Wye Salmon Association

Cymdeithas Eog Gwy

Long term temperature monitoring of Salmon (*Salmo salar*) spawning streams in the (Welsh) Wye river catchment

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Project summary

Overall aim of the project is to monitor water temperatures in key spawning streams over a period of years in order to gain a better understanding of the effect of ambient stream water temperatures on the spawning success and survival of salmon parr and other economically important salmonids.
Temperature data recorders will be used to gather stream water and local air temperatures. In stream temperature data will be correlated with ambient air temperature, fry and parr numbers, supplied from annual NRW published electro fishing data, and other relevant environmental and biological data. The results will used to help NRW/EA develop an effective management plan for salmon and assist in assessing the impact of higher average temperatures (global warming) on the spawning success of salmon and brown trout (*Salmo trutta*). Effective management. of the stock of these economically important salmonids, could contribute significantly towards the maintenance of the 'tourist £' spent on fishing for trout and salmon within the Wye catchment areas of England and Wales.
This project will be undertaken by Wye Salmon Association (WSA) in partnership with National Resources Wales (NRW) and when required, the Environment Agency (EA). WSA will be responsible for managing, collecting and analysing the temperature data and NRW/EA for providing technical and other assistance. Help and support will also be sort from the Universities of Nottingham and Loughborough through our association with The Loughborough University Temperature Network (LUTEN).

Rational for project

In 2016 Environment Agency/National Resources Wales completed the England/Wales salmonid fry and parr survey programme. The data looked at trends in juvenile salmon and trout densities. The surveying programme in the river Wye catchment is split between Natural Resources Wales, who are responsible for the Welsh side, and the Environment Agency on the English side.

Data from this sampling programme indicated juvenile salmon densities across Wales in 2016 were poor, with some catchments showing significant absences of salmon fry. The Wye catchment had not seen these unexpected absences, however
average density in the catchment for both fry and parr was less than expected; roughly half when compared to 2015 and the 5 year catchment average; the lowest for fry since 2007 and the second lowest in survey history. It has been suggested that the variation can be explained by studying water temperatures within the Wye catchment area during the significant

spawning period for salmon. During this period the water temperature was in the order of 10°C compared with circa 12°C on other rivers in the survey.
This decline (in numbers), coupled with the significant absences of salmon fry is unprecedented and of immediate concern. Serious pathogens or parasites and a disease and/or fish health causes have been ruled out by NRW/EA. Other reasons, including a shortfall in the number of spawning fish and damage arising from very high flows, have not been ruled-out as potentially having had a significant localised affect. The decline in numbers was also evidenced in 2014 and 2015 classes and what data is available suggested strongly this to be the result of extreme water temperatures throughout November and December 2015, the key spawning period for salmon.

There are a number of scientific studies which indicate that salmonid breeding success and juvenile survival are sensitive to high ambient temperatures. Gunnes (1979) reared Atlantic salmon eggs at 8, 10 and 12°C, and noted high mortality at the highest temperature (66.1 % mortality, fertilization to hatching) compared to the lower two temperatures which were associated with a mean mortality rate of 14.25%). Peterson et al (1977) also noted increased mortality of salmon eggs at 12°C compared to lower temperatures, perhaps partly due to fungal infections. Gunnes (1979) also noted that mortality at 12°C in his study was higher than that observed at the same temperature by Peterson et al (1977); he suggested that his eggs were derived from stock that may have been genetically adapted to breed in cooler water. Some support for the hypothesis that Atlantic salmon may be genetically adapted to different incubation temperature ranges comes from the results of Ojanguren et al (1999), whose observations of a rather higher temperature tolerance of eggs (discussed above) was based on stock from the southern edge of the species' distribution range, in Spain.

A number of developmental effects induced by incubation temperature have also been observed; these effects may account for the changes in survival reported. Ojanguren et al (1999) observed salmon embryos incubated at higher temperatures had a lower body weight at hatching and at first exogenous feeding. The emerging alevins from the 12°C group in the study by Gunnes (1979) averaged little more than half the weight of those incubated at 8°C.

Increasing water temperatures may adversely affect a range of other environmental conditions which have the potential to cause harm. The toxicity of many pollutants is greater at higher temperatures (Alabaster and Lloyd 1982). Moreover, dissolved oxygen may become a major issue in warm water; the solubility of oxygen in water falls as temperatures rise, air saturation levels are lower, oxygen-consuming processes, such as decay of vegetation, are accelerated at higher temperatures; and the ability of most species to withstand depleted levels of oxygen is reduced at elevated temperatures. The susceptibility of salmonids to pathogens and parasites may also be influenced by temperature.

