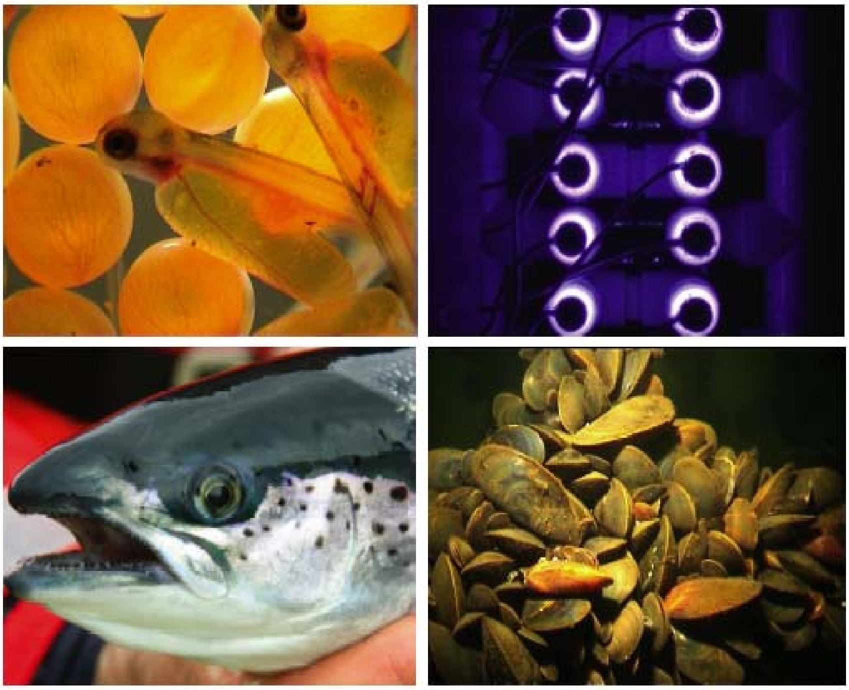
Scottish Aquaculture Research Forum

Sarf068

# Use Of Wrasse In Sea Lice Control



A REPORT COMMISSIONED BY SARF
AND PREPARED BY

Viking Fish Farms Ltd

Published by the: Scottish Aquaculture Research Forum (SARF)

This report is available at: http://www.sarf.org.uk



**Suggested Citation**

**Title:** Use of Wrasse in Sea Lice Control

ISBN: 978-1-907266-56-0

First published: July 2013

**Project Final Report**

# Use of wrasse in sea lice control

SARF068

**Prepared for**

## The Scottish Aquaculture Research Forum

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**27th January 2013**

## Contents



**Abstract**

The use of wrasse for the control of sea lice is being pursued in Norway, Ireland and Scotland as part of an integrated sea lice management strategy. This is to reduce the reliance on medicinal treatments and also to alleviate any potential for the development of resistance to sea lice medicines. Although other wrasse species were used on salmon farms in the 1990s recent interest has been in stocking the larger and more robust ballan wrasse. Currently several hatcheries in Europe are trying to rear the ballan wrasse but the present project had the objective of assessing whether the ballan wrasse is effective in reducing sea lice numbers and in looking at biological and management factors in maximising the efficiency of the technique.

Trials were conducted at five salmon farms using primarily wild caught ballan wrasse but with farmed ballan wrasse on the fifth farm. At the beginning of the project the choice of farm was limited due to the low numbers of wrasse available to the industry. No control pens were available on the farms in Lewis and Spelve on Mull but only 3 medicinal treatments were required in the course of the production cycles compared with more frequent treatments in previous year classes. Lice numbers were compared on salmon in two adjacent farms in Loch Linnhe, one with and the other with no wrasse. The group with wrasse was treated later and two fewer treatments were required compared with the group with no wrasse. In a small scale trial on a farm in Harris, the Western Isles, farmed wrasse were stocked and sea lice numbers on salmon were significantly less than in control pens. In the last trial lice numbers in three pens with ballan wrasse were significantly less than on salmon in three control pens in the first year of the salmon production cycle.

Measures were developed to assess the welfare of wrasse on salmon farms and these included eye condition, snout erosion, skin haemorrhaging, and erosion and splitting of dorsal, pectoral, anal and caudal fins. Baseline values were determined for the five wrasse species with the condition of the caudal fin being the most important welfare index in wrasse. Fin erosion and splitting were significantly higher in corkwing and rock cook wrasse, but goldsinny were aggressive and territorial during the spawning period of June to July and showed high levels of dorsal fin erosion at that time. In one farm the welfare indices for wrasse were calculated for a group of ballan wrasse before stocking on the farm, in the first winter and on harvesting all the salmon. There were no significant differences in the extent of fin erosion and fin splitting in any of the samples, although the index was marginally poorer in winter. The fish were in good condition and did not show signs of emaciation at any sampling point.

Losses of wrasse were measured on three farms and comprised 7.3% at Lewis Salmon and 8.6% at a farm in Loch Sunart in the first year (April to December). In general, some mortalities were largely due to over-inflation of the swimbladder during sea lice treatments and fish farm operations when the net was raised too quickly. Other reported causes were due to escapement with some fish being too small for the mesh size used in stocking. There is some evidence that bird predation was a factor when wrasse hides were inadequate. Losses can be reduced by good management, by the provision of adequate numbers of wrasse hides, and in feeding the wrasse supplementary feed when sea lice numbers are low.

Farms have to establish a plan for the use of wrasse in an integrated sea lice control strategy. The preference appears to be to stock farmed wrasse when these fish become available to the industry, to use a stocking ratio that is low, for example 1:25, and to keep topping up wrasse when numbers decline. Wrasse are also transferred from pens during farm operations and traps are used to retrieve wrasse and to redeploy them from pens with low lice numbers to pens with higher lice numbers. There is a place for stocking larger ballan wrasse in the second year of the production cycle.

## 1. Introduction

With the development and growth of Salmon Farming across Northern Europe during the past three decades, the effect of parasitic sea lice on farm stocks has emerged as one of the major health issues (Pike and Wadsworth, 2000). Sea lice are ectoparasitic copepods that browse the epidermis of fish using a strigil, and mouthparts bring the fish tissue to the mouth. In large numbers sea lice can cause considerable damage to salmon, eventually leading to loss of body fluids through wounds and eventually resulting in death if lice numbers are not controlled (Wootten et al., 1989). Two species of lice are commonly found on salmon in northern Europe (Kabata, 1979; Wootten et al., 1989) the generalist parasite *Caligus elongatus* which is found in UK waters on around 80 marine finfish species and the larger salmonid specific *Lepeophtheirus salmonis* which causes more severe problems for salmon. This species has been termed incorrectly as the "salmon louse" in Norway as it is found on a range of salmonid species (Pike and Wadsworth, 2000). The life cycle of *L. salmonis* comprises nine developmental stages; the first three are free living in the plankton comprising two nauplii stages and then an infective copepodite stage. Thereafter the louse attaches to the salmon using a filament and an adhesive secretion. Then the louse develops through four chalimus stages that are fixed to the fish. The final chalimus satge moults to a mobile pre-adult stage which is followed by pre-adult II and then the adult louse. The entire life cycle is dependent on temperature and can vary from 90 days at 5°C for a female to 19 days at 17°C (Johnson and Albright, 1992).

There is evidence of environmental impacts of sea lice including, the possibility of transfer of sea lice infestations from farmed to wild fish and in the release of treatment chemicals to the environment (Costello, 2006; Jackson, 2012). Over time, greater dependence on sea lice medicines may result in resistance developing in lice to these agents (Lees et al., 2008), thereby further exacerbating the problem both on farms and for wild fish (Costello, 2006).

With the steady development and growth of salmon farming across Northern Europe during the past three decades, the effect of parasitic sea lice on farm stocks has emerged as one of the major health issues. Sea lice have a large impact on fish welfare and it is expected that the cost of sea lice to Norwegian fish farmers is more than 200 M NOK/year (90 million EUR) in Norway and 66 M NOK/year (30 M EUR) in Scotland (Sinnott, 1999), with an annual global figure of 300 M EUR (Costello, 2009). There is evidence of negative environmental impacts (Costello, 2006) including the possibility of transfer of sea lice infestations from farmed to wild fish and in the release of treatment medicines to the environment (Costello, 2006). Over time, greater dependence on sea lice medicines may result in resistance developing among lice against these agents, thereby further exacerbating the problem both on farms and in the wild. A cost-effective and environmentally sustainable solution to prevent the development of resistance by sea lice to medicines is a priority for the aquaculture industry. Current practices for lice control on salmon farms involve the use of chemical treatments. Innovative and sustainable approaches to solve this problem through using a natural predator of lice, is the prospective alternative.

The range of sea lice medicines available to the salmon farming industry is limited with continuous use of cypermethrin and emamectin benzoate, potentially leading to the development of resistance and reduced efficacy (Lees et al., 2008). Where there is a suspected lack of efficacy (Costello, 2006) this should be reported to the Veterinary Medicines Directorate. Although integrated sea lice management was recommended to reduce this likelihood the progress towards this has been slow with reliance still placed on a limited range of medicines.

There is interest in the use of Ballan wrasse (Labridae; *Labrus bergylta*) as a means of reducing dependence on medicines and preventing the development of resistance. However, the use of wrasse dates back to 1989 when Bjordal (1990) tested wrasse in tanks with lice infected salmon and then stocked a range of wrasse species in salmon pens and demonstrated cleaning activity. However, most of these trials used species other than ballan wrasse (Bjordal, 1990) and it was first considered that ballan wrasse would damage salmon by picking at eyes and scales. More recent work in Norway (Sveier, 2011) has suggested that ballan wrasse are hardier and are very effective cleaners of sea lice. In addition this is a larger species that could be deployed with salmon in the second year of the production cycle.

Currently there are questions regarding the potential success and benefit of the use of cleaner fish in an integrated sea control strategy. The current project examines whether the use of ballan wrasse is effective in controlling sea lice on farmed Atlantic salmon *Salmo salar* L. and investigates optimal conditions of use.

