Agenda Item 8.3	Projects and Activities Supported by ASCOBANS Developing Guidelines for Cetacean-friendly Marine Spatial Planning
Information Document 8.3	Technical Note: Guidance on Cumulative Effects Assessment for Cetacean-Sensitive Maritime Spatial Planning
Action Requested	Take note
Submitted by	Peter Evans and Cormac Walsh

Note: Delegates are kindly reminded to bring their own document copies to the meeting, if needed.

Technical Note: Guidance on Cumulative Effects Assessment for Cetacean-Sensitive Maritime Spatial Planning[1]

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1. Cumulative Effects

The assessment of cumulative effects represents an important, yet challenging component of ecosystem-based maritime spatial planning (MSP). Although methodologies are advancing, they remain only partially successful in addressing the complexity of interactions found in the marine environment (Kelly et al 2014, Clarke Murray et al. 2014, Goodsir et al. 2015, Hammar et al. 2020, Lonsdale et al. 2020). It is often not known whether the cumulative effects of multiple pressures are additive (combined effect is the sum of each effect working independently) synergistic (combined effect is greater than the sum of each independently) or antagonistic (combined effect is less than the sum of each independently) (Mullan Crain et al 2008). Individual changes or disturbances in marine ecosystems can lead to positive or negative feedback effects, whereby effects are amplified or dampened due to interactions with other system components. Individual pressures may also occur across a wide range of time-scales (from days to decades) and demonstrate a high degree of geographical variation. The health and resilience of cetacean populations in the North and Baltic Seas, for example, is substantially weakened due to accumulation of chemical contaminants in these waters, some of which have not been produced since the 1980s (Siebert et al 2007, Sonne et al 2020). It is helpful to distinguish between severe-chronic interactions and severe-acute interactions (Goodsir et al 2015):

- ***Severe-chronic interaction***: an impact that will eventually have severe consequences at the spatial scale of the interaction, if it occurs often enough and/or at sufficiently high levels, e.g. where disease levels might build-up over time, eventually leading to levels where a large number of individuals would be killed. No inference is made as to when the pressure impact becomes severe; simply that at some frequency and intensity, a pressure can lead to severe impacts on that ecological component.

- ***Severe-acute interaction***: a severe impact over a short duration, e.g. for species, a large proportion of individuals are killed immediately where there is an interaction between the pressure and the component. For habitats, such interactions cause an immediate change in habitat type, i.e. change or loss of characteristic features and/or species in the area of interaction. An acute interaction can occur after just one event (Goodsir et al 2015, 2249).

It may be assumed that the cumulative effect of severe-acute impacts combined with underlying severe-chronic impacts is likely to lead to significant adverse and, in many cases, irreversible impacts at population level. With respect to cetaceans in the ASCOBANS Area, we can observe a

[1] This technical note has been prepared in conjunction with Draft Guidelines for Cetacean-Sensitive Maritime Spatial Planning for the ASCOBANS Area, available at: https://www.ascobans.org/en/document/draft-guidelines-cetacean-sensitive-maritime-spatial-planning-ascobans-area, hereafter Draft Guidelines.
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situation of increasing volume and intensity of human activities across a range of sectors (incl. shipping, offshore renewable energy), a legacy of contaminants from industrial, agricultural and domestic sources activity and ongoing risk of large-scale pollution incidents, combined with increased vulnerability due to anthropogenic climate change (van Weelden et al. 2021, Draft Guidelines). The challenge of climate change requires that decision-makers navigate a path between stability and transformation, building on the resilience and adaptive capacity of the marine ecosystem (Rölfer et al. 2022). Assessments are characterised by a high degree of uncertainty, due to not only to data limitations but as an inherent characteristic of complex systems (Gissi et al 2017). The assessment of cumulative effects must go hand-in-hand with adherence to the precautionary principle (Draft Guidelines Recommendation V). From this perspective, it should be assumed that the additional pressures on cetacean populations (and the marine environment more generally) will, at a minimum add to, if not amplify existing pressures. In rare cases, antagonistic impacts (dampening effects) may be observed.

The following guidance, is specific to cetaceans. Given the degree of variation in impacts across taxa (e.g. between cetaceans, other marine mammals and birds) and among cetacean species we consider a differentiated approach to be necessary. In some cases, MSP policies and/or conservation actions may benefit certain species and have significant adverse impacts on others. It is important that decision-makers are aware of such trade-offs. It is not sufficient to assume that positive benefits will outweigh negative impacts. In the following we propose a sea-basin approach to take account of the geographical characteristics of each sea-basin and the need to adopt transboundary approaches based on a common methodology. Cetaceans, like other marine taxa, face a range of anthropogenic pressures, the impacts of which vary between human activities and species (ICES 2019). If biodiversity and a healthy marine ecosystem are to be maintained or improved, then MSP needs to incorporate information on the potential impacts on each species of every human activity occurring in the region. This requires knowledge not only on the patterns of usage of the region by each species and their overlap with the particular activity in space and time, but also both their sensitivity and vulnerability to each human pressure.

In this context, the sensitivity of a species to a human activity depends upon population parameters, life history traits, and conservation status. Its vulnerability, on the other hand, depends upon the distribution of that species and the degree to which its ecology and behaviour exposes it to the pressure.

1.1. Species Sensitivity

The status and biology of a cetacean species affects its sensitivity to a human pressure. If the total population size of the species is low or the species is in decline, any natural environmental variability that affects prey resources may lead to greater risk of extinction. The relative importance of the region to the species and any identifiable population units within it also needs to be assessed. If the species is entirely confined to a particular area, human activities will have a proportionately greater impact and place it under greater threat of extinction. And, similarly, if there are populations within the species that appear to be demographically, if not genetically, distinct, then the impact on the conservation status of the species overall will be greater. Species with large geographical ranges will therefore be buffered to a larger extent compared with ones with small ones. This may also reflect their adaptability to changing environmental conditions, whether they have restricted or specific habitat requirements. A species or population inhabiting shallow shelf waters may not be behaviourally or physiologically adapted to live in deep waters beyond the shelf edge. They may favour particular marine habitats, temperature or salinity ranges, or with frontal systems, or in polar regions be associated with ice.

The life history characteristics of a species will affect its ability to recover from a population perturbation. Cetaceans may take several years to reach sexual maturity. Whereas age at sexual maturity in the harbour porpoise is typically 3-5 years, it is 7-12 years in the common dolphin, up to 14 years in the bottlenose dolphin, and up to 17 years in the killer whale (Evans and Stirling, 2001, Boness et al. 2002, Taylor et al. 2007). All cetacean species give birth to single offspring but the interval between births can vary between one and fourteen years depending upon species and local population demography. In general, however, cetacean reproductive rates and population growth rates are relatively low, making them vulnerable to increases in mortality from anthropogenic sources (Evans and Stirling, 2001).

The higher the female age at sexual maturity, the longer the breeding cycle, and the higher the typical life span, the greater will be the significance of any negative impact on the species at the population level. This should be incorporated in any assessment of the population consequence of a human pressure for a particular species.

