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Assessing the sparling Osmerus eperlanus (L.) population of River Cree during the "Saving The Sparling" project 2018

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Summary

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Keywords

Smelt, sparling, Osmerus eperlanus, River Cree

Background

Sparling (*Osmerus eperlanus*), also known as smelt, became exceedingly rare in the last century despite previously supporting large fisheries in many areas. The reasons for these local extinctions are myriad, but include above all over-fishing and pollution. While sparling have returned to a very limited number of rivers they are still considered rare.

The current status of the River Cree population of sparling is relatively unknown despite this being the best studied population in Scotland. Site Condition Monitoring studies (SCM) have been carried out in 2004, 2010 and 2011 to assess the status of this population against a set of predetermined conservation objectives (Ribbens & Graham, 2004; Etheridge, 2010; Etheridge, 2011). This study used recommended protocol developed by Maitland (2003) to assess the population. It was considered at this time to be in a favourable condition.

Main findings

• The use of temperature data in the model developed by Maitland & Lyle (2001) was able to roughly indicate the date of spawning, however low temperatures modified the timing of spawning.

• The length of the main spawning run was over two days. Due to high flow levels on the third day no sparling were seen after this point. It was thought that if high flow did not occur that spawning would likely have continued for several more days.

• The location of spawning was from the Rag Run and The Cut up to the Creebridge weir. These areas are considered to contain some of the best areas for spawning in the River Cree.

• Sparling (N = 200) were captured on the spawning grounds using hand nets on the first day sparling were present. Examination of these fish found females to be on average larger than males. The condition factor of these fish was good considering the sampling time (mean 0.95) where 0.7 = poor condition, 1.3 = good condition.

• The age structure of these fish were found to be as follows, 0+ (0%), 1+ (72.3%), 2+ (27.1%), 3+ (0.5%). Therefore more than 75% of the captured fish were in the 1+/2+ age classes. This would indicate that the population is in a favourable condition.

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1 INTRODUCTION

In the UK and Ireland sparling were historically recorded in at least 29 river systems (15 in Scotland) by Hutchinson (1983), though further populations were recorded by previous authors (Maitland, 1972). Most of these populations in the UK mainland have at one time in the recent past become extinct, though a few have re-established after extirpation, e.g. in the River Thames, River Trent (Hutchinson & Mills, 1987), and the River Forth (Maitland & Lyle, 1996; Greenwood & Maitland, 2008). Historically overfishing, alongside pollution and the construction of barriers to migration have been blamed for contributing to the decline or extirpation of this species in many British rivers (Hutchinson & Mills, 1987; Maitland & Lyle, 1996)). Sparling are a UK Biodiversity Action Plan priority species and appears in the regional biodiversity lists of England, Wales and Scotland. However, this species does not benefit from any legal protection in the UK.

The River Cree population is of particular interest. The River Cree drains into the Solway Firth, where a total of nine populations were originally present in the Rivers Annan, Bladnoch, Cree, Dee, Esk, Fleet, Lochar, Nith and Urr (Service, 1902; Maitland & Lyle, 2001) and several commercial fisheries exploited sparling. This is the best studied of all the Scottish populations and is the only one in which the location of the spawning grounds is well known (Hutchinson, 1983; Hutchinson & Mills, 1987; Maitland & Lyle, 2001). It currently forms the only known population on the west coast of Scotland. This may then form the source of potential natural and artificial reintroduction to local areas of former occurrence.

The River Cree sparling spawn in and just below a town (Newton Stewart) where they are readily accessible and so vulnerable to interference (Maitland & Lyle, 1996). Prior to the spawning run, adult sparling form pre-spawning shoals from October / November in the estuary. These fish move into the lower Cree to spawn over a few days from February to March with temperature playing an important role in the initiation of the spawning run, while tide and river flows play an important role in the exact location of spawning within a 2 km stretch of the River Cree (Lyle & Maitland, 1997; Maitland & Lyle 2001). It has been previously suggested that high flows hinder ascending to the top of the spawning area to access the best spawning substrate, as sparling are thought to be relatively weak swimmers (Scott & Crossman 1973; Hutchinson & Mills, 1987). Nevertheless, their lack of swimming ability (which may have been somewhat overstated, see Clough *et al.,* 2003; Graham & Stevenson, 2004) may only cause problems during very high flows, although it is likely the problem has been exacerbated by the addition of poorly thought-out fishing croys (Ribbens & Graham, 2004). Spawning takes place over a few days over exposed gravel, pebble and cobble substrate. Eggs probably hatch at about 161 degree days (Altukhov & Yerastova, 1974; Ribbens & Graham, 2004). The young fry are then swept down into the upper Cree estuary where they feed on zooplankton. Adult sparling feed extensively on invertebrates but fish, including young sparling, also form an important part of their diet (Doherty & McCarthy, 2004). Sparling also form an important part of the marine and estuarine trophic ecology, being predated on by a large number of piscivorous species.

Due to the importance of this sparling population as a source for translocation and natural reestablishment, the (unknown) importance of this fish to the trophic ecology of the Solway Firth and the biological and conservation interest in this population, monitoring is vital. Part of this monitoring takes the form of this periodic condition assessment to provide information on the current status of this population.

2 AIMS

The objective of the monitoring program was to provide an assessment of the condition of the sparling population within the River Cree. This was to be achieved by the following.

Primary objectives

- Description of the sparling population, with particular reference to age classes present in the spawning stock. For the population to be classed as being in a favourable condition ≥ 75% of individuals should be from the 1+/2+ year classes.
- Commentary on the suitability of the habitat present in the lower river and estuary for maintenance of the sparling population.

Secondary objectives

- Evaluation of the sparling spawning success.
- Description of the condition of the individual sparling.
- Commentary on potential future impacts on sparling spawning habitats, water quality and exploitation.

3 PRE-SPAWNING SURVEY WORK

3.1 Environmental conditions

3.1.1 Introduction

Previous studies have used a variety of methods to predict the location and date of the sparling spawning run in the River Cree. Generally in the Cree spawning is considered to be initiated by temperatures over 5°C, though Belyanina (1969) concluded that throughout its range the sparling begins to spawn at water temperatures greater than 4°C (Hutchinson & Mills, 1987). Lyle & Maitland (1997) suggested that spawning in the River Cree usually occurs 150 ± 20 degree days after 1st February.

