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

Response – [redacted], [redacted]

The case for a risk-based spatial framework for managing interaction between sea lice from salmon farms and wild salmon

On the 18th November2020, [redacted], [redacted] at SEPA, accompanied by [redacted], the [redacted], told the Scottish Parliament's Rural Economy and Connectivity Committee that salmon farms were not responsible for the declines of wild fish.

However, [redacted] did add that there was some concern now that wild stocks are so low, the additional pressure of sea lice could place an added risk on wild fish as they migrate to sea.

This point was reiterated in a virtual meeting I had with SEPA's [redacted] and [redacted] on Tuesday 1st March. It was clearly stated that it is the current low state of the stock that has promoted this proposed framework, even though SEPA did not believe that sea lice were responsible for any perceived declines in wild salmon numbers.

However, the section of the consultation document -requirement for regulation - does not reflect the claim that the framework is required as extra protection for the low numbers of wild salmon that inhabit rivers around the salmon farming area. Instead, the consultation states that nearly 60% of salmon rivers cross Scotland, including the west coast and western isles, salmon populations are in poor conservation status. This statement is factually incorrect.

The figure of 60% of rivers appears to have been derived from the number of Grade 3 conservation status assessments as a percentage of the total for 2021. According to Marine Scotland Science, 36 districts/rivers were classified as Grade One: 35 as Grade Two and 102 as Grade Three. This equates to 58.9% of areas being classified as Grade Three.

When conservation gradings were first introduced in 2015/6, they just related to the 109 recognised fishery districts in Scotland. However, anglers soon began to complain saying that these area assessments did not reflect the conservation status of their own specific river, and these should be assessed independently of the fishery district.

Over the subsequent years, these assessments have expanded from 109 to 173. Unfortunately, they are not all equal, so it is not only wrong, but misleading to suggest that the 102 Grade Three listings for 2021 represent a true picture of the conservation status of salmon rivers throughout Scotland. For example, the relatively unknown salmon river Abhainn Eig consists of 2,779 squares metres of known salmon habitat, yet the similar area for the River Tay covers 17,272,512 square metres. These two fisheries appear to have been given equal weighting in the SEPA calculation even though the River Tay is 6,215 times bigger than Abhainn Eig.

According to the salmon-fishing-scotland.com fishing website, there are over 400 salmon rivers in Scotland, so it is unclear whether the 173 assessments carried out by Marine Scotland even cover every area of known salmon habitat. The total area of known salmon habitat for all 173 graded areas gives a much better representation of the conservation status of Scottish salmon rivers. The percentage area for each conservation grading is as follows:

Grade 1 conservation status applies to 57.2% of the total assessed areas.

Grade 2 conservation status applies to 15.8% of the total assessed areas.

Grade 3 conservation status applies to 26.9% of the total assessed areas.

26.9% for Grade 3 areas is much smaller than the 60% stated in the consultation. However, those Grade 3 areas just within the west coast Aquaculture Zone cover just 5.96% of total Scottish river habitat.

In addition, there are 9 rivers awarded a Grade One classification and 21 that have been awarded a Grade Two classification within the area known as the Aquaculture Zone. These thirty rivers and/or districts are of sufficient conservation status to allow exploitation by anglers, despite the presence of salmon farms in their vicinity

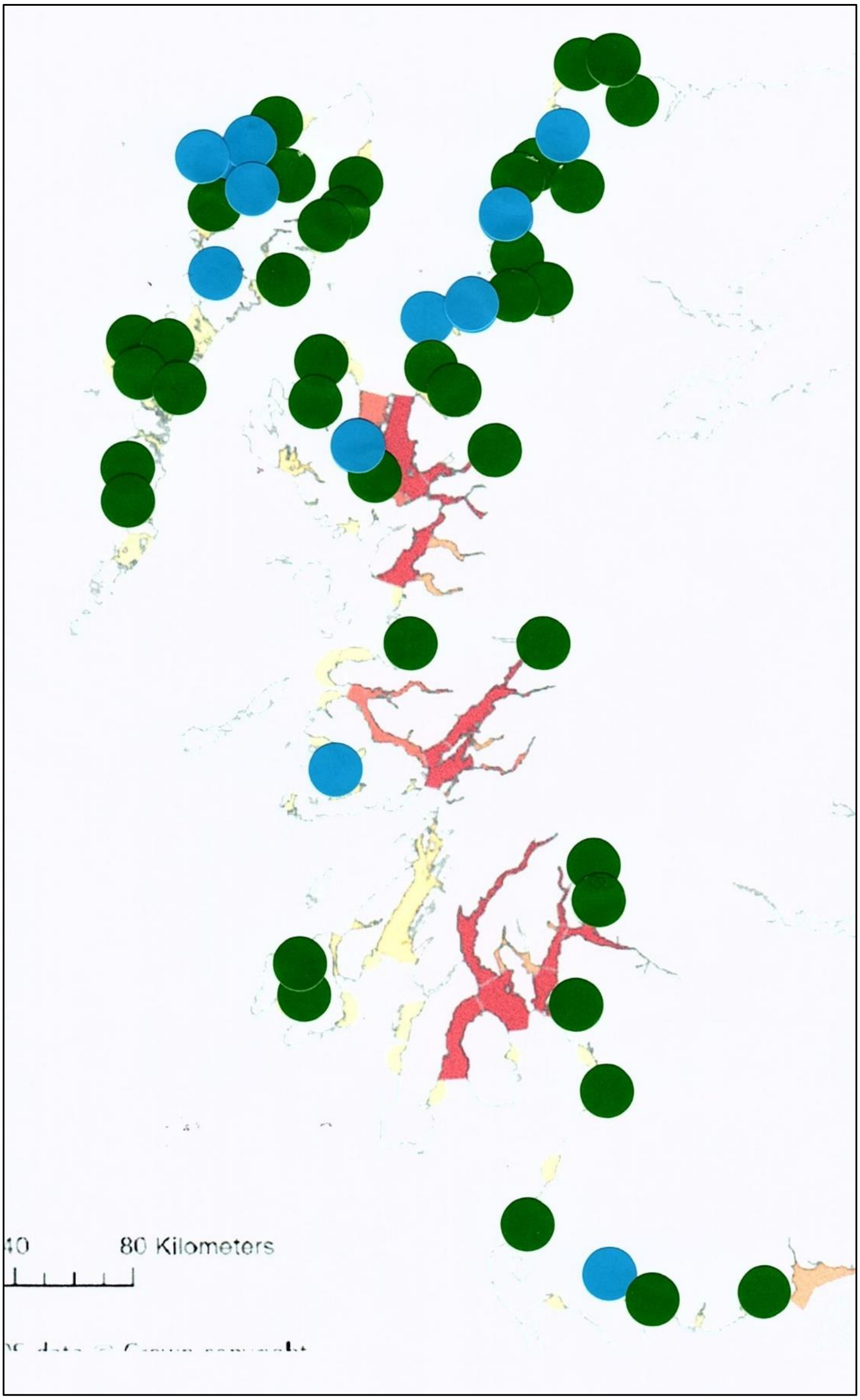
Even Marine Scotland Science now appear confused by the grading system. The summary of the proposed 2022 classification identifies 35 Grade One rivers, 37 Grade Two and 101 Grade Three rivers, which would suggest that the conservation status is not getting worse. However, although the summary table lists 173 areas, the accompanying list totals 223 in number. These consist of 35 Grade One areas, 43 Grade Two and 137 Grade Three. A further 8 areas are ungraded. The reason for this discrepancy is that in 2022, Marine Scotland Science separated some areas that had previously been combined with others.

The way that some of the fishery districts have been divided and sub-divided by Marine Scotland Science has simply confused the grading system. This can be illustrated by comparing two different fishery districts the Tweed and Loch Roag.