1.2. Species Vulnerability

Different cetacean species vary in their vulnerability to particular human pressures by nature of their distribution, ecology and behaviour. Deep diving cetaceans such as sperm whale and beaked whales that feed largely upon cephalopods and in some cases, may use suction feeding to capture prey from close to the sea floor are probably more vulnerable to ingestion of macro-plastics than those that forage largely in the water column. They also may require recovery dives to offset nitrogen build-up after deep dives, and if these are disrupted, for example, by mid-frequency active sonar, they may be more vulnerable to behavioural changes such as disorientation, physiological ones such as bubble formation (embolisms) in tissues, and ultimately stranding. Cetaceans such as the harbour porpoise that typically forage near the seabed on benthic or demersal fish may be more vulnerable to entanglements in bottom set gillnets by comparison with killer whales, for example, that feed upon pelagic shoaling fish such as herring or marine mammals such as seals. On the other hand, killer whales that feed at the very top of the marine food chain are particularly vulnerable to the build-up of contaminant levels of persistent organic pollutants such as PCBs. These are just some examples to illustrate the importance to identify the potential impact that a particular human activity may have on a cetacean species so that these may be taken into account when developing maritime spatial plans in the context of cetacean biodiversity conservation.

In some cases, difficult management decisions will need to be made to balance human socio-economic considerations with conservation priorities. The application of a scoring system based upon both biological sensitivity and vulnerability of each cetacean species to the pressures from different human activities in the region will help inform this process, and enable cumulative effects to be taken into account in at least a semi-quantitative manner, given the major challenges that currently exist to quantitatively assess the population consequences of pressures upon individuals across species (Pirotta et al. 2015, National Academy of Sciences 2017). A similar risk-based scheme can also be applied to other marine taxa so that an ecosystem-based approach is taken.

2. Developing Risk Scores

2.1. Biological Sensitivity

An example of the approach that could be used to weight risk using both sensitivity and vulnerability scores is developed in the accompanying tables. Table 1 summarises the ecological parameters of eighteen cetacean species regularly occurring in the ASCOBANS Agreement Area. Variation in habitat and depth preferences, and the extent of their typical range in terms of climate zones and sea surface temperature variation are summarised for each species and used to develop a simple scoring system relating to ecological niche width (Table 1). Taking the North Sea as a sample region, the overall status of each species and the importance of this regional population globally is also presented.

Seven life history parameters are detailed for each of the eighteen cetacean species: age at sexual maturity, inter-birth interval, generation length, population growth rate, juvenile and adult survival, and life span (Table 2). These are compiled following a wide-ranging review of the recent literature as well as drawing upon earlier reviews by Evans & Stirling (2001), Boness et al. (2002), Taylor et al. (2007), Evans (2008, 2020), and Würsig et al. (2018). Since there are more than 150 literature sources, they are not detailed here but are available on request.

Table 3 presents a possible scheme for sensitivity scoring for the main ecological and life history parameters. For most parameters, there are just three possible scores: 0, 1 and 2, but to give extra weighting to the regional population size, its relative importance in relation to the population inhabiting the ASCOBANS Agreement Area (estimated from the wide-scale SCANS and ObSERVE surveys in summer 2016), scores numbering up to 5 are used. This is purely illustrative of how these can be weighted, and further work will be needed to refine these.

The latest abundance estimates both within the ASCOBANS Agreement Area and over a wider part of the North Atlantic are compiled by species in Table 4. Reference sources are cited, and can be provided in detail on request.

The concept of Management Units (MU) was introduced at the ASCOBANS-HELCOM Workshop on Small Cetacean Population Structure in 2007, in which around forty population geneticists and ecologists participated (Evans & Teilmann, 2009). The following definition was agreed: "*"a group of individuals for which there are different lines of complementary evidence (e.g. genetics, morphometrics, life history parameters, photo-ID) suggesting reduced exchange (migration / dispersal) rates over an extended period (low tens of years)".* The main aim is to identify putative populations that are demographically distinct. Two cetacean species in particular have had smaller MUs than the ASCOBANS Agreement Area identified. These are harbour porpoise and coastal bottlenose dolphin. The most recent abundance estimates for each of the MUs for these two species are given in Table 5. Note that in some fora (e.g. OSPAR), these are referred to as Assessment Units.

Table 6 provides species sensitivity scores for each of the parameters defined in Table 3, as applied to the North Sea ecoregion as an example. Similar tables can readily be prepared for every region within the ASCOBANS Agreement Area.

2.2. Vulnerability to Pressures

In 2019, the ICES Working Group on Marine Mammal Ecology developed threat matrices for several Ecoregions (ICES WGMME, 2019). Within the ASCOBANS Agreement area, this included the Baltic Sea, the Belt Seas & Kattegat, the Greater North Sea, the Celtic Seas (including West Scotland), and the Bay of Biscay and Iberian Peninsula. They defined the various anthropogenic pressures and reviewed evidence for the effects of each pressure, and presented these by species and ecoregion. Those matrices are reproduced in Table 7 (7.1-7.5).

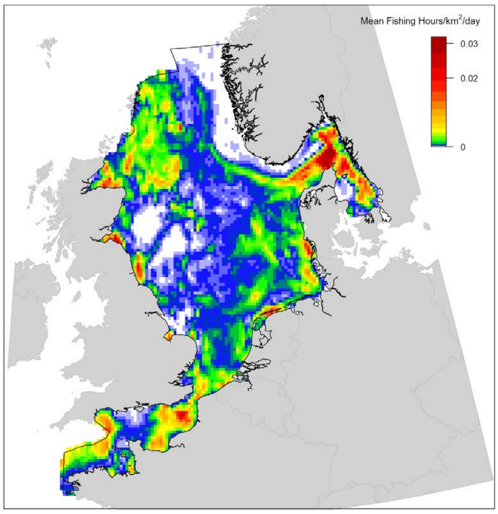
Particularly for some of the more complex pressures, there is a need for further development to refine risk scores. Two of the most important pressures facing marine mammals are bycatch in fishing gear and underwater noise. These will be explored further below.

In December 2018, the North Atlantic Marine Mammal Commission (NAMMCO) in collaboration with the Norwegian Institute of Marine Research (IMR) held a workshop to review our latest knowledge on the biology of the harbour porpoise in the North Atlantic (NAMMCO/IMR, 2020, see Annex 1). For one of the products of this workshop, a risk assessment of acoustic disturbance for the harbour porpoise was made by sub-region around the North Atlantic. The assessment consisted of three separate parts: *Prevalence* of noise sources in the different sub-regions, *Exposure* of porpoises to the noise sources, and *Risk of impact,* and the results for each are presented in Table 8. The method incorporates assessment of the distances for the different noise sources and vulnerability for different regional populations (Table 9), as described in text underneath this Table.

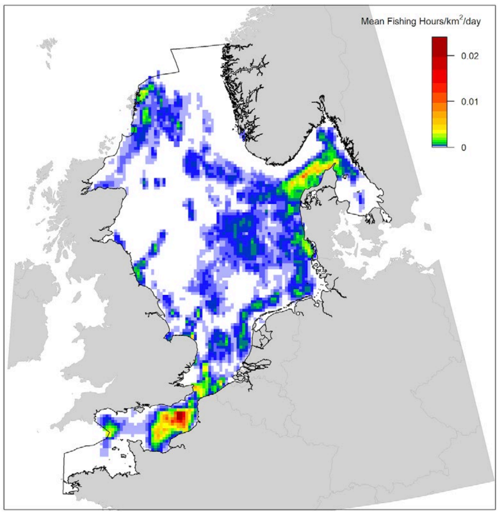
Fisheries by-catch is probably the main anthropogenic source of mortality facing cetaceans. However, vulnerability to by-catch varies between gear types and cetacean species. A literature review covering >100 published papers and reports was used to produce an evidence matrix of risk for the twelve species of cetaceans most commonly occurring in NW European seas, equivalent to the ASCOBANS Agreement Area (see Table 10, from Evans et al. 2021). Fishing effort by gear type was mapped by season, from which assessments of prevalence can be derived. Examples are given in Figure 1. By comparing modelled predictions of density distributions of different species, overlaps between species densities and high-risk fisheries can be mapped in space and time (see Figure 2 for harbour porpoise, as an example). Such risk maps can then inform a scoring system that assesses vulnerability by species and gear type.

