Sea Lice Burdens of Sea Trout at Sound of Shuna, Argyll, 2021

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Background

Argyll Fisheries Trust undertook seine net and fyke net surveys in the Sound of Shuna Farm Management Area in summer 2021 to assess burdens of a parasite (Sea lice; *Lepeophtheirus salmonis*) found on sea trout (*Salmo trutta*).

Main findings

- Mobile seine netting surveys undertaken over six sites sampled four sea trout in June 2021 and a fixed fyke net sampled a further nine seat trout in July, August and September.
- The trout sampled included seven tout < 150 g and six trout > 150 g.
- The percentage of trout sampled that were infected by sea lice (prevalence) was 71.4 % for small trout (< 150 g), 83.3 % for larger trout (> 150 g) and 76.0 % for all trout sampled.
- The total lice-related risk index (Taranger et al., 2015) estimates a high sea lice-related risk of increased mortality, reduced seawater growth and reproductive potential for sea trout in 2021.
- When compared with the lice-related risk index analysis, historical data collected in Loch Craignish, the 2021 result show a similarly high sea lice-related risk of mortality found in 2008 for smaller trout.
- The low number of samples analysed in 2021 make firm conclusions difficult to be drawn, but the limited data suggest that there was a lice-related risk to sea trout in the Sound of Shuna Management Area during the second year of farm production.

Acknowledgements

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1. INTRODUCTION

Mobile sweep net surveys were conducted in Loch Graignish and Loch Melfort in June and July of 2021 and a stationary Fyke net was also used to sample trout in Loch Melfort between July and September 2021. The aims of the surveys were to assess the sea lice burdens of post-smolt sea trout in the Sound of Shuna Farm Management Area, to inform an Environment Monitoring Plan and to assess the suitability of the two methods to sample sea trout in the management area.

Assessing the potential impacts of sea lice on wild migratory salmonids in the Sound of Shuna has been undertaken using a risk index developed within a wider a risk assessment framework for aquaculture in Norway (Taranger et al., 2015). This tool attempts to quantify the increase in lice-rated mortality or reduced seawater growth and compromised reproduction of migratory salmonids caused by sea lice. Due to the behaviour of salmon smolts, which migrate rapidly out of the study area, this study concentrates on the sea trout that mostly reside in coastal waters.

The 2021 results have been compared to the results of seine net sampling undertaken in Loch Craignish in three other years (2008 to 2010) in this report to identify any trends in infection pressure and potential relation to production cycles of farm salmon in the Sound of Shuna.

2. METHODS

Two sampling methods were employed to catch sea trout in Loch Melfort and Loch Craignish between June 10th and September 22nd, 2021.

2.1 Seine net sampling

The surveys of sea trout were undertaken by sweeps of a 50 m length beach seine net which was deployed by motorboat along a length of shoreline and retrieved by hand. Up to four sweeps of the net were undertaken at spots along the shore to locate the fish and capture sufficient fish to inform the study. The trout captured in each sweep were transferred to a container for inspection once the netting had been completed. Several seine net survey sites were assessed in Loch Craignish and Loch Melfort as part of the survey, but sea trout were only caught at one site in Loch Melfort (Table 2.1 and Figure 2.1).

Table 2.1 Seine net survey site location

Loch	Site	Easting	Northing
Loch Melfort	SNA	183692	712854
	SNB	183855	712537
	SNC	183060	714116
Loch Craignish	SND	181427	705054
	SNE	182078	705201
	SNF	182677	704760

2.2 Fyke net sampling

The fyke net deployment and sampling of fish was undertaken using a Standard Operating Procedure developed specifically for this type of net (Lochaber Fisheries Trust, 2020). The coastal fyke net consists of a lead and two wing nets which guide fish into a series of funnels via central area (known as the heart) before entering a residence area which was raised and checked at regular intervals (usually two days fishing time). Fish were removed via a trap door and then sea trout were processed as described in section 2.3. All by-catch was released at the site. The Fyke net was set in three locations in an attempt to find a productive site in Loch Melfort (Table 2.2 and Figure 2.1 and).

Table 2.2 Fyke net survey site location

Site	Start Date	End Date	Easting	Northing
FN1	21/06/2021	15/07/2021	178727	707268
FN2	15/07/2021	26/08/2021	179473	710164
FN3	26/08/2021	22/09/2021	181721	711900

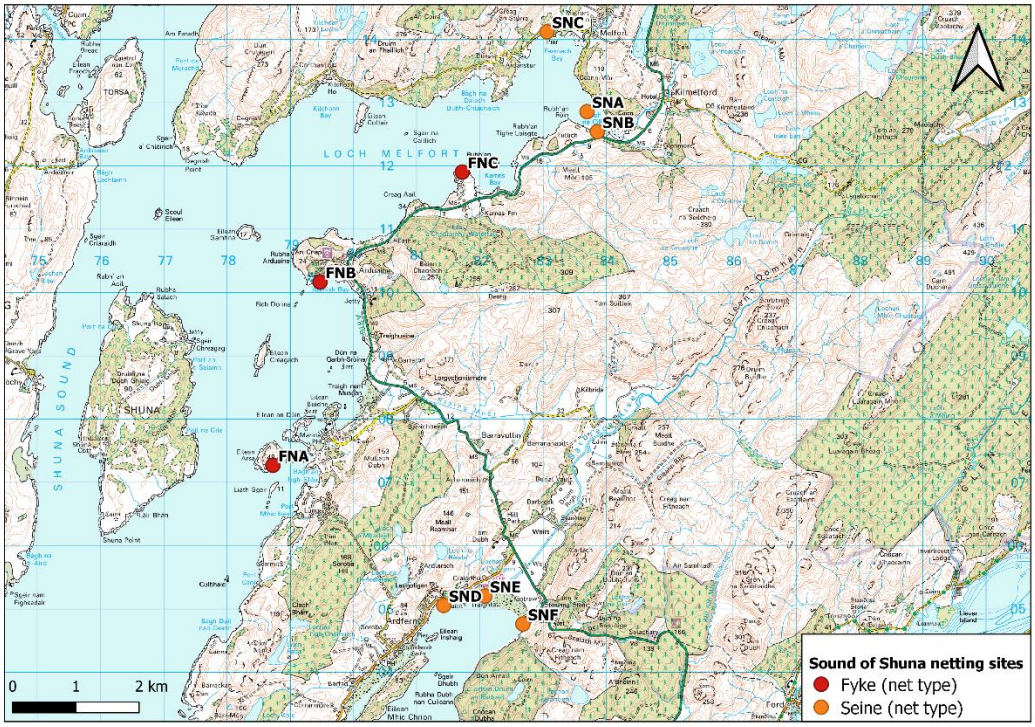
2.3 Data recording and analysis

Trout were anaesthetised prior to collection of length and weight information and counts of sea lice were undertaken according to the protocol prescribed by Scottish Fisheries Coordination Centre (SFCC, 2008). Data on the physical characteristics (length and weight) of the trout sampled and their sea lice burdens were recorded to calculate the following:

- Condition factor (K) – coefficient of the condition of the trout (Ricker, 1975).
- Prevalence of lice – number/percentage of trout sampled with a sea lice burden.
- Abundance of lice – the average (mean) number of sea lice per trout.
- Intensity of infection – the average (mean) number of lice per infected trout.
- The proportion of different life-stages of lice – attached (copepodids and chalimus), Mobile (sub-adults and adults excluding gravid females) and Gravid (adult females with eggs) lice stages.

Analysis was also carried out using the Norwegian risk assessment framework by Taranger et al. (2015) to categorise the increased lice-related risk of mortality to individual trout according to the number of lice present in relation to the body weight of the fish (no. lice/g^{-1}).

