From:	Vicki James
To:	Norfolk Vanguard
Subject:	Norfolk Vanguard Second Written Questions
Date:	11 March 2019 08:49:46
Attachments:	image001.png image002.png image003.png image004.png image005.png image006.png image007.png image008.png image009.png Wright and Cosentino - 2015 - JNCC guidelines for minimising the risk of....pdf JNCC_NoiseSAC_Workshop Report_220317.pdf WDC_NV_PINs_SecondWrittenQuestions_March2019.pdf

Dear Sir/ Madam,

Please find attached Whale and Dolphin Conservation (WDC) response to the Examining Authority's second written questions, along with the relevant papers requested.

If you have any queries, please let me know.

Regards.

Vicki

Vicki James
Policy officer

Telephone: +44 (0)1249 449 500

WDC, Whale and Dolphin Conservation
Brookfield House
38 St Paul Street
Chippenham
Wiltshire
SN15 1LJ
United Kingdom
whales.org

WDC WHALE AND DOLPHIN CONSERVATION

30 PROTECTING WHALES AND DOLPHINS FOR OVER 30 YEARS

Registered with FUNDRAISING REGULATOR

National Infrastructure Planning
Temple Quay House
2 The Square
Bristol,
BS1 6PN

By Email: NorfolkVanguard@pins.gsi.gov.uk

PINS Reference: EN010079

Our Reference: 20011285

11th March 2019

Dear Sir/ Madam,

Norfolk Vanguard Offshore Wind Farm. WDC's Response to The Examining Authority's Second Written Questions and Requests for Information.

The table below sets out WDCs responses to the Examining Authority's First Written Questions and Requests for Information, issued 27th February 2019, for Norfolk Vanguard offshore wind farm.

We are happy to meet to discuss any of these issues further.

Yours faithfully,

[redacted]

Vicki James.
Policy Officer.

WDC, Brookfield House, 38 St Paul Street, Chippenham, Wiltshire SN15 1LJ
T +44 (0)1249 449 500 F +44 (0)1249 449 501 E info@whales.org W whales.org

1.7	Are you satisfied that long-term ecological monitoring during the operational phase of the project is adequately secured in the dDCO? *WDC Response* Whilst there is a commitment in the dDCO to monitoring during the operational phase, there is little detail on the methodology that will be used to undertake this. Without additional detailed information, it impossible to conclude if this will be adequate.
4.8	In your Written Representations [REP1-123 and REP1-124 respectively], and also TWT at the offshore environmental matters Issue Specific Hearing 2 (ISH2) [EV-009 and EV-010] and in its Post Hearing Submission [REP3-063], you consider that an approach of setting noise limits should be adopted and that you do not support the current Statutory Nature Conservation Bodies (SNCB) advice in this regard. The ExA notes the two reports that TWT has cited in [REP3-063] with attached hyperlinks, but please provide any further relevant scientific evidence or justification that you consider casts doubt on the existing SNCB approach. Also, if you are able to, please provide a copy of the statement that was released on 7 February 2019 that TWT has referred to in [REP3-063]. *WDC Response* Papers sent with this response which highlight the concerns over the SNCB approach. Also the workshop reports where the threshold approach was proposed and discussed at a joint stakeholder workshop in 2016, and the approach was objected to by both NGOs, industry and regulators. Additionally in the current Review of Consents, being undertaken by The Department for Business, Energy and Industrial Strategy (BEIS), it is acknowledged the proposed approach by the SNCBs has not been agreed upon.
4.9	At the offshore environmental matters Issue Specific Hearing 2 (ISH2) [EV-009 and EV-010] the Applicant stated that other offshore construction techniques, such as vibration or downward impulses, were being considered. At present Condition 14(f) of Schedules 9 and 10 and Condition 9(f) of Schedules 11 and 12 of the dDCO only requires the submission of a Marine Mammal Mitigation Protocol (MMMP) in the event that driven or part-driven piles are proposed to be used. Furthermore, Conditions 14(m) of Schedules 9 and 10 and 9(l) of Schedules 11 and 12 contain similar wording in relation to the submission of a Site Integrity Plan (SIP). In the event that the Applicant proposed to utilise any other construction techniques, instead of driven or part-driven piling, do you consider that a MMMP and SIP should still be submitted? Please justify your answer. *WDC Response* Due to the location of Norfolk Vanguard lying directly within the SNS SCI, in both summer and winter habitat for harbour porpoises with Norfolk Vanguard West overlapping the year round area (JNCC, 2017, 2016), we strongly recommend that both MMMP and SIP will still need to be submitted to ensure no Adverse Effect on Integrity (AEoI) of the site and the harbour porpoise population it supports. All cetaceans are European Protected Species (EPS), and the requirement to understand and mitigate impacts to ensure strict protection of EPS, including all cetacean species, remains.

	Whilst the impacts from pile driving remain our primary concern, other construction techniques will result in significantly different impacts on cetaceans and the harbour porpoise population supported by the Southern North Sea SCI (SNS SCI), therefore no matter the construction techniques used, MMMPs and SIPS will still be required.
4.10	In your Written Representation [REP1-124] you indicate that you do not wish to see any pile driving, but you also raise concerns about the potential impact on prey species should gravity-based foundations be used. Which of these construction techniques do you consider would have the more significant effects in the long term, and overall which would you prefer to see utilised? *WDC Response* The impacts from pile driving are our primary concern. Research has shown the impacts from piling activities during construction to have significant impacts on harbour porpoise. Less is known about gravity-based foundations, but there are concerns about changes to the sea bed and therefore prey species. We continue to recommend that foundations requiring pile driving are not used, and would prefer to see gravity foundation instead.
4.11	A maximum hammer energy of 5,000kJ has now been specified in condition 14(1)(n) of Schedules 9 and 10 of the dDCO [REP2-017]. However, please comment on whether or not there would be any benefits in having a range of maximum hammer energies being specified in the dDCO, for example the 2,700kJ figure that relates to the worst-case scenario for a 9MW pin pile structure? *WDC Response* WDC can see the benefit of having maximum hammer energies specified in the dDCO, for the different scenarios. This would help ensure that the worst-case scenarios modelled by the applicant aren't breached, which would results in greater impacts than predicted. We agree that these maximum hammer energies should be based on the worst-case scenarios as modelled by the applicant.
23.102	A conclusion of no AEOI on the SNS cSAC relies on appropriate mitigation measures being secured in the final Site Integrity Plan and Marine Mammal Mitigation Protocol. However, these mitigation measures are not yet specified and there remains some doubt over how effective certain measures, such as soft start piling, actually are. Please comment further on this matter. *WDC Response* Whilst WDC agree with the Site Integrity Plan (SIP) and Marine Mammal Mitigation Protocol (MMMP) in principle, there is currently a lack of guidance, based on the latest scientific information, on how to undertake these plans, particularly for SIPs which are relatively new. As a result these documents contain very little detail or assessment and have not included the latest research, they are little more than a commitment to use mitigation methods. As a result in their current form the plans cannot remove all reasonable scientific doubt as to the effects of the projects on cetaceans or ensure no Adverse Effect on Integrity (AEoI) on the SNS SCI.

WHALE AND DOLPHIN CONSERVATION

WDC

30 YEARS OF PROTECTING WHALES AND DOLPHINS

	To ensure the SIP and MMMPs are fit-for–purpose there needs to be guidance from SNCBs on what to include. We recommend this should include a commitment to proven mitigation methods and modelling of likely mitigation measures to be included to ensure that these plans can reduce uncertainty of the impact of offshore wind farm construction. There are a number of studies demonstrating the benefits of mitigation measures (Brandt et al., 2018; Dähne et al., 2017; Nehls et al., 2016; WWF, 2016). Current embedded mitigation measures included in JNCC guidelines have not been proven in studies, and have been widely criticised as arbitrary and with a lack of supportive evidence (Wright and Cosentino, 2015). Additionally the guidelines have not been updated for a number of years and therefore do not include the latest and increasing body of scientific data of the impacts of noise on marine mammals (Wright and Cosentino, 2015). We would also recommend that there also needs to be a robust assessment strategy that includes strategic monitoring to ground-truth the modelling results and verify if the mitigation is successful.

References

Brandt, M., Dragon, A., Diederichs, A., Bellmann, M., Wahl, V., Piper, W., Nabe-Nielsen, J., Nehls, G., 2018. Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Mar. Ecol. Prog. Ser. 596, 213–232. https://doi.org/10.3354/meps12560

Dähne, M., Tougaard, J., Carstensen, J., Rose, A., Nabe-Nielsen, J., 2017. Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. Mar. Ecol. Prog. Ser. 580, 221–237. https://doi.org/10.3354/meps12257

Nehls, G., Rose, A., Diederichs, A., Bellmann, M., Pehlke, H., 2016. Noise Mitigation During Pile Driving Efficiently Reduces Disturbance of Marine Mammals, in: Popper, A.N., Hawkins, A. (Eds.), The Effects of Noise on Aquatic Life II. Springer New York, New York, NY, pp. 755–762. https://doi.org/10.1007/978-1-4939-2981-8_92

Wright, A.J., Cosentino, A.M., 2015. JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better. Mar. Pollut. Bull. 100, 231–239. https://doi.org/10.1016/j.marpolbul.2015.08.045

WWF, 2016. A Positive Future for Porpoises and Renewables. Assessing the Benefits of Noise Reduction to Harbour Porpoises During Offshore Wind Farm Construction.

ARTICLE IN PRESS
MPB-07151; No of Pages 9
Marine Pollution Bulletin xxx (2015) xxx–xxx
Contents lists available at ScienceDirect
Marine Pollution Bulletin
journal homepage: www.elsevier.com/locate/marpolbul

JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better

Andrew J. Wright [a,*], A. Mel Cosentino [b]

[a] Department of Environmental Science and Policy, George Mason University, 4400 University Drive, Fairfax, VA 22030, USA
[b] Wild Earth Foundation, Av de las Ballenas 9500, Puerto Pirámides, Península Valdés, Chubut, Argentina

ARTICLE INFO

Article history:
Received 10 January 2015
Received in revised form 30 August 2015
Accepted 31 August 2015
Available online xxxx

Keywords:
Seismic survey guidelines
Mitigation measures
Marine mammal
Impact
Noise

ABSTRACT

The U.K.'s Joint Nature Conservation Committee 1998 guidelines for minimising acoustic impacts from seismic surveys on marine mammals were the first of their kind. Covering both planning and operations, they included various measures for reducing the potential for damaging hearing – an appropriate focus at the time. Since introduction, the guidelines have been criticised for, among other things: the arbitrarily-sized safety zones; the lack of shut-down provisions; the use of mitigation measures that introduce more noise into the environment (e.g., soft-starts); inadequate observer training; and the lack of standardised data collection protocols. Despite the concerns, the guidelines have remained largely unchanged. Moreover, increasing scientific recognition of the scope and magnitude of non-injurious impacts of sound on marine life has become much more widespread since the last revisions in 2010. Accordingly, here we present feasible and realistic recommendations for such improvements, in light of the current state of knowledge.

1. Introduction

Man-made noise has the potential to impact marine mammals and other species by disrupting essential behaviours, such as communication and foraging (e.g., Hildebrand, 2005; Jasny et al., 2005; Nowacek et al., 2007; NRC, 1994, 2000, 2003, 2005; Richardson et al., 1995; Southall et al., 2007; U.S. Marine Mammal Commission, MMC, 2007; Weilgart, 2007). One of the most regulated sources of noise is the seismic survey conducted by the oil and gas industry and (to a much lesser extent) geological surveys (see Simmonds et al., 2014). These surveys employ airguns that produce sharp, loud sounds that cannot be precisely controlled and include energy at frequencies as high as 22 kHz, (e.g., Goold and Coates, 2006; Goold and Fish, 1998; Hermannsen et al., 2015). The majority of the noise energy, however, is at frequencies below 100 or 200 Hz (Goold and Fish, 1998; Hermannsen et al., 2015) that may propagate over distances as large as 4,000 km (e.g., Nieukirk et al., 2004, 2012) and are used heavily by baleen whales in their own sounds (e.g., Nieukirk et al., 2004; Stafford et al., 1999). While lower frequencies are functional for the surveys (e.g., below 200Hz; OGP and IAGC, 2008), the noise at higher frequencies is unnecessary.

As of 2013 there were 142 seismic survey vessels worldwide, with increases likely in numbers and capacity-per-vessel (Kliewer, 2013). A large proportion of these vessels will be simultaneously active on surveys that may persist for months and extend over huge areas (e.g. 35,000-70,000 sq. km; Clark and Gagnon, 2006). As a result, these typically coastal surveys can be detected above natural background noise levels on 80-95 % of days at some locations on the Mid-Atlantic Ridge (Nieukirk et al., 2012). The cumulative exposure of these surveys for marine life collectively is enormous.

Exposure to seismic survey sounds can lead to avoidance, startle responses, vocalisation changes, and the alteration of dive and respiration patterns (e.g., Gordon et al., 2004). However, airgun exposures can also lead directly to temporary or permanent threshold shift (TTS or PTS; see Southall et al., 2007). PTS has often, but perhaps not appropriately, been used to define the onset of 'injury' by managers (see Southall et al., 2007 and Tougaard et al., 2014).

To address these issues, the Joint Nature Conservation Committee (JNCC) became the first regulatory body in the world to issue guidelines for minimising impacts of noise from seismic surveys on marine mammals (JNCC, 1998). However, the "mitigation measures recommended in the existing guidelines are more relevant to the prevention of injury rather than disturbance" (JNCC, 2010). This focus ran contrary to the fact that the guidelines are titled, "Guidelines for *Minimising Acoustic Disturbance* to Marine Mammals from Seismic Surveys" (emphasis added). Nevertheless, these guidelines, which became statutory in the UK in 2001, filled a policy vacuum and have since been adopted, in whole or in part, by several other management agencies around the world (e.g., Brazil, Aruba, Suriname: Compton et al., 2008; Mama CoCo SEA Project, 2015; also voluntarily used by industry in areas without guidelines; Weir and Dolman, 2007). Any company that wishes to conduct seismic surveys in UK continental shelf (UKCS) waters must

* Corresponding author.
E-mail address: marinebrit@gmail.com (A.J. Wright).

http://dx.doi.org/10.1016/j.marpolbul.2015.08.045
0025-326X/

apply for consent from the Department of Energy and Climate Change (DECC), with adherence to the guidelines being a standard condition.

Mitigation measures required by the 1998 JNCC guidelines were limited and, despite refinements, remain largely unchanged (JNCC, 2010). For example, the training required of visual observers has become formalised into a JNCC-approved course; and more in-depth discussions of PAM and ramp-ups were included. However, the most notable addition was the recognition that visual observers need to be fresh to be effective, with advice that "two marine mammal observers should be used when daylight hours exceed approximately 12 hours per day…or the survey is in an area considered particularly important for marine mammals." However, despite wide acknowledgement of the limitations of the JNCC guidelines and mitigation measures (e.g., Barlow and Gisiner, 2006; Lubchenco, 2010; Nowacek et al., 2013; Parente and de Araújo, 2011; Parsons et al., 2009; U.K. Department of Trade and Industry, DTI, 2002; Weir and Dolman, 2007), there is still no requirement to cease operations (or 'shutdown') should marine mammals be detected within the mitigation zone during operation (JNCC, 2010). Here we re-assess the merits of the JNCC guidelines in light of the current state of knowledge.

2. Planning stages

Adequate planning is critical to reduce or eliminate the impact on marine mammals. Environmental considerations throughout the lifecycle of the project should be included in the planning process as early as possible to facilitate informed decision-making about the best locations for seismic activities (e.g., Nowacek et al., 2013). Avoidance of areas where marine mammals are known to occur should be prioritised, but if it is ultimately not possible, efforts should be made to avoid surveys at times of particular importance, such as breeding periods. Identifying hotspots of marine mammal abundance and those periods when animals are particularly sensitive, however, requires 'baseline' data. Both abundance and habitat use are subject to inter-annual variability, thus a pre-activity record of three or more years in length is preferable. Additionally, planning should be made for a gradual phase-in of an activity in situations or locations when the impacts are especially uncertain, which would inform management prior to escalation at each step.

While the JNCC guidelines have always referred to the need for adequate planning, they have typically fallen short of these goals. For example, the 1998 version (JNCC, 1998) simply stated that seismic surveys projects should, at the planning stages: discuss the merits of the design of any monitoring programs; plan the timing of their surveys to reduce the likelihood of encounters with marine mammals; seek to reduce the unnecessary high frequency noise; and, in areas of importance to marine mammals (as was to be determined "in consultation with the JNCC") seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers (MMOs) on board the seismic survey vessel (preferably experienced cetacean biologists, but at a minimum it was "recommended that observers should have attended an appropriate training course").

