Monitoring of sea trout post-smolts, 2017

A report to the West Sutherland Fisheries Trust, Report No. WSFT2/18

January 2018

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Introduction

Started in 1997, this project has enabled the establishment of a good database of the population dynamics of sea trout within the area. Additional information about lice burdens on the trout within the estuaries has also provided an analysis of the relationship between fish farms and sea trout, with particular regard to sea lice (Marshall 2003; WSFT 2017).

The monitoring of post-smolts was originally designed to give an indication of the migrations and growth of sea trout within the area. The individual tagging of fish, combined with the measurements taken at capture, gave a baseline from which to assess these parameters following re-capture by nets or rod and line. In addition to these data, the numbers of sea lice were also assessed. This has now progressed, such that sea lice counts are the main part of the project, with the tagging of fish giving additional information. No fish were tagged from the Kyle of Durness, although all other information was collected.

Materials & Methods

Three estuaries, Laxford Bay, the Polla estuary and the Kyle of Durness were sampled monthly where possible from May to September, at low tide. Sampling was performed using a 50 m sweep net with a stretched mesh size of 15 mm hand pulled in a large circle to give one sweep of the area. Differences between the number examined and tagged (Table 1) reflect the presence of recaptures, the small size of trout involved or difficulties in loading the injector. Where trout <15 cm are involved, injection of the tags can prove difficult with only a thin membrane available to hold the tag and is therefore not undertaken.

All sea trout were removed and anaesthetised with 2-Phenoxyethanol. The length (± 1 mm) and weight (± 1 g) were recorded, scales removed and a visible implant (VI) tag implanted behind the eye. The fish were examined for the presence of sea lice, which were counted and roughly staged, i.e. chalimus, mobile, adult and gravid female.

The condition index for the trout was calculated from the length and weight such that:

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

Throughout this document, post-smolts are defined as fish that went to sea in this year. Adults refer to fish that have had one year or more at sea.

The Specific Growth Rate (SGR) was calculated for the recaptured fish to give annual variations, such that:

SGR = (((ln(final wt) – ln(initial wt))*100)/time), where weight is in grams and time in days.

Results and Discussion

The largest catch within a single sweep was 156 fish in the Laxford estuary during May (Table 1). A comparison of the catches with time in all estuaries demonstrates the variability in the abundance of fish within the sample sites and the difficulties in using these results to demonstrate population size. The by-catch from the netting in both estuaries was as expected from previous years, with few species and low numbers observed.

Table 1 The number of fish examined and tagged, by estuary and month

	Laxford Bay		Polla estuary		Kyle of Durness
Month	No. examined	No. tagged	No. examined	No. tagged	No. examined
May	56*	11	22	1	6
June	41	2	27	10	43
July	7	5	-	-	25
August	20	12	26	16	7
September	26	15	-	-	9

(*plus 100)

Age, Length, Weight and Condition of Fish Captured

The fish caught were of varied age (Fig. 1) and length (Fig. 2), reflecting a mixed population structure. The age structure in the three estuaries was similar, although the Polla produced few mature fish (Fig. 1). Unlike previous years, there were a number of mature fish found in the Kyle of Durness nets. From Fig. 1 the predominant smolt age in the rivers is 2 years (S2), although there were a number of S3's also present. S1's were also observed in small numbers in the Polla and Laxford. The length distribution of fish within the estuaries was also similar (Fig. 2), with post-smolts dominating each estuary. However there were few larger fish within the Polla samples.

The majority of the fish examined were from the 2017 smolt run (Fig. 1; Table 2). S May smolt run in normal for the Sutherland area (WSFT 2017) and this is supported by these data. However, there appeared to be a number of small fish in the September netting in the Laxford, possibly pointing at an autumn run.

Table 2 The percentage of smolts within the catch

Month	Laxford Bay	Polla estuary	Kyle of Durness
May	77	95	50
June	90	100	93
July	86	-	72
August	50	92	83
September	83	-	83

The presence of post-smolts at all sites throughout the year indicates a heavy usage of estuaries by this group, presumably for feeding and shelter. That the sea trout populations are relatively static can be inferred from the information on recaptures, where all of the tagged fish recaptured during 2017 were taken in the same location as originally tagged.

The mean length, weight and condition index, ± s.d., of post smolts per month are given in Table 3a for Laxford Bay, Table 3b for the Polla estuary and Table 3c for the Kyle of Durness. Problems with the weigh scales, occasioned by strong winds interfering with the reading, meant that the Polla weights could not be calculated during June. Condition index was good throughout the year for all estuaries, with the exception of the Kyle of Durness in August.

