Research Compilation: Sex-Sorting of Atlantic Salmon

Document Nr: TN-0006-1

REV	DATE	REASON FOR ISSUE	PREPARED BY	CHECKED BY	APPROVED BY
1	8.7.2021	First version	TW	EA	EA

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1 Introduction

1.1 Purpose

In the industry of aquaculture, a variety of players are convinced that there are great advantages to sex-sorting farmed salmon. However, quantifying these advantages is challenging.

This document summarizes available research, which substantiate and quantify some of the advantages of sex-sorting fish.

1.2 References

1.2.1 Research

Appendix A

Lien, A: *Using Branch and Price to Optimize the Production of Salmon Under the Risk of Gender Maturation*. Master's thesis in Industrial Economy and Technological Management, NTNU. Supervisor: Peter Schütz. June 2022.

Appendix B

Aasen, R.M.: *Tactical Production Planing for Atlantic Salmon Farming Under Uncertainty of Salmon Lice*. Master's thesis in Industrial Economics and Technology Management, NTNU. Supervisor: Peter Schütz. June 2021.

Appendix C

Næss, M.; Patricksson, F.S.: *Production Planning for Atlantic Salmon under Uncertainty with Impact of Extensive Site Management*. Master's thesis in Industrial Economics and Technology Management, NTNU. Supervisor: Peter Schütz. June 2019.

1.2.2 Publicity

Appendix D

Article on ilaks.no: *FoU-konsesjoner for redusert produksjonstid ved bruk av avlsteknologier innvilget.* Downloaded 30.6.2021 from https://ilaks.no/fou-konsesjoner-for-redusert-produksjonstid-ved-bruk-av-avlsteknologier-innvilget/ (in Norwegian)

Appendix E

Article on kyst.no: *Doktorgrad på ultralydsortering av kjønn og kjønnsmodning hos laks*. Downloaded 27.05.2024 from https://www.kyst.no/aquagen-doktorgrad-forskning/doktorgrad-pa-ultralydsortering-av-kjonn-og-kjonnsmodning-hos-laks/185064 (in Norwegian)

2 Summary

Male fish grow faster than female fish, reaching their harvest weight at an earlier point in their life cycle. Keeping male and female fish in the same cage makes it difficult to exploit this distinction in growth rate between the sexes.

Eidfjord Sjøfarm, in collaboration with Sisomar, NTNU and AquaGen, has researched the effects of sex-sorting, selecting for early sexual maturation, and epigenetics. The research has been conducted on a commercial scale at locations in Norway, specifically in the districts of Nordland and Nord-Troms, since 2018.

In November 2018, 600.000 fish, with an average weight of 60 grams, were sex-separated using ultrasound at Sisomar. Moving forward, males and females were kept separate.

In May 2019, the fish were put in separate, mono-gendered cages.

2.1 Increase in yield

In June 2021, a master's thesis summarized the research project, calculating the maximum possible increase in yield an aquaculture facility may achieve using sex-sorted fish. The paper concluded that using different kinds of smolt can increase total income and harvest weight for fish farmers by up to 10 %. The majority of the increase comes from sex-sorted smolt.

The figure below shows the development in weight for mixed fish, compared to fish in mono-gendered cages. The figure is based on data from AquaGen's research:

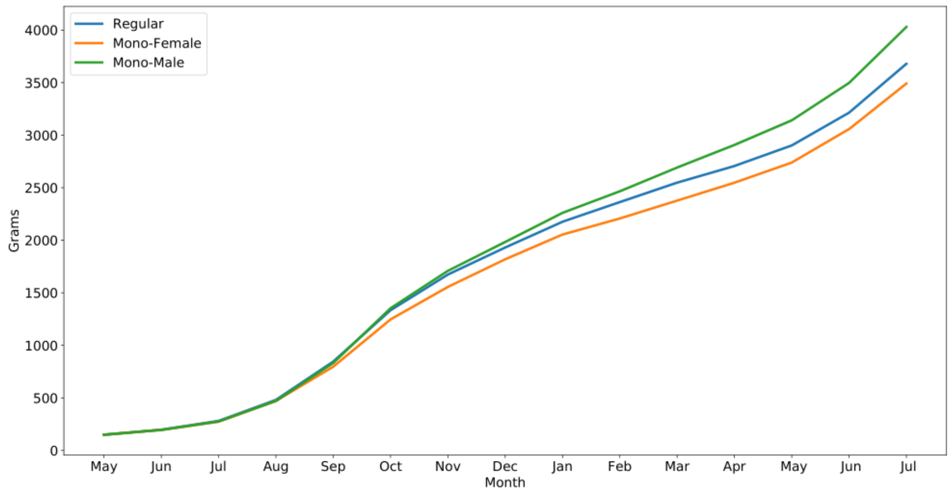

Figure 2.3: Weight development of a 150 gram smolt for both the mono-gender and regular smolt types based on growth rates obtained from sea trials.

2.1.1 Growth rate

The figure below shows the growth rate of different smolt types, based on experiments conducted by AquaGen. The growth rate is shown as Thermal Growth Coefficient (TGC), which accounts for the average temperature of the water throughout the growth period.

The figure also shows that males grow faster, and females grow marginally slower than regular stock. However, the figure also shows that females in sex-separated cages occasionally grows a little faster than normal mixed fish after being released into the sea (month 6, 11, 12, 13 and from 15 and onwards).

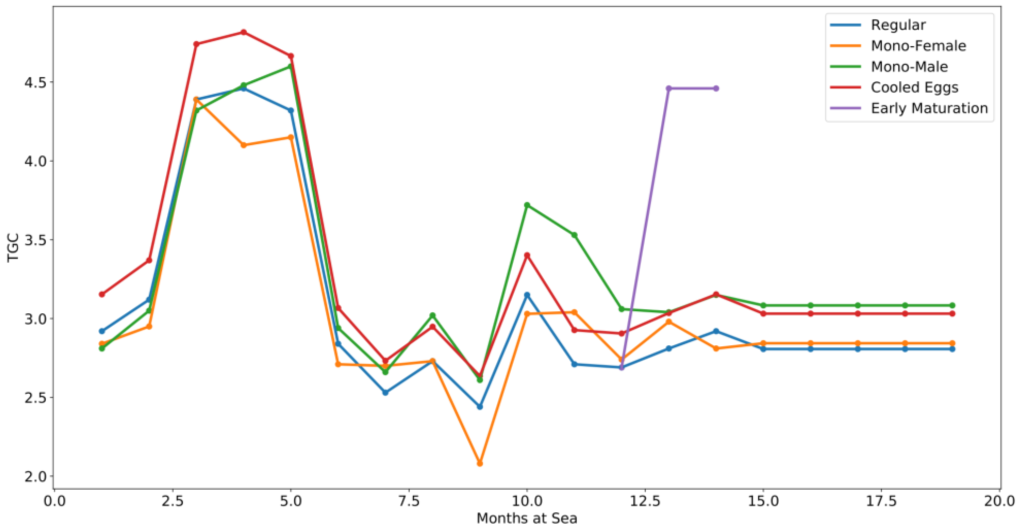

Figure 8.2: TGC of the different smolt types as a function of time spent at sea.

2.1.2 Mortality rate

The figure below shows the mortality rate in fish, based on sea trials, conducted by AquaGen.

The mortality is shown as the proportion of fish that die per month (0,2-0,8 % of stock per month). From the 11th month and onwards, mortality in sex-separated cages is lower for both male and female fish.

