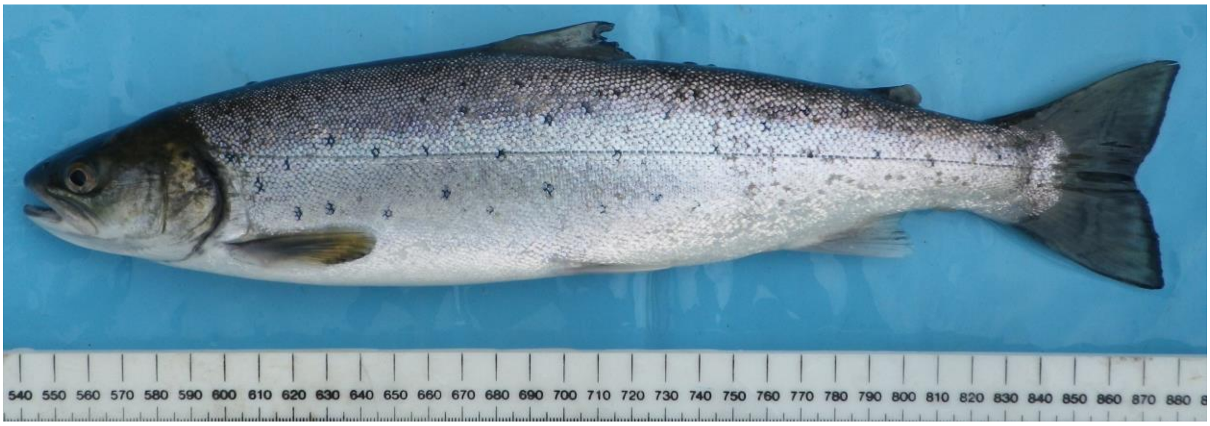
Applecross sea trout monitoring report 2023

to inform Loch Ainort, Caol Mor & Inner Sound EMP

for MOWI Scotland Ltd., Wester Ross Area District Salmon Fisheries Board, The Scottish Government (in place of the Skye District Salmon Fisheries Board) and The Highland Council



Peter Cunningham, November 2023 info@wrft.org.uk

Wester Ross Fisheries Trust (WRFT)
Harbour Centre, Gairloch, Ross-shire, IV21 2 BQ

www.wrft.org.uk
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Applecross sea trout monitoring report 2023 for Loch Ainort, Caol Mor & Inner Sound EMP, 2023

Peter Cunningham, 24th November 2023

Summary

This document presents the results of wild fish monitoring activities at Applecross during the spring and summer of 2023 as part of the Environment Management Plan [EMP] for MOWI salmon farms in Loch Ainort, Caol Mor and the Inner Sound.

Seine netting teams were assembled to sample sea trout in the mouth of the Applecross River each month from May to September 2023. Thirty or more sea trout were caught using a seine net in the sea pool occasion in May, June, July and August. No fish were caught in September. Overall, 140 sea trout were recorded with counts of sea lice taken. All fish were returned following a period of recovery from mild sedation.

Lice levels were very high on sea trout of over 200mm sampled in May (average 138 lice per fish; 0.43 lice per gram of fish) and high in June (average 34 lice per fish; 0.27 lice per gram of fish). Lice levels were much lower on most fish in samples taken in July and August (averages of 0.09 and 0.07 lice per gram of fish respectively). All the lice recorded in May, and nearly all recorded in June were small chalimus stage lice, indicative of recent attachment.

Sea lice levels are likely to have been exacerbated by unusually high sea water temperatures and low rainfall in May and June 2023. July and August were cooer and wetter, providing more freshwater areas where sea trout could delouse.

Reference to reported sea lice levels and on-farm biomass figures for the nearest salmon farms in the East of Skye and in Loch Kishorn support an interpretation that the sea lice infesting wild sea trout at Applecross are likely to have come from farms in both areas, with east of Skye farms providing the major source of lice that infested sea trout in May 2023, and Loch Kishorn farms (on a different production cycle) providing an additional source of lice that could have infested the sea trout sampled in June. By July, east of Skye farms had mostly been harvested out.

The very high sea lice infestation levels of sea trout in samples in May and June 2023 is of particular concern for wild salmon populations nearby. Wild post-smolt salmon migrating through coastal waters near Applecross including juvenile salmon from the Rivers Applecross, Carron, Ling, Elchaig, Croe, Shiel, Broadford, Sligachan and from any other rivers which migrate through Loch Alsh and the Inner Sound, are likely to have also experienced high sea lice infestation pressure. Unlike sea trout, wild salmon post-smolts do not return to freshwater to shed sea lice. Relatively low levels of sea lice infestation of around 10 lice per post-smolt salmon are understood to be lethal.

If this is the case, one can anticipate that the numbers of grilse returning to nearby rivers in 2024 and number of two sea-winter salmon returning to nearby rivers in 2025 will be proportionally much less than for rivers elsewhere in the NW Highlands where post-smolt salmon migrating through coastal waters experienced lower sea louse infestation pressures.

This report has been prepared to inform MOWI, the Wester Ross Area Salmon Fisheries Board, the Skye District Salmon Fisheries Board (or Scottish Government if there is still no DSFB on Skye) and The Highland Council in fulfilment of wild fish monitoring for the Environment Management Plan [EMP] for Loch Ainort, Caol Mor and the Inner Sound.

The report has been prepared to inform discussions regarding options for taking appropriate action to ensure that lice infestation pressures for wild sea trout and salmon are much lower in future years than in spring 2023.

1. Introduction and background

1.1 Location and rational

The Loch Ainort, Caol Mor and the Inner Sound EMP covers an area to the Isle of Skye and around the island of Scalpay (production area M-28) as shown in Figure 1.

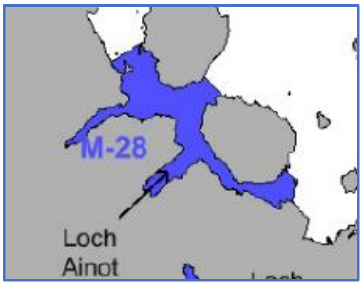


Figure 1. Location of M-28 farm salmon production area.

This area has 5 licenced salmon farms, all operated by MOWI; these are shown in Figure 2.

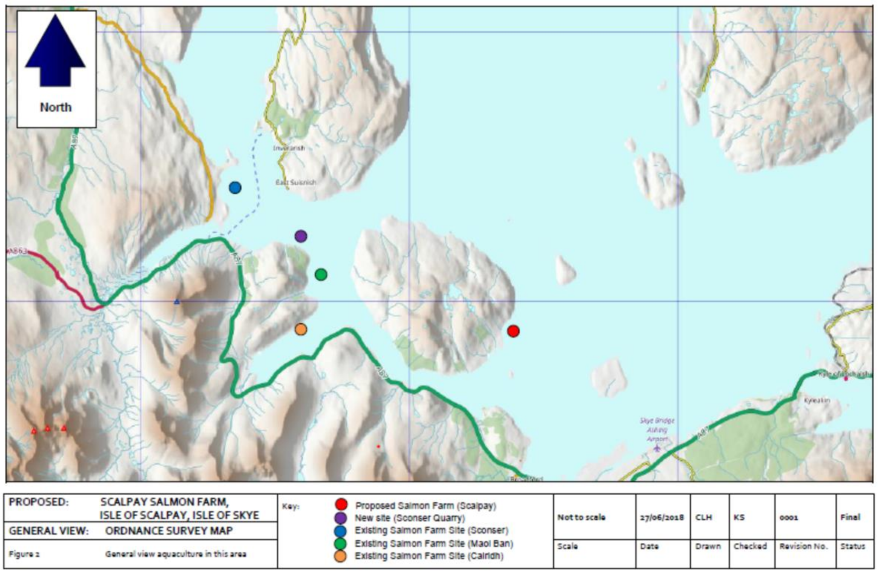


Figure 2, locations of MOWI salmon farms within the area covered by the Loch Ainort, Caol Mor and the Inner Sound. This map is taken from the EMP document.

Following development of the MOWI Scalpay farm, it was agreed that in addition to wild fish monitoring of sites by the Isle of Skye, wild fish should be monitored at Applecross on the mainland.

This was following projections from the sea lice dispersal model submitted by MOWI, in support of the planning application for the Scalpay salmon farm, that the waters around Applecross would be an area where infective stage sea lice could be expected to be present in highest densities within the sea (Figure 3).

This current report describes activities carried out to monitor wild fish at Applecross in 2023.

Figure 3. Reproduced from Figure 1 from Gillibrand (2019) Modelling the Dispersal of Sea Lice Larvae from Scalpay Salmon Farm. MOWI Scotland Ltd. Note the location of the modelled sea lice 'hotspot', just 5km to the west of Applecross.

