PROJECT REPORT: The Effects of Fin Damage on the Condition of Juvenile Lumpfish (*Cyclopterus lumpus*) in Hatcheries and Sea Cages.

Connie Pattillo

Institute of Aquaculture, University of Stirling, Stirling, Scotland, FK9 4LA

Lumpfish are an unusual looking fish with a concealed dorsal fin within a gelatinous dorsal hump. The pelvic fins have transformed a sucker-like appendage to adhere to surfaces and instead of scales is covered in tough leathery skin. Lumpfish is now becoming well known within the aquaculture industry. It is a relatively new species to be used as cleaner fish in the marine salmon farming industry. The lumpfish aid in the removal of sea lice promoting healthy salmon stocks. Ensuring high quality lumpfish are produced in hatcheries will ensure efficient removal of sea lice when lumpfish are deployed into sea cages. Not only will the information gathered improve the health and welfare of lumpfish it will improve our understanding of this morphologically unusual looking marine fish.

This study was initiated and presented by a BSc student during her Honours project but unfortunately the amount of data derived from this work was not enough for publication. The request for a small grant funding was to continue data collection and analysis of lumpfish dissertation project initiated under the undergrad marine biology project. The money was used to fund an internship for the undergrad student that already started the project as her BSc honours project as we need more data and analysis for a scientific publication.

Objectives:

1) Further analysis data on the growth rate of lumpfish
2) Identify a measure of fish condition to use in hatcheries and sea cages
3) Correlating fin condition to body size/condition
4) Study mortality rates in the early stages of juvenile lumpfish

Experimental Approach:

Hatchery Sampling methods -The data used for length-weight relationship were obtained from Lumpfish (*Cyclopterus lumpus*) stock originating from Stofnfiskur hatchery in Iceland. The experimental stock where transported from Iceland by sea 10 weeks' post hatch (1 gram) to Gairloch in the north-west highlands of Scotland and then by road to FAI Aultbea. After settling time, the lumpfish stock was transported to the FAI Aquaculture Research and Development facility in Ardtoe (West coast of Scotland). Lumpfish stock ($n \geq 7000$) were split between two larval recirculating rearing tanks. Average temperature total sampling period 10.85°C, min: 1.8°C, max: 14.2°C. After eight weeks, the lumpfish were vaccinated with the antibiotic Amarine Micro at a dose rate of 0.5mL; needle size 5mL and then graded into 6 tanks.

The lumpfish populations were sampled for morphometrics every two weeks a total of four times. The first two sampling occasions 20 individuals from each tank were caught using a small net. This was reduced to 10 for the third and fourth sampling. Lumpfish were collected at random and from varying locations within the tanks, using a small net. All sampled fish were sacrificed for the project. Once measurements were recorded half of the sample from each tank were placed into formalin and the other half RNA later for tissue bank and posterior gene expression studies.

Using a digital scale, weight was measured and recorded in grams of each lumpfish. A tripod was set up with a camera to take ventral, lateral and dorsal photos against a 5cm ruler (appendix 1). Using the Operational Welfare Index for Fin Damage in Lumpfish (Astier, Rey and McAdam, 2015) (four-point

scale: 0/zero = no visible damage (control), 1 = marginal biting or fin splitting, 2 = major distal fin ray loss, 3 = complete removal of fin and tissue) fin damage from the dorsal, caudal and anal fin were recorded (fig. 1).

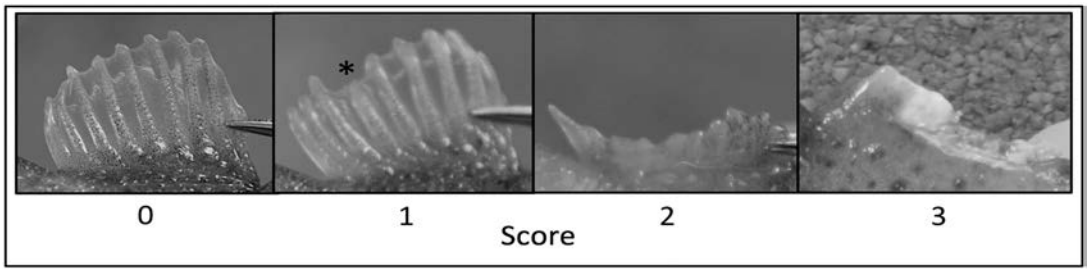


Figure 1: Operational welfare indicator of fin damage in C. lumpus. The score has four numeric categories from 0-3; 0 = no visible damage (control), 1 = marginal biting or fin splitting, 2 = major distal fin ray loss, 3 = complete removal of fin and tissue damage (Astier, Rey and McAdam, 2015).

Additional morphometric and weight data that was collected by a Master's student from a lumpfish study in the Faroe Island for the University of Stirling. This was used to increase sample numbers in fin damage analysis. The data was collected using the same methods as used in the hatchery conditions. Using this data allowed for a wider analysis of fin damage in lumpfish in two different environments. The master student gave permission for this data to be used in the fin damage project.

