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AQUATA – AN INTEGRATED MULTI-TROPHIC AQUACULTURE BUSINESS SOLUTION TO FIGHT CLIMATE CHANGE AND WORLD HUNGER: OPERATIONS

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Abstract

This work project presents a business plan developed for a disruptive and highly innovative aquaculture business within the field of Integrated Multi-Trophic Aquaculture.

The qualitative investigation gave rise to a novel solution focused on a sustainable farming approach for sea cucumbers and scallops. A thorough business plan was developed as a group project, including an operational, marketing and sales, research and development, and financial plan, whereas this individual submission focuses on the operations.

The thesis concluded that the presented IMTA approach is the most natural solution to fight world hunger and climate change by providing a sustainable food source for the growing world population.

Keywords: (Science-Based) Entrepreneurship, Aquaculture, Integrated Multi-Trophic Aquaculture, Sea Cucumbers, Scallops, Operations

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Table of Abbreviations

€	Euro
$	US Dollar
ANI	Portuguese Innovation Agency
APAC	Asia-Pacific Markets
API	Application Programming Interface
ASC	The Aquaculture Stewardship Council
B2B	Business-to-Business
B2C	Business-to-Customer
BAP	Best Aquaculture Practices
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EBV	Estimated Breeding Value
EU	European Union
EV	Enterprise Value
FAO	Food and Agriculture Organization of the United Nations
FCR	Feed Conversion Rate

GHG	Greenhouse Gas
IMTA	Integrated Multi-Trophic Aquaculture
IP	Intellectual Property
KPI	Key Performance Indicator
NDA	Non-Disclosure Agreement
NGO	Non-Governmental Organization
OF	Oceano Fresco
POM	Particulate Organic Matter
R&D	Research and Development
SDGs	Sustainable Development Goals
TAA	Aquaculture Activity Title

1 Executive Summary

AQUATA is an aquafarming business focused on farming scallops and sea cucumbers using an Integrated Multi-Trophic Aquaculture (IMTA) approach. Our idea is inspired by Oceano Fresco (OF), a growing aquaculture startup dedicated to breeding clams in a hatchery in Nazaré and growing them out at their open sea farm in Lagos, Portugal. As the world population continues to increase, current food production systems are unable to meet the global demand while being both environmentally friendly and nutritious. Like OF, our mission is to address the growing global demand for protein, presenting a valuable business opportunity. Our IMTA approach allows us to farm multiple species with minimal additional resource input. As sea cucumbers feed on the excrements of scallops, the combination of the two species reduces waste and improves efficiency.

By focusing on the high-demand markets of Asia and Europe, we aim to capitalize on this business opportunity while fighting climate change. Our goal is to provide a high-quality, sustainable source of protein to these markets, meeting the rising demand and providing economic benefits for our business. Examining the market potential, the opportunity is immersive. On a global level, the bivalve market is expected to grow by $15.36 billion until 2026, while the sea cucumber market will reach a total value of $1436 million in 2028. Considering global trade, consumption, price, and competitors, we decided to target the Asian market with our freeze-dried sea cucumber ('bêche-de-mer') and the Portuguese, Spanish and French markets with our fresh scallops. In the mid-and long-term, we plan to diversify horizontally with dietary supplements and a franchise model, scaling our sustainable impact and revenue. According to our financial plan, AQUATA will generate €102 million in revenues in the first 10 years and will reach unicorn status in 2033, making it an attractive investment opportunity in the blue economy market.

Talking to many different experts and visiting OF's hatchery in Nazaré, we decided to integrate AQUATA vertically through the production of our own animal seeds. The scallops and sea cucumbers will grow out in an open sea farm, by using lantern nets attached to a long-line system.

Moreover, our innovative business model will strongly rely on intelligent technology to ensure efficiency, reliability, and traceability in every step of the farming process. Next to a strong brand image, these aspects play a significant role in our value proposition, delivering great value to our customers and investors and differentiating us from our competitors. We will use a variety of online and offline marketing methods and channels to commercially advertise our products, focusing primarily on the Business-to-Business (B2B) market but also aiming to reach the end user. By communicating our value proposition and mission statement, and establishing strong partnerships and trust, we will be able to promote our brand's benefits and acquire customers. Moreover, we will enhance our value creation through investing in Research & Development (R&D). Our multidisciplinary team will start a global study, travel to different aquafarms and markets, and employ experts helping to create our scientific breeding program. We will further engage in a broad network of aquaculture-related companies to form partnerships and benefit from each other's findings. Non-disclosure agreements (NDAs) will hereby protect AQUATA's Intellectual Property (IP). We considered the UN's Sustainable Development Goals (SDGs) to assess this impact, setting the vision and path to contribute even past their applicability. In 2027 we expect to be profitable and, in 2028, break even, covering our high capital expenditure (CAPEX) of €6.8 million, typical for the aquaculture sector. We aim to fund AQUATA through grants, equity, and debt financing. Finally, a possible exit strategy for us would be an acquisition through OF or one of our early external investors.

2 Why We Need to Find a Solution for the Global World Hunger Crisis

In 1950 there were 2.5 billion people on this planet. We recently crossed the 8.0 billion thresholds in 2022. By the end of the century, it is expected that the world population will have increased to 10.4 billion (Roser et al. 2013). As the population grows, so does the demand for food, water, and natural resources. Moreover, if the trend continues, the demand for calories will have grown by 70% by 2050. These numbers are critical when considering that currently one in three people lack regular access to adequate food (United Nations 2020), 828 million people are going to bed hungry every night and 345 million people are facing acute food insecurities (World Food Programme 2022).

To cope with the growing would population, food production systems that are intended to serve the purpose of eradicating world hunger must be sustainable and deliver sufficient nutritious value despite large production volumes. Meeting these criteria simultaneously is seriously challenging for current food production systems. We have taken this as an inspiration to come up with a solution that addresses these contradictory goals as a step to fight world hunger. However, before we proceed to that, we will outline why current systems are failing to be both sustainable at a large-scale production volume and nutritious.

2.1 The Environmental Impact of Current Food Production Systems

Our destructive consumption habits, urbanization and economic development of emerging markets put pressure on the environment, the climate and on biodiversity (Le Berthe 2018). Considering all the negative consequences feeding into the global food challenge, researchers have found that we would need 1.7 planets to support humanity’s demand (Geneva Environment Network 2022).

Up to 30% of the world's greenhouse gas (GHG) emissions come from current food production systems, which are severely disrupting the ecosystem; Increased temperatures contribute to rising sea levels, which in turn create more heat waves, droughts, violent storms, and other

natural disasters (Willett et al. 2019). Proteins are generally the most carbon-intensive nutrition that our bodies need, making them the worst for the environment and a major cause of climate change. This is because animals like cattle, lambs, and goats rely on specific bacteria in their guts to break down their food, which releases a large amount of methane. This potent GHG contributes significantly to global warming (Hilborn 2019). On top of that, the impact of growing, harvesting, processing and shipping the animal's food also contributes to emissions, while forests are destroyed to get converted into grazing land. Putting these impacts into perspective, around 40% of GHG are produced by land use changes, including agriculture and deforestation (Oreskes 2022).

Another problem of livestock is the concept of the feed conversion ratio (FCR), which measures the conversion of feed mass (input) to the animal's mass (output) (He et al. 2019). A high FCR implies that the conversion is inefficient, as the animal requires a large amount of feed to gain little body mass. Currently, only 12% of the calories from crops used as animal feed end up being consumed by people in the form of animal products (E. S. Cassidy et al. 2013). Hence, existing animal consumption is highly inefficient. According to estimates, additional four billion people could be fed by converting crop calories intended for non-human to direct human consumption (E. S. Cassidy et al. 2013). Such a shift would require the world's population to eat more low-trophic food sources from the bottom of the food chain (Appendix 2).

Not only food production on land, but also in water, is straining our environment. Heavy overfishing, defined as more fish getting caught at a faster speed than stocks take to replenish, is further causing ecosystems to collapse. As of 2021, 90% of the world's fish stocks have been fully exploited or overfished as a result of the more than doubling global consumption from 9kg per person in 1961 to 20.5kg in 2017 (Hughes 2021). According to the Food and Agriculture Organization of the United Nations (FAO), this figure is expected to rise to 21.5kg by 2030 due to the growing population and increasing income (Hughes 2021). Closely related

to overfishing is bycatch, which is the unintentional capture of other marine species (Leigh 2022)). Currently, one in ten animals fished is bycatch threatening the environment through needless loss of billions of fish, sea turtles and dolphins among others (Eit Food 2021). However, the harm caused by overfishing extends beyond the marine ecosystem, as fish is an indispensable source of protein, micronutrients, and income for billions of people (WWF 2022). Even countries like Portugal, Spain or Greece, depend highly on seafood imports, as they cannot meet their high demand due to insufficient national supply. However, already now one-third of the world's evaluated fisheries are biologically overfished (OOOF 2022). Additionally, 98% of fisheries and aquaculture workers come from developing countries, so economic income and food from fishing is an important factor. Consequently, as overfishing increases and fish stocks get depleted the economic income and the already not sufficient amount of food is diminishing for many people relying on this source with their lives.

2.2 Failure of Current Food Production Systems

In the past, there have been several attempts to scale up food production systems without causing too much harm to the environment. For example, during the Green Revolution from mid- to late-20th century, agriculture of cereal crop yields tripled, increasing the amount of available calories, however exhibiting only low micronutrient density (Pingali 2012).

Studies show that micronutrient malnutrition is a very prominent problem in today’s society, leading to various diseases such as diabetes or coronary heart disease (Willett et al. 2019). Researchers agree that a healthy diet should be made up of vegetables, whole grains, legumes, fruits and nuts, seafood, eggs and unsaturated fats (Willett et al. 2019). This is also consistent with a study that discovered that omnivores had a 12% higher mortality risk than people who followed a vegan, vegetarian, or semi-vegetarian diet. Pescatarians had overall the lowest

mortality risk (Orlich et al. 2013). This is the case because, the quality of protein from marine animal sources is often higher than that of plant-based sources, measured by the bioavailability, the composition of essential amino acids, vitamins and iron (Willett et al. 2019).

2.3 Low-Trophic Farmed Aquatic Species as a Solution

Overall, we have found that current food production systems are not able to eradicate world hunger, as they are either not sustainable at a large scale, or are not suitable for a healthy, nutrient-dense diet. On the contrary, as the world attempts to find ways of feeding the growing population low-trophic food sources are a very energy-efficient food production option with a low environmental impact. Plants are perhaps the most obvious example of low-trophic food, but given the mentioned nutrients in seafood, many scientists think we should include more shellfish in our diet (Howell 2022). The benefits of including shellfish, as low-trophic food are huge, because they contain more protein than many plant crops and meat and have high levels of essential omega-3 fatty acids, micronutrients like vitamin B12, zinc, magnesium, and iron. Therefore, shellfish has the potential to meet the nutritional requirements of billions of people in the most vulnerable parts of the world (Lovell 2022). According to the zoologist David Willer, bivalve aquaculture has an even smaller environmental impact than many arable crops (Willer 2020). Moreover, other low-trophic animals referring to echinoderms, like sea cucumbers, sea urchins and starfish are a more sustainable food source, than meat or fish. Apart from the fact, that they are not producing any greenhouse gas emissions, they are also of utmost ecological importance for the environment they live in (Bondaroff 2019). Due to their nutrient recycling and sediment redistribution, they are essential to sustaining biodiverse and productive ecosystems and are consequently essential in battling climate change (MSC 2022). However, these benefits have increasingly been limited in some areas of the world due to the increased overfishing and illegal harvesting that sea cucumbers are experiencing. This could be counteracted by growing sea cucumbers in aquafarms to meet the rising demand and protect

marine wildlife. Although aquafarming is the fastest growing food-producing sector, accounting for 17% of global animal protein production in 2016, it is still heavily discussed and creates a conflict between two important SDGs, namely SDG 2 fighting ‘Zero Hunger’ and SDG 14 of ‘Life below water’ (Correia et al. 2020; Hou et al. 2019). Some practices within aquafarming, like the application of antibiotics to boost development and impede diseases have negative side effects in regards to food safety, quality and environmental sustainability (Hughes 2021). However, the in 2010 introduced IMTA approach is a technology that could boost the production and diminish negative effects on the environment. Within IMTA farmers combine aquatic animals of different trophic levels, the later ones feeding on organic and inorganic materials as well as by-products from other species in the same farm (University of Maine 2022). Thus, it might be a way to improve the aquaculture industry's sustainability, even contributing to the objectives of the EU's Blue Growth policy (Correia et al. 2020).

Moreover, it is a great business opportunity, as the low-trophic species do not require extra nutritional input, and thus add additional value without further expenses. The high demand and the consequently high revenue potential are fueled by the increasing need for sustainable and healthy food sources. Hence, AQUATA will implement IMTA in a fully sustainable and scalable business model to seize this great business opportunity. Like this we aim to minimize the negative impact on the planet and respective animals, and support developing regions around the globe fulfill the growing demand and satisfy the immanent need to feed the growing world population, while helping to protect the environment and tap into the new opportunity of low-trophic aquaculture. Overall, this will help to minimize human’s intake of unhealthy environmental contaminants like heavy metals or mercury, as through farming we have more control over important variables, making it possible to regulate the toxin levels. Additionally, technological development has improved in recent years assisting in developing sustainable farms to produce resource efficient protein, to fill the gap in supply to meet the rising demand

and feed the world's growing population, while protecting wild populations from overfishing and illegal harvesting crucial for a healthy marine environment (M. Cassidy 2019).

3 Our Idea

Understanding the significant negative impact of the described problem, the failure to assess it, and the accompanying implications for our future, we identified a great need to create a solution to combat the world's hunger and climate problem.

3.1 The Origin of Our Idea

Our professor Nuno introduced us to the aquafarming startup OF. Originally, OF wanted to protect native clams through genetic breeding programs, however later developed into an innovative and disruptive aquafarm, producing high quality clams. Through their scientific approach and selective breeding program, they developed a strong competitive advantage over other aquafarms and are soon entering the bivalve market with their premium clams. OF is not only innovative through its research programs but also because they are the first company in Portugal to grow clams in an open sea farm. This brings additional advantages due to the natural habitat and the yield of naturally occurring food sources.

