Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

For the future of our environment

Managing interactions between sea lice from finfish farms and wild salmonids

Proposed new regulatory framework

May 2023

Contents

1. Introduction

This consultation asks for your views on our detailed proposals for a risk-based framework for managing the interaction between sea lice from open-net pen finfish farms and wild salmonids in Scotland.

It follows on from our first consultation on the main elements of the proposed framework, issued in December 2021[1].

In developing the details of the framework, we have followed the Scottish Regulators' Strategic Code of Practice, designing the framework to be transparent, accountable, consistent, and proportionate, targeting action to where it is needed, based on environmental risk.

1.1 Background

The number of sea lice on fish farms is one of several aspects of farm operations that require effective management to protect the environment and enable the sustainable development of the finfish aquaculture sector.

In 2018, the Scottish Parliament's Environment, Climate Change and Land Reform (ECCLR) Committee and Rural Economy and Connectivity (REC) Committee held inquiries into salmon farming in Scotland. The focus of the ECCLR inquiry[2] was to investigate the environmental impact of salmon farming. The REC inquiry[3] focused on identifying opportunities for the future development of the sector and exploring the fish health and environmental issues raised in the ECCLR inquiry.

The findings from both inquiries highlighted concerns over the environmental impacts of fish farming in Scotland, particularly regarding the potential hazard posed by marine farms to wild salmonids. The REC inquiry concluded that the status quo was not an option and that changes to the regulation of the sector were required.

[1] https://consultation.sepa.org.uk/regulatory-services/protection-of-wild-salmon/
[2] https://archive2021.parliament.scot/parliamentarybusiness/currentcommittees/107588.aspx
[3] https://digitalpublications.parliament.scot/Committees/Report/REC/2018/11/27/Salmon-farming-in-Scotland

The Scottish Government's response[4] to the inquiries outlined the action being taken to reduce average sea lice levels on fish farms to support fish health; and confirmed that a Salmon Interactions Working Group (SIWG) would be established to consider the management of risks to wild salmonids.

Varying levels of impact on wild salmonids caused by sea lice from farms have been found in Norway and Ireland; and there is a risk that sea lice from fish farms in Scotland negatively impact populations of wild salmon and sea trout[5,6,7]. The number of sea lice on farmed fish in an area is one contributing risk factor but others are also important, such as how sea lice from the farms are dispersed by local currents; how long wild salmonids spend in the sea area concerned; and the resilience of the salmonid population. A risk management approach specific to Scottish conditions is therefore required.

The SIWG was established by Scottish Ministers in October 2018 and asked to consider the evidence and recommendations coming from the Parliamentary Committee inquiries; review the existing policy framework for managing interactions; and make recommendations on a future approach. The SIWG published its recommendations in May 2020.

Like the Parliamentary inquiries, the SIWG recognised that, whilst some gaps in understanding remained, a framework for managing sea lice interactions could be introduced, based on best available evidence. It recommended that conditions to safeguard wild salmonids should be contained within a licence rather than through planning consent and that the licencing system should be based on an adaptive management approach.

A technical working group of relevant regulators was established to work alongside the SIWG. It was tasked with developing a practical, spatially-based, risk assessment framework, including considering how the framework might be applied under existing environmental legislation and make use of any potential synergies with existing regulatory roles.

[4] https://archive2021.parliament.scot/S5_Rural/20190129_Cab_Sec_RE_-_SG_response_to_Cttee_report_on_salmon_farming_in_Scotland.pdf
[5] https://wildfish.org/wp-content/uploads/2022/06/Thorstad-Finstad-2018-Impacts-of-salmon-lice-NINA-Report-1449-2.pdf
[6] https://www.gov.scot/publications/summary-of-information-relating-to-impacts-of-salmon-lice-from-fish-farms-on-wild-scottish-sea-trout-and-salmon/
[7] Thorstad E. B., Todd C. D., Uglem I., Bjorn P. A., Gargan P. G., Vollset K. W., Haltunen E., Kalas S., Berg M. and Finstad B. (2015). Effects of salmon lice *Lepeophtheirus salmonis* on wild sea trout *Salmo trutta*—a literature review. Aquaculture Environment Interactions; Vol. 7. https://doi.org/10.3354/aei00142

In their response to the SIWG report[8], Scottish Ministers identified that SEPA would become the lead body responsible for managing the risk to wild salmonids from sea lice from fish farms using the Water Environment (Controlled Activities) (Scotland) Regulations 2011. The Regulations place a duty on SEPA to control activities likely to have a significant adverse impact on the water environment. The purposes of the regulatory controls are to enable SEPA to prevent deterioration of the water environment and to contribute to restoring waters to good ecological status. This includes protecting and, where necessary, restoring the status of their wild salmonid populations.

The Government's response included a requirement for SEPA to consult on the outline of a regulatory framework for managing interactions between sea lice from fish farms and wild salmonids. The Scottish Government committed to the implementation of the framework within the Programme for Government 2022/23[9], reiterating the commitment in the Scottish Wild Salmon Strategy[10] and associated Implementation Plan[11]. The latter sets out the range of actions being taken to protect wild salmon from different pressures acting at national and local scales.

SIWG Recommendations.

A single lead body (with appropriate competence and capacity) should be assigned responsibility for regulating wild and farmed fish interactions and given appropriate powers for monitoring and enforcement.

Scottish Government Response to SIWG

The Government response to the Group's recommendations (published in October 2021) confirmed their policy intent for SEPA to become the lead body responsible for managing the risk to wild salmonids from sea lice from fish farms using the Water Environment (Controlled Activities) (Scotland) Regulations 2011. The Government's response included a requirement for SEPA to consult on the outline of the regime.

[8] https://www.gov.scot/publications/salmon-interactions-working-group-report-scottish-government-response/
[9] https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2022/09/stronger-more-resilient-scotland-programme-government-2022-23/documents/stronger-more-resilient-scotland-programme-government-202223/stronger-more-resilient-scotland-programme-government-202223/govscot%3Adocument/stronger-more-resilient-scotland-programme-government-202223.pdf
[10] https://www.gov.scot/publications/scottish-wild-salmon-strategy/pages/1/
[11] https://www.gov.scot/publications/wild-salmon-strategy-implementation-plan-2023-2028/documents/

The commitment to develop a new risk assessment framework was reiterated in The Programme for Government 2022/23.

Scottish Wild Salmon Strategy

The Government's Scottish Wild Salmon Strategy sets the high-level vision and objectives to guide collective action to protect wild salmon. It identifies a series of pressures that have the potential to affect salmon populations. The Wild Salmon Strategy Implementation Plan 2023 – 2028 identifies the actions that will be taken to achieve the vision set out in the strategy. The implementation plan identifies an action for SEPA of "*Continued development and phased implementation of the risk assessment framework for managing the interaction between sea lice from marine fish farm developments and wild salmon and sea trout in Scotland*".

1.2 Engagement

We issued a first consultation on proposals for a Risk Based Framework in December 2021. We proposed to target protection of wild salmon post-smolts in "Wild Salmonid Protection Zones" (WSPZs), which are areas of sea in which post-smolts are at greatest risk of harm if sea lice levels are high, based on an assessment of local Scottish conditions. The approach would be adaptive, informed by monitoring, refinements to modelling, new scientific evidence and actions taken by operators. We also proposed to introduce the framework in phases, prioritising regulation of new and expanding fish farms.

After the first consultation closed, we organised workshops and one-to-one meetings with stakeholders to help inform our response to the consultation and develop the detailed proposals set out in this consultation (see Appendix I). We are grateful for the input, which has helped shape and refine our plans.

You can access the information about this consultation *via* our consultation hub. This is also where you can leave your consultation responses. Alternatively, if you are unable to access the online tool, you can respond by email to aquaculture.regulation@sepa.org.uk. The consultation closes on 15th September 2023.

We will be running workshops during the consultation period to support discussions. We will also welcome one-to-one meetings with interested parties.

1.3 Scope

The framework will aim to protect wild salmon and sea trout populations from sea lice (*Lepeophtheirus salmonis – the salmon louse*) from fish farms.

Initially, protection will be delivered in defined Wild Salmonid Protection Zones (WSPZ) along the West Coast and around the Western Isles. We intend to develop, and consult on, proposals for WSPZs for sea trout in the Northern Isles during 2024.

The framework will protect wild salmon post-smolts between 1st April and 30th May every year. This is also the peak time for sea trout migration into coastal waters. Action to protect salmon during this period will also help protect sea trout. However, we will extend a level of protection for sea trout until 30th June to cover their early weeks as juvenile fish in coastal waters.

Where we set permit controls, these will apply from 16th March every year. This is because lice hatching from lice on farmed fish in mid-March can contribute to concentrations of infective-stage lice in the sea at the start of April.

The modelling, monitoring and research programmes, which will support the framework, will enable us to refine and adapt how the framework protects sea trout and salmon from sea lice over time.

1.4 Objectives

This proposed regulatory framework will deliver benefits for the following three outcomes in the National Performance Framework:

- Communities. “*We live in communities that are inclusive, empowered, resilient and safe.”* We are proposing a risk assessment process that will enable communities to understand the potential risks to their local environment. The pre-application engagement process will give communities the opportunity to raise issues early in the development of proposals. The outcome should be an increased level of trust in the regulatory system.

- Economy. “*We have a globally competitive, entrepreneurial, inclusive and sustainable economy.”* The fish farming industry is one of Scotland’s most important food exporters. It generates income at a local and national level and provides jobs and investment. It markets a value-added product, benefiting from Scotland's reputation for a high-quality natural environment. Fish farmers may benefit reputationally from compliance with permit conditions protecting wild salmonids. Developers will benefit from upfront advice on environmental risk and consenting requirements, which will assist them in planning investments.

- Environment. "*We value, enjoy, protect and enhance our environment*." The proposed regulatory framework will contribute to the protection of one of Scotland's most iconic native species, wild Atlantic salmon. It will also contribute to the protection of populations of critically endangered freshwater pearl mussels and of sea trout. The framework will help guide development to the least environmentally sensitive locations.

1.5 Timetable overview

We are proposing the following timetable for the phased implementation of the framework:

- In line with the Scottish Government's response to the Salmon Interactions Working Group, we will prioritise implementation of the framework within our consenting process for proposed fish farm developments. Subject to the outcome of this consultation, our aim is that from the end of 2023, all applications for new farms and for increases in the number of fish held at existing farms will be risk assessed under the framework and regulated accordingly, with regulatory requirements dependent on the outcome of the risk assessments (see Chapters 4 and 5).

- During the first half of 2024, we will begin adding sea lice control conditions to the permits of those existing fish farms that contribute significantly to the concentrations of sea lice to which wild salmonids are exposed in WSPZs. We will start with farms that pose the greatest risk to wild salmon post-smolts if sea lice numbers on the farms were to increase. The conditions will be designed to ensure that, during the smolt migration window, current sea lice management performance is maintained and any increase in the typical numbers of sea lice on the farms is avoided (see Chapter 6).

- During 2024, we will also begin work to assess whether action is required to reduce the contributions of specific fish farms to exposure of wild salmon post-smolts to infective-stage lice. Our assessments will be targeted at those WSPZs where risk screening assessments indicate that the sea lice exposure threshold is exceeded (see Chapters 6 and 8). The timescales for completing such assessments are likely to vary depending on, for example, how much information is already available to build on. We will act to protect wild salmonid populations as soon as we have good evidence they are being impacted and evidence confirming the contributions of individual farms. Where significant new monitoring or modelling work is required, we anticipate that our assessments could take several farm production cycles to complete. Throughout the implementation of the framework, we will remain evidence-led in our approach to managing sea lice.

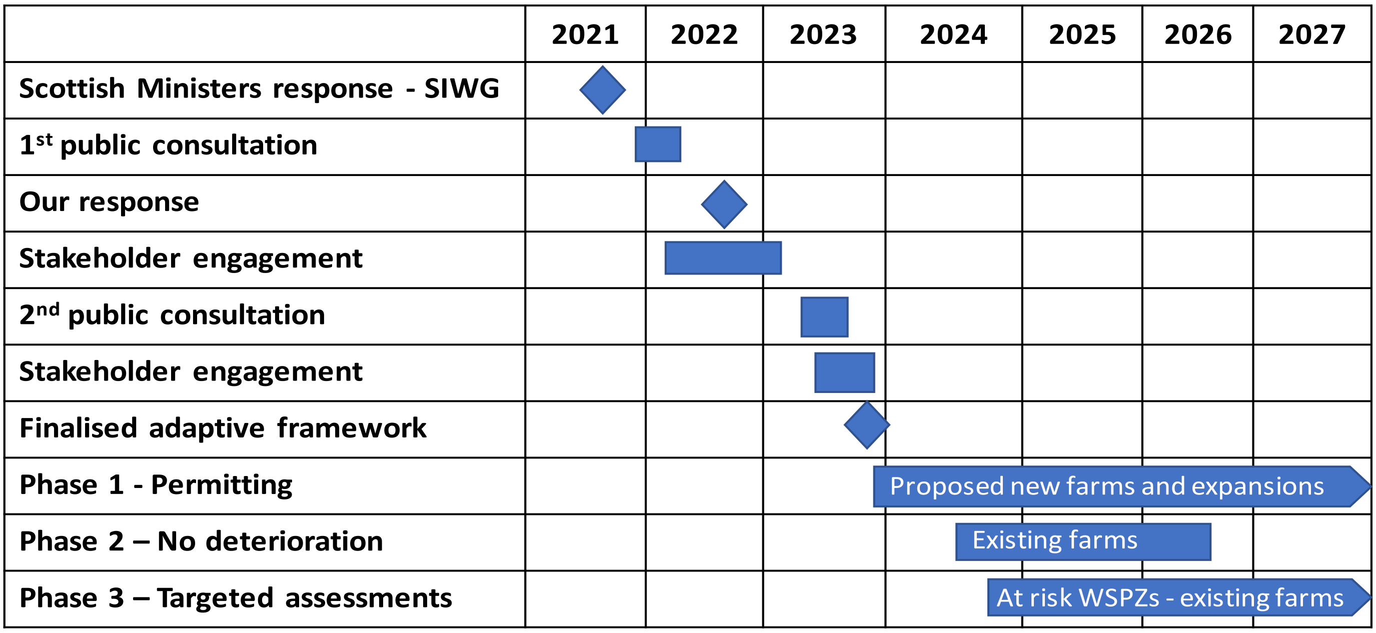

Figure 1: High-level timetable.

1.6 Adaptive approach

The proposed regulatory framework is a new approach to the management of the interaction between sea lice from fish farms and wild salmonids in Scotland. It differs substantially from the existing approach under the land use planning system. As a new approach, we think it is important that the framework is adaptive from the start, evolving and improving in response to experience of its operation and new scientific understanding.

To ensure an effective adaptive approach, we will continue to seek to engage and collaborate with finfish producers, scientists and other interested third parties, including on monitoring, modelling and research programmes. The latter will provide important evidence to inform adaptation of the framework.

1.7 Structure of consultation

This consultation divides into five topics:

- Partnership delivery (Chapter 2).
- Risk assessment framework (Chapter 3).
- Regulatory process (Chapters 4, 5, 6 & 7).
- Monitoring and making data available (Chapters 8 & 9).
- Implications of the framework (Chapter 10).
- Summary and conclusions (Chapter 11).

2. Stronger regulatory partnerships

This chapter provides the wider regulatory context for our proposals, including how they will contribute to rationalising the regulation of marine fish farms.

Over the last 4 years, Scottish Government and SEPA have made several changes designed to help streamline and improve regulation of marine finfish farms.

In 2019, SEPA introduced a significantly revised regulatory framework for managing discharges from farms. This included incorporating risk assessments for discharges of nitrogen compounds (nutrients) alongside improved risk assessments for discharges of fish medicines and organic matter from fish faeces. We have been continuing to refine our risk assessments since 2019, including working to develop suitable marine models to improve the way discharges of nutrients are assessed.

Currently, the interaction between sea lice from fish farm developments and wild salmonids is managed under the land use planning system by the relevant local planning authority. In 2019, the Scottish Government advised local planning authorities to consider the use of "Environmental Management Plans" (EMPs) as a mechanism to strengthen management of risk to wild salmonids. EMPs were advised as an interim measure in advance of the Salmon Interactions Working Group making recommendations and decisions being made on a long-term approach.

In 2020, Scottish Government transferred responsibility for regulating discharges from wellboats from Marine Scotland to SEPA. In 2021, it identified SEPA as the new lead body responsible for managing the interaction between sea lice from fish farms and wild salmonids. This latter change will remove the need for local authorities to require EMPs under the land use planning system.

This series of changes has simplified the regulatory landscape by ensuring that all the main pressures on the water environment associated with the day-to-day operation of finfish farms will be regulated by SEPA.

One of the effects is that, early in the development process, we will be able to provide developers, other regulators and communities with more comprehensive spatially-based environmental risk-screening information than ever before. Over the next five years, the extension of the Environmental Authorisation (Scotland) Regulations 2018[12] to water and waste management will also enable us to deliver further integration of finfish aquaculture regulation.

We think the information generated by our risk screening assessments could also be used by local authorities to inform and streamline their scoping assessments of farm proposals under the Town and Country Planning (Environmental Impact assessment) (Scotland) Regulations 2017.

Between mid-March and late June, The Fish Health Inspectorate (FHI) and SEPA will have common interests in overseeing the effective management of sea lice infestations on farms. For farms in some locations, the limits to which the farmers will be required to manage sea lice for the purposes of protecting wild salmonids will be stricter than those required for farmed fish health purposes. In other locations, the opposite will be the case. FHI and SEPA will work together to develop common reporting and regulatory approaches wherever possible.

Figure 2 summarises the main roles of the key regulators after SEPA takes on the regulation of sea lice interactions with wild salmonids. Table 1 outlines the specific roles of the different regulators in supporting the management of the interaction between sea lice and wild salmonids.

[12] https://www.legislation.gov.uk/ssi/2018/219/contents/made

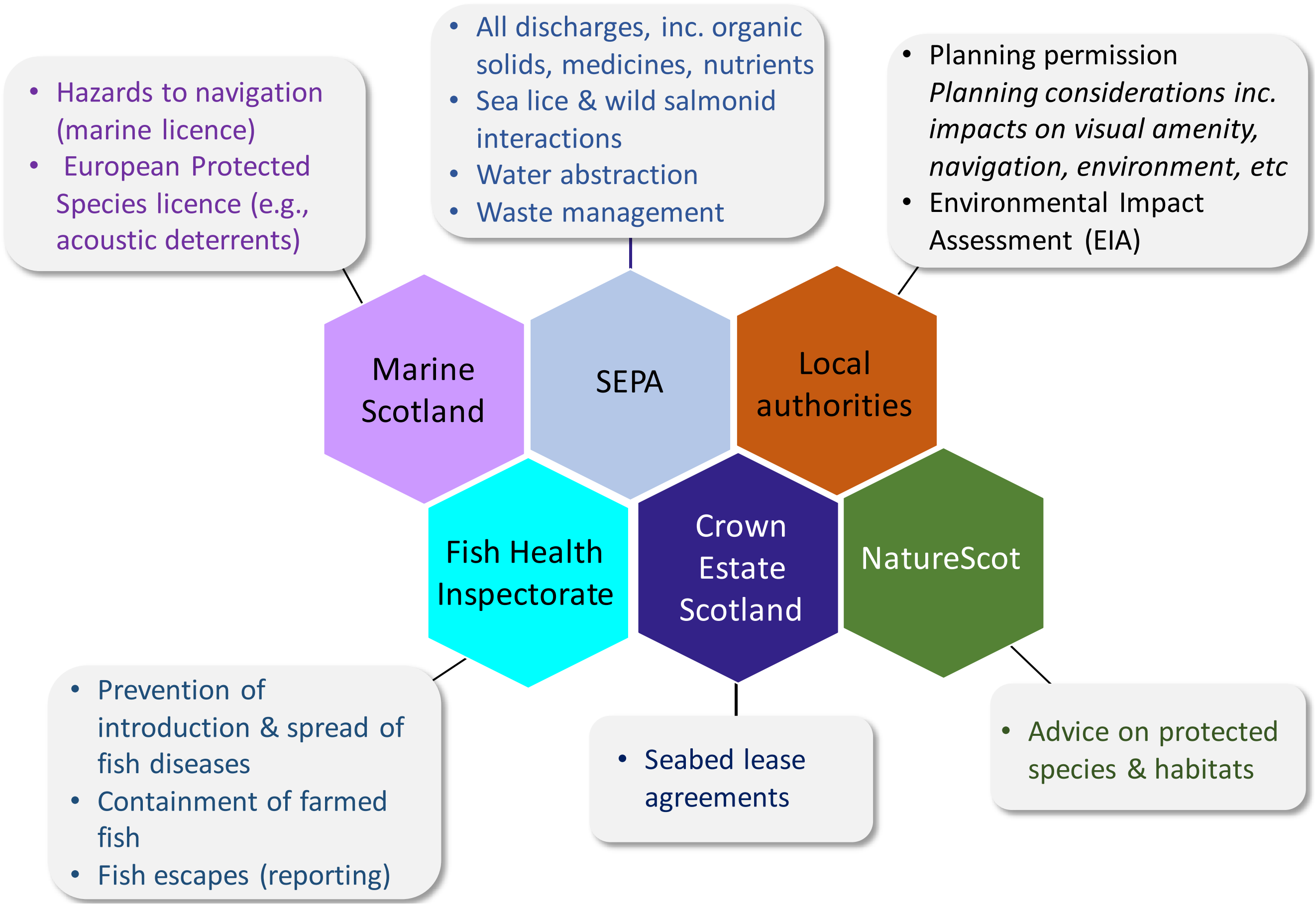

Figure 2: Key organisations involved in the regulation of marine fish farms.

Table 1: Roles of the main bodies in supporting the management of interactions between sea lice from farms and wild salmonids

Organisations	Roles
SEPA, local authorities & NatureScot.	• Pre-application discussions. • Information and advice for environmental impact assessment scoping; and • Consenting decisions.
SEPA, Marine Scotland, NatureScot, Crown Estate Scotland, & local authorities	• Development of coordinated environmental monitoring strategy

FHI[13] & SEPA	• Coordinated regulation (including monitoring and reporting) of sea lice levels on fish farms.
NatureScot & SEPA	• Close liaison on risk assessments for protected salmon and freshwater pearl mussel populations.

[13] FHI (Fish Health Inspectorate) is part of the Marine Directorate of Scottish Government.

3. Risk assessment framework

3.1 Introduction

This chapter explains how the risk to wild salmonids from farm-derived sea lice will be assessed under the regulatory framework.

Risk assessments underpin environmental regulation. They enable us to target our regulatory effort to where the risk of environmental harm is greatest. They also inform engagement with third parties and help ensure the resources of regulated businesses are invested where they will best protect and improve the environment.

We initially developed the risk assessment framework for the purposes of protecting wild salmon post-smolts during April and May. The protection provided for salmon will also provide a level of protection for sea trout. However, unlike salmon, sea trout do not migrate quickly away from the coast. To cover the early phase of their residence in coastal waters, we are proposing to provide a level of protection for juvenile sea trout on the West Coast and Western Isles until the end of June. We are proposing to do this using a simple, interim approach. This uses information on a farm's contribution to the average infective-stage sea lice concentrations within a WSPZ to decide if, and to what limit, the farmer will be required to control of sea lice numbers. Section 5.7 provides further details.

3.2 Wild Salmonid Protection Zones

The greatest risk of large numbers of salmon being infested with harmful levels of sea lice is during their passage, as small post-smolts, through sea lochs and other confined areas of sea at the start of their migration to oceanic feeding grounds.

No specific migration routes are known for West Coast sea trout post-smolts but the limited information available suggests predominantly inshore and local use of coastal waters.

To target protection where potential risk is greatest, we have identified a network of WSPZs along the West Coast and around the Western Isles (Figure 3). The network includes the following areas:

- All sea lochs into which salmon rivers drain.

- Sounds through which salmon populations are likely to migrate.
- Sea areas within 5 km radius of all salmon river mouths, irrespective of whether the river drains into a sea loch or sound.
- All areas of sea within 5 km of rivers designated for the protection of freshwater pearl mussels. This includes salmon rivers and non-salmon rivers. In the latter, trout act as the sole hosts in the lifecycle of the mussels.

Many of the WSPZs have fish farms already located in or near them; and, because of their water currents, have potential to accumulate higher concentrations of infective-stage sea lice than more open sea areas.

3.3 Identification of WSPZs in the Northern Isles

We have not so far proposed any WSPZs in the Northern Isles. The rivers of the Northern Isles lack significant salmon populations but do have populations of trout, some of which smolt and spend part of their lifecycle feeding in coastal waters as sea trout. However, our understanding of which rivers support a significant sea trout component is limited. We propose to work with stakeholders to identify where WSPZs should be identified, starting with Orkney, where some data on populations is already available, and then moving onto Shetland.

Many sea trout remain near the mouth of their home river mouth but movements of up to 20 km within sea loch systems are common[14]. We propose to apply a similar approach to delineating WSPZs for sea trout in the Northern Isles as we used for identifying WSPZs along the West Coast and around the Western Isles. The WSPZs for sea trout will cover confined areas of sea. Within sea loch systems, they will extend up to 20 km from the relevant river mouths. For rivers flowing out into open sea areas, they will extend outward from the river mouth for 5 km. We will consult on our proposals for sea trout WSPZs in the Northern Isles in due course.