The 2010 version of these guidelines (JNCC, 2010) added to the planning stages a requirement to use the lowest practicable power levels necessary to achieve the survey objectives. However, even here there is no specific mention of complete avoidance of particularly important areas, although it could be argued that this might be covered by the additional precautions that JNCC can impose on a case-by-case basis. (It should also be noted, however, that advice regarding wider risk assessments are present in the joint JNCC, Natural England and Countryside Council for Wales guidelines for the Protection of Marine European Protected Species from Injury and Disturbance, although these seemingly remain in draft form: JNCC et al., 2010).

3. Mitigation measures

The JNCC guidelines include a number of mitigation measures designed to reduce the impact of seismic surveys on marine mammals. However, they essentially condense down to two basic elements: maintenance of a pre-survey safety zone and mitigation sources.

3.1. Safety zones: size and function

While many guidelines around the world have implemented a safety zone throughout the duration of a seismic survey (e.g., Kyhn et al., 2011), the JNCC guidelines only require the maintenance of a pre-survey mitigation zone (JNCC, 2010). An area of 500m radius from the centre of the airgun array must be scanned for 30 min before the commencement of the soft-start and determined to be clear of marine mammals (see below). In waters deeper than 200 m the duration of the pre-survey visual scan is extended to 60 minutes to account for long, deep diving species (JNCC, 2010). If any marine mammal is detected the soft-start is to be delayed until 20 min following the last sighting (JNCC, 2010).

One major issue with these requirements is immediately apparent in cases where the airgun array is quite large, resulting in the mitigation zone being mostly, if not entirely, within the array. As a consequence, an animal that is 500m away from the centre of the array can, in fact, be only few metres away from the nearest airgun, potentially suffering irreversible hearing damage.

This highlights the fact that the arbitrary size of the JNCC exclusion zone gives little consideration to the actual source levels or the sensitivity of the species involved (Weir and Dolman, 2007). Elsewhere, only California and Russia (around Sakhalin Island) are known to select an operation-based, site-specific safety zone (Compton et al., 2008; Nowacek et al., 2013; Weir and Dolman, 2007). To be effective, exclusion zones should be based on scientific evidence and consider the species that are likely to occur in the area, as some species are more sensitive to noise than others (e.g., McCarthy et al., 2011; Miller, 2011; Miller et al., 2012; Moretti et al., 2010; Pirotta et al., 2012; Popov et al., 2011a; Tyack et al.,, 2011). For operational simplicity, zone size should be appropriate for the most sensitive species. This is further reinforced by the discovery that longer noise exposures require longer periods of hearing recovery following a temporal threshold shift (TTS) (e.g., Popov et al., 2011b).

The next concern is that the JNCC exclusion zone is only in place prior to the commencement of the survey, which in itself precludes the use of shut downs (JNCC, 2010). The utility of this relies entirely on the assumptions that an animal exposed to the approaching source will experience gradually increasing sound levels, in the same manner as a soft-start, and that the animal will react appropriately by moving away. However, sound levels do not gradually rise with increasing distance from a source and animals may not react logically (see Pre-survey mitigation sources: Soft-starts). As a consequence, there are no guarantees that an animal will not come close enough to be exposed at dangerous levels. Accordingly, many other countries mandate shutdowns, thus also requiring the maintenance of the safety zone during operations (e.g., Australia, Brazil, Colombia, Greenland, New Zealand; DOC, 2013; Kyhn et al., 2011; MaMa CoCo SEA Project., 2015).

Finally, the JNCC does not even actually mandate the pre-survey scans. Instead, operations should "whenever possible" begin producing noise during hours of daylight, so that a pre-activity visual survey can be completed with the greatest level of confidence (JNCC, 2010).

3.2. Safety zones: Marine Mammal Observers (MMOs)

Marine mammal observers (MMOs) are trained individuals whose main role under JNCC guidelines (2010) is to search for marine mammals within a mitigation zone before seismic activity starts. The role of an MMO is "purely advisory," as they can only *recommend* a

Please cite this article as: Wright, A.J., Cosentino, A.M., JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better, Marine Pollution Bulletin (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.08.045

delay in the commencement of the seismic activity if marine mammals are detected (JNCC, 2010). Additionally, MMOs "advise the crew on the procedures set out in the JNCC guidelines and provide advice to ensure that the survey programme is undertaken in accordance with the guidelines" as crew members are not obliged to have knowledge of the guidelines, and it is not required that a copy be available onboard (JNCC, 2010). Consequently, compliance with the guidelines has its foundation in the presentation and the MMOs' judgement calls (e.g., distance to a sighted cetacean) during the survey. This effectively makes them responsible for compliance as well as monitoring, but without the power to enforce the provisions of the guidelines in real time.

One of the main problems for MMOs with regard to monitoring a safety zone is determining the distance between the animal(s) and the centre of the airgun array. JNCC guidelines recommend the use of a "range finding stick" and an equation to estimate where 500 m is (JNCC, 2010). The most obvious issue with this method is that the MMO is not placed in the centre of the array. Also, the MMO must discard the binoculars they use to search for marine mammals before finding the animal(s) again with the naked eye to use the stick. The consequences of this flawed system are not trivial. Detecting a marine mammal at sea is in itself a difficult task (see below) and this method introduces unnecessary errors and associated non-compliance. Using graduated binoculars would improve the situation, although MMOs are still not situated in the centre of the array. Thus, the mitigation zone boundary is subjective and imprecise.

Further issues arise when the required distances are beyond the visual range of the observers, when weather, darkness or sea states compromise their ability to spot marine mammals (e.g., Barlow and Gisner, 2006; Harwood and Joynt, 2009; Parente and de Araújo, 2011; Teilmann, 2003), or when observers have been on duty for too long, reducing their effectiveness (e.g., Gill et al., 2012; Harwood and Joynt, 2009). Additionally, as MMOs are required to provide their own equipment, magnification and binocular quality will vary, as will detection distances and rates.

The level of experience for observers is critical to their ability to detect marine mammals (e.g., Barlow et al., 2006). Even with experienced, fresh observers and perfect conditions visual surveys are imperfect as marine mammals spend most of their time underwater and it is thus entirely possible to miss an animal that is on the survey line (e.g., Thomsen et al., 2005). Despite this, JNCC-approved MMO training course only lasts between one and three days, and attendees are not required to have even seen a marine mammal previously. Training to identify and monitor marine mammals consists of visual aids (e.g., slide presentations and drawings: Pers. Obs.) and a field trip is not always included. In some deference to this, these inexperienced MMOs are not allowed to work in hotspot areas in the UK, however, they can be hired to work where marine mammals are less abundant, to become 'experienced' MMOs (JNCC, 2010).

The U.S. Navy are conducting Lookout Effectiveness (LOE) studies, to compare the relative merits of trained and experienced MMOs against Navy personnel that have gone through the Navy training program (see Alexander, 2009). Raw data from one region (Watwood et al., 2012) suggest that the Navy personnel are not nearly as effective as more experienced MMOs. Elsewhere the U.S. Navy themselves note that, "Results are preliminary, but indicate that the U.S. Navy LOs are not completely effective, and that additional data are needed for more in-depth evaluation" (U.S. Department of the Navy, DoN, 2013).

In short, it is likely that many marine mammals (especially those species with low-profile surfacings and small or absent blows) may stray unseen into the safety zone. This has implications for the level of protection offered by the JNCC pre-operation safety zone, although it becomes a much bigger issue for safety zones maintained throughout operation. Finally, it must be acknowledged that reaching high levels of compliance does not necessarily mean achieving conservation goals. Undetected animals and those judged to be further away from the source than they actually are will suffer the various consequences of exposure to high/dangerous noise levels in much the same way as if the guidelines had not been implemented at all (i.e., the same effects as non-compliance).

3.3. Safety zones: Passive Acoustic Monitoring (PAM)

The JNCC guidelines have always encouraged the use of PAM to supplement visual surveys in maintaining the safety zone (JNCC, 1998, 2010). Incoming sounds are typically assessed by human operators with the assistance of one of several software products, but automated detection is becoming increasingly viable, at least for certain, regularly acoustic species (e.g., Erbe, 2013). While PAM does solve the issue of detecting marine mammals that are underwater, it also suffers from a number of drawbacks (see Bingham, 2011; Gill et al., 2012). Obviously, the system only works when marine mammals are vocalising and, even then, only if they are close enough to the hydrophones and using known vocalisation types. Furthermore, it is not possible to set up software to display the sounds of all species at once in real time: optimal settings for one species may reduce the chance of detecting other animals using different frequencies. As with visual observers, operator experience and exhaustion also come into play (e.g., Barlow and Gisiner, 2006). In contrast, automated detections are susceptible to variations in the sounds produced by marine mammals between one population and another, as well as noise, scattering, spreading and other factors that alter the received sounds.

Distance estimations are needed to determine if an animal is within the safety zone. The orientation of the sound-producing animal in relation to the PAM system influences the levels received and thus also the estimation of distance to the animal. Using multiple hydrophones can address this problem to some extent; however, marine mammals produce sounds at variable levels.

Consequently, PAM suffers from many of the same issues as visual surveys (e.g., undetected animals, errors in distance estimations, reliance upon experienced, fresh operators), as well as additional problems of its own (Bingham, 2011; Gill et al., 2012). However, the technology is still relatively young and rapidly developing in terms of efficiency as a mitigation tool.

3.4. Pre-survey mitigation sources: Soft-starts

Soft-starts (also known as 'ramp-ups') involve slowly building source levels of the airguns to operational levels before the survey, over a period of 20 minutes, "to give adequate time for marine mammals to leave the area" before being exposed to dangerously high levels (JNCC, 2010). Once up and running, sound levels will essentially be continually ramping-up as animals approach the source, or vice versa. Soft-starts are a long-standing cornerstone of operational guidelines for seismic surveys and are increasingly common practice in sonar exercises and pile driving. However, we are only just beginning to look into their effectiveness.

Crucially, there are several fundamental assumptions that remain untested. For example, the procedure relies on the idea that animals will move away from the source in a logical manner; however, 'illogical' responses have been observed. Nowacek et al. (2004) found that right whales responded to some novel sounds by moving near the surface, placing them at greatest risk of being stuck by ships. Likewise, manatees (*Trichechus manatus*) have been observed responding to boat noise exposure by moving into deep waters, which were typically boat channels and thus increasing their risks of both higher exposures and being struck (Miksis-Olds et al., 2007). The 'logical reaction' assumption also relies on the further supposition that animals can, and are willing to, move away from the disturbance. Again, neither may be true. For example, coastal and ice-edge areas may 'trap' animals too close to a source, or force them into geographical features (e.g., coastlines or sea ice) that they may be unable to subsequently escape from, with potentially fatal consequences (e.g., Heide-Jørgensen et al., 2013; Southall et al., 2013). Similarly, animals may remain in important areas, such as with a rich food source, until exposure levels become 'dangerous'. Alternatively, animals that do leave may be excluded from rich foraging, also to their detriment.

There are other problems with soft-starts, especially with regard to moving sources, including: the introduction of additional noise into the environment; the complications raised by 'shadow zones' where levels of noise may be greatly reduced at certain points closer to a source than would be expected (either as a consequence of propagation related mostly to oceanographic features or the topography of the area, especially around coastlines and islands); and the need to carefully consider the relative speeds of moving sources and marine mammals likely to be exposed. All of the above have been discussed in greater detail elsewhere (e.g., Parsons et al., 2009; Weir and Dolman, 2007); however, the JNCC (2010) guidelines appear to only be concerned over the additional noise soft-starts introduce, accordingly setting upper limits on their maximum duration.

Field studies into the effectiveness of soft-starts are only now being conducted with seismic surveys and humpback whales in Australia (e.g., Cato et al., 2012, 2013; Noad et al., 2013). Unfortunately, the available results are still too few and preliminary to draw any firm conclusions. Some assessments have also been made using computer simulations (e.g., Hannay et al., 2010; von Benda-Beckmann et al., 2014). However these are, by their very nature, simplifications that are also based on a number of unsupported suppositions relating to sound propagation (see Madsen et al., 2006) and, more importantly, the reactions of the animals (for a discussion of the importance of this, see Wensveen, 2012).

Soft-starts focus primarily on injury, despite the many other potential impacts of noise on marine mammals. Thus, it seems inappropriate that a model result where "no instances were found in which the threshold levels for hearing injury for cetaceans were reached during the initial stages of the soft-start sequence" could be used to conclude that, "animals are not at significantly greater risk of harm when a soft-start is initiated in low visibility conditions" (International Association of Oil and Gas producers, OGP, 2011). In fact, those responsible for the modelling contained within the OGP report (2011) noted that animals would have time to move away from the source only provided those early exposures were "sensed as disagreeable" (Hannay et al., 2010). Again, these models do not address the suppositions mentioned above regarding sound propagation and the behavioural responses of the animals.

While it seems likely that soft starts will reduce the total number of high-sound level marine mammal exposures to some degree, their effectiveness remains entirely unknown. The technique is probably ineffective at eliminating all high-level exposures and may exacerbate other impacts, such as habitat exclusion (e.g., Culik et al., 2001; Franse, 2005; Gönener and Bilgin, 2009; Haelters and Camphuysen, 2009). Furthermore, logic holds that if soft-starts were completely effective, there would never be cause to implement a shutdown, as required in other parts of the world. In any case, soft-starts must induce potentially problematic avoidance responses to reduce 'injury' from dangerously high-level exposures.

3.5. Other Mitigation Sources

Mitigation sources are based on the same logic as soft-starts and thus suffer from many of the same limitations. For example, the JNCC allows airgun shooting to continue during short breaks in operations to avoid a full soft-start (e.g., JNCC, 2010). Many mitigation sources are lower-level sounds (e.g., Kyhn et al., 2011), however the JNCC only requires that the duty cycle be reduced under certain conditions (as seems also to be the case for soft-starts, e.g., Figure 3.3., Stone 2015b), which may actually provide animals enough time to approach close enough to receive hearing-dangerous exposures, even if all the underlying suppositions are shown to be correct (von Benda-Beckmann et al., 2014). However, there is little or no scientific information to assess effectiveness and it must be acknowledged that mitigation sources also introduce additional noise.

4. Beyond Injury

4.1. Behavioural responses

As mentioned above, much mitigation of impacts from seismic surveys (under the JNCC guidelines and elsewhere) seeks to avoid 'injury' by inciting behavioural responses, particularly avoidance. However, there is evidence that behavioural responses to low noise levels may have greater effects than expected. For example, some strandings of beaked whales found dead or dying are likely to have resulted from behavioural reactions to sonar exposures at relatively low noise levels (e.g., Cox et al., 2006; Hildebrand, 2005; Rommel et al., 2006; Tyack et al., 2006). In another example, over 1,000 narwhals died in Canada and Northwest Greenland due to ice entrapments that may have been the result of seismic survey noise disrupting their normal migration (Heide-Jørgensen et al., 2013). Other behavioural responses, such as cessation of singing and the alteration of dive and respiration patterns (e.g., Gordon et al., 2004) are also likely to occur. The ultimate consequences of these are unknown, but may (at least in some cases) lead to energetic burdens on the animals (e.g., Williams et al., 2006).

It is thus clear that notable impacts at sub-injurious exposure levels can arise from behavioural responses. However, such responses are highly context-dependent. For example, the specific response may depend on the activity of the animal at the time of exposure, or any prior experience that the animal may have (e.g., Andersen et al., 2012; Robertson et al., 2013). They may also vary depending upon the type (Melcón et al., 2012) or extent of the disturbance (e.g., La Manna et al., 2013). This adds further doubts on the general effectiveness of soft-starts and other mitigation measures.

4.2. Beyond behavioural responses

Injury and behavioural harassment criteria "do not determine the overall level of impact [as] physiological stress and other factors also need to be considered" (Fitch et al., 2011). One of these more subtle factors is the potential for seismic surveys to mask sounds of interest to marine species. Masking may be a huge issue for mysticetes, which produce low-frequency signals that may once have allowed them to communicate over vast distances of hundreds, and possibly thousands, of kilometres (e.g., Clark et al., 2009; Møhl, 1980, 1981). However, the effects of masking depend upon many variables, including the frequencies of the sound and the noise, as well as the locations of sources and receiver.

Masking may also compromise foraging efforts in ways that we do not yet understand. For example, the emerging understanding of how odontocetes hear and discriminate between outgoing and incoming clicks (Li et al., 2011; Linnenschmidt and Beedholm, 2012) has implications for how sound could interfere with the interpretation of these signals (Linnenschmidt and Beedholm, 2012). Noise likely also limits the ability of marine mammals to sense their environment through sound. Accordingly, when a whale's 'communication space' is reduced through masking (Clark et al., 2009; Hatch et al., 2012) there may be serious repercussions for breeding, foraging and navigation. The potential for impacts arising from masking in terrestrial species has also been noted with Francis et al. (2011) even suggesting that acoustic masking by anthropogenic noise may be a strong selective force shaping the ecology of birds worldwide.

