



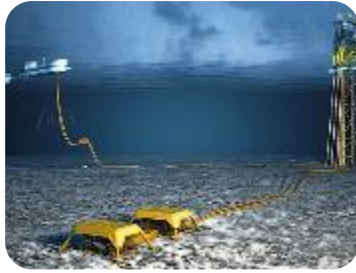
AUTONOMOUS OPERATIONS IN DYNAMICALLY CHANGING ENVIRONMENTS USING UNMANNED UNDERWATER VEHICLES (UUVS)

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SINTEF Ocean, FFU Seminar, January 2019

Underwater Robots for Subsea Applications



Resource Extraction



Science



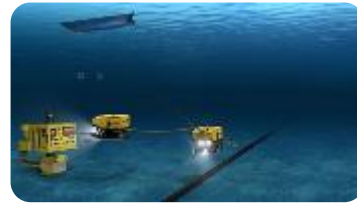
National Defence



Aquaculture



Telecommunications



Construction, Inspection and Maintenance



Archeology



Search and Recovery



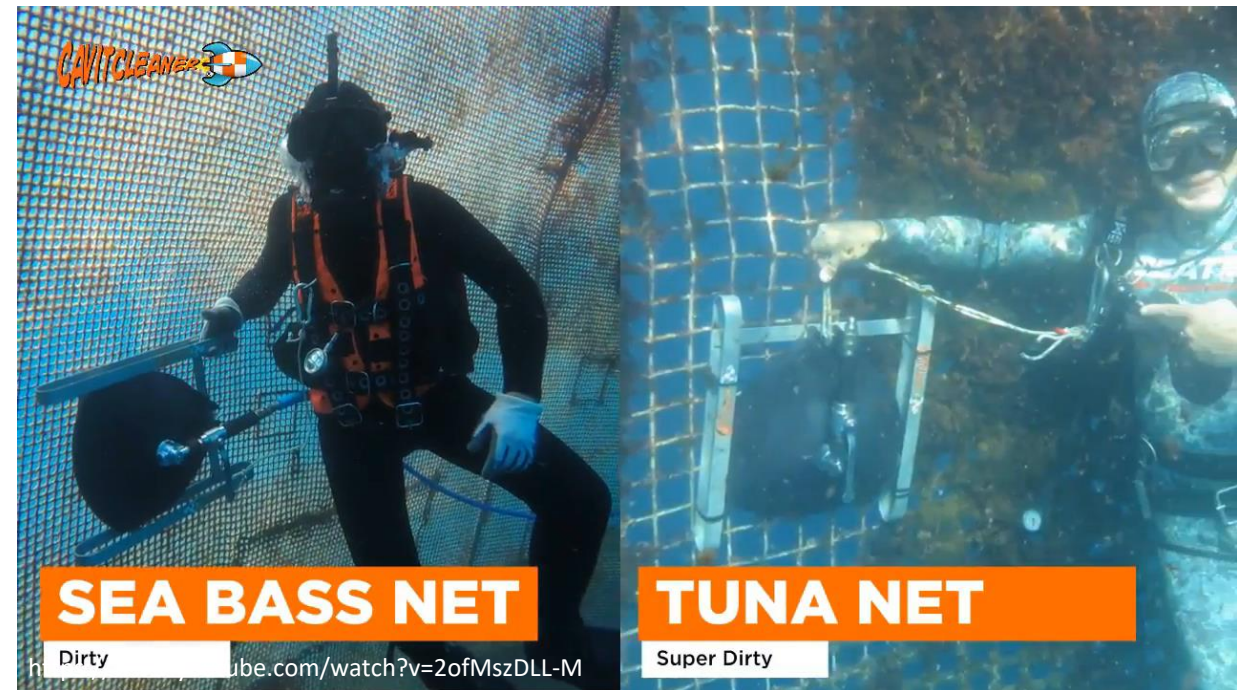
Deep Water

Under Ice

Nuclear plant

Subsea Operations

Reduce the Risk: *'NO man on seabed or surface'*

