



The *Tweed* Foundation

for the *good* of the river



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The Conservation Case  
for  
Tweed Spring Salmon

Prepared by The Tweed Foundation  
for the River Tweed Commission  
May 2018

## SUMMARY

- 1 The Spring Salmon of the Tweed system have a variable history, dominating at times and then existing as a minor component in between.
- 2 Radio-tracking in the mid-1990s showed that there are two major Spring Salmon populations in the Ettrick (old established) and the Whiteadder (new, recently recolonised after opening up of obstacles). This and other observational evidences also show minor populations in the Upper Tweed, Gala, Teviot and Till.
- 3 None of these populations will be in breeding contact with any of the others as they are separated by later running populations in the lower zones of tributaries and in the main stem. This means that the Spring Salmon of the Tweed are fragmented into two major and at least four minor populations and some of the latter could be very small.
- 4 That stock diversity as well as numbers should be a management aim is stated in Verspoor *et al* (2007) where it is recommended to "*Maintain salmon populations at their largest possible size in order to retain genetic variation and adaptive potential, especially in the case of small populations inhabiting extreme, marginal, habitats*". In a constantly changing environment, a population-type only able to hang on in some marginal habitat under present conditions could be the best for some future environment and become a dominant stock. Indeed, such present-day marginal stocks might be survivors from past times when they were the dominant under different conditions that could well come around again.
- 5 During the last Spring Salmon dominated phase (c.1920 - c.1960) a much greater area of the catchment must have produced Spring Salmon than now does so. This means that those areas / populations that still do so are of particular value as they represent the "hard" Spring Salmon stocks that can retain the early running characteristic when others have lost this.
- 6 In recent years, the great majority of Spring Salmon have been five years old (2.2s), though this appears to be changing, with more three sea-winter (3SW) fish and two sea-winter (2SW) fish that smolted at just one year old (1.2s).
- 7 A past five year periodicity in low Spring catches reflected this age pattern and showed that reduced catches in one season predicted reduced Spring catches five years later. This is taken to mean that these low catches indicated stocks so low that recruitment to the next generation was reduced, causing another season of low catches.
- 8 The catch totals in these cycle years are therefore empirical evidence of when stocks are so low that recruitment into the next generation is affected, and so define the Management Targets for Tweed Spring Salmon.

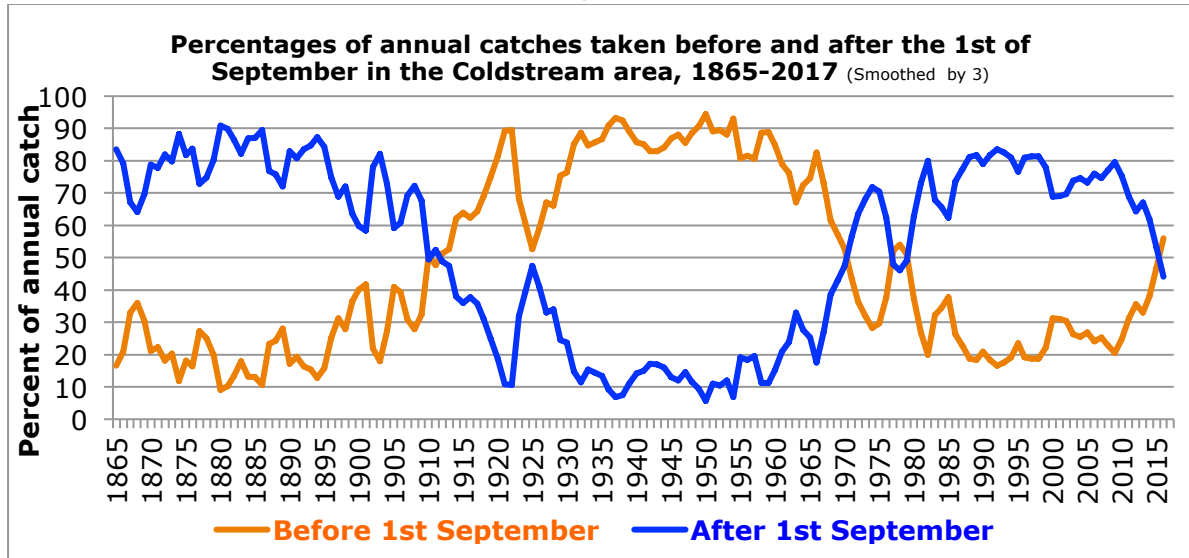
- 9 For the February to June period, the bottom line is 400 fish (as a round number) caught on the Middle Tweed. Catches at or below this level are indicators of stocks so low that recruitment in to the next generation is likely to be affected.
- 10 This baseline has not been met in four of the last 10 years (and 2018 is unlikely to make it).
- 11 At the top of the Ettrick where the earliest running fish would be expected to spawn, fish counter and electro-fishing data indicated that juvenile production is already limited by the number of spawning adults returning to it.
- 12 Angling exploitation rates of February to June salmon are estimated to be around 30%. If applied to Middle and Lower Tweed rod catches, these give population estimates of around 5,000-7,000 fish for the whole catchment. About half of this total would appear to come from the Ettrick, based on the numbers counted at the Selkirk fish counter.
- 13 The remaining number will be split between the other stocks, meaning that breeding populations of early salmon in some areas will be of very small numbers indeed. This creates the risk therefore that, by chance, an entire small stock could be destroyed for a year by a few sweeps of a net.
- 14 Tagging of fish, both Spring and Autumn at the estuary nets has shown that of those caught by anglers upstream, 56% are caught within one month of tagging and 89% within 2 months. If netting ended in May and as rod fishing is completely Catch and Release till the end of June, any fish not caught by nets would only be at risk of being killed by anglers after June 30th, when even the latest May fish would have been a month in the river and therefore have lost more than half their catchability.

