Development of a Modular Design Process for Customised Closed Containment Systems

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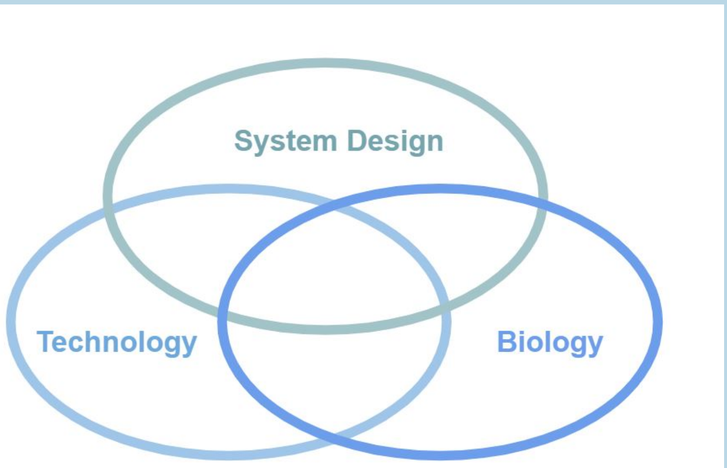
Introduction

The Norwegian government has stated a goal of increasing the production volume of farmed salmon from one million in 2010 to five million in 2050 [1]. Growth can however not be prioritised at any cost, and due to challenges related to lice and the environment footprint, the government has restricted further expansion of the industry [2]. In order to reach the goal, new technical solutions must be brought to light. Closed containment systems at sea is viewed as one possible solution to this problem.



In the design process of a closed containment system, it is found necessary to encapsulate more than one field of knowledge. A three-fold approach will therefore be applied, including both a technological and biological aspect, in addition to elements from system analysis and design.

Objective

The overall objective of this thesis is to develop inside knowledge for design of a customised closed containment system, based on standardised components. Customised in this case means to take environmental parameters and forces acting on the specific site into account in the design, adjust the design based on the production plan for that specific delivery, and to consider other customer wishes. Part of the design is with intention standardised in order to benefit from the advantages of mass production. This requires a thoroughly understanding of the aquaculture system and the different components it consist of, in addition to information about the design process and the parameters affecting the design.

References

[1] Norsk Industri: *Veikart for havbruksnæringen*, https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/veikart-havbruksnaringen_f41_web.pdf, (2016)

[2] Adrian Nyhammer Olsen: *Slik ser fremtidens oppdrett ut*, https://sysla.no/fisk/den-store-guiden-til-fremtidens-oppdrettsanlegg/, (2018)

[3] Botngaard Systems: *Lukkede Merdsystemer*, https://www.botngaard.no/no/produkter/havbruk/lukkede+merdsystemer.html, (2018)

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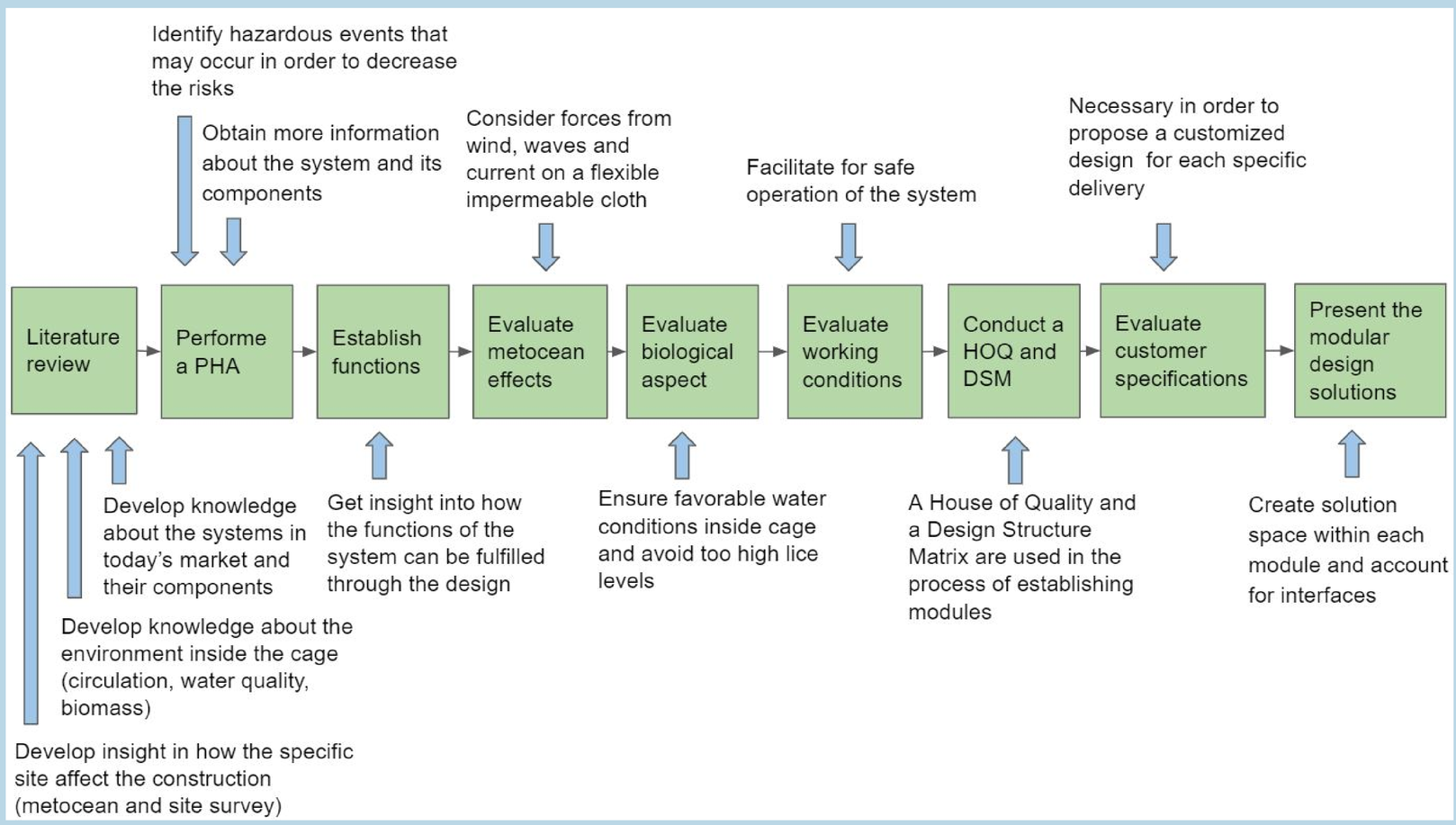
Methodology

