

# Industry Insight

2023 | Digital transformation and digitalization

## Data sharing in the Norwegian aquaculture industry



“Do not make minor decisions over major things. Do not adopt a procurement mindset. Be bold in your investment strategies and make sure that your digitization strategy is linked to the overall business strategy and vision. And in particular, ensure that you do not try to do this alone. Transforming the aquaculture industry into being more digital, you have to collaborate with the parties that are out there to give you a leg-up and help you on your journey.”

*Craig Churchill  
COO, Tidal*



“The ocean is a fragile ecosystem that needs to be understood and protected if we want to continue to benefit from it. We believe digitalization will be *the* driving force to secure a sustainable aquaculture industry in the future. Hence - understanding the ocean requires the collection and sharing of standardized data.

With a managed innovation approach and sharing of standardized data we are better able to *think big, start small, learn fast and scale quickly*. By gathering inputs and insights from multiple sources, we are better able to identify opportunities for further research, synthesize and prioritize. This knowledge then allows us to ideate, iterate, and validate interventions as we move to build, pilot and scale resilient systems that covers most blind spots.

We believe that it is by working in alignment that we produce the most accurate decision-making model.”

*Stig Martin Fiskå  
Global Head of Ocean, Cognizant*

# Foreword

Increased data sharing is a critical success factor to achieve the Norwegian aquaculture industry's growth ambitions: a fivefold increase in salmon production and a sixfold increase in value creation by 2050. Yet, the extent of data shared in aquaculture remains limited, and the industry is lagging behind other industries when it comes to sharing data across the value chain. Nevertheless, we believe that increased data sharing can have positive effects on sustainability, profitability, value creation, and fish health and welfare in the Norwegian aquaculture industry.

There are still a number of obstacles to overcome in order to enhance the extent of data sharing in the aquaculture industry, including structural, technical and organizational challenges. Nonetheless, from NCE Seafood Innovation's perspective, we are seeing an increasingly positive attitude to and growing interest in data sharing among stakeholders, and an expanding desire to strengthen the data sharing culture in the industry.

In recent years, there have been multiple initiatives aimed at stimulating more data sharing in the Norwegian aquaculture industry. We believe that the initiatives in the industry have been important in order to make the industry more mature in this area. However, to realize the full potential, it still remains to generate direct industry value and results from a data sharing ecosystem.

When asked about their visions, ambitions and wishes regarding data sharing, a vast majority of stakeholders in the aquaculture industry point to a well-functioning, democratic and inclusive ecosystem in which standards, policies and regulations are clearly defined. However, we also recognize the industry's demand and need for a clear value proposition related to data sharing and guidance on how to proceed.



With this report, our ambition is to make evident the benefits and opportunities that data sharing can offer the industry. Further, we aim to provide a common understanding and foundation on how to establish this ecosystem and stimulate for increased data sharing in the industry. Our goal has been to highlight the industry's desires and needs, as well as the initiatives currently being implemented. Based on that, this 'Industry Insight' report presents solutions and points for further discussion around data sharing in the aquaculture industry.

We have interviewed many key stakeholders across all segments of the industry, including research institutions, public authorities and subject specialists. Thus, this report is broadly based on 'industry insight'.

The report is meant as a contribution to strategy development in companies and industry stakeholders. Further, it is intended to provide foundation and direction for national incentives and political discussions around this topic.

On behalf of the steering group – we hope that this report will be a valuable contribution to more dialogue, and to a broadened understanding of why we need (more) data sharing, and what value it represents for each player contributing to it.

And lastly, I would like to thank Deloitte for your great contribution in putting this report together.



**Nina Stangeland**

*Managing Director,*  
NCE Seafood Innovation





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# Summary

# Executive summary

In recent years, the Norwegian aquaculture industry has taken major steps towards digitalization and insight-based decision making. However, the most promising and significant opportunities still lie ahead.

Data sharing will be a significant driver for value creation if done properly.

This report provides a rationale for why the industry needs more data sharing, outlines the status quo on what has been achieved so far and provides recommendations on what is needed to move ahead with data sharing, on both an industry and individual company level.

Data sharing is a must if the industry wants to 1) achieve its growth ambitions by improving operational performance and 2) secure its 'license to operate' and deliver on demand for more transparency in the value chain. Solutions to challenges in areas such as fish health or environmental footprint rely on data sharing and cannot be found or established by single companies. Moreover, data sharing is an absolute necessity for the development of more circular business models.

The benefits of data sharing in aquaculture are numerous, and a shared, open and democratic data ecosystem would be an invaluable means for the industry to advance in terms of more optimized, sustainable and safer production. As the amount of collected data grows, data will become an increasingly valuable asset for the industry, but the success of data sharing depends on the following seven enabling factors:



**Set the organization up for data sharing**



**Use the whole playing field**



**Design for data sharing**



**Build trust**



**Take the plunge**



**Establish industry-wide data standards**



**Learn by doing**

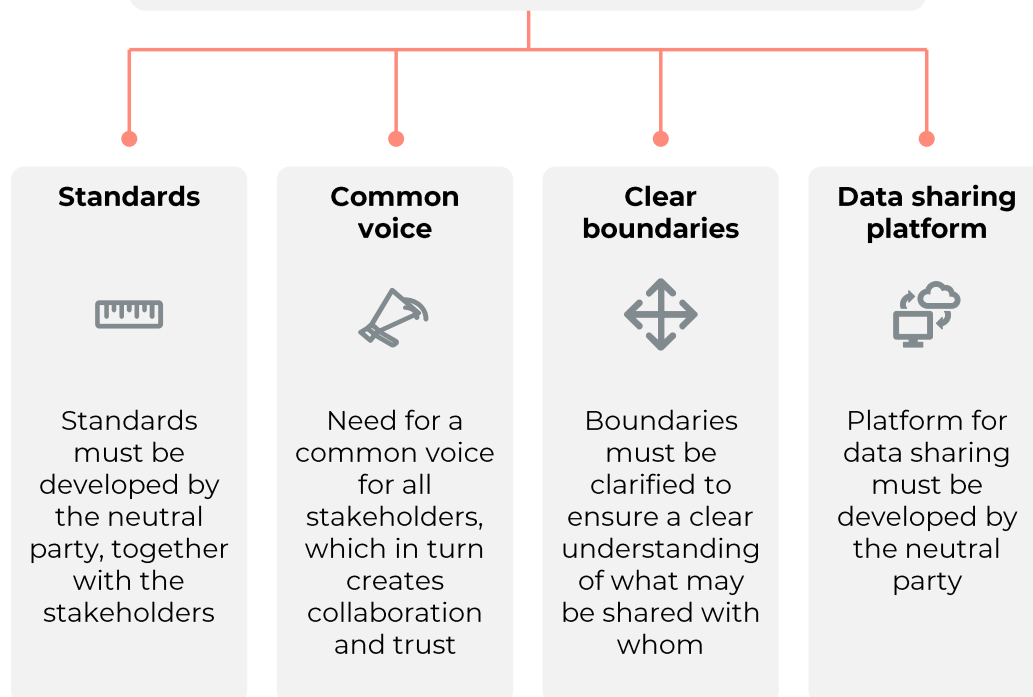
# How to move ahead with data sharing in practice

To move ahead with data sharing, both individual companies and the industry must take action

On an industry level, a neutral party is found to be the key success factor to enhance data sharing

Individual companies can check their readiness for data sharing against the following checklist. We have:

## A neutral party enables the following



1. Defined a clear company digital strategy to guide decision making
2. Established the systems and infrastructure necessary to meet the technical requirements for good data processing and sharing.
3. Obtained an overview of capabilities and competencies, and established if this is sufficient to reach our goals.
4. Competency on data collection and understand how important input data quality is for data sharing
5. Delegated responsibility internally
6. Defined specific and measurable KPIs to monitor and document the progress
7. Defined own use cases to test and learn from

# Stakeholders' roles & benefits

All industry stakeholders should have an interest in moving the industry's data sharing agenda forward, and each one has a unique role to play.

Stakeholder	Current engagement	Expected benefit	Role moving forward
<b>Production &amp; processing</b>	Collect data for own use and reporting	Optimized production & fish health Cost reductions & efficiency Simplified reporting (incl. ESG) Traceability	Strategic sourcing and expectations to providers
<b>Digital/ tech</b>	Collect data from customers and open sources; share with customers	Better products & services Better trained algorithms Increased market shares	Provide open source solutions Innovation
<b>Public authorities *</b>	Collect data to control fish health and environmental factors	Digitalized & more efficient reporting Better control	Legal clarification and guidance Support and involvement in initiatives
<b>Research &amp; development</b>	Analyze and publish available data	Research Innovation Development	Provide informed recommendations Participation and collaboration
<b>Networks &amp; clusters</b>	Facilitator and instigator	Stronger industry Global market shares	Facilitate collaboration Concretize industry ambition

*\*There are diverging opinions regarding the role of public authorities in moving forward. Some see authorities having a minor role, and argue that progress in this realm must stem from within the industry. Others argue that public policy and regulations can be an effective means to increase the amount of data shared.*





