

# Development of UiS-Aqua

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WP4 Leader for KSP SusOffAqua

Professor and Leader for OTICS

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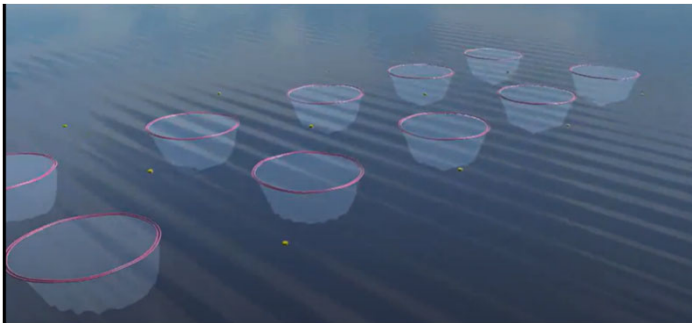
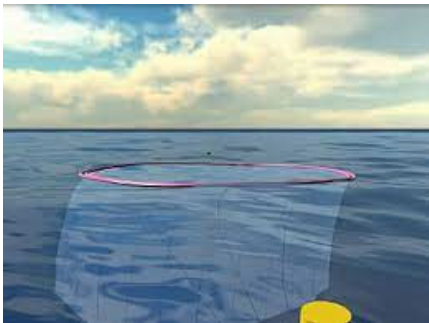
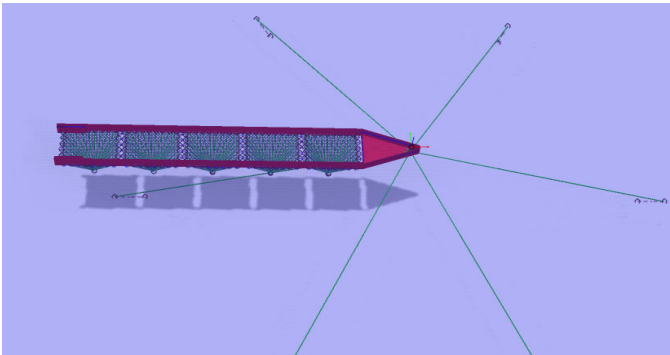
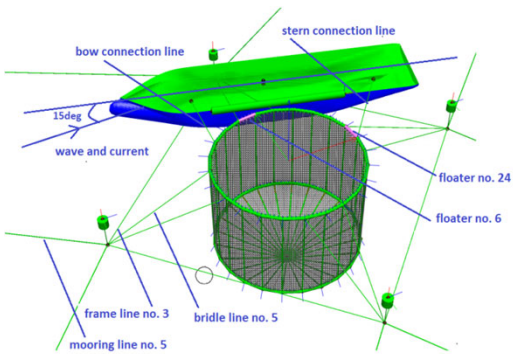
Collaborative and Knowledge-building Project Knowledge-building Project (KSP)

## **Unleashing the sustainable value creation potential of offshore ocean aquaculture**

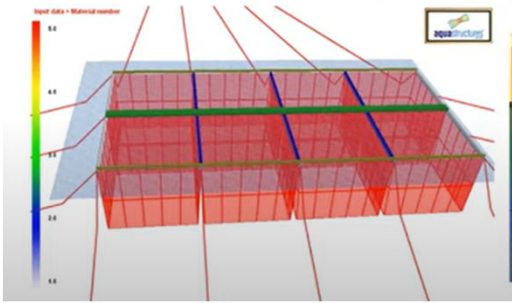
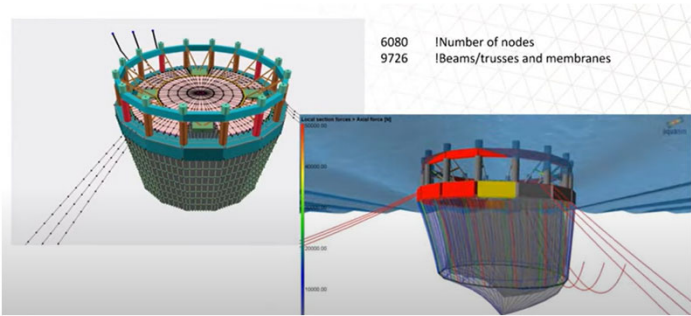
### **WP4 Secure and resilient production- infrastructure open cage production**

- How can open cage fish farms be designed with integrated monitoring capabilities to withstand greater environmental forces?
- How can future dynamic responses and rate of degradation for safe operations be predicted based on a single software platform?

