The digital future in aquaculture: opportunities and challenges

Lars Ebbesson
Norwegian Research Centre (NORCE)
laeb@norceresearch.no

AquaNext Stavanger Nov 15, 2023

NORCE

Divisions

Departments

Research Groups

Technology

Enabling Technologies
- Digital Systems
- Autonomous Systems & IoT
- Smart Instrumentation & Industrial Testing
- Modelling & Simulation
- Measurement Science

Observing Systems
- Drones & Autonomous Systems
- Earth Observation
- Ocean & Coast

Energy
- Drilling & Modelling
- EOR SCAL
- Sustainable Energy Research Labs
- Data Assimilation & Optimization
- Subsurface Characterisation, Simulations & Geomatics
- Computational Geoscience Modelling
- Well Operations & Risk Management

Society & Health

Centres
- Bivirkning
- RKBU Vest
- NKLM-Legevaktmedisin
- AFE-Allmenmedisin

Welfare, Employment Health
- GAMUT-Musikterapi
- Arbeidsliv og Inkludering
- Helsetjenste & Helseøkonomi
- Arbeidsliv & Innovation
- Velferd

Sustainability & Restructuring
- Transformation in Public Sector
- Climate, Environment & Sustainability
- Regional Development
- Center Modelling Social Sciences

Climate & Environment

Biotechnology & Circular Economy
- Industrial Biotechnology
- Marine Biotechnology
- Gene Technology

Ocean & Environment
- Fish Biology & Aquaculture
- Marine Ecology
- LFI
- Molecular Ecology & Paleogenomics
- Ocean Observations

Climate
- Forecasting Eng.
- Regional Climate
- Earth Systems

Commercialisation

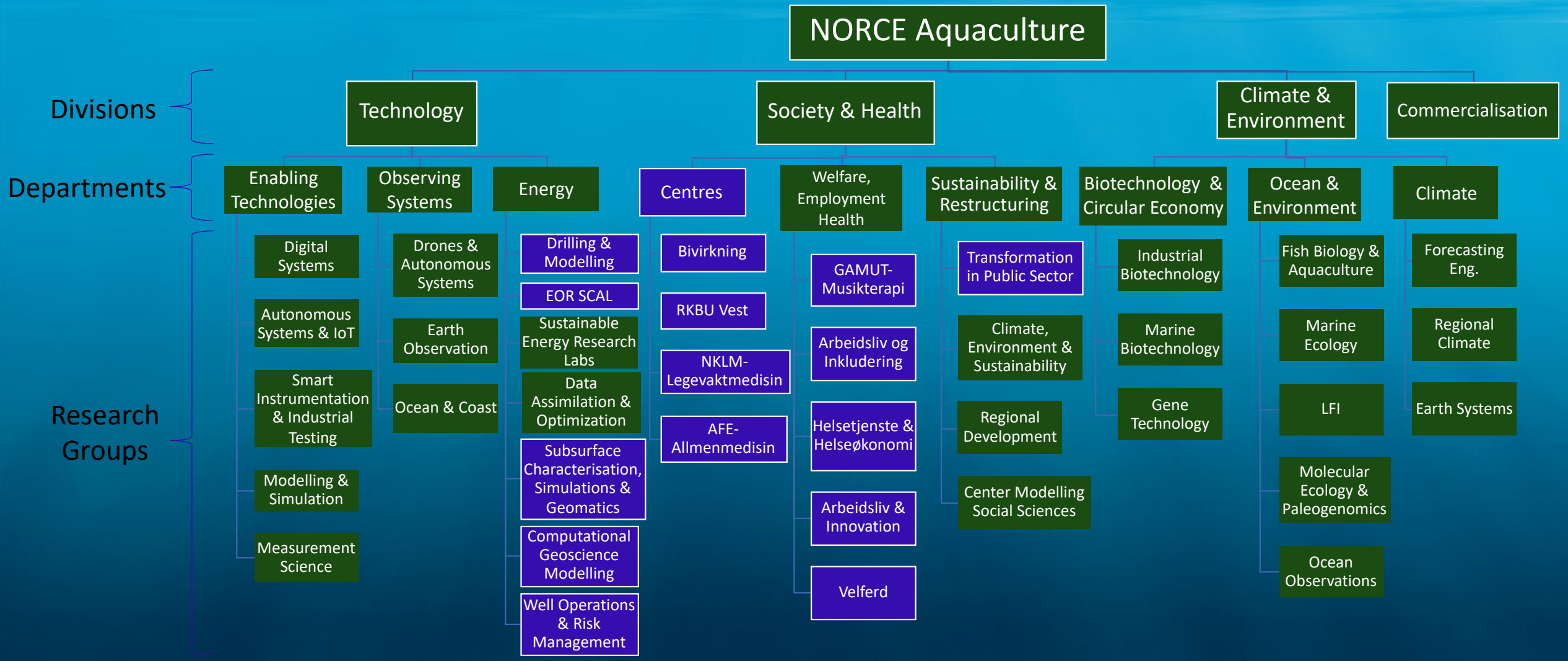
>950 mill

>850 employees

>50 nationalities

75% doctoral degrees

NORCE



Under the 3 Divisions and 9 Departments there are 23 Research Groups (green) and over 100 researchers at NORCE that contribute to sustainable aquaculture research across the value chain for industry, society and the environment.

NORCE Aquaculture

Contributions across the entire value chain

Broodstock	Eggs	Feed	Fish Biology	Production Systems	Environment Impacts	Energy/ Transport	Circularity	Product	Stakeholder Engagement
Monitoring	Early development	Production sustainable feed ingredients	Development	Semi-closed containment RAS Open-cages IMTA	Ecotoxicology	Optimization	Circular economy	Block-chain	Consumer confidence
Biological traits	CRISPR	Fish nutrition/ physiology	Physiology	Biological & Environmental assessments	Climate predictions	Green Energy Systems	Waste to value	Traceability	Policy
Climate predictions	Environment requirement	Functional feeds	Neuroscience	Autonomous operations & control	Wild fish assessments	Green transportation	LCA	Consumer confidence	Regional planning
		Feed evaluation	Stress	Sensors	Location impacts	Logistics	Regional impacts	Health	Consumer engagement
		Feeding	Welfare	IoT	Climate footprint		Socio-economic impacts		Regulations
			Health	Digital twins	Sea lice				
			Disease	Data analytics	Disease				
			Nutrition	Drones	Plastic				
			Microbiome	Location assessments	Sea floor				
			Behaviour	Coastal zone planning	Microbiome				
			Environment						
			Production Biology						
			Digitalization						
			Telemetry						