In general, the average length of the post-smolts tends to increase with time, indicating growth within the estuaries. There would appear to have been good feeding at sea during 2017, as seen within the condition index. However the sweeps showed limited presence of small bait fish.

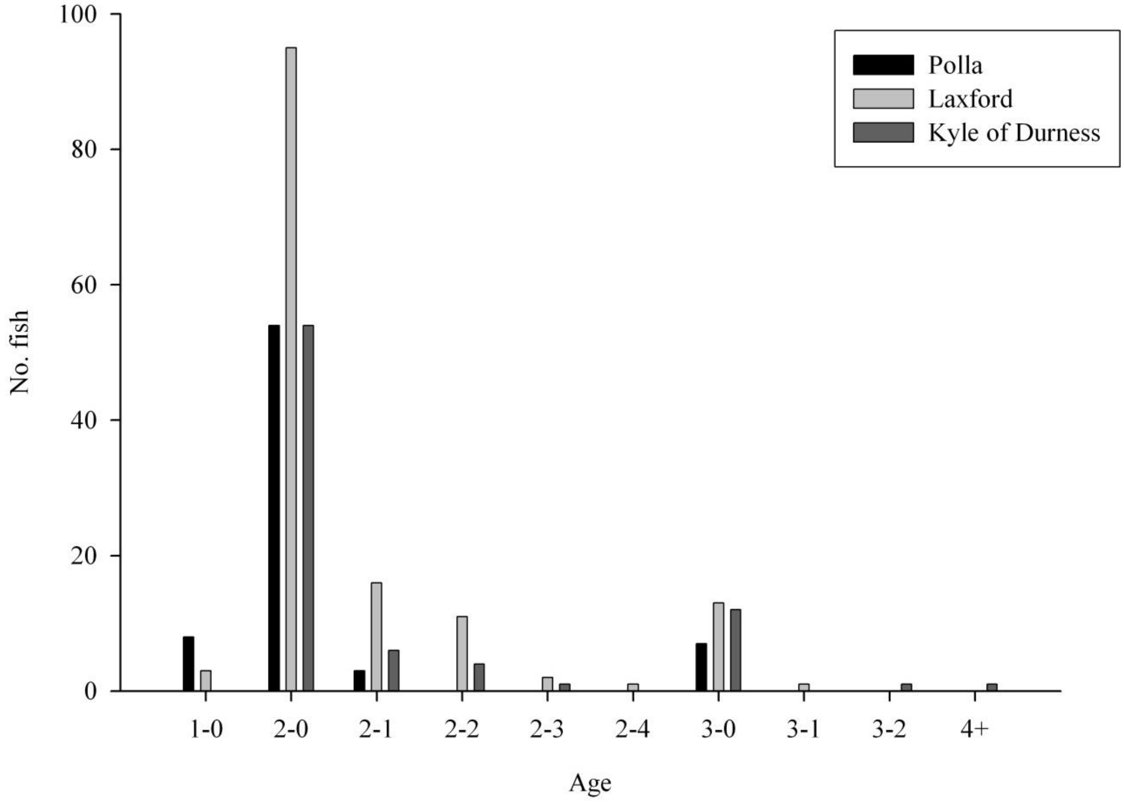

Fig. 1 The number of fish of each age taken in the estuaries

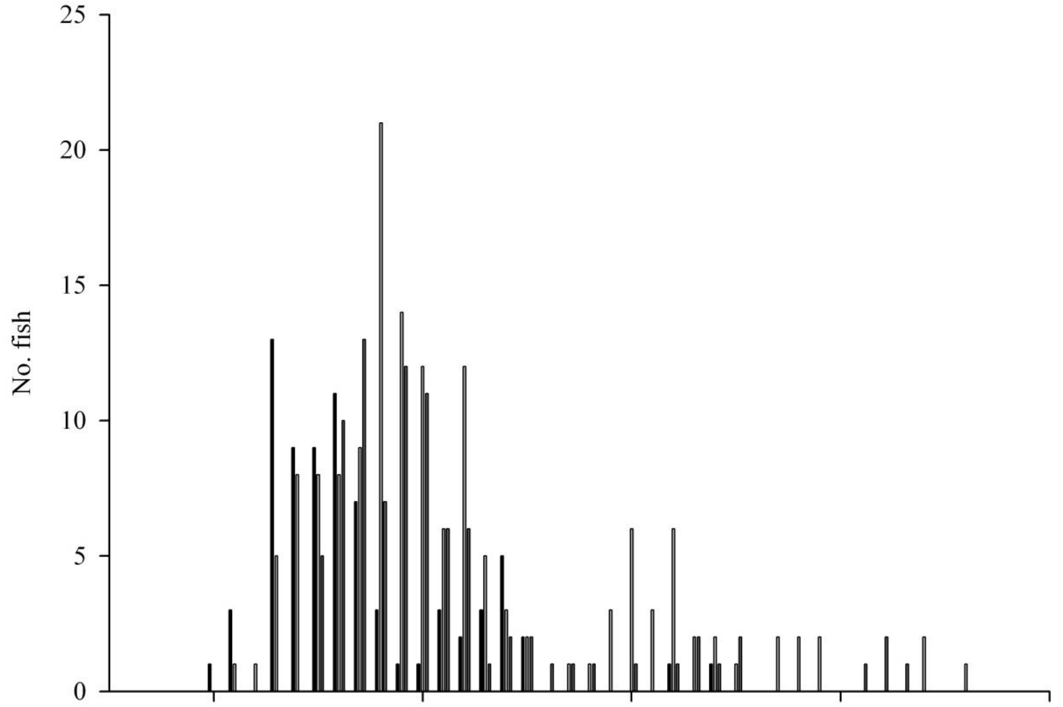

Fig. 2 The number of fish of each length taken in the estuaries

Table 3a The mean length, weight, and condition index of the post-smolts in Laxford Bay, per month

Month	Mean length (± s.d.) (mm)	Mean weight (± s.d.) (g)	Mean Condition Index (± s.d.)
May	183.83 ± 22.47	68.10 ± 26.82	1.06 ± 0.16
June	189.57 ± 30.17	78.94 ± 35.56	1.06 ± 0.09
July	191.33 ± 44.37	99.17 ± 50.36	1.36 ± 0.27
August	205.90 ± 38.69	101.60 ± 47.42	1.08 ± 0.07
September	180.45 ± 36.57	83.45 ± 37.86	1.42 ± 0.32

Table 3b The mean length, weight, and condition index of the post-smolts in Polla estuary, per month

Month	Mean length (± s.d.) (mm)	Mean weight (± s.d.) (g)	Mean Condition Index (± s.d.)
May	145.48 ± 14.97	31.71 ± 9.80	1.02 ± 0.18
June	163.59 ± 21.29	-	-
July	-	-	-
August	196.30 ± 49.95	94.56 ± 59.66	1.05 ± 0.08
September	-	-	-

Table 3c The mean length, weight, and condition index of the post-smolts in Kyle of Durrness, per month

