WORKING GROUP ON BY-CATCH

9–11 April 2026

Marine and Freshwater Research Institute, Hafnarfjörður, Iceland (hybrid)

REPORT

Presented to the 33rd meeting of the Scientific Committee as NAMMCO/SC/33/05

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EXECUTIVE SUMMARY

The NAMMCO Working Group on By-catch (BYCWG) held a meeting in Hafnarfjörður, Iceland, on 9–11 April 2026, chaired by Kimberly Murray. The aim of the meeting was to discuss the methods and current outputs of the by-catch risk mapping project initiated in 2024.

The project goal is to map the co-occurrence of fishing effort data with marine mammal distribution, as a proxy for the risk of animals encountering fishing gear and being by-caught. A research assistant was hired, with funding from the Nordic Council of Ministers AG-Fisk, to carry out this task. Fishing effort data were provided by the NAMMCO Parties, and aggregated by quarter to calculate the relative fishing intensity by different gear types and vessel sizes, at the scale of ICES Rectangles. Marine mammal distribution data were sourced from various national and international projects for ten focal species; relative animal density (in each quarter, per ICES Rectangle) was calculated from directly modelled estimates, or approximated from abundance surveys.

The BYCWG examined different approaches and assumptions that need to be made, based on the spatial, temporal, and qualitative limitations of the available data. For example, the Faroe Islands and Greenland provided coarser fishing effort data, which reduces map accuracy. Foreign fishing vessels were not reported at the same level of detail in Faroese waters, and excluding them from the analysis could underestimate fishing effort by 35–60% in some quarters, negatively biasing the co-occurrence index. Species abundance and distribution data generally stem from summer surveys, with little to no quantifiable information about winter months. As such, year-round density estimates (or proxies) are assumed or extrapolated from the closest time-period with information, which introduces yet more uncertainty in the resulting co-occurrence maps. The quality and resolution of the underlying data is reflected in a confidence score that accompanies each co-occurrence map, which shows how realistic the assumptions of by-catch risk are likely to be.

At the time of the meeting, there were insufficient data (particularly for pinniped distribution) to create comprehensive maps and provide robust interpretations and recommendations for all Parties. Instead, the BYCWG focused on a few examples of how this approached can be used and how the results should be interpreted. The co-occurrence maps presented are preliminary, subject to the inclusion of further datasets and additional analyses discussed at this meeting. Once the maps are final, the BYCWG recommends that NAMMCO consider them as a tool to identifying those gear types, seasons, and areas with relatively high (or low) exposure risk of marine mammal by-catch in order to advance a particular objective. For instance, this could be the design of a more systematic monitoring program to estimate by-catch, to direct research focused on marine mammal fishery interactions, or to implement by-catch mitigation efforts.

Some general points for consideration by managers when interpreting these maps are as follows:

- Areas flagged as low-overlap with high confidence indicate relatively low exposure to by-catch. As such, it can be lower priority to allocate monitoring effort there, especially in cases of limited resources.
- Low-risk gears, as identified in the risk matrix previously developed by the BYCWG, may still impact populations, particularly if fishing effort is high.
- Areas flagged as high-overlap should *not* constitute the sole focal point of by-catch monitoring if the aim is to estimate overall by-catch rates for the entire métier, as this would overinflate the estimates. However, in the absence of other information, such areas could be suitable for trialling or introducing mitigation methods.
- Maps should be interpreted in line with their associated confidence scores; for instance, risk maps with low confidence scores reflect a large amount of uncertainty in the underlying data.

OTHER RECOMMENDATIONS

Recommendations to streamline and expand the current project

- Apply this mapping approach to the remaining species in the NAMMCO area. Additional funding would be required to accomplish this.
- Add all raw and processed data, shapefiles, code, metadata, and any other relevant information to the internal NAMMCO database for future access.
- The current project will generate over a thousand maps. Therefore, the BYCWG recommends creating a data visualisation interface where managers and the public can explore project outputs in a user friendly format. This should be updated as new information becomes available. Additional funding is needed to create this interface.

Recommendations to the Parties

<u>Greenland</u>

- Provide more fine-scale information regarding how fishing effort is generally distributed within each Management Area, to improve co-occurrence analysis.

REPORT

The NAMMCO Working Group on By-catch (BYCWG) held a meeting in Hafnarfjörður, Iceland, on 9–11 April 2026. The meeting was chaired by Kimberly Murray. The aim of the meeting was to discuss the methods and current outputs of the by-catch risk mapping project initiated in 2024 (see document NAMMCO/SC/BYCWG/2026-02/FI01 for more details).

1 MEETING OPENING

The Chair welcomed participants (Appendix 1) to the meeting and thanked the hosts for making all the necessary arrangements. She noted that the goals of this meeting were to review the progress made by Olof Bengtsson, research assistant at the NAMMCO Secretariat, in mapping the focal species' co-ocurrence with fishing gears as a proxy for by-catch risk, discuss various considerations, caveats, and adjustments needed for the analysis, and provide suitable guidance to the Parties regarding by-catch monitoring.

2 ADOPTION OF AGENDA

A draft agenda had been circulated to participants prior to the meeting. The agenda was adopted as shown in Appendix 2.

3 APPOINTMENT OF RAPPORTEURS

Deputy Secretary Maria Garagouni was appointed primary rapporteur, with support from the Chair and participants as needed.

4 REVIEW OF AVAILABLE DOCUMENTS

The list of documents and files available for the meeting is shown in Appendix 3. The Chair noted that NAMMCO/SC/BYCWG/2026-02/05 had not been provided, but could be compiled *ad hoc* during the meeting, in order to establish the most appropriate structure for monitoring recommendations for each Party.

5 REVIEW OF METHODS APPLIED IN RISK CALCULATION

Bengtsson presented NAMMCO/SC/BYCWG/2026-02/04 and 08, an overview of the data included in the mapping exercise and the various modifications and assumptions made in the process. Individual points discussed are organised in the following sections, 5.1 to 5.3.

5.1 DATA INCLUDED IN THE EXERCISE

5.1.1 Fishing effort

Following a data call put out in 2024, the NAMMCO Parties provided information on fishing effort within and beyond their waters, as shown in Table 1. At present there is very limited information on recreational fishing effort in any of the countries; thus, any reference to vessel categories or fishing gears in the following text by default excludes recreational vessels. As fishing regulations and management depend on vessel size in most countries, it was also decided to categorise vessels into large (≥15 m) and small (<15 m) in all analyses.

