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E-Fishent Foods: Mimicking Natural Food Webs to Produce Sustainable Seafood for California

An Eco-E Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management for the Bren School of Environmental Science & Management

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The mission of the Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Eco-E Project fulfills a core requirement for the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small teams of students conduct customer research to develop a business model for a new environmental venture, in addition to focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Eco-E Project Final Report is authored by MESM students and has been reviewed and approved by:

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ABSTRACT

E-Fishent Foods is a sustainable seafood production company that utilizes innovative offshore aquaculture techniques to meet the ever-growing demand for seafood products in California in an environmentally friendly and highly productive manner. Overfishing and unsustainable aquaculture practices pose significant threats to marine ecosystems. Current seafood supply is insufficient to meet the ever-growing seafood demand of consumers in California and globally. The United States is the third largest consumer of seafood in the world and is heavily reliant on imported products, which generated a $10B deficit last year. Increasing scrutiny towards sustainability and transparent labeling reflects a movement towards changing consumer demands in the face of depleting wild fish stocks. Improved aquaculture techniques and fisheries management practices are essential to the resilience of our ocean and the resources it provides us. E-Fishent Foods utilizes integrated multitrophic aquaculture offshore of central California to produce seabass, mussels, and seaweed in a highly efficient and productive manner to meet these growing demands with minimal environmental impact. Our business plan is for a 50 hectare site that has an annual net impact of 1.2 thousand tons of seafood produced, 91 tons of waste eliminated from the environment, $2M domestic retention, and over 130,000 Americans fed. It has a 4 year return on investment and a 10 year $5.7M net present value. E-Fishent Foods is an innovative solution to meet seafood demands, improve marine environments, and lead the sustainable aquaculture movement in the United States.

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EXECUTIVE SUMMARY

The oceans are faced with a rapidly intensifying challenge: the demand for fish is growing while global fisheries catches have plateaued. Scientists and industry experts are looking towards aquaculture, also known as fish farming, to bridge the gap between the quantity of wild-caught seafood that we can sustainably harvest from the ocean and the average person's desire to eat healthy, inexpensive, ecologically-friendly seafood.

E-Fishent Foods provides sustainable, local and competitively priced seafood to wholesale distributors in Santa Barbara and the greater California region that aim to please their customers by meeting the current demand for high-quality environmentally friendly seafood. The E-Fishent Foods model offers local and sustainable farm-raised seabass, mussels, and seaweed, relieving threatened wild fisheries and stressed marine ecosystems, so that wholesale distributors in California can provide a viable alternative to fluctuating local supplies of seafood and imported farm-raised fish. E-Fishent Foods addresses the customer demand for sustainable seafood by utilizing an integrative multitrophic aquaculture system (as opposed to monoculture) that produces three interdependent species to recycle wastes and maximize production. This addresses the customer difficulty with purchasing sustainably sourced, high quality and affordable seafood in California.

Currently most seafood is harvested using conventional methods that often overexploit natural fisheries and have high costs for both the environment and buyers. Damages associated with environmental degradation often make seafood more costly to the producers and buyers. Buying unsustainable fish and shellfish is expensive in the long run and has a high risk of market collapse.

Global aquaculture production is growing at a steady rate and allowing farmed fish to fill the increasing gap between the amount of wild catch seafood and the global consumption of seafood products. The majority of these operations have been overseas, leading to massive importation of seafood into the Unites States. The distance from origin to consumption has led to a lack of transparency in the supply chain and hence the majority of aquaculture operations have a bad reputation with consumers and scientists alike. Immediate need for innovation within aquaculture practices is apparent and necessary in order to increase aquaculture production in the United States.

The E-Fishent Foods' solution is to utilize integrated multitrophic aquaculture (IMTA) to produce seafood in a sustainable, environmentally friendly, and more cost effective manner. The proposed offshore system, to be located in federal waters off the coast of California, will combine three interdependent species at one location.

This arrangement will more closely mimic natural food webs and thus minimize waste and maximize production. The waste resulting from finfish production will be recycled as food for seaweed and mollusks; reducing the likelihood of cultural eutrophication[1]. Both the seaweed and mollusks can also be harvested and sold as byproducts.

During the course of this study E-Fishent Foods conducted almost 100 in-depth interviews with individuals who are experts on the operations and climate of the seafood industry. These interviews were designed to help the team to determine the degree of customer demand for sustainable seafood while also learning more about potential competitors within the industry. These interviews, combined with an extensive literature review helped to determine the overall viability of the proposed business model. The results of this research depict a strong and expansive seafood industry, ripe for the increasing growth of the sustainable seafood sub-sector.

It is only after this thorough review that E-Fishent Foods can truly say that there are significant ecological benefits to utilizing integrated multitrophic aquaculture systems that increase the sustainability of seafood farming practices. Our marketing plan will capture this corner of the market by promoting our innovative environmentally friendly design, promoting the quality and consistency of our products, and using third party validation to ensure sustainability.

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[1] Cultural eutrophication: an ecosystem response generally associated with increased biological activity due to the addition of artificial or natural substances, such as nitrates and phosphates, through human related activities, to an aquatic system.

1 ENVIRONMENTAL CONSIDERATIONS

1.1 Environmental Objective

The primary environmental objective of E-Fishent Foods is to improve the sustainability of seafood within the United States by decreasing the amount of imported seafood and associated transportation emissions, reducing the reliance on unsustainable wild fisheries and overfishing practices, and improving the environmental sustainability of aquaculture practices.

1.2 Environmental Problem Analysis

Increased population growth and per capita consumption of seafood over the past century has placed significant pressure on wild fisheries. Many natural fisheries are highly threatened, over-exploited, and predicted to collapse given our current demands and fishing practices. The United Nations Food and Agriculture Organization estimates that over 84 percent of the world's fisheries are either depleted, over-exploited, or fully exploited, implying that wild marine fish stocks are insufficient to meet the growing needs of an expanding, increasingly affluent global population (1). Overfishing is occurring around the world, and large commercial fleets are having enormous impacts on the ocean environment (2).

Heavy levels of fishing are directly impacting ecosystem biodiversity and abundance. For most species, the average size and fecundity of adults are a fraction of what they were before significant fishing pressure. This greatly threatens the viability and recruitment probability of future generations. Furthermore, fishing practices can cause damage to benthic[2] environments, destroying corals and reef formations that take decades to form. This destruction of habitat can turn once thriving marine communities into barren wastelands. Our reliance on wild fisheries has depleted species across trophic levels. As a target species reaches numbers that are no longer economically viable to fish, fishers generally move onto fishing the next most lucrative fish, thus only shifting the pressure elsewhere. This pattern has caused the health of the marine environment and resources to be highly threatened. There is also a higher pressure for wild caught than farm raised fish due to consumer concerns with farming practices, lack of transparency in practices, and the bad reputation that it has developed over the years.

[2] Benthic zone: the ecological region at the lowest levels of a body of water, including the sediment surface and some sub-surface layers

Global demand for seafood has generated significant growth within the aquaculture industry over the past two decades, despite preferences. The rapid expansion and under-regulation of aquaculture practices have raised many environmental concerns of their own. This quickly growing aquaculture industry is wrestling with many management issues including the overfishing of bait fish to supply fish feed, introduced species, use of antibiotics and hormones, and large-scale waste discharges from fish farms (2; 3; 4; 5). This raises concerns for the preservation of natural biodiversity[3] and healthy ecosystems; as well as the future of our ocean resources (6).

