

Environment, Climate Change and Land Reform Committee: report on the
environmental impacts of salmon farming



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Pàrlamaid na h-Alba

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Dear Edward,

**Environment, Climate Change and Land Reform (ECCLR) Committee report on
the environmental impacts of salmon farming.**

The ECCLR Committee has now concluded its work on the environmental impacts of salmon farming, as agreed, in advance of your committee's first evidence session. Our report is attached and we would be pleased to discuss our findings and conclusions with you.

The SRSL report was focused on the environmental impacts of the industry in relation to the marine environment. Evidence to the Committee highlighted considerable additional environmental impacts, including in relation to freshwater environments. The key additional environmental impacts identified are set out towards the end of our report.

Overall the Committee concluded:

- It is clear to the Committee that the same set of concerns regarding the environmental impact of salmon farming exist now as in 2002 but the scale and impact of these has expanded since 2002. There has been a lack of progress in tackling many of the key issues previously identified and unacceptable levels of mortality persist.
- Over that period there appears to have been too little focus on the application of the precautionary principle in the development and expansion of the sector.

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- Scotland is at a critical point in considering how salmon farming develops in a sustainable way in relation to the environment. The planned expansion of the industry over the next 10-15 years will place huge pressures on the environment. Industry growth targets of 300,000 - 400,000 tonnes by 2030 do not take into account the capacity of the environment to farm that quantity of salmon. If the current issues are not addressed this expansion will be unsustainable and may cause irrecoverable damage to the environment.
- The Committee is deeply concerned that the development and growth of the sector is taking place without a full understanding of the environmental impacts. The Committee considers an independent assessment of the environmental sustainability of the predicted growth of the sector is necessary.
- There are significant gaps in knowledge, data, monitoring and research around the adverse risk the sector poses to ecosystem functions, their resilience and the supply of ecosystem services. Further information is necessary in order to set realistic targets for the industry that fall within environmental limits. There should be a requirement for the industry to fund the independent and independently verified research and development needed.
- The role, responsibilities and interaction of agencies requires review and agencies need to be appropriately funded and resourced to fully meet their environmental duties and obligations. Scotland's public bodies have a duty to protect biodiversity and this must be to the fore when considering the expansion of the sector. We need to progress on the basis of the precautionary principle and agencies need to work together more effectively.
- There need to be changes to current farming practice. The industry needs to demonstrate it can effectively manage and mitigate its impacts.
- Scotland needs an ecosystems-based approach to planning the industry's growth and development in both the marine and freshwater environment, identifying where salmon farming can take place and what the carrying capacity of that environment is. A cohesive framework is needed.
- As a matter of urgency the Committee wishes to see independent research commissioned, including a full cost-benefit analysis of Recirculating Aquaculture Systems (RAS), and a comparative analysis with the sector as it currently operates in Scotland, alongside further development and implementation of alternative technical solutions, supported by the use of incentives.

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- Adaptive management which takes account of the precautionary principle, (using real-time, farm by farm data) could have the potential to reduce environmental impacts, but additional detail is needed on how it would be applied in practice
- The Committee is supportive of aquaculture, but further development and expansion must be on the basis of a precautionary approach and must be based on resolving the environmental problems. **The status quo is not an option.**
- The current consenting and regulatory framework, including the approach to sanctions and enforcement, is inadequate to address the environmental issues. The Committee is not convinced the sector is being regulated sufficiently, or regulated sufficiently effectively. This needs to be addressed urgently because further expansion must be on an environmentally sustainable basis.

Donald Cameron, our reporter to your Committee on its inquiry into the salmon farming industry, plans to attend your first evidence session on 7 March. He would be happy to discuss our findings and conclusions with you and your Committee.

In addition, we have a number of outstanding requests for information following our correspondence with Marine Scotland, SEPA and other agencies and we will ensure you have sight of these as soon as we receive them.

We look forward with interest to your forthcoming enquiry.

Yours sincerely,



Graeme Dey MSP
Convener
Environment, Climate Change and Land Reform Committee

C.C. Cabinet Secretary for Environment, Climate Change and Land Reform.

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Introduction

1. The Environment, Land Reform and Climate Change (ECCLR) Committee agreed its approach to the inquiry into the environmental impacts of salmon farming on 19 December 2017. The Committee subsequently confirmed the timescale for the inquiry on 23 January 2018.

2. The ECCLR Committee's focus is the report commissioned by SPICe and undertaken by SAMS Research Services Ltd (SRSL). The purpose of the report is to inform the Committee's consideration and assist it in reaching its own views in advance of the Rural Economy and Connectivity Committee's inquiry into salmon farming in Scotland. This report was published on 25 January. It contains a review of literature on the environmental impacts of salmon farming in Scotland, the scale of the impacts and approaches to mitigating the impacts. This provides an update of the Scottish Government commissioned report: Review and synthesis of the environmental impacts of aquaculture, published in 2002, as it relates to salmon farming.

Evidence

3. The Committee issued a call for views on the report on 25 January with a closing date of 8 February, in order to report to the REC Committee ahead of its wider inquiry. The Committee heard from SRSL on 30 January and from the following stakeholders on 6 February:

- Scottish Salmon Producers' Organisation (SSPO)
- Community organisation – Friends of the Sound of Jura
- Scottish Environment Link
- Scottish Environment Protection Agency
- Marine Scotland Licencing Operations Team (MS-LOT)
- Marine Scotland Science Fish Health Inspectorate (MSS-FHI)
- Highland Council

4. In addition the Committee received over 80 written submissions that are [published on the Committee's web page](#).

Background

5. The aquaculture industry in Scotland has been growing in recent years and in 2016 produced 163,000 tonnes. The industry plans to extend production to about 200,000 tonnes in 2020 and to 300,000 – 400,000 tonnes by 2030.

The SRSL Report

6. The SRSL report reviews the scientific evidence relating to the environmental effects of salmon farming and where the evidence suggests that there are concerns about harm to marine ecosystems or protected species and habitats the report suggests possible mitigation measures.

7. The report is based on a comprehensive literature review of published scientific and peer reviewed sources and assesses and summarises:

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- The environmental impacts of salmon farming in Scotland
- The scale of these impacts, and
- Approaches to mitigating impacts

8. The report addresses six main areas of environmental impacts:

- Disease impacts on wild and farmed stocks, including the impact of sea lice
- The discharge of waste nutrients and their interaction in the wider marine environment, including: solid wastes from cage farms and effects on sediments and; dissolved nutrient inputs and effects on phytoplankton
- Effects of discharges of medicines and chemicals from salmon farming, including: sea lice medicines; antimicrobial compounds; metals
- Escapes from fish farms and potential effects on wild populations
- Sustainability of feed supplies including research on plant meal substitution
- Emerging environmental impacts, including: Impact on wild wrasse and; impact on marine mammals
- Other environmental impacts, not considered by the report but highlighted in evidence are outlined in pages 65-66

Structure of the SRSL Report

Section 1

9. Section 1 provides background information on salmon, salmon farming, sea lice and the marine environment of north-west Scotland and the islands, where most salmon are farmed. It also explains the conceptual framework employed in the review.

10. The report indicates the activity of salmon farming is likely to generate pressures on natural ecosystems, which may cause change in these systems with consequences for ecosystem services and biodiversity. The report reviews the scientific literature for evidence of causal links between the pressures and their potential effects on ecosystem state.

11. Effects include those on:

- The ecosystem as a whole in which the farm is situated
- Habitats, such as rocky reefs or sea grass beds, which are protected under law or have intrinsic conservation value
- Species protected by law or where there is public opinion favouring their conservation, for example seals or wild salmon

12. The potential impacts of some of these effects depend on spatial scale. For example, effects on species can range from the local scale of a farm (on which sea-

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bed effects are often obvious), through the intermediate scales of sea-loch and coastal water-bodies, to the largest (up to global) scales of fisheries and markets for salmon feed.

Sections 2 – 7

13. These sections consider pressures, effects, and mitigations according to the issues identified in the research specifications. The sections consider:

- the significant environmental effects given the present state of affairs;
- the future state of affairs given current management and regulatory practice, and growth in the industry towards 200,000 tonnes production in 2020 and 300,000 tonnes in 2030, and;
- potential mitigation measures, additional to those presently implemented, for which evidence has been reviewed.

Section 8

14. The final section revisits the criteria used to assess the significance of effects. A comparison between the findings of this review for Scotland is made with a recent risk assessment of the environmental impact of salmon farming in Norway. It also discusses two mitigation measures in further detail that apply to several of the issues considered in Sections 2 - 7. These are Recirculating Aquaculture Systems (RAS) and Adaptive Management.

Structure of the ECCLR Committee report to the REC Committee

15. The key findings of the review, evidence received, and the view of the Committee are set out below on an issue by issue basis, in the order of consideration within the report. Each section begins with the conclusions of the SRSL report in italics, contains a summary of evidence and outlines the view of the Committee.

16. There is also sections on regulation, research and additional environmental and other impacts which were not addressed in the report. The report concludes with a note on key findings.

Note on Section 1

17. SNH expressed concerns about the report's criteria for assessing environmental effects. They state: the definition of significance of an effect seems to exclude Priority Marine Features; there is some inconsistency in the explanation of legal obligations for protected habitats and species, and; the report should have highlighted that a particular impact may not be significant in its own right but it could become significant on a cumulative or in-combination basis.

SRS� Report Summary: Sea lice

Potential for lice from salmon farms to infect wild salmon and damage their populations

Diagnosis

18. *Sea lice are naturally occurring marine parasitic crustacea that attach to the skin of salmon, and harm the fish by feeding on skin and blood and by causing wounds. Eggs laid by female lice hatch into free-living young that are transported by water movements to other salmon, either in the same farm, one at a distance, or to the wild salmon population. The presence of large numbers of salmon, living close together in a farm, can provide conditions that promote the proliferation of lice. Increased abundance of lice on farmed salmon may correlate with increased numbers of lice on wild salmon in the same water-body. There is concern therefore that lice from farmed salmon could damage wild populations of salmon or sea-trout as smolts migrate seawards, and as fish return to rivers to spawn. Although conclusive evidence for damage at the population level is hard to find in Scotland, studies in Norway show that increasing sea lice burdens on wild salmonids adds to pressures on the wild populations already impacted by climate change, river modification, and commercial fishing. Farm controls on lice include; preventing their attachment and development using medicines in the salmon feed, treating salmon using dissolved therapeutants in a bath treatment, and biological control with cleaner fish. These controls can help prevent the build-up of lice populations in the cage pens. Nearly all of these treatments are costly, none are fully effective, and most need to be repeated. They are co-ordinated within farm management areas to help increase efficacy and reduce the likelihood of cross-contamination between farms.*

Prognosis

19. *More farmed salmon implies more sea lice (and thus more costs for farmers and more impact on wild salmon), unless mitigation improves. In addition, sea lice populations also appear to be developing resistance to many existing treatment medicines and therapeutants. The timescale for the development and licencing of new treatments can be protracted and costly. Research gaps and gaps in publically available data in Scotland make it difficult to assess the efficacy of present management and regulatory regimes and have generated some public distrust in the industry and regulator.*

Mitigation

20. *Research into the efficacy of existing lice treatments and their environmental effects. The development of novel lice treatments. Development of lice-resistant salmon through selective breeding. Growing smolts to a larger size in RAS and transferring the fish to net-pens for the final year of production only. Adaptive Management of lice at the farm level, the disease management area level, and the regional level, with monitoring of lice burdens on wild salmon, placing farm lice data in the public domain, and a more integrated marine planning of salmon farming. Modelling can assist area management.*

Additional Commentary

21. *In addition to the risk of infecting wild populations of salmonids and the negative effects on production, the presence of sea lice on farmed salmon is a fish welfare concern and requires treatment for this reason. There are also concerns about environmental effects of sea lice medicines and therapeutants. These concerns include; the long term accumulation of some compounds or their breakdown products, impacts on non-target crustacean species present on the seafloor beneath fish farm cages and further afield.*

Evidence

22. SNH highlighted the limited mention of legal obligations in relation to protected features in this section of the report. They indicated Scotland's west coast has 3 designated SAC's for Atlantic salmon and 10 for freshwater pearl mussel (the latter with a dependence on wild salmonids to maintain healthy populations).

Sea lice and the impact on wild fish

23. SRSL report the problem of sea lice is "a key impediment to the expansion of the Scottish salmon farming industry in the marine environment" and conclude overall the available information provides evidence for disease interactions between farmed salmon and wild populations."

24. Fisheries Management Scotland (FMS) commented on the interpretation of the data in relation to sea lice and wild fish. They highlight an average 20% loss (1 in 5) of returning adult salmon, due to sea lice, with variations over time and geographical location. They state that a small increase in marine mortality, due to sea lice, can result in losses of Atlantic salmon which may be the difference between a river meeting its conservation limits or not – resulting in a Grade 2 rather than Grade 3 categorisation, under Scottish Government conservation measures. They also highlight sea trout are a very important component of west coast fisheries and are Priority Marine Features.

25. The National Trust for Scotland (NTS) stated there are differing impacts on sea trout. Sea trout while at sea spend most of their time in coastal waters, often in close proximity to fish farms and in their view are therefore much more susceptible to the impacts of sea lice infection. The NTS stated the report makes no reference to the population level effects or to the impacts on sea trout populations in the west of Scotland. "Importantly, the specific study on the collapse of the sea trout fishery in Loch Maree has not been mentioned. This is remarkable, given that sea trout have been more seriously impacted in the west of Scotland than salmon and they are also a Priority Marine Feature". The NTS stressed the need to take a precautionary approach to the conservation of these wild salmonids.

26. The Lochaber Fisheries Trust stated "the lice burdens on the wild sea trout on the west coast of Scotland are highest close to farms and patterns in the level of lice on wild sea trout are correlated with farm production cycles.

27. Salmon and Trout Conservation Scotland (S&TCS) stated the Scottish Government's latest classification of Scotland's salmon populations places almost all rivers in the west Highlands and inner Hebrides in the worst-performing categories, with wild salmon stocks not reaching their conservation limits. They also stated west

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highlands and islands mature sea trout are at historically low numbers. A number of submissions referred to significant declines in fish numbers and catch levels in recent years. S&TCS refer to a recent review commissioned from the Norwegian Institute for Nature Research (NINA) which concluded “the combined knowledge from scientific studies provides evidence of a general and pervasive negative effect of salmon lice on salmonid populations in intensively farmed areas of Ireland, Norway and Scotland. ... Levels of additional mortality by salmon lice as indicated in several scientific studies may result in salmon stocks not achieving river specific conservation limits and, if sustained over time, could result in significant cumulative reductions in adult salmon recruitment.”

28. The SSPO acknowledged that the industry is having some impact stating “We will have some impact on wild salmonids. I do not think that that impact is measured easily.” The SSPO was of the view that the impact is insignificant. The SSPO considered the potential impacts of sea lice are one of a number of factors that might impact wild salmonid populations. They have concerns regarding the lack of Scottish science and consider what is needed is matched data on wild fisheries management (including lice data) in order to better understand possible relationships between the two sectors.

29. Marine Harvest accepted there is some level of risk for wild fish and reference the risk to farmed salmon from wild fish.

Sea lice management

30. The report states that farm controls on lice include: preventing their attachment and development using medicines in the salmon feed; treating salmon using dissolved therapeutants in a bath treatment and; biological control with cleaner fish. These controls can help prevent the build-up of lice populations in the cage pens. Nearly all of these treatments are costly, none are fully effective, and most need to be repeated. They are co-ordinated within farm management areas to help increase efficacy and reduce the likelihood of cross-contamination between farms. Environmental issues related to these controls are discussed in later sections of the SRSL report.

31. SRSL highlight that more farmed salmon implies more sea lice and more impact on wild salmon unless mitigation improves. The report also suggests sea lice populations appear to be developing resistance to many existing treatments and research gaps in publically available data in Scotland make it difficult to assess the efficacy of present management and regulatory regimes.

32. The NTS suggested one of the biggest shortcomings in the regulation of sea lice on salmon farms is the failure to effectively control the emission of sea lice into the water column. They stated the impact on wild fish will be a function of the number of lice larvae emitted into the water column (not the number of lice per fish) and control measures for this are needed. Marine Scotland have concluded that “adherence to the suggested criteria for treatment of sea lice stipulated in the industry CoGP may not necessarily prevent release of substantial numbers of lice from aquaculture installations”. The NTS stated “to be effective, a limit on the number of lice per fish must be coupled with a limit on the total number of fish on a farm; one without the other is meaningless....this is particularly important in view of

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the recent consultation by SEPA of new DZR control measures that would allow licensing even larger salmon farms. “

33. S&TCS and others highlighted particular problems in the second year of production. FMS stated lice levels in the environment are significantly higher in the second year of the production cycle. They said harvesting fish before production moves into the second year, and fallowing the production area, has the potential to reduce the number of sea lice in the environment to the benefit of wild fish. In the first instance, they suggested a reduction of the marine phase to less than 1 year through growing fish to 1kg or greater in closed containment, and ideally incorporating fallow periods during the wild smolt run, would be a significant step forward.

34. The S&TCS submission refers to the North Atlantic Salmon Conservation Organisation (NASCO) conclusion of significant adverse impacts from salmon farming and referred to Guidance on best Management Practices to Address Impacts of Sea Lice and Escaped Farmed Salmon on Wild Salmon Stocks'. This established goals for NASCO jurisdictions relating to containment and sea lice management. For sea lice, the goal is that “100% of farms to have effective sea lice management such that there is no increase in sea lice loads or lice-induced mortality of wild salmonids attributable to the farms”.

35. The Lochaber Fisheries Trust said lice levels on wild fish are not monitored in Scotland and to date no large scale studies on the effect of lice on the overall health of salmon and sea trout populations have been completed in Scotland.

Sea lice trigger levels

36. The recommended Code of Good Practice levels (CoGP) requiring treatment are 0.5 or 1 lice per fish depending on the time of year. The report states: “In consultation with the aquaculture industry a new policy was developed that focused on two trigger levels. Exceeding the first trigger level, of an average of 3.0 female lice per fish, requires a site-specific action plan to be undertaken to manage lice numbers. If the average numbers of adult female lice continue to rise and exceed 8.0, then enforcement action may be taken by the Scottish Government, including the possible requirement to reduce biomass but that is not mandatory”.

37. Trigger levels might be set to ensure the welfare of farmed fish or to reduce infections in wild salmon. However, there is no published scientific account of the basis for the setting these levels. It is also not clear why these trigger levels have been set above the recommended CoGP levels requiring treatment. Marine Scotland Fish Health Inspectorate said these levels are not based on “pure science” but on (currently) unpublished analysis of SSPO data on industry experience of lice numbers. As no data has yet been published on the results of this new approach it is unclear how successful it has been in keeping sea lice numbers down. The Committee understands this lack of transparency has led organisations to submit Freedom of Information (FOI) requests to Scottish Ministers. The Committee understands these trigger levels will be reviewed in July 2018.

38. Concerns over the scientific basis for setting trigger levels were expressed in a number of submissions and Jon Gibb, (Fishery Manager River Lochy, Fort William – Clerk/Director of the Lochaber District Salmon Fishery Board) suggested immediate

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clarification is required on the scientific explanation as to why these levels are set and, in particular, why they are considerably less than the existing Industry CoGP levels. SE LINK and others suggested the sea lice trigger levels need to be re-evaluated and supported by robust scientific evidence.

39. S&TCS stated an increasing proportion of the salmon produced in Scotland is breaching the National Sea Lice Treatment Strategy thresholds for treatment. Their submission suggests many fish farms breached the 3 and 8 limits in 2017 and only a single enforcement notice was issued. They state “it remains the case that sea lice limits and enforcement are considerably weaker in Scotland than other European salmon farming countries”. The SSPO took a different view stating the current regulatory regimes in Scotland are regarded as “far more robust, conservative and precautionary than other aquaculture countries”.