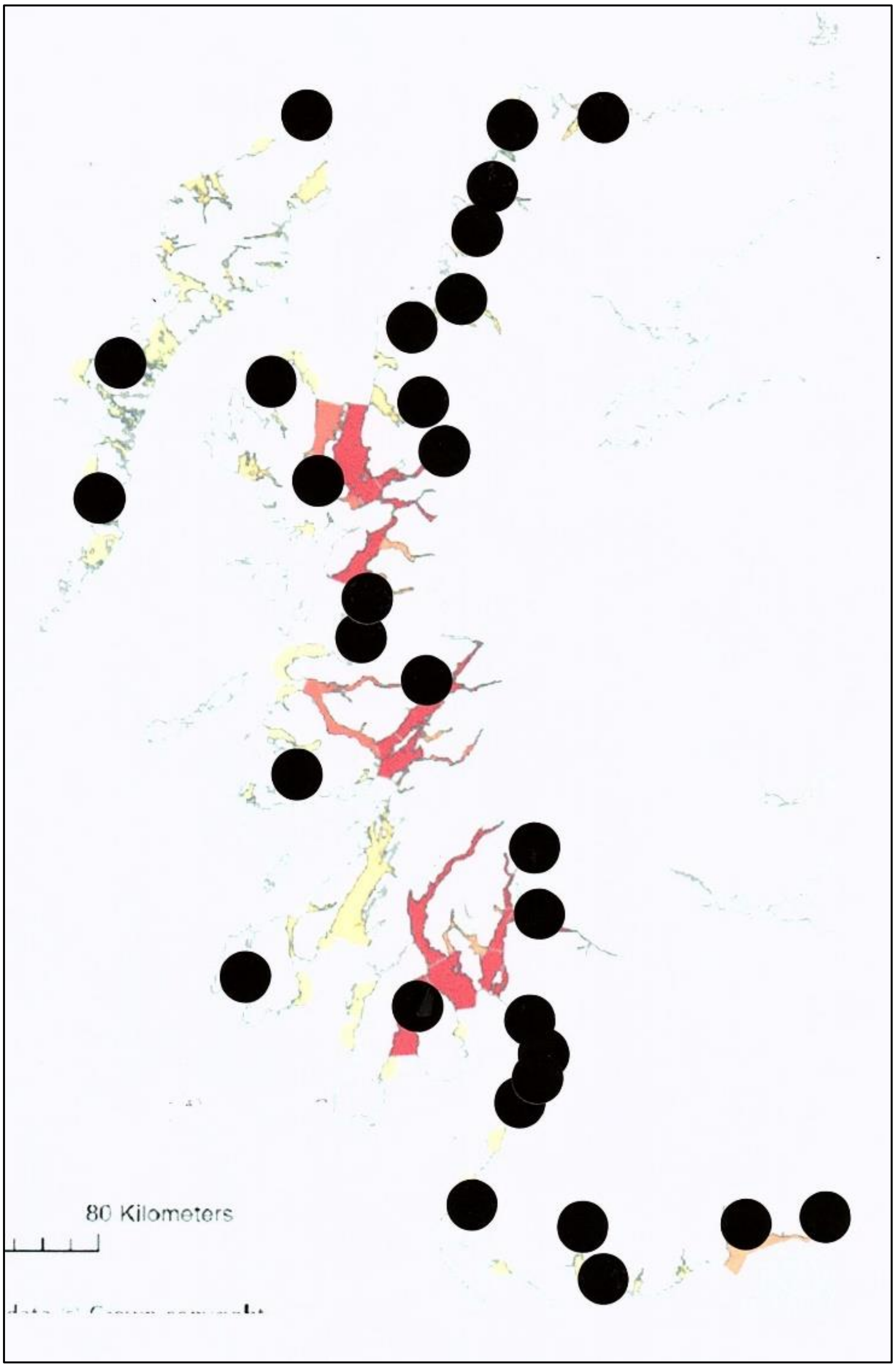
The Tweed fishery district has a single Grade One classification. It has a salmon habitat of 16,229,600 square metres in size.

By comparison, the Loch Roag Fishery District has ten separate classifications consisting of 3 Grade One, 1 of Grade Two and 6 of Grade Three. It has a total salmon habitat of 2,252,274 square metres, which is seven times smaller than the size of the Tweed Fishery District.

By amalgamating all the Grade Three areas into a single figure of 60%, regardless of how it is calculated, the consultation has ignored the widespread distribution not only of the Grade Three areas but also those classified as Grade One or Two. The impression from the consultation is that the perceived poor conservation status of wild salmon stocks is limited to the west coast salmon farming zone, and this is why the introduction of this framework is required. In fact, whilst the large well-known east coast rivers such as the Tay and the Tweed are Grade One rivers, the spread of all grades is throughout the whole of Scotland. There are many rivers classified as Grade Three that are located hundreds of miles from any salmon farm. In the same way, there are quite a number of rivers that are classified as Grade One and Two within the proposed area to be covered by the risk framework. The following illustration covers the proposed framework area and shows Grade One rivers (blue) and Grade Two rivers (green).



Th second illustration highlights those districts which had an increasing salmon catch from the 1950s until 2014/5 (black).



Two of the highest risk areas as illustrated by the proposed framework, appear to be around the Isle of Skye and the Isle of Mull. The River Varragill on the Isle of Skye empties into the channel between the island and the mainland, yet the Varragill is classified as a Grade One river in terms of conservation status. Its high-risk location appears not to have impacted on its conservation status.

The River Forsa, which empties into the channel between the Isle of Mull and the mainland, is a Grade Three river and has been since it was first classified. However, the greatest threat to wild salmon may not be the risk from sea lice infestation. The Benmore Estate, which owns the fishing on the Forsa, continues to promote the fishing with a series of photographic images including the following:

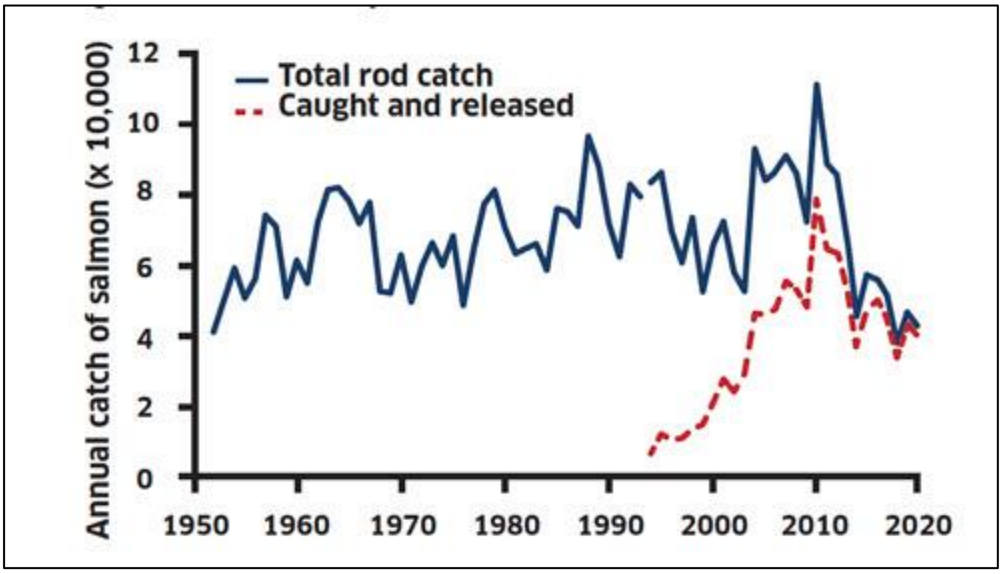
Although exploitation is not considered by Marine Scotland, to be a major threat to the state of wild fish stocks, the number of wild fish killed by anglers from rivers around the west coast Aquaculture Zone over the last fie years is shown in the following table:

Year	Salmon & grilse	Sea trout & finnock
2020	154	424
2019	148	606
2018	89	504
2017	283	649
2016	469	1079

The number of fish killed by anglers has fallen in recent years, but similar falls have been experienced across all of Scotland and are likely due to the impacts of COVID rather than the influence of conservation limits.

Regardless of the highlighted inconsistencies of the wild salmon stock status exhibited in the SEPA consultation document, wild salmon stocks across all of Scotland, not just the west coast, are under threat. Catches of wild salmon from east coast rivers, hundreds of miles from any salmon farm, collapsed after 2011. Some wild fish commentators suggest that wild salmon may become extinct from many Scottish rivers within the next thirty years. The SEPA consultation document fails to address why stocks are now in such a perilous state and what action, other than this localised proposed framework, is being taken to address the issue.