Fig. 2.1 Location of the Sound of Shuna netting sites



The framework assumes that small sea trout post-smolts (<150 g body weight) will suffer 100% lice-related marine mortality, or compromised reproduction potential, if they are infected with >0.3 lice g^{-1} fish weight. Furthermore, the lice-related marine mortality is estimated to be 50% if the infection is between 0.2 and 0.3 lice g^{-1} fish weight, 20% if the infection rate is between 0.1 and 0.2 lice g^{-1} fish weight, and finally 0% lice-related mortality if the salmon lice infection is <0.1 lice g^{-1} fish weight.

For larger sea trout (over 150 g) the risk analysis assumes that increased lice-related mortality or compromised reproduction will be 100% in the group if they have >0.15 lice g^{-1} fish weight, 75% for lice infections between 0.10 and 0.15 lice g^{-1} fish weight, 50% for lice infections between 0.05 and 0.10 lice g^{-1} fish weight, 20% for lice infections between 0.05 and 0.01 lice g^{-1} group, and 0% if the salmon lice infection is <0.01 lice g^{-1} fish weight.

Total increased mortality risk or compromised reproduction are calculated as the sum of the increased mortalities separately for each of the different “infection classes” in the sample, reflecting the distribution of the intensity of salmon lice infections of the different individuals sampled. The total risk to each infection class was further scored according to the system proposed by Taranger et al. (2012a); as low (up to 10% estimated increase in mortality), moderate (between 10 and 30% increase), and high (if the increase is calculated as 30% or more).

In two of the three previous years surveys (2008 and 2009) no fish weight data was recorded. To allow comparison with years when weight data was recorded, a weight was allocated to each trout based on the length of each trout and a condition factor of 1.20 K, which is higher than the average of 1.13 K for both years (2010 and 2021) when trout were weighed, so assumes the trout that were not weighed were in good condition.

3. RESULTS

The samples of the seine and fyke net surveys for 2021 are combined below in terms of the characteristics of the sea trout sampled (3.1), the sea lice burdens of sea trout (3.2), risk analysis of sea lice burdens (3.3) and comparison with historical data (2008-2010) (3.4).

3.1 The sea trout sampled

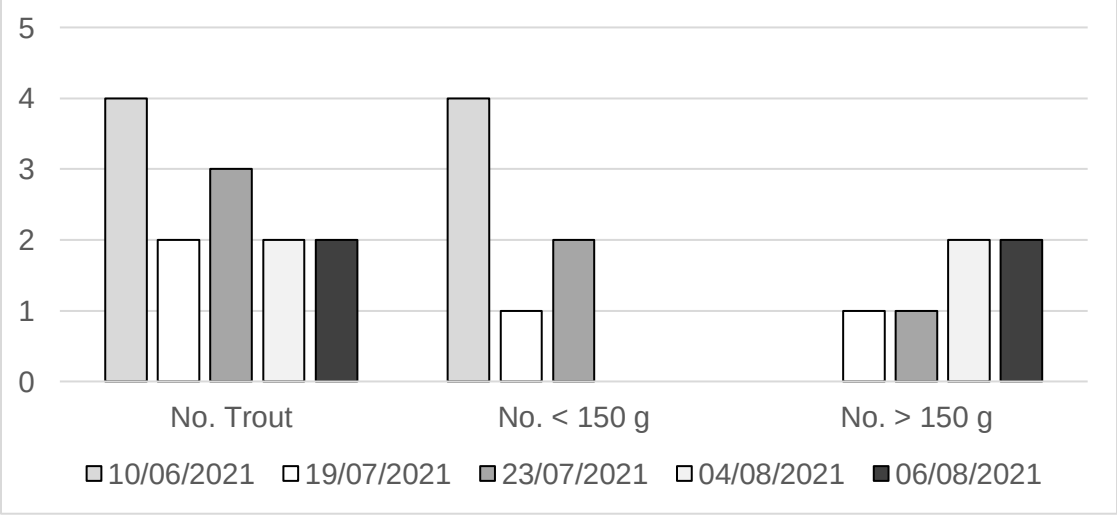
3.1.1 Number of trout analysed

A total of 4 sea trout were sampled in one of the three seine net surveys (on 10/06/21) and further nine trout were surveyed in the Fyke net between 19/07/21 and 06/08/21. The number of trout caught in the fyke net ranged between two (on three occasions) and three trout (on one other occasion) (Table 3.1.1 and Figure 3.1.1). The total sample consisted of seven trout of less than 150 grams wet weight (53.8 % of fish sampled) and 6 trout of more than 150 grams (46.2 % of samples).

Table 3.1.1 Number and size of trout sampled and analysed (2021)

Sample Date	No. Trout	No. < 150 g	No. > 150 g	< 150g (%)	> 150g (%)
10/06/2021	4	4	0	100.0	0.0
19/07/2021	2	1	1	50.0	50.0
23/07/2021	3	2	1	66.7	33.3
04/08/2021	2	0	2	0.0	100.0
06/08/2021	2	0	2	0.0	100.0
All fish	13	7	6	53.8	46.2

Figure 3.1.1 Sample size and no. of trout in two size classes (<150 g and > 150 g)



3.1.2 Characteristics of sea trout sampled

The average length (mm), weight (g) and condition factor (K) of the trout sampled in the surveys are described below in Table 3.1.2.

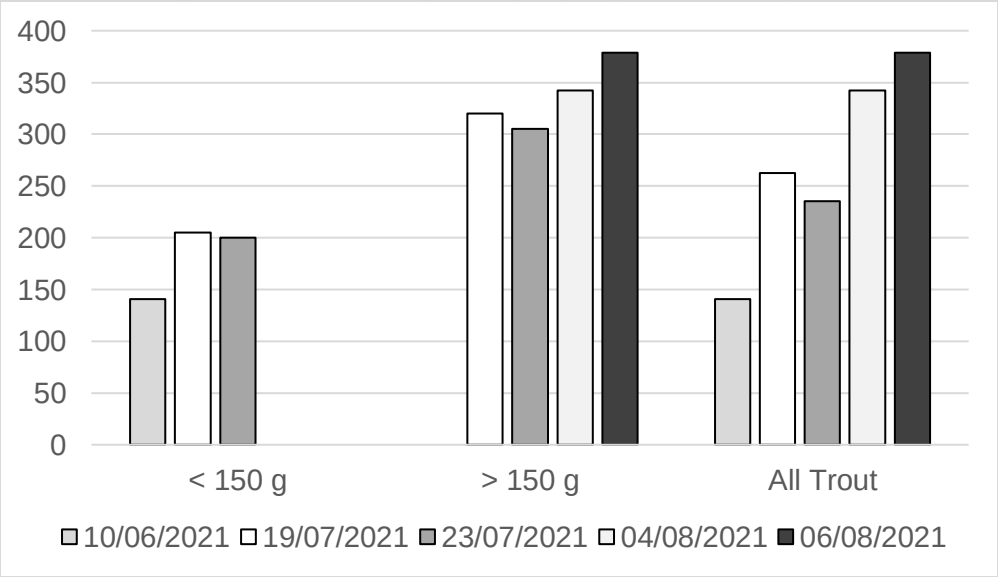
Table 3.1.2 Average length (mm), weight (g) and condition factor of trout sampled

Sample Date	< 150 g			> 150 g			All Trout		
	Length (mm)	Weight (g)	Condition factor (K)	Length (mm)	Weight (g)	Condition factor (K)	Length (mm)	Weight (g)	Condition factor (K)
10/06/2021	141.00	34.63	1.23						
19/07/2021	205.00	90.00	1.04	320.00	293.00	0.89	262.50	191.50	0.97
23/07/2021	200.00	87.00	1.08	305.00	300.00	1.06	235.00	158.00	1.07
04/08/2021				342.50	500.50	1.06	342.50	500.50	1.06
06/08/2021				379.00	594.00	1.08	379.00	594.00	1.08
All Trout	167.00	57.50	1.16	344.67	463.67	1.04	249.00	244.96	1.11

3.1.2.1 Length of sea trout sampled

The average length of all sea trout sampled ranged between 262.5 mm in mid-July and 379.0 mm in early August (Figure 3.1.2.1). The average length of trout of less than 150 g weight rose from 141.0 mm in early June to 205.0 mm in late-July and then fell to 200.0 mm later in July. The average length of trout of more than 150 g weight rose from 320.0 mm in mid-July to 379.0 mm in early August.

