New Uses for Oil and Gas Technology

Technology transfer to other applications

Marine constructions,
applications to offshore wind and aquaculture

Norwegian Education and Research Delegation to Brazil
September 21 2016, São Paolo

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Department of Marine Technology, NTNU

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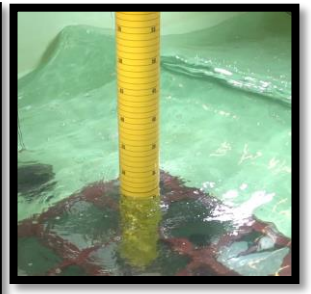
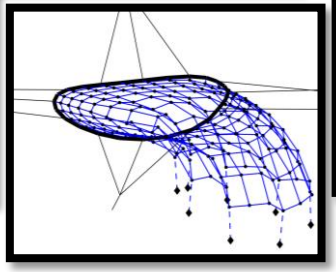
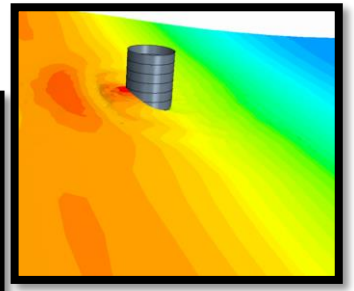
Marine constructions, applications to offshore wind and aquaculture

Floating and fixed structures and vessels

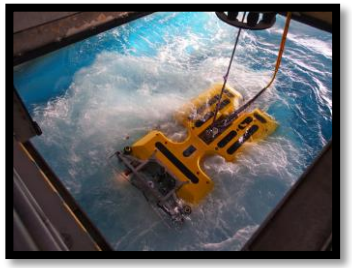


Wave, current and wind loads





Risers and moorings

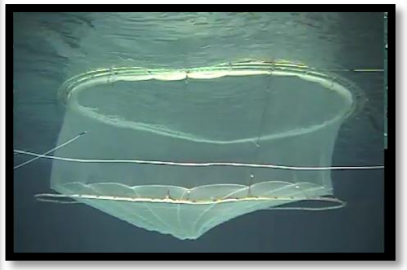


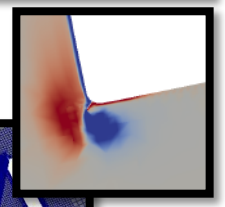
Marine Operations

Operability
Survival

Laboratory tests

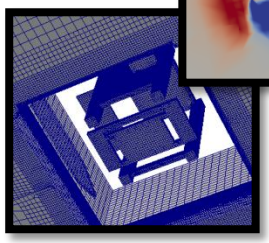
Research methods

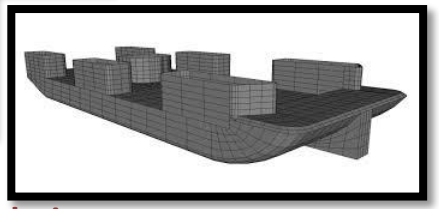




Standards

Risk analysis





Full scale tests

Theory and numerical simulations

Differences:
Lower cost level required
Fish welfare and biology

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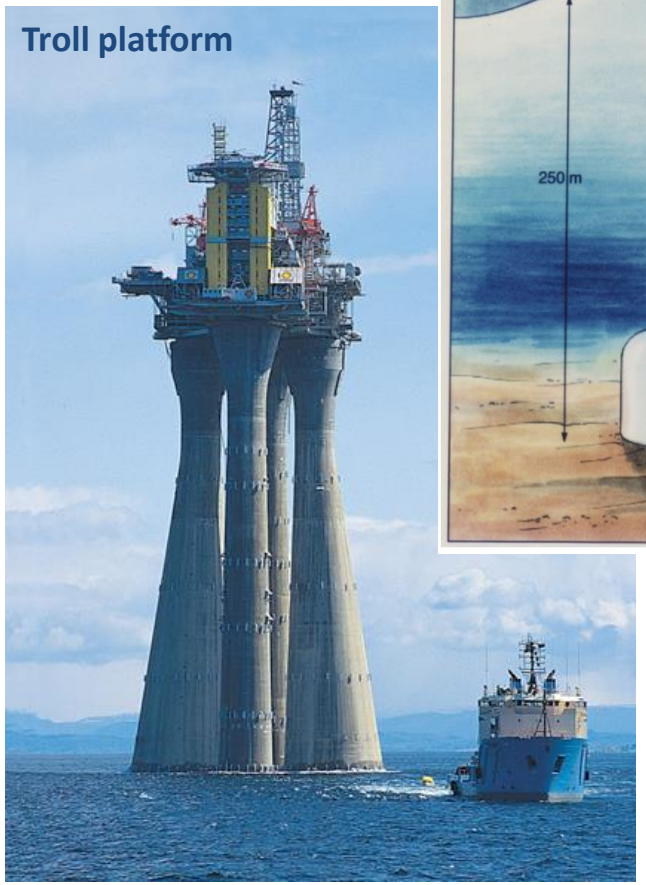
Offshore wind

