Sea Lice Burdens of Sea Trout at Loch Etive, Argyll, 2024

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Background

Argyll Fisheries Trust undertook seine netting surveys at Airds Bay on the south shore of Loch Etive in early summer 2024 to assess burdens of a parasite (Sea lice; *Lepeophtheirus salmonis*) found on sea trout (*Salmo trutta*). The data collected aims to inform the Environment Monitoring Plan of the change in fish farm production in Loch Etive.

Main findings

- Sweep netting surveys were undertaken over four visits between late May and early July in 2024 when the fish farms in Loch Etive had recently (January 2024) been stocked with post-smolt salmon on a six-month farming cycle.
- A total of 47 sea trout were sampled, including 25 small trout (< 150 g weight) and 22 larger trout (> 150 grams).
- The percentage of trout sampled that were infected by sea lice (prevalence) was 40.0 % of the small trout and 68.18 % of the larger trout (53.19 % for all trout sampled).
- For the smaller trout (<150g), the intensity of infection was 2.30 lice per infected trout and was 2.67 lice per infected larger trout (> 150 grams).
- The total lice-related risk index (Taranger et al., 2015) estimates that the small trout had no sea lice-related risk and larger trout had a low (5.7 %) additional risk of increased mortality, reduced seawater growth and reproduction in 2024 because of their sea lice infections.
- When compared with the historical data collected since 2017, a low total lice-related risk of increased marine mortality and reduced seawater growth was found for small trout in six of the seven-year dataset. A moderate risk was found only in 2023.
- In the group of larger trout, the total lice-related risk of increased marine mortality, reduced seawater growth and reproduction was moderate (between 10 and 30 % additional risk) in four years (2017, 2019, 2021 and 2023 and 2024) and was low in one other (2022) of the previous six years when larger trout were sampled.

Acknowledgements

Argyll Fisheries Trust thanks Mowi Scotland Ltd for funding the 2024 study.

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1. INTRODUCTION

Seine net surveys were conducted in the early summer of 2024 to fulfil the 'Loch Etive Wild Fish Monitoring' under contract by Mowi Scotland Ltd. This study continues a timeline of data collection at the site since 2017 which has formerly been funded by the Marine Directorate. The aim of the surveys was to assess the sea lice burdens of post-smolt sea trout in Spring and early summer (May, June and July), shortly after the smolts have migrated from the freshwater to the marine habitat.

Assessing the potential impacts of sea lice on wild migratory salmonids at Loch Etive has been undertaken using a risk index developed within a wider risk assessment framework for aquaculture in Norway (Taranger et al., 2015). This tool attempts to quantify the total sea lice-related risk of increased marine mortality, reduced seawater growth and reproduction of sea trout. 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 2024 results have been compared to previous years (2017 to 2023) in this report to identify any trends in infection pressure and any potential relation to production of farm rainbow trout (2017 to 2023) and salmon (2024) in the Farm Management Area.

2. METHODS

The survey site is located at Airds Bay on the south shore of Loch Etive at the estuary of a small coastal stream: Allt na h-Airde (Figure 2.1 and Table 2.1). Surveys were conducted on four occasions between mid-May and early July 2024. The surveys at the site were undertaken at low tide which provided access to sampling in deeper water compared to high tide and reduced tidal force which allow the seine net to be fished more effectively.

Table 2.1 Sweep net survey site location & frequency

Airds Bay	Easting	Northing
O.S. Grid. Ref.	199974	732176
Survey Date	Week no.	Stage of tide
17/05/2024	20	Low
03/06/2024	23	Low
17/06/2024	25	Low
02/07/2024	27	Low

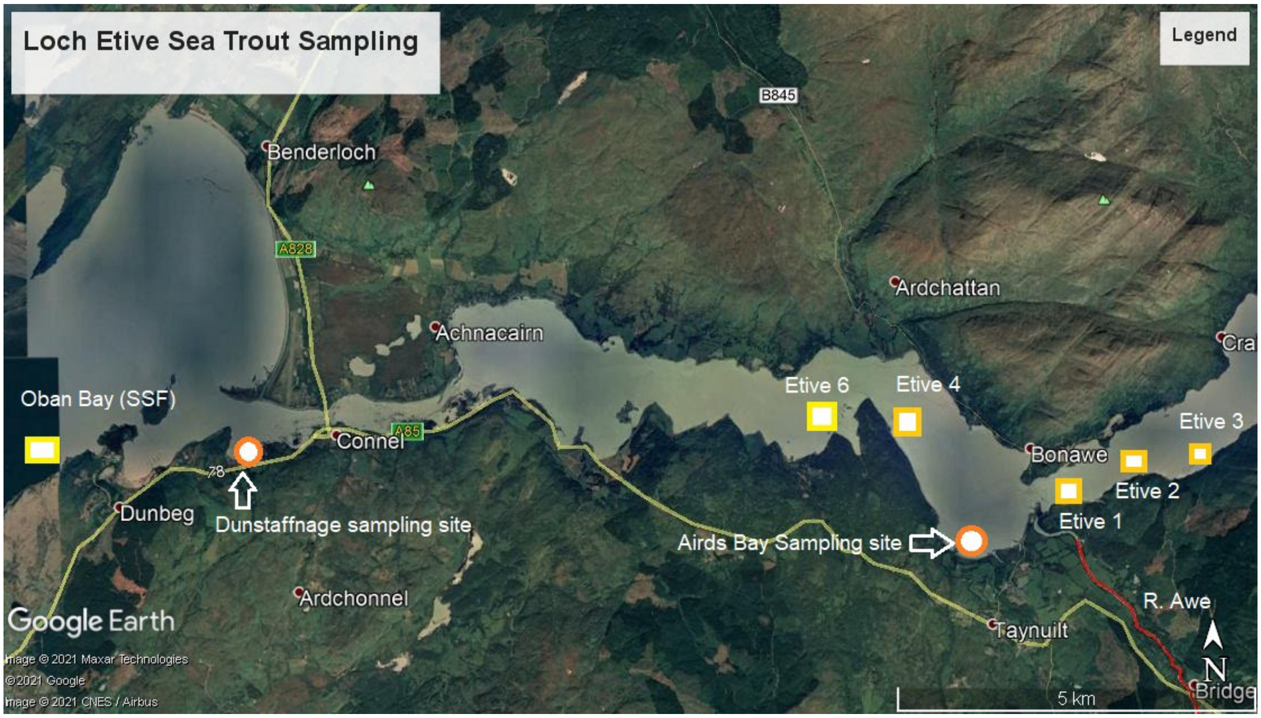
The surveys of sea trout were undertaken by sweeps of a 50 m length beach seine net which was deployed by motorboat along a length of shoreline and retrieved by hand. Up to four sweeps of the net were undertaken at spots along the shore to locate the fish and capture sufficient fish to inform the study. The target number of samples was 30 trout over the study period.

The trout captured in each sweep were transferred to a container for inspection once the netting had been completed. 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 mortality risk or compromised seawater growth or reproduction 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 Loch Etive netting site



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 seawater growth or 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 increased mortality risk or compromised seawater growth or reproduction 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).

3. RESULTS

The results of the 2024 surveys are given below in terms of the characteristics of the sea trout sampled (3.1), their sea lice burdens (3.2), risk analysis of sea lice burdens (3.3) and comparison with historical data (3.4) collected at the site (2017-2023).

3.1 The sea trout sampled

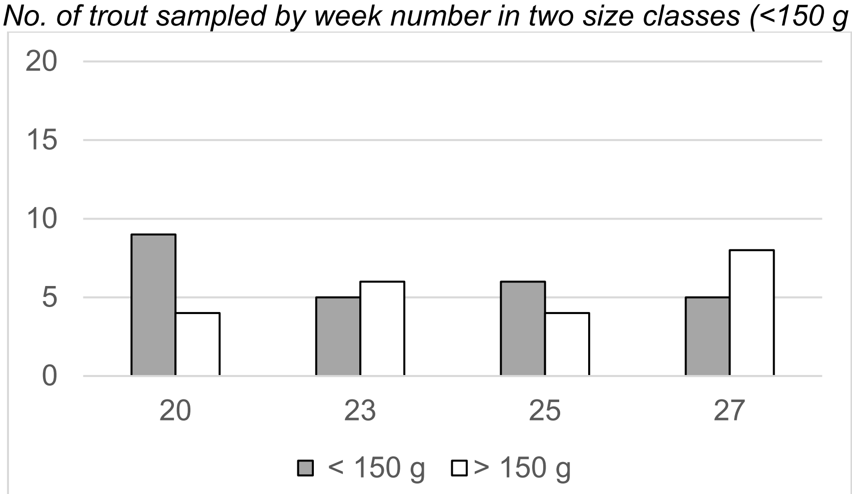
3.1.1 Number of trout analysed

A total of 47 sea trout were sampled in the four surveys conducted in 2024 (Table 3.1.1 and Figure 3.1.1) including 25 small trout (< 150 grams) and 22 larger trout (> 150 grams). The number of trout caught in sweep net surveys was 13 in mid-May (week 20), 11 in early June (week 23), 10 trout in mid-June (week 25) and 13 trout in early July (week 27).

