2019 Survey of Juvenile Salmonids in the Caithness Rivers

Caithness District Salmon Fishery Board

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Backlass Burn, River Thurso, September 2019

Contents

1. Introduction

2019 marked the second year of the National Electrofishing Programme for Scotland (NEPS) run by Marine Scotland Science (MSS). As for 2018, the Board agreed to electric fish 30 NEPS sites for MSS in addition to carrying out its own on-going programme of survey work.

In brief, the NEPS programme is designed to provide regional (ie. Fishery District) assessments of the status of juvenile salmon for possible future inclusion in the annual River Grading exercise. In 2018, the NEPS results for Caithness District were reported by MSS to be highly favourable for both fry and parr (see https://data.marine.gov.scot/sites/default/files//SMFS%201002.pdf).

All the NEPS survey sites are chosen somewhat randomly by MSS and this has involved the Board's team visiting some locations that would not normally be targeted. Yet, all these places are of at least passing interest.

In the form reported by MSS, however, the NEPS fish data are quite highly manipulated and they are not easy to understand or easily comparable with the Board's own survey data. In order to get around this mismatch, the Board's electric-fishing report for 2018 considered the NEPS data in the Board's standard way. This made it possible to view the NEPS sites and the Board's sites together to provide an unusually broad picture of the Caithness rivers.

The Board's electric-fishing strategy for 2019 was again tailored to incorporate the new NEPS work into the Board's own survey programme and to deliver the data required by MSS. In addition, the Board aimed to survey the six key sites (one on each of the six Caithness rivers) that have been surveyed every year since 2013 and to include some new sites on the lower Wick River - a difficult area to survey and the only one remaining in Caithness which has not been adequately covered. The intention was that the 2019 survey would complete the pattern of coverage that the Board has gradually extended since its current series of surveys started in 2013. In the event, however, the summer of 2019 proved to be extremely wet throughout and this hampered efforts to meet this particular objective.

2. Methods

All the methods used were identical to those of previous years and as detailed in previous reports.

It is particularly important to recall two points. Firstly, all the established Board sites surveyed in 2019 exactly replicated the location and units of stream length surveyed in previous years. In the same way, NEPS sites that were repeated from 2018 were exactly replicated. Secondly, as for the Board sites, fish densities for NEPS sites are expressed per area of stream channel rather than according to the wetted area of stream channel (as used by MSS) because, in some locations, wetted area varies from year to year depending on rainfall and stream height. The advantages of using channel area to standardise density measurements are (1) that the values for NEPS sites in 2019 and 2018 can be directly compared and (2) that the NEPS sites can be directly compared with Board sites.

A total of 42 sites were surveyed in 2019 - 30 sites specified by the NEPS project and 12 Board sites including the six key sites that are surveyed each year. Table 1 gives a summary description of all the sites.

Table 1. Summary description of the sites surveyed in 2019.

River	Location	NEPS Code	OS Grid Ref	Date	Length (m)	Area (m^2)	Passes
Forss	Shurrery	CDSFB	Standard site	20/9	-	89.8	3
	Torigil Burn	0951	ND 03404 58880	22/9	35.4	134	1
	Broubster	1031	ND 03594 59657	22/9	20.0	119	3
	Forsie	1041	ND 05033 63416	20/9	7.4	185	1
	Forsie 1	0953	ND 05530 63459	21/9	15.0	108	1
	Westfield	0909	ND 05645 63741	21/9	18.9	145	1
	Lythmore 1	0917	ND 04561 66586	20/9	10.4	164	1
Thurso	Craggan Burn	1044	NC 96855 38267	21/9	50.0	86.0	3
	Rumsdale 4	0960	NC 96953 41202	8/9	14.7	85.0	1
	Rumsdale	CDSFB	Standard site	8/9	-	182	3
	Rumsdale 2	0928	ND 00102 40583	14/8	15.9	122	3
	Rumsdale 3	0956	NC 99404 40768	9/8	12.4	88.0	3
	Backlass 1	0922	ND 07256 41624	15/9	19.5	98.0	3
	Backlass	CDSFB	ND 07153 43453	15/9	19.0	113	3
	Gaineimh	0910	ND 05534 46590	21/7	34.6	121	1
	Tacher	CDSFB	Standard site	14/9	-	131	3
	Inshag 1	0903	ND 15116 48633	26/8	21.1	120	3
	Inshag	CDSFB	Standard site	17/9	-	111	3
	Olgrinmore 1	0923	ND 10780 53597	4/8	37.0	133	1
	Gerston Burn	0955	ND 12218 59633	4/8	44.0	128	3
Wick	Bower 1	0901	ND 19981 59855	17/7	31.0	90.0	1
	Bower 2	1070	ND 20118 59725	17/7	39.2	129	1
	Quoynee	1050	ND 21199 58381	30/7	50.0	240	1
	Shielton	0926	ND 20367 50746	23/7	50.0	105	3
	Acharole 4	0958	ND 23186 52101	6/8	13.4	131	1
	Clow	CDSFB	Standard site	30/8	-	160	3
	Munsary Burn	0959	ND 21312 45171	27/7	50	55.0	1
	Munsary	1043	ND 22000 45412	27/7	50	150	3
	Scorriclet	CDSFB	ND 24799 50277	28/8	10.5	75.6	3
	Achairn Forest	0930	ND 27521 47482	25/7	50.0	165	1
	Puldagon	0902	ND 32698 49028	7/8	22.0	161	1
	Humster	0929	ND 35664 48718	1/8	42.0	176	1
	Thrumster	0957	ND 33006 45716	3/8	50.0	105	1
	Bilbster*	CDSFB	ND 28093 53741	29/8	20.2	*234	3
	Ingimster	CDSFB	ND 29552 55411	29/8	10.2	91.3	3
	Winless	1045	ND 28852 55364	14/7	18.3	60.0	1
Dunbeath	Culvid	CDSFB	Standard site	16/9	-	215	3
Berriedale	Gobernuisgach	CDSFB	NC 98419 31244	4/9	17.8	131	3
	Corrrichoich 1	0908	ND 03018 29556	28/8	26.2	309	3
Langwell	Wagmore Burn	0924	NC 98784 25972	4/10	42.0	100	1
	Wag	CDSFB	Standard site	4/9	-	212	3
	Langwell Policies	1051	ND 11630 22550	24/8	12.7	183	3

* Survey site area reviewed in 2019 due to changes in channel width since date of previous survey.

In Table 1 the NEPS sites are identified by their formal codes. All the sites are also identified by unique trivial names to aid reference. The length and channel area of each site is specified and the Ordnance Survey coordinates specify the downstream limit of each site.

Table 2 shows the colour-coded classification scheme used in all the Board's previous reports to categorise sites according to the abundance of fish present. The yellow colour-code is the average expected classification for northern rivers and green, light blue and dark blue are increasingly above average. Orange is below the expected average and red is the lowest category of all.

Table 2. Classification scheme for salmon fry and parr densities observed on 1-pass electric fishing (after Godfrey, 2005[1]).

	Critical percentile values for density (n/m2) and colour-codings					
	< 20th	**20th – 40th**	**40th – 60th**	**60th – 80th**	**80th - 100th**	**> 100th**
Fry	0.05	0.13	0.28	0.33	0.67	> 0.67
Parr	0.04	0.07	0.13	0.19	0.28	> 0.28

3. Results

3.1 Single-pass fishing

Tables 3 - 6 (Appendix) show 1-pass density values and the colour-coded classifications for all the sites surveyed in 2019, for salmon fry (Tables 3 and 4) and salmon parr (Tables 5 and 6). Additionally, the equivalent data and colour-codes are shown for those of the 2019 sites that were also surveyed in 2018 to allow direct comparison between years.

3.1.1 Salmon fry densities on 1-pass electric-fishing

Figure 1 shows the colour-coded 1-pass densities for fry mapped onto the Caithness river network. Many of the lowest values (coded in red) occur around the peripheral part of the river network outside the range of spawners. In the case of the Wick River catchment, fry were again found to be absent in the western arm of the river network that includes Loch Watten and very sparse in the Newton Burn, the river's easternmost tributary.

