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REPLY COMMENT

River Erriff sea trout *Salmo trutta* revisited: Reply to O'Farrell (2025)

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ABSTRACT: Gargan et al. (2016; Aquacult Environ Interact 8:675–689) used a time series of 15 life history descriptors to demonstrate that the population dynamics of a wild sea trout population could change markedly over a short time period. O'Farrell (2025; Aquacult Environ Interact 17: 21–26) subsequently noted certain errors in the data used in Gargan et al. (2016) and presented a new analysis, inferring that the overall findings of Gargan et al. (2016) might be compromised. Here, we provide comprehensive responses to each of the data issues raised by O'Farrell (2025) and include a brief additional analysis. We conclude that the results and interpretation of Gargan et al. (2016) remain supported.

KEY WORDS: Fish · Sea trout · Fisheries · Western Ireland

1. INTRODUCTION

Gargan et al. (2016) used time series of 15 life history descriptors to demonstrate that the population dynamics of an anadromous fish population could change very markedly over 2 to 3 yr. The key implication of this result was that populations of sea trout might be vulnerable to novel anthropogenic forcing. Gargan et al. (2016) suggested that strong changes observed in the Erriff sea trout population around 1988–1990 might reflect the establishment of local salmon farms. This suggestion was supported by an analysis that showed a significant ($p < 0.05$) positive relationship between the estimated number of salmon lice on the new salmon farm in each year in April and May, and the number of lice on wild sea trout in the nearby Erriff and Delphi Rivers in May and June each year.

A subsequent Comment from O'Farrell (2025) rightly noted that the analysis in Gargan et al. (2016) primarily concerned the 'structure of sea trout populations before and after the widely reported collapse of West of Ireland sea trout stocks in 1989/1990' (p. 1). However, O'Farrell (2025) also states that most of the sea trout life history descriptors ('response variables') used in Gargan et al. (2016) were 'compromised', and that the proposed link to salmon farming was 'not based on the content of their article' (p. 5). Furthermore, O'Farrell (2025) provided a new statistical analysis that purported to demonstrate that there is no evidence for a link between changes in Erriff sea trout abundance (annual run, rod catch and number of kelts) and sea louse pressure from the salmon farm.

In this Reply, we explain how the parameters used in Gargan et al. (2016) are not compromised and do not invalidate our assessment of the characteristics of sea

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trout in the Erriff system. We acknowledge some minor errors in reporting of data, which have been recently corrected (see https://www.int-res.com/abstracts/aei/v8/c_p675-689/). We also comment briefly on the new analysis from O'Farrell (2025), providing an alternative statistical implementation. Finally, we refer to the substantial published literature that upholds the original interpretation of Gargan et al. (2016).

Gargan et al. (2016) used 14 descriptors to characterize state in the Erriff sea trout population (see Table 2 in that paper). O'Farrell (2025) referred to these 14 response variables, noting that the 'Mean number of lice on sea trout' descriptor (Table 2 of Gargan et al. 2016) comprises separate time series from the Erriff and nearby Delphi rivers. The mean number of lice on sea trout descriptor is further broken down into mean number of lice in April and mean number of lice in May in Table 5 of Gargan et al. (2016), raising the number of descriptors from 14 to 15. We respond to each specific concern of O'Farrell (2025) about these metrics in the following sections. Our responses to O'Farrell (2025)'s Supplement are provided in our own Supplement at www.int-res.com/articles/suppl/q017p027_supp.pdf.

2. SALMON FARMING IN KILLARY HARBOUR, NEAR THE ERRIFF SYSTEM

The Comment of O'Farrell (2025) criticizes Gargan et al. (2016) for comparing sea trout population characteristics after 1990 with those during the period 1985–1988, which was originally defined as predating salmon farming in Killary Harbour, close to the Erriff system. O'Farrell (2025) states that the sea trout population characteristics pertaining to 1985–1988 apply to a period that is at least partly contemporaneous with salmon farming, making comparisons meaningless. This statement is not correct as is explained in the following text.

