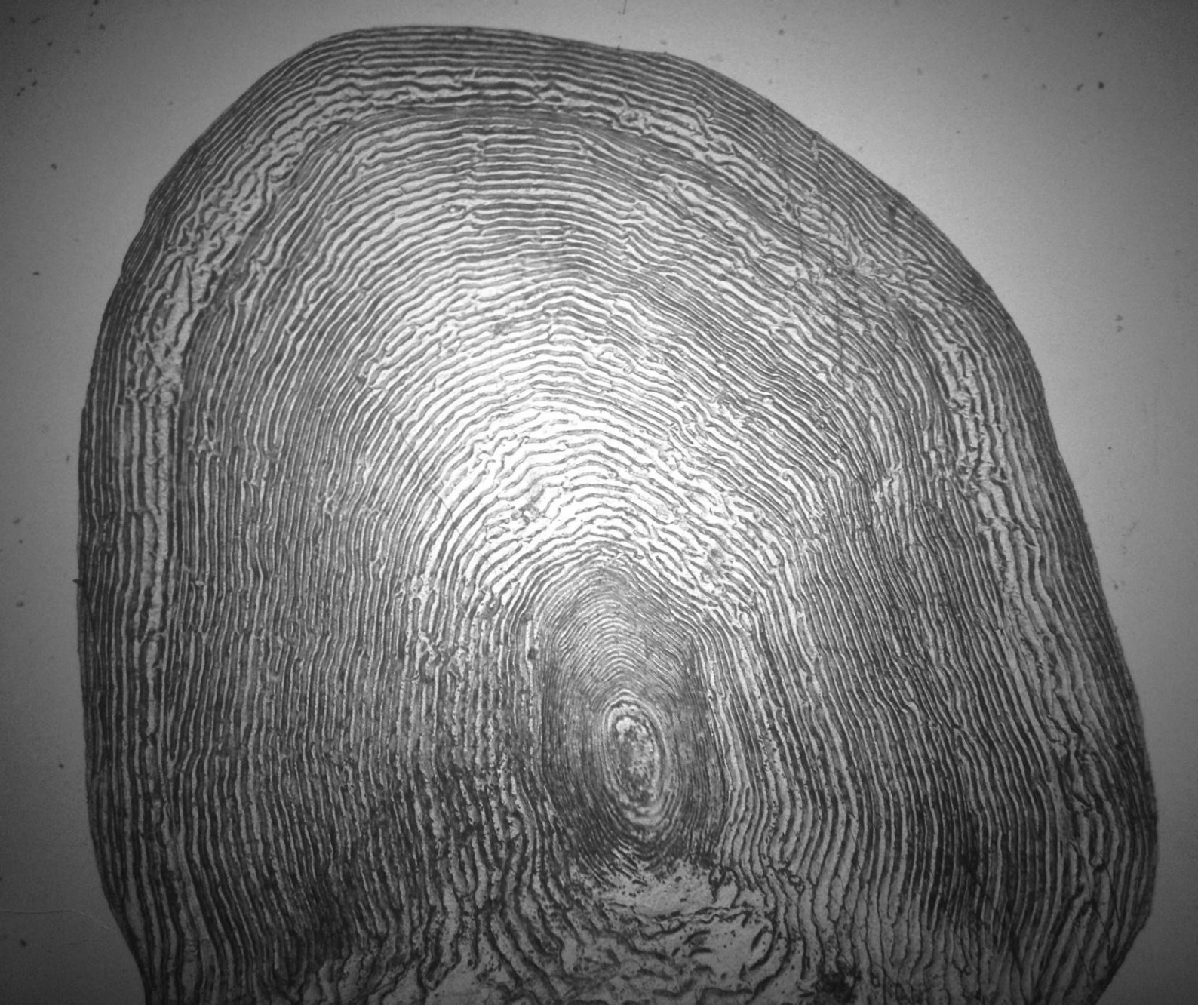

BEAULY DISTRICT SALMON FISHERY BOARD

2015 Adult Scale Sampling Programme

FINAL Version 1.1 – 6th June 2016

Ness & Beauly Fisheries Trust

DOCUMENT CONTROL

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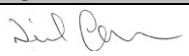
Neil Cameron (Chairman, NBFT)	**06/06/16**	
File Reference	**Revision**	**Notes**

A document prepared by the Ness & Beauly Fisheries Trust, presenting the results of the Beauly District Salmon Fishery Board 2015 adult salmon scale sampling programme.

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EXECUTIVE SUMMARY

- The collection and ageing of Atlantic salmon scales has become a fundamental fisheries management tool. It allows determination of river age, sea age and various scale characteristics for stock discrimination (Shearer, 1992).

- Many of the skeletal structures of fish exhibit growth rings. Scales are usually the chosen structure because they can be sampled without sacrificing the fish.

- Ghillies and selected anglers were issued with scale packets, tweezers and asked as a minimum to take samples from every third fish landed. Normal procedures for minimising trauma and damage to the fish were employed.

- Scale samples were submitted from a total of 85 adult salmon captured between the 14th April and 15th October 2015, equating to ten per cent of the total 2015 salmon catch (877 fish).

- The date of capture was omitted from 17 of the samples, with partial dates included on a further two. It was not possible to determine the number of freshwater years associated with four of the samples, with that another being a best estimate. Overall, the samples were of a very high quality, resulting in 80 complete and five partial ages being determined.

- The majority of those samples for which it was possible to determine the freshwater age (64 per cent) were found to have spent two years in freshwater before smolting. The other 36 per cent were found to have spent three years in fresh water.

- The proportion of three freshwater year fish recorded in the samples from the Farrar catchment (42 per cent) in the upper system was significantly higher than that from the Lower Beauly (32 per cent). This pattern is similar to that seen in other Scottish rivers, with the colder climate in the upper reaches resulting in slower growth of fry and parr.

- The majority of grilse sampled in 2015 were found to have spent two years in freshwater (62 per cent of the total grilse sample). The other 38 per cent were found to have spent three years in freshwater.

- It was not possible to carry out any meaningful analysis on the sea age of the submitted samples as sampling was heavily biased toward sampling of grilse rather than the larger multi sea winter salmon.

- The majority of the fish sampled (grilse and MSW salmon combined) during the 2015 season

(48 per cent) were found to have a combined freshwater and sea age of three years.

- The majority of grilse (62 per cent) had a total age of three years, with a further 38 percent having a total age of four years.

- The MSW salmon ranged between 4 and 6 years of age, the majority having a total age of four years (67 per cent), followed by those having a total age of five years (28 per cent), with a further six per cent at six years of age.

- Analysis of scale samples taken from fish caught between April and May 2015 (the 'spring' period) indicates that the majority were MSW salmon. Furthermore, the results suggest that the return of 3SW fish on the Beauly system is generally associated with the spring period.

- Grilse made up a small proportion of the samples in both May and June (20 and 17 per cent respectively) It is not clear whether this is due to a lack of fish in the system, or a symptom of selective sampling. By July the samples were dominated by grilse, with a small proportion of summer and autumn salmon.

- The April samples were made up of kelts (50 per cent) and spring fish exhibiting 'no plus growth' (50 per cent). Fish exhibiting 'plus growth' made up a majority 60 per cent of the May sample.

- As expected, all of the samples in June were from 'summer' fish exhibiting plus growth. However, four per cent of the July sample was found to be from 'spring' fish with no plus growth. This is a particularly significant observation as it demonstrates that spring fish can be captured throughout the season and the associated importance of releasing 'coloured' fish.

- The results of the 2015 scale sampling programme demonstrate that April and May are particularly important months for spring salmon on the Beauly system. This suggests that the Scottish Government's statutory conservation measures for 'spring' fish (all fish must be returned up to the 1st April) do not go far enough.

- The scale samples collected in 2015 provide information relating to the size ranges (in terms of weight) of both salmon and grilse in the Beauly district. The results suggest that fish over 10 pounds are most likely to be MSW salmon, with fish under 6 pounds most likely being 1SW grilse. Fish between 6 and 10 pounds could be either MSW salmon or grilse and difficult to positively identify without scale reading.

- A slight amendment to the data collected as part of our scale sampling programme would allow us to begin quantifying grilse error. This would involve the use of a scale packet which

asks for length data and a description of the fish in terms of 'salmon' or 'grilse' rather than just salmon.

- The systematic recording of the sex of fish on scale packets would allow us to start building up a picture of the proportions of male and female spawners, i.e. sex ratios. This could in turn help us to gain a greater understanding of egg deposition.

- It is recommended that a Beauly specific 'Length/Weight Conversion Chart' be developed. This would give anglers the ability to determine the weight of a fish using its length rather than actually weighing, significantly reducing handling time.

- A Length/Weight Conversion Chart could also be used to assign a weights to fish photographed as the pass through the SSE fish counters. Combined with analysis of head shape and/or sex data, this could be used to develop estimates of egg deposition.