Animals may use various compensatory mechanisms to counteract masking, including producing louder sounds or shifting frequencies so their sounds do not clash with the noise (e.g., Holt et al., 2011). However, these mechanisms cannot be applied to sounds of interest produced by other sources (e.g., prey), may be of variable use depending upon call type, and likely carry costs to the animal (e.g., Holt et al., 2011, 2015). These costs may be in terms of energy expenditure or in the form of reproductive strategy trade-offs, as demonstrated for at least one singing bird species, the great tit (Halfwerk et al., 2011).

Please cite this article as: Wright, A.J., Cosentino, A.M., JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better, Marine Pollution Bulletin (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.08.045

Other non-behavioural responses include increased stress responses and the potential for chronic stress (see the extensive review by Wright and Highfill, 2007). There are indications, for example, that ship noise may increase levels of the stress hormone cortisol in North Atlantic right whales (Rolland et al., 2012). Even in the absence of a consistent cortisol response, chronic stress has been associated with serious issues in other species, including a suppression of both the immune system and reproduction, disruption of learning and other cognitive functions, and increased mortality rates (see review by Clark and Stansfeld, 2007). It is reasonable to assume that the constant presence of airgun noise in some areas could lead to similar effects.

Another related issue is that of attention and distraction. Following theoretical work by Dukas (2004), data have demonstrated that noise or disturbance can distract animals from the presence of prey or predators. Such changes of focus have been observed in Caribbean hermit crabs (*Coenobita clypeatus*: Chan et al., 2010), three-spined sticklebacks (*Gasterosteus aculeatus*: Purser and Radford, 2011), the shore crab (*Carcinus maenas*: Wale et al., 2013), and possibly also greater mouse-eared bats (*Myotis myotis*: Siemers and Schaub, 2011). With regard to cetaceans, Dudok van Heel (1966) proposed that distraction could potentially lead directly to strandings and recent work suggests that distraction might also raise mortality indirectly, such as by increasing bycatch risks in harbour porpoises (e.g., Nielsen et al., 2012; Wright et al., 2013). With specific regard to seismic surveys, distraction was one possible mechanism for increased entanglement rates of humpback whales (*Megaptera novaeangliae*) in Brazil during a period of intense exploratory activity (Todd et al., 1996).

All the above-mentioned subtle and cryptic impacts show that reducing the potential for ‘injury’ to individual animals is not sufficient to prevent detrimental effects to a wider population.

5. JNCC data collection, analysis and reports

While the main role of MMOs on board seismic vessels is to conduct pre-shooting searches, they are also encouraged to collect data at all times, provided that such effort is not detrimental to their ability “during the crucial time” of pre-survey scanning (JNCC, 2010). As part of the minimum reporting requirements, at the end of the survey the MMO report must include specific information about the size of the airguns, airgun use and species encountered (JNCC, 2010). With this, the JNCC has produced summarised reports of the data collected (Stone, 1997, 1998, 2000, 2003a, 2003b, 2003c; 2006; 2015a,b; Stone and Tasker, 2006). However, given that MMOs are only required to be active and thus collect data during pre-survey checks, the scope and coverage of these reviews are limited accordingly.

Comprehensive management plans should outline a standardised process for collecting (e.g., methodology), recording and reporting MMO data, as well as include a more extensive complementary research program (see Brower et al., 2011). This information can then be fed back into management decisions, and standard procedures adjusted accordingly. The JNCC guidelines fall short of this ideal in various ways. Firstly, data collection techniques may vary. Next, there is no specified process of feedback into the guidelines or any other JNCC process. Perhaps more importantly, however, is that the level of training and experience required to become an MMO means that detection and identification of marine mammals is not guaranteed to be accurate. Group size estimations and behavioural data (including any changes) may also suffer. Consequently, it must be accepted that it is not possible to reliably conclude from this data that any unreported species or behaviours did not occur.

These issues are perhaps best highlighted by a sighting of a North Atlantic right whale (*Eubalaena glacialis*) reported by a MMO in the eastern North Atlantic in 2000 (Stone, 2003a). At 200 m distance, the observer described a great whale lacking a dorsal fin, but did not report the callosities unique to this species despite recounting a good view of the head. The North Atlantic right whale is thought to be extirpated in this area (OSPAR, 2010a). However, if the rest of the MMO’s description is to be believed, it is possible that it details a bowhead whale (*Balaena mysticetus*) that strayed beyond its nearby known range (OSPAR, 2010b). Given the highly endangered status of the North Atlantic right whale (OSPAR, 2010a) the distinction is a very important one. However, the classification of this animal will remain uncertain.

6. Discussion

Noise from oil and gas activities is not limited solely to seismic surveys (see Spence et al., 2007). Drilling rigs and drill ships, tankers and offshore terminals all introduce noise to the environment. However, none of these have received much focus in terms of noise management or mitigation, as they are often individually considered to be negligible sources of noise. This is despite that comprehensive cumulative impact assessments are required by many countries worldwide. Accordingly, in consideration of ocean noise, as well as other environmental and economic factors (e.g., Swift-Hook, 2013), **widespread reductions in the use of (and thus also demand for) oil (and other fossil fuels) are recommended**.

Obviously, this is not going to happen quickly. Thus interim guidance is needed. Fortunately, despite initially following the JNCC guidelines, requirements around the world have generally become more comprehensive (Compton et al., 2008). One good example is the guidelines of the New Zealand Department of Conservation (DOC, 2013). Of particular note, mitigation zones in New Zealand’s water are dependent upon array size, the species detected and the presence of a calf. Upon breaches of these mitigations zones, MMOs and PAM operators, who must have on-the-job experience or be supervised by someone that has, are obliged to call for operational shut-downs (DOC, 2013).

A second good example can be found in Greenland. The guidelines set out by the Danish Centre for Environment and Energy (DCE: Kyhn et al., 2011) include not only descriptions of mitigation measures that should be used (albeit still constrained to an arbitrary 500 m safety zone), but also requirements for what should be included in Environmental Impact Assessments of planned seismic surveys. For example, these guidelines require that noise propagation modelling be included, that these models must take account of all surveys to be carried out in the area, and that the models are confirmed by acoustic measurements in the field (Kyhn et al., 2011).

The Greenlandic guidelines highlight the fact that operational guidelines represent only a small part of the wider management needed for seismic activities. One alternative approach to addressing this is to set regulatory limits on the level of sound that can be detected at a given distance from the source. Based on studies of the sensitivity of harbour porpoises (*Phocoena phocoena*) to seismic and pile driving noise (e.g., Brandt et al., 2013; Lucke et al., 2009; Scheidat et al., 2011), the German Federal Maritime and Hydrographic Agency requires that pile driving for offshore wind farms target levels of 160 dB (Sound Exposure Level – SEL) or 190 dB (peak) at a distance of 750 m (Koschinski and Lüdemann, 2013). (Note: reference levels were not provided by Koschinski and Lüdemann, 2013, but we assume the SEL reference level is $1 \mu Pa^2$-s and the peak reference level is 1μPa.) Initially claimed to be unachievable, this requirement has driven technological advancements that have since made it possible. Similar restrictions could be placed on seismic surveys around the world with the same intent.

In fact, certain technical options for reducing noise from seismic surveys already exist (see Spence et al., 2007; Weilgart, 2010). Furthermore, reducing the proportion of unnecessary sound energy produced by airguns relative to the amount of useful sound may allow lower source levels to be used for obtaining the same results (e.g., Ross et al., 2005). Thus, such standards will not prevent the oil and gas industry from proceeding with exploration and extraction, or turning profit. They will, however, drive the innovation needed to address the environmental consequences of the current technology by reducing the noise introduced by their arrays.

Therefore, it is clear that the most appropriate way to address underwater noise in the mid-term is through the establishment of scientifically-based management objectives and the subsequent development of mitigation measures that can meet these objectives. Accordingly, **governments and regulators are strongly recommended to implement technology-forcing, scientifically-based noise limits for oil and gas activities, including, but not limited to, exploration, extraction and decommissioning, that can be phased in over a period of not more than 10 years**.

In the short-term, it seems likely that appropriate safety zones *in combination with shutdowns* will greatly reduce (but certainly not eliminate) the number of marine mammals exposed to high levels of noise, despite the known limitations. It thus probably remains better to use pre-operation surveys and safety zones *with shutdowns* than to proceed without. However, several factors must be considered to maximise the effectiveness of these mitigation tools, such as the heavy dependence of visual surveys upon visibility and the consistent availability of fresh, experienced observers. While the two recommendations made above represent new guidance on seismic survey impacts, recent evidence supports the conclusion of others on the subject of maximising the effectiveness of current mitigation techniques (e.g., Nowacek et al., 2013; Parsons et al., 2009; Weir and Dolman, 2007). Thus, if 'injury' to marine mammals (and other species) from seismic survey exposure is to be avoided to the maximum extent practicable, we reiterate (with refinement) the **recommendations that management agencies should include the following requirements in their mitigation guidelines:**

- Consideration should be given in the planning stages to unintended and indirect effects on non-target organisms, both as a result of the seismic activity and the mitigation measures.
- Safety zones should be manageable, yet biologically relevant and, whenever possible, species specific, with a size dependent upon the sound level of the seismic source and the sound propagation characteristics of the area.
- Safety zones should be maintained throughout a seismic survey, with shutdowns implemented if a marine mammal is detected within the area.
- Pre-shoot watches should be of appropriate length for species likely to be encountered, being longer if deep divers are likely present or recently observed.
- Pre-shoot watches should not be commenced during a period of operation.
- A team of visual observers should be deployed, so that two may be scanning at any given time, with at least one of those being highly experienced. They should also be furnished with at least one guide for identifying local species, in case their expertise was gained elsewhere.
- MMOs should have demonstrable experience in observing and/or studying marine mammals before attending the JNCC approved MMO training course, which should focus on the legal aspects of the guidelines.
- Visual observers should not scan for more than 2 hours at a time, to avoid a drop in their efficiency. This requires particular consideration at high-latitudes with long hours of daylight.
- A minimum requirement for search equipment should be set (e.g., graduated binoculars) and the use of range sticks should be banned.
- PAM should be used to supplement visual scans, but should only replace the visual scans entirely in rare cases where the species in question are known to produce sound for the vast majority of the time, such as sperm whales and porpoises.
- PAM operators should be additional, dedicated, well-trained personnel and not simply off-shift visual observers, and also limited to shifts of not more than 2 hours to avoid efficiency reductions.
- PAM systems should be set up to detect the sounds produced by species that are expected to be in the area, which may require multiple displays and operators.
- Surveys should not be commenced during periods of restricted visibility, such as at night or in adverse weather conditions, and should only continue into these conditions if conditions for using PAM without visual observers are met.

Given all the above-mentioned limitations, even well-implemented safety zones are unlikely to protect all marine mammals from dangerous exposures. Accordingly, supplementary or alternative impact reduction efforts (such as new technologies) may be required. In the meantime, despite the huge uncertainties regarding their effectiveness, we recommend the continuation of the use of well-designed soft-starts as a precautionary measure. Soft-starts likely help reduce the total number of dangerous exposures; however, research is immediately needed to determine their effectiveness under real world conditions at reducing these high-level exposures to marine mammals, as well as to assess their optimal duration.

There is also a pressing need for assessments of the long-term consequences of exposure to seismic surveys and other oil and gas activity on marine mammals and the ultimate individual and population-level consequences of the numerous emerging noise-related issues. This is due to the plethora of non-injurious impacts that will all, to some extent, be occurring beyond the boundaries of the safety zone. Carefully designed, long-term studies will be needed that governments should fund with due haste. While it is not unreasonable to pass on the costs of this work to the oil and gas industry, independence should be maintained between the industry and the researchers to retain public confidence in the results.

Acknowledgements

Although no funding was directly provided for the preparation of this manuscript, much of this text is based upon a report written under contract by AJW for WWF International. Accordingly, the authors wish to thank WWF International for this support. Many thanks to Mikhail Babenko, Thea Bechshøft, Louise Blight, Aimée Leslie, Chris Parsons, Courtney Smith, Jakob Tougaard, Leslie Walsh and Tonya Wimmer for all their helpful comments and input during the production of the original WWF report, as well as two anonymous reviewers whose comments helped to improve the manuscript.

References

Alexander, T., 2009. Essex watches for marine mammals during Talisman Saber. (NAVY.mil. Story Number: NNS090718-08. URL: http://www.navy.mil/submit/display.asp?story_id=46983).

Andersen, S.M., Teilmann, J., Dietz, R., Schmidt, N.M., Miller, L.A., 2012. Behavioural responses of harbour seals to human-induced disturbances. Aquat. Conserv. Mar. Freshwat. Ecosyst. 22, 113–121.

Barlow, J., Gisiner, R., 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. J. Cetac. Res. Manage. 7, 239–249.

Barlow, J., Ferguson, M.C., Perrin, W.F., Ballance, L., Gerrodette, T., Joyce, G., MacLeod, C.D., Mullin, K., Palka, D.L., Waring, G., 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). J. Cetac. Res. Manage. 7, 263–270.

Bingham, G. (Ed.), 2011. Status and applications of acoustic mitigation and monitoring systems for marine mammals: Workshop proceedings; November 17-19, 2009, Boston, MassachusettsOCS Study BOEMRE 2011-002, New Orleans, LA. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Gulf of Mexico OCS Region.

Brandt, M.J., Höschle, C., Diederichs, A., Betke, K., Matuschek, R., Witte, S., Nehls, G., 2013. Far-reaching effects of a seal scarer on harbour porpoises, *Phocoena phocoena*. Aquat. Conserv. Mar. Freshwat. Ecosyst. 23, 222–232. http://dx.doi.org/10.1002/aqc.2311.

Brower, H., Clark, C.W., Ferguson, M., Gedamke, J., Southall, B., Suydam, R., 2011. Expert panel review of monitoring protocols in applications for incidental harassment authorizations related to oil and gas exploration in the Chukchi and Beaufort Seas, 2011: Statoil and ION Geophysical. (9th March 2011. Anchorage, Alaska. Available at: http://www.nmfs.noaa.gov/pr/pdfs/permits/openwater/peer_review_report2011.pdf.).

Cato, D., Dunlop, R., Noad, M., McCauley, R., Salgado Kent, C., Kniest, H., Paton, D., Noad, J., Jenner, C., 2012. Studies of the effectiveness of ramp-up as a mitigation method in impacts of noise on marine mammals. Abstract Only. p23 In: 11th European Conference on Underwater Acoustics, Edinburgh, Scotland, U.K., 2-6 July 2012.

Cato, D., Noad, M., Dunlop, R., McCauley, R., Gales, N.J., Salgado Kent, C.P., Kniest, H., Paton, D., Jenner, K.C.S., Noad, J., Maggi, A.L., Parnum, I.M., Duncan, A.J., 2013. A study of the behavioural response of whales to the noise of seismic air guns: design, methods and progress. Acoust. Aust. 41 (1), 88–97.

Chan, A.A.Y.H., Stahlman, W.D., Garlick, D., Fast, C.D., Blumstein, D.T., Blaisdell, A.P., 2010. Increased amplitude and duration of acoustic stimuli enhance distraction. Anim. Behav. 80, 1075–1079.

Clark, C.W., Gagnon, G.C., 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. International Whaling Commission Scientific Committee document SC/58/E9.

Clark, C., Stansfeld, S., 2007. Non-auditory effects of noise on human health: a review of recent evidence. Int. J. Comp. Psychol. 20 (2-3), 145–158.

Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., Van Parijs, S.M., Frankel, A., Ponirakis, D., 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Mar. Ecol. Prog. Ser. 395, 201–222.

Compton, R., Goodwin, L., Handy, R., Abbott, V., 2008. A critical examination of worldwide guidelines for minimising the disturbance to marine mammals during seismic surveys. Mar. Policy 32, 255–262.

Cox, T.M., Ragen, T.J., Read, A.J., Vos, E., Baird, R.W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Fernández, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P.D., Ketten, D., MacLeod, C.D., Miller, P., Moore, S., Moundain, D.C., Palka, D., Ponganis, P., Rommel, S., Rowles, T., Taylor, B., Tyack, P., Wartzok, R. Gisiner, Mead, J., Benner, L., 2006. Understanding the impacts of anthropogenic sound on beaked whales. J. Cetac. Res. Manage. 7 (3), 177–187.

Culik, B.M., Koschinski, S., Tregenza, N., Ellis, G.M., 2001. Reactions of harbor porpoises *Phocoena phocoena* and herring *Clupea harengus* to acoustic alarms. Mar. Ecol. Prog. Ser. 211, 255–260.

DOC (the New Zealand Department of Conservation), 2013. 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations. Department of Conservation, Wellington, New Zealand (Available at: http://www.doc.govt.nz/conservation/marine-and-coastal/seismic-surveys-code-of-conduct/code-of-conduct-for-minimising-acoustic-disturbance-to-marine-mammals-from-seismic-survey-operations/).