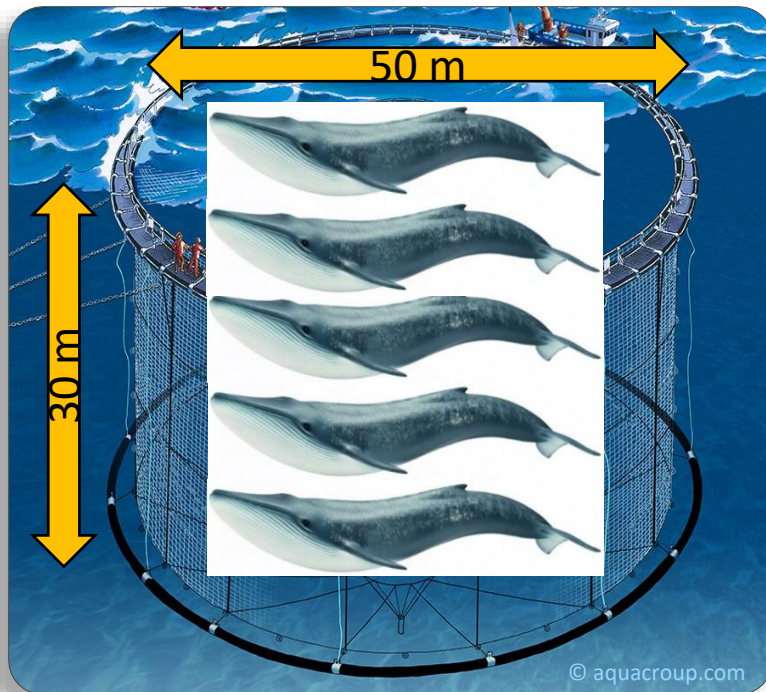
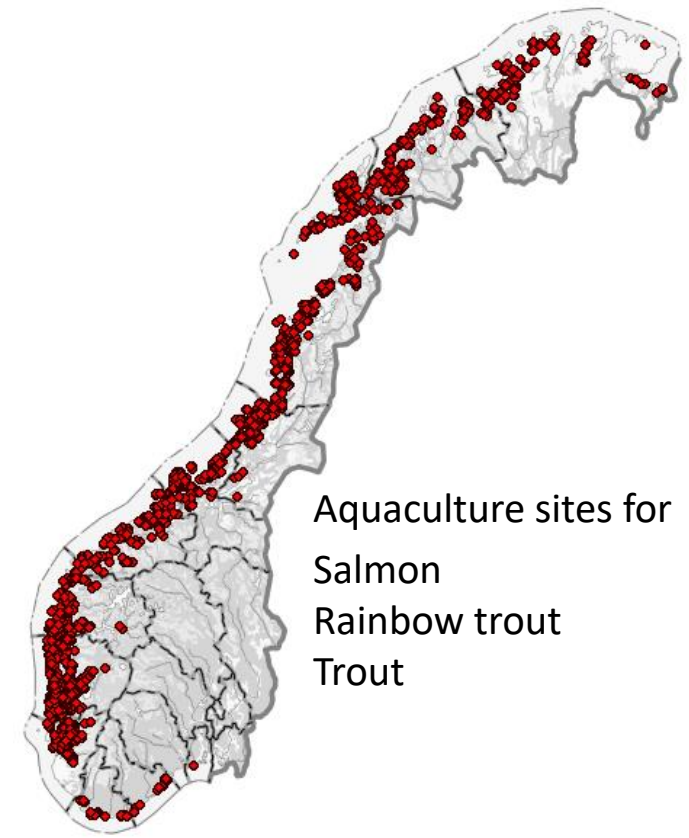


Reduce Cost and Increase Efficiency: *'Adapt autonomous robotic solutions'*

Aquaculture Industry

Salmon Aquaculture in Norway

- 90% of the seafood produced in Norway is Atlantic salmon (*Salmo salar*)
= **1.3 million tonnes in 2016** (~60 % of world production)
- **165 companies with 986 sites** + 98 research licenses



- Max. 200 000 fish /cage
- Slaughter weight: 5 kg /fish
- ➔ 1 000 t fish /cage
- ➔ Up to 15 000 t fish /site



Current Technology and Operations in Aquaculture Industry

- Complex marine operations
- Interaction with the fish
- High risk
- General lack of instrumentation