Contents

1 INTRODUCTION

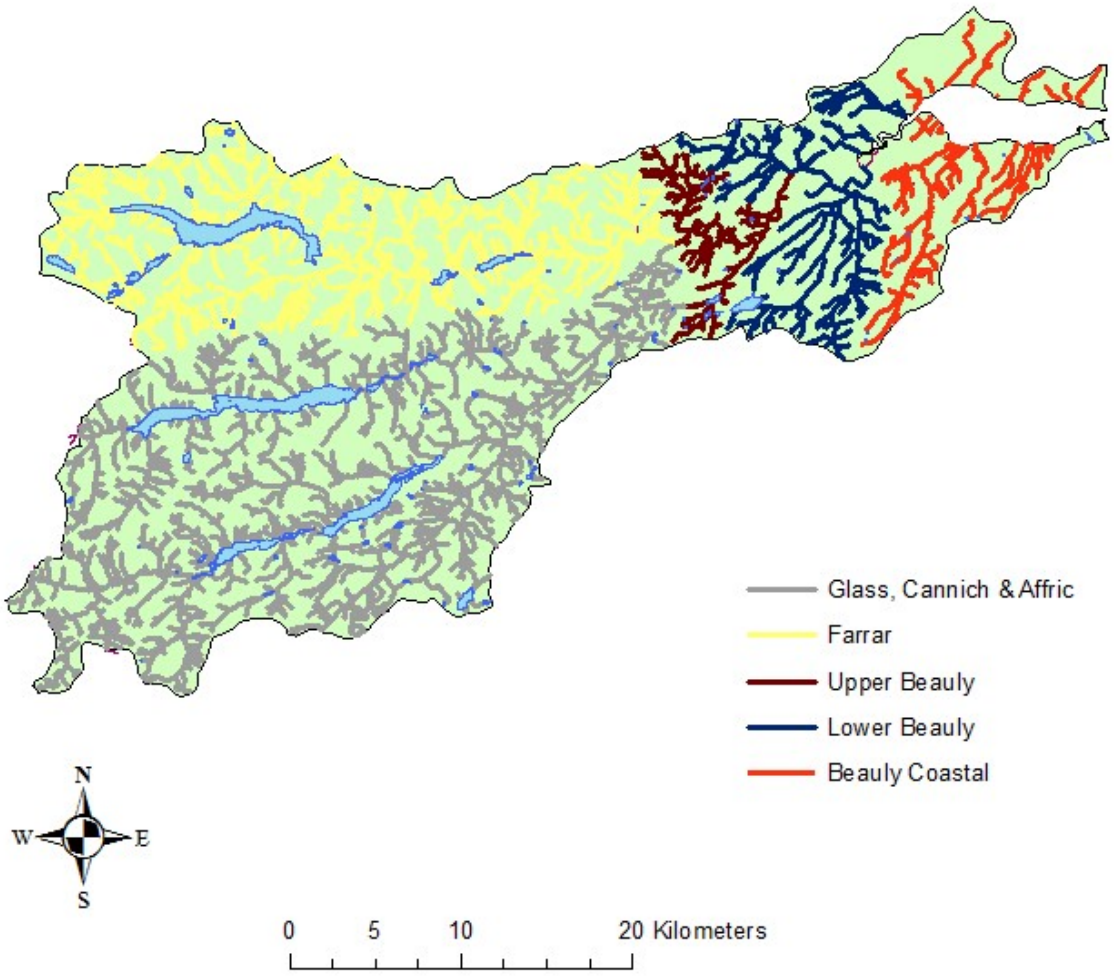
The collection and ageing of Atlantic salmon scales has become a fundamental fisheries management tool. It allows determination of river age, sea age and various scale characteristics for stock discrimination (Shearer, 1992). Growth patterns can be related to production, environmental trends and timing of physiological changes such as maturation, smoltification and spawning can be identified. This information, combined with sex and size data, can be used to inform management decisions within a fishery.

This report gives an overview of the Beauly District Salmon Fishery Board's 2015 Scale Sampling Programme. This includes a description of the basic markings and structure of fish scales, scale ageing techniques and the sampling procedures employed. It goes on to present the results of the programme; including the numbers and quality of scale samples submitted and analysis of the resulting data in terms of age composition and run timing. Finally, the report looks at practical management applications of the scale ageing data and makes recommendations for future years.

2 THE BEAULY SALMON DISTRICT

The River Beauly drains a catchment of approximately 1000 square kilometres of land, making it the second largest catchment north of the Great Glen. The catchment extends almost to the west coast, with the most westerly tributaries being only approximately 7km east of Loch Duich. For management purposes the district can be sub-divided into five management units as shown in **Figure 2.1** below:

Figure 2.1 - Beauly Management Units



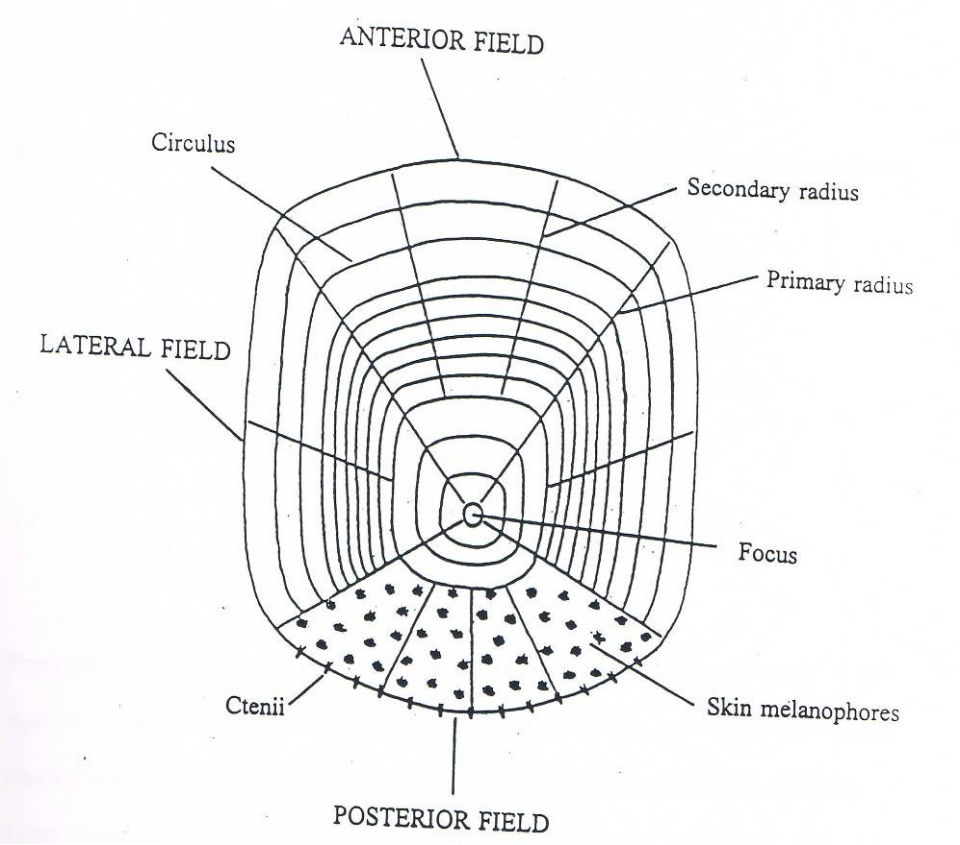
3 PRINCIPLES OF SCALE READING

Many of the skeletal structures of fish such as scales, otoliths, opercular bones and fin rays exhibit growth rings. These rings are formed annually due to seasonal fluctuations in growth and can be used to give an indication of the age of a fish. Scales are usually the chosen structure because they can be sampled without sacrificing the fish.

3.1 BASIC MARKINGS AND STRUCTURE

The basic markings and structure of a typical generic fish scale are shown in **Figure 3.1**. Bands of individual lines known as 'circuli' radiate out from the centre of the scale, the 'Focus'.

Figure 3.1 - Basic markings and structure of a generalised fish scale



When the scales are attached to the fish they are held in pockets. The circuli are formed as the scale pushes against the dermis and the pressure forms ridges on the scale which then become calcified. This process occurs at the edge of the scale where the new growth is soft. As the circuli age and become further away from the edge of the scale, they harden as they become impregnated with mineral salts.

During the summer months, when food availability is high, the fish grows quickly. In the colder months growth slows down or stops and the circuli form closer together leaving incomplete ridges. When the fish begins to grow again in the warmer months a new ridge is formed which 'cuts across' the incomplete circuli, this region is known as an annual 'check' or 'annuli'.

The annuli in different species or specimens may differ in appearance, but will always have one or more of the following characteristics:

- Cutting over of circuli;
- Closely spaced circuli followed by a zone of widely spaced circuli;
- Abrupt ending of circuli;
- Uneven spacing of circuli; and
- Clear patches without any circuli.

The age of the fish can be determined from the number of annual checks (annuli). Temperature is the main contributing factor to annuli formation, due to its effects on the metabolic rate and growth of the fish.

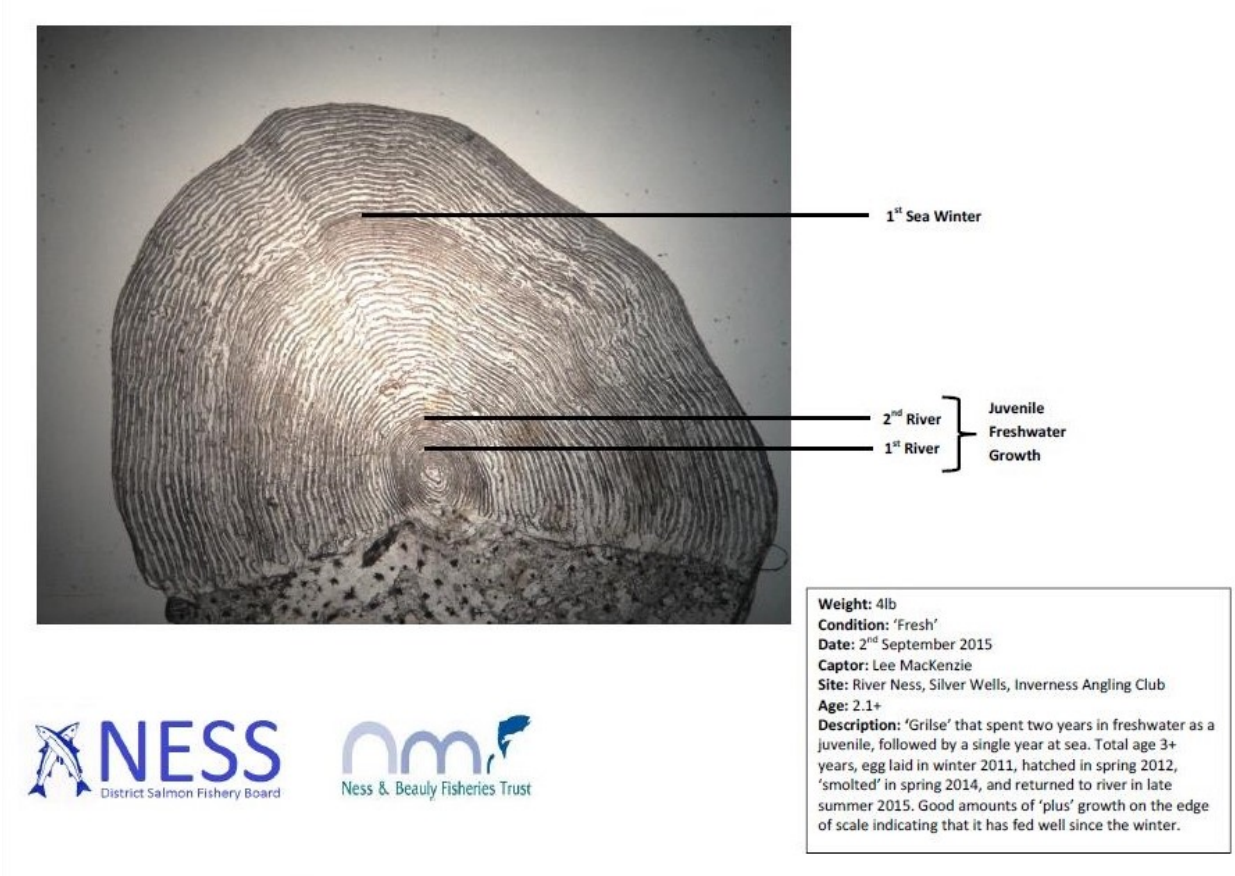
False checks are a common feature on scales, particularly where the growth of the fish has been interrupted by factors such as pollution events, capture by anglers or sudden changes in temperature. This makes the ageing of fish more difficult, especially in cold water species such as salmon and trout. These fish species are very sensitive to extremes of temperature and may stop feeding in very warm or very cold conditions.

