WORKING GROUP ON MARINE MAMMAL ECOLOGY (WGMME)

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Contents

i Executive summary

The Working Group on Marine Mammal Ecology met in 2022 to address five terms of reference. Under the first of these, ToR A, new information on cetacean and seal population abundance, distribution, population/stock structure, was reviewed, including information on vagrant marine mammal species. This was done to ensure the recording of possible range changes in marine mammal species in the future.

For cetaceans, an update is given for the different species, providing for a latest estimate for all species studies. In this report, particular attention is given to the updating of information from Canadian and US waters, and together with those countries, latest estimates for cetacean species are provided. For seals, latest monitoring results are given for harbour, grey and Baltic ringed seals. In addition, where possible, local long-term trends are illustrated for those species, based on earlier WGMME efforts to assemble these data into the WGMME seal database. For both species' groups, a first account of vagrant species is provided

Unlike earlier reports, cetacean and seal management frameworks in the North Atlantic were discussed under ToR B, where an overview is given including local management frameworks and regional conventions regarding marine mammals. Also, implications of the new US Marine Mammal Protection Act import provisions rule were examined.

ToR C provides an overview of new published information with regards to anthropogenic threats to marine mammal populations following on from the review by WGMME in 2015 (ICES, 2015) and subsequent updates. These are considered under the following headings: cumulative effects, fishery interactions, chemical pollution, marine debris, underwater noise, ship strikes and other physical trauma, tourism, and climate change.

ToR D is a collaboration with WGBIODIV to identify foraging areas and estimate prey consumption by harbour seal, grey seal and harbour porpoise in the North Sea case study area. WGBIODV plans to further develop multi species models in the North Sea including large predators and needs information on diet preference for the different species. Based on WGMME 2021, caveats and limitations that may affect the use of these data are explained and were obtained to pilot sample datasets to illustrate the available data. There is a need for comparative studies to calibrate the estimates derived from these different methods, and develop new methods such as the use of DNA. The group expects shifts in the diet of marine top predators and therefore the necessity to ameliorate methods to study this. A workshop on diet studies to be held in association with other relevant bodies in 2023 is suggested to ensure comparable methods are used.

ToR E is in collaboration with WGBYC to contribute to the Roadmap for ICES PETS bycatch advice. This is done by reviewing aspects of marine mammal-fishery interactions which are not fully covered by WGBYC (notably strandings) on marine mammals. The results of the questionnaire held in 2021 are presented, reviewing the benefits and limitations for using strandings to determine bycatch rates, how best procedures can be improved, whilst identify-ing the need for better reporting of strandings of seals across the region. The group suggests to (i) develop a best-practice manual or framework on marine mammal strandings to inform bycatch assessment. This could be published as a CRR; (ii) to develop a data call and database for such data; and (iii) to organise a workshop or workshops to develop (i) and (ii) above.

ii Expert group information

Expert group name	Working Group on Marine Mammal Ecology (WGMME)
Expert group cycle	Annua
Year cycle started	2021
Reporting year in cycle	1/1
Chairs	Sophie Brasseur, The Netherlands
	Peter Evans, UK
Meeting venue and dates	7-10 February 2022, Online (40 participants)

1 ToR A: Review and report on any new information on cetacean and seal population abundance, distribution, population/stock structure, including information on vagrant marine mammals

1.1 Cetacean Abundance and Distribution

1.1.1 Large-scale Surveys

An updated version of the report on abundance estimates from the SCANS-III survey in summer 2016 has been published (Hammond *et al.*, 2021). The report contains corrected abundance estimates for several species.

SCANS-IV: The Small Cetaceans in European Atlantic waters and the North Sea (SCANS) survey is being planned for summer 2022. This project will represent the fourth survey in the SCANS series, in addition to the Cetacean Offshore Distribution and Abundance (CODA) survey. SCANS-IV will deliver regionally coordinated synoptic surveys in shelf and offshore waters of the European Atlantic. It will generate robust abundance estimates for regularly occurring whale and dolphin species and improve power to detect trends in shelf and offshore species. Coverage of offshore waters will provide a third estimate (CODA & SCANS-III), which means that trends in abundance for offshore species could be investigated for the first time. Inclusion of offshore waters is also critical for species which occur both on and off the shelf, such as the common dolphin. Funding has been secured from the governments of Denmark, France, Germany, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Part of the available funding will be used nationally for survey preparation and implementation, in some cases using existing survey teams and scientists. The outputs of the project are timely for Member States' obligations for reporting under the Marine Strategy Framework Directive (MSFD Article 8: due 2024) and the next reporting round under the Habitats Directive (Article 17: 2019 – 2024).

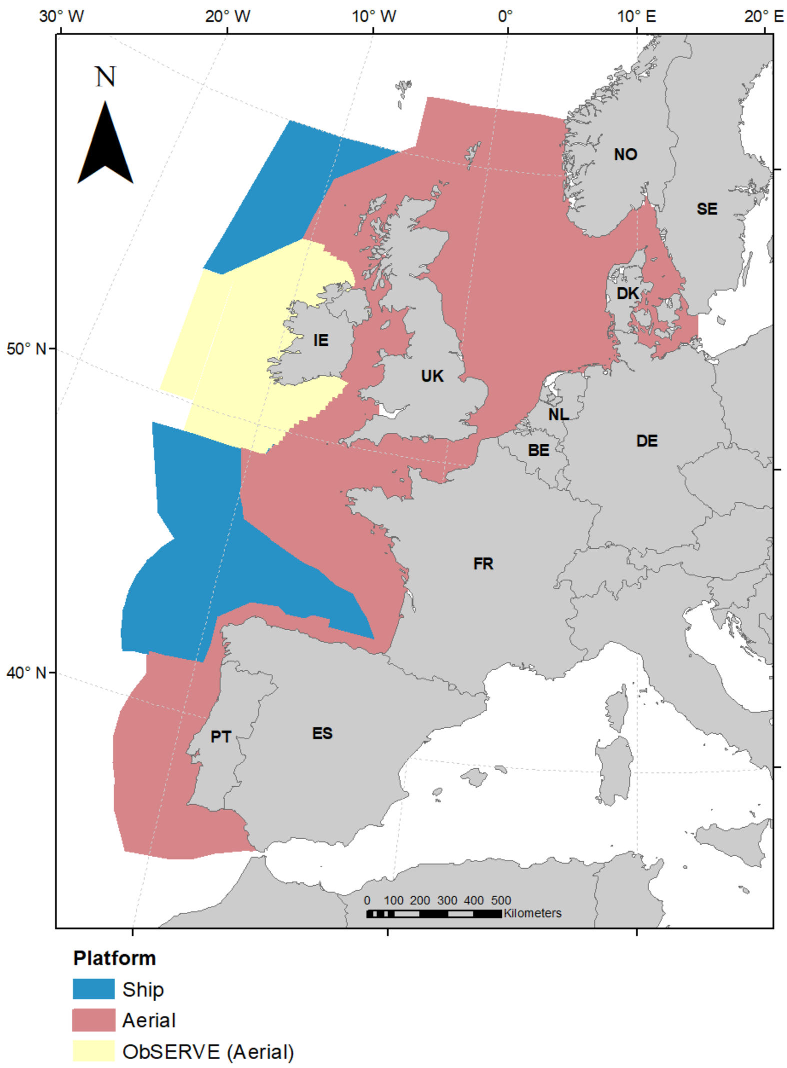

Figure 1.1. Proposed SCANS-IV survey area and anticipated platform coverage. (Note: ObSERVE area is covered independently by Ireland)

1.1.2 Regional Surveys

BELGIUM: In 2021, two aerial marine mammal surveys were conducted covering the Belgian EEZ. The average density of harbour porpoises (*Phocoena phocoena*) in all Belgian waters was estimated at 0.81 (0.52-1.28) and 0.78 (0.44-1.35) animals per km² in June and September, respectively.

DENMARK/GERMANY/SWEDEN: In June and July 2020, Germany, Denmark, and Sweden conducted a dedicated large-scale aerial survey (called MiniSCANS-II) for harbour porpoises in the management area of the Belt Sea population, i.e. between an east-west line between Denmark and Sweden at 56.95°N in the Kattegat Sea, and a north-south line between Sweden and Germany at 13.5°E in the southern Baltic Sea. Observers recorded a total of 202 sightings (251 individuals, of which 16 were calves). The abundance of the Belt Sea population was estimated to be 17 301 harbour porpoises (95% CI = 11 695-25 688; CV = 0.20), with an average density of 0.41 individuals/km² (95% CI = 0.28-0.61). This is the lowest abundance estimate since the first (SCANS) survey was conducted in 1994. For information on trends, see GERMANY.

DENMARK: The annual aerial surveys of harbour porpoises were conducted in Skagerrak in July 2020 and in the Southern North Sea in August 2020. The surveys are part of the national monitoring program NOVANA.

In the North Sea, a total of 147 porpoises (including 6 calves) were observed in groups of 1-3 animals, and with an average group size of 1.2 animals (Figure 1.2.1). All calf observations were within the Natura 2000 sites. The abundance of porpoises in the survey area was estimated to 5345 animals (95% confidence interval: 3895-8310) with a density of 1.20 porpoise/km^2 (During the aerial survey in Skagerrak, a total of 22 porpoises (including two calves) were observed in groups of one or two animals, and with an average group size of 1.22 animals. The observations were distributed throughout the area with only four porpoise observations within the large Natura 2000 site “Skagens Gren and Skagerrak” and none within the two other smaller Natura 2000 sites (Figure 1.2.2). In 2020, a total of 2674 porpoises (95% confidence interval: 1513-4216) were observed with a density of 0.22 porpoise/km^2 (Table 1.1). This estimate is low compared to previous surveys and in general, a negative trend is seen from 2011 to 2020.

Table 1). This is comparable with the results from 2019, but higher than the estimates for 2015–2018. Over the entire monitoring period from 2011–2021, a stable trend of around 4000 porpoises is shown.

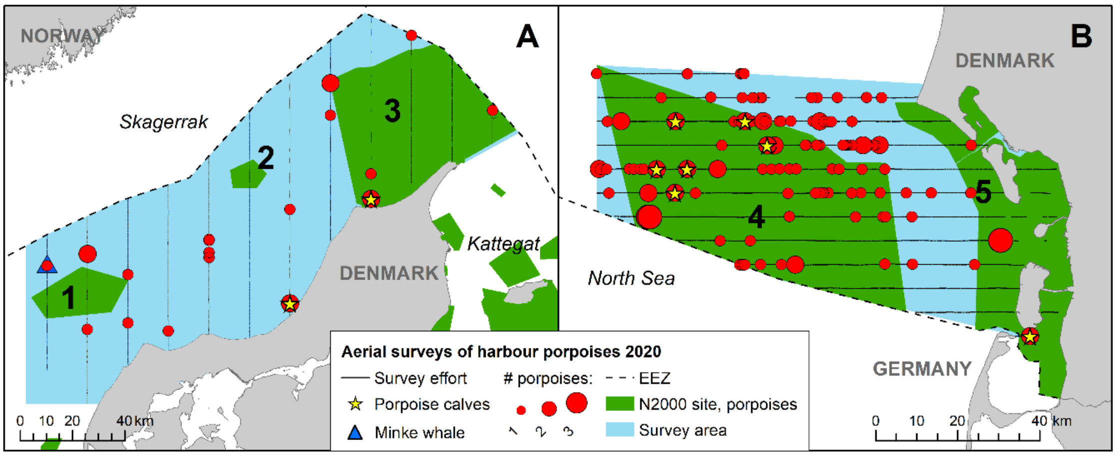

Figure 1.2. Aerial survey of harbour porpoises in A) Skagerrak; July 2020 and B) the Southern North Sea, August 2020. The green areas indicate Natura 2000 sites designated for harbour porpoises: 1) Yellow Reef, 2) Great Reef, 3) Skagens Gren and Skagerrak, 4) Southern North Sea and 5) The Wadden Sea with Ribe Å, Tved Å and Varde Å vest for Varde.

During the aerial survey in Skagerrak, a total of 22 porpoises (including two calves) were observed in groups of one or two animals, and with an average group size of 1.22 animals. The observations were distributed throughout the area with only four porpoise observations within the large Natura 2000 site “Skagens Gren and Skagerrak” and none within the two other smaller Natura 2000 sites (Figure 1.2.2). In 2020, a total of 2674 porpoises (95% confidence interval: 1513-4216) were observed with a density of 0.22 porpoise/km^2 (Table 1.1). This estimate is low compared to previous surveys and in general, a negative trend is seen from 2011 to 2020.

Table 1.1. Data and results for aerial surveys of porpoises conducted in Skagerrak, July 2020 and in the Southern North Sea, August 2020. Survey areas are shown in Figure 1.2. CV indicates the coefficient of variation for the abundance of porpoises.

Survey area	Area (km2)	Transect length (km)	Number of observations		Porpoise abundance (95% CI)	Density (porpoises/km2) (95% CI)	Average group size	CV
			adults	calves				

Skagerrak	12 164	804	22	2	2674 (1513-4216)	0.22 (0.12-0.35)	1.22	0.26
North Sea	5345	837	147	7	5929 (3895-8310)	1.11 (0.73-1.55)	1.20	0.19

FAROE ISLANDS: Estimates of cetacean abundance from the NASS 2015 survey are summarised by North Atlantic Marine Mammal Commission (2020b). A recent analysis based on the NASS series concluded that there are no long-term trends in long-finned pilot whale abundance in the Northeast Atlantic (Pike *et al*., 2019b).

FRANCE: In winter 2021, the second cycle of the SAMM programme (Aerial Survey for Marine Megafauna) was initiated. The SAMM programme is part of the monitoring program implemented within the framework of the MSFD. The aim is to produce an inventory of the distribution and abundance of marine megafauna (mammals, seabirds, turtles and other species of large pelagic fauna) and marine litter, in summer and winter, in French waters. The first cycle took place in 2011-2012.

Preliminary results from the winter of 2021 are now available for the Atlantic and Channel area (distribution of sightings and encounter rates), including a comparison with the first cycle in 2011-2012 (Blanchard *et al*., 2021).

Along the 20 000 km of effort, up to 1200 observations of marine mammals were collected during this campaign (Figure 1.3). The first results reveal differences for many species. The most striking concerns the distribution of small dolphins, with higher and above all more extensive encounter rates in the study area; the group size, on the other hand, is lower. For harbour porpoise and bottlenose dolphin (*Tursiops truncatus*), encounter rates in the Western English Channel are also higher in 2021 (Figure 1.4). Similarly, sightings of Risso's dolphin (*Grampus griseus*), minke whale (*Balaenoptera acutorostrata*) and beaked whales in the Bay of Biscay were significantly higher. Other species of cetaceans, such as the pilot whale and the sperm whale, were observed less. The preliminary results should be interpreted with caution due to the difference in the timing between the surveys of 2011-2012 and 2021.

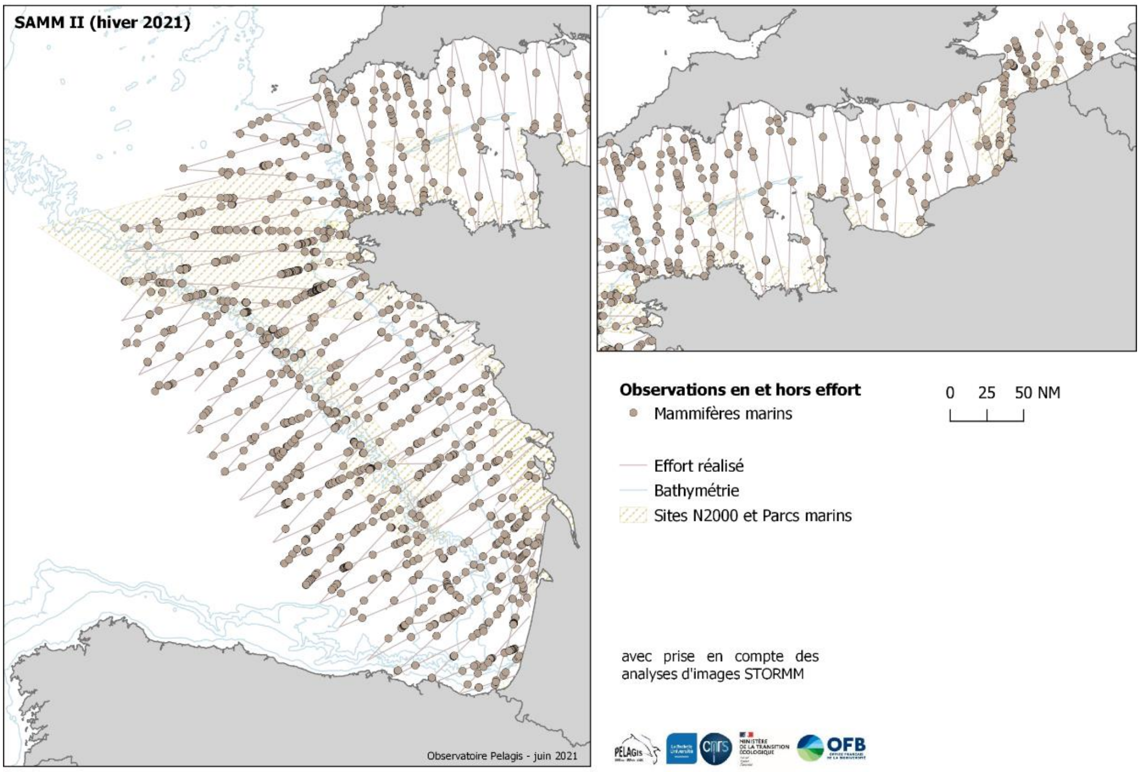

Figure 1.3. Marine mammal sightings (collected in effort and transit) during SAMM II Atlantic-Channel Winter 2021.

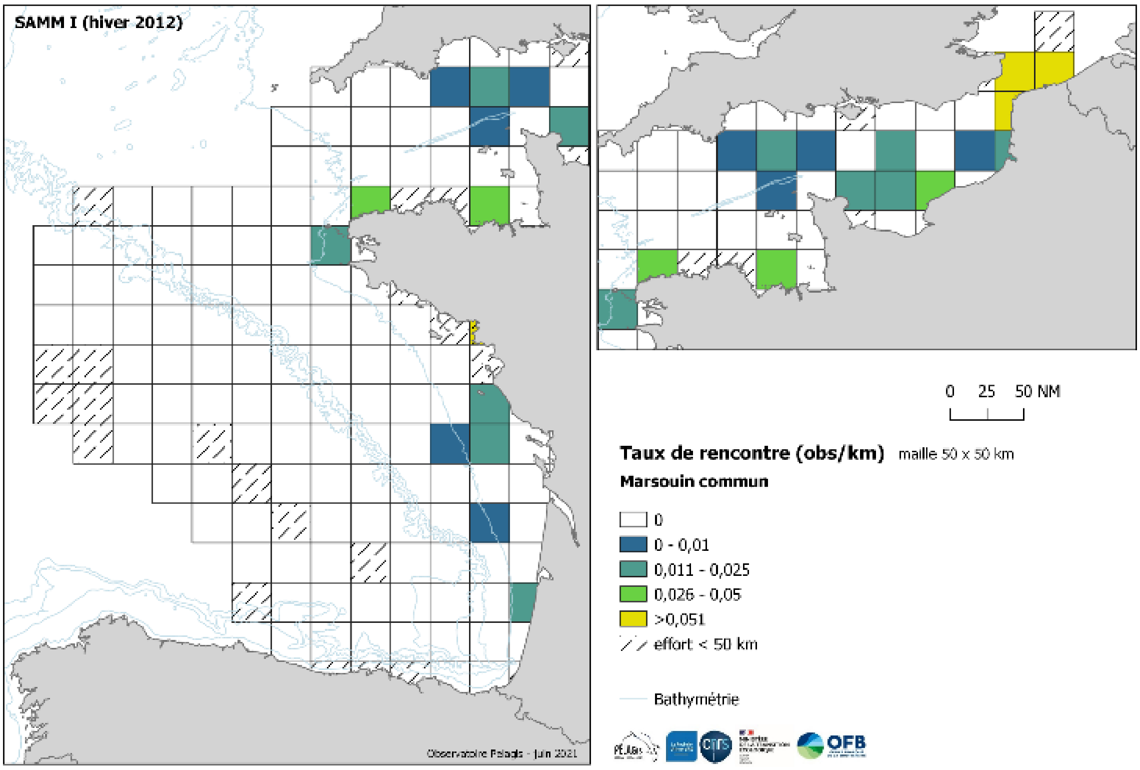

Figure 1.4. Encounter rate for harbour porpoise during SAM I Atlantic-Channel Winter 2012 (left), and SAMM II Atlantic-Channel Winter 2021 (right).

GERMANY: In spring 2021, a total of 84 harbour porpoise groups (102 animals, ten calves) were recorded along 680 km of effort in one survey area in the eastern North Sea (Sylt Outer Reef East, Figure 1.5a). In summer 2021, a total of 128 harbour porpoise groups (147 animals, including seven calves) were observed under 1545 km of effort in three areas in the North Sea (Dogger Bank, Weser-Elbe estuary and Borkum Reef Ground, Figure 1.5b).

One sighting of a white-beaked dolphin (*Lagenorhynchus albirostris*) group (four animals) was observed in the Sylt Outer Reef in spring 2021. The south-western Baltic Sea was surveyed in two areas (Kiel Bight and Fehmarn) in summer 2021 and a total of 17 harbour porpoise groups (22 animals) were sighted along 588 km of effort (Figure 1.5).

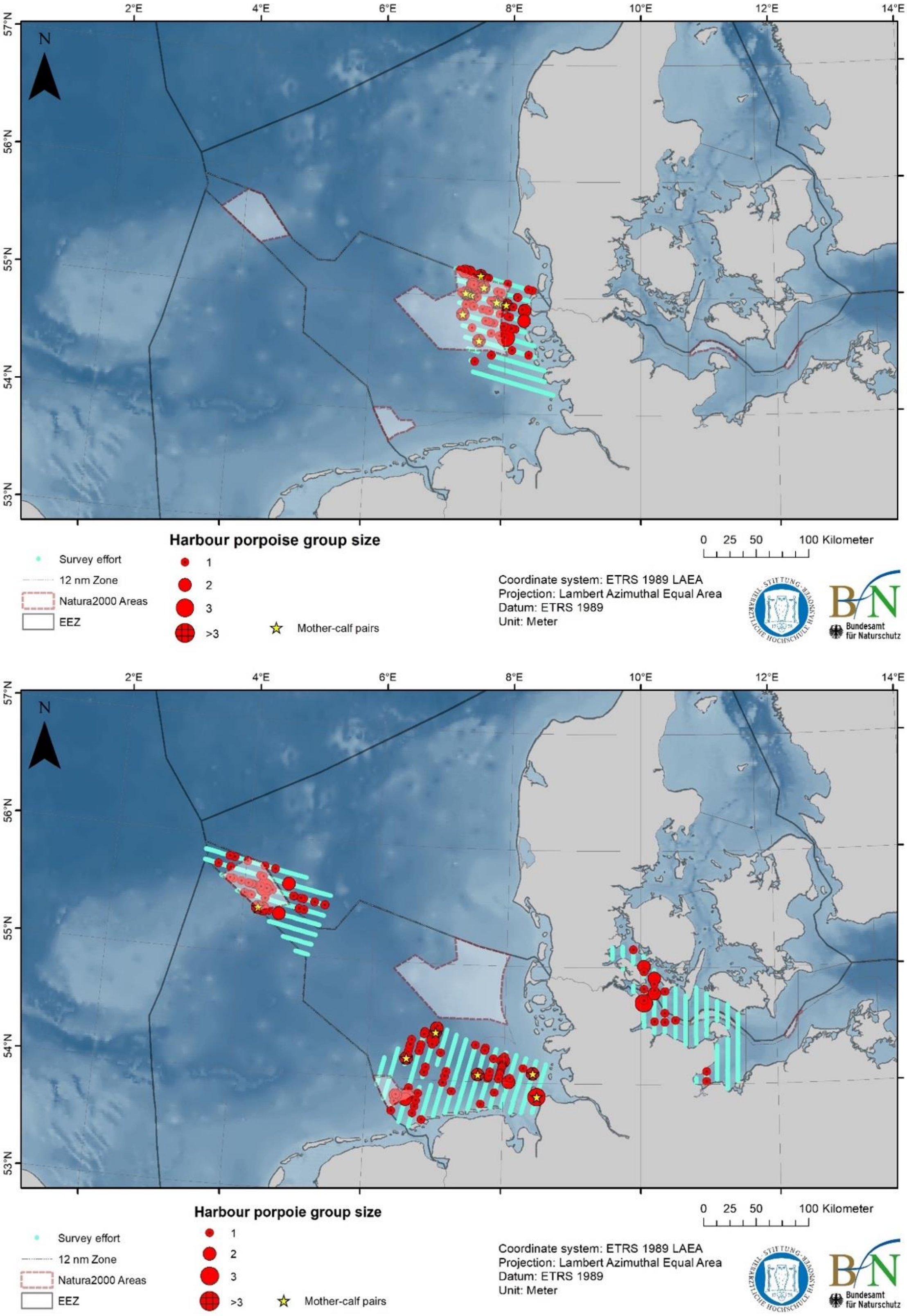

Figure 1.5. Survey effort and harbour porpoise sightings during aerial surveys in the German North and Baltic Sea during a) spring 2021 and b) summer 2021. Harbour porpoise group sizes are indicated using group size dependent red circles; yellow stars mark mother–calf pairs; blue lines indicate covered transect lines (i.e. survey effort).

Despite a conservation status of high concern and an obligation for protection in the European Union, the harbour porpoise can be categorised as under-reported in the Baltic Sea region. Identified as a high regional priority for the HELCOM region, an effort was made to determine trends in abundance of the Belt Sea harbour porpoise population within the HELCOM BLUES project (Gilles *et al*., 2022). Different approaches were applied. The first method followed a simulation approach from Authier *et al*. (2020) using available conventional distance sampling (CDS) estimates from four population-wide surveys spanning 2005-2020 (SCANS-II, SCANS-III, and MiniSCANS, MiniSCANS-II surveys). No trend was observed over this study period. The second approach used the same survey data, however, a Bayesian trend analysis was used (Nachtsheim *et al*., 2021). This method showed a negative trend (-1.2% p.a.; 95% CI: -3.8% - 4.4%) but had a wide credibility interval and 68.5% probability. To bring results into context, the results of aerial surveys in the south-western Baltic Sea, were examined for a trend using a similar Bayesian method for both the western (Kiel and Flensburg Bight) and eastern (Fehmarn Belt) sections of surveys. This showed high variability in porpoise abundance, and indicated no change in the western area and a slight increasing usage around Fehmarn. The power to detect a trend in the population could be increased by enlarging the data (time) series of abundance estimates from dedicated surveys. Therefore, data from the SCANS 1994 survey will need to be revisited and also, for the future, the planned SCANS-IV survey in 2022 will cover the area of the Belt Sea harbour porpoise population.

GREENLAND: Estimates of cetacean abundance from the NASS 2015 survey are summarised by North Atlantic Marine Mammal Commission (2020b). No cetacean surveys were conducted in 2020-2021, but several specific marine mammal surveys were conducted in parts of coastal Greenland in 2016-2019 (F. Ugarte, *pers. comm*.)

ICELAND: The Icelandic Marine and Freshwater Research (MFRI) has in recent years included systematic observations of cetaceans in ecosystem surveys focused on capelin, providing important information on cetacean distribution outside the peak summer season covered by the large scale multi-national NASS surveys 1987-2015). The results from the last two NASS surveys (2007 and 2015) and abundance estimates from all NASS surveys have been published (NAMMCO, 2020ab). The next NASS is at a planning stage and scheduled for the summer of 2024.

In addition to research conducted by the MFRI (e.g. Jourdain *et al*., 2019), two long-term local research projects on killer whales are ongoing, one operating around Vestmannaeyjar islands, south of Iceland and another around Snæfellsnes Peninsula. Both projects focus on various aspect of behaviour and feeding ecology. Photo-identification studies have among other things shown numerous instances of migration between Iceland and Scotland (e.g. Samarra *et al*., 2017), and recently revealed an example of even longer-distance movement between Iceland and the Mediterranean (Mrusczok *et al*., 2021).

Research on ecological niche partitioning between baleen whales in Icelandic waters was published in 2021. This is a part of a collaborative research between the University of Barcelona and the MFRI, using stable isotope analyses of three elements, nitrogen, carbon and sulphur (Garcia-Vernet *et al*., 2021).

Based on aerial surveys over 30 years, Pike and colleagues (2019a) summarised distribution and abundance patterns in Icelandic waters for minke whales, humpback whales, white-beaked dolphins and harbour porpoises. Changes in species' densities between 1986 and 2016 were used as indices of relative abundance. Minke whale relative abundance has decreased by up to 75% after 2001 and has remained at a relatively low level since then, particularly in the southwest and southeast of Iceland. Relative abundance of humpback whales and white-beaked dolphins has increased over the period 1986-2016, particularly in the northern part of the survey area. Harbour porpoise relative abundances were calculated for 2007 and 2016 only, and resulted in abundance estimates of similar magnitude.

IRELAND: In West Connacht Coast SAC, dedicated line transect surveys for bottlenose dolphins were carried out in June and August 2021 (Berrow *et al.*, 2021). The Northern and Southern Components of the SAC were surveyed simultaneously with different teams. A total of 1767 km of survey effort was accomplished and dolphins were exclusively observed in the mouth of Killary Harbour, Ballinakill Bay, and off Cleggan in the Southern Component. From mean group size estimates, a total number of 181 individuals were encountered and of these, images were obtained from 163 (91%) dolphins that could be identified individually. In addition, five juveniles, 11 calves and two neonates were observed, but not included in mark-recapture modelling. Based on on-effort photo-ID data, a final best estimate of 197 ± 24, CV = 0.12 (95% CI 150-243) was obtained. By combining the on-effort data with opportunistically collected photo-ID data, an estimate of 228 ± 21, CV = 0.09 (95% CI = 187-270) was obtained. The 2021 abundance estimates are very similar to those previously derived in the same area, suggesting that the number of bottlenose dolphins using the West Connacht Coast SAC since the first abundance estimate in 2009, is stable.

Against the background of a new National Marine Planning Framework and an increased focus on renewable sources of energy from the sea, Phase 2 of Ireland's ObSERVE Programme has now commenced. This programme comprises extensive aerial surveys for cetaceans, marine birds, and turtles in Irish inshore and offshore waters between 2021 and 2023, with the completion of all analysis and reporting due in April 2024. Similar to Phase 1 (ObSERVE aerial), broadscale surveys will be carried out in two summers and two winters, in addition to finer scale surveys in the coastal regions three times a year.

NORWAY: A ship-based mosaic survey of Northeast Atlantic cetaceans was conducted over a 5-year period in 2014–2019. The area surveyed extends from the North Sea in the south (southern boundary at 53°N), to the ice edge of the Barents Sea and the Greenland Sea. Survey vessels were equipped with two independent observer platforms that detected whales in passing mode and applied tracking procedures for the target species, common minke whales (*Balaenoptera acutorostrata acutorostrata*). The abundance for the total covered area was estimated at 149 722 whales with a CV of 0.152 (Solvang *et al.*, 2021). This abundance estimate has increased by about 50% compared to the three preceding survey periods, i.e. from 101 000 to about 150 000 minke whales, assumed to be caused mainly by shifts in distribution within the North Atlantic. The distribution is illustrated in Figure 1.6.

The abundance estimates for all non-target species for which there were sufficient sightings are presented by Leonard and Øien (2021). The abundance of fin whales (*Balaenoptera physalus*) is estimated to be 11 387 (CV=0.17, 95% CI: 8072–16 063), of humpback whales (*Megaptera novaeangliae*) to be 10 708 (CV=0.38, 95% CI: 4906–23 370), of sperm whales (*Physeter macrocephalus*) to be 5704 (CV=0.26, 95% CI: 3374–9643), of killer whales (*Orcinus orca*) to be 15 056 (CV=0.29, 95% CI: 8 423–26 914), of harbour porpoises to be 255 929 (CV=0.20, 95% CI: 172 742–379 175), dolphins of genus *Lagenorhynchus* to be 192 767 (CV=0.25, 95% CI: 114 033–325 863), and finally of northern bottlenose whales (*Hyperoodon ampullatus*) to be 7800 (CV=0.28, 95% CI: 4373–13 913). The distributions of these species are illustrated in figures 1.6-1.14. Species observed in low numbers were blue whales (*Balaenoptera musculus*), sei whales (*Balaenoptera borealis*), bowhead whales (*Balaena mysticetus*), and pilot whales (*Globicephala melas*) (Figure 1.13). The number of blue whale sightings in the three survey cycles has been 11 in 2002-2007, two in 2008-2013 (Leonard and Øien 2020), and 13 in 2014-2018 (Leonard and Øien 2021).

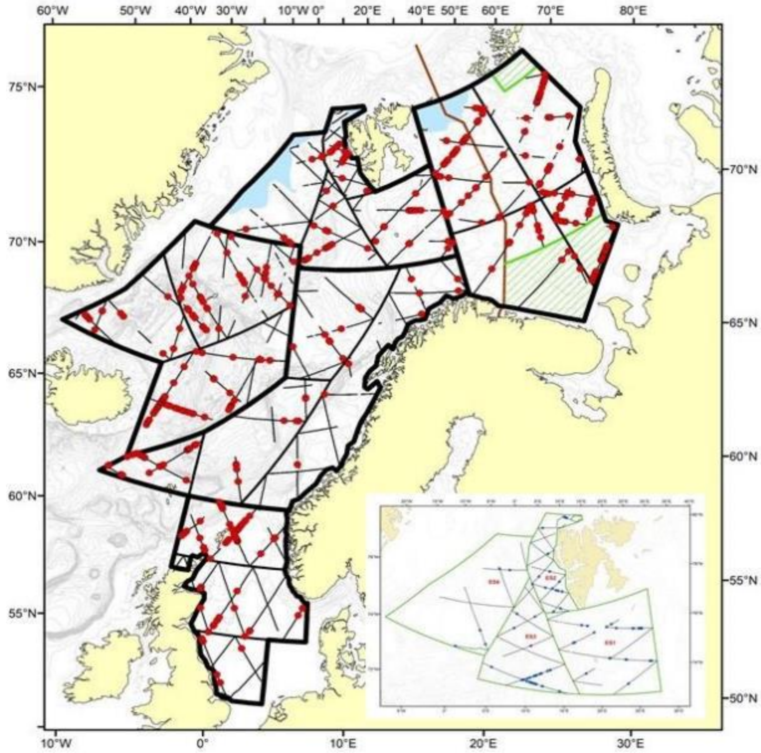

Figure 1.6. Distribution of common minke whale sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Solvang *et al*. (2021).

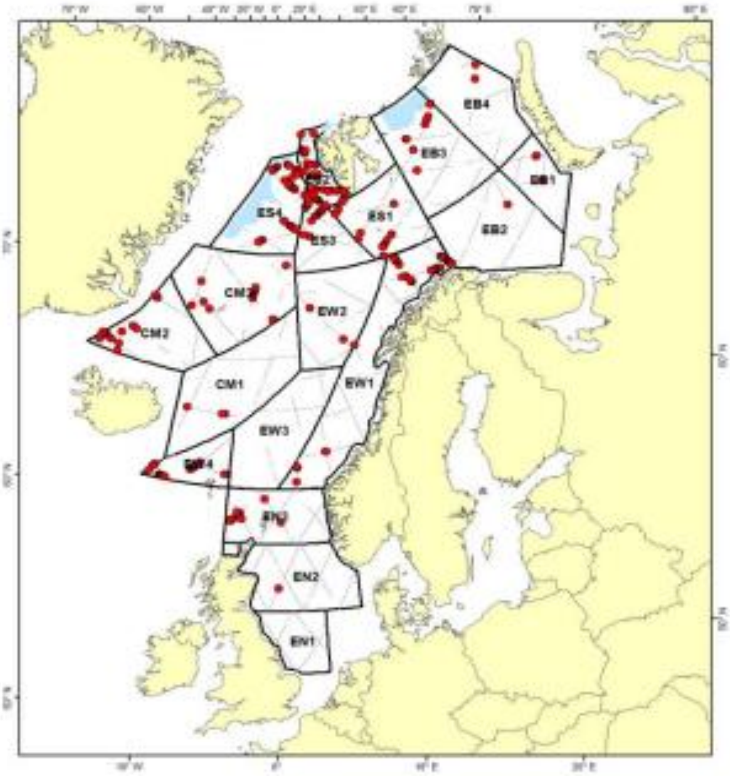

Figure 1.7. Distribution of fin whale sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021).

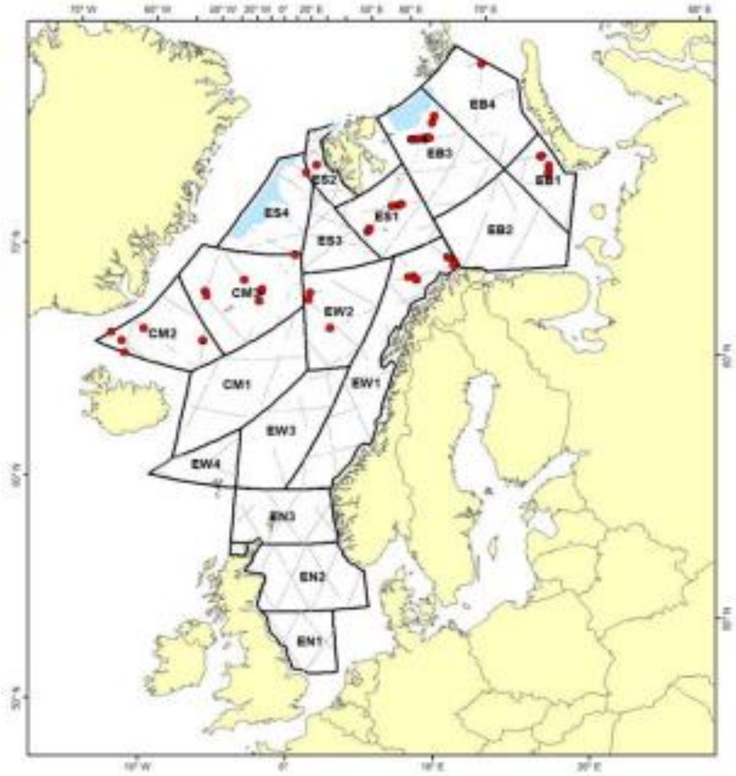

Figure 1.8. Distribution of humpback whale sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021).

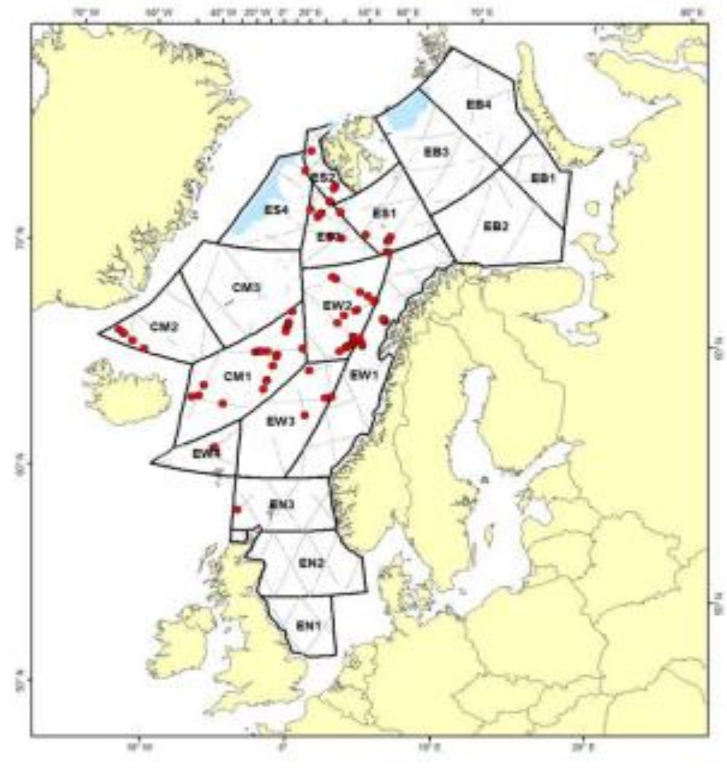

Figure 1.9. Distribution of sperm whale sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021).

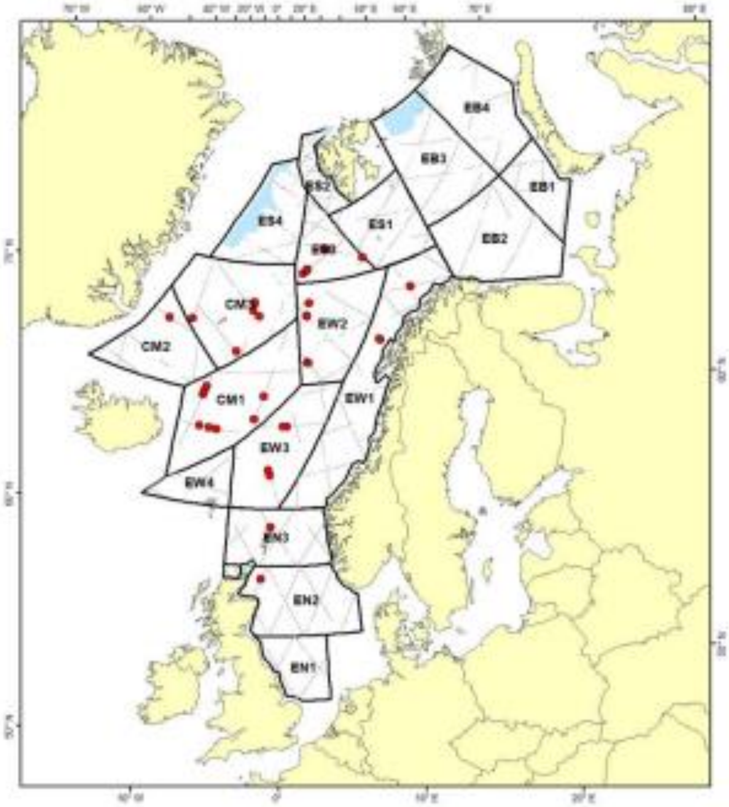

Figure 1.10. Distribution of killer whale sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021).

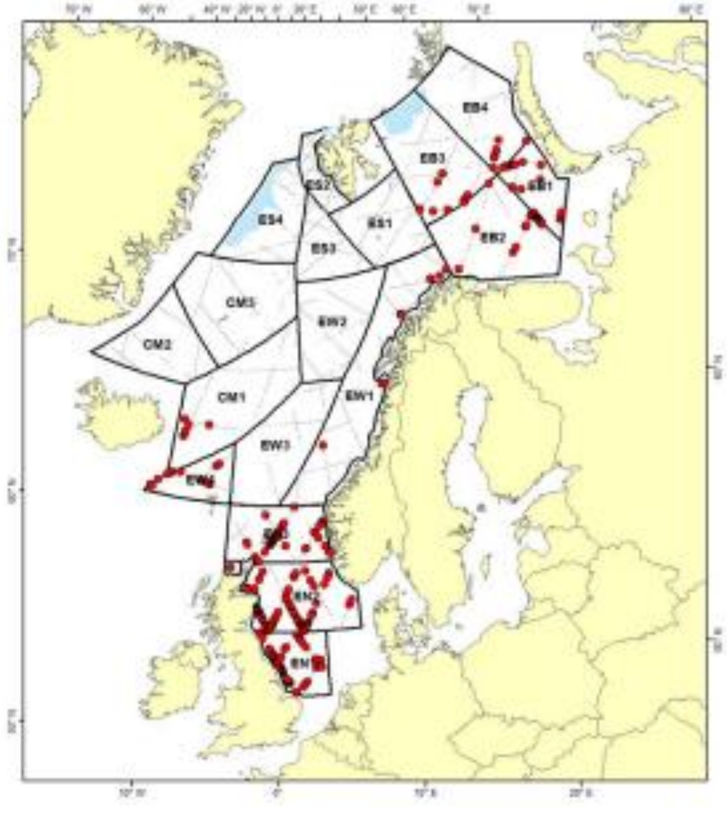

Figure 1.11. Distribution of harbour porpoise sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021)

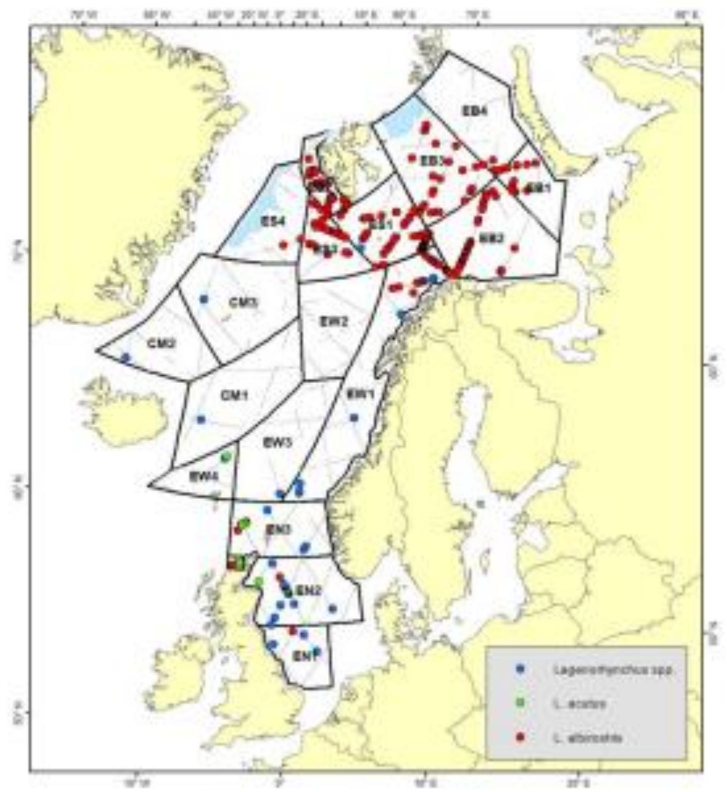

Figure 1.12. Distribution of L*agenorhynchu*s spp. sightings in the Norwegian ship-based mosaic survey in 2014–2018. White-sided dominates in the North Sea and white-beaked in the Barents Sea. From Leonard and Øien (2021).

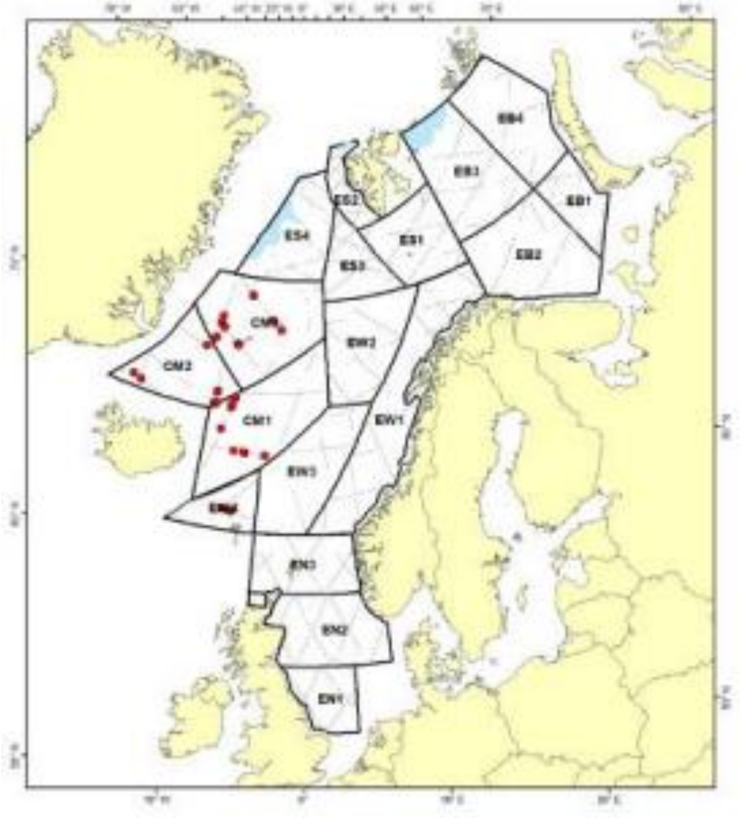

Figure 1.13. Distribution of northern bottlenose whale sightings in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021).

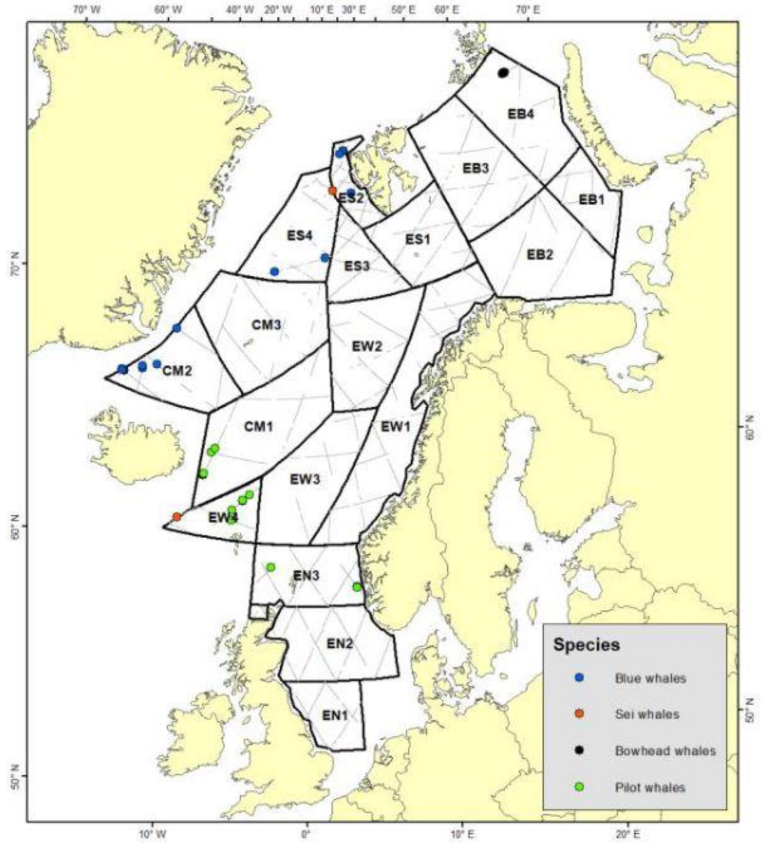

Figure 1.14. Distribution of sightings of blue whale, sei whale, bowhead whale, and pilot whale in the Norwegian ship-based mosaic survey in 2014–2018. From Leonard and Øien (2021).

By tagging during 2005-2018, hotspots of six cetacean species and seven seal species in the Greenland and northern Barents Seas were determined. The cetacean species were bowhead whale, narwhal (*Monodon monoceros*), beluga (*Delphinapterus leucas*), blue whale, fin whale and humpback whale. Hotspots were identified for each species and for all species combined, along with areas of high species richness during summer/autumn (June-December), winter/spring (January-May) and the full year.

PORTUGAL: Pérez-Jorge *et al*. (2021) have analysed environmental drivers for probability of occurrence and monthly distributions of fin, blue and sei whales in the mid-North Atlantic, using generalized additive mixed models (GAMMs). The data consisted of 31 satellite tracks from tags deployed on whales in the Azores from March to July (2008–2016), remotely sensed oceanographic data, and modelled biomass data. The monthly prediction maps for fin whales displayed the highest probability of occurrence above 50°N, expanding from southwest of the Irminger Sea to Iceland from March to July. The predicted preferred habitat for blue whales was a narrow latitudinal band at mid-latitudes (36° to 50°N) in April, expanding towards the northeast during the following months. Finally, for sei whales, the highest level of occurrence was predicted for areas above 45°N, from May to August.

SPAIN: During 2021, the Spanish Institute of Oceanography (IEO-CSIC) and AZTI have completed their annual ship surveys to collect data on top predators in the Bay of Biscay and the Iberian Coast ecoregion (Table1. 2). For the first time, IEO also included a top predator observer in the PECAN0221 survey carried out in the continental shelf waters of the Canary Islands.

Table1. 2. Ship surveys details carried out in the Bay of Biscay and the Iberian Coast ecoregion by IEO and AZTI.

Survey	Organisation	Dates	Area
PECAN0221	IEO	23 Feb-08 Mar	Continental shelf of Canary Islands
PELACUS0321	IEO	25 Mar-18 Apr	Continental shelf of Northern Spain
BIOMAN0521	AZTI	30 Apr-24 May	Continental shelf and slope of Bay of Biscay
JUVENA0921	AZTI	02 Sep-30 Sep	Continental shelf and slope of Bay of Biscay
IBERAS0921	IEO	16 Sep-21 Sep	Continental shelf of Galicia and Portugal

Table 1.3 shows the number of sightings of the cetacean species in each survey. The most frequently registered species in the Bay of Biscay and Iberian Coast ecoregion was the common dolphin (*Delphinus delphis*) with 365 sightings, followed by the bottlenose dolphin and the long-finned pilot whale with 28 and 22 sightings respectively. In the Canary Islands, the most frequently recorded species was the Atlantic spotted dolphin (*Stenella frontalis*) with 21 sightings, followed by the short-finned pilot whale (*Globicephala macrorhynchus*) with 11 sightings.

Table 1.3. Number of cetacean sightings recorded during each ship survey.

Cetacean species	PECAN 0221	PELACUS 0321	BIOMAN 0521	JUVENA 0921	IBERAS 0921
Bottlenose dolphin	3	18	7	1	2
Common dolphin	2	189	48	120	8
Striped dolphin		2	2	4	
Common/Striped dolphin			2		1
Atlantic spotted dolphin	21				
Unidentified dolphin	4	10	4		1
Short-finned pilot whale	11				
Long-finned pilot whale		4	8	10	
Cuvier's beaked whale		2		2	
Unidentified beaked whale		1	1		
Sperm whale		2			
Minke whale		3			
Bryde's whale	4				
Fin whale				13	
Blue whale				1	
Unidentified whale	2				1

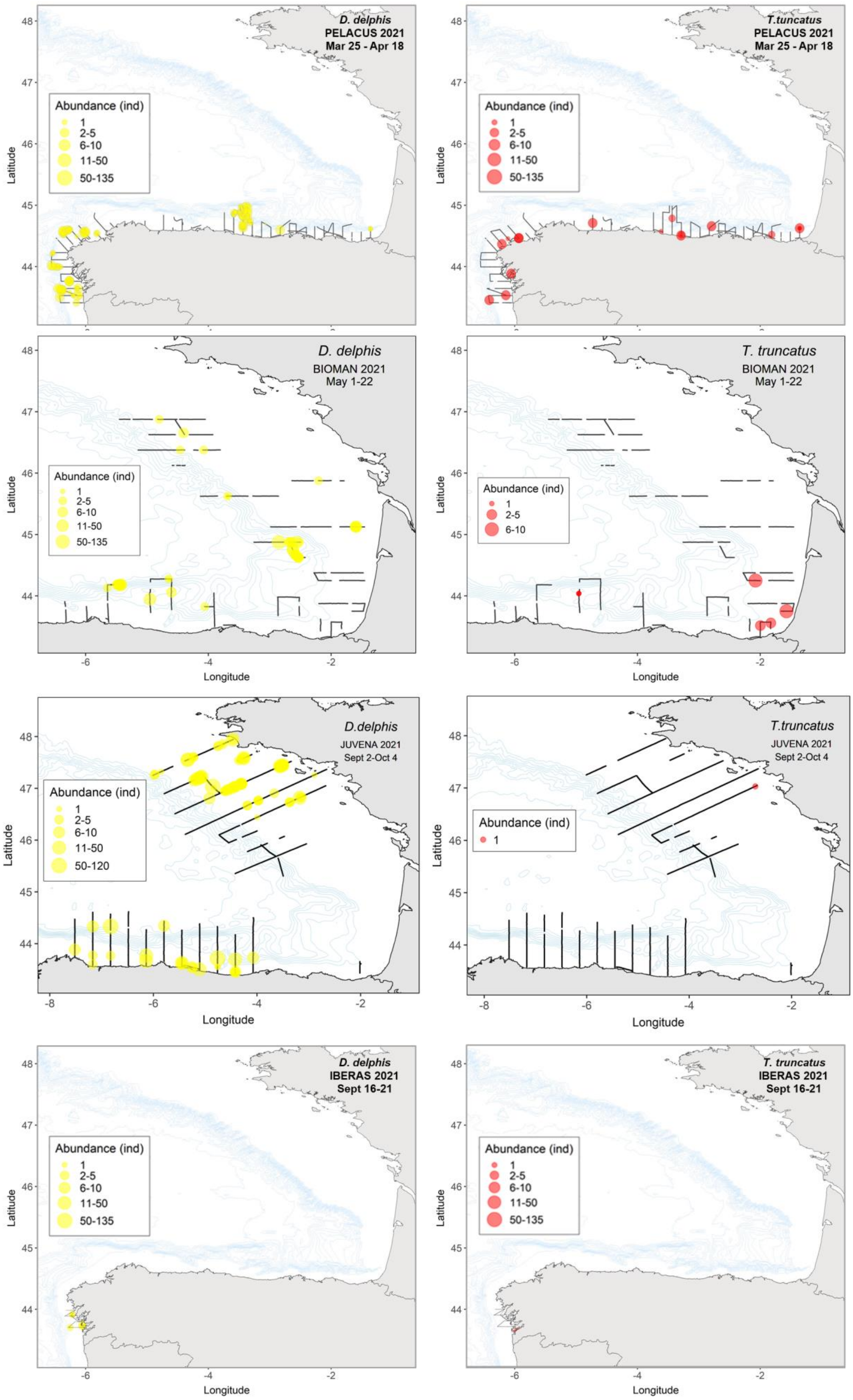

Figure 1.15. Spatial distribution of common and bottlenose dolphins in the Bay of Biscay and Iberian Coast ecoregion

The spatial distribution of the two most frequently observed dolphin species (common and bottlenose dolphins) in the Bay of Biscay and Iberian Coast ecoregion are shown in Figure 1.15. Although the spatial coverage between surveys is unequal, there is evidence of a seasonal distribution pattern for both common and bottlenose dolphins in the area. Common dolphins seem to be quite well distributed along the continental shelf of the Spanish Iberian coast in early spring, with some aggregations in Galicia and in the central part of Cantabrian coast. In May, they seem to move towards the slope area, and in September, are covering both the continental shelf and the slope. By contrast, bottlenose dolphins show preference for more coastal waters, with a clearer seasonal distribution pattern. In early spring, they are distributed along the entire Spanish Iberian coast, while in May, their presence is primarily concentrated in the south-eastern part of the continental shelf in the Bay of Biscay. In early autumn, the species is almost absent (however, note that in JUVENA0921 survey, there is a lack of effort in the western part of Spanish continental shelf and southern part of French continental shelf). These data will be analysed and will be available for the next MSFD reporting.

On a more local scale, Methion and Díaz López (2021) have described the distribution and habitat use of coastal bottlenose and common dolphins in the Ría de Arousa (western Iberian Coast - Southern Galicia) and adjacent waters of the continental shelf and slope. The analysis of the data collected from March 2014 to November 2019 show different patterns of occurrence; while bottlenose dolphins were always observed in the bay, common dolphins were mostly observed outside (Figure 1.16). During the study period, bottlenose dolphins and common dolphins were only observed on five occasions at the same time and in the same area, including three occasions which led to the displacement of the common dolphin(s), and one lethal interaction. Results suggest that bottlenose dolphins killing other cetacean species is likely to be driven by multiple factors acting together, including competition for food resources, practice for infanticide, sexual frustration, or to improve fighting skills.

Giralt *et al*. (2019) applied a species distribution model to assess the habitat suitability of common dolphins in Northwest Spain. Data were collected during 273 days at sea between the years 2014 and 2017 and resulted in 91 sightings. Tide level and sea surface salinity were determined to be the main variables driving the distribution of the species in coastal areas especially in waters over the continental shelf. The study also highlighted most suitable habitat areas for the species.

