Scottish Natural Heritage
Dualchas Nàdair na h-Alba
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Scottish Government
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Date: 28 July 2017

Dear [redacted]

IMPACT OF ACOUSTIC DETERRENT DEVICE (ADD) USE ON CETACEANS

In an email to SNH, dated 8 March 2017, you asked that, "*SNH submit formal statutory advice to Scottish Ministers on the impact of ADD use on cetaceans. This advice should be based on sound scientific evidence concerning the actual impacts of different ADDs on cetaceans.*" In more recent correspondence (1 June 2017), you clarified that this advice should "*focus on the scientific evidence regarding potential impacts of ADDs on cetaceans*" rather than discussing possible subsequent regulatory or management approaches.

Our advice is provided as requested and summarised below. In our view:

1. There is sufficient evidence, both empirical and modelled, to show that ADDs can cause disturbance and displacement of cetaceans.

2. There is sound, scientific evidence to expect that hearing damage, stress and masking may also occur but these are difficult to demonstrate empirically and would require further assessment.

Accordingly, we believe there to be a strong case for managing ADD deployment and use, and we would welcome further discussions with you on potential approaches to take this forward.

Should you have any questions in connection with this advice, please do not hesitate to contact [redacted]

Yours sincerely,

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Head of Policy and Advice
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cc [redacted]

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Annex

Introduction

This paper considers the available evidence for interaction between use of acoustic deterrent devices (ADDs) by the aquaculture industry and potential impacts on cetaceans. It provides advice to Scottish Government in considering the need for management or regulation of the use of ADDs to reduce risk of impacts on cetaceans.

Cetaceans are protected under European legislation 'Council Directi[redacted] on the conservation of natural habitats and of wild fauna and flora' adopted in 1992 and commonly known as the Habitats Directive. This legislation is transposed into Scottish law by the 'Conservation (Natural Habitats, &c.) Regulations 1994' known as the Habitats Regulations. Bottlenose dolphin and harbour porpoise are both listed on Annex II of the Habitats Directive as species of Community interest whose conservation requires the designation of Special Areas of Conservation (SACs). All whales, dolphins and porpoises are listed on Annex IV of the Directive as species of Community interest in need of strict protection. Of relevance to this paper, it is an offence to deliberately or recklessly capture, kill, in[redacted]rass or disturb any whale, dolphin or porpoise.

Acoustic Deterrent Devices (ADDs) used in Aquaculture

The term ADD refers to a variety of acoustic deterrent types that range from lower power 'pinger' types that are used for bycatch mitigation in fisheries, to higher power devices used in aquaculture and offshore wind farm construction. This paper focuses on the higher power devices commonly used in aquaculture. Different device types have different acoustic characteristics in terms of source level[1], frequency content[2], mode of operation[3] and duty cycle[4], and these differences are likely to have a bearing on both the effectiveness in deterring seals and the impact on non-target species.

There are three main types of acoustic transducer/system used in Scottish aquaculture, namely Airmar (dB+II, Mohn Aqua, Gaelforce, OTAQ), Ace-Aquatec, and Terecos (Table 1). The Lofitech device is included for completeness; although not typically used in Scotland, it is marketed for aquaculture and is being used for offshore wind piling mitigation. All of these devices emit sound well within the hearing ranges of cetaceans (*e.g* Götz & Janik, 2013) (Figure 1) and at levels well above underwater background noise levels at substantial distances from source (e.g.15-20 km - Calderan *et al.*, 2007; Findley *et al.*, 2017).

Table 1 - Source level and frequency characteristics of the main ADD types in use.

Manufacturer	Device	Source level dB re 1 µPa	Frequency
Mohn Aqua, Gaelforce, OTAQ	Airmar dB +II	192-198 dB (rms)	10 kHz (tonal with harmonics)
[redacted]			
Ace-Aquatec[5]	US3	195 dB (rms)	10-20 kHz
	Low frequency variant	190 dB (rms)	1-4 kHz
Terecos	DSMS-4	179 dB(rms)	2-70 kHz (broadband)
Lofitech	Universal Scarer	193 dB (rms)	14 kHz (tona[redacted]s)

[redacted]

