AQUACULTURE-WILD FISH: WORKING TOWARDS IMPROVED MANAGEMENT

2015/16

2015 West Coast Fisheries Trusts' Sea Trout

Post Smolt Monitoring Programme

January 2016

RAFTS

Rivers And Fisheries Trusts Of Scotland

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Summary

The Rivers and Fisheries Trusts of Scotland, on behalf of the project partners, has managed the Sea Trout Post Smolt Monitoring Project since 2011. 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 elongates*.

In 2015, the fisheries trusts of the West Coast gathered data from 22 monitoring sites. This involved collecting individual data from almost 1200 captured sea trout.

L. salmonis, the most problematic species of sea lice to sea trout populations, was present at all of the 22 monitoring sites in 2015, compared with *L.salmonis* found at 19 of 21 sites in 2014. At 11 sites over 50% of sea trout were infected with sea lice, with every fish infected at two sites in the Outer Hebrides. The data were analysed to investigate if any sea lice infestations were potentially harmful to sea trout populations using established criteria. Although the results at a number of sites indicated potentially harmful levels of sea lice, only two sites in 2015 had a sufficient sample size and number of sea lice that might indicate an epizootic of sea lice within that population, which were at Camas na Gaul (Lochaber) and Eisgein (Outer Hebrides).

1. Project Background

The 2015 project continues to develop an understanding of the current status and to establish regional trends on interactions between parasitic sea lice and wild fish across the West Coast of Scotland. This is a priority area of work for the Aquaculture-Wild Fish Interactions: Working Towards Improved Management Project. This project is designed to support improved coordination and management of wild fisheries and stocks with the aquaculture industry. There are a number of significant priorities from a wild fish perspective underpinning the work which include: the protection of sensitive and high value fresh water sites; collecting information on wild fish stocks to contribute to help 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. To work towards achieving these strategic objectives three projects were initially identified in 2011 in the Managing Interactions Aquaculture Project 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 is published on the RAFTS website (http://www.rafts.org.uk/aquaculture/). In 2015 only the strategic programme of post smolt sweep netting continues.

The Aquaculture-Wild Fish Interactions: Working Towards Improved Management Project continues much of the work initiated under the Managing Interactions Aquaculture Project.

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 Fisheries Trust
- Skye District Salmon Fisheries Board
- West Sutherland Fisheries Trust
- Outer Hebrides Fisheries Trust
- Western Isles Salmon Fisheries Board
- Lochaber Fisheries Trust (Post Smolt Survey only)

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 RAFTS and its 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 2015.

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 (±1mm) and weight (±1g) 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 and gender, which were 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.

The focus of the subsequent analysis at the monitoring sites described is on the post smolt sea trout populations and included weights, lengths, condition indices and predator damage. Further

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

to the population analysis there will be analysis on the sea lice loadings with comparisons between the monitoring sites.

As highlighted by Hazon *et al* 2006, parasite infestations of hosts generally do not show a normal distribution of variation among individual hosts. Typically, parasite populations show "*overdispersion*", or "*aggregation*" on certain individual hosts (i.e. many or most hosts are parasite-free, but a small number of hosts carry exceptionally heavy infestations). From a statistical viewpoint, it is inappropriate to calculate the arithmetic mean and error terms of infestation intensities if the data are not normally distributed. All lice data in the present study have therefore been log transformed prior to the calculation of the normal mean and error terms. A log transformation usually will stabilize the variance and render the error terms normal. However, calculated means and error terms were subsequently back transformed in order to allow the data to be displayed in a meaningful way. It should be noted however that the back-transformed mean will always be lower than the arithmetic mean. Ensuring that the distribution variation is normalised and appropriately accounted for is crucial to determine if the populations being monitored are experiencing lice loads that could be reported as having a detrimental impact. Analysing such lice loads appropriately can support the local management strategies and policies.

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

- Prevalence: The percentage of fish in the sample infected by sea lice.
- Abundance: The mean number of sea lice per fish in the whole sample.
- Intensity: The mean number of sea lice per infected fish
- Abundance Median: The middle value when ranked numerically of sea lice within the population of fish.

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.

Finally a full range of site environmental factors was recorded at each site. On every visit to the monitoring site, water temperature, air temperature and salinity profiles were recorded. The collection of these environmental factors is important as it has been shown previously that temperature and salinity influence sea lice population dynamics (Butterworth *et al*, 2006).

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

2.2 Site Information

Three new sites were introduced to the monitoring programme for 2015, with the aim to monitor as many aquaculture production areas (http://scottishsalmon.co.uk/) as possible (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, for 2015 this strategy was amended to attempt to monitor wild sea trout populations in as many aquaculture production areas as possible.

Nineteen of the 21 sites visited in 2014 were revisited for 2015. The two sites that we not visited were Loch Goil in Argyll and Kinloch in West Sutherland: due to the nature and locations of these sites, they were not felt to contribute to this monitoring programme. 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 (see appendix 6).

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 1 shows the number of sea trout collected from each monitoring site.

Table 1: Monitoring Site Details

Site ID 2015	Site Name	Fishery Trust Area	Distance to nearest salmon fish farm (km)	Year Site First Sampled
1	Carradale	Argyll	7	2007
2	Loch Fyne	Argyll	24	2005
3	Loch Riddon	Argyll	15	2005
4	Dunstaffnage	Argyll	3	2002
6	Kinlocheil	Lochaber	20	1999
7	Camas na Gaul	Lochaber	6	2002
9	Borrodale	Lochaber	12	2012
10	Tong	Outer Hebrides	38	2009
12	Borve	Outer Hebrides	10	2003
13	Eisgein	Outer Hebrides	3	2009
14	Kyles	Outer Hebrides	29	2007
15	Malacleit	Outer Hebrides	20	2006
25	South Ford	Outer Hebrides	6	2015
26	Morsgail	Outer Hebrides	8	2015
16	Kyles of Durness	West Sutherland	40	2009
17	Polla	West Sutherland	10	1997
18	Laxford	West Sutherland	5	1997
20	Kannaird	Wester Ross	3	2007
21	Boor Bay	Wester Ross	8	2008
22	Flowerdale	Wester Ross	26	2009
23	Slapin	Skye	50	2009
27	Varagill	Skye	2	2015