For visualisation and analysis purposes, all effort data were mapped at the scale of ICES Rectangles (30' by 1°). That is, fishing effort at a coarser resolution was assumed to be evenly distributed across each spatial unit, e.g. management area or ICES Division; the value (number of hauls per quarter) of each of these units was proportionally assigned to all rectangles falling within it, depending on the extent of overlap. This is an oversimplification that creates the illusion of high or low fishing activity across large areas, but further information is needed to pinpoint the rectangles in which effort is actually concentrated.

Table 1. Resolution of fishing effort data provided by the four NAMMCO Parties.

Party	Data available	Spatial resolution	Fishing effort units
Faroe Islands	Domestic vessels >15 m	ICES Area/NAFO subdivision	Number of hauls
	Domestic vessels <15 m	ICES Area	Number of trips
	Foreign vessels	ICES Area/other management areas	Number of trips
Greenland	All vessel sizes/flags	Management areas specific to target species	Number of hauls
Iceland	All vessel sizes/flags	ICES Rectangle	Number of hauls
Norway	All vessels/flags	ICES Rectangle/NAFO subdivision	Number of hauls

It was highlighted that the Faroese fishing effort data was given as number of hooks or hours trawled rather than number of hauls, and coarse resolution (ICES division rather than rectangle) for large vessels. Fishing effort given as number of hooks or hours could be more directly informative in a targeted exercise for specific gears, but was not used in this analysis. However, the analysis can be rerun if fishing effort is provided as number of hauls at the ICES rectangle resolution. For small vessels, fishing effort was reported at a coarse resolution (ICES division) as number of trips.

Foreign fishing effort (besides vessels from other NAMMCO Parties) was also excluded, as the reporting format was incompatible with the analysis needs. This results in an underestimation of the total amount of fishing effort occurring in Faroese waters. To illustrate the scale of potential underestimation: in 2023, there were 24, 29, 27, and 25 large Faroese vessels operating during each quarter. Vessels under UK or Russian flags operating within Faroese waters at the same time numbered 14, 24, 39, and 27, respectively. It is possible, therefore, that the results of this exercise would underestimate the potential co-occurrence of large fishing vessels and marine mammals by anywhere from 35% to 60% in a given quarter (Figure 1).

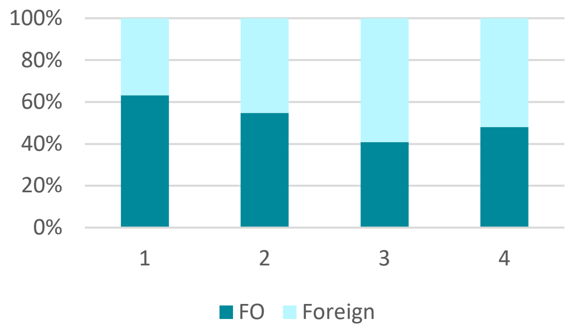


Figure 1. Fishing effort by vessels >15 m in each quarter of 2023, operating under Faroese or UK/Russian flags.

5.1.2 Species distribution data

Species distribution data were sourced from various studies, as shown in Table 2. The appropriateness of different data types, as well as the creation of proxies for species density, were discussed by the group. Additional datasets were also proposed, to be added to the analysis after the meeting itself. For example, minke whale density estimates could be provided by Norway from their dedicated mosaic surveys. Harbour porpoise density in coastal Norway could be roughly calculated from estimates obtained in selected fjord surveys.

At the time of the present meeting, distribution data for white-beaked and white-sided dolphins had been grouped together. Due to their similarity in appearance, these two species are not always distinguished in survey, catch, and by-catch records, making it harder to determine the distribution and movement patterns of each separately. However, the WG suggested an interim approach for this

Table 2. Species distribution data types, spatio-temporal resolution and coverage, and sources, as they were available at the time of the present meeting.

Species	Data type	Spatial resolution	Temporal resolution	Coverage	Source
Harbour porpoise	Density calculated from abundance estimates	Coarser than ICES Rectangle	Single estimate, summer surveys only	North Atlantic	Gilles et al. 2025; Leonard and Øien (2020); Heide-Jørgensen (2025)
Hooded seal	Predicted habitat suitability based on tagging data	Finer than ICES Rectangle	Monthly predictions, year-round	North Atlantic	Vacquiè-Garcia et al. (2024, 2025)
Humpback whale	Predicted density modelled from abundance estimates	Finer than ICES Rectangle	Monthly predictions, May–October	Northeast Atlantic	Cañadas et al. (2021)
	Density calculated from abundance estimates	Coarser than ICES Rectangle	Single estimate, summer surveys only	Greenland	Heide-Jørgensen (2025)
Killer whale	Predicted density modelled from abundance estimates	Finer than ICES Rectangle	Single prediction, summer surveys only	North Atlantic	Ramirez-Martinez (2021)
	Density calculated from abundance estimates	Coarser than ICES Rectangle	Single estimate, summer surveys only	Northeast Atlantic	Leonard and Øien (2020)
Minke whale	Predicted density modelled from abundance estimates	Finer than ICES Rectangle	Single prediction, summer surveys only	North Atlantic	Ramirez-Martinez (2021)
	Density calculated from abundance estimates	Coarser than ICES Rectangle	Single estimate, summer surveys only	Greenland	Heide-Jørgensen (2025)
Pilot whale	Predicted density modelled from abundance estimates	Finer than ICES Rectangle	Single prediction, summer surveys only	North Atlantic	Ramirez-Martinez (2021)
	Density calculated from abundance estimates	Coarser than ICES Rectangle	Single estimate, summer surveys only	Greenland	Heide-Jørgensen (2025)
White-beaked dolphin	Predicted density modelled from abundance estimates	Finer than ICES Rectangle	Single prediction, summer surveys only	North Atlantic	Ramirez-Martinez (2021)
White-sided dolphin	Density calculated from abundance estimates	Coarser than ICES Rectangle	Single estimate, summer surveys only	Central & northeast North Atlantic	Leonard and Øien (2020); Pike et al. (2019)

analysis, whereby the proportion of white-beaked to white-sided dolphins positively identified can be applied across the unidentified dolphins; therefore, density estimates can be allocated accordingly and maps can be provided for each species separately.

5.2 SPATIAL CONSIDERATIONS

5.2.1 Faroe Islands fishing effort

The Faroese fishing effort had originally been given at the resolution of ICES divisions, rather than rectangles. In order to produce maps comparable to the other datasets, fishing effort was assumed to be evenly spread across each ICES division and reprojected at the resolution of ICES rectangles. Finer-scale data at the level of ICES rectangle is available for gillnets, set longlines, purse seines, and bottom trawls and will be used in future analyses.