Project aims and objectives

This projects aims therefore are to:

a. provide the best possible monitoring of stream water and air temperature in the selected locations over a number of years.
b. deepen our understanding of the effects of the in stream temperature regimes on spawning success of salmonids.
c. offer an answer to the question 'what effect does in stream temperature regime have on survival of juvenile salmonids'
d. provide data to inform NRW/EA of the effects of global warming on juvenile salmon and trout allowing effective management plans and mitigations.

Objectives

a. in partnership with NRW/EA identify and prioritise suitable sites for monitoring ambient in stream water temperature and also air temperature in line with regular electro fishing programme.
b. identify and agree with NRW/EA other data needed to be collected such as redd counting, invertebrate sampling, etc.
c. capture a snapshot of salmon spawning sites thermal conditions during key periods within the spawning cycle of salmonids.
d. report results of surveys and monitoring on an annual basis to allow early response to findings.

Project methodology

Up to 100 Tinytag Aquatic 2 temperature data recorders will be deployed over 25 sites identified by NRW/EA as sites considered significant as salmon spawning streams (see attached table) and regularly sampled by the NRW/EA (NRW Know Your Rivers -Salmon and Sea Trout Catchment Summary River Wye 2015). Date recorders will be placed in the stream at each agreed NGR location and another upstream to verify readings. Each will be anchored using bricks or wooden stakes. Care will be taken to ensure recorders will remain submerged under all water conditions and easily recoveredfor sampling. Air temperature recorders will be attached at same locations, to suitable feature such as a tree. Care will be taken that deployment is secure and not to obvious to paasers by or damage from stock,etc. Each recorder will be suitably labelled, including NRW/WSA logos, brief purpose and contact number if found. A document will be compiled and made available showing GPS coordinates' for each recorder along with photographs of locations.
Recorders will be set to record min/max temperature every hour during the sampling period. Data will be down loaded one month after deployment (October/November), then in February/March and then on the anniversary of the deployment of the data recorder. The

temperature data will be presented as an Excel spreadsheet, one for each the sites. This data will be correlated with other environmental and biological data collected at the study sites.

Each year the network will expand towards maximum of 25 sites and will be rationalised by retiring sites where sensors are repeatedly lost or damaged or where sensors consistently record very similar temperatures to other, near-by sites.

Schedule for the deployment of data recorders

	Number of sites*	Number of recorders**	Data download frequency***	Notes
Year 1	10	40	3	Highlighted sites on spreadsheet
Year 2	20	80	3	
Year 3	25	100	3	

*Sites will be selected after discussions with Sophie Gott (author of 'Salmon and Sea Trout Catchment Summary River Wye NRW Report 2016) and staff of the NRW/EA. When selecting sites other factors other than spawning of salmonids will also be taken into account. These will include geological and geographical factors. It is important to take into account geographical orientation and also such factors as the morphology of the stream and the ground water component.
**Two sets of data recorders will be deployed per site. From user and supplier information it is assumed that the batteries in the data recorders will last for more than one year.
***The first data sample will be taken 1 month after deployment; the second sample in the following February/March and the final sample on the anniversary of the first deployment of the data recorder.

Project Timing

WSA intention is to begin project planning and provisioning during May 2017 with first recorders being installed and starting recording in September 2017. Key tasks during the period May to Sept will be;

a. assessing implications of running project within a SAC/SSSI. Chris Rees (NRW) has agreed to pursue this on our behalf.
b. obtaining access approvals from landowners
c. training WSA volunteers
d. trialling recorder installation and data downloading

Costs

A budget cost has been prepared and is attached to this document. Project has been costed as

a match funded project in line with Welsh Government document 140305inkindmatchfundingen.pdf [version 5, Feb 2014].

The value of unpaid WSA volunteer work to the project has been determined taking into account the estimated amount of time spent and the normal hourly and daily rate for the work carried out in line with section 4.1.1 of the Welsh National Rules on the Eligibility of Expenditure.

