As you know, AST has long taken the view that catch and release provides an important opotion for fishery managers when making decisions about conservation of stocks of both wild salmon and sea trout. Indeed, you will be aware of the role of John Webb, the former AST biologist, in pioneering C&R methods. In that context the advice AST can offer your is made on the basis of the available science. It is the job of fishery managers on the River Annan to make the appropriate decision for the fishery based on the science and other factors such as catch records, spawning, recruitment of smolts, coastal netting, predation etc. We therefore support C&R as an effective tool to conserve sea trout stocks where, asmay well be the case on the Annan, that measure is considered by managers to be the best option.

I thought you might like to see some recent papers from research conducted by the Irish Marine Institute on the subject of sea trout fecundity.

Please find attached a copy of the paper on the fecundity of seat trout from the Erriff system in the west of Ireland.

The work clearly showed that, in the case of the Erriff, the bulk of the ova (76%) arose from two key year classes; the 1 and 2 sea winter maiden sea trout.
Sea trout in the west of Ireland are far smaller those found in mainland Britain and as such, the 1 /2 SW sea trout would be some 32 to 45cm in length. These would be proportionately bigger fish in Britain.

The Finnock, even those which matured in freshwater, provided less eggs than these maiden fish. We had clear indications that many of the finnock which overwintered in freshwater did not in fact mature. It is known that other finnock overwinter at sea and it is these which provide the maiden sea trout. Finnock which spawned in their first winter failed to reach high egg deposition levels and failed to live for any appreciable length of time.

In managing sea trout we recommended consideration of a slot limit, where anglers would be free to take a small number of finnock as breakfast fish and would also be free to take a larger trophy fish if they wished to do so. We argued this would have little impact on the overall egg deposition in the catchment. In a later study we looked at the viability of male sea trout and despite the fact that they were seemingly strong, virile fish, based on external characteristics, their sperm count dropped off very steeply after they had spawned twice.

Female sea trout can continue to spawn for many years and our study did not look at the viability of the ova produced by these larger females in any detail but did look at the fecundity of the multi-spawners, which declined over time. In my view it is likely that both the viability of the eggs and the number of ova produced are both likely to decline over time. Graeme Harris points out that the annual spawning of these larger fish, over a considerable period of time, more than makes up for any drop in fecundity rates. It is clear that this area needs to be studied in more detail.

In relation to Nick’s query it is likely that the nets do indeed selectively take the prime sea trout and returning these would be a very worthwhile initiative and could add significantly to the egg deposition in the catchment, provided that a slot limit is in place for anglers.

The Erriff paper should be regarded as an example of what might be occurring in Scottish rivers and I would emphasise that the situation may not in fact be the same. Given that the methodology we used is outlined in some detail in the paper it would be a relatively simple matter to plan a similar study over next summer on the Annan, provided the funding could be found for such a programme.

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K. Whelan

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A PRELIMINARY APPRAISAL OF THE FECUNDITY OF MIGRATORY TROUT (*SALMO TRUTTA*) IN THE ERRIFF CATCHMENT, WESTERN IRELAND

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ABSTRACT

The fecundity of migratory trout in the Erriff catchment was investigated between 1983 and 1986. A significant difference was found between the 1984 and 1986 length:fecundity regression equations. Females which migrated to sea as three year old smolts produced significantly fewer ova per unit length than those which migrated as two year olds. Previous spawners produced fewer, but not significantly fewer, ova per unit length than maiden fish. Among previous spawners it was found that those fish which matured for the first time as post-smolts had a significantly lower fecundity than fish which matured for the first time as one-sea-winter maidens. The fecundity of the population is discussed in terms of structure, viable fecundity and management. It is suggested that one- and two-sea winter fish should be protected by the imposition of a 35-45 cm slot limit.

1. INTRODUCTION

The River Erriff research programme was initiated by the Central Fisheries Board in 1983 with the aims of carrying out quantitative research into the management, development and enhancement of this prestigious Atlantic salmon (*Salmo salar* L.) and migratory trout (*Salmo trutta* L.) recreational fishery and applying findings to other fisheries in the West of Ireland.

The fecundity of migratory trout has been investigated by Elliott (1984), Walker (quoted in Le Cren 1985) and O'Farrell, Whelan (quoted in Le Cren 1985). Traditionally workers have calculated length:fecundity regression equations using log transformed data though Thorpe et al. (1984) found that linear equations best fitted their data on Atlantic salmon.

In this work linear and logarithmic regression equations were fitted to data. Dummy variables (Johnson 1960) were also used to evaluate the effects of stock characteristics on fecundity.

