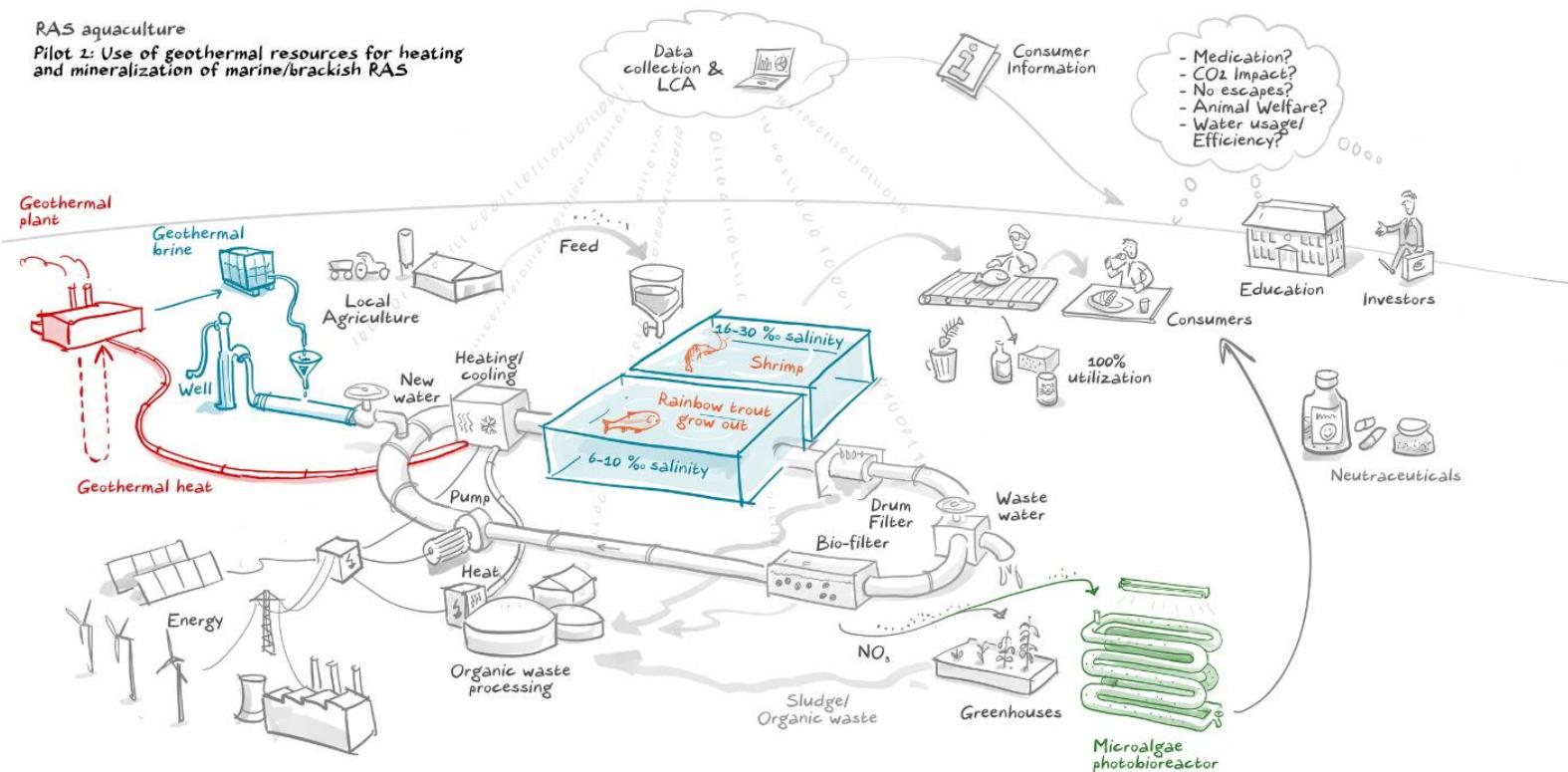


RAS aquaculture

Pilot 2: Use of geothermal resources for heating and mineralization of marine/brackish RAS



# Business Case for Large-Scale Shrimp RAS

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# 1. Executive Summary

## 1.1 Project Overview

This business plan evaluates the potential of developing a multi-site, land-based RAS shrimp platform in Europe to supply fresh, locally produced *Litopenaeus vannamei* shrimp to key EU markets. The reference configuration consists of a 300 t/year facility in Klaipėda (Lithuania) and a 1,000 t/year facility in Germany (greater Berlin region), forming a combined platform capacity of 1,300 t/year. The analysis uses a modular 100 t RAS design as the core building block, enabling staged roll-out, risk-managed scale-up, and future potential replication in additional locations.

The concept is to introduce fresh, high-quality, EU-grown shrimp at scale that meet stringent sustainability and traceability expectations, while delivering competitive unit economics. Where available and economically plausible, geothermal resources (heat and brine) are assessed as an optional integration, offering additional cost and ESG upside but not forming a prerequisite for base-case feasibility.

## 1.2 Market Opportunity

European shrimp consumption exceeds 850,000 t/year, with the majority supplied by warmwater shrimp imports from Latin America and Asia. In parallel, consumer and retailer demand for local, traceable and sustainable seafood is increasing, particularly in high-income urban markets and within premium retail and foodservice segments.

Within this context, the study focuses on a clearly defined premium segment of the European shrimp market:

- TAM (Total Addressable Market): EU vannamei shrimp consumption of approximately 766,000 t/year, equivalent to a value of ~€7 bn.
- SAM (Serviceable Available Market): Vannamei segment in focus countries (DE, FR, NL, BE, Nordics, UK) estimated at 396,000 t/year and €3.5 bn in value.
- SAM in premium tier: Premium Vannamei segment in focus countries estimated at 20,000 - 25,000 t/year.
- SOM (Serviceable Obtainable Market): An assumed share of the premium segment ramping to 1,300 t/year in the initial platform configuration, with potential for further expansion as capacity and geographic footprint grow.

Extensive market research inputs (EUMOFA, IMARC, KONTALI, NIELSEN, KOG Berlin study, Gateway outreach and others) indicate willingness to pay a premium for fresh, locally produced, sustainably farmed shrimp among target customers, and support the underlying demand assumptions used in this analysis. However, the actual demand for the premium shrimp heavily depends on the sales price variance.

## 1.3 Value Proposition & Competitive Differentiation

The evaluated concept is built on four main value pillars:

**Product freshness and quality:** The supply system is structured to deliver fresh, chilled vannamei shrimp directly from EU-based recirculating aquaculture (RAS) facilities to major urban markets through efficient, temperature-controlled logistics. This approach prioritizes minimal transit time to ensure superior product freshness at the point of sale, setting it apart from long-frozen imports.

**EU-based origin and transparent traceability:** Shrimp are cultivated exclusively in land-based systems within the European Union, allowing for detailed tracking of production batches and compliance with strict EU food safety and animal welfare guidelines. The controlled environment supports high levels of transparency in farming methods and responds to consumer and retailer concerns about origin, chemical residues, and social standards in distant aquaculture supply chains.

**Sustainability and resource efficiency:** The system is based on a recirculating aquaculture design that prioritizes sustainability through minimized water discharge, efficient water reuse, and carefully managed energy consumption. Where applicable, integration of geothermal energy and brine utilization can further reduce the carbon and mineral footprint, enhancing the platform's environmental and sustainability credentials without being essential to core financial feasibility.

**Scalability and operational reliability:** The initial setup targets an annual output of 1,300 tonnes, combining a 300-tonne facility in Klaipėda with a 1,000-tonne site in Germany. This is achieved through a scalable design that utilizes standardized 100-tonne production modules, enabling flexible expansion and consistent volumes suitable for large-scale retail, distribution, and foodservice channels.

Compared to traditional pond-farmed imports, this model presents a premium, lower-risk option tailored for European customers who prioritize unique product offerings, strong ESG performance, and dependable sourcing. Unlike small, stand-alone RAS farms, the multi-site platform emphasizes replicability, professionalization, and economies of scale—positioning it as a robust partner for long-term, multi-market supply programs in the premium shrimp segment.

## 1.4 Technology, System Design & Roll-Out Plan

The production system analysed is based on a 100 t RAS module, designed for:

- Stable water quality, high survival rate and competitive eFCR,
- Strong biosecurity and disease prevention,
- Energy-efficient temperature and oxygen management.

The conceptual roll-out is structured in phases:

- Phase 1 - Klaipėda (100 t → 300 t): Construct and ramp an initial 100 t module, followed by expansion to ~300 t/year at the Klaipėda site, which acts as the primary learning and optimisation hub.
- Phase 2 - Germany (1,000 t): Develop and commission a 1,000 t/year facility in the greater Berlin region (or other well suited location), leveraging the proven 100 t module design, operational experience and primary market penetration initiatives from Klaipėda.
- Further Phases - potential of replicating the 1000 t facilities in different target locations.

Geothermal heat and brine integration are treated in the analysis as distinct upside cases that could be implemented at specific sites once economics and technical feasibility are sufficiently validated.

## 1.5 Financial Highlights

The consolidated financial model for the 1,300 t platform (300 t Klaipėda + 1,000 t Germany), based on the assumptions described in this document, yields the following base-case results:

- Base case project IRR: ~17.5%
- Base case equity IRR: ~26.7%
- NPV @ 11.7% WACC: €75m (Years 0–11 cash flows; no terminal value)
- Payback period: Approximately 5-6 years from the start of operations.

These base case returns are calculated without dependence on geothermal integration. Geothermal heat and brine mineralisation are assessed as an additional possible upside:

- Geothermal heat: Potential to cover up to 90% of heat demand at the 1,000 t facility, reducing heating-related COGS by up to ~0.13 €/kg, and improving IRR and NPV after modest connection CAPEX.
- Geothermal brine (mineralisation): Potential partial replacement of commercial salts and reduced chemical usage, which can lower mineralisation-related COGS and strengthen margins and ESG performance.

Scenario and sensitivity analyses demonstrate that the concept is most sensitive to sales prices, biological performance and feed costs, while remaining resilient under conservative assumptions for energy prices and CAPEX. Geothermal options act as an additional cost and ESG optimisation levers, not as core feasibility drivers.

## 1.6 Risk Profile & Mitigation

The evaluated concept exhibits the typical risk profile of a capital-intensive, technology-driven aquaculture project:

- Operational and biological risks (survival, FCR, ramp-up trajectory),
- Resource risks (electricity prices, feed, water, geothermal availability),
- Market risks (pricing pressure, competitive response, adoption of premium positioning),
- Financial and execution risks (CAPEX control, funding structure, timing),
- Regulatory and ESG risks (permitting, compliance, reputation).

The analysis outlines mitigation strategies including:

- A modular system design and phased roll-out to reduce scale-up risk,
- Conservative base-case assumptions and explicit downside scenarios,
- Strong emphasis on biosecurity, SOPs, monitoring and preventive maintenance,
- Diversified customer and market approach across several EU countries and channels,
- Clear governance, reporting and risk management concepts.

## 1.7 Indicative Funding Structure & Use of Proceeds

For the reference configuration (300 t Klaipėda + 1,000 t Germany), total CAPEX is estimated at approximately 51-53 m€, including contingencies. The model evaluates an indicative capital structure comprising:

- Equity funding of approximately 19 m€, and
- Debt funding of approximately 33 m€, and
- Resulting in an equity/debt mix aligned with typical project-finance expectations for assets of this type.

Within this framework, the indicative use of funds includes:

- Detailed design and engineering for Klaipėda and Germany.
- Construction and commissioning of the 100 t module and expansion to 300 t in Klaipėda.
- Construction and commissioning of the 1,000 t facility in Germany.
- Working capital for ramp-up and early operations.

The objective of this document is to present a consistent technical, commercial and financial case for such a platform, and to outline the potential investment profile and risk/return characteristics for stakeholders considering involvement in a large-scale RAS shrimp project with optional geothermal integration in Europe.

## 2. Company Overview (Akola Group)

### Who We Are

Akola Group is an investment company that operates one of the Baltics' leading agricultural and food production platforms, spanning the entire value chain from farm to fork. The Group brings together businesses in farmer partnerships, food production, farming, and supporting services, enabling scale, integration, and operational resilience across the region.

### Scale and footprint

Today Akola unites more than 60 companies and employs close to 5,000 people across the Baltics and select European markets, with additional associates expanding its reach. The holding company performs group management; operating subsidiaries execute trading and production activities in grain and feed, inputs, poultry, flour and instant foods, compound feed, pet food, and veterinary supplies.

### Public company profile

Akola Group is listed on Nasdaq Vilnius (ticker AKO1L, ISIN LT0000128092), where its shares have traded since February 17, 2010.

### Performance snapshot

In the twelve months of the 2024/2025 financial year, consolidated revenue reached €1.58 billion (+4.9% YoY); EBITDA €111 million (+51.5% YoY); net profit €62.6 million (+151% YoY). Segment growth was driven notably by Food Production (poultry, instant foods).

### What we do

The Group's activities are organized into four pillars:

- Partners for Farmers - inputs supply, grain/oilseed/feed trading and logistics;
- Food Production - poultry and poultry products, flour, instant foods, compound feed and premixes;
- Farming - in-house agricultural enterprises;
- Other Products & Services - pet food, veterinary and hygiene products, pest control.

### Sustainability

Akola publishes an annual GRI-aligned Sustainability Report and is preparing for ESRS double-materiality. Disclosures cover energy mix and intensity, Scope 1–3 GHG inventory, water and materials, and EU Taxonomy KPIs. Ongoing initiatives include renewable electricity generation and circular resource projects within the portfolio.

Akola aligns its sustainability program with the UN SDGs and UN Global Compact principles, discloses annually under GRI standards, and submits data to the Nasdaq ESG Data Portal, reinforcing transparent reporting across environmental, social, and governance topics.

Under its Four Hearts initiative, Akola drives progress across four pillars - Economic, Environmental, Social, and Governance - embedding sustainability in daily operations and employee engagement across the Group.

Akola operationalizes ESG through public group policies covering environment, anti-corruption, human rights, equal treatment, OSH, business ethics (including a Partner Code), and group-level Governance & Risk frameworks. The Environmental Protection Policy emphasizes energy efficiency, renewables, GHG and waste reduction, and transparent reporting; integrity is underpinned by an updated anti-corruption policy (10 Sep 2024) and human-rights policies applied across subsidiaries.

Programmatically, Akola invests in GHG-reducing and animal-welfare technologies, co-runs a pilot project on shrimp farming aligned with resource efficiency, and is developing biogas capacity in the portfolio, supporting the Group's decarbonization and circularity goals

The Group's sustainability practices include no-antibiotics poultry production, growing use of renewable energy, and structured support for local communities, education, health/environmental projects, and training institutions across its operating regions.

### Why aquaculture (RAS shrimp)

In line with its mission to unlock the potential of the food sector through innovation and sustainability, Akola is a partner in TETRAS, a Baltic Sea Region programme focused on improving the economic and environmental performance of land-based RAS by coupling aquaculture with industrial resource streams. Within Pilot 2, Akola collaborates to test the use of geothermal resources (for water and heat) in shrimp RAS and to develop a business plan for a large-scale facility.

The project can be pursued by four suggested routes, staged by risk and control. Build (greenfield): own the asset and design for biosecurity and future geothermal tie-ins - highest control, more capex and permitting. Partner/JV: team with a technology provider, utility or geothermal asset owner to share risk and speed access to capability and residual-heat/water resources. Acquire: buy an operating or shelved RAS site to accelerate time-to-market, then retrofit to Akola standards. Minority invest: place option-value capital with board rights while building in-house know-how. EU aquaculture policy and funding instruments can support several of these pathways, especially where projects advance sustainability and circular resource use.

### 3. Pilot 2 Overview

The goal of the Pilot 2, part of TETRAS project, was to test industrial symbiosis between geothermal resources and recirculating aquaculture by asking whether geothermal heat and mineral-rich brine can make marine-brackish RAS cheaper and more energy-efficient without compromising biology or water quality.

Led by Klaipėda University in Klaipėda, Lithuania, with regional partners, the pilot focused on the Western Lithuania Geothermal Anomaly and ran lab-to-pilot experiments on whiteleg shrimp to evaluate growth, physiology, element uptake and meat quality when using diluted geothermal brine, while also benchmarking system performance and treatment trains for storage, dosing, denitrification and microalgae polishing to cut artificial sea-salt use. The intended outputs - feasibility studies on techno-economic viability, practical guidelines for applying geothermal resources in RAS, and a co-developed business case for large-scale shrimp farming with smarter water use, contributing knowledge needed to pair RAS facilities with geothermal users and improve environmental and cost performance in the Baltic Sea region.

#### Pilot 2 objectives

- Assess the techno-economic feasibility of using geothermal resources for RAS: mineralization of marine/brackish water to lower OPEX
- Generate biological evidence on the effects of hypersaline geothermal brine (diluted) on species performance (e.g., *L. vannamei*) and RAS process stability; produce guidelines and a business case for large-scale application.

#### Working hypotheses

- H1 (bio-performance): Shrimp reared in diluted geothermal brine (DGB) will show equal or better survival and similar growth to shrimp reared in artificial sea-salt mixes at comparable salinity.
- H2 (techno-economics): Replacing part/all of commercial sea-salt with DGB will reduce make-up water costs, improving unit economics (€/kg) for RAS shrimp.
- H3 (food safety): DGB use will not cause unsafe accumulation of heavy metals in shrimp flesh relative to regulatory thresholds.
- H4 (operations): RAS water quality and biofilters will remain within acceptable limits under DGB use, with manageable adjustments to denitrification/microalgae polishing steps.

#### Pilot Design & Results

##### Facility & setup:

- Pilot RAS at Klaipėda University / KMTP incubator; three grow-out tanks per run ( $\approx 3.6 \text{ m}^3$  each), standard clear-water RAS (drum filter, biofilter, protein skimmer, denitrification, oxygenation cone, UV, seawater prep).

### Treatments:

- Control: artificial seawater at ~15–16 psu using a low-cost salt mixture (NaCl, MgSO<sub>4</sub>, MgCl<sub>2</sub>, CaCl<sub>2</sub>, KCl).
- Geothermal: diluted geothermal brine (source ≈110 g L<sup>-1</sup> TDS) adjusted to ~15–16 psu.

### Species & cycles:

- *L. vannamei* from PL12–PL15 to market size; three full cycles (Control 2023; Geothermal 2024, Geothermal 2025). Routine monitoring of DO, temp, pH, salinity, NH<sub>4</sub><sup>+</sup>, NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>; periodic length/weight; handling-stress mortality; hemolymph glucose; flesh element analysis.

### Additional pilot elements:

- Evaluation of brine composition vs marine water ions (Na, Ca, Mg, K, Cl, Sr); and concept exploration for water-treatment enhancements (denitrification, microalgae photobioreactors) to cut salt make-up.

Metrics / KPIs	Control (w. LCSM*)	Geothermal Brine 1	Geothermal Brine 2
FCR	1.71	1.52	1.5
Survivability (%)	33	63	42
Growth Rate (g/day)	0.22	0.2	0.29
Dissolved O <sub>2</sub> (%)	70	70	93
Salinity Average (PPT)	22	20.5	23

Figure 1. Experimental Results

## 4. Market Analysis

### 4.1 Global Aquaculture Trends

Aquaculture has outpaced all other food production sectors in growth for several decades. Between 1980 and 2020, global aquaculture production expanded at an average annual rate of approximately 5 - 7%, significantly exceeding the rate of population increase. While the pace of growth has recently begun to level off as the sector matures, total output continues to reach record highs each year.

During the same period, wild capture fisheries have plateaued at roughly 90 million tonnes annually - largely due to biological limits on natural fish stocks. As a result, farmed seafood has become increasingly important in meeting global demand for animal protein. Projections suggest this trend will intensify in coming decades, especially as the global population approaches 9 to 10 billion by 2050. To meet future food needs, global protein supply must increase by at least 50%, even as constraints on freshwater and arable land tighten.

Given that oceans cover more than 70% of the Earth's surface but currently supply only a small fraction of global food consumption (estimated at around 2%), aquaculture presents a major opportunity for sustainable expansion. International organizations - including the FAO and World Bank - expect aquaculture to play a central role in global food systems through 2030 and beyond, particularly in developing regions like Asia and Africa.

Advancements in production systems - such as offshore cages, integrated multi-trophic aquaculture (IMTA), and recirculating aquaculture systems (RAS) - are making it possible to farm aquatic species in new environments with greater efficiency and lower environmental impact. While sustainability concerns remain, the industry has made significant strides in areas such as feed optimization, disease prevention, and waste management, making modern aquaculture more resilient and eco-conscious than in previous decades.

#### 4.1.1 Regional Distribution

Aquaculture production is overwhelmingly concentrated in Asia, which accounts for the vast majority of global output by volume. China alone is responsible for more than half of the world's farmed seafood, with other major contributors including India, Indonesia, Vietnam, and Bangladesh. This regional dominance is supported by favorable climatic conditions, long-standing aquaculture traditions, and significant policy and infrastructure investments.

By the mid-2010s, data showed that in at least 35 countries - home to nearly half of the global population - aquaculture production had surpassed wild-capture fisheries. These countries include some of the most populous and aquaculture-intensive nations, such as China, India, Vietnam, Bangladesh, and Egypt.

In contrast, aquaculture remains a relatively smaller sector in most Western countries. For instance, the United States currently ranks outside the top 15 global producers. This disparity reflects not only environmental differences but also variations in policy support, public

perception, and industry development. While Western regions are increasingly investing in advanced systems such as recirculating aquaculture (RAS), overall output still lags far behind Asia's scale and diversity of production.

#### 4.1.2 Key Species and the Focus on Crustaceans

Crustacean aquaculture - particularly shrimp farming - represents one of the most valuable segments within global aquaculture, despite its relatively small share by volume. Aquaculture now produces over 550 aquatic species for human consumption. While farmed finfish such as carp, tilapia, salmon, and catfish dominate in terms of tonnage, crustaceans contribute disproportionately to the sector's value. In 2018, crustacean farming produced approximately 6.9 million tonnes, accounting for only 8–9% of global farmed aquatic animal volume, but generated an estimated \$36.2 billion - over 22% of total farmed seafood value.

This high value is primarily driven by the global trade in farmed shrimp, especially whiteleg shrimp (*Penaeus vannamei*) and tiger prawn (*P. monodon*). Since the 1990s, shrimp aquaculture has grown rapidly, with major production hubs in Asia - including China, India, Vietnam, Thailand, Indonesia, and Bangladesh - and in Latin America, especially Ecuador, Brazil, and Mexico. These regions offer ideal warm-water conditions for shrimp farming and have developed sophisticated export-oriented industries. Farmed shrimp alone accounts for the majority of crustacean production - roughly 5 million tonnes annually - while other species such as crabs and lobsters are produced in far smaller volumes.

The economic importance of shrimp has made this segment a major focus of technological innovation. Industry-wide advances such as specific pathogen-free (SPF) broodstock, recirculating aquaculture systems (RAS), improved larval rearing protocols, and the use of probiotics are increasingly standard. These technologies aim to reduce disease risk - historically a major challenge - while increasing yields and environmental performance. Shrimp are susceptible to viral diseases such as white spot syndrome virus (WSSV) and early mortality syndrome (EMS), which have caused major losses in the past. In response, modern farms are adopting stricter biosecurity protocols, closed production systems, and improved hatchery management to mitigate these risks.

Environmental impacts have also been a concern in shrimp aquaculture, particularly the destruction of mangrove habitats for pond construction. However, current best practices emphasize responsible siting, effluent treatment, and mangrove conservation, especially in countries aiming to meet international certification standards. Sustainability remains a top priority as the sector continues to expand.

Regionally, crustacean farming is concentrated in Asia and Latin America, where favorable climate and labor costs support high-volume production. In contrast, North America and the European Union produce relatively little but are major importers of farmed shrimp. These high-income markets drive demand for premium shrimp products - often antibiotic-free, traceable, and sustainably produced - which has supported the growth of intensive, biosecure indoor systems such as RAS in temperate countries. For example, producers in the U.S.,

Germany, and Switzerland are investing in local RAS shrimp farms to supply fresh, locally-grown shrimp to restaurants and retailers, reducing reliance on imports and enhancing food security.

In addition to being economically valuable, crustaceans are nutritionally significant. Shrimp and other crustaceans are rich in high-quality protein, vitamin B12, selenium, and other micronutrients. However, they are typically consumed as a high-value export product or specialty item, rather than a dietary staple, in many producing regions.

Looking ahead, crustacean aquaculture is expected to continue growing in both volume and value. Advances in RAS technology, genetics, disease prevention, and integration with renewable energy and circular economy systems (e.g., aquaponics) will likely play key roles in making shrimp farming more resilient and sustainable. At the same time, careful management will be essential to prevent environmental degradation and maintain consumer confidence.

In summary, crustaceans - and shrimp in particular - represent a high-value, strategically important sector within global aquaculture. Despite challenges, ongoing innovation and improved practices are positioning shrimp farming as a key component of sustainable seafood production worldwide.

#### **4.1.3 Aquaculture vs. Other Protein Sources**

Aquaculture - particularly the farming of fish and shellfish - offers several sustainability advantages over conventional animal agriculture and emerging protein alternatives. When evaluated across feed efficiency, environmental impact, and nutritional value, aquaculture proteins often compare favorably.

##### **Feed Efficiency:**

Farmed aquatic species such as salmon, tilapia, and shrimp exhibit highly efficient feed conversion rates (FCR), often ranging from 1.1 to 1.8. This means only slightly more than 1 kg of feed is needed to produce 1 kg of biomass. In contrast, terrestrial livestock such as poultry, pigs, and cattle generally require significantly more feed per kg of growth, with beef frequently exceeding 6 - 10 kg of feed per kg of live weight. This disparity arises from the ectothermic (cold-blooded) nature of fish and their buoyancy in water, which reduces energy expenditure compared to land animals.

##### **Environmental Footprint:**

From a carbon emissions perspective, aquaculture also fares well. Producing 1 kg of farmed fish generally results in lower greenhouse gas (GHG) emissions compared to beef and often rivals chicken in terms of carbon intensity. Species like oysters and mussels require no feed inputs and instead filter nutrients from their environment, sometimes resulting in net ecological benefits such as improved water quality and carbon sequestration in shells.

### Land and Water Use:

Aquaculture minimizes land use, particularly when conducted in offshore systems or through recirculating aquaculture systems (RAS). Compared to cattle farming, which requires large areas for grazing and feed cultivation, fish farming can produce equivalent or greater protein yields with a much smaller spatial footprint. Water use varies by system—open pens draw from the ocean, while land-based RAS recycles water, often achieving 95–99% reuse.

### Nutritional Value:

Seafood offers high-quality, complete proteins with all essential amino acids. Additionally, fish like salmon are rich in omega-3 fatty acids (DHA and EPA), while shellfish provide micronutrients such as selenium, iodine, and vitamin B12. Compared to plant proteins, which often lack one or more essential amino acids and can be harder to digest due to fiber content, seafood represents a highly bioavailable and nutrient-dense food source.

### Feed Inputs and Sustainability:

Historically, aquaculture depended heavily on fishmeal and fish oil derived from wild-caught forage fish. However, modern aquafeeds now include significant proportions of soy, algae, insect protein, and other alternatives to reduce marine dependency. Many herbivorous and omnivorous farmed fish, such as tilapia and carp, are now considered net protein producers - yielding more edible protein than they consume in marine inputs.

### Waste and Pollution:

Poorly managed aquaculture operations can contribute to nutrient loading and local water pollution, especially in coastal pond systems. However, well-designed systems such as RAS or integrated multi-trophic aquaculture (IMTA) can mitigate these risks by capturing waste, reusing water, or pairing different species (e.g., fish with shellfish or seaweeds) to absorb nutrients and reduce environmental impact. In contrast, terrestrial animal farming contributes to runoff, methane emissions, and land degradation, especially in intensive systems.

### Comparison Summary:

Aquaculture, when responsibly managed, stands out as a sustainable protein production method. It offers high yields with relatively low resource input, reduced emissions, and strong nutritional value. While plant-based proteins remain the most land- and emission-efficient, seafood - particularly from sustainable aquaculture - offers a powerful complement to global food security strategies.

## 4.2 Global Shrimp Market Overview

In 2023, global shrimp farming continued to outpace wild capture, with aquaculture producing close to 8 million metric tons - more than double the volume landed from wild fisheries. The sector remains heavily reliant on warmwater species, particularly the whiteleg shrimp (*Litopenaeus vannamei*), which represented approximately 80% of global farmed

shrimp output. This dominance reflects both the species' fast growth and its adaptability to intensive production systems.

#### 4.2.1 Production by Species and Major Regions

Shrimp aquaculture has expanded rapidly across tropical and subtropical zones, with *Litopenaeus vannamei* (whiteleg shrimp) emerging as the dominant species due to its fast growth and high-density compatibility. China remains the world's largest farmed shrimp producer, though much of its output serves domestic demand. Other major players include India, Ecuador, Indonesia, Vietnam, and Thailand - each playing a crucial role in international markets.

Ecuador has seen remarkable growth in recent years, with production exceeding 1.2 million metric tons in 2023, driven by large-scale, vertically integrated operations. India's output also continues to increase, reaching export volumes of over 700,000 tons, despite challenges from disease and market fluctuations. Vietnam and Indonesia remain substantial producers, though both saw declines in export volumes in 2023, partly due to disease-related losses and oversupplied markets. Thailand, once a global leader, now produces significantly less as its industry consolidates and adapts to ongoing disease pressures.

While *L. vannamei* accounts for the vast majority of production across these regions, *Penaeus monodon* (black tiger shrimp) is still farmed at smaller scales, particularly in India, Bangladesh, and Vietnam. Its niche market appeal is based on premium size and coloration, though it comes with higher production costs.

Regionally, production trends are diverging. Ecuador more than doubled its output between 2018 and 2023, making it the world's second-largest exporter, with further but slower growth projected. In contrast, India and Southeast Asian producers are adjusting to declining farm-gate prices, disease outbreaks, and high input costs. Notably, China has increased production through greenhouse shrimp farming - especially in temperate provinces - adding an estimated 200,000 tons of production in 2023 alone.

Looking forward, global shrimp production is expected to continue growing, though at a moderated pace. Estimates suggest farmed output could reach around 6 million metric tons by 2025, depending on price recovery and disease management. In the short term, a supply rebalancing is underway, especially in Asia, where producers are reducing stocking to avoid repeating the price collapse experienced in 2023. Latin America, led by Ecuador, is likely to account for most of the near-term production growth, while Asia focuses on maintaining profitability and market stability.

#### 4.2.2 Major Importing Markets

The international shrimp trade is substantial, with the majority of farmed shrimp entering global markets. The United States and China consistently rank as the top two importers,

together accounting for nearly half of the world's shrimp imports. Other significant importers include the European Union, Japan, and several East Asian nations such as South Korea.

### **United States**

The U.S. is the largest single-country shrimp importer, bringing in approximately 785,000 metric tons in 2023 - a slight decline from 838,000 tons in 2022, largely due to excess inventory and falling prices. Over the past decade, U.S. imports have increased in response to rising domestic demand. India has remained the leading supplier for ten consecutive years, followed by Ecuador, Indonesia, Vietnam, and Thailand. U.S. demand is characterized by a preference for processed and value-added products. India dominates the peeled shrimp segment, while Ecuador leads in shell-on categories. Though import volumes declined in 2023, early 2025 data show signs of recovery. However, recent trade measures - such as increased tariffs on certain exporting countries - could influence future sourcing strategies. Import prices also fell significantly through 2023, returning to 2020 levels by early 2025, which has helped stimulate renewed interest from buyers. Industry outlook suggests stable U.S. demand, barring macroeconomic disruptions.

### **China**

China plays a dual role as both a top producer and importer of shrimp. In 2023, imports reached a record 1 million metric tons, driven by domestic supply shortfalls. Ecuador supplied nearly 700,000 tons - approximately 65% of China's total imports - making it the dominant exporter to this market. India was the second-largest supplier, followed by Canada and Argentina, the latter two primarily shipping coldwater species. Most imports to China are warmwater head-on shell-on (HOSO) vannamei, preferred for distribution in traditional wholesale markets. Coldwater shrimp made up around 10% of the total imported volume. However, domestic production - especially through greenhouse farming - has increased, easing reliance on imports. As a result, imports declined by approximately 3.6% in the first nine months of 2024. Nevertheless, China remains a major player, with the largest import volume in the first half of 2024. Looking forward, while import growth may stabilize, rising consumer demand - especially during festivals - is expected to support continued strong trade flows. Buyers are increasingly interested in value-added formats and higher food safety standards.