Current Robotic Solutions in Aquaculture Operations



Photo: Cavit Net Cleaner



Photo: AKVA Group



Photo: YANMAR



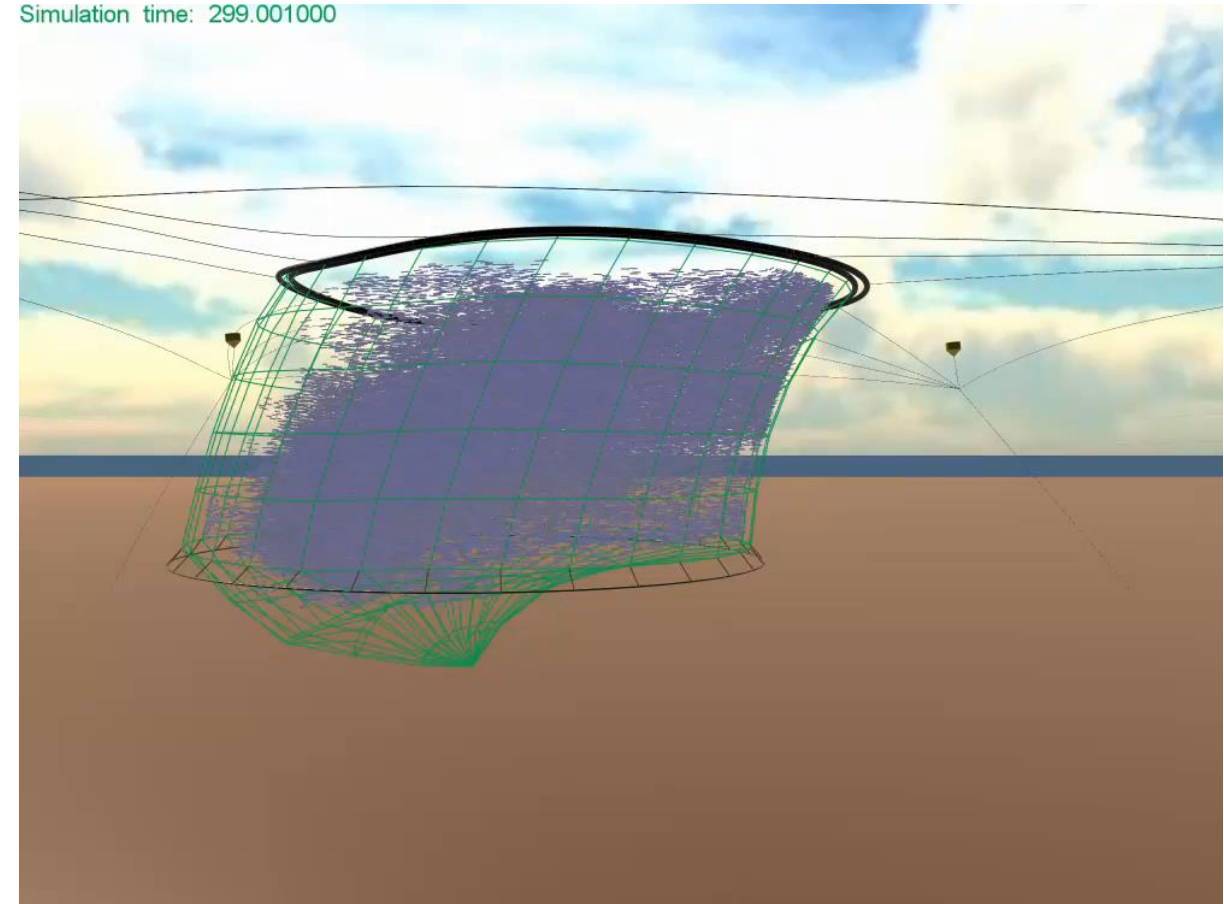
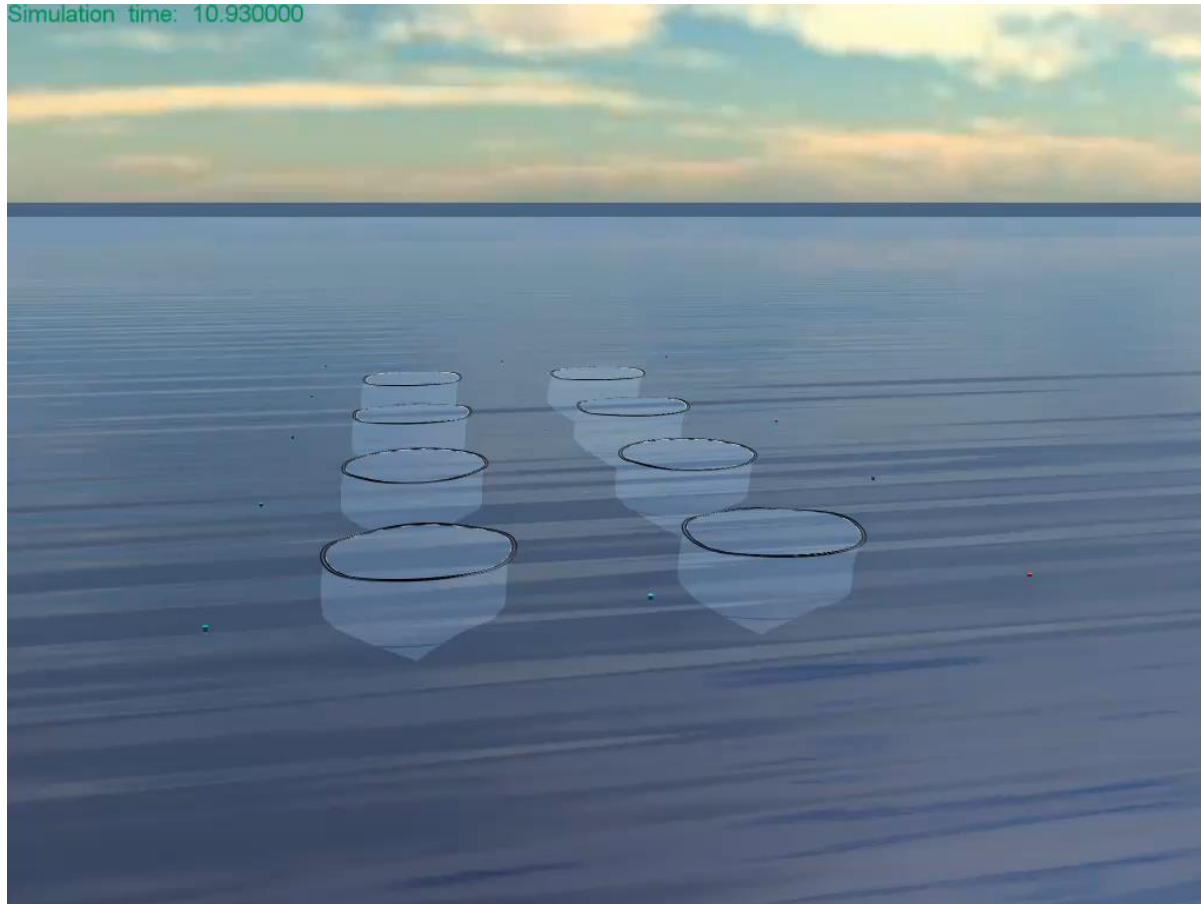
Photo: Ocean AS



