Monitoring for the presence of farmed salmon in West Coast Scottish rivers following an escape from the Carradale North salmon farm

Credit: C. Sommerville

Polly Burns, Stuart Brabbs and Alan Wells

Fisheries Management Scotland

March 2021

Fisheries Management Scotland

Introduction

Atlantic Salmon *Salmo salar* (referred to as salmon hereafter) have been in steady decline in Scotland, facing pressures from a variety of sources both natural and anthropogenic.

Escapes of farmed salmon can have negative impacts on wild salmon populations through genetic introgression arising from interbreeding which reduces salmon production and survival. In addition, direct ecological interactions such as competition for resources can occur. For populations of wild salmon already below their conservation limits, even a small number of farmed salmon interbreeding with wild salmon can have a significant impact. In Norway, pressures from salmon farming are considered to be the greatest threat to wild salmon[1]. In Scotland introgression has been identified within one of 12 groups of high-level pressures on wild Atlantic Salmon developed by the Scottish Government[2].

On the 20th of August 2020, Mowi Scotland Ltd. (referred to as Mowi hereafter) reported that 48,834 farmed salmon had escaped from their Carradale North site (Figure 1) caused by a mooring failing after adverse weather conditions during Storm Ellen. Mowi contacted the Argyll District Salmon Fishery Board and Fisheries Management Scotland immediately and we have been working together to coordinate the response. These farmed salmon were due to be harvested imminently, and though not sexually mature, they were of a size and life-stage where they could head for fresh water.

Figure 1 – Map showing location of Carradale North salmon farm (red dot)

Following early reports of farmed salmon in the River Leven, this study was initiated to understand the distribution of escaped farmed salmon entering fresh water. Therefore, the basis of the study was to monitor, in real time so far as was possible, where the escaped salmon were caught by

[1] Thorstad, E. B., Forseth, T., & Fiske, P. (2019). Klassifisering av tilstanden til 430 norske sjøørretbestander. Vitenskapelig råd for lakseforvaltning. (English summary). Retrieved from https://brage.nina.no/nina-xmlui/handle/11250/2629316

[2] Conservation of wild salmon - gov.scot (www.gov.scot)

anglers with the intention of supporting the knowledge base for escapes in Scotland and ensuring evidence-based management decisions are made. To ensure accuracy in determining where farmed salmon were appearing and assess anglers' accuracy in determining farmed salmon from wild, scale samples were taken so that an identification could be made of farmed or wild origin. Scales show growth patterns, which can be used to differentiate farmed and wild salmon. By reporting the process for monitoring escapes and providing evidence of the distribution of farmed salmon we hope this will contribute to the growing evidence base for what happens when a large-scale escape occurs off Scotland with a view to improving management actions in both the marine and freshwater environments.

The next phase of this work is to understand the genetic impact if any on wild populations. To understand any such impacts, Fisheries Management Scotland alongside Marine Scotland Science and funded by Mowi, have established a genetic monitoring project. The purpose of this work is to determine whether any impact on the genetic integrity of wild salmon populations occurred following this escape. First year baseline data was collected in September 2020, and this will be compared to data collected in 2021 and subsequent years. This work will also show whether the escaped farmed salmon were able to survive and breed the following year and the extent of any genetic introgression. The results from this work will be reported separately.

Methods

Fisheries Management Scotland worked closely with relevant stakeholders surrounding the Kilbrannan Sound – Argyll District Salmon Fishery Board, Argyll Fisheries Trust, Ayrshire Rivers Trust, Clyde River Foundation, Loch Lomond Fisheries Trust and Loch Lomond Angling Improvement Association. All were actively involved in developing a coordinated response and subsequent monitoring of the escape.

Reporting of Escaped Farmed Salmon

At the outset of the escape, Fisheries Management Scotland released guidance for anglers on how to distinguish farmed and wild salmon. The size of the salmon (4-5kg) as reported by Mowi was also highlighted to anglers to aid identification of farmed salmon from this specific escape. Alongside this information, an online reporting system was designed using *Smartsheet* and made available. This system allowed collation of information relating to location of capture, weight, and photographic evidence. Other records were also collated from alternative sources including social media (where permission was given) and reports through local fisheries trusts.