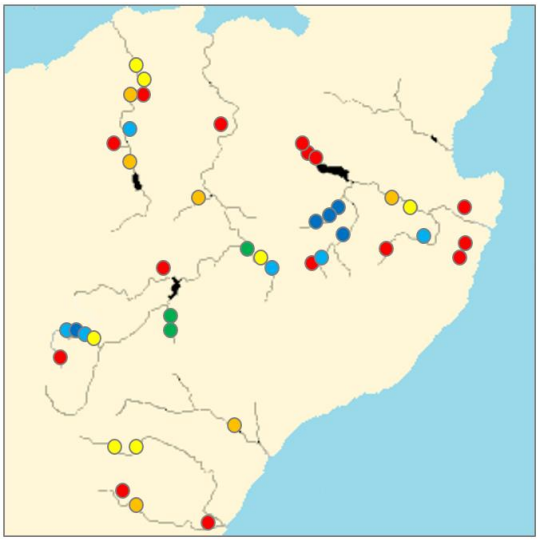


Figure 1. Geographical distribution of densities of fry as observed on 1-pass fishing. The values are colour-coded as per Table 2.

[1] J.D. Godfrey (2005). See https://www2.gov.scot/Resource/Doc/295194/0096508.pdf

Inspection of the values for fry density (Table 3) shows that the status of many of the sites (and their colour-codings) were notably lower in 2019 than to 2018. This pattern aligns with reports that spawning activity was unusually light throughout the Caithness rivers in November 2018 when the eggs generating the 2019 crop of fry were deposited.

In order to check the extent of this effect, Table 3 was edited to exclude those of the NEPS sites that lie outside, or on the very periphery of, those parts of the river catchments that spawning salmon access. These sites are not useful as indicators of changes of fish abundance from year to year.

The edited Table 4 shows that 13 sites that are accessible to spawners were surveyed both in 2018 and in 2019. In 2019 densities of fry on 1-pass fishing were substantially lower than in 2018 (30-90%) at nine of the 13 sites.

In 2019, the median density of fry on 1-pass fishing considered over all the 31 sites shown on Table 4 was 0.26/ m^2. For 2018, the corresponding value for the equivalently edited set of 40 sites (data taken from http://caithness.dsfb.org.uk/files/2019/04/CDSFB-EF-Report-2018.pdf) was 0.51/ m^2.

All the values for individual sites are shown and compared in Figure 2. The distributions again show that fry densities in 2019 were clearly lower than in 2018.

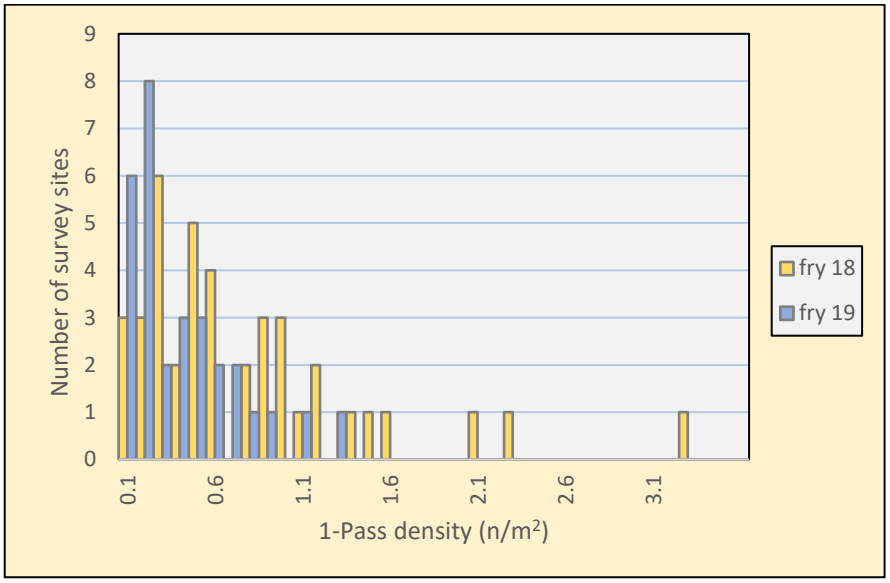


Figure 2. Frequency distribution of 1-pass density values for fry in 2018 and 2019.

3.1.2 Salmon parr densities on 1-pass electric-fishing

Figure 3 shows the 1-pass density values for parr mapped on to the river network. As for the fry, the low-density parr sites colour-coded in red tend to fall round the periphery of the network and, again on the Newton Burn and the Watten arms of the Wick River.

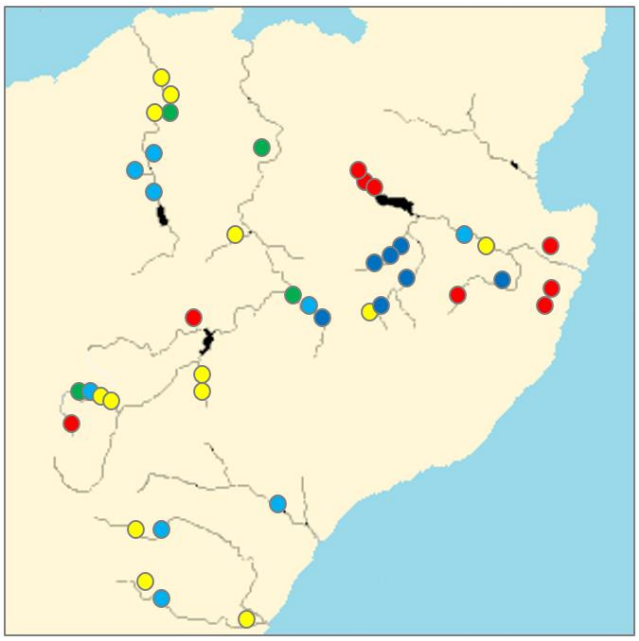


Figure 3. Geographical distribution of densities of parr as observed on 1-pass fishing. The values are colour-coded as per Table 2.

Table 5 (Appendix) shows the 1-pass values for parr for 2019 and the corresponding values for those of the sites that were repeated from 2018.

In Table 6 those sites lying outside, or on the edge of, the areas accessible to spawners have been edited out. As before, this leaves a residual set of 31 sites and these show a median 1-pass density for parr in 2019 of 0.19/m^2. The equivalent value for 2018 based on a similarly edited set of 40 sites (data taken from http://caithness.dsfb.org.uk/files/2019/04/CDSFB-EF-Report-2018.pdf) was almost the same at 0.20/m^2.

Any local differences in parr density in 2019 and 2018 can be examined in greater detail by considering the 13 sites that were surveyed in both years. Parr densities in the eight sites in rivers other than the River Forss were similar or slightly greater in 2019 than in 2018. In contrast, parr densities for all five sites on the River Forss were lower in 2019 relative to 2018 by around 30-60%.

The seemingly poor showing of parr in the Forss is unexpected because the data shown in Table 4 indicate that the density of fry there was relatively high in 2018 (noting that the NEPS site at Forsie is located on a cataract that is not suited to supporting fry).

3.2 Three-pass fishing

3-Pass electric-fishing data were obtained from 12 sites for which the ages of the parr (determined by scale reading) were also available; all the parr were either 1+ or 2+ years of age. Six of the sites were the key sites that the Board routinely surveys each year.

All the sites are listed in Table 3 along with the number of captured fish in each age category.

Table 3. Observed number of fish, by age-class as determined by scale reading

		Number of fish observed on 3-pass fishing		
River	**Location**	**0+**	**1+**	**2+**
Forss	Shurrery	9	20	8
Thurso	Rumsdale	129	63	7
	Backlass	59	7	13
	Tacher	92	70	2
	Inshag	50	20	6
Wick	Clow	290	86	4
	Scorriclet	106	44	5
	Bilbster	42	59	9
	Ingimster	25	9	3
Dunbeath	Culvid	30	67	7
Berriedale	Gobernuisgach	56	20	2
Langwell	Wag	40	70	9

Table 4 combines data for each location from Tables 3 (fish number) and Table 1 (stream channel area) to show the densities observed for each year-class.

Table 4. Observed densities on 3-pass fishing, by age-class as determined by scale reading.