NORCE

Aquaculture Sector Challenges

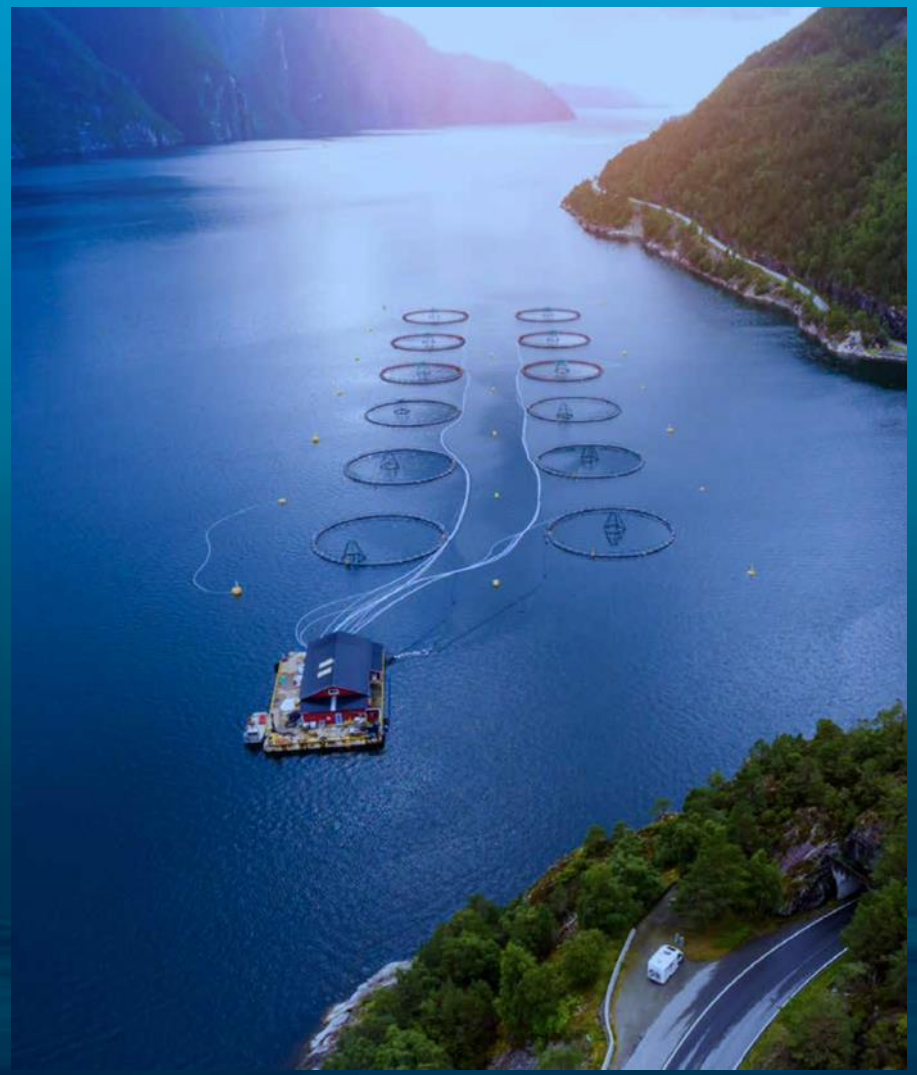
- **Environmental limitations**
  - Common space use and sustainability
  - Waste from aquaculture
  - Escapees: genetic interactions with wild populations
- **Feed sustainability**
  - 3-8% uneaten feed
  - Alternative feed ingredients
- **Welfare, disease and parasite problems**
  - Emerging new diseases especially viruses
  - Outbreaks of existing diseases
  - Parasites, wounds and other welfare events
- **Impacts of climate change on aquaculture**
  - Regional changes and food security

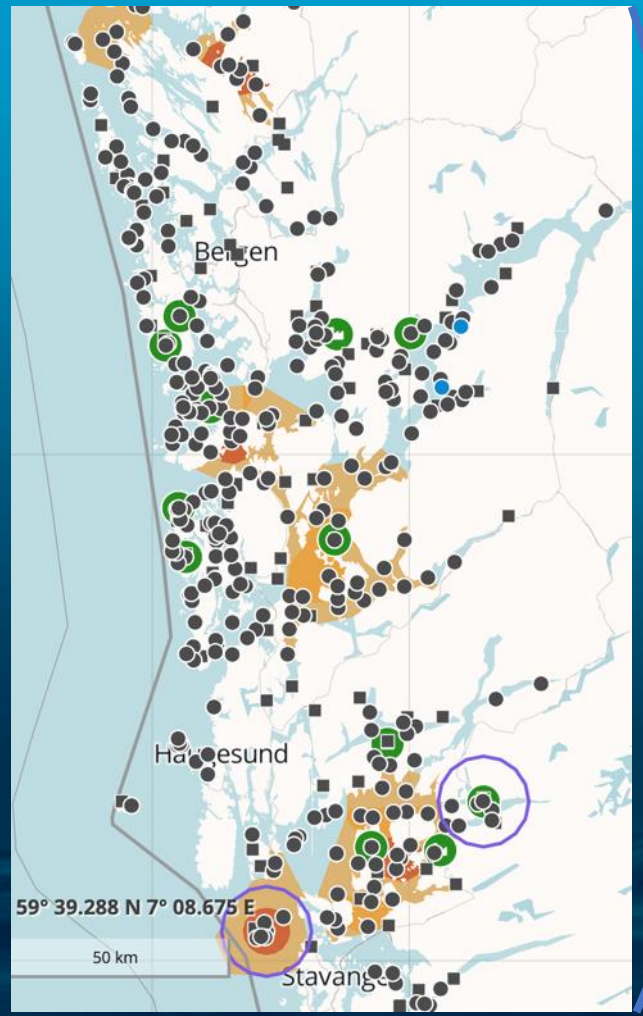
NORCE

Salmon aquaculture

Large and remote systems

Fish farming companies have extensive remote sites spread along the coast and are moving offshore





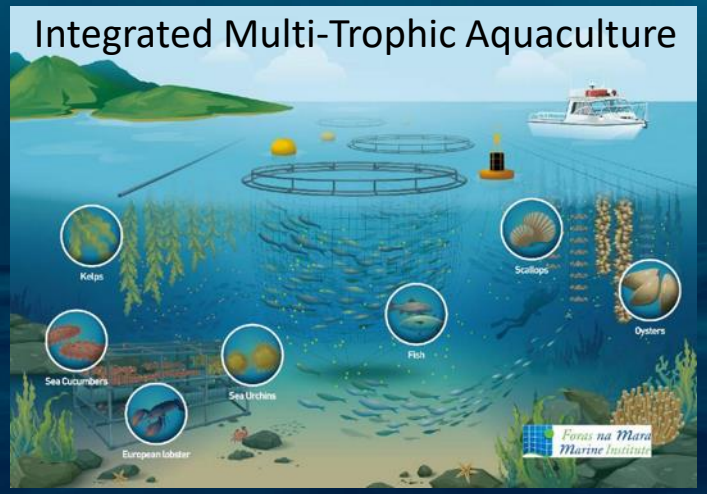
NORCE

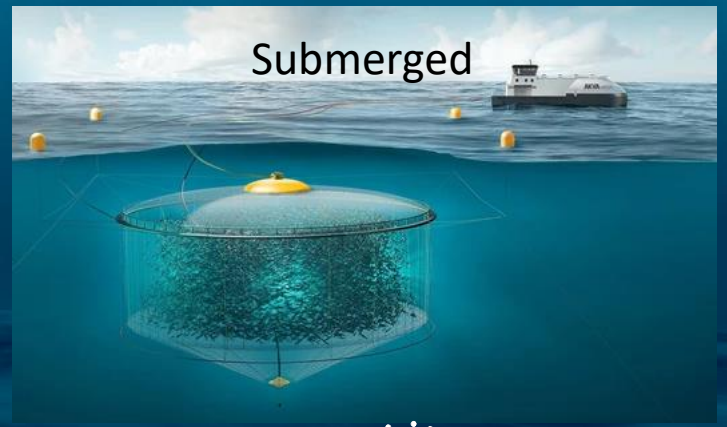
New production systems

to overcome the challenges development of RAS, Semi-closed, and off-shore and exposed more remote areas