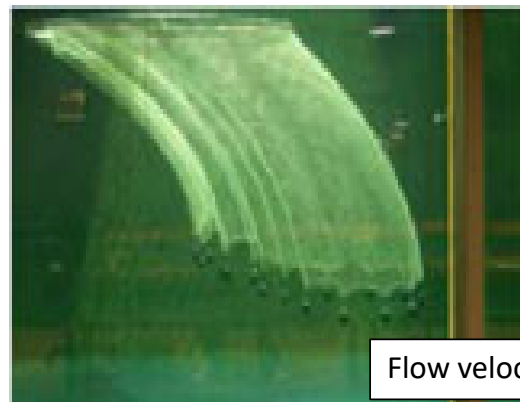
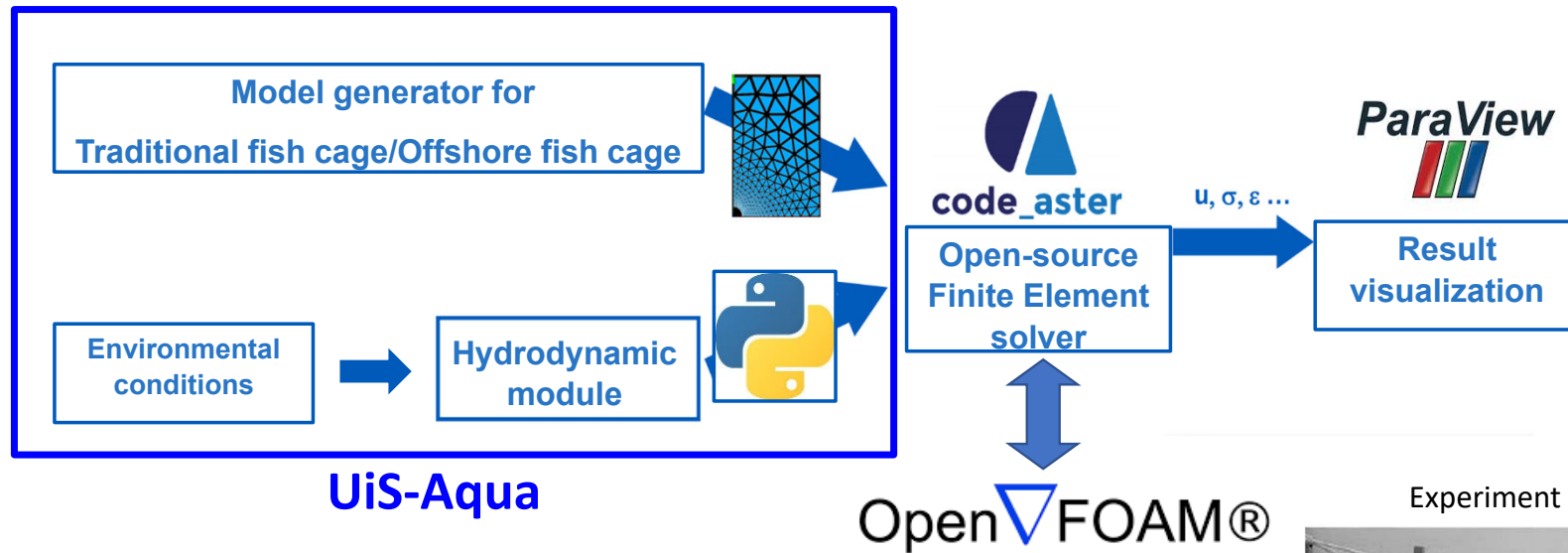
# Available simulation tools for offshore aquacultures in Norway



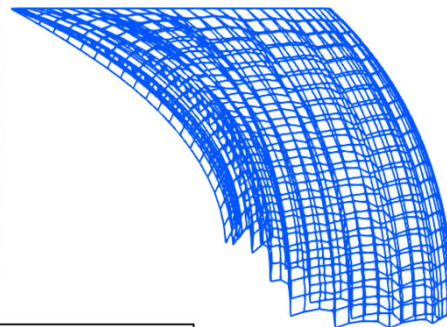
AquaSim



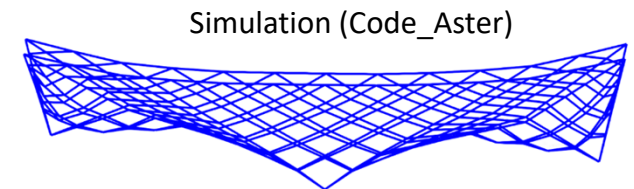
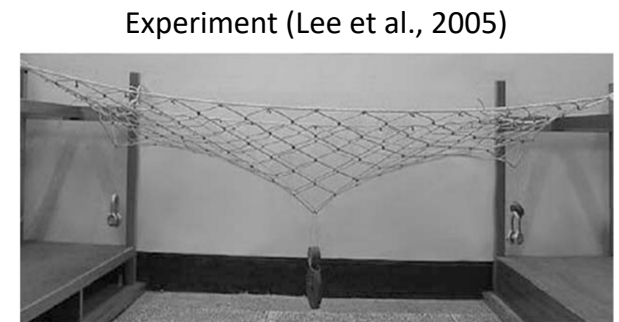
# Development of UiS-Aqua



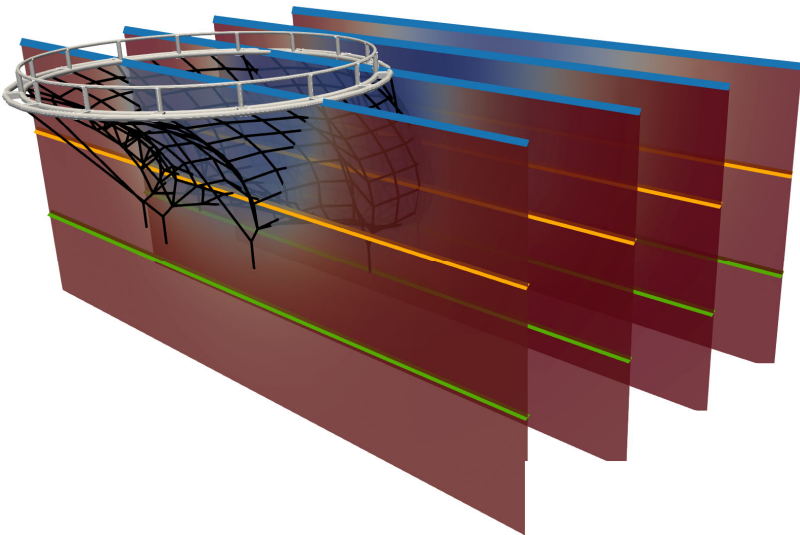
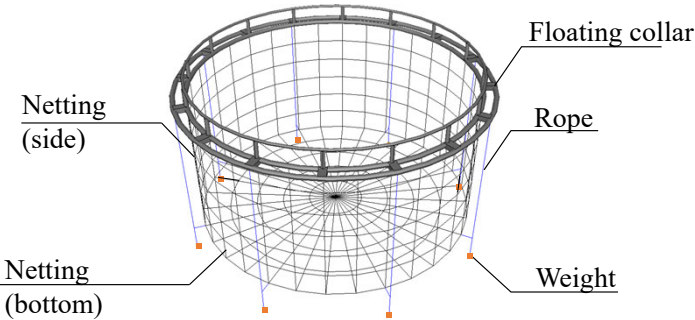
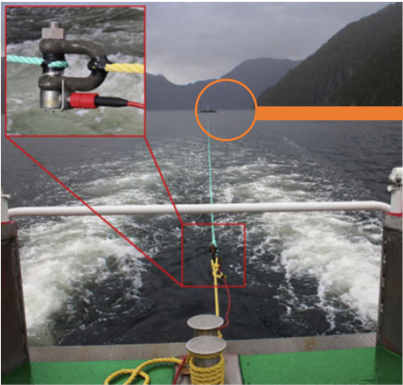
Experiment (Lader et al., 2009)



