SEPA
Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

Proposals for a risk-based, spatial framework for managing interaction between sea lice from marine finfish farm developments and wild Atlantic salmon in Scotland

Scottish Environment Protection Agency

Consultation

December 2021

Glossary	
Biological modelling	Modelling (i.e. creating a mathematical or conceptual representation) of biological processes or systems. For example, particle tracking modelling to assess sea lice dispersal, where the properties of the particle sources and their behaviour in the sea reflect relevant aspects of sea lice biology (e.g. sea lice die-off rates, lice dial vertical migration behaviour driven by light; and low-salinity avoidance).
Hydrodynamic model	A computer programme that simulates the movement (and often temperature, salinity and other properties) of coastal waters. 3-D models can simulate movement and other properties in different sea layers, including the surface layer in which sea lice disperse.
Marine finfish farm development	In this document, refers to any new finfish farm in coastal waters where it is proposed to farm salmonid fish (Atlantic salmon or rainbow trout) or any existing farm in coastal waters where an increase in the number of salmonid fish farmed is proposed.
Sentinel cage	Fixed or towed cage containing fish such that the exact location(s) and time period (e.g. one to three weeks) of environmental exposure of the fish are known. Used to measure the number of sea lice settling on the caged fish.
Salmon post-smolt	A juvenile salmon after it has entered coastal waters from its home river to pass through those waters on its migration to the high seas.
Sea louse	In this document, refers only to the salmon louse; *Lepeophtheirus salmonis.*

1. Introduction

1.1 The Scottish Government has confirmed SEPA as the lead body responsible for managing the risk to wild salmonids from sea lice from marine finfish farms[1].

1.2 This consultation describes SEPA's proposals for the new, spatially based risk assessment framework for regulating the interaction between sea lice from marine finfish farm developments and wild Atlantic salmon. The framework will be applied through the Water Environment (Controlled Activities) (Scotland) Regulations 2011.

1.3 We have worked closely with scientists from Marine Scotland as well as with NatureScot and local planning authorities to develop a means of assessing the risk to wild Atlantic salmon posed by marine finfish farm developments. The core principles of this work were to use best available scientific evidence, ensure the risk assessments are practical to apply within a regulatory decision-making framework, and make the risk assessment process readily adaptive to additional evidence.

1.4 Substantial input from stakeholder groups on the Salmon Interactions Working Group[2] (finfish producers, fishery management organisations and environmental NGOs), including at a series of workshops held between September 2019 and November 2021, has also been invaluable in helping shape and refine the framework during its development to date.

1.5 The proposed framework would be implemented by embedding it within our wider regulatory framework introduced in 2019, which already regulates all discharges from marine finfish farms to the water environment.

1.6 We will use an implementation advisory group and further consultations to assist us with implementation planning. The advisory group will provide a range of expertise and perspectives, and we will include representatives of finfish producers and organisations and groups with responsibilities for, or interests in, the management and protection of wild salmon stocks.

1.7 You can access all the information about this consultation through the SEPA 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.

2. Requirement for regulation – protection of wild salmon

2.1 Scotland is renowned worldwide for the quality of its rivers, lochs and seas. Despite this, in nearly 60% of salmon rivers across Scotland, including on the West Coast and Western Isles, salmon populations are in poor conservation status[3].

2.2 The causes of the poor conservation status of wild salmon stocks are complex and believed to be due to a range of different factors rather than a single cause. The Scottish Government has identified 12 groups of high-level pressures on the status of salmon stocks[4], one of which includes sea lice from marine finfish farms. The proposed regulatory framework described in this document will manage the risk to wild Atlantic salmon posed by this pressure.

2.3 Substantial impacts on the marine survival of wild Atlantic salmon resulting from sea lice from finfish farms have been demonstrated in Ireland and Norway. This has been done by protecting individually tagged smolts against sea lice using an anti-sea lice medicine before releasing protected and unprotected tagged smolts into the sea near their respective home rivers[5,6,7,8,9,10,11,12,13]. It is clear from this work and the wider body of scientific evidence[14] that sea lice from open-net pen finfish farms in Scotland can pose a significant risk to wild salmon populations. The risk will vary depending on a range of factors such as the status of a wild salmon population, the number of juvenile sea lice hatching from sea lice on farmed fish in the sea area concerned, and the topography of the coastline, with the latter influencing wild salmon migration routes and where sea lice accumulate.

2.4 We are also taking action to control and reduce other pressures on wild salmon populations, including through targeted and proportionate action to improve the condition of the water environment. Scotland's planned programme of improvements

to the water environment for the period 2021 to 2027 will be published in river basin management plans in December 2021[15]. A wild salmon strategy, to be published by the Scottish Government, will describe how other pressures on wild salmon populations are being addressed.

2.5 The proposed regulatory framework will deliver on the Scottish Government's response, published in October 2021[16], to the Salmon Interactions Working Group's recommendations on licensing and enforcement with respect to sea lice.

2.6 The Salmon Interactions Working Group was established by Scottish Ministers[17] in 2018 to develop recommendations for a future approach to interactions between finfish aquaculture and wild Atlantic salmon. It published its recommendations in May 2020[18].

2.7 The Salmon Interactions Working Group's recommendations also included recommendations on interactions resulting from escapes of farmed salmon. In its response to these recommendations, the Scottish Government has committed to taking forward a separate programme of work to make fish farm containment measures and regulation more robust, including the introduction of penalties for fish farm escapes.

3. How sea lice interact with wild Atlantic salmon

3.1 The sea louse (*Lepeophtheirus salmonis*) is a parasite of salmon and trout in the sea, feeding on the skin, blood and mucus of its host. Infestation of young wild Atlantic salmon by small numbers of sea lice can result in physiological challenges, secondary infections and death of the host fish. Sub-lethal sea lice infestations may also affect growth of wild salmonid fish during the marine phase of their lifecycles[19,20].

3.2 Sea lice hatch from eggs produced by adult female lice living on salmonid fish (Atlantic salmon and trout) and are dispersed by water currents (Figure 1).

