



Mowi Scotland Loch Alsh, Loch Duich and Loch Hourn EMP

2023 Wild Fish and Sea Lice Monitoring Programme

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## **Executive Summary**

As part of the Mowi Scotland Loch Alsh, Loch Duich and Loch Hourn Environmental Management Plan (EMP), a sea trout and sea lice monitoring programme was conducted in Loch Duich in spring and summer, and electrofishing surveys were carried out in the River Arnisdale by the Skye and Lochalsh Rivers Trust (SLRT) in 2023.

A new seine netting site was identified in Loch Duich near the mouth of the River Shiel to be included as part of the sea trout and sea lice monitoring programme in 2023. Unfortunately, no sea trout were caught at this location. A new methodology and location will need to be selected in 2024.

A large number of juvenile salmon were caught in the main stem of the River Arnisdale, suggesting that the most recent spawning season in the winter of 2022 was productive.

Salmonid populations in the freshwater catchments and in the marine habitats within the management area are at low levels. Any additional negative impacts from environmental and anthropogenic influences in either ecosystem, like elevated sea lice levels, could result in severe and harmful effects on local fish populations.

## 1.0 Introduction

This document summarises the overall findings of native salmonid population monitoring conducted on the Isle of Skye in Loch Duich and the River Arnisdale as part of an Environmental Management Plan for the Mowi Scotland Loch Alsh, Loch Duich and Loch Hourn management area. Coordinates for the relevant catchments and aquaculture sites for this report can be found in the table below (Table 1.1).

<b>Catchment/Site</b>	<b>Latitude</b>	<b>Longitude</b>
Loch Hourn farm site	57.126438	-5.634726
River Arnisdale	57.124587	-5.553802
Loch Alsh farm site	57.267075	-5.678066
Ardintoul farm site	57.255813	-5.613026
Loch Duich farm site	57.250733	-5.494171
River Shiel	57.217437	-5.432505

Table 1.1 List of coordinates for the relevant catchments and aquaculture sites included in this EMP.

The 2023 EMP work programme was agreed between Mowi and the Skye and Lochalsh Rivers Trust (SLRT) in 2023 and SLRT conducted the work reported here. The salmonid populations monitored for this EMP are *Salmo salar* (Atlantic salmon) and *Salmo trutta* (brown trout).

The purpose of this work programme was to gather information on current juvenile salmonid densities in local freshwater systems and monitor local anadromous brown trout populations (hereafter referred to as sea trout) in relevant sea loch habitats.

Special focus was given to the sea lice burdens of captured sea trout, specifically *Lepeophtheirus salmonis* and *Caligus elongatus*. There is a large body of scientific research that demonstrates that the presence of open net-pen salmon aquaculture can result in increased densities of sea lice larvae in the surrounding water column (Thorstad *et al.*, 2015, Shephard *et al.*, 2016). Wild salmonids migrating through and feeding in those habitats are exposed to the increased parasite levels, which can result in elevated lice burdens (Taranger *et al.*, 2015). These increased parasite loads can result in physiological damage, a decline in fish health and condition, and ultimately lead to increased levels of mortality amongst wild fish (Ives *et al.*, 2023).

This monitoring work aims to identify impacts (short- and long-term) on native salmonid populations that could be related to salmon farming activity in the Loch

