2017 West Coast Fisheries Trusts' Sea Trout

Post Smolt Monitoring Programme

January 2018

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Summary

This project is the largest programme in Scotland that monitors the potential impacts of marine salmon aquaculture on wild salmonid populations. The aims of the programme include developing an understanding of the current population status and identifying regional trends on the West Coast of Scotland for wild *Salmo trutta* (Sea Trout) and their interactions with two species of sea lice; *Lepeophtheirus salmonis* and *Caligus elongatus*. It is currently funded by Marine Scotland, with the results feeding into a larger analysis being conducted by them in order to assess aquaculture interactions. This report summarises the 2017 data for the use of FMS and their stakeholders.

In 2017, the fisheries trusts of the West Coast gathered data from 22 monitoring sites. This involved collecting individual data from just over 900 captured sea trout.

L. salmonis, the most problematic species of sea lice to sea trout populations, was present at all of the monitoring sites. At 16 sites over 50% of sea trout were infected with sea lice, with every fish infected at 2 sites in the Outer Hebrides and 2 in Wester Ross. The data were analysed to investigate potential population changing impacts from lice abundance. This indicated that 9 sites were at high risk of population changing effects, while only 7 were at low risk.

The variation in sea lice numbers between sites, and from year to year at the same site, demonstrate that there are many variables that can influence sea lice infestations on wild sea trout. These could include the timing when post smolt sea trout leave their rivers, sea temperatures and coastal salinities, wind directions and strength in the period prior to sampling, as well as the sea lice burdens on nearby aquaculture sites that can augment natural sea lice populations. To enable effective management of wild fish and farmed salmon, it is imperative that these variables are better understood.

1. Project Background

This project is a continuation of a body of work started in 2003 in order to look at interactions between the aquaculture and wild fish industries. For much of this time there has been a strong Scottish Government presence within the project management. Initial efforts centred on communications between Aquaculture and wild fish interests on a local basis, resulting in the establishment of several Area Management Agreements.

Subsequently there have been a number of significant priorities developed from a wild fish perspective to underpin the work. These include: the protection of sensitive and high value fresh water sites; collecting information on wild fish stocks to help to inform the improved practice and management at existing aquaculture sites; and informing decisions on the location and biomass production at current and any proposed aquaculture site. In 2011 the Managing Interactions Aquaculture Project identified three projects as key priorities and work streams within the overall Project.

These were:

- Strategic programme of post smolt sweep netting and analysis;
- Programme of genetic sampling and analysis; and
- Locational guidance and zones of sensitivity analysis.

In 2011 the programme of genetic sampling and analysis was completed and a report on this area of work produced. In addition, a map detailing proposed locational guidance and zones of sensitivity was developed. This has since been superseded by work undertaken by Marine Scotland Science. Only the strategic programme of post smolt sweep netting continues at this time, managed by the Fisheries Management Scotland Fish Farm Committee.

The participating fishery trusts and boards are:

- Argyll Fisheries Trust
- Argyll District Salmon Fishery Board
- Wester Ross Fisheries Trust
- Wester Ross District Salmon Fishery Board
- Skye District Salmon Fisheries Board
- West Sutherland Fisheries Trust
- Outer Hebrides Fisheries Trust
- Western Isles Salmon Fisheries Board
- Lochaber Fisheries Trust
- Lochaber District Salmon Fisheries Board

In 2012, Middlemas *et al* analysed the West Coast fisheries trusts' sea trout sweep netting data from 2003 to 2009 and concluded that;

"*the proportion of wild sea trout with potentially damaging levels of sea lice infestations on the West Coast of Scotland was related to their fork length, distance to the nearest farm and the weight of salmon on that farm*".

The study was able to predict that the maximum range of effect of sea lice from farms is approximately 31km. There remains an inherent uncertainty with this estimation of distance due to the previous study being focused solely on localised investigations. Following on from this work, in 2011, the subsequent project undertaken by the project partners introduced significant refinements. These included the coordinated strategic West Coast Region focus of this project, which also now includes sampling of monitoring sites at greater distances and on the North Coast. The data collected in this project is available to Marine Scotland Science and it is envisaged that the development of the new data set will enable some of the questions and uncertainties identified in the previous work to be further explored and definitive conclusions drawn.

2. Methods and Site Information

2.1 Sweeping Survey Techniques and Data Analysis

All chosen monitoring sites were surveyed in accordance with the Scottish Fisheries Co-Ordination Centre (SFCC) sampling protocol, "Sea Trout Netting and Sea Lice Sampling: A Standard Sweep Netting Protocol for Management, 2009".[1] This ensured that the project complied with current recommended standards. The data gathering was conducted by participating fisheries trusts during the months of May, June and July 2017.