After talking to different employees of OF, such as Andreia Cruz (R&D Senior Manager) and Frederico Reis (Chief Commercial Officer), we realized the huge potential of their aquafarming approach and the market in general. This opinion is also backed by the large amount of funding that OF received, implying that several investors agree with the potential.

OF's mission is to monetize the potential of bivalves as a superior alternative to other protein sources (Oceano Fresco 2022). Together, the worldwide hunger problem and OF's business model inspired us, hence the reason for how we structured our solution and business model. During the process of launching our business 'AQUATA' we have been in steady contact with OF and are working on a strategic partnership in the future. Due to our different product

portfolios and partly different target markets, we are not competitors, but strategic partners tackling the worldwide food and protein insufficiency.

3.2 AQUATA – a Sustainable Aquafarm

AQUATA is a disruptive and highly innovative aquafarm that focuses on farming and selling fresh scallops, freeze-dried sea cucumbers and aquamarine food supplements. AQUATA only focuses on the scallop species *Pecten maximus* and the sea cucumber species *H. poli, H. tubulosa, H. mammata* and *H. arguinensis*. Through our expertise in business and intelligent investments into the brand building of AQUATA, we will aim to become the leading impact driven Aquafarm from Europe. We will first target the B2B market with our scallops and sea cucumbers and build profitable business relationships. Later we will enter the Business-to-Business (B2C) market with our food supplements and use our reoccurring revenues from the B2B sector to quickly take over a significant market share. Through further scaling AQUATA we will combine profitability and impact and fulfill our corporate vision to tackle the global food crisis, climate change and rising protein sufficiency. AQUATA will have a significant impact in shaping the future of farming towards more sustainable and healthy food production.

4 Aquaculture as a Business Opportunity

As mentioned, the world's population continues to grow and the need for sustainable and scalable food supply is becoming ever more urgent. However, many common food production systems damage the environment and cannot be scaled sustainable to satisfy growing demands. Aquaculture on the contrary, offers new sustainable farming methods that are environmentally and economically profitable and achievable at large scale to meet the growing demand.

In general, the aquaculture industry has existed for thousands of years, however, only recently has it evolved significantly, driven by an increased awareness of the negative effects of intensive fishing around the 1970s (Rocha et al. 2022). Since then, the ecological, economical and consumer benefits

of aquaculture have been widely recognized, and its "crucial role in global food security and nutrition, reducing the supply-demand gap for aquatic food" is undeniable (FAO 2022b, 111).

4.1 Opportunity of Low Trophic Species

In general, "Trophic levels are a hierarchical way of classifying organisms according to their feeding relationships within an ecosystem" (Trites 2001, 1) Low trophic marine species include species from the lowest levels of the food chain, mainly bivalves and algae, but also sea cucumbers (Krause et al. 2022). Unlike sea cucumbers and algae, marine bivalves represent a group of several species, including oysters, mussels and scallops (Helm and Bourne 2004).

The introduction of low trophic species in marine aquaculture[1] offers alternatives to common animal production and several (business) opportunities. Aquaculture of low trophic species requires less resources and costs for breeding and growing compared to common farmed marine species, such as tuna or salmon (Fredriksson 2021). Therefore, it is one of the most efficient production methods to create foods rich in to produce high-quality protein foods with essential nutrients. Aquaculture of bivalves and sea cucumbers, for example, offers several environmental benefits since bivalves have the potential to clean their habitat by filtering and recycling the water of excess nutrients (Gallardi 2014). They increase biodiversity and improve environmental conditions in the oceans and are therefore essential for the health of the marine environment. Sea cucumbers can act as nature´s recyclers as they clean their habitat by eating sand, digesting and degrading the organic materials it contains, to eventually remove toxins (Holmyard 2021; S. Purcell et al. 2016).

4.1.1 Opportunity of Farming Scallops

Scallops (*Pectinidae*) are a sub-category of marine bivalve mollusks living in shallow marine waters around the world (Kennedy 2020). They have two fan-shaped valves which enclose the inner soft part, of which the adductor muscle, the coral and the membrane are suited for

[1] "Marine aquaculture refers to the breeding, rearing, and harvesting of aquatic plants and animals" (NOAA 2021)

consumption (Chain (CONTAM) et al. 2021). Scallops are filter feeders, primarily consuming "phytoplankton, especially single celled algae, particulate organic matter (POM), bacteria and other micro-organisms" (Marshall and Wilson 2008, 10).

Scallops are valuable for the environment, since they have been shown to provide habitat and enhance community diversity (Naylor et al. 2021). As they filter the water for phytoplankton, they can improve light availability in the water, which can potentially improve the growing conditions for other species. Throughout the filtering process, they additionally remove significant amounts of nitrogen and phosphorous, thus decreasing nutrient loading (eutrophication), which further prevents algal overgrowth (O'Shea et al. 2019).

Many natural stocks of scallops have been overfished and are close to extinction (Papa et al. 2021). The species that we will use for our farming, *Pecten maximus*, has been fully exploited or overexploited by fisheries across the European Atlantic. This has been caused by poor stock management of fisheries and increased fishing efforts (Cortés et al. 2021). The limited stocks of *P. maximus* has led to low production volumes of fishermen, thereby leading to an upward price pressure as consumers continue to demand the product (Cortés et al. 2021).

AQUATA's solution to the depleted wild stocks is the use of a vertically integrated aquafarm. This means, that no wild population or their seeds will be used as an input to our farming, but we have a circular system in which we use our own broodstock to produce additional seeds. As a result, AQUATA will neither be dependent on a limited resource, nor strain the environment further. Aquaculture of scallops is also more environmentally friendly than wild fishery, as it does not use seafloor habitat and community damaging scallop dredges (Howarth and Stewart 2014). We will be able to sustainably produce high volumes of scallops that far exceed fishermen's volumes, and will benefit from the upward price trend. The high revenue potential of scallop aquaculture is met with low variable costs; As they are filter-feeders, they do not

require any additional feeds. For higher-trophic species, such as salmon aquaculture, this can be a significant cost factor (O'Shea et al. 2019).

Apart from environmental benefits, bivalves are a source of high-quality protein, essential omega-3 fatty acids, vitamin A, B12, and D and several minerals such as iron, zinc, iodine, and selenium calcium (Wijsman et al. 2019). Due to the great nutritional profile, taste, and perception as a gourmet product, the consumer demand has increased significantly (Cortés et al. 2021). The price increase and the unmet demand pose a great economical and business opportunity, which AQUATA will leverage alongside the farming of sea cucumbers.

4.1.2 Opportunity of Farming Sea Cucumbers

Sea cucumbers (*Holothuroidea*) are echinoderms and have the shape of soft-bodied cucumbers with no eyes and no brain (McCurry 2019). Sea cucumbers live in shallow and deep ocean areas and are categorized as ocean dwellers living on or near the ocean floor. The fertilization process takes place when the animals' sperm and eggs come into contact in the water (National Geographic 2010). Sea cucumbers are scavengers, consuming algae, aquatic invertebrates, and waste particles in the benthic zone on the ocean floor and plankton floating in the water column (National Wildlife Federation 2022). They gather small food particles with their "8 to 30 tube-feet that look like tentacles surrounding their mouths" (Jorge A. Domínguez-Godino et al. 2015, 123). After breaking these particles down, they are fed on by bacteria and recycled back into the ocean ecosystem as "inorganic nitrogen and phosphorus […] enhancing the productivity" of the benthic zone, making sea cucumbers natural nutrient recyclers helping to clean the ocean (Khanh, Anh, and Dinh 2020, 1). Additionally, the animal's excretions also increase the alkalinity of the water around them, which is fundamental for protecting nearby oligotrophic water, such as coral reefs, from the effects of ocean acidification (Bittel 2018). This is also the reason why overexploitation of sea cucumbers has such detrimental effects on the environment, as the absence of these animals is likely to worsen the health of the sediment and impair the

rate of nutrient recycling (S. Purcell et al. 2016). Furthermore, like most animals, sea cucumbers are affected by global warming, water pollution and habitat destruction by humans (Kourous 2009). Accordingly, there is an immanent need to secure the survival of this endangered species. Apart from the animals' importance for the aquatic environment and the climate, sea cucumbers are considered a delicacy in many countries, especially in Asia. The edible component of the animal is its body wall, commonly bought in dehydrated form and consumed in stews or soups, is known as 'bêche-de-mer' or 'trepang' (Kubala 2020). Sea cucumbers are high in protein and low in carbohydrates, and further also unveil a remarkable portfolio of valuable micronutrients, such as minerals like iron, calcium, magnesium, and several B vitamins, making them an interesting product for human consumption (Bordbar, Anwar, and Saari 2011). Additionally, they are a source of high-value chemicals with positive health effects, such as collagen, amino acids and carotenoids, they exhibit therapeutic properties and have traditionally been used in medical and pharmacological activities (Bordbar, Anwar, and Saari 2011). Especially in traditional Chinese medicine, sea cucumbers have for a long time been used in creams or as oral dietary supplements to treat ailments like arthritis, cancer, or impotence (Kubala 2020). Recent medical research has also proven that appreciable amounts of chemical and bioactive compounds sea cucumbers exhibit anticancer, anti-inflammatory, antitumor and antimicrobial health benefits (Pangestuti and Arifin 2017). Hence, due to the organisms' many health benefits, it could aid in nourishing the growing world population. Additionally, the growing demand and the current heavy overfishing are disrupting the ocean's natural ecosystem and are strongly increasing prices. In 2019, the sea cucumber market generated $1054 million in revenue and is anticipated to reach $1436 million dollars in 2025 (Absolute Reports Pvt Ltd 2022). The compound annual growth rate (CAGR) of 5.28% shows great economic potential of farming and selling the animals (Absolute Reports Pvt Ltd 2022). Therefore, aquafarming of sea cucumbers poses a great business opportunity, while it could at the same time combat the growing overexploitation of wild animals.

Moreover, they work well in multitrophic aquaculture environments, as they are low-trophic marine invertebrates and feed on other marine animals' deposits (MSG 2022). Consequently, IMTA with sea cucumbers may generate additional commercial value without extra inputs (CCMAR 2017). On top of that, they are even furthering the reduction of environmental waste, when co-culturing with other fish or shellfish. Finally, as they are easy to handle and to harvest, especially in multitrophic aquaculture, we conclude that sea cucumbers are of great economical interest for us. Considering the numerous aspects of sea cucumbers and their benefits, we concluded that it will be highly beneficial and fundamental for AQUATA, the environment and the animals themselves to cultivate sea cucumbers. Especially, as the sea cucumbers feed on other animals' waste and do not require additional input it is a great economic opportunity for IMTA. By including the animals in our aquafarm, AQUATA leverages this business opportunity, tapping into a large and growing market. Like this we will be able to answer the excess demand of sea cucumbers while helping to secure depleting natural stocks.

5 The Aquaculture Market

The market for aquaculture of low-trophic level species is economically attractive as it is constantly growing. Globally, aquaculture has been one of the industries with the fastest growth in the world's food production for the past 50 years (Appendix 3) (McKenna 2021; FAO 2020). Expanding global population, increasing consumer demand for alternative meat products, growing need for food security and scarcity of natural resources are supporting aquaculture businesses' growth.

5.1 Low-Trophic Species as Economic Opportunity

On the **global level**, over 9.4 million tons of bivalves, mainly crustaceans, were produced with a value of $69.3 billion (FAO 2020). The global bivalves market demand has remained stable over the last few years and is expected to reach $15.36 billion from 2021 to 2026 (Technavio 2022).

Aquaculture of sea cucumbers is trying to meet the increasing seafood demand and restore depleted fisheries to sustainable levels (Conand 1988; Toral-Granda et al. 2008; Lovatelli et al. 2004; S. W. Purcell et al. 2013; S. Purcell 2014; González-Wangüemert, Valente, and Aydin 2015). By 2028, the global sea cucumber market is expected to reach $1,436 million (Absolute Reports Pvt Ltd 2022). A direct comparison of the key figures of both species is not possible at this point, since the Technavio bivalves report includes data of several mussel species (clams, scallops, etc.), whereas sea cucumbers are a stand-alone species and are thus not allocated to any subgroup in the Absolute Pvt Ltd report (2022). Nevertheless, these figures outline a growing market with new business potential and opportunities. On the contrary, aquaculture of marine algae, dominated by seaweeds, dropped by 0.7% in 2018 (FAO 2020). However, the FAO still attributes growth potential for aquaculture of algae from temperate latitudes and cold-water species (FAO 2022b).

Overfishing, the growing world population, and the increasing global food demand led to a rising trend in European aquaculture production of low trophic species (Gonçalves 2022). In 2012, 338t of bivalves were produced. However, one year later, the production had already increased to 1,500t, maintaining at the same level until 2016 (Gonçalves 2022). The encyclopedia report shows that bivalves are one of Portugal's most produced mollusk species, making up 67% of all aquaculture production (Gonçalves 2022). On the contrary, the production of sea cucumbers is still in its infancy in most areas of Europe. According to the European Commission (2019), “sea cucumbers may just be the next big thing for European aquaculture.” Therefore, several European non-governmental organizations’ (NGO´s) as well as sustainable seafood companies invest in knowledge, expertise and technology to increase sustainable trophic-level species aquaculture in the Atlantic Ocean (F. Mercedes 2022; Cordis European Commission 2019; The Fish Site 2019). These organizations are working towards new farming methods which are economically profitable and achievable at large scale.

5.2 Chosen Market for Scallops

Trade (Import and Export): The scallop industry is one of the most profitable fisheries in the Atlantic (Sennott 2021). “The (global) scallops segment is expected to expand with the fastest CAGR of 5.1% from 2022 to 2028.” (Grand View Research 2020). In general, **“**Production of oysters, clams and scallops in Europe is much lower than the mussel production.” (Wijsman et al. 2019, 13). Nevertheless, the demand for bivalves, for instance scallops, increased from 2019 until now. According to EUMOFA (2022), in 2020 the European Union (EU) imports of frozen scallops added up to 14,403t and 4,219t of fresh scallops. In contrast, only 2,820t of frozen scallops and 248t of fresh scallops were exported from Europe. France is the leading exporter in Europe, followed by Denmark. France, Spain and Italy are the key importers of scallops.