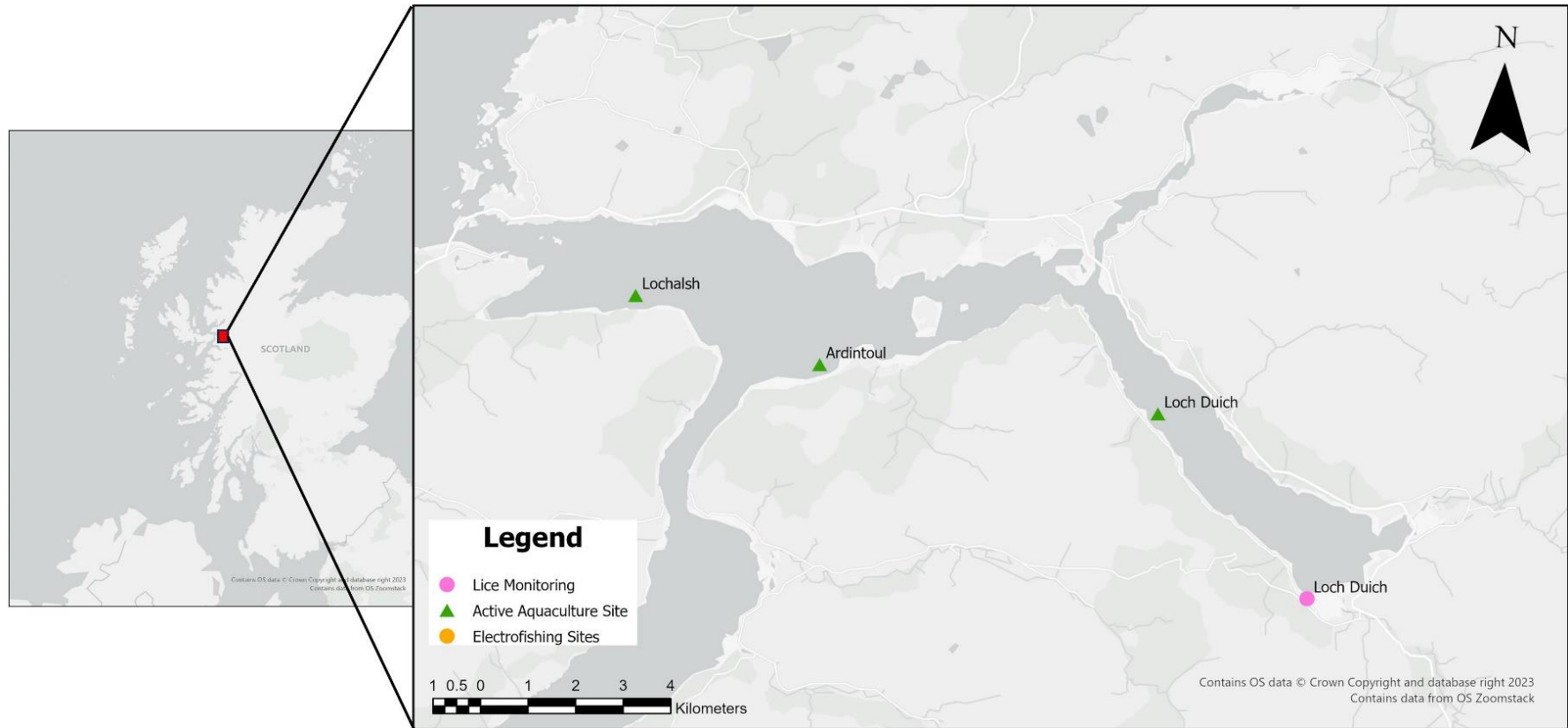


Figure 1.1 Site map with the Mowi Scotland farms located in Loch Alsh and Loch Duich as well as the SLRT sea lice monitoring site.