[1] Level of sound at source (in dB re 1µPa referred to 1m)
[2] Component frequencies used within the sound output in Hertz (Hz or kHz)
[3] E.g. on continuously
[4] The fraction of the period that the device is on in which the signal is active (*e.g.* a 60% duty cycle means the signal is active for 60% of the time, and 40% quiet)
[5] www.aceaquatec.com (US3 Spec) Web page accessed 07/06/2017

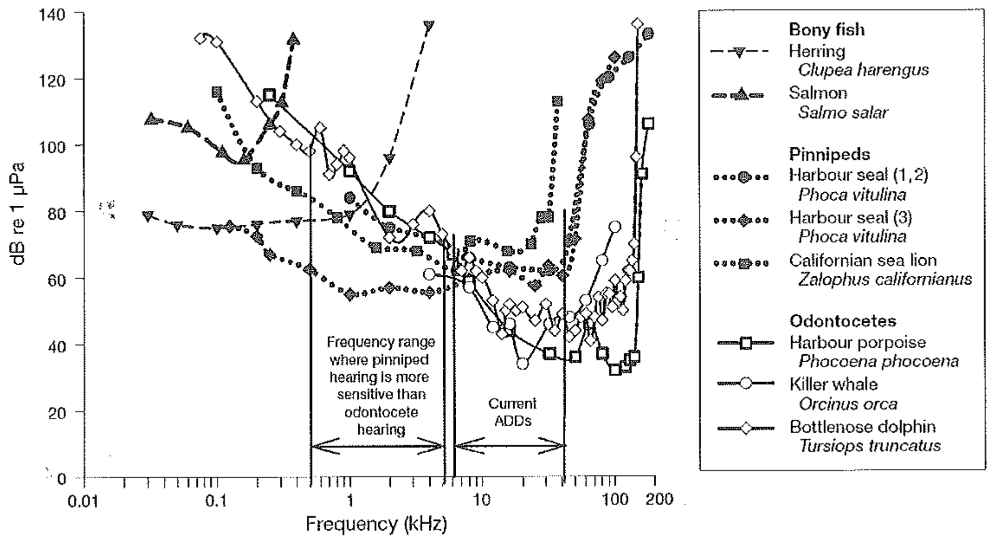

Figure 1 - Hearing thresholds for selected fish (blue dashed lines), pinnipeds (red dotted lines) and cetacean species (black solid lines) from Götz & Janik(2013). Suffixes 1-3, for Harbour seal, refer to data sources cited in Götz & Janik (ibid).

Acoustic deterrents have been used for predator control at fin-fish farms in Scotland since the mid-1980s (Coram *et al.*, 2014). During this time there have been many studies that have highlighted the potential unintended impact on cetaceans (Reviewed in - Gordon & Northridge, 2002; Gordon *et al.*, 2007; Northridge *et al.*, 2010; Götz & Janik, 2013, Coram *et al.*, 2014; Lepper *et al.*, 2014).

The acoustic signal from ADDs, particularly on the west coast of Scotland, is pervasive (Findley *et al.*, 2017). The area ensonified by ADDs has increased over time (ibid.) and is likely to continue to do so if recent trends persist. It is clear that the commonly used ADDs are well within the hearing range of cetaceans, and therefore there is overlap between this pressure and cetacean distribution, not least harbour porpoise within the Inner Hebrides and the Minches cSAC.

Potential negative ecological impacts on cetaceans from ADDs include: disturbance (leading to avoidance and habitat exclusion); hearing damage; masking of biologically significant sounds; and detrimental physiological changes (*e.g* increased stress)(Götz & Janik, 2013).

Disturbance

Avoidance responses to ADDs have been well studied for harbour porpoise and to a lesser extent on other cetacean species. Available studies are reviewed in a number of reports, for example:

- Coram *et al* (2014) Marine Scotland commissioned report – section 4.4.4 page 77; section 7.3 page 105
- Lepper *et al* (2014) SNH commissioned report – Section 3 page 42
- Götz & Janik (2013) review in Marine Ecology Progress Series – page 293
- Gordon *et al* (2007) COWRIE commissioned report – Section 5.4.1.3 page 30

These reviews all draw on the same primary literature and so are not explicitly re-reviewed here; however, key points are drawn out and detailed in Table 2. It is worth highlighting that behavioural reactions to a noise cue are highly context driven. Any response (or lack of) will depend on various factors, for example, the animal's age and previous experience of the noise, its activity when exposed to the noise and the biological value of the location to the individual.