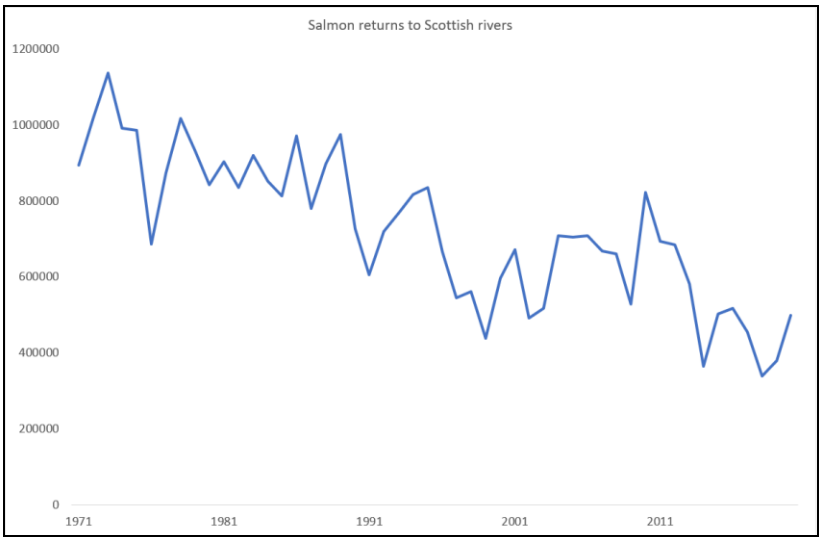
Marine Scotland Science publishes the catch data for salmon and sea trout annually. Catches are used as a guide to the size of the stock, but this assumes that fishing pressure remains relatively constant. Clearly, the knowledge of stock size is less reliable since the onset of COVID. In addition to the data, Marine Scotland Science publish a single graph (a) showing the total salmon and grilse catch for Scotland.



Graph (a): Marine Scotland Science graph of salmon catch data for all of Scotland from 1952.

From the 1950s through until 2010 the number of salmon caught by rod and line increased, peaking at 111,405 fish. Although, Marine Scotland Science started to record the catch data as fish retained and fish released from 1994, there was no official recommendation to return fish rather than kill them. Around this time, the authorities in England and Wales started to introduce conservation limits but it was a further twenty years before similar conservation limits were introduced in Scotland. Up to 2010, there was no real consideration that stocks of wild fish were in trouble, except in the west coast and the problems there were then, and still are, blamed directly on the presence of salmon farms.

However, the indications that stocks in the world-renowned salmon rivers of Scotland might collapse have been apparent for many years. Since 1971, estimates of the number of fish returning to Scottish rivers have been compiled by ICES in Denmark. The decline in numbers of returning fish is apparent from the following graph (b)



Graph (b): ICS estimates of returning salmon numbers to Scottish rivers from 1971.

HRH The Prince of Wales highlighted the problem at the AST's 50th anniversary dinner. He said that in the 1980s about 20% of fish leaving Scottish rivers returned. Today, the number is about 5% and more importantly, we don't know why salmon are returning in ever decreasing numbers.

Five years on from the prince's speech, we are none the wiser. We just know that the numbers of returning salmon continue to decline.

The writing was on the wall in the late 1980s/early 1990s. The salmon rivers on the west coast tend to be just a few kilometres in length, if that. The size of the river is reflected in the size of the stock, which will be very small in these small rivers.

After at least twenty years during which ever fewer fish returned to west coast rivers, it is likely that the number of returning fish were unable to maintain the stock in many of the west coast rivers and the stock collapsed, or at least appeared to collapse. This coincided with the rise of salmon farming and anglers unaware of the changes to returning fish, immediately blamed the presence of the salmon farming industry on the declines.

This has been the ensuing narrative up to 2011.

In 2011, salmon catches in areas of Scotland with no salmon farms began to collapse in the same way as seen in the west twenty years earlier. The continued decline in returning salmon inevitably affected the east coast too. The large reservoir of fish in the big east coast salmon rivers was eventually fished out and the reduced number of returning fish has proved insufficient to main the stock.

Despite this major collapse, there remains little understanding of what has happened. Marine Scotland Science have done nothing to halt the decline. Angling appears to remain a priority. Whilst rivers in Norway and Ireland have been closed to fishing in response to similar problems there, angling continues across all of Scotland. Meanwhile, Marine Scotland Science appear to have spent their time focussed on work such as this spatial risk-based framework to deal with sea lice, although clearly, the problems now apparent in the wild fish sector are not due to sea lice infestations.

If SEPA want to address the problems of declining wild salmon stocks, they need to encourage Marine Scotland Science to address the question of why salmon are failing to return to Scottish rivers. This was a problem in 1971 and remains a problem fifty years later. The fact that 3.6 million have been caught and killed by anglers since records began in 1952 has not helped ease the problem.

Section 4.2 of the consultation document refers to proposed protection zones for each graded river, even though there are no criteria for defining what constitutes a graded area, and for rivers designated as Special Areas of Conservation. Those writing the consultation document have been misinformed for SAC's do not afford any protection to wild salmon. SAC's were designated under the Habitats Directive and relate to the habitat, which is protected, not the fish. This question was taken to the European Commission, and they made it clear that anglers can catch and kill as many fish as they like in SAC's as the fish are irrelevant to the designation. This is why some of the most popular angling rivers in Scotland can be still designated as an SAC.

Callander McDowell

Does the scientific evidence provided in the consultation support the claim that salmon farms are a significant risk to wild fish?

Section 1.3 states that one of the core principles of this framework was to use best available scientific evidence and, in this area, the consultation document shows that this core principle has fallen well short of the mark. This is the undoubtedly due to Marine Scotland Science's extremely selective use of the science to fit the wild fish narrative. There has never been an explanation how the most contentious salmon farm in Scotland in Loch Ewe, which has been blamed on the collapse of the Loch Maree sea trout stock, can be located just five kilometres from the Grade One River Ewe which connects the freshwater Loch Maree to the sea water Loch Ewe.

Discussion of the 'best available scientific evidence' presented in this consultation document will be in section order.

1. Smolt release trials

The consultation document states that substantial impacts on marine survival of wild Atlantic salmon resulting from sea lice from salmon farms has been demonstrated in Ireland and Norway. No, they have not. The consultation references nine papers in support of this claim, however whether any of them actually support the claim of substantial impacts is questionable.

The key reference is Jackson et al (2013) and their earlier version (the only one quoted in MSS summary of science). The conclusion of this work from Ireland involving the release of 352,142 smolts is that the analysis suggests that whilst sea lice induced mortality on outwardly migrating smolts can be significant, **it is a minor and irregular component of marine mortality in the stocks studied and is unlikely to be a significant factor influencing the conservation status of salmon stocks.**

Although the paper suggests that mortality can be significant, the actual number of returning fish was 8529 control fish and 9678 treated fish which equates to 1.13 treated fish for every single control fish, which cannot be considered substantial. These are papers 9 and 10.

The results of the work by Skilbrei & Wennevik (2006) (Paper 7) from Norway is in broad agreement with the work of Jackson et al (2013).

The paper referenced no 11 from Gargan et al (2012) from Ireland arrives at a different conclusion to Jackson suggesting that mortality from sea lice can be significant with 1.8 treated fish returning for every control fish. The total sample was just 472 returning fish from 74,324 smolts. Jackson also suggested that the higher overall mortality might be due to the difference pH values of the rearing river compared to those in which the fish were released.

However, and importantly is that under an arrangement in Ireland, all data is supplied to a Marine Institute database so the work of Gargan et al. from Inland Fisheries Ireland is included in the data used by Jackson et al (2013).

Of the remaining papers cited, no 5 does not refer to the release of treated smolts so is not applicable here. Paper 6 (which is cited incorrectly) by Finstad et al. shows that the number of control fish exceeded treated. These findings do not support the claim made in this section. Paper 8 by Hvidesten et al (2007) found a return rate of 1.5 treated fish to every control fish however, they state that the results should be treated with caution as they say that the figure is within the limits of overall variation in the natural system.

The final papers (12 and 13) by Kroksek et al. include criticism of Jackson's paper. This is because it doesn't fit in with their accepted narrative about sea lice. Their criticism was rebutted by the Irish Marine Institute (see https://vimeo.com/83845976).

There is one significant omission from this list of papers detailing tagged salmon returns. This is the three-year project undertaken by Marine Scotland Science using wild fish from the river Lochy in the west and the river Conon in the east of Scotland. This omission is likely to be due to the fact that it does not support the claimed impacts of sea lice from salmon farms. Most of the returns were recorded from the River Conon on the east coast, where control fish outnumbered those that had been treated.

Contrary to the statement in this consultation that it is clear from the above-mentioned papers and the wider body of scientific evidence (already rebutted in section 1.3 of this response) that sea lice from fish farms can pose a significant risk to wild salmon populations, the risk is actually minimal, regardless of the factors quoted.