### **European Union**

The EU collectively imports an estimated 700,000 - 850,000 metric tons of shrimp annually, making it one of the top global markets. In 2023, import volumes declined by about 5% due to inflationary pressures and existing inventories. Import value dropped even more sharply - around 18% - reflecting global price declines. Warmwater farmed shrimp accounted for over half of the EU's total shrimp imports in 2023, with Ecuador emerging as the largest supplier, especially to Spain, France, and Italy. Asian countries like India, Vietnam, and Bangladesh also contribute, mainly through more processed offerings such as peeled or cooked shrimp. Coldwater shrimp represented about 11% of EU shrimp imports, with Greenland alone supplying over 85% of that category. Market preferences differ across the continent:

Southern Europe favors warmwater species for traditional seafood dishes, while Northern Europe leans toward coldwater products, particularly for use in salads and ready meals. Despite challenges, EU imports ticked upward by 2.4% in the first nine months of 2024. Lower prices and a stabilizing economy are expected to support continued consumption growth into 2025. European buyers maintain a strong focus on sustainability and traceability, often requiring third-party certifications.

#### 4.2.3 Product Forms

The global shrimp trade features a diverse range of product forms, tailored to the preferences of individual markets. Frozen warmwater shrimp represents the dominant format worldwide, typically categorized into shell-on and peeled variants. These can be sold raw, blanched, cooked, or further processed.

In the United States, the largest volume category is peeled shrimp - generally raw, deveined, and shell-free - driven largely by demand from the foodservice and retail sectors for convenient, ready-to-cook options. Shell-on shrimp, including headless shell-on (HLSO), head-on shell-on (HOSO), and easy-peel formats, make up the second-largest share, accounting for roughly 30% of import volumes. Cooked shrimp (often peeled and tail-off) and breaded varieties comprise the remainder of U.S. imports, appealing to consumers looking for ready-to-eat meals and snack foods.

The European market also imports significant quantities of frozen raw shrimp but demonstrates a higher share of value-added products. For example, countries like the UK and Germany frequently source breaded or battered shrimp, including tempura varieties from Asian processors. Northern European markets, particularly Scandinavia, import large volumes of cooked coldwater shrimp for retail sale in salads and ready-to-eat meals.

Product form plays a major role in price differentiation. Value-added items - such as skewered, marinated, or breaded shrimp - command higher unit prices than bulk raw shrimp. This dynamic influences export strategies. Ecuador, for instance, exports predominantly block-frozen HOSO shrimp, intended for reprocessing in the destination market. In contrast, producers in India, Thailand, and Vietnam focus more on processed formats, supplying peeled, cooked, and prepared products that are ready for direct retail or foodservice distribution.

As a result, even though Ecuador leads in export volumes, Asian suppliers retain a critical role in global value chains by delivering higher-margin, consumer-ready products. This differentiation in product form and processing levels allows exporting countries to serve different market segments effectively and maintain competitiveness across diverse regions.

#### 4.2.4 Price Trends and Volatility

The global shrimp market has faced significant price swings in recent years, largely influenced by imbalances in supply and demand, disease-related disruptions, and macroeconomic

factors. After reaching historically high prices in 2021 - driven by post-pandemic demand surges and limited supply - shrimp prices began a prolonged downward trend that persisted through the end of 2023.

By late 2023, wholesale shrimp prices in the U.S. had declined for over a year, with major pricing indices showing an average drop of approximately 17%. This downturn was primarily attributed to an oversupply situation, particularly due to rapid production expansion in Ecuador, which led to an international surplus and pushed prices to multi-year lows. As of early 2025, composite shrimp prices had returned to levels not seen since early 2020, effectively reversing the pandemic-driven gains.

In producing regions such as Southeast Asia, farmers also faced substantial price declines. By early 2025, shrimp farm-gate prices had dropped by 20 - 30% from their late 2024 peaks, putting significant financial pressure on producers. These challenging economics have led many farmers to reduce stocking intensity, aiming to mitigate losses and rebalance the market.

However, signs of market stabilization began emerging in late 2024. With global output growth slowing and inventories being drawn down, average shrimp prices began to recover modestly - rising around 10% in the final quarter of 2024. Strategic policy measures, such as new import tariffs in the U.S., also contributed to price adjustments by affecting trade flows.

Looking ahead, analysts expect a gradual recovery to continue through 2025, assuming demand in major markets like the U.S. and Europe remains stable. Still, some uncertainty persists - particularly due to subdued Chinese imports (linked to growing domestic production) and the broader economic outlook, which can affect shrimp consumption, given its semi-luxury status in many diets.

#### 4.2.5 Advancements in Shrimp Aquaculture

The shrimp farming industry has undergone major transformation in recent years, with innovations focused on intensifying production, improving disease resilience, and reducing environmental impact. These advancements span both traditional pond systems and newer, controlled aquaculture environments.

##### Transition Toward Intensified and Enclosed Systems:

Across Asia, especially in China, conventional open ponds are increasingly replaced by more controlled systems. One notable shift is the widespread adoption of greenhouse-style ponds - low-cost structures covered in plastic film that allow for regulated temperature and year-round farming, even in regions with cooler climates. By 2023, estimates indicated that nearly a third of China's shrimp was farmed in such units, with over 250,000 operational greenhouse ponds contributing approximately 200,000 metric tons to annual output. These systems are affordable to set up and can recover investment costs within a year when operated efficiently. However, concerns around water consumption and effluent discharge are prompting a gradual move toward more advanced, closed-loop systems like indoor Recirculating Aquaculture Systems (RAS). While more capital-intensive, RAS offers biosecurity, low water

use, and stable growing conditions - supporting consistent year-round harvests with reduced environmental footprint. China, the U.S., and parts of Europe are all scaling up such facilities.

#### Water Quality Control and Biofloc Adoption:

Maintaining stable water quality is central to successful shrimp production. The integration of real-time monitoring tools - such as IoT-enabled sensors tracking oxygen, temperature, pH, and ammonia - has helped farmers pre-empt stress events, reducing disease risk and reliance on antibiotics. Another widely adopted innovation is biofloc technology (BFT), which leverages microbial communities to recycle waste nutrients into usable biomass. These beneficial microbes convert uneaten feed and shrimp waste into protein-rich particles that shrimp can consume, effectively supplementing feed while stabilizing water conditions. Countries like Indonesia and India have reported success in implementing biofloc systems even among smallholders, with yields in some cases exceeding 20 tons per hectare—far above traditional pond production rates.

#### Feeding Automation and Digital Farm Management:

Automation is playing an increasingly important role in shrimp aquaculture. Intelligent feeding systems now utilize sensors to detect feeding behavior and deliver feed based on actual demand rather than fixed schedules. This precision feeding enhances feed conversion efficiency and significantly reduces waste, helping to lower the largest cost input in shrimp farming. Alongside feeding, farms are adopting digital tools for growth tracking, water parameter analysis, and early warning of health issues. Some systems integrate AI to forecast optimal harvest times or identify disease risks, allowing more proactive farm management. These technologies are not just limited to large operations - cloud-based platforms and mobile apps have made smart farming accessible to mid-scale producers as well.

#### Genetic Advances and Disease Prevention:

Breeding programs have played a vital role in improving shrimp health and productivity. Selective breeding has produced lines of *Litopenaeus vannamei* that grow faster and are more resistant to common diseases like EMS (Early Mortality Syndrome) and WSSV (White Spot Syndrome Virus). Hatcheries now regularly supply Specific Pathogen Free (SPF) postlarvae, contributing to improved survival rates and reduced antibiotic use. While vaccines remain largely experimental for crustaceans, other tools such as probiotics and immunostimulants are widely used. Improved hatchery protocols, screening of broodstock, and strict on-farm biosecurity (e.g., water filtration, predator exclusion, and disinfection) are also essential elements of modern shrimp disease management strategies.

#### Outlook for Sustainable Growth:

The rapid adoption of technological solutions is driving a shift toward more sustainable and resilient shrimp farming models. Countries like India are supporting transitions to biofloc and RAS through policy and technical assistance. Meanwhile, digital tools are enabling smarter resource use, better yields, and earlier detection of issues. Although challenges such as disease and market fluctuations persist, the sector is better equipped than ever to manage them. With innovations in place and continued investment in farm efficiency, shrimp

aquaculture is evolving into a high-tech, climate-smart sector that can meet growing global seafood demand.

#### **4.2.6 Sustainability in the Global Shrimp Industry (2025 Overview)**

The shrimp industry has historically faced significant environmental and social criticism, but recent years have seen considerable momentum toward improving sustainability standards. Eco-certification, regulatory reforms, and market pressure are reshaping practices across shrimp-producing countries.

##### **Environmental Certification and Market Demand**

A growing share of farmed shrimp now comes from certified or rated operations, reflecting increased scrutiny from importers, retailers, and consumers. Certifications such as Best Aquaculture Practices (BAP) and Aquaculture Stewardship Council (ASC) are widely recognized, and as of 2023, approximately 15.7% of global farmed shrimp was certified under one of these schemes or by Fair Trade. Leading this shift is Ecuador, whose industry is notable for its comprehensive certification coverage and high sustainability ratings. Ecuadorian farms have received praise for minimal antibiotic use, limited mangrove impact, and high-efficiency operations - making them favored suppliers in the U.S. and EU.

Meanwhile, Asian producers like India, Indonesia, Vietnam, and Thailand show a mix of certified and uncertified operations. Many exporters pursue 2 - 4 star BAP or ASC status to access premium markets. In contrast, China, while the largest producer of farmed shrimp, exports relatively little to environmentally demanding markets due to lower certification levels. Increasingly, major retail chains - particularly in the U.S. - only source shrimp that meet recognized sustainability or social responsibility standards.

##### **Mangrove Protection and Habitat Restoration**

The expansion of shrimp aquaculture during the 1980s and 1990s led to widespread mangrove deforestation, especially in tropical Asia and Latin America. Estimates suggest shrimp pond development accounted for 30 - 40% of global mangrove loss during that period, causing significant coastal ecosystem degradation. Today, regulations and sustainability programs actively discourage such practices. In some regions, abandoned ponds are being converted back into mangrove habitat, and silvo-aquaculture - integrating mangrove conservation into shrimp farming - is gaining traction. Vietnam has become a model for this approach, supporting "mangrove-shrimp" farms that maintain 50% mangrove cover and produce organic-certified shrimp. Certification standards typically require no recent deforestation and encourage habitat rehabilitation, helping to improve the sector's ecological footprint.

##### **Labor and Social Responsibility in Shrimp Supply Chains**

Sustainability also encompasses fair labor practices, a long-standing concern in shrimp processing sectors. Notably, a 2015 investigation revealed instances of forced labor in parts of Thailand's shrimp industry, prompting global backlash. Since then, certifications like BAP

and ASC have incorporated labor audits, and buyers are increasingly demanding transparent and ethical sourcing. While progress has been made - many exploitative operations were closed - labor challenges remain, particularly in complex supply chains involving multiple subcontractors. Programs like Fair Trade shrimp are growing, and new initiatives focus on worker safety, wages, and rights. Retailers and foodservice buyers now often evaluate social as well as environmental performance when selecting suppliers.

### Current Challenges and Progress Toward Sustainability

Despite clear progress, the shrimp industry still faces unresolved issues. Some farms continue using prohibited antibiotics, raising concerns about residues and antimicrobial resistance. Water pollution, though reduced through improved pond management and closed-loop systems, remains problematic in certain areas. In the wild-caught shrimp sector, challenges such as bycatch and habitat impact from trawling continue to limit how sustainable these fisheries can be.

However, broader adoption of certification is helping to drive improvement. By 2023, around 8% of wild shrimp landings were certified or in a fishery improvement program (FIP). Programs like the Marine Stewardship Council (MSC) are gaining traction, particularly for coldwater shrimp. On the farmed side, the presence of certified shrimp - bearing BAP, ASC, or Fair-Trade labels - is becoming standard in Western retail markets. For example, many U.S. buyers now prioritize imports from Ecuador and Thailand because all their farmed shrimp meet the "Good Alternative" rating under Seafood Watch or hold full certification.

### Sustainability as a Market Imperative

As sustainability evolves from a niche concern to a market requirement, producers must increasingly align with environmental and social standards to remain competitive. Countries or suppliers perceived as neglecting these standards may face trade barriers or reputational risk. Some Western producers have even raised concerns over "environmental dumping" - the practice of selling uncertified, low-cost shrimp that undercut compliant farms. As the global shrimp market becomes more quality-conscious, compliance with sustainability benchmarks is not just a moral imperative but a strategic necessity.

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## 4.3 EU Shrimp Market

### 4.3.1 EU-Wide Consumption and Demand Trends

Shrimp remains one of the most popular seafood products in Europe, ranking as the third most consumed aquatic species in the EU, behind only tuna and salmon. While average per capita consumption of shrimp across the EU is relatively modest at around 1.5 - 1.7 kg per person per year, the region's large population makes the overall demand highly significant. With total shrimp consumption estimated at 600,000 to 700,000 metric tons annually, the European Union represents approximately 11% of global shrimp demand, making it the third-largest shrimp market worldwide.

Europe's shrimp supply is heavily reliant on imports. Around 70% of shrimp consumed in the EU is imported, while the remaining 30% comes from domestic sources - primarily wild-caught coldwater species from northern waters. In species terms, roughly 60% of the shrimp consumed in Europe is farmed, mostly tropical warmwater varieties such as *Penaeus vannamei*, and 40% comes from wild fisheries, including coldwater shrimp like *Pandalus borealis* and wild warmwater shrimp such as Argentine red shrimp.

#### Consumption and Demand Trends

Following a brief post-pandemic surge in home cooking, European shrimp consumption softened between 2022 and 2023. Rising inflation - particularly in 2022 - pushed seafood prices up by around 10%, causing volume declines across key consumer markets. In fact, household seafood consumption dropped by 15 - 17% in several EU countries during this period. Shrimp imports mirrored this trend, falling in 2023 due to sluggish demand and high inventory levels. For example, imports of *vannamei* shrimp were down approximately 10% compared to 2022.

Nevertheless, the medium-term outlook remains positive. Shrimp maintains strong popularity in European cuisines, from Spanish tapas and Italian seafood pasta dishes to Nordic coldwater shrimp salads. As inflation cools and economies recover, analysts project that the European shrimp market could grow at a 5% compound annual rate through 2030. The increasing availability of shrimp year-round - combined with growing interest in sustainably and locally produced seafood - is expected to support this growth.

#### Market Value and Strategic Opportunities

Shrimp represents a disproportionately large share of the EU's seafood import value. In 2022, while accounting for around 10% of import volume, shrimp made up about 15% of the value of all seafood imports into the EU. The European shrimp market is currently valued at €5 - 6 billion annually, with Southern Europe - particularly countries like Spain and Italy - accounting for the lion's share.

Inflation has played a role in inflating these values: even as shrimp volumes dipped in 2022, EU consumer spending on shrimp rose by roughly 11%. This indicates resilience in consumer interest and a willingness to pay for preferred seafood items despite economic headwinds.

Europe's limited self-sufficiency in shrimp production - only about 9% of consumption is met through domestic supply - creates an opportunity for EU-based shrimp farms. Indoor systems like recirculating aquaculture systems (RAS) can offer fresh, traceable, antibiotic-free shrimp, addressing growing consumer demand for quality and sustainability. Such products may command a premium price in high-end retail and foodservice markets, especially as concerns about overseas farming practices continue to influence buyer preferences.

#### 4.3.2 Imports: Warmwater vs. Coldwater Shrimp Supply

Due to its limited domestic shrimp production, the European Union is heavily reliant on imports to meet consumer demand. In 2022, the EU - 27 imported approximately 5.9 million tonnes of seafood across all species, with shrimp accounting for around 10% of the total volume, or about 600,000 tonnes. Despite inflationary pressures, import volumes rose slightly in 2022, while the value of shrimp imports jumped by 17%, reflecting elevated global prices. However, trade volumes softened in 2023 amid consumer caution and high inventories. By contrast, 2024 and early 2025 have seen a strong recovery, supported by lower shrimp prices and increased exports directed toward the EU. For example, in May 2025, the EU imported over 40,500 tonnes of warmwater shrimp, marking a 27% year-on-year increase and setting a new monthly record.

##### Species and Source Composition

The vast majority of shrimp imported into Europe consists of warmwater tropical species, particularly Pacific white shrimp (*Litopenaeus vannamei*) and, to a lesser extent, black tiger shrimp (*P. monodon*). These farmed varieties dominate the market due to their cost efficiency and year-round availability. By contrast, wild-caught coldwater shrimp (such as *Pandalus borealis* or *Pleoticus muelleri*) make up a smaller but valuable share. One of the most notable wild species in the EU trade is the Argentine red shrimp, which remains especially popular in Southern Europe for its size and flavor. However, market share for Argentine shrimp has declined, as competitively priced vannamei increasingly replaces it in retail and foodservice channels. Spain, once the leading importer of Argentine shrimp, has notably shifted toward more affordable alternatives.

To remain competitive, some Argentine exporters have begun outsourcing processing to lower-cost countries. Other coldwater imports - such as North Sea prawns from Greenland or Canada - are typically cooked and peeled before export and primarily serve Northern European markets.

##### Key Suppliers to the EU Market

Europe sources its shrimp from a broad array of producing nations, with Ecuador, India, and Vietnam leading the way. Together, these three countries significantly expanded their market share in 2022 and have remained dominant since. As of 2025, Ecuador accounts for over 50% of the EU's shrimp import volume, shipping nearly 89,000 tonnes in the first five months of 2025 alone, a 39% increase from the previous year. Ecuador's competitive advantage stems

from efficient large-scale farming and competitive prices, particularly in head-on and shell-on forms.

India ranks second, with a strong presence in peeled and value-added shrimp. By 2023, India surpassed Vietnam as the largest warmwater supplier to Western Europe. Vietnam, meanwhile, maintains its position as a major supplier of processed and ready-to-eat products, including breaded, cooked, and marinated shrimp, which are increasingly favored in convenience-oriented markets such as Germany, France, and the UK.

Other noteworthy suppliers include Bangladesh (primarily for *P. monodon* to niche buyers), Indonesia and Thailand (diverse raw and processed products), and Venezuela, which has recently emerged as a volume supplier to Southern Europe, though its role is currently impacted by domestic instability.

### Product Forms and Processing Flows

Shrimp imports into the EU are evenly split between raw and value-added formats. In Northern and Western Europe, there is strong demand for peeled, cooked, and processed shrimp - offering convenience to retail and foodservice buyers. Much of this is supplied by Asian processing hubs, including Vietnam, Thailand, and Indonesia. For instance, breaded and tempura shrimp have gained popularity in UK and German markets.

In Southern Europe, raw formats dominate, countries like Spain and Portugal import head-on or headless shell-on shrimp, often frozen, which are then cooked locally for fresh retail sale. This practice supports local processors and appeals to consumers seeking freshly prepared products, such as France's well-known "cuit du jour" cooked shrimp sold in supermarket seafood counters.

Intra-EU trade also plays a role. For example, Spain re-exports around 40,000 tonnes of shrimp annually after local processing, while Belgium and the Netherlands serve as major distribution hubs, facilitating shrimp flows across the single market. Overall, the EU shrimp trade is dynamic - balancing raw material imports, local processing, and internal redistribution in response to evolving consumer preferences and price conditions.

#### 4.3.3 Major EU Markets: Country Breakdown

##### Spain's Shrimp Market Overview

Spain is one of Europe's most important shrimp markets, both in terms of volume and cultural significance. With an estimated 3 kg per capita shrimp consumption annually, Spain leads the EU in per-person intake. Total national consumption is estimated between 130,000 and 150,000 tonnes per year, placing Spain among the continent's top shrimp consumers overall. In value terms, the Spanish shrimp market is worth around €1.9 billion, making it the largest shrimp market in the EU by sales.

Shrimp play a central role in Spanish food culture, particularly during festive periods like Christmas and New Year, where prawns are often a centerpiece of family meals. Shrimp are also widely consumed year-round, in both casual and fine dining settings.

## Product Preferences and Species Trends

Spanish consumers display a strong preference for large, whole shrimp - especially head-on, shell-on (HOSO) formats, which are typically served grilled or boiled. A key feature of Spain's shrimp market is its affinity for wild-caught red shrimp, notably the Argentine red shrimp (*Pleoticus muelleri*), known locally as *gamba roja*. These prawns are considered a premium delicacy and are common in paellas, tapas, and celebratory dishes.

Despite the appeal of wild shrimp, farmed tropical species have captured a growing share of the market. In particular, whiteleg shrimp (*Litopenaeus vannamei*) now dominate the affordable and versatile segment. Ecuador is Spain's leading supplier of vannamei, providing approximately 77% of imports of this species in 2023. Venezuela has also emerged as a notable supplier (around 9% of Spain's vannamei imports), although trade dynamics may shift due to regulatory and export challenges. Other supplying nations include India, Honduras, and Argentina (for wild-caught varieties).

## Processing and Trade Structure

Spain is not just a major consumer but also plays a strategic role in regional shrimp distribution. Many Spanish seafood companies import frozen shrimp in bulk, then cook and package it domestically before selling it within Spain or re-exporting to other EU countries. On average, about 40,000 tonnes of shrimp imported into Spain are re-exported annually after local processing.

Spanish processors are especially known for producing cooked shrimp products, often sold chilled in retail outlets as "gambas cocidas". Supermarkets and fishmongers across the country frequently offer freshly cooked shrimp prepared daily, often promoted as "cocido del día" to emphasize freshness. This short supply chain, from import to local cooking and sale, is a distinctive aspect of Spain's shrimp sector.

## Distribution and Consumer Channels

Retail is a primary channel for shrimp sales in Spain, with products available in supermarkets, open-air markets, and specialty fish stores. Shrimp are sold in various formats: chilled whole (raw or cooked), frozen packs, and value-added products like marinated skewers. The foodservice sector is also highly influential, with shrimp featured in countless Spanish dishes across casual eateries, seaside grills (*chiringuitos*), and gourmet restaurants. Dishes featuring Dénia red prawns, for example, command premium prices in fine dining establishments.

Though exact figures are unavailable, a substantial portion of shrimp consumption occurs in the foodservice industry, given Spain's strong culinary tradition and tourism-driven demand. This dual focus - premium wild shrimp for festive and high-end use, alongside farmed vannamei for daily meals - defines Spain's unique position in the European shrimp landscape.

## France (Southern Europe)

France is one of the largest shrimp markets in Europe, marked by a diverse product range and a strong emphasis on quality and sustainability. French consumers eat approximately 1.5 kilograms of shrimp per person annually, placing national consumption in the range of 90,000

to 120,000 tonnes. In value terms, the market is estimated at around €1.7 billion, second only to Spain within the European Union. Shrimp, or crevettes, are widely popular in France and are featured across culinary traditions - from classic cold appetizers such as shrimp cocktails and mayonnaise-based salads to main courses and simple delicacies like chilled cooked shrimp with aioli. This widespread appeal has helped secure shrimp as a staple in both retail and foodservice channels.

France's shrimp supply relies heavily on imports, with farmed whiteleg shrimp (*Penaeus vannamei*) now accounting for the vast majority of trade volume. In 2023, France imported over 100,000 tonnes of vannamei, which represented roughly 81 percent of total shrimp imports. Ecuador was the leading supplier, providing about 32 percent of the total volume, followed by India, Vietnam, and Venezuela – the latter having grown rapidly to account for 21 percent of France's vannamei imports in that year. The remainder of French shrimp imports includes wild-caught species such as Argentine red shrimp and coldwater shrimp used in further processing. France also maintains a niche but notable market for black tiger shrimp (*Penaeus monodon*), nearly 70 percent of which come from Madagascar. These are often certified organic and, in some cases, carry France's Label Rouge designation, positioning them in the premium segment of the market.

Compared to Spain, France shows more diversification in both supplier countries and shrimp species. The product mix in France is likewise varied. Consumers are familiar with both raw and cooked shrimp, as well as shell-on and peeled forms. Frozen raw shrimp, chilled ready-to-eat trays, and value-added products such as marinated or breaded shrimp are all widely available. One of the most prominent product categories in French retail is the "crevette cuite" - cooked shrimp sold chilled, often prepared on-site at supermarkets or by local processors. These are typically mid-sized vannamei shrimp that are cooked shortly before sale, giving them a freshness appeal that resonates strongly with consumers. This segment has become a core focus for international suppliers looking to penetrate the French market. At the same time, France's foodservice sector offers a wide range of shrimp formats, with tropical farmed shrimp used in casual restaurants and wild-caught species like deepwater rose shrimp favored in upscale coastal cuisine.

Sustainability and certification play a central role in shaping the French shrimp market. France is the second-largest organic shrimp market in Europe, behind only Germany, and together the two countries account for more than half of the EU's organic shrimp consumption. Madagascar's organic black tiger shrimp have a particularly strong following among French consumers, supported by branding that highlights sustainable production and exceptional quality. French retailers increasingly require aquaculture products to be certified. The Aquaculture Stewardship Council (ASC) label is commonly found on farmed shrimp, while wild-caught shrimp often carry Marine Stewardship Council (MSC) certification. Label Rouge and organic certification are key quality markers for higher-end products, and supermarket private labels typically demand at least one form of certification. While uncertified shrimp still find their way into foodservice or independent retail, the trend is clearly toward traceability,

environmental assurance, and third-party verification - particularly for products placed in major retail chains.

In sum, France's shrimp market is mature, dynamic, and quality-driven. The dominance of vannamei is tempered by consumer interest in diverse product origins and premium segments such as organic and wild shrimp. The market supports a broad spectrum of shrimp products and rewards suppliers that can meet high standards for sustainability, traceability, and taste. For new entrants such as European RAS farms, France offers compelling opportunities - especially in the fresh, certified, and locally produced categories - with the potential to capture value in a market willing to pay a premium for responsibly farmed shrimp.

#### [Germany, Netherlands & Belgium \(Northwestern Europe\)](#)

Northern Europe - led by Germany, the Netherlands, and Belgium - constitutes one of the most important regions in the European shrimp trade, combining substantial consumer demand with a sophisticated import, processing, and redistribution infrastructure. Germany is the largest market by volume due to its population size, although per-capita consumption is lower than in Southern Europe at roughly one kilogram per person. Even with modest individual consumption, Germany's aggregate market value continues to expand and is forecast to approach €5.8 billion by 2030. The Netherlands and Belgium, despite their smaller populations, play an outsized role as entry points for shrimp destined for the wider EU, with Rotterdam, Antwerp, and Hamburg forming a distribution corridor through which large volumes are imported, processed, and re-exported.

Consumer preferences in this region differ markedly from those in Mediterranean markets. Northern European shoppers favor convenience-oriented formats, and retail assortments reflect this orientation: peeled, headless, and often pre-cooked shrimp dominate supermarket shelves. Frozen peeled products intended for stir-fries or salads, ready-to-eat cocktail shrimp, and lightly seasoned or breaded items are common across Germany, the Netherlands, and Belgium. Whole head-on tropical shrimp are rarely offered in mainstream retail channels and tend to appear only in specialty outlets or during seasonal promotions. The notable exception is the local North Sea brown shrimp (*Crangon crangon*), a small wild species with deep cultural ties in coastal areas of Belgium, the Netherlands, and northern Germany. These shrimp are generally sold pre-cooked and peeled, reflecting long-standing consumption habits, although the tropical shrimp segment still accounts for the overwhelming share of volume.

Sustainability expectations in Northern Europe are among the strictest in the world. Retailers in Germany, the Netherlands, and Belgium have widely adopted procurement policies requiring ASC certification for farmed shrimp, and uncertified products are increasingly restricted to foodservice or lower-priced wholesale segments. This dynamic has encouraged global producers - from Latin America to Southeast Asia - to adopt third-party certifications in order to maintain access to these markets. Germany, in particular, is an important destination for organic seafood, and organic vannamei or black tiger shrimp have developed a small but reliable premium segment there. Wild-caught shrimp imported into the region, such as Argentine red shrimp, increasingly carry MSC certification or originate from fisheries

engaged in structured improvement programs. These requirements reinforce Northern Europe's position as a sustainability-driven market in which environmental and social assurances are decisive factors for retail placement.

Distribution patterns in this region also differ from those in Southern Europe. Retail is the primary channel for shrimp sales, supported by extensive supermarket networks that emphasize frozen and chilled packaged products. Foodservice demand is lower as a share of total volume, but still relevant - particularly in Asian cuisine, where vannamei shrimp are used extensively. Ethnic wholesale markets in large urban centers, including Amsterdam, Brussels, and Berlin, sustain additional demand for specialty items such as larger black tiger shrimp, which remain popular in certain culinary communities despite vannamei's dominance in mainstream retail. Overall, however, vannamei has displaced black tiger shrimp in most high-volume segments due to its pricing, consistency, and broad applicability.

The Netherlands and Belgium retain strategic importance not only as consumption markets but as the logistical backbone of the EU shrimp supply chain. Dutch companies are central actors in the import and reprocessing of vannamei shrimp, receiving bulk shipments that are subsequently packed or processed for distribution throughout Europe. Belgium performs a similar function, with Antwerp remaining a key arrival port for warmwater shrimp destined for distribution into France, Germany, and beyond. Because of these re-export flows, national import statistics often overstate domestic consumption; the region operates as an integrated market in which products may enter through one country, undergo processing in another, and ultimately be sold several borders away.

Taken together, Germany, the Netherlands, and Belgium form a tightly connected Northern European shrimp market defined by high standards, a preference for convenience formats, and strong reliance on certified supply chains. For producers able to meet these expectations - particularly those offering traceable, low-impact shrimp from EU-based RAS systems - the region represents an attractive and receptive market opportunity.

#### [Italy \(Southern Europe\)](#)

Italy represents one of Europe's major shrimp-consuming nations, combining a sizeable population with a culinary culture in which shrimp plays a central role. Annual per-capita consumption is estimated at roughly one to one and a half kilograms, placing Italy between the high-consuming markets of Spain and France and the more convenience-oriented Northern European region. In aggregate terms, this translates into a national market of approximately sixty to eighty thousand tonnes per year, reflecting steady demand in both household consumption and foodservice.

Italy depends largely on imported warmwater shrimp to meet its needs, sourcing substantial volumes from Ecuador, India, Vietnam, Argentina and other major producers. As part of Southern Europe's broader import bloc, Italy consistently ranks among the EU's largest buyers of tropical shrimp. Farmed vannamei dominates the mainstream market and supplies retail freezers, processing plants and restaurant kitchens. Wild Argentine red shrimp also has a strong foothold, prized for its distinctive flavor and used in dishes such as grilled gamberoni

or seafood pasta. Alongside these imports, Italy's own fisheries contribute modest but highly valued catches of Mediterranean species such as deep-water rose shrimp and the celebrated red prawns from the Ionian and Tyrrhenian Seas. These local species occupy the premium tier of the Italian market and are staples in upscale restaurants, but their availability is limited, so imports remain the backbone of national supply.

Product formats in Italy reflect a balance between tradition and convenience. Whole shrimp - particularly large head-on prawns - see strong seasonal demand, especially during Christmas and Easter when seafood features prominently on holiday menus. Throughout the year, retailers offer frozen headless or head-on shrimp, peeled products for quick preparation, and increasingly, an array of breaded or prepared items that tie into Italy's interest in seafood appetizers and ready-to-cook meals. The foodservice sector is a major engine of consumption: shrimp appears across the full spectrum of dining, from pizzerias using small shrimp as toppings, to trattorias serving grilled prawns, to coastal restaurants highlighting local red shrimp in refined preparations. Tourism reinforces this demand, especially in summer months when seafood dishes are prominent on menus nationwide.

Italy has a modest processing industry of its own, focusing largely on adding value to imported raw materials. Companies prepare breaded shrimp, marinated skewers, chilled ready-to-eat products, and shrimp-based components for ready meals. While the scale of this sector does not match Spain or the Netherlands, it plays an important role in supplying Italian retail and foodservice with customized products suited to local tastes.