		Observed density on 3-pass fishing (n/m^2)		
River	**Location**	**0+**	**1+**	**2+**
Forss	Shurrery	0.10	0.22	0.09
Thurso	Rumsdale	0.71	0.35	0.04
	Backlass	0.52	0.06	0.12
	Tacher	0.70	0.53	0.02
	Inshag	0.45	0.18	0.05
Wick	Clow	1.81	0.54	0.03
	Scorriclet	1.40	0.58	0.07
	Bilbster	0.18	0.25	0.04
	Ingimster	0.27	0.10	0.03
Dunbeath	Culvid	0.14	0.31	0.03
Berriedale	Gobernuisgach	0.43	0.15	0.02
Langwell	Wag	0.19	0.33	0.04

Efficiency of capture was estimated separately for fry or parr at each site based on the rate of decline observed in the number of fish captured on successive electric-fishing passes (ie. Zippin correction). In Table 5, values for estimated true density are shown after adjustment of the data shown in Table 4 for variations in capture efficiency.

Table 5. Estimated true densities by age-class.

		Estimated true density (n/m^2)		
River	**Location**	**0+**	**1+**	**2+**
Forss	Shurrery	0.11	0.22	0.09
Thurso	Rumsdale	0.76	0.36	0.04
	Backlass	0.55	0.07	0.13
	Tacher	0.72	0.54	0.02
	Inshag	0.48	0.19	0.05
Wick	Clow	1.85	0.56	0.03
	Scorriclet	1.43	0.60	0.07
	Bilbster	0.20	0.26	0.04
	Ingimster	0.27	0.10	0.03
Dunbeath	Culvid	0.14	0.32	0.03
Berriedale	Gobernuisgach	0.47	0.16	0.02
Langwell	Wag	0.19	0.34	0.04

Table 6 shows the average body length (fork length) of each age-class at each site. Table 6 also shows the standard deviation for those cases in which the number of fish present was sufficient to generate a meaningful value.

Table 6. Body length of each age age-classes at each site; the standard deviation is shown in parentheses.

		Body length (mm)		
River	**Location**	**0+**	**1+**	**2+**
Forss	Shurrery	60.1 (4.20)	102.2 (9.82)	120.8 (9.94)
Thurso	Rumsdale	59.1 (4.62)	96.3 (7.29)	113.7 (2.21)
	Backlass	63.7 (6.15)	104.7 (2.43)	116.7 (5.17)
	Tacher	58.0 (5.06)	94.7 (13.0)	124.0 (n/a)
	Inshag	61.0 (4.07)	97.8 (8.92)	123.8 (7.57)
Wick	Clow	55.8 (5.29)	95.0 (8.48)	125.0 (n/a)
	Scorriclet	44.6 (4.72)	76.8 (7.96)	106.4 (6.62)
	Bilbster	59.3 (6.17)	105.6 (8.63)	124.2 (3.67)
	Ingimster	61.7 (4.06)	94.5 (11.3)	121.5 (n/a)
Dunbeath	Culvid	49.2 (5.06)	88.3 (10.7)	115.0 (2.94)
Berriedale	Gobernuisgach	55.3 (5.33)	99.9 (7.89)	129.5 (n/a)
Langwell	Wag	64.7 (4.17)	105.0 (7.30)	125.0 (6.36)

The body weight of each of the individuals captured at each site was estimated according to Shackley's formula (see previous reports). The average values for estimated body weight were combined with the data shown in Table 5 to give estimates of biomass density (ie.the weight of fish per unit of stream channel area for each age-class). These values are shown in Table 7.

Table 7. Estimated biomass density by age-class. The total value for each site is also shown.

		Estimated biomass density (g/m^2)			
River	**Location**	**0+**	**1+**	**2+**	**Total**
Forss	Shurrery	0.23	2.75	1.93	**4.91**
Thurso	Rumsdale	1.54	3.65	0.69	**5.88**
	Backlass	1.45	0.92	2.46	**4.83**
	Tacher	1.38	5.44	0.46	**7.28**
	Inshag	1.08	2.04	1.15	**4.27**
Wick	Clow	3.07	5.49	0.71	**9.27**
	Scorriclet	1.17	2.94	0.98	**5.09**
	Bilbster	0.42	3.59	0.92	**4.93**
	Ingimster	0.63	0.98	0.65	**2.26**
Dunbeath	Culvid	0.16	2.53	0.54	**3.23**
Berriedale	Gobernuisgach	0.78	1.84	0.53	**3.15**
Langwell	Wag	0.51	4.58	0.95	**6.04**

The values shown in Tables 5 and 7 are used in the site assessments presented in the following section.

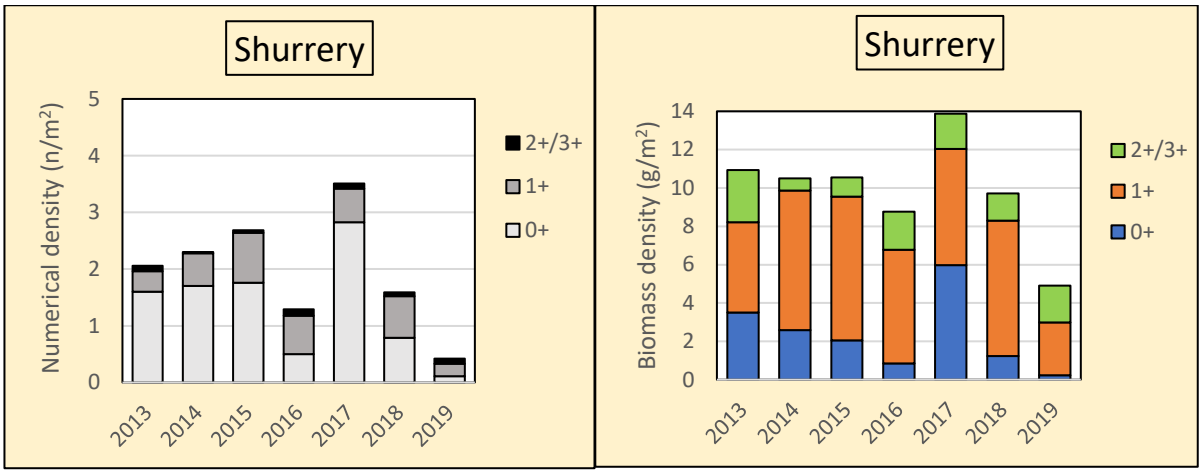
3.3 Site assessments based on 3-pass fishing

As for previous Board reports, each site is assessed below using two panels showing stacked graphs. The left-hand panel shows the numerical densities (ie. the number of fish per m^2) for fry, 1+ parr and older parr. The right-hand panel shows biomass density (ie. body weight in grams per m^2) for the same age-groups. Any data obtained for the same site in previous years is also shown. The dimensions of the graph axes are held constant across all the sites in order to aid comparison between them.

Values for 1+ and older parr are considered as a single group (“all parr”) at the Culvid, Gobernuisgach and Wag sites for 2018 only because no scale samples were obtained for age determination that year.

The average body lengths for each age-class for the six key sites that are surveyed every year are shown in the Appendix: Figure 8 shows values for fry and Figure 9 shows values for 1+ parr.

3.3.1 River Forss

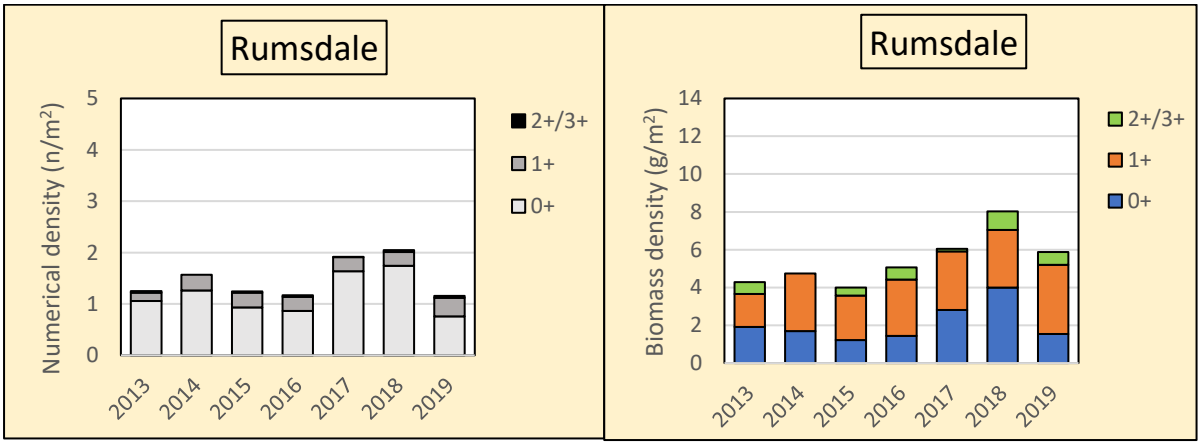


In 2019, the numerical density of fry at Shurrery was only 0.11/m^2. This was the lowest value observed so far in the annual survey series. Based on previous years, the expected value is around 1.0/m^2. The 2019 value was only about 20% of the previous lowest value (0.50/m^2 in 2016). By any measure, therefore, the shortfall in fry at Shurrery in 2019 was substantial.

