Matsa: White Paper

Harnessing Geospatial AI and Edge Computing to Build Resilient, Profitable, and Sustainable Aquaculture.

DATE

Q3 - 2025

PROJECT

Matsa

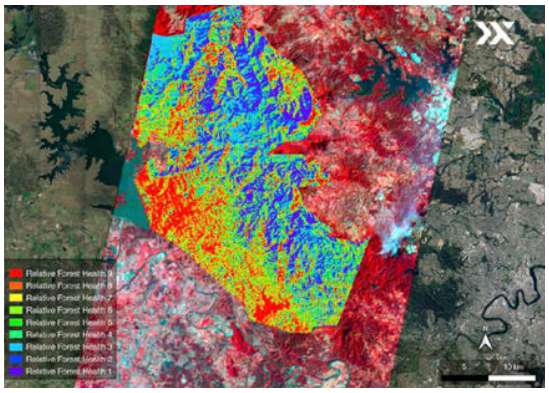
COACTIVE .SCIENCE

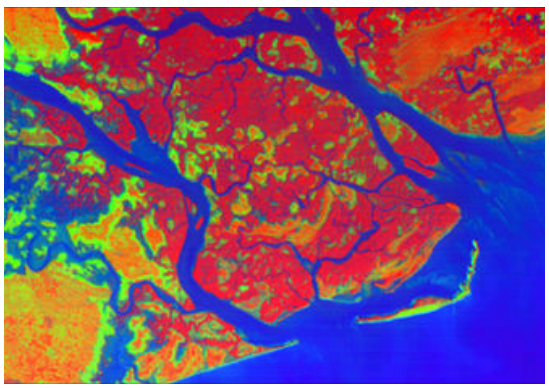
Executive Summary

Aquaculture is at a digital tipping point. As global demand for sustainable seafood rises, operators face mounting pressure from environmental risks, regulatory requirements, and market expectations. Traditional monitoring and management methods are no longer enough to protect profitability, animal welfare, or compliance.

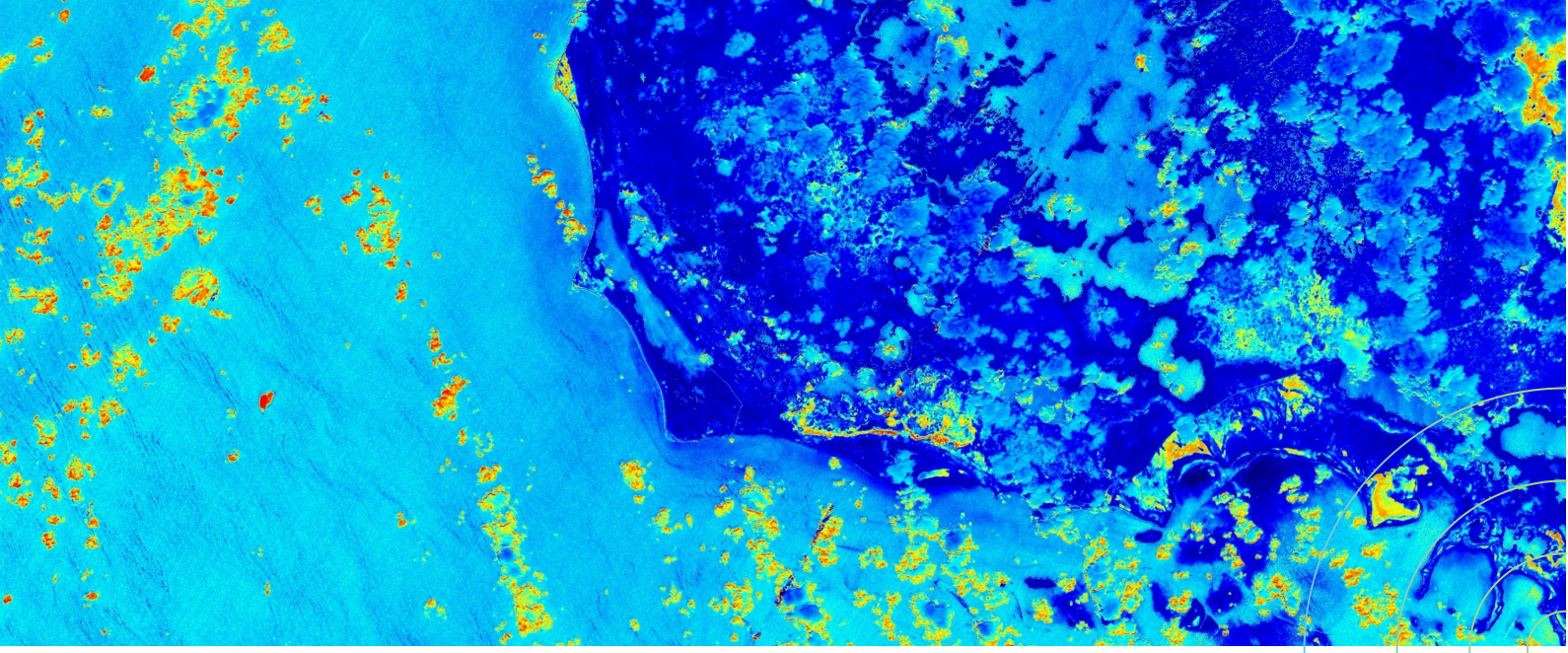
This brochure introduces a next generation, integrated solution that combines satellite remote sensing, advanced edge AI cameras, and real-time cloud analytics to deliver:

- Proactive risk mitigation: Early detection of harmful algal blooms (HABs), pollution, and operational maintenance.
- Optimized resource use: AI-driven monitoring to reduce waste by up to 30%.
- Enhanced welfare and compliance: Automated, continuous monitoring for fish health and regulatory reporting.
- Rapid return on investment: Proven payback periods of 12–18 months with added value from risk avoidance and compliance cost savings.
- Future-proof operations: Modular, scalable architecture that adapts to new technologies and regulations.





Through detailed technical architecture, ROI/ESG calculators, and real-world case studies, this white paper offers a practical roadmap for aquaculture operators, investors, and regulators seeking to build smarter, more sustainable, and more resilient aquatic food production systems.



The Digital Transformation of Aquaculture

Modern fish farming is no longer about manual observation and reactive management. The convergence of AI, remote sensing, and real-time monitoring is revolutionizing operations—optimizing efficiency, preventing disease, managing resources, and ensuring compliance.

Satellite data from Sentinel and Pixxel provide continuous, large-scale environmental insights, detecting HABs, water quality changes, and unregulated activities across vast farming areas. Edge AI systems analyze in-cage camera feeds and IoT sensor data, empowering fish farmers with actionable intelligence—from precise biomass estimation and health monitoring to automated feeding and early operational warnings.

This technological synergy drives smarter, more sustainable practices, reducing feed waste, minimizing disease outbreaks, and supporting compliance with ESG and market requirements

The Urgent Challenge

Despite technological advances, aquaculture remains vulnerable to HABs— rapid proliferations of toxin-producing or oxygen-depleting algae. Fueled by climate change, nutrient runoff, and coastal development, HABs are becoming more frequent and severe, causing mass fish mortalities, ecosystem disruption, public health risks, and multi-million dollar losses.

Example: The High Cost of HABs : 2016 Chiloé Island HAB Crisis

Event Overview: Two consecutive HABs devastated Chile's Chiloé Archipelago, causing catastrophic economic losses, environmental damage, and social unrest.

Key Impacts:

- **Salmon farming:** 39 million farmed salmonlost (≈100,000 metric tons), valued at USD 800 million.
- **Shellfish sector:** 15% drop in harvests,prolonged closures, and artisanal fishers losing USD 9 million/day during peakclosures.
- **Social unrest:** Protests and roadblocks paralyzed Chiloé for 18days.

Environmental and Climatic Factors

- **El Niño Influence:** Elevated sea surface temperatures, reduced rainfall, and calm winds created optimal HAB conditions.
- **Coastal Dynamics:** A cyclonic gyre near the salmon dumping site may have transported nutrients to shore, potentially fueling the A. catenella bloom.
- **Ecosystem Collapse:** Mass beaching of surf clams (Mesodesma donacium) in Cucao Bay highlighted cascading ecological impacts, with toxin levels **110x above regulatory limits.**

Rising Regulatory Mandates

EU

The European Union has developed a robust regulatory framework to ensure that pisciculture and aquaculture contribute meaningfully to climate neutrality and circular economy goals. Central to this effort is the Common Fisheries Policy (CFP) 2013, recently revised to mandate ecosystem-based management principles.