Aquaculture Sector Responses

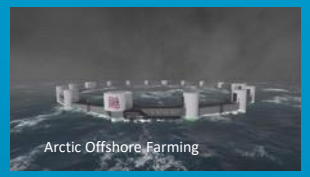
Closed & Integrated Production Systems



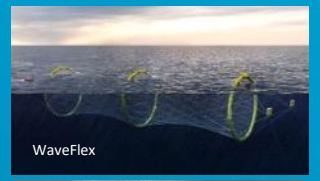


NORCE

Exposed concepts


Arctic Offshore Farming

Atlantis Subsea Farming


WaveFlex


Octopus

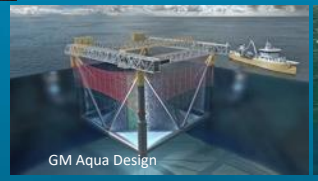

Hex Box

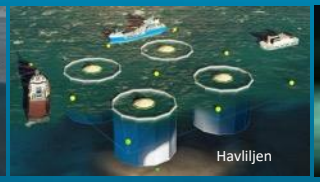

Havfarm 1 og Havfarm 2


Unitech Salmo Solar


Øymerd


North Sea Fishfarm


GM Aqua Design

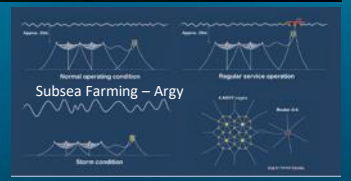

Havliljen


Aquastorm


Gigante Offshoremerd

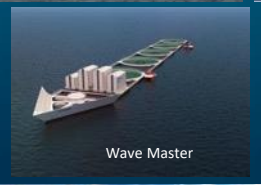

Viewpoint Seafarm


Spidercage



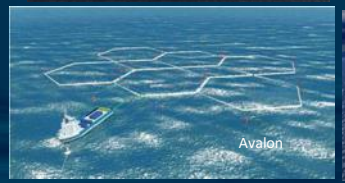

Ocean Farm


Smart Fish Farm


Wave Master


Beck Cage


Blue Farm

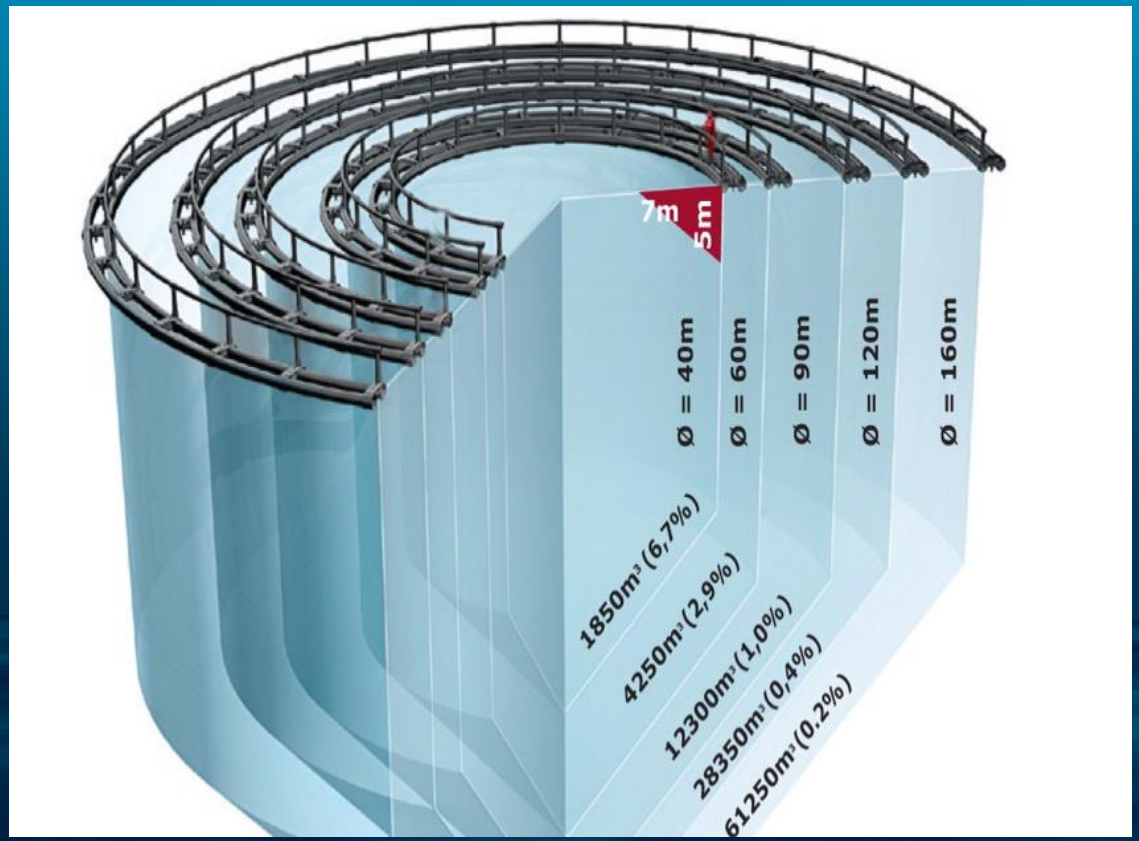

Avalon


OceanGlobe


Aqua Semi

- Remote off-shore
- Large production per unit
- High investment

Production systems today reduce our knowledge of the fish