2. STUDY AREA

The Erriff catchment in Western Ireland has an area of 166.3 km^2 (Fig. 1). It is an acidic spate river. The main soil types are peaty podsols and the underlying rock derives from the Ordovician period. The recreational fishery on the system is renowned. On the river salmon is the main quarry, migratory trout being a by-catch, while on Tawnyard Lough the reverse is the case.

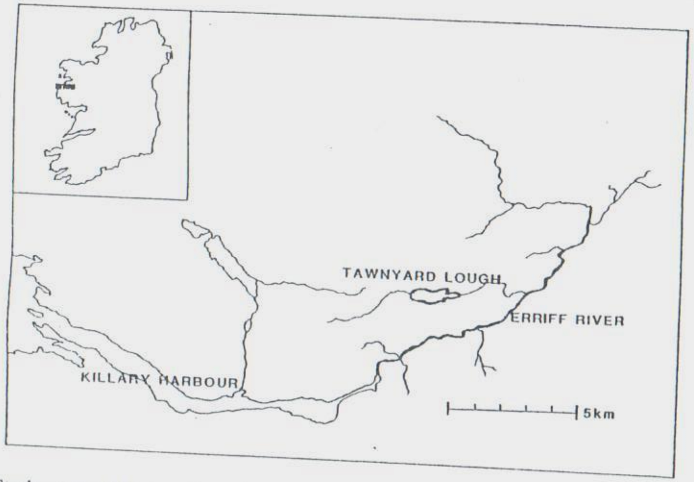

Fig. 1. Study area with sampling sites (Tawnyard Lough and Erriff River) highlighted. Inset: location of study area on the west coast of Ireland

3. MATERIALS AND METHODS

Ovaries were collected from maturing rod caught fish during the 1983–1986 angling seasons. Only fish taken later than August 1 were used in analyses as it was felt that ovaries had developed sufficiently by this date and that potentially atretic ova were excluded (Prouzet et al. 1984). Details of fork-length, wet weight and a scale sample were also collected from each fish. Ova were counted after hardening in Gilsons fluid or 4% formalin. In 1983 all ova from one ovary of each female were counted and counts adjusted to the weight of both ovaries. Total counts from both ovaries were carried out on samples collected between 1984 and 1986. The number of eggs per female was related to fork-length as follows:

$F = a + bL$ (linear)

$\log_{10} F = \log_{10} a + b\log_{10} L$ (logarithmic) (1)

$\log_{10} F = \log_{10} a + b\log_{10} L + cZ$ (dummy variable) (2)

(3)

where F = number of ova

L = fork-length (cm)

a, b and c are constants

Z = code for biological variable

The dummy variable technique (Johnson 1960) was used to evaluate the effect of certain stock characteristics on fecundity. It is a method for measuring the effect of categorical variables i.e. variables which reflect whether or not an observation belongs to a particular category. Geometrically the dummy variables coefficient measures a shift in the intercept of the regression equation.

The terminology for migratory trout recommended by Allan, Ritter (1977) is used throughout.

4. RESULTS

SAMPLES

The sea ages and numbers of females collected each year are given in Table I. Due to the exploitation pattern of migratory trout in the fishery (post-smolt predominate in the Erriff R. catch) samples from Tawnyard Lough had a significantly higher sea age (mean = 1.2; 0.95 C.I. = 0.934-1.466; $n = 45$) compared with samples from the Erriff River (mean = 0.762; 0.95 C.I. = 0.614-0.910; $n = 105$). Since 1985 migratory trout kelts and smolts have been trapped and marked as they left Tawnyard Lough. Marked fish returns from both sections of the fishery indicate that maturing fish destined for the lake are infrequently taken anglers on the river.

Table I. Numbers of female migratory trout from River Erriff (E) and Tawnyard Lough (T) used in fecundity determinations (1983–1986)

Sea age		1983	1984	1985	1986	Combined
0	(E)	11	10	8	10	39
	(T)	1	3	3	—	7
1	(E)	18	14	16	9	57
	(T)	1	7	5	15	28
2	(E)	1	1	1	2	5
	(T)	—	1	2	2	5
3	(E)	1	—	2	—	3
	(T)	—	—	3	1	4
4	(E)	—	—	—	1	1
	(T)	1	—	—	—	1
	Totals	34	36	40	40	150

LENGTH:FECUNDITY RELATIONSHIP EACH YEAR

Linear and logarithmic regressions fitted length: fecundity data equally well (Fig. 2 and Table II). A significant difference between the slopes and/or intercepts of the 1984 and 1986 regression equations was found (Table III).