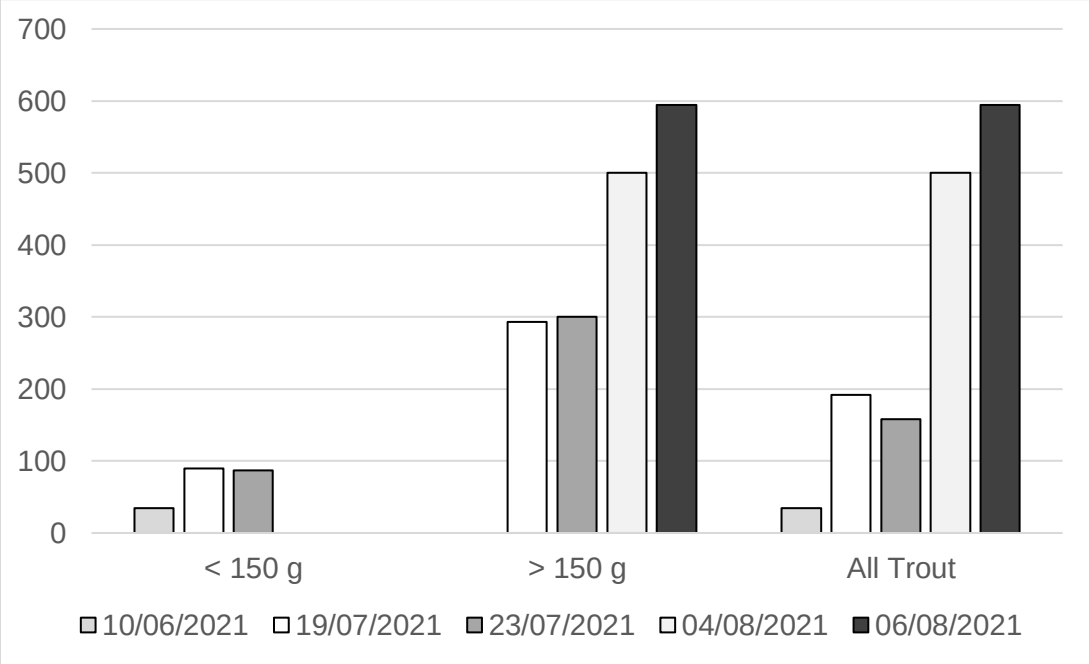
Figure 3.1.2.1 Average Length (mm) of trout sampled



3.1.2.2 Weight of sea trout sampled

The average weight of all sea trout sampled ranged between 34.6 grams in early June and 594.0 grams in early August (Figure 3.1.2.2). The average weight of trout of less than 150 g weight rose from 34.6 g in early June to 90.0 g in mid-July but fell to 87.0 g later in July. The average weight of trout of more than 150 g weight rose from 293.0 g in mid-July to 594.0 g in early August.

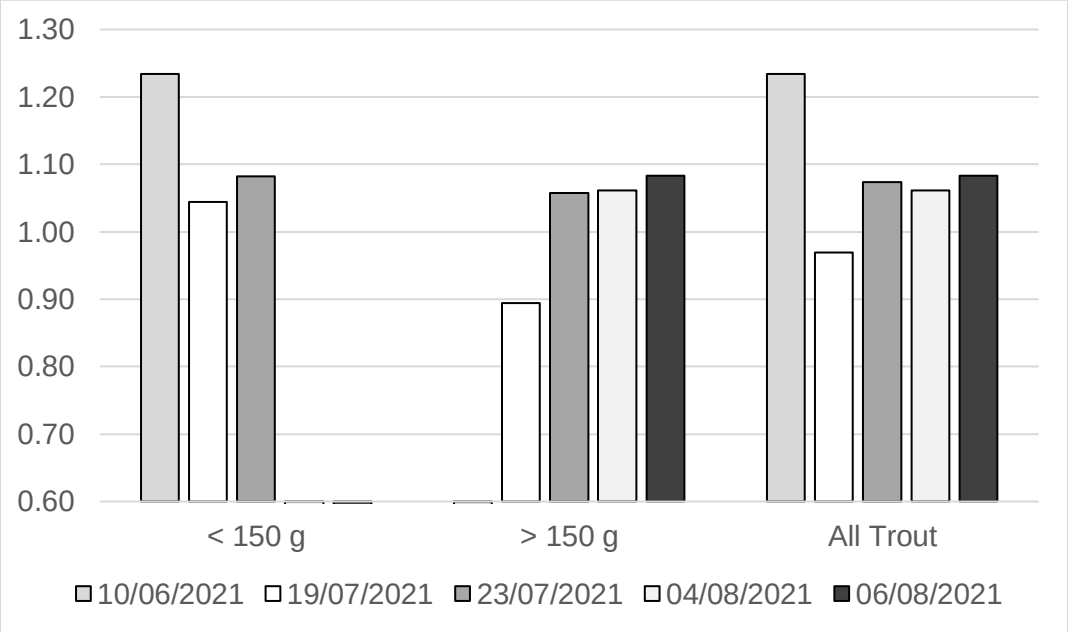
Figure 3.1.2.2 Average Weight (g) of trout sampled



3.1.2.3 Condition factor of sea trout sampled

The average condition factor of all sea trout sampled ranged between 0.97 in mid-July and 1.23 in early June (Figure 3.1.2.3). The condition factor of trout of less than 150 g weight fell from 1.23 in early June to 1.04 in mid-July and 1.08 later in July. The average condition factor of trout of more than 150 g weight rose from 0.89 in early July to 1.08 in early August.

Figure 3.1.2.3 Average Condition Factor of trout sampled



3.2 Sea lice burdens of sea trout

The sea lice burdens of sea trout samples in 2021 are summarised in terms of the prevalence of lice (% of fish infected), abundance of lice (average number of lice per fish) and intensity of infection (average number of lice per infected fish) below (Table 3.2.1).

Table 3.2.1 Sea lice burdens of sea trout sampled

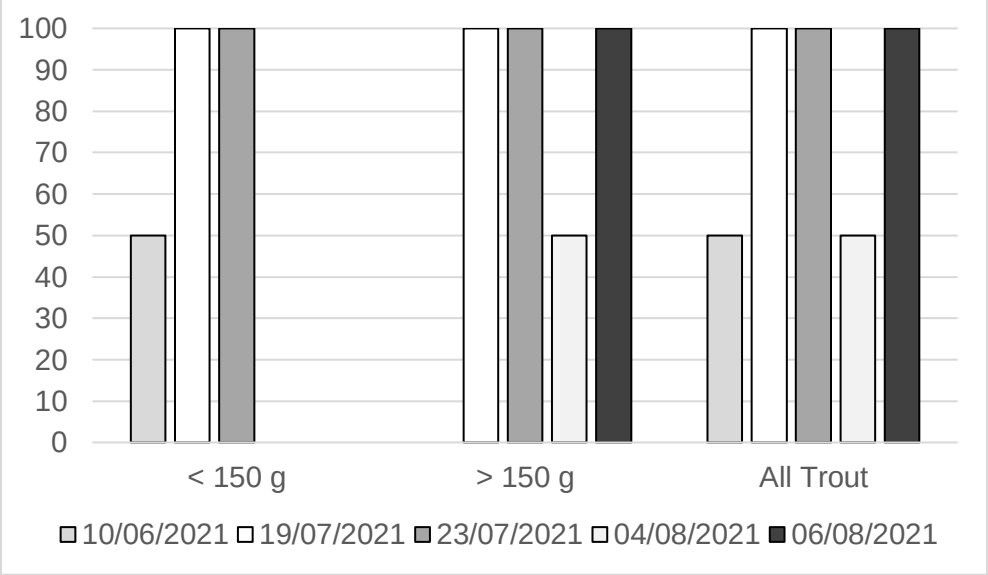
Sample Date	< 150 g			> 150 g			All Trout		
	Prevalence	Abundance	Intensity	Prevalence	Abundance	Intensity	Prevalence	Abundance	Intensity
10/06/2021	50.00	3.75	7.50				50.00	3.75	7.50
19/07/2021	100.00	23.00	23.00	100.00	43.00	43.00	100.00	33.00	33.00
23/07/2021	100.00	53.50	53.50	100.00	15.00	15.00	100.00	40.67	40.67
04/08/2021				50.00	5.50	11.00	50.00	5.50	11.00
06/08/2021				100.00	10.50	10.50	100.00	10.50	10.50
All trout	71.43	18.57	26.00	83.33	18.50	19.88	88.89	22.42	23.79

