Compensation Measures Harbour porpoise

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Content

Resume

This report discusses various strategies to protect harbour porpoises in Danish and Swedish waters, focusing on potential compensation measures for impacts caused by offshore wind farms. The EU Habitats Directive mandates strict protection for all cetacean species, including harbour porpoises, requiring the designation of Special Sites of Conservation (SACs) to avoid significant disturbances to these species and to ensure a favorable conservation status. There are 35 Natura 2000 sites in Danish waters and six in Swedish waters (in close vicinity to Danish waters) designated to protect harbour porpoises, with specific conservation goals and guidelines to address threats such as bycatch and habitat degradation. The report has focused on the Danish and Swedish Natura 2000 sites, but is also relevant for Natura 2000 sites in e.g. German waters. The establishment of offshore wind farms can impact harbour porpoise due to underwater noise from construction activities, leading to temporary habitat loss and disturbance. The report presents a 'catalogue of ideas' for potential compensation measures on harbour porpoise. Potential compensation measures were scored against criteria such as ecological function, location, technical feasibility, functional feasibility, timing, additionality, and scale to ensure robustness and transparency.

The compensation measure with the highest scores relates to gillnet fisheries closure/exclusion zones inside SACs. The measure could reduce both the direct threat on harbour porpoises related to bycatch as well as the indirect threat related to reducing fishing pressure to increase prey availability inside the SACs. Although the compensation measure is feasible from a technical and functional perspective, it will be difficult to implement due to other substantial challenges. Other possible identified compensation measures include: bycatch reduction by implementing or increasing the use of i.e. pingers on gillnets in SACs, provision of supporting habitat or improved supporting habitat e.g.. construction of additional stone reefs, without fishery, promote the use of an operational wind farm for marine nature, including exclusion of certain activities such as fisheries and promotion of others, such as stone reefs, reduce the risk of disturbance related to recreational and commercial vessels, provision of new or replacement of protected areas to be managed for harbour porpoises, reduce the risk of entanglement in especially ghost fishing gear and implementation of "quiet zones".

1 Introduction

The EU Habitats Directive lists all cetacean species under Annex IV and are therefore strictly protected in their natural range. In addition harbour porpoises (*Phocoena phocoena*) are also listed on Annex II of the Habitats Directive. Annex II requires the designation of Special Sites of Conservation (SACs) with appropriate conservation objectives, such as measures to avoid significant disturbance of concerned species, to secure their "favourable conservation status". Any project that is not necessary for the management of a Natura 2000 site and is likely to have a significant effect on that site is subject to Appropriate Assessment under Article 6.3 of the Habitats Directive. This is to ensure that the project does not have a significant impact on the integrity of the site. If it does, a derogation process is needed. This also includes projects outside the Natura 2000 boundaries e.g. nearby offshore wind farms.

Although development in the marine environment has the potential to significantly impact marine mammal species, to our knowledge there are currently no examples where compensatory measures have been applied to compensate for realized impacts on cetaceans (including harbour porpoise) directly. Further, for cetaceans which forage widely such as harbour porpoise, it is difficult to target measures for a specific population. This is because the presence or absence of individuals from a population in the vicinity of an impact area is difficult to predict. In addition, no assessment conclusions are currently available and therefore no indication on the Natura 2000 site(s) that may require compensation or how much (i.e. how many individual animals may be adversely affected and from which site). The current report concerns specifically the potential requirements for compensation for harbour porpoise, a designated feature of 41 Natura 2000 sites across Danish and Swedish waters (Figure 1.1).

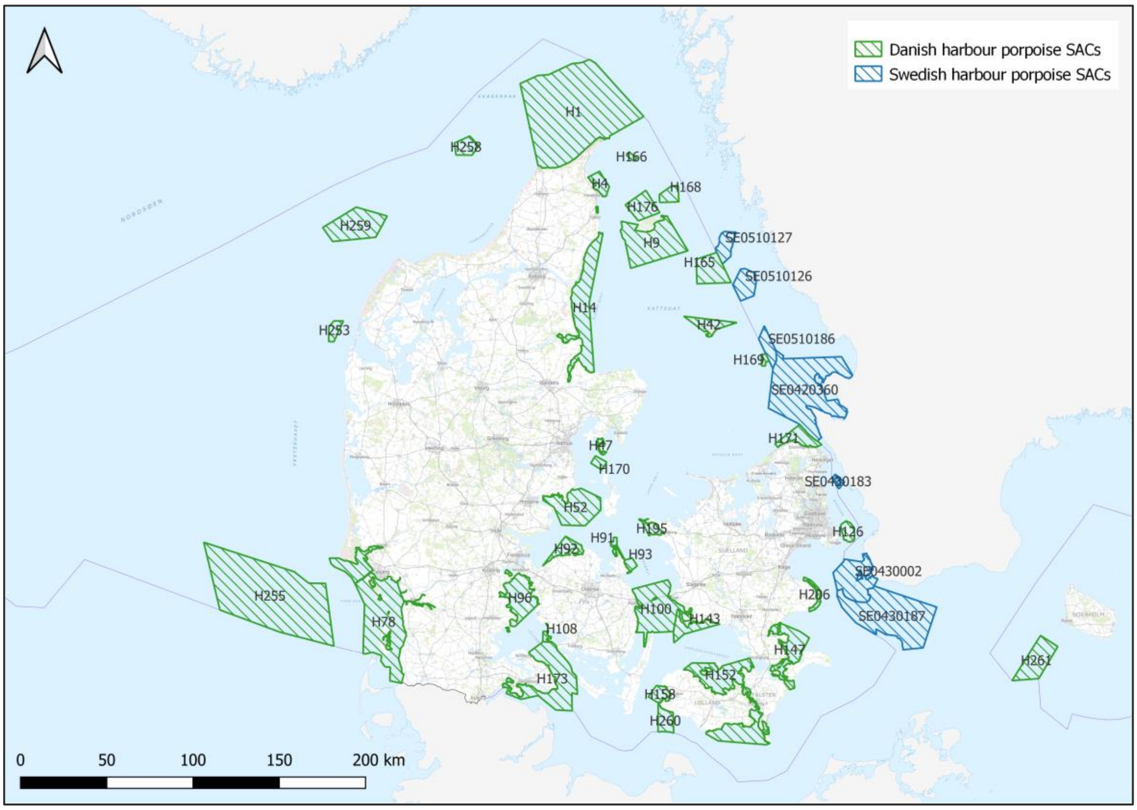

Figure 1.1: Natura 2000 sites across Danish and Swedish waters appointed to protect harbour porpoises.

Therefore, this report presents a 'catalogue of ideas' of possible compensation measures that could be progressed to deliver compensation for harbour porpoise across the relevant sea site. The catalogue of ideas will use the approach developed in UK for compensation measures in relation to Marine Protected Sites in general (DEFRA, 2021). The catalogue of ideas consists of three parts; general knowledge about harbour porpoises, a longlist (as an Appendix A to this report) and a shortlist of suitable compensation measures.

2 Methods

Based on how compensation measures are evaluated in the UK (DEFRA, 2021), the process for generating a catalogue of ideas started with a literature study. The literature search drew on existing information on compensation measures, such as options from previous compensation proposals, published scientific literature, grey literature, relevant guidance on compensation options, and expert knowledge and experience held by NIRAS' marine mammal experts.

This search has been used to inform the catalogue of ideas by providing an initial background description of harbour porpoise biology and information related to key life stages with regards to conservation. The literature search also included a thorough review of up-to-date literature on the most important factors that can adversely affect the survival and reproductive success of cetaceans with a focus on harbour porpoise (as harbour porpoises are the only cetacean species listed at both Danish and Swedish Natura 2000 sites and therefore the only cetacean species with the potential to require compensation). Thereafter, based on this description and the literature study, a longlist of potential 'like for like' compensation measures was prepared. Like for like measures refer to compensation measures which directly or indirectly benefit the feature affected, so there is no net loss to that feature, in this case harbour porpoises.

The catalogue of ideas has not been developed for a specific Natura 2000 site, but is intended to provide a list of measures that could be drawn on once an Natura 2000 Appropriate Assessment has been produced and a Natura 2000 site has been identified where an adverse effect applies. Therefore, the longlist is compiled at a general level and for broad application, but is not linked to specific locations or conservation objectives. For a compensation measure to be developed further, a feasible location to deliver the compensation measure would be required.

The longlist provides a robust and fully encompassing foundation from which to develop compensation options for cetaceans with a focus on the harbour porpoise.

Once measures were identified in the longlist, they were investigated to understand their suitability and alignment with relevant compensation guidance. To evaluate the potential compensation measures in a robust and transparent manner, each of the options were scored against the compensation criteria NIRAS has developed through the development and delivery of successive compensation cases for offshore wind plans and projects in the UK, as based on UK guidelines (DEFRA, 2021). The criteria are described in full in Table 2.1, noting that the specific wording has been adapted from previous examples to take account of the ecology of cetaceans.

Table 2.1 Screening criteria applied for 'Like for Like' longlist compensation measures based on the UK guidelines for marine protected sites (DEFRA, 2021).

Criterion	Description	Score
Preference	Initial preference hierarchy based on the British guidance[1]	4 = Provide the same ecological function as the impacted feature at the same location.
		3 = Provide the same ecological function as the impacted feature; if necessary, in a different location, or at a different time.
		2 = Comparable ecological function in the same location.
		1 = Comparable ecological function in a different location.
Location	Measures should be in a location where they will be most effective at maintaining the overall coherence of the Natura 2000 network. Delivering	4 = Option can be utilised by species from a protected site.
		3 = Species within a protected site can be affected positively by the option.

[1] https://consult.defra.gov.uk/marine-planning-licensing-team/mpa-compensation-guidance-consultation/supporting_documents/mpacompensatorymeasuresbestpracticeguidance.pdf

	compensation at the affected Special protected area (SPA), or other protected site, should be considered the most effective and will score higher.	2 = Species from the DK management unit's (North Sea, Belt Sea and Baltic Sea) core site can be affected positively by option.
		1 = Option can be reached by species and is located within the wider region and outside the subpopulations core site.
Technical Feasibility	Compensation options must be technically feasible (can it be done in practice) to allow implementation. This criterion will be decided based on evidence of lack of challenges to implementation, with effect of options supported by evidence and with limited barriers to delivery gaining a higher score (this criterion is related to practical implementation and do not include difficulties in e.g. legal implementation).	5 = Technical delivery of option is well evidenced, achievable without any substantial challenges and there is certainty in the outcomes.
		4 = Technical delivery is evidenced but some challenges with delivery and some uncertainty in the outcomes.
		3 = There is some evidence of delivery and some uncertainty regarding outcomes.
		2 = Little to no evidence of delivery and considerable uncertainty in outcomes.
		1 = No evidence of delivery and considerable uncertainty in outcomes.
Functional Feasibility	Compensation options must be functionally feasible to allow implementation (i.e. it is technically possible, but will it actually result in the intended outcome). This criterion will be decided based on evidence of effect of implementation, with options supported by evidence and with limited barriers to delivery gaining a higher score.	4 = Function delivery of option is well evidenced, achievable without any substantial challenges and there is certainty in the outcomes.
		3 = There is some evidence of delivery and some uncertainty regarding outcomes.
		2 = Little to no evidence of delivery and considerable uncertainty in outcomes.
		1 = No evidence of delivery and considerable uncertainty in outcomes.
Timing	Compensation should be secured before the species is impacted. High scoring compensation options in this category will be those which can be in place, functioning and contributing to the coherence of the Natura 2000 network before any impact occurs. Higher scores are also awarded	4 = High degree of certainty compensation will be in place, functioning and contributing to the coherence of the Natura 2000 network before impact.
		3 = Some certainty compensation will be in place, functioning and contributing to the coherence of the Natura 2000 network before impact occurs.

	to those with higher certainty associated with their timelines.	2 = Low certainty compensation will be in place, functioning and contributing to the coherence of the Natura 2000 network before impact occurs.
		1 = Compensation will not be in place, functioning and contributing to the coherence of the Natura 2000 network before impact occurs.
Additionality	Compensation must be additional to the normal practices required for the protection and management of the Protected Site. Any measures that will already be undertaken by Government bodies to ensure that sites or species are in favourable condition should not be considered.	2 = Confidence that measure will exceed what is considered 'normal' site management.
		1 = Unlikely that measure will exceed what is considered 'normal' site management.
Scale	Compensatory measures should address the impact of the activity at a scale sufficient to deliver the required ratio of compensation	3 = High possibility that the compensatory measure will deliver the required ratio of compensation.
		2 = Moderate possibility that the compensatory measure will deliver the required ratio of compensation, or it will occur at a later time.
		1 = Low possibility that the compensatory measure will deliver the required ratio of compensation.