Month	Mean length (± s.d.) (mm)	Mean weight (± s.d.) (g)	Mean Condition Index (± s.d.)
May	196.00 ± 43.49	81.00 ± 49.49	1.01 ± 0.07
June	179.97 ± 17.76	71.38 ± 18.33	1.22 ± 0.19
July	204.78 ± 19.18	91.28 ± 25.92	1.05 ± 0.10
August	188.00 ± 19.17	50.20 ± 30.27	0.70 ± 0.25
September	210.20 ± 26.23	99.40 ± 37.26	1.02 ± 0.11

Recaptures

There were 8 recaptures during 2017, all within the Laxford estuary netting. The growth of recaptured trout is shown in Table 4. Of the recaptured trout, 2 were originally tagged in 2016, with the rest in 2017. All fish were taken in the area of original tagging. This pattern is common to the sampling programme over the past 20 years and demonstrates that the majority of sea trout do not stray far from their home rivers. The majority of the fish were originally tagged in the Badna Bay smolt trap, indicating that a high proportion of the fish within this area come from the smaller system.

Average growth rates within the Laxford were 14.75 mm, and 37.57 g per month. This is higher than that seen in 2016.

Figure 3 shows that the specific growth rates (SGR) in the Laxford, is particularly high compared to levels seen previously within this estuary. The good condition was evident from the appearance of the fish in the net. The results from this analysis demonstrate the complexity of trout population dynamics and the interactions with external factors, such as food supply and temperature.