40. The Committee explored the appropriateness of the trigger levels for the reporting mechanism in relation to sea lice with Marine Scotland. Marine Scotland stated the purpose for which the triggers are designed is to enable the industry to avoid big peaks. Marine Scotland considers the trigger levels to be appropriate to meet that objective. Marine Scotland said the measures are aimed at ensuring individual farms do not lose control. However, these levels vary significantly from the numbers in the CoGP. The Committee heard from Marine Scotland that the decision on levels is “a kind of adaptive approach”.

41. Highland Council stressed the importance of local control and the need for assessment on a site-by-site basis. They considered this to be particularly important as, in their view, there are sites of greater and lesser sensitivity and tighter control over sea lice numbers in some areas and less tight control in others may be required. They stated it is not necessarily appropriate to have one figure for all sites.

42. The SSPO consider the regulatory measures relating to sea lice control introduced in 2017 need time to allow any potential improvements in lice levels to be realised and they want time for the Farmed Fish Health Framework and related work to be realised.

Sea lice data

43. The lack of public provision of farm level sea lice data has been a concern for some time.

44. Providing oral evidence to the Committee the SSPO confirmed the industry will publish all data on sea lice counts on farms in Scotland on a farm-by-farm basis. The SSPO stated it was in the best interests of the industry and the environment to manage down the numbers of sea lice and the industry had great success in doing this.

45. SE LINK considered there should be a statutory requirement to provide sea lice data. They suggested the sooner and more regularly the data can be provided, the better. “If we are trying to identify rapid spikes in sea lice numbers, we want to do that as quickly as possible and act as quickly as possible to solve the problem. The process could be improved by identifying a clear, standardised methodology for collecting and presenting sea lice data so that it could be easily accessed and

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analysed.” When questioned by the Committee, the SSPO raised no concerns with this being a statutory requirement.

46. SEPA also supported real time publically available information being a legislative requirement of the industry “...a regulatory control is required to be applied because, as was pointed out, the Scottish Salmon Producers Organisation does not represent the entirety of the Scottish industry. Given that we are talking about the entirety of the impact on an industry in Scottish waters, it is relevant that all the information should be available at one time to add weight to R and D work”. Highland Council supported statutory publication and suggested having publically available information on sea lice will allow the focus of the Environmental Management Plan (EMP) to move on to the issue of wild fish monitoring. Argyll and Bute Council stated site specific data would help regulators and statutory consultees assess the acceptability of individual applications for new development.”

47. On real-time farm by farm data, Professor Owens said: “One of the limitations that we have in getting a predictive model as to where sea lice will be transported to from fish farms and so on is the availability of live, real-time data. If we had farm-by-farm data on the distribution and numbers of sea lice in the cages, we would have a considerable improvement in our predictive capabilities, certainly of the distribution of the sea lice. We then move into a biological question as to what might happen to those sea lice and the impact that they might have on the salmon.”

48. FMS also supported the provision of historic data in the public domain and considered publication of the number of fish (rather than the weight of fish) to be a vital component of reporting on fish farms. Marine Scotland said that researchers often look at long-term data sets and want to be able to compare fish data with sea lice data, so the availability of historical data is strategically important. SNH also encouraged the release of historical records to assist in understanding trends.

Regulation

49. S&TCS consider wild fish are insufficiently protected in domestic law and further legislation is required to protect wild fish from potential damage caused by fish-farms, including a statutory duty to control sea lice on fish farms. This view was shared by a number of others.

50. When questioned as to whether there are gaps in regulation that require to be filled for the benefit of the environment, Mark Harvey of Highland Council stated “From our point of view, the most obvious one is the protection of wild fish, particularly from sea lice. From our point of view, we share that problem with Marine Scotland, which is a consultee for us. However, it is not in a position to offer support or make objections with regard to sea lice impacts on wild fish, because the scientific data is not there that would allow it to defend its position, were it to be challenged.

51. S&TCS suggested full publication of farm-specific sea lice and sea lice control data required could be achieved by amending the Fish Farming Businesses (Record Keeping) (Scotland) Order 2008.

View of the Committee

52. The Committee is of the view that addressing the problem of sea lice is essential to further sustainable expansion of the Scottish salmon farming industry in the marine and freshwater environment. The Committee endorses the overall conclusion of the SRSL report that the available information provides evidence for sea lice interactions between farmed salmon and wild populations.

53. The Committee also considers research into best management practice, including the efficacy of existing lice treatments and their environmental effects, alternative approaches, the length of fallowing period and reduction of the marine phase to less than one year, is required. The Committee considers that all farms should be operating to best practice. The Committee outlines its views in relation to the use and impact of chemicals and the requirements for further regulation later in the report.

54. The Committee considers in order to mitigate the risk of transfer of sea lice, fish farms should be located away from salmonoid migration routes. The Committee considers that further research may be needed to ensure migration routes are adequately mapped and understood, but the Committee is clear that the precautionary principle should be applied.

55. The Committee considers that further independent research on the impact of sea lice on wild salmonoids is needed and the industry should play a full part in funding that research. Monitoring of lice burdens on wild salmonoids is required.

56. The Committee questions the basis of setting the trigger levels. The Committee has not yet received a satisfactory explanation on this from Marine Scotland and has written seeking further information on how the levels were decided and why they differ so much from the levels in the Code of Good Practice. As there is no published data on this new approach there is no indication as to its success in keeping sea lice numbers down.

57. The Committee considers there should be a mandatory requirement to keep sea lice levels within those identified in the Code of Good Practice. Sea lice levels should be set with the objective of protecting wild fish and the planned review of trigger levels should consider the scientific evidence that underpins an appropriate trigger level with action and enforcement linked to this. The Committee expects the anticipated review to address these issues.

58. The Committee believes the efforts of the industry have proven to be largely insufficient to address lice issues. The Committee welcomes the announcement by the SSPO that sea lice data will be published on a farm by farm basis. For that data to be most useful the Committee considers there should be no unreasonable delay in its publication. The industry should be required to publish it in real time. Data should be published in a consistent and comparable basis and should include numbers of fish and action taken in response. This information would advance the science and solutions available to the industry. The industry should also be required to publish consistent and comparable weekly historic data sets on sea lice figures on a farm by farm basis from the time records are available. There should be no delay in the

industry publishing this information so this should initially be published on a voluntary basis by the end of April 2018.

59. The Committee also considers that the industry must be required to publish data on salmon mortality on a farm by farm basis and publish accompanying information on disease issues that might be associated with that mortality. The industry should also be required to publish consistent and comparable weekly historic data sets on salmon mortality on a farm by farm basis from the time records are available. There should be no delay in the industry publishing this information and so this should also initially be published on a voluntary basis by the end of April 2018.

60. This reporting should be a statutory obligation to ensure transparency and facilitate public access to information, particularly as not all salmon farmers are members of the SSPO.

61. The Committee considers there may be greater scope for growing smolts to a larger size in close containment and RAS and transferring the fish to net pens for the final year of production only. The Committee encourages the industry to explore this further.

62. There is also a need for further investigation and development of good practice in the adaptive management of lice at the farm level, the disease management area level and the regional level. This should be based on reduced trigger levels, using real time data.

SRS� Report Summary: Diseases

Diseases of farmed fish might spread to other animals, especially wild salmon

Diagnosis

63. *Salmon can be infected by a range of pathogens and parasites, some of which may cause significant losses of farmed fish. About a dozen pathogens and parasites are economically important for salmon farming in Scotland. These infections, and their prevention or treatment, have been much studied in cultivated salmon; less is known about their incidence in wild salmon. The presence of large numbers of fish living close together in a farm provides a favourable habitat for the growth and spread of populations of pathogens and parasites. Depending upon the mode of infection, water currents can spread pathogens between farms and potential between wild and farmed salmon populations. Prevention and treatment measures include biosecurity, fish vaccination, and the use of a range of chemotherapeutants and small amounts of antibiotics. Serious fish or shellfish diseases are called 'notifiable' because farmers must immediately report that they suspect or know about the disease to the Fish Health Inspectorate. There are currently eight notifiable diseases of fish in the UK of which six may be found in salmonids. Suspicion of notifiable diseases will result in movement restrictions and may require the eradication of the infected farm stock. There is some evidence that some disease is*

transmitted between farmed and wild fish by direct infection, by escapees, or by infection from wild to farmed fish. There are few data allowing the risk of disease transfer between wild and farmed populations to be reliably estimated.

Prognosis

64. *Increased numbers and sizes of farms could lead to increased risk of infection of wild fish unless improvements in farm biosecurity and disease prevention outpace the expansion of production.*

Mitigation

65. *Technical mitigations include continued development of effective fish medicines, disease resistant salmon strains, fish vaccines and enhanced biosecurity, especially in hatcheries and RAS. Proactive implementation of management zones and controls on movements of fish to contain disease outbreaks and limit or eliminate their spread. Sampling environmental DNA (eDNA) around farms has the potential provide information on the presence of pathogens. Mathematical models can then be used in some circumstances to estimate risk to wild populations as well as farms.*

Additional Commentary

66. *As an example of a disease, Infectious Salmon Anaemia (ISA), caused losses in Scottish farms in 1998-1999 and 2008-2009 (all fish at ISA confirmed farms were slaughtered under Government order). The virus is spread by contact with infected fish or their secretions, or contact with equipment or people who have handled infected fish, or perhaps by sea lice. This virus can survive in salt-water, and may therefore be transmitted by water movements. As an example of a parasite, the fluke *Diplostomum spathaceum* has a complex lifecycle, passing through fish-eating seabirds and freshwater snails before infecting fish, especially their eyes, causing cataracts and mortality. Although infected in freshwater, the disease may not manifest itself until smolts have been put to sea.*

Evidence

67. There is evidence that some disease is transmitted between farmed and wild fish by direct infection, by escapees, or by infection from wild to farmed fish. There is little data enabling the risk of disease transfer between wild and farmed populations to be reliably estimated. The report states that the lack of knowledge about the disease interactions between farmed salmon and wild populations is of concern.

68. Marine Scotland confirmed they differ from SRSL in their interpretation of the 2017 Wallace paper and consider the impact of infectious disease on wild fish is likely to be minimal. Therefore Marine Scotland stated it has focused resources on trying to understand the sea lice interactions.

69. The Committee explored the environmental impacts of fish disease and mortality, what the industry is doing to improve fish health, what it should be doing, and what government and the regulators are doing to improve fish health and reduce mortality and environmental impact. The Committee also looked at the level of mortality throughout the production process, the primary cause of this mortality, how dead fish are disposed of and how this is monitored and regulated.

Impact of disease on farmed fish

70. On disease, the report states an estimated approximately 33% of marine fish mortalities within a major salmon farming company in Scotland were attributed to infectious diseases.

71. In their written submission Onekind referenced the impact of various treatment practices on the welfare of farmed salmon. Based on data obtained via an FOI request they indicate that “treatment” was the most frequently cited reason for mortalities between January 2016 and September 2017.

Research

72. Marine Scotland told the Committee they have a long-term programme of research looking at the distribution of wild salmon and the migratory routes and that knowledge, together with information on the location of lice in the environment, can be used to inform the planning process. Marine Scotland confirmed they have developed tools for monitoring lice in the environment and the migratory routes of salmon and sea trout. They said they have evidence in relation to settlement and impacts on individual trout, but they do not yet understand how to take that to a population impact. They also referred to research, which started about three years ago, through the Scottish Aquaculture Research Forum, that aims to identify impacts on wild salmon.

73. The SSPO stated “We strongly believe that comparisons should not be made with other countries, since Scotland is different in many regards, for example, in its regulatory framework, farming, environment and scale of production”.

Powers of the Fish Health Inspectorate

74. In oral evidence Rob Raynard of Marine Scotland stated legislation covers a number of listed and notifiable diseases and, if disease is found Marine Scotland looks outside the farm to see whether wild fish have been affected or how the presence of the disease in wild fish might impede or have a bearing on how the farm is treated. The Committee understands the remit out-with the farm relates only to listed diseases that are part of the EU framework that is implemented in Scotland.

75. A written submission from Fisheries Management Scotland (FMS) comments on the current legislative framework and the powers of the Fish Health Inspectorate “...it is important to recognise that the legislative powers conferred by this legislation are limited to the health and welfare of the fish within the cages and cannot be used to regulate any impacts on wild fish outside the cages. This is also the case in relation to the consideration that SEPA gives when consenting biomass – the impact of sea lice from that biomass on wild fish is not considered. We note under the Nature Conservation (Scotland) Act (2004), all public bodies in Scotland are required to further the conservation of biodiversity when carrying out their responsibilities.”

Regulatory Process for considering the impacts on wild salmonoids

76. Argyll and Bute Council stated the interaction between farmed and wild salmonoids is not covered by the regulatory processes of the Fish Health Inspectorate. Commenting on the new Fish Health Inspectorate regime, Argyll and Bute Council stated: “the focus of the FHI regime is the health and welfare of the

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farmed fish only and therefore is not considered to adequately mitigate the risk to wild salmonoids from sea lice on salmon farms”.

77. Argyll and Bute Council commented on the planning process: “For new fish farm development the consideration of potential impacts on wild salmonids is a material consideration in the determination of planning applications for new sites or expansions. This issue only sits with planning because no other regulatory process currently manages it. The interaction between farmed and wild fish is considered by planning authorities based on national policy (National Marine Plan), local planning policy, information provided by the applicant and in particular, advice from statutory consultees, Marine Scotland and the local District Salmon Fisheries Board.” In written evidence, Highland Council raised concerns about the lack of clear guidance from Marine Scotland on the potential impacts of an application on wild salmonoids. This evidence also appears to suggest that SNH is not involved in commenting on the issue.

78. Environmental Management Plans (EMPs) were discussed by Argyll and Bute Council which said these: “...have been considered and developed in some instances where a significant risk to wild salmonids is considered likely. These identify proposed mitigation, process for monitoring, reporting and review to allow changes in management where proposed measures are not successful. An EMP tied to a planning consent can only relate to specific measures on that farm site and therefore has significant drawbacks in that it cannot influence the management of other sites in the same farm management area...”

79. Argyll and Bute Council supported the Aquaculture Consenting Review recommendation to explore removing the consideration of potential wild salmonid impacts from planning to be considered in a separate more appropriate regulatory process.

Management practice

80. The Committee explored measures to reduce the impacts on wild fish populations. SE LINK suggested having stricter protocols on how fish are managed to try to account for human error is important. They suggested stronger netting to minimise escapes and the use of containment and the creation of a solid barrier between the farmed and wild fish.

Farmed fish mortality - the scale of the issue

81. The issue of mortalities of farmed fish was not discussed significantly in the report but it was raised in evidence to the Committee. Marine Scotland Fish Health Inspectorate stated: “Throughout the 1990s and 2000s there was around 20% mortality of farmed salmon throughout the production cycle. This seems to have increased from 2014 to the present day.” The SSPO highlighted gill health challenges, which have led to increased mortality and other problems, suggesting there are a complex set of reasons why mortality has increased. In their written submission the SSPO stated mortality levels varied from year to year.

82. The Committee questioned the SSPO about research on the cumulative impacts of different challenges and diseases working to cause deaths. In an additional written submission the SSPO said this is an area where there is scope for new research. They suggested it is an area of science which is currently lacking

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where fish health is concerned and supported the need for improved academic research around complex and interacting health challenges.

Causes of mortalities

83. The Committee questioned Marine Scotland on the reasons for the increased level of mortalities and they stated about one third of mortalities are caused by infectious disease and two thirds by other means. Marine Scotland referenced particular challenges around harmful algae and microscopic phytoplankton that damage and irritate the gills of the salmon. They also referred to unpredictable jellyfish blooms that can cause fish health issues, and there are other events such as storms. The Committee heard there are complex reasons for mortalities, including gill health issues and the bath treatments that are associated with treating fish with lice. Mortalities might be attributable to a complex mix of environmental factors, including the presence of a paramoeba that is associated with gill health problems and has been found to grow on the surfaces of farm equipment. Marine Scotland also highlighted viral diseases including some that result in heart problems in fish and confirmed if fish are affected by heart issues and the gills are also affected, that gives them a respiratory challenge.

84. The Committee heard from SE LINK that it is the density at which the fish are farmed that causes outbreaks. Concerns were raised if the size and number of farms are increased the number of outbreaks will increase. SE LINK said “If we factor in the rise in sea temperatures, which will increase the rate of outbreaks, we see that the problem is clearly not going away soon”.

Management solutions

85. The Committee heard while mortality rates have gone up the availability of specialised fish veterinary advice has expanded massively. The Committee also heard there are solutions for dealing with the challenge of gill health and the industry is investing in the treatment of fish with fresh water in well boats or other contained units and when gill health deteriorates beyond the point at which the industry considers it is sensible to keep those fish in the sea they are harvested early and then go into the food chain.

Disposal of dead fish

86. Concerns were expressed in relation to disposal. In evidence Dr. Hughes said: “Where there are large numbers of fish deaths, a robust system of disposal needs to be in place. That is really difficult, because a lot of the locations are remote and the events might occur only once in five or 10 years. Planning for them will therefore be difficult and expensive, and it will need to be proportionate to the risk.” The Committee also heard that Zero Waste Scotland published a report in 2017, which says the waste is valuable because the lipids and proteins in it are of high quality, and it identifies routes, including pharmaceutical, for using such products. The Committee heard it is possible to place small bio-digesters onto sites. In most cases, they can deal with the mortalities but large-scale mortalities are of such a volume they have to be dealt with off-site.

Transportation of dead fish

87. The Committee questioned how planning authorities take the transport of dead fish into account and Highland Council suggested the issue is material, because there is a physical impact on the road system and it might raise other environmental

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issues. The Committee heard the mortality rate is not a material consideration and is not currently taken into account in planning decisions. However, the Committee is aware that an Environmental Impact Assessment (EIA) is required for an installation designed to produce more than 10 tonnes of dead fish weight a year and Mark Harvey of Highland Council said the Environmental Statements include a short section on mortalities. The Committee heard Marine Scotland Science and the Fish Health Inspectorate are statutory consultees in the planning process and they take account of whether a farm has provided for dealing with large-scale mortalities. SEPA confirmed they regulate the transportation of waste and said they are concerned about the issue, given the volume of dead fish. SEPA also confirmed they will be exploring the issue in more detail with the industry including on-going issues at the point of receipt and suggested “we need to identify proximity solutions for a range of organic waste”. However, SEPA also stated the animal by-product regulations are enforced by the Animal and Plant Health Agency so that agency, rather than SEPA, is responsible for regulating transportation of dead fish.

An acceptable level of mortalities

88. Marine Scotland confirmed the industry will need to address the mortality issues in order to be able to expand. The Committee sought to explore what could be considered an acceptable level of mortality in a salmon production system. Marine Scotland could not identify an acceptable level, suggesting the context is critical.

View of the Committee

89. The Committee is aware of some research on the distribution of wild salmon and the migratory routes of salmon and sea trout and some research on sea lice, however this appears to be at an early stage and as yet incomplete. The Committee is unclear how this is being used to inform planning and consenting and manage wild fish stocks. As stated in paragraph 54 the Committee considers in order to mitigate the risk of transfer of sea lice, fish farms should be located away from salmonoid migration routes. The Committee considers that further research may be needed to ensure migration routes are adequately mapped and understood, but the Committee is clear that the precautionary principle should be applied.

90. The Committee is unclear all agencies are fully discharging their duty in the Nature Conservation (Scotland) Act 2004 to further the conservation of biodiversity with respect to salmon farming.

91. The Committee is concerned that there appears to be no locus in the agencies for the protection and health of wild fish. While Marine Scotland suggested where disease is found they look at the effect on wild fish and the interaction with the farm, that responsibility does not extend to wild fish. The Committee is firmly of the view there should be a competent regulatory body charged with the protection and health of wild salmon and trout.

92. The Committee is of the view that a more integrated marine planning of salmon farming is required, including a monitoring strategy for wild salmonoids, which addresses cumulative impacts. The body responsible for protecting and promoting the health of wild salmonoids should progress this as a matter of urgency.

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93. The Committee understands there are a number of technical mitigations, including the development of RAS. These are discussed later in the report. There is also further scope for the proactive implementation of management zones and controls on movements of fish to contain disease outbreaks or limit their spread. The Committee has written to Marine Scotland to ask how widely these approaches have been adopted across the sector and what the resulting impact is.