DoN (U.S. Department of the Navy), 2013. Comprehensive exercise and marine species monitoring report for the U.S. Navy's Atlantic Fleet Active Sonar Training (AFAST) and Virginia Capes, Cherry Point, Jacksonville, and Gulf of Mexico range complexes 2009-2012. Submitted to National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland, January 24, 2013 by the Department of the Navy, United States Fleet Forces Command, Norfolk, Virginia.

DTI (U.K. Department of Trade and Industry), 2002. Strategic environmental assessment of parts of the Central and Southern North Sea SEA 3. (Available at: http://www.offshore-sea.org.uk/consultations/SEA_3/SEA3_Assessment_Document_Rev1_W.pdf).

Dudok van Heel, W.H., 1966. Navigation in Cetacea. In: Norris, K.D. (Ed.), Whales, dolphins and porpoises. University of California Press, Berkeley and Los Angeles, pp. 597–606.

Dukas, R., 2004. Causes and consequences of limited attention. Brain Behav. Evol. 63, 197–210. http://dx.doi.org/10.1159/000076781.

Erbe, C., 2013. Underwater passive acoustic monitoring & noise impacts on marine fauna – a workshop report. Acoust. Aust. 41 (1), 113–119.

Fitch, R., Harrison, J., Lewandowski, J., 2011. Marine mammal and sound workshop July 13 and 14, 2010. Report to the National Ocean Council Ocean Science and Technology Interagency Policy Committee. Washington, D.C (Available at: http://www.nmfs.noaa.gov/pr/pdfs/acoustics/mm_sound_workshop_report.pdf).

Francis, C.D., Ortega, C.P., Cruz, A., 2011. Noise pollution filters bird communities based on vocal frequency. PLoS One 6 (11), e27052. http://dx.doi.org/10.1371/journal.pone.0027052.

Franse, R., 2005. Effectiveness of acoustic deterrent devices (pingers). Universiteit Leiden, Centrum voor Milieuwetenschappen, Leiden, the Netherlands.

Gill, A., Weir, C., Barton, C., Shrimpton, J., Barrs, J., Barry, S., Lacey, C., Lyne, P., Mustoe, S., McRae, H., Robertson, F., 2012. Marine mammal observer association: position statements. the key issues that should be addressed when developing mitigation plans to minimise the effects of anthropogenic sound on species of concern. Version 1. Consultation Document – 10th September 2012. Marine Mammal Observer Association, London, U.K.

Gönener, S., Bilgin, S., 2009. The effect of pingers on harbour porpoise, *Phocoena phocoena* bycatch and fishing effort in the turbot gill net fishery in the Turkish Black Sea Coast. Turk. J. Fish. Aquat. Sci. 9, 151–157.

Goold, J.C., Coates, R.F.W., 2006. Near source, high frequency air-gun signatures. International Whaling Commission Scientific Committee document SC/58/E30.

Goold, J.C., Fish, P.J., 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. J. Acoust. Soc. Am. 103, 2177–2184.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R., Thompson, D., 2004. A review of the effects of seismic surveys on marine mammals. Mar. Technol. Soc. J. 37, 16–34. http://dx.doi.org/10.4031/002533203787536998.

Haelters, J., Camphuysen, K., 2009. The harbour porpoise in the southern North Sea: abundance, threats and research- and management proposals. Royal Belgian Institute of Natural Sciences (RBINS/MUMM) and the Royal Netherlands Institute for Sea Research (NIOZ); report commissioned by the International Fund for Animal Welfare (IFAW).

Halfwerk, W., Bot, S., van der Buikx, J., Velde, M., Komdeur, J., ten Cate, C., Hans Slabbekoorn, H., 2011. Low-frequency songs lose their potency in noisy urban conditions. Proc. Natl. Acad. Sci. 108 (35), 14549–14554.

Hannay, D., Racca, R., MacGillivray, A., 2010. *Model based assessment of underwater noise from an airgun array soft-start operation*. 8 October 2010. JASCO Applied Sciences. Victoria, BC. OGP, 2011. Model based assessment of underwater noise from an airgun array soft-start operation. OGP Report No. 451. February, 2011. London, U.K.

Harwood, L.A., Joynt, A., 2009. *Factors influencing the effectiveness of Marine Mammal Observers on seismic vessels, with examples from the Canadian Beaufort Sea*. Sci. Advis. Sec. Res. Doc. 2009/048. Department of Fisheries and Oceans Canada.

Hatch, L.T., Clark, C.W., Van Parijs, S.M., Frankel, A., Ponirakis, D.W., 2012. Quantifying loss of acoustic communication space for right whales in and around a U.S. national marine sanctuary. Conserv. Biol. 26, 983–994. http://dx.doi.org/10.1111/j.1523-1739.2012.01908.

Heide-Jørgensen, M.P., Guldborg Hansen, R., Westdal, K., Reeves, R.R., Mosbech, A., 2013. Narwhals and seismic exploration: Is seismic noise increasing the risk of ice entrapments? Biol. Conserv. 158, 50–54.

Hermannsen, L., Tougaard, J., Beedholm, K., Nabe-Nielsen, J., Madsen, P.T., 2015. Characteristics and propagation of airgun pulses in shallow water with implications for effects on small marine mammals. PLoS One 10 (7), e0133436. http://dx.doi.org/10.1371/journal.pone.0133436.

Hildebrand, J.A., 2005. Impacts of anthropogenic sound. In: Reynolds, J.E., Perrin, W.F., Reeves, R.R., Montgomery, S., Ragen, T.J. (Eds.), Marine mammal research: Conservation beyond crisis. The Johns Hopkins University Press, Baltimore, MD, pp. 101–124.

Holt, M.M., Noren, D.P., Emmons, C.K., 2011. Effects of noise levels and call types on the source levels of killer whale calls. J. Acoust. Soc. Am. 130 (5), 3100–3106.

Holt, M.M., Noren, D.P., Dunkin, R.C., Williams, T.M., 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. J. Exp. Biol. http://dx.doi.org/10.1242/jeb.122424 (Posted online 7th April 2015).

Jasny, M., Reynolds, J., Horowitz, C., Wetzler, A., 2005. Sounding the depths. 2nd edition. Natural Resources Defense Council, New York, NY (Available at: http://www.nrdc.org/wildlife/marine/sound/sound.pdf).

JNCC (U.K. Joint Nature Conservation Committee), 1998. Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys. Joint Nature Conservation Committee, Peterborough, UK.

JNCC (U.K. Joint Nature Conservation Committee), 2010. JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys August 2010. Joint Nature Conservation Committee, Aberdeen, UK.

JNCC (U.K. Joint Nature Conservation Committee), Natural England, Countryside Council for Wales, 2010. The protection of marine European Protected Species from injury and disturbance: Guidance for the marine area in England and Wales and the UK offshore marine area. DRAFT. Joint Nature Conservation Committee, Peterborough, UK.

Kliewer, G., 2013. Seismic survey vessel capabilities go up while count goes down. Offshore (Posted: 8th March 2013. Available at: http://www.offshore-mag.com/articles/print/volume-73/issue-3/geology-geophysics/seismic-survey-vessel-capabilities-go-up-while-count-goes-down.html).

Koschinski, S., Lüdemann, K., 2013. Development of noise mitigation measures in offshore wind farm construction 2013. Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN), Hamburg, Germany (Available at: http://tethys.pnnl.gov/sites/default/files/publications/Koschinski-and-Ludemann-2013.pdf).

Kyhn, L.A., Boertmann, D., Tougaard, J., Johansen, K., Mosbech, A., 2011. Guidelines to environmental impact assessment of seismic activities in Greenland waters. 3rd revised edition. Danish Center for Environment and Energy, Roskilde, Denmark Dec. 2011.

La Manna, G., Manghi, M., Pavan, G., Lo Mascolo, F., Sarà, G., 2013. Behavioural strategy of common bottlenose dolphins (*Tursiops truncatus*) in response to different kinds of boats in the waters of Lampedusa Island (Italy). Aquat. Conserv. Mar. Freshwat. Ecosyst. 23, 745–757. http://dx.doi.org/10.1002/aqc.2355.

Li, S., Nachtigall, P.E., Breese, M., 2011. Dolphin hearing during echolocation: evoked potential responses in an Atlantic bottlenose dolphin (*Tursiops truncatus*). J. Exp. Biol. 214, 2027–2035.

Linnenschmidt, M., Beedholm, K., 2012. What we see is not what they hear: How porpoises perceive their outgoing clicks. In: Linnenschmidt, M. (Ed.), Harbour porpoise target detection and echo processing abilities. Institute of Biology, University of Southern Denmark, Odense, pp. 78–87 (Ph.D. Dissertation).

Lubchenco, J., 2010. Memorandum from NOAA Administrator to N. Sutley, Chair of the Council on Environmental, Quality (Jan. 19, 2010).

Lucke, K., Siebert, U., Lepper, P.A., Blanchet, M.-A., 2009. Temporary shift in masked hearing thresholds in a harbour porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. J. Acoust. Soc. Am. 125, 4060–4070.

Madsen, P.T., Johnson, M., Miller, P.J.O., Aguilar Soto, N., Lynch, J., Tyack, P., 2006. Quantitative measures of air gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. J. Acoust. Soc. Am. 120, 2366–2379.

MaMa CoCo SEA Project, 2015. A review of seismic mitigation measures used along the coast of northern south America, from north brazil Up to Colombia 2015. Reference Document for the MaMa CoCo SEA Steering Committee (Available at: http://www.car-spaw-rac.org/IMG/pdf/seismic_mitigation_measures_review_mamacocosea.pdf).

McCarthy, E., Moretti, D., Thomas, L., DiMarzio, N., Morrissey, R., Jarvis, S., Ward, J., Izzi, A., Dilley, A., 2011. Changes in spatial and temporal distribution and vocal behavior of Blainville's beaked whales (*Mesoplodon densirostris*) during multiship exercises with mid-frequency sonar. Mar. Mamm. Sci. 27, E206–E226.

Melcón, M.L., Cummins, A.J., Kerosky, S.M., Roche, L.K., Wiggins, S.M., Hildebrand, J.A., 2012. Blue whales respond to anthropogenic noise. PLoS One 7 (2), e32681. http://dx.doi.org/10.1371/journal.pone.0032681.

Miksis-Olds, J.L., Donaghay, P.L., Miller, J.H., Tyack, P.L., Reynolds, J.E., 2007. Simulated vessel approaches elicit differential responses from manatees. Mar. Mamm. Sci. 23 (3), 629–649.

Miller, P., 2011. Cetaceans and naval sonar: behavioral response as a function of sonar frequency. Annual report to Office of Naval Research FY11, under Award Number: N00014-08-1-0984 (Available at: http://www.onr.navy.mil/reports/FY11/mbmille1.pdf).

Miller, P.J.O., Kvadsheim, P.H., Lam, F.-P.A., Wensveen, P.J., Antunes, R., Catarina Alves, A., Visser, F., Kleivane, L., Tyack, P.L., Doksæter Sivle, L., 2012. The severity of behavioral changes observed during experimental exposures of killer (*Orcinus orca*), long-finned pilot (*Globicephala melas*), and sperm (*Physeter macrocephalus*) whales to naval sonar. Aquat. Mamm. 38 (4), 362–401. http://dx.doi.org/10.1578/AM.38.4.2012.

MMC (U.S. Marine Mammal Commission), 2007. Marine mammals and noise – a sound approach to research and management. A Report to Congress from the Marine Mammal Commission (Bethesda, MD. Available at: http://www.mmc.gov/reports/workshop/pdf/fullsoundreport.pdf).

Møhl, B., 1980. Marine mammals and noise. Arctic Seas Bull. 2, 1–2.

Møhl, B., 1981. Masking effects of noise: their distribution in time and space. In: Peterson, N.M. (Ed.), The question of sound from icebreaker operations: Proceedings from a workshop. Arctic Pilot Project, Calgary, Alberta, pp. 259–266.

Moretti, D., Marques, T.A., Thomas, L., DiMarzio, N., Dilley, A., Morrissey, R., McCarthy, E., Ward, J., Jarvis, S., 2010. A dive counting density estimation method for Blainville's beaked whale (*Mesoplodon densirostris*) using a bottom-mounted hydrophone field as applied to a Mid-Frequency Active (MFA) sonar operation. Appl. Acoust. 71, 1036–1042. http://dx.doi.org/10.1016/j.apacoust.2010.04.011.

Nielsen, T.P., Wahlberg, M., Heikkilä, S., Jensen, M., Sabinsky, P., Dabelsteen, T., 2012. Swimming patterns of wild harbour porpoises *Phocoena phocoena* show detection and avoidance of gillnets at very long ranges. Mar. Ecol. Prog. Ser. 453, 241–248. http://dx.doi.org/10.3354/meps09630.

Nieukirk, S.L., Stafford, K.M., Mellinger, D.K., Dziak, R.P., Fox, C.G., 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. J. Acoust. Soc. Am. 115 (4), 1832–1843.

Nieukirk, S.L., Mellinger, D.K., Moore, S.E., Klinck, K., Dziak, R.P., Goslin, J., 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. J. Acoust. Soc. Am. 131 (2), 1102–1112.

Noad, M.J., Cato, D.H., Dunlop, R.A., McCauley, R., 2013. An interdisciplinary approach to measuring behavioural impacts of seismic surveys on humpback whales. Abstract Only In: 27th Conference of the European Cetacean Society: Interdisciplinary Approaches in the Study of Marine Mammals, 8th-10th April, Setúbal, Portugal, p. 125.

Nowacek, D.P., Johnson, M.P., Tyack, P.L., 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proc. R. Soc. B Biol. Sci. 271, 227–231.

Nowacek, D.P., Thorne, L.H., Johnston, D.W., Tyack, P.L., 2007. Responses of cetaceans to anthropogenic noise. Mammal Rev. 37, 81–115.

Nowacek, D.P., Bröker, K., Donovan, G., Gailey, G., Racca, R., Reeves, R.R., Vedenev, A.I., Weller, D.W., Southall, B.L., 2013. Responsible practices for minimizing and monitoring environmental impacts of marine seismic surveys with an emphasis on marine mammals. Aquat. Mamm. 39 (4), 356–377. http://dx.doi.org/10.1578/AM.39.4.2013.356.

NRC (U.S. National Research Council), 1994. Low-frequency sound and marine mammals: current knowledge and research needs. National Academy Press, Washington, D.C.

NRC (U.S. National Research Council), 2000. Marine mammals and low-frequency sound. National Academy Press, Washington, D.C.

NRC (U.S. National Research Council), 2003. Ocean noise and marine mammals. National Academy Press, Washington, D.C.

NRC (U.S. National Research Council), 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects. National Academy Press, Washington, D.C.

OGP (International Association of Oil and Gas Producers), 2011. Model based assessment of underwater noise from an airgun array soft-start operation. OGP Report No. 451. February, 2011 (London, U.K).

OGP (International Association of Oil and Gas Producers), IAGC (International Association of Geophysical Contractors), 2008. Seismic surveys and marine mammals. IAGC, Houston, TX, USA and OGP, London, UK (Available from: http://www.ogp.org.uk/pubs/358.pdf).

OSPAR Commission, 2010a. Background document for northern right whale *Eubalaena glacialis* Available at: http://qsr2010.ospar.org/media/assessments/Species/p00496_northern_right_whale.pdf.

OSPAR Commission, 2010b. Background document for bowhead whale Balaena mysticetus. Available at: http://www.ospar.org/documents%5Cdbase%5Cpublications%5CP00494_ Bowhead_whale.pdf.

Parente, C.L., de Araújo, M.E., 2011. Effectiveness of monitoring marine mammals during marine seismic surveys off Northeast Brazil. Rev Ges Cost Integr 11 (4), 409–419.

Parsons, E.C.M., Dolman, S.J., Jasny, M., Rose, N.A., Simmonds, M.P., Wright, A.J., 2009. A Critique of the UK's JNCC Seismic Survey Guidelines for minimising acoustic disturbance to marine mammals: Best Practise? Mar. Pollut. Bull. 58, 643–651.

Pirotta, E., Milor, R., Quick, N., Moretti, D., Di Marzio, N., Tyack, P., Boyd, I., Hastie, G., 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. PLoS One 7 (8), e42535. http://dx.doi.org/10.1371/journal.pone.0042535.

Popov, V.V., Supin, A.Y., Wang, D., Wang, K., Dong, L., Wang, S., 2011a. Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises *Neophocaena phocaenoides asiaorientalis*. J. Acoust. Soc. Am. 130, 574–584.