Table 4a The lengths and weights of recaptured trout within Laxford Bay

Tag number		Tagged	Recaptured	Difference
N73[*]	Date	22.4.17	26.5.17	1 mth
	Length (mm)	172	190	18
	Weight (g)	47	94	47
N32	Date	6.6.16	26.5.17	11 mths
	Length (mm)	222	298	76
	Weight (g)	84	252	168
N90[*]	Date	16.5.17	26.5.17	0.5 mths
	Length (mm)	163	166	3
	Weight (g)	33	61	28
N92[*]	Date	17.5.17	26.6.17	1 mth
	Length (mm)	171	202	31
	Weight (g)	52	89	37
N95[*]	Date	17.5.17	26.6.17	1 mth
	Length (mm)	177	220	43
	Weight (g)	51	113	62
O07	Date	26.5.17	23.8.17	3 mths
	Length (mm)	272	300	28
	Weight (g)	209	325	116
P33[*]	Date	6.5.16	23.8.17	15 mths
	Length (mm)	206	371	165
	Weight (g)	-	543	-
N99[*]	Date	18.5.17	21.9.17	4 mths
	Length (mm)	164	255	91
	Weight (g)	46	192	146

[*]Tagged in Badna Bay trap

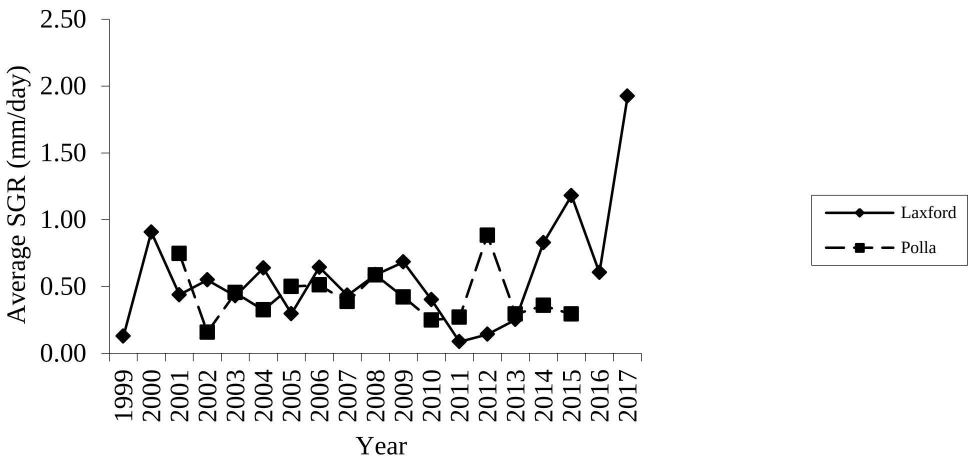

Fig. 3 Showing the average SGR for fish within the Laxford and Polla estuaries, by year

Sea Lice Infestations

Sea lice were present to a varying degree in all estuaries (Table 5), with lice found during all sampling occasions in all estuaries. Each estuary showed a mixture of all lice stages throughout the year (Fig. 4). Within the Laxford this comprised predominantly Chalimus until July, when older stages appeared and the Chalimus disappeared (Fig 4a). The Polla samples demonstrated a mixture of lice stages over the year, although only Chalimus were present in May before maturation was apparent (Fig. 4b). In contrast, the Kyle of Durness samples were composed of predominantly post-Chalimus stages throughout the year (Fig. 4c). Total lice numbers were lower in the latter half of the season for all systems, with the Polla showing the highest number of lice in total. However, the total lice number per sample is dependent on sample size and the use of abundance and intensity data give a better assessment of the situation.

