Towards Circular Solutions in Aquaculture

Mapping challenges and design opportunities to reduce plastic waste in one of Norway's largest industries

Method & Data Collection

To explore circular plastic solutions in Norwegian aquaculture, we adopted a mixed-method, stakeholder-centered approach. Our goal was to gain both strategic insight into circularity practices and practical understanding of on-site waste handling.

Stakeholder Interviews

We interviewed a range of key actors, including aquaculture companies, equipment producers, waste managers, and recycling operators, to understand current routines, logistics, and barriers to circularity. A structured R-strategy self-assessment survey, covering strategies from Refuse to Recycle, was used to evaluate the level of adoption across stakeholder groups. Responses were scored from 0 (not at all) to 3 (fully integrated).

Field Visits

Site visits in Nordland and Sør-Varanger provided essential context for both data analysis and design work. We observed daily operations, access conditions, waste sorting practices, repair activities, and available infrastructure. Visual documentation supported both stakeholder mapping and design decision-making.

Land-based support facility for aquaculture operations at Lanabukt quay in Sør-Varanger

Design & Analysis

Findings from interviews and site visits informed:

- Stakeholder-specific analysis of circular practices.
- Identification of gaps and opportunities in R-strategy implementation.
- Development of design criteria for a user-friendly, site-adapted plastic collection point compatible with existing workflows.

By combining circular economy evaluation with field-based design research, our approach bridges strategic and practical aspects of sustainability in aquaculture.

Aquaculture is one of Norway's most important industries and a key part of the country's blue economy. However, the sector generates significant plastic waste from gear such as nets, cages, and ropes, contributing to environmental challenges including ghost fishing and microplastic pollution.

This summer, as part of NTNU's **Circular Plastic in Aquaculture** project supported by Handelens Miljøfond, our interdisciplinary student team was based in Kirkenes and Mo i Rana, mapping both local and national challenges and opportunities related to plastic waste.

Our research combined two complementary approaches. From a circular economy perspective, one of us examined how the R-strategies—Refuse, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover—are currently implemented by aquaculture stakeholders. Through field visits and surveys with producers, fish farmers, and waste managers, we assessed existing practices and identified gaps and opportunities for improvement.

From an architecture and design perspective, the other focused on how improved infrastructure for plastic collection can support more effective and user-friendly waste handling. The goal was not to redesign aquaculture structures themselves, but to propose intuitive and accessible design interventions that make circular practices easier to adopt.

Illustration of a designated collection point for plastic waste generated in aquaculture operations

Key Findings

Circular Strategies Are Unevenly Applied

- Producers prioritize Rethink by integrating circularity into product design and recyclability; however, further empirical validation is needed to verify whether reported adoption aligns with actual implementation.
- Fish farmers prioritized strategies aimed at extending the lifespan of existing gear; however, Repair and Reuse are not fully implemented due to logistical constraints and regulatory barriers.
- Recycle is emphasized by waste managers, producers, and fish farmers as a key strategy; however, limited downstream infrastructure, poor material recyclability, and restricted processing capacity hinder effective implementation.
- Strategies such as Refuse, Reduce, Repair, Refurbish, Remanufacture, and Repurpose are not fully implemented across stakeholder groups, reflecting persistent linear practices, limited infrastructure, low perceived feasibility, and a lack of regulatory or economic incentives.

Systemic and Policy Barriers

- Strict re-certification rules limit the reuse and repair of gear.
- Upcoming Extended Producer Responsibility (EPR) regulations may shift costs and responsibilities to producers, creating both pressure and design opportunities.
- High recycling quality requires plastic to be clean, dry, and pre-sorted, but current systems rarely support this.

