Dear Mr McKinlay,

Thank you for the opportunity to provide information to the Scottish Animal Welfare Commission's (SAWC) review of the welfare implications of the use of acoustic deterrent devices (ADDs) in Scottish salmon and trout farming. Here we provide responses to your specific questions, with additional supporting information, images and footage accompanying this response. Annex 1 provides details of files that accompany this document.

We would also like to take this opportunity to invite you and relevant members of SAWC to visit a marine salmon farm, to discuss the issues raised in our submission in a practical setting. This visit would include farm personnel and relevant regional managers who will be able to provide further context to these issues raised in our submission.

1. ***Firstly, please state which organisation/company you are representing and your role in that organisation, or whether you are replying independently***

This response is submitted by Dr Iain Berrill (Head of Technical) at the Scottish Salmon Producers' Organisation (SSPO).

SSPO is the trade body representing the Scottish farmed salmon sector. Our current membership produces all (100%) of the salmon farmed in Scotland. Our members farm exclusively on the West coast of Scotland and the Western and Northern Isles (Orkney and Shetland), with farms taking up a relatively small area of the sea, a total for all farms of c. 180 hectares (surface area).

Our response to SAWC is made on behalf of all marine salmon farming interests in Scotland and the information provided is representative of the entire sector. Salmon farming companies may provide individual responses to SAWC, but to confirm, we have engaged and collated information from all marine salmon farming companies ahead of submitting this sector response.

Overarching statement on seals and their management

Seals are a persistent challenge for salmon farmers and a significant welfare concern for our farmed fish. A recent analysis of mortality data submitted to the Scottish Government's Farmed Fish Health Framework (https://blogs.gov.scot/marine-scotland/2020/10/30/new-focus-for-farmed-fish-group/) demonstrated that seals have been responsible for up to 8.34% of the fish losses recorded on Scottish salmon farms in recent years (see *File 1 - Scottish Salmon Sector Mortality Analysis.pdf*). These data only represent direct impacts from seal attacks (i.e., mortality) and do not include the secondary impacts that are presented in further detail in this SAWC submission (e.g., increased stress, reduced growth, suppressed immune system).

The management of interactions between seals and salmon farms is complex and highly site specific. Management approaches that might work on one farm, may not work on another, even closely located farm. Furthermore, the predation pressure that farms experience is not necessarily similar. Some farms are heavily targeted, whereas other farms, again perhaps closely located to farms that are heavily predated upon, may experience few or no attacks. On some farms, attacks may be more prevalent during hours when farm staff are not physically on site, although this is not always the case. Attacks may vary across the year and typically salmon farmers report an increase in seal predation over the winter months. Anecdotally, this coincides with the reduced availability of other prey fish within the sea during winter months. Seal attacks can also vary in their duration. Some attacks can be short lived, caused by a single seal. Others can be sustained throughout the production cycle of

the farm, caused by a number of seals, leading to significant losses and wider impacts. In short, there is no “typical” seal attack.

Seal interactions with salmon farms generally present in three specific ways.

1) Seals residing in the vicinity of the farm and potentially attacking the farm / nets but not gaining access to the fish. This results in significant stress to the fish, with indirect impacts including, for example, reduced feeding, growth rate and immunocompetence.

2) Seals damaging / injuring / killing / consuming fish by attacking them through the net or by making holes in the net (see *File 2 - Video - Seal with hole in the net to access fish*). This will also lead to significant stress for any fish not directly injured, with indirect impacts such as reduced feeding, growth and immunocompetence. It may also lead to other impacts, for example fish escapes.

3) Seals entering the pen, either through a hole they have made in the net beneath the waterline, or by entering the pen over the top of the net, via the walkway. Fish are then directly damaged / injured / killed / consumed, and the entire pen will experience significant stress due to the presence of the predator, again with indirect impacts such as reduced feeding, growth and immunocompetence. It is important to note that farmers have experienced single and multiple seals within a pen at a time. Clearly, in cases where there are multiple seals within a pen, the challenges with regard to fish welfare and removing the seals are magnified.

N.B. Throughout this submission, we refer to these three aspects of seal / farm interactions collectively as “seal attacks”.

The tools and management practices available to farmers to protect their fish from seals are limited and have reduced due to legislative and policy changes that have come into force in the last 12 months. Indeed, overall, the legal framework surrounding seals is highly complex with seals receiving specific legislative protection unlike many other predators of livestock (c.f. foxes, certain birds). This legal framework also conflicts with a fish farmers’ legal and ethical responsibilities to protect the health and welfare of fish under their care (through the Animal Health and Welfare (Scotland) Act 2006).

All of this means that seals can have devasting impacts on farmed salmon, with farms often reporting high and sustained mortality due to seal attacks. Not only is this a significant health and welfare concern for the fish on the farm (both those killed and the remaining population) but it also represents a significant economic impact to businesses that support Scotland’s rural economy. Furthermore, it is highly distressing for salmon farmers to see their stock attacked, often routinely, and to experience the sight of high numbers of slaughtered fish, as illustrated in the images below. This distress is not to be underestimated, with farmers often powerless to protect their fish from attack.