# Contributions

# Multistakeholder involvement

## Steering group



**Henning Knivsberg Moe**

*Global Digitalization Manager*  
Cermaq Global



**Trond Kathenes**

*CIO*  
Grieg Seafood



**Anders Storebø**

*Lead Digital Transformation Farming*  
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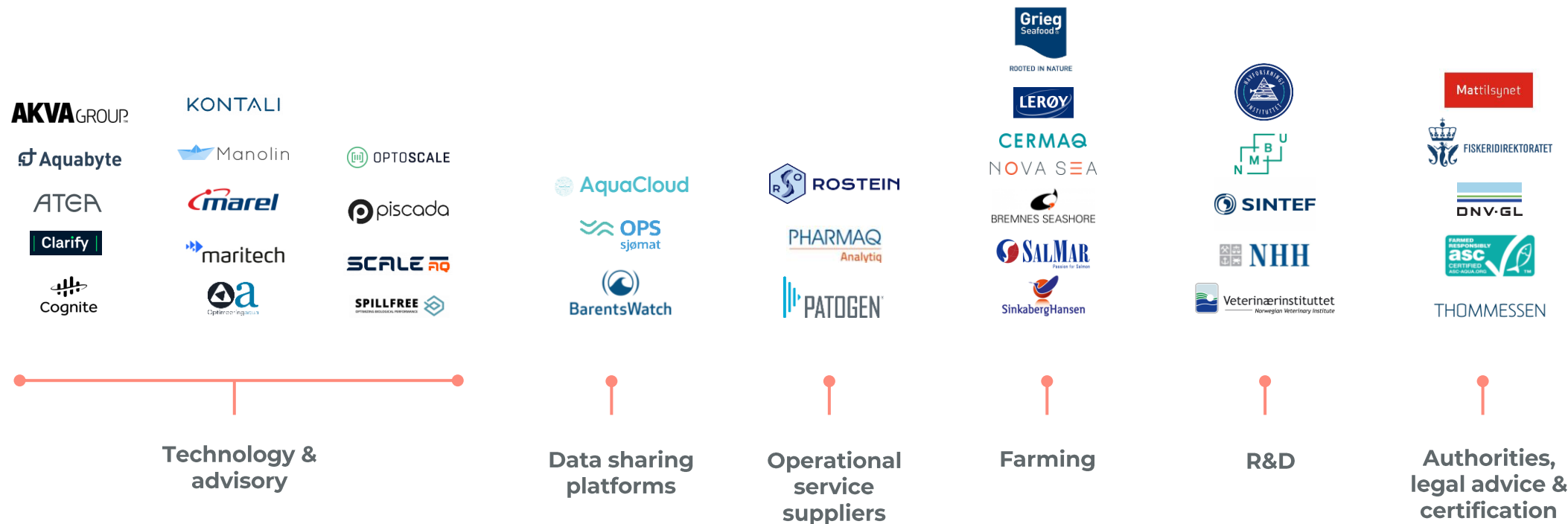
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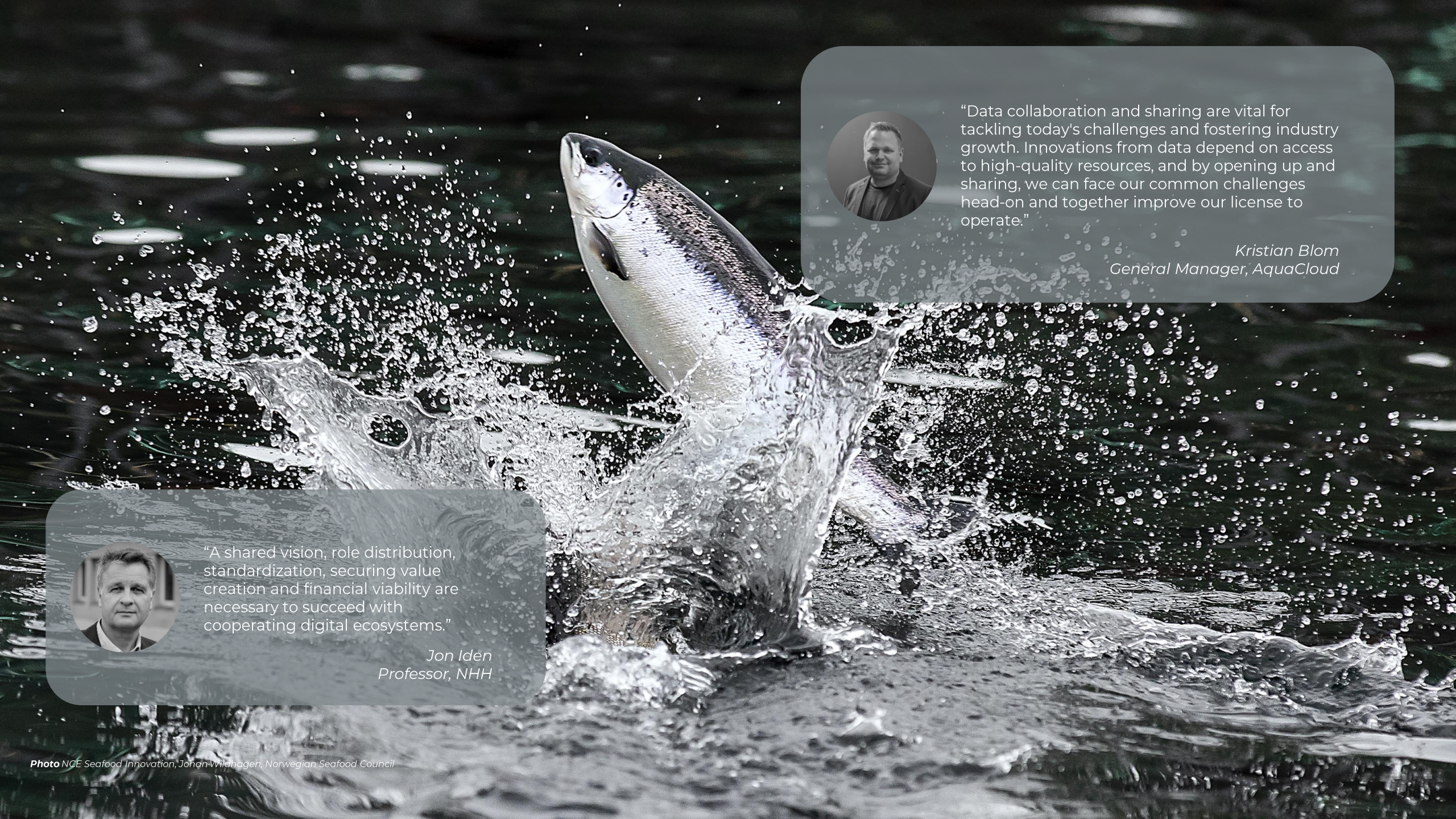
Anders Vik  
*Consultant*

# Industry insight from value chain stakeholders

Insights presented in this report stem primarily from the industry itself, or closely associated stakeholders. Their participation in this research has been an invaluable contribution! 36 interviews have been conducted in total, with institutions covering a wide spectrum of interests and perspectives. \*



\* The scope of this document is limited to the stakeholders and categories visualized in the figure above. Categories such as sales/retail, distribution and consumers are beyond the scope of the research. Please find more detailed information about the interviewees at the end of this report.



“Data collaboration and sharing are vital for tackling today's challenges and fostering industry growth. Innovations from data depend on access to high-quality resources, and by opening up and sharing, we can face our common challenges head-on and together improve our license to operate.”

*Kristian Blom  
General Manager, AquaCloud*



“A shared vision, role distribution, standardization, securing value creation and financial viability are necessary to succeed with cooperating digital ecosystems.”

*Jon Iden  
Professor, NHH*

# Part 1

Rationale –  
Why Share Your Data?



“Data sharing will improve the understanding of biological causes and effects which is fundamental to increase the ability to prevent and respond to diseases more effectively and thus reduce fish mortality and improve welfare.”

*The Thanh Nguyen  
Head of Section Infrastructure & Digitalization,  
Norwegian Veterinary Institute*



“Through implementation of our digitalization strategy, we have already recognized improved insight into several fish health challenges.”

*Trond Kathenes  
CIO, Grieg Seafood*



“The degree to which we will manage to improve operational performance will largely depend on how successful we will be in sharing data with other farmers. Insights generated from shared, standardized data with proper data quality will be able to help improve a lot of operational processes such as lice treatments and fish welfare monitoring.”

*Henning Knivsberg Moe  
Global Digitalization Manager, Cermaq Global*

# Data sharing creates value

Digital collaborating platforms and a data sharing ecosystem will generate value and can help to solve challenges too big and complex to be solved by a single company <sup>5, 20</sup>

Value is generated by data sharing and data refinement with the focus on innovation  
(sharing, analyses, combination and new use)

Data can be combined and reused almost without any incremental costs

Data can be used in new contexts

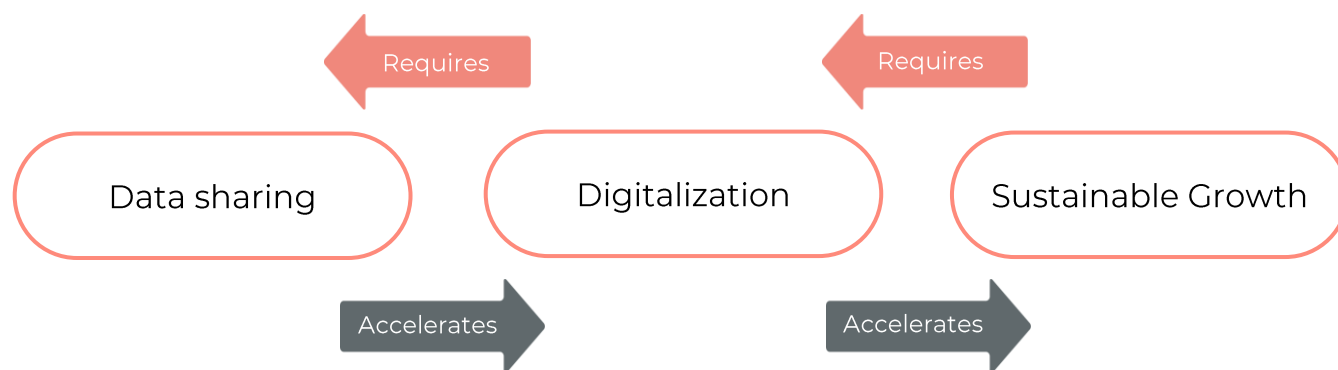
Data can be used by innovators in the ecosystem who can develop digital solutions and services exploiting and combining data in new ways and for new purposes

Generative characteristics of data

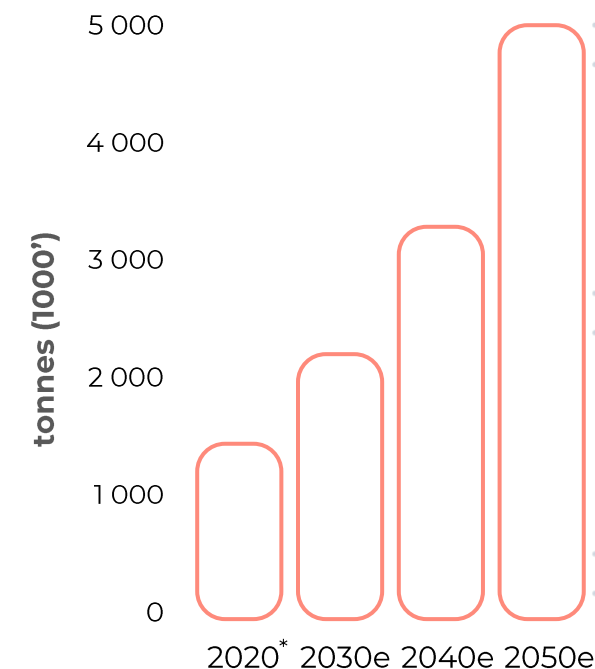
# One for all, all for one

An industry united around data sharing is essential for reaching the five-million-tonnes vision by 2050, while competing in a global market for sustainable animal and alternative proteins<sup>21, 23</sup>

Sustainable growth will require more digitalization. More digitalization is dependent on more data sharing.