From the longlist, each identified compensation measure was scored according to a scale that depends on the weight of the criteria (with 1 being the minimum score) for each of the criteria identified (Table 2.1). The differences in potential highest scores in the scale is due to an intentional weighting of the different criteria as it is assessed that some criteria has higher impact on the success of the measure being effective. An overall score of all the criteria was then calculated for each potential measure (highest score = 26). Detail behind the scoring of each measure is provided in Appendix A. Measures scoring above 16 (Figure 2.1) form the shortlist.

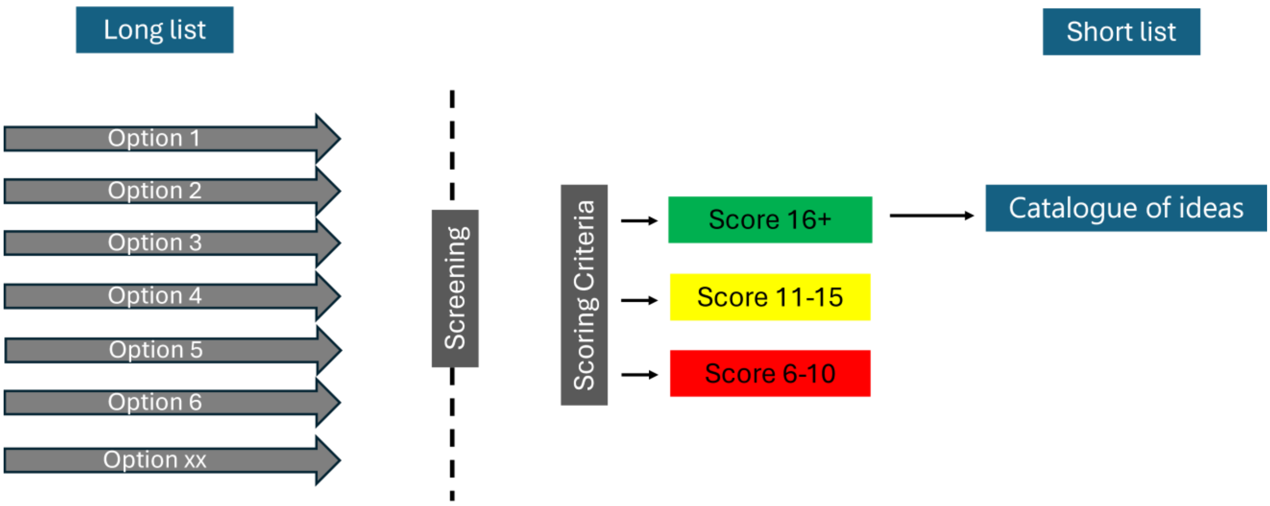

Figure 2.1: Screening process for compensation measure.

3 Harbour porpoise (*Phocoena phocoena*)

There is detailed knowledge about harbour porpoises and, to some extent, white-beaked dolphins in Danish waters in terms of distribution and numbers. Harbour porpoise are the most common cetacean species in Danish waters and white-beaked dolphin is the second most common cetacean species in the North Sea and probably also in inner Danish waters. There are no Danish Natura 2000 areas appointed to protect white beaked dolphins, as such sites are only designated for species listed on Annex II of the Habitats Directive (white beaked dolphin and all cetacean are listed on Annex IV but only harbour porpoise and bottlenose dolphin are included in Annex II and therefore require designation of sites). White beaked dolphins are therefore not further addressed in the idea catalogue.

Harbour porpoises in Danish waters are divided into three management units based on population differences in distribution, genetics, and morphology; the North Sea population, the Belt Sea population, and the Baltic Proper population (Sveegaard, et al., 2015; Celemín, et al., 2023). The North Sea population includes the Danish part of the North Sea, Skagerrak, and continues into Kattegat (Figure 3.1).

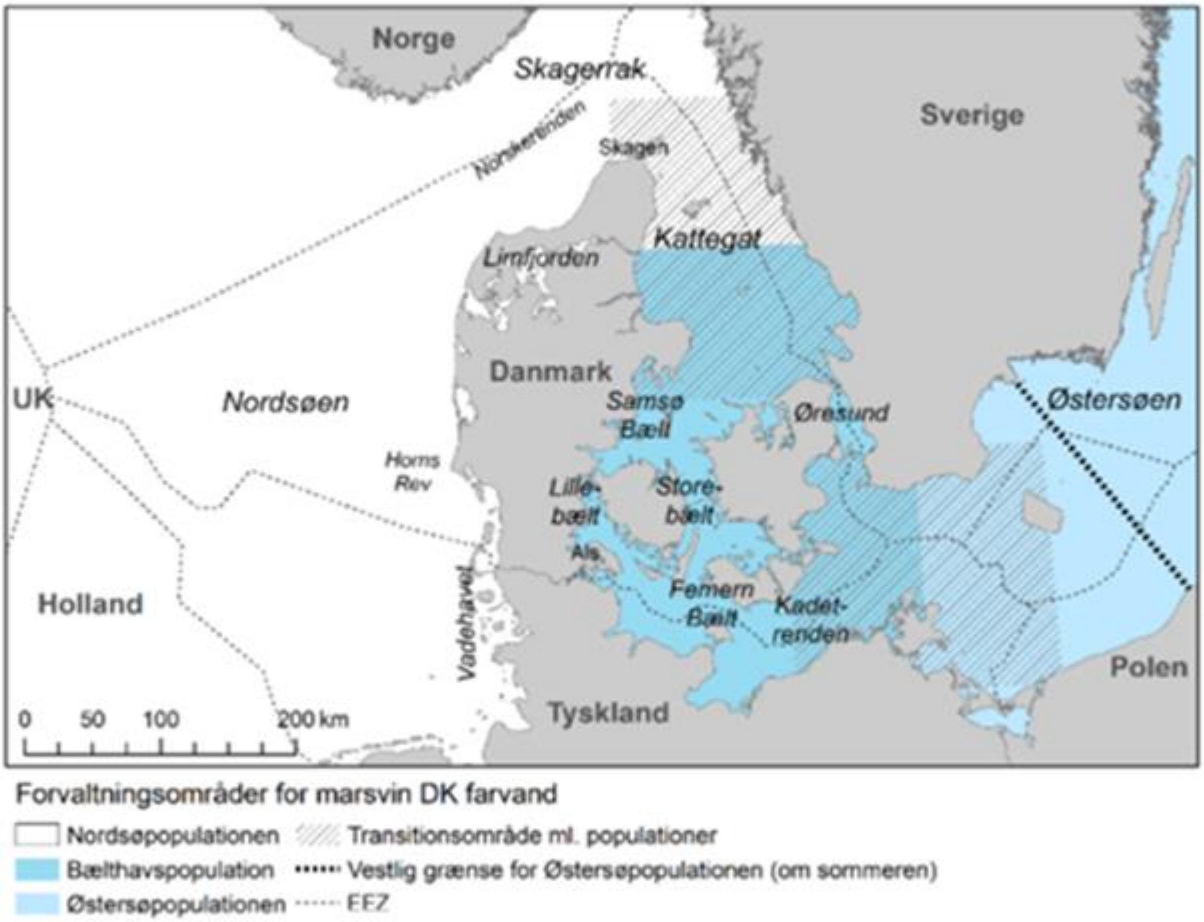

Figure 3.1: Harbour porpoise populations in Danish and Swedish waters (Sveegaard, Nabe-Nielsen, & Teilmann, 2018).

Each population is assessed individually. In the North Sea, the population has been counted during four SCANS surveys (Gilles, et al., 2023; Waggitt, et al., 2019; Hammond, et al., 2021; Hammond, et al., 2013; Hammond, et al., 2017) in 1994, 2005, 2016, and 2022. The population in the North Sea appears to be stable and consists of approximately 350,000 individuals. In the Belt Sea, the population has been counted during the four SCANS surveys and two miniSCANS surveys in the years 1994, 2005, 2012, 2016, 2020, and 2022 (Gilles, et al., 2023; Hammond, et al., 2017; Hammond, et al., 2013; Viquerat, et al., 2014). The population in the Belt Sea has decreased by approximately 2.68% per year (95% credibility interval, -4.13% to +1.26%) from 2005 to 2022, with a probability of 90.5% (Owen, 2024), decreasing from approximately 40,000 individuals to about 14,000 animals, which is a significant decline. The population in the Baltic Proper was in 2022 estimated to consist of only 500 animals (71–1,100 individuals, 95% CI, point estimate 491) (Amundin, 2022).

Porpoises breed in all management sites (Koschinski, 2001; Lockyer & Kinze, 2003). There is very limited knowledge about their breeding sites, but calves have been observed scattered across the North Sea, the Belt Sea, and according to historical data from the Baltic Sea (Koschinski, 2001). It is assumed that the breeding season is roughly the same for the three Danish porpoise populations. In the Inner Danish Waters, the calving period is from April to October, with a peak in July-August (Lockyer & Kinze, 2003). Gestation lasts about 10-11 months, and mating takes place about a month after birth (Lockyer, 2003). A calf stays with its mother for 10-11 months, during which it learns how to catch fish (Camphuysen & Kropp, 2011) and gradually becomes more independent, eventually leaving its mother at about 11 months of age (Teilmann, Larsen, & Desportes., 2007). Mortality is highest for porpoises under 1 year, and the youngest age groups are overrepresented in bycatch statistics (Berggren, 1994).

3.1 Threats in general

Harbour porpoise are exposed to several threats. The following sections provide a brief description of the most threats relevant for the catalogue of ideas. For more detailed description of threat see e.g. (HELCOM, 2023; ASCOBANS, 2016; ICES, 2019).