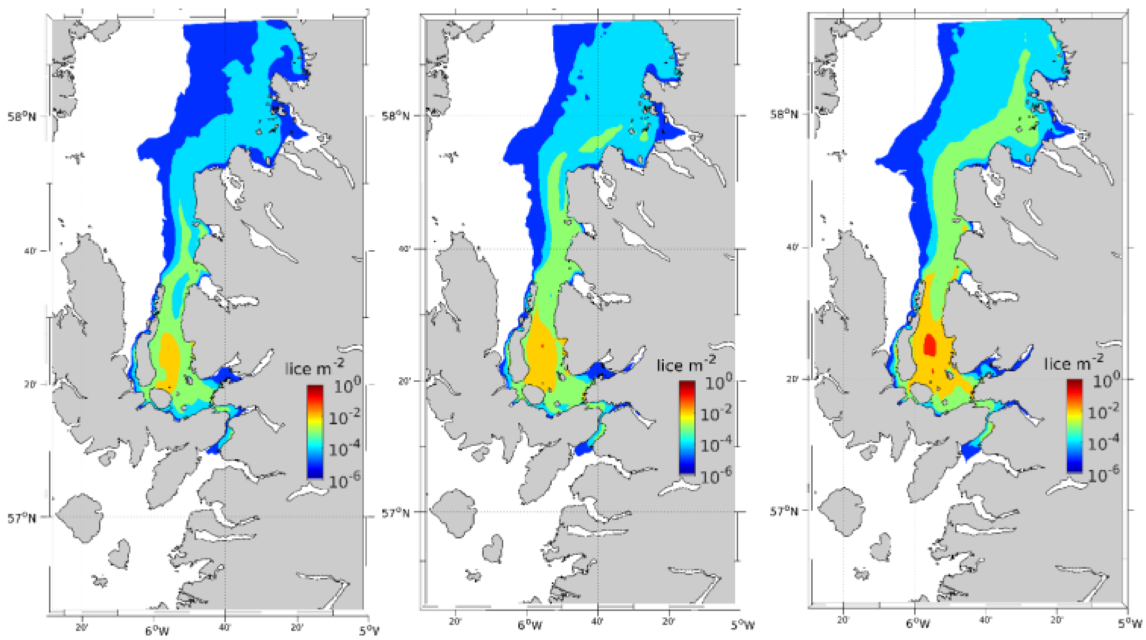


Figure 1. Predicted mean lice density (lice m^{-2}) for April – June from Simulation 1 (Scalpay only) with average adult female lice count of 0.2 (left), 0.5 (middle) and 1.0 (right). Note that the colour scale is logarithmic, indicating orders of magnitude of density, with a highest value of 1 copepodid per m^2.

1.2 Monitoring lice infestation on wild salmonids for Loch Ainort, Caol Mor and the Inner Sound EMP

The EMP states that 'The key element of the monitoring strategy will be a programme of wild fish monitoring to measure levels of sea lice infection pressure on wild salmonids in coastal waters. The monitoring programme should be designed to detect the potential effect (if any) of aquaculture on the local wild fisheries within a zone of 30 kilometres from the Management Area.'

'Given the relative lack of knowledge of the distribution of migrating salmon smolts in coastal waters, it is recognised that the monitoring programme should be designed with the focus on the sampling of juvenile sea trout as a surrogate means of assessing sea lice infestation pressure.'

There are four wild fish monitoring sites for wild fish for the purposes of informing the Loch Ainort, Caol Mor and the Inner Sound EMP. These are listed in Table 1.

Table 1 Monitoring sites for wild fish within the Loch Ainort, Caol Mor and the Inner Sound EMP area.

Freshwater Catchment	Marine Loch	Trust area
River Sligachan	Loch Slapin	S&LRT
River Snizort	Loch Snizort	S&LRT
River Strath Mor	Loch Sligachan	S&LRT
Applecross River	Inner Sound	Wester Ross FT

In 2022, for the purposes of informing the EMP, MOWI commissioned WRFT to sample sea trout in the Applecross River to gain data to complement that collected by Skye and Lochalsh River Trust by the Isle of Skye.

2. Monitoring sea trout at Applecross

2.1 Previous wild fish monitoring at Applecross

In 2022, the WRFT sea trout monitoring team visited on four occasions to sample sea trout for the EMP. Altogether, only 16 trout were recorded from which sea lice data was obtained. Only two of these were caught using the seine net in the sea or in sea pools of the river; the other 14 were caught from the sea pools using rod and line by anglers using a small size 12 teal and blue fly with crimped barb. A report was prepared (WRFT, 2022) in which the challenges of obtaining sea trout samples in 2022 are discussed and results are presented.

Previous experience had suggested that sea trout could be caught using a sweep net in the sea pool at the mouth of the Applecross River. On 18th July 2018, 17 sea trout were caught using a sweep net at the mouth of the Applecross River by Wester Ross Fisheries Trust. These were mostly post-smolts, but including a much larger sea trout. Lice levels were mostly below 10 lice per fish. The post-smolts were a bit thin for the time of year; however, the big fish was in good condition other than for a slightly tatty dorsal fin.

So, despite limited success with sea trout sampling at Applecross in 2022, further attempts were made to obtain sea trout samples at the Applecross site in 2023.

2.2 Monitoring of wild fish at Applecross in 2023

The WRFT sweep netting team organised five visits to Applecross to sample sea trout in 2023. These are listed in Table 2.

Table 2: Sea trout monitoring days at Applecross in 2023

Visit	Date	Methods used	Number of trout processed
#1	25th May 2023	Seine net sea pool of river	42
#2	21st June 2023	Seine net sea pool of river	30
#3	19th July 2023	Seine net sea pool of river	33
#4	16th August 2023	Seine net sea pool of river	36
#5	27th September 2023	Seine net sea pool of river	0

Each visit again focussed on using a seine net to obtain samples of sea trout. Using additional snorkellers to man-handle the lead line of the seine net over the riverbed of the sea pool, many more fish were caught than in 2022.

The net used on visits #1 & #2 was approximately 50m x 3m with floats along the top, and leaded bottom line, of mesh size 18mm knot to knot; the same net as used in 2022. For visit #3, a net of 45m x 3m of mesh size 22mm knot to knot was used (a slightly lighter weight seine net), however some of the smaller fish were caught by the gills on this occasion, so this net was not used again; the 50m net was used on visits #4 and #5.

On each occasion the minimum team size was 5 people, comprising two or more from WRFT (setting off in the morning from Gairloch) and remaining team members from the Applecross area including Applecross Trust staff.

All fish caught were transferred to a tub. Fish were lightly sedated using anaesthetic (eugenol). The length (in mm), weight (to nearest 5g) and records of the following were noted: numbers of sea lice (three categories of *Lepeophtheirus salmonis*; check for adult *Caligus elongatus*), dorsal fin damage score (0 [no damage] – 3 [over 2/3 of dorsal fin eroded away]), predator damage, and ‘black spots’ (*Cryptocotyle lingua*) spots per cm^2 of caudal fin. Scale samples and photos were taken. All fish were returned to the river following recovery.

3. Results

Results are presented in Tables 3a-3d.

Altogether 140 sea trout were processed, many others were caught. Fish were held in the river by the bank in a bag (fold) in the net, from where they transferred in small batches of randomly selected fish into tubs for processing. After processing a minimum of 30 sea trout, surplus fish were released back into the river along with all those that had been processed.

In May 2023 (Table 3a), 42 trout were caught and processed. 31 of these were larger trout of over 200mm in length; 10 were small silvery trout (smolts or post-smolts), and two were recorded as brown trout. Weights were recorded for most of the larger trout of above 200mm in length; however, the weighing scales failed preventing records of weight for the smaller trout, so weights have been estimated. The average number of lice per fish on the sea trout larger than 200mm recorded was 138. The most heavily infested fish carried over 500 lice. Many fish had damage to dorsal fins. All except one of the smaller trout (of less than 200mm) carried no lice.

In June (Table 3b), lice levels on larger sea trout were lower than in the May sample; however, the sample also included 11 small sea trout of less than 250mm in length all of which carried lice levels which put them in the ‘50%’ or ‘100%’ mortality categories using the projected mortality method described by Taranger *et al* 2014.

In July (Table 3c), many small post-smolt sea trout were caught. Some of these small fish experienced scale loss after becoming gilled in the net; a pair of scissors was used to cut the net to free them with minimal damage. Many of these fish were less than 200mm in length so unexpectedly small for the time of year; and still rather thin with condition factors mostly less than 1. Lice levels were low; however, lice scarring could be seen on some of these fish.

In August (Table 3d), the majority of fish in the sample were finnock-sized sea trout of between 200mm and 280mm in length carrying very few sea lice. Some of these fish had healed dorsal fins and scars indicative of recovery after having higher levels of infestation earlier in the year.

No sea trout were caught in the September sampling.

Further information from each sampling occasion is presented in the Appendix of this report.

Table 3a ***Data recorded for sea trout sampled at Applecross in 2023****. All fish taken in the sea pool of the Applecross River using a seine net by WRFT team.*

Details of lice stages, dorsal fin damage, predator damage and *Cryptocotyle lingua* spots on caudal fin on sea trout sampled at Applecross in summer 2023. Including calculation for projected mortality based on method described by Taranger *et al* 2014 and adopted by Fisheries Management Scotland for analyses of Scottish Government funded sweep netting within the West of Scotland in 2022. Legend and further explanation of colour scheme can be found on next page.