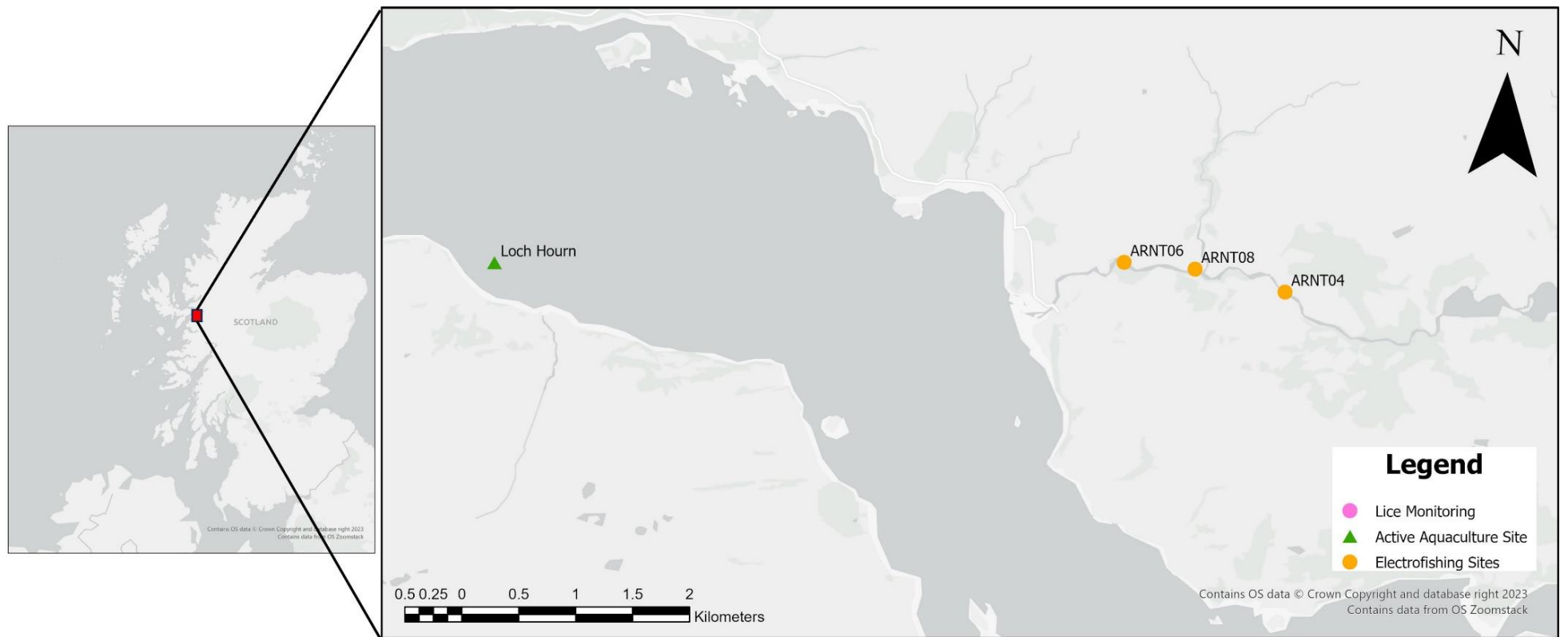


Figure 1.2 Site map with the Mowi Scotland farm located in Loch Hourn and the River Arnisdale electrofishing sites.

Duich and Loch Hourn areas and to provide data to inform responsive adaptive management procedures delivered by Mowi.

The 2023 EMP programme included sea trout monitoring surveys in the estuary of Loch Duich near the mouth of the River Shiel (Figure 1.1) and electrofishing surveys at three historical sites along the River Arnisdale (Figure 1.2).

## **2.0 Methods**

### **2.1 Sea trout and sea lice monitoring**

In 2022, sea trout monitoring occurred within Loch Long near the mouths of the Rivers Ling and Elchaig. This site was successful and caught small numbers of sea trout (N=35) over the course of the season, however, it was agreed between SLRT and Mowi that the location was too far removed from the main sea loch system (Loch Alsh and Loch Duich) to accurately demonstrate what sea lice levels local sea trout might be exposed to closer to the relevant farm sites. For the 2023 EMP work programme, SLRT sought to identify a new estuarine monitoring site that was within the main sea loch and chose to focus their efforts at the mouth of the River Shiel, approximately 4.5km from the Loch Duich farm site (Figure 1.1).

Two seine netting sessions were conducted in the Loch Duich estuary using a 30m seine net with a 14mm mesh size following Scottish Fishery Coordination Centre (SFCC) protocol. The first session was held on 30<sup>th</sup> June 2023 and the second was held on the 1<sup>st</sup> August 2023. A two-person team was used at both surveys.

At both sessions, SLRT staff sought to make use of an existing historical fish trap in the estuary. During the first session, SLRT placed the seine net across a large opening within the trap wall several hours before low tide with the intention of blocking the exit of any sea trout that might have been feeding within the trap. Once the tide was low enough to access the majority of the tidal area on foot, staff splashed through the water behind the fish trap towards the seine net to flush any fish towards the opening and then pulled the seine net to shore.

During the second session, SLRT placed the seine net in the same opening in the trap wall several hours ahead of low tide, but also added smaller barrier nets (10m with micromesh netting) to smaller gaps in the wall to seal off more possible exit routes. Similarly to the first session, splashing methods were carried out at low tide to drive fish towards the main opening in the wall and the net was then dragged to shore.

Any fish caught during these sampling periods were identified and safely released back into the water.

## **2.2 Electrofishing**

One fully quantitative and two semi-quantitative electrofishing surveys were conducted on the River Arnisdale on the 28<sup>th</sup> July 2023 (Figure 1.2) using SFCC electrofishing protocols. This protocol was primarily designed to survey 0+ and >0+ age classes of salmon and trout. Fully quantitative electrofishing requires at least 3 passes or “rounds” of electrofishing at the same site in order to report the most accurate estimate of fish density. All three sites were selected to replicated previous surveys and monitor for temporal trends in existing juvenile salmonid populations.

An electrofishing survey on the River Ling was originally included in the 2023 EMP work plan but due to inclement weather, SLRT was unable to deliver this work before the end of the field season.