Sustainability and certification are gaining prominence in the Italian market, albeit more gradually than in Northern Europe. Retailers increasingly list ASC-certified farmed shrimp and MSC-labelled wild shrimp, particularly under private-label brands. Organic shrimp is a niche but recognizable category, present mainly in specialty retailers. Although traditional culinary preferences and price sensitivity still shape purchase decisions for many Italian households, Italy is progressively aligning with broader EU expectations regarding traceability, environmental assurances and responsible sourcing.

Overall, Italy stands out as a substantial and multifaceted shrimp market - grounded in a strong foodservice sector, supported by consistent household demand, and shaped by a dual identity that blends imported warmwater shrimp with deep-rooted appreciation for local Mediterranean species. This combination creates opportunities for differentiated products, including high-quality, sustainably produced European shrimp.

#### 4.3.4 European Shrimp Price Trends Across the Value Chain (2022–2025)

Shrimp prices in the European Union have experienced notable volatility in recent years, shaped by global supply fluctuations, cost inflation, and shifting demand. At the import level, prices surged in 2022 as suppliers responded to increased post-pandemic consumption, higher feed and freight costs, and constrained global production. The average CIF (Cost, Insurance, and Freight) price for shrimp imported into the EU rose by approximately 15% compared to the previous year. This sharp increase in unit value, coupled with only modest

growth in volume, translated into a disproportionately higher total import bill. Similar trends were recorded in benchmark markets such as the United States, where shrimp import prices climbed to nearly \$9.85 per kilogram at their 2022 peak.

By contrast, the pricing environment shifted markedly through 2023 and into 2024. With production ramping up in key exporting countries and demand softening in major markets like China and the U.S., European buyers benefited from an influx of competitively priced shrimp. As a result, CIF prices declined across the board. By mid-2023, European importers were securing vannamei shrimp at significantly lower prices than the previous year - a welcome reversal following the inflation-driven highs of 2022. Rabobank and other industry analysts noted that Europe had become an attractive destination for surplus shrimp volumes, contributing to a temporary oversupply and subsequent price correction. Spain, one of the EU's largest shrimp importers, recorded an average CIF price of around €6.80 per kilogram in spring 2023, which dropped further by mid-2025 to approximately €6.50/kg. Pricing remained product- and origin-specific: for example, bulk shipments of head-on shell-on shrimp from Ecuador were typically priced at €5–6/kg, while processed, value-added shrimp (e.g. peeled and cooked vannamei from Vietnam) commanded €8–9/kg.

Wholesale markets followed a similar trajectory. Prices reached their apex in early 2022, particularly for premium wild shrimp like Argentine red shrimp (L1 grade), which fetched around €6.90/kg in Spain. However, by the end of 2023, wholesale prices for the same product had declined to under €5/kg, reflecting weaker demand and saturated inventories. Similar corrections occurred across France, Germany, and other key markets, where both tropical and coldwater shrimp categories experienced downward pricing pressure. Spot market data from late 2023 showed medium-sized vannamei shrimp (60 - 70 count) trading at €4 - 5/kg wholesale, down 10 - 20% year-on-year. This deflation occurred even as overall food prices in Europe continued to rise, indicating that shrimp, in contrast to many proteins, became more affordable due to its global oversupply.

Seasonality remains a defining feature of wholesale shrimp pricing. Larger whole shrimp typically command premiums during festive periods, particularly around Christmas and New Year's, when demand for celebratory meals spikes. However, the 2023 holiday season was notably muted compared to 2022: inventories remained high, and price increases were subdued. For instance, Spanish wholesalers offered 30/40 and 40/60 count vannamei in December 2023 for around €4.70/kg, substantially below the levels seen the prior year. Peeled and smaller processed shrimp, on the other hand, experienced less seasonal fluctuation and remained stable throughout the year.

At the retail level, shrimp continues to occupy the premium tier among animal proteins, though price movements have increasingly mirrored trends in the wholesale market. In 2022, consumer prices surged across most European markets, driven by rising upstream costs. Retailers passed these increases along to shoppers, leading to noticeable declines in shrimp purchase volumes - especially in countries like the UK, where household budgets were already under strain. However, by late 2023 and into 2024, retail shrimp prices began to stabilize. In several countries, promotions and cost normalization supported a modest recovery in sales.

Retail prices vary widely depending on product form, processing level, and market positioning. In Spain, shrimp products on supermarket shelves in 2024 ranged from €7 - 14/kg, with standard frozen vannamei priced at the lower end and specialty or festive items at the higher end. Chilled, ready-to-eat cooked shrimp typically sold for €10 - 15/kg, while large, fresh prawns could exceed €15/kg at seafood counters. In France and Germany, price points were broadly similar, with mid-sized frozen shrimp retailing between €8 and €12/kg, and organic or premium certified products reaching €20/kg or more. It is also common for shrimp to be sold in small retail packs (e.g. 200 - 300g), which can obscure the relatively high per-kilo cost to the average consumer.

Product form plays a central role in determining retail value. Whole shrimp - especially large sizes - remain the most expensive segment, while peeled and cooked formats may appear more affordable on a per-unit basis, though the actual shrimp content is lower. For example, a 300g jar of tiny peeled coldwater shrimp might retail for €5 - 6, equating to well over €16/kg. Processed items like breaded scampi or tempura shrimp are priced per pack but can easily surpass €18 - 20/kg in shrimp content once processing and branding are factored in. At the top of the price ladder, organic shrimp and eco-certified wild products command significant premiums. Organic vannamei from Ecuador or Madagascar can reach €25/kg in France, while large Argentine red shrimp sold fresh during peak season may fetch up to €22 - 25/kg - although in 2023, some grades were available at nearly half that price due to excess supply.

In conclusion, shrimp pricing in Europe has shifted from a high-cost environment in 2022 to a more affordable and competitive market by 2024 - 25. This transformation has been driven largely by supply-side dynamics and global redistribution of trade flows. For new entrants - particularly land-based or RAS shrimp farms within the EU - these price benchmarks are critical for positioning. Locally produced fresh shrimp will likely need to compete at the higher end of the market, where freshness, sustainability, and traceability can justify price premiums that offset higher production costs.

#### 4.3.5 Shifting Dynamics in EU Shrimp Trade (2023 - 2025)

The European Union's shrimp trade has undergone notable shifts in recent years, shaped by external market disruptions and changing global supply routes. One of the most consequential developments between 2023 and 2024 was the imposition of elevated tariffs on Asian shrimp by the United States. This prompted many Asian exporters to redirect substantial volumes toward Europe, where market access remained comparatively open. Analysts from Rabobank and other institutions identified Europe as a key alternative destination for excess global shrimp, a trend that played a major role in boosting EU imports to record levels in 2024 - 2025. While this created opportunities for buyers to secure competitively priced product, it also intensified oversupply conditions, contributing to market saturation and downward price pressure.

Producers from India, Vietnam, and Indonesia have aggressively pursued greater access to the EU market in light of stagnating sales elsewhere. Simultaneously, Ecuador - already a dominant force in global shrimp exports - has continued to expand its footprint across all

major regions, including Europe. The result has been a noticeable rebalancing in the composition of EU imports, with Latin American suppliers, particularly Ecuador, Honduras, and Nicaragua, increasing their share alongside long-established Asian exporters.

One of the more significant trends within the trade has been the diversification in the types of shrimp products entering the European market. In Western Europe, demand has shifted notably toward value-added formats, including pre-peeled, breaded, and cooked shrimp. This trend gained momentum through 2021 - 2022 and remains strong. As consumers increasingly seek convenient seafood options for ready meals and restaurant-style dishes, exporters from Vietnam, Thailand, and China have taken advantage of this shift, supplying a wide array of processed products such as tempura shrimp, marinated skewers, and shrimp dumplings.

By contrast, Southern European markets continue to rely heavily on raw frozen shrimp, particularly whole or shell-on products. Spain, for example, remains a major importer of head-on shell-on (HOSO) shrimp, which are cooked locally for retail and foodservice use. Italy and Portugal follow similar patterns. The structure of intra-EU trade also reflects these differences in product form. Shrimp processed in Spain or peeled in the Netherlands is often distributed onward to other EU member states or even non-EU neighbors such as Switzerland and the UK. The Netherlands, in particular, acts as a key re-export hub, managing significant volumes that are repackaged and shipped across the continent.

In terms of size preferences, the European shrimp market is largely centered on medium sizes, typically in the 30 - 70 count per kilogram range. These sizes are well-suited to mass-market formats such as frozen bags, ready-to-eat salads, and breaded products. Over the past few years, global vannamei production has trended toward smaller sizes due to faster harvest cycles and cost considerations. European importers have adjusted accordingly: demand for 60/70 count shrimp has grown, as this size offers a favorable price-to-volume ratio and integrates well into processed food formats.

Nonetheless, a stable niche market remains for large shrimp - those under 20 count per kilogram - especially during holiday seasons or for foodservice applications. Spain and Italy are key destinations for these premium categories, often using them in grilled dishes or festive meals. These larger shrimp are supplied both by farmed producers (e.g., giant tiger prawns from India and Mozambique) and by wild fisheries such as Argentina's red shrimp sector. There is also some crossover with tropical rock lobster products marketed under the "giant shrimp" label in upscale channels.

An ongoing tension in the European market is the interplay between wild-caught and farmed shrimp. The wild Argentine red shrimp, typically sold whole, competes directly with larger-sized farmed vannamei in price-sensitive Southern markets. When farmed shrimp prices fall - as they did through 2023 - some buyers pivot toward vannamei as a cost-effective alternative, creating headwinds for Argentine exporters who rely on price premiums to offset higher harvesting costs. Conversely, when farmed shrimp prices rise, wild shrimp can gain market share. This cyclical relationship is further influenced by sustainability standards. Retailers and buyers often make sourcing decisions based on certification availability -

choosing between ASC-certified farmed products and MSC-certified wild shrimp, or sourcing from fisheries engaged in credible improvement projects.

Logistics and exchange rates also continue to shape trade flows. During the height of the COVID-19 pandemic, elevated freight costs disproportionately impacted suppliers in Asia, reducing their competitiveness in distant markets like Europe. As shipping costs normalized through 2023, Asian exports rebounded. Exchange rate fluctuations added another layer of complexity: in 2022, a strong U.S. dollar made dollar-denominated shrimp more expensive for eurozone importers. But as the euro regained strength, purchasing shrimp from dollar-based markets became more financially viable, encouraging renewed sourcing from Asia.

Taken together, these developments reflect a highly dynamic and competitive European shrimp market. At present, the region enjoys abundant supply, diversified sources, and the bargaining power that comes with being a major global importer. Buyers are increasingly able to tailor procurement strategies based on price, certification, product form, and origin. For new entrants - such as European land-based or recirculating aquaculture system (RAS) shrimp farms - this poses both a challenge and an opportunity. Competing on price or volume is unrealistic against global giants like Ecuador or India. However, EU producers may find success by focusing on attributes such as ultra-fresh delivery, environmental performance, and local traceability. In an import-driven landscape, these differentiators could provide the edge needed to carve out a high-value niche despite the flood of low-cost, imported alternatives.

#### **4.3.6 Sustainability Certifications in the European Shrimp Market**

Over the past decade, certified sustainable shrimp has moved from a niche segment to a standard expectation across the European seafood value chain. Today, certification plays a decisive role in shaping sourcing decisions, product pricing, and access to retail and foodservice channels. As sustainability concerns grow among European consumers and buyers, the demand for eco-labeled shrimp has become an essential feature of market entry strategies, particularly in Northern and Western Europe.

##### **ASC - Aquaculture Stewardship Council**

The Aquaculture Stewardship Council (ASC) has emerged as the most widely recognized and accepted certification for farmed shrimp in the European market. In many EU countries - particularly Germany, the Netherlands, Belgium, Scandinavia, and the UK - ASC certification is now effectively a prerequisite for access to high-value retail supply chains. Leading supermarket groups typically require all farmed shrimp to carry the ASC label, though in some cases alternative standards such as GlobalG.A.P. or BAP may be accepted. However, ASC remains the dominant label with the greatest consumer recognition.

In response to this market requirement, producing countries have increasingly invested in certification systems. Vietnam, for example, has become the largest global supplier of ASC - certified black tiger shrimp, accounting for the vast majority of product in that category. Although the wholesale price premium for ASC - certified shrimp may be modest (typically just a few percent), the key benefit lies in improved market access and reduced competition

from uncertified producers. The shift toward certified supply was notably accelerated during the COVID-19 pandemic: as foodservice demand declined and inventory was redirected to retail, only shrimp with appropriate certification could be sold, driving a spike in ASC-labeled products on supermarket shelves. For exporters targeting Europe, ASC certification now functions less as a value-add and more as a baseline requirement.

#### **MSC - Marine Stewardship Council**

For wild-caught shrimp, the Marine Stewardship Council (MSC) is the leading sustainability certification. Several coldwater shrimp fisheries that serve the European market - such as those in Canada and Greenland - have maintained MSC certification for years. These products, often destined for markets in Northern Europe (including the UK, Denmark, and Sweden), benefit from widespread retailer and consumer familiarity with the MSC label. The North Sea brown shrimp fishery also achieved MSC status, supporting sustainably sourced local shrimp in Germany and the Netherlands.

Within the warmwater segment, MSC certification remains less common, though progress has been made. Some fishing zones within Argentina's red shrimp fishery have achieved MSC certification in recent years. While not all wild shrimp sold in the EU carries an MSC label, certified products generally enjoy better market access and are preferred by buyers with sustainable procurement policies, particularly in the foodservice and institutional catering sectors.

#### **BAP - Best Aquaculture Practices**

The Best Aquaculture Practices (BAP) certification, developed by the Global Seafood Alliance, is widely used in North America but has a more limited presence in European markets. Some EU importers and processors adhere to BAP standards within their supply chains, especially for internal quality assurance. However, the BAP label is rarely visible on consumer packaging in Europe and carries less marketing value than ASC. While BAP 4-star certified shrimp (indicating full supply chain certification) may enter the EU indirectly, most European retailers and foodservice operators prefer ASC for front-facing sustainability claims. Nonetheless, BAP is occasionally recognized within technical procurement frameworks, particularly in multi-national buying groups or foodservice networks.

#### **Organic Certification**

Organic shrimp occupies a small but high-value niche in the European market. Certified organic shrimp must meet stringent criteria related to feed, stocking density, water quality, and chemical use. Although volumes remain low, organic shrimp command significant price premiums - often 30 - 50% higher than conventional alternatives of similar size. Europe is the primary global market for organic shrimp, with France, Germany, and Switzerland leading in both availability and consumer demand.

In France, suppliers such as OSO and Unima have developed a strong market presence with organic-certified black tiger shrimp from Madagascar, many of which also carry the national Label Rouge quality designation. In Germany, organic retailers such as Alnatura periodically offer organic vannamei from certified farms in Latin America. The steady growth of the

organic food segment in Europe has helped support consistent demand for this category, even as other seafood segments fluctuate with price and availability.

For producers operating within the EU - particularly those using land-based or recirculating aquaculture systems (RAS) - organic certification may represent a viable strategy to target premium market segments. The controlled environment of RAS operations may facilitate compliance with organic standards, offering an opportunity to differentiate from conventional imports and align with sustainability-focused consumer preferences.

### Other Sustainability Labels and Claims

Beyond the main certification schemes, several additional labels and attributes are gaining relevance in the EU shrimp market. France's Label Rouge continues to signify premium quality, especially for traditionally produced and sustainably sourced seafood. Social certification programs, such as the Global Seafood Alliance's BSP (Best Social Practices), are increasingly integrated into procurement criteria, particularly by large buyers seeking to ensure labor and human rights standards across their supply chains.

Antibiotic-free production and full traceability are also central to the perception of sustainability among European consumers. Investigations and media coverage of banned antibiotic residues in imported shrimp have raised public concern and increased demand for "clean" products. Certification schemes such as ASC and organic inherently address these issues by enforcing strict standards, further reinforcing their value in the market.

### Conclusion

Sustainability certification is now a core component of shrimp marketing and procurement strategy in Europe. Whether through ASC for farmed shrimp, MSC for wild catch, or organic and national labels for premium segments, certified shrimp is becoming the norm rather than the exception. For exporters and producers aiming to succeed in Europe, investing in appropriate certification is not simply a branding exercise - it is increasingly essential to securing access to the continent's most lucrative retail and foodservice channels. As sustainability expectations continue to evolve, certification will remain central to meeting regulatory requirements, maintaining consumer trust, and ensuring long-term competitiveness in the European shrimp sector.

#### **4.3.7 The Influence of Certification on Sourcing Strategies and Pricing in the European Shrimp Sector**

The growing emphasis on sustainability in European seafood markets is not only a matter of consumer preference but a key driver of sourcing decisions and commercial strategies across the shrimp value chain. Certification - particularly through the ASC (Aquaculture Stewardship Council) and MSC (Marine Stewardship Council) - now plays a pivotal role in determining supplier selection, pricing dynamics, and retail positioning.

### Sourcing Implications

Importers and buyers in countries such as the Netherlands and Germany increasingly prioritize certified shrimp in their procurement processes, often selecting suppliers specifically on the basis of certification status. This trend has altered the competitive landscape: for example, Vietnamese and Indian exporters have captured significant EU market share by offering consistently ASC-certified vannamei shrimp, while some competing origins - despite offering lower-cost product - have lost ground due to limited certification uptake.

The case of black tiger shrimp (*Penaeus monodon*) illustrates this shift. Historically favored for its size and texture, *monodon* has seen reduced market penetration in Europe, partly due to the slower adoption of certification among producers. Until recently, relatively few *monodon* farms were ASC-certified, making it more challenging for buyers to meet corporate sustainability targets when sourcing this species. In contrast, vannamei producers - particularly in Asia and Latin America - have invested in certification more proactively, allowing them to meet the increasingly stringent requirements of European retailers and foodservice operators.

### Impact on Pricing

While exact premiums for certified shrimp are difficult to quantify through retail scanner data, anecdotal and trade evidence suggests that ASC and MSC certifications support modest price differentials at the wholesale and retail levels. Certified products are often positioned as higher quality or more responsible choices, allowing retailers to justify a slightly higher price point compared to non-certified alternatives of the same species and size.

From the supplier perspective, certification can improve price stability. Retailers seeking to maintain certified supply may enter into longer-term contracts or agree to fixed pricing arrangements with certified exporters, insulating producers from some of the volatility associated with the spot market. In this sense, certification not only enhances access to key markets but also contributes to more predictable revenue streams.

### Branding and Retail Strategy

For European retailers, offering certified seafood - particularly ASC or MSC-labeled shrimp - has become central to corporate sustainability strategies and brand positioning. Many supermarket groups now promote their seafood assortments with claims such as "100% responsibly sourced," a message that relies on verifiable third-party certification. Having access to certified shrimp enables retailers to meet these public commitments and build consumer trust.

This marketing imperative extends to product packaging, in-store signage, and digital promotions, where sustainability credentials often serve as differentiators in a crowded market. Certification thus supports not only ethical procurement but also commercial value creation through brand alignment with environmental and social responsibility.

## Strategic Opportunities for EU Producers

In this environment, a European-based shrimp producer - particularly one using land-based or recirculating aquaculture systems (RAS) - has an opportunity to differentiate through sustainability credentials. Although production costs for such operations are typically higher than for tropical producers, local RAS farms may benefit from positioning their shrimp as fresh, traceable, and environmentally low-impact. If the facility meets the requirements for ASC, organic, or other certifications (including emerging eco-labels such as carbon footprint or locality-based tags), the product could access premium price segments.

Moreover, the ability to deliver certified, locally produced shrimp aligns closely with evolving consumer priorities in Europe, including support for regional food systems, reduced environmental impact, and assurance of food safety and traceability. This strategic positioning may enable European producers to compete not on volume or price, but on quality, transparency, and sustainability - factors that increasingly influence purchase decisions across the EU market.

### 4.3.8 Shrimp Distribution Channels in the EU: Strategic Implications for Market Entry

The European shrimp market is structured around three principal distribution channels: retail, foodservice, and the processing/industrial segment. Understanding the dynamics, strengths, and limitations of each channel is essential for evaluating market entry opportunities, particularly for premium or locally produced shrimp such as those from European RAS farms.

#### Retail Sector

Retail represents a cornerstone of shrimp consumption across Europe, accounting for a significant share - estimated at up to 50% in many countries. The retail channel includes supermarkets, hypermarkets, discounters, open-air markets, and independent fishmongers. Within this channel, both frozen and chilled shrimp are widely available, with formats ranging from whole shell-on to peeled, cooked, and value-added options.

Retail shrimp sales experienced a sharp increase during the 2020 - 2021 pandemic period, as home cooking surged under lockdowns. Many households opted for shrimp as an affordable indulgence during that time. However, retail volumes declined in 2022 and 2023, driven by seafood inflation, reduced household spending power, and a rebound in foodservice dining. Countries such as Spain and Italy recorded double-digit reductions in at-home seafood consumption during this period.

Despite this volatility, retail remains a key access point for shrimp in Europe. There has been a notable shift toward convenience-oriented offerings, such as ready-to-eat or quick-cook packs. Private label (store-brand) products dominate freezer aisles, especially for peeled and frozen shrimp. These private labels typically impose strict product specifications, often requiring third-party certifications such as ASC or MSC. For any new supplier entering the European market - especially one aiming to supply retail under its own brand or as part of a store's private label program - meeting these requirements is essential. Alternatively, a local

producer could pursue a differentiated approach by offering live or ultra-fresh shrimp with qualities that imported frozen products cannot match.

### Foodservice Sector

The foodservice channel, encompassing restaurants, catering, hotels, and institutional buyers, plays a crucial role in European shrimp consumption. Prior to the COVID-19 pandemic, foodservice accounted for a substantial portion of demand - particularly in Southern Europe, where shrimp is a common feature in restaurant cuisine. During the 2020 - 2021 period, this segment contracted sharply due to lockdowns and travel restrictions, but it rebounded in 2022 as restaurants reopened and tourism resumed.

By 2023, however, high inflation began to affect dining habits. While volumes recovered from pandemic lows, some consumers reduced the frequency of dining out or opted for lower-cost menu items, impacting seafood orders. Nevertheless, foodservice continues to represent an estimated 30 - 50% of shrimp consumption in Western Europe. In countries like Spain, the proportion may be close to half; in Germany or the Netherlands, it is likely closer to one-third, reflecting differences in food culture and restaurant usage.

This channel is highly segmented. High-end restaurants often prefer specialty wild-caught shrimp - such as Mediterranean red prawns or North Sea brown shrimp - valued for their flavour, provenance, and differentiation. These establishments typically avoid imported frozen shrimp, instead opting for traceable, fresh, or even live local seafood. In contrast, casual dining outlets, buffets, and chain restaurants tend to rely on consistent, cost-effective supplies of frozen farmed shrimp, especially vannamei.

For local producers, the foodservice sector may offer a valuable opportunity to bypass the frozen import supply chain and deliver ultra-fresh, high-quality shrimp directly to chefs. Many upscale or boutique restaurants are willing to pay a premium for live or freshly harvested shrimp with traceable, local origins. This positioning could be ideal for land-based European shrimp farms producing limited volumes but aiming for high-margin sales.

### Processing and Industrial Sector

The third major channel comprises seafood processors and industrial users, many of whom purchase shrimp in bulk for value-added production. This includes peeling, cooking, breading, marinating, or incorporating shrimp into ready meals and chilled seafood products. These operations are particularly active in countries like Spain (which specializes in cooked shrimp production), the Netherlands (a reprocessing and redistribution hub), France (known for sauced seafood dishes), and Poland (which has significant seafood manufacturing capacity).

Processors typically prioritize low input costs and require high-volume, uniform, and dependable shrimp supply - factors that make imported frozen vannamei the dominant raw material. Due to tight margins in this sector, local farmed shrimp is rarely cost-competitive unless it forms part of a premium or differentiated product line, such as a "fresh, never frozen" ready meal or a regionally branded chilled seafood offering. Local shrimp farms might consider partnerships with artisanal or regional processors to develop unique product formats that justify premium pricing.

In terms of industrial non-food uses - such as the extraction of chitosan from shrimp shells or the inclusion of shrimp byproducts in pet food - volumes are minor and limited to byproducts or processing waste, with minimal market impact.

### Shifting Channel Dynamics and Strategic Considerations

The interplay between retail, foodservice, and processing has evolved in response to macroeconomic and geopolitical changes. During the pandemic, as foodservice demand collapsed, retail absorbed additional volumes, leading to supermarkets offering larger shrimp sizes and expanded product ranges. Post-pandemic, demand has rebalanced, but both retail and foodservice remain sensitive to inflation and shifting consumer preferences.

Estimates of the split between these channels vary by country and product form, but experts often suggest an approximate 50/50 balance between retail and foodservice across the EU. In Southern Europe, foodservice dominates due to restaurant-centric food culture and tourism, whereas in Northern Europe, retail tends to play a larger role. Processing serves both primary channels and is best viewed as a midstream segment rather than a final point of consumption.

For a prospective EU-based shrimp producer - especially a land-based RAS farm - each channel presents different challenges and opportunities. Retail offers volume but demands strict specifications and certifications. Foodservice allows for direct-to-customer relationships, particularly at the premium end. Processing is suitable only if the producer can supply at scale or develop a differentiated, value-added product.

### The Rise of Shorter Supply Chains

A notable recent trend is the growing interest in shorter, more resilient supply chains. The disruptions of 2020 - 2021, combined with more recent geopolitical shocks (e.g., trade disputes, fuel price volatility), have led some European buyers to seek local or regional suppliers as a hedge against future risks. This creates a modest opening for local shrimp production, particularly when combined with attributes such as antibiotic-free farming, ultra-fresh delivery, and verifiable sustainability.

Some small-scale RAS shrimp farms in the Netherlands and Germany have already begun to exploit this niche, marketing their product as locally produced, free from harmful additives, and delivered fresh within hours of harvest. These producers often work directly with restaurants or niche seafood wholesalers specializing in live or chilled distribution.

### Conclusion

The EU shrimp market is complex and diversified, with each distribution channel presenting unique entry conditions and strategic potential. Retail and foodservice jointly account for the majority of consumption, while the processing sector plays a critical role in shaping product availability and form. For a high-cost but high-quality local producer, success will likely hinge on identifying niche channels - such as premium retail or fine dining - that value freshness, traceability, and sustainability over price. As European consumers and buyers increasingly

demand responsible sourcing, short supply chains, and eco-certified seafood, land-based shrimp production within the EU is well positioned to meet these evolving expectations.

**Sources:**

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#### 4.3.9 Premium Shrimp Segment in EU

The premium shrimp segment in the European Union refers to products that command significantly higher prices than conventional imported farmed shrimp. This pricing premium is driven by a combination of factors, including superior freshness, sustainable production, local origin, and specialty certifications. While still representing a small share of the overall market, this segment is evolving quickly, particularly in response to consumer demand for traceable, ethical, and high-quality seafood. Among the most notable developments is the emergence of land-based Recirculating Aquaculture Systems (RAS), which produce shrimp locally in controlled indoor environments.

##### [Locally Farmed Indoor Shrimp: Characteristics of the RAS Premium Segment](#)

One of the clearest examples of premium differentiation in the EU shrimp market is the rise of indoor RAS farms producing *Litopenaeus vannamei*, or Pacific whiteleg shrimp. These facilities operate near urban markets in countries such as Switzerland, Germany, the Netherlands, and Denmark. Because of their high capital and operating costs, RAS farms cannot compete with imported frozen shrimp on price. Instead, they position their product as a gourmet item, offering added value in several key areas.

##### [Exceptional Freshness and Short Supply Chains](#)

RAS systems enable shrimp to be harvested and delivered within hours, without freezing. This provides a level of freshness rarely achievable through traditional global supply chains. Unlike most imported shrimp - which are typically frozen immediately after harvest and may be stored for weeks or months - RAS shrimp can reach consumers or chefs within 24 hours of harvest. For example, Swiss-based SwissShrimp AG delivers chilled, never-frozen shrimp directly to select retail outlets and individual customers via express logistics, maintaining full cold-chain integrity. This emphasis on freshness is a central feature of the premium proposition and aligns well with high-end retail and foodservice expectations.

##### [Local, Sustainable, and Antibiotic-Free Production](#)

Sustainability is another core attribute of the premium RAS shrimp segment. Indoor farms operate in biosecure, closed-loop systems that eliminate the risk of disease escape or environmental contamination. Many producers emphasize that their shrimp are raised without antibiotics, do not contribute to deforestation or mangrove loss, and use less water and land than conventional aquaculture. Some operations even incorporate renewable energy or waste heat to reduce carbon footprint. These environmental credentials support both regulatory compliance and consumer expectations in markets such as Germany, Switzerland, and Scandinavia, where sustainability concerns are central to purchasing decisions.

Moreover, the local origin of these shrimp offers additional traceability and supply security. In a post-pandemic and geopolitically uncertain landscape, the ability to offer EU-produced shrimp - with transparent sourcing, reduced transport distances, and minimal food miles - adds credibility and market appeal, especially in premium and organic food channels.

## Premium Pricing and Market Positioning

The economics of indoor shrimp farming require a premium pricing strategy. RAS-produced shrimp typically retail at prices well above those of imported farmed shrimp. In some European markets, these products are sold at €50 - 90 per kilogram, reflecting the high costs of production (notably energy, feed, and labour). In exceptional cases, pricing can exceed even these levels: SwissShrimp, for instance, has marketed 480 g packages for CHF 99 (approximately €190 per kilogram), positioning the product as a luxury item in Switzerland's gourmet food sector.

By contrast, standard warmwater farmed shrimp - typically imported frozen from Asia or Latin America - sell in supermarkets for €12 - 25 per kilogram depending on product form, size, and origin. This substantial price gap underscores the niche nature of the RAS segment: these products are not intended to replace commodity imports but to cater to a different clientele entirely - those willing to pay for freshness, sustainability, and provenance.

## Conclusion

The premium shrimp market in Europe remains a small but growing segment, with clear potential for expansion through differentiated products. Indoor RAS farms represent one of the most promising innovations in this space, offering locally produced, environmentally responsible shrimp with unmatched freshness. While these products are far too expensive for mass-market retail, they align well with premium distribution channels such as gourmet supermarkets, specialty seafood retailers, and high-end restaurants. As consumer demand for traceable and sustainable seafood continues to rise, the premium shrimp segment could serve as a profitable niche - particularly for European producers who can leverage proximity, quality, and values-based branding.

The European market for locally farmed, premium shrimp remains a niche segment, yet it is gradually gaining traction - particularly among high-end culinary buyers. Many chefs and gourmet restaurants are drawn to these shrimp not only for their exceptional freshness but also for the sustainable and regional production story behind them. In Germany, for instance, shrimp from indoor farms in Bavaria - now operating under the Oceanloop (formerly Crusta Nova) brand - have featured on the menus of upscale dining establishments and have also been sold directly to consumers as a specialty product. Similarly, SwissShrimp has positioned its offering within the Swiss market as a luxury item, delivered fresh and never frozen, appealing to consumers willing to pay a premium for traceability and quality.

Despite these successes, scaling up remains a key challenge. Widespread retail adoption has been slow, largely due to high production costs that result in prices well above standard imported shrimp. A comparable example from the United States highlights the difficulty: CP Foods launched an indoor shrimp operation in Florida with the aim of marketing directly to consumers. However, the venture struggled to sell its harvest at the necessary premium to compete with lower-priced imports, leading the company to reconsider its retail strategy and shift toward alternative sales channels. Learning from such outcomes, European land-based

farms have focused more narrowly on premium outlets - such as gastronomy, specialty retailers, and environmentally conscious consumers - where price sensitivity is lower, and product differentiation is more valued.

Several European RAS shrimp farms have emerged over the past decade, including Oceanloop's facilities in Munich and Kiel, SwissShrimp in Switzerland, Alpine Shrimp in Austria, Lisaqua in France, and others across the Netherlands and Belgium. While these ventures are still small in scale - typically producing tens to a few hundred tonnes annually - they collectively aim to expand, with Oceanloop targeting around 2,000 tonnes per year by 2027. These farms commonly market their products under themes such as "Made in Europe," antibiotic-free, and environmentally friendly, using their proximity to market and enhanced freshness as selling points.