## **BACKGROUND**

### **A: The history of Spring Salmon on the Tweed**

- 1 The evidence is that Spring Salmon do not form a consistent part of the stocks of the Tweed over the long-term, but instead have phases in which they dominate. It is well known that Spring Salmon formed the majority of Tweed rod catches from c.1920 to c.1960 and Fig A.1 below shows how the bulk of catches were made before 1<sup>st</sup> September during this period. There is also evidence for a previous Spring Salmon phase in the latter part of the 18<sup>th</sup> century when Salmon catches at the Sandstell netting station outnumbered Grilse.

Fig A.1:



2 Outside their phases of dominance, Spring Salmon form only a minor component of the stocks of the Tweed, so care has to be taken to compare like with like. Spring Salmon catches cannot be compared across the boundaries of such phases, they can only be compared within or outside of such periods. A convenient starting point for catch record analyses of Spring Salmon in the recent, Autumn-dominated phase, is therefore 1970 as the transition from the Spring-dominated phase of c.1920 to c.1960 to that situation had been fully completed by then.

**B: Geographic locations of Spring Salmon stocks within the Tweed catchment**

3 The present distribution of Spring Salmon stocks was shown by radio-tracking work carried out by the Tweed Foundation and the then SOAFD from 1994-96, the results of which are summarised in Map I (page 14). They are divided in to at least six, geographically separated, stocks: two major (Ettrick and Whiteadder) and four minor (Upper Tweed, Teviot, Gala/Leader and Till) – and there is probably further division within the many tributaries of the Teviot and the Upper Tweed.

4 The picture therefore is of a number of independent (in the sense of not interbreeding) populations of Spring Salmon in the upper zones of the tributaries separated from one another by populations of Summer and Autumn fish in the main channel and to an unknown extent in the lower zones of the tributaries. Some of these isolated populations could be very small indeed.

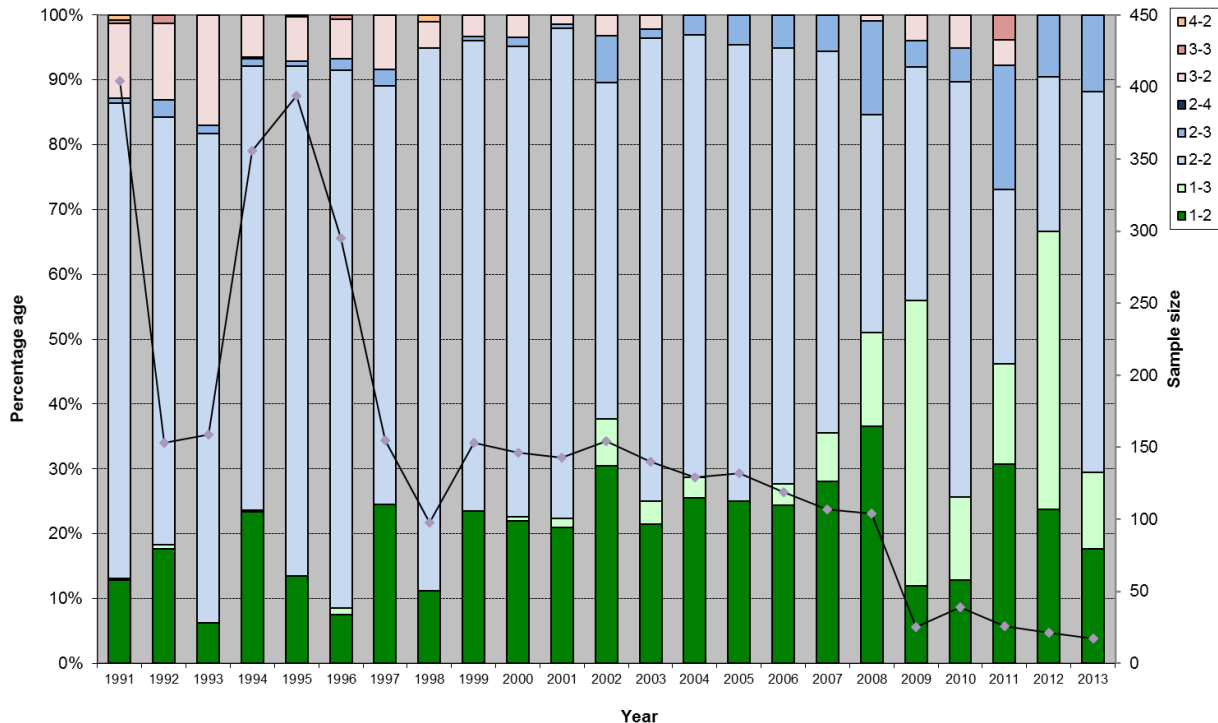
5 The fishery of the Middle Tweed is almost entirely dependent on Ettrick fish with the Lower Tweed having wider support, from the Ettrick, Whiteadder, Till and Teviot populations. Whether or not there are Spring Salmon populations in the Leader Water is unclear.