Popov, V.V., Klishin, V.O., Nechaev, D.I., Pletenko, M.G., Rozhnov, V.V., Supin, A.Y., Sysueva, E.V., Tarakanov, M.B., 2011b. Influence of acoustic noises on the white whale hearing thresholds. Dokl. Biol. Sci. 440, 332–334.

Purser, J., Radford, A.N., 2011. Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (*Gasterosteus aculeatus*). PLoS One 6 (2), e17478. http://dx.doi.org/10.1371/journal.pone.0017478.

Richardson, W.J., Greene Jr., C.R., Malme, C.I., Thomson, D.H., 1995. Marine mammals and noise. Academic Press, New York, NY.

Robertson, F.C., Koski, W.R., Thomas, T.A., Richardson, W.J., Würsig, B., Trites, A.W., 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endanger. Species Res. 21, 143–160. http://dx.doi.org/10.3354/esr00515.

Rolland, R.M., Parks, S.E., Hunt, K.E., Castellote, M., Corkeron, P.J., Nowacek, D.P., Wasser, S.K., Kraus, S.D., 2012. Evidence that ship noise increases stress in right whales. Proc. R. Soc. B Biol. Sci. 279, 2363–2368.

Rommel, S.A., Costidid, A.M., Fernández, A., Jepson, P.D., Pabst, D.A., McLellan, W.W., Houser, D.S., Cranford, T.W., Van Helden, A.L., Allen, D.M., Barros, N.B., 2006. Elements of beaked whale anatomy and diving physiology and some hypothetical causes of sonar-related stranding. J. Cetac. Res. Manage. 7, 189–209.

Ross, W., Lee, P., Heiney, S., Young, J., Drake, E., Tenghamn, R., Stenzel, A., 2005. Mitigating seismic noise with an acoustic blanket – the promise and the challenge. Lead. Edge 24 (3), 303–313. http://dx.doi.org/10.1190/1.1895317.

Scheidat, M., Tougaard, J., Brasseur, S., Carstensen, J., van Polanen Petel, T., Teilmann, J., Reijnders, P., 2011. Harbour porpoises (*Phocoena phocoena*) and wind farms: a case study in the Dutch North Sea. Environ. Res. Lett. 6, 025102. http://dx.doi.org/10.1088/1748-9326/6/2/025102.

Siemers, B.M., Schaub, A., 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. Proc. R. Soc. B Biol. Sci. 278, 1646–1652 (Published Online 17th November 2010).

Simmonds, M.P., Dolman, S.J., Jasny, M., Parsons, E.C.M., Weilgart, L., Wright, A.J., Leaper, R., 2014. Marine noise pollution – increasing recognition but need for more practical action. J. Ocean Technol. 9, 70–90.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr., C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., Tyack, P.L., 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquat. Mamm. 33 (4), 411–522.

Southall, B.L., Rowles, T., Gulland, F., Baird, R.W., Jepson, P.D., 2013. *Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*)* in Antsohihy. Madagascar (Available at: http://iwc.int/cache/downloads/4b0mkc030sg0gogkg8kog4o4w/Madagascar%20ISRP%20FINAL%20REPORT.pdf).

Spence, J., Fischer, R., Bahtiarian, M., Boroditsky, L., Jones, N., Dempsey, R., 2007. Review of existing and future potential treatments for reducing underwater sound from oil and gas industry activities. NCE REPORT 07-001. Noise Control Engineering, Inc., Billerica, MA.

Stafford, K.M., Nieukirk, S.L., Fox, C.G., 1999. An acoustic link between blue whales in the Eastern Tropical Pacific and the Northeast Pacific. Mar. Mamm. Sci. 15, 1258–1268.

Stone, C.J., 1997. The Effects of Seismic Activities on Marine Mammals in UK Waters 1996. JNCC Report 228. Joint Nature Conservation Committee, Peterborough.

Stone, C.J., 1998. JNCC Report 278. Joint Nature Conservation Committee, Peterborough.

Stone, C.J., 2000. The effects of seismic activities on marine mammals in UK waters, 1998. JNCC Report 301. Joint Nature Conservation Committee, Peterborough.

Stone, C.J., 2003a. The effects of seismic activities on marine mammals in UK waters, 1999. JNCC Report 316. Joint Nature Conservation Committee, Peterborough.

Stone, C.J., 2003b. The effects of seismic activities on marine mammals in UK waters 2000. JNCC Report 322. Joint Nature Conservation Committee, Peterborough.

Stone, C.J., 2003c. The effects of seismic activities on marine mammals in UK waters 1998–2000. JNCC Report 323.

Stone, C.J., 2006. Marine mammal observations during seismic surveys in 2001 and 2002. JNCC Report 359. Joint Nature Conservation Committee, Peterborough.

Stone, C.J., 2015a. Marine mammal observations during seismic surveys from 1994-2010. JNCC report, No. 463a. Joint Nature Conservation Committee, Peterborough (Available from: http://jncc.defra.gov.uk/page-6985).

Stone, C.J., 2015b. Implementation of and considerations for revisions to the JNCC guidelines for seismic surveys. JNCC report, No. 463bJoint Nature Conservation Committee, Peterborough (Available from: http://jncc.defra.gov.uk/page-6986).

Stone, C.J., Tasker, M.L., 2006. The effects of seismic airguns on cetaceans in UK waters. J. Cetac. Res. Manage. 8, 255–263.

Swift-Hook, D., 2013. The case for renewables apart from global warming. Renew. Energy 49, 147e150. http://dx.doi.org/10.1016/j.renene.2012.01.043.

Teilmann, J., 2003. Influence of sea states on density estimates of harbour porpoises (*Phocoena phocoena*). J. Cetac. Res. Manage. 5 (1), 85–92.

Thomsen, F., Ugarte, F., Evans, P.G.H. (Eds.), 2005. Proceedings of the workshop on estimation of g(0) in line-transect surveys of cetaceans. Held at the European Cetacean Society's 18th Annual Conference, Vildmarkshotellet at Kolmården Djur Park, Kolmården, Sweden, 28th March 2004. ECS Newsletter 44 (Special Issue), April 2005.

Todd, S., Stevick, P., Lien, J., Marques, F., Ketten, D.R., 1996. Behavioural effects of exposure to underwater explosions in humpback whales (Megaptera novaean- gliae). Can. J. Zool. 74, 1661–1672.

Tougaard, J., Wright, A.J., Madsen, P.T., 2014. Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises. Mar. Pollut. Bull. http://dx.doi.org/10.1016/j.marpolbul.2014.10.051.) (Published online: 20th Nov 2014).

Tyack, P.L., Johnson, M., Aguilar de Soto, N., Sturlese, A., Madsen, P.T., 2006. Extreme diving of beaked whales. J. Exp. Biol. 209, 4238–4253.

Tyack, P.L., Zimmer, W.M.X., Moretti, D., Southall, B.L., Claridge, D.E., Durban, J.W., Clark, C.W., D'Amico, A., DiMarzio, N., Jarvis, S., McCarthy, E., Morrissey, R., Ward, J., Boyd, I.L., 2011. Beaked whales respond to simulated and actual navy sonar. PLoS One 6 (3), e17009. http://dx.doi.org/10.1371/journal.pone.0017009.

von Benda-Beckmann, A.M., Wensveen, P.J., Kvadsheim, P.H., Lam, F.P.A., Miller, P.J.O., Tyack, P.L., Ainslie, M.A., 2014. Modeling ramp-up effectiveness at mitigating impact of sonar sounds on marine mammals. Conserv. Biol. 28, 119–128.

Wale, M.A., Simpson, S.D., Radford, A.N., 2013. Size-dependent physiological responses of shore crabs to single and repeated playback of ship noise. Biol. Lett. 9, 20121194. http://dx.doi.org/10.1098/rsbl.2012.1194.

Watwood, S., Uyeyama, R., Balla-Holden, A., Jefferson, T., 2012. Cruise report, marine species monitoring and lookout effectiveness study submarine commanders course. Range Complex, Hawai'i (February 2012).

Weilgart, L.S., 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Can. J. Zool. 85, 1091–1116.

Weilgart, L. (Ed.), 2010. Report of the Workshop on Alternative Technologies to Seismic Airgun Surveys for Oil and Gas Exploration and their Potential for Reducing Impacts on Marine Mammals. Monterey, CA, USA, 31 August-1 Sept. 2009. Okeanos - Foundation for the Sea, Darmstadt (Available at: http://www.okeanos-stiftung.org/assets/Uploads/Airgun.pdf).

Weir, C.R., Dolman, S.J., 2007. Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. J Int Wildl Law Policy 10, 1–27.

Wensveen, P.J., 2012. The effects of sound propagation and avoidance behaviour on naval sonar levels received by cetaceans. Thesis Submitted for the Degree of MPhil at the University of St. Andrews, Scotland.

Williams, R., Lusseau, D., Hammond, P.S., 2006. Potential energetic cost to killer whales of disturbance by vessels and the role of a marine protected area. Biol. Conserv. 133 (3), 301–311.

Wright, A.J., Highfill, L., 2007. Considerations of the effects of noise on marine mammals and other animals. Int. J. Comp. Psychol. 20 (2-3), 89–316.

Wright, A.J., Maar, M., Mohn, C., Nabe-Nielsen, J., Siebert, U., Fast Jensen, L., Baagøe, H.J., Teilmann, J., 2013. Possible causes of a harbour porpoise mass stranding in Danish waters in 2005. PLoS One 8 (2), e55553. http://dx.doi.org/10.1371/journal.pone.0055553.

Harbour porpoise SACs noise management Stakeholder workshop

Report

1. Introduction

This report provides a summary of the one-day stakeholder workshop organised by the Joint Nature Conservation Committee and held in Edinburgh on February 27th, 2016.

The workshop was an important stage in the process of developing management approaches for the SACs ("Special Areas of Conservation") that have been identified and designated for the protection of the harbour porpoise.

This workshop was concerned with the management of underwater noise within the SACs, the expectations of key stakeholders, and the material impact on marine industries. It was aimed at furthering the discussions and contributing to the development of advice for the regulatory authorities that will need to make consenting and licensing decisions on industry plan and project applications. In doing so they will look to their statutory nature conservation bodies (SNCBs)s for advice on matters to do with harbour porpoise conservation within the SACs. The SNCBs will wish to have practical and preferably well understood & supported guidance in place for regulatory authorities to use in the context of SACs.

This report summarises the workshop outputs; in particular, three themed discussion sessions that took place.

2. The participants

A full list of participants is given in Annex 1. The attendees were selected to be broadly representative of the key sectors and included a range of stakeholders. There were representatives from regulatory authorities (BEIS, OPRED, MMO), industry (mainly the renewable energy industry given the workshop's focus), statutory nature conservation bodies (JNCC, Natural England, Natural Resources Wales, Scottish Natural Heritage, Department of the Environment Northern Ireland), and environmental NGOs (Whale & Dolphin Conservation, The Wildlife Trusts, Marine Conservation Society, Client Earth).

A range of stakeholders was critical to the success of the event, since the intention was to understand their views and concerns and to ensure that all participants had an equal opportunity to be involved in exploring the options and solutions. All participants had received a discussion paper setting out the SNCB proposed approach to noise assessment and management and a set of three introductory briefing papers to stimulate discussion on themed topics in three breakout groups – see Annexes 2 & 3.

3. The workshop structure

3.1 The morning session was structured around presentations from the range of stakeholder interests present:

- Dominic Pattinson of Defra presented a brief overview of the policy context.
- **Noise management in harbour porpoise SACs** – a joint presentation by Kelly Macleod (JNCC), Caroline Carter (SNH – Scottish Natural Heritage), and Tom Stringell (NRW – Natural Resources Wales)
- **Industry activities in harbour porpoise SACs - an NGO perspective** - Alec Taylor (WWF Worldwide Fund for Nature)
- **Planning related aspects of offshore wind farm development** Pete Gaches (GoBe consultants) Rebecca Sherwood (Innogy); Gillian Sutherland (Scottish Power Renewables)
- **Experiences from offshore windfarm construction and deployment of noise mitigation technologies** Eva Philipp (Vattenfall).
- **The regulatory perspective- renewables, oil, and gas** Siobhan Browne and Julie Cook, (BEIS)

3.2 The second session after lunch was structured around three parallel group sessions, and each ran three times, ensuring that all participants had the opportunity to discuss each issue. These covered:

1. Threshold justification
2. Implementation of a threshold approach
3. Alternative/complementary approaches for management

A summary of discussions is presented in section 4.

3.3 The final session of the day was a plenary discussion at which each group reported on key issues arising.

4. Breakout group reports

This section summarises the discussions and the key issues arising from the breakout groups. Where there was significant overlap across all the groups on some issues; key points have been grouped together.

4.1. Threshold justification

The breakout session developed some areas of broad agreement:

- An 'area of habitat' based approach is probably better than a numbers-based approach given the spatial and temporal variability in distribution/density of harbour porpoise
- A daily threshold is not useful / achievable
- A seasonal average will be more achievable
- There is a stronger logic to the 20% limit than the 10%

There were also areas of disagreement

- Thresholds were not precautionary enough v thresholds were too precautionary
- Maximum daily 20% not needed and may not be manageable because of the daily time scale. Disagreement as to whether a maximum was needed at all.
- The ecological justification for the thresholds; some thought it was weak
- The need for a set threshold; why not have a range with an upper/lower threshold which would allow greater flexibility within planning schedules
- Effective Deterrent Radius of 26km – over/under precautionary. Some preferred modelling the EDR on a case-by-case basis, using noise propagation principles and then monitor in the field to corroborate predictions.

It was questioned whether a threshold approach may prolong the piling period and site installation which could prove worse for harbour porpoise population and the site's contribution to Favourable Conservation Status (FCS). Is there a "get on with it and get it over" view – is there any / adequate evidence on the pros and cons to support either approach?

There were unresolved issues about how to monitor noise disturbance to keep it within the thresholds. It was agreed that there needs to be some certainty on the management approach as a first step.

4.2. Implementation

This session focused on the practicalities of operation and regulation of a possible area based thresholds approach. Several areas of uncertainty were discussed.

- **Regulation**

There are several regulators covering a range of industry sectors and geographic areas and there is no mechanism for joint decision making – this was identified as a problem. It is not clear who has the full overview, nor where responsibility and accountability would rest for a cross-sectoral thresholds approach.

There is a need for the regulators to work together to develop clear assessment processes. One suggestion was that a new ‘hypothetical’ regulator is needed for the thresholds approach to work, because it will be reliant on understanding activities across sectors for full cumulative assessment.   This could involve the development of ‘noise quota’ systems which might be managed centrally.

At present, there is no existing mechanism for developers and regulators to coordinate overlapping activities. Does this point towards some form of noise ‘emissions trading scheme’? Without a clear system, there would be the risk of a ‘first come, first served’ / ‘land grab’ situation.

There are hard questions to be asked that will need to be resolved, given a wide range of commercial interests operating in a competitive environment and varying levels of engagement.

- **The Daily limit**

A daily limit on noise maxima is a component of the proposed approach. It was widely felt that this is simply impractical. Operational requirements at sea, including availability of vessels and the need to exploit weather windows, make it clear that to limit work on a daily basis could be very expensive and very challenging to plan and enforce. Questions were raised over concurrent piling.

A longer-term limit system may be feasible: further work needed on what a ‘longer term’ is (e.g. a season, multiple seasons or an average over several years). Industry raised the concern that delays in piling one wind farm could result in overlap with the construction of another project or a seismic survey which could mean the thresholds were exceeded causing further delays which can seriously impact projects.

- **The Planning Process**

There are significant issues to be addressed about how impacts on porpoise SACs are assessed and at what stage in the process. The two key stages are the main application for consent and then finalisation of operational plans for construction (e.g. monitoring and mitigation plans). At the first stage the build envelope is too broad to make a realistic assessment, at the last stage it is too late to make an assessment. A step in between to undertake an assessment on a realistic build scenario would be beneficial. The Contract for Difference (CfD) process also creates complications. The main issue is having confidence in a realistic build scenario – some adaptability will be needed, especially if there was to be a quota system as proposed in the threshold approach. Some industry reps felt that a quota system would be very challenging for industry.

OPRED is finalising its strategic Habitats Regulations Assessment (HRA) for the oil & gas industry; It was felt by some that it was important to bring together the oil & gas HRA with a Renewable energy HRA, particularly with regards to noise disturbance assessment.

It was suggested that the thresholds approach could work for assessment purposes but not for management given the challenges of implementation.

The fixed 26km radius of piling noise disturbance (effective deterrent radius – EDR) was raised, and to what extent this would vary depending upon site conditions. The use of noise reduction technologies could reduce the radius of disturbance, but there are considerable technological and logistical challenges to its deployment. In addition, not all technology types are proven and none have yet been operated in the deeper waters where UK wind farm projects are currently planned.

The use of acoustic deterrent devices (ADD's) could add to overall noise levels and disturbance.