Lyle & Maitland (1997) also found that the onset of the main spawning is closely associated with high tides and the new moon. Adverse conditions such as high flows can also delay the expected arrival of sparling in the river (Lyle & Maitland, 1997).

3.1.2 Methods

Observations were made in the spawning area using methodology developed by Maitland (2003). The physical parameters which influence the timing and location of sparling migration and spawning, i.e. water temperature, tide times and tide height, and river flow were recorded. River Cree temperature data was collected every morning from 1st February close to the SEPA monitoring station in Newton Stewart (NX 412 653), this was used to calculate degree days (T_n) from 1st February where t = daily temperature reading.

$$T_n = \sum_{i=1}^{n} t_i$$

The timing and relative heights of the tidal cycle, was taken from the 2018 Solway Tides tide tables and the Willy Weather webpage. River Cree flow data was provided by the Scottish Environment Protection Agency (SEPA).

3.1.3 Results

From the 1st February temperature was collected from the River Cree at the Newton Stewart river monitoring station. On-foot surveys began from when the 100 degree day (9th March) was reached. Water temperature displayed high levels of variation from 1st February to 9th March. Water temperatures only reached 5°C or above on two occasions (21st and 22nd February). All other readings were <5°C with temperature as low as 0.4°C on the 2nd March.

No evidence of the sparling presence was identified before the spawning event. Arrival and spawning of the sparling was identified on 13th March at 121.4 degree days. On this date the temperature was 4.8°C (running mean 2.96°C) and flow was 6.4 m^3/s (mean 9.4 m^3/s). Temperature and tide data have been summarised in Figure 1.

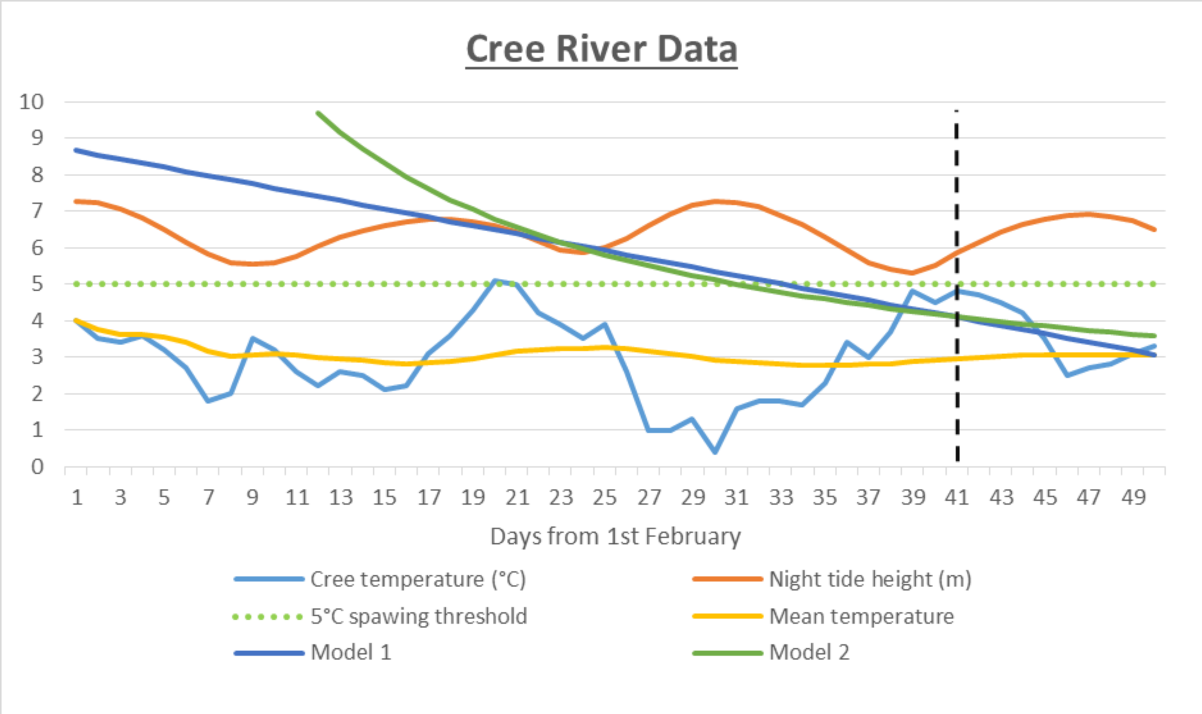

Figure 1: Temperature data and tidal data over the study period with spawning threshold indicated. Black dashed line indicates the start of the sparling spawning event. Models 1 and 2 described in section 4.1 are indicated.

3.1.4 Discussion

Spawning began from 121 degree days, below the 150 ± 20 degree days suggested by Lyle & Maitland (1997) for River Cree sparling spawn. Due to cold weather conditions water temperatures did not reach >5°C with the exception of one day (20th February). Due to cold water temperature the 100 degree days from the 1st February took longer to achieve. Extended periods of cold delayed spawning. Spawning did coincide with an increase in temperature of close to 5°C. As the preferable spawning temperature is >5°C this would help explain the delay in spawning until later in the season and mass arrival when water temperature finally reached near optimal spawning temperature. Determination of a good or bad spawning year cannot be assessed through this data alone, but age class data will provide an insight.

3.2 Behaviour of fish predators

3.2.1 Introduction

Other indicators of the presence of sparling in the River Cree are the presence and behaviour of predators of sparling. Groups of piscivorous bird and mammal predators feeding and or congregating have in the past, been observed as a prelude to the sparling spawning. These have included birds such as heron (Ardea cinerea), cormorants (Phalacrocorax carbo) and goosanders (Mergus merganser), and mammals such as mink (Mustela vison), otters (Lutra lutra), grey seals (Halichoerus grypus) and a porpoise (Phocoena phocoena). Historically, these sightings were used to inform netting times by commercial nets men (Ribbens & Graham, 2004).