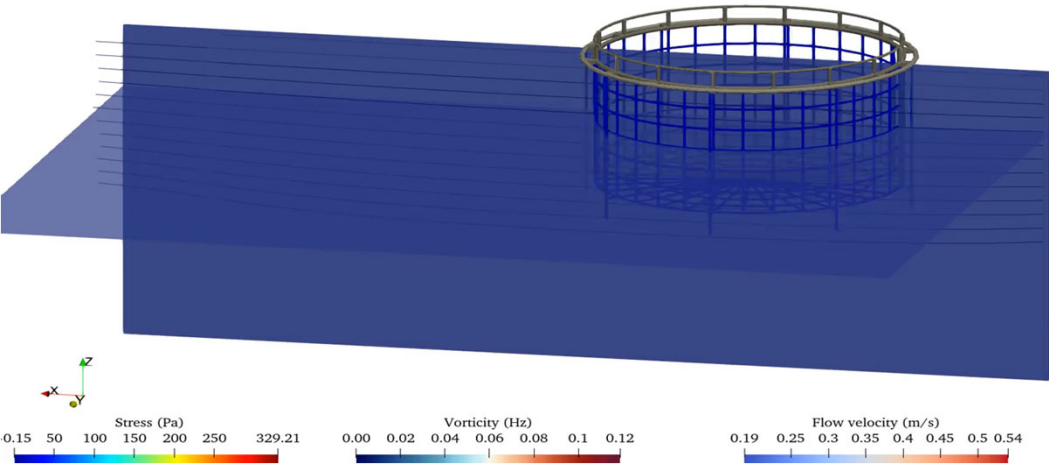
Simulation (Code\_Aster)



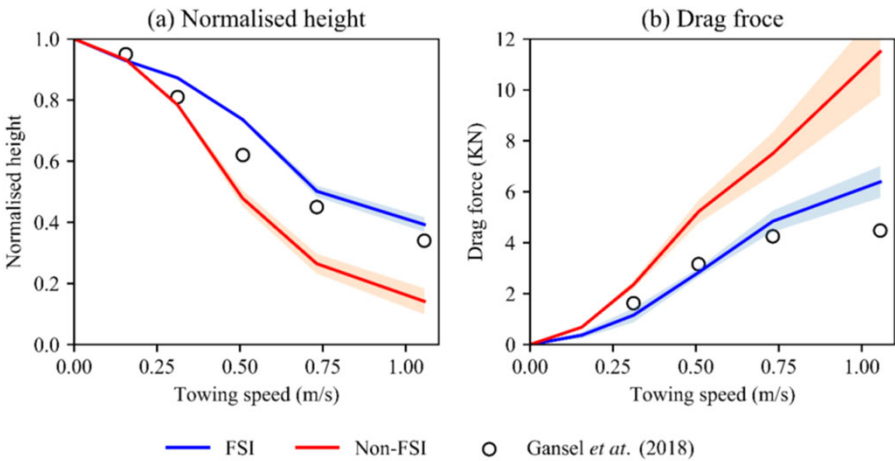
# Fully coupled numerical model for a fish cage



Towing test (Gansel et al. 2018)



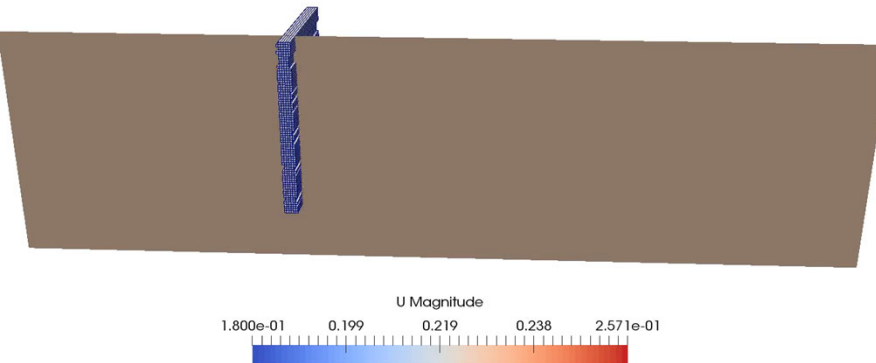
Cheng, H., Ong, M.C., Li, L., Chen, H., 2022. Development of a coupling algorithm for fluid-structure interaction analysis of submerged aquaculture nets. *Ocean Engineering* 243, 110208.



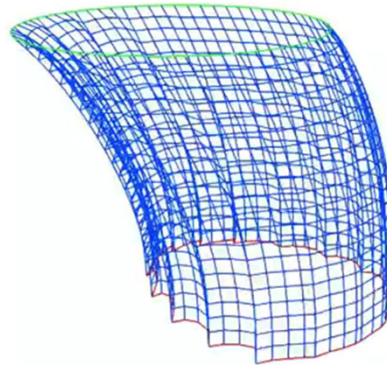
Gansel, L.C., Oppedal, F., Birkevold, J., Tuene, S.A., 2018. Drag forces and deformation of aquaculture cages—Full-scale towing tests in the field. *Aquacultural Engineering* 81, 46–56.

