West Sutherland Fisheries Trust

2015 Electro-fishing Surveys

A report to the West Sutherland Fisheries Trust, Report No. WSFT1/16

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Introduction

As part of West Sutherland Fisheries Trust's work programme, established sites in each freshwater catchment are routinely monitored every two years by undertaking electro-fishing surveys, which are carried out in accordance with Scottish Fisheries Coordination Centre (SFCC) protocol. This provides valuable information on temporal changes within juvenile salmonid densities. Where possible all sites were revisited, although some could not be accessed due to time and flow constraints. Some sites were removed from the surveys on the basis of previous results and additional sites were added in some instances. This report summarises the data for each catchment. Maps giving the location of each site and pictorially represented densities are available on request. Similarly, graphic data for each catchment is also available.

Methodology

Electro-fishing equipment operates by creating an electrical field in the water which affects the muscles of the fish, causing them to swim towards the positive electrode (anode) and subsequently immobilises them for a brief period; at this point they can be captured for processing before being released unharmed into the river sections from which they were caught. As the electrical field is restricted in size and the conductivity of the water generally extremely low in all WSFT catchments, the best operating conditions are within shallow water in narrow tributaries. While it is possible to sample large main river stems, the escape rate is higher than that found in the narrower tributaries. Similarly, a high escape rate is found in exceptionally shallow, stony or weedy areas, where fish can move into the substrate and are thus inaccessible to the nets.

Semi quantitative surveys are conducted in compliance with SFCC protocol. This involves one fishing run of a site in order to calculate a minimum estimate of juvenile salmonid densities. Although semi-quantitative surveys do not calculate absolute densities (as fully quantitative multiple fishing run depletion surveys do), this is a more appropriate method when considering the purpose of the surveys; to monitor temporal changes in juvenile populations within a single catchment. A greater number of sites can be fished given available resources and the physical nature of the west Sutherland catchments. This results in a broad picture of the population status of each catchment which can then be easily compared from year to year.

Fish densities were assessed using an electracatch backpack supplying smooth direct current (DC). Fish drawn to the hand-held anode were netted into a bucket, most commonly using small hand nets due to the narrow water channels and slow flows, and were retained until the end of the run for processing. The sites were fished systematically in an upstream direction, applying the same fishing pressure throughout to ensure that all fish had the same probability of capture as far as possible, thus increasing the reliability and accuracy of the minimum estimates of density.

All fish were anaesthetised using 2 Phenoxyethanol, identified to species and measured (± 1 mm). Small scale samples were taken from a proportion of each length range for age determination. The fish were then placed in a bucket before being returned to the survey site upon complete recovery. Densities of fish were calculated as minimum estimates, such that a minimum number of fish present per 100 m^2 could be determined. Water level was not used in the density estimates, although it must be realised that stream conditions will have an impact on the density determined and efficiency of the fishing technique. Bankside and instream characteristics, including substrate type, water flow, and riparian cover, were recorded at each site in accordance with the SFCC habitat survey associated with electrofishing surveys.

Results

1. Laxford catchment

Table 1.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 1.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	River	Situation
L14	230500	942700	50	Tributary	Beside Loch Stack
L18A	230900	942200	40	Lone Burn	Downstream of bridge at Lone
L18D	231300	942600	55	Allt Horn	Within conifer corridor (Scots Pine/Rowan)
L19	230700	941700	40	Tributary	Near quarry on way to Lone, below track
L20	230700	941600	50	Allt a' Chuilinn	50m u/s of trees from riffle to drop off - deep scour
L26A	229500	939700	50	Allt Achfaraidh	Below Ian's house in the gorse bushes
L36	230900	938200	50	Tributary of Loch More	Maternity Burn, below road
L53	234700	935900	40	Tributary of Loch More	Below rough track into Allt a Reinidh
L59A	234800	934800	50	Allt Ceann Loch	Below houses
L59B	234800	934300	60	Allt Ceann Loch	50m above bridge

Table 1.1: *Electro-fishing site details*

			Minimum density (100m^2)			
Site Code	**Length (m)**	**Area m^2**	**Salmon Fry**	**Salmon Parr**	**Trout Fry**	**Trout Parr**
L14	41	105.2	3.801	0	14.254	1.901
L18A	9.9	76.9	98.843	14.306	5.202	0
L18D	7.6	29.6	33.738	13.495	10.121	3.374
L19	29	45.4	0	0	105.657	0
L20	10.7	46.7	47.089	2.14	17.123	2.14
L26A	9.8	53,6	28.001	18.667	7.467	1.867
L36	8.5	13	0	0	46.048	30.698
L53	16.5	17.9	44.768	0	235.031	5.596
L59A	10	31.3	60.645	41.494	9.575	12.767
L59B	6.3	35.5	30.995	28.177	11.271	14.088

Table 1.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 1.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	0	98.843	34.788
Salmon parr	0	41.494	11.827
Trout fry	5.202	235.031	46.174
Trout parr	0	30.698	7.2431

Table 1.3: *A summary of the densities determined for all sites surveyed*

While trout are present in all sites, there is a dominance of salmon in all sites other than L14, L19, L36, and L53, with L19 and L36 having no salmon present. Both salmon and trout fry occurred in much higher densities than parr with the exceptions of L59A and L59B where trout parr densities were higher than trout fry. Eels were present at all sites in the catchment except L59B and were most abundant at L14. Minnows were also present at three sites, with the highest density at L19.

Four distinct age classes can be seen within juvenile salmonid populations from 0+ years to 3+ years. Only one salmon parr was found at 3+ years, suggesting salmon parr of this age are uncommon within the Laxford catchment.

Figures 1.1 and 1.2 show temporal changes in juvenile salmon and trout densities per 100 m^2 by catchment average, only including historic data from the sites surveyed in 2015 in order to show more accurate trends as far as possible. As such, previous years (where not all of the 2015 sites were included) may bring down the average density for that year; the number of sites surveyed is noted under the date, which should be taken into consideration when interpreting results.

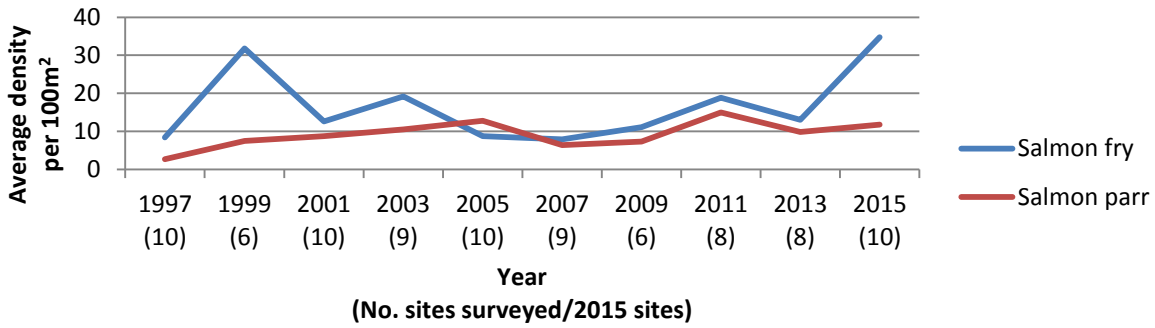

Figure 1.1: *Temporal changes in average salmon densities within the Laxford catchment*

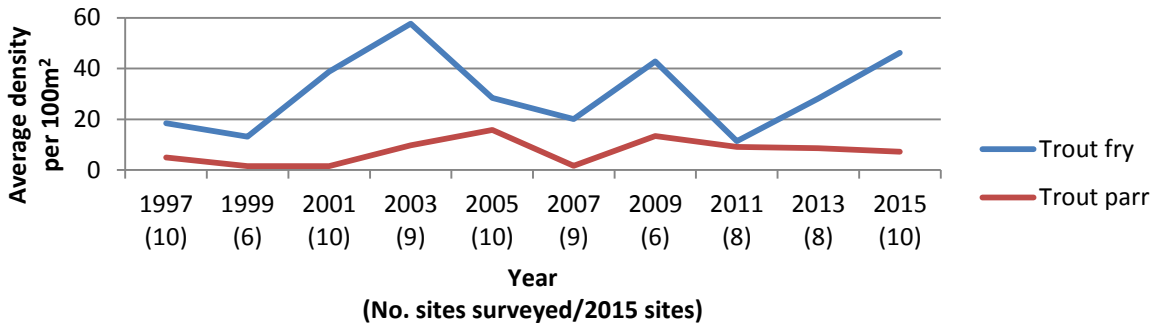

Figure 1.2: *Temporal changes in average trout densities within the Laxford catchment*

Figure 1.1 shows the 2015 surveys to have the highest recorded average salmon fry density since surveys began in 1997. This suggests an excellent spawning season in 2014. Average salmon parr densities are above the catchment average since surveys began. Figure 1.2 shows that trout fry densities have seen a solid increase since 2011 and are above the average, while trout parr densities have been dropping off since 2009 yet are still well within the catchment average.