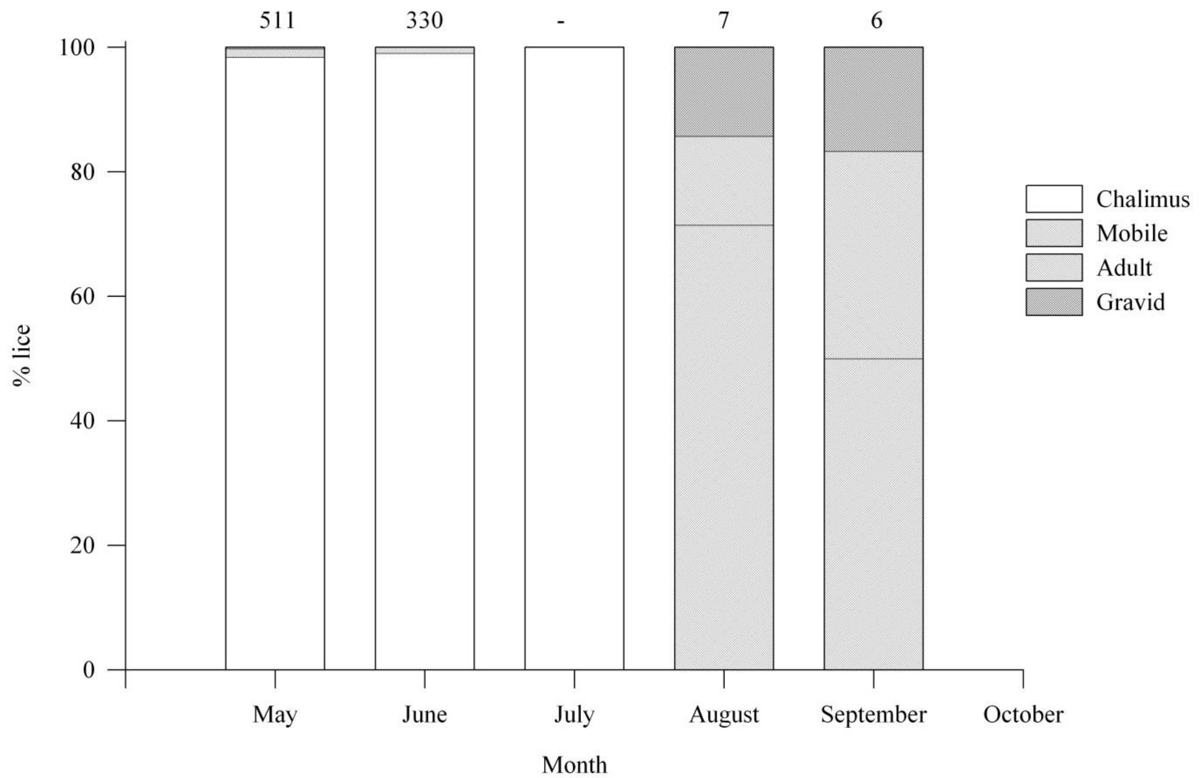

Fig. 4a Showing the proportion of each stage of lice within the Laxford samples, by month. The total number of lice is given at the top.

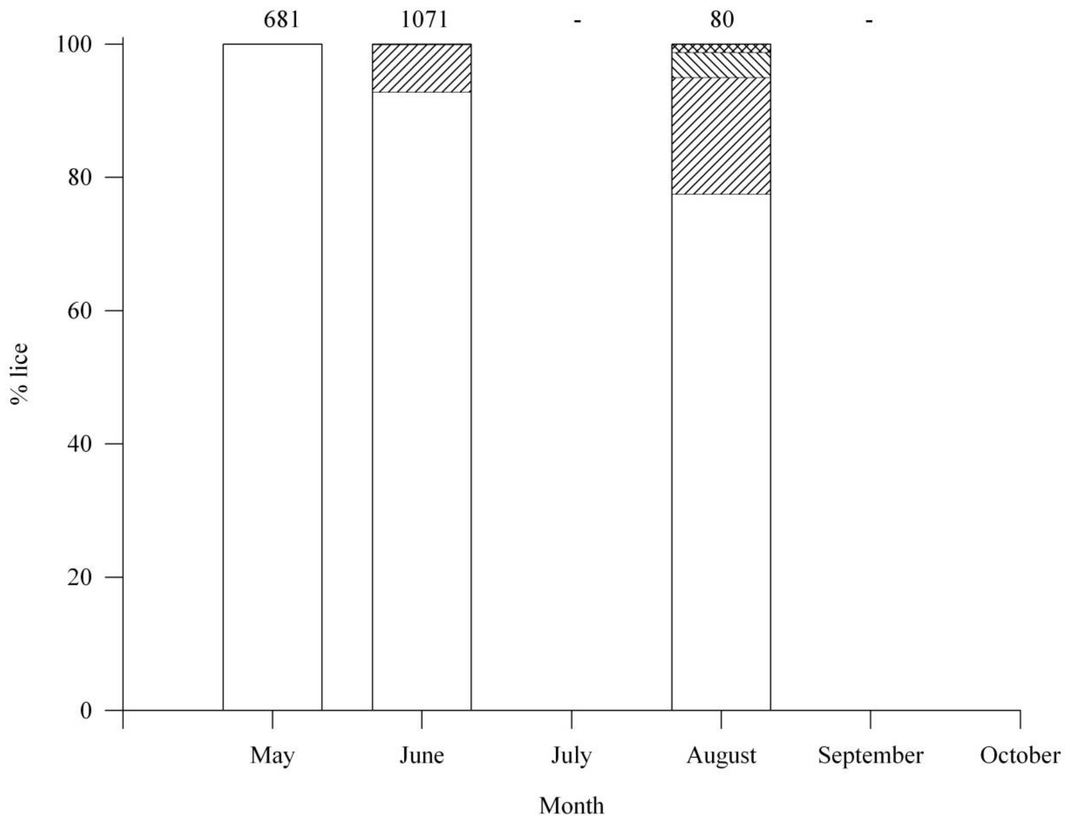

Fig. 4b Showing the proportion of each stage of lice within the Polla samples, by month. The total number of lice is given at the top.