3.2 SALMON SCALES

Salmon are anadromous and so their scales exhibit features from their freshwater and seawater years. After hatching, the salmon spends an average of two years in freshwater, where it is known as a 'parr'. The salmon then undergoes 'smoltification' and migrates downstream towards the sea for the first time, marking the end of freshwater growth.

The fish stays at sea for at least one winter where its scales exhibit large growth rates due to the abundance of food available. If they first return after one sea winter they become known as grilse. An image of a typical grilse scale is presented in **Figure 3.2** below.

Figure 3.2 - Scale from a grilse aged 2.1+ (two years in the river and one year in the sea)

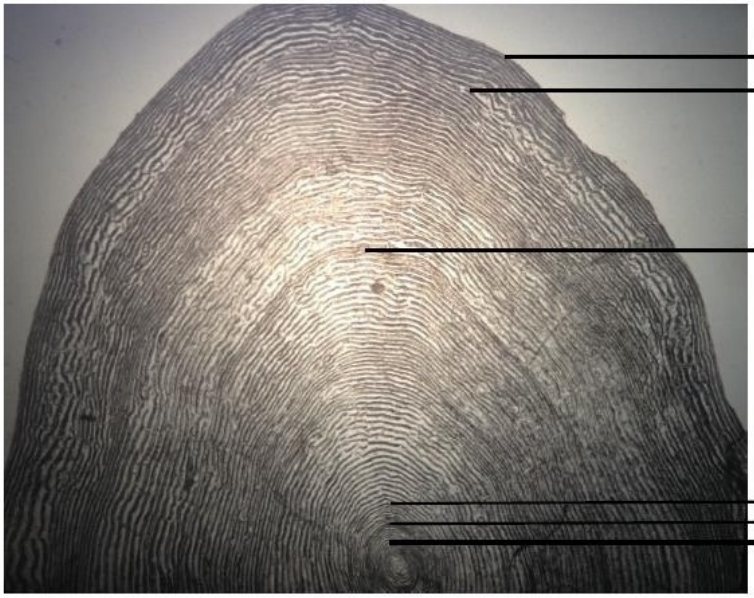


Fish that stay at sea for more than one winter return at a larger average size. These 'multi sea winter (MSW)' fish are believed begin returning very early in the year (sometime late November/early December in the previous year), compared to the main grilse run which usually return between June and October. Scales from typical MSW salmon are presented in **Figure 3.3**.

The first fish aged 3.3 years was captured in April and so is classed as a 'spring' fish. This is confirmed by the scale which shows no growth after the third sea winter check. This indicates that the fish entered the river early in the year without putting on any significant growth since the last winter.

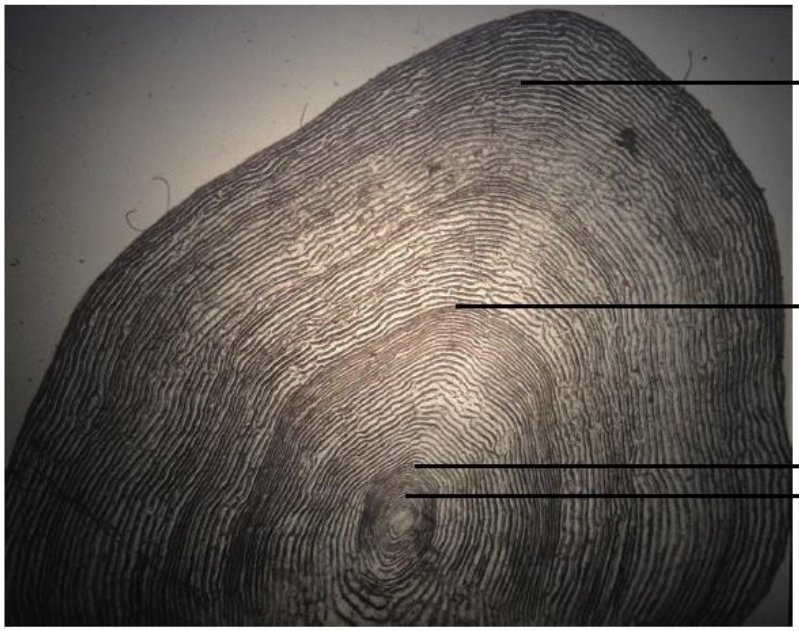
The second fish was captured as a 'fresh' run fish in July and so is classed as a 'summer' salmon. This fish exhibits 'plus' growth after the second sea winter check, consistent with the fact that it had more time to feed at sea since the last winter.

Figure 3.3 - Scale from a 3.3 multi sea winter 'spring' salmon and a 2.2+ multi sea winter 'summer' salmon.



NESS District Salmon Fishery Board
Ness & Beauly Fisheries Trust

Weight: 23.5lb
Condition: 'Fresh'
Date: 26th April 2015
Site: River Moriston
Age: 3.3
Description: 'Spring' salmon that spent three years in freshwater as a juvenile, followed by three years at sea. Total age six years, egg laid in winter 2008, hatched in spring 2009, smolted in spring 2012, returned to river in spring 2015.



NESS District Salmon Fishery Board
Ness & Beauly Fisheries Trust

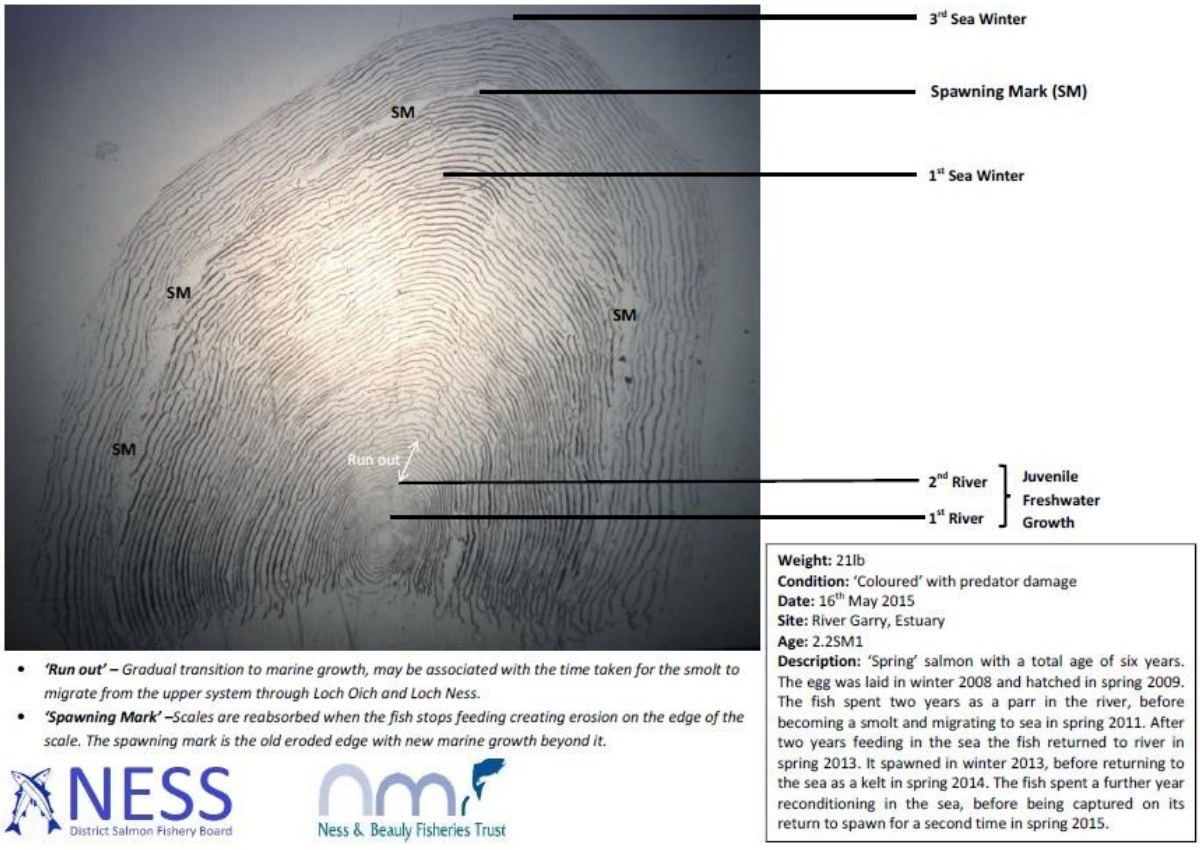
Weight: 16.5lb
Condition: 'Fresh'
Date: 25th July 2015
Site: River Ness, Town Water
Age: 2.2+
Description: Summer salmon that spent two years in freshwater as a juvenile, followed by two plus years at sea. Total age four plus years: egg laid in winter 2010, hatched in spring 2011 and smolted in spring 2013. The fish then returned to river as an adult in summer 2015, having put on a little plus growth since its last sea winter.