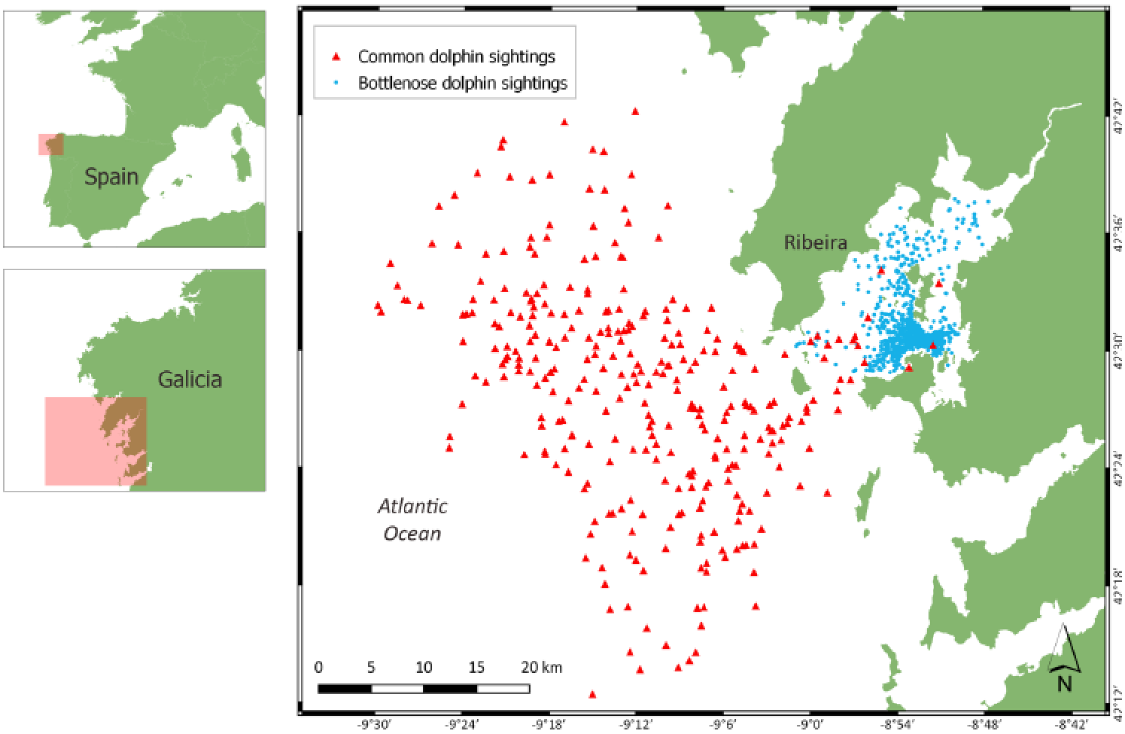

Figure 1.16. Study area (Ría de Arousa and surrounding waters, Northwest Spain) with sightings of bottlenose dolphins (blue dots) and sightings of common dolphins (red triangles) throughout the entire six-year study period (Methion and Díaz López, 2021).

Until now, the only specific study to determine the population abundance of bottlenose dolphins using capture-mark-recapture methodology in the area of Rias Baixas (Galicia) has been carried out in the Ría de Arousa (Methion and Díaz López, 2018). During 170 sampling days distributed between March 2014 and June 2016, a total of 517 hours and 4 285 km of sampling effort was obtained. Groups of bottlenose dolphins were detected during 92% of the sampling days, and 97% of the encounters were within the Arousa estuary. The group size ranged between one and 64 individuals (mean 13 ±0.6 individuals).

Table 1.4. Seasonal abundance estimates of bottlenose dolphins in the study area. N = estimation of the marked population; SE = standard error; Y = proportion of distinctly marked adult individuals; Nt = total population size; CI = confidence interval.

Year	Season	Number of dolphins identified	N	SE	Y	N_t	95% CI
2014	Spring	73	76	2.8	0.68	111	107–125
	Summer	100	85	3.0	0.69	123	118–138
	Autumn	37	50	1.8	0.89	56	55–66
2015	Winter	115	122	6.7	0.85	144	133–166
	Spring	46	46	1.8	0.81	57	56–67
	Summer	82	68	1.2	0.88	77	76–84
	Autumn	40	61	3.5	0.92	66	62–78
2016	Winter	84	87	3.3	0.75	116	110–130
	Spring	114	110	4.0	0.79	139	133–153

The abundance estimates obtained through the analyses of Pollock robust design models, ranged from 56 (95%CI: 55.2–66.4) in autumn 2014, to 144 (95%CI: 133.1–165.6) in winter 2015 (Table 1.4). The authors suggest that the pattern of temporal variation in bottlenose dolphin abundance within the Ría de Arousa, with maximum numbers in winter, could be explained by the peaks of fish prey availability.

Recently, there have been an increasing number of records of blue whales in the south of Galicia. Díaz López *et al.* (2021) have reported five sightings in 2017, six sightings in the 2018-2019 period, and 20 sightings in 2020. In the framework of BALAENATUR project, 43 days of effort were carried out between January and October 2020. The presence of blue whales in the area shows a clear seasonal pattern, with sightings recorded in late summer and early autumn (two in August, 16 in September, and two in October). The spatial distribution of blue whales in the area indicates a preference for more coastal waters by comparison to the fin whale (Figure 1.17), also present in the area with a higher number of sightings and during a longer period from June until October. The presence of these species of baleen whales in this region is highly impacted by upwelling, which seems to be related to feeding behaviour (Díaz López and Methion, 2019). In recent years, blue whales have also been observed on the Spanish Iberian continental shelf and slope, indicating an increasing presence also in these waters.

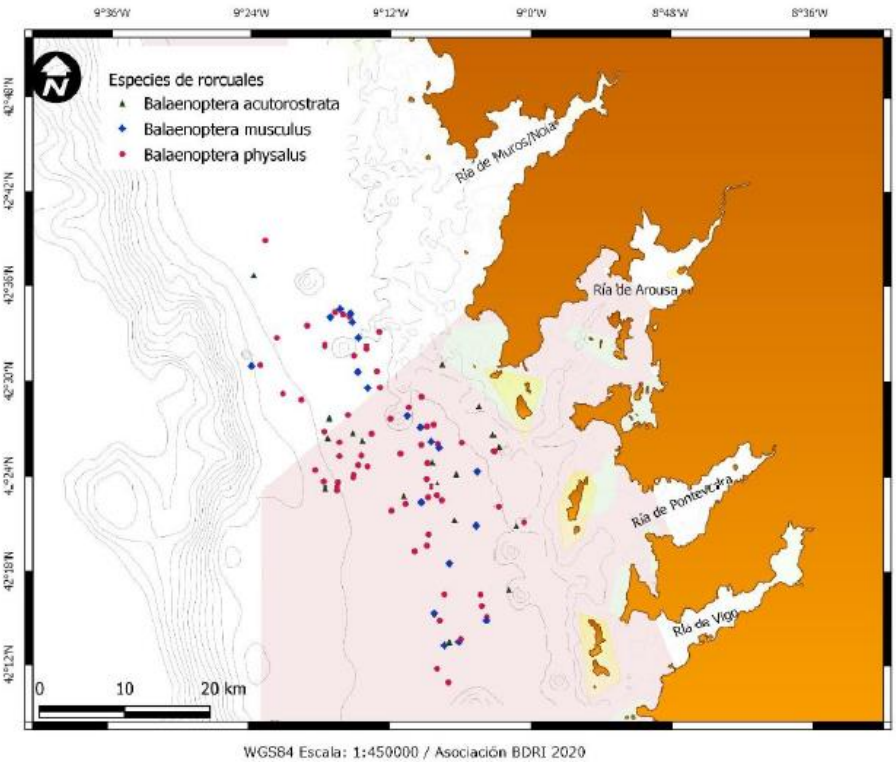

Figure 1.17. Spatial distribution of baleen whales in the south of Galicia (Díaz López *et al*., 2021).

UNITED KINGDOM: Coastal bottlenose dolphins have been monitored in the Moray Firth (East Scotland) since 1990, and in Cardigan Bay (West Wales) since 2001.

Mark–recapture estimates of the East Coast Scotland population have varied in the range of 87–244 individuals, with the latest estimate (2019) being 213 individuals (95% highest posterior density intervals (HPDI): 186–244 individuals) (Cheney *et al*., 2019). The population has extended its range in recent years, now occurring regularly and in all months of the year off the coasts of Northumberland, Durham, and Yorkshire (Sea Watch Foundation, unpublished data). The population is considered to be stable or probably increasing (Cheney *et al*., 2019; Arso Civil *et al*., 2021).

Elsewhere in the North Sea, bottlenose dolphins have either been linked to the East Coast of Scotland population through photo-ID matches or appear to represent transient groups. In July 2019, nine individuals of a group of 20 bottlenose dolphins observed in the Marsdiep, the Netherlands, were matched with animals from the East Coast of Scotland, some of which were re-sighted there subsequently, with others photographed later in Danish waters (Hoekendijk *et al*., 2021). In summer 2021, a mass stranding of bottlenose dolphins occurred in the Moray Firth, but none could be matched to local animals, suggesting these also were transients from an offshore population outside the North Sea.

Annual monitoring of bottlenose dolphins in the Cardigan Bay Special Area of Conservation (SAC), West Wales, has continued since 2001, with surveys incorporating the wider Cardigan Bay area occurring in some years from 2005 onwards. Since 2007, there has also been opportunistic photo-identification surveys in the coastal waters of North Wales, and occasionally around the Isle of Man and in Liverpool Bay (Lohrengel *et al*., 2017). A proportion of the population inhabiting Cardigan Bay in summer ranges more widely between November and April, occurring particularly off the northern coast of Anglesey, the mainland coast of North Wales, and further north around the Isle of Man (Feingold and Evans, 2014; Lohrengel *et al*., 2017).

Summer mark–recapture estimates for Cardigan Bay SAC have varied in the range of 135–260 individuals. The latest estimate (2019) is 138 individuals (95% confidence interval (CI): 68–303 individuals), indicating a decline over the last ten-year period, but no significant change since the start of the time series. For the wider Cardigan Bay (including both SACs), summer mark–recapture estimates have varied in the range of 152–342 individuals, with the latest estimate (2015) being 222 individuals (95% CI: 184–300 individuals). The estimates in recent years have been amongst the lowest recorded, and the robust design models indicate some permanent emigration from Cardigan Bay (Lohrengel *et al.*, 2017).

Bottlenose dolphins have regularly inhabited the south and southwest coasts of England since the 1990s, being commonest around Cornwall but rare east of Dorset (Williams *et al.*, 1997; Brereton *et al.*, 2018; Corr, 2020; Evans and Waggitt, 2020b). No systematic photo-identification surveys have been undertaken, but Corr (2020) has estimated the coastal southwest English population in the Channel at 40 individuals (95% CI: 30-59) using a Bayesian multi-site method of mark-recapture analysis.

CANADA: More than 20 species of cetaceans occur in Atlantic Canadian waters, including both seasonal migrants and year-round residents, and several species at risk (Table 1.5). Extensive cetacean monitoring efforts are conducted by a number of organizations off eastern Canada, and include aerial surveys, vessel-based field studies, and passive acoustic monitoring (PAM) from autonomous stationary and mobile platforms.

There has been much focus on North Atlantic right whales in recent years in particular, largely driven by an ongoing Unusual Mortality Event that began in 2017[1] and has involved 21 confirmed mortalities in Canadian waters, many of which were attributed to entanglements or vessel strikes (Daoust *et al.*, 2018; Bourque *et al.*, 2020). Critical habitat in Canadian waters was previously identified for right whales based on historical sightings and traditional feeding areas, and included Grand Manan Basin in the Bay of Fundy and Roseway Basin off southwest Nova Scotia (DFO 2014). However, the number of sightings and acoustic detections of right whales in the Gulf of St. Lawrence has been increasing since 2015 (Simard *et al.*, 2019; DFO, 2019, 2020b; Pettis *et al.*, 2021), indicating a shift in their summer foraging distribution. The changing distribution of right whales has been associated with a decrease in the availability of their preferred prey in traditional feeding areas caused by climate change (Meyer-Gutbrod *et al.*, 2015, Record *et al.*, 2019). Research, monitoring and surveillance activities are conducted by Fisheries and Oceans Canada (DFO), Transport Canada (TC), and a large number of non-governmental organizations to increase understanding of right whale occurrence in Canadian waters throughout the year and inform management measures[2]. Static and dynamic management measures, including a combination of temporary and seasonal fisheries closures[3] and vessel speed restriction zones[4], have been implemented off eastern Canada to reduce vessel strikes and entanglements.

[1] https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2022-north-atlantic-right-whale-unusual-mortality-event

[2] https://www.dfo-mpo.gc.ca/fisheries-peches/commercial-commerciale/atl-arc/narw-bnan/narw-science-eng.html

[3] https://www.dfo-mpo.gc.ca/fisheries-peches/commercial-commerciale/atl-arc/narw-bnan/management-gestion-eng.html

[4] https://tc.canada.ca/en/marine-transportation/navigation-marine-conditions/protecting-north-atlantic-right-whales-collisions-vessels-gulf-st-lawrence#toc_1

Table 1.5. List of cetacean species and populations found in Atlantic Canada including their status as assessed by the Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and under the Canadian Species at Risk Act (SARA).

Species/Population	COSEWIC Status	SARA Status
Mysticetes		
Atlantic blue whale	Endangered	Endangered
Atlantic fin whale	Special Concern	Special Concern
Atlantic sei whale	Endangered	Not listed
North Atlantic minke whale	Not at risk	Not listed
Western north Atlantic humpback whale	Not at risk	Not listed
North Atlantic right whale	Endangered	Endangered
Eastern Canada-West Greenland bowhead whale	Special Concern	Not listed
Odontocetes		
Sperm whale	Not at risk	Not listed
Scotian Shelf northern bottlenose whale	Endangered	Endangered
Davis Strait-Baffin Bay-Labrador Sea northern bottlenose whale	Special Concern	Not listed
Sowerby’s beaked whale	Special Concern	Special Concern
Cuvier’s beaked whale	Not at risk	Not listed
True’s beaked whale	Not at risk	Not listed
St. Lawrence Estuary beluga	Endangered	Endangered
Narwhal	Special Concern	Not listed
Northwest Atlantic/Eastern Arctic population killer whale	Special Concern	Not listed
Long-finned pilot whale	Not at risk	Not listed
Atlantic white-sided dolphin	Not at risk	Not listed
Short-beaked common dolphin	Not at risk	Not listed
White-beaked dolphin	Not at risk	Not listed
Bottlenose dolphin	Not at risk	Not listed
Risso’s dolphin	Not at risk	Not listed
Striped dolphin	Not at risk	Not listed
Northwest Atlantic harbour porpoise	Special Concern	Not listed

Aerial survey efforts conducted by DFO Science off eastern Canada over the past few years have included large-scale cetacean line-transect surveys such as the Trans North Atlantic Sightings Survey conducted in 2007 (TNASS; DFO, 2009), the North Atlantic International Sightings Survey (NAISS) which repeated the TNASS survey design in 2016, and multispecies cetacean surveys conducted annually in the Gulf of St. Lawrence, Bay of Fundy, Scotian Shelf, and off Newfoundland and Labrador in support of right whale monitoring (e.g. see DFO, 2019, 2020b). In addition, DFO Conservation and Protection and TC conduct marine mammal focused surveillance flights to help monitor fisheries management zones and vessel speed restriction zones[2]. NOAA has also conducted aerial photo-identification mark-recapture studies in the Gulf of St. Lawrence (e.g. Cole *et al*., 2020; Crowe *et al*., 2021). Many of these aerial survey and surveillance efforts can be viewed on WhaleMap[5]: an interactive web-based tool for viewing baleen whale visual and acoustic detections off eastern Canada and the United States (Johnson *et al*., 2021). WhaleMap also hosts baleen whale observations obtained from other sources, such as from vessel-based field surveys, opportunistically reported sightings from mariners and the general public, and near real-time acoustic detections from bottom-moored buoys and autonomous gliders. By opening the "interactive map", a user can select the date, detection platform, and species of interest, as well as choose to display platform track-lines (for platforms which have submitted track-line data).

A summary of the status and trends of marine mammal populations in eastern Canada, including 22 Atlantic cetacean populations, can be found in the DFO "State of the Atlantic Ocean" report series, last published in 2017 (see Table 3.5-1; Stenson *et al.*, 2018), but recently updated (to be published in 2022). Abundance estimates for these species/populations are obtained from studies conducted by different organisations using various methods. Abundance estimates, either exact or approximate, exist for 15/22 populations (abundance remains unknown for seven populations), although many of these estimates are more than ten years old. Of these populations for which some data on abundance exist, two are increasing (Western North Atlantic humpback whales and Eastern Canada-West Greenland bowhead whales), one is stable (Scotian Shelf northern bottlenose whales), one is stable or declining (Atlantic blue whales), and two are declining (North Atlantic right whales and St. Lawrence Estuary beluga whales).

Since the 2017 report, new abundance and trend information has been obtained for two cetacean populations: Scotian Shelf northern bottlenose whales and North Atlantic right whales. The most recent abundance estimates for Scotian Shelf northern bottlenose whales are obtained from photo-identification mark-recapture models based on data collected from 1988-2019 (Feyrer, 2021). In 2019, the population was estimated to be approximately 174 individuals (left-side dorsal fin estimate: 174.0, 95% CI: 134.2-167.4; right-side dorsal fin estimate: 172.4, 95% CI: 116.3-238.0). Over the 30-year study period, the population decreased between 1988-2010 (with estimates of approximately 113-120 individuals in the 2004-2010 period), and has since been increasing (Feyrer, 2021). Similarly, North Atlantic right whale abundance estimates are also derived from photo-identification mark-recapture models (Pace *et al*., 2017). The most recent population estimate for North Atlantic right whales is 336 individuals (95% CI: 322-350) in 2020, which represents an 8% decline from the 2019 estimate, and is part of a longer-term decreasing population trend (Pettis *et. al*., 2022).

While all marine mammals and their habitat are protected by the general prohibitions of the Canadian Fisheries Act (FA 1985) and the marine mammal specific regulations outlined under the Marine Mammal Regulations section of the Fisheries Act (MMR, 1993), additional protection for at-risk species (Endangered, Threatened, or species of Special Concern) are provided by the Canadian Species at Risk Act (SARA; SARA, 2002). Of the 24 Atlantic cetacean populations listed

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[5] https://whalemap.ocean.dal.ca/

in Table 1.5, 12 have been assessed as at-risk by the Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and six populations have been formally listed under the Canadian Species at Risk Act (SARA) as Endangered, Threatened or Special Concern (Table 1.5).

Critical habitat is defined under the SARA as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species" (SARA, 2002). Critical habitat has been identified for three of the Atlantic SARA-listed populations[6]:

- Part of the lower and upper St. Lawrence Estuary have been identified as critical habitat for St. Lawrence Estuary beluga whales (DFO, 2012).
- Grand Manan Basin in the Bay of Fundy and Roseway Basin off Southwest Nova Scotia have been identified as critical habitat for North Atlantic right whales (DFO, 2014).
- The Gully, Shortland and Haldimand canyons along the slope of the eastern Scotian Shelf have been identified as critical habitat for Scotian Shelf northern bottlenose whales (DFO, 2016).

Additionally, other important habitat (not formally recognised as critical habitat) has been identified for two of the Atlantic SARA-listed populations:

- Areas in the lower St. Lawrence Estuary and northwest Gulf of St. Lawrence, Honguedo Strait, Cabot Strait, shelf waters south and southwest of Newfoundland, the Mecatina Trough area, and the continental shelf edge of Nova Scotia, Newfoundland and the Grand Banks have been identified as important habitat for Atlantic blue whales[7] (DFO, 2018).
- The shelf edge areas between the Gully, Shortland and Haldimand canyons have been identified as important habitat for Scotian Shelf northern bottlenose whales[8] (DFO, 2020a).

USA: In 1994, the U.S. Marine Mammal Protection Act was re-authorised to require the National Oceanic and Atmospheric Administration (NOAA) to use science-based research to monitor marine mammal populations. Specifically, MMPA Section 117 requires regular assessments of strategic stocks. Table 1.6 summarises the most recent abundance estimates for strategic stocks of the Western North Atlantic region based on longitudinal studies dating back to 1995 for certain species and made available via a public website (https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock). Despite an almost 30-year time series for some cetacean stocks, NOAA compiled data often lack the statistical power to detect a trend in abundance due to the relatively imprecise abundance estimates and/or long survey interval. Additionally, the population size or estimates for portions of the stock's range are unknown for some species, and therefore a trend analysis cannot be conducted.

[6] https://open.canada.ca/data/en/dataset/db177a8c-5d7d-49eb-8290-31e6a45d786c

[7] https://open.canada.ca/data/en/dataset/8fafd919-fcbe-43a3-a911-3d9461273441

[8] https://open.canada.ca/data/en/dataset/9fd7d004-970c-11eb-a2f3-1860247f53e3

Table 1.6. Abundance estimates and trends for stocks (stock area and subareas) of cetaceans in US waters.

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
North Atlantic right whale	Western North Atlantic	412	2018	Recovering slowly; An increase in carcass detections in 2004 and 2005 was a cause for serious concern (Kraus et al. 2005).
Humpback whale	Gulf of Maine (formerly Western North Atlantic)	1396	2016	Positive trend in abundance; Estimating abundance for the Gulf of Maine stock has proved problematic. Three approaches have been investigated: mark-recapture estimates, minimum population size from photo ids, and line-transect survey estimates. Most of the mark-recapture estimates were affected by heterogeneity of sampling, which was heavily focused on the southwestern Gulf of Maine.
Fin whale	Western North Atlantic (Central Virginia to Newfoundland/Labrador)	6802	2016	This abundance estimate largely represents only the U.S. portion of this stock, and a small portion in Canadian waters. In earlier years, there were insufficient data to determine population trends for this species.
	Florida to lower Bay of Fundy	3006	2016	
	Bay of Fundy/Scotian Shelf	2235	2016	
	Newfoundland/Labrador	2177	2016	
Sei whale	Halifax, Nova Scotia to Florida (formerly Western North Atlantic)	6292	2010-2013	Population size is unknown for earlier years. There are, however, estimates for portions of the stock's range. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. A trend analysis has not been conducted for this stock.
	Maine to Florida in U.S. waters only	627	1999-2013	
	Gulf of St Lawrence entrance to Florida	717	1995-2013	
	Continental shelf break waters from New Jersey to south of Nova Scotia	28	2016	
Minke whale	Canadian East Coast (central Virginia to Labrador)	21 968	2016	Earlier abundance estimates only cover U.S. waters and slightly beyond into Canadian waters, and thus does not cover the habitat of the entire Canadian East Coast stock. A key uncertainty in the current abundance estimate is the number of animals in Canadian waters. Additionally, the current abundance estimate does not account for availability bias due to submerged animals. Without a correction for this bias, the abundance estimate is likely biased low. A trend analysis has not been conducted for this stock.

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
	Central Virginia to lower Bay of Fundy	2802	2016	
	Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf	6158	2016	
	Newfoundland/Labrador	13 008	2016	
Blue whale	Western North Atlantic	unknown	1980-2008	Little is known about the population size of blue whales except for the Gulf of St. Lawrence area. There are insufficient data to determine population trends for this species.
	Gulf of Saint Lawrence Catalogue	402	1980-2008	
	Central Virginia to lower Bay of Fundy	39	2016	
Sperm whale	North Atlantic (central Florida to lower Bay of Fundy)	4349	2016	Several estimates from selected regions of sperm whale habitat exist for select time periods, however, at present there is no reliable estimate of total sperm whale abundance for the entire North Atlantic. A trend analysis has not been conducted for this stock. There are insufficient data to determine the population trends for this species
	Central Virginia to lower Bay of Fundy	3321	2016	
	Central Florida to Virginia	1028	2016	
Dwarf sperm whale & Pygmy sperm whale	Western North Atlantic (central Florida to lower Bay of Fund)	7750	2016	Estimate for *Kogia* spp. only. Pygmy sperm whales (*Kogia breviceps*) and dwarf sperm whales (*Kogia sima*) are difficult to differentiate at sea. The available information is insufficient to evaluate population trends for this species in the western North Atlantic.
	New Jersey to lower Bay of Fundy	4548	2016	
	Central Florida to New Jersey	3202	2016	
Killer whale	Western North Atlantic	unknown	2016	The total number of killer whales off the eastern U.S. coast is unknown. Killer whales are characterized as uncommon or rare in waters of the U.S. Atlantic Exclusive Economic Zone (EEZ) (Katona et al. 1988).
Pygmy killer whale	Western North Atlantic	unknown	2016	The number of pygmy killer whales off the U.S. Atlantic coast is unknown since it was rarely seen in any surveys.

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
False killer whale	Western North Atlantic (central Florida to lower Bay of Fundy)	1791	2016	False killer whales are rarely sighted during abundance surveys, and the resulting estimates of abundance are both highly variable between years and highly uncertain. The rare encounter rates limit the ability to assess or interpret trends in population size.
	New Jersey to lower Bay of Fundy	1182	2016	
	Central Florida to New Jersey	609	2016	
Northern bottlenose whale	Western North Atlantic	unknown	2016	The total number of northern bottlenose whales off the eastern U.S. coast is unknown. The status of northern bottlenose whales relative to OSP in U.S. Atlantic EEZ is unknown; however, the depletion in Canadian waters in the 1970s may have impacted U.S. distribution and may be relevant to current status in U.S. waters.
Cuvier's beaked whale	Western North Atlantic (Central Florida to lower Bay of Fundy)	5774	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval.
	Central Virginia to lower Bay of Fundy	3897	2016	
	Central Florida to Virginia	1847	2016	
Blainville’s beaked whale; Gervais beaked whale; Sowerby’s beaked whale; True’s beaked whale	Western North Atlantic (Central Florida to lower Bay of Fundy)	10 107	2016	Estimates for *Mesoplodon* spp. Within the genus Mesoplodon, there are four species of beaked whales that reside in the northwest Atlantic. These include True's beaked whale, *M. mirus*; Gervais' beaked whale, *M. europaeus*; Blainville's beaked whale, *M. densirostris*; and Sowerby's beaked whale, *M. bidens* (Mead 1989).
	Central Virginia to lower Bay of Fundy	6760	2016	
	Central Florida to Virginia	3347	2016	
Melon-headed whale	Western North Atlantic	unknown	2016	The number of melon-headed whales off the U.S. Atlantic coast is unknown because they were rarely seen in any surveys. There are insufficient data to determine the population trends for this stock because no estimates of population size are available.
Risso's dolphin	Western North Atlantic (Central Florida to Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf)	35 439	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval.

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
	Central Florida to Central Virginia	7245		
	Central Virginia to lower Bay of Fundy	22 175		
	Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf	6073		
Long-finned pilot whale	Western North Atlantic (Central Virginia to Labrador)	39 215	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval.
	Central Virginia to Lower Bay of Fundy	10 997	2016	
	Newfoundland/Labrador	28 218	2016	
Short-finned pilot whale	Western North Atlantic (Central Florida to lower Bay of Fundy)	28 924	2016	There are three available coast-wide abundance estimates for short-finned pilot whales from the summers of 2004, 2011, and 2016. The resulting estimates were 24,674 (CV=0.52) in 2004, 21,515 (CV=0.36) in 2011, and 28,924 (CV=0.24) in 2016 (Garrison and Palka, 2018). A generalised linear model indicated no significant trend in these abundance estimates.
	New Jersey to lower Bay of Fundy	3810	2016	
	Central Florida to New Jersey	25 114	2016	
Atlantic white-sided dolphin	Western North Atlantic (Central Virginia to Labrador)	93 233	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval.
	Central Virginia to Maine (US part of Gulf of Maine population)	31 912	2016	
	Bay of Fundy to Gulf of St. Lawrence (Canadian part of Gulf of Maine and all of Gulf of St. Lawrence population)	61 321	2016	
	Newfoundland and Labrador (part of the Labrador population)	0	2016	
White-beaked dolphin	Western North Atlantic (Canadian Atlantic waters)	536 016	2016	There are insufficient data to determine population trends for this species. The change in abundance estimates between the DFO 2007 and 2016 aerial surveys in Canadian waters could

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
				not have resulted from reproduction alone so immigration from other areas of the north Atlantic likely occurred.
	Bay of Fundy/Scotian Shelf	5478	2016	
	Newfoundland/Labrador	530 538	2016	
Common dolphin	Western North Atlantic (Florida to Newfoundland/Labrador)	172 974	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval (see Appendix IV for a survey history of this stock).
	Central Virginia to lower Bay of Fundy	80 227	2016	
	Florida to Central Virginia	900	2016	
	Newfoundland/Labrador	48 574	2016	
	Bay of Fundy/Scotian Shelf/Gulf of St. Lawrence	43 124	2016	
Atlantic spotted dolphin	Western North Atlantic (Central Florida to Bay of Fundy)	39 921	2016	There are three available coast-wide abundance estimates for Atlantic spotted dolphins from the summers of 2004, 2011, and 2016. Each of these is derived from vessel surveys with similar survey designs and all three used the two-team independent observer approach to estimate abundance. The resulting estimates were 50,978 (CV=0.42) in 2004, 44,715 (CV=0.43) in 2011, and 39,921 (CV=0.27) in 2016 (Garrison and Palka, 2018). A generalized linear model indicated a statistically significant (p=0.011) linear decrease in these abundance estimates.
	New Jersey to Bay of Fundy	8247	2016	
	Central Florida to New Jersey	31 674	2016	
Pantropical spotted dolphin	Western North Atlantic (Central Florida to lower Bay of Fundy)	6593	2016	There are three available coast-wide abundance estimates for pantropical spotted dolphins from the summers of 2004, 2011, and 2016. Each of these is derived from vessel surveys with similar survey designs and all three used the two-team independent observer approach to estimate abundance. The resulting estimates were 4,439 (CV=0.49) in 2004, 3,333 (CV=0.91) in 2011, and 6,593 (CV=0.52) in 2016 (Garrison and Palka, 2018). A generalized linear model indicated no statistically significant (p=0.645) linear trend in these abundance estimates.

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
	New Jersey to lower Bay of Fundy	0	2016	
	Central Florida to New Jersey	6593	2016	
Striped dolphin	Western North Atlantic (Florida to lower Bay of Fundy)	67 036	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval.
	Central Virginia to lower Bay of Fundy	42 783	2016	
	Florida to Central Virginia	24 163	2016	
Fraser's dolphin	Western North Atlantic	unknown	2016	There are insufficient data to determine the population trends for this stock because no estimates of population size are available.
Rough-toothed dolphin	Western North Atlantic (Central Florida to lower Bay of Fundy)	0 / 136	2016	A trend analysis cannot be conducted for this stock due to the small number of sightings in any single year.
	Central Virginia to lower Bay of Fundy	0	2016	
	Central Florida to central Virginia	0	2016	
Clymene dolphin	Western North Atlantic	4237	2016	Clymene dolphins are rarely sighted during abundance surveys, and the resulting estimates of abundance are both highly variable between years and highly uncertain. The rare encounter rates limit the ability to assess or interpret trends in population size.
Spinner dolphin	Western North Atlantic (central Florida to the lower Bay of Fundy)	4102	2016	The number of spinner dolphins off the U.S. Atlantic coast has not previously been estimated because there have only been three sightings during recent NMFS surveys. There are insufficient data to determine the population trends for this stock because only one estimate of population size is available.
Common bottlenose dolphin	Western North Atlantic, Offshore (Central Florida to lower Bay of Fundy)	62 851	2016	There are three available coast-wide abundance estimates for offshore common bottlenose dolphins from the summers of 2004, 2011, and 2016. The resulting estimates were 54,739 (CV=0.24) in 2004, 77,532 (CV=0.40) in 2011, and 62,851 (CV=0.23) in 2016 (Garrison, 2020; Palka, 2020). A generalized linear model did not indicate a statistically significant (p=0.646) trend in these estimates. The high level of uncertainty in these estimates limits the ability to detect a statistically significant trend.

Species	Stock area and subareas	Recent abundance estimate	Last survey year	Abundance trends / comments
	New Jersey to lower Bay of Fundy	17 958	2016	
	Central Florida to New Jersey	44 893	2016	
	Western North Atlantic, Northern Migratory Coastal Assateague, Virginia (37.9°N) to Sandy Hook, New Jersey (40.3°N))	6639	2016	For the Northern Migratory Coastal Stock, the resulting mean abundance estimate for 2002–2004 was 8,597 (CV=0.53), and that for 2010–2011 was 15,232 (CV=0.35). There was no significant difference between these estimates and the estimate of 6,639 (CV=0.41) for 2016. There is limited power to detect a significant change given the high CV of the estimates, interannual variability in spatial distribution and stock abundance between 2002 and 2004, and the availability of only one recent survey (Garrison *et al.*, 2017a).
Harbor porpoise	Central Virginia to Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf	95 543	2016	A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval.
	Central Virginia to Maine	75 079	2016	
	Gulf of St. Lawrence/ Bay of Fundy/ Scotian Shelf	20 464	2016	

1.1.3 Acoustic Monitoring

Several countries employ acoustics, particularly passive acoustic monitoring (PAM) to determine temporal and spatial trends in occurrence of cetacean species to supplement evidence from visual surveys of distribution and abundance. Recent studies are reported for some countries below.

ICELAND: Research on northern bottlenose whales continued in 2021, including deployments of mono and stereo acoustic recorders in deep waters off the east and northeast of Iceland to study acoustic occurrence and movement directions, and photographic analyses for understanding individual movement, group composition, and age-sex distributions.

IRELAND: Barile *et al.* (2021) explored the occurrence of Cuvier’s and Sowerby’s beaked whales along the Irish Shelf Edge based on acoustic records. The authors used GAMs to relate whale occurrence and a set of oceanographic variables; chlorophyll a concentration (chla in mg/m^3), standard deviation of sea surface temperature (sdSST in °C), mean relative SST (relSST in °C), and sea surface height (SSH). For both species, the four oceanographic covariates were retained in the final selected models. The model results revealed that both Cuvier’s and Sowerby’s beaked whale clicks were overall less likely to be detected with increasing chla concentrations. With increasing relSST, the detection probability of Cuvier’s beaked whale was found to increase as well, while the detection probability of Sowerby’s beaked whale was found to decrease. For both species, probabilities of detection were relatively stable throughout the range of sdSST until a decrease occurred above values of approximately 0.30 °C. The probability of detecting both species increased overall as SSH values increased. In addition, for Sowerby's beaked whales, there was a clear north-to-south decreasing gradient in probabilities of detection.

PORTUGAL: There is no new information on the abundance and distribution of cetaceans off the Portuguese mainland, but from the Macaronesian region, Romagosa *et al*. (2021) have analysed over five years of data (2008-2012) collected by passive acoustic devices placed on three submarine sea mountains: Azores, Condor, and Gigante. Acoustic presence of fin, blue and sei whales showed a marked seasonality. A similar pattern was found across years and locations for both fin and blue whales, with increasing daily call rates in autumn, reaching a maximum in winter and decreasing again in spring with no detections in summer. Sei whales showed a different pattern from that of fin and blue whales with the number of calls peaking in spring and autumn in all locations.

SCOTLAND, UK: Several PAM projects have been carried out in Scottish waters during the last decade.

In Western Scotland, several PAM projects have been conducted since 2017 (Figure 1.18). The COMPASS project (recording time: Nov 2017 – June 2022) has deployed Sound traps 300HF and C-PODs, and in 2021 also F-PODs at some sites. The project aims to detect ambient noise levels and seasonal and diel patterns from the following species: harbour porpoise (from C-POD and Sound trap click detector data), delphinids (from C-POD and Sound trap data), Risso's dolphin (at Tolsta, NE Lewis MPA), minke whale, humpback whale. The project will also look at C-POD/F-POD comparisons (in collaboration with SAMOSAS) and C-POD/Sound trap click detector comparison (D. Risch, *pers. comm.*).

The SAMOSAS project (recording time: Sep/Oct 2020 – Aug 2021, final report in March 2022) have deployed RTSYS Sylence LP, C-PODs and F-PODs. The project has examined ambient noise (monthly averaged TOL and PSD levels for all sites), anthropogenic noise (sonar, seismic and ship presence) and presence of harbour porpoises, delphinids (without species differentiation), baleen whales (minke, humpback, fin whale, sei and blue whales) as well as sperm whales (D. Risch, *pers. comm*.).

The MarPAMM project (recording time: 2019, report by March 2022) has deployed 5 stations (contact: Suzanne Beck at AFBI). The project will collect data on the abundance, distribution and movement of marine protected species, which will be used to produce new habitat maps and develop models for a range of species (M. Pommier, pe*rs. comm*).

The SeaMonitor project (recording time: October 2020 – October 2022) has deployed SoundTraps, C-PODs and from 2021 also F-PODs (contact: Morgane Pommier/Joanne O'Brien at GMIT). The analysis will focus on ambient noise levels (temporal trends and soundscape characterization), harbour porpoise (and maybe delphinids, without species discrimination) temporal patterns of occurrence across the SeaMonitor array (C-POD and SoundTrap data). Furthermore, it will examine the influence of the Islay front on the occurrence of cetaceans (porpoises, delphinids and potentially minke whales) over the Malin Shelf (in collaboration with COMPASS, using data from some of their sites to supplement SeaMonitor) (M. Pommier, *pers. comm*.).

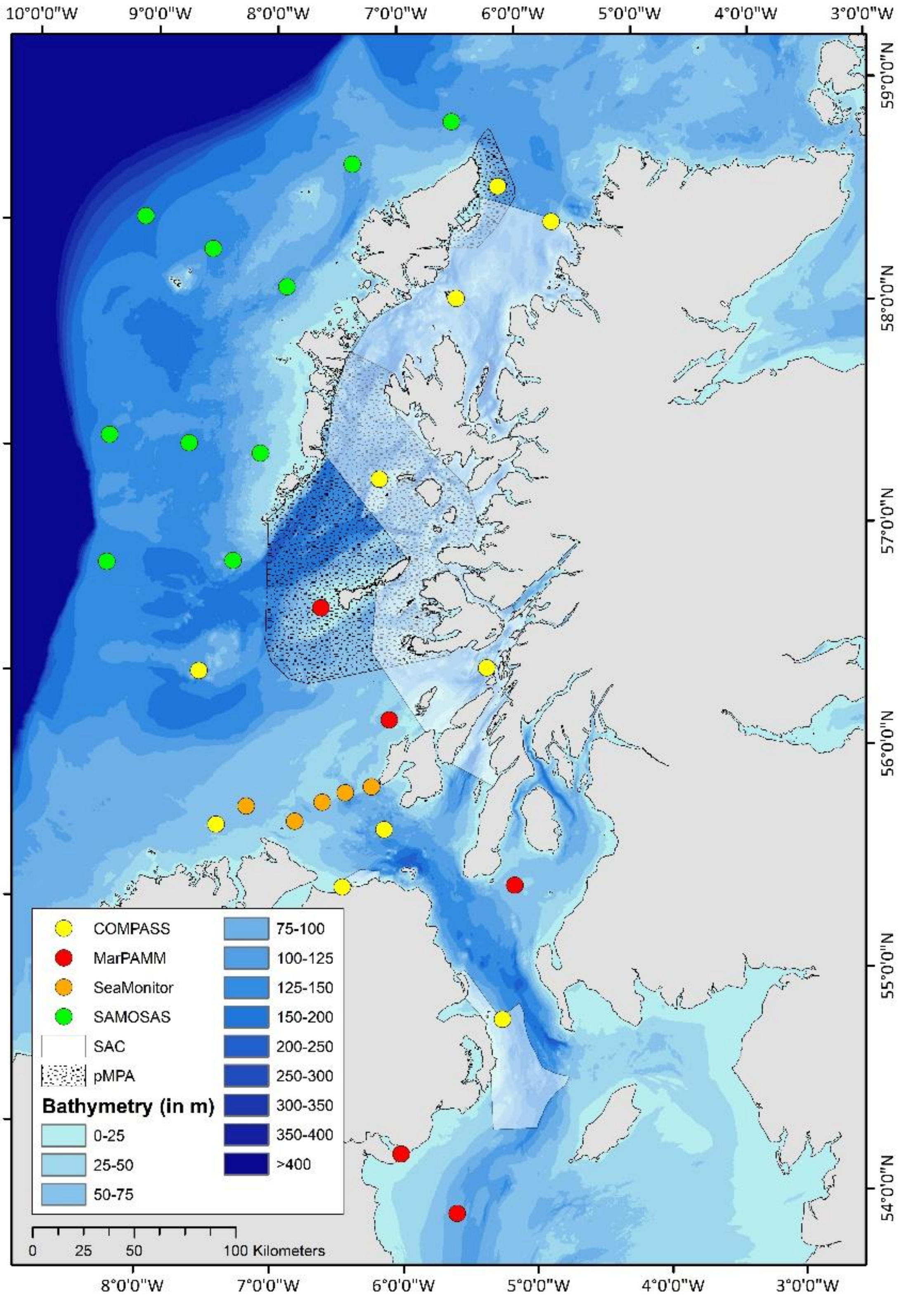

Figure 1.18. Map of location of passive acoustic monitoring stations in Western Scotland 2017-2021.

In Eastern Scotland, the ECOMASS project has been running since 2013 by Marine Scotland Science. It is a large-scale strategic project monitoring the effects of offshore wind farm construction on dolphins and harbour porpoises. Additional objectives are underwater noise level monitoring (used for MSFD/OSPAR reporting), and general ecology of the cetacean species in the area. An analysis plan is under development, and ECOMASS data have already been used in several publications: on underwater noise levels (Merchant *et al*., 2016), cetacean presence and habitat use (Palmer *et al*., 2019; Risch *et al*., 2019), and methodological aspects on acoustic monitoring (Williamson *et al*., 2016; Palmer *et al*., 2017; Van Geel *et al*., 2020) (K. Brookes, *pers. comm*, 16 March 2022).

BALTIC SEA: WGMME has reported on passive acoustic monitoring (PAM) of harbour porpoises using C-PODs in Denmark, Finland, Germany, Poland and Sweden in 2018–2020 (ICES, 2018; 2019; 2020; 2021). The following new information can be added:

DENMARK: The Ministry of Environment is funding the national monitoring of harbour porpoises in Denmark, carried out by Aarhus University. In the waters around Bornholm, C-PODs were last deployed 2018–2019 (Sveegaard *et al*., 2019; Sveegaard, 2020), and the plan is to repeat this monitoring again in 2023–2024 or during SAMBAH II (if funded).

In the Belt Sea population area, PAM is carried out in six SACs assessed to be most important to the species. Two SACs are monitored at a time, using five C-POD stations in each area, for a period of 12–16 months. From 2012 and onward, a general positive trend has been observed in five of the six sites and in one (in Fehmarn Belt), the detection rates were unchanged. In 2021, the results from the two sites “Flensborg Fjord and Bredgrund og farvandet omkring Als” and ”Lillebælt”, were reported. These two sites have been monitored during three periods: 2013–2014, 2015–2016, and 2019–2020. In both sites, detection rates varied across seasons, but in general an increasing trend was found across the three periods (Hansen and Høgslund, 2021).

FINLAND: PAM for harbour porpoises has been carried out since 2016, funded by the Ministry of Environment and the Åland Government and operated by Turku University of Applied Sciences. C-PODs are deployed at 11 previous SAMBAH stations and 2-12 additional stations (depending on gear availability), in the offshore area south of the Archipelago Sea and the Åland Islands. Data show that harbour porpoises are present on a regular and predictable basis in the monitored area, albeit in small numbers. A report on the status of harbour porpoise in the northern and eastern Baltic Sea is planned to be published.

GERMANY: The long-term monitoring project TopMarine, where PAM in the Baltic Sea is conducted by the German Oceanographic Museum, was continued in 2021 and will at the earliest end in June 2022. In addition to 15 long-term monitoring stations using C-PODs located from the island of Fehmarn to the Pomeranian Bay, measurements were carried out at up to 11 stations in the German North Sea from May to September in 2021. At a subset of all stations, SoundTraps and F-PODs were deployed in addition to the C-PODs. The project is funded by the German Federal Agency for Nature Conservation and will be continued (A. Gallus, *pers. comm*, 17 March 2022).

POLAND: Harbour porpoise monitoring is covered by the State Monitoring Programme on behalf of the Chief Inspectorate of Environmental Protection. During the 2016–2018 monitoring (24 months), 10 stations were selected at former SAMBAH stations at Pomeranian Bay and Stilo Bank (five stations in each area) using C-POD devices. Current monitoring (started March 2021) is running at 15 stations at Pomeranian Bay, Stilo Bank and Gdansk Bay using F-POD devices, as well as C-POD devices at five of the stations for comparison studies. Monitoring is planned to be carried out until the end of October 2022, with possible continuation to March 2023 (M. Malinga, *pers. comm.*).

Hel Marine Station of the University of Gdańsk undertake PAM to study the seasonal distribution and occurrence of harbour porpoises in Polish coastal waters. Data collection began in October 2020, but due to technical problems, it will be extended into 2022 to obtain a full year of data.

SWEDEN: The national monitoring programme of harbour porpoises is funded by the Swedish Agency for Marine and Water Management and carried out by the Swedish Museum of Natural History (NRM). Data on detection rates are publicly available at Sharkweb, hosted by the Swedish Meteorological and Hydrological Institute (https://sharkweb.smhi.se/). Within the summer management area of the Baltic Proper harbour porpoise population in the Baltic Sea, continuous PAM using C-PODs has been carried with smaller adjustments since 2017, focusing on the Baltic Proper population. In 2021, 10 previous SAMBAH stations were monitored. At the station with the highest detection rate, two rigs were deployed, each equipped with both a C-POD and an underwater sound recorder. The sound recordings are carried out by the Swedish Defence Research Agency, FOI, as part of the national monitoring programme of underwater noise. In the Kattegat Sea, continuous PAM using C-PODs has been carried out at 14 stations located in five Natura 2000 sites in the Kattegat Sea, focusing on the Belt Sea harbour porpoise population. Further, one station located in the southern Skagerrak Sea, within the summer management area of the North Sea population, was monitored jointly with underwater noise in 2015–2018. This station was continued again in summer 2020, and was continuously monitored in 2021.

A comparison of the acoustic detection rates at 12 stations during SAMBAH (2011–2013) and the national monitoring programme (2017–2020) show that there was a 29% increase in the mean daily detection rate during May–October (over the breeding season) between the two study periods (Owen *et al*., 2021). At the three stations with the highest number of detections, log linear regression revealed a yearly increase of 2.4% between 2011 and 2019 (-4.4 to +9.6, 95% CI). This may be indicative of the beginnings of population recovery, or simply an indication that the decline has stalled. The rate of increase is still well below the potential for porpoise populations, and unlikely to buffer against any potential increase in pressures in the future. An evaluation of the first years of monitoring in the Kattegat Sea is carried out in 2021.

In addition to the national monitoring programme in Sweden, some County Administrative Boards (CABs) carry out local/regional monitoring, and a coordinated regional monitoring programme including all CABs within the currently known distribution range of the Baltic Proper harbour porpoise population was planned to start up in 2021. However, the launch of the programme was prevented by the Swedish Armed Forces within most of the relevant area in the Baltic Sea, and it is currently not known when it can begin. Also, regional PAM data are to be uploaded to Sharkweb.

In 2021, a common format for PAM data was agreed within HELCOM, and all Contracting Parties carrying out PAM for harbour porpoises as part of their national monitoring programmes were to upload their national monitoring data before the end of the year. In the process, it has become evident that there are slight differences among the countries in the methods for data collection and data processing, and the format allows these. The data will be publicly available through the HELCOM Biodiversity Database (https://maps.helcom.fi/website/biodiversity/). Harmonisation across countries has been planned as part of the SAMBAH II project.

Abundance estimates from the SAMBAH project have now been published (Amundin *et al*., 2022). By logging porpoise echolocation signals at 298 stations during May 2011–April 2013, calibrating the loggers' spatial detection performance at sea, and measuring the click rate of tagged individuals, an abundance of 71–1105 individuals (95% CI, point estimate 491) was estimated during May–October within the proposed management borders of the Baltic Proper harbour porpoise population. The small abundance estimate strongly supports the conclusion that the Baltic Proper harbour porpoise is facing an extremely high risk of extinction, and highlights the need for immediate and effective conservation actions through international cooperation. It also provides a starting point for monitoring the trend of the population abundance to evaluate the effectiveness of management measures and determine interactions with the larger neighbouring Belt Sea population. Further, the study offers evidence that design-based passive acoustic monitoring can generate reliable estimates of the abundance of rare and cryptic animal populations across large spatial scales.

In February 2021, a full application was submitted for the SAMBAH II LIFE project to the EU LIFE programme, after a successful concept note application submitted in May 2020. The consortium involved a total of 17 research organisations and management authorities in Denmark, Estonia, Finland, Germany, Lithuania, Poland and Sweden. However, the full application was rejected, and there are currently no open calls where the project fits. With regards to abundance and distribution, the project objectives were:

- Provide a comprehensive assessment of the status of the Baltic Proper harbour porpoise population, listing the key conservation actions to secure its survival.
- Provide estimates of population-specific and national GES thresholds and FRVs for the entire Belt Sea and Baltic Proper porpoise populations where possible.
- Provide updated and more precise abundance estimates of porpoises, by country and population, and by season, including in waters deeper than 80 m not previously surveyed.
- Provide monthly maps of porpoise density (i.e. not only detections) across the survey area.
- Investigate whether the abundance and distribution of the Baltic Proper population has changed during the last decade.
- Provide knowledge on the spatio-temporal impact of prey quantity and quality on porpoise density and echolocation behaviour.
- Test a novel method for acoustic identification of calves and, if successful, identify when calving takes place in the Baltic Proper population.
- Provide a Baltic-wide harmonised method for acoustic monitoring of porpoises by EU Member States.

In addition to this, the project would also address questions related to the threats of bycatch and underwater noise, and for increased public awareness. Improvement of the management of the Baltic Proper harbour porpoise population, including provision of data needed for the reporting according to the MSFD and the Habitats Directive, and the development of MSFD indicators, rely heavily on the accomplishment of the SAMBAH II project.

CANADA: PAM efforts to monitor the occurrence of cetaceans off eastern Canada have grown substantially in the past few years. These include data collection using archival bottom-moored PAM systems, and development and implementation of near real-time PAM systems on buoy and glider platforms. As an example of the increasing PAM efforts, DFO maintained three PAM sites off Nova Scotia annually in the 2012-2014 period, which has increased to 11-13 PAM sites maintained annually off Nova Scotia in recent years (the metadata associated with these deployments off Nova Scotia has been submitted to the International Quiet Ocean Experiment and can be viewed on their website under "Fixed Autonomous Systems"[9]). Acoustic monitoring programmes have similarly been expanding in other regions off eastern Canada such as in the St. Lawrence Estuary, Gulf of St. Lawrence, and off Newfoundland and Labrador. For one particularly large PAM study, JASCO Applied Sciences deployed and maintained 20 PAM stations off Nova Scotia, Newfoundland and Labrador over a two-year period from 2015-2017 and analysed these for presence of calls produced by a variety of baleen and toothed whales (Delarue *et al.*, 2018). Acoustic monitoring efforts from bottom-moored archival systems such as these have provided information on the seasonal occurrence of blue, fin, sei, humpback and right whales (e.g. Davis *et al.*, 2017, 2020; Kowarski *et al.*, 2017; Moors-Murphy *et al.*, 2019; Simard *et al.*, 2016, 2019),

[9] https://www.iqoe.org/systems

as well as beaked whales (e.g. Stanistreet *et al.*, 2017, 2021), belugas (e.g. Giard *et al.*, 2020) and other cetaceans in Atlantic Canada (e.g. Delarue *et al.*, 2018), providing detection data for sperm whales, delphinid clicks and whistles, and harbour porpoise. Some of these analysed data can be viewed on NOAA's online tool for storing and viewing confirmed acoustic detections of cetaceans: the Passive Acoustic Cetacean Map[10]. Oceanographic buoys in the Gulf of St. Lawrence[11] and deployments of Slocum gliders equipped with acoustic recorders[12] have been providing near real-time acoustic detections of right whales to inform management measures in the Gulf of St. Lawrence and other areas off Nova Scotia, which can be viewed on WhaleMap[5].

1.1.4 Cetacean Strandings

BELGIUM: In 2021, a total of 79 harbour porpoises were found stranded. No overall assessment has been made of causes of death yet, but at least 14 died due to grey seal predation. No other cetacean species was found washed ashore. The yearly number of stranded harbour porpoises in Belgium between 1970 and 2021 is shown in Figure 1.19.

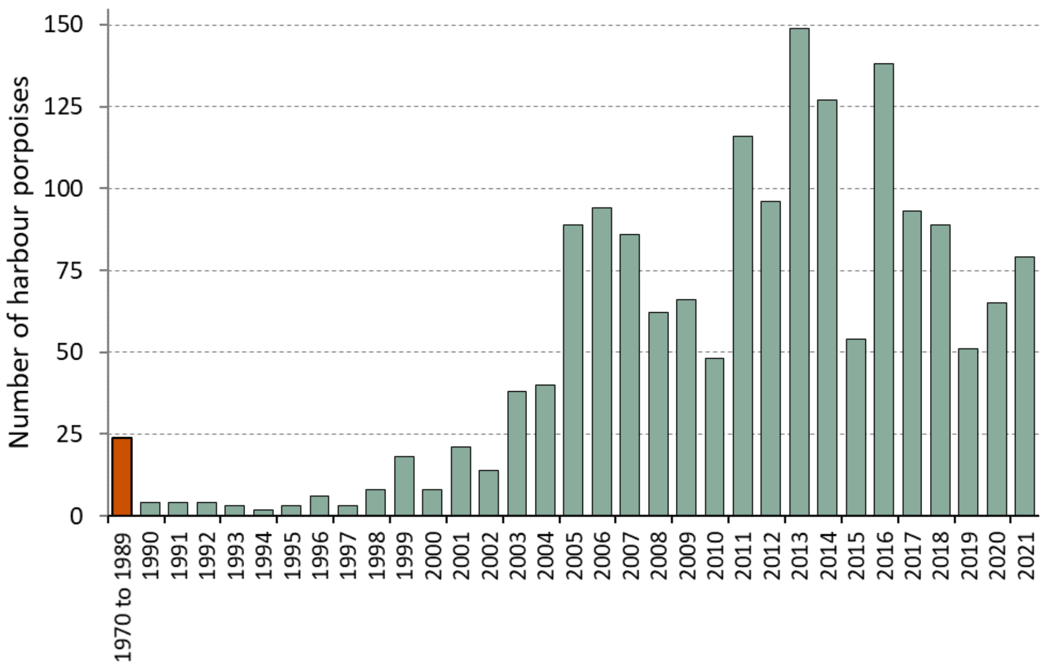

Figure 1.19. Yearly number of stranded porpoises in Belgium, 1970-2021; 1970-1989 is total number recorded for this period (Data RBINS).

FRANCE: Information on strandings along all French coasts is available through the national strandings database (in French): http://pelagis.in2p3.fr/public/histo-carto/index.php.

GERMANY: A review of cetacean strandings along the German North Sea coastline and the lower reaches of the major rivers discharging into the German Bight, covering the years 1604-2017, has been carried out by Kinze *et al.* (2021). Records have been found of 19 cetacean species

[10] https://apps-nefsc.fisheries.noaa.gov/pacm/#/

[11] https://slgo.ca/viking/?lg=en

[12] http://dcs.whoi.edu/

that either stranded dead or were put to death. The harbour porpoise is the commonest species, with written sources dating back to at least 1651, although with statistical data only available from 1990. The other 18 documented species are: white-beaked dolphin, bottlenose dolphin, Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common dolphin, striped dolphin (*Stenella coeruleoalba*), Risso's dolphin, long-finned pilot whale, killer whale, beluga whale, narwhal, Sowerby's beaked whale (*Mesoplodon bidens*), northern bottlenose whale, sperm whale, minke whale, sei whale, fin whale, blue whale, and humpback whale. The review corrects several false species identifications earlier introduced to the literature based on incorrect scientific or ambiguous German vernacular names, and recovers lost records of beluga whale, northern bottlenose whale, sperm whale and fin whale.

NETHERLANDS: In 2021, a total of 739 cetaceans were recorded stranded, of which 731 harbour porpoises (www.walvis-strandingen.nl). This is the third highest number recorded since 1990 (ICES, 2021). The other species recorded were fin whale (one), minke whale (one), sperm whale (one), Sowerby's beaked whale (two), bottlenose dolphin (one), white-sided dolphin (one), and an unidentified dolphin (one).

NORWAY: In 2020, an unusual high frequency of cetacean strandings occurred from 28 March to 2 May (Bjørge *et al*., 2020). In total, six sperm whales, four humpback whales, two northern bottlenose whales, two long-finned pilot whales, one fin whale and one unknown large whale, together with one white-beaked dolphin and a harbour porpoise were found stranded during these days. One of the strandings occurred in southern Norway, the rest between 65.67°N and 70.24°N in northern Norway. Twelve of the 18 carcasses were sampled. This is an unusual number of strandings in a relatively small area over a short period of time and the cause is unclear.

ICELAND: A total of 43 stranding events of cetaceans was recorded by the MFRI in 2021, including a mass stranding of long-finned pilot whales (60 animals), and nine single strandings of sperm whales.

SWEDEN: In total, 31 stranded harbour porpoises were collected during 2021 and examined by necropsy. Similar to previous years, bycatch (confirmed or probable, n=12) was the most common cause of death. Causes of death were assigned as follows: bycatch (confirmed n=10 and probable n=2), infectious disease (n=3), abandoned (n= 3 neonates), emaciation (n=1), predation (n=1, predator species not confirmed), stillborn (n=1), drowning (n=1, unknown cause), unknown (n=5) and unsuitable material (n= 4, advanced autolysis). Of note, one of the stranded porpoises originated from well within the Baltic Proper on the island of Öland, and most likely came from the critically endangered Baltic Sea population. The total number of porpoises reported stranded in Sweden in 2021 was at least 31 animals, but these data have not yet been compiled (A. Neimanis, *pers. comm*.).

Additionally, a young, male humpback whale washed up dead on the Baltic island of Öland in April and was sampled in the field. In June 2021, a young female northern bottlenose whale stranded dead just north of Gothenburg on the west coast of Sweden and was necropsied. Cause of death was not definitely determined due to advanced autolysis, but severe haemorrhaging consistent with blunt trauma was observed (A. Neimanis, *pers. comm*.).

UNITED KINGDOM: In Scotland, the Scottish Marine Animal Stranding Scheme (SMASS) operates an opportunistic surveillance programme aiming to identify, quantify and understand threats and pressures on marine animals in Scottish waters. The programme largely relies on opportunistic reporting by stakeholders and members of the public and therefore maintaining and developing public awareness and engagement has been an active component to the work. Consequently, any apparent increase in incidence of these species is likely to be at least partially attributable to an increased reporting effort over the past decade. A map of rare and/or vagrant species reported to SMASS from 2010 to the end of 2021 (see Table 1) can be accessed here: https://batchgeo.com/map/b033c55491cc8c084a228d018401cf2b

CANADA: A number of cetacean species are associated with carcasses, live stranding events, entanglements, entrapments, injuries, and other similar incidents reported off eastern Canada. Data on documented marine mammal incidents and mortalities are mainly collected and tracked by marine animal response organisations that maintain marine animal incident reporting hotlines in the Atlantic Provinces. A recent report released by the Marine Animal Response Society examines data collected by incident reporting hotlines in Nova Scotia, New Brunswick, Prince Edward Island, Quebec, Newfoundland and Labrador over the period of 2004-2019 (Wimmer and Maclean, 2021). The report summarises information for 3,139 incidents over this time period, involving 25 cetacean species (with humpback whales, minke whales, beluga whales and harbour porpoise comprising the majority of incidents), and highlights that the limited data suggests human-caused threats are impacting many (if not all) cetacean species off Atlantic Canada and that the number of reported incidents is expected to increase.