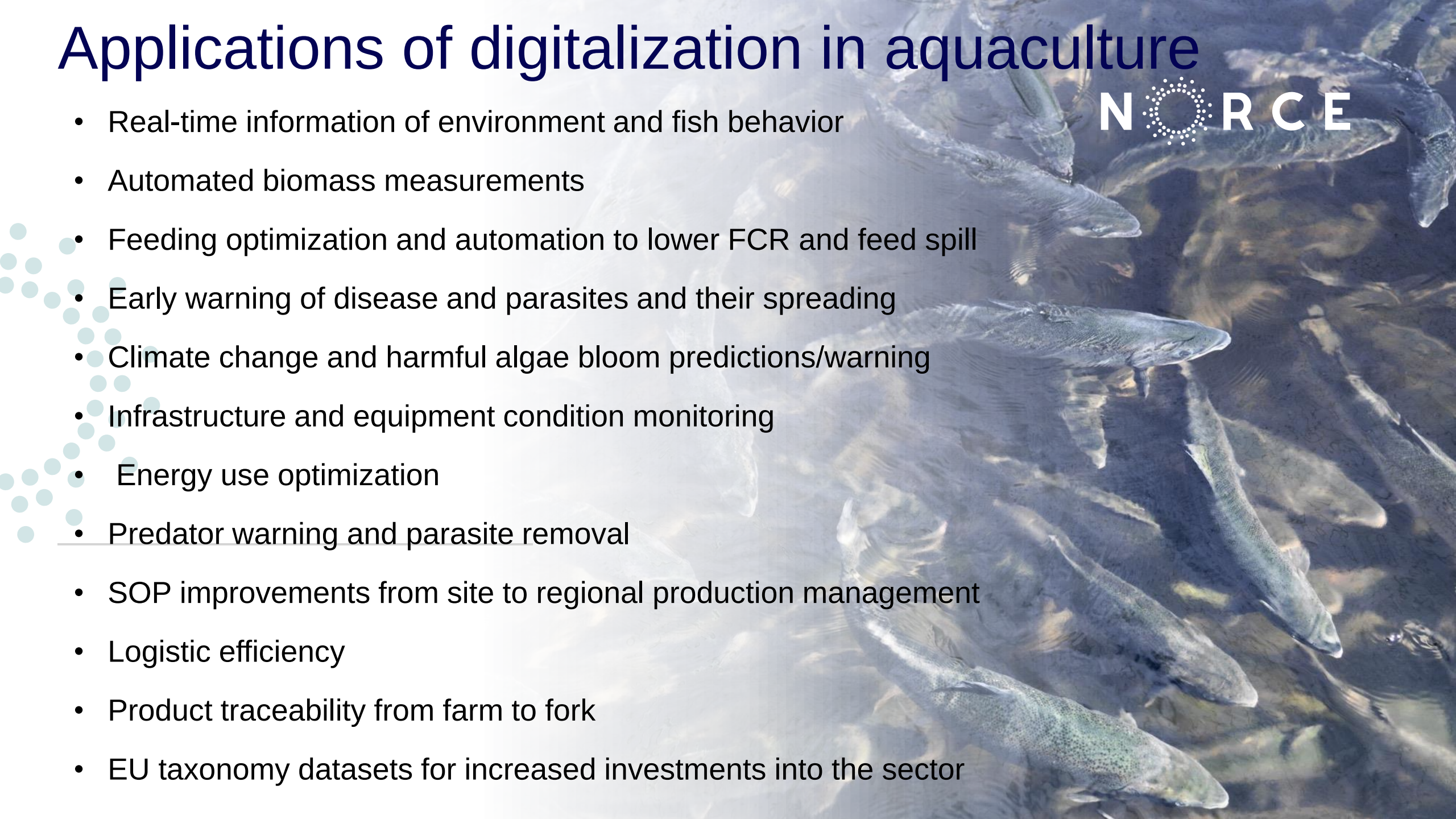


Machine vision and AI will improve sector sustainability

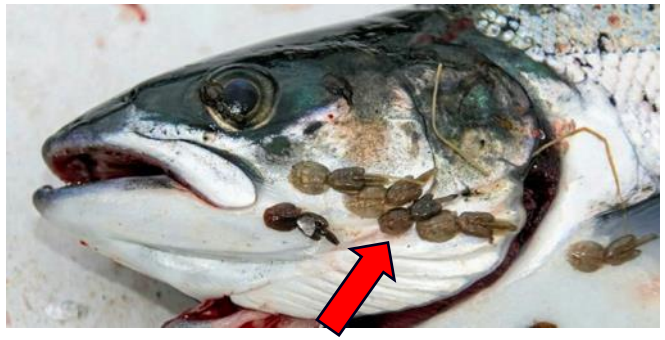
Smart farming

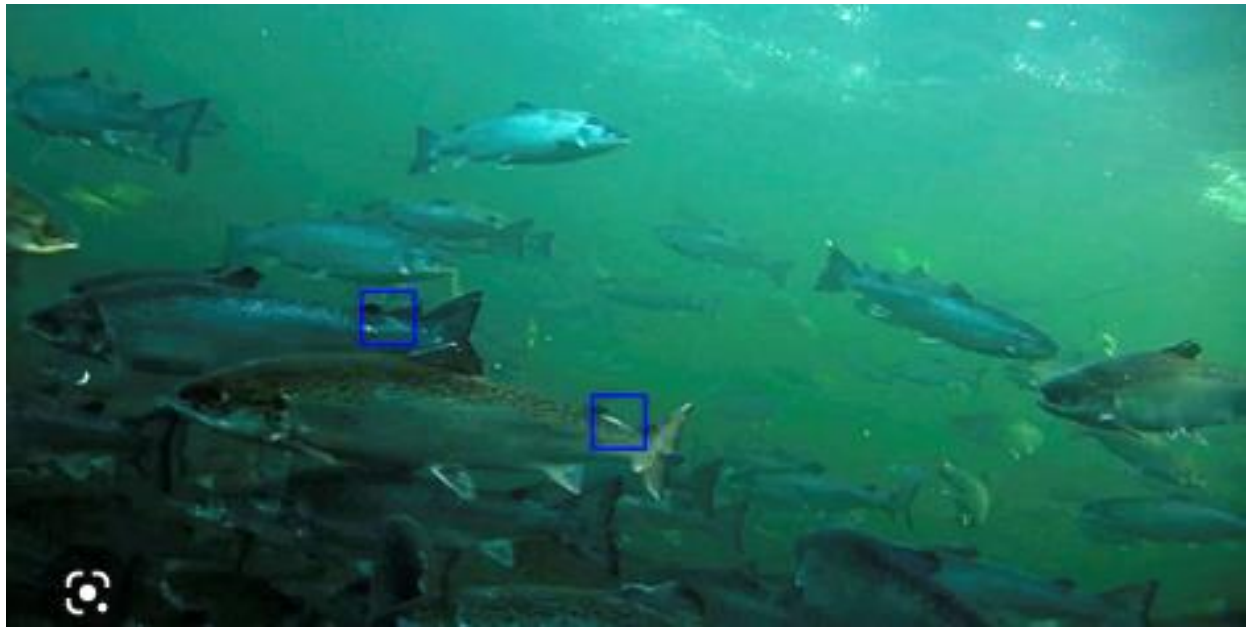
Applications of digitalization in aquaculture

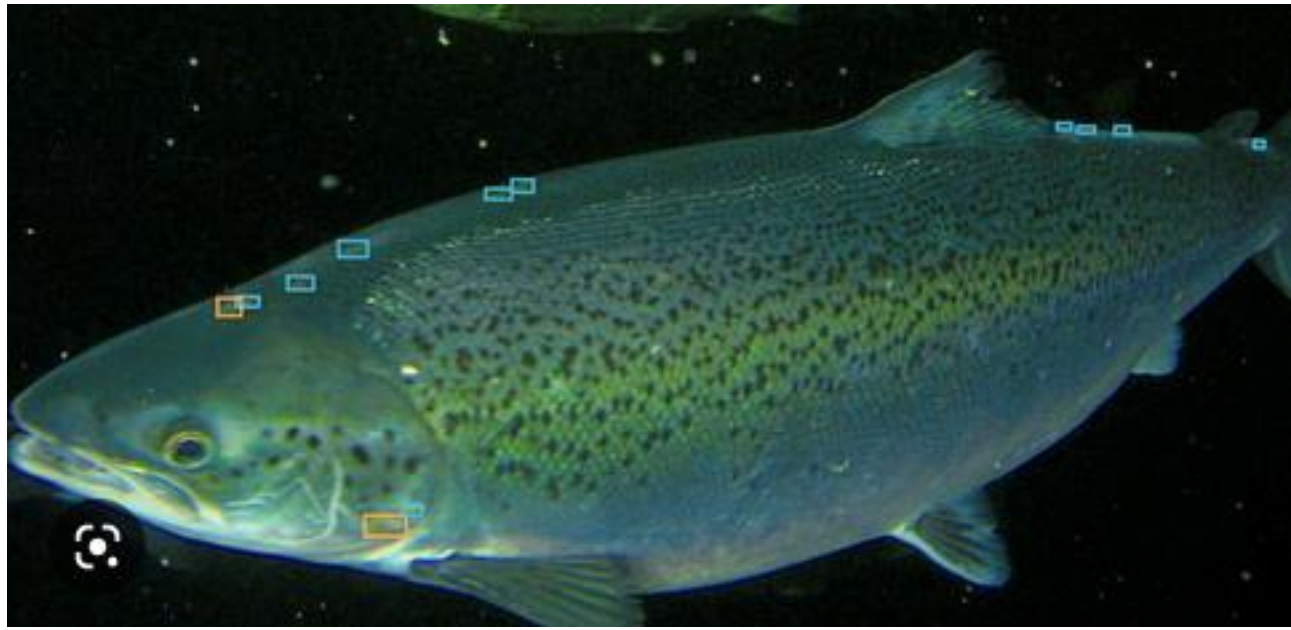
- Real-time information of environment and fish behavior
- Automated biomass measurements
- Feeding optimization and automation to lower FCR and feed spill
- Early warning of disease and parasites and their spreading
- Climate change and harmful algae bloom predictions/warning
- Infrastructure and equipment condition monitoring
- Energy use optimization
- Predator warning and parasite removal
- SOP improvements from site to regional production management
- Logistic efficiency
- Product traceability from farm to fork
- EU taxonomy datasets for increased investments into the sector