Table 3.1.1 Number of trout sampled (2024)

Date	Week no.	< 150 g	> 150 g	Total	% of sample
17/05/24	20	9	4	13	27.7
03/06/24	23	5	6	11	23.4
17/06/24	25	6	4	10	21.3
02/07/24	27	5	8	13	27.7
Total		25	22	47	100

Figure 3.1.1 No. of trout sampled by week number 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 (CF) (K) of the trout sampled in seine net surveys are described below in Table 3.1.2.

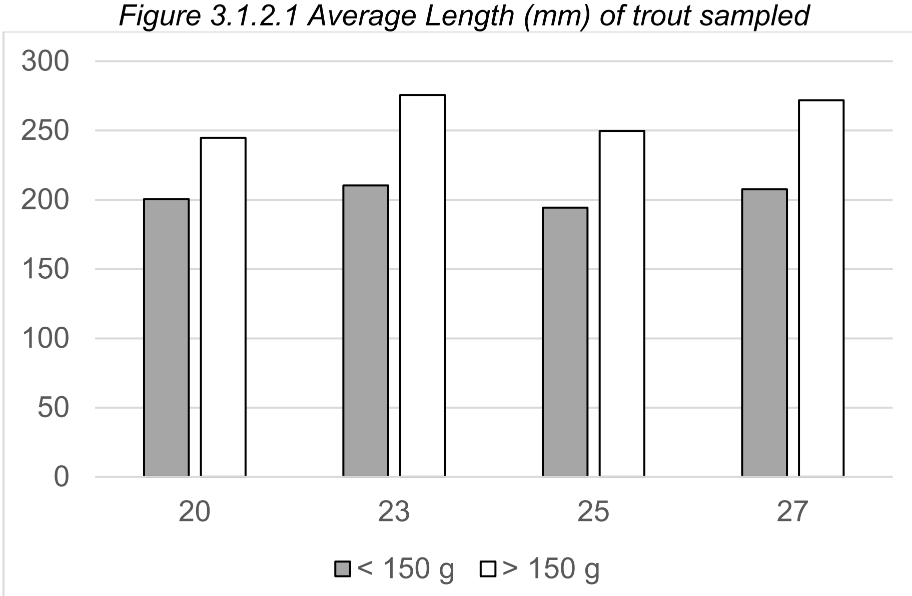
Table 3.1.2 Average length (mm), weight (g) and condition factor (CF) (K) of trout

Date	Week no.	< 150 g			> 150 g		
		Length (mm)	Weight (g)	C.F. (K)	Length (mm)	Weight (g)	C.F. (K)
17/05/24	20	200.56	92.94	1.07	244.75	163.75	1.12
03/06/24	23	210.40	98.50	1.01	275.67	232.17	1.07
17/06/24	25	194.30	57.75	1.18	249.75	193.63	1.20
02/07/24	27	207.60	109.20	1.17	271.88	247.06	1.15
All Trout		193.56	88.86	1.10	263.95	218.14	1.15

3.1.2.1 Length of sea trout sampled.

The average length of sea trout (Figure 3.1.2.1) less than 150 g weight ranged from 194.30 mm in mid-June (week 25) to 210.40 mm in early June (week 23) with a mean length of 193.56 mm across all smaller trout. The average length of trout of more than 150 g weight ranged from 244.75 mm in mid-May (week 20) to 275.67 mm in early June with a mean of 263.95 mm across all larger trout.

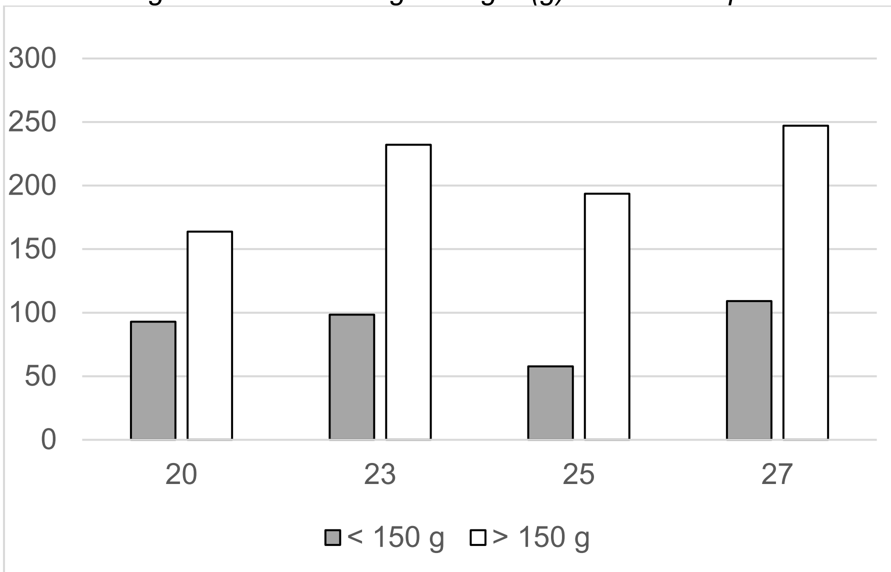
Figure 3.1.2.1 Average Length (mm) of trout sampled



3.1.2.2 Weight of sea trout sampled

The average weight of trout (Figure 3.1.2.2) of less than 150 g weight ranged from 57.75 g in mid-June (week 25) to 109.20 g in early July (week 27) with a mean of 88.86 g across all smaller trout. The average weight of trout of more than 150 g weight ranged from 193.63 g in mid-June to 247.06 g in early July with a mean of 218.14 g across all larger trout.

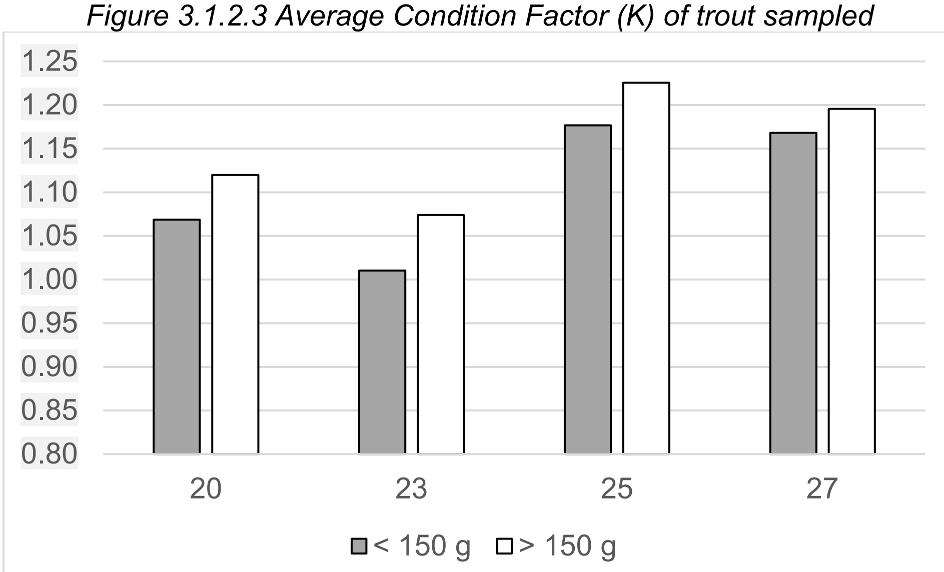
Figure 3.1.2.2 Average Weight (g) of trout sampled



3.1.2.3 Condition factor of sea trout sampled

The average condition factor of trout (Figure 3.1.2.3) of less than 150 g weight ranged from 1.01 K in early June (week 23) to 1.18 K in mid-June (week 25) with a mean of 1.10 across all smaller trout. The average condition factor of trout of more than 150 g weight ranged from 1.07 K in early June, to 1.23 K in mid-June with a mean of 1.15 K across all larger trout.

Figure 3.1.2.3 Average Condition Factor (K) of trout sampled



3.2 Sea lice burdens of sea trout

The sea lice burdens of sea trout sampled in 2024 are summarised (Table 3.2.1) in terms of the prevalence of lice (% of fish infected), abundance of lice (average number of lice per fish), intensity of infection (average number of lice per infected fish) and the different life stages of lice.