2. Summary of the Science

The consultation document states that it is clear from the wider body of evidence supplied by Marine Scotland Science that sea lice from salmon farms can pose a significant risk to wild salmon populations. The wider body of evidence is referenced from a summary of the science posted on the Scottish Government website. Marine Scotland responded to a FOI request in February 2022 stating that inclusion of studies in the summary of science does not necessarily imply that they form part of Scottish Government policy position and are included for information.

The observational studies included in the summary are supposed to demonstrate the impacts of sea lice on actual wild stocks but if their inclusion is for information only rather than helping form Scottish Government policy, then it is unclear which of the science cited is used in the formation of Scottish Government policy.

If these observation studies are not helping form Scottish Government policy, then it must be the experimental studies that are. The references cited in the summary relate to the smolt release trials discussed in the SEPA consultation. However, the summer omits the key Jackson paper of 2013 but includes one by Vollset et al 2016 which is not cited in the SEPA document. The Vollset paper is not a new study but uses a different statistical approach to implicate sea lice.

The latest version of the summary of the science concludes:

"The body of scientific information indicates that there is a risk that sea lice from aquaculture facilities negatively affect populations of salmon and sea trout on the west coast of Scotland."

The summary contains six sections but only section 3.2 Observational Studies provides any evidence to support their wider claims. Most studies relating to sea lice infestations involve mathematical modelling of what might happen rather than consideration of whether sea lice from salmon farms have had an impact on the actual salmon and sea trout stock, not a conceptual one.

Section 3.2 Observational Studies cites three scientific papers as evidence of an impact of sea lice from salmon farms on the west coast salmon stock.

(i) Butler & Watt (2003)

"Butler & Watt (2003) found densities of juvenile salmon to be lowest in west coast rivers near salmon aquaculture sites ". The first point about this work is that the reference cited in the summary is not the correct one for this paper. It is for a paper by Butler in 2002. The actual paper was published in a book 'Salmon at the Edge' edited by Derek Mills.

This paper might have been considered as proof of the impacts of salmon farming prior to 2011 but subsequent to 2011, when stocks on the east coast, where there is no salmon farming, collapsed. The reduction in the stock in rivers, most of which are less than 7km long can be better explained by the reduction of returning adult salmon to Scottish rivers as identified by ICES (WAGNAS) and NASCO. During the 1990s, the number returning to the west coast fell below that required to maintain a sustaining stock. By 2011, the same effect was seen in the east coast rivers. The much larger stock of fish in these larger rivers was eventually impacted by a combination of increased exploitation and fewer returning fish (now estimated at about 3%).

Also, consideration should be given to the fact that nine rivers on the west coast have been classified as Grade One conservation status rivers despite their close proximity to salmon farms.

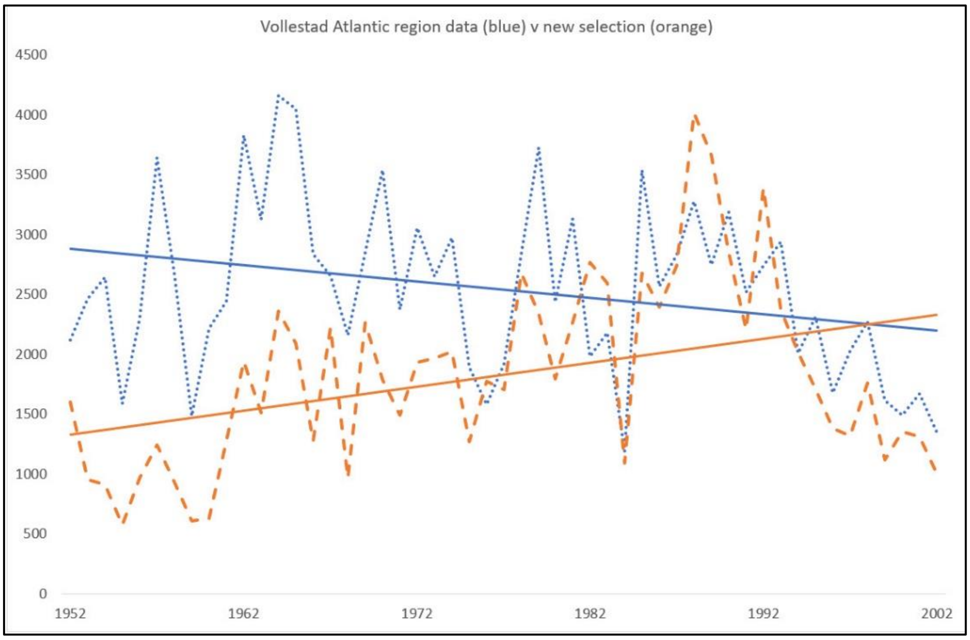
(ii) Vøllestad et al. (2009)

"Analysis of historical rod catch records from Scotland systematically allocated Scottish rivers into 3 areas: draining into the North Sea, Irish sea, or Atlantic Ocean, which for west coast mainland rivers is via the Minches. Catches of wild salmon after the late 1980s declined on the Scottish Atlantic coast relative to elsewhere (Vøllestad et al. 2009). This area covers most mainland Scotland's salmon farms although the authors stressed that this did not prove a causative link with aquaculture."

The seeming qualification for this papers inclusion in the summary is that one of the authors is currently head of the Freshwater Fisheries Laboratory. Despite repeated requests over six years for an explanation of why this paper is relevant to this issue, has not produced a response.

The paper is not about salmon farming but an investigation of trends in salmon rivers in Scotland and Norway. Rivers analysed were selected on being a similar distance apart thus the data comes from just 48 rivers across all of Scotland divided into three areas related to the sea into which the river discharged. Two of the areas contain both rivers in the salmon farming area and rivers outside the salmon farming area, complicating any comparison.

Rivers on the west coast did exhibit declining catches but as the summary states, **this does not prove a causative link**. More importantly, the rivers used were just a selection of those in the area and thus may not be representative of the observations made. The same observations from a different selection of local rivers produces a completely different outcome as illustrated in the following graph (c).



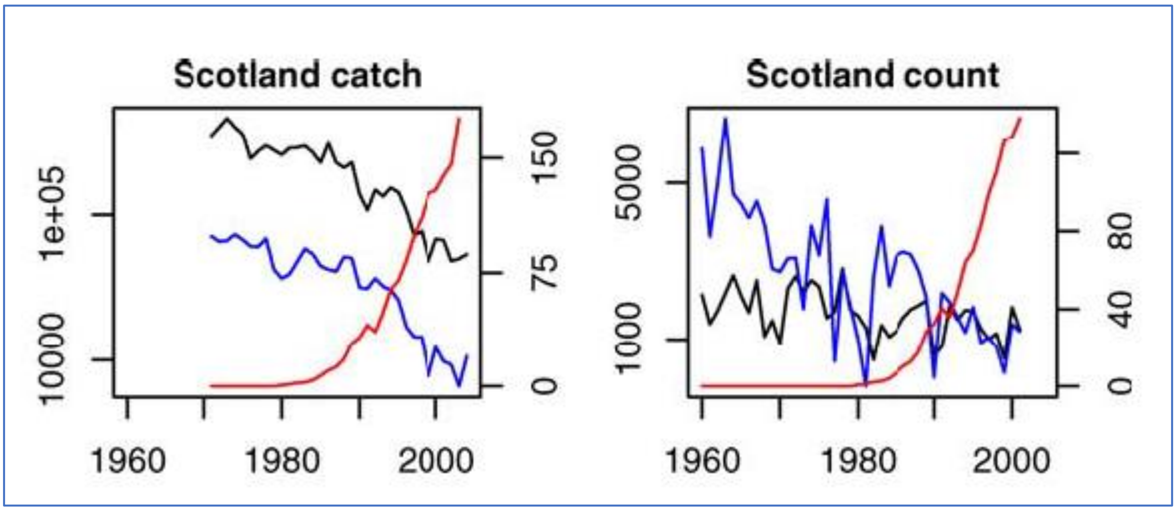
Graph (c): Decline of salmon catches from selected rivers in the Atlantic Sea area after Vøllestad (blue). Alternative outcome using an alternative selection of rivers from the same area (orange).

The conclusion of this paper is more of an assumption rather than proven science.

(iii) Ford & Myers (2008)

"Ford & Myers (2008) compared indices of salmon abundance on the east and west coasts of Scotland together with farm production data. They found a relative reduction in the catches and counts of salmon on the west coast correlating with increased production of farmed salmon."