Scale reading

To corroborate anglers' visual identifications of farmed or wild salmon, we requested that anglers take scale samples from any salmon caught. Salmon scales have 'circuli', ridges which when examined under a microscope provide information on the fish's life history. Farmed salmon have very uniform, close-together circuli, reflecting a relatively constant growth, in comparison to wild salmon whose growth will vary with the season and whether in marine or fresh water. As part of the guidance given to anglers, and within the online reporting system itself, information on how to take and store scale samples from salmon was provided. Scale packets were distributed to the rivers dealing with high numbers of salmon caught to facilitate storage and transport. Staff at Ayrshire Rivers Trust read, catalogued, and classified scales as either farmed or wild as per Scottish Fisheries Coordination Centre scale reading protocols.

Scales were dried then examined under either a Fluke 1473 Stereo microscope (10x eyepiece) or Brunel MXt 4 Stereo Microscope. Using Fuji X Mount adapters, the scales were photographed using Fiji XT20 and XT3 cameras with microscope adaptors. The scales were classified as either farmed or wild, assigned a unique code and the same code was applied to any photographs of the corresponding salmon (where available). To ensure there was no double counting of records, or that nothing had been omitted, a quality assurance process was instigated between Fisheries Management Scotland and Ayrshire Rivers Trust.

Due to the high-profile nature of the escape, and the importance of accurate information, we elected to seek independent verification of the categorisation of scales. Therefore, Marine Scotland Science re-analysed the samples. This was done "blind", without prior knowledge of the classification assigned by Ayrshire Rivers Trust, but with access to the photographs of the salmon (where available). Results from these two analyses are presented below.

Categorisation

Given that not all records came through the Fisheries Management Scotland reporting system, there are different types of records that form our analysis (Table 1). Only records which included scales have been categorically confirmed as farmed or wild.

Table 1 – types of records received from anglers on farmed salmon records.

Type of record	**Information included**
Complete	Photograph of salmon and scale provided, alongside other data including location, date, and weight
Photograph only	Photograph of salmon but no scales, alongside other data including location, date, and weight
Descriptive information only	Location, date, and weight

Results

Location of records

There were 17 rivers across Scotland and North-West England with confirmed captures of farmed salmon through the scale reading process (Figure 2). However, there were six further rivers from which no scale samples were available for verification (Table 2).

Table 2 – locations of the farmed salmon records confirmed by scale sampling and across all records.

River	Verified records by scale reading	Total records
Annan	1	1
Ayr	12	14
Barassie Beach	-	2
Black Cart	-	2
Derwent	1	12
Doon	41	55
Echaig	5	36
Eden	1	1
Fyne	-	1
Garnock	8	10
Girvan	38	61
Irvine	9	11
Kelvin	1	1
Laggan (Islay)	-	1
Leven	118	194
Lomond	1	1
Luce	-	1
Lune	1	1
Naver	-	1
Border Esk	4	4
Ehen	2	2
Ruel	1	1
Stinchar	51	52