[14] Atenico B. J., Thorstad E. B. Audun H., Rikardsen A. H. and Jensen J. L. A. (2021). Keeping close to the river, shore and surface: the first marine migration of brown trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) post-smolts. Journal of Fish Biology. https://doi.org/10.1111/jfb.14737

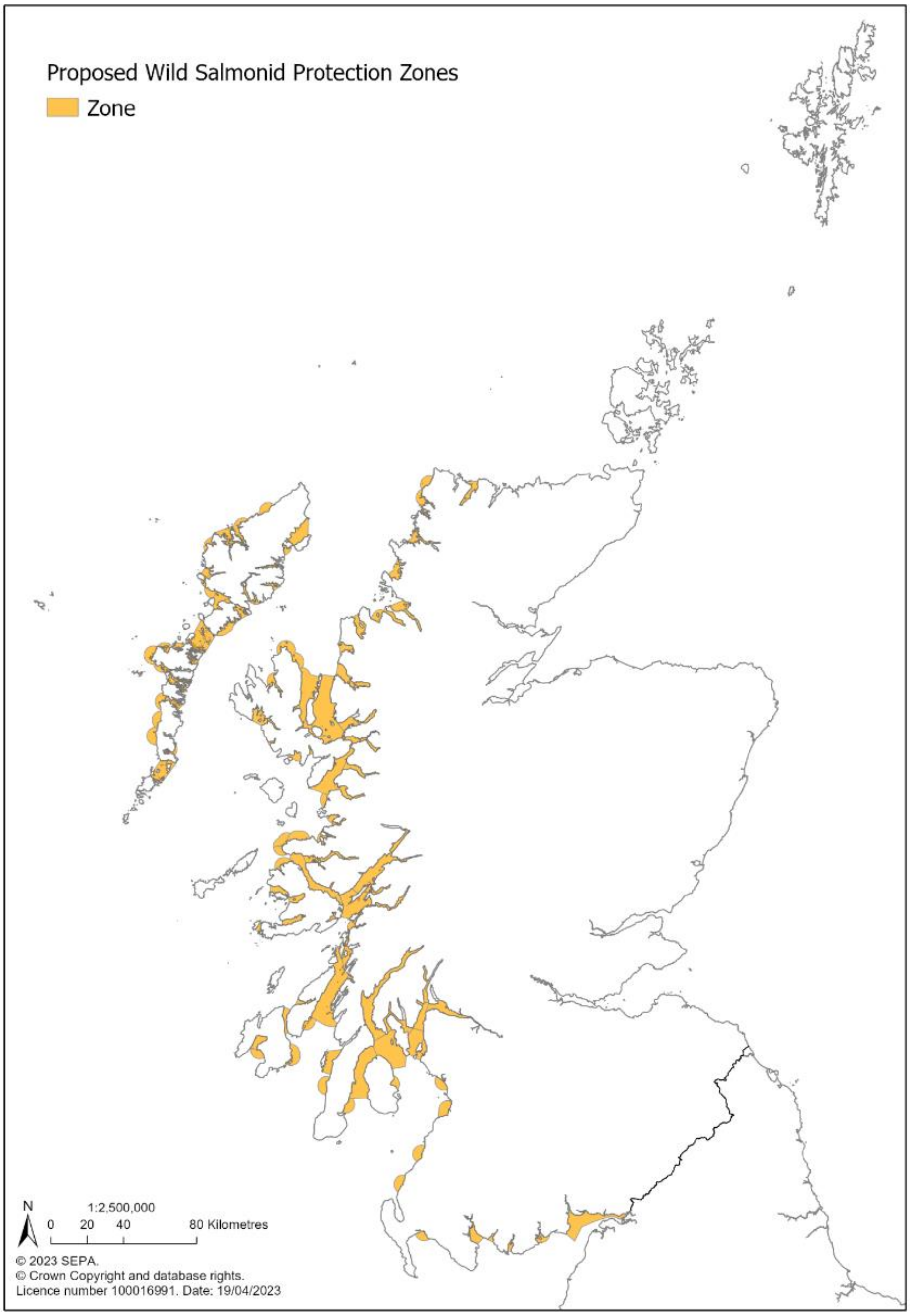

Figure 3: Map of updated WSPZs. An interactive version is available online[15].

We have made the following changes to WSPZs based on feedback received on our first consultation:

[15] https://scottishepa.maps.arcgis.com/apps/instant/basic/index.html?appid=40d9ab4f21cc4037b344060c7d87fe37

- WSPZs for all salmon rivers extend for a minimum of 5 km from the river mouth. In our first consultation, some rivers entering the sea within a short distance of the seaward end of a sea loch WSPZ had an effective WSPZ of less than 5 km radius.

- WSPZs for all freshwater pearl mussel Special Areas of Conservation (SACs) have been identified. In our first consultation, we did not identify WSPZs for the small number of freshwater pearl mussel SAC rivers that do not support populations of salmon.

- The Northwest end of the Sound of Mull WSPZ has been extended to reflect where the Sound opens into the Sea of Hebrides.

We also received suggestions that we should:

- Extend WSPZs into open sea areas, such as the Minch.
- Identify WSPZs for rivers not identified as salmon rivers or which had salmon populations in the past but no longer do so.

As specific migration distributions of different salmon populations become better understood, we will re-examine potential exposures after post-smolts exit WSPZs and consider how to adapt the risk framework as appropriate. At this stage, we are targeting protection in confined areas of sea (WSPZs) through which we know large proportions of wild salmon post-smolts must pass and, hence, in which elevated infective-stage sea lice concentrations pose the greatest risk. Beyond these sea areas, the potential paths that salmon post-smolts could take on their migration start to multiply considerably. Infective-stage lice concentrations are also generally low away from WSPZs and patchy in time and space. We think targeting protection in the confined sea areas represented by WSPZs is the most effective means of managing the overall exposure of migratory salmon to infective-stage sea lice.

We are also not proposing to identify WSPZs for rivers that do not have a notable salmon population. Should this change in future, for example because of wider restoration action, additional WSPZs will be identified as needed. Where we have relevant evidence, we will identify WSPZs for rivers that support significant sea trout populations but lack significant salmon populations.

Question 1: Do you agree with our revisions to the WSPZ? If not, please explain why you disagree and what would be your alternative.

Question 2: Do you have any additional information on, or suggestions how we could identify, important sea trout rivers in the West Coast, Western Isles and Northern Isles?

3.4 Screening models

We propose to use our own spatially-based screening models as the basis for assessing the exposure of wild salmon to infective-stage sea lice in WSPZs. Only where our screening models indicate there may be what we regard as harmful levels of exposure (See Section 3.6) would developers be required to provide more detailed assessments using appropriately refined models when applying for a licence.

Risk screening is an important means of ensuring that our use of resources, and the requirements we place on developers, are:

- proportionate to environmental risk; and
- deliver the greatest benefit for environment.

We already use spatially-based screening models for initial risk assessments of proposed discharges from fish farms of anti-sea lice medicines, organic matter from fish faeces and nutrients. The models provide a triage of high and low risks and identify where more detailed assessment using refined models is required to decide if a development can proceed. The screening models we use are designed to make robust assessments of risk but to not underestimate risk (i.e., the benefit of doubt is given to the environment). Refined models include more sophisticated representations of the system being modelled and a greater degree of calibration and validation.

Over the last year, we have developed screening models that predict the concentrations of infective-stage sea lice during April and May along the West Coast and around the Western Isles. We have not yet developed screening models for the Northern Isles.

The screening models include three components:

(a) A three-dimensional hydrodynamic model, which simulates time-evolving physical characteristics, including the movement of water.

(b) A particle tracking model, which simulates the dispersion of sea lice from existing and proposed farms and the resulting concentrations of infective stage sea lice.

(c) A virtual salmon post-smolt tracking model which simulates the potential exposure to infective-stage sea lice experienced by migrating post-smolts as they pass through WSPZs.

We have built virtual salmon post-smolt tracking into our screening models for the Loch Linnhe system WSPZ and for the Loch Fyne system WSPZ. We will progressively build virtual salmon post-smolt tracking models for other WSPZs, prioritising those with long migration routes. Where we have not done so in advance, we will create salmon post-smolt tracking models when assessing farm development proposals.

If you want access to the screening model input/output files and scripts, please send an email to us at aquaculture.regulation@sepa.org.uk. We will then arrange access to the data for you. Earlier this year, we shared hydrodynamic and particle tracking model output files with a range of stakeholders. These were for the Firth of Clyde area. Similar outputs are now available for the Wider Loch Linnhe area.

Technical work to improve and refine the sea lice screening process is ongoing. A summary of the current method can be found in Appendices 3 and 4.

We are very interested in technical feedback on the model and its performance. When sending us comments, please remember that the purposes of risk screening models are to triage risk and help understand the relative contributions of different sites to infective-stage sea lice concentrations.

Question 3: Do you have any suggestions to improve our screening models?

Question 4: Do you have any suggestions on how we could better present the outputs of the models?

3.5 Refined models

Where our risk screening indicates that a proposal may result in the sea lice exposure threshold being exceeded, or further exceeded, the developer will need to provide a refined model that demonstrates that the development can be accommodated without the sea lice exposure threshold being compromised. We will carry out checks of these models before accepting them for the purposes of determining applications (See Chapters 4 and 5).

The development of refined models will be able to draw on research in Norway and Scotland, including the recent SPILLS Project[16]. More refined models have already been developed for some areas by researchers and by modellers in the finfish farming industry. We will build on these initiatives and, from 2024, engage with Scotland's community of modellers to develop suitably refined models for those WSPZs in which screening models indicate that the sea lice exposure threshold could be exceeded.

An important part of the screening process is to critically evaluate modelling results, considering other relevant information. This evaluation process may conclude that it is also necessary to develop more refined models in some areas where confidence in the screening model output is low.

3.6 Application of sea lice exposure threshold

As outlined above, our screening models will predict the exposure levels that could be experienced by wild salmon in a WSPZ. The prediction will be based on modelled exposures of virtual salmon post-smolts emigrating through the WSPZ at different time steps and following different paths.

Sea lice exposure threshold

Infestation with enough sea lice results in harm to wild salmon post-smolts, including an increased probability of mortality. The number of sea lice a salmon post-smolt can tolerate without a risk of significant harm depends on its size. The smaller the fish, the fewer lice it can tolerate.

Infections of around 0.08 sea lice per gram of salmon post-smolt (i.e., more than 1 louse on an average 20-gram post-smolt) cause serious physiological effects with potential to result in indirect mortality[19]. The probability of mortality, including mortality resulting directly from the infestation, increases with the lice burden. At around 0.1 sea lice per gram (2 lice on an average 20-gram post-smolt), the probability of mortality is

[16] https://www.gov.scot/publications/salmon-parasite-interactions-linnhe-lorn-shuna-spills-final-project-report/
[19] https://www.int-res.com/articles/aei2023/15/q015p073.pdf

We are proposing to use a series of relatively direct paths[17], including one along, and the others offset either side of, the midline of the WSPZ. Movements of salmon post-smolts during the first phase of coastal migration can be complex, with some taking a direct route towards the sea and others moving in different directions over short temporal and spatial scales[18]. We will modify the paths used in modelling as knowledge of the paths used by wild salmon post-smolts in WSPZs improves.

The modelling will generate exposure results in lice per m^2 days for large numbers of virtual salmon post-smolts. We will order the modelled exposures by magnitude and apply the exposure threshold to the 95[th] percentile exposure value. Exceeding the exposure threshold at the 95[th] percentile value will indicate that the development would be likely to have a significant adverse impact.

The use of a 95[th] percentile statistic means that the highest 5 % of modelled exposures are excluded. We think it is important to do this because predicted high exposure values may include artefacts of modelling

likely to be up to 20 %[20]. At around 0.24 sea lice per gram of post-smolt, the probability of mortality is estimated[21] to be 50 %.

The number of sea lice with which a salmon post-smolt is infected depends on the concentration of infective-stage sea lice in the sea through which it swims; and the time it is exposed to those concentrations. Exposure to a high concentration of infective-stage lice for an extended period would lead to infestation with more lice than exposure to the same concentration for a short time.

The sea lice exposure threshold defines the level of exposure beyond which the likelihood of salmon post-smolts being infected with harmful numbers of sea lice is significant. The exposure threshold is expressed in sea lice per m^2 days and describes the maximum cumulative concentration of infective-stage sea lice integrated over the upper 2 metres of sea to which salmon post-smolts can be exposed without a likely significant impact. For example, 1 day exposed to a concentration of 0.75 lice per m^2 or 2 days exposed to a concentration of 0.375 lice per m^2 would be produce exposures at the exposure threshold, which is 0.75 sea lice per m^2 days.

The sea lice exposure threshold has been derived from scientific studies in close consultation with scientists from Marine Scotland and discussion with experts in Norway. Following comments received on the exposure threshold in response to our 2021 consultation, we reviewed the latest available scientific evidence. Based on the review, we are satisfied that the proposed threshold of 0.75 infective-stage sea lice per m^2 days is suitable for assessing whether a significant impact on salmon post-smolts is likely. The evidence is summarised in Appendix 2. We will continue to review and adapt the threshold as new scientific evidence becomes available.

[17] cf Kristoffersen et al 2018 in which the shortest direct paths were used for the modelling study https://doi.org/10.1016/j.epidem.2017.11.001
[18] Thorstad et al (2012) https://doi.org/10.1111/j.1095-8649.2012.03370.x
[20] https://academic.oup.com/icesjms/article/72/3/997/686282
[21] https://www.int-res.com/articles/aei2023/15/q015p073.pdf

and, if not excluded, could lead to substantial overestimates of risk.

More than one river catchment's population of wild salmon emigrate through some WSPZs. In assessing risk, we will model the exposure of virtual salmon post-smolts emigrating from rivers furthest from the seaward end of WSPZs. Salmon post-smolts emigrating from rivers close to the seaward end of a WSPZ will be at lower risk because they will spend less time within the WSPZ.

3.7 Risk assessment framework for sea trout

We have not yet developed screening models for the Northern Isles. We will aim to have a screening model for Orkney in place by 2024. It is likely to take until 2025 before we can complete screening models for Shetland, where more work is required to develop a suitable hydrodynamic model.

Once we have identified sea trout WSPZs and developed sea lice dispersion models for the Northern Isles, we are proposing to apply a sea trout-specific risk assessment framework. To help develop this framework, we will engage with scientists, including Scottish Government scientists, and widely with other interested parties. We intend to consult on a proposed framework during 2024.

We are planning to base the framework on the spatial extent of high infective-stage sea lice concentrations in WSPZs during the period from 1st April to 30th June. Currently, we do not think screening models using virtual post-smolt tracking models are a suitable basis for assessing risks to sea trout. This is because many sea trout stay close to the mouth of their home rivers, and we do not have sufficient understanding of longer distance sea trout movements.

Norwegian researchers[22] have developed proposals for a risk assessment method for sea trout in Norway. This is based on assessment of the effect of sea lice from farms on the marine feeding time of sea trout. This method may be suitable for assessing risk to sea trout in Scotland and is an option we will explore in developing our proposals.

[22] Finstad B., Sandvik A. D., Ugedal O., Vollset K. W., et al (2021) Development of a risk assessment method for sea trout in coastal areas exploited for aquaculture. Aquaculture Environment Interactions 13:133-144. https://doi.org/10.3354/aei00391

The framework will be designed to be adaptive to improvements in scientific understanding of local sea trout migration patterns, including time spent at sea; the vulnerability of early sea trout post-smolts to sea lice; and the status of sea trout populations.

In the interim, for WSPZs along the West Coast and around the Western Isles, we will apply a simple interim approach to provide a level of protection for early post-smolt sea trout. The approach will use the outputs of our sea lice dispersion models to identify development proposals that would result in high average infective-stage sea lice concentrations in WSPZs (See Section 5.7).

Question 5: Do you agree with our proposed approach to developing a risk assessment framework for sea trout? If not, please explain why you disagree and what would be your alternative?

3.8 Risk assessment matrix

We have created a spatially-based risk assessment matrix for wild salmon. It is built from two components, which are described in the following sections:

- The capacity available within WSPZs (calculated from screening model).
- The contribution made by each farm to the exposures of salmon to infective-stage sea lice within each WSPZ.

We plan to use the matrix to help prioritise further assessments and to tailor the regulatory controls we apply so that they are proportionate to environmental risk. For example:

- Farms that contribute substantially to the use of capacity in WSPZs that have little or no available capacity will require appropriately tight control of the number of sea lice on the farm to avoid the sea lice exposure threshold being exceeded.
- Farms that contribute little to the use of capacity in WSPZs with large available capacity will not need to control lice numbers to the same extent to ensure the sea lice exposure threshold is no compromised.

The matrix will be used when:

- Determining when, and what, permit conditions to include when authorising new farms or significant increases in the number of fish held at existing farms (Chapter 5).
- Deciding on when, and what, conditions to add to permits for existing farms (Chapter 6).
- Prioritising our compliance assessment work. (Chapter 7).
- Targeting environmental monitoring programmes (Chapter 8).

3.8.1 Capacity available within WSPZs

The capacity of an environmental system describes the extent to which it can sustainably accommodate additional pressure before there is a risk of significant adverse impacts. Many activities, from water abstraction to discharges of waste effluents, make use of environmental capacity. Environmental standards and thresholds, including the sea lice exposure threshold, are used to identify the limits of environmental capacity beyond which there is risk of significant adverse impact.

Understanding available capacity is important for risk management. Environmental systems with limited available capacity require tight control of developments to avoid environmental standards or thresholds being breached; and opportunities for future development being unnecessarily compromised.

The available capacity of a WSPZ depends on the additional exposure to infective-stage sea lice that can be accommodated without the exposure threshold being exceeded. This capacity can be represented in terms of how far the 95th percentile of exposures is from the exposure threshold (0.75 infective-stage sea lice per m^2 days). For example, if the 95th percentile of exposures is 0.9 lice per m^2 days, the capacity of the WSPZ is exceeded and there is no available capacity. In contrast, if 95th percentile exposure values are closer to zero lice per m^2 days, there would be considerable available capacity.

3.8.2 Interim approach: assessing available capacity

In the absence of modelled exposures for virtual salmon post-smolt in all WSPZs, we have carried out an initial, simple assessment using modelled average infective-stage sea lice concentrations during April and May for each WSPZ and the length of each WSPZ. The larger WSPZs consist of more than one sea loch or sound. For this interim approach, we subdivided these WSPZs into different sea areas. For example, in the Loch Fyne system WSPZ, we subdivided the WSPZ into Loch Fyne, Kilbrannan Sound and the Sound of Bute.

We modelled a conservative scenario in which all farms are operating at their maximum biomass during the Spring period and the average number of adult female sea lice per fish on each farm is 0.4.

Combining the infective-stage sea lice concentrations predicted on these assumptions and the lengths of the relevant WSPZs, or parts of WSPZs, generates a simple, relative ranking of the potential sea lice infestation pressure on salmon post-smolts for all WSPZs.

We are proposing to use this first triaging of WSPZs to prioritise, for further screening, those in which the method indicates infestation pressure may be high. We will use our virtual salmon post-smolt model to further screen this subset of WSPZs, triaging them into those in which capacity may be limited or exceeded and those in which there is at least an intermediate level of remaining capacity.

The 8 WSPZs prioritised for further assessment in this way are listed in Table 2. Their prioritisation does not infer impact. So far, we have built virtual salmon post-smolt models for two of the WSPZs, the Loch Linnhe system WSPZ and the Loch Fyne system WSPZ. Information on these models is provided in Appendix 3.

Table 2: WSPZs prioritised for further assessment	
• Loch Linnhe system • Loch Carron and East Skye system • Loch Fyne system • Kyles of Bute	• Loch Sunart • Loch Nevis • Loch Seaforth • Loch Torridon

3.8.3 Contributions of individual farms

Our screening models allow us to calculate the contribution that individual farms make to infective-stage sea lice concentrations within WSPZs. The outputs indicate that a relatively small number of farms make large contributions to exposure risk.

The screening model outputs for the Loch Linnhe system and Loch Fyne system WSPZs show that a farm's contribution to salmon post-smolts' exposures to sea lice is highly dependent on the location chosen for a development. The contribution to exposures is highest where:

- Most of the farm's sea lice stay within the WSPZ during their infective stage and are dispersed across multiple potential migration routes.
- The WSPZ is long, resulting in salmon post-smolts taking multiple days to pass through it.

For example, a development near the seaward end of a WSPZ in a location where local currents would disperse most of the lice from the farm out of the WSPZ before the lice become infective would have little or no effect on exposure.

3.8.4 Categorising relative risk

By combining assessments of available capacity and of the contribution made by individual farms, the relative risk posed by lice infestations on different farms can be categorised. Figure 4 illustrates the resulting risk assessment matrix.

We have populated the matrix and Table 3 with the results of an initial screening assessment for all authorised farms along the West Coast and around the Western Isles. For this initial assessment, we used the simplified interim approach to assessing available capacity described above and a simple classification of the size of individual farm contributions to infective-stage sea lice concentrations. For the latter, average contributions over April and May of greater than or equal to 0.04 infective-stage lice per m^2 were classed as substantial and contributions of less than 0.02 as negligible. Appendix 4 provides further details. The approach allowed us to provide a simple, consistent, initial classification of the relative risk of all the authorised fish farms outside of the Northern Isles.

A relative risk categorisation of "4" in the resulting risk matrix means that:

- changes in sea lice infestation on the farm can have a large effect on infective-stage sea lice concentrations in a WSPZ; and
- infestation pressure in the affected WSPZ may be high.

Farms with this categorisation are likely to pose the greatest risk to wild salmon post-smolts if adult female sea lice numbers on their fish are not closely controlled. This is a relative risk. It does not imply impact. Its purpose is to help prioritise where further assessment is targeted.

We will update the matrix as we complete virtual salmon post-smolt models for the WSPZs. Once we have done so, a risk categorisation of “4” will indicate that a farm is likely to pose a high risk of the sea lice exposure threshold being exceeded, or further exceeded, if sea lice numbers on the farm increase; a categorisation of “3”, a considerable risk; “2” a medium risk; and “1” a low risk.

Contribution to infective-stage sea lice concentration	Remaining available capacity in WSPZ		
	Large (108)	Intermediate (5)	Little or none (8)
Negligible	50	5	4
Small	8	6	7
Moderate	9	4	5
Substantial	28	15	21

Key: Relative risk posed by farm

1 2 3 4

Lowest to highest

Figure 4: Proposed risk assessment matrix for categorising the relative potential risk posed by individual farms. *Note: The numbers in each cell are authorised fish farms listed as active on the Scotland’s Aquaculture website as of the end of January 2023 along the West Coast and around the Western Isles, including farms we have authorised, but which are not yet operational. The matrix describes relative risk based on a simple, initial, interim screening assessment. It does not imply impact. Changes in sea lice infestations on farms in the bottom row can have a large effect on the concentration of infective stage sea lice in a WSPZ. Changes in sea lice infestations on farms in the top row do not. The matrix triages where we will focus further screening assessments using our virtual salmon post-smolt model (i.e., WSPZs in the right-hand column).*

Table 3: Summary of matrix categorisations of relative risk

Relative risk (1, lowest; 4, highest)	**Number of farms**	**Proportion of farms (%)**

1 (including 2 farms with no influence on any WSPZs)	84	51
2	39	24
3	20	12
4	21	13
Totals	164	100

Question 6: Do you agree with our proposed risk assessment methodology? If not, please explain why you disagree and what would be your alternative.

3.9 Timetable summary

This Chapter described the approach we have developed to risk assessment.

We have already developed full risk screening models for the Loch Fyne area WSPZ and the Loch Linnhe area WSPZ. Over the remainder of 2023, we plan to add virtual salmon post-smolt models to the hydrodynamic models and particle (sea lice) tracking models that we have developed for the small number of other main WSPZs in which initial screening indicates infestation pressure may be high. This will enable us to complete risk screening for these WSPZs and prioritise subsequent assessment work accordingly.

For all other WSPZs, we will progressively add virtual salmon post-smolt models as we prepare risk-screening reports to support pre-application discussions on proposed developments and assess applications. We will do this as soon as the framework is implemented.

We are aiming to develop sea lice dispersion models for the Orkney Islands and Shetland Islands over the period 2023 to 2025. The first step of this work will be to identify river catchments that are important for sea trout.

We will be working on more refined models for the WSPZ that are most at risk from 2024 onwards.

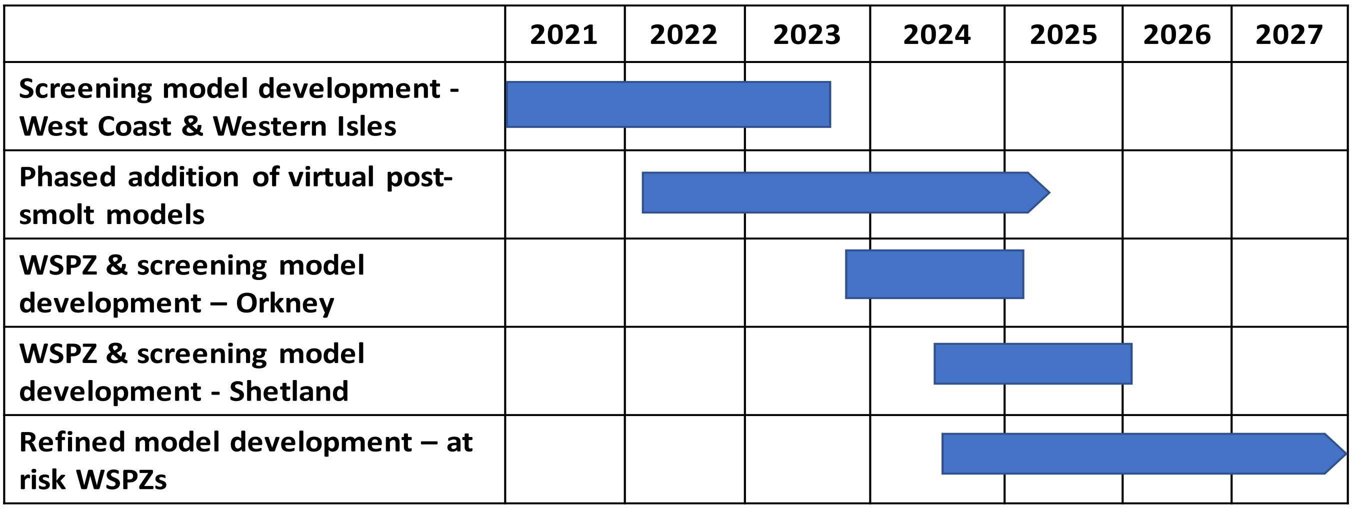

Figure 5: Projected timetable for the development of our risk assessment process.

Question 7: Do you agree with the proposed timetable? If not, please explain why you disagree and what would be your alternative.

4. Pre-application process

4.1 Introduction

This chapter explains how we propose to incorporate the sea lice framework into our existing pre-application process. Pre-application discussions are intended to provide understanding of the environmental implications of proposals to develop new farms or expand existing farms. To do this, we promote early engagement between the developer, local communities and SEPA.

SIWG Recommendations

Local engagement mechanisms between finfish farmers and wild fishery managers should be established as a minimum, to engage in pre-application consultation, agree joint local management priorities and projects, act as a forum for information and data exchange, identify research priorities and request management action as appropriate."