3.2.1 Prevalence of sea lice

The percentage of all trout infected by sea lice ranged between 50 % in early June and early August to 100 % in all other surveys (Figure 3.2.1) and averaged 88.89 % across all surveys in 2021. The percentage of trout less than 150 grams weight infected by lice was 50 % in early June

and 100 % in mid-to-late July. The percentage of trout more than 150 grams weight infected by lice was 50 % in early August and 100 % in all other surveys.

Figure 3.2.1 Prevalence of sea lice infection (% of trout sampled)



3.2.2 Abundance of sea lice

The average number of sea lice found across all the trout sampled ranged between 3.75 in early June and 40.67 lice per fish in late July (Figure 3.2.2) and averaged 22.42 across all surveys in 2021. The abundance of lice found on trout under 150 grams weight was 3.75 in early June, 23.0 in mid-July and 53.5 lice later in July and 18.57 lice across all trout under 150 grams. The abundance of lice found on trout over 150 grams weight was 43.00 and 15.0 in mid and late July respectively and 5.5 and 10.5 lice on the early August samples and 18.5 lice across all trout over 150 grams.

3.2.3 Intensity of sea lice infection

The average number of sea lice found across all the infected trout ranged between 7.5 lice in early June and 40.67 lice per fish in late July (Figure 3.2.3) and averaged 23.79 lice across all samples. The intensity of infection found on trout under 150 grams weight was 7.5 lice in early June, 23.0 and 53.5 in mid-to-late July and 26.0 lice across all trout under 150 grams. The intensity of infection found on trout over 150 grams weight fell from 43.0 from mid-July to 15.0 later in July and 11.0 and 10.5 lice in the early August samples and 19.88 lice across all trout over 150 grams.

Figure 3.2.2 Abundance of sea lice (avg. no. of lice on all trout sampled)

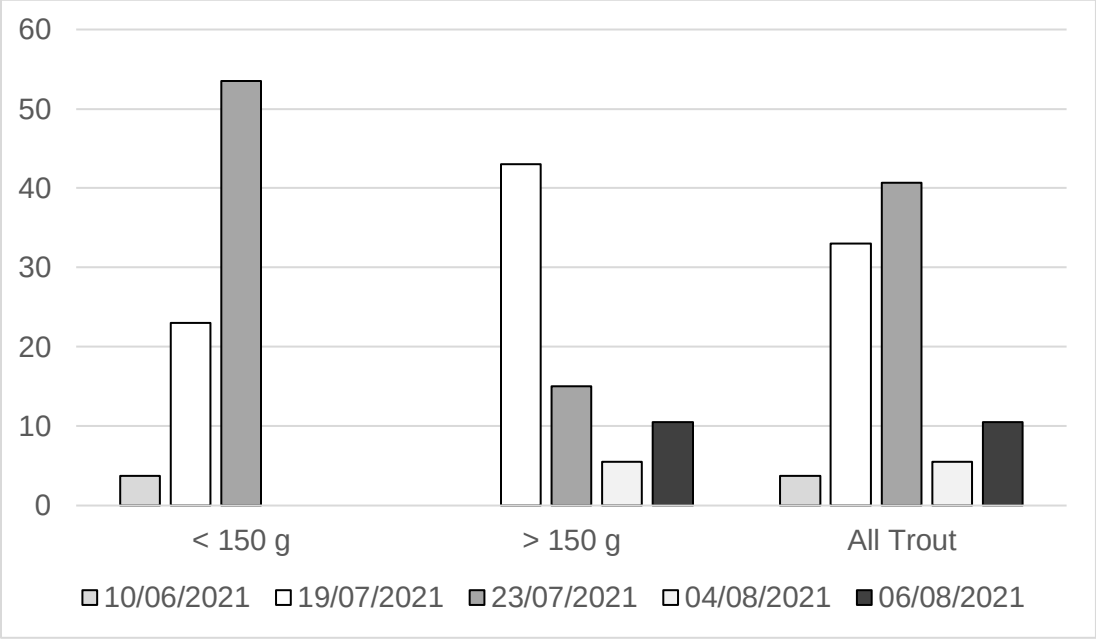
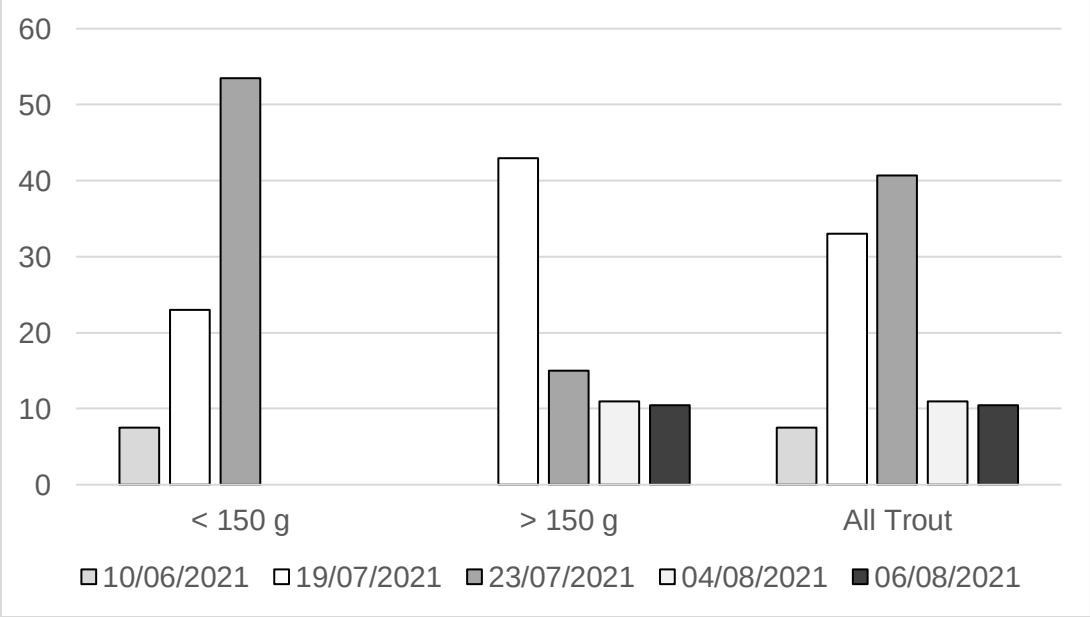


Figure 3.2.3 Intensity of sea lice infection (avg. no. of lice on infected trout sampled)