3.1.1 Bycatch

Incidental and unintended catches (bycatch) remain the dominant threat for the conservation of harbour porpoises and many other small cetacean species (ICES, Working group on Marine Mammal Ecology (WGMME), 2019; Brownell, et al., 2019). The impact of fishing activities on different species of cetaceans is considered one of the main threats to small cetaceans globally. Across the North Atlantic (including Danish waters), gillnets, including bottom-set gillnets, tangle nets and drifting gillnets, are responsible for most of the harbor porpoise bycatch. The fisheries responsible for the majority of harbor porpoise by-catch tend to be those using medium to large mesh-size gillnets set for species such as cod (*Gadus morhua*), hake (*Merluccius bilinearis*), turbot (*Scophthalmus maximus*), monkfish (*Lophius piscatorius*) and lumpfish (*Cyclopterus lumpus*) (IUCN, 2024). The reason for the high by-catch rates in these fisheries is a combination of net type and fishing effort. Larsen et al. 2021 estimated the magnitude of the bycatch of harbour porpoises in Danish gill-net fisheries, and how this bycatch is distributed geographically and seasonally based on registrations from 16 Danish commercial gillnetters between 2010 and 2018 (see Table 3.1).

Table 3.1. Mean (and 95% CI) quarterly fleet-wide harbour porpoise bycatch estimates in the North Sea, Skagerrak, Øresund and the Belt Sea in the Danish commercial gillnet fleet between 2010 and 2018 (Larsen, Kindt-Larsen, Sørensen, & Glemarec, 2021).

HARBOUR PORPOISE					
Area	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Year**
North Sea	123 (0-337)	515 (246-822)	984 (492-1,644)	0 (0-0)	**1,622** (739-2,804)
Skagerrak	64 (28-106)	134 (56-223)	211 (105-344)	96 (48-154)	**505** (238-827)
Øresund	19 (10-30)	10 (5-18)	30 (15-46)	43 (23-69)	**102** (52-163)
Belt Seas	57 (21-100)	145 (95-199)	201 (130-282)	90 (48-144)	**493** (294-752)
All areas	**263** (59-573)	**804** (402-1,262)	**1,426** (743-2,317)	**229** (119-366)	**2,722** (1,323-4,518)

In Kindt-Larsen et al., (2023) the quarterly bycatch rates in 2020 for each sub site was estimated by modelling for both the Swedish and Danish gillnet fisheries (Figure 3.2).

	area	quarter 1	quarter 2	quarter 3	quarter 4	year
North Sea & Skagerrak	Skagerrak (IIIa20)	14 (4–47)	149 (43–514)	53 (18–154)	40 (12–130)	255 (77–845)
	Skagerrak (IIIa20) no pinger	14 (4–49)	149 (43–516)	84 (28–255)	46 (14–157)	294 (89–977)
	North Sea (IVb)	166 (61–453)	441 (183–1065)	282 (85–933)	82 (22–304)	972 (351–2755)
	North Sea (IVb) no pinger	167 (61–453)	465 (193–1120)	669 (204–2192)	97 (29–332)	1398 (487–4097)
	total porpoise bycatch	**180 (65–500)**	**590 (226–1579)**	**335 (103–1087)**	**122 (34–434)**	**1227 (428–3600)**
	total porpoise bycatch no pinger	**168 (65–502)**	**614 (236–1636)**	**753 (232–2447)**	**143 (43–489)**	**1678 (576–5074)**
Western Baltic	Kattegat (IIIa21)	269 (61–1182)	103 (25–413)	48 (16–148)	8 (2–32)	428 (104–1775)
	Kattegat (IIIa21) no pinger	341 (26–1656)	103 (26–413)	53 (18–155)	8 (2–32)	505 (72–2256)
	The Sound (IIIb23)	20 (5–85)	23 (5–101)	36 (10–132)	40 (12–136)	119 (32–454)
	The Sound (IIIb23) no pinger	20 (5–85)	23 (5–101)	36 (10–132)	40 (12–136)	119 (32–454)
	Belt Sea (IIIc22)	44 (13–141)	72 (25–211)	116 (39–340)	83 (25–277)	315 (102–969)
	Belt Sea (IIIc22) no pinger	44 (13–141)	72 (25–211)	116 (39–340)	83 (25–277)	315 (102–969)
	total porpoise bycatch	**333 (79–1408)**	**198 (55–725)**	**200 (65–620)**	**131 (39–445)**	**862 (238–3198)**
	total porpoise bycatch no pinger	**405 (44–1882)**	**198 (56–725)**	**205 (67–627)**	**131 (39–445)**	**939 (206–3679)**
all areas	**total porpoise bycatch**	**513 (144–1908)**	**788 (281–2304)**	**535 (168–1707)**	**253 (73–879)**	**2089 (666–6798)**
	total porpoise bycatch no pinger	**586 (109–2384)**	**812 (292–2361)**	**958 299–3074)**	**274 (82–934)**	**2617 (782–8753)**

Figure 3.2: Comparison between quarterly and yearly porpoise bycatch per ICES site and per focal site (in bold), with and without the use of pingers in sites where pingers are mandatory (Kindt-Larsen, et al., 2023).

In the study from 2023 the modelling of bycatch rates was conducted for two scenarios, one with no use of pingers and one with the use of pingers. Pingers are mandatory for vessel at 12 meters or longer in some sites (see Figure 7.1). In the modelling a 100% bycatch reduction is assumed when pingers are used in the sites where pingers are mandatory. The modelled results are based on data from the Danish and Swedish commercial gillnet fleets for year 2020 (Kindt-Larsen, et al., 2023). According to this study the total yearly bycatch rate in all sites (North Sea, Skagerrak, Kattegat, the Sound and the Belt Sea) are 2617 harbour porpoise without the use of pingers and 2089 harbour porpoises with the use of pingers.

3.1.2 Prey depletion, habitat loss and degradation

Depletion of prey by overfishing is another threat to harbour porpoises, as harbour porpoises are relatively intolerant to a lack of food (Kastelein, Hardeman, & Boer, 1997; Koopman, Pabst, McLellan, Dillaman, & Read, 2002; Bjørge, 2003; Lockyer, Anderson, Labberté, & Siebert, 2003). Harbour porpoises are known to feed on a relatively broad spectrum of prey. They mainly feed on small and medium sized pelagic fish as well as on demersal and benthic fish species (Santos & Pierce, 2003). Prey species such as sandeel (*Ammodytes sp.*), gobies (*Gobiidae sp.*), cod and herring have been shown to be important prey in the North Sea and in the Baltic Sea (Gilles, Andreasen, Müller, & Siebert, 2008; Sveegaard, et al., 2011). Since the early 1990s, most stocks of cod and herring in ICES subdivision 20-24 in inner Danish waters (Kattegat, Skagerrak and Western Baltic) and in the North Sea have decreased (ICES, 2024; ICES, 2023a; ICES, 2023b; ICES, 2022).

3.1.3 Climate and habitat changes

Furthermore, climate change is expected to have an increasing negative impact on fish stocks in the future. Climate change can affect fish stocks directly (e.g., as warming decreases oxygen levels), or indirectly due to reduced recruitment and growth (e.g., by effects on the availability of food for larvae), can impact the distributional range of species or their prey e.g., by changes in water temperature, salinity or ecological interactions or through changes in competition including from invasive species (MacKenzie, Gaslason, Möllmann, & Köster, 2007).

3.1.4 Underwater noise

Underwater noise can affect harbour porpoises in several ways. Anthropogenic underwater noise comes from various sources e.g.: shipping, geophysical surveys, leisure crafts, unexploded ordnance detonations as well as during the construction of wind farms such as piling. Depending on the noise source, underwater noise can travel very far and fast in water, about four times faster than in air due to the higher density of water. How noise affects marine mammals depends on different properties of the noise source, e.g. the frequency, intensity, duration and how fast the noise increase in intensity as well as the marine mammal hearing abilities.

Noise sources are commonly divided into impulsive sources and continuous or non-impulsive sources. Impulsive noise is somewhat loosely characterized as sound pulses of short duration (seconds or less), occurring with a low duty cycle. The loudest sources are (in no particular order): underwater explosions, seismic 3D airgun surveys, percussive pile driving and certain types of powerful low- and mid-frequency military sonars, but other impulsive sources of interest include seal scarers, net pingers, and less powerful fish-finding and navigational sonars, echo-sounders etc. Continuous noise sources are typically of longer duration (hours to days) and without clear onset and offset. At close range they are typically identifiable above the background noise, but at longer distances they blend into and add to the natural ambient noise from wind, waves etc. and result in an elevation of the ambient noise. The most dominant contribution by far comes from ship noise (propeller noise and engine noise) (North Atlantic Marine Mammal Commission and the Norwegian Institute of Marine Research., 2019). A third, but increasingly important sound source is the non-impulsive Ultra Short Baseline system (USBL) that functions as an underwater GPS to keep track of instruments used underwater, such as trawls, towed geophysical instruments, ROVs etc. There is a transceiver on the vessel and transponders on the towed equipment. The transponders respond with a reply signal when receiving a signal from the transceiver on the vessel. There can be many transponders. The source level is high and the frequency is about 25 kHz, where harbour porpoises hear very well (Pace, Robinson, Lumsden, & Martin, 2021).

As noise spreads through the water, its acoustic energy decreases due to propagation loss. Effects of noise can range from acoustic disturbance, to temporary (TTS) or permanent hearing loss (PTS), or even physical injuries and mortality. The most detrimental effect from noise on individuals is injury or death due to high intensity impulsive noise. PTS has direct implications for porpoises' viability as they rely on their hearing to find prey, communicate, and orientate (HELCOM, 2019; Southall, et al., 2007; Richardson, Greene, Malme, & Thompson, 1995). Disturbance can lead to a wide variety of responses with variable implications for the animals, including a change in behaviour, a missed opportunity (for foraging, mating etc.) or both (Bas, Christiansen, Ozturk, Ozturk, & McIntosh, 2017); which consequently could affect the energy budget of the animal, as well as habitat loss (due to animals fleeing an site). An individual disturbance event may be small and the effect insignificant but could cumulate across repetitive disturbances (North Atlantic Marine Mammal Commission and the Norwegian Institute of Marine Research., 2019).

The most recent guidance for marine mammals in order to avoid temporary hearing loss and injury to the auditory system is given by NMFS and Southall, et al., (2018; 2019) and behavioural avoidance responses is given by Tougaard (2021). With respect to disturbance, harbour porpoises are especially sensitive to the high-frequency (10-

140 kHz) part of the spectrum at which they show behavioural reactions (Wisniewska, 2018). It has been demonstrated that even low levels of mid- and/or high frequency components of broadband sounds, such as from ships, elicit a behavioural response (Dyndo et al., 2015).

3.1.5 Marine debris: ingestions and entanglement

During the last few decades, there has been an increasing focus on and awareness of marine litter, its origin and the consequences of this litter (including lost fishing gear) on the oceans and the marine life. The wide distribution and abundance of man-made litter, in particular plastics, affects a broad range of marine organisms through entanglement and ingestion (Kühn, 2015; IJsseldijk, et al., 2022; van Franeker, et al., 2018).

A previous study on harbor porpoises from Dutch waters found marine debris in between 7% and 15% of harbour porpoise stomachs. These pieces of debris can be expected to pass through the gastrointestinal tract in a similar way to food items, and hence are indicative of pollution of the marine environment. A recent study from German waters investigates microplastics (1-5 mm) in intestinal samples from harbour porpoises found along the coastline of Schleswig-Holstein (Germany) between 2014 and 2018. Out of 30 individuals found along the North Sea and the Baltic Sea coast, 28 specimens contained microplastic, where specimens from the Baltic Sea contained more microplastics than the ones from the North Sea (Phillipp, Unger, Ehlers, Koop, & Siebert, 2021). Tissue damage and inflammations are assumed to be caused by micro- and nanoplastic occurrence in mammals (Carr, 2012; Stock, 2019). According to Nelms et al. (2019) a possible relationship was found between the cause of death and microplastic abundance, indicating that cetaceans that died due to infectious diseases had a slightly higher number of particles than those that died of trauma and other drivers of mortality. It is not possible, however, to draw any firm conclusions on mortality in harbour porpoise caused by ingestion of microplastics (HELCOM, 2023). In Danish Waters, stomachs from 26 harbour porpoises were analyzed for plastic in the following size categories: 1-5 mm (micro), 5-25 mm (meso) and >25 mm. None of the stomachs contained plastic. Ingestion of plastic is therefore not considered an extensive problem in Danish Waters (Mikkelsen, Strand, & Kyhn, 2022).