1.1.5 Vagrant Cetacean Species

In this section, (non-exhaustive) information on vagrant species within the Atlantic is compiled with a focus on the years 2010-2021. Vagrant species are here loosely defined as species found outside their natural geographical range, taking historical records into account.

Bowhead whale: In the East Atlantic, a bowhead whale was first seen off the coast of St. Agnes, Isles of Scilly (UK) in February 2015, then off Marazion, Cornwall (UK) in May 2016, in County Down (Northern Ireland) in May 2016, Brittany (France) also in May 2016, then the following year in Co. Cork (Ireland) in April 2017, at Ostende (Belgium) in March – April 2017, and Vlissingen (The Netherlands) in April 2017 (Haelters, 2017; Evans and Waggitt, 2020b). Images taken on 1st April in Belgian waters showed that the animal was entangled by its tail, probably by a bottom set gill net. No efforts were undertaken to disentangle it due to adverse weather conditions and lack of available experience and equipment. At least some if not all of the sightings were believed to be the same individual (de Boer *at al*., 2017; Evans and Waggitt, 2020b). The sighting in Belgian waters was the first of this species in the North Sea (Haelters, 2017).

In the West Atlantic, a bowhead whale, identified as being the same individual, has been observed 13 times in the Gulf of Maine (both Canadian and US waters) in 2012, 2014 and 2017, far south of the normal range of this species (Accardo *et al*., 2018).

North Atlantic right whale: There has been a North Atlantic right whale recorded on several occasions off the north Biscay coast (France). The recognisable individual was born in 2008, travelled from the north-east coast of the United States to near Reykjavik in Iceland in March 2019, then back to Cape Cod Bay, then in June 2019 appeared off the French coast at Penmarch (Evans and Waggitt, 2020b). A North Atlantic right whale, possibly the same individual, was seen in the same area in July 2020 (Sea Watch Foundation, unpublished data). A 4-metre long North Atlantic right whale calf (with foetal folds) appeared at El Hierro in the Canary Islands in December 2020 (N. Aguilar, *pers. comm.*).

Sei whale: This species was observed in Hobro, Eastern Denmark, in 2018 (C. C. Kinze, *pers. comm*).

Humpback whale: Since 2008, there are a few observations of humpback whales in the Baltic Sea. In July 2008, one individual was observed among fishing vessels in The Sound between Denmark and Sweden in July, and again two weeks later off the island of Bornholm in the southern Baltic (probably the same individual). In August 2014 one individual was sighted off the island of Fårö north of Gotland, Sweden, in the northern Baltic Proper, and again in March 2015 in the Bothnian

Sea (probably the same individual) (Lysén and Lundin, 2017). In May 2016, one or two humpback whales were observed in the archipelago of Gryt at the Swedish east coast (occasionally at 7-10 m depth) in the Baltic Proper. Yet another likely observation was made in the same area in September the same year. In September 2017, two sightings were made of a probable humpback whale off Bullerön in Stockholm archipelago, Sweden. In May 2018, a humpback whale was observed in Nordmalingsfjärden, between Umeå and Örnsköldsvik along the Swedish coast of the northern Bothnian Sea. The following day, a humpback whale (probably the same individual) became entangled in static net close to the Finnish village of Vasa. It was released by the coast guard, and a few days later caught again in a hoop net off Raumo, 250 km south of Vasa, and was released again. In September 2018, at least two humpback whales were sighted off Sandhamn in the Stockholm archipelago, Sweden (www.valar.se).

Over the last ten years, sightings of humpbacks have been steadily increasing in the North Sea (Leopold *et al.*, 2016) and also around the British Isles (Evans and Waggitt, 2020b).

Dwarf sperm whale: An individual live-stranded in Mounts Bay, Cornwall (UK) in October 2011. It was re-floated and went back out to sea. This was the first record of the species in the UK (Evans and Waggitt, 2020b). A dwarf sperm whale was found stranded at Ribeira in Galicia (northwest Spain) in March 2019, following a re-floated live stranding 1.3 km away in the previous month (Covelo and Lopez, 2021). In France, there was a live sighting in 2010, and a live stranding at Anglet in November 2015 (Van Canneyt *et al*., 2016).

Pygmy sperm whale (Kogia breviceps): Strandings of single individuals have been found in 2011 (Argyll and Bute, West Scotland, 2013 (Aberdeenshire, East Scotland), 2014 (Shetland), and 2016 (Highland, Northwest Scotland) (A Brownlow, *pers. comm*).

Beluga: In May 2014, a much-decomposed unidentified cetacean, later identified as a beluga, was found in Lunan Bay, Angus, East Scotland (A. Brownlow, *pers. comm*.). Prior to this the last recorded beluga strandings in UK occurred in October 1932 and three in 1949. However, since 2015, there have been four confirmed live sightings: one in July 2015 in Co. Antrim (Northern Ireland), one in August 2015 off the coast of Northumberland (North-east England), one visiting the Thames Estuary, London (UK) between September 2018 and May 2019 (Anonymous, 2021), and the most recent off Unst, Shetland (Scotland) in July 2021. In Danish waters, a beluga was observed in the Little Belt in 2011 and 2012 (C. C. Kinze, *pers. comm*.).

Narwhal: An individual swam up the River Scheldt (Belgium) in March 2016, and was subsequently found dead the following month (Haelters et al., 2018). The animal, a juvenile male of likely 5 to 6 years old. It is the most southerly record ever in the North-East Atlantic region, and the first record of a narwhal in the North Sea for the last 70 years. In the North-West Atlantic, a narwhal has been observed in the St Lawrence River (Canada) every year from 2016 to 2020 in company of belugas (Nunny and Simmonds, 2020).

Fraser's dolphin (Lagenodelphis hosei): A mass stranding of 11 individuals of this tropical species occurred in north Brittany (France) in 1984, and there was a single stranding record from the Outer Hebrides (Northwest Scotland) in 1996 (Evans, 2020), but there have been no records in northern Europe since then.

True's beaked whale: The first record of the species in the UK was an individual found stranded in Kearvaig Bay, Sutherland (West Scotland) in January 2020 (Kitchener *et al*., 2020).

Other beaked whale species: In 2020, ASCOBANS made a compilation of stranded beaked whales from France to Sweden in 1970-2019 (Dolman *et al*., 2021). Since then, a Sowerby's beaked whale has stranded at the island of Öckerö at the Swedish west coast in July 2020, and a freshly dead Sowerby's beaked whale was found on the northern shore of the island of Alrø in Horsens Fjord at the Danish east coast in August 2021 (C. C. Kinze, *pers. comm*.). Also, a northern bottlenose whale died in the harbour of Kolding at the Danish in east coast in January 2022 (C. C. Kinze, *pers. comm*.). Around the British Isles, northern bottlenose whales occasionally come into shelf seas, mainly within the Hebrides, but also sometimes in the North Sea and English Channel (Evans and Waggitt, 2020b).

CANADA: Wimmer and Maclean (2021) provide some information on incidents involving reported vagrant cetaceans (which they consider a live animal outside of their normal range for which intervention may be required) off eastern Canada. Vagrants represent 4% of incidents reported over the 2004-2019 period, and mainly involved young belugas occurring in areas outside their normal range (such as off Nova Scotia and Newfoundland) that sometimes have a tendency to try and initiate close contact with vessels/humans which may warrant response actions (e.g. see the Whale Stewardship Project[13]).

1.1.6 Cetacean Population Structure

FAROE ISLANDS: Ongoing tagging of pilot whales is expected to reveal new information on distribution and stock structure of the species (B. Mikkelsen, *pers. comm*.).

ICELAND: Research on stock structure of several cetacean species, including fin whales, sei whales, humpback whales, common minke whales, killer whale and harbour porpoises is ongoing using genetic and other methods (e.g. Huijser *et al*., 2018, Smith *et al*., 2021, Olsen *et al*., 2022, MFRI unpublished information, Vighi *et al*., 2019, Gauffier *et al*., 2020). Several instances of hybridization between blue and fin whales have been documented in recent years, and the first example of a 2nd generation hybrid (between fin/blue hybrid and a fin whale) was discovered in 2020 (Pampoulie *et al*., 2021).

Bottlenose dolphin

Dinis *et al.* (2021) explored large-scale movements of common bottlenose dolphins in the Atlantic by comparing bottlenose dolphin photo-identification catalogues from the Azores, Madeira, The Canary Islands and the Portuguese continental shelf. Results showed individual matches, the majority between Madeira and the Canary Islands (n = 23) that are relatively close archipelagos, but also three matches between Azores and Madeira. No matches were found between the Canary Islands and the Azores, nor between Madeira and Sagres (southwest tip of the Iberian Peninsula). The identified large movements of bottlenose dolphins in the Macaronesia region support the high level of gene flow described for oceanic bottlenose dolphins inhabiting the North Atlantic. The authors underline the need for a review of the marine protected areas established for the species within the three archipelagos, taking the dynamics of the long-term movements into account.

Louis *et al.* (2021) analysed complete genomes of 57 bottlenose dolphins to address repeated adaptation to novel environments (i.e. coastal habitats). The authors found that ancient alleles present in pelagic populations were selected in geographically distant coastal populations, indicating parallel adaptation during coastal habitat colonisation in previous interglacial periods. The authors hypothesise that ancient genetic variation has been the source of past adaptation and may be critical for species to cope with the current global climatic change.

Harbour porpoise

Ben Chehida *et al.* (2020) investigated patterns of population structure of harbour porpoises across the North Atlantic and Black Sea by analysing 10 microsatellite loci and a quarter of the

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[13] http://www.whalestewardship.org/Home.html

mitochondrial DNA of 925 porpoises. Four main mtDNA lineages equally divergent from each other were found: Black Sea, Iberia-Mauritania, North East Atlantic, and West Greenland. The West Greenland lineage, carried by a single individual, was described for the first time. In the Bay of Biscay, the highest mtDNA diversity of all geographical regions was found due to haplotypes from *P. p. phocoena* mixing with those from Iberia-Mauritania. This confirmed previously reported hybridisation between the two subspecies and the predominantly northward gene flow. The study supports previous evidence of female philopatry since isolation by distance was higher at mitochondrial DNA (maternally inherited) than nuclear DNA (inherited from both parents). A bioclimatic model was used to predict harbour porpoise habitat suitability in the North East Atlantic for the year 2050. The model used sea ice concentration, depth, and sea surface temperature as predicted by the IPCC as variables in the niche envelope. The model predicted that abiotic environmental suitability for this particular species will not change dramatically compared with the present one.

Tiedemann *et al.* (2017) analysed 196 harbour porpoises from the North and Baltic Seas via ddRAD-sequencing. Of these, 109 specimens were genotyped at the same 2518 informative Single Nucleotide Polymorphisms (SNPs). These were jointly analysed with 37 specimens from the area previously typed at 1874 SNP loci (Lah *et al.*, 2016). Major findings are:

- There is a clear genetic distinction between the porpoise populations of the North Sea and Baltic Sea, with a transition zone in the Kattegat.
- Within the Baltic Sea, there are two subpopulations, one western in the Belt Sea and one eastern in the Baltic Proper.
- Within the Belt Sea, all specimens were assigned to the western Baltic subpopulation.
- Within the Baltic Proper, 65-70% of the specimens were assigned to the local Baltic Proper subpopulation, about 10% were inferred to be migrants from the Belt Sea subpopulation, and for 20-25% of the specimens, no consistent assignment was possible.

Altogether, there are now 4000 new informative SNP markers which could form the basis of an informative SNP panel for population assignment of further specimens (e.g. strandings). The specimens analysed here cover a period of 30 years. It would be desirable to have more recent samples analysed from the Baltic Proper population.

1.2 Seal Abundance and Distribution

1.2.1 Seal Abundance

In many ICES areas, seal populations are surveyed regularly, providing for a comprehensive long-term monitoring of these pinnipeds. This is mostly the case for the more temperate species including harbour, grey and ringed seals in the North Atlantic and Baltic Sea. The numbers of these species are described annually based on available data, and added to the "seal database" of the WGMME. This is the basis for the graphs indicating the long-term trends. Trends in harp and hooded seals are described in the WGHARP reports (ICES, 2019a). The group discussed that in the future, other species should be reported to allow for observations of trends with respect to global changes. Therefore, vagrants observed are included in this report (see Table 1.10).

Tables 1.7-1.9 summarise the most recent available seal survey data, analogous to what WGMME has presented in previous years. In the following, assessments of population status and developments are presented individually for the different countries or management units and different species, including trajectories of (available) counts. Unless it is stated otherwise that a figure refers to a population abundance estimate, numbers of seals reported are those counted on haul outs, which do not include seals at sea during surveys.

Table 1.7. Recent harbour seal survey data.

Country		Recent Survey Year(s)	Moult (All seals)	Breeding (Pups)	References
NORWAY	North of 62N	2021	4922		Nilssen *et al.*, 2021
	South of 62N	2016–2018	1054		Nilssen and Bjørge, 2019
	Finnmark	2012–2013	981		Nilssen and Bjørge, 2017a, b
	Skagerrak	2016–2018	543		Nilssen and Bjørge, 2019
	Svalbarð	2009–2010	1888		Merkel *et al*. 2013
ICELAND		2020	10 319		Granquist, 2021
WADDEN SEA		2021	26 838	10 903	Galatius *et al.*, 2021a
DUTCH DELTA AREA		2019-2020	1274	199 (2019)	Hoekstein *et al.* 2021
FRANCE	Mainland	2021	1319	301	Poncet *et al.,* in press
UK					
	Scotland	2016–2019	26 846		SCOS, 2021
	England and Wales	2016–2019 2021*	3886 3639		SCOS, 2021 * SE England
	Northern Ireland	2018	1012		SCOS, 2021
IRELAND		2017–2018	4007		Morris and Duck, 2019
USA		2018	47 371 (estimate)		Sigourney *et al.*, 2021
CANADA	south of Labrador	1970s	12 700		NAMMCO
	Estuary and Gulf of St Lawrence	1994–2000	4000–5000		
FRANCE	Saint-Pierre et Miquelon (NW Atlantic)	2021	1069	NA	DTAM; Vincent, C, unpublished data
SWEDEN & DENMARK	Skagerrak east coast	2021	2877		Swedish Museum of Nat. Hist.
	Kattegat/ Danish Straits	2021	8419		Swedish Museum of Nat. Hist., Aarhus University
	Southwestern Baltic	2021	1181		Aarhus University
	Limfjord	2021	1043	429	Aarhus University
	Kalmarsund	2021	2049		Swedish Museum of Nat. Hist.

Table 1.8. Recent grey seal survey data.

Country		Recent Survey Year(s)	Moult (All seals)	Breeding (Pups)	References
NORWAY	Troms & Finnmark	2020–2021		275	Kjell Nilssen (unpublished data)
	Mid Norway 62N-68N	2018–2020		404	Kjell Nilssen (unpublished data)
	Norway south of 62N	2017		35	Nilssen and Bjørge, 2017a, b
ICELAND		2017	6269	1452	Granquist and Hauksson, 2019a
WADDEN SEA		2021	9069	1927 (2020-2021)	Brasseur *et al*., 2021
DUTCH DELTA AREA		2020	1550	23 (2019-2020)	Hoekstein *et al*., 2021
FRANCE	Mainland	2021	2602	91	Poncet *et al*., in press
UK	Inner Hebrides	2019		4455	SCOS, 2021
	Outer Hebrides	2019		16 083	SCOS, 2021
	NW Scotland	2019		609	SCOS, 2021
	Scottish North Sea	2019, 2004*		32 213	SCOS, 2021; * Shetland
	English North Sea	2019		10 725	National Trust, Lincolnshire Wildlife Trust, Natural England, Friends of Horsey Seals
	SW England & Wales	2019		2750	SCOS, 2021
REPUBLIC OF IRELAND		2012	7284	2100	Ó Cadhla *et al*., 2013
CANADA	Sable Island	2016		83 594	den Heyer *et al*., 2017
	Gulf of St Lawrence + eastern Canada	2016		15 090	den Heyer, *et al*., 2017; Hammill *et al*., 2017
FRANCE	Saint-Pierre et Miquelon (NW Atlantic)	2021	180*	0	DTAM; C. Vincent, unpublished data * Summer counts (harbour seal moult)
USA	USA east coast	2019		6253	Wood *et al*., 2019
BALTIC	Baltic	2020	42 000		HELCOM

Table 1.9: Recent ringed seal survey data.

Country		Survey Year(s)	Moult (All seals)	References
SWEDEN, FINLAND	Bothnian Bay	2018	9 919	HELCOM (close to normal ice conditions)
	Bothnian Bay	2021	11 509	HELCOM (unusual ice conditions)
		2015	19 936	2015: the highest unusual result
ESTONIA, FINLAND, RUSSIA	Gulf of Finland	2021	116	M. Verevkin, *pers. comm*. (suitable ice only on Russian side)
ESTONIA, LATVIA	Gulf of Riga	2021	1 029	I. Jüssi, M. Jüssi, *pers. comm*.
FINLAND	Finnish Archipelago Sea	2018	122, popula-tion estimate 200–300	M. Kunnasranta, *pers. comm*.

ICELAND

Harbour seal

The Icelandic harbour seal (*Phoca vitulina*) population is currently in decline, decreasing from an estimated abundance of 33 000 animals in the first census in 1980 to 7700 animals in 2016, which historically is the lowest estimate observed (Figure 1.20). New data from surveys carried out in 2018 and 2020 show an increase in the estimated population size to around 9400 individuals in 2018 (Granquist and Hauksson, 2019b) and 10 319 individuals in 2020 (Granquist, 2021). Despite the increase, this number is still below the set management target of a population size of 12 000 harbour seals.

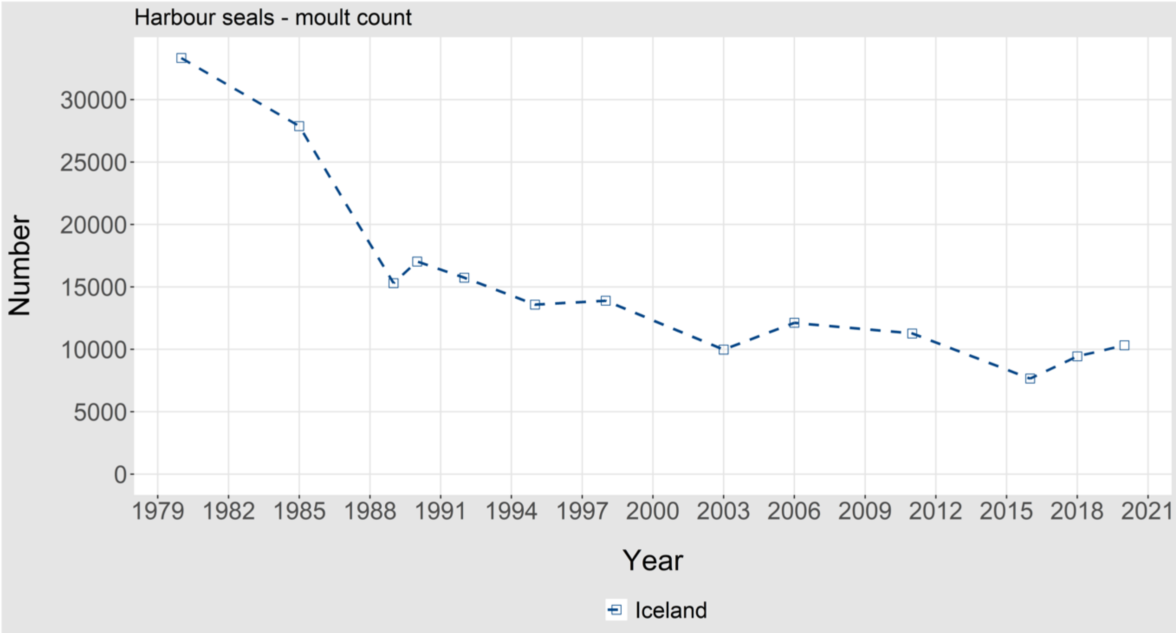

Figure 1.20. The trend of survey results of harbour seals in Iceland, estimated population abundance.

Grey seal

The Icelandic grey seal population has been surveyed at irregular intervals since 1982 when the population abundance was estimated to be 9000 animals. The latest estimate from 2017 indicated a population abundance of 6269 animals, based on a pup survey yielding 1452 pups (Figure 1.21; Granquist and Hauksson, 2019a).

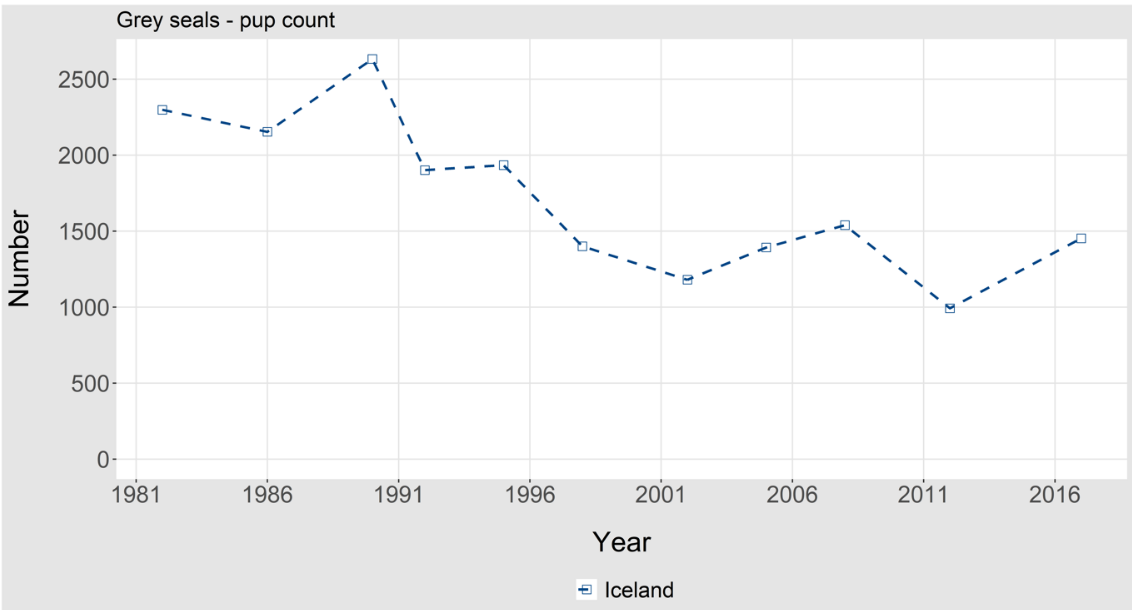

Figure 1.21. The trend of counted grey seal pups in Iceland.

Annual marine mammal bycatch in the lumpsucker fishery based on observations from 2014–2018 was estimated at 3223 (1225–5221) animals, comprising 1389 (903–1875) harbour seals, 989 (405–1573) grey seals, 240 (82–398) harp seals, 49 (1–98) ringed seals, and 28 (10–46) bearded seals. These estimates are per year and are stratified by management area (ICES, 2019b). There is some discussion within NAMMCO on the accuracy of the estimated bycatch of this specific fishery. There is concern that mortality due to the lumpsucker fishery is affecting the Icelandic harbour and grey seal populations, especially as other fisheries also occur in the area. In addition to this threat, growing tourism including seal watching could affect the seals in the area (Granquist and Sigurjonsdottir, 2014).

BALTIC SEA:

Ringed seal

Ringed seal (*Pusa hispida* ssp. *botnica*) breeding and moulting distribution is related to sea ice in winter and spring. Their breeding success is highly dependent on sufficient ice cover and overlying snow layer through the breeding and nursing season. After breeding, they haul out scattered on ice for their annual moult. Favourable ice-conditions usually occur to some extent every year in the Bothnian Bay, where the moult surveys have been carried out since 1988 using line-transect methodology. In years with largely normal ice-conditions the number of hauled out individuals during the surveys has increased from around 2000 in 1988 to 9919 in 2018 (Figure 1.22), corresponding to an annual average population increase of 4.7%. The increase rate has been slightly higher in the latter half of the period (2004–2018: 5.6% per year). Nevertheless, both increase rates are clearly below the intrinsic growth rate for this species. In the last decade, anomalous survey results were obtained, considered to be a result of early ice breakup (2013, 2014, 2015, 2017, 2019, 2020 and 2021). These data points were therefore excluded from the trend analysis. It is also questionable if the data points from 2016 and 2018 should be included. The result for 2016 fits the trend based on the earlier data-points, but the surveyed sample of the ice-covered area was only 6.5% then, while 13% is needed for moderate random variation (Härkönen and Lunneryd, 1992). The result for 2018 is at a somewhat higher level compared to the trend, but in the absence of comparable data points it is impossible to observe true changes in the population growth rate as well as to judge if these individual data points are comparable or not.

It is still unclear how early ice breakup affects the obtained results, and besides their deviation from results for 'normal' ice years, there is a large amount of variation in counts among 'anomalous' ice years. The situation was discussed in the WGMME 2018 report (ICES, 2018).

The ringed seal subpopulation in the Bothnian Bay is the largest in the Baltic. It is recovering from a population decline during the 20th century due to hunting and subsequent reproductive problems caused by contaminants. However, recently raised hunting quotas and deteriorating ice conditions increase the pressures on this subpopulation. It is concerning that the deteriorating ice conditions affecting breeding success are also compromising monitoring data, making impacts on abundance trends difficult to assess.

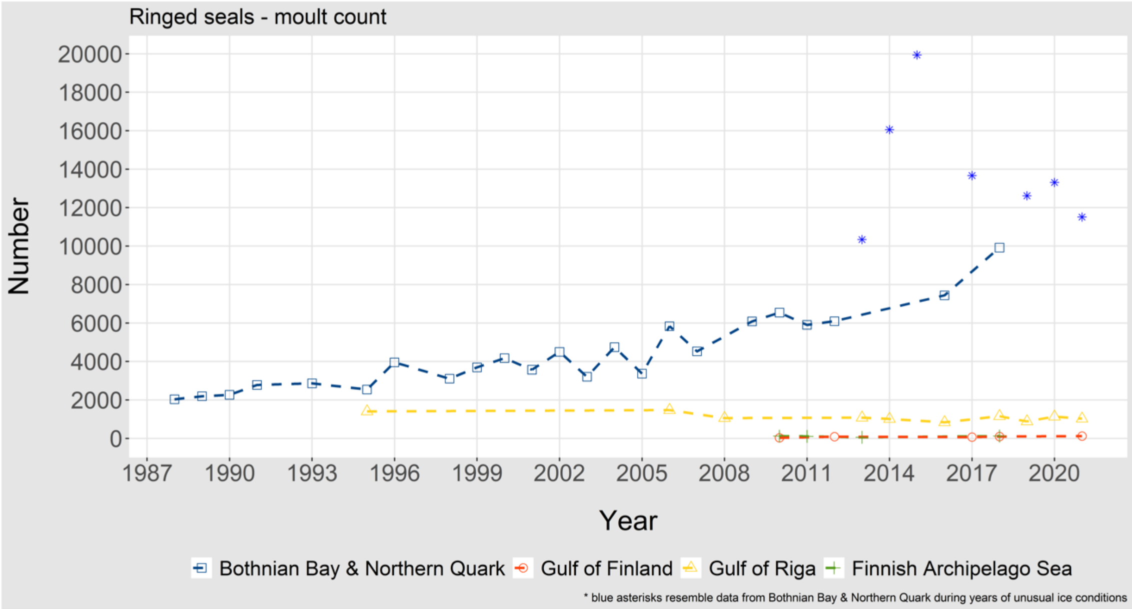

Figure 1.22. Trends of estimated numbers of ringed seals hauled out on sea ice and haul-outs during moult surveys in the Baltic. Counts in years during which the ice conditions resulted in unusual results are represented with *.

Southern ringed seal populations in the Baltic Sea: As a result of population declines during the 20th century, Baltic ringed seals were divided into four subpopulations. In addition to the largest subpopulation in the Bothnian Bay, three Baltic ringed seal subpopulations can be found: in the Gulf of Finland, the Gulf of Riga, and the Finnish Archipelago Sea. The three southern subpopulations are currently threatened with extinction, largely as a result of reduced breeding success caused by decreased extent and duration of sea ice with less snow compared to historical winter averages.

For the southern subpopulations, traditional surveys have been impossible in most recent years. The lack of monitoring data provides a severely fragmented view of population development. The few survey results indicate stable or decreasing trends. The status of the southern ringed seals as well as the roles of climate warming and other pressures were discussed in the WGMME 2018 report (ICES, 2018).

In 2021, two replicate aerial surveys in the Russian area of Gulf of Finland produced hauled out population estimates of 135 and 96 (averaging 116). This indicates that the population in the Gulf of Finland is very small, but has not decreased recently.

In other southern areas, no aerial surveys were carried out due to lack of ice. Instead, land haul-outs in the Väinämeri area in western Estonia were surveyed from land or boat (I. Jüssi, personal communication). The result of 1029 ringed seals in 2021 is in line with recent results from aerial surveys (2013: 1077 ±449, 2018: 1152) as well as counts in ice-free conditions (2008: 1055; 2014: 1010, 2016: 834; 2019: 884: 1134; Figure 21). Based on those series, it can be concluded that the subpopulation in the Gulf of Riga has been rather stable since the first aerial survey in 1996 when the survey, in good ice conditions, produced an estimate of 1407± 590 ringed seals on ice (Härkönen *et al.* 1998).

Boat and land-based surveys have also been developed in the Finnish Archipelago Sea, but mapping of the land haul outs has not yet covered the whole area.

Lack of ice has become most common in the southern areas of ringed seal distribution during the moulting time, and advanced ice break-up has resulted in population estimates in the Bothnian Bay that are not comparable to earlier results. Alternative monitoring techniques need to be developed for all the areas. Boat surveys in ice-free circumstances tend to produce similar abundance estimates to the aerial transect surveys over ice in the southern areas, but the method is difficult to apply in the Bothnian Bay, where the potential survey area is markedly larger. Instead a correction factor for ice-conditions is needed as a first step.

Harbour seal

Harbour seals in the Baltic (HELCOM) area (Denmark and Sweden) are surveyed annually using replicate annual aerial surveys during the moulting period in August (Figure 1.23). They are split into four management units: Limfjord, Kattegat and the Danish Belt Sea, Southwestern Baltic, and Baltic Proper (Kalmarsund).

LIMFJORD: The number of harbour seals counted in Limfjord has fluctuated around 1000 since the early 1990s and, thus, the numbers appear to be fluctuating around a carrying capacity. Genetic analyses indicate that the seals in the fjord originate from two different populations: (1) the population originally inhabiting the fjord, primarily found in the Central Limfjord, before a storm opened the passage to the North Sea in 1825; and (2) seals from the Wadden Sea (Olsen *et al.*, 2014). It is not known to what extent the seals from the Wadden Sea use the fjord for other purposes than hauling out, and to what extent they interbreed with the native seal population. A proper assessment of the Limfjord harbour seals is contingent on clarification of these issues. In 2021, 1043 seals were counted in the fjord, 641 of these in the central part (Aarhus University).

KATTEGAT and the DANISH BELT SEA: The harbour seal population in Kattegat and the northern Danish Belt Sea experienced two dramatic mass mortality events due to PDV when more than 50% and about 30% of the population died in 1988 and 2002, respectively (Härkönen *et al.*, 2006). Unusually large numbers also died in 2007, but the reason for this mortality remains unclear (Härkönen *et al*., 2007). In spring and summer of 2014, some seals appearing to show signs of pneumonia were found in Sweden and Denmark. Avian influenza H10N7 was isolated from a number of these seals (Zohari *et al*., 2014; Krog *et al*., 2015; Bodewes *et al*., 2016). The rate of increase between the two PDV epidemics was close to 12% per year, as in the adjacent North Sea populations. The annual population growth rate in Kattegat and the Danish Belt Sea remained close to 12% per year until 2010, but data suggest that it is levelling off, even if the increased mortality in 2014 due to the influenza epidemic is taken into account (Zohari *et al*., 2014; Krog *et al*., 2015; Bodewes *et al*., 2016). This is likely to be caused by density dependence, indicating that the population is approaching carrying capacity.

In response to the OSPAR data-call 2021, the border between Kattegat and Skagerrak reporting units was updated to follow the HELCOM sub-basin borders. In practice, this meant moving the border northwards along the Swedish coast. For consistency, the same geographical areas were applied also to this ICES WGMME reporting, with Skagerrak reported under Atlantic Scandinavia. The variable for the reporting was also changed from "trimmed mean" (mean of two highest daily counts) to mean of all complete counts. The results were recalculated for all the years presented (1978-present), leading to differences (less smoothed results) from earlier reports. The mean number of seals counted in the two-three replicate surveys was 10 825 in 2019 (Aarhus University, Swedish Museum of Natural History), but only 7529 in 2020, possibly due to hot weather and high level of disturbance from recreational boats. However, in 2021, the result of 8419 was still relatively low.

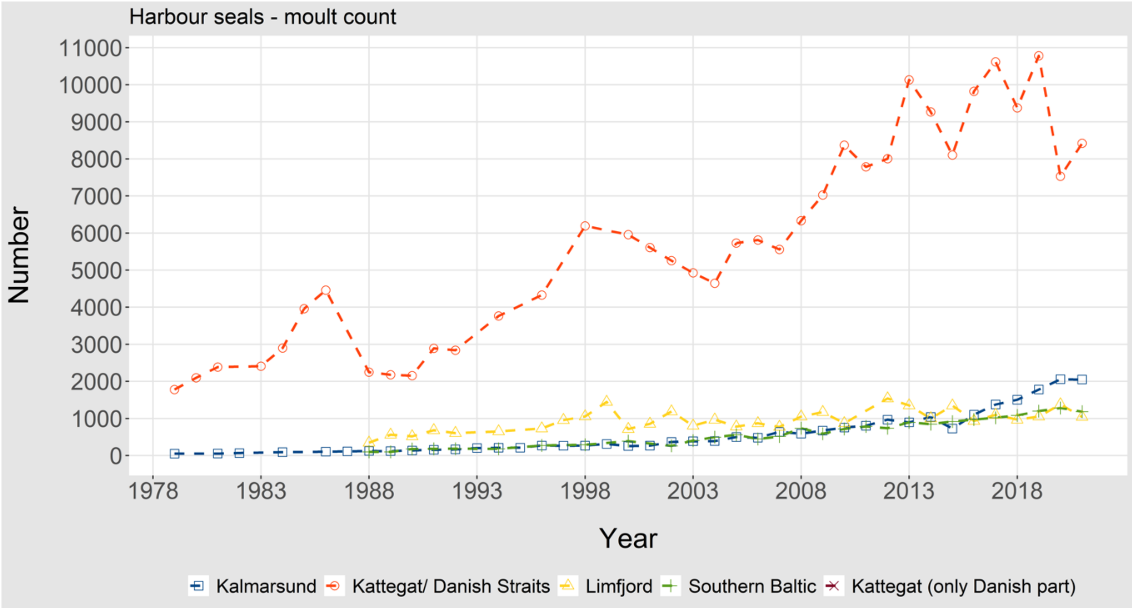

Figure 1.23. Trends of moult counts of harbour seals in the Kattegat and the Danish Belt Sea (Danish Straits), Southwestern Baltic, Limfjord and Kalmarsund.

SOUTHWESTERN BALTIC: This population appears to have been growing exponentially since it was first surveyed in 1990 (Galatius *et al.*, 2021b). A mean of 1181 seals were counted in the area in 2021 (Aarhus University).

BALTIC PROPER/KALMARSUND: The harbour seal population in Kalmarsund is genetically divergent from adjacent harbour seal populations (Goodman *et al.*, 1998) and experienced a severe bottleneck in the 1970s when only some 30 seals were counted. Long-term isolation and small numbers have resulted in low genetic variation in this population (Härkönen *et al.*, 2006). The population has increased annually by ca. 9% since 1975, and 2 049 harbour seals were counted in 2021 (Swedish Museum of Natural History). In contrast to other harbour seal reporting units, the maximum result of replicate surveys is used for the Kalmarsund population.

Grey seal

Monitoring of the grey seal population in the Baltic Sea (*Halichoerus grypus* ssp. *grypus*) is coordinated internationally during the moulting season, with coverage of the entire Baltic moulting distribution of the species. The maximum number (not corrected for individuals in the water) counted during 2–3 replicate surveys in each sea area is used for assessing abundance and trends. The grey seal population in the Baltic has been growing throughout the span of the coordinated surveys (starting in 2003; Figure 1.24), although levelling off was suspected in the middle of 2010s when the result for the whole Baltic was just over 30 000 for four years. Then around 38 000 seals were counted in 2019, 40 000 in 2020, and 42 000 in 2021, indicating that the population is still growing (HELCOM EG MAMA).

The growth has been most pronounced in the southern and western parts of the moulting distribution until very recently, when a regional exchange from central Sweden to southwestern Finland occurred, possibly due to increased hunting pressure in the Swedish area.

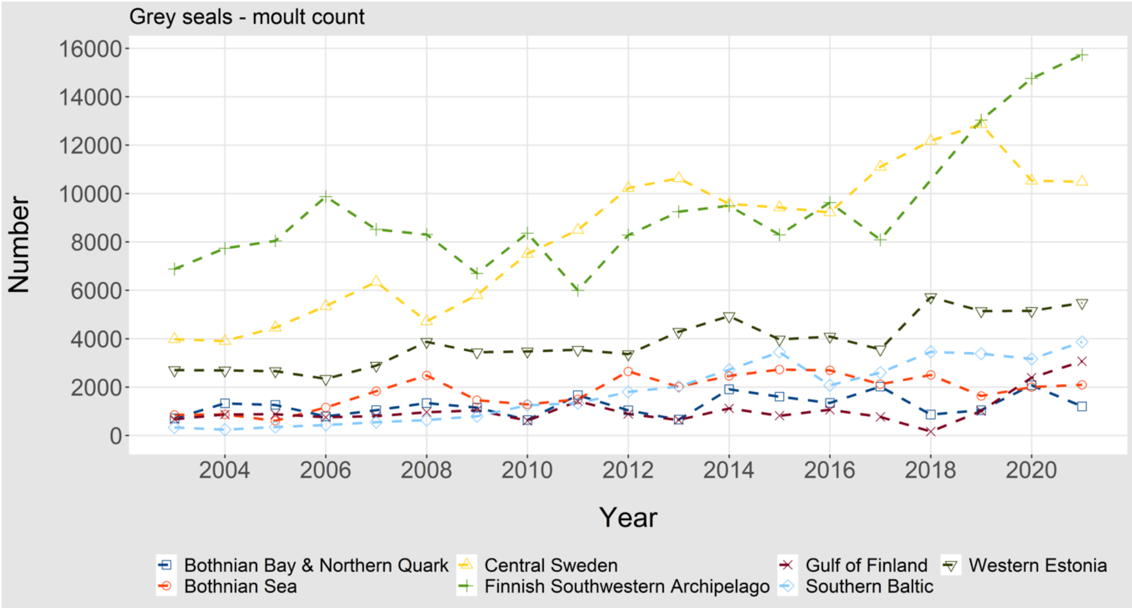

Figure 1.24. Trends for results of moult counts of grey seals in subareas of the Baltic Sea.

Of the hauled-out population, around 80% were found in the core moulting area in the central Baltic Proper (archipelagos of central Sweden, southwestern Finland, and western Estonia). Outside the breeding and moulting seasons, grey seals travel and forage in other areas too. As the size of the population has increased, its range has expanded to also include the southern Baltic, where grey seals have been breeding regularly, although in small numbers, since 2003 (Galatius *et al*., 2020). In most recent years, pups have also been observed in the Kattegat area. (Galatius *et al.*, 2020). This expansion has brought Baltic grey seals in contact with the Atlantic subspecies, and there are strong indications of hybridisation between the two groups based on microsatellite data from the southern Baltic (Fietz *et al*., 2016).

Grey seals use islands for breeding in the Central Baltic in years when the ice cover is limited due to mild winters. The numbers of pups born on land is negatively correlated with maximum ice cover in the Baltic Sea, as ice is the preferred breeding platform (Jüssi *et. al*., 2008). Pup surveys on the Estonian west coast have only been systematic since 1990, and among years without coastal ice during the breeding season in February-March, there is an increasing trend (Figure 1.25).

In 2021, a complete survey of grey seal pups born on land along the ice-free coastal areas of Sweden was carried out. It revealed an important land breeding area in the Stockholm archipelago, which supports the earlier impression based on knowledge from Estonia and Finland that the core land breeding area for the Baltic grey seals is in the northern parts of the main Baltic Proper. Minor land breeding areas were found along the whole Swedish area of the Baltic Proper, but no land breeding areas were found in the Bothnian Sea. However, a few observations of grey seal pups on Bothnian Bay ice were made from ice-breakers.

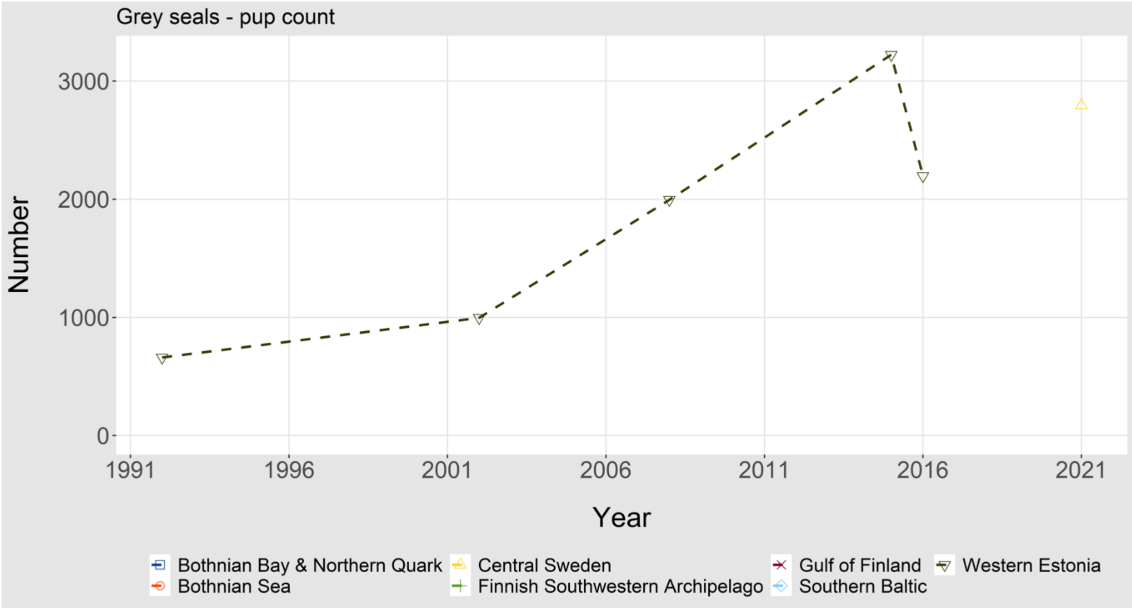

Figure 1.25. Trends of counts of grey seal pups in West Estonia in years without ice in the breeding areas and of Central Sweden.

ATLANTIC SCANDINAVIA

Harbour seal

In parallel with the Kattegat population, the Skagerrak harbour seal population collapsed by roughly 50% during the PDV epidemics in 1988 and 2002. Before the two collapses, the population increased at high rates, indicating no factors restricting growth. After the latter collapse, the rate of increase has been lower, which may indicate that the population is approaching carrying capacity. The number of harbour seals along the eastern coast of Skagerrak (starting from the eastern half of the Oslo Fjord in the north) counted during the moult was 5276 in 2019, 3865 in 2020 and 2877 in 2021 (Figure 1.26). The low result in 2020 was thought to have resulted from a combination of hot weather and high level of disturbance from recreational boats, but the result in 2021 was even lower. Along the northern coast of Skagerrak (west of the Oslo Fjord), the harbour seal numbers (animals counted during moult) have decreased from 680 in 2008–2015 to 543 in 2016–2018.

Along the Norwegian west coast, south of 62°N, the harbour seal count increased from 860 in 2011–2015 to 1054 in 2018 (Nilssen and Bjørge, 2019). Counts in the northern Norwegian areas (north of 62°N) conducted between 2019 and 2021 yielded a count of 4922 harbour seals (Nilssen *et al*., 2021).

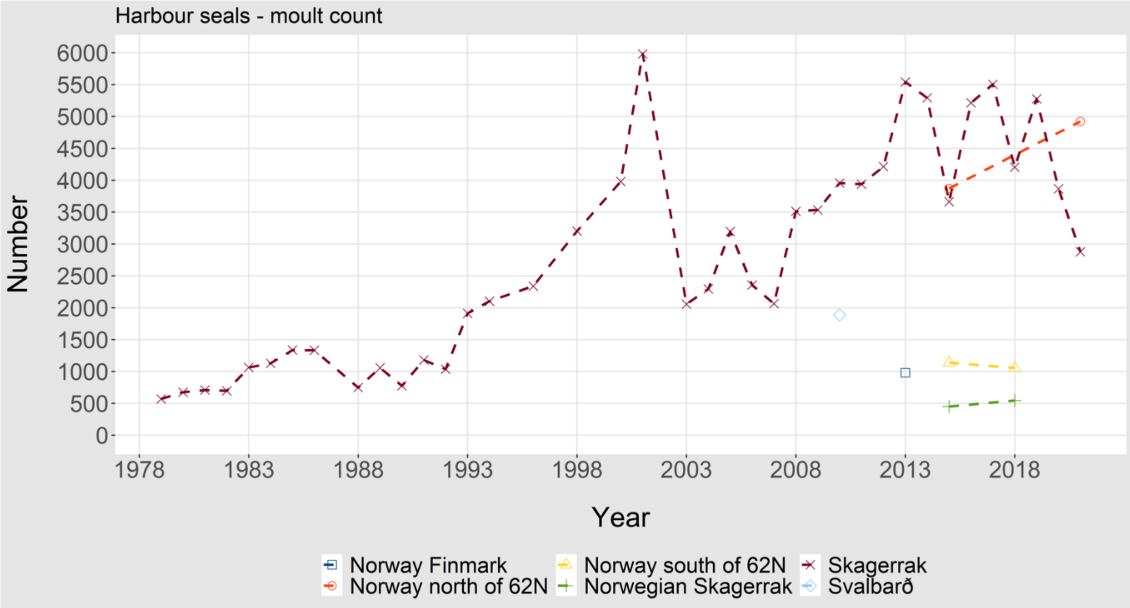

Figure 1.26. Trends of moult counts of harbour seals in the Skagerrak and Norwegian coast.

Grey seal

From the early 1960s to 2010, the numbers of grey seals have increased in Norway. Based on pup production estimates from 2006 to 2008, a total population (including pups) of 8740 (95% CI: 7320–10 170) animals in 2011 was estimated by modelling (Øigård *et al.*, 2012). However, a significant reduction in pup production has been observed between 62°N and 68°N in Trøndelag and Nordland counties (mid-Norway) in 2014–2015 (Nilssen and Bjørge, 2017). In other areas along the coast, pup production has been stable (Figure 1.27). A new survey was carried out in mid-Norway in 2018, which confirmed that pup production was low

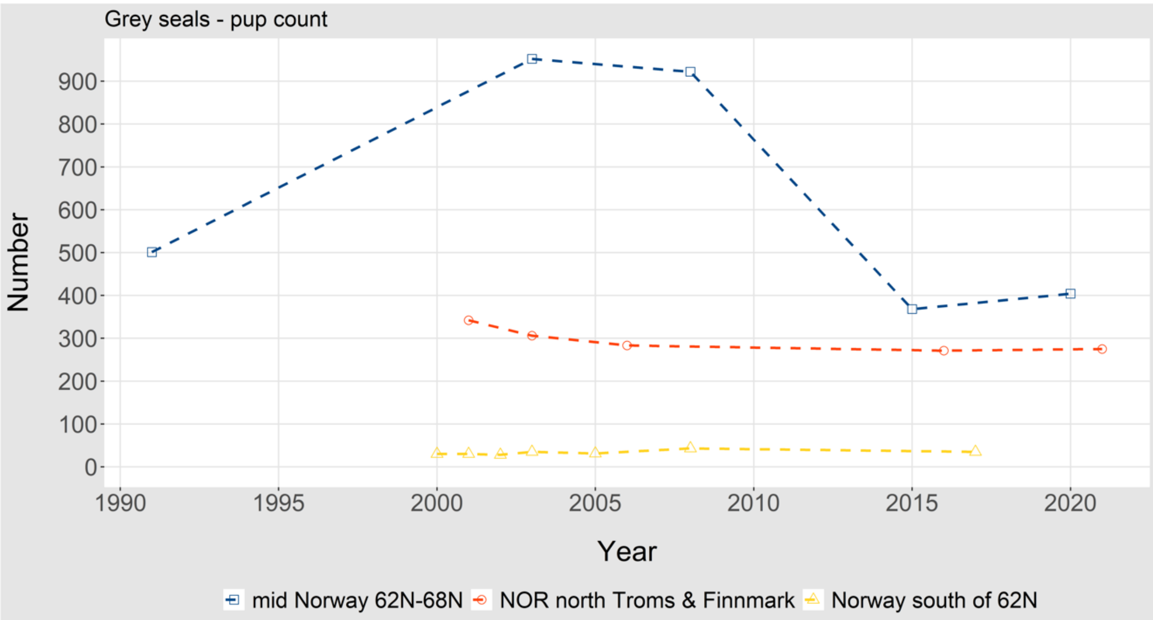

Figure 1.27. Trends of counts of grey seal pups in Norway.

The significant reduction in pup production in mid-Norway suggests a dramatic decline in the Norwegian grey seal abundance to a total population of 3850 (95% CI: 3504–4196) individuals, when scaling pup production using a multiplier of 5.7 (Nilssen and Bjørge, 2019). The most probable reason behind the reduced pup production is high bycatches of grey seals in gillnet fisheries for mainly monkfish, but also in cod gillnets.

CONTINENTAL COAST, WADDEN SEA TO FRANCE

Harbour seal

WADDEN SEA (Denmark, Germany, the Netherlands): Harbour seal surveys in the Wadden Sea are coordinated among Danish, German and Dutch scientists. Brasseur *et al.* (2018) examined a 40-year time-series (1974–2014) of harbour seal moult counts in the Wadden Sea to study underlying processes of recovery, and demonstrated the influence of historical regional differences in management regimes on the recovery of this population. Mortality rates were close to 50% during both PDV epidemics in 1988 and 2002, and between and after the epidemics, population growth rate has been closed to the maximum intrinsic exponential growth rate of harbour seals at 12–13%.

Since 2012, the trend levelled off with a median annual growth rate of 1.6%. In contrast, pup counts continue to increase (Figure 1.28). In 2021, 26 838 harbour seals were counted during moult surveys (Galatius *et al.*, 2021a). Pup counts in 2021 increased to 10 903 pups counted, representing nearly 41% of the moult counts. The cause of this apparent mismatch between the good pup production and the stagnating population growth is unclear. Either mortality in this population is equivalent to the pup production, as there is no growth despite increasing pup production, or a substantial change in haul-out behaviour has occurred which could have affected the survey results. Either way, there is a clear indication of a recent change in the population.

Results from Brasseur *et al.* (2018) indicate interesting exchanges between the different regions of the Wadden Sea with disproportionally high pup production relative to moult counts in the German states, while after the breeding period, seals redistribute throughout the area. As the entire Wadden Sea area is monitored synchronously, lack of growth is unlikely to be an artefact of redistribution of the animals. Future efforts should concentrate on understanding the mechanisms underlying these changes in population trends.

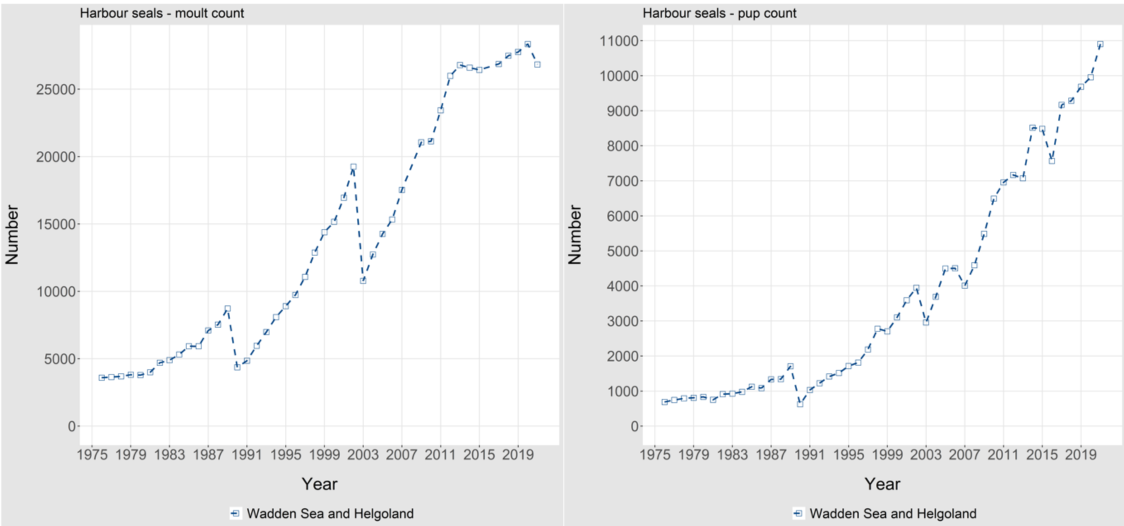

Figure 1.28. Trends of counts of moulting harbour seals (left) and harbour seal pups (right) in the Wadden Sea.

SOUTHERN NETHERLANDS, BELGIUM and FRANCE: The growing harbour seal colony in the Dutch Delta area in the southern Netherlands is thought to be connected to the Wadden Sea population as there are insufficient local births (199 pups in 2019) to explain its growth (Figure 1.29). Telemetry data show regular exchange between this area and the Wadden Sea. Moreover, although there is a lack of systematic stranding data, an average of 80 dead harbour seals are reported annually in the area (Brasseur, 2018). Over 1274 animals were counted in the Dutch Delta area in 2019 (Hoekstein *et al.*, 2021), and numbers have been growing at almost 15% annually since 2002. Exchanges may also occur with French and southern English colonies.

In 2021, seal counts amounted to a maximum of 1319 harbour seals in the colonies on the French coast from Normandy to the Belgian border (data compiled by S. Poncet, in press). Until 2015, the average rate of increase of harbour seals in the Northeast Channel (southern North Sea) was 15% per year (Vincent *et al.*, 2017). From 2017 to 2020, the maximum number of harbour seals counted during the moult in the main colonies of the area seemed to level off (around 600 seals); in 2021 however, the abundance of harbour seals in the main colony (Baie de Somme) increased again (to a maximum of 755 in July 2021).

In Belgium, there are no true seal colonies, however tens of animals strand annually along the coasts (99 in 2021, dead and dying, and excluding seals that were taken to a rehabilitation facility). The number of harbour seals observed hauling out in Belgium, especially in the port of Nieuwpoort, is rising and seals are seen daily. In 2021, around 18 harbour seals are regularly observed hauled out. As in previous years, multiple animals were injured by fishing gear including hooks and rope (RBINS unpubl.; Haelters *et al.*, 2021).

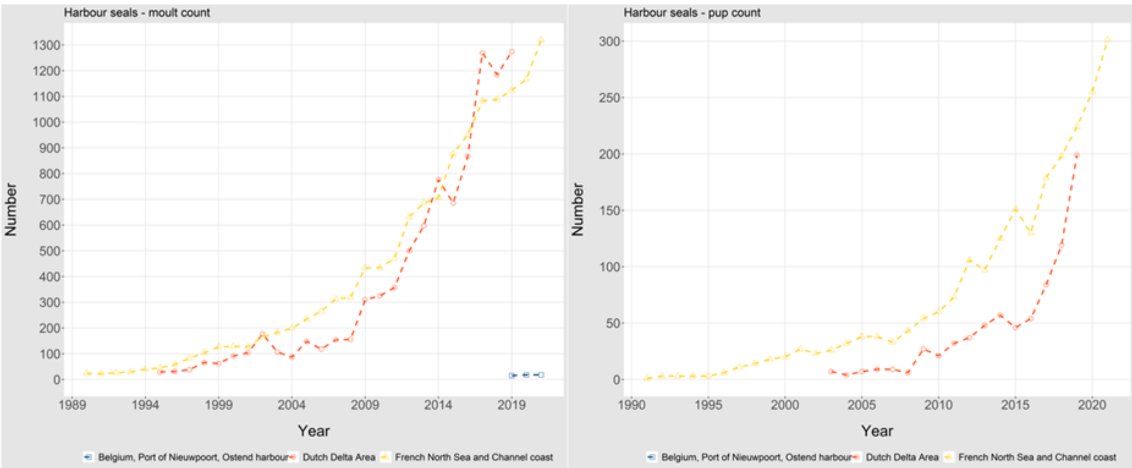

Figure 1.29. Trends of counts of moulting harbour seals and harbour seal pups in the Dutch Delta, and French and Belgium Coasts.

Grey seal

After centuries of almost complete absence, grey seals have shown a remarkable recovery throughout the southernmost North Sea including the Wadden Sea area, where more than 9000 were counted during the moult in 2021 (Brasseur *et al.*, 2021). In the same area, 1927 pups were counted in the winter of 2020/2021 (Brasseur *et al.*, 2021; Figure 1.30). Colonies started in Germany and the Netherlands in the 1980s and have since expanded to Denmark. The growth rate of the breeding population is higher than might be expected based on local recruitment, and is thus thought to be partially fuelled by immigration from the UK (Brasseur *et al.*, 2015). During the moult, the majority of the grey seals counted in the Wadden Sea are counted in the Netherlands (~75%), while recently, counts in the German Wadden Sea (especially Helgoland and the Kachelotplate) have grown in importance (>20%), as have the numbers in Denmark (~3.5%).

During the breeding season, a relatively large proportion (almost 47%) of pups are now born in Germany.

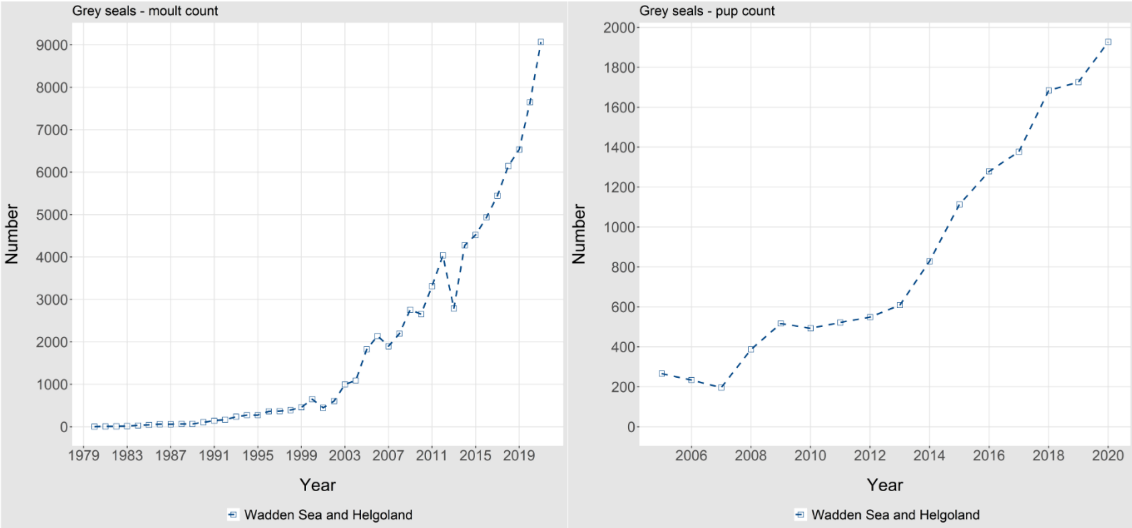

Figure 1.30. Trends of moulting grey seals and grey seal pups in the Wadden Sea.

The difference in relative distribution might be indicative of the importance of the exchange with the UK population. Possibly seals from the UK use the Dutch area more than other parts of the Wadden Sea.

