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Concurrent Collapses of Demersal Fish and Sea Trout (*Salmo trutta*) on Scotland's West Coast following the Removal of the "Three-Mile Fishing Limit"

Martin Jaffa. Callander McDowell, Manchester M45 0FN.UK.

Email: mrj@callandermcdowell.co.uk

Orchid No: 0000-0001-6156-8466

Abstract

Salmon farming has been blamed for the collapse of the sea trout (*Salmo trutta*) fishery in Loch Maree on Scotland's west coast despite the absence of any direct evidence. Stocks of west coast demersal marine fish, especially around the Clyde Estuary have also declined over a similar time span. The decline of these marine fish stocks can be attributed to the removal of the "three-mile fishing limit" in 1984 by UK Government legislation. Sea trout inhabit the same inshore waters as targeted demersal fish and can be caught as by-catch. Comparisons of the decline of demersal species and the sea trout from Loch Maree and the west coast show a high degree of correlation. Stocks of whiting (*Merlangius merlangus*) from inshore waters have found to consist of small fish which mirrors the stock makeup of the Loch Maree sea trout stock.

Key Words: fisheries; fish farming; demersal fish; sea trout; stock collapse; three-mile fishing limit

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1. Introduction

For over thirty years, salmon farming has been blamed for the decline in catches of wild sea trout (*Salmo trutta*) along Scotland's west coast. Much of the focus has been on the collapse of the Loch Maree sea trout fishery and this continues to be a contentious issue long after the collapse was first recorded during the late 1980s (Walker, 2017). Butler & Walker (2006) conducted the first, and only, study of the collapse. Their aim was to consider the reasons behind the collapse but looked at the arrival of the salmon farm as the sole possible cause.

The River Ewe system comprises the 20km long Loch Maree connected by the 4km long River Ewe to Loch Ewe, a sea loch. Changes in rod catches of sea trout from the Loch Maree fishery followed the establishment of two commercial salmon farms in Loch Ewe in 1987. The authors claim that unprecedented reduction in marine growth and survival of sea trout followed their arrival. Prior to 1987, annual catches of sea trout ranged between 546 and 1575 whilst from 1988 to 2001, catches fluctuated between 35 and 342, the lowest number being recorded in 2001. The mean weight of the fish caught declined from 0.54kg between 1971 and 1980 to 0.34kg after 1992. Changes were also observed in marine growth rates with the maximum age of fish declining from 11 years to around 5 years old. Butler and Walker (2006) claimed that the data available to them allowed a detailed examination of the symptoms and possible causes of the stock collapse, although the only cause they appear to have considered was the arrival of two salmon farm sites.

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Many allegations have been made about the involvement of salmon farms in the decline of wild salmon and sea trout because they are perceived to be a significant source of sea lice. Some individual wild sea trout have been observed carrying large numbers of lice and it is often implied that this is likely to result in significant mortality.

Scottish government agencies started to collect information and record the number of wild salmon and sea trout caught by anglers in 1952. What is apparent from this data is that sea trout catches have been in decline since then, and possibly even before, across all of Scotland (Marine Scotland, 2018). Many different factors have been implicated in the decline of sea trout as well as wild salmon, such as forestry, land use changes, acid rain, global and local climate change and overexploitation, although these have attracted considerably less attention than salmon farming.

Thurston & Roberts (2010) investigated changes that have taken place in the west coast sea fishing industry over the last 200 years. In more recent times the implementation of new legislation, in the form of the Inshore Fishing (Scotland) Act 1984, repealed a ban on fishing within three nautical miles of the low water mark. This “three-mile limit” had been introduced in 1889 in the interest of protecting fish stocks against overexploitation. The opening of inshore waters in 1984 meant that fishing vessels were once again able to trawl for fish within the confines of west coast sea lochs, including Loch Ewe.

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This paper considers whether the removal of the "three-mile limit" may have been a significant contributory factor in the collapse of sea trout stocks in the River Ewe & Loch Maree fishery and possibly elsewhere.