94. The Committee understands with any livestock production there will be health challenges and the aquaculture industry is no different in that regard. However the levels of mortality have been increasing and the Committee is of the view that the figures suggest the industry has a significant problem with fish deaths. The overall number of deaths as result of disease, ill health and stress may be masked by the early harvesting of fish with disease or life threatening conditions. This activity warrants further review.

95. The Committee is concerned that diseases are still leading to large numbers of farmed fish being slaughtered. The Committee is concerned that the industry and regulators appear to be incapable of reducing the level of mortality. These levels would not be considered acceptable in other livestock sectors and should not be considered to be acceptable in the salmon farming industry.

96. The Committee is concerned that salmon mortality will increase if production is doubled and considers fish health problems should be addressed across the sector, with a related decline in mortality rates, before further significant expansion of the sector.

97. The Committee is also concerned about the environmental impacts of disease in terms of rearing fish and the disposal of slaughtered fish. The Committee is interested to know what action the industry and SEPA are taking in response to the findings of the recent report from [Zero Waste Scotland](#), given the focus on circular economy objectives.

98. The Committee has a number of concerns in relation to the transportation and disposal of dead fish. The Committee has written to the Animal and Plant Health Agency to explore the issue of biosecurity, related regulations and protocols, engagement with other regulators and enforcement provisions.

99. The Committee is concerned that the consenting process does not adequately deal with mortalities and is of the view that the use of Environmental Management Plans (EMPs) should be expanded to address the issues relating to disposal. The Committee considers environmental statements accompanying applications for planning consents should fully address the issues in relation to the disposal of mortalities, including transportation, final destination and treatment.

SRS� Report Summary: Organic waste

Salmon farm organic waste accumulating on the seabed can significantly degrade communities of benthic animals beneath or near farms

Diagnosis

100. *In some fish-farm sites in lochs and voes where water currents are relatively slow and wave action is limited (low dispersion environments), sinking particulate organic matter results in a farm 'footprint' on the seafloor, within which oxygen demand is much increased as the organic matter is degraded. A combination of reduced oxygen levels coupled to the physical smothering effect of the particulates, the diversity of the community of seabed (benthic) animals is much reduced.*

101. *This footprint has an area of about half a square kilometre beneath a 1,500 tonne farm. Footprint dimensions and the organic carbon load are estimated by predictive models and confirmed by monitoring. This process is formally regulated. Aggregated footprints only exceed 4% of total seabed in a few lochs and voes. Benthic communities recover when sites are left to fallow, but the recovery rate varies with local conditions. Full recovery may take more than the two years typically allowed. Lack of recent research in Scottish lochs, and failure to synthesise monitoring data, gives rise to some concerns about long-term sustainability of some sites affected by organic waste.*

102. *Farms make a significant, but not overwhelming, contribution to the organic matter supply in lochs. Site licensing procedures aim to avoid the risk of farm organic waste falling on protected habitats, but there is some evidence of impact in the case of maerl beds.*

Prognosis

103. *Increased salmon production will lead to increased organic waste, either adding to the intensity of input at existing sites or adding to the number of 'footprints' as new sites are established. Benthic monitoring near farms, and in relation to protected habitats, is not sufficiently synthesised to allow tracking of long-term changes.*

Mitigation

104. *Better modelling when selecting sites, and Adaptive Management of site use, could help to prevent the Assimilative Capacity (AC) of the seabed of a loch or voe for organic waste from being exceeded within the footprint of the farm. As predicted by models, increased use of more dispersive sites could reduce the risk of exceeding AC, resulting in a more diffuse input over a larger area. Research is needed to better understand loch-scale waste AC and to understand long term changes in the benthos of lochs and voes. RAS can retain organic waste but the extent to which this material may be discharged and therefore have an impact on the AC of any given water body will be system and site specific. RAS require energy inputs which must also be taken into account as part of assessing their overall environmental footprint.*

Additional Commentary

105. *Relevant protected habitats include sea-grass beds, maerl beds of slow-growing calcareous red seaweeds, and unusual reefs of serpulid tube-worms.*

Evidence

Affected features

106. SNH supported the conclusion that fish farms make a significant but not overwhelming contribution to organic matter. However, SNH stated the report highlights the lack of data on the potential recovery of benthic features, but the link to the consequences of this in terms of protected habitats and species is not made, where these may be impacted by waste deposition.

107. SNH expressed concerns about the conclusion in relation to hard substrate impacts. One of the key conclusions of the review was the lack of evidence in this area. In addition, SNH pointed out evidence in 3.3.4 highlights some impacts do occur even in areas of high dispersion.

108. SNH suggested the protected features section 3.3 is not as thorough in its review as section 4 (chemical impacts), and they would have expected the focus to be on designated site features and Priority Marine Features (PMF's) rather than on UKBAP habitats. In addition, they stated only a subset of habitats is discussed (They presume this is based on availability of evidence) rather than the full range of habitats that might be impacted.

The siting of fish farms in relation to MPA's SAC's and PMF's

109. The Committee queried the siting of fish farms in relation to MPAs', SAC's and priority marine features. The Committee received evidence from Marine Scotland confirming there are 288 farms directly on or in a PMF area of which 103 are currently registered active (no buffers applied). 159 sites are located within 500m of a PMF and 192 sites are located within 1000m of a PMF. The NTS confirmed that of the 227 active salmon farms in the sea, 22% are within MPA's, 18% are in SACs and 2% are in SPAs. They said in total, 32% are within some form of protected area.

110. The Committee was also keen to understand how many PMF's and MPA's have been affected by fish farms; in what locations; which features have been affected and whether licences have been adjusted or revoked. SEPA failed to provide any further information on the damage to maerl beds or to other protected features. SEPA further stated "SEPA has not had cause to reduce the permitted biomass at, or revoke the authorisation for, any fish farm for the purposes of ensuring the achievement of a protected area objective, including those for maerl." In addition, they stated "SEPA has reduced the permitted biomass at a number of farms where there were unacceptable impacts on the health of the sea bed, but this action was not taken to address impacts on maerl per se." SEPA did not provide any information on the nature of the unacceptable impacts; the number of times permitted biomass was reduced or the subsequent impact of that reduction. The Committee has written once again to SEPA on this issue.

111. In their written submission Argyll and Bute Council state "Section 4.9 makes reference to BAP habitats and species but the key focus of marine conservation

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outside designated sites should be Priority Marine Features. What is most important is a focus on the specific habitats and species which are sensitive to the environmental pressures from aquaculture development, rather than the presence of any protected habitat or species.” The Marine Conservation Society raised “particular concern” about “the rather light consideration of a range of PMFs and Scottish MPA designated features within the report. We simply do not know the impacts of salmon farms on most individual PMFs and MPA designated features, or the wider cumulative impact of multiple farms in sea loch systems containing many PMFs, underlining the importance of the precautionary principle when planning and licencing”.

112. In evidence, Dr. Hughes said “...given that an MPA is usually designated for a specific purpose—maerl beds or transient cetacean populations, for example—if aquaculture is to be sited within MPAs, as much aquaculture in Scotland already is, we need to understand the impact of the industry on the specific objective of the protection.” When questioned by the Committee SEPA confirmed there are 29 fish farms in and around areas where maerl beds were present and maerl has not been recorded as present recently at 13 of these 29 farms. The Committee asked SEPA to confirm that 16 maerl beds in the vicinity of fish farms have now disappeared or been damaged and how many maerl beds or other protected features have been damaged. SEPA advised that further analysis is needed it would respond to the Committee on this. In a further response SEPA stated “This was incorrect and we apologise for this. Such conclusions cannot be drawn from the data we have.”

113. The discussion in the report of the long-term environmental impacts of a fish farm contains no assessment of the previous sea-bed community but the NTS stress this is vital in predicting the recovery time. They stated several sea bed habitats in Scotland’s inshore waters are characterised by extremely long-lived species “Many faunal turf communities contain complex communities of invertebrates that would take many years to regenerate.” The NTS also said the fallowing system used by fish farms is not suited to maerl habitats because of the likely longevity of the damage caused and they questioned the conclusion that as long as the cage footprint is small compared with the total area of the loch floor, the sediment fauna will recover eventually.

Planning and monitoring

114. SNH considered whilst the footprint of the Allowable Zone of Effect (AZE) may be avoided during the planning stage, there are still issues of lack of information of potential impacts on protected species and habitats outside the AZE. They said deposition (of nutrient and chemical inputs) will still occur in these areas but at a lesser degree (current monitoring does not capture this), and this raises cumulative impact issues which are difficult to assess.

115. SE LINK provided evidence on monitoring of the benthic environment, stating there is monitoring of the amount of chemicals in the sediment but not necessarily of which species are found in the sediments, how the species composition has changed over time because of use of chemicals, or how the amounts of chemicals that have been used have impacted on the benthic community.

116. The Committee asked SEPA how many unannounced visits it had made to fish farms. In revised follow up evidence SEPA provided percentages in relation to the

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environmental impacts of salmon farming

total number of unannounced visits which translate into the following numbers which shows a decline in the annual number of both visits and unannounced visits since 2015:

- In 2015, 14% of 174 visits were unannounced (24 unannounced visits)
- In 2016, 13% of 152 visits were unannounced (20 unannounced visits)
- In 2017, 9% of 160 visits were unannounced (14 unannounced visits)

117. The Committee also sought information on the process and criteria for determining the programme of unannounced visits and whether this had changed over time. SEPA failed to provide this information to the Committee. The Committee has written once again to SEPA.

118. The Committee asked what action SEPA and SNH had taken in relation to individual farms and compliance. The Committee asked if licences had been adjusted or revoked. The Committee also asked for information on the process of stopping the activities of a fish farm that is affecting a maerl bed or any other protected feature. In response SEPA stated it enforces compliance with the conditions of licences and has powers to vary the conditions or to revoke them. In a follow up response SEPA confirmed no licences had been revoked and the biomass for some licences had been reduced. SEPA failed to provide information on the number of farms for which licences had been adjusted. The Committee has written once again to SEPA.

119. SEPA was asked to provide detail on the work it is doing to monitor the impact of fish farms in the vicinity of protected features (PMF's, MPA's, SAC's). The Committee asked how proactive SEPA is in this. SEPA failed to provide the detail requested so the Committee remains unclear as to the adequacy of the protection of PMF's, MPA's and SAC's and the extent of the impact of fish farms. The Committee understands in the period 2015 – 2017 SEPA carried out 23 aquaculture related monitoring surveys. Information from Marine Scotland indicates 192 active fish farms are located within 1000m of a PMF . Based on these figures it appears that monitoring surveys took place in relation to 12 percent of fish farms in the vicinity of a PMF.

Sediment quality and Marine Scotland locational guidelines

120. The Committee explored whether sediment quality could and should be incorporated into Marine Scotland locational guidelines.

121. Professor Tett discussed the effect of chemicals on sediment. He agreed it was an area worthy of further study and could be included in Marine Scotland's locational guidelines. "We have a precedent in the locational guidelines that Marine Scotland brought out in 2002—and updates regularly—which consider effects on the sea bed and the water column. They could be expanded to take into account variations in sediment quality."

122. When questioned whether sediment quality should be incorporated into Marine Scotland locational guidelines SEPA confirmed having all the information in a single framework would be a positive step. SEPA also confirmed the overall assessment of cumulative impacts and spatial locations is an area that they are keen to explore with

other regulators. They confirmed there are gaps in the information and the ability to fill those gaps is key.

Depositional zone and depositional zone regulations

123. The NTS reference SEPA's confirmation that the existing model is unsatisfactory as it over-estimates the accumulation of material below the farm cages and underestimates the quantities accumulating further out. The NTS said this means that the environmental footprint of all affected farms is considerably wider than was foreseen when SEPA granted licences to operate.

124. The depositional zone is the maximum area of seabed that can be adversely affected by an individual site as a result of uneaten food and fish wastes settling onto it. The report discusses a proposed new approach by SEPA. Under the proposed new regime Depositional Zone Regulations (DZR) biodiversity must approach background conditions at the edge of the AZE. Existing consents allow somewhat degraded conditions (ITI = 30) at the AZE boundary. In many cases the size of the AZE will be larger under the new regulations (especially for energetic sites) which, the report states, may compensate for the stricter standard.

125. The Committee understands the new DZR that is being consulted on seems to allow the expansion of fish farms in more exposed locations while requiring a tightening of the monitoring of nutrient waste. Dr. Hughes discussed the DZR: "The changeover to DZR has allowed a review of the current way that the fish biomass is consented for a site, and that is to be welcomed. The prescribed maximum limit of 2,500 tonnes of salmon per site had no real basis in evidence; it was an arbitrary figure. The DZR will allow a more adaptive and responsive management of the biomass, which will be allowed to increase or decrease depending on the impacts on the benthos. Scientists do not have any clear understanding of the detail of the mechanisms behind the DZR. The proposal has gone out for consultation and we do not have the results. It is difficult to say whether the scientific evidence supports a move to DZR, because we do not know what such a move would mean."

126. Providing oral evidence to the Committee, Dr. Collin of SE LINK confirmed their focus on environmental impacts and mitigation. He suggested the new modelling tool is more accurate and can give a more detailed view on the environmental impact. SE LINK want to see this being used to ensure all fish farms are meeting the standards that are in the new DZR.

127. This view was not shared by all. Written evidence from Highland Council raised concerns in relation to SEPA's approach to the development of the DZR changes, suggesting a consideration of the impacts of this had not been undertaken. John Aitchison highlighted concerns that extending the scale of farms to 8,000 tonnes instead of 2,500 tonnes and monitoring the effect before allowing each increase until an effect is detected does not address the evidence in the SRSL report and the PAMP 2 studies which show that impacts are not immediately recognisable. He suggested it could take many years to identify an impact and referenced emamectin living for four and a half years on the sea bed, remaining poisonous. He also raised concerns in relation to cocktail effects and accumulation. In their written submission Friends of the Sound of Jura highlighted concerns that the model used by SEPA to predict where waste and associated emamectin will go does not take account of seabed slope and the shift of waste out-with the area. Others also state SEPA's new

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model only considers dispersal of waste and emamecin up to 1km from fish farms and does not model cumulative effect.

128. The SSPO were supportive of proposed changes to the regulatory regime (i.e. DZR) that focus on measuring actual, rather than modelled, outcomes.

129. The Committee heard the DZR consultation has now closed and SEPA is reviewing the responses. The Committee was told proposals will be brought forward by the end of June. From the discussion with SEPA it appears the intention is there will be a transition across the entire fish farm licence process. SEPA also said collaborative work to develop a genetic monitoring technique to measure the impacts of aquaculture activities on seabed quality was underway and due to be complete in early 2019.

Information gaps

130. The Committee asked if SEPA considers there to be gaps in the information in relation to the sea-bed in the vicinity of fish farms. In follow up correspondence SEPA referred the Committee to its general response on research and other initiatives so the Committee remains unclear as to what SEPA's view is on this important question. The Committee has written once again to SEPA.

View of the Committee

131. The Committee is very concerned that monitoring of the benthic environment in the past, and currently, has not provided an understanding of the impact of chemical discharges on the species found in the sediment, how the species composition has changed over time or the impacts on the benthic community. The Committee also understands that current monitoring does not capture impacts out-with the AZE.

132. The Committee is concerned about the lack of recent research and failure to synthesise monitoring data. The Committee shares the concerns identified in the report in relation to the long term sustainability of sites affected by organic waste.

133. The SRSL report focused on the environmental impacts on the marine and seawater environment and further work is required to understand the environmental impacts on freshwater environments.

134. The Committee considers further sustained and long term research is needed in a number of areas, including:

- how waste is recycled in inshore areas
- the relationship between waste and pathogenic organisms.
- the cumulative effect of fish farms, including in inshore areas, which have different hydrodynamics to lochs and voes.
- environmental impacts in freshwater environments
- acceptable levels of sediment loading for different sediment types.
- The issue of the lack of recently synthesised data on the conditions of the benthos near fish farms needs to be resolved.

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135. The Committee considers a review of the planning processes is needed to minimise the impact of fish farms near protected sites and features including PMF's and to improve the zoning of aquaculture activities.

136. The Committee welcomes the proposal to incorporate sediment quality into Marine Scotland Locational guidelines.

137. The Committee remains deeply concerned that it appears a precautionary approach has not been, and is not being, applied to the development of fish farms and in particular to farms in MPA's or in the vicinity of a PMF. The Committee questions this approach and the environmental consequences.

138. The Committee is concerned that development of the new DZR model has not been peer reviewed. There is a lack of available scientific and published evidence to support the model. It is unclear what assumptions are built into it and whether there has been public and independent expert scientific scrutiny of the model.

139. The Committee is concerned about the lack of scientific evidence to underpin the DZR approach and is unclear as to what difference SEPA's new DZR approach will make to the environmental impact of fish farms. The Committee is also unclear how the model takes impacts beyond deposition on the sea bed into account. The Committee has written to SEPA seeking further information on the development of the model, including consultation and how responses have been taken into account.

140. The Committee understands for some time the industry has operated to a 2,500 tonne farm limit which appears to be an arbitrary limit. The new depositional model has now resulted in a removal of that limit and the result has been more interest in much larger farms. The Committee has concerns about expansion of tonnage when there is considerable and ongoing concern about the environmental impact of this.

141. The Committee is concerned about possible unintended impacts of pushing fish farms out into more exposed locations in MPA's. The Committee heard some of these chemicals can have an impact at very low concentrations and when farms are moved to more exposed environments the footprint of the area that can be exposed to low concentrations is increased.

142. The Committee understands the approach appears to be limited to expansions in more exposed locations. The Committee would welcome an explanation of the rationale for this from SEPA and confirmation that the intention is to cover the entire industry including existing fish farms in more inshore waters. The Committee is strongly of the view that there should not be a two tier approach to regulation and consenting. Existing, expanding and new fish farms should be subject to the same process and conditions with regard to environmental protection.

143. The Committee understands the volume of waste (and untreated waste) discharged from fish farms into the marine environment is half the volume of human (treated) effluent of Scotland. The industry needs to take full responsibility for all environmental costs of production. This would not be acceptable in any other sector and the Committee questions why this has been allowed to happen in the development and expansion of the salmon farming industry.

SRS� Report Summary: Eutrophication

Significant enrichment of lochs and regional seas by salmon farm nutrients could lead to enhanced growth of phytoplankton, and undesirable disturbance to the balance of organisms and to water quality

Diagnosis

144. *Increased (but not harmful) concentrations of ammonium and phosphate can be observed within a few tens of metres from farms. Models predict, and limited observations confirm, increased nutrients in lochs from salmon farming. In some lochs and voes the increase may be substantial during summer. Calculations suggest that this could also be happening in coastal waters such as the Minch. There is, however, no evidence of increased phytoplankton growth or production due to these nutrients. The 'balance of organisms' in the phytoplankton is changing in at least one loch used for farming, but this is likely due to causes other than nutrients from salmon. In most cases, data allowing an assessment in the changes in plankton communities over time are not available. Models suggest that organic waste from farms could add to the risk of deoxygenation in a few lochs with poorly flushed basin water (i.e. water that is trapped behind sills). Enhanced growth of opportunistic green seaweeds can occur near farms, but this is not significant when assessed over lochs as a whole.*

Prognosis

145. *Increased salmon production will lead to increased nutrient input and (without mitigation) could result in greater risk of eutrophication or other undesirable change, especially when coupled with effects of other pressures. The greatest risk lies in those lochs and voes where nutrient Assimilative Capacity (AC) becomes overloaded during summer. Although specified harmful algae are currently monitored in Scottish waters because their toxins can cause harm to humans who eat contaminated shellfish, only in two lochs are sufficient observations being made, and interpreted, to track and understand changes in the phytoplankton as a whole.*

Mitigation

146. *Better modelling in choice of sites and stocking, and Adaptive Management of site use, could help to prevent the nutrient AC of a loch or voe from being overloaded. Current schemes for monitoring Harmful Algae could be extended to monitor full plankton communities at selected sites, in order to track and understand larger-scale change. RAS remove some, but in most cases not all, fish-excreted nutrients, and are energy expensive. Loch-scale Integrated Multitrophic Aquaculture (IMTA) involving shellfish and seaweed cultivation might beneficially use nutrients excreted by salmon as well as increasing AC. However, there is insufficient evidence about the use of these techniques, and experts differ as to their feasibility and effectiveness.*

Additional Commentary

147. *Since the early 2000s, monitoring and research have concentrated on Harmful Algae and their blooms (HABs), which can threaten salmon farming by causing fish mortalities and by contaminating cultivated and wild shellfish, rendering these products dangerous for human consumption whilst the contamination persists. Naturally occurring spiny phytoplankton may pose a risk to fish health through damaging gills. Gelatinous plankton such as jelly fish, when present in large numbers, also pose a risk to net-cage farming but little is known about the conditions that give rise to these events.*

Evidence

148. The report highlights the potential for Loch-scale Integrated Multitrophic Aquaculture (IMTA) involving shellfish and seaweed cultivation and suggests this might beneficially use nutrients excreted by salmon as well as increasing AC. However it states there is insufficient evidence about the use of these techniques, and experts differ as to their feasibility and effectiveness.