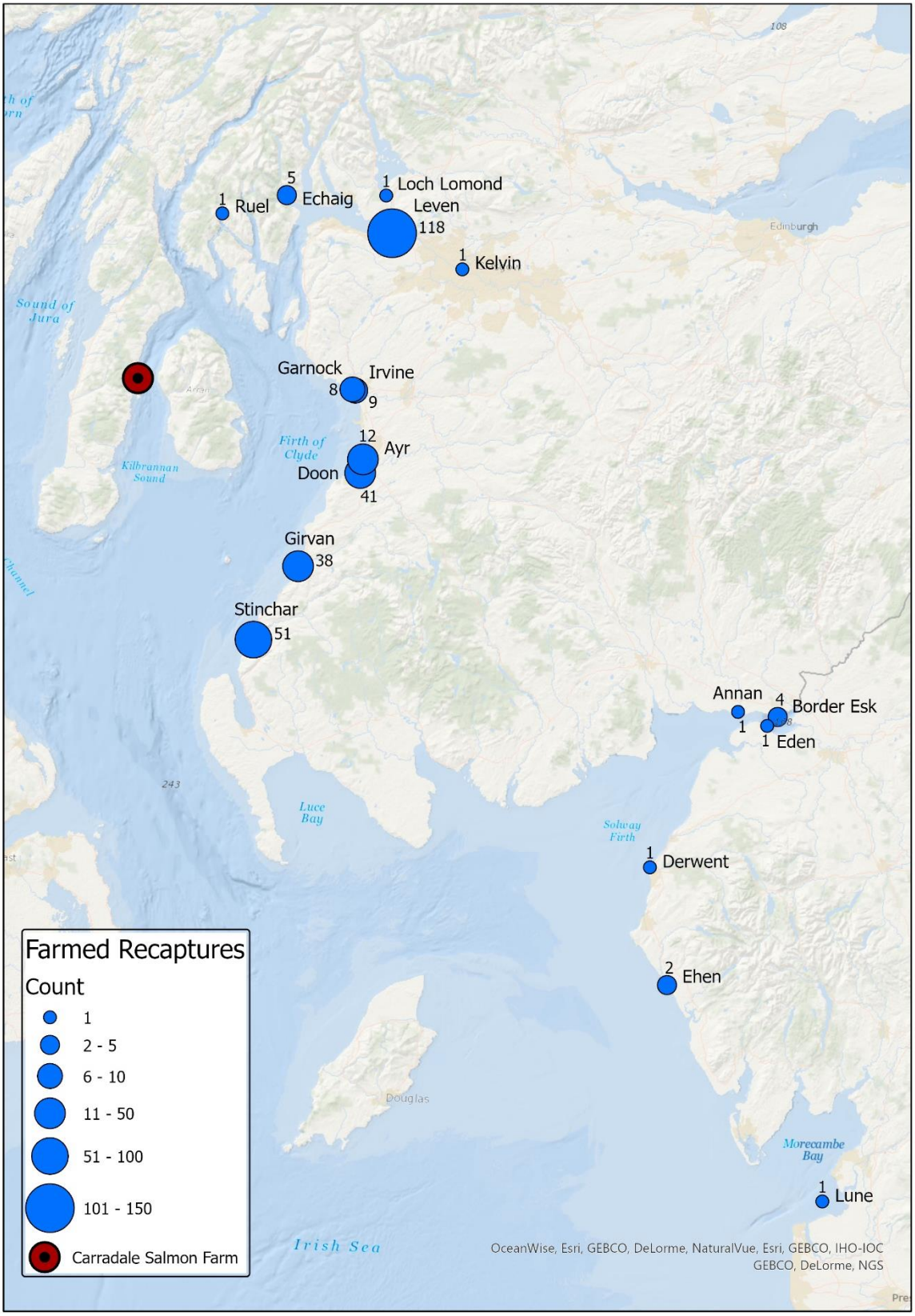

Figure 2 – Locations of farmed salmon captures validated by scale reading only (N=310)

Classification of salmon

A total of 466 reports of farmed salmon were received (Table 3). Of those, 310 records had scale samples associated with them and could therefore be verified as farmed or wild.

Table 3 – Breakdown of type of records received by Fisheries Management Scotland and Ayrshire Rivers Trust combined

Complete records	310
Photograph only	29
Descriptive information only	127
Total records	**466**

Ayrshire Rivers Trust read a higher number of scales than Marine Scotland Science, as additional scales were received by the Trust late in the year after issuing the scale photographs to Marine Scotland Science. These additional scales were classified only by Ayrshire Rivers Trust. From Ayrshire Rivers Trust's analysis, 295 were classified as farmed salmon (Table 4). Of the 15 classified as wild salmon, two were originally identified by the anglers as wild and were subsequently released back into the river.

Table 4 – Ayrshire Rivers Trust's classification details from scale reading

Category of record	**Number**	**%**
Total salmon classified using scales	310	
Farmed salmon	295	95.2
Wild salmon	15	4.8

Marine Scotland Science read 285 scales. This number was lower than Ayrshire Rivers Trust as 11 scales were deemed unreadable due to poor quality scales. Marine Scotland Science classified 277 scales as farmed, representing 97% of their total sample (Table 5). Overall, there was a high level of agreement in the classification of scales read by Marine Scotland Science and Ayrshire Rivers Trust. Of the 285 scales read by Marine Scotland Science, scales from five fish were classified differently to Ayrshire Rivers Trust.