3.3 The growth in the number of salmon and trout farmed in open-net pens in coastal waters over several decades has resulted in a substantial increase in the availability of potential hosts for sea lice in Scottish waters.

3.4 The infestation pressure on wild and farmed salmon depends on the number of host fish, the number of gravid female sea lice on each host and how the juvenile sea lice disperse in the environment.

3.5 Juvenile sea lice become infective (able to latch onto a host fish) after a few days (e.g. after four days at 10˚C) in the sea. The warmer the sea, the shorter the period between hatching and reaching the infective stage.

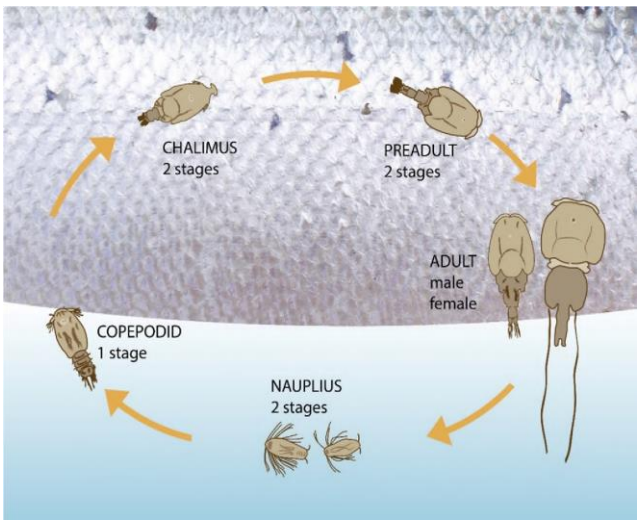

Figure 1: Life cycle of the salmon louse, *Lepeophtheirus salmonis* (courtesy Kari Sivertsen, NINA[21])

3.6 Wild salmon smolts migrate from rivers into coastal waters in April and May. The post-smolt juvenile salmon then head to the high seas. If an infective stage sea louse encounters a migrating wild salmon post-smolt, it may attach to it.

3.7 The number of sea lice that a salmon post-smolt is at risk of being infected with depends on the concentration of infective stage sea lice and how long the post-smolt is exposed to that concentration (i.e. its passage time).

3.8 Further information on the science of the interaction between sea lice from marine finfish farms and wild Atlantic salmon is published by the Scottish Government[22].

4. Main components of the framework

4.1 The proposed framework would operate to protect wild Atlantic salmon post-smolts during April and May. It would have two main components:

(i) wild salmon protection zones;
(ii) a sea lice exposure threshold that applies in these zones.

4.2 Wild salmon protection zones are narrow or constrained areas of sea (e.g. sea lochs and sounds) that wild salmon post-smolts have to pass through, and are hence concentrated, as they migrate away from the coast to the open sea. The proposed zones have been identified taking account of advice from Marine Scotland and fisheries managers.

4.3 The proposed framework delineates protection zones for each graded salmon river under the Conservation of Salmon (Scotland) Regulations 2016 and for rivers designated as Special Areas of Conservation or Sites of Special Scientific Interest for the conservation of Atlantic salmon or the freshwater pearl mussel. The latter species is dependent on salmonids for part of its lifecycle. Details of the proposed wild salmon protection zones are provided in Annex A.

4.4 The proposed sea lice exposure threshold is based on peer reviewed research by Norwegian scientists and separate analyses by Marine Scotland scientists. It would apply in the wild salmon protection zones during the period of smolt migration from rivers (April and May).

4.5 When exposure is greater than the proposed threshold, there is an increasing risk of significant impacts, including mortality, among wild salmon in their sea phase. Details of the threshold and how it would apply to take account of exposure are provided in Annex B.

5. Operation of the framework

5.1 The framework would be implemented under the Water Environment (Controlled Activities) (Scotland) Regulations 2011.

5.2 All proposals for new marine finfish farms or increases in fish numbers at existing finfish farms would be subject to an assessment of the risk posed to wild salmon post-smolts. This risk assessment would consider whether the proposed development would be likely to result in the sea lice exposure threshold being exceeded in a wild salmon protection zone (Figure 2).

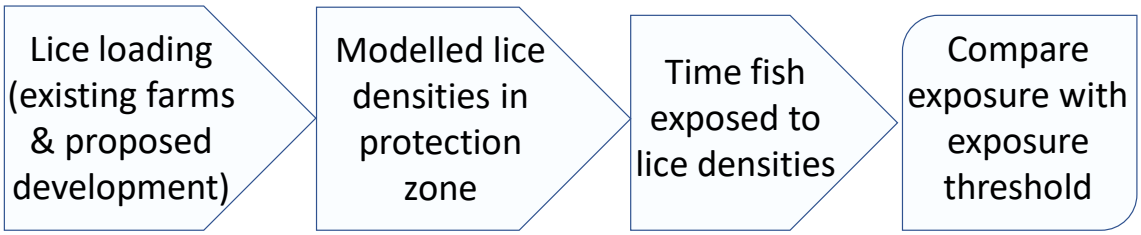

Figure 2: Overview of risk assessment process for proposed farm developments

5.3 The risk assessment would be integrated into our existing regulatory framework for marine finfish farms and form part of a single, enhanced, and comprehensive risk assessment framework covering all pressures from marine finfish farms on the water environment.

5.4 The level of assessment required under the proposed, new framework for controlling the interaction between sea lice from marine finfish farms and wild salmon would be proportionate to the risk, with screening assessments used to identify where more detailed risk assessments are required. If a development proposal is screened by SEPA (using our screening models) as likely to increase infective-stage sea lice concentrations in a wild salmon protection zone, we would require the developer to quantify the proposal's effects on sea lice concentrations in the protection zone using appropriately detailed 3-D hydrodynamic marine models. The results of this modelling would be compared with the sea lice threshold to determine the suitability of the proposal for authorisation.

5.5 Any proposal where expected contribution of sea lice into the environment could not be accommodated within the sea lice exposure threshold would not be granted authorisation.