Scottish Government Response to SIWG

We agree that local engagement mechanisms between finfish farmers and wild fishery managers should be established as a minimum, to facilitate pre-application consultation, agree joint local management priorities and projects, act as a forum for information and data exchange, and identify research priorities and request management action as appropriate.

In 2019, we introduced a new service for developers and other interested parties. We started to produce screening reports providing an initial assessment of farm development proposals. We publish these screening reports on our website. They provide:

- Developers with our initial assessment of the suitability of a potential development location and an understanding of the information necessary to support an application.

- Interested third parties with an opportunity to identify relevant local issues (e.g. important local environmental features that might be affected by the development or other uses being made of the area of sea concerned). Identifying local issues early enables developers to provide information on how they plan to avoid impacts when applying to us for a permit.

Currently, the screening reports cover deposition of organic material, discharges of anti-sea lice medicines and, where relevant, discharges of nutrients. The models described in Chapter 3 will allow us to add an assessment of the potential for interaction between sea lice from a potential farm development and wild salmonids, and an improved assessment of discharges of nutrients.

The screening models for sea lice will also provide information on the extent to which a potential location for a farm development is likely to be exposed to concentrations of infective-stage sea lice from other farms in the area. Managing sea lice infestations adds to the costs of fish production for finfish farmers. Early information on whether infestation pressure is likely to be high or low at potential development locations will help inform investment planning.

We remain committed to working with the Scottish Government, the sector and others to deliver a more streamlined fish farm consenting system. We think that the work we are proposing to expand and enhance our pre-application risk screening service will help in this context by delivering more efficient and effective pre-application processes.

4.2 Pre-application process and sea lice framework

The pre-application process will help developers to understand the relative challenges of developing farms in different locations and the information we will require them to provide with their applications to enable us to assess potential risks to wild salmonids. The process will follow a similar approach to the one we already use for biomass and medicines. It is summarised in Figure 6.

We expect developers will notify us of their plans to apply for a permit for a farm and provide basic details to allow us to understand the proposal.

Where open-net pens are planned, the following information would be needed.

Basic information for screening

1. Proposed location.
2. Maximum number of fish to be held at any one time between 16th March and the end of the wild salmonid migration period by year of production cycle at sea (i.e., number in first year; number in second year if cycle length is greater than 1 year).

3. The maximum average number of adult female lice per fish to which the developer intends to manage the farm during the wild salmonid migration period by year of production cycle at sea (i.e., number in first year; number in second year if cycle lengths are greater than 1 year).

Subsequent information required to support an application.

4. If the site will be fallowed for part, or all, of the wild salmonid migration period each production cycle, and details of the production cycle timings.

5. The measures that the developer plans to take to control sea lice numbers on the farms to maintain the proposed levels. This information will include the developer's assessment of the sufficiency of the range of lice control measures[23] that the farm will have access to, including anti-sea lice medicines; and a description of any lice management coordination agreements with other relevant farms in the area.

For developments screened as likely to result in the sea lice exposure threshold being exceeded (or further exceeded):

6. Suitably refined models showing that the proposal would not pose a risk to wild salmonid populations and the corresponding number of adult female sea lice on the farm at which the model demonstrates this will be the case.

Using the basic information required for screening, we will undertake an assessment of the proposal using our screening models (including virtual salmon post-smolt models) and identify the risk that it poses to wild salmon post-smolts in WSPZs. We will also calculate the relative scale of the contribution of the proposal to exposure to infective-stage sea lice in the WSPZ.

One of the purposes of the screening report is to support engagement with interested parties. This engagement is important as it can identify potential issues in relation to which information may need to be prepared to support a subsequent application. We expect developers to organise engagement and use the screening reports to inform discussions. We will publish the screening report in advance of engagement sessions to facilitate this.

[23] Operators must take all reasonable steps to minimise discharges of medicines. One way to minimise discharges is to deploy a range of non-medicinal sea lice control measures to reduce reliance on anti-sea lice medicines.

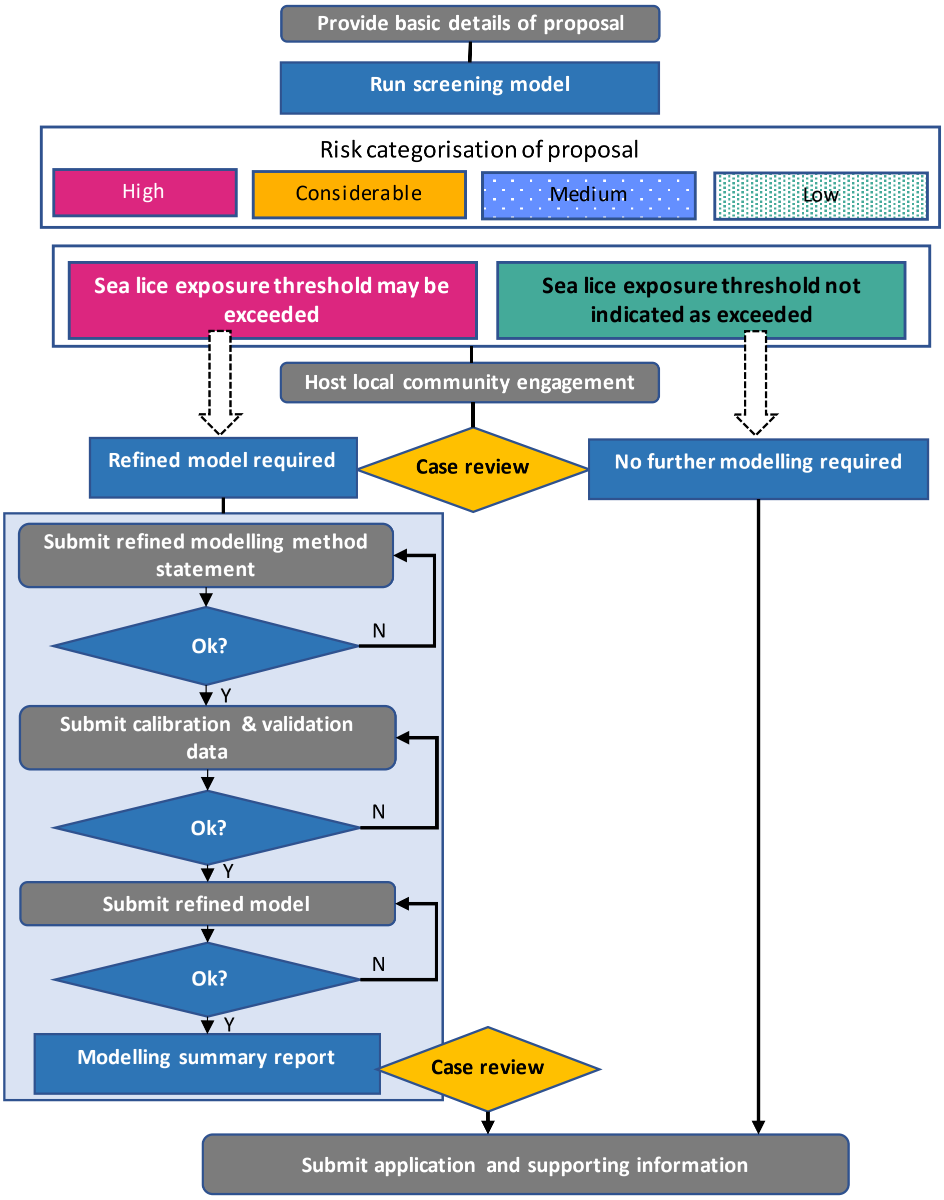

Figure 6: Pre-application process for assessing the potential risk posed by sea lice from farm developments to wild salmonids.

When the output of the screening model indicates that the development could result in the sea lice exposure threshold being exceeded, or further exceeded, we will ask the developer to build and submit a refined model that meets our performance requirements and will enable the risk to be evaluated.

Our expectation is that most development proposals will not require refined modelling. However, in those cases where our risk screening indicates that a proposal may result in the sea lice exposure threshold being exceeded, the developer will need to provide a suitable refined model to demonstrate that the development can be accommodated without the sea lice exposure threshold being compromised before we can consider granting an application.

We will advise developers whether the methods they are proposing to use to build refined models meet our performance requirements for such models. We will also carry out checks of refined models when they are submitted to ensure the models meet our requirements for use in assessing risk.

The level of sophistication and validation required of a refined model will depend on what is necessary to demonstrate that the proposal will not result in the sea lice exposure threshold being exceeded.

A suitably calibrated and validated hydrodynamic model and a best-practice particle (sea lice) tracking model may be a sufficient, first level refined model to demonstrate that the development would not pose a risk of the sea lice threshold being exceeded. If not, a refined model that has been validated using a sentinel cage study may be required (See Chapter 8).

Question 8: Do you agree with the proposed workflow for pre-applications? If not, please explain why you disagree and what would be your alternative.

4.3 Phasing-in of screening

We will undertake sea lice screening assessments of all pre-applications and applications received after the publication of this consultation. These screening assessments will provide applicants with an understanding of how the framework could affect their development proposal. The screening assessments will be made using the approach described in this consultation and, hence, may need to be updated if our approach to screening is revised after we have considered the responses to the consultation.

4.4 Timetable summary

This Chapter described our proposed pre-application process aimed at ensuring developers have an early understanding of any issues; and tailored advice on the information needed to support permit applications.

We will be able to use our screening models to support pre-application discussions on potential farm developments along the West Coast and around the Western Isles from the start of the implementation of the framework.

During 2024, we intend to begin the process of collaborative development of refined models for those WSPZs in which screening indicates the sea lice exposure threshold may be exceeded.

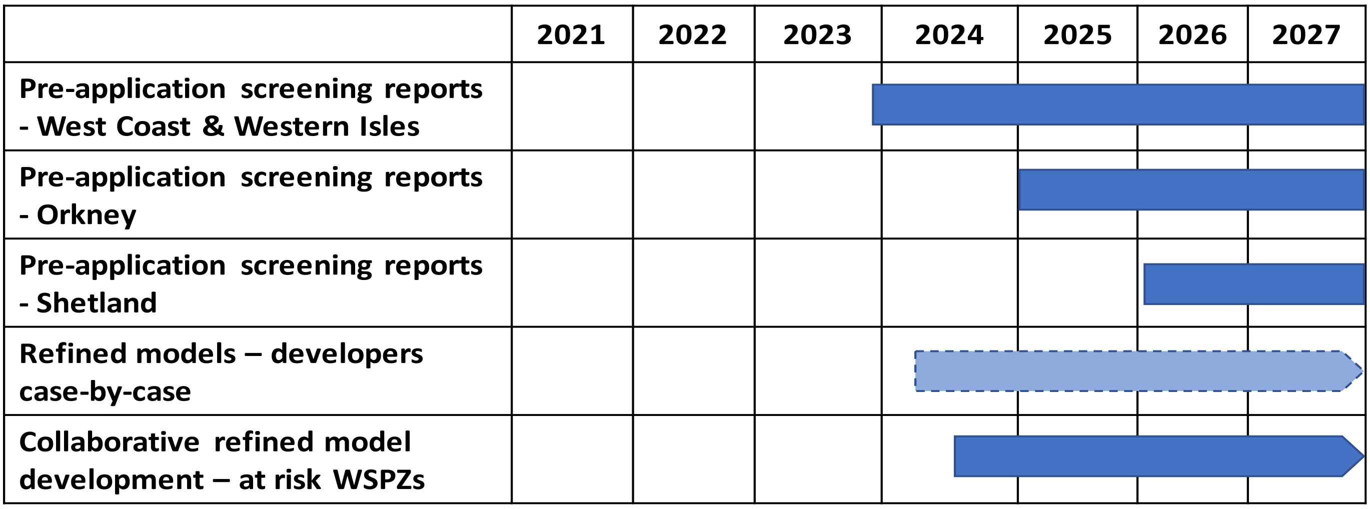

Figure 7: Projected timetable for the development of pre-application environmental assessment.

Question 9: Do you agree with the proposed timetable? If not, please explain why you disagree and what would be your alternative.

5. Applications for new or expanding farms

5.1 Introduction

This chapter explains how we propose to apply the sea lice framework when considering permit applications for new sites or for increases in the number of fish kept at existing sites.

Farmers are already required to obtain authorisation from us for the operation of fish farms, including the discharge of fish faeces, anti-sea lice medicines and other substances. The permits we issue specify the maximum tonnage of fish allowed on the farm at any time. This limit is designed to control the quantity of fish faeces that can be discharged.

Permits issued under the proposed framework will allow for the keeping of salmonid fish in open-net pens. If using open-net pens, the potential effect of a farm at a given site on the exposure of wild salmonids to infective-stage sea lice is directly proportionate to the number of fish (rather than fish biomass) on the farm that can act as hosts for sea lice.

Under the framework, farmers will be required to obtain authorisation to increase the numbers of fish kept in open-net pens. This includes increases resulting from:

- Establishing a new farm using open-net pens.
- Increasing an existing farm's biomass.
- Switching the use of an existing farm from growing fish to full harvest weight to growing more fish to a sub-harvest weight before transferring them to another site.

Increases in the number of fish resulting from the latter type of change in the operation of an existing farm may result in a reduction in the maximum number of lice dispersing from the farm. This is because there will normally be a much shorter time between fallow periods, avoiding the higher sea lice infestation levels that farms can experience in the second year of production. The operator may also be able to time fallowing to coincide with the post-smolt migration window each year. Any proposal that leads to a reduction in the maximum number of sea lice typically dispersing from the farm will be assessed as not adding any additional pressure on capacity and authorised accordingly.

SIWG Recommendations (May 2020)

Robust conditions, based on an adaptive management approach, to safeguard wild salmonids should be contained within a licence rather than through planning consent;
As a priority, the consenting of new developments should be managed within an adaptive spatial planning model which is risk based, of suitable resolution, underpinned by best available scientific evidence, and takes into account the cumulative effect of management practices of existing developments and impacts on wild salmonid fish.

Scottish Government Response to SIWG (October 2021)
We agree that robust conditions, based on an adaptive management approach, to safeguard wild salmonids should be contained within a licence rather than through planning consent and that the relevant licence conditions should apply to existing, as well as new, fish farms.
We agree that, as a priority, the consenting of new developments should be managed through the application of an adaptive spatially based risk assessment tool, underpinned by the best scientific evidence available and which takes into account the cumulative effect of management practices of existing developments and potential impacts on wild salmon.
It is intended that development proposals involving increases in the numbers of fish farmed, including applications for new farms or expansion of existing farms, will be assessed using the new spatially-based risk assessment framework as part of the CAR licence determination process and where there is the potential for interaction, subject to conditions appropriately limiting their contribution to lice loads in coastal waters.

5.2 Principles of the approach

When determining any application for an activity that has the potential to adversely affect the water environment, our objectives include:

- Ensuring environmental standards are not compromised and so deliver our purpose of preventing deterioration of the environment.
- Ensuring efficient use of environmental capacity to avoid unnecessarily limiting scope for future development.

For the second of these two objectives, the approach we are proposing is that, where capacity is under significant pressure, we will apply lice control limits based on achievable but high standards of sea lice management.

5.3 Application process

Developers must apply for a permit from SEPA which allows them to keep fish in open-net pens if they wish to develop a new farm or keep more fish at an existing farm. SEPA will set permit conditions to protect wild salmonids between 16th March and 30th June.

This requirement will apply to fish farm developments within, and outside of, WSPZs. This is because infective-stage lice from developments outside of WSPZs can be carried into WSPZs. It will not apply to start with to fish farm developments around the Northern Isles. We will introduce permit application requirements in Orkney and Shetland once we have identified WSPZs and developed a specific risk framework for sea trout protection (See Section 3.7). However, interactions between sea lice from fish farm development proposals and wild sea trout will continue to be a consideration in planning decisions made by Orkney Islands Council and Shetland Islands Council.

Developments using enclosed or semi-enclosed pens that prevent, or ensure minimal, sea lice exchange between the farmed fish and the surrounding sea will not be subject to sea lice-related permit controls.

By the time an application for a permit is submitted, the developer should have a good understanding of the issues associated with the development of a site.

This understanding will be based on the SEPA Screening Report, the collection of the information required to support the application, and discussions with SEPA staff and interested parties. Where the preparation work has been completed and stakeholders have been well engaged, the technical process of consultation and permit determination should normally flow smoothly.

If any information we required the developer to provide to support an application is not submitted with the application, the application will normally be returned, and no progress will be made until the deficiencies have been addressed.

The stages of determining an application are presented as a process diagram on the aquaculture section of our website.

5.4 Risk assessment

To enable us to protect the environment, our permitting decisions are based on assessments of whether development proposals would pose a risk to the environment.

A core purpose of the proposed regulatory framework is to protect against deterioration of wild salmonid populations by managing the risk to salmon post-smolts from lice from fish farm developments. Avoidance of deterioration is also one of the purposes of our regulation of a range of other activities, such as building and engineering works in rivers that could otherwise result in the creation of barriers to fish migration.

When determining applications for new farm developments or for increases in the number of fish that can be held at existing farms, we will assess the likelihood of wild salmon post-smolts being infected with harmful levels of lice during their passage through WSPZs. To do this, we will:

a) Use modelling to assess the potential infective-stage sea lice concentrations within the relevant WSPZ during April and May, considering the proposed development and existing farms.
b) Determine the potential exposure to infective-stage sea lice to which salmon post-smolts may be subject during their passage through the WSPZ.
c) Apply a sea lice exposure threshold of 0.75 lice per m^2 days.

We will conclude that a proposed development poses a significant risk of wild salmon post-smolts being infected with harmful levels of lice if it is predicted to cause:

- The exposure threshold to be exceeded.
- An increase in the extent by which the exposure threshold is already exceeded.

5.5 Decision to grant a permit

Applications for farm developments likely to result in the sea lice exposure threshold being exceeded, or further exceeded, are unlikely to be granted authorisation.

Where our screening assessments indicate that a proposal may result in the threshold being exceeded, or further exceeded, the developer may:

- Revise the proposal before making an application (e.g., select a different location; reduce the number of fish planned to be kept; propose to keep fish in a non-open-net pen system; etc).
- Undertake suitable refined modelling to assess whether the sea lice exposure threshold would be exceeded.

5.6 Permit conditions

SIWG Recommendations

The licence should contain conditions relating to:

- *Requirement for undertaking, recording and reporting of a weekly sea louse count;*
- *Trigger levels for sea lice intervention action specific to the farm management area (to be reviewed subject to adaptive management);*
- *Requirement to monitor lice levels in the environment and assess impacts on wild salmonids;*
- *Requirement to report on the results of such monitoring;*
- *Requirement to contribute to research to understand the migratory distributions of wild salmonids within the West Coast and Northern Isles context;*
- *The actions that are required to be taken where monitoring demonstrates adverse impacts on wild salmonids and the timeframe in which demonstrable actions should be successfully delivered;*
- *Requirement for the farm to be party to a farm management agreement for the farm management area;*
- *Requirement to undertake an end of farm cycle review which informs the next production cycle process;*

5.6.1 Use of risk assessment matrix

When granting authorisations, we will include conditions of authorisation where we consider it necessary and expedient to do so for the protection of the water environment. Permit conditions will include, as appropriate:

- Limits on the total number of sea lice permitted on the farm.
- Monitoring and reporting conditions.

We will use the risk assessment matrix to determine what permit conditions to apply. Figure 8 below summarises this schema.

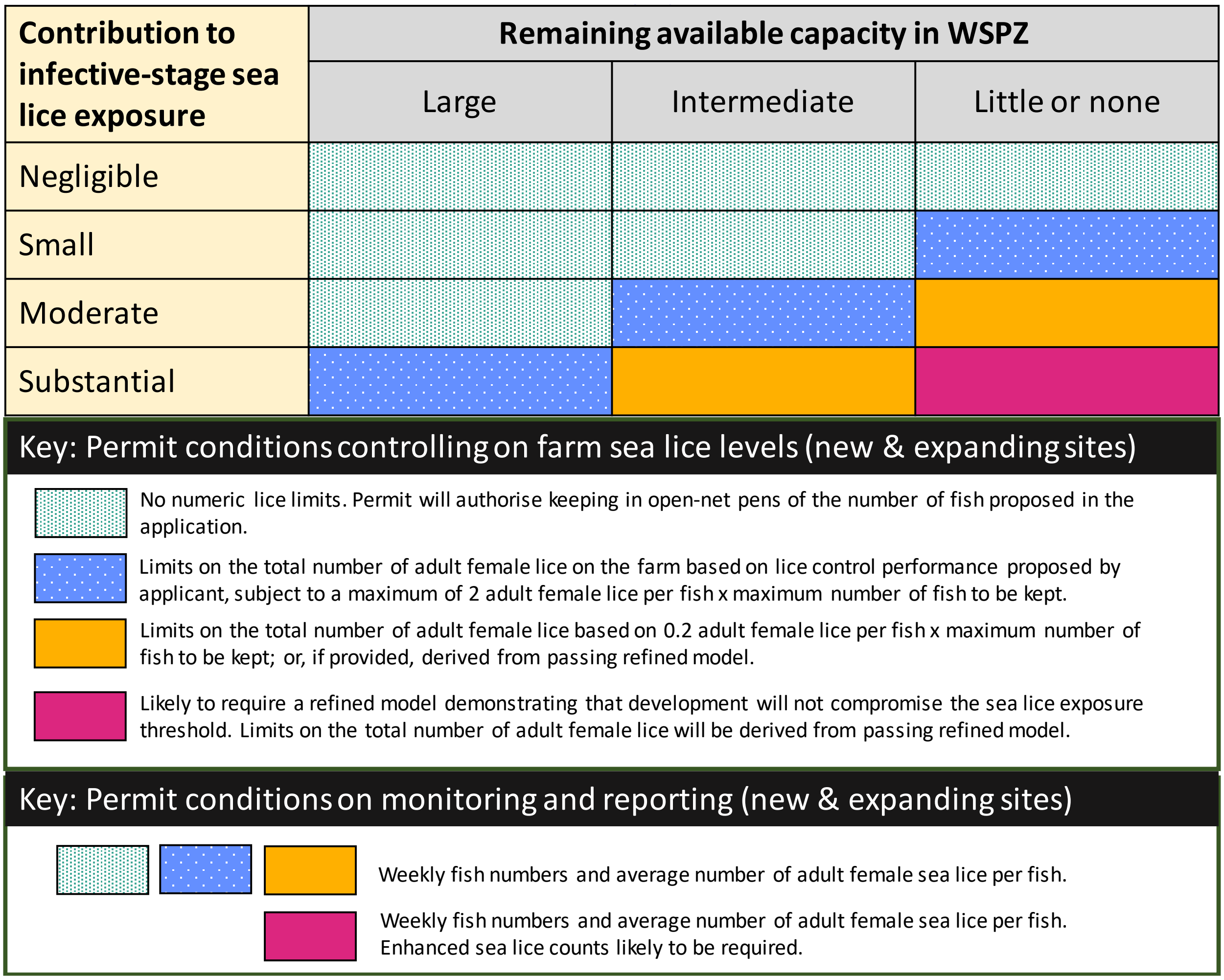

Figure 8: Schema illustrating the sea lice control conditions for new or expanding farms. *The schema is designed to achieve the permitting objectives of guarding against the risk of deterioration (exceedance of the sea lice threshold) and avoiding unnecessarily limiting scope for future development. Note: The schema above applies only to proposals that do not result in an exposure threshold being exceeded, or further exceeded. Those that do will be refused authorisation.*

The **available capacity** is the capacity remaining in the WSPZ after taking account of the contributions to exposure to infective-stage sea lice levels of all existing farms and the contribution of any proposed development being assessed.

Question 10: Do you agree with the way we have used the risk assessment matrix to identify where we will apply permit conditions for reporting and lice limits? If you disagree, please explain how you would apply the matrix and why this would deliver a better outcome.

5.6.2 Permit limits on sea lice numbers

When granting authorisation for new farms or increases in the number of fish at existing farms, in some permits, we are proposing to include conditions limiting the total number of adult female lice permitted on a farm.

We will include limit conditions if the sea lice exposure threshold in a WSPZ is at risk of being exceeded if sea lice numbers on the farm are not adequately controlled. The risk assessment matrix in Figure 8 describes when we will include limit conditions.

The requirements regarding lice management on fish farms under fish health legislation administered by the FHI will continue to apply, including at farms where we do not include numeric limits in our permits.

5.6.3 How numeric limits will be framed

Limit conditions for protecting wild salmon will be based on the maximum number of adult female sea lice there can be on the farm. They will apply from 16th March to 30th May to control infective-stage sea lice concentrations in WSPZs during the period of wild salmon post-smolt migration.

For the purposes of the limit conditions, the total number of adult female sea lice on a farm will be based on: *Number of fish on the farm x average number of adult female sea lice per fish.*

The average number of adult female sea lice per fish will be calculated from counts of lice on a sub-sample of the farm's fish. We will specify the counting protocol that farmers must use for this purpose. We will work with FHI in developing the protocol.

Farmers will be able to meet the condition by managing fish numbers; lice levels; or a combination of fish numbers and lice levels. As a result, farmers will have flexibility in how they comply.

Examples

Suppose the limit for a farm is set at 300,000 adult female sea lice. The farm operator decides to stock the farm with 600,000 fish. With this number of fish, the operator must manage the average number of adult female sea lice per fish to no more than 0.5 (i.e., 6000,000 x 0.5 = 300,000).

By the time of the wild salmon post-smolt migration period of the second year of production, the farmer has reduced the number of fish on the farm from 600,000 to 400,000 through selective harvesting. To comply with the limit on the total number of sea lice, the farmer must now manage the average number of sea lice per fish to no more than 0.75 (i.e., 400,000 x 0.75 = 300,000).

Another developer has demonstrated through modelling that a proposed farm can be accommodated within a wild salmonid protection zone if a limit of 60,000 adult female sea lice can be met. The farmer decides to operate the site using 48-week production cycles separated by 4-week fallow periods. The farm is stocked with 600,000 fish at the end of April. The farmer must manage the average number of adult sea lice per fish to no more than 0.1 for the remainder of the migration period. The preceding fallow period and the timing of the stocking helps the farmer comply with the low average number of adult female lice per fish required. The farm is cleared of fish in the following March.

Question 11: Do you agree with our proposal for setting permit limits on the number of lice on a farm? If not, please explain why you disagree and what would be your alternative.