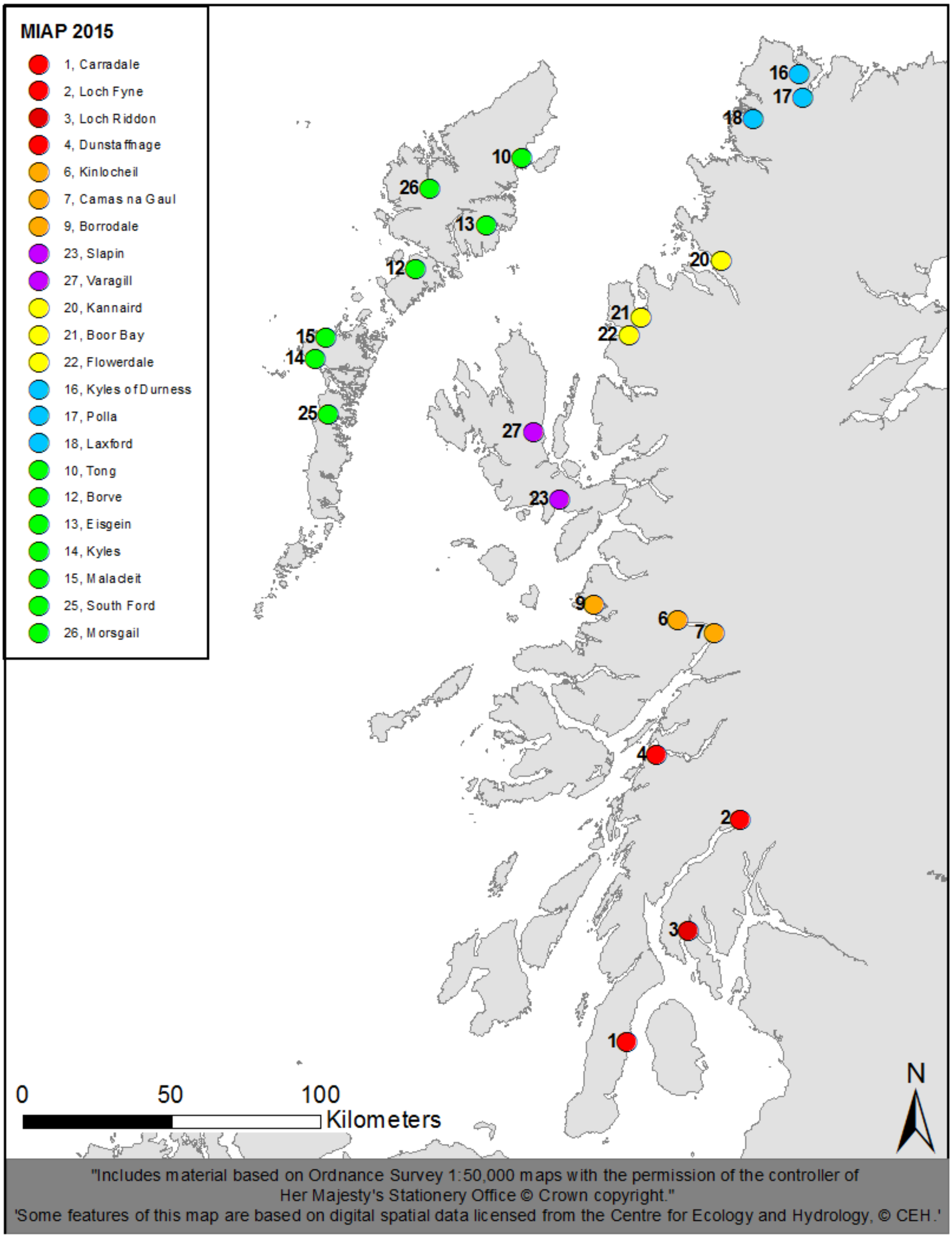

Figure 1: Geographical spread of monitoring sites sampled in 2015

3. Sweep Netting Analysis Results

3.1. Sea Trout Analysis

In 2015, the total number of sea trout caught was 1191. The SFCC Protocol calls for a target of a minimum of 30 fish per sample, however it recognises that it is not always possible to achieve this.

This compares with 946 post-smolt sea trout in 2013 and 971 in 2012. Under the SFCC protocol, the recommended sample size for statistical analysis is currently advised as 30 sea trout. 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.

To explore the sea trout post smolt condition factor, Fulton's 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 for Fulton's Condition Factor is:

$$K = \frac{W}{L^3}$$

K = Fulton Condition Factor

W = Weight

L = Total Length

Finally a scaling factor is implemented to bring the factor close to 1.

As a general rule a condition factor of 1 or above would be considered healthy. Of the 21 monitoring sites for 2015, the calculated Fulton Condition Factor was 'healthy' for 15 sites, with six sites falling just below a condition factor of 1. 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). The consistency of size of fish across sites and across years suggests that there are no major differences in the size of sea trout between years, which indicate that changes in sea lice levels are not due to fish size (see 2014 report; http://www.rafts.org.uk/aquaculture/).

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

Site ID 2015	Site Name	Total Fish Caught 2015	Mean Length (mm)	Mean Weight (g)	Mean Condition Factor
1	Carradale	60	161	49	1.07
2	Loch Fyne	73	230	202	1.13
3	Loch Riddon	149	157	93	1.13
4	Dunstaffnage	37	211	56	1.11
6	Kinlocheil	41	151	43	1.02
7	Camas na Gaul	77	194	92	1.15
9	Borrodale	21	231	25	0.9
10	Tong	99	198	93	1.14
12	Borve	100	184	74	1.13
13	Eisgein	83	182	76	1.15
14	Kyles	40	215	124	1.19
15	Malacleit	9	218	135	1.21
25	South Ford	16	228	149	1.21
26	Morsgail	18	171	68	1.15
16	Kyles of Durness	58	205	97	1.07
17	Polla	47	218	209	1.02
18	Laxford	152	239	167	0.97
20	Kannaird	14	214	160	0.98
21	Boor Bay	44	216	113	0.92
22	Flowerdale	20	178	63	1.01
23	Slapin	22	236	108	0.82
27	Varagill	11	219	141	0.9

3.2 Sea Lice Analysis

3.2.1 *L. salmonis* all life Stages.

Of the 14 sites with a sample size greater than 30 sea trout, the sites with the highest prevalence of *L.salmonis* were Dunstaffnage (Argyll) with 97%; Kyles and Eisgein (Outer Hebrides) with 73% and 78% respectively.

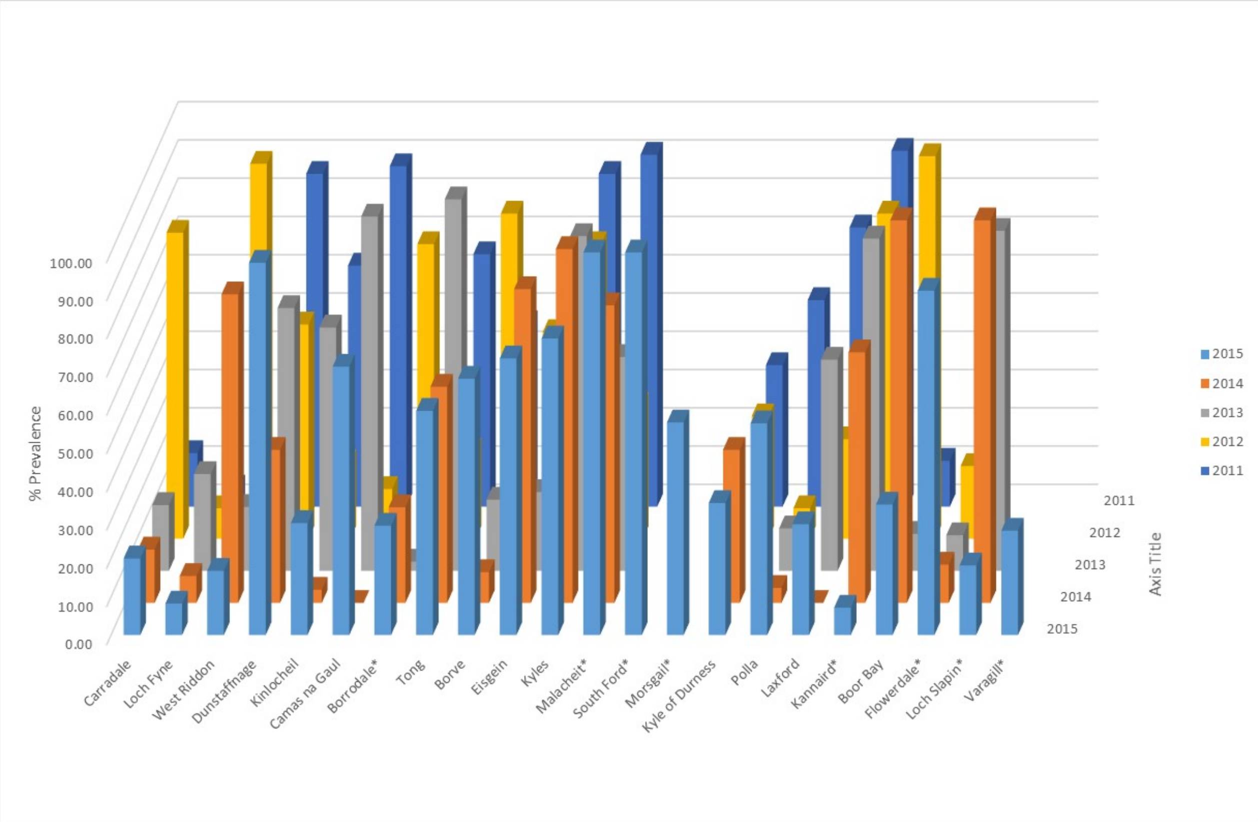

*Figure 2: L. salmonis all life Stages Prevalence results for 2012, 2013, 2014 and 2015 for all sites. (Sites with * denote < 30 fish caught)*

