ACE AQUATEC

REIMAGINING SUSTAINABLE AQUACULTURE

Sound Propagation Modelling

General Introduction

17th May 2022

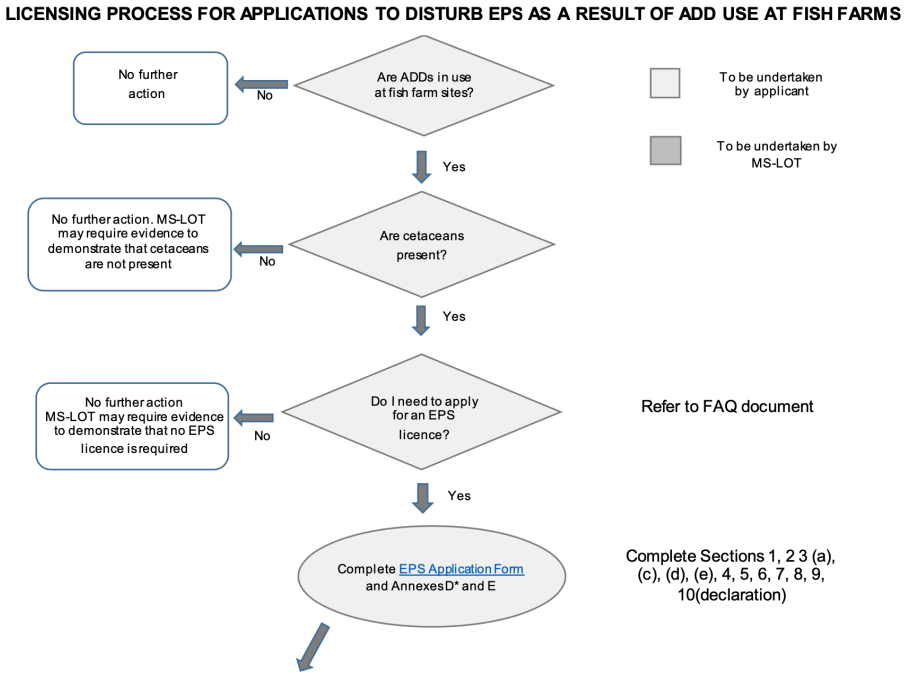
Introduction

Regulators, salmon growers and equipment suppliers all have an interest in ensuring that the industry is well regulated, takes responsibility for the health and welfare of the farmed fish and has minimal impact on the natural environment including the sea mammal population.

The Scottish government have identified that acoustic seal deterrent devices (ADDs) risk causing disturbance and acoustic injury to wild sea mammals. To mitigate this risk, they have generated a simple and clear approach to quantifying the risk of acoustic injury and disturbance to sea mammals.

Requirements for EPS licensing in Scotland

Marine Scotland recently set out the requirements for farms using acoustic deterrent devices (A.D.D.s) to submit EPS applications if they are negatively impacting marine wildlife around farms. The flow diagram below sets out the process:



Ace Aquatec's deterrent systems have been modelled within the Marine Scotland propagation generator tool, and neither cause injury or disturbance. Sound propagation maps are included in this document for

the purposes of validating our claim that an EPS license is not required with these environmentally responsible systems. This submission is made on behalf of our customer.

Historical Context for Ace Aquatec's Acoustic Startle Response (ASR) Systems

Ace Aquatec developed the first of its acoustic startle systems, the All New Silent Scrammer (ANSS) in 2001, and these have continued to be developed in under the US3 and RT1 products. These products were introduced to the market in response to the negative impact of the dominant acoustic deterrent devices (ADDs) at the time which were made by Airmar. These Airmar devices were continuous noise makers, or acoustic barrier systems, which worked by creating a painful barrier of sound around farms. Ace Aquatec considered these systems indiscriminate and having a potential to harm seals as well as non-target species such as whales and porpoises.

Ace Aquatec's ANSS system was the first deterrent to come with three unique modes of operation: 1) TIMED: extremely low duty cycle timed startle sounds; 2) CONDITIONED: a low volume pre pulse was played ten seconds before the main startle sounds to train seals beviourally; 3) TRIGGERED: movements of fish were used to determine that a seal was predating, and the startle sound was triggered. All three modes continue to be used across the Ace Aquatec deterrents today.