For small vessels, it was suggested that a known operational range from ports or depth contours for a given métier would allow for more detailed inferences of where the effort is actually located. Bjarni Mikkelsen highlighted a working paper from 2017 (added as NAMMCO/SC/BYCWG/2026-02/FI13) in which such details are listed, e.g., that gillnets and longlines targeting monkfish and Greenland halibut are set below the 380 m and 500 m depth contour, respectively.

5.2.2 Greenlandic fishing effort

Greenlandic fishing effort is recorded in large management areas that differ by target species (aligning with the local quota system). These areas vary in size and shape and are considerably larger than ICES rectangles. However, given a lack of more detailed information, it was assumed that documented fishing effort (number of hauls) is evenly distributed across each area within a given quarter. Niels Lyberth informed that small vessels under 6 m remain near the coast, and, conversely, large trawlers are not allowed to fish within fjords. It was suggested that AIS/VMS data could be used as an indicator of where effort by larger vessels is distributed. However, this type of data is not only highly sensitive but also bulky, and the time constraints of the current project are fairly limiting in that regard.

5.2.3 Harbour porpoise density

Harbour porpoise density in 14 different fjords along the Norwegian coastline (from Varangerfjorden to Boknafjorden) has been estimated from earlier surveys and described by the NAMMCO Scientific Committee Working Group on Harbour Porpoise (NAMMCO 2022). These were used to complement density estimates in fjords and coastal areas not covered by Northeast Atlantic surveys (Leonard & Øien 2020). As densities were only estimated for certain fjords/fjord systems, polygons were arbitrarily created around these fjords to get a consistent coverage along the Norwegian coastline, assuming equal harbour porpoise density in neighbouring fjords and surrounding coastal waters.

5.3 TEMPORAL CONSIDERATIONS

For most species, the available density estimates (or proxies for that) are based on surveys conducted during summer months. In order to provide an indication of species co-occurrence with fishing effort in other quarters, some assumptions must be made about their distribution at other times of the year. The BYCWG deliberated on the most suitable approach for each of the focal species, and agreed on the methods listed below.

5.3.1 Minke whale

Based on occurrence information gleaned from whale-watching and hunting activities, minke whales are presumed present in the study area in Q2 and Q3, but largely absent in Q1 and Q4; co-occurrence with fisheries is therefore *a priori* considered low in Q1 and Q4.

5.3.2 Dolphins

At present, it is generally understood that neither white-beaked nor white-sided dolphins undertake large-scale seasonal migrations. It is likely they exhibit seasonal movements following prey distribution; however, in the absence of more detailed information, a static year-round distribution is assumed from the current data.

5.3.3 Harbour porpoise

Harbour porpoises are known to move in and out of fjords, with some acoustic monitoring data potentially indicating potential seasonality in these movements in northern Norway. By-catch rates in Norwegian waters appear somewhat higher in autumn and winter gillnet fisheries targeting cod and monkfish. In Greenland, the hunting season has extended in recent years (due to increased porpoise presence following environmental changes), from May–June to year-round. As concluded for dolphins, in the absence of further information, a static year-round distribution is assumed for the moment.

5.3.4 Pilot whale

Satellite tracking data of pilot whales tagged in the Faroe Islands and Norway suggests some seasonal movements within the eastern North Atlantic, but no distinct north–south migration (i.e., year-round presence in the study area). As for dolphins and harbour porpoise, for the purposes of this exercise, a static year-round distribution is assumed.

5.3.5 Humpback whale

Humpback whales are known to be a migratory species, but not every individual in a given population migrates north–south every year. Indeed, in northern Norway, some animals not only remain in the area during Q1, but also interact quite frequently with the local herring fishery. However, this is a highly localised issue and it is not known how many individual whales are involved each year, that is, it could be a small fraction of the overall population. Given the absence of information on the actual density of animals during Q1, it was agreed not to extend the seasonal information to that quarter, but to leave it out of the current analysis. The BYCWG **highlighted** that this absence of information should not be interpreted as a reduced need for monitoring during that time of year, but as motivation to improve our knowledge of the species' abundance and movement patterns.

It was further agreed to assume that, for all areas except West Greenland, the data available for the month of October is representative of Q4, until more information can be obtained. As West Greenland is only represented by surveys conducted in Q3, a static distribution is extended to Q2 and Q4 as well.

5.3.6 Hooded seal

Monthly modelled data are available for this species from three locations. For two locations, these estimates only cover March to June. In those months, the average of all three datasets is to be used, while for the remaining months, the single dataset can be considered sufficiently representative.

5.3.7 Harbour and grey seals

Telemetry data from coastal seals tagged in different regions indicates varying dispersal behaviours not only between species, but also between populations. As such, it would likely be an oversimplification to assume a static distribution year-round. By-catch of these species is primarily associated with juveniles as they leave the breeding ground. It was agreed to use pup counts as proxies for animal density around the breeding season only.

5.3.8 Killer whale

Killer whales are known to be present in the study area year-round (albeit perhaps less regularly in Greenlandic waters, if catch records are any indication). Similarly to humpback whales, killer whales are known to overlap and interact with herring, capelin, and mackerel fisheries, and are found in

Norwegian fjords during winter months. However, there are no density estimates outside of summer months, and as a result, the WG agreed to assume a year-round static distribution based on the Q3 estimates.

6 MAPPING CO-OCCURRENCE INDICES

From the information available to the BYCWG, it appears that the Parties' by-catch monitoring and management schemes are at varying stages of planning and implementation. Moreover, large and small vessels are managed separately. Therefore, the WG agreed that the co-occurrence of fishing effort and species distribution that could lead to increased by-catch potential should be visualised separately for the two categories, as well as per gear type and quarter.

As the appropriate data had not been fully sourced and/or processed (as discussed under item 5) at the time of the meeting, the following graphics are **not** intended as final guidance for the Parties. Rather, they serve as a preliminary illustration of how to implement this mapping approach and interpret the resulting co-occurrence indices.

Figures 2–4 illustrate the process of reaching a spatio-temporal index of co-occurrence of fishing effort and marine mammals. For each metric, four panels are included, showing the four quarters of the year, standardised so that the values are directly comparable between different seasons: fishing effort is shown as the relative number of hauls of the selected métier across the four quarters; species density is shown as the relative proportion of individuals likely to be found somewhere in each quarter (taking into account the generalisations discussed under 5.3); and risk represents the relative likelihood that fishing effort with the selected métier and individuals of the selected species will co-occur in time and (two-dimensional) space.