Images demonstrating the daily removal of fish killed by seals

In your experience, please provide any information you may have on:

2. The extent of fish predation by seals:

a. estimates of numbers of attacks, number of fish predated and economic losses. Information on any other impacts of seal presence would be very useful

Direct impacts

Taken as a whole, across the entire Scottish salmon farming sector, seals currently have the following direct impacts in terms of mortality arising from attacks:

Time period	Total number of fish killed (directly) by seals [1]	Lost revenue [2]
2020	516,443	£12,523,743
2021 to Aug.	347,917	£8,436,987

[1] These are fish killed as the direct result of a seal attack. This figure does not include those fish which will have died some time following a seal attack, as the result of stress, injury leading to secondary infection etc.

[2] Based on an average weight at harvest calculated as 5kg, using figures published in the Marine Scotland Scottish Fish Farm Production Survey 2020 (Table 26; https://www.gov.scot/publications/scottish-fish-farm-production-survey-2020/).

The following table breaks these total figures down to consider the direct impacts of seals per stocked farm. However, please bear in mind that these are average figures, taken across the entire sector. As described within this submission to SAWC, seal predation can vary greatly between farms:

Time period	Average number of fish killed by seals per farm [1]	Lost revenue[2] per farm[3]
2020	2,792	£67,696
2021 to Aug.	1,955	£47,399

N.B. There are approximately 210 active salmon farms in Scotland. At any one-time c. 70% of these farms will be stocked

[1] These are fish killed as the direct result of a seal attack. This figure does not include those fish which will have died some time following a seal attack, as the result of stress, injury leading to secondary infection etc.

[2] Based on an average weight at harvest calculated as 5kg using figures published in the Marine Scotland Scottish Fish Farm Production Survey 2020 (Table 26: https://www.gov.scot/publications/scottish-fish-farm-production-survey-2020/).

[3] Farms stocked in the region during the relevant time period.

However, it is known that different salmon farming regions experience different pressure from seals. The table below provides a breakdown of direct losses (total) in each of the five Local Authority regions where salmon farming takes place:

Region	Time period	Total number of fish killed (directly) by seals [1]	Lost revenue [2]
Argyll and Bute (inc. North Ayrshire)	2020	46,844	£1,135,967
	2021 to Aug.	21,496	£521,278
Highland	2020	89,284	£2,165,137
	2021 to Aug.	158,251	£3,837,587
Orkney	2020	67,292	£1,631,831
	2021 to Aug.	12,194	£295,705
Shetland	2020	119,984	£2,909,612
	2021 to Aug.	61,237	£1,484,997
Western Isles	2020	193,039	£4,681,196
	2021 to Aug.	94,739	£2,297,421

[1] These are fish killed as the direct result of a seal attack. This figure does not include those fish which will have died some time following a seal attack, as the result of stress, injury leading to secondary infection etc.

[2] Based on an average weight at harvest calculated as 5kg, using figures published in the Marine Scotland Scottish Fish Farm Production Survey 2020 (Table 26: https://www.gov.scot/publications/scottish-fish-farm-production-survey-2020/).

The following table further breaks this down, providing the figures on a per farm basis, which therefore accounts for different farming capacity within each region. Again, please bear in mind that these are average figures, taken across the respective region. As described within this submission to SAWC, seal predation can vary greatly between farms:

Region	Time period	Average number of fish killed (directly) by seals [1] per farm[2]	Lost revenue [3] per farm[2]
Argyll and Bute (inc. North Ayrshire)	2020	1,301	£31,555
	2021 to Aug.	597	£14,480
Highland	2020	1,786	£43,303
	2021 to Aug.	3,517	£85,280
Orkney	2020	2,804	£67,993
	2021 to Aug.	469	£11,373

Shetland	2020	3,157	£76,569
	2021 to Aug.	1,612	£39,079
Western Isles	2020	5,217	£126,519
	2021 to Aug.	2,871	£69,619

[1] These are fish killed as the direct result of a seal attack. This figure does not include those fish which will have died some time following a seal attack, as the result of stress, injury leading to secondary infection etc.

[2] Farms stocked in the region during the relevant time period.

[3] Based on an average weight at harvest calculated as 5kg using figures published in the Marine Scotland Scottish Fish Farm Production Survey 2020 (Table 26: https://www.gov.scot/publications/scottish-fish-farm-production-survey-2020/).