From an investment standpoint, the long-term viability of RAS shrimp hinges on achieving greater economies of scale. Industry analysts suggest that for land-based shrimp to move beyond the luxury tier, production costs may eventually need to drop to around €25–30 per kilogram. Until such cost-efficiencies are reached, however, premium positioning remains essential - not only to justify pricing but also to build strong brand identities and secure loyal market segments. For now, freshness, sustainability, and regional provenance are the core pillars that enable these European farms to compete in a marketplace otherwise dominated by low-cost imports.

### Consumer Perspective

Consumers attracted to locally farmed shrimp from European Recirculating Aquaculture Systems (RAS) are typically affluent, environmentally aware, and health-conscious. This group places high value on food provenance, ethical production practices, and chemical-free aquaculture. Notably, the COVID-19 pandemic reinforced many of these preferences: heightened public awareness of food safety, logistics, and traceability encouraged greater interest in locally sourced, minimally handled food products [eurofish.dk]. For this niche, paying a premium for fresh, locally raised shrimp is considered worthwhile - both for the perceived quality and the reassurance of transparent production.

Nevertheless, this segment remains limited in size relative to the broader shrimp-consuming population, as price sensitivity continues to restrict wider adoption. Studies indicate that higher-income consumers are more likely to prioritize factors such as animal welfare, organic standards, and local sourcing in their seafood purchases [CBI.eu]. These priorities align well with the core selling points of RAS-farmed shrimp, which are typically free from antibiotics, produced without habitat destruction, and marketed with strong traceability credentials. This suggests that a modest but growing market exists within Europe's upper-middle-class consumers, sustainability-oriented shoppers, and culinary enthusiasts - individuals willing to pay for a more ethical and high-quality seafood product.

### B2B Perspective

From a business-to-business standpoint, chefs, restaurants, and specialty retailers are key stakeholders in the premium shrimp ecosystem. High-end restaurants in particular value

differentiation, and locally farmed shrimp offer a compelling menu highlight in a market dominated by frozen imports. Indeed, many fine-dining establishments across Europe already favour wild-caught regional crustaceans when in season, and land-based farmed shrimp provide a year-round alternative that satisfies similar expectations for freshness and sustainability.

Some producers have successfully targeted this channel from the outset. For example, Germany's Crusta Nova (now part of Honest Catch) initially built its brand reputation by supplying live and ultra-fresh shrimp to Michelin-star chefs. Only later did it expand to direct-to-consumer and online retail sales. Likewise, SwissShrimp has carved out a space in the Swiss market, supplying fresh shrimp to top-tier retailers like Coop and Migros, who carry the product as a premium offering in select stores [metrohm.com]. However, retail participation remains cautious - supermarkets typically only stock quantities that are pre-ordered and priced high enough to justify the limited supply.

In B2B markets, reliability and uniqueness are essential. Buyers are willing to pay more for products that are consistently available and offer a clear value proposition. This has led to strategic collaborations – for instance, partnerships between RAS startups and technology providers, or exclusive distribution agreements with seafood wholesalers. While current uptake is concentrated in gourmet restaurants and specialist outlets, there is potential for broader B2B expansion. For this to occur, however, production volumes must increase and costs must decrease, making premium shrimp more accessible to a wider range of foodservice operators.

### Certified Organic and Specialty Import Shrimp in Europe

An important component of the premium shrimp segment in Europe is high-quality imported shrimp that carry organic or specialty certifications. Although these products are not locally farmed, they differentiate themselves from mass-market imports by meeting more stringent environmental, ethical, and quality standards. These include organic farming practices, reduced stocking densities, ethical labour frameworks, and support for small-scale or artisanal producers.

#### Organic Shrimp

Organic-certified shrimp represent a niche but growing category within Europe's seafood market. Under EU Organic regulations and other private certification schemes such as Germany's Naturland, producers must adhere to strict criteria including the use of organic feed, the exclusion of antibiotics and synthetic chemicals, and environmentally sensitive farming practices. Major exporters of organic shrimp include Ecuador (known for organic whiteleg shrimp) and Asian countries such as Vietnam, India, Bangladesh, and Madagascar, which produce organic black tiger shrimp under various certification labels.

Although volumes remain small, the value of the market is significant. In 2019, for example, the EU imported approximately 7,000 tonnes of organic fish and seafood, a meaningful portion of which was shrimp. Organic shrimp producers typically benefit from substantial price premiums - global studies suggest organic aquaculture products often sell for 20 - 30%

more than conventional equivalents. In the European retail market, organic shrimp can cost about 33% more than comparable non-organic products, reflecting both production costs and consumer willingness to pay for certified sustainability.

### Certifications and Trust Labels

In addition to the EU Organic label, several other certifications enhance the perceived value of premium shrimp. Germany's Naturland, for example, has been instrumental in developing organic aquaculture standards and has documented price premiums of around 20% for certified shrimp. Some producers also pursue ethical certifications such as Fair Trade, which appeals to consumers interested in social responsibility and small-scale farming - although Fair Trade shrimp is currently more established in the U.S. market than in Europe.

The Aquaculture Stewardship Council (ASC) remains a key certification for farmed shrimp across Europe. However, ASC certification is increasingly considered a baseline requirement for entry into mainstream retail chains, rather than a premium differentiator. Most large supermarkets in Northern and Western Europe now require ASC compliance for farmed shrimp in their private label programs. For a product to stand out in the premium tier, additional attributes such as organic status or artisanal production are often necessary.

### Premium Wild-Caught and Artisanal Shrimp

Beyond certified farmed products, the premium shrimp category in Europe also includes select wild-caught shrimp. Examples include Argentine red shrimp (*Pleoticus muelleri*), which is popular in Southern European markets for its size, flavor, and vibrant red color - traits that enhance its retail appeal. French and Spanish buyers often pay up to 20% more for shrimp with specific coloration and freshness characteristics.

Mediterranean wild prawns such as Carabineros or deep-water rose shrimp are also prized by gourmet chefs and sold at premium prices, typically in head-on form to preserve flavor. Though not organic (due to wild harvest origin), these shrimp sometimes carry MSC (Marine Stewardship Council) certification, which signals sustainable fishery practices to eco-conscious consumers. Label Rouge, France's national quality label, is also used to identify exceptionally high-quality shrimp.

One standout example is Madagascar-based Unima Group, which produces organically certified, Label Rouge-accredited giant tiger prawns. Farmed in mangrove-integrated systems under low-density, antibiotic-free conditions, these shrimp have earned multiple certifications (EU Organic, ASC, Label Rouge) and are positioned as a luxury product for HORECA and premium retail sectors. In 2023, Unima's shrimp won the Seafood Excellence Global award for Best HORECA Product, praised for its superior texture and delicately iodised flavor.

### Pricing and Market Access

Retailers and importers treat certified specialty shrimp as high-value items with unique branding potential. Given the limited and sometimes irregular supply from small-scale or organic farms, sourcing typically focuses on a few consistent, reliable exporters. For instance,

Swiss retailer Coop reportedly pays up to 15% above market price to secure processed organic shrimp for its premium seafood range. Likewise, Dutch retailer Albert Heijn and upscale stores in Germany and the UK have featured organic shrimp under private or branded labels, catering to discerning consumers.

Such specialty shrimp are often sold in dedicated sections of supermarkets or in gourmet food shops. Although volumes remain small, the high margin per unit makes them an attractive proposition for retailers seeking to differentiate their seafood offering. Retailers are also increasingly using these products to meet corporate sustainability goals and consumer expectations for ethical sourcing.

European consumers who purchase organic or certified premium shrimp typically fall into a higher-income, more educated demographic that values sustainability, health, and food ethics. These consumers often perceive organic shrimp as a safer, cleaner option - free from antibiotics or chemical additives - and are attracted to the environmental standards such products represent. Surveys across the region indicate that a meaningful share of the population sees organic food as integral to a healthy and responsible lifestyle. Still, this remains a niche market, as higher prices limit accessibility for mainstream consumers. Among those who do purchase organic or certified shrimp, the decision is usually part of a broader pattern of conscious consumption, where eco-labels and trustmarks strongly influence purchase behavior. When offered a choice between certified and conventional shrimp, many European shoppers show a clear preference for the certified option, provided the price premium remains within a moderate range. A 20 - 30% markup is often acceptable in retail, whereas extreme premiums - such as those seen in locally farmed RAS shrimp - are typically limited to a much smaller, high-end market.

On the business-to-business side, importers and retailers play a pivotal role in managing and distributing certified premium shrimp. Specialized importers often handle organic and fair-trade products, while larger mainstream players may carry limited volumes to fulfill sustainability commitments or serve premium retail segments. Supermarkets across Northern Europe increasingly view organic and certified seafood as essential to their responsible sourcing strategies, using these products to differentiate themselves and appeal to a niche but growing group of discerning consumers. However, retailers also require reliability and consistency, meaning only those certified producers who can ensure stable year-round supply tend to secure shelf space.

In the foodservice sector, certified and artisanal shrimp products also attract interest, particularly among high-end restaurants and gourmet catering services. These buyers prioritize uniqueness and quality, making wild Argentine red shrimp or organic black tiger prawns from Madagascar suitable for premium menu offerings. Chefs value not just the taste and presentation of these shrimp, but the narrative behind them - whether that's a sustainably managed fishery, a community-based farm, or exceptional production standards. These products often reach the end-user through specialty distributors that connect artisanal producers to select restaurants or luxury hotels. The scale of this segment is modest, but the

willingness to pay is significantly higher when the product is distinct and consistently delivered.

From a broader market perspective, the evolving values of European consumers are increasingly aligned with the qualities offered by premium shrimp. Environmental concerns - ranging from habitat destruction and carbon emissions to labor conditions in global supply chains - are shaping seafood choices. Premium shrimp, whether locally farmed in Europe or certified organic from abroad, directly address these anxieties by offering traceable, ethically produced alternatives. This connection is particularly strong among younger and environmentally conscious consumers, who now associate sustainable seafood with broader values like climate responsibility, biodiversity preservation, and health-conscious living.

Shrimp is also viewed as a luxury item by many European households, consumed less frequently than other proteins. When it is purchased, consumers often seek high quality and are willing to pay for attributes like freshness, taste, and food safety. Premium shrimp positions itself as the superior option - emphasizing cleaner farming practices, better taste profiles, and the absence of contaminants. In a post-pandemic context, growing health awareness has only reinforced consumer openness to paying more for products that offer peace of mind in terms of production practices and ingredient safety.

Willingness to pay remains a defining constraint. While eco-labeled shrimp can command a premium of 20–30% over conventional products in retail, products priced several times higher - such as RAS-farmed local shrimp - are only viable within a small, high-end consumer segment. Affluent consumers, food enthusiasts, and sustainability-driven shoppers may support these products, but they are unlikely to displace mainstream imports in volume terms. Instead, premium shrimp will likely remain a parallel category - much like organic food does in the broader grocery market - offering an alternative for those who can and wish to pay for it.

Finally, awareness and education play a central role in expanding this segment. Many consumers remain unaware of the availability of local or organic shrimp due to limited distribution and low visibility. As premium products become more common in upscale supermarkets or feature in local media stories, awareness is growing. Companies behind these products are actively investing in marketing to educate consumers on their benefits, from improved taste to reduced environmental impact. The success of these efforts often hinges on effective storytelling - whether about the local farmer, the eco-friendly production system, or the superior quality of the shrimp. These narratives help shape consumer perceptions and justify the price premium, reinforcing the position of certified and artisanal shrimp as the future-facing, values-driven tier of the European shrimp market.

## B2B Market Dynamics and Outlook

The business-to-business (B2B) landscape for premium shrimp in Europe is undergoing transformation, shaped by changing supply chain models, evolving retailer strategies, and the selective uptake by the foodservice industry. While still a niche segment, premium shrimp has prompted a rethinking of traditional sourcing and distribution approaches, particularly as

sustainability, freshness, and product differentiation become more critical in seafood procurement.

One of the defining features of premium shrimp distribution is the shift towards integrated and adaptive supply chains. Unlike conventional frozen shrimp imports, premium products often require short lead times, chilled or live delivery, and tailored handling. This has led to the emergence of innovative logistics solutions - including direct-to-restaurant delivery by land-based shrimp farms and regional partnerships between producers and specialty distributors. Many of these farms operate outside the conventional seafood wholesale system, which is optimized for frozen, bulk-volume trade. As a result, new distribution frameworks are being developed, and investment activity has started to support this evolution. Some established seafood companies have also entered the premium segment by launching certified, value-added shrimp lines in collaboration with producers and feed suppliers, aligning their portfolios with growing demand for sustainable, high-quality offerings.

Supermarkets across Europe are refining their seafood strategies by segmenting products into value and premium tiers. Premium shrimp is positioned within the latter category, often packaged in smaller units, with distinctive labeling and branding that emphasizes local origin, organic status, or artisanal production. These products appeal to environmentally conscious and quality-driven consumers, and help retailers bolster their sustainability credentials. However, for producers, gaining retail access comes with challenges. Supermarkets expect consistent year-round supply and cost-effective pricing. Domestic RAS shrimp farms, often operating at small scale, struggle to meet this expectation, which is why many remain focused on regional markets or pilot phases. In contrast, organic imports from countries with larger production capacities, such as Ecuador or Vietnam, are often preferred by retailers who prioritize reliability and logistics efficiency.

In the foodservice sector, premium shrimp has found a receptive audience among high-end restaurants and gourmet chefs. These buyers value the story, origin, and sensory appeal of specialty products, and are often willing to pay a premium for unique ingredients that enhance the dining experience. Organic or artisanal shrimp products have featured on fine dining menus, supported by specialty seafood suppliers who bridge the gap between producers and the restaurant market. This model enables small-volume, high-margin sales, with producers delivering fresh or chilled shrimp to chefs who seek differentiation through exceptional quality. As more RAS farms emerge across Europe, there is potential for a decentralized supply network serving regional restaurant markets with locally grown shrimp, in a model that mirrors farm-to-table agriculture.

Despite growing interest, premium shrimp producers face significant barriers in scaling B2B operations. Price remains a critical constraint. Restaurants operate under tight margins and are sensitive to cost variations, particularly when conventional alternatives - such as wild-caught Argentine shrimp - are available at much lower prices. Retailers, too, are cautious about allocating shelf space to slow-moving, high-priced items, especially when moderately priced certified shrimp from overseas can satisfy consumer demand for sustainability.

Certification requirements add another layer of complexity, as B2B buyers increasingly demand traceability and verification of production practices. This necessitates investment in documentation and compliance, increasing operational costs for producers.

Furthermore, as the quality of mainstream shrimp continues to improve, the bar for differentiation is rising. Retailers now offer ASC-certified frozen shrimp at relatively accessible prices, making it harder for ultra-premium products to justify a significantly higher price point. To succeed in this environment, premium shrimp must deliver clearly superior attributes - such as being never frozen, regionally distinctive, or organoleptically exceptional - and these qualities must be effectively communicated to buyers. For producers, maintaining supply reliability and forging close, trust-based relationships with distributors and end clients will be essential to long-term success in the B2B space.

In summary, while the B2B market offers meaningful opportunities for premium shrimp, particularly in foodservice and specialty retail, it also presents structural challenges. Producers must navigate high expectations around consistency, documentation, and pricing, while investing in supply chain innovations that align with their product's unique characteristics. As the market matures, those who can balance quality with reliability and effectively position their product within targeted channels are most likely to secure a foothold in Europe's evolving seafood landscape.

Looking ahead, the premium shrimp segment in Europe is poised for gradual but meaningful growth, driven by evolving consumer preferences, rising sustainability expectations, and continued innovation in aquaculture. While it is unlikely to surpass the conventional shrimp market in volume - Europe will continue importing hundreds of thousands of tonnes of affordable warmwater shrimp - it holds the potential to capture a disproportionate share of value within the high-end seafood segment.

Overall shrimp demand in Europe is projected to increase steadily, with commodity products like vannamei remaining dominant in volume terms. However, as consumer segmentation becomes more pronounced, niche markets for high-quality, sustainable, and differentiated shrimp are expected to expand. This includes both domestically produced shrimp from indoor Recirculating Aquaculture Systems (RAS) and high-standard imports, such as organic-certified or artisanal wild-caught shrimp. These products cater to a growing subset of consumers who prioritize ethical sourcing, local production, and traceability in their food choices.

The segment may also evolve through hybrid supply models. Some European companies are already investing in premium shrimp production abroad - supporting high-standard farms in Latin America, Africa, or Asia - to ensure steady access to certified and traceable shrimp while maintaining competitive pricing. Simultaneously, advances in processing and freezing technologies are improving the quality of imported products, allowing select shrimp to retain more of the "fresh" attributes typically associated with domestic or premium supply.

On the production side, RAS technology continues to mature. As farms scale and operational efficiency improves, production costs are expected to decline. If local farms can achieve cost reductions while maintaining quality and sustainability credentials, the price gap between

domestic premium shrimp and imported conventional shrimp may begin to narrow. This could make locally farmed shrimp more accessible to a broader consumer base, expanding the segment beyond its current niche.

However, increased competition may put downward pressure on premium prices over time. As more players enter the market - whether in Europe or abroad - pricing power may diminish, and differentiation will become even more critical. Producers that can build strong brand identities and communicate compelling value propositions - such as "Bavarian shrimp," "organic mangrove-farmed shrimp," or "low-carbon local seafood" - will be better positioned to maintain margins and secure long-term buyer relationships.

In conclusion, Europe's premium shrimp segment, encompassing local RAS production, certified organic imports, and specialty wild-caught products, represents a dynamic and innovative corner of the seafood market. Although still small in absolute terms, it reflects broader shifts in consumer values toward sustainability, health, and transparency. On the B2B side, success will depend on the ability to establish reliable, cost-effective supply chains and partnerships that deliver high-quality, differentiated products to restaurants, retailers, and discerning consumers. As aquaculture technologies evolve and sustainability continues to shape purchasing decisions, this segment is expected to play an increasingly influential role in setting higher standards across the European shrimp value chain.

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## 4.4 Target Market & Customer Segments

### 4.4.1 TAM, SAM, SOM – EU Vannamei Shrimp

#### Approach and Definitions

For the RAS vannamei project, the market is quantified in three nested layers:

- TAM - Total Addressable Market
  - All European demand for vannamei shrimp, across all countries, channels, and price tiers.
- SAM - Serviceable Available Market
  - The premium vannamei segment that is relevant to Akola's proposition: mainly North-West European markets and premium channels where EU-grown, sustainable, high-quality shrimp can compete.
- SOM - Serviceable Obtainable Market
  - The portion of the SAM that Akola can realistically capture, given its capacity ramp (100 → 1,300 t/y) and an adoption period of 3–4 years.

All numbers are rounded and should be treated as order-of-magnitude planning assumptions, not precise forecasts.

#### TAM – EU Vannamei Shrimp

According to EUMOFA / Kontali data (see table xxx), total EU shrimp import in 2024 was approximately:

- 852,000 tonnes (all species, all forms, all channels)

Vannamei is by far the dominant farmed shrimp species in Europe. Based on data, following assumption is made:

- Vannamei share of total shrimp volume ≈ 90%

This yields an estimated EU vannamei volume of:

- $852,000 \text{ t} \times 90\% \approx 766,800 \text{ tonnes/year}$

Using the indicative wholesale import price ≈ 9 €/kg:

- $766,800,000 \text{ kg} \times 9 \text{ €/kg} \approx 6.9 \text{ billion €/year}$  (wholesale value)

TAM (EU vannamei, wholesale) ≈ 767,000 t / 6.9 bn € per year

This TAM represents all vannamei shrimp in the EU – including low-priced frozen commodity imports, private label products, foodservice bulk, as well as higher-priced branded and certified products.

#### SAM – Premium Vannamei in Target Region and Channels

Real addressable market is smaller than the TAM, limited by geography, channel fit, and quality tier.

#### Geography – Target Region

Primary target cluster is North-Western Europe, where premium seafood consumption and willingness to pay are relatively high:

- Germany (DE) – 55,000 t vannamei
- France (FR) – 105,000 t
- Belgium (BE) – 65,000 t
- Netherlands (NL) – 86,000 t
- United Kingdom (UK) – 70,000 t
- Scandinavia (DK + SE + NO + FI etc.) – 15,600 t

Total - 55k + 105k + 65k + 86k + 70k + 15.6k  $\approx$  396,600 tonnes/year. So this core region accounts for roughly:

- 396,600 t / 766,800 t  $\approx$  52% of EU vannamei volume

About half of all EU vannamei consumption is concentrated in the markets with initial focus on. This justifies using this region as the main geographical focus for the SAM.

#### Premium segment – Europe-wide volume

According to Kontali data, the total premium European split for common shrimp (vannamei) is around:

- 35,000 tonnes/year

This 35,000 t already reflects a premium filter (product/price tier), cutting out most low-priced commodity volume.

To get regional SAM, the assumption is made that premium demand is at least as concentrated in North-Western Europe as total vannamei demand:

- Regional share of total vannamei  $\approx$  52%
- Applying this share to the premium segment gives:
  - SAM min (volume)  $\approx$  35,000 t  $\times$  50%  $\approx$  17,500 t/year
  - SAM base (volume)  $\approx$  35,000 t  $\times$  60%  $\approx$  21,000 t/year
  - SAM max (volume) = 35,000 t/year (if all Europe is targeted)

For this business plan  $\approx$  20,000 t/year is used as a rounded base-case SAM volume for the premium vannamei segment in Akola's initial geography.

#### Price level in premium tier

We indicate that premium commodity vannamei in Europe trades at 18–30 €/kg. Using 25 €/kg as a base:

- SAM\_base (value)  $\approx$  20,000 t  $\times$  1,000 kg/t  $\times$  25 €/kg  
 $\approx$  20,000,000 kg  $\times$  25 €/kg  
 $\approx$  500 million €/year

Corresponding range:

- SAM min (value) - 17,500 t at ~20 €/kg ≈ 350 million €/year
- SAM max (value) - 35,000 t at ~30 €/kg ≈ 1.050 billion €/year

SAM (premium vannamei in the target region) ≈ 18–21k t / 0.44–0.60 bn € per year (base case: ~20k t / 0.6 bn €)

This is the premium pie within which the Project could be positioned its EU-grown, RAS-farmed shrimp.

#### [SOM – What Akola Can Realistically Capture](#)

SOM is limited by capacity ramp-up and market adoption over 3–4 years.

Capacity and ramp-up:

- According to expansion plan (production, not just installed capacity) is:
  - Year 0: 0 t/y
  - Year 1: 50 t/y
  - Year 2: 260 t/y
  - Year 3: 1000 t/y
  - Year 4+: 1300 t/y

Compared to the SAM\_base of ~20,000 t, this means:

- At maturity with continuous production of 1300 t/y ≈ 6.5% of SAM

Even at 1,300 t/year, the total output would serve only around 6.5% of the premium vannamei segment in its target region, and just ~0.16% of the total EU vannamei TAM (1,300 / 766,800 t). This underlines that the project does not depend on heroic market share assumptions; it is about carving out a relatively small, defensible premium niche.

*Table 1. Summary – TAM, SAM, SOM (Base Case)*

Layer	Definition	Volume (t/year)	Value (€/year, approx.)	Share
TAM	All EU vannamei shrimp (all channels, tiers)	~766,800 t	~6.9 bn € (wholesale @ 9 €/kg)	100%
SAM (Base)	Premium vannamei in Akola's target region (DE, FR, BE, NL, UK, Scandinavia etc.)	~20,000 t	~600 m € (@ 30 €/kg)	~2.6% of TAM by volume
SOM (base, 4 year)	Akola's targeted annual sales at maturity (Phase 3)	1,300 t	~25 m € (@ 19 €/kg; actual realised price may differ)	~6.5% of SAM; ~0.16% of TAM

## 4.5 Berlin Case Study – Consumer Potential for Premium, Locally Grown Shrimp

This case study summarises findings from the KOG (Institute for Marketing and Communication Sciences) 2022 survey of Berlin urban shrimp consumers. The sample covers 350 Berlin residents aged 18–65 who eat shrimp at least once per year, with a particular focus on a clearly identifiable high-potential target group (TG)

- Target group (TG): men aged 31–40, living in Central Berlin, with high income, university degree, working as managers, and frequent shrimp buyers.

The study is designed as a local blueprint for comparable EU cities with similar affluent, central-urban consumer segments (e.g. Munich, Hamburg, Amsterdam, Copenhagen, Stockholm, Paris intramuros).

### Snapshot of the Opportunity

- Who to target
  - The TG above shows the strongest purchase intent and willingness to pay for premium shrimp concepts, especially when products are positioned as fresh, EU-grown and sustainable.
- Where to Sell
  - Shrimp is purchased primarily in supermarkets (59%), which are the baseline channel across all Berlin regions. Fresh markets and specialty stores are also important (each used by ~40% of consumers), especially in Central, West and South Berlin, and over-indexed among high-income consumers and the TG.
- What to sell
  - The broader market leans toward frozen shrimp and peeled/headless forms. However, the TG clearly prefers fresh shrimp and is much more open to shell-on/head-on options than the average consumer. Across the sample, 74% prefer large or at least average-sized shrimp; this preference is strongest among higher-income, 31–40-year-old managers.
- How often they would buy
  - When presented with a sustainably EU-grown premium shrimp concept, around 39% of consumers say they would buy it two to three times per month or more, and this figure rises to roughly 60–70% within the TG. Another ~34% would buy it less often, indicating a substantial potential base for regular repeat purchase.
- How to price
  - Using a Van Westendorp price sensitivity meter, the study finds:
    - “Too cheap”: around €20–25/kg (quality doubts increase).
    - “Optimal” mass shelf price: around €30–35/kg.
    - “Too expensive”: above €50–55/kg.
  - For a premium EU-grown sustainable shrimp concept, 57% of consumers say they would buy even at €65/kg, but purchase intent does not increase much if the price is only slightly lower (e.g. €55–60/kg). A meaningful uplift in purchase intent occurs when the price drops to around €50/kg, equivalent to a 20–25% discount from a €62–65/kg regular shelf price.
- Education gap
  - Consumers show high interest in sustainability but low and inconsistent knowledge:
    - About 60% say they check origin, yet roughly half believe shrimp quality does not depend on origin.
    - 53% say they look for organic shrimp, but 52% believe farmed shrimp are never organic, and 47% say they are against farmed shrimp.

This reveals a major misconception around farming, organic standards and sustainability – and a clear communication opportunity for a RAS-based, EU-grown product.

### Consumption and Purchase Behaviour in Berlin Today

#### Frequency and habits

- Shrimp ranks as the second most popular seafood among respondents.
- Approx. one third of consumers eat shrimp at least once per week.
- Consumption is skewed toward men aged 31–40 with higher income and managerial positions – strongly overlapping with the defined TG.
- Home cooking frequency is similar to overall consumption frequency, suggesting a large part of shrimp consumption happens at home rather than exclusively in restaurants.

#### Channels – where they buy

- Supermarkets: 59% of respondents buy shrimp here – the primary channel across the city.
- Fresh markets: ~40% buy shrimp here; particularly relevant in Central and South Berlin.
- Specialty stores (fish shops, delicatessens): ~40% also; over-represented among higher-income consumers and the TG.
- Online channels:
  - ~32% use online grocery sites.
  - 21% use specialty e-shops.
  - 14% use delivery start-ups / apps
    - These online channels are significantly more common among higher income groups and the TG, highlighting potential for D2C and premium e-commerce offerings.

#### Product type, size, form, packaging

- Fresh vs. frozen
  - The general market leans towards frozen shrimp, largely driven by convenience and price. In contrast, the TG prioritises fresh shrimp, seeing it as higher quality and worth a premium.
- Size
  - Across all respondents, about 74% prefer shrimp that are large or at least above average size, and this preference becomes stronger with higher income and within 31–40-year-old managers.
- Form (shell & head)
  - 54% prefer peeled/headless shrimp.
  - Around 29% prefer shell-on/head-on.
  - However, in the target group, this difference nearly disappears: they show almost equal acceptance of shell-on/head-on and peeled/headless, meaning premium, whole shrimp presentations (HOSO/HLSO) are viable for this segment, especially in fresh counters and premium retail.
- Packaging & quantities
  - 58% prefer packed/ready-to-take products (vs. loose). Even the TG tends to prefer packed over loose, especially in supermarkets.

- The typical take-home weight per purchase is 300–600 g, with larger basket sizes for higher income groups and especially within the 31–40 age bracket.

### Sustainability and Origin – Misconceptions and Opportunity

- The study highlights a strong interest in sustainability but also confusion about farming and origin:
- Around 6 in 10 consumers claim to check country of origin when buying shrimp, yet about half simultaneously believe that shrimp quality does not depend on origin.
- While 53% say they look for organic products, 52% believe that farmed shrimp can never be organic, and 47% say they are against “farmed shrimp” in general. This inconsistency suggests misinformation about seafood farming, organic standards and certifications.
- In terms of perceived quality and sustainability by region:
  - Shrimp from the EU is considered high-quality and sustainable by roughly 70% of respondents.
  - Shrimp from Central America and Southeast Asia is rated high-quality by only about half of respondents, and sustainable by only about 40%.

At the same time, 58% of respondents know that most shrimp consumed in Germany actually comes from Asia or Central America, underlining a mismatch between current supply and where consumers think high-quality, sustainable shrimp should come from.

### Implications

There is clear headroom for a premium, EU-grown shrimp given extensive communication on how this local shrimp are produced:

- Local, EU-grown (not from Asia/Latin America)
- Clean RAS, antibiotic-free, high animal-welfare
- Certifiable as ASC and potentially organic
- Fully traceable

By explicitly addressing myths (e.g. “farmed can be sustainable and even organic,” “RAS ≠ intensive antibiotic use”) it is possible to convert sustainability intentions into justified willingness to pay.

### Tactical Implications for Launch (Berlin and Similar EU Cities)

Taken together, the KOG Berlin findings suggest a clear tactical roadmap for launching and scaling a locally farmed, premium shrimp concept in Berlin and comparable EU cities:

#### 1. Ramp-up years (Years 1–3): price for scarcity & positioning

In the early years, volumes from the new RAS platform will be constrained by staged capacity build-out and biological ramp-up. The KOG study shows that the high-value urban target group is willing to pay a significant premium for EU-grown, sustainable shrimp and that purchase intent remains robust even at elevated shelf prices, as long as the value story (fresh, local, clean, traceable) is credible. This supports a deliberate strategy in Years 1–3 to:

- Focus on fewer, stronger partners (key supermarkets in central Berlin plus flagship specialty/fresh markets).

- Position the product clearly at the top of the shrimp shelf, with higher introductory prices that reflect limited supply and strong differentiation.
- Position the product clearly at the top of the shrimp shelf, with higher introductory prices that reflect limited supply and strong differentiation.

In practical terms, during ramp-up it is consistent with both the KOG data and the business model to maintain higher realised prices than the long-term average, monetising scarcity and helping to absorb initial fixed costs and learning curve effects.

## 2. Full-capacity years: move to a “sweet spot” of 19-20 €/kg (exworks)

As the platform reaches full output (1,000 t/year Germany facility and 1,300 t/year total), the strategic priority shifts from scarcity management to volume reliability and share-of-shelf in the premium segment. At that point, economies of scale, operational learning and optimised logistics should allow the average net realised price (ex-factory / ex-platform) to move towards a sustainable “sweet spot” of roughly 19-20 €/kg for the core fresh product range.

- Assuming typical retailer and distributor margins, this ex-factory band translates into retail shelf prices broadly in line with the KOG-identified “acceptable / optimal” price zone for premium and high-quality shrimp in Berlin.
- This pricing trajectory keeps the product clearly above commodity imports, but within the range of regular purchase for the high-income, urban consumers identified in the study, especially when combined with occasional promotional pulses.

In other words, the KOG willingness-to-pay patterns validate a two-step price path:

- Ramp-up (1–3 years): maintain higher prices supported by strong WTP and limited volumes.
- Steady state: converge towards 19-20 €/kg exworks, delivering competitive COGS and attractive margins while still being acceptable and attractive to the Berlin target group.