Statistical analysis – Weight and fin damage from hatchery and Faroe Island data was combined into a .csv file. Using the aggregate function of R Studio (version 1.0.44) (R version 3.3.2 (2016)) the mean and standard deviation for each tank/cage and sampling occurrence was calculated. Statistical analysis of the data was done to determine the specific data needed to build a potential model to predict the severity of damage using weight as a unit of measure. The aggregate function was used to produce the following data sets: average weight per tank/cage, SD of weight per tank/cage, number of fish per tank/cage; Number of fish with severe damage (TRUE = score of 3; FALSE = 0,1,2), SD of weight as a fraction of average weight and the fraction with severe damage.

Results and Conclusion:

Accurate and timely assessment of fish health and welfare is central to good aquaculture husbandry and to maximise revenue from commercial fishing activities (Blackwell, Brown and Willis, 2000). The aim of this study was to develop a model that would aid in determining the potential severity of fin damage using lumpfish weight as a reference in both tank and cage environments. To use this to assess and improve the health and welfare of lumpfish. The study builds upon previous studies by Astier, Rey and McAdam (2015) on gross fin damage in lumpfish to understand the connection between body morphology and fin damage.

Fin erosion is a fish welfare issue as it the injury to tissue that contains nerves and blood vessels that can lead to poor condition and death (Ellis et al., 2009). By reducing the rate of fin damage, the overall condition of lumpfish will be improved. Application of the operational welfare indicator of fin damage (Astier, Rey and McAdam, 2015) to weight data was important in identifying the impact fin damage has on lumpfish. Results indicated that there was a significant relationship between fin damage and weight specifically in tank conditions with marginal relationships seen in cage environments. This was due to limited sample numbers. It can be suggested from the results that the smaller fish in a tank population will have higher fin damage scores. With larger individuals having low scores, most having no indication of damage at all. A few of the larger sampled individuals often showed signs of scar tissue indicating healing of previous injury. Knowing that fins can be repaired is important as it can allow for improvement of condition if the grading process is delayed.

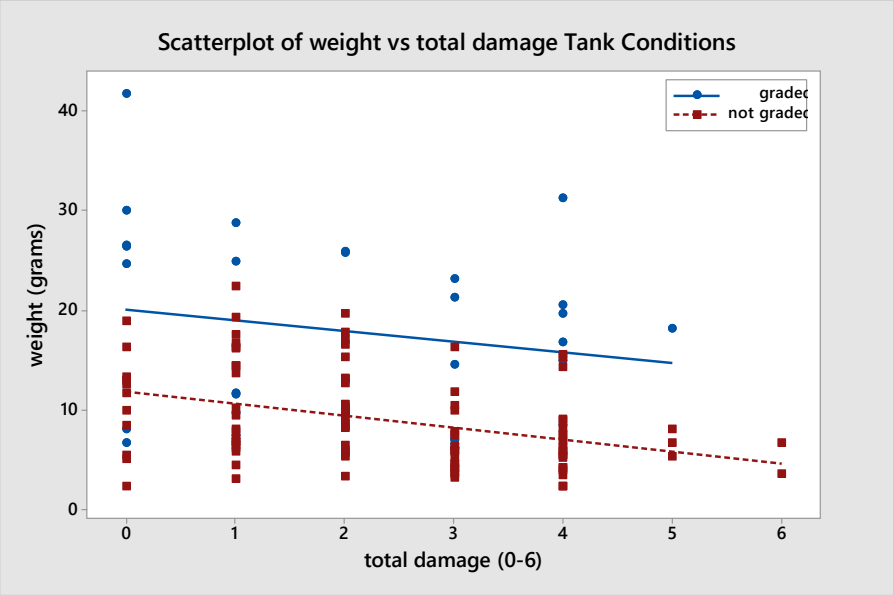


Figure 2: The relationship between weight of lumpfish in relationship to their total fin damage and with or without grading. Created using Minitab 17 Statistical Software (2010).

(Fig 2) Statistical analysis of variance (regression) indicates a significant relationship between weight and the severity of fin damage (p=0.00, R^2 = 30.05%, $F_{1,129}$= 32.78). Regression Equation; (Graded) Weight = 20.25 – 1.169 total damage, (Not Graded) weight = 11.753 – 1.169 total damage. There is clear evidence of higher fin damage scores being recorded more frequently before grading. With the smaller sized individuals receiving the highest scores. Grading is an important tool in preventing fin damage in tank conditions.