By increasing the amount of data and trust in data models, data sharing will accelerate digitalization and therefore production growth.



The national ambition of 5 million tonnes of salmon in 2050 will require significant improvements in production

\*Salmonid production in Norway, Kontali (2021). Figures for 2030e and 2040e are extrapolated (CAGR) to fit the 2050 ambition.



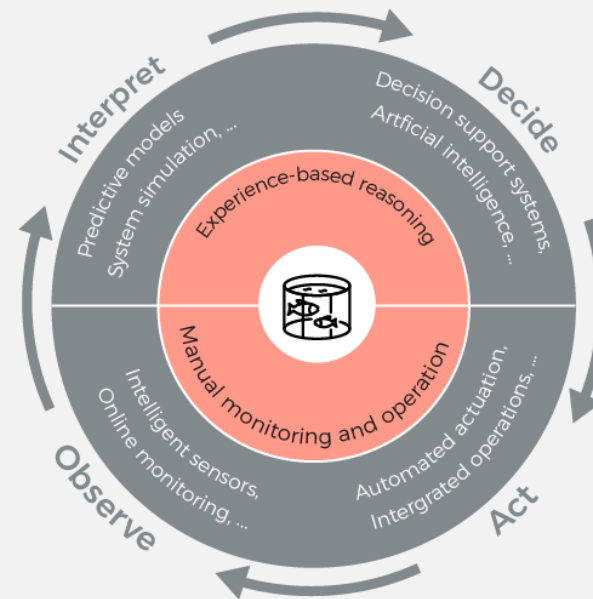
# Data sharing to improve operational performance

Aggregating production data sets increases players' understanding of the factors driving their operational performance <sup>30</sup>

Data sharing can improve production by <sup>15, 16</sup>

Specifically, this can improve <sup>\* 21</sup>

- 1 Improving accuracy, precision and repeatability in farming operations
- 2 Providing more reliable decision support, supporting a transition from experience-based to data-based decision making
- 3 Reducing dependencies on manual labor and improving employee safety



Adopted from Føre et al. (2018)

Fish health & welfare

- Welfare monitoring
- Vaccination schedules
- Lice counting & treatments
- Disease management & analysis

Growth

- Growth strategies, e.g. light regimes
- Technology (open, closed, land-based, on-shore, off-shore)
- Genetic analyses

Feed utilization

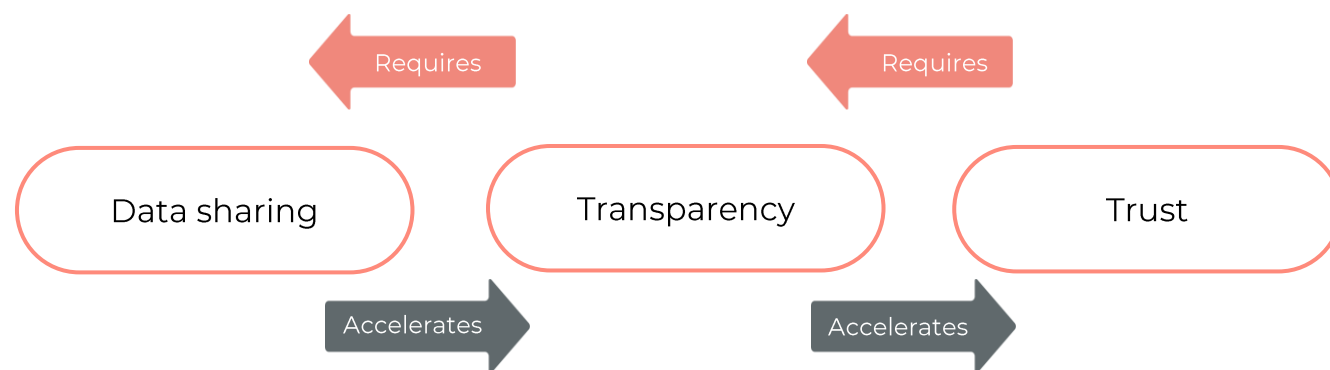
- Feeding schemes
- Feed waste analysis
- Feed composition & diet
- Development of future ingredients

*\* The mentioned aspects mentioned here are referred to for their importance, but not meant to be an exclusive list of where data sharing can have an impact.*

# Data sharing to secure trust

Data sharing and transparency are fundamental to securing the public's trust in the industry, meeting growing disclosure requirements and solving key 'license to operate' issues <sup>21, 24</sup>

Securing trust and the industry's 'license to operate' requires more transparency. More transparency requires more data sharing



By increasing and simplifying the data flow between stakeholders, data sharing can accelerate transparency and improvements on key trust and 'license to operate' issues

## *License to operate*

### **Growing disclosure requirements**

- Certifications
- Taxation schemes
- Production licenses
- Banks, investors & financiers
- Food safety & traceability
- Consumers
- Local population

### **Key issues to be solved**

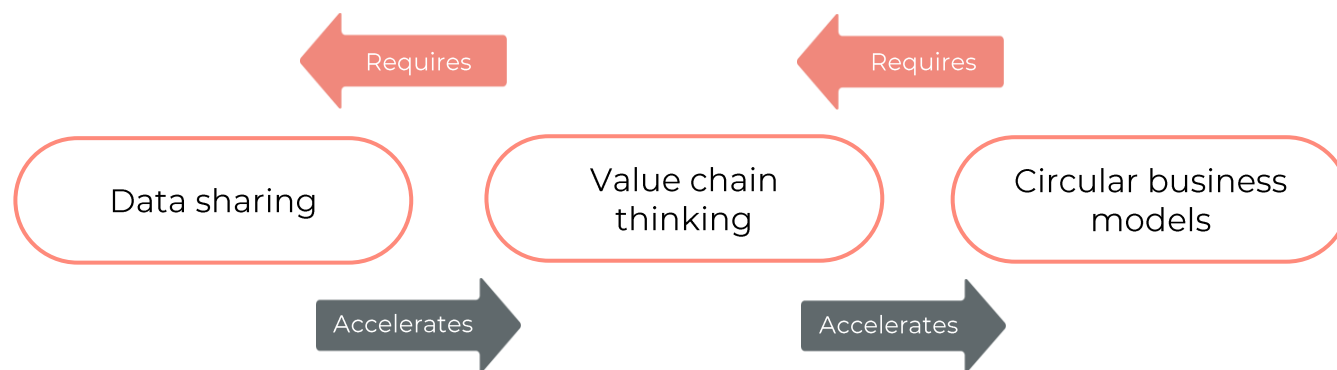
- Climate accounting
- Local emissions
- Waste management & recycling
- Biodiversity management
- Life cycle analyses
- Animal welfare
- Human rights protection
- etc.



# Data sharing to enable circularity

Data sharing and value chain thinking will be required to transition from a linear 'take-make-dispose' approach to a circular economy <sup>22, 28</sup>

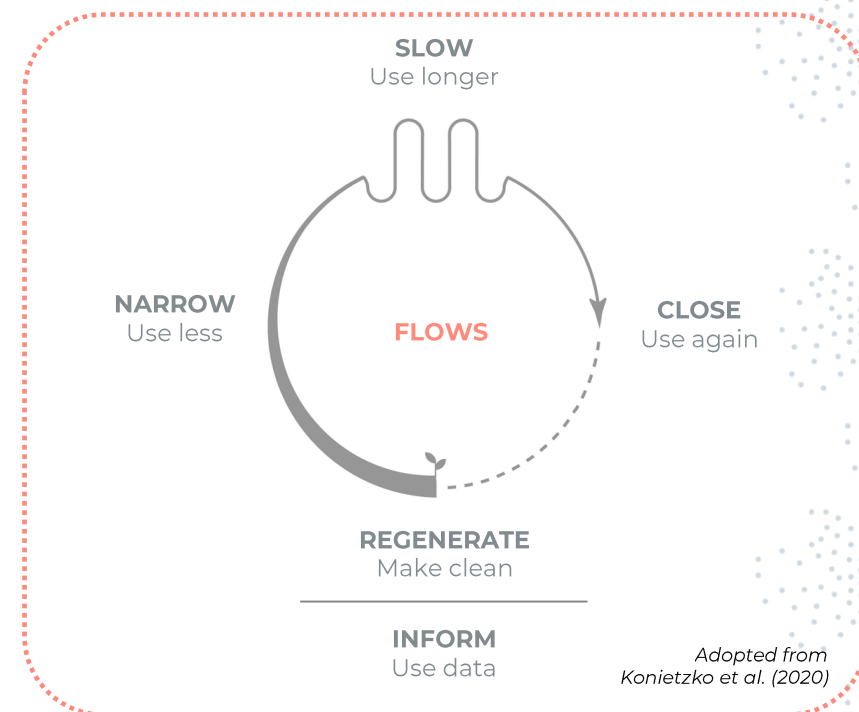
The development of circular business models requires thinking and acting along and across value chains. This will only be possible with data sharing.



Data sharing will by nature foster value chain thinking and reveal new circular business opportunities

## Baseline

Circularity will be a key tool to solving some of the industry's most critical environmental and resource challenges (e.g., feed, sludge or plastics) and will open new opportunities for revenue generation.