Operators are now required to regularly quantify environmental impacts—such as benthic organic loading, predator interactions, and antibiotic resistance gene transfer—while also implementing advanced monitoring and reporting systems.

The EU Aquaculture Assistance Mechanism supports these requirements through technical guidelines for early warning systems for harmful algal blooms, energy efficiency benchmarking for recirculating aquaculture systems, and waste reduction via polyculture integration. As of 2024, the Corporate Sustainability Reporting Directive (CSRD) imposes comprehensive environmental and social impact disclosures for larger enterprises, covering supply chain traceability, risk assessments, and climate resilience planning aligned with international standards.

"Navigating Regulatory Challenges and Unlocking Opportunities in EU Aquaculture"

This evolving regulatory landscape presents both challenges and opportunities for EU aquaculture operators.

Compliance with CSRD and the forthcoming Aquaculture Product Environmental Footprint (PEF) standards will require significant investment in digital infrastructure for real-time monitoring, as well as collaborative R&D for climate-resilient production systems and transparent stakeholder engagement.

However, early adopters of technologies such as AI-driven feed optimization and traceability are poised to capture premium market positions and access green financing.

Ultimately, success in the sector will depend on balancing ecological sustainability with economic viability, necessitating deeper integration of marine science, data analytics, and circular design principles

Rising Regulatory Mandates

UAE

The United Arab Emirates is positioning itself as a regional leader in sustainable aquaculture by implementing rigorous environmental, social, and governance (ESG) reporting requirements that align with national climate commitments such as Net Zero by 2050.

Regulatory frameworks, including the UAE Green Agenda 2030 and Federal Decree-Law No. 11 (2024), mandate detailed disclosures on greenhouse gas emissions, water quality, and waste management for all aquaculture operators.

These measures are reinforced by emirate-specific policies such as the Abu Dhabi Sustainable Aquaculture Policy, which requires environmental impact assessments and annual reporting on feed conversion ratios, wastewater recycling, and by-product utilization. For listed companies, enhanced ESG obligations under SCA Regulations 2024 and ADX guidelines require disclosure of nitrogen and phosphate discharges, predator control measures, and climate vulnerability assessments, ensuring comprehensive monitoring and transparency across the sector

"Navigating Regulatory Challenges and Unlocking Opportunities in UAE Aquaculture"

This evolving regulatory landscape presents both challenges and opportunities for UAE aquaculture operators.

Compliance with increasingly complex sustainability reporting—including quarterly monitoring of environmental indicators and traceability—demands significant investment in digital and predictive technologies, as well as strategic partnerships with renewable energy providers and carbon markets.

While compliance costs may be substantial for smaller operators, those who embrace innovation and align with these mandates are well-positioned to access premium export markets and secure preferential financing.

Ongoing regulatory expansion, such as the planned Aquaculture Sustainability Certification Scheme and Dubai Reef monitoring requirements, signals continued sectoral transformation, requiring operators to remain agile and proactive in integrating sustainability into their core operations

Smart Aquaculture - Overcoming Constraints

Threats

- Driven by rising demand for sustainable seafood and the need to supplement declining wild fish stocks.
- The rural and coastal locations and limited transportation infrastructure & regulatory barriers and limited access to foreign labour programs can leave positions unfilled, directly impacting

Key catalysts

- Labour Shortages in High-Risk Roles
- Diver scarcity:
- Ageing workforce:
- Competition from adjacent industries:

Cost and Efficiency Pressures

- Manual inspections cost USD 8,000–12,000 per dive, with limited coverage and data granularity.
- Labour shortages delay maintenance, increasing risks of net breaches, fish escapes, and disease outbreaks.

Opportunities

- AI, and digital monitoring systems to maintain productivity, efficiency, and sustainability.
- Automation of Core Tasks, Data driven Management and Sustainability and Resilience are transforming farm operations
- Future-proof their businesses against ongoing workforce constraints and reducing costs by adopting productive technologies.