2. Materials & Methods

2.1. Examination of pre-existing data- Sea trout and Loch Maree

Butler & Walker (2006) illustrated the decline of the Loch Maree sea trout fishery with a graph of annual sea trout catches from the Loch Maree Hotel fishery. They also included a marker highlighting the point at which salmon farming was introduced to Loch Ewe. In addition to the catch data, the authors incorporated the five-year catch average into the graph. Five-year average data is widely used in the interpretation of recreational fishing as it evens out some of the inconsistencies especially relating to fishing effort. Fig 1 replicates Butler & Walker's graph but using data from the whole catchment.

The five-year average catch data demonstrates that the sea trout fishery was already in decline for at least eight years prior to the arrival of salmon farming to Loch Ewe. No attempt was made by Butler & Walker (2006) to explain this decline. They also did not consider any other possible causes that might have brought about this collapse, especially consideration of the impacts of removing the "three-mile fishing limit".

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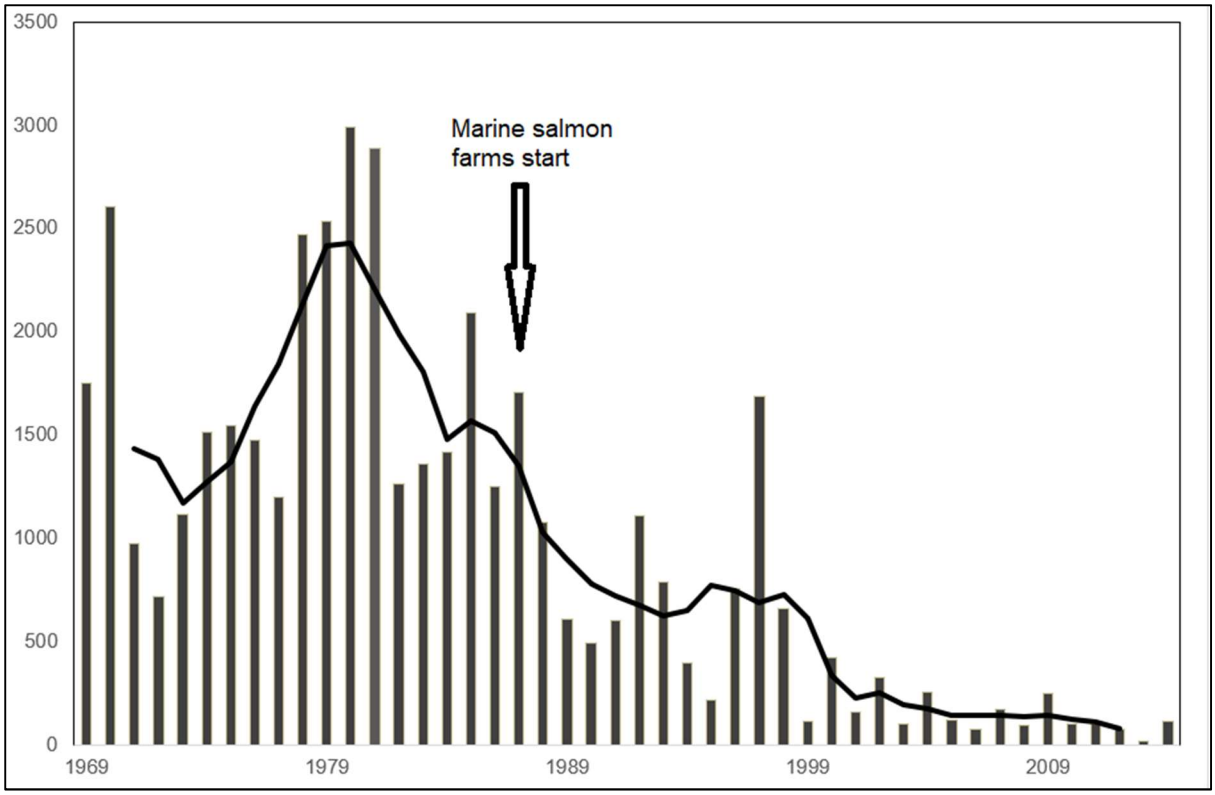

Fig. 1. Annual sea trout catches from the Loch Ewe catchment (after Butler & Walker, 2006). The bars represent the annual catch. The line represents the moving five-year average.