If porpoises are not in favourable conservation status (FCS) (although current UK and Marine Atlantic Regional Level Article 17 assessments suggest they are[1]) then thresholds should be set with this in mind. It was suggested that PCBs contaminants may emerge as an issue in future FCS assessments.

4.3. Alternative/complementary approaches

In this session, alternative and complementary approaches to the proposed area thresholds approaches were discussed. In addition, the discussion briefly touched on the potential application of the IROPI provision in Article 6.4 of the Habitats Directive, in the event of an adverse effect on site integrity and no satisfactory alternatives.

- **Noise at source mitigation and alternative foundations**

Noise mitigation was raised on several occasions in the presentations. There is plenty of work on mitigation at source and monitoring of effectiveness. Key points include:

- There seem to be significant benefits from modest noise reduction.
- There is uncertainty of effectiveness- based on modelling in reducing displacement.
- What incentives are there for industry to reduce noise? This is an issue for the regulators to consider.
- There needs to be more exploration of the different sound frequencies generated by pile driving and how these propagate and then how might mitigation work in buffering different frequencies and any influence on the extent and magnitude of disturbance.
- Concerns exist about the commercial viability of mitigation, relating in part to the supply chain and size of project.
- There is some baseline disturbance on sites, with decades of oil and gas exploration for example in the southern North Sea candidate SAC and yet the area displayed persistent high densities.
- You cannot only ask one industry to employ mitigation. The oil and gas industry should also have to mitigate for noise.
- There are variations in mitigation approaches and effectiveness, and an adaptive approach ('learn as you try') will help show what works.

---

1 http://art17.eionet.europa.eu/article17/reports2012/species/summary/?period=3&group=Mammals&subject=Phocoena+phocoena&region=MATL

There was a concern that there might be little incentive to use mitigation in a threshold/quota type approach as that would just be giving more noise 'quota' to others. There could be other impacts from alternative approaches e.g. large footprint of gravity base.

- We will need a timeframe to enable discussions and decisions on management decisions given constraints on industry.

- Are these alternatives feasible in time for round 3 projects?

- The options for installation relate to site specific conditions (e.g. geology) - there will be a need to assess what is best for the business case. e.g. suction buckets are only for sandy substrate sites).

- **Seasonal restrictions** (according to the seasonality of the Southern North Sea cSAC for example)

There were two key issues discussed:

1) Given high demand and limited vessel availability developers will want to work at full stretch in the best conditions. Piling work in winter can face serious weather challenges, and poor weather can cause delays and disrupt programme plans. Installation work could potentially have to be spread over several years if only able to install for 6 months of the year. It could work for projects with a smaller disturbance footprint on the site, particularly in the winter area.

2) The contested robustness of the evidence for a consistent seasonal pattern year on year and the risk that if the seasonal demarcations were wrong, more piling could happen when higher densities are present in the site, negating benefits of seasonal restriction. There may also be variation in harbour porpoise sensitivity at different times of the year. These include breeding cycles and winter blubber thickness. More detailed information may be needed here. More monitoring is needed on distribution and research into what is driving that.

- **IROPI and compensation**

This subject was only briefly discussed and people felt that a workshop focussed on IROPI would be of value. UK government has preferred not to use this Habitats Directive provision. There was a discussion on whether there were any satisfactory alternatives to pile driving or the location of the windfarms. Again, this would be case specific. Some felt it could be argued that there would be a satisfactory alternative in locating the wind farms outside the cSACs. Would cost be an acceptable justification for the lack of satisfactory alternative solutions in the IROPI context?

In terms of compensation, and beyond designating another site which would be difficult given that the sites chosen were the best per the data analyses, a couple of ideas were mentioned such as reducing other pressures on site or on the population. Could having even a fraction of the 15 - 30 million spent on noise mitigation in one German wind farm to spend on bycatch reduction count as compensation?

There was a call for monitoring the potential positive benefits of the wind farm structures once in place – e.g. reef effect – enhancing foraging opportunities in the cSAC which could potentially compensate the temporary disturbance.

5. Issues arising and next steps – a summary of the key points

Discussion around noise management will need to be clear on the conservation goal to be achieved. The key objective remains to avoid significant disturbance of harbour porpoise within the SAC, over space and time. It is important to note that this is not just an issue for renewables – it also applies to oil and gas and other activities that generate loud noise.

Ways to minimise impacts to acceptable levels appear to include three main options:

- Restrictions in space and time
- Alternative foundations
- Noise mitigation

There are issues with all options and the industry wishes for flexibility in terms of the final installation set up given industry related constraints such as supply chain, cost and risk reduction aims, health and safety, operational contingency, finance and technological developments. Whilst understandable this flexibility poses some challenges from a cumulative noise assessment and management perspective. There is uncertainty as to whether noise mitigation technology and alternative non-noisy foundations will be operational and available for construction of Round 3 projects given that currently these technologies are mainly just concepts or have been applied with varying levels of success in shallower water areas closer to the coast. It was also clear that within the consenting process we need to establish clear timeframes for key decisions to be made on noise management.

Compensation and IROPI were briefly touched on with the realisation that this discussion would probably benefit from a separate workshop.

Regulation

It appears that there are several public bodies and government departments that have some responsibility in regulation. If there is to be an effective and adequate noise management process, then the senior management of these bodies will need to work together to develop that process. How this would happen is not clear and may require one regulator to take a lead. There may be a need for a regulator forum, and possibly a regulator group for each cSAC, and their work / approach will need to be consistent.

Next steps

While participants were positive about what had been discussed and the opportunities for better mutual understanding, there were concerns raised on the noise assessment and management approaches currently in discussion. The various presentations had made it clear that there are no easy and immediate solutions. Some felt that there was now more uncertainty on regulation and the requirements on operators.

In summary, a range of questions need to be answered:

- Which agency will ultimately by responsible for noise management?
- How would regulators prioritise activities if cumulative thresholds are breached?
- How do we ensure the sharing of information from developers?
- How would developers work together in developing cumulative scenarios?
- A review of thresholds / activities is needed
- How could an allocation protocol work – is this something like ‘emissions trading’?
- There is still a lot of work to be done to develop a workable system.

Annex 1: Participant List

Participant	Organisation	Briefing Group		
Alan Gibson	Marine Management Organisation (MMO)	3	1	2
Alec Taylor	World Wildlife Fund (WWF)	3	1	2
Alice Puritz	Client Earth	2	3	1
Alison Elliot	Department for Environment Food & Rural Affairs (Defra)	1	2	3
Caroline Carter	Scottish Natural Heritage (SNH)	1	2	3
Carol Sparling	SMRU Consulting	2	3	1
Chris Church	Oxford Facilitation Services	Facilitator		
Claire Ludgate	Natural England (NE)	2	3	1
Colin McAllister	Innogy	3	1	2
David Still	Business Energy & Industrial Strategy (BEIS)	2	3	1
Dominic Pattinson	Department for Environment Food & Rural Affairs (Defra)	3	1	2
Eva Philipp	Vattenfall	1	2	3
Filippo Locatelli	Renewable UK	2	3	1
Francesca Marubini	Hartley Anderson	3	1	2
Gareth Lewis	RenewablesCG	1	2	3
Gillian Sutherland	Scottish Power	3	1	2
Ian Davies	Marine Scotland	2	3	1
Jennifer Learmonth	Royal-Haskoning	3	1	2
Jennifer Brack	Dong Energy	2	3	1
Jesper Kyed-Larsen	Vattenfall	3	1	2
Jessica Campbell	Crown Estate	2	3	1
John Goold	Joint Nature Conservation Committee (JNCC)	Briefing Lead (2)		
Jonathan Wilson	SSE Renewables	2	3	1
Julie Cook	Business Energy & Industrial Strategy (BEIS)	1	2	3
Karen Hall	Scottish Natural Heritage (SNH)	3	1	2
Kate Brookes	Marine Scotland	1	2	3
Kelly Macleod	Joint Nature Conservation Committee (JNCC)	Briefing Lead (1)		
Nancy McLean	Natural Power Consultants	3	1	2
Nick Brockie	SSE Renewables	3	1	2
Pete Gaches	GoBe Consultants	1	2	3
Peter Evans	Sea Watch Foundation	3	1	2
Philip Bloor	Pelagica	1	2	3
Rachel Furlong	Scottish Power	2	3	1
Rebecca Sherwood	Triton Knoll	2	3	1
Rebecca Walker	Natural England (NE)	1	2	3
Richard Green	Marine Management Organisation (MMO)	2	3	1
Ross Hodson	Marine Management Organisation (MMO)	1	2	3
Sarah Canning	Joint Nature Conservation Committee (JNCC)			
Sarah Dolman	Whale and Dolphin Conservation (WDC)	1	2	3
Siobhan Browne	Business Energy & Industrial Strategy (BEIS)	3	1	2
Sonia Mendes	Joint Nature Conservation Committee (JNCC)	Briefing Lead (3)		
Stephen Foster	Department of Agriculture, Environment and Rural Affairs (DAERA)	3	1	2
Tania Davey	Wildlife Trusts	2	3	1

Tessa McGarry	RPS Group	2	3	1
Tom Stringell	Natural Resources Wales (NRW)	2	3	1
Trevor Baker	Innogy	1	2	3
Victoria Crossland	Business Energy & Industrial Strategy (BEIS)	3	1	2
Briefing Group	**Title**	**Briefing Lead**		
1	Threshold justification	Kelly Macleod		
2	Implementation	John Goold		
3	Alternative / complementary approaches	Sonia Mendes		

Annex 2: Themed Discussion Briefing Notes

Briefing note 1: Use of thresholds to assess and manage the effects of noise on site integrity

Background

The designation of harbour porpoise cSACs requires appropriate management to ensure the conservation objectives of the sites are met. The proposed assessment and management approach in relation to 'noisy activities' which harbour porpoise are susceptible to (e.g. pile driving and seismic survey operations) is based on the concept of a threshold, both spatially and temporally. It is a pragmatic approach that aims to balance the need for conservation measures for the SACs, but recognises the need for renewables in light of climate change.

Introduction

The conservation objectives for the harbour porpoise SACs in England, Wales, Northern Ireland and offshore waters include:

'There is no significant disturbance of the species'

And in Scotland:

'[maintain] *the distribution of harbour porpoise throughout the site by avoiding significant disturbance'*

Article 6 of the Habitats Directive requires '*Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives'*. For assessments, it will need to be determined whether there is disturbance within the cSAC and whether this is significant. CNCBs have proposed that for the purpose of assessments that *significant disturbance* means: '*the exclusion of harbour porpoise from a significant portion of the SAC for a period of time'.*

This definition had been expanded further to:

Noise disturbance within a SAC from a plan/project individually or in combination will not exclude harbour porpoises from a maximum of 20% of the relevant area[2] of the SAC for a period of 1 day. And,

Over a season, the noise disturbance within a SAC from a plan/project individually or in combination per day will not exclude harbour porpoises from an average of 10% of the relevant area of the SAC.

Further details on the proposed approach are set out in the discussion document that has been circulated in advance of the workshop.

Potential discussion points:

1. Discuss the pros/cons of the 'area' versus 'number' approach for the porpoise sites. Is the area approach justified?
2. Assumptions around area/carrying capacity/numbers logical?

[2] The relevant area is defined as that part of the SAC that was designated on the basis of higher persistent densities for that season (summer defined as April to September inclusive, winter as October to March inclusive).

3. The ‘thresholds’ have been derived through reference to the ASCOBANS objective. Does the rationale in the document support the choice of threshold values?
4. Is the use of thresholds for *disturbance* justified and if not, is there an alternative?
5. Would the threshold approach stand up to scrutiny in light of the high bar test set by the Wadenzee judgement, i.e. a plan or project can only be approved where no reasonable scientific doubt remains as to the absence of an adverse effect on site integrity?

Briefing note 2: Implementing the noise thresholds approach in harbour porpoise SACs

Background

The designation of harbour porpoise SACs requires appropriate management in order to uphold the conservation objectives of the sites.

The proposed approach in relation to assessment of ‘noisy activities’ which harbour porpoise are susceptible to (e.g. pile driving and seismic survey operations) is based on the concept of a threshold, both spatially and temporally. It is a pragmatic approach that aims to balance the need for conservation measures for the SACs, but recognises the need for renewables in light of climate change.

It is also worth noting that these activities have not previously been managed within protected sites at the scale (both spatially and temporally) currently being proposed in UK waters.

Implementing the proposed assessment approach

Initial feedback from stakeholders on the proposed threshold approach included some points on aspects of implementation as follows:

Coordination among regulators

- Concerns regarding the practical aspects of implementing the approach across regulators of different industry sectors with differing remits (e.g. OPRED, BEIS and the MMO). Coordination amongst regulators is needed for the thresholds approach to work as it is applicable to all noisy activities.

- Concerns regarding the practical aspects of implementing the approach, in terms of tools/ techniques that could be utilised to manage and monitor compliance across sectors in a timely manner.

Simplicity of threshold approach

- Positive feedback in relation to the simplicity of the thresholds approach in the risk assessment/ EIA stage. Having quantitative thresholds is an objective way with which to assess individual developments and would likely help Regulators by allowing more consistency between assessments and avoid the need for complex noise/ population numbers models

- There were views that whilst there are challenges in the application of the threshold approach these are not insurmountable.

General Operability

There are a number of points to consider here:

- Variability in timelines, practice and regulatory processes between different sector activities. For example:
    - o Offshore windfarm piling schedules are generally unknown until an advanced stage in the post consent process.
    - o Applications for large scale seismic surveys (e.g. 3D surveys) usually request a lengthy time period within which to undertake operations (i.e. many months), whereas active seismic activities may only take place on a much smaller number of days within the consented time period.
    - o Planning activities down to specific days is impractical (although reporting this after the event is feasible). For example, OPRED usually approve a window of activity for oil & gas operations. If the thresholds approach requires a daily schedule for cross sectoral assessment, this could be extremely challenging given contingency for live circumstances, such as weather down-time.
- The mechanism by which regulators will communicate to assess the cumulative impact of noisy activities, and for spatial and temporal management and compliance.

Compliance and reporting

- The thresholds approach may require quicker compliance reporting and monitoring across sectors to inform regulatory compliance and site management (and review the management approach to inform revisions if needed). Practicalities, as well as resource implications for review of such aspects needs to be considered (across regulators and their advisors).
-

Briefing note 3: Alternative approaches to assessment and management with a focus on offshore wind turbine installation

Background
Whether or not the SNCB proposed threshold approach is adopted to use as the main noise disturbance assessment and management tool in harbour porpoise SACs there is a need to explore other options for noise management. This is due to a likelihood that for some plans and projects it will not be possible to conclude that no reasonable scientific doubt remains[3] as to the absence of adverse effects on site integrity. This breakout session will elicit views from participants on what approaches to noise assessment and management may be available to allow for both the objectives of the offshore wind industry and the Southern North Sea cSAC's conservation objectives to be fulfilled.
Alternative/Complementary approaches

a) *Less noisy alternatives (piling with noise mitigation/alternative foundations)*

[3] This ruling has set the bar high (Case C-127/02 *Waddenvereniging and Vogelbeschermingsvereniging,* Waddenzee).

There are several techniques proven to partially reduce piling noise into the water column and therefore reducing the disturbance spatial footprint. No method has been found to totally buffer the noise. Some have already been used in Germany, others are in development. For example:

- AdBm Noise Abatement System
- Bubble curtains, noise mitigation screens
- Blue piling

Q1: What are the constraints to the application of such measures in offshore wind in the UK?
Q2: Would their use mean no adverse effect on site integrity?

There are alternative foundations:

- Suction buckets
- Floating
- Gravity base

Q1: What are the constraints to the application of such measures in offshore wind in the UK?
Q2: Would their use mean no adverse effect on site integrity?

b) IROPI and compensation

The Habitats Directive provides a clear framework and flexible instruments within which appropriate decisions can be taken, so that the right balance can be struck between economic development and habitat/species conservation. For example, it makes provision for adverse effect on site integrity if there are Imperative Reasons of Overriding Public Interest (IROPI). The relevant Article, 6(4), states that:
"'*If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted*."

IROPI
'It is reasonable to consider that the "imperative reasons of overriding public interest, including those of social and economic nature" refer to situations where plans or projects envisaged prove to be indispensable:
- within the framework of actions or policies aiming to protect fundamental values for the citizens' life (health, safety, environment);
- within the framework of fundamental policies for the State and the Society;
- within the framework of carrying out activities of economic or social nature, fulfilling specific obligations of public service.'

Compensation
'The compensatory measures constitute measures specific to a project or plan, additional to the normal practices of implementation of the "Nature" Directives. They aim to offset the negative impact of a project and to provide compensation corresponding precisely to the negative effects on the species or habitat concerned. The compensatory measures constitute the "last resort". They are used only when the other safeguards provided for by the directive are ineffectual and the decision has been taken to consider, nevertheless, a project/plan having a negative effect on the Natura 2000 site.'