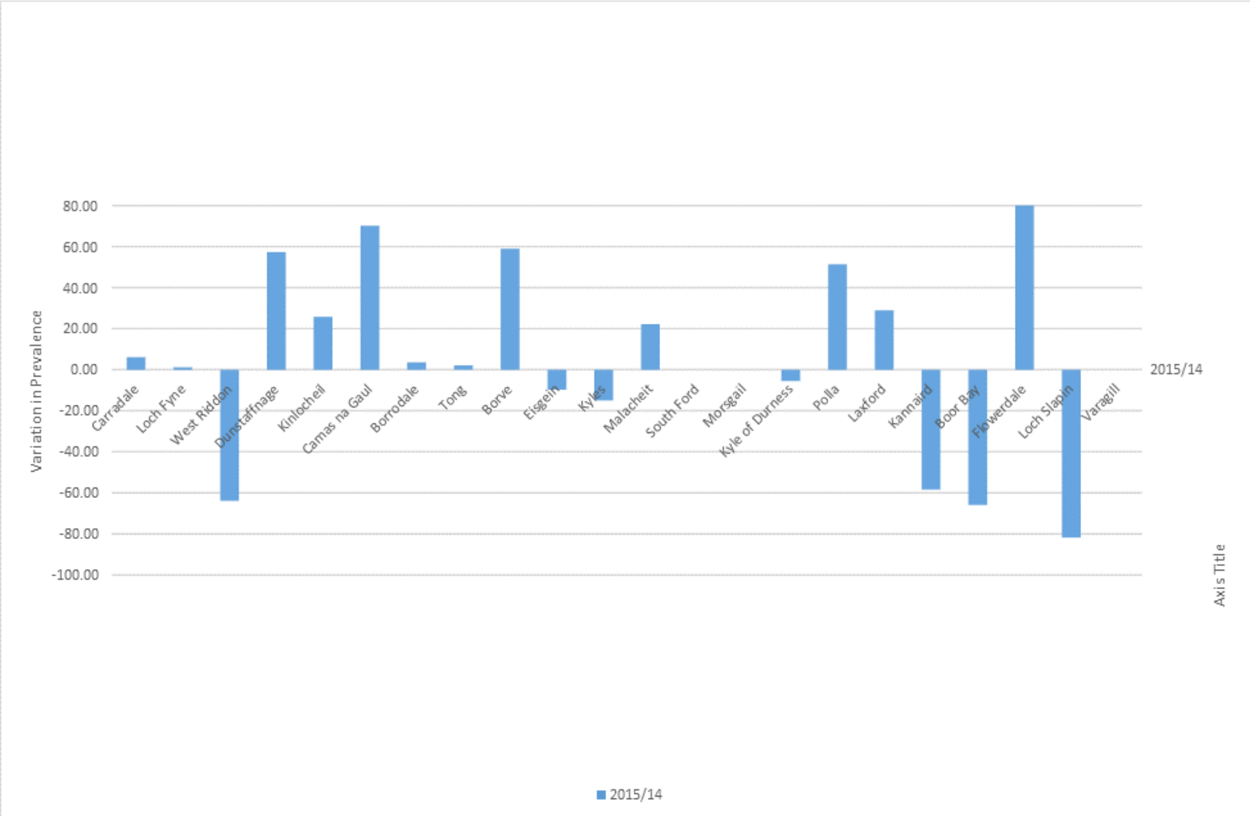

Figure 3: Variation in prevalence between 2015 and 2014.

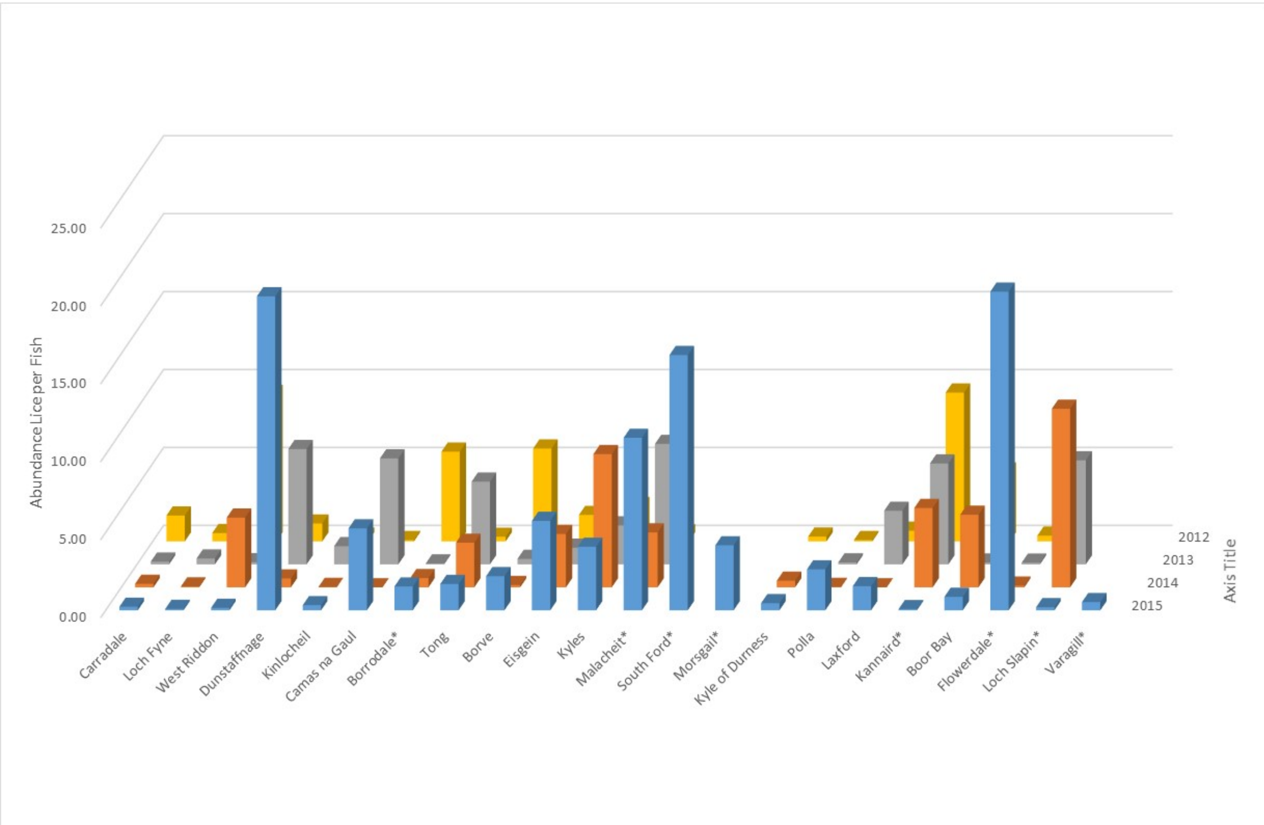

*Figure 4: Back Transformed Abundance for all L. salmonis stages at each monitoring site for 2012, 2013, 2014 and 2015. (Sites with * denote < 30 fish caught)*

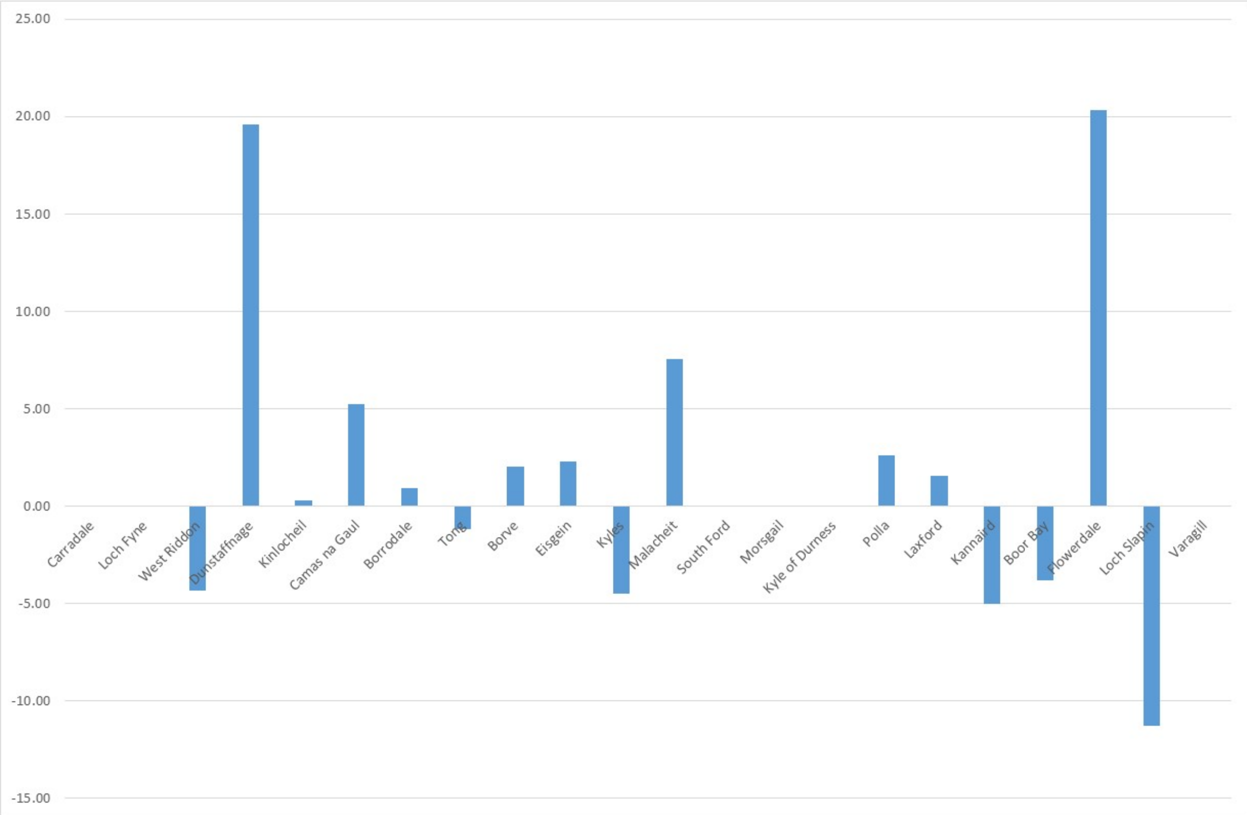

Figure 5: Variation in abundance between 2015 and 2014 data.