5.6 The number of juvenile sea lice dispersing from open-net pen farms depends on the number of fish on the farm and the average number of adult female sea lice with eggs (gravid lice) per fish.

5.7 Permits for approved farm developments would include such conditions as necessary to ensure the number of sea lice emanating from the developments is kept low enough to protect wild salmon post-smolts as they pass through wild salmon protection zones. The detail of these conditions will be developed during the implementation process (see Annex C).

6. Sea lice from existing farms

6.1 Our initial and overriding focus will be to implement the proposed framework to protect wild salmon populations against harmful increases in infective-stage sea lice concentrations. We will do this by assessing the risk to wild salmon when determining applications for proposed new farms and for proposed increases in the number of fish farmed at existing farms.

6.2 Permits for all existing farms that can contribute to infective-stage sea lice in wild salmon protection zones would be changed to enable inclusion of conditions that:

(a) appropriately control the factors determining the number of juvenile sea lice emanating from the farms so that those numbers cannot significantly increase without prior authorisation;
(b) require sufficient information to be provided about the operation of the farms to enable calculation of the number of juvenile lice hatching from lice on the farms' fish and the resulting infective-stage sea lice concentrations in wild salmon protection zones. This is needed to assess the additive effect of a development proposal on infective-stage lice densities in the protection zones.

6.3 Our proposed initial focus reflects the Scottish Government's stated priority, which is for a new framework for considering the risk to wild salmon from sea lice when consenting finfish farm developments[23]. It is also necessary because more information is needed to enable an assessment of whether the operation of existing farms is resulting in a hazard to wild salmon populations. Some of this information will be provided through the implementation of the proposed framework.

6.4 Once the framework is established, we will work over the longer term to identify any wild salmon protection zones where the densities of infective-stage lice resulting from the operation of existing farms is posing a hazard to wild salmon populations. In those situations where this is the case, we will work with the operators of the farms concerned to enable them to identify the best means of achieving an appropriate reduction in infective-stage sea lice densities in the relevant wild salmon protection zone.

7. Adaptive approach

7.1 The way we regulate will be adaptive, enabling us to respond over the appropriate timescale to, for example:

(a) inclusion in development proposals of technological innovation that would result in the number of juvenile sea lice likely to emanate from the farm being minimised.
(b) refinements to the precision of computer models used to quantify the effects of development proposals on sea lice concentrations in wild salmon protection zones, including refinements based on evidence from monitoring of the distribution and densities of infective-stage sea lice in wild salmon protection zones.
(c) actions by operators of existing farms that reduces the number of sea lice emanating from those farms and, so, increases capacity for farm development.

(d) evidence from scientific studies of differences in the precise timings and duration of salmon migration from different salmon rivers and the average passage times of salmon post-smolts through different wild salmon protection zones.

(e) evidence from scientific studies for adjusting and refining sea lice exposure thresholds for different wild salmon protection zones or for groups of such zones.

(f) over the longer-term, evidence of effects from climate change on sea lice development rates, mortality, or dispersion; or on juvenile wild salmon behaviour.

Are there other types of information that you think could usefully inform the adaptive development of the proposed framework? If so, please outline how this information could be used?

7.2 As part of implementation planning, we will define the practical arrangements for ensuring transparent, evidence-based operation of the adaptive approach. This will include:

(a) identifying arrangements for ensuring all relevant parties are appropriately consulted about different types of adaptation.

(b) developing principles about the evidence needed to inform adaptations. For example, the evidence required to adjust modelled background lice concentrations in wild salmon protection zones where measures are taken at existing farms with the aim of lowering the number of juvenile sea lice emanating from those farms.

(c) working collaboratively with Marine Scotland Science to understand how the latest research findings could be incorporated into the framework, identify future research priorities, and provide advice and support to partnership research projects, including with finfish producers and other interested parties.

8. Preparing for implementation

8.1 To implement the proposed framework effectively, we will put in place the necessary systems and procedures and embed these into our existing regulatory framework[24].

8.2 Doing this will take time and we will work closely with all relevant parties throughout the process. This will enable us to benefit from their knowledge and expertise and help finfish producers prepare for implementation, for example, by having early understanding of modelling and monitoring protocols.

8.3 We propose to work with an advisory group to help us develop the practical regulatory arrangements and technical protocols necessary to implement the sea lice framework.

Which groups and organisations do you think we should include on technical advisory groups to assist us with the development of the detailed working arrangements and methods needed to implement the framework?

8.4 Annex C identifies some of the work we need to do collaboratively to implement the proposed framework effectively. Following this consultation, we expect it to take around 12 months to implement the framework fully, including considering and taking account of consultation responses. In the meantime, local planning authorities will remain the lead bodies for considering the risk posed to wild salmon from marine finfish farm developments when determining planning applications and may require environmental management plans as a condition of planning permission.

8.5 As we prepare to implement the framework, we will work closely with local authorities to establish future working arrangements. This will include identifying how different aspects of environmental management plans required under planning consents will be addressed under those arrangements, for example, by incorporation into our permit requirements if appropriate.

8.6 Once the framework is implemented, we will establish suitable arrangements to ensure we can get early views and advice on the operation of the adaptive approach going forward. We will take account of the ideas and views of the implementation advisory group in deciding on those arrangements.

9. Sea trout

9.1 Wild sea trout can become infested with salmon lice[25]. However, we are not proposing to define protection zones for sea trout. Understanding of the interaction between sea trout and sea lice is improving but more science is needed before knowledge is sufficient to enable us to design a practical, risk-based regulatory framework. Interactions with sea trout will continue to be a consideration in local planning decisions. Once sufficient knowledge is available, we will bring forward proposals for an appropriate and proportionate risk-based regulatory framework.

9.2 In comparison with salmon, there is very limited information on the status of sea trout populations in Scotland. Available sea trout catch statistics indicate a long-term decline on the West Coast, starting in the 1950s (pre-dating the development of finfish aquaculture) and continuing until around the 1990s. Since then, catches appear to have stabilised or even increased[26]. No systematic catch information is available for Orkney[27].