On their return to freshwater salmon do not feed, the mineralisation process is reversed and the scales are reabsorbed from the outside edge. This demineralisation process is known as the 'Crichton Effect' (after it was described by Crichton in 1935) and provides a source of calcium during periods of deficiency.

The erosion observed on a scale as a result of this process is called a 'spawning mark'. The degree of erosion can be used to given an indication as to how long a fish has been in freshwater, or to identify kelts, i.e. 'spent' fish which have spawned, survived and are on their way back to the sea.

The presence of a spawning mark can also be used to identify previous spawners, i.e. those fish that have entered the river and spawned, returned to the sea, then entered the river again to spawn for a second time. An example of a multi sea winter salmon scale exhibiting a previous spawning mark is presented in **Figure 3.4**.

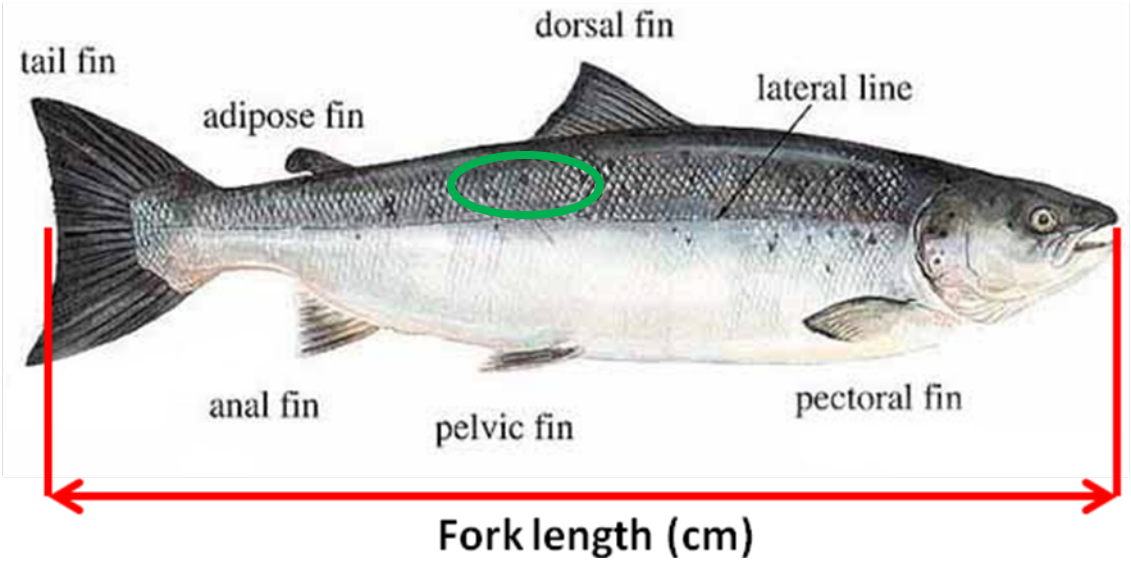
Figure 3.4 – Impression of a scale from a 2.2(SM) 1 'repeat spawning' salmon caught on the River Garry in May 2015



4 SCALE SAMPLING PROCEDURE

Ghillies and anglers were issued with scale packets, tweezers and asked as a minimum to take samples from every third fish landed. Normal procedures for minimising trauma and damage to the fish were employed (e.g. minimum handling time and wet hands). The fish were kept under as much control as possible, preferably remaining in the landing net. The fish were weighed as usual and the anglers asked to record their 'fork length', measured from the tip of the snout to the fork of the tail (see **Figure 4.1** below).

Figure 4.1 Adult salmon showing fork length and scale sample area



The weight of the fish was recorded on the scale packet provided, together with the date and location of capture (the river, beat and pool from which it was taken). Further comments were included in the 'Remarks' section, together with the sex of the fish (if possible).

Scales were taken from the area highlighted in green (see **Figure 4.1** above) between the dorsal fin and lateral line. This ensures that the best possible shaped scales are taken making reading much easier. A total of four to five individual scales were removed from each fish. This allows the age to be verified and accounts for any 'replacement' scales. The scales were then transferred to the completed scale packet.

Scale packets were submitted to trust biologists. These were then given a reference number before being sent to a specialist scale reader (Bryce Whyte) for validation. The raw data was then sent back in a spreadsheet and subsequently analysed. The results are presented in the following sections of this report.

5 RESULTS

This section of the report presents the results of the 2015 Beauly Scale Sample Programme; including the numbers and quality of scale samples submitted and analysis of the resulting data in terms of age composition and month of capture. Furthermore, the results of a number of historical Beauly samples are also presented.

5.1 SCALE AGES

2015 Scale samples were submitted from a total of 85 adult salmon captured between the 14th April and 15th October 2015, equating to ten per cent of the total 2015 salmon catch (877 fish). A further ten historical samples were submitted from 2006 and two from 2014. The details recorded on each scale packet and the age determined for the fish are presented in **Table 1** and **Table 2** below. The age is generally presented as a three number code, where:

- The first number = river (or freshwater) age
- The second number = sea age
- Third number = 0 (no plus growth)
- Third number = 1 (plus growth)
- Third number = 2 (previous spawner)
- Third number = 3 (full erosion)

For example, if the age of a fish is given as '320', this fish spent three years in the river and two years at sea with no plus growth (indicating that it entered the river early in the year and so was a 'spring' salmon).

Where it was not possible to age the fish (due to poor scale quality or low numbers of scales included in the sample) the number '-1' is put into the 'age' column. Where it was not possible to age part of the scale (e.g. the river age) then a '?' symbol was included instead.

Table 1 - Details of 2015 scales submitted for ageing

Capture Date	Weight (lb)	Age	Management Unit	Beat	Site	Remarks on Scale Packet	Scale Reader Comments
14/04/15		332	Lower Beauly	BAC Bt3		Good Condition	Kelt
20/04/15	8	220	Lower Beauly	Lower Beauly	Glide pool		
07/05/15	12	320	Lower Beauly	Beauly	Dam pool	Sea liced	
12/05/15	16	230	Lower Beauly		North run	Sea liced	
18/05/15	11	321	Lower Beauly	BAC	Beat 2		
27/05/15	13	221	Lower Beauly	Falls Beat	Ferry North	Sea liced	
27/05/15	5	211	Lower Beauly	Falls Beat	Stones		
01/06/15	8	221	Lower Beauly	Falls Beat	Stones	Sea liced	
01/06/15	12	221	Lower Beauly	Falls Beat	Ferry		
01/06/15	10	221	Lower Beauly	Home Beat		Severe Predator damage	
09/06/15	8	321	Lower Beauly	Falls Beat	Ferry		
15/06/15	11	321	Lower Beauly	Falls Beat	Dam	Dolphin marks	
03/07/15	9	220	Farrar	Bobs Tail		Clean	
07/07/15	5	211	Lower Beauly	Falls Beat	Ferry	Red Vent	
09/07/15	6	211	Lower Beauly	Falls Beat	Glide	Net marked	
10/07/15	5	311	Farrar	Lower Ross		Getting Coloured	
13/07/15	5	?11	Lower Beauly	Falls Beat	Ferry	Sea liced	
13/07/15	5	?11	Lower Beauly	Falls Beat	Ferry	Sea liced	
13/07/15	9	311	Lower Beauly	Beauly	Dam	Sea liced	
13/07/15	9	221	Lower Beauly	Falls Beat	Ferry	Sea liced	
16/07/15	9	211	Lower Beauly	Falls Beat	Dam		
16/07/15	9	221	Lower Beauly	Falls Beat	Ferry		
16/07/15	4	211	Lower Beauly	Falls Beat	Dam		
16/07/15	5	211	Lower Beauly	Falls Beat	Dam		
16/07/15	4	211	Lower Beauly	Falls Beat	Dam		
16/07/15	5	311	Lower Beauly	Falls Beat	Dam		
20/07/15	4	311	Lower Beauly	Falls Beat	Dam		
20/07/15	5	211	Lower Beauly	Falls Beat	Dam		
23/07/15	5	211	Lower Beauly	Falls Beat	Ferry		
23/07/15	5	211	Lower Beauly	Falls Beat	Dam		
23/07/15	5	3?11	Lower Beauly	Falls Beat	Ferry		
27/07/15	5	311	Lower Beauly	Falls Beat	Ferry	Red Vent	
27/07/15	7	311	Lower Beauly	Falls Beat	Glide		
27/07/15	4	211	Lower Beauly	Falls Beat	Ferry		
28/07/15	10	221	Farrar	Culliegraw		Quite Clean Fresh	
30/07/15	5	211	Lower Beauly	Falls Beat	Glide		
03/08/15	4	211	Lower Beauly	Falls Beat	Ferry		
03/08/15	5	?11	Lower Beauly	BAC	Beat1	Sea liced	
04/08/15	4	211	Lower Beauly	Home Beat			
06/08/15	5	311	Lower Beauly	Falls Beat	Glide		
10/08/15	5	211	Lower Beauly	Falls Beat	Ferry		