Automatic lice counting







Machine vision and lasers kill sealice on salmon in pens like Star Wars

https-//youtu.be/HBAXFN0yQVI

https://www.youtube.com/watch?v=bZxw-Ji7K94

Hydroacoustics

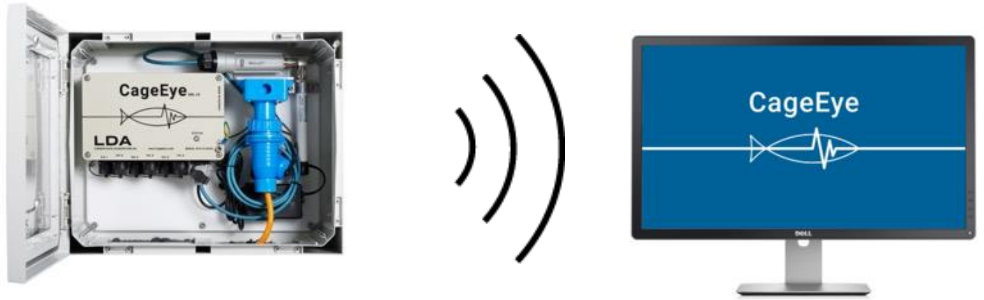
Sound waves echoing off swim bladder;

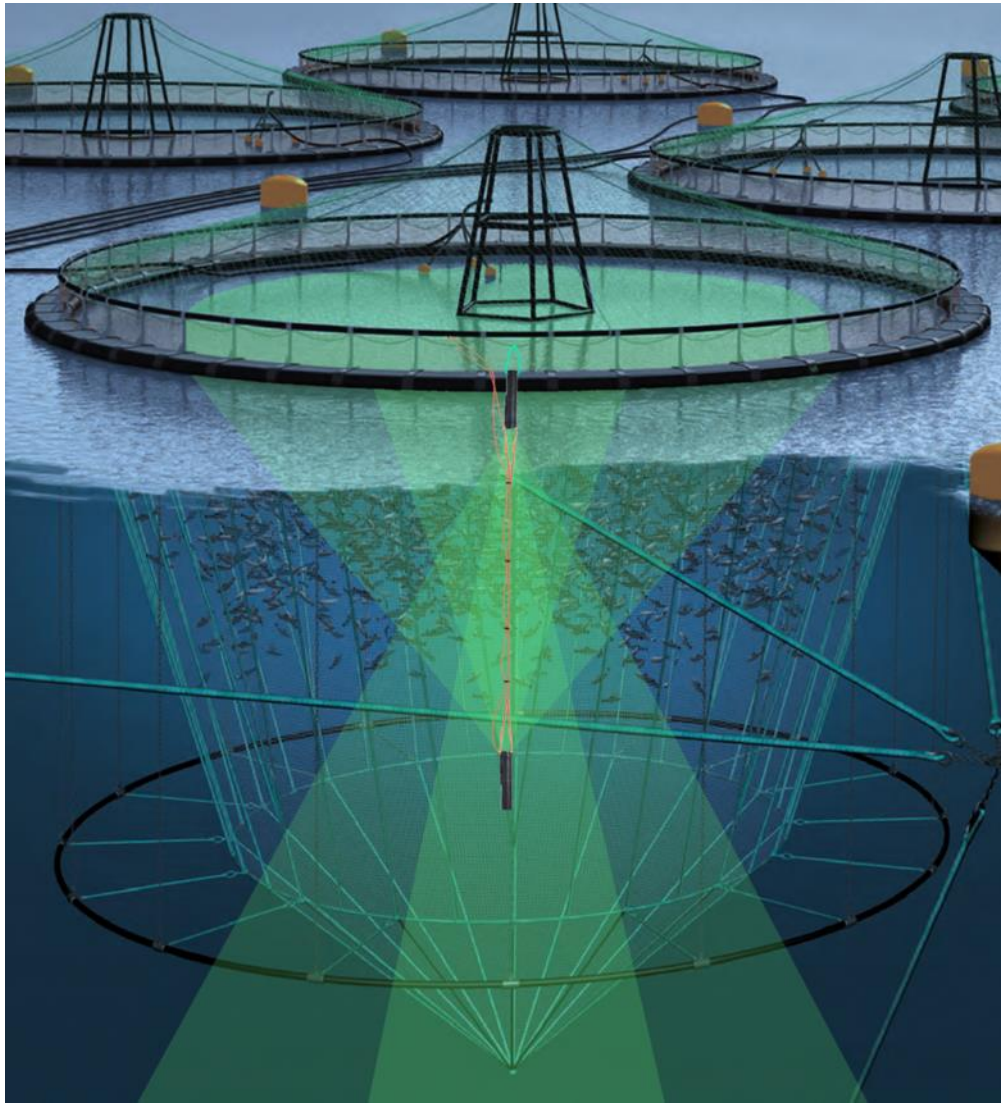
Cover large volumes

Measuring every second

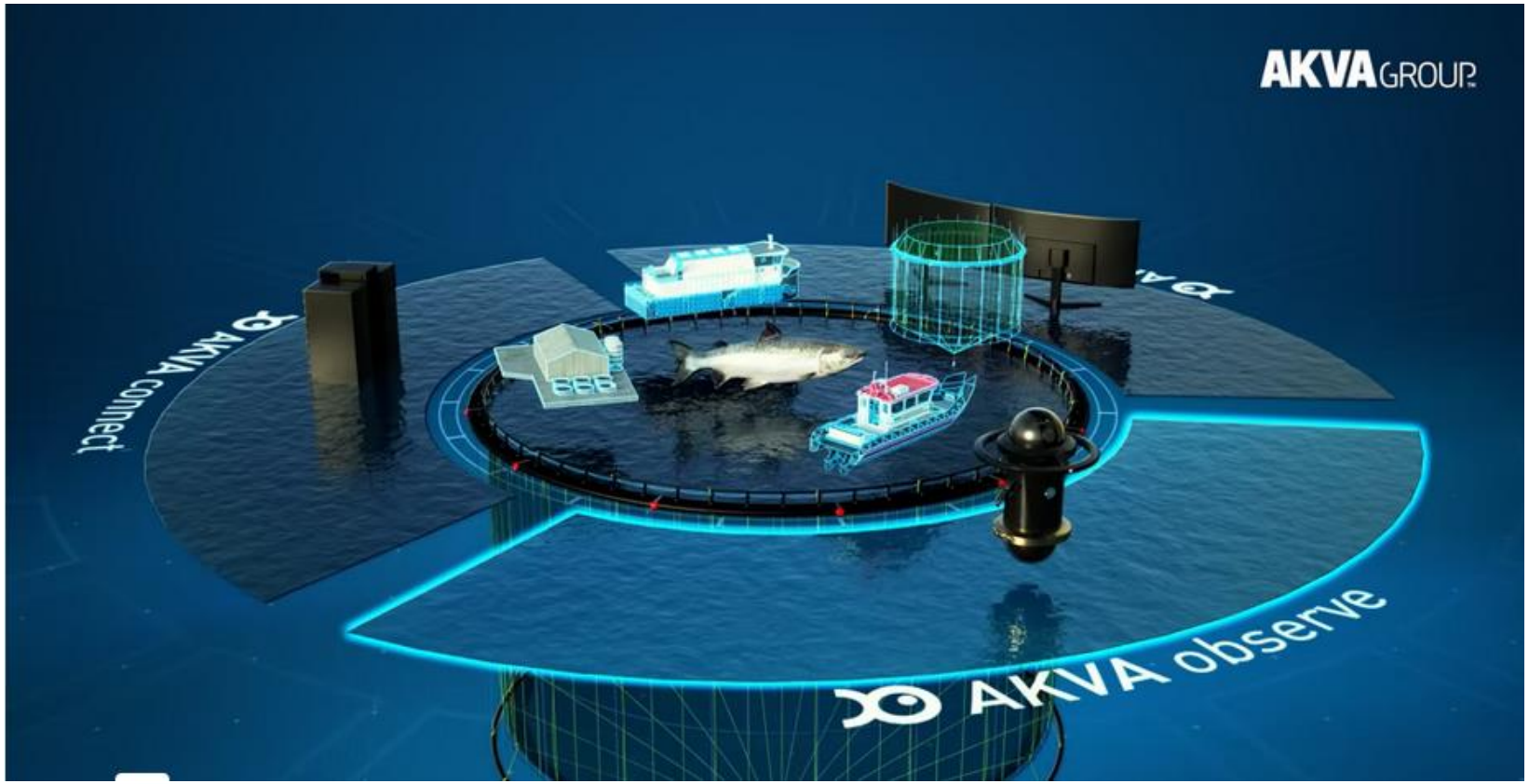
Independent of light, water quality

Little maintenance





In fish sensors for position, heartbeat and activity