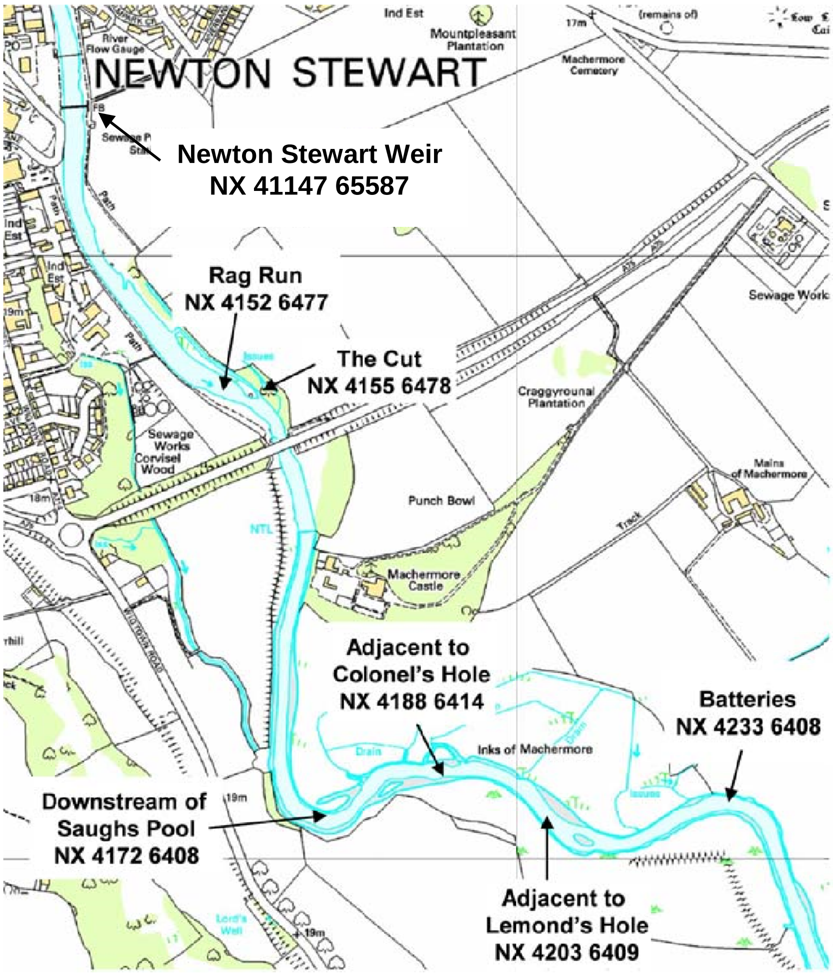

Figure 2: Map of spawning sites (Rag Run, Creebridge Weir and The Cut) and potential aggregation areas

3.2.2 Methods

Daytime pre-spawning surveys, commencing on 3rd March, consisted of visual inspections of the River Cree from Rag Run to Batteries (see Figure 2) at a low tide. Predator presence, species and numbers were noted while carrying out these daily on foot survey. Indicators of predation on sparling e.g. scales, fish carcass/remains on banksides were actively sought out and were to be recorded if found.

3.2.3 Results

All noted predator sightings were of piscivorous birds including cormorants, goosander, herons and crows (see Table 1). The first sighting was recorded on 1st March and predators were recorded continually until the 6th March. After the 6th March predators were noted once more on 11th March. On the 12th March the day before sparling arrival no predators were recorded. This was the final day of surveys due to the arrival of sparling, but it should be noted that predators were seen when the sparling spawning event began. No indicators of predation on sparling e.g. scales, fish carcass/remains were recorded until the sparling arrived.

Table 1: Observations of piscivorous birds observed during diurnal on-foot surveys on the River Cree (✓indicates predator presence, x indicates a survey was completed, but that no predators were observed)

Date	Heron	Goosander	Crow	Otter	Cormorant
01/03/18	✓	X	✓	X	✓
02/03/18	✓	✓	X	X	X
03/03/18	✓	✓	✓	X	X
04/03/18	✓	X	✓	X	X
05/03/18	X	✓	X	X	X
06/03/18	✓	X	X	X	X
07/03/18	X	X	X	X	X
08/03/18	X	X	X	X	X
09/03/18					
10/03/18					
11/03/18	✓	✓	X	X	X
12/03/18	X	X	X	X	X

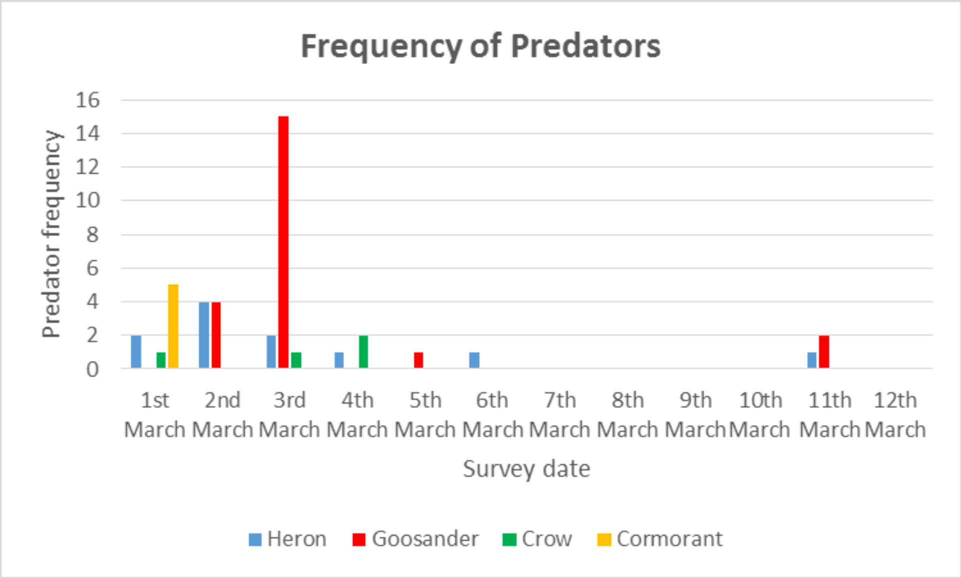

Figure 3: Frequency of piscivorous species observed by date

3.2.4 Discussion

Sightings were highest at the start of the predator surveys and reduced to no sightings from the 7th March – 10th March. Only one more positive day of sightings was recorded on the 11th March before the end of the survey (see Figure 3). This could have been due to the extreme weather conditions halting sparling migration. Upon sparling arrival within the Cree, predator numbers were noted to increase. This would further indicate that the sparling migrated in mass and were not present in the Cree before this point. During this year's surveys the collection of predator presence did not assist in the prediction of the spawning event. Findings were similar to the 2010 survey which also found an absence of predator build up prior to the spawning event. Low predator presence was recorded two days before the arrival of sparling but were absent for six days before this. The 2011 SCM report showed a successful use of predator presence indicating arrival of sparling four days prior to arrival.