Capture Date	Weight (lb)	Age	Management Unit	Beat	Site	Remarks on Scale Packet	Scale Reader Comments
10/08/15	5	211	Lower Beauly	Falls Beat	Ferry		
19/08/15	5	211	Lower Beauly	Falls Beat	Dam pool		
19/08/15	4	211	Lower Beauly	Downie Beat		Red Vent	
19/08/15	3	211	Farrar	River Farrer	Gate Pool	Fresh	
20/08/15	5	211	Lower Beauly	Falls Beat	Stones	Red Vent	
20/08/15	6	211	Farrar		AWT Pool	Slightly Coloured	
24/08/15	5	311	Lower Beauly	Falls Beat	New Pool	Red Vent	
29/08/15	4	211	Lower Beauly	Home Beat		Red Vent	
31/08/15	4	211	Farrar		Cave Pool	Clean	
31/08/15	3	211	Farrar		Gate Pool	Very Clean	
03/09/15	5	211	Farrar	Hole in the Hole		Fresh	
07/09/15	5	311	Farrar	River Farrer		Clean Red Vent	
08/09/15	9	221	Lower Beauly	Home Beat		Dolphin marks	
09/09/15	3	211	Farrar	River Farrer	Cave Pool	Clean	
10/09/15	6	221	Lower Beauly	Downie Beat			
10/09/15	4	311	Farrar	River Farrer			
14/09/15	2	211	Farrar	Long Cast		Very Clean	
28/09/15	5	211	Farrar	Nearty Beach		Slightly Coloured	
06/10/15	5	311	Farrar		Cave Pool	Fairly Clean	
08/10/15	5	211	Farrar	River Farrer		Fresh	
08/10/15	5-6	311	Farrar		Fir Tree	Slightly Coloured	
08/10/15	5-6	211	Farrar		Double Bend	Fairly Clean	
08/10/15	10	311	Farrar	River Farrer			Weight??
09/10/15	6	311	Farrar		Fir Tree	Coloured	
15/10/15	5	211	Farrar	River Farrer	Pulpit	Fresh	
August	5	211	Lower Beauly	BAC	Beat1		
??/06/15	6	311	Farrar	Colonel		Fairly Clean	Kelt??
	4	311	Lower Beauly	Falls Beat	Glide pool		
	4	311	Lower Beauly	Falls Beat			
	5	311	Lower Beauly	Falls Beat	Glide pool		
	5	211	Lower Beauly	Falls Beat	Stones pool		
	4	211	Lower Beauly	Home Beat	Silver pool		
	4	211	Lower Beauly	Falls Beat			
	10	221	Farrar	River Farrer	Twin Stones	Coloured	
	5	311	Farrar	River Farrer	Cave Pool		
	5	311	Farrar	River Farrer			
	5	211	Farrar	River Farrer	Cave Pool		
	6	211	Farrar	River Farrer			
	10	311	Farrar	River Farrer	Gate Pool		Weight??
	4	311	Farrar			Fresh	

Capture Date	Weight (lb)	Age	Management Unit	Beat	Site	Remarks on Scale Packet	Scale Reader Comments
	6	211	Farrar	River Farrer	Cave Pool	Coloured	
	6	?11	Farrar	River Farrer		Red Vent	
		211	Farrar			Clean	No Details
	5	311	Farrar	River Farrer			

Table 2 - Details of historical scales submitted for ageing

Capture Date	Weight (lb)	Age	Management Unit	Beat	Site	Remarks on Scale Packet	Scale Reader Comments
08/08/06	4	211	Lower Beauly	Falls Beat	Dam pool		
08/08/06	4	211	Lower Beauly	Falls Beat	Dam pool		
08/08/06	5	211	Lower Beauly	Falls Beat	Glide pool		
08/08/06	4	211	Lower Beauly	Falls Beat	Dam pool		
11/08/06	4	311	Lower Beauly	Falls Beat			
11/08/06	4	211	Lower Beauly	Downie Beat	Priests pool		
15/08/06	13.5	221	Lower Beauly	Falls Beat	Ferry pool		
19/08/06	4.5	211	Lower Beauly	Falls Beat	Dam pool		
25/08/06	4	211	Lower Beauly	Falls Beat	Glide pool		
29/08/06	3	211	Lower Beauly	Falls Beat			
06/09/14	4	211	Lower Beauly	BAC	Beat 2	Sea liced	
24/09/14	4	311	Lower Beauly	BAC	Dam pool		

5.2 SAMPLE QUALITY

The date of capture was omitted from 17 of the samples (20 per cent), with partial dates included on a further two. It was not possible to determine the number of freshwater years associated with four of the samples, with that of another being a best estimate. Overall, the samples submitted by anglers and ghillies were of a very high quality, resulting in 80 complete and five partial ages being determined.

5.3 KELTS, BAGGOTS AND RAWNERS

A scale sample taken from what was thought to be a fresh run 'spring' salmon (captured on the Lower Beauly on the 14th April 2015) indicated that this fish was actually a well mended a 'kelt'. The scale reader also noted that another fish captured on the Farrar in June 2015 may have also been a well mended kelt, although this was not quite so clear cut.

A kelt is a salmon which has spawned. Usually identified by the thin shape, distended vent and presence of 'gill maggots' on the gill filaments, they are often encountered by anglers in spring when they regain a silvery appearance and can be mistaken for fresh run 'springers'. A 'rawner' (male) or

'baggot' (female) is a fish that has spawned late or not at all. These fish are occasionally caught in springtime on the early rivers.

5.4 PREVIOUS SPAWNERS

No 'previous spawners' were identified in this year's scale samples (see **Figure 5.1** below). These are fish that entered the river and spawned, returned to the sea and then entered the river again for a second time.

Figure 5.1 - 'Healed' spawning damage on the caudal (tail) fin of a confirmed repeat spawner.

Repeat spawning fish are important for the entire river stock for a number of reasons:

- Older salmon are larger and have a better chance of spawning successfully;
- The larger females are more aggressive and capture the optimum spawning sites in the river, improving the chances of spawning success;
- The larger the hen salmon, the more fecund it will be (i.e. it will deposit a larger number of eggs);
- Large salmon are known to be more attractive to other fish than the smaller ones and so the eggs are more likely to be fertilised; and
- The larger the salmon the bigger the eggs, providing the fry with a larger food reserve and increasing survival.

These 'veterans' are acting to 'fill the gaps' left by poor returns of maiden spawners. They also remind us of the importance of returning as many salmon as possible. By removing even the smallest of fish you may prevent it from spawning not just once, but even two or three times.

5.5 FISH FARM ESCAPEES

No fish farm escapees were identified from the scales samples collected in 2015. However, escapes from fish farms are a cause for concern and anglers should know how to identify them.

For conservation and wild fish interests, escaped fish may: represent a disease hazard; occupy valuable habitat to the exclusion of wild fish; and have the potential to interbreed with wild fish, leading to dilution of genetic integrity.

Farmed salmon can differ morphologically from wild salmon in several ways:

- Shortened gill covers such that the gills are visible when the covers are normally closed;
- Snout/jaw deformations;
- Bud fins (when dorsal or pectoral fins are worn down to a cartilage-like stump where the rays are no longer visible);
- wavy rays on dorsal or pectoral fins;
- Rounded tail lobes; and
- Higher numbers of dark spots below the lateral line.

Photographs of a typical escaped farm salmon is shown in **Figure 5.2** below. This illustrates the shortened gill cover, wavy rays on pectoral fins and damaged dorsal fin.

Figure 5.2 - A confirmed fish farm escapee with shortened gill-cover, wavy rays on pectoral fin and damaged dorsal fin.

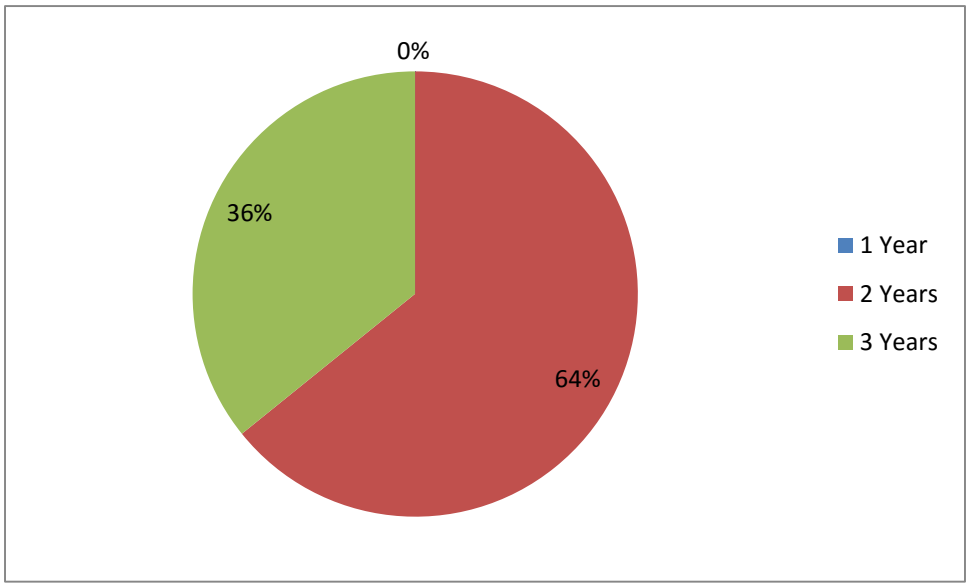
5.6 AGE COMPOSITION

The sea ages of Atlantic salmon indicate crucial differences between oceanic feeding zones, which have important implications for conservation and management (Bacon *et al*, 2010). It is also known that '1 Sea Winter (1SW)' and 'Multi Sea Winter (MSW)' fish can have different freshwater habitat preferences (lowland and upland areas respectively). An understanding of the age composition of a salmon therefore provides important details regarding their lifestyles and requirements of the fish and their populations (Bacon *et al*, 2010).

5.6.1 Freshwater Age

It was possible to determine the freshwater age for 81 of the scale samples submitted during the 2015 season. The majority of these fish (64 per cent) were found to have spent two years in freshwater before smolting and returning to the sea (see **Figure 5.3** below). A further 36 per cent were found to have spent three years in fresh water.