The numerical density of 1+ parr in 2019 (0.22/m^2) was also the lowest so far observed and less than 50% of the average value for previous years. This is unexpected. The shortfall in 1+ parr cannot be clearly linked to the relative weakness of the fry crop in 2018 (0.79/m^2) because the even weaker crop of fry in 2016 (0.50/m^2) raised a roughly average crop of 1+ parr (0.59/m^2) in the following year. The density of 2+ parr in 2019 was as expected.

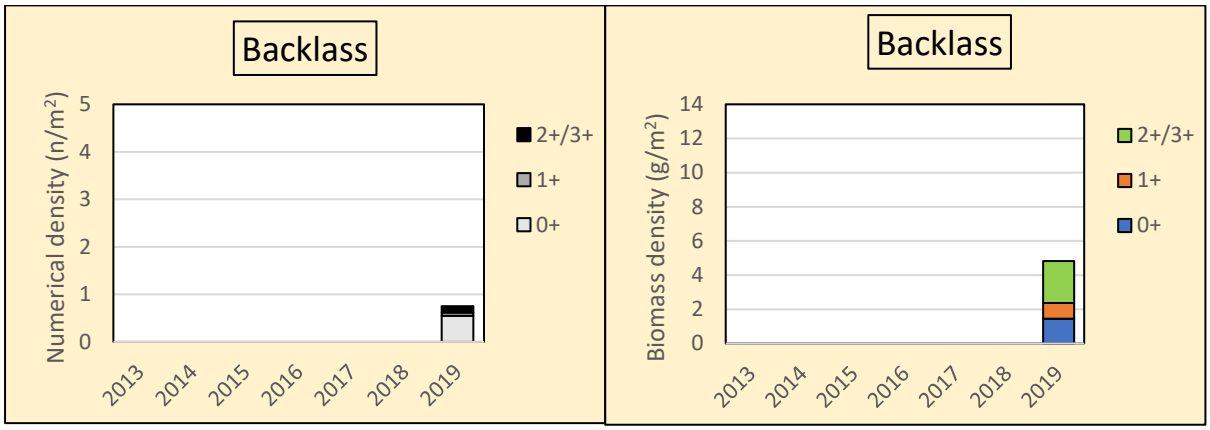
In 2019 the biomass densities of both the fry (0.23g/m^2) and the 1+ parr (2.75 g/m^2) were the lowest values observed so far; the biomass density of the 2+ parr was as expected. The total biomass density of fry and parr was 4.91g/m^2 - about 50% of the expected value.

3.3.2. River Thurso



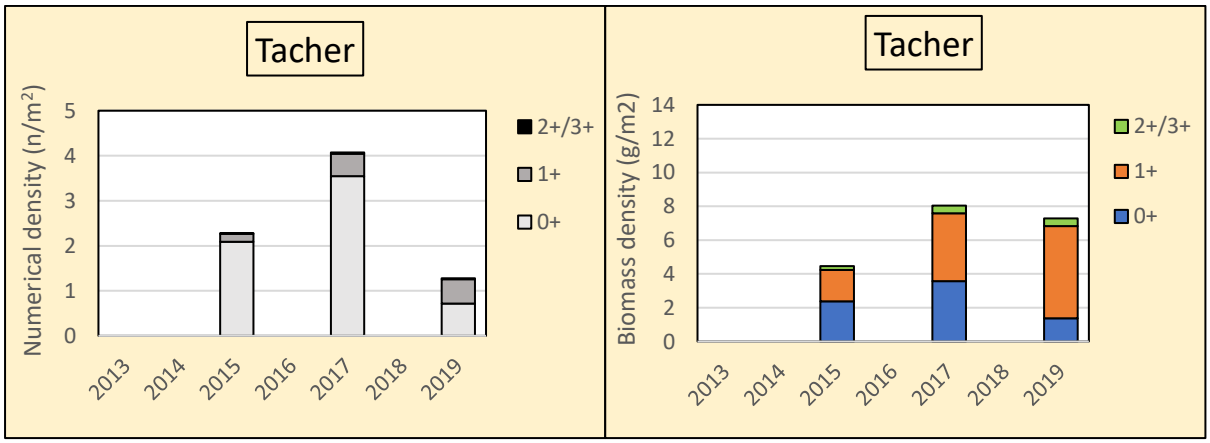
The density of fry at Rumsdale (0.76/m^2) was the lowest value observed in the time series and about 60% of the average value for previous years. However, the fry had grown relatively well (av. 59mm) and their biomass density (1.54 g/m^2) was therefore about average for the site.

The numerical density of 1+ parr (0.36/m^2) and their biomass density (3.65 g/m^2) were slightly greater than in all previous years. The total biomass density for Rumsdale was slightly better than usual being driven by the above-average contribution of the 1+ parr.

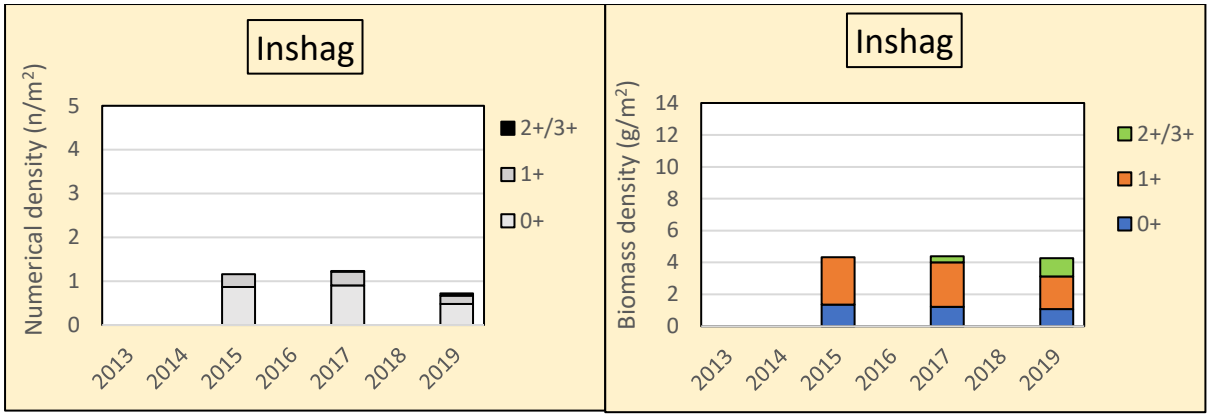


The Backlass Burn has not been surveyed previously. The stream drains an extensive catchment to the south of Loch More, including Loch Tulachan and Loch Sand. The age composition of the salmon present at the site was unusual. Fry density was modest at 0.55/m^2 (although this value may be lower than normal given the weakness of the 2019 fry crop in Caithness generally). The density of 1+ parr was very low at 0.07/m^2 - the lowest value observed at any of the 12 sites for which 3-pass data were available - but 2+ parr were well-represented relative to sites elsewhere. Both the fry (av. 64mm) and the 1+ parr (av. 105mm) were larger than those observed in most other sites. This suggests that the Backlass site may be capable of supporting greater densities of fish than those observed in 2019. Buoyed by the fishes' good growth, the total biomass density was 4.83g/m^2 which is about average for sites in Caithness.

Much of the Backlass Burn has an attractive superficial conformation (see cover photograph) but like some other streams in the area it carries a high bed-load of sandy material originating from glacial deposits lying below the peat cover. This material blocks the interstices among the larger cobbles on the streambed, smoothing the streambed profile and reducing its suitability for young fish and other aquatic life. It would be informative to survey the Backlass site again in order to establish whether the patterns observed in 2019 are typical of other years.