This paper considers stocks of wild salmonids from locations around the world where salmon farming can be found. The paper includes two graphs (d) showing salmonid numbers from catches and counters for areas where there is salmon farming (blue) and control areas (black). The red line is the growth of salmon farming.



Graph (d) from Ford & Myers.

Marine Scotland Science have yet to provide an explanation of why these graphs demonstrate an impact of salmon farming on wild fish. Catches from both the farmed and control areas are clearly in decline and have been prior to the arrival of salmon farming. Any differences could be due to the fact that the control area is nearly ten times greater than the farmed.

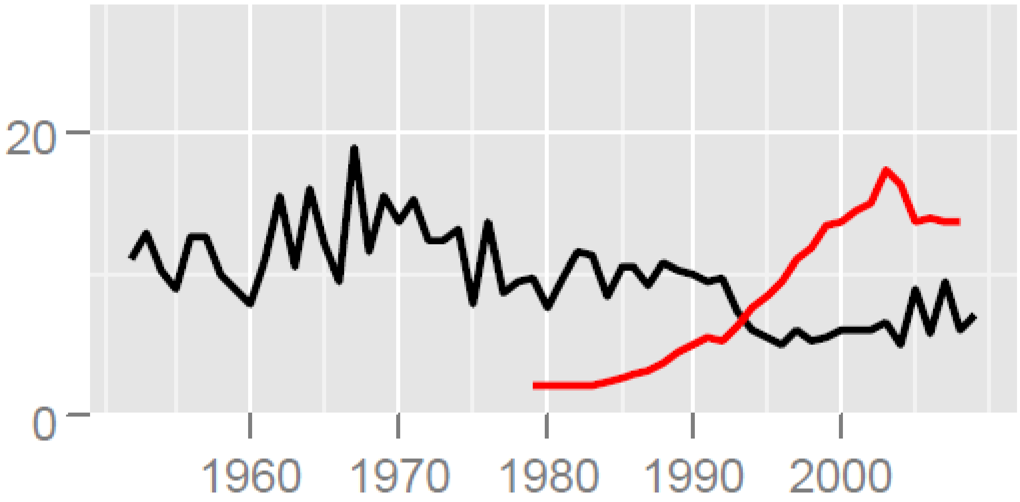
The inclusion of these three papers in the section about actual salmon stocks rather than those resulting from mathematical modelling does not demonstrate an impact from salmon farming. Despite extensive research, Marine Scotland Science have yet to provide any definitive rather than circumstantial evidence of the impacts of salmon farming.

The claim that "The body of scientific information indicates that there is a risk that sea lice from aquaculture facilities negatively affect populations of salmon and sea trout on the west coast of Scotland" does not appear to be supported.

However, there is other evidence that indicates that the salmon farming does not have the claimed impact, but this has been ignored by Marine Scotland Science on the basis that the work doesn't actually mention sea lice.

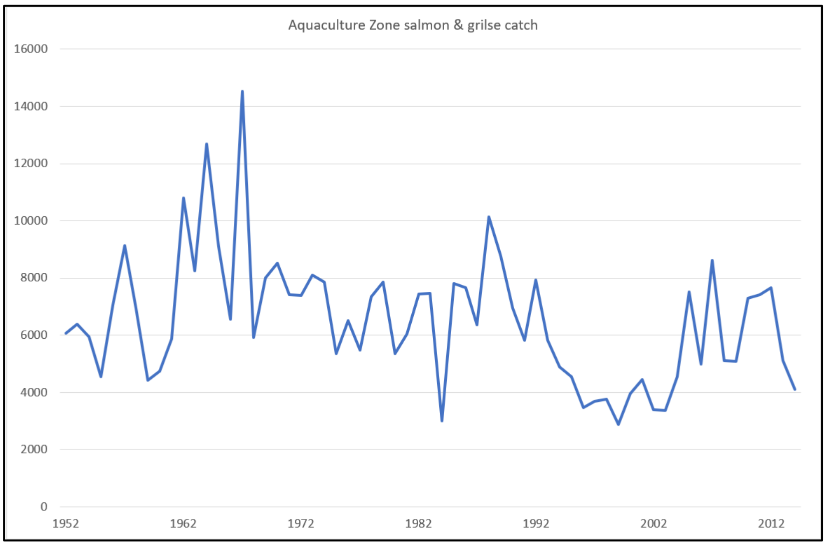
3. Latest observational studies

Marine Scotland Science have indicated that the expansion of the salmon farming industry is consistent with the decline of salmon catches in the salmon farming area relative to non-farming areas. Their graph (e) shows the percentage of the Scottish catch caught from the farming area along with the increase in salmon farming production. However, this approach is flawed as any declines in the salmon farming area may be due to increased catches elsewhere. This is misleading.



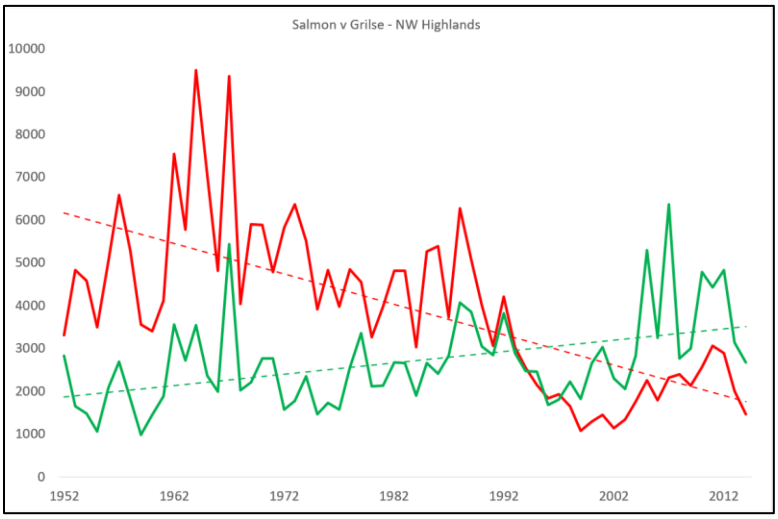
Graph (e) Percentage of salmon catch from the west coast (black) Salmon farm production (red) from Marine Scotland Science.

Although, the graph of percentage catch is similar to the one of absolute catches, there are significant differences. Catches did decline in the early 1990s but subsequently recovered. The decline has been attributed to the presence of salmon farms, yet catches did recover even though the salmon farming industry continued to expand. Unfortunately, Marine Scotland Science did not record angling effort at the time but the likely explanation for the decline and subsequent recovery is that the angling organisations were then warning that salmon farming had destroyed the fishing on the west coast. This deterred anglers from visiting and the reduced angling effort led to reduced catches. Eventually, anglers began to hear that there were good fish still to be caught and began returning to the area to fish. Overall, numbers have fallen but numbers of fish caught have fallen across all of Scotland since 2011 (Graph (f)).



Graph (f): Salmon catches by number from rivers in Aquaculture Zone (Marine Scotland Science data).

A new study by myself published in September 2021 shows that the perceived decline of the wild salmon stock along the north-west Highlands are actually the result of long-term changes to the salmon stock components, which are apparent across all of Scotland, not just in the northwest. Catches of MSW large salmon have been in decline from the 1950s to 2010 whilst catches of grilse have increased across the same period (Graph (g)). Such changes have been recorded on the River Tweed since 1740.



Graph (g): Decline in MSW salmon (red) compared to increased grilse catch (green) in the AZ.

The implication of this work for this consultation is that increased catches of grilse do not support the claim that the lethal effects of sea lice are negatively impacting the size of the stock. MSW salmon are in decline in the north-west but also across all of Scotland and in areas where there are no salmon farms.

4. Natural sea lice infestations.

This consultation assumes that any sea lice present on the wild fish must come from local salmon farms. There has been a number of studies which have sampled sea lice elsewhere in Scotland. Mackenzie, Longshaw, Begg and McVicar (1998) sampled fish from the River Eden and the South Esk on the east coast. The prevalence for all sea lice including C. elongatus ranged from 0 to 98.1%. The River Eden abundance was 33.3% and that for the South Esk was 61.4%.