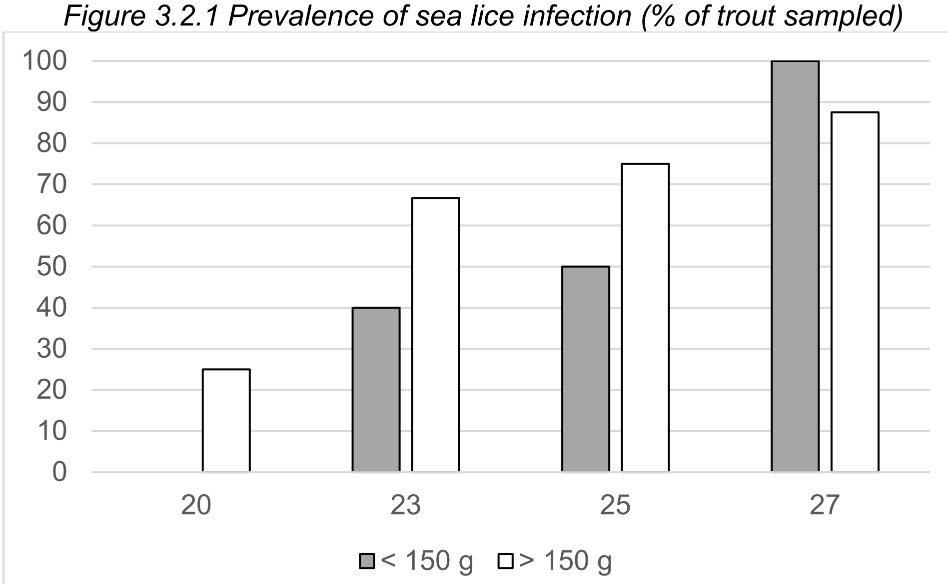
Table 3.2.1 Sea lice burdens of sea trout sampled

Date	Week no.	< 150 g			> 150 g		
		Prevalence (%)	Abundance	Intensity	Prevalence (%)	Abundance	Intensity
17/05/24	20	0.00	0.00	0.00	25.00	0.25	1.00
03/06/24	23	40.00	0.40	0.40	66.67	2.83	4.25
17/06/24	25	50.00	0.67	1.33	75.00	1.50	2.00
02/07/24	27	100	3.40	3.40	87.50	2.00	2.29
All Trout		40.00	0.92	2.30	68.18	1.82	2.67

3.2.1 Prevalence of sea lice

The percentage of trout less than 150 grams weight infected by lice (Figure 3.2.1) rose from none in mid-May (week 20) to 100 % in early July (week 27) with a mean of 40.0 % across all smaller trout sampled. The percentage of trout more than 150 grams weight infected by lice rose from 25.0 % in mid-May to 87.5 % in early July with a mean of 68.18 % across all larger trout.

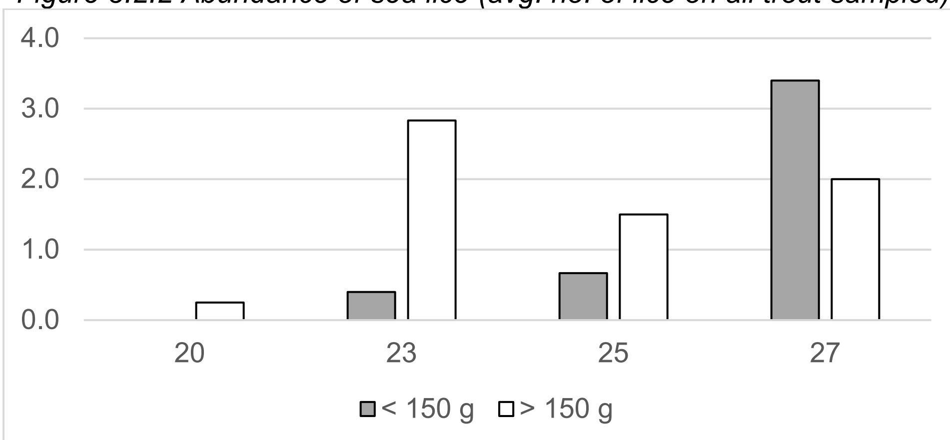
Figure 3.2.1 Prevalence of sea lice infection (% of trout sampled)



3.2.2 Abundance of sea lice

When found, the average number of sea lice found across all the trout (abundance) under 150 grams weight (Figure 3.2.2) rose from 0.40 lice per trout in early June (week 23) to 3.40 in early July (week 27) with a mean of 0.92 lice across all smaller trout. The abundance of lice found on trout over 150 grams weight ranged from 0.25 lice in mid-May (week 20) to 2.83 lice in early June with a mean of 1.82 lice across all larger trout.

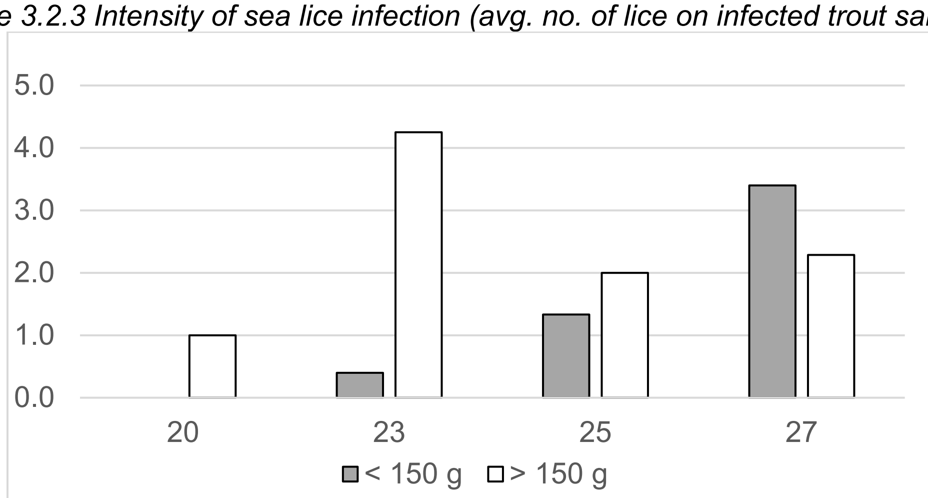
Figure 3.2.2 Abundance of sea lice (avg. no. of lice on all trout sampled)



3.2.3 Intensity of sea lice infection

When found, the average number of sea lice found on infected trout (Figure 3.2.3) under 150 grams weight rose from 0.40 lice in early June (week 23) to 3.40 lice in early July (week 27) with a mean of 2.30 lice across all smaller trout. The intensity of infection found on trout over 150 grams weight ranged from 1.00 lice in mid-May (week 20) to 4.25 lice in early June with a mean of 2.67 lice across all larger trout.

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. The three stages of lice recorded were attached (stage 1), mobile (stage 2) and gravid female (stage 3).

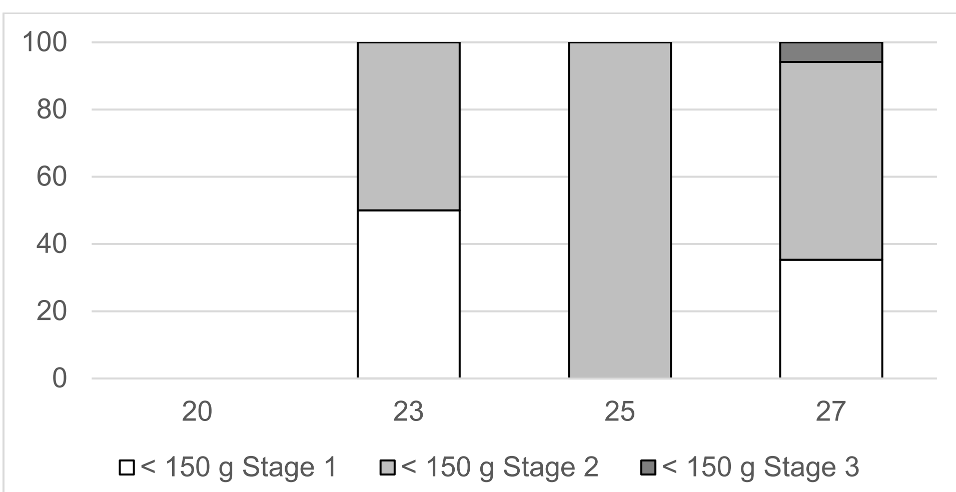
Table 3.2.2 Life-stage of sea lice found on sea trout (% of all lice found)

Date	Week no.	< 150 g			> 150g		
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
17/05/24	20	0.0	0.0	0.0	100	0.0	0.0
03/06/24	23	50.0	50.0	0.0	29.4	70.6	0.0
17/06/24	25	0.0	100.0	0.0	0.0	50.0	50.0
02/07/24	27	35.3	58.8	5.9	0.0	93.8	6.3
All trout		30.4	65.2	4.3	15.0	75.0	10.0

The proportion of attached sea lice (stage 1) found was 30.4 % on all trout of less than 150 g weight and 15.0 % on all larger trout of more than 150 g. The proportion of mobile sea lice (stage 2) was 65.2 % on all smaller trout and 75.0 % of lice found on all larger trout. The proportion of gravid female sea lice (stage 3) found on all smaller trout was 4.3 % and 10 % of lice found on the larger trout.

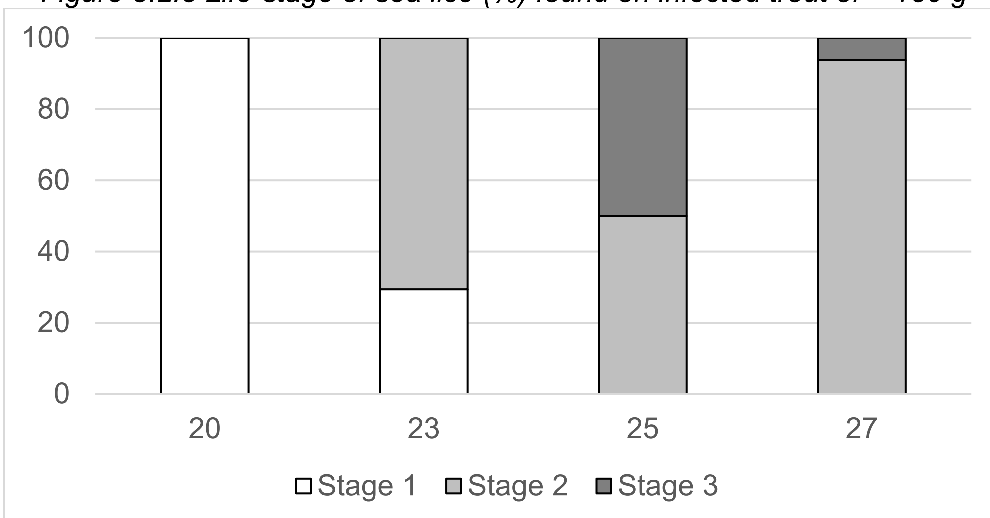
When found, the proportion of attached sea lice (stage 1) found on trout of less than 150 g weight (Figure 3.2.4) ranged from 35.3 in early July (week 27) to 50.0 % in early June (week 23). The proportion of mobile sea lice (stage 2) ranged from 50.0 % in early June to 100 % in mid-June (week 25). The proportion of gravid female sea lice (stage 3) found on all smaller trout was 5.9 % in early July.