## 3. Channel sequencing and mix

The KOG data confirm that supermarkets remain the primary volume channel, with specialty stores and fresh markets acting as discovery and storytelling hubs, and online channels as a convenience layer for high-income buyers. Tactically, this implies:

- Year 1–2: lead with flagship listings in selected central / high-profile supermarkets plus a few specialty/fresh market partners willing to support higher prices and strong in-store communication.
- Year 2–3: broaden supermarket penetration and online availability, still within Berlin/Brandenburg, as supply grows and prices start to move towards the long-term band.
- Year 4+: once the German facility is at or near full capacity, expand distribution to additional German cities with similar demographics and replicate the Berlin playbook.

## 4. Communication focus – from education to reinforcement

During ramp-up, communication should focus on education and myth-busting (origin, farming method, sustainability, animal welfare). As the brand and product become

established and prices move towards the 19-20 €/kg sweet spot, the emphasis can gradually shift to reinforcing trust and consistency (freshness, reliability, “every week” premium staple) rather than just novelty.

Overall, the Berlin case study supports a phased pricing and channel strategy: use higher initial prices during the limited-volume ramp-up to reflect scarcity and recoup early costs, then transition, as capacity and brand recognition grow, to a stable, scalable pricing band of 19-20 €/kg ex-works that aligns with both KOG’s consumer economics and the long-term financial model of the platform.

## 5. Marketing & Sales

### 5.1 Objectives and Strategic Positioning

The marketing and sales strategy is designed to position a large-scale, land-based RAS shrimp platform as a reliable, premium supplier of fresh, EU-grown vannamei shrimp to key European markets. The concept targets a subset of the overall European shrimp market, which reached approximately 878,000 t in 2024 and is forecast to grow to about 1,016,000 t by 2033 (1.6% CAGR). Within this broader market, the focus is on the premium segment (fresh, high-quality, sustainably produced shrimp) in Northern and Central Europe.

The core positioning themes are:

- Fresh, never long-frozen: short, chilled supply chains to urban consumers.
- Local and traceable: EU production, transparent origin and farming methods.
- Sustainable and efficient: RAS-based, with optional geothermal integration for low-carbon heat and mineralisation.
- Antibiotic free

This positioning is aligned with medium-term market trends: steady growth in shrimp demand, rising emphasis on sustainable and responsibly sourced seafood, and a shift towards convenience and value-added forms, including ready-to-cook and ready-to-eat shrimp products.

### 5.2 Target Markets and Customer Segments

The concept primarily targets B2B customers, with the end-consumer focus derived from KOG Berlin study and other consumer insights.

#### Priority B2B customer segments

1. Large food retailers (hypermarkets, supermarkets, discounters)
  - Germany, France, the Netherlands, Belgium and the Nordics together account for a large share of EU processed seafood consumption; the top four EU countries (Germany, Spain, Italy, France) represent ~75% of processed seafood volumes.
  - Retailers are expanding their shrimp selections and increasingly differentiate via freshness, sustainability claims and private labels.
2. Foodservice operators (HoReCa, premium casual chains, caterers)
  - Restaurants and hotel chains seek consistent, high-quality shrimp for menu items, with growing interest in local and sustainable sourcing to support brand positioning.
3. Seafood wholesalers and specialty distributors
  - Act as aggregators into independent retailers, fishmongers and HoReCa, particularly in Germany, Benelux and the Nordics.
4. Online grocery and e-commerce retailers
  - The European online grocery market was valued at USD 66.3 billion in 2024 and is projected to reach USD 440.3 billion by 2033 (23.4% CAGR), driven by convenience and better cold-chain logistics.

- Fresh and frozen seafood are increasingly included in online assortments, creating a complementary channel for high-income, convenience-oriented consumers.

### End-consumer segments (based on KOG Berlin and other EU studies)

Consumer-facing targeting builds on:

- KOG Berlin case study – urban, high-income consumers (initial TG: men 31–40, central Berlin, high income, managers, frequent shrimp buyers) with strong interest in fresh, EU-grown, sustainable shrimp and high willingness to pay.
- Broader European studies showing 7–20% willingness-to-pay premiums for sustainable seafood attributes in several EU countries, depending on the claim and market.
- 2024 MSC / GlobeScan and EU consumer surveys which confirm that freshness, taste and price still dominate purchase decisions, but sustainability and origin are now among the top motivators for a substantial share of consumers.

The platform concept is therefore aligned to serve:

- Primary: Affluent, urban, environmentally aware consumers in Germany and neighbouring markets, willing to pay a premium for fresh, local and sustainable shrimp.
- Secondary: Mainstream retail consumers who will adopt the product once pricing converges towards the 20 €/kg exworks “sweet spot” and brand awareness is established.

## 5.3 Channel Strategy and Route to Market

The route-to-market strategy combines high-volume channels with high-visibility channels for storytelling.

### Retail (core volume channel)

- Retail remains the largest volume outlet for seafood in Europe, but household consumption of fresh seafood declined in 2023–2024 due to inflation, even as overall spending increased and aquaculture products gained share.
- Against this backdrop, a locally farmed, fresh, sustainable shrimp offers retailers:
  - A differentiated premium product that can justify higher price points,
  - A way to support their ESG and “local sourcing” narratives,
  - A candidate for co-branded or private-label premium ranges, given private labels account for ~39% of grocery sales value in Europe and are expected to reach 40–42% by 2030.

### Tactical implication:

Anchor listings in leading retailers in Germany and neighbouring markets, starting with flagships in metropolitan areas (e.g. Berlin, Hamburg, Munich, Amsterdam, Copenhagen) where premium seafood demand and willingness to pay are highest.

### Foodservice and gastronomy

Foodservice channels (restaurants, hotels, high-end catering) are critical for:

- Building reputation and credibility through chef endorsement,
- Demonstrating product quality in prepared dishes,
- Smoothing demand peaks and troughs through menu planning.

The strategy is to partner with a limited number of flagship restaurant groups and hotel chains during ramp-up to showcase the product, then gradually broaden to premium casual and mid-market chains once volumes allow.

### Specialty retail and fresh markets

- Specialty fishmongers and fresh markets play an outsized role in discovery and education, particularly in urban centres such as Berlin, Hamburg and Amsterdam.
- KOG's Berlin data shows strong interest among frequent shrimp buyers in buying at supermarkets, specialty shops and fresh markets, with each channel serving a distinct role in the consumer journey.

Limited but carefully curated presence in high-visibility specialty outlets and fresh markets will support the brand story and provide feedback on product and pricing.

### Online grocery and D2C

- With European online grocery expected to grow at >20% CAGR to 2033, fresh seafood and ready-to-cook shrimp will increasingly be ordered online.
- Online and D2C channels are particularly attractive for:
  - High-income, time-pressed consumers,
  - Subscription-style “seafood boxes”,
  - Story-driven marketing (farm videos, sustainability narratives).

The concept can be integrated into existing online grocery platforms and/or limited direct-to-consumer offerings once cold-chain and packaging formats are optimised.

## 5.4 Pricing Strategy and Revenue Model

The pricing strategy balances:

- The need to monetise scarcity and risk during ramp-up,
- The need to monetise scarcity and risk during ramp-up,
- The reality of a European market where households are price-sensitive, but selected segments still pay a meaningful premium for sustainable, local seafood.

### Ramp-up (Years 1–3) – “positioning and scarcity”

In the early years, volumes from the Klaipėda and Germany facilities are limited. KOG's Berlin study indicates that the high-value target group is willing to pay substantially higher prices for fresh, EU-grown shrimp, with strong purchase intent even at elevated price points, provided the sustainability and origin story is credible.

It is therefore consistent with both:

- The market evidence (KOG and broader WTP studies), and
- The risk profile of a new production platform.

To target higher average realised exworks prices during ramp-up, positioning the product at the top of the shrimp category in participating retailers and foodservice outlets. Promotions in this phase are tactical and focused on trial, not on price competition.

## Steady state (from Year 4) – “sweet spot” of 19-20 €/kg exworks

As the 1,000 t Germany facility and the 300 t Klaipėda hub reach full production:

- Fixed costs per kg decrease,
- Operational performance and yields stabilise, and
- Supply becomes more reliable for key accounts.

At this stage, the concept assumes convergence of the average exworks price for fresh product into a sustainable sweet spot of ~19-20 €/kg (for the core range), which:

- Maintains a clear premium over commodity imports,
- Aligns with KOG’s identified willingness-to-pay zone for regular purchase in Berlin when retail margins are applied,
- Remains compatible with a 7–20% WTP premium for sustainable/local seafood found in multi-country EU studies,
- Supports attractive project and equity returns in the financial model.

Frozen and value-added products (e.g. marinated, ready-to-cook formats) can be priced above this band, while specific large-volume contracts (e.g. for private label) may be negotiated closer to the lower end of the range.

## 5.5 Geographic Roll-Out and Key Account Strategy

The marketing and sales approach follows the platform’s geographic ramp-up:

1. Core launch market – Germany (Berlin region as anchor)
  - Build on insights from the Berlin KOG case study and early partner discussions.
  - Secure anchor listings with 1–2 leading national or regional retailers, complemented by a small number of flagship HoReCa and specialty partners.
2. Northern & Central Europe extension
  - Gradual expansion to neighbouring high-potential markets (Netherlands, Belgium, Denmark, Austria, Swiss metropolitan areas, Nordics) as production in Germany and Klaipėda stabilises.
  - Focus initially on urban centres with similar demographic and psychographic profiles to the Berlin TG (affluent, sustainability-conscious consumers with frequent shrimp consumption).
3. Platform-level key account management
  - Establish a key account management structure capable of handling cross-country agreements with major retail and foodservice groups, aligning contract volumes with the ramp-up of production and ensuring service-level reliability.

## 5.6 Brand, Communication and ESG Positioning

Marketing communication focuses on a small set of clear messages:

- “Fresh, EU-grown shrimp” – highlighting short supply chains and consistent quality.
- “Clean RAS, traceable and controlled” – emphasising biosecurity, absence of prophylactic antibiotics, and controlled effluents.

- “Lower footprint, future-ready” – where geothermal heat and brine integration is implemented, emphasise reduced energy and mineral footprint and circular use of local resources.

This is fully aligned with recent European consumer research, which shows that:

- Freshness and taste remain primary motivators,
- Sustainability, origin and traceability are increasingly important, especially for younger and higher-income segments,
- Consumers are willing to pay a clear premium for verified sustainable seafood claims in multiple EU countries.

Tools to convey this story include:

- On-pack and in-store information (QR codes linking to farm videos, simplified environmental metrics),
- Digital content for online grocery and D2C channels,
- Chef partnerships and foodservice co-marketing,
- Participation in relevant certifications and eco-label schemes where appropriate.

## 5.7 Commercial & Marketing Budget Framework

This subsection outlines an indicative framework for marketing and sales (commercial) budgets associated with the 1,300 t/year RAS shrimp platform. The aim is to size budgets in a way that:

- Supports brand-building and market entry in the ramp-up phase (Years 0–3), and
- Converges to a sustainable percentage of net revenue at steady state (Year 4 onwards).

For planning purposes, the analysis assumes that:

- Marketing & sales budgets are expressed as a combination of absolute amounts (€/year) and percentages of net revenue.
- Ramp-up years typically require higher spend per kg and higher % of revenue, due to initial brand creation, listings, and trade support.
- At steady state, marketing & sales costs stabilise at a lower but still meaningful share of revenue to sustain brand awareness, trade marketing and key account management.

Table 2. Indicative Marketing & Sales Budget by Phase

Year / Phase	Gross Profit (m€)	Marketing & Sales budget (m€)	Marketing & Sales as % of Gross Profit	Notes (focus)
Year 0 – Pre-launch	0	0.1	-	Brand concept, design, research, launch prep
Year 1 – Initial ramp (50 t)	0.93	0.2	21.5	Launch, key listings, activation, KAM set-up
Year 2 – Intermediate (260 t)	5.52	0.2	3.6	Expansion of customers, in-store support, HoReCa pilots

<b>Year 3 – Near full (1,000 t)</b>	12	0.7	5.8	Wider distribution, brand-building, promo optimisation
<b>Year 4+ – Steady state (1,300 t)</b>	16.6	0.7	4.2	Ongoing brand support, trade marketing, KAM, digital, POS.

## 6. Facility & Operations

### 6.1 General Recirculating Aquaculture (RAS) Shrimp Farm Designs and Production Models

#### Overview of RAS Shrimp Farming

Recirculating Aquaculture Systems (RAS) make it possible to grow Pacific white shrimp (*Litopenaeus vannamei*) in fully controlled indoor facilities rather than outdoor ponds. These systems filter and reuse water continuously, which allows consistent production even in cooler climates. Because the environment is tightly managed, RAS operations can maintain stable water quality and strong biosecurity, reducing disease risks and exposure to external environmental shifts. In recent years, Europe and North America have seen growing interest in RAS-based shrimp production as a way to supply fresh, locally farmed shrimp without relying on antibiotics or practices linked to habitat degradation in traditional pond farming.

Although RAS facilities require greater upfront investment and higher running costs than conventional pond systems, they can deliver more consistent production conditions and higher product quality. Producers in Europe note that the technology allows tight control over core parameters - such as temperature, salinity, and feed regimes - which supports the production of high-grade shrimp for nearby markets. In the United States, several companies promote land-based shrimp farming as a way to reduce dependence on both wild-caught and imported shrimp while supplying consumers with locally grown seafood.

Global shrimp production remains heavily weighted toward outdoor ponds, but interest in RAS is increasing as system designs mature and commercially successful operations emerge. The following sections outline how RAS shrimp farms are typically configured and operated, with emphasis on Pacific white shrimp in temperate regions, including the EU and the U.S.

#### RAS Shrimp Farm System Design

A typical RAS shrimp facility consists of grow-out tanks for the shrimp and a recirculating water treatment loop that continuously filters and reconditions the water. Key design components include the following:

##### [Culture Tanks and Layout.](#)

Shrimp in RAS systems are cultivated in a variety of tank types, including shallow raceways and circular tanks. Some operations favor long rectangular raceways - sometimes 30 to 40 meters in length and divided into sections - while others use circular tanks designed for efficient water circulation during the grow-out phase. Facility designs differ across regions: one European farm replicates a shallow pond-like environment using multiple wide, shallow raceways, while a U.S. facility has adopted a large number of circular tanks for grow-out. U-shaped raceways are also gaining popularity in Europe, offering streamlined water flow and reduced energy consumption. Materials used in tank construction include food-safe plastic and coated concrete, with installations configured at ground level or stacked vertically to optimize space. Vertical systems, such as those used in some U.S.-based operations, leverage gravity-assisted flow to maximize shrimp output per square meter in indoor setups.

### Mechanical Filtration (Solids Removal)

In land-based shrimp RAS, maintaining water quality requires effective removal of solid waste, including uneaten feed, feces, and molted shells. This is typically achieved through mechanical filtration systems such as drum or screen filters, which capture suspended particles as water exits the culture tanks. These filters often operate by gravity flow and are periodically cleaned using a backwashing process to discharge the collected solids. Prompt removal of these materials helps avoid the buildup of ammonia and curbs microbial activity that could degrade water quality.

To further polish water clarity and remove dissolved organic matter, many RAS setups employ protein skimmers (also known as foam fractionators). These devices use air bubbles - sometimes enhanced with ozone - to attract fine particles and proteins, creating foam that is collected from the water surface. This method, adapted from aquarium and finfish RAS systems, supports "clearwater" operations, improving visual monitoring and helping to prevent undesirable flavors in the harvested shrimp. Modern systems often consider skimmer capacity a critical factor in overall RAS performance.

### Biological Filtration (Nitrification)

Effective waste management in shrimp RAS relies heavily on biological filtration to remove harmful nitrogen compounds. Biofilters play a central role by hosting beneficial bacteria that convert ammonia - released through shrimp metabolism - into less toxic nitrate. Most facilities utilize either moving-bed bioreactors (MBBRs) or fixed-film systems packed with high-surface-area plastic media to support robust bacterial growth.

As water flows through these biofilters, ammonia is first oxidized into nitrite and then further converted to nitrate, ensuring that both intermediates stay within safe concentrations. Commercial operations, such as those in Germany, often employ specialized floating media tailored for efficient nitrification, originally adapted from high-performance fish RAS systems.

Biofiltration requirements vary by species. Pacific white shrimp (*Litopenaeus vannamei*), for example, are particularly sensitive to ammonia and nitrite, with stress occurring even at low levels. Ideal water chemistry for this species typically includes temperatures of 27 - 30 °C, salinity between 15 - 25 ppt, pH of 7.5 - 8.0, and moderate alkalinity (100 - 200 mg/L as  $\text{CaCO}_3$ ), which also support stable bacterial function.

To ensure the system handles the waste load appropriately, biofilter sizing must account for feed input and shrimp density - usually lower than in fish farming. Biofilters must be inoculated with nitrifying bacteria (seeding) and closely monitored through routine testing of ammonia and nitrite levels to maintain optimal water quality and system performance.

### Nitrate Control

Nitrate ( $\text{NO}_3^-$ ), the final product of the nitrification process, is considerably less harmful to shrimp than ammonia or nitrite. However, in closed-loop RAS systems, it can gradually accumulate to levels that may compromise animal health over time. To manage this, many

shrimp farms maintain a limited amount of water exchange, aiming to keep nitrate concentrations below 100 - 150 mg/L of nitrogen.

Some facilities incorporate specialized treatment components, such as denitrification units - anaerobic reactors where nitrate is biologically reduced to nitrogen gas by heterotrophic bacteria. These systems are often supplemented with a carbon source to support microbial activity. For example, certain European RAS designs have adopted stand-alone nitrate removal reactors, which help minimize discharge and enable more sustainable operation.

In addition, alternative technologies like electrocoagulation are emerging. These systems use low-voltage electrical currents to trigger chemical reactions in the water, generating compounds that help eliminate nitrogenous waste products, including ammonia and nitrate. This approach is being tested in commercial setups as a potential complement to traditional biological filtration.

Regardless of method, the objective is to prevent nitrate buildup that could negatively impact shrimp or necessitate large-scale water replacement. Many successful operations achieve this by combining biological filtration, periodic water exchange, and optional denitrification steps to maintain nitrate within safe limits.

#### [Disinfection and Pathogen Control](#)

Maintaining strict biosecurity is essential in recirculating aquaculture systems, where disease outbreaks can have severe consequences. To reduce microbial and viral risks, many RAS farms integrate ultraviolet (UV) sterilizers and ozone-based disinfection units into their water treatment loops. Ozone - used either in dedicated chambers or as part of foam fractionation - helps degrade organic matter while providing broad-spectrum antimicrobial action. UV units are commonly installed after key filtration stages to neutralize residual pathogens before water returns to the culture tanks.

These closed-loop safeguards are particularly important for shrimp species like *Litopenaeus vannamei*, which are vulnerable to serious viral diseases such as WSSV and EMS. Beyond in-system treatments, farms follow rigorous external biosecurity protocols. For instance, most EU and U.S. facilities rely on Specific Pathogen Free (SPF) shrimp post-larvae sourced from approved hatcheries, coupled with sanitary practices like disinfection footbaths, controlled facility access, and “all-in/all-out” stocking strategies. Due to regulatory restrictions, live shrimp imports from high-risk regions (such as parts of Asia) are prohibited in Europe, with some farms opting to import SPF seed stock from vetted suppliers in the U.S.

Internally, RAS designs often separate production units by using independent water circuits for different batches or life stages. This setup helps isolate potential health issues and avoid cross-contamination. For example, certain European facilities operate multiple isolated loops within a single farm, while similar practices are adopted in North American systems. Such compartmentalization enhances resilience by enabling partial containment in case of a disease event.

## Aeration and Oxygenation

Because shrimp require significant amounts of dissolved oxygen - especially when reared at higher densities - oxygen management is a critical element in RAS facility design. Aeration is typically achieved using air diffusers or energy-efficient blowers, with many farms supplementing with pure oxygen to maintain dissolved oxygen (DO) levels above 5 mg/L. To ensure consistent delivery, systems may incorporate oxygen injection devices such as cones or diffusers positioned in the water return line. In some facilities, liquid oxygen (LOX) is stored on-site, and emergency power systems are in place to guarantee oxygenation during outages.

Sufficient oxygen is not only essential for shrimp health - since animals tend to cluster near the tank bottom where oxygen depletion can lead to localized mortality - but also for the biological filtration process, which relies on oxygen-dependent bacteria for nitrification.

At the same time, managing carbon dioxide (CO<sub>2</sub>) is important, as both shrimp respiration and bacterial activity generate CO<sub>2</sub>, which can build up and reduce pH if not removed. Degassing solutions such as cascade aeration systems, packed columns, and foam fractionation units are commonly used to vent CO<sub>2</sub> and stabilize water chemistry. Interestingly, a survey of European shrimp RAS operators found that although CO<sub>2</sub> management is acknowledged as a priority, routine monitoring of CO<sub>2</sub> levels is still lacking in many facilities - highlighting a potential gap in system optimization as the industry continues to grow.

## Heating/Cooling and Climate Control

As a tropical species, *Litopenaeus vannamei* requires consistently warm water - typically around 28 °C - for optimal growth and survival. In cooler climates, recirculating aquaculture systems (RAS) must incorporate reliable heating systems to maintain these temperatures year-round. Common solutions include the use of heat exchangers connected to boilers, district heating networks, or renewable energy sources. Some farms are adopting sustainable approaches by recovering waste heat from nearby industrial facilities. For instance, a shrimp RAS facility in Switzerland utilizes thermal energy from a neighboring salt production plant to warm its tanks, reducing operational costs and environmental impact.

Effective insulation of tanks and buildings is also essential in temperate and cold regions to minimize heat loss and maintain energy efficiency. Conversely, in hot or tropical climates, excessive water temperatures can pose a challenge. Farms in regions like the Middle East or Southeast Asia may require cooling systems - such as chillers or evaporative cooling - to prevent water temperatures from exceeding optimal levels, particularly during summer.

Across all regions, keeping shrimp within a stable temperature range of 27 - 30 °C is considered a key design goal. Climate conditions also influence infrastructure: in warmer zones such as Florida or the UAE, simple structures like greenhouses or warehouses may suffice, while farms in Northern Europe often require insulated buildings with integrated heating systems to ensure thermal stability and biosecurity. Full environmental control - including temperature, humidity, and light cycles - is commonly employed to support consistent production and animal welfare.

## Automation and Monitoring

Modern shrimp RAS operations depend heavily on automated monitoring and control technologies to maintain stable rearing conditions. Commonly used instrumentation includes real-time sensors that track key water quality parameters such as temperature, salinity, pH, dissolved oxygen, oxidation-reduction potential (used in ozone management), water levels, and flow rates. Some systems also integrate ammonia or nitrate monitoring to provide early warning of imbalances.

Programmable logic controllers (PLCs) and centralized computer systems manage critical functions - regulating pumps, heating units, and oxygen delivery - while generating alerts when readings move outside target ranges. Surveys suggest that a majority of farms, around 76%, now rely on remote alert systems to notify personnel in the event of equipment malfunctions. Despite high levels of automation, daily on-site inspections remain standard practice, with 83% of operators conducting at least one full system check each day to identify potential issues early.

Automation enhances efficiency, but cannot fully replace manual oversight. Staff are still required to assess animal health, service sensors, and verify emergency systems - such as standby generators or backup oxygenation equipment - are operational. These contingency systems are viewed as essential safeguards, especially during unexpected power outages or mechanical failures.

As digital technologies advance, some RAS farms are experimenting with high-tech monitoring tools, including artificial intelligence and camera systems that can observe shrimp behavior continuously. At the Oceanloop facility in Germany, for instance, AI-assisted imaging is being trialed to track mortality and feeding responses in real time - an area traditionally difficult to monitor due to rapid cannibalism of dead shrimp. These innovations aim to improve both production efficiency and animal welfare by flagging behavioral anomalies such as lethargy or reduced appetite before they escalate into health issues.

## Design Parameters for *L. vannamei* in RAS

Pacific white shrimp is well-suited to RAS due to its tolerance of crowding and variable salinity, but specific water quality parameters must be maintained for success.

### Water Quality Optima

The optimal temperature range for cultivating *Litopenaeus vannamei* in RAS is between 27 and 30 °C. When temperatures fall below approximately 20 °C, shrimp experience reduced growth and compromised immune responses. At the other extreme, water temperatures above 32 °C can cause thermal stress and lower dissolved oxygen availability.

pH levels are typically maintained in the range of 7.5 to 8.0, supporting both shell development and biological filtration processes. Salinity is commonly adjusted to brackish levels, between 15 and 25 ppt, even though *L. vannamei* is known for its broad salinity tolerance. This range reduces salt input costs and can enhance biofilter efficiency. Alkalinity,

usually kept within 100 - 200 mg/L as CaCO<sub>3</sub>, plays a dual role - buffering pH fluctuations and supplying carbonate needed for molting.

Nitrogen compounds are closely monitored: total ammonia nitrogen (TAN) is generally kept below 0.1 mg/L, and nitrite under 1 mg/L, to avoid sub-lethal effects. While nitrate is less toxic, levels are usually kept below 150 mg/L to prevent chronic stress. Dissolved oxygen is maintained close to saturation - around 5 to 6 mg/L or 70–100% - with levels below 4 mg/L potentially causing stress. Although not always continuously measured, carbon dioxide levels should remain below 20 mg/L; CO<sub>2</sub> control is typically managed through aeration, degassing units, and adequate alkalinity.

Water clarity is another key variable. In clearwater systems, turbidity is kept low, which allows operators to observe shrimp behavior and health directly. Alternatively, biofloc systems are designed to maintain suspended microbial aggregates, which help process waste and can provide supplemental nutrition. Each method has trade-offs: biofloc reduces feed costs and enhances microbial stability, while clearwater systems simplify visual monitoring and make water chemistry easier to regulate.

Research suggests that shrimp grown under both systems can perform similarly in terms of growth and taste when well managed. However, many farms - particularly in Europe - favor clearwater RAS for its compatibility with automated monitoring technologies and its operational simplicity.

#### Stocking Density and Yields

Recirculating aquaculture systems (RAS) enable significantly higher shrimp stocking densities than traditional pond systems, though practical and biological limits must be observed to maintain water quality and animal welfare. Commercial RAS facilities typically aim for grow-out densities of 1 to 5 kilograms per square meter of tank surface, translating roughly to 5 - 15 kg per cubic meter, depending on water depth. While experimental systems have reached densities as high as 10 kg/m<sup>2</sup>, most European farms operate closer to 8 - 10 kg/m<sup>3</sup> without encountering oxygenation problems.

However, higher stocking densities can increase the risk of physical injuries, including damage to antennae and eyes due to crowding or aggressive behavior. One survey indicated that farms stocking at 8 kg/m<sup>2</sup> reported significantly more injuries than those operating at more moderate levels of 1–2 kg/m<sup>3</sup>. As a result, many system designers and producers opt for balanced densities - often around 3–6 kg/m<sup>2</sup> - to ensure good welfare and manageability. Across the EU, standard yields for indoor RAS shrimp farms generally range from 1 to 5 kg/m<sup>2</sup>, with outliers exceeding 10 kg/m<sup>2</sup> under optimized conditions. At this scale, a compact facility with several hundred square meters of tank area can produce 10 to 20 metric tons of shrimp annually.

Under well-managed conditions, *Litopenaeus vannamei* can reach market size (typically 20 - 30 grams) within 4 to 6 months, allowing for two to three production cycles per year. Some operations, particularly in warmer climates or using accelerated growth protocols, have achieved up to four crops annually by harvesting smaller shrimp (~20 g) more frequently. This

approach, combined with optimized genetics and nutrition, supports year-round output. For example, a Florida-based farm reportedly targets four cycles per year to achieve an annual production volume of 720 metric tons.

Final yield also depends on survival rates and feed efficiency. High survival - often above 85% - is a key performance benchmark. Feeding must be carefully managed, using high-protein commercial pellets and ensuring mineral balance in the water. Minerals such as calcium, magnesium, and potassium are essential for molting and shell formation. In some cases, increased cannibalism of molts has been linked to mineral deficiencies, prompting farms to supplement the water or diet to support healthy exoskeleton development.

#### [Process Flow and Batch Scheduling](#)

Shrimp RAS facilities can be operated using either batch-based or continuous production systems, depending on management preferences and processing needs. In batch operations, all shrimp within a given tank or production unit are stocked at the same time - typically as postlarvae - and grown for a full cycle of around 4 to 6 months before the tank is fully harvested and reset. This model simplifies management but results in intermittent harvests and idle time between crops.

To maintain a steady harvest rhythm, many commercial farms use a staggered production approach across multiple tanks. For instance, a facility with 12 tanks might begin stocking two tanks per month, creating a rolling schedule where two tanks are harvested monthly after the initial start-up period. This rotational method helps balance labor and processing capacity while ensuring a regular product supply.

Another approach, gaining popularity in Europe, involves the use of compartmentalized raceways. These elongated tanks are divided into several connected sections (often three to five), with each section housing shrimp at a different growth stage. At regular intervals - typically every two months - shrimp are gently transferred from one section to the next, with the most mature animals reaching the final compartment for harvest. New postlarvae are then introduced to the first section, keeping the system in continuous operation.

This “cascade” model, tested by producers like FutureFish and Oceanloop in Germany, allows consistent harvests at predictable intervals while optimizing tank usage and minimizing handling stress. For example, Oceanloop’s raceway design incorporates U-turn channels that guide shrimp through the system with minimal disruption as they grow.

Regardless of production model, some farms incorporate grading steps during transfers to separate shrimp by size and reduce aggressive behavior or cannibalism. To further reduce stress, automated pumping or vacuum systems are often used to move shrimp between compartments gently, improving welfare and operational efficiency.

#### [Hardware Requirements](#)

##### 1. Grow-out Tanks

The main production units, typically constructed from food-safe plastic or coated concrete. Tanks may be covered or partially sheltered to minimize light exposure, evaporation, and temperature fluctuations.

## 2. Nursery Tanks

If a dedicated nursery phase is used, smaller tanks or shallow raceways are deployed to raise juvenile shrimp before transferring them to grow-out systems.

## 3. Solid Waste Removal (Mechanical Filtration)

Primary filtration systems such as drum filters or radial flow settlers are used to capture uneaten feed, faeces, and other suspended solids before water enters biological treatment.

## 4. Biofiltration

Biological filters - commonly moving bed bioreactors (MBBRs) filled with high-surface-area media - are used to convert ammonia to nitrate. Some systems may include an anaerobic unit for nitrate removal via denitrification.

## 5. Water Circulation

Water movement is maintained by low-lift circulation pumps or airlift systems, designed for energy efficiency. Gravity flow is integrated where feasible to reduce power consumption (e.g., from tanks to filters).

## 6. Oxygenation and Aeration

Aeration is typically achieved with air blowers and diffusers, while dissolved oxygen levels may be supplemented with pure oxygen systems - either via oxygen generators or liquid oxygen (LOX) storage, paired with diffusers or oxygen cones.

## 7. Water Disinfection

Ultraviolet (UV) sterilizers and/or ozone generators are commonly installed to control pathogens and oxidize dissolved organic matter within the water.

## 8. Foam Fractionation (Protein Skimmer)

Often used in conjunction with ozone injection, this unit removes fine particulates and dissolved organics, improving water clarity and reducing biochemical oxygen demand (BOD).

## 9. Heating and Cooling Systems

Water temperature is regulated using heat exchangers, boilers, or heat pumps. In colder regions, systems may integrate industrial waste heat or geothermal sources. In hot climates, chillers or evaporative cooling systems may be required to prevent overheating.

## 10. Sensors and Control Systems

Monitoring equipment includes sensors for dissolved oxygen (DO), temperature, pH, salinity, oxidation-reduction potential (ORP), and water level. These are typically connected to a programmable logic controller (PLC) or central monitoring system with automated alerts for parameter deviations.

## 11. Emergency Power Backup

A dedicated generator is critical to maintain life-support systems during outages, especially aeration, oxygenation, and water circulation.

## 12. Biosecurity Measures

Infrastructure to reduce pathogen risk includes water pre-treatment for all incoming supply (e.g., filtration and UV), enclosed buildings with controlled access, footbaths, and dedicated areas for quarantine or hatchery operations. These features help ensure a disease-free production environment.