The data in Fig. 5 of Gargan et al. (2016) refer to sea trout kelts that migrated into the Erriff catchment from the sea in the previous year. Therefore, kelts counted in 1985, 1986 and 1987 entered the river in 1984, 1985 and 1986, respectively, prior to salmon farming. When the salmon farm was established in 1986, only salmon smolts were present on the farm in March, and these would have been free of sea lice as they were only recently taken from freshwater. The kelt data for 1988 comprise sea trout that entered the river at the latest in 1987 when the lowest number of overwintered farmed salmon were present (75 000) over the time series. It was estimated from scale reading that these sea trout comprised sea trout finnock (42.6%) that migrated in spring 1987 when there was the lowest number of overwintered salmon present in the bay and of sea trout (57.4%) which were one sea winter fish or older, meaning that they had migrated to sea before there were overwintered salmon present in the bay. We therefore regard the kelt data over the 1985 to 1988 period as reflecting a typical sea trout population structure having little or no effect from sea louse infestation on out-migrating sea trout smolts and the associated mortality.

In this context, O'Farrell (2025) suggested that if there is an effect of sea lice pressure from the salmon farm on Erriff sea trout, then this should be evident in (1) the number of lice observed on sea trout in the river and (2) also in appropriate abundance indicators for the sea trout population. O'Farrell (2025) then presented a brief analysis that tested for relevant correlations. We respond to the 2 points below.

(1) Sea lice on sea trout. An important result shown in Table 1 in the analysis of O'Farrell (2025) was a significant positive correlation between estimated number of lice on the farm and lice counted on sea trout. This finding supports the similar results in Table 5 in Gargan et al. (2016). There is a wealth of evidence that moderate levels of sea louse infestation can have serious negative impacts on sea trout, including physiological, behavioural and population regulating effects (Bjørn & Finstad 1997, Thorstad et al. 2015, Gargan et al. 2017). It is thus reasonable to infer that an anthropogenic increase in louse infestation on Erriff sea trout might have had population level consequences.

(2) Abundance indicators of the sea trout population. O'Farrell (2025) also presented some tests for correlations in his Table 1 between estimated numbers of sea lice on the salmon farm and 3 sea trout abundance metrics: number of kelts, rod catch, and annual sea trout run. These tests did not reveal any statistically significant results ($p > 0.05$). However, the analyses were limited in some respects. Firstly, the tested sea trout run data series only included 7 yr of data (1998–2004), providing very limited power to detect direct year to year correlations. Secondly, the kelt data incorporate various potential sources of mortality, e.g. winter survival, which might confound a direct louse effect. In contrast, we agree with O'Farrell (2025) that the Erriff sea trout rod catch data might be a reasonably direct population abundance indicator and so we conducted a new analysis to further explore possible sea louse impacts on this metric. Briefly, this new analysis comprised 2 negative binomial models. The models tested the potential effects of estimated louse counts (L_y) from the salmon farm in April of each year (Y) on corresponding annual sea trout catch (C_y, a run index) in the Erriff. Only the April data were used because previous analysis has shown that this period most closely relates to louse pressure on migrating sea trout (Shephard & Gargan 2021).

The first model used raw estimated louse counts (as in O'Farrell 2025), while the second model used log-transformed counts, addressing the orders of magnitude variation in this variable among years. Both models included year as a continuous co-variate, to capture background variation in annual Erriff sea trout runs. The model was formulated as follows:

$$C_y \sim \mathrm{NB}(\mu_y, k)$$
$$E(C_y) = \mu_y \text{ and } \mathrm{var}(C_y) = \mu_y + \mu_y^2/k$$
$$\log(\mu_y) = L_y + Y$$

where NB is a negative binomial, μ and k are the parameters of the NB distribution function, and E is Edwards design model. All statistical analysis was conducted using the R statistical software (R Core Team 2023).

Akaike's information criterion (AIC) was used to compare between the 2 tested models and showed that the model with log-transformed louse counts (AIC = 161.6) had much better fit to the data (ΔAIC > 8) compared to the model with untransformed counts (AIC = 170.2). The lower AIC model showed a strongly negative relationship between log-transformed salmon farm louse counts in April and the annual sea trout run ($p < 0.001$). This result contrasts with the lack of correlation shown in O'Farrell (2025).