Figure 1. Sample maps of fishing activity by gear type for the Greater North Sea (from Evans et al. 2021)

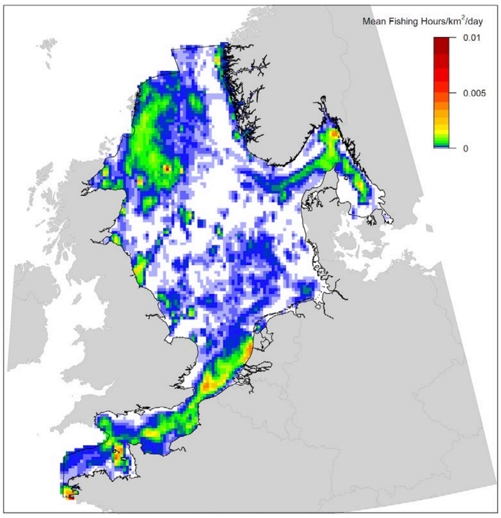
a) Demersal Trawls



b) Demersal Seines



c) Pelagic Trawls & Seines



d) Static Gill Nets

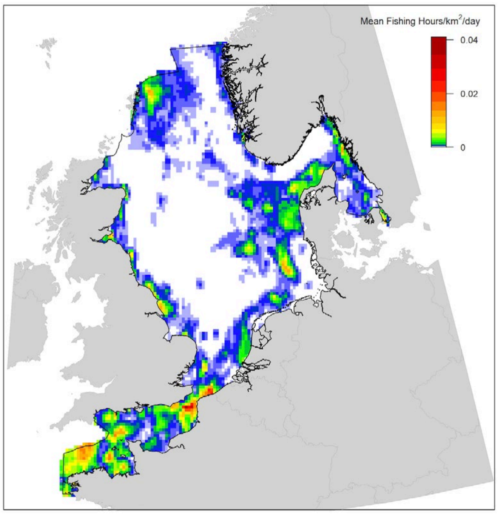
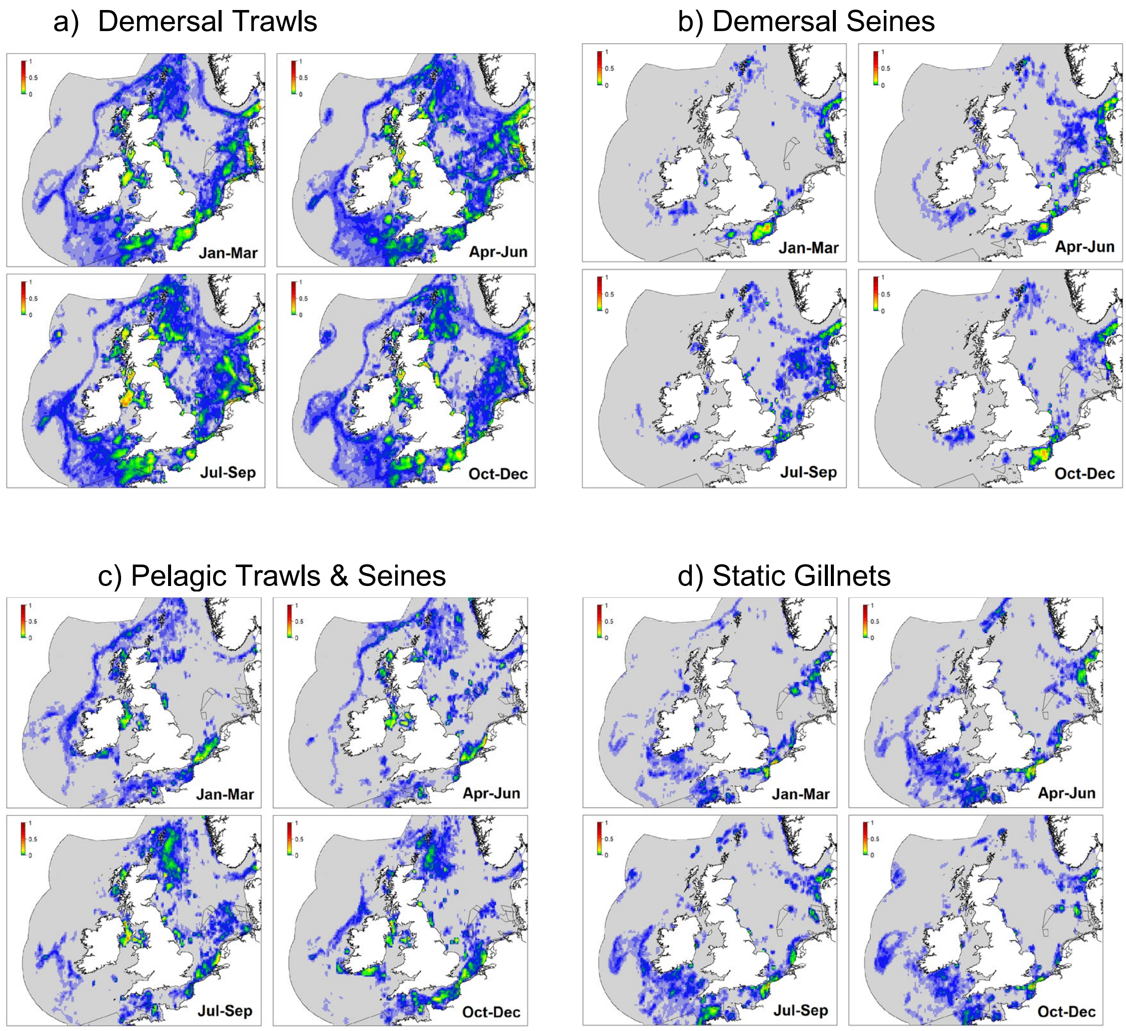


Figure 2. Sample maps of seasonal overlap between harbour porpoise modelled density distributions and fishing activity by gear type for northern Europe (from Evans et al. 2021)



2.3. Cumulative Pressures Scoring

Impact risks can be scored across pressures and species. Table 11 presents such a scheme. Further work is needed to refine the weightings incorporating extra information. This has not been possible in the time available for this contract. One of the benefits of this approach is that it is simple and very flexible. One can examine relative risks for a particular species and pressure, or for combined species (grouped within a taxon such as cetaceans, or across taxa, for example all Protected, Endangered and Threatened Species) and combined pressures. The scoring system can be incorporated as weightings to risk maps. As new information becomes available, the formulae used can be made more quantitative, but in the meantime once the scoring system has been agreed upon, it represents a quick and easy method of addressing cumulative impacts across species and broader taxa.

3. Recommendations and Next Steps

This technical note represents a first step in the development and application of cumulative effects assessments for cetacean-sensitive MSP. There is scope for further refinement of the proposed methodology. Expert workshops at regional seas level will be necessary to develop robust cumulative pressures scoring, incorporating differentiated weighting for individual pressures. Such workshops may be conducted in association with the relevant committees of the regional sea commissions (e.g. HELCOM, OSPAR), and in liaison with the ICES Working Group on Marine Mammal Ecology.

The further development of cumulative effects assessment supports and, is in turn supported by Recommendations III, IV, V (ecosystem-based MSP), XIV-XVII (environmental assessment) and XVIII-XXI (Information sharing and transboundary cooperation) of the Draft Guidelines. It is proposed that the terms of reference of the ASCOBANS Working Group on MSP should be extended to encompass a coordination role in the development of common assessment and monitoring methodologies for cetacean-sensitive MSP and the sharing of relevant cetacean conservation expertise (Recommendation XXIII).