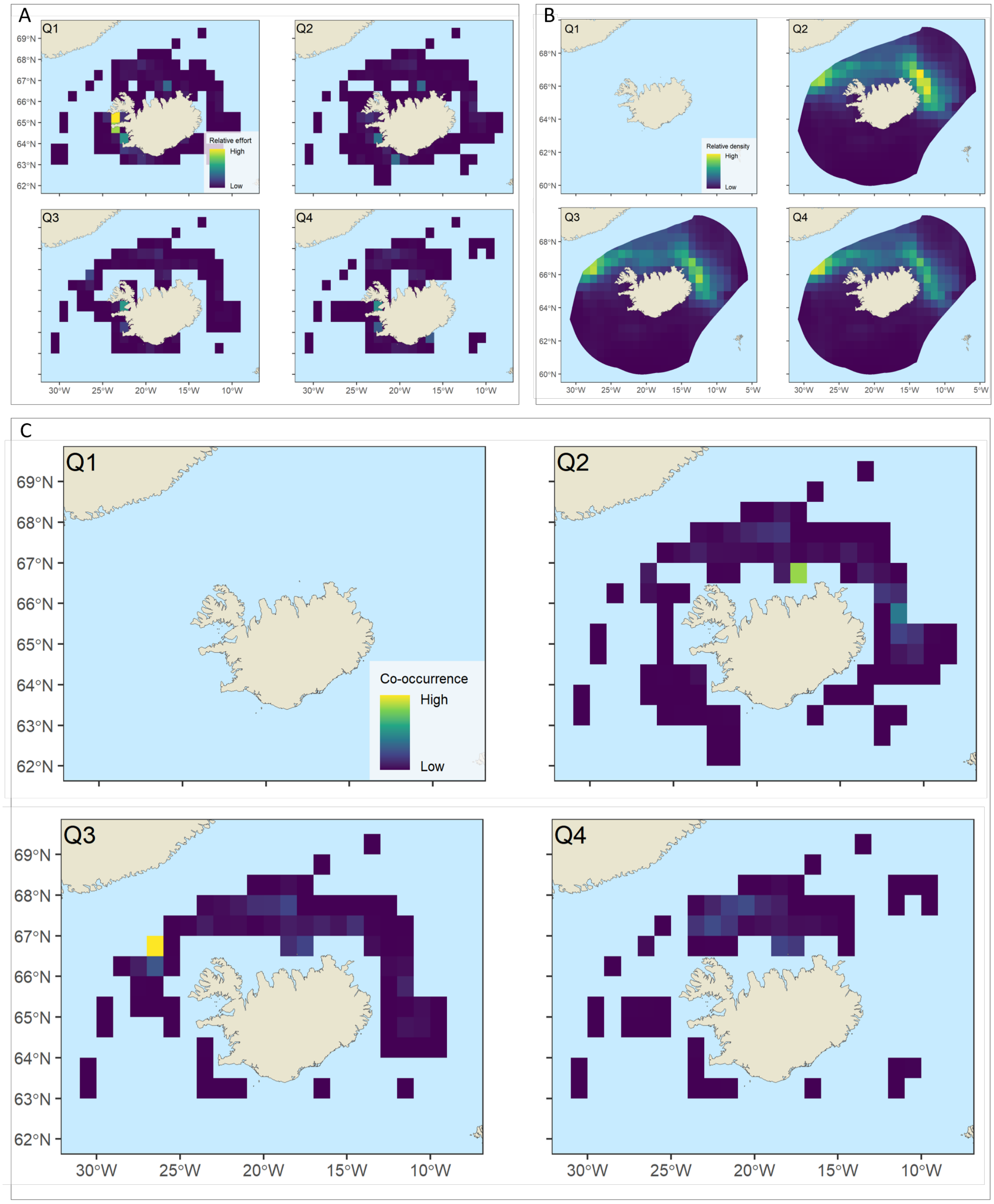
Different fishing gear types do not all present the same threat of entanglement and by-catch to marine mammals. This depends both on the nature of the gear itself (its physical properties and how it is deployed) and on the behaviour of the species in question. For example, bottom-set gillnets form a pliable wall along the seabed, in which harbour porpoises and small seals may very easily become entangled while trying to approach fish in and around the nets, and from which they lack the strength or ability to break free. As such, gillnets can be considered a high-risk métier for porpoises and seals, but moderate-risk for dolphins or large whales, which are not as easily entangled or can pull free. In contrast, set longlines, a single rope with hooks attached at regular intervals, are not very likely entangle dolphins, porpoises, or seals, and can be considered a low-risk métier for those animals. Large whales, however, may get the longline rope caught in their mouth or around their flippers/body while manoeuvring and may not be able to disentangle themselves without human intervention. At its 2024 meeting, the BYCWG created a risk matrix for the different gear types present in the data provided by the Parties (NAMMCO 2024, Appendix 5). The co-occurrence examples below are for high-risk fishing gears, as those are the most likely to pose a threat at the individual and population level.

Maps for gears that are considered to pose low entanglement risk can be produced following the same procedure, however, these are likely only of interest for monitoring if there is considerable effort within a given fishery. That is, even a métier that is not considered a threat on its own may pose a non-negligible risk of by-catch if the cumulative effort is high (see Figure 5) and/or if multiple species exhibit high densities in the same locations. Another reason to visualise these data may be to conduct targeted research of potential interactions between marine mammals and fishing gear in high-overlap areas.

Each co-occurrence map is displayed along with an associated confidence score. The ICES WGBYC has developed a confidence metric to quantify how accurate such visualisations are (NAMMCO/SC/BYCWG/2026-02/FI04, section 4.4). These criteria, with some slight modifications to better suit the BYCWG approach, are listed in Table 3.

Table 3. Confidence scoring criteria (adapted from ICES 2025) that reflect the robustness of any inferences made regarding the co-occurrence of fishing effort and marine mammals, depending on the quality of the underlying data.