Many aquaculture systems are highly intensified, meaning that the highest biomass per unit volume is produced over the shortest period of time. This often has many adverse effects on the seafood products themselves as well as on the surrounding environment. Highly concentrated production generally exposes the surrounding environment to large amounts of nutrient inputs from wastes and excess feed. This can lead to cultural eutrophication and associated concerns including hypoxia, decrease in biodiversity and ecosystem health, and decreased water quality (7). Wastes also imply a poor use of organic resources. Intensified fish aquaculture often makes use of antibiotics to combat the increased incidence of infection, disease, and parasites. In addition, growth hormones are often added to increase growth rates of products. These antibiotics and hormones contaminate the surrounding environment as well as the targeted recipients, thus polluting natural ecosystems and potentially the health of seafood products. Raising non-native species in marine systems increases the risk of species introduction, which can alter natural communities and have ripple effects throughout food webs (8). Furthermore, the accidental escape of farm-raised species can also decrease the genetic heterogeneity of wild populations if these fish are capable of interbreeding. These concerns are valid for aquaculture operations around the world, and especially in third world countries where regulation is more lenient. Lastly, increased demand for fishmeal used in feeds has placed higher fishing pressure on lower trophic level fishes, which increases their vulnerability to collapse (3). The current methods used to meet our seafood demands are environmentally unsustainable.

1.3 Environmentally Policy Analysis

There are many regulations in effect to control fishing practices here in the United States. In the US, the federal government has begun to take the initiative to address these problems associated with current fisheries practices. Recent new

[3] Biodiversity: the variety of life in a particular habitat or ecosystem

guidelines regarding aquaculture use and sustainable fisheries practices are being established, however implementation and adaptation has been slow to come to fruition. In fact, the Sustainable Fisheries Act (1996) called for “increased attention to the reduction of bycatch and the protection of fisheries habitat” (9). The Magnuson-Stevens Fishery Conservation and Management Act sets general fishing protocols and standards for wild fishing practices in the United States. Each state also has its own annually renewed regulations for fishing; In California regulations are set by the CA Department of Fish and Wildlife.

Aquaculture has a less established regulatory framework within California and on the federal level. In order to establish an aquaculture program in state waters you are required to adhere to CA policies. This requires a full California Environmental Quality Act review process including review and permission from the CA Coastal Commission and CA Fish and Game Commission for the site lease, aquaculture license, species-specific licenses, and stakeholder meetings. Further requirements include the construction license through the Army Core of Engineers, the buoy registration with the Coast Guard, weekly water and product quality monitoring through the CA Department of Health, and product health approval with the FDA. All this said, there is still no state policy that sets specific regulatory requirements for offshore aquaculture in California.

In national waters the regulatory process is somewhat more manageable but also has no set framework. In June 2011, the National Sustainable Offshore Aquaculture Act was introduced to congress, but was eventually referred to committee and failed to progress. Currently, the federal policy regarding offshore aquaculture is a National Environmental Policy Act review process with the National Oceanographic and Atmospheric Administration. Site leasing is nonexistent in federal waters (3-200 miles offshore), and the licensing is attained directly through this process. Approval from the Army Core and Coast Guard for the structure, and product health monitoring from the FDA are also required. Under current regulation, monitoring of environmental quality around offshore aquaculture operations is stipulated as part of the NEPA review process. Quantitative standards remain to be set in policy.

1.4 Environmental Solution Analysis

Increased knowledge and development of new methods within marine biotechnology have generated important breakthroughs for the aquaculture industry, and further advances within this sector continue to be important (10; 11). Modern intensive, single species aquaculture systems cannot satisfy present and future seafood demands because they require high levels of inputs per yield of biomass, and produce large quantities of undesirable wastes (12). Furthermore, in an attempt to maximize coastal space use, intensified fish culture often leads to high levels of disease and mortality due to over stocked cages and poor waste management (13; 14).

The inefficiencies commonly associated with aquaculture must be addressed in order for aquaculture to be considered a sustainable operation. Jerry Shubel, the CEO of Aquarium of the Pacific, explains, “This is a good example where innovative integrated multitrophic aquaculture could play a role… using seaweed (kelp) to take-up nutrients and harvesting the seaweed for food and other uses (8)”. Polyculture and integrated aquaculture systems have been cited to significantly improve the reliability, resource use, and production efficiency of seafood farming (15; 16). E-Fishent Foods will make use of integrated multitrophic aquaculture offshore of Central California to significantly reduce environmental impacts generally produced by intensive monoculture systems, alleviate pressure on wild fish stocks, and decrease transportation emissions associated with imported seafood.

With growing seafood demands, aquaculture is the most viable solution to meet the supply without causing the collapse of wild fisheries (17). On a large enough scale, aquaculture in conjunction with proper fisheries management would make overfishing a thing of the past. Properly implemented, sustainable, domestic aquaculture would replace our national reliance on poor environmental practices often associated with imported aquaculture products. In open water fish cage culture, mollusks and seaweed down current can absorb excess feed and waste products from the fish, assimilate these nutrients as biomass, and provide other sources of seafood for harvest (18; 10). As in natural ecosystems, nutrients are passed down trophic levels and utilized in different manners. These interactions and basic ecological principles can be used to develop seafood production systems which have less negative environmental impacts, yet produce a greater quantity of seafood to meet the growing demand in an efficient manner (19).

A portion of the mussels and seaweed produced within our system can be reintegrated as feed fish, thereby reducing the reliance on fishmeal from wild fishery sources. Furthermore, the protein conversion ratio of farm-raised fish is nearly three times as efficient as that of wild caught fish (3). This means that about a third of lower trophic level fish will be consumed to produce each kilogram of our product in comparison with fish caught in the ocean. This addresses the environmental problem regarding the reliance on other fisheries for farm-raised fish. Our multitrophic system will also produce significant quantities of mussels, which are sources of low energy protein. The result is a highly nutrient-conversion efficient system.

Reducing the carbon footprint and resource use of aquaculture operations is also essential to allow for sustainable expansion within the seafood industry. Restricting the distribution of our seafood products to California and surrounding states reduces the transportation emissions associated with the majority of current supplies that are imported from afar. Because these seafood products will go from ocean to plate in three days or less, the likelihood of food spoiling or decrease in freshness is also greatly reduced. An offshore system, in comparison to onshore, uses very low amounts of energy inputs because it does not require heating, lighting, or electricity to power recirculation pumps. Filtration is also not required for an offshore integrated system because the seaweed and mussels will function as biofilters for the effluent, further reducing energy use (20). The close proximity of cages and lines will minimize the use of fuel for harvesting and maintenance periods. The E-Fishent Foods system design is highly energy conservative.

2 BACKGROUND INFORMATION

2.1 Industry Analysis

Seafood

An analysis of the American seafood industry shows that the majority of seafood is consumed within restaurants. Although some fishermen sell directly to restaurants, markets, and even end consumers, our analysis indicated that the most common and often most cost-effective method of distribution is via wholesalers. Buying sustainable seafood is generally more expensive and less reliable than utilizing conventional sourcing techniques. Research has shown that many restaurants and end consumers, however, would prefer their seafood to be sourced sustainably, but not at the expense of quality, reliability and price. According to a local seafood restaurant owner, many restaurants cannot serve certain species of fish because the fishery is not qualified as sustainable, and sourcing many species can be both difficult and expensive due to limited catch and availability (21). It is also difficult and costly to find local, sustainably produced seafood. The Santa Barbara channel is one of the top producers of California seafood, but more than 85 percent of the local catch is shipped out of the area to be distributed across the state and even globally (22). This presents a customer problem for distributors who wish to fill the restaurant and end consumer demand for locally produced, competitively priced, high quality sustainable seafood.

Customers are currently dealing with this problem by either paying a premium for sustainable seafood, sourcing seafood from non-local distributors, or most often not purchasing sustainably sourced foods. This current method presents a shortfall to customers by providing a less desirable product or causing them to spend more money to buy sustainably. Also distributors that rely on sustainable seafood risk receiving from unreliable sources. Many restaurants that want to serve sustainable seafood find it difficult to source it, maintain certifications, and provide the types of high quality foods end consumers want.

E-Fishent Foods will be located within the seafood industry, targeting the sustainable seafood subsector niche. The seafood industry is well developed within the US; continually ranked the third largest consumer of seafood, behind China and Japan (23). In fact, consumer trends have shown that the average American consumes 7.2 kg of fish per year, even in the face of decreasing fish stocks (23). This high per capita consumption of seafood in the United States has led to substantial importation of seafood into the U.S. to the degree that imports of edible fishery products were valued at $13.7 billion in 2007, or approximately 86 percent of total seafood consumed (24; 25).