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Table 1: Ecological Parameters for 18 Cetacean Species occurring in the ASCOBANS Agreement Area giving status of each species in the North Sea (from Evans, 2008, 2020)

Species	Habitat	Depth preferences	SST preferences	Range	Ecological niche width	Status in the North Sea	Importance of the regional population globally
Harbour porpoise	Mainly shelf seas	20-100m	2 – 22º C	Arctic – subtropical	2	Abundant	0
Bottlenose dolphin	Coastal & shelf edge	5-100m	11 – 28º C	Cold temperate – tropical	0	Uncommon	0
Common dolphin	Mainly shelf slope	50-200m	10 – 26º C	Cold temperate – tropical	0	Uncommon	0
Risso's dolphin	Coastal deep waters	50-1500m	12 – 28º C	Temperate – tropical	2	Uncommon	0
Striped dolphin	Pelagic deep waters	200-2000m	13 – 26º C	Temperate – tropical	0	Casual	0
Atlantic white-sided dolphin	Mainly shelf slope	100-300m	6 – 16º C	Subarctic – warm temperate	1	Uncommon	0
White-beaked dolphin	Mainly shelf seas	50-100m	4 – 18º C	Arctic – temperate	2	Common	1
Killer whale	Pelagic deep waters	100-1000m	2 – 24º C	Arctic – subtropical	0	Rare (N)	0
Long-finned pilot whale	Pelagic deep waters	200-3000m	6 – 24º C	Subarctic – subtropical	0	Rare (N)	0
Northern bottlenose whale	Deep canyons	500-3000m	2 – 24º C	Arctic – subtropical	2	Casual (N)	0
Sowerby's beaked whale	Deep canyons	500-3000m	10 – 25º C	Cold temper. – subtropical	2	Vagrant	0
Blainville's beaked whale	Deep canyons	500-3000m	14 – 28º C	Warm temperate – tropical	1	Vagrant	0
Cuvier's beaked whale	Deep canyons	500-3000m	12 – 28º C	Temperate – tropical	0	Vagrant	0
Pygmy sperm whale	Pelagic deep waters	200-2000m	16 – 28º C	Warm temperate – tropical	1	Vagrant	0
Minke whale	Mainly shelf seas	50-200m	2 – 24º C	Arctic – subtropical	1	Common (N)	0
Fin whale	Mainly shelf slope	100-2000m	2 – 26º C	Arctic – tropical	1	Rare	0
Sei whale	Pelagic deep waters	500-3000m	2 – 24º C	Arctic – subtropical	1	Vagrant	0
Humpback whale	Coastal deep waters	50-500m	4 – 28º C	Arctic – tropical	1	Casual (N)	0

NOTE: regional population for cetaceans is defined in this context as the population inhabiting the ASCOBANS Area (NW Europe)

Table 2: Life history Parameters for 18 Cetacean Species occurring in the ASCOBANS Agreement Area (from Evans & Stirling, 2001; Boness et al.*, 2002; Taylor* et al.*, 2007; Evans 2008, 2020)*

Species	Age at Sexual Maturity (years)	Inter-birth Interval (years)	Generation Length (years)	Population growth rate	Juvenile Survival (%)	Adult Survival (%)	Life Span (years)
Harbour porpoise	M: 3-5; F: 3-5	1-2	7-8	0.11	85 – 87	80 – 92	12-24
Bottlenose dolphin	M: 9-14; F: 5-13	3-4(2-9)	20-21	0.00	81 – 90	96 – 99	M: 40-45; F: 52
Common dolphin	M: 7-12; F: 6-9	1-4	13-15	0.02	*80* – 88	87 - 93	30
Striped dolphin	M: 7-15; F: 6-18	2-4	21-23	0.01	*80*	*95*	30-35 (58)
Risso's dolphin	M: 7-12; F: 8-10	2-4	18-20	0.04	*80*	*95*	45-50
Atlantic white-sided dolphin	M: 7-11; F: 6-12	1-3	15-16	0.01	*80*	*95*	M: 22; F: 27
White-beaked dolphin	M: 8-12; F: 6-10	2-3	17-18	0.02	*80*	*95*	M: 32+; F: 39
Killer whale	M: 15-16; F: 8-17	5(2-14)	24-26	0.02	78 – 91	96 – 99	M: 50-60; F: 80-90
Long-finned pilot whale	M: 8-22; F: 5-15	3-5	21-24	0.04	83	98 – 99	M: 35-45; F: 60+
Northern bottlenose whale	M: 7-9; F: 8-13	2-3	17-18	?	*80*	*95*	M: 37; F: 27
Sowerby's beaked whale	M: 7; F: 7	?	?	?	*80*	*95*	?
Cuvier's beaked whale	M: 11; F: 11	>6	?	?	*80*	*95*	M: 36+; F: 30
Sperm whale	M: 18-21; F: 7-13	5-7	26-32	0.03	*83*	90 – 99	M: 90-94; F: 93-95
Minke whale	M: 7-10: F: 7-10	1	13-22	0.09	77	91 – 96	40-50 (57.5)
Blue whale	M: 8-10; F:10	2-3	21-22	0.05	82	98	M: 80-90; F:110+
Fin whale	M: 8-12; F: 6-10	2-3	19-26	0.04	*81*	*96*	85-90
Sei whale	M: 7-12; F: 5-12	2-3	18-23	0.04	*81*	94 – 96	50-74
Humpback whale	M: 4-10; F: 4-10	(1)2-3	14-22	0.05	76 – 88	95 – 96	80-90

M = Male; F = Female

Table 3: Summary of Sensitivity Weightings

Factor	Sensitivity Weighting
Female age at sexual maturity (using maximum values)	2 = ≥10 yrs 1 = 6-9 yrs 0 = 5 yrs or less
Generation Length	2 = >20 yrs 1 = 11-20 yrs 0 = 5-10 yrs
Typical life span	2 = ≥50 yrs 1 = 26-49 yrs 0 = 25 yrs or less
Estimated size of Management Unit	5 = 500 or less 4 = 501-1000 3 = 1001-10,000 2 = 10,001-50,000 1 = 50,001-100,000 0 = ≥100,000
Proportional importance of the MU in relation to the regional population size (taken as equivalent to the ASCOBANS Agreement Area)	5 = 81-100% 4 = 61-80% 3 = 41-60% 2 = 21-40% 1 = 11-20% 0 = 10% or less
Proportional importance of the regional (ASCOBANS area) population globally	2 = >50% 1 = 25-50% 0 = <25%
Ecological niche width (based upon geographic range, number of habitats in which it occurs, and range of sea surface temperatures occupied)	2 = Narrow 1 = Moderate 0 = Wide