149. The Committee had limited time to explore whether Loch-scale Integrated Multitrophic Aquaculture (IMTA) could help reduce the environmental impact of salmon farms and the Committee received limited evidence on this.

150. In their written submission SEPA state that the nutrient loads from salmon farming in itself doesn't necessarily present a problem. The "Population Equivalent" (PE) is not necessarily an environmental management issue. In relation to eutrophication SEPA also state while there can be localised effects, large scale eutrophication is generally not a significant issue.

View of the Committee

151. The Committee understands there is insufficient evidence on the potential of IMTA and there are a range of views on the use of the techniques. This is an area that would benefit from further research, particularly given the anticipated expansion of the industry and related waste produced.

SRS� Report Summary: Medicines and chemicals

Synthetic chemicals (including antibiotics) used to treat lice infestation or salmon diseases, to prevent fouling of farm structure, or as dietary supplements, might be harming other organisms and, perhaps, ecosystems

Diagnosis

152. *Chemicals used in bath treatments for sea lice include hydrogen peroxide, synthetic pyrethroids, and organophosphates (the latter including the widely used azamethipos). Systemic (in feed) treatments tend to be more efficient; of these, only emamectin benzoate (EMB) is currently used in Scotland. Excepting hydrogen peroxide, both bath and in-feed treatment chemicals can persist in the environment.*

Lice are becoming resistant to existing medicines treatments. Therapeutants are also used in bath treatments for fungal infections and antibiotics (in diet) are used for several types of bacterial infection. Antifouling compounds based on copper and zinc retard the development of the microbial and micro-algal base layers on maritime structures, which lead to fouling by seaweeds and invertebrates. Derivatives from these compounds can leach into the water column. Use of all these compounds is strictly regulated; Controlled Activity Regulations (CAR) licences are given on the basis of dispersal modelling and Environmental Quality Standards (EQS) are based on laboratory toxicity testing, and updated when necessary. Because these chemicals are designed as biocides, their persistence in the environment can create pressures on populations of non-target organisms. There is a lack of knowledge about diffuse, far-field effects of these chemicals on benthic and pelagic ecosystem components, and this renders uncertain the amount of precaution needed in setting EQS.

Prognosis

153. Increased production is likely to require additional use of existing or newly developed chemicals. There is a lack of ability to adequately predict low-level effects of long-term usage of these chemicals on benthic and pelagic ecosystem components at the scale of lochs. The concept of Assimilative Capacity (AC) may not be applicable.

Mitigation

154. Replacement of therapeutic treatments for lice which have negative environmental impacts. Development of physical treatments to remove lice, or the use of cleaner-fish (e.g. wrasse and lumpsuckers); development of lice-resistant strains of salmon. Development of vaccines for sea lice has been a long term goal, but there has been no progress in this area despite considerable research effort. An adequate strategy for monitoring and transparently reporting compounds in the environment in relation to benthic and pelagic ecosystem state, and for supporting relevant research using these data. Improved biosecurity (in freshwater hatcheries and in marine farms) to exclude causes of disease (especially untreatable viruses), and increased use of vaccination against bacterial disease, allowing further reduction in antibiotic use.

Additional Commentary

155. Emamectin benzoate (EMB) is the active ingredient in the compound SLICE® that is added into feed, and is used for the control of infestations of all parasitic stages of sea lice.

Evidence

Textual accuracy

156. In its written evidence SEPA stated the report contains some inaccuracies in relevant regulations and a mixing up of responsibilities and procedures across different chemical regulations. SEPA provide further detail on this in the annex to its submission. SEPA also highlighted some inaccurate references to chemicals and confirm there are no products containing cypermethrin, dichlorvos and diflubenzuron that hold marketing authorisations from the VMD for use in fish and therefore they

cannot be used. SEPA confirm in the UK only the products emamectin benzoate (SLICE) and teflubenzuron (CALICIDE) benefit from active marketing authorisations under the Veterinary Medicines Regulations 2013 (VMR). Of the anti-microbial discussed, only three have VMD marketing authorisations for use in fish in the UK – amoxicillin trihydrate, florfenicol and oxytetracycline hydrochloride.

157. SEPA stated the summary provided on the setting of EQS and the use of standards in connection with medicines is inaccurate. SEPA confirms most of the standards they use in connection with medicines and other pollutants are regulatory standards rather than formal EQS. SEPA confirms the UK National Centre for Environmental Toxicology (NCET) in WRc is not directly involved in the setting of EQS. There is no mention in this section of “bath” or topical sea louse medicine treatments and their regulation.

Implementation of Procedures

158. The report states “If the SEPA procedures ... are rigorously implemented, neither conservation features nor ecosystem function outside the allowable zone of effect of a fish farm should be exposed to harmful concentrations of chemicals. This assumes that:

- The exposure modelling is accurate;
- The EQS represent safe levels for both periodic and chronic exposure for all important organisms characteristic of the feature;
- Effects of chemicals on key ecosystem functions (e.g. primary production, food web transfers, sediment aeration by burrowers) is well understood.”

159. The report states “The threat from the anti-sea lice chemicals in Table 1.1 is potentially that from EMB: it is widely used; it decays only slowly in sediment; it is especially toxic to crustaceans, but affects physiological processes more widely.”

160. In written evidence the NTS stated “none of these conditions has been fulfilled”. In their submission they say: All of the consents that have been granted to date depend on an outdated model of deposition (AUTODEPOMOD) that does not deal effectively with deposition in areas with irregular topography or high currents. The EQS for EMB has recently had to be radically reduced following a rapid review. This throws doubt on the statement that “The EQS may be regarded as highly precautionary”. Reviews of the other therapeutic chemicals need to be urgently reassessed. The Committee was told there is currently no guidance on the use of Hydrogen Peroxide.

Data on use and impact of chemicals

161. The report suggests there is a lack of data on discharge of medicines and chemicals. i.e. “There are no publically available data on use of hydrogen peroxide, other disinfectants, antibiotics or antifouling paints in salmon farming in Scotland, and no synthesis of annual usage could be found, either per farm or for the country as a whole.” and “Very few studies have addressed possible effects of several chemicals acting in concert at low concentrations, and given the complexity of testing that would be required this is unlikely to change. Various approaches to this problem have been suggested (Crane, et al., 2006) including transforming and plotting presumed cumulative or additive effects of several chemical stressors. Careful

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monitoring and analysis will be required to address this issue and validate or otherwise any such approaches.”

162. The NTS expressed grave concerns about the use of hydrogen peroxide, given its toxicity, the lack of agreed EQS and the rapidly increasing usage. A number of other submissions share this concern. The NTS also has concerns that there is little mention of the PAMP2 study which prompted the recent review of SEPA’s EQS and said failure to consider the PAMP2 study has led to the dangerous conclusion in Section 4.9.1 that “In-feed treatments reach the sea bed together with the organic wastes, and the depositional footprint around the cages will be similar...Siting of fish farms in close proximity to Special Areas of Conservation, Biodiversity Action Plan habitats or PMF is therefore more likely to cause concern from an enrichment/smothering perspective than from chemical use..” The NTS refer to evidence that the impact of in-feed chemicals is far more widespread and may affect whole sea lochs.

163. The NTS also said, in their view the diagnosis by and large reviews out of date information: “There is no discussion of the recent recommendation by SEPA of the need to reduce the EQS for EMB by a factor of around 100 and the subsequent arguments to curtail its implementation”. The “reference to SARF 046 (the proximity of fish farms to protected features) predates the establishment of MPAs and there is virtually no consideration of this important impact.” They also consider “the mention of SEPA having addressed Priority Marine Features (PMFs) and Marine Protected Areas (MPAs) with respect to fish farming in its interim EMB policy statement is simplistic as it only addresses one aspect of the impact” The NTS suggest there is evidence the implementation of this guidance by SEPA has been inconsistent. They also highlight the lack of reference to the work by SNH and Marine Scotland in assessing the potential impact of aquaculture on PMF’s (through the FEAST tool) and state “This is an extraordinary omission, particularly in view of the urgent need to review this guidance.”

164. SE LINK and many others said the amount of chemicals, in particular emamectin benzoate, that are used is concerning. In their view SEPA’s recent reduction in the use of emamectin highlights how little we know about its impact, particularly at low concentrations. SE LINK expressed concerns in relation to the approach to assessment “At the moment, assessments focus on the benthic environment surrounding a farm, but we know that emamectin can impact on some species at low concentrations. The impact of emamectin could be much larger; its footprint could be much larger than the size of the currently monitored areas.”

Impact of chemical use

165. The Scottish Creel Fishermans’ Federation highlighted concerns about the cumulative impacts of several farms in inshore areas and the impact of biomass and accumulation of waste. In written evidence they state that the total mass of emamectin benzoate increased six-fold between 2002 and 2015. They are concerned about the impact of this on arthropods (including prawns, lobster, crabs) and state the long-term effects of neurotoxin pesticides on scallops and mussels remain ill defined. Scallop stocks appear to be declining in areas with salmon farms. They also have serious concerns on the impact of anti sea lice formulations on target crab (*metacarcinus edwardii*). They consider there is too little independent research on bio-accumulation and on the longer term effects on inshore water ecosystems.

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They express concerns about the impact of fish farm expansion on creeling grounds and hand diving areas. The Committee understands the PAMP2 study found a correlation between the use of emamectin and a 60% decline in crustaceans.

166. John Aitchison referred to an internal document from SEPA accessed via a freedom of information request which states: “Fish farming is unique in that it is a sector which is allowed to discharge substantial quantities of biocides, some of them Priority Substances in terms of the Water Framework Directive and all at least List II substances in terms of the old EU ‘Dangerous Substances Directive ... the waters in which salmon farming is practiced are usually the same waters in which Scotland’s valuable crustacean fisheries are located ... it is not tenable for SEPA to adopt a position where commercial shellfish species are impacted by the day-to-day activities of fish farms.”

Emamectin benzoate and environmental quality standards EQS

167. In evidence to the Committee Professor Tett talked about two issues related to emamectin benzoate environmental quality standards. “The first is whether we are introducing enough precaution into the EQS and whether we know how sensitive certain animals are. Secondly, when we are developing the EQSs, we talk about the direct effects on particular animals, but are there more general, diffuse and long-term effects on ecosystems, such as on the behaviour and reproductive capacity of animals, that will not show up as mortality but will interfere. It has proven difficult to get evidence on that other level.”

168. The use of emamectin is controversial. In June 2017 SEPA commissioned a Review of Environmental Quality Standard Emamectin Benzoate (SLICE), in fish farms. The review proposed new Environmental Quality Standards (EQSs). This also proved controversial. The Committee understands SEPA is currently consulting on the use of emamectin. The Committee heard a ban was proposed, but SEPA withdrew the proposal. The Committee heard this withdrawal was under pressure from the industry. SEPA confirmed an environmental quality standard for the use of emamectin benzoate was set a number of years ago. The Committee was told that SEPA recently commissioned a desk-based study on emamectin benzoate, which recommended a tighter environmental quality standard.

169. Subsequently, SEPA consulted on the review, is now conducting an external peer review of the report and published an interim position statement. Once that, and the additional material provided in the subsequent consultation, has been peer reviewed by the UK technical advisory group UKTAG (due to report at the end of June 2018) SEPA will then provide it to the Scottish Government and the Committee understands the Scottish Government will make a direction to SEPA on the appropriate EQS in due course.

170. In the interim period SEPA confirmed they have temporarily introduced tighter controls for all new applications that involve a marine protected area or a priority marine feature. In evidence to the Committee Anne Anderson of SEPA stated “Recently, in relation to emamectin benzoate, we extended that process to include priority marine features and to recognise the species rather than a fixed place. Identification of a species in an area is particularly important, given that it is a medicine issue. That forms part of the assessment process for the controls that we put in play. The issue has become more self-evident over recent years. Some of the

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facilities that we referred to earlier have been established for quite some time, since the early stages of fish farming.”

171. The Committee was told when the process identifies features that might be impacted by the use of emamectin benzoate, that tighter standard is being adopted with regard to the measurement and usage of the substance. The Committee heard the stricter standard was only being employed in areas in which emamectin benzoate has not been used before—in particular, in areas that have a crustacean population or a sediment population of concern. The Committee also heard that two fish farms in MPA's, at Loch Duich and Rum, have recently been allowed without that condition, although they are in MPA's.

172. The Committee asked why the interim stricter standard for emamectin benzoate is not being applied to existing fish farms in MPA's or in the vicinity of a PMF. SEPA replied the interim regulatory position is designed to ensure marine protected areas and priority marine features are not put at any risk of deterioration whilst the environmental standard for emamectin benzoate is under review. Under the position, SEPA will not authorise proposed increases in the use of emamectin benzoate if doing so would risk deterioration of the conservation interests. SEPA stated it has tightened the conditions of most existing farm licences which permit the use of emamectin in order to ensure that less of this medicine is used.

173. SEPA confirmed that additional research is being undertaken on the ecotoxicity of emamectin benzoate.

View of the Committee

174. The Committee is concerned that there appear to be very significant data and analysis gaps related to the discharge of medicines and chemicals into the environment, including analysis of cumulative or additive effects. This requires to be addressed. The Committee has seen little evidence of proactive activity or action to systematically address the data gaps, either by the industry or the regulator.

175. Research is needed in a number of areas, including on: the impact of zinc pyrrithione on species, communities, and food webs; the degradation of chemicals (including metals which can change form); the retention of anti-louse medicines in the seabed following treatment, and the subsequent impact on the benthos; the effects on juvenile shellfish species; the impacts of several chemicals acting in concert at low concentrations and further research out on the use of salmon farms in inshore or open sea areas.

176. The Committee considers data held on the use of hydrogen peroxides, other disinfectants, antibiotics, and antifouling paints in salmon farming should be made publicly available to promote industry transparency.

177. The Committee is particularly concerned that the industry does not appear to be operating on the basis of a precautionary approach with respect to the use of chemicals and the potential impact on MPA's, PMF's and wider impacts for other sectors. Given the information available and the emerging information, the Committee questions the approach that has allowed open cage salmon farming in these locations.

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178. The Committee is concerned that the tighter standards applying to emamectin benzoate are not being applied to all fish farms in MPA's and in the vicinity of PMF's.

179. The Committee remains unclear how the dispersal of waste (including chemicals) is monitored and accounted for and has concerns about the adequacy of the pollution permissioning and the adequacy of the current modelling.

180. The Committee is unclear how the long term and cumulative effects of chemicals related to fish farms are assessed and how appropriate standards are set, monitored and evaluated.

181. The Committee considers that data on the chemicals used, quantities and the impact of their discharge at low concentrations should be publically available on a farm by farm basis.

182. The Committee is extremely concerned that SEPA may, in the past, or may currently, be permitting the discharge of priority substances and potentially damaging substances.

SRS� Report Summary: Escapes

Salmon escaping from farms could interbreed with wild salmon populations, harming the adaptiveness of the wild fish

Diagnosis

183. *An average of 146,000 cultivated adult salmon are reported to enter the sea from salmon farms each year in Scotland. Causes include holes in nets, human errors and effects of predators. The number is likely to be under-reported. Although the majority of these fish do not survive to mix with wild populations, the number of survivors is estimated to be significant in relation to numbers of wild salmon in Scotland (about a third of a million). Most evidence about the effects of escapes comes from Norway, where flow of genes into wild populations has been documented. There is little information on the extent to which such genetic mixing occurs in Scottish salmon. Although farmed salmon are descended from wild salmon, the genetic makeup of farmed salmon has diverged as a result of artificial selection for survival and growth in farm conditions. Thus, gene flow from escapees to wild salmon, which has been shown to change smolt maturation age and size in Norway, could weaken population adaptiveness to conditions in the wild fishes' natal rivers. There is also the potential for indirect genetic changes to wild populations as a result of changes to the environment experienced by wild populations e.g. increased exposure to sea lice or other pathogens. These could affect the ability of wild populations to deal with natural wild environmental changes e.g. global warming. Additional adverse effects of escapes of cultivated salmon include competition by the escaped fish for food and breeding territory; escaped fish are potential prey and this increased availability of food might attract larger numbers of predators, with greater impacts on the wild populations. There appear to be no studies that quantify these indirect effects.*

Prognosis

184. *Increase in numbers of farmed salmon is likely to result in more escapees, unless farming practices are changes.*

Mitigation

185. *Changes in farm construction and management practices (e.g. Technical Standard for Scottish Finfish Aquaculture published in 2015) could reduce escapes. Development of salmon strains that are sterile (preventing interbreeding with wild fish). Increased knowledge about the extent of genetic interchange between farmed and wild salmon, and its effects on the latter in Scotland, would benefit assessment of effects and the need for mitigation. Some of this knowledge could be gained by routine genetic monitoring of wild salmon.*

Additional Commentary

186. *Triploids, strains of cultivated salmon with three sets of chromosomes, cannot cross-breed with wild salmon. However, experiments to develop triploid strains have so far not proven commercially successful.*

Evidence

Scale of escapes

187. The report states in Scotland between October 2002 and October 2017 approximately 2,193,886 Atlantic salmon were reported to have escaped. Drip escapes are difficult to identify and quantify and are not encompassed by reported escape events, but in Norway this has been estimated to be substantial. The top causes of escapes are human error, hole in net, the weather and predators.

188. The report states that escapes are accepted as unavoidable by the aquaculture industry in open water net pen rearing operations. Most evidence about the effects of escapes comes from Norway, where the flow of genes into wild populations has been documented. There is little information on the extent to which such genetic mixing occurs in Scottish salmon.

Information on the level of introgression

189. Providing oral evidence to the Committee Professor Verspoor said “In Scotland, we have very little information on levels of introgression.... we need to monitor levels of introgression in Scottish wild stocks regularly and then manage them according to their actual effects, as we know that, if introgression occurs, it is extremely likely that there will be negative impacts to some degree, which will probably scale with the level of introgression.”

190. SNH identified escapes as a key concern saying as we are not clear how widespread introgression is in Scotland we are unable to determine the level of impacts on native populations. SNH welcomed the 2015 (industry-led) introduction of the Scottish Technical Standard to reduce the risk of escapes, but considers there is a lack of information on the uptake of the Standard to allow the success of these measures to be assessed.

191. Marine Scotland is exploring the development of a regular system of national assessment for introgression. The Committee heard there has been research on

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introgression in Scotland but it been hindered by past practice as historically, some farmed fish were deliberately released into rivers for restocking purposes and those genes are present from that historic activity.

Impact of escapes

192. FMS highlighted work undertaken in 2011/12 by Rivers and Fisheries Trusts of Scotland (RAFTS) in conjunction with the Fisheries Trusts which concluded that 25.1% of sampled juvenile fish on the west coast of Scotland showed evidence of hybridisation between farmed and wild fish. S&TCS highlight concerns about introgression of salmon populations of rivers protected under the Habitats Directive with the European Commission suggesting a precautionary approach must be adopted. The submissions from FMS and S&TCS confirm that in Norway, escapes of farmed fish are considered to be the greatest threat to wild salmon.