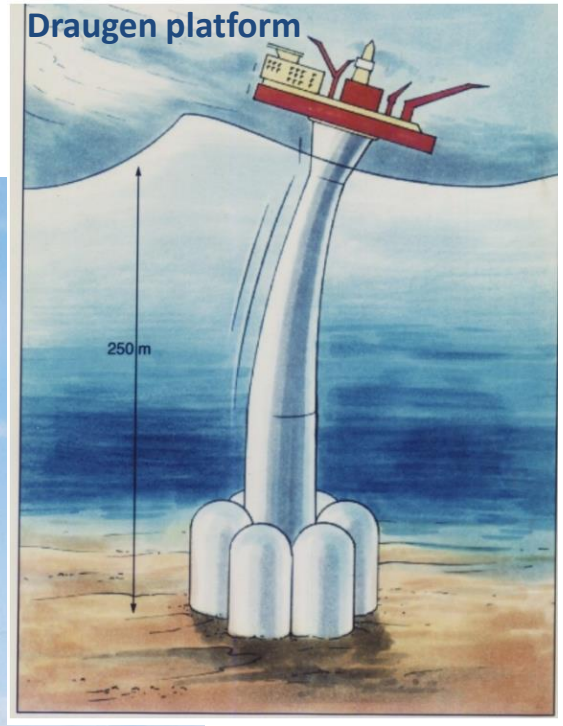
Marine constructions, applications to offshore wind and aquaculture

Example: Wind turbine in severe waves («Ringing»)