Consumption: Scallops are highly demanded due to their nutritional value and good taste. One of the primary growth factors for scallops as a food product is the rising inclination of Europeans towards a healthier lifestyle, which led to higher consumption of protein-rich seafood such as scallops (Shahbandeh 2022; Grand View Research 2020; FACT.MR 2022). Additionally, the growing demand for high-quality food, considering freshness, product variety and food safety, is a substantial advantage for the European scallop market. The main scallop customers are distributors, retailers, restaurants and hotels (Europages 2022; Gradner Pinfold Consulting Economists Limited 2001). The market is confined essentially to scallop meats: the edible adductor muscle.

Taking a closer look at the Portuguese market, the country is one of the largest consumers of fish in Europe, consuming an average 60kg of fish per person per year, ranking third among developed nations in terms of seafood consumption (per capita) (Laurenti 2010; Vanhonacker, Pieniak, and Verbeke 2012; NEF 2016). Approximately 70% of the Portuguese eat seafood once a week (Pieniak, Vanhonacker, and Verbeke 2013). In addition, 2% of the fish consumed is produced domestically in aquaculture. Portuguese wild fisheries made up to 35%, whereas imports accounted for 63% of the consumed fish (WWF MMI 2017).

Price: The FAO (2021) shows that the seafood price skyrocketed in 2021, pushing up scallop prices predominantly for large specimens of scallops. In May 2021, in Galicia, the market price for scallops (typically sold including the shell) reached on average 5 - 6 €/unit depending on the size (Cortés et al. 2021), which translates to 43.5 - 52.2€/kg at 8.7 units/kg (The Fish Society 2022). According to the global trading platform Tridge (2022b), the price collection of representative wholesale prices for fresh scallops in Rungis France has jumped to 42.99 €/kg (meat only) in December 2022 (Tridge 2022b). In Catalonia Spain, the wholesale prices for fresh scallops reached 17.17 €/kg (Tridge 2022b).

Competitors: The European scallop market is defined as a highly fragmented sector. Companies in the European scallop aquaculture sector have a very marginal commercial activity (Strand, Louro, and Duncan 2016). France and Spain are one of the key players competing within the scallop *Pecten maximus* aquaculture industry (Magnesen 2022; Da Costa 2022). L'écloserie du Tinduff (Comité Départemental des Pêches 2022) from Plougastel-Daoulas (France) produce scallops in their hatchery and open sea farm. As a result, nearly 10 million spawns are produced each year, of which three million are sown in the Bay of Brest (located in Brittany in north-western France). Integrated aquaculture companies with commercial hatcheries co-cultivate *Pecten maximus*, in their larval state (spat) with other shellfish species are currently not existent in our key market Portugal (Araújo 2022). Overall, the market is dominated by aquaculture companies producing shellfish like clams, oyster, mussels. The scallop aquaculture sector is also facing increasing competition from commercial fisheries. In 2013, the fisheries' produced 49,400t of *Pecten maximus* and *Aequipecten opercularis* scallops in the UK (Strand, Louro, and Duncan 2016) and 23,600t in France.

5.3 Chosen Market for Sea Cucumbers

Trade (Import and Export): Aquaculture of sea cucumbers is a highly dynamic industrial segment in Asia. According to (Louw and Bürgener 2022), China dominates the international

sea cucumber trade. Generally, “China Hong Kong SAR, China, Singapore, Malaysia, Taiwan Province of China, Republic of Korea and Japan account for almost 90 percent of the total imports of trepang, with approximately 80 percent of the overall international trade destined initially for China, Hong Kong SAR. “ (Toral-Granda et al. 2008, 101). China imports multiple sea cucumber species as a result of its varied purchasing power (Choo 2008). Hong Kong is the major trade hub and leading importer for sea cucumbers in Asia with an import value of $197.25 million and import volume of 2.38 million tons in 2021 (Tridge 2022a). In addition, Hong Kong is "having the largest entrepôt controlling 80 percent of the global import-export sea cucumber trade." (Toral-Granda et al. 2008, 101). From 2012 to 2019, Hong Kong made up to 63% of the total sea cucumber imports. Predominantly Africa, Japan, China, USA, and Canada supply Hong Kong with sea cucumbers (Appendix 4). Mainland China is the second top importer for sea cucumber products (Louw and Bürgener 2022).

In 2021, Hongkong was the world´s largest export destination of sea cucumbers with an export value of $27.80 million and an export volume of 1.40 million tons (Tridge 2022a). Hong Kong's current share of the world's total sea cucumber's market is 11.91%.

Consumption: Sea cucumbers are mainly consumed in China, but also in Singapore, Vietnam, Korea, Malaysia and Japan (Rahman and Yusoff 2017). Dried sea cucumbers of excellent quality are high-demand trending products in Asia, regardless of the species. A significant proportion of consumers in Asia, especially Taiwanese and Hong Kong citizens, are willing to pay more for high-quality sea cucumbers (Ferdouse et al. 2004). Sea cucumbers are frequently served at events such as weddings and banquets or at festive meals (Clarke 2004). Around festive seasons, for example Chinese Lunar New Year, businesses in that industry can reach their highest sales volume. Sales prices increase by up to 20-30%, just before Chinese Lunar New Year starts (Alvarez 2022; Clarke 2004).

Price: Due to the increasing demand, bêche-de-mer prices are kept at an attractive level. In Asia, consumers are willing to pay from €300 to €1,500/kg for a premium product (Barboza 2008). Especially Hong Kong, Taiwan, and Singapore fetch high bêche-de-mer prices (Choo 2008). The product price is based on the type of species, size, and post-harvest quality (Altamarino and Zaidnuddin 2022; Choo 2008). According to Shelley Clarke (2004), size, species, level of processed product dryness, and time of year are the major price determinants for sea cucumbers. Generally, "Updated price data, which could serve as the basis for formulating sound production and marketing decisions, do not exist." (Rahman and Yusoff 2017, 28). In general, sea cucumber species of Asian origin are perceived as more prestigious compared to European ones. However, European species are receiving more attention due to higher quality and environmental standards in the EU.

Competitors: High-quality sea cucumbers are mainly grown in Japan, the Pacific Coast of South America, South Africa and Australia (Choo 2008). Sea cucumbers farmed in Indonesia, the Philippines, and China are "of lower quality due to species composition and inferior processing techniques." (Clarke 2004, 54). Water pollution, ineffective processing management systems and techniques specific to sea cucumber conservation (conventional drying methods), lead to lower product quality in these regions (Choo 2008; Perez and Brown 2012; Barboza 2008; S. W. Purcell et al. 2013). An accurate understanding of efficient aquaculture techniques is necessary to produce high-quality products. Due to complex cultivation programs and extended production times, the volume of production has been steadily declining across Asia (Toral-Granda et al. 2008). Thus, the development of highly innovative and technological aquaculture solutions are needed to meet the high demand in Asia (Maritime Fairtrade 2022; Giraspy and Walsalam 2009).

Opportunity with Supplements: Bêche-de-mer powder is also used for food supplements in traditional Chinese medicine (Cheon 2021). Sea cucumber supplements provide many health and nutritional benefits, "from acting as a natural antioxidant to providing active compounds

and essential nutrients to nourish the body" (Nova Sea Atlantic 2022). According to Precedence Research (2022), the global dietary supplements market is expected to increase until 2030. In 2021, the market size was estimated to be worth $335.24 billion, and by 2030, it is predicted to reach over $624.7 billion, growing at a notable CAGR of 7.1% from 2022 to 2030. Sea cucumber supplements can be sold for nearly $1 a gram (Azari 2022).

5.4 Economical Background on Aquaculture of Aquatic Animals

"In 2020, global aquaculture **production** reached a record of 122.6 million tons, with a total value of USD 281.5 billion" (FAO 2020). Thus, aquaculture accounted for 49.2% of total aquatic animal production of aquaculture and fisheries combined in 2020, while in 1990 it accounted for 13.4%. Excluding Norway, in Europe the share of aquaculture is below 14%.

The most dominant producing region is Asia, which contributed to 88.4% of global aquafarming production of aquatic animals (FAO 2020). In addition to that, the top five aquaculture countries are in Asia. America, Europe, and Africa account for 5.0%, 3.7%, and 2.6%, respectively.

From 1990 to 2020, aquaculture for aquatic animals has grown at an annual rate of 6.5%, however, growth is slowing down. The projection for 2030 is that aquatic food production will grow by 15%, and that this growth will mainly be attributed by an intensification and expansion of sustainable aquaculture. On a global scale, aquaculture production growth has been steady, as local fluctuations have been compensated by the prevalence of international **trade**, and demand experienced a continuous rise. "In 2020, world exports of aquatic products, [meaning combined fishery and aquaculture] excluding algae" (FAO 2022b), totaled 60 million tons at $151 billion. From 1976 to 2020, the nominal annual growth rate of aquatic products' trade value was 6.9%, and the inflation adjusted growth rate was 3.9%, "corresponding to an annual growth rate of 2.9% in terms of quantities over the same period" (FAO 2022b). The European

Union is the strongest importing region at 34%, and the US and China also have strong imports at 15% and 10%, respectively (FAO 2022b).

In parallel to the trade, total **consumption** of aquatic foods has also increased by 3% annually from 1961 to 2020, at almost twice the rate of global population growth in the same time period (1.6%). This has manifested in an increased consumption per capita of aquatic foods: from 9.9kg in the 1960s to 20.2kg in 2020 (excluding algae) (FAO 2022b). Consequently, aquatic foods globally cover 17% of the animal proteins consumed nowadays. Just like aquatic food production, consumption is expected to increase by 15% until 2030, to 21.4kg per capita. FAO attributes this to "rising incomes and urbanization, improvements in post-harvest practices and changes in dietary trends" (FAO 2022b).

To conclude, aquaculture is a dynamic industry that is developing strongly in terms of production and trade volumes, and consumption. This does not only present a great opportunity for AQUATA but will likely attract more and more attention from investors.

6 Feasibility of Our Solution

In the following part, the potential for AQUATA as a fast-growing business and promising business opportunity is examined by analyzing the aquaculture market environment in Portugal, the aquaculture process of scallops and sea cucumbers, and strategic partnerships to decrease AQUATA's market entry barriers.

6.1 The Beneficial Environment in Portugal

Conditions: The Portuguese aquaculture industry benefits from ideal climate and environmental conditions as Portugal is located in the second-largest marine area in the world (Cadete 2022). Aquaculture businesses operating near the Algarve in the South of Portugal are well positioned as the North Atlantic Ocean offers a high-quality growing environment, including ample marine space, excellent water and natural food quality. The Algarve has

optimal weather conditions as the climate is stable over the year, which is one of the crucial aspects to achieve high growth rates in our open sea farm. According to the EU Water Framework Directive, “the Algarve coast is classified as a mesotidal, moderately exposed Atlantic coastal type. This coast is affected by seasonal upwelling induced by northerly winds from May to September, which can supply nutrient rich water resulting in high primary productivity contributing to a commercially valuable fishery as well as bivalve aquaculture.” (Scottish Marine Institute 2015). However, climate conditions can change. In 2019, Algae toxins occurred in the Atlantic and led to the interdiction of bivalve harvesting near the Algarve coast (Domingues 2021). These algal blooms species can negatively impact coastal ecosystems, fisheries and the aquaculture industry through their production of biotoxins that could accumulate and concentrate in shellfish flesh. In that case, aquaculture companies should be prepared to intervene and save their seeds from toxins when conditions change, for example when transporting the species to an offshore operational center and store them until conditions get better. Overall, aquaculture companies benefit from premium marine conditions and Portugal’s costal nation by having major economic activities such as fisheries, port and (seafood) market activity close to the coast. In addition, Governments support fisheries and aquaculture sectors through a wide range of policies and investments, including over €12 million for green and digital transition in 2022 (Redacción 2022). The Portuguese government supports both sectors in order to increase the sustainable use of the marine resources.

Certifications: Voluntary certifications are becoming increasingly important in the aquaculture sector as they demonstrate compliance along the supply chain and reward aquaculture companies’ commitment to developing sustainable, high-quality products. Portuguese firms can apply for several certifications (ASC 2022), such as The Aquaculture Stewardship Council (ASC) certification, which certifies high-quality and responsible production. ASC is available for 17 marine species (e.g., scallops and oysters) and addresses challenges like seafood mislabeling (NSF 2022). ASC also uses Marine Stewardship Council Chain of Custody (MSC

CoC) standards for the supply chain to prove aquafarming businesses. In addition, the Best Aquaculture Practices (BAP) (SGS 2022) certification enables aquaculture companies to demonstrate the environmental, and social responsibility of their farming practices, including aspects like animal welfare, food safety, and traceability.

In 1979, the European Union introduced the council ´"Shellfish Waters Directive 79/923/EEC" to protect the (marine) environment and to control the quality of shellfish waters and products (Lexparency 2022). Since, for instance, shellfish (scallops) and other marine invertebrates (sea cucumbers) can accumulate toxic substances from the ocean that can compromise their viability and quality, different seafood certifications have been established. The following three classification classes were developed to evaluate shellfish quality (Wijsman et al. 2019): Class A indicates "molluscs can be harvested for direct human consumption." Class B indicates, […] "molluscs can be sold for human consumption after purification in an approved plant, or after re-laying in an approved Class A re-laying area, or after an EC-approved heat treatment process." Lastly, "Class C molluscs can be sold for human consumption only after re-laying for at least 2 months in an approved re-laying area, where necessary, by treatment in a purification center, or after an EC-approved heat treatment process." (Wijsman et al. 2019). The importance of seafood certifications is based on the increasing consumers demand for information about regional origins, production and legality of seafood products.

6.2 Aquaculture with Scallops

The scallop market is a very interesting business opportunity, because the demand clearly extends the current supply. In addition, there is currently no scallop aquafarm existent in Portugal, but according to Magnesen (2022) the technology of spawning and farming scallops has developed strongly, making it feasible to farm scallops nowadays. Interestingly OF also found scallops in their open sea farm lanterns, which proves that scallops can grow in the open sea farm and the Algarve water conditions. Besides the feasibility and business opportunity,

scallops also strongly match our corporate vision to fight the world hunger crisis, because they are very beneficial for the human consumption as they have a high protein content of 12.06% and are low in fats (European Commission 2022b). Additionally, they are beneficial to the environment by filtering and cleaning the ocean (Marshall and Wilson 2008).