Compensation for disturbance of annex II species is unprecedented, could the following compensatory measures be acceptable?
- Maintaining or improving species' prey availability within the site
- Creation of highly protected areas within the cSAC, where no activity is allowed
- Reduction of other threats (e.g. bycatch)

Research, monitoring, or education – should not be considered as compensation. 'Also, payment for nature compensation should not be considered as compensation (see ECJ judgement C-209/04) till the money are used for real compensatory measures.'

Q1: In the absence of satisfactory alternatives and an inability to conclude beyond reasonable scientific doubt that the plan or project would have no adverse effect on the site, would the IROPI instrument provided in the Habitats Directive be a realistic option?
Q2: What would be the advantages / disadvantages and constraints of the IROPI avenue?

References
Geert Van Hoorick. Compensatory Measures in European Nature Conservation Law. Utrecht Law Review. *http://www.utrechtlawreview.org | Volume 10, Issue 2 (May) 2014 | URN:NBN:NL:UI:10-1-115820*
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82647/habitats-directive-iropi-draft-guidance-20120807.pdf
http://www.ceeweb.org/wp-content/uploads/2012/01/Compensation_guidance.pdf
http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/guidance_art6_4_en.pdf
http://ec.europa.eu/environment/nature/natura2000/management/opinion_en.htm

IROPI example
Commission says imperative reasons of overriding public interest outweigh adverse effects of extending a DASA group factory on the Müehlenberger Loch in Hamburg
In an opinion delivered today, the Commission has said that the adverse environmental impact of extending a factory belonging to the DASA group on the Müehlenberger Loch in Hamburg can be justified on grounds of overriding public interest. The project concerns an extension of the DASA factory over some 170 ha of an area known as the Müehlenberger Loch, to expand production of the Airbus A 3XX jumbo jet.

- Germany says there is nowhere else in the country where the project can be carried out.
- For reasons of competitiveness and on technical grounds, the factory has to be next to an existing factory with a skilled workforce and the equipment needed.
- For functional reasons and because of the size of the workshops needed to build the jumbo jet, the project can only be located at the spot in question.
- The project is of overriding public interest for social reasons: the factory will generate at least 4000 jobs, and possibly as many as 8000, in the Hamburg region, but also in the *Länder* of Schleswig-Holstein and Niedersachsen; for economic and technical reasons: the project is targeted on a new market. The market for jumbo jets is dominated by a single manufacturer, and Europe still does not produce any;
- for reasons of Community interest: the scheme is so important and the economic interests at stake are on such a scale that it is a matter of Community-wide concern. The project calls for extensive cooperation between various Member States, and it is vital that Germany works alongside its other partners if the scheme is to be a success.

Annex 3: SNCB Discussion Paper

A potential approach to assessing the significance of disturbance against conservation objectives of the harbour porpoise cSACs.

1 Development of approach

A suite of five pSACs for harbour porpoise in Welsh, Northern Ireland, English and offshore waters were consulted on between January and May 2016. A site in Scottish waters was consulted on between March and May 2016. The start of public consultation triggers 'policy protection' and pSACs become a material consideration in assessments of plans/projects. For this reason, guidance on the implementation of Conservation Objectives for the sites is needed so that CNCBs can fulfil their statutory role of providing advice to Regulators and stakeholders. All six sites have now been submitted to the European Commission and are formally candidate SACs (cSACs).

This document sets out a potential approach to assessing and consequently managing noise disturbance within harbour porpoise cSACs and has been developed through the Inter-Agency Marine Mammal Working Group (IAMMWG). The document was developed with a focus on testing the approach using pile driving in the installation of offshore wind turbine foundations; an activity known to disturb harbour porpoises, as this has been the most pressing need with regards to ongoing casework. As such, this approach is driven by plans/projects that occur within or overlap (if the noise zone overlaps with the cSAC boundary) with the Southern North Sea cSAC. There are currently no plans or projects to install offshore wind farms within cSACs off Wales, Northern Ireland or Scotland. However, the intention is that the approach described would apply to all activities that could potentially cause similar noise disturbance to porpoise within any cSAC (or outside a cSAC if the noise zone overlaps with the cSAC), and all activities potentially causing noise disturbance may need to be assessed cumulatively or in combination using this approach. To demonstrate the wider application of the approach, a further case study, recently completed by SNH, to assess disturbance from aquaculture is appended (Appendix I).

2 Purpose of the approach

Harbour porpoises are European Protected Species (EPS) on Annex IV of the EU Habitats Directive and are strictly protected throughout their EU range. Wider measures, for example bycatch reduction and monitoring (under Regulation 812/2004), are also in place to protect the species in EU waters. This species is also on Annex II, which means SACs need to be designated in order to complement the wider measures in contributing to the Favourable Conservation Status of the species.

Supplementary advice is under further development to accompany Conservation Objectives (COs) for the sites. In particular, this document has been produced to aid the assessment (and consequently management) of noise generating activities that potentially present a risk to achievement of the Conservation Objective that relates to disturbance of harbour porpoise within cSACs. This advice does not explicitly cover the related issue of *permanent* displacement of harbour porpoise from habitat within sites, e.g. through permanent placement of structures.

The draft COs for the five harbour porpoise cSACs in English, Welsh, Northern Ireland and offshore waters are:

'To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status for the UK harbour porpoise. To ensure for harbour porpoise that, subject to natural change, the following are maintained or restored in the long term: 1. The species is a viable component of the site; 2. There is no significant disturbance of the species; and 3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.'

In Scotland, the draft COs for the site are:

1. To avoid deterioration of the habitats or significant disturbance of harbour porpoise thus ensuring that the integrity of the site is maintained and it continues to make an appropriate contribution to harbour porpoise remaining at favourable conservation status in UK waters. 2. To ensure that, within the context of environmental change, the following are maintained in the long term: 2a. the relatively high density of harbour porpoise throughout the site compared to other parts of the continental shelf within the West Scotland Management Unit. 2b. the distribution of harbour porpoise throughout the site by avoiding significant disturbance 2c. the condition of supporting habitats and processes, and the availability of prey for harbour porpoise.

Management of disturbance within the SACs should ensure the relevant Conservation Objective is met.

This document proposes an approach that defines 'significant disturbance' for activities causing noise, in relation to the relevant Conservation Objectives and its implications for management of an activity affecting a cSAC.

3 Introduction

Harbour porpoise are a European Protected Species (EPS) and are sensitive to noise from pile driving, which may result in disturbance and, if unmitigated, injury. It is an offence under the Habitats Directive to deliberately kill, injure or disturb an EPS. Pile driving undertaken for installation of offshore wind turbines would typically require an EPS licence to avoid committing an offence and developers undertaking pile driving may be required to minimise the risk of injury to marine mammals, typically by following the widely accepted JNCC protocol[4]. However, the protocol primarily addresses the avoidance of injury in close proximity to the noise source.

[4]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/50006/jncc-pprotocol.pdf

Current practice (in the absence of SACs), is to assess the effects of disturbance on harbour porpoise at the population level by using the best available population estimate of the relevant Management Unit (IAMMWG, 2015). Such assessments are typically carried out as part of Environmental Impact Assessments and Strategic Environmental Assessments. With the designation of cSACs for harbour porpoise a draft site specific conservation objective that relates to disturbance has been introduced. Therefore, the effects of noise disturbance from plans or projects need to be considered in a Habitats Regulations Assessment (HRA). Given the immediacy of the site designations, a clear approach to assessing the potential impacts of noise generating activities within sites is needed and one such approach is provided here.

4 Developing the approach

The purpose of an HRA is to determine whether a proposed plan or project (occurring within or outside a SAC) could adversely affect a site's integrity. The critical consideration in relation to site integrity is whether any activities having an effect on a site, either individually or in combination with other plans or projects, affect the site's ability to achieve its Conservation Objectives and to contribute to the Favourable Conservation Status of the species.

The suitability of using *abundance* of harbour porpoise as a component of the Conservation Objectives was initially considered because the sites were selected based on the persistently higher densities of porpoise within sites compared to other areas of the Management Units (MUs). However, as mobile and wide-ranging species, density of harbour porpoise within the site varies at any one time; for example, the average density of harbour porpoise in the Bristol Channel Approaches cSAC is 0.37animals/km^2 based on the SCANS-II estimate from July 2005 but this is double what the estimate from the SCANS survey of 1994 was. It is not, therefore, appropriate or practical to maintain a given harbour porpoise abundance within a site because of the natural variability in numbers. Any assessment of changes in the numbers of porpoise using the site would require long term studies (potentially 10 years or more), and it is acknowledged that these time scales would be unachievable for any short term assessment. As long as the abundance within the MU is maintained *and* the site conservation objectives are met, Favourable Conservation Status of the species will be maintained. The conservation status of harbour porpoise will be re-assessed and reported on in the next Habitats Directive Article 17 reporting round covering the period 2013 -2018.

The Habitats Directive (Article 3(1)) states that the Natura 2000 network comprises sites hosting *habitats for the species* on Annex II; such a network will ensure that the habitats of the species' concerned should be maintained. The sites for harbour porpoises have been identified on the basis of habitat models which show areas that persistently have higher densities of harbour porpoise, presumably because they offer good foraging opportunities or support other stages of the harbour porpoise life cycle. It is therefore important that harbour porpoise can access and utilise the habitats within the site. Taking piling as an example, it is well known that pile driving will exclude harbour porpoise from an area of habitat for the duration of pile driving and for a period of time after pile driving has ceased. The length of time it takes for porpoises to return after the cessation of pile driving varies, generally between a few hours (less than a day - Tougaard et al. 2009; Brandt et al. 2012; Dahne et al. 2013) and up to 3 days (Diederichs et al. 2009; Brandt et al. 2011). The extent of displacement and length of the response may be driven by the sound characteristics of the noise propagating away from the pile driving and/or of the habitat and value to the porpoise or behavioural context. There is a single case where harbour porpoise did not return to a wind-farm, even 10 years' post- construction (Teilmann and Carstensen 2012); however, in this case, the wind farm was on the periphery of the harbour porpoise range and the value of the area pre-construction to the harbour porpoise may have been low.

The interpretation of 'significant disturbance', without using porpoise abundance, can therefore be split into two components: disturbance in time and in space. Thus, the disturbance Conservation Objective can be further developed and defined to ensure that **'disturbance does not lead to the exclusion of harbour porpoise from a *significant portion* of the SAC for a period of time'.**

4.1 Definition of significant portion

It is not immediately clear how disturbance leading to displacement manifests itself as changes in populations. Complex models (PCAD; iPCoD and DEPONS) provide conceptual frameworks of how the process might work but empirical knowledge needed to parameterise these is lacking. An alternative approach could be to quantify areas of habitat from which harbour porpoise have been disturbed and displaced, i.e. 'gaps', due to anthropogenic activity. These 'gaps' can be translated into effects on species distribution and population viability (Tougaard et al. 2013). In other words, displacement of harbour porpoise from their habitat may result in the carrying capacity[5] (K) of the wider area being reduced. A definition of '*significant portion*' at the site level can, therefore, be based on the effects of the 'loss' of habitat available to harbour porpoise and its reduction in the carrying capacity of the site, since this will reduce the ability of the site to make a full contribution to maintaining the population. Long-term, permanent reduction in K may manifest in population declines. The assumption is, therefore, that disturbance of harbour porpoise by pile driving noise will result in their exclusion from the habitat and consequently impact the carrying capacity of the site. This approach makes it possible to consider possible impacts of habitat exclusion as a result of pile driving and other noisy activities and can be used to inform management decisions. The impact is mediated through the effects of disturbance driven habitat exclusion on the vital rates of the population.

European Signatory States to ASCOBANS[6] defined and agreed the Conservation Objective that would enable the aims of the Agreement to be realised as 'to allow populations to recover to and/or maintain 80% of carrying capacity in the long term'. ASCOBANS arrived at this objective having considered work undertaken within the International Whaling Commission (IWC) in developing their Revised Management Procedure. The IWC adopted an approach that would lead to whale stocks being restored to and maintained at 72% of carrying capacity; the rationale underpinning this was in ensuring management of whale stocks allowed maximum yields. In the USA, the Marine Mammal Protection Act led to the development of an approach that would allow populations of cetaceans to recover (after exploitation) to 60% of carrying capacity after 100years. ASCOBANS, with its conservation focus, agreed that a more precautionary approach was required and accepted that recovery to and/or maintaining 80% of carrying capacity in the long term would be the objective.

In the absence of other data/metrics to inform what would be a significant reduction in habitat, the SNCBs have chosen to use this objective to provide guidance on what magnitude of temporary 'habitat loss' might be considered significant. Whilst the ASCOBANS objective was not developed to meet the requirements of the Habitats Directive, it was developed as a precautionary standard to assess a significant reduction in the wider harbour porpoise population. For current purposes, we assume a directly proportional

[5] The carrying capacity of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.
[6] http://www.ascobans.org/

relationship between loss of access to habitat and carrying capacity (as per Tougaard et al. 2013) and for simplicity that the distribution of porpoise density is approximately uniform within the site[7]. Therefore, application of this objective to the maintenance of carrying capacity implies that 80% of harbour porpoise habitat (and hence carrying capacity) within a site needs to be accessible in the long-term or conversely, no more than 20% of the habitat should be inaccessible without adversely affecting carrying capacity. However, as the ASCOBANS objective is intended for the population (or Management Units) then the SNCBs concluded that the loss of access to habitat within a cSAC should be less than the 20% that the objective implies, especially as it is known that the density of harbour porpoises within the cSACs is on average higher than elsewhere. Therefore, the SNCBs have determined that an average loss of access to 10% or more of the cSAC would be considered significant, recognising that the cSAC habitats supports elevated densities of porpoises compared to the rest of the MU (assume density within the site is, on average, twice that outside the site[8]). The need to maintain site integrity also requires that the loss of access to habitats by harbour porpoise cannot be permanent and there should be no lasting harm on the site. Maintenance of the site's carrying capacity in the long term through management of temporary habitat 'loss' to below the defined thresholds would ensure that it continues to contribute to the maintenance of the UK's harbour porpoise population at Favourable Conservation Status.

Some SACs have seasonal areas or are designated entirely for their summer (April – September) or winter (October – March) elevated densities of harbour porpoise. The definition of seasons is based on the modelling outputs of Heinänen and Skov (2015) which predicted persistent, seasonal high density areas of harbour porpoise based on 18 years of data (1994-2011); this is the evidence underpinning the identification of the cSACs. The seasonality of proposed plans or projects should be taken into account when considering whether it will adversely affect the integrity of the site. Plans or projects occurring within the boundary of a SAC but operating outside of the season for which the SAC was designated, will not contribute to a 'significant portion'; instead such activities will be considered through the regular channels for EPS.

4.2 Definition of adverse effects on site integrity

For the purposes of developing this approach, site integrity will be affected by a loss of carrying capacity mediated through loss of access to an area of cSAC habitat over a period of time. This will define the threshold for 'adverse effect on integrity (AEOI)' for the purposes of an Appropriate Assessment (AA: part of an HRA).

5 The proposed approach

1. Ultimately, the purpose of the cSACs is to contribute to maintaining FCS for harbour porpoise and in order to do this, the site's integrity needs to be maintained in line with the site's Conservation Objectives.

---

[7] The variation in porpoise density within the sites is not well understood because of a lack of information on how they use the site.

[8] Based on the SCANS-II (Hammond et al. 2013) the average density in the Southern North Sea cSAC using the overlapping block estimates (B and U) is 0.46animals/km^2.The average density in the wholly North Sea blocks with no cSAC overlap (T and V) is 0.22 animals/km^2.

2. Noise disturbance within a cSAC from a plan/project individually or in combination will not exclude harbour porpoises from a maximum of 20% of the relevant area[9] of the cSAC for a period of 1 day. And,

3. Over a season, the noise disturbance within a cSAC from a plan/project individually or in combination per day will not exclude harbour porpoises from an average of 10% of the relevant area of the cSAC.

4. This approach would suggest that plans or projects individually or in combination that breach points 2 or 3 would be deemed to have an adverse effect on site integrity, and mitigation beyond routine EPS measures would be required.

5. Advice with regard to impact monitoring will be considered with consents and review of consents. A strategic approach that carefully considers the scale and nature of monitoring required and coordination in conjunction with SNCBs may better enable the success of the implementation of this approach to be reviewed and updated where needed.

5.1 Example application to pile driving in the Southern North Sea cSAC

Significant noise disturbance cannot take place within the cSAC indefinitely. Taking piling as an example of a noisy activity, the installation of a single pile generally requires a few hours (<6) of pile driving within a 24 – 48 -hour time period. Installations of piles are often punctuated by days/weeks of no piling due to poor weather or other factors. For successful implementation of this approach, an approximate daily and realistic schedule of pile driving will be needed for assessments. Seismic operations, UXO detonations etc will also be required as and when projects undertake an HRA.