Table 5 – Marine Scotland Science's classification details from scale reading

Category of record	**Number**	**%**
Total salmon classified using scales	285	
Farmed salmon	277	97.2
Wild salmon	8	2.8

Timing of records

Looking at only those records verified using scale samples, the first record of a farmed salmon was reported within nine days of the escape. Farmed salmon captures tailed off in late October (possibly as a result of adverse angling conditions and constant high-water levels), and the season ended for most rivers at the end of October. At that point angling effort ceased. However, we received some reports of suspected farmed salmon in the River Leven. In addition, at the time of finalising this report, on the 2nd March 2021, there have been six suspected records of farmed salmon captures in the Leven.

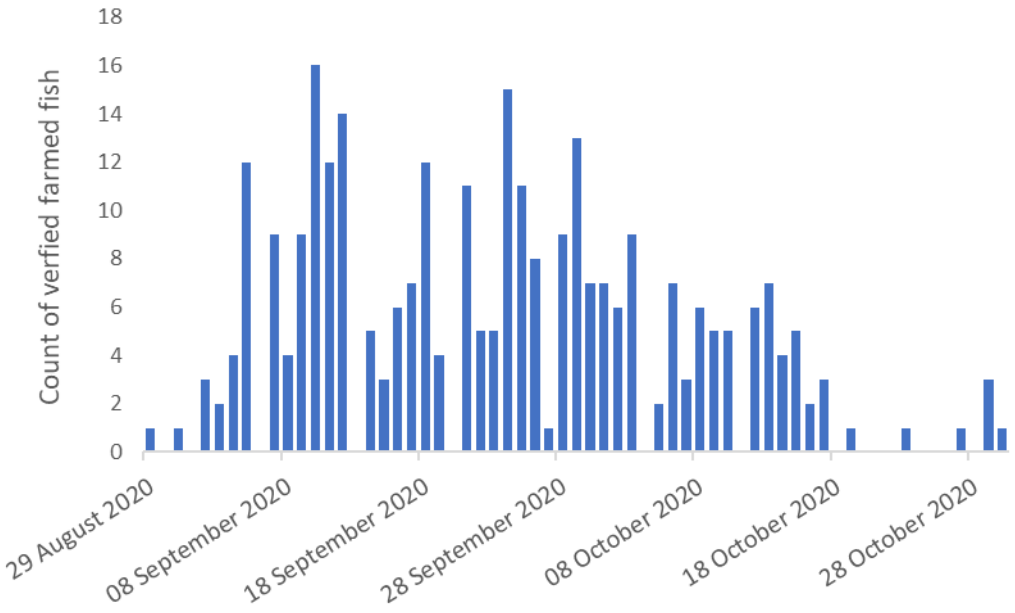

Figure 3 – Counts of verified farmed salmon (using scale reading) against date of capture

Summary

The results presented here demonstrate that escaped farmed salmon originating from the Kilbrannan Sound, rapidly dispersed and appeared in many rivers across the west of Scotland and north west England. Fisheries Management Scotland received reports of escaped farmed salmon from 22 rivers. Escaped farmed salmon were verified through scale reading as definitely entering 17 rivers, but the analysis demonstrates that visual identification of farmed salmon by anglers was highly accurate (95-97%). The results demonstrate the speed and high level of dispersal with which the farmed salmon entered fresh water (Figure 3). The first capture was 9 days after the event. It should be noted that the techniques deployed in this study cannot guarantee that all the salmon caught originated from Carradale North. However, given the timing of the captures and that the farmed salmon were all a similar size to those reported by Mowi, we are confident that the majority did come from this specific escape.

Fisheries Management Scotland are in the process of establishing a workstream with regulators and industry to assess the feasibility and practicality of recapturing escaped farmed salmon as soon as possible after an escape event and before they enter rivers. It is important to emphasise that salmon caught as part of the current study were not captured with the purpose of trying to remove all, or even the majority, of the escaped salmon. The vast majority of escaped salmon remain unaccounted for.