Note!
A number of other similar networks exist (The Loughborough University Temperature Network (LUTEN) provides detailed measurements of air and water temperature in the Rivers Dove and Manifold, Peak District, UK] or are planned, Loughborough University propose expanding to a second network in Leicestershire and the Salmon and Trout Conservation UK are considering temperature sensors in their southern chalk streams. We would hope to be able to share this information online.

References

Alabaster and Lloyd (1982), Water quality criteria for freshwater fish, Butterworth-Heinemann.

Gunnes (1979), Survival and development of Atlantic salmon eggs and fry at 3 different temperatures, Aquaculture 16 (3), 211-218.

Ojanguren et al (1999), Effects of Temperature on Growth and Efficiency of Yolk Utilisation in Eggs and Pre-feeding Larval Stages of Atlantic Salmon, Aquaculture International (1999) 7: 81.

Peterson et al (1977), Development of Atlantic Salmon (Salmo salar) Eggs and Alevins Under Varied Temperature Regimes, Journal of the Fisheries Research Board of Canada, 1977, 34(1): 31-43, 10.1139/f77-004.

Salmon stocks threatened by decline in fry numbers NRW report 2016 https://naturalresources.wales/about-us/news-and-events/news-releases/salmon-stocks-threatened-by-decline-in-fry-numbers/?lang=en

Know Your Rivers -Salmon and Sea Trout Catchment Summary River Wye NRW report 2016 https://naturalresources.wales/media/679905/know-your-rivers-wye-2015v4.pdf

Appendix - Data from 2016 electric fishing surveys in the Wye catchment.

River	NGR	Site Code	Date Fished	Survey Type	0+ Sal No. per 100m²	0+ Sal Grade	>0+ Sal No. per 100m²	>0+ Sal Grade	Overall Sal Grade	0+ BT No. per 100m²	0+ BT Grade	>0+ BT No. per 100m²	>0+ BT Grade	Overall BT Grade
Dernol	SN 90185 75300	W001	01-Sep-16	Q	117.7	A	6.2	C	A	25.4	B	6.2	C	C
Marteg	SN 95819 71432	W002	09-Sep-16	Q	28.4	C	5.3	C	D	1.8	E	1	E	E
Llanwrthwl Dulas	SN 97371 63696	W003	01-Sep-16	Q	13.8	D	0	F	E	46.9	A	7.7	C	B
Ithon	SO 10454 68113	W004	14-Sep-16	SQ	4.5	D	0.3	E	D	0	F	0	F	F
Clywedog	SO 08394 65065	W005	13-Sep-16	Q	31.2	C	0.9	E	D	0	F	0	F	F
South Dulas - Irfon	SN 91822 46916	W007	02-Sep-16	Q	22.95	D	1.82	E	D	0.45	E	0.23	E	E
Garth Dulas	SN 94231 50110	W008a	16-Aug-16	Q	36.41	C	4.2	D	C	0.35	E	4.9	D	E
Chwerfri	SO 02772 51289	W009	25-Aug-16	Q	83.4	B	0.5	E	C	1.03	E	1.03	E	E
Duhonw	SO 06195 50899	W010	26-Aug-16	Q	28.7	C	1.2	E	D	1.2	E	7.7	C	D
Edw	SO 10952 48673	W011	18-Aug-16	Q	32.3	C	4	D	D	1.8	E	3.7	D	E
Sgithwen	SO 11331 41427	W012	23-Aug-16	SQ	3.03	D	1.52	D	D	3.03	D	1.01	D	D
Lugg	SO 23685 68473	W014	08-Sep-16	Q	0	F	0	F	F	16.1	C	5.1	C	C
Hindwell	SO 27992 60729	W016	14-Sep-16	Q	0	F	0	F	F	31.9	B	20.4	B	B
Honddu	SO 29013 27284	W020	01-Sep-16	Q	0	F	0	F	F	4.1	D	7.8	C	D
Wye	SN 87945 80366	W025	31-Aug-16	Q	6.99	E	1.02	E	E	1.46	E	0	F	E