Indirect impacts

There are a range of indirect impacts resulting from seal attacks, including those that are associated with the stress caused by seals attacking, or being in the general vicinity of, salmon farms. These impacts are difficult to quantify with data, and they are discussed qualitatively in more detail in our response to subsequent questions, below. However, in broad terms these impacts can be defined as:

Reduced feeding	Salmon typically respond to severe stress events by ceasing feeding or at the very least being less inclined to eat.
Reduced feed conversion efficiency	The physiological responses fish make to stress will lead to less efficient conversion of feed that is eaten and used for "normal" physiology and growth. This not only impacts growth and development, but also the composition of wastes (faeces) coming from the fish / farm (thus the environmental impact) and a fishes immunocompetence.
Reduced growth	Reduced feeding and inefficient feed conversion will lead to a reduction in growth. The presence of seals will result in a change to normal swimming behaviour, with increased bouts of burst swimming, using more energy, thus diverting that energy away from growth. Furthermore, the presence of a predator typically results in a diversion of energy reserves for the classic "fight or flight" response. These responses will all further impact fish growth.
Reduced immunocompetence / disease	Physiological responses to stress are known to impact fish immunocompetence, with knock on implications for a fish's ability to avoid disease or health challenges. Farmed salmon are raised in wild, natural lochs, and as such are potentially exposed to a range of pathogens. A reduced immune system can easily shift the balance between host and pathogen, in favour of the pathogen, leading to infection.

Injury (without death)	Below (Q3) we describe the injuries caused by seals. Typically, salmon that are injured from seal attacks are either killed as a direct result of the attack or succumb to secondary health challenges as a result of injury and die thereafter. However, a number of salmon may survive, depending on the severity of the injury. This represents a welfare concern for the farmer, who may be unable to remove the fish from the wider population (due to practicality) and humanely euthanise them. Also, due to physical damage, these fish are unlikely to be processed or sold for human consumption. With the farmer unable to separate them from the wider population (and remove / euthanise them), they represent an inefficiency and added cost to production.
Wider impacts from health challenges	Salmon farms can hold in excess of 1 million fish reared in a number of fish pens. Health issues presenting in a specific part of the population (that may arise due to a seal attack on a specific pen), or impacting a number of fish within a pen, can rapidly spread throughout the farm, leading to the amplification of health challenges associated with seal attacks.
Production activities	There are a number of important and necessary husbandry activities that can be significantly hindered by the presence of a seal(s), with resultant impacts on fish health and welfare. Fish are crowded for grading, treatment and harvesting. At this time fish are condensed into a smaller space, leaving them more vulnerable to attack by a seal and in some circumstances requiring farm staff to cease the relevant husbandry operation to protect fish welfare. Seals can also impact the completion of a required in-feed medicinal treatment. By impacting feed intake and the efficiency with which feed is utilised a farmer, vet or health professional may take the decision to cut short a required in-feed treatment to prevent fish being treated without effect, to prevent fish receiving a non-efficacious dose or to protect the wider environment. (i.e., if medicated feed is not eaten or the medicine is not taken up by the fish as expected).
Escapes	No farmer wants their fish to escape. Escaped fish present a concern for the wider environment and they represent an economic loss for the farm, but moreover, they represent a welfare concern for those escaping fish, with farmed salmon known to survive poorly outside of captivity. Whilst escape incidents are generally rare, seal attacks have been identified as one of the key causes of suspected escape by Scottish farmed salmon. There is a statutory responsibility for salmon farmers to report any incidents of suspected fish escape, regardless of whether any fish are subsequently found to have escaped. These data are published on the Scotland's Aquaculture Database: http://aquaculture.scotland.gov.uk/ A review of data available within this database shows that:

	In 2019, predators (seals) were cited as a reason for 12 (63%) of the 19 reports of suspected escape in seawater salmon farms. In 2020, predators (seals) were cited as a reason for 5 (29%) of the 17 reports of suspected escape in seawater salmon farms. In a detailed review of escapes in the Scottish fish farming sector, commissioned by SARF, Taylor and Kelly (2010) reported that holes in farm nets caused by predation resulted in the highest number of escape incidents (26%) and the third highest number of escaped fish by cause (12% of fish). Taylor, M., Kelly, R. (2010) Assessment of Protocols and Development of Best Practice Contingency Guidance to Improve Stock Containment at Cage and Land-based Sites Volume 1: Report. pp 74.

3. The impact of seal attack or presence on farmed salmonids in terms of the physical aspects of fish welfare:

a. Types of injuries and mortality and numbers of fish affected

Types of injury

The injuries caused by seals are very distinctive. These can be categorised as:

Slash / bites targeting the liver:	These are typified by characteristic slash / bite wounds to the underside of the fish, just behind the head. This is where the liver can be found, with seals specifically targeting the liver due to its high energy content.
Slash / bite marks to the flanks / belly:	These wounds can affect the dermis and skeletal muscle. Wounds may be so deep that internal organs are damaged, resulting in evisceration. Lesions may also involve bone fracture (i.e., broken spine). Although typically severe and leading to mortality, in less severe cases, fish may be able to survive with (relatively) minor injuries (although see elsewhere, comments on secondary issues for fish that survive a seal attack).
Abrasions / descaling:	General abrasion injuries and / or descaling can result from direct contact from seals, but also from fish swimming erratically (as a population) due to a seal attack, with fish rubbing against the fish net (or “burrowing”) or other fish. Scales provide a vital protective function for fish. They are embedded within the dermis and their loss represents a health and welfare concern. Abrasions (and scale loss) can also lead to secondary health issues (infections, sea lice etc.).