Acoustic startle is a well-documented reaction in mammals to very well-defined acoustic properties. Habituation (decreasing response to noises after successive exposures) and sensitization (getting a stronger reaction to noises with successive exposures) was well documented by Moyer (Moyer, 1963) in rodents. In 1965 Fleshler identified that if an acoustic stimulus reaches a high enough intensity during the first 15 milliseconds of its onset, a startle response will be elicited. Pilz and Schnitzler (1996) identified that the strength of the response in mammals increases with the rate of increase in acoustic energy. John Ace-Hopkins and Gavin Haywood, in the 1995 Management of Seal Predation, at the Scottish Aquaculture Conference, argued that the philosophical differences between the startle methodology and the existing acoustic barrier systems was significant, and would result in drastically different impacts on non-target species, as well as seals. In 2001, John Ace-Hopkins bought out the rights to Ferranti Thomson's deterrent technology and started Ace Aquatec. Its first deterrent system, the All New Silent Scrammer (ANSS), set the standards for a different kind of deterrent, with low duty cycle, low average volume (SEL) and triggered mechanism to evoke a startle response.

In 2011, when Nathan Pyne-Carter took over Ace Aquatec, the company added a range of lower frequency transducers (0.8-5khz) which could target the hearing range of seals while remaining outside the sensitive hearing range of porpoises, as well as electric startle reflex (E.S.R) deterrents, such as electric enclosures, electric decoy fish, and a surface electric net. Ace Aquatec is presently launching its artificial intelligence (A.I.) triggers, which use day and nighttime cameras to detect wildlife around farms, in order to determine when a seal is present and predating on fish. These innovative solutions reflect the core philosophy of Ace Aquatec's deterrent history which is to harness the instinctive responses of the seals in order to make deterrent sounds more effective while having a lower impact on non-target species.

System Design

These ASR systems have been development for over twenty years and our ESR systems have been

developed in the last five years. Several core system features are integral to an assessment of their impact on non-target species.

- Pulse train characteristics (Peaks and troughs determine the average received volumes)
- Pulse and pulse train length (Duration of pulses and their pulse trains determines average received volumes as well as duty cycle.

ASR and ADD systems are inherently different. ADDs create a barrier of sound which is necessarily high in acoustic energy, with continuous duty cycles. ASR systems are by necessity random in nature and have extremely low duty cycles with high rise times of less than 12 milliseconds.

Transducers

Ace Aquatec produces two broad classification of systems which replicate the same operational features, but transposed into two different frequency bands:

US3 – Mid frequency – at 8-11khz (uses a T203 sourced from Neptune Sonar)

RT1 – Low frequency – at 0.8-5khz (uses either a T473 Flex or a T161 sourced from Neptune Sonar)

https://www.neptune-sonar.co.uk/products/projectors

Programming:

The tonal characteristics of Ace Aquatec's deterrents are very precisely defined in order to elicit the startle reflex in mammals. A pulse generator creates randomized 3-12 millisecond pulses within the frequency spectrum defined by the device. These pulses are played randomly in a longer pulse train, where the frequency and volume of each tonal pulse is randomized. The duration of a pulse train is typically 2.6-2.8 seconds (2600-2800 milliseconds, which is the indexed against the received hearing integration time of seals).

Each deterrent comes with three modes:

1) **Timed scramming** – two tones are available (tone 1 is a continuous 2.6-2.8 second burst; tone 2 is a broken pulse train in 1000, 750 and 550 milliseconds broken by 500 millisecond silences)
2) **Conditioned scramming** – as with timed, except a pre tone of 10-30 milliseconds occurs 9 seconds before the startle tone.

3) **Triggered scramming** - as with 1) and 2) above, except output volume is relative to the detected distance of the predator.

Tone 1 represents the standard Ace Aquatec startle characteristics: a 3-12 millisecond randomized pulse train (see Leppar et al. 2004) lasting no more than 2800 milliseconds. The SEL of tone 1 has been well mapped and is displayed on the spec sheets has this tone has the highest rms source level dB re 1uPa @1m over the transmission.

Tone 2 contains the same 3-12 millisecond pulses, but in randomized trains of 1000, 750 and 550 milliseconds, with pauses between pulses at 500 milliseconds. The SEL is 170/174dB (respectively for the RT1 and US3).

Conditioned scramming has a SEL of 170/174 dB respectively for the RT1 and US3.

Triggered deterrents calibrate volume output to the zoom length, but typically operate at 30% lower average volume levels due to closer proximity of seals.

Multiple deterrents with intelligent scramming:

All deterrents on single site can scram intelligently – meaning they understand there is more than one device on the farm, and they never play sounds overlapping with each other. This is important in order to avoid a compound effect of noise, which can increase the impact of the sound, causing disturbance.