There is also concern to ensure good survival and welfare of wrasse stocked in salmon pens. This present project studied different measures to optimise wrasse welfare such as the use of refuges, alternative feeds when there are few lice, protection against disease, and handling during net changes/swim through. These measures are important for fish welfare but also for certification bodies such as the RSPCA's Freedom Foods accreditation scheme (RSPCA, 2012). The Freedom Foods standard indicates that the use of cleaner fish is prohibited, but all the farms that have stocked wrasse have been working under derogations from Freedom Foods. The main objective was to determine welfare indices that would be suitable to use to monitor the welfare of wrasse, to set baseline welfare indices, and also to monitor wrasse welfare index scores in salmon pens.

Conventional sea lice control has been with preventive methods such as fallowing, stocking of single year classes, and by using medicines such as cypermethrin Excis™, Alphamax™, Salmosan™, hydrogen peroxide and the in feed treatment SLICE™. There has been a suspicion that some of these medicines have been less effective and attention has focussed on finding alternative lice control methods. The use of cleaner fish called wrasse to pick sea lice from the salmon is being applied on many salmon farms. Wrasse are stocked at a ratio of 1 wrasse to 25 salmon and the estimated demand for farmed wrasse in Norway is over 10 million fish and in Scotland in the region of 1.5 million wrasse. This year only a small amount of farmed wrasse was available to the salmon farms in Scotland. There is therefore a high potential demand for farmed wrasse in Scotland of around 50 to 70 grams to stock in pens to clean sea lice from the salmon. These wrasse are currently captured in the wild by fishermen using baited creels and pots. However, this is unsustainable because of overfishing and there is an advantage in using farmed wrasse that can be certified as disease free and can be supplied at a time when the farmer requires them. Currently wild wrasse can only be captured when sea water temperatures are higher, and this is generally between May and October.

The specific objectives of the project were:

1. The farm testing of the effects of cleaner fish on sea lice abundance at a range of sites.

2. Assessment of the use of wrasse in different years of the production cycle.

3. Specifications for the use of wrasse on farms.

4. To maintain good welfare of wrasse in cages and to assess measures of welfare.

5. Formulate recommendations of good practice to the industry.

## 2. Establishment of farm trials

An initial enquiry to salmon farming companies had indicated that farmed wrasse would not be available for some time and farm trials would have to be established using wild caught fish supplied by fishermen. The first part of the project was a series of discussions with the fish farm companies to ensure that sufficient wrasse could be captured for the trials and also to discuss how the wrasse would be stocked on the farms. The two companies identified initially in the project application were Lewis Salmon on the Western Isles as it was the only company to have used wrasse in Scotland in the last four years. A second company initially approached to take part in the project was unable to catch sufficient numbers of wrasse. Several of the other salmon farming companies in Scotland were therefore contacted to see if farm trials could be instigated and to keep the companies appraised of developments in the application of wrasse. Further feedback on the SARF project was provided to the industry through occasional wrasse workshops organised by the Scottish Salmon Producers' Organisation (January 2012, August 2012, January 2013) and at the SARF Sea Lice Symposium in Edinburgh, 2011.

## 3. Procedure for wrasse capture and transport

Good handling practice and the optimum environmental conditions for wrasse during capture and transport promotes wrasse welfare and ensures that the wrasse being stocked are of good quality. Stress during capture and transport may make the fish more susceptible infections such as atypical *Aeromonas salmonicida* and physical abrasion can cause skin loss and damage to fins and result in secondary Flexibacter infection. Mortalities to these pathogens manifest 2 to 4 weeks after stocking wrasse in pens and may not be noticeable when the fish are received. The handling, capture and transport of wrasse was discussed with the RSPCA Freedom Foods organisation to contribute to a draft code of practice for the capture and transport of wrasse (2012). Capture and transport protocols were discussed with two of the fishermen in the course of the project. A site visit was also arranged to one of the prospective salmon farms in Lewis and the staff and management were briefed on the receipt and stocking of wrasse (Appendix 1).

## 4. Trials to assess the effectiveness of wrasse use

### 4.1. Trials with no designated control pens

Farm trials with wrasse were established in the first year of the project to assess their effectiveness in controlling sea lice. The health and condition of wrasse were also examined and methods for maintaining the welfare of the fish. There were distinct limitations in establishing the trials. The number of companies stocking wrasse was restricted with only two established companies, Scottish Sea Farms and Lewis Salmon, stocking wild caught wrasse at the start of the project. The initial trials were set up on two farms and after the first year it was apparent that both farms were insistent on stocking wrasse in all pens. The thinking behind this was to ensure maximum control of sea lice. As the second farm had organic certification there was limited access to sea lice medicines and the farm wished to ensure maximum benefit of wrasse in controlling sea lice infestation by using wrasse in all pens. At the end of the first year of the project, although data and useful information were obtained from both farms, it was apparent that trials should be initiated on other farms that would enable the use of control pens to allow comparison with pens where no wrasse were stocked. The emphasis during the project was to follow up the two main objectives:

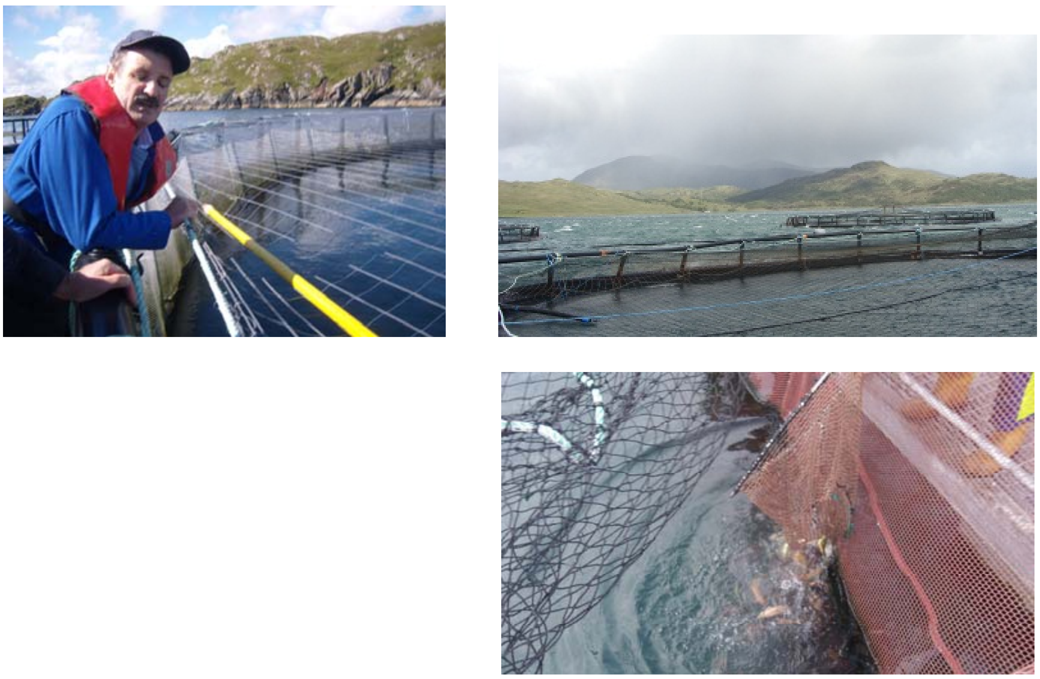
*How well do wrasse work in controlling sea lice? And*

*What measures and conditions are required to ensure good welfare of wrasse.*

Table 1. Details of the five farms involved in trials in the current project.

| Site no. | Location | Control used? | Stocking density to salmon | Details |
|---|---|---|---|---|
| 1 | Lewis Salmon | no | 1:21 salmon | Only 3 medicinal treatments required in 2 year production cycle |
| 2 | Loch Spelve, SSF | no | 1:25, large proportion of ballan | Only 3 medicinal treatments required in cycle; fish topped up and moved between pens |
| 3 | Loch Linnhe, SSF | Compared groups with and without wrasse | 1:25 | Delayed treatments, 2 fewer medicinal treatments where wrasse stocked |
| 4 | Harris, SSC | One pen with wrasse compared with 2 with none | 1:27 | Lower lice numbers in pen with wrasse; Welfare indices also monitored |
| 5 | Loch Sunart, MH | One group with wrasse, two without | 1:25 | Pens with no wrasse available as controls. The welfare of wrasse was monitored through the production cycle. |

Fig. 1. Photos of project sites (clockwise from top left): Lewis salmon, Loch Spelve, Stockinish.



#### 4.1.1. Trial 1 Lewis Salmon

Lewis Salmon is a small independently run salmon farm that rears salmon to organic standards and is certified by the Soil Association (note: this farm was subsequently acquired by Marine Harvest following the trials and now new management regimes and infrastructure may be in place). The farm comprises six polar cirkles of 70 metres circumference and is located in a sheltered bay on the east side of Lewis 15 km south of Stornoway at Loch Leurbost. There are other salmon farms to the north and south of the farm within the same biological zone. A total of 150,000 smolts was stocked in March 2009 and the fish were farmed for 18 months prior to early harvest in September 2010 to meet the requirements for fallowing of the site in compliance with a management agreement. The wrasse, 7200 fish of several species, were stocked at a ratio of 1:21 salmon in June 2009, three months after the smolts were introduced. The company agreed to provide sea lice counts for the SARF project.

Lice counts were carried out by a health observer who was trained in lice counting and his knowledge and level of accuracy were assessed to verify accurate identification of the various sea lice developmental stages. The sea lice were counted weekly on 5 fish from 5 cages which agrees with the outline agreed by the SSPO in relation to a statistically recommended protocol (Treasurer and Pope, 2000; Revie et al., 2005). The lice were classified as: attached chalimus stages, pre-adults (juveniles) and adults of *L. salmonis;* and all developmental stages of *Caligus elongatus* were grouped together. Lice numbers remained negligible (on most dates zero numbers were recorded) from March until September 2009 (Fig. 2) when there was an influx of Caligus from wild fish. Caligus increased from 21st October. Mobile *L. salmonis* increased suddenly from 11th November while there was no infestation by attached stages, suggesting that the lice may have infested from wild non salmonid fish. The fish at Lewis Salmon were treated with SLICE™ (Emamectin Benzoate, Schering Plough) in November 2009 and with Alphamax™ (Novartis) in February 2010 and *L. salmonis* numbers declined to a range of 3 to 5 mobiles. The numbers of *L. salmonis* increased in March 2010 and the fish were treated for a second time with SLICE in compliance with the national sea lice strategic treatments in Scotland. Thereafter, despite the increasing biomass of fish on the neighbouring farm, lice numbers remained below 3 per fish until all fish had been harvested in September 2010.