3.3 Monitoring at sparling spawning grounds

In 2018, sparling were only observed on the spawning grounds from the start of the main spawning run. Therefore, monitoring at sparling spawning grounds is discussed within the spawning survey work in section 4.4.

4 SPAWNING SURVEY WORK

4.1 Environmental conditions

4.1.1 Introduction

Sparling tend to spawn in shallow fast flowing riffles on pebble/cobble substrate, usually during the hours of darkness. The timing of sparling spawning has been mainly linked to temperature by a number of authors (Hutchinson & Mills, 1987 and references therein). However, phase of the moon, tidal cycles and river flows have also been considered to have an impact on the timing and location of spawning (Lyle & Maitland, 1997).

Temperature of the lower river is the most important factor in determining the timing of the sparling spawning run (Lyle & Maitland, 1997; Maitland & Lyle, 2001). A linear relationship between the number of days from the 1st February and the mean water temperatures was described by Maitland & Lyle (2001). Subsequently a further relationship between D and T has been described using data for 13 of the years between 1990 and 2009, T = 55.14D-0.699, (R2 = 0.88) (Lyle *et al.,* 2009). The detection of sparling in the spawning area usually coincides with first spawning, although fish can be found prior to spawning commencing (Lyle & Maitland, 1997; Ribbens & Graham 2004).

4.1.2 Methods

The temperature data collected during the pre-spawning surveys (Section 3.1) was used to predict the rough time of spawning in 2011 using the models described by Maitland & Lyle (2001) (Model 1) and Lyle *et al.,* (2009) (Model 2). Each was used to predict the spawning date as temperature data was collected.

4.1.3 Results

Model 1 predicted that at a mean temperature of 3°C, the first spawning would occur 50 days from 1st February, while Model 2 predicted that at this mean temperature first spawning would occur 62 days from the 1st February.

The 13th March (41 days from the 1st February) was the first day of spawning when the presence of eggs and large groups of sparling were identified. The 2018 spawning event did not closely follow either model or fall with the Lyle & Maitland (1997) 150 ± 20 estimates. The spawning event fell nine days before Model 1 (50 days from 1st February) and 21 days before Model 2 (62 days from 1st February).

4.1.4 Discussion

The model developed by Maitland & Lyle (2001) was found to closely estimate the spawning time in other SCM reports, but did not predict the current (2018) spawning event. Mean temperature is a major influencing factor on the timing of the arriving sparling. Due to the low temperatures, that only reached >5°C once throughout this study period, the accuracy of the models could have been affected. This is supported by previous SCM reports that had a higher mean temperature and fell within the parameters of Model 1. The mean temperature was the lowest recorded from the 2004, 2010 and 2011 reports. The recorded mean temperature was also the lower than any of the mean values used to create Model 2, explaining the extreme difference in estimated arrival and actual arrival. Mean values used to create Model 1 were closer to this year's temperature but still higher, further explaining the difference in arrival and predicted arrival but not to the same extremes as Model 2.

4.2 Pre-spawning egg count surveys

4.2.1 Introduction

Other indicators of the presence of sparling in the River Cree are the presence of sparling eggs. A small amount of initial spawning as a lead up to the main spawning event can sometimes be detected by the presence of a few eggs on and around spawning grounds. Sparling are highly fecund, Hutchinson & Mills (1987) found 40,000 – 106,000 eggs per female from the River Cree. These eggs are small (c. 1 mm diameter), sticky and attach to surrounding substrate and weed, therefore even low numbers of individuals spawning may be detected by the presence of eggs due to the numbers released. Certainly Lyle & Maitland (1997) considered that substrate inspection for eggs was adequate for determining the date and location of first spawning. Previous workers have considered that examination of the spawning areas for evidence of sparling should begin from 100 degree days (from 1st February).

4.2.2 Methods

Day time pre-spawning surveys involved on foot inspections from Rag Run to the Batteries (Figure 2) at low tide. During these surveys five potential spawning sites were examined for the presence of eggs. At each of five sites a standard search for eggs was completed (Table 2). Ten stones were randomly selected and lifted clear of the water to be closely examined for sparling eggs. The stones were lifted clear of the water since fertile sparling eggs are transparent underwater and difficult to see (Lyle & Maitland, 1997). If found, these eggs were counted up to 50, any greater number was denoted as 50+. The numbers of infertile/dead eggs which are opaque and cream coloured was also noted if found. In addition, various bankside and instream vegetation was examined for eggs.

Table 2: Observations of eggs on 10 randomly selected stones at each site (✓ indicates egg presence, X indicates a survey was completed, but no eggs were found)

Date	Rag Run	Saughs Pool riffle	Colonel's Hole riffle	Lemond's Hole riffle	Batteries riffle
01/03/18	X	X	X	X	X
02/03/18	X	X	X	X	X
03/03/18	X	X	X	X	X
04/03/18	X	X	X	X	X
05/03/18	X	X	X	X	X
06/03/18	X	X	X	X	X
07/03/18	X	X	X	X	X
08/03/18	X	X	X	X	X
09/03/18					
10/03/18					
11/03/18	X	X	X	X	X
12/03/18	X	X	X	X	X

4.2.3 Results

No eggs were found throughout the survey. Eggs were only identified from the 13th March when the main spawning event began.

4.2.4 Discussion

The pre-spawning egg surveys are used to help indicate the arrival of sparling before the main spawning event. This is another tool used alongside predator checks to reaffirm sparling presence in the river.