Table II. Migratory trout annual fecundity on fork-length regression equations

Linear	a	b	r	S.E.b
1983	−1082.45	55.70	0.910	4.47
1984	−1094.52	55.18	0.909	4.33
1985	−1238.49	60.67	0.941	3.53
1986	−1205.18	61.43	0.839	6.46
Logarithmic	**Log a**	**b**	**r**	**S.E.b**
1983	−0.62	2.28	0.902	0.193
1984	−0.89	2.45	0.928	0.168
1985	−0.30	2.09	0.938	0.126
1986	−0.52	2.24	0.865	0.211

Table III. Migratory trout annual fecundity on fork-length regression equation comparisons. F-ratio (and significance) are shown

Linear	1984	1985	1986
1983	0.362(0.697)	0.544(0.577)	1.748(0.181)
1984		1.629(0.203)	3.659(0.030)*
1985			1.043(0.357)
Logarithmic			
1983	0.205(0.815)	1.221(0.301)	2.367(0.101)
1984		3.074(0.052)	3.843(0.025)*
1985			1.183(0.311)

*significantly different slopes and or intercepts.

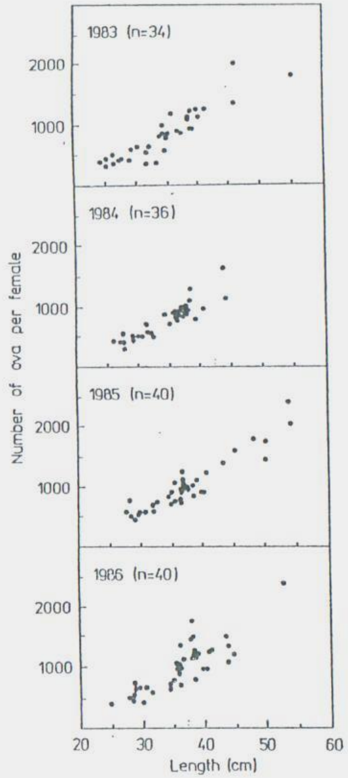

Fig. 2. Relationship between fecundity and fork-length for migratory trout 1983–1986

SMOLT AGE

Maturing fish derived from three year old smolts were found to have a significantly lower fecundity per unit length than those derived from two year olds ($Z = 0$ for fish derived from two year old smolts and 1 for those derived from three year olds and t-values are given in parentheses).

$$\text{Log } F = -0.555 + 2.267 \text{ Log } L - 0.050\ Z \qquad r = 0.914$$
$$(4.17) \quad (26.48) \quad (4.01) \quad \text{(all significant at the 0.1\% level)}$$

POST-SMOLT "COHORTS"

Table IV describes the fecundity distributions of post-smolt "cohorts" i.e. fish which migrated to sea for the first time in the same year. It was found that the fecundity of post-smolts in 1983 (mean = 481; 0.95 C.I. = 418.4 – 543.5, $n = 12$) was significantly lower than in 1985 (mean = 607.5; 0.95 C.I. = 545.5 – 669.5; $n = 11$) ($t = -2.867$ with 21 d.f.; $p < 0.05$). Similarly the fecundity of one-sea-winter fish in 1984 (mean = 930.5; 0.95 C.I. = 858.4 – 1002.6; $n = 20$) was significantly lower than that of one-sea-winter fish in 1986 (mean = 1096.8; 0.95 C.I. = 981.3 – 1212.3; $n = 24$) ($t = -2.417$ with 42 d.f.; $P < 0.05$). Due to the truncated nature of samples the length: fecundity relationships of only two "cohorts" were compared (1983 and 1984) and were found not to have significantly different slopes and/or intercepts (F – ratio = 0.781; $P = 0.462$).

Table IV. The fecundity (mean and 0.95 C. I.) of migratory trout post-smolt "cohorts" (1982 – 1986)

"Cohort"	Sea age	Number of females	Number of eggs per female	
			Mean	0.95 C. I.
1982	1	19	950	836 – 1063
	2	2	1406	922 – 1890
	3	5	1922	1611 – 2233
	4	1	2405	–
1983	0	12	481	418 – 543
	1	21	931	865 – 996
	2	3	1327	893 – 1760
	3	1	1235	–
1984	0	13	540	461 – 619
	1	21	968	903 – 1033
	2	4	1317	1152 – 1482
1985	0	11	607	545 – 669
	1	24	1096	985 – 1208
1986	0	10	574	501 – 647

PREVIOUSLY SPAWNED FISH

Previously spawned fish were found to be less, but not significantly less, fecund per unit length than maiden fish ($Z = 0$ for maidens and 1 for previous spawners and t-values are given in parentheses).