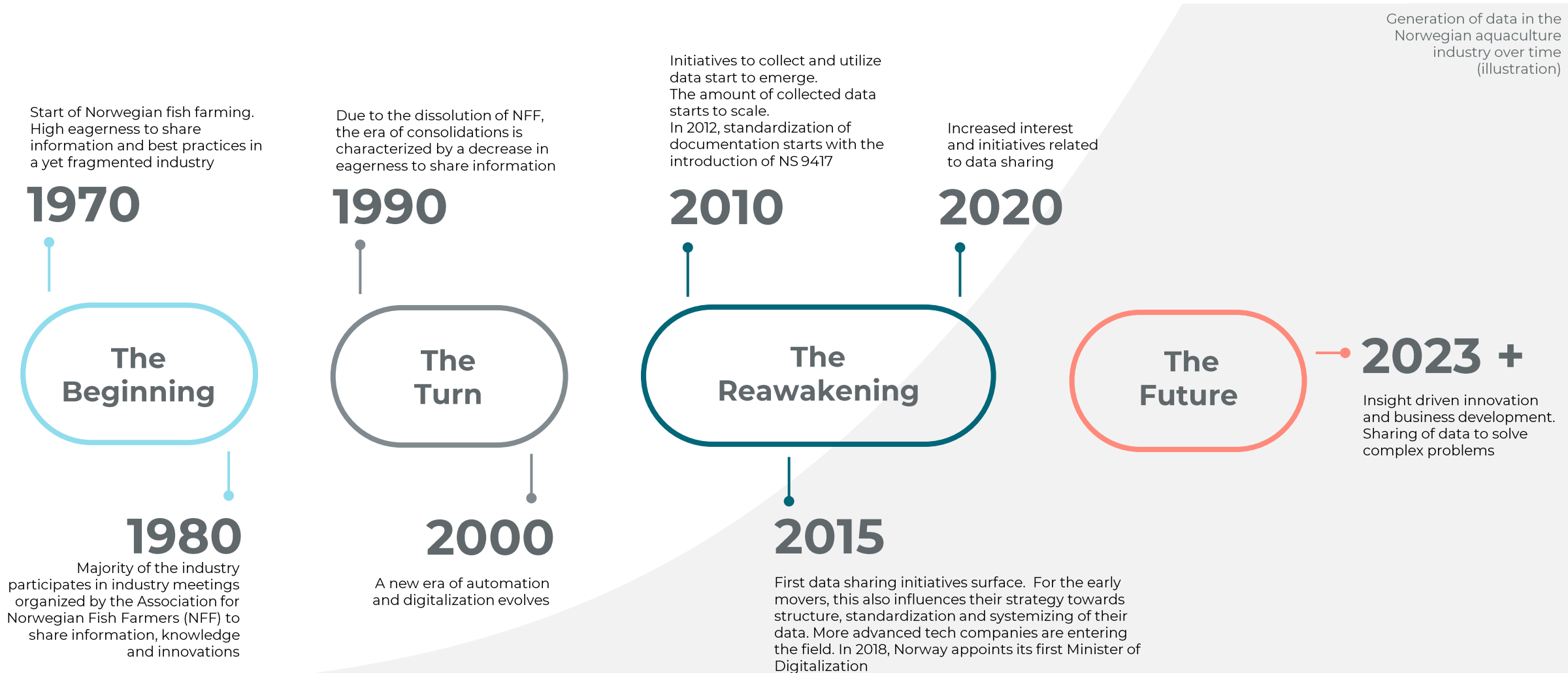


To become 'circular', firms need to use less material and energy, use products, components and material longer and again, use non-toxic material, renewable energy and regenerate natural ecosystems.

# Part 2

Status

# History of knowledge and data sharing <sup>21, 27</sup>



# Political strategies aim for data sharing

Data sharing finds political support in Norway and has recently been defined as a fundamental prerequisite for the green industrial transition <sup>18</sup>

## 3 key political aspects to data sharing <sup>17</sup>



- 1 Arrange and **make available data** to improve knowledge and facilitate innovative data usage
- 2 **Improve collaboration**, interaction and data sharing among both public and private stakeholders
- 3 **Install better solutions** and opportunities for documenting quality data along the supply chain, including data related to sustainability

## Data sharing as a prerequisite for a green industrial transition \* <sup>19</sup>

“The Government will facilitate increased value creation with data by stimulating increased sharing and use of data in and across sectors, businesses and industries.”



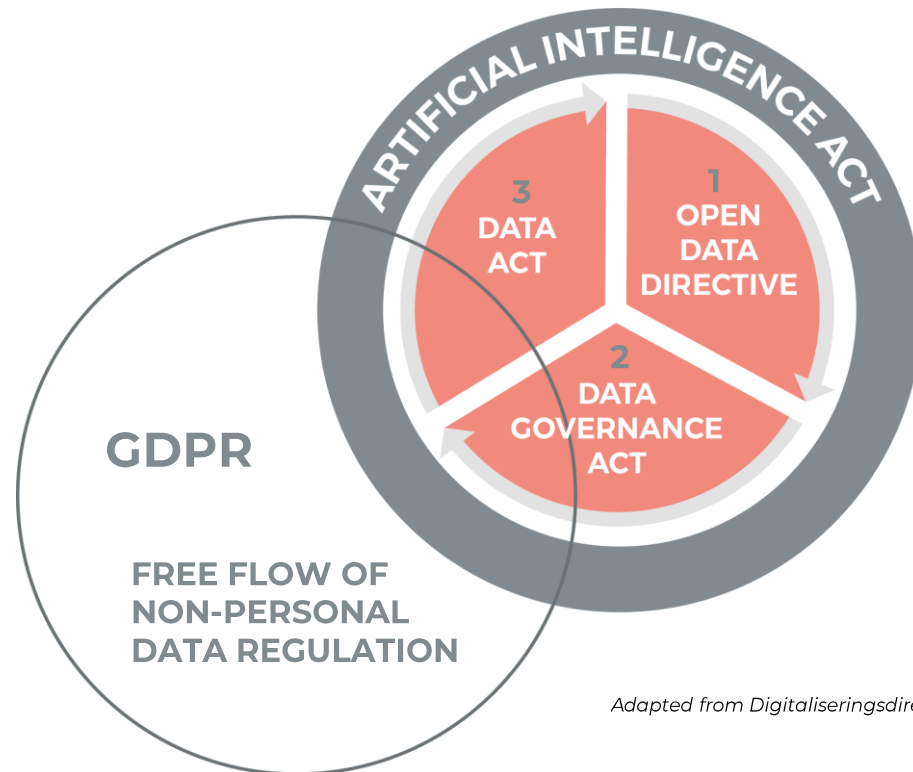
\* Measure 35 in the Government's strategy 'The Green Industrial Initiative' (2022)

# European law making data sharing mandatory

Employing different regulations and directives on the sharing and use of data, the European Commission is working to establish a legal framework for a fair and innovative data economy <sup>10, 13, 14, 29</sup>

Current EU framework for data sharing and use

Overall goal: create balance between data sharing when possible and protecting data when necessary



Adapted from Digitaliseringsdirektoratet (2022)

1

**Open Data Directive (2019):** Encourages countries to make as much information available for reuse as possible. Addresses material held by public sector bodies, at national, regional and local levels.

2

**Data Governance Act (2022):** Creates the processes and structures to facilitate data sharing by companies, individuals and the public sector.

3

**Data Act (proposed):** Clarifies who can create value from data and under which conditions. Aims to give SMEs access to data and avoid data monopolies for tech giants.

**Forthcoming regulations:** There are other forthcoming regulations that will impact the current data rules, as the **Digital Markets Act** or the **Digital Services Act**.



“Transparency is a key component in Cermaq’s way of operating. Today, we use recognized certifications standards such as ASC and GLOBALG.A.P., our cuts in GHG emissions are according to the Science Base Target initiative (SBTi) and our reporting is prepared in accordance with the Global Reporting Initiative (GRI) standards’ requirements. ESG reporting is becoming increasingly mandatory and demands on data quality and assurance, including certifications, are rising. To be able to satisfy the transparency standards we are setting ourselves also in the future, data sharing with our partners and suppliers along the value chain will be a necessity.”

*Lars Galtung  
Chief Communication and Sustainability Officer, Cermaq Global*



“Increased data sharing can make the interaction between the industry and governmental agencies easier, more efficient, and more transparent. There are benefits for all parties if we share more data.”

*Ingunn Midttun Godal  
CEO, Norwegian Food Safety Authority*



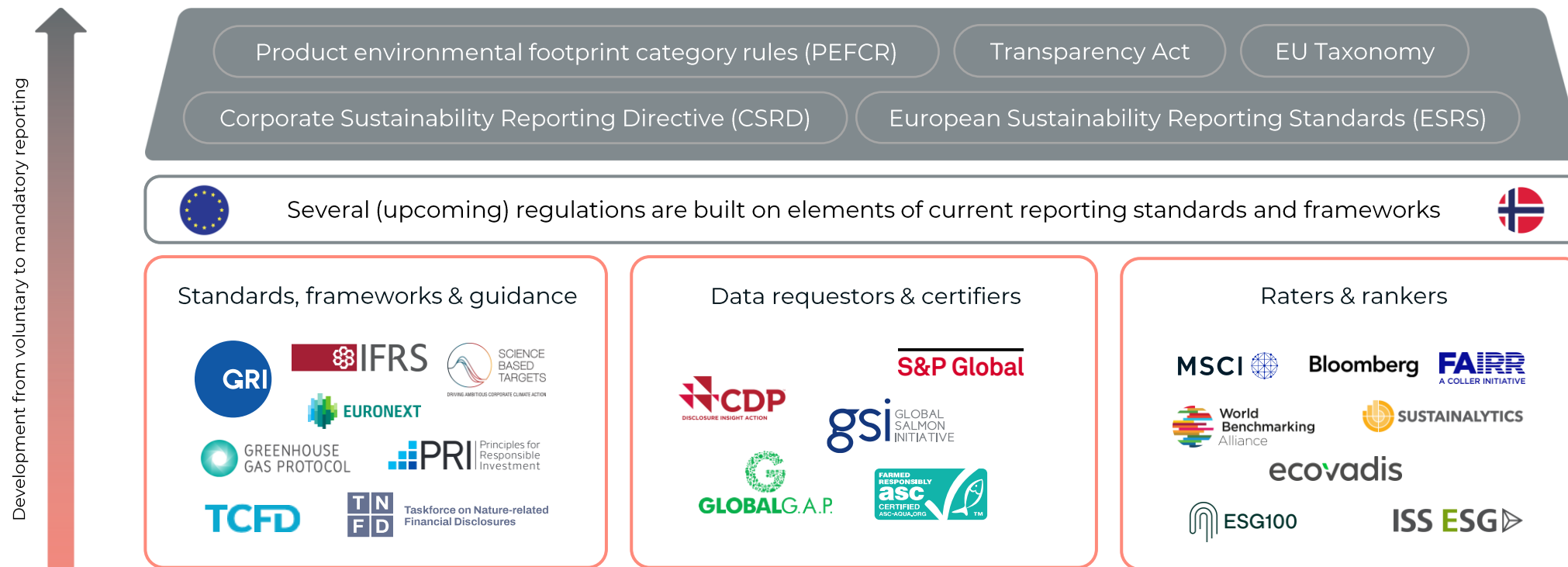
“To encourage data sharing in and with smaller organizations with limited resources, it will be necessary to foster a culture of trust, incentivize participation, and give support for capacity building and technology adoption. Giving more SMEs opportunities to access relevant data will foster new collaborations and new innovations in the value chains. In this light, the new EU Data Act also aims to ensure increased access to data, encouraging new market segments and business models.”