# Application of UiS-Aqua

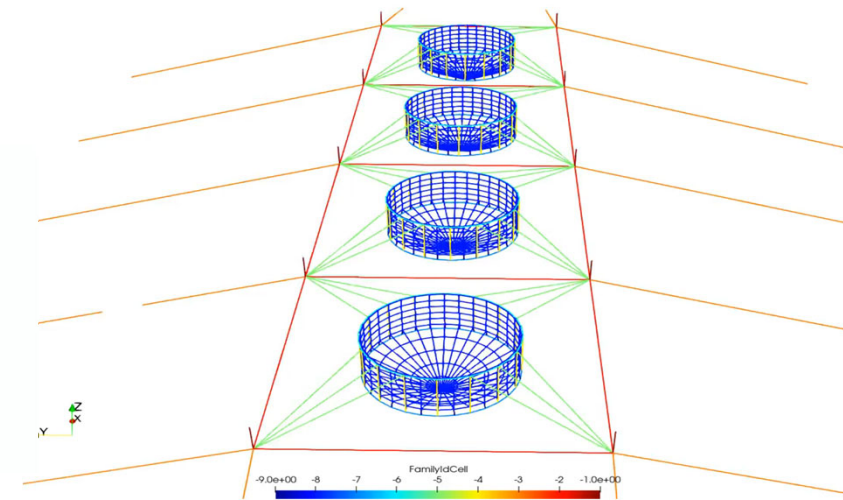
**Current flow pass through a flexible net panel**



**Fish cage motion in waves and current**



**Accidental failure investigations**

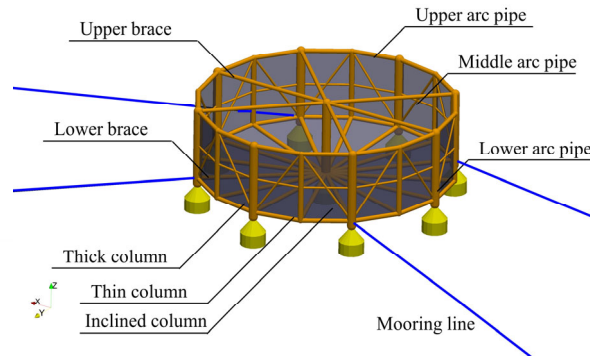
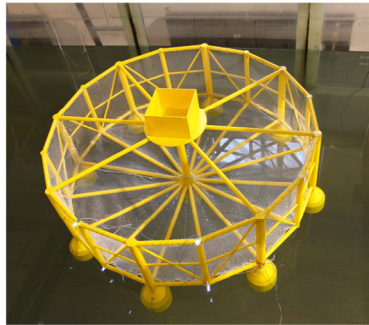


Cheng, H., Li, L., Aarsæther, K.G., Ong, M.C., 2020. Typical hydrodynamic models for aquaculture nets: A comparative study under pure current conditions. *Aquacultural Engineering* 90, 102070.

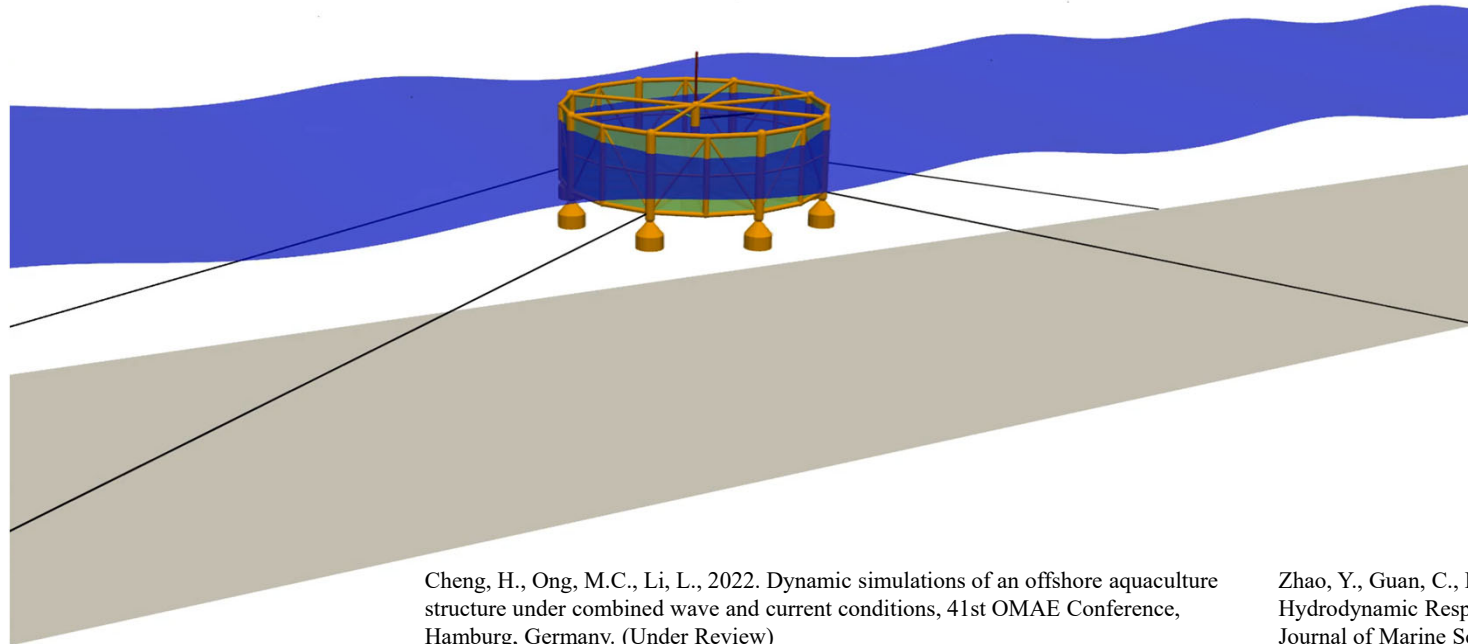
Cheng, H., Li, L., Ong, M.C., Aarsæther, K.G., Sim, J., 2021. Effects of mooring line breakage on dynamic responses of grid moored fish farms under pure current conditions. *Ocean Engineering* 237, 109638.