Component	Element	Confidence rating	Score	Explanation	Final score
Spatial Overlap score Confidence (SOC)	Species distribution (SD)	High	5	Density map -high spatial resolution (ICES rectangles or higher)	SOC
		Good	4	Density map - low spatial resolution (lower than ICES rectangle)	
		Moderate	3	Habitat/foraging suitability	
		Low	2	Presence/absence	
		Very low	1	Low resolution presence only (i.e. perimeter map)	
	Fishing effort (FE)	High	5	>80% of effort density reported at scale of ICES rectangles	
		Good	4	≤80 of effort density reported at scale of ICES rectangles	
		Moderate	3	≤60 of effort density reported at scale of ICES rectangles	
		Low	2	≤40 of effort density reported at scale of ICES rectangles	
		Very low	1	≤20 of effort density reported at scale of ICES rectangles	
Seasonal density score Confidence (SDC)	Species distribution (SD)	High	5	High temporal resolution (all quarters/≥10 months)	SDC
		Good	4	Good temporal resolution (3 quarters/7-9 months)	
		Moderate	3	Moderate resolution (2 Quarters/5-6 months)	
		Low	2	Low resolution (1 Quarter/Annual/1-4 months)	
		Very low	1	Occasional records of presence.	
Density relevancy score Confidence (DRC)	Species distribution (SD)	High	5	Recent or contemporary data (e.g., <10 years old)	DRC
		Good	4	Relatively contemporary data (e.g., <15 years old)	
		Moderate	3	Moderately recent data (e.g., <20 years old)	
		Low	2	Old data (e.g., <30 years old)	
		Very low	1	Historical data (e.g., >30 years old)	



Component	Score justification	Score
Density spatial resolution score	Density estimates from Cañadas et al. 2021 reported a higher resolution than ICES rectangles.	5
Effort spatial resolution score	>95.80% of the fishing effort is reported by ICES rectangle.	5
Seasonal density score	Monthly estimates from May to October (6 months)	3
Density relevancy score	Density estimates <10 years old. (Survey data from 1998-2018)	5
	Total score (average of all components)	**4.5/5**

Figure 2. Visualisation and confidence scoring of: relative effort of large vessels fishing with set gillnets in the Icelandic EEZ, averaged across 2021–2023 (panel A); relative humpback whale density (panel B), based on predictive modelling by Cañadas et al. (2021); and co-occurrence index of the two (panel C), for each quarter (Q1–Q4) of the year.

This confidence score reflects the certainty around both the fishing effort and species density data. As the fishing effort, species density, and overlap within each quarter are all calculated as relative to the other quarters, confidence in their visualisation is influenced by the data in every quarter; therefore, it is considered appropriate that a single confidence score be assigned to all four quarters. When combining information from multiple datasets at different resolutions, the most conservative approach is to apply the lowest confidence score applicable. When combining information from multiple species, an average of their individual scores could be used.

In the example of humpback whale co-occurrence with gillnets in Icelandic waters (Figure 2, panel C), it appears there is a high index in the north and northeast during Q2 and higher still in the northeast in Q3, with a comparatively lower co-occurrence index during Q4. Areas with the highest fishing effort along the eastern coast (panel A) do not have a high co-occurrence index, as the predicted density of humpback whales in those areas is low (panel B). The confidence score for this species-métier combination is high (4.5 out of a possible 5) based on the data included. However, as noted in section 5.3.5, the lack of co-occurrence during Q1 is due to a paucity of information on actual humpback whale presence during that time of year and, therefore, should *not* be interpreted as a complete lack of by-catch risk.

