Logistics of service vessels used in a more exposed Norwegian aquaculture industry

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Introduction

This master thesis treats the problem of increasing the efficiency of service vessels used in the Norwegian aquaculture industry. It is based on operational research and utilizes both mathematical optimization models and simulation tools to analyze different fleet compositions and evaluate their robustness against bad weather.

Problem

The increased impact on the Norwegian coastline from the aquaculture industry has caused fish-farmers to move their facilities further offshore to obtain better growth conditions for their salmon and reduce the negative influence on existing wildlife [1]. This has led to rougher sea conditions and an increased demand for bigger vessels to service the production facilities. Bigger vessels lead to higher operational costs which has increased the need for efficient routing of the vessels.

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Method

A hypothetical scenario for demand of maintenance is created. The scenario consists of a set of jobs with specific time windows to be performed during a time horizon of four weeks. Potential ways to cover the given demand is evaluated. The thesis uses a path flow optimization model based on pre-generated routes [2] in order to find optimal solutions regarding fleet composition and which routes to travel to minimize cost. The solutions found using our optimization model is then tested in a simulation model to evaluate the robustness of the solutions towards bad weather and time windows for the given maintenance jobs.

Operability

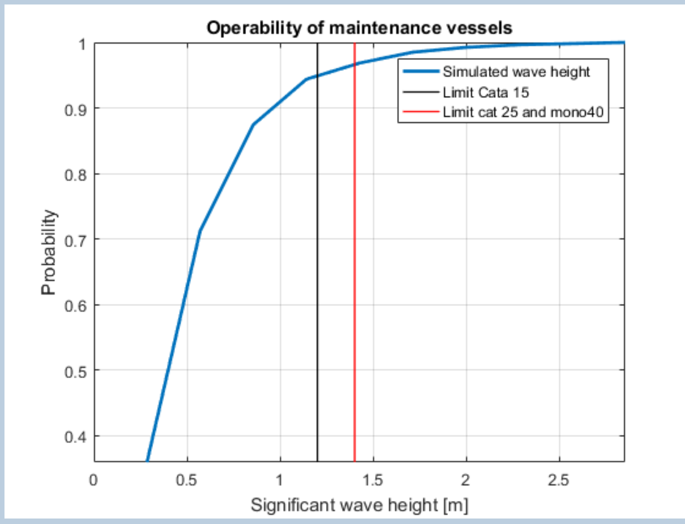

Figure 1: Operability of service vessels when the need for maintenance is at its highest, week 26 to 41, weather data from 2016.

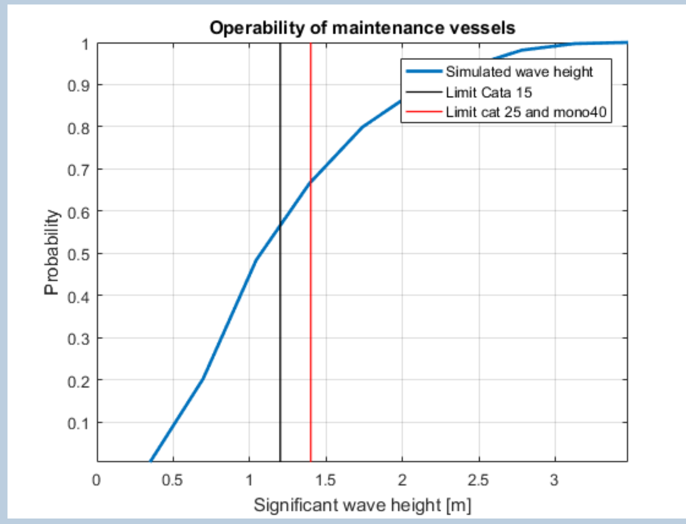

Figure 2: Operability of service vessels during winter season, weather data from 2016.

Four service vessel types are used during optimization and simulation. Figure 1 and 2 show operability during high season and winter season, respectively. The figures show that the operability during winter season have decreased from 95 % operability during high season to approximately 65 and 55 % during winter season. The weather simulated during winter season may be an indicator to what the weather may be like at more exposed locations and that better planning will be important to perform maintenance in the future.

