TRULY EXPOSED CAGE FARMING
WHAT ARE THE UNKNOWNS OR UNSPOKEN CHALLENGES?

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Development licenses, low oil prices and high salmon prices leads to investments and a high rate of innovation.

Both closed, semi-closed and open systems under development.

The fish farm industry is leaving familiar grounds and its experience from technology and operational procedures.

Significant international potential.
Current exposed salmon sites in Norway

Typical high capacity Norwegian fish-farms

- 15,000 metric tonnes salmon per cycle
- 10 – 16 cages Ø 50 meter
- 40,000 m³ volume per cage and max. 200,000 fish per cage
- 1,000-1,500 metric tonnes/man year
- Exposed but not offshore/open ocean

Photo: SINTEF/ACE
Degree of exposure and technological concepts

Diversification – Experimentation with an aim to utilise the whole coast

- Closed (RAS)
- Semi-closed
- Open, flexible cage
- Sheltered/submergible cage
- More rigid, larger cage

Current exposed salmon sites in Norway
SFI EXPOSED - The coast of Norway offers great opportunities

Significant parts of the Norwegian coast is today unavailable to industrial fish farming due to remoteness and exposure to harsh wind, wave, current and ice conditions. Regular as well as infrequent operations are challenging.

The Exposed Aquaculture Operations Centre will draw upon Norway's strong position in the aquaculture, maritime and offshore sectors to enable safe and sustainable seafood production in exposed coastal and ocean areas.

The centre is funded by the Norwegian Research Council and the 22 centre partners, has a planned duration of 8 years, starting in 2015 and a total budget of 210 MNOK (≈ 22 M USD) and 15-25 PhDs.

Photo: Salmar
6 Research areas

**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

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The "operations" in "EXPOSED Aquaculture Operations"

**Operations - Safer, more controlled and continuous**

Regular as well as infrequent operations are challenging. Postponed operations due to weather:

- Transport of fish
- Treatment of fish
- Daily inspections
- Removal of dead fish

Sites have been abandoned due to difficulties to perform key operations – farm production must be sustained under all conditions.

**Technological innovations** (such as more autonomous systems, offshore structures and vessels) are needed to enable safer, more controlled and continuous operations.
Cost

- Fear of increasing production costs
  - Compared to current technologies – But growth at current sites are limited
  - Compared to salmon price – But favourable conditions for development licenses
- Potential for benefits of harmonized production at several sites with different technology and sheltering
What we (don't) know about exposure

Coastal conditions differs from offshore conditions
Environmental loads on farms are challenging to measure adequately
- Covers large areas with significant variations and interactions
- Flexible structures with costly infrastructure

Relevant classification of exposure
- Includes extreme values, means, combinatory factors and regularity

Serviceability Limit State
- More precise criteria for operations, working environment and fish welfare needed to develop technology
What we (don't) know about the capacity of the fish

- Fish performance and welfare must be ensured in exposed conditions, as well as under the new operational solutions
  - Water current
  - Waves
  - Crowding and behaviour
- Larger units – larger populations
  - Maintaining control
- Fish – structure – wave interaction
  - Volume reduction
  - More rigid nets
Documenting fish limitations and performance

Novel methodology for investigating current tolerance in individual and groups of salmon are developed.

- Small post smolts, large post smolts and adults tested in new swim tunnel
- Post smolts tested individually in the small tunnel
Documenting fish behaviour and state in full scale and harsh environments

**Group data**
- Machine vision
- Sonar

**Individual data**
- Telemetry
- Sensor fish

Biomass estimation; Response of feeding, crowding and other operations; Detection of lice, colour, structures
Standards for new technology and farming sites
- Challenging to find adequate standards for new technologies
- Also shortcomings for current sites and technologies
- Revisions to NS9415 and new proposed DNV GL class

Fragmented regulation
- Several governmental bodies with some overlapping or unclear responsibilities
  - Examples: worker safety, vessel-structure interaction, feed barges
- Need for coordination
Competence and project risks

Some reflections on the current development licenses:

- Many concepts represent **fundamental shifts** - The fish farm industry is leaving familiar grounds and its experience from technology and operational procedures
  - The central structures and technological concept must still facilitate all farm operations
  - New auxiliary systems must be developed

- Larger scale and **larger fish populations**
  - Risk management and contingency planning – how to treat 1 million fish in rough weather?

- **Highly diverse project teams and scopes**
  - How are farmers as customers of highly complex technology?
  - How will the fish welfare be safeguarded when addressing all the technological challenges?
Current technologies will be prevalent, but experimentation the next 5 – 10 years

• A huge potential for new knowledge and solutions

Not an "either or", but rather a "both"

• Combinations of sheltered and more exposed sites

Should gain more than space and increased production

• Increased investments should result in more robust, safe and efficient fish farming
Technology for a better society