Table 2 details some variability in terms of response distances; however, the general conclusion can be drawn that there is a zone of exclusion within a few hundred metres and a wider zone of disturbance up to several kilometres within which numbers of individuals decrease. The information also seems to suggest that different devices may stimulate different levels of response (or lack of) and this is most likely due to differing acoustic characteristics of the devices.

Table 2 - Summary of studies that have investigated disturbance effect of ADDs.

Device	Species of interest in study	Results	Source
Airmar	Harbour porpoise	When switched on abundance of HP in area (measured out to 3.5km) was less than 10% of abundance in control sessions. HP completely excluded from 400m.	Olesiuk *et al.*, 2002
Airmar	Harbour porpoise	HP excluded from 650-991m HP observed to move out of the area when ADD switched on.	Johnston, 2002
Lofitech	Harbour porpoise	HP density reduced to 1% of pre exposure within a 1km area. Avoidance responses within 1.9km	Brandt *et al.*, 2013
Lofitech	Harbour porpoise	Clear evidence of a reduction in detections, measured out to 7.5km and no indication that this was the maximum range of effect	Brandt *et al.*, 2012
Brand not specified	Killer whale	Considerable decrease in numbers on ADD activation. Recovery of sighting once deactivated. Study over 15 yrs – no habituation observed.	Morton & Symonds, 2002
Brand not specified	White sided dolphin	Abundance decreased.	Morton, 2000
Airmar	Harbour porpoise	Decreased abundance measured out to 2.5km.	Kyhn *et al.*, 2015
Lofitech	Minke whale	Clear movement away from ADD deployment site	ORJIP phase 2 project 4 – unpublished draft 2017[6]
Ace-Aquatec	Harbour porpoise	Model indicates deterrence of HP at ranges out to 1.2km, in absence of competing source of attraction	Kastelein *et al.*, 2010
Terecos	Harbour porpoise	Possible reduction in acoustic behaviour up to 1km	Northridge *et al.*, 2010
Terecos	Harbour porpoise	No significant effect	Northridge *et al.*, 2013
Genuswave[7]	Harbour porpoise	At frequencies tested (peak frequency at 1 kHz, source level 180 dB re 1μPa) - no response from HP	Götz & Janik, 2014

[6] When published will be added to https://www.carbontrust.com/client-services/programmes/offshore-wind/offshore-renewables-joint-industry-programme-orjip/

[7] New device under development using frequencies that harbour porpoise are less sensitive to.

The available literature does not provide evidence that cetaceans habituate to acoustic deterrents (Götz & Janik, 2013). However, Northridge *et al* (2010) found that harbour porpoise were more likely to react to new ADDs than those in areas where there has been ADD use previously. They also found that animals returned to the area once the ADD was de-activated.

It is often mentioned by the Aquaculture Industry that cetaceans are observed in the vicinity of fish farms using active ADDs. However, there is a behavioural context involved in any reaction. The variety of ADD acoustic characteristics, as well as the biological value of the location to the individual(s) concerned, means that the response to these devices is complex and site specific.

Consideration of evidence – We believe there is sufficient evidence to conclude that cetaceans can be disturbed and displaced by certain types of ADDs. The same evidence pool has been used to support the use of acoustic deterrents as pre-piling mitigation (European offshore wind construction, and more recently for BOWL offshore wind farm) with the intention of disturbing marine mammals out of a potential injury zone.

Effects on hearing

Hearing damage has been widely speculated[8] both for seals and cetaceans that are frequently exposed to acoustic signals (Gordon & Northridge, 2002; Coram *et al.*, 2014, Lepper *et al.*, 2014). Hearing is considered to be damaged at the onset of permanent hearing threshold shift (PTS) *i.e.* a permanent reduction in hearing ability. Exposure to noise can also result in a temporary reduction in hearing ability (TTS) which could lead to permanent damage if it occurs repeatedly. Potentially, hearing damage could affect biological fitness and/ or survival. The reduction of an individual's ability to distinguish certain sound signals could result in reduced foraging success, reduced ability to perceive predators and reduced ability to communicate.