Richardson et al. (2019) estimate, based on reviews of 68 publications from 1975-2017, that 5.7% of all fishing nets (trawl & seine fragments and gillnets), 8.6% of all traps, and 29% of all lines, are lost around the world each year. In EU waters it is estimated that 27% (in weight) of the marine litter, equivalent to 11,000 tons annually, originates from the fishing and aquaculture industry (CWD, 2018). Ghost nets are a general term for abandoned, lost or otherwise discarded fishing gear (ALDFG) and cover all types of fishing gear (trawl, gillnet, fyke, pot or even jigs) and it can originate from all types of fishing: recreational, part-time and professional.

Ghost nets will in many cases continue to fish for the targeted and non-targeted species including seabirds, marine mammals, shellfish, other fish and prey species of marine mammals. Whether the ALDFG are ghost fishing or not, is very much depending on the type of ghost gear, it's actual location on the bottom/structure or wreck, on the age of the gear and on the coverage with biological material e.g. macrophytes, blue mussels or with sediment. In general, gillnets, traps and pots are known to ghost fish for variable amounts of time. In 2021 it was estimated that there are 49.000 net pieces in Danish waters (Pedersen, et al., 2021). Studies have shown, that catches of lost gillnets decrease gradually over time, however lost gillnets continue to catch fish for four months and even to up to 2 years if nets are lost in deep water (Brown, Macfadyen, Huntington, & Tumilty, 2005).

It is unknown how many harbour porpoises are bycaught in the ghost fishing gear. However in the case of endangered or threatened species/populations e.g. the Baltic Proper population, even low-level entanglement may affect populations directly and so be an obstacle to population recovery (Brown, Macfadyen, Huntington, & Tumilty, 2005).

3.1.6 Pollution

Chemical pollutants, specifically Polychlorinated biphenyls (PCBs) have been described as having adverse effects on harbour porpoises (IUCN, 2024). Reproductive dysfunction in porpoises may be related to PCB exposure occurring either through endocrine disrupting effects or via immunosuppression and increased disease risk (Murphy, et al., 2015). Following the EU-wide ban of commercial penta- and octa-mix polybrominated diphenyl ether (PBDE) products in 2004 (Law, et al., 2012), a significant (and consistent) decline was observed in concentrations of brominated diphenyl ethers (BDEs) in marine sentinel species (including the harbour porpoise) during the period 2008 to 2012 (Law, et al., 2012). Declines were also observed in Hexabromocyclododecane (HBCD), tributyltin (TBT) and organochlorine pesticide concentrations in the blubber of UK-stranded harbour porpoises over the same period (Law, et al., 2012). Concentrations of PCB, a known endocrine disruptor, in harbor porpoise blubber have remained stable since 1997, with mean ΣPCB concentrations in adult male and female porpoises (sampled between 1990 and 2012) exceeding an established mammalian toxicity threshold of 9 mg/kg ΣPCB for onset of physiological (immunological and reproductive) endpoints in marine mammals (Kannan, 2000; Law, et al., 2012).

In addition, habitat loss and habitat degradation caused by eutrophication from agriculture, leads to hypoxic and anoxic conditions in large parts of Inner Danish waters. Such conditions can impact prey stocks and further reduce food sources for harbour porpoises as fish eggs and larvae die off in oxygen depleted waters. The latest monitoring in Inner Danish waters show large contiguous sites of low oxygen content in the Kattegat and Great Belt (Figure 3.3). In some of the waters, the oxygen depletion was very intense, and in several locations the bottom water was anoxic or nearly anoxic. In several locations, the oxygen depletion caused toxic hydrogen sulphide to be released into the bottom water. Oxygen depletion was the reason why dead benthic animals and fish were observed in Limfjorden in June and dead fish were observed in Roskilde Fjord in August (Hansen & Rytter, 2024).

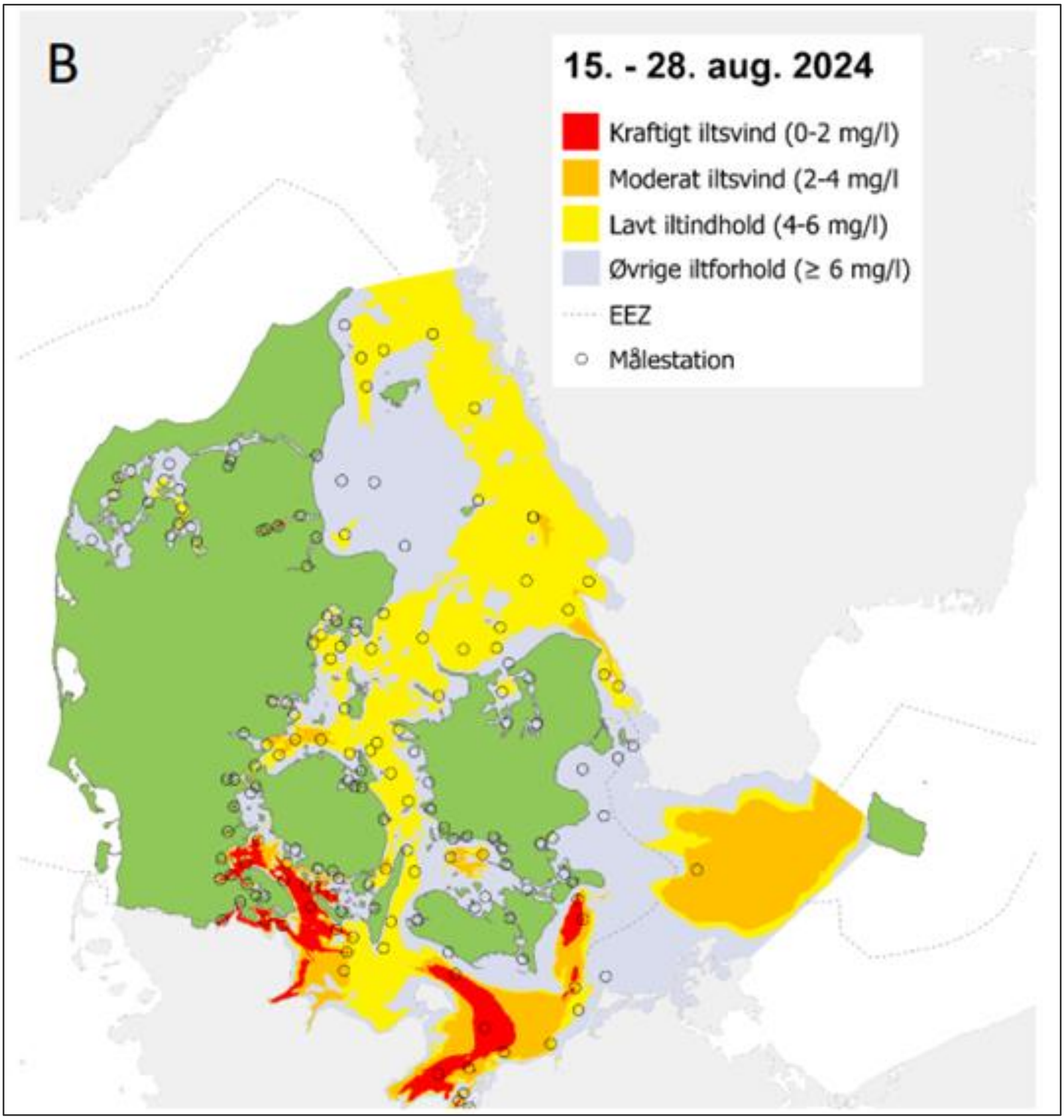

Figure 3.3: Site distribution of oxygen conditions modelled based on measurements from 15-28 August in 2024 (Hansen & Rytter, 2024). Red= Severe oxygen depletion, Orange=Moderate oxygen depletion, Yellow=Low oxygen levels. Grey indcate areas without oxygen deficiency.

3.1.7 Vessel strikes

The direct pressure to individual harbour porpoises resulting from maritime traffic is the concern of collision (from ship strike). A vessel strike is defined as any impact between any part of a watercraft (most commonly bow or propeller) and a live marine animal (Peel, Smith, & Childerhouse, 2018). Vessel strikes often result in physical trauma or death (Schoeman, Patterson-Abrolat, & Plön, 2020). The issue of fatal collisions with commercial ships and ferries usually refers to large whales such as baleen whales, and reports of vessel strikes with smaller species are scarce. In Denmark, up to 25 harbour porpoises are necropsied per year to assess cause of death in the national contingency plan for marine mammals. No individuals have been deemed killed by vessel strikes till now, with the most common cause of death being bycatch (Thøstesen & Kristensen, 2024) (REF). However, injury *indicative* of vessel strikes on harbour porpoise such as blunt trauma, skull fracture or multiple lacerations is frequently reported from other parts of the world (Parsons, 2000; Sabin & Law, 2005; IJsseldijk, et al., 2022).

3.1.8 Diseases

Non-direct human-induced population threats of diseases are also important to consider, as it can induce high mortality rates, lower reproductive success and increase the virulence of other diseases. Environmental quality such as concentration of contaminants, seem to play a role in the infectious diseases in harbour porpoises (Van Bressem, 2009; IUCN, 2024; HELCOM, 2023).

One of the largest health assessments of harbour porpoises from the Baltic was conducted by Siebert *et al*. (2020). Data were collected from animals coming from Latvia, Poland, Germany and Denmark for years between 1990 and 2015. The animals were either known to be by-caught or found dead on the coastline (also included bycaught animals). The respiratory tract had the highest number of pathological lesions. An additional study completed post-mortem examinations on 128 stranded harbour porpoises, collected over 15 years from Swedish waters (Neimanis, 2022). The majority of animals likely originated from the Belt Sea and the North Sea populations of harbour porpoises. Pneumonia was the most frequent cause of death (21 %), followed by infectious diseases caused by bacterial infections, parasitic infections, fungal infections and brain inflammations. Besides infections that were the direct cause of death, the vast majority of stranded porpoises (61%) had milder parasitic infections and associated inflammatory tissue changes.

Disease factors and mortality etiologies of free-ranging wild cetaceans such as the harbour porpoise are difficult to study. Although diseases are often considered a natural cause of death, it is worth underlining that the population health of an apex predator such as the harbour porpoise may mirror the overall health and stability of marine ecosystems and the effects of human activities on coastal environments (HELCOM, 2023).

4 Potential impact from OWF

The most significant impact on marine mammals caused by the establishment of fixed bottom offshore wind farms is typically considered to be underwater noise from pre-construction (geophysical surveys and UXO clearance) and construction activities (e.g. pile driving) and ship traffic. Pile driving and UXO clearance are assumed to have the most potential for a significant effect on marine mammals, as these result in loud impulsive noise that can occur intermittently for months pre and during construction (Madsen, Wahlberg, Tougaard, Lucke, & Tyack, 2006; Tougaard, Carstensen, Teilmann, Skov, & Rasmussen, 2009; Bailey, et al., 2010). At distances close to the source, these sounds may cause permanent (PTS) or temporary (TTS) hearing loss, while at greater distances animals are disturbed and potentially displaced, leading to temporary habitat loss.