2.2. Examination of pre-existing data - Demersal fish catches and the "three-mile limit"

Thurstan & Roberts (2010) examined the decline of catches of marine fish such as cod (*Gadus morhua*), whiting (*Merlangius merlangus*) and saithe (*Pollachius virens*) from the Inner Clyde fishing grounds. These declines reveal a remarkable similarity to the decline of sea trout from Loch Maree during the late 1980's (Fig. 2.)

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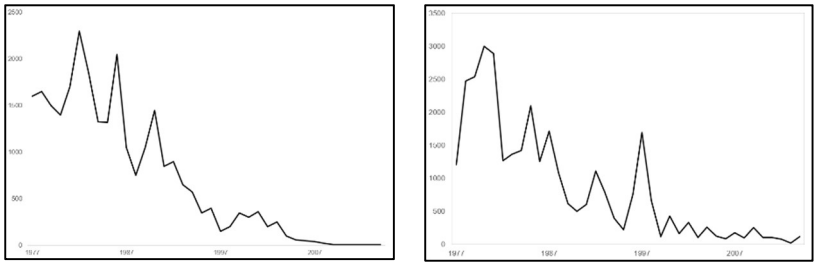

Fig.2. Comparison of cod catches (a) from the Clyde fishing grounds and sea trout catches (b) from the Loch Ewe catchment.

The various data sets were analysed to ascertain the likelihood that the collapse of the Loch Maree fishery might be one of the consequences of changes to marine fishing legislation, specifically the removal of the "three-mile limit". The literature was reviewed to determine whether there is other supporting evidence for this hypothesis.

2.3. Statistical analysis

Regression analyses

One complication in analysing such data is the different ways in which information for the different species are expressed in different locations. Some data was recorded as numbers of fish, whilst other data was based around weight of fish. Given the varying numbers for different species/locations, the approach taken in the analysis was to examine the relative change in fish numbers/weight over time using simple linear regression.

$$Y = \beta_0 + \beta_1 X_1 + \in$$

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Where β_0 is the intercept, β_1 represents the beta (β) coefficient (parameter estimate), X_1 is the values of the variable in the regression model and $\in$ is the error term (residuals).

Comparison of regression slopes

For comparison of the slopes, a methodology using Z-statistic has been applied.

$$Z = \frac{b_1 - b_2}{\sqrt{SEb_1 + SEb_2}}$$

Where b_1 is the slope of line 1, b_2 is the slope of line 2, $SEb_1$is the standard error of slope 1 and SEb_2 is the standard error of the slope of line 2. The resulting Z-value was compared to the normal distribution to identify the statistical significance.

Graphical presentation

All the sets of data were converted to a centred moving average and subsequently standardised to the same scale. The use of standardisation focuses on the pattern of catches rather than the actual volume.

The transformation of each variable was achieved using the formula

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$$Z = \frac{x - \bar{x}}{\sigma}$$

Where x is the volume of each fish species in a single year, $\bar{x}$ is the mean average volume of each fish species over all years and σ is the standard deviation of volume of each fish species over all years. This will result in a variable with a mean of zero and a standard deviation of 1.

3. Results

3.1. Demersal fish & the lifting of the "three-mile limit"

In 1984, the government removed the "three-mile limit" allowing fishing boats to trawl in inshore waters around Scotland. Thurstan & Roberts (2010) demonstrated that this resulted in a reduction of catches of marine demersal fish in the Inner Clyde. This is the most intensively studied area of inshore waters in Scotland, but the impacts are likely to be similar elsewhere around the Scottish coast.

3.2. The Inner Clyde

Thurstan & Roberts (2010) collated a variety of catch data from marine fisheries around the Clyde fishing grounds. Following the removal of the "three-mile limit", catches of most demersal species declined rapidly. It is therefore not inconceivable that anadromous sea trout were also caught by inshore trawling and consequently there was a decline in their numbers too.

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3.3. West Coast

The Inner Clyde fishing grounds are located at the most southerly point of the Scottish west coast 'Aquaculture Zone'. Other fishing grounds are located along the length of the west coast and fish were landed at a number of small fishing ports. These include Oban, Mallaig and Ullapool. The landings for cod, whiting and saithe are recorded by the Scottish Government and are published in an annual report.

