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Sea reared rainbow trout *Oncorhynchus mykiss* need fewer sea lice treatments than farmed Atlantic salmon *Salmo salar*

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Abstract

A field investigation at a marine finfish farm site which stocked both Atlantic salmon and rainbow trout was carried out over a period of 14 years. Abundance of *Lepeophtheirus salmonis* at this site was found to be similar on both species, however, the quantity of sea lice treatments carried out on each stock of fish show a marked difference between species, with over three times the amount of sea lice treatments being carried out on salmon to maintain the same level of sea lice control. A different management regime had to be employed for the two fish species with a higher treatment effort being implemented for the salmon stocks to maintain sea lice infestation levels within the required thresholds.

Introduction

Sea lice are marine copepods, ectoparasites of the Family Caligidae which occur on many species of marine fish worldwide and are regarded as having the most commercially damaging effect on farmed salmonids worldwide. The two main species of concern for salmonid farmers in Ireland are *Lepeophtheirus salmonis* and *Caligus elongatus*. Sea lice cause damage to the host by grazing on mucus, epidermal tissue and blood. *L. salmonis* is regarded as the most important sea lice species with respect to disease (Jackson, 2011), and significant economic losses can be attributed to infestation of farmed fish by this parasite (O'Donohoe and McDermott, 2014). The life-cycle of *L. salmonis* comprises 8 stages (Schram, 1993; Hamre et al., 2013).

Sea lice infestation can begin immediately after fish are put to sea, sources of this infestation can be from wild fish (Jackson et al., 2012), either indigenous anadromous sea trout *Salmo trutta* or returning wild or ranched Atlantic salmon. Neighbouring fish farm sites can also act as a source of sea lice infestation particularly if adjoining farm sites contain one-sea-winter fish or older (Jackson et al., 1997).

Studies carried out on prevalence and abundance of sea lice on farmed salmonids in Ireland have shown that Atlantic salmon experience higher sea lice infestation levels than rainbow trout (Jackson and Minchin, 1992). However, a Norwegian controlled infestation study (Gjerde and Saltkjelvik, 2009), where the predicted sea lice counts for salmon and rainbow trout of similar body weight were compared, the salmon count was lower than the count for rainbow trout.

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Salmonid farming began in Ireland in the early 1970s. Salmon and rainbow trout have been produced in each of the three fish farming regions in Ireland over this period of time, on occasion within the same bays and infrequently on the same sites (O'Donohoe et al., 2005). Farmed rainbow trout stocks in Ireland did not breach the National treatment trigger levels (0.5 ovigerous *L. salmonis* per fish in March, April and May and 2 ovigerous *L. salmonis* per fish for the remaining months of the year) for sea lice abundance in 2013 (O'Donohoe et al., 2014), while one sea-winter salmon were in breach of these levels for 18% of inspections in this period of time and two sea-winter salmon were in breach of the treatment trigger levels for 100% of inspections carried out in 2013.

Sea lice infestation levels tend to increase with increased lengths of time at sea (Jackson et al., 2000). While the husbandry of farmed salmon and rainbow trout are similar, one of the main differences is the shorter production cycle of trout in the sea. Salmon take longer than trout to grow to marketable size and this longer cycle at sea leads to heavier sea lice burdens on salmon, particularly two-sea-winter fish (Jackson et al., 2000), however rainbow trout show lower sea lice abundance than salmon (Jackson and Minchin, 1992). Rainbow trout have a thicker epidermal layer than salmon and produce more mucus cells per cross sectional area (Fast et al., 2002a). Slower development of sea lice coupled with delayed immune response parameters suggests that rainbow trout are slightly more resistant to sea lice infection than salmon (Fast et al., 2002b).

Greater knowledge of the infestation patterns of sea lice on rainbow trout may have implications for fish husbandry, fallowing of farm sites, treatment regimes, duration of production cycles and location of sites.

In order to investigate the infestation parameters and the underlying levels of susceptibility of Atlantic salmon and rainbow trout to *L. salmonis* a longitudinal study was carried out. This was based on an extensive data set of sea lice infestation parameters held by the Marine Institute, Ireland covering 14 years. The objectives of this study were to evaluate the abundance of *L. salmonis* on both species of fish and to assess and compare the sea lice treatment effort carried out on Atlantic salmon and rainbow trout stocks at one production site when the two species were farmed concurrently.