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



When found, the proportion of attached sea lice (stage 1) found on trout of more than 150 g weight (Figure 3.2.5) ranged from 29.4 in early June (week 23) to 100 % in mid-May (week 20). The proportion of mobile sea lice (stage 2) ranged from 50.0 % in mid-June (week 25) to 93.8 % in early July (week 27). The proportion of gravid female sea lice (stage 3) ranged from 6.3 % of lice in early July to 50.0 % of lice in mid-June.

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



3.3 Risk analysis of sea lice burdens

The Total increased mortality risk or compromised seawater growth or reproduction 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

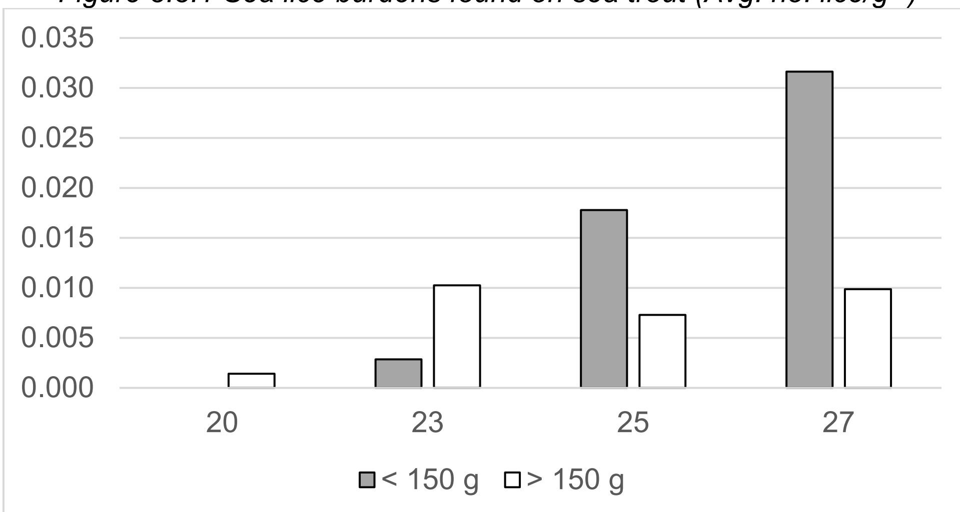
The average lice per gram of fish weight (lice / g^{-1}) is given for fish in both weight categories (above and below 150 grams weight) and across all fish in sampled in each survey below (Table 3.3.1 and Figure 3.3.1).

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

Date	Week no.	< 150 g	> 150 g	All trout
17/05/24	20	0.000	0.001	0.000
03/06/24	23	0.003	0.010	0.007
17/06/24	25	0.018	0.007	0.014
02/07/24	27	0.032	0.010	0.018
All trout		0.011	0.008	0.010

The average number of sea lice per gram on fish under 150 grams was none in mid-May (week 20), 0.003 lice per gram in early June (week 23), 0.018 lice in mid-June (week 25) and 0.032 lice per gram in early July (week 27). The average number of sea lice per gram on fish over 150 grams was 0.001 in mid-May, 0.010 in early June, 0.007 in mid-June and 0.010 lice per gram in early July.

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

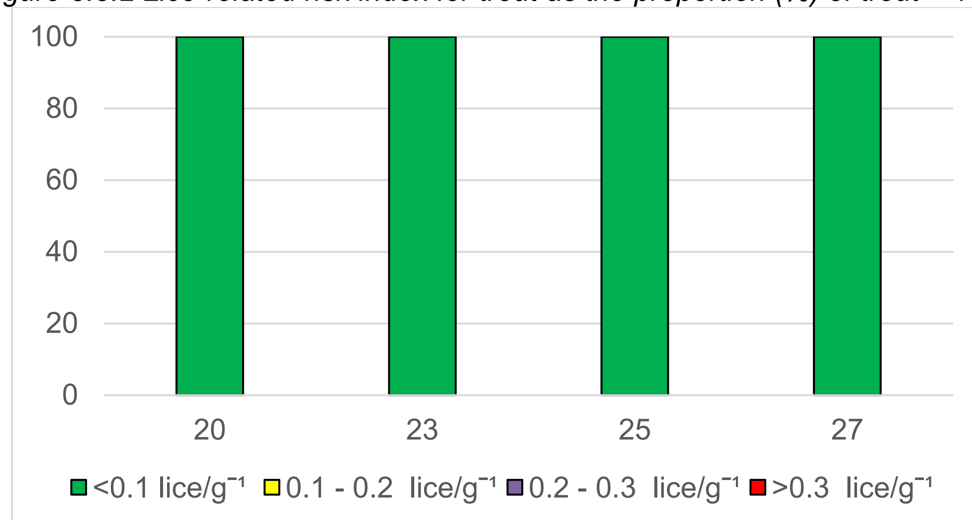
The average sea lice burden per gram of fish weight for sea trout under 150 grams is categorised below using the salmon lice risk index described by Taranger et. al. (2015). This is recorded as a proportion of fish which fell into each category on each sample date (Table 3.3.2 and Figure 3.3.2).

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

Sample Date	Week no.	Proportion (%) of sea trout (<150g) which fell into each risk assessment category				Total Risk
		<0.1 lice/g⁻¹	0.1 - 0.2 lice/g⁻¹	0.2 - 0.3 lice/g⁻¹	>0.3 lice/g⁻¹	(%)
17/05/24	20	100.0	0.0	0.0	0.0	0.0
03/06/24	23	100.0	0.0	0.0	0.0	0.0
17/06/24	25	100.0	0.0	0.0	0.0	0.0
02/07/24	27	100.0	0.0	0.0	0.0	0.0
All trout		100.0	0.0	0.0	0.0	0.0

The percentage of smaller trout (<150 g) which had a burden of <0.1 lice/g⁻¹ was 100 % in all four surveys. No smaller trout had between 0.1 – 0.2 lice/g⁻¹, between 0.2 – 0.3 lice/g⁻¹ and > 0.3 lice/g⁻¹. The Total lice-related risk is calculated as the sum of the increased mortalities in the sample (Table 3.3.2) which was 0 % in 2024 for the smaller group of trout sampled and therefore categorised as being low (less than 10 % total lice-related risk).

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



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 recorded as a proportion of fish which fell into each category on each sample date (Table 3.3.3 and Figure 3.3.3).

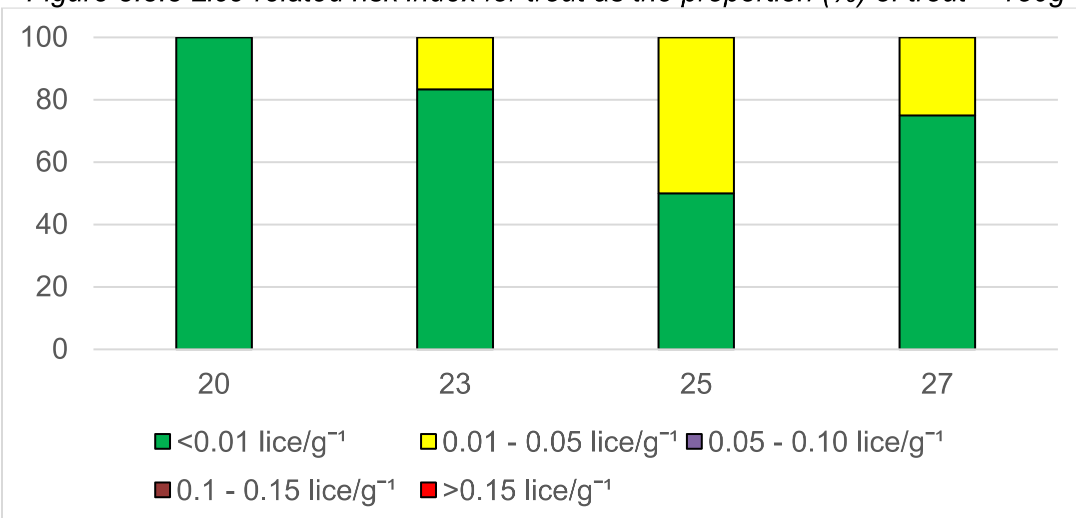
Table 3.3.3 Lice-related risk index for trout as the proportion (%) of trout > 150g

Sample Date	Week no.	Proportion (%) of sea trout (>150g) which fell into each risk assessment category					Total Risk
		<0.01 lice/g^{-1}	0.01 - 0.05 lice/g^{-1}	0.05 - 0.10 lice/g^{-1}	0.1 - 0.15 lice/g^{-1}	>0.15 lice/g^{-1}	(%)
17/05/24	20	100.0	0.0	0.0	0.0	0.0	0.0
03/06/24	23	83.3	16.7	0.0	0.0	0.0	4.2
17/06/24	25	50.0	50.0	0.0	0.0	0.0	12.5
02/07/24	27	75.0	25.0	0.0	0.0	0.0	6.3
All trout		77.3	22.7	0.0	0.0	0.0	5.7

The percentage of larger trout (>150g) that had <0.01 lice/g^{-1} was 100 % in mid-May (week 20), 83.3 % in early June (week 23), 50.0 % in mid-June (week 25) and 75.0 % of trout in early July (week 27). The percentage of larger trout sampled which had between 0.01 – 0.05 lice/g^{-1} was none in mid-May, 16.7 % in early June, 50.0 % in mid-June and 25.0 % in early July. No larger trout had burdens of between 0.05 – 0.10 lice/g^{-1}, between 0.10 – 0.15 lice/g^{-1} or > 0.15 lice/g^{-1}.