Catch data for cod, whiting and saithe from the west coast were compiled and are shown in Fig. 3. Landings for the port of Kinlochbervie were not included as this port is used as a drop off point for east coast boats that have fished out into the North Atlantic to ensure that the fish will be fresher when they reach markets than if landed at their home port.

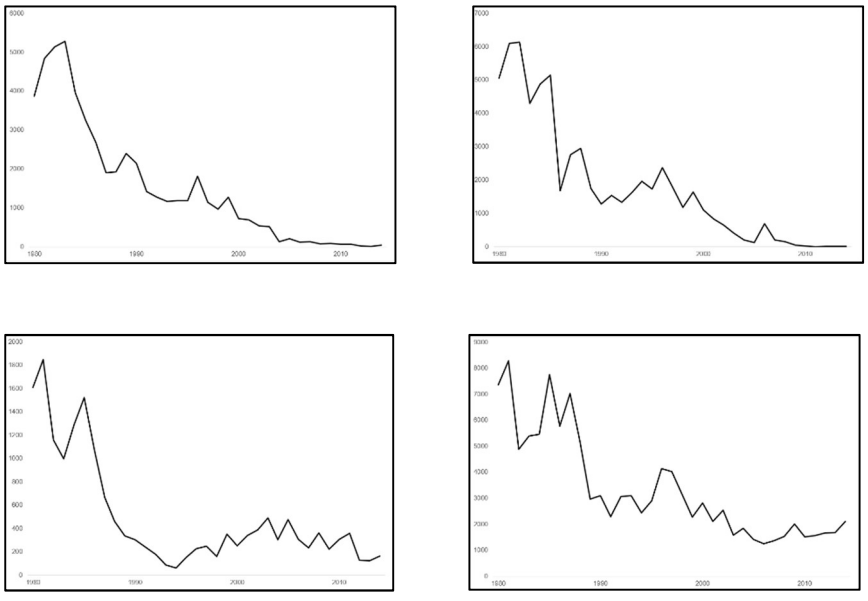

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Fig. 3. Catches of a) cod, b) whiting, c) saithe landed at west coast ports and d) sea trout catches from west coast fishery districts following removal of the 'three-mile limit' in 1984.

The decline in catches of demersal fish landed at west coast ports follows a similar pattern to the decline identified by Thurstan & Roberts (2010) in the Inner Clyde. Opening the "three-mile limit" to inshore fishing has negatively impacted fish stocks along the whole of the Scottish west coast.

Fig. 4 combines the data for the four species using a five-point centred moving average on a standardised scale of the weight of fish landed. This clearly shows the similarities between the decline of marine species and sea trout.

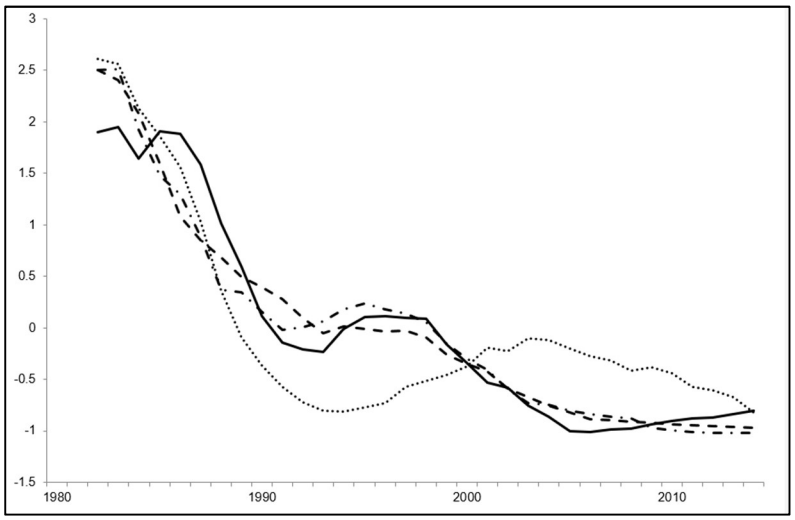

Fig. 4. Five-point centred moving weight average on a standardised scale for west coast landings of cod (dashed line), whiting (dashed and dotted line), saithe (dotted line) and sea trout (solid line).