**C: The age structure of Tweed Spring Salmon**

6 In terms of sea age, the overall picture is that Tweed Spring Salmon were overwhelmingly two 2.2 fish (two winters in the river, two in the sea) till around 2006

when three Sea-winter fish became much more common, as did one river winter fish (1.2 & 1.3). Three sea-winter fish are not now necessarily larger than 2SW fish. The results of scale-reading are shown in Fig C.1, where the pale-blue parts of the columns show the proportion of 2.2 fish, the pale green the 1.3 fish and the dark green the 1.2 fish.

Fig C.1: The types of Spring Salmon from 1991 as shown by scale reading



Scale samples from Spring Salmon have become increasingly fewer since the introduction of partial Catch and Release in 1998, so later data is less robust than earlier.

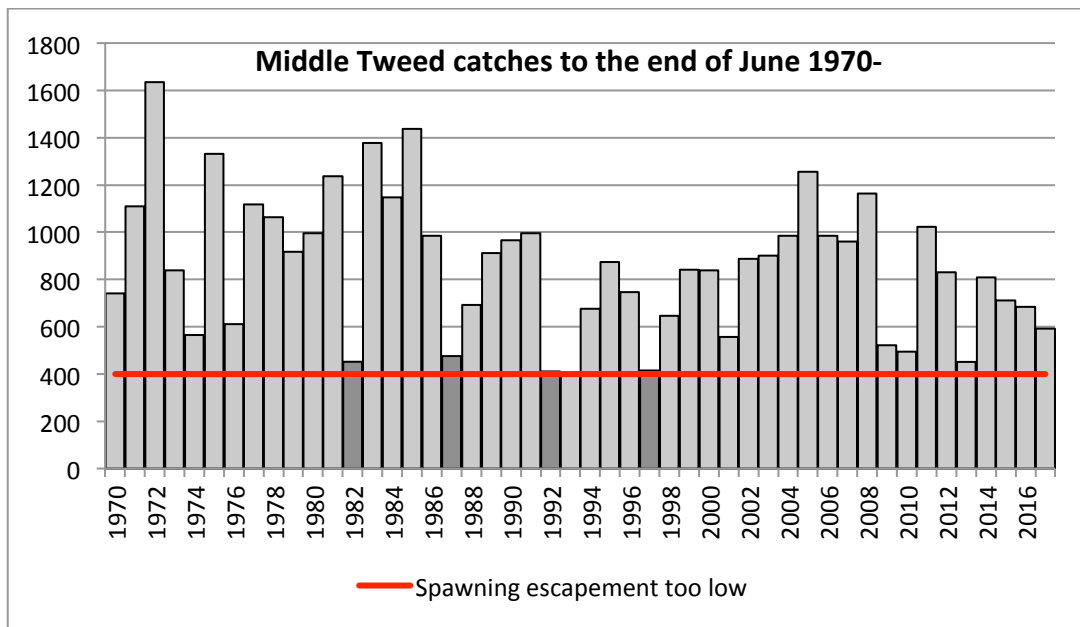
## D The Ettrick Spring Salmon stock

- 7 As shown by the radio-tracking results shown in Map I (p. 13), the Ettrick is the main source of the Spring Salmon that run the river upstream of the Whiteadder, making it the most important early-season stock in the catchment. Spring catches on the middle Tweed will therefore largely reflect the Ettrick stock, as the Upper Tweed and those of the Gala and (possibly) Leader are minor stocks – only five fish were tracked back to those rivers, so the very high proportion of these that were Spring and Summer fish do not actually represent large stocks.
- 8 The catches on the Middle Tweed to the end of June are shown in Fig D.1 and it can be seen that for a period of 20 years or so in the 1980s and 1990s there was a five-year period between a series of low catch years (darker columns in the diagram), starting in 1982, five years after the massive flood on the Ettrick on 31<sup>st</sup> October / 1<sup>st</sup> November 1977. The significance of five years is apparent from Fig C.1 which shows that in the 1990s Spring Salmon were very largely 2.2 fish (two river winters, two sea-winters plus one winter in the gravel as eggs = five years total age) – there is no scale reading data for the 1980s.
- 9 The implication of this is that the stock was so badly damaged by the 1977 flood, which occurred just at peak Spring Salmon spawning time that it fell below the

numbers required to fully stock its nursery areas five years afterwards and failed to do so for the its next three generations.

- 10 This seems to be contrary to the concept that reduced spawning results in increased survival of juveniles so restoring a stock within one generation, but in the 1980s and 1990s exploitation of Spring Salmon was heavy. Not only were almost all rod-caught fish killed and catch rates for Spring Salmon are much higher than for other runs – the estimate for the Tweed is 30% (see Para 22) and rates of 40% have been found on the Welsh Dee (Davidson *et al*, 1996), but there was also early season netting. Both the Northumberland drift and coastal nets started operations in March, while the Tweed coastal, estuary and river nets started in mid-February. Twelve river netting stations closed in 1986/87 leaving most netting effort in the estuary. Netting in February and March generally stopped in 1985 on the Tweed, and April and May netting in 1998. These levels of exploitation would have hindered a damaged generation in its recovery.

Fig D.1: Catches on the Middle Tweed to the end of June from 1970



(Figures to the end of June are used here, to give May-entry fish time to reach the Middle Tweed)

- 11 These five yearly low rod catch levels for 1982 to 1997 therefore give a practical target for the management of the Spring stocks - when rod catches fall to these levels, it is an indication of stocks too low for full spawning of their nursery areas (if there are no other explanations, such as low river flows for them). **This baseline is 400 fish caught on the Middle Tweed before the end of June (red line on Fig D.1)**
- 12 The repetition of this cycle stopped when low Spring catches did not occur, as might have been expected, in 2002 though this year, in fact, had a somewhat lower proportion of five year old fish (2.2s) than the years around it (Fig C.1) suggesting

there was still some effect but disguised by increased numbers of four and six year old fish.