Estimates for the sustainable seafood subsector niche are ambiguous, but E-Fishent Foods has identified positive trends within the industry. According to the 2009 US Market for Fish and Seafood Report, 7 percent of the world's edible wild seafood is Marine Sustainability Council certified, with an increasing percentage every year. This is reflective of the sustainable seafood movement gaining momentum as more people become aware about both overfishing and environmentally destructive fishing methods (24). Simultaneously, studies have shown seafood consumption is expected to increase in the following years due to growing public awareness of the health benefits associated with seafood, country of origin labeling to help assure consumers of safety, and reduced prices and increased availability due to increased aquaculture production. E-Fishent Foods interprets this increased sustainable seafood certification, coupled with an anticipated increased consumption of seafood, to signify anticipated growth of the sustainable seafood subsector.

Aquaculture

Aquaculture has begun to fulfill the customer demand for seafood, but often has limitations of its own. Monoculture techniques can in many cases lead to a lower quality seafood product, localized environmental degradation, and a higher risk to producers that essentially concentrate their liability in one source.

Aquaculture is the reason for which the seafood industry has continued to remain so large in the face of increased fishing regulations and depleted fishing stocks. Globally, aquaculture is growing faster than any other form of food production, growing at approximately 8.3 percent annually. The chart provided by Appendix 10.1, Figure 7 displays growth in millions of tons for global fisheries and aquaculture over the past 30 years. Currently, wild capture has leveled off at 80 million tons per year, while aquaculture continues to grow linearly; estimated value for aquaculture totals approximately $100 billion globally (25). The last couple years support this growth rate, as the amount of seafood produced by aquaculture in 2008 was 52.5 million tons, and grew to 60 million tons in 2011 (26). At this rate, the United Nation Food and Agriculture Organization predicts that in the next few years consumption of farm-raised fish will surpass that caught in the wild for the first time (27).

U.S. aquaculture is small compared to global production, indicating enormous potential to increase national aquaculture productions. Industry reports indicate that current aquaculture productions in the U.S. satisfy only 5-7 percent of the national demand for seafood, with very few options for the seafood connoisseur demanding variety and high quality products. Most of the U.S. aquaculture production is catfish, oysters, clams, mussels, Atlantic salmon, Tilapia, and shrimp (24; 25) (Appendix 10.1, Table 5). These are the most popular species for aquaculture due to their high market demand and growth rates. Many of these operations suffer from low public opinion due to their high environmental impact and often lower product quality. Simultaneously, studies show that there is an increasing consumer demand for health information and eco-labels for fresh fish and seafood (24). For this reason, Conservation International recommends that innovation and supply-demand analysis is two core focuses for aquaculture policy in the United States during the next decade (7). Appendix 10.1, Figure 8 shows Conservation Internationals four principle foci for global aquaculture operations. With regards to innovation, they call for continued support for "technologies that make best use of land and water and feed resources and that minimize demands on environmental services" (7). If these initiatives are successful, annual aquaculture production in the U.S. could increase from 0.5 million tons to 1.5 million tons by the year 2025 (24).

2.2 Market Analysis

The total available market for E-Fishent foods is assumed to be the greater California population. The value of this total available market is estimated to be $1.8 billion dollars[4]. The average annual catch within Santa Barbara County is about $22 million annually. Nearly 75 percent of the local catch based on annual ex-vessel value was accounted for by three fisheries - squid, sea urchin, and spiny lobster, the

[4] The 2011 Census reports that the population of California was 37,691,912 individuals. To calculate the total available market value, this population count was multiplied by the national average per capita seafood consumption of 7.2 kg, and a conservative ex-vessel value of $6.2/kg.

overwhelming majority of which was exported from the state. Our initial target market therefore has a local demand that is not met by the local supply. Using other figures reported by the FAO, E-Fishent Foods determined that the market size for seafood in this country is $16.6 billion a year, based on the average annual domestic consumption of 7.2 kg per year (Appendix 10.1, Table 6) and the total US population. Recent changes in fisheries regulations put in place largely as a result of overfishing, significantly decreased the quotas for most near shore and groundfish fisheries. This imbalance of local marine fisheries accounts for the substantial distributive effort of seafood into and out of the area: currently over 95 percent of the seafood consumed by the community of Santa Barbara is imported, and at least 85 percent of the seafood caught locally is exported (22). The annual potential market demand for E-Fishent Foods is based on the 2008 Santa Barbara County population census and average American consumption of seafood (about 400,000 people at 7.2 kg per person per year), and is estimated to be around 3 thousand tons of seafood, or around $20 million per year. This estimate is also close to the average annual catch in Santa Barbara County, although most of the local seafood is exported and other species imported. E-Fishent Foods will compete with other local and imported seafood sources to meet this demand; this quantity demonstrates a clear demand for locally harvested seafood in the area. E-Fishent Foods chose to raise white seabass as our finfish species due to the presence of a high demand in California and previous research by Hubbs Institute that has demonstrated its success as an offshore farm-raised species in the area.

E-Fishent Foods determined the market for mussels by using reports by FAO and Phil Cruver which illustrated that the market for mussels requires greater production in the US in order to help alleviate the growing import debt. The US currently imports 29 thousand tons of mussels every year, a number that is only growing (26). E-Fishent Foods chose to raise black mussels after reviewing scientific data that backed up the success of it thriving around central California in the wild and being successfully farm raised, and conducting multiple interviews with people in the restaurant and wholesale industries that sell mussels.

To date, most of the market research for seaweed has been done indirectly through market reports found under the Fisheries and Aquaculture Department (FAO). The market data found in the report, “Introduction to Commercial Seaweeds.” was invaluable in helping determine the correct species for successful marketing in the food industry (26). Brown seaweeds make most economic sense in terms of the benefits we hope to gain from seaweed production. Marketing seaweed for food instead of for industrial purposes, like alginate, will allow for us to recover most of the costs associated with seaweed production. The potential to put 10-15 percent of the seaweed back into the system in the form of fish feed is also a possibility. This will help to offset the costs associated with seaweed production, such as harvesting, drying, and packaging for sale. Also, E-Fishent Foods will save on fish meal by incorporating our own seaweed product back into the fish feed system. According to a paper by Peteiro *et. al* (28), there has been research into how much of our species can be put back into the fish feed while maintaining healthy production levels of the fish. This paper also states the importance of Laminaria for human consumption, and that any increase in demand for this product would require the use of human mariculture. For this reason and its success growing naturally in the region we chose to raise laminaria as our species of seaweed.

2.3 Competitive Analysis

High ecological productivity along California's Central Coast, resulting from the mixing of cold and warm waters, provides E-Fishent Foods with an excellent foundation from which to cultivate multiple species. As this area is also a major upwelling zone, natural fisheries have been extremely productive (22), and thus E-Fishent Foods anticipates high yields of cultivated species due to favorable environmental conditions for the offshore system. Farming interdependent species within one system recycles wastes and increases the overall product to input ratio, thus maximizing efficiency.

E-Fishent Foods has a competitive advantage because it can produce sustainable seafood efficiently, locally and consistently based on location and systems design. The competitive positioning map in Appendix 10.1, Figure 9 helps to illustrate how E-Fishent Foods ranks in comparison to its competitors within the addressable seafood market. Indirect competitors are large-scale nationwide seafood companies including Trans-Ocean, Vita Food Products, and Ocean Beauty. For example, Trans-Ocean earned $33 million in the center-plate dinner seafood category during 2010, growing 7 percent over the previous year (24)(Appendix 10.1, Table 7). It is important to note that while large, these companies focus solely on the distribution of processed and frozen seafood. E-Fishent Foods will compete more directly in the fresh seafood market, specifically within Central California.