5.6.4 How compliance with numeric limits will be assessed

Numeric sea lice limits will comprise:

- A limit applied on the number of adult female lice as a rolling 28-day average, with 16th March being the first day of the first 28-day period in the control period; and 30th May being the last day of the control period.

- A limit applied as a maximum number of adult female lice on any day of the control period.

Data for calculating the average (i.e., average number of adult female sea lice per fish and number of fish) must be collected and reported at least once every 7 days.

Our screening modelling shows that it is the average lice management performance of the farms contributing to infective-stage sea lice concentrations in a WSPZ that is most important in managing exposure risk. Occasional small peaks do not drive the exposure risk. This is because exposure risk is dependent on the accumulation of infective-stage sea lice from multiple farms.

For this reason, we want farmers to focus on maintaining low average numbers of lice on their farms during the wild salmon post-smolt migration period. We expect farmers to be guided by the build-up of pre-adults on their fish in determining when to act, and to aim to prevent the development of gravid female sea lice[24] as far as possible during the post-smolt migration window.

Large peaks can pose a potential risk. We will make clear that farm operators must take preventative action to avoid large peaks by including a maximum daily limit on the number of adult female sea lice when issuing permits. We are proposing to set the limit at a value equivalent to greater than 4 times the allowed 28-day average. Failing this limit would indicate wholly inadequate sea lice control on the farm. It would also lead to a failure of the 28-day rolling average limit.

Question 1213: Do you agree with our proposal for applying a rolling average limit, and a maximum daily limit on the number of adult female sea lice? If not, please explain why you disagree and what would be your alternative.

5.6.5 How the limits will be derived

For a development screened as posing a medium risk (see Figure 8 risk matrix), the numeric limit conditions will be calculated based on the sea lice control performance proposed in the permit application. Proposed performances equivalent to a higher adult female sea lice number than 2 x the maximum number of fish to be kept on the farm will not be accepted. A weekly

[24] i.e., adult female sea lice that are carrying eggs in egg strings.

average of 2 adult female sea lice per fish is the “increased monitoring level” under farmed fish health legislation[25].

For developments screened as posing a considerable risk if sea lice are not tightly controlled, the limit conditions will be calculated based on:

- 0.2 adult female sea lice per fish at maximum fish numbers; or
- The on-farm lice numbers derived from a refined model demonstrating that the development can be accommodated without the sea lice exposure threshold being exceeded, or further exceeded, as applicable.

A substantial proportion of farms in Scotland achieve levels of 0.2 adult female lice per fish or fewer during the Spring. In 2021 and 2022, close to 60% of reported weekly averages were less than or equal to 0.2 adult female lice per fish[26]. In Norway, large numbers of farms report compliance with the mandatory average of 0.2 adult female lice per fish in sensitive areas during the main migration period. Performance of farms in Norway against this limit is published on the Barents Watch website[27]. Basing controls on this standard of good practice (i.e., an average of 0.2 adult female sea lice per fish or fewer) that has been demonstrated as achievable will ensure that developments use environmental capacity efficiently and so do not unnecessarily limit scope for future development.

Applicants for farm developments categorised as high risk will typically have been required to provide a refined model demonstrating that the development will not result in the sea lice exposure threshold being exceeded. Limit conditions for these farms will be based on the farm lice numbers used in running the refined model.

5.6.6 Monitoring and reporting conditions

Monitoring and reporting are important. They enable regulated businesses to understand their environmental performance and demonstrate compliance; and they help us to check compliance

[25] https://www.gov.scot/binaries/content/documents/govscot/publications/transparency-data/2019/11/fish-health-inspectorate-sea-lice-information/documents/sea-lice-regulation-topic-sheet/sea-lice-regulation-topic-sheet/govscot%3Adocument/71%2BThe%2BRegulation%2Bof%2BSea%2BLice%2Bin%2BScotland%2B2021.pdf
[26] http://aquaculture.scotland.gov.uk/
[27] https://www.barentswatch.no/fiskehelse/2023/10

and update risk assessments, with the outcome of the latter being dependent on the accuracy of information on lice numbers on farms.

We are proposing to include monitoring and reporting conditions when permitting new farms and increases in the number of fish kept at existing farms. As summarised in Figure 8, farms will be required to monitor and report:

- The average adult female lice per fish on the farm at least once per week.
- The total number of fish held on the farm at the time of the count.

The conditions will require compliance with performance standards for counts of sea lice and counts of fish numbers. For the latter, farmers will be required to monitor and report the number of fish added to, or removed from, farms for any reason, using accurately calibrated fish counting machines.

The results of weekly counts of adult female sea lice are already reported to FHI[28] under fish health legislation and published on Scotland's Aquaculture Website[29]. We will work with FHI and fish farmers to ensure reporting for both purposes is as simple and streamlined as possible.

Because high-risk sites require the tightest management control to avoid the sea lice exposure threshold being exceeded, we consider that:

- Enhanced sea lice monitoring will be required, including to ensure sufficient fish are sampled to provide confidence in the estimated average number of lice per fish. More fish need to be sampled to provide a confident estimate when compliance with the limit condition requires very low numbers of adult female lice per fish.

- Monitoring should be automated as soon as practical using interpretation of suitable imagery by artificial intelligence.

[28] https://www.gov.scot/policies/fish-health-inspectorate/
[29] http://aquaculture.scotland.gov.uk/

We are proposing to include conditions requiring high risk farms to implement automated lice counting technology within three years of the issue of the permit[30]. We will also consider whether doing so is also appropriate for farms we categorise as posing a considerable risk if their lice numbers increase. Automated lice counting will:

- Make it much easier to sample the larger number of fish required to reliably determine the average number of adult female lice per fish when that average is low. This is particularly important for high-risk sites where the limit condition will require the average number of adult female lice on the farm to be kept low.
- Enable more frequent assessments, allowing farmers to detect, and act on, trends in sea lice numbers earlier to manage compliance.
- Enable frequent counts of gravid sea lice numbers; and for permit limits to be specified in terms of gravid lice. Counts of all adult female sea lice are used when counts are only once per week because they provide an understanding of the likely potential average number of gravid sea lice during the week following the count.
- Improve public confidence that the farm's performance is based on counts that are reliable and objective.
- Provide counts when manual counting would otherwise not be possible (e.g., because of weather conditions).
- Avoid the need to handle fish.

We would also support and encourage finfish producers to implement such technology for monitoring sea lice numbers on other farms. This type of technology also has potential for use in assessing fish biomass on farms[31]. We will work with the sector to explore the development of its use for this purpose too.

Question 13: Do you agree that it is proportionate to require enhanced sea lice counts at high-risk sites and that this should be delivered in due course via automated systems using artificial intelligence? Please give reasons for your answer.

[30] Potential systems are already on the market or in development e.g., https://aquabyte.ai/produkt/performance/; https://ecotone.com/automatisk-luseteller-fra-ecotone/?lang=en
[31] https://www.sciencedirect.com/science/article/abs/pii/S0144860921000352; https://onlinelibrary.wiley.com/doi/10.1111/raq.12388; https://www.nature.com/articles/s41598-022-19932-9#:~:text=Images%20captured%20by%20a%20stereoscopic%20camera%20are%20used,of%20fish%2C%20such%20as%20body%20length%20and%20weight.; Potential systems are already on the market or in development e.g., https://www.innovasea.com/aquaculture-intelligence/biomass-estimation/

5.7 New applications and sea trout

During the wild salmon post-smolt migration period on the West Coast and the Western Isles, the protection that the framework provides for salmon post-smolts will also provide a level of protection for sea trout.

We are proposing to extend a level of protection for sea trout post-smolts in all WSPZs until the end of June. We will implement a simple, interim approach while we develop proposals for a sea trout-specific risk framework (See Section 3.7). For this, we will use our screening models to identify farm development proposals likely to make a substantial contribution to average concentrations of infective-stage sea lice in WSPZs. We will apply the same benchmark (0.04 infective-stage lice per m^2) for defining a “substantial” contribution that we have used to create the risk assessment matrix for wild salmon post-smolts (See Appendix 4).

Proposals predicted to make a substantial contribution to infective-stage sea lice concentrations within a WSPZ will be subject to permit limits on the maximum number of sea lice allowed on the farm from 1st June until 28th June. The limit will be calculated as 0.5 (average number of adult female sea lice per fish) x the maximum number of fish to be held on the farm applied as a 28-day rolling average. The limit will apply to 28th June. This will provide protection until the end of June because lice dispersing from a farm on or after 28th June date will become infective only after the end of June.

Question 14: Do you agree with how we propose to provide a level of protection until the end of June for sea trout on the West Coast and around the Western Isles while we develop a new risk framework for sea trout? If you disagree, please explain how you would apply the matrix and why this would deliver a better outcome.

Question 15: Do you agree with how we propose to set permit conditions to protect sea trout populations? If not, please explain why you disagree and what would be your alternative.

5.8 Phasing-in of the framework

The new framework will come into effect on the implementation date, which we will identify when publishing our response to the feedback we receive on this consultation.

When determining applications, we are required by our statutory duties under the Water Environment and Water Services (Scotland) Act 2003 (WEWS) and the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) to assess the risk to the water environment posed by proposed controlled activities and to set such permit conditions as we consider necessary to protect the water environment.

Our intention is to apply the framework to all determinations we undertake after the implementation date, no matter when the application was submitted.

We recognise that applying the framework to determinations of applications submitted before the implementation date has the potential to slow down the decision-making process. Determination times for these applications will be extended if an applicant needs to provide suitably refined sea lice modelling to demonstrate that a proposal is not likely to have a significant adverse impact on the water environment. We expect this to apply to very few applications and we will work with applicants to help keep all delays to a minimum.

Question 16: Do you have any comments or suggestions on how we plan to phase in the framework?

5.9 Timetable summary

This Chapter described our proposals for permitting. We will use the consultation response to finalise our approach and develop the legal text of conditions for inclusion in an update to our existing fish farm permit template[32]. We will make this template available for comment before its use.

[32] https://www.sepa.org.uk/media/594697/car-mpff-permit-272-embz-standard.pdf

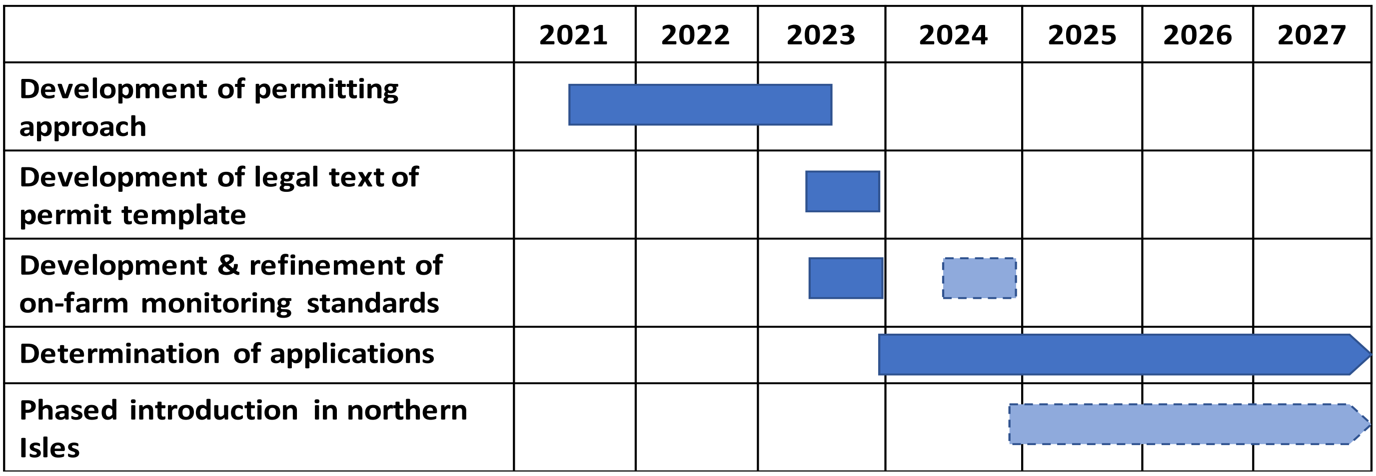

Figure 9: Projected timetable for permitting.

We are aiming to implement the proposed application process by the end of 2023, subject to the outcome of this consultation. We will phase-in consideration of risks to sea trout populations in our application process for farm developments in the Northern Isles once we have established an operational risk framework, including a network of WSPZs and screening models.

Question 17: Do you agree with the proposed timetable? If not, please explain why you disagree and what would be your alternative.

6. Regulation of existing farms

6.1 Introduction

The licences held by existing farms do not currently impose any obligations in relation to sea lice management on fish farm operators. This chapter explains how we propose to apply the sea lice framework to existing farms.

SIWG Recommendations

For sites where best scientific evidence indicates that an existing site presents an adverse impact on wild salmonids:

- *In the first instance, tighter regulatory standards should apply (see section 2 below);*
- *The consenting regime should be amended to enable efficient relocation of existing biomass to a suitable alternative location, within a spatial planning and area management framework.*

Scottish Government Response to SIWG

We agree that robust conditions, based on an adaptive management approach, to safeguard wild salmonids should be contained within a licence rather than through planning consent and that the relevant licence conditions should apply to existing, as well as new, fish farms.

6.2 Regulatory objectives

When considering the regulation of an existing site, our objectives include

- Preventing deterioration of the environment.
- Reducing the impact on the environment of existing activities where they are resulting in impacts on the status of the water environment.

These objectives apply to all activities affecting the water environment that we regulate.

6.3 Preventing deterioration

We set permit conditions to control activities that have the potential to cause significant adverse impacts. Normally, this is done as part of the application process.

If a site's permit does not cover an activity, or have suitable conditions relating to an activity, carried on at the site that has the potential to cause adverse impact, we will normally amend the permit to cover the activity. In doing so, we will include suitable conditions to ensure the activity is managed to prevent an increase in pressure likely to cause deterioration of the water environment.

The conditions we apply for this purpose reflect the current operation of the site and are identified in consultation with the operator of the site.

These "no-deterioration" conditions enable the activity to continue without affecting its normal performance. If the operator wanted to increase the activity, an application to vary the permit would need to be made to us. This would allow us to assess the risk of the proposed increase in the activity, taking account of any mitigation proposed by the operator.

To enable us to protect salmonid populations against deterioration, we propose to vary permits for existing farms to include the following permit conditions (See Figure 10).

- For all farms, monitoring and reporting conditions requiring the collection and submission of weekly sea lice counts between 16th March and 30th May.
- For all farms, monitoring and reporting conditions requiring the submission of weekly estimated fish numbers 16th March and 30th May.
- For farms categorised as medium risk, considerable risk or high risk, conditions limiting the maximum number of adult female sea lice on the farm to the typical maximum for that farm.

Our proposal to include monitoring and reporting conditions in all permits would enable us to use the reported information:

- For assessing compliance with sea lice limit conditions, where applicable.
- For re-running and improving screening assessments, including assessments of the contributions of individual farms to infective-stage sea lice exposures.
- To provide accurate input data for further, targeted assessments of risk using refined models.

By re-running and improving screening assessments, we will be able to review the risk categorisation of individual farms, taking account of changes over time, including improved understand of local patterns of sea lice dispersion and wild salmonid post-smolt movements.

The outcomes of updated assessments of risk would be used to:

- Identify and target any further action necessary to prevent deterioration, such as adding, or revising, sea lice control conditions in farm permits.
- Advise farmers on the outcomes of their management of sea lice and our latest assessments of environmental capacity.
- Help identify if, and where, action to reduce infestation pressure on wild salmon may be required.

Because of the importance of accurate information on sea lice numbers on fish farms in managing risk, we will work with the farmers and FHI to develop quality assurance standards for sea lice counts. This will enhance confidence in the reported figures. It is likely that we will require additional monitoring of farm lice levels for farms that we assess as being in the high-risk category. We will also review whether additional monitoring may be required for farms in the considerable risk category to ensure accurate estimates of the average number of adult female sea lice per fish.

Use of capacity by farm	Remaining available capacity in WSPZ		
	Large (108)	Intermediate (5)	Little or none (8)
Negligible	50	5	4
Small	8	6	7
Moderate	9	4	5
Substantial	28	15	21

Key: Permit conditions controlling on farm sea lice levels (existing sites)

No numeric lice limits. Permit will authorise keeping in open-net pens of the maximum number of fish with which the farm is typically stocked on the farm

Limits on the total number of adult female lice set to reflect farm's performance over the last three Spring periods

Key: Permit conditions on monitoring and reporting (existing sites)

Weekly fish numbers and average numbers of adult female sea lice per fish.

Weekly fish numbers and average numbers of adult female sea lice per fish. Enhanced sea lice counts likely to be required.

Figure 10: Matrix illustrating the no deterioration conditions that will apply to existing farms. *Note: The addition of conditions to existing permits will be phased, with the priority for 2024 being farms assessed as high risk or considerable risk farms in WSPZs with little or no capacity. The assessments will be made using full screening assessments, including the virtual salmon post-smolt model. The number of farms and WSPZs shown in the matrix cells in the Figure are indicative only as they are derived from our simple, initial screening assessment method. This does not include the virtual salmon-post smolt model; describes relative risk only; and identifies WSPZs in which infestation pressure is likely to be highest.*

Question 18: Do you agree with our approach to monitoring and reporting conditions and the way we have used the risk assessment matrix to identify where we will add lice limits to permits? If you disagree, please explain how you would apply the matrix and why this would deliver a better outcome.

We will phase variations starting in 2024, when we will focus on farms identified using our screening models as posing a high risk or a considerable risk of causing the sea lice exposure threshold to be exceeded, or further exceeded, if the numbers of adult female sea lice on the farm increase.

The numeric lice limits will require farmers to maintain their current performance in managing lice numbers on their farms during the Spring post-smolt migration period. We will engage with farm operators in setting the conditions, which will be based on available data for at least 3 years. The conditions will not require changes in the normal management of sea lice on the farms. Section 6.4 explains when action to reduce sea lice on a farm may be required.

6.4 Reducing pressure on wild salmonid populations

Where pressure on the water environment from regulated activities is leading to adverse impacts, we use our regulatory powers to help improve the condition of the water environment. If the pressure is not due to non-compliance with permit conditions, we impose permit conditions on the regulated activities requiring a reduction in the pressure on the environment. Typically, this regulatory action will drive changes to the management of a regulated site, such as the introduction of improved effluent treatment at a wastewater treatment works; the installation of a fish pass on a weir; or a reduction in biomass at a marine fish farm.

This type of regulatory action has the potential to impose major costs on operators (investment or reduced production). Before we take such action, we must ensure the action is evidence-based, proportionate, reasonable and necessary.

- We need to be confident based on suitable evidence that the activity is contributing to the adverse impact.
- We will consider if the action is proportionate, taking into consideration impact on the site relative to the scale of the adverse impact.
- We will consider the timing of the actions, taking into consideration the operator's business plans.

One of the core objectives of the Scottish Wild Salmon Strategy[33] is for Scotland's rivers to have healthy, self-sustaining populations of wild Atlantic salmon that achieve good conservation

[33] https://www.gov.scot/publications/scottish-wild-salmon-strategy/pages/3/

status. Restoring wild fish populations in Scotland's rivers to good status is also one of the main objectives of river basin management planning[34,35].

For salmon populations that are not in good status, restoring them to good status will require action to address the key pressures impacting on the populations.

We have a wide range of existing regulatory tools for reducing pressures on wild salmonid populations, including tools we can use to:

- reduce point and diffuse source pollution.
- fund river habitat restoration.
- reduce water abstractions.
- ensure fish passage by requiring or funding restoration of fish passage at existing, artificial barriers to fish migration.

The sea lice regulatory framework will be added to this regulatory toolbox.

It is our normal practice to use an appropriate combination of actions to improve the environment, including to improve the strength and resilience of salmon populations that are not in a good state. The 2021 river basin management plans provide examples of the many measures that will contribute to strengthening and improving salmonid populations that we plan to take over the next few years.

In working to improve a salmon population, we take a river catchment approach, using the relevant combination of regulatory tools in a coordinated manner to reduce the different pressures on the population concerned. The tools we use will include the sea lice regulatory framework where we are confident that the sea lice exposure threshold is exceeded.

Evidence-based decision-making

[34] https://www.sepa.org.uk/environment/water/river-basin-management-planning/
[35] https://www.gov.scot/policies/water/water-environment/

> We will consider the weight of evidence to decide if we are confident that action to reduce infective-stage sea lice concentrations is required. This will include considering the results of:
>
> - sensitivity analyses of the outputs of calibrated and validated models; and
> - environmental monitoring.
>
> Chapter 8 describes the range of environmental monitoring proposed. This includes monitoring of infestation pressure in WSPZs using sentinel cage studies; and monitoring lice levels on wild juvenile sea trout.

We are proposing to use the following stepwise process to decide whether, and where, action to reduce concentrations of infective-stage sea lice is required to improve the state of a salmon population:

(i) Use our risk screening models to identify those WSPZs in which the sea lice exposure is potentially exceeded.

(ii) If the salmon populations in the WSPZs identified in step (i) are not in a good state or are declining, work collaboratively to develop refined models for the WSPZs, including collecting sufficient, suitable environmental monitoring information to calibrate and validate the models. Information for validation will typically include data from sentinel cage studies in which fish are held for a period at fixed locations within a wild salmonid protection zone (See Chapter 8).

(iii) If the models developed in step (ii) indicate that the sea lice exposure threshold is exceeded, carry out sensitivity analyses to evaluate uncertainties and assess confidence in the model conclusions. The analyses will consider the magnitude by which model indicates the sea lice exposure threshold is exceeded and explore the relative sensitivity of the model result to different model inputs and parameters (e.g., salmon post-smolt progression rate through the WSPZ).

(iv) If we are confident based on the analyses in step (iii) that the exposure threshold is exceeded, we will include reducing infective-stage sea lice concentrations in the WSPZ as part of an appropriate combination of measures for improving the salmon population concerned.

(v) Use the outputs of the refined models to focus action to reduce infective-stage sea lice concentrations in the WSPZ proportionately and effectively. This will involve targeting action to reduce the contribution to infective stage sea lice concentrations of farms:

- categorised using our risk matrix as high risk because of the scale of their contributions; and,
- if necessary to address the exceedance of the sea lice exposure threshold, those categorised as representing a considerable risk (Figure 11).

Use of capacity by farm	Remaining available capacity in WSPZ		
	Large	Intermediate	Little or none
Negligible			
Small			
Moderate			5
Substantial			21

Key: Focus for potential improvement action *if assessments confirm action is required* (existing sites)

Principal focus – farms categorised as high risk

Potential secondary focus – farms categorised as considerable risk

Figure 11: Matrix illustrating how potential improvement action will be focused if assessments conclude such action is necessary. *Note: The numbers of farms referred to in the cells in the right-hand column are intended to be indicative only. They are derived from the results of our interim screening approach. This approach does not include application of the virtual salmon post-smolt model; is based on the conservative scenario that all farms are at maximum biomass and have an average of 0.4 adult female sea lice per fish throughout the Spring; and does not distinguish between WSPZs with little remaining capacity and those where the sea lice exposure threshold may be exceeded.*

Our initial, simple interim screening assessment (see Chapter 3) indicate that:

- There are eight WSPZs in which infestation pressure is high and, hence, where further assessments will be prioritised to determine if the sea lice exposure threshold is exceeded. These include the three largest WSPZs: the Loch Linnhe system WSPZ; the Loch Carron and East Skye system WSPZ; and the Loch Fyne system WSPZ.

- A small number of farms make a large contribution to infective-stage sea lice exposures in each of these large WSPZs.

- Running the screening model for the Loch Linnhe system WSPZ for Spring 2021 and Spring 2022 with a scenario in which the maximum average number of sea lice per fish on farms was 0.2 brought exposures comfortably below the sea lice exposure threshold.

Question 19: Do you have any existing evidence that could be used to assist assessments of the WSPZs where the sea lice exposure threshold is potentially being exceeded?

Question 20: Would you be interested in collaborating with us in carrying out the assessments required to determine if action is required to reduce infective-stage sea lice concentrations in those WSPZs in which screening suggests the sea lice exposure threshold may be exceeded?

If so, how would you be willing to contribute?

6.5 Timetable summary

This Chapter described how we will introduce regulatory measures for existing farms.

The screening model will:

- identify WSPZs in which the sea lice exposure threshold may be exceeded; and
- the scale of the contribution to sea lice exposure of individual farms.

Over the period 2023 and 2024 (Figure 12), we will complete the build of virtual salmon post-smolt models for the small number of WSPZs in which our initial simple assessment of risk indicates may be close to, or exceeding, the sea lice exposure threshold. We will use the outputs of this modelling to update our screening assessment of WSPZs in which the sea lice exposure threshold may be exceeded.

From 2024, we will start the collaborative work necessary to develop, calibrate and validate refined models for those WSPZs where screening indicates that the sea lice exposure may be exceeded. We will also work with others to monitor the condition of potentially affected wild salmonid populations.

Where we are confident that the sea lice exposure threshold in a WSPZ is exceeded and salmon populations are not in a good state or are declining, we will work with the operators of those farms making the greatest contribution to exposure to require action to reduce pressure from sea lice on the wild salmon population.