Results

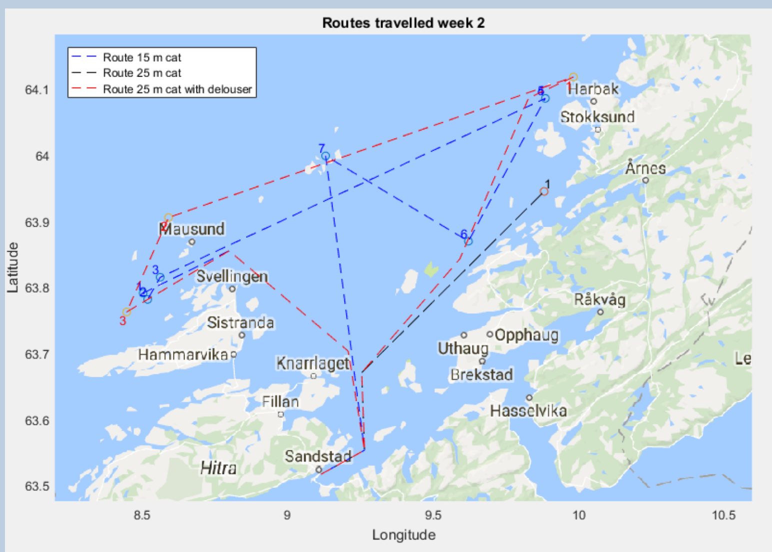

Figure 3: Example of solution from optimization model displaying optimal routes for a given weekly demand.

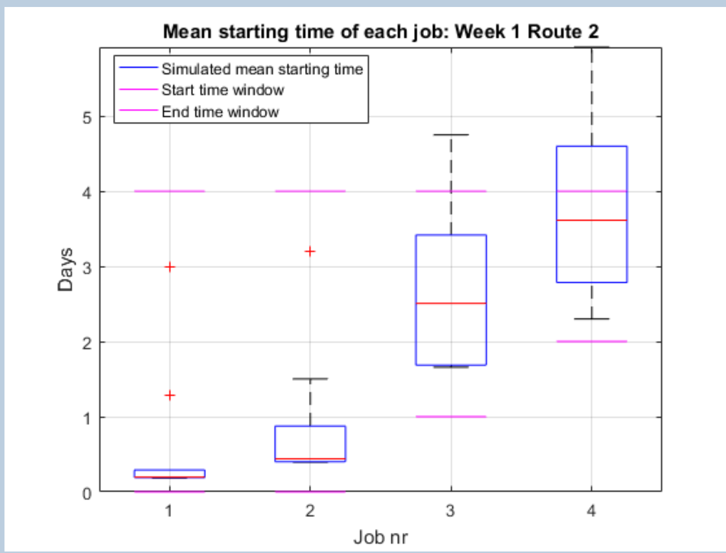

Figure 4: Simulated mean starting times of jobs versus given time windows.

A proposed solution to the routing problem generated by our optimization model can be seen in figure 3. The solution is designed to cover the demand during a given week while minimizing costs. The model finds the optimal routes and which vessel types to use for the specific routes which is dependant on what kind of operations that are required at the different locations. After an optimal solution is found we test the solution in our simulation model. The results from the simulation can be seen in figure 4. The main criteria for testing the robustness of the solution is the duration of the route and when the vessel arrives at the different locations. The time is recorded at each location and compared with the results from the optimization model and in such a way we can identify where possible delays happen.

The simulated weather used in this simulation is based on a winter scenario. For this exact route and week, one can see that the starting time of job 4 will usually be within the time window. However, one can see that there are several occurrences where starting within the given time window is not possible due to rough weather. Adding slack to the time windows for some jobs may be an option to see if the optimized solution may be realistic at more exposed locations.

Conclusion

This thesis should provide a contribution on how optimization models can be used in order to perform fleet scheduling in a more efficient way. Many of the results from our simulation model are not yet complete, but the results so far indicate that vessels with better operability with respect to rougher sea conditions will be necessary in order to meet the increasing demand for maintenance. Our results from simulations with bad weather indicate that small vessels will not be able to perform the requested operations within the given time windows and delays will most likely occur. Robust planning will help avoid such delays which can be very costly for the fish-farmers.

References

[1] Exposed aquaculture 2016. *About Exposed.* From `http://exposedaquaculture.no/en/about-exposed2/`

[2] Halvorsen-Weare, Elin E., Fagerholt, Kjetil, Nonås, Lars Magne, Asbjørnslett, Bjørn Egil, 2012. *Optimal fleet composition and periodic routing of offshore supply vessels*, European Journal of Operational Research, Volume 223, Issue 2, 1 December 2012, Pages 508–517.