### Species-Specific Design Notes

As a species that naturally occupies the lower part of the water column, *Litopenaeus vannamei* is well suited to shallow tank designs. Rather than prioritizing water depth, most RAS facilities emphasize horizontal floor space to optimize stocking density and simplify harvesting. Typical water depths range from 0.5 to 1.2 meters. In deeper tanks, some systems incorporate shelving or multi-level structures to increase the usable bottom surface area.

To enhance shrimp welfare and behavioral conditions, some farms introduce shelter materials such as plastic mesh or suspended ropes, offering both physical structure and additional surface area. However, their use varies by region and system design. A European industry survey noted that while some producers employ enrichment to reduce aggression or encourage natural behaviors, others avoid it, potentially due to maintenance complexity.

Lighting in shrimp RAS is generally kept subdued. Bright lighting is unnecessary, and softer or natural light cycles may reduce stress and promote stable molting patterns. Moult occurs regularly - typically every few weeks - during which shrimp shed their exoskeletons (exuviae). Whether to remove these molts is subject to operational preference. In systems with clear water, molts are often removed using protein skimmers or manual netting to reduce the potential buildup of organic material and associated pathogens. In contrast, biofloc systems commonly leave molts in the tanks, allowing shrimp to consume them as a source of minerals like calcium and phosphorus.

Each farm develops its own protocol based on system type, water clarity, and labor strategy. While removing molts may support cleanliness and reduce microbial risk, allowing their consumption may support mineral recycling and reduce feed demand—highlighting the balance between biosecurity and sustainability in system management.

### Production Model & Operations

Operating a RAS shrimp farm involves managing the entire lifecycle from post-larvae to market harvest in a biosecure, recirculating environment. Key operational aspects include:

#### Seed Stock (Hatchery/Nursery)

In shrimp RAS operations, post-larvae (PL) are typically sourced either from certified external hatcheries or produced in-house, depending on the farm's size and level of integration. Larger vertically integrated operations - such as CP Foods' U.S.-based facility - operate their own

hatcheries, producing tens of millions of disease-free PLs each year. This approach ensures biosecurity and consistency of juvenile shrimp supply.

Smaller or mid-sized farms often rely on specialized hatcheries to supply SPF (Specific Pathogen Free) PLs, usually at developmental stages between PL10 and PL15, corresponding to about 10 - 15 days after hatching. Upon delivery, these juveniles are gradually acclimated to the farm's water conditions and transferred into nursery tanks, where they are reared at high densities in relatively small volumes.

The nursery phase typically lasts several weeks and plays a crucial role in improving early survival rates. During this stage, shrimp are transitioned from live feeds or microdiets to formulated feeds and grown to a size of roughly 1 - 2 grams before being stocked into grow-out tanks. This two-phase rearing strategy improves space utilization in the main production system and allows for better early-stage management.

Alternatively, some operations omit a dedicated nursery and introduce PLs directly into grow-out tanks at lower densities. While this reduces system complexity, it requires more precise control over feeding, water quality, and grading to ensure uniform growth and minimize stress-related losses.

#### Feeding & Growth Management

In recirculating aquaculture systems (RAS), shrimp are typically fed high-quality commercial pellets multiple times throughout the day. This is often managed using automated feeders or scheduled manual rounds. Given the limited water volume and high biomass in RAS tanks, feeding must be carefully controlled to avoid excess waste and maintain water quality. Many farms adopt a "little and often" approach - delivering small, frequent portions using belt feeders or hourly intervals - to better match shrimp consumption patterns and reduce uneaten feed.

Under well-managed conditions, feed conversion ratios (FCRs) in the range of 1.2 to 1.8:1 are common, reflecting high feed efficiency - meaning approximately 1.5 kg of feed is needed to produce 1 kg of shrimp biomass. Staff monitor feeding activity either visually in clearwater systems or by checking feeding trays in more turbid environments, and adjust rations based on observed appetite and behavior.

Optimal environmental stability in RAS allows *L. vannamei* to grow rapidly - averaging 1.2 to 1.5 grams per week. Market sizes of 20 to 30 grams are typically reached within 4 to 5 months, though some operations targeting premium markets grow shrimp beyond 30 grams to produce jumbo-sized products. Continuous growth monitoring - through sampling or emerging technologies like AI-based camera systems - is used to forecast harvest readiness and estimate biomass in real time.

Maintaining low stress is essential to support steady growth. The controlled nature of RAS minimizes environmental fluctuations, allowing shrimp to dedicate more energy to feeding and development. However, system failures - such as loss of aeration - can cause rapid stock loss, especially at high densities. For this reason, daily operational checks include inspecting

all pumps, oxygen delivery systems, backup generators, and observing animal behavior to detect early warning signs of stress or equipment malfunction.

### Health Management

While the closed-loop nature of RAS facilities significantly reduces the risk of disease entry from external sources, any pathogen introduced into the system can spread rapidly due to shared water circulation. As a result, preventative health management is central to RAS operations. This begins with strict biosecurity protocols and extends to continuous observation of shrimp health and behavior. Farmers regularly look for early warning signs of distress - such as abnormal swimming patterns, reduced appetite, lethargy, or spasms - which are commonly associated with underlying health issues. In response to such symptoms, immediate checks of water parameters are typically performed, as fluctuations in ammonia, oxygen, or pH are often contributing factors.

To further safeguard stock health, some producers conduct regular diagnostics, including PCR screening for viral pathogens or microscopic examinations for parasites. Probiotics may be administered through feed or directly into the water system to support digestive and microbial balance, although their effectiveness in RAS is still under evaluation.

There is increasing industry interest in developing standardized welfare indicators for shrimp, particularly behavior-based monitoring frameworks, to formalize health surveillance in intensive indoor systems. One operational advantage of RAS is the ability to compartmentalize - if an issue arises, a single module can be isolated to prevent a broader outbreak, unlike pond farms where waterborne diseases can rapidly affect entire facilities.

Emergency protocols are critical in RAS management. For example, a sudden rise in ammonia - whether from a biofilter malfunction or mass mortality - may prompt water exchanges or targeted interventions, such as chemical treatments or technologies that rapidly neutralize nitrogenous waste. In one notable case, electrochemical water treatment systems have been used to remove toxic compounds efficiently.

Backup systems, including oxygen supply and power generators, are always kept on standby. Since high-density RAS tanks can become fatal within minutes if aeration fails, system reliability is a top priority. In fact, surveys of indoor shrimp farms consistently identify technical malfunctions - particularly pump or aeration failures - as leading threats to animal welfare, highlighting the importance of constant monitoring and proactive maintenance.

### Harvesting & Post-Harvest

Once shrimp reach the target market size, harvesting is carried out either by netting or by gradually draining the culture tanks. Most RAS tanks are designed with central drains or screened outlets that allow operators to lower the water level, concentrating the shrimp for efficient collection. In some systems, gentle siphoning or pumping methods are used to remove shrimp with minimal stress.

Because freshness is a key value proposition for RAS-grown shrimp, harvesting often occurs in small, scheduled batches to fulfill customer orders. For example, Swiss-based producers

deliver chilled shrimp within 24 hours of harvest, catering to local consumers seeking high-quality, never-frozen seafood. Similarly, many U.S. indoor shrimp farms supply live or freshly packed product to high-end restaurants and specialty retailers.

In batch production systems, once harvesting is completed, tanks are thoroughly cleaned and disinfected before the next cycle begins. Continuous or staggered systems may harvest only the largest shrimp at a time, allowing smaller individuals to remain and continue growing. These systems typically avoid full water drainage, but routine waste removal and strict biosecurity protocols are still applied between cohorts.

Survival rates from post-larvae to harvest are a key performance metric. Well-managed RAS operations often achieve survival rates in the 80 - 90% range. Production volume per cycle varies widely depending on farm size and system design. Large-scale farms such as CP Foods' U.S. facility have projected annual outputs of over 700 metric tons by operating four crop cycles per year across numerous tanks, achieving high throughput through careful scheduling and automation.

Smaller European farms currently operate at more modest scales, typically producing between 5 and 50 metric tons per year. However, as experience accumulates and system designs evolve, the sector is trending toward larger operations. Many developers suggest that reaching a production scale of around 1,000 metric tons annually may be a tipping point for long-term profitability, driving the planning and construction of next-generation commercial RAS shrimp facilities.

#### [Routine Maintenance](#)

Routine daily operations in a shrimp RAS facility revolve around maintaining system performance, biosecurity, and animal welfare. Key tasks include flushing mechanical filters, servicing protein skimmers, cleaning sensor probes, and removing any buildup of organic material or biofilm from tank bottoms. If the system is not self-cleaning, shed exoskeletons (molt) may also need to be collected manually to prevent microbial issues.

Feeding systems are monitored and replenished regularly, with calibration checks to ensure accurate delivery. In multi-stage or "stepped-growth" setups, staff may spend time transferring shrimp between compartments based on size, ensuring even growth and reducing cannibalism.

Due to the high degree of environmental control in RAS, minor technical faults - such as partial pump failure, clogged lines, or a sudden drop in dissolved oxygen - can escalate quickly. As such, trained personnel are required to be vigilant, and most farms implement 24/7 alert systems that notify staff immediately if parameters deviate from set thresholds.

Strict biosecurity measures are enforced to prevent disease introduction or spread. Tools, nets, and other equipment are disinfected between tanks, and any mortalities are quickly removed for examination. Cleanliness and system hygiene are seen as core components of operational success.

Waste management is another integral aspect. Solids removed during filter backwashing or skimmer cleaning are typically collected as sludge, which can be thickened or dewatered for use as an agricultural fertilizer. Some farms also treat this wastewater for reuse or safe discharge.

Thanks to high-efficiency water recirculation - often exceeding 95% reuse - overall water consumption in shrimp RAS is minimal compared to traditional pond systems. Some operators report using as little as 1% of the water per kilogram of shrimp produced compared to conventional methods. However, this comes with increased energy demand, which farms must balance through efficient system design and, where possible, renewable energy integration.

### Climate Considerations and Regional Challenges

RAS shrimp farm designs must adapt to different climates, each presenting unique needs and challenges:

#### [Temperate/Cold Climates \(e.g. Northern Europe, Northern U.S.\)](#)

Operating RAS shrimp farms in colder climates presents unique technical and economic challenges, primarily due to the need to maintain tropical water temperatures year-round. This requires well-insulated facilities and substantial energy input to heat both air and water. As a result, many farms in temperate regions actively seek out affordable or renewable heat sources to improve sustainability and reduce costs.

One effective strategy is to co-locate with industrial facilities that generate excess thermal energy. A notable example is SwissShrimp, which partners with a neighboring salt factory to harness over 8 megawatts of residual heat from brine evaporation. This setup significantly offsets heating costs and lowers environmental impact by repurposing energy that would otherwise be wasted.

Because these farms must be fully enclosed to retain heat and ensure biosecurity, construction costs are typically higher compared to facilities in warmer regions. Additionally, dry winter air may necessitate humidity control to prevent excessive evaporation and reduce molting issues among shrimp.

Despite these technical demands, RAS operations in cold climates often benefit from strong market positioning. Locally grown shrimp command premium prices in European markets, where consumers value freshness, antibiotic-free production, and sustainable sourcing. German and Swiss producers, for example, supply high-end restaurants and retailers with shrimp marketed as eco-friendly and locally produced.

Regulatory frameworks in many temperate countries further support RAS, particularly where discharge of saline or nutrient-rich water is tightly restricted. The closed-loop nature of RAS aligns well with these environmental regulations by minimizing emissions and water usage.

A notable challenge, however, is the shortage of trained personnel. Since RAS shrimp farming is still relatively new in Europe, many facilities face a learning curve in operations. To address

this, collaborative initiatives - such as EuroShrimp - are working to build a knowledge base, provide training, and encourage best-practice sharing across the sector.

#### [Tropical/Hot Climates \(e.g. Middle East, Southeast U.S., Southern Europe\)](#)

In warm climates, maintaining the optimal temperature range for shrimp is generally less challenging than in colder regions - but overheating can become a concern, particularly during peak summer months. Facilities often require less insulation and may utilize lightweight structures like greenhouses or shade-netted enclosures that rely on ambient heat. However, when water temperatures exceed ideal thresholds, cooling systems and oxygen management become critical.

In arid regions such as the Middle East, extremely high daytime temperatures can lead to thermal stress in shrimp tanks. To mitigate this, farms may install evaporative cooling systems or mechanical chillers, which require a reliable energy supply - making backup power systems essential to avoid catastrophic losses during power interruptions. On the positive side, these regions often have high solar irradiance, creating opportunities to integrate solar power for running essential systems like aeration, pumps, or temperature control.

Water scarcity is a major driver for RAS adoption in regions like the UAE, where freshwater resources are limited. The closed-loop nature of RAS - requiring only minimal water input - makes it highly compatible with national water conservation strategies. A notable project planned near Dubai aims to produce over 1,000 metric tons of shrimp annually using intensive, biosecure RAS methods, aligning with food security goals and reducing dependence on seafood imports.

In tropical areas where shrimp pond farming is widespread, RAS provides a stable and controlled production environment that can help mitigate issues such as disease outbreaks (e.g., early mortality syndrome) and seasonal disruptions caused by monsoons or temperature fluctuations. Some companies are experimenting with compact, modular RAS facilities located close to urban markets, enabling year-round production with reduced logistical costs.

One of the biggest challenges in warm-climate regions is cost competitiveness. Traditional pond-raised shrimp tend to have lower production costs, which means RAS systems must differentiate through consistent quality, traceability, and biosecurity - attributes that appeal to premium or export markets. Enhanced pathogen control is especially important in tropical environments, where microbial loads and disease vectors are more prevalent. Measures such as pre-treatment of all incoming water (e.g., via ozonation or UV), air filtration, and strict facility sanitation are often implemented to minimize risk.

Overall, RAS farms in warm regions benefit from reduced heating demands but must focus on optimizing energy use, maintaining water quality, and achieving market differentiation to remain economically viable.

#### Scalability

Scalability is a core consideration in the design and development of RAS shrimp farming systems, regardless of climate. Many projects begin with a small or pilot-scale facility - often producing just a few tons per year - to validate technology, optimize operations, and gather performance data. Once the system proves reliable and cost-effective, operators typically plan expansion to commercial volumes, ranging from several hundred to over a thousand tons annually.

A modular approach to design is commonly used to support phased growth. For example, some farms implement standardized modules - such as 7.5-ton annual production units - that can be replicated as demand increases or funding becomes available. This setup also improves operational flexibility and risk management: dividing production into multiple discrete systems (or “clusters”) creates biosecurity buffers between units, helping to contain potential disease outbreaks.

Larger facilities, such as those run by CP Foods, organize dozens of tanks into semi-independent water loops, allowing high-volume production while retaining compartmentalized control. Other enterprises, like Oceanloop in Germany, are pursuing a distributed model: instead of building a single massive facility, they propose establishing several mid-sized RAS farms - each located near key urban markets. These 500 - 1,000 ton/year sites would reduce logistics costs, improve freshness, and spread operational risk.

In high-consumption regions such as the Middle East, a 1,000-ton facility is already in development, targeting import replacement and food security goals. Yet even such large projects represent only a fraction of national demand - suggesting that future expansion may involve networks of regionally located RAS farms rather than centralized mega-projects.

Ultimately, scalability in RAS is not just about production volume - it also involves replicable systems, local adaptation, and market integration. The goal is to build systems that are flexible, biosecure, and economically viable across diverse geographies.

### Resource integration

Integrating RAS shrimp farms with other resource-efficient systems is emerging as a promising trend in sustainable aquaculture. Beyond the use of geothermal heat, some projects are exploring synergies with renewable energy sources and adjacent food production systems to maximize circularity and minimize waste.

One approach involves coupling RAS with controlled-environment agriculture, such as greenhouse vegetable production. In these integrated models, nutrient-rich effluents from shrimp tanks may be reused to support plant growth - either in an aquaponics-style setup or through side-stream irrigation in hydroponic systems. This allows partial nutrient recovery while reducing the need for external fertilizers.

More advanced concepts propose vertical integration of multiple systems within the same facility. For example, a pilot initiative in Puerto Rico is investigating a multi-level configuration where shrimp cultivation, hydroponic crops, and energy recovery systems operate together in a closed-loop. This model aims to improve land-use efficiency and significantly reduce water consumption by reusing heat and nutrients across sectors. Some developers claim such

systems could achieve dozens of times greater food output per square meter compared to conventional farming, though these numbers are still experimental and site-dependent.

While still in the early stages, integrated RAS systems highlight the potential of aquaculture to play a broader role in sustainable urban or semi-urban food production. In regions with limited arable land or water scarcity - and where indoor farming is already gaining momentum - these hybrid models may offer both ecological and economic advantages.

### Summary

In conclusion, while climate significantly shapes the infrastructure and energy requirements of RAS shrimp farms - particularly in areas such as heating, cooling, and facility insulation - the fundamental components of recirculating systems remain largely uniform across regions. Success hinges on adapting system design to local conditions: harnessing waste heat in colder climates, managing thermal excess in hotter ones, or capitalizing on nearby markets willing to pay a premium for fresh, locally raised shrimp.

By aligning technical design with regional strengths and proactively addressing site-specific challenges like water scarcity or high energy demand, RAS shrimp farms have demonstrated their viability in a wide range of geographic settings. Notably, commercial-scale operations in Europe and North America have proven that tropical shrimp can now be produced reliably even in cold-weather regions. What was once seen as a novelty - shrimp farming in snowy climates - has evolved into a scalable, increasingly sustainable model for localized aquaculture.

A well-designed shrimp RAS creates a tightly controlled aquatic environment that consistently meets the biological requirements of *L. vannamei* while minimizing water use through high-efficiency recirculation. Effective production depends on aligning biological processes - growth, behavior, and health - with reliable engineering systems such as filtration, aeration, pumping, and monitoring. At the core of every system are strong mechanical and biological filtration units, rigorous biosecurity measures, and operational routines that keep water quality stable. Climate primarily influences how these core elements are packaged - dictating insulation, heating or cooling strategies, and building layout - rather than changing the fundamental RAS architecture.

In temperate areas, including much of Europe and the northern United States, fully enclosed RAS facilities have become the only practical way to raise tropical shrimp. Producers in these regions have demonstrated that with precise environmental control and strict discharge management, high-quality shrimp can be grown throughout the winter. Warmer regions benefit differently: here, RAS offers constant, biosecure production that helps buffer against seasonal disease pressure and reduces reliance on imports. The appeal of fresh, locally grown, traceable shrimp strengthens the business case in both settings.

Scalability and long-term sustainability are now central priorities. Many new farms begin with modest pilot units and expand through modular duplication. Concepts for 1,000-ton facilities - whether in the Gulf region, Europe, or elsewhere - typically rely on clusters of semi-independent modules to manage risk and simplify operation. Designs increasingly incorporate

renewable energy, heat recovery, nutrient reuse, or integration with greenhouse and hydroponic systems to support circular production models.

Operational best practices are also becoming standardized. Daily inspections, automated alert systems, and redundant life-support equipment are essential to prevent losses in high-density tanks. Maintaining stable water chemistry - controlling nitrogen compounds, ensuring adequate oxygenation, and supplementing minerals for healthy molting - is now routine. Farms that consistently apply these practices generally achieve strong survival and growth, while those operating with insufficient filtration capacity or monitoring often encounter setbacks.

Some producers are experimenting with hybrid configurations that blend elements of biofloc and clearwater RAS. Allowing moderate floc development inside otherwise conventional RAS tanks can help process organic waste and supply natural microbial nutrition, though it requires careful management to avoid instability. Both approaches - clearwater and biofloc - enhance pathogen control and reduce dependence on antibiotics compared to traditional pond farming, supporting responsible aquaculture objectives.

Overall, a general RAS shrimp farm for *L. vannamei* combines the appropriate physical infrastructure - tanks, filtration systems, oxygenation, temperature control - with an operational strategy tailored to stocking density, water-quality targets, and health management. Experience from diverse regions has produced a growing knowledge base covering everything from handling molts and optimizing densities to integrating AI monitoring and renewable heat sources. These lessons directly inform the design of a 100-ton annual production unit and provide a pathway for modular expansion toward 1,000 tons per year in a scalable, resilient, and high-quality production model.

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## 6.2 Proposed RAS Shrimp Facility, System Design & Production Model

### 6.2.1 Purpose, Scope and Design Philosophy

This section outlines Akola's proposed Recirculating Aquaculture System (RAS) shrimp facility concept, focusing on the technical design and production model that will underpin both the pilot-scale operations and future large-scale deployment. The primary reference design is a 100 t/year RAS shrimp module ("100 t module"), which serves as the core, fully specified building block for the project. This module is intended to be replicable and scalable to an aggregate capacity of 500 t/year within a single site by adding additional modules and optimising shared infrastructure.

In parallel, a conceptual design for a 1,000 t/year facility in Germany is being developed. This larger facility is not a simple repetition of ten 100 t modules; it employs adapted tank sizes, system configuration and centralised utilities to capture economies of scale and meet the requirements of an industrial-scale operation. Accordingly, this section treats the 100 t module as the main detailed reference (layout, process flow, production model), and then presents the 1,000 t/year facility at a higher, conceptual level, highlighting how it builds on and extends the validated 100 t design principles.

The scope of this section is limited to the core RAS and production concept: tank systems, water treatment trains, process flows, biosecurity, production cycles and operating parameters. Geothermal integration and energy system optimisation are intentionally excluded here and are described separately in the Resource and Sustainability Integration section.

The overall design philosophy is guided by the following principles:

- Biological robustness and biosecurity - stable, biosecure RAS environment with controlled inputs, minimised disease risk and high survival rates.
- Product and market orientation - consistent production of premium-quality Vannamei shrimp tailored to EU fresh and value-added markets, with target sizes of 22 g and above.
- Modularity and scalability – a 100 t module that can be replicated and adapted to 500 t on one site, and technically scaled to a 1,000 t/year facility while maintaining process integrity.
- Operational efficiency – optimised layout, automation and shared utilities to reduce labour, energy and unit costs over time.

This design framework provides a clear, coherent technical basis for Project's implementation in Klaipeda and for the subsequent rollout of larger-scale facilities.

### 6.2.2 100 t RAS Module – Design Overview

The 100 t/year RAS shrimp module ("100 t module") is the core technical building block of Akola's production concept. It represents a fully specified, standalone unit designed to deliver approximately 100 t/year of market-size 22-23g shrimp under controlled indoor conditions, while meeting EU market requirements for premium quality, traceability and biosecurity. This module is the reference design for the Klaipeda facility and the primary technical template for future modular expansions.

## Design Basis and Performance Targets

The 100 t module is dimensioned and engineered around a clear set of biological and operational targets:

- Species: Litopenaeus vannamei
- Annual production: 100 t live weight per year
- Target market size: 22-24 g/shrimp
- Production approach: staggered cohorts with potential weekly or bi-weekly harvests
- Cycles per year: 15 full production cycles after full ramp-up period (nursery + grow-out)
- Accumulated Survival rate: 50% from PL to harvest
- Target eFCR: 1.9 kg feed/kg shrimp
- Average stocking density: up to 15 kg/m<sup>3</sup> in grow-out at peak biomass

These parameters form the basis for tank sizing, water volume, RAS component selection and utility dimensioning for the module.

## Layout and Zoning

The 100 t module is organised into clearly defined functional zones to ensure efficient operations and robust biosecurity:

- External and logistics zone: vehicle access, raw material reception, product dispatch.
- Controlled access zone: staff entrance, hygiene facilities, storage and technical rooms.
- Production zone: nursery and grow-out area, and associated RAS technical spaces.
- Post-harvest zone: harvest handling, chilling and packing.

Internal flows for staff, water, feed, animals and harvested product are designed to be unidirectional, minimising cross-contamination and simplifying hygiene procedures. High-risk activities (e.g. waste handling, live animal reception) are physically separated from clean areas.

## Process Flow and Core RAS Components

The 100 t module follows a standardised RAS process flow, from PL reception through to harvest:

1. PL reception and acclimation – controlled introduction of certified PL from approved hatcheries.
2. Nursery phase - early rearing in smaller tanks with higher temperatures and intensive control.
3. Grow-out phase - transfer to dedicated grow-out tanks for on-growing to market size.
4. Harvest - biomass removal and grading.
5. Chilling and packing - cooling, packing and preparation for distribution.

Core RAS components include:

- Smaller round water tanks, dedicated for nursery / quarantine of PLs (post-larvae);
- Larger round water tanks for grow-out period (specially designed to increase surface area);
- Drum filter for filtering out solid waste (e.g. uneaten feed and feces);
- Settling tank for allowing heavier solids to settle;
- Protein skimmer or Foam Fractionators for removing dissolved organic matter from water;

- Biofilter (using beneficial bacteria) for converting toxic ammonia (NH3) and nitrite (NO2) into less harmful nitrate (NO3)
- UV Sterilizer for killing bacteria and viruses;
- Ozone generator for oxidize contaminants and pathogens;
- Oxygenation and Aeration units for introducing air or pure O2, dissolving O2 and increasing dissolved O2 levels;
- Circulation pumps for moving water at high rates through the system;
- Automated feeding system for precision feed distribution;
- Monitoring and Control systems for continuous monitoring and adjusting pH, temperature, ORP, dissolved oxygen.
- Smart AI based monitoring systems for measuring stress levels, counting individuals and biomass assessment in real time.

Peripheral technology related components:

- Salting (mineralization) tank;
- Heat pumps for providing heating;
- HVAC equipment (Heating, ventilation, air-conditioning);
- Operation Tank for collecting harvest water and resupply back to the system;
- Shrimp sorting and processing machine;
- Packaging equipment.

### Biosecurity, Health and Welfare Concept

The 100 t module is designed around preventive biosecurity and stable culture conditions:

- Controlled PL sourcing with defined health status and documented traceability.
- Zoning, access control and hygiene barriers (e.g. dedicated changing areas, footbaths).
- Defined SOPs for cleaning, disinfection and waste handling.
- Backup systems for power and oxygen to protect stock during emergencies.

Animal health and welfare are supported by:

- Stable water quality parameters within narrow limits for DO, pH, TAN, nitrite, temperature and salinity.
- Low-stress handling procedures and harvesting protocols.
- Regular health monitoring and record-keeping aligned with veterinary guidance.

### Operational Parameters and Utilities

The 100 t module is dimensioned for efficient use of water, energy and labour while maintaining high production reliability:

System Design	
Total System Water Volume (m3)	~2100
Daily New Water Intake (% of total volume)	0.7 - 1
Max. Stocking Density (kg/m3)	15
Water Recirculation Rate (%)	~95-98
Constant Electricity Requirement (KWH)	90
Staffing Required	6

Operational KPIs	
Weekly Growth Rate (g/week)	1.8-1.9
Accumulated Survival (%)	>50%
eFCR	<1.9

### 6.2.3 Production Model for the 100 t Module

#### Production Cycle Structure

The 100 t module is operated according to a planned, repeatable production cycle that balances biological performance, operational simplicity and market supply stability. The model is based on 15 production cycles per year, combining a nursery phase of approximately 19-21 days with a grow-out phase of around 80-84 days, resulting in a total culture period of 100-110 days from PL to harvest.

The intended stocking approach is to utilize staggered stocking with overlapping cohorts, enabling near-continuous harvests and smoother utilisation of processing and logistics. The production calendar is planned to achieve a relatively even weekly or monthly output, aligned with downstream customer requirements and logistics windows.

#### Stocking, Growth and Harvest Strategy

Stocking in the 100 t module is based on certified PL with a target starting weight of 4 mg and an initial stocking density of 0.1 kg/m<sup>3</sup>. Growth is modelled using a standard growth curve, targeting a final market weight of 22-24 g over the culture period.

The harvest strategy is designed to support both operational efficiency and market responsiveness. In the base model, each cohort is harvested through weekly or bi-weekly, delivering a steady stream of product while avoiding excessive peak biomass and maintaining water quality margins. Where required by specific clients, grading can be applied to create defined size classes, with by-products and sub-sizes directed to value-added or secondary channels.

#### Feed and FCR Assumptions

Feed strategy in the 100 t module is built around high-quality RAS-compatible shrimp feeds sourced from reputable suppliers, with formulations designed for low waste, good digestibility and stable water quality. The base model targets an eFCR of 1.8-1.9 kg feed/kg shrimp, corresponding to an annual feed consumption of approximately 190 t/year per 100 t module at full production.

Feeding is performed using automated belt feeders or central automated feeding system with SOPs for multiple small meals throughout the day and/or night, adjusted based on biomass estimates, behaviour and feed trays/feedback. Continuous monitoring of FCR, growth and

water quality is used to fine-tune feeding regimes and identify performance deviations early. These feed and FCR assumptions are directly linked into the financial model and are key drivers of operating cost per kg.

#### 6.2.4 Conceptual Design for 1,000 t/year Facility (Germany)

##### Scaling Logic and Design Philosophy vs 100 t Module

The proposed 1,000 t/year facility in Germany represents a step from modular pilot- and mid-scale operations to a fully industrial-scale platform. While it builds directly on the biological and operational experience of the 100 t module, it does not simply replicate ten identical modules. Instead, the design employs:

- Potentially larger grow-out tank volumes and optimised tank group layouts
- More extensive centralisation of water treatment, oxygenation and monitoring systems
- A higher degree of automation in feeding, data collection and alarm management

The guiding logic is to maintain the proven RAS principles and biosecurity framework from the 100 t design, while re-configuring the physical layout and equipment scale to achieve economies of scale and fit the spatial, regulatory and logistics context of the German site.

##### High-Level System Design and Layout

At a high level, the 1,000 t facility consists of multiple production halls organised around shared RAS technical centres and post-harvest infrastructure:

- Production halls housing large grow-out tanks and associated nursery systems, grouped into biosecurity units.
- Central RAS technical rooms in each hall (or cluster of halls), hosting pumps, mechanical filters, biofilters, degassers and oxygenation units.
- A central utility spine for oxygen, power, control and communication.
- A dedicated processing, chilling and packing area designed for continuous or near-continuous throughput at full capacity.
- Clearly separated flows for staff, raw materials, live shrimp, harvested product and waste streams.

The layout is designed to support:

- Robust biosecurity zoning at hall and site level
- Efficient internal logistics (short distances for feed delivery and harvest removal)
- Potential future integration of geothermal and other sustainability features (addressed in a separate section)

##### Operational Concept and Economies of Scale

Operationally, the 1,000 t facility applies the same production logic as the 100 t module—controlled RAS environment, defined growth cycles, premium product specification—but at much larger scale:

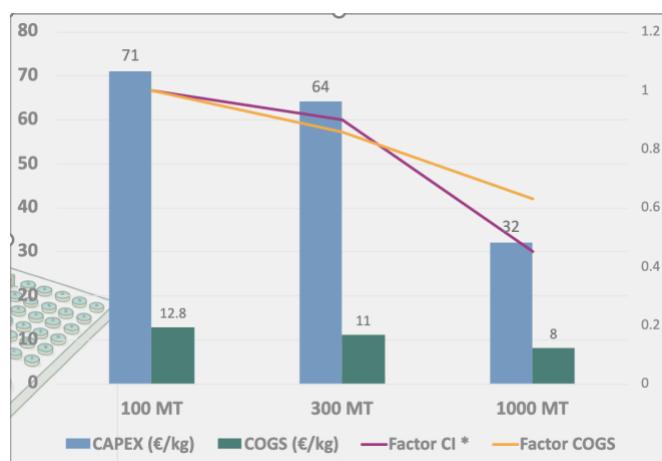
- Higher level of automation in feeding, monitoring and alarm management, reducing labour per tonne.
- Centralised data systems enabling detailed performance tracking by hall/cohort and continuous improvement.
- Optimised staffing model, with specialised roles for production, technical, quality and planning, and a significantly lower FTE per tonne ratio than in the 100 t module.

- Enhanced maintenance planning and redundancy to keep critical systems operational at all times.

From a financial perspective, the 1,000 t facility is expected to benefit from:

- Lower unit CAPEX per installed tonne (€/t) compared to smaller sites.
- Lower operating cost per kg for key cost categories (labour, energy, some overheads).
- Stronger commercial position, with sufficient volume to secure long-term B2B relationships and support branded premium offerings.