Rivers with sea lice abundance below that from the South Esk included Ailort (45.8%), Ewe (16.1%), Feochan (16.7%), Gruinard (33.3%), Hope (15.4%), Laxford (41.1%), Sheil (9.2%) and the Snizort (50%)

Urquhart, Fryer, Cook, Weir, Kilburn, McCarthy, Simons, McBeath, Matejusova & Bricknell (2010) counted parasites from three east coast sites, one on the Solway Firth and one in the North-West Highlands.

The prevalence of both L. salmonis and C. elongatus were:

North Esk

	2005	2006	2007
L. salmonis	100	93	87
C. elongatus	90	43	50

Upper Forth Estuary

	2006	2007
L. salmonis	29	60
C. elongatus		3

Stonehaven Bay

	2006
L. salmonis	84
C. elongatus	50

River Carron

	2007
L. salmonis	3
C. elongatus	

River Annan

	2006	2007
L. salmonis	23	10
C. elongatus		

The authors state that there was no evidence from their study of sea trout having higher parasite burdens in areas where aquaculture is present than in those devoid of aquaculture activity.

5. Sea lice distribution around farms

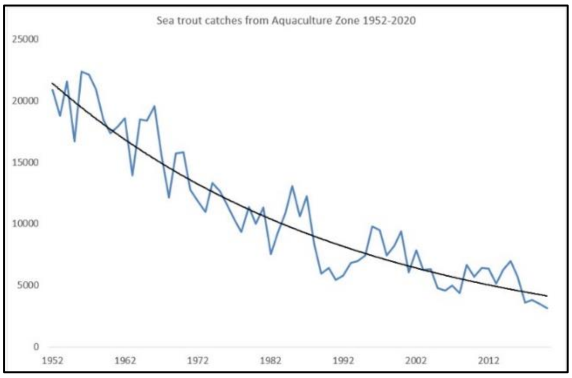
The Marine Scotland Science summary of the science refer to a paper by Murray and Moriarty (of MSS) who have modelled the spread of sea lice from salmon farms. In their abstract, they state that this is “based on a simple kernel of copepodid distribution around farms; within this kernel the copepodid are assumed either to disperse evenly or to be transported in a concentrated plume”. (Kernel refers to a computer algorithm).

The paper includes 22 inclusions of the word assume and its variations. It fails to include any research of sea lice distribution around a salmon farm and simply assumes that larval sea lice will be carried away from the farm on currents and tides. No reference is made to a paper by Nelson, Robinson, Feindel, Sterling, Byrne, and Pee Ang from 2017. The work was presented at the 11th International Conference on Sea Lice in 2016. The researchers found that the density of sea lice nauplii dropped an order of magnitude at a distance of 100m and densities ranged from 10 larvae/m3 to zero. Their conclusion was that the early life history stages of sea lice originate from, and may remain close to, active salmon farms creating a self-sustaining population.

6. Sea trout

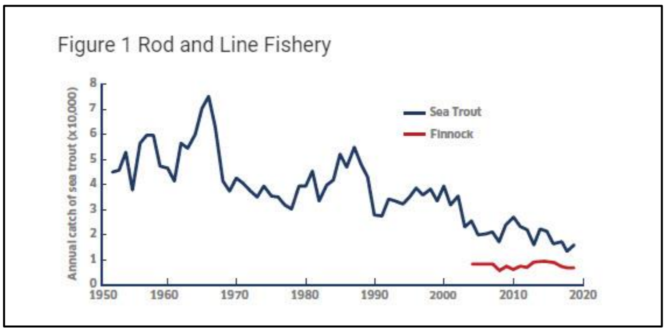
The consultation document suggest that knowledge of sea trout populations is not as great as for salmon. The reality is that knowledge of stocks of both is weak. Sea trout are brown trout that go to sea to feed. There may be a genetic element driving the fish to migrate to sea but equally, a lack of food may prompt others to do so. It is possible that when food is abundant, fish are less inclined to migrate leading to the impression that stocks are in decline.

As stated, sea trout catches indicate a long-term decline, predating the development of salmon farms. This decline has slowed since the 1990s despite the increase in salmon farming activity (Graph (h).



Graph (h): Sea trout catches from rivers in the Aquaculture Zone.

More importantly, this decline has been apparent across all of Scotland, not just in the salmon farming areas (Graph (i).



Graph (i): Marine Scotland Science graph of sea trout catches from across all Scotland.

The science relating to proposed wild salmon protection zones

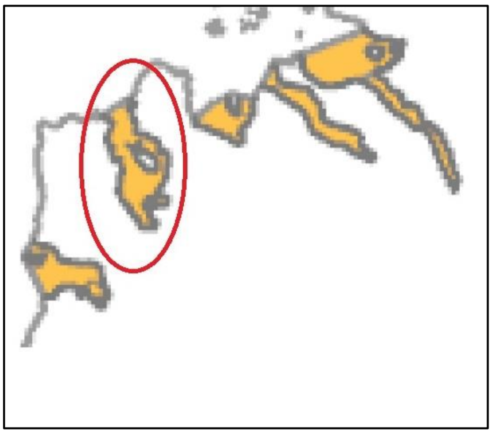
Section 1.3 of the consultation document states that the core principle of this work was to use the best available scientific evidence.

The document states that 'To protect salmon post smolts in the first few hours of their life at sea, the rea contained within a 5Km radius of each such river mouth will be treated as a wild salmon protection zone'.

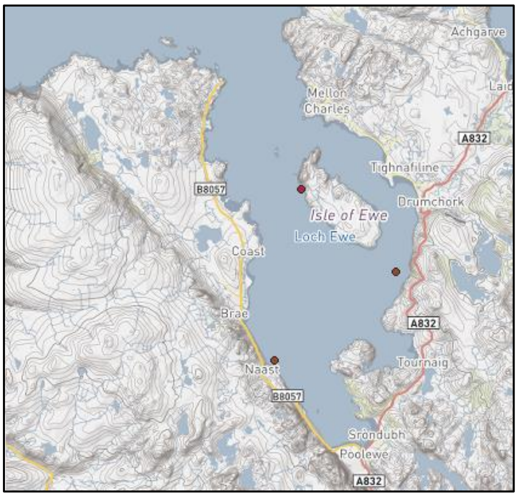
Although there is a reference citation attached to this statement, it simply provides extra information about river mouth identification. There is no scientific evidence provided to support a 5km zone. This appears to be an arbitrary figure.

The proximity to the river mouth has been established as the main area for natural infestation of sea lice irrespective of whether in a salmon farming area or not. There will be a natural population of sea lice regardless of the presence of any farm. There does not seem any consideration of whether sea lice present in the protection zone are of farmed or natural origin. There is a possibility that nearby farms could be penalised for a natural effect.

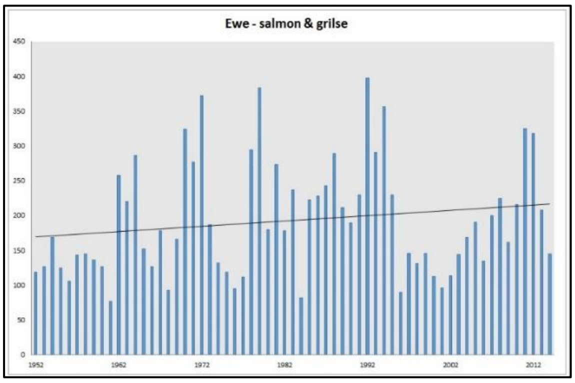
The presence of an existing farm within the 5km protection zone has not been shown to have a negative impact on wild fish. For example, it is proposed that the whole of Loch Ewe will become a protection zone under the new proposals.



Loch Ewe was home to salmon farming from 1987 to 2020.

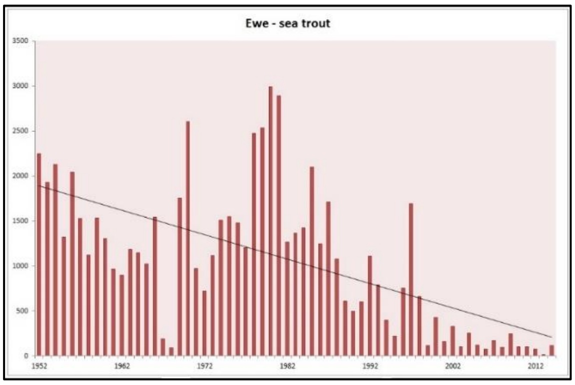


Originally, there were two farms, but these were amalgamated together in 2004 to a new location off the Isle of Ewe. The site at Naast was about three kilometres from the mouth of the River Ewe. Catches of salmon and grilse have increased throughout the period that this farm was in operation (Graph (j)). The River Ewe has been classified as a Grade One salmon river.