Here we provide some images illustrating the wounds typically experienced by a seal attack:

Typical slash / bite wounds targeting the liver

Typical slash / bite wounds targeting the liver, with evisceration

Slash / bite wounds to the flanks

Bite wounds to the flanks (with descaling)

Mortality and numbers of fish affected

These are reported in the tables above (in answer to Q2).

b. Effects on growth rates and disease? & c. Do you have any data available to support this?

It is important to note that the impacts of seals do not occur in isolation (e.g., reduced feeding and growth). However, here we provide a general position for the most significant impacts on farmed salmon.

Growth rates

Seal attacks have a negative impact on growth rates in farmed salmon. This is associated with reduced feeding and inefficient feed conversion, erratic swimming behaviour with increased bouts of burst swimming, and a diversion of energy from "normal" physiological processes to classical "fight or flight" physiology, i.e., energy used in preparing the body to react to a stressor, rather than for normal growth and development.

Reduced growth has significant knock-on implications for fish welfare and production. Reduced growth will lead to fish being held for longer than expected on marine farms. Increased production cycles increase the time over which fish can be exposed to (and suffer from) health and environmental challenges (e.g., sea lice, gill health, harmful plankton). These challenges may require specific medicinal or non-medicinal intervention (e.g., the use of hydro- or thermo-licers) placing further pressure on the effective management of fish health and welfare. Longer production cycles also place pressure on production planning (which is focused on health and welfare management across all farms), and increases costs (personnel, feed, boats, medicines etc.).

Data / evidence: There is considerable anecdotal evidence that demonstrates an impact of seals on growth rates. It is universally accepted by salmon farmers that there is a clear impact of seal attacks on fish growth. Quantifying those impacts, however, is difficult. All companies maintain sophisticated databases which log growth rates (and a considerable range of other metrics). However, linking a specific seal attack to a reduction in growth from that data is complex, not least due to the wide range of other, relevant factors that impact growth, alongside the variable way seal attacks may present themselves. Carefully controlled, scientifically robust studies (and statistics) would be required to defined quantitatively the impacts of seals on salmon growth.

Feeding

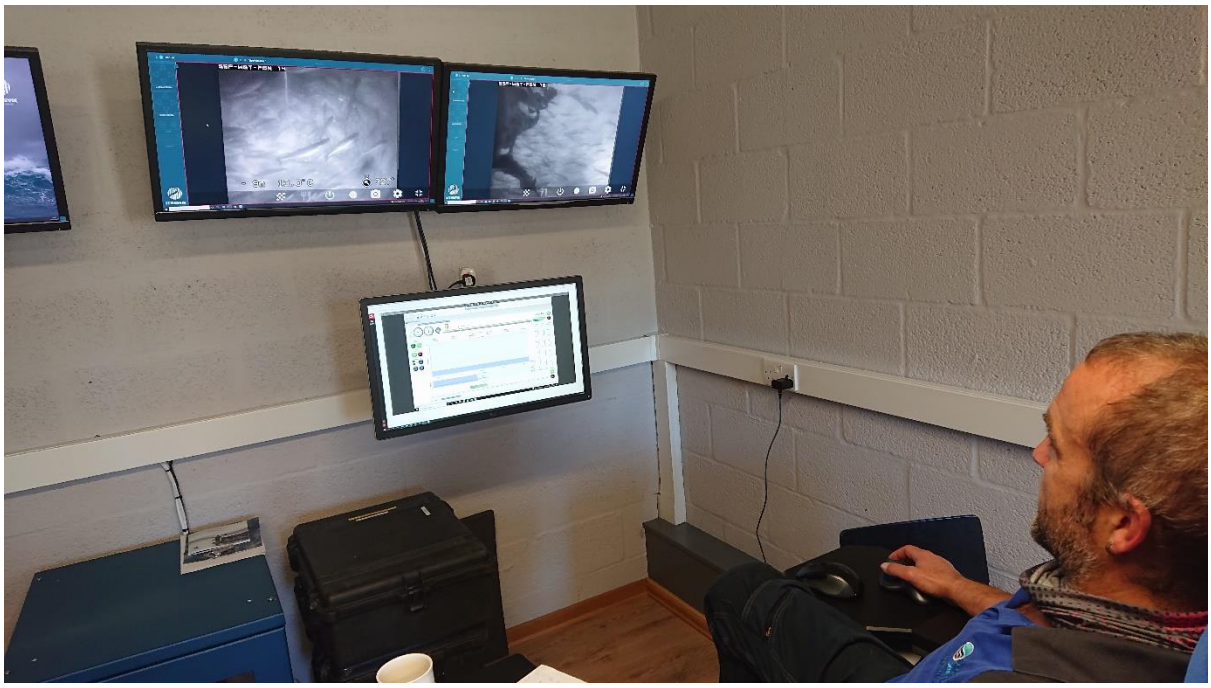
Seal attacks result in two impacts with regard to feeding: a decrease in feeding / appetite and a decrease in the efficiency with which feed is utilised for growth / physiological processes. This is often observed as an increase in the Feed Conversion Ratio (FCR). These effects will be observed across the entire farm but will be especially noticeable on those pens that are specifically targeted by seals.