DUTCH DELTA AREA: As is the case for harbour seals, grey seal numbers have been growing in the Dutch Delta area, despite there being no pups produced, and an apparent high mortality rate (~40 deaths reported per year). Since 2018 however, some births have been recorded in the area though numbers are still low and do not match the large number of animals seen during the moult. In December 2019 23 pups were counted. The continuous growth in grey seal numbers suggests a constant exchange between this area, the Wadden Sea and the UK, where numbers are growing, or southwards towards Belgium and France. In 2020, a maximum moult count of 1550 grey seals in the Delta area was reported and 23 pups have been recorded (Hoekstein *et al.*, 2021). The continuous growth in grey seal numbers suggests a constant exchange between this area, the Wadden Sea and the UK, where numbers are growing, or southwards towards Belgium and France.

BELGIUM and FRANCE: Occasionally a few grey seals (two) are seen to haul out on the Belgian coasts (Haelters *et al.* 2021). The maximum moult count along the French coasts was 2602 in 2021, and on the breeding sites, 91 pups were observed (Figure 1.31; data compiled by S. Poncet, in press). The maximum number of grey seals counted in France increased sharply since 2020 (2 602 vs. 1350): while seal counts increase in a number of colonies along the French coast, this is mainly due to the observation in 2021 of a larger number of seals at Walde (Northern France), most probably linked to the proximity to the large haulout site of Goodwin Sands (England). Numerous exchanges with the UK and the Wadden Sea have been recorded using telemetry. Wind farm projects are planned in the Channel along the French coasts, and more tracking and monitoring of the seal colonies will be carried out in both the eastern Channel and Normandy in the coming years.

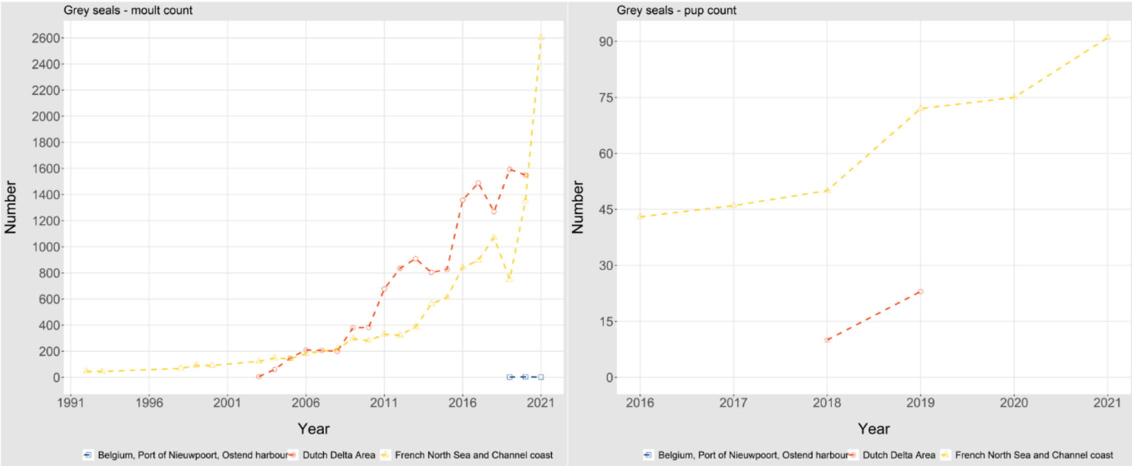

Figure 1.31. Trends of moult counts of grey seals (left) and grey seal pups (right) in the Dutch Delta Area, and France and Belgium Coasts.

UK and REPUBLIC OF IRELAND

Harbour seal

Scotland, Northern Ireland and Southeast (SE) England account for the majority of UK harbour seals, with only small populations elsewhere (South England, Northeast England). A recent study (Carroll et al. 2020) combining genetics, movement and population trend data indicated that the UK population belongs to two distinct metapopulations: northern (Scotland, Northern Ireland) and southern (SE England) with the latter being part of the continental Europe group. These metapopulations encompass differing population trends.

Harbour seal populations in the UK are primarily monitored via August moult counts largely at the scale of Seal Management Units (SMUs). Annual surveys are conducted covering different areas, with the aim of covering the Scottish and English SMUs within a five-year period. More frequent surveys are conducted in areas of continuing decline (e.g. Orkney), and the populations in SE England, and in the Moray Firth and Firth of Tay in East Scotland are surveyed annually. No large-scale surveys of harbour seals in Scotland were undertaken in 2020 due to COVID restrictions. In England, a survey of the East Anglian coast was undertaken in 2020 and a series of three surveys across the Southeast England SMU were carried out in 2021.

The UK harbour seal population has remained reasonably stable over the last 25 years; the latest UK count total from surveys conducted between 2016 and 2019 (with the addition of 2021 data for the Southeast of England) was 31 497 (SCOS, 2021), giving rise to an estimated population of 43 750 (approximate 95% CI: 36 000-58 700).

NORTHERN UK.: Counts in the northern metapopulation show varying trends from continuing decline (Orkney & North Coast, East Scotland SMUs), depleted but stable (Shetland, Moray Firth), stable (Western Isles, Southwest Scotland) with indications of an increase (West Scotland) (Figure 1.32). The latest counts (2019) covered Orkney, Shetland and the north section of the Moray Firth SMU, completing the round-Scotland survey round, which started in 2016 producing an overall count of 26 846. This is just over 5% higher than the previous Scotland census in 2011-2015, but almost 10% lower than the highest Scotland total counted in 1996-1997.

NORTHERN IRELAND: The latest count of 1012 (2018) in Northern Ireland indicates little change in population since the previous count in 2011 (948). Research is ongoing into the proximate and ultimate cause of the declines in Scotland. The rate of decline suggest that they are, in part, due to increased adult mortality. Ultimate causes under investigation are bio-toxins, grey seal competition and predation.

SOUTH-EAST ENGLAND: The UK component of the southern metapopulation, almost entirely in SE England SMU, had been showing sustained increases, punctuated by PDV epidemics in 1988 and 2002. However, the latest SE England count of 3505 (2021) continues the previously described trend whereby the 2019 count (3752) was approximately 25% lower than the counts of the last three years and similar to the post epidemic minimum counts in 2004-2006. This is driven by a particularly low count for The Wash, a Special Area of Conservation (SAC), which until 2019 accounted for around 75% of the Southeast population. Given the substantial variation in the proportion of the population hauled out, further data are urgently required to confirm the decline and quantify the rate. The reasons behind such levelling off and potential decline are unclear, but the relative abundance of grey seals may be a factor; the ratio of harbour: grey seals in SE England SMU has changed from 10:1 in 1988 to 1:10 in 2019. Pup counts have been conducted within this SAC between 2001 and 2019. Although the pup production trend had been increasing, there is evidence this may have levelled off in recent years (Thompson, 2019).

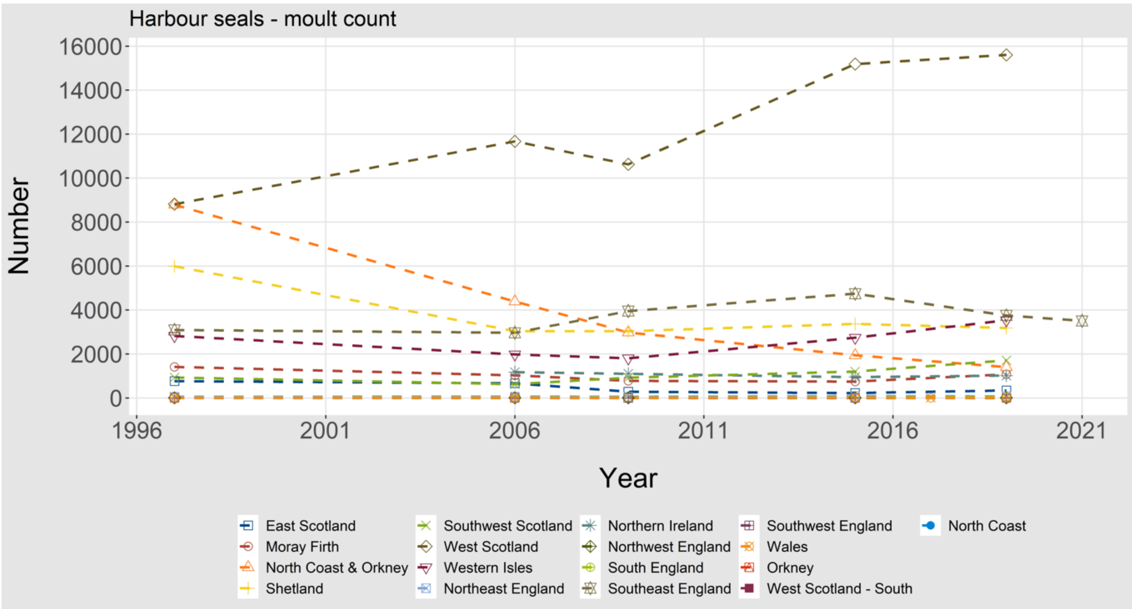

Figure 1.32. Trends of moulting harbour seals in the subareas of the UK.

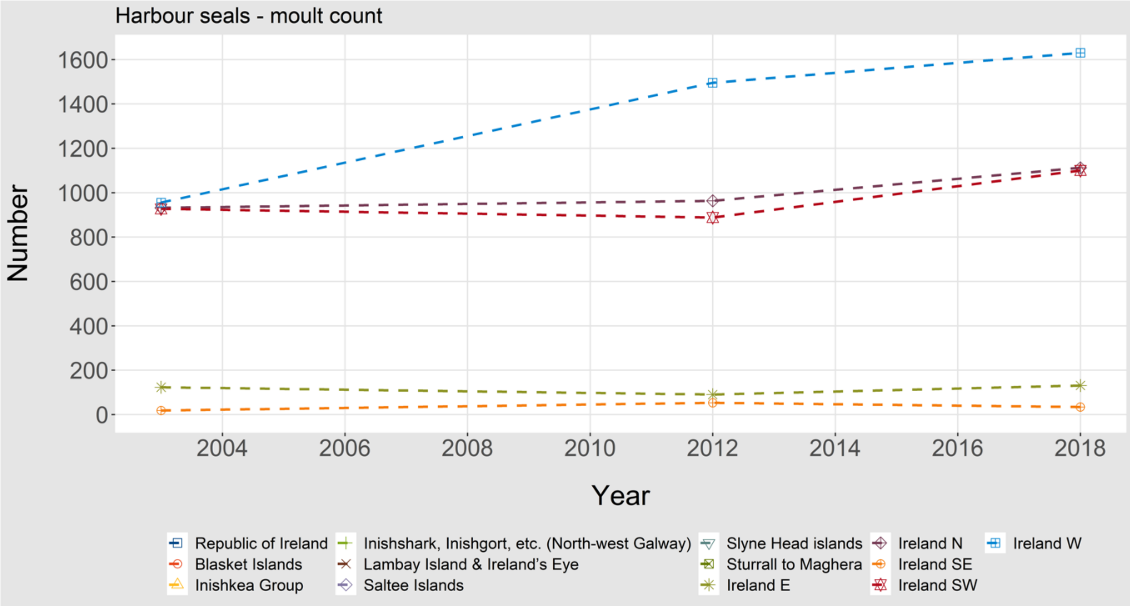

Figure 1.33. Trends of moulting harbour seals in the subareas of the Republic of Ireland.

REPUBLIC OF IRELAND: In the Republic of Ireland, 4007 harbour seals were counted in August 2017 and 2018, using aerial thermal imaging (Figure 1.33). This number represents an increase relative to the two previous surveys of 2003 (3489 seals) and 2011-2012 (2955 seals). As in previous surveys, most seals were counted in the West region.

Grey seal

The UK grey seal population appears to comprise one metapopulation that extends into the rest of Europe. Indeed, there are considerable movements between UK Seal Management Units, Ireland, and the continent (Brasseur *et al*., 2015; Russell and Carter, 2021). Population size is estimated using a Bayesian state-space population dynamics model (Thomas, 2020) in which prior information on vital rates (Russell *et al*., 2020) is combined with two sources of data: (1) a region-specific time series of pup production, and (2) 'independent' estimates of grey seal population (2008, 2014 and 2017; independent from pup production) which are derived by combining August counts and an estimate of the proportion of the population available to count (from telemetry data). The population model incorporates ca. 90% of UK pup production and thus the output provides trends, but not absolute estimates, of regional pup production and abundance. Scaling up the output of the population model provides a UK population estimate (individuals of age 1+) in 2020 of 157 500 (approximate 95% CI 146 000-169 400; SCOS, 2021). This estimate includes the recent pup production estimates from aerial surveyed colonies across Scotland and the east coast of England as well as aerial and ground surveyed colonies in the North Sea. Grey seal moult count trends for subareas in the UK are shown in Figure 1.34.

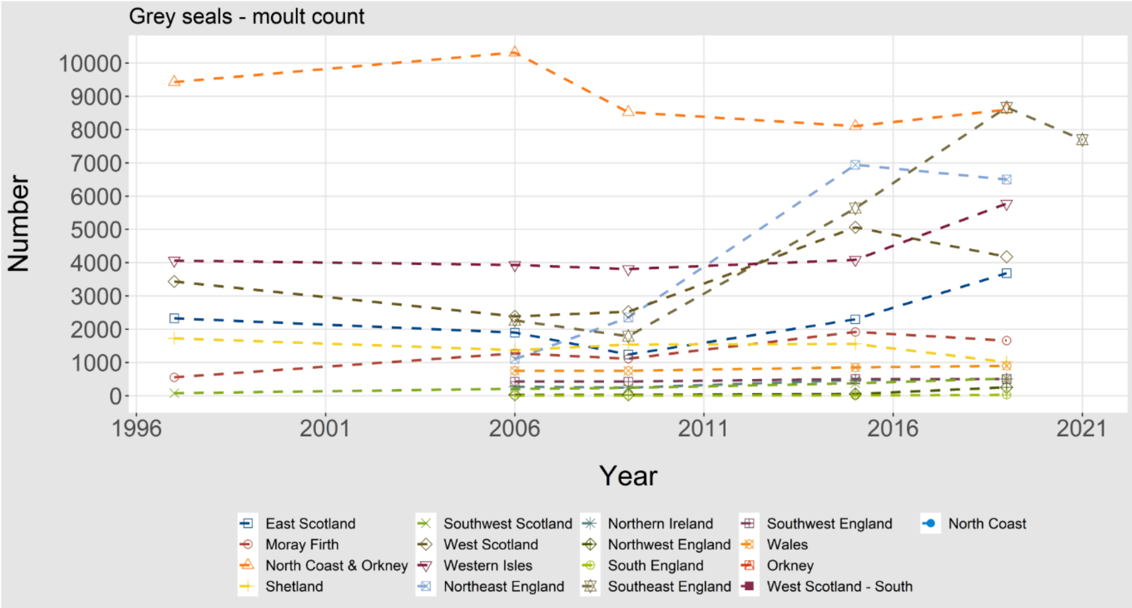

Figure 1.34. Trends of moulting grey seals in the subareas of the UK.

The delayed 2018 Scottish aerial pup survey was successfully carried out in 2019. This data alongside aerial and ground count data from Northeast and Southeast England has been incorporated into the latest pup production model. Notwithstanding changes in aerial survey methods which are associated with a jump in pup production between 2010 and 2012, pup production appears to have levelled off in three (Inner Hebrides c. 2000, Outer Hebrides mid-1990s, Orkney early 2000s) of the pup monitoring regions with only the North Sea showing continued increase (Russell *et al*., 2019). Grey seal pup count trends for subareas in the UK are shown in Figure 1.35, and for Republic of Ireland in Figure 1.36.

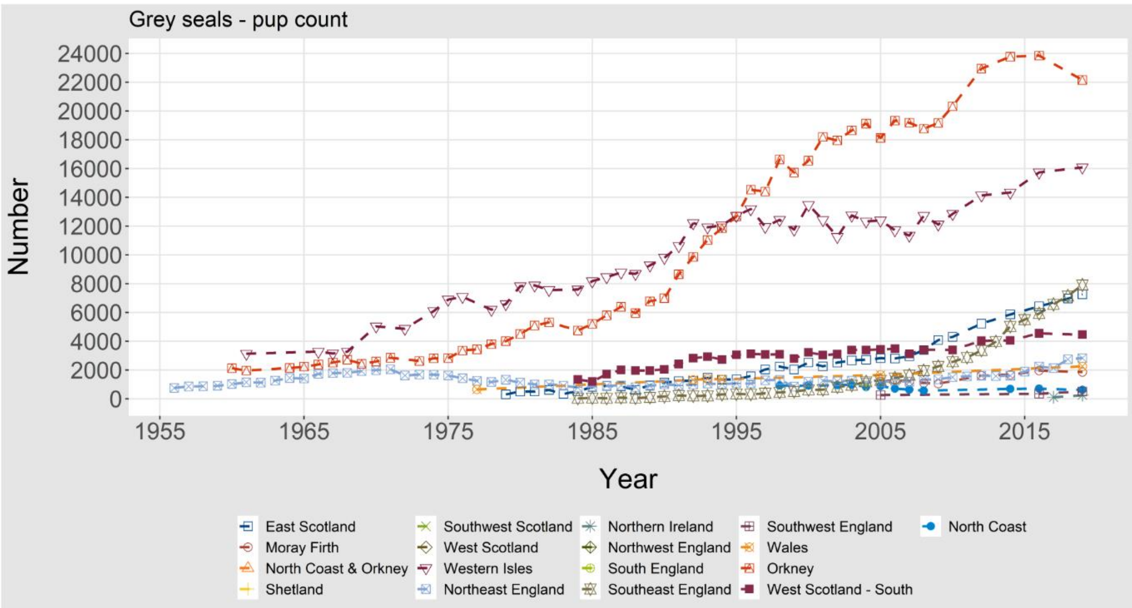

Figure 1.35. Trends of estimated pup production of grey seals in subareas of the UK.

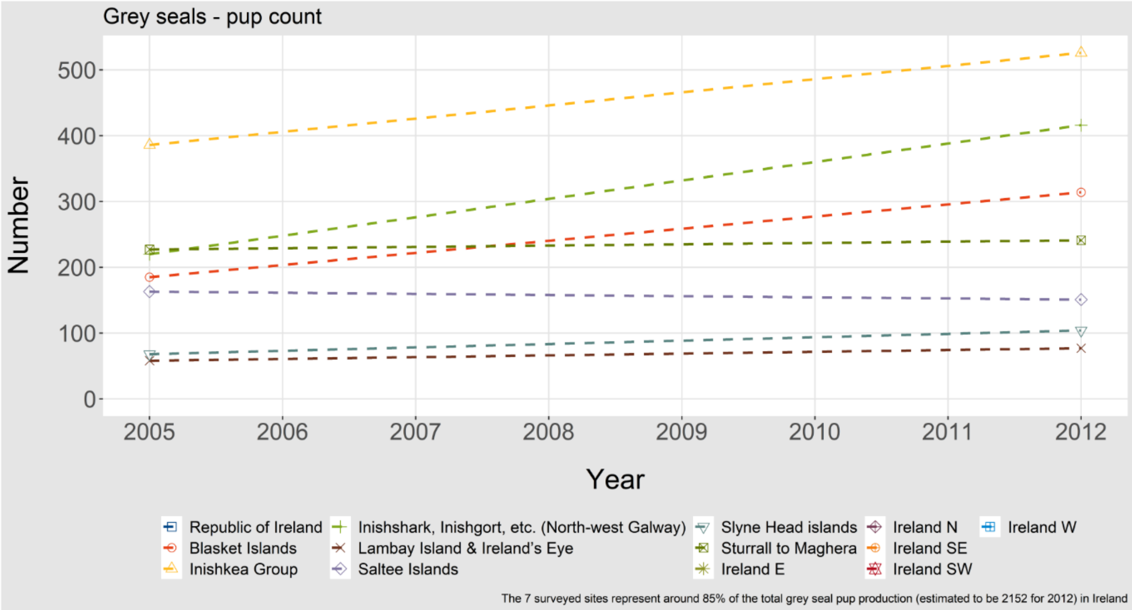

Figure 1.36. Trends of pup counts of grey seals in the subareas of the Republic of Ireland.

REPUBLIC OF IRELAND: Based on a total count of 2 081 new-born grey seal pups during the period 2009 – 2012 (Figure 1.36), the abundance of grey seals in Ireland was estimated at 7 284 - 9 365 seals of all ages. Compared with previous observations, this suggests a sustained growth in abundance since the mid-1990s, possibly since the early 1980s (Ó Cadhla *et al.*, 2013). It is probable that this growth has continued since then, as 3 698 grey seals were counted during the August harbour seal surveys in 2017-2018, compared to a count of 2 964 in the corresponding 2011-2012 surveys (Morris and Duck, 2019).

NORTH AMERICA

Harbour seal

UNITED STATES: Based on pup surveys, Sigourney *et al.* (2021) applied a Bayesian hierarchical model to estimate harbour seal abundance trends in the Gulf of Maine over the years 1993–2018 (Figure 1.37). Before 2001, non-pup annual growth rate was estimated at 2.1 % with a probability of positive growth of 97%. Between 2001 and 2012, estimated annual growth of non-pups decreased to –1.9% with a posterior probability of negative growth of 95%. Between 2012 and 2018, posterior estimates of growth rate were close to 0, suggesting little change in abundance of non-pups.

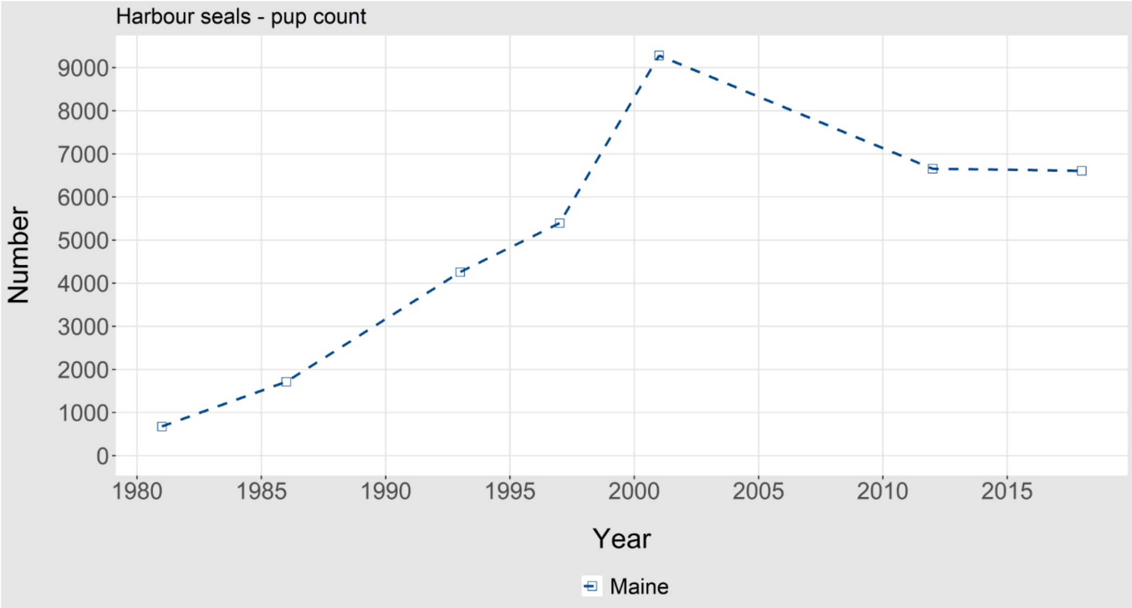

Figure 1.37. Trends of pup counts of harbour seals in the Gulf of Maine.

Estimates of growth for pups were at 9.4% annually between 1993 and 2001 with posterior probability of positive growth of >99%. These estimates were close to zero between 2001 and 2012 and reached a low of -2.5% per year with a posterior probability of negative growth of 0.94 at the end of the time-series suggesting a decrease in pup abundance between 2012 and 2018 (Figure 1.38). The total number of harbour seals in Maine in 2018 was estimated to be 61 336 (CV = 0.08).

SAINT-PIERRE AND MIQUELON (French territory south of Newfoundland, Canada): In Saint-Pierre and Miquelon, 1069 harbour seals were counted along the shore in early September, 2021. Satellite telemetry conducted in 2020 and 2021 showed that harbour seals captured in Saint-Pierre et Miquelon and tracked from October to February/March spent most of their time around the archipelago, but several of them moved along the coast of Newfoundland (Canada), or further south at sea for foraging (Figure 1.39; C. Vincent, in prep.).

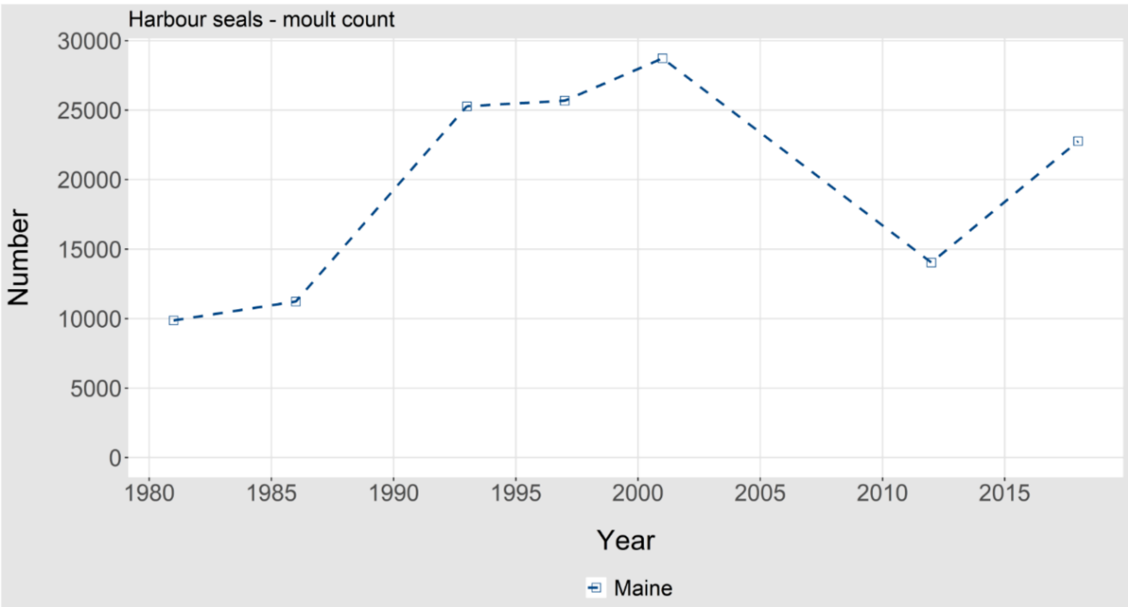

Figure 1.38: Trends of moulting harbour seals in Maine.

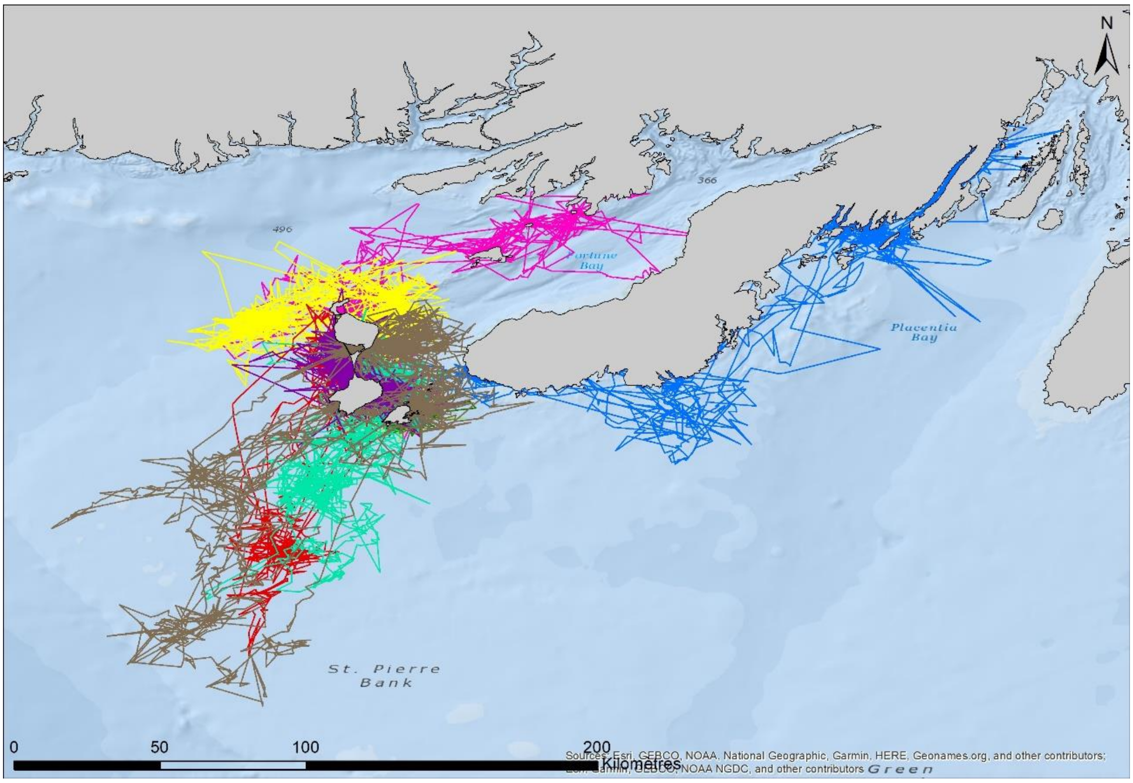

Figure 1.39: Satellite tracking of 10 harbour seals from Saint-Pierre et Miquelon in 2019 and 2020 (from October to February/March). Each colour represents one individual. Vincent *et al*. (in prep).

Grey seal

CANADA: Grey seal population trends are assessed from counts of pups during the breeding season. In 2016, the pup production on Sable Island accounted for 85% of the estimated total number of pups born in Canadian waters, with 11% in the Gulf of St Lawrence and 4% along the coast of Nova Scotia. The total estimated Canadian grey seal population in 2016 was 424 300 (95% CI=263 600–578 300), with a Sable Island and coastal Nova Scotia herd of 380 300 (95% CI=234 000–517 200), and 44 100 (95% CI=29 600–61 100) for Gulf of St Lawrence stock. This estimate was 4% lower than in 2014 (Hammill *et al*., 2014; 2017)

UNITED STATES: A smaller, but growing number of grey seal pups are born along the US east coast in Maine and Massachusetts. The number of pups born at US breeding colonies can be used to approximate the total size (pups and adults) of the grey seal population in US waters, based on the ratio of total population size to pups in Canadian waters (4.3:1). Using this approach, the abundance estimate in US waters is 27 131 (95% CI: 22 162 – 33 215) animals in 2017 (Hayes *et al*., 2018). There is uncertainty regarding this abundance level in the US because life-history parameters that influence the ratio of pups to total abundance in this portion of the population are unknown. It also does not reflect seasonal changes in stock abundance in the northeast region for a transboundary stock. For example, roughly 24 000 seals were observed in south-eastern Massachusetts alone in 2015 (Pace *et al*., 2019), and 28 000 – 40 000 grey seals were estimated in south-eastern Massachusetts in 2015, using correction factors applied to seal counts visible in Google Earth imagery (Moxley *et al*., 2017). Observed counts of grey seal pups from the North American east coast are shown in Figure 39.

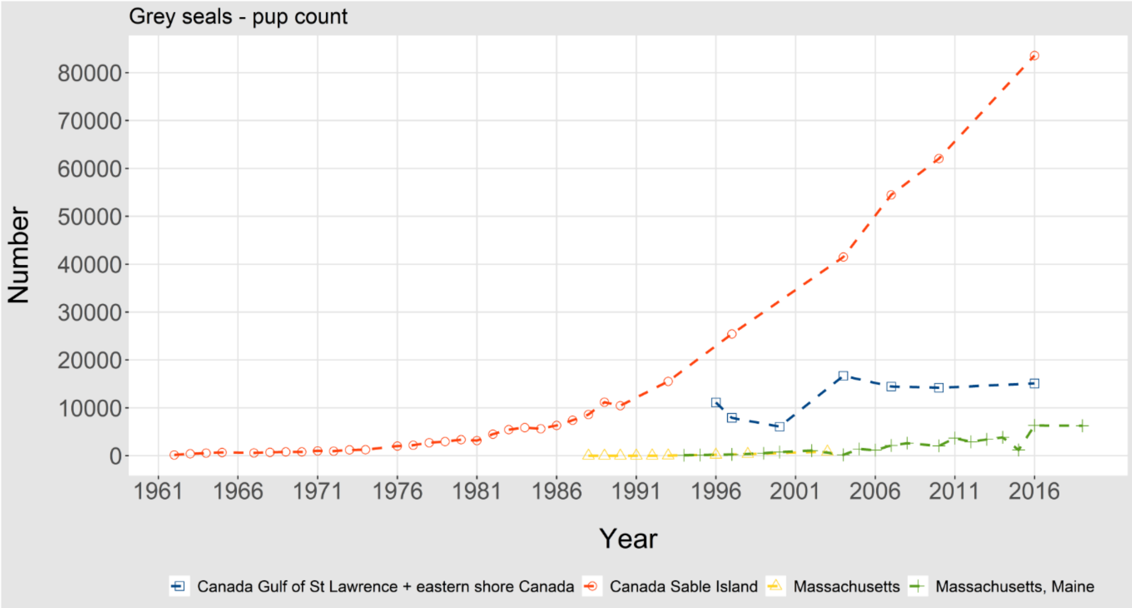

Figure 1.40. Trends of pup counts of grey seals in subareas of North America.

The grey seal pup counts from the US coast in 2008–2014 do not include Seal Island, which is the 2nd largest breeding site, in theory a few hundred pups would have been missed. The most recent grey seal pup count for the US East Coast reported 6253 pups in 2018-2019 across Muskeget Island, Nomans Island, Green Island, Great Point, Monomoy Island, Matinicus Rock, Seal Island, Wooden Ball and Mt. Desert Rock (Wood *et al*., 2019). Figure 1.40 shows trends in pup counts of grey seals in North America.

SAINT-PIERRE and MIQUELON: Grey seals haul out during most of the year in the archipelago, but disappear during the breeding season (winter). Satellite tracking shows that most go to Sable Island to breed (see Figure 1.41 for the most recent tracking). Grey seal numbers in the archipelago were only censused once in 2021 (180 grey seals in September 2021). Censuses are yet too irregular to assess trends in abundance.

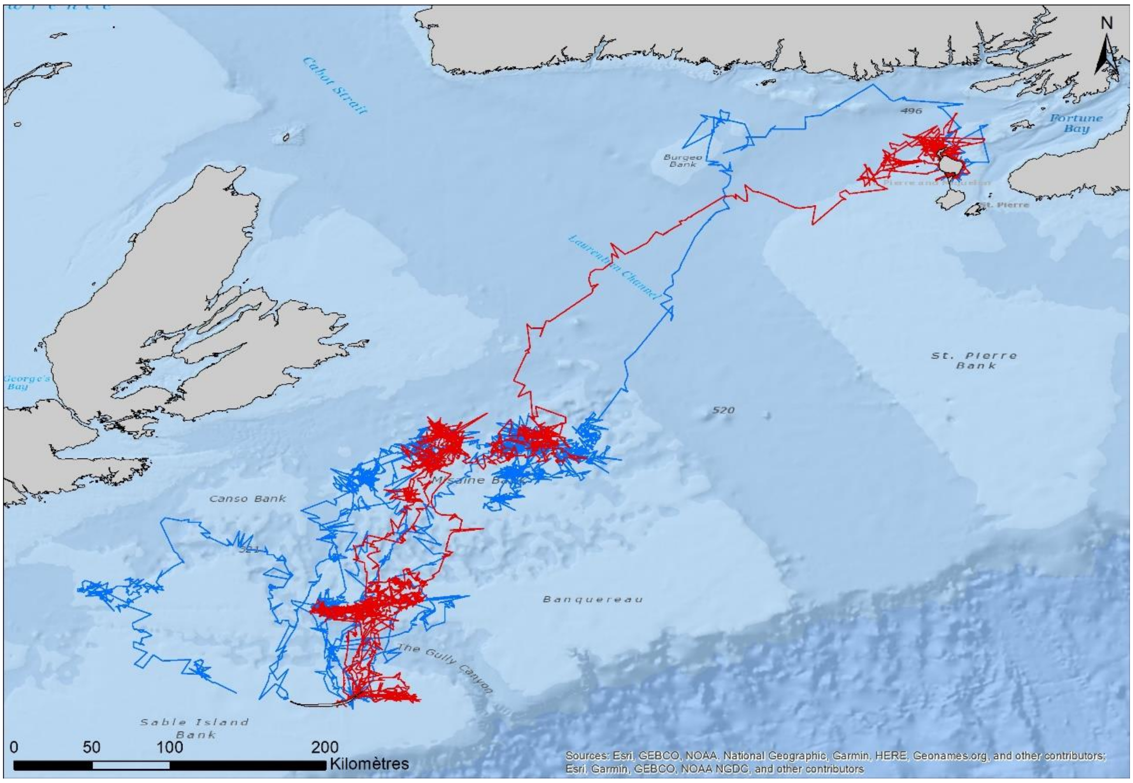

Figure 1.41. Satellite tracking of two grey seal females from Saint-Pierre et Miquelon (from October 2020 to January 2021). Each colour represents one individual. Vincent *et al*. (in prep).

GREENLAND and BARENTS SEA: The distribution of 13 species of marine mammals, six pinnipeds, six cetaceans and polar bear has been assessed in a large-scale tagging study presented in Hamilton *et al.* (2021). By combining the results of multiple tagging data sets, general species distribution as well as individual hot spots could be identified, highlighting several areas of potential special conservation interest in the Greenland and the Barents Seas. For example, for harbour seals, local hotspots were identified in north-western Svalbard (Hamilton *et al.*, 2021).

Harbour seal

Greenlandic harbour seals (*Phoca vitulina*) have been hunted to near extinction in West Greenland. A small population about 50+ animals (42 seen in August 2019) live in the south-eastern part (from Cape Farwell to around 62°N). Harbour seals are also seen further north along the east coast, especially around 63-64°N, but the moulting and breeding sites for these seals are still not located and there is no estimate of their numbers. On the west coast, there is a known breeding/moulting site with 20+ seals (a group of 17-19 adult seals seen June 2020), located in a fjord (Majorariaq - 62°38N, 50°05W). At another site (Kangerlussuaq - 67°00N, 50°43W), which had hundreds of harbour seals in the 1960s have each year during 2019-2021, 2 adult seals and a new born pup were seen in June. A few harbour seals are also regularly seen at other localities along the west coast, indicating that there are a few more stocks, but their breeding/moulting sites have still not been located and there is no estimate of their numbers.

FAROE ISLANDS

Grey seal

With an isolated breeding population, the grey seal is the only pinniped in the Faroe archipelago. Due to human impact and limited breeding space, this population has never increased to high numbers. During historical time, grey seals have been hunted by the locals, also during bounty hunts. Their survival from this relatively intensive pressure may be attributed mainly to their difficult accessibility during breeding in winter, which occurs partly in caves. In more recent years, seals have been culled in relatively high numbers around salmon farms, but this practice was banned in 2020. By-catch is very low, due to the absence of gillnet fishery efforts in shallow waters. A project with the aim of obtaining a total count of the grey seal population in summer was initiated in 2018. A preliminary minimum uncorrected total count, using the highest numbers in each of four main survey areas (surveys in 2018, 2019 and 2021) is 604 grey seals. The census will continue, aiming to correct for availability and movements between areas (expected to be neutral) from telemetry studies.

1.2.2 Seal Monitoring and Management

DENMARK: Galatius *et al*. (2021b) used GLMs to investigate the effects of timing and weather variables on harbour seal moult counts in the southwestern Baltic Sea, based on surveys conducted between 1990 and 2020. Survey date within the 16-day survey window was the most important variable, with higher counts observed earlier in August. Cloud cover, wind speed and temperature were also included in the final model, with fewer seals predicted on land on cloudy and windy days as well as on clear, calm days. These latter effects are likely related to temperature regulation of the seals during the moult. Power analyses suggested that correction for survey conditions would allow detection of a one percentage point annual change in population growth rate with 80% power up to four years sooner than without taking conditions into account.

POLAND: Kielpinska and Kowalski (2021) proposed a model allowing calculation of grey seal culling rates in different regions of the Baltic Sea, to mitigate seal-fisheries conflicts without sacrificing distribution targets in terms of numbers of colonies. The model was criticised by Galatius *et al.* (2021c), who found that it included several flawed assumptions with regard to grey seal biology, that the modelling itself was not transparent and that the authors did not include information or experiences from past marine mammal culling campaigns and ecosystem modelling of the relationships between grey seals and their prey in the Baltic Sea.

UNITED KINGDOM: Langley *et al*. (2021) investigated the performance of three open source pattern recognition software algorithms for harbour seal photo-ID, namely ExtractCompare, (IS)-S-3 Pattern and Wild-ID. The cumulative density function (CDF – a measure of successfully scoring matching images higher than non-matching images) was highest for Wild-ID (CDF1 = 0.34-0.58), followed by ExtractCompare (CDF1 = 0.24-0.36) and (IS)-S-3 pattern (CDF1 = 0.02-0.3). The highest performing aspects in ExtractCompare were left heads, whereas in (IS)-S-3 Pat-tern and Wild-ID these were front heads. Overall, Wild-ID outperformed both ExtractCompare and (IS)-S-3 Pattern under tested scenarios.

1.2.3 Seal Population Structure

DENMARK: Liu *et al.* (2022) investigated range-wide population genomics of harbour seals using ca 13 500 SNPs from 286 individuals from 22 localities. The results point to a North Pacific origin of the species with subsequent colonisation of the Atlantic via the Canadian Arctic. From there, the species spread across the North Atlantic in a stepping-stone fashion, accompanied by successive loss of genetic diversity. The latest groups to branch off were harbour seals in the southern North Sea. There was fine-scale genetic structure observed at both regional and local scales, consistent with the strong philopatry of the species. In the Atlantic, three major groups stood out: the western Atlantic, the Arctic (Greenland, Iceland and Svalbard) and the eastern Atlantic.

IRELAND: Work is being undertaken on assessing the genetic population structure in both harbour and grey seals in western European waters at the Galway-Mayo Institute of Technology, Ireland, as part of the PhD thesis of Kristina Steinmetz.

Harbour seal

Harbour seals (*Phoca vitulina*) occurring in Irish waters are currently viewed as a single nationwide panmictic population (and hence management unit, MU), though this assumption is not based on knowledge of population structure, due to a lack of available genetic data. Thus, the present study used mitochondrial control region sequences and 9-11 microsatellite loci from harbour seals from Ireland and Northern Ireland (up to n = 123) and adjacent UK/European waters (up to n = 289) to provide insights into the genetic population structure and diversity of harbour seals in the studied areas. Within the island of Ireland, genetic analyses revealed the presence of three genetically distinct putative populations characterised by high genetic diversity, hereby defined as: North-western and Northern Ireland (NWNI), Southwestern Ireland (SWI) and Eastern Ireland (EI). Using previously published and newly generated data, a subsequent wider scale analysis revealed that the Irish SWI and EI putative populations were genetically distinct from neighbouring UK/European areas, whereas seals from the NWNI area could not be distinguished from a previously identified northern UK metapopulation. Migration rate estimates showed that NWNI receives migrants from Northwest Scotland, with NWNI acting as a genetic source for both SWI and EI. The present study provides the most comprehensive genetic assessment of harbour seals in European waters to date, with findings indicating that conservation strategies for harbour seals in Irish waters should be amended to accommodate at least three genetically distinct putative populations/MUs. The use of interdisciplinary approaches considering ecological as well as genetic parameters is recommended for future assessments and delineation of units of ecological relevance for conservation management purposes.

Grey seal

Delineation of MUs for grey seals (*Halichoerus grypus*) in the Northeast Atlantic has largely been based on movement patterns identified by telemetry data, as significant geographical sampling gaps have hindered the thorough assessment of population genetic structure. We addressed these sampling gaps by generating mitochondrial (up to 456bp of the control region) and nuclear data (11 microsatellites) from seals in areas that had not been previously studied, including Ireland, Northern Ireland, southwest England and the German / Danish North Sea coasts. New mitochondrial data were merged with previously published data to generate an unprecedentedly large dataset of over 2000 individuals. Both mitochondrial and nuclear diversity were high in all sub-regions. Genetic structuring results revealed that grey seals from Ireland and Northern Ireland are part of the same interbreeding population. Southwest England and the southern North Sea (Germany, Denmark) were identified as source areas of migrants to Ireland/ Northern Ireland, though it may be possible that the southern North Sea shares a common source of migrants not included within the nuclear analysis, rather than representing a direct source for Ireland/ Northern Ireland. Based on genetic findings, two distinct MUs are proposed for the Northeast Atlantic: (i) Faroe Islands, Scotland and Greater North Sea; and (ii) Northern Ireland, Ireland, southwestern UK (Cornwall), and France. While further sampling will be required to accurately delimit the boundaries between these MUs, two transition zones are hereby proposed: (i) Northwest Scotland and (ii) the English Channel/ southern (Dutch) North Sea. To account for potential ongoing admixture between the proposed MUs (and hence a shift or even eventually disappearing of the proposed boundaries), continued monitoring and assessment of regional population structure using a multidisciplinary framework is advised.

1.2.4 Vagrant Seal Species

Seals are highly mobile species and naturally utilise a wide range of habitats (Cronin *et al*., 2013; Jones *et al.,* 2015). However, until now ICES WGMME (for example ICES 2021) only reported seals occurring within their assumed natural range. As global changes are expected, the group agreed to annually also report the vagrant species observed. Table 1.10 summarises the first effort to do so and will be completed in the following years.

While it is natural that within certain spatial limits seals travel over long distances to explore their habitat, and utilise different types of resources (Carter *et al*., 2019; Peschko *et al*., 2020), due to different reasons, occasionally seals travel beyond their natural range (Bester, 2021). Animals seen outside their natural range are termed "vagrant" and underlying mechanisms for such behaviour can be complex and are usually difficult to characterise.

In order to detect an increase in such events e.g. as the result of climatic changes, it is necessary to keep records of such sightings which may seem as a "one off" event seen from the small local scale, but may be an emerging pattern when looked at from a large spatial scale. Therefore, it was decided during the annual WGMME meeting, that a collation of such sightings should be initialised in order to enable an assessment over a large spatial scale (Table 1.10).

Table 1.10. Sighting data of vagrant seal species.

Year	Place and country	Number of individuals	Comment	Ref*.
BEARDED SEAL				
1988	Yerseke (NL)	1	in rehab.	B)
2010	Yell (Shetland, UK)	1		E)
2011	Baltasound, Unst (Shetland, UK)	1		E)
2011	Aberdeenshire (E Scotland, UK)	1		E)
2011 – 2012	Firth of Tay (E Scotland, UK)	1		E)
2013	Yell (Shetland, UK)	1		E)
2017	Timoleague (IE)	1		E)
2018	Lerwick (Shetland, UK)	1		E)
2020	Caithness (UK)	1		E)
HARP SEAL				
1987	Rottumerplaat; Texel, Grevelingen, Den Oever, Veerse Dam, Ameland, Renesse (NL)	6	juveniles & adults	B)

Year	Place and country	Number of individuals	Comment	Ref*.
1990	Terschelling, Den Helder (NL)	2	juvenile, adult: rehab.	B)
1994	Zurich; Brouwersdam; Terschelling (NL)	3	juveniles rehab.	B)
1995	Brouwersdam (NL)	1	died in rehab.	B)
1996	Texel (NL)	1	dead	B)
1997	Terschelling (NL)	1	juvenile rehab.	B)
2000	Terschelling (NL)	1	dead	B)
2001	Kloosterburen (NL)	1	juvenile rehab.	B)
2003	Middelkerke (BE)	1	female; died in rehab.	G)
2003	Middelkerke (BE)	1		G)
2005	Voorne (NL)	2	adult	B)
2006	Zeebrugge (BE)	1		G)
2006	Harlingen (NL)	1	juvenile	B)
2016	Den Oever (NL)	1	adult rehab.	B)
2019	Westerschouwen; Noordwijk aan Zee (NL)	2	juvenile rehab.; adult dead	B)
HOODED SEAL				
1981	Rilland (NL)	1	juvenile	B)
1982	Ouwerkerk (NL)	1	juvenile	B)
1988	St Phillipsland, Renesse (NL)	2	juveniles	B)
1989	Gent/Doornik (BE)	1	female; died in rehab.	G)
1990	Vlieland (NL)	1	juvenile rehab.	B)
1996	Schleswig-Holstein coast (DE)	1		D)
1996	Texel, Frewert, Scheveningen, Vlieland (NL)	4		B)
1997	Den Helder, Callantsoog (NL)	2	juveniles, one dead	B)
1998	Schleswig-Holstein coast (DE)	1		D)
1998	Vlieland, Den Helder, Terschelling (NL)	3	juveniles, rehab.	B)
1999	Heist (BE)	1	male	G)
2000	Knokke (BE)	1	female; died in rehab.	G)
2000	Lauwersoog, (NL)	1		B)

Year	Place and country	Number of individuals	Comment	Ref*.
2001	Schleswig-Holstein coast (DE)	1		D)
2003	Middelkerke (BE)	1	male; died in rehab.	G)
2004	Arnhem (NL)	1		B)
2005	Camperduin, Terschelling, Balgzand, Westvoorne (NL)	4		B)
2010	Rottumeroog (NL)	1		B)
2011	Schleswig-Holstein coast (DE)	1		D)
2011	North Yorkshire (E England, UK)	1	recorded before in DE	E)
2013	Hartlepool (NE England, UK)	1		E)
2013	Maasvlakte (NL)	1		B)
2014	Baarland, Texel (NL)	2		B)
2018	Scheveningen (NL)	1		B)
RINGED SEAL				
1972	Breskens, Rilland (NL)	2		B)
1973	Engelsmanplaat (NL)	1		B)
1977	Ameland, Zierikzee, Ameland (NL)	3		B)
1979	Schiermonnikoog (NL)	1		B)
1980	Oosterschelde, Sliedracht (NL)	2	both in rehab.	B)
1982	Westvoorne, Oosterhout (NL)	2	both in rehab.	B)
1985	Terneuzen, Moddergat Terneuzen (NL)	3		B)
1986	Ameland (NL)	1		B)
1987	Wenduine (BE)	1	female; taken to rehab.	G)
1987	Kallo (BE)	1	taken to rehab.	G)
1987	Zeebrugge (BE)	1	taken to rehab.	G)
1988	Ouddorp (NL)	1		B)
1989	De Haan (BE)	1	taken to rehab.	G)
1990	Breezanddijk, Texel (NL)	2		B)
1991	Berkheide, Wassenaar (NL)	2		B)
1993	Zoutelande (NL)	1		B)

Year	Place and country	Number of individuals	Comment	Ref*.
1994	Schiermonnikoog, Grevelingen (NL)	2		B)
1994	Belgium	2		G)
1996	Schiermonnikoog (NL)	1		B)
1998	Schiermonnikoog, Vlieland (NL)	2		B)
2000	Katwijk (NL)	1		B)
2002	Terschelling (NL)	1		B)
2007	Wierum Zaandam, Zoutelande (NL)	3		B)
2008	Terschelling, Texel (NL)	3		B)
2009	Vlieland (NL)	1		B)
2011	Vlieland (NL)	1		B)
2013	Ameland, Vlieland (NL)	2		B)
2015	Utrecht (NL)	1	rehab.	B)
2016	Plymouth (SW England, UK)	1		E)
2018	Borssele (NL)	1	dead	B)
2019	Amsterdam (NL)	1	rehab.	B)
2021	Cove Bay (E Scotland, UK)	1	in rehab. released in Shetland	E)
WALRUS				
1926	Den Helder (NL)	1	adult male	B)
1945	Zeebrugge (BE)	1	killed on beach	G)
1960	Sylt (DE)	1		A)
1976	Zeebrugge (BE)	1		G)
1976	Texel, Colijnsplaat (NL)	2	1 male, same animal in Belgium?	B)
1977	Texel, Oosterschelde (NL)	2		B)
1979	Texel (NL)	1	swimming	B)
1981	Terschelling (NL)	1	rehab.	B)
1982	Den Helder (NL)	2		B)
1983	Sylt (DE)	1		A)
1993	Ijmuiden (NL)	1		B)
1998	Sylt (DE)	1		A)

Year	Place and country	Number of individuals	Comment	Ref*.
1998	Juist (DE)	1		A)
1998	Ameland(NL)	1		B)
2012	Camperduin (NL)	1		B)
2013	North Ronaldsay (Orkney, UK)	1		E)
2018	Sanday and North Ronaldsay (Orkney, UK)	1		E)
2018	Skerries (Shetland, UK)	1		E)
2021	Valencia Island (Co. Kerry, IE)		young male named “Wally”	E)
2021	Pembrokeshire (Wales, UK)			E)
2021	Cornwall (England, UK)			E)
2021	Les Sables-d'Olonne (FR)			E)
2021	Bilbao and Santander (ES)			E)
2021	Cornwall (England, UK)			E)
2021	Co. Cork (IE)			E)
2021	Iceland			F)
2021	Denmark	1	young female named “Wanda or Freya”	C)
2021	East Frisian Islands (DE)			D)
2021	Den Helder (NL)			D)
2021	Seahouses, (Northumberland, UK)			D)
2021 – 2022	Shetland, (UK)			E)
2022	Hvide Sand (DK)			C)
GREY SEAL				
2022	Motril (ES)	1		H)

*References: A) beachexplorer.org; B) Broekhuizen, S., Spoelstra, K., Thissen, J.B., Canters, K.J., Buys, J.C., 2016. Atlas van de Nederlandse zoogdieren. Naturalis Biodiversity Center; Updated with waarneming.nl; C) Fiskeri- og Søfartsmuseet; D) ITAW Germany pers. comm.; E) P.G.H. Evans pers. comm.; F) ‘Out of Habitat’ Marine Mammals Workshop Report. (2021).; G) J. Haelters pers. comm. H) www.theolivepress.es

1.3 Acknowledgements

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2 ToR B: Review and report on any new information on seal and cetacean management frameworks in the North Atlantic

2.1 High-level summary of earlier reports

Seal and cetacean management frameworks in the European Union are covered by the European Common Fisheries Policy (in particular amendments under Regulation 1380/2013), the Habitats Directive (Directive 92/43/EEC), Regulation 2019/1241 (which has replaced Regulation 812/2004), and the Marine Strategy Framework Directive (Directive 2008/56/EC) among others.

Marine Strategy Framework Directive (2008/56/EC)

WGMME has reported in previous years on the development of common indicators and targets for the Marine Strategy Framework Directive (MSFD; e.g. ICES, 2020c and reference therein). In 2018, Member States reported to the European Commission on the Good Environmental Status (GES) of marine ecosystems (Palialexis and Boschetti, 2021). Marine mammals had more complete assessments and good regional coordination for GES determination compared to the previous reporting cycle in 2012. The four-seal species recorded, including grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*), Mediterranean monk seal (*Monachus monachus*) and Baltic ringed seal (*Phoca hispida botnica*) are well studied and reported by almost all Member States where they occur. The small toothed cetacean species are sparsely reported apart from four species (common *Delphinus delphis* and striped dolphin *Stenella coeruleoalba*, coastal bottlenose dolphin *Tursiops truncatus*, and harbour porpoise *Phocoena phocoena*). Only three species (out of 12 registered species) were reported amongst deep-diving cetaceans (long-finned pilot whale *Globicephala melas*, sperm whale *Physeter macrocephalus* and Cuvier's beaked whale *Ziphius cavirostris*). Those that were not reported have distributions beyond coastal waters in the Northeast Atlantic. A similar pattern occurs for the baleen whales, where only two member states reported three out of the seven species distributed in offshore waters (Palialexis and Boschetti, 2021).

Habitats Directive (92/43/EEC)

WGMME has reported in previous years on the EU Habitats Directive (HD), which set out specific requirements for Member States with regard to the protection of marine mammals (e.g. ICES, 2021c). Article 17 of the HD requires Member States to report every six years on progress with respect to the implementation of the HD. Monitoring of conservation status is an obligation arising from Article 11 of the HD for all habitats listed in Annex I, and species listed in Annex II, IV and V. All marine mammal species are listed under Annex IV. Grey seals (*Halichoerus grypus*), harbour seals (*Phoca vitulina*), Mediterranean monk seals (*Monachus monachus*), bottlenose dolphins and harbour porpoises are listed under Annex II. The latest reporting from Member States under Article 17 is available for 2012-2018 at https://nature-art17.eionet.europa.eu/article17/

In the latest reporting, marine mammals as a group had the highest proportion of unknown assessments under Article 17 due to a lack of appropriate monitoring (EEA, 2020). This is particularly true for cetaceans, for which, apart from species listed on Annex II, the range, population size, and suitable habitat area are unknown in the majority of Member States (EEA 2020). Marine mammals, including the common dolphin and harbour porpoise are most noticeably affected by bycatch and marine harvesting activities (EEA, 2020). Seal bycatch is less well reported (ToR E), thus its effect on the populations is unknown. As a consequence, EU frameworks and other groups have mostly concentrated their efforts on cetacean bycatch.

Data Collection Framework (Common Fisheries Policy, CFP)

EU Regulation 2019/1241 requests Member States to "take the necessary steps to collect scientific data on incidental catches of sensitive species" and, given "scientific evidence, validated by ICES, the Scientific, technical and economic committee for fisheries (STECF), or in the framework of GFCM, of negative impacts of fishing gear on sensitive species", to "submit joint recommendations for additional mitigation measures for the reduction of incidental catches". The relevant objectives of this regulation include: (i) to ensure that incidental catches of sensitive marine species, including those listed under Directives 92/43/EEC and 2009/147/EC (Habitats and Bird Directives,, that are a result of fishing, are minimised and where possible eliminated so that they do not represent a threat to the conservation status of these species, and (ii) to ensure, including by using appropriate incentives, that the negative environmental impacts of fishing on marine habitats are minimized. Its targets include: incidental catches of marine mammals, marine reptiles, seabirds and other non-commercially exploited species do not exceed levels provided for in Union legislation and international agreements that are binding on the Union.

The objectives of CFP amendments under Regulation 1380/2013 include implementation of the ecosystem based approach to fisheries management so as to ensure that negative impacts of fishing activities on the marine ecosystem are minimized, and there is coherence with the Union environmental legislation, in particular with the objective of achieving GES under the MSFD (see above).

In 2019, STECF was requested to provide a holistic review of the effectiveness of the current regulation based on ICES advice and other sources of information in terms of mitigating bycatch of cetaceans (STECF, 2019). Among other things, STECF was requested to provide a summary of candidate thresholds (removals limits) for the cetacean species most typically caught as bycatch. STECF (2019) stressed that setting thresholds for anthropogenic removals require clear conservation objectives and targets. There is, however, a lack of agreed conservation objectives at the EU scale (ICES, 2014b). The continued absence of action on conservation objectives is impeding the use of procedures to compute thresholds (see Palialexis *et al.*, 2021 for an overview of threshold setting methods). STECF (2019) reiterates the advice presented in ICES (2014a, b) that the European Commission establishes a process involving policy, scientists, managers and other stakeholders to compute bycatch thresholds based first on agreement of conservation objectives. Integral to management is a clear understanding of the conservation and management objectives to be achieved. Currently, those specified in European environmental legislation require further definition to be able to be used quantitatively in the modelling approaches to threshold setting (ICES 2014a, b; STECF 2019).

STECF (2019) concluded that the requirements to establish a system of surveillance of incidental capture under the HD appears to have been overshadowed by other monitoring requirements (Article 11[14]) and those in the (now repealed) Regulation (EU) 812/2004. STECF (2019) concluded that this regulation should have included all fleet segments - all vessels regardless of size in all EU waters in order to enable a robust assessment of the overall impact of fisheries on cetaceans. Dedicated marine mammal observer programmes are needed to remove the downward bias in bycatch estimates generated from the non-dedicated monitoring of cetacean bycatch under the Data Collection Framework.

