess marine bird by-catch and fishing effort. The adequate monitoring of marine bird by-catch is legally binding for EU Member States according to the Commission Delegated Decision (EU) 2021 / 1167. In addition to the established method to survey by-catch by on-board observers (Northridge et al. 2020) or through trained self-sampling by fishermen (Bærum et al. 2019), the development of electronic technologies in recent years, including electronic monitoring with video (**Figure g**), offers new and cost-effective ways to collect fisheries-dependent data over long periods and for extended areas (Dalskov et al. 2021, van Helmond et al. 2021, Larsen et al. 2021). Such data are essential input to run the future PVAs as described in *Assessment Method 1*.

Figure g: Adult male common eider entangled in a gillnet recorded with a CCTV camera during hauling (taken from Glemarec et al. 2020).

Knowledge Gaps (brief)

Despite various legal obligations for the monitoring of by-catch of protected, endangered and threatened species (including marine birds) in fisheries, there is a long-lasting and persisting data deficiency for most species and from most parts of the OSPAR Maritime Area. In addition, relevant fishing effort data are still not available or are of insufficient quality. This persistently poor data situation significantly hinders the assessment of the by-catch problem and makes it difficult to plan and apply specifically tailored management measures.

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Assessment Metadata

Field	Data Type	
Assessment type	List	Pilot Assessment
SDG Indicator	List	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Thematic Activity	List	Biological Diversity and Ecosystems - Targeted actions for the protection and conservation of species, habitats and ecosystem
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Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.

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