In order to understand the scallop aquaculture and its feasibility, we conducted further research through interviews and literature reviews. After educating ourselves through research and meetings with scallop experts, we got advised that the most economically profitable and most suitable species for our operations, is the King Scallop, *Pecten maximus* (Magnesen 2022). Another reason is the natural occurrence of the scallop in the European Atlantic and in the waters around West Africa (Marshall and Wilson 2008). Hence, it is native to Portugal, which is one of the most important characteristics when choosing the species, we would like to cultivate. It can reach a size from ten to 16cm and is fan shaped with a so-called ear and two shell valves (Marshall and Wilson 2008). The King Scallop is a filter feeder, extracting particles from the surrounding water via a feeding current (Beaumont and Gjedrem 2007). Therefore, its diet consists of "phytoplankton, especially single celled algae, POM, bacteria and other micro-organisms" (Marshall and Wilson 2008, 10). Favorable growing conditions include water depth of 10 to 110 meters (Marshall and Wilson 2008) and temperatures above 6.5 degrees Celsius. The growth is improved when the water gets warmer, up to a maximum of 23 degrees Celsius (Laing 2000). They prefer low-mud areas and full salinity of 30-40 psu (Marshall and Wilson 2008). To ensure high survival rates and fast growth in our hatchery, we will artificially create the perfect growing environment for the scallops. The artificial adjustment of the hatchery's environment is also essential for the reproduction of our scallops. Usually scallops have two spawning seasons, one in spring and one in late August, but we will try to influence their spawning behavior through simulating temperature changes, heat shocks and food deprivation, which according to Magnesen (2022) is a normal procedure in their hatchery. After fertilization, the settlement of larvae usually takes place 35 to 45 days later (Robinson et al. 2016). After 3 months the scallops will have

reached a size of ten to 15 mm and are ready for the open sea farm. In the open sea farm, they will spend another three years until they reach the commercial size of 10cm (Magnesen 2022).

Natural predators are starfish, crabs, and the common dragonet, but King Scallops are able to jump away from predators (Veale, Hill, and Brand 2001). However, when growing them in our lanterns they would not be able to escape, wherefore we need to secure the lanterns accordingly and do periodic controls. In addition to the scallops' predators, we also must ensure the animals health, by checking them for diseases, especially in the larvae stage. Another threat is the pathogen *vibrio pectenicida,* which can increase the larvae mortality drastically (Lambert et al. 1998). Therefore, regular checks for the pathogen in our laboratory are essential to ensure that the damage caused is minimal.

After the larvae stage the scallops are either grown out through the so-called ear hanging technique, in pearl nets or in lantern nets. Ear hanging describes the process of nailing the individual scallops on to a rope which is then released into the sea. This technique is very resource intensive, because every scallop must be attached individually (Wright 2016). Growing scallops in pearl nets, which are small pyramid shaped nets, has the advantage that the nets are light and collapsible and therefore easy to handle. On the contrary, the light pearl nets are usually not able to fully grow out the scallops due to the adult's weight (Hardy 2006). In addition, according to Maguire and Burnell (2001) scallops grown in pearl nets were on average 10mm smaller and 32g lighter than scallops in lantern nets. Lantern nets are the most typical grow-out method for scallops (Hardy 2006). Due to the lantern net's larger size and stable construction, they are usually used to grow out scallops until they reach adulthood and are ready to harvest. Therefore, we decided that lantern nets are the most efficient and suitable farming method for AQUATA.

Due to the scallop's diet and their lower place in the food chain, they are suitable for IMTA with sea cucumbers. Sea cucumbers feed on the scallops' excrements, enabling an efficient polyculture farming process. According to Zhou et al. (2006) the polyculture with scallops and sea cucumbers

in lantern nets did not decrease the survival rate of the scallops in comparison to monocultures, where the survival rate in monoculture and polyculture experiments ranged from 86% to 95%.

6.3 Aquaculture with Sea Cucumbers

Conducting thorough literature research, expert interviews and analyzing secondary data, we have found that aquaculture of sea cucumbers would assist in fulfilling the current needs of the growing world population. It would aid in combating the global food challenge and oppose the ongoing overexploitation of the animals, while tapping into a growing economic market, posing a valuable business opportunity. Aquaculture is a natural response to the mentioned aspects. However, many businesses are still in the early stage and unable to meet demand. Therefore, high levels of exploitation, primarily for Asian markets, are endangering natural stock levels (Projecto - Sea Cucumber 2022). Thus, in the following we will describe the aquafarming process of farming sea cucumbers, keeping in mind our idea of building our business around multitrophic aquaculture in Portugal and orientating towards OF as a role model. The main goal of our research is to find the best suitable species for aquaculture in the Atlantic and create an appropriate aquaculture biotechnology for the native species (Jorge Antonio Domínguez-Godino and González-Wangüemert 2019).

Dr. Beni Azari, head consultant of a sea cucumber consultancy, recommended us that we should work with a variety of species that naturally exist around the Portuguese coast in order to diversify our stock portfolio and realize the full potential of our aquafarm. Thus we considered the different geographical occurrences and specific conditions necessary for sea cucumbers to thrive in, evaluating several species, according to their specific needs, natural occurrences, the current state of exploitation and their economical profitability (Jorge Antonio, Mehmet, and Mercedes 2016). Based on his recommendations and our research, we choose the commercial *sea cucumbers H. mammata, H. tubulosa, H. poli,* and *H. arguinensis*. The latter one exhibits the highest economical revenue considering its profitability with a dried kilogram of the brown-orange animals selling

for at least €250. Valuable is the greater wet weight and thicker body wall compared to individuals of equal length (Jorge Antonio, Mehmet, and Mercedes 2016; Venâncio et al. 2022; González-Wangüemert, Valente, and Aydin 2015). Additionally, this species is of growing interest because the development of biotechnology for this species reproduction in aquaculture has increased facilitating the aquaculture process. Moreover, compared to the afore-mentioned species it has a more constrained range of natural occurrence and is most pressured by illicit fishing (Jorge A. Domínguez-Godino et al. 2015; Jorge Antonio, Mehmet, and Mercedes 2016). Hence, we have chosen to use *H. arguinensis* to illustrate the aquafarming process. *H. arguinensis* natural habitat includes the Canary Islands and the area from the Berlengas Islands to Morocco and Mauritania, including and some parts of the Mediterranean Sea. The species is found from the intertidal zone, where the ocean meets the land up to 52 meter depth, exhibiting no shelter-seeking behaviour (Marquet et al. 2017). Hence, the species is native to Portugal, just like *H. poli*, which occurs in the subtropical zone with large populations in the Atlantic Ocean and the Mediterranean Sea (Jorge A. Domínguez-Godino et al. 2015). *H. tubulosa*, can also be found in "the eastern Atlantic Ocean as far north as the Bay of Biscay and in the Mediterranean Sea" (MSG 2022, 1). Moreover, *H. arguinensis*, as it is relatively large in size with an average of 30 cm. The species is edible and exhibits high levels of proteins adequate for human consumption, making up more than 40% of the total dry weight (De Carvalho-Souza, Roque-Atienza, and González-Ortegón 2022). It is also acceptable for human consumption with its nutritional content being comparable to that of other typical commercial sea cucumber species (Jorge Antonio Domínguez-Godino and González-Wangüemert 2019). Moreover, all of the mentioned species exhibit significant antioxidant activities and are low in carbohydrates and fat, wherefore they are highly sought after in the Asia-Pacific region. Currently, the Mediterranean and Atlantic species are gaining more attention, due to the existent unmet demand and the consequential economic opportunity especially in the Asian markets (Jorge A. Domínguez-Godino et al. 2015). Thus, next to the economic reason and the sea cucumber's potential as alternative food source, there is also a growing interest to farm the

animals and the mentioned species, as the aquafarming biotechnology for larvae and juveniles have recently evolved, facilitating the development of aquaculture (G.-W. Mercedes and Jorge Antonio 2016). Moreover, they are promising candidates for IMTA as they are high in market value, but low-trophic, deposit-feeding organisms. Therefore, as something that removes organic waste, which can have a negative impact on the seafloor and on the aquafarm, the animals present a great environmental and economic opportunity.

According to Dr. Beni Azari, prior careful planning and the broodstock management system is of high relevance determining the outcomes success. Hence, before starting our aquafarm, it is important to carefully plan and calculate, set key performance indicators (KPIs) and conduct as much field research as possible. Moreover, it is essential to always take protocol of all influencing factors, like the sea cucumbers sizes and weight, but also the temperature in the hatchery or open sea farm, the spawning process and reproductive pattern and occurring environmental parameters, which are subject to seasonal fluctuations (Marquet et al. 2017).

Overall, the process of farming sea cucumbers is divided into different phases, starting with the broodstock collection and maintenance, followed by the spawning and fertilization. After that, the animals' evolution from embryo to larval to juvenile needs to be supported in a hatchery before the animals can be transferred into the open water.

The first step in cultivating sea cucumbers should be the collection of wild broodstock, which is native to the region, where the open sea farm or the cultivating ponds are located; in our case the Algarve in the South of Portugal (Azari 2022). Sticking to native species raises the probability of survival, mitigating risks related to diseases or necessary environmental conditions while a negative interference with nature is limited. Additionally, as the health of the individual broodstock animals is crucial to the hatchery's performance, only the biggest and healthiest animals should be used for broodstock (Cruz 2022). After the catch, they need to be carefully transported in individual cages filled with aerated water, as the animals suffer from motion

sickness (Holmyard 2021). These individuals should be kept in large tanks with sand to allow burrowing behavior and previously collected sediment for to ensure natural feeding conditions. They should be “filled with flowing sand-filtered seawater at ambient temperature” and the water should be changed every day and the sand every fortnight (Jorge A. Domínguez-Godino et al. 2015, 13). Moreover, they need to be fed with microalgae consisting of planktonic and benthic diatoms, because good nutrition and water conditions ultimately render the success of the following spawning process. Obtaining knowledge and “understanding the reproductive biology of a species is central to sound fishery management” (Marquet et al. 2017, 121). Thus, considering the reproduction cycle, one important thing to notice is that the chosen species usually spawn around different times during the year. However, in the hatchery one can work with temperature shocks to induce spawning, as it simulates nature’s seasonal temperature changes. For the spawning induction the animals should first be cleaned with fresh “sea water to remove sediment and other organisms” and then be divided into groups of 25 to 35 for each 250-L tank (Nguyen, Mariamu, and Pham 2021). There are several methods that can be used for spawning. One established methodology is called thermal stimulation, in which aquarium heaters are utilized to raise the water temperature three to five degrees Celsius above ambient to approximately 25 to 27 degrees Celsius. Afterwards the broodstock is placed in the tanks and the heat is maintained over a maximum of one hour and 30 minutes. After the females have spawned, the eggs were left in the tanks for another hour to ensure fertilization and then sieved into a bucket to clean them. The eggs transform into larvae within 48 hours after fertilization and start feeding on microalgae, which needs to be provided in the tanks. The microalgae quantity should be gradually increased as larvae grow until they metamorphose into the short non-feeding phase around day 18 until 20. Mortality during the larval phase is especially high as after 20 days the survival rate drops to 30 - 34% (Rashdi et al. 2012). After around one month of larval development reaching a length of 20mm the Juveniles are maintained in the hatchery for another two months in sand-based nursery tanks. After that, the grow out phase happens once the sea cucumbers weigh around 10 to 15g

and are three to seven cm long (Azari 2022). To cultivate the animals in lanterns in the open sea farm, factors like the carrying capacity, the number of juveniles, the needed square meters, space in the lantern nets and other tools like the cleaning equipment or a boat needs to be considered. Moreover, the water quality and the food circulation needs to be assessed, to understand the environmental conditions and to choose the location for the farm in the first place. During the first grow-out cycle the initial biomass and stocking density should be low. Moreover, the juveniles can either be stocked on a regular basis so that cohorts of various sizes coexist in the lantern, helping to keep the total biomass as close to the carrying capacity as possible (Pascal and Robinson 2011). Sea cucumbers cultivated in lanterns can reach a market size of 350 to 400g between five and twelve months, depending on the different sites and seasons. As theft is a present issue, the sea cucumber stocks should be guarded at night (Pascal and Robinson 2011).

For the harvest, Dr. Azari recommended selective harvesting, even though it is human resource intensive. This includes only harvesting the ones that have reached an adequate size and letting the small ones grow out. Overall, in reference to our idea of farming sea cucumbers, Dr. Azari recommended to start as a pilot to analyze all parameters, observe our findings and calculate the needed investments for investors, before scaling our operations (Azari 2022).

6.4 Aquafarming Entry Barriers

When newcomers enter markets, they will face barriers that can prevent or impede newcomers from entering a new market or industry sector. This can be advantageous for companies already existing in a specific sector but can damage the whole industry. Without new competition, the pressure to innovate is minimal, leading to inefficient and outdated companies and solutions. Depending on the sector, these barriers are complex or less challenging to overcome. They exist due to specific requirements needed to succeed in the industry, such as knowledge, talent, capital, technology, or rare materials. In the following, the market entry barriers in the aquaculture market are analyzed and several solutions to overcome these barriers are presented.

6.4.1 Challenges of Starting a Business in Aquaculture

Aquafarming is a massive business opportunity but is also bound to several limitations and challenges, as due to very high market entry barriers, the market is not satisfied yet. These limitations occur for several human-made reasons due to irresponsible and excessive behavior, such as pollution through throwing trash in the ocean, over-fishing, and unsustainable fishing methods.

First, the mentioned human behavior has limited the space for sustainable aquaculture because many areas are polluted with toxins and other chemicals, leaving them with low water quality. The low water quality can either decrease the survival rate of bivalves or fill them with toxins due to their filter feeding, making them unsuitable for human consumption. The limited space has created strict regulations in the aquafarming market, making it increasingly challenging to obtain open sea farm licenses. In addition, it also makes aquafarming hard to scale, because the population density of the species is a central bottleneck for aquafarms due to the high competition for food.

Second, aquafarming is a capital-intensive business because it requires licenses for the open sea farm, a highly technological hatchery, boats, laboratory equipment, and other expensive equipment. In addition, some species take several years to reach commercial size, are season dependent, can only reproduce at certain times, or have high mortality rates. Also, the risk of losing a whole batch due to diseases is high. The capital is invested for an extended time before revenue is generated, while the expenses are reoccurring and must be paid. This financial market entry barrier is a significant problem. It can only be overcome through prolonged farm growth or significant investments covering the first years in which no revenue will be generated.