Sample #1: 25th May 2023. Weights for fishes highlighted in pink were estimated based on average condition factor of other fish due to failure of weigh scales.

					Lepeophtheirus salmonis																			
Fish number on field sheet	Fish	length (mm)	Recorded weight or *estimated weight (g)	Recorded condition factor or *projected condition factor	Copepodid & Chalimus	Pre-adult & adult	Ovigerous females	Total L. s	*estimated lice/g fish weight	^Dorsal fin damage score	*Cryptocotyle ligua spots per cm2 of caudal fin*	Predator damage	Photo	Scale sample	Comments	≥13 lice/fish ?	Lice/g fish weight	Range	Mortality					Projected mortality %
1	Sea trout	397	612	0.98	360	0	0	**360**	0.588	3	0	n	y	y	photo of dorsal fin	Yes	0.588	>0.3	100%	16	42	38.10	38.10	
2	Sea trout	313	274	0.89	300	0	0	**300**	1.095	3	4	y	y	y	bird beak scar	Yes	1.095	0.2-0.3	50%	2		4.76	2.38	
3	Sea trout	503	1085	0.85	60	0	0	**60**	0.055	3	0	n	y	y	at least 200 lice spots on ta	Yes	0.055	0.1-0.2	20%	1		2.38	0.48	
4	Sea trout	283	185	0.82	5	2	0	**7**	0.038	1	0	n	y	y		No	0.038	<0.1	0%	23		54.76	0.00	**40.95**
5	Sea trout	333	363	0.98	300	1	0	**301**	0.829	2	0	n	y	y	caudal fin eroded	Yes	0.829							
6	Sea trout	362	408	0.86	200	0	0	**200**	0.490	2	1	n	y	y		Yes	0.490							
7	Sea trout	330	280	0.78	0	0	0	**0**	0.000	0	1	n	y	y		No	0.000							
8	Sea trout	308	260	0.89	0	0	0	**0**	0.000	1	0	n	y	y	lice off (lice spots)	No	0.000							
9	Sea trout	305	236	0.83	55	0	0	**55**	0.233	2.5	1	y	y	y	old predator damage	Yes	0.233							
12	Sea trout	275	174	0.84	55	0	0	**55**	0.316	2	2	y	y	y	old predator damage	Yes	0.316							
13	Sea trout	350	382	0.89	350	0	0	**350**	0.916	1.5	1	n	y	y		Yes	0.916							
14	Sea trout	299	235.2	0.88	550	0	0	**550**	2.338	1.5	0	n	y	y	smart phone photos	Yes	2.338							
15	Sea trout	305	256	0.90	250	0	0	**250**	0.977	2	0	n	y	y		Yes	0.977							
16	Sea trout	315	271	0.87	88	0	0	**88**	0.325	1	0	n	y	y		Yes	0.325							
17	Sea trout	335	340	0.90	120	0	0	**120**	0.353	2	10	n	y	y	many lice spots (lice off)	Yes	0.353							
18	Sea trout	297	230	0.88	20	1	0	**21**	0.091	1	0	n	y	y		Yes	0.091							
19	Sea trout	320	262	0.80	0	0	0	**0**	0.000	0.5	3	n	y	y	lice off (lice spots)	No	0.000							
20	Sea trout	292	170	0.68	5	1	0	**6**	0.035	2.5	0	y	y	y	tail damaged, lice off	No	0.035							
26	Sea trout	340	395	1.00	60	0	0	**60**	0.152	2	0	n	y	y	lice off, fatter fish	Yes	0.152							
27	Sea trout	352	360	0.83	180	0	0	**180**	0.500	2	0	n	y	y	?2 photos of fish	Yes	0.500							
28	Sea trout	365	530	1.09	180	0	0	**180**	0.340	2	0	y	y	y	bird; chunky fish	Yes	0.340							
29	Sea trout	336	330	0.87	0	0	0	**0**	0.000	1.5	0	y	y	y	bird beak damage; lice off	No	0.000							
30	Sea trout	363	465	0.97	420	0	0	**420**	0.903	2	0	n	y	y		Yes	0.903							
31	Sea trout	307	260	0.90	3	0	0	**3**	0.012	1	0	n	y	y	lice off, healed	No	0.012							
32	Sea trout	320	283	0.86	3	1	0	**4**	0.014	3	0	y	y	y	minor predator damage	No	0.014							
33	Sea trout	293	221.4	0.88	100	0	0	**100**	0.452	2	0	n	y	y		Yes	0.452							
34	Sea trout	296	228.2	0.88	400	0	0	**400**	1.753	2	0	n	y	y		Yes	1.753							
35	Sea trout	342	352.0	0.88	220	1	0	**221**	0.628	2	2	y	y	y	old predator damage	Yes	0.628							
36	Sea trout	294	223.6	0.88	0	0	0	**0**	0.000	1	3	n	y	y		No	0.000							
37	Sea trout	306	252.1	0.88	10	1	0	**11**	0.044	1	0	n	y	y		No	0.044							
38	Sea trout	295	225.9	0.88	0	0	0	**0**	0.000	1.5	1	n	y	y	lice off (lice spots)	No	0.000							
Averages for sea trout >200mm in length		**327**		**0.88**	**139**	**0**	**0**	**139**	**0.435**	**1.76**	**0.94**													
Smolts and recent post-smolts (less than 200mm in length)																								
10	Sea trout	162	37	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							
11	Estuary trout	154	32	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							
21	Sea trout	143	26	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							
22	Sea trout	160	36	0.88	0	0	0	**0**	0.000	0	0	n	y	y	stocked?	No	0.000							
24	Sea trout	170	43	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							
25	Sea trout	155	33	0.88	0	0	0	**0**	0.000	0	0	n	y	y	hook scar deformity	No	0.000							
40	Sea trout	140	24	0.88	5	0	0	**5**	0.207	0	0	n	y	y		No	0.207							
41	Estuary trout	155	33	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							
42	Estuary trout	145	27	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							
Brown trout																								
39	Brown trout	230	107	0.88	0	0	0	**0**	0.000	0	0	n	y	y	another parasite protrudir	No	0.000							
23	Brown trout	140	24	0.88	0	0	0	**0**	0.000	0	0	n	y	y		No	0.000							

Table 3a ***Data recorded for sea trout sampled at Applecross in 2023****. All fish taken in the sea pool of the Applecross River using a seine net by WRFT team (cont.)*

Explanation (for Table 3a – 3d):

^Dorsal fin damage score: '1' is for up to 1/3 of fin damaged; '2' is for >1/3 an <2/3 of fin damaged; '3' is for over 2/3 of dorsal fin damaged
Estimation of projected mortality or early return to freshwater from Taranger et al 2014:

Notes:		
based on the assumption that small salmonid post-smolts (<150g body weight) will suffer 100% lice-related marine mortality, or return prematurely to freshwater for sea trout in the wild if the are infected with >0.3 lice per g of fish weight.		
Furthermore, the lice related marine mortality is estmated to 50%, if the infection is between 0.2 and 0.3 lice per g fish weight, 20% if the infection rate is between 0.1 and 0.2 lice per g fish weight, and finally 0% if the salmon lice infection is <0.1 g fish weight.		
0.05 and 0.1 lice per g fish weight, 20% for lice infections between 0.05 and 0.01 lice per g fish weight, and finally 0% if the salmon lice infection is <0.01 lice g fish weight.		
	colour code	
Taranger, G. L., Karlsen, Ø., Bannister, R. J., Glover, K. A., Husa,V., Karlsbakk, E., Kvamme, B. O., Boxaspen, K. K., Bjørn, P. A., Finstad, B.,		100% sea lice related mortality or early return to freshwater
Madhun, A. S., Morton, H. C., and Svaˆsand, T. (2014) Risk assessment of the environmental impact of Norwegian Atlantic salmon farming.		>50% to 99% sea lice related mortality or early return to freshwater
– ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu132.		>20% to 50% sea lice related mortality or early return to freshwater
https://www.researchgate.net/publication/266672998_Risk_assessment_of_the_environmental_impact_of_Norwegian_Atlantic_salmon_farming		

***Table 3b Data recorded for sea trout sampled at Applecross in 2023**. All fish taken in the sea pool of the Applecross River using a seine net by WRFT team.*

Details of lice stages, dorsal fin damage, predator damage and *Cryptocotyle lingua* spots on caudal fin on sea trout sampled at Applecross in 2023.

Sample #2: 21st June 2023.