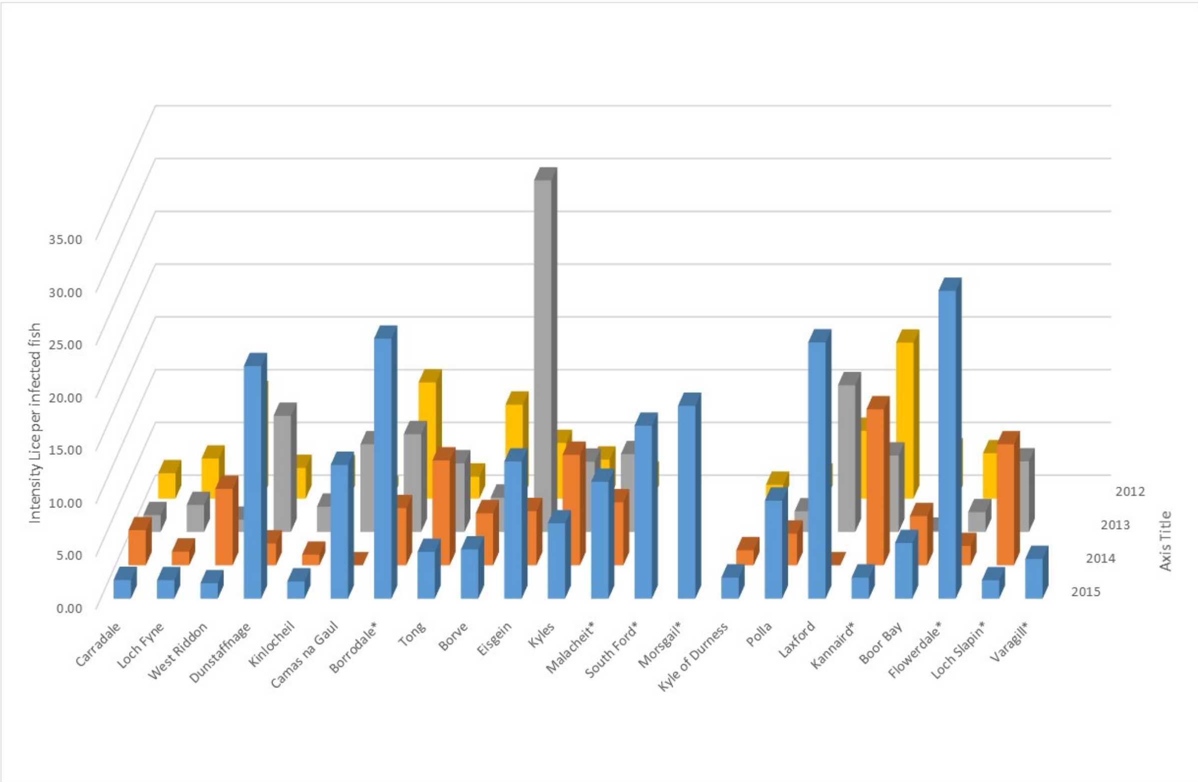

*Figure 6: Back Transformed Intensity for all L. salmonis stages at each monitoring site for 2012, 2013, 2014 and 2015. (Sites with * denote < 30 fish caught)*

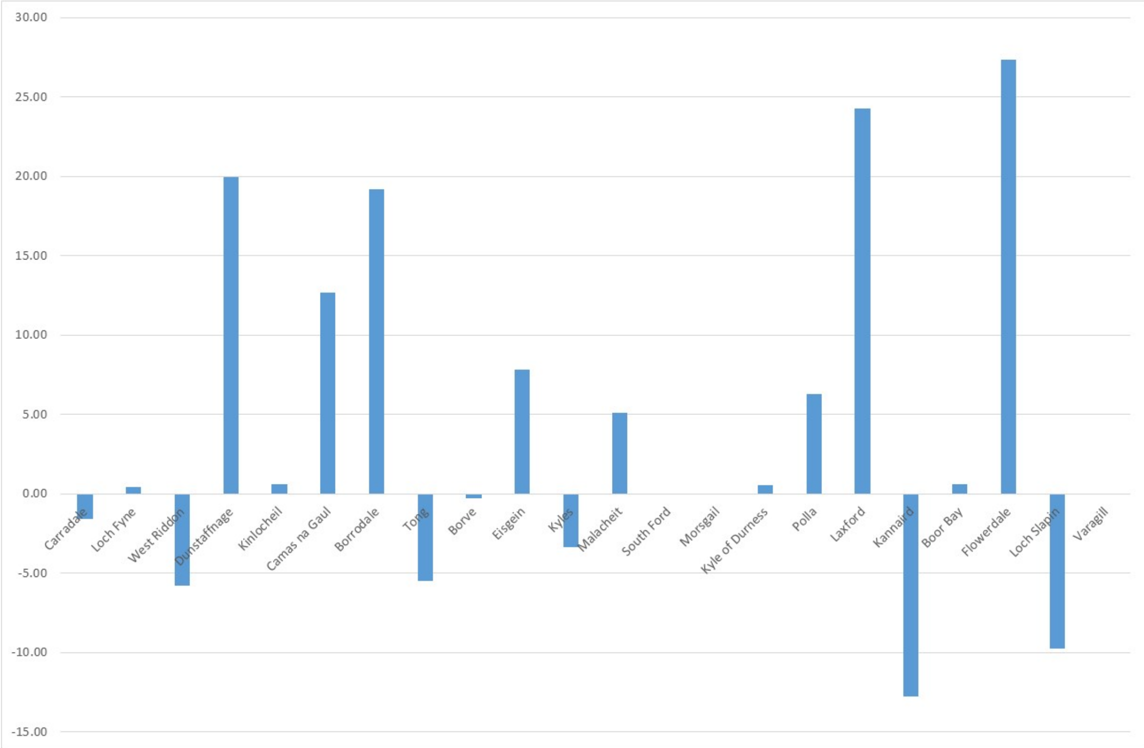

Figure 7: Variation in intensity between 2015 and 2014.

3.2.2 *C. elongatus*

Caligus elongatus is smaller than *L. salmonis*, lighter in colouration and a host generalist (Wootten *et al*., 1982) that has been recorded on over eighty host species (Kabata, 1979). The *C. elongatus* life cycle has fewer stages then *L. salmonis* as it moults directly from chalimus IV to the adult stages (Piasecki, 1996). Whilst currently of lesser concern in Scotland than the salmon louse *L. salmonis, C. elongatus* is present and does have the potential to become a problem. Bergh *et al*., 2001 reported high intensity *C. elongatus* infestations, and consequentially severe head lesions, for juvenile farmed halibut *Hippoglossus hippoglossu*. As a host generalist there are possibilities in Scotland that if levels become elevated, both farmed and wild fish could experience detrimental problems from *C. elongatus*.

From the data collected across the monitoring sites in 2015 *C. elongatus* was present in two trust areas: Outer Hebrides and West Sutherland. Where *C.* elongates was found, prevalence and abundance figures were relatively low across monitoring sites in 2015, and *C. elongatus* was not considered a detrimental factor to sea trout populations.