Lastly, high-quality seeds or broodstock of a species are a valuable and rare resource, nevertheless essential to start with the aquafarming process. This resource is not rare due to scarcity but because aquafarms invest time and resources to identify resilient and genetically optimal individuals. This is a significant factor for the efficiency and economic viability of the farm, as well as a substantial competitive advantage over other farms. The broodstock will

therefore have to be collected in nature and will only compete with other aquafarm's broodstock through excessive research and development (R&D) expenditures.

6.4.2 Strategic Partnership with OF as a Market Entry Facilitator

OF is a highly technological and innovative startup that produces high-quality clams in their open sea farm close to the Algarve. As stated before, OF is the inspiration for our business model and has been a close contact since the beginning of the business model development phase. Therefore, we are also planning on engaging in a strategic partnership with OF, helping both ventures grow and scale even more efficiently. Our strategic alliance with OF will help to eliminate significant market entry barriers for AQUATA and tackle challenges that OF could face during further scaling phases. Currently, OF is using up to 50% of its space in the open sea farm and by the time AQUATA launches in 2025, OF will have expanded to a second open sea farm. OF will only be able to fill part of the new space with their clams because producing that many clam seeds will take several years. Therefore, AQUATA agreed with OF to share the second open sea farm for five years, for example. This partnership will be a risk-sharing agreement, of which several different versions exist (Reis 2022). Therefore, both parties will have to discuss the kind of compensation for the usage of the open sea farm. First, OF could become a shareholder of AQUATA and will profit from our future growth. Second, AQUATA could pay a fixed rent for the used open sea farm space. Lastly, OF could receive partial revenue shares of AQUATA's future revenue.

Through sharing the open sea farm, AQUATA will remove the market entry barrier of licensing an open sea farm, which is a highly complex process and can take up to five years. In exchange, OF can either increase their profit margin per kilogram of clams because the fixed costs of the open sea farm are lower due to our rent payments or will profit from AQUATA's growth in the future by being a shareholder or receiving revenue shares.

7 Our Solution

AQUATA is a highly innovative and technologically advanced scallop and sea cucumber aquaculture business. Its focus lies on efficient and sustainable farming procedures, allowing us to become a respected and recognizable European aquafarming brand, supplying Portugal, Spain, France, and specific Asian countries with our high-quality products. AQUATA is an independent, legally registered company but maintains close connections with OF. Through expansion and scaling, we will increase our revenue and invest in our own sea farm to scale our value creation, income, shareholder return, and impact.

7.1 Pillars of Innovation

AQUATA relies on three pillars of innovation which build the foundation of our competitive advantage and set us apart from other aquafarming companies. Combining all three pillars allows AQUATA to be economically efficient, resourceful, and rapidly scalable.

7.1.1 Integrated Multitrophic Aquaculture

IMTA refers to a balanced ecosystem in which the by-products of one cultivated species are transferred to another, resulting in high profits and environmental cleanup (Toral-Granda et al. 2008). IMTA is possible when two or more species coexist in an aquaculture system and require similar environmental conditions without competing for food and space. This is known as ecological compatibility (Zhou et al. 2006). By combining species that complement each other, the resource input must only be minimally increased while the economic output increases strongly, making it a very efficient, economically valuable, and sustainable aquafarming method. In the last decade, the IMTA approach has gained significant importance because the reabsorption of waste products of one species by another is more sustainable than monoculture (Neori et al. 2004).

AQUATA uses this IMTA approach because sea cucumbers are deposit feeders and act as scavengers, while scallops are bio-deposit-producing bivalves, making the two species ecologically compatible. Scallops feed on micro-algae / phytoplankton as their primary food source, while sea cucumbers feed on excrements of other species and phytoplankton. The sea cucumber's diet is advantageous in the hatchery and the open sea farm because there is nearly no extra nutrition needed to grow the sea cucumbers. In addition, they decrease the excrement in the water, saving time when cleaning the water, animal containers, and lanterns. The reasons above and their ability to use various organic resources from sediments make sea cucumbers particularly desirable for our polyculture system (Zhou et al. 2006). In the hatchery, the tanks that contain the animals will be split into two levels through a net structure, allowing the water to flow freely between the two levels. On the top level, we will store the scallops that feed on the microalgae, which we add to the water. We will store the sea cucumbers on the lower level, enabling them to feed on the scallop excrement sinking to the ground.

The concept will be very similar in our open sea farm, but it must be tested more precisely due to unpredictable circumstances such as currents, water flow, and sunlight. AQUATA will intensely experiment with the distribution of sea cucumbers across lantern levels to understand how the excrements of the scallops can be captured efficiently. Therefore, we will, for example, track the growth rate if the lantern levels are filled with sea cucumbers and scallops alternately and analyze it when the sea cucumbers are only in the lower levels. In addition, we will also combine scallops and sea cucumbers in lantern levels to see if this increases their complementary effects.

7.1.2 Genetic Breeding

Genetic breeding “is a branch of animal science that addresses the evaluation of genetic value in terms of estimated breeding value (EBV)” (Gupta and Gupta 2014, 345). It has been used for domestic livestock for quite a while but is emerging for aquaculture and aquafarms. Genetic

breeding can be described as a simulation of evolution through which the optimal genetic requirements of sea cucumbers and scallops can be reached quickly. This will be done by analyzing the genetics of our broodstock and their seeds to find individuals with a genetic composition supporting high growth, high resistance towards specific diseases, commercially valuable sizes, and forms, and other economically advantageous characteristics.

Genetic breeding will help AQUATA develop a competitive advantage over other aquafarms. Decreasing our input and maximizing our output will make processes more efficient and drastically increases our profit margin. This improvement will occur because the selection of genetically optimal broodstock will lower the mortality rates, decrease the needed resources and increase the animal's growth rate.

7.1.3 Our Innovative Technological Approach

AQUATA strongly relies on technology to ensure efficiency in every step of the farming process. By implementing a monitoring and prediction system in our hatchery, we have a real-time overview of the single parameters essential for the broodstock and larvae stage. This will help us minimize the mortality rate of the scallops and sea cucumbers and at the same time will collect data about the composition of parameters that create the perfect environment and conditioning for healthy growth. After collecting a large amount of data, AQUATA will be able to decrease the resource input and the animal's time spent in the hatchery and increase our production volume. In addition, we will later implement automation and robotics that can take over a significant amount of manual work, such as sieving the scallops, cleaning the tanks, and moving the animals from one tank to the other. We especially want to automate these tasks because they are standardized and labor-intensive (Magnesen 2022; Cruz 2022).

In the open sea farm, we will also heavily rely on technology. We will implement a prediction and monitoring system to understand the condition of the animals in the lanterns and to predict the optimal harvesting time. Additionally, we will invest in underwater drone data collectors

because utilizing divers is very expensive. In contrast, underwater drones are easy to manage, cheaper, and offer the same level of accurate inspection. The drones will mainly “track environmental parameters such as pH, salinity, oxygen levels, turbidity, and pollutants” (Le 2020). At the same time, we can check for mortalities, pollution, and damage in and on the lanterns.

8 Our Business Model

In the following chapter, we will explain AQUATA's business model in detail by individually describing each step of the operational and production process and showing how AQUATA creates value. In addition, AQUATA's revenue streams, future diversification strategy and our mid- and long-term business model will be explained, showing how the created value is scaled.

8.1 Operations

Aquafarming is a very complicated and highly technological process. Our process is divided into the hatchery stage, the open sea farm / grow-out stage, the genetic breeding program, and our operation center activities.

8.1.1 Equipment and Technology

Several essential resources are necessary to manage our aquafarm and ensure value creation. For a company in the aquafarming business physical assets are essential, and a large amount of equipment must be acquired.

To build the hatchery, we will first identify and rent a suitable piece of land close to high-quality seawater, which will be pumped into the hatchery and used for the scallops and sea cucumbers. Therefore, we decided to build our hatchery in Nazaré close to the Atlantic Ocean. The water quality is excellent in that region, and there are pieces of land that can be rented (Marques 2022). Once the hatchery is built, we require large water tanks, pumps, measurement devices, containers to store the animals, and other equipment. When building the hatchery, this

must be calculated. It is essential to build the pipe system twice to ensure the functionality of the whole hatchery if malfunctions occur and to provide the possibility to clean the pipe system without shutting down the production of the hatchery (Cruz 2022). Other equipment that will be necessary at the hatchery will include the setup of the monitoring systems. We need measurement devices and the IT infrastructure, including cables, Wi-Fi, computers, servers, and other electronic devices. In addition, we will have to supply offices for our employees and therefore need computers, desks, kitchen supplies, chairs and an area where they can take breaks. Storage tanks for broodstock, seeds, juveniles, and microalgae must also be bought. Additionally, necessary laboratory equipment for our genetic breeding program, such as microscopes, clean storage space, bunsen burners, and test tubes are essential. We will have to buy or lease a car and the correct containers to transport the seeds from the hatchery to the open sea farm. Later we will upgrade the car to a large transporter or hire a logistic partner.

The open sea farm will also require the purchase and installation of equipment. First, a long-line system is essential because it is the infrastructure to which the lanterns will be attached. The construction should be finished five months after we finish the construction of our hatchery. Second, we need several lanterns to grow our scallops and sea cucumbers. These will be filled and connected to our long-line system as soon as the first batch of animals arrives. The open sea farm will also have a monitoring system to estimate the perfect harvesting time. Therefore, we must implement measurement devices in the lanterns to increase prediction accuracy. Lastly, all the processes mentioned above require a boat, which is why we will invest early in a boat that allows us to access the open sea farm easily.

After the farming process, the products will be shipped back to our operations center, where we will need water containers to store the scallops and sea cucumbers and a machine that cleans and sorts the animals by size. In addition, the scallops must be stored in water tanks to increase the time they can be stored before they are packaged in nets and sold fresh to our distributors

and nearby restaurants. The sea cucumbers will be processed in a low-temperature freeze-drying machine, packaged and sent to our distributors.

8.1.2 Hatchery

Our hatchery will be in Nazaré and divided into several stations that the scallops and sea cucumbers will go through during their evolvement and growth. As soon as the animals are able to survive in the open sea farm, they will be moved there, allowing them to profit from the environment in the Atlantic Ocean. To begin our production, we will need broodstock for both species that can be used to breed our seeds. Therefore, we will buy our broodstock from a regional supplier and transport it to the hatchery. This process will be repeated several times to have enough variation of broodstock. We will buy broodstock in different seasons and from different places to increase our chances of buying genetically superior and valuable individuals. We must buy different scallop and sea cucumber families to ensure genetic diversity. After one lifecycle of approximately three years for scallops and one year for sea cucumbers, we will stop buying broodstock and use the animals we optimized in our genetic breeding program.

In our hatchery, there will be the broodstock room which contains several smaller water containers in which grown-out scallops and sea cucumbers are maintained (Appendix 5). Both species will be separated at this stage because the semen and the species' eggs should not be mixed and should not be released in the same water containers. In the broodstock room, the females and males usually have a one-to-one ratio and are only exposed to water, air, and food (microalgae). When more seeds are required, we will use two methods to influence the scallops and sea cucumbers to release their eggs and semen. To start with, they are deprived of food over one night to trigger a survival instinct, which increases their readiness to reproduce. Later they will be exposed to heat waves, which simulate different seasons, making the animals believe that it is time to reproduce again, leading them to release the semen and eggs.

Afterwards, the fertilized eggs will be collected and moved to the larvae stage room, which is used for growing the eggs. The primary goal is to reach a high survival and growth rate of our eggs, we will achieve this through the correct kind and amount of nutrition, oxygen, fresh water, population density in each container, and reliable transportation methods. One female scallop can release millions of eggs into the water, mixing with the semen of male scallops. Often, a large amount does not grow to maturity, but by increasing the survival rate, the economic output can be increased dramatically. Sea cucumbers follow a similar reproduction approach as scallops because they release several eggs and semen into the water, which then mix. The two species are separated in this process and will be mixed in the later larvae stages.

In the larvae stage, they are kept in the first containers for two to three days and are then moved to smaller containers, where they stay for another 35 to 40 days. During this time, rapid cell division and growth take place and the animals will regularly be moved to new containers based on their size. This process is essential because it increases the survival and growth rate of smaller bivalves. Otherwise, the larger bivalves consume most of the provided food. The sieving and classification process of scallops and sea cucumbers based on their size is repeated until only animals are left with the necessary size to survive in the open sea farm. Usually, they are moved to the open sea farm, after three months of growth at the hatchery.

In addition, other activities are carried out at the hatchery, such as food production, hatchery monitoring, and genetic analysis and breeding, which will be explained in detail later.

For food production, different species of microalgae with complementing characteristics are collected or bought in tubes. The small tubes are stored in a room, and the algae are exposed to light, oxygen, co2, and water. After a few days, the algae is decanted in a 6-L tube for another few weeks and will then be moved into a 30-L plastic container. The individual algae species often have different nutritional values and are the perfect food for scallops and sea cucumbers.

Therefore, we will mix the different species and test multiple nutritional diets to improve the growth and health of the animals.

To ensure that every step in growing sea cucumbers and scallops goes as planned, we will also have a hatchery monitoring system and broodstock management system. These will be provided by either the Spanish company BAÜP or the American company ARGUS. The monitoring system will track every production step and send warning signals if specific measurements are in critical areas. These warning signals allow instant interventions, because we can adapt the salinity, pumps, temperature, pH levels, and water quality in our breeding tanks. In addition to monitoring, the systems will constantly analyze data and test different container characteristics levels to understand which composition optimizes growth. This system will also be implemented in the open sea farm to track the species' growth and allocate human resources accordingly to the growth progress.

Lastly, the hatchery also contains a laboratory and innovation center to optimize water and nutrition control. In addition, a selective breeding program will be developed to identify high-performing scallop and sea cucumber individuals. The breeding program will test the genetic synergy of our animals with the hatchery's environment to find optimal combinations. We are aware of the tests' complexity and know it will take time to have promising results.