*Liv Dingsør  
CEO, Digital Norway*



# ESG reporting depends on data sharing

Stakeholders depend on each other's ESG data for their own reporting. In a consolidating and increasingly mandatory ESG landscape, proper data sharing is gaining importance <sup>9, 10, 11, 12, 35</sup>



## Data sharing – the foundation of ESG reporting

ESG data is collected (mostly manually) throughout the value chain according to different standards and on different aggregation levels. Therefore, data sharing is essential to enable all stakeholders within the aquaculture ecosystem to execute their ESG strategies and deliver on the disclosure requirements imposed upon them.

# Balancing rules of competition and data sharing

Proper governance structures and collaboration agreements can secure data sharing in the interest of and for the benefit of the public, while complying with the statutory competition rules <sup>34</sup>

## Competition sensitivity of data depends on

1

### Type of data

- Species
- Biomass
- Temperature
- Oxygen
- Mortality
- Treatments

2

### Level of aggregation

- Company level
- Regional level
- Site level
- Pen level

3

### Temporal aspect

How old is the data?

## Data sharing possibilities depend on

1

### Data sensitivity

- Public
- Limited
- Confidential

2

### Data governance

- Structures
- Steering group & roles

3

### Agreements with 3rd parties and data users

# Data sharing must not affect market behavior

Legal prohibition of exchange of information will be the case with some data. Exchange of information between competitors that can reduce insecurity in each others market behavior is illegal. \*

“Sharing knowledge and data is good for everyone as it can drive the industry forward by understanding the bigger picture. However, the challenge is that people are often afraid to share their data. They may fear losing control over who accesses the data, particularly if it falls into the hands of someone who might use it against them. Also, competition law sets certain boundaries. Therefore, it is crucial to establish good governance structures and procedures that create security, clarity, and trust, which enable people to share more data without having to worry about the potential risks.”



*Mons Alfred Paulsen  
Lawyer, Thommessen*

## ‘Red flag’ list for data that cannot be shared: \*\*

- 1 **Price setting for current and future production**
- 2 **Planned production and sales volumes**
- 3 **New production areas**
- 4 **Target customer groups**

*\* Exceptions from the prohibition can be made if exchange of information is required to yield efficiency gains (e.g., in the form of cost reductions or product development)*

*\*\* This is the most important examples, but not meant to be an exhaustive list. Depending on the situation, other examples may also include certain R&D projects, future marketing strategies or detailed, historical production volumes, etc.*

# Current data sharing platforms

Multiple data sharing initiatives and platforms already exist within the aquaculture sector. In addition, there are other interesting data sharing-stakeholders to watch out for in the years to come

## Existing data sharing platforms and -initiatives



### **AquaCloud**<sup>3</sup>

A 'big data' project anchored in the industry's need to solve common challenges to create sustainable growth



### **BarentsWatch**<sup>4</sup>

Collects, develops and shares information about Norwegian coastal and marine areas through open systems



### **Sjømatdata**<sup>33</sup>

Established to enhance collaboration between the industry and public authorities. Provides access to high-quality data

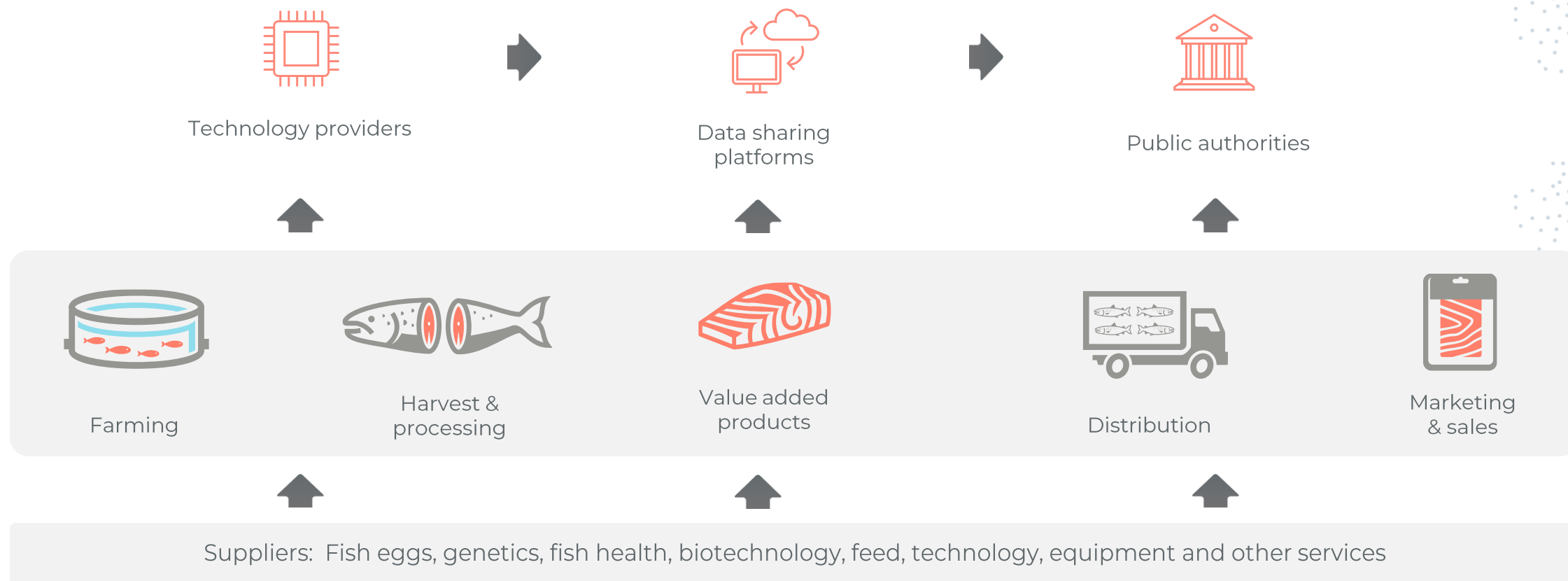


### **VIHUB (2023)**<sup>31</sup>

Interaction platform enabling automatic data collection from private diagnostic laboratories, data quality control from the Norwegian Veterinary Institute and data evaluation capability for fish farmers

# Current data flow is mainly upwards

Industry players collect a lot of data. However, data flows primarily from data owners to technology providers or public authorities. There is still not that much data sharing between players in the value chain <sup>21, 39</sup>



Adapted from Tekna (2018)

# Diversification as a driver for data sharing

In a historically oligopoly-like data market, new, global players are about to enter the field. This diversification can be a driver for and impose new requirements upon data sharing

Historically, data collection has been dominated by few actors <sup>21</sup>




New players are entering the data market

New players are currently developing and piloting different solutions and have the potential to impact the progress of digitalization in the aquaculture.

As some of the new players entering the field are global corporates, their impact potential might also affect progress as well as standards and routines regarding data sharing.

A digitalization watchlist of global players \*



**Aquaculture 4.0**, in collaboration with Singapore Aquaculture Technologies (SAT) <sup>37</sup>

Floating farm equipped with sensors connected via cloud to an automated system to monitor and run the operations, tested with SAT



**Tidal underwater system** by Alphabet's X <sup>40</sup>

Underwater camera and AI that enables the continuous monitoring of fish behavior and welfare, tested in collaboration with Mowi



**Microsoft**, in collaboration with Pescanova <sup>26</sup>

Sensors for water temperature and oxygen levels, combined with a smart platform to create an optimal environment for farming, tested with Pescanova in Spain



**ABB**, in collaboration with Microsoft <sup>1</sup>

Underwater cameras to monitor and count fish automatically using AI, tested with Norway Royal Salmon



**EcoStruxure Plant Aquaculture 4.0** <sup>36</sup>

Sensors and equipment to digitalize the whole farming process, tested with Blue Ocean Technology and Lerøy Seafood Group

\*The mentioned players are referred to for their impact potential, but not meant to constitute an exclusive list

# Data accumulation increases cyber risks

Moving forward with data sharing, industry stakeholders must be aware of and mitigate increasing cyber threats and challenges <sup>6</sup>

## Cyber security concerns about data sharing

### Data breaches & misconfiguration risks

Unauthorized access to sensitive data due to weak security measures, system vulnerabilities or human error. The risk of attacks and exploitation of encryption misconfiguration increases. Service providers vary in their configuration practices, and many users lack sufficiently stringent configuration management procedures

### Data privacy & compliance

Unauthorized accesses, leaked, stolen or misused data can have severe consequences, potentially violating laws and reducing trust. Failure to comply with laws and regulations may result in legal consequences, fines and reputational damage.

### Insider threat

Employees, vendors and partners with platform access pose a significant cyber risk. Breaches may occur due to malicious intent or unintentional mistakes.

### Cloud security

Security of the cloud service provider is a concern that affects the security of the data stored on the platform

### More attack surfaces

5G expands the number of connected (and exposed) devices and increases the number of domains exposed and vulnerable for cyber attacks.

### Artificial intelligence (AI)

AI increases the sophistication and potency of malware and attacks and reduces the technical competence required by hackers. This suggests a surge in opportunistic attacks.