[14] Article 11 of the Habitats Directive requires Member States to monitor the habitats and species listed in the annexes (habitats in the Annex I and species in the Annexes II, IV and V).

Regulation (EU) 812/2004 was repealed in 2019 with the introduction of Regulation (EU) 2019/1241 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures (hereafter referred to as 'Technical Measures'). Article 3 sets the objectives, including, among others, to 'ensure that incidental catches of sensitive marine species, including those listed under Directives 92/43/EEC and 2009/147/EC, that are a result of fishing, are minimised and where possible eliminated so that they do not represent a threat to the conservation status of these species'. Article 4 sets targets, including 'incidental catches of marine mammals, marine reptiles, seabirds and other non-commercially exploited species do not exceed levels provided for in Union legislation and international agreements that are binding on the Union.' New legislations are further detailed in ICES (2020b, 2020c).

STECF (2019) concluded that the carryover of the monitoring requirements of Regulation (EU) 812/2004 into the proposed Technical Measures Regulation in Annex XIII is unhelpful as it does not remedy the deficiencies with respect to marine mammal bycatch monitoring (see also STEFC, 2021 or EC, 2021). Bycatch has been highlighted as the greatest anthropogenic threat to Baltic harbour porpoises in the Baltic Sea, Iberian harbour porpoises in the Iberian Peninsula, and common dolphins in the Northeast Atlantic.

ASCOBANS

The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) is a daughter instrument to the Convention on Migratory Species (CMS or Bonn Convention) and entered into force in 1994.

The North Sea Group is a working group of the ASCOBANS Advisory Committee and is the Steering Group for the ASCOBANS Conservation Plan for the Harbour Porpoise in the North Sea, whilst the Jastarnia Group is the equivalent Steering Group for the ASCOBANS Recovery Plan for Baltic Harbour Porpoises, and for the Conservation Plan for the Harbour Porpoise Population in the Western Baltic, the Belt Sea and the Kattegat. WGMME previously reported on the Jastarnia Plan (ICES, 2021c).

ASCOBANS also provides a platform within which to form a coordinated transboundary approach to the conservation of a species via a Species Action Plan (SAP). In 2019, a SAP was agreed for the common dolphin in the Northeast Atlantic (ASCOBANS 2020). The SAP aims to strengthen the evidence base and make management decisions at an appropriate spatial and transboundary scale for this wide-ranging species.

With respect to cetacean bycatch, ASCOBANS passed two resolutions, one in 2000 (Resolution 3.3 on Incidental Take of Small Cetaceans) and the other in 2006 (Resolution 5.5 on Incidental Take of Small Cetaceans) which

- defines "unacceptable interactions" as being, in the short term, a total anthropogenic removal above 1.7% of the best available estimate of abundance (Res.3.3); and
- underlines the intermediate precautionary objective to reduce by-catches to less than 1% of the best available population estimate (Res.3.3 and Res.5.5).

A joint ASCOBANS-ACCOBAMS working group on bycatcvh was established in 2019, and held a two-day workshop in February 2021 to identify conservation priorities. Following this, the 26th Advisory Committee of ASCOBANS agreed in 2021 to organize an 'Expert workshop to recommend small cetacean conservation objectives in relation to anthropogenic removals'. The aim of this two-part workshop is to decide an appropriate conservation objective for small cetacean species (ASCOBANS, 2021a).

The European Union Biodiversity Strategy for 2030

The EU Biodiversity Strategy for 2030[15] (EUBS, 2030) is an aspirational long-term plan for protecting nature and reversing the degradation of ecosystems in the European Union. The EUBS 2030 contains specific commitments and actions to be delivered by 2030 including (i) establishing a larger EU-wide network of protected areas on land and at sea; (ii) launching an EU nature restoration plan or (iii) introducing measures to enable the necessary transformative change for restoration.

EUBS 2030 plans to achieve a target of 30% of European marine waters under protection, with 10% strictly protected. Currently, 12.4% of the EU marine area is designated as a Marine Protected Area (WWF, 2019). To achieve the target, the surface of the EU marine area to be designated as a Marine Protected Area needs to increase two-fold. However, the European Environmental Agency reported that less than 1% of European Marine Protected Areas could be considered marine reserves with full protection (e.g. through fishing bans), and that management of Marine Protected Areas needed to be strengthened (EEA, 2019).

The European Court of Auditors critically reviewed the effectiveness of marine protection policy in the EU in 2020: marine ecosystems in the EU have not been restored to GES, nor is fishing being practiced at sustainable levels (Anon., 2020). In particular, the European Court of Auditors concluded that

- EU protection rules have not led to the recovery of significant ecosystems and habitats;
- the network of marine protected areas was not representative of the EU's diverse seas and sometimes provided little protection;
- in practice, the provisions to coordinate fisheries policy with environmental policy had not worked as intended (see also OceanCare, 2021), and the species and habitats protected by birds and habitats directives were based on outdated threat assessments.

EUBS 2030 is relevant to seal and cetacean management because their protection is primarily driven by the HD via the establishment of protected areas (Natura 2000 sites) for species listed on Annex II of the directive (see above).

Finally, the European Commission is to adopt an Action Plan to conserve fisheries resources and protect marine ecosystems[16]. The plan, announced in the EUBS 2030, aims to outline where action is needed to address the bycatch of sensitive species (including all marine mammals) through technical measures such as area closures, gear changes and mitigation measures. After a public consultation in late 2021, its adoption is planned for spring 2022.

Assessment Units

WGMME previously reported on assessment units (ICES, 2018; 2019; 2020c). These assessment units were discussed within several fora, including the OSPAR Marine Mammal Expert Group (OMMEG, see section 1.3 below). These updated assessment units will serve to assess ecological status in the QSR 2023. ICES (2020c, 2021c) provided a recent description of management frameworks for both seals and cetaceans under the two regional sea conventions HELCOM and OSPAR. Local seal management frameworks are detailed below in 2.2.

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[15] https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en

[16] https://ec.europa.eu/oceans-and-fisheries/news/action-plan-conserve-fisheries-resources-and-protect-marine-ecosystems-your-opinion-counts-take-part-2021-10-25_en

2.1.1 Hunting of marine mammals

WGMME has previously reported on marine mammal hunting (e.g. ICES, 2019). Hunting of cetaceans does not occur within the regions under consideration. However, minke whales are taken during the Norwegian whaling activities directly to the north of the North Sea, and fin and minke whales in Icelandic waters. In the Faroes, long-finned pilot whale (*Globicephala melas*) and on occasions, Atlantic white-sided dolphin (*Lagenorhyunchus acutus*), bottlenose dolphin, Risso's dolphin *Grampus griseus*), and northern bottlenose whale (*Hyperoodon* ampullatus) are taken in drive fisheries (see https://www.whaling.fo/en/regulated/450-years-of-statistics/catches/). In September 2021, a type of whale hunting which involves the beaching and slaughtering of whales (a so called 'Grindadráp' or 'grind'), was carried out at Skálabotnur beach in the Faroe Islands. This traditional hunt usually involves the long-finned pilot whale and occasionally the Atlantic white-sided dolphin. The September 2021 grind is believed to be the largest one, involving the take of over 1,400 Atlantic white-sided dolphins (ASCOBANS, 2021b). In 2019 and 2020, 10 and 35 dolphins were killed. Contracting parties to ASCOBANS (save Denmark who did not partake in the vote) agreed to send a letter from the ASCOBANS Secretariat to Denmark and the Faroe Islands on the practice of the grind, indicating therein their preference for applying the same strict cetacean protection as other EU member states.

Deliberate killing of small cetaceans (e.g. common dolphins, bottlenose dolphins) occasionally occurs when fishers regard these as in conflict with their activities. In the latter part of the 20th century, this was quite common amongst French fishers either as bait or for human consumption (Baulaz and Morin-Repinçay, 2015). There have been no reports in recent years but some strandings of common dolphins on the French Atlantic seaboard are highly suggestive of meat being taken from carcasses for human consumption.

Hunting of seals occurs in Iceland, Norway, Sweden and Finland, with three species (grey, harbour, and ringed seal) taken within their range (HELCOM, 2009; 2018). Seals are often killed because they are perceived to be a threat to some human activity, for example, by taking fish of commercial value. For this reason, grey seals are culled under licence in the Baltic (HELCOM, 2009; 2018), and both grey and harbour seals have been taken in Scotland (Greater North Sea and Celtic Seas regions) under the Marine (Scotland) Act 2010 (OSPAR, 2010; Marine Scotland, 2010). Some unlicensed/illegal killing of seals almost certainly also has occurred, although probably much reduced from former times, for example, of monk seals in Macaronesia (Madeira: Karamanlidis *et al*., 2016). In the UK, it has been legal to kill seals under certain conditions without licence under the Conservation of Seals Act 1970. In the EU, there is a ban on commercially importing harp and hooded seal pup skins and any products containing such skin.

For the status in the US, see section 2.4 below on the 'US Marine Mammal Protection Act import provisions rule'.

UNITED KINGDOM

It is an offence to intentionally or recklessly kill, injure or take a seal in UK waters. However, there is a general exemption for taking a seal that is disabled for the sole purpose of tending and releasing it when no longer disabled, or killing a seal that is so seriously disabled that there is no reasonable chance of its recovering. As of 1 March 2021 amendments made to the Conservation of Seals Act 1970, the Wildlife (Northern Ireland) Order 1985 by Schedule 9 of the Fisheries Act 2020, and in Scotland via the Animals and Wildlife (Penalties, Protections, and Poweers) (Scotland) Act 2020, amending the Marine (Scotland) Act (2010), all came into force. Individual seals can no longer be controlled (killed *red.*) under the 'netsman's defence' as this defence was removed from the legislation as of 1 March 2021.

The trading and importing of seal products is regulated for all species of pinnipeds by the Seal Products Regulations 2010. The regulations introduced a ban on commercially importing and marketing all seal products and any related products. The ban applies to all seal products unless any of the following are true. If they:

- result from traditional hunts conducted by Inuit and other indigenous communities and contribute to their subsistence.
- result from hunts regulated under national law with the sole purpose of the sustainable management of marine resources and where the products are marketed on a non-profit basis.
- are exclusively for the personal use of travellers or their families and only occasionally imported.

BALTIC SEA

Hunting for seals as a resource has probably been going on in the Baltic Sea region for as long as humans and seals have co-existed (Storå, 2002). At the end of the 19th century, a bounty system was introduced in several countries with the aim of reducing problems for fisheries, while at the same time providing an important income for hunters. The size of the grey seal population in the Baltic Sea was greatly reduced by hunting in the first half of the 20th century (Hårding and Härkönen, 1999, Kokko *et al*., 1999). Following protection measures, including a ban on hunting, and improved environmental conditions, the Baltic Sea seal populations recovered. The grey seal population size increased from only a few thousand seals in the 1980s to more than 40,000 counted individuals in 2021 (this report).

The management of the Baltic Sea seal populations falls under the remit of The Convention on Biological Diversity, The Bern Convention, The Bonn Convention and The Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, HELCOM), as well as national legislations. The ringed seal is listed in Annex V, while harbour and grey seal are listed in Annex II and Annex V in the EU Habitats Directive. Exploitation of seals can only be allowed if the status of the populations is monitored to ensure favourable conservation status. HELCOM Recommendations have been a key tool in the conservation and management of seals in the Baltic Sea since the 1980s. Recommendation 3/3 was adopted in 1982, Recommendation 9/1 was adopted in 1988 and the latest Recommendation 27-28/2 was adopted in 2006 (HELCOM, 1982; HELCOM, 1988; HELCOM, 2006).

Following the recovery of the seal populations in the late 20th–early 21st century, damage to commercial catches and fishing gear caused by (grey) seals increased. The recommendation 9/1 was controversial since it recommended a ban of hunting at the same time as seal hunting was an increasingly urgent matter for some stakeholders both in Sweden and in Finland in the late 1990s. Effective stakeholder lobbying resulted in the reintroduction of seal hunting as a management measure. In 1995, an exemption was introduced under which permits for limited hunting could be issued for scientific purposes, for evaluations of the effects of the hunt, and, in exceptional cases, to minimize seal-induced damage (HELCOM, 1995). Seal hunting was then considered to be in line with the HELCOM rules and a research hunt study was initiated in Sweden in 1997 (Westerberg *et al*., 2006).

The latest recommendation (27-28/2) recognized national management plans as suitable to address regional differences in priorities of seal management, and recommended their development and implementation under overarching population level long-term objectives and the following reference levels (HELCOM, 2006; HELCOM, 2018):

- Limit Reference Level: The population size where the long-term persistence of the population is ensured. No hunting licenses should be issued when population size < LRL;

- Precautionary Approach Level: The population size where the population is at maximum productivity level. Hunting licences can only be issued if a significant positive long-term growth can be observed, and special care needs to be taken to avoid jeopardizing of the long-term population growth;
- Target Reference Level: The population size where the population growth rate starts to level off to an asymptotic population level, approaching the current carrying capacity level. Hunting licences can be issued if the long-term objectives of the General Management principles are not compromised.

Although no effects in terms of reduced damage to fishing gear could be observed in the research hunt study, hunting of grey seals, in the form of protection hunting, was reintroduced in Sweden in 2001 (Westerberg *et al*., 2006). Protection hunting of harbour seals in the Kattegat and ringed seals in the Bothnian Bay started in 2009 and 2016, respectively. However, special personal permits for protection hunting of single seals were assigned before the more general, regional, quotas were introduced (2001, 2009 and 2016). In Finland and Åland, the recent history of seal hunting overall follows similar patterns as in Sweden: going from a ban on hunting in the 1970s-1980s to some form of hunting during the late 1990s-early 2000s to deal with increasing conflicts between fisheries and growing grey seal populations. The objective of the protection hunt was to reduce damage to fishing gear and catches, based on the theory that it is a limited number of seals that are the main cause of damage. Initially, the protection hunt took place in specific seal damage areas but later (2015 for grey seals), hunting was only allowed in the vicinity of 'a place where fishing is conducted and where seals have caused damage to fishing gear or taken catch from the gear'.

In 2020, licensed hunting of grey seals was introduced in Sweden, and continued in 2021. The purpose of licence hunting, i.e. population regulation hunting, is to reduce conflicts between grey seals and humans in regions with high seal abundance by regulating the population according to the objective justified and set out in the management plan. The Swedish Environmental Protection Agency may decide on a licensed hunting, provided that the hunt is carried out in a controlled manner, that there is no other appropriate solution, and that the hunt does not jeopardise the conservation status of the seal population.

When licensed hunting started, a common quota for the entire Swedish Baltic Sea was allocated (n=2000), in contrast to previous years when county-specific maximum numbers were allocated. During recent years, the quotas for grey seals have been 2000 in Sweden, 1050 in Finland and 500 in Åland. The quotas for ringed seals were 420 in Sweden and 375 in Finland. The quota for harbour seals was 340 in the Kattegat. The quantities of seals reported shot vary between years, but typically are around half (31-67%) of the grey seal quota, >50% of the ringed seal quota and <50% of the harbour seal quota is filled. The recent hunting of grey seals in Sweden is carried out between April and January, of ringed seals: between May and January, and of harbour seals between July and May. More details on the hunting of grey seals in the Baltic Sea will be presented in an upcoming report (Lundström, 2022).

In connection with the decision on the licensed hunting of grey seals, the Swedish Government commissioned the Swedish Agency for Marine and Water Management (SwAM) and the Swedish Environmental Protection Agency to revise the national management plan for grey seals (Havs- och Vattenmyndigheten, 2012; Havs- och Vattenmyndigheten, 2019; Naturvårdsverket, 2001). In the revised management plan, besides the overall management objectives of favourable conservation status and neutral or positive impact on human interests, three additional objectives to further clarify the management of grey seals in the Baltic Sea were defined:

- Knowledge and dialogue on the role of seals in the ecosystem, including their impact on fish and fisheries, in a regional and national perspective, will be increased;

- Conditions for coexistence between the grey seal population with a favourable conservation status and sustainable fisheries will be improved;
- Management measures, including hunting, will be evaluated scientifically to ensure that the objectives of the management plan are met.

National management plans exist also in Finland, Åland and Denmark (Ministry of Agriculture and Forestry, 2007, Ålands Landskapsregering. 2007, Miljøstyrelsen, 2020).

FAROE ISLANDS

In the Faroe Islands, no management plan exists for grey seals. This isolated population, the only pinniped breeding in the islands, is not subject to recreational hunting or significant bycatch pressure. But, historically, a limited harvest has occurred, and bounty hunts have also periodically been in action, the motivation being reducing numbers and competition with fishermen. With the development of the aquaculture industry, grey seals were culled as a protective act around fish farms, a removal that seemed to prevent the population from increasing in numbers. However, culling of grey seals around fish farms was banned by law in 2020. A census was initiated in 2018, in order to count the total population during summer. This survey, which also includes photo monitoring and satellite tracking, is ingoing and may deliver an abundance estimate within the next two years.

ICELAND

In Iceland, a new regulation for seal hunting in Iceland was enacted in 2019 to ban all seal hunting due to the sensitive status of the harbour seal and grey seal populations. It is, however, possible for landowners to apply for exemptions for so-called traditional utilization of seals (Ministry of Industry and Innovation, 2019). Prior to 2019, there was no hunting management system in effect for seal hunting in Iceland and registration of seal hunting statistics was not compulsory (Granquist and Hauksson, 2016).

GREENLAND

There are four species that are common in Greenland: ringed seal, harp seal, hooded seal and bearded seal. Only ringed seals and harp seals are hunted in large number, and the hunt is believed to bet sustainable. Harbour seals were once common, but overhunting resulted in the species becoming critically endangered in Greenland. Harbour seals have been protected since 2010; their confirmed distribution is limited to South Greenland, with very few observations outside of the Cape Farewell area.

Advice on catch levels for harp and hooded seals are given by an ICES/NAFO/NAMMCO working group. Hooded seals that breed in the Greenland Sea are protected against hunting, because they were reduced in the years following the Second World War. The catch numbers of the other stocks have been below the estimated allowable catch for many years (ICES, 2019c).

Advice on ringed seals and bearded seals in the Atlantic region is given by NAMMCO. Unlike the harp and hooded seals that breed concentrated at high densities in the same areas every year, ringed and bearded seals are spread out all over the Arctic, and the ringed seals give birth in lairs that they dig out in the snow. And as a result, there are not the same opportunities to monitor the populations. Their distribution over very wide areas, however, protects them against overharvest, because the hunt is only in a small fraction of their habitat. An evaluation of the ringed seal situation was undertaken by NAMMCO in 1996 (NAMMCO, 1996). A new evaluation on ringed seals will be madeby NAMMCO in autumn 2022. The situation for bearded seals has never been thoroughly evaluated by NAMMCO, but a joint NAMMCO – CAFF working group with the purpose to evaluate thestatus of bearded seals, is planned for May 2022

NORWAY

In Norway, harbour and grey seals are hunted based on given quotas in local management areas along the coast (Figure 2.1). In the management plans, target levels of the populations were given and the hunting quota level set to ca. 5% of the abundance estimates (less or more based on increase/decrease in the populations). The hunt is stopped if the populations decline to <50% of the target levels. There is a system for annual reporting on shot animals (including struck and lost seals). In mid-Norway, the hunt on grey seals was stopped due to very low abundance assessments (<50% under target level) in 2015, probably caused by high bycatches in gillnet fisheries.

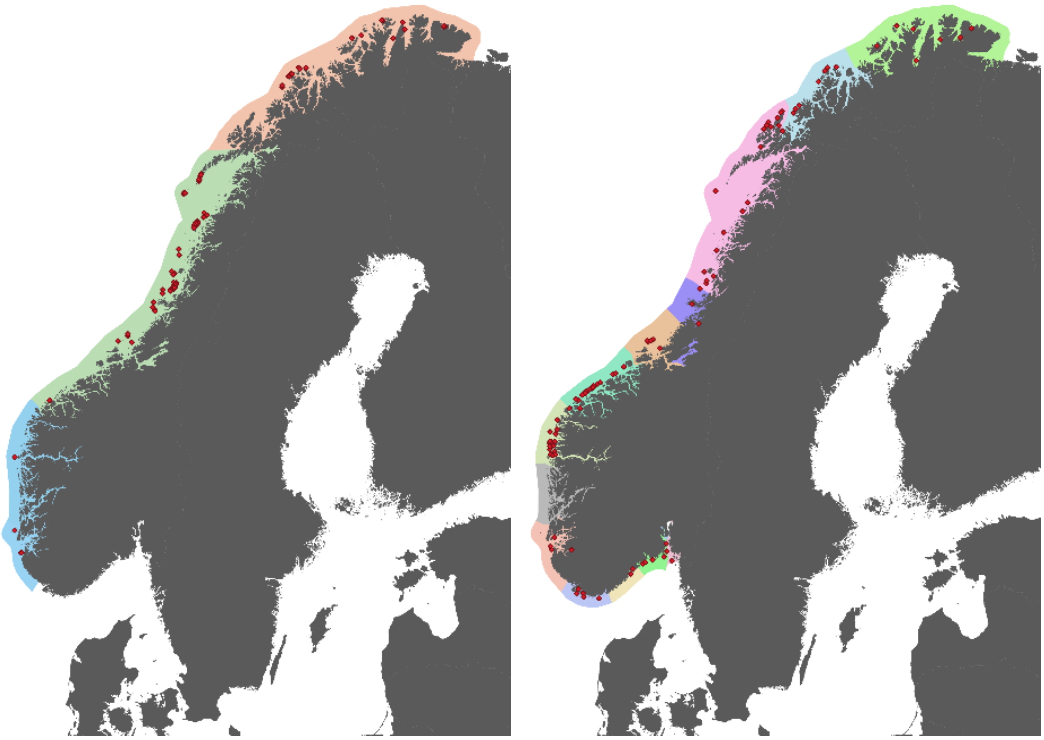

Figure 2.1. Management areas for grey seals (left) and harbour seals (right) in Norway.

During the period 2007-2020, grey seal quotas and catches have varied: in the southern area; the quota has been 60 seals and catches 12-65 seals; mid area quotas have varied from 0-905 and catches 0-210 seals; in the north area, quotas have varied from 140-225 and catches from 4-240 seals. In 2009-2020, total harbour seal quotas have been 425-704 and catches 159-585 seals.

2.2 Regional Sea Conventions, and Marine Mammal indicators under OSPAR and HELCOM

OSPAR

WGMME has reported previously on the OSPAR common indicators (e.g. ICES, 2016). There are four common indicators related to marine mammals, and two candidate indicators ('marine mammal bycatch in OSPAR region I) and 'Persistent chemicals in marine mammals', which WGMME reported on previously; e.g. ICES, 2020c). Assessments of the common indicators will inform the upcoming OSPAR Quality Status Report of 2023 (QSR 2023). The objective of QSR 2023 is to (i) assess the environmental status of the Northeast Atlantic against the objectives of the North East Atlantic Environmental Strategy 2010-2020 (NEAES, 2020); (ii) evaluate any updated or additional objectives from NEAES 2020-2030; and (iii) identify the priority elements for actions to achieve OSPAR's vision for a clean, healthy, biologically diverse sea, used sustainably.

QSR 2023 can be used by Contracting Parties that are also EU Member States to support their reporting MSFD obligations for 2024.

There are currently two common indicators for seals: M3 (harbour and grey) seal abundance and distribution, and M5 grey seal pup production. The assessment of seal abundance and distribution aims to determine if populations are in a healthy state, with no long-term decrease in population size, beyond natural variability. Assessments of pup production examine trends in the number of grey seal pups born at long-established breeding sites. Assessments of these two common indicators for the Quality Status Report 2023 were signed off at the meeting of the OSPAR Biodiversity Committee (BDC) in April 2022.

There are currently two common indicators for cetaceans: M4 cetacean abundance and distribution, and M6 marine mammal bycatch. The assessment of cetacean abundance and distribution aims to determine if populations are in a healthy state, with no long-term decrease in population size, beyond natural variability. Assessment of these common indicators for the QSR 2023 was signed off at the meeting of BDC in April 2022. The assessment of marine mammal bycatch aims to determine the impact of fisheries bycatch on the long-term viability of harbour porpoises, common dolphins and grey seals in the Northeast Atlantic. The assessment of common indicator M6 was not signed off at BDC in April 2022: it was, however, agreed to further clarify the assessment text with respect to conservation objectives to address some remaining reservations from contracting parties.

A new pilot indicator “Trends and Status of PCBs in marine mammals” is going to be developed under OSPAR HASEC, with OSPAR BDC being informed of the development. This pilot indicator is led by Koen Parmentier (BE) and Marianna Pinzone (DE). Upon complete development and operationalization, this indicator will both inform on the health of marine mammals and that of the marine environment. This pilot indicator is also of MSFD relevance, especially with respect to Descriptor 8 (contaminants).

NEAES 2020-2030

OSPAR NEAES 2030 sets out collective objectives for OSPAR contracting parties to tackle biodiversity loss, pollution (including marine litter) and climate change in the OSPAR Maritime Area. Of relevance to marine mammal management is Strategic Objective 7: « ensure that uses of the marine environment are sustainable, through the integrated management of current and emerging human activities, including addressing their cumulative impacts. » In particular, « OSPAR will work with relevant competent authorities and other stakeholders to minimise, and where possible eliminate, incidental bycatch 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 bycatch by 2025 » (S7O6). This objective aligns with the outcomes of the 2019 joint OSPAR-HELCOM workshop on bycatch (see ICES, 2020c). This workshop recommended, *inter alia*, the following conservation objective: "Minimise and where possible eliminate incidental catches of all marine mammal and bird species such that they do not represent a threat to the conservation status of these species"; and proposed as a management objective that "the mortality rate from incidental catches should be below levels which threaten any protected species, such that their long-term viability is ensured".

HELCOM

WGMME has previously reported on HELCOM core indicators (e.g. ICES, 2020c). In the Baltic Sea, HELCOM uses three core indicators for seals: Population trends and abundance of seals, Distribution of Baltic seals, and Reproductive Status of Seals. The evaluation of the indicators is based on the data from the standardized aerial monitoring during the moult and on more scattered information on breeding and foraging distributions. The Population trends and abundance of seals evaluates the state of the seal populations in each management unit. The reproductive status of seals in the Baltic Sea is assessed as in good status when the annual reproductive rate (i.e. the proportion of females pregnant/showing postpartum pregnancy signs per year) is at least 90% for harbour seals of five years and older, and grey and ringed seals of six years and older. A reproductive rate of 90% is defined as the threshold for each of these parameters as this is indicative of increasing populations.

HELCOM has a core indicator for marine mammal bycatch: Number of drowned mammals and waterbirds in fishing gear. This indicator aims to provide an evaluation of whether the number of incidentally by-caught marine mammals are below mortality levels that the long-term viability of populations in the HELCOM area is not threatened.

HOLAS III

The HELCOM Holistic Assessments provide a comprehensive overview of the ecosystem health of the entire Baltic Sea over a specific time span. The third Holistic Assessment of the Baltic Sea (HOLAS III) covers the assessment period 2016–2021 and is expected to be published in 2023.

Sveegaard *et al*. (2022) provided a new map of harbour porpoise presence within the HELCOM area for HOLAS-III. The map was based on data from telemetry and visual surveys for the Belt Sea population and passive acoustic monitoring (SAMBAH and national surveys) and national expert judgement for the Baltic Proper population (see also ToR A for new information on abundance).

WADDEN SEA SEAL AGREEMENT (Denmark, Germany and the Netherlands)

The protection of seals in the Wadden Sea is regulated by the Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea Seal Agreement, WSSA) between Denmark, Germany and the Netherlands. The agreement was implemented in 1990 and was the first international, legally binding agreement under the auspices of the UN Convention on the Conservation of Migratory Species of Wild Animals (CMS). The Trilateral Wadden Sea Cooperation's aim with the agreement was to achieve and maintain a favourable conservation status for the Wadden Sea harbour seal population through close collaboration in research and monitoring and by increasing public awareness of seals. As grey seals have become more abundant since the signing of the Wadden Sea Seal Agreement, they have been included in the Seal Management Plan elaborated under the Wadden Sea Seal Agreement, while they are not covered by the Agreement itself.

The Seal Management Plan builds on the Seal Agreement and contains objectives and action points on research and monitoring, taking of seals, rehabilitation, habitat protection, pollution, and increase of public awareness. The plan covers the Wadden Sea population of harbour seal and has been extended to cover the grey seals in the Wadden Sea, including both the breeding colonies and the grey seals from other colonies migrating in and out of the area.

The aim of the Seal Management Plan is to ***restore and maintain viable seal stocks and a natural reproduction capacity, including the survival of juveniles of the two seal species.*** A comprehensive set of suggested actions is included based on scientific research and changes in the conservation needs of the Wadden Sea seals. The SMP seeks a balance between conservation and economic development and management of the area. Every five years, the signatories amend the plan in order to meet the challenge of protecting these iconic species of the Wadden Sea. Among the actions covered by the SMP are:

- Coordination of research and monitoring of the seals, including anthropogenic effects.
- Prohibition of taking of seals from the Wadden Sea (with exceptions for scientific purposes and euthanisation)

- Research on habitat use and feeding ecology supporting measures for protection of habitats, including a network of protected areas including haul-outs and migration corridors, protection from disturbances and effects from outside the protected areas
- Reduction of pollution, and research into the sources/effects of pollutants
- Raising public awareness.

2.3 US Marine Mammal Protection Act import provisions rule

The US Marine Mammal Protection Act (MMPA) now includes provisions to reduce marine mammal bycatch associated with fisheries that supply imports to the US (Williams *et al*., 2016). The MMPA bans imports of commercial fish or fish products caught in commercial fisheries resulting in the accidental killing or serious injury (bycatch) of marine mammals in excess of US standards. After a five-year, one-time exemption (beginning January 2017) and from 1 January 2022, harvesting nations must apply to the US National Marine Fisheries Service (NMFS) for a 'comparability finding' whereby NMFS must assess that the harvesting nation regulates bycatch of marine mammal with measures comparable in effectiveness to the US MMPA. The assessment of comparability is based on

- the prohibition of the intentional killing or serious injury of marine mammals in all fisheries;
- the existence of programs to assess marine mammal stocks, estimate bycatch, calculate bycatch limits, and reduce total bycatch below the bycatch limit for fisheries that have interactions with marine mammals; or
- the implementation of alternative measures comparable in effectiveness for those fisheries.

The import provisions provide incentives and opportunities to reduce marine mammal bycatch. Bering *et al.* (2022) provided a first analysis of this new rule (hereafter, the Import Rule) on harvesting nations at the close of 2021. After identifying harvesting nations most likely to lose economically if denied a comparability finding, Bering *et al.* (2022) broadly classified some 20 nations into three main groups depending on their approaches to marine mammal monitoring, fisheries management and enforcement capacity. The first group had fisheries and marine mammal management programs along with a strong enforcement capacity. This group has a high likelihood of being granted a comparability finding. The second had some general provisions for bycatch management un fisheries but was lacking data on marine mammals and specific policies on marine mammal protection or bycatch. The third group had less robust fishery management programs, little enforcement capacity, and little or no data on marine mammal or bycatch. China, as the world's leading exporter nation of fish and sea products, was discussed separately.

LENFEST OCEAN PROGRAM

Many of the harvesting nations may not have sufficient data or regulatory capacity to monitor, evaluate, and reduce marine mammal mortality (Bering *et al*., 2022). A dedicated research program was funded in 2018 by the Lenfest Ocean Program to develop scientific tools (including user-friendly software) to evaluate data sets and methods for determining bycatch rates for marine mammal populations (https://www.lenfestocean.org/fr/research-projects/developing-recommendations-to-estimate-bycatch-for-the-marine-mammal-protection-act).

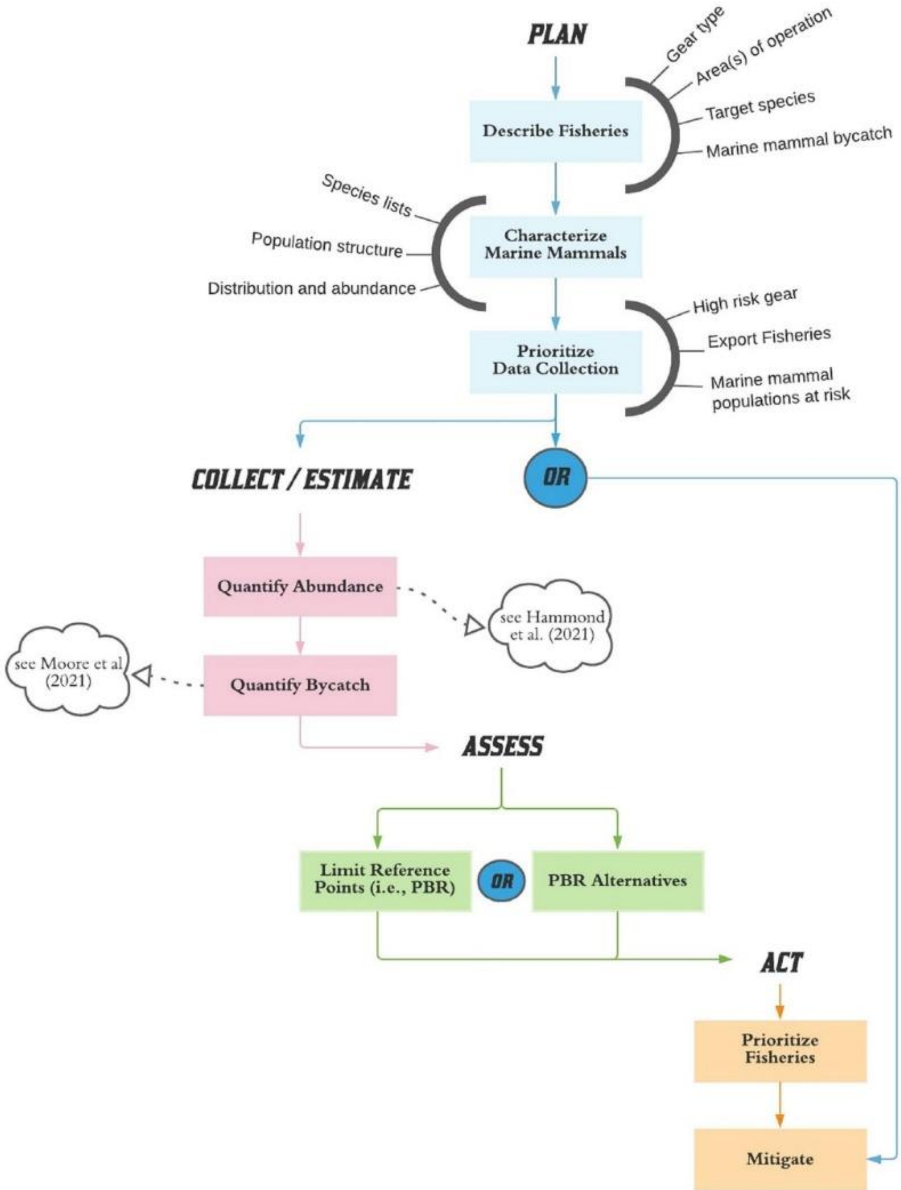

Figure 2.2. Flow chart outlining the conceptual framework for assessing and managing bycatch of marine mammals (Wade *et al.*, 2021; source: https://www.frontiersin.org/files/Articles/757330/fmars-08-757330-HTML-r1/image_m/fmars-08-757330-g001.jpg)

The output of this project includes several review papers published in a special issue of the scientific journal *Frontiers in Marine Science* (https://www.frontiersin.org/research-topics/20611/assessment-approaches-to-support-bycatch-management-for-marine-mammals#articles) and an R shiny app to assist harvesting nations so that they can evaluate potential management strategies (https://msiple.shinyapps.io/mmrefpoints/).

In particular, Wade *et al*. (2021) outlined a framework for assessing and managing marine mammal bycatch (Figure 2.2). The steps involved include (i) collecting data on the abundance (comprehensively reviewed in Hammond *et al*., 2021b), (ii) estimating bycatch of marine fauna and on fisheries that are known or suspected to cause bycatch mammals (comprehensively reviewed in Moore *et al*., 2021); and assessing the impact of bycatch in relation to reference points or removals limits (an example of which is provided by Genu *et al*., 2021). More information of the outcomes of the Lenfest Ocean program are available at https://www.youtube.com/user/lenfestocean.

EFFECT OF THE US IMPORT RULE IN ICES COUNTRIES

WGMME designed a short questionnaire to inquire about the implementation of the US import rule in ICES countries. Results are summarized in Table 2.1.

Table 2.1: Summary of received answers on the implementation of the US Import Rule (NA: not available).

Country	Response	Export to US? (applicability of Import Rule)	Submitted comparability finding application?	Any legislation change to meet requirements of the Import Rule?
Belgium	no	NA	NA	NA
Denmark	yes	yes	yes	no
Faroes	yes	yes	yes	yes
Finland	no	NA	NA	NA
France	yes	yes	yes	no
Germany	yes	no	no	
Greenland	yes	yes	yes	no
Ireland	yes	yes	yes	no
The Netherlands	yes	yes	yes	no
Norway	no	NA	NA	NA
Poland	no	NA	NA	NA
Portugal	no	NA	NA	NA
Spain	yes	yes	yes	no
Sweden	yes	yes	yes	no
United Kingdom	yes	yes	yes	yes

10 countries out of 15 provided an answer. The majority of countries responding reported to have submitted a comparability finding application for at least one of their fisheries (9 out of 10): the country that did not do so (Germany), does not export fish products to the USA. Applications were mainly submitted by ministries in charge of fisheries or agriculture. A minority (2 out 9) of countries, which had submitted an application, had made legislative changes to meet the requirements on the import rule, although some did not exclude the option. Changes made were with respect to the management of seals (culling ban enforcement) and the monitoring of interactions between marine mammals and fisheries.

Brief questionnaire regarding the US Marine Mammal Protection Act (MMPA) import provisions

From 01 Jan 2022, after a five-year exemption period, a new US import rule (US Marine Mammal Protection Act (MMPA) import provisions; hereafter the Rule) has been coming into effect. This means that any foreign fish nation which produces, imports, processes, or re-exports fish or fish/seafood products (also from aquaculture) to the United States needs to enforce fishery or protected species conservation and management regulations to address incidental mortality as well as measures to address intentional mortality and serious injury of marine mammals. These products can only be imported to the US if the nation has applied for and received a 'comparability finding' from the National Marine Fisheries Service (NMFS). NMFS emphasizes the need for calculation of a bycatch removal level, like the Potential Biological Removal in the US. The methods used to calculate allowable removal levels of a marine mammal must be based on recent data.

Sources:
https://www.federalregister.gov/documents/2016/08/15/2016-19158/fish-and-fish-product-import-provisions-of-the-marine-mammal-protection-act
https://media.fisheries.noaa.gov/dam-migration/mmpa_import_rule_compliance_guide_april_2019_eng_508.pdf

Questions
Did your country apply to receive a comparability finding for the fishery?
If yes

a) can you provide some more information on the current status of the process (comparability finding has been granted…) and the fisheries / marine mammal species involved?
b) did the process led to any change in monitoring or management (e.g. ban on shootings of problematic animals depredating aquacultures? new legislation on either the protection of marine mammals or the regulation of fisheries, including aquaculture? new monitoring requirements? new surveys to assess marine mammal populations?)
c) do you know who was involved in the process (Ministry in charge of fisheries? Ministry in charge of the protection/conservation of marine mammals?) ?

If no (multiple answers are possible), is it because

d) your country does not export fish/seafood product to the US (note that the Rule still apply if a country process fish/seafood that it has imported from elsewhere and export the end product to the US)?
e) of a lack of legislation on marine mammal protection in your country (the Rule requires the strict prohibition of intentional killing of marine mammals)?
f) of a lack of monitoring of marine mammal stocks/populations in your country?
g) of a lack of monitoring of marine mammal interactions with fisheries in your country?
h) of unknown reasons
i) of other reasons: please describe any other reasons

BOX 1. Short questionnaire sent by WGMME to investigate the effect of the US import provision

This short survey was carried out as countries which have submitted an application have yet to have feedback from the US National Marine Fisheries Service (NMFS). Results nevertheless point to a majority of countries to have applied at this stage without legislative changes. This result aligns with findings from Bering *et al.* (2022), who noted that developed countries had a strong enforcement capacity and little obstacle to apply for a comparability finding.

2.4 Acknowledgements

We would like to thank the following for providing supporting information on management: Mathieu Rateau (France), Jenny Renell (ASCOBANS Secretariat), Aqqalu Rosing-Asvid, and Fernando Ugarte (Greenland).

3 ToR C: Review and report on any new information on seal and cetacean anthropogenic threats (including cu-mulative effects) to individual health and population status in the North Atlantic

3.1 General Information

The aim of this ToR is to list recent published information about anthropogenic threats to marine mammals (cetaceans and seals) described in the ICES area and including relevant studies in the North Atlantic Ocean. In previous rapports, (for example ICES 2019; ToR D) a threat matrix was developed for the majority of areas covered by ICES and an effort was made to produce an inventory of possible threats and their relative effects on the different marine mammal species occurring in each ICES ecoregion. Here we provide for an update of such threats. It must be noted that the absence of information in some regions does not imply a lack of emerging and ongoing threats, or exempt us from, regular monitoring not only to inform about current threats but also to detect possible emerging threats.

3.2 Cumulative effects

3.2.1 General

Given the diversity of existing approaches for assessing the combined effects of multiple stressors on wildlife populations, and the need for a consistent use of concepts and terms across disciplines involved, Pirotta *et al*. (2022) presented a conceptual framework that brought together existing analytical approaches. They suggested that all approaches lie along a spectrum reflecting increasing assumptions about the mechanisms that regulate the action of single stressors and their combined effects, from data-driven (i.e. phenomenological) to process-driven approaches (i.e. mechanistic). The spectrum presented can be translated into specific analytical methods and this was demonstrated using the North Atlantic right whales as an example, which is concurrently affected by limited prey resources and fishing gear entanglement risk. Following their approach of adaptive management, depending on the management needs and priorities, as well as the data available, different stressor combinations were selected and a suitable trade-off between precision and bias could then be applied for each case-specific assessment.

The factors driving reproductive success in small cetaceans were investigated by IJsseldijk *et al.* (2021), using the harbour porpoise, an extensively studied species, as an example. First, they studied the effect of intrinsic factors (such as health and nutritional status) on reproductive success in terms of pregnancy and foetal growth rates. Then, they investigated the extrinsic factors (prey energy density, cumulative human impact, and PCB contamination) effect on life history parameters. Their results showed that in the Northern Hemisphere, pregnancy rates of small cetaceans are best explained by prey density which determines their reproductive success and as a result, the population size, highlighting the need for undisturbed access to highly energetic prey.

3.2.2 Regional

NORTH SEA: Since 2000, many countries have built windfarms in the North Sea, reaching a capacity of approximately 20 GWs in 2020 (Gușatu *et al*., 2021). The aim for a large majority of countries to transition to renewable energy sources will result in the coming decades facing even greater challenges, especially for the marine environment. Areas in the southern North Sea in particular will be under continuous construction, aiming at a total capacity of between 180 GW and 212 GW by 2050 (Figure 3.1). There is, however, a general lack of understanding to oversee the possible cumulative effects on the species inhabiting these areas already under pressure from different stressors, including: heavy marine traffic (Rotterdam, Antwerp and Hamburg being among the largest ports in the world), fisheries, sand mining (for coastal protection as sea level rises), and other activities such as pollution, oil and gas extraction, military activities, sonar exploration and the explosion of bombs left over from the 2nd World War. The most studied were the effects of the construction phase of offshore wind farms (OWFs), more specifically pile driving. However, there are additional and less studied effects related to construction and operation of OWFs including disturbance from other activities such as increased marine traffic, sonar, airguns, bomb explosions, disturbance and displacement of prey. Moreover, very few studies have been commissioned to understand the effects of multiple sites being constructed or in operation at the same time, or a combination of these. In the near future, many coastal marine mammal populations will be confronted with the intensified use of the coastal regions for the production of renewable energy on top of the growth of other uses of their marine environment. Much effort will be needed to collect data and provide advice on the management of the marine mammal populations and ensuring sufficient resilience in the populations to cope with these changes.

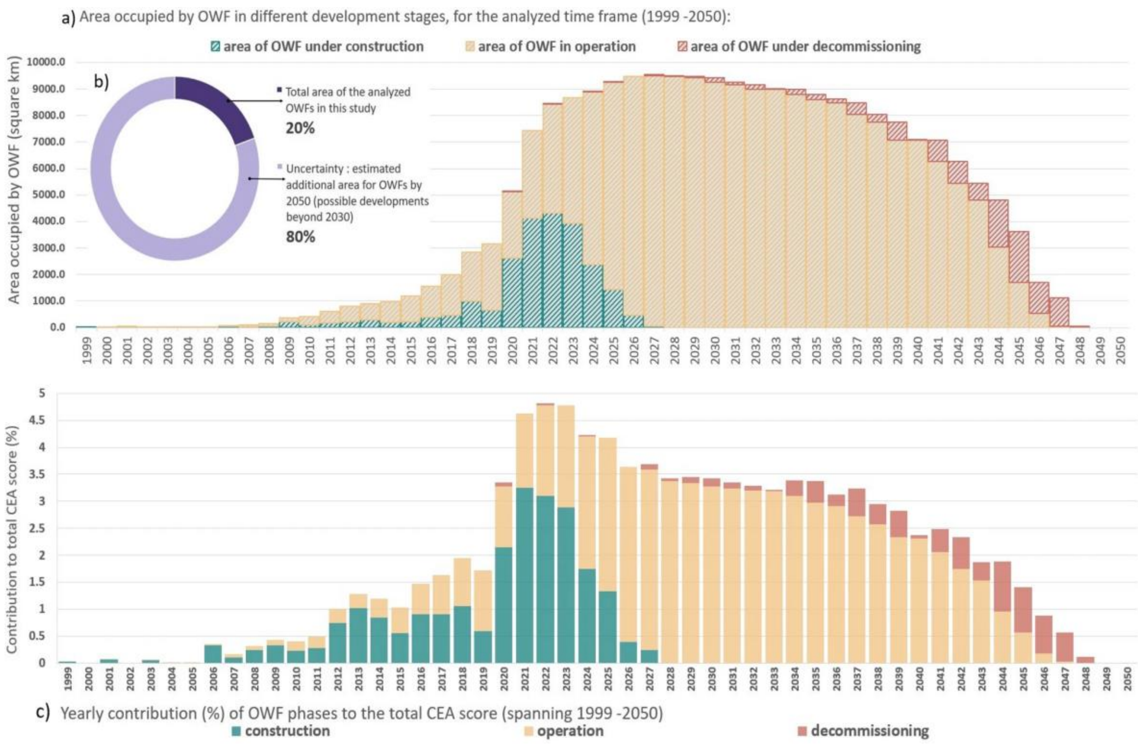

Figure 3.1. (a) Area occupied by OWFs in different development stages, for the analysed time frame (1999–2050); (b) estimated additional area for OWFs by 2050 (search areas, development areas, scoping areas for deployments beyond 2030)—uncertainty; (c) yearly contribution (%) of OWF phases to the total CEA score (spanning 1990–2050). Extracted from Gușatu *et al.* (2021).

3.3 Fishery Interactions

3.3.1 General

For most marine mammal species, entanglement in fishing gear is considered the main anthropogenic source of mortality. This has been the case for several decades and despite various attempts in Europe to reduce its impact specifically on cetaceans through legislative instruments, the problem remains, and there is little understanding of the population effects upon seals. One reason is the lack of knowledge to apply appropriate mitigation measures due to the significant financial and human resources required to monitor bycatch rates, identify areas, times and precise gear presenting greatest risk, before applying appropriate mitigation measures.

In response to a request from the European Commission, Evans *et al.* (2021) produced risk maps depicting the spatial and temporal overlap of fishing effort by gear type and density distributions of cetacean species regularly occurring in the North-east Atlantic and demonstrated from the literature to be vulnerable to bycatch. Using AIS data and machine-learning algorithms developed by Global Fishing Watch to better measure actual fishing effort, maps were prepared for ten gear type groupings (pelagic trawls, pelagic seines, demersal trawls, demersal seines, driftnets, static gillnets, trammel nets, set longlines, drifting longlines, pots & traps) for the Atlantic area from southern Norway to Portugal covering the years 2015 to 2018, and by nation. Maps of density distributions of 12 cetacean species (and 13 seabird species) were prepared by season using a modelling approach that incorporated environmental variables applied to two oceanographic domains: southern Scandinavia to NW France (northern) and NW France to southern Portugal (southern). These were based upon 1.25 million kilometres of dedicated survey effort for the northern domain, and 0.82 million kilometres for the southern domain, provided by 47 research groups, with surveys undertaken across the period 2005 to 2020. Standardised AIS effort rasters and animal density rasters were multiplied to create new rasters of relative bycatch risk for all twelve species. Overlap for every species-gear type combination was mapped for northern and southern domains on a seasonal basis, and with overlays of protected areas, identifying areas and times of greatest risk.

3.3.2 Regional

ICELAND: Efforts to estimate bycatch of cetaceans in Icelandic fisheries continued at the Marine and Freshwater Research Institute (MFRI), including experiments with acoustic deterrents, as well as direct observations and analysis of logbooks (Basran and Sigurðsson 2021, MFRI unpublished data).

BALTIC SEA: Danish and Swedish commercial gillnet fisheries operating in the ICES subdivisions 3.a.21, 3.b.23, and 3.c.22 were monitored with the aim of estimating the number of bycaught harbour porpoises and seals by these fleets (Glemarec *et al*., 2021). These bycatch rates were estimated from remote electronic monitoring data gathered from nine Danish commercial gillnet vessels. In 2018, a total of 601 bycaught harbour porpoises were estimated and in the case of seals, not identified to species level, the number of individuals bycaught was estimated to be 286 individuals. Most of the bycatch events were predicted in spring in Subregion 3.a.21, and in spring and summer in the Subregion 3.c.22.

NORWAY: Bycatch rates and total bycatch were estimated for harbour porpoise (between 2006-2018) and harbour and grey seal (between 2006-2020) in Norwegian commercial gillnet fisheries. A total bycatch of 757 seals (394 harbour seals and 363 grey seals) was estimated (Moan *et al*., 2021). In the case of the harbour porpoise, the estimated number of porpoises bycaught varied between 1151 and 6144 per year. Most (75%) harbour porpoise bycatch occurred in monkfish fisheries. These fisheries showed a decline in fishing effort during the last 4-5 years, which was also reflected in the bycatch estimates as a decrease in bycaught animals (Moan *et al*., 2020).

SWEDEN: Post-mortem examinations were performed on 128 stranded harbour porpoises collected over 15 years (2006-2020) in Swedish waters. Information was gathered on their general health, disease findings, and causes of death. The main cause of death was bycatch in fishing gear (31% of the cases confirmed or suspected). However, disease, most often pneumonia, was also a frequent cause of death (21%). (Neimanis *et al*., 2022)

DENMARK: Total bycatch in the Danish commercial gillnet fishery was estimated for seabirds and marine mammals, using electronic monitoring (EM) (Larsen *et al*., 2021). This monitoring recorded the fishing activity of 16 vessels between 2010 and 2016 in the North Sea, Skagerrak, Kattegat, Belt Sea, and Western Baltic Sea. Temporal and spatial distribution of bycatch events in gillnets and mean quarterly bycatch rates were estimated for the areas with enough EM data. The season with greater bycatch impact on harbour porpoises and seals was the 3rd quarter, with a total average of 2722 porpoise and 890 seal bycatches per year. Using a modelling approach and data from interviews with commercial fishermen, it was concluded that bycatch of seals and harbour porpoises was highly influenced by mesh size, fishing depth, distance to the shore and quarter of the year.

GERMANY: The bycatch risk that fishing nets pose could be reduced by increasing their detectability. Kratzer *et al.* (2020) identified small, passive reflective objects which might improve the detectability of gillnets for various frequencies that could be used for many odontocete species. They simulated the acoustic reflectivity and calculated the detection distances of a wide range of materials, mainly synthetic polymers, in different shapes, sizes, and environmental conditions. Attaching acrylic glass spheres to the net, at intervals smaller than 0.5 m, increases the detection of the net at a frequency of 130 kHz, equalling the detection of the entire net to the detection of the floatline. Modifications of the netting material itself (e.g. using barium sulphate additives) did not seem to significantly increase the acoustic reflectivity of the net.

Chladek *et al*. (2020) tested another form of acoustic alerting device called Porpoise ALert (PAL) in commercial gillnetting vessels between 2014 and 2016, carrying out a total of 778 trips. They deployed 1120 net strings of PAL-equipped nets and 1529 control nets without PAL. Overall, 18 harbour porpoises were bycaught in control strings, and five harbour porpoises in strings equipped with PAL. Generalised linear mixed model (GLMM) revealed a significant negative relationship between the expected bycatch and PAL deployment. The deployment of PAL caused a decrease in the expected bycatch of 64.9% (C.I: 8.7-88.7%). Reducing the device spacing to ≤ 200 m significantly increased the effectiveness of the PAL.

FRANCE: The number of bycaught dolphins per week was estimated for 10 different ICES divisions between 2004 and 2020 (Rouby *et al*., 2022). Bycatch risk, haul duration, and number of hauls per days at sea, were estimated jointly with the number of bycaught dolphins. They used a regularised multilevel regression with post-stratification in a Bayesian framework to estimate total bycatch from unrepresentative samples and total fishing effort. The results showed that during winter 2017 and 2019, French pair trawlers posed the highest bycatch risk, associated with the longest haul duration. Also, the shelf part of the Bay of Biscay (ICES divisions 8a and 8b) was estimated to have the highest bycatch of common dolphin.

For further general information on bycatch, see also ToR E. And for management of hunting of marine mammals, see ToR B.

3.4 Chemical Pollution

3.4.1 General

Currently, only a fraction of the extractable organofluorines (EOF) occurring in the marine environment are routinely monitored, comprising around 20 perfluoroalkyl and polyfluoroalkyl substances (PFAS). To assess whether PFAS exposure may be underestimated in marine mammals inhabiting waters of the Northern Hemisphere, Spaan *et al.* (2020) performed a fluorine mass balance on liver tissue of 11 species of marine mammals. The screening revealed almost 40 additional PFAS that have not been included in routine monitoring, and also presented the first report of FTCA in polar bears and cetaceans. Therefore, current monitoring was found to be underestimating the exposure of marine mammals to these substances, for most of which hazard data are currently unavailable.

3.4.2 Regional

ICELAND: Remili *et al.* (2021) determined the concentration of PCBs, DDTs, chlordane, PBDEs and HCBs in killer whales of the southern and western waters of Iceland. They analysed 64 biopsies of skin and blubber from 50 individuals, collected in 2014 and 2016. The PCB concentrations ranged between 1.3 and 428.6 $mg \cdot kg^{-1}$ lipid weight. The mean PCB concentration in the most polluted individual was 300 times higher than in the least polluted. Killer whales in these waters are thought to be feeding on herring, but recently they have been recorded feeding also on other marine mammals. Killer whales feeding on fish were identified by their lower $\delta^{15}N$ values and were observed following herring around Iceland, while mixed-diet killer whales showed higher $\delta^{15}N$ values and were observed travelling to Scotland, where they target marine mammals. Individuals with a mixed diet (of herring and marine mammals) showed a PCB concentration 6-9 times higher than the ones feeding only on herring.

BALTIC SEA: The relationship between persistent organic pollutants (POPs) and mercury with transcription profiles of seven health-related genes involved in xenobiotic metabolism, endocrine disruption and stress in ringed seals was studied by Ometere *et al.* (2020). Between 2018 and 2019, they collected tissue samples from 15 ringed seals. POPs and Hg concentrations varied between age classes, being higher in adults and lower in sub-adults, whilst no significant differences were found between sexes. Thyroid hormone receptor alpha (TRα) was highly correlated with POP levels and with Hg concentrations in liver, while retinoic acid receptor (RARα) and heat shock protein 70 (HSP70) were only correlated with POPs concentrations.

NORWAY: Stranded and bycaught killer whales from northern Norway were sampled between 2015 and 2017, to investigate tissue partitioning and maternal transfer of legacy and emerging contaminants, focusing on non-regulated brominated flame retardants (BFR) (Andvik *et al.*, 2021). PCBs made up between 40 and 62% of the total contaminant levels in each individual and tissue type while emerging BFR levels were found to be several orders of magnitude lower, only contributing 0.4%, but were higher in blubber. In 7 out of 8 individuals, PCB levels in blubber exceeded the threshold set for physiological effects (9 μg/g lipid weight) and 2 adult males exceeded the threshold for profound reproductive impairment (41 μg/g lipid weight). Perfluoroalkyl substances (PFAs) and total mercury levels were lower in neonates than in adults, reflecting an inefficient maternal transfer of these compounds. In contrast, PBT and HBB levels observed in the neonate sample constituted the first reported maternal transfer of emerging BFRs in marine mammals.

SWEDEN: The prevalence of intestinal ulcers in grey seals from the Baltic Sea was investigated by Bäcklin *et al.* (2021). They found an increase in prevalence in the early 1980s, followed by a decrease in the mid-1990s. These changes were concurrent with similar fluctuations of concentrations of perfluorinated compounds, brominated flame retardants, and cadmium in the most common prey item of Baltic grey seals, herring. Frequency of ulcers was related to intensity of acanthocephalan parasite infestation, seal age, and region within the Baltic Sea. Out of a total of 2172 grey seals, ulcers were the cause of death in 26 Atlantic grey seals while 49 of the examined individuals did not have any ulcers.

DENMARK: Desforges *et al*. (2021) characterised the distribution and speciation of mercury across multiple brain regions and marine mammal species. They found differences in the concentrations of total mercury and methylmercury between species, not only in mean brain concentrations but also in brain region-specific concentrations. Higher concentrations were found in toothed whales compared to fur-bearing animals, which was associated with a marked reduction in the percentage of methyl mercury and to an overall higher number of mercury-associated neurochemical biomarker correlations. Some of the region-specific exposures to mercury may be associated with sub-clinical changes in their neurochemistry.

UNITED KINGDOM: The effects of persistent organic pollutants on mass gain rate of grey seal pups from the Isle of May, Scotland were studied by Bennett *et al*. (2021). They found that the repressive effect of dioxin-like PCBs on blubber glucose uptake was associated with significant reduction of weaning weight. Polybrominated diphenyl ethers, on the other hand, were associated with faster mass gain. The largest pollutant-induced reductions of weaning weight were estimated to occur in the smallest pups, which may compromise their first-year survival.

Also, in grey seal pups, the presence of *Chlamydia*-like organisms (CLOs) in the nasal cavities was investigated by Dagleish *et al.* (2021). These organisms have been associated with human sewage and agricultural run-off. DNA from CLOs was detected in 32 of 92 nasal swabs from live and dead pups. No difference was found in the detection rates between live and dead pups, suggesting that the organisms are commensal rather than pathogenic, although their potential as opportunistic secondary pathogens could not be determined.

IRELAND: Galway-Mayo Institute of Technology (GMIT), in collaboration with the Institute of Zoology, London, were awarded an Irish Marine Institute tender in 2021, studying the "*Assessment of pollutant burdens and associated risks to small cetaceans in Irish waters*". The work includes collating and quality checking contemporary and historical data from cetaceans in Irish waters, undertaking an assessment of the pollutant burdens and associated risks to small cetaceans in Irish waters, as well as providing recommendations for future monitoring and assessment. To aid the development of OSPAR's marine mammal contaminant indicator and Member State obligations under the MSFD, the current study also aims to further develop appropriate methodological standards using data collected by the established UK marine mammal pollutant monitoring programme to assess the trends and status of PCBs in harbour porpoises sampled in UK waters, as a case study. The work includes assessing the statistical power to detect trends in UK juvenile harbour porpoise ΣPCB data.