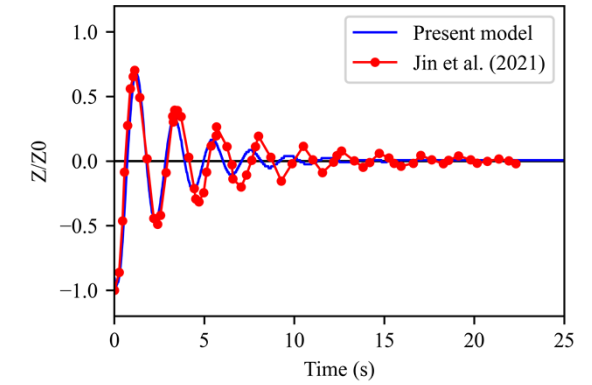
# Application of UiS-Aqua



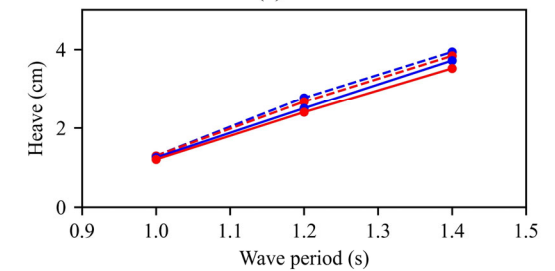
Model experiments conducted by Zhao et al (2019)



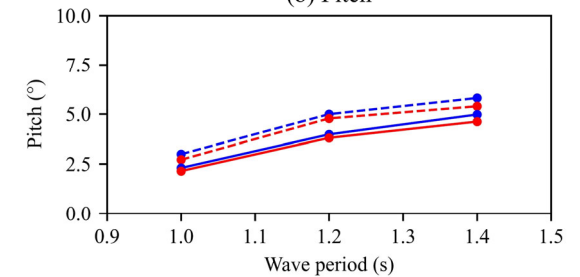
Cheng, H., Ong, M.C., Li, L., 2022. Dynamic simulations of an offshore aquaculture structure under combined wave and current conditions, 41st OMAE Conference, Hamburg, Germany. (Under Review)



(a) Heave



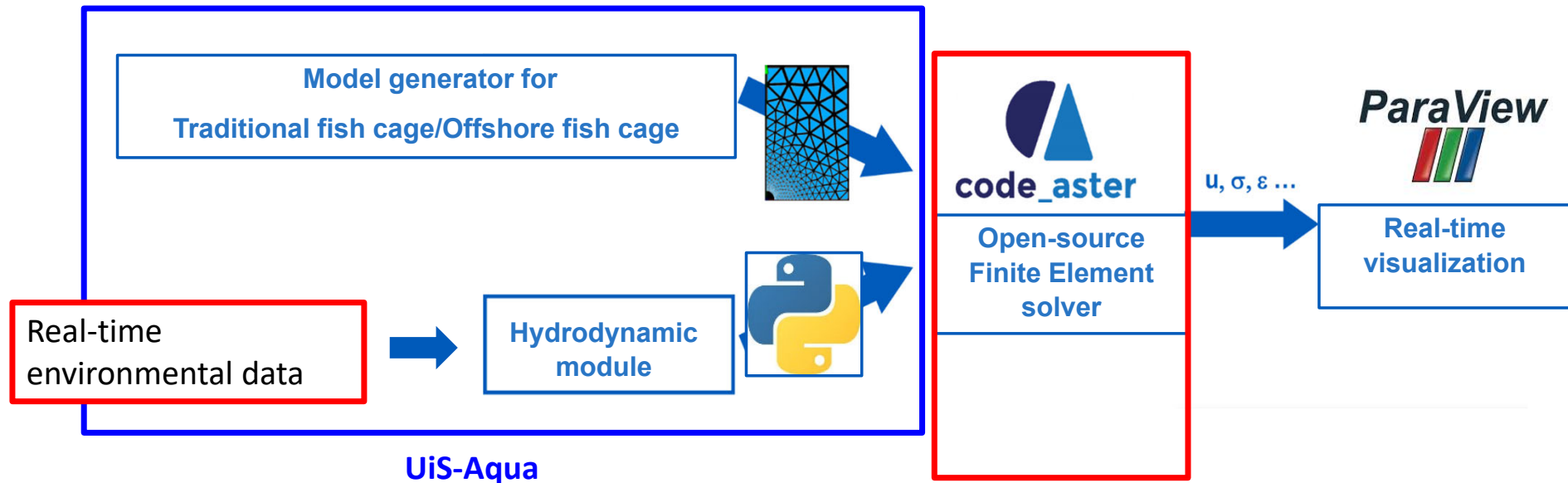
(b) Pitch



- - d = 28 cm, Num.      - - d = 36 cm, Num.  
 - - d = 28 cm, Exp.      - - d = 36 cm, Exp.

Zhao, Y., Guan, C., Bi, C., Liu, H., Cui, Y., 2019. Experimental Investigations on Hydrodynamic Responses of a Semi-Submersible Offshore Fish Farm in Waves. Journal of Marine Science and Engineering 7, 238.

# UiS-Aqua for Digital Twin



Faster method for solving ODEs  
to accelerate the computation



## Workpackage objectives (include short description of deliverables):

- To design offshore fish farming with integrated monitoring capabilities to withstand greater environmental forces.
- To predict future dynamic responses and rate of degradation for safe operations be predicted based on a single software platform.