The composition of the methods making up the methodology for development of a standardised design strategy for a customised closed containment systems, is illustrated in the figure below. Intended outcome of the methods and a brief explanation of why they are carrying out, is given in the figure.



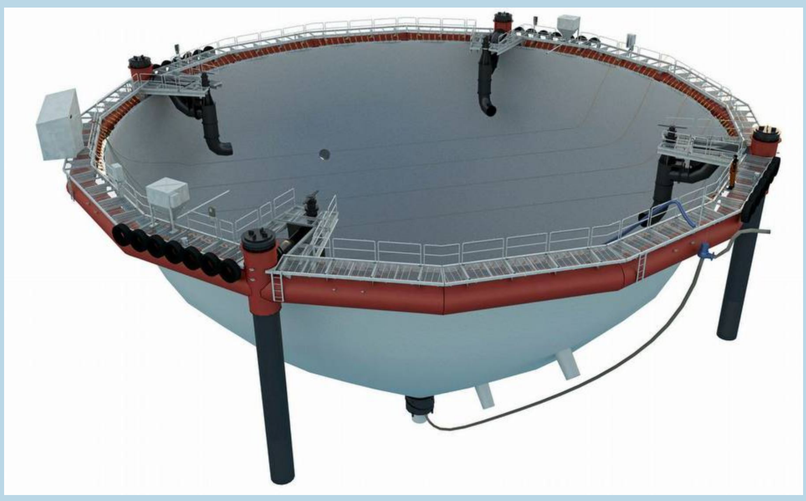
Result

The following is found to be essential inside knowledge for developing a design process for customised closed containment systems. Firstly, insight into the rules and regulations, mainly given by NYTEK and NS9415:2009, is essential. Secondly, a thoroughly understanding of the metocean effects on the location and how these will affect the system must be obtain. This includes how forces from wind, waves and current affect the construction and accordingly the design of it. How flexible impermeable constructions behave when exposed to hydrodynamic forces, is not yet thoroughly understood, and is therefore a challenge part of this process. Thirdly, the biological aspect must be taken into account. Finally, the concept of modularisation and the opportunities related to this design concept, must be understood.

In order to design a system that is customised for each specific delivery, the following customer specifications must be considered:

- The customers production plan, including information such as the maximum biomass the cage shall be designed for.
- The site survey for the specific location. It contains information about current velocity, significant wave height, effect of ice, water depth, bottom type and infrastructure.
- Additional customer wishes.

The figure to the right illustrates a possible design of the closed aquaculture cage [3].



Discussion and conclusion

Modular systems have the benefit of reduced design and construction costs and time, and leading to shorter and cheaper maintenance periods. Further, modular systems are more flexible and well suited for later upgrades. As the results from the HOQ and DSM analysis has shown, closed containment systems are possible to modularise, as groups of components interact with each other. The modularisation process resulted in 18 modules, of which ten are standard in all deliveries and eight are customised for each specific delivery. The solution space within each module determines the area of application of the final design, and the development of these are a compromise between the advantages and drawbacks of standardisation and customisation. A case study is performed for the location Rataren outside of Frøya, and it illustrates how a customised design of a closed containment system can be obtained, based on standardised components.