Sea trout were captured during the hours of daylight using a sweep net which was deployed from the shoreline. Trust teams using the sweep nets would either employ hand hauling techniques or deploy the net from a boat. The sweep nets used were fifty metres in length and had a standard stretched mesh size of 20 mm. All sea trout caught within the sweep were removed and anaesthetised. Under anaesthesia the length (±1 mm) and weight (±1 g) were recorded and where possible, a scale sample was also taken. The sea trout were examined for the presence of sea lice, which if found to be present were counted and staged. Sea Lice counts were classified according to the two species under investigation; *Lepeophtheirus salmonis* (Krøyer) and/or *Caligus elongatus* (Nordmann). *L. salmonis* was further staged by one of three life-stages, copepodid/chalimi, pre-adult/adult and ovigerous females, as per the SFCC Protocol. Additional information was also collected on any other parasites present or any predator damage to the fish.

Different assessment methods were used to describe the sea lice distribution on the sea trout post smolt populations at the monitoring sites. These were:

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[1] SFCC "Sea Trout Netting and Sea Lice Sampling: A Standard Sweep Netting Protocol for Management, 2009".

- Prevalence: The percentage of fish in the sample infected by sea lice.
- Abundance: The average number of lice per fish within the sample.
- Intensity: The average number of lice on the fish carrying lice.
- Median: The middle value of lice observed, when all figures are arranged in numerical order.
- The proportion of lice within the population at each life-stage.
- The potential biological risk to the population of the lice infestations, using the method derived by Taranger, *et al* (2014).

Prevalence is an indication of the percentage of infected sea trout versus uninfected sea trout. To obtain a more comprehensive view of the distribution of sea lice amongst the sea trout sampled, abundance and intensity analysis was explored. Abundance gives an indication of the overall number of lice within the population whilst intensity provides a more accurate indication of the level of infestation on infected fish. Use of the median value will 'neutralise' extreme values present on a small number of fish.

The sampling data from all the trusts were compiled by the project coordinator in an Excel (2010) spreadsheet. Analyses of the data involved descriptive statistics and graphs which were prepared in Excel (2010).

2.2 Site Information

Two new sites, Loch Etive (Argyll) and Pooltiel (Skye), were introduced to the monitoring programme for 2017 as a result of low trout numbers and difficulties in sampling at other sites within the regions (Table 1 and Figure 1). From 2011 to 2014, the sampling strategy was designed to investigate the relationship between sea lice levels on post smolt sea trout sampled at monitoring sites and the distance to the nearest salmon fish farm, as discussed by Middlemas *et al*. (2012). However, this strategy was amended in 2015 to attempt to monitor wild sea trout populations in as many aquaculture production areas as possible.

The project has a core focus of sampling efforts on the sea trout post smolt run as previous studies have shown that post smolts are potentially the most vulnerable stage to sea lice infection (Finstad *et al*., 2000), however all age groups sampled were processed. This work is a continuation of previous post-smolt sweep netting which was a part of the Tripartite Working Group Area Management Groups, and is a continuation of a long time data series for some sites (Table 1).

In accordance with the SFCC protocol, the project Steering Group agreed that for each site a target of >30 fish should be included in each sample and that this sample should be collected from a minimum of two survey dates at each site. Additional survey dates and greater number of fish would further improve and enhance the sample size available for analysis and the robustness of the analysis subsequently possible. Table 2 shows the number of sea trout collected from each monitoring site.

The current sampling programme is funded by the Scottish Government, with the data supplied to Marine Scotland for analysis. These analyses form part of a wider body of work by Marine Scotland into the issue of Aquaculture interactions. This report is separate to these analyses and serves as a summary document for stakeholders within the FMS network.

Table 1: Monitoring Site Details

Site Name	Fishery Trust Area	Distance to nearest salmon fish farm (km)	Year Site First Sampled
Carradale	Argyll	7	2007
Loch Fyne	Argyll	24	2005
Loch Riddon	Argyll	15	2005
Dunstaffnage	Argyll	3	2002
Loch Etive*	Argyll	22.6	2017
Kinlocheil	Lochaber	20	1999
Camas na Gaul	Lochaber	6	2002
Sunart	Lochaber	12	2012
Borve	Outer Hebrides	10	2003
Eisgein	Outer Hebrides	3	2009
Malacleit	Outer Hebrides	20	2006
South Ford	Outer Hebrides	6	2015
Morsgail	Outer Hebrides	8	2015
Kyle of Durness	West Sutherland	40	2009
Polla	West Sutherland	10	1997
Laxford	West Sutherland	5	1997
Kannaird	Wester Ross	3	2007
Boor Bay	Wester Ross	8	2008
Flowerdale	Wester Ross	26	2009
Slapin	Skye	50	2009
Snizort	Skye	2	2015
Pooltiel	Skye	11	2017