Discussion

While there is a prolonged dip in the catchment average of juvenile salmon densities between 2003 and 2011, the trend shows there to be a general increase since surveys began in 1997. The dip may have been part of a longer term natural cycle, and is likely to have been influenced by marine pressures. The trout populations fluctuate fairly dramatically, particularly in fry densities. This is likely to be a result of natural ecosystem dynamics, and varying marine pressures on sea trout. It is also important to consider that the Laxford is a salmon dominated system, and both adult and juvenile salmon will out-compete trout for territories. Despite the fluctuations, the salmonid populations within the Laxford catchment appear to be healthy and stable, and while the trout populations are most variable, they do appear to gravitate back towards comfortable levels over time.

2. Inver catchment

Table 2.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 2.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	Situation
I11C	215150	924600	65	Just above deer fence to mossy rock on right
I23	220700	925800	80	Allt na Doire: between bridge on new road and old road
I30A	223500	924400	60	Skiag: at road junction
I32B	224100	923800	70	Loch Assynt tributary: by Ardvreck Castle, left tributary at mouth of loch
I33A	224300	923500	70	D/S of road bridge
I35A	225000	921700	70	Downstream of road bridge. Downstream of tree on left bank for 18 m
I35B	225800	921900	95	Just below the bridge
I4A	212300	923700	50	Allt na-h-Airbhe: moorland at the mouth of the tributary near Brackloch.
I4B	212700	923600	50	Allt na-h-Airbhe: 400m U/S from river
LB1	214050	925300	65	River out of Loch Beannach by large rock in stream
LB2	214100	925500	65	In left hand braid, below Loch Uidh na Geadaig
LB3	213600	925500	65	Just below Loch Bad nan Aighean
LB4	213400	926000	70	Just below Loch Beannach

Table 2.1: *Electro-fishing site details*

Site Code	Length (m)	Area m^2	Minimum density ($100m^2$)			
			Salmon Fry	Salmon Parr	Trout Fry	Trout Parr
I11C	10.7	92.02	11.954	15.214	0	0
I23	15	27.5	3.636	21.818	50.909	7.273
I30A	4.6	17.79	78.696	5.621	16.863	5.621
I32B	10.1	28.62	3.494	3.494	24.458	0
I33A	5.7	25.65	101.365	42.885	3.899	3.899
I35A	7.9	78.21	43.473	24.294	7.672	0
I35B	9	46.5	0	2.151	4.301	6.452
I4A	25	117.5	22.979	16.170	4.255	2.553
I4B	15.4	61.09	9.822	11.459	6.548	8.185
LB1	9	56.7	3.527	0	5.291	0
LB2	7.5	14	0	0	14.286	0
LB3	11.1	55.13	5.442	38.092	25.395	1.814
LB4	14.5	58.48	51.300	29.070	1.710	13.680

Table 2.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 2.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	0	101.365	25.822
Salmon parr	0	42.885	16.174
Trout fry	0	50.909	12.737
Trout parr	0	13.680	3.806

Table 2.3: *A summary of the densities determined for all sites surveyed*

Four distinct age classes can be seen within juvenile salmonid populations from 0+ years to 3+ years. While trout are present in all sites other than I11C, there is a general dominance of salmon other than within I23, I32B, I35B, and LB1, with LB2 having no salmon present. Both salmon and trout fry occurred in higher densities than parr in the majority of sites with the exceptions of I11C, I23, I4B, and LB3 where salmon parr densities were greater than salmon fry. I35B, I4B, and LB4 contained higher densities of trout parr than trout fry. Eels were not present at any sites in the catchment. This is unusual within the west Sutherland area, and may be attributable to the sluice systems on the lower sections of the river Inver. Minnows were present at four sites, with the highest density at LB4.

Figures 2.1 and 2.2 show temporal changes in juvenile salmon and trout densities per 100 m^2 by catchment average, only including historic data from the sites surveyed in 2015 in order to show more accurate trends as far as possible. As such, previous years (where not all of the 2015 sites were included) may bring down the average density for that year; the number of sites surveyed is noted under the date, which should be taken into consideration when interpreting results.

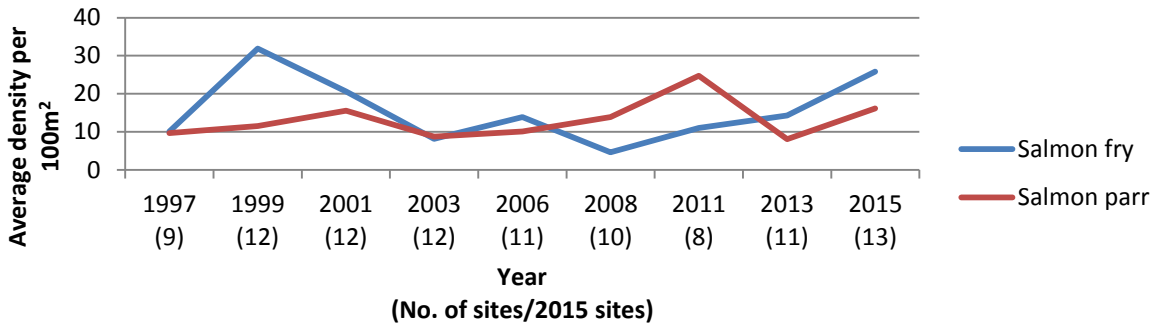

Figure 2.1: *Temporal changes in average salmon densities within the Inver catchment*

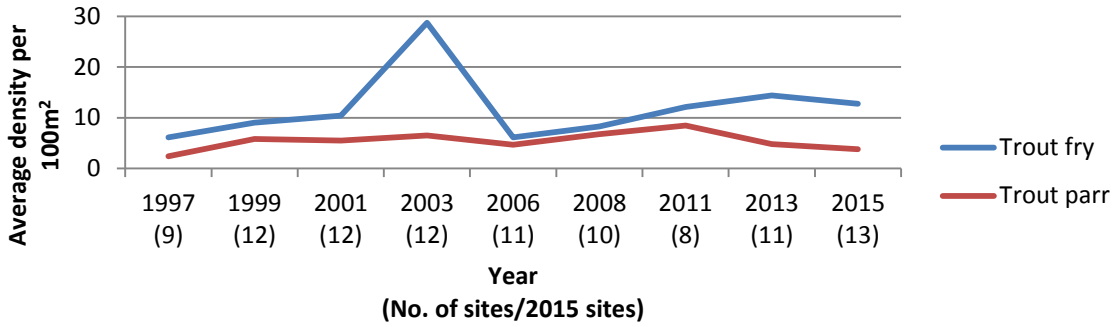

Figure 2.2: *Temporal changes in average trout densities within the Inver catchment*

Figure 2.1 shows the 2015 surveys to have the highest recorded average salmon fry density since 1999. Salmon parr densities are higher than those recorded in 2013, and while lower than those recorded in 2011, they are well within the catchment average since surveys began. Figure 2.2 shows that trout fry densities have taken a slight decrease since 2013 yet are comfortably within the average. Trout parr densities have been dropping off since 2011; although densities in 2015 are slightly below average they remain above those found in 1997.

Discussion

When considering the high average density of salmon fry found in 2015, there has clearly been prolific salmon spawning in 2014. While there is a pronounced dip in the catchment average of juvenile salmon fry densities between 1999 and 2015, the trend shows a slight increase in salmon parr densities since surveys began in 1997. The dip may have been part of a longer term natural cycle, although as noted in the 2008 report, the artificial spate in 2004 followed by the drying of the river to allow repairs may have been damaging to salmonid populations. The salmonid populations within the Inver catchment fluctuate fairly dramatically, suggesting sporadic spawning due to environmental conditions, as well as natural ecosystem dynamics and varying marine pressures on salmon and sea trout. It is also important to consider that the Inver is a salmon dominated system, and both adult and juvenile salmon will out-compete trout for territories. Despite the fluctuations, the salmonid populations within the Inver catchment appear to be healthy and reasonably stable.