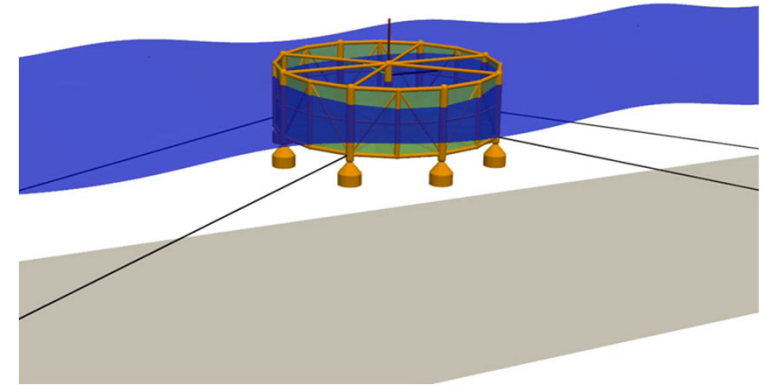
**Deliverables:** Digital twin open cage fish farm under a single software platform.

## Status: what have been done so far and plan for next 3 months?

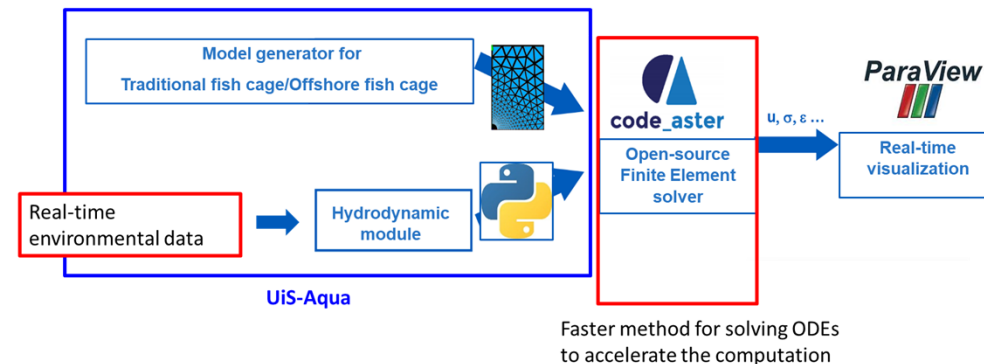
- UiS-Aqua code has been developed and validated against gravity-type open cages. Currently, a validation study is carried out against large semi-submersible open cages.
- Recruiting a 2-year Post-doctoral researcher and the deadline of job application is on 5 June 2022. <https://www.jobbnorge.no/ledige-stillinger/stilling/226223/postdoktor-i-offshoreteknologi>

## Critical elements and risk:

- To increase computational efficiency and handle data processing and management.



## UiS-Aqua for Digital Twin

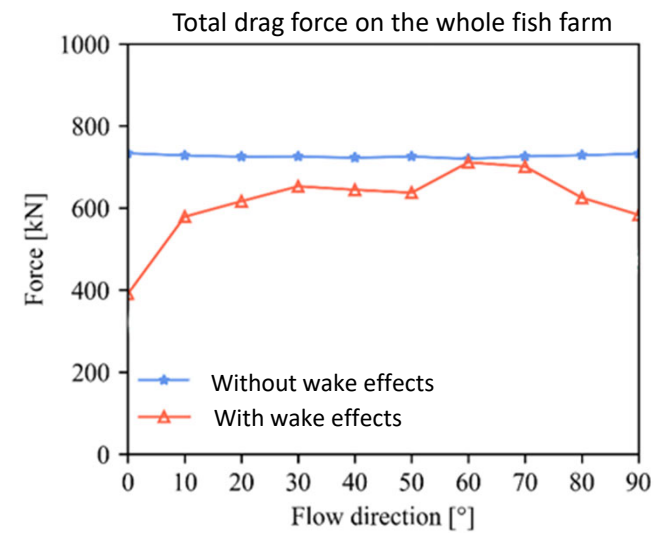
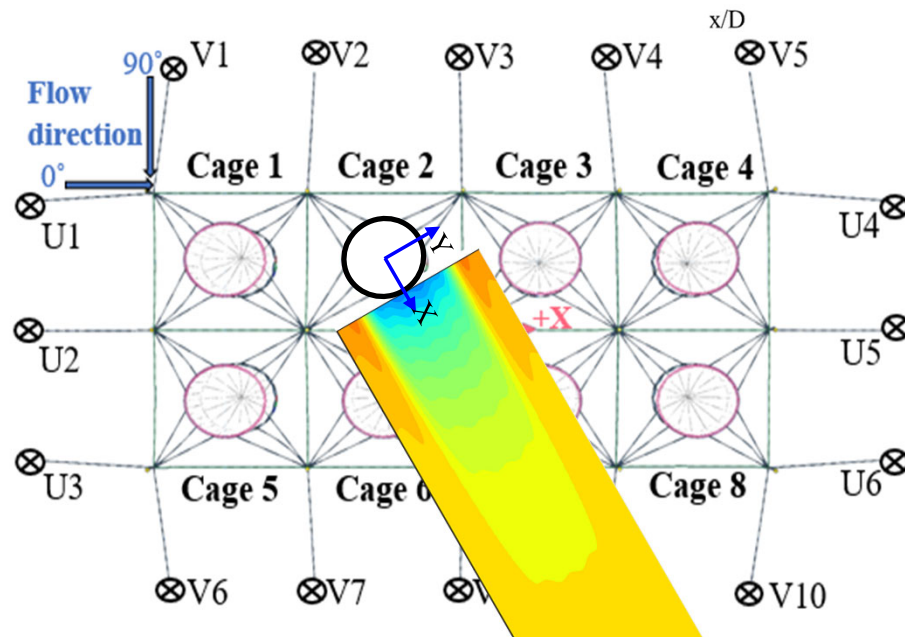
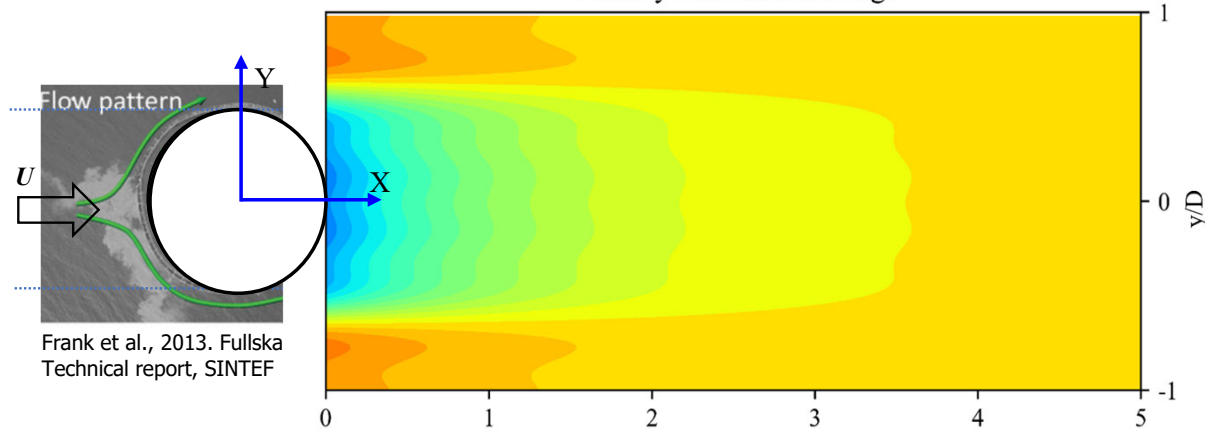