Photo: Mithal AS

Operation in Dynamically Changing Environments

Flexible and Deformable Structures





HAUGE AQUA

New concepts – New challenges

Photo: Marius Dahle Olsen

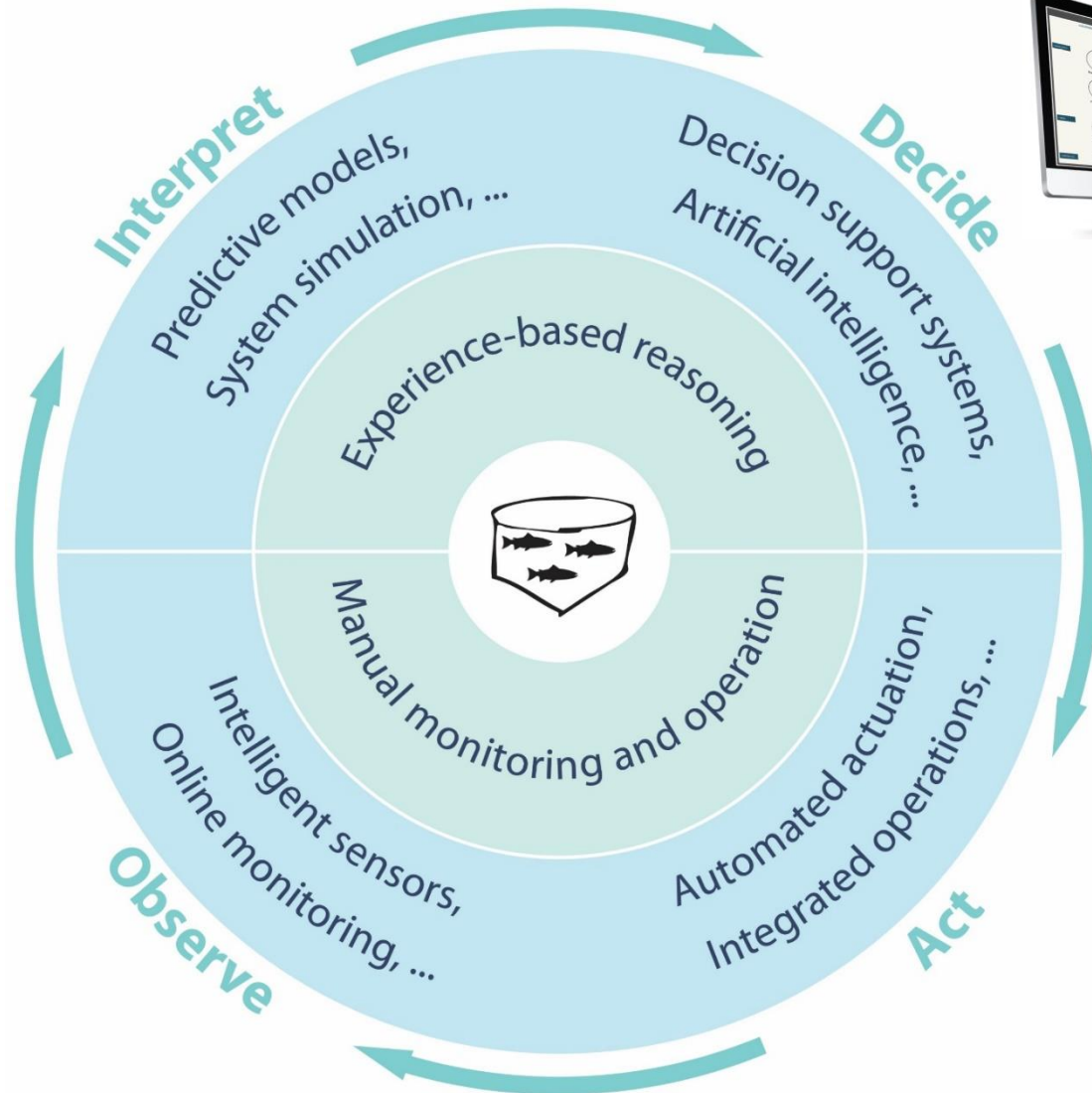
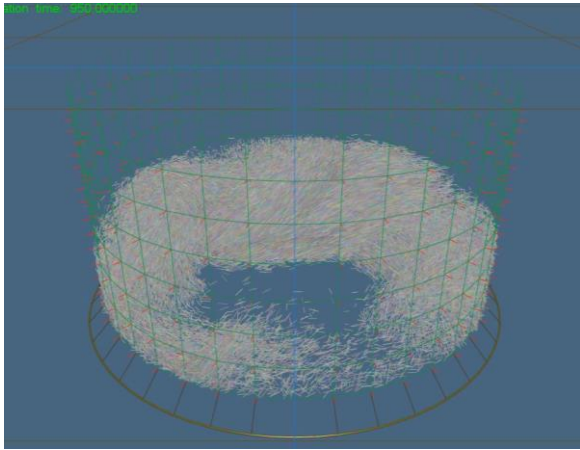
NEEDS FOR AUTONOMOUS *Inspection, Maintenance and Repair* OPERATIONS IN AQUACULTURE

An aerial photograph of a vast aquaculture farm. The water is a deep blue, and the sky is a lighter blue. Numerous circular pens are visible, arranged in a grid-like pattern. A long, thin structure, likely a feed line or mooring system, stretches across the water, connecting various pens. The overall scene is a large-scale industrial operation in a coastal or offshore area.

- More fish farms
- More exposed areas
- Need for autonomous operations
- Strict demands for autonomous IMR operations
- Increase welfare and reduced cost

Precision Fish Farming – PFF

A new framework to improve production in aquaculture - Developed in SINTEF Ocean



SINTEF ACE – Full Scale Aquaculture Engineering Laboratory

Two seaweed farming sites located in Hitra/Frøya.