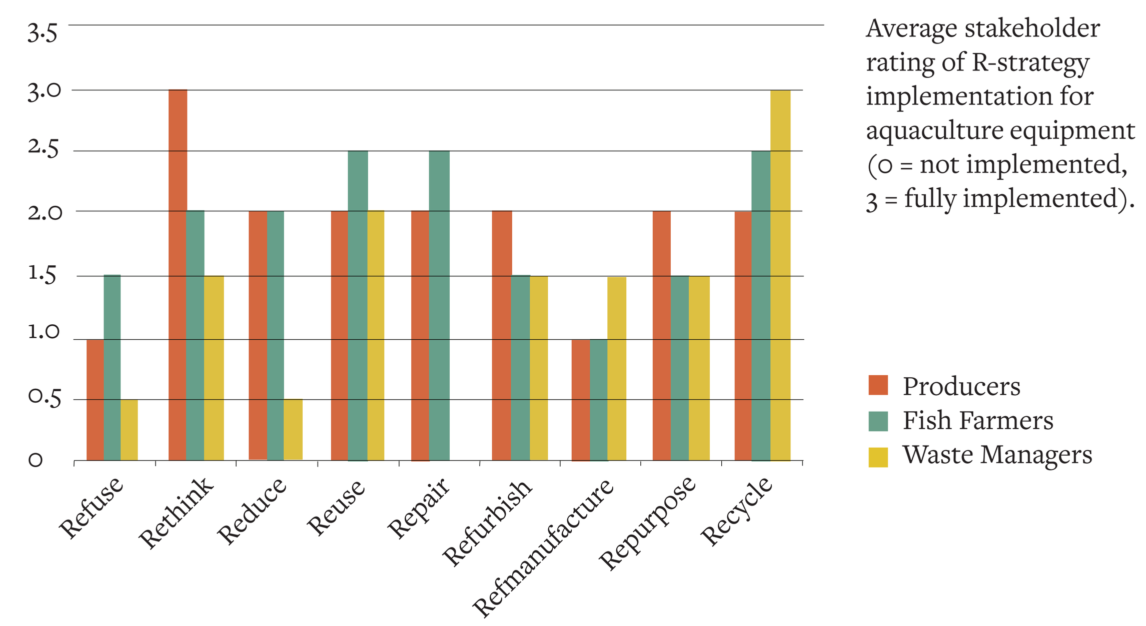
Infrastructure Gaps

- Collection systems are fragmented, varying by harbor and region.
- Issues include lack of standard containers, inconsistent access, and minimal sorting capacity.
- Operational challenges include seasonal waste fluctuations, space constraints, and language barriers (e.g., among Russian crews).

Barriers & Recommendations

Key Barriers

- Regulatory & Certification Hurdles: Strict rules require re-certification for reused equipment like nets and cages, making repair and reuse costly and time-consuming. Low traceability of plastic materials complicates compliance and circular reporting.
- Economic & Financial Constraints: For many operators, especially smaller ones, it is cheaper to buy new gear than to repair, recycle, or transport used materials. Labor, logistics, and facility access drive up costs.
- Infrastructure & Logistics Gaps: Remote farms often lack nearby recycling or repair facilities. Port infrastructure is inconsistent, with limited space, containers, and collection schemes. Seasonal peaks, limited crew time, and language barriers (e.g., Russian-speaking crews) affect daily waste handling.
- Informational & Mindset Barriers: Linear thinking persists, some stakeholders distrust reused materials and lack awareness of circular alternatives. Absence of standardized sorting, storing, or collecting systems makes it harder to scale effective solutions.
- Aesthetic & Spatial Conflicts: In scenic or heritage-sensitive areas, bulky or industrial-looking infrastructure may face local resistance.



Average stakeholder rating of R-strategy implementation for aquaculture equipment (0 = not implemented, 3 = fully implemented).

Strategies for Circular Transition

Design for recyclability

This ensures that materials can be easily separated and processed for efficient end-of-life recycling.

Infrastructure development

This involves building collection points, repair hubs, and harbour facilities to support circular handling of aquaculture plastics.

Deposit Refund Incentives

This approach encourages the return of used plastic equipment by offering formal incentives or financial reimbursement.

Innovation Partnership for Material Reuse

This will drive circularity by bringing together industry and research to transform aquaculture plastic waste into valuable resources.

Repair and Reuse Programs

These programs help extend the lifespan of aquaculture equipment, reducing waste and maximizing resource efficiency before recycling is needed.