## List of publications

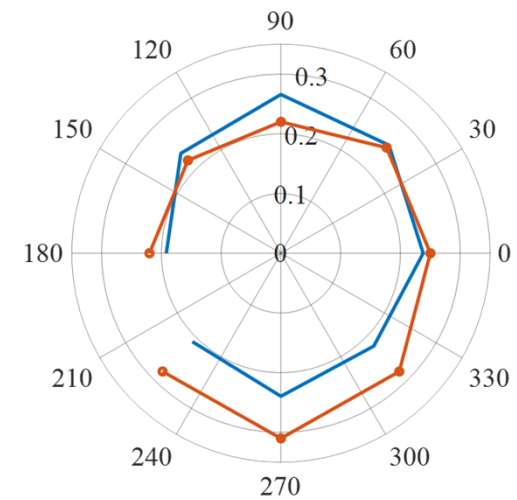
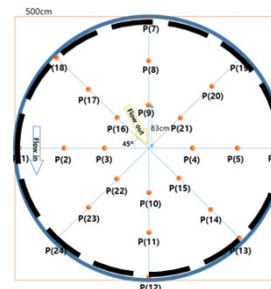
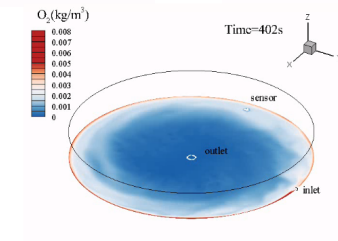
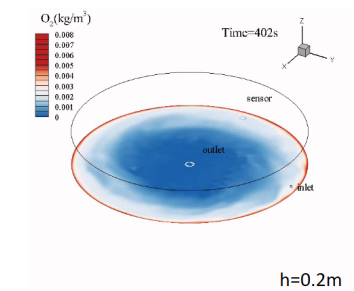
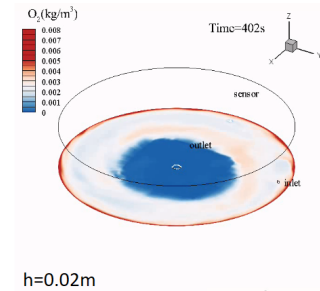
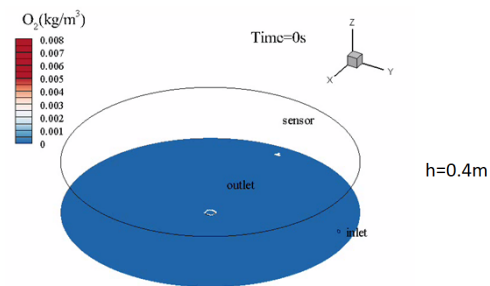
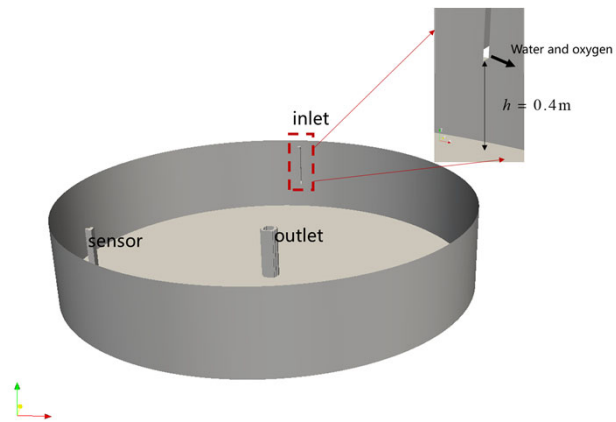
1. Cheng, H., Li, L., Aarsæther, K.G., Ong, M.C., 2020. Typical hydrodynamic models for aquaculture nets: A comparative study under pure current conditions. *Aquacultural Engineering* 90, 102070. <https://doi.org/10.1016/j.aquaeng.2020.102070>
2. Cheng, H., Ong, M.C., Li, L., Chen, H., 2022. Development of a coupling algorithm for fluid-structure interaction analysis of submerged aquaculture nets. *Ocean Engineering* 243, 110208. <https://doi.org/10.1016/j.oceaneng.2021.110208>
3. Cheng, H., Aarsæther, K.G., Li, L., Ong, M.C., 2020. Numerical Study of a Single-Point Mooring Gravity Fish Cage with Different Deformation-Suppression Methods. *Journal of Offshore Mechanics and Arctic Engineering* 142, 041301. <https://doi.org/10.1115/1.4046115>
4. Cheng, H., Li, L., Ong, M.C., Aarsæther, K.G., Sim, J., 2021. Effects of mooring line breakage on dynamic responses of grid moored fish farms under pure current conditions. *Ocean Engineering* 237, 109638. <https://doi.org/10.1016/j.oceaneng.2021.109638>
5. Sim, J., Cheng, H., Aarsæther, K.G., Li, L., Ong, M.C., 2021. Numerical Investigation on the Cage-to-Cage Wake Effect: A Case Study of a  $4 \times 2$  Cage Array. *Journal of Offshore Mechanics and Arctic Engineering* 143, 051301. <https://doi.org/10.1115/1.4049831>
6. Mjåtveit, M.A., Cheng, H., Ong, M.C., Lee, J., 2022. Comparative study of circular and square gravity-based fish cages with different dimensions under pure current conditions. *Aquacultural Engineering* 96, 102223. <https://doi.org/10.1016/j.aquaeng.2021.102223>
7. Cheng, H., Ong, M.C., Li, L., 2022. Dynamic simulations of an offshore aquaculture structure under combined wave and current conditions, 41<sup>st</sup> OMAE Conference, Hamburg, Germany.
8. Cheng, H., Li, L., Ong, M.C., 2022. Comparative study of five commonly-used gravity type fish cages under pure current conditions, *Ocean Engineering*, 250, 110977. <https://doi.org/10.1016/j.oceaneng.2022.110977>