193. The Committee is aware that a significant amount of fish farming happens in freshwater lochs. SE LINK expressed concern about farming in fresh water related to escapes of juvenile salmon into the river system and their integration.

Regulation and Enforcement

194. The Committee understands there is no fine for escapes in Scotland and SEPA has no role in managing or regulating escapes. The Committee heard the measures in place under the 2013 Act mean that an enforcement notice can be issued, and failure to comply with that notice is a criminal offence. However, SEPA advised, in practice many of the issues that are found are dealt with through written correspondence.

195. The Committee heard from SEPA that a Scottish containment standard is being developed and could be implemented in future.

Triploid or sterile fish

196. Argyll and Bute Council suggested the use of triploid or sterile fish, if feasible, would be a more attractive solution than seeking to move to onshore CCS. However the use of such fish would primarily address issues of introgression and would not address other environmental concerns. However, some submissions highlight research indicating triploid fish may be more susceptible to disease and ill health than diploids.

View of the Committee

197. Wild Salmon and Trout are PMF's and as such are considered to be marine nature conservation priorities in Scottish waters. The Committee has significant concerns that genetic mixing of farmed stocks with wild stocks may have negative consequences.

198. The Committee was told the majority of salmon that escape from farms will not survive to interact with wild fisheries populations. However the Committee considers the overall numbers of escapes and the possibility that a significant minority of these could be interacting with wild fisheries populations is of great concern.

199. The Committee is also concerned about the potential for indirect genetic changes to wild populations as a result of changes to the environment experienced by wild populations e.g. increased exposure to sea lice or other pathogens. These

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could affect the ability of wild populations to deal with natural wild environmental changes e.g. global warming.

200. The Committee is aware of additional adverse effects of escapes of cultivated salmon including competition for food and breeding territory; increased predator activity and greater impacts on the wild populations. The Committee is concerned that there appear to be no studies to quantify these indirect effects.

201. The Committee is concerned that the industry appears to consider escapes from open water net pen rearing operations to be unavoidable and only unacceptable from an economic perspective. It appears in practice fish farms face little or no meaningful regulatory consequences if fish escape.

202. The Committee is significantly concerned that an increase in the numbers of farmed salmon is likely to result in increased numbers of escapees without changes in farming practice.

203. There appears to be a lack of priority or urgency in addressing the issue of escapes and it is unclear to the Committee what action the industry is currently engaged in and planning to prevent escapes, and to prevent introgression when escapes do occur.

204. There is an urgent need for increased knowledge about the extent of genetic interchange between farmed and wild salmon in Scotland, and its effects and a need for research that assesses and quantifies the indirect effects. The Committee is concerned that there is insufficient monitoring and research taking place to understand levels of introgression in Scotland and more needs to be done in this area. Some of this knowledge could be gained by routine genetic monitoring of wild salmon.

205. The Committee is interested to explore the plans of Marine Scotland to develop a system of national assessment of introgression.

206. The Committee understands that changes in farm construction and management practices could reduce escapes and the issue of closed containment and recirculating aquaculture systems is discussed later. The Committee would welcome further information on the uptake of the Scottish technical Standard to reduce escapes.

207. The Committee is aware of work on the development of sterile salmon strains but there are issues in relation to the health and resilience of triploids. This requires further investigation.

208. The Committee would welcome further information from SEPA on the development and implementation of a Scottish containment standard. The Committee has written to SEPA on this.

SRS� Report Summary: Feed sustainability

How to provide enough protein and 'omega-3' rich oil to farmed salmon, without adverse effects on the environment including on stocks of wild fish captured for making feed

Diagnosis

209. Atlantic salmon require feed with a high protein content to grow well, plus a high content of 'omega-3' lipids if they are to satisfy human dietary needs for these products. During the early years of salmon farming these requirements were met by feed containing about 90% fishmeal (FM) and fish oil (FO), obtained mainly from European and South American catches of small pelagic 'forage fish', such as the Peruvian anchovy. These fisheries are now mostly well-managed and sustainable, but they are finite and their natural productivity varies strongly inter annually in response to environmental conditions. Consequently, salmon feeds have been reformulated during the last 25 years, and now contain up to 70% (high-protein) vegetable meal (VM) and an amount of vegetable oil (VO). As a result, salmon farming now produces more marine protein than it consumes.

210. However, FO has proved harder to substitute than fish meal, because VO does not naturally contain 'omega 3'. There are also concerns about using agricultural land to grow oil crops, even if salmon are more efficient than farmed sheep, cattle, pigs or chickens at converting their feed into edible flesh.

Prognosis

211. Increasing salmon production in Scotland and elsewhere (e.g. Norway) will necessarily increase the demand for the raw materials for feed, and will compete in this with increased production elsewhere (especially, in Norway).

Mitigation

212. Taking the raw materials for feed from certified sources will aid sustainable management of fisheries. Increased use could be made of directly recycled ingredients such as fish trimmings. Exploring the economic and environmental efficiency of insects grown on waste food, or the products of Integrated Multitrophic Aquaculture (IMTA), could bring additional sources of protein into feed. The required additional, sustainable, source of 'omega-3' could be obtained from transgenic oilseed crops. However, this is not currently possible because of the Scottish ban on Genetically Modified (GM) crops and the widespread European reluctance to allow GM products in diets. An alternative, needing more development and probably more costly, is the use of cultivated micro-organisms.

Additional Commentary

213. The term 'omega-3' refers to a group of long chain polyunsaturated fatty acids (LC-PUFA) that are common in fish oils, and which originate in marine algae before passing up the food chain. Vertebrates (including humans) use them metabolically but have difficulty synthesising them from other foodstuffs. Terrestrial plant (vegetable) oils can contain the related 'omega-6' PUFA and short-chain omega-3, neither of which can substitute for omega-3 LC-PUFA.

Evidence

Significance of the issue

214. The sustainable supply of feed was considered by Professor Tett to be one of the top three environmental challenges for the sector.

215. The Committee heard the industry has moved towards a mix of marine and plant or vegetable ingredients and as a result does not appear to see issues with the future sustainability of feed supply. The industry stressed their desire to maintain a high level of marine omega 3 in feed and there was recognition of pressure on the fish oil element of the diet and the need for solutions to that. The SSPO advised the feed used currently includes recycled elements and they highlighted significant developments in relation to algal oils and other substitutes from plant and vegetable oils that provide omega 3 for inclusion in feed.

216. The Committee heard that fisheries in Europe and South American were at maximum sustainable yield and concerns were expressed in both written and oral evidence in relation to the environmental impact of sourcing feed and the conversion rates. The Committee is aware that 10 million fish died in 2016 and had to be disposed of. A significant volume of feed went to feeding those fish, which could not then be utilised by the market.

217. The Committee is also aware as the industry moves towards the use of cleaner fish to control sea lice, and moves to the farming of those fish, there will also be a requirement for a food source for cleaner fish.

View of the Committee

218. The Committee understands that increasing salmon production in Scotland and elsewhere will increase the demand for the raw materials for feed and Scottish Salmon farms will be in competition with others for this.

219. The Committee also understands that the sustainable fisheries used as a source of fish meal and fish oil are currently at maximum sustainable yield and cannot supply the volume of fish feed required for industry expansion.

220. The Committee understands shifting to farmed cleaner fish will add additional pressures to source sustainably produced feed and is interested to know how the industry plans to address this.

221. The Committee recognises that sourcing omega 3 from transgenic oilseed crops is not possible due to the Scottish ban on Genetically Modified (GM) crops.

222. The Committee heard the industry is keen to maintain high levels of marine sourced omega 3 in feed but the Committee is unclear as to how the industry plans to source sufficient fish feed in the future as the industry expands. The Committee is concerned to ensure the industry operates sustainably, including the sourcing of all inputs. The Committee heard no evidence of consideration of innovative methods to achieve this aim and would welcome further exploration of options for sustainable fish feed with the sector.

223. The Committee considers when looking at conversion rates the volume of feed used and the number of fish that go to market is what is important rather than the number of fish that are being fed.

SRS� Report Summary: Predators

Deterrence of piscivorous predators by netting, or acoustic methods, or by shooting of seals, might harm populations of protected marine mammals and seabirds

Diagnosis

224. Salmon-farms are attractive to marine mammals and birds. Reasons include perches (for birds) and sources of food - either the farmed fish, or wild fish (of various species) that are attracted to waste feed, shelter etc. provided by the farms. Birds and mammals, especially seals, may take, injure or frighten farmed fish, or damage nets leading to escapes. Anti-predator nets above net-pens are intended to prevent loss to birds; however, there are few data on the efficiency of this protection. Entanglement in nets above and below water is a potential, although poorly-studied, mortality risk for birds and marine mammals. Seals can be shot under Scottish government licence. Based on reported numbers of seals shot, current mortality levels represent a small proportion of Scottish seal populations. There may, however, be potential seal welfare problems (e.g. seals wounded rather than killed, nursing females killed leaving dependent pups). Acoustic Deterrent Devices (ADDs), which produce a loud underwater noise, are widely used as non-lethal seal deterrents. There is, however, little evidence concerning the efficacy of ADD. Their use adds to underwater noise pollution, which is known to cause behavioural changes in acoustically sensitive marine mammals (in particular cetaceans). No publications were found that assessed secondary effects of synthetic therapeutants or antibiotics used at farms on marine mammals and birds, nor any potential effects of plastic waste which may come from farms.

Prognosis

225. A simple prediction is that effects on predators will increase as salmon production increases, but the outcome may depend on factors such as siting of farms in relation to seal haul-out areas, and on the availability of other food for the mammal and bird populations.

Mitigation

226. Additional regulation of shooting could improve seal welfare, e.g. through the reintroduction of closed seasons for shooting corresponding to the main nursing periods for seals. Validation of shooting reports, and additional post mortems on shot seals could increase the proportion of 'clean kills'. Better reporting of ADD usage, and improved understanding of ADD function, impact and efficacy, could help to assess and manage the trade-off between seal deterrence and acoustic pollution with its potential effects on cetaceans. Net modifications and good husbandry

practices can also reduce depredation risk from seals. Research into entanglement risk to marine mammals and birds might help in designing better and safer gear.

Additional Commentary

227. *Only a proportion of seals may predate farmed fish. Others may be attracted by wild fish, or be curious about farm activities.*

Evidence

Location of fish farms

228. Seals Marine Concern, Whale and Dolphin Conservation and others, stated some farms are located very close to seal haul out sites (e.g. a farm in Lismore is located 20 metres from the haul out site) and suggest restrictions should be placed on farms close to protected haul out sites and no farm should be granted consent close to a haul out site.

Lethal control measures related to seals – welfare concerns

229. Shooting of seals raises a number of significant animal welfare issues that need to be considered. Despite being a license condition, most shot seals are not presently made available for necropsy, preventing an independent assessment of whether seals are shot according to the Scottish Seal Management Code of Practice and in such a manner to “ensure against a prolonged and painful death” (Marine Scotland, 2011).

Data collection and verification

230. The report states that although the present licensing system has resulted in a decline in the number of seal shooting licenses issued, there are several areas where additional attention is still required. The data made available by Marine Scotland is based on self-reporting by license holders, and are not verified independently. This potentially risks under-reporting or the shooting of seals without license. Seals Concern Scotland and others suggest there should be independent scrutiny of data on seal shoots.

Review of the licencing scheme

231. The Committee understands a review covering the first four complete years of the new licensing scheme (2011-2014) was published by Marine Scotland in 2015. This reported a significant reduction in reported shootings of seals at fish farms and coastal fisheries during this period. This was considered to have been driven by a number of factors, including improvements in non-lethal seal deterrent measures such as correct net tensioning techniques, prompt removal of dead fish, antipredator netting, and use of Acoustic Deterrent Devices (ADDs).

232. Subsequent data reported by Marine Scotland in 2017 suggest that the number of seal licenses issued, and associated numbers of seals reported shot, have continued to decline although there was some regional variation. An average of 51% of licensed shootings took place at fish farms during 2011-2016.

233. In their written submission the SSPO stated shooting is not a management option, but is a last resort. In terms of shooting, the sector has a “stated aspiration to reach zero.” Seals Concern Scotland also suggested shooting should be used as a

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last resort. There were calls for additional regulation of shooting to improve seal welfare including the re-introduction of closed seasons corresponding to the main nursing periods for seals, validation of shooting reports, tagging of carcasses and additional post mortems.

234. The Committee understands the regulations that allow the killing of seals in Scotland fall foul of the United States Marine Mammal Protection Act, which “Prohibits the intentional killing or serious injury of marine mammals in all fisheries.” As a result, we could face an export ban on all our fisheries products in four years. The Committee questioned what Marine Scotland is doing to address that including considering withdrawing the regulations that allow the intentional killing of seals. Marine Scotland confirmed that they, and part of the wider Scottish Government, is looking to understand exactly what it means, what is required and what the expectations are. The Committee asked Marine Scotland to confirm what action it is taking to ensure Scotland does not face an export ban on fisheries products to the US and the timescale for that action. In a written reponse Marine Scotland indicated that while the regulation does not come into force until 2022, countries are required to demonstrate compliance or working toward compliance by 2019. Marine Scotland referenced various ongoing discussions but did not outline any specific action, either underway or planned, to ensure Scotland is compliant.

Use of Acoustic Deterrent Devices (ADDs) - evidence of effectiveness

235. Acoustic Deterrent Devices (ADDs) are used on Scottish fish farms as a non-lethal method to reduce the risk of seal depredation by producing loud, aversive underwater sounds. However, the report states that “Despite their widespread use in Scottish aquaculture, the long-term effectiveness of ADDs as a seal deterrent remains unproven.”

Current use of ADDs

236. The Committee is aware of reports of large numbers of fish farms operating ADDs continuously. The Committee asked the SSPO how many farms are operating ADDs on a continuous basis. In a further written response the SSPO said no system continuously emits a noise. All have different cycles of sound propagation, with periods where no noise is produced. The SSPO did not provide detail on numbers but said they understood 50-60% of ADDs/farms that currently use ADDs use them in a manner where they are turned on continuously. They said industry is keen to support continuous improvement in design and adaptation of anti-predator systems, including research to better quantify if our use of ADDs is having any actual effect on non-target species. They stated “Our current experiences of interaction with wildlife around fish farming areas points to this not being a problem.” The Committee understands there is no consistency of approach in the use of ADDs with fish farms relying on differing manufacturers guidelines.

Impact of ADDs on marine wildlife

237. The report says “...the absence of a consistent ADD monitoring scheme and/or licensing process currently poses a significant challenge to the assessment of the scale of ADD-related noise pollution and consequently its impact on marine species. ADDs are currently not being recorded consistently in any national marine noise register.” SNH confirmed the report reflects their concerns about the potential impacts of ADD use on marine wildlife (especially European Protected Species),

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including disturbance/displacement; auditory injury and long-term impacts such as increased stress levels. They state there is evidence of an increase in the extent of marine acoustic pollution in areas of Scottish waters that are important to cetaceans. These concerns are reflected across evidence including the submission from the Hebridean Whale and Dolphin Trust who raised concerns about the siting of fish farms in critical areas of habitat for cetaceans.

238. SE LINK referred to a growing body of evidence on the impact of ADDs on harbour porpoises saying the devices induce stress, cause hearing damage and cause displacement—they change the behaviour of harbour porpoises by preventing them from going to certain areas. SE LINK stated although ADDs are not proven to be effective on seals, they have a significant impact on cetaceans. The Scottish Salmon think tank suggested there should be a moratorium on deployment of ADDs while research on the deleterious impacts on seals and cetaceans is investigated.

Regulation, monitoring and management of ADDs

239. Argyll and Bute Council discussed the regulatory process for ADDs: “ADD use is considered by planning authorities when determining a planning application for a new or expanded farm. ADDs are normally proposed as part of a number of anti-predator control measures and used only if other measures such as tensioned netting are not effective. The acceptability of ADD use is assessed based on the sensitivity of the location, the type and frequency of the ADD and how it will be operated. SNH provide advice as a statutory consultee and normally if planning permission is approved for a development, it is subject to a planning condition that ensures that ADD use cannot take place unless the details of ADD use have been agreed by the Planning Authority in consultation with SNH and thereafter the development maintained as such unless any variation is agreed in advance by the Planning Authority. While ADD use is considered in individual applications there is currently no formal monitoring requirement directly linked to existing regulatory consents.”

240. Highland Council confirmed they look to control ADD use at the planning application stage and subsequently through the compliance with the condition placed on planning consents to require the operator to retain a log of ADD use. They are also looking retrospectively at the existing use of ADDs on farms and the need to take action by requiring adjustments to the way in which they are used including adjusting frequencies to affect seals but not harbour porpoise and other cetaceans.

241. SNH raised concerns about the lack of a consistent approach to the monitoring and management of ADD usage. SNH suggest that a more formal ADD registration system would provide data required to better understand this issue and manage it effectively.

242. On ADD noise-related pollution Marine Scotland Licencing confirmed there is a case for better monitoring and licensing and they confirmed their intention to lead on this and to work collaboratively with Scottish Natural Heritage.

Other approaches

243. The SRS� report and evidence to the Committee suggested there are other options for seal management including: tension nets and extending the use of double

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skinned predator nets; improved animal husbandry practices to reduce depredation risk and research into better design of gear to reduce entanglement risk.

244. The Committee received evidence that the Aquaculture Stewardship Council requires that certified farms worldwide comply with strict requirements for responsible farming. Certified farms cannot use ADDs or kill marine mammals. The Committee understands in Norway a total of 115 salmon farms are certified including 49 Marine Harvest farms and in Scotland only 2 are certified.

Birds

245. There was little consideration in the report or in subsequent evidence on the impact of fish farms on birds. However, SNH welcomed recent industry improvements to net tensioning and strengthening which they consider had significantly reduced entanglement risks to birds and other wildlife.

View of the Committee

246. The Committee is extremely concerned to ensure seal welfare is maintained and promoted and it has not been convinced that seals in the vicinity of fish farms are being shot only as a last resort. Seals are a European marine mammal protected species and there is a requirement to ensure their protection.

247. The Committee considers Scotland needs to act now to ensure it does not fall foul of the US Marine Mammal Protection Act, which prohibits the intentional killing or serious injury of marine mammals in all fisheries. The Committee considers all fish farms in Scotland should be required, via legislative or any other appropriate means, to follow the position of the Aquaculture Stewardship Council in relation to marine mammals. This ensures farms cannot kill marine mammals.

248. The Committee heard ADD's are not effective as a seal deterrent and has seen little evidence of their efficacy. The Committee understands most ADDs are left to operate continuously and is particularly concerned about this as it heard impacts from ADDs are cumulative and unintended and widespread underwater noise pollution may be affecting cetaceans. The Committee is also concerned there appears to be no assessment by government and regulators of the scale of ADD-related noise pollution and its impact on marine species since 2014 and no related action. The Committee has significant concerns about the use and operation of ADDs and their cumulative impact and considers all fish farms in Scotland should be required, via legislative or any other appropriate means, to follow the position of the Aquaculture Stewardship Council in relation to ADDs. This ensures fish farms cannot use ADDs.

249. The Committee considers the industry should manage the risk of predation through extension of the use of double skinned predator nets.

250. The Committee is concerned that there appears to be little or no research on the secondary effects of therapeutants or antibiotics used at farms on marine mammals and birds and on the potential effects of plastic waste which may come from farms. The Committee considers this needs to be addressed.