Ringing = Flexible global vibrations induced by severe storm waves

Can potentially damage or break the structure

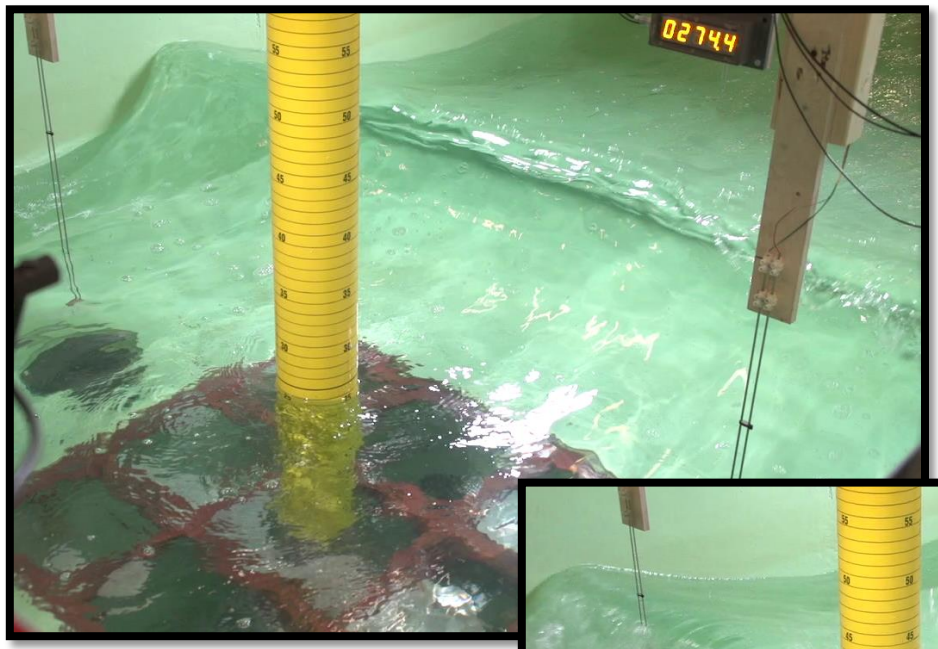


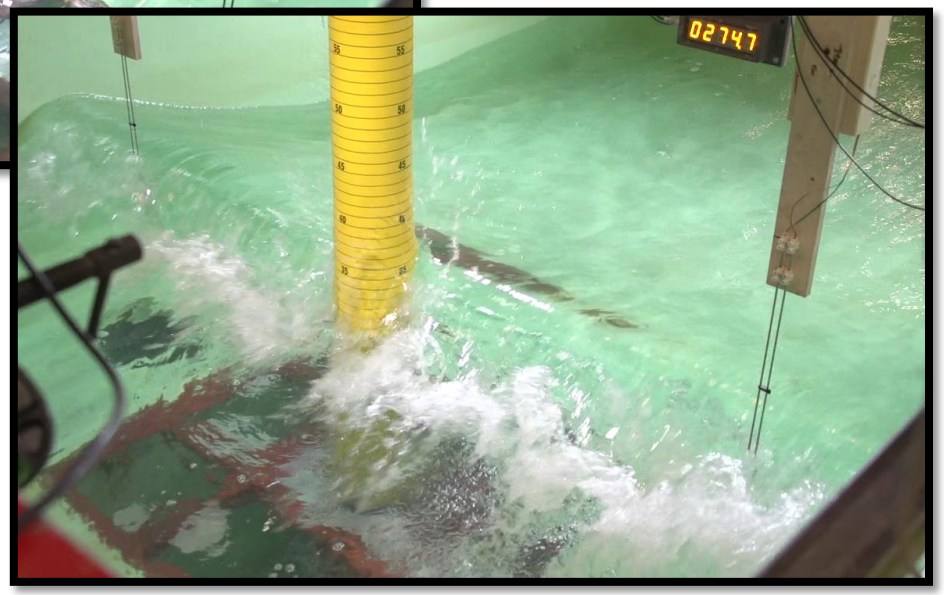


Not predicted by standard theories

Ringing load theories 1990s

Applicable to offshore wind turbines





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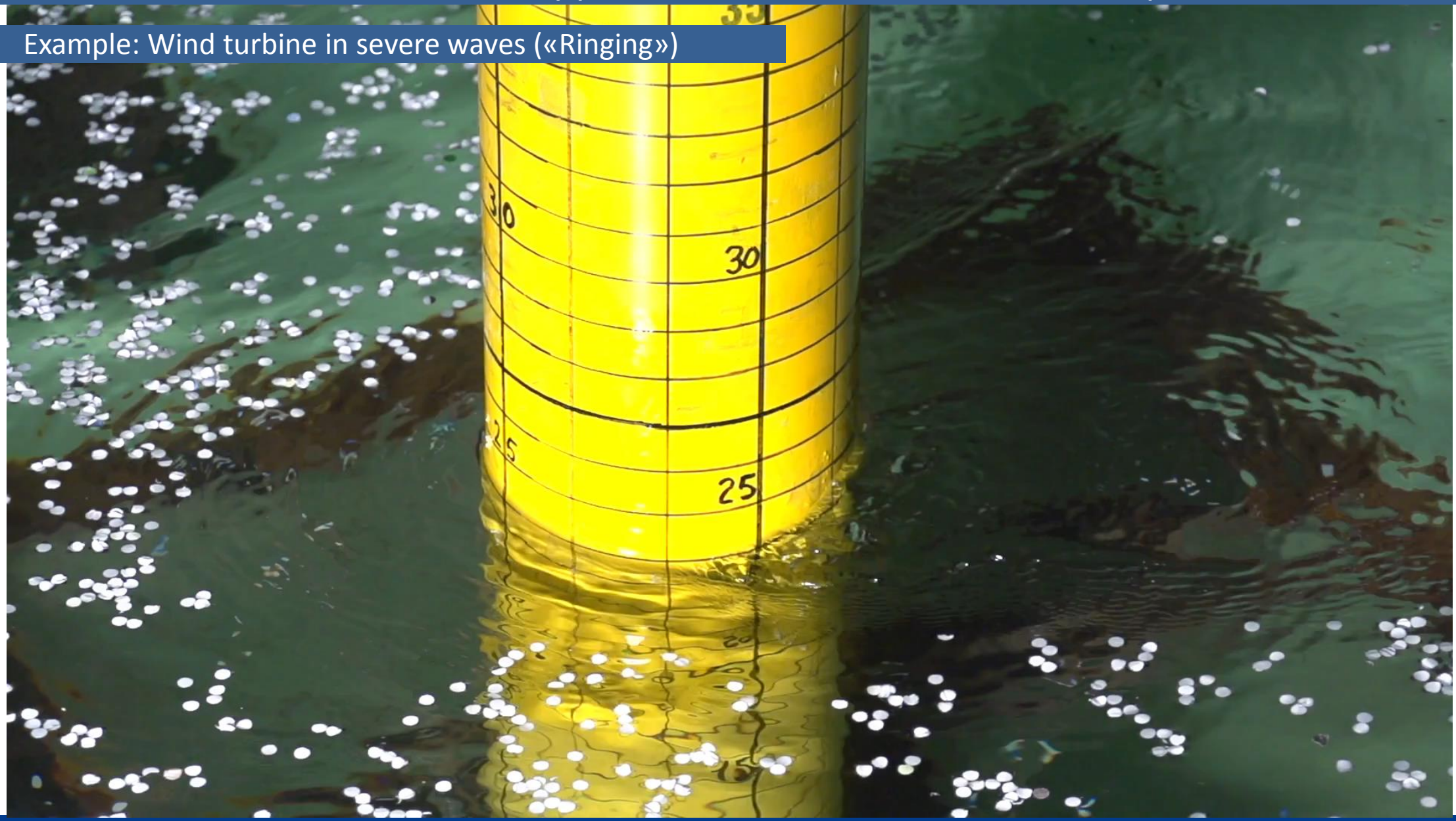
Example: Wind turbine in severe waves («Ringing»)



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Marine constructions, applications to offshore wind and aquaculture

Offshore wind