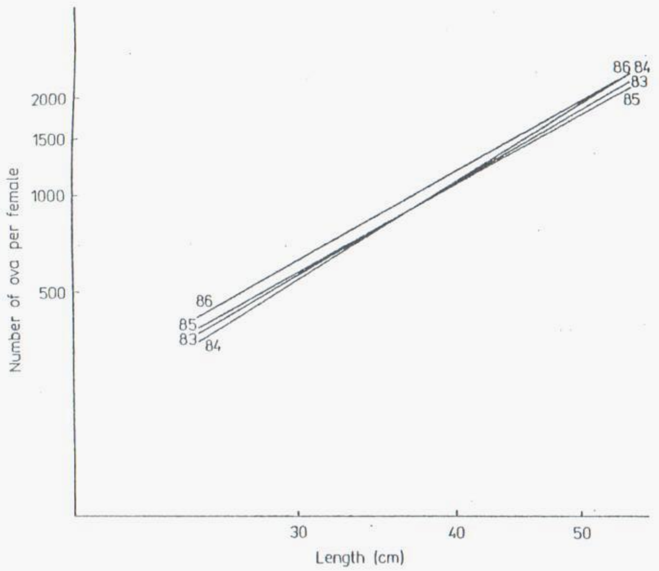

Fig. 3. Regressions of fecundity on fork-length for migratory trout 1983–1986 (Log-Log scales)

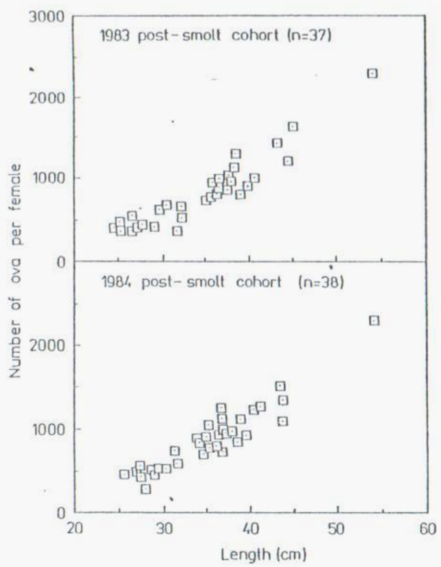

Fig. 4. Relationship between fecundity and fork-length for 1983 and 1984 post-smolt "cohorts" of migratory trout

$$\text{Log } F = -0.698 + 2.348 \text{ Log } L - 0.021Z \qquad r = 0.906$$
$$(4.29)^{***}(22.12) \qquad (0.10) \qquad (^{***}\text{significant at } 0.1\% \text{ level})$$

When post-smolts were omitted (reducing samples to 78 maidens and 26 previous spawners) previous spawners were again less, but not significantly less, fecund per unit length than maiden fish.

$$\text{Log } F = -0.676 + 2.336 \text{ Log } L - 0.023Z \qquad r = 0.810$$
$$(2.16)^{*} \quad (11.72)^{***} \qquad (1.09) \qquad (^{***}\text{significant at } 0.1\% \text{ level; } ^{*}\text{significant at } 5\% \text{ level})$$

The length:fecundity relationship of previously spawned fish is shown in Fig. 5. Fish which spawned as post-smolt did not achieve high fecundity or great length and were significantly less fecund than fish which matured for the first time as one or two-sea-winter maidens (mean = 981.5; 0.95 C.I. = 874.5 – 1088.5; $n = 10$ compared with mean = 1654.5; 0.95 C.I. = 1439.3 – 1869.7; $n = 16$) ($t = -4.692$ with 24 d.f.; $P < 0.05$).