## Measures to mitigate cyber threats and risks

- 1 Choose **vendors with strong security track record** and guarantee of sufficient configuration practices
- 2 **Encrypt** all sensitive data, both in transit, at rest in the cloud and on connected devices
- 3 **Monitor devices** connected to the company systems or that contain sensitive data. Consider remote mobile management solutions to protect devices
- 4 Ensure **robust authentication practices**, i.e., multi-factor authentication (MFA). Be cautious of new attack trend that aim to exploit 'MFA fatigue'
- 5 **Stay informed** on latest developments regarding functional AI, and prepare for its impact on data security
- 6 Install **privacy-preserving technologies** such as blockchain or homomorphic encryption. Blockchain enhances trust through transparency, decentralization and cryptography

# Part 3

Towards data sharing in  
aquaculture



# Contrasting views on development speed

The industry's main ambition regarding data sharing is to establish frameworks and structures that allow data to flow between systems, and that enable better communication and monitoring of data <sup>21</sup>

## Contrasting timelines

There is significant disagreement on what stakeholders consider a realistic timeline for achieving the future ambition for data sharing, with a common data ecosystem to allow data to flow between systems.

Technology suppliers:  
**1-2 years**

Argue that an industry-wide data ecosystem is feasible to establish within the next two years

**vs.**

Farmers:  
**5-10 years**

Claim that a common data ecosystem is achievable no sooner than 5 to 10 years

With no action, the industry's estimate is likely to be correct due to their buyer power. To accelerate the data sharing journey, industry stakeholders should understand their opportunities regarding data sharing, and collaborate with tech suppliers to create a realistic roadmap.

# Data ecosystem over single solutions

None of the stakeholders consider consolidation on a single platform or with a single vendor a tenable data sharing solution in the foreseeable future

## Single solutions are unlikely for three main reasons

- 1 Companies want to use the best available tool for the job, regardless of the provider
- 2 Many companies have recently invested heavily in new technology, inducing significant replacement costs
- 3 It is not evident who should establish and operate this platform, as the platform should be independent from authorities and not driven based on a single vendor's commercial agenda

## Data ecosystem as desired solution

A common **data ecosystem\*** based on APIs and shared standards is highlighted as a more plausible scenario to enable seamless data sharing in the industry.

**Composable systems\*\*** that allow interconnectivity across components will play a vital role in enabling this ambition.

\* **Data ecosystem:** Data infrastructure (data assets, standards, technologies, policies) and the people, communities and organizations that benefit from the value created by it <sup>32</sup>

\*\* **Composable systems:** Composable systems break down larger structures into smaller, more modular "components" that address a specific problem or use case each <sup>16</sup>

# The future of data sharing is now

Several technological trends provide the breeding ground for an 'era of data sharing'<sup>7,8</sup>

## Technological trends

1

### Learning to trust artificial intelligence (AI)

There is an increasing focus in the industry on transparency, explainability and reliability to enhance trust in data and AI

3

### Above the cloud

Industry stakeholders are building compatibility layers above various systems and platforms, to simplify and centralize control

5

### Cloud goes vertical

Vendors are developing industry-specific cloud solutions based on use cases specifically important to aquaculture

2

### Decentralized architecture and ecosystems

The industry is exploring secure opportunities for external data sharing in an ecosystem through mechanisms such as blockchain

4

### Data sharing made easy

The industry is exploring opportunities to create seamless, secure data sharing capabilities to tackle common challenges

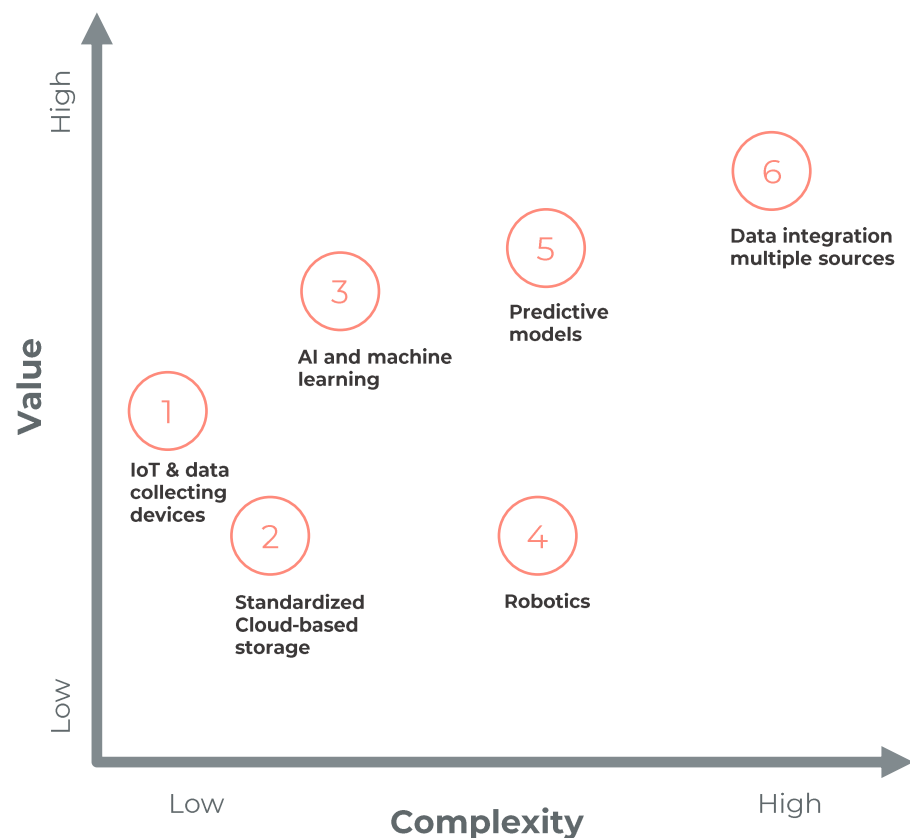
6

### Tech stack goes physical

The range of physical devices and capabilities available to aquaculture is expanding, which requires new expertise and skill sets

# 6 critical moves towards data sharing

According to the trends and predictions, the industry should make six critical technological moves towards data sharing in the next few years <sup>7,8</sup>



- 1 **Adopt IoT sensors and data collecting devices in fish farms**  
Sensors can gather data on parameters such as water temperature, pH levels, dissolved oxygen, feed consumption, salinity etc.
- 2 **Enhance use of cloud-based storage, management systems and standardized data formats**  
Simplify and enables data collection and sharing across industry stakeholders
- 3 **Install AI and machine learning to optimize feed formulations and feeding strategies**  
May improve feed conversion ratios and reduce feed waste
- 4 **Integrate robotics and AI into fish farming operations**  
I.e., use of autonomous underwater vehicles for monitoring and maintaining fish farms, reducing the need for manual operations
- 5 **Developing predictive models based on collected data**  
Models may be a means to predict and accommodate growth and fish health, and allow early issue response and mitigations
- 6 **Data integration from multiple sources across supply chain**  
Production and value chain optimization, improved profitability and fish welfare, and more sustainable and high-quality seafood products in the market

# Part 4

Enabling data sharing in  
aquaculture

# Enabling factors for data sharing

The following 7 factors have been identified as keys to stimulate and enhance data sharing in aquaculture



## Set the organization up for data sharing

Companies feature varying degrees of maturity to engage in an industry data ecosystem. To succeed in data sharing as a company, it is critical to take an integrated approach where digitalization permeates operation and decision-making.



## Use the whole playing field

Industry stakeholders are wary of potential negative consequences of data sharing. For fear of being penalized for tripping over the sidelines, they remain in the midfield.



## Design for data sharing

Proprietary systems that predominantly allow one-to-one data sharing between industry stakeholder and vendor is a significant impediment to increased data sharing in aquaculture.



## Build trust

Stakeholders are hesitant to share data, due to skepticism on data quality and fear of data being misinterpreted, misused or abused.



## Take the plunge

There is an ongoing waiting game, where no one is taking lead to move forward. However, everyone stands to gain once the first step has been taken



## Establish industry-wide data standards

Standardization is an important prerequisite for industry data sharing and data-driven value creation. In aquaculture, there is currently minimal data standardization, which hampers the industry's opportunity to aggregate, compare and extract value from data.



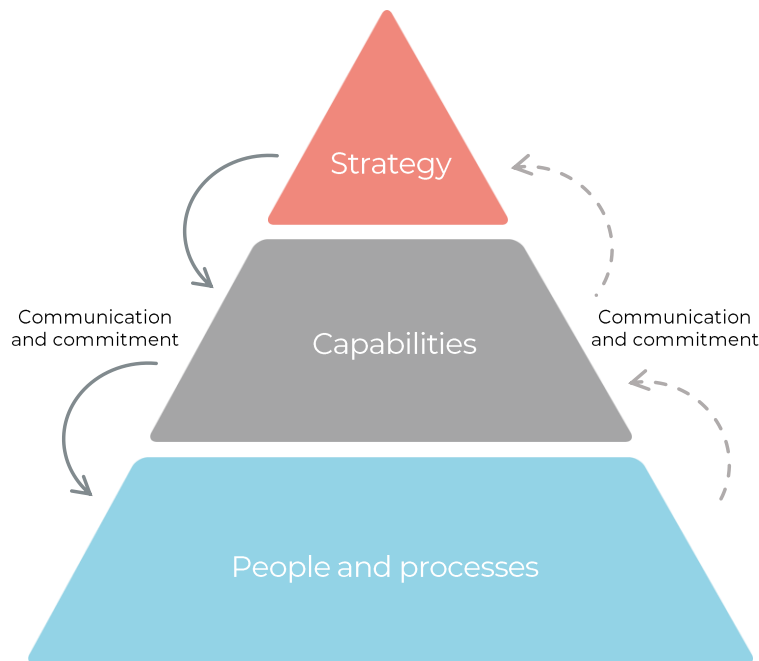
## Learn by doing

Ambiguity about the return on investments in data sharing can be solved by making the value real in incremental steps, use cases and iterations.

# Set the organization up for data sharing



Companies are varyingly mature to engage in a data ecosystem. To succeed, it is critical to take an integrated approach where digitalization permeates operation and decision making.