The lice numbers increased at the onset of winter when temperature and light conditions may have affected the general activity as well as the cleaning behaviour of wrasse (Fig. 2). Given that the organic farm had a large salmon farm in close proximity (3 km) the number of treatments at Lewis Salmon through a production cycle was low and low lice numbers were maintained for much of the production cycle. Lice numbers are generally higher in the second year of the production cycle in most farms in Scotland (Revie et al., 2002) and the consistently low numbers of lice at Lewis Salmon through the second spring and summer suggests that wrasse did assist in maintaining low lice numbers.

The wrasse remaining after the production cycle were culled on the direction of Marine Scotland. This may not have been required if wrasse had been health screened at the end of the production cycle as none was showing clinical disease condition.

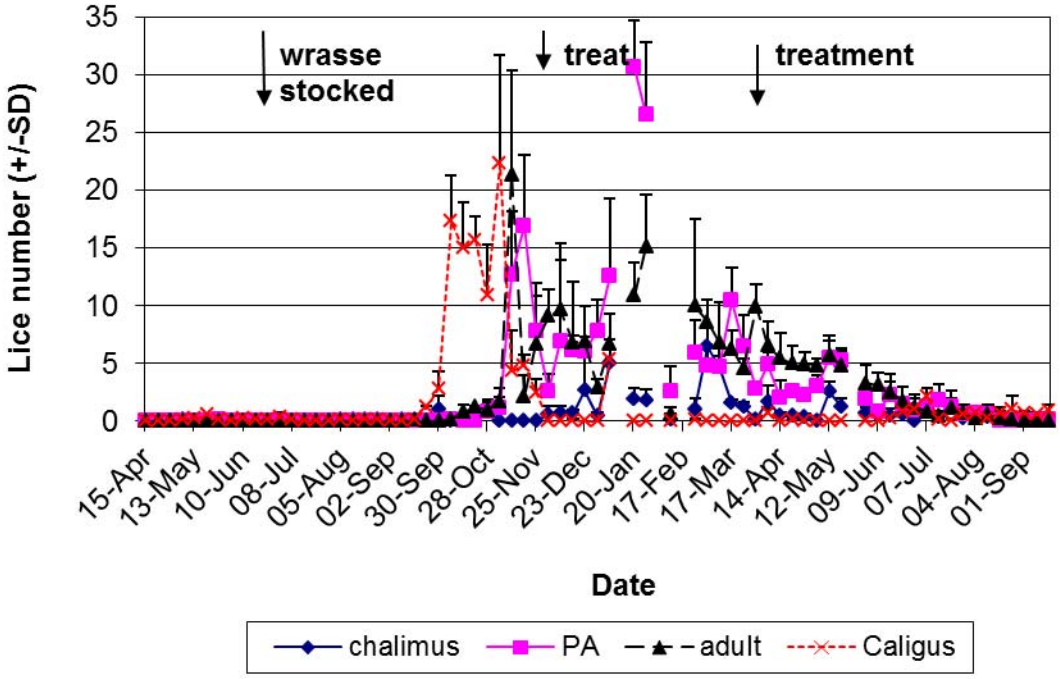



Fig. 2. Numbers of sea lice during the wrasse trial at Lewis Salmon 2009-2010. Chalimus=fixed stages of *L. salmonis*; PA=pre-adults of *L. salmonis*.

2011-2012 salmon year class

Wrasse were also stocked at Lewis Salmon in a second two year production cycle in 2011-12. This was intended to be studied in parallel with a neighbouring larger farm. However, the second farm could not obtain sufficient wild caught wrasse to initiate stocking and a full trial with wrasse.

The site called Arbhair, in Loch Leurbost was stocked with 140,000 salmon in March 2011 and was fully harvested by 7$^{th}$ December 2012. The pens were 70 metre polar cirkles and the nets had a 15 mm mesh. Initially there were five pens with fish and this, after harvesting commenced, was reduced to 4 pens in the last 6 months of the production cycle. The fish on the neighbouring farm were all harvested by March 2012. The Lewis Salmon site did not operate swim throughs of fish from one pen to the next for net cleaning but used an Idema net washing system. 6000 wrasse of mixed species were stocked in June 2011 to give a stocking ratio of 1:23 salmon. The strategy was to stock all pens with a mixture of wrasse species in the first year and then to add some extra larger ballan wrasse in the second production year.

The site provided four box design of hides, one at each compass point on each pen. The wrasse were seen to use these and supplementary feed was provided in these when lice numbers were low. The farm staff observed that the wrasse took some time to resume feeding on sea lice once they had been offered crushed mussels and crabs for some time.

The farm provided a record of sea lice counts (Fig. 3). These were based on anaesthetising and examination of 5 fish from each of 5 pens and subsequently 7 fish per pen when only 4 pens were stocked. The louse species was mainly Caligus in the first summer and then increasing numbers of *L. salmonis* from December 2011 to 15 adult lice per fish. The fish were therefore bath treated with Alphamax$^{TM}$ on 23rd December which gave a good reduction in lice numbers, and this was followed by an in-feed SLICE treatment on 10th February 2012 when sea lice numbers were 6 and another bath treatment on 13 April 2012 when lice numbers were 8 per fish. It has been difficult to assess the overall effectiveness of wrasse use as no control pens were used but lice numbers remained low through most of the production cycle and especially in the more difficult second year. Also, there were fewer medicinal treatments required than historically for the period from 1990 to 2004 (L. Macleod, pers. comm.). Wrasse appeared more effective after winter conditions. Wrasse were observed by eye and with underwater camera and were seen to be less active in winter but all wrasse species survived well over this period. There was no evidence of any aggressive behaviour to salmon and subsequent eye damage.

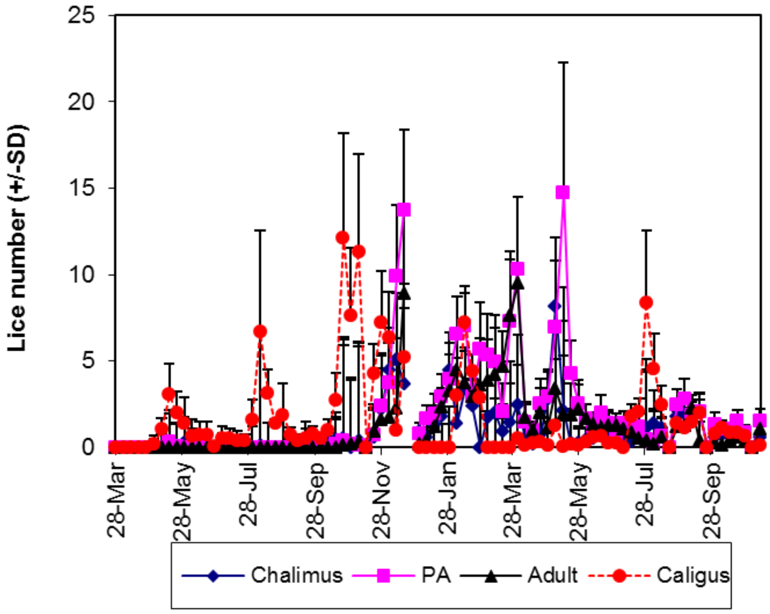



Fig. 3. Numbers of sea lice during the wrasse trial at Lewis Salmon 2010-2011. Chalimus=fixed stages of *L. salmonis*; PA=pre-adults of *L. salmonis*. The SD is shown as error bars.

**4.1.2. Trial 2. Scottish Sea Farms, Loch Spelve**

The salmon farm in Loch Spelve is situated on the south coast of Mull. The farm was stocked with salmon in October 2009, with more fish stocked in April 2010. An inshore group (Spelve A) comprised 8 steel pens of 24 metre square (6 stocked with fish). 25,000 fish were stocked in each of these pens with a 15 mm mesh net. The remaining fish at the Spelve B site on the opposite side of the loch (2 km distant) comprised 8 polar circles of 80 m circumference with 25 mm diameter net mesh. Six of these held 25,000 salmon each, giving a total for the two sites of 300,000 salmon. There was no wide variation in size range, so there may be no requirement for grading. The site commenced harvesting from January 2011 and this continued until October 2011. Wrasse were stocked from July 2010 in all the pens at a ratio of 1:20 salmon. Two thirds of the fish were ballan wrasse in the size range 17-25 cm and the balance was a mix of other wrasse species but mainly goldsinny in the large mesh nets. In the case of the smaller mesh nets fish of 30 to 100 g were stocked and 50% of the fish were ballan and the rest were other species. Two pens were left unstocked in Spelve B as control cages. Cover for wrasse was provided with polyrope, these are large plastic string sheets which provided a refuge and were transferred between pens during swim throughs. The wrasse swam between pens when the cover was pulled across. Feed bags of small mesh and filled with crushed shellfish were placed in each pen at 2 metre depth. Video footage was taken by divers of the wrasse on both pens and they seemed in good condition and settled. Wrasse swam through the shoals of salmon and in the opposite direction to the salmon and darting into the shoal and cleaning the fish. Many wrasse were seen using the artificial kelp provided and also some were aligned along the side of the pen net. The ballan wrasse were swimming in the upper water column, whereas the goldsinny and other wrasse species were near the bottom of the net.