*1.7 km from the nearest rainbow trout farm

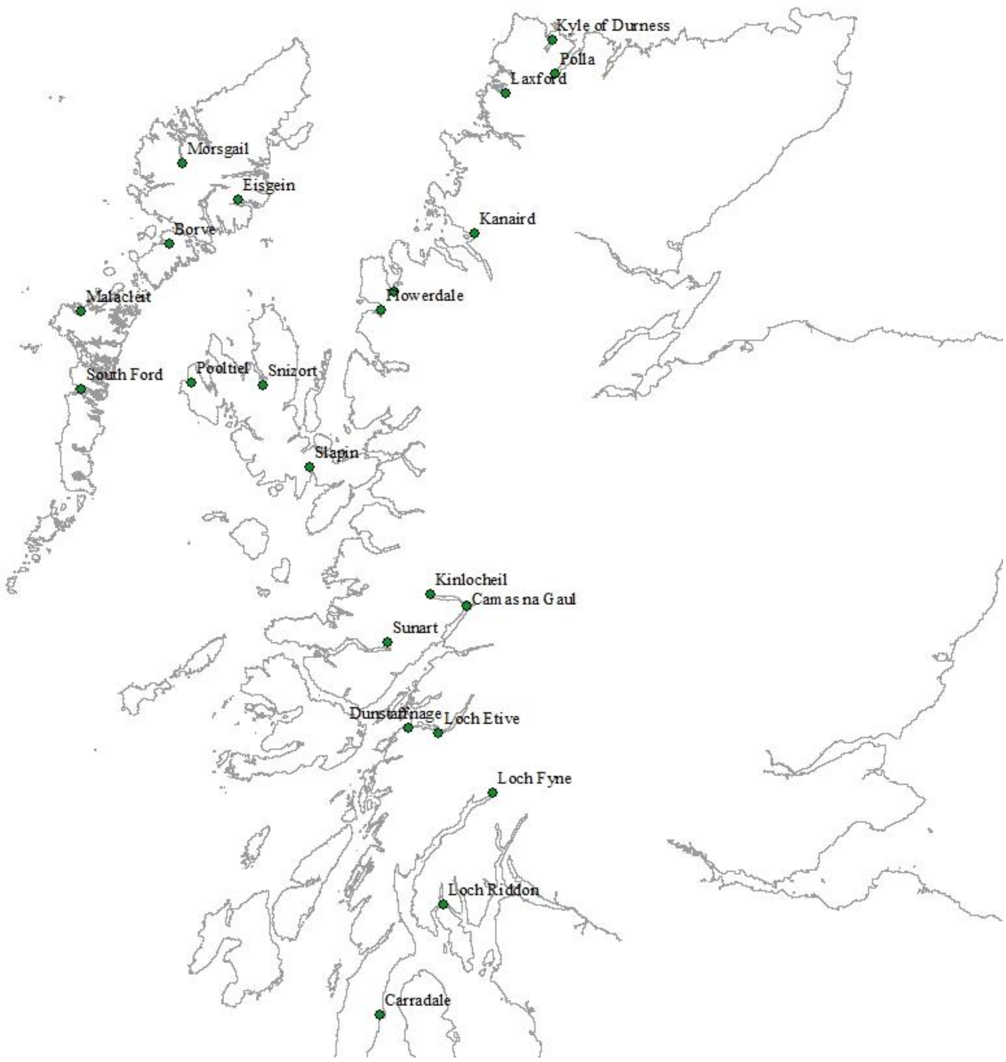

Figure 1: Geographical spread of monitoring sites sampled in 2017

3. Sweep Netting Analysis Results

3.1. Sea Trout Analysis

The SFCC protocol recommends that unless scale samples are taken from sea trout, then assigning the fish as post-smolt or finnock is not recommended. In view of this, all sea trout collected during the sampling were processed and the results described below.

Of the 22 sites surveyed, only 13 returned a sample of 30 fish or more (Table 2). Two sites, South Ford and Snizort, had a sample size of only 2 and therefore results for these sites should be treated with caution. Similarly 3 sites, Boor Bay, Slapin and Pooltiel, were only sampled on one occasion, thus giving a restricted picture of the sea lice infestation at those sites. A further site, Snizort, while sampled on 2 occasions only returned fish on the second sampling date.