Opportunities

- Worldwide renewable energy targets
- Significant and consistent wind resources at sea

Main challenge: Reducing LCOE (levelised cost of energy)

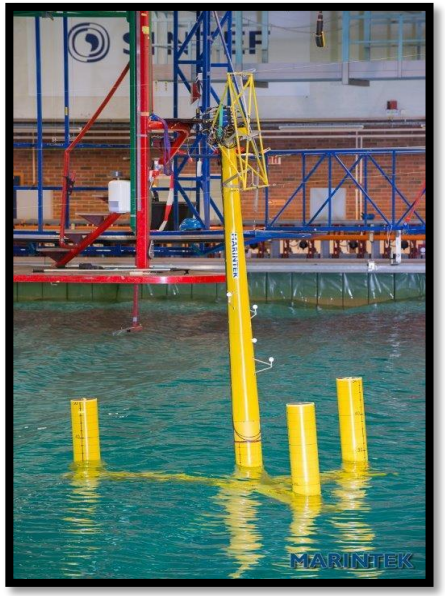
- Complex (Structural – Hydrodynamic – Aerodynamic – Soil – Control – Electrical)
- Reduce cost of marine operations (installation, maintanance)
- Reduce construction costs (support structure design)

NTNU's contributions to technology transfer

- Fixed and floating substructures (design and analysis)
- Risk and reliability
- Operation & Maintenance concepts and strategies