No eggs were found during this survey which ended upon the arrival of the sparling and beginning of the spawning event. In 2011 eggs were only found once the main spawning event had started (first eggs found on 8th March). In 2004 eggs were found over a longer time period and a greater distance of the lower river, but this was not the case in 2010. In 2010 and 2011, eggs were only found in Rag Run and it appeared that spawning did not take place in any other location.

4.3 Monitoring at sparling spawning grounds / collecting sparling samples

4.3.1 Introduction

Temperature of the lower river is the most important factor in determining the timing of the sparling spawning run (Lyle & Maitland, 1997; Maitland & Lyle, 2001). However, tidal cycles and river flows have also been considered to have an impact on the timing and location of spawning (Lyle & Maitland, 1997). Sparling are considered to spawn over a few days between mid-February and mid-March in the River Cree. In 2004, the first evidence of spawning was recorded on the 5th March (Ribbens & Graham, 2004), in 2010 on the 17th March (Etheridge, 2010) and in 2011 on the 4th March (Etheridge, 2011). In 2018 monitoring was included with the daily temperature recordings during the daily daytime surveys from the 1st March. In previous years fish have been gathered using hand nets during the night surveys leading up to the main spawning event and then additional sparling collected from the main spawning. This year no sparling were gathered before the main spawning event. The collection of sparling was carried out on the 13th March.

4.3.2 Methods

Similar methods were used to capture the sparling on the spawning grounds as in previous years. Hand nets were used to capture sparling in the Rag Run and The Cut (see Figure 2) at low tide. Black plastic buckets were used as temporary holding units along the riverbank. When buckets reached capacity the sparling were placed into keepnets stationed along the river. Four keepnets were used each in shaded low flow areas. A maximum of 50 sparling were housed in each keepnet to avoid overcrowding and possible injury. After filling the keepnets the sparling were then transported to the trailer where sparling were placed in a large water tank. When all 200 sparling were loaded into the tank they were then transported alive to a nearby hatchery for later processing.

4.3.3 Results

All 200 sparling required for the study were collected on the 13th March both during the day and night high tide. This was 121 degree days from the 1st February. Tide high was 5.85 m and water temperature was 4.8°C.

4.3.4 Discussion

In previous years numerous night surveys were carried out to check for sparling presence. Night surveys consist of monitoring the night tide for presence of sparling moving into the Cree. If sparling were seen they were to be captured, when possible using hand nets, and were to be included as part of the spawning sample for that year. Due to the cold weathers effect on spawning behaviour the night surveys were only to be carried out (this year) once sparling presence was noted in daytime surveys e.g. eggs, visual sightings of sparling, high levels of predators and predator kill sites. This would have prompted the night surveys if sparling presence occurred before the main spawning event. In previous years the night surveys have been carried out after >100 degree days. Though a delay was thought to be the most sensible course of action as other indicators were not highlighting sparling presence in 2018.

The sparling presence was identified on the morning of the 13th March. A sample of 200 sparling was needed and all were collected on the first spawning day. The population present on the 13th March was conceded to be a good representation of the spawning population. The 2011 SCM study fell short of the 200 sample size due to high flow restricting access to spawning grounds. This year's spawning was also impacted by high flow. After two days of mass spawning no sparlings were noted in the spawning area due to high rainfall increasing river flow.

No estimation of overall population was carried out during the collection of the sparling due to the wide distribution of the spawning fish. Distribution of sparling was sporadic across the spawning area that was upstream of the A75 road bridge and extended up to the Creebridge weir (see Figure 2). The mark and recapture method of population estimates outlined by Maitland (2003) was not attempted after Ribbens and Graham (2004) found it to be an unfeasible method. This year's spawning population was noted as being of a high density compared to many previous years (J. Ribbens, personal communication, 13th March 2018).

Sparling optimum spawning conditions is >5°C, high spring tides, and low-medium flow (Lyle & Maitland, 1997). The 2018 spawning did not follow the normal pattern followed by this species over previous years. On the 13th March the water temperature was 4.8°C but from the 1st February water temperature only maintained a mean temperature of 2.9°C. Tide height was low reaching only 5.85 m. This year's spawning was also later than SCM projects carried out in 2004, 2010 and 2011. As temperature is considered the main driving focus behind the spawning event (Lyle & Maitland, 1997; Maitland & Lyle, 2001) it is acceptable to consider the low mean water temperature as a major factor in the unusually behaviour seen in this year's spawning event.

The presence of few predators from the start of the predator surveys is an indication that the spawning event occurred as one mass migration. Probably prompted by warming water temperature of close to optimum spawning temperature (4.8°C) after a drop to <1°C.

4.4 Analysis of fish samples

4.4.1 Introduction

The normal range in length of sparling is 10 – 20 cm but they can reach 30 cm in some populations, including that found in the River Cree, the mean lengths and weights of females are generally greater than those of males (Maitland & Lyle, 1996). River Cree sparling first enter the spawning stock as 1+ fish (Hutchinson 1983); though in many other sparling populations fish enter the spawning stock at 2+ fish and mature 0+ fish are also known from the Thames (Hutchinson & Mills, 1987). Recruits to the spawning stock tend to dominate the spawning runs, but a large year class can also be detected beyond recruitment, as noted by Hutchinson (1983).

Shifts towards male dominance in the later stages of the spawning run are often found since males stay on the spawning grounds waiting for females, whereas females usually spend less time on the spawning grounds, leaving once they have spawned (Hutchinson & Mills, 1987 and references therein). In 1995 it was found that male sparling in the River Cree remained in the vicinity of the spawning beds for a mean of 6.45 days while the female fish were present for a mean of 2.43 days (Applied Environmental Research Centre, 1996). In addition, separate spawning peaks associated spawning aggregations sorting according to size and age have been reported (Belvanina, 1969) although there is no evidence to suggest this occurs in the River Cree population (Hutchinson & Mills, 1987).