3.2.4 Life-stage of sea lice

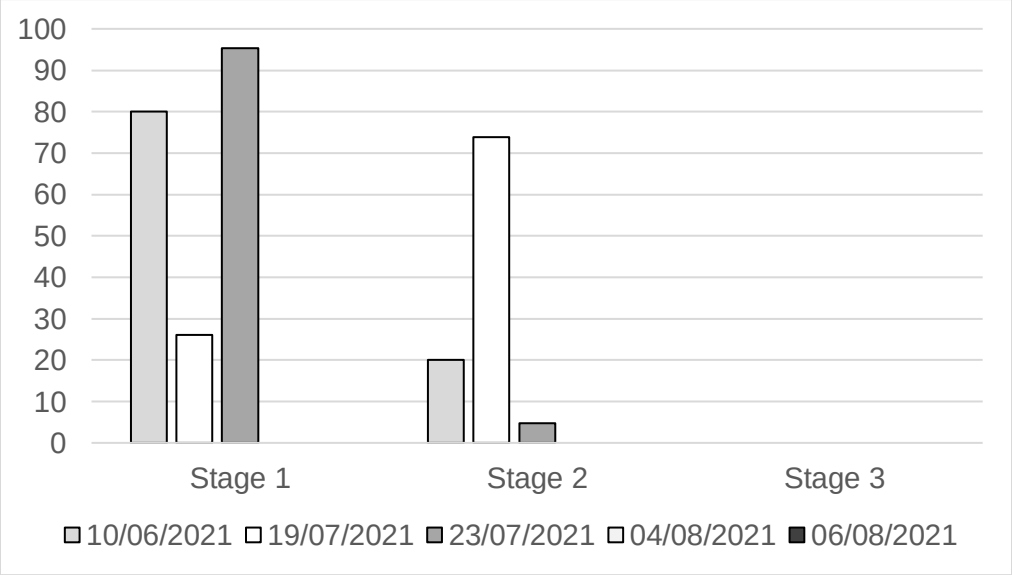
The proportion of the number of each life-stage of sea lice recorded are described below (Table 3.2.2) for trout under and over 150 grams weight. The three stages of lice recorded were attached (stage 1), mobile (stage 2) and gravid female (stage 3).

Table 3.2.2 Life-stage of sea lice found on sea trout

Sample Date	< 150 g			> 150 g		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
10/06/2021	80.00	20.00	0.00			
19/07/2021	26.09	73.91	0.00	76.74	20.93	2.33
23/07/2021	95.33	4.67	0.00	40.00	46.67	13.33
04/08/2021	0.00	0.00	0.00	72.73	27.27	0.00
06/08/2021	0.00	0.00	0.00	0.00	47.62	52.38
All trout	82.76	17.24	0.00	52.22	32.22	15.56

On trout under 150 grams (Figure 3.2.4), the proportion of attached sea lice (stage 1) found on trout fell from 80% in early June to 26.1 % in mid-July and rose again to 95.3 % later in July and averaged 82.8% across all trout under 150 grams. The proportion of mobile sea lice (stage 2) rose from 20 % in early June to 73.9 % in mid-July and fell to 4.7 % later in July and was 17.2 % across all trout under 150 grams. No gravid female mobile sea lice (stage 3) were found on trout of under 150 grams weight.

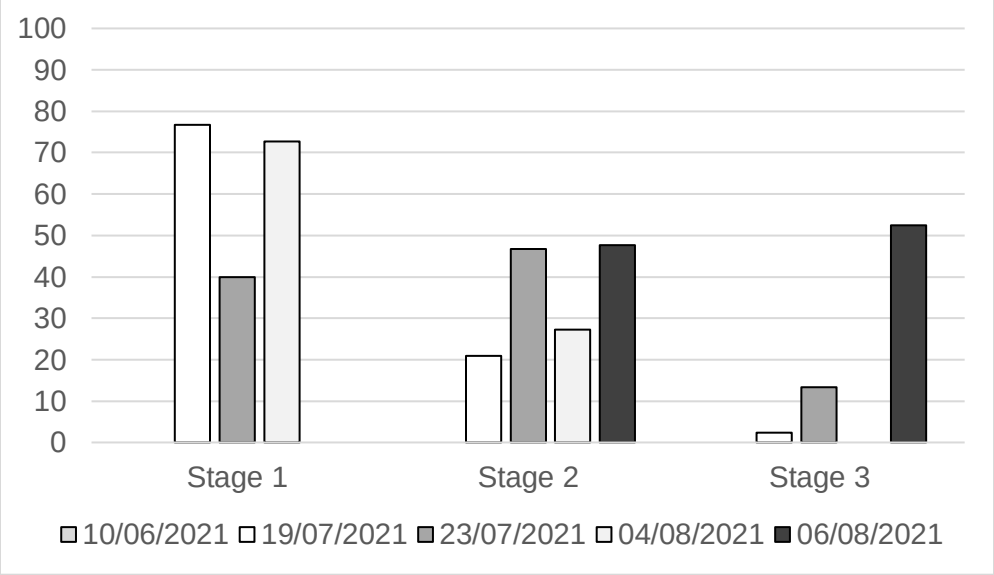
Figure 3.2.4 Life-stage of sea lice found on infected trout < 150 g



On trout over 150 grams (Figure 3.2.5), the proportion of attached sea lice (stage 1) found on trout fell from 76.7% in mid-July to 40.0 % later in July and rose to 72.7 % later in July and averaged 52.2% across all trout over 150 grams. The proportion of mobile sea lice (stage 2) rose from 20.9 % in mid-July to 46.7 % later in July and was 27.3 % and 47.6 % in the early August samples and 32.2 % across all trout over 150 grams. The proportion of gravid female mobile sea lice (stage 3)

rose from 2.3 % in mid-July to 13.3 % later in July and 52.4 % in early August and 15.6 % across all trout over 150 grams weight.

Figure 3.2.5 Life-stage of sea lice found on infected trout > 150 g



3.3 Risk analysis of sea lice burdens

The lice-related risk of mortality was calculated based on the number of lice per gram of fish weight and analysis was conducted separately for trout above and below 150 grams weight.

3.3.1 Average lice per gram fish weight

The average lice per gram of fish weight (lice / g^{-1}) is given for fish in both weight categories (above and below 150 grams weight) and across all fish sampled in each survey below (Table 3.3.1 and Figure 3.3.1).

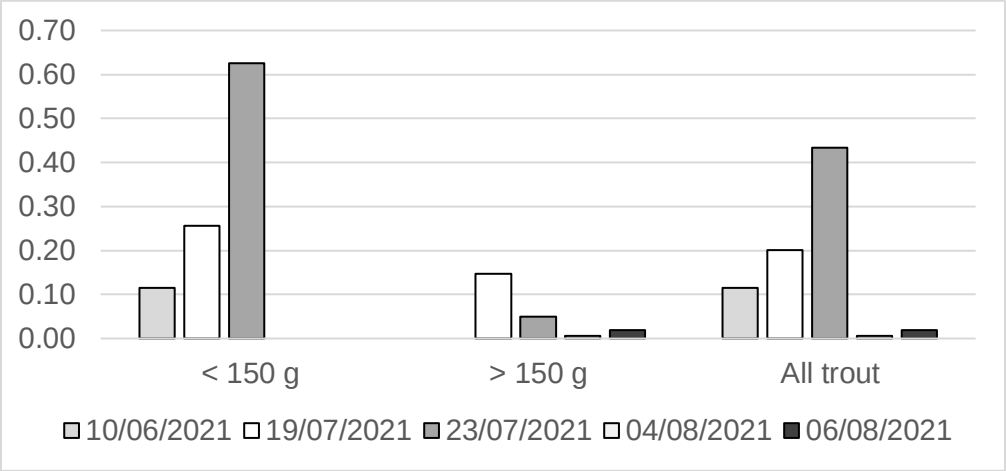
Table 3.3.1 Sea lice burdens found on sea trout (Avg. no. lice/g^{-1})

Sample Date	Lice/g^{-1}		
	< 150 g	> 150 g	All trout
10/06/2021	0.116		0.116
19/07/2021	0.256	0.147	0.201
23/07/2021	0.625	0.050	0.433
04/08/2021		0.007	0.007
06/08/2021		0.018	0.018

The average number of sea lice per gram found on trout under 150 grams rose from 0.116 in early June, 0.256 in mid-July and 0.625 lice per gram later in July. The average number of sea lice per

gram on trout over 150 grams was 0.147 in mid-July, but then fell to 0.050 later in July and 0.007 and 0.018 in the early August. The average number of sea lice per gram on all fish sampled rose from 0.116 in early June to 0.201 in mid-July and 0.433 lice per gram later in July, but then fell to 0.007 and 0.018 in the early August samples.