Scalable and Adaptive Infrastructure

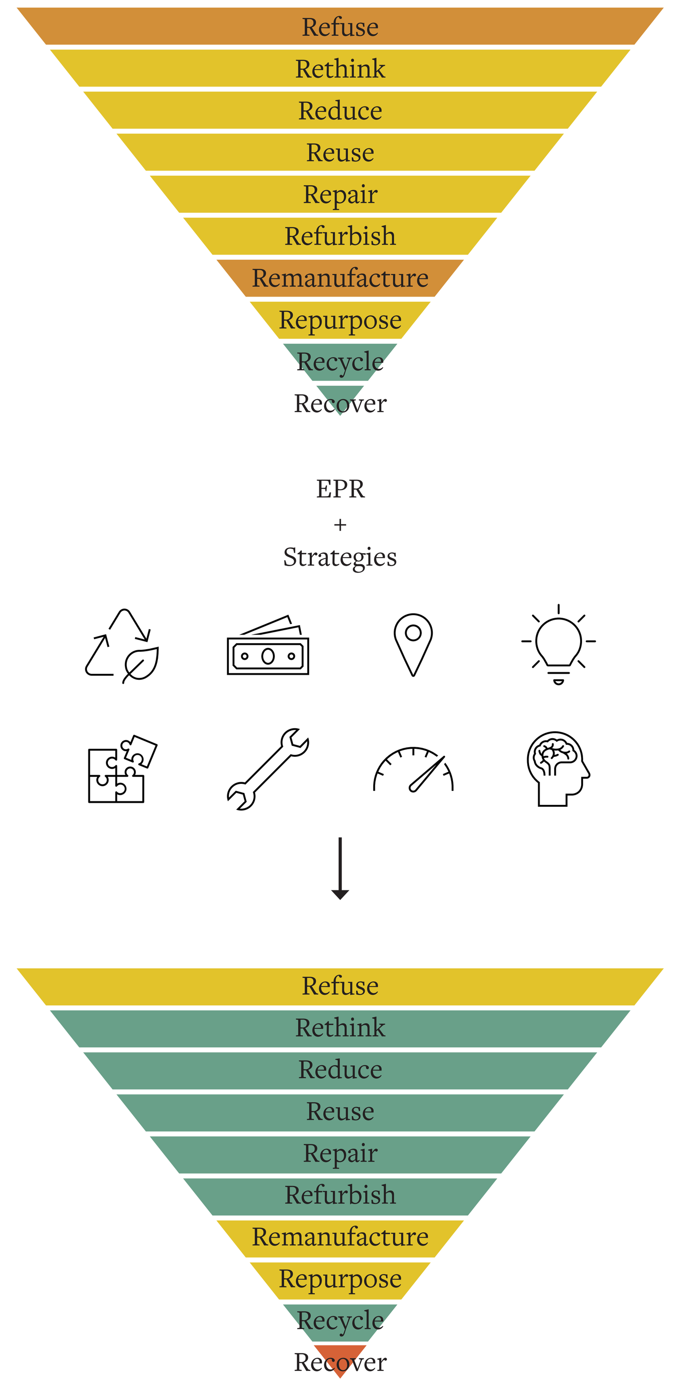
Create modular, flexible collection systems that fit both large ports and small harbors.

Digital Tools and Tracebility

Integrate weight sensors, access logs, and photo documentation to improve transparency and support EPR reporting.

Behavioral Design and Multilingual Support

Use intuitive color coding, signage, and educational panels to promote correct sorting and raise awareness—across language and literacy levels.



The Impact of EPR and Circular Strategies on R-Strategy Adoption in Norwegian Aquaculture.

Fully implemented
Moderatly implement
Fairly implemented
Not implemented

Conclusion

The transition to circular plastic systems in Norwegian aquaculture is underway but remains uneven across the value chain. While producers are advancing in circular product design, fish farmers and waste managers face practical, economic, and regulatory barriers that hinder the broader adoption of reuse, repair, and recycling strategies.

This project combined stakeholder analysis with field-based design research to identify key obstacles and opportunities, including fragmented infrastructure, certification challenges, user constraints, and behavioral gaps. The interdisciplinary approach highlights the need for both system-level transformation and site-specific design interventions.

Design plays a critical role in making circularity actionable. By developing modular, adaptable collection points that respond to real operational contexts, we aim to support cleaner material loops, better traceability, and more sustainable practices along the coast.

Moving forward, the integration of policy instruments like Extended Producer Responsibility (EPR), localized recycling hubs, and user-centered infrastructure will be essential to turn circularity from intention into reality—creating lasting environmental and economic value for Norway's blue economy.

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Links to our reports: Toluse Natalia

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