3. Polla catchment

Table 3.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 3.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	River	Situation
P4A	239100	951800	20	Polla	By Strabeg House, in trees
P5A	239200	951900	30	Polla	Tributary next to Strabeg House, 50 m from main river
P7A	238800	952600	20	Polla	Tributary downstream of loch Bad na h Achlaise
P8A	238800	952400	20	Polla	Burn running out of loch Bad na h Achlaise, downstream of Strabeg House
P9A	239100	952300	20	Polla	Tributary downstream of Strabeg House, same bank
P10A	238700	954100	20	Polla	Tributary on the left bank upstream of the fishing hut by the dam

Table 3.1: *Electro-fishing site details*

			Minimum density (100m^2)			
Site Code	**Length (m)**	**Area m^2**	**Salmon Fry**	**Salmon Parr**	**Trout Fry**	**Trout Parr**
P4A	4.7	31.65	22.116	9.478	12.638	0
P5A	14.7	57.82	20.754	24.213	20.754	5.188
P7A	11.5	14.95	0	0	6.688	0
P8A	18.5	34.53	2.896	5.792	2.896	5.792
P9A	11.6	18.17	5.503	5.503	55.035	5.503
P10A	12.8	30.72	13.020	0	9.765	0

Table 3.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 3.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	0	22.116	10.715
Salmon parr	0	24.213	7.497
Trout fry	2.896	55.035	17.963
Trout parr	0	5.792	2.747

Table 3.3: *A summary of the densities determined for all sites surveyed*

Two distinct age classes can be seen within juvenile salmon populations from 0+ years to 1+ years, while trout populations showed four age classes from 0+years to 3+years. Trout were present in all sites, with an overall dominance of salmon within half of the sites. P9A showed exceptionally high trout densities, P8A contained equal densities of salmon and trout, with P7A having only trout present. Salmon fry occurred in higher densities than salmon parr with the exceptions of P5A and P8A, where salmon parr densities were higher than salmon fry. P9A contained equal densities of salmon fry and parr. Trout fry densities were higher than trout parr at all sites other than P8A where trout parr densities were higher. Eels were present at all sites in the catchment except P7A and were most abundant at P5A with 8 counted. Minnows were not present at any of the sites.

Figures 3.1 and 3.2 show temporal changes in juvenile salmon and trout densities per 100 m^2 by catchment average, only including historic data from the sites surveyed in 2015 in order to show more accurate trends as far as possible. As such, previous years (where not all of the 2015 sites were included) may bring down the average density for that year; the number of sites surveyed is noted under the date, which should be taken into consideration when interpreting results.

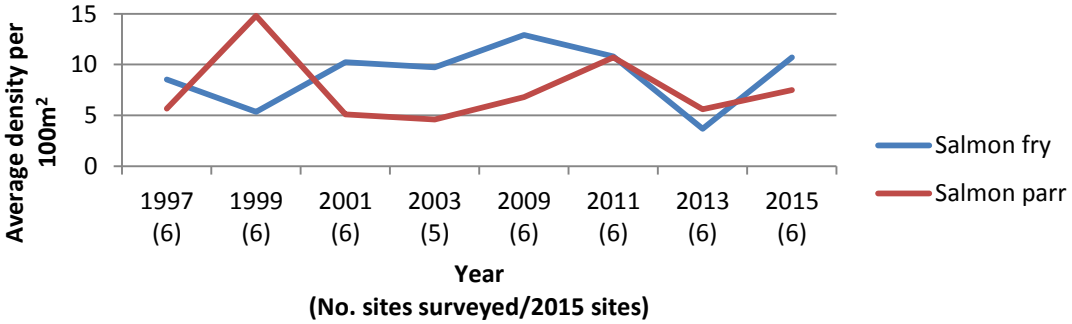

Figure 3.1: *Temporal changes in average salmon densities within the Polla catchment*

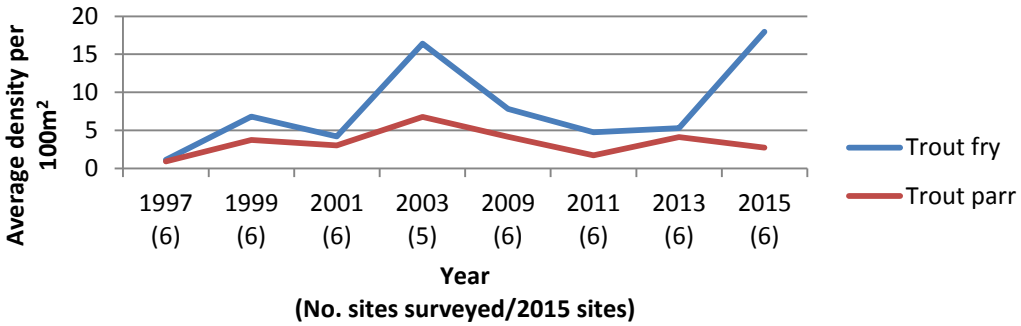

Figure 3.2: *Temporal changes in average trout densities within the Polla catchment*

Figure 3.1 shows a marked increase in salmon fry densities since the last surveys were undertaken in 2013. This suggests a good spawning season in 2014. Salmon parr densities are also higher than those recorded in 2013, yet are slightly below the catchment average figure since surveys began in 1997. Figure 3.2 shows the 2015 surveys to contain the highest recorded trout fry densities since surveys began, with the prolific numbers of fry found in P9A clearly having an pronounced impact on this. Conversely, trout parr densities in 2015 have dropped since 2013 yet remain comfortably within the average range.

Discussion

Whilst there are pronounced peaks and troughs within the catchment average of juvenile salmonid densities, the trend shows there to be a slight increase in salmonid densities since surveys began in 1997, with the exception of salmon parr, where there has been a slight decrease. The trout populations fluctuate fairly dramatically, particularly in fry densities. The years containing high densities of fry suggest prolific sea trout spawning, which is underpinned by a fairly stable population of resident trout. However, the heavy flooding following hurricane Bertha in 2014 has clearly affected certain stream courses, and substrate deposition. Whilst flooding is a natural process, the effects of floods would be less acute and immediate, and would follow a more natural pathway given solid bankside root systems within the tributaries as a result of strategic planting of mixed broadleaf; this in turn would provide elevated habitat opportunities, particularly for trout.

4. Hope catchment

Table 4.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 4.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	Situation
H1A	247700	957800	30	Allt a Muillin
H2B	247500	956900	15	Braesgill burn, above road and below sheep dip.
H2C	247450	956900	10	Braesgill burn, about 30 m downstream of road
H3A	246100	952700	10	An Garbh-allt
H4A	246300	947700	25	Tributary at shed by Ben Hope path.
H9A	242000	941500	120	Abhains Strath Coir an Easaidh
H9B	243600	941800	60	Abhainn Strath Coir an Easaidh
H10A	243200	941500	100	Allt a Choire Ghrainde
H12A	245200	942600	30	By passing place on road to Gober, above bridge

Table 4.1: *Electro-fishing site details*

			Minimum density (100m^2)			
Site Code	Length (m)	Area m^2	Salmon Fry	Salmon Parr	Trout Fry	Trout Parr
H1A	11.8	25.57	3.910	3.910	11.732	7.821
H2B	11.2	45.92	6.533	0	8.710	0
H2C	13.7	30.14	13.271	6.635	13.271	0
H3A	14.3	76.27	3.933	9.177	2.622	3.933
H4A	8.2	24.05	8.316	70.686	12.474	29.106
H9A	7.6	84.36	0	1.185	1.185	2.370
H9B	15.3	116.28	2.579	14.619	0	1.719
H10A	5.8	43.89	0	0	11.392	6.835
H12A	9.2	92	1.086	10.869	3.260	2.173

Table 4.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 4.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	0	13.271	4.403
Salmon parr	0	70.686	13.009
Trout fry	0	13.271	7.183
Trout parr	0	29.106	5.995

Table 4.3: *A summary of the densities determined for all sites surveyed*

Three distinct age classes can be seen within juvenile salmon populations from 0+ years to 2+ years, although 2 year old salmon parr are clearly uncommon in the Hope catchment, with only 1 fish being found at this age. Both salmon and trout were present in all sites other than H10A where only trout were present. Where salmon were present, fry densities were lower than parr densities with the exceptions of H2B (where no parr were present), H2C where salmon fry densities were higher than parr, and H1A where fry and parr densities were equal. Trout fry densities were higher than parr in five of the nine sites sampled. Eels were present at H1A, H3A, H9B, H10A, and H12A, with the highest numbers (10) occurring in H1A. Minnows were not present within any of the sites surveyed.