Lice numbers increased to November 2010 coincident with a decline in wrasse numbers and also a shorter daylength. As the net was lifted for a sea lice bath treatment In November a couple of fish were seen with over-inflated swimbladders, but otherwise the fish were not affected. The fish were bath treated again at the end of January. This would suggest that due to cold temperatures and the shorter daylength that wrasse were less active and cleaning less effectively. During sea lice treatments in March it was noted when lifting the nets that many of the salmon that had not been treated had few lice and there was a suggestion that the wrasse were becoming more active. The wrasse were less inclined to come to the surface to clean the salmon. As the salmon were harvested the wrasse were removed from the pens prior to harvest using traps. These were baited with shellfish but it did not seem to be critical to use bait. Over a number of days the numbers of wrasse retrieved from the pens declined. Only one wrasse was retrieved at the end of the harvest in one pen, and the trap method of removal appeared to work successfully. Lice numbers were low in spring 2011, less than 1 gravid per 100 fish.

The lice numbers remained low from stocking of salmon in October 2009 and lice numbers were only noted to increase in July 2010. The fish were treated twice in spring 2010 with Alphamax™ to comply with the national strategic treatment policy and once in June before the wrasse were stocked, although lice levels were low. There were no further treatments after the wrasse were stocked until January 2011 when lice numbers started to increase and a further bath treatment was necessary. This was not completely successful and an additional bath treatment was carried out in March.

### 4.2. Trials with wrasse when control pens were designated

These three trials involved the use of control pens for comparison where no wrasse were stocked (Table 1). In the first trial the numbers of sea lice on salmon in adjacent pen groups with and without wrasse were compared. In the second there were only sufficient wrasse numbers for stocking wrasse in one pen and lice numbers here were compared with two pens where no wrasse were stocked. In the third trial lice numbers on salmon stocked with wrasse in three pens were compared with lice numbers on salmon in three pens with no wrasse.

#### 4.2.1. Trial 3. Trials in Loch Linnhe

Salmon were stocked in the first Linnhe site (A) in March 2010. Wild caught wrasse of a mix of species were stocked, but were dominated by ballan of a length range of 10 to 27 cm. These were stocked at a ratio of 1:25 salmon from June 2010 in all 90 metre polar cirkle pens in one farm in Loch Linnhe. Lice numbers were negligible through the summer (Fig. 4). In the last week of September half the salmon from farm A were transferred to a nearby site B (5 km distant) but all the wrasse were left at site A. Within a month the total mobile lice numbers had increased to 0.52 at site B and the salmon were given a medicinal bath treatment, whereas lice numbers at the original site A remained at zero. All farms in the Linnhe loch system were treated on week commencing 26th November with a bath treatment as part of a coordinated treatment strategy as part of an Area Management Agreement and lice numbers were reduced to zero on both farms A and B (Fig. 4). Within 3 weeks the lice numbers on salmon on farm B had risen to 0.68 per fish compared with only 0.1 per fish on farm A and a bath treatment was only required on Farm B. Lice numbers on both farms increased to 0.5 per fish by the middle of February 2011 and a bath treatment was required on each. Thereafter lice numbers remained similar on both farms and treatments of lice were required in the first week of May. This would suggest that wrasse were less effective in the colder months with reduced daylength.

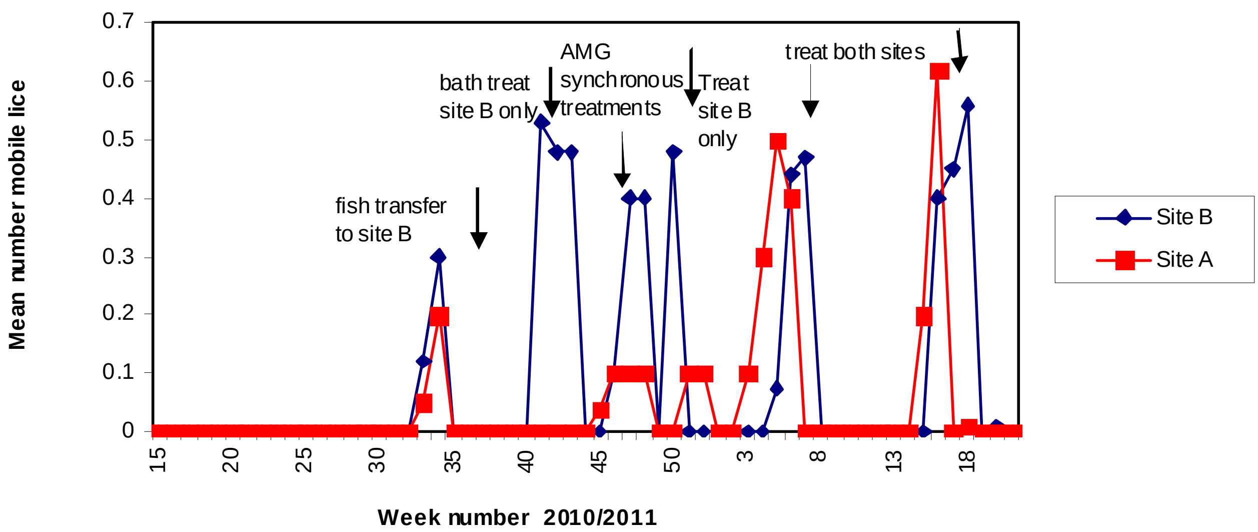



Fig. 4. Sea lice numbers on adjacent farms in Loch Linnne; Farm A=with wrasse and farm B=none.

#### 4.2.2. Trial 4. Controlled trial with farmed ballan wrasse

This trial utilized the first farmed ballan wrasse reared in Scotland. Only 650 ballan were available and these were transferred in September 2012 to Stockinish salmon farm in Harris and these were supplemented with 300 wild caught wrasse from the vicinity of the farm. The group of pens comprised 6 steel pens of 24 m square fitted with a 15 mm mesh net of 10 m depth. Only three of the pens were stocked with salmon, each with 54,000 salmon, and these were of 900 g mean weight on sampling. The ballan wrasse of 70 g mean weight were stocked to give a ratio of 1:27 salmon.

Hides

Three hides of approx. 1 metre long comprising a large plastic pipe filled with 50 mm pipes inside were located in each pen 4 m from the water surface and suspended from each net corner. On the 4$^{th}$ corner, on the outer pen side and nearest the central walkway, a large wrasse house manufactured by Fusion Marine was located. This had numerous small pipes at right angles to the line of the hide. There was some fouling on the hides which gave them a natural appearance. This was a good design although the size of this hide was large which made it harder to handle and more protection could have been offered to the fish if one side of each pipe had been sealed.

Supplementary feed

Baskets were hung in the pen corners and filled with crushed mussels to provide additional feeding when lice numbers were low.

Sea lice numbers

Lice were counted on 20 salmon taken from each pen 10 weeks after stocking the wrasse. There were no lice on any of the fish and the mean numbers of sea lice on the control pens were higher. Sea lice mobile numbers were 0.3 and 0.24 in the two pens without wrasse (Fig. 5). This trial is ongoing.

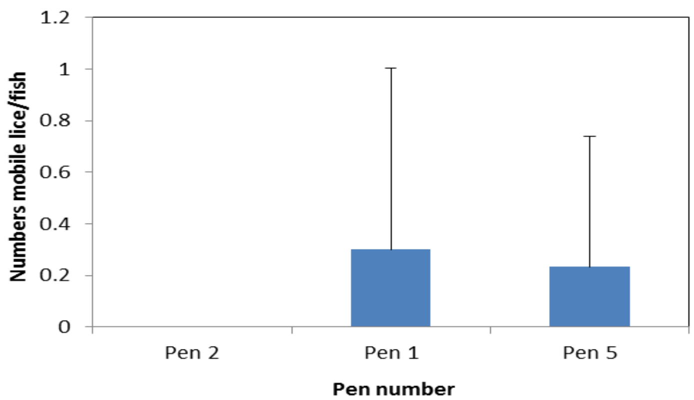



Fig. 5. Sea lice numbers in a pen with wrasse (p.2) compared with two pens (1 and 5) with no stocked wrasse. Sample size= lice counts from 20 salmon from each pen. The SD is shown.

**4.2.3. Trial 5. Trial in Loch Sunart**

1,000,000 salmon were stocked in 3 pen groups in February 2011 on a farm in Loch Sunart. A total of 250,000 fish was transferred by well boat to a nearby farm in November 2011, leaving 750,000 fish at the trial site. The fish were harvested by the end of August 2012. 13,000 wrasse of five species were stocked on the second of the three pen groups in July 2011. Most of the wrasse were transferred with the salmon to the nearby farm in December 2011. Only two pens were left with wrasse on the 2$^{nd}$ group and approximately half of these fish were transferred to another pen on the third group to give 3 pens stocked with wrasse.

A total of 3 SLICE and several bath treatments were given in this production cycle as only one pen group was stocked with wrasse. Initially SLICE was used for smaller salmon with 3 treatments in 2011, and then Alphamax was used for 2 treatments and then there was a treatment with Salmosan, and latterly hydrogen peroxide was used.

Wrasse hides were positioned where salmon were mainly present, about 3 to 4 metres from the water surface.

Sea lice counts
A comparison was made of sea lice numbers on salmon from the three pens with wrasse, number 6, 8 and 17 with 3 pens with no wrasse in the first summer. This showed a significantly (ANOVA, $P<0.05$) lower number of mobile lice in the pens with wrasse.

Conclusions from the three farm trials

In the three trials that included pens with no wrasse as controls, the numbers of mobile sea lice were significantly less in the pens stocked with wrasse. Cleaning activity appeared to be less effective in the winter months.

## 5. Welfare of wrasse

The welfare classification scale used in many fish species utilizes the condition of the fins and measurements of fin erosion and splitting have been the main items examined (Hoyle, 2007; Huntingford et al., 2006). These are based on a five point classification devised by Bosakowski and Wagner (1994) and also developed by Moutou et al. (1998) which utilizes the scoring of erosion and splitting of fins as in salmonids (Table 2).

Table 2. The main indicators of wrasse welfare were scored on the following scale:

Operculae: damage/or no damage.

Eyes: damage/no damage.

Body: lesions/no lesions.

Dorsal fin, tail, anal fins, pectoral fins:

Erosion on a scale of 0=none, 1=slight, 2=moderate erosion, 3=half fin damaged, 4=severely eroded
Fin splitting 0=none, 1=one split, 2=2 splits, 3=3 splits, 4=severe general splitting.