Materials and methods

Sea lice data was obtained through the Marine Institute Sea lice Monitoring Programme (DMNR Monitoring Protocol No.3. 2000) (O'Donohoe et al., 2014). Farmed stocks of salmon and rainbow trout in Ireland were inspected on 14 occasions throughout the year to monitor sea lice levels as part of this national programme. At each inspection 2 samples were taken for each generation of fish on site. Thirty fish were examined for each sample by anaesthetising each fish using tricaine methane sulphonate (MS222) in seawater. The seawater was sieved for any detached lice at the end of each sample. Each fish was examined individually for all mobile sea lice. The mean number of sea lice per fish was calculated (including the number of detached sea lice from the sieved seawater), results presented are mean total mobile sea lice levels for *L. salmonis* per fish.

Seven year classes/stock of Atlantic salmon AS1999 – AS2005 and 14 year classes/stock of rainbow trout RT1999 – RT2012 were examined at the one location in a bay off the west coast of Ireland. The abundance of *L. salmonis* on each stock of fish on site was measured for a period of 14 years, 1999 to 2012 inclusive. Salmon and trout were stocked concurrently at the production site until June 2006 after which only trout were stocked. Sea lice treatment data was obtained on a confidential basis from the farm in question for the purpose of this study to establish the numbers of treatments used in the period in question.

Mann Whitney analysis was used to examine the data.

Results

A large data set of sea lice counts was used to determine the mean *L. salmonis* levels on stocks of salmon and trout at the production site from 1999 to 2012 inclusive (Figure 1). Mean sea lice counts were found not to be significantly different ($p= 0.9110$) between the two species of fish, salmon had a mean sea lice count of 2.59 ±4.24 *L. salmonis* per fish, rainbow trout had 2.12 ±2.74 *L. salmonis* per fish. Maximum sea lice levels were recorded at 34.14 *L. salmonis* per fish for the salmon and 13.6 *L. salmonis* on the trout. At this production site salmon were grown at sea for approximately 15 months (range 14 - 16 months), whereas the trout production period at sea was for a mean of 10.3 months (range 9 - 12 months). Twenty-four sea lice treatments were carried out on the salmon stock from 1999 to June 2006 inclusive (Figure 2) at which stage the salmon were harvested out, 8 sea lice treatments were carried out on the rainbow trout stock in the same period. In 2005 no treatment was carried out on the trout. Each year class of salmon were administered an average 3.43 chemotherapeutants per production cycle, while the trout received an average of 1 treatment per cycle while stocked concurrently. At no stage were the trout treated more frequently than the salmon. Four sea lice treatments were administered from June 2006 until the end of 2012, when rainbow trout were the only species being farmed. The trout were treated on average 0.66 times per production cycle after 2006.

Discussion

Atlantic salmon and rainbow trout were located on the same fish farm production site from 1999 to mid-2006. Without a quantitative assessment of larval *L. salmonis* in the water column the infestation pressure cannot be measured but it is reasonable to assume that the challenge from larval sea lice would be similar given the proximity of these stocks. Abundance of *L. salmonis* at this site was found to be similar on both species, however, over three times the number of sea lice treatments per cycle were used to treat the salmon to maintain the same level of sea lice control. The treatments regime implemented at this site for sea lice control was designed to maintain lice levels in line with those required by the Monitoring Protocol (Department of the Marine and Natural Resources (2000)). The level of sea lice treatment effort required to maintain the lice levels on salmon within these thresholds was more than three times greater (mean of 3.4 treatments per production cycle) than that for trout (mean of 1 treatment per production cycle). The trout were treated on average 0.66 times per stock after 2006.

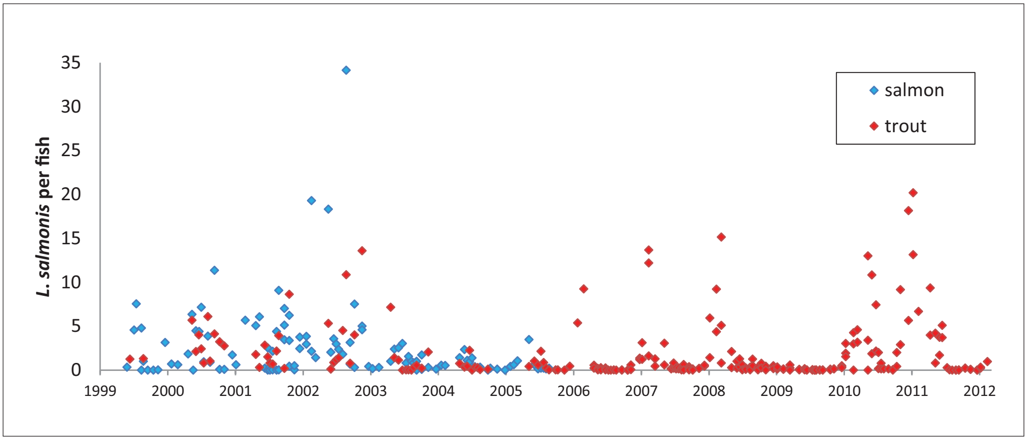

Figure 1. *Lepeophtheirus salmonis* abundance on salmon and trout at a production site in western Ireland.