Figures 4.1 and 4.2 show temporal changes in juvenile salmon and trout densities per 100 m^2 by catchment average, only including historic data from the sites surveyed in 2015 in order to show more accurate trends as far as possible. As such, previous years (where not all of the 2015 sites were included) may bring down the average density for that year; the number of sites surveyed is noted under the date, which should be taken into consideration when interpreting results.

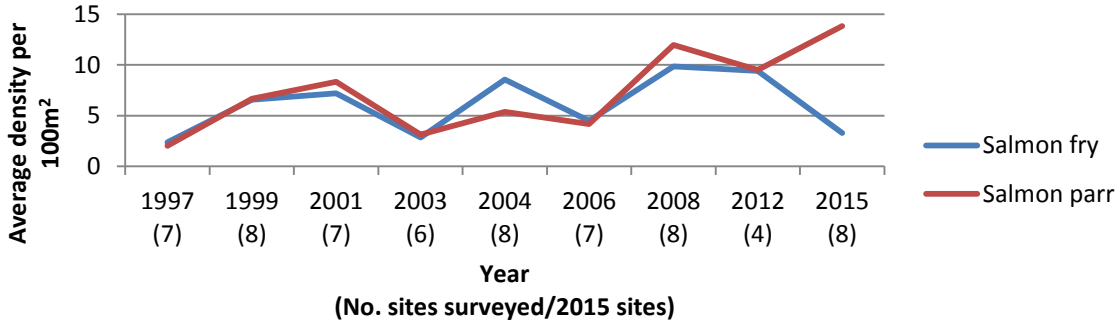

Figure 4.1: *Temporal changes in average salmon densities within the Hope catchment*

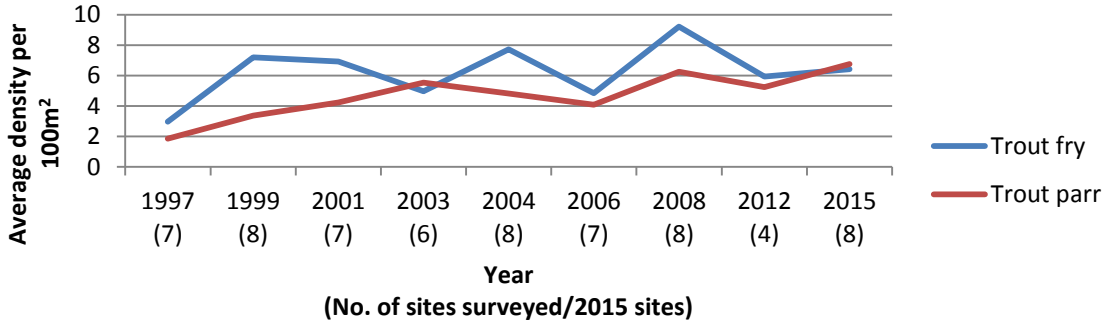

Figure 4.2: *Temporal changes in average trout densities within the Hope catchment*

Figure 4.1 shows the 2015 surveys to have the highest recorded average salmon parr density since surveys began in 1997. However, the average salmon fry density is the lowest since 2003, and has seen a dramatic decrease since 2013. Figure 4.2 shows that trout fry and parr densities have taken an increase since 2013, with parr reaching their highest recorded average density in 2015.

Discussion

The high average density of salmon parr suggests an excellent spawning season in 2013, with the prolific numbers found within H4A massively pushing up the average. The dramatic decrease in the average fry density may be attributable to a poor spawning season in 2014. In addition, due to the flooding following hurricane Bertha in 2014, the Braesgill and Mhuiesell burns have suffered dramatic landslips in areas of steep gradient upstream of the survey sites, and have been depositing large amounts of gravel, cobble, and boulder substrate in subsequent floods; this is likely to have caused redd washouts over the winter months of 2014-2015. The salmon fry densities found in these burns (sites H2B and H4A) are among the lowest on record since surveys began in 1997, which will undoubtedly have brought the average down for 2015. This is particularly unfortunate, as these burns show the highest salmon densities historically, with salmon densities within sites further up the catchment likely being more flow dependent. The fact that fry densities were low across the whole catchment certainly supports the probability of a poor spawning season in 2014, and while it is likely that future salmon redds and fry survival will be sporadic in the most negatively affected burns until the substrate re-stabilises, salmon will undoubtedly continue to populate the catchment elsewhere.

Interestingly, trout fry densities appear to have been less affected by the post flood washouts in the Braesgill burn, which is unusual as trout use smaller gravels for spawning. It is also unusual that parr were absent from this site although it is possible that surviving trout parr may have migrated downstream into Loch Hope, as trout do not fare as well as salmon in high flows. The consistently high densities of trout fry seen in H1A, H2B, and H4A suggest spawning sea trout due to the higher fecundity of these larger fish, which in turn are able to use larger gravels for spawning than smaller resident trout; this may explain the presence of both salmon and trout fry in H2B and H2C. While the average densities for both trout and salmon naturally fluctuate over time, the trend is showing a steady increase since surveys began in 1997, showing positive promise for salmonid populations within the Hope catchment.

H3A: Excellent juvenile habitat with mixed broadleaf trees creating fish cover and bankside stability
Photo: Adam Beynon-Jones

The post flooding effects following hurricane Bertha in an area lacking bankside tree root structures
Photo: Shona Marshall

5. Duart catchment

Table 5.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 5.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	Situation
D2	220100	937400	40	Above hatchery, just before bend into waterfall pool. From the first trees to the riffle
D3	218300	937200	50	In riffle, just before bend down to falls
D4	219000	937400	25	Right braid of river between the two lochs
D5	221400	936400	60	Near mouth of river, just after boulder bar before sharp bend
D6	221400	936200	60	Approx. 100m from loch, just before small fall at bend. Near stock fence on right.
D8	221000	936200	60	Left braid of riffle below Loch Allt nan Ramh
D9	220600	936400	50	In riffle area above Loch Yucal, by corner of deer fence

Table 5.1: *Electro-fishing site details*

			Minimum density (100m^2)			
Site Code	**Length (m)**	**Area m^2**	**Salmon Fry**	**Salmon Parr**	**Trout Fry**	**Trout Parr**
D2	15.6	46.8	10.684	12.821	14.957	17.094
D3	9.7	31.69	28.400	0.000	18.933	3.156
D4	9.8	40.83	0.000	0.000	4.898	0.000
D5	9.9	22.44	53.476	35.651	4.456	4.456
D6	12.4	26.45	3.781	22.684	7.561	22.684
D8	4.1	21.73	73.631	23.010	4.602	0.000
D9	6.3	19.53	0.000	5.120	5.120	5.120

Table 5.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 5.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	0	73.631	24.281
Salmon parr	0	35.651	14.183
Trout fry	4.456	18.933	8.647
Trout parr	0	22.684	7.501

Table 5.3: *A summary of the densities determined for all sites surveyed*

Three distinct age classes can be seen within juvenile salmonid populations from 0+ years to 2+ years. Both salmon and trout were present at all sites other than D4 where only a small number of trout fry were present. Salmon densities were significantly dominant over trout densities at D3, D5, and D8. Salmon fry occurred in higher densities than parr within D3 (no salmon parr present), D5, and D8. Trout fry densities were higher than trout parr densities at D3, D4, and D8 (with D4 and D8 having no trout parr present). Eels were not present at any sites in the catchment. This is unusual

within the west Sutherland area, and may be attributable to the natural waterfall on the Duart downstream from the survey sites. Minnows were present only at D2 where their numbers were prolific.