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The data was analysed to determine the correlation between species. Sea trout is strongly correlated with cod ($r = 0.83$, $p < 0.0001$), whiting ($r = 0.88$, $p < 0.0001$) and saithe ($r = 0.83$, $p < 0.0001$).

Comparison of the rate of decline between species using regression slopes found that sea trout declined at a similar rate to cod ($Z = -1.30$, $p = 0.1933$) and whiting ($Z = -0.34$, $p = 0.7322$) but faster than saithe ($Z = -6.90$, $p < 0.0001$). This difference may be due to variability of different stocks in the west coast fishing grounds.

The west coast data covers the whole of the west coast excluding the furthest north. Landings of demersal can be identified from specific ports. Mallaig is an important fishing port half way up the west coast. Fig. 5 shows the landings at Mallaig compared to sea trout catches as a five-point centred moving average on a standardised scale for the weight of fish landed.

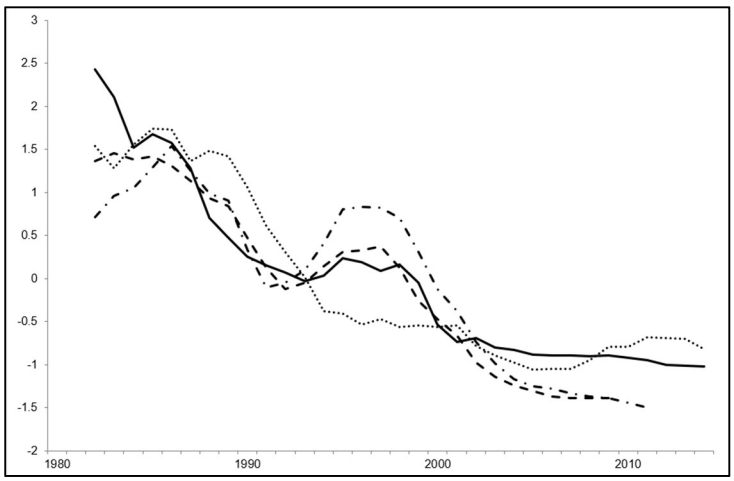

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Fig. 5. Five-point centred moving weight average on a standardised scale for Mallaig catches of cod (dashed line), whiting (dashed and dotted line), saithe (dotted line) and sea trout (solid line).

The correlation between sea trout and the demersal species is less strong than for the west coast. This is not unexpected as marine fish stocks will vary along the coast due to the nature of the coastline. Sea trout is most correlated with cod ($r = 0.68$, $p < 0.0001$) but less correlated with whiting ($r = 0.56$, $p = 0.0005$) and saithe ($r = 0.59$, $p = 0.0002$).

The comparison of the rate of decline using regression lines suggests that sea trout declined at a faster rate than demersal fish around Mallaig. However, the regression line for sea trout is likely to have bene influenced by the outlying points of high numbers in 1980 and 1981. Had the data started from 1982, the rate of decline would have been less steep. The data suggests that sea trout have declined faster than cod ($Z = -4.01$, $p < 0.0001$), whiting ($Z = -2.17$, $p = 0.0300$) and saithe ($Z = -7.15$, $p < 0.0001$).

3.4. Loch Ewe

Fishing boats began fishing in Loch Ewe in 1984 mainly targeting herring and mackerel, but these stocks quickly collapsed due to the intensity of the fishing (McLennan personal communication). Unlike salmon, sea trout do not migrate far from their home river and thus were vulnerable to fishing after 1984, which was only three years before the salmon farm arrived in the loch.

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Butler & Walker (2006) compared catches before and after the arrival of salmon farming to Loch Ewe. The average annual sea trout catch over the fifteen years preceding the establishment of the salmon sites in 1987 was 938 fish. Average annual catches in the period after the salmon sites were established was 169 fish, a decline of 769 fish per year.

By comparison, catches measured before and after the removal of the "three-mile limit" in 1984 were 1036 and 281 fish per year respectively, representing a decline of 755 fish per year. The pattern of collapse is identical after the removal of the "three-mile limit" and the introduction of salmon farming to Loch Ewe. The removal of the "three-mile limit" offers a credible alternative to salmon farming as the cause of the decline.