9.3 Sea trout typically spend much of, or all, the sea phase of their lifecycle in coastal waters where, on the West Coast and around the islands, they may be exposed to sea lice from marine finfish farms. In contrast, salmon post-smolts move away from the coast and onto the high seas. There is also evidence that at least some sea trout can re-enter freshwater to rid themselves of sea lice infestations[28]. Consequently, a different framework may be needed for sea trout to the one we are proposing for protecting wild salmon.

9.4 In Norway, scientists are working on the development of a framework for managing risks from sea lice to sea trout[29]. We will follow these developments along with scientists from Marine Scotland. We will also develop and use new, screening models to help estimate infective-sea lice densities around sea trout rivers and work with Marine Scotland to improve knowledge of sea trout stocks in Scotland’s coastal waters and rivers.

10. Conclusion

10.1 This consultation is the first step in the development of a new regulatory system for managing the risk to wild Atlantic salmon from sea lice from marine finfish farms.

10.2 The new framework we are proposing is intended to contribute to ensuring a sustainable future for Scotland's wild salmon populations and its aquaculture industry.

10.3 The framework is underpinned by a new risk assessment approach based on wild salmon protection zones and a sea lice exposure threshold. The approach has been designed to enable practical regulatory decision-making and has been developed using the best available scientific evidence. Monitoring and feedback from implementation will be used to build on, and refine, the approach overtime as part of an adaptive management process.

10.4 We are proposing to integrate controls for protecting wild salmon fully into our wider regulatory framework that we use to control other pressures on the water environment from marine finfish farms, including discharges of fish faeces and medicines. By so doing, we will be able to further simplify and streamline regulation, including making it easier for developers, coastal communities and others to engage with us as we consider development proposals.

The purpose of the proposed framework is to help us ensure Scotland's environment is protected and improving. It is important for everyone that, as far as possible, this purpose is delivered in ways that also contribute to improving people's health and wellbeing and to achieving sustainable economic growth.

Do you think the design of the proposed framework, or how it is implemented, could affect your community or business interests either positively or negatively? Please tell us what you think the effects could be and why?

Do you have suggestions about how any potential negative effects could be reduced or avoided, or potential positive effects delivered or enhanced, without compromising the environmental protection purpose of the proposed framework?

Annex A

Proposed wild salmon protection zones

A.1 This annex describes the way that the framework will be spatially targeted through the identification of wild salmon protection zones.

A.2 The framework will regulate marine finfish farms to protect wild Atlantic salmon post-smolts as they migrate away from the coast through the wild salmon protection zones (Figure A1).

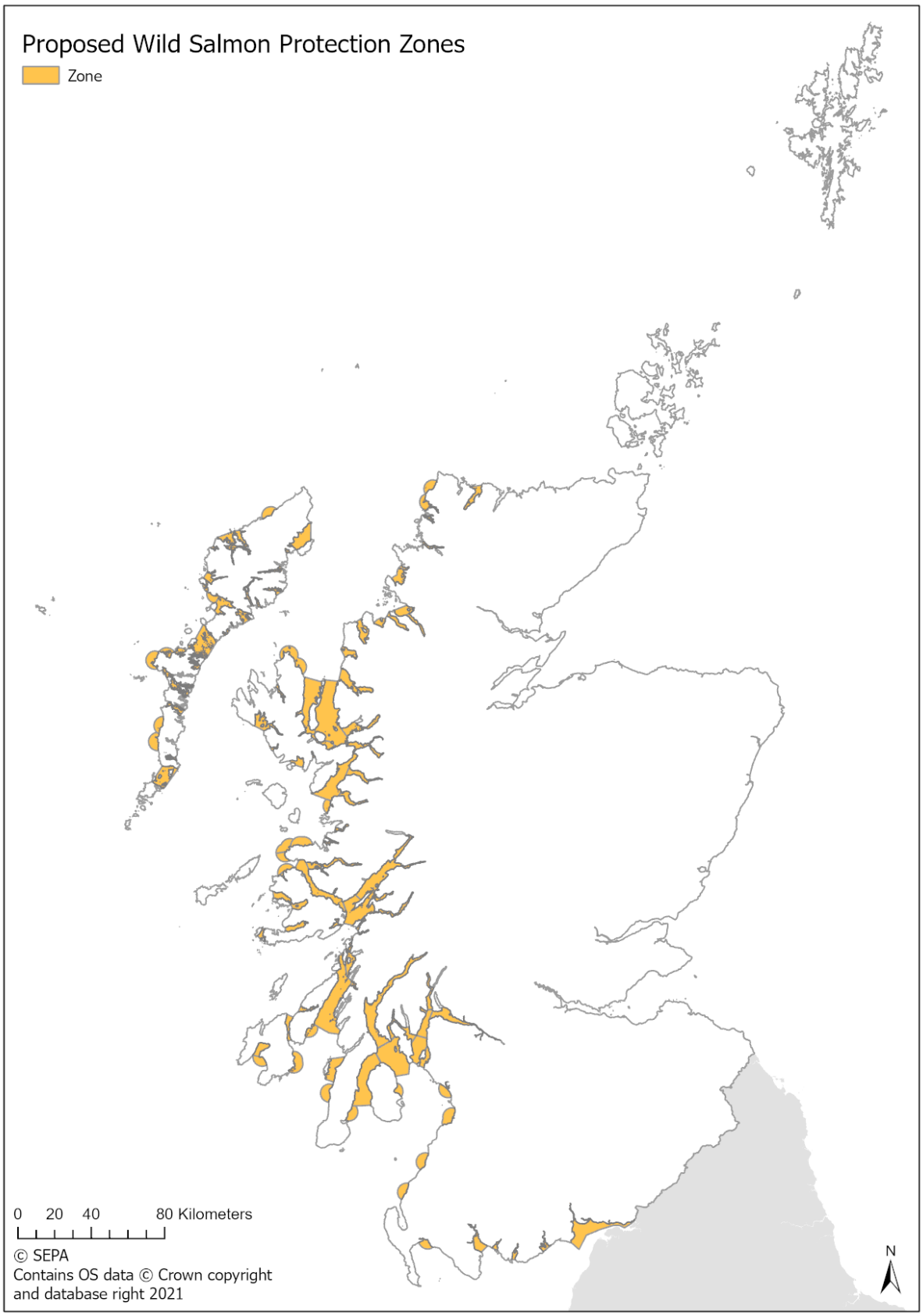

Figure A1: Proposed wild salmon protection zone. An interactive map version is available.