Major competitors include the local commercial fishing sector, local shellfish farmers, and primarily the imported seafood sector. Because 95 percent of seafood consumed in Santa Barbara County is imported, these constituents are and will continue to be the largest competitors. Their advantages include massive scales of production, regional specific species advantages, less stringent regulations, and established relationships with distributors (29). Weaknesses include increased operating costs resulting from the escalating price of fuel, the inability to meet the demand for locally harvested seafood, the decline of most international fisheries due to lack of regulation, and reduced freshness. In terms of competition in the aquaculture field, China currently leads the aquaculture industry, responsible for 61 percent of the world's aquaculture (30). As illustrated by a diagram produced by Conservation International (Appendix 10.1, Figure 10), when aggregated across the continent, Asia is responsible for 91 percent of the world's aquaculture production. Right now, the United States is a major consumer of aquaculture products – we import 86 percent of our seafood – yet we are a minor producer. Half of what we import is from aquaculture, yet we produce only five percent of the seafood that Americans eat from domestic freshwater and marine aquaculture (25). The lack of aquaculture in this country has been the result of an absence of regulatory system in place to promote its growth. Only recently has aquaculture been seen as necessary to keep up with the growing demand for seafood. As such, federal regulations are beginning to take shape. Accordingly, E-Fishent Foods will face the most competition within the aquaculture industry from the imported seafood market.

Competition with foreign seafood is significant, and within the next 5-10 years the management of California fisheries will change substantially. The California Ocean Protection Council's (OPC) Strategic Plan for managing ocean and coastal resources, the California Marine Life Management Act, and the California Marine Life Protection Act will most likely lead to the establishment of additional marine reserves and management activities within California, undoubtedly affecting fishing activities. The effect of these is increased dependence on imported seafood in California during a time when demand continues to grow. E-Fishent Foods will help revitalize the local seafood industry and will thereby be in direct competition with imported sources. Barriers to entry include the reliance on imported seafood, competition with other California fishing sectors, and the technical and logistical difficulties associated with establishing an offshore aquaculture facility in the area.

Primary research conducted by E-Fishent Foods indicated the siting process for the offshore aquaculture operation will be difficult due to oceanographic factors, significant engineering costs, and complex biological interactions. E-Fishent Foods has conducted an analysis to evaluate the feasibility of sites in the area with regards to oceanographic factors. E-Fishent Foods has found several locations of very large size that would be feasible for our operations (Appendix 10.1, Figure 11). This took into account such factors as substrate type, depth (between 24 and 36 m), local biodiversity and ecosystem richness, oil platforms, prevailing currents, MPA's and shipping lanes. E-Fishent Foods will use species-specific husbandry knowledge to build and maintain the best stocks possible within these areas while constantly monitoring water quality and product health.

Emerging competitors will face direct competition with E-Fishent Foods in addition to these barriers to entry. The entry of integrative multitrophic aquaculture into the market will receive some opposition by local fishermen, but may be supported by others. While E-Fishent Foods will increase direct competition for some local fishermen, it will support the local seafood industry and availability of species during different periods of the year. Seafood that is farmed and imported will have to compete with E-Fishent Foods on both price and quality. As a result of keeping the operations local, the savings in shipping can be passed on to the customer. Also, E-Fishent Foods products will be of higher quality due to the shortened time to bring the seafood from harvest to consumption. Some of the choices consumers will get to make when deciding to buy E-Fishent Foods products over others will be if it is local, sustainable, and quality. They will be able to say yes to all of those with E-Fishent Foods products. Overall, E-Fishent Foods will likely contribute to community support of the local seafood industry thus benefiting many potential local competitors.

2.4 Analogous Business Model Analysis

The integrative multitrophic system that E-Fishent Foods is proposing has no exact analogous model to compare with. However, internationally China, Japan, and Canada have found success using a type of system similar to this, catering to very high consumption rates and demand for sustainably produced seafood. In the US, monoculture systems have predominantly been used, although near shore mariculture production has been utilized since the 1980's (31). The technology for implementing this type of system has already been established and has found success. By crossing over this technology to meet the standards within the US, E-Fishent Foods feels that very little new technology will be needed, only integration of current systems into one. Mainly some improvements within the current system will most likely be needed to coincide with the different species of choice.

Offshore monoculture models are in place or are being proposed locally. One such company is the Santa Barbara Mariculture facility that farms mussels and oysters using near shore long lines. There is also a startup lead by Phil Cruver off the coast of Long Beach that will also be raising mussels, but in federal waters and on a larger scale. The company has a provisional permit from the US Army Corps of Engineers for a 100 acre site about 9 miles off shore. Construction for this site has been scheduled for early 2013. Both of these business models have been helpful in understanding the regulatory and permitting processes that offshore facilities have to go through, as well as the ins and outs of production cycles, ease of harvest, and logistics.

It was from these business models that E-Fishent Foods determined that federal waters would be easier to get permitting for than state waters. The Army Corps of Engineers is the only permit needed as of now to establish an aquaculture site in federal waters. Another important insight E-Fishent Foods received from studying these models was the predicted start-up costs of building an aquaculture facility in addition to the market value of mussels. From these values E-Fishent Foods was able to establish an expected break even projection.

Hubbs Institute is currently operating a seabass aquaculture farm on Catalina Island, but for stock rebuilding not consumption. Because we will be raising the same species of mussels and fish, and our seaweed grows well locally, we are confident that our design and production schedule are realistic and position our company for success. E-Fishent Foods sees the success of these businesses as indicative of the potential for similar operations to thrive.

3 CUSTOMER AND INDUSTRY RESEARCH

3.1 Objectives

In order to build a successful business model, E-Fishent Foods needed to learn more about the primary customer and end consumer whose needs would be met with the seabass, mussels, and seaweed produced. It was also crucial that the team learn about the current regulations and permitting process for aquaculture in the United States.

In order to learn more about the target customer and end consumer, E-Fishent Foods interviewed seafood wholesalers and seafood restaurants. Regional seafood wholesalers were identified as the primary customer for E-Fishent Foods because the most common, and often most cost-effective, method of distribution is via wholesalers. Individuals dining at seafood restaurants were targeted as the end consumer within the E-Fishent Foods business model because American Seafood Industry Reports show that the majority of seafood is consumed within restaurants (32).

The questions that E-Fishent Foods aimed to answer with wholesaler and restaurant interviews were:

- What are the key factors influencing the purchasing decisions made by wholesalers?
- What type of seasonality exists within the wholesale business?
- What are the bestselling species and how much is being sold?

- Are there any species that wholesalers wish were available in greater quantities or in different seasons?
- Is product locality important to wholesalers? How is it defined?
- Is product sustainability important to wholesalers? How is it defined?
- What channels do these wholesalers use to reach their customers?
- What are the key factors influencing the purchasing decisions made by restaurants that buy products from these wholesalers?

E-Fishent Foods expected that interviews and hands-on experience with aquaculture and seafood industry experts would answer the logistical and operational questions pertinent to the E-Fishent Foods opportunity concept. For this reason the team sought to interview representatives from various government agencies and non-profit organizations, marine scientists, and certifying agencies. The team also attended multiple aquaculture workshops, sustainable seafood events, and two individuals in the team completed summer internships with aquaculture businesses.

The goal of these interviews and hands-on experience was to answer the following questions:

- Is an onshore or offshore aquaculture a more viable business opportunity in Central California?
- When will the regulatory framework be developed offshore finfish aquaculture?
- Should the first E-Fishent Foods site be located in state or federal waters?
- Which agencies will be responsible for granting the necessary permits in order to begin construction and production at the site?
- Which agencies will be responsible for certifying the sustainability and health characteristics of the E-Fishent Foods products?
- Would it be more favorably viewed by the scientific community and authorizing agencies to raise native or non-native species?
- Which site characteristics (depth, substrate, and temperature) would be most beneficial to the viability of our multi-trophic system?

- What are the environmental and legislative risks associated with developing a new venture in the aquaculture industry?

The following methodology and results section will highlight the process and answers obtained from the interviews and experiences with wholesalers, restaurants, consumers, and industry experts.

3.2 Methodology

In order to learn more about the primary customer, the team conducted twenty four in-depth interviews with regional seafood wholesalers. The wholesalers E-Fishent Foods interviewed were located from Los Angeles to San Francisco, with the majority of interviews conducted with locals in Santa Barbara. Appendix 10.2 (a) contains the questionnaire used when interviewing wholesalers.