Figures 5.1 and 5.2 show temporal changes in juvenile salmon and trout densities per 100 m^2 by catchment average, only including historic data from the sites surveyed in 2015 in order to show more accurate trends as far as possible. As such, previous years (where not all of the 2015 sites were included) may bring down the average density for that year; the number of sites surveyed is noted under the date, which should be taken into consideration when interpreting results.

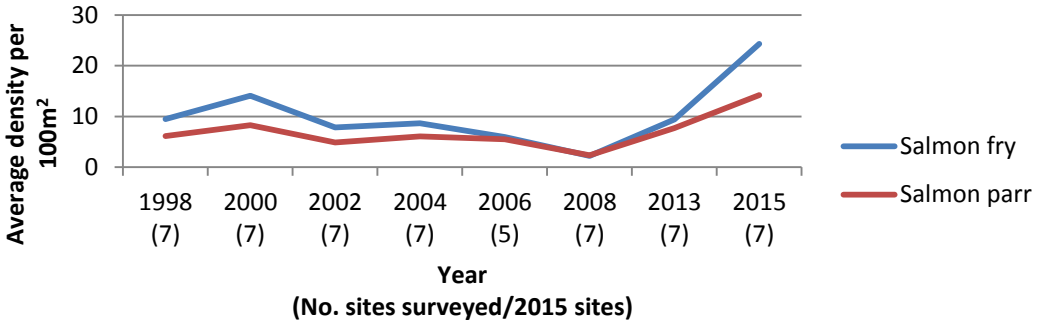

Figure 5.1: *Temporal changes in average salmon densities within the Duart catchment*

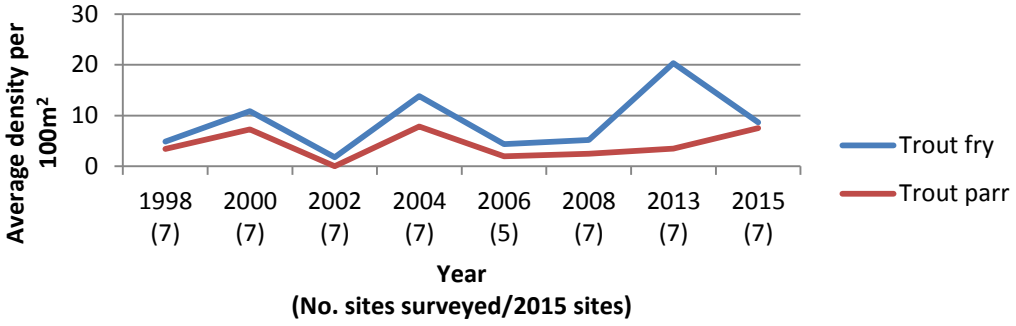

Figure 5.2: *Temporal changes in average trout densities within the Duart catchment*

Figure 5.1 shows the 2015 surveys to have the highest recorded average juvenile salmon densities since surveys began in 1998. Figure 5.2 shows that trout fry densities have taken a decrease since 2013 yet are comfortably within the average. Trout parr densities have been increasing since 2006, with the 2015 surveys showing the 2nd highest recorded average density since surveys began in 1998.

Discussion

Since the decline in recorded average salmon density since 2000 (reaching the lowest figures in 2008), the average densities have seen a dramatic increase, with what appears to have been exceptional salmon spawning in 2014. This trough and peak is likely to have been part of a longer term natural cycle, with marine pressures potentially playing a large part. The peaks and troughs within trout populations are also likely to be a result of natural ecosystem dynamics with temporal fluctuations. There certainly seems to be a steady base population of resident trout, which appears to be augmented with prolific fry numbers cyclically, suggesting spawning sea trout; these fish are naturally also heavily susceptible to fluctuating marine pressures.

6. Bhadaidh Daraich catchment

Table 6.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 6.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	Situation
BD1	215689	944820	10	Below house in reeds by wall
BD4	216300	944200	35	Between small rocks and higher barrier (with heather in middle of barrier)
BD5	216300	944100	45	Just below loch

Table 6.1: *Electro-fishing site details*

			Minimum density (100m^2)			
Site Code	**Length (m)**	**Area m^2**	**Salmon Fry**	**Salmon Parr**	**Trout Fry**	**Trout Parr**
BD1	12	28.4	0	0	17.60563	17.605634
BD4	11.8	22	0	0	59.01044	0
BD5	21.5	57.3	0	0	33.14146	1.7442875

Table 6.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 6.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	0	0	0
Salmon parr	0	0	0
Trout fry	17.605	59.010	36.585
Trout parr	0	17.605	6.449

Table 6.3: *A summary of the densities determined for all sites surveyed*

Four age classes can be seen within the trout populations from 0+ years to 3+ years. No salmon were present within the survey sites. Trout fry occurred in higher densities than parr in the two sites above Loch a' Bhadaidh Daraich, where trout parr densities were low. Eels were present within all three sites, with the highest numbers occurring at BD1 with 25 eels present. Minnows were present at BD5 in prolific numbers in excess of 100.

Figure 6.1 shows temporal changes in average juvenile trout densities per 100 $m^{2.}$ In order to show accurate trends as far as possible only historic data from the sites surveyed in 2015 have been included in this data set (in each of these years all three sites were surveyed).

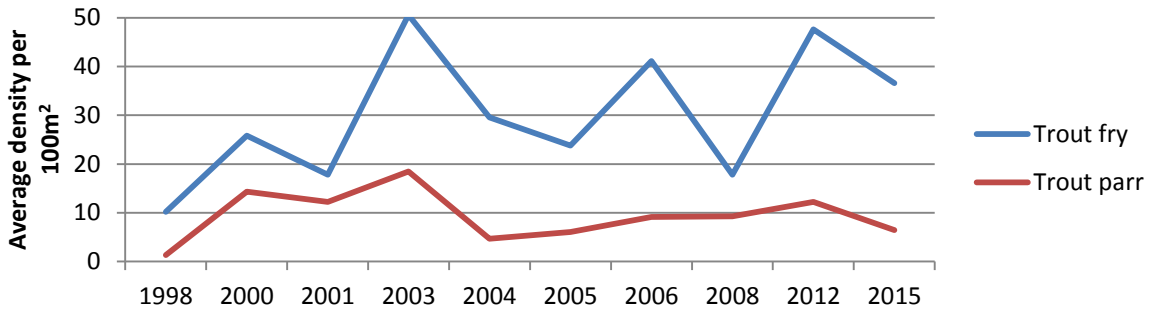

Figure 6.1: *Temporal changes in average trout densities within the Bhadaidh Daraich catchment*

Figure 6.1 shows the fry density to be above average despite dropping since 2013. The average trout parr density has also dropped since 2013, and is slightly below average.

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Discussion

BD5 was the only site of the three to be surveyed in 2013, and shows exceptionally low numbers of fry, suggesting poor spawning within this burn in 2012. This would lead to explain the general absence of parr within BD4 and BD5 in 2015 when compared to previous years. However, there appears to be a strong population of trout within the Bhadaidh Daraich catchment, supported by good spawning grounds and fry habitat. This suggests there is no major cause for concern regarding the natural habitat in terms of instream characteristics. Yet, there is room for improvement in regard to parr and adult trout habitat. Parr numbers are historically low within BD4 and more so within BD5. The fry numbers remain consistently high, with some years showing exceptionally high densities while the lower parr numbers remain relatively constant. This may be explained by the suboptimal bankside cover of the burns above Loch a' Bhadaidh Daraich (parr numbers in BD1 where bankside cover is excellent are consistently high). It is also possible that the carrying capacity for parr is exceeded within the burns, resulting in migration into the nearby lochs.

7. Geisgeil catchment

Table 7.1 gives the grid reference, altitude, and location of each site fished. The length and area fished are presented in Table 7.2, together with minimum estimates of density for salmon and trout fry (0+ years) and parr (>1 year) per 100 m^2.

Site Code	Easting	Northing	Altitude	Situation
G1	217352	941790	20	Just above fence line to step/falls
G3	217401	941613	20	By loch, below fence

Table 7.1: *Electro-fishing site details*

			Minimum density (100m^2)			
Site Code	Length (m)	Area m^2	Salmon Fry	Salmon Parr	Trout Fry	Trout Parr
G1	8	66.93	1.494098	10.45869	8.96459	7.470492
G3	4.3	18.63	5.367	0	0	5.367

Table 7.2: *A summary of the density of salmon and trout fry (0+ years) and parr (greater than 1 year) at each site per 100 m^2*

The maximum, minimum and mean densities are given for all sites (Table 7.3). This summarises the data and allows comparisons within the system and with other systems within the west Sutherland area.