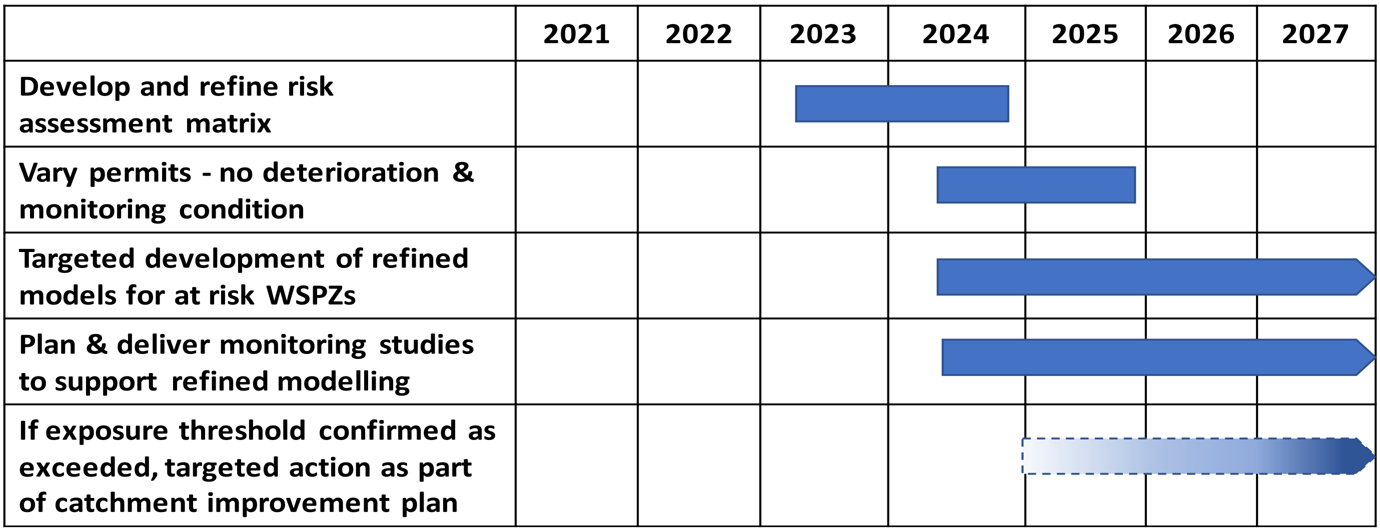

Figure 12: Projected timetable for introducing measures at existing farms.

We expect it will take several production cycles before we have generated sufficiently robust evidence from refined models and monitoring to determine if and where action is required to reduce pressures on wild salmon populations from sea lice.

Question 21: Do you agree with the proposed timetable? If not, please explain why you disagree and what would be your alternative.

7. Compliance assessment

7.1 Introduction

This chapter explains how we propose to work with farm operators to ensure they comply with permit conditions for the protection of wild salmonids from sea lice. This may require us to take enforcement action against those who are not compliant.

SIWG Recommendations

A single lead body (with appropriate competence and capacity) should be assigned responsibility for regulating wild and farmed fish interactions and given appropriate powers for monitoring and enforcement.

An enforcement policy should be published, informed by existing controls, to include specific penalties and sanctions for breaching conditions but incorporating some flexibility to respond to specific local conditions;"

Enforcement sanctions relating to sea lice and escapes, including the use of fixed and variable monetary penalties, should have a mechanism to allow monies to be invested into wild salmonid conservation work. Alternatively, this could be informed by the approach taken in Norway through OURO."

Scottish Government Response to SIWG

We welcome these jointly agreed recommendations which ask for a step change in how the risk of sea lice transfer from farmed to wild fish is managed. We agree that the regulatory regime for the protection of wild salmonids should be robust, transparent, enforceable and enforced.

We note SIWG calls for one lead body to take responsibility for interactions and that conditions and enforcement should be achieved through a licensing regime. We will consider this in forming our policy options, including how the Technical Standard for Scottish Finfish Aquaculture would fit within or alongside any enforcement regime.

7.2 Regulatory objectives

SEPA aims to ensure compliance with environmental legislation to protect the environment in ways that, as far as possible, also create benefits for:

- human health and wellbeing; and
- sustainable economic development.

We do this by checking on the performance of regulated activities, sites and companies/persons. We have enforcement powers to drive improvements in performance where this is required.

We also recognise the importance of publicly accessible information on site compliance. Such information can be valuable to operators, who can use it to enhance their businesses' environmental reputations. It can also be used by to inform decision-making by other interested parties. For example, it can be used by:

- Quality assurance schemes to inform their assessment processes.
- Supermarkets to influence where they purchase, and how they market, products.

We are currently developing a new approach to assessing, and reporting on, the environmental performance of the businesses we regulate, including fish farm businesses.

The new approach will replace our previous Compliance Assessment Scheme (CAS), which we have not used since the start of the Pandemic. Our intention is to develop the new approach over the period 2023 to 2025, consulting at appropriate times. Further information will be published on our website as the work progresses.

In the interim, we will continue to publish the data reported to us by fish farmers under permit conditions on Scotland's Aquaculture Website. The data will include information reported for the purposes of our proposed regulatory framework for managing risks to wild salmonids from sea lice.

7.3 Regulatory principles

It is the responsibility of operators to monitor their performance relative to their environmental obligations. They must act when there is a problem and notify us where necessary. It is our job to assess and report on the effectiveness of operators in complying with their environmental obligations. In making such assessments, we will be consistent, proportionate and transparent[36].

7.4 Our approach to ensuring compliance

Focused, on-farm management and company-wide strategies are key to ensuring compliance with fish farm permits. Our role is to check and ensure that focus is maintained. Our approach includes the following methods.

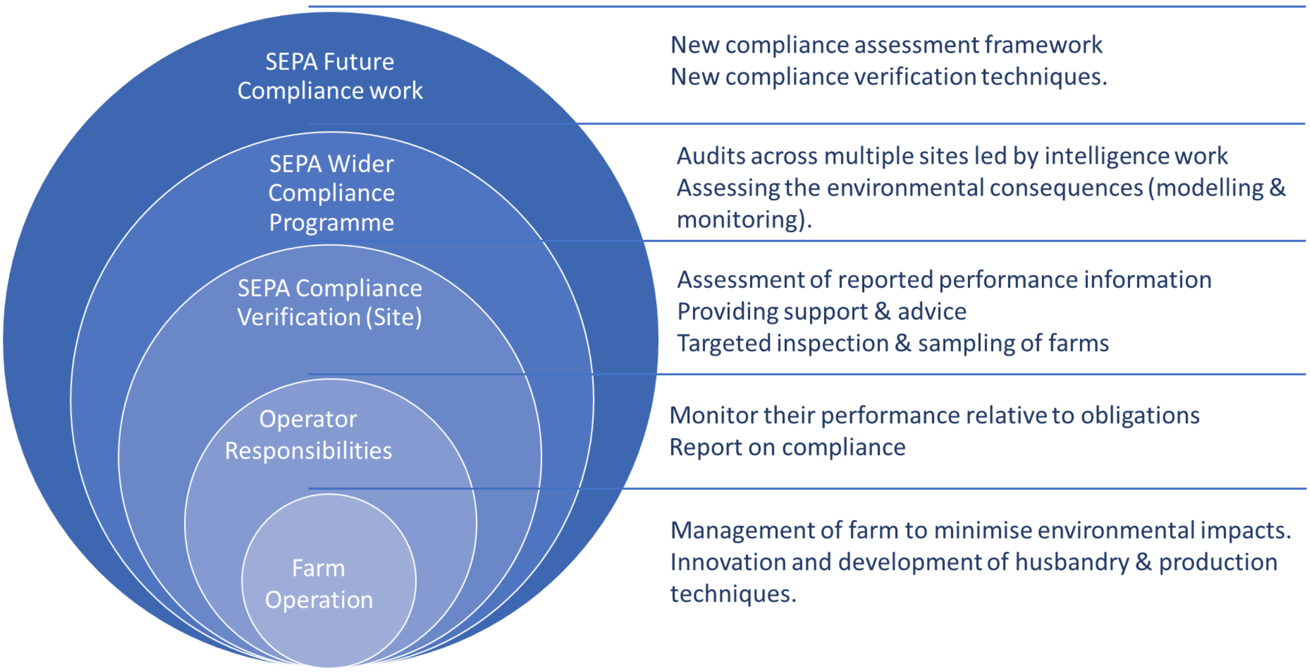

Figure 13: Overview of the approach to ensuring compliance.

7.4.1 Auditing reported data

Reporting by farmers is an important means by which compliance with permit conditions can be monitored. We can also analyse reported data to check for patterns through time or across farms (within a company or across the sector) and will undertake reviews of records held at farms and shore bases. Such analyses and checks provide us with intelligence to help target farm inspections or company/sector-wide investigations.

We will also work with farmers to encourage and support implementation of new ways of providing information on farm environmental performance that will enhance confidence in the regulatory regime and the sector’s environmental performance. For example, the use of on-farm

[36] https://www.sepa.org.uk/media/219244/enforcement-policy.pdf

sensors or simple video monitoring could offer opportunities to improve operators' management of what is happening on their farms and help to demonstrate compliance in ways that build trust among interested parties. For those farms posing a high risk to wild salmonids if lice are not tightly controlled, we are proposing to require automated lice counting using video imagery analysis by artificial intelligence systems within three years (see Chapter 5).

7.4.2 Providing support and advice

We will regularly provide advice to farmers to help them effectively target their efforts to maintain and improve their environmental performance. This will include highlighting our latest assessments of sea lice exposure risks; discussing farm environmental performance; and encouraging innovation in how compliance is secured and demonstrated. We will provide advice at farm, company or sector level as appropriate.

We will focus our work to support and advise farmers in advance of, and during the early part of, the Spring salmon post-smolt migration period. This timing allows us to check that operators of farms that could pose a considerable or high risk are focused on controlling lice from the start of the regulatory control period on 16th March.

We will monitor compliance over the whole of the season and review performance at the end of the season. We will then discuss with farmers any implications for next year's season. We think that this pattern of intervening early in the year to ensure farmers are prepared and then reviewing performance at the end of the season provides the best way to profile our regulatory work.

7.4.3 Undertaking targeted inspections and investigations

The extent to which information reported by farmers is trusted by interested parties is largely dependent on effective, independent programmes of audit checks. These are undertaken by us and other regulators, such as FHI. Participation in independent quality assurance schemes can also improve confidence.

We will target farm inspections and investigations based on our assessments of environmental risk and any intelligence indicating potential issues with environmental performance. This means our inspection programmes and investigations may be targeted at specific farms; geographic areas; or companies. The primary purpose of inspections will be to audit counts of sea lice and fish numbers. Our focus will be to assess the accuracy and precision of counts, including compliance with the protocols we will require to be followed to assure the quality of counts. We will also undertake reviews of records held at the farms and shore bases; and check whether sea lice management measures are in place.

7.4.4 Assessing environmental consequences

Each year, we will review our risk assessments. We will do this by running the latest versions of our screening models with that year's data on the number of adult female sea lice and the number of fish on farms; and relevant, new data collected from monitoring programmes. We will use the results to inform our programmes of inspections and investigations, and to provide advice to farmers.

7.4.5 Taking appropriate enforcement action

Where permit conditions for sea lice have not been complied with, we will report non-compliance and work with operators to make sure that appropriate steps are taken to ensure that the non-compliance is addressed. The onus will be on the farmers to develop and deliver appropriate responses to prevent future non-compliances.

Where necessary, we will make use of our enforcement powers to secure compliance. We have a wide range of enforcement tools, including variation of permit conditions and monetary penalties and we will use the most appropriate of them in the circumstances, in line with our enforcement policy[37] and Guidance on the Use of Enforcement Action.

7.5 Prioritising our approach

This section describes how we will use our assessments of risk to help target our compliance assessment work.

We will focus our regulatory effort on farms which are categorised as posing a high risk or a considerable risk to wild salmonids if lice on the farms is not well controlled (see Figure 14).

[37] https://www.sepa.org.uk/regulations/enforcement/

For other farms, we will continue to check data submissions, carry out compliance verification visits and inspections at a randomised subset of farms; and re-assess farm risk categorisations if new data suggests that this is necessary. Our inspections of randomised subsets of farms will be part of our wider inspection programmes that will cover all aspects of our regulation of fish farms.

We will be responsive to any credible intelligence about farm environmental performance, including from other regulators or the public.

Use of capacity by farm	Remaining available capacity in WSPZ		
	Large (108)	Intermediate (5)	Little or none (8)
Negligible	50	5	4
Small	8	6	7
Moderate	9	4	5
Substantial	28	15	21

SEPA's Compliance assessment work (existing sites)

- Magenta / Orange: Primary focus for targeted inspections and early season discussion with farmers
- Blue dotted: Secondary focus for inspections and early season discussion with farmers, which may be based on randomised subsets in an area or across a company.
- Green stippled: Randomised subsets subject to periodic annual checks

Figure 14: The greatest regulatory effort will be focused on farms posing high or considerable risk. *Note: The numbers of farms in the different cells of the table are indicative only based on the interim screening assessments developed to support this consultation.*

Question 22: Do you agree with the way we are proposing to use the risk assessment matrix to identify where we should focus our regulatory effort. If you disagree, please give your reasons and describe what you would propose instead.

7.6 Compliance and fish health

In some circumstances, farm operators are faced with reconciling the requirements to control lice for the protection of the environment with managing other fish health issues, which may preclude some active interventions to control lice (for example, gill disease can mean that anti-sea lice medicine treatments may lead to fish mortality and poor welfare outcomes).

Under such circumstances and based on veterinary advice, the farmer may decide not to take the action required to comply with permit limits on lice numbers. We will record this as a non-compliance with the permit conditions but will take account of the individual circumstances when considering what further action to take. If this type of non-compliance occurs repeatedly, we will require the operator to re-assess whether the farm is sustainable in its current form, taking account of its location, stocking density, and operating model.

A similar issue may sometimes occur in delivering reporting requirements associated with lice and fish numbers. Any failure to monitor and report sea lice numbers in accordance with permit conditions will be recorded as a non-compliance. However, our regulatory response will depend on the reason for the non-compliance and the effort made by the operator to find ways to enable counts to be made in accordance with permit conditions.

7.7 Timetable summary

This chapter described how we propose to plan our compliance work.

We will start reviewing data from farms for Spring 2023 to allow us to re-run our screening model using several years' actual data. This will inform the further development of our risk assessment. We will also work to improve our understanding of the state of wild salmonid populations. We will use this information to target farm inspections.

We cannot start reporting compliance until permit conditions are in place. We are expecting to start reporting on compliance in late 2024 or early 2025.

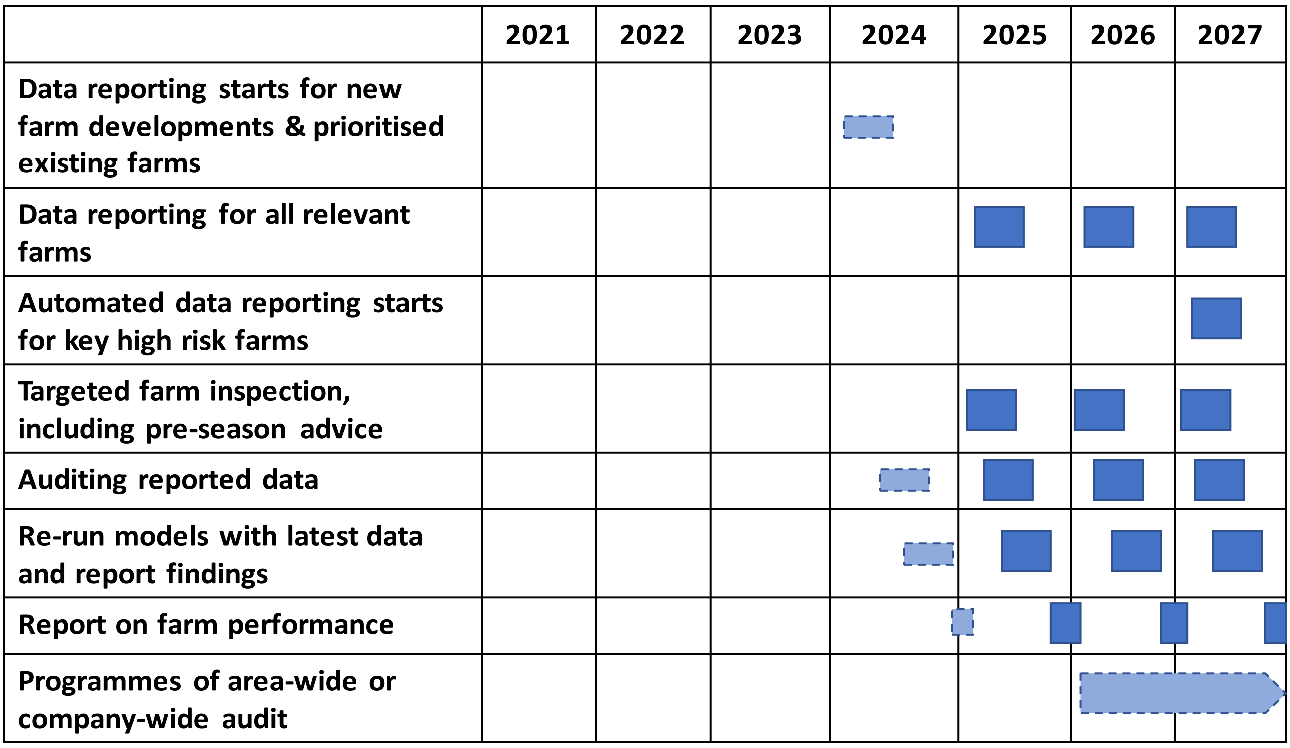

Figure 15: Projected timetable for our compliance work.

Question 23: Do you agree with the proposed timetable? If not, please explain why you disagree and what would be your alternative

8. Environmental monitoring

8.1 Introduction

Our management of the environment is informed by various forms of models and environmental monitoring. Models integrate scientific knowledge to provide an understanding of the functioning of complex environmental systems and how changes in human activity are likely to affect such systems.

Environmental monitoring helps identify where environmental models are needed to help assess and manage risks to the environment. By providing the essential data needed to calibrate, validate and improve environmental models, environmental monitoring helps us understand the level of confidence we should have in the models; and how we should adapt and improve them.

This chapter outlines:

- the environmental monitoring needed to support implementation and adaptation of the proposed regulatory framework for protecting wild salmonids from sea lice from fish farms; and
- our strategy for securing delivery of that monitoring.

8.2 Objectives and scope

Our main objectives for the first environmental monitoring strategy for the sea lice framework are to:

- Support and complement the development and validation of refined models for the small number of WSPZs in which screening indicates the sea lice exposure threshold may be exceeded.
- Gather data to assess the effectiveness of the combination of actions taken to protect wild salmonid populations, including action to manage risks from sea lice.
- Support the development and introduction of a framework for assessing risks to sea trout, including in the Northern Isles.

There are eight WSPZs on the West Coast and around the Western Isles in which our initial screening assessments indicate infestation may be high.

Over the next 6 months, we will prioritise improving screening assessments for these WSPZs using our virtual salmon post-smolt model and reported data on sea lice numbers on farmed fish.

Once this work is complete, for those WSPZs in which the sea lice exposure threshold is indicated as potentially exceeded, we will work collaboratively to develop, calibrate and validate refined models. We will start with the WSPZs where the risk that the sea lice exposure is exceeded appears to be greatest. We expect this to be in the largest 3 WSPZs, the Loch Linnhe system WSPZ, the Loch Carron and East Skye WSPZ and the Loch Fyne WSPZ.

For the Northern Isles, we will prioritise work to gather information to help identify WSPZs for sea trout; and to promote and support development of an improved resolution hydrodynamic model for Shetland.

For some WSPZs on the West Coast, the resolution of the core hydrodynamic models is limited. If we think capacity in any of these WSPZs may be limited, as a secondary focus we will work collaboratively to help promote the development of improved hydrodynamic model coverage in the relevant sea areas. In assessing whether this may be necessary, we will consider the length of the WSPZ, water residence times and the scale of farming in the area.

Question 24: Do you agree with how we propose to prioritise where we target effort under the first environmental monitoring strategy for the framework? If not, please explain your reasons and what you think we should do instead.

The scope of monitoring that we think should be part of the strategy includes monitoring of:

(a) The physical characteristics of sea areas (e. g. tidal flows, salinity, temperature; winds; dispersal characteristics) where needed to help calibrate and develop hydrodynamic models.

(b) Sea lice infestation pressure within WSPZs to help validate model predictions (e.g., using targeted sentinel cage studies; wild fish capture studies; or developing and implementing innovative new assessment techniques).

(c) The dispersion patterns of wild salmonid post-smolts in WSPZs to help refine virtual post-smolt models (e.g., tracking studies to assess the behaviour of post-smolts in, and, in the case of salmon post-smolts, rates of progression through, WSPZs).

(d) Sea lice behaviour to fine-tune calibration of sea lice dispersion (particle tracking models) and virtual post-smolt models (e.g., scientific studies to investigate vertical positioning; avoidance of freshwater; variation in mortality rates; etc).

(e) Trends in the condition of wild salmon and sea trout stocks, including returning adults, to inform where protection or reduction in pressures is most required; and to assess responses to the combination of measures taken under the Wild Salmon Strategy[38] (e.g., monitoring of wild salmonids in rivers; and monitoring of returning adults using strategically deployed counters where possible, and analysis of catch statistics)

Question 25: Do you think the focus of the monitoring strategy should be on the types of monitoring listed above? If not, please explain your reasons and what you propose instead or in addition.

8.3 Collaborative approach

We are proposing a collaborative approach for developing and delivering a monitoring strategy to support the implementation and adaptation of the sea lice regulatory framework. Our aim is to utilise the knowledge, capabilities and resources of the wide range of public bodies and organisations in Scotland and beyond with relevant interests.

There are already good examples of multiple organisations, including finfish producers, working together to deliver aquaculture-related projects, including the recent SPILLS Project[39] funded by Crown Estate Scotland and Scottish Government. By focusing on key evidence needs, such projects have been able to successfully access the necessary expertise and funding.

To help promote and facilitate collaboration, we propose that, once a year, those working on sea lice and wild fish interactions meet to discuss and review priorities; identify opportunities for joint projects; and create and refine a shared multi-year monitoring plan.

38 https://www.gov.scot/publications/scottish-wild-salmon-strategy/
39 https://marine.gov.scot/information/salmon-parasite-interactions-linnhe-lorn-and-shuna-spills

We think that monitoring to support the framework can be divided into three main areas:

(a) Monitoring in WSPZs (i.e., physical characteristics of the sea; sea lice infestation pressure; and dispersion patterns of wild salmonids).

(b) Targeted scientific research studies (e.g., sea lice behaviour studies; development of innovative methods for assessing sea lice infestation pressure; etc).

(c) Monitoring the health of wild salmonid stocks.

We propose that the focus of the multi-year monitoring plan should be on the delivery of monitoring priorities for the relevant WSPZs. We will develop plans for this monitoring in an inclusive and collaborative way. This will include working with finfish producers, whom we expect will wish to engage in the collaborative approach, contributing expertise and funding to help design and deliver the programmes, as they have done in other projects.

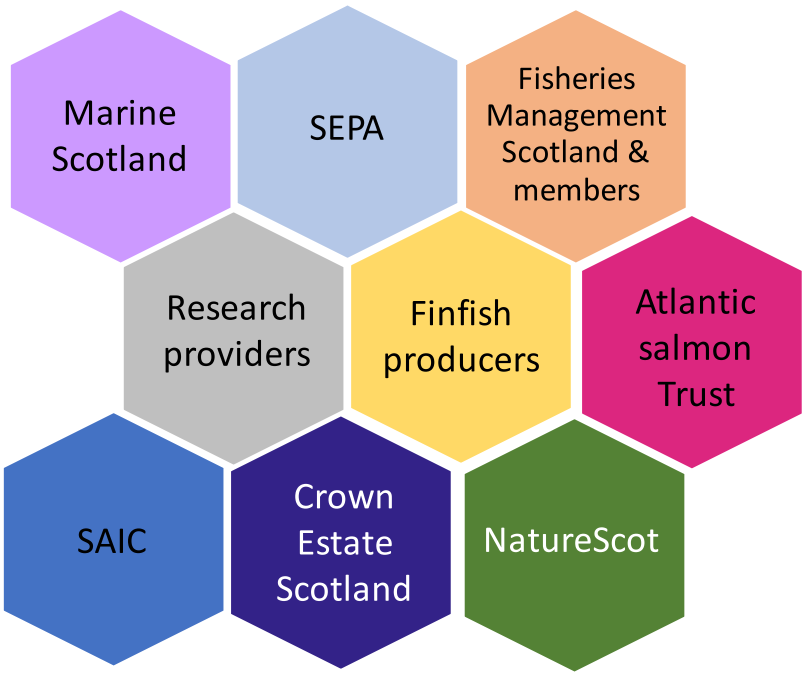

Figure 16: Key bodies and organisations with whom we will seek to collaborate to design and deliver environmental monitoring programmes. *Note: Research providers include a*

wide range of Universities[40] and organisations such as SAMS[41]. "SAIC" is the Sustainable Aquaculture Innovation Centre[42].

We think that co-developing monitoring projects for WSPZs with a range of partners who can contribute variously to the projects' design, delivery and funding will build trust in the projects, as well as maximising efficient use of collective resources. This is why we are not proposing at this stage to undertake, or commission, the necessary environmental monitoring ourselves and recover the costs of doing so via our charging scheme.

We also think it is important that we work with key scientists, including Scottish Government scientists, to build partnerships with the wide range of research providers in the UK and in countries such as Norway. We will use these partnerships to identify and communicate key research needs to research providers; and to promote and support collaborative scientific research studies to deliver them. The latter work could include, for example, engaging with research funders and providing letters of support to researchers seeking funding for relevant projects.

Question 26: Do you think that the proposed collaborative approach is the best mechanism for developing and delivering a monitoring plan? If not, please give your reasons and describe what you would propose instead.

Question 27: Are there other bodies and organisations you think would be interested assisting with a collaborative approach to environmental monitoring? If so, please can you say who they are and how you think they could contribute?

8.4 Monitoring plans for WSPZS

We propose to develop targeted and collaborative monitoring plans for those WSPZs in which screening indicates the sea lice exposure threshold could be exceeded.

[40] E.g., see https://masts.ac.uk/
[41] https://www.sams.ac.uk/about/
[42] https://www.sustainableaquaculture.com/about-saic/

The plans will be designed to provide suitable data with which to adequately calibrate and validate refined models for the zones. We will work collaboratively with Scotland's marine modelling community, including modellers working for finfish producers and for coastal communities, to help design the monitoring plan and to develop and validate the models.

8.4.1 Calibration and validation data for hydrodynamic models

The hydrodynamics of a sea area drives the dispersion of sea lice. Monitoring data is used to calibrate and validate hydrodynamic models, improving their ability to accurately and reliable model water movements.

Monitoring data for this purpose includes measurements of water temperature; salinity; water currents using acoustic doppler current profilers (ADCP); dispersion characteristics using dye and drogues; and wind measurements. Some of this data can be expensive to collect. A collaborative approach based on clear objectives will maximise opportunities for collecting data efficiently. It will make use of opportunities to use existing infrastructure to collect monitoring data (e.g., getting the help of fish farm operators to collect water temperature and salinity readings at their farms) and maximise the use of data collected for other purposes (e.g., ADCP data provided to support fish farm applications can also be used to inform refined model development).