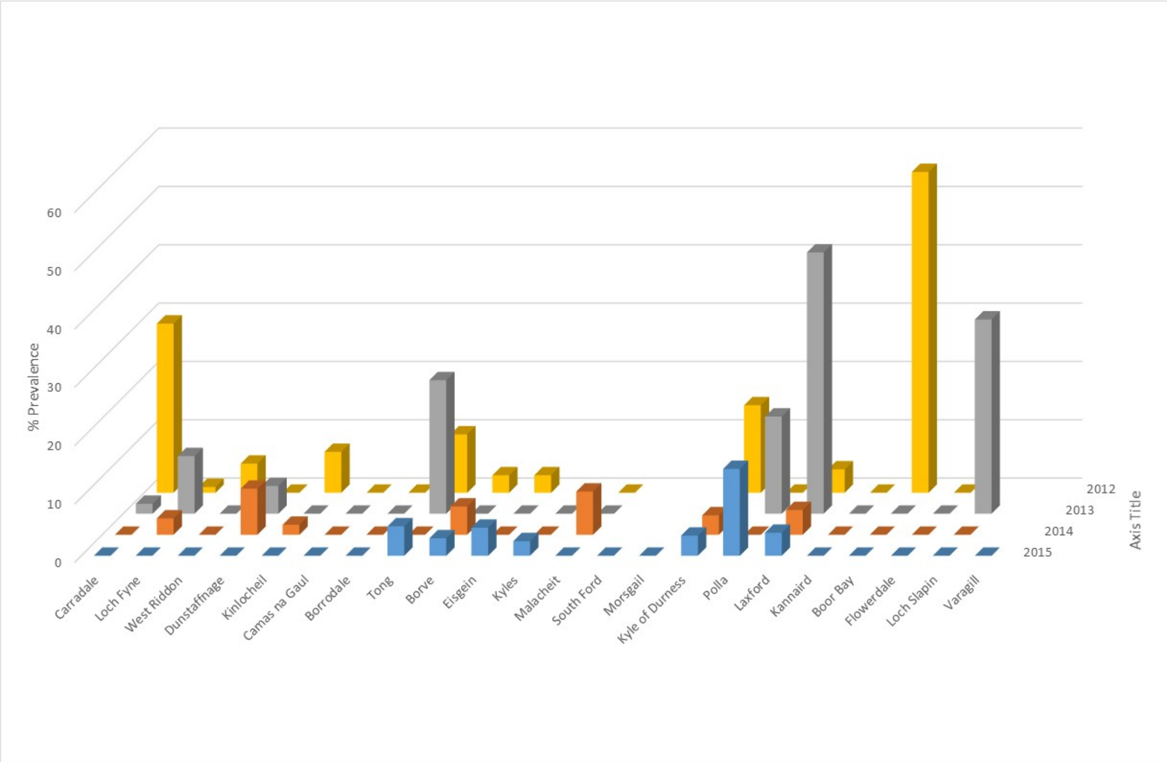

Figure 8: Caligus elongatus prevalence for 2012, 2013, 2014 and 2015.

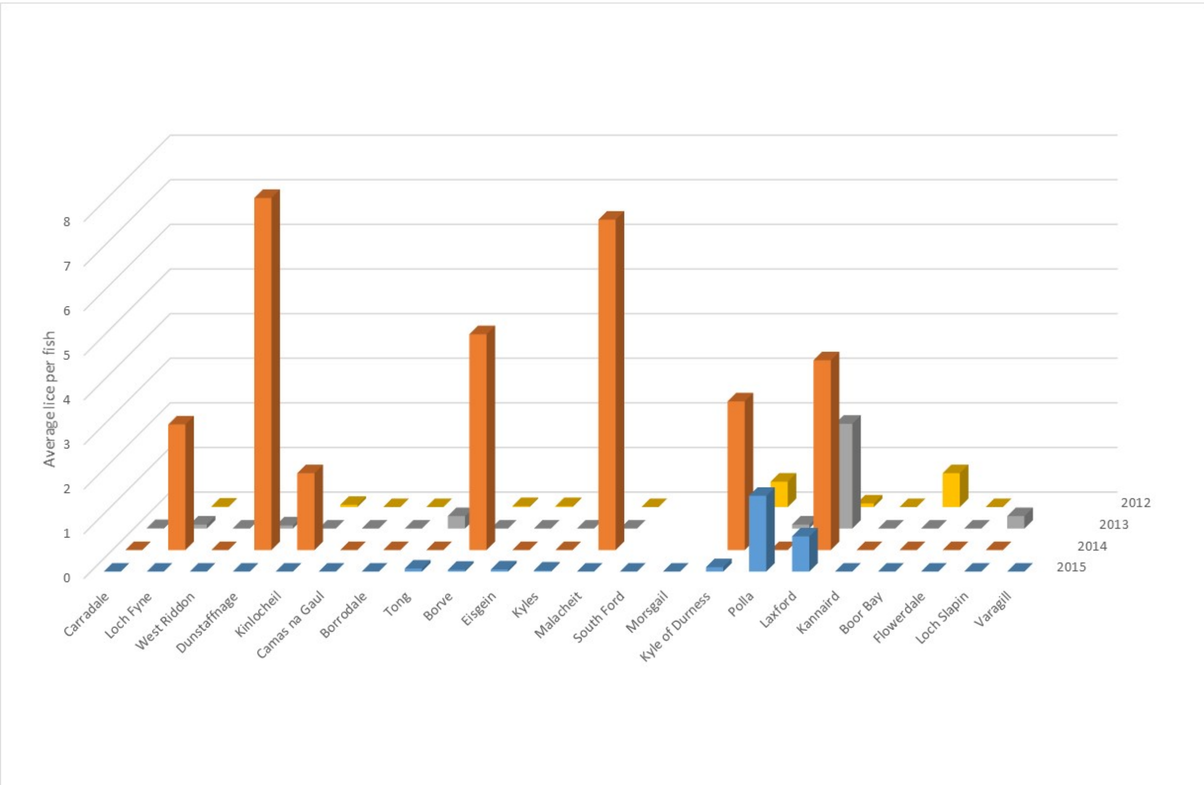

Figure 9: Caligus elongatus abundance for 2012, 2013, 2014 and 2015.

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.

To further explore the sea lice infestation pressure on wild sea trout populations, data from each monitoring site were examined to determine if the levels of observed sea lice infection could be classed as an epizootic. Sea lice epizootics are characterised by mass fatal infestations of the earliest life-stages of salmon lice, and although currently rare in Scotland they have previously been reported (Butler, 2002). Epizootics recorded on sea trout in Europe and Pacific salmon in British Columbia tend to have over 60% prevalence and more than 5 lice per fish (Costello, 2009 and Beamish *et al*, 2009).

Based on the 2015 results, sea trout from six sites experienced potentially epizootic levels of sea lice: these were Dunstaffnage, Camas na Gaul, Eisgein, Malacleit, South Ford and Flowerdale. Identifying potential epizootics only indicates that these sea trout populations are experiencing heavy, large infestations and further analysis is required to determine if these high observed levels are having a detrimental impact. To examine these high levels in more depth a tolerance threshold level was explored.

The threshold level for impact to be explored is from Wells *et al*. (2006) where this study found that abrupt changes in a range of physiological parameters occurred at thirteen mobile lice per fish (weight range 19-70g). This level could be detrimental to the fish host. It was suggested within this study that a management strategy should be applied if the populations are experiencing more than 13 mobile lice per fish. The lice figures used in this analysis were all mobile stages and the proportion of chalimi converted into the expected number of mobile lice. To calculate the likely survival rate of chalimi to adult stages Bjørn and Finstad (1997) recommended survival rate of 0.63 which was implemented. Only those fish below 198mm (the equivalent of 70g) were considered in this analysis. It was also deemed appropriate only to consider monitoring sites that have sample sizes of thirty fish or greater.

In 2015, there were insufficient fish under 198mm sampled at Dunstaffnage, Malacleit, South Ford and Flowerdale sites (Table 1) to conduct a robust analysis. However, at Camas na Gaul and Eisgein sufficient fish under 198mm were sampled. Analysis of the results showed that 13% of sea trout at Camas na Gaul and 20% of sea trout at Eisgein carried a mobile sea lice burden in excess of 13 lice per fish, indicating that these populations are at increased risk of harm from sea lice. For information purposes only, of a sample size of 17 fish under 198mm, 47% of fish at Dunstaffnage had greater than 13 mobile lice, while at Flowerdale from a sample size of 10 30% of fish had greater than 13 mobile lice.

4 **Discussion**

4.1 Managing Interactions

The 2015 data provide a snapshot of the levels of sea lice on post-smolt sea trout of the West Coast of Scotland. The current sampling strategy is designed to explore the relationship between sea lice burdens on post-smolt sea trout and the distance to the nearest salmon aquaculture site to build upon the analysis conducted by Middlemas *et al.* (2012). 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.

When considering the epizootic threshold (Costello, 2009) and the *L. salmonis* mobile threshold (Wells *et al,* 2006), it is possible to identify the sea trout populations in the study areas that are under pressure from detrimental sea lice loadings. It is important that management strategies are developed to support the reduction of sea lice burdens on such post smolt populations.