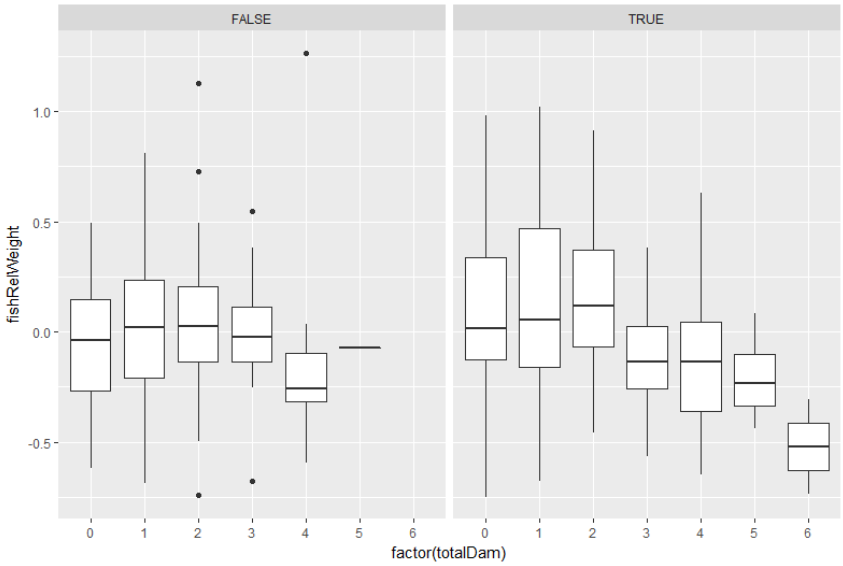


Figure 3: Boxplot illustrating how the size of a lumpfish in relation to the mean weight average (%) in either a tank (true) or cage (false) can influence the severity of fin damage it receives. Created using GGplot in R version 3.3.2 (2016) using R studio (version 1.0.44).

(Fig. 3) One-way ANOVA analysis: p=0.002, R^2= 15.64, $F_{6,129}$ = 3.80. There is greater evidence that in tank conditions those individuals that fall 50% or more below the average weight (%) will score the highest fin damage score of 6. For the cage analysis (One-way ANOVA: p=0.889, R^2= 1.84%, $F_{5,95}$ = 0.34), there is weak evidence that fin damage increases with decreasing weight. While there is a decline there is not enough data to statistically support the same findings in the tank conditions.

Results from the project indicate that it is possible to develop a fin damage predictor model for lumpfish when in tank conditions in a hatchery. It is not possible to apply the same model to lumpfish deployed in sea cages. Results indicate that the rate of damage is population specific, the relative weight of an individual as a percentage of the population indicated significant results. These findings suggest that grading of lumpfish in tank conditions prevents fin damage and will promote good lumpfish body condition. However, the model is still in the early development stage and more time is needed to finalise the specific model.

NB: It was not possible to further study the mortality rates in lumpfish as this data was not collected during the Faroe Island studies resulting in not enough data to make statistically viable results.

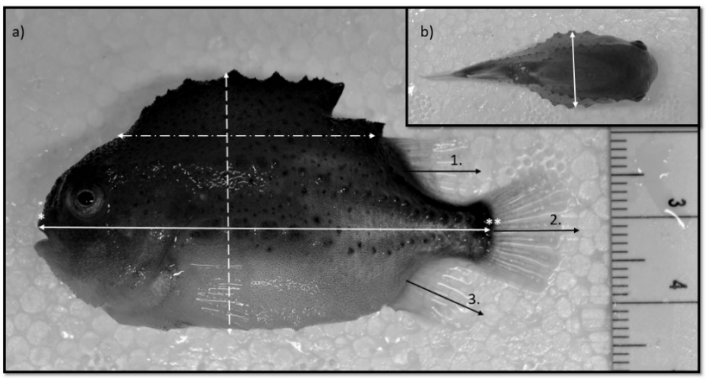
Further work: It would be beneficial to collect more data from lumpfish deployed in sea cages. Not enough data was collected during sampling to confidently apply the fin damage model to deployed lumpfish. The results indicated that there might be potential for the fin damage model to be applicable however more data to run analysis on would confirm if this is possible.

Financial Breakdown:

MASTS funding (£2275) was used to provide a salary during the Internship period. This aided in accommodation and living costs for the student during the study period.

Item	Cost	Date
Internship Salary	£2275	28th July 2017

Appendix:



Appendix 1: Photo of sampled specimen; (a) lateral view: (*) snout, (**) hypural plate; (white solid double arrow) standard length, (white dashed double arrow) depth, Dorsal hump length (white solid and dashed double arrow); (b) dorsal view: (white double arrow) width. (a) position and direction of fin sample for histology (1) dorsal fin, (2) caudal fin, (3) anal fin. All measurements in cm.

References:

Astier, A, Rey S. and McAdam, B. (2015). *Multivariate dorsal fin damage assessment in Lumpfish Cyclopterus lumpus (Linnaeus, 1758) as an operational welfare indicator (OWI)*. Masters. Stirling Univeristy.

Blackwell, B., Brown, M. and Willis, D. (2000). Relative Weight (Wr) Status and Current Use in Fisheries Assessment and Management. *Reviews in Fisheries Science*, 8(1), pp.1-44.

Ellis, T., Hoyle, I., Oidtmann, B., Turnbull, J., Jacklin, T. and Knowles, T. (2009). Further development of the "Fin Index" method for quantifying fin erosion in rainbow trout. *Aquaculture*, 289(3-4), pp.283-288.

Minitab 17 Statistical Software (2010). [Computer software]. State College, PA: Minitab, Inc. (www.minitab.com)

R, C. (2013). *R: A language and environment for statistical computing*. Vienna, Austria.: R Foundation for Statistical Computing.