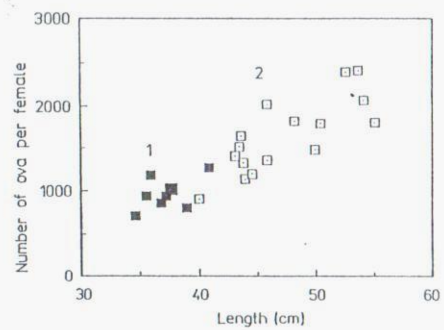

Fig. 5. Relationship between fecundity and fork-length for previously spawned migratory trout (1 – fish which spawned for first time as post-smolt; 2 – fish which spawned for first time as one or two-sea-winter maidens)

5. DISCUSSION

Recent investigations in Ireland have shown that the interpretation of many aspects of the life-cycle of migratory trout is problematical:

(1) Defining the freshwater age of a migratory trout can be very difficult. For example, distinguishing between 2B and 3A fish i.e. 2 year old smolts which exhibit freshwater growth on their scales in the year in which they first migrate to sea and three year old smolts which do not, is necessarily subjective;

(2) Frost, Brown (1967) and Elliott (1985) stated that the presence of a spawning mark on scales was positive evidence of sexual maturity but that the absence of a mark was not proof that a fish was a maiden. The interpretation of "spawning marks", particularly the spawning mark at the post-smolt stage can be erroneous. O'Farrell, Whelan, quoted in Le Cren (1985) showed that previously spawned post-smolt sometimes exhibited little

evidence of spawning on their scales — but had residual ova in their abdominal cavities;

(3) C. P. R. Mills (pers. comm.) has found from tagging studies in the Burrishoole system that scale absorption in older migratory trout can be so extensive as to obliterate previous growth and/or evidence of spawning with the results that sea age and/or number of spawnings would be underestimated.

Scale reading of samples used in this work was carried out with these considerations in mind.

Though preliminary, the results show that:

- length: fecundity regression equations differ between years;
- migratory trout derived from three year old smolts have a lower fecundity per unit length than those derived from two year olds (Thorpe et al. (1984) also found that this was true for Atlantic salmon and the result obtained in this work suggests that freshwater ageing was reasonably accurate):
- length: fecundity relationships for post-smolt "cohorts" may differ between years (data collected to date are inadequate to test this) possibly reflecting varying marine conditions (temperature, feeding) or indeed freshwater conditions (temperature and timing of kelt/smolt migrations);
- females which first spawned at the post-smolt stage never achieve high fecundity or great length.

Female migratory trout examined in the present study were not in spawning condition therefore no data on ova size in relation to female fork-length, age etc were available. Larsson, pers. comm. (quoted in Christensen, Larsson (1979) found that in Atlantic salmon ova size was positively correlated with sea age while the number of ova per kg of unstripped fish was negatively correlated with sea age.

In the present study evidence was also presented which showed that previous spawners have a reduced fecundity per unit length compared with maiden fish. Information is also accumulating on the numbers of residual ova found in the abdominal cavities of previously spawned fish. Though insufficient data are yet to hand it appears that large fish contain far more residual ova than smaller ones which suggests that spawning efficiency may decrease with spawning frequency.

Mr J. J. Nixon (pers. comm.) found during several years of hatchery work in the West of Ireland that ova from very large sea trout were not as viable as those from middle-sized fish and that a high percentage of ova from these large fish did not become fertilised.

If this is the case in the wild it may be more appropriate to think of viable ova and of the length: viable fecundity relationship of migratory trout being an asymptotic one — with the asymptote at 40–45 cm fork-length.

How can this information be applied to the management and enhancement of migratory trout stocks in recreational fisheries?

O'Farrell and Whelan (unpubl.) have examined catch structures (Killary Harbour draft-net fishery, Erriff R. and Tawnyard L. recreational fishery, Tawnyard L. kelt/smolt trap) and having considered the sex ratio, percentage maturation, fecundity and relative abundance of each sea age group calculated that sea age groups make the following contribution to egg deposition in the

Tawnyard Lough catchment (1986 egg deposition estimated at 252, 140 from a spawning escapement of 745 fish):

sea age	0	1	2	3	4	5
% contribution	5.6	40.6	35.3	13.0	4.4	1.0

The main spawners therefore appear to be the one- and two-sea-winter fish. Elliott (1984) has shown that egg size correlates positively with female size and that small alevins derived from small eggs survive starvation for shorter periods than large alevins derived from large eggs. On the other hand there is also evidence that very large migratory trout are less fecund, less efficient at spawning and produce less viable ova compared with fish of an intermediate size.

The aim of management therefore should be to protect one- and two-sea-winter females as these fish not only lay the bulk of the ova (75.9%) but they may also be laying the most viable ova. The imposition of a size slot-limit of 35–45 cm would protect this valuable stock component and allow anglers to crop post-smolt and larger trophy fish. During the latter part of the angling season, when sexes can be differentiated, anglers could also be permitted to keep male fish within the size slot-limit. Had this size slot-limit been in operation for the 1986 angling season an extra 39 172 ova (representing an additional 20.4% of the most viable ova) would have been deposited.

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