There is currently no guidance on the acceptable proportion of fish exceeding the Wells *et al* (2006) threshold. However, the final report of the EU project "Sustainable Management of Interactions between Aquaculture and Wild Salmonid" Hazon *et al* (2006) proposes:

"*that a level of 10% or fewer of wild sea trout in any given population in Ireland bearing total infestations of ≥13 lice/fish should be adopted as indicative of a satisfactory or acceptable lice loading. Within any given sea trout stock, frequencies of heavily-infested juvenile sea trout (i.e. those ≥13 lice/ fish) >10% should perhaps be considered a cause for concern*."

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, rather than using fish with a lice load of *≥13 lice/fish*. This approach is being used in Ireland and Norway, and we propose using the same approach in Scotland. This would 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.

To fully benefit from using the Taranger et al approach for displaying risk to wild salmonid populations from sea lice, research is recommended which will inform and refine our understanding of risks to wild salmonids.

- Fundamentally, we need to better understand sea trout populations, such as their size, the geographical area covered by a population, what factors influence the populations, and how sea trout behave in the coastal environment.

- We need to better understand salmon migration routes, as well as developing methods to monitor wild smolts in coastal environments. The use of towed sentinel cages may be useful for this work.

- We need to better understand the relationship between farm-derived sea lice infecting wild salmonids, and vice versa. We also need to better understand at what point raised lice levels become harmful to wild salmonid populations. The aquaculture Code of Good Practice does not address this issue, and until it is better understood local management will be difficult.

4.2 Farmed fish sea lice counts.

Every active fish farm in Scotland is required to conduct regular counts of sea lice on the farmed salmon. The Scottish Salmon Producers Organisation (SSPO) collates and aggregates the data, which are published in publicly available reports on their website for 30 management regions across Scotland (reports can be downloaded from http://www.scottishsalmon.co.uk/science/sea_lice/regional_reports%281%29.aspx).

The lice counts are for adult female sea lice, and therefore do not include chalimus, pre adult or adult male stages, which are included in the post smolt sweep netting counts. The values provided are averages for all active farms within a production area and do not give details of sea lice levels on individual farms. 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). 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. Conclusions

In 2015 at 22 monitoring sites across the West coast and islands of Scotland nearly 1200 sea trout were evaluated and essential data recorded. Sea lice were recorded on wild sea trout at all 22 locations.

The 2015 data indicate that two sites experienced sea lice infestations that could impact at a population level. The management threshold level for infestation levels (Wells et al, 2006) was used to determine if the infection levels resulted in detrimental impact effects. This critical threshold level indicates that one of the monitoring sites had elevated levels of sea lice presence within the fish population that potentially could be having a critical detrimental impact. For future work, it is recommended that the analysis developed by Taranger et al (2014) is used: this method is currently being used by researchers in Norway and Ireland, allowing international comparisons to be made; lice impacts are assessed for all sea trout and is not restricted to those up to 198mm, as is the case with the Wells analysis; and the traffic light system is easier for regulators and other stakeholders to understand.

This report is intended to simply present the data, and does not attempt to draw conclusions about the impact of salmon aquaculture on the wild fish populations of the West Coast of Scotland. It is recommended that a robust statistical analysis be conducted on all data collected for this project since 2011 to answer some of the fundamental questions relating to interactions between wild salmon and aquaculture.

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7. Appendices

Appendix 1

Table A2: Prevalence, Abundance, Intensity and Median analysis for Copepodid/Chalimi at each monitoring site 2015

Site ID	Site Name	Sample Size	Prevalence	Abundance	Intensity	Median
1	Carradale	60	16.67	0.15	1.26	0
2	Loch Fyne	73	0	0	0	0
3	West Riddon	149	9.4	0.07	1.12	0
4	Dunstaffnage	37	89.19	15.13	21.6	18
6	Kinlocheil	41	19.51	0.18	1.29	0
7	Camas na Gaul	77	64.94	3.83	10.32	4
9	Borrodale	21	14.29	0.27	4.43	0
10	Tong	99	14.14	0.27	4.46	0
12	Borve	100	27	0.79	7.57	0
13	Eisgein	83	45.78	1.87	9.02	0
14	Kyles	40	25	0.82	9.9	0
15	Malacheit	9	77.78	5.66	10.45	8
25	South Ford	16	68.75	6.9	19.22	8
26	Morsgail	18	38.89	2.11	17.46	0
16	Kyle of Durness	58	8.62	0.1	2.1	0
17	Polla	47	17.02	0.47	8.46	0
18	Laxford	152	26.97	1.47	27.65	0
20	Kannaird	14	7.14	0.05	1	0
21	Boor Bay	44	18.18	0.58	11.45	0
22	Flowerdale	20	85	14.56	24.25	18
23	Loch Slapin	22	0	0	0	0
27	Varagill	11	18.18	0.18	1.45	0

Appendix 2

Table A3: Prevalence, Abundance, Intensity and Median analysis for Preadult/Adult at each monitoring site 2015

Site ID	Site Name	Sample Size	Prevalence	Abundance	Intensity	Median
1	Carradale	60	10	0.1	1.57	0
2	Loch Fyne	73	8.2	0.07	1.4	0
3	West Riddon	149	8.05	0.09	1.82	0
4	Dunstaffnage	37	67.57	2.18	4.55	2
6	Kinlocheil	41	17.07	0.17	1.48	0
7	Camas na Gaul	77	63.64	1.66	3.65	1
9	Borrodale	21	28.57	1.27	16.61	0
10	Tong	99	56.57	1.44	3.86	1
12	Borve	100	60	1.45	3.45	1
13	Eisgein	83	72.29	4.03	8.36	6
14	Kyles	40	70	2.01	4.03	2
15	Malacheit	9	77.78	2.98	4.91	4
25	South Ford	16	93.75	4.63	5.32	6
26	Morsgail	18	55.56	2.42	8.16	3
16	Kyle of Dur-ness	58	29.31	0.3	1.48	0
17	Polla	47	53.19	2.21	7.98	1
18	Laxford	152	3.29	0.04	2.2	0
20	Kannaird	14	7.14	0.05	1	0
21	Boor Bay	44	22.73	0.34	2.58	0
22	Flowerdale	20	50	1.63	5.91	0.5
23	Loch Slapin	22	18.18	0.19	1.63	0
27	Varagill	11	27.27	0.39	2.3	0

Appendix 3

Table A4: Prevalence, Abundance, Intensity and Median analysis for Ovigerous Females at each monitoring site 2015.

Site ID	Site Name	Sample Size	Prevalence	Abundance	Intensity	Median
1	Carradale	60	0	0	0	0
2	Loch Fyne	73	2.74	0.02	1.45	0
3	West Riddon	149	0.67	0.01	2	0
4	Dunstaffnage	37	2.7	0.19	1	0
6	Kinlocheil	41	0	0	0	0
7	Camas na Gaul	77	12.99	0.12	1.35	0
9	Borrodale	21	23.81	0.57	5.65	0
10	Tong	99	8.08	0.07	1.18	0
12	Borve	100	2	0.01	1	0
13	Eisgein	83	18.07	0.25	2.48	0
14	Kyles	40	42.5	0.74	2.66	0
15	Malacheit	9	33.33	0.62	3.22	0
25	South Ford	16	43.75	0.73	2.52	0
26	Morsgail	18	16.67	0.21	2.11	0
16	Kyle of Dur-ness	58	6.9	0.06	1.21	0
17	Polla	47	8.51	0.09	1.63	0
18	Laxford	152	0	0	0	0
20	Kannaird	14	0	0	0	0
21	Boor Bay	44	0	0	0	0
22	Flowerdale	20	20	0.15	1	0
23	Loch Slapin	22	4.55	0.03	1	0
27	Varagill	11	9.09	0.07	1	0

Appendix 4

Table A5: Prevalence, Abundance, Intensity and Median analysis for total L. salmonis at each monitoring site 2015