The Total lice-related risk is calculated as the sum of the increased mortalities in the sample (Table 3.3.3) which was 5.7 % in 2024 for the larger group of trout sampled and therefore categorised as being low (< 10 % total lice-related risk).

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



3.4 Comparison of historical data

A comparison of previous survey results can be made to provide additional context for the 2024 survey results. The number of trout and their sea lice burdens sampled since 2017 are described below. No sampling was undertaken in 2020 due to restrictions under Scottish Government guidance for the Coronavirus pandemic.

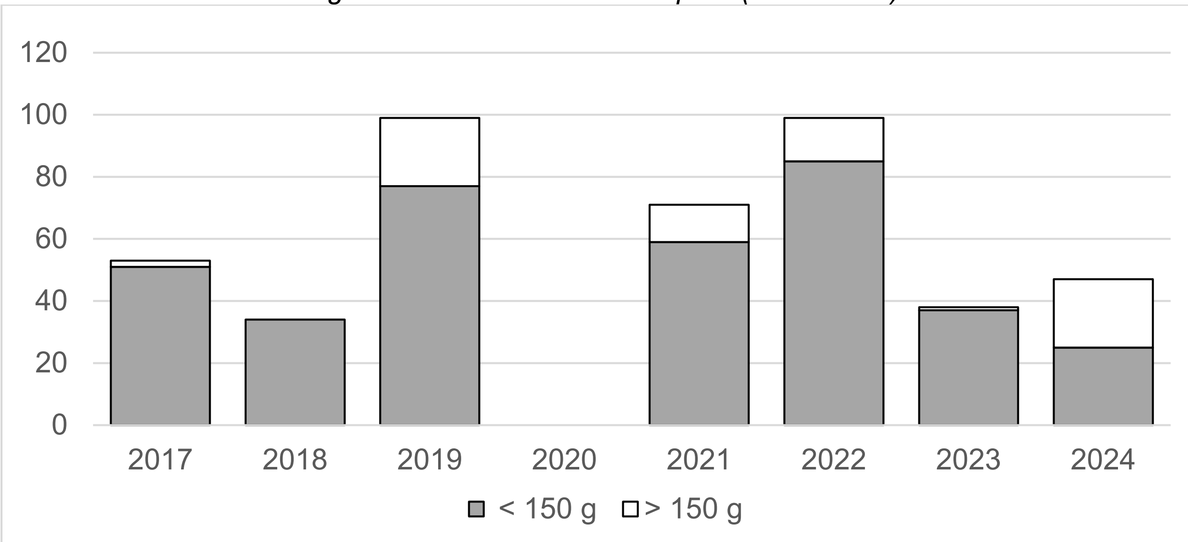
3.4.1 Number of trout analysed (2017-2024)

A total of 441 trout were sampled between 2017 and 2024 including 368 of less than 150 grams (83.4 % of all samples) and 73 trout of over 150 grams (16.6 % of all samples) (Table 3.4.1 and Figure 3.4.1).

Table 3.4.1 Number of trout sampled and analysed (2017-2024)

Year	< 150 g	> 150 g	Total	Year	< 150 g	> 150 g	Total
2017	51	2	53	2022	85	14	99
2018	34	0	34	2023	37	1	38
2019	77	22	99	2024	25	22	47
2020				Avg.	52.6	10.4	63.0
2021	59	12	71				

Figure 3.4.1 No. of trout sampled (2017-2024)



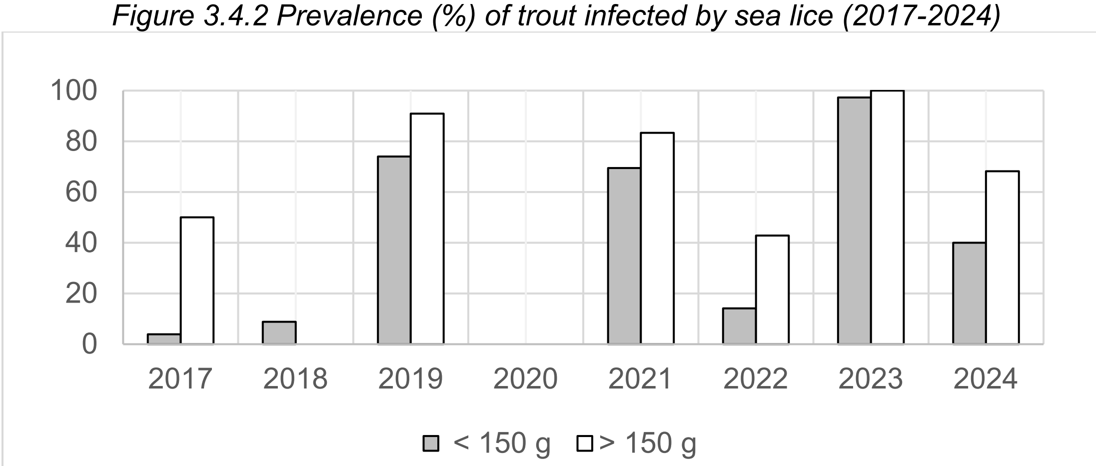
3.4.2 Prevalence of sea lice (2017-2024)

The percentage of trout under 150 grams infected by sea lice ranged between 3.9 % in 2017 and 97.3 % in 2023, averaging 44.0 % across all smaller trout sampled over the study period (Table 3.4.2 and Figure 3.4.2). The percentage of trout over 150 grams infected by sea lice ranged between 42.9 % in 2022 and 100 % in 2023, averaging 72.5 % for all larger trout over the study period.

Table 3.4.2 Prevalence (%) of lice found on sea trout (2017-2024)

Year	< 150 g	> 150 g	All trout	Year	< 150 g	> 150 g	All trout
2017	3.9	50.0	5.7	2022	14.1	42.9	18.2
2018	8.8		8.8	2023	97.3	100.0	97.4
2019	74.0	90.9	77.8	2024	40.0	68.2	53.2
2020				Avg.	44.0	72.5	46.7
2021	69.5	83.3	66.2				

Figure 3.4.2 Prevalence (%) of trout infected by sea lice (2017-2024)



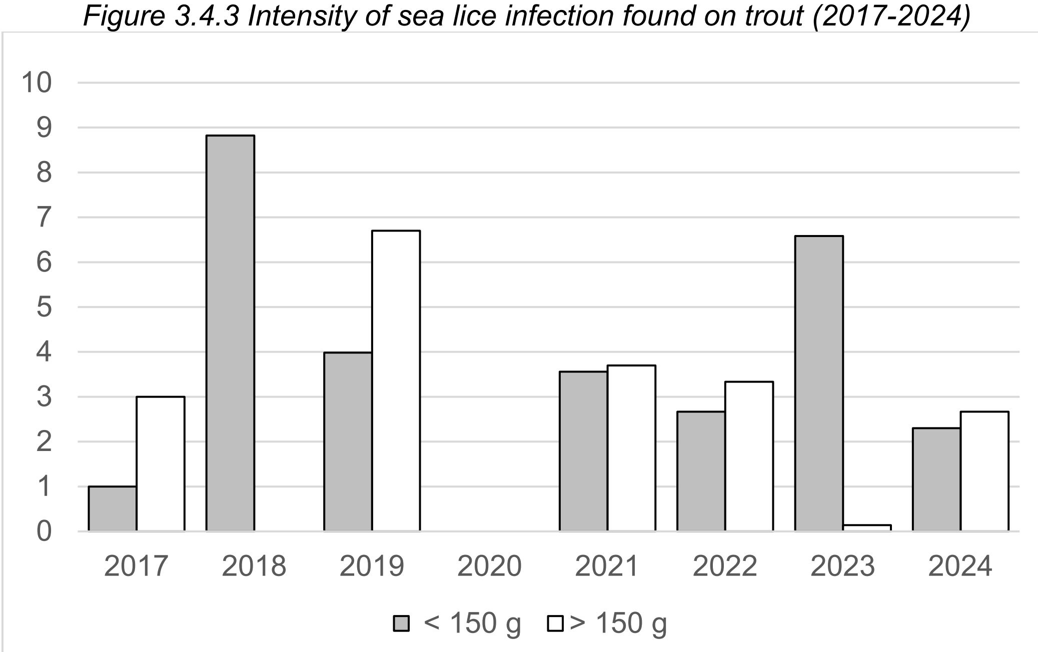
3.4.3 Intensity of sea lice infection (2017-2024)

The average number of sea lice found on infected sea trout under 150 grams ranged between 1.0 lice in 2017 and 8.8 lice in 2018, averaging 4.1 lice over the study period (Table 3.4.3 and Figure 3.4.3). The average number of lice on infected trout over 150 grams ranged between 0.1 lice in 2023 and 2024 and 6.7 lice in 2019, averaging 2.8 lice per infected trout sampled over the study period.