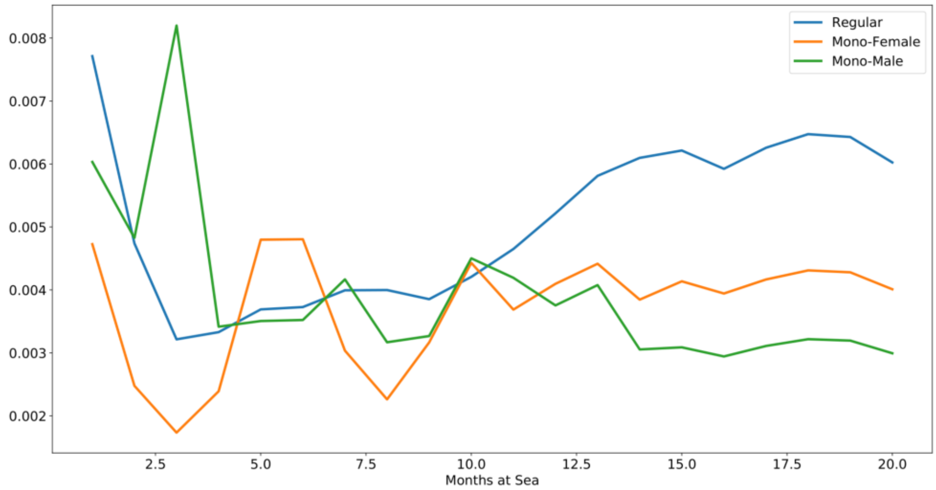

Figure 8.3: Scaled mortality rates for the regular, mono-female, and mono-male smolt type. We assume that the cooled eggs and early maturation smolt types exhibit the same mortality rates as the regular smolt type.

2.1.3 Harvested volumes

The master's thesis indicates that harvested volumes (in tonnes) increase by an average of 8,8 % (from 82,469 to 89,765 tonnes) when using sex-sorted smolt.

The harvested volume only increases an additional 0,5 % when using smolt from chilled eggs and smolt selected for early sexual maturation. Calculations are done in several different ways, with approximately the same result.

Increased earnings are primarily achieved by reducing the time fish spend in the sea, to not exceed the maximum permitted biomass (MTB), in accordance with licenses.

2.2 21 % increase in production

The results from another master's thesis, from 2019, shows a 21 % increase in production when using sex-sorted male smolt, as compared to only using traditional mixed smolt.

The thesis analyses measurements from a 2017 AquaGen experiment. Based on these measurements, the researchers calculated the difference in average weight per fish, applying the study to fish released with a weight of 150 grams.

The figure shows up to 34 % increased weight per fish, for cages with only male fish, compared to mixed cages. This means that male fish in mono-gendered cages reaches an average weight of 4,5 kg approximately 3,5 months faster than fish in mixed-gender cages.

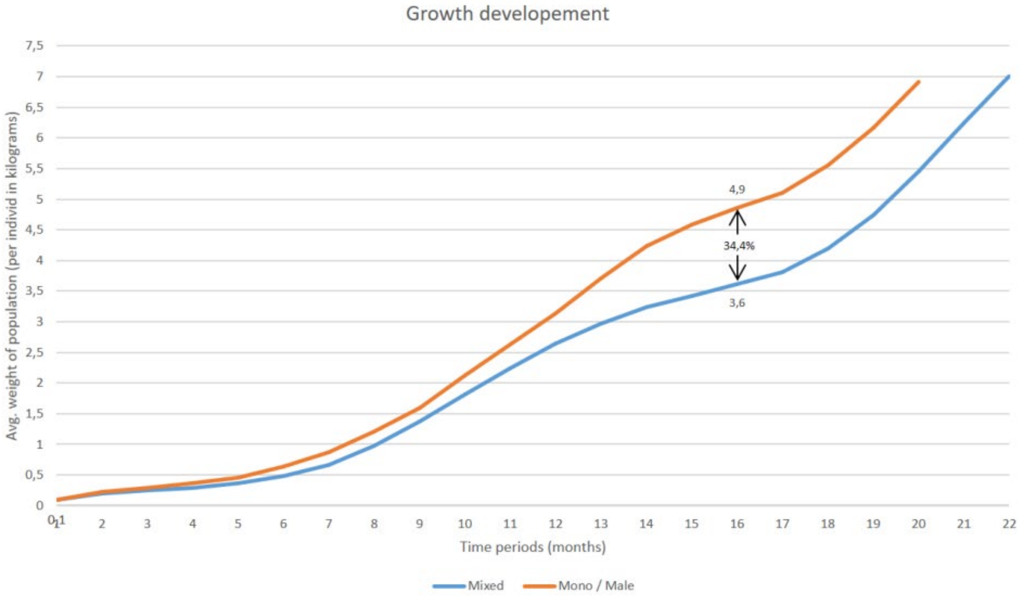

Figure 6.4: Simulated development in growth for two separate population, with start in January

2.3 Summary

In summary, the research indicates that:

- Fish farmers can increase their earnings by 9-21 % by utilizing sex-sorted smolt.
- Both sexes of fish grow faster when they are sex-sorted.
- Mortality decreases when fish are sex-sorted, increasing both profits and fish welfare.