8.1.3 Open Sea Farm

After a few months in the hatchery, scallop and sea cucumber juveniles will be taken to the open sea farm, where they will grow to commercial size. The current open sea farm is a 100-hectare large area close to Lagos in the Algarve and is licensed by OF. It is only reachable by boat, and the current occupancy is around 50% (Reis 2022). As stated above, we will contract a risk-sharing agreement with OF and use their next open sea farm, which will be approximately licensed when we start production. The farm will have long line systems anchored to the sea ground, which are used to suspend the 10 thousand lanterns in which the seeds are grown.

The lanterns have 20 levels that can be filled with seeds, enabling space for around 225kg of grown-out scallops and sea cucumbers in total. The lanterns are transported to the long lines via boat, filled with around 400 seeds per level, and are then exposed to the open sea. After releasing the lanterns into the water, it is essential to clean them regularly because the scallops' excrements, other bivalve species, and microalgae get caught in the lanterns' nets. This clogs the nets and decreases the food supply, which is in the water and usually flows through the lanterns. This process is usually very resource intensive because each lantern must be collected from the water, cleaned, and then released again (Reis 2022; Cruz 2022). After interviewing Magnesen (2022), who helped build a scallop farm in Norway and supervised the R&D program, we adapted their strategy to clean lanterns using large high-pressure water tubes. The tubes will be lowered into the water until they surround the lanterns. After that, we will use high-pressure water glands to remove the excrement, microalgae, and other pollution from the lanterns. By using high pressure underwater, the water stream will only clear the outside of the lantern and will not reach the inside. Therefore, no damage is done to the scallops and sea cucumbers. Besides cleaning the lanterns, we will sort the animals by size and redistribute them to other levels of the lanterns with animals similar in size to decrease the food competition and to ensure that all animals receive enough food and have higher chances of growing to maturity. The sorting of the animals by size will be done every four months, allowing us to track the growing process of the sea cucumbers and scallops.

Through the co-cultivation of scallops and sea cucumbers, the cleaning process can be decreased drastically because the scallops feed on the microalgae and the sea cucumbers feed on the scallops' excrements, leading to cleaner lanterns and more efficient growth. According to Azari (2022), this could decrease internal lantern pollution by 50 - 60% and possibly lower pollution on the outside of the lanterns. It is essential to constantly improve the open sea farm's efficiency by testing new methods and lantern compositions. Therefore, we will change our farming strategy on each lantern to understand the optimal growth conditions for scallops and

sea cucumbers. This includes the number of seeds kept in each lantern level, the distribution of sea cucumbers and scallops in the lantern, and the lantern density per hectare.

The number of seeds per level will be tested by filling some levels with 200, 400, 600, or even 800 individual scallops to understand which number of individuals is the maximum to grow successfully to commercial size. This test will also be combined with the distribution of the individuals to see if lower or higher levels in the lanterns have optimal food supply and enable more individual animals to grow. The sea cucumbers later feed on phytoplankton and the scallops' excrements, allowing the scallops and sea cucumbers to have a complementing effect. According to Zhou et al. (2006) sea cucumbers can grow in suspended scallop lanterns nets. There is no difference in growth, size, and survival rates between a scallop monoculture and a sea cucumber and scallop polyculture. The survival rate of scallops ranged from 86% to 95% in monoculture and polyculture experiments.

It is essential to test different sea cucumber and scallop compositions to understand which optimizes the complementary effect. Here, we will start our testing based on research by (Zhou et al. 2006) which states that sea cucumbers can be grown in the same lantern levels as scallops. According to this research, “it was estimated that, theoretically, a sea cucumber requires the food from 11-ind scallops” (Zhou et al. 2006, 517). Sea cucumbers can be produced as a lucrative crop in a co-culture with bivalves without the need for additional feed inputs. In our first test, sea cucumbers will be in the lower levels of the lantern because the excrement will sink to the ground and have scallops in the higher levels because more sunlight reaches the higher levels of the lantern, ensuring higher micro-algae growth and supply and therefore more scallop food sources.

Lastly, it is essential to implement a monitoring system for the open sea farm to farm as efficiently as possible by tracking the animal's sizes and the lantern's pollution. This will ensure efficient processes for harvesting and cleaning the lanterns, leading to more economic output and fewer resources invested. Thus, we will either adapt the BAÜP or ARGUS system from

the hatchery or implement another open sea farm monitoring system, such as smartoysters adapted to scallops and sea cucumbers. Hereby, it is essential that the systems we use in the hatchery and the open sea farm are either the same or can be connected through an application programming interface (API). The monitoring systems will also be filled with data that we collect with our underwater drones, which are used to track the lanterns' pollution, the animals' growth, potential outbreaks of diseases and water quality.

8.1.4 Operational Center

Our intelligent open sea farm monitoring system can precisely predict when the scallops and sea cucumbers are ready to harvest. After we receive the notification, we will use the boat to harvest the lanterns and bring them back to shore. The animals will be collected in containers and shipped to our operational center. Machines will divide the scallops by size at the operational center and package them. After this process they are ready, to get picked up by a logistics partner and will then be shipped shelled and fresh directly to restaurants, supermarkets, and distributors who sell the scallops in Spain, Portugal, and France. In the operations center, we will have water containers, enabling us to store the scallops longer, allowing us to be more flexible with our sales and logistics. As stated in the market analysis, the scallop price is influenced by size, shape, and the quality of the environment they were grown in. The sea cucumbers will be processed by instantly freeze-drying them at our operational center, which improves their shelf life to two years. This is essential as our target market is Asia, and the shipping time requires a long shelf life. In addition, the long shelf life allows us to delay our sales until the market prices peak. This will increase our profit and our flexibility rapidly. The price of sea cucumber is strongly driven by the dried end product's size, shape, color, and scarcity (Zamora et al. 2018). However, it can be increased through sustainability certificates and the quality of the environment it was grown (Azari 2022). In our mid-term business model, we plan on using sea cucumbers to produce food supplements, which are in great demand in the European, the US, and the Asia-Pacific markets (APAC). The dried sea cucumbers will be

grounded and mixed with other typical food supplement ingredients. By offering supplements based on sea cucumbers, we can introduce our sea cucumbers to the western market and widen our product portfolio. As mentioned in our market section, food supplements can be sold for nearly $1 a gram (Azari 2022), increasing our profit margin enormously.

The dried sea cucumbers will be stored at our facility until the market price is advantageous. If our agreements with the distributors state differently, we will deliver our sea cucumbers according to our agreed delivery contracts. Storing the sea cucumbers over an extended period will also be advantageous when negotiating with distributors because we do not have to ship them quickly and can therefore agree to better contract terms. Our logistics partner will also transport them to our distributors in Asia by plane.

8.1.5 Supply Chain and Logistics

Overall, our supply chain will contain three development stages (Appendix 6).

In the first stage, we will buy broodstock and microalgae which is used for our genetic breeding program and first reproduction cycles. Our revenue in the first stage will solely be generated by sea cucumbers due to their one year grow-out time. The grown-out sea cucumbers will then be sold to our distribution partners and shipped to our target market China. The second development stage will be reached when we use our own animals as broodstock. By using our own animals, we can integrate vertically and produce all resources for the farming process ourselves. At this stage, we will start selling fresh scallops and sea cucumbers to our distribution partners and restaurants. Here we will have to adapt our supply chain to transporting fresh scallops to our target markets Portugal, France and Spain. Shipping fresh animals is more challenging than freeze-dried sea cucumbers and will require more complex supply chain management. The last stage is reached when we produce our sea cucumber food supplements. At this stage our supply chain will adapt again, because we will additionally target the US, APAC and broader European market.

8.2 Our Strategic Vision and Positioning

To scale our business and impact, we will constantly work on setting new goals to implement new product categories, target new markets and evolve our strategy. In the mid-term, we will focus on creating supplements from sea cucumbers. At the same time, we will work on scaling our sustainable mission and increasing our brand awareness through implementing a franchise business model in the long term.

8.2.1 Mid-Term: Supplement Market

Once we have established our brand and sales processes, we plan to diversify our product portfolio by including a different product range for a different market. The versatile nature and functional properties of sea cucumbers have been extensively studied. Due to their outstanding nutritional profile, marine dwellers have a high potential to serve as a base for dietary supplements or novel foods (Azari, 2022). Apart from the animal's high nutritional profile, “the availability of unique bioactive compounds” combined with “therapeutic properties” has increased its “position as a functional food ingredient” (Senadheera, Dave, and Shahidi 2020, 1). Some Asian cultures have recognized their anti-inflammatory, wound healing, and anti-angiogenic effects for a long time, using the organism for traditional medical practices (Bordbar, Anwar, and Saari 2011). Thus, recently, companies have used collagen, gelatin, vitamins, peptides, amino acids, and numerous other bioactive compounds extracted from sea cucumbers to create different supplements. These are useful for treating chronic fatigue, joint pain, constipation, impotence, and improving the immune system (Bordbar, Anwar, and Saari 2011). Nowadays, sea cucumber supplements not only promote better health conditions and assist in energy and weight management but are also part of cosmetic care and beauty products, promising increased skin hydration, hair and nail growth, and better sleep. Most commonly, these are taken as capsules or liquid extracts.

Sea cucumbers have primarily drawn more attention as dietary food supplements since they are one of the key components of premium marine collagen. It is an excellent alternative to mammalian collagen, which some people avoid for religious or dietary reasons. Sea cucumbers have different amounts and types of collagens depending on the species, their diet, and the biological environment (Senadheera, Dave, and Shahidi 2020). So far, no studies have been published covering our chosen species, which are native to Portugal. Thus, we will need to engage in more R&D and understand the production process from animal to the product. We must educate ourselves on the equipment required, what regulations we will need to consider, and the quality of the products. One possible option would be to outsource the production process to a supplement production company to use their valuable expertise and save R&D costs. For instance, leading supplement companies experienced in producing marine collagen, like Abyss, Primal State, or Vital Proteins, could be potential partners (Wernecke 2022). The business could be structured as a joint venture or regulated by a partnership agreement; however, we would like to sell under our brand name to increase brand awareness. Moreover, we also need to consider different business operations and supply chains apart from product development. The product belongs to a different category and has a different purpose so that it would appeal to other consumers opening new potential markets. Due to the new market orientation, we could achieve a greater revenue stream and mitigate possible risks by diversifying our product segment. Although this is a niche market, the predictions for the future are promising: "the global dietary supplements market size was valued at $151.1 billion in 2021 and is expected to expand at a compound annual growth rate (CAGR) of 8.9% from 2022 to 2030" (Grand View Research 2022, 1). The growth is related to consumers' increased awareness regarding health, well-being, and the struggle to fulfill dietary nutrient requirements (Grand View Research 2022). Especially the "rise in health conditions like arthritis, osteoarthritis" and obesity, "leads to increased consumption of marine collagen-based supplements" (Fortune Business Insights 2021). When talking to Dr. Azari, he confirmed that adding sea cucumber

supplements to our portfolio is beneficial, as we would target not only the Asian market but also Europe, America, and Australia (Azari 2022). Additionally, the product provides a great alternative and addition to existing supplements for terrestrial animals (Azari 2022). This is further reflected in the forecasted demand of the protein and amino acid segment growing with a CAGR of 13.4%, and thus, this would pose a tremendous economic opportunity (Fezzardini 2022).

Apart from tapping into the financially attractive European, Northern American, and APAC markets, the supplements would add to our storytelling and create additional impact. The products could support serving the greater good of nourishing the growing world population, as marine collagen is very high in proteins, vitamins, and minerals and can be easily stored, shipped, and added to people's diets (Grand View Research 2022). Thus, by selling with a lower margin than to our primary target markets, we would also make it accessible to developing countries, opening a broader customer segment.

8.2.2 Long-Term: Franchise Model to Scale Our Business and Impact

As our mission is to aid in feeding the growing world population and satisfying the rising demand for protein sustainably, we want to enable developing countries to take care of their own needs. By empowering small villages and local fishermen to diversify their aquafarming skills, we will equip them to combat the increasing problem of overfishing and dying marine life due to environmental conditions (Berman 2021). Thus, our long-term plan is to increase our impact and scale our brand by starting a franchise model. A franchise model is defined as a contractual business arrangement in which we, as a franchisor, permit a proprietor to use our branding, trademark, business model, and intellectual property (IFA 2022). We will receive a recurring percentage of sales revenue and other fees in exchange. Overall, IP protection, regulated through NDAs, is significant in protecting our brand and knowledge.

In summary, we will share our expertise and engage in R&D for specifically chosen regions in coastal nations that exhibit great potential for aquaculture and a great need to overcome economic problems. Essential prerequisites are hereby the natural occurrence of bivalves or sea cucumbers. Moreover, the franchisees must follow specific guidelines to avoid negative implications that could harm AQUATA's reputation and brand image. Hence, we will define clear environmental and social criteria that the franchisees must fulfill and will be contractually designated. To start the process, companies or individuals will be able to apply, or we will reach out to them if we discover a potentially good candidate suiting our concept. In case of an application, we will conduct thorough due diligence on the applicant and the environmental conditions of the location they want to operate in to mitigate the risk of failure and evaluate the commercial potential. After applicants get accepted, they will be supported financially, operationally, and strategically. By obtaining the allowance and access to use our brand, network, aquafarming knowledge base, and technology, they can jump-start their aquafarm and become a productive member of the AQUATA franchise model. We will support them at the beginning with our knowledge of how to build, manage and operate a hatchery and an open sea farm. We will also consult them regarding equipment, team, processes, and integrated aquaculture guidelines they need to follow. Our franchisees would also use our marketing and sales strategies to target and convert respective customers. In return, we will earn royalties based on our franchisee's sales while benefitting from a steady inflow of new and research findings.

As different sea cucumber and scallop species are native to different locations worldwide, we will benefit from our franchisees as we can diversify our product portfolio (Lovatelli et al. 2004). Moreover, we could reach new customers, as other seafood merchants demand other products. Additionally, we would be able to target various regions across the globe, spreading brand awareness and enhancing our network. Reinvesting our revenue in these projects will add to our storytelling and increase our impact. We also plan to establish a foundation, accepting

funding and donations from independent individuals and companies to support our goal of enabling developing nations to engage in productive aquaculture. Supporting responsible production and economic growth will enable us to protect marine life and feed the growing world population (Sea Cucumber Farm 2022). Within aquafarming, we would be the first to develop such a plan. This innovation will allow AQUATA to scale the business and grow strongly on an international level. At the same time, this will accelerate the positive social and environmental impact of AQUATA and ensure that we will fulfill our company's mission.