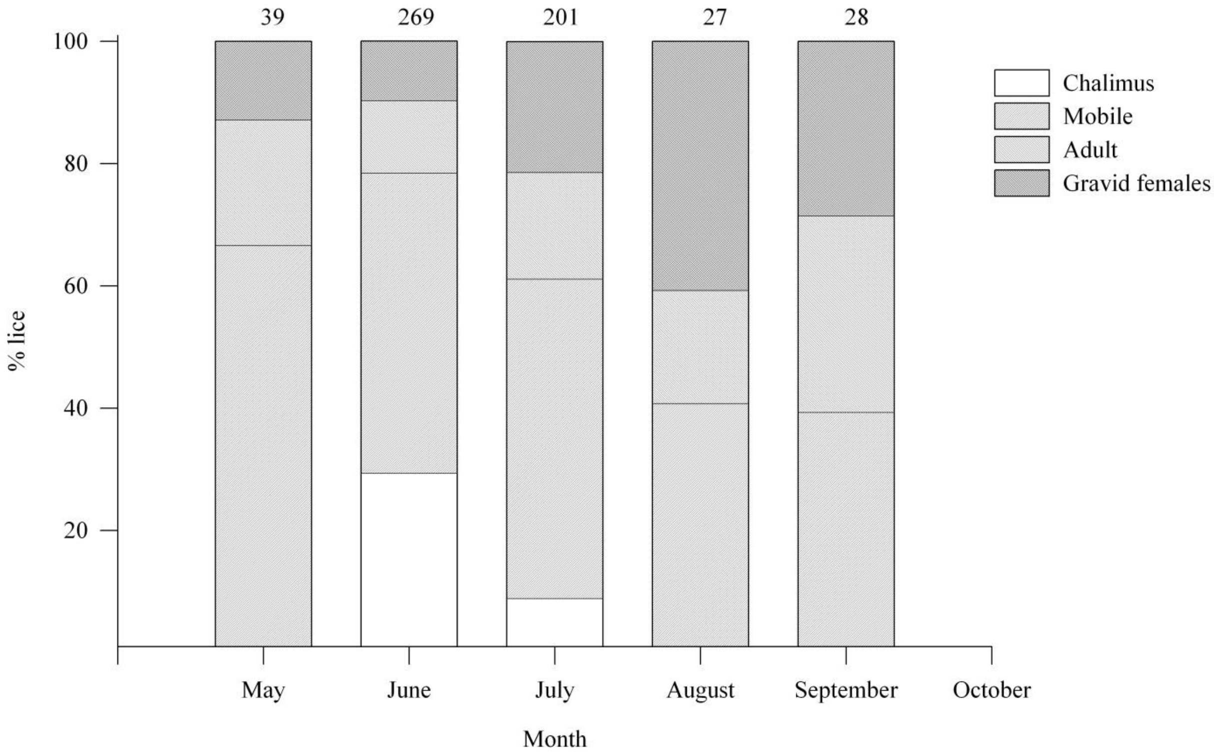

Fig. 4c Showing the proportion of each stage of lice within the Kyle of Durness samples, by month. The total number of lice is given at the top.

Table 5 The percentage of sea trout with the salmon louse, by estuary and month

Month	Laxford Bay	Polla estuary	Kyle of Durness
May	30	45	67
June	44	89	88
July	29	-	100
August	20	35	100
September	15	-	56

It was shown in Ireland that there appears to be a link between the lice stages observed within the wild fish population and distance from neighbouring farms, such that Chalimus dominate catches on populations within 30 km of a farm (Gargan, *et al.* 2003). While this does not hold true for this study, it is possible that where Chalimus are seen to dominate the population there is increased lice production within the neighbouring farms.

In order to determine the potential impacts of sea lice on fish it is important to know the number of lice present per fish, as well as their occurrence (Tables 6 (Laxford), 7 (Polla) & 8 (Kyle of Durness)). The use of intensity will give a more accurate impression of the degree of infestation, being the number of lice on the infected fish, but abundance gives a better impression of the lice within the population. In addition, abundance is used in several studies, including Butler (2002), and is the preferred method of recording within the neighbouring farms and is therefore given here. The use of the median value, being the middle value if they are ranked numerically, also gives an indication of the degree of infestation within the population, while removing the bias created by a single heavily infected individual.