3. SEA AGE, LENGTH FREQUENCY DISTRIBUTION AND SPAWNING HISTORY OF TAWNYARD LOUGH SEA TROUT KELTS

O'Farrell (2025) referred in his Table 2 to the differences in sea age structure cited in O'Farrell & Whelan (1991) and Gargan et al. (2016) and suggested that data from the 1985 to 1988 period are not in agreement. However, sea age structures for 2 years (1985 and 1988) are very similar and there is good agreement for data from 1987. Taken together, the sea age structure for the 1985–1988 period is not markedly different from that in O'Farrell & Whelan (1991) and both sets of data for the 1985–1988 period indicate that a stable sea trout population structure typical of the West of Ireland was present prior to 1989; the population was dominated by a peak of finnock (0+ sea age trout), a second peak of 1 sea-winter maidens and some older and larger sea-age classes and previous return spawners. This sea age population structure is markedly different from that recorded after 1990, when the population was dominated by 0 group sea trout until 1995 (Table 4 of Gargan et al. 2016). We therefore assert that while there is some divergence in the data for a single year prior to the 1989/1990 sea trout collapse, both sets of data show a similar sea age population structure. It is important to note that the scales from the Tawnyard sea trout trap were re-read during the 1990s (Gargan et al. 2016) and differences in sea age structure may partly reflect subjective differences in interpretation.

4. SEA TROUT EGG DEPOSITION IN THE TAWNYARD LOUGH SUBCATCHMENT OF THE ERRIFF SYSTEM

In calculation of potential sea trout egg deposition for the Tawnyard Lough subcatchment of the Erriff system, O'Farrell (2025) noted the absence of any reference to sea trout sex ratio in the calculation of population fecundity in Gargan et al. (2016). The average female sea trout percentage for each sea age class was taken from O'Farrell (unpubl. data: 'Erriff sea trout: post smolt maturity and their contribution to egg deposition'). According to this work, 53.3% of 0 group sea age fish were classed as female, 50% of 1 sea age fish were classed as female, 53.3% of 2 sea age fish were classed as female and 66% of 4 sea age fish were classed as female. Gargan et al. (2016) omitted to refer to this source in their Section 2, relating to calculation of potential sea trout egg deposition as the source was from unpublished data. This paper was in the historic files at the River Erriff Research Station and was preliminary work by Dr. O'Farrell. Much of these sea trout fecundity data were subsequently published in a more detailed paper, O'Farrell et al. (1989), which is cited in Gargan et al. (2016).

5. SEA TROUT SMOLT AGE AND LENGTH

We accept the comment by O'Farrell (2025) that smolt length distributions cannot be reliably described using small sample sizes. Table 3 in Gargan et al. (2016) provides data on smolt age composition and the mean length of sampled smolts. In examining the data, we find that the values for 'Total no. of smolts' in Table 3 represent the number of smolts aged, not the total sample size of smolts. The number of smolts measured (length, cm) in each sampling year (1985–2002) ranged from N = 335 to N = 2555, except for

1993 (N = 73) and 2002 (N = 61). Unfortunately, these total numbers of smolts measured are not provided in Table 3 of Gargan et al. (2016) as this table was an amalgamation of 3 previous tables that were advised by the editor to be combined, but the larger total numbers of smolts measured were used for the statistical analyses referred to in the text.

6. ROD CATCHES AND EFFORT INFORMATION FOR THE ERRIFF FISHERY AND THE CONNEMARA DISTRICT SINCE 1990

Gargan et al. (2016) commented that after 1990, a bylaw was enforced, which permitted angling only on a catch and release basis in both the Erriff and Connemara fisheries, and speculated that the introduction of this bylaw may have reduced fishing effort in Connemara and Erriff fisheries. O'Farrell (2025) suggested that there was a significant drop in angling effort after 1990 and inferred that this decline in effort partly explains the observed reduction in sea trout catches.

While we acknowledge that there was a reduction in fishing effort on the Erriff and other Connemara sea trout fisheries post-1990, it is our view that this reduction does not explain the observed reduction in sea trout catches between 1988 and 1990. An analysis of sea trout rod catches and effort data (catch per unit effort, CPUE) for 4 Connemara fisheries (Gargan et al. 2006) has indicated that the sea trout catch decline recorded between 1988 and 1990 was not related to reduced angling effort but instead reflected a marked reduction in CPUE. In addition, as pointed out by O'Farrell (2025), salmon angling continued to take place on the River Erriff, which would have resulted in a sea trout bycatch, which were also recorded and used in the analyses of Gargan et al. (2016).