To explore the condition of the sea trout, Fultons condition factor (Ricker, 1975) was employed. This factor assumes a relationship between the weight of a fish and its length, which calculates and allows for the description of the individual fish condition. The formula is:

Condition Factor = $100W/L^3$, where weight (W) is in grams and length (L) in cm.

As a general rule a condition factor of 1 or above would be considered healthy. Of the 22 monitoring sites for 2017, the calculated Condition Factor was 'healthy' for 21 sites, with only one (Flowerdale) falling just below a condition factor of 1 (Table 2). A total of 929 sea trout were analysed.

Table 2: Number of sea trout caught by site, mean length, mean weight and mean condition factor.

Site Name	Total Fish Caught	Mean Length (mm)	Mean Weight (g)	Mean Condition Factor
Carradale	17	187.88	76.94	1.08
Loch Fyne	75	205.81	132.63	1.13
Loch Riddon	52	189.13	95.60	1.13
Dunstaffnage	11	187.91	61.67	1.19
Loch Etive	65	166.15	102.13	1.11
Kinlocheil	49	168.94	65.77	1.08
Camas na Gaul	83	160.65	56.29	1.07
Sunart	32	163.84	60.79	1.01
Borve	49	244.88	292.22	1.17
Eisgein	115	269.12	246.27	1.10
Malacleit	17	265.71	262.06	1.13
South Ford	2	268.00	315.50	1.17
Morsgail	14	179.21	87.86	1.23
Kyle of Durness	49	199.02	101.00	1.16
Polla	49	159.16	41.64	1.00
Laxford	96	214.15	124.80	1.03
Kannaird	54	180.30	83.31	1.02
Boor Bay	10	229.70	139.10	1.06
Flowerdale	39	301.69	373.30	0.97
Slapin	20	248.35	272.36	1.12
Snizort	2	176.00	61.00	1.10
Pooltiel	29	164.94	49.13	1.07

When analysing the sea lice data, it is important to have confidence that the observed differences in sea lice levels are not due to the size of sea trout sampled, as larger sea trout can carry more sea lice (Middlemas et al. 2012). There are a range of trout sizes within this study, which may have some effect on the results within this study. However this is also considered within subsequent analyses.

3.2 Sea Lice Analysis

Of the 13 sites with a sample size greater than 30 sea trout, the sites with the highest prevalence of *L. salmonis* were Flowerdale (Wester Ross) with 100%; Eisgein (Outer Hebrides) with 96% and Camas na Gaul (Lochaber) with 87% (Table 3). However Table 3 and Fig. 2 demonstrate that there are 16 sites with prevalence equal to or greater than 50%, with Loch Etive (Argyll) showing the lowest prevalence of lice at 8%.

*Table 3 Prevalence, Abundance, Intensity and median value of lice found at each site (*denotes sites with <30 fish)*

Site Name	Prevalence	Abundance	Intensity	Median
Carradale*	0.24	0.35	1.50	0
Loch Fyne	0.49	8.00	16.22	0
Loch Riddon	0.60	2.77	4.65	1
Dunstaffnage*	0.91	16.18	17.80	16
Loch Etive	0.08	0.11	1.40	0
Kinlocheil	0.80	13.25	16.64	7
Camas Na Gaul	0.87	56.04	64.60	53
Sunart	0.59	15.16	25.53	6.5
Borve	0.51	19.78	38.76	1
Eisgein	0.96	14.92	15.60	14
Malacleit*	1.00	11.53	11.53	10
South Ford*	1.00	63.5	63.5	63.5
Morsgail*	0.21	0.36	1.67	0
Kyle of Durness	0.86	6.29	7.33	5
Polla	0.69	35.76	51.53	22
Laxford	0.35	8.73	24.65	0
Kannaird	0.30	2.06	6.94	0
Boor Bay*	1.00	33.30	33.30	19
Flowerdale	1.00	110.44	110.44	95
Slapin*	0.95	5.65	5.95	4.5
Snizort*	0.5	1.50	3.00	1.5
Pooltiel*	0.97	5.60	6.18	3

While prevalence demonstrates the presence of lice, this does not indicate impact on the fish. Abundance and intensity give a better indication of the lice burdens on the fish, and therefore the potential for physical or physiological impacts. As expected, abundance and intensity data follow the same pattern (Table 3), and therefore abundance data will be described and graphed (Fig. 3). Of the sites with >30 sea trout, the sites with the highest abundance of *L. salmonis* were Flowerdale (Wester Ross) with 110.44 lice per fish; Camas na Gaul (Lochaber) with 56.04 lice per fish and Polla (West Sutherland) with 35.76 lice per fish (Table 3). The lowest abundance of 0.11 lice per fish was recorded at Loch Etive (Argyll).