4.4.2 Methods

Fish were sexed by external examination for tubercles (a male secondary sexual character) and extrusion of gametes. Fork length (Lf) in mm and weight (W) in g were measured. Scale samples were collected from the left side below and behind the dorsal fin. The condition factor (K) was calculated using the data collected:

$$K = W / (Lf / 10)3 \times 100$$

4.4.3 Results

4.4.3.1 Sex ratio

Of the 200 sampled sparling, taken on the 13th March, there was found to be a large bias in the sex ratio towards females. From the sample population 73.5% were female and 26.5% were male. The sex ratio of male to female was as follows, for every 1 male : 2.8 females were present.

4.4.3.2 Size

The Lf all 200 sampled sparling was 186-261 mm with a mean of 214 mm. The weight for total sample size ranged from 52-189g with a mean of 95g. The Lf of female sampled sparling was 190-262 mm with a mean of 217 mm. The female weight ranged from 62-189g with a mean of 101g. The Lf of male sampled sparling was 186-257 mm with a mean of 206 mm. The male weight ranged from 52-148g with a mean of 77g.

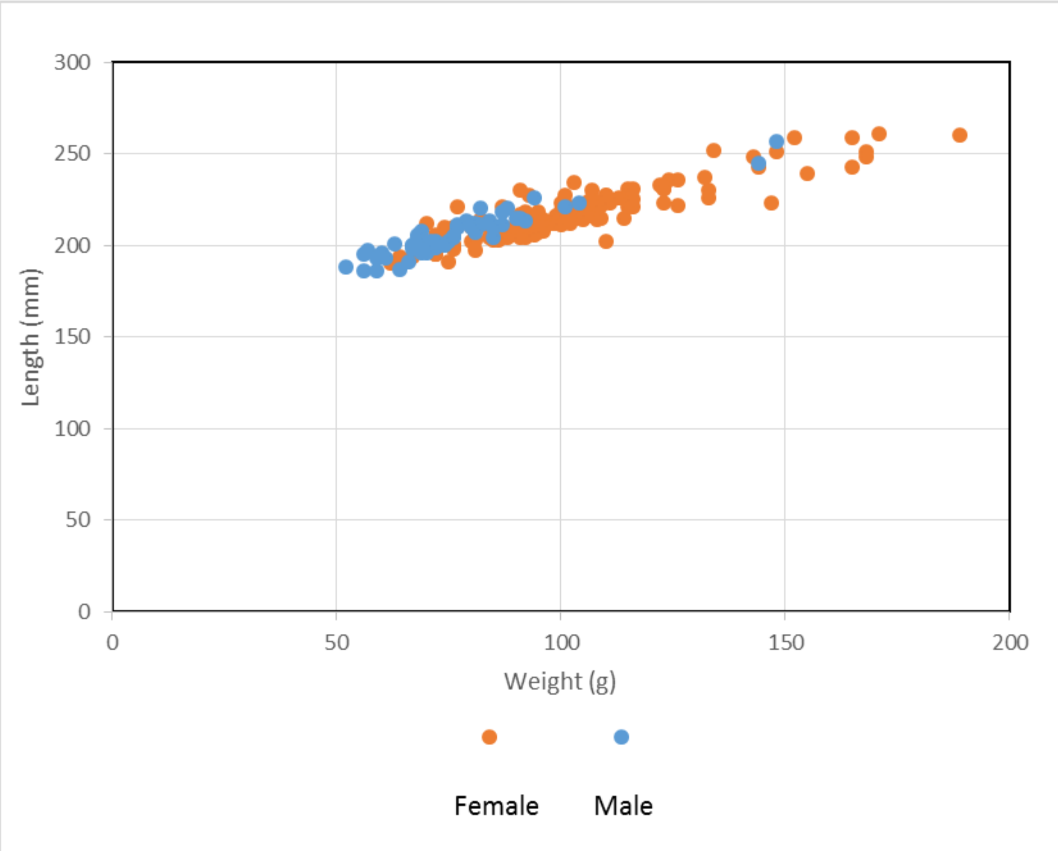

Figure 4: Lf and W in River Cree sparling sampled in 2018

4.4.3.3 Condition factor

The condition factor (K) of all sampled sparling (N = 200) was a mean value of 0.95. The range of K values was 0.6-1.3. The mean K value of female sparlings was 0.98. The mean K value of male sparling was 0.86 (see Figure 5).

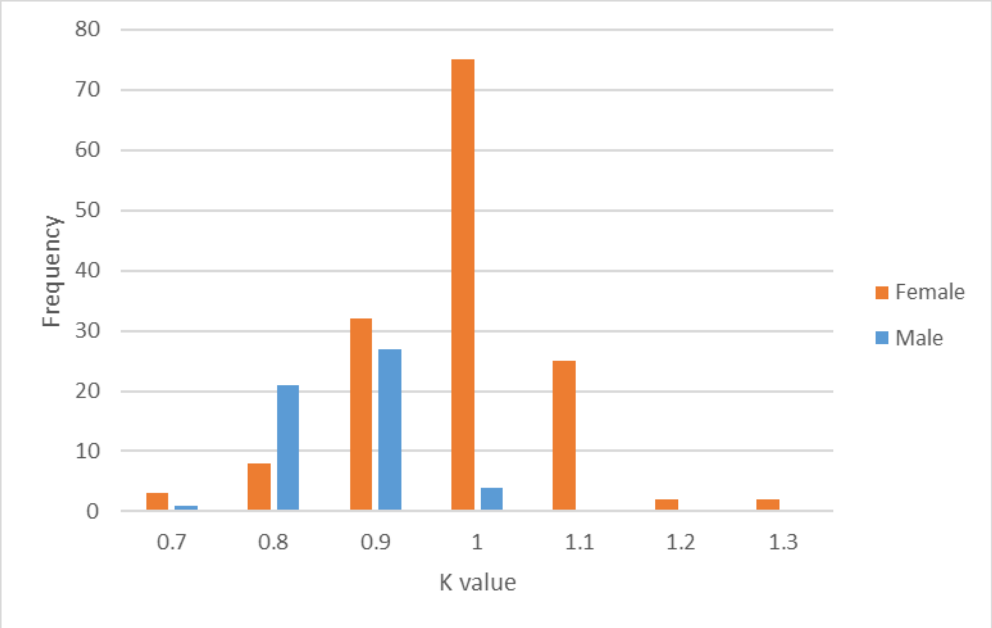

Figure 5: Frequency of K values for male and female sparlings sampled in 2018

4.4.3.4 Age classes

Three age classes were represented in the data collected 1+, 2+ and 3+ years. The 1+ age group made up 72.3% of the sampled sparling, 2+ was 27.1% and 3+ 0.5%. One scale sample was unreadable resulting in 199 samples being processed and successfully read for age structure.