Species/age class	Minimum	Maximum	Mean
Salmon fry	1.494	5.367	3.430
Salmon parr	0	10.458	5.229
Trout fry	0	8.964	4.482
Trout parr	5.367	7.470	6.419

Table 7.3: *A summary of the densities determined for all sites surveyed*

Two distinct age classes can be seen within the juvenile salmon populations from 0+ years to 1+ years, where 3 age classes can be seen within the trout populations from 0+ years to 2+ years. Trout fry dominated salmon fry within G1 while salmon parr densities were slightly higher than trout parr. G3 contained only salmon fry and trout parr. Eels were present within both sites with 19 counted in G1, and 1 counted at G3. G1 also contained 2 minnows.

Additional consistent monitoring of at least two sites is needed before realistic comparisons of temporal changes in average densities can be made. However, figures 7.1 and 7.2 show temporal changes in juvenile salmonid densities by individual site data, separated by salmon and trout.

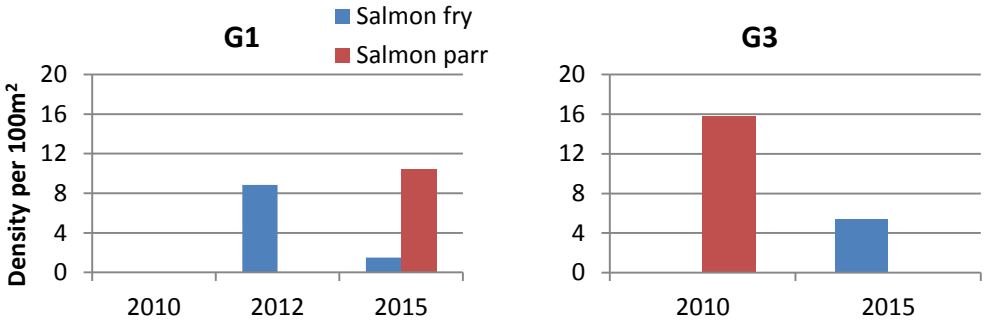

Figure 7.1: *Temporal changes in juvenile salmon densities by survey site within the Geisgeil catchment*

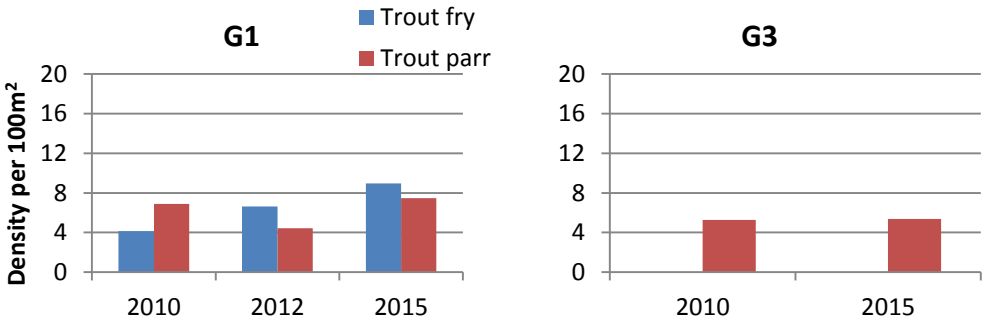

Figure 7.2: *Temporal changes in juvenile trout densities by survey site within the Geisgeil catchment*

Discussion

While surveys of the Geisgeil catchment are in their early stages, there is likely to be a stable catchment-wide population of trout when considering similar catchments within close proximity in the West Sutherland area; G1 is already showing to be a consistently important site for juvenile trout, while G3 is only so far showing trout parr to be present. Salmon are using both sites, but fry and parr presence is showing to be inconsistent at this point. However, the burns above the loch appear to be potentially prosperous for consistent salmon populations when considering the sporadic, yet reasonable densities of juveniles that have been found. The low numbers of salmon fry found in 2015 suggest poor spawning in 2014 which may be attributable to low flows affecting the efficacy of fish passage over the barrier; the inconsistent juvenile salmon densities since 2010 would certainly support the probability that salmon access is flow dependant. It is known that the improvements to fish passage on the barrier have deteriorated over time, which is an issue that should be addressed. In any case, continued monitoring will allow more stable temporal comparisons to be made between site and catchment average densities.

8. Average for the West Sutherland Fisheries Trust area

The average densities of fish within each catchment are summarised (Table 8.1). This allows comparison between the catchments, although it should be noted that temporal changes in density throughout the summer months, and habitat differences between catchments are not considered in this table. The timing of sampling is important, with fish moving within the tributaries as a result of water height and temperature, food availability and size. Thus sampling after a spate may give a low density as a result of washout, whilst drought may decrease density as fish move into deeper water to avoid predation or desiccation, or may increase density as a result of concentration in severe cases. Similarly, densities will be greater shortly after hatching, reducing with time as the fish grow and require a larger territory for survival.

	Average density (100m^2)			
Catchment	**Salmon fry**	**Salmon parr**	**Trout fry**	**Trout parr**
Laxford	34.788	11.827	46.174	7.243
Inver	25.822	16.174	12.737	3.806
Polla	10.715	7.497	17.963	2.747
Hope	4.403	13.009	7.183	5.995
Duart	24.281	14.183	8.647	7.501
Bhadaidh Daraich	0	0	36.585	6.449
Geisgeil	3.43	5.229	4.482	6.419
West Sutherland area average	**14.777**	**9.702**	**19.110**	**5.737**

Table 8.1: *Average densities of salmonids per catchment surveyed*

As evident from Figures 8.1 and 8.2 there is a good distribution of salmonid species throughout the west Sutherland area with trout present in every system surveyed. With the exception of Bhadaidh Daraich, salmon were also recorded in each catchment. In general trout are more abundant with trout fry dominating the area; however, trout parr numbers are consistently low across the catchments, and were heavily dominated by salmon parr. Trout fry dominated in all catchments over trout parr, with the exception of Geisgeil. Salmon parr were dominated by salmon fry in all catchments other than Hope and Geisgeil.

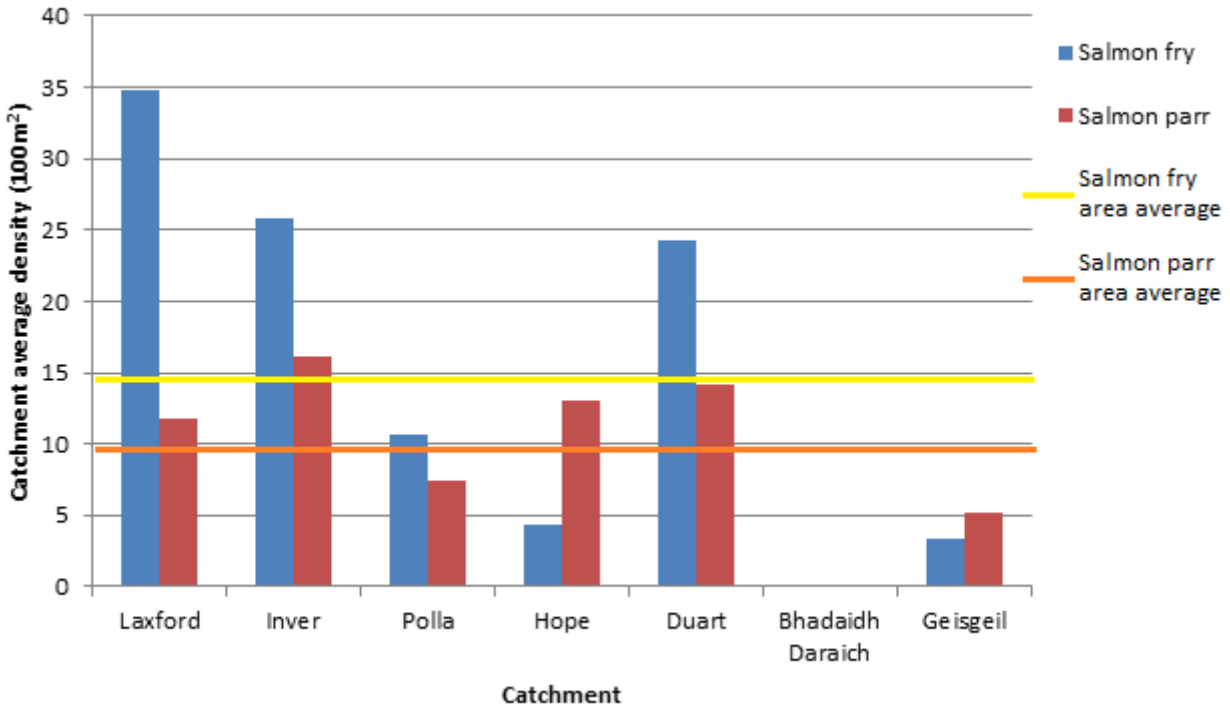

Figure 8.1: *Average salmon fry and parr densities within West Sutherland catchments shown against the average fry and parr densities for the West Sutherland area 2015*