It has previously been shown that 13 mobile lice/fish is sufficient to have a physiological effect on fish < 70g in weight (198 mm in length) (Wells *et al.* 2006). While this situation is not described in these data, which include Chalimus stages and fish greater than 198 mm, and therefore is not being used within this analysis, it still gives a threshold level from which to look at the data. Table 3 shows that 10 of the sites had abundance greater than 13 lice per fish, increasing to 13 sites where intensity is used.

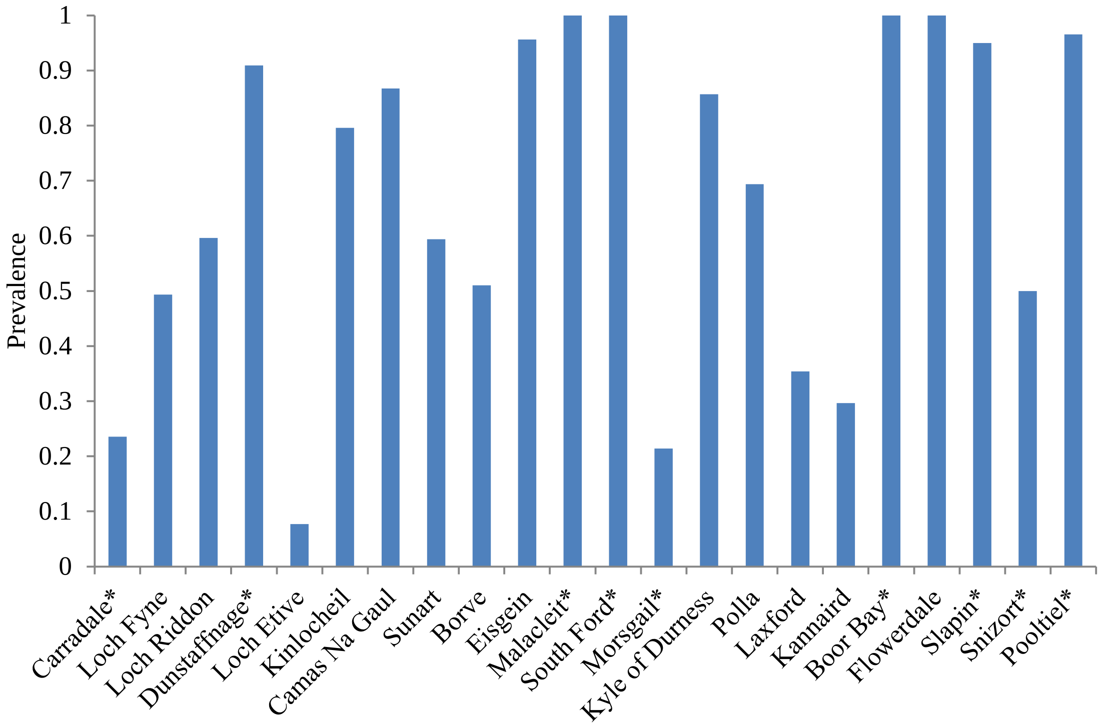

*Figure 2: Prevalence of all site stages of L. salmonis for all sites (*denotes sites with <30 fish)*