# Wake Effects in Fish Farm

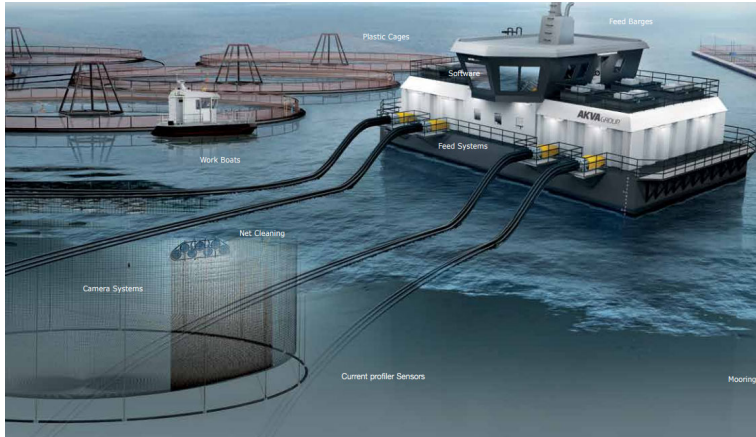
Wake effect outside a fish cage



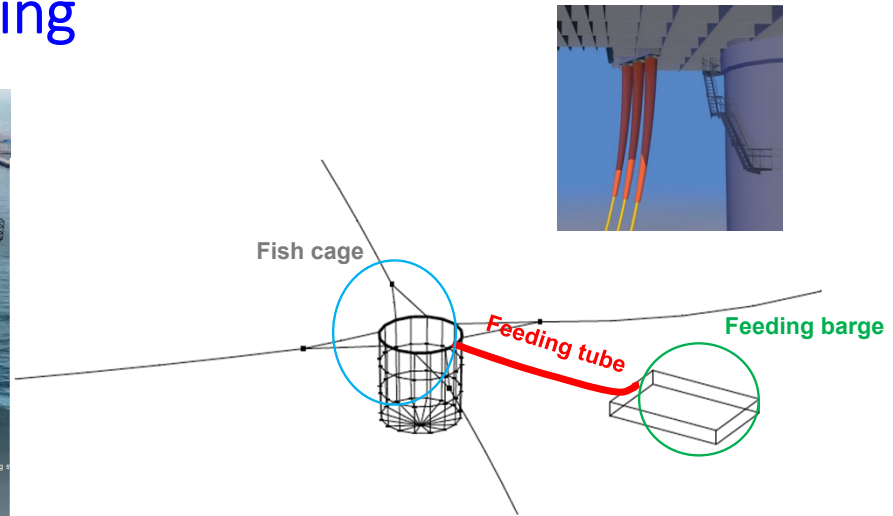
# Oxygen Distribution in Flow-Through Tank



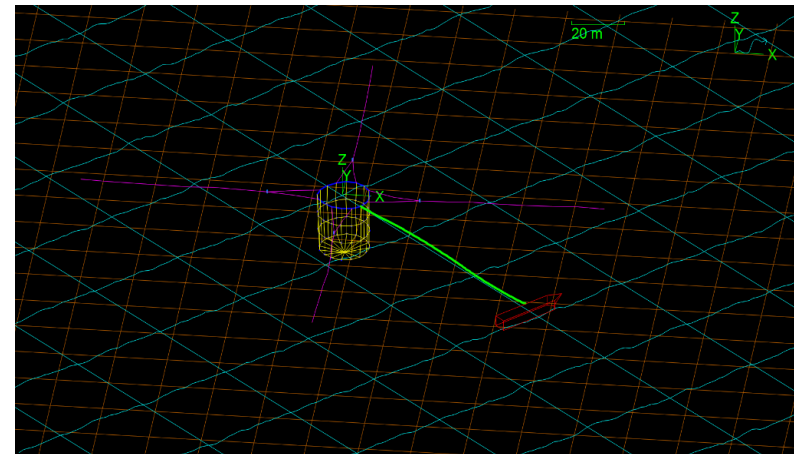
# Feeding Pipes for Fish Farming



<http://www.akvagroup.com/>



Dynamic analysis of feeding tube in exposed seas for fish farming



OrcaFlex simulations

## Feed Pellets Free Fall in Water Column