21st June 2023, Sweep Net Sample, Applecross River																								
				Caligus	***Lepeophtheirus salmonis***																			
Sea trout No.	**length (mm)**	**weight (g)**	**condition**	**total**	**Copepodid & Chalimus (estimate)**	**Pre-adult & adult**	**Ovigerous female**	**Total lice**	**Lice per gram**	**Dorsal fin damage**	***Cryptocotyle lingua (Black spots per cm² of tail fin)***	**Predator damage**	**Photo**	**scale sample?**	**Comments**	**≥13 lice/fish?**	**Lice/g fish weight**	**Range**	**Mortality**					**Projected mortality %**
1	345	440	1.07	0	40	10	0	**50**	0.114	2	1	N	y	y	fatter	Yes	0.11	>0.3	100%	12	34	35.29	35.29	
2	206	85	0.97	0	13	8	1	**22**	0.259	0	1	N	y	y	this years smolt	Yes	0.26	0.2-0.3	50%	6		17.65	8.82	
3	195	72	0.97	0	12	4	0	**16**	0.222	0	1	N	y	y		Yes	0.22	0.1-0.2	20%	5		14.71	2.94	
4	315	300	0.96	0	18	5	0	**23**	0.077	1	8	Y	y	y	lower caudal missing	Yes	0.08	<0.1	0%	11		32.35	0.00	**47.06**
5	183	59	0.96	0	12	16	0	**28**	0.475	0	1	N	y	y		Yes	0.47							
6	212	96	1.01	0	90	11	1	**102**	1.063	0	1	N	y	y	fresh settlement	Yes	1.06							
7	183	52	0.85	0	85	14	0	**99**	1.904	0	1	N	y	y		Yes	1.90							
8	272	170	0.84	0	35	0	0	**35**	0.206	2	0	Y	y	y	sunny photo. Damaged flank	Yes	0.21							
9	400	467	0.73	0	8	9	0	**17**	0.036	2	1	N	y	y	twisted jaw, thin male	Yes	0.04							
10	290	260	1.07	0	11	11	0	**22**	0.085	1	0	N	y	y	quite fat	Yes	0.08							
11	365	431	0.89	0	11	5	0	**16**	0.037	2	2	N	y	y	red raw predator hole	Yes	0.04							
12	378	492	0.91	0	50	6	0	**56**	0.114	1	0	N	y	y		Yes	0.11							
13	335	380	1.01	0	26	16	0	**42**	0.111	1.5	2	N	y	y	recapture?	Yes	0.11							
14	395	615	1.00	0	25	16	1	**42**	0.068	2	0	N	y	y		Yes	0.07							
15	330	432	1.20	0	5	5	0	**10**	0.023	2	0	N	y	y	fatter	No	0.02							
16	355	455	1.02	0	22	6	1	**29**	0.064	2	1	Y	y	y	split dorsal fin; recapture?	Yes	0.06							
17	277	180	0.85	0	12	13	0	**25**	0.139	2	3	N	y	y	squinty photo	Yes	0.14							
18	300	255	0.94	0	16	4	0	**20**	0.078	2	0	N	y	y		Yes	0.08							
19	275	182	0.88	0	32	2	0	**34**	0.187	1	1	N	y	y		Yes	0.19							
20	360	335	0.72	0	70	4	0	**74**	0.221	0.5	0	N	y	y	damaged tail, recent settlement	Yes	0.22							
21	223	98	0.88	0	23	10	1	**34**	0.347	0.5	1	N	y	y		Yes	0.35							
22	215	83	0.84	0	10	8	0	**18**	0.217	1	0	N	y	y		Yes	0.22							
23	380	542	0.99	0	10	8	0	**18**	0.033	1.5	2	N	y	y		Yes	0.03							
24	200	77	0.96	0	10	5	1	**16**	0.208	0.5	0	N	y	y		Yes	0.21							
25	283	213	0.94	0	14	5	0	**19**	0.089	0.5	1	N	y	y		Yes	0.09							
26	195	64	0.86	0	26	4	0	**30**	0.469	0	0	N	y	y		Yes	0.47							
27	330	310	0.86	0	0	2	0	**2**	0.006	0.2	0	Y	y	y	scar near gills and mark on tail	No	0.01							
28	193	68	0.95	0	22	3	0	**25**	0.368	0	0	N	y	y		Yes	0.37							
29	252	155	0.97	0	55	10	0	**65**	0.419	1	0	Y	y	y	old predator damage	Yes	0.42							
30	209	79	0.87	0	20	6	1	**27**	0.342	0.2	1	N	y	y		Yes	0.34							
Averages	**281.70**	**248.23**	**0.93**	**0.00**	**26.10**	**7.53**	**0.23**	**33.87**	**0.27**	**0.98**	**0.97**													

Table 3c Data recorded for sea trout sampled at Applecross in 2023. *All fish taken in the sea pool of the Applecross River using a seine net by WRFT team.*

Sample #3: 19th July 2023.

19th July 2023, Sweep net sample, Applecross River sea pool																								
				Caligus	*Lepeophtheirus salmonis*																			
Sea trout No.	length (mm)	weight (g)	condition	total	Copepodid & Chalimus (estimate)	Pre-adult & adult	Ovigerous female	Total lice	Lice per gram	Dorsal fin damage	*Cryptocotyle lingua (Black spots per cm² of tail fin)*	Predator damage	Photo	scale sample?	Comments	≥13 lice/fish?	Lice/g fish weight	Range	Mortality					Projected mortality %
1	345	461	1.12	0	0	0	0	**0**	0.000	1	0	n	y	y	recap, lice scars	No	0.00	>0.3	100%	3	33	9.09	9.09	
2	383	635	1.13	0	10	0	0	**10**	0.016	2	0	n	y	y	recap?; bit raw	No	0.02	0.2-0.3	50%	0		0.00	0.00	
3	370	540	1.07	0	6	1	0	**7**	0.013	1.5	1	n	y	y	split dorsal	No	0.01	0.1-0.2	20%	1		3.03	0.61	
4	208	85	0.94	0	0	0	0	**0**	0.000	0.5	1	n	y	y		No	0.00	<0.1	0%	29		87.88	0.00	**9.70**
5	180	68	1.17	0	0	0	0	**0**	0.000	0	3	n	y	y	net marks	No	0.00							
6	171	49	0.98	0	0	0	0	**0**	0.000	0	0	y	y	y	net marks	No	0.00							
7	227	112	0.96	0	0	0	0	**0**	0.000	1	4	n	y	y	split dorsal	No	0.00							
8	193	74	1.03	0	30	0	0	**30**	0.405	0.2	5	n	y	y		Yes	0.41							
9	200	72	0.90	0	0	0	0	**0**	0.000	0.2	0	y	y	y	lice scars, gilled	No	0.00							
10	205	75	0.87	0	0	0	0	**0**	0.000	0.2	0	n	y	y	net damage	No	0.00							
11	193	69	0.96	0	0	0	0	**0**	0.000	0	3	n	y	y	net damage	No	0.00							
12	185	60	0.95	0	0	0	0	**0**	0.000	0	0	n	y	y	net damage	No	0.00							
13	170	53	1.08	0	0	0	0	**0**	0.000	0	0	y	y	y	estuarine, net damage	No	0.00							
14	190	66.0	0.96	0	94	0	1	**95**	1.439	0	2	y	y	y	net damage; bird damage tail	Yes	1.44							
15	201	88	1.08	0	0	0	0	**0**	0.000	0	1	n	y	y	plump, lice scarred	No	0.00							
16	209	84	0.92	0	0	0	0	**0**	0.000	0.2	4	n	y	y	gilled	No	0.00							
17	195	75	1.01	0	0	0	0	**0**	0.000	0	3	n	y	y	split dorsal	No	0.00							
18	201	84	1.03	0	70	0	0	**70**	0.833	0.2	3	y	y	y	much scale loss	Yes	0.83							
19	195	63	0.85	0	9	0	0	**9**	0.143	1	4	n	y	y	thin, tatty dorsal	No	0.14							
20	201	72	0.89	0	0	0	0	**0**	0.000	1	1	n	y	y	thin, lice off, net damage	No	0.00							
21	221	90	0.83	0	0	0	0	**0**	0.000	0.5	1	n	y	y	lice off, thin	No	0.00							
22	200	82	1.03	0	0	1	0	**1**	0.012	0.2	0	n	y	y	gilled	No	0.01							
23	183	65	1.06	0	0	0	0	**0**	0.000	0	1	y	y	y	healed on tail, no photo, net damag	No	0.00							
24	190	77	1.12	0	0	0	0	**0**	0.000	0.5	0	n	y	y	net damage	No	0.00							
25	195	75	1.01	0	0	0	0	**0**	0.000	0.2	2	n	y	y	lice off, net damage	No	0.00							
26	245	163	1.11	0	10	1	0	**11**	0.067	0.2	4	n	y	y	lice samples to Steve Kett	No	0.07							
27	193	68	0.95	0	0	0	0	**0**	0.000	0	3	n	y	y	net damage	No	0.00							
28	211	87	0.93	0	2	1	0	**3**	0.034	0.5	1	y	y	y	old bird beak	No	0.03							
29	220	105	0.99	0	0	0	0	**0**	0.000	0	4	Y	y	y	very old	No	0.00							
30	210	88	0.95	0	0	0	0	**0**	0.000	2	0	Y	y	y	old healing	No	0.00							
31	217	98	0.96	0	2	0	0	**2**	0.020	1	1	n	y	y	?recapture, lice off	No	0.02							
32	208	90	1.00	0	0	0	0	**0**	0.000	0.2	1	n	y	y		No	0.00							
33	380	650	1.18	0	0	1	0	**1**	0.002	1	1	n	y	y	big louse maybe from salmon	No	0.00							
Averages	**221.06**	**140.09**	**1.00**	**0.00**	**7.06**	**0.15**	**0.03**	**7.24**	**0.09**	**0.46**	**1.64**													

Table 3d Data recorded for sea trout sampled at Applecross in 2023. *All fish taken in the sea pool of the Applecross River using a seine net by WRFT team.*

Sample #4: 16th August 2023.