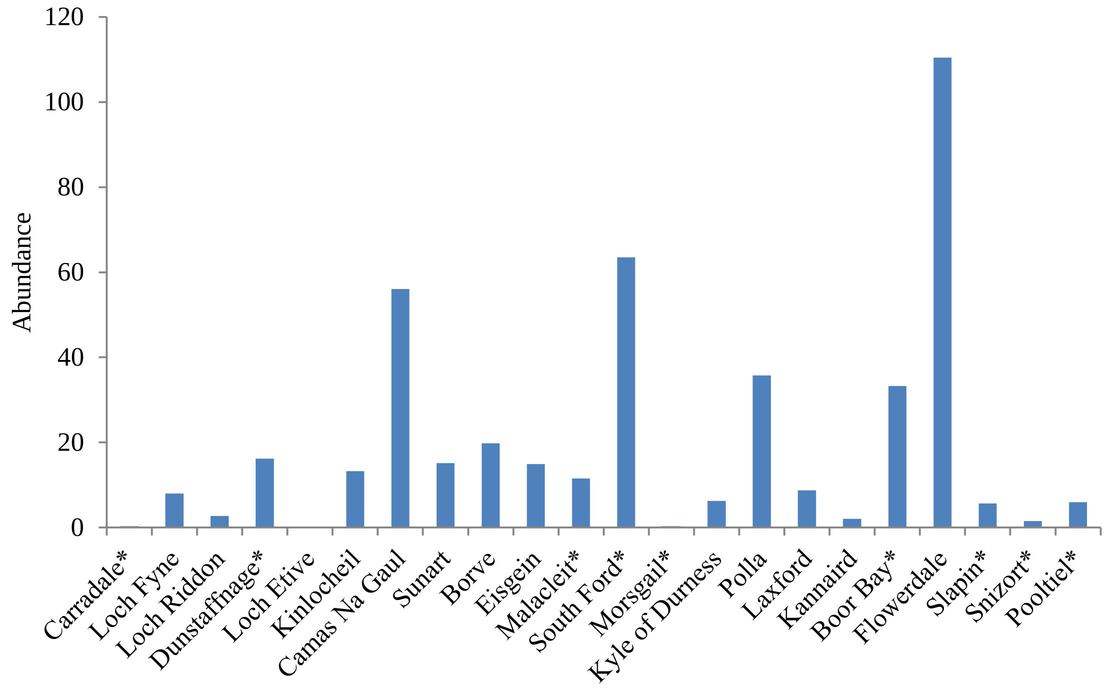

*Figure 3: Abundance of all site stages of L. salmonis for all sites (*denotes sites with <30 fish)*

In addition to the total number of lice present, the lice stages present will give an indication of the status of the population, with a mix of stages expected within a naturally occurring population. It has been shown previously that Chalimus dominate lice populations within 30 km of a fish farm, with equal proportions of Chalimus and post-Chalimus stages found at distances between 30 km and 100 km, while post-Chalimus stages will dominate at distances > 100 km (Gargan, *et al.* 2003). With the exception of Slapin and Kyle of Durness, all of the sites within this study are within 30 km of a nearby fish farm.

During 2017 all sites had a range of stages present (Fig. 4), although several (Camas na Gaul and Sunart (Lochaber), Polla and Laxford (West Sutherland) and Flowerdale (Wester Ross) had over 90% of the population comprising Chalimus. Only Carradale (Argyll), Morsgail (Outer Hebrides) and Snizort (Skye) did not have Chalimus present. Ovigerous lice were present in low numbers at all sites, with the exception of Loch Fyne (Argyll), Camas na Gaul (Lochaber), Polla and Laxford (West Sutherland) and Flowerdale (Wester Ross). The high proportion of ovigerous lice in Snizort is likely to reflect the small number of fish (2) sampled.