A.3 Wild Atlantic salmon migrate as smolts and then as post-smolts into coastal waters from their home rivers during April and May on their journey to the northern high seas.

A.4 The focus of the framework is on the protection of salmon post-smolts. This is because the tolerance of salmon to sea lice infections generally increases with fish size, making juvenile fish particularly vulnerable, being both small and carrying any sea lice infections they pick up in coastal waters with them as they head to the open seas. In contrast, adult salmon returning to their home rivers are much larger and any sea lice they pick up in coastal waters are lost as they enter rivers, where sea lice cannot survive.

A.5 Many rivers and burns enter the sea along the West Coast and around the islands. We are proposing to identify wild salmon protection zones only in relation to those rivers where there is evidence that they are locally or nationally important for salmon. The rivers we have included in this category are:

a) salmon rivers that have a data-based conservation grading for 2021[30] under the Conservation of Salmon (Scotland) Regulations 2016;
b) rivers designated as Special Areas of Conservation or Sites of Special Scientific Interest for Atlantic salmon or freshwater pearl mussels (excluding those where the mussels are known not to be dependent on salmon).

A.6 There are no rivers in these categories in the Northern Isles. We have also excluded rivers on the East Coast, as coastal waters on the east coast are not used for finfish aquaculture.

A.7 To reach the open sea, salmon post-smolts from many of these rivers must pass through sea lochs and sounds (Figure A2). These areas act as risk-bottlenecks to migration where, if infestation pressure is significant, large proportions of a river's post-smolts could be affected. Under the framework, we are proposing that sea lochs into which a salmon river drains, and sounds, will be treated as wild salmon protection zones.

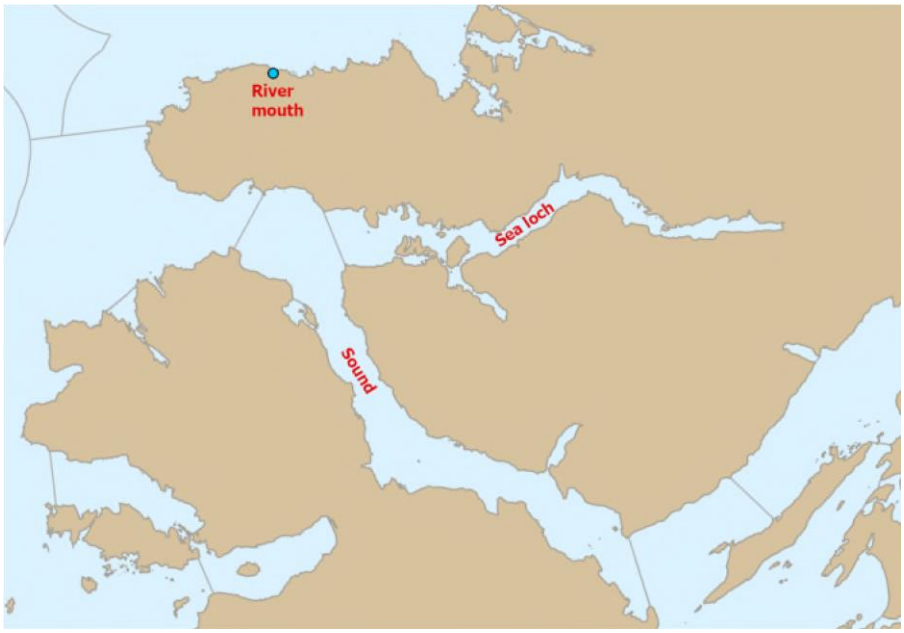

Figure A2: Examples of a sound, sea loch and river mouth opening onto the open coast

A.8 Some salmon rivers enter the sea on open coastlines rather than in a sea loch or sound (Figure A2). All smolts emigrating from these rivers will be concentrated initially in a relatively small sea area leading away from the river mouth. To protect salmon post-smolts in the first few hours of their life in the sea, the area contained within a 5km radius of each such river mouth[31] will be treated as a wild salmon protection zone. Passage time through these zones for most post-smolts is expected to be less than half a day (see Annex B on salmon post-smolt progression speeds).

Do you think that there are important areas for wild salmon post-smolt migration that we have not identified as wild salmon protection zones? If so, please explain why these areas should be identified as protection zones and the evidence on which your suggestions are based.

Do you think that any of the areas we are proposing as wild salmon protection zones should not be so identified? If so, please explain why you think these areas are not important for wild salmon post-smolt migration and the evidence on which your view is based.

Appendix B

Proposed sea lice exposure threshold

B.1 To protect wild salmon populations, sea lice from marine finfish farm developments must not increase the exposure of wild salmon post-smolts to numbers of infective-stage sea lice likely to put a significant proportion of the post-smolts at risk. In practice, the delivery of this protection can be achieved by identifying, and maintaining, exposure below a sea lice exposure threshold. This threshold would define an exposure, above which, damage to individual wild salmon post-smolts is increasingly likely to occur. At or below the threshold, although the risk to some individual wild salmon post-smolts would not be zero, the vast majority would not experience a harmful number of sea lice attaching to them.

B.2 The exposure of emigrating salmon post-smolts to infective-stage sea lice depends on the rate the fish move away from the coast to the open sea and the densities of sea lice across their migration routes. These factors vary in space and time and, in the case of progression speeds, also by fish size. The risk from a particular level of sea lice exposure also varies depending on factors such as a post-smolt's size. This high degree of multi-factor-related variability is not unusual in environmental systems. It means that it is impossible to know the precise level of risk at a particular time to an individual fish. However, by taking account of the potential range of variability, a suitable sea lice exposure threshold for protecting against population-level risks to wild salmon stocks can be estimated.