Laxford

Lice were present within the Laxford throughout the year (Table 6). The greatest densities were found in June and July, before declining markedly. This would appear to reflect a loss of Chalimus from the population (Fig. 4a). *Caligus* were present on a few fish every month except September.

The neighbouring cages were stocked in December 2016, following a 7 month fallow. Lice numbers continued to build until late June, when control was achieved and numbers declined. This pattern is also reflected in the lice densities seen within the wild fish population, where the population appeared to crash in July.

Table 6 The abundance, intensity and median value of the salmon louse on wild sea trout in Laxford Bay, where abundance is the mean number of lice per fish and intensity is the mean number of lice per infected fish.

	Abundance		Intensity		
Month	mean	range	mean	range	Median
May	9.12	0 - 101	30.06	1 - 101	0
June	8.05	0 - 69	18.33	2 - 69	0
July	1.57	0 - 6	5.5	5 - 6	0
August	0.35	0 - 3	1.75	1 - 3	0
September	0.23	0 - 2	1.50	1 - 2	0

Polla

Lice abundance was relatively high within the Polla samples, with the greatest infestations found in June (Table 7). However it declined significantly in August. The majority of lice found were Chalimus, with only a small number of mobile and adult stages seen. This proportion increased with time (Fig. 4b). *Caligus* were present throughout the year, with the highest level of infestation observed in June.

The neighbouring cages were fallow from the start of August. Prior to this numbers of *Lepeophtheirus* were quite high within the cages, responding to treatment before starting to build again. This is in contrast to previous years, but is reflected in the value determined from the Taranger analysis.

Table 7 The abundance, intensity and median value of the salmon louse on wild sea trout in Polla estuary, where abundance is the mean number of lice per fish and intensity is the mean number of lice per infected fish.

	Abundance		Intensity		
Month	mean	range	mean	range	Median
May	30.95	0 - 250	68.10	11 - 250	0
June	39.67	0 - 98	44.63	13 - 98	36
July	-	-	-	-	-
August	3.08	0 - 25	8.89	1 - 25	0
September	-	-	-	-	-

Kyle of Durness

Lice were present on most fish throughout the year within the Kyle of Durness (Table 5). Table 8 indicates that densities were relatively low, although some fish showed a reasonable lice burden. There was a mix of stages present throughout the year (Fig. 4c), with few Chalimus observed. *Caligus* were present in low numbers on a few fish each month throughout the year.

Table 8 The abundance, intensity and median value of the salmon louse on wild sea trout in Kyle of Durness, where abundance is the mean number of lice per fish and intensity is the mean number of lice per infected fish.

	Abundance		Intensity		
Month	mean	range	mean	range	Median
May	6.50	0 - 24	9.75	1 - 24	1
June	6.26	0 - 22	7.08	1 - 22	5
July	8.04	2 - 40	8.04	2 - 40	7
August	3.86	2 - 6	3.86	2 - 6	4
September	3.11	0 - 10	5.60	1 - 10	1

A risk assessment of the lice numbers present within the wild trout

Taranger, *et al.* (2014) gives a method to assess the increased mortality risk to salmonid populations based on the number of lice present per gram of fish. This is based on physiological effects determined from laboratory experiments taken from literature, and the use of sentinel cages within fjords.

The data are treated differently depending on fish size and give a potential increased risk of mortality to each fish, with increasing risk as the number of lice increase. Thus, 0.1 – 0.2 lice/g will give a 20% increased risk of mortality to a salmonid of < 150g. In order to determine the likely population effect, the proportion of fish within the population appearing in each band is calculated and a population risk determined. Fig. 5 gives the results by year for each estuary, with the banding indicating whether the risk is low (green), moderate (yellow) or high (red). Within the green zone it can be taken that there is minimal risk to the population, while the yellow and red zones show potentially population altering impacts.

From this, it can be seen that the potential risks within the Polla estuary during 2016 were the greatest observed within that estuary over the period of the study. However, it is only the second time in 19 years where the potential risk to the wild population has been in the amber zone. This is a positive reflection on the situation within the estuary, not perhaps seen in previous analyses based solely on lice abundance. It may, however, be more reflective of the rod catches, which have remained steady or increasing with time.