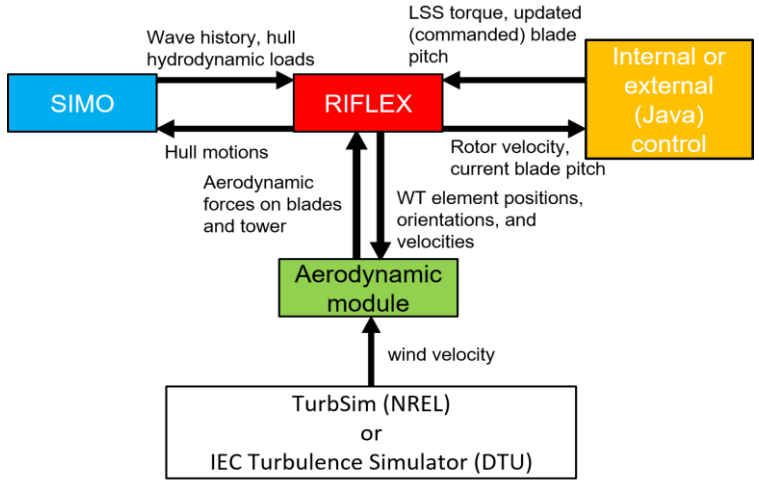
Emerging topics

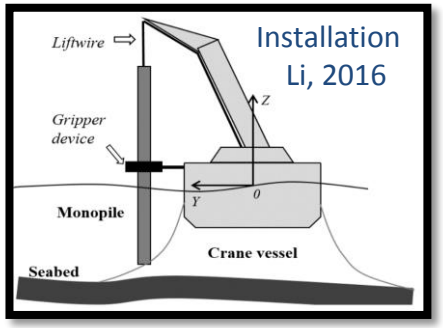
- Optimization
- Lifetime extension/structural health monitoring
- Multi-use platforms