B.3 Studies have shown that low numbers of sea lice on salmon post-smolts (above about 0.1 mobile sea lice per gram of host fish) can produce substantial stress-related effects[32] and impaired swimming ability[33]. Under laboratory conditions, mortality of at least a proportion of individual salmon post-smolts due to sea lice, including indirectly through secondary infections, is likely at 0.2 mobile sea lice per gram of host fish and becomes more likely as the level of infection increases[34,35,36] (Table B1).

Table B1: Expected effects of mobile sea lice infestation levels on salmon post-smolts		
No. sea lice per gram of fish	**No. sea lice on a 20 gram (approx. 12.5 cm) fish[37]**	**Expected impact**
< 0.1	1	Impact unlikely
0.1 to 0.2	2 to 3	Substantial stress-related effects and impaired swimming ability
> 0.2	4 or more	Substantial and increasing rates of mortality expected

B.4 To deliver effective protection for wild salmon, the sea lice exposure threshold must represent a low infestation pressure likely to result in less than 0.1 mobile sea lice per gram of wild salmon post-smolt. This is a safe level to which most wild salmon post-smolts could be exposed in a wild salmon protection zone.

B.5 We are proposing to apply an exposure threshold of 0.7 infective-stage sea lice-days m^2 integrated over the upper 2m of the sea for this purpose (e.g. exposure for one day to a concentration of 0.7 infective-stage sea lice per m^2; or exposure to 0.3 infective-stage sea lice per m^2 on the first day of migration and to 0.4 infective-stage sea lice per m^2 on the second day).

B.6 Our proposed exposure threshold is derived from scientific studies in Norway in which sea lice numbers found on salmon post-smolts held in sentinel cages were compared with the corresponding environmental concentrations of infective-stage sea lice[38]. The sea lice concentrations were estimated from sea lice dispersion modelling. The proposed threshold of 0.7 sea lice-days m^2 is the exposure level up to which sea lice infection levels found on sentinel caged fish are indicative of sea areas where infestation pressure on wild salmon post-smolts is low.

B.7 Norway's classification scheme for infestation pressure on wild salmon post-smolts uses information on lice numbers from wild salmonids caught by trawling and a risk estimation scheme under which an infection of less than 0.1 mobile sea lice per gram of host fish is assumed not to result in sea lice-related mortality[39,40,41].

B.8 First principles, biological models have been developed by scientists in Scotland[42] incorporating realistic estimates of sea lice swimming velocities and attachment success as well as salmon post-smolt swimming speeds. The findings of these models are consistent with a sea lice exposure of around 0.7 sea lice-days m^2 being capable of producing infestation levels of close to 0.1 mobile sea lice per gram of a wild salmon post-smolt.

B.9 The exposure threshold will take account of the densities of infective-stage lice in a wild salmon protection zone during April and May and the length of time wild salmon post-smolts are likely to spend in those sea lice concentrations. This length of time will depend on the lengths of the zones and the progression speeds of wild salmon post-smolts through the zones.

B.10 The progression speeds of wild salmon post-smolts reflect their swimming speeds, which vary during migration and between individuals, and their swimming directionality. The average progression speed of wild tagged post-smolts found in Norway[43] and Scotland[44] through sea loch systems is around 1 body length per second. For example, an average size, Scottish wild salmon post-smolt[45] of 12.5cm would be expected to navigate through nearly 11km of a wild salmon protection zone in 24 hours, assuming a general orientation along the most direct route to the open sea[46].

B.11 Figure B1 and Figure B2 show estimated minimum passage times for a 12.5cm salmon post-smolt through the proposed wild salmon protection zones. Passage times for smaller, 10cm post-smolts would be 25% longer. The number of infective-stage lice to which salmon post-smolts are exposed depends on the sea lice densities within a wild salmon protection zone as well as the passage time through the zone. Consequently, the lengths of the zones do not directly correlate with their capacity to

safely accommodate increases in numbers of infective-stage sea lice resulting from finfish farm developments.

Do you have any scientific evidence that should be considered to ensure the sea lice exposure threshold is effective in protecting wild salmon populations? This includes any evidence for a refinement of the threshold. If so, please can you provide that evidence?

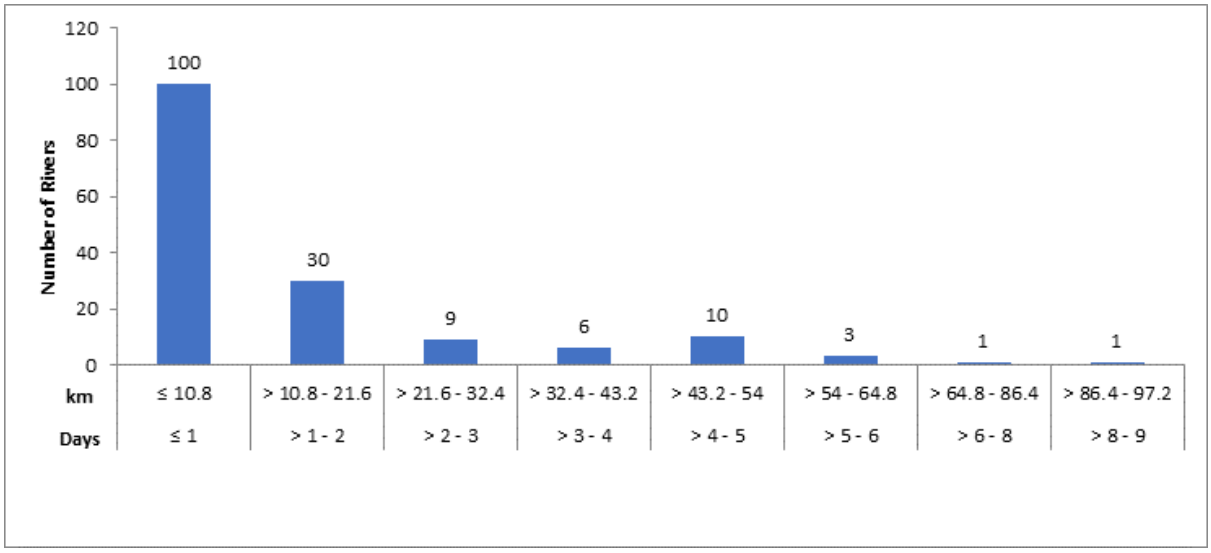

Figure B1: Chart of number of salmon rivers by estimated minimum passage times through associated wild salmon protection zones for a 12.5cm salmon post-smolt at a progression speed of 1 body length per second.