AKVA connect

Management system for fish farming

AKVA fishtalk

Production control and planning system

AKVA ecosystem

The glue between digital solutions

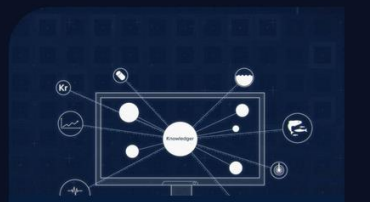
AKVA observe

Artificial intelligence in feeding

SCALE AQ

Barge Control

FeedStation



Knowledger

Mercatus Farmer

Mercatus Finance

Mercatus Future

Mercatus Vet

Vision

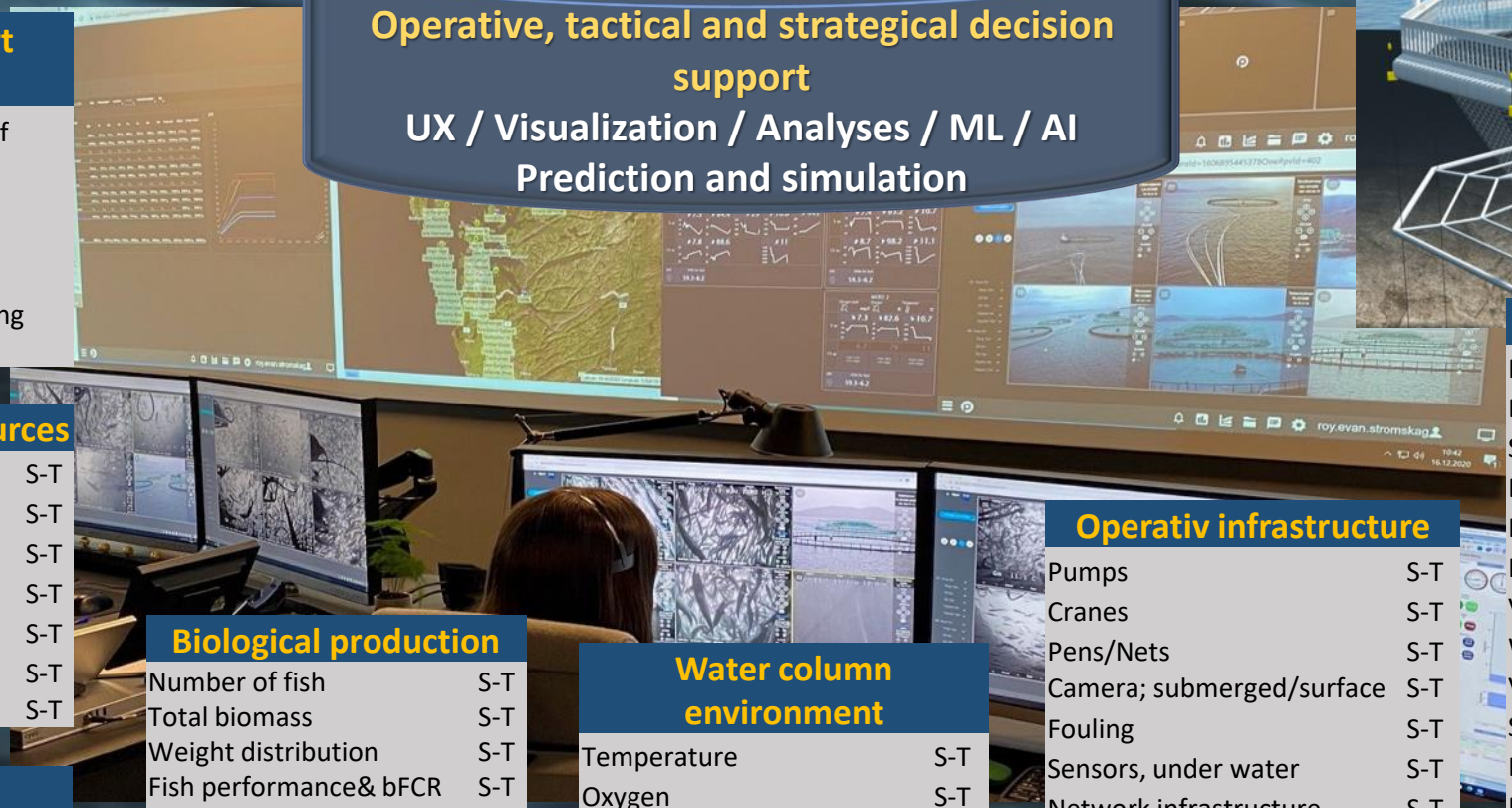
Future control systems, surveillance and operation of remote semi-autonomous aquaculture farming