Juvenile Salmonid Summary
River Wye

River	NGR	Site Code	Date Fished	Survey Type	0+ Sal No. per 100m^2	0+ Sal Grade	>0+ Sal No. per 100m^2	>0+ Sal Grade	Overall Sal Grade	0+ BT No. per 100m^2	0+ BT Grade	>0+ BT No. per 100m^2	>0+ BT Grade	Overall BT Grade
Bidno	SN 89096 80823	W029	30-Aug-16	Q	67.8	B	12.9	B	B	5.8	D	0.9	E	E
Ithon	SO 08351 80941	W032d	13-Sep-16	Q	66.7	B	2.5	E	C	1.7	E	0.8	E	E
Aran	SO 15603 71044	W033	12-Sep-16	Q	1.4	E	0.9	E	E	16.3	C	2.3	D	D
Dulas - Ithon	SO 06143 64518	W035a	12-Sep-16	Q	3.6	E	1	E	E	1	E	1.5	E	E
Cammarch	SN 92635 50312	W043a	17-Aug-16	Q	69.3	B	5.97	C	B	4.18	D	1.79	E	E
Einon	SN 90800 50434	W044b	17-Aug-16	Q	0	F	0	F	F	69.47	A	3.16	D	A
Llynfi	SO 14382 33065	W047e	15-Aug-16	Q	0	F	0	F	F	2.43	E	6.25	C	D
Arrow	SO 21776 50634	W052	06-Sep-16	Q	0	F	0	F	F	14.5	C	7.99	C	C
Irfon	SN 85064 52855	W095L	24-Aug-16	Q	31.6	C	2.05	E	D	8.86	C	0	F	E
Arrow	SO 34400 59302	The Forge	01-Sep-16	SQ	0	F	0	F	F	11	B	25	A	B
Pinsley Brook	SO 45085 60611	Cobnash	31-Aug-16	SQ	0	F	0	F	F	5	C	32	A	B
Arrow	SO 46157 57789	Monk land	01-Sep-16	SQ	0	F	1	D	E	0	F	18	A	C
Lodon	SO 61844 49376	Stoke Lacy	31-Aug-16	SQ	0	F	0	F	F	0	F	13	B	C

Temperature Monitoring Costing [Estimate]	Qty	Unit Cost	£s					Comments
			2017	2018	2019	2020	Total	
Revenue	No. of Sites		10	20	25	25	25	No of sites monitored in year
Tinytag Aquatic 2 Temp Recorders TG-4100	100	82	3276	3276	1638	0	8190	4 per site
Software Pack SWPK-3-USB	2	78	156				156	
Induction Pack ACS-3030	2	42	84				84	
Replacement Tinytag Aquatic 2 Temp Recorders TG-4100	20	82		546	546	546	1638	For lost/stolen/washed away
Hand Held GPS Device	2	30	60				60	
Stakes, Fixings & sundries	100	2	80	80	40	0	200	
Stakes, Fixings & sundries mantenance	10	2		20	20	20	60	For lost/stolen/washed away
Liability Insurances	1	407	407	407	407	407	1628	Mead Insurance Quote
Replacement Batteries * Sevice Kits	320	2	80	160	200	200	640	
Sub Total			4143	4489	2851	1173	12656	
Labour [in kind costing]	**Year 1**	**Rate/hr**	1	0	0	1		% of year 1 costs
Project Management [planning, control, etc]	144	22	3128	1032	1032	1564	6756	Year 1 6mths @ 2 day per month plus 6mths at 1 day per month
Data Processing [dowloading data, collating,]	n/a	17	368	728	908	924	2928	year 1 to 3 1hr per recorder per month plus 8 hrs annual report. Year 4 same except 24 hrs final report
Project Research[Locating landowners, permissions , etc]	n/a	17	331	331	166	0	828	2hrs/landowner [1per site}
Administration [Purchasing, accounting ,etc]	16	10	162	53	53	0	269	
Labour [Setting out, status checking, replacing batteries etc]	n/a	10	1600	2800	3200	3000	10600	4hrs/site to set plus 1hr per month check/security per site
Sub Total £			5589	4945	5359	5488	21380	
Expenses		£/mile						
Project Manager Travel		0	125	83	103	156	467	50 miles per site
Data Processing Analyst Travel	100	0	25	8	8	13	54	100 miles year 1
Project Researcher Travel		0	75	75	38	0	188	30 miles per landowner
Project Administrator Travel	100	0	25	8	8	13	54	100 miles year 1
Unskilled Labour Travel	10	0	300	600	750	750	2400	Avge 10 miles per site per month
Sub Total £			550	774	907	931	3162	
Total Cost £			**10282**	**10208**	**9117**	**7592**	**37199**	
Note!								
Marginal Costing £s			4693	5263	3758	2104	15819	
Labour [in kind] Costing £s			5589	4945	5359	5488	21380	