Tristeinen



Korsneset



Rataren



Hosenøya

Autonomous Aquaculture Robotic Lab - SINTEF ACE

- Fish status
- Cage and mooring inspection
- Net inspection
- Environmental monitoring
- Light intervention

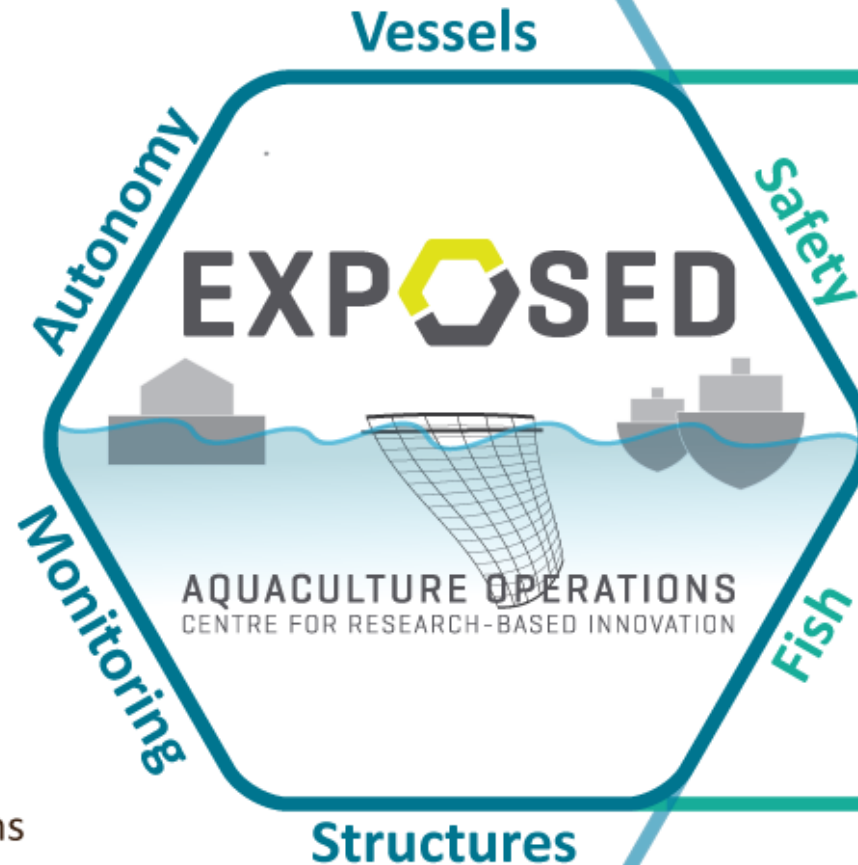


Photo: TNA Fish Machine Interaction project

EXPOSED Aquaculture Operations research centre

Technological innovation

- AREA 1 **Autonomous** systems and technologies for remote operations
- AREA 2 **Monitoring** and operational decision support
- AREA 3 **Structures** for exposed locations
- AREA 4 **Vessel** design for exposed operations



Requirements for sustainable production

- AREA 5 **Safety** and risk management
- AREA 6 **Fish** behaviour and welfare

Relevant Projects

MERDROV-ROV as tool for net cage operations

Developed knowledge, technology and demonstrators for semi-autonomous ROV operation for net inspection and repair

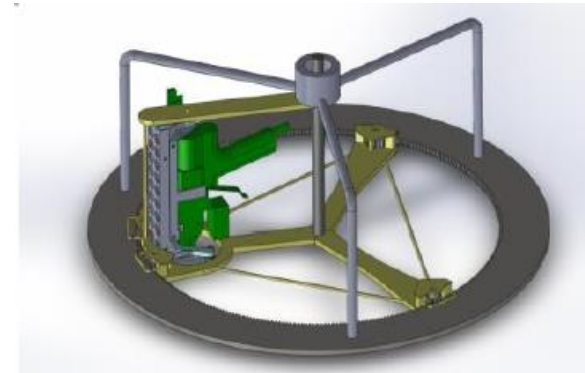
Navigation and motion control – net tracking