Table 4: Abundance estimates of cetaceans in the ASCOBANS Area

	Species	***Scientific name***	**Abundance estimate**	**Survey area & reference source**
cetaceans	Harbour porpoise	*Phocoena phocoena*	493,205 (95% CI 371,000-656,000) 43,179 (95% CI 31,755-161,899) 5,175 (95% CI 3,457-17,637) 497 (95% CI: 80-1091)	PS Hammond, in Evans (2020), from SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017) Icelandic Waters, (summer 2007) (Gilles *et al*. (2020) Faroese Waters (summer 2010) (Gilles *et al*., 2020) Baltic Proper (2011-2013) (SAMBAH, 2016)
	Common Bottlenose Dolphin	*Tursiops truncatus*	115,127 (95% CI 83,100-159,000)	SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017)
	Striped Dolphin	*Stenella coeruleoalba*	372,340* (95% CI 199,000-698,000)	SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017)
	Common Dolphin	*Delphinus delphis*	481,306* (95% CI 293,000-791,000)	SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017)
	White-beaked Dolphin	*Lagenorhynchus albirostris*	39,535 (95% CI 23,600-66,300) 159,000 (95% CI 49,957-506,054)	SCANS III & ObSERVE Survey Areas (Summer 2016) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a)
	Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	17,431 (95% CI 5,500-55,000) 131,022 (95% CI 35,251-486,981)	SCANS III & ObSERVE Survey Areas (Summer 2016) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a)
	Risso's Dolphin	*Grampus griseus*	13,584 (95% CI 5,900-31,000) 2,630 (95% CI 1200-5700)	SCANS III Survey Area (July 2016) Irish EEZ (ObSERVE Survey Area, 2016)
	Killer Whale	*Orcinus orca*	9,563 (95% CI 4,713-19,403) 22,100 (95% CI: 15,282-32,023)	Barents & Norwegian Sea, 2008-2013 (Leonard & Øien, 2020) Central & Eastern North Atlantic, 2015 (Pike *et al.* 2020c)
	Long-finned Pilot Whale	*Globicephala melas*	33,190 (95% CI 19,300-57,100) 344,148 (95% CI 162,795-727,527)	SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019b)
	Northern Bottlenose Whale	*Hyperoodon ampullatus*	19,975 (95% CI 5,562-71,737) 127 (95% CI: 35-468)	Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a) Coastal Azores (2018) Mistic Seas Project (Freitas *et al.,* 2020)

	Species	Scientific name	Abundance estimate	Survey area & reference source
	Sperm Whale	*Physeter macrocephaluis*	13,518 (95% CI 6,200-29,600) 3,962 (95% CI 2,218-7,079) 23,166 (95% CI 7,699-69,709) 275 (95% CI: 188-404) (2014) -367 (95% CI: 248-542) (2012) c. 1,470 visited Azores between 2009-15 129 (95% CI: 85-196)	SCANS III Survey Area (July 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017) Barents & Norwegian Sea, 2008-2013 (Leonard & Øien, 2020) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019) Coastal Azores (2009-15) using Photo-ID CMR estimates applying MSORD model (Boys *et al*., 2019) Coastal Azores (2018) Mistic Seas Project (Freitas *et al.,* 2020)
	Humpback Whale	*Megaptera novaeangliae*	12,411 (95% CI 6,847-22,497) 9,867 (95% CI 4,854-20,058)	Barents & Norwegian Sea, 2008-2013 (Leonard & Oien, 2020) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a)
	Common Minke Whale	*Balaenoptera acutorostratra*	21,158 (95% CI 12,500-35,800) 23,407 (95% CI 13,035-42,032)	SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a)
	Sei Whale	*Balaenoptera borealis*	3,767 (95% CI 1,156-12,270) 42 (95% CI: 22-82)	Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a) Coastal Azores (2018) Mistic Seas Project (Freitas *et al.,* 2020)
	Fin Whale	*Balaenoptera physalus*	18,240 (95% CI 9,900-33,700) 10,861 (95% CI 6,433-18,339) 36,773 (95% CI 25,811-52,392)	SCANS III & ObSERVE Survey Areas (Summer 2016) (Hammond *et al*., 2017; Rogan *et al.*, 2017) Barents & Norwegian Sea, 2008-2013 (Leonard & Øien, 2020) Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a)
	Blue Whale	*Balaenoptera musculus*	3,000 (95% CI 1,377-6,534)	Central N Atlantic (Icelandic & Faroese Waters), 2015 (Pike *et al.*, 2019a)

Sources of Cetacean Abundance Estimates:
SAMBAH (2016), SCANS III (Hammond *et al*., 2017), ObSERVE (Rogan *et al*., 2018) summarised in Evans (2020); Würsig *et al*. (2018), IUCN Polar Bear Species Specialist Group (2019), SCOS (2019), Gilles *et al*. (2020); Freitas *et al.* (2019), Pike *et al.* (2019a), Pike *et al*. (2019b), Pike *et al.* (2020), Leonard & Øien (2019), Aars *et al.* (2009), IUCN (2019)

NOTES
* includes unidentified common/striped dolphins: of 158,167 (95% CI 110,000-228,000) from SCANS III
** Ziphiidae (including unidentified species) estimated at 820 (95% CI: 704-883)
*** *Mesoplodon* spp. estimated at 367 (95% CI: 218-619)

Table 5: Regional Abundance & Trends for Harbour Porpoise & Bottlenose Dolphin Management Units

	Species	Abundance estimate		Regional groupings by recommended Management Unit
cetaceans	Harbour Porpoise	345,373	(95% CI: 246,526-495,752 (stable 1994-2016)	North Sea
		26,700	(95% CI: 16,055-42,128)	Celtic /Irish Seas (partial)
		24,370	(95% CI: 15,074-37,858)	West Scotland
		2,898	(95% CI: 1,386-5,122)	Iberian Peninsula
		42,324	(95% CI: 23,368-76,658)	Kattegat & Belt Seas
		24,526	(95% CI: 14,035-40,829)	Norwegian coastal waters
		497	(95% CI: 80-1091)	Baltic Proper
		5,175	(95% CI: 3,457-17,637)	Faroes
		43,179	(95% CI: 31,755-161,899)	Iceland
	Bottlenose Dolphin	170	(95% CI: 87-208) (2017, slight increase)	East Coast Scotland
		45	(2012)	West Coast Scotland + Barra
		222	(95% CI: 184-300) (2015, slight decline)	Coastal Wales
		113	(95% CI: 87-142) (2008-13)	Coastal SW England
		151	(95% CI: 140-190) (2014)	Coastal Ireland
		114	(95% CI: 90-143) (2015, stable)	Shannon Estuary
		340	(95% CI: 290-380) (2014)	Coastal Normandy + Brittany
		58	(2001)	Iroise Sea
		352	(95% CI: 294-437) (2008-14)	Coastal Portugal
		27	(2015, decline)	Sado Estuary
		397	(95% CI: 300-562) (2009-10, stable)	Gulf of Cadiz

Sources of Cetacean Abundance Estimates:
Harbour porpoise: SAMBAH (2016), Rogan et al. (2017), Gilles et al. (2020), Hammond et al. (2021)
Bottlenose dolphin: OSPAR (2016), Rogan et al. (2017), Hammond et al. (2021)
All other cetacean species: Rogan et al. (2017), Hammond et al. (2021), Gilles et al. (2020)

Table 6: Biological Sensitivity Weightings for Cetacean Species in the North Sea

Species	Female age at sexual maturity	Generation Length	Life span	MU size	Regional Significance	Global Significance	Ecological Niche Width	Sensitivity Score / 20
Harbour porpoise	0	0	0	0	4	0	1	5
Bottlenose dolphin	2	2	1	5	0[2]	0	1[2]	11
Common dolphin	1	1	1	0	2	0	0	5
Striped dolphin	2	2	1	-	-	0	0	5
Risso's dolphin	2	1	1	2	0	0	1	7
Atlantic white-sided dolphin	2	1	1	0	0	0	1	5
White-beaked dolphin	2	1	1	2	5	1	2	14
Killer whale	2	2	2	2/5[1]	0	0	0	6/11
Long-finned pilot whale	2	2	2	2	0	0	0	8
Northern bottlenose whale	2	2	1	-	-	0	2	7
Sowerby's beaked whale	1	2?	1?	-	-	0	2	6
Cuvier's beaked whale	2	2?	1	-	-	0	2	7
Sperm whale	2	2	2	-	-	0	1	7
Minke whale	2	1	2	2	2	0	1	10
Fin whale	2	1	2	2	0	0	1	8
Sei whale	2	1	2	-	-	0	1	6
Humpback whale	2	1	2	3	0	0	1	9