There are a number of noise abatement systems available for large-scale pile driving, such as air bubble curtains or static absorbers/reflectors (e.g. hydro sound damper) (Bellmann, et al., 2020; Koschinski & Lüdemann, 2020), that efficiently reduces the impact from noise on marine mammals (Dähne, Tougaard, Carstensen, Rose, & Nabe-Nielsen, 2017; Nehls & Bellmann, 2016; Rose, et al., 2019; Brandt, et al., 2018). In accordance with the Danish guidelines for impact piling, underwater noise levels causing PTS beyond 200 meters from the installation sites are not allowed (Energistyrelsen, 2023). Therefore the impact from foundation installation on harbour porpoises and other cetaceans are mainly related to avoidance responses and a temporary habitat loss. How important the temporary habitat loss is, depends on the importance of the lost site and time of the year. Other activities, such as dredging, transportation of materials and equipment, are also likely to cause disturbance and noise, although at much lower sound pressure levels than piledriving of foundations or clearance of UXO.

Therefore, impacts on harbour porpoises and other cetacean species from establishment of offshore wind farms are most likely related to disturbance following underwater noise, potentially resulting in individual cetaceans leaving the site and thereby suffering temporary habitat loss. Previous constructions of wind farms have shown displacement of marine mammals during construction (Tougaard, Carstensen, Teilmann, Skov, & Rasmussen, 2009; Brandt, Diederichs, Betke, & Nehls, 2011; Dähne, et al., 2013; Dähne, Tougaard, Carstensen, Rose, & Nabe-Nielsen, 2017; Rose, et al., 2019; Brandt, et al., 2018). During operation of wind farms, the occurrence of harbour porpoises has mostly returned to baseline levels from before the construction phase or to higher levels (Tougaard, et al., 2006; Scheidat, et al., 2011; Petel, Geelhoed, & Meesters, 2012; Rose, et al., 2019). Noise from operating wind turbines is low compared to noise from, e.g., shipping (Tougaard et al. 2020).

5 Natura 2000 sites (SACs) appointed to protect harbour porpoises

5.1 Danish Natura 2000 sites

There are 35 Natura 2000 sites appointed to protect harbour porpoises in Danish waters. For each Natura 2000 site, goals/objectives of conservations are provided in their specific Natura 2000 plan. A list with the 35 Natura 2000 sites and their goals of conservation (general and specific) relevant for harbour porpoises can be found in Appendix A. Furthermore relevant site specific guidelines for harbour porpoises are listed in Appendix A. A summary of the most relevant goals of conservation and site of specific guidelines are described in the following section.

The minimum general objective for all Natura 2000 sites is: *For species without a status assessment system, the conservation goal (as a minimum) is to contribute to achieving a favorable conservation status at the biogeographical level (see the Natura 2000 plans for the individual sites). The condition of the habitats (assessed in terms of occurrence and distribution) and the total site should be stable or improving*. Furthermore in several of the plans of conservation it is stated that for the site's protected marine habitat types (primarily reefs and sandbanks) the goal is to develop well-established bottom vegetation and fauna, which can, among other things, ensure the food source for porpoises.

As described in section 3.1 and also reflected in the Natura 2000 plans, fishing, particularly bycatch in gillnets, and habitat degradation, partly due to fishing, lack of prey due to fishing and oxygen depletion caused by agriculture are the biggest threats to harbour porpoises in Danish Waters. Figure 5.1 shows the bottom trawling intensity in Danish waters from 2017-2022 including inside the marine protected Natura 2000 sites. From this figure it is evident, that bottom trawling occurs in several parts of Danish waters, including marine protected sites (Biodiversitetsrådet, 2024).

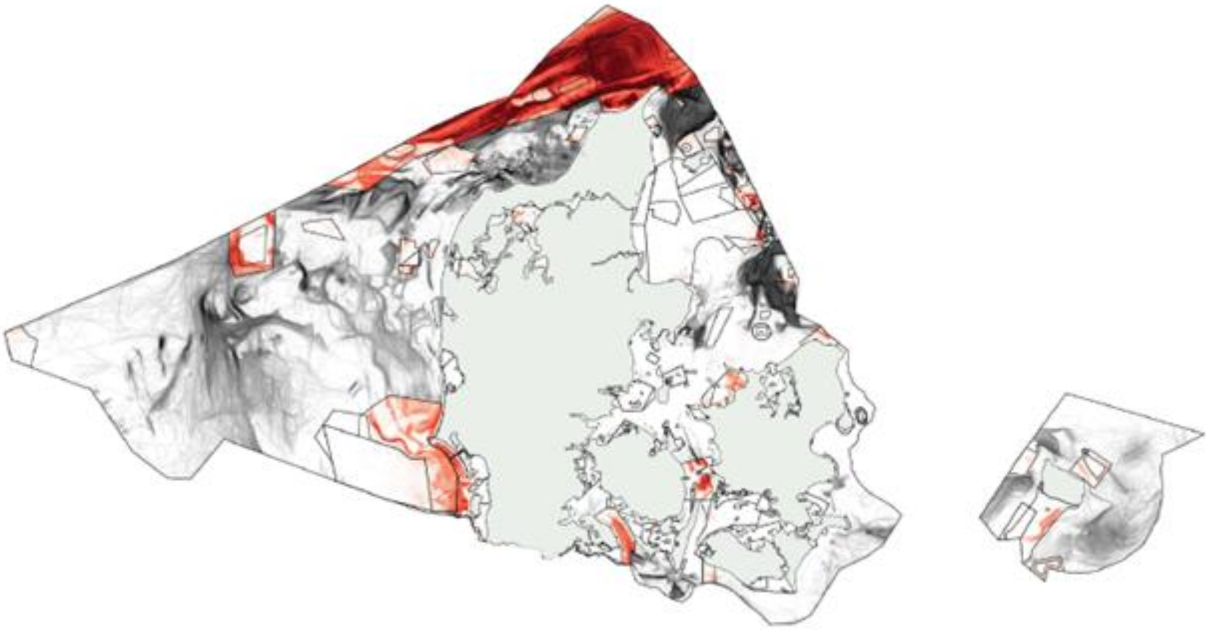

Figure 5.1: The extent of fishing carried out by Danish fishing vessels with bottom trawling gear in Danish waters from 2017-2022, including marine protected Natura 2000 sites. Gray and black tracks indicate fishing with bottom trawling gear outside protection sites, and red tracks indicate fishing with bottom trawling gear in marine protected sites (Natura 2000). The darker the color, the more fishing has taken place in the site (Biodiversitetsrådet, 2024).

In the current Natura 2000 plans (plan period 2022-2027) for 34 of the 35 Natura 2000 sites appointed to protect harbour porpoises there is a ban on fishing with bottom trawling gear in parts of the Natura 2000 sites where protected reefs (1170) or submarine structures made by leaking gases (1180) have been registered (but not in the entire site). Bottom trawling gear is more of an indirect threat to harbour porpoises, as bottom trawling gear removes the food source for harbour porpoises, and because bycatch of porpoises in bottom trawling gear is very limited (Larsen, Kindt-Larsen, Sørensen, & Glemarec, 2021).

The most direct threat to harbour porpoises, as previously mentioned, is bycatch in gillnets (see section 3.1.1). According to the current Natura 2000 plans, there is a ban on the use of standing fishing gear, including gillnets, in 4 of the 35 Natura 2000 sites, near protected reefs and submarine structures made by leaking gases (see Appendix A). For all of the 35 Natura 2000 sites, the action programs state that the work to assess the need for establishing any necessary fishing regulations to protect harbour porpoises from bycatch in Danish waters must continue. In Natura 2000 sites appointed to protect reefs and submarine structures made by leaking gases it is stated that, the ongoing process of necessary fishing regulations should be completed for reefs and submarine structures made by leaking gases in order to protect the reef structures and provide indirect protection of food resources for harbour porpoises.

5.2 Swedish Natura 2000 sites

There are six Swedish Natura 2000 sites appointed to protect harbour porpoises in close vicinity to Danish waters (Appendix A). These sites might be exposed to impact from the development of offshore wind in Danish waters. As for the Danish Natura 2000 sites, there are in four of the six relevant Swedish sites, established Natura 2000 plans with goals for conservation and site specific guidelines for harbour porpoises. A summary of the most relevant goals for conservation and site specific guidelines are described in the following section.

Similar to the Danish Natura 2000 sites the minimum general objective is to contribute to achieving a favorable conservation status at the biogeographical level. The condition of the habitats (assessed in terms of occurrence and distribution) and the total site should be stable or improving. More specifically, it is stated in the Swedish Natura 2000 plans that species (harbour porpoise) and habitats that are declining, threatened, protected, or covered by action programs should be able to develop natural densities and age structures for the site. Human activities should not negatively impact important processes, functions, structures, as well as characteristic and typical species. Bycatch should be limited and should be zero within some sites, e.g. Sydvästskånes utsjövatten. There should be no lost fishing gear that can catch animals or affect the seabed. The supply of energy, including underwater noise, should be at levels that do not negatively affect marine habitats or species. In the Natura 2000 plan for Sydvästskånes utsjövatten impulsive noise or continuous underwater noise, including shipping, should not cause behavioral impacts on individual harbour porpoises within the Natura 2000 site (Länsstyrelsen Skåne, 2022). For other Swedish Natura 2000 sites, the requirements relate to impulsive noise or continuous underwater noise, including shipping, specifically that this should not cause behavioral impacts in sites where the detection frequency of porpoises is highest. In sites where the detection frequency is lower, activities generating underwater noise that exceeds the porpoise's hearing threshold by 40 dB should be minimized (Appendix A).

6 Results

The result of the longlisting exercise for compensation measures can be found in Appendix B. The longlist is ordered in descending scoring order and includes a brief summary of the main driver of the score. The compensation measures identified are all potential measures that could be implemented to reduce, manage or alleviate one of the threats to harbour porpoise identified in section 3.1, with the expectation that relieving a known threat has the potential to result in a benefit to individual animals. The longlist considered the following compensation measures grouped in four compensation types:

Habitat support; creation or re-creation of harbour porpoise habitat or supporting habitat (including prey supporting habitat):

- Designation of new or extension of existing offshore Natura 2000 sites
- Provision of supporting habitat or improved existing supporting habitat (e.g. re-creation of important habitat nature types in SACs)
- Designation of offshore wind farm sites as marine mammal protection zones

Rights acquisition; methods to compensate by acquiring rights for natural resources:

- Purchase of or reduction in fishery quota

Species recovery; Any measure that works towards directly or indirectly increasing the numbers of harbour porpoises (or reducing the number removed from the population):

- Fishery closure in SACS with enforcement (to reduce bycatch and/or increase prey availability)
- Fishery exclusion zone in SACs with enforcement (to reduce bycatch and/or increase prey availability)
- Bycatch reduction with implementation of e.g. pingers
- Improvement in fishing gear (to reduce risk of entanglement)
- Hazardous plastic/nets removal (to reduce risk of entanglement)
- Financial support to existing strategies (e.g. a charity that aims to protect marine mammals)

Threat reduction: Reduction of threats towards the species site that typically result in non fatal (or low level mortality) in Danish waters:

- Vessel management to reduce of shipping disturbance (commercial and recreational vessels)
- Management of underwater noise (to reduce or manage disturbance)
- Management of marine litter (to reduce the risk of ingestion)
- Increasing environmental education
- Pollution prevention and management
- Disease management
- Framework for industry collaboration
- Supporting research to improve the evidence base

The longlist (Appendix B) resulted in a subsequent shortlist consisting of the highest scoring recommendations (those measures that scored 16 or above). These short listed measures have been considered below under the following headings: restrictions in fisheries, bycatch reduction, removal of lost fishing gear, vessel management (reduction of underwater noise from ships), creation of new SAC or extension of existing SACs and habitat support, and are discussed further below (see Tabel 6.1).

