Circutech

Circular Competence Training for Aquaculture Waste Management using VR and AR Tools

SWOT factsheet

From Spain, Italy, and Portugal

includes EU Med regional data from desktop research for reference

Co-funded by
the European Union

prepared by AlterContacts based on data from the CIRCU-TECH consortium partners and desktop research

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SPAIN

STRENGTHS

- ★ **Leadership and Research Excellence**, highest number of scientists and researchers in aquaculture globally.
- ★ **Environmental Certification and Sustainability Performance**, 98% certification rate for aquaculture production.
- ★ **Animal Welfare Commitment within the sector,** dedicated Fish Welfare Working Group established in 2022.
- ★ **Production System Diversity** and fully integrated value chains allow adaptability to varying environmental conditions.
- ★ **Sectoral Collaboration and Transparency**, with 22 companies contributing to the 2025 Sustainability Report country-wide.

WEAKNESSES

- ★ **Production Volume and Import Dependency**, unrealized production potential to meet domestic demand.
- ★ **Energy Transition Challenges**, varying carbon footprint associated with feed, transport and cold chain logistics.
- ★ **Regulatory Complexity and Administrative Barriers**, inconsistent across different regions and EU framework.
- ★ **Consumer Awareness and Market Positioning**, knowledge among consumers, competition from imported products.
- ★ **Gender Equality and Social Inclusion**, need for more structured approaches to diversity and inclusion.

OPPORTUNITIES

- ★ **Leadership in Blue Transformation**, lower environmental impact compared to land-based animal production.
- ★ **Rural Development and Territorial Cohesion**, integrating models of aquaculture and tourism, benefiting local communities.
- ★ **Technological Innovation and Digitalization**, utilizing analytics to optimize feeding, health management, and harvesting.
- ★ **Strategic Alignment with SDG 2, 13, 14**, and indirectly to 6, 12 and 15, enables opportunities for sustainability-focused funding.
- ★ **Consumer Trends and Market Development**, increasing environmental and health benefits awareness, digital channels.

THREATS

- ★ **Climate Change Impacts**, increasing sea temperature, extreme weather, drought, ocean acidification, need adaptation strategies.
- ★ **Market Competition and Price Pressure**, competition from non-EU countries, with lower environmental and social standards.
- ★ **Evolving Regulatory Requirements** can lead to higher costs, new animal welfare standards can affect operational practices.
- ★ **Public Perception and Social License**, misinformation, media coverage may not always reflect sustainability improvements.
- ★ **Resource Constraints and Input Costs**, feed ingredients, imported inputs. energy cost fluctuation, competition for coastal space.

ITALY (shell fish)

STRENGTHS

- ★ **Mussel farming aligns with EU sustainability goals**, requiring no inputs while enhancing water quality through natural filtration.
- ★ **Bivalves enhance biodiversity and offer nutrient regulation**, acting as natural bioindicators for pollution monitoring.
- ★ **Shellfish farming generates minimal waste,** mostly polypropylene socks, which can be recycled. Other materials are manageable via existing collection systems with no added burden to farmers.
- ★ **Low waste and nutrient-free nature**, shellfish farming is inherently sustainable. Circular solutions, such as recycling gear and adopting greener practices, can further reduce its environmental footprint.

WEAKNESSES

- ★ **Polypropylene socks, the main waste product**, are classified as special waste, requiring costly certified disposal. Recycling is hindered by organic residue buildup, making the process complex and economically unviable.
- ★ **Lack of specialized recycling facilities**, most used socks are incinerated for energy recovery, meeting compliance but undermining circularity through carbon emissions.
- ★ **Waste management practices vary widely across regions and ports**. Inconsistent outcomes and uneven costs hinder the adoption of standardized, sector-wide best practices.

OPPORTUNITIES

- ★ **Emerging EU-funded projects**, showcase viable Innovations such as on-site mobile recycling units enabling circularity by transforming used socks into new products.
- ★ **Biodegradable and renewable materials** to replace polypropylene, reducing microplastic and pollution while advancing low-impact aquaculture practices.
- ★ **Cross-sectoral circularity**, with plastics repurposed for 3D printing and mussel shells reused in green construction, agriculture, and cosmetics.
- ★ **R&D collaboration** between industry, science, and policymakers, is key to accelerating circular sustainability in shellfish farming.