These economies of scale are captured in the financial model and further discussed in the Financial Plan section, while the present section focuses on the conceptual technical foundations for achieving them.



### Implementation and Interface with Other Sections

The RAS designs and production models outlined above form the technical backbone of Akola's project. They interface directly with:

- The Market Analysis and Product Strategy, which defines target segments, product forms and size ranges that the production system is engineered to supply.
- The Resource and Sustainability Integration section, which builds on the baseline RAS design to incorporate geothermal integration and other resource-efficiency measures.
- The Financial Plan, which uses consolidated 1300 t production from 2 facilities concept to derive CAPEX budgets, operating cost structures and scenario analyses.

Together, these sections provide a coherent picture of how Large Scale RAS shrimp facilities should be designed, built and operated to deliver premium, sustainable shrimp at scale to EU markets.

## 7. Resource and Sustainability Integration

### 7.1 Purpose and Scope of Resource Integration

Akola's RAS shrimp platform is designed not only for biological and economic performance, but also for a step change in resource efficiency versus conventional shrimp supply chains. This section describes how the project considers the possibility to integrate geothermal resources into the RAS facility concept, with two complementary use cases:

Pilot 2 - Use of diluted geothermal brine as part of production water, tested at the Klaipeda Pilot 2 site, and

Geothermal heat integration, evaluated through a desk study for the large-scale facility.

**The scope of this section is to:**

- Summarise the baseline energy, water and mineralization footprint of a conventional, non-geothermal RAS operation.
- Describe the technical concepts for geothermal brine and heat integration.
- Outline the expected sustainability benefits (energy, CO<sub>2</sub>, water, chemicals) and key uncertainties.

### 7.2 Baseline Resource Profile (Non-Geothermal RAS)

In the base case, without geothermal integration, the 100 t module and the 1,300 t multi-site platform rely on conventional utilities:

- Heat supply: Usually the electric heat pumps to maintain process water at 28-29 °C.
- Electricity: from solar panels and from the grid, covering pumping, aeration/oxygenation, filtration, lighting and control systems.
- Water supply: municipal or well water, conditioned to the required salinity and quality, with typical make-up rates of 0.7-1.5% of system volume per day.
- Salt and other minerals: for the required salinity and other essential ion balance

Based on the engineering design, the indicative yearly energy consumption for water heating is approximately 2500 MW/h for a 1000 t facility at steady-state operation, translating to 2.5 KWH/kg.

### 7.3 Geothermal Brine Integration – Pilot 2 Concept

#### Concept and Objectives

Pilot 2 explored the use of diluted geothermal brine as part of production water for RAS shrimp, leveraging an existing geothermal well at Klaipeda site. The geothermal resource provides:

- Part of process water with salinity of 110 ppt, and
- A high mineral content that, if properly managed, may partially reduce the need for added salts and minerals.

The objectives of Pilot 2 were to:

- Evaluate biological, economical, technical aspects of geothermal brine use in RAS

- Quantify effects on growth, survival and health versus conventional make-up water.

### Technical Integration and Treatment Train

The geothermal brine is integrated upstream of the RAS make-up water system, with the following main steps:

- Transportation from geothermal powerplant's reservoir at salinity of 110 ppt.
- Pre-treatment was not needed as the lab testing of geothermal brine showed good results, suitable for human consumption.
- Blending and dilution with freshwater to reach the target culture salinity of 15-20 ppt and acceptable ion balance for shrimp.

Key design tasks include:

- Establishing acceptable ranges for critical ions (e.g.  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Sr}^{2+}$ , heavy metals) and comparing geothermal brine composition to shrimp tolerance.

### Expected Benefits and Risks

If successful, geothermal brine integration can deliver:

- Reduced the need for salt and other essential minerals (some minerals already present in brine).
- A differentiated sustainability story ("geothermal RAS shrimp") with strong marketing value.

Key risks and uncertainties to manage:

- Long-term effects of trace elements and scaling on system components and animal health.
- Operational complexity of pre-treatment (if needed) and blending at industrial scale.
- Regulatory approval for using geothermal brine in food production and for discharge (if applicable).

## 7.4 Geothermal Heat Integration – Desk Study Concept

Geothermal heat is considered as a strategic option to reduce the thermal energy cost and  $\text{CO}_2$  footprint of large scale RAS shrimp facilities. Rather than focusing on a specific geothermal well, the project evaluates any potential site in terms of:

- Geothermal water temperature at surface ( $^{\circ}\text{C}$ )
- Sustainable flow rate ( $\text{m}^3/\text{h}$ )
- Utilisation capacity (share of RAS heat demand that can be covered)
- Distance and connection options between the geothermal source and the RAS facility

This subsection outlines a generic evaluation framework that can be applied to candidate sites during project development in different regions.

### Heat Demand and Geothermal Supply

The first step in evaluating geothermal heat potential is to understand the heat demand profile of the RAS facilities, independent of any specific site.

The desk study evaluates how geothermal heat could substitute conventional heat sources for maintaining RAS water at 28-29  $^{\circ}\text{C}$ . For the 1000 t German site, the annual water heating demand is estimated at around 2500 MWh/year, driven mainly by:

- Heat for supply water heating.
- Heat to cover surface heat loss.
- Heating for constant water temp.

### Geothermal Resource Quality and Integration Concepts

On the supply side, geothermal resources are classified in terms of resource quality and suitability for direct use or heat-pump-assisted configurations. Key parameters:

- Outlet temperature at surface (°C)
- Sustainable flow rate (m<sup>3</sup>/h or kg/s)
- Thermal capacity (kW = flow × temperature difference × specific heat)
- Chemical composition (scaling, corrosion potential)
- Distance to RAS facility and feasibility of a pipeline corridor
- Operational availability (hours/year, redundancy, maintenance requirements)

For planning purposes, Akola uses a generic classification of geothermal resources:

Table 3. Generic Geothermal Resource Quality Classes

Class	Temperature range (°C)	Typical use configuration	Indicative share of RAS water heat demand that could be covered* (%)
<b>Low-quality resource</b>	15-25	Heat pump required, geothermal as source	20-40
<b>Medium-quality</b>	25-60	Direct low-T heat +/- heat pump	40-70
<b>High-quality</b>	60+	Direct use with simple exchangers	70-100

\* Actual coverage depends strongly on flow rate, distance, and detailed design; the percentages above are indicative planning ranges.

Two generic integration concepts are evaluated for any potential site:

1. Direct-use integration
  - Geothermal water passes through plate heat exchangers, transferring heat to a closed secondary loop feeding RAS heat exchangers.
  - Feasible where geothermal outlet temperature significantly exceeds culture temperature and flow rate is sufficient.
2. Geothermal-assisted heat pump
  - Geothermal water serves as a stable heat source for high-efficiency heat pumps, upgrading low/medium temperature resources to the required level.
  - Particularly suitable where temperatures are moderate but highly stable, and where electricity prices and CO<sub>2</sub> factors reward a higher COP.

#### 7.4.1 Scenario-Based Impact of Geothermal Heat Integration

Instead of committing to a single site, Akola evaluates geothermal heat integration using generic scenarios representing different resource quality levels. Each scenario is defined by:

- Resource class (low / medium / high quality)
- Assumed share of heat demand covered (%)
- Impact on electricity use, specific energy (kWh/kg).

This approach allows the project to quantify the range of possible benefits and to test robustness in the financial model, while keeping the door open to multiple geographic options.

*Table 4. Indicative Geothermal Heat Scenarios (1,000 t Facility Example)*

Scenario	Resource class	Share of heat demand covered (%)	Impact on electricity for heating	Specific energy for water heating (kWh/kg)*
Baseline (no geothermal)				0.56
Scenario 1 – Low-quality geo	Low-quality resource	30	-30	0.39
Scenario 2 – Medium-quality geo	Medium-quality	60	-60	0.22
Scenario 3 – High-quality geo	High-quality resource	90	-90	0.06

For scenario analysis, we assume that the share of heat demand covered by geothermal heat (30/60/90%) translates linearly into the same share reduction in electricity for heating, based on a baseline heat pump COP of approximately 4.5 and an electricity price of 0.25 €/kWh. In detailed engineering, these estimates must be refined to account for the efficiency of geothermal-assisted heat pumps and any electricity used by geothermal pumping.

For the purpose of this business-plan level analysis, geothermal heat is treated as a zero-marginal-cost energy source for the RAS facilities. In other words, we assume that the thermal energy delivered to the shrimp farm is effectively “free” at the point of use, because it is supplied either as cascaded heat from an upstream geothermal application (e.g. district heating, spa, greenhouse) or as otherwise unused waste heat from an existing geothermal installation. Under this simplifying assumption, any share of the RAS heat demand that is covered by geothermal heat (30/60/90% in the scenarios) is assumed to displace an equivalent share of electricity-based heat, and the net cost of geothermal-side pumping and auxiliaries is neglected at this stage. These assumptions must be revisited and refined during front-end engineering once specific geothermal partnerships and site configurations are defined.

## 8. Financial Plan

This chapter presents the financial profile of the Project's multi-site RAS shrimp platform, consisting of:

- Two facilities in Klaipeda (Lithuania) with a combined capacity of 300 t/year (100 t + 200 t), and
- One 1,000 t/year facility in Germany (Berlin region).

Together, these facilities form a consolidated platform with 1,300 t/year total capacity. All projections are based on a detailed 11-year consolidated financial model (P&L, balance sheet, cash flow, funding, ratios and valuation).

While the model covers all three sites, the German 1,000 t facility is treated as the core large-scale reference unit for the TETRAS deliverable, with Klaipeda acting as a stepping-stone and learning platform that should de-risk technology and market entry.

### 8.1 Required Investment

The development of Akola's multi-site RAS shrimp platform requires a substantial upfront capital investment to establish a 300 t/year facility in Klaipeda and a 1,000 t/year flagship facility in Germany. The total CAPEX covers Growing Area Building, Energy Infrastructure, Ventilation, Office, Warehouse, Storage, Territory Infrastructure, Water and Technology categories. The following subsection summarises the total required investment by facility and illustrates the internal CAPEX structure for each site, providing a clear view of the capital intensity, cost drivers and relative scale of Klaipeda versus Germany.

Required CAPEX (€)	Klaipeda (300 t)	Germany (1000 t)	Combined (1300 t)
Growing Area Building	2,940,000	5,600,000	8,540,000
Solar panels + Heat Pumps	750,000	1,714,286	2,464,286
Ventilation	300,000	600,000	900,000
Office, warehouse, feed storage etc.	348,000	720,000	1,068,000
Territory infra	350,000	350,000	700,000
Water + waste water mngmt. infra.	150,000	350,000	500,000
Technology	12,600,000	19,751,309	32,351,309
<b>TOTAL</b>	<b>19,181,800</b>	<b>31,994,154</b>	<b>51,200,000</b>

Total Capital expenditure for the whole Platform comes to:

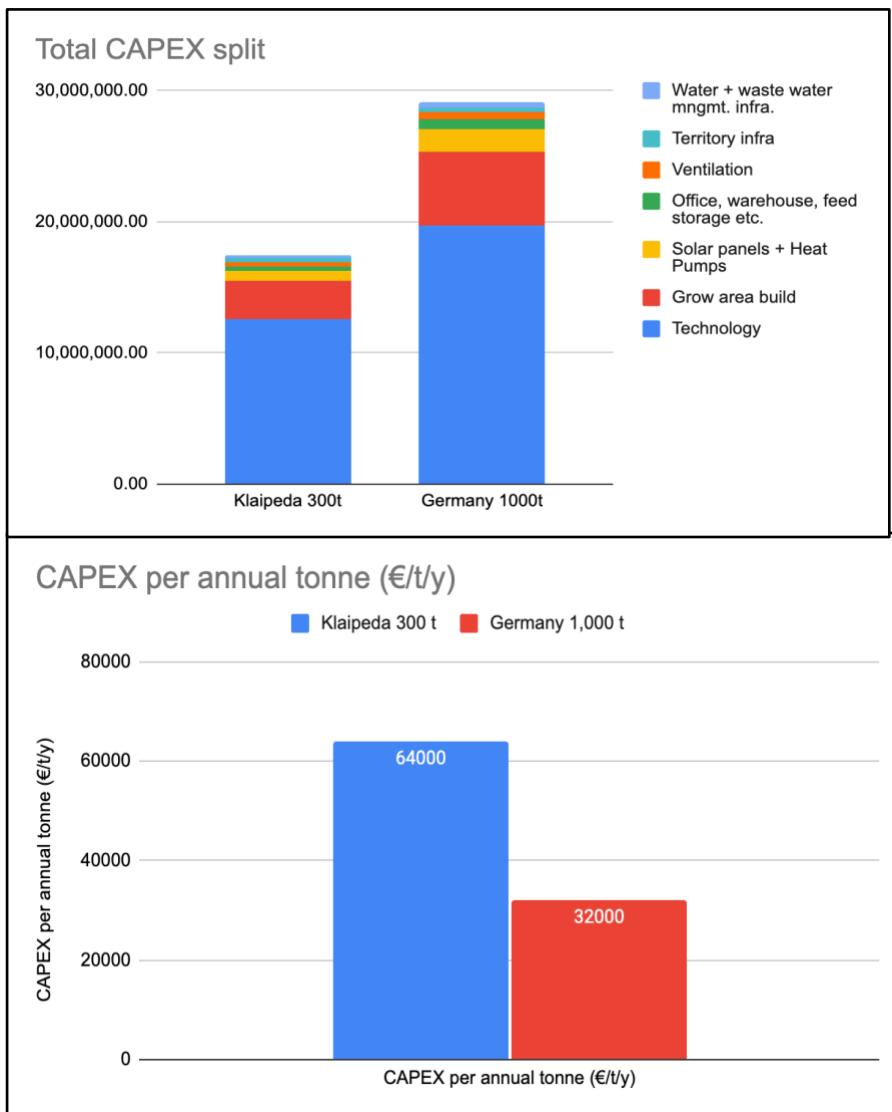


Figure 2. TOTAL CAPEX per ANNUAL TONE

## 8.2 Financial Overview – Consolidated 1,300 t Platform

The implementation plan is phased to reflect a realistic roll-out and learning curve:

- **Year 0:** First funding round and construction of the initial 100 t facility in Klaipeda.
- **Year 1:** First commercial year, with consolidated production of 50 t, corresponding to roughly 50% utilisation of the first 100 t Klaipeda module.
- **Year 2:** Consolidated production rise to 260 t, reflecting full utilisation of the 100 t facility and partial utilisation of the subsequent 200 t facility in Klaipeda.
- **Year 3:** Consolidated production jump to 1000 t, comprising 100% output from Klaipeda (300 t) and ramped output from the new German 1,000 t facility (approx. 70% utilisation).
- **Year 4 onwards:** Consolidated production reach 1300 t, with all three facilities at 100% capacity (Klaipeda 300 t + Germany 1,000 t).

At consolidated steady state (from Year 4 onwards), the platform is expected to generate annual revenues of approximately €25.5 million, with an EBITDA margin of around 50% and an EBIT of 33%. Over the 11-year horizon, cumulative operating cash flows are sufficient to service debt, recover total capex and deliver attractive returns to equity investors.

Total project capital expenditure across all three facilities is estimated at €51 million. In the base case, the consolidated platform yields a project IRR of 17.5% and an equity IRR of 26.7%, with a payback period of around 5 years from the start of construction.

### 8.3 Key Assumptions and Drivers

The financial model is underpinned by a coherent set of assumptions that link the Market Analysis, technical design and financing structure.

#### Market & price assumptions

- Premium serviceable available market (SAM) for vannamei shrimp in Akola's target region (Europe): 21,000 t/year.
- Consolidated volume at maturity: 1,300 t/year, equal to approximately 6% of the relevant premium SAM.
- Average blended farm-gate selling price across the platform (fresh + frozen, all channels):
  - Early stage fresh shrimp average price: €32/kg.
  - Early stage frozen shrimp average price: €20/kg.
  - **Base case at maturity: €19/kg.**
  - Fresh shrimp average price: €20/kg.
  - Frozen shrimp average price: €18/kg.

#### Product mix assumptions

- Klaipeda (300 t/year):
  - 100% of output sold as fresh shrimp at maturity (0% frozen).
- Germany (1,000 t/year):
  - 90% fresh (900 t/year),
  - 10% frozen (100 t/year).

Consolidated at maturity, the platform therefore produces approximately 1,200 t/year fresh and 100 t/year frozen, i.e. around 92% fresh and 8% frozen by volume, with pricing differentiated accordingly in the model.

#### Operational assumptions

- Consolidated volume ramp:
  - Year 1: 50 t
  - Year 2: 260 t
  - Year 3: 1000 t
  - Year 4+: 1300 t
- Minimum expected biological survival rate (across facilities): 48%.
- Economic Feed conversion ratio (eFCR): 1.9 kg feed per kg shrimp.

#### Financial assumptions

- General inflation: 2%/year.
- Feed price escalation: 3%/year.
- Energy price escalation: 2%/year.
- Corporate tax rate: 15%.
- Discount rate (WACC) for valuation: 11.7%.

## 8.4 Revenue Model and Unit Economics

### 8.4.1 Revenue Development and Roll-out Logic

Revenues are driven by the phased commissioning of facilities, the volume ramp described above, and the fresh vs frozen product mix.

- In Year 1, only the first Klaipeda facility contributes, with net sales of 50 t at an average blended price of €26/kg, resulting in revenues of approximately €1.6 million.
- In Year 2, full output from the 100 t Klaipeda module and partial output from the 200 t module yield consolidated sales of 260 t, at an average price of €26/kg, for revenues of €8.08 million.
- In Year 3, the 1,000 t German facility enters at partial utilisation, bringing consolidated sales to 1000 t, with a blended price of €18/kg and revenues of €19.5 million.
- From Year 4 onward, all three facilities operate at full capacity, delivering 1300 t per year, at a blended price of €18/kg, and revenues of around €25.5 million per year.

Volumes at maturity are split as:

- Fresh shrimp: ~1,200 t/year, at an average price of €20/kg.
- Frozen shrimp: ~100 t/year, at an average price of €18/kg.

### 8.4.2 Unit Economics at Maturity (Consolidated per kg)

At consolidated steady state, the platform achieves an average selling price of €19 per kg and a total cash cost of €13.8 per kg, yielding an EBITDA of €13.8 per kg and an EBITDA margin of 52-54%.

**The per-kg cost stack is composed of:**

- Feed
- Post-larvae (PL)
- Energy and utilities
- Labour: approx.
- Other variable costs: approx.
- Allocated fixed overheads

*Table 5. Unit Economics at Maturity (Consolidated per kg).*

€ / kg	Year 4 snapshot
<b>Feed</b>	2.5
<b>Post-larvae</b>	1.2
<b>Utilities &amp; Consumables</b>	1.9
<b>Fixed Overheads</b>	2.1
<b>Depreciation &amp; Financing</b>	5.4
<b>Processing Cost of Shrimp (Input Basis)</b>	13.7 - 14

## 8.5 Projected Financial Statements (11-Year Consolidated)

The following subsections present condensed versions of the consolidated 11-year P&L, cash flow statement and balance sheet for the three-facility platform.

### 8.5.1 Condensed Profit & Loss (Consolidated)

The consolidated P&L reflects the gradual transition from early-stage losses to stable profitability at full capacity. In Year 1 and Year 2, EBITDA is €0.04 million and €4.30 million respectively, as fixed costs are spread over limited volumes. From Year 2 EBITDA increases in line with volumes and margin improvement, reaching €13.8 million at maturity, corresponding to an EBITDA margin of 52-54%.

Net income follows a similar pattern, lagging EBITDA due to depreciation and interest charges. Net profit turns positive in Year 2 and stabilises at around €6 million per year in the later years of the projection.

*Table 6. Condensed P&L (Consolidated, Base Case)*

m. €	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Revenue</b>	1.6	8.08	19.52	25.52	25.52
<b>Total COGS</b>	(0.67)	(2.56)	(7.46)	(8.91)	(8.91)
<b>Gross Profit</b>	0.93	5.52	12.06	16.61	16.61
<b>Total Overheads</b>	(0.90)	(1.22)	(2.69)	(2.79)	(2.79)
<b>EBITDA</b>	0.04	4.31	9.36	13.81	13.81
<b>EBIT</b>	0.04	3.43	6.85	9.09	9.09
<b>NP</b>	(0.12)	2.64	5.33	5.75	5.83

### 8.5.2 Cash Flow Overview (Consolidated)

The consolidated cash flow statement combines operating cash flows, capex, debt drawdowns and debt service to show the overall financing needs and value creation over time.

- In Years 0 to 1, cash flows are negative, driven by capex disbursements and limited revenues.
- As volumes ramp and EBITDA turns positive, operating cash flows improve and become sufficient to cover debt service and ongoing maintenance capex.
- Free cash flow to equity becomes consistently positive from Year 3 onwards, allowing for distributions or reinvestment.

Table 7. Cash Flow Summary (Consolidated, Base Case)

€ m.	Year 0	Year 1	Year 2	Year 3	Year 4
<b>Cashflow</b>	(0.3)	(0.4)	2.4	5.7	9.4
<b>Free Cash Flow</b>	(4.6)	(6.0)	(13.7)	(19.7)	9.4
<b>Free Cash Flow to Equity</b>	(2.5)	(4.1)	(10.8)	4.9	7.9
<b>Unlevered Free Cash Flow</b>	(4.6)	(5.8)	(13.5)	(19.2)	11.3

### 8.5.3 Balance Sheet Snapshot (Consolidated)

The projected balance sheets reflect the build-up and subsequent depreciation of fixed assets, the evolution of working capital and the gradual reduction of debt.

Table 8. Balance Sheet Summary (Selected Years)

€ m.	Year 0	Year 1	Year 2	Year 3	Year 4
<b>Fixed Assets</b>	4.4	10.0	25.5	48.7	44.3
<b>Current Assets</b>	-	0.3	3.5	8.0	14.2
<b>Total Assets</b>	4.4	10.3	29.0	56.7	58.5
<b>Non-Current Liabilities</b>	2.2	4.0	6.9	31.5	30.0
<b>Current Liabilities</b>	-	0.3	0.7	1.2	1.5
<b>Total Liabilities</b>	2.2	4.3	7.6	32.7	31.6
<b>Total Equity</b>	2.2	6.0	21.4	24.1	26.9

## 8.6 Performance Ratios and Valuation

### 8.6.1 Key Financial Ratios (Consolidated)

The consolidated model calculates standard liquidity, leverage and profitability ratios, which are important for lenders and investors.

Table 9. Selected Financial Ratios (Consolidated, Base Case)

	Year 0	Year 1	Year 5	Year 11
<b>Current Liquidity Ratio (Current Assets/Current Liabilities)</b>	-	1.0	4.6	2.8
<b>Cash Ratio (Cash Eq./Current Liabilities)</b>	-	-	3.0	2.2
<b>Operating Cashflow Ratio (CFO/Current Liabilities)</b>	-	(1.3)	3.4	1.5
<b>Debt to Equity Ratio (Total Liabilities/Shareholders' Equity)</b>	1.0	0.7	1.0	0.3
<b>Gross Margin (GP/Revenue)</b>	0.0%	58.1%	65.1%	65.1%
<b>Return on Invested Capital (NOPAT/Dedicated Assets)</b>	-5.3%	0.3%	17.2%	38.8%

## 8.7 Scenario and Sensitivity Analysis

### 8.7.1 Scenario Analysis – Base, Downside and Upside Cases

To assess the robustness of the multi-site 1,300 t platform (Klaipeda 300 t + Germany 1,000 t), Akola has applied a structured three-scenario framework: Base Case, Downside Case and Upside Case. Each scenario adjusts a small number of key drivers - primarily selling prices, input costs and ramp-up dynamics - while keeping the overall technical and market concept unchanged.

#### Scenario Definitions

##### Base Case

The Base Case reflects Akola's central view of market and operating conditions. It is fully consistent with the assumptions presented in other sections.

Key elements include:

- Consolidated volume ramp of 50 t in Year 1, 260 t in Year 2, 1000 t in Year 3 and 1300 t in Year 4 onward.
- Average blended selling price at maturity of €18/kg, based on a mix of fresh and frozen premium shrimp across retail, HORECA and distribution channels.
- Feed, energy and labour costs as per the base assumptions.
- Resulting project IRR of 17.5%, equity IRR of 26.7%, project NPV of €75 million (Years 0–11 cash flows; no terminal value) and payback period of 5 years.

The Base Case therefore serves as the reference against which the Downside and Upside Cases are compared.

##### Downside Case

The Downside Case reflects a combination of less favourable market and cost conditions that are still considered plausible under current industry dynamics. It is designed to test whether the project remains viable under stress.

Relative to the Base Case, the Downside Case assumes:

- Lower price realisation: average selling prices 10% below Base (e.g. weaker premium uptake or more persistent discounting).
- Higher input costs: feed costs 10% higher and energy costs 15% higher than Base.
- Slightly slower ramp-up: consolidated volumes in the first years reduced by approximately 10-20% versus Base, with 1,300 t/year reached one year later or at slightly lower utilisation.
- Lower than anticipated FCR figure by 15%.

Under these combined stresses, the project IRR decreases to 4.7%, equity IRR to 2.8% and project NPV to €47 million (Years 0–11 cash flows; no terminal value), with a payback period of 8.2 years. Importantly, EBITDA remains positive at maturity with a margin of approximately 44%.

#### Upside Case

The Upside Case illustrates the potential value enhancement if the project outperforms the Base Case on price realisation, cost efficiency and/or ramp-up.

Relative to the Base Case, the Upside Case assumes:

- Stronger premium realisation: average selling prices 10% above Base (e.g. higher share of fresh, stronger brand positioning and sustained premium in key markets).
- Improved cost efficiency: reduced energy costs by 15% versus Base; modest feed efficiency and procurement gains equivalent to 5% lower feed costs.
- Slightly faster or smoother ramp-up: volumes reach 1,300 t/year in line with or slightly ahead of Base, with higher utilisation of premium channels at maturity.
- Better FCR than anticipated, lower by 10%.

In this scenario, project IRR increases to 29.1%, equity IRR to 45.1% and project NPV to €99 million (Years 0–11 cash flows; no terminal value), with a payback period shortened to approximately 3.6 years. EBITDA margins at maturity improve to around 60%, demonstrating the upside potential of strong commercial execution and successful geothermal integration.

#### 8.7.2 Scenario Comparison

Table 10 summarises the impact of the three scenarios on key financial metrics. The analysis shows that the project is most sensitive to changes in selling prices and feed/energy costs - as is typical in intensive aquaculture - but remains economically viable under a conservative Downside Case, while offering attractive upside in the case of stronger price realisation and cost savings.

Table 10. Scenario Comparison (Key Financial Metrics)

Metric	Downside	Base Case	Upside
Project IRR (%)	4.7	17.5	29.1
Equity IRR (%)	2.8	26.7	45.1

Project NPV Year 0 – Year 11 (€m, avg. 11.7% WACC)	47	75	99
EBITDA margin at maturity (%)	44	54	60
Payback period (years)	8.2	5	3.6

Table 11 summarises the key drivers that impact the Downside and Upside scenarios in comparison to Base Case.

Table 11. Scenario Drivers (Relative to Base Case)

Driver	Base Case	Downside Case	Upside Case
Average selling price	1.00x	0.90x (-10%)	1.10x (+10%)
Ramp volume (Y1–Y3)	1.00x	0.80–0.90x (slower ramp)	1.05x (slightly faster / smoother)
Feed cost per kg	1.00x	1.10x (+10%)	0.95x (-5%)
FCR (feed conversion ratio)	1.00x	1.15x	0.90x
Energy cost	1.00x	1.15x	0.85x
Total capex	1.00x	1.15x (+15% overrun)	0.90x

Overall, the analysis shows that project returns are most sensitive to changes in selling price, feed cost and energy cost, which is typical for intensive aquaculture, while ramp-up speed and capex overruns mainly affect the timing rather than the existence of value. The combination of a robust Base Case, a still-viable Downside Case and a highly attractive Upside Case supports the conclusion that the large-scale RAS shrimp platform offers a favourable risk–return profile, provided that disciplined execution on premium market positioning, cost control and stable biology is maintained.

### 8.7.3 Sensitivity Analysis

To complement the scenario analysis, Akola has performed a one-way sensitivity analysis on the consolidated 1,300 t platform, varying one key driver at a time while keeping all other assumptions at their Base Case levels. This approach highlights which variables have the greatest impact on project value and where risk management and optimisation efforts should be focused.

#### Methodology and Key Drivers

The sensitivity analysis is based on the same free cash flow to firm (FCFF) and valuation framework described in other sections, using a benchmark discount rate of 11.7% and the

Base Case production ramp (50 / 260 / 1,000 / 1,300 t). For each driver, Akola evaluates the impact of a  $\pm 10\%$  change relative to the Base Case, and, where relevant, an additional stress at  $\pm 20\%$ , on two headline metrics:

- Project NPV (€, 11.7% WACC) (Years 0–11 cash flows; no terminal value)
- Project IRR (%)

The following drivers are tested:

**1. Average selling price (€/kg)**

- Captures the combined effect of premium realisation, channel mix (fresh vs frozen) and market conditions.

**2. Feed cost**

- Reflects both feed price, the dominant operating cost in intensive shrimp RAS.

**3. Feed conversion ratio (FCR)**

- Reflects the biology side of the operation and how well the system converts the feed to biomass.

**4. Energy cost**

- Represents electricity and other energy inputs.

**5. Total capital expenditure (capex)**

- Tests the impact of construction cost overruns or savings across all three facilities.

For each driver, the Base Case input is adjusted by  $-10\%$ ,  $-5\%$ ,  $+5\%$  and  $+10\%$ , holding all other assumptions constant, and the resulting NPV and IRR are recorded.

#### Sensitivity Analysis Results

Table 12 summarises the impact of a  $\pm 10\%$  change in each key driver on Project NPV and Project IRR, relative to the Base Case.

*Table 12. Impact of  $\pm 10\%$  Changes in Key Drivers (vs Base Case)*

Driver	Change vs Base	Project NPV in 11 year period (€m, avg. 11.7% WACC)	$\Delta$ NPV vs Base (€, m) 75.6	Project IRR (%)	$\Delta$ IRR vs Base (pp) 17.5
Average selling price	-10%	61.7	13.9	12.3	5.2
	+10%	88.2	-12.6	22.3	-4.8
Feed Cost	-10%	77.2	1.6	18.2	0.7
	+10%	73.9	-1.7	16.8	-0.7
FCR	-10%	77.2	1.6	18.2	0.7

	+10%	73.9	-1.7	16.8	-0.7
<b>Energy cost</b>	-10%	76.1	0.5	17.8	0.3
	+10%	75	-0.6	17.2	-0.3
<b>Total capex</b>	-10%	84.7	9.1	20.6	3.1
	+10%	67.2	-8.4	14.8	-2.7
<b>Volume at maturity (t/year)</b>	-10%	62.4	-13.2	13.4	-4.1
	+10%	87.7	12.1	21.2	3.7

On this basis, a tornado chart is constructed using the absolute NPV change ( $\Delta$ NPV vs Base) for each driver, ranking them from the most impactful to the least. Typically, average selling price and feed cost sit at the top, followed by capex and volume, with energy costs also material but of slightly smaller magnitude.