16th August 2023, Sweep net sample, Applecross River sea pool																								
				Caligus	***Lepeophtheirus salmonis***																			
Sea trout No.	**length (mm)**	**weight (g)**	**condition**	**total**	**Copepodid & Chalimus (estimate)**	**Pre-adult & adult**	**Ovigerous female**	**Total lice**	**Lice per gram**	**Dorsal fin damage**	***Cryptocotyle lingua (Black spots per cm² of tail fin)***	**Predator damage**	**Photo**	**scale sample?**	**Comments**	**≥13 lice/fish?**	**Lice/g fish weight**	**Range**	**Mortality**					**Projected mortality of fish in sample %**
1	230	116	0.95	0	36	6	0	**42**	0.362	3	2	y	y	y	recap?, Split dorsal	Yes	0.362	>0.3	100%	2	35	5.71	5.71	
2	210	85	0.92	0	0	0	0	**0**	0.000	0	2	y	y	y	thin	No	0.000	0.2-0.3	50%	0		0.00	0.00	
3	305	288	1.02	0	52	0	0	**52**	0.181	2	6	n	y	y	recap?, Split dorsal	Yes	0.181	0.1-0.2	20%	6		17.14	3.43	
4	140	NR	#VALUE!	0	0	0	0	**0**	#VALUE!	0	0	n	y	y		No	#VALUE!	<0.1	0%	27		77.14	0.00	**9.14**
5	225	116	1.02	0	20	0	0	**20**	0.172	0.2	0	n	y	y		Yes	0.17							
6	233	128	1.01	0	3	0	0	**3**	0.023	1	1	n	y	y		No	0.02							
7	318	343	1.07	0	0	1	0	**1**	0.003	2	1	y	y	y	old predator	No	0.00							
8	350	386	0.90	0	20	1	0	**21**	0.054	2	3	n	y	y	slightly yellow	Yes	0.05							
9	245	143	0.97	0	0	0	0	**0**	0.000	0.5	1	n	y	y	fatter	No	0.00							
10	233	120	0.95	0	8	1	0	**9**	0.075	1	2	n	y	y	recap?	No	0.08							
11	254	130	0.79	0	48	12	0	**60**	0.462	1	1	n	y	y	recap?	Yes	0.46							
12	270	170	0.86	0	3	1	0	**4**	0.024	0.5	1	n	y	y	recap?	No	0.02							
13	250	150	0.96	0	4	0	0	**4**	0.027	0.2	0	n	y	y		No	0.03							
14	185	65.0	1.03	0	0	0	0	**0**	0.000	0	0	n	y	y	recap?	No	0.00							
15	263	173	0.95	0	0	1	0	**1**	0.006	0.2	0	n	y	y		No	0.01							
16	209	85	0.93	0	1	0	0	**1**	0.012	0.2	1	n	y	y	thin	No	0.01							
17	270	173	0.88	0	6	0	0	**6**	0.035	2	4	n	y	y	thin healed scarring	No	0.03							
18	235	135	1.04	0	25	0	0	**25**	0.185	1.5	0	n	y	y		Yes	0.19							
19	246	144	0.97	0	12	1	0	**13**	0.090	0.5	1	n	y	y		Yes	0.09							
20	245	145	0.99	0	2	4	0	**6**	0.041	1	3	n	y	y		No	0.04							
21	203	69	0.82	0	0	0	0	**0**	0.000	0	1	y	y	y	old, various scars	No	0.00							
22	240	135	0.98	0	3	0	0	**3**	0.022	0.2	0	n	y	y	recapture	No	0.02							
23	253	155	0.96	0	0	0	0	**0**	0.000	0.2	0	n	y	y	split tail	No	0.00							
24	265	47	0.25	0	6	1	0	**7**	0.149	3	1	n	y	y	thin, lice damage	No	0.15							
25	240	110	0.80	0	6	0	0	**6**	0.055	0.2	0	n	y	y	net damage, thin	No	0.05							
26	208	80	0.89	0	0	0	0	**0**	0.000	0.2	1	n	y	y	thin	No	0.00							
27	248	131	0.86	0	0	0	0	**0**	0.000	1	3	n	y	y		No	0.00							
28	250	155	0.99	0	25	0	0	**25**	0.161	1	0	n	y	y	split tail and dorsal	Yes	0.16							
29	243	133	0.93	0	24	0	0	**24**	0.180	0.2	1	n	y	y		Yes	0.18							
30	182	64	1.06	0	0	0	0	**0**	0.000	0	0	n	y	y	recapture?	No	0.00							
31	243	148	1.03	0	0	0	0	**0**	0.000	0.5	1	n	y	y	fat, lice off	No	0.00							
32	230	124	1.02	0	0	1	0	**1**	0.008	2	1	n	y	y		No	0.01							
33	330	388	1.08	0	0	0	0	**0**	0.000	2	0	n	y	y	fat	No	0.00							
34	368	500	1.00	0	27	1	0	**28**	0.056	2	1	n	y	y	fat, lice off	Yes	0.06							
35	350	508	1.18	0	0	0	0	**0**	0.000	1	1	n	y	y		No	0.00							
36	372	600	1.17	0	1	0	0	**1**	0.002	2	0	n	y	y		No	0.00							
Averages	**257.171**	**184.057**	**0.949**	**0.000**	**9.486**	**0.886**	**0.000**	**10.371**	**0.068**	**0.980**	**1.143**													

4. Discussion

In contrast to 2022, sampling of sea trout at Applecross in 2023 was very effective in terms of obtaining useful numbers of fish. The greater success of seine netting of the Applecross River Sea pool in 2023 than in 2022 is likely to have been partly due to congregation of trout associated with sea lice infestation. Sea trout are known to return early to freshwater if they become infested with high numbers of sea lice (Birkeland & Jakobsen, 1997). The WRFT team's previous experience and approach in 2023 using typically two or three snorkellers on each occasion may have also contributed to much greater success in 2023 than in 2022.

The dry sunny weather with little freshwater entering the sea during May and early June 2023 is also a factor which may have influenced the movement of sea trout. Sea temperatures were unusually warm in June, this may have also affected lice infestation.

Samples of sea trout taken in May and June included many fish carrying high numbers of sea lice at levels which provide clear evidence of very high sea lice infestation pressures in nearby water.

For the May sample, the projected mortality of the larger sea trout of above 200mm in length was 53%. These larger fish that would have been subject to lice infestation pressure in nearby waters for more than a few days. In contrast the smolts and post-smolts in this sample may not yet have experienced full marine conditions given that the sample was taken in the sea pool of the river when river levels were low, potentially delaying smolt migration to the sea.

For the June sample, in contrast to May, the larger sea trout taken carried fewer sea lice, but the smaller post-smolt sized sea trout carried high numbers of lice. The larger trout may have been able to shed lice since may by remaining in freshwater, whereas the smaller trout may have more recently returned to freshwater from the sea. Many of the larger fish had damaged dorsal fins and other scarring indicative of higher sea lice burdens previously.

The great majority of lice attached to the sea trout were small chalimus stage sea lice indicative of infestation within three or four weeks prior to the sample being taken.

Based on previous experiences (e.g., at Flowerdale, Gairloch) and tracking studies elsewhere, it is likely that most of the sea trout caught at Applecross had overwintered and become infected nearby (within 10 - 20km of Applecross).

Based on the sea lice dispersal model by Gillibrand prepared in support of the planning application for the Scalpay salmon farm in 2019 (referred to earlier in this report) and reference to data published on Scotland's Aquaculture website[1], these results are consistent with an interpretation that salmon farms on the east coast of Skye were a major source of sea lice that infested sea trout sampled at Applecross in May 2023.

However, they may not have been the only major source of larval sea lice, particularly for the fish sampled in June.

Table 4 presents some of the data published on Scotland's Aquaculture website for nearby farms for the period March to June 2023. This table provides data for reported weekly adult female sea lice counts; and for reported monthly biomass for salmon farms within 30km of the Applecross sea trout sampling site.

[1] Scotland's Aquaculture website http://aquaculture.scotland.gov.uk/default.aspx

Table 4. Reported adult female sea lice counts and reported monthly biomass figures from Scotland Aquaculture website (http://aquaculture.scotland.go.uk/). Figures highlighted in bold and in pink suggest multiple potential sources of larval sea lice.