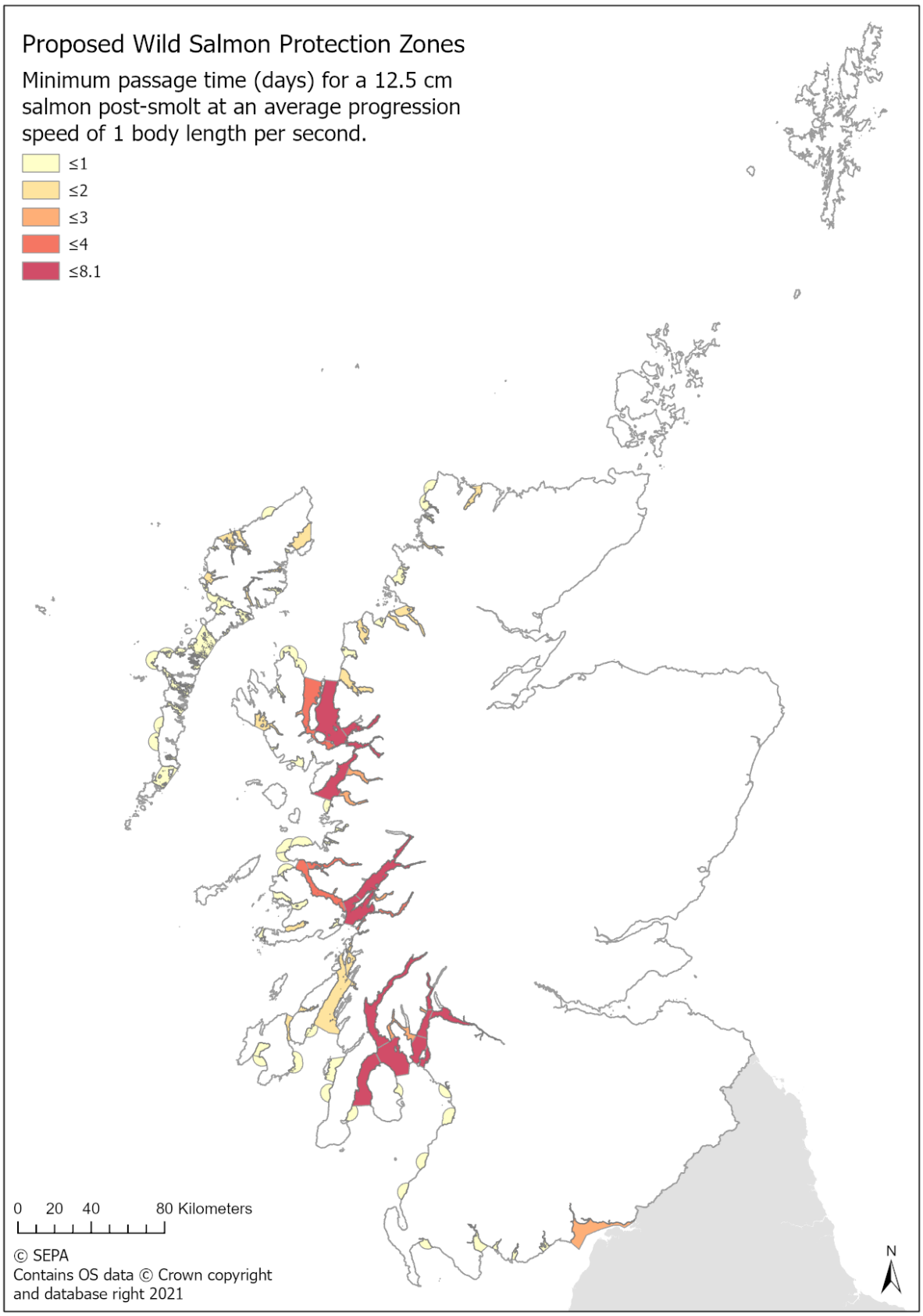

Figure B2: Estimated minimum passage times through wild salmon protection zones for a 12.5cm salmon post-smolt at a progression speed of 1 body length per second.

Note: The shadings show the shortest passage times from the most inland salmon river in a protection zone to the open sea at the edge of that protection zone. Where a salmon river is in an arm of a protection zone, the arm is shaded to show passage times for salmon post-smolts from that river. Where the migration route from that arm joins a longer migration route from another river, the shading shows the passage time for the latter route only. An interactive map version is available.

Annex C

Regulation: Implementation process

C.1 This annex describes some of the key, post-consultation steps necessary for effective implementation of the proposed framework.

Screening models

C.2 We currently carry out screening modelling to inform our pre-application discussions with operators. The modelling identifies the way emissions of medicines and fish faeces from potential finfish farm developments are likely to disperse in the water environment.

C.3 The information this screening modelling provides helps:

a) developers understand what they may need to do to match their proposals, in terms of scale and investment in emission minimisation, to the environment's capacity to accommodate infective-stage sea lice and farm wastes;

b) communities and other interested groups and individuals understand the potential environmental effects of development proposals and engage more effectively in subsequent consultations;

c) developers provide us with the right environmental information for us to determine subsequent applications for authorisation and so avoid unnecessary delays in processing applications.

C.4 A key implementation task will be to incorporate sea lice and wild salmon interaction assessments into the screening process. To do this, we will need to modify the marine models that underpin screening modelling; and incorporate sea lice biology[47,48,49] into our dispersion assessments.