8.4.2 Dispersion patterns of wild salmonid post-smolts

There has already been extensive data collected on salmon post-smolt dispersion through some WSPZs, including Loch Linnhe and Loch Torridon. Salmon post-smolt tracking studies have also been undertaken in other sea lochs in 2022 and 2023 as part of the West Coast Tracking Project[43], a partnership project between the Atlantic Salmon Trust, Fisheries Management Scotland and Marine Scotland Science.

These studies are providing information on the progression rates of salmon post-smolts through WSPZs and information about the routes taken.

Such studies will help us refine virtual post-smolt models. We will work with the partnership to identify priorities for future tracking studies. This will include considering priorities for tracking in

[43] https://atlanticsalmontrust.org/our-work/the-west-coast-tracking-project/

sea areas where there is a high risk of tracking receivers being lost (e.g., because of the use of the area by fishing vessels or because of fast currents). For example, such sea areas can include areas towards the outer end of some WSPZs where there is more than one option (e.g., around an island) that salmon post-smolts could take to reach more open sea.

As we develop the sea trout risk framework, we will also explore the potential with partners for tracking studies to be used to understand the movements of sea trout post-smolts.

8.4.3 Sea lice infestation pressure in WSPZs

Obtaining a measure of sea lice infestation pressure across a WSPZ is needed for a fully validated refined model.

Sentinel cage studies

Currently, the most effective way to obtain a measure of sea lice infestation pressure is using sentinel cage studies[44]. In such a study, multiple sentinel cages holding farmed salmon smolts are deployed at locations across the area of interest. After 2 to 3 weeks, the cages are retrieved, and the lice accumulated by the fish in the cages are counted.

Well-designed studies are needed if they are to provide valuable data cost-effectively. For example, robust data on sea lice levels on all farms contributing to infective-stage sea lice in the WSPZs needs to be collected in advance of, and during, the period of deployment to facilitate the testing of model predictions against the sentinel cage data. Information to help calibrate hydrodynamic models for the period concerned can also help evaluate model performance.

We will work collaboratively to develop detailed plans for sentinel cage studies in those WSPZs in which screening indicates the sea lice exposure threshold may be exceeded. The plans will be developed in discussion with modellers developing a refined model for the area.

We propose to plan and undertake the studies using a collaborative approach. This will include seeking technical and funding support from different partners, including fish farm operators.

[44] Pert C. C., Fryer R. J., Cook P., Kilburn R., McBeath S., McBeath A., Matejusova I., Urquhart K., Weir S. J., McCarthy U., Collins C., Amundrud T., and Bricknell I. R. (2014). Using sentinel cages to estimate infestation pressure on salmonids from sea lice in Loch Shieldaig, Scotland. Aquaculture Environment Interactions. Volume 5: 49 – 59. https://doi.org/10.3354/aei00094

Direct monitoring of sea lice

When suitable techniques are available, we will replace sentinel cage studies with direct measurements of sea lice concentrations in the environment. Sea lice distributions in the environment are predicted to be patchy in space and time. As a result, current water sampling techniques do not provide a suitably time integrated measure of sea lice concentrations[45].

The development of new methods may provide a solution. We will work with research providers and others to promote innovation in monitoring techniques. Possible methods could include, for example, using sentinel lice traps; or sampling and analysing large volumes of sea water over a suitable period using DNA fingerprinting, or automated lice counting systems that interpret imagery using artificial intelligence.

Direct measurements of lice burdens on wild salmonids have the potential to provide information on infestation pressure. This form of monitoring involves capturing wild post-smolt sea trout in fyke traps or sweep nets.

Monitoring sea lice on wild salmonids

Fisheries Trusts along the West Coast of Scotland undertake annual programmes of juvenile sea trout monitoring[46]. The programme is funded by Marine Scotland and Crown Estate Scotland and published by Fisheries Management Scotland[47]. In some areas, the monitoring is funded directly by fish farm operators as part of Environmental Management Plan requirements of their farms' planning consents.

Information on sea lice burdens on sea trout can provide an indication of variation in general infestation pressure over time. However, without information on the movement history of the sampled fish, the data cannot be used directly to validate a refined model or infer the infestation pressure to which wild salmon post-smolts migrating through a WSPZ may be subject. However, if the monitoring results could be allied to an understanding of sea trout movements, information on sea lice burdens on wild juvenile sea trout could prove valuable for model validation.

45 https://www.gov.scot/publications/salmon-parasite-interactions-linnhe-lorn-shuna-spills-final-project-report/documents/
46 https://fms.scot/projects/sea-lice-monitoring/
47 https://fms.scot/fish-farming/publications-and-data/

We think it is important that the potential to develop approaches to monitoring and interpreting sea lice burdens on wild caught sea trout is explored further; and we will work with others to promote and encourage such initiatives.

8.4.4 Monitoring the health of wild salmonid populations

The Scientific Advisory Board[48] set up under the Wild Salmon Strategy will advise on facilitating a coordinated and collaborative approach to monitoring the health of wild salmon stocks across Scotland.

We propose to use the output of our screening assessments to inform the Scientific Advisory Board on populations of salmon that may be affected by sea lice from fish farms. This will help it in in advising on the prioritising of collaborative work to monitor and assess trends in the state of those wild salmon stocks, including when considering future deployments of automated counters of returning adults.

We will work with the Scientific Advisory Board and Scottish Government to help develop targeted plans for rivers draining into WSPZs in which sea lice infestation pressure is high. Our fish ecologists will then work with others to help implement the monitoring plans in the rivers concerned.

We will also work with all the delivery partners for the Wild Salmon Strategy to seek a similar collaborative approach to improving understanding of trout populations, including in the Northern Isles.

8.5 Timetable summary

This Chapter described our plans for developing a collaborative strategy for delivering the environmental monitoring needs of the framework. The strategy will be aimed at:

- Providing information to help calibrate, validate and improve models of the interaction between sea lice from farms and wild salmonids in WSPZs.

[48] https://www.gov.scot/publications/wild-salmon-strategy-implementation-plan-2023-2028/pages/9/

- Supporting, and advising on priorities, for monitoring the condition of wild salmonid populations and assessing their response to the combinations of actions taken across a catchment to reduce pressures on them.

Significant elements of the strategy, such as wild salmon post-smolt tracking projects and the development of methods for surveying juvenile salmon populations, have already been started. The strategy will provide information to help inform, prioritise and target these existing programmes.

New or increased monitoring work will also be required, such as sentinel cage studies and collecting data to calibrate and validate hydrodynamic models, respectively. The strategy will be designed to ensure this work is targeted; carefully planned and designed; and delivered collaboratively.

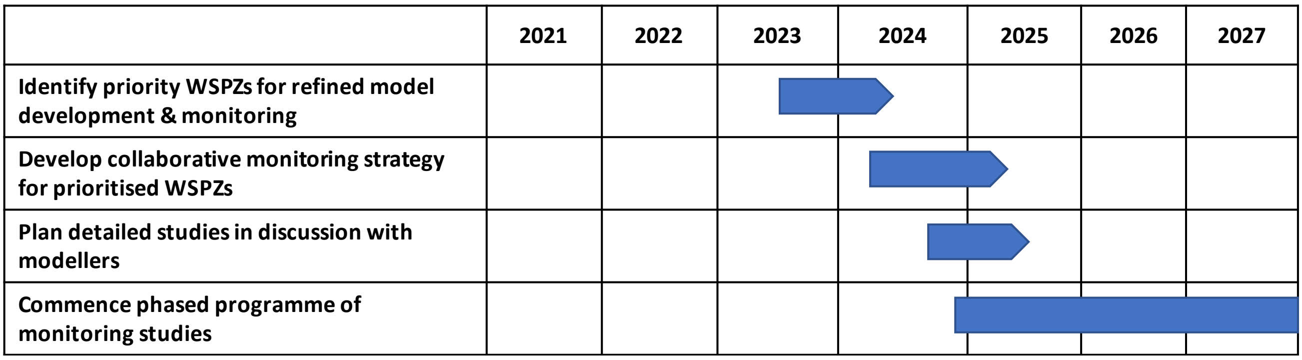

Figure 17: Projected timetable for the development of the Framework monitoring plans.

Question 28: Do you agree with the proposed timetable? If not, please explain why you disagree and what would be your alternative

9. Making data available

9.1 Introduction

Making our assessments of the environmental performance of regulated businesses easily accessible is important, as it:

- Helps businesses to see how they are performing, including in comparison to others in the sector.
- Informs assurance schemes.
- Provides confidence for customers of the businesses, and wider interest groups.
- Brings openness and transparency to how we regulate.

SIWG Recommendations

The SIWG recommends that Scottish Ministers invest in the appropriate infrastructure to collect and report catch and associated data, which maintains, as far as possible, the continuity of data since 1952, whilst allowing catch data to be reported in as close to real time as possible.

Scottish Government Response to SIWG

We are absolutely committed to open and transparent regulation and making data available to the public and other users of the marine environment.

We will continue to contribute funds to the Scotland's Aquaculture Website improvement programme, led by SEPA.

SEPA is committed to the continued publication of information collected through the CAR licence regime, including any additional information relating to sea lice collected as the CAR regime adapts.

We commit to focussing on data requirements within the proposed Wild Salmon Strategy which will seek to bring together information that will lead to a better understanding of the geographical variation in pressures and opportunities for action as identified by the SIWG in collaboration with stakeholders, including the District Salmon Fisheries Boards and Trusts.

9.2 Our objectives

We will aim to contribute to three of the objectives identified in Digital Scotland's Strategy "A Changing Nation: How Scotland will Thrive in a Digital World:

- Inclusive, Ethical and User Focussed. We focus on the outcomes we want to achieve and design services from a user's perspective rather than from our organisational perspective. We value and strive to design and deliver products and services that are inclusive, ethical and resilient, and uphold people's digital rights.
- Data-Driven. We value the transformational role that data can play in increasing transparency, empowering communities, transforming products and services, fuelling innovation, and improving outcomes.
- Collaborative. We recognise that digitisation delivers better benefits when we collaborate. This means collaborating at a community, local, regional and national level, and collaborating across the public, private, voluntary, and academic sectors.

9.3 Making information available

We are proposing to make the information we gather about the management of interactions between sea lice from fish farms and wild salmonids as easily accessible as possible. We think the information should be published alongside appropriate and wider contextual information. This should cover multiple themes and, where possible, include information generated by other regulators.

We think that there are two key platforms, which would allow us to present information in the appropriate context:

- Scotland's Aquaculture Website; and
- Scottish Wild Salmon Strategy annual reports.

9.3.1 Scotland's Aquaculture Website

Scotland Aquaculture Website[49] already brings together data on finfish and shellfish farming from Marine Scotland, Crown Estate Scotland, Foods Standards Scotland, NatureScot and SEPA. Data on farm sea lice counts has been published on the site since March 2021.

Our aspiration is for the Website to be updated and modernised, expanding the range of information available and making the information easier to explore and use. For example, this could include publishing interactive screening model information. We will work with all the

[49] http://aquaculture.scotland.gov.uk/default.aspx

partners for the Website and other interested organisations to find ways of delivering the investment required to achieve this.

9.3.2 Scottish Wild Salmon Strategy

Assessing the health of wild salmonid populations is one of the objectives of the Wild Salmon Strategy. We will make the data we collect on wild salmonid populations and the results of our sea lice risk assessments available for inclusion in the annual publications proposed under the Strategy. We also propose to publish our data on Scotland's Environment Web[50] until such time as there is a central repository under the Wild Salmon Strategy.

9.4 Timetable summary

This Chapter outlined the proposed approach to improving the information published on finfish farming and sea lice interactions with wild salmonid populations. Renewing Scotland's Aquaculture website will play a key role. We will also progressively re-build of our public register.

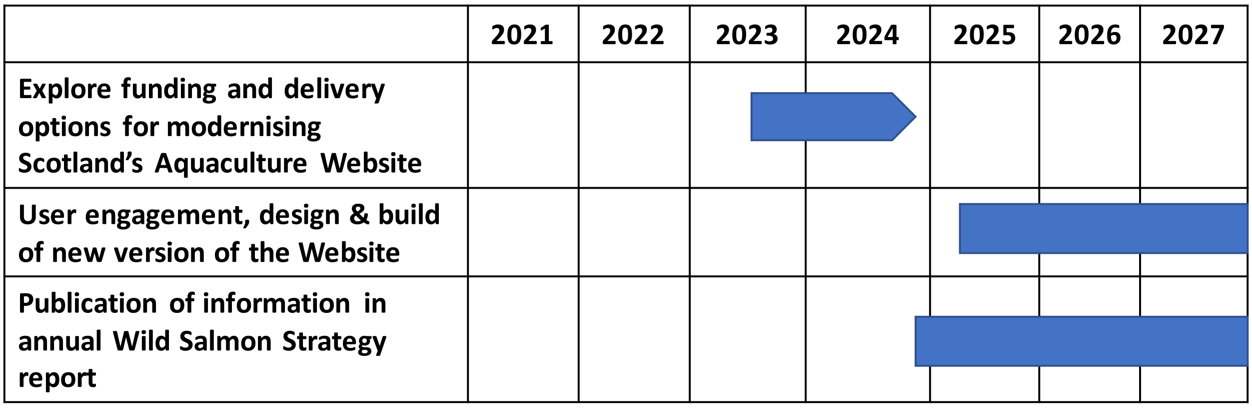

Figure 18: Projected timetable for the renewal of Scotland's Aquaculture Website and improving access to information via other platforms.

Question 29: Do you agree with the proposed timetable for improving accessibility of information collected in implementing the framework? If not, please explain why you disagree and what would be your alternative.

[50] https://www.environment.gov.scot/

10. Analysis of implications

10.1 Introduction

SEPA's primary role is to protect and improve the environment. In carrying out our regulatory functions for this purpose, we must contribute to improving the health and wellbeing of people in Scotland and to achieving sustainable economic growth, except if doing so would be inconsistent with our primary role[51].

We also have specific duties to:

- have regard to the social and economic impact of the exercise of our functions in protecting the water environment; and
- act in the way best calculated to contribute to the achievement of sustainable development in so far as is consistent with our purpose of protecting the water environment[52].

When developing any new regulatory framework for protecting and improving the environment, engagement and consultation with relevant stakeholders allows us to understand the effects of our proposals on their interests.

We want to hear from you about the effects that you think our proposed regulatory framework on sea lice is likely to have on your interests. In this chapter, we have set out our initial analysis of the implications of the proposals. This analysis reflects what we have taken from discussions with, and comments from, a wide range of interests, including finfish producers, environmental NGOs, community groups, other regulators and public bodies, wild fishery organisations, and researchers during the development of the proposals. We have included the initial analysis to help stimulate your thinking about the effects of our detailed proposals.

For this analysis, we considered the National Performance Framework outcomes[53], and focussed on the Communities, Economy and Environment outcomes (See Section 10.2 below).

We will consider all consultation responses before making final decisions on the details of the framework.

51 https://www.legislation.gov.uk/asp/2014/3/section/51
52 https://www.legislation.gov.uk/asp/2003/3/part/1/chapter/1/2022-10-24?timeline=false&view=plain
53 https://nationalperformance.gov.scot/national-outcomes

10.2 Context for the assessment

Scottish Ministers have made the commitment that the regulatory framework must:

- be designed to protect the environment by managing the risk to wild salmonids from sea lice from fish farms.
- utilise an adaptive, spatially-based risk assessment framework.
- be applied through the Water Environment (Controlled Activities) (Scotland) Regulations 2011.

The proposed framework is intended to support the following three outcomes in the National Performance Framework:

- Communities. *We live in communities that are inclusive, empowered, resilient and safe.*

There are strongly divergent views among local communities and third sector bodies. Many welcome the investment and jobs that aquaculture developments can bring. Others are strongly opposed to such developments because of concerns about risks to the local environment, including to wild salmonid populations.

Our proposed framework is based on an objective risk assessment process. This will improve understanding of the potential environmental effects of farm developments, helping developers and communities identify the best locations for farm developments.

- Economy. *We have a globally competitive, entrepreneurial inclusive and sustainable economy.*

The proposed framework will help fish farm developers understand where it will be relatively easy to develop a farm and where more investment in lice control, and in evidence to justify development, will be required. Operators of farms that are in compliance with the conditions of their licence will be able to reassure fish buyers of their farms' environmental performance.

- Environment. "*We value, enjoy, protect and enhance our environment*."

Atlantic salmon have been in serious decline in recent decades across their North Atlantic range. Scotland has an international responsibility to play its full part in a collective response.

The proposed framework aims to help prevent further deterioration in the condition of wild salmonids by managing risks to wild salmonid post-smolts from sea lice from farm developments. It will also allow action to be taken to reduce pressure from sea lice where impacts are identified.

These outcomes, our general purpose and Scottish Ministers' specific expectations for the regulatory framework have framed the choices we have made in developing our proposals.

10.3 How we have structured the assessment

Our initial assessment considers the implications of our proposed regulatory framework in relation to each of the three National Performance Framework outcomes referred to above.

In assessing the implications of the proposal, we have considered differences between what we expect once the framework is implemented and the situation under the current arrangements for managing interactions between sea lice from finfish farms and wild salmonids.

We have also considered the likely differences in the implications of our proposal, compared to the implications of adopting

> Under existing arrangements, local authorities are responsible for assessing the risk to wild salmonids from sea lice from fish farms when determining planning applications.
>
> Marine Scotland Science and NatureScot (if a Special Area of Conservation or Marine Protected Area is potentially affected) provide advice[54], on risks to wild salmonids to local authorities as statutory consultees.
>
> Local authorities can also require farmers to produce an environmental management plan as a condition of planning consent. The plan can require farmers to report fish numbers and adult female lice numbers; carry out monitoring to assess potential interaction with wild salmonids; and detail how monitoring information will feed back to management practice.

[54] https://www.gov.scot/binaries/content/documents/govscot/publications/factsheet/2020/11/marine-scotland-science-requirements-for-planning-applications-and-environmental-impact-assessments/documents/working-arrangements/working-arrangements/govscot%3Adocument/working%2Barrangements.pdf

Norway's spatially-based risk management framework, known as the traffic light system.	

We have focused the assessment on the groups and organisations that we think are most likely to be affected by the proposal:

- Marine finfish farm operators
- Parts of the food chain (e.g., buyers such as supermarkets)
- Coastal communities
- Wild salmonid fishery organisations
- Regulators and public body consultees: Marine Scotland, NatureScot, local authorities, SEPA.

10.4 Initial analysis of implications

Communities. *We live in communities that are inclusive, empowered, resilient and safe.*

	Industry	**Market**	**Communities**	**Fishery interests**	**Regulators**
Early engagement on development proposals			+++		+
Information on environmental risk/farm environmental performance			++	++	+
Public debate based on objective risk assessment			+	+	++

Key: *Relative magnitude of an implication is indicated by the number of "+" signs (for positive implications) or "-"signs (for negative implications).*

Early engagem ent

- Access to comprehensive screening assessments, including on sea lice and wild salmonid interaction.
- Understanding of the environmental challenges that proposed fish farm developments would need to overcome.
- Enhanced ability to engage in early pre-application consultations.
- Reassurance that environmental concerns are being considered from the outset, helping reduce worry and concern.

Information and data provided

- Comprehensive information about key aspects of finfish farm environmental performance.
- Increased confidence and assurance that there is a clear framework in place to consider risks to the environment and act when necessary.

Public debate

- Mechanism available for first time to understand the scale of risk to wild salmonids in Scotland.
- Public debate on sea lice and wild salmonid interactions moved onto an objective basis (how models are constructed etc).
- More and better information available to understand where environmental risks are greatest and where risk is low.

Economy. *We have a globally competitive, entrepreneurial inclusive and sustainable economy.*

	Industry	**Market**	**Communities**	**Fisheries**	**Regulators**
Predictable regulatory decision-making	+++			+	

Risk of reputational harm reduced	++	+++			
Change in regulatory burden	--				+
Cost of expansion	-		-		
Increase in costs	-				-

Key: *Relative magnitude of an implication is indicated by the number of "+" signs (for positive implications) or "-"signs (for negative implications*).

Predictable regulatory decision-making

- Developers know in advance if obtaining permits will be straightforward; or will need investment to provide evidence for proposals' environmentally acceptability and to ensure high performance in lice control.
- Developers informed about whether proposed farms likely to be subject to high lice infestation pressure from lice from existing farms. Better able to evaluate potential operating costs before deciding on investments[55]; or to plan farm consolidations to reduce cross-infection risk.
- Local authorities can rely on advice from SEPA on risk assessments making the planning process more straightforward and streamlined.

Risk of reputational harm reduced

- Objective basis for understanding the risks posed by sea lice to wild salmonid populations and a clear decision-making framework to manage those risks.
- Fish farm operators able to demonstrate to product buyers and the wider public that they are complying with permit conditions for protecting wild salmonid populations.

Change in regulatory burden

- Developers wishing to expand in some sea areas may be required to develop suitably refined models to support applications. Expansion proposals in a high proportion of these sea areas are also likely to require refined models to demonstrate there is capacity to

[55] https://www.gov.scot/publications/understanding-relative-cost-effectiveness-sea-lice-management-measures-farmed-salmon-production-scotland/documents/

assimilate farm discharges. The same refined hydrodynamic model will support both sea lice and discharge modelling.

- The pre-application process will minimise risk of subsequent applications being refused.
- Farms assessed as high risk will need to invest in due course in automatic lice monitoring systems. The cost of such system may be at least partially offset because of the improved data they can provide for precision farm management more broadly; reducing the need to handle fish; and increasing trust among buyers and other interests.
- Regulation of all risks to the water environment will simplify and streamline regulatory regime for developers.
- Local authorities will be able to work with SEPA to simplify the Environmental Impact Assessment process. The requirement for local authority environmental management plans will be phased out.
- No additional regulatory burdens in low-risk areas for developers, and fish farm consenting processes in these areas should become demonstrably more straightforward.

Costs of expansion.

- Expansion in areas of sea where there is little or no available environmental capacity is likely to require either investment in pen designs that minimise contact between sea lice and farmed fish; or the use of the farm for appropriately timed, sub-1 year production cycles.
- Many locations with little or no remaining capacity for infective-stage sea lice are also likely to have low dispersion. Where this is the case, the potential for expansion of conventional farms may be already be limited because of a lack of capacity to accommodate large discharges of fish faeces or anti-sea lice medicines.
- Initial screening assessment is that 8 out of over 120 WSPZs may have limited capacity. Where further assessments confirm that capacity is limited, it does not mean there will be no locations within the WSPZ at which farm developments using conventional open-net pen designs could proceed. Our assessments indicate that sea lice from farms in some locations in WSPZs do not add significantly to exposure risk: For example, our assessments indicate that sea lice from farms in some locations disperse out of the WSPZ before reaching the infective stage.

Increased costs for existing farms.

- "No deterioration conditions" applied to existing farms. Not expected to add significant new cost.
- Technical and funding support to help develop, calibrate and validate refined models for up to 8 WSPZs in which our initial, simple screening method indicates sea lice infestation pressure is highest.

Action requiring farmers to reduce sea lice numbers at existing farms (i.e., by amending farm permit conditions) will not be taken until suitable evidence of the need for such action is available. Consequently, no analysis of implications is included here.

Screening using our virtual post-smolt model in the Loch Linnhe system WSPZ and the Loch Fyne system WSPZ (See Appendix 3) indicates that a very small number of farms contribute a large proportion of exposure; and tight but achievable lice control on key farms during the relevant part of the year is likely to be sufficient to address any exceedance of the sea lice exposure threshold.

Environment. *We value, enjoy, protect and enhance our environment*.

	Industry	**Market**	**Communities**	**Fisheries**	**Regulators**
Protect wild salmonid populations				++	+
Identify where environmental improvements required				++	+
Enhance Scotland's environmental reputation	+	++	+	+	++

Key: *Relative magnitude of an implication is indicated by the number of "+" signs (for positive implications) or "-"signs (for negative implications*).

Protect wild salmonid populations.

- Risk-based approach will contribute to protecting wild salmonid populations. This will also contribute to the protection of freshwater pearl mussel populations in rivers on the West Coast and Western Isles.

Identify where improvements required.

- Targeted monitoring and modelling programmes identify where reducing pressure for sea lice will contribute to improving the resilience and state of salmon populations.

Enhanced environmental reputation.

- Robust, transparent and science-led framework, which gives confidence that pressures on wild salmonids are being appropriately managed.

10.5 Comparison with Norway's regulatory framework

Norway's traffic light system represents an alternative mechanism for delivering a spatial risk-assessment framework for managing interactions between sea lice from fish farms and wild salmon.

Features of Norway's regulatory framework	Features of our proposed regulatory framework
Applies to large sea areas with low cross-area sea lice transmission (i.e., work as independent management zones for sea lice)	Based on comparatively small WSPZs. Lice from a farm may contribute to infestation pressure in multiple WSPZs.
Approach based on classification of large sea areas (by infestation pressure) and associated area-wide rules. Provides upfront certainty for developers and communities.	Site-based environmental capacity approach. Screening reports and access to screening models will allow developers and others to understand the capacity available at different locations.
Automatic 6 % reduction in biomass at farms in red areas	Process to determine if, and where, reductions in sea lice infestation pressure are necessary is part of implementation

	process rather than an upfront classification of WSPZs. Initial analysis indicates that, if reduction in infestation pressure is required, tight lice control at key farms is likely to be sufficient. Any action will be targeted according to the contributions of farms to exposure risk.
A clear, simple no expansion in production rule in amber and red areas.	No area-wide rules. Expansion is dependent on: • the available environmental capacity for sea lice in WSPZs; and • the contribution to wild salmonid exposure to infective-stage sea lice that a development will make. Inclusion in development proposals of mitigation[56] to reduce contributions to exposure is considered. For example, developments involving a suitably timed, sub-1 year production cycle; or using pen designs that minimise contact between farmed fish and sea lice may be able to proceed at locations where there is very limited remaining environmental capacity, subject to meeting other regulatory requirements. Developments may also be able to proceed using conventional open-net pen containment designs in WSPZs with no or

[56] Barrett L. T., Oppedal F., Robinson N. and Dempster, T. (2020). Prevention not cure: a review of methods to avoid sea lice infestations in salmon aquaculture. Reviews in Aquaculture; Vol. 12: https://doi.org/10.1111/raq.12456

	very limited remaining environmental capacity if the location of the development means that infective-stage lice from the farm will not add to infestation pressure (e.g., because sea lice from the farm will disperse out of the WSPZ before reaching the infective stage.
Up to 6 % production increase allowed in green areas	No specific limit on production increases but also no automatic allowance. Permitted increases in production depend on assessments of available capacity. Screening models and, where necessary, refined models used to assess available capacity
Upfront modelling and monitoring by agencies and science institutes used to categorise sea lice infestation pressure of sea areas	Our screening models used to provide initial assessments. Collaborative approach, including sector modellers, for developing refined models for WSPZs where sea lice exposure threshold may be exceeded. Developers can provide a refined model to support a development proposal where screening indicates there may be insufficient capacity. We will audit the model.
Standard on-farm control limits of an average of 0.2 adult female sea lice per fish during sensitive wild salmonid migration period and 0.5 at other times.	Permit limits variable depending on risk categorisation of farm using risk matrix.