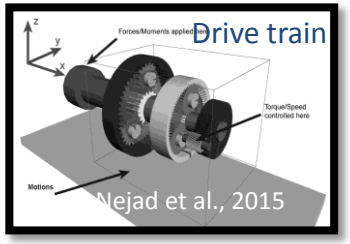
Bachynski et al., 2016

Integrated simulation tool

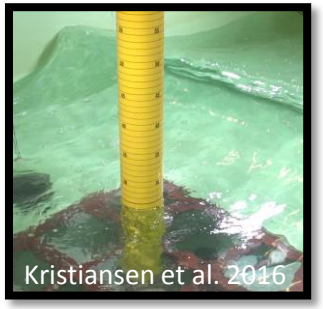




Installation
Li, 2016

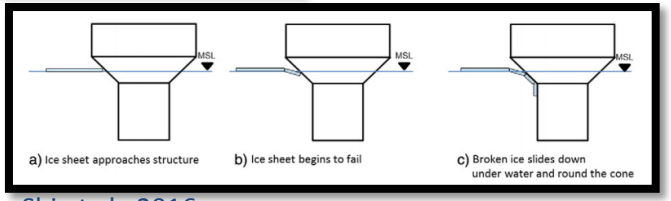


Drive train
Nejad et al., 2015

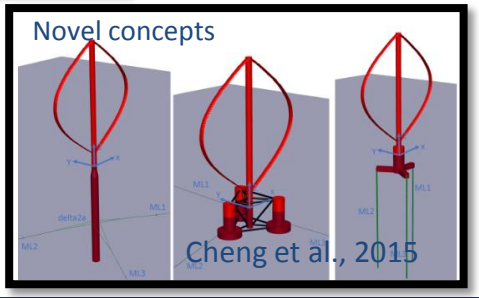


Kristiansen et al. 2016

Wave, ice and wind loads



Shi et al., 2016



Novel concepts

Cheng et al., 2015

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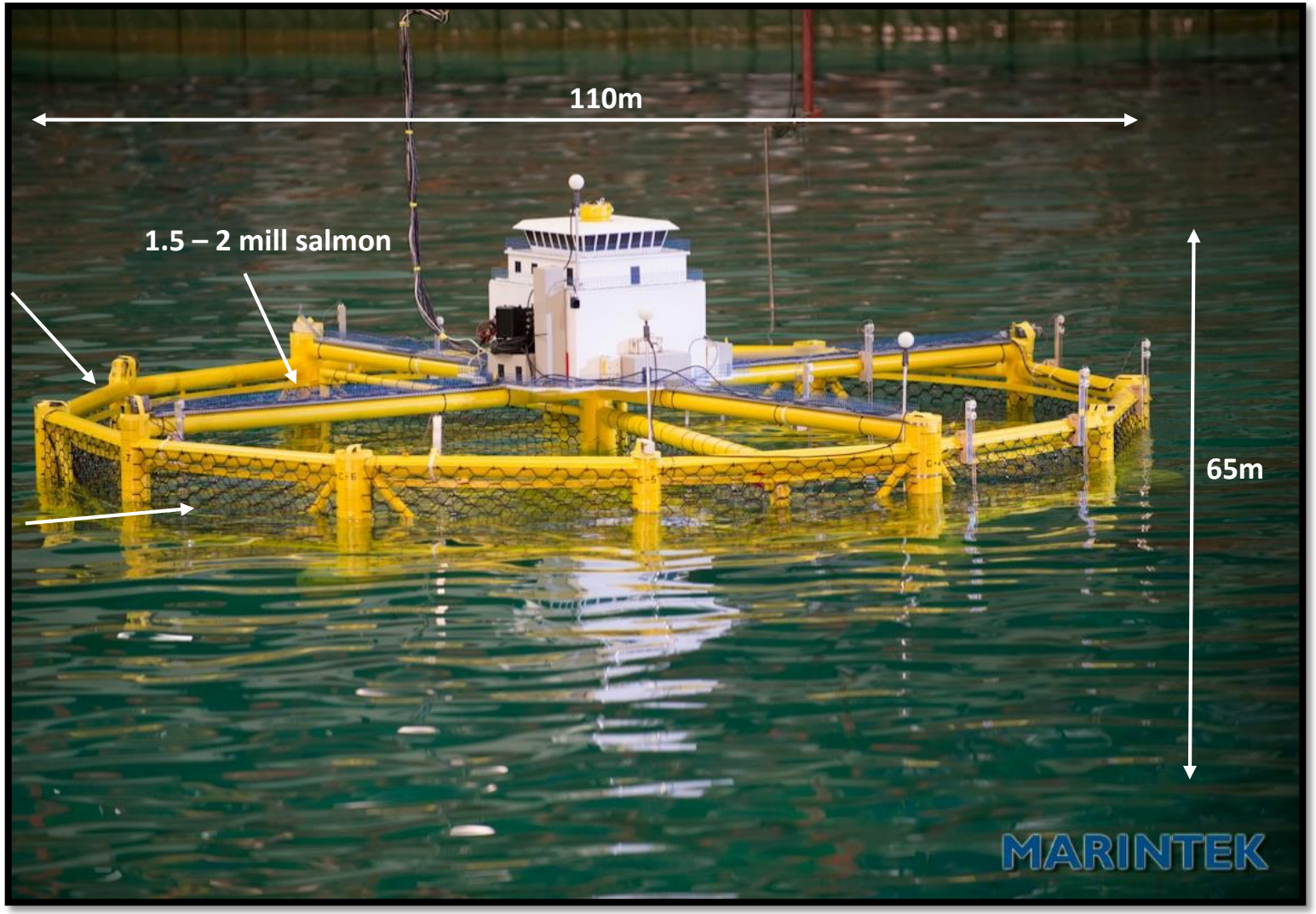
Aquaculture

Marine constructions, applications to offshore wind and aquaculture

Example 1: Ocean Farming tested in waves and current

Truss works

Net



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Marine constructions, applications to offshore wind and aquaculture

Example 2: Traditional aquaculture farm in waves and current

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Marine constructions, applications to offshore wind and aquaculture

Aquaculture

Opportunities

The need for marine bioresources – growing population
International sustainability standards

Challenges

Biological – Fish health & welfare, environmental interactions
Structural – Fish escape, cost-effective, exposed areas
Marine operations – Logistics, cost-efficiency, fish handling

NTNU's contributions to technology transfer

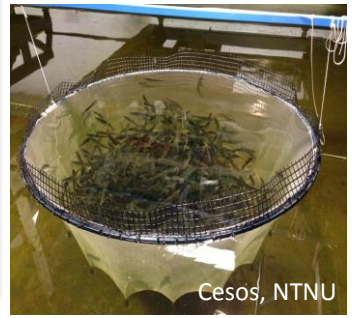
Marine structures
Marine operations – new vessel designs
Logistics
Life cycle analysis
Surveillance