Figure 5.3 - Proportion of sampled 2015 rod catch (percentage) shown by years spent in freshwater



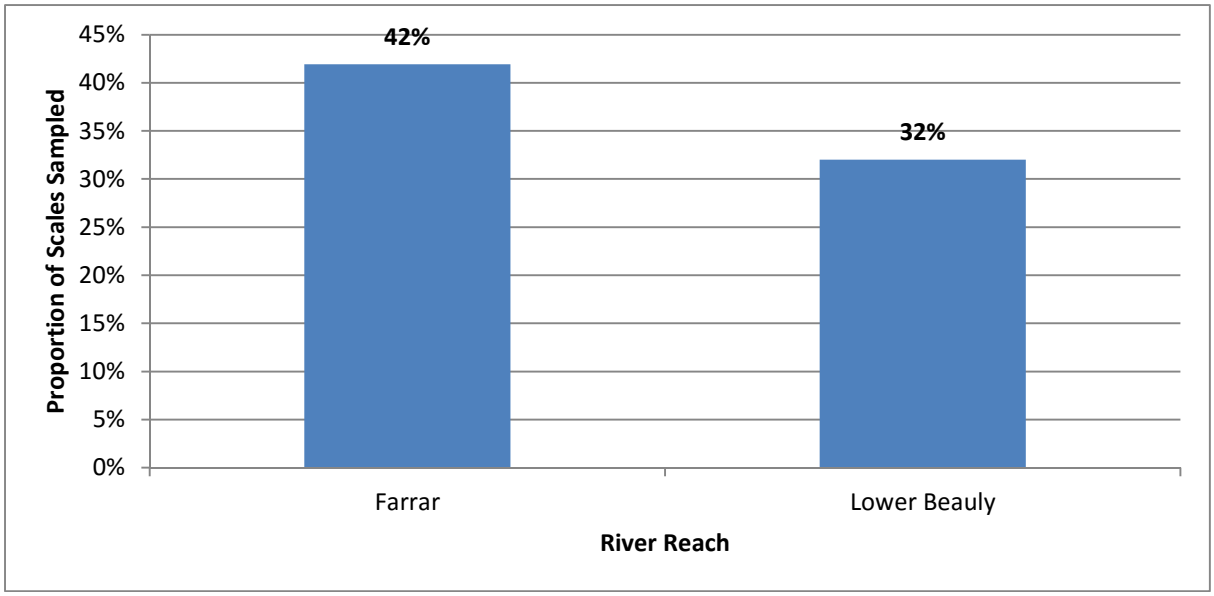
Each spring, the largest parr become silvery smolts and migrate downstream towards the sea. In the southern rivers of the United Kingdom this can happen after just one year. In the more northerly Scottish rivers (which have shorter growing seasons) smolts are usually two to three years of age, as is clearly the case in the Beauly district

Studies of salmon scale samples taken from other rivers in Scotland indicate that a greater proportion of fish with three freshwater years (and above) are found to originate from the upper reaches of rivers than the lower reaches. This is thought to be due to the colder climate in these

areas and subsequent lack of nutrients resulting in slower growth rates of fry and parr.

A similar pattern is evident from adult scale samples taken across the Beauly District. The proportion of three freshwater year fish recorded in the samples from the Farrar catchment (42 per cent) in the upper system was significantly higher than that on Lower Beauly (32 per cent) at the bottom of the system (see **Figure 5.4** below).

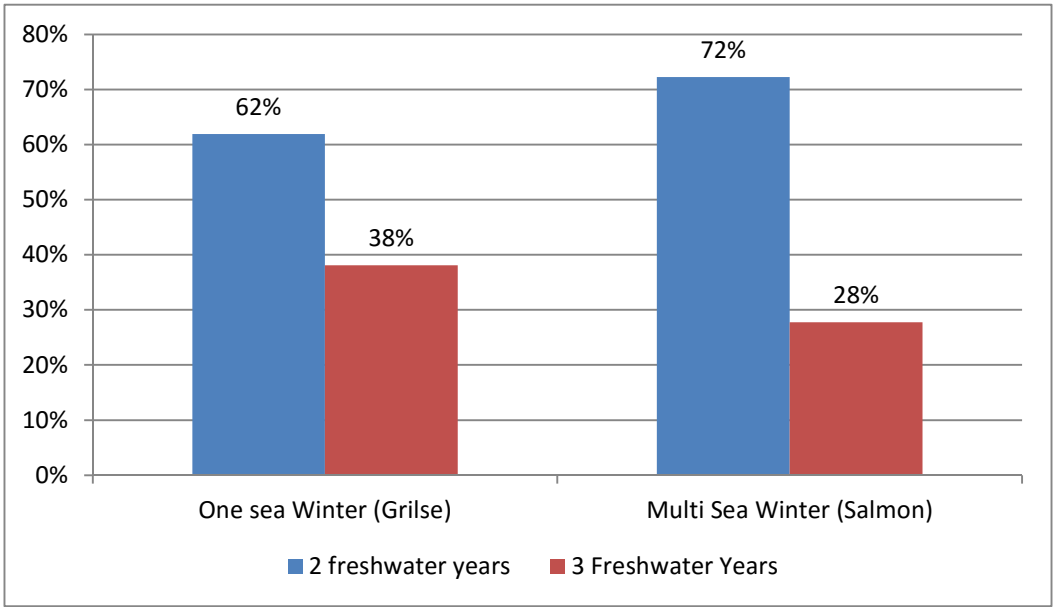
Figure 5.4 - Proportion of sampled rod catch on sampled reach of the Beauly District found to have spent three years in freshwater (2015)



For interest, the proportion of three freshwater year fish found in the Lower Beauly was significantly greater than in the neighbouring Lower River Ness (seven per cent). This may be related to the influence that Loch Ness has on maintaining a steady water temperature in the River Ness with associated higher productivity and nutrient levels. This may result in higher growth rates in juvenile salmon, which are subsequently ready to smolt at a younger age.

The proportion of scales sampled from grilse (1SW) and salmon (MSW) falling into each freshwater year class is compared in **Figure 5.5** below.

Figure 5.5 - Proportion of scales sampled from grilse (1SW) and salmon (MSW) falling into each freshwater year class



The majority of grilse sampled in the 2015 programme were found to have spent two years in freshwater (equating to 62 per cent of the total grilse sample). A further 38 per cent of the grilse were found to have spent three years in freshwater, much greater than the 12 per cent of three freshwater year grilse recorded on the neighbouring Ness system in the same year. This suggests lower freshwater growth rates in the Beauly, or perhaps they were from early running grilse associated with the upper reaches of the system.

Overall, scale readings from fish captured in 2015 indicate that the majority of both 1SW grilse and MSW salmon spent two years in freshwater, with a smaller proportion spending three years in freshwater.

5.6.2 Sea Age

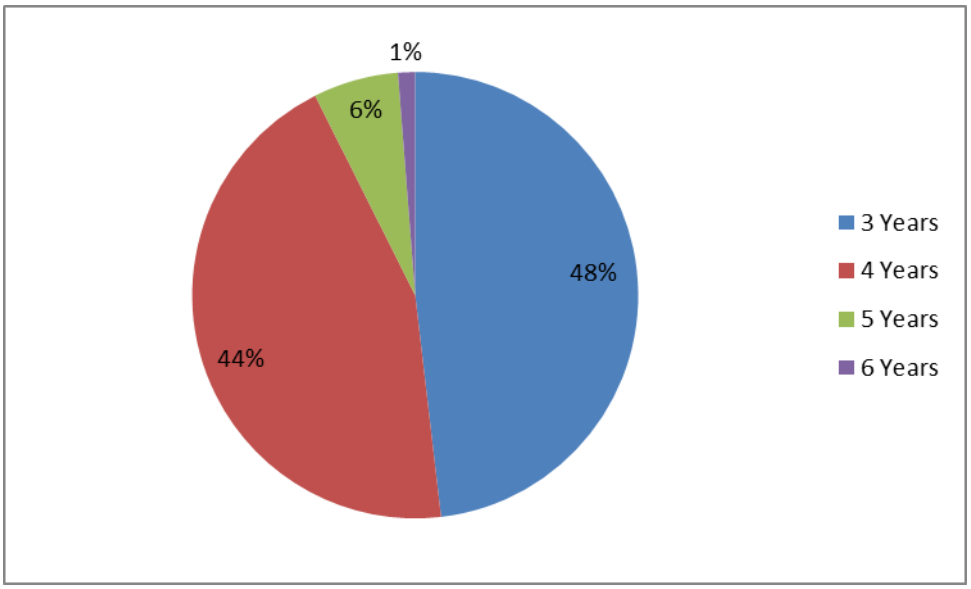
It was not possible to carry out any meaningful analysis on the sea age of the submitted samples. This is due to the fact that sampling in 2015 seemed to be heavily biased toward sampling of smaller grilse. Of the 85 samples suitable for sea age composition analysis, 67 were found to be grilse, with just 18 found to be MSW salmon.

5.6.3 Total Age (Freshwater and Sea Combined)

The majority of the fish sampled (grilse and MSW salmon combined) during the 2015 season (48 per

cent) were found to have a combined freshwater and sea age of three years (see **Figure 5.6** below). A further 44 per cent were found to have a total age of four years and 6 per cent with a total age of five years. Once again, this presents a different picture to that found on the Ness where 52 per cent of the fish sampled were found to have a total age of four years.