- = not scored as not a common/regular inhabitant of the North Sea; for deriving an overall score, these species are given a ranking of 0

[1]value depends upon interpretation of MU which has not yet been formally assessed (if MU is based upon regional North Sea population, it would be 5; if based on the central and eastern North Atlantic, it would be 2)

[2]based on coastal ecotype

Table 7

Table 7. 1: Threat matrix for marine mammals in the Baltic Sea (from ICES, 2019)

			Harbour porpoise	Grey seal	Harbour seal	Ringed seal
POLLUTION & OTHER CHEMICAL CHANGES	Contaminants		H	H	H	H
	Nutrient enrichment		L	L	L	L
	Microplastics		Risk of contamination leading to ill health or death possible, but no evidence of to date			
PHYSICAL LOSS	Habitat loss		L	M	L	H
PHYSICAL DAMAGE	Habitat degradation		M	M	M	H
OTHER PHYSICAL PRESSURES	Litter (including plastics and discarded fishing gear)		L	L	L	L
	Underwater noise	Military Sonar	H	L	L	L
		Seismic surveys	H	L	L	L
		Pile-driving	M	L	L	L
		Explosions	H	L	L	L
		Shipping	M	L	L	L
	Barrier to species movement (offshore windfarm, wave or tidal device arrays)		L	L	L	L
	Death or injury by collision	Death or injury by collision (with ships)	L	L	L	L
		Death or injury by collision (with tidal devices)	Tidal devices do not exist in the region			
BIOLOGICAL PRESSURES	Introduction of microbial pathogens		L	L	L	L
	Removal of target and non-target species (prey depletion)		M	M	M	M
	Removal of non-target species (marine mammal bycatch)		H	M	M	H
	Disturbance (e.g. wildlife watching)		L	L	L	L
	Deliberate killing + hunting		Does not take place within the region	M	M	M

Table 7. 2: Threat matrix for marine mammals in the Belt Seas & Kattegat (from ICES, 2019)

			Harbour porpoise	Grey seal	Harbour seal
POLLUTION & OTHER CHEMICAL CHANGES	Contaminants		H	H	H
	Nutrient enrichment		L	L	L
	Microplastics		Risk of contamination leading to ill health or death possible, but no evidence of to date		
PHYSICAL LOSS	Habitat loss		L	L	L
PHYSICAL DAMAGE	Habitat degradation		M	M	M
OTHER PHYSICAL PRESSURES	Litter (including plastics and discarded fishing gear)		L	L	L
	Underwater noise	Military Sonar	M	L	L
		Seismic surveys	L	L	L
		Pile-driving	M	L	L
		Explosions	M	L	L
		Shipping	M	L	L
	Barrier to species movement (offshore windfarm, wave or tidal device arrays)		L	L	L
	Death or injury by collision	Death or injury by collision (with ships)	L	L	L
		Death or injury by collision (with tidal devices)	Tidal devices do not exist in the region		
TBIOLOGICAL PRESSURES	Introduction of microbial pathogens		L	L	L
	Removal of target and non-target species (prey depletion)		M	M	M
	Removal of non-target species (marine mammal bycatch)		H	M	M
	Disturbance (e.g. wildlife watching)		L	L	L
	Deliberate killing + hunting		Does not take place within the region	M	M

Table 7. 3: Threat matrix for marine mammals in the Greater North Sea (from ICES, 2019)

			Harbour porpoise	**Common dolphin**	**White-beaked dolphin**	**Atlantic white-sided dolphin**	**Risso's dolphin**	**Minke whale**	**Long-finned pilot whale**	**Killer whale**	**Coastal bottlenose dolphin**	**Grey seal**	**Harbour seal**
POLLUTION & OTHER CHEMICAL CHANGES	Contaminants		H	M	M	M	M	L	M	H	H	M	M
	Nutrient enrichment		L	L	L	L	L	L	L	L	L	M	M
	Microplastics		Risk of contamination leading to ill health or death possible, but no evidence to date										
PHYSICAL LOSS	Habitat loss		L	L	L	L	L	L	L	L	L	M	M
PHYSICAL DAMAGE	Habitat degradation		L	L	L	L	L	L	L	L	L	M	M
OTHER PHYSICAL PRESSURES	Litter (including plastics and discarded fishing gear)		L	L	L	L	L	M	L	L	L	M	M
	Underwater noise	Military Sonar	M	L	L	L	L	M	M	M	L	L	L
		Seismic surveys	M	L	L	L	L	M	L	L	L	L	L
		Pile-driving	M	L	L	L	L	M	L	L	M	L	M
		Explosions	M	L	L	L	L	M	L	L	M	L	M
		Shipping	M	L	L	L	L	M	L	L	M	L	L
	Barrier to species movement (offshore windfarm, wave or tidal device arrays)		L	L	L	L	L	L	L	L	L	L	L
	Death or injury by collision	with ships	L	L	L	L	L	M	L	L	M	L	L
		with tidal devices)	Risk of collision leading to death or injury is considered possible, but no evidence to date										
BIOLOGICAL PRESSURES	Introduction of microbial pathogens		L	L	L	L	L	L	L	L	L	L	M
	Removal of target and non-target species (prey depletion)		M	L	L	L	L	M	L	L	M	M	M

		Harbour porpoise	Common dolphin	White-beaked dolphin	Atlantic white-sided dolphin	Risso's dolphin	Minke whale	Long-finned pilot whale	Killer whale	Coastal bottlenose dolphin	Grey seal	Harbour seal
	Removal of non-target species (marine mammal bycatch)	H	L	L	L	L	M	L	L	L	M	M
	Disturbance (e.g. wildlife watching)	L	L	L	L	L	L	L	L	M	L	M
	Deliberate killing + hunting	Does not take place within the region									L	L

Table 7. 4: Threat matrix for marine mammals in the Celtic Seas including West Scotland (from ICES, 2019)

			Harbour porpoise	Common dolphin	White-beaked dolphin	Atlantic white-sided dolphin	Risso's dolphin	Minke whale	Long-finned pilot whale	Killer whale	Fin whale	Sperm whale	Offshore bottlenose dolphin	Coastal bottlenose dolphin	Northern bottlenose whale	Cuvier's beaked whale	Sowerby's beaked whale	Grey seal	Harbour seal
POLLUTION & OTHER CHEMICAL CHANGES	Contaminants		H	M	M	M	M	L	M	H	L	M	M	H	L	L	L	M	M
	Nutrient enrichment		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Microplastics		Risk of contamination leading to ill health or death possible, but no evidence to date																
PHYSICAL LOSS	Habitat loss		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	M
PHYSICAL DAMAGE	Habitat degradation		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	M
OTHER PHYSICAL PRESSURES	Litter (including plastics, discarded fishing gear)		L	L	L	L	L	M	L	L	L	M	L	L	L	M	M	M	M
	Under-water noise	Military Sonar	M	L	L	L	L	M	M	M	L	L	L	L	H	H	H	L	L
		Seismic surveys	M	M	M	M	M	H	M	M	H	H	M	M	H	H	H	L	L
		Pile-driving	M	L	L	L	L	L	L	L	L	L	L	M	L	L	L	M	M
		Shipping	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L
	Barrier to species movement (offshore		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