In contrast, the Laxford analysis would indicate that sea lice populations are creating a potential population changing effect on a regular basis. While there is a biannual effect observed, primarily giving a moderate effect, on 2 years, 2011 and 2013, this was identified as high. This is perhaps a better reflection of the impression drawn from the previous analyses of the abundance data, but serves to highlight the population changes observed with the rod catches. During 2017 however, despite a demonstration of the biannual trend observed previously, the overall risk remained within the green zone and therefore considered minimal.

Sampling within the Kyle of Durness has been more restricted than the other 2 estuaries, but results would indicate that there is a low risk to the population arising from the lice burdens within the population. The exception to this was in 2005, where a high potential risk was recorded and 2017 where the risk was identified as amber, albeit to the lower end of this classification. Catch records, again, mirror to some extent the potential risk to the population identified.

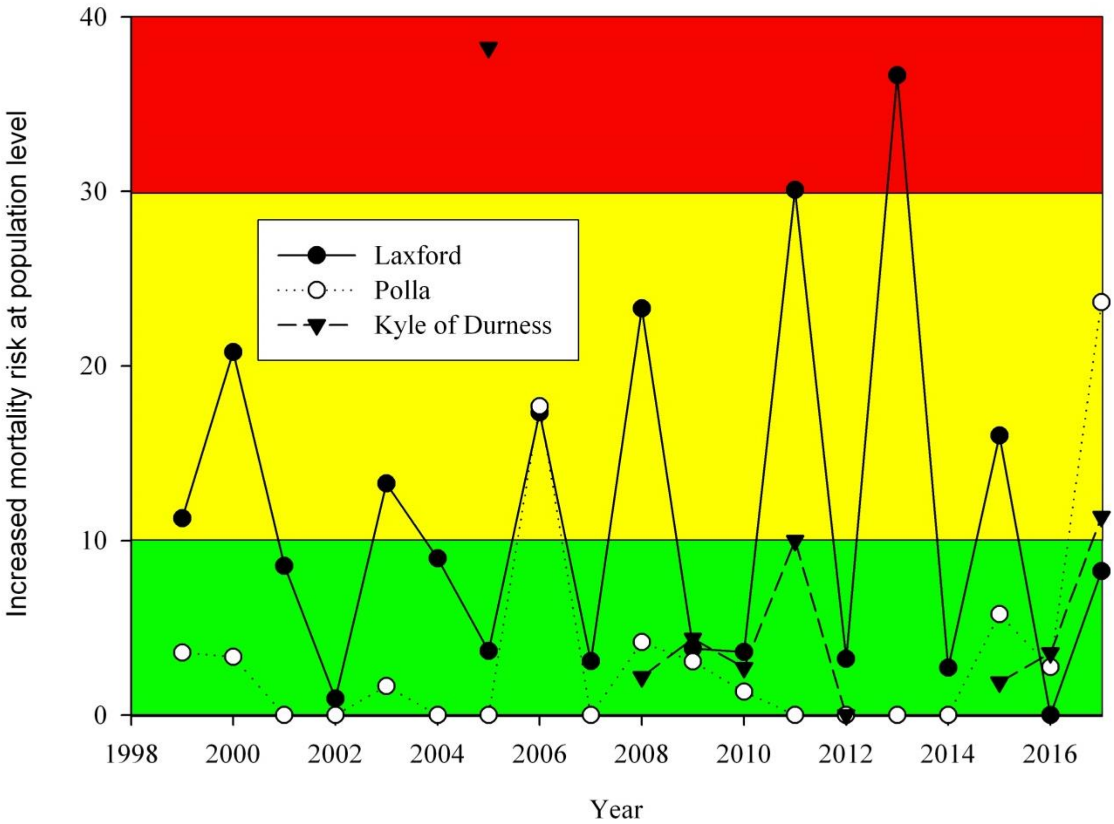

Fig. 5 Showing the increased mortality risk at population level created by sea lice

Recommendations for further research

1. It is recommended that the current programme be continued in order to maintain the existing dataset.
2. It is recommended that further research into the dynamics of the sea trout population in both marine and freshwaters be undertaken. This should also examine the relationship between the resident and migratory components of the population.
3. It is recommended that additional research on the sea lice population be undertaken.

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Acknowledgements

Thanks must be given to the many people who assisted with the sampling over the past year and without whom the project could not have been completed, particularly Ross Barnes, Dave Debour, Iain MacDonald, Rex Onions and Donald Reid. Thanks also to Reay Forest and Wildland Estates and the River Dionard Committee of Management for permitting the work to be undertaken. This project has received partial funding from the North & West DSFB and the Scottish Government *via* FMS.

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