Figure 3.3.1 Sea lice burdens found on sea trout (Avg. no. lice/g⁻¹)



3.3.2 Risk analysis for trout under 150 grams weight

The average sea lice burden per gram of fish weight (for sea trout under 150 grams) is categorised below using the salmon lice risk index described by Taranger et. al. (2015). This is shown as a proportion of fish which fell into each category on each sample date (Table 3.3.2 and Figure 3.3.2).

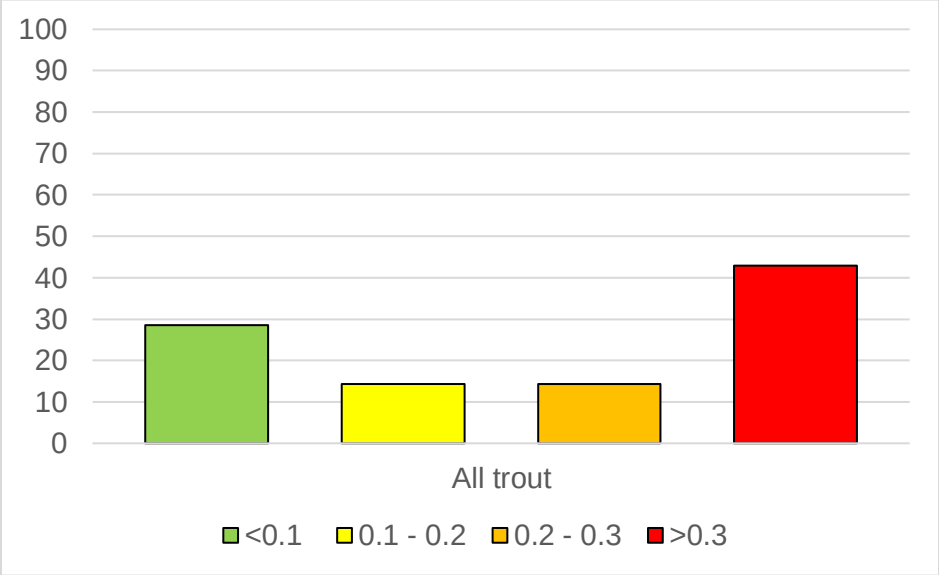
Table 3.3.2 Lice-related risk index for trout as the proportion (%) of trout < 150g (2021)

Sample Date	Categories Sea lice/g⁻¹ (< 150 g)				Total Mortality (%)
	<0.1	0.1 - 0.2	0.2 - 0.3	>0.3	
10/06/2021	50.0	25.0	0.0	25.0	30.0
19/07/2021	0.0	0.0	100.0	0.0	50.0
23/07/2021	0.0	0.0	0.0	100.0	100.0
04/08/2021					0.0
06/08/2021					0.0
All trout	28.57	14.29	14.29	42.86	52.9

The percentage of smaller trout (<150 g) which had a burden of <0.1 lice/g⁻¹ was 50 % in early June and 28.6 % across all samples. The percentage of smaller trout which had between 0.1 – 0.2 lice/g⁻¹ was 25 % in early June and 14.3 % across all smaller trout sampled. The percentage having between 0.2 – 0.3 lice/g⁻¹ was 100 % in mid-July (one trout) and 14.3 % across all smaller

trout sampled. The percentage of smaller fish which had > 0.3 lice/g^{-1} was 25 % in early June, 100 % later in July and 42.9 % across all larger trout (seven trout).

Figure 3.3.2 Lice-related risk index for trout as the proportion (%) of trout < 150g (2021)



The total increased lice-related mortality (or compromised reproduction) risk is calculated as the sum of the increased mortalities in the sample (Table 3.3.2). Total lice-related mortality for trout under 150 grams ranged between 30 % in early June and 50 % and 100 % in mid-to-late July in 2021 and 52.9 % across all samples in 2021. All smaller trout sampled were therefore categorised as being at high risk (> 30% total lice-related mortality) in 2021.

3.3.3 Risk analysis for trout over 150 grams weight

The average sea lice burden per gram of fish weight (for sea trout over 150 grams) is categorised below using the salmon lice risk index described by Taranger et. al. (2015). This is shown as a proportion of fish which fell into each category on each sample date (Table 3.3.3 and Figure 3.3.3).

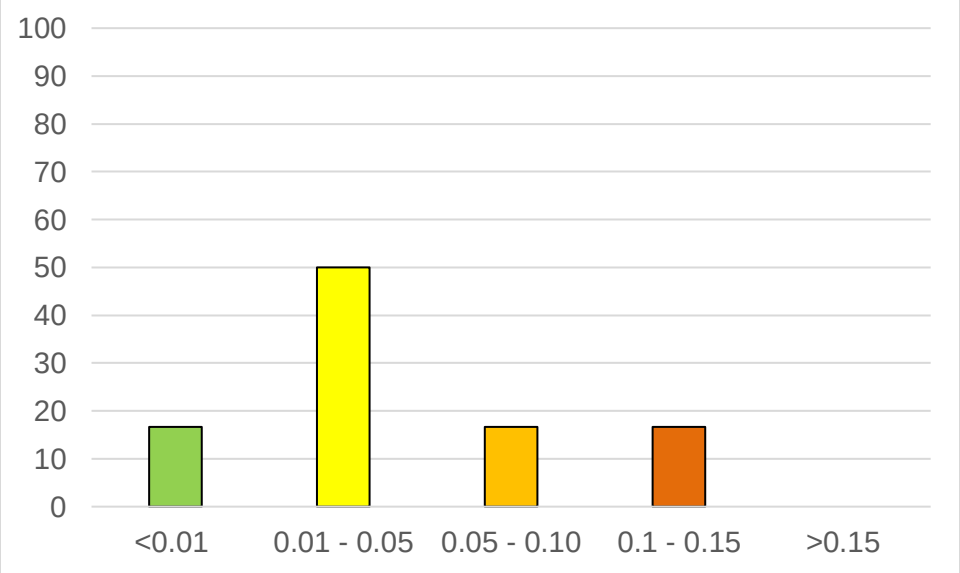
Table 3.3.3 Lice-related risk index for trout as the proportion (%) of trout > 150g

Sample Date	Categories Sea lice/g^{-1} (> 150 g)					Total Mortality (%)
	<0.01	0.01 - 0.05	0.05 - 0.10	0.1 - 0.15	>0.15	
10/06/2021						0.0
19/07/2021	0.0	0.0	0.0	100.0	0.0	75.0
23/07/2021	0.0	0.0	100.0	0.0	0.0	50.0
04/08/2021	50.0	50.0	0.0	0.0	0.0	12.5
06/08/2021	0.0	100.0	0.0	0.0	0.0	25.0
All trout	16.67	50.00	16.67	16.67	0.00	33.3

The percentage of larger fish sampled which had <0.01 lice/g^{-1} was 50 % in one of the early August surveys and 16.7% across all larger trout. The percentage which had between 0.01 – 0.05 lice/g^{-1} was 50 % and 100 % in the early August samples and 50.0 % across all larger fish sampled. The percentage which had between 0.05 – 0.10 lice/g^{-1} was 100% in mid-July and 16.7% across all larger trout. The percentage of trout which had between 0.10 – 0.15 lice/g^{-1} was 100 % in mid-July (one trout) and 16.7% across all larger trout sampled. No larger trout had a burden over 0.15 lice/g^{-1}.

The total increased lice-related mortality (or compromised reproduction) risk is calculated as the sum of the increased mortalities in the sample (Table 3.3.3). Total lice-related mortality for trout over 150 grams was moderate (between 10 and 30 % mortality) in the early August samples and high risk (more than 30 % lice-related risk) in mid-to-late July samples and across all samples in 2021 (33.3 %).