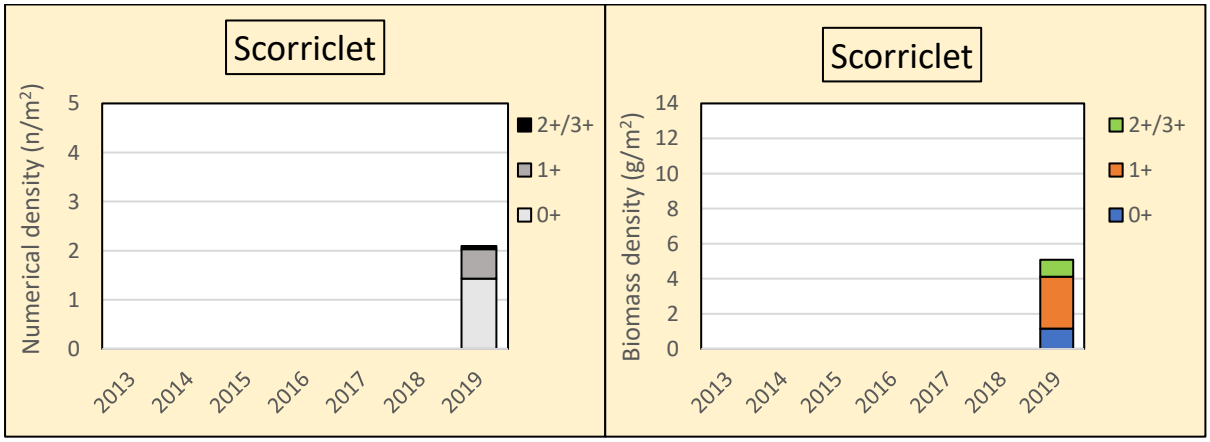
The Tacher site on the Little River was previously surveyed in 2015 and 2017. In 2019, the density of fry was lower (0.72/m^2) than previously in line with most of the other survey sites in Caithness. The densities of 1+ and 2+ parr were roughly as expected and the total biomass value (7.28g/m^2) for 2019 was only slightly less than the high value of 2017.



The Inshag site also lies on the Little River about 4km downstream from Tacher. Like Tacher, Inshag was previously surveyed in 2015 and 2017. In 2019, fry density at Inshag was lower than in previous years – as for most other sites - at 0.48/m^2. Parr values were roughly as expected and the total biomass density was also in line with previous values at 4.27g/m^2.

Over the three survey years, density and biomass density values have mostly been much less at Inshag than at the Tacher site upstream. There may be a number of reasons for the difference but the Inshag site, like the Backlass site, is adversely affected by the passage of glacial sands being eroded from below the peat cover. The Tacher site is not affected in this way.

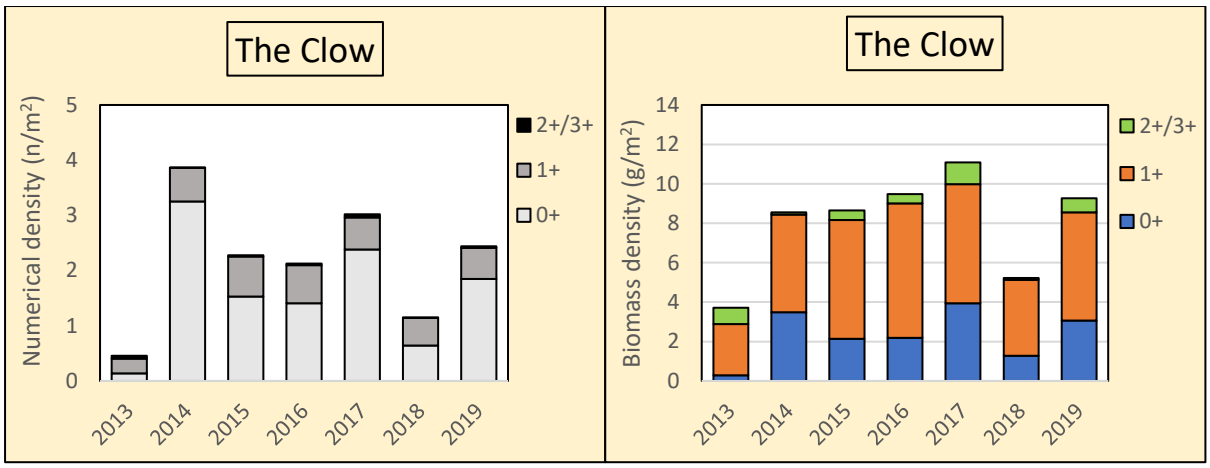
3.3.3 Wick River



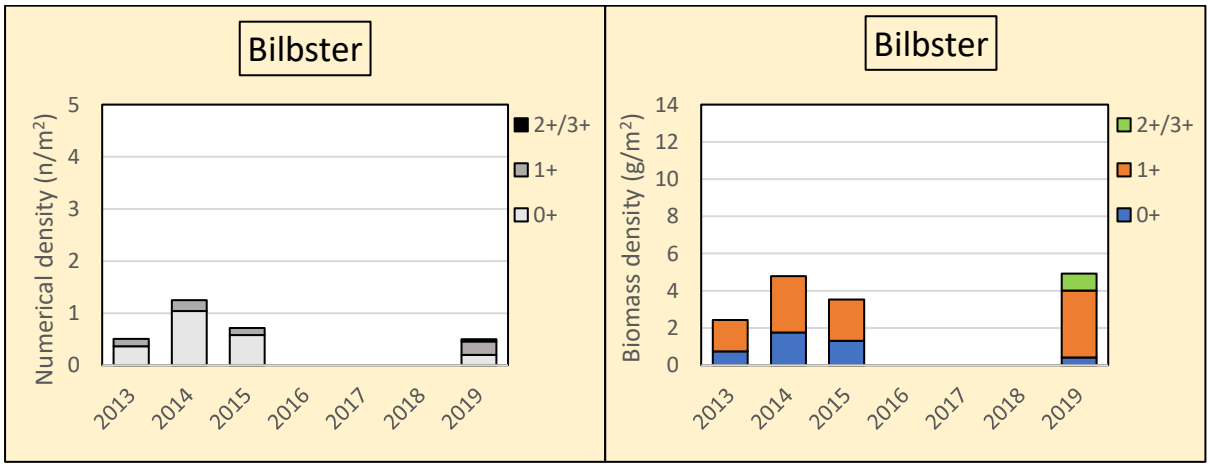
Scorriclet has not been surveyed previously. In 2019 the density of fry (1.43/m^2) at Scorriclett was second only to that at The Clow (see below); the density of 1+ parr (0.60/m^2) was the greatest observed. However, both the fry (av. 45mm) and the 1+ parr (av. 75mm) were by far the smallest encountered at any of the survey sites. Despite the fishes' high densities and because of their small

size, the total biomass density attained at Scorriclet was ca. 5g/m^2, only slightly better than the Caithness average.

The densities of fish at Scorriclet are probably unnaturally high due to repeated stocking in the vicinity of hatchery fish and the site may well be saturated. If this is the case, the biomass density measured in 2019 is likely to be close to the maximum attainable value.



The Clow is one of the key Board sites that is surveyed every year. In 2019, fry density was again high (1.85/m^2) and the greatest value observed at any of the Caithness survey sites. The density of 1+ fish (0.56/m^2) was in line with expectation based on previous years. The growth of both fry and 1+ parr was relatively good for the site and the total biomass density (9.27g/m^2), This was fully in line with values from previous years bearing in mind that the ability of fry to access the site appears to have been impeded in the summer drought years of 2013 and 2018.