NETHERLANDS: Van den Heuvel-Greve *et al.* (2021) investigated the generational transfer of PCBs, PBDEs and HCB from adult harbour porpoises to foetuses, using samples from individuals stranded along the southern North Sea. The concentration of contaminants in the placenta and the foetus blubber were similar, but after birth, the levels in new-borns increased significantly through suckling, especially those of low halogenated contaminants. Nutritionally stressed females produced a higher offloading in the milk, which caused greater potential for toxicity in calves. Of all animals studied, almost 40% exceeded threshold level for negative health effects (>9mg/kg lipid weight). As the PCB concentration grows, the probability of a porpoise dying due to infectious disease or debilitation increases.

In harbour seals from the Wadden Sea, the relationship between trace elements, including heavy metals, and oxidative stress biomarkers such as triglycerides, thiols, malondialdehyde and glutathione was investigated by Gismondi *et al.* (2021). Correlations with concentrations of copper, lead, mercury, nickel and zinc were found. The findings suggest that these biomarkers are useful in the assessment of oxidative stress in seals exposed to those elements.

FRANCE: Temporal trends of mercury (Hg), cadmium (Cd) and lead (Pb) were determined through the analysis of 264 individuals from two cetacean species, the common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*) stranded along the French Atlantic coasts between 2000 and 2017 (Méndez-Fernández *et al*., 2022). These individuals belonged to two different management units. The results showed that the Pb concentration decreased over time in both species and management units. The differences found in Hg and Cd trends in both species probably reflected different levels of contamination of the habitat and prey species.

SPAIN: The main objective of the project TRANSITION is to model the interactions between key species of ocean nekton and fisheries. As part of it, blubber samples of the three main species of cetaceans stranded in Galicia (NW Spain) - common dolphin, bottlenose dolphin and harbour porpoise, were analysed to determine the concentrations of PCB, OCP and PBDE. The samples selected were collected from carcasses stranded between 2009 and 2019, including both males and females, with a regular distribution over the years. These analyses were coupled with stable isotope analysis and the full analysis results will be ready shortly. Preliminary results show a higher concentration of organic pollutants in male bottlenose dolphins, followed by harbour porpoise.

PORTUGAL: Concentrations of nine trace elements in kidney, liver and muscle samples from 31 striped dolphins stranded along the western coast of Portugal from 2005 to 2014 were evaluated by Monteiro *et al*. (2020). All the trace elements increased as a function of dolphin body length, except Mn and Zn. High concentrations of hepatic and renal Cd, and renal Se were correlated to the presence of gross pathologies, while dolphins with parasites showed higher Hg concentration in the muscle. A decreasing gradient of concentrations in liver > kidney > muscle was found.

MACARONESIA (Madeira, Canary Islands): Montoto-Martínez *et al*. (2021) studied the presence of eleven POPs (nonylphenols, bisphenols, phthalates, and pesticides) in twelve muscle samples from six odontocete species: short-finned pilot whale, Risso’s dolphin, Fraser’s dolphin, pygmy sperm whale, striped dolphin and bottlenose dolphin stranded between 2018 and 2019 along the coasts of Madeira and the Canary Islands. The predominant detected pollutants were bisphenols (4–984 ng/g) and DEHP (102–1533 ng/g). Except for two individuals, all animals had pesticide levels in their tissues, although in lower concentrations. No correlations were found among the analysed organic persistent contaminants and microplastic abundance, nor among the size of the animal and the total contaminants present in tissue.

USA: Lian *et al*. (2021) investigated the correlations between mercury concentrations and different types of behaviour in harbour seal pups admitted to a marine mammal centre in California between 2015 and 2019. There was a significant negative correlation between the concentration of THg and responses to tactile stimulation and movements, measured in both hair and whole blood. Additionally, there was a significant association between greater concentration of THg and the number of days spent in rehabilitation, although there was no relationship between concentration of THg and survival. These findings suggest small, but significant, associations between gestational mercury exposure and sensory performance and behavioural attributes.

3.5 Marine Debris

3.5.1 General

The project INDICIT II (*Implementation of the indicator "Impacts of marine litter on sea turtles and biota" in RSC and MSFD areas*) has just finished (2019-2021) (Darmon *et al*., 2022). This project developed standardised tools for monitoring the impact of marine litter on marine fauna (sea turtles, cetaceans, seabirds, and fishes) for the indicators of marine litter developed in the previous project (INDICIT I). A review of images of entangled marine megafauna found on social media and other opportunistic platforms was carried out following the developed "*Social media protocol for entanglement*". In Atlantic waters of France, Portugal and Spain, a total of 17 entangled cetaceans and 1 entangled seal were found. Of the total number of records of stranded cetaceans (a total of 114 cases were found from Mediterranean and Atlantic waters), almost half of the events were classified as bycatch (48.7%) while 11.1% were considered entangled cetaceans, 4.2% were doubtful cases, 4.2% were neither bycatch nor entangled animals, and for 34.7% of the records, there was insufficient data to classify them. Regarding the type of marine litter that affected cetaceans, almost three-quarters were affected by litter from fisheries and maritime uses (fishing nets (40.9%), rope, strings and cords (31.8%) and fishing lines (22.7%)). Three cases of entangled seals were found on social media for both Mediterranean and Atlantic waters. All of them were entangled in marine litter of fisheries and maritime uses: fishing nets (66.6%) and fishing lines (33.3%) (INDICIT II, in press).

As part of routine reporting in the North Sea, Kühn & van Franeker (2020) published a global review on all marine mammal species that have been found to interact with marine debris by either ingesting it or by getting entangled in debris. Out of 123 marine mammal species, 69 were recorded with ingested plastics and 49 as being entangled. In total, 86 marine mammal species were found to have interacted with marine debris.

3.5.2 Regional

ICELAND: The daily ingestion rates of synthetic particles by fin whales feeding in western Iceland was estimated by Garcia-Garin *et al*. (2021). Authors analysed samples of krill collected from the forestomach of 25 fin whales and confirmed the composition of the synthetic items using Micro-Fourier Transform Infrared Spectroscopy. Sixteen synthetic particles were found, ranging from 0 to 2 items per sample. Blue fibres smaller than 0.5mm were the most frequent items found. Authors estimated a daily ingestion rate of between 38 646 ± 43 392 and 77 292 ± 86 784 synthetic particles.

GERMANY: The presence of microplastics in harbour porpoises along the Baltic and North Sea coasts of Schleswig-Holstein (Germany) was investigated by Philipp *et al*. (2021). Microplastics were found in 28 intestinal samples out of the 30 harbour porpoises analysed. A total of 401 microplastics were found and 361 particles were determined (Phillipp *et al*., 2020). Fibres and fragments were present almost in the same proportions, with PEST being the most frequent polymer. Higher numbers of microplastics were found in harbour porpoises from the Baltic Sea than those from the North Sea. The common fibres represented 51.44% for the Baltic Sea and 47.97% for the North Sea. Results showed that individuals with a good or moderate nutritional status had more microplastics compared to individuals of poor nutritional status. No differences were found between the sexes, nor any relationship between parasite presence, tissue damage and microplastic burden.

MACARONESIA (MADEIRA AND CANARY ISLANDS): As part of the study described earlier in the Chemical Pollution section of this report, Montoto-Martínez *et al.* (2021) performed an analysis of the gastrointestinal content of twelve individuals of six odontocete species for the presence of macro- and microdebris. No macrodebris (particles >5mm) was found, except for two plastic labels in the same dolphin. All individuals had microplastics, most of them being fibres (98.06%, n = 708). Previously, in the Canary Islands, a retrospective study regarding foreign bodies (FB) (Puig-Lozano *et al.*, 2018) in stranded cetaceans found a prevalence of 7.74% in the cetacean samples studied, with plastic being the most common item found (80.56%). As a consequence of FB ingestion, 3% of necropsied animals died. Statistical analysis found that poor body condition and deep-diving behaviour were risk factors for FB ingestion, whereas adult age was a protective factor.

3.6 Underwater Noise

3.6.1 General

The presence of *prestin*, a motor protein of the outer hair cells (that may function as a cochlear amplifier for high frequency sounds), has been reported by Morell *et al*. (2020) all along the cochlear spiral in five echolocating cetacean species (harbour porpoise, bottlenose dolphin, common dolphin, striped dolphin and beluga whale) and two bat species. Based on *prestin* labelling, they described a potential methodology for detecting cases of acute noise-induced hearing loss in stranded marine mammals and therefore to potentially assess the effects of underwater anthropogenic noise. They also present a protocol to distinguish between newly formed and old lesions through the labelling of the cells of the Organ of Corti and associated innervations, combining several antibodies.

Southall *et al*. (2021) made a review of the latest studies on marine mammal noise exposure since their last publication in 2007. From their initial severity scale that segregated noise exposure into "pulse" and "non-pulse", they now present a new approach in which noise sources are segregated into functional categories (effective industrial categories). The response of wildlife to noise can be estimated through probabilistic response functions that provide greater accuracy for predicting effects than all-or-nothing thresholds. The estimated probability of an individual responding varies as a function of the acoustic exposure, which can be determined using different parameters for acoustic dosage, and pooling data from sets of populations and sound types. Since poor pooling will fail in estimating the response of sensitive species, they advocate for a framework for systematically and objectively assessing available science and yield a manageable number of probabilistic functions to make informed decisions. To do so, pooling should be made for taxa, sounds and contexts that show similar dose-response patterns, as the number of response studies increase. They also advocate and recommend a robust and systematic reporting of key exposure, contextual and response metrics in experimental and observational studies since the framework proposed requires data to be integrated from many separate studies that should have common measures.

A possible predictor of behavioural response of marine mammals to anthropogenic sound may be the perceived loudness of a given sound, which is in fact a common metric used for sound exposure. Various factors are related to the loudness, such as stimulus duration and frequency content, which can be approximated by applying weighting functions to the signal in both frequency (using auditory weighting functions) and time (using the running rms-average (L_{eq})). Tougaard and Beedholm (2019) have developed a practical implementation of these functions to derive the weighted peak of a signal, which can be used as a proxy for loudness. An auditory frequency weighting function developed specifically for marine mammals can be used so it reflects the perceived loudness in such species as accurately as possible.

To simulate the response of whales to anthropogenic sound through space and time, Joy *et al*. (2022) developed a stochastic movement modelling approach, based on a sequential Monte Carlo sampler. The model considers the vertical dimension which is coupled to a model of horizontal movement. These random movements, or trajectories, are guided by historical distribution and density of the whales in the area. Then, through the use of a biphasic dose-response function (dependent on the received sound level), noise disturbance is incorporated into the model to define the probability of a behavioural response. The aggregated impact is assessed by considering the duration of the foraging loss and the change to a less favourable habitat. They applied the modelling approach to a population of fin whales in Southern California, whose distribution overlaps naval sonar testing activities.

3.6.2 Regional

SWEDEN: Through spatially explicit modelling, Tougaard and Mikaelsen (2020) performed and updated the behavioural disturbance assessment of sound pressure levels around the construction (pile driving) and operation of an offshore wind farm on Krieger's Flak, in Sweden, bordering a Natura 2000 site. They also evaluated the efficacy of mitigation measures, such as noise abatement systems, on harbour porpoise and grey seals. The results showed that noise is capable of affecting porpoise behaviour up to 5-10 km away, which includes a large part of the neighbouring Natura 2000 site, but the number of impacted porpoises is relatively low. Although quantitative assessment for seals was not possible, it is likely to be similar or smaller than the impact on porpoises. Turbine noise during the operation of the wind farm was low and therefore also constitutes a minor impact on both species. Regarding noise abatement systems, if adequate systems are used (e.g. equivalent or better than a double big air bubble curtain), the predicted impact of pile driving, and related radiated noise, is reduced to a level where it is assessed to constitute only a minor impact on the marine mammal populations in the area. Indeed, the behavioural disturbance for porpoises can be reduced by a factor of more than 10. Acoustic deterrent devices should be used with caution, as they may constitute a disturbance equal or exceeding pile driving. Therefore, if efficient abatement systems are used, they are for the most part, not necessary.

DENMARK: Clausen *et al*. (2021) investigated the presence and behaviour of harbour porpoises, through autonomous acoustic loggers, around the largest oil platform in the Danish North Sea between 2013 and 2015. Harbour porpoises were detected at all distances from the platform and year-round, presenting two distinct seasonal activity patterns. Porpoises may be attracted to oil and gas platforms, regardless of underwater noise, due to increased prey availability in the vicinity of such structures. Significantly higher echolocation rates and foraging activity were detected within 800 m of the platform compared to the surrounding area, especially at night and during July-January.

In order to improve the approach used in the assessment of pile driving impacts, Tougaard *et al*. (2020) determined the most frequent marine mammal species that occur in Danish waters. For pinnipeds, six species have been recorded in Danish waters, but only two are frequent during the whole year: the harbour seal and the grey seal. Regarding cetaceans, the most common species are harbour porpoise, white-beaked dolphin, minke whale, long-finned pilot whale, killer whale, fin whale and bottlenose dolphins. Consequently, these nine species of marine mammals were the ones proposed for pile-driving assessment in Danish waters.

SCOTLAND: The effect of tidal turbine operations on harbour porpoise presence were studied by Palmer *et al.* (2021). A tidal turbine was equipped with hydrophones to detect cetacean vocalisations. This passive acoustic monitoring (PAM) system operated for 383 days between 2017 and 2019. Harbour porpoise presence was reduced by 78% (95% C.I: 51 % - 91%) when the turbine was operating in periods of high flow. Porpoise presence varied with the tidal state, being greater with the flood tide and lower during the ebb tide.

Findlay *et al*. (2021) used acoustic propagation modelling to investigate the extent of acoustic deterrent device (ADD) noise through the west coast of Scotland and across a Special Area of Conservation (SAC), between 2017 and 2018. The analysis of risk of auditory impairment for harbour porpoises, when exposed to ADDs as used in aquaculture sites, indicated that large areas of Scottish inshore waters would be exposed to noise levels that could exceed temporary and permanent threshold shift (TTS and PTS) exposure thresholds. For example, when considering a single device per aquaculture site, around 23% of the SAC designated for harbour porpoise on the west coast was predicted to fall within a TTS zone. Management interventions should consider this potential collateral damage of ADDs used for pinnipeds, extending to non-target species, like harbour porpoises.

Todd *et al*. (2021) also used noise propagation modelling to simulate the potential impact of real and fictional acoustic deterrent devices and to investigate their impact on non-target species in Scotland and how it could be reduced. The range of temporary threshold shifts (TTS) to very high frequency cetaceans (VHF) depended on the operational characteristics of the ADDs, reaching up to 32 km in the case of the simulated devices operating at the highest outputs. The source level (SL) was found to cause the greatest reduction in potential impact, thus the ADDs with the highest SL exhibited greatest temporary and permanent threshold shifts (TTS and PTS).

GERMANY: In Germany, the project NavES produced a technical report that documents the cross-project analysis of the construction projects for 21 offshore wind farms in the German EEZ of the North and Baltic Sea, from 2012 to 2019 (Bellmann *et al*., 2020). The report is focused on the technical Noise Abatement Systems and Mitigation Measures, providing a comprehensive and updated database to improve the development and implementation of noise mitigation concepts for future construction projects. It includes a revision and description of the factors influencing pile-driving noise, a revision of offshore suitable market-ready Noise Abatement Systems, and future challenges for incoming projects, presenting Alternative Noise mitigation measures.

Müller *et al.* (2020) applied the OSPAR indicator for the risk of impact from impulsive noise, using the habitat approach, and investigated the influence of temporal-spatial resolution and mitigation measures (as sound abatement systems) on the exposure index (EI). They exemplified this using, as an example, the harbour porpoise population inhabiting the German EEZ of the North Sea, where three wind farms were constructed in 2018. They suggest that nature conservation areas (such as Natura 2000 sites) should be evaluated separately in the assessment. They proposed and tested the use of the concept established in 2013 in Germany for the protection of harbour porpoises, which states that the proportion of the area affected by impulsive noise shall not exceed 10% of the nature conservation areas. Their results showed that the use of EI alone for assessing specific situations is not suitable and it might be better complemented by additional spatial-temporal criteria, such as the percentage of exposed area.

MACARONESIA (Canary Islands): The acoustic profiles of 13 whale-watching vessels from Australia and Canary Islands were studied by Arranz *et al*. (2021). They deployed acoustic recorders to measure low, mid and high frequency sounds of different types of vessels: motor sailing, catamarans and motor vessels, all of them operating at a speed of eight knots. A total of seven vessels from the Canary Islands were recorded between 2019 and 2020. Large catamarans with inboard engines produced the highest source levels, while smaller motor vessels and hybrid vessels powered by electric outboard engines produced the lowest source levels. The authors suggest that when the distance between the boat and the cetaceans is less than 500m, boats should adopt a broadband between 0.2-10 kHz and a source level <150 dB re 1μPa (RMS). This could be achieved by reducing the speed, avoiding gear-shifts when approaching cetaceans, and increasing the distance with target animals.

3.6.3 Ongoing Projects

NORTH AND BALTIC SEAS: In July 2020, the major shipping lane between the North Sea and the Baltic Sea was partially relocated. Taking advantage of this opportunity, the TANGO project was initiated to study how a relocation of a major shipping lane impacts the underwater soundscape and harbour porpoise presence and foraging behaviour. The project was carried out by Aarhus University (Denmark), the Swedish Defence Research Agency, and the National Museum of Natural History (Sweden), funded by the Nordic Council, Dansk Center for Havforskning and the European Maritime and Fisheries Fund (EMFF), the Swedish Transport Administration, and the Swedish Agency for Marine and Water Management. During one year before, and one year after the relocation, underwater sound recorders and C-PODs have been deployed jointly at eight stations, and only C-PODs at an additional eight stations, in both Danish and Swedish waters. The data are being analysed in spring 2022.

In February 2021, the project SATURN (Solutions At Underwater Radiated Noise) started in Danish waters. The main objective of the project is to determine the negative effects of underwater radiated noise at an individual and population level for different marine species, while at the same time, developing technologies and measures to reduce and mitigate the impact of underwater noise. The results are expected to be available in February 2025.

3.7 Ship Strikes and Other Physical Trauma

BALTIC SEA: The possible consequences on harbour porpoises of the controlled 2nd World War ground mine detonations by NATO in August 2019 were investigated by Siebert *et al*. (2022). Between September and November 2019, 24 harbour porpoises were found dead and examined for possible direct or indirect blast injuries. A total of eight porpoises out of 24 showed different lesions correlated with blast injury, suggesting that it was the most likely cause of death. One bycaught porpoise and another dead porpoise with signs of blunt force trauma also showed blast injury evidence. The other 14 animals presented different causes of death, with two individuals being impossible to determine.

MACARONESIA (Canary Islands): The presence of fat emboli within the lung microvasculature is used to determine a severe "in vivo" trauma in forensic medicine. Regarding cetacean carcasses, Arregui *et al*. (2019) demonstrated that an osmium tetroxide (OsO4) based histochemical technique is useful for fat emboli detection in lung samples of cetaceans, even in decomposed tissues kept in formaldehyde for long periods of time. In a more recent study, Arregui *et al.* (2020) proposed two other histochemical techniques, chromic acid and Oil Red O frozen, that can also be used for the detection of fat embolism. Specifically, the chromic acid technique was proven to be a good alternative to osmium tetroxide due to its slightly lower toxicity, its equivalent or even superior capacity for fat emboli detection, and its significantly lower economic cost. Recently, Sierra *et al*. (2022) report systemic skeletal muscle embolism in an adult female Sowerby's beaked whale found floating dead with external signs of trauma. Although the origin of the trauma could not be identified, this is the first description of this kind of embolism in a wild animal, the previous description corresponding to a woman after peritoneal dialysis.

3.8 Tourism

ICELAND: It has been reported that between 2015 and 2016, the number of foreign visitors to Iceland increased by 39% (Chauvat *et al*., 2021). Iceland is a breeding area for grey and harbour seals, which tend to haul out next to the shore, in accessible locations, and therefore particularly susceptible to disturbance from tourists. A questionnaire was made and distributed to determine the tourists' acceptability for different management strategies. The results of the questionnaires showed that seal watching visitors in general had high biospheric values which were found to be correlated with a higher acceptance of the management actions suggested, and with a greater awareness of the usefulness of those regulations.

Since 2010, the number of tourists in Iceland has increased from 459,000 to 2 million in 2019. One of the most popular activities is land-based watching of harbour seals. This activity can cause disturbance that can affect the behaviour and distribution patterns of the animals. Aquino *et al.* (2021) developed an Ethical Management Framework (EMF) for promoting the use of ethical practices for managing such human-wildlife interactions. The main application of this framework is to predict potential conflicts with the stakeholder groups due to the application of management actions.

UNITED KINGDOM: Captive harbour seals expended much more energy while entering the water after hauling out during the moult as opposed to post-moult (Paterson *et al*., 2021). This is likely to be due to increased skin temperature to optimise skin and hair growth. As a consequence, disturbances to hauled out seals have much greater energetic costs during the moult and outside the moulting season.

The effects of recreational boating and dolphin-watching activities on the bottlenose dolphin population inhabiting Cardigan Bay SAC, an area with increasing human pressure over the years, were evaluated by Vergara-Peña (2020). The evaluation performed through boat- and land-based surveys, and social science questionnaire surveys demonstrated that the type of boat and the temporal scale at which the study is performed, was related to the probability of encountering dolphins. In the short-term, avoidance responses by dolphins were observed related to high travel speed of the vessels and close approaches by boats. Over the long-term, an increase in boat traffic was observed within the SAC. Overall, the study showed neutral or positive reactions to the long-standing code of conduct area in the SAC, demonstrating their effectiveness for area-based management.

IRELAND: Tadeo *et al.* (2021) studied the effects of ecotourism on a grey seal colony at Great Blasket Island, Co. Kerry. The greatest effects were found for vessels that approached within 500m and presence of tourists on the beach. Effects were seen in terms of seals entering the water, increased vigilance and decrease in resting behaviour. The authors suggest adoption of a strict code of conduct for tourists and boats in the area, and recommend a set of best practices based on their results.

3.9 Climate Change

3.9.1 General

The long-term effects on distribution, abundance and inter-ocean connectivity caused by global warming since the last glacial maximum were studied by Cabrera *et al.* (2022). These effects were studied for eight whale species and seven prey species (five zooplankton species and two fish species) in the South and North regions of the Atlantic Ocean. Genetic analysis of the species showed that during the last 30 000 years, whale populations have experienced an expansion in both ocean basins. In the South Atlantic Ocean, exponential and synchronised increases in the abundance of baleen whales and their prey were observed. By contrast, in the North Atlantic Ocean, the demographic fluctuations varied across taxa and time.

The possible health effects on bottlenose dolphins, caused by the exposure to low salinity waters due to anthropogenically driven changes in salinity, were estimated by Booth and Thomas (2022). Using the Sheffield Elicitation Framework, a panel of seven experts studied the consequences of three different scenarios of low salinity exposure. The final product were dose-response functions, which suggested that bottlenose dolphins may resist different periods of exposure to waters below salinity values of 5 ppt before health is impacted, depending on the characteristics of the exposure. In scenarios of extended continuous salinity, they should be able to withstand 20-30 days, while in acute salinity change scenarios, the maximum time before health ends up being impacted would be 6-8 days.

NW EUROPE: A review of climate change impacts on marine mammals in North-west European seas, but with emphasis upon the British Isles (Evans and Waggitt, 2020a) concluded that the main observed effects have been geographical range shifts and loss of habitat through ice cover loss, changes to the food web, increased exposure to algal toxins as well as susceptibility to disease. Climate-change impacts on marine mammals are particularly evident in polar regions where there has been physical loss of sea-ice habitat. Species most affected include polar bear, walrus, bearded seal, ringed seal, and narwhal. Earlier and more-extensive phytoplankton blooms in subpolar and polar regions due to increased solar radiation leading to enhanced thermal stratification and hence higher productivity may have helped population increases in some baleen whale species, such as bowhead whale.

In mid-latitudes in the Northern Hemisphere such as around the British Isles, geographical range shifts appear to be occurring, with northward extensions of the range of warmer water species, such as striped dolphin, common dolphin, and Cuvier's beaked whale, and possible range contractions of cold-water species such as white-beaked dolphin.

In low latitudes where sea temperatures are highest, some species (e.g. bottlenose dolphin, baleen whales, manatees) have experienced occasional mass die-offs linked to the presence of algal toxins. These may now also be affecting marine mammal species in mid-latitudes, such as Californian sea lions and harbour seals.

Continued rises in sea temperature could result in a shift in the species composition for cetaceans around the British Isles, with increased biodiversity particularly of subtropical and warm temperate pelagic species. Marine mammal species that traditionally make long-distance seasonal migrations (e.g. most baleen whales) will likely arrive earlier or remain in high latitudes for longer, with increased breeding attempts. Ecosystem regime shifts in UK waters may result in lower food availability for a number of marine mammal species, and lead to re-distribution of some regional populations.

ARCTIC: The current status and identification of the factors influencing population dynamics of three different harp seal populations (White and Barents Seas, Greenland Sea and Northwest Atlantic) were reviewed by Stenson *et al*. (2020). For each of the populations, they investigated the changes and effects over the last decades of interrelated parameters affecting population dynamics such as harvest, abundance, diet ecology, changes in prey assemblages, and the environmental impacts on body condition and reproduction. Their results showed a gradient in the population response to climate changes, between the three populations: 1) Barents Sea population showed a pronounced negative response; 2) Greenland population showed a less strong negative response; 3) NWA population showed a continuous increase, although there were some inter-annual variations in body condition and fecundity. The gradient observed may be because the NW Atlantic population is still influenced by the cold Labrador current, while Greenland and Barents Sea populations are now influenced by warmer Atlantic waters. In fact, the reduction in sea ice cover (associated with climate change) is impacting the three populations although with different intensities. Seasonal ice cover influences the timing and strength of primary production and the abundance and distribution of key prey species for harp seals. Therefore, different changes in each area may produce different answers in each of the studied populations, that in the end are reflected as changes in body condition and vital rates. Overall, their investigations suggest that the three harp seal populations are not influenced by harvesting, but are influenced directly by climate change through 1) the changes in ice and its ice-related mortality of young of the year and/or displacement of whelping patches; and 2) changes in prey availability, due to the collapse of prey populations or to competition with other species, such as Atlantic cod.

Lameris *et al*. (2021) reviewed the existing literature to assess the possible existence of shifts in migration timing and distribution for a wide range of Arctic species in response to climate warming. For cetaceans and pinnipeds, earlier migrations were not reported although some species showed a delay in the spring migration. Sub-arctic species of pinnipeds and cetaceans seem to have changed their distribution northwards, probably due to changes in ice cover, following better areas for feeding and reproduction. As most arctic marine mammals are dependent on prey availability close to the edge of the pack ice, shifts in their distribution are consistent with the retreat of ice cover.

Skrovind *et al.* (2021) investigated the response of belugas to previous climate fluctuations by analysing 206 beluga whale mitochondrial genomes sampled from across their circumpolar range and 4 nuclear genomes covering Atlantic and Pacific Arctic regions. Four distinct mitochondrial lineages established before the last glacial expansion (~110,000 years ago) were identified. Using species distribution models, authors investigated changes in suitable habitat during the LGM (Last Glacial Maximum), present and the year 2100. Habitat models relied on the species environmental parameters (physical) and do not include such ecological parameters as prey availability, competition and predation. The authors forecast conditions to 2100 and as ocean warming conditions continue, model outputs indicated that suitable habitat for beluga may decrease by 39% and shift northwards by 4.9°N. This would leave areas such as the St Lawrence Estuary and the Sea of Okhotsk with none to limited suitable habitat. Populations in the St Lawrence Estuary and Shelikhov Bay hold larger proportions of unique genome diversity and so the decline or loss of these individuals may have a greater impact on species-wide genetic diversity and hence the ability of the species to respond and adapt to environmental changes. How belugas more widely may respond to the northward shift, and overall contraction of suitable habitat may be dependent on population-specific combinations of site fidelity and flexibility, combined with interactions with prey availability, predation and anthropogenic activities.

GREENLAND: Aerial surveys over Greenland were performed by Biuw *et al.* (2022) to estimate pup production in harp and hooded seals during March 2018. GPS beacons were deployed on the whelping concentrations detected to monitor ice movements. The estimated pup production was 54 181 pups of harp seals, the lowest since 1991, and 12 977 pups of hooded seals, significantly lower than the last survey in 2012. The declines observed in Greenland's pup production are similar to the declines observed in the Barents and White Seas during the mid-2000s, and may be caused by large-scale environmental or ecological changes.

WALES: Bull *et al*. (2021) studied the pupping phenology of grey seals in Wales in relation to sea surface temperature, and, by extension, climate change, using data from 1992 to 2018. A temperature increase of 2°C was associated with a pupping season advance of seven days at a population level. However, the age of the mothers was the most important factor determining pupping date rather than temperature. Warmer years were associated with older mothers, and the phenological changes were thus due to temperature-related transient changes in age structure.

3.10 Other Emerging Threats

Nelms *et al.* (2022) reviewed the main anthropogenic threats for marine mammals (climate change, fisheries, exploitation, industrial development and pollution), the possible conservation mechanisms, and new research and monitoring techniques required to gather information on those threats and to control the status of the populations. Over the last years, due to urbanisation of coastal areas, ballast waters and globalisation, an emerging threat has been gaining importance: pathogen pollution. This type of pollution occurs when pathogens of land animals begin to appear in the ocean. For example, the protozoan *Giardia*, typical of mammalian faeces, has been recorded in marine mammals from the Arctic to the Antarctic. Parasites such as *Toxoplasma gondii*, a cat-dependent protozoan, pose an important cause of death for Hawaiian monk seals and California sea otters in the USA, and for Maui dolphins in New Zealand.

4 ToR D: In collaboration with WGBIODIV, identify for-aging areas and estimate prey consumption by harbour seal, grey seal and harbour porpoise in the North Sea case study area

4.1 WGBIODIV, multi-species interactions in the North Sea, and data requirements

To support effective ecosystem based fisheries management (EBFM) marine apex predators need to be included in multi-species or ecosystem models, and there is a need for ongoing diet studies to monitor the dynamic and responsive changes in marine mammal diets as prey abundance changes, e.g. due to fishing and climate change. Additionally, marine mammal populations themselves are changing. In the past decades, the North Sea has seen growing numbers of seals and a re-distribution of harbour porpoises but with overall consistently high numbers since the 1990s, whilst recently there have been declines or levelling-off in some North Sea harbour seal populations. There have also been changes in the occurrences of large cetacean in the area, though quantification of these changes is less well documented (see ToR A for changes in abundance of the different marine mammal species)

WGBIODIV plans to continue developing multi-species work to support EBFM and has specifically requested marine mammal diet information to inform **North Sea prey guild models**, with an indication of the importance of each prey taxon in the diet of each marine mammal species.

For ECOPATH (EwE) modelling of the North Sea, estimates of North Sea predator diets for the year 1991 (the baseline year of their models) are requested by WGBIODIV. There will be a focus on the particular fish species or groups that are included in the EwE modelling in progress for the North Sea. This information will be used to parameterise the baseline EwE model to estimate predator preferences for different prey. However, in the 1990s, marine mammals were much less abundant in the North Sea than currently. This will obviously affect the total amount of prey consumed by this group, but possibly also the prey composition.

The marine mammal data sets potentially available for use, in both North Sea prey guild models and ECOPATH models, are diverse, although in many cases limited either spatially or temporally or both. An overview was given in the WGMME reports 2020 and 2021 (ICES 2020; 2021). We present here a brief description of some that are accessible to this Working Group, and potentially available for use by WGBIODIV. Based on WGMME 2021, we outline important caveats and limitations that may affect the use of these data in EwE or in prey guild models, and approaches that could be used to collate the available data for input into these models. We also describe the provision of pilot sample data sets to WGBIODIV from this working group.

Marine mammal diets have mostly been estimated from hard prey remains recovered from gastro-intestinal tracts (GITs, usually stomachs) or faeces (scats). Samples for analysis can be from stranded or bycaught animals, or from scats collected onshore. DNA-based analysis from scats or GITs can also provide information on diet, as can the analysis of fatty acids and stable isotopes in marine mammal tissues. All these approaches make a range of assumptions about the sample data and the analytical methods are subject to limitations and biases, see reviews in Tollit *et al*. (2010) and Bowen and Iverson (2013).

4.2 North Sea Marine Mammal diet datasets

In the next sections, we outline in more detail some of the North Sea marine mammal diet studies that are relevant to the work of WGBIODIV and which can potentially provide inputs to the WGBIODIV modelling. Here we aim at depicting the type of data available.

4.2.1 North Sea seal diet studies from the UK

Grey seal diet composition

In the North Sea, grey seal populations first grew along the UK coasts before colonising the continental coasts, in the southern North Sea as late as the 1980s (Brasseur *et al.,* 2015). Information on diet of these marine mammals in the 1990s will therefore mostly have been collected in the UK (see also ToR B, ICES 2020). Grey seal diet composition has been estimated UK-wide, including along the North Sea coastline, in three sampling periods, 1985, 2002, and 2010/11 based on measurements of fish otoliths and cephalopod beaks recovered from scats (Hammond and Grellier, 2006; Wilson and Hammond, 2016). The sampling design aimed to collect sufficient scats for robust analysis in a number of defined regions and in each quarter of the year. In the North Sea, the defined regions are southern, central and northern (including Orkney), though more fine-scale spatial resolution may be possible in some areas. Grey seal diet composition estimates from these data are thus available at two temporal resolutions (seasonal and approximately decadal) and at a regional spatial resolution. Additional samples for Scotland were collected by the University of Aberdeen during 1986-88, while samples from Orkney continued to be collected until 2006 and further samples from the Ythan estuary (Aberdeenshire) were collected during 2010-15.

In analysis, otolith and beak measurements were corrected to account for partial and complete digestion using experimentally derived correction factors (Grellier and Hammond 2006; Wilson *et al*., 2017). Diet composition was estimated as the percentage, by biomass, of each species in the diet for each region and season. Estimates of prey consumption have been made by incorporating information on regional population size and energy requirements of grey seals. Associated estimates of uncertainty for diet composition and prey consumption have been calculated. Methods are described in more detail in Hammond and Wilson (2016).

Results show that the diet is broad but dominated by relatively few species (Hammond and Wilson, 2016). There is substantial decadal, regional and seasonal variation in estimated diet composition in the three regions in the North Sea in 2010/11, expressed as the percentage of total diet by biomass. Errors around these estimates can be substantial, particularly for smaller percentages. In the 12 months from April 2010 to March 2011, grey seals were estimated to have consumed 129 200t (95% CI: 114 800-149 400 t) of prey in the North Sea (ICES Subarea 4). Hammond and Wilson (2016) give consumption estimates for this period by prey species and results for 1985 and 2002. Results are also available for much of the material collected by the University of Aberdeen, although otolith size was not corrected for digestive erosion.

Harbour seal diet composition

Harbour seal diet composition was estimated UK-wide, including along the North Sea coast, in 2010/12 (Wilson and Hammond, 2019). Methods for estimating diet composition and total prey consumption were similar to those used for grey seals (Wilson and Hammond, 2016a). The University of Aberdeen sampled harbour seal diet from several locations in Scotland during 1986-1989 and again during 2003-2004, with sampling in Orkney continuing until 2006.

4.2.2 Kattegat and Skagerrak harbour seal diet studies

Assessments of the diet of harbour seals in the Kattegat-Skagerrak area date back to the late 1970s. Thereafter, additional studies are available from the 1980s (Kattegat, Skagerrak), 1990s (Skagerrak), and 2000s (Kattegat, Skagerrak).

The most extensive studies have been based on scat samples collected during several months in the Skagerrak in the 1970s, 1980s and 1990s, enabling assessments of inter-seasonal prey preferences as well as long-term dietary changes (Härkönen, 1987; Härkönen and Heide-Jørgensen, 1991; Olsen and Bjørge, 1995). Later studies from the Skagerrak are more limited in sample sizes (Strömberg *et al.*, 2012; Sørlie *et al.*, 2020). The diet of harbour seals in the Kattegat has not been studied to the same extent as in the Skagerrak, and available information is based on fewer samples and more limited seasonal coverage (Härkönen, 1987; Härkönen, 1988; Strömberg *et al.*, 2012; Lundström *et al.*, 2017). Previous studies from the Kattegat-Skagerrak area are typically based on collection of samples from a limited area, and regional variations in diet (e.g. within the Skagerrak) are poorly known. However, a more recent study by Sørlie *et al.* (2020) presents area-specific variation in diet within the Skagerrak.

The most important prey were species belonging to the families Gadidae, Pleuronectidae, Clupeidae and Ammodytidae, with some variation between studies. Gadidae species were more common in the Skagerrak and frequently occurring species were Atlantic cod, Norway pout, poor cod, blue whiting and whiting. Pleuronectidae species, on the other hand, were more common in the Kattegat, dominated by common dab, European plaice and European flounder.

Due to the absence of recent diet data from the Kattegat-Skagerrak area, diet samples, both scats and digestive tracts from hunted seals, are currently collected to obtain updated results on harbour seal diet, including spatial and temporal variability (K. Lundström, SLU).

Harbour seal diet studies have also been conducted, in the Limfjord and along the Norwegian North Sea coast (Friis *et al.*, 1994; Olsen and Bjørge, 1995; Bjørge *et al.*, 2002; Østbøll, 2005; Andersen *et al.*, 2007).

4.2.3 Diet and prey studies of harbour and grey seals in Norway

In Norwegian coastal waters harbour and grey seal diets have been studied using both traditional fish otoliths and DNA analyses. DNA analyses in grey seal diet were also used to split unidentified digested otoliths from codfishes into species (Nilssen *et al.*, 2019). In harp seal studies, in addition, fatty acid analysis can complement hard part analyses (Grahl-Nilssen *et al.*, 2011; Haug *et al.*, 2017).

To obtain knowledge of feeding habits and prey consumption of grey seals, diet data were sampled in selected areas where grey seals are most abundant along the Norwegian coast. The most important prey were saithe, cod and wolffish. Wolffish was mainly eaten by seals ≥5 years old. Otherwise, the data did not suggest important temporal or spatial variations between the main prey items in the grey seal diet. However, capelin was eaten during spring in the northern area suggesting that seasonally abundant pelagic fish species could be regionally important. Total annual grey seal consumption of various species was estimated using bio-energetic modelling. The input variables were seal numbers, energy demands, and diet composition in terms of biomass and seasonal variation in energy densities of prey species. Assuming the observed grey seal diet composition in the sampling areas were representative for the diet along the Norwegian coast, the mean total annual consumption by 3850 grey seals was estimated to be 8084 tonnes in Norwegian waters; saithe, cod and wolffish were consumed in highest quantities (Nilssen *et al.*, 2019)

Harbour seal diets have been studied in various areas along the Norwegian coast. In all studies, the diet consisted of about 20 fish species, mainly small fish species or young age classes (10-30 cm) of larger fish species. The studies confirmed seasonal variations in diets, and suggested that harbour seals were eating the most abundant fish species such as saithe, cod, haddock, herring, sprat, Norway pout, poor cod, blue whiting, whiting, sandeel, and various flatfishes (Olsen and Bjørge, 1995; Berg *et al*., 2002; Ramasco *et al*., 2017; Sørlie *et al*., 2020). In a study in the Norwegian Skagerrak, harbour seal diet was studied using both hard-parts analyses and DNA metabarcoding. The DNA analyses revealed that birds and skates may also be components of harbour seal diet in the region. The hard-parts analysis indicated cephalopods were prey as well. The results from molecular and morphological analyses were similar in regard to important prey species, but finer taxonomic resolution of important prey groups was achieved using DNA metabarcoding compared to the more traditional morphological analysis (Salinger, 2021)

4.2.4 Diet studies for harbour seals in the Netherlands

Scat samples are collected from tidal haul out sites in the Netherlands. These are tidal or at least flushed regularly, so scat samples will therefor represent diet within days/weeks of consumption.

Seal scats are collected opportunistically, mostly in relation to other work on the sandbanks spanning 30 years of sampling along the Dutch coasts. Scats are placed individually in plastic bags and kept frozen (-20°C). DNA samples of the scat may be taken either by sampling a small part or more recently, by placing the scat in a buffer solution and taking a sample of this prior to washing the scats. For this, the scat is placed in nested meshed bags (120 μ and 300 μ) and then washed using a washing machine (Aarts *et al*., 2019). After drying, all recognizable parts are collected and otoliths are measured. DNA was initially used to determine the predator (grey or harbour seal) but can now be used to determine prey (by sequencing methods similar to e-DNA).

4.2.5 North East Atlantic cetacean diet studies: review and collation of literature

As part of the UK-based NERC-Defra funded five-year Marine Ecosystems Research Programme (MERP, 2014-18), several dynamic ecosystem models for the NE Atlantic were developed (Spence et al., 2018). Two of these (MIZER and Species Size-Spectrum model) examined size spectra through the food chain from phytoplankton to marine mammals, whilst two (Strathclyde end-to-end Ecosystem model and Ecopath with Ecosim) incorporated marine food web and fisheries interactions (Heymans *et al*., 2016; Heath *et al*., 2020). For cetacean and seabird species, survey data sets were collated and density distributions modelled for different time periods and at various spatial scales (Waggitt *et al*., 2020). That work has been extended to examine spatial and temporal trends in predator-prey relationships within the eastern North Atlantic and North Sea including results of many of the local dietary studies presented in the WGMME report in 2020 (ICES 2020). Diet matrices were developed for twelve regularly occurring cetacean species (harbour porpoise, bottlenose dolphin, common dolphin, striped dolphin, white-beaked dolphin, Atlantic white-sided dolphin, Risso's dolphin, long-finned pilot whale, killer whale, sperm whale, minke whale, and fin whale) based on the analysis of GIT contents from stranded or bycaught animals. This started as part of MERP, but continues to require updating and refining. Models are currently being developed to assess spatial and temporal variation in fish and cephalopod distributions, and trends in stock sizes of commercial fish species in relation to top predator seasonal and longer-term trends, with work ongoing through two PhD studies at Bangor University.

4.2.5.1 Harbour porpoise diet studies, Scottish East Coast (UK)

The stomachs analysed by the University of Aberdeen and, latterly, the Marine Institute in Vigo come from porpoises stranded on the Scottish coast and necropsied by the Scottish Marine Animal Stranding Scheme during 1992-2016, although the University received relatively few samples for the last few years of that period. Data from several other cetacean species were analysed during the same period. The data include information from the east coast including the southern border of Orkney and the Shetland islands, although the precise boundary to delimit the North Sea area could be changed to suit the planned analysis. Data collection spanned the period 1992-2016. Results are provided at individual stomach level so will presumably refer to feeding during up to a few days before the death of the animal. There may be biases/noise in the data due to geographical and temporal variation in sampling effort and, sometimes, budget limitations. It is also worth considering the nature of the deaths sampled. On the Scottish east coast, a high number of porpoise deaths is attributable to bottlenose dolphin attacks so the samples from that area are likely to contain more trauma deaths than samples from other areas.

As far as possible, all hard prey remains are identified. This includes fish otoliths and bones and cephalopod beaks. Some remains are easier to identify to species level than others so some prey are identified to genus, family or higher level. All identifications are checked by experienced workers. Species which are identified to genus or other taxonomic group levels (e.g. cod, haddock, pollack and saithe which have similar otoliths when they are eroded) were pooled as species considering the percentage of identified prey to species level found in the same porpoise, if possible, or porpoises stranded at similar period of time of the year.

Prey size is estimated from measurements of hard parts (otoliths, jaw bones etc). No corrections have been made for digestive erosion or for total loss of some easily digested prey remains.

4.3 Caveats and Limitations

Marine mammal diet data in general are not necessarily straightforward to interpret for the following reasons:

- For a scat sample or GIT sample of diet, the location of foraging at which the predator consumed prey will be uncertain, although for seals it may be possible from telemetry data to suggest likely areas within which foraging could have occurred at sea, prior to sample collection onshore.
- Sample collection may be targeted or opportunistic
- GIT studies are often carried out on stranded animals. The cause of death is likely to affect the prey ingested, diseased animals may be restricted in their prey choice and in the case of bycaught animals, they may be biased to the target prey of the fishery
- In contrast to GIT studies, for faecal samples, it is often impossible to determine the size or age of the animal that deposited the scat, and what constitutes one sample is sometimes difficult to define, e.g. when many scats are harvested from a haul-out site.
- Primary data may be in the form of otolith measurements and identifications, but some data sets present data that have been collated and analysed. Some of the processing and analytical steps that might be performed are designed to address biases in the raw data, such as erosion of otoliths during digestion. Corrections and analysis may have been applied in different ways in different diet studies.

4.3.1 North Sea Prey Guild Model data requirements

Data were requested in the form of observations of consumption of prey by marine mammal predators, with spatial locations and dates, and with an indication of the strength of trophic links.

The group agreed that this strength would be best represented by the proportion of diet comprised of a particular prey.

4.3.2 EwE Data requirements

Marine mammal diets typically vary in space and in time (both annually, and seasonally) and diet data are typically available sporadically in space and time. The ECOPATH modelling framework for the North Sea will treat each marine mammal predator species as a single population that is assumed to mix freely over the whole area. As such, it will be assumed that any observed regional, seasonal and/or inter-annual variation in diet results from differences in local prey abundance.

The WGMME noted that given marine mammals were less abundant than now and relatively few studies were carried out there are few data for 1991, the baseline year of the ECOPATH model. Notwithstanding this, the following analysis steps are proposed to aggregate diet estimates from multiple locations and collection dates, to provide inputs in the form of a diet table for ECOPATH, for a given year Y at a whole-North-Sea scale. The same logic could be used to produce aggregate estimates of diet for subareas of the North Sea in future model runs.

For each species under consideration, it is required to decide upon a time 'window' over which diet data are to be attributed to year Y (1991 in this case): this must be long enough to allow reasonable spatial/seasonal coverage by the diet sampling.

For harbour porpoise, stranded and bycaught animals are used in the estimation of diets from gastro-intestinal tract (GIT) contents. Harbour porpoises have a high metabolic rate and limited energy storage capacity and therefore have high feeding rates. GIT diet information is associated with a geographical area where they obtained their last meal. Estimating the most likely foraging area of stranded animals is challenging, because carcasses could have drifted for a considerable period at sea before stranding. A way to estimate this has been described by Ransijn *et al*. 2021 (see also Peltier *et al*., 2013). An estimate of the number of porpoises in this region could be derived from a spatial model of (seasonal) population density (e.g. Gilles *et al*., 2016; Waggitt *et al*., 2020).

For North Sea seals, diets are estimated from the analysis of hard prey remains in faecal samples collected from haul-out sites to which the animals regularly return during the foraging season. The relative size of the local seal population that is associated with this diet can be estimated from haul-out counts (Thomas *et al*., 2019; Thompson *et al*.,2019). Such counts could be corrected for animals at sea, using telemetry-based correction factors, but this is not required if the proportion at sea can be assumed to be consistent among haul-out sites.

For a marine mammal consuming a variety of prey species, numbered 1 to M, the following steps are suggested, to produce a single point estimate for diet in a given period and area.

- Assemble all available diet estimates in the area and period. A diet estimate is a vector of proportions $(p_1, p_2 \ldots p_M)_{x,t}$ with associated location x and date t.
- Assemble estimates of the size of the marine mammal "population" associated with each diet estimate, $N_{x,t}$ (see above). This number can vary by place, year and/or season, as appropriate, and therefore can allow for seasonal variation in density.
- The aggregated diet estimate will be given by

$$(\hat{p}_1, \hat{p}_2 \ldots \hat{p}_M)_{x,t} = \frac{\sum_{x,t} N_{x,t}\,(p_1, p_2 \ldots p_M)_{x,t}}{\sum_{x,t} N_{x,t}}$$

To estimate uncertainty in this estimate, a protocol to incorporate uncertainties in the estimates of diet and "population" size is required; a bootstrap resampling approach may be appropriate.

The steps above present a 'weighted mean' approach, based on available samples that might be subject to considerable bias towards diets consumed close to the coast. This is likely to be important especially for pelagic cetaceans such as harbour porpoise, much of whose foraging in fact occurs away from these coastal locations. An alternative approach currently under investigation within the ECOSTAR project involves the use of a fitted model of predator diet as a function of local prey abundance, based on the coastal diet data, but then applied to estimate predator diets over wider spatial scales (Ransijn *et al*. 2021, Smout *et al*. 2014)

4.4 Sample datasets

Given the diversity of data sets and levels of analysis to which data have been subjected, it is important to establish feasible data formats for different diet studies, so that the information provided can inform the feeding guild and EwE work.

Therefore, a set of example diet matrices were compiled for consideration by WGBIODIV with the aim that this will allow pilot studies and help to establish workflow between the WGs. The studies that provide data for these example diet matrices are summarised in Table 4.1.

Table 4.1. Summary of example North Sea marine mammal diet data provided to WGBIODIV illustrating how diet-matrix data can be used in their EwE/prey guild models. See Table 2.5 in the WGMME 2020 report (ICES 2020) for a more complete overview of available data. Numbers refer to the sections in the section 'Marine mammal data sets' where these studies are described in more detail.

	Description of the study and species	Time/date/location	Analysis	Type of results	Contact person
1	Scat sampling (Jan-Mar 2011), UK grey and harbour seals	Orkney	Otoliths and squid beaks identified to species, measured and counted.	% diet by mass	Phil Hammond/ Sophie Smout
2	Scat sampling (1977-1979), GITs from hunted harbour seals (2009-2010)	Kattegat/Skagerrak	Otoliths and other hard parts identified to species, measured and counted.	% diet by mass	Karl Lundstrom
3	Scat sampling (2005), harbour seals	Netherlands	Otoliths and other hard parts identified measured and counted	prey counts	Sophie Brasseur
4	Spatio-temporal comparisons between distributions of 12 cetacean species and their known prey, using reviews of literature on GIT contents from stranded and bycaught cetaceans (1990-present)	Northeast Atlantic including North Sea	Modelled density distributions in time and space for predators and known prey (identified in literature from otoliths and other hard parts identified to species, counted and in some cases measured)	% diet by mass and/or by number of prey in the sample	Peter Evans / James Waggitt
5	GIT contents (1992-2014) from stranded and bycaught harbour porpoises	Entire North Sea	Otoliths and other hard parts identified to species, measured and counted.	% by mass and by number of prey in the sample, frequency of occurrence	Graham Pierce

4.5 Discussion

Monitoring of marine mammal diets requires appreciable field effort, and availability of experienced staff for identifying and measuring otoliths or other prey hard parts. It is imperative however that this monitoring continues, because the marine environment is changing and marine mammal diets are expected to respond, with potentially very important consequences for their welfare and populations, but also for their impact on prey species including commercial fish stocks. There is potential that use of DNA might speed up analysis of samples and detect fish species that are not easily identified by the analysis of hard parts, though measurable hard parts will still be essential to estimate prey size. There may be additional potential for such studies to also return some characteristics of the marine mammals themselves e.g. using biomarkers for sex identification. There is a need for comparative studies to calibrate the estimates derived from these different methods, potentially also to use DNA to quantify prey ingested. As such there may be an important role for future captive studies to ground-truth and calibrate diet estimates.

Shifts in the future diet of these marine top predators are foreseeable due to changes in climate and anthropogenic use of the marine environment. It will therefore be even more important to understand the feeding ecology of these animals. Though across the study areas, methods are somewhat similar, there may be issues when collating the data. To overcome this and share best practice, new methodology, identify missing information, and set research priorities, we suggest a workshop on diet studies to be held in association with other relevant bodies in 2023.

5 ToR E: In collaboration with WGBYC contribute to the Roadmap for ICES PETS bycatch advice by re-view-ing selected aspects of marine mammal-fish-ery interac-tions and assembling data and qualitative information available from other sources not fully covered by WGBYC (notably strandings) on marine mammals

5.1 Introduction

In response to an ACOM request to prioritise the assembly of data and qualitative information on strandings of PET species, it was agreed that WGMME would focus on marine mammal (cetacean and seal) strandings for the 2022 report. It should be noted that not all stranded marine mammal species are recorded or studied equally throughout the different ICES countries. Generally, strandings of large cetaceans are extensively reported unless they occur in remote areas such as the coasts of Norway. In many cases, this is also true of smaller cetacean and efforts to collect data on stranded animals are supported by organisations such as IWC, ASCOBANS, and OSPAR. On the other hand, possibly due to the lack of equivalent organisations with a focus on pinnipeds, data on dead strandings of pinnipeds are lacking or sparse in many countries. Moreover, in those areas where hunting of seals is practised, data can be collected from hunted animals, with little value attached to data from strandings. Therefore, arguably, there is a general lack of understanding of the causes of mortality in seals, including the importance of bycatch.

More use could be made of stranding data to inform bycatch assessment in marine mammals, but this implies maximising the quality of information available (subject to logistical constraints), as well as adding value where possible, for example providing context for cause of death by taking into account age, reproductive status and health status, and providing insights into mortality at the population level based on drift modelling and/or use of life tables. For a future data call, all marine mammal species in the ICES area should be included and agreement will be needed on a suitable data format, accommodating the inevitable variation in data quality, both within and between networks, e.g. due to variation in the state of preservation of different stranded animals and limited resources to undertake necropsies and sample analysis). In addition, flexibility is needed to allow information to be summarised/analysed at ecoregion level, and not only by country.

A questionnaire that was sent out to stranding networks by WGMME in 2021 (see ICES, 2021) allowed us to establish contact and collaboration with many of the extant stranding monitoring networks covering the Atlantic coasts of Europe, and gathered a wealth of data about network activities and capacities, as well as the constraints on collection of data on bycatch. Responses also confirmed that networks were concerned about the possible extra work and duplication of effort implied by a new ICES data call. Noting that other organisations (e.g. IWC, ASCOBANS) already request cetacean stranding data, an extra burden on stranding networks could be minimised by harmonising and/or joining data calls for stranding data (including information on both cetaceans and seals) by all relevant organisations. During discussions, it was noted that bycatch and entanglement of marine mammals also have animal welfare implications that should perhaps receive further attention within WGMME by incorporation into its Terms of Reference.

ICES published a Roadmap for PETS bycatch advice in 2020. Strandings are described in the roadmap as a source of additional information that can help evaluate the susceptibility of a population/species to bycatch in a particular fishery. The roadmap also highlights the need for effective cooperation with conservation and regional sea management organisations (e.g. ACCOBAMS, ASCOBANS, HELCOM and OSPAR) to improve data collection, information sharing, indicator development, joint methodology and efficient use of resources. ICES deliver advice to the EU every year in relation to bycatch of protected, endangered, and threatened species based on data received from ICES member countries and some EU-Mediterranean countries. Based on the EU regulation 2019/1241 on technical measures, EU countries are requested to demonstrate that incidental catches are minimised to prevent unacceptable effects on sensitive marine species (ICES 2020). Data from mammal strandings are usually reported within the advice as supporting information on the general distribution of bycatch of marine mammals in fishing gears, which can augment at-sea monitoring data. In 2020, data from strandings of common dolphins in the Bay of Biscay were used to evaluate bycatch estimates and potential emergency measures to prevent bycatch of this species as part of WKEMBYC (ICES, 2020). The ICES Advisory Committee (ACOM) recommended WGBYC and WGMME to initiate systematic collection of stranding data and develop the data format.

5.2 Coordination with other bodies

WGMME sought the views of contacts within ASCOBANS, HELCOM and IWC concerning the coordinated collation of data on marine mammal strandings. It should be noted that the ambition is not simply to document stranded animals and their cause of death where known but, also, to provide information on necropsy findings and sample analysis, e.g. life history parameters and health status, which could aid in the interpretation of the data and improve our understanding of fishery bycatch mortality in marine mammals.

During February 2022, a HELCOM-ICES bilateral coordination meeting was held. Support was expressed for more cooperation on harbour porpoise (bycatch) data collection to avoid duplication of effort. In recent years, HELCOM has invested in further developing a biodiversity database to include historical harbour porpoise data from the HELCOM/ASCOBANS database (which HELCOM has hosted since 2010), as well as acoustic monitoring data for the Baltic. HELCOM has also been developing its reporting format as well as guidance on data collection for strandings, bycatch, and other information (such as incidental sightings), as collected under the HELCOM EG MAMA group in their annual meetings. Currently in HELCOM, there is no specific data call for bycatch/stranding data, other than the regular annual reporting. It may be possible to utilise this existing data flow for the Baltic countries and supplement it with data collection from other ICES countries. Some planning and joint meetings would be required to agree on the scope and practicalities. One step forward could be to include this in the agenda of the next HELCOM EG MAMA meeting in autumn 2022.

In September 2021, ASCOBANS contacted ACCOBAMS, HELCOM and IWC on the topic of cetacean stranding and necropsy databases and proposed a brainstorming workshop for further development of ideas (ASCOBANS AC26, Action Point 46, see text box below). It should be noted that ASCOBANS, ACCOBAMS and IWC are specifically focused on cetaceans, while HELCOM and ICES also have an interest in seals.

Web-accessed Database for Marine Mammal Stranding and Necropsy Data

Action Point 46) The Secretariat to organise a virtual brainstorming meeting on the stranding and necropsy database. Invitees to include data users, database experts, strandings and necropsy experts, and other relevant stakeholders, such as IWC, HELCOM, ACCOBAMS. The workshop would aim to:

1. Discuss and scope the scientific, social, and administrative drivers for the creation of an online database of marine strandings.
2. Review existing or planned databases containing marine stranding data.
3. Identify i) common and ii) diverging requirements/specifications of present stakeholders (ASCOBANS, ACCOBAMS, IWC, HELCOM).
4. Identify anticipated constraints, limitations or concerns of taking either a unilateral or shared approach.
5. Outline a design brief divided into 'essential' 'useful' and 'nice to have' attributes.
6. Discuss the technical aspects of the implementation and maintenance of a relational database.
7. Produce estimated costs and time for delivery.
8. Identify potential database architect candidates and a steering group to take this work forward.

At the time of writing, IWC was seeking to appoint a new Bycatch Coordinator but, in their response, they confirmed that there had been a lot of discussion recently within IWC but also with the previously mentioned organisations, about a strandings database and how this could tie together existing information and encourage more input while also reducing the amount of necessary reporting. IWC has been scoping the possibility of a strandings database and has contacted various networks to see what they have, what their requirements are, and what level of interest/use there could be for such a common database.

5.3 Benefits and Challenges of using Stranding Data to assess Bycatch Mortality

Stranding data have usually been viewed as a secondary source of data on bycatch and entanglement mortality even if experience to date suggests that sufficient coverage of relevant fishing fleets by on-board observers may never be achieved. Given that ICES wish to initiate systematic collection of stranding data and develop an appropriate data format, it is relevant now to review the advantages and limitations of stranding data, including:

- Which countries can provide stranding data and to what extent do they document bycatch mortality?
- What gaps and limitations exist in coverage and data quality, including issues related to the species recorded, knowledge, skills and resources?
- Considering the need to rule out and rule in different factors contributing to bycatch mortality, what ancillary data are needed / can be provided to put bycatch mortality in context (e.g. age, sex, reproductive status, health status)?
- What biases exist in the data provided (e.g. where do animals strand, which ones are discovered, which ones are necropsied)?
- How can we adapt to variable "levels" of stranding data? What are the likely resource needs for "optimal" data collection and analysis?

- At what scale should strandings be reported and analysed (e.g. ecoregion, country)?
- To what extent can we estimate bycatch mortality at the population level (e.g. through the application of drift modelling, life tables, etc.)? Can we determine the probability of stranding, detection and necropsy at every location?
- Is there a need for new and/or improved best-practice guides (e.g. in addition to necropsy guides)?

A questionnaire was developed last year by ICES WGMME to gain insights into the potential contribution of European stranding monitoring networks to understanding and quantifying mortality of marine mammals due to fishery bycatch and entanglement, from strandings. The networks are based in ICES member countries and as such the results refer mainly to the ICES region, as well as Macaronesia and the Mediterranean in some cases. The final results will be compiled into a scientific publication to highlight differences between ecoregions.