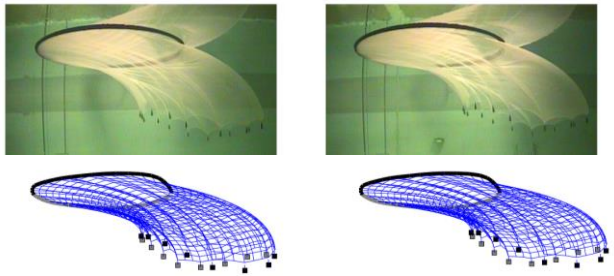
Emerging topics

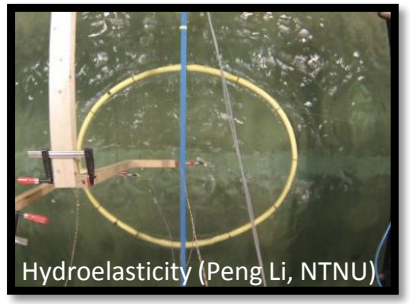
Fish transport, methods and optimization
Closed fish farms


Ocean farming structure (Jørgen Amdahl, NTNU)


Environmental interactions (Yngvar Olsen, NTNU)

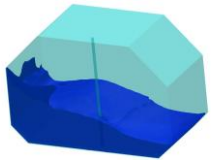

Cesos, NTNU


Aquaculture nets (Trygve Kristiansen, NTNU)

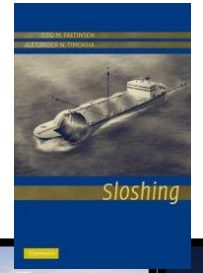

Hydroelasticity (Peng Li, NTNU)


(LNG carrier)

Sloshing



Closed fish farms



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Selected recent publications (from NTNU)

Offshore wind turbines:

1. Trygve Kristiansen and Odd M. Faltinsen. *Ringing excitation loads on a circular cylinder in finite water depth* (To be submitted 2016) J. Fluid Mech.
2. Erin Bachynski, Trygve Kristiansen, Reza Firoozkoohi and Maxime Thys. *Experimental and numerical investigations of monopile ringing in irregular shallow water waves* (To be submitted 2016) Appl. Ocean Research
3. Erin Bachynski and Trygve Kristiansen. *Reproduction of monopile ringing events in reduced-duration model tests* (To be submitted 2016) OMAE2017.
4. Amir Nejad, Erin Bachynski, Marit Kvittem, Chenyu Luan, Zhen Gao, and Torgeir Moan. *Stochastic dynamic load effect and fatigue damage analysis of drivetrains in land-based and TLP, spar and semi-submersible floating wind turbines.* Marine Structures, 2015, 42, 137-153.
5. Wei Shi, Xiang Tan, Zhen Gao, and Torgeir Moan, *Numerical study of ice-induced loads and responses of a monopile-type offshore wind turbine in parked and operating conditions*. Cold Regions Science and Technology, 2016. 123: p. 121-139.
6. Erin Bachynski, Maxime Thys, Thomas Sauder, Valentin Chabaud, and Lars Ove Sæther. *Real-Time Hybrid Model Testing of a Braceless Semi-Submersible Wind Turbine: Part II: Experimental Results*. Proceedings of the ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering, 2016.
7. Lin Li. *Dynamic Analysis of the Installation of Monopiles for Offshore Wind Turbines.* PhD Thesis, NTNU, 2016.
8. Zhengshun Cheng, Kai Wang, Zhen Gao and Torgeir Moan. *Dynamic Response Analysis of Three Floating Wind Turbine Concepts with a Two-Bladed Darrieus Rotor*. Journal of Ocean and Wind Energy, 2015, 2, p. 213-222.

Aquaculture:

1. Peng Li, O. M. Faltinsen and Claudio Lugni. *Nonlinear vertical accelerations of a floating torus in regular waves* (In review **2016**) J. Fluids and Structures,
2. Trygve Kristiansen and Odd M. Faltinsen. *Experimental and numerical study of an aquaculture net cage with floater in waves and current* (**2015**) J. Fluids and Structures, 54
3. Trygve Kristiansen and Odd M. Faltinsen. *Modelling of current loads on aquaculture net cages* (**2012**) J. Fluids and Structures, 34
4. Odd M. Faltinsen and Alexander Timokha. *Sloshing* (2009) Cambridge

https://www.**ntnu**.edu/**oceans**

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Strategic Research Area 2014–2023

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Thank you!

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