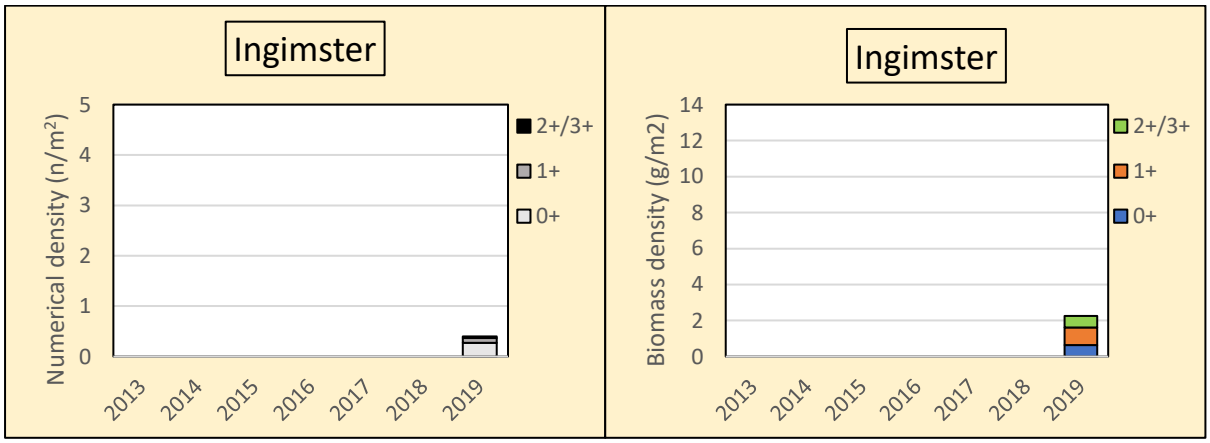


Between Watten and the sea Wick River is generally of low-gradient and mostly canal-like. The Bilbster site lies in the middle part of this section of the river. The site is one of the few places of higher gradient that appears well-suited to supporting young fish although the shortage of spawning habitat nearby may well limit recruitment.

The site was previously surveyed in 2013-15. In the interim, however, the stream channel has narrowed markedly following bankside fencing and exclusion of stock. Accordingly, stream channel width was re-measured in 2019; the channel area of the site is now estimated to be 234m^2 compared with the former value of 387m^2. This is a large change which may have affected the continuity of the time series.

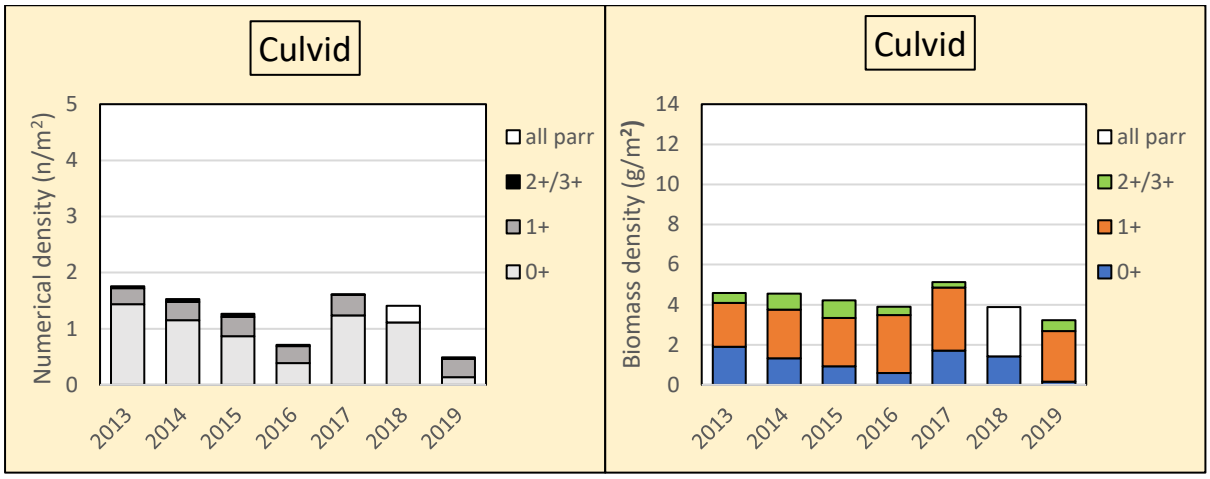
In 2019, fry density was very low at 0.20/m^2. The value was lower than for previous survey years although this may just reflect the generally poor spawning of 2018. The density of 1+ parr was greater than previously at 0.26/m^2 although the increase may be illusory due to the changed dimensions of the site. In view of the changes to the river channel, the Bilbster data set should be reset to start anew in 2019 and reviewed again if the stream channel continues to change.

Despite the poor crop of fry and given the presence of a reasonable class of 1+ parr of large size (av. 106mm) the total biomass density at Bilbster was an unremarkable 4.93 g/m^2, around average for the Caithness rivers.



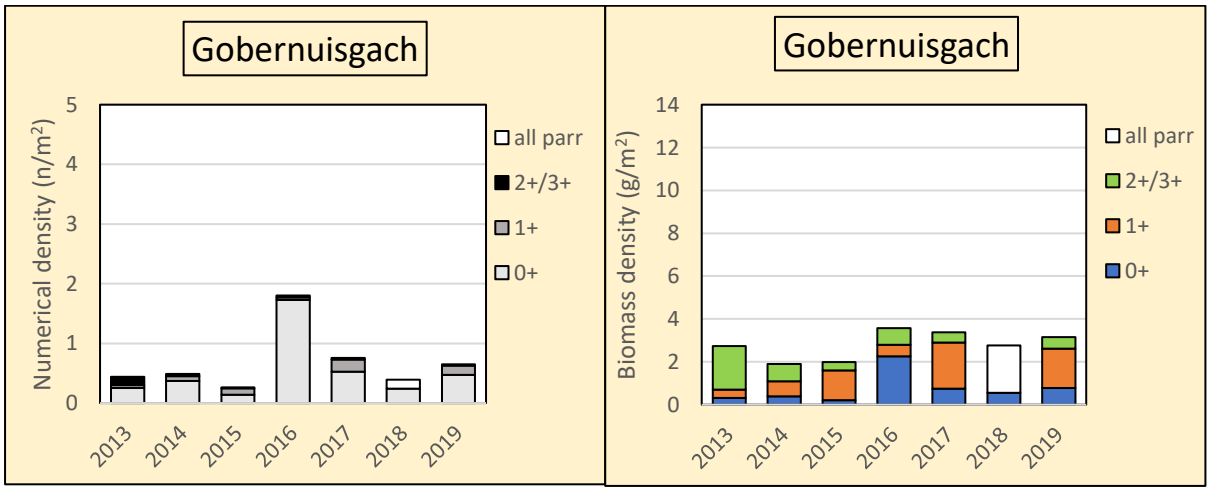
The Ingimster site has not been surveyed previously. The site is also on the mainstem of Wick River, 2km downstream of Bilbster. As for Bilbster, the density of fry was low (0.27/m^2) suggesting that spawning opportunities in the vicinity are limited. Parr also were few in number. The total biomass density was only 2.26 g/m^2 putting the site in the very lowest part of the range typical of the Caithness rivers and making it the least productive of the sites surveyed in 2019.

3.3.4 Dunbeath Water



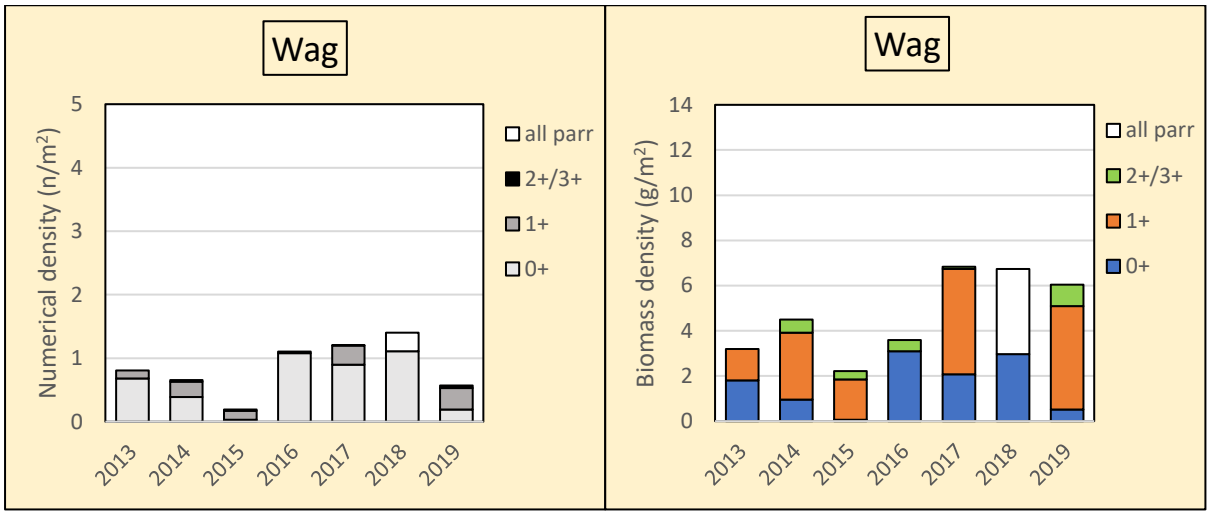
As for many of the other sites, fry density at Culvid in 2019 (0.14/m^2) was lower than for previous years although the shortfall at Culvid was extreme. The density of 1+ parr (0.32/m^2) was fully in line with expectation. Total biomass density was slightly lower than usual but only because of the dearth of fry.