THREATS

- ★ **Environmental changes**; shifts in temperature, salinity, or oxygen levels can severely impact yields and long-term viability.
- ★ **classification of used polypropylene socks as special waste** imposes complex legal requirements, creating uncertainty and administrative burdens for farmers navigating compliance..
- ★ **Lack of port infrastructure** and distant disposal sites raise costs, while strict transport rules expose farmers to legal risks.
- ★ **Current regulations**, though well-intentioned, clash with on-the-ground realities—creating complexities and costs that hinder compliance and may unintentionally drive improper disposal.

ITALY (fin fish)

STRENGTHS

- ★ **Biodiversity Enhancement.:**diversity of farmed finfish species boosts local aquatic biodiversity, supporting ecosystem resilience.
- ★ **Robust Environmental Monitoring**: both farms and authorities ensures frequent, reliable environmental data
- ★ **Cultural and Environmental Stewardship:** sustains communities, preserve traditional practices and conserve aquatic environments.
- ★ **Ecosystem Contribution**: supports ecosystem functions including bio-remediation, carbon sequestration, and climate regulation.
- ★ **Sustainable Technologies**: cutting-edge solutions, and waste treatment systems to optimize production and minimize impact.

WEAKNESSES

- ★ **Fragmented Production Landscape** hinders the efficiency and cost-effectiveness of waste management systems.
- ★ **High Costs and Infrastructure Gaps**: by-products requires costly temporary storage and energy-intensive equipment.
- ★ **Bureaucratic Complexity**: Cumbersome procedures, inconsistent recordkeeping requirements, and unclear rules.
- ★ **Limited Training and Knowledge Transfer**: challenges accessing clear, consistent guidance and training.
- ★ **Uneven Regulatory Landscape** creates operational disparities and undermines sector-wide cohesion and circularity efforts

OPPORTUNITIES

- ★ **Waste-to-Value Solutions**: Convert organic by-products into biogas, fertilizers, or soil improvers, generating revenue streams.
- ★ **Funding Support**: Access EMFAF and Just Transition funds for sustainable aquaculture and regional socio-economic adaptation.
- ★ **Cross-Sector Partnerships**: feed, pet food, cosmetics, and pharmaceutical industries to jointly turn waste into raw materials.
- ★ **Market Differentiation**: Use sustainability certifications to target premium markets, especially in high-end gastronomy.
- ★ **Innovative Technologies:** nutrient recovery, aquaponics, and wastewater fertigation to improve efficiency and diversification

THREATS

- ★ **Climate change impacts**: Heatwaves, storms, algal blooms, and disease outbreaks increasingly threaten both mariculture and freshwater fish farming.
- ★ **Regulatory complexity**: Fragmented, inconsistent rules and region-specific procedures make marine waste and by-product management costly and difficult.
- ★ **Sustainability misperceptions**: Public confusion with unrelated practices fuels doubts about medicines use and animal welfare in Italian aquaculture.
- ★ **Market resistance**: Retailers often reject EU Organic and other certifications, favouring private-label fish over certified sustainable products.

PORTUGAL

STRENGTHS

- ★ **Established waste management systems** – Certified companies handle plastics, metals, Styrofoam, nets, buoys, and organic by-products, ensuring proper recycling or incineration.
- ★ **Innovative reuse practices** – Shells repurposed into cement blocks.
- ★ **Positive ecosystem contribution** – Bivalve farming supports biodiversity, preserves and even improves water quality, with lower environmental impact than many other food production sectors.
- ★ **Emerging sustainable technologies** – New durable, recyclable aquaculture gear (i.e, polyethylene floats). Young farmers are finding ways to reduce plastic waste (i.e, using larger feed bags).

WEAKNESSES

- ★ **Low awareness and knowledge** of waste management and sustainable practices among workers, business owners and consumers, amplified by educational levels and language barriers.
- ★ **Training accessibility and availability**: Few training programs tailored to aquaculture; online platforms require individual registration, discouraging participation.
- ★ **Bureaucratic and regulatory hurdles**: Confusing regulations, unclear marine litter origins, and mandatory platforms (e.g., Sociedade Ponto Verde) that don't match sector needs.
- ★ **Inadequate disposal infrastructure**: Some regions lack facilities for waste management and waste disposal at ports is insufficient.