Figure 5.6 - Proportion of sampled rod catch (percentage) shown by combined freshwater and sea or total age

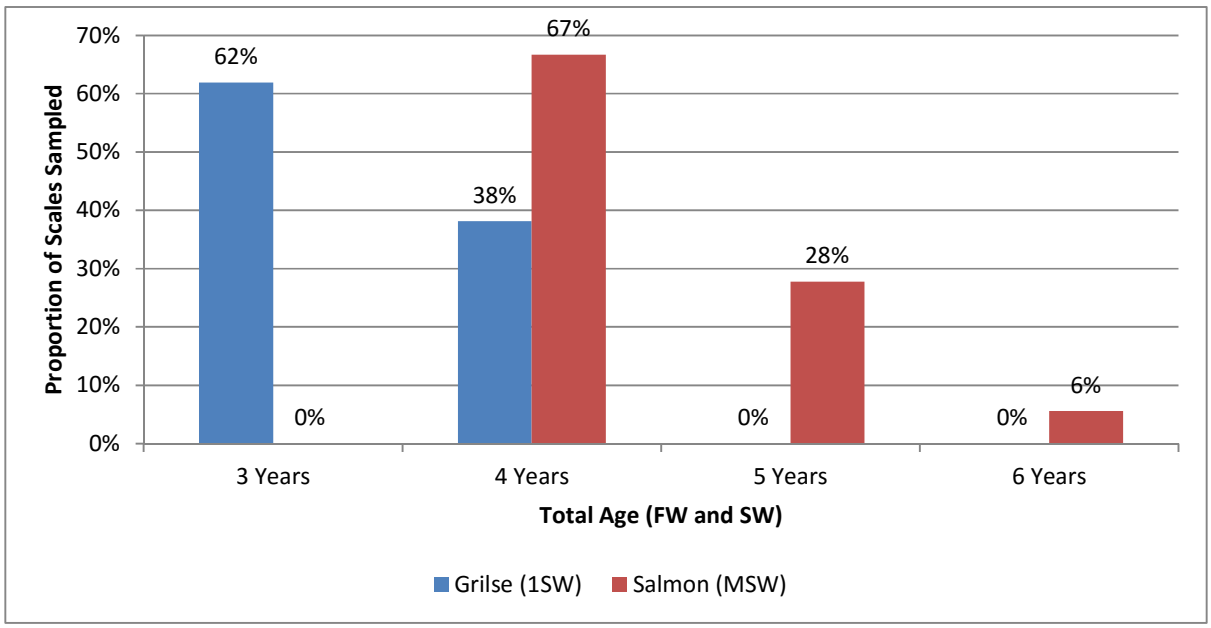


This provides a general 'rule of thumb' regarding the total age of salmon on their return to the river. It does not however consider the differences between salmon and grilse. This is important because, as mentioned previously, the samples taken in 2015 were heavily biased towards grilse.

Figure 5.7 presents the proportions of both salmon and grilse sampled in 2015 falling into each total age category. The majority of grilse (62 per cent) had a total age of three years, with a further 38 per cent having a total age of four years.

The MSW salmon ranged between 4 and 6 years of age, the majority having a total age of four years (67 per cent), followed by those having a total age of five years (28 per cent), with a further six per cent at six years of age.

Figure 5.7 - Proportions of salmon and grilse falling into each 'total' age class



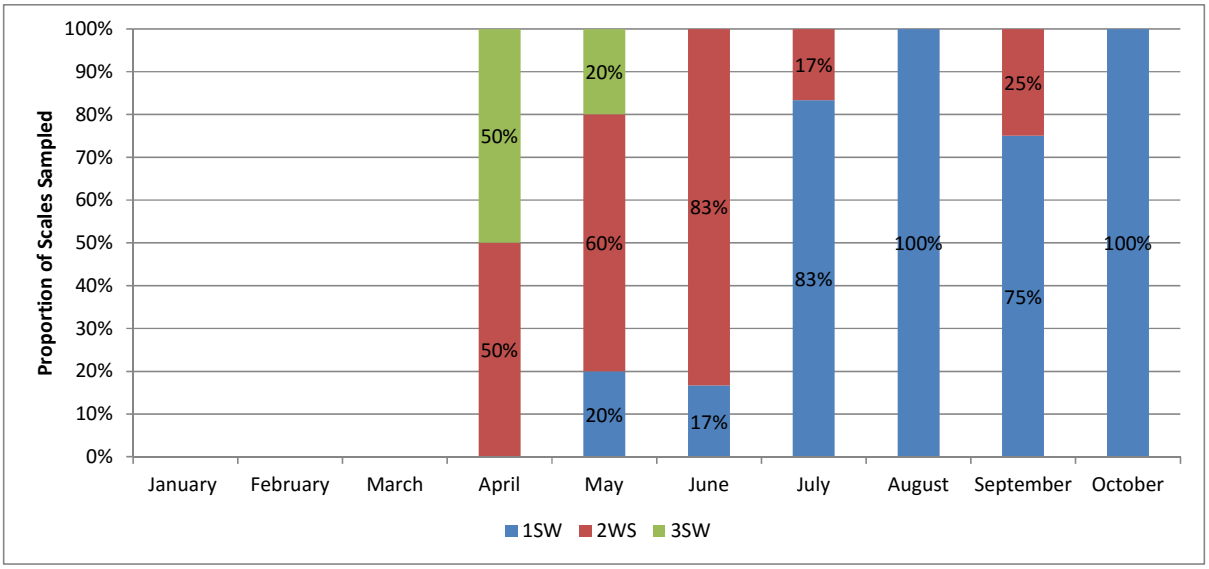
5.7 RUN TIMING

Research has shown that the spawning destination of salmon can be related to timing of river entry. Early run fish are known to travel further upstream, with later running fish remaining lower in the catchment (Bacon *et al*, 2010). This diversity is particularly important with regards to the economics of a fishery as it extends the fishing season (Bacon *et al*, 2010). Information gained from scale reading regarding run timing is therefore of particular interest.

5.7.1 Relative Proportions of 1SW and MSW Fish

Analysis of scale samples taken from fish caught between April and May 2015 (the 'spring' period) indicates that the majority were MSW salmon (see **Figure 5.8** below). The April samples were equally split between 2SW and 3SW fish, with the May catches being dominated by 2SW (60 per cent), with equal proportions of 3SW salmon and 1SW early running grilse (20 per cent each). This suggests that the return of 3SW fish on the Beauly system is generally associated with the spring period

Figure 5.8 - Relative proportions of 1SW, 2SW and 3SW fish identified from scale samples taken in each month of the season



Grilse made up a small proportion of the samples in both May and June (20 and 17 per cent respectively). It is not clear whether this is due to a lack of fish in the system, or a symptom of selective sampling (i.e. scales only being taken from the larger MSW fish). By July the samples were dominated by grilse, with a small proportion of summer and autumn 2SW salmon featuring in the July and September samples (17 and 25 per cent respectively).

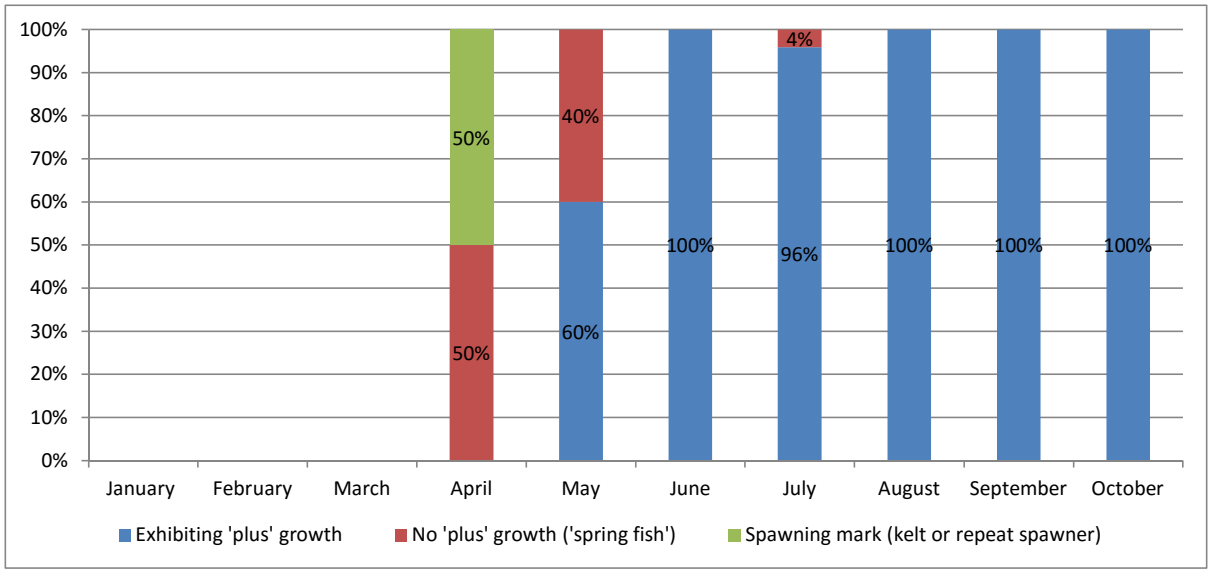
5.7.2 Plus Growth

'Plus growth' refers to the amount of growth shown on the fish scale since the last winter check. Fish entering the river during the early 'spring' period do so before they have the opportunity to feed and so show little or no growth since the last winter check. The fish that enter the river later in the year (such as grilse and summer/autumn salmon) spent longer feeding at sea and so their scales exhibit a much greater degree of growth since the last winter check.

This difference in the amount of plus growth on a scale enables 'spring' salmon to be identified. This is illustrated in **Figure 5.9** below, which presents the relative proportion of scale samples showing

either 'no plus growth', 'plus growth' or spawning mark.

Figure 5.9 - Proportions of scale samples showing either 'no plus growth', 'plus growth' or spawning mark.



The April scale samples were made up of kelts (50 per cent) and 'spring' fish exhibiting no plus growth. Fish exhibiting 'plus growth' made up a majority 60 per cent in May, with those with no plus growth making up the other 40 per cent.

These results suggest that the months of both April and May are of particular importance in terms of 'spring' salmon on the Beauly system. The Scottish Government's statutory conservation measures only protect 'spring' fish up to the 1st April and so should perhaps be extend through till the end of May.

As expected, all of the samples submitted in June were from 'summer' fish exhibiting plus growth. However, four per cent of the July samples were found to be from fish with no plus growth. This equated to a single 9lb fish captured in 'Bob's Tail' on the River Farrar which was most likely a 'spring' fish that had entered the river earlier in the year.

This is a particularly significant observation as it demonstrates that spring fish can be captured throughout the season. If this vulnerable component is to be protected, then it is important that all 'coloured' fish are released. It also demonstrated that scale reading can be used to identify and protect vulnerable 'spring' fish throughout the season.

By August, all fish in the samples were found to show plus growth, a pattern that continued through to the last sample which was taken in October.

6 PRACTICAL MANAGEMENT APPLICATIONS

A key challenge facing Scottish fishery managers is the ability to balance the conservation of stocks of MSW salmon, whilst still maintaining an economically viable fishery (Bacon *et al*, 2010). The information gained from scale reading, combined with length and weight data, can be used to inform management decisions which help to achieve this. Two particularly topical practical applications are illustrated in further detail below.