3.5. Nephrops fishery

Thurstan & Roberts (2010) chart changes to in-shore fishing catches. Following the collapse of demersal fish stocks in in-shore waters, fishing boast have targeted prawns and specifically Nephrops. This crustacean has almost replaced fish has the main catch in the Inner Clyde. Prawns are also targeted from ports around the Scottish coast. In 2016, Nephrops represented the second largest value of seafood landed at Scottish ports at £79 million with 21,000 tonnes which is greater than both cod and haddock together at £65 million.

McIntyre et al. (2012) highlight that the North East Atlantic Nephrops trawling fishery has been ranked as having the fifth highest discard rate in the world. In the Clyde this

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is estimated to be between 66 and 80%. This are species that are not targeted by the fishing boat and are subsequently discarded. It is possible that these discards include sea trout.

4. Discussion

4.1. Interactions between salmon farming and wild sea trout

The review of the Loch Maree sea trout fishery by Butler & Walker (2006) concluded that salmon farming was likely to be the main cause of the collapse. Yet, some aspects of their data do not appear to support their claims. The graphical presentation includes a linear representation of the five-year catch average, a measure of catches often used in the wild fisheries sector. This indicates that catches fell into decline at least eight years before the salmon farm was established in Loch Ewe. The Loch Maree Hotel fishery constitutes only part of Loch Maree and the wider Ewe catchment. Butler & Walker say that catches from this fishery provide the most accurate data available and can be related to a known number of rods. The data they use appears to suggest that prior to 1987, rod catches were relatively stable and only collapsed after the arrival of salmon farming.

The catch data from the Loch Maree Hotel fishery was not the only data available to Butler & Walker. Scottish government agencies had been collecting catch data for the whole Ewe catchment since 1952. Catches of sea trout for the whole catchment exhibited considerable variation over many years. From 1952, catches declined rapidly followed by a period of two years when they fell to almost zero. This specifically

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related to a national outbreak of UDN (Ulcerative Dermal Necrosis) when fishing was discouraged to help prevent the spread of the disease.

From this all-time low, catches began to increase until 1982, when they again began to decline through the 1990s to the current low level. The increase from 1970 onwards is attributed to improved policing of illegal netting in Loch Ewe (Picken, 1987). This would allow more larger fish to pass up the River Ewe in Loch Maree resulting in an increased catch of large fish from the Loch Maree Hotel fishery. In 1984, catches of these larger fish collapsed (Dear, Personal communication). This was three years prior to the arrival of the salmon farm in Loch Ewe. These larger fish represent only a small proportion of the sea trout and finnock caught by anglers at the Loch Maree Hotel fishery, so it was unlikely that their disappearance was immediately noticed. Instead, Butler & Walker (2006) state that the coincidence of a sea trout stock collapse soon after the establishment of marine salmon farms in their vicinity raised speculation of a causal link.

Walker (1994) reported that a decline in sea trout catches in north-western rivers was probably due to an increase in marine mortality. He reported that attempts to gain a full understanding of the underlying causes are inhibited by the small number of fish available for scale analysis. He also reported that studies on the River Ewe had shown a marked reduction in older and larger fish but that it was not possible to say whether this was due to a reduced growth performance or a shorter period of marine feeding. He did not discuss the presence of the salmon farm.

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4.2. Collapse of stocks of demersal fish

Thurstan & Roberts (2010) report on the removal of the "three-mile limit" in 1984. Catches had increased during the 1960s and 1970s because key fishing grounds around the Clyde had been opened to more efficient pair-trawling, but these higher catches were not maintained. Under pressure from the fishermen to help increases catches, the Government introduced the Inshore Fishing (Scotland) Act in 1984. This repealed a ban on trawling in inshore water which had been imposed since 1889. The new legislation removed the restriction on fishing within the "three-mile limit" expanding fishing opportunities as fisherman struggled to catch enough fish to sustain their livelihoods. The whole of the Firth of Clyde as well as other west coast fishing grounds were opened to trawling allowing exploitation of species such as cod, whiting and saithe. However, the reopening of the "three-mile limit" did not bring an increase in landings as between 1984 and 2009, landings decreased by 99% (Hislop, 1986). In addition to cod, saithe and whiting, stocks of haddock, hake, herring, flounder and plaice all showed a similar downward trajectory (Thurstan & Roberts, 2010, McIntyre et al. 2012).