Labor shortages are accelerating the adoptionof automation and digital solutions in aquaculture, ensuring efficiency andsustainability. Embracing technology is now essential for producers to meetdemand and secure the sector’s future.

Our Solution

A Modular, Scalable Platform

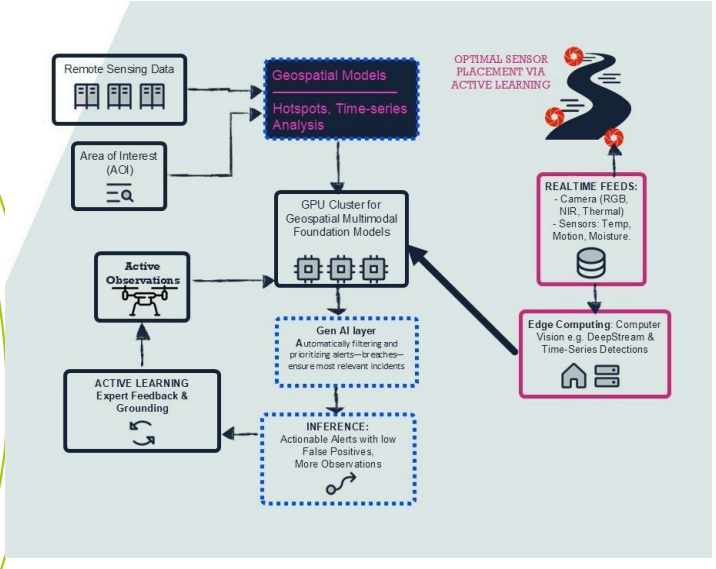
Our integrated solution combines

- Satellite Remote Sensing: Wide-area, early-warning capabilities for HABs and water quality threats.
- Edge AI Cameras: High-frequency, Operational, in-cage behavioral and biomass analytics.
- Real-Time Cloud Analytics: Actionable insights for proactive management and compliance.

Key Benefits

- Mitigate risks proactively: Early alerts for HABs, pollution, operational and water quality threats.
- Optimize feed and resource use: AI-driven appetite detection and feed control, reducing waste by up to 30%.
- Enhance welfare and compliance: Automated, continuous monitoring for fish health and regulatory reporting.
- Achieve rapid ROI: Payback in 12–18 months, with added value from risk avoidance and compliance cost savings.
- Future-proof operations: Modular, scalable architecture supports integration with emerging technologies and evolving regulation

Model



Case Study - 1

Remote sensing data and incorporating Hyperspectral data

Case Site: Tallebudgera Creek, East coast of Australia

Summary:

In 2019, Tallebudgera Creek faced significant sedimentation and turbidity challenges, threatening navigation, aquatic life, and recreational use. Coactive Science's Matsa Leveraging Sentinel satellite analytics & Pixxels hyperspectral imaging, delivers actionable insights that can empower stakeholders to optimize dredging operations, minimize environmental impact, and enhance waterway health.

This case study demonstrates how advanced remote sensing transforms waterway management and supports sustainable decision-making

Our Solution: Satellite Analytics

We deployed a multi-indicator satellite analysis, providing a comprehensive, 60-day view (June–August 2019) of Tallebudgera Creek. Key metrics included:

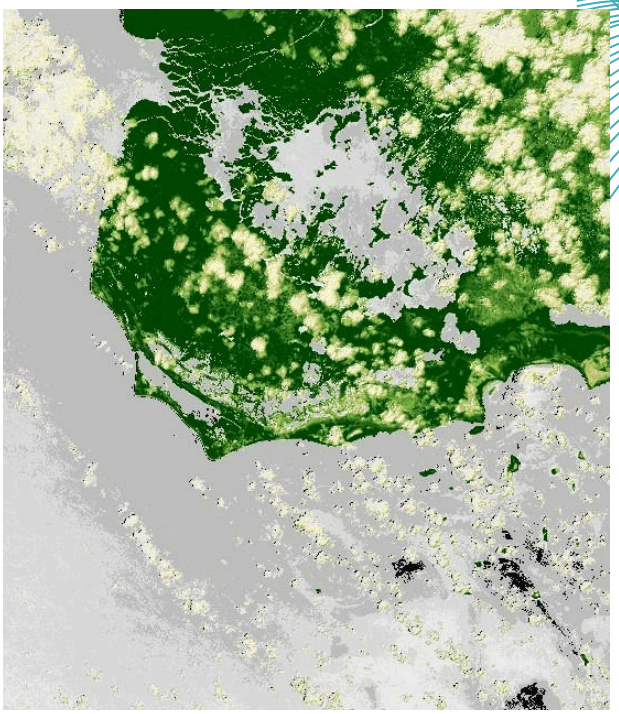
1. **Composite Dredging Need Index**
   What it shows: Real-time risk of sediment accumulation.
   Insights: Moderate variability with peaks in late July and mid-August, validating the need for targeted dredging.

