Fleet size and mix in the Norwegian aquaculture sector

A fleet renewal problem with an uncertain future

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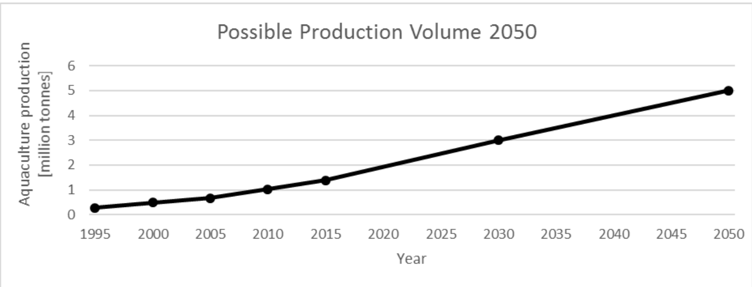
Introduction

During the period from 1997 to 2012 the Norwegian aquaculture sector increased their sales of salmon from less than 400 000 tons to over 1 200 000 tons. Even though the aquaculture has experienced a tremendous growth over the last 15 years, the sector still aims to grow at a high rate towards 2050.

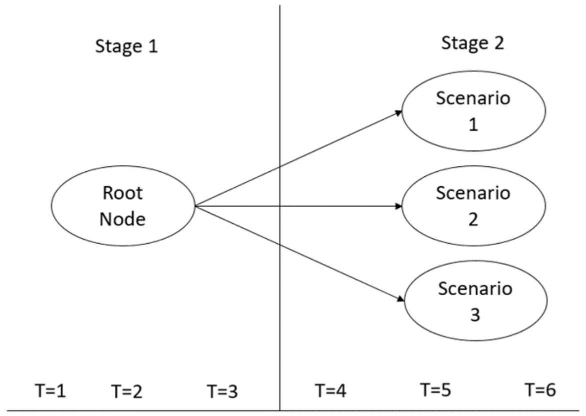


Since service and transport tasks in the aquaculture sector is done by well-boats and service vessels, an increase in production volumes are likely to lead to an increase in demand for vessels.

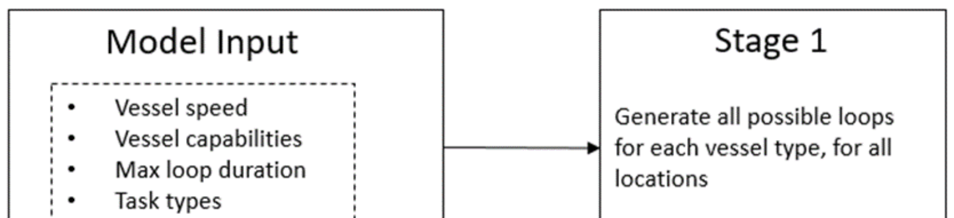
The Norwegian government is trying to stimulate the development of new technological solutions for fish farming by making it possible to apply for development licenses. With different new concepts comes a range of possibilities for the nature of the future growth of the sector. Some new concepts are made to move the aquaculture sector out into more exposed waters. While other concepts are made to enable denser production units in sheltered waters. Any of these concepts can enable a massive increase in production volumes, but the demand for service operations can vary significantly from one concept to the other.

Modelling

To solve the fleet size and mix problem, a two stage stochastic programming model was created. In the first stage the demand for each task is assumed to be known. While for the second stage scenarios with different demands are created to illustrate the uncertain future of the sector.



The modelling is done in two steps. Step 1 is the generation of all possible trips a vessel can perform before returning to shore. Step 2 is to chose the optimal combination of loops to be serviced.



Objectives

The aim of this report is to propose a general formulation of an optimal fleet size and mix model which can be used for service vessels in the Norwegian aquaculture sector with an uncertain future. Furthermore, the model should be implemented and used to solve a generic problem.

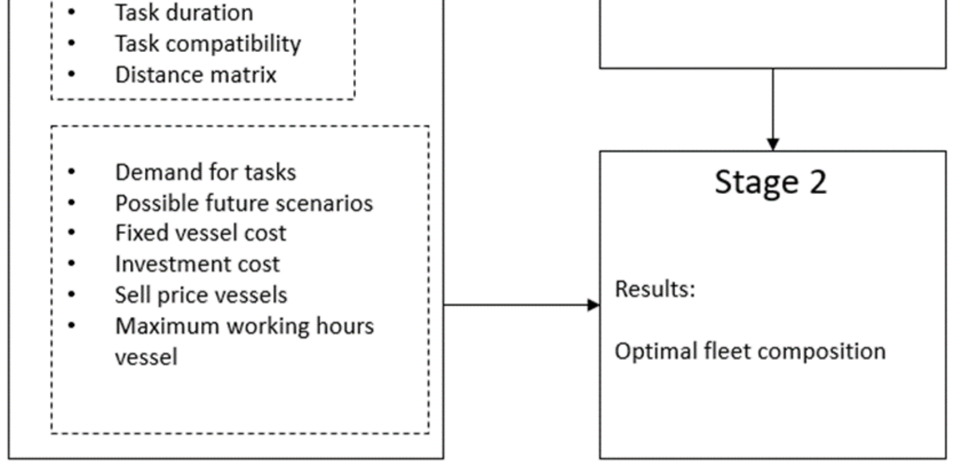
In order to reach this aim several objectives should be completed:

- Describe the problem which the model shall describe
- Review other optimization models to understand how other\similar problems have been solved
- Present a general model formulation for the problem
- Define which input data the model requires to solve the problem,
- Implement the model using Matlab and Xpress

Problem description

Simply put, the problem is to decide how many vessels of which kind one needs to serve the aquaculture sector, with uncertainty regarding the future demand. Seven different vessel types have been included, and the demand has been divided into 13 different tasks. The tasks range from transporting smolt and mature salmon, to washing nets and treating lice at the farming location.

The different vessel types are able to solve different sets of tasks at different rates. All the vessel types have a certain number of operating hours available in each time period. There may be both seasonal and geographical variations in the demand for each task.



Step 1 is done using Matlab to perform a tree-search to construct all possible trips. The second step is done by implementing the optimization model in Xpress. Once the first step is completed several different analyses with different demands and scenarios can be done in Xpress without having to go back to step 1. For the test instances the solver spends between 5 and 10 minutes to find the optimal solution.

Conclusions and Further Work

The model presented can be seen as a good basis for a decision support tool in the aquaculture sector. Since the thesis is still in progress, more detailed conclusions regarding model performance are still to be addressed.

There is a lot to be done in regards to collecting better input data both regarding tasks and demands. This might also lead to changes in the model restrictions. Furthermore, more exact cost estimates should be found.