## Critical components to set up organizations for success in data sharing

### Strategy

- A well-defined strategy for digital transformation that defines the company's ambitions is **essential** to success
- To ensure consistency, the digital strategy should be **integrated** with the overall business strategy
- The strategy should be used **consistently** to guide investments

### Capabilities

- New digital services and technologies require different **expertise and skill sets**
- It is critical that businesses acquire necessary digital **capabilities and competence**, also among decision-makers and in procurement
- If necessary, companies should **source capabilities externally** from other industries
- The organization must also have **data collection competence** to ensure input quality of data

### People & processes

- Digital transformations have significant impact on **employees and operational processes** – and success depends on the people
- To succeed with data sharing and usage, it is necessary to apply a **company-wide and people-centric** change management approach
- **Operating personnel must understand their role** in data sharing as it depends on correct and standardized data input coming from operations

## Communication & commitment

Communication and commitment to the company's data sharing ambitions must transcend all activities and decisions, to enforce the agenda and ensure alignment

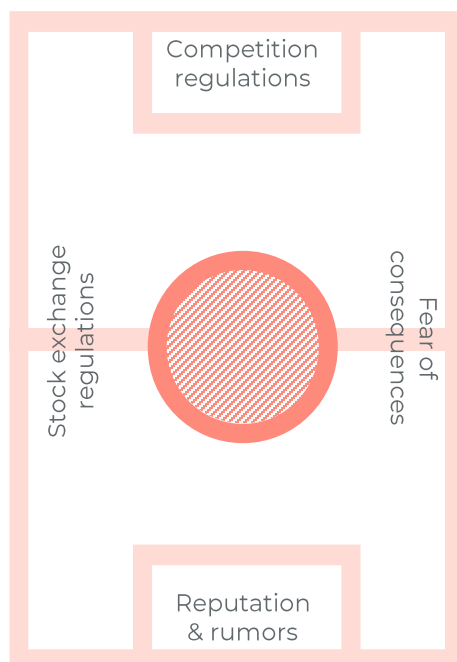
# Use the whole playing field





Industry stakeholders are wary of potential negative consequences of data sharing and therefore keep to the center ground.

Industry stakeholders currently stay clear of the side lines

Enable data sharing and innovation through confidential computing and confidence-preserving techniques <sup>7</sup>



**The football field analogy:**

-  Space available for data sharing
-  Space actually utilized

**Fear of legal breaches**

Infamous cases of price-fixing lawsuits have made the industry wary of legal breaches, especially in regard to data coupling \*

**Fear of misuse and misinterpretation**

There are ambiguous and unclear guidelines on how data must be used and interpreted

**Lack of incentives**

Despite significant opportunities for innovation along the edges, companies report lack of incentives to to expand the field of play unless the whole industry joins in

**No clear first-mover advantage**

Data sharing costs great efforts and require collaboration. There are no clear benefits for companies to move towards the edges if not the whole industry joins

**Fully homomorphic encryption:** Encryption before data sharing that allow analysis but not decoding of original information

**Differential privacy:** Noise added to the dataset so that it is impossible to reverse-engineer the original inputs.

**Functional encryption:** Select users have a key that allows them to view some parts of encrypted text.

**Federated analysis:** Parties share insights from their analysis without sharing the data itself.

**Zero-knowledge proofs:** Users can prove their knowledge of a value without revealing the value itself.

**Secure multiparty computation:** Data analysis is spread across multiple parties such that no single party can see the complete set of inputs

**Clear rules for responsible data use:** such as legal liability

**Shared understanding:** of legal boundaries and the relationship between law and technology, to avoid uncertainty and reluctance

*\* In this case, data coupling refers to the accumulated insight that combined data may provide. Although industry stakeholders understand the regulatory constraints on the sharing of individual items of data, it is unclear at what point the combination of data sets will prove too revealing to be considered lawful.*



# Design for data sharing



Proprietary systems that predominantly allow one-to-one data sharing between industry stakeholder and vendor are a significant impediment to increased data sharing in aquaculture.

Eagerness to develop digital assets has created a tangled web of heterogenous systems

## A myriad of digital products

In aquaculture, there is a myriad of digital products and services available, addressing various needs and challenges.

## Redundant services

The complex and chaotic web of available products is sometimes interconnected, but just as often redundant. Many companies are paying for redundant services.

## Hard to navigate

Aquaculture business buyers experience the landscape of available digital assets hard to navigate, resulting in uncertainty and a reluctance to make new investments. The simple choice is to postpone the decision.

## Lack of system connectivity and digital compatibility

This hampers companies' ability to realize benefits from data, and translate data into value and insight.

To overcome the barrier posed by proprietary systems, stakeholders must collaborate to design architectures appropriate for data sharing

Stakeholder	Action	Rationale
Business buyers	Acquire understanding and acceptance of alternative business models, such as subscription and Software-as-a-Service (SaaS)	Industry stakeholders are accustomed to software being a free add-on to hardware. Many open source software vendors would rather rely on a subscription-based SaaS business model for sales and income
	Implement procurement policies that stimulate open source adoption	To motivate vendors to develop open source solutions, there must be an evident business case and demand from buyers
Vendors	Demonstrate use cases	Vendors should convince business buyers to replace proprietary systems with open source solutions, by clearly demonstrating expected returns
	Develop systems and assets that allow connectivity and compatibility	Instead of participating in the ongoing industry waiting game, vendors should build compatibility layers and facilitate cloud interconnectivity
Industry-wide networks	Take lead in establishing industry-wide data standards	Standards are essential for enabling data sharing in aquaculture, and neutral industry bodies should organize collaboration

# Build trust



Stakeholders are hesitant to share data, due to scepticism on data quality and fear of data being misinterpreted, misused or abused.

## The issue of mistrust is multifaceted

### Data quality

The data quality is not trusted, and operational experience influence decision-making more than insight through data. Stakeholders are skeptical to the data quality of other data owners.

### Data misuse and abuse

Potential misuse or abuse of company data is a critical trust issue in aquaculture. Industry stakeholders experience lack of control, and fear data may be leaked or stolen

### Trust among stakeholders

Lack of trust among various industry stakeholders is a significant issue hampering data sharing in aquaculture. Companies fear misinterpretation and consequences, from both competitors and public institutions

## Building trust must happen step-by-step<sup>8</sup>

### 1 Build trust in structures

Fostered by:

- Rules
- Norms
- Fairness
- Transparency
- Buy-in
- Standards

2

### 2 Build trust between actors

Create opportunities for stakeholder interaction, as repeated interactions build relationships and trust

3

### 3 Build trust in the ecosystem

Trust enables formation of ecosystems based on relationships with shared goals and ambitions. Trust in the ecosystem will accelerate development and performance improvement

*Adapted from Deloitte (2011)*

# Take the plunge



There is an ongoing waiting game regarding data sharing in aquaculture, where no one is taking the lead to move forward

Despite a common ambition, stakeholders are reluctant to lead the data sharing agenda forward

Who wants data sharing?



Who wants to take the lead?



Who wants to pay?



To move forward, all industry stakeholders must understand their roles and join forces <sup>25</sup>

- 1 Successful establishment of an aquaculture data ecosystem relies on stakeholders' understanding of their own **role and impact**
- 2 It is critical to **join forces** in the industry, and establish industry-wide collaboration
- 3 Critical data sharing-initiatives must be led by a **neutral industry-wide party** (e.g., Collabor8). To ensure neutrality, both funding and value should come from and benefit the industry

# Establish industry-wide data standards

**IOIO** Currently, there is minimal data standardization, which hampers the industry's  
**IOIO** opportunity to aggregate, compare and extract value from data

## Significant consequences of inadequate standardization

Data is **not searchable** across companies and vendors, complicating the task of identifying useful and relevant data from third-parties

One **cannot guarantee the trustworthiness and quality** of data shared by others

Unstandardized data **has limited use and value** across various stakeholders, who cannot compare their own data with others

It **hampers ability to connect and verify** datasets securely and effectively across vendors

Shared architectures and initiatives (i.e. AquaCloud) have **limited function**, especially without significant data cleansing

## Principles and best practices of establishing and adopting industry-wide standards <sup>38</sup>

- 1 **Transparency:** Standard-making must be a cooperative, transparent process and open to all industry and associated stakeholders
- 2 **Neutrality:** Cooperation should be organized by a neutral body (i.e. trade associations)
- 3 **Voluntary:** Standards are established based on initiative from the industry itself
- 4 **Participation:** For industry-wide adoption, it is crucial that all stakeholders engage in design and implementation of new standards
- 5 **Consensus:** Standards are based upon shared understandings and interests in common industry guidelines
- 6 **Purpose:** To establish industry-wide guidelines to ensure expedient and secure products

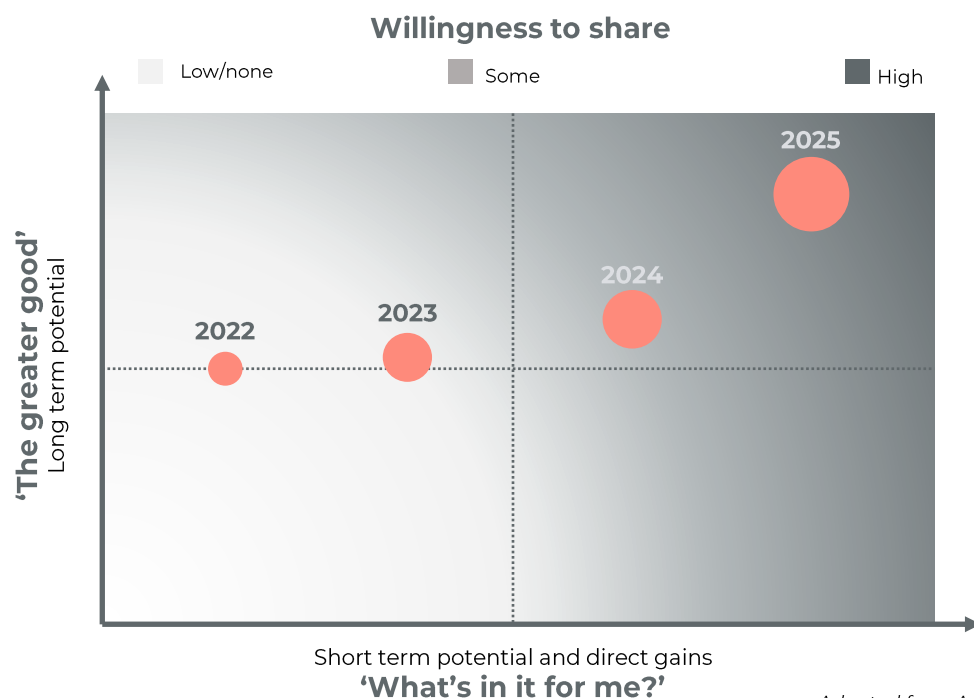
# Learn by doing



Ambiguity about the return on investments in data sharing can be solved by making the value real in incremental steps, use cases and iterations.