Reported adult female sea lice figures (from Scotland's Aquaculture website)														
Site	**Portree**	**Potree Outer**	**Sconser Quary**	**Maol Ban**	**Cairaidh**	**Scalpay**	**Loch Alsh**	**Ardintoul**	**Loch Duich**	**Kishorn West**	**Kishorn A**	**Kishorn B**	**West Strome**	**Sgeir Dughall**
Company	**Bakkafrost**	**Bakkafrost**	**MOWI**	**MOWI**	**MOWI**	**MOWI**	**MOWI**	**MOWI**	**MOWI**	**SSF**	**SSF**	**SSF**	**Bakkfrost**	**Bakkfrost**
Distance to Applecross (km approx)	30	30	19	23	20	18	22	26	31	17	21	24	26	26
Week														
22 (June)	0.17	0.04	0.11	0.16	fallow	fallow	**0.23**	**0.07**	0.09	**0.98**	**0.43**	**0.70**	**1.41**	1.79
21 (May)	0.11	0.05	0.1	0.08	fallow	fallow	**0.44**	**0.53**	0.12	**0.33**	**0.24**	**0.59**	**0.39**	1.31
20 (May)	0.01	0	**0.33**	**0.39**	fallow	no count	**0.28**	**0.61**	0.10	**0.23**	**0.21**	**0.34**	**0.35**	0.44
19 (May)	0.23	0.1	0.22	0.1	fallow	no count	0.19	0.12	0.08	0.10	0.10	0.12	0.35	0.37
18 (May)	0.34	0.06	0.16	0.17	fallow	no count	0.11	0.06	0.04	0.07	0.04	0.07	0.11	0.01
17 (April)	0.25	0.12	0.25	0.03	fallow	no count	0.21	0.02	0.03	0.07	0.05	0.05	0.04	0.37
16 (April)	0.21	0.01	0.05	0.19	fallow	**0.48**	0.18	0	0.04	0.05	0.04	0.03	0.14	0.38
15 (April)	0.11	0.07	**0.44**	0.16	fallow	**0.55**	0.15	0	0	0.05	0.06	0.11	0.21	0.04
14 (April)	0	0.01	**1.4**	0.33	fallow	**0.54**	0.08	0	0	0.06	0.1	0.06	0.09	0.22
Reported monthly biomass (tonnes)														
June			2182	866	0	979	**513**			**1653**	**1884**	**1290**	**983**	
May			2057	891	0	881	**414**			**1680**	**1785**	**1437**	**853**	
April			**1996**	**1620**	0	**2366**	279			**1389**	**1629**	**1420**	**734**	
March			2185	1824	450	2476	172			1137	1420	1307	1057	
February			2359	1665	1225	2431	111			920	1155	1102	896	
http://aquaculture.scotland.gov.uk/														

Three MOWI east of Skye farms (Scalpay, Maol Ban, and Sconser Quarry) were in the second year of the production cycle in spring 2023 with a combined biomass of nearly 6000 tonnes in April 2023; and average reported sea louse burden of 0.46 lice per fish during weeks 14 to 16. Although this figure is below the Code of Good Practice level of 0.5 adult female lice per farmed fish for the period January to June; the cumulative sea lice population on all the fish in the three nearby farms combined may have been high enough to cause the high levels of sea lice infestation seen on wild sea trout at Applecross.

However, in addition to the east of Skye MOWI farms, salmon farms in Loch Kishorn and Loch Carron (Scottish Sea Farms and Bakkerfrost), located a similar distance from Applecross as the fish swims, were just entering the 2nd year of production in spring 2023. Reported sea lice counts on these farms rose rapidly in May and early June 2023. Loch Kishorn & Carron farms and farms near Loch Alsh may have been a primary source of the sea lice on the small sea trout sampled at Applecross in June 2023 by which time the MOWI farms in the east of Skye were being harvested out.

The apparent lack of synchronised production and a co-ordinated regional fallow period for all the farms the Loch Alsh area – East of Skye area – Loch Kishorn & Loch Carron areas means that cross-infection of sea lice from farm to farm may have been inevitable, contributing to the unusually rapid increases in sea lice populations on salmon farms in the Loch Kishorn – Loch Carron in 2023.

5. Conclusions and implications for wild salmon populations

The WRFT sea trout sampling team were successful in obtaining large samples of sea trout at Applecross in 2023. All fish were taken using a seine net from the sea pool of the Applecross River. Net samples contained more fish than were processed; reflecting high numbers of 'early-returned' sea trout in the river estuary.

Burdens of small early-stage chalimus sea lice were very high on the majority of fish in May and on many fish especially smaller post-smolt sea trout in June. Many of the fish had damaged dorsal fins indicating that some of the lice had been shed prior to being sampled.

The high sea lice numbers on sea trout were indicative of high sea lice infestation pressures in coastal waters nearby in late April - June 2023. Unusually high sea water temperatures and a long period without rainfall in May and early June may have exacerbated sea lice infestation pressure.

Reference to figure published on Scotland's Aquaculture website suggests several potential sources of sea lice. Lice infestation of sea trout sampled at Applecross may have been associated with release of larval sea lice from farms in both the east of Skye, Loch Kishorn and perhaps also the Loch Alsh area; a consequence of cumulative infestation pressure associated with many farms.

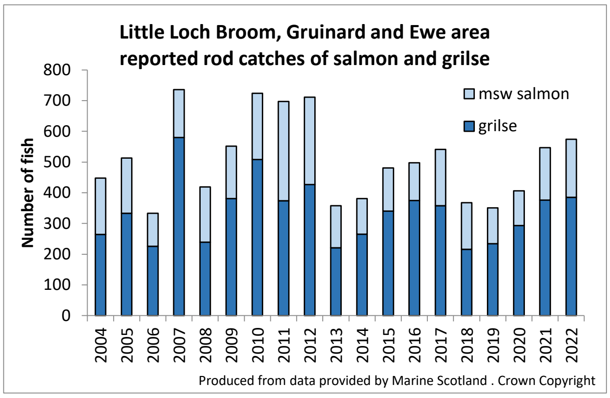
The very high sea lice infestation levels of sea trout sampled in May and June 2023 is of particular concern for wild salmon populations nearby. Wild post-smolt salmon migrating through coastal waters near Applecross including juvenile salmon from the Rivers Applecross, Carron, Ling, Elchaig, Croe, Shiel, Broadford, Sligachan and from any other rivers which migrate through Loch Alsh and the Inner Sound, are likely to have also experienced high sea lice infestation pressure.

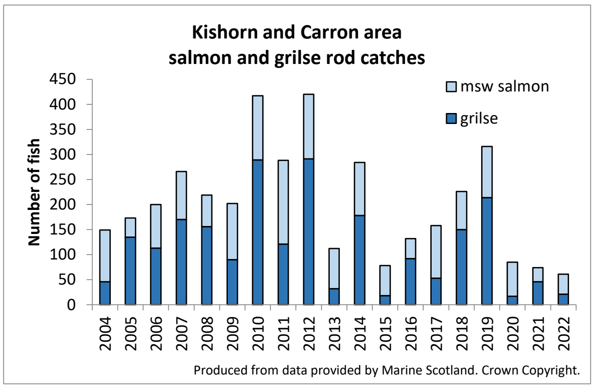
Unlike sea trout, wild salmon post-smolts do not return to freshwater to shed sea lice. Relatively low levels of sea lice infestation of around 10 lice per post-smolt salmon are understood to be lethal.

Research in Norway[2] (Vollset *et al*, 2017) has clarified relationships between lice levels on sea trout and on post-smolt salmon migrating nearby. It is beyond the scope of this report to provide a prediction of % mortality for post-smolt salmon migrating through the Inner Sound; however, by following Vollset et al (2017), such an estimate could be made using data provided here and from sampling sites on the east of Skye.

It is important to be able to understand the risk to wild salmon populations. A relationship between salmon catches in the River Carron and nearby salmon farm production cycles was discussed in the SWRFT Review 2018 (Cunningham et al 2018). Subsequently sea lice infestation pressures in the wider area may have increased as a consequence of increases in overall levels of farm salmon production within the East of Skye – Loch Kishorn areas and with corresponding increases in larval sea lice emissions, leading to even greater mortality of post-smolt salmon from the River Carron, so fewer returning salmon and lower rod catches (Figure 4).

Figure 4. Reported rod catch graphs for the Rivers Dundonnell, Gruinard, Little Gruinard and Ewe areas (which flow into the Wester Ross Marine Protected area) and for the Kishorn-Carron area. Contrast rod catch figures for the Kishorn-Carron area (mostly River Carron rod catch) from which post-smolt salmon must swim through Loch Kishorn and the Inner Sound en-route to the open sea with those for major rivers which flow into the Wester Ross MPA.





[2] Vollset et al (2017) Salmon lice infestation on sea trout predicts infestation on migrating salmon post-smolts https://academic.oup.com/icesjms/article/74/9/2354/3860036

For wild salmon populations, the consequences of unsynchronised farm salmon production and inadequately co-ordinated sea lice management between different companies in the region (exacerbating the likelihood of cross infestation) may have been particularly damaging.