3.3.5 Berriedale Water



The densities of fry (0.47g/m^2) and 1+ parr (0.16/m^2) at Gobernuisgach in 2019 were broadly in line with expectations based on previous years. Total biomass density (3.15g/m^2) was also as expected.

3.3.6. Langwell Water



As for most other sites, fry density at Wag (0.19/m^2) was lower than in previous years - excepting only 2015 which was also affected by poor spawning the previous year. In 2019, the density of 1+ parr (0.34/m^2) was better than average. The growth of fry (av. = 65 mm) and 1+ parr (av. 105 mm) was better than at any of the other Caithness sites – as has consistently been the case in previous years. Despite a weak contribution from the fry, the total biomass density for Wag (6g/m^2) was in the higher part of the range seen previously as a result of the high abundance of 1+ parr and their good growth

4. Conclusions

4.1 Overview

Following the prolonged and severe summer drought of 2018, spawning was poor throughout all of the Caithness rivers and fry densities were lower than usual in 2019.

For the large number of Caithness sites for which 1-pass data was available, the 2019 average for fry density was only about 50% of the average value for 2018.

More specifically, the average density of fry on 1-pass fishing was 0.26/ m^2 in 2019 which, assuming a 60% capture rate, is equivalent to a 3-pass value of about 0.4 fry/m^2. Again, this much less than expected based on comparisons with equivalent values cited in previous survey reports.

For single sites with several years of 3-pass data, fry densities were lower in 2019 than previously in almost every case. However, the extent of the deficit did vary substantially from site to site and Wick and Thurso Rivers appear to be least affected.

Based on previous findings, the 2019 shortfall in fry is large enough to reduce the numbers of 1+ parr that will be present in some parts of Caithness in 2020 and to reduce the number of smolts that will leave these places in 2021.

On a more upbeat note, the effects of the poor crop of fry will probably be fleeting in most cases since a strong spawning was observed for the Caithness rivers in 2019. In 2020, this new crop of fry will face less competition than usual due to the weakness of previous cohort of fish. Based on the results of previous surveys, this is likely to result in an unusually large crop of fry in 2020 and a large crop of 1+ parr in 2021. An unusually strong smolt run should then follow in 2022 - when order will be restored.

The average density of 1+ parr at all the sites covered by 1-pass fishing was 0.19/m^2 which, assuming a capture efficiency of 70% is equivalent to a 3-pass value of about 0.3/m^2. This figure compares favourably with equivalent values for previous years. This assessment is confirmed, in the main, by comparison of current and previous parr values at sites with multiple years of data.

These findings allay any residual concerns about the possible adverse effects of the extremely low water levels and high river temperatures that the fish experienced during the drought in 2018.

4.3 Forss

The overall picture of parr densities is favourable but the general picture obscures a striking local anomaly on the River Forss. Here, the density of parr in 2019 was substantially reduced (by 30-60%) relative to 2018 values for all five Forss sites that were surveyed in both years.

Data is available for every year since 2013 at the key Board site of Shurrery; in 2019 the density of 1+ parr was substantially lower at Shurrery than in any previous year. The density of 1+ parr was also much lower than expected given the density of fry the previous year, as Figure 4 below shows.

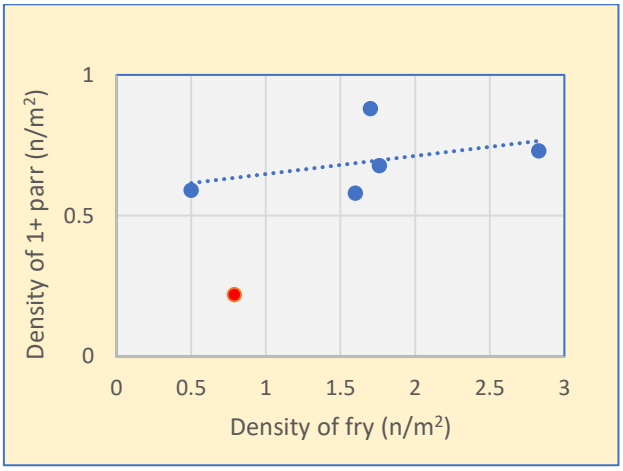


Figure 4. Relationship between fry density and 1+ parr density in the following year at the Shurrery survey site. Data for fry 2013 to 2017 versus 1+ parr 2014 to 2018 are shown in blue; the 2018 fry versus the 2019 1+ parr is shown in red.

It can be seen that between 2013 and 2017, fry densities varying from 0.5 to 2.8/m^2 generated 1+ parr densities ranging from 0.6 to 0.9/m^2 by the following year. The low anomaly for the 1+ parr generated from the fry of 2018 is shown in red. The density of 1+ parr in 2019 was about 30% of the expected value based on comparison with the five previous years.

The anomaly at Shurrery, and for Forss generally, is probably due to the accidental closure of the dam outlet at Loch Shurrery in late August 2018. The 2018 survey of the Forss sites was completed on 28th August, when fry and parr levels at all the survey sites were found to be favourable. Shortly thereafter the outlet from Shurrery dam was reportedly closed, cutting off the lower river from its upper catchment and reducing the river's flow. The problem was eventually rectified when the alarm was raised on the lower river due to the loss of flow there.

Bearing in mind that the river was in any case very low due to the drought, the sudden interruption of the passage of water through the dam may well have killed fish living downstream through stranding and through reduced the oxygen availability.

The reaches of the main river just below the dam (including the Shurrery site 500m below the dam) are likely to have been most affected. Inputs from tributary streams and seepage from the peatlands may have partially protected the lowermost reaches of the river from the effects of the dam closure. However, this effect was probably slight given the severity of the prior drought and, indeed, it was a marked drop in flow in the lower river that caused the alarm to be raised.

Any extra mortality caused by the dam closure would explain how relatively favourable fry levels at survey in 2018 were transformed to anomalously low parr levels a year later.

Furthermore, if fry died as a result of the dam closure it must be considered that parr were affected in the same way. It is not possible to test this possibility or to quantify any effect because those fish that were parr in 2018 left the river as smolts in April/May, 2019 – several months before the 2019 survey took place.

4.3 Wick River mainstem

One of the goals for the 2019 survey was to obtain representative information for the mainstem of Wick River between Watten and the sea. This section of river does not constitute prime habitat for young salmon since it is of uniformly low gradient and much of it is canal-like. In the event, continuously high water in 2019 prevented a comprehensive survey but sites at Bilbster and Ingimster were fished. These sites are not typical of the river as a whole in being shallower, faster-flowing and seemingly more suited to supporting young salmon than the deeper, slower reaches elsewhere.

Based on the survey findings and on additional data for the Bilbster site in 2013-15, the productivity of mainstream sites on Wick River is probably limited by the lack of spawning habitat and consequent low recruitment of fry. The density of parr of all ages was 0.30 m^2 at Bilbster and 0.13/m^2 at Ingimster, both in the lower part of the Caithness range.

However, the river is about 16km long between Watten and the sea and, assuming (conservatively) an average width of 5m, the area of stream potentially available to young salmon is around 80,000 m^2. Therefore, even if Ingimster is more typical of the river as a whole than Bilbster, the main river may produce ca. 10,000 parr - equivalent to ca. 500 adult fish if the return on the parr is 5%.

It is possible, therefore, that the mainstem of Wick river is a substantial asset. It will be worthwhile testing this in a year when survey conditions are more favourable.