The electrofishing equipment used was an E-Fish Solutions backpack unit that provided a smooth direct current output of variable voltage which was modified on a site-by-site basis to reflect the water conductivity at each location. Voltage was regulated upwards to maximise catches at sites with low conductivity and downward to minimise the negative effects on fish in areas of high conductivity.

All fish collected during the survey period were anaesthetised using MS-222, identified for species, counted and measured to fork-length (mm). The fish were allowed to recover from the anaesthetic in a holding tank before being returned to the river unharmed.

### **2.2.1 Electrofishing data analysis**

To account for the differing sampling effort between rivers and between years, catch data were corrected to a catch per unit effort (CPUE) expressed as the number of fish collected per minute electrofishing.

The salmon data collected during the 2023 survey were also entered into an electrofishing data analysis app maintained by Marine Scotland Science as part of the National Electrofishing Programme for Scotland (NEPS). The app uses the submitted data to obtain estimates of the total density of salmon fry and parr at a particular site (MSS, 2023). Additionally, the density estimates can be compared to a benchmark, or expected density, for the site. This app will be referred to hereafter as the NEPS app.

## **3.0 Results**

The raw data collected from this monitoring programme are reported in Appendix A.

### **3.1 Sea trout and sea lice monitoring**

Despite conducting two separate monitoring surveys, no sea trout were caught in the estuary of Loch Duich. Fish were observed jumping near the trap during the first survey, but no fish were caught by the seine net.

During the second survey, a large shoal of sandeels was found next to one of the smaller barrier nets but no fish were caught at the main opening where the seine net was located.

### **3.2 Electrofishing**

Semi-quantitative electrofishing surveys were conducted at Sites ARNT04 and ARNT06 (Figure 1.2). Both sites were fished for 15 minutes. A fully quantitative three-pass electrofishing survey was conducted at Site ARNT08. The site was fished for a total of 80 minutes.

Juvenile salmon were caught at all three sites. One individual was caught at Site ARNT04, while 16 salmon were reported at Site ARNT06. A total of 99 juvenile salmon were captured at Site ARNT08. Trout were captured at Sites ARNT04 (one individual) and ARNT08 (two individuals). No trout were recorded at Site ARNT06.

European eels (*Anguilla anguilla*) were recorded at Sites ARNT06 and ARNT08, with 11 and 10 individuals caught at each site respectively. No eels were captured at Site ARNT04.

#### **3.2.1 Catch per unit effort (CPUE)**

The data was corrected for sampling effort using a catch per unit effort (CPUE) metric and compared to the most recent electrofishing surveys completed at the same locations to investigate potential changes in population.

Site ARNT04 reported a decrease in CPUE for juvenile salmon from 0.16 in 2022 to 0.07 in 2023 (Table 3.1 and Figure 3.1). The CPUE metrics of juvenile salmon increased at Sites ARNT06 and ARNT08 between 2022 and 2023, with the largest increase (0.51 to 1.24) reported at Site ARNT08.

Sites ARNT04 and ARNT08 reported similar trout CPUE metrics in 2022 and 2023, with a 0.02 increase at each location (Table 3.1 and Figure 3.1). No trout were reported at Site ARNT06 where a trout CPUE metric of 0.7 had been previously recorded in 2022.



Site	Year	Salmon CPUE	Trout CPUE
ARNT04	2021	0.20	0.20
ARNT04	2022	0.16	0.05
ARNT04	2023	0.07	0.07
ARNT06	2021	1.00	0.00
ARNT06	2022	0.13	0.07
ARNT06	2023	1.07	0.00
ARNT08	2021	0.53	0.00
ARNT08	2022	0.51	0.01
ARNT08	2023	1.24	0.03

Table 3.1. Catch per unit effort (fish per minute electrofishing) for Sites ARNT04, ARNT06, ARNT08 in the River Arnisdale (2021-2023).



Figure 3.1. Catch per unit effort (fish per minute electrofishing) data for Sites ARNT04, ARNT06, ARNT08 on the River Arnisdale from 2021-2023 for comparison.

### 3.2.2 Expected densities

The observed densities of salmon fry and parr were compared to benchmark densities (average expected densities) calculated by the NEPS app. The difference between observed and predicted densities can be found below (Table 3.2).