Site ID	Site Name	Sample Size	Prevalence	Abundance	Intensity	Median
1	Carradale	60	20.00	0.23	1.77	0
2	Loch Fyne	73	8.22	0.09	1.75	0
3	West Riddon	149	16.78	0.16	1.46	0
4	Dunstaffnage	37	97.29	20.15	22.03	26
6	Kinlocheil	41	29.27	0.33	1.63	0
7	Camas na Gaul	77	70.13	5.26	12.67	5
9	Borrodale	21	28.57	1.53	24.63	0
10	Tong	99	58.59	1.69	4.43	1
12	Borve	100	67.00	2.19	4.66	1.5
13	Eisgein	83	72.29	5.74	12.99	10
14	Kyles	40	77.50	4.08	7.13	4.5
15	Malacheit	9	100.00	11.07	11.07	14
25	South Ford	16	100.00	16.38	16.38	16.5
26	Morsgail	18	55.56	4.17	18.27	4
16	Kyle of Durness	58	34.49	0.46	2	0
17	Polla	47	55.32	2.63	9.28	1
18	Laxford	152	28.95	1.55	24.27	0
20	Kannaird	14	7.14	0.08	2	0
21	Boor Bay	44	34.09	0.87	5.27	0
22	Flowerdale	20	90.00	20.45	29.16	19.5
23	Loch Slapin	22	18.18	0.20	1.74	0
27	Varagill	11	27.27	0.53	3.76	0