6. Recommendations (for discussion)

- Sea trout sea lice data can be used to predict the likely mortality levels of post-smolt salmon migrating through the area in 2023, in the same way as described by Vollset *et al* 2017. Such analyses could provide estimates of predicted associated reductions in the numbers of grilse returning to the River Carron in 2024 and numbers of 2 sea-winter salmon returning in 2025, in comparison to rivers elsewhere in in the NW Highlands where post-smolt salmon migrating through coastal waters experienced lower sea louse infestation pressures.
- Monitoring of sea trout at Applecross should continue in future years to learn more about relationships between sea lice levels on sea trout at Applecross and wild salmon populations around the Inner Sound area.
- In addition to sea trout monitoring for sea lice, electro-fishing surveys of juvenile salmon could be extended to all rivers with wild salmon populations around the Inner Sound area.
- For some rivers (?rivers on Skye, Ling, Elchaig, Shiel, Glenelg river) there may now be a need to set up gene banks to safeguard locally adapted wild salmon populations.
- All companies with open cage salmon farms in the area (MOWI, Scottish Sea Farms and Bakkerfrost) need to improve their co-ordinated management of sea lice to safeguard many wild salmon populations.

Acknowledgements

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Appendix 1. Sea trout sampling at Applecross further notes and some photos

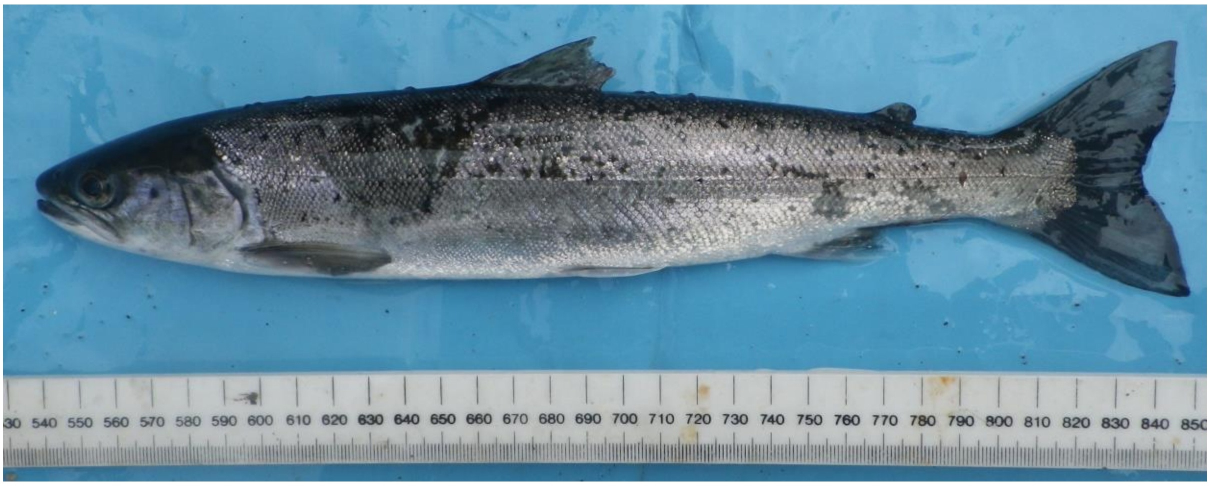
Sampling visit #1: 25th May 2023

Water level was low; one sweep was made of the sea pool using two snorkellers to help to herd the fish and move the lead line over the stream bed.

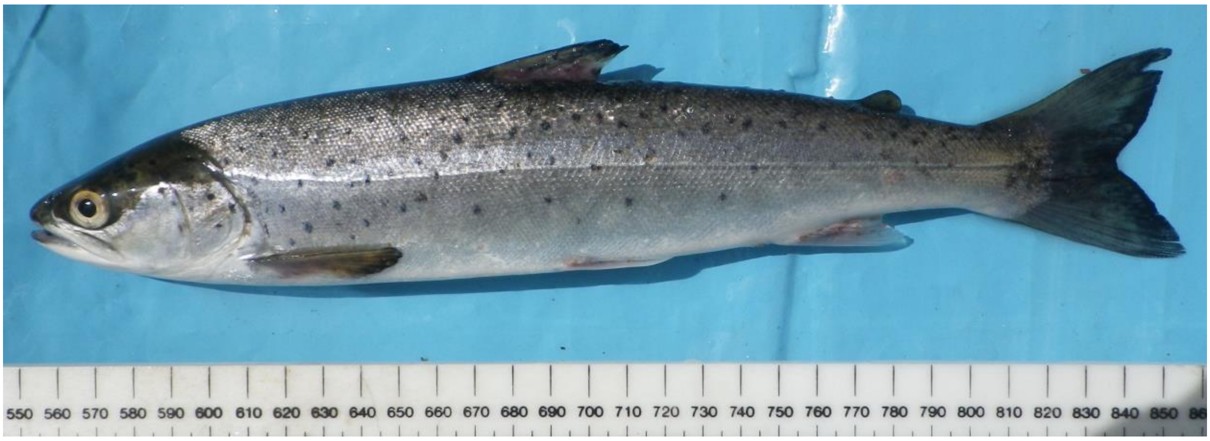
Sea trout were held in a bag of the net against the bank prior to being processed.

(below) The sweep netting team and processing area following completion of processing.

Sea trout with over 300 small copepodid and chalimus stage sea lice (Applecross 25 May 23).



Sea trout of 299mm with over 500 copepodid and chalimus stage sea lice (Applecross 25 May 23);



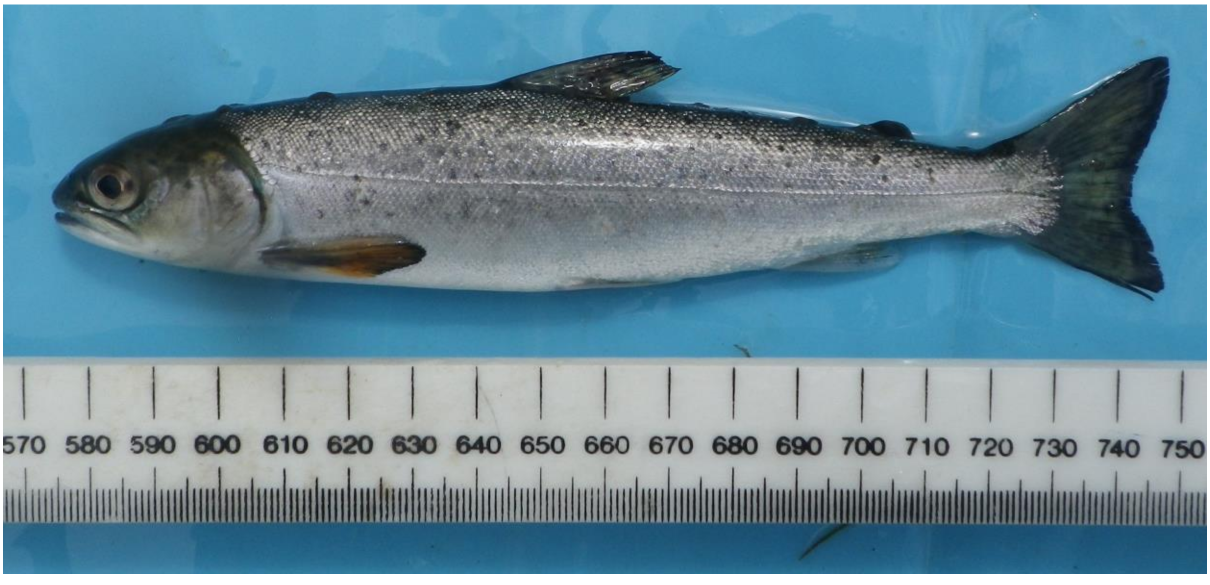
Close up of some of the lice (Applecross 25 May 23).

Sampling visit #2: 21st June 2023

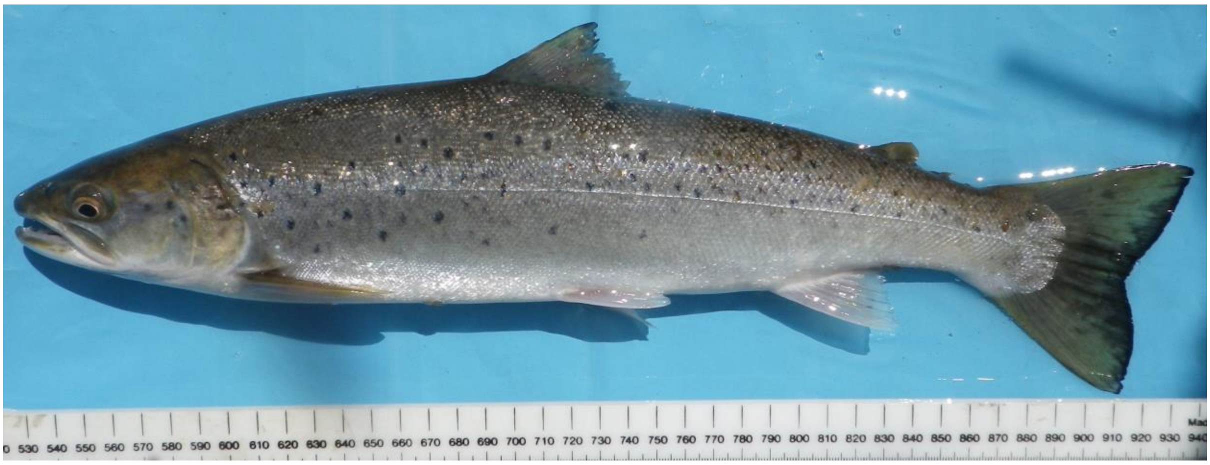
Water level low. Fish were caught at the top of the sea pool. About 60 fish were netted of which a random 30 were taken for processing; all were released following processing.