The opening inshore waters to trawling has devastated stocks of marine fish. Whilst Thurstan & Roberts, (2010) focus on the catches from the southerly end of the' Aquaculture Zone', fishing vessels were also trawling further along the 'Aquaculture Zone' coast including within sea lochs such as Loch Ewe. Fishing vessels were seen to

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return repeatedly to Loch Ewe until all the local stocks had been fished-out (McLennan. Personal communication).

4.3. Relationship between sea trout and demersal stock collapses

The decline of sea trout catches from Scotland's west coast strongly correlate with declines of landings of marine demersal fish at west coast fish ports with similar declines of sea trout, cod and whiting. It is therefore likely that the collapse of west coast sea trout populations is strongly linked to the increased fishing effort due to the removal of the "three-mile limit" allowing trawlers to fish close to shore.

4.4. Sea Trout

The decline of sea trout catches from the Loch Maree fishery closely mirrors the decline of white fish catches from the Clyde Estuary. This is supported by the results of a statistical analysis which found that there was no difference between the decline of Loch Maree sea trout and cod and whiting stocks from inshore fisheries around the southern end of the 'Aquaculture Zone'.

4.5. Similarities between demersal fish and sea trout stocks

A study by Heath & Speirs (2011) found that the intensive fishing of inshore waters had significantly altered the mix of species within the Clyde. The mix of species had changed from one with many large predator species to one dominated by whiting. More than 70% of the Clyde stock now comprises of whiting and the majority are small fish of less than one year of age. This mix has remained consistent from the late 1990s.

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Hunter at al. (2015) have identified that whilst commercial fishing for demersal fish no longer takes place around the Clyde fishing grounds, fishing for Nephrops prawns has increased with a significant by-catch of demersal species. They suggest that this form of fishing has selectively remove the larger fish and encouraged early maturation of species such as whiting. They suggest that this trend towards smaller fish cannot be reversed whilst the Nephrops fisheries continues to operate in the Clyde.

The composition of local sea trout stocks has not been published since Butler & Walker (2006) but reports in the angling press suggest that the sea trout population in the River Ewe catchment consists of mainly small fish. Large fish are reported to be virtually non-existent (Graham-Stewart, 2017). The 2018 Wester Ross Fishery Trust Review reports that there were no reports of sea trout in excess of 3lbs caught from Loch Maree in either 2016 or 2017. The largest fish reported was estimated to weigh 2.75lb. (Anon, 2018). The Wester Ross Fishery Trust review illustrates the continued decline of sea trout in the River Ewe catchment and the much larger ratio of finnock to sea trout. In 2018, only 4 sea trout were caught from Loch Maree (Anon, 2019).

4.6. Impacts of the collapse of demersal fish stocks

The opening of the "three-mile limit" may have also had other unseen effects on wild fish. In the early days of the salmon farming industry, sea lice were not considered a major disease issue. It was only during the early 1990's that sea lice became a significant problem for salmon farmers (Shepherd, Joy, Bracken, Bradley, Personal Communications). A possible hypothesis of why this changed may be due to the loss

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of breeding marine fish stocks. The absence of young marine fish in coastal water may have allowed larval sea lice to flourish, whereas normally, these planktonic young parasites would have been targeted as food.

The disappearance of young marine fish from coastal waters may also impact on the sea trout stocks directly as the loss of a source of food. Walker (2017) discusses that young fish feature in the diet of larger sea trout. The lack of food could reduce growth and survival. Pemberton (1976) examined the stomach contents of over a thousand sea trout caught around Loch Etive and Loch Eil and found young herring featured in the diets of many of the fish. Thurstan & Roberts (2010) found that herring stocks had also collapsed due to over-exploitation. The angling sector have always argued that if salmon farms were removed form the west coast, sea trout stocks would recover. This is unlikely due to the absence of their main food. It would require the re-imposition of the "three-mile limit" to allow their main food source to replenish.