Appendix 5: Long term data series

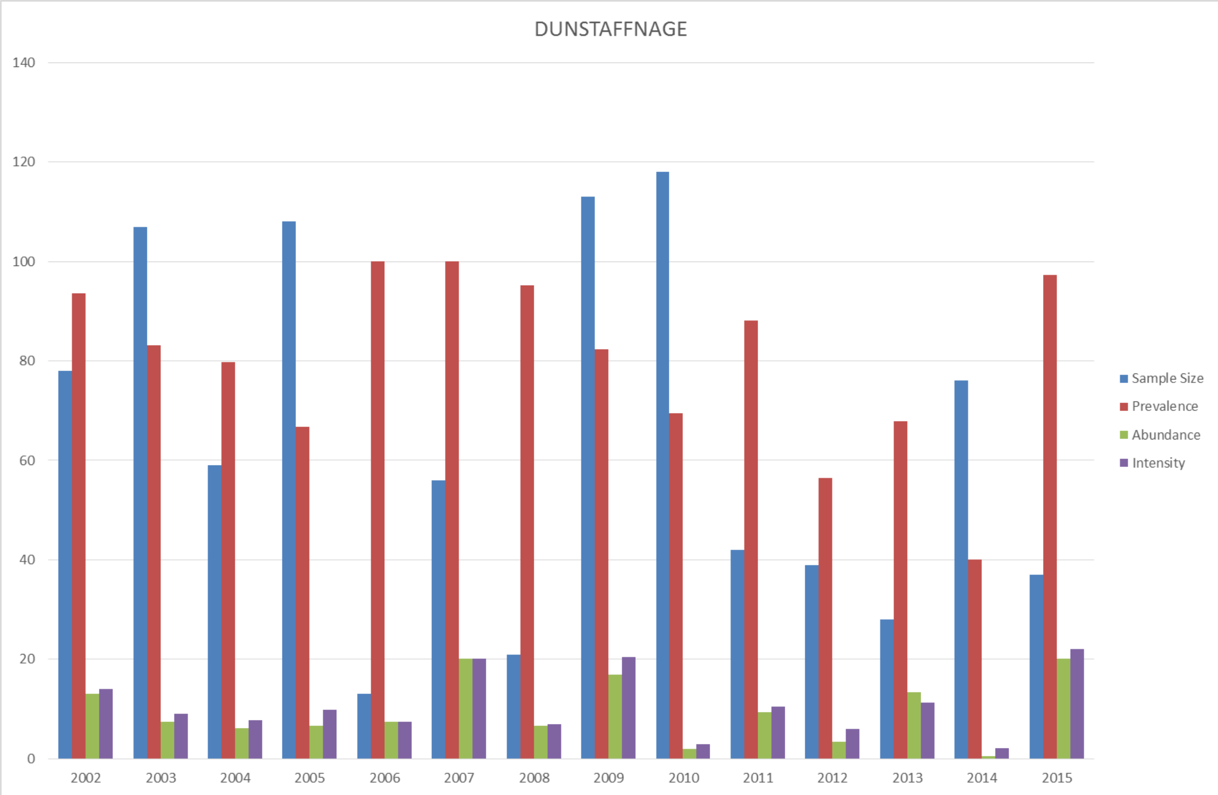

Figure A1: Abundance and intensity values for Dunstaffnage from 2002-2015

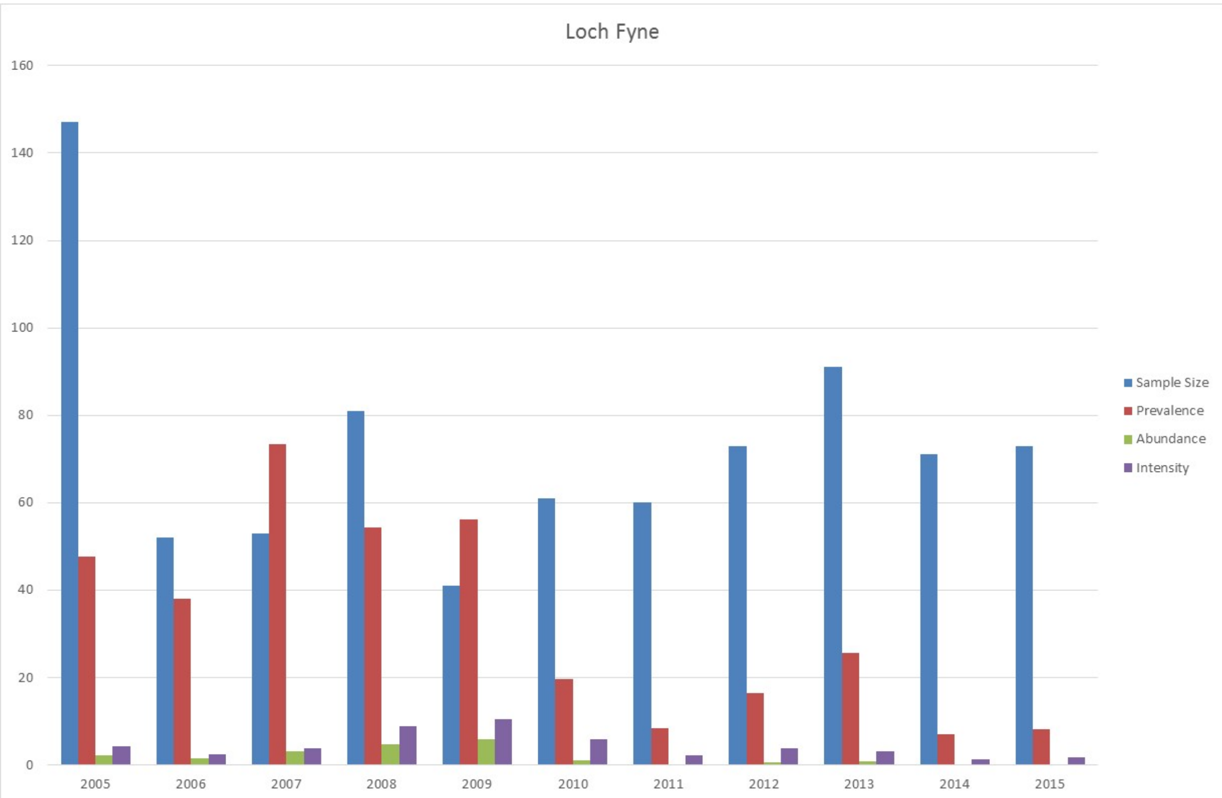

Figure A2: Abundance and intensity values for Loch Fyne from 2005-2015

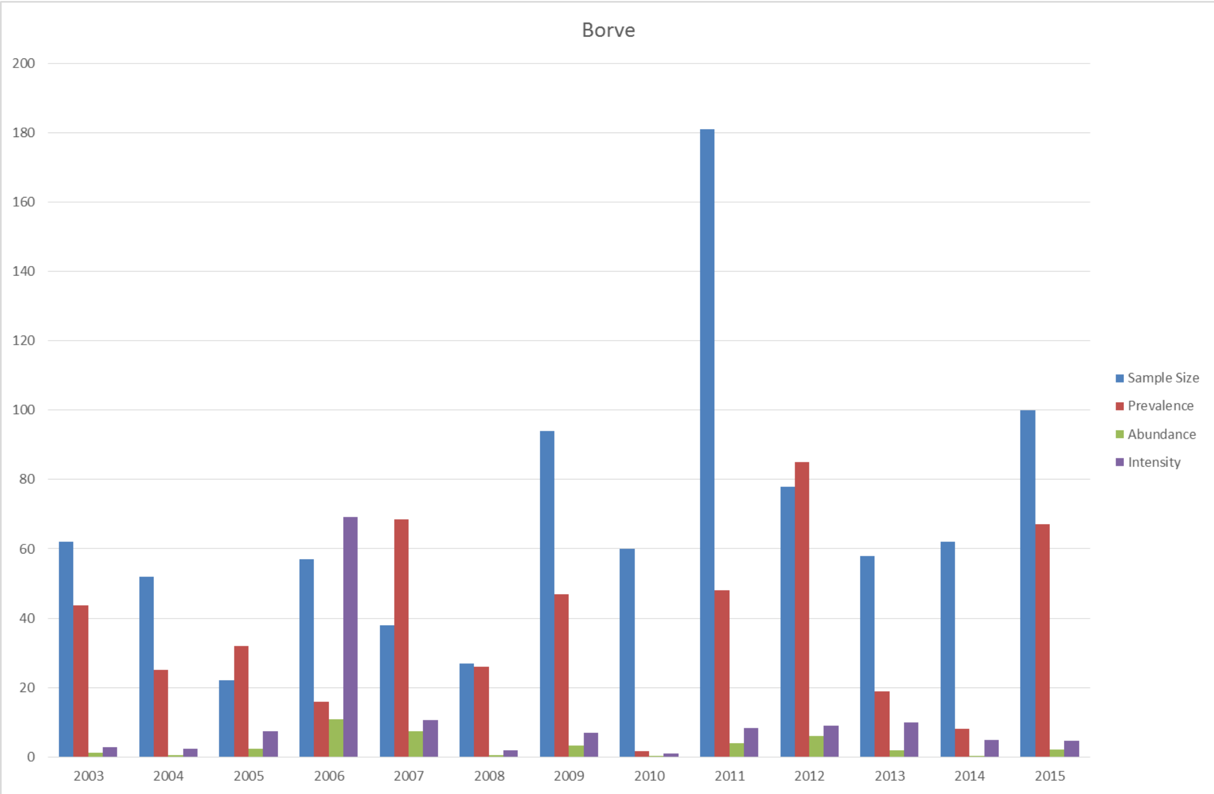

Figure A3: Abundance and intensity values for Borve from 2003-2015

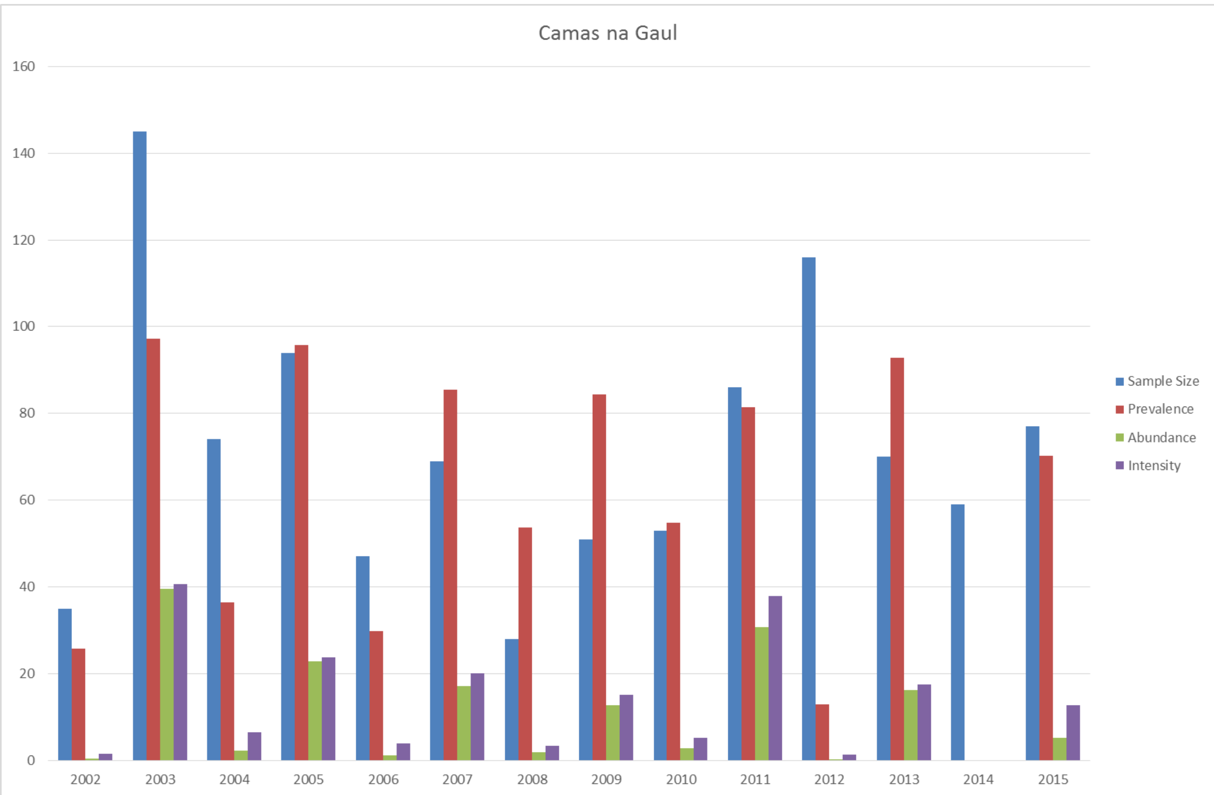

Figure A4: Abundance and intensity values for Camas na Gaul from 2002-2015

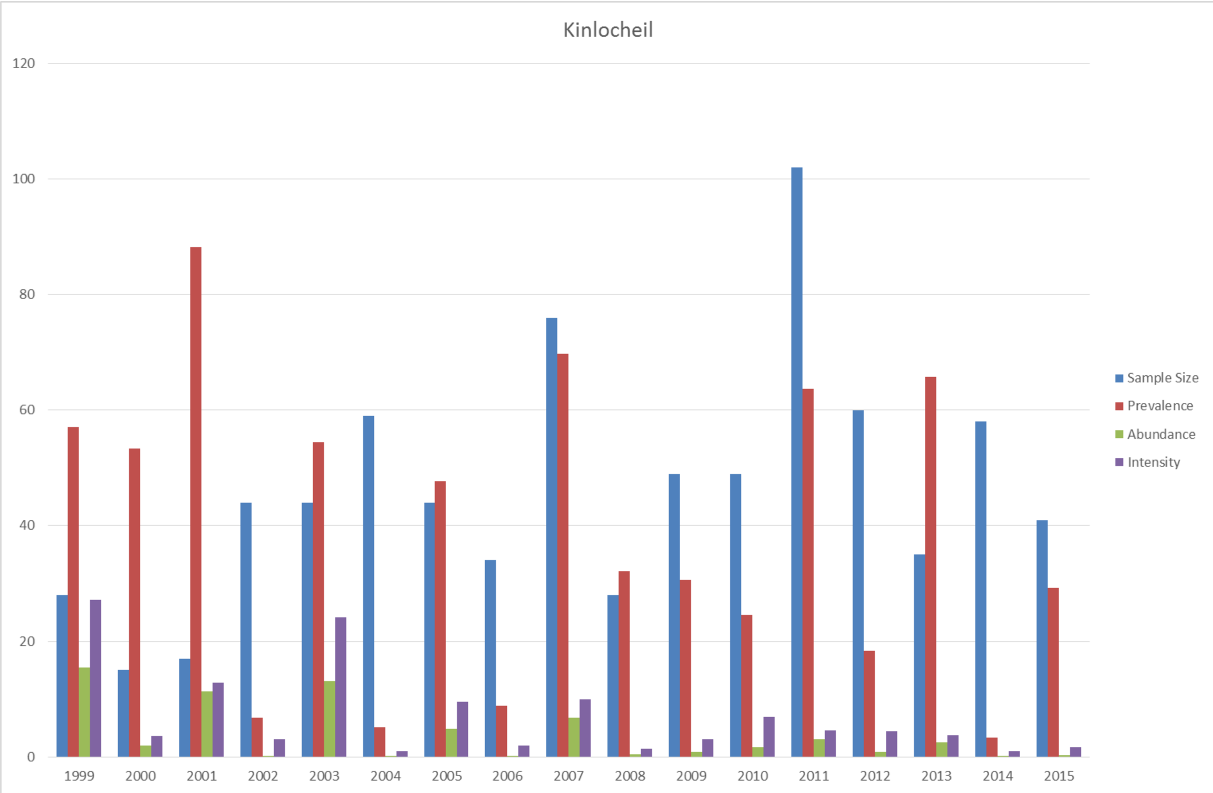

Figure A5: Abundance and intensity values for Kinlocheil from 1999-2015