Tabel 6.1: Compensations measures from the longlist that scores 16 or above and are therefore included in the catalogue of ideas.

Measure	Compensation type	Description	Screening score	Section where it is discussed
Fisheries closure in the entire SAC	Species recovery	Reducing bycatch	21-23	6.1
Fisheries exclusion zone in part of the SAC	Species recovery	Reducing bycatch	21-23	6.1
Fisheries closure in the entire SAC	Species recovery	Reducing fishing pressure to increase prey availability	21-22	6.1
Fisheries exclusion zone in part of the SAC	Species recovery	Reducing fishing pressure to increase prey availability	21-22	6.1
Bycatch reduction	Species recovery	Implement mitigation measures (i.e., pingers on gillnets) to reduce or avoid bycatch	20-21	6.2
Supporting habitats	Habitat support	Provision of supporting habitat or improved supporting habitat e.x. construction of additional stone reefs, without fishery	20	6.3
Designation of offshore wind farm areas as marine mammal protection zone	Habitat support	Promote the use of an operational wind farm for marine nature, including exclusion of	20	6.3

Measure	Compensation type	Description	Screening score	Section where it is discussed
		certain activities such as fisheries and promotion of others, such as stone reefs.		
Vessel management (re-creational)	Threat reduction	To reduce the risk of disturbance. Relating to recreational vessels most likely to be area/zonal, vessel behavioural and speed related.	18-20	6.4
Vessel management (commercial)	Threat reduction	To reduce the risk of disturbance. Relating to commercial vessels most likely to be area/zonal, potentially seasonal.	17-18	6.4
Marine SAC designation or extension	Habitat support	Provision of new or replacement protected areas to be managed for harbour porpoise. Potential for management measures to be included in the management plan.	18-19	6.5
Hazardous plastic/nets removal/material	Species recovery	Reduce risk of entanglement in especially ghost fishing gear	17	6.6
Management of underwater noise	Threat reduction	Implementation of 'quiet zones'	16-17	6.4

6.1 Fisheries closure in the entire SAC and fisheries exclusion zones in part of the SAC

Closure of fishery or introduction of fishery exclusion zones in SACs introduce a direct compensation measure by a reduction in bycatch (scoring 21-23 point at the longlist for both), but it also introduce an indirect measure by increasing prey availability (scoring 21-23 point at the longlist for both). In the following section first bycatch as a compensation measure is discussed followed by a discussion on increase in prey availability is discussed.

Bycatch in nets has a very direct impact on the survival. Especially harbour porpoises, because of the high number of harbour porpoise drowning in mainly gillnets each year (see section 3.1.1). Many of the Natura 2000 sites designated for harbour porpoise serve as high-quality foraging sites for harbour porpoises as well as important fishing grounds for the gillnet fishery (Kindt-Larsen, et al., 2016). The most effective method of bycatch reduction is spatio-temporal restrictions: closure of the fishery/fisheries with highest bycatch rates (based on gear types) either temporarily/sesonally or permanently. Whilst reducing bycatch to zero within sites, however, the resulting benefit at a population level would depend on bycatch outside the site, particularly if fishing effort is shifted rather than removed. It is therefore important to ensure that fishing effort and cetacean bycatch are not merely shifted spatially. The restriction on using bottom set gillnets or entangling nets in existing porpoise SACs (in addition to others) and other key harbour porpoise sites, either permanently or temporarily/seasonally, or as part of a zoning scheme, could be recognized as part of a suite of conservation measure.

Reduction in the pressure from the fishery could also have an indirect impact on harbour porpoise by increasing the available food sources. Harbour porpoises are largely piscivorous, feeding mainly on small fish from both demersal and pelagic habitats (Santos & Pierce, 2003). Prey is variable both spatially and seasonally.

Harbour porpoise diet overlaps with diets of other piscivorous marine predators (e.g. other cetaceans, large predatory fish, seabirds and seals) and many of the main prey species are also taken by commercial fisheries. Santos and Pierce (2003) suggested that in the northeast Atlantic there has been a long-term shift from predation on clupeid fish (mainly herring) to predation on sandeels and gadoid fish, possibly related to the depression in herring stocks from the mid-1960s to the 2000s caused by fisheries. A similar shift is observed in Inner Danish Waters, where harbour porpoises were observed to forage primarily on fish with a length of 3-10 cm (Wisniewska et al. 2016), whereas previous studies showed a preference for much larger species (Andreasen et al., 2009). The new preferred species is most likely gobies, as larger species to a large degree have disappeared from Inner Danish Waters due to a combination of fishing of the mature fish and oxygen depletion hindering recruitment.

However, reduction in fishing efforts can be controversial, and may be difficult to enforce, as it has a potential of direct economic impact on the fishing industry. Such difficulties are currently being experienced in the UK, where restrictions on the sandeel fishery (to benefit seabirds) are being sought and are in conflict with fishers[1].

6.2 Bycatch reduction with mitigation measures

Separate to fishery closures or exclusion zones, the most widespread measure to reduce bycatch of harbor porpoises is the use of active alarms, or so-called "pingers". Pingers emit noises that alert or scare harbor porpoises away from a hazard, such as gillnets. Pingers effectively reduce bycatch of harbor porpoises (Larsen, Kindt-Larsen, Sørensen, & Glemarec, 2021; Kindt-Larsen, et al., 2023) and are mandatory for EU vessels more than 12 m in length in certain sites specified in (Bek nr. 1495 af 29.06.2021) and shown in Figure 6.1.

[1] https://oceans-and-fisheries.ec.europa.eu/news/eu-requests-establishment-arbitration-tribunal-over-uks-prohibition-fishing-sandeel-2024-10-25_en

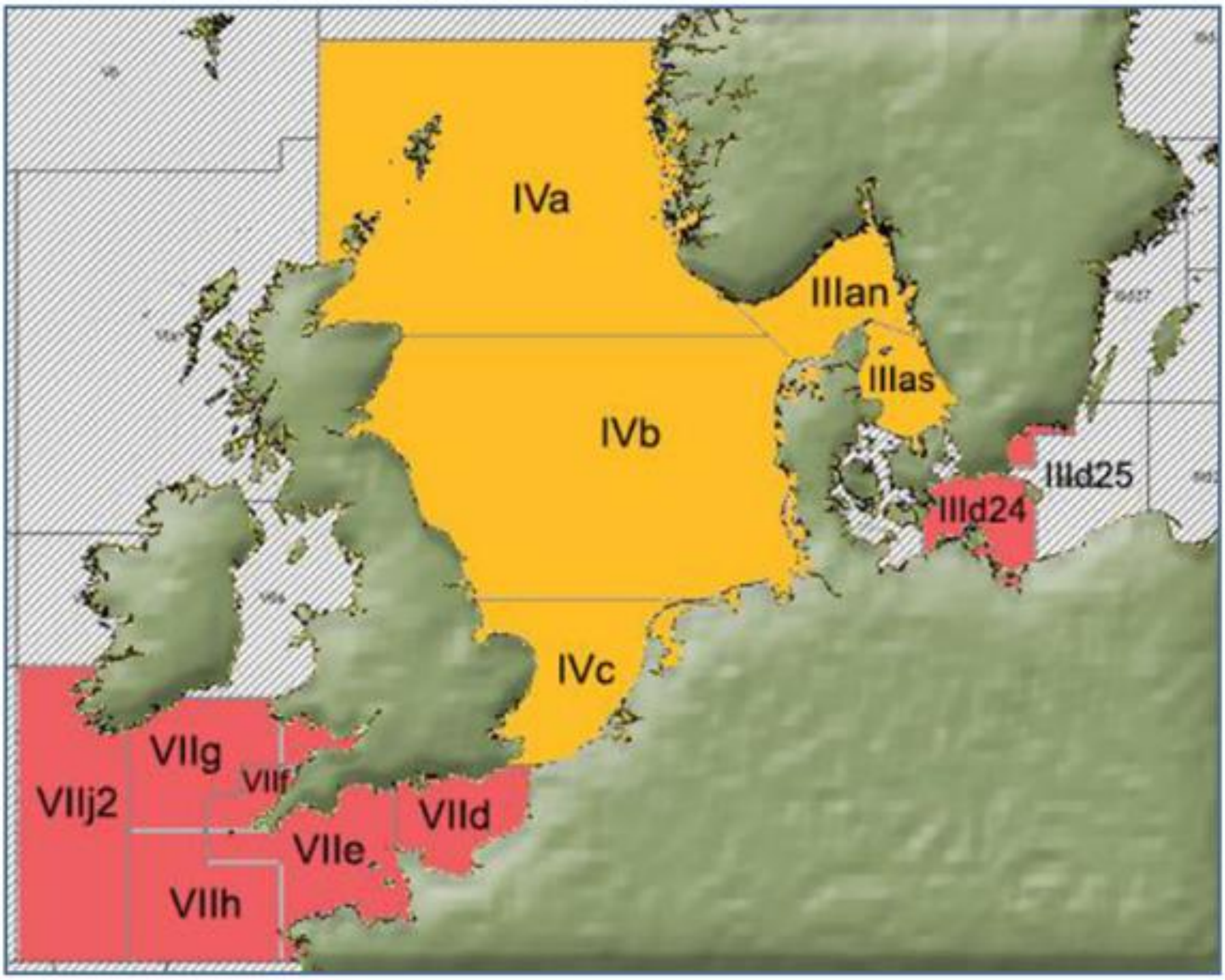

Figure 6.1: Sites where use of acoustic alarms/ pingers on standing fishing nets (e.g. gillnets and entanglement nets) are mandatory for fishing vessels that are 12 meters or longer. For the orange sites the following applies: if the total length does not exceed 400 meters, acoustic alarms (pingers) must be used from August 1st to October 31st. If the mesh size is 220 mm or larger, you must use acoustic alarms (pingers) all year round, regardless of the length. For the red sites the *following applies*: All standing fishing nets, acoustic alarms (pingers) must be used all year round. *(Bek nr. 1495 af 29.06.2021)*.

As shown in Figure 6.1 acoustic alarms are not mandatory at all in some parts of Inner Danish waters (the Belt Sea) and they are only mandatory from August 1st to October 31st in the North Sea, Skagerrak and the northern part of Kattegat. In the western part of the Baltic Sea acoustic alarms are mandatory all year round. Furthermore the demand of acoustic alarms only apply for vessels that are 12 meters or longer. In inshore sites, the proportion of the fleet comprising smaller vessels (<12m) increases, resulting in a sector of the fleet falling below the requirements for monitoring, mitigation and regulation of cetacean bycatch.