	Limit is on a measure of adult female sea lice on the farm. This means operators will have flexibility to manage compliance by controlling lice, fish numbers or both.
Comprehensive and easily accessible information on sea lice performance of farms published on BarentsWatch website[57], including information on different lice development stages.	Aim to modernise Scotland's Aquaculture website. Information published will combine fish numbers and average adult female sea lice per fish to help understanding of overall lice numbers on farms.

57 https://www.barentswatch.no/fiskehelse/?lang=en

11. Summary and conclusions

The health of Wild Atlantic salmon populations can be affected by a wide range of pressures, including pressures in their high seas feeding grounds in the northern part of the Atlantic Ocean; and in their home rivers and adjoining coastal waters.

There has been a serious decline in Scottish salmon populations in recent decades, with many populations now in a weakened condition.

In response, Scottish Ministers established a Wild Salmon Strategy in 2022 to ensure the protection and recovery of salmon populations. The Strategy's goal is to build resilience and transform the fortunes of wild Atlantic salmon through coordinated action to manage and reduce pressures in rivers and coastal waters.

This consultation describes our detailed proposals for a new regulatory framework to help manage one of these pressures, sea lice from fish farms. Sea lice can pose a risk to the health of wild salmon and sea trout and to the health of farmed salmon and rainbow trout in coastal waters. They are also an economic burden for fish farmers.

In October 2021, Scottish Ministers confirmed that SEPA will be the new lead body responsible for managing the risk to wild salmon and sea trout from sea lice. We launched our first consultation on how we propose to do this in December 2021. Since then, we have continued to engage extensively with leading scientists in Scotland and Norway; other regulators; finfish producers; environmental NGOs; coastal community groups and wild fishery interests.

The detailed regulatory framework we are now proposing will be fully integrated into our wider regulatory framework for marine fish farms, helping simplify and streamline the regulatory process for all.

Juvenile salmon and sea trout enter coastal waters in April and May, with salmon migrating quickly away from the coast to the open sea. Populations of migrating fish are particularly vulnerable close to river mouths and as they disperse through sea lochs and other confined areas of sea where sea lice can accumulate.

To protect wild salmon populations in these migration bottlenecks, we have identified a network of over 120 Wild Salmonid Protection Zones (WSPZs) along the West Coast and around the Western Isles. There are sea trout populations in the Northern Isles but no significant salmon populations.

Risk-based approach

To ensure our efforts, and those of fish farmers, to protect wild salmon are risk-targeted, we have developed new, purpose-built screening models for sea lice. These cover the WSPZs and all fish farms on the West Coast and around the Western Isles, including farms that are not yet operational. The models simulate the potential exposures to sea lice that wild salmon may experience as they pass through the WSPZs during April and May. This provides an initial assessment of risk, allowing us to triage development proposals and WSPZs to identify those requiring more detailed assessment.

The key findings of the initial screening work done to support this consultation are that:

- Further assessment is needed of 8 WSPZs. These WSPZs are where sea lice infestation pressure on wild salmon is likely to be highest. They include three large WSPZs: The Loch Fyne system WSPZ, the Loch Linnhe system WSPZ and the Loch Carron & East Skye WSPZ.

- A small number of fish farms in large WSPZs are responsible for a large proportion of the infestation pressure on wild salmon.

- If further assessments conclude that infestation pressure is at levels harmful to wild salmon, tight but achievable levels of sea lice control on key fish farms should be sufficient to protect wild salmon populations.

- In WSPZs in which infestation pressure is high, farm developments could proceed without adding significantly to infestation pressure by using conventional open-net pen containment at carefully selected locations or for production cycles lasting up to 1 year; or by using containment designs that minimise contact between sea lice and farmed fish.

Benefits

We have sought to design the proposed framework so that it will help support local communities and the long-term success of fish farming in Scotland's coastal waters. We believe the proposed framework will:

- Contribute to achieving Scotland's Wild Salmon Strategy's objectives, which include rivers having healthy, self-sustaining populations of wild Atlantic salmon that achieve good conservation status; and maximising the environmental and socio-economic benefits arising from such populations.

- Help simplify regulatory arrangements for fish farm developments.

- Provide interested third parties with screening information on the potential consequences for wild salmonids of proposed fish farm developments. We think this will help build trust and reassure local communities and interest groups that their environmental concerns are being considered and addressed through the regulatory process, reducing worry and conflict about fish farm expansion in their local area.

- Provide fish farm developers with early screening assessments to help them match their ambitions to the capacity of the coastal water environment, enabling them to plan developments with increased certainty of success.

- Provide fish farm developers with information on sea lice connectivity between farms, helping them assess potential sea lice management costs; and, if considering farm consolidations, strategically plan them to avoid locations where cross-infection risk is high.

- Create an opportunity for fish farmers to benefit reputationally by growing Scottish farmed salmon and rainbow trout in compliance with permit conditions that protect wild salmonid populations. We hope that this will benefit the long-term success of the fish farming sector and that of the businesses and communities that it depends on and supports.

Timetable

We are proposing introduce the framework around the end of 2023, initially applying it to assessments of proposed new farms and proposed increases in the number of fish farmed at existing farms.

During 2024, we plan to start amending the permits of existing farms to require farmers to maintain their current performance in managing sea lice numbers during the Spring. We will begin with farms that risk increasing infestation pressure the most if sea lice numbers on the farms were to increase. Farms triaged as posing only a low risk will not be subject to this requirement.

In 2024, we will also begin planning and initiating targeted further assessments to determine if infestation pressure in any WSPZs is at levels harmful to wild salmon. This will involve developing collaborative programmes of environmental monitoring and refined model development. We think it is likely that these programmes will take several farm production cycles to complete. If we conclude that infestation pressure is at harmful levels, we will work with the operators of the farms contributing most to infestation pressure in the affected WSPZ to ensure appropriate reductions in sea lice numbers on the farms are made.

From the outset, the framework will also provide an improved level of protection from April to the end of June for wild sea trout in WSPZs on the West Coast and around the Western Isles. Over the course of the next year or so, we will work to identify a network of WSPZs for sea trout in the Northern Isles. We are aiming to begin phasing in implementation of a risk-framework tailored to sea trout protection, starting with Orkney in advance of the Spring 2025 sea trout migration.

Responses to this consultation

A wide range of interested parties have engaged with us and provided comments and suggestions since our first consultation was issued in December 2021. This input has been invaluable in helping inform and shape our detailed proposals. We now look forward to receiving your comments and suggestions. We will consider them fully and use them to inform the work required to finalise and introduce the framework.

The framework will be adaptive, and we will continue to refine and improve it following its implementation based on feedback and advances in scientific understanding.

Appendix 1: Engagement history

This appendix provides a non-exhaustive list of the engagement we have undertaken with interested parties to assist in developing the proposed regulatory framework.

Session	Date
1st consultation launched	3rd December 2021
One-to-1 Engagement Sessions	1st February 2022 to 8th March 2022
Open-to-all stakeholder engagement session - monitoring	27th June 2022
Open-to-all stakeholder engagement session - modelling	28th June 2022
Open-to-all stakeholder engagement session - regulation & compliance	28th June 2022
SEPA Consultation Response Release	25th August 2022
Industry & SEPA Modelling Session	13th September 2022
Industry & SEPA Monitoring Session	14th September 2022
Industry & SEPA Regulation Session	15th September 2022
Regulators Session	30th November 2022
SEPA makes its modelling files available to the sector and interest third parties	December 2022
All stakeholder Engagement Workshop	5th December 2022
All Stakeholder Engagement Workshop	6th December 2022
One-to-1 engagement session on environmental monitoring – Wild fishery managers	7th December 2022

SEPA and industry modeller meeting	12th December 2022
Scottish Government, SEPA, Industry Engagement Session	17th January 2023
One-to-1 engagement session on environmental monitoring – Wild fishery managers	17th January
All stakeholder Sea Lice Threshold Technical Workshop	1st February 2023
One-to-1 engagement session on environmental monitoring – Wild fishery managers	7th February 2023
Virtual salmon post-smolt MATLAB files shared with MOWI modellers	February 2023
Scottish Government, SEPA, Industry Engagement Session	28th February 2023
Scottish Environment Link & SEPA engagement session	7th March 2023
Coastal Communities Network & SEPA sea lice modelling meeting	9th March 2023
Engagement session on environmental monitoring – Wild fishery managers, wild fish scientists and Crown estate Scotland	13th March 2023
SEPA & MOWI – technical modellers meeting	16th March 2023

Appendix 2: Sea lice exposure threshold

The proposed sea lice exposure threshold (0.75 infective-stage sea lice per m^2 days) is based on the findings of two different research approaches, one led by Norwegian scientists and the other led by Scottish scientists.

The Norwegian study[58,59] was based on Norwegian scientists' understanding of the relationship between the number of sea lice recorded on fish held in sentinel cages and the infestation pressure on wild salmonids. The classification of infestation pressure underpins the identification of sea areas as red, amber or green under Norway's traffic light system[60] for managing risk to wild salmonids from sea lice from fish farms.

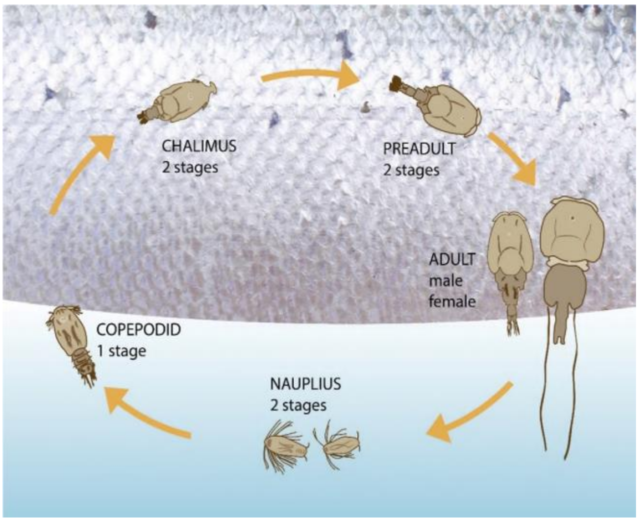

Figure A: Life cycle of the salmon louse, *Lepeophtheirus salmonis* *(courtesy Kari Sivertsen, NINA)*[61] showing the infective-stage (copepodid) of the sea louse lifecycle.

The study identified the modelled exposures of the fish in the sentinel cages to infective-stage sea lice which best predicted low infestation pressure ("Green", probability of wild salmonid mortality < 10 %, permitting a 6 % increase in production); and high infestation pressure ("Red", probability of wild salmonid mortality > 30 %, leading to a 6 % reduction in production).

The best predictor of low infestation was a modelled exposure of 0.7 infective-stage sea lice per m^2 days (next was best 0.8); and of high infestation pressure was 1.8 infective-stage sea lice per m^2 days.

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[58] Sandvik A. D., Johnsen I. A., Myksvoll M. S., Saevik P. N. and Skogen M. D. (2020). Prediction of the salmon lice infestation pressure in a Norwegian fjord. ICES Journal of Marine Science; 77(2), 746 – 756. https://doi.org/10.1093/icesjms/fsz256

[59] Sandvik A. D., Bjørn P. A., Ådlandsvik B., Asplin L., Skarðhamar J., Johnsen I. A., Myksvoll M., and Skogen M. D. (2016). Toward a model-based prediction system for salmon lice infestation pressure. Aquaculture Environment Interactions, 8: 527–542. https://doi.org/10.3354/aei00193

[60] https://www.regjeringen.no/contentassets/6d27616f18af458aa930f4db9492fbe5/no/pdfs/stm201420150016000dddpdfs.pdf

[61] Figure first published as Figure 1, the five phases of the salmon louse life cycle, in Thorstad Eva B., et al (2015). Effects of salmon lice Lepeophtheirus salmonis on wild sea trout Salmo trutta—a literature review, Aquaculture Environment Interactions, Vol. 7: 91 – 113. https://doi.org/10.3354/aei00142

The Scottish scientists developed a deterministic model[62,63,64]. The model included:

- infection rate, depending on infective-stage lice concentration; louse burst swim speed; attachment success; and the size and swimming velocity of the salmon post-smolt.
- lice development time to the harmful mobile stage on the post-smolt, taking account of lice mortality.
- growth of the salmon post-smolt prior to the lice developing into harmful mobile stages.

The model predicts the exposure to infective-stage sea lice in lice per m^2 days likely to give rise to harmful levels of mobile lice on wild salmon post-smolts. For a 12.5 cm salmon post-smolt swimming at 1 body length per second, the exposure predicted to result in 0.1 mobile lice per gram of post-smolt was around 0.8 lice per m^2 days. It predicts a slightly lower exposure of around 0.65 lice per m^2 days at 0.8 mobile lice per gram of post-smolt, the infestation level identified in the latest meta-analysis[65] as the level at which serious physiological impacts start to occur.

The latest Scottish and Norwegian research suggest that the threshold is less than 0.8 infective-stage sea lice per m^2. When we consulted in 2021, we proposed a sea lice exposure threshold of 0.7 lice per m^2 days. In this consultation, we are proposing to express the exposure threshold to 2 decimal places as 0.75 infective-stage sea lice per m^2 days. The evidence from all studies suggests that exposures higher than this are likely to result in significant impact.

The proposed threshold will be exceeded at any value greater than 0.75. However, it would not be exceeded at values within 50 hundredths of 0.7 infective-stage sea lice per m^2 days.

[62] Murray A. G. and Moriarty M. (2021). A simple modelling tool for assessing interaction with host and local infestation of sea lice from salmonid farms on wild salmonids based on processes operating at multiple scales in space and time. Ecological Modelling (443). https://doi.org/10.1016/j.ecolmodel.2021.109459
[63] Murray A. G., Ives, S. C., Murphy J. and Moriarty M. (2022). Modelling parasite-driven impacts of aquaculture on wild fish: The case of the salmon louse (*Lepeophtheirus Salmonis*). Proceedings of the Society for Veterinary Epidemiology and Preventive Medicine annual meeting in Belfast, Northern Ireland, March 23-25 2022 (SVEPM Proceedings); Robinson, P. and McIntyre, M. (eds): ISBN 978-0948073656 (available on Amazon).
[64] Moriarty M., Ives S. C., Murphy J. M. and Murray A. G. (2023). Modelling parasite impacts of aquaculture on wild fish: The case of the salmon louse (*Lepeophtheirus salmonis*) on out-migrating wild Atlantic salmon (*Salmo salar*) smolt. Preventive Veterinary Medicine, Volume 214. https://doi.org/10.1016/j.prevetmed.2023.105888
[65] Ives S. C., Armstrong J. D., Collins C., Moriarty M., and Murray A. G. (2023). Salmon lice loads on Atlantic salmon smolts associated with reduced welfare and increased population mortalities. Aquaculture Environment Interactions; Volume 15: 73 – 83. https://doi.org/10.3354/aei00453

Appendix 3: Virtual salmon post-smolt modelling

This appendix illustrates the use of virtual salmon post-smolt models in assessing exposure risk in two WSPZs, the Loch Fyne system WSPZ and the Loch Linnhe system WSPZ.

Loch Fyne system WSPZ

Our virtual salmon post-smolt model for the Loch Fyne system WSPZ simulates the emigration of 28,534 post-smolts from the River Fyne at the head of Loch Fyne and their passage through the WSPZ.

In the simulation, 22 virtual post-smolts start their migration at hourly intervals during April and May, each following 1 of 22 representative routes through the WSPZ, 11 of which exit through Kilbrannan Sound and 11 through the Sound of Bute (Figure A).

For the simulation illustrated, all the virtual post-smolts progressed at a constant rate of 12.5 cm per second, equivalent to 1 body length per second for an average size salmon post-smolt.

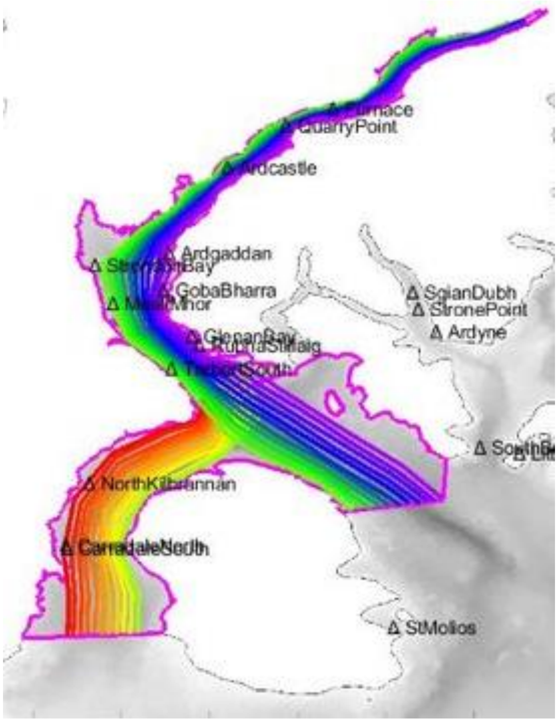


Figure A: Simulated routes of virtual salmon post-smolts through the Loch Fyne system WSPZ.

Reported information on weekly average numbers of adult female sea lice per farmed fish were used in modelling infective-stage lice concentrations in Spring 2021 and Spring 2022. For the simulations shown, the average of the reported weekly values for each farm in each year was used. The number of fish held on farms is not currently reported. For the model simulation, all farms were assumed to be holding their estimated maximum number of fish as calculated using the formula: *(1.75 x farm's maximum permitted biomass in kilograms) ÷ 5 kg.*

The cumulative exposure in infective-stage lice per m^2 days for each virtual salmon post-smolt was modelled, with the results for all virtual post-smolts ordered by the exposure magnitude and the 95th percentile exposure value derived.

The results for Spring 2021 indicate that up to around 20 % of the virtual post-smolts accumulated exposures greater than the sea lice exposure threshold (0.75 lice per m^2 days), with the 95th percentile of exposures being 1.04 lice per m^2 days (Figure B). Most farms in that year were in their second year of production. This means that the number of fish on the farms may have been substantially lower than assumed in the model, due to selective harvesting of larger fish and mortalities.

The results for Spring 2022 indicate that there was a very low risk to wild salmon post-smolts, with all of virtual post-smolt exposures less than the exposure threshold; and a 95th percentile exposure of 0.1 lice per m^2 days (Figure C).

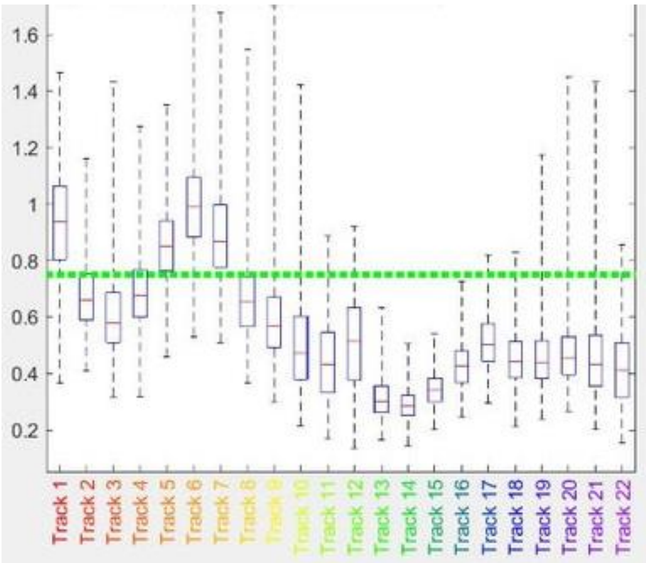


Figure B: Virtual salmon post-smolt simulation results for Spring 2021 in Loch Fyne WSPZ.

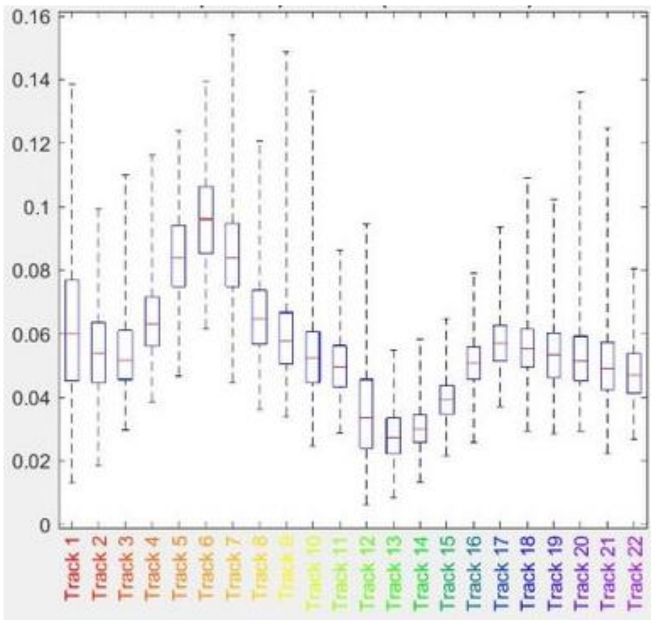


Figure C: Virtual salmon post-smolt simulation results for Spring 2022 in Loch Fyne WSPZ.

The simulation for Spring 2021 shows that a very small number of farms contributed a large proportion of the total exposure (Figure D).

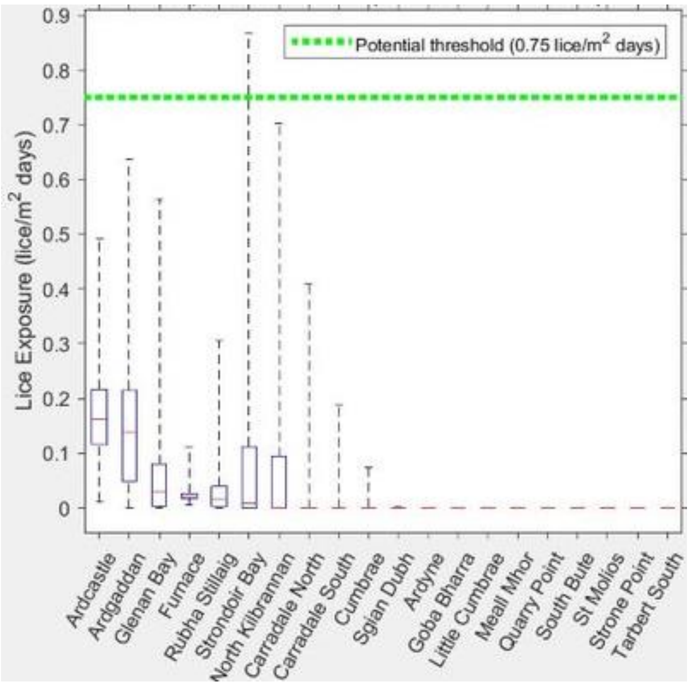
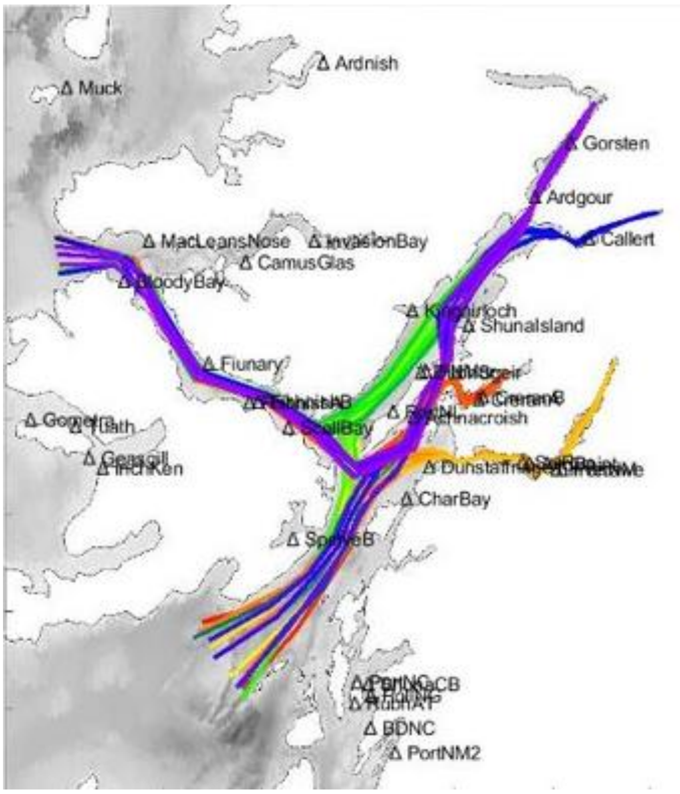


Figure D: Modelled relative contributions of different farms to exposure of virtual salmon post-smolts to infective-stage sea lice in Spring 2021.

Loch Linnhe system WSPZ

For the Loch Linnhe system WSPZ, we modelled virtual salmon post-smolts emigrating from rivers closest to the head of each sea loch in the system: the River Lochy, the River Leven, the River Creran and the River Etive.

We modelled virtual post-smolts leaving each hour during April and May of 2021 and 2022. The post-smolts used different representative routes through the WSPZ, with some exiting the WSPZ at the end of the Sound of Mull and the others through the Firth of Lorn (Figure E).



As for the Loch Fyne system model, all the virtual salmon post-smolts in the simulation progressed at a constant rate of 12.5 cm per second.

Figure E: Simulated routes of virtual salmon post-smolts through the Loch Linnhe system WSPZ.