Table 3: Age composition of spawning runs from previous years

Year	% 0+	% 1+	% 2+	% 3+	% 4+	% 1+ & 2+	Reference
1980	0	73.1	25.5	1.4	0	98.6	Hutchinson, 1983
1981	0	49.6	49.7	0.8	0	99.2	Hutchinson, 1983
1999	0.7	65.1	34.2	0	0	99.3	Brown, 1999
2004	0.3	18.6	69.7	9.7	1.7	88.3	Ribbens & Graham, 2004
2010	0	37.7	49	12.6	0.8	86.6	Etheridge, 2010
2011	0	12.5	55.4	29.8	2.4	67.9	Etheridge, 2011
2018	0	72.3	27.1	0.5	0	99.4	Present study

Figure 6: Frequency of inclusion in age classes for male and female sparling sampled in 2018

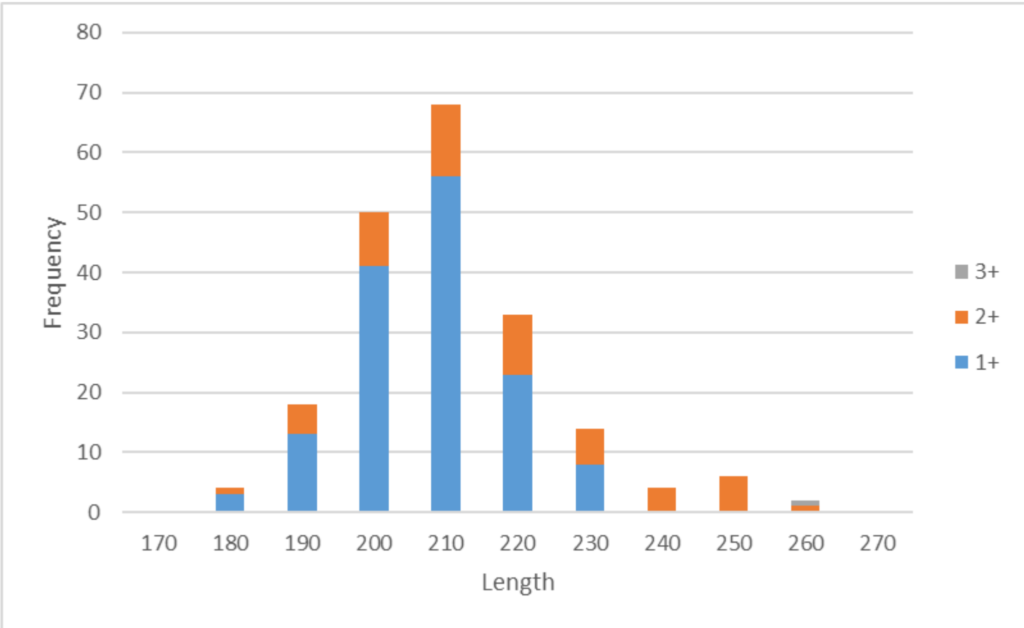

Figure 7: Frequency of age classes in Lf categories of sparling sampled in 2018

4.4.4 Discussion

Due to the sparling arriving and leaving suddenly and being caught entirely on one day (day and night tides) it is not possible to examine the sex ratio across the spawning period. It is also not possible to look into the changing ratio between spawning days. It is however possible to see the sex ratio of the sampled group. Females made up 73.5% of the sample group and male 26.5%. This is different to the findings of Etheridge's (2011) assessment of sex ratio throughout the spawning season. In previous SCM reports on the Cree (Ribbens & Graham 2004, Etheridge 2010, Etheridge, 2011) sparling sex ratio has been in favour of the males. This year's netting is the first year to find a higher ratio of female sparling. Without samples being gathered continually throughout the spawning period and due to the short period this spawning covered little further analysis can be carried out. The method of capture was unbiased and all measures were taken to control and standardise the sampling of sparling.

Males are first to the spawning ground and usually remain in these areas longer than the females (Maitland, 2001). A high density of males can therefore indicate the start or end of a spawn. Bailey (1964) found that sparling reach almost equal sex ratio at the peak of the spawn. In Etheridge (2011) report findings supported the understanding that males arrive early in higher density then reach a more equal ratio further into the spawning event. Due to the sudden arrival of the sparling, potentially brought on by extreme fluctuations of weather, the normal sex ratio could have been effected in 2018.

River Cree sparling are generally longer than most other British populations (Maitland & Lyle, 1996; Doherty & McCarthy, 2004). The Lf range of sparling found in 2018 (186-261 mm) was within ranges previously reported for this population i.e. 185-279 mm (Hutchinson & Mills, 1987), 139-297 mm (Ribbens & Graham, 2004), 188-296 mm (Etheridge, 2010) and 187-287 mm (Etheridge, 2011). Females were significantly larger than males as typically found (Maitland & Lyle, 1996).

The condition factor (K) was calculated, this is a measure of the fishes status of physical health. It is typical for K to range between 0.7 and 1.3, with 0.7 being a fish in poor condition, while 1.3 is a fish in good condition (Maitland, 2003). The mean K value was 0.95 and considered in good condition. Female K value (0.98) was higher than males (0.86). This is to be expected over the spawning season as female weight will be effected by being gravid. These finding are similar to the 2011 (Etheridge, 2011) SCM report that found a mean K value of 0.94. Also this report found females to have a higher mean K value than males.