- 13 During the period of increasing catches from 2002 to 2008 (Fig D.1) it was thought that the conservation measures taken in 1998 (partial catch and release, restrictions on lures) had succeeded in stabilising the Spring stocks. However, in 2009, 2010 & 2013 catch levels of around 400 returned, indicating that stocks were again falling too low for full spawning to be presumed, and that therefore further conservation measures were required.
- 14 The low catches of 2009 and 2010 did not, however, mean poor catches five years later on in 2014 and 2015 as Spring Salmon are no longer so concentrated in the five year age group - the increase in numbers of fish of other ages is shown in Fig C.1. This reduces the impact of poor spawning of any one year-class on the numbers returning in a single year. With Catch and Release, however, too few scale samples are now available for Spring Salmon for their age composition to be properly tracked.

### The Ettrick fish counter data and population modelling

15 Fish Counter data:

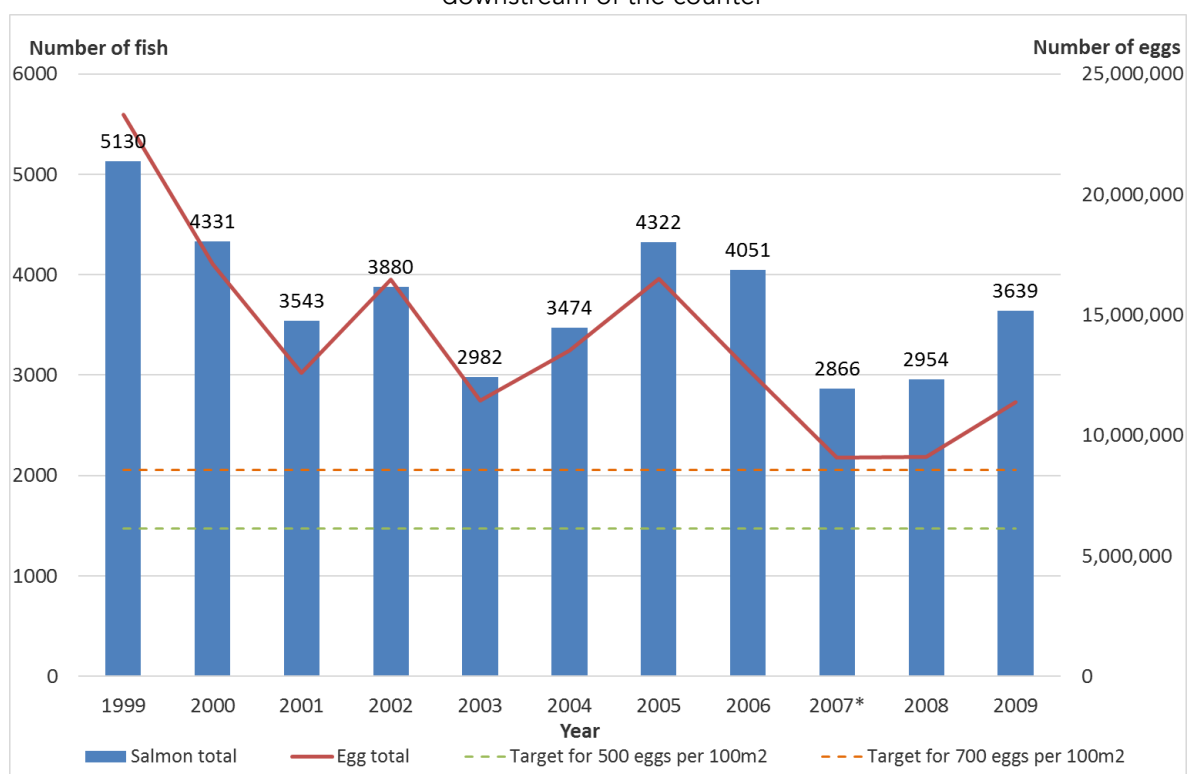
A VAKI fish counter was installed in the fish ladder of the Murray Cauld on the Ettrick (at Selkirk) in 1998 (results in Table D.1) which as well as counting fish could measure their length. In 2005 a video chamber was added so that fish could be directly identified to species from pictures and its data was used to re-calculate species proportions from before 2005. While a few Sea-trout could get over the face of this cauld in exceptional circumstances, the count can be considered as complete for Salmon.

Table D.1: Monthly salmon counts of the Ettrick fish counter

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
<b>1999</b>	0	0	0	31	160	200	23	15	1978	1981	705	37	5130
<b>2000</b>	21	3	0	50	68	379	39	471	1957	1037	294	12	4331
<b>2001</b>	0	0	0	4	6	9	55	346	759	2036	279	49	3543
<b>2002</b>	12	0	0	15	431	315	73	351	786	858	1011	28	3880
<b>2003</b>	-1	0	0	24	304	0	89	53	53	944	1498	18	2982
<b>2004</b>	0	0	2	14	82	90	147	562	1437	940	186	14	3474
<b>2005</b>	0	0	12	12	184	165	2	101	1302	2008	253	283	4322
<b>2006</b>	39	1	0	0	238	122	54	40	1962	1319	265	11	4051
<b>2007</b>	1	0	0	18	98	0	0	111	638	1597	373	30	2866
<b>2008</b>	3	0	1	6	43	91	44	45	763	1655	303	0	2954
<b>2009</b>	0	0	0	4	164	78	62	300	363	2404	236	29	3640
<b>Total</b>	75	4	15	178	1778	1449	588	2395	11998	16779	5403	511	41173
<b>Percent</b>	0.2	0.0	0.0	0.4	4.3	3.5	1.4	5.8	29.1	40.8	13.1	1.2	100
<i>This whole-year data series ended in 2009 when there were various technical problems with the counter and it was removed</i>													