O'Farrell (2025) was also critical of the fact that Gargan et al. (2016) refer to Tawnyard Lough as the principal sea trout fishery on the Erriff fishery and went on to show in his Fig. 3 a larger sea trout catch on the main River Erriff than on Tawnyard Lough. We feel this is a moot point as Tawnyard Lough is the main fishery for sea trout on the Erriff system. In addition, O'Farrell (2025) stated that sea trout are the main target for anglers on Tawnyard Lough. Importantly, the sea trout rod catch data used in Gargan et al. (2016), Fig. 2a, included records from both Tawnyard Lough and the River Erriff.

O'Farrell (2025) suggested that sea trout rod catch on the Erriff fishery was an unsuitable and unreliable response variable because fishing effort for sea trout after the 1989 stock collapse was significantly lower than that which applied prior to the stock collapse. As pointed out above, Gargan et al. (2006) assessed sea trout rod catch and effort data (CPUE) and found that the sea trout catch collapse recorded in West of Ireland fisheries over the 1989/1990 was not related to reduced angling effort but to an actual collapse in stock, indexed by CPUE. The use of sea trout rod catch in Gargan et al. (2016) is therefore appropriate as a response variable.

7. CONCLUSION

There is strong evidence that moderate levels of sea louse infestation from marine salmon farms can have serious negative impacts on sea trout, including physiological, behavioural and population regulating effects. It is therefore reasonable to anticipate that the anthropogenic increase in louse infestation on Erriff sea trout reported by Gargan et al. (2016) and O'Farrell (2025) could have had population level consequences. In this Reply, we explain how the sea trout life history descriptors used in Gargan et al. (2016) are not compromised, affirming strong and short-term changes in population structure and abundance. We also link increased sea louse infestation statistically to impaired annual runs of sea trout on the River Erriff. Consequently, we uphold the conclusion of Gargan et al. (2016) that the introduction of salmon farming into the local estuary most likely contributed to observed changes in Erriff sea trout population dynamics.

LITERATURE CITED

Bjørn PA, Finstad B (1997) The physiological effects of salmon lice infection on sea trout post smolts. Nord J Freshw Res 73:60–72

Gargan PG, Roche WK, Forde GP, Ferguson A (2006) Characteristics of the sea trout (*Salmo trutta* L.) stocks from the Owengowla and Invermore fisheries, Connemara, Western Ireland, and recent trends in marine survival. In: Harris G, Milner N (eds) Sea trout: biology, conservation and management. Blackwell, Oxford, p 60–75

Gargan PG, Kelly FL, Shephard S, Whelan KF (2016) Temporal variation in sea trout *Salmo trutta* life history traits in the Erriff River, western Ireland. Aquacult Environ Interact 8:675–689

Gargan PG, Shephard S, MacIntyre C (2017) Assessment of the increased mortality risk and population regulating effect of sea lice *(Lepeophtheirus salmonis)* from marine salmon farms on wild sea trout in Ireland and Scotland. In: Harris G (ed) Sea trout: science & management. Proc 2nd Int Sea Trout Symp. Matador Publishing, Leicester, p 507–522

O'Farrell MM (2025) River Erriff sea trout *Salmo trutta* revisited: Comment on Gargan et al. (2016). Aquacult Environ Interact 17:21–26

O'Farrell MM, Whelan KF (1991) Management of migratory trout (*Salmo trutta* L.) populations in the Erriff and other catchments in Western Ireland. In: Steer MW (ed) Irish rivers: biology and management. Royal Irish Academy, Dublin, p 99–112
O'Farrell MM, Whelan KF, Whelan BJ (1989) A preliminary appraisal of the fecundity of migratory trout (*Salmo trutta*) in the Erriff catchment, Western Ireland. Pol Arch Hydrobiol 36:273–281
R Core Team (2023) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna
Shephard S, Gargan P (2021) System-specific salmon louse infestation thresholds for salmon farms to minimize impacts on wild sea trout populations. Aquacult Environ Interact 13:377–388
Thorstad E, Todd CD, Uglem I, Bjørn PA and others (2015) Effects of salmon lice *Lepeophtheirus salmonis* on wild sea trout *Salmo trutta* — a literature review. Aquacult Environ Interact 7:91–113

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