To learn about the end consumer, E-Fishent foods also interviewed chefs, owners, or staff members at 23 restaurants serving primarily seafood. The restaurants that E-Fishent Foods interviewed were all based in the Santa Barbara region and specialized in selling seafood, or at least commonly promoted it on their menus. E-Fishent Foods made sure to interview both local and chain restaurants. Appendix 10.2 (b) contains the questionnaire used when interviewing restaurants.

E-Fishent Foods conducted in-depth interviews with 41 industry experts, attended 2 aquaculture workshops, 4 sustainable seafood events, and took ample notes during the course of their summer internships. E-Fishent Foods did not use a specific questionnaire when conducting interviews with industry experts or at aquaculture or seafood events because the background of each interviewee varied greatly.

3.3 Results

After conducting the aforementioned interviews, E-Fishent Foods developed a list of the most important key findings for each customer segment (seafood wholesalers, restaurants, seafood consumers) and industry experts. They are:

Wholesalers

- Wholesalers who sell to restaurants do not usually also sell to retail locations.
- Wholesalers or restaurants will take care of the processing and distribution of fish from the aquaculture operation onwards.

- Requests from restaurants will lead wholesalers to purchase seafood with particular characteristics such as a specific species, cut, weight, quality.
- Requests from seafood restaurants drive the wholesaler's demand for sustainable seafood.
- Price, quality and accessibility are the most important considerations for regional seafood wholesalers because this is their value proposition to restaurants.

Regional seafood wholesalers were identified as E-Fishent Foods' target customers because numerous interviews illustrated that wholesalers can utilize their network to distribute the seafood products far more efficiently than the producer could do on its own.

For wholesalers, "sustainable seafood" is defined as seafood caught or farmed in a way that considers the long term health of the target species and its aquatic ecosystem. The impetus for fishermen or aquaculture operations to provide sustainable products to wholesalers varies depending on the reach and size of their target customer. Large distributors may be less concerned with sustainable sourcing because the impacts from overfishing may not directly impact them; they can source from other fisheries that have not been depleted (33). Distributors that supply seafood exclusively from local fisheries have more of an incentive to source sustainably because their future success is directly correlated with the success of local fisheries (34). Some wholesalers are taking a sustainability initiative as well and are beginning to see more of an increased demand for these types of products.

Wholesalers that rely on sustainable seafood risk receiving from unreliable sources. Monoculture techniques can in many cases lead to a lower quality seafood product, localized environmental degradation, and a higher risk to producers that have invested all of their effort and financial resources into farming operations. In exchange for this additional risk, the wholesaler often places a price premium on sustainably sourced products. One seafood wholesaler explains:

"Lower priced sustainable seafood would attract all types of customers to this growing market."- Seafood Wholesaler (33)

While most wholesalers are consistent with their request for a product of particular quality and availability, only some are able to sell sustainable seafood because of the increase in cost to the purchasing restaurants. For example, Kanaloa Fish Co, a sustainable seafood distributor and market, has targeted a specific niche of consumers that are willing to pay a price premium for higher quality sustainable seafood. Appendix 10.2, Table 9 is provides a list of the wholesalers and retailers interviewed, along with the key findings of the interview.

Restaurants

- Restaurants maintain long-term relationships with wholesalers and distributors.
- NGO's provide information that influences menus created by restaurants.
- Sustainably-minded seafood consumers influence the restaurant's likelihood to request sustainable seafood from their distributor or seafood wholesaler.
- Sustainability is of greater importance than locality; what is sold as "local" may actually be regional.
- Publicizing sustainability and high quality can attract target customers

Today, increasingly more restaurants are now faced with difficult decisions regarding whether or not to buy sustainable seafood. E-Fishent Foods discovered conflicting results about what ultimately drives a restaurant to buy sustainably. For some restaurant owners, the decision to source sustainable seafood was driven by personal environmental values (35; 36). Research suggests that many restaurants cannot serve certain fish because the fishery is not qualified as sustainable, and sourcing many species can be both difficult and expensive due to limited catch and availability (36). For the restaurants that sell dishes both with and without sustainable seafood, the owner or manager cited that price was a significant factor in choosing an unsustainable option over sustainable seafood (36).

For other restaurants, the drive for sustainable seafood was driven by consumers. One interviewee stated:

"There is enough demand in this community for local, sustainable products. It can be profitable. It's just about figuring out how to get the products to them."
- Sustainable Food Supplier

Without direct customer demand, some restaurant owners were more inclined to purchase seafood based on what products sell best regardless of its sustainability (30).

Once a restaurant has decided to purchase sustainable seafood, they often find it difficult to source it, maintain certifications, and provide the types of high quality foods end consumers want. Restaurants are currently dealing with this problem by either paying a premium for sustainable seafood, sourcing seafood from non-local distributors, or most often not purchasing sustainably sourced foods. This current method presents a shortfall to the restaurants by providing a less desirable product or causing them to spend more money to buy sustainably. The inconsistency of supply can force them to constantly be changing their menus or buy frozen products. Appendix 10.2, Table 10 lists the restaurants interviewed and the key findings from each interview.

Seafood Consumers

- The majority of consumers don't ask where their seafood comes from
- NGO's provide information that influences consumers
- "Farmed" fish has a bad reputation but the average consumer can't articulate why
- Transparent labeling and marketing of sustainable seafood important
- One of the biggest challenges with producing less known species is consumer education.

Like restaurants, seafood consumers stated a preference for sustainable seafood but cited price, quality and accessibility as key deciding factors.

These findings validated our customer discovery hypothesis that there is in fact a large demand for sustainable seafood in Central California. The difficulties are associated with providing it consistently and cost-effectively. E-Fishent Foods' unique approach to seafood production addresses these difficulties at the source by providing high quality, locally sourced, and competitively priced sustainable seafood.

Industry Experts

- Due to the high cost of land in California, offshore aquaculture will be more cost effective than onshore aquaculture
- The regulatory framework for finfish aquaculture is currently being developed and is expected to be finished in 2013 or 2014.
- The E-Fishent Foods site should be located in federal waters because the permitting process is more streamlined. The system will be less susceptible to near shore contamination and will not impact the view shed of coastal residences.
- The Army Core of Engineers (ACE) is the issuing agency for aquaculture operations in federal waters. Representatives from NOAA may serve as advisors to ACE but they will not have final decision-making authority.
- Third-Party certifiers like Fishwise, the Monterrey Bay Aquarium Seafood Watch, or the Aquaculture Stewardship Council will evaluate and promote the sustainability of our seafood

- It is more favorably viewed by the scientific community to grow species that are already found in California waters.

- There are many factors to consider before choosing a site for a new aquaculture farm. [5] Some spatial data has already been collected but additional sampling should be done before selecting the final location.

Interviews with industry experts were a critical component of the E-Fishent Foods opportunity development. The vast majority of interviewees agreed that the right type of aquaculture venture could be successfully launched off the coast of Central California. Some notable statements from these interviews include:

"The demand for fresh and sustainable seafood is so high that a new aquaculture operation wouldn't present a conflict for the local fishing community."
– Local Industry Advisor

"The only reason it hasn't happened yet is that no one has bothered to do it. It's totally possible…it's only a matter of time before someone makes it work."
– Local Mariculturist

"It's no longer a question about whether aquaculture is something we should or shouldn't embrace. It's here. The question is how we'll do it."
– Representative for the Seafood Choices Alliance

"Well-thought-out, smartly done aquaculture certainly has some promise here. We need to think about it in a more sustainable way, then it will be more widely accepted."
– California Marine Policy Expert

Many of the interviewees also stated that public education and community outreach would be crucial to the success of E-Fishent Foods. California has one of the most protected coastlines in the world, thus there are many agencies and stakeholders that are opposed to seeing aquaculture development in this region. As a first mover, E-Fishent Foods will have to demonstrate the sustainability of our system and be extremely proactive regarding water quality and disease monitoring. Appendix 10.2, Table 8, Table 11 and Table 12 list the industry experts, marine researchers, and policy experts interviewed and the key findings from each interview.

[5] These considerations are explained with greater detail under the siting analysis section.