Spatial planning advice

C.5 As our modelling capacity develops, we will use it to provide an assessment of the sea's capacity to accommodate infective-stage sea lice and the emissions of different

pollutants from farm developments. The assessment will take account of spatial and cumulative effects on coastal waters.

C.6 This assessment of the sea's capacity to accommodate sea lice and waste emissions will provide additional, spatial information for fish farm developers to help them consider the appropriate location, size and approach to emission minimisation for their developments before they start discussions with us.

Preparing an application

C.7 Where a proposed new farm or expansion of an existing farm is likely to add to infective-stage lice concentrations in a wild salmon protection zone, an applicant will normally be expected to undertake modelling to quantify their proposal's effects. These modelling requirements will be informed by our screening assessment.

C.8 An important part of preparing for implementation of the framework will be defining the modelling protocols to be used by developers. This will enable applicants to understand what they need to do to build the type of model necessary for us to assess their development proposals.

C.9 Under our existing regulatory framework, applicants provide us with hydrodynamic modelling of the expected dispersion of emissions of medicines and fish faeces from their proposed farm developments. We will work with finfish producers to identify a common, basic protocol for all hydrodynamic modelling, including model calibration. This will enable applicants to build and utilise a multi-purpose core model to prepare applications for authorisation.

C.10 We will engage widely during the development of modelling protocols, taking account, for example, of the findings of the collaborative project, Salmon Parasite Interactions in Linnhe, Lorn, and Shuna (SPILLS)[50]. Once we have draft proposals, we will publish them as part of a consultation process. This will ensure that the modelling protocols represent the best available approach to assessing the dispersion of sea lice from a farm.

C.11 The risk assessments involved in assessing applications will consider the existing, infective-stage sea lice densities in wild salmon protection zones during April and May. To do this, the assessments will require information on gravid sea lice numbers on active finfish farms so that the number of juvenile sea lice emanating from those farms and the resulting densities of infective-stage lice in wild salmon protection zones can be taken into account in our screening models and in the models built by developers. One of the tasks involved in preparing for implementation will be to collect the information needed about the operation of existing farms to allow modelling of existing infective-stage sea lice densities. We will work with finfish farm operators to collect this information.

Do you have relevant expertise that you would be happy to share with us during implementation planning to help us develop modelling protocols?

If so, please tell us about your area of expertise?

If you happy for us to contact you about this, please advise how we should do so.

Permitting and site regulation

C.12 Developers can apply to us for a permit or permit variation once they have completed the modelling and prepared other information that we will require in an application. As part of the determination of the permit application, we will make all the supporting information publicly available to inform the consultation process on the applications.

C.13 The quantities of anti-sea lice medicines we authorise to be discharged depends on the sea's capacity to assimilate the waste medicines. For some developments, the sea's capacity to accommodate anti-sea lice medicines may prevent the use of such medicines in the quantities necessary for effective control of sea lice infestations. In such circumstances, the developers will need to demonstrate to us that they have access to alternative and adequate sea lice infestation prevention or control measures (e.g. freshwater baths) or use systems to capture and remove a sufficient quantity of waste medicines from discharges to the water environment.

C.14 We will incorporate authorisation conditions relating to sea lice in updated and consolidated farm permits that also cover all discharges from farms to the water environment. To prepare for implementation, we will develop appropriate permit conditions for:

a) appropriately controlling the combination of factors (numbers of fish farmed and number of gravid sea lice per fish) that determines the number of juvenile sea lice emanating from farms;
b) monitoring by operators to demonstrate compliance with the framework's requirements.

C.15 We will make sure these conditions are simple to understand and that compliance with them can be effectively checked. For monitoring conditions, we will also develop standardised protocols to ensure consistency and trust in information quality.

C.16 We will ensure that the information we require operators to provide to demonstrate compliance is made public so that anyone with an interest in the environmental performance of a farm will be able to access the information about that farm's performance.

C.17 Our initial proposals on the core monitoring information we will require operators to provide:

a) counts of the number of gravid sea lice per farmed fish;
b) the number of fish being farmed;
c) records of the methods used to reduce lice infestation (Note: This is already required under the existing regulatory framework).

C.18 As part of the implementation process, we will consult on the approaches that we will use to assess compliance, such as auditing gravid sea lice counts. We already have sophisticated analytical methods that allow us to quality assure data provided by farm operators.

Do you have any suggestions for how SEPA could most efficiently and effectively assess compliance? If so, please could you outline these?

Enforcement of permit conditions

C.19 Any necessary enforcement action to drive compliance by operators with conditions to control sea-lice will be based on SEPA's enforcement policy and guidance[51].

Transitional arrangements

C.20 Interactions between sea lice from finfish farms and wild Atlantic salmon are currently considered by local authorities during determination of planning consents. Marine Scotland, NatureScot and District Salmon Fishery Boards provide advice as consultees on sea lice and wild salmon interactions to local planning authorities.

C.21 In preparing for implementation, we will work closely with local authorities and the consultees to ensure a smooth transition to regulation of sea lice and wild salmon interactions under our environmental regulatory regime. This will include consideration of the role of environmental management plans required under existing planning consents.

Monitoring the effectiveness of the framework

C.22 It is important that the effectiveness of the framework is evaluated overtime and the findings used to inform the adaptive approach (see below). We think the best way to deliver the monitoring necessary for this will be through different collaborative initiatives. These may involve a range of collaborators, such as finfish aquaculture trade associations, fisheries managers and researchers from Marine Scotland and research institutions.

C.23 As part of implementation planning, we will work with relevant groups and organisations to develop and design practical strategies for effectiveness monitoring.

Do you have any suggestions on how we should develop a monitoring plan to assess the effectiveness of the framework? If so, please could you outline these?

Do you think there are components that should be included in an effectiveness monitoring programme that you could help deliver? If so, please let us know what these components are?

If you happy for us to contact you about this, please advise how we should do so?

Do you have any additional feedback on any of the proposals outlined in this proposed framework?

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