Acknowledgements. Many thanks are due to those who took part in the survey work at various times – John Bain, Neil Groat, Jamie Loughlin, David Mackay, John Mackay, David Miller, Matthew Miller, Jamie McCarthy, Pat Quinn and Gordon Warren

Appendix

Table 3. *Classification of all 2019 sites by salmon fry densities observed on 1-pass electric-fishing. Equivalent values for 2018 are shown for sites that were surveyed in both 2018 and 2019. The colour codings are as per Table 2. The observed value for 1-pass density (n/m^2) is included in each cell.*

River	Location	2018	2019
Forss	Shurrery	0.52	0.06
	Torigil Burn		0.01
	Broubster	0.86	0.35
	Forsie	0.01	O.09
	Forsie 1		0.04
	Westfield	2.22	0.23
	Lythmore 1	0.44	0.16
Thurso	Craggan Burn		0.00
	Rumsdale 4		0.66
	Rumsdale	1.10	0.45
	Rumsdale 2		0.58
	Rumsdale 3		0.19
	Backlass 1		0.48
	Backlass		0.33
	Gaineimh	0.01	0.00
	Tacher		0.50
	Inshag 1		0.14
	Inshag		0.31
	Olgrinmore 1		0.09
	Gerston Burn		0.02
Wick	Bower 1	0.00	0.00
	Bower 2	0.00	0.00
	Quoynee		0.00
	Winless		0.00
	Shielton		0.84
	Acharole 4		0.71
	Clow	0.40	1.30
	Munsary Burn		0.00
	Munsary		0.59
	Scorriclet		1.03
	Achairn Forest		0.01
	Puldagon	0.97	0.67
	Humster		0.00
	Thrumster		0.02
	Bilbster		0.11
	Ingimster		0.16
Dunbeath	Culvid	0.73	0.11
Berriedale	Gobernuisgach	0.24	0.28
	Corrrichoich 1	0.31	0.17
Langwell	Wagmore Burn		0.00
	Wag	0.58	0.12
	Langwell Policies	0.04	0.02

Table 4. *Edited version of Table 3 in which NEPS sites outside the range of spawning salmon are excluded.*

River	Location	2018	2019
Forss	Shurrery	0.52	0.06
	Torigil Burn		0.01
	Broubster	0.86	0.35
	Forsie	0.01	O.09
	Forsie 1		0.04
	Westfield	2.22	0.23
	Lythmore 1	0.44	0.16
Thurso	Craggan Burn		
	Rumsdale 4		0.66
	Rumsdale	1.10	0.45
	Rumsdale 2		0.58
	Rumsdale 3		0.19
	Backlass 1		0.48
	Backlass		0.33
	Gaineimh		
	Tacher		0.50
	Inshag 1		0.14
	Inshag		0.31
	Olgrinmore 1		0.09
	Gerston Burn		0.02
Wick	Bower 1		
	Bower 2		
	Quoynee		
	Winless		
	Shielton		0.84
	Acharole 4		0.71
	Clow	0.40	1.30
	Munsary Burn		
	Munsary		0.59
	Scorriclet		1.03
	Achairn Forest		
	Puldagon	0.97	0.67
	Humster		
	Thrumster		
	Bilbster		0.11
	Ingimster		0.16
Dunbeath	Culvid	0.73	0.11
Berriedale	Gobernuisgach	0.24	0.28
	Corrrichoich 1	0.31	0.17
Langwell	Wagmore Burn		
	Wag	0.58	0.12
	Langwell Policies	0.04	0.02

Table 5. *Classification of all 2019 sites by salmon parr densities observed on 1-pass electric-fishing. Equivalent values for 2018 are shown for sites that were surveyed in both 2018 and 2019. The colour codings are as per Table 2. The observed value for 1-pass density (n/m^2) is included in each cell.*

River	Location	2018	2019
Forss	Shurrery	0.56	0.26
	Torigil Burn		0.27
	Broubster	0.35	0.24
	Forsie	0.17	0.09
	Forsie 1		0.18
	Westfield	0.20	0.08
	Lythmore 1	0.16	0.09
Thurso	Craggan Burn		0.00
	Rumsdale 4		0.19
	Rumsdale	0.25	0.27
	Rumsdale 2		0.16
	Rumsdale 3		0.18
	Backlass 1		0.16
	Backlass		0.12
	Gaineimh	0.00	0.00
	Tacher		0.41
	Inshag 1		0.20
	Inshag		0.14
	Olgrinmore 1		0.17
	Gerston Burn		0.14
Wick	Bower 1	0.00	0.00
	Bower 2	0.00	0.00
	Quoynee		0.00
	Winless		0.00
	Shielton		0.08
	Acharole 4		0.30
	Clow	0.44	0.48
	Munsary Burn		0.04
	Munsary		0.22
	Scorriclet		0.46
	Achairn Forest		0.03
	Puldagon	0.20	0.33
	Humster		0.01
	Thrumster		0.00
	Bilbster		0.20
	Ingimster		0.08
Dunbeath	Culvid	0.22	0.25
Berriedale	Gobernuisgach	0.11	0.11
	Corrrichoich 1	0.23	0.27
Langwell	Wagmore Burn		0.08
	Wag	0.23	0.27
	Langwell Policies	0.14	0.11

Table 6. *Edited version of Table 5 in which NEPS sites outside the range of spawning salmon are excluded.*

River	Location	2018	2019
Forss	Shurrery	0.56	0.26
	Torigil Burn		0.27
	Broubster	0.35	0.24
	Forsie	0.17	0.09
	Forsie 1		0.18
	Westfield	0.20	0.08
	Lythmore 1	0.16	0.09
Thurso	Craggan Burn		
	Rumsdale 4		0.19
	Rumsdale	0.25	0.27
	Rumsdale 2		0.16
	Rumsdale 3		0.18
	Backlass 1		0.16
	Backlass		0.12
	Gaineimh		
	Tacher		0.41
	Inshag 1		0.20
	Inshag		0.14
	Olgrinmore 1		0.17
	Gerston Burn		0.14
Wick	Bower 1		
	Bower 2		
	Quoynee		
	Winless		
	Shielton		0.08
	Acharole 4		0.30
	Clow	0.44	0.48
	Munsary Burn		
	Munsary		0.22
	Scorriclet		0.46
	Achairn Forest		
	Puldagon	0.20	0.33
	Humster		
	Thrumster		
	Bilbster		0.20
	Ingimster		0.08
Dunbeath	Culvid	0.22	0.25
Berriedale	Gobernuisgach	0.11	0.11
	Corrrichoich 1	0.23	0.27
Langwell	Wagmore Burn		
	Wag	0.23	0.27
	Langwell Policies	0.14	0.11

Table 8.

Average body length of fry in 2019 (blue bars). The average body lenths in previous years (2013-18) are shown by grey bars.

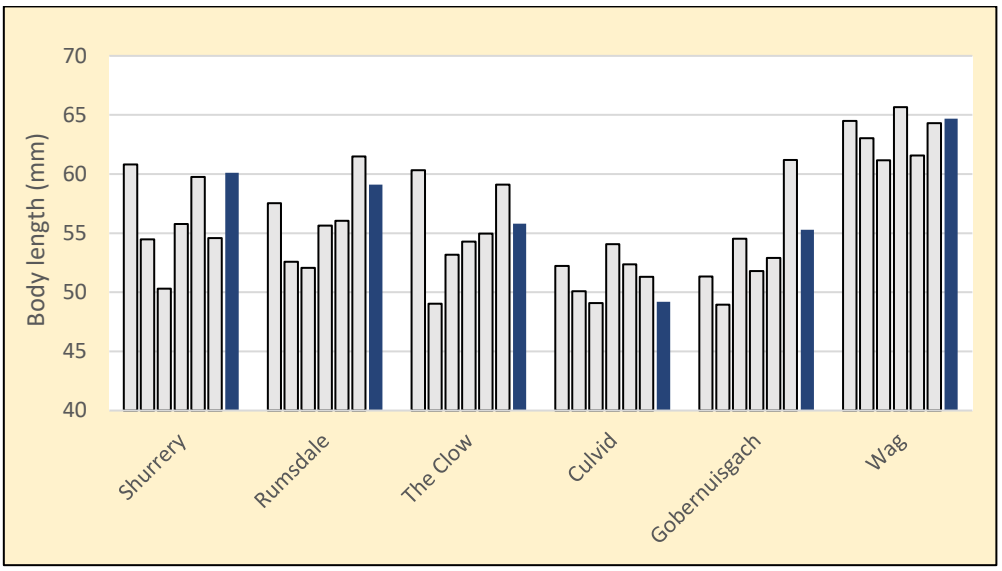


Table 9.

Average body length of 1+ parr in 2019 (blue bars). The average body lenths in previous years (2013-18) are shown by grey bars.