- 16 As Table D1 shows, most fish pass through in September and October, though the radio-tracking has shown that the majority are Spring and Summer Salmon and entered the river earlier in the year. Peak spawning time in most of the Ettrick is the first week of November. Fish coming in later will therefore not be part of the main population, and the numbers passing upstream drop off sharply in November. In 2002 and 2003 however, there were significant numbers counted in that month but the bulk of these were in the first week and were probably "overspill" from October rather than actual, late-running, November fish.
- 17 Excluding the years 2002 and 2003, which had different run patterns from all other years, the average number of Salmon counted through before the end of October is 3597. Not all these fish will be Spring Salmon – there is also a good run of Summer Salmon in to the Ettrick and late spawning fish occupy a few kilometres upstream of the counter, to the Prison Linns at Ettrickbrigend.
- 18 Population modelling of Ettrick Salmon  
 The Salmon counts at the Ettrick counter can be converted to egg numbers using the fish-length / egg-number relationships for Tweed Salmon and an estimated sex ratio of 55% (female) to 45% (male). This estimated number of eggs carried upstream through the counter can then be compared to a target of 500 or 700 eggs per 100 m<sup>2</sup> for the area of streambed upstream of the Ettrick counter, which has been calculated from aerial photographs. This gives a target of 6,125,180 eggs for a 500 eggs per 100m<sup>2</sup> of streambed rating and 8,575,252 eggs for a 700 eggs per 100m<sup>2</sup> rate. As Fig D2 shows, the estimated egg deposition exceeded both target levels every year, although the deposition levels in 2007 and 2008 were very close to the 700 eggs per 100m<sup>2</sup> target.

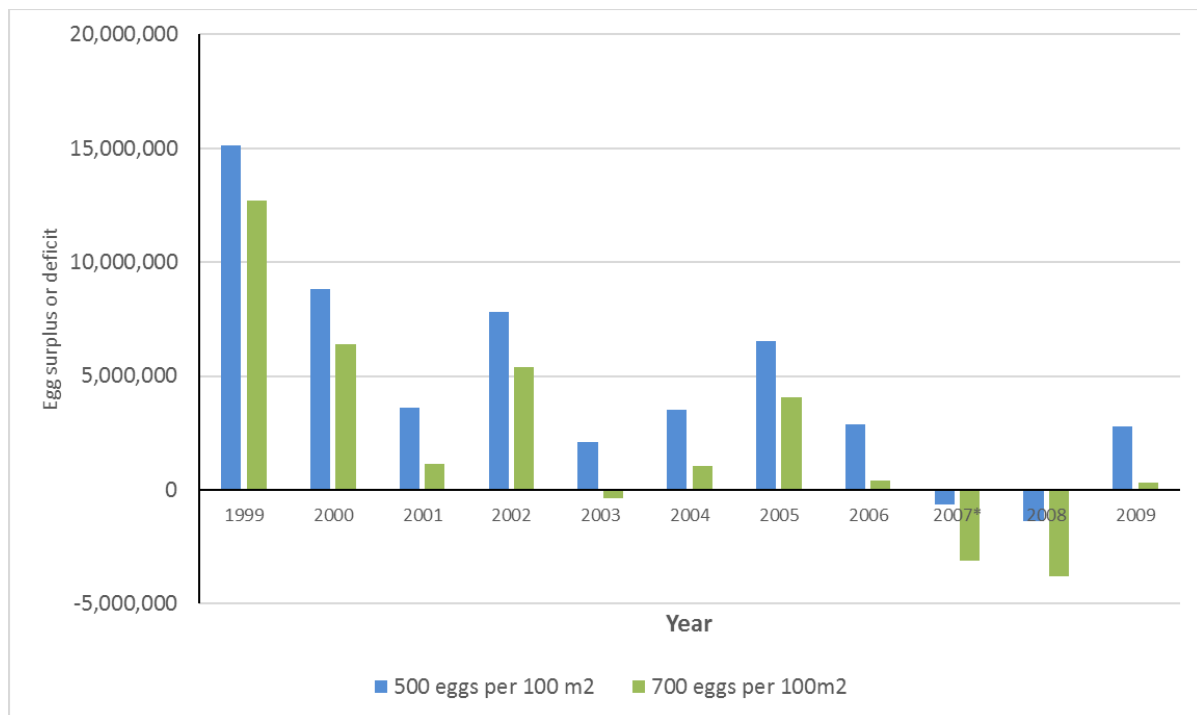
Fig D.2: Spawning targets for the Ettrick, including fish caught and released downstream of the counter





However the contribution of the Ettrick fish caught and released downstream of the counter has to be accounted for as well. The numbers of Ettrick salmon caught and released in the Middle and Lower Tweed can be estimated using historic radio tracking data, from which 50% of lower river Spring salmon are estimated to be Ettrick fish and 80% of middle river (with lower percentages later in the season). The effect on the two spawning targets if all of these released fish had been killed can then be estimated (Fig D.3). In this scenario, however, there are deficits in 2007 and 2008 for both targets and another a small deficit in 2003 for the 700 eggs per 100 m<sup>2</sup> target. It is also apparent though, that the surpluses over the targets are generally decreasing over this period. Given the uncertainties and assumptions that have to be made in any modelling, this is a sign that careful management of the Ettrick Spring Salmon populations is required. (*Appendix I shows the numbers used in this.*)

Fig D.3: Surplus of eggs over spawning targets for the Ettrick, not including fish caught and released downstream.