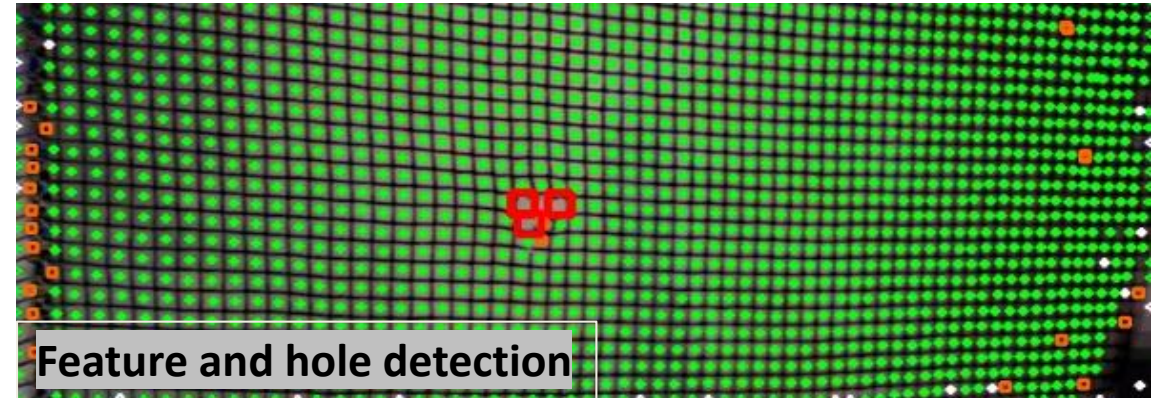
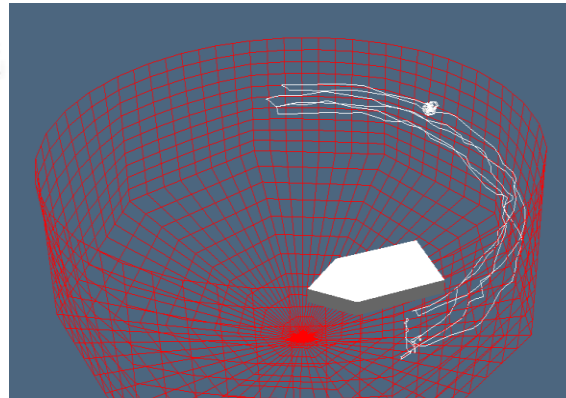
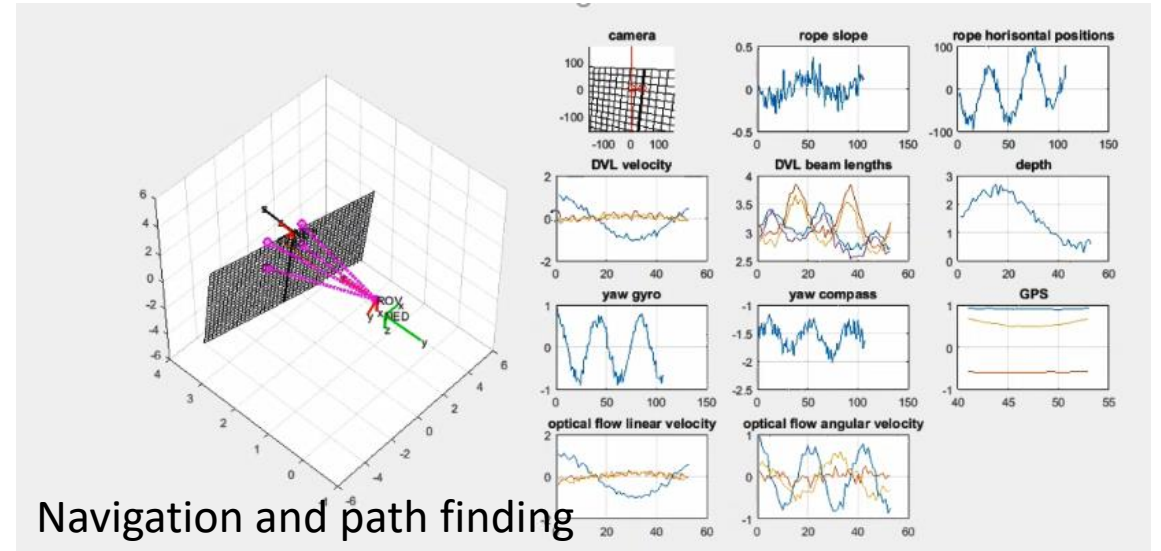
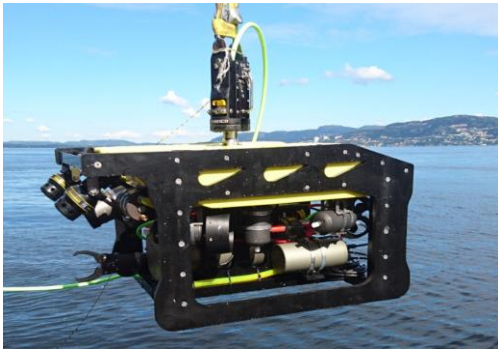
Net failure detection using machine vision