Table 3.4.3 Intensity of lice infection of sea trout (2017-2024)

Year	< 150 g	> 150 g	All trout	Year	< 150 g	> 150 g	All trout
2017	1.0	3.0	1.7	2022	2.7	3.3	2.9
2018	8.8		8.8	2023	6.6	0.1	6.6
2019	4.0	6.7	4.7	2024	2.3	0.1	2.5
2020				Avg.	4.1	2.8	4.4
2021	3.6	3.7	3.9				

Figure 3.4.3 Intensity of sea lice infection found on trout (2017-2024)



3.4.4 Lice-related risk index for trout under 150 grams (2017-2024)

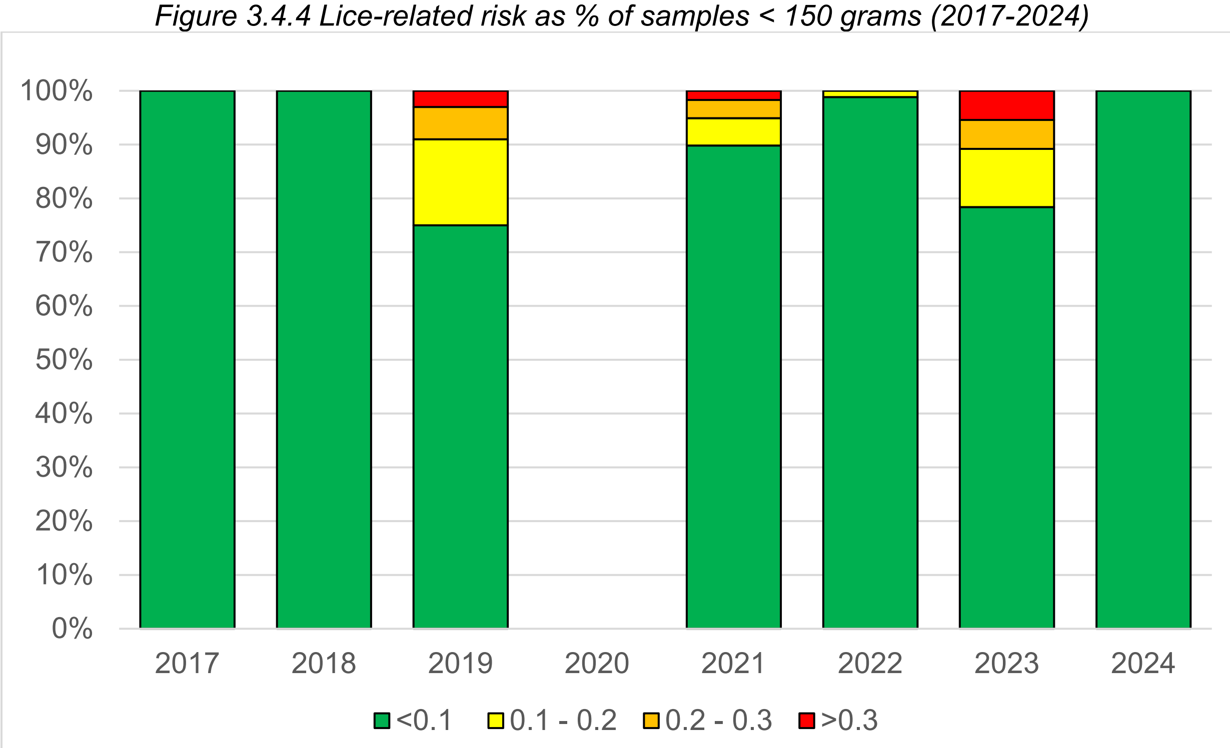
According to the lice-related risk index proposed by Taranger et al. (2015) for trout under 150 grams, the percentage of trout that had less than 0.1 lice/g^{-1} ranged from 75.0 % in 2019 and 100 % in 2017, 2018 and 2024 with a mean of 91.72 % across all years. Of the smaller trout sampled, that had between 0.1 and 0.2 lice/g^{-1} ranged between none in 2017, 2018 and 2024 and 16.0 % in 2019 with a mean of 4.2 % across all years. The percentage of smaller trout that had between 0.2 and 0.3 lice/g^{-1} ranged from none in four years and 6.0 % in 2019 with a mean of 2.11 %

across all years. The percentage of fish that had burdens over 0.3 lice/g⁻¹ ranged from none in four years to 5.4 % in 2023 with a mean of 1.44 % across all years (Table 3.4.4 and Figure 3.4.4).

Table 3.4.4 Lice-related risk as % of samples for trout < 150 grams (2017-2024)

Year	Proportion (%) of sea trout (<150g) which fell into each risk assessment category				Total Risk (%)
	<0.1 lice/g⁻¹	0.1 - 0.2 lice/g⁻¹	0.2 - 0.3 lice/g⁻¹	>0.3 lice/g⁻¹	
2017	100	0.0	0.0	0.0	0.0
2018	100	0.0	0.0	0.0	0.0
2019	75.0	16.0	6.0	3.0	9.2
2020					
2021	89.8	5.1	3.4	1.7	4.4
2022	98.8	1.2	0.0	0.0	0.2
2023	78.4	10.8	5.4	5.4	10.3
2024	100	0.0	0.0	0.0	0.0
Avg.	91.72	4.72	2.11	1.44	3.4

Figure 3.4.4 Lice-related risk as % of samples < 150 grams (2017-2024)



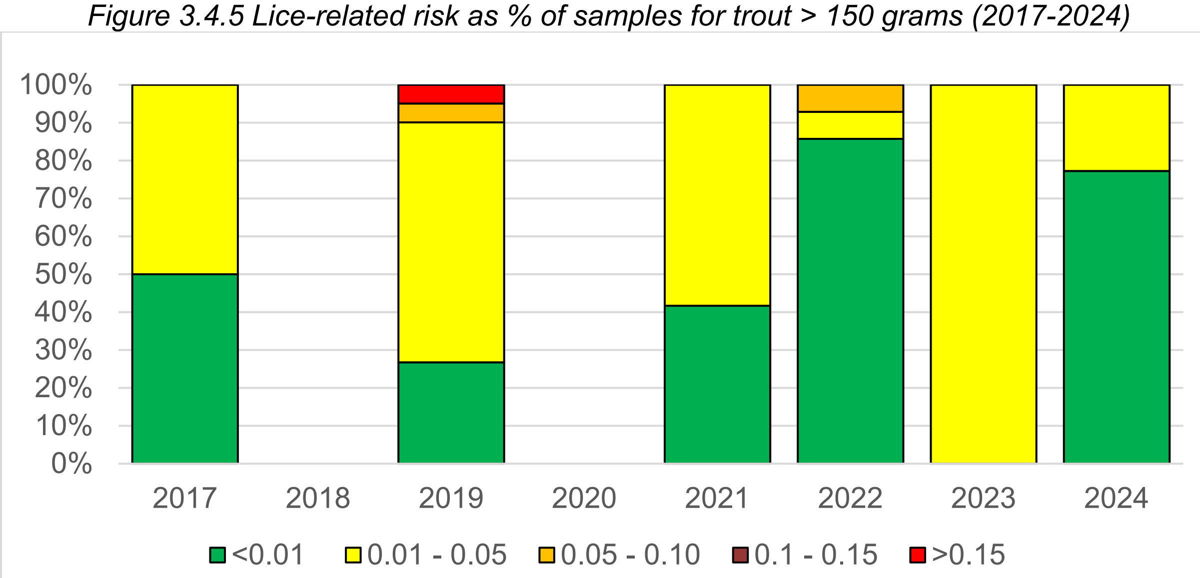
3.4.5 Lice-related risk index for trout over 150 grams (2007-2024)

According to the lice-related risk index proposed by Taranger et al. (2015) for trout over 150 grams, the percentage of trout that had less than 0.01 lice/g^{-1} ranged from 0.0 % in 2023 and 85.7 % in 2022 with a mean of 46.99 % across all years. Of the larger trout sampled, that had between 0.01 and 0.05 lice/g^{-1} ranged between 7.1 % in 2022 and 100 % in 2023 with a mean of 50.31 % across all years. The percentage of larger trout that had between 0.05 and 0.10 lice/g^{-1} ranged from none in four years and 7.1 % in 2022 with a mean of 1.95 % across all years. No larger trout had between 0.1 and 0.15 lice/g^{-1} in any survey. The percentage of fish that had burdens over 0.15 lice/g^{-1} ranged from none in five years to 4.5 % in 2019 with a mean of 0.76 % across all years (Table 3.4.5 and Figure 3.4.5).