The condition of fins was assessed separately for the dorsal, caudal, anal, left pectoral and right pectoral fins. An assessment was also carried out on other welfare indices such as jaw damage, eye damage, epidermis condition, and also in the fish condition factor K= ($W^3$ in grams/L in mm)*1000. A baseline of welfare indices for these parameters was initially assessed and compared between the five wrasse species captured in inshore waters of west Scotland: goldsinny, rock cook, corkwing, cuckoo and ballan wrasse. Fifty fish of the species goldsinny, rock cook and ballan and 15 cuckoo and 30 corkwing were taken from holding tanks and anaesthetised in 200 ppm phenoxyethanol and examined by extending the fins gently. Statistical comparison of the average score for each parameter was made by ANOVA with significance accepted at $P=0.05$, after testing data for homogeneity of variance by Bartlett’s test.

Assessment of welfare indices was carried out on ballan wrasse on a salmon farm through the production cycle in Loch Sunart (MH) on stocking (n=50), in December 2011 (n=40), and prior to final harvest in September 2012 (n=75). Welfare was also assessed in 30 ballan wrasse stocked on a farm in Harris, the Western Isles, in November 2012.

Results

The mean lengths and weights of wrasse sampled from the holding tanks in the baseline study are shown in Fig. 6 and these reflect the size of wild wrasse stocked on salmon farms. The condition factors were 1.36 for goldsinny, 1.46 for rock cook, 1.43 for corkwing and 1.42 for ballan wrasse and these did not differ significantly (P>0.05), although all were significantly higher than 0.98 for cuckoo wrasse which reflects the long slimmer body shape of the latter. Eye and mouth damage were negligible in the five wrasse species, and there was no skin haemorrhaging in any fish.

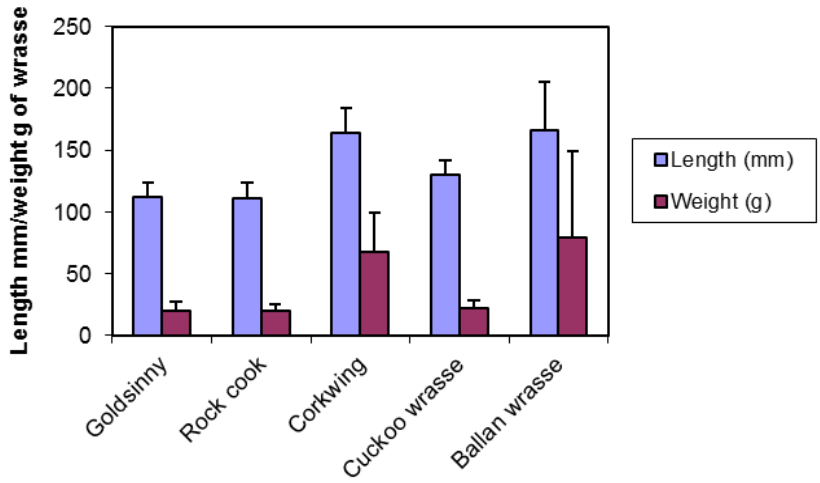



Fig. 6. Lengths and weights with SD of wild caught wrasse captured for stocking on salmon farms. Sample size= 50 fish each of goldsinny, rock cook and ballan, n=30 corkwing and n=15 cuckoo wrasse.

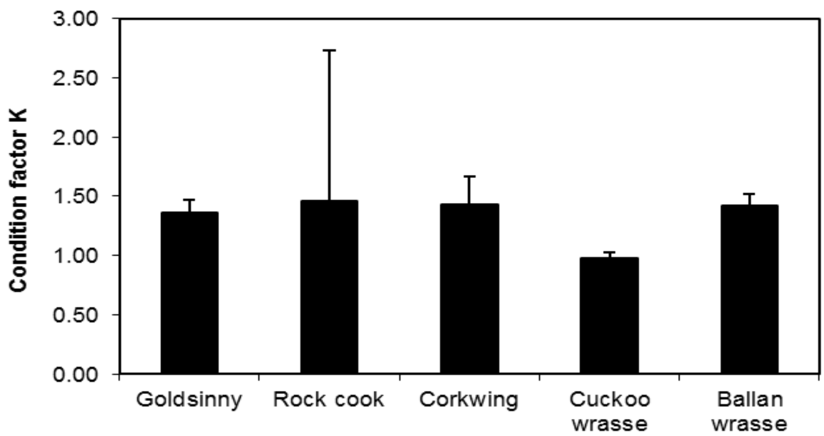



Fig. 7. The condition factor of five species of wrasse held in holding tanks. Sample size=as in Fig. 6.

Figure 8 shows examples of typical fin erosion and fin splitting in the five wrasse species. Note in goldsinny wrasse, from the top fish photograph=severe tail splitting, middle dorsal fin erosion and severe tail erosion, bottom photograph=severe dorsal fin erosion. This can be compared with rock cook in which all three fish (Fig. 8) show some tail splitting and dorsal fin erosion. The corkwing top photo shows some tail erosion (index 2) and the middle and bottom fish show high dorsal fin erosion (category 4). The cuckoo wrasse showed good fin condition, and the middle photo=a ballan wrasse with mild tail splitting, and the bottom ballan shows=no damage.

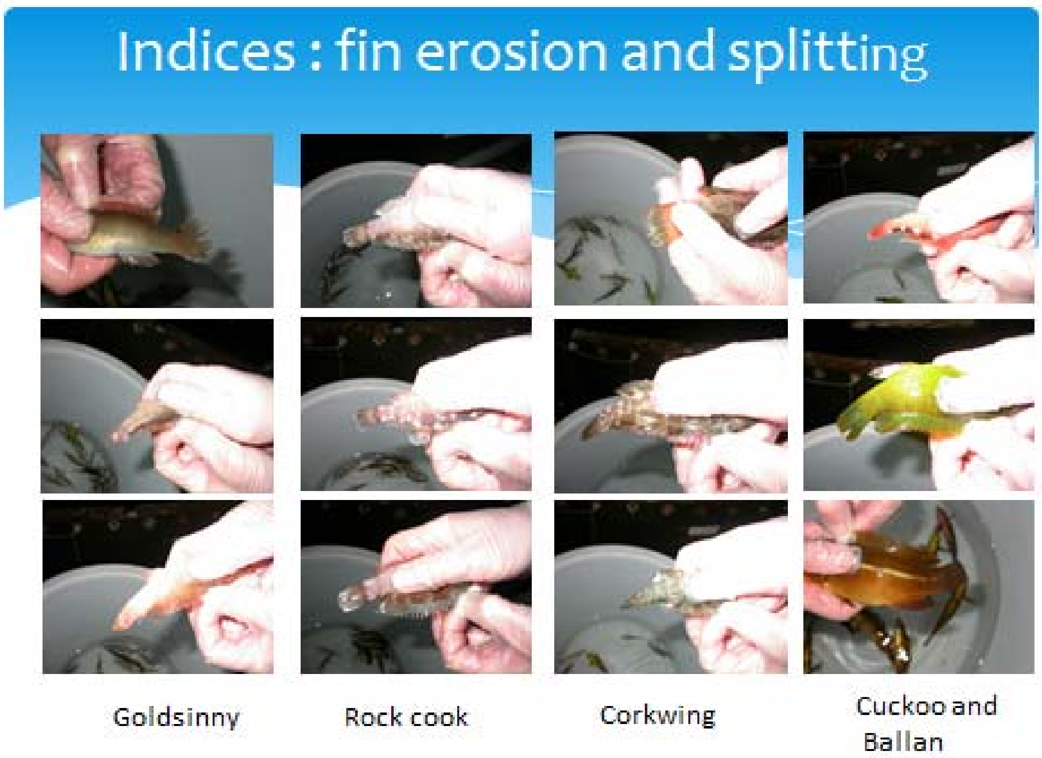



Fig. 8. Comparison of the welfare indices fin erosion and fin splitting in five wrasse species. Descriptions of each condition/photograph are given in the text.

Dorsal fin erosion was significantly higher ($P<0.05$) in goldsinny and cuckoo wrasse than the other species (Fig. 9) but was still only slight (score 0.5). Splitting of the dorsal, anal and pectoral fins was also negligible (circa 0.01) in all wrasse species. The main indicator of fish condition was splitting in the caudal fin and this was significantly higher (ANOVA, $P<0.05$) than for splitting in other fins in all wrasse species. Splitting of the caudal fin was high (average score 2.8) in rock cook wrasse and also corkwing (2.17) and these values were significantly higher ($P<0.05$) than in goldsinny, cuckoo and ballan wrasse. This baseline assessment of possible welfare indices in wrasse indicates that splitting of the caudal fin is the most sensitive indicator of poor welfare condition or damage. It also indicates that rock cook and corkwing wrasse are the species most likely to incur damage.

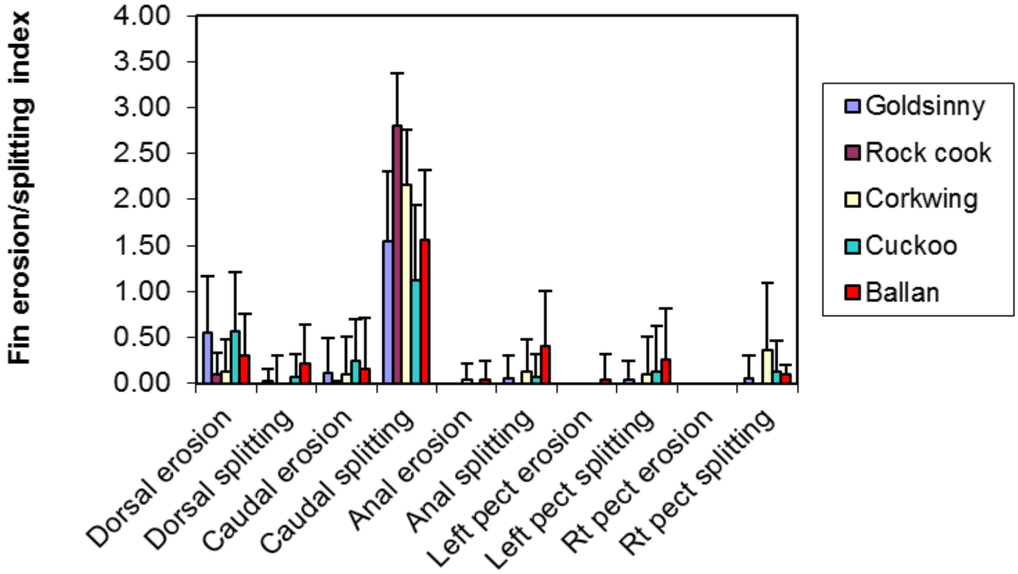



Fig. 9. Fin erosion and splitting in five species of wrasse. SD=vertical bars. The incidence of splitting of the caudal fin was significantly higher than the other welfare indices.