Acute and chronic stress induced appetite suppression is well documented in the scientific literature. It is reasonable to assert that the presence of a predator, for short or prolonged periods, would invoke such stress responses and this, too, is likely to be the confirmed within the scientific literature.

Ultimately such reductions in feeding and feed conversion can lead to a calorific deficit for routine physiological processes and growth, resulting in fish growing more slowly than typically expected and leaving them less able to react / defend themselves against other health challenges. Again, as outlined above, reduced growth will lead to an extended production cycle, which will have knock on implications for fish health and welfare, production planning and the economic viability of farms.

Data / evidence: There is considerable anecdotal evidence to support the position that seal attacks lead to reduced feeding and feed conversion efficiency.

When salmon are fed, a dedicated, specifically trained feed technician manages the delivery of feed to the fish via the feeding system. That person monitors feeding behaviour constantly via underwater cameras in each pen. These cameras can be rotated through 360 degrees and raised or lowered, such that the feed technician can observe feeding behaviour and adjust feed delivery accordingly. An example of this system is shown below:



Behavioural changes in the population of fish in response to seal attacks / presence are observed via these cameras.

Quantifying changes in feed intake and feed conversion efficiency is challenging and, similar to quantifying seal impacts on growth, it may be difficult to separate the impacts resulting from seals from other variables that impact feeding. Data on feed rates before and after an attack may provide some quantifiable impact and an in-depth assessment would be required examining seal predation events, daily ration fluctuations and comparable growth / FCR. Again, it may be very difficult to pinpoint impacts to single predation events. However, as previously stated, the effect of stress on metabolism in fish is well documented in the scientific literature and provides sufficient evidence to support the noted effects of seal presence on fish feeding response, without the necessity of having to quantify the effects numerically.

Disease / other health challenges:

Seal attacks can result in significant impacts on the health and welfare of fish, aside from those fish directly killed as the result of a seal attack. The impacts include:

Surviving fish with injuries	As well as large numbers of fish killed as a direct result of a seal attack, some fish and will survive an attack, at least initially. The welfare of these fish is a considerable concern to farmers, not least due to the wounds / damage they will have experienced as a result of the attack. These fish will be at increased

	susceptibility of secondary infection from other health challenges, due to the loss of scales, presence of open wounds, or due to reduce immunocompetence associated with injury / stress. Not only is this an issue for the individual fish concerned, but ill fish then become a health and welfare concern for the remaining, healthy population of fish on the farm (i.e., due to the potential spread of infection from ill to healthy fish). *File 3 – Video - Young salmon injured by a seal attack* illustrates how a fish may survive an attack by a seal.
Abrasion injuries	Fish that are startled by a seal will try to escape and will often burrow against the net or collide with other fish, causing scale loss, eye damage, fin damage and abrasion injuries. These injuries leave the fish more susceptible to secondary infections from pathogens (bacteria, viruses etc.).
Stress-induced secondary infections	Exposure to, in particular, chronic stress, such as that arising from the presence of predators, compromises immune function in all animals, and consequently it is widely accepted that stress increases the susceptibility of animals to pathogens that are present in the environment. Evidence for this is available within the scientific literature. Farmed salmon that are injured are prone to other health challenges, which can be broad ranging, including, for example Amoebic Gill Disease (AGD), sea lice and bacterial infections such as Enteric Redmouth disease (ERM). However, cardiomyopathies (caused by viruses) have been identified as secondary health issues linked to seal attacks, including Pancreas Disease (PD), Cardiomyopathy Syndrome (CMS) and Heart and Skeletal Muscle Inflammation (HSMI). To note, an analysis of the causes of mortality, submitted to the Farmed Fish Health Framework (*File 1 - Scottish Salmon Sector Mortality Analysis.pdf*) demonstrated that viral diseases were responsible for up to 13.44% of mortalities in recent years. Although it is not possible to link all of these to seal attacks, it is likely that seals will be a contributing factor in at least some of these cases. Finally, on occasion it has been necessary to cease in-feed treatments for sea lice due to the presence of a seal and its impact on fish feeding and behaviour. This further complicates the management of sea lice and potentially other health issues (e.g., in-feed treatments for lice may be a preferred option for fish experiencing a gill health challenge. For those fish, a bath medicine or physical treatment (e.g., hydro-licer) might not be appropriate).

Evidence: Production data held by salmon farming companies demonstrates a link between specific health issues and seal presence / attacks.

Furthermore, the SSPO Prescribing Vets Group (an independent group of the sectors leading fish vets, representing all veterinary practices prescribing for salmon) has recently produced a position statement on the impacts of seals on farmed salmon. This statement was submitted for consideration to the Scottish Government's Farmed Fish Health Framework, and is attached to this SAWC response:

File 4 – SSPO Prescribing Vets Group position on the impact of seals on farmed salmon.pdf

4. ***The impact of seal attack or presence on farmed salmonids in terms of behavioural responses:***

   a. ***Are there observable responses from the fish to seal presence or seal attack such as changes in feeding or changes in swimming patterns or schooling?***

Yes. Behavioural responses are typically observed through cameras positioned within each pen. Erratic swimming behaviour, burst swimming and swimming out with the usual schooling pattern is commonly observed in response to the presence of a seal or a seal attack. The changes that occur in feeding and feeding behaviour, in response to the presence or attack by a seal have been discussed in detail in response to previous questions, above (Q2 and Q3).