Site	Salmon Lifestage	Counts	Area (m <sup>2</sup> )	Observed Density (life stage/m <sup>2</sup> )	Benchmark Fry Density (fry/m <sup>2</sup> )	Benchmark Parr Density (parr/m <sup>2</sup> )	Density Difference (life stage/m <sup>2</sup> )
ARNT04	Fry	1	50.6	0.04	0.40	0.10	-0.36
ARNT04	Parr	0	50.6	0.00	0.40	0.10	-0.10
ARNT06	Fry	16	140.12	0.21	0.40	0.08	-0.18
ARNT06	Parr	0	140.12	0.00	0.40	0.08	-0.08
ARNT08	Fry	96	114.95	0.94	0.40	0.08	0.55
ARNT08	Parr	1	114.95	0.01	0.40	0.08	-0.07

*Table 3.2. Counts of juvenile salmon recorded at each electrofishing site and the observed and predicted densities of each life stage as calculated by the NEPS app. Where the observed density was higher than predicted, the increase is noted in green and where the observed density was lower than predicted, the decrease is noted in red.*

Salmon fry and parr densities were lower than the NEPS predicted densities at all sites except for Site ARNT08, where the observed fry densities (0.94 fry/m<sup>2</sup>) were noticeably higher than the predicted densities (0.40 fry/m<sup>2</sup>).

The greatest negative disparity between observed and predicted salmon densities was reported at Site ARNT04, with a difference of -0.36 fry/m<sup>2</sup>.

## 4.0 Discussion

### 4.1 Sea trout and sea lice monitoring

The Loch Duich estuary netting site did not prove to be a viable location for sea trout monitoring. There were several factors that could have contributed to this, including high water flows at low tide that made the seine net difficult to manipulate and a number of small exit points within the fish trap wall that could have been exploited by fish leaving the trap.

SLRT will investigate other sites that might be better suited for future sea trout monitoring work, including possible locations for coastal fyke net deployment.

## **4.2 Electrofishing**

The results from the electrofishing surveys conducted in 2023 demonstrate that salmon and trout populations are present and reproducing in the River Arnisdale, but at low levels.

Juvenile salmon populations at Sites ARNT06 and ARNT08 both saw increases in their CPUE metrics relative to the survey results from 2022. The large number of salmon fry recorded in Site ARNT08 (N=98) demonstrated that there was a successful spawning season in the winter of 2022, and that this location is an important juvenile habitat within the river catchment. The available habitat of Site ARNT08 was not classed as excellent juvenile habitat for salmonids due to the homogenous substrate, heavy bankside erosion, constant presence of large livestock, and lack of instream cover, however, large numbers of macroinvertebrates were observed in the water column at the time of the survey which would suggest that there is a good supply of food for juvenile fish within the site. It is concerning that only one salmon parr was recorded at Site ARNT08, however, the older fish might have already begun their downstream migration to another section of the river where more parr-appropriate habitat is available.

The results from the electrofishing survey at Site ARNT06 are similar to those reported in 2021 (Table 3.1 and Figure 3.1). Although it is concerning that no trout were found at this site in 2023 when a small number of individuals were reported in 2022, there is not enough long-term data available to determine which is the more “normal” population structure for the site. Similarly to ARNT08, the available habitat at ARNT06 does not appear to be well suited to juvenile salmonids in that it is heavily eroded and has homogeneous substrate throughout.

Site ARNT04 has consistently reported low densities of salmonids in the last three years. Water levels at the time of the survey were higher this year than in previous years and could have impacted visibility in the site. Of the three sites included in this year’s electrofishing surveys, ARNT04 is considered to have the best available salmonid habitat so it is surprising that more fish are not found there. However, it is possible that there is limited spawning habitat near the site, resulting in lower juvenile densities in the area.

## **5.0 Concluding comments**

It was disappointing to not find a suitable sea trout monitoring location in Loch Duich during the 2023 survey period. However, SLRT is committed to identifying a location

where some method of monitoring can be undertaken to provide data on the sea lice burdens of wild fish.

A positive outcome from this year's electrofishing work was the large number of juvenile salmon caught in the main stem of the River Arnisdale. It is hoped that higher parr densities will be observed in future surveys to provide some information about the survival of salmon past their first year in the river.

Similarly to most of the catchments in SLRT's area, it appears that salmon and trout populations are present, but at low levels. Because of these low densities of wild fish, any additional negative impacts from environmental and anthropogenic factors, including habitat degradation in the freshwater catchment and elevated sea lice levels associated with local salmon aquaculture sites, could result in severe and harmful effects on the local fish communities. Therefore, every effort should be made to mitigate against these impacts to support the continued survival of both wild salmon and trout populations.

## 6.0 References

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