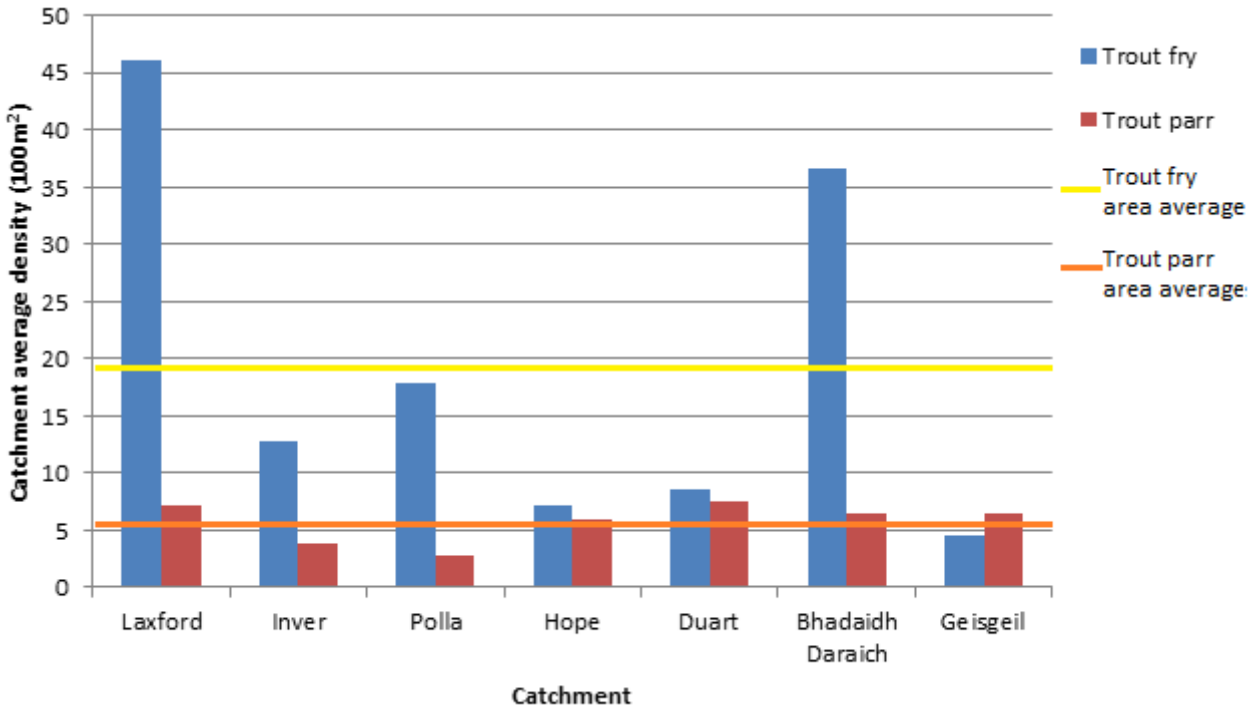

Figure 8.2: *Average trout fry and parr densities within West Sutherland catchments shown against the average fry and parr densities for the West Sutherland area 2015*

9. SFCC Classification

The SFCC absolute regional classification scheme, presented in Table 9.1, was developed so that fish populations could be compared across Scotland, allowing electrofishing results in Sutherland to be presented in a Scottish context. Unlike the relative regional classification scheme, this does not take into account river width which is known to affect salmonid densities with generally more fish present in narrower tributaries. When compared to the SFCC regional classification scheme for the north west area, salmonid densities range from absent (unclassified) to excellent and there is a lot of within-catchment variation, in part due to the location and habitat type.

		Minimum density per 100m^2			
SFCC Class	**Descriptor**	**Salmon fry**	**Salmon parr**	**Trout fry**	**Trout parr**
A	Excellent	26.05	13.09	15.80	8.58
B	Good	14.15	8.04	8.25	4.31
C	Moderate	8.00	4.67	4.26	2.72
D	Poor	4.42	2.58	1.99	1.52
E	Very poor	0.78	0.66	0.44	0.22
U	Unclassified	0	0	0	0

Table 9.1: *SFCC salmonid density classification scheme for the north west area*

The percentages of SFCC classifications across the west Sutherland area are displayed in Figure 9.1. 48% of all sites were classed as having moderate to excellent salmon fry densities (34% classed as excellent), with salmon parr densities classed as moderate to excellent within 60% of all sites (42% classed as excellent). Trout fry densities were classed as moderate to excellent in 80% of all sites, (30% classed as excellent), whereas trout parr densities contrasted this with 52% of sites containing moderate to excellent densities (16% classed as excellent).

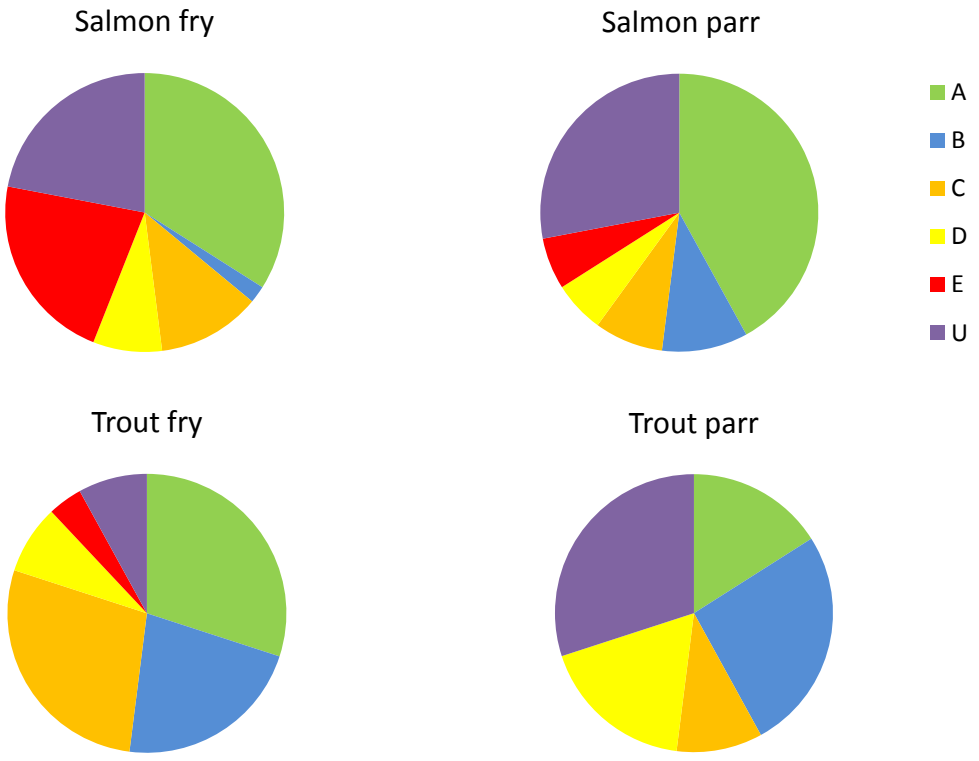

Figure 9.1: *West Sutherland area salmonid densities according to the SFCC classification scheme*

The Laxford system contains excellent mixed habitat for salmonids, complemented by separate areas of niche habitat for salmon and trout. Salmon fry and parr densities were classed as excellent in 70% and 50% of sites respectively. Trout generally fared better within the areas lacking salmon, with prolific numbers of trout fry densities in a small number of sites; trout fry and parr densities were classed as moderate to excellent in 100% and 50% of the sites respectively.

