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Summary of Science

Summary of information relating to impacts of salmon lice from fish farms on wild Scottish sea trout and salmon

The salmon louse is a native parasite that infests both farmed and wild salmonids to the potential detriment of aquaculture and angling interests (Torrissen *et al.* 2013). Recent reviews have considered information concerning interactions between salmon farms and wild salmonids (e.g. Taranger *et al.* 2015; Thorstad *et al.* 2015). Here, the evidence available to assess the likelihood and scale of impact of salmon lice from salmon farms on Scottish wild salmonids is summarised. The aim is not to repeat existing reviews but to focus on key issues relevant to locating fish farms in the Scottish coastal zone.

Are salmon farms a significant source of salmon lice?

Yes, salmon farms have been shown to be a more important contributor than wild fish to the total numbers of salmon lice in the environment (Morton *et al.* 2011; Penston & Davies, 2009).

Is there an association between levels of lice on salmon farms and in the surrounding environment?

Yes, environmental larval lice concentrations relate to local farm lice loads (Penston and Davies 2009). The distribution of lice depends on hydrodynamic conditions and so the relationship may be highly variable at any specific location (Salama *et al.* 2013).

Is there an association between levels of lice on salmon farms and on wild sea trout?

Yes, analysis of data from Norway highlights a significant relationship between infection potential from farms and settlement on wild sea trout (Hellend *et al.* 2015). Data collected throughout the west coast of Scotland shows that the proportion of individual sea trout with sea louse burdens above a level known to cause physiological stress increased with the mean weight of salmon on the nearest fish farm (a measure of where they are in their production cycle), and decreased with distance from that farm (Middlemas *et al.* 2013).

Is there an effect of salmon lice on wild sea trout at the individual level?

Individual wild sea trout sampled on the west coast of Scotland have been shown to have salmon louse infestations above a level known to cause physiological harm (Middlemas *et al.* 2010, 2013).

Is there evidence of an effect of salmon lice on wild sea trout at the population level?

No such direct evidence for a Scottish situation has been published.

An experiment in Norway, comparing survival of anti-lice treated sea trout smolts with non-treated smolts, indicated an increased survival rate of 3.41% over 1.76% , this is about a 50% reduction in the stock returning to the river, suggesting that salmon lice can negatively affect sea trout populations (Skaala *et al.* 2014).

Is there an association between levels of lice on salmon farms and on wild salmon?

No information is available for wild salmon in Scotland. However, an association between lice levels on farms with louse settlement on salmon held short distances away has been noted. However it is inconclusive as to whether it is possible to estimate infection pressure from salmon farms at specific points in time (Pert *et al.* 2014). In Scotland and Norway, salmon lice abundance on farmed fish is lowest in early spring and peaks during autumn, (Jansen *et al.* 2012; Murray 2016a). This seasonal change in lice infestation levels is comparable to those observed on wild salmonids in Norway (Serra-Llinares *et al.* 2014).

Is there an effect of salmon lice on wild salmon at the individual level?

No information is available for Scotland.

Is there an effect of salmon lice on wild salmon at the population level?

Declines in catches of wild salmon have been steeper on the Scottish west coast than elsewhere in Scotland and Norway (Vållestad *et al.* 2009) although the authors stressed that this did not prove a causative link with aquaculture. Ford & Myers (2008) compared indices of salmon abundance on the East and West coasts of Scotland together with farm production data. They found a reduction in the catches and counts of salmon on the west coast correlating with increased production of farmed salmon. In addition Butler & Watt (2003) showed that rivers with farms had significantly lower abundances of juvenile salmon than those without farms.

Experiments comparing survival of smolts treated or untreated with anti-sea lice medicines have shown that sea lice adversely affect certain salmon populations in Norway and Ireland (e.g. Vollset *et al.* 2015). There is a great deal of year-to-year and site-to-site variability in the magnitude of such impacts and the reduction in numbers of returning salmon associated with lice infestations is in the range of 0-39% (Jackson *et al.* 2013; Krkošek *et al.* 2013; Skilbrei *et al.* 2013; Vollset *et al.* 2015). A meta-analysis of all available Norwegian studies showed anti-lice treatment increased returns of adult salmon by an average of 18% (Vollset *et al.* 2015). It is not clear in these studies how much of the estimated impact of lice is due to baseline natural levels in the environment and how much is associated with an additional effect caused by salmon aquaculture.

No information exists on impacts of lice on wild populations of salmon in Scotland. However, the estimated mean effect size of lice seen in other countries is of a similar magnitude to the difference between the aquaculture zone and east coast of Scotland in the reduction in abundance of wild salmon determined using data from fish counters (Ford & Myers 2008). It is not clear how much of this regional variation may be due to factors besides aquaculture.

Over what distance do farms influence environmental lice levels?

Salmon lice transport modelling in a Scottish system reports that >97.5% of sea lice are transported within 15 km of fish farms (Salama *et al.* 2016). However, site specific factors such as prevailing wind and currents, and local topography can have a large impact on the direction and distance of lice dispersal (Salama *et al.* 2013; Adams *et al.* 2012).

Middlemas *et al.* (2013) found a significant relationship between sea lice infestations on sea trout and the distance to the nearest salmon farm. Infestation levels were highest when sea trout were sampled near to a salmon farm and reduced as the distance to the nearest farm increased. There is considerable scatter around the general relationship found by Middlemas *et al.* (2013) which likely reflects unknown site specific factors and unaccounted fish movements.

Do we understand the dispersal patterns of sea trout and salmon?

Salmon smolts depart rapidly from home rivers but there is no knowledge of their subsequent distribution in relation to the Scottish coast. In general sea trout remain near shore for their first two months at sea and then disperse more widely. There is no understanding of the scale of sea trout dispersal or whether it is uniform in direction relative to the home river (Middlemas *et al.* 2009).

Can fish farmers reduce numbers of lice released into the environment?

There are a number of control strategies that farms can use to reduce salmon lice infestation. These include chemical, physical and biological methods. Historically chemical treatments have been favoured, reduced efficacy of treatments has been documented (Lees *et al.* 2008; Aaen *et al.* 2015) as has increased frequency of treatment (Murray 2016b). This has encouraged alternative control methods to be investigated. One of these is the use of cleaner fish, such as wrasse, as a biological control. These fish are introduced into pens to directly eat lice off salmon (Leclercq *et al.* 2013). This adds an additional method to control sea lice as part of integrated pest management; other methods include functional feeds (Jensen *et al.* 2015), cage design to control salmon's depth (Stein *et al.* 2016), and selective breeding (Gharbi *et al.* 2015).

Summary

Salmon aquaculture can result in elevated numbers of sea lice in open water and hence is likely to increase the infestation potential on wild salmonids. This in turn could have an adverse effect on populations of wild salmonids in some circumstances. The magnitude of any such impact in relation to overall mortality levels is not known for Scotland. However, concerns that there may be a significant impact of aquaculture have been raised due to declines in catches of both salmon and sea trout on the Scottish west coast. There is scientific evidence that individual Scottish sea trout can experience physiological detrimental burdens of salmon lice in areas with salmon aquaculture but the effects on populations in different areas is not known. Scientific evidence from Norway and Ireland indicates that early protection against salmon lice parasitism results in reduced absolute marine mortality, increasing recapture rates of experimental salmon, and reduces the time spent at sea, indicating that salmon lice can influence the population status of wild salmon. Marine Scotland Science has recently commenced a [project to address this data gap for Scottish salmon](#). Further information on this project can be found [online](#) and [details of all references cited](#) are also available.

