NESS & BEAULY FISHERIES TRUST

Trout (*Salmo trutta*) as predators of juvenile Atlantic salmon (*Salmo salar)*: a literature review.

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1 INTRODUCTION

In 2016, the Lower Beauly Fishing Syndicate enjoyed their highest catch of sea trout (*Salmo trutta*) for many years. Indeed, catches of sea trout outnumbered salmon landings by a ratio of 1.9:1. To the author's knowledge, this is the first time this has happened in living memory. Whilst this news has been welcomed by many, there have been some river uses who have aired concerns that this apparent sudden influx of sea trout may have negative impacts on the established population of Atlantic salmon (*Salmo salar L.*) through active predation on juveniles. To this end, The Ness and Beauly Fisheries Trust (NBFT) agreed to review the current literature on the aforementioned subject and produce a report documenting their findings.

2 THE SEA TROUT

Sea trout are the anadromous (migratory) form of the brown trout. Anadromous trout are not as extensively distributed as inland populations of brown trout but are found in Iceland, Scandinavia as well as the Baltic and North Sea and as far south in the Atlantic as the Bay of Biscay (Frost & Brown 1967). Early life history traits of sea trout follow that of the brown trout and salmon; adults spawn in the late autumn/winter in small and large waterbodies with the resultant ova developing over winter and hatch in the subsequent spring. Following a period of endogenous (yolk sack consumption period) feeding during the larval (alevin) stage, the resultant fry begin to actively feed on aquatic invertebrates. Following a period of two-three years, some trout may become quite sedentary in rivers but can often appear to move about river catchments freely (Gowan *et al* 1994).

Brown trout occurring in rivers with unhindered access to the sea can form anadromous populations and will leave their natal streams in the spring for coastal waters in a process termed 'smoltification'. It is at this point that brown trout become sea trout. According to Nall (1929), sea trout of Beauly origin do not venture further than the Inner Moray Firth. The migration to sea be may be for one summer only before returning as 'finnock'. These small sea trout (typically weighing 0.5to 0.75lb) will return to their natal stream but may not spawn during this time unlike larger (multi-sea winter) sea trout who will spawn with their counterparts close to, or in the waterbody from which they were spawned (Fahy 1978). Some sea trout perish post-spawning although some individuals of Beauly origin may spawn up to four times (Nall 1929).

3 THE DIET OF BROWN TROUT

The brown trout is widely accepted as an opportunistic feeder with the diet varying with fish size, age, habitat and season (Bridcut & Giller 1995). The diet of stream dwelling brown trout is well documented (Hernandez & Cobo 2015, Jonsson & Gravem 1985). As young parr and fry, insect larvae of chironomids can be the main food item but surface arthropods such as flying insects may also be taken. With increasing size, trout will gradually move on to larger food items such as the larvae and adult forms of the groups Ephemeroptera (mayfly) and Trichoptera (caddis). Grey (2001) documented aspects of dietary specialisation rather than opportunism in stream dwelling trout with some individuals targeting one food item (e.g. chironomid larvae) whilst seemingly ignoring other food items.

Loch dwelling trout may even turn wholly piscivorous and will actively predate on other trout and species such as char (*Salvelinus aplinus*) and three-spined stickleback (*Gastorosteus aculeatus*) (Grey 2001). Piscivory in river dwelling trout in the UK is less well documented although this has been recorded in Norway (Forseth & Jonsson 1994), Ireland (Keeley & Grant 2001) and New Zealand (McIntosh 2011). However, anecdotal evidence from Mckelvey 2017 (personal communication, February 2017) and Walker 2017 (personal communication, March 2017) suggests that brown dwelling in and around hydro-electric storage reservoirs can actively predate on Atlantic salmon smolts during their outward migration. These areas act as 'pinch points' where smolts congregate at entrances to Borlund fish lifts or turbine intakes. Furthermore, in 'truck and transport' operations conducted on the River Conon, brown trout have exhibited habitual behaviour; congregating in areas where salmon smolts will be transported to and actively predating on disorientated individuals (Mckelvey 2017, personal communication February 2017) upon release.

These communications are in line with work published by Piggins (1962) who concluded that brown trout of 230-320mm in length were "serious" predators of salmon smolts in Ireland whilst Mills (1964) noted brown trout of the same length consumed salmon fry between April and November in Ross-shire. Predation on salmon fry by brown trout has also been reported by Skaala *et al* (2014) in a Norwegian river system. More recent research conducted on the River Conon showed in-river mortality of salmon smolts to be in the order of 20% and this was partly attributed to predation by brown trout (unpublished data).