			Harbour porpoise	Common dolphin	White-beaked dolphin	Atlantic white-sided dolphin	Risso's dolphin	Minke whale	Long-finned pilot whale	Killer whale	Fin whale
	windfarm, wave or tidal device arrays)										
	Death or injury by collision	with ships	L	L	L	L	L	M	L	L	M
		with tidal devices	Risk of collision leading to death or injury is considered possible but no evidence to date								
BIOLOGICAL PRESSURES	Introduction of microbial pathogens		L	L	L	L	L	L	L	L	L
	Removal of target and non-target species (prey depletion)		M	M	M	M	L	M	L	L	L
	Removal of non-target species (by-catch)		H	H	M	M	M	M	L	L	L
	Disturbance (e.g. wildlife watching)		L	L	L	L	L	L	L	L	L
	Deliberate killing + hunting		Does not take place within the region								

			Sperm whale	Offshore bottlenose dolphin	Coastal bottlenose dolphin	Northern bottlenose whale	Cuvier's beaked whale	Sowerby's beaked whale	Grey seal	Harbour seal
	windfarm, wave or tidal device arrays)									
	Death or injury by collision	with ships	M	L	M	L	L	L	L	L
		with tidal devices								
BIOLOGICAL PRESSURES	Introduction of microbial pathogens		L	L	L	L	L	L	L	L
	Removal of target and non-target species (prey depletion)		L	L	M	L	L	L	M	M
	Removal of non-target species (by-catch)		L	L	L	L	L	L	M	M
	Disturbance (e.g. wildlife watching)		L	L	M	L	L	L	L	M
	Deliberate killing + hunting								M	M

Table 7. 5: Threat matrix for marine mammals in the Bay of Biscay and Iberian Peninsula (from ICES, 2019)

			Harbour porpoise	Common dolphin	Striped dolphin	Risso's dolphin	Minke whale	Long-finned pilot whale	Killer whale	Fin whale	Sperm whale	Northern bottlenose whale	Cuvier´s beaked whale	Sowerby's beaked whale	Offshore bottlenose dolphin	Coastal bottlenose dolphin
POLLUTION & OTHER CHEMICAL CHANGES	Contaminants		H	M	M	L	L	M	H	L	L	L	L	L	M	H
	Nutrient enrichment		L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Microplastics															
PHYSICAL LOSS	Habitat loss		L	L	L	L	L	L	L	L	L	L	L	L	L	L
PHYSICAL DAMAGE	Habitat degradation		L	L	L	L	L	L	L	L	L	L	L	L	L	L
OTHER PHYSICAL PRESSURES	Litter (including plastics and discarded fishing gear)		L	L	L	L	L	L	L	L	M	M	M	M	L	L
	Underwater noise	Sonar	L	L	L	L	M	M	L	L	L	H	H	H	L	L
		Seismic surveys	L	L	L	L	M	L	L	M	L	M	H	M	L	L
		Pile-driving														
		Shipping	L	L	L	L	M	L	L	M	L	L	L	L	L	L
	Barrier to species movement (offshore windfarm, wave or tidal device arrays)		L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Death or injury by collision	with ships	L	L	L	L	M	L	L	H	H	L	L	L	L	L
		with tidal devices														
BIOLOGICAL PRESSURES	Introduction of microbial pathogens		L	L	L	L	L	L	L	L	L	L	L	L	L	L

	Harbour porpoise	Common dolphin	Striped dolphin	Risso's dolphin	Minke whale	Long-finned pilot whale	Killer whale	Fin whale	Sperm whale	Northern bottlenose whale	Cuvier´s beaked whale	Sowerby's beaked whale	Offshore bottlenose dolphin	Coastal bottlenose dolphin
Removal of target and non-target species (prey depletion)	M	L	L	L	L	L	L	L	L	L	L	L	L	M
Removal of non-target species (bycatch)	H	H	M	L	L	L	L	L	L	L	L	L	M	M
Disturbance (e.g. wildlife watching)	L	L	L	L	L	L	L	L	L	L	L	L	L	M
Deliberate killing + hunting														

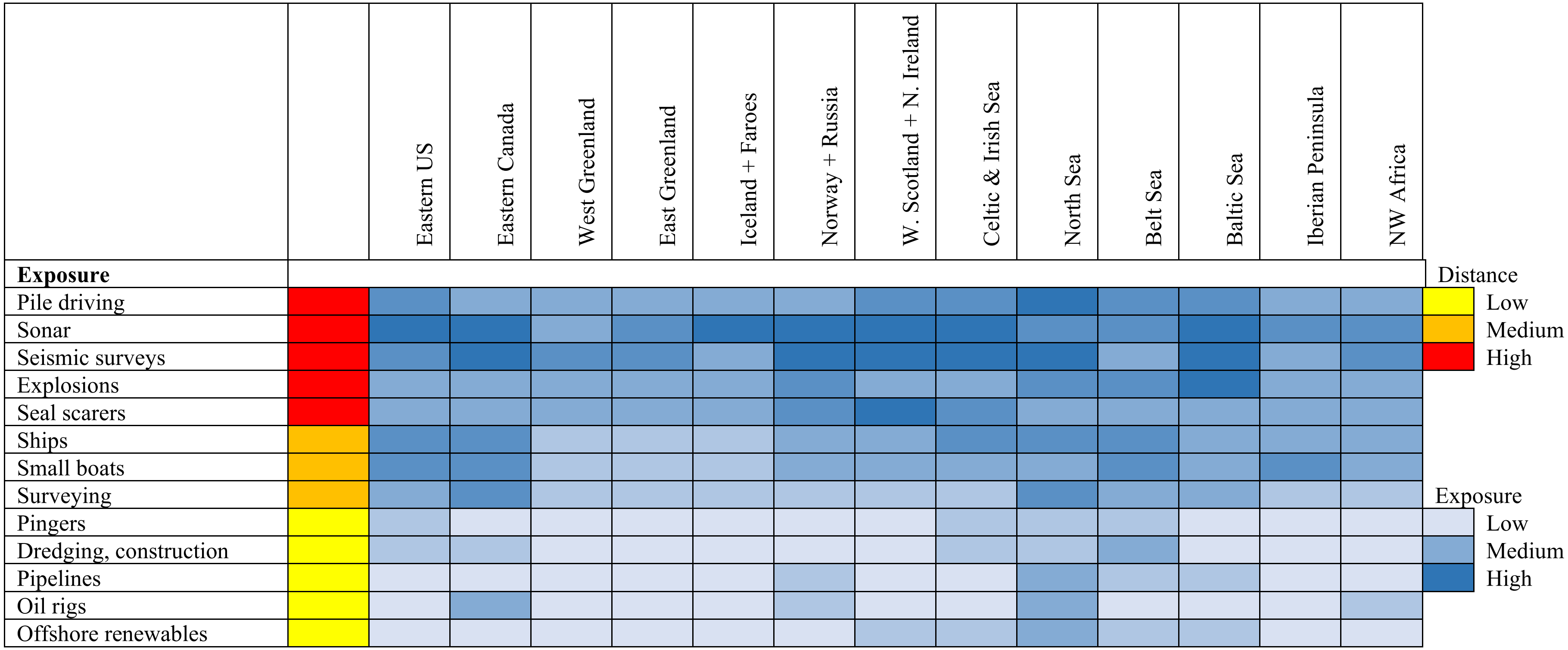
Table 8: Assessment of acoustic disturbance on harbour porpoise populations in the North Atlantic (from NAMMCO/IMR, 2021)

a)