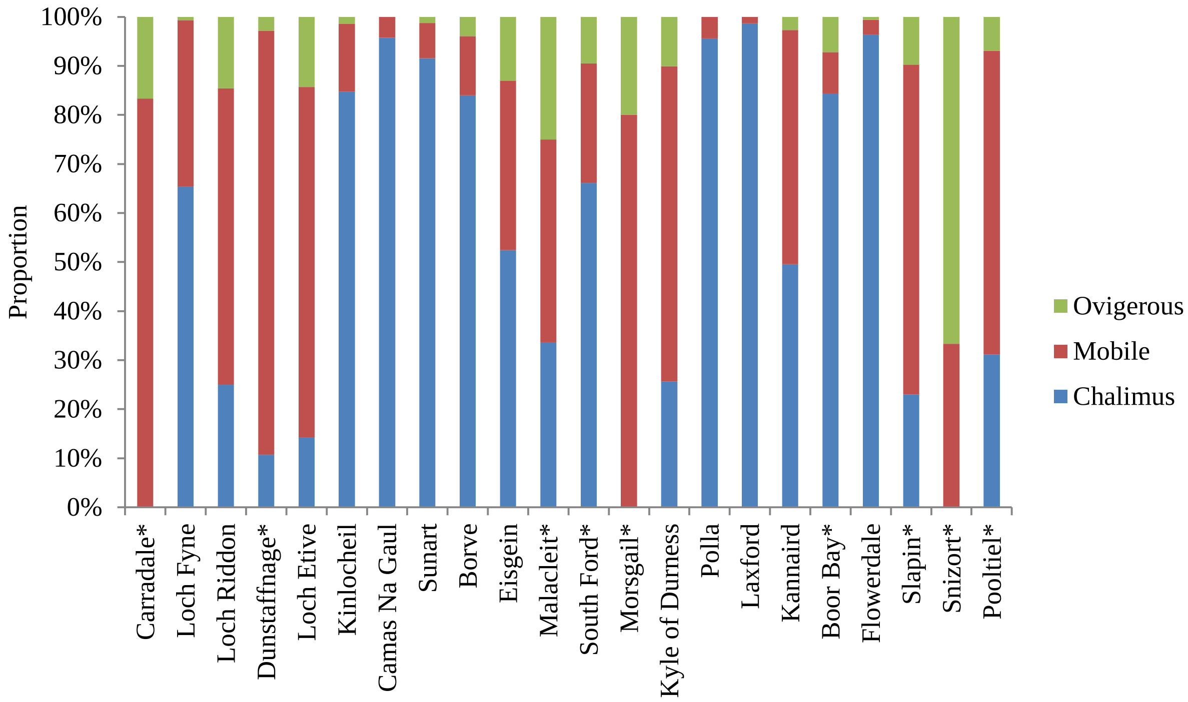

*Figure 4: Proportion of each lice stage present at each site (*denotes sites with <30 fish)*

3.3 Exploring the pressures from sea lice on wild sea trout populations

A number of factors need to be considered when analysing the results collected at the monitoring sites. Sweep netting studies may over- or under-estimate the levels of lice on wild fish. Fish which have succumbed to heavy infestation loads will not have been sampled, potentially leading to an underestimate of the true lice levels. Equally, it is possible that those fish with no lice or small levels of lice are better able to evade the net than fish with higher lice levels, potentially leading to overestimates. Therefore presenting a true reflection of infestation levels on the sea trout population as a whole is problematic and leads to an inherent difficulty in drawing meaningful conclusions on threshold levels and their impact on sea trout populations (Middlemas et al., 2010). As long as these inherent difficulties are presented and considered it is possible to draw conclusions that can be attributed to the population and inform local management strategies and policies.

Taranger, *et al* (2014) suggest a risk assessment approach that uses a traffic light system to denote risk to wild salmonid populations based on lice per gram fish weight. It also differentiates by size of fish, with the assumption that fish under 150 g will suffer 100% mortality if infected by >0.3 lice per gram but that an infection of >0.15 lice per gram will have 100% mortality in fish great that 150 g. This approach is being used in Ireland and Norway, and we have run the same model in Scotland (Fig. 5). This will allow the Scottish context to be compared with other major salmon farming areas in Europe, and will support policy development for more effective local management strategies.

This model has been devised for salmonids, and specifically refers to sea trout within the descriptions. This is in contrast to many other analyses undertaken that have been devised primarily for salmon. There are, however, a number of caveats to the use of the Taranger, *et al* analysis, which makes assumptions on the size of fish and the impacts of varying lice levels on the population and that the individuals caught are representative of the entire population within the area.

Not withstanding these caveats, this analysis is a useful and descriptive assessment of the impacts of sea lice on the wild fish populations. Further research is recommended to fully inform and refine our understanding of risks on wild salmonids.