Table 3.4.5 Lice-related risk as % of samples for trout > 150 grams (2017-2024)

Year	Proportion (%) of sea trout (>150g) which fell into each risk assessment category					Total Risk
	<0.01 lice/g^{-1}	0.01 - 0.05 lice/g^{-1}	0.05 - 0.10 lice/g^{-1}	0.1 - 0.15 lice/g^{-1}	>0.15 lice/g^{-1}	(%)
2017	50.0	50.0	0.0	0.0	0.0	12.5
2018						
2019	27.3	63.6	4.5	0.0	4.5	22.7
2020						
2021	41.7	58.3	0.0	0.0	0.0	14.6
2022	85.7	7.1	7.1	0.0	0.0	5.4
2023	0.0	100	0.0	0.0	0.0	25.0
2024	77.3	22.7	0.0	0.0	0.0	5.7
Avg.	46.99	50.31	1.95	0.00	0.76	14.31

Figure 3.4.5 Lice-related risk as % of samples for trout > 150 grams (2017-2024)



3.4.6 Estimated total increased lice-related risk (2017-2024)

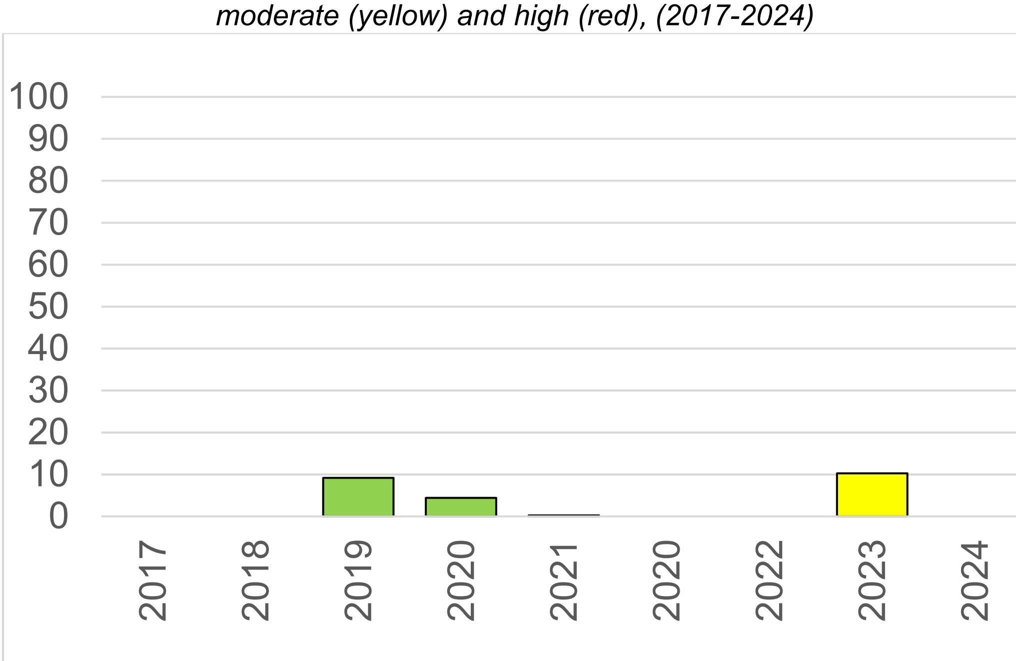
The total increased additional risk of marine mortality or compromised seawater growth or reproduction is calculated as the sum of the increased mortalities separately for each of the two different size groups in the sample (Table 3.4.6, Figure 3.4.6, and Figure 3.4.7). Total lice-related mortality in 2024 was estimated to be none for trout under 150g and 5.7 % for trout over 150g, which was categorised as being of low risk (< 10 % total lice-related risk).

Table 3.4.6 Total lice-related risk to the sea trout of less and more than 150g (% of sample), categorised as low (green), moderate (yellow) and high (red), 2017-2024

Year	< 150 g	> 150 g	Year	< 150 g	> 150 g
2017	0.0	12.5	2021	0.0	14.6
2018	0.0		2022	0.2	5.4
2019	9.2	23.5	2023	10.3	25.0
2020	4.4	0.0	2024	0.0	5.7
			Avg.	3.44	10.83

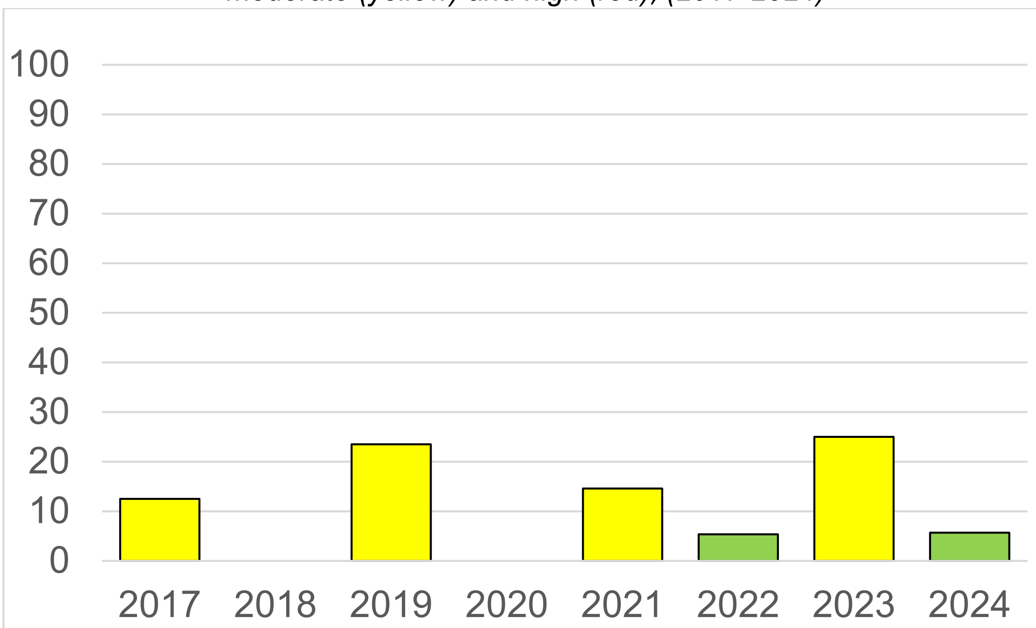
The total increased risk of additional marine mortality or compromised seawater growth for the smaller trout (< 150g) was categorised as low in all annual surveys except for 2023 when a moderate risk (between 10 and 30%) was estimated at 10.3 %.

Figure 3.4.6 Total lice-related risk (% of sample) for sea trout < 150g categorised as low (green), moderate (yellow) and high (red), (2017-2024)



The total increased risk of marine mortality or compromised seawater growth or reproduction for the larger trout (> 150g) was categorised as a low risk (< 10 % of samples) was estimated in 2022 and 2024. A moderate risk (between 10 and 30%) was found in four years (2017, 2019, 2021 and 2023).

Figure 3.4.7 Total lice-related risk (% of sample) for sea trout > 150g categorised as low (green), moderate (yellow) and high (red), (2017-2024)



4. DISCUSSION

4.1 Factors affecting the number and size of trout sampled

The number and size of trout sampled in each year may have been influenced by many factors related to recruitment of trout in freshwater, movements of trout in the marine environment, the behaviour and abundance of prey and predators, and sea lice burdens. The number of smaller trout sampled in 2024 (25 trout) was below the average (52.6 trout) for the 2017 to 2024 sampling period, although the number of larger trout (22 trout) was much higher compared to the average (10.4 trout) and formed a higher percentage (53.2 %) of the sample in 2024 compared the average (16.6 %). This may suggest that larger trout have become a more prominent component of the population or may be because of behaviour as a response to changes in environmental conditions.

The number of trout sampled in the smaller and larger groups were relatively consistent in each of the four samples over the survey period in 2024, which may suggest that the same group of trout were sampled on multiple occasions. However, on average the longest and heaviest trout in both groups were sampled in week 23 (early June) during the second visit with trout of smaller average size being sampled by the third and fourth visits. The decrease in the size of trout found in later visits therefore suggest that the sample consisted of at least some different individual trout. It may be expected to see an increase in size of trout in both the smaller and larger groups over the study period if the same individuals were sampled on multiple occasions. The average condition factor of trout in both the smaller and larger groups of trout were higher at the end of the study period compared to the beginning, suggesting that in general, the trout in Loch Etive were increasing in condition.