Figure 3.3.3 Lice-related risk index for trout as the proportion (%) of trout > 150g (2021)



3.4 Comparison of historical data

A comparison of previous survey results can be made to provide additional context for the 2021 survey results. There were no trout sampled over 150 grams in the previous surveys so only trout

under 150 grams sampled between 2008 and 2010 in Loch Craignish are compared below (Table 3.4.1).

3.4.1 Number of trout analysed

In addition to the seven trout under 150 grams sampled in 2021, 33 trout were sampled in 2008, two trout in 2009 and one trout in 2010.

Table 3.4.1 Number of trout sampled and analysed (2008-2021)

Year	no. samples	Prevalence (%)	Abundance	Intensity
2008	33	75.76	7.61	10.04
2009	2	100.00	2.50	2.50
2010	1	100.00	7.00	7.00
2021	7	71.43	18.57	26.00
Total	43			
Avg.	10.75	86.80	8.92	11.39
Min.	1	71.43	2.5	2.5
Max.	33	100	18.57	26.00

3.4.2 Prevalence of sea lice

The percentage of trout under 150 grams infected by sea lice was 75.8 % in 2008, 100 % in 2009 and 2010 and 71.4 % in 2021, averaging 86.8 % across all trout sampled over the study period.

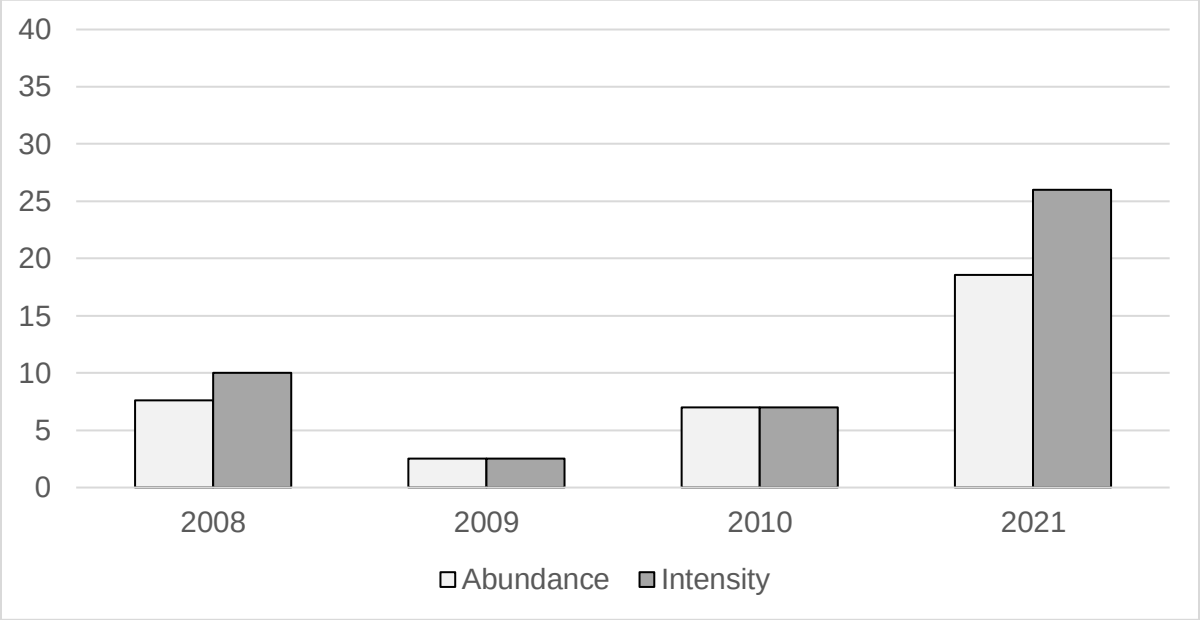
3.4.3 Abundance of sea lice infection

The average number of sea lice found on all trout under 150 grams was 7.6 in 2008, 2.5 lice in 2009, 7.0 lice in 2010 and 18.6 lice in 2021, averaging 8.9 lice over the study period (Figure 3.4.1).

3.4.4 Intensity of sea lice infection

The average number of sea lice found on infected sea trout under 150 grams was 10.0 in 2008, 2.5 lice in 2009, 7.0 lice in 2010 and 26.0 lice in 2021, averaging 11.4 lice over the study period (Figure 3.4.1).

Figure 3.4.1 Abundance and intensity of sea lice infection found on trout (2008-2021)



3.4.5 Comparison of Total lice-related risk index for trout under 150 grams (2008-2021)

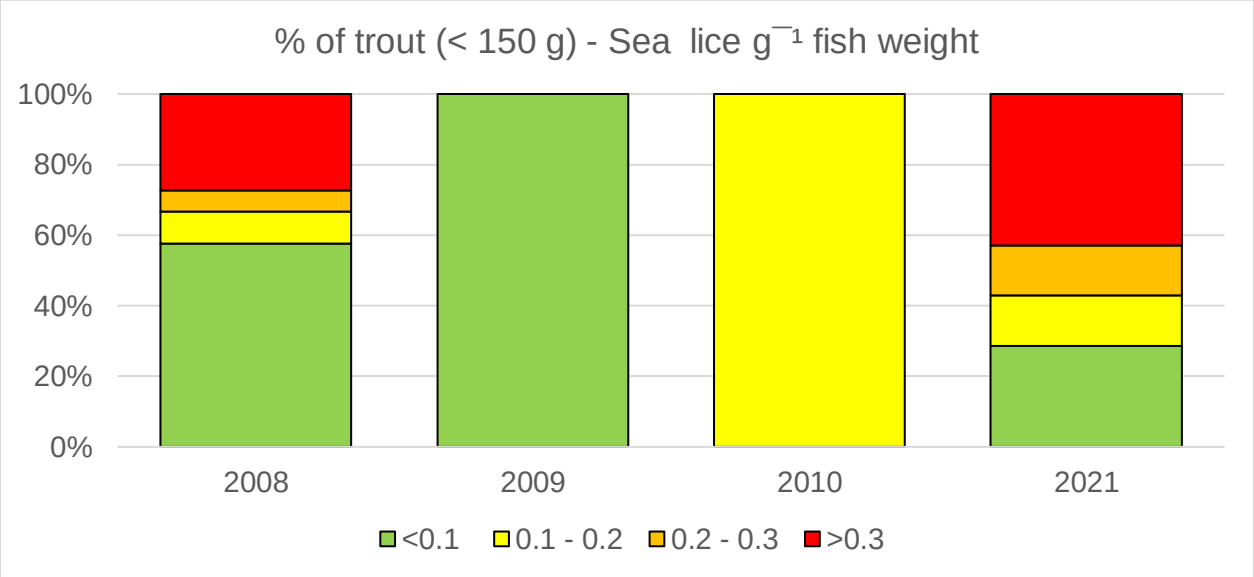
Of the smaller trout sampled over the study period 2008 – 2021, 57.6 % and 100 % and 28.6 % of trout had less than 0.1 lice/g^{-1} in 2008, 2009 and 2021 respectively. A total of 9.1 %, 100 % and 14.3 % of trout had between 0.1 and 0.2 lice/g^{-1} in 2008, 2010 and 2021 respectively. A total of 6.1 % and 14.3 % of trout had between 0.2 and 0.3 lice/g^{-1} in 2008 and 2021 respectively and a total of 27.3 % in 2008 and 42.9 % had more than 0.3 lice/g^{-1} (Table 3.4.2 and Figure 3.4.2).