As stated in Appendix B, fishing with standing nets are allowed in all of the 35 Danish Natura 2000 sites, but for 4 of the sites appointed to protect reefs and submarine structures made by leaking gases there is a ban on the use of standing fishing gear, including gillnets, at and in a buffer zone around the reef structures (see Appendix B). For all of the 35 Natura 2000 sites, the action programs states that the work to assess the need for establishing any necessary fishing regulations to protect harbour porpoises from bycatch in Danish waters must continue;

therefore any compensation measure seeking to contribute must demonstrate additionality. Many of the Natura 2000 sites appointed for harbour porpoises serve as important fishing grounds in the gillnet fishery. As a compensation measure acoustic alarms could be suggested for all vessels (including vessels smaller than 12 meters) and for the entire Natura 2000 site and not just sites with reef and submarine structures made by leaking gases, to prevent bycatch of harbour porpoise. Since pingers do not affect the catch rates of fish, the fishery will not have any loss in terms of catch opportunities if pingers are implemented on a larger scale. Pingers are, however, the only bycatch mitigation method that will allow gillnet fisheries to continue fishing at the current level within Natura 2000 sites and pingers will thus have the least financial impact on the fishery (compared to closing sites for gillnet fishing).

There are however drawbacks with the use of pingers as, using pingers means that an additional source of noise is introduced into the environment and there is the potential for displacement of harbor porpoises from high-quality foraging habitat due to the intense sounds (Carlstrom, Berggren, & Tregenza, 2009; Kyhn, et al., 2015), which appears contradictory to the purpose of this exercise, which is to compensate for noise and deterrence in the first place. Whether this exclusion will have an appreciable effect on porpoise populations exposed to pingers will depend both on the geographical extent and longevity of such exclusion sites as well as on whether these sites are of critical importance to harbour porpoise populations (Van Best, Kindt-Larsen, Bastardie, Bartolino, & Nabe_Nielsen, 2017). It could therefore be beneficial to advocate the use of pinger types that have the lowest impact radii in order to displace the porpoises as little as possible. If the use of pingers is increased, the impact of habitat exclusion must therefore be considered concurrently with reduction in bycatch.

6.3 Supporting habitats including offshore windfarms as sanctuaries

Habitat loss is one of the main human impacts on coastal ecosystems. In Denmark alone, extraction of rocky material eliminated at least 55 km^2 of rocky reef from 1900–2000 (Helmig, Nielsen, & Petersen, 2020). As a result, vast marine sites have undergone a depletion in hard substrata, turning the seafloor into bare sandy bottom (Airoldi et al., 2008; Støttrup et al., 2014), which may result in declining species diversity and overall biomass (Flávio, Seitz, Eggleston, Svendsen, & Støttrup, 2023; Casabona & Svendsen, 2024).

Restoring reefs could increase the availability of biodiversity and higher fish density and biomass (Folpp, et al., 2020; Wilms, et al., 2020) (Folpp et al., 2020; Wilms et al., 2021), which would lead to more available prey species for harbour porpoise. There are several examples of how restoring reefs increase fish production. In a review where several reef recreations were conducted, the overall conclusion was that hard-bottom habitats generally support higher fish densities than surrounding habitat types, although not all fish species benefit from hard-bottom habitats. Of the commercially important species, cod (*Gadus morhua*) was the most frequently studied species, with enhanced biomass, density, feeding, and spawning on hard-bottom habitats compared to unstructured habitats. Moreover, hard-bottom habitats appear to be of particular importance for spawning of herring (*Clupea harengus*) (Flávio, Seitz, Eggleston, Svendsen, & Støttrup, 2023). Both cod and herring are important prey species for harbour porpoises. In Sønderborg Bay in Flensborg Fjord, two former stone reefs were restored in sites where extraction of rocky material is well documented. The study found positive reef restoration in three species: cod, goldsinny wrasse (*Ctenolabrus rupestris*) and two-spotted goby (*Pomatoschistus flavescens*) (Casabona, et al., 2024). One study demonstrated that reef restoration would benefit the presence of harbour porpoise (Mikkelsen, et al., 2013). In 2008, the nature restoration project Blue Reef re-established 45 000 m^2 of cavernous stony reef at Læsø Trindel in the northern Kattegat, Denmark. The presence of harbour porpoises was studied with passive acoustic monitoring (before and after the reef was re-established) and the results showed that harbour porpoise activity increased significantly at Læsø Trindel reef after the reconstruction in 2008 (Mikkelsen, et al., 2013).

Therefore in some Natura 2000 sites with stone reef structures or former stone reef structures, creation or re-creation of stone reefs could be a relevant compensation measure.

This measure could also be used in offshore wind farm sites, to generate marine protected sites with hard-bottom substrate. The introduction of hard-bottom substrates, in the form of foundations, will create changes to the habitat. It is expected that most of the development area will remain unaffected. Furthermore, the OWF area could be a "sanctuary" for harbour porpoise. The hard-bottom substrate surrounding the foundations (scour protection) may form the basis of artificial reef structures where sessile organisms can settle. Additionally, young fish are attracted by the shelter of the artificial reef structures. Furthermore, the exclusion or regulation and limitation of fishery would also support the enhancement of the young fish population (Gutow, et al., 2014). Taking both effects in to account the overall presence of prey items will probably increase, attracting opportunistic feeders like harbour porpoises. In the Netherlands, there are studies of porpoises in two wind farm areas. In one area, Egmond aan Zee (Scheidat et al., 2011), the occurrence of porpoises increased during the operational phase compared to before the OWF was constructed. Scheidat et al. (2011) suggested two reasons for this increase: 1) all navigation was prohibited in the wind farm area, including a 500 m buffer zone. This prevented trawling activity, and as a likely result, both the number of fish species and individuals in the wind farm area increased (ter Hofstede, 2008), providing more prey and attracting porpoises to the area, 2) a 'shelter effect', where all ship traffic disappeared in an otherwise heavily trafficked and fished area, making the wind farm area quieter. Because the surrounding areas were unattractive, the wind farm area became attractive to porpoises (Scheidat et al., 2011). In a nearby wind farm in the Netherlands, no difference was found between baseline and operation (Petel et al., 2012). It was discussed that any positive effects occurred before the baseline began, as the wind farm area is close to Egmond aan Zee, from where positive effects were described.

6.4 Reduction of underwater noise from commercial and recreational vessels

Reduction of underwater noise from both commercial and recreational vessels could result in reduced disturbance of harbour porpoise, with most benefit to the animals likely to arise from a reduction in underwater noise within Natura 2000 sites, especially sites subject to significant ship traffic. For example, key sites could be sites were the main shipping lanes passing through the Natura 2000 site (Figure 6.2) or Natura 2000 sites close to the coast where a significant contribution to the underwater noise comes from recreational vessels.

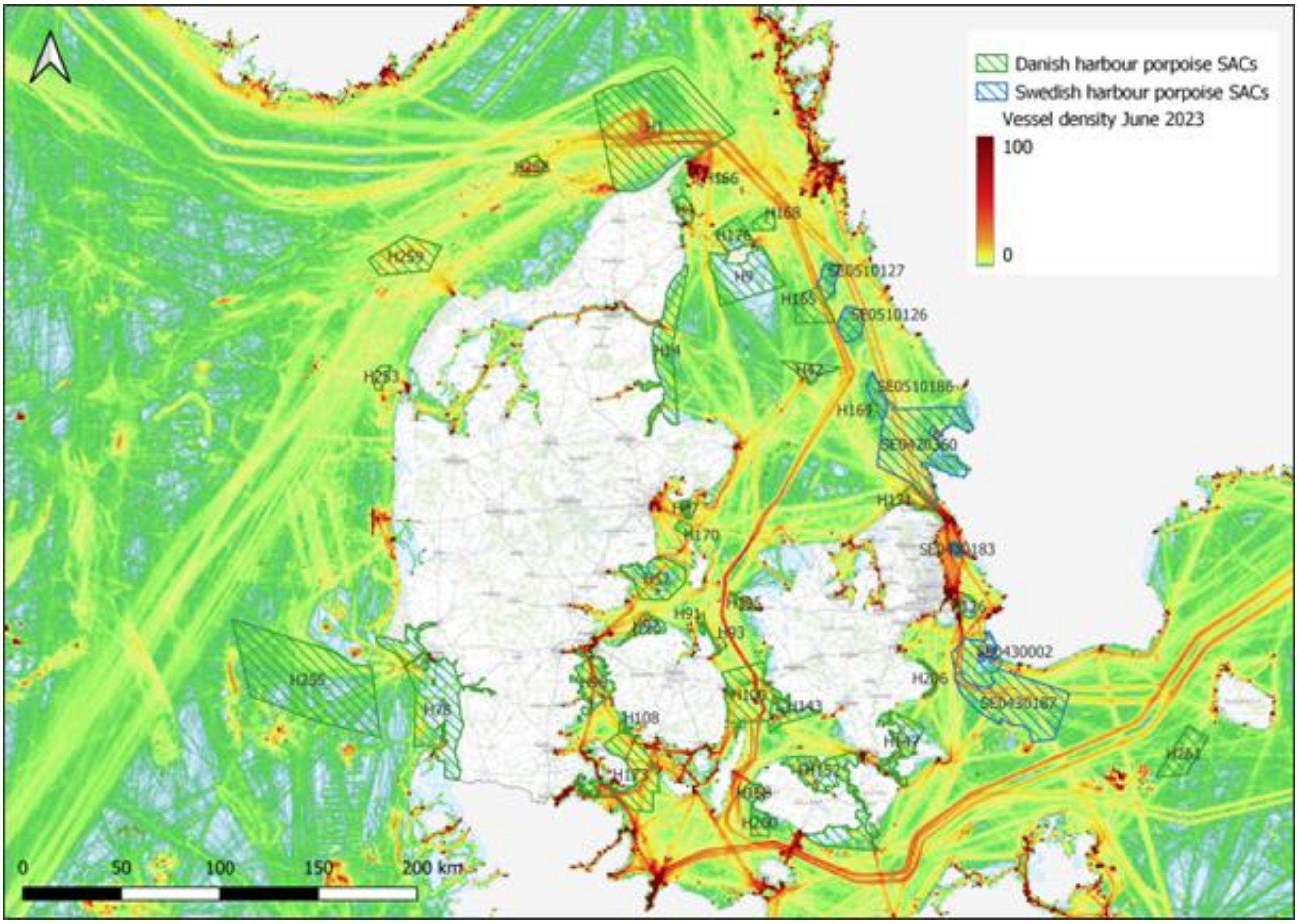

Figure 6.2: Main shipping lanes in Danish waters and N2000 sites.

A recent study from 2023 modelled the effects of how reducing vessel noise through vessel slowdowns and technological modification can reduce impact on marine mammals (Findlay, Doñate, Tougaard, Johnson, & Madsen, 2023). They found that the size of the area exposed to ship noise reduced markedly with moderate source-level reductions that can be achieved with small reductions in vessel speed. For example, a 20 % reduction in vessel speed reduced the underwater noise by 6 dB (a reduction corresponding to a halving). Furthermore, they found that despite the longer time that a slower vessel takes to pass an animal, slowdowns reduced the impact on marine mammals (Findlay, Doñate, Tougaard, Johnson, & Madsen, 2023). See Figure 6.3 for a demonstration of the impact on radiated vessel noise by reduction of vessel speed (source level).