We used the reported data on weekly average sea lice counts for each farm in the same way as for the Loch Fyne WSPZ. For farms in their first year of production, we assumed the maximum number of fish were being farmed as calculated using the same formula described above for the Loch Fyne WSPZ model. However, for farms in their second year of production, we reduced the estimated maximum number of fish on farms by 25 % to account for partial harvesting.

The results indicated that the sea lice exposure threshold may have been exceeded in Spring 2021 and Spring 2022, with 95th percentile of virtual post-smolt exposures of 1.79 lice per m^2 days in 2021 and 0.97 lice per m^2 days in 2022 (Figures F and G).

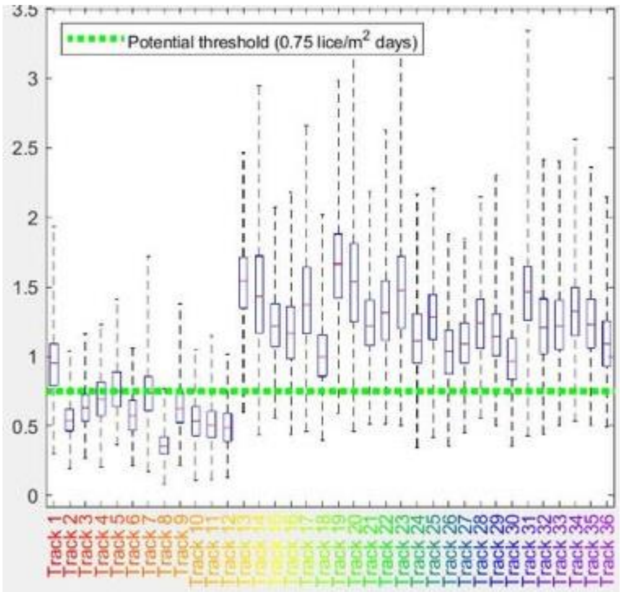


Figure F: Virtual salmon post-smolt simulation results for Spring 2021 in Loch Linnhe WSPZ.

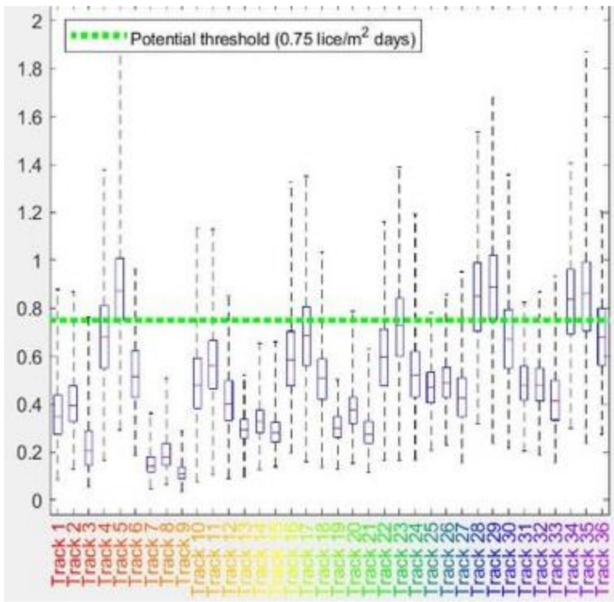


Figure G: Virtual salmon post-smolt simulation results for Spring 2022 in Loch Linnhe WSPZ.

As with the Loch Fyne WSPZ, the model indicated that a very small number of farms contributed a large proportion of the exposure (Figure H).

To explore the effect of tighter management of lice on farms, we re-ran the virtual salmon post-smolt model with the maximum average number of adult female sea lice per fish on each farm capped at 0.2. This is the limit applying under Norway's regulatory framework. Under this scenario, the 95th percentiles of virtual salmon post-smolt exposures would have been 0.44 lice per m^2 days in 2021 and 0.39 lice per m^2 days in 2022, well below the sea lice exposure threshold.

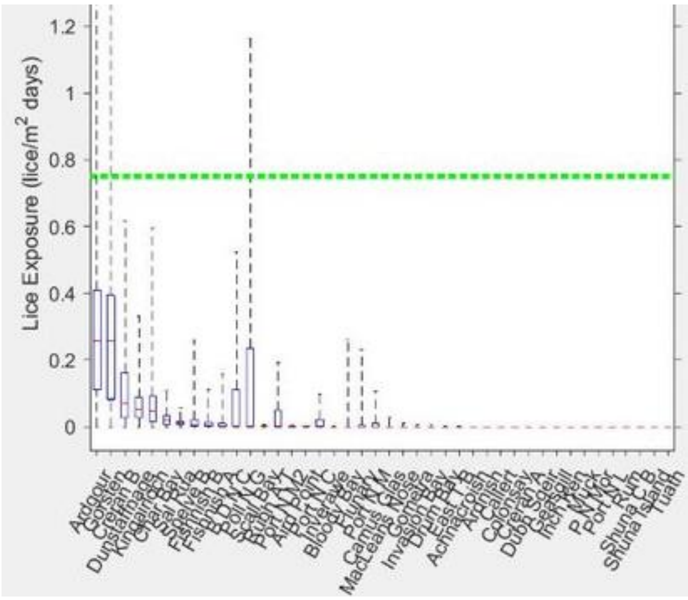


Figure H: Modelled relative contributions of different farms to exposure of virtual salmon post-smolts to infective-stage sea lice in Spring 2021 in the Loch Linnhe system WSPZ.

Appendix 4: Screening model approach and outputs

Contained within this appendix is a summary of the screening modelling method and a selection of model outputs. Full modelling input/output files and processed results are available on request.

Screening model method - Introduction

Screening for sea lice builds on the current screening methods for bath medicines and solid waste. More information on this approach can be found at: Screening Modelling and Risk Identification Reports. Bath and solid screening is currently done using 2D, depth averaged, modelling tools. These were not considered appropriate for sea lice modelling, where modelled processes in the vertical are critical to an accurate prediction.

As in the 2D screening, we have taken the available Marine Scotland Scottish Shelf Sub Area models and translated them from the FVCOM modelling system to the MIKE 3 modelling system. In doing this, we recognise that we may move away from the present calibration and validation status of the original models. However, we are carrying out a detailed analysis of the performance of our translated models against the original and available observed data. So far, our analysis indicates that the MIKE model versions used in screening are very similar to the original FVCOM solution. They are comparing reasonably well in many areas and both models have varying success in representing observed data. Results of this analysis are available on request. These are extremely large models with varying degrees of resolution (grid size). Improving them to have uniform accuracy in all locations is a significant task. As with our current screening approach, we will evaluate the likely confidence in model output from one location to another.

We are extremely grateful to colleagues in Marine Scotland, and their external partners, for the work they have done on the sub-area models.

Screening model method – Steps and key assumptions

We have translated three Scottish Shelf Sub area models. More information on each model can be found at the links below; also shown is the number of farms modelled in each domain:

- The Firth of Clyde (FOC) - 20 farms
- The Wider Loch Linnhe System (WLLS) - 42 farms
- The East Coast of Lewis and Harris (ECLH) - 102 farms

Please note that in almost all cases, we have used the climatology forcing for model runs, as outlined in the links above. Some exceptions are detailed below.

All model domains were translated to a 3D 10-layer Sigma scheme with equal layer spacing. The original FVCOM WLLS model was set up with a hybrid fixed layer/sigma scheme. This has not been replicated in our translation.

For all sub area models, we have translated the following model forcings:

- Tidal Boundaries: FOC – 2019 tides, re-predicted from 1993 “average” tides used in the sub area climatology forcing. We intend to re-run with 1993 average tides for final screening. WLLS and ECLH – 1993 "average” tides.
- Meteorological Forcing: climatology forcing for wind speed and direction. For heating, we have used a mixture of climatology factors and a simple analytical heating model. This appears to replicate observed heating reasonably well.
- Freshwater Forcing: climatology forcing for many large and small rivers derived from the Centre For Ecology and Hydrology (CEH) Grid 2 Grid model.
- For creating the Hydrodynamic (HD) forcing for the Sea Lice particle tracking modelling, we have used the following:
    - Low order, fast algorithm solutions for the shallow water equations and temperature and salinity equations.
    - Density as a function of temperature and salinity.
    - Horizontal Eddy Viscosity: Smagorinsky formulation with Constant of 0.28
    - Vertical Eddy Viscosity: Log law formulation
    - Horizontal Dispersion for Temperature and Salinity: Scaled eddy viscosity formulation with a constant of 1.
    - Vertical Dispersion for Temperature and Salinity: Scaled eddy viscosity formulation with a constant of 0.01.
    - These have been chosen to speed up the computation within the computing resources available.

In all cases, models were spun up to similar initial conditions for the start of the Sea Lice hydrodynamic output, that is the 19th of March.

- For the FOC, HD results were derived from weekly runs from 01/01/2019.
- For WLLS and ECLH, HD results were derived from an 18-day run from 01/03/1993, with the initial conditions, except velocity, derived from FVCOM output files.
- All models we run from 19/03 (1993 or 2019) until 01/06/2019 00:00:00 using a 30 second timestep.
- HD forcing for subsequent sea lice particle tracking modelling was made at 15-minute intervals.

Sea lice dispersal and potential contribution to infection was modelled using the MIKE Agent Based Modelling Lab package. Each site was modelled individually so that the number of particles released could be maximised and the contribution from individual sites could be easily assessed. The key steps and assumptions are given below and many of these were chosen based on advice from colleagues from Marine Scotland; we are very grateful for their advice.

Particles were released every 5 minutes from each site over the total length of the model run from the 19th of March to midnight on the 1st of June.

A “unit” release approach was used for relating modelled particles to sea lice concentration. Each particle was given a notional mass of 1 kg for calculation purposes. Particle fields can then be scaled according to varying source terms. This is a common approach in modelling of this type.

For each site, particles were released at 1 m below the water surface. This ensured that particles start near the surface, which can be considered conservative.
The horizontal release points for particles were the positions stated on the Scotland' Aquaculture website. These were checked against commonly available satellite imagery and were almost always near the centre of the farm cages.

The particle integration method used was Euler. RK4 was also tested but found to make little difference to the results.

Particles were allowed to move in 3 dimensions and were advected with the two horizontal velocity components and the vertical component.

Particles were dispersed in the horizontal using a dispersion coefficient of 0.1 m^2/s

Particles were dispersed in the vertical using a dispersion coefficient of 0.001 m^2/s. This is considered a conservative vertical mixing approach.

Particles were given a small upward velocity of 0.0014 m/s. This had the effect of retaining most particles within the top 10 m of the modelled water column which is considered a conservative approach. This is in-lieu of explicit vertical swimming behaviour.

Sea lice maturation to infectivity was not driven by the direct interaction of the particles with water temperature fields. Particle age was tracked, and particles were considered infective when they were older than 4 days and less than 17 days old.

Sea lice interactions with low salinity water fields were not explicitly modelled.

Sea lice mortality was set at a fixed rate of 17 % per day. This was applied to the mass of the particles.

All particles information was tracked and output at 15-minute intervals.

Screening model results – Initial processing

Particle tracks from the runs detailed above were processed in Matlab.

Tracks were loaded into the software and worked on to produce concentration fields of decayed particle mass integrated over the top 2 m of the model. Concentration, in mass/m^2, was mapped on to the Hydrodynamic model grid. Only particles between 4 and 17 days old were included in the concentration fields, representing lice which are considered infective.

For the FOC model concentration, fields were produced every 15 minutes. For WLLS and ECLH, they were produced every hour.

Concentration fields were scaled using various source terms to convert mass/m^2 to lice/m^2.

The source term to convert mass to lice consisted of the following information:

- The number of fish on the site (Number of Fish - NF): derived from the peak licenced biomass in kilograms multiplied by a conversion factor of 1.75 to provide an estimate of the produced biomass from the farm; and then divided by 5 kilograms, the assumed average harvest weight of fish.
- The average number of adult female lice expected on each fish (Lice Per Fish - LPF). This is usually derived from lice count data. When first implementing the framework, we will derive an average number of adult female lice per fish value for use in screening assessments from the lice count data reported to FHI and published on Scotland's Aquaculture Website for March, April and May of 2021, 2022 and 2023.
- The number of new lice produced by each adult female per day (New Lice Per Day - NLPD). For the results presented here, this has been set at 30.
- Multiplying NF x LPF x NLPD gives the total number of new lice released per day when the farm is a peak biomass for a given LPF number.

As we know the number of particles released during the model run, we can calculate the number of lice that each particle represents. As each particle has the same mass, we can derive a mass-to-lice conversion factor.

Due to the unit release approach, the source term can be varied in many possible ways.

Concentration fields for each site can be summed to produce a total concentration field for all sites.

Screening model results – Output

Lice concentration fields throughout the modelled April and May periods have been subjected to a virtual salmon post-smolt modelling analysis, as outlined in Appendix 3. This is the proposed method to allow the comparison of modelling results with the suggested exposure threshold.

Available concentration fields (of lice/m^2 over the top 2m) can also be used to produce an initial, relative risk assessment of the potential influence of sea lice on designated Wild Salmon Protection Zones. To do this, concentration fields have been averaged for each site of the April and May modelled period. In doing this, we are left with a conservative single expression of the relative potential sea lice influence in WSPZs. This allows both an initial assessment of the relative capacity of each WSPZ and the relative contribution of each site in the zones. We have done this using average climatic conditions and some conservative assumptions about fish numbers. Figures A to C below show the average modelled concentration of lice/m^2 over the top 2m of the water. Each figure shows the concentration fields in an accessible colour scheme alongside the modelled sites (circles with size scaled to biomass) and current WSPZ (highlighted boundaries). Various figures are produced at the same scale, for varying geographic areas. Plate A contains details on the colour scheme used in the figures. Please note that values less than 0.04 lice/m^2 have not been plotted. A simple analysis of data in these figures, including all values, forms the basis of the capacity and contribution estimates presented in main document, e.g., the information in Figure 10. Please note, the GIS Shapefiles which underpin these plots can be provided on request.

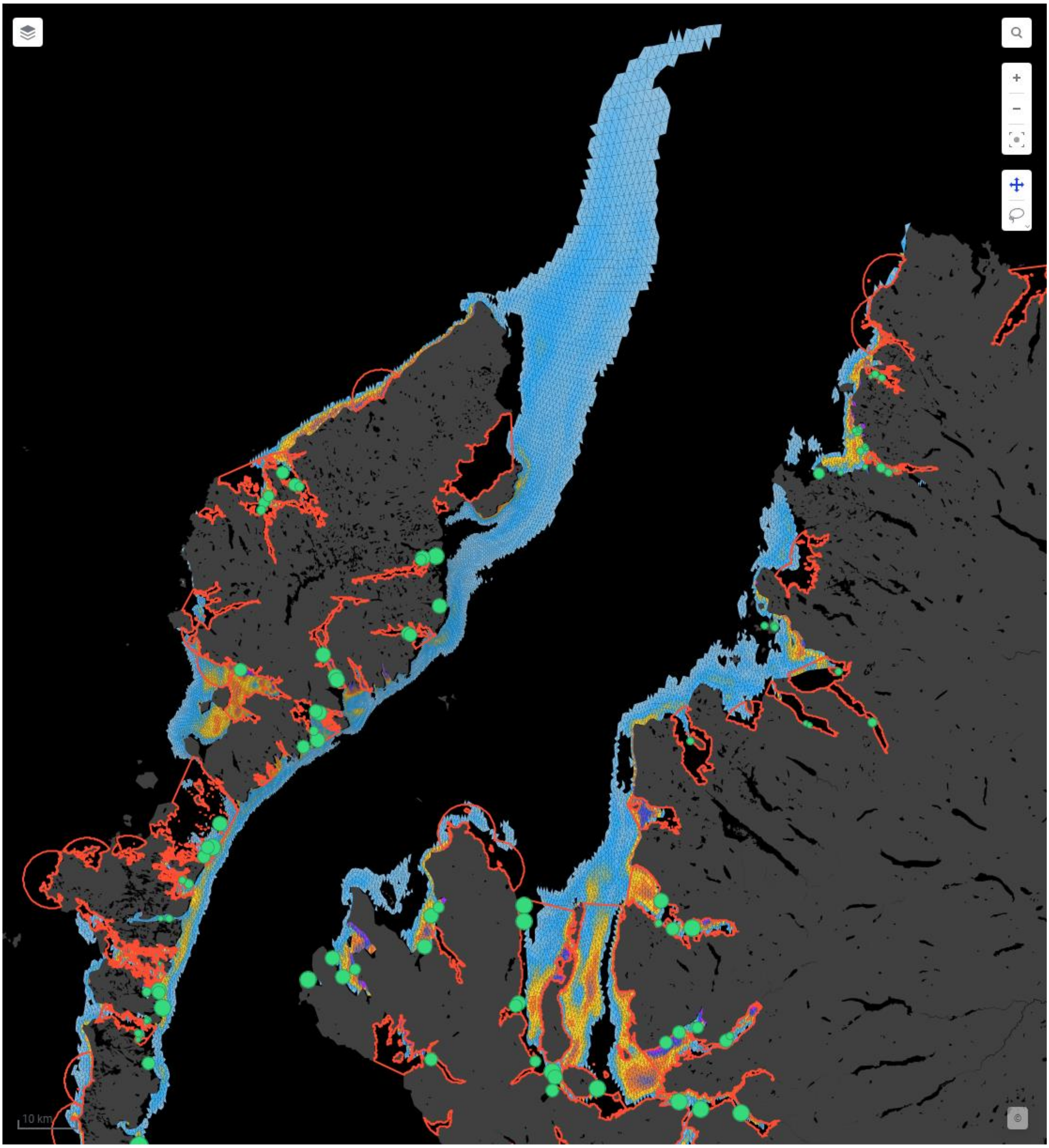


Figure A: Average lice/m^2 concentration > 0.04 over April and May shown against sites and WSPZ. Please refer to Plate A for colour scheme legend information. Geographical Area 1.

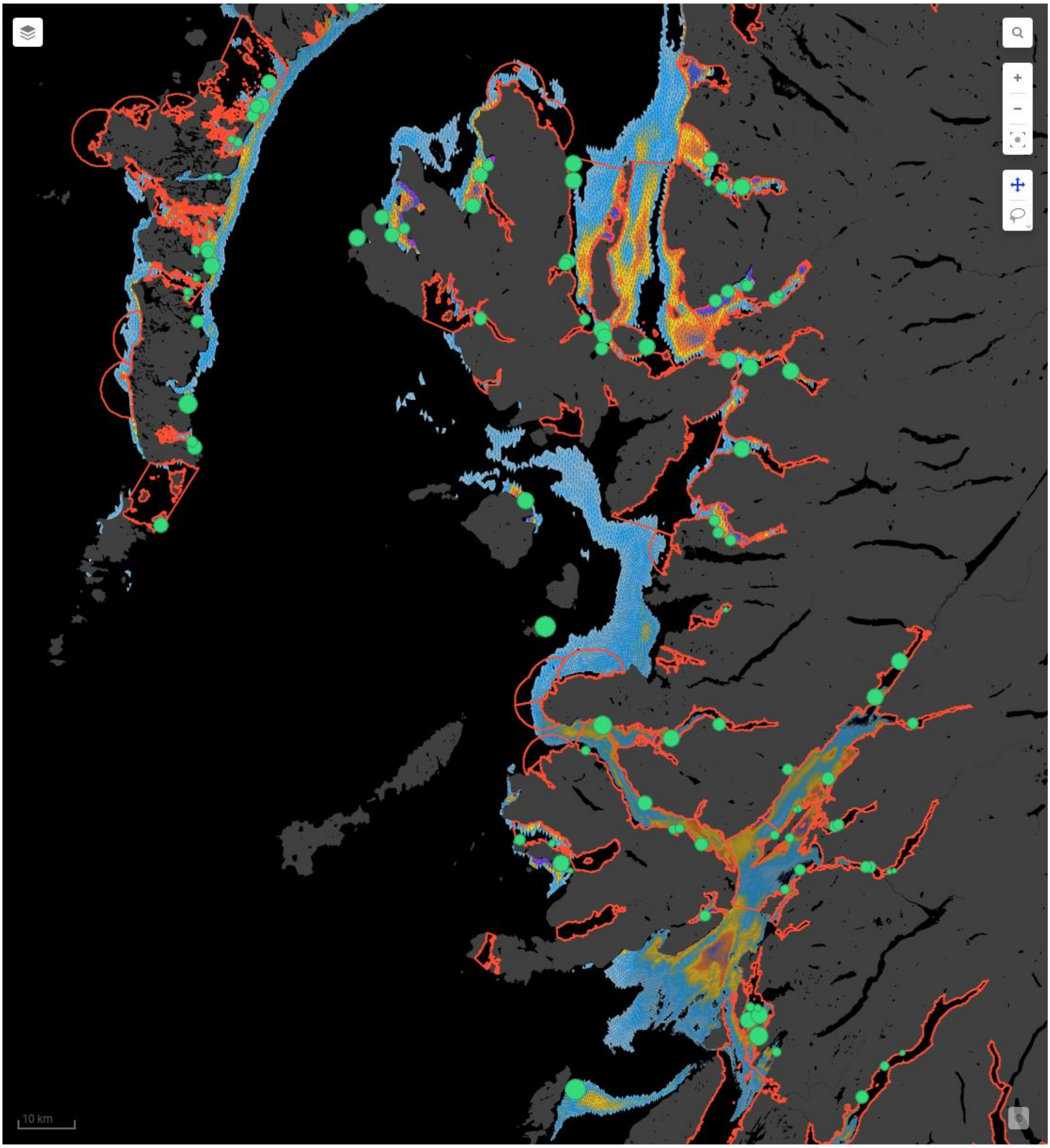


Figure B: Average lice/m^2 concentration > 0.04 over April and May shown against sites and WSPZ. Please refer to Plate A for colour scheme legend information. Geographical Area 2.

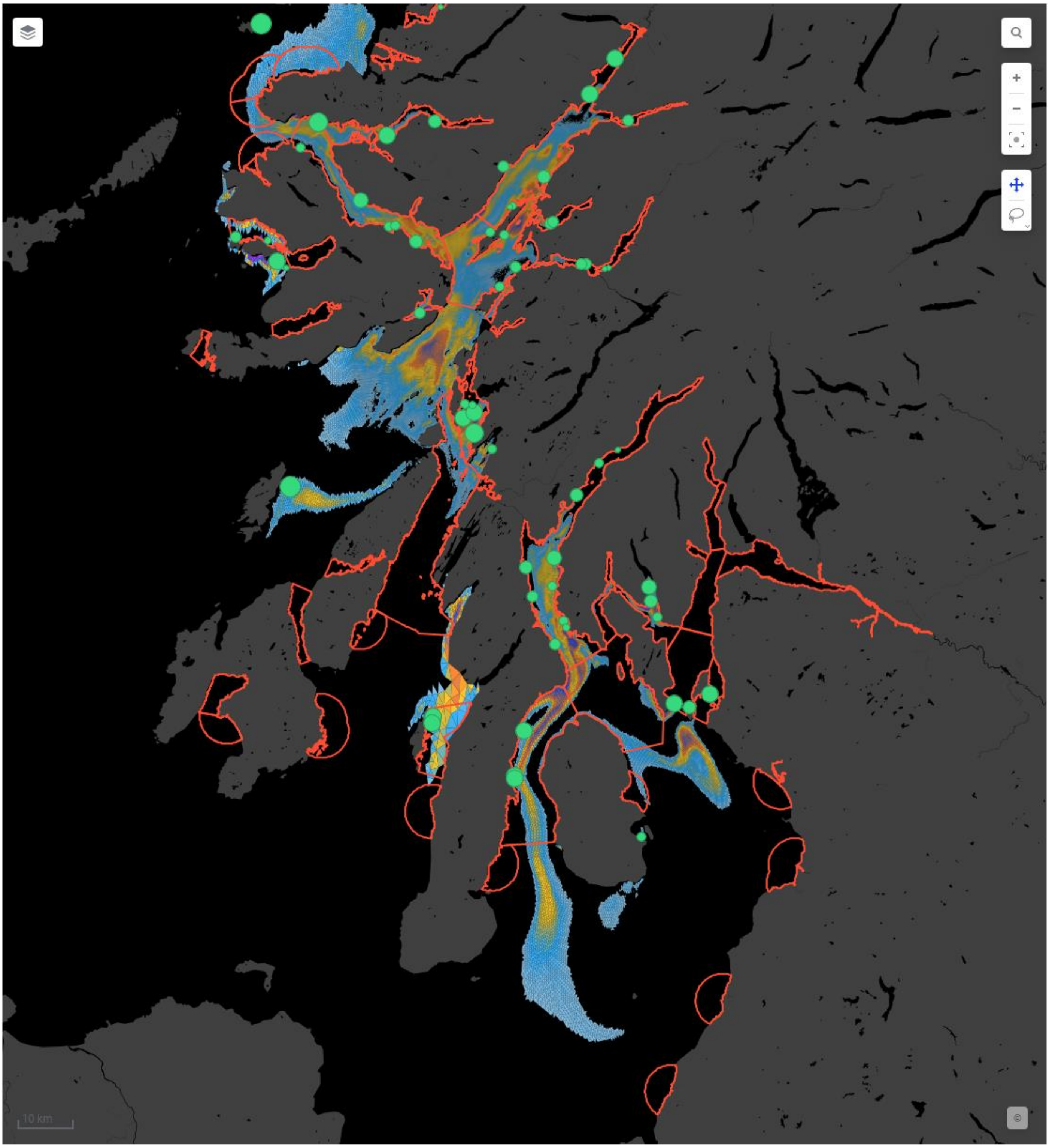


Figure C: Average lice/m^2 concentration > 0.04 over April and May shown against sites and WSPZ. Please refer to Plate A for colour scheme legend information. Geographical Area 3.

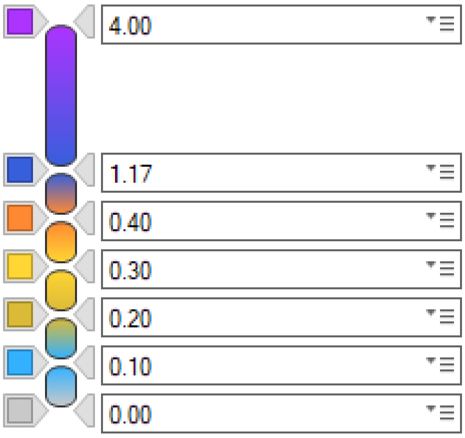


Plate A: Colour scheme used in Figures A to C. Values in lice/m^2

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