File 5 - Video - Seal impacts on fish feeding behaviour provides an example of how fish behaviour changes in response to a seal.

   b. ***How close do seals need to be to elicit these responses?***

Wider context to Q4b and Q4c. Before answering Questions 4b and 4c it is important to provide relevant context. Seal attacks can vary greatly in how they present themselves at the farm / pen. Whilst seal attacks may, in a small number of cases, occur in isolation this is rarely what farmers see in practice. What would be deemed a seal attack could last for many days / weeks / months or in fact be a persistent pressure on the farm with seals continuously in the vicinity of a farm if they have chosen to remain in a location and attack the fish.

As such, it will be difficult to establish definitively how close a seal needs to be to elicit a response (with "overlapping" attacks possible) or how long responses last after individual attacks.

Response to Q4b:

Water clarity will be a factor affecting how close a seal needs to be to elicit a response in farmed salmon. However, farmers would expect to experience behavioural responses in their fish when seals are anywhere up to 25 metres from the farm.

   c. ***How long do these responses persist if the seals move away?***

It is important to note that it is not practical to ascertain how long, following a seal attack, the stress response continues within the fish, with potentially subtle changes in behaviour and also changes in fish physiology, continuing without clearly visible signs.

However, more broadly, behavioural responses (in terms of feeding and swimming behaviour) will be observed for a minimum of an hour, following a seal attack / presence but routinely up to the remainder of the day. Of course, with the continued presence of a seal or seals at a farm, such behavioural responses can be observed for days / weeks etc.

   d. ***Are any data or video footage available that illustrates this?***

Observations of fish behaviour are made during feeding activities, and these clearly demonstrate to farmers when a seal is in the vicinity of the farm. However, due to the fact that a large number of seal attacks occur beneath the water, it can be difficult to link changes in feeding behaviour, or changes observed through farm data, to precisely when a seal was around the farm and, in relation to this question, when and for how long after it left the farm. Furthermore, in terms of feeding behaviour, once a population of fish reduces or ceases feeding due to the presence of a seal it is not appropriate for the farmer to continually try to feed them. This will waste feed with associated environmental and economic impacts. Feed will be introduced at the next planned meal (which may be later in the day /

the following day) and if the fish are still not feeding, again, the farmer will not persist in trying to feed those fish. Establishing datasets and footage to evidence such longer-term impacts in not practical.

5. *What is your opinion on the efficacy of currently used acoustic deterrent devices in deterring seals?*

Important note: Currently, due to uncertainty surrounding the legal framework concerning ADDs, and the need (or not) for EPS licencing, Scottish salmon farmers are not actively using ADDs. However, our response is based on those most recently used ADDs, which includes low and medium frequency devices, and devices that are termed Acoustic Deterrents Devices (ADDs) and Acoustic Startle Devices (ASDs).

A recent Scottish Government project assessed the Use and Efficacy of Acoustic Deterrent Devices (ADDs) in Aquaculture:

Coram, A., Ragnarsson, V., Thomas, L., and Sparling, C. E. (2021). Use and Efficacy of Acoustic Deterrent Devices (ADDs) in Aquaculture. Marine and Freshwater Science.

Although concluded, this project is yet to be published on the Scottish Government website. It should be noted, however, that despite this being the most up to date reference reporting on ADD use by Scottish fish farmers this is a rapidly developing area. As such the ADD usage information documented in the report is already out of date with current practice and should be used with caution.

a. Are they effective in preventing seal approach or attack?

ADDs are believed to be effective at preventing seal approaches or attacks. It is important to state that ADDs form one part of a wider predator management strategy on farms. Such strategies are tailored to each farm, its current and historical experience with seals, as well as the (often limited) availability of tools, which may be further impacted by regional permit / licencing restrictions (see Q6 below). There are two key goals of a predator management plan: 1) to deter seals from the farm and 2) to prevent seals gaining direct access to the fish (i.e., providing a barrier between the seal and fish). In this regard, ADDs are specifically used to deter seals from the farm, compared to, for example, tensioned nets, which have the specific purpose of preventing seals getting access to the fish once at the farm.

b. In what circumstances are they or are they not effective?

The use of any management tool within a wider predator management strategy or plan incorporates the principle of adaptive management. It is a common misconception that ADDs, along with other predator management tools, are used / turned on and left to work without any further involvement from the farmer / equipment suppliers. All tools and their use are under continual assessment, review and adaptation. ADDs will be used adaptively with different use profiles and the collation and interrogation of data. If a particular ADD is deemed to becoming less effective, a change is made, which may involve a change of ADD type, how it is used, the sound output etc.

c. Are some devices more effective than others?