Table 3.4.2 Lice-related risk as % of samples for trout < 150 grams (2008-2021)

Year	<0.1	0.1 - 0.2	0.2 - 0.3	>0.3	Total Mortality (%)
2008	57.6	9.1	6.1	27.3	32.1
2009	100.0	0.0	0.0	0.0	0.0
2010	0.0	100.0	0.0	0.0	20.0
2021	28.6	14.3	14.3	42.9	52.9

The total increased lice-related mortality (or compromised reproduction) risk is calculated as the sum of the increased mortalities separately (Table 3.4.2 and Figure 3.4.2). Total lice-related risk of mortality was estimated to be high (> 30% total lice-related mortality) in 2008 (32.1 %) and 2021 (52.9 %). Total lice-related mortality was estimated to be moderate (between 10 and 30 %) in 2010 (20 %) and low risk (< 10 % total lice-related risk) in 2009 (0%).

Figure 3.4.2 Lice-related risk as % of samples < 150 grams (2008-2021)



4. DISCUSSION

4.1 Factors affecting the number trout sampled

The number and size of trout sampled by the survey may be influenced by several factors. The 2021 surveys sampled relatively few trout in both the mobile seine net and the fixed fyke net sampling.

Data collected from numerous sites over several years in the region suggest sea trout post-smolts remain relatively close to river estuaries for the first few weeks after entering the sea before dispersing more widely as the summer progresses. This dispersal has meant that sampling sea trout in significant numbers becomes more difficult later in the summer. Consequently, seine net surveys are mostly conducted relatively close to river mouths in May and June when the density of trout may provide sufficient samples for analysis. However, the actively fished seine net requires a team of people to be deployed at the stage of tide and weather conditions when trout are present in a relatively small area of habitat. Additionally, these surveys do not usually sample numbers of older, larger sea trout which may have spent more time in the marine environment and therefore may be more exposed to infection by sea lice than the smaller post-smolts. Sea trout with a significant burden of sea lice may return to freshwater to shed lice, providing an opportunity to record this behaviour if it takes place during the survey period, but such fish may not be fully representative of the wider population, which may have fewer sea lice. The addition of a fixed fyke net, located further away from estuaries, was potentially able to catch larger sea trout as they move further afield.

The seine net surveys in this study were conducted later than usual (starting in mid-June rather than early May) after a relatively cold and dry spring which may potentially delay the timing of the smolt migration from freshwater into the sea loch. The surveys were also conducted during drought conditions where the salinity of the water at river estuaries may have been higher than usual. While the seine net sampling sites visited in Loch Melfort and Loch Craignish had suitable shallow gradient to fish the net effectively, these sites also had abundant seaweed growth, which hinder the retrieval of the net and lift the lead line from the bottom, providing an opportunity for any trout in the net to escape. These factors may therefore have contributed to the low number of fish sampled by the seine net surveys.

The fixed fyke net aims to sample trout over a much longer period to provide data on sea lice burdens after a longer period at sea and they are likely to be present at a much lower density compared to that found in estuaries earlier in the summer. Despite fishing the fyke net in three different locations over a period of 90 days between mid-July and mid-September, this method also caught relatively few trout despite catching numerous other fish species, including wrasse, pollack, saith, ling, conger eel and mackerel during the study.

The low productivity of both methods may suggest that relatively few sea trout may be present in the study area or that both net types were ineffective. While the effectiveness of the seine net may have been hampered by the weed on most occasions, the number of other fish caught by the fyke net suggest that it was potentially effective.

The trout sampled in each of the net types did however find that the smallest trout were sampled by the seine net at an estuary, while the fyke net caught larger, older trout which was the aim of using the two netting methods. The low number of samples collected, however, make the result and conclusions on sea lice burdens of trout in the Farm Management Area less than robust.

4.2 Sea lice burdens of sea trout

Of the four smaller trout sampled by the seine net in mid-June, one trout had a high burden, while the other three had lower or no burden at all. The larger trout sampled by the fyke net in July had a much higher lice burden compared to the smaller trout sampled in June by the seine net. Additionally, the July samples also had much high burdens of lice compared to the other larger trout sampled in the fyke net in early August. The proportion of attached lice compared to mobile lice found on trout generally remained similar or higher over the study period except for the last fish sampled in August when only mobile life-stages were found. This may suggest that there were sufficient sea lice larvae in the environment to infect trout over the earlier part of the study period but may have reduced in August. Comparison of the 2021 sea lice burdens of sea trout lice with previous surveys found that lice abundance and intensity of infection was higher than in the fish sampled in 2008, 2009 and 2010. This data suggest the number of lice larvae in the environment may have been higher in 2021.

4.3 Factors affecting the lice-related risk for sea trout

Environmental factors impacting the reproduction of sea lice and the distribution of larvae can influence sea lice numbers found on sea trout at the survey site. The influence of these many

factors may vary significantly from year-to-year making it difficult to attribute the influence of any specific environmental factor on sea lice burdens found on sea trout. Anthropogenic influences on sea lice larvae in the environment such as fish farms are more easily identified and can be managed through a variety of on-farm lice control methods. The number of potential hosts for sea lice at fish farm sites and the average number of adult female sea lice (i.e., the reproductive stage) per fish on the farm can be calculated and therefore their potential influence on the results of surveys can be estimated. The number of lice on farm fish generally tend to increase over time during a farm's production cycle and therefore, the number of lice larvae present in the environment is expected to be higher in the second year of the production cycle. At the time of survey in early summer 2021, fish farms in the Sound of Shuna were entering their second year of the two-year farming cycle. Published sea lice data for salmon farms (through Scottish Government's Aquaculture website) show that average adult female lice numbers on farmed fish in the Sound of Shuna were mostly higher than the SSPO's Code of Good Practice level of 0.5 adult female lice per fish during the study period, which may have influenced the results of these surveys.

The low number of trout sampled in 2021 and the limited data collected on the sea lice burdens of sea trout in Loch Craignish between 2008 and 2010 make comparison of results difficult to interpret. The data does however suggest that sea lice burdens appear to be potentially detrimental to the health of sea trout when analysed by the methods described by Taranger. The few samples of trout analysed suggested that the lice-related risk was high in all five groups of trout analysed over the study period in 2021. The data collected in 2008 (33 trout sampled) also found a high lice-related risk, but the very few trout sampled in 2009 and 2010 suggest a lower lice-related risk. However, the low number of samples collected in 2009 and 2010, do not make it possible to draw firm conclusions from historical data in this case.

4.4 Sampling site and method considerations for future monitoring

The risk analysis assumes that individuals caught in the study are representative for the sea trout populations in the area, which may originate from several different rivers in the Sound of Shuna Farm Management Area. The location of the seine net survey site that sampled a few trout, which is close to the estuary of the Allt na Cille, may sample a higher proportion of trout originating from this river and therefore could be less representative for those populations of trout originating from rivers located further away from the survey site.

The risk analysis is also not able to identify the proportion of the population that are resident or have returned to the site to shed lice or visit the site for short periods. The datasets from other sampling sites do suggest that relatively high numbers of trout with no or relatively low lice burdens are sampled at sites close to estuaries, suggesting that smaller trout do normally inhabit these estuarine sites in the late spring and early summer period. The surveys sample fish that have not ventured very far from the estuary and therefore may have a reduced risk of infection. The fyke net locations used in this study were further away from estuaries and did sample a higher proportion of larger trout, providing some optimism that the technique can be useful in monitoring the lice burdens on the larger trout that are thought to be more transient and more likely to accumulate a lice burden over time. The location of the fyke net may be crucial in sampling enough trout to make the findings more conclusive and therefore gathering information on the movement of trout in the Sound of Shuna may be key to ensuring that monitoring efforts provide sufficient samples from which to draw firm conclusions. Acoustic tags and receivers may be used to track the movements of individual sea trout to better identify potential sampling sites and understand any differences in the risk of infection to different age groups of trout over a wider area.

The beach seine net sampling technique has proven reliable at some sites where the gradient is shallow and relatively weed-free, which allows the net to be fished effectively. However, this method is limited to a relatively small portion of the shoreline which is largely of steeper gradient and has more aquatic vegetation where other sampling techniques would be required. The beach seine sampling is also undertaken over a relatively short period close to estuaries where post-smolt sea trout appear to remain for some time. Sampling earlier in May and June may produce more samples than was the case in 2021.

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