8.3 Revenue Streams

AQUATA diversifies its revenue streams in two dimensions; on the one hand, we farm two species demanded in different target markets. On the other hand, we use different processing methods for the species, which enables a broader product portfolio and, therefore, additional diversification. Due to the different grow-out periods for the sea cucumbers and scallops, the diversification of our product portfolio will increase over time. To further minimize risks AQUATA is vertically integrated. After approximately three years, we will supply the required resources to farm scallops and sea cucumbers ourselves.

Our first few years of sales will solely be based on freeze-dried sea cucumbers that we sell to the Asian market because their total grow-out phase is only one year. Here, due to the increased shelf life, the market timing strategy will help us be financially sound.

After three years of production, we will reach our first diversification stage because the scallops will take three years to reach commercial size and will be sold fresh to distributors and restaurants in the Portuguese, French and Spanish market. The countries' distance to Portugal will determine our expansion sequence, due to the challenging supply chain of fresh products. The scallops will slowly increase our sales volume and become our primary revenue source.

In the mid-term, after five years of production, we will further diversify our product portfolio by processing sea cucumbers into dietary supplements. According to Azari (2022), supplements

have a way higher profit margin but also require research and regulatory approvals. Therefore, we will use the first five years to research the optimal composition of our food supplements and enter the European, US and Australian market once the research is finished. The food supplements will also slowly transform into our main revenue driver and our brand building activities that we pursue during our first years of sales will help es enter the competitive supplements and beauty product market.

9 Regulations

Any aquaculture business needs to obtain several **licenses** before its business activity starts. AQUATA will apply for the Aquaculture Activity Title (TAA) to engage in aquafarming activities in on- and offshore facilities (ePortugal 2022). To build our hatchery on rented land in the port area of Nazaré, we will apply for a ground lease provided by the state-owned institution Docapesca. Docapesca manages all fishing ports in Portugal from Vila Praia de Âncora to Vila Real de Santo António. The license will allow us to build a private hatchery close to the North Atlantic and get access to ocean-water resources to be able to use fresh ocean water for our animals of Portuguese origin (ePortugal 2022). In addition, when starting our business, we will apply for an open sea farm license to breed, operate and sell our species and to be independent as soon as possible. As mentioned before, our strategic partner OF agreed to offer space in the second open sea farm for five years, starting 2025. In addition, the European Commission developed several **strategic guidelines** for planned and existing aquaculture activities, among others, to prevent potential adverse environmental impact in order to ensure health and animal welfare standards for cultivated species (FAO 2022a). In 2021, the Commission proposed new guidelines, including recommendations regarding aquaculture activities for a more sustainable, resilient, and competitive EU aquaculture sector until 2030. These guidelines promote a strategic direction for AQUATA on how to successfully develop an advanced aquaculture program that contributes to a blue bioeconomy (European Commission 2021). The European Commission defined the blue

bioeconomy as “any economic activity associated with the use of renewable aquatic biological resources to make products” (EUMOFA 2018). European policies for **organic production** are governing the aquaculture sector. One main objective is to set a minimum standard for organic production in (and import to) the EU, mainly for bivalves and seaweed (European Commission 2022a). Due to AQUATA´s premium production standards, we ensure compliance with organic production guidelines to reach the best **eco-labeling options** (GAA, ASC Standards, etc.) and production standards for various production systems. As mentioned, our production standards include high-quality feed, optimized water and nutrition control, and the renunciation of artificial pesticides, antibiotics, and hormones (artificially induced spawning). However, we have to comply with specific aquaculture **legislation**, including “the use of water resources, the water law, the maritime spatial planning, and the environmental impact assessment” as well as “hygienic and sanitary conditions of the purification and dispatch centers for live bivalve mollusks.” (DGRM 2022).

9.1 Regulatory Barriers

Starting an aquaculture venture is associated with long and complex legal tasks and multiple interactions with regulatory bodies. One of the main burdens that can appear in the European legislation and could hinder our initial business growth, are delays in the administrative process, especially lengthy processing times and unpredictable outcomes of licensing applications (IMPAQT 2022). As commercial sea cucumber and scallop cultivation remains a novel aquaculture program for several EU countries, it can cause uncertainty in licensing procedures, especially when applying for an IMTA license. According to IMPAQT (2022), regulators do not have enough evidence for the development of new regulations, particularly related to the development of commercial-scale IMTA operations (Krause et al. 2022).

As there is a large body of European legislation and potential regulatory barriers covering our aquaculture activities, we will hand over this part to our legal specialist Claude Kaplan, as briefly

mentioned in the team section (Kaplan 2022). With the help of our theoretical analysis, we see the advantage of speeding up the legal application process and acquire some knowledge for ourselves.

10 Roadmap

AQUATA's roadmap will outline our key milestones that are required to launch a successful aquaculture business. The current milestones are set to determine our journey until 2033 (Appendix 7).

10.1 Our Company through Time

We will start our actions by travelling to multiple aquafarms, restaurants, and aquafarming specialists in our target markets. Our goal is to build a strong network in these markets and to learn about the farming procedures in more detail. Our travel will start in March 2023 and will take until August 2023. At the same time our R&D specialist Gonçalo Araújo will begin with the development of our scientific breeding program.

In early 2024, the construction of our hatchery will begin and take up to one year. While building the hatchery we will focus on all essential parts for our production first, allowing us to start the production already in November 2024. During the summer of 2024, we will also acquire our first boat and build the first long line system. Since the production can start in November 2024, we will transport our first sea cucumbers and scallops to the open sea farm in January 2025. The first batch of sea cucumbers will be grown out and sold in November 2025 and the first batch of scallops in November 2027. When the first batch of each species is grown out, we can use them as broodstock and will integrate our supply chain vertically. In 2029, we will diversify horizontally by selling our sea cucumber supplements. At this point in time, we also focus on scaling our aquafarm and will invest into our second long line system and second hatchery. AQUATA will scale further in 2034, when we will build our third long line system.

From a financial perspective, our roadmap will begin with the receipt of our first grant in March 2023. In October 2023, we as the founding team will join an accelerator program for 5 months, to further develop AQUATA. Further investments in AQUATA are the Seed round which will take place in May 2024 and our Series A which starts in May 2025. Last but not least, we will prepare our exit in 2032 and will go through with our prepared strategy in 2033.

10.2 Exit Strategy

Although we are just starting now, we need to have an exit strategy from the beginning. This is particularly important as we already use external investors early on. These are usually only willing to invest and thus take risks if they can see that they can get a significant return on their investment within a few years.

Our valuation for the exit was derived using enterprise value (EV) multiples. We adopted these from integrated salmon producers, as suggested by the investor guide from TNC and Encourage Capital, as it is the only sub-sector that has "many large, public companies, broad research coverage, and available data regarding valuation and operational metrics" (O'Shea et al. 2019, 74). The metric that seems to be best suited for our valuation is EV divided by earnings before interest, taxes, depreciation, and amortization (EV/EBITDA); On the one hand this is one of the most commonly used multiples (Indeed Editorial Team 2021), and on the other hand it accounts for the fact that the cost structure of a salmon farm is quite different from ours. Out of eight salmon aquafarms that were explored, the median EV/EBITDA ratio was 10.3 (O'Shea et al. 2019). This implies that in 2033, where our EBITDA is €102 million, our valuation will be €1.05 billion, thus achieving unicorn status. This would therefore be a desirable timing for an exit.

For us, an acquisition by another company in the aquaculture sector is particularly realistic and desirable. Here we see the greatest synergy opportunities and therefore anticipate the highest

possible valuation. We want to explain this with two specific acquisition examples: Oceano Fresco and Nutreco.

OF currently has two clam species in their range. They will sell these indirectly and directly to restaurants, the indirect sales channel being through distributors (Reis 2022). Revenue synergies could come from cross-selling the products, an expanded customer base, or increased pricing power. Since no restaurant has only clams on its menu, other seafood products have to be sourced from other producers. The larger the product portfolio of a single producer, the more convenient this is for restaurants, and it is plausible that they will be willing to pay more for it. Potential cost synergies can be achieved by combining marketing and sales activities, reduced professional services fees, shared facilities and areas, and shared resources that are not fully utilized. It is also likely that the knowledge transfer resulting from the expert cooperation will lead to a reduction in costs, as best practices can be implemented which, for example, can increase the species' survival rate. In addition, the portfolio diversification reduces the operational risk, for example by avoiding that a large part of the animals is wiped out by a specific predator or disease. OF has told us that they are looking to expand the portfolio, so we believe they would be open about an acquisition (Reis 2022).

Nutreco, a manufacturer of agriculture and aquaculture feeds, has strategically invested in and acquired other companies to create synergies (Nutreco 2022). In addition to the synergy opportunities that AQUATA could have with OF, it is also possible that costs can be reduced by lowering mortality through disease treatment options in Nutreco’s portfolio. The geographic diversification would also be beneficial for Nutreco, as it would lower their business risk.

Another exit option for AQUATA is an **Initial Public Offering** (IPO). Unlike the acquisition case, our valuation could not be positively influenced by synergies. However, a factor that could potentially lift our valuation up is if blue economy would become a new trending topic. Currently, climate action and clean energy are strongly in the focus of investors (Dealroom

2022) is therefore not unlikely that blue economy and zero hunger will also receive a boost in the coming years. An IPO would also have a strong signaling effect on other entrepreneurs and investors, who could see that aquaculture is indeed a financially viable field. Lastly, by going public, the general public could invest in AQUATA and support our impactful mission.

11 Conclusion

In conclusion, AQUATA is a great business opportunity with huge potential. We presented our solution of an IMTA approach to provide a sustainable food source for the growing world population. AQUATA is well-positioned to take economic advantage of the ever-increasing demand for protein while generating sustainable impact and contributing to the UN's SDGs. The focus on multitrophic farming of sea cucumbers and scallops, rather than other marine animals, allows us to differentiate ourselves from other aquaculture businesses. By doing this, we can establish and market our reputation as Portugal's pioneer. In our first years, we will produce fresh scallops and bêche-de-mer with a focus on the Asian and European markets, where the demand is high and growing. Our scientific and innovative approach, excellent product quality, and aquafarming certificates will enhance our positive brand reputation and credibility making us appealing to our target customers. Apart from our promising value proposition, we will establish strong customer relationships through our engaging commercial strategy.

Additionally, we mitigate financial and market risks through our diversified product portfolio and the sales of dietary supplements in the mid-term. This allows us to tap into a strongly growing market, exploiting its immersive potential. With our long-term franchise model, we aim to scale our impact and revenue even further. As a founder team, we have substantial experience in entrepreneurship and management, covering the business side of our startup. We have already developed significant relationships and ties with international professionals and

scientists, which complement our business expertise. We will leverage this network, bringing some of them onto our team to add to our aquaculture expertise. Overall, AQUATA exhibits promising financial returns, making us an excellent investment opportunity to support the growing blue economy trend.

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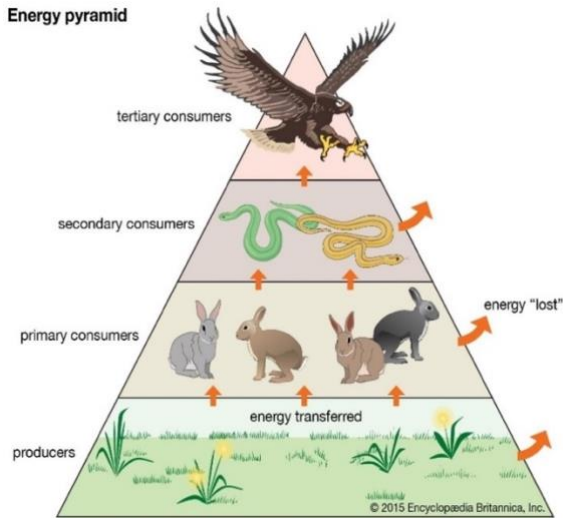
13 Appendix

Table 1: Our expert interviews – full names and contact details of interviewees

Name	**Current- Position**	**Contact**
Andreia Cruz	R&D Senior Manager ▪ Oceano Fresco	LinkedIn: https://www.linkedin.com/in/andreia-cruz-10725783/ Mail: andreia.cruz@oceano-fresco.pt
Dr. Beni Azari	Principal Consultant ▪ Seacucumber Consultancy pty. Ltd.	LinkedIn: https://www.linkedin.com/in/benigiraspy/ Mail: beni@seacucumberconsultancy.com.au
Claude Kaplan	Chief Executive Officer ▪ Kuehnle AgroSystems Inc.	LinkedIn: https://www.linkedin.com/in/claudekaplan/ Mail: claude@hatch.blue

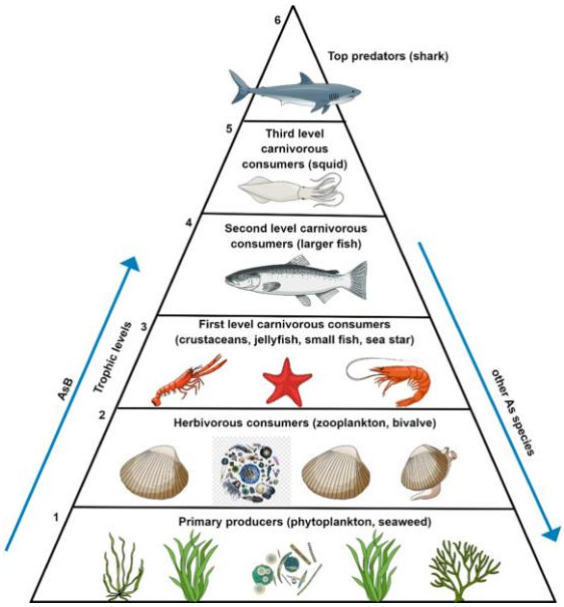
Frederico Reis	Chief Commercial Officer ▪ Oceano Fresco	LinkedIn: https://www.linkedin.com/in/fredericoreis/ Mail: frederico.reis@oceano-fresco.pt
Ricardo Marques	Chief Financial Officer ▪ Oceano Fresco	LinkedIn: https://www.linkedin.com/in/rmarques71/ Mail: ricardo.marques@oceano-fresco.pt
Fiz da Costa	Researcher ▪ Instituto Español de Oceanografía · Lifetime Civil Servant	LinkedIn: https://www.linkedin.com/in/fizdacosta/ Mail: fiz.dacosta@ieo.csic.es
Gonçalo Araújo	Research Fellow ▪ Nova School of Business and Economics	LinkedIn: https://www.linkedin.com/in/araujog/ Mail: goncalo.araujo@novasbe.pt
Valentin Hering	Senior Growth Marketing Consultant ▪ Entity X	LinkedIn:https://www.linkedin.com/in/valentinhering/?originalSubdomain=de Mail: valentin@entityx.com
Marcin Lewandowski	Investment Associate ▪ Techstars	LinkedIn: https://www.linkedin.com/in/marcin-lewandowski-679b6a166/ Mail: marcin.lewandowski@techstarsassociates.com
Thorolf Magnesen	Associate Professor at the Department of Biology ▪ University of Bergen	LinkedIn: https://www.uib.no/personer/Thorolf.Magnesen; Mail: thorolf.magnesen@uib.no
Ana Ward	Investment Associate ▪ Nutreco	LinkedIn: https://www.linkedin.com/in/ana-ward/ Mail: ana.ward@nutreco.com
Jannis Wernecke	Product Development ▪ Primal State Performance GmbH	LinkedIn: https://www.linkedin.com/in/jannis-wernecke-5232101a5/ Mail: jannis@primal-state.de

Appendix 1: Energy pyramid and trophic level pyramid for land-based animals.