(Below) Fish processing buckets and netting team by the Applecross River on 21st June 2023.

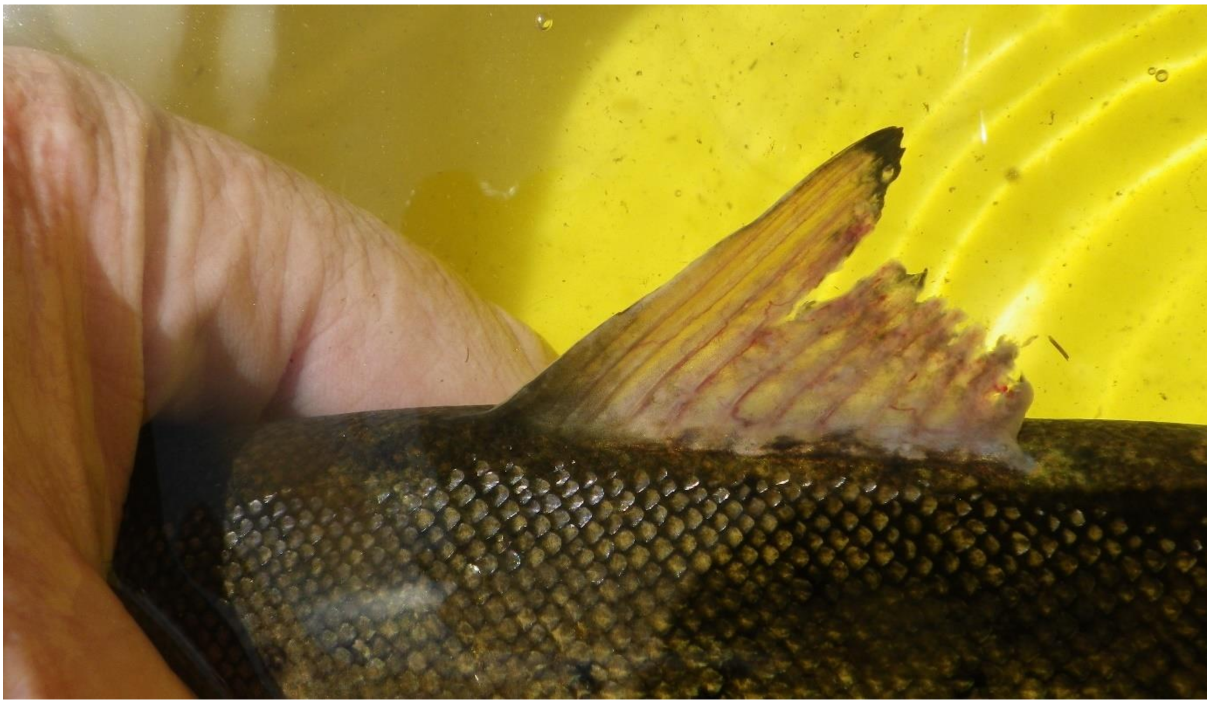
(below) Sea trout of 188mm; 99 lice recorded, Applecross 21 June 23



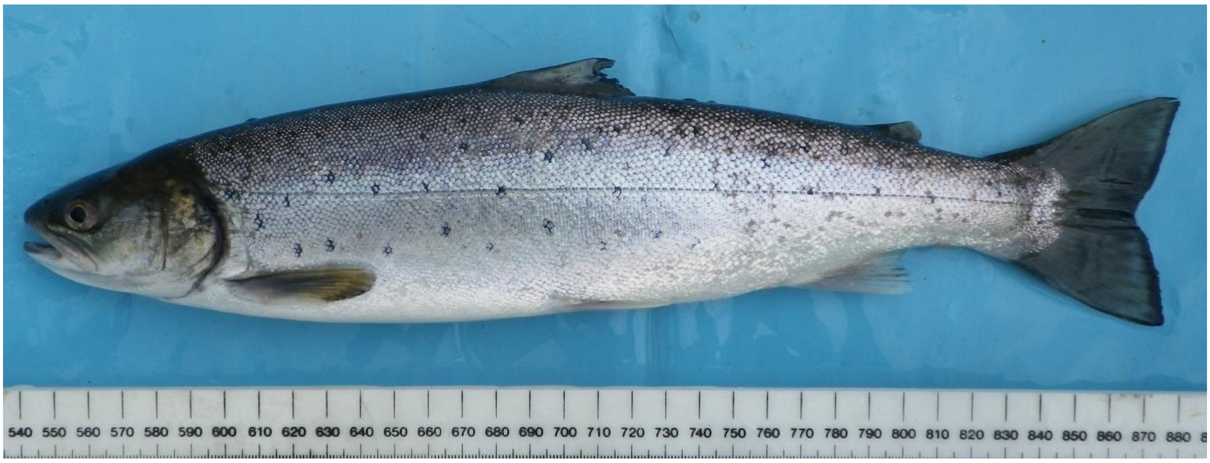
Sea trout of 395mm, 615g Applecross, 21 June 2023



(Below) louse damaged dorsal fin on sea trout.



(below) Sea trout 345mm, 440g Applecross, 21 June 2023

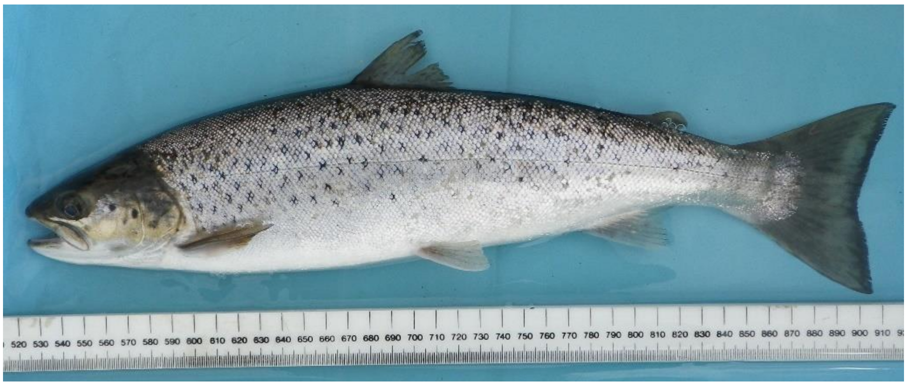


Sample visit #3: 19th July 2023

A smaller net with 22mm mesh size was used than in May and June; however many unexpectedly small post-smolt sea trout were caught by the gills; these were release using a pair of sharp scissors to cut the net to minimise damage to the fish. This net will not be used again for sampling sea trout!

Sweep netting team 19th July 2023

Sea trout 380mm

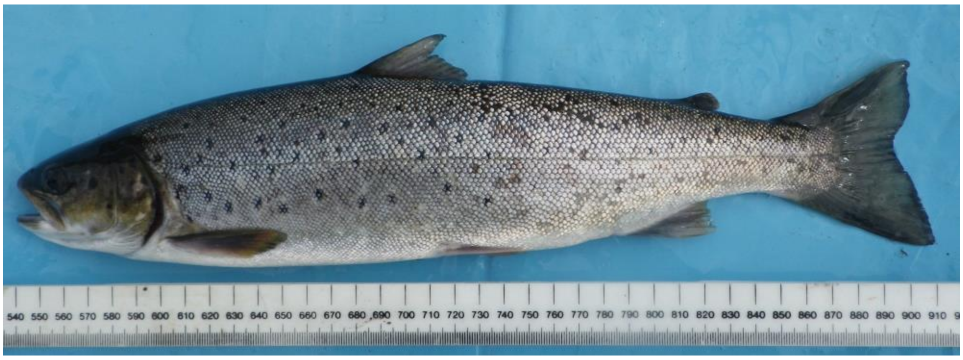


Damaged dorsal fin on sea trout, Applecross 19th July 2023

Sample visit #4: 16th August 2023

Water level low. One sweep of the sea pool; 4 snorkellers to help with netting fish.

Sea trout with healing dorsal fin taken at Applecross on 16th August 2023



Sample Visit #5 27th September 2023

Water level was medium high and dropping after heavy rain.

We netted the sea pool twice with three snorkellers to manhandle the lead line over the river bed as on previous occasions; seeing small flounders, an eel, but no trout seen or caught this time. Following several days with higher water, the sea trout would likely have moved upstream or dispersed more widely within the Applecross Bay area.

WRFT sweep netting team on 27th September 2023