OPPORTUNITIES

- ★ **Reusable and sustainable transport packaging** has potential to improve durability, sanitization, and quality in the supply chain.
- ★ **Collaboration with research and innovation centers**, universities, technology companies, and associations to co-develop targeted waste and by-product management technologies.
- ★ **Valorization of by-products**: Shells and other aquaculture waste show potential to solve some agriculture challenges, livestock feed calcium enrichment, and fertilizer production.
- ★ **Market positioning through sustainability**: promoting sustainable production and raising producer awareness can enhance consumer trust and potentially open premium markets.

THREATS

- ★ **Climate change impacts**: rising temperatures, lower oxygen levels, toxic algal blooms, invasive species, and new diseases.
- ★ **Regulations, legislation and policies challenges** are often based on misconceptions, creating bureaucratic hurdles and logistical barriers for proper disposal and reuse.
- ★ **Public perception and misinformation**: aquaculture is wrongly viewed as a source of marine litter, microplastics, and habitat loss, with products perceived as less healthy or more expensive.
- ★ **Sectoral pressures**: fisheries lobbying, competition with tourism industry, and limited consumer demand for sustainable products.
- ★ **Knowledge and infrastructure gaps**: Lack of training; limited waste and by-product management facilities.

EU Med area

STRENGTHS

- ★ **Innovation and leadership**: The Med region dominates global seabass and seabream production with full lifecycle control and advanced hatchery technologies that reduce costs.
- ★ **Circular aquaculture**: Integrated Multi-Trophic Aquaculture, Recirculating Aquaculture Systems, and bio-floc systems minimize environmental impact and maximize resource efficiency.
- ★ **Waste valorization**: By-products like shells, heads, and bones are used for fishmeal, biogas, soil amendments, and emerging bioplastics, with strategic projects advancing nutrient recovery.
- ★ **Policy and institutional support**: EU & regional strategy frameworks and knowledge transfer for sustainable, circular practices.

WEAKNESSES

- ★ **Limited scaling of circular technologies** – IMTA, RAS, bio-floc, and aquaponics add complexity and require better skill training.
- ★ **Economic viability**: Low profitability, high feed costs, inefficient labor productivity, and narrow margins do not attract investors.
- ★ **Market structure limitations**: Fragmented industrial structures and limited product diversification restrict economies of scale and access to growing processed and convenience food markets.
- ★ **Circular economy implementation gaps** – Supply chains connecting by-product producers to value-adding entities are often missing, and SMEs lack equipment, infrastructure, and financial capacity to scale pilots.

OPPORTUNITIES

- ★ **Regulatory drivers for circularity**: Extended Producer Responsibility (EPR) and EU guidelines on alternative feed ingredients create incentives for sustainable practices and new market opportunities.
- ★ **Species and technology diversification** – Emerging species and climate-adaptive technologies, including offshore aquaculture, support resilience and portfolio expansion.
- ★ **Regional cooperation initiatives**: Mediterranean frameworks, WestMED, and demonstration centers promote knowledge transfer, sustainable practices, and development of low-trophic species.
- ★ **Bio-based and circular economy growth**: Untapped potential in algae, insect-based feeds, and by-product valorization.

THREATS

- ★ **Climate change impacts**: Rising temperatures, marine heatwaves, and extreme weather events threaten biomass, growth consistency, and profit stability across Mediterranean farms.
- ★ **Environmental and regulatory pressures**: Nutrient loads, pollution scrutiny, spatial conflicts, overlapping authorities, and complex licensing hamper sector expansion and sustainability.
- ★ **Market and financial risks**: Currency fluctuations, high financing costs, narrow margins, and investor reluctance reduce economic viability and market stability.
- ★ **Disease and health management challenges**: Pathogens, bacterial threats, betanodavirus, and antimicrobial resistance, compromise production; diagnostic gaps create regional vulnerabilities.

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