Control systems

Operative, tactical and strategical decision support

UX / Visualization / Analyses / ML / AI

Prediction and simulation



Decision support ecosystems

- Process optimization of aquaculture at sea
- Increased survival
- Preventive biosafety
- Real-time digital environment monitoring
- Digital twins

Open accessible sources

Weather forecast	S-T
Waves; frequency/height	S-T
Current map/prediction	S-T
Coastal current	S-T
Tidal current information	S-T
AIS – traffic information	S-T
Pollution warnings	S-T

Other sources

Area surveillance (algae)	S-T
Surveillance of marine biology	S-T

Biological production

Number of fish	S-T
Total biomass	S-T
Weight distribution	S-T
Fish performance& bFCR	S-T
Fish behavior monitoring	S-T
Skin health status	S-T
Maturation	S-T
Heart associated diseases	S-T
Lice counts/handling	S-T
Mortality handling	S-T

Water column environment

Temperature	S-T
Oxygen	S-T
Current strenght and direction	S-T
Salinity	S-T
Turbidity	S-T
Light (Lumen)	S-T
++	

Operativ infrastructure

Pumps	S-T
Cranes	S-T
Pens/Nets	S-T
Camera; submerged/surface	S-T
Fouling	S-T
Sensors, under water	S-T
Network infrastructure	S-T
Winches	S-T
Net cleaners	S-T
Drone	S-T
Feeding system	S-T
Feed storage, status and type	S-T

Platform status

Mooring stretch load	S-T
Displacement / Icing	S-T
Stability / GZ	S-T
Energy consumption	S-T
Hatches	S
Heating	S-T
Vibration	S-T
Water intrution	S
Ventilation	S
Storage of chemicals	S-T
Ensilage tanks	S-T
Mooring	S
Rescue equipment	S
++	

S = Status
T = Trend

From GSF

Digitalisation challenges in aquaculture

- Outdated sensor data standards
- Industry fragmented digital infrastructure
- Inadequate real-time sensing/understanding of fish biology and environment
- Great span in digital maturity in the industry.
- Reluctancy of sharing data between salmon farmers.

- Insufficient access to data from industry (data sharing)
- Insufficient prediction and decision support tools
- Holistic data analytics for industry

Scaling of understanding and applications

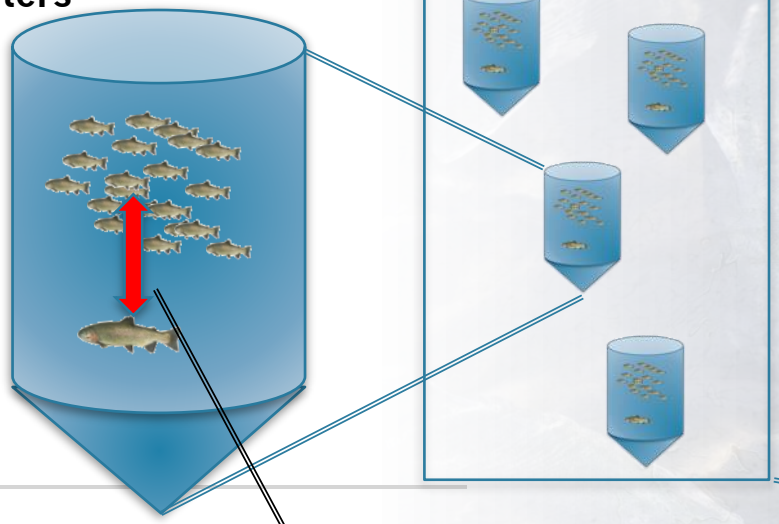
Digitizing Production Sites

Environmental Parameters

- Density
- Temperature
- Light
- Water speed
- Water quality
- Salinity
- Noise
- Organisms