Graph (j): Salmon catches from the Ewe Fishery District.

Yet, anglers blame these farms for the collapse of the local sea trout population (Graph (k)). There has been no attempt to explain the two different trends.



Graph (k): Sea trout catches from the Ewe Fishery District.

The science of proposed sea lice exposure thresholds

The consultation document highlights laboratory studies in which stress related effects and impaired swimming ability were identified in post-smolts infested with relatively low numbers of sea lice. Infestation with sea lice will undoubtedly have some effect on host fish, however comparison of what happens to fish artificially infested in laboratory studies with what happens naturally in the wild can be misleading due to the wide range of experimental designs. This can be best illustrated by a scientific paper cited by Marine Scotland Science in their summary of science. This is the paper by Wells et al. 2006.

Marine Scotland Science state in their summary that 'Under laboratory conditions, over 13 attached sea lice (at the pre-adult and adult mobile stages) per trout (19-70 g) caused physiological stress and was potentially lethal (Wells et al. 2006).' However, the title of the paper is the 'physiological effect of simultaneous abrupt sea water entry and sea lice infection on wild sea run brown trout.' The mortality attributed to sea lice may have been exacerbated by the fish being abruptly transferred from freshwater to sea water, however Marine Scotland Science make no mention that the abrupt transfer of the fish to sea water may have a role in the mortality of the fish rather than just the sea lice. It is unlikely that such abrupt transfer will occur in the wild, although the researchers said that they were trying to mimic environmentally realistic circumstances.

The consultation document suggests that under laboratory conditions some of the mortality may be due to secondary infections. In the wild, it is also likely that the sea lice infestations are themselves a secondary infection attacking fish that are already weak or sick.

Table B1 includes a citation to a paper by Johnson et al 2020. This paper further develops a previous sea lice migration model used to estimate sea lice induced mortality on migrating wild fish. The paper describes how the model was refined and calibrated against salmon post smolts caught by surface trawling. Based on their model they estimated that 82 rivers would experience mortality of over 30%.

Whilst this paper is cited by SEPA in the development of the spatial risk-framework for Scotland, it has been the subject of major criticism in Norway. Following publication, the science was questioned in a paper by two independent researchers. They claimed that the estimates of the risk of mortality were too high. They re-analysed the data from the trawls used by Johnson et al. and found that they did not match Johnson's model. The number of areas identified within the group estimating mortality below 10% was 6 for the model and 18 from the reanalysis. For the group with an estimated mortality of 10-30%, the number for the model was 8 compared to 6 after reanalysis. The group with an estimated mortality of over 30% totalled 13 for the model whereas the reanalysis produced just 4 areas.

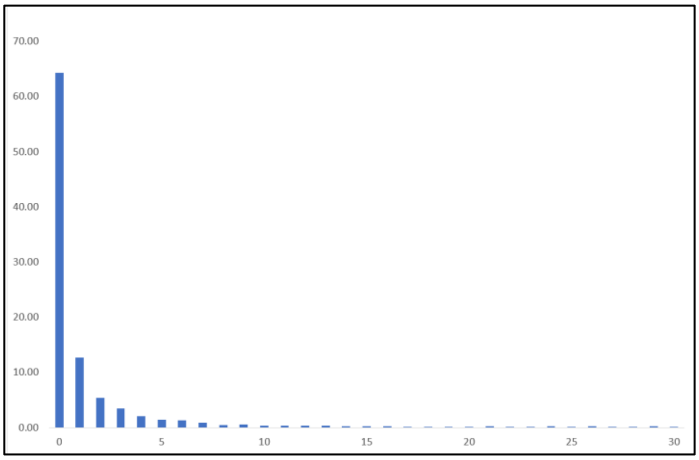
Johnson et al, subsequently rebutted this criticism in another paper but the journal then refused the independent researchers to defend their approach. Instead, they posted an extensive commentary on one of the Norwegian news websites identifying the weaknesses in Johnson's paper

However, neither set of researchers recognised that the large dataset of trawled salmon post-smolts provided a real opportunity to examine the infestation rate of real fish in real zones of infection, as opposed to relying on a constructed model.

The size of the sample was 8,419 fish caught over a period from 2017 to 2020. Sixty four percent of these fish carried no lice at all. Seventeen percent carried just one sea lice, and this equated to 1066 fish. The number of fish with thirteen lice (Wells mortality threshold) or more totalled 529 which equates to 6.2% or well below the 10% lower threshold established by the model.

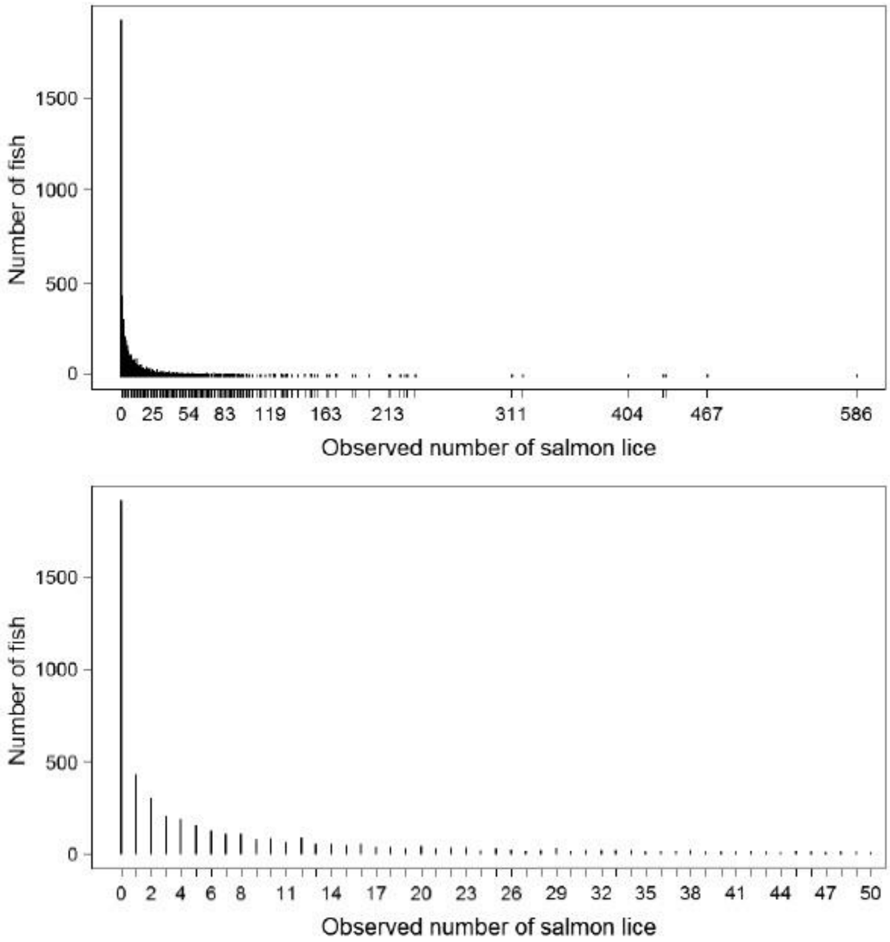
As yet, no-one from Norway has been able to, or willing to explain how this large sample does not reflect the mortality levels established by the model.

The graph shows the percentage frequency of host fish with increasing numbers of sea lice. This is in the form of a typical aggregated distribution which is common to all parasites. There are many hosts with no or few parasites but just a few hosts carrying many parasites (Graph (l)).