Again, it is not appropriate to consider some devices as more or less effective. Predator management varies with location. When ADDs have been deployed their use is tailored to the relevant scenario / farming environment to ensure they are used as effectively as possible.

6. *What alternative practices or deterrents are effective?*

As mentioned in relation to Q5, there is an important distinction to be made with regard to the different practices and tools that are used within a defined farm specific predator management plan. Essentially, practices and tools fall into one of two categories: 1) those that are designed to deter seals from the farm and 2) those that prevent seals gaining direct access to the fish, if it comes into proximity to the farm. Some practices and tools fall into both categories, e.g., the regular removal of mortalities, will deter seals from coming to the farm by removing a visual and olfactory cue but mortality removal will also prevent the seal actually attacking and removing mortalities and thereafter other fish.

a. *If you farm salmonids, what other alternative practices or devices (e.g. seal blinds, tension nets) have you tried and how effective are they?*

The following options are available to farmers as part of their predator / seal management plans. All are considered effective.

Practice / device	**Comments / additional context**
Net tensioning	Keeping nets properly tensioned is critical to helping to prevent seals from reaching / biting / striking salmon when they "charge" the net / pen. Nets can be tensioned with, for example, centre weights or sinker tubes / Froyer rings (which are rigid weighted tubes at the base of the net, providing tension, for examples see https://scaleaq.com/product/sinker-tube/ or https://www.gaelforcegroup.com/sectors/aquaculture/pen-systems/sinker-tubes).
High strength, abrasion resistant netting materials (e.g., HDPE)	The sector is currently undergoing a significant programme of investment to use HDPE nets across its farms. Whilst these are by no means a panacea to seal attacks, they help to prevent seals from tearing the net and accessing fish. Year on year investment by the sector in HDPE nets is c. £5million. This is limited not by the desire of companies to transfer to HDPE nets, but by the manufacture and delivery of nets alongside existing net replacement plans. A conservative estimate for the overall investment by the average salmon farming company in transferring to HDPE nets is c. £10m.
Seal blinds	Seal blinds effectively mask (visually) key areas of the pen that are particularly susceptible to seal attack, notably the base of the pen and the "morts sock" - the device used to collect any mortalities, facilitating easy removal.
Handrail height	Increasing the height of the handrail can help to prevent seals climbing over the net and entering the pen. However, it should be noted that seals are adept at entering pens over the handrail and primary net as illustrated in the following image:

	
Top net	Ensuring that top nets are properly tensioned, that it comes down well over the handrail and is tied in. However, as *File 6 - Video - Seal trying to untie top nets* demonstrates, this does not deter seals from attempting to access the fish in that way, with many seals being successful at entering the pen.
Stocking density	Whilst not possible in all locations, reduced fish stocking densities can help prevent attracting seals to farms.
Removing mortalities / moribund fish	Regular removal of mortalities / moribund fish is critical for limiting seal attacks. The "morts sock" is often a focal point for attacks. By regularly removing dead fish seals are less likely to be attracted to the farm.
Anti-predator nets	These are secondary nets, of a larger mesh size, placed a short distance outside the primary net. They require appropriate tensioning and can be highly effective at preventing seals accessing the fish. However, local permitting restrictions (i.e., planning permission conditions) restrict their use in many locations, due to concerns around entanglement.

b. What other methods do you think may be effective (whether you have tried these or not)?

Over the years, the sector has supported research to investigate a range of other deterrent / exclusion options, including (but not limited to) electric fences, netting or model fish (similar to that used on land-based farms) and taste aversion.

Recently a Scottish Government funded project has reported on seal / sealion deterrent options used globally (https://data.marine.gov.scot/dataset/review-non-lethal-seal-control-options-limit-seal-predation-salmonids-rivers-and-finfish). However, it must be noted that many of the options presented in this report are either impractical, known to be ineffective in a Scottish context, or not permitted due to current Scottish licencing restrictions. There is a current, ongoing workstream, using this report as a base, to discuss and identify potential options for research and innovation, to better understand seal attacks and to identify potential additional management tools. However, we must emphasise that interactions between farmed salmon and seals have occurred for many years. As a

result, farmers and equipment manufacturers are experienced in what may or may not work, and what is practical for use on a farm.

7. *Are there other impacts in terms of sustainability of the business or in terms of social acceptability of approaches to deal with seal presence?*

Salmon farmers have always sought solid, underpinning science to support their farming activities. We make decisions based on science. However, seals and their management are emotive and politically charged subjects. As such, it is likely that there will be challenges surrounding the social acceptability of seal management that, in our opinion, are not necessarily driven by science, best practice or balanced opinion. This is evidenced by the attention received surrounding seal management on salmon farms compared to that of predator management within other livestock sectors, for example, a land-based farmer seeking to protect their lambs / hens from foxes.

8. *Please also provide any other comments you would like to make on this issue*

We wish to highlight some further, relevant information in relation to seals and their management.