2. **Turbidity Proxy**
   What it shows: Water clarity and sediment suspension.
   Insights: A sharp turbidity spike in early July pinpointed a natural disturbance, guiding operational response.

3. **Satellite-Derived Bathymetry (SDB)**
   What it shows: Changes in water depth due to sediment deposition.
   Insights: A mid-July shallowing event signaled significant sediment inflow, informing dredging schedules.

4. **Estimated Volume Change**
   What it shows: Net sediment gain/loss in cubic meters.
   Insights: A major mid-July deposition event (+400 m^3) followed by a net loss (-2000 m^3), capturing the dynamic sediment cycle.

5. **Spatial Plume Analysis**
   What it shows: Extent and intensity of sediment plumes from dredging.
   Insights: Detected both localized (July 5) and extensive (July 20) plumes—critical for understanding far-field impacts.



Results & Impact:

- **Real-Time Decision Support**: Authorities receive actionable alerts on sedimentation and turbidity events.
- **Optimized Dredging**: Data-driven scheduling, minimized unnecessary dredging, reducing costs and ecological disruption.
- **Environmental Stewardship**: Spatial plume mapping enabled rapid response to far-field impacts, protecting sensitive habitats.
- **Stakeholder Confidence**: Transparent, visual reporting built trust among regulators, community groups, and industry partners.

Case Study - 2

Enhancing Aquaculture Operations with Intelligent Video Camera Analytics

Case Site: Coastal Aquaculture farm, Norway

Summary:

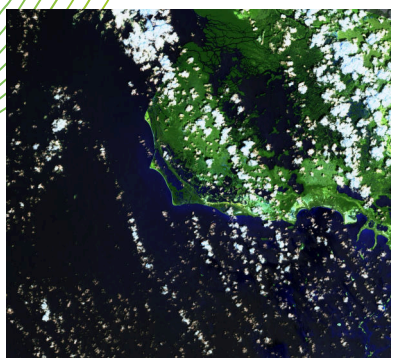
A leading coastal aquaculture operation in Norway faced mounting challenges in site security, equipment integrity, and environmental risk management. To address these issues, the farm implemented a comprehensive video camera analytics system, integrating advanced AI for real-time monitoring of site activities, environmental parameters, and biosecurity threats.

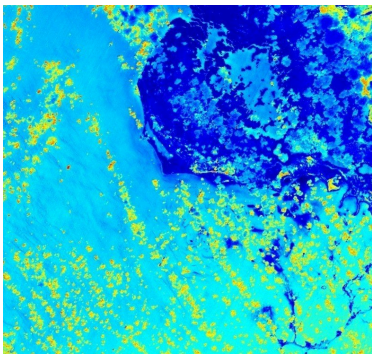
This case study demonstrates how intelligent video analytics can transform operational oversight, support risk management, and foster sustainable, resilient aquaculture practices

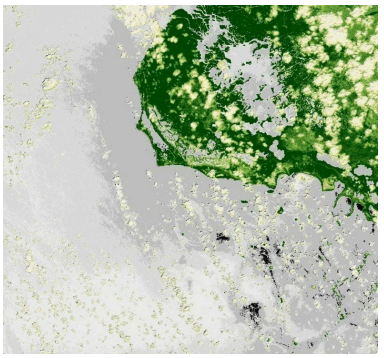
The Challenge

The farm's traditional monitoring methods relied on periodic manual inspections, which were labor-intensive and prone to delays. Key operational risks included:

- **Comprehensive Site Assessment and Planning**: Inadequate spatial data for infrastructure placement and risk mapping.
- **Surveillance and Theft Prevention**: Limited ability to detect unauthorized access or equipment theft.
- **Equipment Integrity and Operational Safety**: Delayed identification of structural failures or unsafe conditions.
- **Multi-Scale Water Quality Assessment**: Inconsistent water quality monitoring, especially during adverse weather.
- **Advanced Environmental Parameter Detection**: Limited capacity to detect early signs of harmful algal blooms (HABs) or water quality anomalies.
- **Real-Time Pathogen and Disease Monitoring**: Slow response to disease outbreaks due to infrequent sampling.







Case Study - 2

Enhancing Aquaculture Operations with Intelligent Video Camera Analytics

Case Site: Coastal Aquaculture farm, Norway

Our Solution: Video Camera Analytics

The farm deployed a network of high-resolution, weatherproof cameras equipped with AI-driven analytics across critical zones. The system provided continuous monitoring and automated alerts, focusing on:

1. **Comprehensive Site Assessment and Planning**
   What it shows: Real-time mapping of site infrastructure and activity hotspots.
   Insights: Identified optimal locations for new equipment and improved risk zoning.

2. **Surveillance and Theft Prevention**
   What it shows: Automated detection of unauthorized personnel and suspicious activities.
   Insights: Reduced incidents of theft and vandalism, enhancing site security.

3. **Equipment Integrity and Operational Safety**
   What it shows: Continuous monitoring of equipment status and worker safety practices.
   Insights: Early detection of structural wear or unsafe conditions, reducing downtime and accidents.

4. **Multi-Scale Water Quality Assessment**
   What it shows: Visual monitoring of surface water conditions and sediment plumes.
   Insights: Rapid identification of turbidity spikes and localized contamination events.

5. **Advanced Environmental Parameter Detection**
   What it shows: AI-based analysis of water color and surface patterns for HAB detection.
   Insights: Detected both localized (July 5) and extensive (July 20) plumes—critical for understanding far-field impacts.

6. **Real-Time Pathogen and Disease Monitoring**
   What it shows: Automated observation of fish behavior and surface anomalies.
   Insights: Early detection of disease symptoms, enabling swift biosecurity response.

Results & Impact:

- **Real-Time Decision Support:** Managers received instant alerts for security breaches, equipment issues, and environmental anomalies.
- **Optimized Operations:** Data-driven insights improved site planning, equipment maintenance, and workforce safety.
- **Environmental Stewardship:** Early detection of HABs and water quality issues minimized ecological impact and protected fish health.
- **Biosecurity Excellence:** Rapid identification of disease symptoms enabled targeted interventions, reducing losses and improving stock welfare.
- **Stakeholder Confidence:** Transparent, visual reporting and automated logs-built trust with regulators, investors, and community partners.

Gen AI

Our Generative AI enables aquaculture operators and critical infrastructure managers to efficiently process vast volumes of logs and incident data. By automatically filtering and prioritizing alerts—such as early signs of harmful algal blooms, equipment failures, or security breaches—AI systems reduce noise and ensure only the most relevant incidents reach human experts. This targeted approach streamlines workflows, accelerates response times, and supports proactive risk management, ultimately enhancing operational resilience and regulatory compliance.

Case Study - 3

Integrated Monitoring for Resilient Aquaculture

Case Site: Coastal Aquaculture Farm, Norway

Summary:

A major coastal aquaculture facility in Norway sought to enhance its operational resilience, environmental compliance, and biosecurity. By integrating advanced remote sensing, hyperspectral imaging, and video analytics, the facility achieved a new standard in sustainable and risk-aware aquaculture management. This case study details the "Orbit-to-Onsite" system, which fuses multiple high-frequency data streams to create an automated, evidentiary record that supports daily operations, simplifies compliance, and unlocks next-generation parametric insurance products.