6.1 SPRING CONSERVATION MEASURES

In line with recommendations contained in the Wild Fisheries Review group's report regarding declining spring salmon catches and following a consultation period, the Scottish Government introduced statutory conservation measures to ensure that no salmon are taken in Scotland before 1st April each year. The national measure came into force on Friday 9 January 2015, the key elements of which are detailed below:

- The annual close time has been extended until 31st March;
- The start of the net fishing season is delayed until 1st April;
- Fishing by rod and line can take place from the season start date within the district until 31st March on a catch and release basis (any salmon caught must be returned to the water with the least possible harm);
- The measures seek to underpin any existing voluntary/statutory measures; and
- The measures will be reviewed annually.

The results of both the 2015 scale sampling programmes indicate that the Scottish Government's spring conservation measures do not go far enough. As the regulations currently stand, all fish must be returned up to the 1st April.

The results of scale sampling suggest that the months of April and May are particularly important for spring salmon on the Beauly system. This information may support an extension of the spring conservation period to the 31st May.

6.2 NEW CONSERVATION REGULATIONS

The Scottish Government recently announced new conservation regulations which took effect from the 1st April 2016, running on from the existing spring conservation regulations which conclude on the 31st March 2016. This means that the killing of Atlantic salmon will now be managed on an

annual basis by categorising fishery districts and Special Areas of Conservation (SACs) by their conservation status. The Beauly district has been categorised as 'Grade 3' for the 2016 season, meaning that mandatory catch and release will be in force across the system.

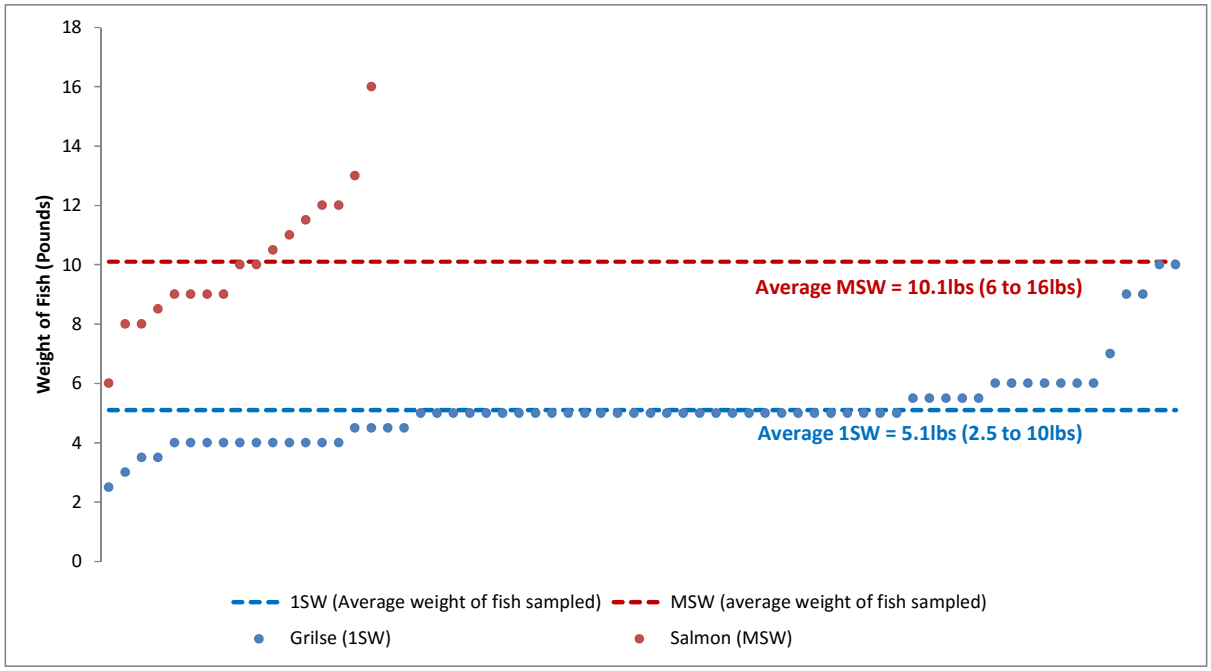
The Scottish Government has determined the conservation status of each fishery district using the 'best available' information. Reported rod catches were the only information readily available for estimating the level of salmon stocks throughout Scotland. This was combined with information regarding exploitation rates (the proportion of the stock taken by the fishery) to estimate spawning populations. These were then converted to egg depositions using information on the sex ratios and the mean number of eggs per female.

There are a number of areas where information collected as part of the scale sampling programme has the potential to provide further resolution when determining the conservation status of the Beauly district. These are described in further detail below:

6.2.1 Grilse Error

The scales samples collected in 2015 provide information relating to the size ranges (in terms of weight) of both salmon and grilse (see **Figure 6.1** below).

Figure 6.1 - Size ranges of 1SW Grilse, MSW salmon sampled in 2015



Fish in the sample aged as grilse (1SW) were found to range between 2.5 and 10 pounds in weight, with an average weight 5.1 pounds. The 2SW salmon ranged from 6 to 16 pounds in weight, with an average weight of 10.1 pounds.

If we assume that these samples are representative of the wider salmon population in the Beauly system, then the results suggest that fish over 10 pounds are most likely to be MSW salmon, with fish under 6 pounds most likely being 1SW grilse. Fish between 6 and 10 pounds could be either MSW salmon or grilse and difficult to positively identify without scale reading. This is supported by the fact that a number of fish were misidentified on the scale envelope.

The systematic misreporting of grilse as MSW salmon (grilse error) is a problem associated with Scottish rod fisheries in the summer and autumn months (Shearer, 1992; MacLean, Smith and Laughton, 1996). This bias can have significant consequences for the management of salmon stocks in terms of over representation of MSW salmon.

This is important because a greater proportion of MSW than grilse are known to be female. The use of uncorrected data could lead to an overestimate of the number of spawning females and the eggs that they produce. This has significant implications with regards to the setting of conservation limits for salmon.

There is currently little information available regarding the variation in grilse error across the country. The current Marine Scotland Science model for calculating of conservation limits uses the data from MacLean, Smith and Laughton (1996) who examined grilse error on two beats of the River Spey. A slight amendment to the data collected as part of our scale sampling programme would allow us to examine Ness District wide and specific tributary grilse error. This would require the use of a scale packet which asks for length data together with a description of the fish in terms of 'salmon' or 'grilse'.

6.2.2 Sex Ratio

Conservation limits are expressed in terms of egg requirement per unit area of river. This requires information regarding the number of female salmon returning to a particular area of river, with the total number of spawners adjusted using information on the sex ratio of returning salmon.

Few accurate data sets are available regarding the proportion of females returning to Scottish rivers. This is largely due to the difficulties in ascribing sex to salmon based on physical characteristics before they enter the breeding phase (see **Figure 6.2** below).

Figure 6.2 - Fresh run male (left) and female (right) Atlantic salmon; head shape can be an effective way to ascribe sex before they enter the breeding phase.

Routinely recording the sex of fish on scale packets would allow us to start building up a picture of the proportions of male and female spawners in terms of grilse and MSW salmon. It may then be possible to apply this to other data sets such as rod catches and fish counts from the SSE counters, allowing an estimate of total egg deposition.

6.2.3 Length/Weight Relationship

With mandatory catch and release now in force throughout the season on the Beauly system, it is important that anglers reduce handling time and return fish as quickly as possible. The ability to determine the weight of a fish using its length (which can easily be measured in the landing net) rather than actually weighing it can significantly reduce handling while providing important information.

Catchment specific salmon weight/length conversion charts have proven to be very popular. The majority of these charts were developed using data collected on the River Dee in Aberdeenshire. There is however some indication that the Dee fish have a different length to weight ratio to Beauly fish (particularly the larger fish). Furthermore, it is possible that different sub-populations of salmon across the Beauly system have different weight/length ratios. It is therefore recommended that, as a

minimum, the length and weight data collected during scale sampling be used to develop a 'Beauly Specific' Length/weight conversion chart.

Over time it would be possible to use the information collected as part of the scale sampling programme to assign weights to fish photographed as they pass through the fish counters. This would be achieved by determining the length of the fish using image analysis software (see **Figure 6.3** below).

Figure 6.3 - Example of the use of image analysis software to determine the length of fish passing through Dundreggan Dam on the River Moriston

The length/weight conversion chart could then be used to assign a weight to the fish, with head shape and/or sex data used to give an estimate of sex ratio and subsequent egg deposition.

7 RECOMMENDATIONS

- Ghillies should continue to take adult scale samples from an unbiased sample of the rod fishery. This can be achieved by sampling strategically (e.g. every 2nd to 3rd fish landed). This will avoid any 'choice' in which fish to sample;

- Details of length, weight, date of capture, place of capture, sex, MSW salmon/grilse, condition of fish and any further remarks that the captor may have should be included on all scales samples submitted. This will increase the overall usable sample size and allow more detailed analysis;

- An adequate number of scales (4-5) should be taken from the optimum scale sample area to ensure the best possible shaped scale and allow the full age profile of the fish to be determined;

- Scales samples should be taken from fish caught throughout the season. This is particularly true during the early 'spring' period, which is currently under represented. In addition to this, it is important that scale samples are taken from the full size range of fish (both MSW salmon and grilse). This will add extra accuracy to any future length/weight conversion chart;

- The results of scale samples taken during the period when MSW fish and early running grilse overlap (May and June) should be carried out as early as possible and the results made available to anglers and ghillies. This will help to inform ghillies and anglers regarding the differentiation of the two.

- Scale reading should be used to investigate the captures of 'spring' fish throughout the season;

- Recording a description of the fish in terms of 'salmon' or 'grilse' will allow the examination of 'grilse error' across the Beauly system;

- Recording the sex of fish on the scale packets will allow us to build a picture of the proportions of male and female spawners, informing an estimates of total egg deposition; and

- The production of a 'Length/Weight Relationship Chart' populated with scale reading data taken over a number of years may be useful for ghillies and anglers. It could also be used to assign a weight to fish photographed whilst passing through fish counters, with head shape and/or sex data used to give an estimate of sex ratio and subsequent egg deposition.

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