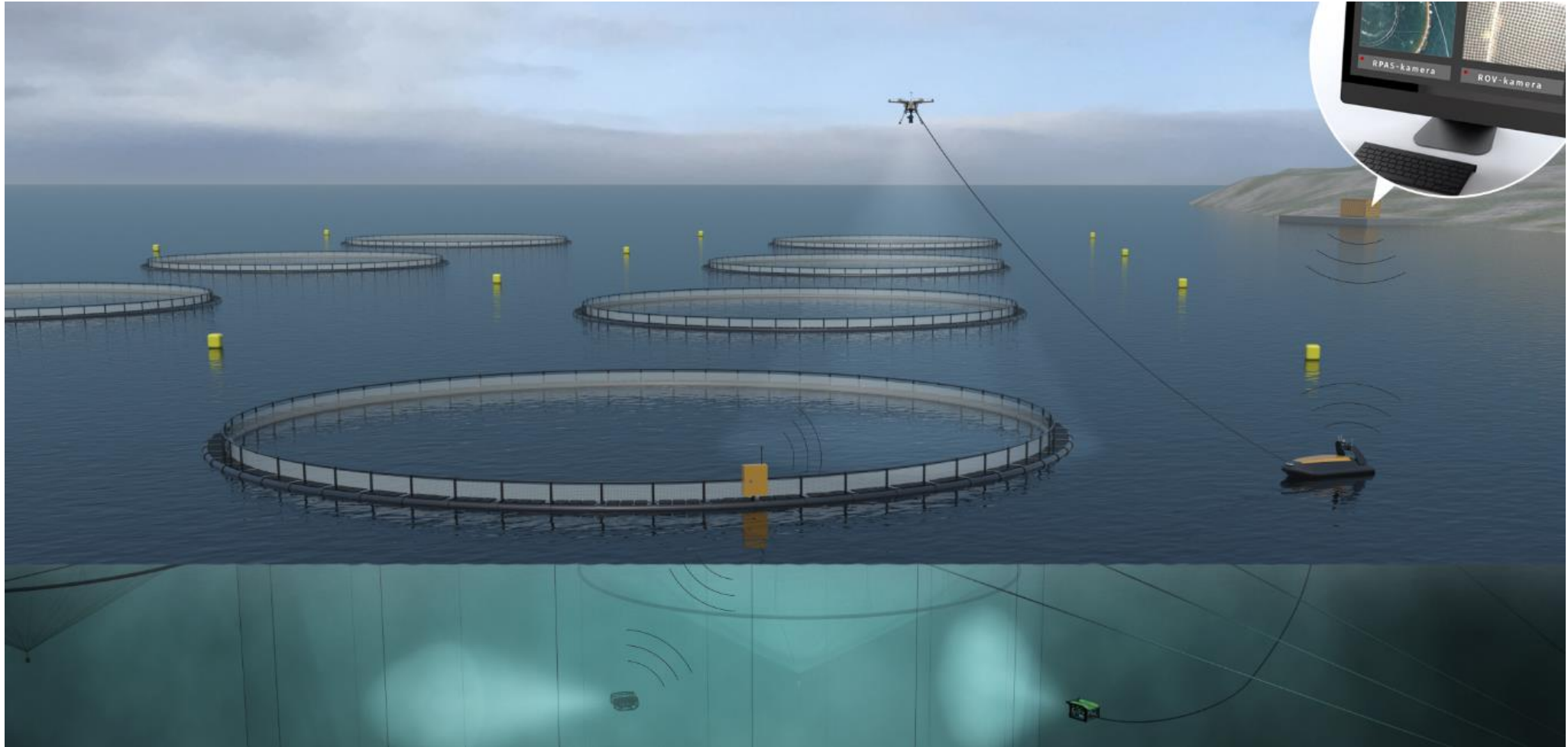
ROV-based net repair tool



Approaches to preventing escapees

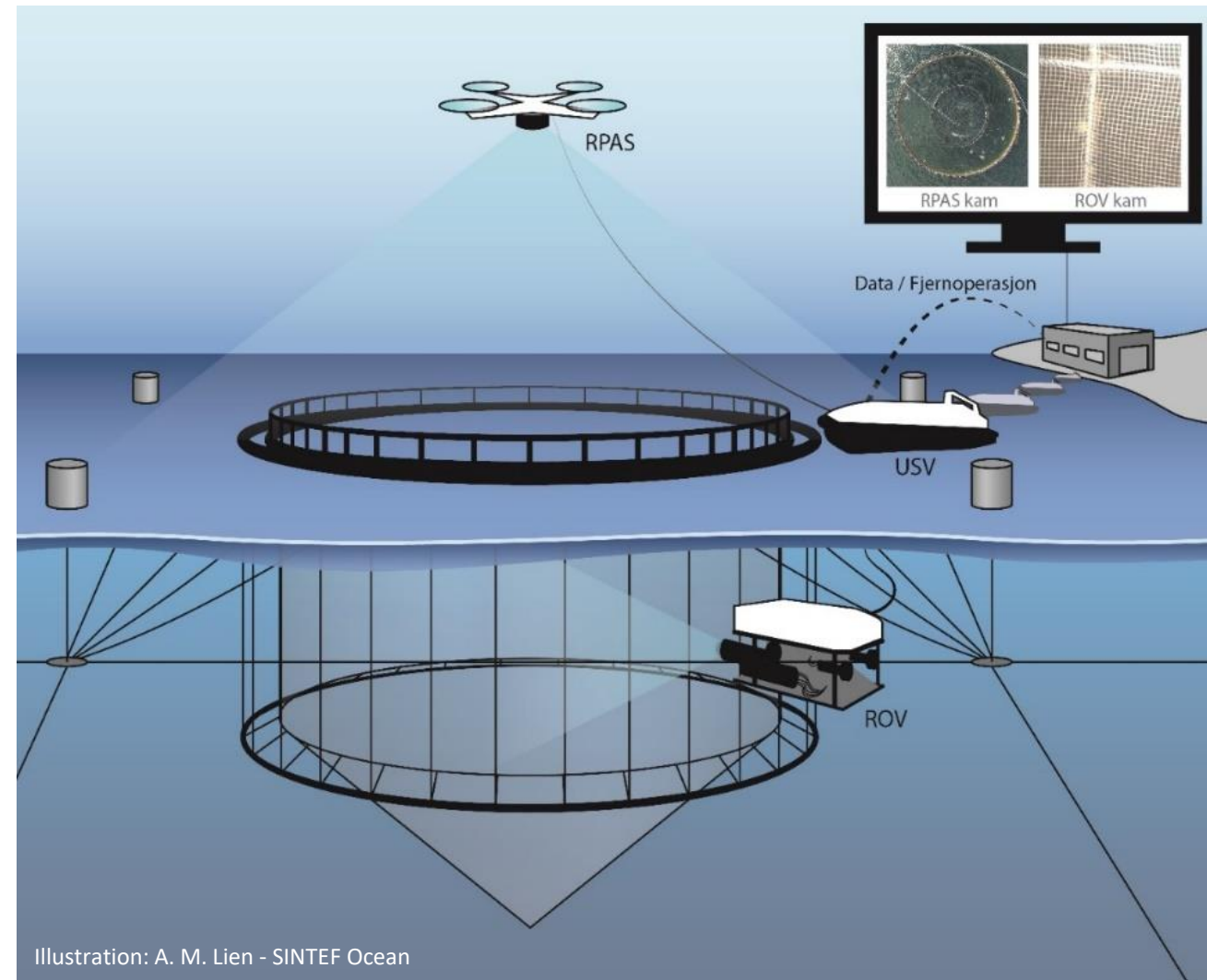


Unmanned Underwater Vehicles (UUVs): Operations in Fish Farms-ARTIFEX Project



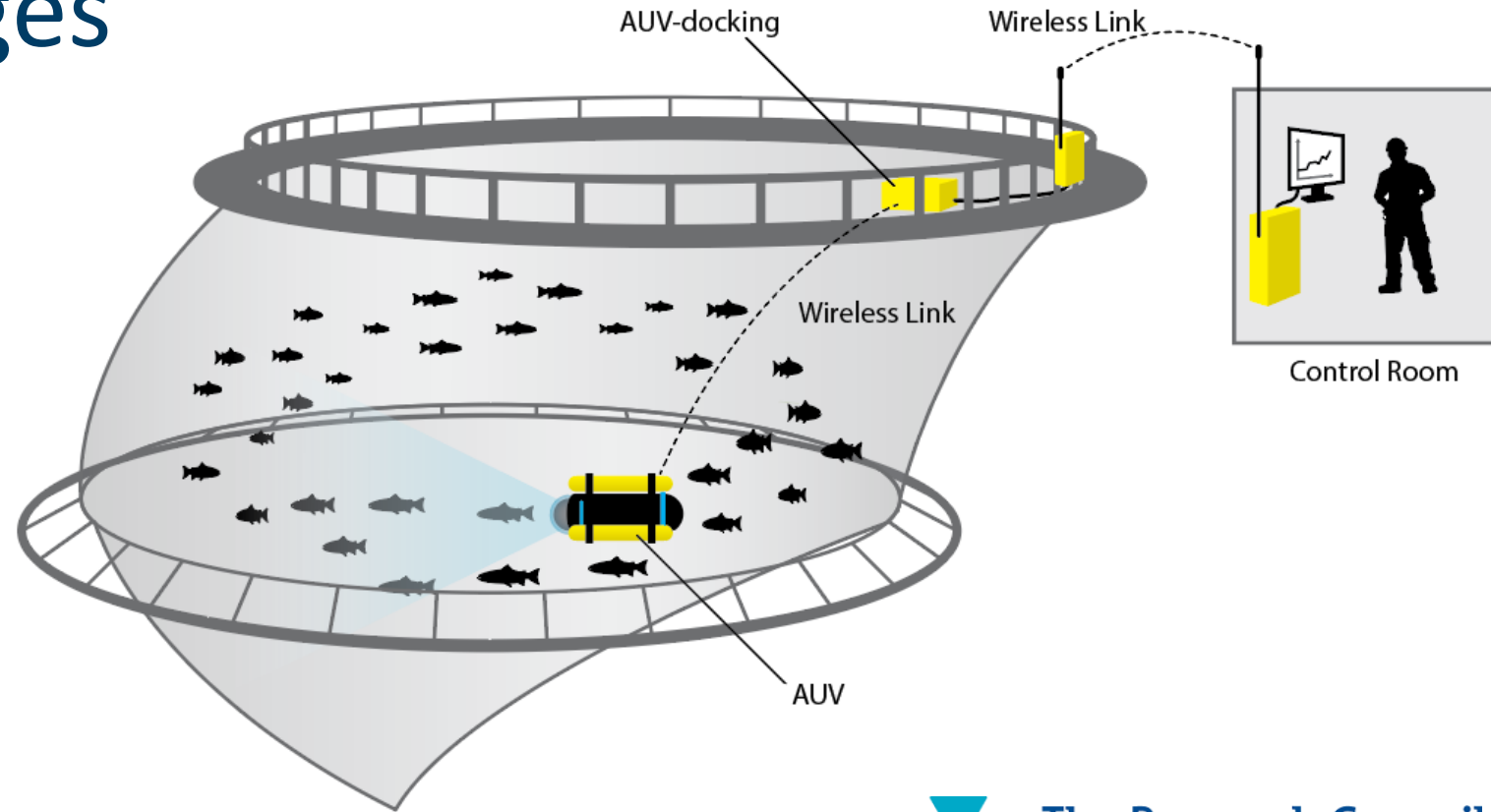
ARTIFEX – Remotely controlled operations

Daily and periodic operations using Unmanned Surface Vehicle (**USV**) as carrier of **ROV** and **RPAS** (Remotely Piloted Aircraft System)



CageReporter – Autonomy and Bio-interactivity in Aquaculture Cages

Resident (24/7), autonomous, non-tethered vehicle (AUV) for high quality data acquisition



INDISAL – Individual based observation

Develop an **individual biometric "finger-print" identification of each salmon**



SINTEF Ocean

Autonomous Aquaculture and Robotic Lab

COMBINE BIOLOGY AND TECHNOLOGY



MULTIDISCIPLINARY RESEARCH



FULL SCALE VALIDATION



SOLUTIONS TO AQUACULTURE INDUSTRY

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Teknologi for et bedre samfunn