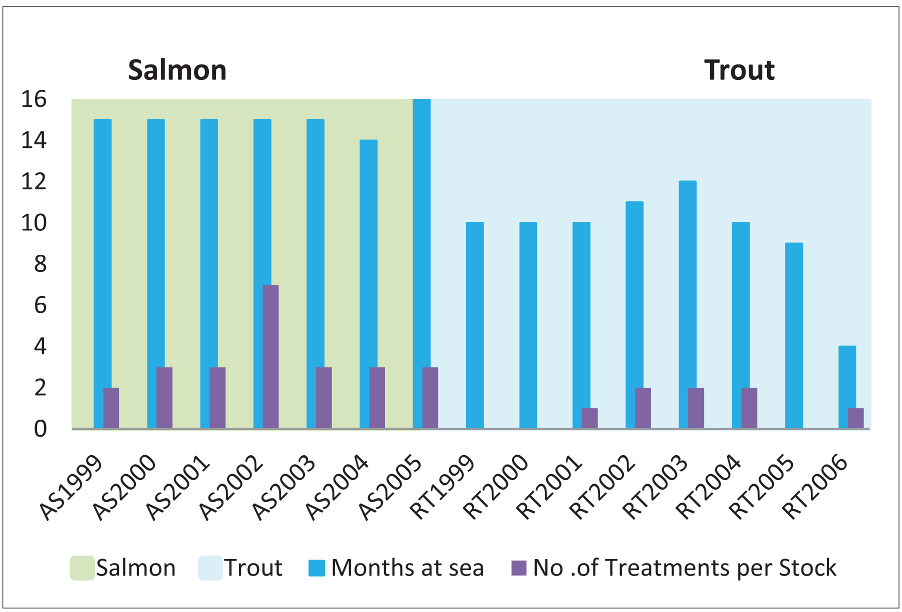

Figure 2. Sea age and numbers of treatments per year class of Atlantic salmon and rainbow trout at a production site in western Ireland from 1999 to June 2006.

This study demonstrates that rainbow trout require fewer chemotherapeutants to manage and control sea lice challenges at sea. As sea lice treatments are a significant cost to the industry the reduced requirement for sea lice treatments over a production cycle represents a saving in production costs per kilo of fish produced. This may have management implications for the production of rainbow trout and salmon, farmed in isolation or together, and may inform treatment regimes and fallowing plans within sites or bays. This research suggests that farming one generation of salmon concurrently with a single generation of rainbow trout may prove to be a realistic approach with co-ordinated treatments plans for both stocks to maximise production capacity, in line with licence requirements or as a means to meet market demand. Recent research has shown that applying treatment at an early growth stage is more economical than at a later stage (Liu and Bjelland, 2014) and that during a 2 year production cycle the first pair of treatments are best administered during the autumn of the first year at sea (Robbins et al., 2010). A strategic co-ordinated treatment approach may prove to be a viable economical option in bays where sea lice control has been problematic when differing year classes of salmon have been farmed. Two stocks, one of salmon and one of rainbow trout, could be a viable alternative production strategy to fill the production capacity in a bay while improving sea lice control. Resistance to sea lice therapeutants has developed rapidly with the expansion of fish farming (Igboeli et al., 2014). In Norway reduced sensitivity towards hydrogen peroxide has been documented (Helgesen et al., 2015), also reductions in efficacy of other treatments such as pyrethroids, azamethiphos and emamectin benzoate have been described previously (Grøntvedt et al., 2014; Helgesen and Horsberg, 2013; Sevatdal et al., 2005; Sevatdal and Horsberg, 2003). Extensive use of medicines has been a factor leading to the development of resistance (Aaen et al. 2015). This study shows that a reduction in the use of chemotherapeutants can be achieved by stocking rainbow trout. Polyculture of Atlantic salmon and rainbow trout could be an alternative to salmon monoculture production in areas where sea lice control has proven difficult. This approach could also have long term benefits in slowing the rate of potential resistance development.

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