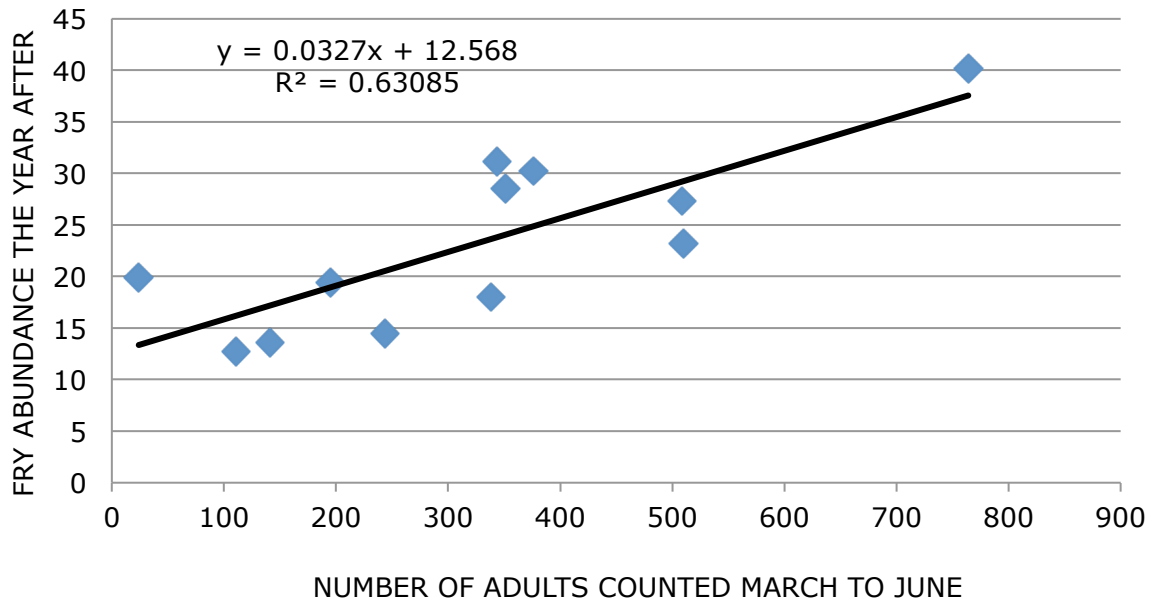
19 Juvenile Salmon abundances in the Ettrick:

From 1997 to 2012 (excluding 2000 & 2011 due to high water) an average of 81 Fry Index sites along the Ettrick were sampled using the method of Crozier and Kennedy (1994) (five minutes downstream electric-fishing in shallow water). This was done to build up a data series of adult numbers counted in one year and the resulting fry abundances and distribution in the next. *This data series will be resumed with the new fish counter installed in the Murray Cauld fish-pass in 2018.*

20 While no overall relationship was found between total adult numbers and fry abundances in general during this period, a significant relationship was found between numbers of adults counted through before the end of June and the numbers of fry at the very top of the Ettrick, where such early fish could be expected

to spawn. While there are no whole-year adult counts for 2010 and 2011, there are counts for the first halves of those years which can be used in this analysis. While it should not be thought that the fish passing through the counter by the end of June represented the whole of the upper Etrick stock – some could come through much later – it is assumed that the number through by the end of June will be an index of this total.

Fig D.4: The numbers of fish counted through the Etrick counter from March to June and the abundance of salmon fry upstream of the Tima Water the year after, 1998-2011



This shows that the number of fry at the top of the Etrick is limited by the number of adults that spawn there – the more adults, the more fry and *vice-versa*. If more adults escaped to spawn in this area therefore, there would be more fry.

#### E: Estimates of total Spring salmon population size for the Tweed

- 21 An estimate of the angling exploitation rate can be made from the Radio-tracking work of 1994-96, although the sample is small and problems with tags meant that some tagged fish were not picked up by the recording stations. This became apparent because some fish were caught by anglers well upriver without having been detected by any listening stations. There is therefore some doubt as to the exact numbers of fish that ran upriver and were available to anglers.
- 22 Of those that could definitely be said to have run upriver beyond the Whiteadder before the end of May, 31% were caught by anglers. If a catch rate of 30% is applied to the angling catches of the Middle and Lower Tweed (to the end of June, to allow for "delay" in the catch of Spring fish) of the different periods since 1970, then the estimates of the stocks of early season fish (not including the Whiteadder, which was not fully assessed till 2002 and has only partial catch records prior to that) are:

1970-2001	Non-cycle years average catch = 1,707; Cycle years average catch = 928;	Stock estimate = 5,691 Stock estimate = 3,094
2002-2017	Average catch = 2,037;	Stock estimate = 6,791