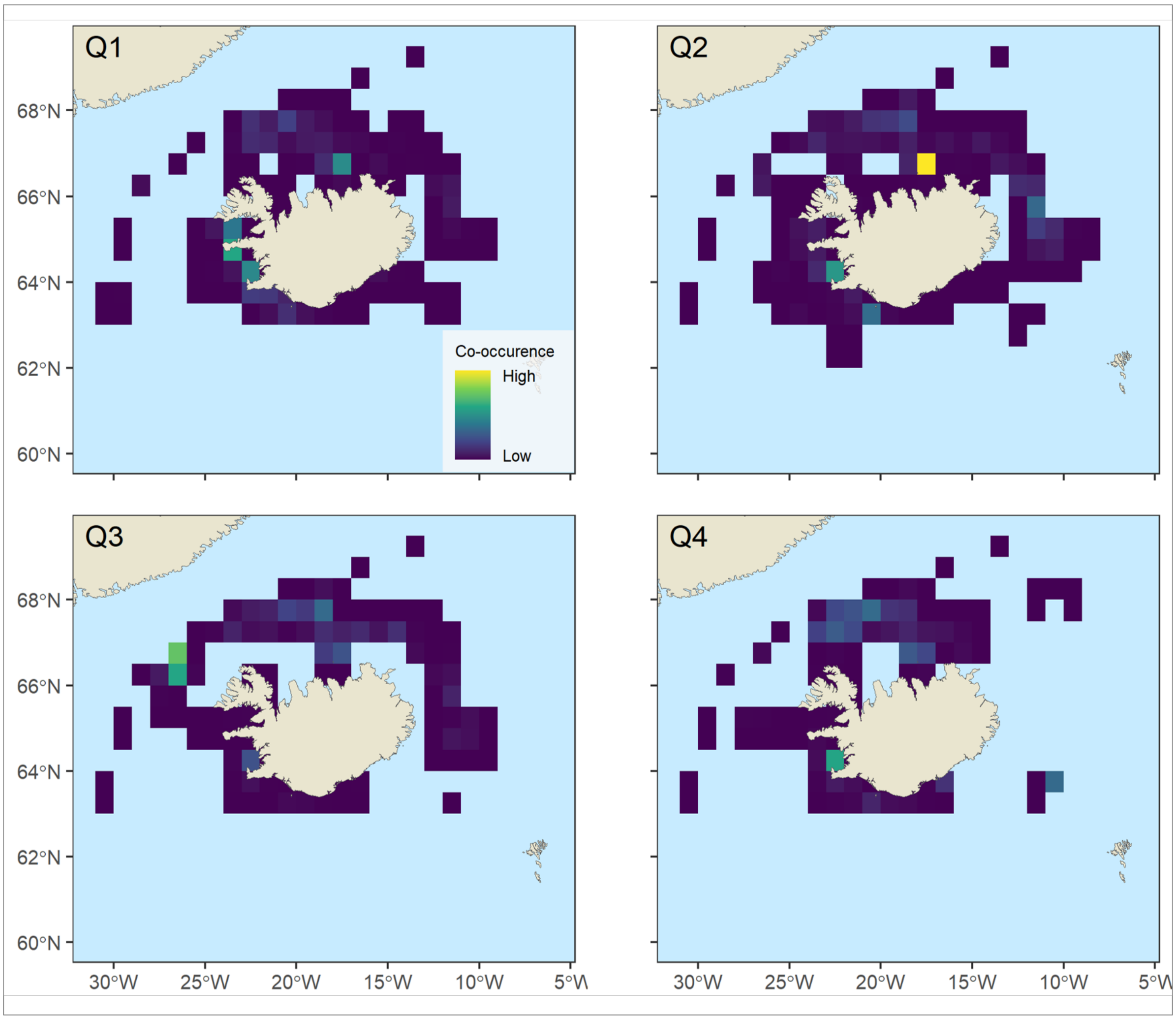
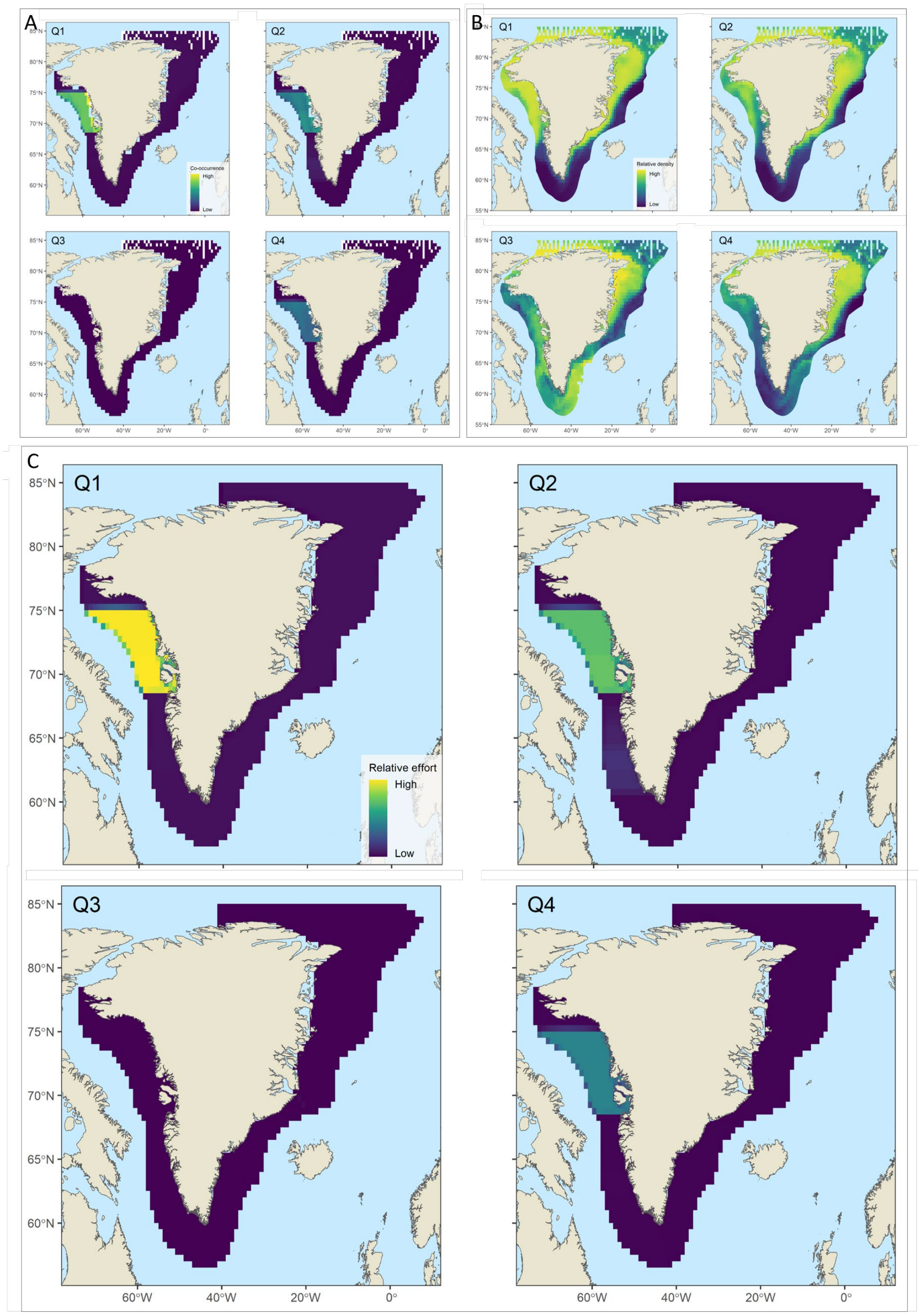


Figure 3. Visualisation of co-occurrence index of relative effort of large vessels fishing with set gillnets in the Icelandic EEZ, averaged across 2021–2023, and the relative animal density of six marine mammal species (hooded seal, humpback whale, minke whale, pilot whale, white-beaked dolphin, and white-sided dolphin, for each quarter (Q1–Q4) of the year. Confidence scoring follows on next page.

Figure 3 continued: Confidence scoring of co-occurrence index of multiple species with set gillnets in the Icelandic EEZ.

Species	Component	Score justification	Score
Hooded seal	Density spatial resolution score	Habitat suitability scores and not actual density estimates.	3
	Effort spatial resolution score	>78.47% of the fishing effort is reported by ICES rectangle.	4
	Seasonal density score	Monthly habitat suitability scores for the whole year.	5
	Density relevancy score	Habitat suitability scores modelled for 2007 (<15 years old).	4
Humpback whale	Density spatial resolution score	Density estimates from Cañadas et al. 2021 reported at a higher resolution than ICES rectangles.	5
	Effort spatial resolution score	>78.47% of the fishing effort is reported by ICES rectangle.	4
	Seasonal density score	Monthly estimates from May to October (6 months)	3
	Density relevancy score	Density estimates <10 years old. (Survey data from 1998-2018)	5
Minke whale	Density spatial resolution score	Density estimates from Pike et al. 2019 (NASS 2015) reported at a lower resolution than ICES rectangles.	4
	Effort spatial resolution score	>78.47% of the fishing effort is reported by ICES rectangle.	4
	Seasonal density score	Only one (summer) density estimate	2
	Density relevancy score	Density estimate <10 years old. (Survey from 2015)	5
Pilot whale	Density spatial resolution score	Density estimates reported at a higher resolution than ICES rectangles.	5
	Effort spatial resolution score	>78.47% of the fishing effort is reported by ICES rectangle.	4
	Seasonal density score	Density only estimated for summer (Jun-Aug).	2
	Density relevancy score	Density estimates <10 years old (surveys conducted 1998-2015)	5
White-beaked dolphin	Density spatial resolution score	Density estimates from Pike et al. 2019 (NASS 2015) reported at a lower resolution than ICES rectangles.	4
	Effort spatial resolution score	>78.47% of the fishing effort is reported by ICES rectangle.	4
	Seasonal density score	Only one (summer) density estimate	2
	Density relevancy score	Density estimate <10 years old. (Survey from 2015)	5
White-sided dolphin	Density spatial resolution score	Density estimates from Pike et al. 2019 (NASS 2015) reported at a lower resolution than ICES rectangles.	4
	Effort spatial resolution score	>78.47% of the fishing effort is reported by ICES rectangle.	4
	Seasonal density score	Only one (summer) density estimate	2
	Density relevancy score	Density estimate <10 years old. (Survey from 2015)	5
		Total score (averaged across species)	**3.9/5**