3.4 Customer Archetype

With the findings of the in-depth customer interviews E-Fishent Foods was also able to construct an archetype for regional wholesalers serving sustainably minded restaurants. This archetype includes the demographics, motivation and traits typically observed within this customer segment:

Demographics

- Wholesaler activity is a Business to Business (B to B) operation.
- On average, a regional wholesaler will have 100 – 200 routine clients.
- The total amount of sales varies drastically from one wholesaler to the next.
- Most operations employ only the minimal amount of sourcing and sales staff.
- The typical regional seafood wholesaler is a technology laggard.

Motivation

- The wholesaler loses time sales opportunities when supply is inconsistent.
- Seafood wholesalers are the target of increasing environmental media and consumer scrutiny.
- They are a player in a competitive and quickly changing industry
- A wholesaler fears decreased sales from support of unsustainable practices

Traits

- The wholesaler imports the majority of their products from outside California
- They sells both wild-caught and farm-raised seafood
- Values long-term sales contracts/relationships
- Wants high quality products at lowest price

This customer archetype will guide E-Fishent Foods' marketing strategies and determine the optimal distribution methodologies and sales channels. Keeping this profile in consideration at every point in the business development will ensure that these customer needs are met.

4 PROPOSED BUSINESS MODEL

4.1 Customer Problem

E-Fishent Foods addresses the customer demand for sustainable seafood to address the customer difficulty with purchasing sustainably sourced, high quality and affordable seafood in California. Purchasing sustainable and high quality fish and shellfish is often expensive and difficult to do locally. Currently most seafood is harvested using conventional methods that often overexploit natural fisheries, and are associated with high costs to both the environment and buyers. Damages associated with environmental degradation often make seafood more costly to the producers and buyers. Buying unsustainable fish and shellfish is expensive in the long run and has a high risk of market collapse; current aquaculture techniques are not sufficient to compensate for this shortfall.

Analysis of the American seafood industry shows that the majority of seafood is consumed within restaurants. Although some fishermen sell directly to restaurants, markets, and even end consumers, our analysis indicated that the most common and often most cost-effective method of distribution is via wholesalers. Buying sustainable seafood is generally more expensive and less reliable than utilizing conventional sourcing techniques. Many restaurants and end consumers, however, would prefer their seafood to be sourced sustainably, but not at the expense of quality, reliability and price. According to a local seafood restaurant owner, many restaurants cannot serve certain species of fish because the fishery is not qualified as sustainable, and sourcing many species can be both difficult and expensive due to limited catch and availability. It is also difficult and costly to find local, sustainably produced seafood. Furthermore, the supply of seafood products is often inconsistent and freshness is highly dependent upon fishing seasons. The Santa Barbara channel is one of the top producers of California seafood, but more than 85 percent of the local catch is shipped out of the area to be distributed across the state and even globally. This presents a customer problem for distributors who wish to fill the restaurant and end consumer demand for competitively priced, high quality, sustainable seafood.

Customers are currently dealing with this problem by either paying a premium for sustainable seafood, sourcing seafood from non-local distributors, or most often not purchasing sustainably sourced foods. This current method presents a shortfall to customers by providing a less desirable product or causing them to spend more money to buy sustainably. Also distributors that rely on sustainable seafood risk receiving from unreliable sources. Many restaurants that want to serve sustainable seafood find it difficult to source it, maintain certifications, and provide the types of high quality foods end consumers want. Aquaculture has begun to fulfill the customer demand for seafood, but often has limitations of its own. Monoculture techniques can in many cases lead to a lower quality seafood product, localized environmental degradation, and a higher risk to producers that essentially have all their eggs in one basket.

Key pivots of our research when defining the customer included: the customer whose problem we are addressing is the seafood wholesaler and not the end consumer, sustainability is of greater importance than locality, wholesalers lose sales opportunities when supply of products is inconsistent, they are the target of environmental media and consumer scrutiny, they are players in a competitively priced and quickly changing industry, and they fear losing sales from buying from unsustainable sources. E-Fishent Foods took all of the customer problems into consideration when designing our production plan, business structure, and marketing strategy.

4.2 The E-Fishent Solution

The driving force behind the team's Eco-E opportunity hypothesis comes from the belief that ecologically oriented aquaculture can solve the customer problem while simultaneously providing an environmental benefit. E-Fishent Foods addresses the customer demand for sustainable seafood by utilizing an integrative multitrophic aquaculture system.

In contrast to traditional monoculture systems that grow only one species, our multitrophic aquaculture model combines three species from different trophic levels, farming white seabass (*Atractoscion nobilis*), black mussel (*Mytilus californianus*), and laminaria (*Laminaria spp*.) at one site. By uniting these species and their respective biological processes, we can reduce the overall waste produced by our system by up to 80 percent. This arrangement would also maximize the productivity of the system so the mussels and seaweed in the multitrophic system grow faster and larger than they would under monoculture conditions (8; 37; 38).

Polyculture and integrated aquaculture systems have been cited to significantly improve the reliability, resource use, and production efficiency of seafood farming (15; 16). In open water fish cage culture, mollusks and seaweed down current can absorb excess feed and waste products from the fish, assimilate these nutrients as biomass, and provide other sources of seafood for harvest (18; 10; 39). These interactions and basic ecological principles can be used to develop seafood production systems which have less negative environmental impacts, yet produce a greater quantity of seafood to meet the growing demand in an efficient manner (40).

4.3 Validated Business Model

Throughout 2011, 2012, and 2013 E-Fishent Foods has been testing and validating several hypotheses in order to establish the definitive proposed business model in order to provide the solutions suggested in the previous section. According to the methodology suggested by Blank and Dorf (41) and after several significant pivots we have validated the majority of the variables identified in our business canvas (Figure 1). A detailed explanation of our whole business proposition is detailed below.

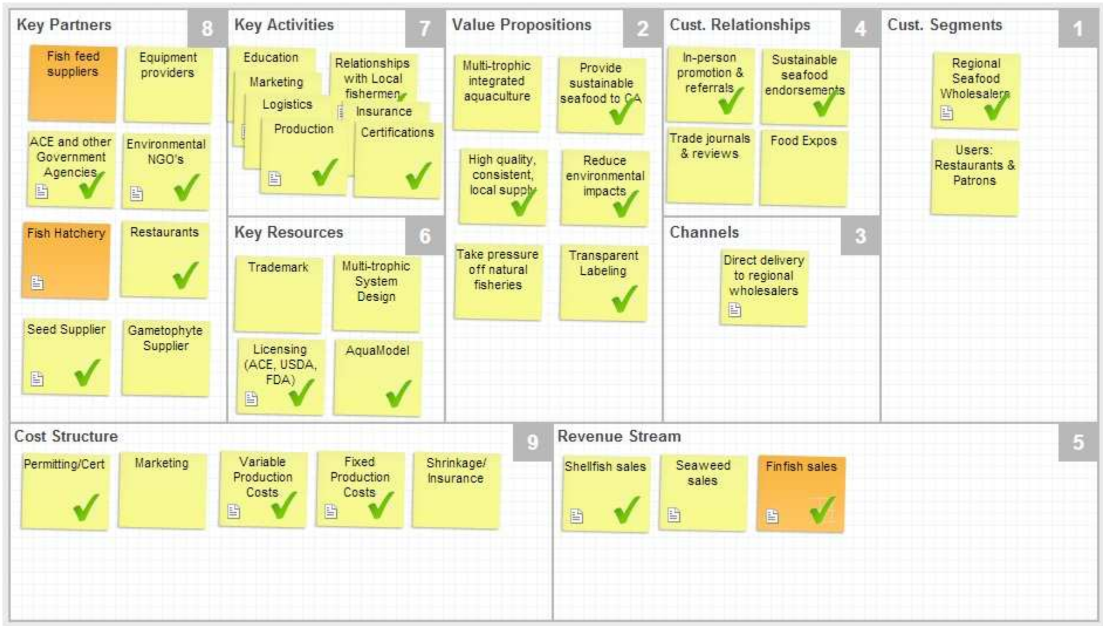


Figure 1: E-Fishent Foods Business Canvas

Customer Segment

As a result of our research, we have identified regional seafood wholesalers as our customer segment. There are several benefits to dealing directly with wholesalers, which include a decrease in logistics complexity and a secure high volume demand for our output. The wholesalers will distribute to the final users, whether they sell directly to restaurants or any other customer in their own networks.