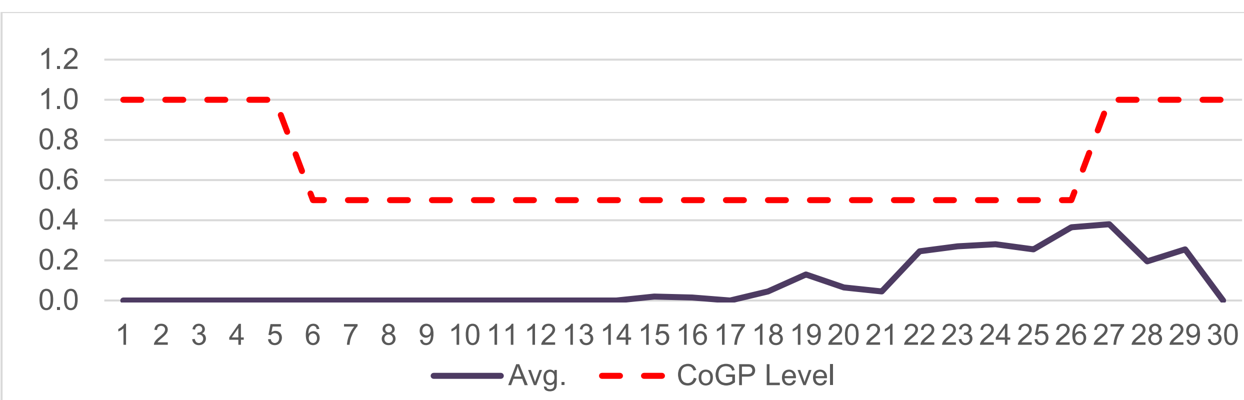
4.2 Factors affecting the lice-related risk for sea trout

Environmental factors impacting the reproduction of sea lice and the distribution of larvae may 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 compared against the results of these surveys. The number of lice on farm fish generally tend to increase over time during a traditional two-year farm production cycle. However, the farming cycle in Loch Etive was in the first of two six-month annual growing cycles during the 2024 survey. Salmon farms in lower Loch Linnhe were in the first of a two-year farming cycle during this survey and therefore, the number of lice larvae present in the environment is expected to be lower in 2024 compared to the second year of production. The published sea lice data for salmon farms (through Scottish Government's Aquaculture website http://aquaculture.scotland.gov.uk/data/data.aspx) show that average adult female lice numbers on farmed fish in Loch Etive sites (Figure 4.2.1), were much lower (0.00 lice per farm fish) than the industry's Code of Good Practice (CoGP) level of 0.5 adult female lice per fish prior to and during the 20-week lower threshold period (mid-February to late June).

Fig. 4.2.1. Sea lice count (Avg. adult female) at Loch Etive (weeks 1 to 30) 2024

The sea lice count reported for farm fish for the two farm sites in production in Lower Loch Linnhe (Figure 4.2.2) suggest that sea lice numbers on farms were increasing, but remained below CoGP level and therefore may not have influenced the results of the Loch Etive survey.

Fig. 4.2.2. Sea lice count (Avg. adult female) at Lower Loch Linnhe (weeks 1 to 30) 2024



The fish farm lice count data for Loch Etive and lower Loch Linnhe suggests that infection pressure from lice was low prior to and during the 2024 survey and few lice were found on both the smaller and larger groups of sea trout. Further research is required to draw any conclusions on what may be considered to be natural background levels of sea lice in the area and what numbers of sea lice on farm fish (and number of farm fish present) may potentially cause above natural levels of sea lice infestation on sea trout in the area.

The longer-term data collected suggest that potential increased mortality risk or compromised seawater growth to the smaller group of trout was categorised as low (< 10 %) in all years except for 2023 when a borderline moderate risk was found (10.3 %). The sampling between 2017 and 2023 coincides with the continuous farm production of rainbow trout. On-farm counts of sea lice on rainbow trout suggest that higher numbers of lice were recorded later in the summer period of some years, which is outside of the time covered by these studies. Anecdotal information suggests that sea trout in Loch Etive were also occasionally heavily infected by sea lice in late summer in some years.

The larger sea trout were found to have a moderate increased risk of mortality or compromised seawater growth or reproduction in four previous years including 2017, 2019, 2021 and 2023 which coincide with the second year of farm production cycles in lower Loch Linnhe and higher lice burdens were also found on sea trout at a near-by sampling station (at Dunstaffnage) in these years. This data suggest that the larger sea trout may be affected by fish farm production further afield, probably because of their larger habitat range compared to the younger smaller trout that may have remained relatively close to their natal stream habitat. Continued sampling of sea trout in Loch Etive and lower Loch Linnhe will be required to better inform any trends in the lice burdens of older trout in relation to the production of farmed fish.

4.3 Sampling site and method considerations for future monitoring

The Taranger 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 area. The location of the sampling site at Airds Bay is close to the estuaries of several rivers including Allt na h-Airde, River Nant, River Awe to the east and Allt Nathais and the Lusragan Burn to the west so may sample trout originating from all or some of these watercourses and therefore may be representative for populations of trout originating from rivers located further away from the survey site.

The Taranger risk analysis is also not able to identify the proportion of the population that return to the site to shed lice, are resident or visit the site for short periods. The dataset shows that relatively high numbers of trout with no or relatively low lice burdens have been sampled at the site in most years between 2017 and 2024, suggesting that smaller trout do normally inhabit the site in the late spring and early summer period. The surveys may also sample fish that have not ventured outside of Loch Etive where the salinity of the water is usually lower compared to that found in lower Loch Linnhe. While the salinity of Loch Etive may increase during times of drought (when the discharge of freshwater from rivers in Loch Etive may be reduced), the low salinity may reduce the survival of sea lice. Therefore, the low number of sea lice found on the smaller trout in most years suggest that they may remain in Loch Etive and therefore may have a reduced risk of infection. The lack of information on the movement of sea trout between Loch Etive and lower Loch Linnhe makes the influence of these factors on the survey results difficult to determine. To further inform the conclusions drawn from the results of the surveys at Airds Bay, sea lice data collected at Dunstaffnage in lower Loch Linnhe need to be considered alongside these results over a longer period in the context of changes made to farm fish production in both waterbodies.

The beach seine net sampling technique has proven reliable at this site 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. Occasional sampling later in the summer may provide a higher number of sea trout that may have ventured outside of Loch Etive for analysis, improving our knowledge of sea lice burdens on sea trout during the remainder of the year.
Acoustic telemetry may also be used to track the movements of individual sea trout to better identify their use of habitat and identify additional sampling sites over a wider area.

5. REFERENCES

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APPENDIX I – Sea trout and sea lice counts at Loch Etive 2024

Surveys		Sea Trout			Sea lice burdens				
Date	Count	Length (mm)	Weight (g)	C.F. (K)	1	2	3	Total	Lice / gram^{-1}
17/05/2024	1	210	92.5	0.999	0	0	0	0	0.000
17/05/2024	2	245	152	1.034	0	0	0	0	0.000
17/05/2024	3	205	81	0.940	0	0	0	0	0.000
17/05/2024	4	232	139.5	1.117	0	0	0	0	0.000
17/05/2024	5	253	165.5	1.022	0	0	0	0	0.000
17/05/2024	6	202	88	1.068	0	0	0	0	0.000
17/05/2024	7	238	160.5	1.191	0	0	0	0	0.000
17/05/2024	8	110	16	1.202	0	0	0	0	0.000
17/05/2024	9	215	96.5	0.971	0	0	0	0	0.000
17/05/2024	10	243	177	1.234	1	0	0	1	0.006
17/05/2024	11	177	59	1.064	0	0	0	0	0.000
17/05/2024	12	225	127	1.115	0	0	0	0	0.000
17/05/2024	13	229	137	1.141	0	0	0	0	0.000
03/06/2024	14	205	87	1.010	0	0	0	0	0.000
03/06/2024	15	188	69.5	1.046	0	0	0	0	0.000
03/06/2024	16	236	143	1.088	1	0	0	1	0.007
03/06/2024	17	230	136.5	1.122	0	1	0	1	0.007
03/06/2024	18	240	150.5	1.089	0	0	0	0	0.000
03/06/2024	19	307	283.5	0.980	5	6	0	11	0.039
03/06/2024	20	302	305	1.107	0	3	0	3	0.010
03/06/2024	21	193	56.5	0.786	0	0	0	0	0.000
03/06/2024	22	250	151.5	0.970	0	1	0	1	0.007
03/06/2024	23	303	317	1.140	0	2	0	2	0.006
03/06/2024	24	252	185.5	1.159	0	0	0	0	0.000
17/06/2024	25	271	265.5	1.334	0	0	3	3	0.011

17/06/2024	26	238	170	1.261	0	1	0	1	0.006
17/06/2024	27	175	69.5	1.297	0	0	0	0	0.000
17/06/2024	28	105	13.5	1.166	0	0	0	0	0.000
17/06/2024	29	218	120	1.158	0	2	0	2	0.017
17/06/2024	30	241	166.5	1.189	0	2	0	2	0.012
17/06/2024	31	198	99.5	1.282	0	1	0	1	0.010
17/06/2024	32	105	12.5	1.080	0	1	0	1	0.080
17/06/2024	33	143	31.5	1.077	0	0	0	0	0.000
17/06/2024	34	249	172.5	1.117	0	0	0	0	0.000
02/07/2024	35	260	233	1.326	0	0	0	0	0.000
02/07/2024	36	280	246	1.121	0	1	0	1	0.004
02/07/2024	37	321	414	1.252	0	2	0	2	0.005
02/07/2024	38	302	304.5	1.106	0	1	0	1	0.003
02/07/2024	39	227	147.5	1.261	1	5	1	7	0.047
02/07/2024	40	210	119	1.285	0	2	0	2	0.017
02/07/2024	41	254	193	1.178	0	5	1	6	0.031
02/07/2024	42	238	151.5	1.124	0	4	0	4	0.026
02/07/2024	43	247	188.5	1.251	0	1	0	1	0.005
02/07/2024	44	273	246	1.209	0	1	0	1	0.004
02/07/2024	45	208	91.5	1.017	2	1	0	3	0.033
02/07/2024	46	168	51	1.076	2	0	0	2	0.039
02/07/2024	47	225	137	1.203	1	2	0	3	0.022