Component	Score justification	Score
Density spatial resolution score	Habitat suitability scores and not actual density estimates.	3
Effort spatial resolution score	99.98% of the fishing effort is reported at lower resolution than ICES rectangle (GL management areas)	1
Seasonal density score	Monthly habitat suitability scores for the whole year.	5
Density relevancy score	Habitat suitability scores modelled for 2007 (<15 years old).	4
	Total score (average of all components)	**3.25/5**

Figure 4. Visualisation and confidence scoring of: relative effort of small vessels fishing with gillnets in the Greenlandic EEZ, averaged across 2021–2023 (panel A); relative hooded seal density (panel B), based on habitat modelling by Vacquiè-Garcia et al. (2024, 2025); and co-occurrence index of the two (panel C), for each quarter (Q1–Q4) of the year.

In the multispecies example for Icelandic waters (Figure 3), using the same fishing effort data as for the single-species example, coastal areas in the east have a higher co-occurrence index than humpback whales alone did, indicating that other species are driving this overlap with concentrated fishing effort. The ICES rectangle with the highest co-occurrence index is in Q2, north of Iceland. This is clearly not due to fishing effort alone (as evidenced by other rectangles having the same relative effort in Q2, shown in Figure 2, panel A). Rather, it appears that the aggregated species densities are higher there than elsewhere or in any other season. The confidence score for this species-métier combination is lower than the single-species one, due largely to poorer information on the seasonality of cetacean movements and abundance. It should be highlighted, however, that this exercise only included six focal species, so it is not truly representative of all marine mammals in Icelandic waters.

In the case study of hooded seal co-occurrence with gillnets deployed by small vessels in Greenlandic waters (Figure 4), there are some obvious inadequacies. The species distribution (panel B) uses predicted habitat suitability rather than actual observed or predicted animal densities, albeit at a fine resolution. More importantly, the fishing effort was provided at a very coarse scale, over very large management areas (panel A). This impacts the resolution of the final product, whereby the co-occurrence index appears more evenly distributed than it likely is. As such, the confidence score is lower than in the previous examples, and the results likely do not represent reality, highlighting the importance of detailed information on fishing effort.

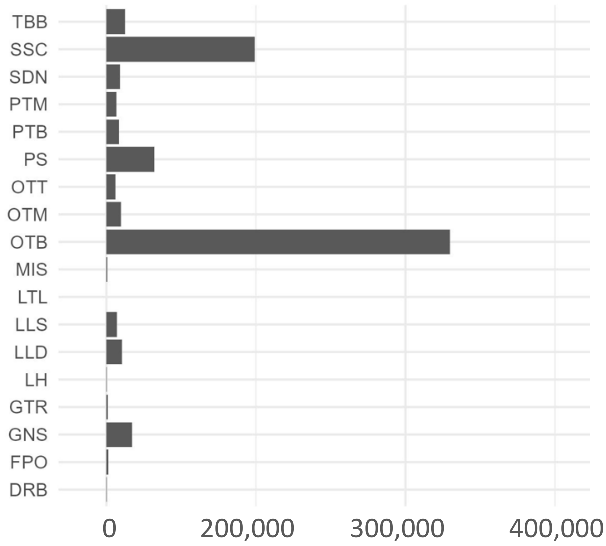


Figure 5. Number of hauls conducted by different métiers in Norway. Note the much higher fishing effort with bottom otter trawls (OTB) and fly-shooting seines (SSC), both of which are overall low-risk gear types, compared to gillnets, an overall high-risk gear type.

7 RECOMMENDATIONS FOR BY-CATCH MONITORING

The maps presented in this report illustrate the co-occurrence patterns between fishing effort and various marine mammal species of interest to NAMMCO and for which spatial density estimates were available from historic surveys. For gear types with known potential for by-catch (NAMMCO/SC/BYCWG/2026-02/FI04), the maps depict exposure risk by ICES statistical rectangle and calendar quarter, with uncertainty characterised by a confidence metric value. This resolution of exposure risk can help prioritise efforts for improved monitoring of by-catch of vessels fishing in NAMMCO country waters, by directing resources toward specific gear types, seasons, areas, or species of interest (Wade et al. 2021). Sampling programs can then be designed appropriately depending on the objective. For instance, if the goal is to estimate by-catch with a desired level of precision, then data should be collected from a representative sample of the fishery with respect to the suite of attributes that characterise fishing effort, such as temporal and spatial distribution, vessel and gear characteristics (Moore et al. 2021). Factors to consider in the design of monitoring programs for fisheries with a limited level of by-catch information are available from additional sources (for instance, see also ICES 2024, Curtis and Carretta 2020, ICES 2011).

WG recommendation:

Currently, the co-occurrence maps are preliminary, subject to additional analyses discussed at this meeting. Once the maps are final, the WG recommends that NAMMCO consider them as a tool to identifying those gear types, seasons and areas with relatively high (or low) exposure risk of marine mammal by-catch in order to advance a particular objective. For instance, this could be the design of a more systematic monitoring program to estimate by-catch, to direct research focused on marine mammal fishery interactions, or to implement by-catch mitigation efforts.

Some general points for consideration by managers when interpreting these maps are as follows:

- Areas flagged as low-overlap with high confidence indicate relatively low exposure to by-catch. As such, it can be lower priority to allocate monitoring effort there, especially in cases of limited resources.
- Low-risk gears, as identified in the risk matrix, may still impact populations, particularly if fishing effort is high.
- Areas flagged as high-overlap should not constitute the sole focal point of by-catch monitoring if the aim is to estimate overall by-catch rates for the entire métier, as this would overinflate the estimates. However, in the absence of other information, such areas could be suitable for trialling or introducing mitigation methods.
- Maps should be interpreted in line with their associated confidence scores; for instance, risk maps with low confidence scores reflect a large amount of uncertainty in the underlying data.