A brief account of the results from the (then) 25 respondents, which included 22 completed questionnaires, was published in the 2021 report (see WGMME 2021 for further information). Results from the questionnaire provided: 1) an insight into the organisation of stranding networks, e.g., their role, their effort over time, and their funding; 2) information on attending stranded animals, e.g., procedures to report strandings, and decisions about which animals to attend; 3) information about the strandings, e.g. species and numbers of animals; 4) information about the type of data and samples collected and analysed from dead strandings; 5) information about necropsies performed by the networks, e.g. number of necropsies carried out, protocols used, causes of death); and 6) specific information about bycatch mortality, e.g., its frequency, trends and patterns.

Since the publication of the report, ten additional questionnaires have been received, from Ireland (1) and Spain (9), giving a total of 35 contributions. A few other contributions are still expected, which will likely cover geographical gaps. It should be noted that nations with regional networks (e.g. Spain) rather than national networks are overrepresented in terms of numbers of responses.

5.3.1 Type of funding

European stranding networks typically base their activities on voluntary work (16 out of 35 respondents), regional (16) and national government (14) funding. Less commonly, they depend on donations and grant applications (7), membership (3) and volunteer fees (2), incoming visitors (1) and/or their own funding (1). Different sources of funding result in different levels of financial stability. Long-term planning and continuity of staffing may be compromised either due to dependence on volunteer work, donations, and/or membership fees, or the need to regularly (sometimes annually) re-apply and compete for government funding.

5.3.2 Organisation of the networks

Four main types of networks could be distinguished according to the distribution of tasks related to stranding attendance in each region: in some regions, stranding monitoring activities are centralised in one network, while in others there are several stranding networks with different roles that either collaborate together or generally work independently but collaborate on (for example) scientific projects. Finally, some regions lack a formal stranding network. The existence of multiple networks can present challenges of communication and coordination as well as potentially leading to competition for personnel or financial resources.

5.3.3 Constraints on the quantification of bycatch

Table 5.1 summarises the importance attached to different types of constraint. Financial resources were the most frequently mentioned limitation to determining the incidence of bycatch mortality in marine mammals. Only one stranding network reported having sufficient resources, while several commented that these are insufficient to monitor their area, examine more strandings, have a dedicated centre and/or hire qualified professionals. Decomposed carcasses and lack of human resources were also frequently reported as limiting factors. Determining the cause of death in highly decomposed animals is difficult and results in an information gap for regions where a significant proportion of stranded animals are highly decomposed. Some networks also commented that insufficient human resources limited their ability to analyse samples or to work with fishers on bycatch.

The lack of a volunteer network is a limitation in some regions. Some networks find it difficult to train volunteers and to ensure adequate coverage of the whole region. A lack of veterinary expertise is an important issue for some networks, although one respondent noted that experienced biologists may be better able to diagnose bycatch mortality than inexperienced veterinarians, especially in relation to recognising external and macroscopic signs.

Logistical problems associated with recovering carcasses affect some stranding networks, e.g. when carcasses do not reach the shore or strand in remote areas or on islands. Some networks collaborate with fishers who bring bycaught carcasses for examination, while others find such collaborations to be complicated either due to the lack of interest or difficulties (e.g. legal issues) in landing the animals. One respondent noted the need for trust between fishers and stranding networks. Other issues mentioned included lack of reporting of stranded animals or difficulties in dealing with the local authorities responsible for granting access to/disposing of stranded animals.

Table 5.1. Responses to the questionnaire sent to stranding networks about the perceived importance of different types of constraints on diagnosing bycatch mortality.

Type of problem / Importance	High	Medium	Low	N/A	No reply	Total
Financial resources	11	8	5	6	5	35
Carcasses often decomposed	9	12	7	6	1	35
Human resources	7	11	5	6	6	35
No volunteer network	5	4	4	14	8	35
Lack of veterinary expertise	5	5	13	8	4	35
Issues with carcass recovery	5	5	12	6	7	35
Few carcasses are reported	4	5	16	3	7	35
Access to remote areas	3	7	13	7	5	35
Administration issues	3	7	10	7	8	35
Issues with carcass examination	3	8	12	5	7	35
Distribution of volunteers	2	8	6	12	7	35

5.3.4 Who does what?

Most stranding networks reported that the number of necropsies conducted in specialised facilities exceed the number of *in situ* carcass examinations (Table 5.2). Both necropsy and post-mortem examinations are primarily carried out by trained veterinary pathologists and biologists. *In situ* post-mortem examinations are performed with similar frequency by veterinary pathologists and biologists whereas necropsies at specialist facilities are more frequently carried out by veterinary pathologists. The expertise of trained personnel (as well as better working conditions in specialised facilities) should help ensure the quality of the information and samples collected and ultimately improve the reliability of the diagnosis of the cause of death (although it may also be the case that only fresh and slightly decomposed animals are transported to specialist facilities). However, several networks lack veterinary expertise. In a few networks, untrained personnel or personnel from other organisations examine carcases and perform necropsies (Table 5.3). In some regions, untrained personnel and members of the public are involved in taking photos, measuring carcasses and collecting samples from stranded animals *in situ* (Table 5.3.3).

Table 5.2. Staff in charge of examining the carcass post-mortem on site and performing the necropsy at a specialist facility (Frequency of involvement: A = Always, U = Usually, S = Sometimes, N = Never. Two respondents selected multiple frequency values, so these answers were counted as "No reply").

Who does what?	Post-mortem examination of carcass on site						Necropsy at a specialist facility					
	A	U	S	N	No reply	Total	A	U	S	N	No reply	Total
Veterinary pathologist	3	4	12	8	8	35	10	8	5	7	5	35
Other trained personnel	3	6	12	6	8	35	6	4	6	10	9	35
Untrained personnel	0	1	4	16	14	35	0	1	1	21	12	35
Another organisation	0	0	3	19	13	35	0	1	3	20	11	35
Members of the public	0	0	0	23	12	35	0	0	0	25	10	35

Table 5.3. Staff in charge of taking measurements and photos of the stranded animal and collecting samples from carcasses on site (Frequency of involvement: A = Always, U = Usually, S = Sometimes, N = Never. Two respondents selected multiple frequency values, so these answers were counted as "No reply").

Who does what?	Photos, measuring and sampling on site						Photos, measuring and sampling at a specialist facility					
	A	U	S	N	No reply	Total	A	U	S	N	No reply	Total
Veterinary pathologist	2	3	14	8	8	35	2	3	12	10	8	35
Other trained personnel	8	13	4	3	7	35	5	8	9	6	7	35
Untrained personnel	0	2	13	9	11	35	0	1	4	18	12	35
Another organisation	2	1	9	12	11	35	0	1	7	16	11	35
Members of the public	0	1	10	15	9	35	0	0	1	25	9	35

5.3.5 Decisions about which animals to attend

Decisions about which strandings to attend are most frequently based on the decomposition state of the animals (18 networks), the importance of the species or population (16), and the availability of personnel (11). Other factors include the representativeness of the sampling (9), accessibility (9), funding constraints (8), and specific research questions (7). The reporting of live stranded animals is of high importance for one network. Some respondents commented that the decision process might take into account the number of recent strandings. Such decisions may result in unconscious biases in the information collected, e.g. because strandings in less accessible locations (due to their distance from the location of network personnel or the local topography) are more likely to be badly decomposed when discovered. In addition, funding constraints, and availability of personnel may be relevant factors responsible for some biases in long-term datasets.

5.3.6 Measures of search effort

Indicators of the amount of effort which goes into looking for stranded animals could provide insight into the extent to which the stranding data collected are representative of a population and/or a region. However, very few stranding networks record search effort (6 respondents), although some networks state that they are confident that every stranding is reported and attended. Human population density (4 respondents), the number of volunteers (3), and accessibility (3) are all used as effort indicators. One network uses an App to record the kilometres of the coastline covered during searching and another relies on estimates calculated by the volunteers. All these approaches have merits although the ideal indicator of effort would probably need to integrate all these other indicators.

5.3.7 Number of strandings reported/attended/dead/necropsied in 2019

We selected 2019 as a recent reference year not influenced by the pandemic. Valuable information (e.g. the species, body measurements, photographs) and samples can be collected from attended animals even if they are not necropsied. Some signs of bycatch can be detected through external examination and based on samples collected. Overall, 51.5% of the reported strandings of marine mammals were attended, although the proportion varied among respondents from 0% of animals being attended to 100%. Evidently, the way the carcass was processed should be taken into account when interpreting the results. While all data from attended animals are valuable, necropsies (especially by trained veterinarians) allow an exhaustive examination, providing a range of information and samples, to help ensure both the accuracy of any cause of death determination and its relationship to the underlying health status. Overall, 15.6% of the dead stranded marine mammals are necropsied, although, again, varying among regions from 0% to 100%.

5.3.8 Types of data and samples collected

Among the data collected from dead stranded animals, the decomposition state of the individuals is especially relevant for diagnosis of bycatch mortality. This information can be collected from all attended animals even if not necropsied. Around half of the networks collect such data from all attended animals (i.e., recovered, sampled and necropsied cases) while 13% (4/28) of the networks collect these data only for necropsied animals

5.3.9 Photographs

To detect evidence of bycatch in cetaceans, photos of sufficient quality that cover the entire body, including the flanks, are needed. Photographs are a useful repository of information that can be accessed for retrospective studies of bycatch (e.g. Puig-Lozano *et al*., 2020).

Twenty-five networks responded to questions about photographs. Overall, photographs were taken for 87.4% of strandings, ranging among the different networks from 10% to 100%. All photos are archived and 21 out of the 25 networks responding to this question confirmed that they have photographs showing signs of bycatch. Stranding networks were asked for their opinion about the proportion of their pictures that could be used to look for external evidence or signs of bycatch (i.e., photos of the whole body, of sufficient quality, etc). Of the archived pictures, overall 34.7% were considered to be suitable for this purpose, although the percentages reported ranged from 0% to 100%.

5.3.10 Analyses carried out on samples of stranded animals

Demographic information can be used to build life tables (e.g. with age-specific survival and birth rates) to help assess total mortality and specific bycatch mortality for a population, as well as to indicate which components of the population are most susceptible to bycatch mortality. Although no networks reported having produced a life table, some networks reported routinely determining maturity (16/35), female reproductive status (13/35), male reproductive status (9/35) and age (8/35), although in the latter case, around half of the respondents (15/35) do so on an ad-hoc basis. Caution is needed in interpreting these answers because, of the 14 networks which responded to specific questions about the methods, only one reported routinely determining maturity status using sampled gonads, while seven inferred maturity from previously determined body length or age at sexual maturity. Similarly, six networks inferred age from species-specific length-at-age relationships while none routinely used tooth samples to determine age. In addition, 10/35 networks collect diet information routinely.

5.3.11 Decomposition state

Approximately half (12/23) of the stranding networks that responded to this question said that the majority of stranded animals were received in an advanced state of decomposition, which usually precludes determination of cause of death. Overall, an average of 20.5% of stranded animals (including live and dead strandings) are fresh carcasses.

5.3.12 Decision process to select carcasses for necropsy and proportion of carcasses necropsied

As is the case for decisions about attendance at carcasses, criteria followed to select carcasses for necropsy may affect whether the information collected is representative of the sampled populations. Stranding networks reported using various (not mutually exclusive) criteria for selecting carcasses (see Table 5.4), with the decomposition state of the animals (22/26) being the most frequently reported. Ten stranding networks do not perform any necropsies and only 7 out of the 30 respondents carry out necropsies on more than half of the available stranded animals.

Table 5.4. Criteria used to decide which animals will be necropsied.

Decision process	Yes	No	No reply	Total
Decomposition state	22	4	9	35
Important species	14	12	9	35
Specific research questions	11	15	9	35
Funding constraints (fixed numbers)	11	15	9	35
Ease of access	10	16	9	35
Body size (ease of transport)	9	17	9	35
Representative sampling	9	17	9	35
Availability of personnel	8	18	9	35

5.3.13 Storage of carcasses prior to necropsy

Eighteen stranding networks out of 31 respondents freeze carcasses prior to necropsies. Seven of these networks freeze more than 80% of carcasses, including one that freezes 100% of carcasses.

5.3.14 Where necropsies are carried out and by whom

Six stranding networks out of the 28 that responded to the corresponding question do not have specific facilities to perform necropsies. Experienced veterinarians perform most of the necropsies (on average 65.1%) in the 25 stranding networks that responded to this question, while experienced biologists are involved in 37.6%. However, there are important differences between networks. In some networks, animals are necropsied only by veterinarians, while in others necropsies are performed only by biologists. Although no networks reported that necropsies are performed solely by inexperienced personnel, inexperienced veterinarians assist in 5.6% of the necropsies.

5.3.15 Protocols for necropsies

Almost all strandings networks which responded (24/25) follow a specific protocol for performing necropsies. The majority of networks (18/25) follow the protocol of the European Cetacean Society (ECS). Other protocols used include those of ASCOBANS and ACCOBAMS guidelines (11/25), the Society of Marine Mammalogy (3/25), HELCOM (1/25) and an unspecified national protocol (1/25). Seven networks used other protocols, although most of these were based on the ECS protocol.

5.3.16 Criteria to determine bycatch

Twenty-five stranding networks provided information on the criteria used to diagnose cases of bycatch, of which the majority (19) used both external and internal evidence, although six used only external evidence to diagnose bycatch. When processing dead animals, 24 of the 35 networks collect information on external bycatch signs from necropsied animals, 13/35 from sampled animals (which were not necropsied), and 13/35 from recorded animals (which were not sampled or necropsied). Most networks used similar types of evidence, e.g. external marks caused by interactions with fishing gear, amputations, recently ingested food in the stomach, lung lesions, and the absence of evidence of other possible cause of death. A few stranding networks (8/35) record evidence that dead stranded animals were feeding in or around fishing gears (e.g., presence of pieces of nets in the mouth, oesophagus and stomach). One of them also collate information from fisheries observers on live animals feeding in and around fishing gear.

The majority of networks (22/35) routinely undertake gross pathology on animals in which bycatch is suspected, while histopathology (13), bacteriology (12), parasitology (11), virology (7) and persistent organic pollutant (4) analyses are carried out by fewer networks. Two networks commented that they additionally performed computed tomography analyses and another one, molecular studies.

5.3.17 Index of uncertainty of bycatch diagnosis

Of the 26 stranding networks that replied about this, almost two-thirds (16) apply an index of uncertainty to each bycatch diagnosis. Most networks use a classification system based on the robustness of the different indicators used to diagnose bycatch: 1) certain bycatch, where the bycatch event is known (e.g. fishers handed over the carcass); 2) highly likely bycatch (almost all indicators used to diagnose bycatch are present); 3) probable bycatch (fewer indicators); 4) possible bycatch (even fewer indicators).

5.3.18 Importance of bycatch mortality

Overall, 29/35 networks gave their opinion on the importance of bycatch/entanglement as a cause of marine mammal mortality in their region. Of these, 65.5% considered bycatch/entanglement a "very important" or "important" cause of mortality, 24.2% considered it to be of "regular" importance, and 10.3% as "unimportant" or "very unimportant". Nineteen networks shared information regarding the frequencies of different causes of death categories (i.e., bycatch/entanglement, other known causes of death, and unknown causes of death). Bycatch and entanglements appear to be most frequently recorded in stranded pelagic delphinids (average 26.2%, range 0.54% to 90%) and baleen whales (20.6%, 0% to 80%), followed by harbour porpoises (17.9%, 0% to 45%). On average, 14.7% of toothed whales (i.e., larger odontocetes) and 10.3% of seals were recorded bycaught or entangled. Not all networks that responded to this question provided data for each cause of death category and there was considerable variation between countries/regions in the reported percentages.

5.3.19 Mass strandings

Networks were asked about the frequency of mass strandings (which we originally defined as events involving 10 or more animals) and Unusual Mortality Events (UME) in their region. Fourteen networks reported having had mass strandings and a few others reported stranding events involving between 2–9 individuals. Only one of the eight networks in the Mediterranean declared that mass strandings occurred in their region. Species involved in mass strandings and Unusual Mortality Events include grey and harbour seals, pilot whales, common dolphins, bottlenose dolphins, spinner dolphins, striped dolphins, Fraser's dolphins, Risso's dolphins, sperm whales, beaked whales (including northern bottlenose whales), and false killer whales.

5.3.20 Patterns and trends in strandings and bycatch mortality

The taxa reported by stranding networks are summarised in Table 5.5. Most record cetaceans and many record seals, sea turtles, and sharks.

Table 5.5. Taxa recorded by the stranding networks.

Taxon	Yes	No	No reply	Total
Cetaceans	32	1	2	35
Pinnipeds	26	8	1	35
Seabirds	9	23	3	35
Sea turtles	25	7	3	35
Sharks	18	13	4	35
Others	12	20	3	35

Stranding networks were asked whether they had observed any important patterns or trends in the numbers of stranded marine mammals recently (e.g. changes over the years, seasonal patterns). Thirty networks responded to this question, of which 24 indicated that they had indeed detected trends, with the remaining six respondents not having detected any trends or patterns.

Amongst the 24 networks that declared having detected patterns and trends, the majority (16/24) of networks reported having detected multi-annual trends in the numbers of stranded marine mammals (see Table 5.6). Increases or decreases in the numbers of particular species (e.g. common dolphins, harbour porpoises, grey and harbour seals, white-beaked dolphins) were identified by networks. Seasonal patterns were also frequently detected. Networks also indicated having detected trends in numbers due to epizootic events (e.g. influenza and morbillivirus in the Baltic and Mediterranean) and unusual mortality events and/or mass stranding events (e.g. beaked whale mass mortalities in the British Isles, Ireland and Iceland). A few networks also reported some spatial patterns in bycatch-related mortality, an increase in the stranding of extralimital species, and some "unusual" events (e.g. two sperm whales stranding in less than 5 months in the Balearic Islands – although this might be considered usual in winter on North Sea coasts).

Table 5.6. Summary of the number of respondents who reported identifying trends or patterns in numbers of stranded marine mammals recently (based on 24 responses).

Type of trend/pattern	No. of respondents
Multi-annual trends	16
Seasonal patterns	9
Epizootic mortality	2
Unusual Mortality Event (UME)/ Mass Stranding Events (MSE)	2
Spatial pattern	1
Unusual events	1
Extralimital species	1

Eighteen respondents provided information regarding current trends in numbers of marine mammals dying of bycatch/entanglement in their area and/or information on bycatch hotspots.

A few networks reported an upward trend in bycatch/entanglement deaths of porpoises (n=3), pelagic delphinids (n = 5), seals (n = 3) and baleen whales (n = 2). Downward trends in porpoise bycatches were reported by two networks (Belgium and the Netherlands). The remaining networks reported they did not see any trend in numbers. Areas and seasons of high bycatch (e.g. of common dolphins) were identified by some respondents.

5.3.21 Collaboration with fishers

The majority of networks (24 networks out of a total of 28 respondents) collaborate with fishers to obtain information on cetacean bycatch, for example by helping to disentangle/release live bycaught animals, record cetacean bycatches reported by fishers, perform necropsies on bycaught animals submitted by fishers and/or run carcasss tagging programmes using dead bycaught cetaceans. Some note that such records/carcasses are treated separately from the strandings. Only four networks declared no collaboration with fishers through any of the above-mentioned activities.

5.3.22 Use of data on bycatch from strandings

Twenty out of 35 networks use the information they collect on bycatch to identify the gears or fisheries involved in marine mammal bycatch mortality in their region. Gears identified include static gears (several type of gillnets), towed and floating gears (trawlers and purse seine), traps and pots (creel fishing and fyke nets), and pole and line fishing.

Twenty-five networks report the information they collect on bycatch to various organisations (i.e. ASCOBANS, IWC, national/regional/local governments, HELCOM, NAMMCO, European Commission, ICES). The frequency with which networks report to organisations varies from bi-monthly to a single reporting incidence. Four networks declared that they do not report bycatch information to any of these organisations.

Only two networks out of 35 carry out tagging programmes on bycaught carcasses. Information provided by these programmes can be used for drift modelling and estimating total bycatch mortality. In addition, a third network indicated that tagging programmes are conducted by other organisations in their country, and another network specified that a tagging programme was implemented in the past but that no animals were tagged during the course of the programme.

5.3.23 Seals

Noting that, generally, strandings of seals have received less attention than those of cetaceans, here we summarise some findings specifically related to seal strandings. Twenty-six networks report pinnipeds: all but three networks active in the Northeast Atlantic region, two out of the four Macaronesian networks, and five out of the nine Mediterranean Spanish networks (Table 5).

Pinnipeds (all species pooled) represent the majority (i.e., above 50%) of the marine mammal strandings reported in Sweden, Latvia, Poland, Denmark, Scotland, and the Netherlands. It should be noted that the Latvian stranding network only collects information on seals. One of the two networks in Germany reported that seals represent almost half of the strandings. When asked to provide percentages of the different seal species that strand in the area covered by their networks, the Mediterranean Spanish networks that declared reporting pinnipeds indicated that only a few animals had been reported, including harbour seal, grey seal, harp seal, hooded seal, and unidentified seals. The majority of networks indicated that most reported live stranded seals are transferred to rescue centres.

In Ireland, one of the long- running stranding networks reported solely focusing on cetacean strandings and not recording information on seals. Instead, information on seal strandings is gathered by rescue centres in the country. A similar situation applies in the Netherlands, where all three respondents indicated reporting information on pinnipeds. One of these networks focuses on cetacean necropsies and had examined very few seals while the other two networks reported that seals represent the majority of stranded animals they receive. The lack of a long-term necropsy program focusing on seals precludes the collation of information about health status, ecology and biology, as well as the threats they are facing in these two regions. We also note that some Nordic countries may not focus their activities on seal strandings since information is available from hunted individuals. However, information coming from hunted seals is generally not suitable for bycatch-related studies.

5.4 What will be needed from a strandings data call to serve the needs of bycatch assessment?

Currently, WGBYC reports annual species-specific percentages of cetacean mortality attributed to bycatch (% of examined animals with bycatch evidence) by country (where data are available) based on data received on the total numbers of stranded animals, the number of fresh or slightly decomposed animals which underwent examination, and the number of these animals with evidence of bycatch. This type of data is generally lacking for pinnipeds (although France and Belgium do collect such data). It is also true that more attention may be given to large cetaceans than to small cetaceans. In the Netherlands, all baleen whales are necropsied but only about 20% of (the much more numerous) porpoise, and hardly any seals. Efforts are therefore needed to procure information on those marine mammal species currently receiving less attention.

The provision of additional information, both biological and methodological, can greatly enhance the value of reported bycatches. To enable temporal and spatial trends in bycatch to be examined, data on the location (i.e. latitude/longitude or ICES statistical rectangle) and date of encounter of each stranded animal, and basic biological information on species and specimen condition is required. This information would enable trends in the seasonality and relative abundance of stranded species to be assessed in areas for which records are available. The more detailed location of the area where the stranded animals were found could aid in identification of bycatch hotspots. However, caution is needed in interpreting location data. Carcasses may be carried considerable distance by currents, and vagrant individuals may strand outside their usual distribution range. In the Netherlands, seal strandings tend not to coincide with the known distribution of the species (Brasseur, 2018).

More external information on apparent cause of death and signs of bycatch would enhance these data further, allowing relative estimates of bycatch to be made and contributing to identifying seasonal and temporal trends in bycatch. Biological measurement and external observations of body condition would give indications of any biases in sex ratios of bycaught stranded species.

If a comprehensive necropsy examination is carried out and detailed information relevant to cause of death and body condition of the specimen (e.g. body condition, stomach contents, presence of litter in stomach etc) are provided, a more complete picture of the health of the stranded animal can be attained. Likewise, any evidence of the type of fishing gear involved in specimens determined to have died as a result of bycatch would enhance our understanding of fishing-marine mammal interactions. Additional information in relation to the types of fishing gear that pose a greater bycatch risk to marine mammals may help to target monitoring and/or mitigation efforts towards high-risk metiers.

In addition to the benefits of spatiotemporal and detailed biological and cause of death information, the availability of data on the methodologies used to collect strandings can also be invaluable. Data relating to the effort involved in the stranding network such as the levels of search effort undertaken, whether this effort is dedicated or opportunistic, and the spatial coverage of search effort, can put into context any strandings associated with bycatch. Understanding effort coverage provides an opportunity to standardise bycatch records across networks, and the potential to estimate relative bycatch rates on a regional scale. Methodological information on the proportion of strandings that are necropsied and how these necropsied specimens are chosen, the extent of the examinations (i.e. whether complete necropsy is carried out on each specimen, and whether histology or bacteriology analyses are undertaken) and the experience (including veterinary expertise) of those carrying out the examinations can also inform standardisation of relative bycatch estimates between stranding networks. Such information would also aid the interpretation of apparent local or regional trends. Knowledge of the methodology used to determine age and reproductive status is also important to judge the utility of the data (e.g. age information inferred from length does not have the same value as actual age readings from teeth; it is less precise and prone to variation with body condition and regional environmental conditions).

Finally, if biases in the data can be accounted for, or at least understood, for example by incorporating survey data on distribution, drift modelling of carcass movements incorporating currents, weather effects, and estimated time of death, and life tables, strandings could ultimately be used to estimate number of bycatch deaths and the annual mortality rate due to bycatch.

Possible uses of stranding data are briefly summarised in Table 5.7 below, considering different intensities of data collection and acknowledging the above-mentioned limitations and biases.

Table 5.7. Current and future use of strandings data and ancillary data, based on different levels of data collection

No	TYPE OF DATA	USES OF DATA	CAVEATS	APPLICABILITY TO ASSESSMENT OF BY-CATCH AND BYCATCH RISK
1	Location, date, species length, sex, blubber thickness, etc.	Presence of species, seasonality and relative abundance in coastal waters; indicators of sex ratio, population size structure, condition.	Strandings sometimes outside the normal distribution range. It is important to understand whether detected strandings are "representative" (e.g. considering, the "catchment" area, current systems, weather effects, carcass buoyancy in relation to size and body condition, distribution of search effort).	Help identify areas of overlap of marine mammals and fisheries (assuming data on the distribution of fishing effort are available). Begin to look at geographical patterns, annual and seasonal trends in bycatch mortality; examine trends at a regional or ecoregion scale Supplement at-sea observer or tracking data, particularly for regions or areas that lack such data.
2	1 + recording apparent cause of death, including signs of by-catch mortality	Number and proportion of bycaught animals, seasonality of by-catch, size, sex and "condition" of bycaught animals, possible identification of fishery (gear) involved.	Appropriate protocols and trained personnel are needed. The representativeness of the carcasses selected for examination and sampling should be considered (e.g. if based on decomposition state, does this vary seasonally and regionally?)	Occurrence of bycatch and mass mortality events, minimum number of bycatches, proportion of mortality "caused" by bycatch, identification of the most frequently bycaught components of a population. Indication of type of fishery.
3	2 + full necropsy + pathology + histopathology, stomach contents analysis, contaminants analysis	More reliable diagnosis of bycatch deaths. Full picture of health status of bycaught animals, diet, contaminant burdens. Identification of pregnant and lactating females will help indicate fecundity.	The representativeness of the carcases selected for necropsy and analysis should be considered.	Provides more context and potential "explanations" for bycatch deaths and further insight into bycatch risk.
4	3 + samples to provide life history data (teeth, whiskers or baleen for age, gonads for reproductive status.	Age distribution, of all, and bycaught, animals, pregnancy rate, life table with estimates of annual mortality and reproductive output. Indications of population status.	Even with representative sampling, biases may occur, e.g. if teeth of older dolphins are more difficult to read. A large data set is needed to estimate life history parameters, especially to detect changes over time. To determine age or length at sexual maturity it is useful to have more animals of around this age or length.	Estimate of mortality rate due to bycatch. Generation time and population reproductive capacity (both are useful to determine bycatch limits).
5	4 + drift modelling and reverse drift modelling + information on distribution at sea	Understanding of the geographical source of stranded animals, quantification of spatial and body-size-related biases in numbers reaching the beach. Possible overlap with specific habitat including human activities. Life tables can be corrected for arrival bias (application of models of mortality at age can also help compensate for under-representation of small animals)	In order to provide fully quantitative information, drift models should be linked to information on the spatial distribution of cetaceans at sea and how it varies seasonally (a uniform distribution can be assumed but this may introduce biases), and factors such as estimated time of death, currents system, weather effects accounted for.	Estimate of the number of animals bycaught and determination of their geographical origin. Improved estimates of bycatch mortality rates. Identify areas of overlap of marine mammals and fisheries (again, assuming data on the distribution of fishing effort are available).

Several marine science organisations and regional sea conventions have an interest in stranding data. ACCOBAMS, ASCOBANS, the European Cetacean Society (ECS), and the Specially Protected Areas Regional Activity Centre (RPA/RAC) organized a Joint workshop on marine debris and cetacean strandings in 2018. ICES have cooperation agreements with a range of organisations (see full list here) including HELCOM and OSPAR.

The questionnaire provided an opportunity to ask European stranding networks about their willingness to provide detailed data on strandings, and diagnosed bycatch mortality through a potential annual data call. Thirty-two stranding networks responded to the relevant question, of which 28 confirmed their willingness to share their data through an ICES data call. Among the remaining networks, two of them did not respond to this question while another clarified that it has no competence to decide on this matter. One stranding network mentioned the need to better organise data calls from different international organisations requesting data.

Given the different approaches and different levels of resourcing of different networks, a one-size-fits-all solution is unlikely, but a call coordinated across the various interested international organisations seems plausible and relevant metadata could be requested to establish the limitations and biases associated with each dataset. The adoption of a database and annual data call for stranding data will require the development of a specific data policy. For other biodiversity databases within ICES, a specific policy is applied to determine user rights to restricted and public data accessed through the database. Consideration is also needed of the appropriate entities to which the data call will be sent. It might be logical for this to be at national level, although this presumes an appropriate level of national coordination of input from individual networks and such a "two-stage" data call might be less efficient at capturing all the information needed. Agreement will be needed on permitted uses of the submitted data.

The success of a data call could be enhanced by (further) agreement on necropsy protocols as well as provision of support / advice about quantifying and reducing biases in the data, promotion of the value of obtaining full health status information rather than simply determining cause of death, assistance with training personnel and technical support for the process of uploading data. It might be appropriate for ICES WGMME and WGBYC to form a joint sub-group or sub-groups to develop the data call and monitor its implementation. Consultation with data providers, clients (end users of any data products), and bycatch scientists should be undertaken to determine the most appropriate way to analyse and present any and all strandings data collated.

5.5 Recommendations

The results from the questionnaire survey should be published soon in a journal paper.

In consultation/collaboration with other relevant bodies, ICES should:

i. develop a best-practice manual or framework for the collection and use of information from marine mammal strandings to inform bycatch assessment, to obtain data on all relevant species, to obtain the best possible data from the networks and ensure that data are used in the best way. This could be published as a CRR;

ii. develop a data call and database for such data;

iii. organise a workshop or workshops to develop (i) and (ii) above

ICES member countries should improve coordination and resourcing of stranding monitoring networks, to standardise and enhance the data available on bycatch mortality from strandings.

6 References

Aarts, G., Brasseur, S., Poos, J. J., Schop, J., Kirkwood, R., Van Kooten, T., Mul, E.,et al. 2019. Top-down pressure on a coastal ecosystem by harbor seals. Ecosphere 10, e02538..

Accardo, C. M., Ganley, L. C., Brown, M. W., Duley, P. A., George, J. C., Reeves, R. R., and Mayo, C. A. 2018. Sightings of a bowhead whale (*Balaena mysticetus*) in the Gulf of Maine and its interactions with other baleen whales. Journal of Cetacean Research & Management, 19, 23-30.

Ålands Landskapsregering. 2007. Förvaltningsplan för gråsälen på Åland. 56 pp.

Amundin, M., Carlström, J., Thomas, L., Carlén, I., Koblitz, J., Teilmann, J., Tougaard, J., *et al.* 2022. Estimating the abundance of the critically endangered Baltic Proper harbour porpoise (*Phocoena phocoena*) population using passive acoustic monitoring. Ecology and Evolution, 12, e8554. https://doi.org/10.1002/ece3.8554

Andersen, S. M., Teilmann, J., Harders, P. B., Hansen, E. H., Hjollund, D. 2007. Diet of harbour seals and great cormorants in Limfjord, Denmark: interspecific competition and interaction with fishery. ICES Journal of Marine Science, 64: 1235–1245

Andvik, C., Jourdain, E., Lyche, J. L., Karoliussen, R., Borgå, K. 2021. High levels of legacy and emerging contaminants in killer whales (*Orcinus orca*) from Norway, 2015 to 2017. Environmental Toxicology and Chemistry, 40(7), 1848-1858. https://doi.org/10.1002/etc.5064

Anon. 2020. Special Report 26/2020 Marine environment: EU protection is wide but not deep 2020/C 412/09 (OJ C, C/412, 30.11.2020, p. 9, CELEX: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020SA0026(01))

Anonymous. 2021. 'Out of Habitat' Marine Mammals Workshop Report. 30 Sept – 1 Oct 2021. Held virtually. 46pp. https://wildanimalwelfare.com/reports/

Aquino, J. F., Burns, G. L., Granquist, S. M. 2021. A responsible framework for managing wildlife watching tourism: The case of seal watching in Iceland. Ocean & Coastal Management, 210, 105670. https://doi.org/10.1016/j.ocecoaman.2021.105670

Arranz, P., de Soto, N. A., Madsen, P. T., Sprogis, K. R. 2021. Whale-watch vessel noise levels with applications to whale-watching guidelines and conservation. Marine Policy, 134, 104776. https://doi.org/10.1016/j.marpol.2021.104776

Arregui, M., Bernaldo de Quirós, Y., Saavedra, P., Sierra, E., Suárez-Santana, C.M., Arbelo, M., Díaz-Delgado, J., *et al.* 2019. Fat Embolism and Sperm Whale Ship Strikes. Front. Mar. Sci. 6:379. doi: 10.3389/fmars.2019.00379

Arregui, M., Fernández, A., Paz-Sánchez, Y., Santana, Á., Sacchini, S., Sierra, E., Arbelo, M., *et al.* 2020. Comparison of three histological techniques for fat emboli detection in lung cetacean tissue. Scientific Reports, 10(1), 1-7.

Arso Civil, M., Quick, N., Mews, S., Hague, E., Cheney, B. J., Thompson, P. M. and Hammond, P. S. 2021. Improving understanding of bottlenose dolphin movements along the east coast of Scotland. Final report. Report number SMRUC-VAT-2020-10 provided to European Offshore Wind Deployment Centre (EOWDC), March 2021, 54pp.

ASCOBANS. 2020. Species Action Plan for the North-East Atlantic Common Dolphin. 9th Meeting of the Parties ASCOBANS/MOP9/Inf.6.1.4. https://www.ascobans.org/sites/default/files/document/ascobans_mop9_inf6.1.4_sap-common-dolphin_.pdf

ASCOBANS. 2021a. Prioritisation of Activities Requiring Funding. 26th Advisory Committee Meeting, Document 8.3/Rev1. https://www.ascobans.org/sites/default/files/document/ascobans_ac26_doc8.3_rev1_prioritisation-activities.pdf

ASCOBANS. 2021b. Mass Killing of the Atlantic White-sided Dolphin (Lagenorhynchus acutus) in the Faroe Islands in September 2021. ASCOBANS/AC26/Inf.4.2. https://www.ascobans.org/sites/default/files/document/ascobans_ac26_doc4.2_lagenorhynchus-acutus-mass-killing.pdf

Bäcklin, B.-M., Persson, S., Faxneld, S., Riget, F.F., Roos, R.M., 2021. Temporal and Geographical Variation of Intestinal Ulcers in Grey Seals (Halichoerus grypus) and Environmental Contaminants in Baltic Biota during Four Decades. Animals-Basel 11.

Barile, C., Berrow, S. and O'Brien, J., 2021. Oceanographic Drivers of Cuvier's (*Ziphius cavirostris*) and Sowerby's (Mesoplodon bidens) Beaked Whales Acoustic Occurrence along the Irish Shelf Edge. Journal of Marine Science & Engineering, 9: 1081. https://doi.org/10.3390/jmse9101081

Basran, C. J., Sigurðsson, G. M. 2021. Using Case Studies to Investigate Cetacean Bycatch/Interaction Under-Reporting in Countries with Reporting Legislation. Frontiers in Marine Science, 8, 1811. https://doi.org/10.3389/fmars.2021.779066

Baulaz Y. & Morin-Repinçay, A. 2015. Mémoire de pêcheurs - Pêche et mammifères marins dans le golfe de Gascogne. https://lienss.univ-larochelle.fr/IMG/pdf/livret_me_moires_de_pe_cheurs2.pdf

Bellmann M. A., Brinkmann J., May A., Wendt T., Gerlach S., Remmers P. 2020. Underwater noise during the impulse pile-driving procedure: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU)), FKZ UM16 881500. Commissioned and managed by the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie (BSH)), Order No. 10036866. Edited by the itap GmbH.

Ben Chehida, Y., Loughnane, R., Thumloup, J., Kaschner, K., Garilao, C., Rosel, P. E. and Fontaine, M.C., 2021. No leading-edge effect in North Atlantic harbor porpoises: Evolutionary and conservation implications. Evolutionary Applications, 14: 1588–1611. https://doi.org/10.1111/eva.13227

Bennett, K.A., Robinson, K.J., Armstrong, H.C., Moss, S.E.W., Scholl, G., Tranganida, A., Eppe, G., *et al.* 2021. Predicting consequences of POP-induced disruption of blubber glucose uptake, mass gain rate and thyroid hormone levels for weaning mass in grey seal pups. Environ Int 152.

Bering, J.; Gargan, H.; Kuesel, J.; Morrison, M.; Mullaney, C.; Read, A. J.; Roady, S. E. & Rowe, A. 2022. Will Unilateral Action Improve the Global Conservation Status of Marine Mammals? A First Analysis of the U.S. Marine Mammal Protection Act's Import Provisions Rule. Marine Policy, 135, 104832. https://doi.org/10.1016/j.marpol.2021.104832

Berrow, S., Daly, M., Levesque, S., Regan, S. and O'Brien, J. 2021. Boat-based visual surveys for Bottlenose dolphin in the West Connacht Coast SAC in 2021. National Parks and Wildlife Service, Department of Housing, Heritage and Local Government, Ireland, 41pp.

Bester, M. N. 2021. Vagrant sub-Antarctic fur seal at tropical Ascension Island, South Atlantic Ocean. Polar Biology, 44(2): 451–454. https://doi.org/10.1007/s00300-021-02800-z

Biuw, M., Øigård, T.A., Nilssen, K. T., Stenson, G., Lindblom, L., Poltermann, M., Kristianssen, M., *et al.* 2022. Recent harp and hooded seal pup production estimates in the Greenland Sea suggest ecology-driven declines. NAMMCO Scientific Publications 12. https://doi.org/10.7557/3.5821

Bjorge, A., Bekkby, T., Bakkestuen, V., Framstad, E., 2002. Interactions between harbour seals, *Phoca vitulina*, and fisheries in complex coastal waters explored by combined Geographic Information System (GIS) and energetics modelling. Ices Journal of Marine Science, 59, 29-42

Bjørge, A., Ryeng, K.A., Jourdain, E. and Wiig, J.R. 2020. A short note on unusual high frequency of cetacean strandings in Northern Norway, 28th March – 2nd May 2020. IWC SC/68B/E/06.

Blanchard, A., Dorémus, G., Laran, S., Nivière, M., Sanchez, T., Spitz, J. Van Canneyt, O. 2021. Distribution et abondance de la mégafaune marine en France métropolitaine. Rapport de campagne SAMM II Atlantique-Manche - Hiver 2021, de l'Observatoire Pelagis (UMS 3462, La Rochelle Université / CNRS) pour la Direction de l'Eau et de la Biodiversité et L'Office Français de la Biodiversité. 103 pp.

Bodewes, R., Zohari, S., Krog, J. S., Hall, M. D., Harder, T. C., Bestebroer, T. M., van de Bildt, M.W., *et al.* 2016. Spatiotemporal analysis of the genetic diversity of seal influenza A(H10N7) virus, Northwest-ern Europe. Journal of Virology, 90: JVI.03046-15.

Booth, C., Thomas, L. 2022. An Expert Elicitation of the Effects of Low Salinity Water Exposure on Bottle-nose Dolphins. Oceans 2021, 1, 179–192. https://doi.org/10.3390/oceans2010011

Bourque, L., Wimmer, T., Lair, S., Jones, M., Daoust, P.-Y. 2020. Incident Report: North Atlantic Right Whale Mortality Event in Eastern Canada, 2019. Collaborative Report Produced by: Canadian Wildlife Health Cooperative and Marine Animal Response Society. 210 pp. http://www.cwhc-rcsf.ca/docs/2019%20NARW%20incident%20report_June%202020.pdf

Bowen, W. D., Iverson, S. J., 2013. Methods of estimating marine mammal diets: A review of validation experiments and sources of bias and uncertainty. Marine Mammal Science 29, 719-754.

Brasseur, S. 2018. Stranding and Rehabilitation in Numbers: Population development and stranding data on the Dutch coasts, 1990-2016; Analysis of new data from a public database. Wageningen Marine Re-search Report. 36 pp.

Brasseur, S. M. J. M., Reijnders, P. J. H., Cremer, J., Meesters, E., Kirkwood, R., Jensen, L. F., Jeβ, A. *et al.* 2018. Echoes from the past: Regional variations in recovery within a harbour seal population. PLoS ONE, 13(1), e0189674. https://doi.org/10.1371/journal.pone.0189674

Brasseur, S. M. J. M., van Polanen Petel, T. D., Gerrodette, T., Meesters, E. H. W.G., Reijnders, P .J. H., Aarts, G., 2015. Rapid recovery of Dutch grey seal colonies fueled by immigration. Marine Mammal Science, 31: 405-426.

Brasseur, S., Abel, C., Galatius, A., Jeß, A., Körber, P., Meise K., Schop J., *et al.* 2021. EG-Marine Mammals grey seal surveys in the Wadden Sea and Helgoland in 2020-2021. Wilhelmshaven, Germany: Common Wadden Sea Secretariat (CWSS). Retrieved from https://www.waddensea-worldheritage.org/sites/de-fault/files/Wadden_Sea_Grey_Seal_Report_2021_0.pdf

Brereton, T., Jones, D., Leeves, K., Lewis, K., Davies, R. Russell, T. 2018. Population structure, mobility and conservation of Common Bottlenose Dolphin off southwest England from photo-identification studies. Journal of the Marine Biological Association of the United Kingdom, 98(5): 1055–1063. https://doi.org/10.1017/S0025315417000121.

Broekhuizen, S., Spoelstra, K., Thissen, J. B., Canters, K. J., Buys, J. C., 2016. Atlas van de Nederlandse zo-ogdieren. Naturalis Biodiversity Center

Brose, U., Archambault, A., Barnes, A. D., Bersier, L.-F., Boy, T., Canning-Clode, J., Conti, E., *et al.* 2019. Predator traits determine food-web architecture across ecosystems. Nature Ecology & Evolution 3: 919–927.

Bull, J. C., Jones, O. R., Borger, L., Franconi, N., Banga, R., Lock, K., Stringell, T. B., 2021. Climate causes shifts in grey seal phenology by modifying age structure. Proceedings of the Royal Society B - Biolog-ical Sciences, 288. https://doi.org/10.1098/rspb.2021.2284

Cabrera, A. A., Schall, E., Bérubé, M., Anderwald, P., Bachmann, L., Berrow, S., Best, P. B., *et al*. 2022. Strong and lasting impacts of past global warming on baleen whales and their prey. Global Change Biology, 00, 1–21. https://doi.org/10.1111/gcb.16085

Carroll, E. L., Hall, A., Olsen, M. T., Onoufriou, A. B., Gaggiotti, O. E. and Russell, D. J. F. 2020. Perturbation drives changing metapopulation dynamics in a top marine predator. Proceedings of the Royal Society B, 287(1928), 20200318.

Carter, M. I. D., McClintock, B. T., Embling, C. B., Bennett, K. A., Thompson, D. and Russell, D. J. F. 2019. From pup to predator; generalized hidden Markov models reveal rapid development of movement strategies in a naïve long-lived vertebrate. Oikos, oik.06853. https://doi.org/10.1111/oik.06853

Chauvat, C. M., Aquino, J., Granquist, S. M. 2021. Visitors’ values and perceptions of seal watching man-agement in Northwestern Iceland. Journal of Sustainable Tourism, 1-20. https://doi.org/10.1080/09669582.2021.1995395

Cheney, B. J., Thompson, P. M., Cordes, L. S. 2019. Increasing trends in fecundity and calf survival of bottlenose dolphins in a marine protected area. Scientific Reports, 9 (1): 1767. DOI: 10.1038/s41598-018-38278-9

Chladek, J., Culik, B., Kindt-Larsen, L., Albertsen, C. M., von Dorrien, C. 2020. Synthetic harbour porpoise (Phocoena phocoena) communication signals emitted by acoustic alerting device (Porpoise ALert, PAL) significantly reduce their bycatch in western Baltic gillnet fisheries. Fisheries Research, 232, 105732. https://doi.org/10.1016/j.fishres.2020.105732

Clausen, K. T., Teilmann, J., Wisniewska, D. M., Balle, J. D., Delefosse, M., van Beest, F. M. 2021. Echolocation activity of harbour porpoises, *Phocoena phocoena*, shows seasonal artificial reef attraction despite elevated noise levels close to oil and gas platforms. Ecological Solutions and Evidence, 2(1), e12055. https://doi.org/10.1002/2688-8319.12055

Cole, T. V. N., Crowe, L. M., Corkeron, P. J. and Vanderlaan, A. S . M. 2020. North Atlantic right whale abundance, demography and residency in the southern Gulf of St. Lawrence derived from directed aerial surveys. DFO Canadian Science Advisory Secretariat Research. Document 2020/063. iv + 13 pp. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2020/2020_063-eng.html

Corr, S. 2020. Using citizen science data to assess the vulnerability of bottlenose dolphins (*Tursiops truncatus*) along England’s south coast. MRes thesis, University of Plymouth. 50pp.

Covelo, P. Lopéz, A. 2021. First record of dwarf sperm whale (*Kogia sima*) in the north of Spain. Galemys, 33: 64-68.

Cronin, M., Pomeroy, P., Jessopp, M. 2013. Size and seasonal influences on the foraging range of female grey seals in the northeast Atlantic. Marine Biology, 160(3): 531–539. https://doi.org/10.1007/s00227-012-2109-0

Crowe, L. M., Brown, M. W., Corkeron, P. J., Hamilton, P. K., Ramp, C., Ratelle, S., Vanderlaan, A.S.M., Cole, T. V. N. 2021. In plane sight: a mark–recapture analysis of North Atlantic right whales in the Gulf of St. Lawrence. Endangered Species Research 46: 227-251

Dagleish, M. P., Flockhart, A. F., Baily, J. L., Hall, A. J., Simpson, T. I., Longbottom, D., 2021. Presence of DNA from Chlamydia-like organisms in the nasal cavities of grey seal pups (Halichoerus grypus) and three different substrates present in a breeding colony. Bmc Veterinary Research, 17.

Daoust, P. -Y., Couture, E. L., Wimmer, T., Bourque, L. 2018. Incident Report: North Atlantic Right Whale Mortality Event in the Gulf of St. Lawrence, 2017. Collaborative Report Produced by: Canadian Wildlife Health Cooperative, Marine Animal Response Society and Fisheries and Oceans Canada. 256 pp. http://www.cwhc-rcsf.ca/docs/technical_reports/NARW_Incident_Report-%2020180405%20MD.pdf

Darmon G., Andrea de Lucia, G., Baini, M., Bradai, M. N., Bray, L., Broderick, A., Camedda, A., *et al.* 2022. Implementation of the indicator “Impacts of marine litter on sea turtles and biota” in RSC and MSFD areas. Final report of the INDICIT-II project, Directorate-Generale for the Environment, European Union, 170 pp. + appendices. Joy, R., Schick, R. S., Dowd, M., Margolina, T., Joseph, J. E., Thomas, L. 2022. A fine-scale marine mammal movement model for assessing long-term aggregate noise exposure. Ecological Modelling, 464, 109798. https://doi.org/10.1016/j.ecolmodel.2021.109798

Davis, G. E., Baumgartner, M. F., Bonnell, J. M., Bell, J., Berchok, C., Bort Thornton, J., Brault, S., *et al.* 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. Scientific Reports, 7: 13460.

Davis, G. E., Baumgartner, M. F., Corkeron, P. J., Bell, J., Berchok, C., Bonnell, J. M., Thornton, J. B. *et al.* Exploring movement patterns and changing distributions of baleen whales in the western North Atlantic using a decade of passive acoustic data. Global Change Biology, 1-30.

de Boer, M. N., Jones, D., and Jones, H. 2017. Ocean wanderers: extralimital encounters with bowhead whales (*Balaena mysticetus*) in temperate European shallow waters. Aquatic Mammals, 43(3): 279.

Delarue, J., Kowarski, K., Maxner, K., MacDonnell, J., Martin, B. 2018. Acoustic Monitoring Along Canada’s East Coast: August 2015 to July 2017. Environmental Studies Research Fund Report Number 215 (2018). https://static1.squarespace.com/static/52aa2773e4b0f29916f46675/t/5c784432e5e5f0533d5756f0/1551385685533/ESRF215_Delarue%2C+J_et+al_optimized.pdf den Heyer, C. E., Lang, S. L. C., Bowen, W. D., Hammill, M. O. 2017. Pup Production at Scotian Shelf Grey Seal (*Halichoerus grypus*) colonies in 2016. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/056. v + 34 pp.

Desforges, J. P., Mikkelsen, B., Dam, M., Rigét, F., Sveegaard, S., Sonne, C., Dietz, R., Basu, N. 2021. Mercury and neurochemical biomarkers in multiple brain regions of five Arctic marine mammals. NeuroToxicology, 84: 136-145. https://doi.org/10.1016/j.neuro.2021.03.006

DFO. 2009. Lawson. J.W., Gosselin, J.-F. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's marine megafauna survey - a component of the 2007 TNASS. DFO Canadian Science Advisory Secretariat Research Document 2009/031. vi + 28 pp. https://waves-vagues.dfo-mpo.gc.ca/Library/338449.pdf

DFO. 2012. Recovery Strategy for the beluga whale (*Delphinapterus leucas*) St. Lawrence Estuary population in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. xx + 88 pp..

DFO. 2014. Recovery Strategy for the North Atlantic Right Whale *(Eubalaena glacialis*) in Atlantic Canadian Waters [Final]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 68 pp. https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/rs_bnan_narw_am_0414_e.pdf

DFO. 2016. Recovery Strategy for the Northern Bottlenose Whale, (*Hyperoodan ampullatus*), Scotian Shelf population, in Atlantic Canadian Waters [Final]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 70 pp. https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/RecoveryStrategy-NorthernBottlenoseWhale-v00-2016Jun07-Amended-Eng.pdf

DFO. 2018. Identification of habitats important to the blue whale in the western North Atlantic. DFO Canadian Science Advisory Secretariat Science Advisory Report 2018/003. https://waves-vagues.dfo-mpo.gc.ca/Library/40687776.pdf

DFO. 2019. Review of North Atlantic right whale occurrence and risk of entanglements in fishing gear and vessel strike in Canadian waters. DFO Canadian Science Advisory Secretariat Science Advisory Report 2019/028. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2019/2019_028-eng.html

DFO. 2020a. Assessment of the Distribution, Movements and Habitat Use of Northern Bottlenose Whales on the Scotian Shelf to Support the Identification of Important Habitat. DFO Canadian Science Advisory Secretariat Science Advisory Report 2020/008. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2020/2020_008-eng.html

DFO. 2020b. Updated information on the distribution of North Atlantic right whale in Canadian waters. DFO Canadian Science Advisory Secretariat Science Advisory Report 2020/037. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2020/2020_037-eng.html

Díaz López, B .and Methion, S. 2019. Habitat drivers of endangered rorqual whales in a highly impacted upwelling region. Ecological Indicators, 103: 610 – 616.

Díaz López, B., Methion, S., Giralt Paradell, O., and Mosca O., 2021. Proyecto BALAENATUR: seguimiento del rorcual azul en la red Natura 2000. Bottlenose Dolphin Research Institute, O Grove. 44pp.

Dinis, A., Molina, C., Tobeña, M., Sambolino, A., Hartman, K., Fernandez, M., Magalhães, S., *et al.*2021. Large-scale movements of common bottlenose dolphins in the Atlantic: dolphins with an international courtyard. PeerJ 9, e11069. https://doi.org/10.7717/peerj.11069

Dolman, S. J., Berrow, S. D., Brownlow, A., Deaville, R., Evans, P. G.H., Fernandez, A., Gordon, J.C.D., *et al.*2021. Overcoming Challenges to Protect Beaked Whales in the Northeast Atlantic. ASCOBANS Intersessional Working Group Report, September 2021. ASCOBANS/AC26/Doc.4.3. https://www.ascobans.org/sites/default/files/document/ascobans_ac26_doc4.3_iwg-beaked-whales-report.pdf.

EC. 2021. Rport from the Commission to the European Parliament and the Council. Implementation of the Technical Measures Regulation (Article 31 of Regulation (EU) 2019/1241). {SWD(2021) 268 final}. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0583&from=EN

EEA. 2019. Marine messages II - Navigating the course towards clean, healthy and productive seas through implementation of an ecosystem-based approach. European Environmental Agency report No 17/2019. ISSN 1977-8449

EEA. 2020. State of nature in the EU Results from reporting under the nature directives 2013-2018. European Environmental Agency report No 10/2020. ISSN 1725-9177

Evans, P.G.H. 2020. European Whales, Dolphins and Porpoises. Marine Mammal Conservation in Practice. Academic Press, London & New York. 306pp.

Evans, P. G. H., Waggitt, J. J. 2020a. Impacts of climate change on marine mammals, relevant to the coastal and marine environment around the UK. MCCIP Science Review 2020, 421-455. http://www.mccip.org.uk/media/2022/19_marine_mammals_2020.pdf

Evans, P. G. H., Waggitt, J. J. 2020b. Cetaceans. Pp. 134-184. In: Crawley, D., Coomber, F., Kubasiewicz, L., Harrower, C., Evans, P., Waggitt, J., Smith, B. and Mathews, F. (Editors) Atlas of the Mammals of Great Britain and Northern Ireland. Published for The Mammal Society by Pelagic Publishing, Exeter. 205 pp.

Evans, P. G. H., Carrington, C., Waggitt, J. 2021. *Risk Assessment of Bycatch of Protected Species in Fishing Activities*. European Commission, Brussels. 213pp. https://ec.europa.eu/environment/nature/natura2000/marine/docs/RISK MAPPING REPORT.pdf

Feingold, D. and Evans, P. G. H. 2014b. Connectivity of Bottlenose Dolphins in Welsh Waters: North Wales Photo-Monitoring Report. Natural Resources Wales Research Report, 1-15.

Feyrer, L.J. 2021. Northern bottlenose whales in Canada: the story of exploitation, conservation and recovery. PhD Thesis. Dalhousie University, Halifax, NS, Canada. http://hdl.handle.net/10222/80660

Fietz, K., Galatius, A., Teilmann, J., Dietz, R., Frie, A.K., Klimova, A., Palsbøll, P.J., *et al.*2016. Shift of grey seal subspecies boundaries in response to climate, culling and conservation. Molecular Ecology 25(17): 4097–4112. doi:10.1111/mec.13748.

Findlay, C. R., Aleynik, D., Farcas, A., Merchant, N. D., Risch, D., Wilson, B. 2021. Auditory impairment from acoustic seal deterrents predicted for harbour porpoises in a marine protected area. Journal of Applied Ecology, 58(8), 1631-1642. https://doi.org/10.1111/1365-2664.13910

Fisheries Act. 1985. c. F-14. https://laws-lois.justice.gc.ca/PDF/F-14.pdf.

Friis, L. W., Jensen, A. H., Molzen, J., Rebsdorf, M. 1994. Harbour seal diet in the central broads of Limfjorden, Denmark. , 100: 57–62. Flora og Fauna, 100: 57-62.

Galatius, A., Abel, C., Brackmann, J., Brasseur, S., Jeß, A., Meise, K., Meyer, J., *et al.* 2021a. Wilhelmshaven, Germany: Common Wadden Sea Secretariat (CWSS). https://www.waddensea-worldheritage.org/sites/default/files/2021_Harbour_Seal_Report.pdf

Galatius, A., Engbo, S. G., Teilmann, J., van Beest, F. M. 2021b. Using environmental variation to optimize aerial surveys of harbour seals. ICES Journal of Marine Science, 78(4): 1500–1507. https://doi.org/10.1093/icesjms/fsab041

Galatius, A., Teilmann, J., Dähne, M., Ahola, M., Westphal, L., Kyhn, L. A., Pawliczka, I., *et al.*2020. Grey seal, *Halichoerus grypus*, recolonisation of the southern Baltic Sea, Danish Straits and Kattegat. Wildlife Biology, 2020(4). https://doi.org/10.2981/wlb.00711

Galatius, A., Teilmann, J., Olsen, M. T., van Beest, F. M. 2021c. Response to Kiełpińska and Kowalski: A stab in a self-imposed darkness. Ecological Indicators, 127, 107808. https://doi.org/10.1016/j.ecolind.2021.107808

Garcia-Garin, O., Aguilar, A., Vighi, M., Víkingsson, G. A., Chosson, V., Borrell, A. 2021. Ingestion of synthetic particles by fin whales feeding off western Iceland in summer. Chemosphere, 279. https://doi.org/10.1016/j.chemosphere.2021.130564

García-Vernet, R., Borrell, A., Víkingsson, G., Halldórsson, S. D., Aguilar, A. 2021. Ecological niche partitioning between baleen whales inhabiting Icelandic waters. Progress in Oceanography, 199, 102690. https://doi.org/10.1016/j.pocean.2021.102690

Garrison, L. 2020. Abundance of marine mammals in waters of the US south eastern Atlantic during summer 2016.

Garrison, L. P. and Palka, D. 2018. Abundance of short-finned pilot whales along the U.S. east coast from summer 2016 vessel surveys. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, FL 33140. PRBD Contribution # PRBD-2018-07, 18 pp.

Garrison, L. P., Stokes, L. 2017. Estimated bycatch of marine mammals and sea turtles in the US Atlantic pelagic longline fleet during 2015.

Gauffier, P., Borrell, A., Silva, M. A., Víkingsson, G., López, A., Giménez, J., Colaço, A., *et al*. 2020. Wait your turn, North Atlantic fin whales share a common feeding ground sequentially. Marine Environmental Research:104884

Genu, M., Gilles, A., Hammond, P., Macleod, K., Paillé, J., Paradinas, I. A., Smout, S., *et al.* 2021. Evaluating Strategies for Managing Anthropogenic Mortality on Marine Mammals: an R Implementation with the Package RLA. Frontiers in Marine Science, 2021, 8, 795953. doi: 10.3389/fmars.2021.795953

Giard S., Simard Y., Roy N. 2020. Decadal passive acoustics time series of St. Lawrence estuary beluga. Journal of the Acoustical Society of America, .147(3): 1874

Gilles, A., Viquerat, S., Becker, E. A., Forney, K. A., Geelhoed, S. C. V., Haelters, J., Nabe-Nielsen, J., *et al.* 2016. Seasonal habitat based density models for a marine top predator, the harbor porpoise, in a dynamic environment. Ecosphere 7, 1–22. doi: 10.1002/ecs2.1367.

Giralt Paradell O., Díaz López B., Methion S. 2019. Modelling common dolphin (*Delphinus delphis*) coastal distribution and habitat use: insights for conservation. Ocean and Coastal Management. DOI:10.1016/j.ocecoaman.2019.104836.

Gismondi, E., Daneels, L., Damseaux, F., Lehnert, K., Siebert, U., Das, K., 2021. Preliminary study of oxidative stress biomarkers and trace elements in North Sea Harbour Seals. Marine Pollution Bulletin, 163. https://doi.org/10.1016/j.marpolbul.2020.111905

Glemarec, G., Königson, S., Kindt-Larsen, L. 2021. Bycatch in Baltic Sea commercial fisheries: High-risk areas and evaluation of measures to reduce bycatch. HELCOM ACTION.