However, another sample of wrasse was examined in June (Fig. 10) and, in this, the fin erosion of the caudal fins in goldsinny wrasse was high, with an index of 2.6 for erosion and 2.5 for splitting. This was when goldsinny were reproducing and eggs and milt could be easily extruded from the fish. The goldsinny is territorial (Hillden, 1978) and holding the fish at densities higher than in the sea may have led to aggression between fish.

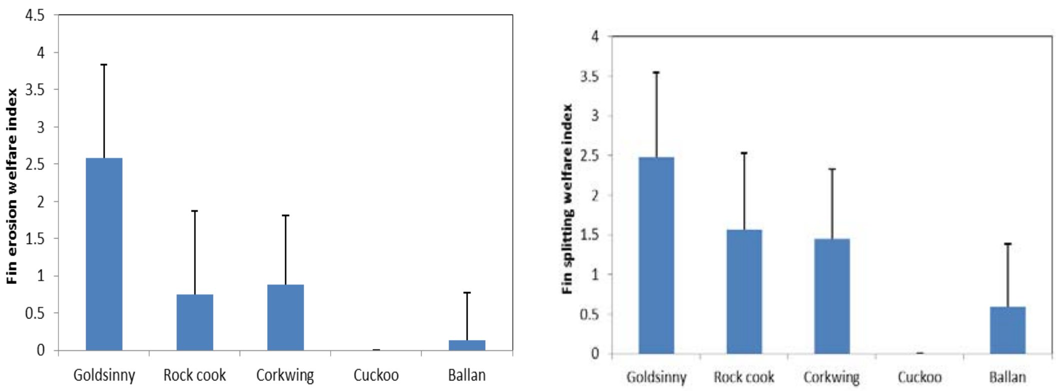



Fig. 10, a and b. Caudal fin erosion and splitting indices in wrasse species held in storage during the breeding period, June to July. N=50 fish of each species. SD is shown as vertical bars.

### 5.1. Farm assessment of welfare indices through the production cycle on one salmon farm

Fin welfare scores were assigned to ballan wrasse on stocking, in winter, and just prior to final harvest and these are shown in Fig. 11. There was minimal fin erosion on stocking, during the production cycle and on harvest. The level of fin splitting was mild and confined to the tail and there was no significant difference (P>0.05) in the fin splitting score for individual fins prior to stocking, during the winter and on harvest. There was no eye or opercular damage at any sampling point. The ballan wrasse were examined at the end of the production cycle. There was no damage to the body in any fish, the fins were intact, and the appearance of the fish looked good with no signs of emaciation.

The conclusion from the assessment of wrasse welfare indices is that the condition of the ballan wrasse specified by scores for fin erosion and splitting was maintained in net pens during the production cycle. Fish showed good condition and were not anorexic.

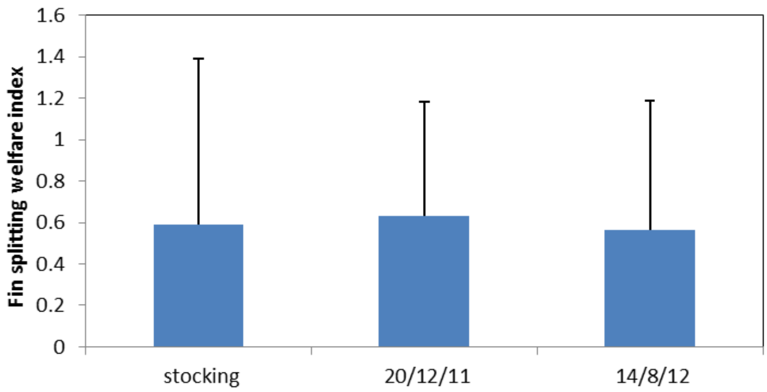



Fig. 11. The fin splitting welfare score (graded 0 to 4 in occurrence, see text) of ballan wrasse on stocking, in the winter, and on harvesting at the end of the production cycle. Sample size N=50 and 40 fish respectively on the first two occasions and 75 fish on 14th August. The vertical bars=SD. There were no significant differences ($P>0.05$) in fin splitting indices between dates.

**5.2. Examination of fish at Stockinish**

Farmed wrasse were seen swimming and browsing near the surface 10 weeks after stocking in water of 50 cm deep and the behaviour appeared normal. Thirty wrasse were retrieved for examination of welfare indices. None of the fish was emaciated. The average fin erosion score was 0.2 and the fin splitting score 0.05.

**5.3. Supplementary feed**

All five farms that participated in the project were aware of the requirement to use supplementary feed for wrasse when sea lice numbers were low and especially in the first year and after stocking. Some wrasse were sampled and the gut was examined at Loch Spelve and there were shrimps and mussels in the contents suggesting that wrasse can maintain their condition on marine biofouling present on the nets. This reduces the incentive for wrasse to eat sea lice. For this reason the farms involved in the project inspected the nets and ensured that biofouling was not too advanced.

In most cases the farms provided supplementary feed of crushed shore crab or mussels when wrasse were initially stocked. The feed was presented in a number of ways, for example in bags made from netting (Loch Spelve Fig. 12a) in open baskets (Scottish Salmon Company), and in hides used for wrasse capture (Lewis salmon Fig. 12b). The use of this feed also encouraged wrasse not to seek feed in the mortality collection sock in the bottom of the salmon net. The only negative view presented about the practise was by Lewis Salmon where they gave the opinion that wrasse acclimated to feeding on supplementary feed took some time to feed on sea lice again.

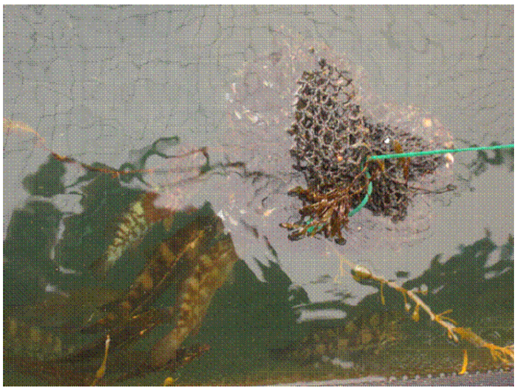


Fig. 12. Baskets used for providing supplementary feed for wrasse at (a) Loch Spelve and (b) Lewis Salmon.

**5.4. Use of hides**

Hides (or refuges) were used with wrasse for a number of reasons:

- To afford wrasse protection from temperature and environmental conditions as well as bad weather. Hides are essential when wrasse are less active at low temperatures.
- To provide an area for resting from salmon and also protection from tidal flows
- To give an area to sleep in and provide protection. Wrasse are known to be inactive and unresponsive in darkness (asleep) and may give easy access to predators such as cormorants when they rest on the nets.

Environmental conditions were examined within a range of specially constructed wrasse shelters made of small diameter tubing with end stops in some of the pipes (Treasurer and Sayer, 1996). It was found that these hides did buffer fluctuations in salinity and temperature and improved wrasse survival.

In the current project various designs of hides were developed by farm staff and tested (Fig. 13). These included:

- Several small tyres linked together in a stack (SSF Sound of Mull)
- Large bin structure (Lewis)
- Square cages with cage netting (Lewis)
- Four to 5 pipes of 50 mm diameter mounted inside a larger protective pipe (SSC)
- Artificial kelp strands (Spelve SSF)
- A larger specially produced hide made of several polar cirkles linked together, manufactured by Fusion Marine. This design was effective but cumbersome and less manoeuvrable in the pens (SSC).

Innovative trap designs were used at Lewis Salmon to retrieve wrasse from pens and to transfer wrasse between cages (Fig. 13). The front side of the traps could be removed and they were baited and used as feeding stations for wrasse when lice numbers on salmon were low. Various designs of wrasse hides were developed and these refuges were used by wrasse.

These hides were lifted and examined and the wrasse were seen to use these in large numbers. They could also be used to transfer fish from pen to pen during net cleaning operations. The depth of the hides is also important and these should be located mid depth in the pen or where salmon spend much of their time, to enable wrasse to readily swim and mix with the salmon.

Fig. 13. Examples of wrasse hides, left at Lewis Salmon, right SSC at Stockinish.

## 6. Sea lice treatments and other farm operations

When sea lice numbers exceeded treatment thresholds or during periods when strategic sea lice treatments had to be undertaken as part of a National Treatment Strategy or an Area Management Agreement the salmon had to be treated with (normally) a bath treatment such as Alphamax. The nets were lifted, oxygen supplied, and a fully enclosed tarpaulin fitted round the raised net, and then the medicine added for a one hour treatment period. In many cases farmers would attempt to retrieve and remove the wrasse before treating the salmon but removal of all wrasse was impracticable. Reports on wrasse survival have been conflicting with survival being reported as good with hydrogen peroxide bath treatment but large numbers of wrasse were lost during other treatments. There was no evidence to suggest that the medicines were toxic to the wrasse. However, there were frequent observations that during routine operations when nets were lifted or when nets were being raised for sea lice treatments that some of the wrasse displayed over-inflated swimbladders and subsequently died. This also occurred when baited traps were placed in the cages to retrieve wrasse and to transfer them to other pens. The over-inflation of swimbladders in marine finfish such as cod can be a response to stress, or the nets may have been lifted too quickly and prevented the swimbladder of wrasse from adjusting in volume.