SRS� Report Summary: Wrasse/lumpsucker fishery

The harvesting of wrasse and lumpsucker for use as lice cleaners, could harm the wild populations of these fish

Diagnosis

251. *There is increasing use of small 'cleaner fish' in salmon farming. Kept in fish cages, where they eat sea lice growing on salmon, they provide an alternative to chemical treatments for lice. The fish used are wrasse (several species), and lumpsuckers. Although most wrasse can be reared in hatcheries, production is at present limited to the species most in demand (ballan wrasse), and is inadequate to meet that demand. An increasing wild fishery bridges the gap. Lumpsuckers are easier and cheaper to rear, and so there is less demand for wild-caught fish. Breeding stock is still obtained from a pre-existing commercial fishery. The (largely unregulated) wrasse fishery may be having direct and indirect effects on wild populations in the coastal waters of Scotland and the SW of England.*

Prognosis

252. *There seems to be a growing trend towards rearing lumpsuckers (which are adapted to cold waters) in preference to wrasse (which are fish of temperate and tropical waters). However, it is not clear whether wrasse can, or will, be completely replaced by hatchery-grown lumpsuckers. Increasing unregulated capture of wild wrasse for use as cleaner-fish associated with increasing production of salmon in Scotland, coupled with potential increasing demand for wrasse from Norway, could damage wild wrasse populations.*

Mitigation

253. *The industry is moving in the direction of growing cleaner-fish (both wrasse and lumpsucker) in hatcheries. If this can be achieved in Scotland by 2019 (as the industry has stated), the pressure on wild stocks will be reduced. An assessment is required of future demand for cleaner-fish and of the prospects of fully meeting the demand with hatchery reared wrasse or lumpsucker. Such an assessment would be a precursor to identifying whether there is a need to introduce management measures for wild fisheries, especially those for wrasse, if hatchery supply cannot meet industry demand.*

Additional Commentary

254. *The use of wrasse as cleaner-fish to remove sea lice in salmon farms dates back to the late 1980s. The main species used in Scottish, Irish and Norwegian farms are goldsinny, corkwing, rock cook and juvenile ballan wrasse. In SW England and some Scottish inshore fisheries, the fishing and export of live wild wrasse for use as cleaner fish is of commercial importance.*

Evidence

Use of wrasse and lumpsucker

255. The report says that wrasse and lumpsucker appear to provide an effective means to control lice infestations, or, at least, to reduce the frequency of chemical treatment of infected salmon. Official statistics report that 1,752,000 lumpsuckers and 1,000,000 wrasse were bought by the Scottish salmon farming industry in 2016.

256. In written evidence Marine Harvest state that the Review reports that in 2016 some 262,000 lumpsucker were reared. But in that year Marine Harvest reared close to 800,000 lumpsucker.

257. In oral evidence Professor Tett said “Information from the industry suggests that by 2019 it would like to be able to cultivate all the wrasse that it uses, but it is not clear whether that is an achievable target. If it is not achievable, clearly the demand for wild wrasse will continue. In that case, there will be a need for fisheries management of the wrasse fishery.”

Welfare Concerns

258. A number of submissions, including the submission from Onekind, raised welfare concerns in relation to the use of cleaner fish: harm caused as a result of interactions between wrasse and salmon; disease and parasite treatments impacting cleaner fish; cleaner fish spreading pathogens and parasites to salmon causing harm, and the slaughter (and disposal) of the cleaner fish at the end of the production cycle.

The need for additional regulation

259. Given the likely increase in the use of wrasse and lumpsucker as cleaner fish, the Committee questioned whether there is a need for additional regulation to deal with impacts on wild fisheries.

260. SE LINK advised the Committee that providing the number of wrasse or lumpsucker fish that are required to meet the demands of the industry will require a new form of aquaculture with related resources, food and pest management. In their written submission they suggest the use of wild-caught cleaner fish needs tighter control and a fisheries management plan for wrasse is required. There is also a question over what will be done with wrasse and lumpsuckers at the end of the production cycle.

261. In written evidence SNH expressed concern that the report is deficient in addressing the wider natural heritage issues relating to wrasse and lumpsucker fishery in terms of scope and the formal process/obligations (e.g. Habitat Regulations Assessment). SNH is strongly in favour of formal management measures being introduced to ensure the fishery is sustainable (including mitigating the potential impact on Natura features, the MPA network and relevant PMFs). SNH was of the view in order to progress this, spatial information on the location and intensity of fishing is required, at a scale that is relevant to the MPA network.

262. The Committee understands SEPA has no role in managing or regulating wrasse or lumpsuckers other than in relation to potential environmental impacts

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through use of the species within caged fish farming. SEPA provided no comment on the need for further regulation.

263. The Committee heard that Marine Scotland is in discussion with stakeholders and fishermen as to what management needs to be put in place before the beginning of the 2018 fishing season.

View of the Committee

264. The Committee is of the view that wrasse and lumpsucker appear to provide an effective means to control lice infestations, or, at least, to reduce the frequency of chemical treatment of infected salmon. However the Committee remains unclear as to how they are being used in practice as lice are still a problem.

265. The Committee is aware that significant numbers of fish are bought by the Scottish salmon farming industry, demand outstrips the supply of farmed cleaner fish and the future demand for cleaner fish is likely to increase with the expansion of the sector. It is unclear as to whether the industry will be able to achieve its target of cultivating all the wrasse that it uses by 2019.

266. The Committee considers there is an urgent need for an assessment of future demand for cleaner fish and the likelihood of the industry fully meeting that demand. That assessment needs to take full account of all associated environmental implications of the farming and use of cleaner fish in their own right (including what happens at the end of the production cycle).

267. The Committee is concerned about the increased unregulated capture of wild wrasse and is of the view that in order to ensure that the use of cleaner fish to control lice in the Scottish salmon farming industry is sustainable there is a requirement for additional regulation.

268. The Committee supports SNH's view that formal (rather than voluntary) management measures need to be introduced to ensure the fishery is sustainable (including mitigating the potential impact on Natura features, the MPA network and relevant PMF's) and a fisheries management plan for wrasse is required.

269. The Committee also supports SNH's position that to progress this spatial information on the location and intensity of fishing is required at a scale relevant to the MPA network. The Committee would welcome further information on the wrasse wild fishery in Scotland.

SRSL Report Summary: Recirculating Aquaculture Systems (RAS)

270. The report discusses Recirculating Aquaculture Systems (RAS) as a way of mitigating many of the environmental impacts from salmon farming. The report states by isolating fish from the natural environment RAS provide security from diseases, infestations and predators, in addition to eliminating potential risks to wild salmon. By retaining wastes, they prevent organic and nutrient impacts on the environment. However, the capital costs of establishing RAS units are high, the energy costs for

pumping and treating large amounts of water must be factored in, and 100% removal of waste from effluent water is infeasible. RAS waste streams will therefore continue to make demands on environmental assimilative capacity, albeit significantly lower per unit production than open pen cage systems. Freshwater RAS are coming into use as hatcheries, and salt-water RAS might be used to on-grow smolts in order to reduce time spent in net-pens, potentially allowing increased output from cage systems. However, the report states “the technology required is still being refined and it seems likely that net-pen farming will continue as the dominant mode of production for at least the next decade.”

Evidence

Industry view

271. In their written submission the SSPO highlighted “significant” challenges with scaling technology and state no commercial scale RAS system for the seawater production of salmon has, to date, been commercially successful. The Committee heard from the SSPO that in the future the industry will move towards recirculating aquaculture systems and systems that control smolt production in a different way but heard the industry will do that as well as continuing to do what it currently does. The SSPO raised concerns about the carbon and physical footprint of land-based recirculating aquaculture systems.

Planning Issues

272. Highland Council also suggested land-based containment raises planning problems as it is land hungry and the installations can be large. They said planning authorities could not guarantee they would immediately be able to identify a sufficient number of sites.

Support for RAS

273. Much of the evidence commented on the potential of RAS. S&TCS believe the only long-term sustainable future for Scottish salmon farming is to grow salmon in full closed containment, with 'biological separation' of wild and farmed fish, for the whole cycle. They suggested a positive approach to the adoption of RAS technology is needed and moving to full closed containment of farmed salmon production as soon as is practical. This view was shared by many contributors.

274. FMS considered that RAS or closed containment, have a significant role to play in the future of the Scottish salmon farming industry but recognise that the technology is not currently ready to roll out in Scotland. They supported the use of incentives to facilitate the development of such technology in Scotland. Jon Gibb, (Fishery Manager River Lochy, Fort William – Clerk/Director of the Lochaber District Salmon Fishery Board) said – “Bigger offshore farms and incentivisation to develop new RAS and enclosed seawater systems would satisfy the industry expansion targets and also provide significant protection to wild salmon runs.” The Atlantic Salmon Trust (AST) believed that RAS requires, and should receive, far greater support and encouragement from Government, not least during a transition period from traditional open cage farming practices.

275. The Scottish Salmon Think Tank stated closed containment should be the overriding aim of the Scottish Government for the development of salmon aquaculture in

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Scotland and suggested the Scottish Government should actively investigate RAS technologies and undertake a full cost benefit analysis with a tax being applied to the industry to promote the development of RAS. They also suggested a moratorium on further marine aquaculture development until there is a consensus on the way forward. SE LINK suggested closed-containment technology has huge potential for alleviating a number of the problems but stated there are other environmental concerns in its use. They support a clear cost benefit analysis is to compare the two different approaches. The SSPO concurred with the need for such an analysis.

Examples of RAS developments

276. Evidence to the Committee highlighted plans of a Norwegian aquaculture company to build one of the world's largest land based salmon farms in the United States. Once at capacity this should produce 20% of the current output in tonnes of the Scottish sector. The Committee also understands that incentives are being provided by the Norwegian Government for their salmon farming industry to develop RAS technology.

Research and other technologies

277. The Committee heard SEPA is looking at the increase in the carbon footprint as a result of moving to closed containment in the onshore rearing of fish set against the environmental benefits of that approach and is assessing these new technologies.

278. The Committee is aware of other technologies and their application in reducing the environmental impact of the sector. SE LINK and SEPA referenced approaches in Tasmania where a funnel is used underneath salmon farms. This catches 60 to 70 per cent of the waste. It is then funnelled out, part of it is converted into fertiliser, and the rest is treated.

279. There has also been some early research on the use of hatchery waste. SEPA has been involved in a project with industry and other partners to identify suitable and sustainable uses of such waste, and one element that will be considered is the detritus that falls from the bottom of the cages. SEPA referred to a range of different products being trialled globally, and advised there have been discussions in Scotland about their use. SEPA stressed the need for flexibility and different solutions for different locations.

View of the Committee

280. While RAS offers an attractive solution in terms of addressing a number of the concerns in relation to impacts on the marine environment and wild fisheries set out in the report, there are concerns in relation to the development of the technology, wider environmental impacts (related primarily to energy consumption, visual impact and availability of suitable sites) and cost.

281. As a matter of urgency the Committee would like to see independent research commissioned including a full cost-benefit analysis of RAS with a comparative analysis with the sector as it currently operates in Scotland. While independent of the industry, Government and Government agencies, the research should be substantially funded by the industry. The Committee would also like to see the Government and industry fully explore the potential of closed containment.

282. Further investment in research into the use of alternative technologies and their application, such as those in use in Tasmania, is also urgently required.

283. The Committee would also like to see the Scottish Government consider the potential of levies and incentives for investment in research and development in the use of RAS and alternative technologies for the Scottish salmon farming industry.

SRS� Report Summary: Adaptive Management

284. *Adaptive management is another mitigation approach that is discussed in the report. It is recommended by the FAO as part of the Ecosystem Approach to Aquaculture and it is defined in the report as "the incorporation of a formal learning process into management actions ... [i.e.] the integration of planning, implementation, monitoring and evaluation to provide a framework to systematically test assumptions, promote learning, and provide timely information for management decisions"*

285. *The report states that adaptive management already takes place to some extent at farms and within interactions between farms and regulators. However, there is a deficiency of integration. Monitoring, for example, is used to check observance of EQS or other CAR stipulations. However, beyond this it appears that monitoring data are not designed to feed into a learning process at farm or industry level, or to help distinguish whether changes in Scotland's marine ecosystems result from salmon farming or are due to other causes. The report states "Care must however be taken to ensure that co-operation between industry and regulators is not seen collusion, leading to public distrust of the latter."*

286. *The report also states that at the national level, adaptive management of the salmon farming industry will require an enhanced approach to research, in which farmers, regulators, citizens and scientists work together to co-produce knowledge that can guide operational and planning decisions.*

Evidence

287. In oral evidence, Professor Verspoor said "Adaptive management is essentially evidence-based management being done in an adaptive way. As evidence accumulates, management gets better because it is based on that expanding body of information and understanding of the system." Professor Owens said that adaptive management might involve real-time data and communities in order to minimise conflicts.

288. Overall there was broad support for the concept and application of adaptive management. SNH highlighted existing examples, such as the use of Environmental Management Plans as a response to issues with sea lice/wild salmonid interaction and ADDs and cetaceans. FMS considered it to be a "key component of the changes that we wish to see to the planning and regulatory regime in Scotland." FMS highlighted the potential benefits to wild fish of Aquaculture Stewardship Council certification and stated "we see such adaptive management mechanisms as the only means, short of if action is not demonstrated to be full closed containment, through which the salmon farming industry can demonstrate environmental sustainability." This was also supported by Argyll and Bute Council who suggested adaptive

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management should further mitigate potential environmental impacts, allow salmon farming to adapt to environmental changes and allow the regulatory system to adapt to innovation and new farming practices.

289. The Atlantic Salmon Trust (AST) support the principle of adaptive management but recognise it has potential pitfalls. It suggested “the approach proposed by the report will require more detail on how it would be applied in practice, how it would operate, what methods would be applied, what teeth it would have, what investment would be required for its implementation, what standards would be applied, and whether it would form part of a regulatory framework. - We believe there must be an appropriate regulatory framework by which to implement and underpin an adaptive management process.”

290. The Lochaber Fisheries Trust suggested adaptive management is a pragmatic middle ground until closed containment is adopted but stress the need for effective implementation referencing the two examples of adaptive management of wild fish impacts through EMPs that have failed to deliver “due to poorly designed monitoring programmes, ill-defined trigger thresholds and management actions and a failure to enforce agreements on the part of the planning authority”.

291. SNH stated “Crucially, these approaches require a clear link from monitoring results through to management measures, backed up by robust sanctions if action is not demonstrated to be effective”. This was endorsed by the Marine Conservation Society which expressed concerns about the emphasis on adaptive management as a mitigation tool. They stated “For adaptive management to be successful data collection needs to be implemented and the results analysed. These results then need to be presented to decision makers and acted upon. Therefore it is imperative that comprehensive monitoring and data collection needs to take place consistently, comprehensively and without bias”.

292. The Committee understands Iceland has developed an adaptive management model, however, further information on this was not available to the Committee within the timeframe of the inquiry.

View of the Committee

293. While the Committee heard from the sector and others that adaptive management is happening now it is unsure as to the extent of this and whether this is being undertaken in a systematic, independent and structured way.

294. Adaptive management which takes account of the precautionary principle, (using real-time, farm by farm data) could have the potential to reduce environmental impacts but additional detail is needed on how it would be applied in practice: how it would operate; what methods would be used; what standards would be applied; whether it would form part of a regulatory framework; what the role of the regulator would be; what data collection, monitoring and enforcement regime would be in place; what investment would be required for its implementation, and; how this would be funded. The Committee would welcome further exploration of this within the wider REC Committee inquiry.

Regulation and the regulatory process

295. In their written submission the Scottish Salmon Producers Organisation (SSPO) stated the consenting regime for Scottish aquaculture will be the over-riding factor that determines sustainable growth of the sector into the future. The SSPO also expressed concern that the report did not provide information on the regulatory framework relating to salmon farming in Scotland.

Biodiversity Duty and the Precautionary Principle

296. Under the Nature Conservation (Scotland) Act (2004), all public bodies in Scotland are required to further the conservation of biodiversity when carrying out their responsibilities. The Committee received evidence, including from FMS highlighting the precautionary principle as a key component of EU Environmental legislation and stating a greater degree of regulation is required to provide assurance that the aquaculture industry can operate in a truly environmentally sustainable manner. Written evidence from Highland Council questioned the increasing growth targets for the farmed salmon industry stating: “this appears to be based on a complete lack of any Sustainability Appraisal, as would be expected for such a topic given the significant environmental concerns. It seems to be accepted without any consideration of the impacts...The government should therefore undertake a SA before committing that support”.

The Planning System

297. Evidence from FMS states “The regulatory system for the salmon farming industry is unusual in that there is no formal requirement for pre-application or post-consent monitoring of wild fish. This is not the case with terrestrial wind farms, marine renewable development, hydro schemes, or a range of other developments.” Highland Council confirmed as a planning authority there is a need for ongoing post-consent monitoring as fish farms are active and planning permissions are permanent.

298. Providing oral evidence to the Committee John Aitcheson highlighted concerns with the planning process, suggesting planning authorities receive inadequate data from Marine Scotland as it does not give advice on the population impacts of fish farms. He identified concerns in the data available to councils on the location of sensitive sites, migration routes and farm-by-farm data. He also expressed concern about the inability of the planning process to look beyond individual farms and consider the cumulative effect of fish farms and raised concerns about the ability of councils to adequately monitor fish farms and enforce conditions.

299. SNH said “it is important to be able to demonstrate that the potential impacts of elevated sea lice burdens on wild salmonids are effectively managed through the aquaculture consenting process, particularly in relation to European sites. In our recent casework advice to Local Authorities, we have been seeking to address these issues through the use of Environmental Management Plans, linked to conditions on effective monitoring and management. However, there are concerns that the planning system is not the appropriate place to regulate for sea lice and wild salmonid issues. Further exploration of whether these issues could be better regulated through marine licensing (with the Fish Health Inspectorate able to provide technical input on sea lice control) would be useful.”

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300. Argyll and Bute Council also questioned the appropriateness of the planning system stating “responsibility for wild fish interactions has been inappropriately allocated to Planning Authorities, who given their reactive role, are not in my opinion the best placed regulator to address this issue on a comprehensive basis, taking into account cumulative effects.” They also considered EMP’s to be inappropriate to provide an area wide response to the overall impact of sea lice. They stated “EMP’s are resorted to by Planning Authorities given the lack of an overall area based approach to wild fish interests founded around cumulative impacts. They are only capable of providing a somewhat random and ad hoc response to an issue which is ongoing, regardless of the incidence of planning applications. Accordingly, we have situations where a loch with no applications holding many thousands of tonnes of biomass may not be subject to any ongoing consideration of wild fish interactions, whereas another loch with an application for an extension of a few hundred tonnes may prompt the requirement for an EMP and the potential need to address cumulation with other sites. They are in effect a sticking plaster, not a systematic means of assuring well-being in the wider environment.” They suggested monitoring the impact of sea lice from multiple sources upon a given water body would be best addressed routinely on an area wide basis (by Marine Scotland with input from SNH and the DSFB’s) taking into account all existing development, and operating experience.

301. Responding to questioning on the regulation of the sector Mark Harvey of Highland Council said the use of environmental management plans, embedded as conditions in planning permissions provide a method of engaging with the industry over time. In his view this effectively amounted to a monitoring condition. He also stated that from the point of view of a planning authority the regulations are quite frustrating “we do not feel able to come up with very clear answers or recommendations for our committees...As a consequence, the environmental management plan takes a slightly soft-edged approach to monitoring instead of the more hard-edged approach that we probably apply in other areas of our work.”

302. The Committee is aware of the recommendation of the aquaculture consenting review that the consideration of potential wild salmonid impacts be removed from planning and instead be considered in a separate and more appropriate regulatory process.

303. Argyll and Bute Council supported the recommendation to explore removing the consideration of potential wild salmonid impacts from planning – “the consenting review offers opportunities to change the way some environmental impacts are regulated by considering the best process which can most effectively assess the level of risk to the environment but also monitor impacts, review, change management and where appropriate take enforcement action throughout the operational life of the development”.

SEPA and the consenting regime

304. Discussing regulation with SEPA, Anne Anderson said the environmental quality standards that SEPA set in the CAR consenting regime offer protection out-with the zone of impact, and they relate both to organic and to chemical loads. She confirmed that monitoring is largely done by the operators, and SEPA undertakes a

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compliance and auditing monitoring programme, undertaking sampling and analysis in respect of compliance and audit checks.

305. FMS confirmed when consenting biomass SEPA does not consider the impact of sea lice from that biomass on wild fish. “We consider that the biomass of farmed fish within a production area is a crucial factor determining the extent of any impacts on wild fish. The potential impacts of sea lice arising from farmed fish are a function both of the number of farmed fish within an area and the number of lice per fish.”