Goodman, S. J. 1998. Patterns of extensive genetic differentiation and variation among European harbor seals (*Phoca vitulina vitulina*) revealed using microsatellite DNA polymorphisms. Molecular Biology and Evolution 15(2), 104–118.

Grahl-Nielsen, O., Haug, T., Lindstrøm, U., Nilssen, K. T. 2011. Fatty acids in harp seal blubber do not necessarily reflect their diet. Marine Ecology Progress Series, 426: 263-276.

Granquist, S. M. 2021. The Icelandic harbour seal (*Phoca vitulina*): Population estimate in 2020, summary of trends and the current status. (HV 2019-36). Reykjavík: Marine and Freshwater Research Institute.

Granquist, S. M., Hauksson, E. 2019a. Aerial census of the Icelandic grey seal (*Halichoerus grypus*) population in 2017: Pup production, population estimate, trends and current status [Útselstalning 2017: Stofnstærðarmat, sveiflur og ástand stofns]. Marine and Freshwater Research Institution, HV 2019-02. Reykjavík 2019. 19 pp.

Granquist, S. M., Hauksson, E. 2019b. Population estimate, trends and current status of the Icelandic harbour seal (*Phoca vitulina*) population in 2018 [Landselstalning 2018: Stofnstærðarmat, sveiflur og ástand stofns]. Marine and Freshwater Research Institution, HV 2019-36. Reykjavík 2019. 22 pp.

Granquist, S. M., Sigurjonsdottir, H. 2014. The effect of land based seal watching tourism on the haul out behaviour of harbour seals (*Phoca vitulina*) in Iceland. Applied Animal Behaviour Science, 156: 85– 93.

Granquist, S. M., Hauksson, E. (2016). Management and status of harbour seal population in Iceland 2016: Catches, population assessments and current knowledge. (VMST/16024). Reykjavík: Institute of Freshwater Fisheries. 12pp.

Grellier, K., Hammond, P.S., 2006. Robust digestion and passage rate estimates for hard parts of grey seal (*Halichoerus grypus*) prey. Canadian Journal of Fisheries & Aquatic Sciences, 63: 1982-1998.

Gușatu, L. F., Menegon, S., Depellegrin, D., Zuidema, C., Faaij, A., Yamu, C. 2021. Spatial and temporal analysis of cumulative environmental effects of offshore wind farms in the North Sea basin. Scientific Reports, 11(1): 1-18. https://doi.org/10.1038/s41598-021-89537-1

Haelters. J. *et al.* (in prep). Strandings and sightings of marine mammals in Belgium in 2021. Royal Belgian Institute of Natural Sciences.

Haelters, J., 2017. Arctic climate fugitives? Lutra 60(1): 1-3. https://zoogdierwinkel.nl/sites/default/files/imce/nieuwesite/Winkel/pdf%20download/Lutra%2060(1)_Haelters_Editorial_2017.pdf

Haelters, J. Kerckhof, F., Moreau, K., Team SeaLife, Lambert, E., Jauniaux, T. 2021. Strandingen en waarnemingen van zeezoogdieren en opmerkelijke andere soorten in België in 2020 [Strandings and sightings of marine mammals and remarkable other species in Belgium in 2020]. Koninklijk Belgisch Instituut voor Natuurwetenschappen (KBIN), Brussel. 34 pp

Haelters, J., Kerckhof, F., Doom, M., Evans, P. G. H., Van den Neucker, T., Jauniaux, T. 2018. New extralimital record of a narwhal (*Monodon monoceros*) in Europe. Aquatic Mammals, 44(1): 39-50. doi: 10.1578/AM.44.1.2018.39.

Hamilton, C. D., Lydersen, C., Aars, J., Biuw, M., Boltunov, A. N., Born, E. W., Kovacs, K. M. 2021. Marine mammal hotspots in the Greenland and Barents Seas. Marine Ecology Progress Series, 659: 3-28.

Hamilton, C., Lydersen, C., Aars, J., Biuw, M., Boltunov, A., Born, E. W., Dietz, R., *et al.*2021.. Marine mammal hotspots in the Greenland and Barents Seas. Marine Ecology Progress Series, 659: 3–28. https://doi.org/10.3354/meps13584

Hammill, M. O., den Heyer, C. E., Bowen, W.D. 2014. Grey Seal Population Trends in Canadian Waters, 1960–2014. Canadian Science Advisory Secretariat (CSAS), Research Document 2014/037.

Hammill, M. O., Gosselin, J-F., Stenson, G. B. 2017. Pup production of Northwest Atlantic grey seals in the Gulf of St Lawrence. DFO Canadian Science Advisory Secretariat (CSAS), Research Document 2017/043. iv + 14 pp.

Hammond, P. S., Wilson, L. J. 2016. Grey seal diet composition and prey consumption. Scottish Marine and Freshwater Science Vol. 7 No. 20. 47pp. DOI: 10.7489/1799-1.

Hammond, P. S., Francis, T., Heinemann, D., Long, K. J., Moore, J., Punt, A. E., Reeves, R. *et al.* 2021b. Estimating the Abundance of Marine Mammal Populations. Frontiers in Marine Science, 8, 735770. doi: 10.3389/fmars.2021.735770

Hammond, P., Grellier, K., 2006. Grey seal diet composition and prey consumption in the North Sea. Final report to Department for Environment Food and Rural Affairs on project MF0319.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Boerjesson, P., Herr, H., Macleod, K., *et al.* 2021a. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Sea Mammal Research Unit, St. Andrews. Revised June 2021.

Hammond, P. S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., *et al*. 2021a. Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. SCANS III final report. 41 pages.

Hårding, K. C., Härkönen, T. J. 1999. Development in the Baltic grey seal (Halichoerus grypus) and ringed seal (Phoca hispida) populations during the 20th century. Ambio, 28: 619-625.ICES. 2014a. Report of the Working Group on Bycatch of Protected Species (WGBYC 2014), 4-7 February 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:28, 96 pp.

Härkönen, T., Lunneryd, S.G. 1992. Estimating abundance of ringed seals in the Bothnian Bay. Ambio 21(8): 497-503.

Härkönen, T., 1987. Seasonal and Regional Variations in the Feeding-Habits of the Harbor Seal, *Phoca vitulina,* in the Skagerrak and the Kattegat. Journal of Zoology 213: 535-543.

Härkönen, T., Dietz, R., Reijnders, P., Teilmann, J., Harding, K., Hall, A., Brasseur, S., *et al*. 2006. A review of the 1988 and 2002 phocine distemper virus epidemics in European harbour seals. Diseases of Aquatic Organisms 68: 115–130.

Härkönen, T., Harding, K., Rasmussen, T.D., Teilmann, J. and Dietz, R. 2007. Age- and Sex-specific Mortality Patterns in an Emerging Wildlife Epidemic: the Phocine Distemper in European Harbour Seals. PLoS ONE 2(9): e887.

Härkönen, T., Heide- Jørgensen, M. P. 1991. The Harbor Seal *Phoca vitulina* as a Predator in the Skagerrak. Ophelia 34: 191-207.

Härkönen, T., Stenman, O., Jüssi, M., Jüssi, I., Sagitov, R., Verevkin, M. 1998. Population size and distribution of the Baltic ringed seal (*Phoca hispida botnica*). NAMMCO Scientific Pubications, 1(167), 80 pp.

Haug, T., Falk-Petersen, S., Greenacre, M., Hop, H., Lindstrøm, U., Meier, S., Nilssen, K.T., *et al.* 2017. Trophic level and fatty acids in harp seals compared with common minke whales in the Barents Sea. Marine Biology Research 13: 919-932. Doi.org/10.1080/17451000.2017.1313988.

Havs- och Vattenmyndigheten. 2012. Nationell förvaltningsplan för gråsäl (Halichoerus grypus) i Östersjön. 67 pp.

Havs- och Vattenmyndigheten. 2019. Nationell förvaltningsplan för gråsäl (Halichoerus grypus) i Östersjön. Havs- och vattenmyndighetens rapport, 2019:24: 83 pp.

Hayes, S. A., Josephson, E., Maze-Foley, K., Rosel, P.E., Byrd, R., Chavez-Rosales, S., Col, T. V. N., *et al.* 2018. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments—2017. NOAA Technical Memorandum NMFS NE-245; 371 pp.

Heath, M. R., Speirs, D. C., Thurlbeck, I., Wilson, R. J. 2020. StrathE2E2: An r package for modelling the dynamics of marine food webs and fisheries. Methods in Ecology and Evolution, DOI: 10.1111/2041-210X.13510.

HELCOM 1982. HELCOM Recommendation 3/3. Recommendation concerning protection of seals in the Baltic Sea area. 1 p.

HELCOM 1988. HELCOM Recommendation 9/1. Recommendatiom concering protection of selas in the Baltic Sea area. 1 p.

HELCOM 1995. Report of the 6th Meeting of the Environment Committee (EC), Helsinki, Finland

HELCOM 2006. HELCOM Recommendation 27-28/2. Conservation of seals in the Baltic Sea area. 4 pp.

HELCOM 2018. Population trends and abundance of seals. HELCOM core indicator report. 34 pp.

Heymans, J. J., Coll, M., Link, J. S., Mackinson, S., Steenbeck, J., Walters, C., Christensen, V. 2016. Best practice in Ecopath with Ecosim food-web models for ecosystem-based management. Ecological Modelling, 331, DOI: 10.1016/j.ecolmodel.2015.12.007.

Hoekendijk, J. P. A., Leopold, M. F., Cheney, B. J. 2021. Bottlenose dolphins in the Netherlands come from two sides: across the North Sea and through the English Channel. Journal of the Marine Biological Association of the United Kingdom, 101 (5): 853-859. DOI: https://doi.org/10.1017/S0025315421000679

Hoekstein, M. S. J., Janse, W. M., Sluijter M., van Straalen, K. D. 2021. Watervogels en zeezoogdieren in de Zoute Delta 2019/2020. Rijkswaterstaat, Centrale informatievoorziening Rapport BM 21.06. Deltamilieu Projecten Rapportnr. 2021-04. Deltamilieu Projecten, Vlissingen.

Huijser, L. A., Bérubé, M., Cabrera, A. A., Prieto, R., Silva, M. A., Robbins, J., Kanda, N., *et al.* 2018. Population structure of North Atlantic and North Pacific sei whales (*Balaenoptera borealis*) inferred from mitochondrial control region DNA sequences and microsatellite genotypes. Conservation Genetics, 19: 1007–1024.

ICES. 2014b. Report of the Working Group on Marine Mammal Ecology (WGMME), 10–13 March 2014, Woods Hole, Massachusetts, USA. ICES CM 2014/ACOM:27. 234 pp.

ICES. 2019a. ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP). ICES Scientific Reports (Vol. 1). https://doi.org/0.17895/ices.pub.5617

ICES. 2016. Report of the Working Group on Marine Mammal Ecology (WGMME), 8–12 February 2016, Madrid, Spain. ICES CM 2016/ACOM:26.

ICES. 2018. Report of the Working Group on Marine Mammal Ecology (WGMME), 19–22 February 2018, La Rochelle, France. ICES CM 2018/ACOM:28. 120 pp.

ICES. 2018. Report of the Working Group on Marine Mammal Ecology (WGMME), 19–22 February 2018, La Rochelle, France. ICES CM 2018/ACOM:28. 120 pp.

ICES. 2019. Working Group on Marine Mammal Ecology (WGMME). ICES Scientific Reports. 1:22. 131 pp. http://doi.org/10.17895/ices.pub.4980.

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

ICES. 2019c. ICES/NAFO/NAMMCO Working Group on Harp and Hooded Seals (WGHARP). ICES Scientific Reports. 1:72. 193 pp.http://doi.org/10.17895/ices.pub.5617

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

ICES. 2020b. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 2:81. 216 pp. http://doi.org/10.17895/ices.pub.7471

ICES. 2020c. Working Group on Marine Mammal Ecology (WGMME). ICES Scientific Reports. 2:39. 85 pp. http://doi.org/10.17895/ices.pub.5975

ICES. 2021a. Working Group on Marine Mammal Ecology (WGMME). ICES Scientific Reports (Vol. 3). International Council for the Exploration of the Sea. https://doi.org/10.17895/ices.pub.8141

ICES. 2021b. Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA). ICES Scientific Reports. 3:106. 95 pp. https://doi.org/10.17895/ices.pub.9257ICES. 2021b. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 3:107. 168 pp. https://doi.org/10.17895/ices.pub.9256

ICES. 2021c. Working Group on Marine Mammal Ecology (WGMME). ICES Scientific Reports. 3:19. 155 pp. https://doi.org/10.17895/ices.pub.8141

ICES. 2022. External report on the review of monitoring PETS bycatch of mammals, birds, turtles and fish for ICES under the service of EC DG Environment. ICES Scientific Reports. 4:17. 69 pp. http://doi.org/10.17895/ices.pub.10075

IJsseldijk, L. L., Hessing, S., Mairo, A., Ten Doeschate, M. T., Treep, J., van den Broek, J., Leopold, M. F. 2021. Nutritional status and prey energy density govern reproductive success in a small cetacean. Scientific Reports, 11(1), 1-13. https://doi.org/10.1038/s41598-021-98629-x

Johnson, A. F., Caillat, M., Verutes, G. M., Peter, C., Junchompoo, C., Long, V., Ponnampalam, L. S. 2017. Poor Fisheries Struggle with U.S. Import Rule. Science, 355: 1031-1032. DOI: 10.1126/science.aam9153

Johnson, H. D., Morrison, D., Taggart, C. T. 2021. WhaleMap: a tool to collate and display whale survey results in near real-time. Journal of Open Source Software. 6(62), 3094. https://doi.org/10.21105/joss.03094

Jones, E., McConnell, B. J., Smout, S., Hammond, P. S., Duck, C. D., Morris, C. D., Thompson, D., *et al.* 2015. Patterns of space use in sympatric marine colonial predators reveal scales of spatial partitioning. Marine Ecology Progress Series, 534: 235–249. https://doi.org/10.3354/meps11370

Jourdain E., Ugarte F., Víkingsson G. A., Samarra F. I., Ferguson S. H., Lawson J., Vongraven D., Desportes G. 2019. North Atlantic killer whale *Orcinus orca* populations: a review of current knowledge and threats to conservation. Mammal Review, 49: 384–400.

Joy, R., Schick, R. S., Dowd, M., Margolina, T., Joseph, J. E., Thomas, L. 2022. A fine-scale marine mammal movement model for assessing long-term aggregate noise exposure. Ecological Modelling, 464, 109798. https://doi.org/10.1016/j.ecolmodel.2021.109798

Jüssi, M., Härkönen, T., Helle, E., Jüssi, I. 2008. Decreasing ice coverage will reduce the breeding success of Baltic grey seal (*Halichoerus grypus*) females. AMBIO: A Journal of the Human Environment, 37(2): 80-85.

Katona, S. K., Beard, J. A., Girton, P. E., Wenzel, F. 1988. Killer whales (*Orcinus orca*) from the Bay of Fundy to the Equator, including the Gulf of Mexico. Rit Fiskideildar, 11: 205-224.

Kiełpińska, J., Kowalski, P. A. 2021. Numerical modelling of the population of grey seal (*Halichoerus grypus*) from the Baltic Sea in the context of reduction of damage to fishing economy. Ecological Indicators, 124, 107423. https://doi.org/10.1016/j.ecolind.2021.107423

Kinze, C. C., Czeck, R., Herr, H., Siebert, U., 2021. Cetacean strandings along the German North Sea coastline 1604–2017. Journal of the Marine Biological Association U.K. 101: 483–502. https://doi.org/10.1017/S0025315421000503

Kitchener, A. C., Hantke, G., Herman, J. S., ten Doeschate, M., Brownlow, A. C. 2020. First record of True's beaked whale, *Mesoplodon mirus*, in Britain. Mammal Communications, 6: 29-33, London.

Kokko, H., Helle, E., Lindström, J., Ranta, E., Sipilä, T., Courchamp, F. 1999. Backcasting population sizes of ringed and grey seals in the Baltic and Lake Saimaa during the 20th century. Annales Zoologici Fennici, 36: 65-73.

Kowarski, K., Evers, C., Moors-Murphy, H. B., Martin, B., Denes, S.L. 2017. Singing through winter nights: The seasonal and diel occurrence of humpback whale calls in and around the Gully MPA, offshore eastern Canada. Canadian Journal of Zoology. 34: 169-189

Kratzer, I. M., Schäfer, I., Stoltenberg, A., Chladek, J. C., Kindt-Larsen, L., Larsen, F., Stepputtis, D. 2020. Determination of optimal acoustic passive reflectors to reduce bycatch of odontocetes in gillnets. Frontiers in Marine Science, 7, 539. https://doi.org/10.3389/fmars.2020.00539

Kraus, S. D., Brown, M. W., Caswell, H., Clark, C. W., Fujiwara, M., Hamilton, P. K., *et al.*2005. North Atlantic right whales in crisis. Science, 309(5734), 561-562.

Krog, J. S., Hansen, M. S., Holm, E., Hjulsager, C. K., Chriél, M., Pedersen, K. Andresen, L. O., *et al.* 2015. Influenza A (H10N7) virus in dead harbor seals, Denmark. Emerging Infectious Diseases Journal, 21: 684.

Kühn, S., Van Franeker, J. 2020. Quantitative overview of marine debris ingested by marine megafauna (incl. Online Suppl.). Marine Pollution Bulletin, 151. 10.1016/j.marpolbul.2019.110858.

Lah, L., Trense, D., Benke, H., Berggren, P., Gunnlaugsson, Þ., Lockyer, C., Öztürk, A., *et al.* 2016. Spatially explicit analysis of genome-wide SNPs detects subtle population structure in a mobile marine mammal, the harbor porpoise. PLoS ONE 11, e0162792. https://doi.org/10.1371/journal.pone.0162792

Lameris, T., Hoekendijk, J., Aarts, G., Aarts, A., Allen, A., Bienfait, L., Bijleveld, A., *et al.* 2021. Migratory vertebrates shift migration timing and distributions in a warming Arctic. Animal Migration, 8. 110-131. 10.1515/ami-2020-0112.

Langley, I., Hague, E., Civil, M. A. 2021. Assessing the performance of open-source, semi-automated pattern recognition software for harbour seal (*P. v. vitulina*) photo ID. Mammalian Biology. https://doi.org/10.1007/s42991-021-00165-8

Larsen, F., Kindt-Larsen, L., Sørensen, T. K., Glemarec, G. 2021. Bycatch of marine mammals and seabirds. Occurrence and mitigation. DTU Aqua Report no. 389- 2021. National Institute of Aquatic Resources, Technical University of Denmark. 69 pp.

Leonard, D. M., Øien, N. I. 2021. Estimated abundances of cetacean species in the Northeast Atlantic from Norwegian shipboard surveys conducted in 2014-2018. NAMMCO Scientific Publications 11. https://doi.org/ 10.7557/3.4694

Leonard, D., Øien, N. 2020. Estimated Abundances of Cetacean Species in the Northeast Atlantic from Two Multiyear Surveys Conducted by Norwegian Vessels between 2002–2013. NAMMCO Scientific Publications, 11. https://doi.org/10.7557/3.4695

Lian, M., Field, C. L., van Wijngaarden, E., Rios, C., Castellini, J. M., Greig, D. J., Rea, L. D., *et al.* 2021. Assessment of clinical outcomes associated with mercury concentrations in harbor seal pups (*Phoca vitulina richardii*) in central California. Science of the Total Environment, 758.

Liu, X., Schjøtt, S. R., Granquist, S. M., Rosing-Asvid, A., Dietz, R., Teilmann, J., Galatius, A., *et al.* 2022. Origin and expansion of the world's most widespread pinniped: range-wide population genomics of the harbour seal (*Phoca vitulina*). Molecular Ecology, (January), 1–18. https://doi.org/10.1111/mec.16365.

Lohrengel, K., Evans, P. G. H., Lindenbaum, C. P., Morris, C. W., Stringell, T. B. 2017. Bottlenose dolphin and harbour porpoise monitoring in Cardigan Bay and Pen Llŷn a'r Sarnau Special Areas of Conservation, 2014-16. NRW Evidence Report No: 191. Natural Resources Wales, Bangor. 154pp.

Louis, M., Galimberti, M., Archer, F., Berrow, S., Brownlow, A., Fallon, R., Nykänen, M., *et al.* 2021. Selection on ancestral genetic variation fuels repeated ecotype formation in bottlenose dolphins. Science Advances, 7, eabg1245. https://doi.org/10.1126/sciadv.abg1245

Lundström, K. 2022. Hunting of grey seals in Sweden 2001-2021 (Jakt på gråsäl i Sverige 2001-2021). Aqua Report. Swedish University of Agricultural Sciences (SLU).

Lundström, K., Lövgren, J., Eero, M. 2017. Kattegat cod numbers eaten by harbour seals. *In* ICES. 2017. Report of the Benchmark Workshop on Baltic Stocks (WKBALT), 7–10 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:30. 108 pp.: 97-107.

Lysén, S., Lundin, K. 2017. Valar i svenska vatten. Göteborgs naturhistoriska museums årstryck, 57-66. https://www.gnm.se/siteassets/gnm/om-museet/gnm_arstryck_2017_webb.pdf.

Marine Mammal Regulations. 1993. SOR/93-56. https://laws-lois.justice.gc.ca/PDF/SOR-93-56.pdf.

Mead, J. G. 1989. Beaked whales of the genus Mesoplodon. Handbook of Marine Mammals, 4, River Dolphins and the Larger Toothed Whales, 349-430.

Méndez-Fernández, P., Spitz, J., Dars, C., Dabin, W., Mahfouz, C., André, J. M., Chouvelon, T., Authier, M., Caurant, F. 2022. Two cetacean species reveal different long-term trends for toxic trace elements in European Atlantic French waters. Chemosphere, 133676. https://doi.org/10.1016/j.chemosphere.2022.133676

Merchant, N. D., Brookes, K. L., Faulkner, R. C., Bicknell, A. W. J., Godley, B. J., Witt, M. J., 2016. Underwater noise levels in UK waters. Scientific Reports. 6, 36942. https://doi.org/10.1038/srep36942

Merkel, B., Lydersen, C., Yoccoz, N. G., Kovacs, K. M. 2013. The world's northernmost harbour seal population - how many are there? PloS ONE, 8(7), e67576. https://doi.org/10.1371/journal.pone.0067576

Methion, S., Díaz López, B. 2021. Spatial segregation and interspecific killing of common dolphins (*Delphinus delphis*) by bottlenose dolphins (*Tursiops truncatus*). Acta Ethologica 10.1007/s10211-021-00363-0

Methion, S., Díaz López, B. 2018. Abundance and demographic parameters of bottlenose dolphins in a highly affected coastal ecosystem. Marine and Freshwater Research https://doi.org/10.1071/MF17346.

Meyer-Gutbrod, E. L., Greene, C. H., Sullivan, P. J., Pershing, A. J. 2015. Climate-associated changes in prey availability drive reproductive dynamics of the North Atlantic right whale population. Marine Ecology Progress Series 535: 243-258.

Miljøstyrelsen. 2020. Forvaltningsplan for sæler 2020. Miljø- og Fødevareministeriet. Miljøstyrelsen. 38 pp. + 38 appendices.

Ministry of Agriculture and Forestry. 2007. Management Plan for the Finnish Seal Populations in the Baltic Sea. Ministry of Agriculture and Forestry 4b/2007: 96 pp.

Ministry of Industry and Innovation. 2019. Regulations prohibiting seal hunting. Retrieved from https://www.stjornartidindi.is/Advert.aspx?recordID=98fc730b-d3a3-40a5-a279-e3ae19c5e6a8

Moan, A., Bjørge, A. 2021. Bycatch of coastal seals in Norwegian gillnet fisheries conducted by coastal fishing vessels. NAMMCO SC Working Group on Bycatch SC/28/BYCWG/04.

Moan, A., Skern-Mauritzen, M., Vølstad, J. H., Bjørge, A. 2020. Assessing the impact of fisheries-related mortality of harbour porpoise (Phocoena phocoena) caused by incidental bycatch in the dynamic Norwegian gillnet fisheries. ICES Journal of Marine Science, 77(7-8), 3039-3049.

Monteiro, S. S., Bozzetti, M., Torres, J., Tavares, A. S., Ferreira, M., Pereira, A. T., Sá, S., *et al.* 2020. Striped dolphins as trace element biomonitoring tools in oceanic waters: Accounting for health-related variables. Science of the Total Environment, 699, 134410. https://doi.org/10.1016/j.scitotenv.2019.134410

Montoto-Martínez, T., De la Fuente, J., Puig-Lozano, R., Marques, N., Arbelo, M., Hernández-Brito, J. J., Fernández, A., Gelado-Caballero, M. D., 2021. Microplastics, bisphenols, phthalates and pesticides in odontocete species in the Macaronesian Region (Eastern North Atlantic). Marine Pollution Bulletin, 173, 113105. https://doi.org/10.1016/j.marpolbul.2021.113105

Moore, J., Heinemann, D., Francis, T., Hammond, P., Long, K. J., Punt, A. E., Reeves, R., *et al.* 2021. Estimating Bycatch Mortality for Marine Mammal Stock Assessment: Concepts and Best Practices. Frontiers in Marine Science, 8, 752356. 10.3389/fmars.2021.752356

Moors-Murphy, H. B., Lawson, J.W., Rubin, B., Marotte, E., Renaud, G., Fuentes-Yaco, C. 2019. Occurrence of Blue Whales (*Balaenoptera musculus*) off Nova Scotia, Newfoundland and Labrador. DFO Canadian Science Advisory Secretariat Research Document 2018/007. iv + 55 pp.

Morell, M., Vogl, A. W., IJsseldijk, L. L., Piscitelli-Doshkov, M., Tong, L., Ostertag, S., Ferreira, M., *et al.* 2020. Echolocating Whales and Bats Express the Motor Protein Prestin in the Inner Ear: A Potential Marker for Hearing Loss. Frontiers of Veterinary Science, 7: 429. https://doi.org/10.3389/fvets.2020.00429

Morris, C. D., Duck, C. D. 2019. Aerial thermal-imaging survey of seals in Ireland, 2017 to 2018. Irish Wildlife Manuals, No. 111 National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland.

Moxley, J. H., Bogomolni, A., Hammill, M. O., Moore, K. M. T., Polito, M. J., Sette, L., Sharp, W. B., *et al.* 2017. Google haul out: earth observation imagery and digital aerial surveys in coastal wildlife management and abundance estimation. Bioscience. 2017; 67:760–768. doi: 10.1093/biosci/bix059.

Mrusczok, M.-T., Violi, B., Fakhri, M., Calogero, G., Biasissi, E., Jaouhar, A., Scullion, A., Würtz, M. 2021. Long-distance movements of North Atlantic killer whales (*Orcinus orca*) from Iceland via Spain and Italy to Lebanon. Marine Mammal Science, 1– 10. https://doi.org/10.1111/mms.12866

Müller, A., Maquil, T., Eigenmann, R., Juretzek, C. 2020. Classification and assessment of impulsive noise with and without noise mitigation measures – Exposure Index based on a habitat approach. Technical Report, R&D "Assessment approaches for underwater sound monitoring associated with offshore approval procedures, maritime spatial planning and the marine strategy framework directive – BeMo", Order No. 10036955, Bundesamt für Seeschifffahrt und Hydrographie (BSH)

Naturvårdsverket. 2001. Nationell förvaltningsplan för gråsälbeståndet i Östersjön - Gråsäl (Halichoerus grypus). 83 pp.

Neimanis, A., Stavenow, J., Ågren, E. O., Wikström-Lassa, E., Roos, A. M. 2022. Causes of Death and Pathological Findings in Stranded Harbour Porpoises (*Phocoena phocoena*) from Swedish Waters. Animals, 12(3), 369. https://doi.org/10.3390/ani12030369

Nelms, S. E., Alfaro-Shigueto, J., Arnould, J. P. Y., Avila, I. C. *et al.* 2021. Marine mammal conservation: over the horizon. Endangered Species Research, 44, 291-325. https://doi.org/10.3354/esr01115

Nilssen K. T., Bjørge A. 2019. Status for kystsel: Anbefaling av jaktkvoter for 2020 [Status of coastal seals: recommendation of hunting allowances for 2020]. Norway: Sjøpattedyrutvalget [Committee for Marine Mammals], Institute of Marine Research

Nilssen, K. T., Bjørge, A. 2017a. Havert og steinkobbe [Grey and harbour seals]. Pages 68–69 in I.E. Bakketeig, M. Hauge and C. Kvamme (eds). Havforskningsrapporten 2017. Fisken og havet, særnr, 1-2017. 98 pp.

Nilssen, K. T., Bjørge, A. 2017b. Status for kystsel. Anbefaling av jaktkvoter for 2018 [Status for coastal seals. Recommendation for harvest quotas for 2018]. Document to the Norwegian Marine Mammal Scientific Advisory Board, October 2017. 9 pp.

Nilssen, K. T., Bjørge, A., Biuw, M. 2021. Status for kystsel - anbefaling av jaktkvoter 2022. Møte i Sjøpattedyrutvalget, Tromsø, 24–25 October 2021. 14 pp. (In Norwegian).

Nilssen, K. T., Lindstrøm, U., Westgaard, J. I., Lindblom, L., Blencke, T.-R., Haug, T. 2019. Diet and prey consumption of grey seals (*Halichoerus grypus*) in Norway. Marine Biology Research, 15: 137-149. Doi: 10.1080/17451000.2019.1605182.

North Atlantic Marine Mammal Commission (NAMMCO). 1996. http://nammco.wpengine.com/wp-content/uploads/2016/09/WG-Ringed-Seals-1996-FINAL-Report.pdf

North Atlantic Marine Mammal Commission (NAMMCO). 2020a. Sightings Surveys in the North Atlantic: 30 years of counting whales. 11. https://doi.org/10.7557/3.11

North Atlantic Marine Mammal Commission (NAMMCO). 2020b. Estimates of cetacean abundance in the North Atlantic of relevance to NAMMCO. NAMMCO Scientific Publications, 11. https://doi.org/10.7557/3.5732

Nunny, L., Simmonds, M. P. 2020. Cetaceans 'Out of Habitat'. 24 pp.: https://wildanimalwelfare.com/reports/

Ó Cadhla, O., Keena, T., Strong, D., Duck, C., Hiby, L. 2013. Monitoring of the breeding population of grey seals in Ireland, 2009–2012. National Parks and Wildlife Service, Department of the Environment, Heritage and the Gaeltacht, Dublin, Ireland.

OceanCare. 2021. Under Pressure: The need to protect whales and dolphins in European waters. An OceanCare report. https://www.oceancare.org/wp-content/uploads/2021/04/Report_UNDER-PRESSURE_need-to-protect-whales-and-dolphins-in-European-waters_OC.pdf

Øigård, T. A., Frie. A. K., Nilssen, K. T., Hammill, M. O. 2012. Modelling the abundance of grey seals (*Halichoerus grypus*) along the Norwegian coast. ICES Journal of Marine Science, 69: 1446–1447. doi:10.1093/icesjms/fsq103.

Olsen, M. T., Nielsen, N. H., Biard, V., Teilmann, J., Ngô, M. C., Víkingsson, G., Gunnlaugsson, T., *et al.* 2022. Genetic and behavioural data confirm the existence of a distinct harbour porpoise ecotype in West Greenland. Ecological Genetics and Genomics, 22, 100108. https://doi.org/10.1016/j.egg.2021.100108

Olsen, M., Bjørge, A. 1995. Seasonal and regional variations in the diet of harbour seal in Norwegian waters. In: Blix AS, Walløe.L, Ulltang Ø, editors. Whales, seals, fish and man. Amsterdam: Elsevier Science. P 271-825.

Olsen, M., Wesley, T. Andersen, L., Dietz, R., Teilmann, J., Harkonen, T., Siegismund, H. R. 2014. Integrating genetic data and population viability analyses for the identification of harbour seal (*Phoca vitulina*) populations and management units. Molecular Ecology, 23: 815–831.

Ometere Boyi, J., Stokholm, I., Hillmann, M., Søndergaard, J., Persson, S., de Witd, A. C., Siebert, U., *et al*. 2022. Relationships between gene transcription and contaminant concentrations in Baltic ringed seals: A comparison between tissue matrices. Aquatic Toxicology, 242. https://doi.org/10.1016/j.aquatox.2021.106035

Østbøll. 2005. Diettanalyse av steinkobbe på Nordvestlandet. Cand. scient. thesis. Biologisk institutt. University of Oslo. 69 pp.

Owen, K., Sköld, M., Carlström, J., 2021. An increase in detection rates of the critically endangered Baltic Proper harbor porpoise in Swedish waters in recent years. Conservation Science and Practice. 3, e468. https://doi.org/10.1111/csp2.468

Pace, R. M. III, Williams, R., Kraus, S. D., Knowlton, A. R., Pettis, H. M. 2017. Cryptic mortality of North Atlantic right whales. Conservation Science and Practice. 2021;3:e346. https://doi.org/10.1111/csp2.346

Pace, R. M., Josephson, E., Wood, S. A., Murray, K., Waring, G. T. 2019. Trends and patterns of seal abundance at haul-out sites in a gray seal recolonization zone. NOAA Tech Memo NMFS-NE 251; 17 pp.

Palialexis A., Korpinen, S., Rees, A.F., Mitchell, I., Micu, D., Gonzalvo, J., Damalas, D. *et al.* 2021 Species thresholds: Review of methods to support the EU Marine Strategy Framework Directive, EUR 30680 EN, Publications Office of the European Union, Luxembourg. ISBN 978-92-76-36342-2, doi:10.2760/52931, JRC124947.

Palialexis, A., Boschetti, S. 2021. Marine Strategy Framework Directive - Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity, EUR 30664 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-34256-4 (online), doi:10.2760/27700 (online), JRC124085.

Palka, D. 2020. Cetacean abundance in the US Northwestern Atlantic Ocean: summer 2016.

Palmer, K. J., Brookes, K., Rendell, L. 2017. Categorizing click trains to increase taxonomic precision in echolocation click loggers. Journal of the Acoustical Society of America, 142(2): 863-877.

Palmer, K.J., Brookes, K.L., Davies, I.M., Edwards, E., Rendell, L., 2019. Habitat use of a coastal delphinid population investigated using passive acoustic monitoring. Aquatic Conservation. Marine and Freshwater Ecosystems, 29: 254–270. https://doi.org/10.1002/aqc.3166

Palmer, L., Gillespie, D., MacAulay, J. D., Sparling, C. E., Russell, D. J., Hastie, G. D. 2021. Harbour porpoise (*Phocoena phocoena*) presence is reduced during tidal turbine operation. Aquatic Conservation: Marine and Freshwater Ecosystems, 31(12), 3543-3553. https://doi.org/10.1002/aqc.3737

Pampoulie, C., Gíslason, D., Ólafsdóttir, G., Chosson, V., Halldórsson, S. D., Mariani, S., Elvarsson, B. Þ., *et al.* 2021. Evidence of unidirectional hybridization and second-generation adult hybrid between the two largest animals on Earth, the fin and blue whales. Evolutionary Applications, 14: 314–321. https://doi.org/10.1111/eva.13091

Paterson, W. D., Moss, S. E., Milne, R., Currie, J. I., McCafferty, D. J., Thompson, D. 2021. Increased Metabolic Rate of Hauled-Out Harbor Seals (*Phoca vitulina*) during the Molt. Physiological and Biochemical Zoology, 94, 152-161. https://doi.org/10.1086/713958

Peltier, H., Baagøe, H. J., Camphuysen, C. J., Czeck, R., Dabin, W., Daniel, P., Deaville, R., *et al.*, 2013. The Stranding Anomaly as Population Indicator: The Case of Harbour Porpoise Phocoena phocoena in North-Western Europe. PLOS ONE 8, e62180.

Pérez-Jorge, S., Tobeña, M., Prieto, R., Vandeperre, F., Calmettes, B., Lehodey, P., Silva, M. A. 2020. Environmental drivers of large-scale movements of baleen whales in the mid-North Atlantic Ocean. Diversity and Distributions. DOI:10.1111/ddi.13038.

Peschko, V., Müller, S., Schwemmer, P., Mercker, M., Lienau, P., Rosenberger, T., Sundermeyer, J., Garthe, S., 2020. Wide dispersal of recently weaned grey seal pups in the Southern North Sea. ICES Journal of Marine Science, 77(5), 1762–1771. https://doi.org/10.1093/icesjms/fsaa045

Pettis, H. M., Pace, R. M. III, Hamilton, P. K. 2022. North Atlantic Right Whale Consortium 2021 Annual Report Card. Report to the North Atlantic Right Whale Consortium. https://www.narwc.org/uploads/1/1/6/6/116623219/2020narwcreport_cardfinal.pdf

Philipp, C., Unger, B., Ehlers, S. M., Koop, J. H. E., Siebert, U. 2021. First evidence of retrospective findings of microplastics in harbour porpoises (*Phocoena phocoena*) from German waters. Frontiers in Marine Science, 8:682532. https://doi.org/10.3389/fmars.2021.682532

Philipp, C., Unger, B., Fischer, E. K., Schnitzler, J. G., Siebert, U. 2020. Handle with care—microplastic particles in intestine samples of seals from German waters. Sustainability, 12:10424. doi: 10.3390/su122410424

Pike, D. G., Gunnlaugsson, T., Desportes, G., Mikkelsen, B., Víkingsson, G., and Bloch, D. 2019b. Estimates of the Relative Abundance of Long-finned Pilot Whales (*Globicephala melas*) in the Northeast Atlantic from 1987 to 2015 indicate no long-term trends. NAMMCO Scientific Publications, 11. https://doi.org/10.7557/3.4643

Pike, D.G., Gunnlaugsson, T., Sigurjónsson, J., Víkingsson, G., 2019a. Distribution and abundance of cetaceans in Icelandic waters over 30 years of aerial surveys. NAMMCO Scientific Publications, 11. https://doi.org/10.7557/3.4805

Pirotta, E., Thomas, L., Costa, D. P., Hall, A. J., Harris, C. M., Harwood, J., Kraus, S. D., *et al.* 2022. Understanding the combined effects of multiple stressors: A new perspective on a longstanding challenge. Science of The Total Environment, 153322. https://doi.org/10.1016/j.scitotenv.2022.153322

Puig-Lozano, R., de Quirós, Y. B., Díaz-Delgado, J., García-Álvarez, N., Sierra, E., De la Fuente, J., Sacchini, S., *et al.* 2018. Retrospective study of foreign body-associated pathology in stranded cetaceans, Canary Islands (2000–2015). Environmental Pollution, 243, 519-527. https://doi.org/10.1016/j.envpol.2018.09.012

Puig-Lozano, R., Fernández, A., Sierra, E., Saavedra, P., Suárez-Santana, C. M., De la Fuente, J., Díaz-Delgado, J., Godinho, A., García-Álvarez, N., Zucca, D., Xuriach, A., Arregui, M., Felipe-Jiménez, I., Consoli, F., Díaz-Santana, P. J., Segura-Göthlin, S., Câmara, N., Rivero, M. A., Sacchini, S., … Arbelo, M. (2020). Retrospective Study of Fishery Interactions in Stranded Cetaceans, Canary Islands. *Frontiers in Veterinary Science*, *7*(October), 1–15. https://doi.org/10.3389/fvets.2020.567258

Ramasco, V., Lindstrøm, U., Nilssen, K. T. 2017. Selection and foraging response of harbor seals in an area of changing prey resources. Marine Ecology Progress Series 581: 199-214

Ransijn, J. M., Hammond, P. S., Leopold, M. F., Sveegaard, S., Smout, S. C. 2021. Integrating disparate datasets to model the functional response of a marine predator: A case study of harbour porpoises in the southern North Sea. Ecology and Evolution. doi:10.1002/ece3.8380.

Record, N. R., Runge, J. A., Pendleton, D. E., Balch, W. M., Davies, K. T. A., Pershing, A. J., Johnson, C. L., *et al*. 2019. Rapid climate-driven circulation changes threaten conservation of endangered north Atlantic right whales. Oceanography, 32: 162-169.

Remili, A., Letcher, R., Samarra, F., Dietz, R., Sonne, C., Desforges, J. P., Víkingsson, G., *et al.* 2021. Individual Prey Specialization Drives PCBs in Icelandic Killer Whales. Environmental Science & Technology, 55. 10.1021/acs.est.0c08563.

Risch, D., Wilson, S. C., Hoogerwerf, M., Van Geel, N. C., Edwards, E. W., Brookes, K. L. 2019. Seasonal and diel acoustic presence of North Atlantic minke whales in the North Sea. Scientific Reports, 9(1) : 1-11.

Romagosa, M., Baumgartner, M., Cascão, I., Lammers, M-O., Marques, T.A., Santos, R.S. and Silva, M.A. 2020. Baleen whale acoustic presence and behaviour at a Mid-Atlantic migratory habitat, the Azores Archipelago. Scientific Reports 10, 4766. DOI: 10.1038/s41598-020-61849-8.

Rouby, E., Dubroca, L., Cloâtre, T., Demanèche, S., Genu, M., Macleod, K., Peltier, H., *et al.* 2022. Estimating Bycatch from Non-Representative Samples (II): A Case Study of Pair Trawlers and Common Dolphins in the Bay of Biscay. Frontiers in Marine Science, 8:795942. doi: 10.3389/fmars.2021.795942

Russell, D. J. F., Carter, M. I. D. 2021. Estimating the proportion of grey seals hauled out during August surveys. SCOS Briefing Paper 21/XX, Sea Mammal Research Unit, University of St Andrews.

Russell, D. J. F., Thompson, D., Thomas, L. 2020. Annual review of priors for grey seal population model 2020. SCOS Briefing Paper 20/02. Sea Mammal Research Unit, University of St Andrews.

Salinger, A. 2021. Feeding ecology of harbor seals (*Phoca vitulina*) in the outer Oslofjord quantified by DNA metabarcoding of scat soft-matrix and morphological analysis of hard prey remains. Master's Thesis, BIO-3950. UIT, The Arctic University of Norway. 83 pp.

SATURN: Solutions At Underwater Radiated Noise project, in progress. European Union's Horizon 2020, grant agreement No. 101006443.

SCOS. 2021. Scientific Advice on Matters Related to the Management of Seal Populations: 2021. Sea Mammal Research Unit, St Andrews, Scotland.

Siebert, U., Stürznickel, J., Schaffeld, T., Oheim, R., Rolvien, T., Prenger-Berninghoff, E., Wohlsein, P., *et al.* 2022. Blast injury on harbour porpoises (*Phocoena phocoena*) from the Baltic Sea after explosions of deposits of World War II ammunition. Environment international, 159, 107014. https://doi.org/10.1016/j.envint.2021.107014

Sierra, E., Ramírez, T., Bernaldo de Quirós, Y., Arregui, M., Mompeó, B., Rivero, M.A., Fernández, A. 2022. Pulmonary and Systemic Skeletal Muscle Embolism in a Beaked Whale with a Massive Trauma of Unknown Aetiology. Animals (Basel) 12(4):508. doi: 10.3390/ani12040508.

Sigourney, D. B., Murray, K. T., Gilbert, J. R., Ver Hoef, J. M., Josephson, E., DiGiovanni, R. A. 2021. Application of a Bayesian hierarchical model to estimate trends in Atlantic harbor seal (*Phoca vitulina vitulina*) abundance in Maine, U.S.A., 1993–2018. Marine Mammal Science, (August), 1–17. https://doi.org/10.1111/mms.12873

Simard, Y., Roy N., Aulanier, F., Giard, S. 2016. Blue whale continuous frequentations of St. Lawrence habitats from multi-year PAM series. DFO Canadian Science Advisory Secretariat Research Document 2016/091. v + 14 pp. https://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2016/2016_091-eng.html?msclkid=21b423dec00811ec8e2a1152dda5ab8c

Simard, Y., Roy, N., Giard, S., Aulanier, F. 2019 North Atlantic right whale shift to the Gulf of St. Lawrence in 2015, revealed by long-term passive acoustics. Endangered Species Research, 40: 271-284.

Smith, K. J., Trueman, C. N., France, C. A. M., Sparks, J. P., Brownlow, A. C., Dähne, M., Davison, N. J., *et al*. 2021. Stable Isotope Analysis of Specimens of Opportunity Reveals Ocean-Scale Site Fidelity in an Elusive Whale Species. Frontiers in Conservation Science, 2, 13. https://doi.org/10.3389/fcosc.2021.653766

Smout, S., Rindorf, A., Hammond, P. S., Harwood, J., Matthiopoulos, J. 2014, Modelling prey consumption and switching by UK grey seals. ICES Journal of Marine Science, 71: 81–89.

Solvang, H. K., Skaug, H. J., Øien, N. I. 2021. Abundance of common minke whales in the Northeast Atlantic based on survey data collected over the period 2014-2019. Document SC/68C/ASI/04 submitted to the IWC Scientific Committee.

Sørlie, M., Nilssen, K.T., Bjørge, A., Freitas, C. 2020. Diet composition and biomass consumption of harbor seals in Telemark, Aust Agder and Norwegian Skagerrak. Marine Biology Research 16: 299-310. https://doi.10.1080/17451000.2020.1751205

Southall, B. L., Nowacek, D. P., Bowles, A. E., Senigaglia, V., Bejder, L., Tyack, P. L. 2021. Marine Mammal Noise Exposure Criteria: Assessing the Severity of Marine Mammal Behavioral Responses to Human Noise. Aquatic Mammals, 47(5), 421-464. https://doi.org/10.1578/AM.47.5.2021.421

Spaan, K. M., van Noordenburg, C., Plassmann, M. M., Schultes, L., Shaw, S., Berger, M., Heide-Jørgensen, M. P., *et al.* 2020. Fluorine Mass Balance and Suspect Screening in Marine Mammals from the Northern Hemisphere Environmental Science & Technology, 54, 7pp. 4046-4058 13 p. https://doi.org/10.1021/acs.est.9b06773

Species at Risk Act. 2002. c. 29. https://laws-lois.justice.gc.ca/PDF/S-15.3.pdf.

Spence, M. A., Blanchard, J. J., Rossberg, A. G., Heath, M. R., Heymans, J. J., Mackinson, S., Serpetti, N., *et al.* 2018. A general framework for combining ecosystem models. Fish and Fisheries, DOI: 10.1111/faf.12310.

Stanistreet, J. E., Feyrer, L. J., Moors-Murphy, H. B. 2021. Distribution, movements and habitat use of northern bottlenose whales (*Hyperoodon ampullatus*) on the Scotian Shelf. DFO Canadian Science Advisory Secretariat Research Document 2021/074. vi + 34 pp.

Stanistreet, J. E., Nowacek, D. P., Baumann-Pickering, S., Bell, J. T., Cholewiak, D. M., Hildebrand, J. A., Hodge, L. E. W., *et al.* 2017. Using passive acoustic monitoring to document the distribution of beaked whale species in the western North Atlantic Ocean. Canadian Journal of Fisheries and Aquatic Sciences, 74(12): 2098–2109.

STECF. 2019. Review of the Implementation of the EU Regulation on the Incidental Catches of Cetaceans (STECF-19-07). Sala, A.; Konrad, C. & Doerner, H. (Eds.) Publications Office of the European Union. https://stecf.jrc.ec.europa.eu/documents/43805/2489016/STECF+19-07+-+Incid+catches+cetaceans.pdf/3485bafd-4350-40af-8d72-0226a68cb86e

STECF 2021. Scientific, Technical and Economic Committee for Fisheries (STECF) - 66th Plenary Report (PLEN-21-01). Ulrich, C., and Doerner, H. (Eds). Publications Office of the European Union, Luxembourg. https://stecf.jrc.ec.europa.eu/documents/43805/2850498/STECF+PLEN+21-01.pdf

Stenson, G. B., Hammill, M. O., den Heyer, C. E., Buren, A., Lawson, J., Gosselin, J. F., Moors-Murphy, H. B., Ratelle, S., 2018. Marine Mammals (Section 3.5). *In:* Bernier, R. Y., Jamieson, R. E., and Moore, A. M. (eds.) State of the Atlantic Ocean Synthesis Report. Can. Tech. Rep. Fish. Aquat. Sci. 3167: iii + 149 pp. https://waves-vagues.dfo-mpo.gc.ca/Library/40801755.pdf

Storå, J. 2002. Neolithic seal exploitation on the Åland Islands in the Baltic Sea on the basis of epiphyseal fusion data and metric studies. International Journal of Osteoarchaeology, 12: 49-64.

Strömberg, A., Svärd, C., Karlsson, O. 2012. Dietstudier av gråsäl (Halichoerus grypus) i Östersjön och knubbsäl (Phoca vitulina) i Skagerrak och Kattegatt insamlade 2010. NV-02210-11. Naturhistoriska Riksmuséet. Rapport nr 5:2012. 9 ppThomas, L., Russell, D. J. F., Duck, C. D., Morris, C. D., Lonergan, M., Empacher, F., Thompson, D., & Harwood, J. (2019). Modelling the population size and dynamics of the British grey seal. Aquatic Conservation: Marine and Freshwater Ecosystems, 29(S1): 6–23.

Sveegaard, S., Carlén, I., Carlström, J., Dähne, M., Gilles, A., Loisa, O., Owen, K., Pawliczka, I. 2022. HOLAS-III harbour porpoise importance map. Methodology. Aarhus University, DCE – Danish Centre for Environment and Energy, 20 pp. Technical Report No. 240. http://dce2.au.dk/pub/TR240.pdf

Tadeo, M. P., Gammell, M., O'Brien, J. 2021. Assessment of Anthropogenic Disturbances Due to Ecotourism on a Grey Seal (*Halichoerus grypus*) Colony in the Blasket Islands SAC, Southwest Ireland, and Recommendations on Best Practices. Aquatic Mammals, 47: 268-282.

Thomas, L. 2020 Estimating the Size of the UK Grey Seal Population between 1984 and 2018. SCOS. Briefing Paper 19/01. Sea Mammal Research Unit, University of St Andrews.

Thompson, D., Duck, C. D., Morris, C. D., Russell, D. J. F. 2019. The status of harbour seals (*Phoca vitulina*) in the UK. Aquatic Conservation: Marine and Freshwater Ecosystems, 29(S1): 40–60

Tiedemann, R., Lah, L., Authenrieth, M. 2017. Individuenspezifische genetische Populationszuordnung baltischer Schweinswale mittels hochauflösender Single Nucleotide Polymorphisms (SNPs)-Technologie. Final report to Federal Agency for Nature Conservation, 29 pp. https://www.bfn.de/sites/default/files/2021-04/Abschlussbericht_SNPs_2017-3.pdf (in German).

Todd, V. L., Williamson, L. D., Jiang, J., Cox, S. E., Todd, I. B., Ruffert, M. 2021. Prediction of marine mammal auditory-impact risk from Acoustic Deterrent Devices used in Scottish aquaculture. Marine Pollution Bulletin, 165, 112171. https://doi.org/10.1016/j.marpolbul.2021.112171

Tollit, D. J., Pierce, G. J., Hobson, K. A., Bowen W. D., Iverson, S. J. 2010. Diet. In: IL Boyd, WD Bowen and SJ Iverson (Eds) Marine Mammal Ecology and Conservation, A Handbook of Techniques. OUP, Oxford.

Tougaard, J. Mikaelsen, M. 2020. Effects of larger turbines for the offshore wind farm at Krieger's Flak, Sweden. Addendum with revised and extended assessment of impact on marine mammals. Aarhus University, DCE – Danish Centre for Environment and Energy Scientific Report No. 366. 32 pp.

Tougaard, J., Beedholm, K. 2019. Practical implementation of auditory time and frequency weighting in marine bioacoustics. Applied Acoustics, 145, 137-143. https://doi.org/10.1016/j.apacoust.2018.09.022

Tougaard, J., Sveegaard, S., Galatius, A. 2020. Marine mammal species of relevance for assessment of impact from pile driving in Danish waters. Background note to revision of guidelines from the Danish Energy Agency. Draft. D. A. Bioscience, Roskilde. https://ens.dk/sites/ens.dk/files/Vindenergi/marine_mammal_species_of_relevance_for_assessment_of_impulsive_noise_sources_in_danish_waters.pdf

Van Canneyt, O., Dars, C., Authier, M., Dabin, W., Demaret, F., Dorémus, G. Peltier, H., Spitz, J. 2016. Les échouages de mamífères marins sur le littoral français en 2015. Rapport scientifique de l'Observatoire PELAGIS. 37 pp + annexes.

van den Heuvel-Greve, M. J., van den Brink, A. M., Kotterman, M. J., Kwadijk, C. J., Geelhoed, S. C.V,, Murphy, S., van den Broek, J. *et al.* 2021. Polluted porpoises: Generational transfer of organic contaminants in harbour porpoises from the southern North Sea. Science of the Total Environment, 796: 148936. https://doi.org/10.1016/j.scitotenv.2021.148936

Van Geel, N. C., Merchant, N. D., Culloch, R. M., Edwards, E. W., Davies, I. M., O'Hara Murray, R. B., Brookes, K. L. 2020. Exclusion of tidal influence on ambient sound measurements. Journal of the Acoustical Society of America, 148(2), 701-712.

Vergara-Peña, A. 2019. The Effects of Marine Tourism on Bottlenose Dolphins in Cardigan Bay. PhD thesis, Bangor University, UK..

Vighi, M., Borrell, A., Víkingsson, G., Gunnlaugsson, T., Aguilar, A. 2019. Strontium in fin whale baleen: A potential tracer of mysticete movements across the oceans? Science of the Total Environment, 650: 1224–1230.

Vincent, C., Huon, M., Caurant, F., Dabin, W., Deniau, A., Dixneuf, S., Dupuis, L., *et al.* 2017. Grey and harbour seals in France: Distribution at sea, connectivity and trends in abundance at haulout sites. Deep Sea Research Part II: Topical Studies in Oceanography, 141(April), 294–305. https://doi.org/10.1016/j.dsr2.2017.04.004

Wade, P. R., Long, K., Francis, T., Punt, A. E., Hammond, P., Heinemann, D., Moore, J., *et al.* 2021. Best Practices for Assessing and Managing Bycatch of Marine Mammals. Frontiers in Marine Science, 8, 757330. 10.3389/fmars.2021.757330

Waggitt, J. J., Evans, P. G. H., Andrade, J., Banks, A. N, Boisseau, O., Bolton, M., Bradbury, G., *et al.* 2020, Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57: 253-269. DOI: 10.1111/1365-2664.13525.

Westerberg, H., Lunneryd, S. G., Fjälling, A., Wahlberg, M. 2006. Reconciling fisheries acivities with the conservation of seals throughout the development of new fishing gear: A case study from the Baltic fishery-grey seal conflict. American Fisheries Society Symposium, 2006: 587-597.

Williams, A. D., Williams, R., Heimlich-Boran, J. R., Evans, P. G. H., Tregenza, N. J. C., Ridoux, V., Liret, C. Savage, S. 1997. A preliminary report on an investigation into bottlenose dolphins (*Tursiops truncatus*) of the English Channel: a collaborative approach. European Research on Cetaceans, 10: 217-220.

Williams, R., Burgess, M. G., Ashe, E., Galnes, S. D., Reeves, R. 2016. U.S. Seafood Import Restriction Presents Opportunity and Risk. Science, 354, 1372-1374. doi: 10.1126/science.aai8222.

Williamson, L. D., Brookes, K. L., Scott, B. E., Graham, I. M., Bradbury, G., Hammond, P. S., Thompson, P. M. 2016. Echolocation detections and digital video surveys provide reliable estimates of the relative density of harbour porpoises. Methods in Ecology and Evolution, 7(7): 762-769.

Wilson, L., Hammond, P. 2016a. Grey Seal Diet Composition and Prey Consumption Scottish Marine and Freshwater Science Report.

Wilson, L., Hammond, P. 2016b. Harbour seal diet composition and diversity. Scottish Marine and Freshwater Science Vol 7 No 21, 84pp. DOI: 10.7489/1801-1

Wilson, L. J., Grellier, K., Hammond, P. S. 2017. Improved estimates of digestion correction factors and passage rates for harbor seal (*Phoca vitulina*) prey in the northeast Atlantic. Marine Mammal Science 33: 1149-1169.

Wilson, L. J., Hammond, P.S. 2019. The diet of harbour and grey seals around Britain: Examining the role of prey as a potential cause of harbour seal declines. Aquatic Conservation. Marine and Freshwater Ecosystems 29(S1): 71– 85.

Wimmer, T., Maclean, C. 2021. Beyond the Numbers: a 15-year Retrospective of Cetacean Incidents in Eastern Canada. Produced by the Marine Animal Response Society. 69 pp. https://drive.google.com/file/d/1-362Cc5I50sTsa4Y4Pgxu-SHhYhQoMP7/view

Wood, S.A., Murray, K.T., Josephson, E. and Gilbert, J. 2019. Rates of increase in gray seal (*Halichoerus grypus atlantica*) pupping at recolonized sites in the United States, 1988–2019. Journal of Mammalogy, XX(X): 1–8.

WWF. 2019 Protecting Our Ocean: Europe's challenges to meet the 2020 deadlines. https://www.wwf.eu/?352798/Protecting-Our-Ocean-Europes-challenges-to-meet-the-2020-deadlines

Zohari, S., Neimanis, A., Härkönen, T., Moraeus, C., Valarcher, J. F. 2014. Avian influenza A (H10N7) virus involvement in mass mortality of harbour seals (*Phoca vitulina*) in Sweden, March through October 2014. European Surveillance, 19(46): 20967

Annex 1: Resolution

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group.

2021/OT/EPDSG01 The **Working Group on Marine Mammal Ecology** (WGMME), chaired by Sophie Brasseur*, the Netherlands; and Peter Evans*, UK; will meet online, 7–10 February 2022 to:

a) Review and report on any new information on seal and cetacean population abundance, distribution, population/stock structure in the North Atlantic (including North Sea and Baltic Sea), including information on vagrant species of marine mammals in the area of interest and updating the seal database with abundance estimates and new data points
b) Review and report on any new information on seal and cetacean management frameworks (including indicators and targets for MSFD assessments) in the North Atlantic (as defined above)
c) Review and report on any new information on seal and cetacean and anthropogenic threats (including cumulative effects) to individual health and population status in the North Atlantic
d) In collaboration with WGBIODIV, identify foraging areas and estimate prey consumption by harbour seal, grey seal and harbour porpoise in the North Sea case study area
e) In collaboration with WGBYC contribute to the Roadmap for ICES PETS bycatch advice by reviewing selected aspects of marine mammal-fishery interactions and assembling data and qualitative information available from other sources not fully covered by WGBYC (notably strandings) on marine mammals.

WGMME will report by 11 March 2022 (via EPDSG) for the attention of ACOM and SCICOM.

Supporting Information

Priority	The activities of this Group contribute to the understanding of the ecological role of marine mammals
Scientific justification	ToRs a and b are standing terms of reference. Its scope was expanded by toR c) since it would be useful to include information on threats to population status, including cumulative effects of multiple stressors. Theoretical frameworks and approaches for assessing cumulative effects of multiple stressors were reviewed in 2019 but new information can be provided. ToR d aims to review species-specific foraging distributions (considering horizontal and vertical dimensions depending on data availability) and estimate consumption by marine mammal species representative in case study areas. ToR d has been agreed between WGMME and WGBIODIV to support WGBIODIV's ToR "*Investigate mechanisms linking trophic guilds under contrasting levels of pressure and/or primary production in case study areas*". ToR e reflects common interests between WGMME and WGBYC, recognising that some aspects of marine mammal fishery interactions may otherwise not be covered by either group. Detailed content of this ToR will be agreed between WGMME and WGBYC in consultation with the ICES Secretariat.
Resource requirements	None
Participants	The Group is expected to be attended by 15–20 members.
Secretariat facilities	Web conference

Financial	None
Linkages to advisory committees	ACOM
Linkages to other committees or groups	WGBYC, WGHARP, WGBIODIV, WGSAM, SCICOM
Linkages to other organizations	OSPAR, HELCOM, ASCOBANS; IWC

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