8 OTHER RECOMMENDATIONS

8.1 RECOMMENDATIONS TO STREAMLINE AND EXPAND THE CURRENT PROJECT

- Apply this mapping approach to the remaining species in the NAMMCO area. Additional funding would be required to accomplish this.
- Add all raw and processed data, shapefiles, code, metadata, and any other relevant information to the internal NAMMCO database for future access.
- The current project will generate over a thousand maps. Therefore, the BYCWG recommends creating a data visualisation interface where managers and the public can explore project outputs in a user friendly format. This should be updated as new information becomes available. Additional funding is needed to create this interface.

8.2 RECOMMENDATIONS TO THE PARTIES

Greenland

- Provide more fine-scale information regarding how fishing effort is generally distributed within each Management Area, to improve co-occurrence analysis.

9 RELEVANT RESEARCH PRODUCTS

Direct outputs of the current project mapping fishing effort and marine mammal co-occurrence as a proxy for by-catch risk are: a poster to be presented by Bengtsson at the annual conference of the European Cetacean Society (20–24 April 2026), and a manuscript to be submitted for peer-reviewed publication in the coming months. Both will present the methods applied by the BYCWG on select case studies, illustrating the usefulness of this tool for management.

Other members of the BYCWG are part of two international projects on marine megafauna by-catch mitigation, namely CIBBRiNA and Marine Beacon. A poster on best practices for collaboration with fishers to minimise by-catch was also scheduled to be presented at the upcoming ECS conference. Additionally, Dunja Jusufovski organised a workshop to be held at that same conference, with participation from scientists, fishers, and managers, to discuss current knowledge, challenges, developments, and interdisciplinary collaborations for the mitigation of bycatch. The Marine Beacon project aims, among other things, to develop species distribution models and improve overall knowledge on by-catch risk, for monitoring and mitigation purposes.

10 ADOPTION OF REPORT

A draft of the report was agreed upon during the meeting. The final version of the report was adopted by correspondence on 29 June 2026.

11 MEETING CLOSE

The Chair thanked all participants for their enthusiastic participation, particularly the online attendees, as well as the hosts for arranging the meeting practicalities. The WG congratulated Bengtsson for the amount of progress achieved in a limited timeframe, and thanked Murray for her able chairing of the meeting.

12 REFERENCES

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APPENDIX 1: AGENDA

1. **Welcome from Chair and opening remarks**
2. **Adoption of agenda**
3. **Appointment of rapporteurs**
4. **Review of available meeting documents**
5. **Review of methods applied in risk calculation**
    - 5.1. Data included
    - 5.2. Spatial considerations
        - 5.2.1. Faroe Islands
        - 5.2.2. Greenland
        - 5.2.3. Iceland
        - 5.2.4. Norway
    - 5.3 Temporal considerations
        - 5.2.5. Pilot whale
        - 5.2.6. Humppack whale
        - 5.2.7. Hooded seal
        - 5.2.8. Etc.
6. **Identification of high and low risk of exposure to by-catch risk**
    - 6.1. Visualisation of risk maps by species
    - 6.2. Application of confidence metrics
7. **Recommendations for prioritisation of by-catch monitoring efforts**
    - 7.1. Faroe Islands
    - 7.2. Greenland
    - 7.3. Iceland
    - 7.4. Norway
8. **Recommendations for further analyses by the WG**
9. **Research products and upcoming conferences/workshops relevant to this assessment**
10. **Adoption of report**
11. **Meeting close**

APPENDIX 2: LIST OF PARTICIPANTS

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APPENDIX 3: LIST OF DOCUMENTS

Document Reference	Title	Agenda Item
Working Documents		
BYCWG/2026-02/01	Draft Agenda	1, 2
BYCWG/2026-02/02	Draft List of Participants	1, 3
BYCWG/2026-02/03	Draft List of Documents	4
BYCWG/2026-02/04	Overview of methods applied during risk calculation process	5, 8
BYCWG/2026-02/05	Information from Parties on by-catch management and monitoring process	6, 7
BYCWG/2026-02/06	GIS project with individual risk layers calculated	5, 6, 7
BYCWG/2026-02/07	WGBYC confidence metric tailored to this project	6, 7
BYCWG/2026-02/08	Overview of species distribution data	5
For information documents		
BYCWG/2026-02/FI01	Report of BYCWG 2024	All
BYCWG/2026-02/FI02	Meeting minutes BYCWG 2025-01	All
BYCWG/2026-02/FI03	Meeting minutes BYCWG 2026-01	All
BYCWG/2026-02/FI04	ICES WGBYC Report 2025	6.2
BYCWG/2026-02/FI05	Ramirez Martinez 2021, Cetacean distribution and habitat use in the central and north-eastern North Atlantic	5.1
BYCWG/2026-02/FI06	Cañadas et al. 2021, Development of exploratory marine species density models in the NAVEUR/C6F study area	5.1
BYCWG/2026-02/FI07	Vacquiè-Garcia et al. 2024, Intra-species differences in impacts of climate change: A case study of the hooded seal (*Cystophora cristata*)	5.1
BYCWG/2026-02/FI08	Vacquiè-Garcia et al. 2025, Foraging habits of Northwest Atlantic hooded seals over the past 30 years: Future habitat suitability under global warming	5.1
BYCWG/2026-02/FI09	Leonard & Øien 2020, Estimated abundances of cetacean species in the Northeast Atlantic from Norwegian shipboard surveys conducted in 2014–2018	5.1
BYCWG/2026-02/FI10	Gilles et al. 2025, Spatial models of cetacean density in European Atlantic waters based on SCANS-IV summer 2022 survey data	5.1
BYCWG/2026-02/FI11	De Clerk et al. 2025, Trans-Atlantic movements of Atlantic white-sided dolphins, *Leucopleurus acutus*	5.1

BYCWG/2026-02/FI12	Heide-Jørgensen 2025, Analysis of a whale survey in West and East Greenland in 2024	5.1
BYCWG/2026-02/FI13	Fisheries and by-catch in Faroese waters (Working document BYCWG 2017)	5.2
BYCWG/2026-02/FI14	By-catch observation efforts in Faroese waters (Working document BYCWG 2020)	5.2
BYCWG/2026-02/FI15	Skern-Mauritzen et al. 2022, Marine mammal consumption and fisheries removals in the Nordic and Barents Seas	5.3