Monitoring and Reporting

306. The Committee asked for SEPA's view of gaps in regulation e.g. in relation to the protection of wild fish. SEPA said the Water Framework Directive requires SEPA to report on the status of wild fish in freshwaters. Where populations are found to be failing to reach good status, pressures have to be identified to explain this, and measures identified to deal with these and restore systems to the required standard. This requirement does not extend into the marine environment. SEPA suggested a good example of a possible approach which could be adopted is in line with the developing Aquaculture Stewardship Council standards, which include detailed proposals to monitor and manage sea lice, escapees and introgression rates.

307. The Committee asked SEPA, to what extent it undertakes independent monitoring and analysis, rather than relying on information provided by the sector. It also asked what additional resource is planned as a result of DZR. Some general information was provided but this was lacking in detail and it appears to the Committee that SEPA is heavily reliant on information provided by the sector and there is little independent monitoring and analysis.

View of the Committee

Biodiversity Duty and the Precautionary Principle

308. The Committee is deeply concerned that the development and growth of the sector is taking place without a full understanding of the environmental impacts. The Committee considers an independent assessment of the environmental sustainability of the predicted growth of the sector is necessary.

309. The Committee is unclear if, in practice, all public bodies involved in the regulation of salmon farming have the biodiversity duty to the fore. The Committee is not convinced that the precautionary principle underpins the development and expansion of the sector.

Appropriateness of the current regulatory system

310. The Committee is not convinced the sector is being regulated sufficiently or regulated sufficiently effectively. The Committee is also concerned that the engagement and interaction of the relevant agencies is not as effective in the protection of the environment as it could be. There are too many regulators and too little effective regulation.

Local Authorities and the Planning Framework

311. The Committee considers the current regulatory process does not give sufficient consideration to the impact of salmon farming on wild salmonoids. There

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should be a formal requirement for pre-application and post-consent monitoring of wild fish.

312. The Committee is aware of the proposal to remove consideration of potential wild salmonid impacts from the planning system. It is not clear to the Committee what that separate and “more appropriate” regulatory process is, how that would engage with the planning process and how communities and interested individuals and groups could engage in this process. The Committee believes further information on this is required and has written to Marine Scotland.

313. The Committee was concerned to hear councils saying an environmental management plan is only capable of a random and ad hoc response, it can only relate to specific measures on that farm site and cannot affect the management of other sites in the same farm management area. The Committee considers cumulative effects must be taken into consideration and further investigation into current regulatory and planning practice is required to ensure the system can provide an overall area based approach to wild fish interests founded around cumulative impacts.

SEPA

314. The Committee is not convinced SEPA (or any other agency) is effectively monitoring the environmental impact of salmon fisheries. The Committee is also not convinced that the regulations, protocols and options for enforcement and prosecution for the sector are appropriate, and being appropriately deployed. The Committee understands that the industry and the regulators need to share information. The Committee is concerned that there is an over-reliance on data provided by the sector and insufficient independent monitoring and analysis by SEPA.

315. The Committee is keen to understand the resource SEPA is currently allocating to monitoring and reporting on the sector and what change in resource is planned as a result of the planned introduction of DZR and the expansion of the sector. The Committee has written to SEPA on this.

Marine Scotland Licencing

316. It is not clear to the Committee how, in practice, Marine Scotland Licencing interacts with the statutory consultees (SEPA, SNH, FMS and DSFB) in decisions to grant licences and how it takes account of their representations. The Committee is unclear if, and how often, decisions to grant licences, contrary to the advice of these agencies, are taken. Appropriate consideration of these issues requires to be informed by further information and the Committee has written to Marine Scotland on this.

317. It is not clear to the Committee what triggers intervention from Marine Scotland Licencing in the operation of a fish farm and what and how information flows influence a decision to undertake an investigation. The Committee would welcome further information on this and on decisions taken to revoke licences based on environmental concerns. The Committee is also keen to understand why licences are not granted for a time limited period with fixed conditions. The Committee has written to Marine Scotland on this.

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318. The Committee questions whether Marine Scotland Licencing, or any of the existing agencies, currently have the capacity, expertise, or access to the necessary data to undertake full consideration of potential wild salmonid impacts as part of the planning and consenting system. The Committee has written to Marine Scotland on this.

Marine Scotland Fish Health Inspectorate

319. The Committee is concerned to hear that planning authorities often fail to receive clear advice from the Fish Health inspectorate on applications and their potential impact on wild fish health and wild fish stocks. The Committee would be interested to explore this further to understand the barriers to providing clear direction.

320. The Committee expressed concern earlier in this report that the focus of Marine Scotland is the health of the farmed salmon. The Committee considers that an agency should be charged with the health and welfare of wild salmon and trout.

Crown Estate Scotland

321. The Committee is keen to understand the justification for granting leases in perpetuity and why they are not granted for a limited time period with fixed conditions. The Committee intends to explore the issue of limited time licences with Crown Estate Scotland in its consideration of the Scottish Crown Estate Bill.

Research

322. Issues in relation to the adequacy of the available knowledge base, data and research arose in respect of every environmental concern identified in the SRSL report. The Committee understands there are significant knowledge gaps that require to be addressed and was keen to understand how the industry was contributing to the research needs in the Scottish context. The SSPO provided additional information to the Committee on this.

Engagement of the industry in research

323. The Committee asked for further information from the SSPO on the way in which the sector contributes to the science. The SSPO provided supplementary evidence indicating it does so through academic research, direct financial support, through in-kind support via the provision of personnel, equipment and relevant farm services. It referenced applied academic research into the production and use of cleaner fish and the development and optimisation of physical removal technologies. It highlighted collaborative work and links between Scottish farming companies, and those operating in other farming nations.

324. The Committee asked what specific financial contribution to science has been undertaken by the sector in Scotland in relation to the Scottish industry. The SSPO stated providing an accurate figure for the investment made by our sector is highly challenging because of the way national and international funding initiatives are managed and rolled out. They also said a great deal of research and development activity is conducted “in house” and as part of best farming practice. Over the last 5-10 years: “Current industry wide funding for defined projects equates to approximately £6.7 million per annum. Current industry investment in R&D is

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estimated to be £56-61 million per annum.” It appeared to the Committee, from the information provided, that the larger figure relates to the wider industry and to research in other countries.

Engagement of the agencies in research

325. The Committee asked SEPA what work (including research) SEPA is engaged with, looking at solutions to the environmental issues of fish farming and alternative approaches. SEPA provided no specific detail to the Committee simply referring to the Finfish Sectoral Development Plan. From the information available to the Committee it appears that other than SEPA’s engagement with the work of SARF on closed containment production the Committee must conclude that little proactive work is being done by SEPA to look at solutions and alternative approaches. The Committee would also be interested to understand what related research Marine Scotland Science is engaged in.

View of the Committee

326. There is a growing body of evidence of salmon farming’s impact on the environment, however, gaps in data, monitoring and research remain. The data that is available often stems from in-house studies and studies carried out in sea lochs which may not translate when used to assess or model the impact salmon farms have on inshore areas or in the open sea.

327. This research is fundamental to understand, manage and ameliorate the impacts of salmon farming on the environment, especially in light of the planned expansion of the sector. We need more investment in science and independent and independently verified research and the industry should be largely funding this.

328. There are knowledge gaps in:

- wild fish populations and likely migration routes and the number of smolts leaving individual sites
- population level effects of sea lice on wild salmonoids
- the risk of disease transfer between wild and farmed populations in Scotland
- impacts of sea lice treatments – long term and low level on the benthic diversity and vulnerable species such as cetaceans
- science based trigger levels for sea lice treatment
- diffuse far field effects of chemicals on the benthic and pelagic ecosystem components and cumulative impacts
- the environmental impacts on freshwater lochs
- monitoring of long term protected species
- the extent of genetic mixing between escaped farmed and wild salmonoids (including deliberate releases)
- the impact of wrasse fisheries on wild populations
- the application of new and emerging technological solutions including RAS
- the impact of climate change

Additional Environmental Issues

329. The Committee is aware there are environmental impacts that the report did not address. A number of submissions to the Committee highlight additional issues and these are summarised below:

Wild Fish

330. Jon Gibb, (Fishery Manager River Lochy, Fort William – Clerk/Director of the Lochaber District Salmon Fishery Board) suggests there are two impacts that have not been listed – salmon farms interruption of the pheromone scent that wild fish use to get to spawning grounds, and the creation of an increased food source, delaying sea trout in their migration and impacting historic salmon spawning tributaries. Evidence from SNH, SE LINK and others suggest the report does not adequately address the impacts of sea lice on sea trout. Evidence from Dr. Jaffa indicates a decline in the number of sea trout caught since 1952 but a slowing in the rate of decline in catch in recent years

Freshwater ecosystems

331. The Atlantic Salmon Trust (AST) considers the report largely neglects impacts in freshwater ecosystems through salmon smolt production intended for coastal aquaculture. In particular they suggest cage farming of fin-fish, particularly in freshwater lochs, has the potential to generate significant amounts of organic waste which can result in alterations to the fish population structure.

Marine Protected Areas and Priority Marine Features

332. SE LINK and others suggest the report does very little to address the current and potential impacts on marine protected areas, particularly the network of nature conservation MPA's. In oral evidence Dr. Collin stressed this something that requires investigation, "particularly in light of the fact that the majority of predicted salmon farming growth will impact inshore nature conservation MPA's, many of which have protected features that are at direct risk from aquaculture activity." In their written submission SE LINK highlight "significant shortcomings" in the information covered by the review particularly in relation to the impacts on Priority Marine Features and Marine Protected Areas.

Sea bed communities

333. The National Trust for Scotland (NTS) expressed concern that the report did not include assessment of previous sea bed communities in the discussion of environmental impact. Their evidence highlights several seabed habitats characterised by extremely long lived species and lengthy recovery times.

Landscape and Visual Impacts

334. SNH said it would have liked the report to include landscape and visual impacts, "which are an important part of the Environmental Impact Assessment process." SNH consider this to be a significant omission. Other evidence raised concerns about the visual impact and related consequences for tourism and related businesses.

Birds

335. In relation to birds, SNH is concerned that section 7 of the report does not mention the risks associated with aquaculture-related disturbance which may lead to displacement of birds (especially those species that are sensitive to boat traffic) from regular feeding or resting areas. SNH stated “This would be expected to increase adverse impacts on the birds through negative energy budgets, but it is an area where data is lacking so requires further investigation, particularly within relevant SPA’s.”

Marine Debris

336. Whale and Dolphin Conservation suggested the impact of marine debris from salmon farming is not well known and needs investigation. This was highlighted in other submissions.

Operational and logistical environmental impacts

337. In written evidence, Corin Smith said the report does not consider operational and logistical environmental impacts including: the use of HGVs and wellboats; large numbers of journeys for fish removals, feed transportation and mortalities; the effects of air pollution (carbon, nitrogen and particulate emissions; grey water; black water; accidental fuel and biological material spills and litter on beaches. She expressed concern that the impact on freshwater lochs and downstream/supply chain activities were also excluded.

Climate Change and aquaculture

338. The Lochaber Fisheries Trust suggested more consideration needs to be given to the potential effect that climate change could have on the environmental impacts of aquaculture, with rising temperatures and the emergence of new diseases.

Other Issues

Current farming practice

339. The SSPO expressed concern that the report did not provide information on current farming best practice. This was out-with the scope of the research.

The role of third party standards

340. The SSPO referenced the role of third party standards with regard to environmental protection, stating “We believe that such standards are a key link between producers, retailers and consumers and as such have a considerable role in supporting and driving forward improvements in many aspects of salmon farming, including environmental performance.”

Suitable zones for new development

341. Argyll and Bute Council stated it is very difficult to identify suitable zones for new development which are based on all of the relevant environmental, social and economic criteria considered when determining regulatory consents.

Animal welfare

342. Many submissions, including Compassion in World Farming, highlighted the need to consider the impact of sea lice mitigation strategies on animal welfare.

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Concern was also expressed in relation to welfare implications of farming salmon in deep, exposed waters.

Employment and tourism

343. Many submissions highlighted the negative impact of the salmon farming industry on employment and tourism. The Committee understands the REC Committee will be considering these issues in its wider inquiry.

Conclusions

344. It is clear to the Committee that the same set of concerns regarding the environmental impact of salmon farming exist now as in 2002 but the scale and impact of these has expanded since 2002. There has been a lack of progress in tackling many of the key issues previously identified and unacceptable levels of mortality persist.

345. Over that period there appears to have been too little focus on the application of the precautionary principle in the development and expansion of the sector.

346. Scotland is at a critical point in considering how salmon farming develops in a sustainable way in relation to the environment. The planned expansion of the industry over the next 10-15 years will place huge pressures on the environment. Industry growth targets of 300,000 - 400,000 tonnes by 2030 do not take into account the capacity of the environment to farm that quantity of salmon. If the current issues are not addressed this expansion will be unsustainable and may cause irrecoverable damage to the environment.

347. The Committee is deeply concerned that the development and growth of the sector is taking place without a full understanding of the environmental impacts. The Committee considers an independent assessment of the environmental sustainability of the predicted growth of the sector is necessary.

348. There are significant gaps in knowledge, data, monitoring and research around the adverse risk the sector poses to ecosystem functions, their resilience and the supply of ecosystem services. Further information is necessary in order to set realistic targets for the industry that fall within environmental limits. There should be a requirement for the industry to fund the independent and independently verified research and development needed.

349. The role, responsibilities and interaction of agencies requires review and agencies need to be appropriately funded and resourced to fully meet their environmental duties and obligations. Scotland's public bodies have a duty to protect biodiversity and this must be to the fore when considering the expansion of the sector. We need to progress on the basis of the precautionary principle and agencies need to work together more effectively.

350. There need to be changes to current farming practice. The industry needs to demonstrate it can effectively manage and mitigate its impacts.

351. Scotland needs an ecosystems-based approach to planning the industry's growth and development in both the marine and freshwater environment, identifying

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where salmon farming can take place and what the carrying capacity of that environment is. A cohesive framework is needed.

352. As a matter of urgency, the Committee wishes to see independent research commissioned, including a full cost-benefit analysis of Recirculating Aquaculture Systems (RAS), and a comparative analysis with the sector as it currently operates in Scotland, alongside further development and implementation of alternative technical solutions, supported by the use of incentives.

353. Adaptive management which takes account of the precautionary principle, (using real-time, farm by farm data) could have the potential to reduce environmental impacts but additional detail is needed on how it would be applied in practice.

354. The Committee is supportive of aquaculture, but further development and expansion must be on the basis of a precautionary approach and must be based on resolving the environmental problems. **The status quo is not an option.**

355. The current consenting and regulatory framework, including the approach to sanctions and enforcement, is inadequate to address the environmental issues. The Committee is not convinced the sector is being regulated sufficiently, or regulated sufficiently effectively. This needs to be addressed urgently because further expansion must be on an environmentally sustainable basis.

GLOSSARY

Adaptive Management: A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.

Alga (plural, Algae): The earliest forms of plant life to have evolved on our planet are Cyanobacteria, once called 'blue-green algae' but now distinguished from other aquatic photosynthesisers because their cells contain no nucleus. An Alga is any simple photosynthetic organism with cells containing nuclei and Chloroplasts (the organelles of photosynthesis). Many are single-celled (and referred to as Micro-Algae), others are multicellular: these are the Macro-Algae, commonly known as brown, red and green seaweeds. 'Higher plants' evolved from green algae that adapted to conditions on land, although some re-adapted to aquatic conditions as sea-grass. The term Macrophyte includes both higher plants and seaweeds.

Allowable Zone of Effect (AZE): Spatial area around a fish farm defined by SEPA Regulation; AZEs are defined as *"the area (or volume) of sea bed or receiving water in which SEPA will allow some exceedance of a relevant Environmental Quality Standard (EQS)."* SEPA, 2005.

Anaerobic, Anoxic, Hypoxic: Most animals have a predominantly aerobic metabolism, which means that they require oxygen. A Hypoxic environment contains too little oxygen to support normal metabolism; an Anoxic environment contains no free oxygen. Only organisms with an Anaerobic metabolism can live under these conditions. Whereas aerobic metabolism typically uses oxygen to 'burn' carbohydrate, producing energy, carbon dioxide and water, anaerobic metabolism uses, for example, sulphate instead of oxygen and produces toxic hydrogen sulphide instead of water.

Anadromous: Anadromous fish migrate from the sea into fresh water bodies to spawn.

Anoxia: Areas of sea water, fresh water, or groundwater that are depleted of dissolved oxygen and are a more severe condition of hypoxia.

Amnesic Shellfish Poisoning (ASP): Illness caused by consumption of the marine biotoxin called domoic acid, which is produced naturally by marine diatoms. When accumulated in high concentrations by shellfish during filter feeding, domoic acid can then be passed on to birds, marine mammals and humans via consumption of the contaminated shellfish. In mammals, including humans, domoic acid acts as a neurotoxin, causing permanent short-term memory loss, brain damage, and death in severe cases

Assimilative Capacity: *"...the ability of the ecosystem in a water body to absorb anthropogenic inputs of substances without damaging the health of the ecosystem or its ability to provide goods and services."* (Tett *et al.*, 2011a) The Health of a marine ecosystem is societally defined by concepts such as 'Good Ecological Status' according to the Water Framework Directive or 'Good Environmental Status'

according to the **Marine Strategy Framework Directive**: Ecosystem Services are *"'exports' from ecosystems to human economies that bring benefits to the people in these economies"* (Turner & Schafsma, 2014); examples are fish caught by a fishery, coastal protection by a salt marsh or seagrass meadow, and assimilative capacity itself.

Balance of Organisms: A state of dynamic equilibrium within a community of organisms in which genetic, species and ecosystem diversity remain relatively stable, subject to gradual changes through natural succession

Basin: A drainage basin or 'catchment area' is any area of land where rainfall collects and drains off into a common outlet, such as into a river, bay, loch or other body of water.

Benthos, Benthic: The Benthos (adjective: Benthic) is the biotic community living on or in the seabed; it includes many burrowing or tube living animals (bivalves, worms, prawns, brittlestars, etc.) plus smaller worms and crustaceans that live in the spaces between sediment particles, and protozoa and bacteria. Phyto**benthos** includes seaweeds and seagrasses which produce organic matter by photosynthesis, but they can only live where sufficient light reaches the sea-floor, and most of the food of the benthos is that produced by phytoplankton and arrives in the form of sinking matter: dead or dying phytoplankton, or the faeces of animals that have fed on phytoplankton.

Bioturbation: The disturbance of sediment layers by biological activity i.e. animals burrowing, crawling through the sediment etc.

Chalimus: Stage of the sea lice life cycle where the parasite, once attached to a suitable host feed for a period of time prior to moulting to the chalimus I stage. Sea lice continue their development through 3 additional chalimus stages each separated by a moult. A characteristic feature of all 4 chalimus stages is that they are physically attached to the host.

Chlorophyll: Refers to any of several related green pigments found in cyanobacteria and the chloroplasts of algae and plants. Chlorophyll is essential in photosynthesis, allowing plants to absorb energy from light.

Copepods: Group of small crustaceans found in the sea and nearly every freshwater habitat.

Cyanobacteria: Formerly called 'blue-green algae': see Alga

DAIN, DIN, DON: DAIN stands for 'Dissolved Available Inorganic Nitrogen', including ammonium and nitrate; these are more commonly aggregated as 'Dissolved Inorganic Nitrogen', DIN; however, the greatest amounts of nitrogen in seawater are as dissolved nitrogen gas, which is inorganic but not directly available to most micro-algae; DON stands for 'Dissolved organic Nitrogen', including urea, amino acids, and similar organic compounds.

DAIP: Stands for 'Dissolved Available Inorganic Phosphorus'; which is mainly phosphate; the acronym is perhaps not needed, as there is no free unavailable form of inorganic phosphorus (unlike nitrogen)

Deoxygenation: Chemical reaction where oxygen atoms are removed from a molecule.