Biological Parameters

- Growth, FCR
- Feeding,
- Stress
- maturation
- Welfare
- Physiology

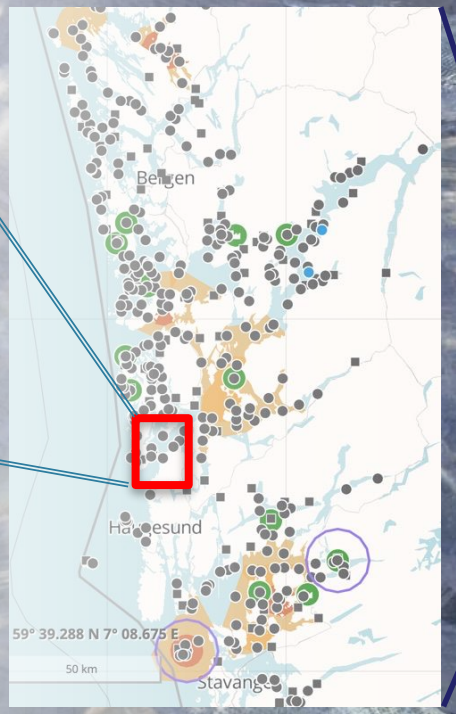


Site-to-Site Interaction

Individual and population

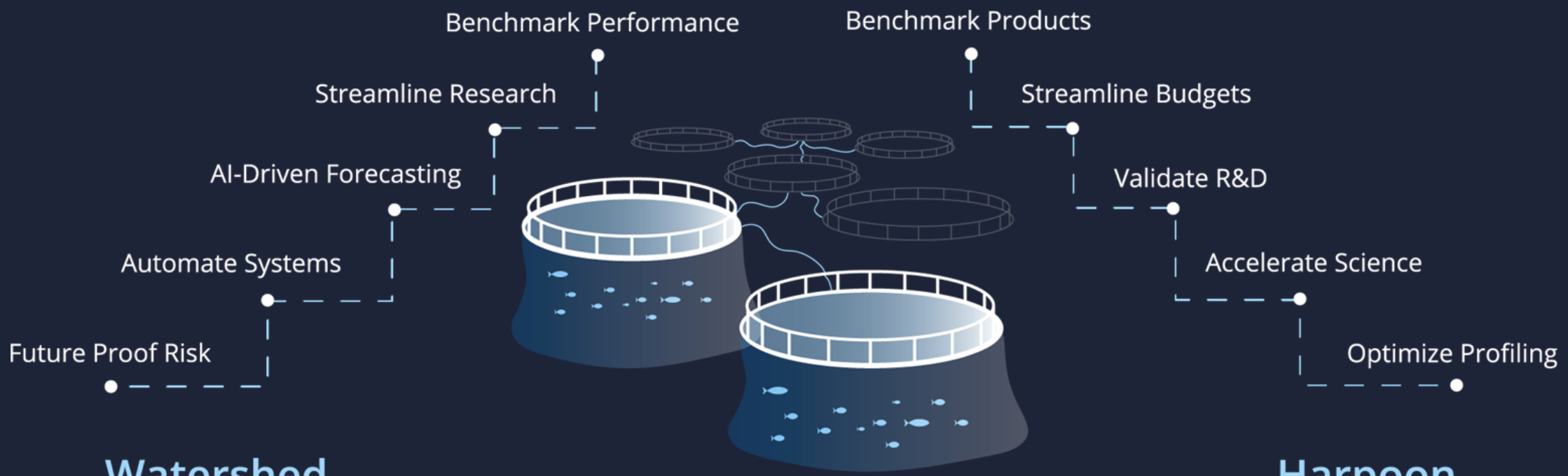
Sentinal fish/Cameras/hydroacoustics

Regional



National

Manolin Overview



Watershed

For Farmers

Harpoon

For Suppliers

Benchmarking

Fish Health

Research

Forecasting

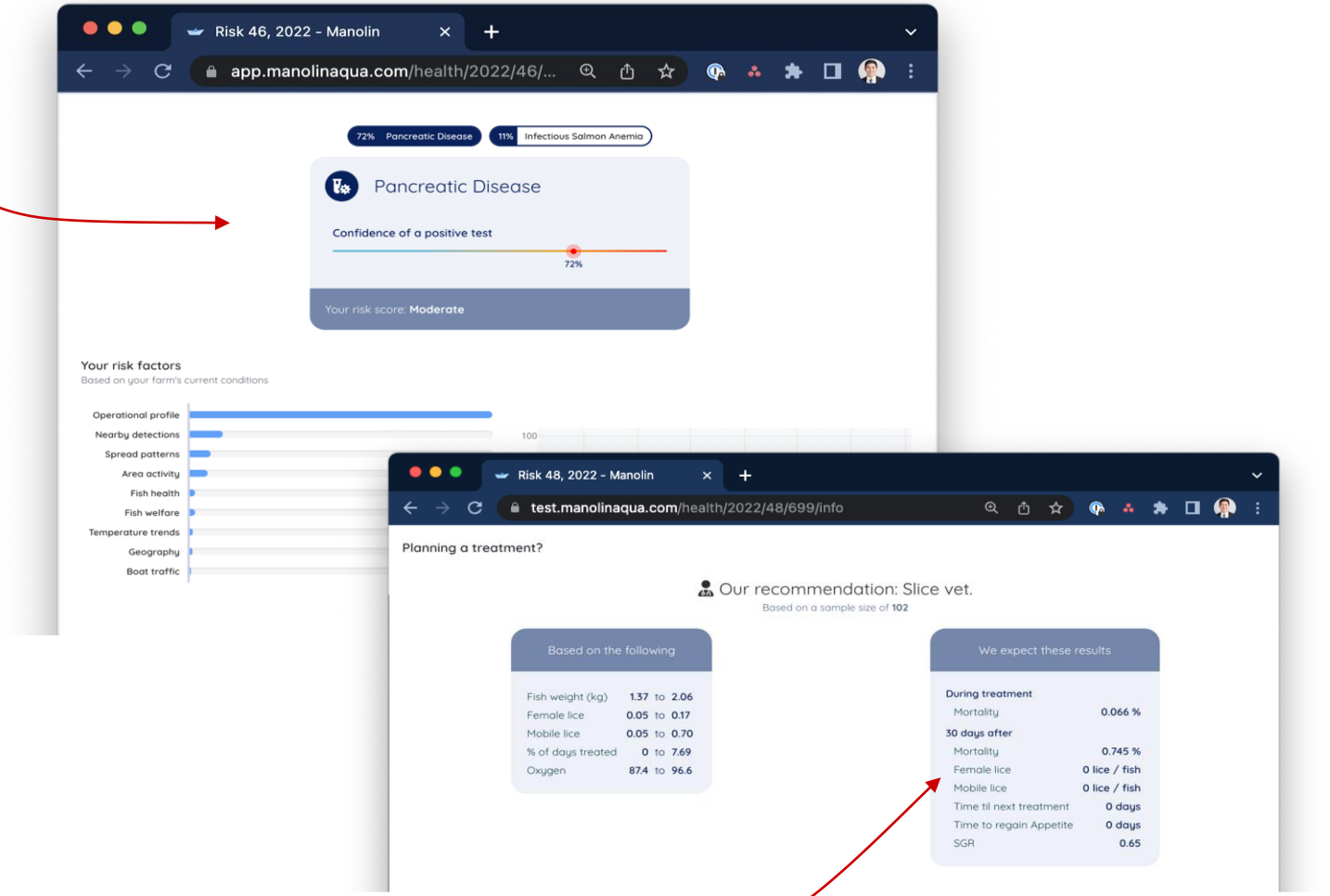
Performance Insights

Risk Analysis

MANOLIN WATERSHED (*For Farmers*)

An AI-power farm specific analytics system

AI DRIVEN EPIDEMIOLOGICAL MODELS



PERSONALIZED CUSTOM RETURN ON INVESTMENT ANALYSIS

KVARØY ARCTIC

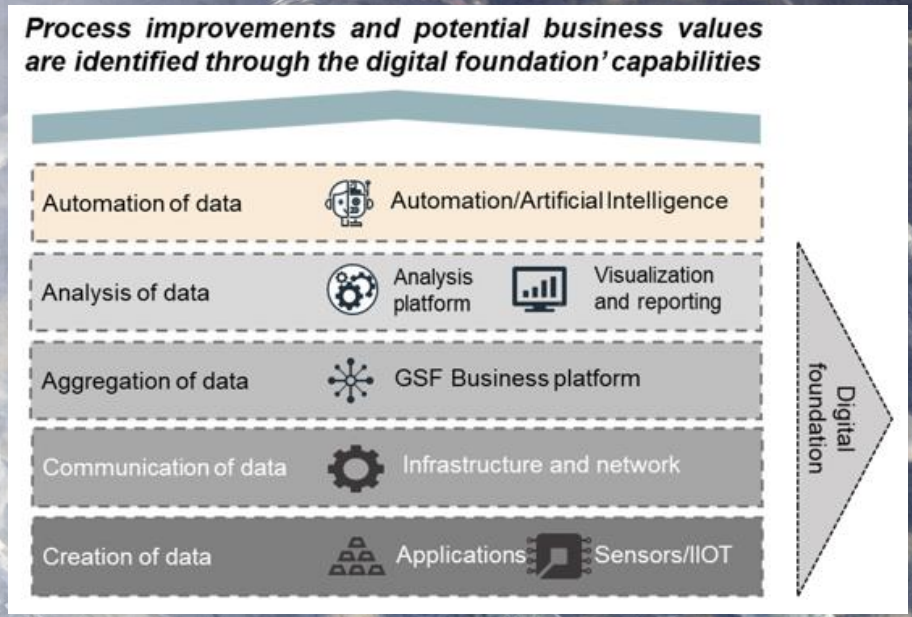
HOFSETH

Firda

LINGA LAKS

Possibilities of digitalization in the aquaculture sector

- Build a digital foundation for the future state of utilizing automatic data acquisition (IOT), data communication capabilities, aggregation and analysis of data enhancing automation and data driven decision support.
- Utilize data driven insight for automated/semi automated decision support (AI) on operational and tactical level.
- Enable data analytics and algorithms (ML) for decision support on tactical and strategic level.
- Utilize digital twins for traceability, scenario predictions and simulations (biological/technical).
- Increase traceability throughout the value chain from genetics to market.



From GSF

Thank you. Takk. Merci. Gracias. Obrigado.

Lars Ebbesson
laeb@norceresearch.no

norceresearch.no

NORCE