Seals within pens: As outlined in the opening statement, seals can attack fish from outside the pen, but a further significant challenge occurs if a seal gains access to the pen, either via a hole it creates in the net, or by entering over the handrail / via the walkway (see *File 6 - Video - Seal trying to untie top nets* as well as the photograph provided in the table relating to Q6a).

If a seal enters a pen this represents a significant health and welfare concern for the fish, with fish directly attack / injured / consumed and with the remaining population experiencing high levels of acute stress. Removing the seal from the pen becomes a critical task. In some circumstances a seal may leave through the hole in the net through which it entered the pen. However, if a seal entered the pen via the walkway, there is no practical way for it to exit the pen itself. It entered by having the walkway to allow it to get over the top of the pen, but inside the pen there is no such platform to allow it to climb out again. Furthermore, with a freely available supply of prey fish in the pen, there is little incentive for the seal to leave of its own accord.

In these circumstances, farm staff must try to usher the seal out of the pen by lowering an area of the net. However, it must be noted that this brings with it potential legal conflict. Farmers are legally required to maintain satisfactory measures for the containment of their fish (ref.: Aquaculture and Fisheries (Scotland) Act 2007: enforcement section; https://www.legislation.gov.uk/asp/2007/12/contents) and lowering a pen net may, as well as allowing the seal to exit, provide a potential route for fish to escape.

It should also be noted that sometimes a seal (or seals) simply refuses to leave the pen. In these circumstances, and despite the significant health and welfare impacts on the fish, the options available to a farmer to remove the seal become extremely limited. Legal constraints prevent the humane euthanisation of the seal unless its welfare is demonstrably impacted and it is suffering. For farmers, this represents a significant conflict of law with their obligations to protect the health and welfare of fish in their pen, which can number many tens of thousands. The option to sedate / anaesthetise the seal and to then physically remove it is also not an option. There is currently no suitable anaesthetic to achieve appropriate sedation in a timely manner and there is a lack of a suitably accurate way of delivering an anaesthetic to the seal within a pen / at distance. Current best practice for anaesthetising seals within the research community utilises anaesthetics that take c. 10min to act and which are delivered by blow dart. As such, for research, anaesthetisation is only attempted with seals that hauled out on land. To deliver a suitable anaesthetic (if one were available) would require a

ballistic based delivery mechanism to ensure accuracy. Further, there is a strong likelihood that following anaesthetisation a seal would dive / sink, with a significant risk of drowning.

In a recent example, a seal entered a pen and, despite all efforts to encourage it to leave, it remained in the pen for several days. The company concerned took the extreme decision to bring in a well boat to remove the fish, such that the net could be dropped, allowing the seal to leave. This action would have placed the fish under further undue stress (pumping into a well boat), but it was also extremely costly (c. £15,000). This experience has been captured in the following film: *File 7 – Video – Use of a well boat to allow removal of a seal from a pen*.

Finally, it is important to note that farmers do not only experience single seals within a pen but have experienced multiple seals entering a pen at one time, greatly complicating their removal.

Seal population size and wider impacts: There is growing evidence that the grey seal population, at least, is growing in Scottish waters. The Special Committee on Seals (SCOS) reports annually on seal numbers and populations trends (http://www.smru.st-andrews.ac.uk/scos/scos-reports/). Additionally, a recent report, commissioned by SSPO and the Scottish White Fish Producers Association (see *File 8 – SSPO SWFPA report The management of Scotland's seal populations.pdf*) highlights population growth by seals, further illustrating the growing pressure on socially and economically important rural sectors within Scotland.

The *Management of Scotland's seal populations report* considers the population dynamics of both Grey and Harbour seals in Scottish waters, their impact on economically or environmentally relevant species and reviews predator management strategies that have been adopted globally, to address conflict between growing predator populations and economically, socially and environmentally important factors. We believe this report provides important wider context for the SAWC review.

By way of further reading with regard to the impacts of seals on economically important species the following Scottish Government reports detail diet composition and the consumption of economically important species by Grey and Harbour seals:

> *Hammond PS, Wilson LJ (2016) Grey seal diet composition and prey consumption. Scottish Marine and Freshwater Science 7: No 20*
>
> *Wilson LJ, Hammond PS (2016). Common seal diet composition and diversity: Scottish Marine and Freshwater Science, 7:1-84.*

By way of context, these reports demonstrate that annual consumption of ballan wrasse by grey seals is estimated to be 3,551t, compared to the on average 50t of all wild Scottish wrasse species currently fished for and used by Scottish salmon farmers, to support lice control.

Annex 1: Files attached to this SAWC submission

File 1 - Scottish Salmon Sector Mortality Analysis.pdf

File 2 - Video - Seal with hole in the net to access fish

File 3 – Video - Young salmon injured by a seal attack

File 4 – SSPO Prescribing Vets Group position on the impact of seals on farmed salmon.pdf

File 5 - Video - Seal impacts on fish feeding behaviour

File 6 - Video - Seal trying to untie top nets

File 7 – Video – Use of well boat to allow removal of a seal from a pen

File 8 – The management of Scotland's seal populations.pdf