Lepper *et al.*, 2014 considered the risk of hearing damage and concluded that the risk should not be discounted. They also concluded (based on the modelling work conducted) that hearing could be damaged if an individual (seal or cetacean) was within a few hundred metres for a few hours, and that the more ADDs deployed in one location the shorter the time-span needed before the injury threshold is breached. A cumulative dose may be received if there are a number of fish farms in the same area or along a transit route, particularly in areas that are restricted (*e.g.* straits, sounds)(also see Götz & Janik, 2013).

Given the output noise levels of ADDs used in aquaculture, it is unlikely that hearing will be damaged by instant exposure; it is more probable that the risk of hearing damage is from cumulative exposure (Götz & Janik, 2013; Coram *et al.*, 2014; Lepper *et al.*, 2014).

Consideration of evidence – Based on the available evidence, we consider that hearing damage via instant or short-term exposure is a relatively low risk. However there may be risk of damage with repeated exposure. We therefore consider there to be a risk of cumulative exposure in restricted areas (*e.g.* straits, sounds) where there are multiple ADD sources.

Masking and stress

Masking occurs when the detection of one sound signal (*e.g.* communication between marine mammals) is hidden by a second sound signal (*e.g.* an ADD). This will only occur if the frequencies of the two sound signals are similar. Although cetaceans have excellent discrimination of different sounds the potential of masking remains, which would result in missed opportunities to react to relevant noise cues. There have not been any direct studies to our knowledge, but there has been work conducted indicating a likely reduction of communication space due to vessel noise (baleen whales – Clark *et al.*, 2009; delphinids – Erbe, 2002; Jensen *et al.*, 2009). Some ADDs generate noise within a similar frequency range to small boats highlighting the potential for a similar impact (Götz & Janik, 2013).

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[8] It is not possible to test hearing damage on cetaceans directly. It is inferred based on understanding of temporary hearing loss (see Southall *et al.*, 2007).

There is limited ability to study stress effects on marine mammals in the marine environment. One opportunistic study, (Rolland *et al.*, 2012) found the reduction of noise related to a temporary cessation of shipping traffic was associated with a reduction in stress hormones in right whales. We understand from terrestrial studies that individuals living in a noisy environment suffer with stress related conditions, ultimately affecting the individual's health (EU 2015). In addition there is the awareness that a lack of obvious response does not necessarily mean there is no effect.

Consideration of evidence – We consider that the possibility of masking and stress is real, but is difficult to demonstrate empirically and complicated by other noise sources in the same region (*e.g.* vessel noise). Further work would be needed to ascertain the significance of any impacts.

Conclusions

The balance of scientific evidence indicates that ADDs emit frequencies within the hearing range of cetaceans; can cause disturbance and displacement; and have the potential to cause injury, masking and stress (though these latter aspects are difficult to demonstrate empirically).

The consensus in academic opinion is that ADDs can deter animals from an area[9] which implies a risk of habitat exclusion arising from persistent ADD use. This is particularly relevant in restricted environments (e.g. straits or narrows), where cumulative ADD use could present a barrier to passage by cetaceans. The extent of any habitat exclusion may well be site and context specific, and any resulting impacts on individual foraging success or population level consequences are not yet well understood. However current legislative protection requires a precautionary approach where a risk cannot be discounted beyond scientific doubt.

There is currently little formal regulation or monitoring of ADD use in aquaculture and as such it is difficult to understand the actual level of anthropogenic noise being contributed to the environment from this source. Given the increase in the marine area ensonified by ADD use and growing attention to the potential impacts of underwater noise (e.g. MSFD- Indicator 11) we consider that management of persistent noise sources such as ADD use by aquaculture is necessary.

In summary, ADDs used in aquaculture are of the frequency range and level that has been shown to disturb and displace cetacean species in various scientific studies. SNH advises that the potential for these impacts is real and therefore the requirements for protection conferred upon these species through the Habitats Regulations need to be considered.

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[9] Note that the likelihood of such displacement is the reason why ADD use for pre-piling mitigation in the Moray Firth was agreed and why ADDs are being proposed as potential mitigation for tidal turbine operation impacts.

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