The Challenge

Modern aquaculture operations face a dual challenge: managing immediate, site-specific risks (like net breaches or disease) while also monitoring broader environmental threats (like harmful algal blooms). Traditional methods, which rely on manual inspections and fragmented data, are often too slow and unreliable to prevent significant losses. The facility needed a unified system that could:

- Continuously monitor underwater, surface, and regional conditions in real-time.
- Automatically detect and flag critical incidents without human intervention.
- Generate trusted, verifiable reports for regulators, auditors, and insurers.
- Reduce the significant manual effort required for compliance and incident review.

Our Solution: Satellite Analytics

Coactive Science deployed an "Orbit-to-Onsite" solution that stitches together three high-frequency evidence streams to create a continuous, holistic monitor for the farm.

1. **Continuous Evidence Streams**: The system fuses data from three distinct, independent sensor types:

   Under-water cage cameras: Capturing fish-health anomalies, net tears, and feeding efficiency at 1–5 fps with edge inference.
   Perimeter / security cameras: Providing 24x7 monitoring of unauthorized vessels, equipment faults, and predator strikes using object tracking.
   Multi-spectral satellite passes: Tracking harmful algal blooms (HABs), turbidity plumes, and temperature stress across the wider lease area, with 2–5 overpasses per week.

2. **AI-Driven Triage & Reporting**: Every detection event is logged with geo-time metadata and pushed to the cloud in near-real-time. A vision-language foundation model then ingests these heterogeneous logs, filters false positives, and assembles daily digests that can be exported in two clicks:

   Regulator-Ready Summary: An auto-formatted report aligned with EU CSRD, ASC, or UAE ESG templates, complete with annotated images and satellite panels.
   Forensic Timeline: A minute-by-minute narrative linking back to the source video or satellite pixel, creating an immutable evidence archive for internal QA or insurer audits.

Case Study - 3

Integrated Monitoring for Resilient Aquaculture

Case Site: Coastal Aquaculture Farm, Norway

Enabling Parametric Insurance

This system is "Parametric-Ready" because every qualifying peril is documented by tamper-proof logs from at least two independent sensors. This direct, verifiable evidence de-risks underwriting and allows insurers to move from slow, adjuster-driven claims to automated parametric triggers.

For example, a policy can be triggered automatically when a HAB signature above an agreed threshold is confirmed by a Sentinel-2 satellite pass and a corresponding drop in in-cage oxygen levels is detected. This enables claim payouts within 48 hours, eliminating disputes and loss-adjustment costs.

Results & Impact:
This automated triage and reporting system slashes human review time by over 80%, allowing site managers to focus on true exceptions. The tangible value delivered includes:

- **Compliance Certainty**: Automated, evidence-grade reports satisfy the scrutiny of regulators and investors without the need for manual spreadsheets.
- **Liquidity When It Matters**: Rapid parametric payouts protect working capital during critical events, avoiding crippling cull-to-cashflow gaps.
- **Operational Resilience**: Early-warning alerts from pilot sites have already cut downtime and stock loss, delivering up to a 30% reduction in feed-waste and fewer disease events.
- **Stakeholder Trust**: Transparent, visual logs build confidence with insurers, auditors, and local communities, which helps to ease permitting and future expansion.

To explore the full details and actionable insights from this innovative case study, *click here to request the complete analysis or contact our team for a personalized briefing.*

Discover how integrated remote sensing, hyperspectral, and video analytics can elevate your aquaculture operations—let's connect and unlock the next level of sustainable aquaculture management.

Join Us

Unlock the Future of Aquaculture Operations with Coactive Science

Are you ready to transform your aquaculture site with cutting-edge monitoring technologies? Join our exclusive pilot program and experience the power of integrated satellite analytics, hyperspectral imaging, and AI-driven video camera analytics—all tailored to your operational needs.

Why Participate?

Proven Technology Stack:
Leverage best-in-class remote sensing, hyperspectral, and video analytics for actionable insights.

Cost:
Pilot participants can get access at a reduced cost to technology and support during the trial period.

Tailored Solutions:
Customized integration and reporting based on your site's unique challenges.

Path to Full Implementation:
Successful pilots are eligible for ongoing support and scaled deployment.

How to Apply?

To request more details or to apply for the pilot program, please click here or contact our team directly. Limited spaces are available—secure your spot today and be at the forefront of sustainable, resilient aquaculture operations.

(Click here to request full case study details and pilot application)

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