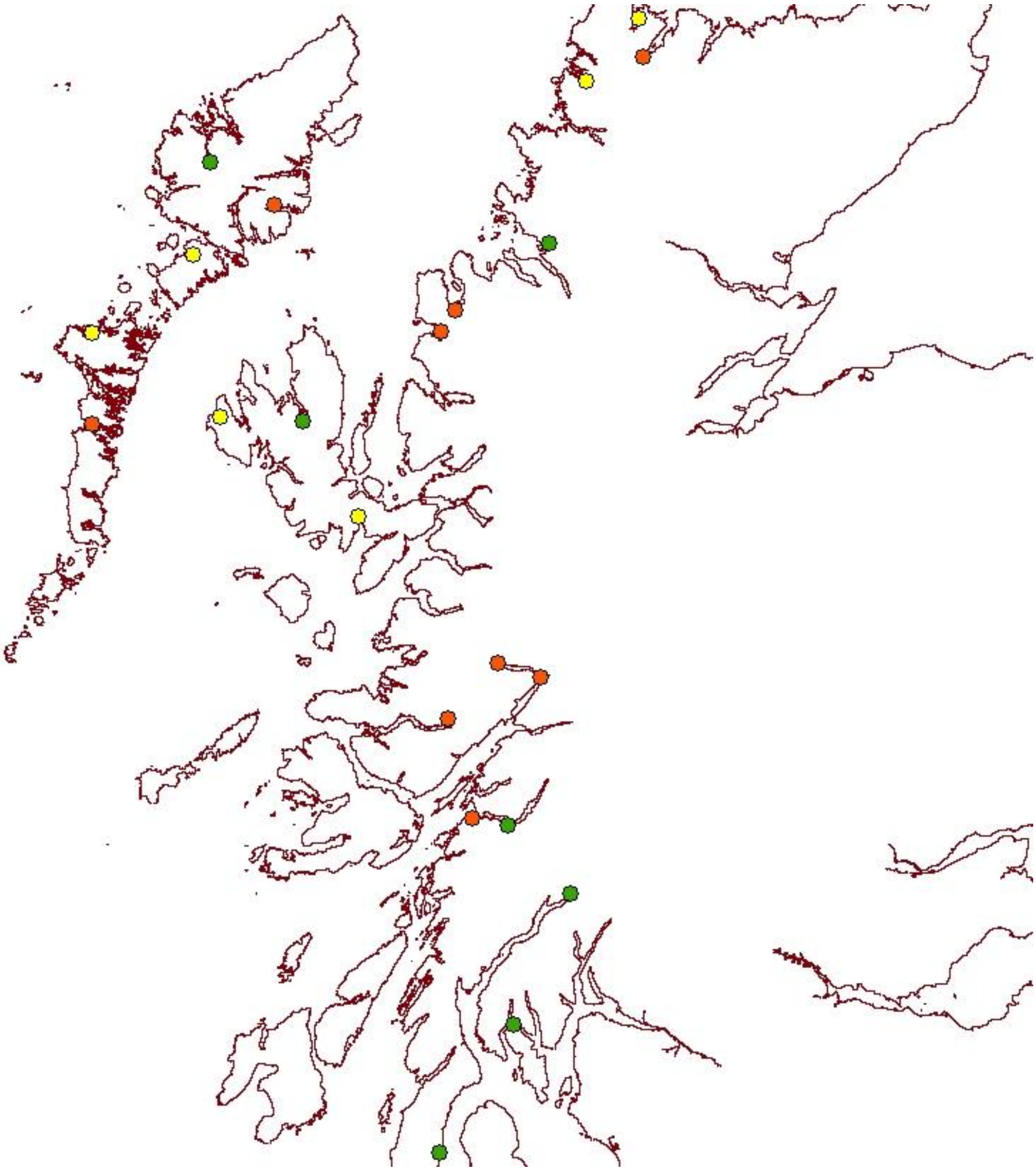

Fig. 5 Risk assessment to the sea trout population, calculated from the Taranger, *et al* model (green denotes low risk, yellow = medium risk and red = high risk)

4 Discussion

The 2017 data provide a snapshot of the levels of sea lice on post-smolt sea trout of the West Coast of Scotland. For this project, no attempt is made to link sea lice levels found on wild sea trout to the nearest salmon fish farm, however the data are viewed in the context of fish farming. Attempting to link sea lice levels on wild sea trout to the nearest fish farm may not be appropriate, as prevailing wind direction and sea currents may transport fish farm derived sea lice away from salmonid rivers (Adams et al. 2012), and sea trout in the marine environment are mobile and can interact with more than one fish farm.

The use of the risk assessment approach developed by Taranger *et al* (2014), using a traffic light system to denote risk to wild salmonid populations, demonstrates the variability of impacts around the country. Of interest, however, is the fact that where several sites exist within a sea loch, they all appear to have the same identified risk. This supports the notion that management decisions, particularly involving industrial developments (including aquaculture), must be made on a wider scale.

This type of analysis will assist with local management decisions. However we need a better understanding of the sea trout populations, their size, the geographical area covered by each population, factors influencing the populations and how they utilise the coastal environment. While the Trusts are able to answer some of these questions there is much that is unknown about the populations within Scotland, particularly in the coastal and marine environment. This should be the basis for additional research in order to fully influence local management strategies.

While Taranger, *et al* (2014) provides an assessment of risks to wild fish from sea lice, there is a need to better understand the relationship between farm-derived sea lice infecting wild salmonids, and *vice versa* in order to better manage the interactions. This will require a greater understanding of the lice populations, their build up within the cages and wider environment and the impacts on the wild salmonids. Until these issues are better understood local management will remain difficult.

Every active fish farm in Scotland is required to conduct regular counts of sea lice on the farmed salmon. These are reported by the Scottish Salmon Producers Organisation and made available as counts of adult female sea lice per management area at www.scottishsalmon.co.uk/publications/.

The SSPO Code of Good Practice suggests treatment thresholds for female adult lice of an average of 0.5 louse per fish during the wild smolt run (February to June inclusive), and an average of 1 louse per fish at other times (July to January inclusive) and it is assumed that these figures are still adhered to. However, it should be noted that these limits are treatment thresholds, and do not state what the maximum permitted lice loadings on farmed fish should be.

5. References

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