To understand the geographic extent to which escaped farmed salmon dispersed, it is necessary to rely on accurate records from anglers. As highlighted above, this is in part a function of angler effort, but it is also dependent on the willingness of anglers to formally report captures of suspected farmed salmon. We received a number of anecdotal records of farmed salmon being captured, but not reported. For example, there are anecdotal records of multiple farmed salmon having been caught in the Clyde region, but only one record is available (Pers. Comm. W. Yeomans, 2021.). On that basis, the figures reported here should be considered to be the minimum number of farmed salmon captured. There were also several rivers which had little to no angler effort but would be expected to have escaped salmon presence. This highlights the importance of further investigation to understand the extent of genetic introgression, if any, arising from this escape.

A high proportion of the overall number of farmed salmon recorded in rivers were in the Loch Lomond system, focussed on the River Leven. There was a significant angling presence on the river, and this angling effort is potentially reflected in the number of farmed salmon recorded on that system. The River Endrick is designated as a Special Area of Conservation with Atlantic salmon species present as a qualifying feature. Site condition monitoring undertaken by NatureScot shows this Special Area of Conservation is currently in an unfavourable condition. Across the six Ayrshire rivers, there were also a significant number of farmed salmon captured and reported despite adverse angling conditions prevailing during the month of October.

Whilst there is variation in the catch efficiency of anglers both geographically and throughout the angling season, it is generally accepted that anglers catch in order of 10% of the wild salmon entering Scotland's rivers. If a capture efficiency of 10% is applied, we can predict that a minimum of 3000 farmed salmon entered Scottish rivers. As highlighted above, it is likely that this is an under-estimate of the total numbers of farmed salmon entering rivers. Returns of wild salmon from sea have been in decline for several decades and many of the rivers in question are currently below their conservation limits. Particularly where rivers are below their conservation limits, any interbreeding

between farmed and wild salmon has the potential to do substantial damage to wild populations[3]. The impact of such genetic introgression is accepted within peer reviewed scientific literature. However, as described above, the farmed salmon from the Carradale site were not sexually mature, and therefore were unlikely to breed in winter of 2020.

If the farmed salmon from this escape can survive, we need to know what impact that will have on the wild salmon populations. By undertaking genetic monitoring for at least two years after the escape, we will have specific information of the impact on the genetics of wild salmon from across the Firth of Clyde region.

It is clearly in the best interest of both the farmed and wild salmon sectors to ensure that escapes do not occur. This principle was recognised and agreed within the Salmon Interactions Working Group. We welcome the open and transparent communications from Mowi surrounding the escape incident and their subsequent proactive engagement and cooperation in the monitoring phase. There have been other escape incidents in Scotland since the Carradale North event which have demonstrated the need for a more consistent and strategic approach to managing escapes and a need for more effective communications with wild fisheries managers. Fisheries Management Scotland continues to work collaboratively with the finfish farming sector with the aim of reducing and ultimately eliminating escapes.

Acknowledgements

Fisheries Management Scotland would like to thank:

- All anglers who took the time to report their catches to us and submit scales – it is invaluable information.
- Dave Stewart and Marine Scotland Science for scale reading and assistance with logistics.
- Ayrshire Rivers Trust for the scale reading.
- Sean Dugan for the production of maps using ArcGIS.
- Mowi Scotland Ltd. who funded the collection and analysis of data on the ground by Fisheries Management Scotland members.

Fisheries Management Scotland received no specific funding for the production of this report or coordination of the escape management.

[3] Thorstad, E. B., Forseth, T., & Fiske, P. (2019). Klassifisering av tilstanden til 430 norske sjøørretbestander. Vitenskapelig råd for lakseforvaltning. (English summary). Retrieved from https://brage.nina.no/nina-xmlui/handle/11250/2629316; Glover, K. A., Solberg, M. F., McGinnity, P., Hindar, K., Verspoor, E., Coulson, M. W., Hansen, M. M., Araki, H., Skaala, Ø., & Svåsand, T. (2017). Half a century of genetic interaction between farmed and wild Atlantic salmon: Status of knowledge and unanswered questions. Fish and Fisheries, 18(5), 890–927. https://doi.org/10.1111/faf.12214