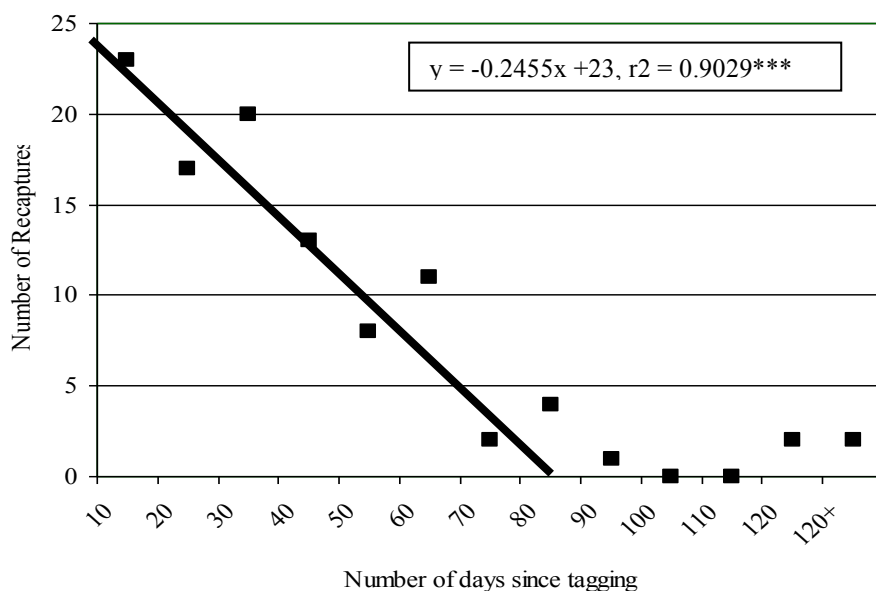
The indication therefore is that in the cycle years there were only just over half the Spring fish that there were in "normal" years.

- 23 As said above, Tweed Spring Salmon are split in to two major stocks in the Ettrick and the Whiteadder and at least four minor stocks, in the Upper Tweed, Gala/Leader, Teviot and Till. For February to April fish, the Till may also be a major stock. The Whiteadder stock does not contribute much to the fishery, as its home tributary actually joins the estuary rather than the river. The 5-7,000 or so Spring fish estimated from the above are therefore split between these different populations, with the data from the Ettrick fish counter suggesting that around half of these may be from the Ettrick
- 24 This would then leave 3-4,000 fish to make up all the other stocks of Spring fish in the catchment showing that these are not large and robust populations. The appearance of cycles in the Ettrick stock shows that this too, though the largest in the catchment is vulnerable.

**F: Catchability of salmon in the Tweed.**

- 25 The information on this for the Tweed comes from the tagging work and radio-tracking work done since the mid 1990s: fish are tagged at the bottom of the river or in the estuary to see what proportion are then caught upstream by anglers.
- 26 Since the date on which these fish were tagged is at, or very close to, the time at which they entered the river and the date of recapture is reported by the anglers catching the fish, the length of time that recaptured fish have been in the river is known: to date, there are 103 Salmon for which these details are known.
- 27 As Fig F.1 shows the number of fish recaptured declines with time since tagging: the largest number of recaptures is of fish that have been in the river for 10 days or less while the smallest number of recaptures is of fish that had been in for 90-100 days

Fig F.1: Average number of days in the river of recaptured tagged Salmon



- 28 There is a period of 100-120 days for which no recaptures have yet been reported and then a few for more than 120 days: this late increase in catchability is a feature seen elsewhere and represents fish at spawning time when they become aggressive and more catchable again.
- 29 Overall, 58% of tagged fish were caught within 30 days of tagging and 89% within 60 days so assuming that there is no difference in catchability between tagged and untagged fish this means that 58% of the fish that are caught by anglers on the Tweed are captured within 30 days of entering the river and 89% within 60 days. A fish that has been in the river for two months or more is therefore very unlikely to be caught.
- 30 This means that if nets did not fish from February to May and as rod fishing is completely Catch and Release till the end of June, any fish not caught by the nets is only at risk of being killed by anglers after 1<sup>st</sup> July, when even the latest May fish would have been a month in the river and therefore unlikely to be caught as shown above. Any February to April fish would be almost uncatchable by anglers by 1<sup>st</sup> July and would be far too stale to be killed even if caught. There would, therefore, be little issue of fish being safeguarded from netting only to be later killed by anglers on the river.

**G: Other data sources**

31 Netting Catches:

These are unfortunately of little use as the Holmes group would only submit a group total to the RTC each year till 1985 (averaging 15,500 fish per season 1970-84). This included all their netting stations, coastal, estuary and river, and was for the season as a whole, without monthly breakdown. This practice ended in 1984 so the total numbers of salmon netted early in the season are available from 1985 onwards. Before that year, the only records available are for a few, relatively minor, stations but early season netting effort was much reduced after 1987 (when almost all the

river nets were bought out) and ended after 1997. There is therefore no useful data series from the nets.