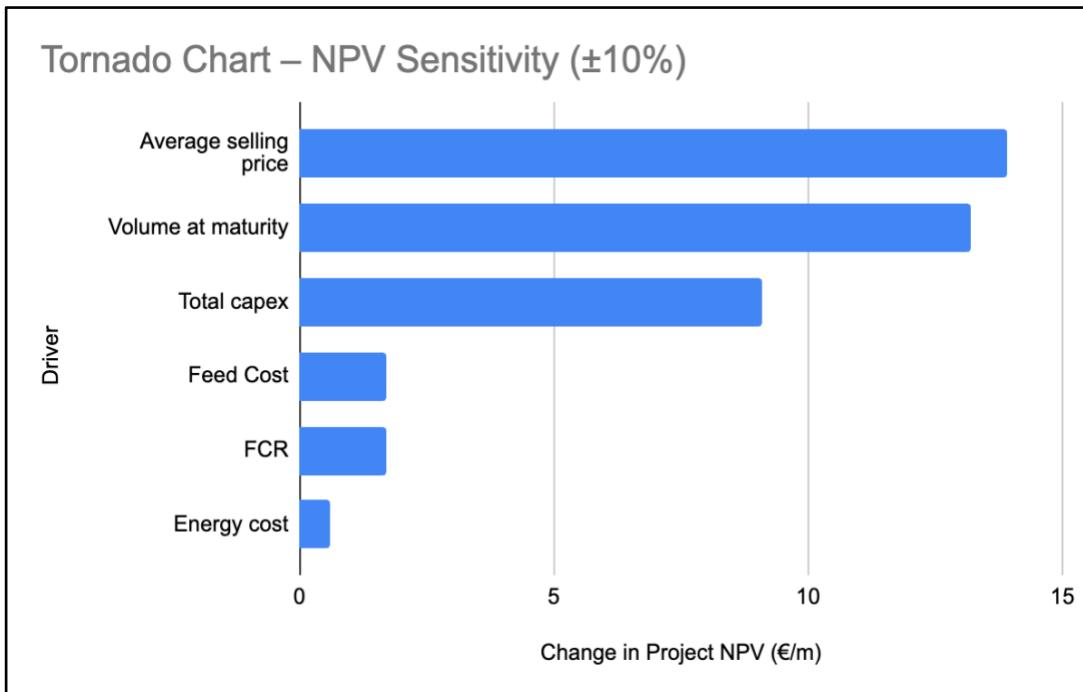


Figure 3. Tornado Chart - NPV Sensitivity ( $\pm 10\%$ )

## Interpretation and Implications

The sensitivity results confirm that the most critical value drivers for the project are:

- Average selling price – A  $\pm 10\%$  change in realised farm-gate price (driven by premium positioning, fresh share and channel mix) produces the largest swing in NPV and IRR. This underlines the importance of executing the premium strategy, building strong B2B relationships and maintaining a high fresh share in key EU markets.

- Feed cost and FCR - As the largest component of operating costs, variations in feed price and FCR performance have a substantial impact on value. Robust feed procurement, formulation, and operational discipline on FCR are therefore central to protecting margins.
- Total capex and volume at maturity - Capex overruns reduce NPV and IRR primarily through higher upfront investment, while shortfalls in long-term volume (e.g. due to lower survival or utilisation) reduce the scale benefits of the 1,300 t platform. This highlights the need for rigorous project management during construction and conservative biological assumptions during operations.
- Energy cost - While important, energy cost variations over the tested range have a somewhat smaller impact than price and feed. The successful implementation of geothermal integration might provide an effective hedge against energy price volatility and contribute meaningfully to the project's resilience.

Overall, the sensitivity analysis reinforces the conclusions of the scenario analysis: project value is most sensitive to commercial execution (price and volume) and key cost drivers (feed and capex), while the combination of geothermal integration, multi-site scale and premium market positioning provides a robust base against adverse movements in individual variables. This supports a focused risk-management strategy centred on long-term offtake relationships, disciplined cost control, and technically robust design and operations.

## 8.8 Geothermal Brine Integration – Mineralisation Cost Impact

### 8.8.1 Technical Context and Scope

Akola has evaluated the use of geothermal brine as a mineralisation source for process water. The concept is to use treated (if needed) and diluted geothermal water to supply part or all of the ionic composition required for *Litopenaeus vannamei* (Na, Cl, Ca, Mg, K, etc.), thereby reducing the need for purchased salts.

For the 1,000 t/year facility in Germany, the indicative hydraulic design is:

- Total system volume: ~24,000 m<sup>3</sup>
- Daily new water intake: ~170–200 m<sup>3</sup>/day
- Annual new water volume:
  - 170 m<sup>3</sup>/d → ~62,050 m<sup>3</sup>/year
  - 200 m<sup>3</sup>/d → ~73,000 m<sup>3</sup>/year

This corresponds to a daily exchange rate of roughly 0.7–0.8% of system volume per day. Every m<sup>3</sup> of new water must be adjusted to the target culture salinity and ionic balance. In the base case, this is achieved by blending freshwater with commercial salts and mineral additives.

Geothermal brine integration is treated here as a potential upside that can partially or fully offset these mineralisation costs.

### 8.8.2 Baseline Mineralisation and Water Treatment Costs

In the base case (no geothermal brine), mineralisation costs for the 1,000 t facility consist of:

- LCSM (low-cost salt mixture)

## Baseline Mineralisation and Water-Treatment OPEX (No Geothermal Brine)

Cost Category	Annual quantity (t/year)	Unit cost (€/kg)	Annual cost (€/year)	COGS share (%)
LCSM	0.9	0.44	385,000	5

### 8.8.3 Geothermal Brine Scenarios – OPEX and COGS Impact

#### Concept and scenario definitions

Because geothermal brine quality and treatment design are site-specific, the financial model uses percentage reductions on the relevant cost categories rather than fixed absolute numbers.

We define three illustrative utilisation scenarios:

- Scenario B1 – Low utilisation
  - Covers a modest share of mineralisation demand.
  - Assumed reductions: 20% of base salt mix cost.
- Scenario B2 – Medium utilisation
  - Geothermal brine provides a substantial part of the ionic load.
  - Assumed reductions: 40% of base salt mix cost, 20%.
- Scenario B3 – High utilisation
  - Geothermal brine provides most of the base mineralization. Some fine-tuning still done with commercial products.
  - Assumed reductions: 80% of base salt cost.

These percentages are conservative planning values; they must be refined with site-specific brine chemistry/treatment designs.

#### Annual savings and COGS/kg impact

Table 13. Geothermal Brine Mineralisation Scenarios (OPEX and COGS Impact)

Scenario	Mineralization cost reduction	Annual mineralization saving (€/year)	Impact on COGS from mineralisation (€/kg) *
Base – no geo brine	0%	0	0
B1 – Low utilisation	20%	77,000	0.078
B2 – Medium utilisation	40%	154,000	0.156
B3 – High utilisation	70%	270,000	0.273

#### 8.8.4 Impact of Geothermal Integration on Financial Performance

Based on market prices for industrial 40–50 m<sup>3</sup> GRP/HDPE tanks and pre-engineered chemical dosing skids, and applying standard installation factors, we estimate the incremental CAPEX for geothermal-brine mineralisation at 80–180 k€ per 1,000 t facility

Table 14. Geothermal Brine Mineralisation Scenarios – Impact on Key Financial Metrics (1,000 t Facility)

Case / Scenario	Brine integration CAPEX (€)	Project IRR (%)	Equity IRR (%)	Δ Project NPV vs Base (€, {{WACC_PCT}}%)
Base – No geo brine	0			
B1 – Low utilisation	180,000	17.6	27	61.5
B2 – Medium utilisation	180,000	17.8	27.4	62.2
B3 – High utilisation	180,000	18.1	28	63.1

#### Scope and Methodology

This subsection quantifies the potential financial impact of geothermal integration, treating it as an optional upside to the base-case financial model. Two independent use cases are considered:

- Geothermal heat integration, where “free” or low-marginal-cost geothermal heat (cascaded or waste heat) replaces electricity-based heat from heat pumps; and
- Geothermal brine integration, where mineralised geothermal water partially substitutes conventional salts and minerals.

The base case assumes a 1,000 t/year facility with an annual heat demand of 2,500 MWh/year for water temperature control and an electricity price of 0.25 €/kWh, supplied via heat pumps with an effective COP of approximately 4.5. This corresponds to:

- Annual electricity for water heating of approx. 556 MWh/year; and
- An effective baseline heat cost of approx. 55–56 €/MWh<sub>heat</sub>, or ~139 k€/year in total heating OPEX.

For geothermal heat, we assume that cascaded/waste geothermal heat is available at zero marginal cost at the facility boundary, such that any share of RAS heat demand covered by geothermal heat (30/60/90% in the scenarios) is assumed to displace an equivalent share of electricity-based heat. For geothermal brine, we assume that mineralised geothermal water can reduce annual salt and selected chemical costs without materially increasing other OPEX at this stage. Both use cases are treated conservatively and must be refined during front-end engineering.

## 8.9 Geothermal Heat – Incremental CAPEX, OPEX and Savings

### 8.9.1 Assumptions and Scenarios

For the 1,000 t facility, the annual heat demand of 2,500 MWh/year is used as the basis for three geothermal heat scenarios:

- Scenario H1 – Low-quality geothermal: 30% of heat demand covered by geothermal heat
- Scenario H2 – Medium-quality geothermal: 60% of heat demand covered
- Scenario H3 – High-quality geothermal: 90% of heat demand covered

Under the business-plan assumption that geothermal heat is available as cascaded/waste heat at zero marginal cost, these coverage levels are assumed to reduce the electricity used for heating by the same percentages. With baseline heating OPEX of approx. 139 k€/year, the resulting savings are as follows.

Table 15. Geothermal Heat Scenarios for 1,000 t Facility (Illustrative)

Scenario	Heat demand covered by geothermal	Baseline heating cost (€/year)	Residual heating cost (€/year)	Annual saving (€/year)	Impact on COGS (€/kg)*
Base (no geothermal)	0%	139,000	139,000	0	0.000
H1 – Low-quality geo	30%	139,000	≈ 97,300	≈ 41,700	0.042
H2 – Medium-quality geo	60%	139,000	≈ 55,600	≈ 83,400	0.083
H3 – High-quality geo	90%	139,000	≈ 13,900	≈ 125,100	0.125

### Incremental CAPEX and Simple Payback (Germany)

Geothermal heat integration requires additional CAPEX, including heat exchangers, piping, integration with upstream geothermal users, and control systems. At this stage, Akola treats this as a standalone CAPEX package for the 1,000 t facility, with the exact amount dependent on the selected site and configuration.

#### German benchmarks for district heating / geothermal connection

From recent German sources:

- Typical Fernwärme house connection incl. Übergabestation costs for residential buildings are:
  - ~6,000–20,000 € total per building (incl. installation), depending on effort and provider.
- A detailed municipal tariff sheet from Kommunalwerke Kaufering (Bavaria) gives:
  - Baukostenzuschuss (connection fee) up to 150 kW:

- i. 120 €/kW for first 20 kW, stepping down to 80 €/kW for 60–150 kW.
- Pipeline on the property (Hausanschlussleitung), per metre (net):
  - i. 672 €/m (DN25) up to 25 kW, 900 €/m (DN32) for 25–60 kW, 840 €/m (DN50) for 60–150 kW.
- In-building piping: 244–328 €/m net.
- Substation (Wärmeübergabestation): up to 7,000 € net for 60–150 kW.
- Example: a 15 kW house with 7 m outside line and 2 m inside line totals ~12,600 € gross.

These numbers are for up to 150 kW; our shrimp facility is larger (~300 kW\_th). For such loads, German utilities usually quote project-specific prices, but scaling the Kaufering structure gives us a reasonable order-of-magnitude basis.

#### Scaling to our case: 1,000 t RAS facility (~300 kW\_th)

From our model:

- Annual heat demand: 2,500 MWh/year
- Average heat load  $\approx 2,500,000 \text{ kWh} / 8,760 \text{ h} \approx 285 \text{ kW_th}$
- For sizing, we assume a 300 kW\_th geothermal / DH connection.

A plausible German cost build-up for a 300 kW\_th industrial off-taker:

1. Connection fee (Baukostenzuschuss)
  - For 150 kW, Kaufering calc  $\approx 14–17 \text{ k€}$  gross. Scaling roughly to 300 kW gives  $\approx 25–30 \text{ k€}$  gross.
2. Pipeline on the property (Hausanschlussleitung)
  - For 60–150 kW, tariff is  $\approx 1,000 \text{ €/m}$  gross (840 €/m net).
  - For a 300 kW connection with DN50–DN65, using  $\approx 1,000 \text{ €/m}$  gross as a planning value is reasonable.
3. In-building piping + house entry + substation
  - From Kaufering:
    - i. House entry:  $\approx 4,600 \text{ €}$  gross (up to 150 kW).
    - ii. In-building lines: few thousand € gross.
    - iii. Substation: 7,000 € net ( $\approx 8,330 \text{ €}$  gross) for up to 150 kW; a 300 kW station might be  $\approx 15–20 \text{ k€}$  gross.
  - Aggregated, it is reasonable to assume  $\approx 50–70 \text{ k€}$  gross for all in-building + substation items at this scale.

Putting this together and including a design + contingency margin:

Assumed distances (branch to geothermal / DH main)

To differentiate H1/H2/H3, we can link them to increasing physical integration effort:

- H1 – Low integration:  $\approx 100 \text{ m}$  branch line
- H2 – Medium integration:  $\approx 150 \text{ m}$  branch line
- H3 – High integration:  $\approx 250 \text{ m}$  branch line

### Cost calculation (rounded, gross)

Using ~1,000 €/m for the outdoor branch and adding fixed items:

- H1 – 100 m branch
  - Pipeline:  $100 \text{ m} \times 1,000 \text{ €/m} \approx 100,000 \text{ €}$
  - Connection / substation / in-building: ~70,000 €
  - Design, contingencies (~40–50%): ~80,000 €
  - **Total indicative CAPEX: ≈ 250,000 €**
- H2 – 150 m branch
  - Pipeline:  $150 \text{ m} \times 1,000 \text{ €/m} \approx 150,000 \text{ €}$
  - Connection / substation / in-building: ~70,000 €
  - Design, contingencies: ~100,000 €
  - **Total indicative CAPEX: ≈ 320,000 €**
- H3 – 250 m branch
  - Pipeline:  $250 \text{ m} \times 1,000 \text{ €/m} \approx 250,000 \text{ €}$
  - Connection / substation / in-building: ~80,000 € (slightly larger system)
  - Design, contingencies: ~120,000 €
  - **Total indicative CAPEX: ≈ 450,000 €**

These are Germany-based connection costs, not including any upstream drilling or main network expansion. They are consistent with:

- Residential connection benchmarks (5,000–20,000 € for ~15–20 kW)
- Detailed tariff sheet for German municipal DH connections up to 150 kW, scaled to your higher load and branch lengths.

For illustration, Table 16 summarises the relationship between assumed geothermal heat CAPEX and the resulting simple payback period using the annual savings. This provides a first-order view of economic feasibility and prioritisation of geothermal heat projects.

*Table 16. Geothermal Heat CAPEX vs Annual Savings and Simple Payback (Illustrative)*

Scenario	Coverage	Annual saving (€/year)	Assumed geo heat CAPEX (€)	Simple payback (years)
<b>H1 – Low-quality (30%)</b>	30%	~41,700	~250,000	~6.0
<b>H2 – Medium-quality (60%)</b>	60%	~83,400	~320,000	~3.8
<b>H3 – High-quality (90%)</b>	90%	~125,100	~450,000	~3.6

Based on current German district heating connection tariffs and municipal price sheets, the incremental CAPEX required to connect a 1,000 t/year RAS facility (~300 kW<sub>th</sub>) to an existing geothermal or district heating grid is estimated at ~0.25–0.45 m€ per site, depending primarily on the branch distance to the main line and the level of integration. Using the business-plan assumptions for heat demand (2,500 MWh/year) and electricity price (0.25 €/kWh via heat pumps), geothermal heat scenarios covering 30–90% of the heat demand

yield annual OPEX savings of ~42–125 k€ and simple payback periods of roughly 3½–6 years, before any subsidies or CO<sub>2</sub>-related incentives.

Table 17. German benchmarks for district heating / geothermal connection

Scenario	Project IRR (%)	Δ vs Base	Equity IRR (%)	Δ vs Base (pp)	Δ Project NPV vs Base (€, 11.7%)
Base – No geothermal	17.5		26.7		61.2
H1 – Low coverage	17.5	0	26.9	0.2	61.5
H2 – Medium coverage	17.8	0.3	27.4	0.7	62.2
H3 – High coverage	18	1.5	27.8	1.1	63

Under the high geothermal heat scenario (~90% of heat demand covered), annual heating OPEX decreases by approximately 125 k€, corresponding to a reduction in heating-related COGS of ~0.13 €/kg. After accounting for the required connection CAPEX, this improves equity IRR from 26.7% to around 27.8% and increases project NPV, while leaving the core investment case fundamentally driven by production scale, sales prices and biological performance.

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## 9. Risk Management

### 9.1 Risk Management Approach

Akola applies a structured risk management approach to the development of the multi-site RAS shrimp platform. Key risk categories include operational, resource and infrastructure, market and commercial, financial, and governance/ESG risks. For each risk, the project team identifies likelihood and impact, defines mitigation measures, and monitors selected key risk indicators (KRIs) throughout planning, construction, ramp-up and steady-state operations. Scenario and sensitivity analyses in the Financial Plan (Section 7) complement this framework by quantifying the impact of adverse developments on cash flows, IRR and funding needs.

### 9.2 Operational Risks

Operational risks relate to the design, construction and day-to-day running of the RAS shrimp facilities. The main exposures include biological performance (growth, survival, FCR), biosecurity and disease outbreaks, technical failures in critical systems (oxygenation, filtration, temperature control), ramp-up delays, and dependency on specialised staff and operational know-how.

Mitigation measures include (i) a robust and proven RAS design with redundancy for mission-critical components, (ii) strict biosecurity protocols and health monitoring, (iii) standard operating procedures (SOPs) for all key processes, (iv) preventive maintenance and remote monitoring/alarms, and (v) investing in training and retention of a skilled operations team and external technical support. The 100 t module concept should allow the Project to de-risk at smaller scale before fully deploying the 300 t Klaipėda and 1,000 t Germany facilities.

### 9.3 Resource & Infrastructure Risks

Resource risks relate to the availability, quality and reliability of key inputs: water, energy, feed, and (where applicable) geothermal resources. RAS performance depends on sufficient and stable water supply meeting predefined quality parameters, reliable electricity supply at acceptable prices, and secure sourcing of high-quality shrimp feed. For geothermal integration, additional risks concern actual well temperatures and flow rates, long-term availability of heat and brine, and integration risks between geothermal and RAS systems.

Mitigation measures include thorough site due diligence, conservative design margins for water and power capacity, long-term power and feed procurement strategies, and contingency options (e.g. backup boilers or alternative heat sources). For geothermal options, Akola assumes geothermal heat and brine as upside cases only, based on preliminary technical and economic screening; the base case business plan remains bankable without geothermal integration. Where feasible, stepwise implementation and clear performance guarantees (or availability commitments) are sought from geothermal partners.

## 9.4 Market & Commercial Risks

Market risks arise from uncertainty around demand, price levels and the strength of the premium positioning. Key exposures include increased competition from imported warmwater shrimp, price volatility at the commodity end of the market, slower-than-expected adoption of locally farmed premium shrimp, and potential pressure from retailers and distributors on margins and contract terms. There is also a risk that sustainability and certification requirements evolve faster than anticipated, requiring additional investments.

Mitigation measures include a diversified customer portfolio across countries and channels (retail, foodservice, specialty, online), a clear value proposition built around freshness, local EU origin, sustainability and traceability, and proactive engagement with leading buyers early in the project. The business plan is underpinned by conservative price and volume assumptions, while upside scenarios capture higher penetration of the premium segment and stronger pricing. Continuous monitoring of competitor activity and certification/ESG trends will inform product development and pricing strategies.

## 9.5 Financial & Funding Risks

Financial risks relate to the scale and timing of capital expenditures, cost overruns, working capital needs, and the chosen capital structure. Construction and commissioning of the Klaipėda and Germany facilities involves significant upfront CAPEX and ramp-up risk, while project returns are sensitive to sales prices, biological performance and key input costs (feed, energy). Additional risks include interest rate changes, refinancing risk at the end of loan tenors, currency risk (if revenues and costs are in different currencies), and the ability to secure follow-on funding on acceptable terms.

Mitigation measures include phased implementation (100 t → 300 t Klaipėda → 1,000 t Germany), robust CAPEX and contingency budgeting, conservative gearing, and alignment of debt tenor and grace periods with construction and ramp-up timelines. Detailed downside and upside scenarios are presented in the Financial Plan to test resilience of project IRR and equity IRR under adverse assumptions. Regular reporting to investors and lenders, combined with covenants tailored to the ramp-up profile, will further support financial risk management.

## 9.6 Governance, Legal & ESG / Other Risks

Other material risks concern permitting and regulatory approvals (for aquaculture, food safety, labour, environmental and, where relevant, geothermal use), compliance with evolving EU and national ESG and reporting frameworks, and potential reputational risks related to animal welfare, environmental performance or social issues. Non-compliance or delays in permitting could impact timelines and increase costs; reputational issues could undermine the premium positioning and buyer relationships.

Mitigation measures include early and continuous engagement with relevant authorities, use of experienced legal and permitting advisors, and designing the facilities to meet or exceed applicable environmental, welfare and safety standards from the outset. Akola intends to adopt recognised certification schemes (e.g. for sustainability and food safety) and transparent communication about production methods and environmental performance. Clear governance structures, internal policies and regular audits will support ongoing compliance.

## 9.7 Risk Summary and Next Steps

Overall, the project's risk profile is typical of a capital-intensive, technology-driven aquaculture platform entering a fast-developing premium market segment. The main value drivers (biological performance, sales prices, energy and feed costs, and ramp-up speed) are explicitly addressed through technical design, operational protocols, conservative financial assumptions and scenario analysis. Geothermal integration is treated as an upside option rather than a dependency, further limiting resource risk in the base case. Going forward, Akola will formalise a risk register and KRI dashboard, updated at least quarterly, to ensure that key risks are monitored, and mitigation actions are implemented in a timely manner.

## 10. Appendices

## 10.1 Profit & Loss

Project Management	€ m	(0.12)	-	-	-	-	-	-	-	-	-	-	-
RM Procurement & Logistics	€ m	-	-	-	-	-	-	-	-	-	-	-	-
Plant management	€ m	-	(0.04)	(0.04)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)	(0.31)
Finance Central	€ m	-	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Marketing & Communications	€ m	-	-	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Research & Development	€ m	-	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Sales	€ m	-	(0.09)	(0.09)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)
CEO office	€ m	(0.15)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)	(0.17)
Administration	€ m	(0.27)	(0.63)	(0.70)	(1.09)	(1.09)	(1.09)	(1.09)	(1.09)	(1.09)	(1.09)	(1.09)	(1.09)
Corporate Overhead	€ m	-	-	-	-	-	-	-	-	-	-	-	-
Cost of Innovation Centers	€ m	-	-	-	-	-	-	-	-	-	-	-	-
Market Development Expenses	€ m	-	(0.20)	(0.20)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)	(0.66)
Product Development	€ m	-	-	-	-	-	-	-	-	-	-	-	-
Other	€ m	-	(0.07)	(0.25)	(0.85)	(0.85)	(0.85)	(0.85)	(0.85)	(0.85)	(0.85)	(0.85)	(0.85)
Maintenance Expenses	€ m	-	-	(0.07)	(0.10)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Patent Royalties	€ m	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total Overheads</b>	<b>€ m</b>	<b>(0.27)</b>	<b>(0.90)</b>	<b>(1.22)</b>	<b>(2.69)</b>	<b>(2.79)</b>							
<b>EBITDA</b>	<b>€ m</b>	<b>(0.27)</b>	<b>0.04</b>	<b>4.31</b>	<b>9.36</b>	<b>13.81</b>							
<i>EBIDTA Margin</i>	%		2.2%	53.3%	48.0%	54.1%	54.1%	54.1%	54.1%	54.1%	54.1%	54.1%	54.1%
Depreciation	€ m	-	-	(0.88)	(2.51)	(4.72)	(4.72)	(4.72)	(4.66)	(3.86)	(3.86)	(3.86)	(3.86)
Amortization	€ m	-	-	-	-	-	-	-	-	-	-	-	-
<b>EBIT</b>	<b>€ m</b>	<b>(0.27)</b>	<b>0.04</b>	<b>3.43</b>	<b>6.85</b>	<b>9.09</b>	<b>9.09</b>	<b>9.09</b>	<b>9.15</b>	<b>9.95</b>	<b>9.95</b>	<b>9.95</b>	<b>9.95</b>
<i>EBIT Margin</i>	%		2.2%	42.4%	35.1%	35.6%	35.6%	35.6%	35.9%	39.0%	39.0%	39.0%	39.0%

<i>OH Ratio</i>	%		55.9%	26.0%	26.7%	29.4%	29.4%	29.4%	29.2%	26.1%	26.1%	26.1%	26.1%
Interest on Short-Term Debt	€ m		-	(0.04)	(0.10)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
Interest Paid on Bonds	€ m	-	-	-	-	-	-	-	-	-	-	-	-
Interest on Long-Term Debt	€ m		(0.15)	(0.28)	(0.48)	(2.20)	(2.10)	(1.64)	(1.19)	(0.76)	(0.36)	(0.00)	(0.00)
<b>PBT</b>	<b>€ m</b>	<b>(0.27)</b>	<b>(0.12)</b>	<b>3.11</b>	<b>6.27</b>	<b>6.76</b>	<b>6.86</b>	<b>7.32</b>	<b>7.84</b>	<b>9.07</b>	<b>9.47</b>	<b>9.82</b>	<b>9.82</b>
Tax Expense	€ m	-	-	(0.47)	(0.94)	(1.01)	(1.03)	(1.10)	(1.18)	(1.36)	(1.42)	(1.47)	(1.47)
<b>NP</b>	<b>€ m</b>	<b>(0.27)</b>	<b>(0.12)</b>	<b>2.64</b>	<b>5.33</b>	<b>5.75</b>	<b>5.83</b>	<b>6.22</b>	<b>6.66</b>	<b>7.71</b>	<b>8.05</b>	<b>8.35</b>	<b>8.35</b>
Dividend Payout	€ m	-	-	-	2.7	2.9	5.2	5.6	6.0	6.9	7.2	7.5	7.5
Shares Outstanding	m.	1.0	2.7	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Earnings Per Share	€	(0.3)	(0.0)	0.3	0.6	0.7	0.7	0.7	0.8	0.9	0.9	1.0	1.0
<b>Unit Cost Calculation</b>													
<b>Direct Cost</b>													
Feed Usage	€/Kg		(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)
PL Usage	€/Kg		(1.7)	(1.7)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)	(1.2)
Utilities & Consumables	€/Kg		(4.2)	(4.2)	(4.2)	(2.1)	(1.9)	(1.9)	(1.9)	(1.9)	(1.9)	(1.9)	(1.9)
<b>COGS per Kg</b>	<b>€/Kg</b>	<b>13.4</b>	<b>9.8</b>	<b>7.5</b>	<b>6.9</b>								
<b>Fixed Overheads</b>													
Plant Manpower	€/Kg		(5.0)	(1.5)	(1.7)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)
Administration	€/Kg		(12.5)	(2.7)	(1.1)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
Corporate Overhead	€/Kg		-	-	-	-	-	-	-	-	-	-	-
Cost of Innovation Centers	€/Kg		-	-	-	-	-	-	-	-	-	-	-
Product Development	€/Kg		-	-	-	-	-	-	-	-	-	-	-

Market Development Expenses	€/Kg		(4.0)	(0.8)	(0.7)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
Maintenance Expenses	€/Kg		-	(0.3)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Patent Royalties	€/Kg		-	-	-	-	-	-	-	-	-	-	-	-
Fixed Overheads per Kg	€/Kg		17.9	4.7	2.7	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
<b><u>Depreciation &amp; Financing</u></b>														
Depreciation	€/Kg		-	(3.4)	(2.5)	(3.6)	(3.6)	(3.6)	(3.6)	(3.0)	(3.0)	(3.0)	(3.0)	(3.0)
Amortization	€/Kg		-	-	-	-	-	-	-	-	-	-	-	-
Interest on Short-Term Debt	€/Kg		-	(0.2)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Interest Paid on Bonds	€/Kg		-	-	-	-	-	-	-	-	-	-	-	-
Interest on Long-Term Debt	€/Kg		(3.0)	(1.1)	(0.5)	(1.7)	(1.6)	(1.3)	(0.9)	(0.6)	(0.3)	(0.0)	(0.0)	(0.0)
Processing Cost of Shrimp (Input Basis)	€/Kg		32.9	18.1	14.5	14.0	13.7	13.3	12.9	12.0	11.7	11.4	11.4	11.4

## 10.2 Production Table

Week	Initial Stocking	1	2	3	Phase I	4	5	6	7	8	9	10	11	12	13	14	15
Average Weight (g) per individual	0.004	0.03	0.20	0.60		2.00	3.50	5.30	7.10	9.00	10.90	12.80	14.70	16.60	18.50	20.40	22.30
Weekly Individual growth (g)		0.026	0.17	0.40		1.40	1.50	1.80	1.80	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
Weekly Survival Rate		97.4%	97.4%	97.4%		95.3%	95.3%	95.3%	95.3%	95.3%	95.3%	95.3%	95.3%	95.3%	95.3%	95.3%	95.3%
Accumulated Survival Rate (incl. dilution)		97.4%	94.9%	92.4%		83.7%	79.7%	76.0%	72.4%	69.0%	65.8%	62.7%	59.7%	56.9%	54.2%	51.7%	49.3%

% of total harvest		0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.0%	0.0%	0.0%	85.0%
harvested biomass (kg)		0	0	0		0	0	0	0	0	0	0	0	2876.7	0	0	16301.4
harvested # of shrimps		0	0	0		0	0	0	0	0	0	0	0	173,296	0	0	731,003
Dillution Rate		0%	0%	5%		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
# of shrimps S.O. Week (after dillution/harvest)		1,788,373	1,741,875	1,696,586		1,569,851	1,496,068	1,425,753	1,358,743	1,294,882	1,234,022	1,176,023	1,120,750	1,068,075	844,580	804,884	767,055
# of shrimps E.O. Week (pre dillution/harvest)		1,788,373	1,741,875	1,696,586	1,652,475	1,569,851	1,496,068	1,425,753	1,358,743	1,294,882	1,234,022	1,176,023	1,120,750	1,068,075	1,017,875	804,884	767,055
Biomass at S.O. Week (kg)		7.2	52.3	339.3		941.9	2,992.1	4,990.1	7,201.3	9,193.7	11,106.2	12,818.7	14,345.6	15,700.7	14,020.0	14,890.4	15,647.9
Biomass at E.O. Week (kg)		7.15	52.3	339.3	991.5	1,383.1	2,992.1	4,990.1	7,201.3	9,193.7	11,106.2	12,818.7	14,345.6	15,700.7	16,896.7	14,890.4	15,647.9
Water Volume		55.4	55.4	55.4	166.3	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9	121.9
Density (kg/m3)		0.94	6.12	17.89		24.54	40.93	59.07	75.41	91.09	105.14	117.67	128.78	138.59	122.13	128.35	133.71
<b>Feed Calculations</b>																	
Average Existence Biomass		29.70	195.79	665.40		1967.02	3991.14	6095.74	8197.50	10149.93	11962.43	13582.13	15023.15	16298.72	14455.19	15269.14	15974.64
Biologic Biomass addition		45.29	288.42	660.99		2094.50	2138.63	2445.74	2330.79	2344.64	2234.44	2129.43	2029.34	1933.96	1529.28	1457.40	1388.91
Biologic FCR		0.90	0.92	0.95		0.99	1.05	1.10	1.19	1.31	1.43	1.58	1.77	1.91	1.98	2.00	2.02
Economic FCR		0.91	0.93	0.96		1.04	1.12	1.22	1.39	1.60	1.87	2.21	2.65	3.09	3.48	3.85	4.30

Existence Feed(kg)		0.5	3.6	8.9		29.8	34.4	44.3	47.7	56.4	62.5	68.5	77.6	84.6	71.6	72.6	73.6
Growth Feed(kg)		40.3	262.9	616.4		2043.7	2200.4	2646.0	2721.3	3012.8	3132.8	3304.5	3516.4	3617.0	2956.4	2845.1	2737.6
Total Feed(kg)		40.9	266.5	625.3		2073.6	2234.9	2690.3	2769.0	3069.1	3195.3	3373.0	3594.0	3701.6	3028.0	2917.7	2811.1
Oxygen consumption (kg)		32.4	211.3	495.9		1,644.3	1,772.3	2,133.4	2,195.8	2,433.8	2,533.8	2,674.8	2,850.0	2,935.4	2,401.2	2,313.8	2,229.2