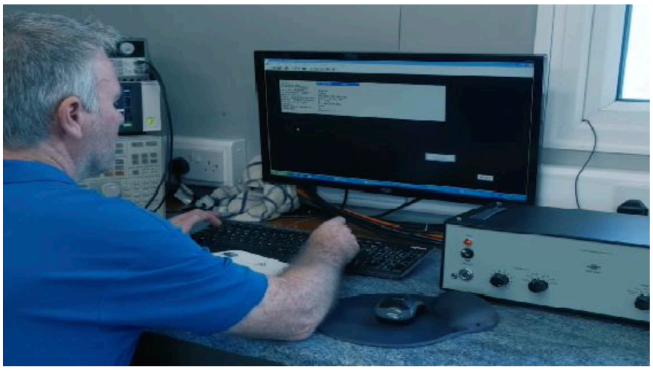
Connectivity:

All of Ace Aquatec's deterrents are connected to an internet connected portal. This portal provides our Ave Aquatec staff and users with information about when a system is active or in need of maintenance. It also sends data to our central server informing us of whenever a deterrent is making noise. This is provided as a time stamped download in excel, showing gps co-ordinates, length of on/off and status of the system.

Measurements:

With the increased scrutiny over the systems we offer, we have had our US3 and RT1 Flex systems mapped in the water by Neptune Sonar in March 2020, and independently by Dr Jeffrey Lines and Alex Coram of St Andrews University in May 2021.

All of the deterrents are manufactured and tested in the water by Neptune Sonar at their calibration facility in Driffield.



Tests in March (see appendix 1 for full experimental setup):

System	Length of scram (Tone 1) (s)	Rms source level dB re 1uPa @1m	Frequency
FS1	2.8	175.8	800 – 1200 Hz
RT1	2.8	179.6	1000 – 2000 Hz
US3	2.6	180.6	8000 – 11000 Hz

NOTE: all tests are conducted on the loudest mode: TIMED. CONDITION and TRIGGER mode all operate at significantly lower SEL (176dB and 170dB respectively)

Test in May (See appendix 2 for full details of results)

Work conducted by Dr Jeffrey Lines and Alex Coram of St Andrews University has further confirmed output from the deterrents when operating in standard mode, program 1. These are in press for publication.

Modelling sites in Scotland:

The following methodology enables us to identify the maximum permitted output level for which an EPS license is not required.

The Marine Scotland modelling methodology indicates a method to calculate the range at which acoustic sources of various levels may be considered to disturb marine mammals. Marine Scotland also indicates the density of marine mammals expected to be found in the sea at various locations around Scotland.

Using Google Earth Pro we identify the location of each farm and for a range of potential source levels use the circle tool to draw a circle on the map centred on the farm, representative of the range at which the source levels may potentially disturb marine mammals. We then use the polygon tool to identify the areas of sea within the propagation range for each source level rejecting sea areas that are clearly in sound shadow. These areas allow us to model the number of animals of each species expected to be affected by the acoustic device. In this way the site-specific source level that disturbs exactly 1.0 marine mammals of any species can be identified. This source level represents the source levels below which an EPS licence is not required.

To support this analysis, we grab screen shots from Google Earth showing the various circles and associated sea area calculations.

The Ace ASR system source levels can be adjusted down using the nine-step volume control. This enables us to identify the maximum setting at which a farm is permitted to operate its ASR devices. Compliance with this limited output can be ascertained by examination of the online portal records.

	dB decrease	dB decrease
level	flex	US3
9	0.0	0.0
8	-1.1	-1.0
7	-2.3	-2.1
6	-3.8	-3.3
5	-5.5	-4.8
4	-7.5	-6.6
3	-10.2	-8.9
2	-14.0	-12.1
1	-20.4	-17.7

Marine Scotland Zones and permitted levels:

According to the Marine Scotland generator tool, there are seven zones in Scotland. Each zone has a permitted area of sea permitted:

LOCATION	ZONE	Sq KM
Argyll	G	2.98
Zone H	H	11.11
Minch	I	2.52
Hebrides West Coast	J	17.24
North Coast West	K	3.25
North Coast & Orkney	S	6.58
Shetland	T	2.49

SPL (dB)	Radius (m)
173	787
174	893
175	1013
176	1148
177	1302
178	1477
179	1675
180	1900
181	2154
182	2443
183	2771

These levels indicate disturbance levels and are the same for Ring, Flex and US3.

These levels apply regardless of the number of ASR devices on a site

Ace Aquatec systems do not have high enough duty cycles to create any injury levels, as seen in both the MMPA NOAA tool, and within Marine Scotland's generator too.

Company Specific Modelling:

Ace Aquatec has applied the modeling exercise above to each of its customers' sites in Scotland. These site maps are included as appendix 3.

Site Locations:

The site co-ordinates are provided in the appendices for farms either hosting currently, or potentially hosting Ace Aquatec's equipment. They have been mapped and modelled using the modelling provided by Marine Scotland.

While Ace Aquatec prefers to deploy as few systems as possible, multiples of US3s and RT1s do not impact the injury or disturbance levels. This is because the ASR devices work with very low duty cycles. Our deterrents are intelligent systems and know when other systems occupy close GPS co-ordinates. By default, all systems are set to avoid playing sounds at the same time as other systems in the location.