## REFERENCES

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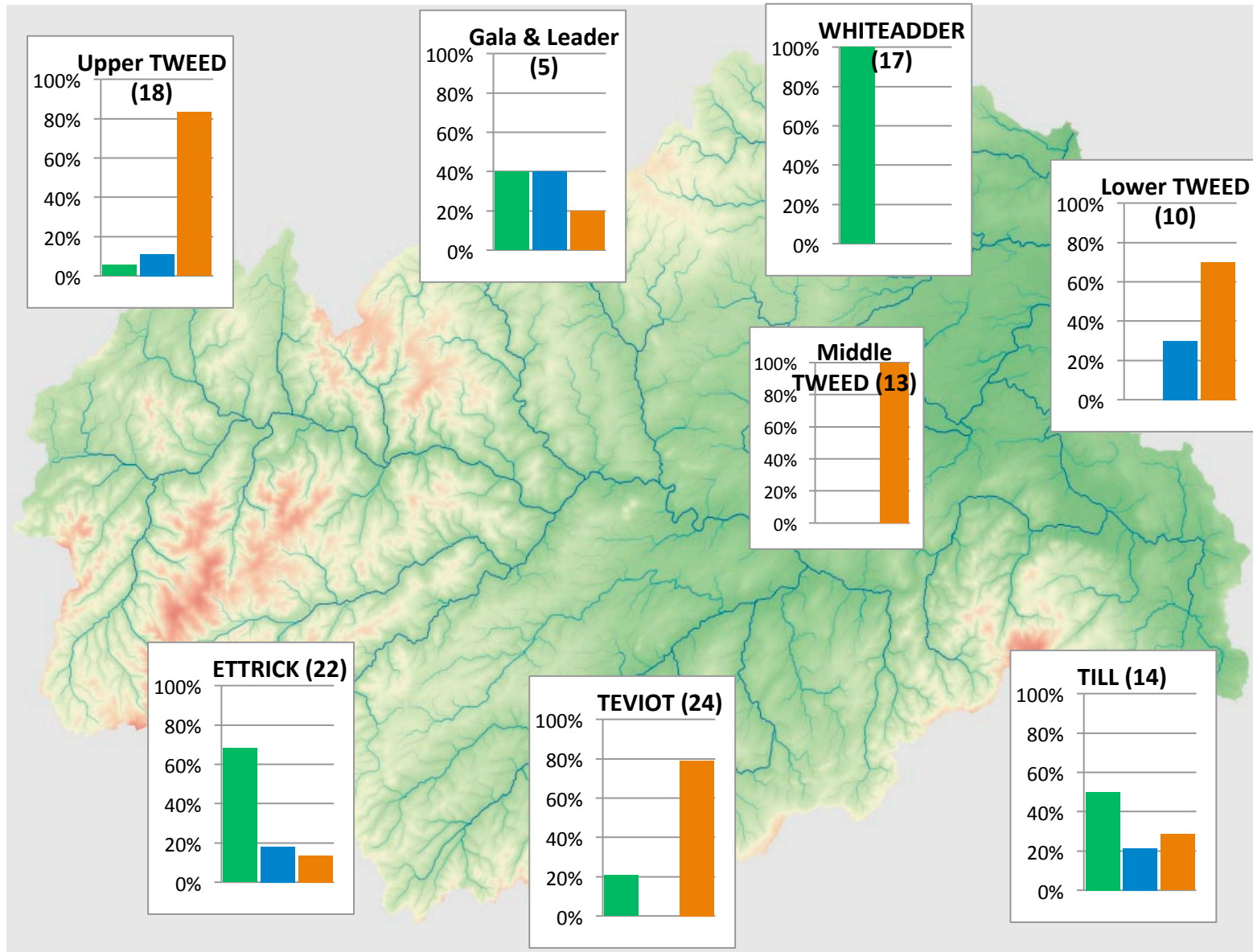
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**Appendix I: Spawning targets for the Ettrick upstream of the Murray Cauld and estimates of egg deposition numbers without the contribution of fish caught & released downstream.**

<b>Figures</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007*</b>	<b>2008</b>	<b>2009</b>
Salmon fish counter total	5130	4331	3543	3880	2982	3474	4322	4051	2866	2954	3640
Salmon total converted to egg total	23,295,158	17,120,301	12,584,102	16,453,059	11,453,544	13,525,915	16,495,830	12,716,463	9,081,162	9,105,635	11,389,898
eggs per 100m2 upstream of the counter	1902	1398	1027	1343	935	1104	1347	1038	741	743	930
Surplus / deficit eggs @ 500m2	17,169,978	10,995,121	6,458,922	10,327,879	5,328,364	7,400,735	10,370,650	6,591,283	2,955,982	2,980,455	5,264,718
Surplus / deficit eggs @ 700m2	14,719,906	8,545,049	4,008,850	7,877,807	2,878,292	4,950,663	7,920,578	4,141,211	505,910	530,383	2,814,646
Total released from rods and nets	455	485	645	561	728	874	864	836	813	974	559
Percentage female (55:45)	250.47	266.97	354.585	308.275	400.455	480.81	475.31	459.745	447.205	535.81	307.175
Egg loss if all released fish killed	2,027,555	2,161,122	2,870,366	2,495,486	3,241,683	3,892,157	3,847,634	3,721,636	3,620,124	4,337,382	2,486,582
Surplus / deficit eggs @ 500m2	15,142,423	8,833,999	3,588,556	7,832,393	2,086,681	3,508,578	6,523,016	2,869,647	-664,142	-1,356,927	2,778,136
Surplus / deficit eggs @ 700m2	12,692,351	6,383,927	1,138,484	5,382,321	-363,391	1,058,506	4,072,944	419,575	-3,114,214	-3,806,999	328,064

MAP I: Home destinations of Salmon radio-tagged in the Tweed estuary, 1994-96



**KEY**

**Destinations of:-**

**Fish radio-tagged at Berwick February to June – SPRING**

**Fish radio-tagged at Berwick July and August – SUMMER**

**Fish radio-tagged at Berwick September to November – AUTUMN**