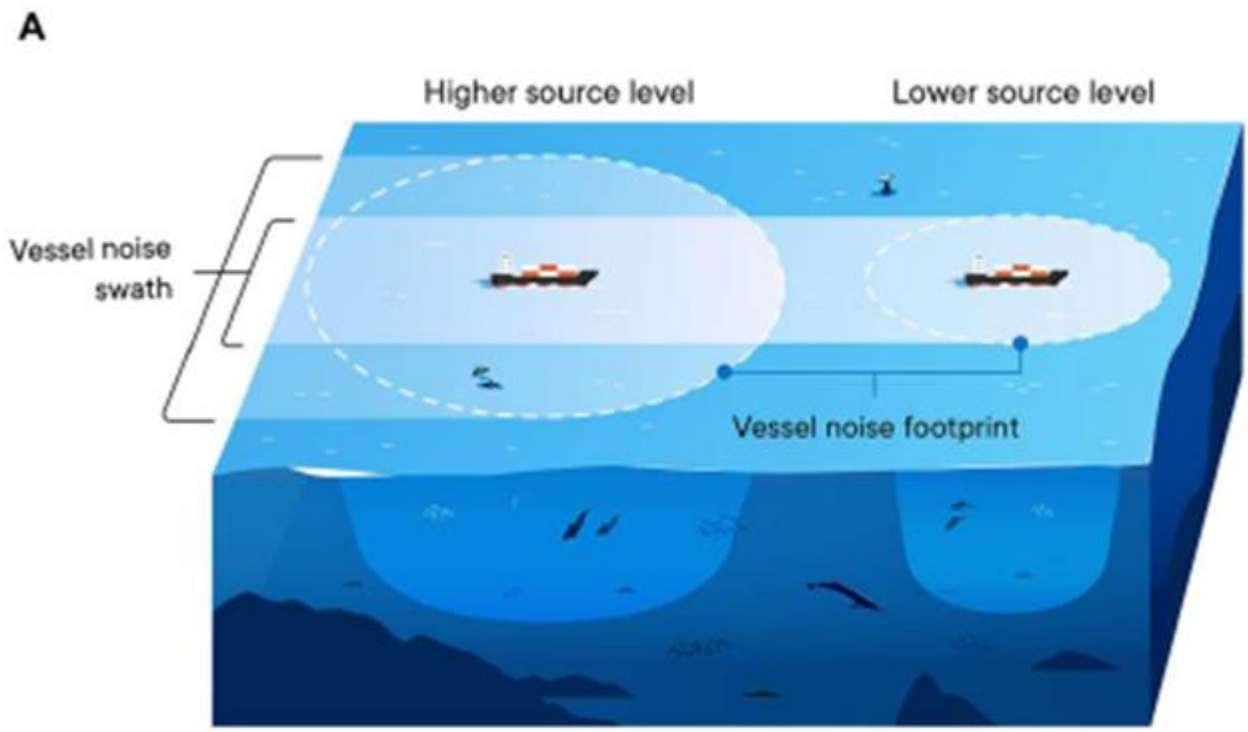

Figure 6.3: Illustration showing the spatial reduction in radiated underwater noise by reduction in vessel speed from two identical ships (Findlay, Doñate, Tougaard, Johnson, & Madsen, 2023).

There are few studies addressing the impact on harbour porpoises from recreational boats. A recent study used drone video footage to quantify how harbour porpoise responded to an approaching boat at a speed of either 10 or 20 knots (Hao, et al., 2024). Porpoises were more likely to move further away from the path of the boat when approached at 10 knots, but not when approached at 20 knots. In contrast, they swam faster when approached at 20 knots, but not when approached at 10 knots. The received sound level recorded did not depend on how fast the boat approached, suggesting that differences in porpoise responses were related to the speed of the approaching boat rather than to sound intensity. In addition, porpoises generally reacted within close proximity (<200 m) to the approaching boat and quickly (<50 s) resumed their natural behaviour once the boat had passed, indicating that the direct impact of small vessels on porpoise behaviour was most likely small. Nevertheless, repeated exposure to noise from small vessels may influence porpoises' activity or energy budget, and cause them to relocate from disturbed sites (Hao, et al., 2024). Another Danish study used satellite data to identify sites where re-creational boats overlap with harbour porpoise presence and thus where the animals may be affected by boat noise. They found that harbour porpoises' main high-density habitats overlapped with several coastal sites close to marinas (Figure 6.4), and porpoises were thus likely to be negatively influenced by boat noise in those sites (Hao & Nabe-Nielsen, 2023).

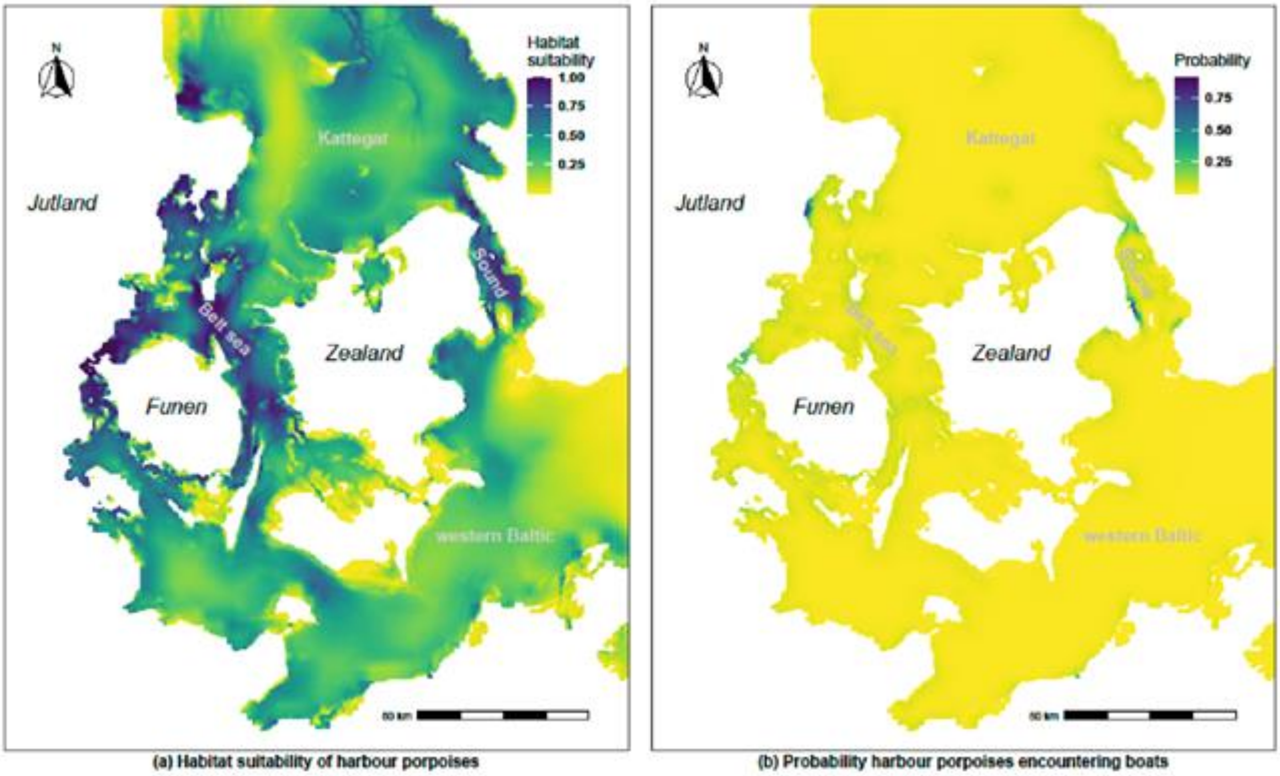

Figure 6.4: Predicted habitat suitability of harbour porpoises in the summer between 2007 and 2015 and the predicted probability of observing both boats and porpoises in the same site (Hao & Nabe-Nielsen, 2023).

However, when re-routing vessel traffic through the Danish Straits, porpoise data loggers were deployed to see if their presence changed as the vessel noise changed. The rerouting of the major shipping lane through important harbour porpoise habitat caused no detectable change in annual occurrence or foraging patterns of harbour porpoises (Owen, 2024). This does however, not equal a lack of disturbance, as the data loggers could not show whether animals changed behaviour following exposure, but no detectable change in presence was observed.

Therefore, in some Natura 2000 sites a reduction in vessel noise from either commercial or recreational or both could be a relevant compensation measure. A reduction in underwater noise to create "quiet" zones will also depend on reduction of underwater noise from the shipping traffic. Enforcement should be considered carefully before enacted, as this would likely require legislation by government to control the activities undertaken by another industry (with the associated risk of conflict between industries, not least because a reduction in speed is likely to result in increased travel times and associated costs to the vessel owner).

6.5 Marine SAC designation or extension

The designation of additional sites has also been proposed as a compensatory measure as European guidance indicates that it may be possible to compensate for impacts to designated features through the inclusion of additional sites within the overall SAC list. It should be noted, however, that there is currently no formal process by which this might be progressed. However, examples do exist such as the habitat compensation delivered by the Port of Rotterdam for Maasvlakte 2[2] and potential compensation measures explored by offshore wind farms in the UK specifically in relation to benthic habitat (e.g. the proposed extension to an existing designated site by Outer Dowsing[3]).

In addition, the identification of a suitable site (that meets the required criteria), designation of the site, and implementation of subsequent management measures to deliver an observable benefit would require government intervention and is likely to have a significant timescale to deliver.

6.6 Removal of ghost nets and marine litter

Removal of ghost nets have been given some attention lately. Ghost nets will in many cases continue to fish for the targeted and non-targeted species including marine mammals. In 2021 it was estimated that there are 49.000 net pieces in Danish waters, (Pedersen, et al., 2021). It is unknown how many harbour porpoises are bycaught in ghost fishing gear per year. However in the case of endangered or threatened species/populations e.g. the Baltic Proper population, even low-level entanglement may affect populations directly and so be an obstacle to population recovery (Brown, Macfadyen, Huntington, & Tumilty, 2005). Today, ghost nets and other marine debris are primarily removed by private individuals or organizations that have applied for and received funding for the work. For this purpose, 12 million DKK was allocated in 2023 and 2024, primarily from EU funds[4] .

It is likely that the number of lost nets from professional fishers have and will decrease with the decreasing fleet of both gillnetters and trawlers. The number of fishing vessels in Denmark have decreased almost 60% during the last 25 years from a total of 4,830 vessels in 1996 to 1,998 in 2020. The largest reduction is found among the number of trawlers which reduced close to 1/3 in number of the 1996 level, whereas the number of gillnetters has been halved. The amount of lost fishing gear has been reduced in later years partly due to reductions in fishing fleets and partly due to improvement of the weather forecasts and the navigation technology (Pedersen, et al., 2021). However, in Denmark the number of new and maybe unexperienced recreational fishermen increased by 13% from 28,352 in 2019 to 32,686 in 2020 (4), which potentially could increase the risk of gear loss (Pedersen, et al., 2021).

For marine SACs, where ghost nets are a problem, removal of ghost nets could be a compensation measure. In the Baltic Sea the World Wildlife Foundation (WWF) have started a project to map the occurrence of ghost nets called Ghost Gear Mapping in Swedish Waters with focus on the Natura 2000 area Hoburgs bank och Midsjöbankarna (WWF, 2024). However, during the first expedition in 2024 no ghost nets were found in the scanned sites, at Midsjöbankarna within the SAC Hoburgs bank och Midsjöbankarna which might indicate that ghost nets are not a large problem in that site.

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[3] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010130/EN010130-000546-7.6.3%20Without%20Prejudice%20Benthic%20Compensation%20Evidence%20Base%20and%20Road%20Map.pdf

[4] https://oceanplasticforum.dk/2023/08/01/new-project-collection-of-ghost-nets-in-the-marine-nature-reserve-oresund/

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