There has been no work to determine experimentally whether wrasse can tolerate sea lice medicines and there is some scope for experimentation in this area. The advice that can be given is that nets lifted during routine farm operations such as grading fish, fish transfers, harvests, net cleaning, and sea lice treatments should be carried out steadily and slowly to reduce the risk of over-inflation of swimbladders.

A number of wrasse were caught up on the folds of the pen netting from the vacated net during cleaning of the nets by swim throughs, and the netting should be checked at the end of the operation.

## 7. Welfare of salmon

A number of salmon on one farm suffered eye damage caused by ballan wrasse in October 2010, despite the wrasse having been stocked since July with no damage to scales or eyes. The eyes had been punctured and the fish bled to death and this was evident from the anaemic appearance of the gills. Otherwise, the salmon were in good condition and there was no other possible cause of this condition. The sea lice numbers had declined, although alternative feed in the form of crushed mussels in bags was provided daily when lice numbers were low. The farm took remedial action by removing the wrasse from the worst affected cages and transferring them to a holding cage until the lice numbers increased. This action reduced the eye nipping to negligible levels overwinter with no further losses until March 2011 when one salmon was noted with eye damage.

There were no reports of eye biting on any of the other four salmon farms that were involved in the project. These generally used smaller ballan wrasse (70-150 grams) compared with the larger ballan (200-500 grams). The reason for stocking larger wrasse was to ensure retention in the large mesh size of 25 mm that was used.

## 8. Wrasse mortalities, categorisation of losses, and health issues

### 8.1. Lewis Salmon

The salmon and wrasse mortalities at Lewis Salmon were collected twice weekly by divers. In the 2011-2012 production cycle the total wrasse losses were 436 of 6000 wrasse stocked which was 7.3% of the stock. The casualties were identified as due to bird predation and due to lifting nets resulting in over-inflation of the swimbladder.

### 8.2. Loch Sunart

Mortalities of wrasse were recovered from pens each 3 days and the numbers recorded. Fig. 14 shows the mortalities of wrasse in six pens in the first year of the production cycle on the farm in Loch Sunart. Overall mortality for the period from May to December 2011 was 1121 wrasse of 13040 fish stocked, which was 8.6% of fish stocked. Most of these mortalities occurred during two routine site activities (Fig. 14), the first during a bath sea lice treatment when a total of 463 wrasse were recovered= 3.6% of initial numbers stocked. These fish showed over-inflated swimbladders and the rapid lifting of the nets did not allow adjustment of the swimbladder and there may also have been stress involved with the sea lice treatment. It is not considered that the medicine itself, in this case Alphamax™ a pyrethroid, would have been toxic. The second peak in mortality occurred when the nets were lifted in December to transfer some salmon offsite. In this case the lifting of the nets was again responsible for the over-inflation of the swimbladder and this problem was also demonstrated when wrasse traps were used to recover wrasse for the pens for examination.

In several cases the fish returned to the pens had difficulty in adjusting the swimbladder volume.

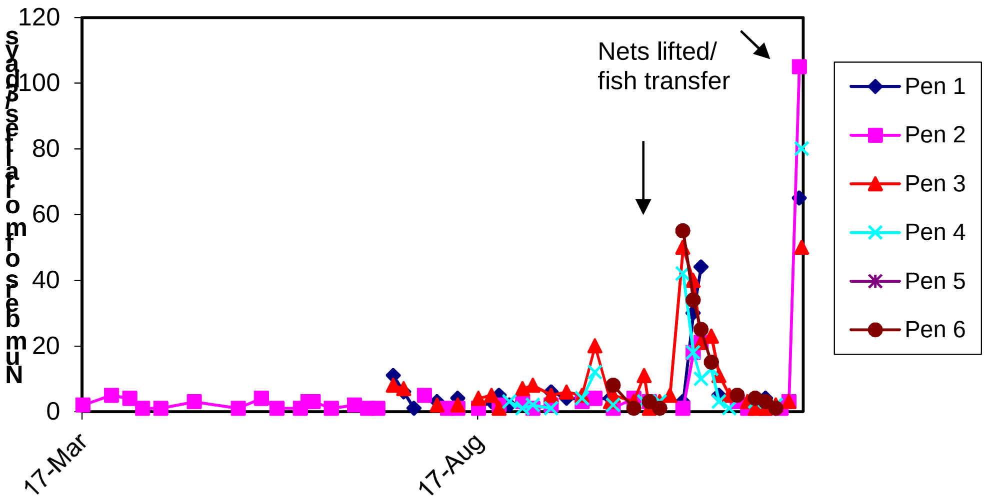



Fig. 14. Mortality of wrasse in the first year of the production cycle.

Less complete data on wrasse survival are available for the second year of the production cycle as most wrasse were transferred offsite with salmon. However, peaks in mortality of wrasse were associated with a further bath treatment and also on several occasions when nets were cleaned by transferring salmon in to clean nets by "swim through" operations. Some wrasse were again subject to overinflated swimbladders by raising the nets too rapidly and there were also some wrasse caught up in the folds of the raised dirty nets following the swim through operations. No fish showing disease signs were recovered on any occasion although there were two incidences of 5 and 7 fish showing peck marks from diving birds (cormorants or shags) and resulting in mortality.

### 8.3. Stockinish

In this trial 650 farmed ballan wrasse were stocked in September 2012 and only 5 mortalities (0.8% of stock) were recovered by divers removing salmon mortalities to the period ending 31st December 2012. These mortalities had the appearance of thin runting fish and there were no signs of disease. These data indicate the good adaptation of farmed ballan wrasse to salmon pens.

### 8.4. Spelve

The salmon mortalities were removed on average once each week and any wrasse mortalities were noted. The only identified cause of wrasse mortality was predation with fish having the head removed when they are disturbed and touched the cage net.

There were no mortalities due to possible bacterial disease. Likewise there was no mortality in the salmon that might be attributed to cross infection from wrasse. In certain pens losses since stocking in June were moderate with only ca. 30% of wrasse still present in March

2011. The wrasse were sufficiently large not to escape through the net mesh. As the wrasse that were retrieved from the cages after the winter looked in good condition predation remains the only identified cause of losses. The visual appearance was good, with a deep belly, and good scale, eye, snout and fin condition.

## 9. Management strategies in the use of wrasse

In 2009 and 2010 SSF stocked over 95% of wild caught wrasse used in Scotland and in 2011 the use of wrasse by that company still represented over 90% of wrasse used by salmon farmers in Scotland. This company together with Lewis Salmon where wrasse have been used on a longer term basis for 6 years have been at the forefront of using wrasse to control sea lice numbers. The strategy used by both companies has been to stock all five wrasse species that are captured by fishermen at a ratio of 1:25 salmon, and to top up numbers of wrasse as numbers decline. The current study had intended to examine the effectiveness of different stocking densities on cleaning activity but this was not possible within the constraints of commercial salmon production. In addition the companies stocked all pens with wrasse in the first production summer to maximise the effectiveness of cleaner fish. Therefore it was not possible to quantify and compare the efficiency in using wrasse in the first and second years of production.

The net mesh diameter of salmon nets varies from 15 mm to 25 mm with larger mesh being used as fish progress in size to reduce the extent of biofouling and to encourage good water exchange. Stocking wrasse dictated that most farmers had to retain the 15 mm mesh size so that wrasse did not escape or, at least, they had to use 18 mm mesh. This problem of using 25 mm mesh nets was circumvented on several farms by using larger ballan wrasse of 200 to 500 grams. While ballan can be uncommon in several localities compared with goldsinny and rock wrasse fishermen have been able to target specific localities and ground for ballan and have been able to provide sufficient numbers of large wrasse, up to 15% of total wrasse catches in specific areas (D. Lamont, pers. comm.).

During the current study it had been intended to compare the use of small ballan in the first year of production with larger ballan in the second year but this was not possible as numbers of ballan were insufficient to permit a controlled trial on any particular farm. However, some of the farms indicated that this could be a strategy in the future and one salmon farm had stocked larger ballan in the second year to see if larger wrasse were more effective cleaners of larger salmon, although another motivation was the larger mesh size that was being used.

While some farms found that wrasse numbers were stable over the first winter of a salmon production cycle other farms chose to top up numbers of wrasse in the second year. Wrasse numbers can be lower following the first winter. A single cause cannot be identified but losses may be due to escapement, predation, and to sea lice treatments and grading operations on the farm. Assessment and top up of wrasse numbers in spring should therefore be considered.

One of the noticeable management tools was to redeploy wrasse to other pens when certain pens were harvested. Also, in practice, there has been a large retrieval and relocation of wrasse using prawn creels and other baited traps from pens where sea lice were low and under control to other pens on the farm where lice numbers were comparatively higher. This is done on a regular basis by farm staff and suggests that wrasse use is being micromanaged at many locations to maximise effect and to ensure higher wrasse stocking numbers where sea lice numbers are higher. This is likely to remain the pattern.

Salmon farms require to consider the place of cleaner fish in the overall mix of integrated treatments for control of sea lice including medicinal treatments.

## 10. Conclusions

There was difficulty in carrying out large scale trials under commercial salmon farming conditions when it was not possible to dictate that control pens should be provided. There were also initial restrictions in obtaining sufficient numbers of wrasse to commence trials. Given these limitations and the restriction by farmers of stocking wrasse in all pens on most farms and using the highest stocking density of all wrasse species of 1:25 salmon it was not possible to designate control pens in all cases. It was therefore necessary to make comparisons with the number of historical medicinal interventions in previous production cycles.

However, the two main considerations of the current project were addressed:

1. The efficacy of cleaning activity of wrasse on sea lice, that is, was the technique effective, and

2. The establishment of welfare indicators for wrasse and the measurement of baseline values. This was taken together with mortality records of wrasse on farms to examine causes of health issues.