In most European populations of sparling, fish reach sexual maturity at between 2+ and 3+ years of age (Doherty & McCarthy, 2004), though mature 0+ fish have been identified from at least one population (Hutchinson, 1983). River Cree sparling first enter the spawning stock as 1+ fish, having spent two winters in the estuary (Hutchinson & Mills, 1987). Findings from the 2018 spawning found +1(72.3%) to be the most abundant age class followed by +2 (27.1%) (see Table 3). Maitland (2004) suggested that a population of <75% within the +1 - +2 age classes is unfavourable. The 2018 sampled sparling consisted of 99.4% within the desired age classes (+1/+2). These findings show recent spawning years have been successful as high percentages were returning to spawn. Only three age classes were represented in the sample group, but this is to be expected with healthy spawning population with a high density of the +1/+2 age classes and is also the case in three previous studies on the Cree sparling (Hutchinson, 1983, Hutchinson, 1983 & Brown, 1999).

5 POST SPAWNING EGG SURVEYS

A basic presence and absence study was carried out on the upper limits of the spawning grounds. In the 2010 and 2011 (Etheridge) SMC reports the Rag Run was recorded as the only spawning location but in 2004 (Ribbens & Graham) eggs were found up to the SEPA gauging station. This year's spawning survey found eggs upstream of the A75 road bridge to the Creebridge weir. This is further upstream than previously recorded in recent years.

6 HABITAT DESCRIPTION

There has been little appreciable change in habitat in the lower River Cree and River Cree estuary since the previous SCMs (Ribbens & Graham, 2004; Etheridge, 2010; Etheridge, 2011). Bank erosion has altered the river dynamics of the Saughs Pool. This has not affect the movement of sparling through this area, as evident from successive spawning since 2011. Further erosion could affect the success of migrating fish in the Cree and monitoring of these levels of erosion should be considered.

7 SUITABILITY FOR MAINTAINING A HEALTHY POPULATION

7.1 Lower River Cree

The habitat in the lower Cree continues to be suitable for supporting the spawning of the River Cree sparling population. However, there are several current and possible future activities that may impact and over time adversely alter that habitat suitability in this area.

The lower Cree has previously been strongly affected by an aggressively invasive non-native plant species called Japanese knotweed (Fallopia japonica). On rivers Japanese knotweed can weaken flood defences and promote bank erosion causing river widening and siltation (Crowhurst, 2006) thus threatening to degrade the lower river habitat. Control of Japanese knotweed is now undertaken by a third party.

Due to the nature of their spawning strategy involving a mass migration over a short time period to a limited area, sparling are very susceptible to exploitation. At the present time there is no commercial exploitation and few reports of private harvesting for consumption or as bait sources have been recorded. The findings in this report indicates a healthy spawning stock, but due to the limited distribution across the Solway recommendation to reopen commercial fishing would be strongly opposed. The spawning population is still thought to be contained solely within the Cree, harvesting within spawning periods on the Cree could have devastating effects on the remaining population.

Other potential threats involve pollution and sedimentation via runoff from surrounding buildings, and the A75 Bridge; other water quality impacts may stem from land use such as commercial forestry upstream. While most of the runoff in Newton Stewart will end up in the treatment works, runoff from the road, which is very close to the spawning grounds, may have the potential to introduce some pollution to this sensitive area. No forestry associated pollution impacts are seen as far down the River Cree as Newton Stewart, however, forestry drainage has altered the flow regime of the Cree. Sparling are very sensitive to water quality changes and this has been one of the reasons for their disappearance in some UK Rivers. SEPA samples the catchment and tributaries to monitor water quality and water ecology and will continue to do so to comply with Water Framework Directive objectives.

Flood defences are currently being discussed to prevent flooding in Newton Stewart. Construction of flood defences is a potential concern as work could affect the flow of the river around the A75 road bridge. Due to the proximity of this work to the sparlings only known spawning ground, special measures should be taken to protect this essential area for sparling. Plans have not yet been fully developed but this should be a key point of concern raised prior to flood defence work being designed. Pollution from the construction process should also be considered, with work not being carried out during the expected spawning months or while eggs are developing in the Cree.

Construction of the new footbridge (Sparling Bridge) over the Cree would increase public presence close to the river while also potentially causing pollutants to enter the river during construction and runoff post construction. Access to the river may also increase the exposure of spawning sparling to disturbance from people. The correct timing of construction works could alleviate some of the issues posed by the construction. Public knowledge and awareness attained through public event and school project could help reduce negative interactions by the public. Lighting on and around the bridge could be an issue as sparling are sensitive to light and spawning takes place at night. Increased light could alter the spawning behaviour.

7.2 River Cree estuary

Sparling spend a fraction of their lives in freshwater. The larger portion of its life is spent in estuary and coastal water. The Cree estuary joins the Solway Firth which is a key habitat for sparling. On the English side of the Solway Firth plans to create a Marine Protected Zone (MPZ) are currently underway. Protection of the sparling population is the main focus of developing the MPZ and is a reaction to the population crash seen in sparling within this area of the UK. It recognises the Solway as a region that is of particular importance to the sparlings life cycle. If a Marine Protected Area (MPA) was create to cover the Scottish side of the Solway Firth this could offer the sparling greater protection when they are in the estuary.

A number of major concerns were raised in the 2011 (Etheridge, 2011) SCM report concerning the potential negative effect on sparling and other migratory fish. Three issues raised have now been cancelled or have not progressed. The offshore wind farm proposed in the mouth of Wigtown Bay was rejected by the Scottish Government. Kirkmabreck Quarry Pier has not progressed towards reopening since 2010. The Solway Barrage was also not constructed post feasibility assessment.

8 CONCLUSIONS

(1) To achieve favourable condition, the sparling population in the River Cree should have at least 75% of individuals in the 1+/2+ age classes.

In 2018 the sample taken (N = 200) from the spawning population consisted of >75% within the 1+/2+ age classes. 99.4% fell within the favourable age classes. This would be considered a healthy spawning population.

(2) The 2018 spawning was considered to be successful as sparling were able to reach primary habitat and complete the spawning process.

To conclude, sparling were able to successfully spawn in 2018, but spawning was thought to be cut short due to high flow after the second day of spawning. The age classes dominate in the population were 1+ and 2+ and deeming the population favourable. The mean condition factor was 0.95 that falls within the good condition margins. The spawning habitat is relatively unchanged since the 2011 SCM report. It provides high quality spawning habitat with unimpeded access from the estuary. Though this population is deemed to be in good condition it is still fragile and is the only population to inhabit the nine rivers flowing into the Solway from Scotland.

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