4 THE DIET OF SEA TROUT

Feeding habits of sea trout in the marine environment has been extensively studied (Pemberton 1976, Fahy 1983, Grovnik & Klemetsen 1987, Lyse *et al* 1998, Knutsen *et al* 2001) and more generally by Nall (1930) and Went (1962) as reviewed by Elliot *et al* (1992). In a study from a Scottish Sea Loch, it was found that sea trout took about 50 prey species, according to the contents of 1,277 stomachs examined over one year (Pemberton 1976). In larger individuals of >21cm, clupeid fishes such as herring (*Clupea harengus*), sprat (*Sprattus sparattus*) and sand eel (*Hyperoplus lanceolatus*) were the dominant food whilst smaller fish of <21cm were seen to feed on small crustaceans and insects. These findings were largely confirmed by Fahy (1985) although this study found sea trout to be feeding on 60 different prey items including sprats, sand eels, stickleback and sand smelts (*Atherina presbyter*).

Prior to a study looking at the impact of marine fish predation on salmon smolts in the Tana Estuary, Norway; sea trout were assumed to be (along with other marine species) major predators of salmon smolts in the River Estuary (Svenning *et al* 2005). However, their findings confirmed this was not the case as salmonid remains (were absent from the stomach contents of 56 adult sea trout caught over the space of around two months. These results are in contrast to the findings of Vollset *et al* (2016) who found salmon smolts in low numbers in the stomachs of adult sea trout. In the opinion of Mahlum 2017 (personal communication, February 2017) it is unlikely sea trout are having a large impact on the population of salmon and that the predation on salmon smolts was much more pronounced in species such as cod (*Gadhus morhua*) and pollack (*Pollachius virens*).

There is very little information on the food of adult sea trout after they have migrated into fresh water (Elliot *et al* 1992). Indeed, some sources would suggest that sea trout may not feed at all in fresh water (Wild Trout Trust 2017). Early information summarised by Harris (1971) concluded that Nall (1926, 1930) was the only worker to examine the stomachs of sea trout caught above the tidal limit. Nall's analysis of 150 sea trout ranging from 0.5lb to 3.5lb in weight indicated a diet of terrestrial insects, aquatic insects and crustaceans but no fish. Harris (1971) examined the stomachs of 150 sea trout caught in a Welsh river between 1968 and 1969. These fish were seen to have been in freshwater for up to three weeks; 2% contained any appreciable amount of food with 75% (112 stomachs) were recorded as empty. Of those 2%, stomach contents were a mixture of terrestrial and freshwater invertebrates together with a small number of salmonid eggs and parr.

Elliot (1996) conducted a much larger study of 467 sea trout stomachs (246 males, 221 females) from six NW England rivers ranging from 0.35lb and 2lb in weight. Fish were taken at a range of sampling reaches from 2km to 25km from the tidal limit. 64% of the samples exhibited empty stomachs whilst those captured at a range of 2km to 12km from the tide had remains of marine species in their stomachs such as clupeid fishes, brown shrimp (*Crangon vulgaris*) and shore crab (*Carcinus maenus*). In the rivers furthest from the tidal limit, there was a marked change in diet from marine to freshwater and terrestrial food. No salmonid fish were identified in any of the stomachs despite each river containing a viable population of both salmon and trout. To the author's knowledge, this is the only peer reviewed study on the stomach contents of sea trout caught in fresh water.

5 DISCUSSION AND CONCLUSIONS

This document has investigated the currently available peer reviewed literature on the subject of sea trout as predators of Atlantic salmon. Given the anadromous nature of trout, it has also included references to the non-anadromous trout as predators of salmon.

Whilst evidence would suggest that sea trout will predate on juvenile salmon in both the freshwater and marine environment; those authors who have specifically targeted research in this area have concluded that effects on established populations of salmon would be negligible (Mahlum 2017) (personal communication, February 2017) and largely agree with Nall (1926) who concluded that "*There is little doubt that after leaving salt water sea trout feed more intermittently and with a less robust appetite than brown trout*".

With a rise in numbers of sea trout within the Beauly catchment, there is little doubt that densities of juvenile trout will increase and this is already being seen, particularly in the main tributary burns of the Lower River Beauly; namely the Belladrum Burn, Bruiach Burn and Culburnie Burn. Young salmon and trout forage for the same food items and will utilise similar habitats during the fry stage. Therein lies the question of whether an increase in juvenile trout will impact on juvenile salmon through increased competition in the nursery areas.

This has been addressed and debated for many years (Heggberget *et al* 1988, Kalleberg 1958, Kennedy & Strange 1986). Most recently this was addressed by Milner *et al* (2006) who stated "*… in spite of unambiguous evidence of interspecific competition, there is as yet no clear demonstration of negative*

interactions between salmon and sea trout populations at fishery or catchment management scales… the possibility of such effects cannot be eliminated… because the required studies in to combined species stock-recruitment relationships have never been carried out and this represents a continuing research need".

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