Value Propositions

The E-Fishent solution will generate value within many fields compared both to wild fisheries and traditional aquaculture. First, we will incorporate and develop technical expertise that will allow the implementation of a multitrophic aquaculture system. This system will allow us deliver seafood that is high quality with a consistent supply to our customers while being sustainable.

As explained previously we will be able to reduce total environmental impact compared to traditional aquaculture, making us the best option for wholesalers that are concerned with sustainability issues from aquaculture products (42; 43; 44). According to our estimations we will not have a significant environmental impact using the proper siting as laid out by our analysis, and undertaking production processes properly.

By providing sustainable seafood, we hope to generate a decrease in the overall fishing pressure on some of the wild stocks that are being imported into the US and may have sustainability issues (45; 46; 47). These benefits are then spread not only over the state of California but also over fisheries abroad. One of the concerns we have identified during our research stage is the so-called “fish-meal trap” as a constraint for aquaculture production and sustainability. However there is enough information that tackles the validity of this argument and concludes that this is not the case for aquaculture, given that natural fisheries require a relatively higher amount of lower trophic level fish for the same amount of growth, and technology developments that decrease the use of fish meal in fish feed is advancing (48; 49).

Finally, given our location and the commitment with traceability and environmental performance (21) we will offer our customers the full ability to trace our production, allowing for both certification and feedback along the production chain and from the end consumers.

Channels

Our distribution channel would be a direct link between our production site and the regional wholesalers, decreasing any excessive complexity related to delivery procedures (50; 51). The distribution could include direct collection from our production site, or the direct delivery to the wholesaler’s location depending on the convenience of the parts, and the optimization in cost management. Most wholesalers will process our seafood in-house, removing processing plants from our channels.

Customer Relationships

As we identified during our interviews with customers, there are several concerns regarding aquaculture production and its sustainability (52; 30). In order to deal with this reality, we will need active promotions for our customers and end users (53; 54; 55). We will have to do in-person promotions and referrals, as well as work our way into sustainability certification and sponsorship from external entities that deal with this type of information.

Under this scenario we will also have to attend to food expositions and trade meetings in order to establish relationships with our customers and to spread the benefits of the E-Fishent solution. We have also considered an active presence in the media in order to educate and motivate end users towards our product, promoting its quality and sustainability. We will market that we are revamping the California seafood industry and reducing our reliance on products from foreign countries, were less sustainable practices are common.

Revenue Stream

The revenue stream of the E-Fishent solution is strictly related to the sale of our production of all three trophic levels: fish, mussels and seaweed. According to our market research, we will have our main revenue stream coming from the sales of both fish and mussels. For seaweed, the market is still somewhat unclear although we have identified a significant potential use for it in the abalone aquaculture industry (56; 57; 58); we haven't yet been able to accurately identify the size of this market and therefore the estimation of our potential revenue stream coming from seaweed production is very conservative.

Our product will be harvested on-site and it will be subjected to basic processing, so it can be transported without sacrificing the quality and the freshness after the harvesting process. After harvest, the product will be transported in bins with iced water allowing for safe transportation directly to the wholesalers in refrigerated vehicles; we will not conduct any further processing none of the species leaving that process in charge of the subsequent processing stages. Section 5.2 contains a detailed analysis of the revenue stream for a startup small scale site, analysis that we used to estimate the financial viability of our proposed business model.

Key Resources

In order to assure the proper operation of the company, E-Fishent Foods will have to develop and secure several key resources along the production process as well as in the market sector. Some of these key resources include the development of a trademark for our products, a resource that will help us differentiate our products from traditional aquaculture production, as well as to build an image that can ensure better marketing and success.

On the other hand we will develop an aquaculture system that has not been used previously in the U.S. by using a unique design that may have patent issues or even potential for patenting. Regardless of these potentials we have decided to use the most typical structures for aquaculture activities, cages for fish and longlines for mussels and seaweed, making our production setup straight forward in terms of suppliers and infrastructure required. Given these conditions, we will need to secure all the respective patent compliances with manufacturers and suppliers.

Also, in order to comply with federal regulations we need to secure all licensing permits for our operation, including authorizations from government agencies that regulate marine activities in the country (59; 60; 61). These organizations include the Army Corp of Engineers (ACE), the National Oceanic and Atmospheric Administration (NOAA) and the Food and Drug Administration (FDA). As far as our research has pointed out, the previous three listed governmental bodies are in charge of regulating and establishing the legal status of any aquaculture venture in U.S. federal waters.

Key Activities

In order to ensure the success of this business, we will need to carry several key activities that will help us create and maintain a market niche. Since the main characteristic of the E-Fishent Solution is its environmental benefits when compared to traditional aquaculture activities, we would need to educate our customers and end consumers about the benefits we are providing along with all the value propositions previously described. We expect these activities to be part of our day to day schedule in order to assure our success. Also, we will complement this education with a constant marketing strategy in order to ensure that people understand the differences between our products and others, and promote the quality of our products.

Given the complexity of both the production and the delivering stages of our activities, we will need to secure both activities in order minimize any error margins and any losses than can come with it. We would need to secure all processes involved in the production stage including seed supply, feed supply, farming and harvesting practices and contingency plans in order to maintain a constant production output at our desired level of quality. It is also necessary to secure our logistic network so the quality and the timing our customers expect from us are met as proposed in our value proposition; these two activities are the core of the operational section of our business plan. Also, in case any unexpected circumstances occur we will have to work on the insurance of both our production and delivery stages, so we can maintain our liability and potential losses at a minimum.

As we explained before, most of the current problems with traditional aquaculture are not only related to its environmental performance but also to its bad reputation. In order tackle these issues in our model we will work on getting sustainability certifications that are credible for customers. Also, in order to boost our position in the local communities and to prevent local complications (62; 63) we will have to work on building strong relationships with local fishermen. These relationships will both increasing the acceptance of our operations and the potential size of our market.

Key Partners

All the previous sections of our business plan have highlighted the high complexity of the venture; this plethora of requirements cannot be fulfilled if several key partnerships are not established all on the production side as well as in the market and regulatory sectors. For the production stage we will need to establish partnerships with the equipment providers and the seed and feed suppliers, which will ensure that our installation and supply chain has no bottle necks that could affect our production schedule. Such relationships will have to be established for local, regional and international suppliers with long-term agreements that ensure our operations in the long run.

Finally, aquaculture activities in the U.S. have not been implemented at the full scale, meaning that further development without the support of any government agencies could be extremely difficult. We will have to ensure partnerships for sustainable aquaculture in the U.S. with the proper governmental bodies in charge of marine economic activities, including ACE, NOAA and the FDA. Without these key government partners our business plan cannot proceed past paper.

Ensuring the proper market positioning we expect to achieve is also a key activity included in our business model. This activity will require establishing key partnerships in the market sector, where we believe it is crucial to create and maintain alliances with selected restaurants in California in order to create demand and to establish our product as the preferred aquaculture production product of the end-consumers.

Cost Structure

Our cost structure is divided in several cost categories depending on their nature and how often they affect our cash flow. First we separated the normal cost indicators for production activities into fixed and variable costs. Fixed costs will be those that are independent of any production output from the harvesting site, including utilities, administrative expenses, and regular consulting. For variable costs, we consider all those that are directly related to our production output, including feed, seed, labor and other minor expenses that qualify under the same category.

We have grouped permitting and certification costs in the same category, as we consider them to be both crucial but independent from our main production activities. Permitting costs are required in order to carry our activities in federal waters and to commercialize edible goods, depending on the partnerships achieved with the regulating branch in the government; we can manage these costs independently from our production on-site. On the same level, certification expenses are not directly related with our production processes, but they are required in order to achieve both our environmental objectives and a desirable product for consumers.