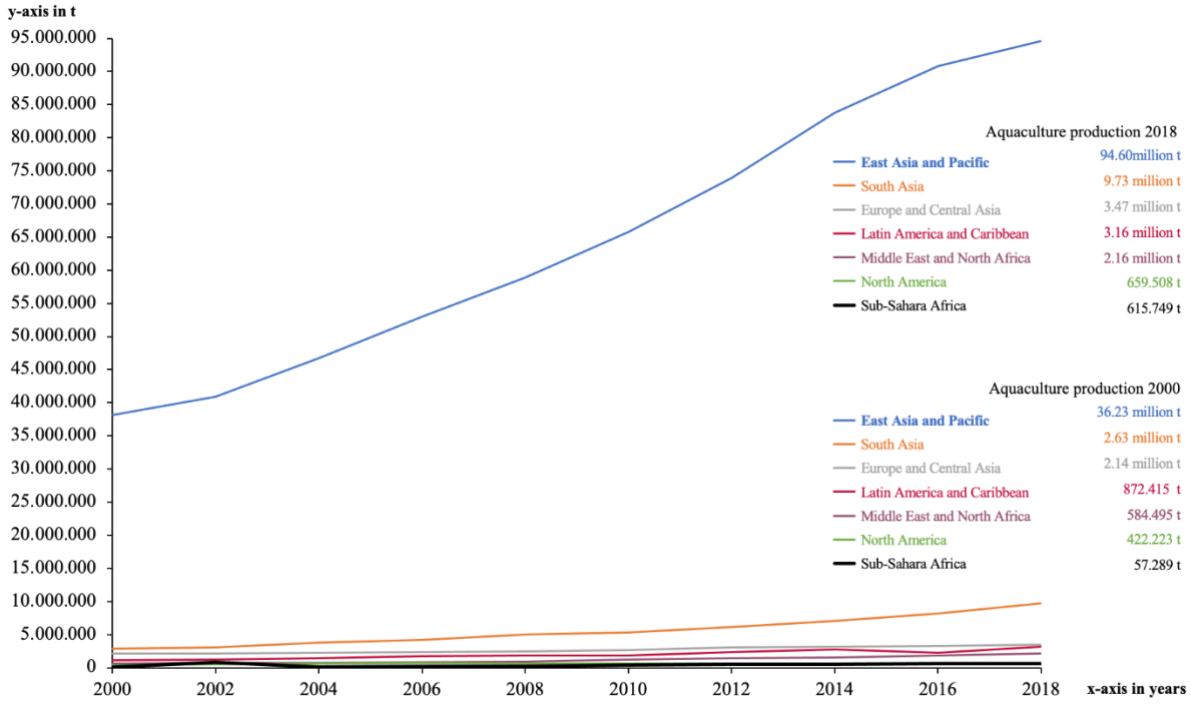
Source: (Kato et al. 2020)

Appendix 2: Energy pyramid and trophic level pyramid for aquatic animals.



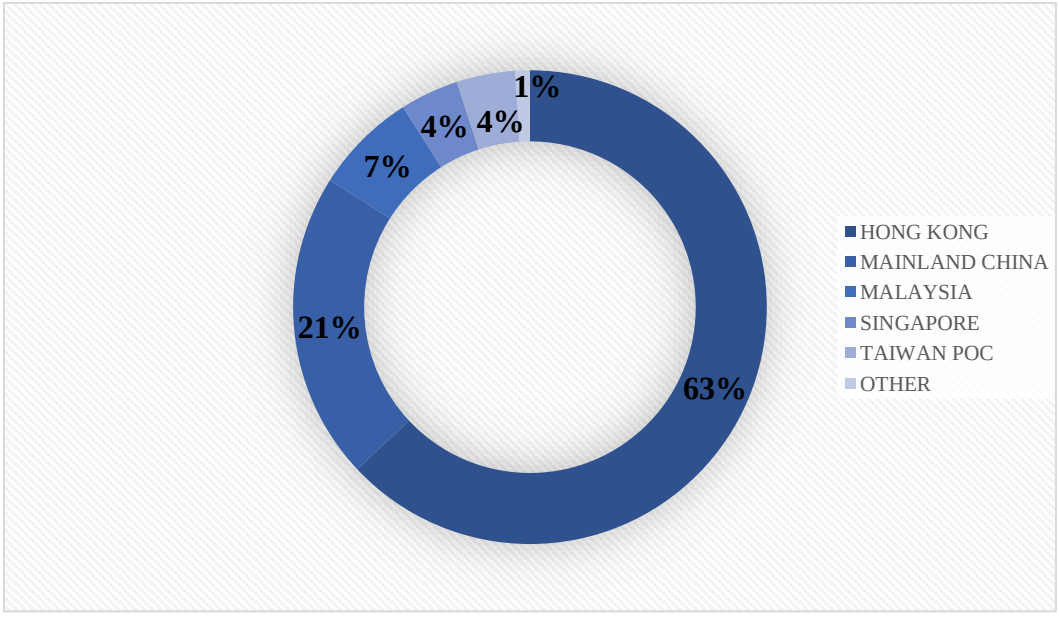
Source: (Kato et al. 2020)

Appendix 3: Global Aquaculture production volume in tons.



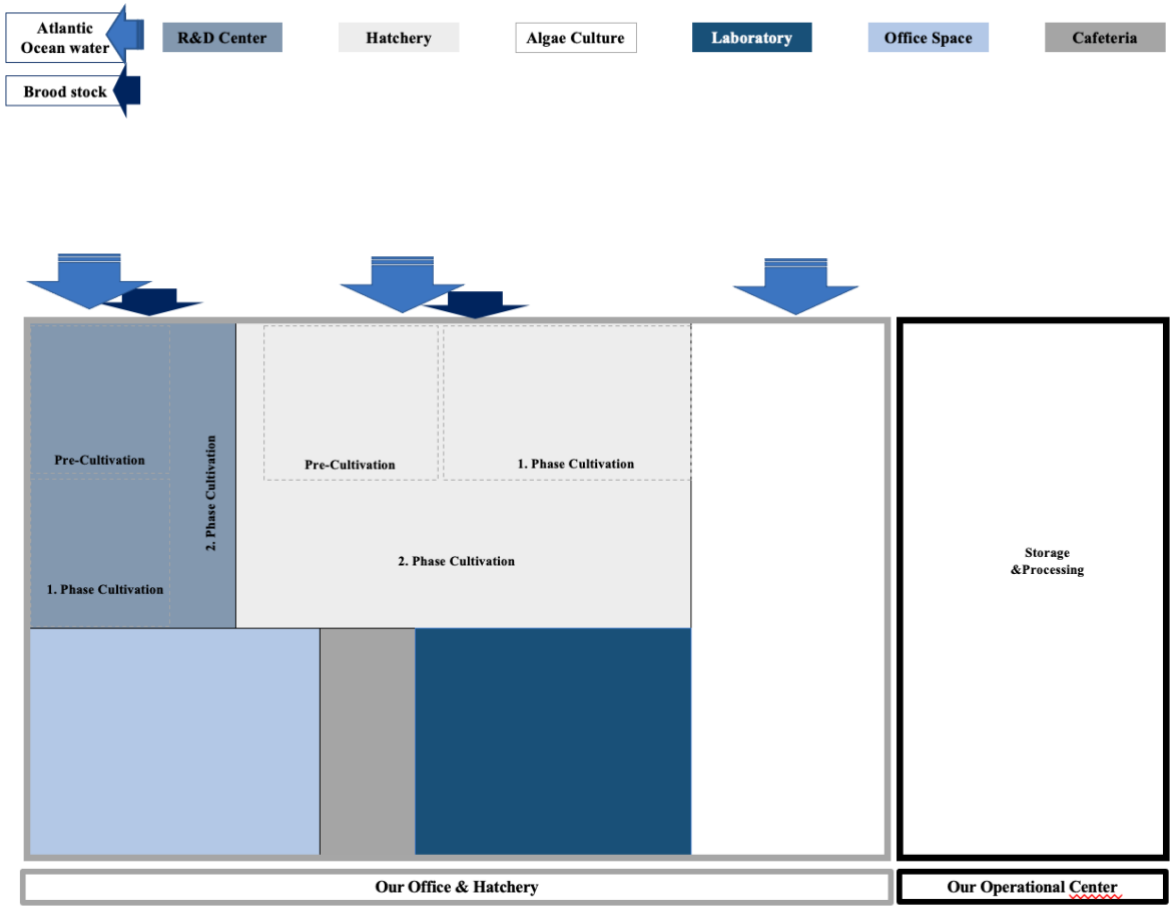
Source: (Food and Agriculture Organization of the United Nations 2022).

Appendix 4: The top importers in kilogram for sea cucumber products in Asia, 2012–2019.

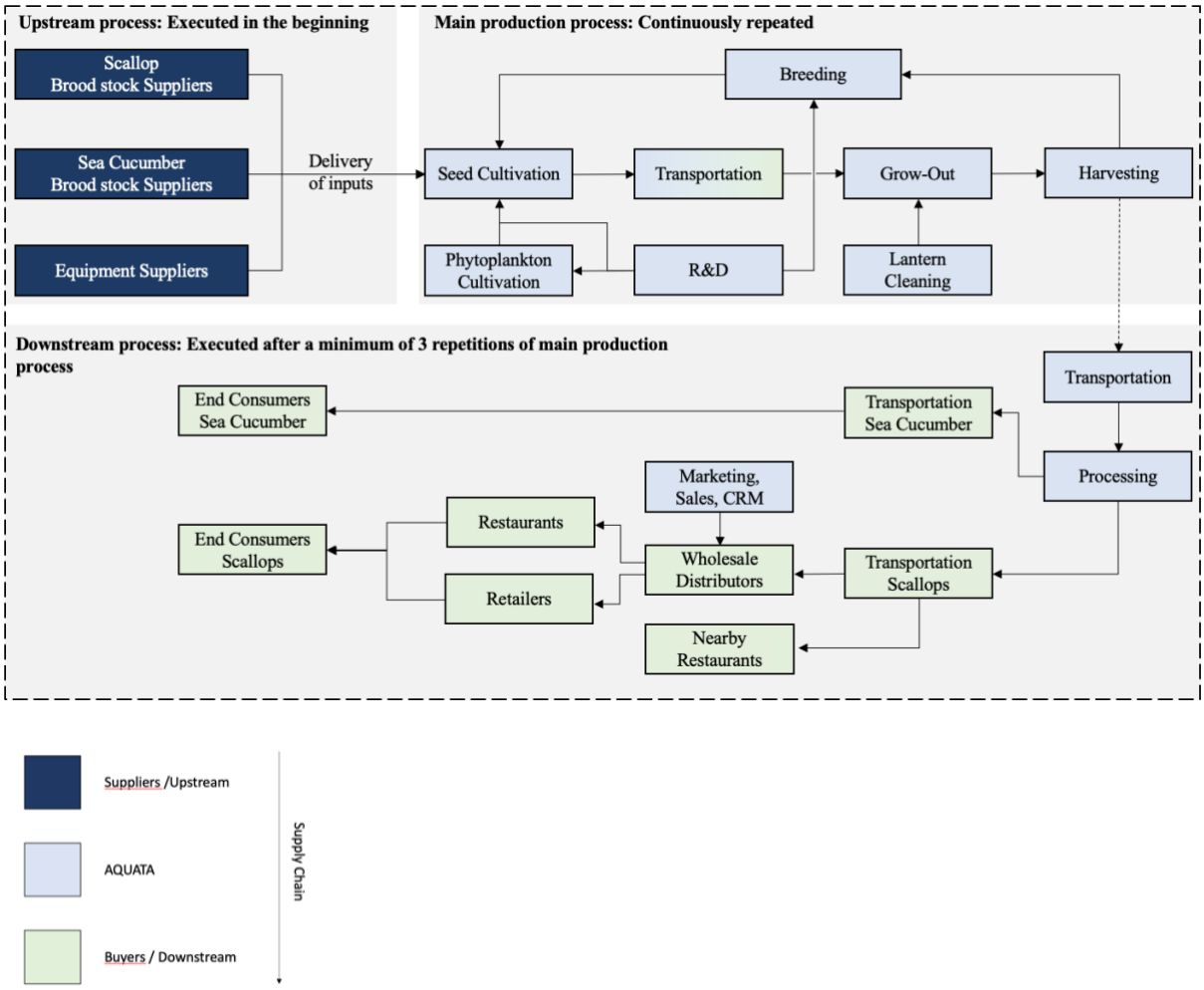


Source: (Louw and Bürgener 2022)

Appendix 5: Overview of our future Office, Hatchery and Operational Center.



Appendix 6: Supply Chain Process.



Appendix 7: Roadmap and Milestones until exit 2033.