The salmonid habitat within the sites surveyed in the Inver catchment is predominantly mixed juvenile of moderate to excellent nature, with seven of the thirteen sites being more suited to salmon due to higher flows and size of spawning substrates. The remainder of the sites are more shallow and narrow and as such are better suited to trout. Salmon fry and parr densities were classed as moderate to excellent in 54% and 69% of sites respectively, while trout fry and parr densities were classed as moderate to excellent in 77%, and 46% of sites respectively.

The Polla, not faring quite so well, showed 50% of sites to contain moderate to good salmon fry densities, and 67% of sites containing moderate to excellent salmon parr densities. Trout fry densities however, were classed as moderate to excellent in 83% of sites, while trout parr densities were classed as good within 50% of the sites with the remainder being absent; 50% of the sites were of mixed juvenile habitat with the remaining 50% being predominantly fry habitat. The instream cover within the Polla catchment generally provides only moderate parr cover, and bankside cover is severely lacking within the tributaries.

Salmon fry densities were notably low within the Hope catchment, classed as poor to moderate in 78% of the sites, and absent from the remainder; it should be noted however, that H10 has never contained salmon due to a natural impassable barrier. Conversely, salmon parr densities were classed as moderate to excellent in 55% of sites, as were trout fry. Trout parr densities did not favour so well, with 44% of sites classed as moderate to excellent. There is good mixed juvenile habitat within the Hope catchment, suited to both trout and salmon; however, the recent destabilising of the substrate in certain burns has undoubtedly had a negative impact on densities.

The Duart catchment has some excellent mixed juvenile habitat in terms of instream boulder cover and instream vegetation cover, most of which is suited to salmon. However, in some areas flows are too strong and bankside cover is insufficient to hold optimum trout densities. 57% of the sites contained moderate to excellent salmon fry densities (42% excellent), and 71% of sites contained moderate to excellent trout and salmon parr densities. Trout fry densities were moderate to excellent in 100% of the sites.

The quality of juvenile trout habitat is split in the Bhadaidh Daraich catchment between excellent in the burn below the loch, and poor to moderate in the burn surveyed above the loch. The burns above the loch simply lack bankside cover. Trout fry densities were classed as excellent, whereas parr densities were very poor or absent in the sites above the loch, and excellent in the site below the loch.

There is a good mixture of prosperous salmonid habitat within the Geisgeil catchment, which appears to be sporadically accessible to salmon. Between the two survey sites, salmon fry densities were classed as very poor and poor, with salmon parr and trout fry densities classed as good and absent. Trout parr densities were classed as good.

10. Discussion

Minimum density estimates are underestimates of the total fish population, particularly when fishing efficiency is reduced as a result of fish being lost in stones or weeds, or if the water flow is high, and where conductivity is especially low. In 2015, salmonid fry and parr were recorded in every catchment, and populations appear to be healthy, despite being small in some catchments.

Salmonid fry densities are naturally higher than parr in all freshwater catchments as a result of density dependent mortality combined with migration as the parr grow and move into new feeding territories. Whilst this is reflected in the surveys within the west Sutherland catchments, there are certain years where salmonid fry numbers are dramatically high (suggesting prosperous spawning in the previous year), yet parr numbers remain relatively constant in comparison. It is likely that the carrying capacity for parr is exceeded within the burns, resulting in migration into the lochs; the water is deeper and provides more cover, as well as having a greater expanse in which to support feeding territories for higher parr densities. This seems to occur most notably in trout populations.

When compared to the previous surveys within these systems, juvenile salmon densities have increased across the majority of all catchments surveyed. Not taking the Bhadaidh Daraich and Geisgeil catchments into consideration (where salmon are historically absent in the Bhadaidh Daraich catchment and are sporadically present due to the barrier in the Geisgeil catchment), the only case of a reduction in salmon densities occurred in the Hope catchment where fry densities decreased dramatically. This is likely to be due to destabilised substrate causing redd washouts following the spawning season of 2014 (possibly combined with poor 2014 spawning), and as such is an isolated case in spite of which the salmon fry densities remain within the range found in previous years. In contrast, juvenile trout densities did not show any discernible patterns, increasing in some systems whilst decreasing in others. However, all of the trout densities remained within the ranges recorded in previous years, indicating that there are no major problems within these catchments. Stocking does not form a major part in the management of the systems monitored in 2015.

The historical data shows peaks and troughs in salmonid populations which reflect natural cycles as a result of ecosystem dynamics. The peaks following the troughs, particularly in recent years in the case of salmon, show that there is no major cause for concern in regard to freshwater habitat in terms of instream characteristics; the habitat is being used to the optimum given the abundance of spawning adults. However, there is a severe lack of bankside cover across all of the catchments within the West Sutherland area; a habitat feature which is of vital importance to parr and adult trout, and is likely to be attributable to the consistently low densities of trout parr in spite of the refuge of nearby lochs within many of the systems. Strategic planting of mixed broadleaf trees within riparian zones would undoubtedly improve fish cover, food availability, and bankside stability; this is particularly vital in areas susceptible to dramatic landslips. Flooding is a natural occurrence, but a lack of structural bankside stability afforded through the root systems of complex bankside vegetation speeds up the process of erosion, and can have catastrophic consequences, as was seen within tributaries of the Hope and Polla systems following the heavy flooding in August 2014. The knock-on effects of this have undoubtedly had a negative impact on juvenile salmonid populations through rapid changes to stream courses and redd washouts.

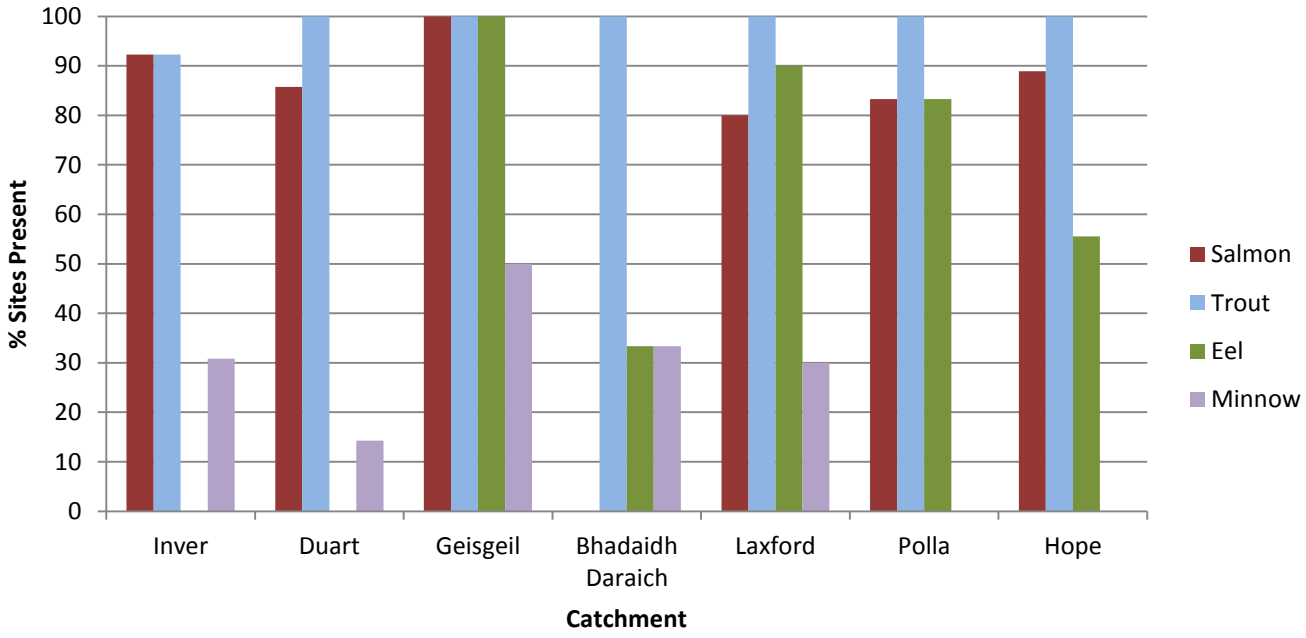

Figure 10.1: *Species compostion and distribution per catchment*

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