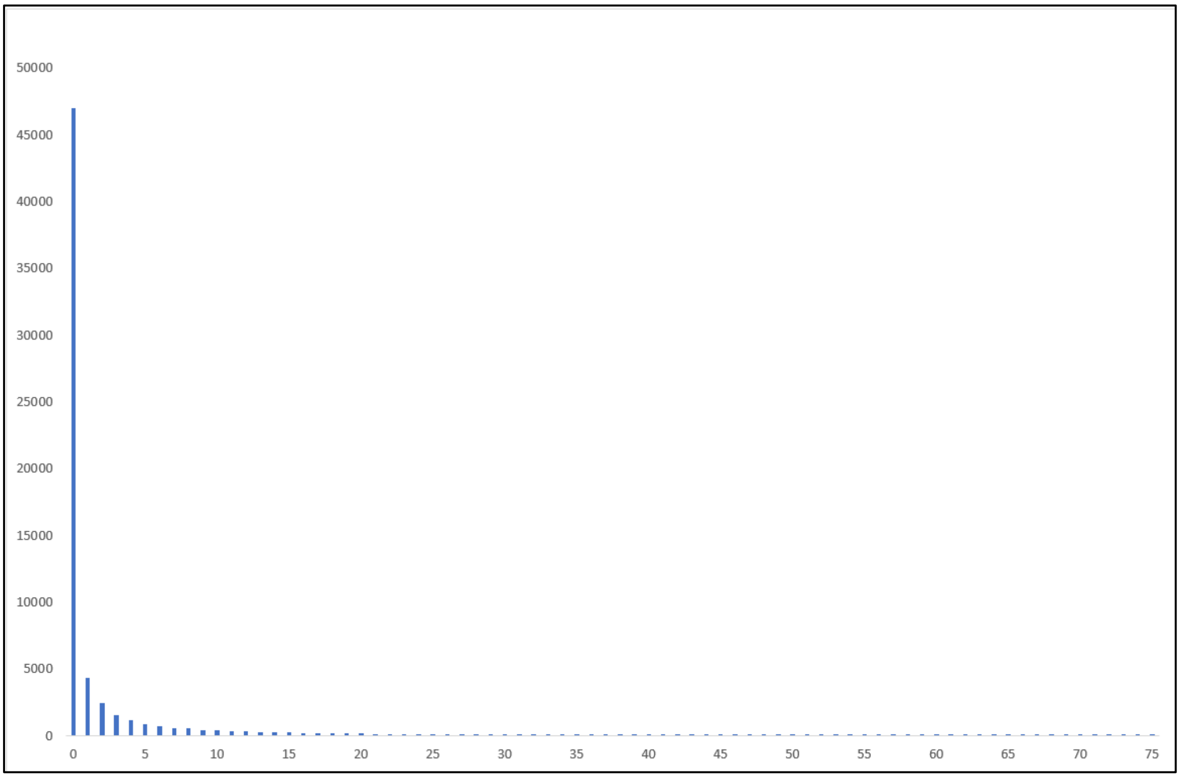
Graph (l): Aggregated distribution of sea lice on wild fish using data from Johnson et al.

This form of distribution is rarely mentioned in the literature relating to sea lice – The Summary of Science for example. However, one example has been published. This involves 4,890 sea trout caught from various sampling sites along the Norwegian coast between 2004 and 2010. Helland et al (2015) plotted the frequency of distribution as shown in the follow graph. (The lower graph showing hosts with up to 50 parasites only) (Graph (m)).



Graph (m): Aggregated distribution of sea lice from Helland et al. (2015).

However, the Norwegian samples, pale into insignificance with the publication of sea trout sampling data collected by the west coast fishery trusts on behalf of Marine Scotland Science from 1997 to 2019. The sample size is 64,885 fish of which 72% were totally free of sea lice. The graph goes up to 75 lice per fish, but the maximum number recorded was over 200 on a couple of fish (Graph (n)).



Graph (n): Aggregated distribution of sea lice from data collected from west coast Fishery Trusts from 1997 to 2019.

The significance of these distributions is that when fish are sampled in small numbers with high lice counts, they are not representative of the population, although the angling sector would argue differently. Unfortunately, Marine Scotland Science have not corrected this misleading image of sea lice infestation.

The Helland et al paper is not cited in the SEPA consultation but is significant as the original work contributed to the evaluation of the most appropriate statistical approach of reference no 40 (Taranger et al 2015) that is cited as the risk estimation scheme used in the Norwegian Traffic Light System under which fish with an infestation of less than 0.1 mobile sea lice per gram. Taranger is widely used by the wild fish sector in Scotland to demonstrate the negative impacts of sea lice on wild fish. However, Helland had problems fitting the statistics to the aggregated distribution that they identified. In order to make it fit, they discarded all the fish below 0.1 mobile sea lice per gram from the distribution and this is the approach taken by Taranger. However, it distorts the risk as the statistics no longer consider that the population is dominated by fish with no lice. Their fish population only includes fish that are infested with 0.1 lice per gram and above and thus the risk is over-estimated.

This can be demonstrated with an example from Scotland. [redacted] of Lochaber Fisheries Trust told the Sunday Times that the lice levels observed in sampled fish during 2021 led her to believe that the estimated mortality of sea trout would be around 85%. This was repeated in a presentation to the Fisheries Biologists conference hosted by Fisheries Management Scotland.

If 85% mortality is applied to the Scottish sample, then at least 9,000 of the fish would die from sea lice infestation even though these fish were all lice free. An explanation for this discrepancy has been sought from [redacted] but he has failed to respond.

In Norway, there has been much concern about the estimated risk of mortality established by Taranger that farmers have sued the Norwegian Government for using these estimates in the existing Traffic Light System. The court case is ongoing.

Meanwhile, the Norwegian Government commissioned a group of international scientists to evaluate the methodology of the Traffic Light System. Their report recommended that as the mortality risk has never been reassessed that its appropriateness should be assessed on a regular basis. They also recommended that studies should be undertaken to actually assess the impacts of sea lice on a population basis rather than rely on the model. The samples discussed earlier in the response to the consultation already demonstrate that the models used do not reflect the impacts on both salmon and sea trout populations.

The failings of the Norwegian Traffic Light System will clearly be reflected in the model proposed by SEPA and Marine Scotland Science.

B6 –It is stated that the exposure threshold of 0.7 infective stage sea lice per m2 was determined by a Norwegian study using sentinel cages. However, the model they used is flawed. Sentinel cages have a weakness in that they reflect the dynamic of a salmon cage with once a fish is infected, then the infection can be spread from within the cage rather than from the wider environment.

However, there is a bigger flaw in that the fish were held in the sentinel cages for three weeks, yet section B10 of the consultation document states that a Scottish wild salmon post smolt of 12.5 cm would be expected to navigate through nearly 11 km of a wild salmon protection zone in 24 hours. This means that the fish held in the sentinel cages are exposed to 21 times more sea lice pressure than a migrating post-smolt.

B7 – First principles, biological models have been developed by Marine Scotland Science that incorporate realistic estimates of sea lice swimming velocities an attachment success as well as salmon post-smolt swimming speeds. The glossary listed at the beginning of the consultation document states that biological models are the creation of a mathematical or conceptual representation of a biological process. An example is given of particle tracking modelling to assess sea lice dispersal.

The model cited in the consultation document for sea lice dispersal does not include any verification that the process identified in the model actually happens in the natural environment. The only conclusion is that this is a conceptual model that supports the theory that sea lice must damage wild fish populations. However, the paper by Nelson et al, discussed previously, shows that sea lice do not spread far from salmon cages but remain close to a significant number of potential hosts.

It is worth noting that Marine Scotland Science has been working on sea lice dispersion models including this paper. However, another scientific work cited by this paper from Marine Scotland Science includes development of a sea lice dispersion model using the services of an international engineering company. This is further illustration that the conceptual models being developed are far removed from the reality of sea lice infestation.

Figure B1 is a chart of the number of salmon rivers assessed for speed of travel through proposed protection zones. In total, there are 160 rivers.

The Scottish Government have classified 173 rivers and districts for the whole of Scotland.

Summary table

Category	2016 (Districts)	2017 (Rivers)	2018	2019	2020	2021	2022 (Proposed)
1	11	47	28	48	36	36	35
2	15	48	21	30	34	35	37
3	82	73	122	95	103	102	101

In 2022, although Marine Scotland Science claim there to be 173 rivers and fishery districts that have been allocated a conservation status, the full list is about 223 areas including several that have not been assessed. (The way these are displayed by Marine Scotland Science on their website makes counting difficult unlike previous years) These additional areas make the count for the west coast to be 164 which is much closer to the number in the proposed SEPA framework. The exact number will depend on where the boundary is drawn. The uncertainly as to how many classified areas are included in the conservation measures contributes to uncertainty about the framework.

Conclusion

The scientific evidence presented in this consultation does not support the view that sea lice, whether from farms or natural sources, exerts a population regulating effect. To the contrary, the best scientific evidence would indicate that there is no population regulating effect due to sea lice. The risk-based spatial framework proposed in this consultation is pointless regulation and will not safeguard the future survival of stocks of wild salmon.

Added observation – to access the scientific references cited in this consultation requires the payment of access fees totalling £360, which makes this consultation selectively exclusive.

Additional references

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