Diatoms: Silicon-requiring micro-algae, with cells that often take pill-box or lozenge shapes with glassy (i.e. silica-strengthened) walls, often with spines and in many species forming short chains of cells; conventionally held to be the 'good' members of the phytoplankton, giving rise to the spring bloom and providing much of the primary production used by marine food webs; however they include the genus *Pseudo-nitzschia*, capable of causing Amnesic Shellfish Poisoning, and blooms of spiny diatoms have been linked to damage to the gills of farmed fish

Dinoflagellate: Dinoflagellates are a large group of flagellate dinoflagellate that constitute the phylum Dinoflagellata. Most are marine plankton but they are common in freshwater habitats, as well. Their populations are distributed depending on temperature, salinity or depth. Many dinoflagellates are known to be photosynthetic, but a large fraction of these are in fact mixotrophic, combining photosynthesis with ingestion of prey (phagotrophy).

Diarrhetic Shellfish Poisoning (DSP): Causative agent is okadaic acid, which is produced naturally by marine phytoplankton. The symptoms include intense diarrhoea and severe abdominal pains, with nausea and vomiting also sometimes occurring. DSP and its symptoms usually set in within about half an hour of ingesting infected shellfish, and last for about one day.

Ecosystem: Is a community of living organisms in conjunction with the non-living components of their environment (air, water and mineral soil), interacting as a system.

Ecosystem Functioning: A general term that includes stocks of materials (e.g., carbon, water, mineral nutrients) and rates of processes involving fluxes of energy and matter between trophic levels and the environment.

Ecosystem Resilience: Is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.

Ecosystem Services: Are the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems. Such ecosystems include, for example; agroecosystems, forest ecosystems, grassland ecosystems and aquatic ecosystems. Ecosystem services are defined into 4 categories, Provisioning services (e.g. food, resources); Regulating services (e.g. waste decomposition, water purification); Cultural services (e.g. ecotourism, historical) and supporting services which assist in the delivery of the other 3 categories.

Environmental Quality Standard (EQS): Is a value, generally defined by regulation, which specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water.

Epiphytes: An epiphyte is an organism that grows on the surface of a plant, and which derives nutrients from the surrounding environment.

Eutrophication: Defined by the Urban Waste Water Treatment Directive (91/271/EEC, article 2) as "*... the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned*". An expansion was drafted by a European expert group in 2009 (Ferreira *et al.*, 2011): "*Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services.*"

Flagellate: Refers to any single-celled organisms (not a bacterium) with the organ of motility called a flagellum, a long thin motile external process used to move the organism through water.

Food Conversion Ratio (FCR): Term used in animal husbandry; FCR is a ratio or rate measuring of the efficiency with which the bodies of livestock convert animal feed into the desired output.

Forage Fisheries: Fisheries where the target species are those which are the prey of the important commercial species. Although there are some directed fisheries for these species, for the most part they are too small or otherwise of no interest.

Fjords: Refer to the definition provided for sea-lochs.

Fucoid: Seaweeds include the brown wracks of the sea-shore

Good Environmental Status: The main goal of the EU Marine Directive is to achieve Good Environmental Status of marine waters by 2020. The Directive defines GES as "*The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive*". GES means that the different uses made of the marine resources are conducted at a sustainable level, ensuring their continuity for future generations. Annex I of the Directive set out 11 qualitative descriptors of what the environment will look like when GES has been achieved:

- Descriptor 1. Biodiversity is maintained
- Descriptor 2. Non-indigenous species do not adversely alter the ecosystem
- Descriptor 3. The population of commercial fish species is healthy

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- Descriptor 4. Elements of food webs ensure long-term abundance and reproduction
- Descriptor 5. Eutrophication is minimised
- Descriptor 6. The sea floor integrity ensures functioning of the ecosystem
- Descriptor 7. Permanent alteration of hydrographical conditions does not adversely affect the ecosystem
- Descriptor 8. Concentrations of contaminants give no effects
- Descriptor 9. Contaminants in seafood are below safe levels
- Descriptor 10. Marine litter does not cause harm
- Descriptor 11. Introduction of energy (including underwater noise) does not adversely affect the ecosystem

HA and HAB: stands for 'Harmful Algae' and Harmful Algal Blooms'. A rapid increase or accumulation in the population of algae in freshwater or marine water systems, which causes negative impacts to other organisms via production of natural toxins, mechanical damage to other organisms, or by other means. HABs are often associated with large-scale marine mortality events and have been associated with various types of shellfish poisonings (ASP, DSP, PSP).

Heterotrophic: Mode of nutrition in which organisms depends on other organisms to survive. All animals and non-green plants are heterotrophic. Heterotrophic organisms have to acquire and take in all the organic substances they need to survive.

Hypoxia: Deficiency in the amount of oxygen within the environment or within biological tissues.

Integrated Multitrophic Aquaculture (IMTA): Integrated Multi-Trophic Aquaculture, the synergistic growing of different kinds of cultivated organisms together. In the present case it describes systems in which seaweeds are grown in the same water-bodies as salmon-farms, to absorb some of the nutrients, and mussels or similar shellfish cultivated to remove some of the phytoplankton produced with these nutrients.

Lipid: Substance of biological origin that is soluble in non-polar solvents. It comprises of a group of molecules that include fats, waxes, and sterols amongst others. Although the term "lipid" is sometimes used as a synonym for fats, fats are a subgroup of lipids called triglycerides. Lipids also encompass molecules such as fatty acids and their derivatives. Although humans and other mammals use various biosynthetic pathways both to break down and to synthesize lipids, some essential lipids cannot be made this way and must be obtained from the diet.

Locational Guidelines: Introduced to facilitate the transfer of authorisation to permit marine fish farm developments from the Crown Estate (CEC) to Scottish local authorities following the announcement in 1997 that. The purpose of the Locational

Guidelines was to facilitate this transfer by providing guidance to local authorities, other regulatory bodies and the industry on the future location of marine fish farms.

Macrobenthic, Macrobenthos: Classification of marine benthic organisms defined by body size, visible to the naked eye. Depending on classification scheme, it may refer to all organisms larger to 1mm, or 0.5 mm.

Macrophyte: Translates as 'large plant'. It is used of aquatic photosynthetic organisms that are large enough to be seen with the naked eye. In the present case these are seaweeds (macro-algae) and sea-grasses. The former include brown, red and green algae, which are seen by taxonomists as different from each other as they are from Animals and Fungi. Sea-grasses are true plants: indeed they are monocotyledons, like terrestrial grasses, but within this category they are only distantly related to those grasses. Some call them eel-grass.

Marine Spatial Planning (MSP): Is a process that brings together multiple users of the ocean – including energy, industry, government, conservation and recreation – to make informed and coordinated decisions about how to use marine resources sustainably.

Maximum Residue Limit (MRL): The maximum concentration of residue accepted by the European Union (EU) in a food product obtained from an animal that has received a veterinary medicine or that has been exposed to a biocidal product for use in animal husbandry.

Mesozooplankton: Middle-sized animal Plankton.

Micro-algae: Single celled Algae,

Mixotroph (-ic, -y) or Myxotroph (-ic, -y): An organism that can use particulate or dissolved organic matter (POM or DOM) as a source of energy and nutrients, whilst retaining the ability to photosynthesise. In the case of marine pelagic mixotrophs the POM might be non-living, or in the form of bacteria or other algae or protozoa. A familiar example of a mixotroph is a sundew, a small plant growing in nutrient-poor boggy soils that trap insects as a source of nitrogen. Mixotrophic is the adjective, mixotrophy refers to the mode of nutrition. Given the derivation from (classical Greek), the terms are sometimes spelt myxotroph.

Morbidity: Refers to the condition of being diseased and the rate of disease in a population.

Nutrients: Defined by the Urban Waste Water Treatment Directive as "... especially compounds of nitrogen and/or phosphorus, [capable of] causing an accelerated growth of algae and higher forms of plant life"; the main compounds are dissolved and ionic, i.e. nitrate (NO_3^-), ammonium (NH_4^+) and phosphate (PO_4^{3-}). In solid form they correspond to compounds such as ammonium nitrate or calcium phosphate in artificial fertiliser. The elements nitrogen (N) and phosphorus (P) are essential components of living matter, but are often in short supply in the environment in forms that can be assimilated; it is because of this that their enrichment can stimulate plant

or algal growth. Aquatic ecosystems tend towards a ratio of 16 atoms of (available) nitrogen to one atom of (available) phosphorus; disturbances to this ratio may lead to disturbances to the 'balance of organisms' (Tett, Hydes & Sanders, 2003). The element silicon (Si), usually in the form of dissolved silica, is an essential nutrient for the growth of the type of phytoplankton called Diatoms, which use it to strengthen their cell walls, which are characteristic of temperate coastal seas during much of the year, and which provide much of the input to marine food webs. Increase in N relative to Si may stimulate other kinds of phytoplankton, with undesirable consequences for the food webs.

Oligotrophic: Refers to waters that are literally those poor in food for fish, people etc. The reason for this is great scarcity of nutrients for phytoplankton and their production of organic matter subsequently used in marine food webs.

OSPAR: The mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic; OSPAR is so named because of the original Oslo and Paris Conventions ("OS" for Oslo and "PAR" for Paris). It has for several decades co-ordinated member states in a 'Strategy to Combat Eutrophication' in the seas and coastal waters of N-W Europe.

Oxic: (of a process or environment) in which oxygen is involved or present.

Phytobenthos: The community of photosynthetic organisms living on the seabed, within the reach of light penetrating from the sea-surface. It includes seaweeds and seagrasses (see Macrophytes) and single-celled micro-algae.

Plankton, Phyto- and Zoo-: The (mostly small) 'plants' and 'animals' of the sea, found most abundantly in its illuminated upper waters and unable to swim against currents. Strictly, the term Plankton applies to the community of organisms, while Plankton denotes an individual or a species. The Phytoplankton consists of micro-algae such as diatoms and dinoflagellates and photosynthetic blue-green bacteria, all of which are functionally plants (in that they photosynthesise with the aid of the green pigment chlorophyll) but most of which unrelated to the taxonomic entity called 'Plants' which includes ferns, grasses and trees. The exceptions are green micro-algae, the group from which the land plants evolved, and the blue-green bacteria, which gave rise, through symbiosis, to the chloroplasts (containing chlorophyll) found in all algae and Plants. The Zooplankton are notionally animal, in the functional sense of being unable to photosynthesise, and some are taxonomically animal, in that they are multicellular creatures (from jellyfish to small crustaceans) with muscles and a nervous system. However, the functional grouping also includes many single-celled creatures, the Protozoa, which (it is becoming increasingly apparent) are often the main feeders on micro-algae. The term Mesozooplankton (middle-sized zooplankton) is used here to refer to the small animal section of the zooplankton, i.e. excluding both the smaller Protozoa and the larger jellyfish.

Phototrophic: Using light energy to obtain a source of organic carbon, usually from DIC, also DOC of photosynthesis

Phytoplankton: see Plankton.

Pressure: A result of a driver-initiated mechanism (human activity/natural process) causing an effect on any part of an ecosystem that may alter the environmental state.

Priority Marine Feature (PMF): A list of 81 marine features that represent habitats and species of conservation concern that are considered important components of the biodiversity of Scottish seas.

Protected Habitat: A habitat which is forbidden by law to harm or destroy.

Protected Species: A species of animal or plant which is forbidden by law to harm or destroy.

Protozoa: Biological classification of organisms; mostly used informally to designate single-celled, non-photosynthetic protists, such as the ciliates, amoebae and flagellates.

Paralytic Shellfish Poisoning (PSP): Caused by consumption of shellfish in which neurotoxins (principally saxitoxin) have accumulated in high levels. The toxins are produced naturally by marine phytoplankton. Symptoms include nausea, vomiting, diarrhoea, abdominal pain, tingling or burning lips, gums, tongue, face, neck, arms, legs, and toes. Shortness of breath, dry mouth, a choking feeling, confused or slurred speech, and loss of coordination are also possible. PSP can be fatal in extreme cases.

Recirculating Aquaculture Systems (RAS): Are used in home aquaria and for fish production where water exchange is limited and the use of biofiltration is required to reduce ammonia toxicity. Other types of filtration and environmental control are often also necessary to maintain clean water and provide a suitable habitat for fish.

Seagrass: Flowering plants (angiosperms) that grow in marine, fully saline environments. They grow in sheltered waters such as inlets, bays, estuaries and saltwater lagoons, and have long thin leaves. Seagrass beds are regarded as Priority Marine Features in Scottish Waters.

Sea-Lochs (Fjords): Glacially over-deepened river valleys now flooded by the sea; characteristically long and thin, with most freshwater arriving near the heads, they include surprisingly deep basins partly isolated from the sea by a shallow entrance sill. This sill may result in stagnation of basin deep water for weeks or months; the upper layers of sea-lochs, however, usually exchange vigorously with the sea as a result of tidal flows and a fresh-water driven circulation. Many Scottish Firths (such as those of Clyde and Lorn) are also fjords, but have more complex circulations because of their width.

The Scottish Environment Protection Agency (SEPA): A non-departmental public body accountable to Scottish ministers, and one of four main consultees for marine aquaculture planning applications (Anonymous, 2010); in particular, it applies the

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Controlled Activities Regulations to licence and monitor aquaculture activities (<https://www.sepa.org.uk/environment/water/aquaculture/>).

Simpson's Evenness: This is a measure of the evenness of the abundance distribution of different taxa within an assemblage.

Smolts: A young salmon (or trout) after the parr stage, when it becomes silvery and migrates to the sea for the first time.

Scottish Natural Heritage (SNH): A non-departmental public body accountable to Scottish ministers; it "... promotes, cares for and improves Scotland's nature and landscapes" <https://www.snh.scot/about-snh>; it is one of four main consultees for marine aquaculture planning applications (Anonymous, 2010), its main role being to protect biodiversity, especially in relation to species and habitats identified as of conservation value.

State: The actual condition of the ecosystem and its components established in a certain area at a specific time frame, that can be quantitatively-qualitatively described based on physical (e.g. temperature, light), biological (e.g. genetic-, species-, community- habitat levels), and chemical (e.g. nitrogen level, atmospheric gas concentration) characteristics.

Water Framework Directive (WFD): Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, adopted on October 23rd 2000. It is a European Union directive which commits European Union member states to achieve good qualitative and quantitative status of all water bodies.

Zooplankton: see Plankton

Acronyms & Abbreviations

AC	Assimilative Capacity
ADD	Acoustic Deterrent Device
ADI	Acceptable Daily Intake
ADM	Archer Daniels Midland
AGD	Amoebic Gill Disease
AHD	Acoustic Harassment Device
AMBI	AZTI Marine Biotic Index
ASC	Aquaculture Stewardship Council
AZE	Allowable Zone of Effect

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BAP	Best Aquaculture Plan
BKD	Bacterial Kidney Disease
CAR	Controlled Activity Regulations
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFP	Common Fisheries Policy
CoGP	Code of Good Practice
CoGPSA	Code of Good Practice for Scottish Finfish Aquaculture
CSTT	Comprehensive Studies Task Team
DAIN	Dissolved Available Inorganic Nitrogen
DAIP	Dissolved Available Inorganic Phosphorus
DE	Digestible Energy
Defra	Department for Environment, Food & Rural Affairs
DFO	Fisheries and Oceans Canada
DHA	Docosahexaenoic acid
DNA	Deoxyribonucleic Acid
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphate
DOM	Dissolved Organic Matter
DON	Dissolved Organic Nitrogen
DP	Digestible Protein
DPSIR	Driver-Pressure-State-Impact-Response
DSD	Dangerous Substance Directive
DSi	Dissolved Silicon
DSP	Diarrhetic Shellfish Poisoning
DZR	Depositional Zone Regulations
ECASA	Ecosystem Approach to Sustainable Aquaculture
ECE	Equilibrium Concentration Enhancement
EC50	Median Effective Concentration
eDNA	Environmental DNA
EFA	Essential Fatty Acids
EMB	Emamectin Benzoate
EPA	Eicosapentaenoic Acid

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EPS	European Protected Species
EQS	Environmental Quality Standard
ERSEM	The European Regional Seas Ecosystem Model
EU	European Union
FAO	Food and Agriculture Organisation
FCR	Feed Conversion Ratio
FFDR	Forage Fish Dependency Ratio
FHI	Fish Health Inspectors
FIFO	Fish in/Fish out Ratio
FM	Fishmeal
FMD	Floating Marine Debris
FO	Fish Oil
FOI	Freedom of Information
GOED	Global Organisation for EPA and DHA Omega -3S
GM	Genetically Modified
GMO	Genetically Modified Organism
HA	Harmful Algae
HABs	Harmful Algal Blooms
HDPE	High Density Polyethylene
HRA	Habitat Regulation Assessment
ICES	International Council for the Exploration of the Sea
IFG	Inshore Fisheries Group
IHN	Infectious Haematopoietic Necrosis
IUU	Illegal, Unreported and Unregulated
IFCA	Inshore Fisheries and Conservation Authorities
IMTA	Integrated Multitrophic Aquaculture
IPN(V)	Infectious Pancreatic Necrosis (Virus)
ISLM	Integrated Sea Lice Management
ISA(V)	Infectious Salmon Anaemia (Virus)
IQI	Infaunal Quality Index
ITI	Infaunal Trophic Index
LAP	Processed Animal Protein (PAP) derived from Land Animal

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LCA	Life Cycle Analysis
LC50	Median Lethal Concentration
LC-PUFA	Long Chain Polyunsaturated Fatty Acids
LNA	Linolenic Acid
LOEC	Lowest Observed Effect Concentration
MA	Marketing Authorisation
MASTS	Marine Alliance for Science and Technology for Scotland
MCZ	Marine Conservation Zone
MHC	Major Histocompatibility Complex
MLS	Minimum Landing Sizes
MMAP	Marine Mammal Protection Act
MO	Marine Oil
MODR	Marine Oil Dependency Ratio
MP	Marine Protein
MPA	Marine Protected Areas
MPDR	Marine Protein Dependency Ratio
MRL	Maximum Residue Limit
MSC	Marine Stewardship Council
MSFD	Marine Strategy Framework Directive
MSP	Marine Spatial Planning
MSS	Marine Science Scotland
MTQ	Maximum Treatment Quantity
N	Nitrogen
NGO	Non-Governmental Organisation
NH ₄ ⁺	Ammonium
NO ₃ ⁻	Nitrate
NOEC	No Observed Effect Concentration
P	Phosphorus
PAP	Processed Animal Protein
PBDEs	Polybrominated Diphenyl Ethers
PBR	Potential Biological Removal
PCBs	Polychlorinated Biphenyls

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PD	Pancreas Disease
PO ₄ ³⁻	Phosphate
POPs	Persistent Organic Pollutants
PMF	Priority Marine Features
PNEC	Predicted No Effect Concentration
RAS	Recirculating Aquaculture Systems
RIFGs	Regional Inshore Fisheries Groups
RSPCA	The Royal Society for the Prevention of Cruelty to Animals
RTRS	Roundtable on Responsible Soy
SAC	Special Area of Conservation
SAMS	Scottish Association for Marine Science
SARF	Scottish Aquaculture Research Forum
SAV	Salmonid alphavirus
SCOS	Special Committee on Seals
SEPA	Scottish Environment Protection Agency
Si	Silicon
SNH	Scottish Natural Heritage
SPA	Special Protection Areas
SPICe	Scottish Parliament Information Centre
SRSL	SAMS Research Services Ltd.
SSPO	Scottish Salmon Producers Organisation
SSSI	Site of Special Scientific Interest
TAQ	Total Allowable Quantity
TBT	Tributyltin
UFAS	Universal Feed Assurance Scheme
UKBAP	UK Biodiversity Action Plan
V	Volume
VHS(V)	Viral Haemorrhagic Septicaemia (Virus)
VM	Vegetable Meal
VMD	Veterinary Medicines Directorate
VO	Vegetable Oils
WCA	Wildlife and Countryside Act

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WCRIFG West Coast Regional Inshore Fisheries Group

WFD Water Framework Directive