		Eastern US	Eastern Canada	West Greenland	East Greenland	Iceland + Faroes	Norway + Russia	W. Scotland + N. Ireland	Celtic & Irish Sea	North Sea	Belt Sea	Baltic Sea	Iberian Peninsula	NW Africa
Prevalence of sources														
Pile driving		Medium	Low	Low	Low	Low	Low	Medium	Medium	High	Medium	Medium	Low	Low
Sonar		High	High	Low	Medium	High	High	High	High	Medium	Medium	High	Medium	Medium
Seismic surveys		Medium	High	Medium	Medium	Low	High	High	High	High	Low	High	Low	Medium
Explosions		Low	Low	Low	Low	Low	Medium	Low	Low	Medium	Medium	High	Low	Low
Seal scarers		Low	Low	Low	Low	Low	Medium	High	Medium	Low	Low	Low	Low	Low
Ships		High	High	Low	Low	Low	Medium	Medium	High	High	High	Medium	Medium	Medium
Small boats		High	High	Low	Low	Low	Medium	Medium	Medium	Medium	High	Medium	High	Medium
Surveying		Medium	High	Low	Low	Low	Low	Low	Low	High	Medium	Medium	Low	Low
Pingers		Medium	Low	Low	Low	Low	Low	Low	Medium	Medium	Medium	Low	Low	Low
Dredging, construction		Medium	Medium	Low	Low	Low	Low	Low	Medium	Medium	High	Low	Low	Low
Pipelines		Low	Low	Low	Low	Low	Medium	Low	Low	High	Medium	Medium	Low	Low
Oil rigs		Low	High	Low	Low	Low	Medium	Low	Low	High	Low	Low	Low	Medium
Offshore renewables		Low	Low	Low	Low	Low	Low	Medium	Medium	High	Medium	Medium	Low	Low

Prevalence
- Low
- Medium
- High

b)


Eastern US
Eastern Canada
West Greenland
East Greenland
Iceland + Faroes
Norway + Russia
W. Scotland + N. Ireland
Celtic & Irish Sea
North Sea
Belt Sea
Baltic Sea
Iberian Peninsula
NW Africa
Exposure
Pile driving
Sonar
Seismic surveys
Explosions
Seal scarers
Ships
Small boats
Surveying
Pingers
Dredging, construction
Pipelines
Oil rigs
Offshore renewables
Distance
Low
Medium
High
Exposure
Low
Medium
High

c)

		Eastern US	Eastern Canada	West Greenland	East Greenland	Iceland + Faroes	Norway + Russia	W. Scotland + N. Ireland	Celtic & Irish Sea	North Sea	Belt Sea	Baltic Sea	Iberian Peninsula	NW Africa
Risk of impact														
Vulnerability														
Pile driving														
Sonar														
Seismic surveys														
Explosions														
Seal scarers														
Ships														
Small boats														
Surveying														
Pingers														
Dredging, construct.														
Pipelines														
Oil rigs														
Offshore renewables														

Low
Medium
High

Risk
Low
Medium
High

Table 9: Impact distances for the different noise sources (left) and vulnerability for populations (right). See text below for more detailed explanation.

Activity	Distance
Pile driving	2
Sonar	2
Seismic surveys	2
Explosions	2
seal scarers	2
Ships	1
Small boats	1
Surveying	1
Pingers	0
Dredging, construction	0
Pipelines	0
Oil rigs	0
Offshore renewables	0

Population	Vulnerability
Eastern US	1
Eastern Canada	1
Greenland	0
Iceland + Faroes	0
Norway + Russia	1
W. Scotland + N. Ireland	1
Celtic & Irish Sea	1
North Sea	0
Kattegat + Belt Seas	0
Baltic Sea	2
Iberian Peninsula	2
NW Africa	2

Table 10: Bycatch Risk by gear type for Cetacean Species in the ASCOBANS Agreement Area (from Evans et al., 2021)

Species	**Pelagic Trawls** (PTM, OTM)	**Bottom Trawls** (PTB, OTB, OTT)	**Purse Seines** (PS, LA)	**Bottom Seines** (SDN, SPR, SSC)	**Gill Nets** (GNS, GTR, GNC, GTN)	**Drift Nets** (GND)	**Long lines** (LLS, LLD)	**Pots & Traps** (FPO)
Harbour Porpoise	2	2	2	2	3	3	2	1
Bottlenose Dolphin	2	2	2	2	3	3	2	1
Common Dolphin	3	3	3	2	3	3	2	1
Striped Dolphin	3	3	3	2	3	3	2	1
White-beaked Dolphin	2	2	2	2	3	3	1	1
White-sided Dolphin	3	2	2	2	3	3	1	1
Risso's Dolphin	1	3	2	2	3	2	3	1
Killer Whale	1	1	1	1	1	1	1	2
Long-finned Pilot Whale	2	2	2	2	2	3	3	2
Sperm Whale	2	2	2	2	2	3	3	2
Minke Whale	1	1	1	1	2	2	2	2
Fin Whale	1	1	1	1	2	2	2	2

1 = low evidence of risk; 2 = moderate evidence of risk; 3 = high evidence of risk

Table 11: Summary of Weightings for Biological Sensitivity & Vulnerability of Cetacean Species regularly inhabiting the North Sea for combined pressures

Species	**Sensitivity Score / 20**	**Vulnerability Score / 48**
Harbour porpoise	5	26
Bottlenose dolphin	11	24
Common dolphin	5	17
Risso's dolphin	7	17
Atlantic white-sided dolphin	5	17
White-beaked dolphin	14	17
Killer whale	6/11	19
Long-finned pilot whale	8	18
Minke whale	10	25

Vulnerability scored for 16 pressures for which evidence exists (see Table 7.3). Each pressure is treated as equivalents; however, extra weighting is likely to be more appropriate for certain pressures

Annex 1: Assessment of Acoustic Disturbance on Harbour Porpoises in the North Atlantic (from NAMMCO/IMR, 2021)

Given the large uncertainties in information about the impact of different noise sources, together with similar uncertainties in knowledge on distribution, abundance and status of the different porpoise subpopulations, it is impossible to conduct any form of quantitative comparison of the different sources of disturbance. Despite this, a qualitative assessment of the risk of impact is attempted in the following. The assessment consists of three separate parts: *Prevalence* of noise sources in the different sub-regions, *Exposure* of porpoises to the noise sources and *Risk of impact.*

Prevalence
The prevalence of the different activities is scored on a three-step scale: low (i.e. absent or occasional), medium and high. The three steps are assigned integer values of 0, 1 and 2, respectively.

Exposure
Exposure is the combination of the prevalence (P) of the sources and the estimated impact ranges. Impact distances (R) were scored on a three-step scale: Low (local, < 1 km), medium (< 10 km) and high (>10 km).

As for prevalence, steps are assigned integer values of 0, 1 and 2, respectively. The impact distances are listed in Table 9. Prevalence (P) and distance (D) are combined into the exposure index, E:

$$E = \frac{(D + P)}{2}$$

The exposure index can thus take values between 0 and 2. A value of 0 indicates either absence of the source, or low impact range, or both, whereas a value of 2 indicates high prevalence of the source and high impact range.

Risk of impact
The exposure index is a pressure indicator, i.e. the abundance and vulnerability of animals is not factored into the index. The exposure index informs about the magnitude of the *source* of disturbance, not the actual impact. The exposure index can be high in an area, but if there are no animals (for reasons unrelated to the noise), there cannot be any impact. The vulnerability (V) of the different populations were assessed on a three-step scale: low (favourable conservation status), medium (sensitive) and high (threatened). As above, the steps were assigned values of 0, 1 and 2, respectively. Vulnerability of the populations is given in Table 8c.

The risk index (R) is then computed as

$$R = \frac{(E + 2\,V)}{3}$$

The vulnerability is thus factored in as twice as important as the exposure, which is a precautionary approach.

The resulting assessments, subdivided into combinations of areas and noise sources, are given in Table 8.