Unclear value propositions justifying investments are a significant hindrance for increased data sharing <sup>2</sup>

Clarify value proposition step-by-step



Adopted from AquaCloud (2022)

## Incremental steps

- To break the industry stasis, the emphasis should be on quickly implementing the first viable data sharing solution, however imperfect, in order to learn from real-life use cases
- It is useful to start with use cases of limited complexity to minimize risk and enhance probability of success

## Use cases

- Once value from a data sharing initiative is realized, further use cases should be generated
- Successful use cases and lessons learned should be communicated continually internally and externally to encourage and help other stakeholders

## Iterations

- Companies should apply a test-and-learn approach, and learn by doing
- It is useful to follow the cycle: build-measure-learn



We strongly support the development of guidelines and protocols for data and exchange of data built on open standards that enable communication and analysis across company borders. The value of having standardized data lasts forever and even increases the more data is added to the data set. This effect can be multiplied by making use of data sharing.

*Anders Storebø  
Lead Digital Transformation Farming, Lerøy Seafood Group*



Standardization when gathering and sharing data is crucial for interoperability, efficiency and facilitating collaboration across stakeholders.

*Jacob Mehus  
CEO, Standards Norway*





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# References

# References

#	Contributor	Reference	Year
1	ABB	<a href="#">Feeding the world responsibly and sustainably with Artificial Intelligence by ABB and Microsoft</a>	2020
2	AquaCloud	AquaCloud company presentation	2022
3	AquaCloud	<a href="#">AquaCloud standards for data and sensors</a>	2023
4	BarentsWatch	<a href="#">BarentsWatch – About us</a>	n.d.
5	Deloitte	<a href="#">Data-sharing technologies made easy   Deloitte Insights</a>	2022
6	Deloitte	<a href="#">Deloitte Insights Tech Trends 2022</a>	2022
7	Deloitte	<a href="#">Deloitte Insights Tech Trends 2023</a>	2023
8	Deloitte	<a href="#">Performance Ecosystems</a>	2011
9	Deloitte	<a href="#">The importance of ESG Data Management – Challenges and opportunities for the real estate ecosystem</a>	2021
10	EFRAG	<a href="#">First Set of draft ESRS</a>	2023
11	European Commission	<a href="#">Common fisheries policy (CFP)</a>	2023
12	European Commission	<a href="#">PEFCR for Marine fish</a>	2022
13	EY	<a href="#">The Data Act: new EU rules for data sharing</a>	2022
14	EY	<a href="#">The Norwegian Aquaculture Analysis 2022</a>	2023
15	Føre et al.	<a href="#">Precision fish farming: A new framework to improve production in aquaculture</a>	2018
16	Gartner	<a href="#">Gartner Top Data and Analytics Trends for 2021</a>	2021
17	Government of Norway	<a href="#">A Sea of Opportunities</a>	2021
18	Government of Norway	<a href="#">Hurdalsrapporten - For en regjering utgått fra Arbeiderpartiet og Senterpartiet 2021-2025</a>	2021
19	Government of Norway	<a href="#">Roadmap – The green industrial initiative</a>	2022
20	Iden & Costabile	<a href="#">Perspektiver på data og økosystemer for deling av data</a>	2022



# References continued

#	Contributor	Reference	Year
21	Industry Experts	Interviews and meetings	2023
22	Konietzko et al.	<a href="#">A Tool to Analyze, Ideate and Develop Circular Innovation Ecosystems</a>	2020
23	Kontali	<a href="#">The Salmon Farming Industry in Norway 2021 Report</a>	2021
24	Lovdata	<a href="#">Lov om akvakultur (Akvakulturloven)</a>	2005
25	McKinsey & Co. and Fraunhofer	<a href="#">Data sharing in industrial ecosystems</a>	2020
26	Microsoft	<a href="#">Industry Solutions – Creating the worlds first intelligent farm with Pescanova</a>	2023
27	Myrseth	Historien om oppdrett i Norge	2022
28	Nordic Innovation	<a href="#">Data sharing for a circular economy in the Nordics</a>	2021
29	Norwegian Digitalization Agency	<a href="#">Dataforordningen (Data Act) – Kort innledning</a>	2022
30	Norwegian Veterinary Institute	<a href="#">Fiskehelse rapporten</a>	2018-22
31	Norwegian Veterinary Institute	VIHUB	2023
32	Open Data Institute	<a href="#">Sharing data to create value in the private sector</a>	2020
33	OPS Sjømat	<a href="#">OPS Sjømat – About us</a>	2021
34	Paulsen	<a href="#">Datadeling i havbruksnæringen – De juridiske aspektene ved deling av data i oppdrettsnæringen</a>	2022
35	SASB	<a href="#">Implementation Webinar Series, SASB 101: Overview &amp; Roadmap</a>	2020
36	Schneider Electric	<a href="#">Bedre fiskevelferd og produktivitet med EcoStuxure</a>	2023
37	Siemens	<a href="#">Siemens Aquaculture 4.0 – The future of fish farming</a>	2023
38	Standards Norway	<a href="#">Hvordan lages standarder?</a>	2022
39	Tekna	<a href="#">Et hav av big data</a>	2018
40	X	<a href="#">Introducing Tidal. A moonshot to protect the ocean and feed humanity sustainably</a>	2020



“In addition to sharing data, we must ensure that we have enough competence to translate the data into knowledge and insight. We must work harder to attract graduates with digital skills and show that our industry has enormous potential for value creation by data sharing and digitalization.”

*Henning Beltestad  
CEO, Lerøy Seafood Group*



“As we handle more data in the aquaculture industry, addressing cyber security risks becomes increasingly important. To ensure success with data sharing, we need to significantly ramp up information technology education and recruitment of resources in the industry to effectively mitigate these risks. By improving our knowledge and understanding of these risks, we can better protect our data and drive growth in the aquaculture sector.”

*Geir Johan Birkeland  
Head of IT, Nova Sea*



# Interviewees

# The interviewees

## Software, technology & advisory



Loyd Jone Andreassen  
*Director Digital Innovation*



Stein-Erik Jøllanger  
*Software Product Specialist*



Trude Jansen Hagland  
*Head of Expansion and External Affairs*



Oddvar Husby  
*VP Data Science*



Trond Henriksen  
*Group Lead FoodTrust & Blockchain*



Erlend Torgnes  
*CEO & Co-Founder*



Tore Norheim Hagtun  
*CEO & Co-Founder*



Sven Jørund Kolstø  
*CEO & Founder*



Tord-Leth Olsen  
*Director, Aquaculture and Manufacturing Excellence*



Sondre Slathia  
*CTO*



Thomas Aas  
*Managing Director*



Pål Herstad  
*Director Digital Product Management*



John Costantino  
*Co-Founder / CTO*



Olav Jamtøy  
*Chairman of the Board*



## Data sharing platforms



Alf-Martin Sollund  
*Senior Advisor*



Jon Arne Grøttum  
*Director Aquaculture*



## Operational suppliers & service providers



Jørn Ulheim  
*CEO*



Nils Arne Grønlie  
*General Manager*



Helge Ervik  
*HSEQ Manager*



# The interviewees

## Farming



Geir Magne Knutsen  
*Director Strategy & Development*



Henning Knivsberg Moe  
*Global Digitalization Manager*



ROOTED IN NATURE

Trond Kathenes  
*CIO*



Anders Storebø  
*Lead Digital Transformation Farming*



Geir Johan Birkeland  
*Head of IT*



Håvar Sandvik  
*IT Manager*



Guttorm T. Johansen  
*IT Director*



## R&D



Jan Erik Stiansen  
*Research Director*



Jon Iden  
*Professor*



Arnfinn Aunsmo  
*Professor*



Leif Magne Sunde  
*Senior Business Developer*



The Thanh Nguyen  
*Head of Section Infrastructure & Digitalization*



## Authorities, legal advice & certification



Alastair Dingwall  
*Senior Director of Technical Operations*



Lisa T. De Jager  
*Aquaculture Director*



Erik Vikingstad  
*Senior Advisor*



Tobias Munter  
*Product Owner Aquaculture*



Mons Alfred Paulsen  
*Lawyer*





The salmon farming industry is dependent on trust from not only politicians, but from the society as such in order to earn the right of further growth. I believe the industry's 'license to operate' can be significantly improved through more openness, and sharing not only successes but also challenges. Data sharing and transparency is fundamental to the trust we need as an industry and fundamental for the right to operate, to grow and to establish fair and future oriented regulations.

*Einar Wathne*

*Chairman of the Board, NCE Seafood Innovation*

## Disclaimer

The information presented in this report has been compiled mainly from interviews conducted with industry experts – to be found in the 'Interviewees' part at the end of this report. Further references are indicated where necessary, even though this report is not expected to fulfill the criteria of a scientific paper.

Given that this report encompasses input from a wide range of different technology and advisory suppliers, salmon farmers and other industry players, conclusions drawn by NCE Seafood Innovation based on this research do not necessarily represent each contributor's individual opinion.

Each quote in this report is published with the written consent of its author.

About NCE Seafood Innovation

# A collective effort for sustainable seafood growth

NCE Seafood Innovation is a leading business cluster within the seafood industry, with more than 120 partners and members representing the whole seafood value chain. The cluster plays a central role in contributing to the sustainable growth and development of the seafood industry.

Promoting team efforts is a focal point. We believe that mobilizing joint forces is the way forward, and our cluster contributes through sustainable innovation projects and by facilitating interaction across the industry.

We work within five industrial areas of priority, which are defined by the industry, and which reflect the challenges we need to solve together with partners and members to realize opportunities for sustainable growth and development in the seafood industry:

- Climate, environment and circular economy
- Digital transformation and digitalization
- Fish health and welfare
- Future feed ingredients
- Future competence and talent attraction

This report is part of our 'Industry Insight' report series.



**Deloitte.**

*Thank you for your contribution to the production of this report*

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 **NCE Seafood  
Innovation**