4.7. Sea trout stocks

There are 109 fishery districts across all of Scotland. Each is very different in nature and the number of fish caught annually. Most sea trout stocks from west coast fishery districts have shown a decline over many years, but there can be some variation as to when the decline began and by how much. There are numerous reasons why these stocks have declined, and none are likely to be the sole reason. It has been easy to blame salmon farms for the declines because they can be seen by those fishing for

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salmon and sea trout in these rivers, unlike, for example, over-fishing which is invisible.

Sea trout stocks have been in decline since records were first collected in 1952, long before the arrival of salmon farms to the west coast. It is been impossible to identify the exact cause of these declines. Sea trout catches in the Clayburn fishery district in the Outer Hebrides collapsed in 1976 and has never recovered. There has been no scientific investigation into this collapse, and it remains a complete mystery. The sea trout fishery in Loch Maree appears to have collapsed only after the arrival of the salmon farm in Loch Ewe, yet there is no direct evidence to support the connection between the salmon farm and the stock collapse.

Marine catch data for demersal species such as cod and saithe have also collapsed in a similar time scale to that of the Loch Maree sea trout. The loss of marine fish can be attributed to the removal of the "three-mile limit" in 1984 which allowed fishing boats to trawl in inshore waters including sea lochs such as Loch Ewe. Although sea trout stocks were already in decline, the removal of the "three-mile fishing limit" provides much more persuasive evidence that this was the cause of the collapse rather than the salmon farm.

5. Acknowledgements

This study was self-funded.

All the data used is available from the Scottish Government Statistics website

Sea fisheries - https://www2.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/TrendSeaFisheries

Sea trout - https://www2.gov.scot/Topics/marine/Publications/stats/SalmonSeaTroutCatches

The author is connected to the aquaculture industry and has undertaken this study out of personal interest and has not been commissioned or encouraged by any representative organisation or commercial company.

6. References

Anon (2018) Wester Ross Fishery Trust Annual Review. http://www.wrft.org.uk/files/SWRFT%20Review%20February%202018%20Final%20for%20web%20V2.pdf

Anon (2019). Wester Ross Fishery Trust newsletter Feb 2019. https://www.wrft.org.uk/files/SWRFT%20Newsletter%20February%202019%20v%2011%20Feb%202019.pdf

Butler, J.R.A. & Walker A.F (2006) Characteristics of the Sea Trout (Salmo trutta) Stock Collapse in the River Ewe (Wester Ross Scotland), in 1988-2001. In Sea Trout: Biology, Conservation and Management. Edited by Harris, G. & Milner, N. Blackwell Publishing Page 45-59.

Graham-Stewart, A (2017) Salmon & Trout Conservation Scotland.

Hislop, J.R.G. (1986) The demersal fishery in the Clyde sea area. Proc. Roy. Soc. B 90: 423–437.

Hunter, A., Speirs, D. C., & Heath, M. R. (2015). Fishery-induced changes to age and length dependent maturation schedules of three demersal fish species in the Firth of Clyde. Fisheries Research, 170, 14-23.

McIntyre, F., Fernandes P. G. & Turrell, W.R. (2012). Clyde Ecosystem Review. Scottish Marine and Freshwater Science vol. 3, No.3.

Pemberton, R. (1976). Sea trout in North Argyll sea lochs II. Diet. Journal of Fish Biology, 9. 195-208.

Picken M. J., (1987). The Sea Trout in Scotland. Symposium Proceedings. Scottish Marine Biological Association. June 1987. Pages 53-59

Thurstan, R.H. & Roberts, C.M. (2010). Ecological meltdown in the Firth of Clyde, Scotland, Two centuries of change in a coastal marine ecosystem. PLos ONE 5(7): e11767.doi:10.1371/journal.pone.0011767.

Walker, A.F. (2006). The rapid establishment of a resident brown trout population from sea trout progeny in a fishless stream. In: Sea Trout Biology, Conservation & Management (Harris, G.S. & Milner N.J. eds). Proceedings of the First International Sea Trout Symposium. July 2004. Cardiff, Wales. Blackwell Publishing Oxford. Pp 389 – 400.