The present study demonstrates that the stocking of wrasse on five salmon farms significantly reduced the numbers of mobile lice and/or the number of medicinal treatments required. However, sea lice numbers increased overwinter on one farm and the movement of wrasse between pens was required to deal with lice “hotspots”. However, Scottish Sea Farms claim high efficacy with using wrasse and the technique has been adopted on a large scale basis by that company (Rae, 2011). The benefits of wrasse use have indicated that there is a place for the use of wrasse in an integrated sea lice control strategy, especially as resistance to sea lice medicines may become a problem. The current project has shown that improvements in the use of wrasse can make the technique more effective, such as ensuring nets are raised slowly during sea lice treatments and other farm operations such as grading, and also checking nets after fish are swum through from one net to another during net cleaning operations. The use of hides to reduce stress in wrasse and to increase survival, especially overwinter, has been beneficial and is critical to making the technique work and in ensuring wrasse welfare and survival. The density of wrasse has been mainly at 1:25 salmon and much higher than the numbers used on many farms in the 1990s which were recommended as 1:50 (Darwall et al., 1992) and frequently up to 1:100 (Treasurer, 1996). Survival of wrasse has also been increased by providing supplementary feeding when lice numbers are low. There has been little evidence of routine damage to salmon eyes by picking by ballan wrasse.

Wrasse have been used on salmon farms since 1991 and much of the literature regarding the use of the technique and of field trials emanates from the 1990s. Darwall et al. (1992) summarised trials using wrasse, reporting of stocking densities and commented on effectiveness. They reported that goldsinny, rock cook and cuckoo wrasse had been stocked extensively in Norway, Shetland, Scotland and Ireland and found that in most farms the numbers of sea lice treatments required on pens with wrasse were low compared with pens where no wrasse were present. Interestingly most of the trials in 1991 were on 12 metre square pens, whereas most square pens in current use are now 24 $m^2$ and the volume of the polar cirkles is even larger. Stocking density of wrasse in these early trials was mainly higher than today with the ratio ranging in the main from 1:50 to 1:100 salmon. Further reports on farm use of wrasse were made by Darwall et al. (1992), Deady et al. (1995), Kvenseth (1996), and Treasurer (1996). These more detailed and controlled trials showed that sea lice numbers on salmon in pens with wrasse were significantly less than in pens with no wrasse and the frequency of medicinal treatments was lower. None of these earlier trials used ballan wrasse. There have been few reports of current use of wrasse in recent years and much of the information available remains anecdotal. However, most of the recent work has highlighted the advantages of using ballan wrasse. Sveier (2011) reported that wrasse, and increasingly ballan wrasse, were being stocked on farms in Norway with noticeable effects in reducing lice numbers and the use of wrasse was being applied on a large scale. Rea (2011) reported that in one Scottish sea loch the use of wrasse delayed the onset of medicinal treatments by 6 months and lice numbers were significantly lower where wrasse were stocked with two fewer medicinal treatments compared with an adjacent pen group. Groner et al. (2012) devised an epidemiological model for the assessment of the use of wrasse on salmon pens in Norway and Canada but this has still to be validated using farm data.

During the project support and advice was given to farmers on the deployment of wrasse and use on salmon farms. Farms frequently had one nominated member of staff who was responsible for wrasse use and welfare and this appears helpful in ensuring the technique is effective and that the use of wrasse is being measured and assessed. Staff training in the application and care of wrasse is also helpful as some support is required in the use of wrasse.

Fish welfare and the assessment of measurement indices have been an important development in ensuring fish health is maintained in aquaculture generally (Huntingford et al., 2006). Several indices have been developed and many of these rely on the use of scores of fin erosion and splitting (Bosakowski and Wagner, 1994). In the current study a modified welfare scale based on Hoyle et al. (2007) was used and was found to be a representative welfare index in wrasse. The erosion and splitting of the fins was the most common welfare indicator and these indices can be used in an ongoing way to assess the condition of wrasse in salmon pens. Rock cook and corkwing appear more prone to damage compared with the other wrasse species. Ballan appears to be the most robust wrasse species in pens overwinter. The welfare of wrasse should be assessed routinely to ensure that the fish are being maintained to the standards of any farmed fish. The welfare indices used in the present study have been shown to be useful and robust in assessing the welfare of wrasse in salmon pens and baseline indices have been established here.

Wrasse losses on one farm were attributed to raising the salmon net too quickly or to wrasse being caught up in the folds of nets during net cleaning. These are surmountable issues and require continued training of staff. Therefore action can be undertaken to ensure maximum survival of wrasse in the salmon pens. There was no evidence of mortalities of wrasse due to bacterial or viral health issues on any of the farms within the project. Reports from other studies of losses of wrasse have indicated that some wrasse have been lost overwinter (Darwall et al., 1992) and in some cases the net mesh size was too large (Deady, et al., 1995) and wrasse escaped. By using wrasse hides and maintaining high standards of welfare wrasse can be an important part of an integrated strategy for the control of sea lice.

There may be biosecurity issues in using large numbers of wild caught wrasse and also concerns about the effect of fishing on wild fish stocks (Varian et al., 1996).

## 11. Further developments in wrasse use

The industry is currently sponsoring research into the rearing of farmed juvenile ballan wrasse for stocking in salmon pens. The availability of hatchery reared wrasse remains the priority for the immediate future so that the industry can gain access to the quantities of cleaner fish required.

There are several conclusions from the current investigative report and this may form the basis of deeper and more focussed work involving wrasse. Although the present study indicates the benefit to salmon farmers in stocking wrasse there are openings for study of both captured and farmed wrasse interactions with salmon. The small trial with farmed wrasse shows that there are no concerns about their ability to seek out and eat lice and, given the limitations in the availability of wild wrasse stocks, this gives further encouragement to the current development of breeding of wrasse. Further development is required of the use of wrasse hides and their effective use as a refuge from predators and to provide rest areas.

Other areas for examination are:
-Development of effective techniques for the recovery of wrasse that may be required as a result of confirmation of a listed disease.
-The sponsoring of projects on the rearing of wrasse and other species such as lumpsuckers to ensure that there is less reliance on the capture of wild wrasse.
-The development of appropriate screening techniques for disease and stress tests.
-The development of a best practice code for the use of cleaner fish with the RSPCA, the Code of Good Practice and the Industry.

There are concerns about the impact of Amoebic Gill Disease on salmon farms and there should be further examination of the impact of AGD on cleaner fish.

The Appendix to this report gives recommendations for welfare standards for capture, transport and stocking of wrasse in salmon pens. This could be the subject of further consultation with the industry with a view to refinement of the procedures and formalisation as part of good practice. This is being reviewed by the RSPCA in the Freedom Foods Standard.

There should be further consideration of the use or disposal of wrasse at the end of the salmon production cycle and the fallowing of the salmon farms.

**Acknowledgements**

We are grateful to farm, company and health managers for assistance and discussion during the project. In particular we thank Geoff Kidd, Lewis MacLeod, Scott Cameron, Steven Morrison, John Rea and Dale Hill for information and their support. Helpful logistical support was made to the project by Lewis Salmon (now taken over by Marine Harvest), Scottish Sea Farms, the Scottish Salmon Company and Marine Harvest. The project was discussed and progress reported at several meetings of the SSPO technical group looking at the rearing and use of wrasse on salmon farms, and comments from the group and SSPO staff are appreciated.

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## Appendix 1. Recommendations for welfare standards for capture, transport and stocking of wrasse in salmon pens.

Wrasse should be treated as any farmed fish with care and attention to the biological requirements and welfare of the fish, for example similar to the standards applied by the RSPCA to Atlantic salmon (2010).

### 1. Capture of wild wrasse

Wrasse fishermen should have suitable storage tanks for wrasse on the vessel and equipment for the handling and transfer of wrasse. Specialised wrasse fishermen should maintain quality control standards defined by the purchasing company.

A licence to capture wrasse for sale is required by commercial fishermen and this should be obtained from Marine Scotland.

By-catch in traps should be kept to a minimum. The use of specialist traps for wrasse to minimise trauma and damage caused by crabs, eels and other by-catch should be encouraged.

The traps should be fitted with otter guards where necessary to prevent the capture of otters, especially in shallow water. The traps if set in deep water should be lifted gradually.

Wrasse that are not of the minimum length, normally over 100 mm, should be returned in good condition to the sea.

The holding water on the boat should be kept cool and exchanged as necessary to maintain water quality and to ensure that the temperature fluctuation from ambient does not exceed 2 degrees.

If large numbers of wrasse are being held supplementary oxygen should be provided.

Diseased and damaged fish should be humanely dispatched and numbers recorded.

The fish held on the boat should be kept in the shade and protected from strong sunlight.

A soft fine fish net should be used for handling fish.

Wrasse should not be removed from the water for longer than 30 seconds.

## 2. Transport of wrasse

Wrasse should be transferred to the receiving farm within 3 days of capture.

If wrasse are held for more than 2 days after capture supplementary feed should be offered to the fish.

Wrasse should be fasted for 24 hours prior to transfer to farms using a transport tank.

The maximum stocking density for wrasse during transfer is recommended as 30 kg $m^{-3}$.

Water quality should be monitored during the journey by recording temperature and oxygen.

The fish welfare should be assessed during the journey.

Records should be kept of the transport details including times of loading and discharge, vehicle details, operator, and site.

Transport tanks should be cleaned and disinfected before and after transport.

## 3. Handling and stocking of wrasse in pens

Avoid stocking wrasse in sites with low salinity, for example under 25 ppt.

The minimum length of wrasse on stocking should be checked.

Refuges for wrasse should be provided within the salmon pen.

Wrasse should be collected from the dirty net during net cleaning operations involving swim throughs to the new clean net. This can be done by using traps to retrieve wrasse from pens. Nets should be raised gradually and slowly to avoid wrasse being subject to over-inflation of the swimbladder.

Nets should be kept as clean as possible as wrasse may browse on fouling organisms colonising the nets.

During any site operations such as grading salmon care should be taken to transfer wrasse to the new pen.

During sea lice treatments the pen nets should be lifted gradually to prevent over-inflation of swimbladders. Wrasse may be removed prior to treatment using baited creels.

The disposal of wrasse at the end of the production cycle should be considered and biosecure disposal of mortalities should be carried out.

Scottish Aquaculture Research Forum