For assessment purposes, the effective deterrent radius (EDR) of a single monopile is taken to be 26 km (Tougaard et al. 2013) and the area of harbour porpoise exclusion approximates 2,100 km^2 during a single pile driving event. For other activities, such as seismic surveys, the effective deterrent radius will be different. Field measurements of the distance over which harbour porpoise respond to pile driving may be expected to vary with pile diameter. However, piles used at Alpha Ventus were 2.5m (500kj hammer energy) compared with the larger 4m piles used at the Horns Reef I and II (900kj hammer energy) and reaction distances were broadly similar: 15-25km (Diederichs et al. 2009; Dahne et al. 2013) and 18-21km (Brandt et al., 2011; Tougaard et al. 2009) respectively. The proposed effective deterrent radius of 26km is based on a ‘typical’ monopile of 60-70m in length, 4-6.5 m wide and with a wall thickness of a few centimetres (Tougaard et al. 2013). The effective deterrent distance was based on the displacement function from Dahne et al. (2013). There will be periodic consideration of the suitability of this EDR in light of accumulating scientific knowledge should this approach be taken forward.

The distribution of wind farm areas in relation to the Southern North Sea cSAC is shown in Figure 1. Based on the 26km effective deterrent distance, two to three (‘actual’ area equivalent is 2.5 pile driving events) geographically separated pile driving events wholly within the summer Southern North Sea cSAC area in one day would approach the maximum of 20% disturbance.

In the winter area, one to two (‘actual’ area equivalent is 1.3) pile driving events wholly within the winter area of the cSAC would approach the daily maximum of 20% disturbance. On a daily basis, the 20% must not be exceeded and for a conclusion of no effect on site integrity

[9] The relevant area is defined as that part of the SAC that was designated on the basis of higher persistent densities for that season (summer defined as April to September inclusive, winter as October to March inclusive).

to be reached, the planned piling must not exceed an average of 10% over the relevant season.

Pile driving events planned in close proximity to each other would reduce the spatial footprint and potentially enable additional events.

Similarly, events at the edge (or in some cases beyond the edge) of the SAC will contribute less to the allowable spatial footprint within the cSAC.

However, other noisy activities would need to be assessed in the same way and thereby these thresholds may be less than indicated above.

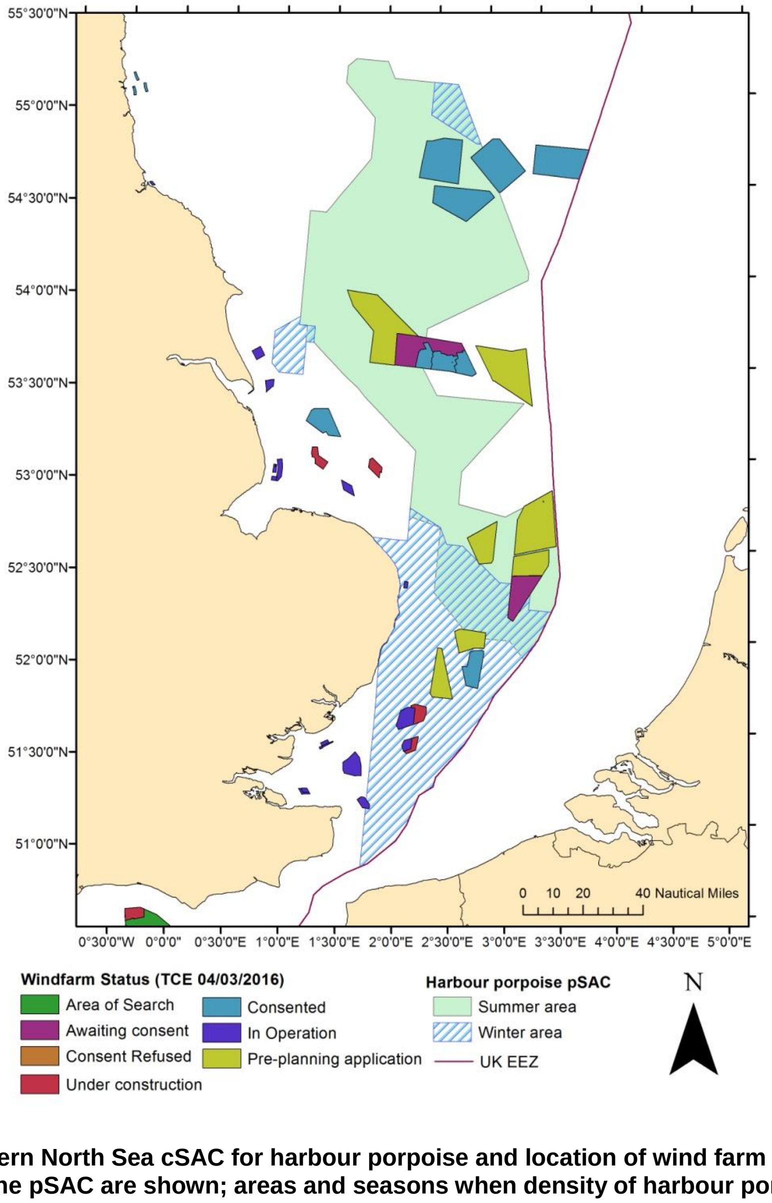

Figure 1: Southern North Sea cSAC for harbour porpoise and location of wind farm areas. Seasonal components of the pSAC are shown; areas and seasons when density of harbour porpoise is highest.

5.2 Management options when conditions are exceeded

Where developments collectively within a cSAC exceed the significance thresholds, a number of options for reducing impacts will need to be considered for consent to be granted:

1. Schedule activities so that limits are not exceeded. Careful planning and phasing of noisy activities could be undertaken so as to ensure site integrity is not affected.

2. Use of alternative foundations that do not require pile driving (e.g. suction buckets), noting that these may in some cases have other impacts.

3. Use of alternative methods of piling (e.g. vibropiling) to reduce the noise footprint.

4. Use of technology to reduce the sound at source, to reduce the noise footprint.

References

Brandt, M.J., Diederichs, A., Betke, K., and Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. *Marine Ecology Progress Series*, **421**: 205–216.

Brandt, M., Diederichs, A., Betke, K., and Nehls, G. (2012). Effects of Offshore Pile Driving on Harbor Porpoises (Phocoena phocoena). Pp. 281–284 in: Popper, A.N., and Hawkins, A. (eds.) The effects of noise on aquatic life, Advances in Experimental Medicine and Biology, vol. 730. Springer, New York.

Dähne, M., Gilles, A., Lucke, K., Peschko, V., Adler, S., Krügel, K., Sundermeyer, J., and Siebert, U. (2013). Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. *Environmental Research Letters* **8**, 025002.

Diederichs A, Brandt MJ, Nehls G (2009). Effects of construction of the transformer platform on harbor porpoises at the offshore test field “alpha ventus.” Report to Stiftung Offshore-Windenergie, BioConsult SH, Husum, Germany.

Hammond, P., Berggren, P., Benke, H., Borchers, D., Collet, A., Heide-Jorgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N. (2002). Abundance and harbour porpoises and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology*, **39:** pp. 361-376.

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D., Gordon, J., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C.G.M., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., van Canneyt, O. & Vázquez, J.A. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation,* **164:** pp. 107–122.

IAMMWG. (2015). Management Units for cetaceans in UK waters (January 2015). JNCC Report No. 547, JNCC Peterborough. http://jncc.defra.gov.uk/pdf/Report_547_webv2.pdf

Teilmann, J. and Cartensen,J. (2012). Negative long-term effects on harbour porpoises from a large scale offshore windfarm in the Baltic – evidence of a slow recovery. *Environmental Research Letters* **7** 045101 (10pp).

Tougaard, J., Carstensen, J., Teilmann, J., Skov, H., and Rasmussen, P. (2009). Pile driving zone of responsiveness extends beyond 20 km for harbour porpoises (*Phocoena phocoena*, (L.)). *Journal of the Acoustical Society of America*. **126**, 11-14.

Tougaard, J., Buckland, S., Robinson, S. and Southall, B. (2013). An analysis of potential broad-scale impacts on harbour porpoise from proposed pile driving activities in the North Sea. Report of an expert group convened under the Habitats and Wild Birds Directive – Marine Evidence Group MB0138. 38pp.

Appendix I: Application of approach to assessing noise disturbance as a result of the aquaculture industry within the Inner Hebrides and Minches cSAC

Background

For this example of application, we focus on the potential noise disturbance from the use of acoustic deterrent devices (ADDs) by aquaculture within the Inner Hebrides and Minches cSAC. This is located on the west coast of Scotland (Fig 1) and encompasses an area of approximately 13,802km^2.

ADDs are used in aquaculture as part of the industries' predator control methodology. The availability of different ADD systems means that the acoustic output can vary from site to site depending on the devices used. Currently, on the west coast there are mainly three types of device used: Airmar[10], Terecos and Ace Aquatec.

Standard ADD types emit sound in the hearing range of both cetaceans and seals, and there is a body of evidence (see ORJIP[11] for a review) to show that these ADDs can elicit a disturbance/ deterrence effect, potentially over significant distances.

It is challenging to determine exactly the number and locations of fish farm ADD use, as there is currently no requirement for this to be registered centrally. In addition, their use is likely to vary from year to year and, potentially within the year. It is also not clear as to how the individual fish farms deploy the ADDs (continuous, triggered, as and when necessary) as this seems to depend on the preference of each site manager and this is not necessarily logged in detail.

ADD disturbance radii

The distance from source that harbour porpoise may be disturbed is not well understood, and depends on many variables, notably;

- the acoustic characteristics of the ADD
- the sound propagation of the site
- the animals' behavioural response to the received sound

Sound propagation can be modelled; however, the degree of 'accuracy' of the modelling predictions often depends on the complexity of the model, and preferably requires ground truthing measurements. There is a wide range of modelling techniques and it is possible to obtain very different predictions depending on the model selected. Simple models do not account for site specific environmental variables, whereas more sophisticated models can but are far more computationally complex.

[10] Airmar transducer is now used within newer products that use different management systems.
[11] Offshore Renewables Joint Industry Program – Project 4 – ADD efficacy

Fish farm locations are usually in relatively sheltered locations, sheltered by the mainland or by islands nearby. This topography as well as bathymetry and seabed type will have an effect on how the sound will propagate. Land/islands will form an acoustic barrier, so if an ADD is placed in front of an island, the island will shadow the noise output beyond the island. Some noise will diffract around the land, but will lose intensity in doing so.

Rather than model the complexity of the cSAC, it was decided to gain a broad brush indication of the degree of disturbance that we might expect from ADDs. We therefore modelled propagation loss using the semi-empirical expressions of Marsh and Schulkin (M&S) (Urick, 1983). These equations incorporate parameters for the depth of the water column, sound absorption, shallow water attenuation and near field anomalies, and allow for sea bed type (mud or sand) and sea state (same parameters used site wide). Disturbance radii estimated for different devices ranged from <100m (Terecos) to about 2.5 km (Airmar type). Comparison of estimated transmission loss, with the transmission loss estimated in Lepper et al (2014) suggests that the M&S model as we used it may not be as conservative as the more complex model Lepper used. Coram et al (2014) presented a disturbance radius of 3.5 km based on a literature review. Brandt et al (2013) found a disturbance effect at 7.5 km from a Lofitech ADD. It is clear that there could be a significant uncertainty in the estimation of disturbance from ADDs in the cSAC both temporally and spatially.

For this example, we have used the disturbance radius of 3 km, as a compromise between our results and Coram et al (2014).

Active finfish farms & estimation of area disturbed

Figure 1 details the active and inactive fin fish farms as at March 2016. This is a snapshot as we are aware that the number of active finfish farms is likely to be variable due to the industry using different sites at different times.

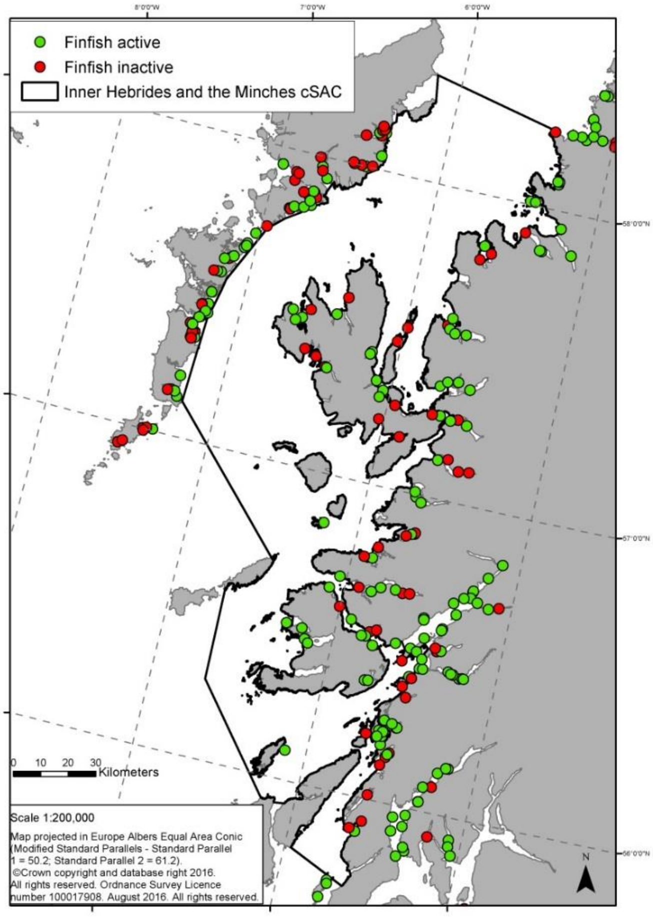

Figure 1 - Finfish aquaculture sites in relation to the cSAC.

Assumptions

We consider that the disturbance area can only be seaward of each fish farm group (due to presence of land); therefore, rather than including the entire area in a circular buffer with the diameter of 3 km, half this area was used. This may still be conservative as the presence of other topography and islands may further restrict this zone.

For fish farms that are not contained within the cSAC, it is relevant to consider if any of the 3 km buffer zone extends into the cSAC (*e.g.* those farms on the outer isles). It is not proportionate to include the entire 3 km area for these locations, therefore a quarter of the buffer area was assumed.

Due to the potential variable numbers of active fish farms, different scenarios were used to consider the potential percentage area of the cSAC that may be disturbed due to ADD use.

The numbers of farms used in this example were;

- within the cSAC boundary (30,35,45, 55)
- outer isles edge (10, 20)

Results

On this basis, it can be seen (Table 1) that noise disturbance from ADD use currently does not breach the threshold (Section 5, point 3) of excluding harbour porpoises from an average of 10% of the area of the cSAC for any of these scenarios. Currently we believe that 35 farms may be the best estimate.

Table 1- Percentage area of cSAC potentially disturbed by ADD use for a range of active fin fish farms

Within cSAC	% of cSAC disturbed	% of cSAC disturbed plus 10 outer Isles	% of cSAC disturbed plus 20 outer Isles
30 farms	3.1	3.6	4.1
35 farms	3.6	4.1	4.6
45 farms	4.6	5.1	5.6
55 farms	5.6	6.1	6.7

However, within this site there is potential for noise disturbance to arise from a number of other activities including: acoustic surveys, construction (ports and harbours, marine renewable developments), vessels (both commercial and recreational) and MOD activities. In addition, there is the potential for the aquaculture industry to expand and thus an increase in use of ADDs may be expected. Discussions are underway with the industry to better understand the use of ADDs in the area and to promote best practice use which will help to minimise disturbance from these devices in areas of restricted topography.

Any assessment of disturbance from other plans or projects would need to consider this baseline of existing potential disturbance from ADDs.

References

Brandt M.J., Hoschle C., Diederichs A., Betke K., Matuschek R., Witte S., & Nehls G. (2013) Far-reaching effects of a seal scarer on harbour porpoises, Phocoena phocoena. *Aquatic Conserv: Mar. Freshw. Ecosyst.* 23: 222-232

Coram a., Gordon J., Thompson D., & Northridge S. (2014) Evaluating and assessing the relative effectiveness of non-lethal measures, including Acoustic Deterrent Devices, on marine mammals. Scottish Government.

Lepper P.A., Gordon J., Booth C., Theobold P., Robinson S.P., & Wang L. (2014) Establishing the sensitivity of cetaceans and seals to acoustic deterrent devices in Scotland SNH Commissioned Report No. 517

ORJIP. Offshore Renewables Joint Industry Program. Project 4. Efficacy of acoustic deterrent devices. Accessed at https://www.carbontrust.com/client-services/programmes/offshore-wind/offshore-renewables-joint-industry-programme-orjip/

Urick R.J. (1983) *Principles of underwater Sound.* 3rd Ed. McGraw-Hill, Inc. USA