Finally, we have included constant marketing costs in order to position ourselves in the market, and to maintain that position over time, making the marketing effort necessary from period to period. We have also included all shrinkage and insurance activities. Given that we are working with livestock our production output maybe less or more expensive than our calculation for each cycle. This condition makes us highly susceptible to environmental conditions, feed quality, animal stress levels, and any unexpected variability that can decrease or even jeopardize our production. This shrinkage is integrated into our production and revenue model. Appendix 10.3 presents in detail all the assumptions related to our costs and how these were included in our financial analysis.

5 FINANCIAL EVALUATION

5.1 Proposed Startup Site

Following the research to define the proposed business model in the previous section, we have come to the decision of implementing a multitrophic aquaculture system with three species, namely white seabass, black mussels, and laminaria. We will farm them using two types of technologies, cages for fish and longlines for mussels and seaweed, where the proposed structures for farming are presented with their respective dimensions in Figure 2.

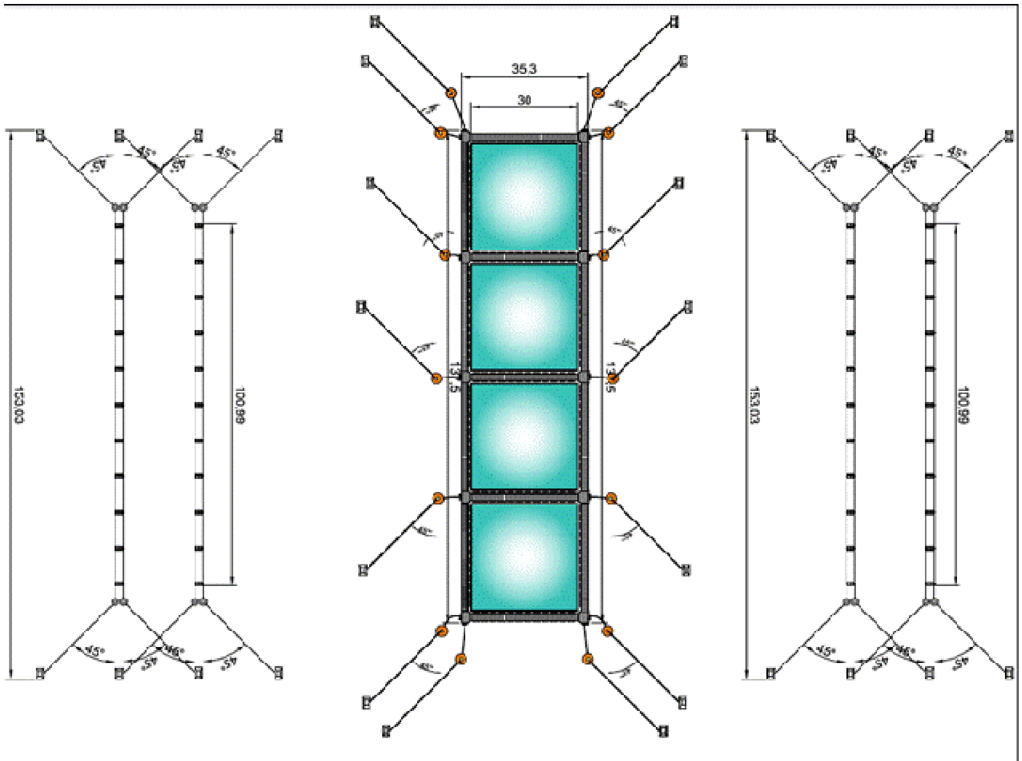


Figure 2: Upper view of the proposed structures for the farming process with longlines at the far left and right sides and cages at the center (all lengths are measured in meters).

After validating our hypotheses in the previous sections, we did several evaluations of the bioeconomic model presented in Appendix 10.3 in order to define sizes and proportions that would be the ideal[6] according to our previously stated objectives. Our findings show that both financial and regulation limitations set an ideal startup site as a 50 ha site off the coast of California in federal waters. We have divided our production area into 40 percent destined for fish, 40 percent destined for mussels and a 20percent for seaweed; where these percentages are mainly a result of the minimum seaweed cover needed to maintain a significant environmental benefit in our site. Under these conditions we expect to achieve a total production capacity (per cycle) of 587 tons of fish, 492 tons of mussels, and 272 tons of seaweed.

For our startup activities we have decided to start only with mussels and seaweed production, adding in the fish production during the second year. This

[6] By ideal we mean maintaining our economic and environmental objectives in mind. We did not perform an optimization routine to determine the size and proportions used, but selected the distribution that allowed us to make considerable profit without sacrificing environmental performance

strategy is suggested in order to alleviate initial investment and mitigate any complications that may arise from finfish aquaculture regulation. Given these conditions and the natural cycles of the organisms we are farming, the time line of our production schedule will look as presented in Figure 3, where seeding and harvesting of mussels and seaweed will occur every year, and very one and half years for fish. Under this scenario we expect to obtain a total Net Present Value of $5.7 million at the end of year 10 after production starts with farming cycles of 17 months for fish, 10 months for mussels, and 12 months for seaweed. With this production schedule we expect to generate a cost-utility ratio of $1.65 for fish, $1.82 for mussels and $1.28 for seaweed. A detailed analysis of the cash flow for our startup site is presented in the next section.

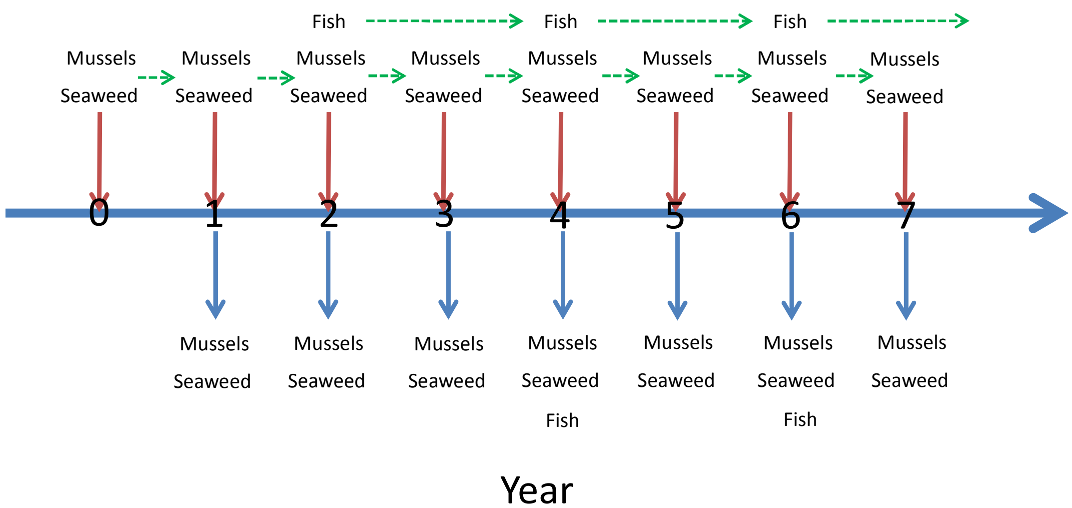


Figure 3: Time line of the startup site.
Red arrows represent seeding and blue arrows represent harvesting

5.2 Cash Flow Analysis

Using the assumptions and modeling approach detailed in Appendix 10.3 provided for each species we have projected our business plan into a 10 year fully operational period following a multi-period cycle independently for each of the species over time. Even though other experiences with similar models have been reported by Sharma *et al.* (64), Ridler *et al.* (65) and Troell *et al.* (10) for instance, E-Fishent Foods has estimated and validated several key findings for our business proposition.

Our cash flow analysis is divided in five main sections, namely initial investment, general expenses, fish production, mussel production and seaweed production. Each of the species has its own independent model and cycle, which forces us to divide them into different production sections and to group other expenses. Below, there is a complete description of the cash flow components and the final results for our startup site.

Investment

The investment section compiles all investment required for farming units as well as general infrastructure and other assets required for operation. Table 1 provides a detail of all items included for our investment categories. At year five some investments will have to be repeated after their complete production potential has been reached due to the recommended life span of equipment.

Table 1: Investment required for the E-Fishent Foods Startup Site (SS)

ITEM	Quantity (units)	Life spawn (years)	Value/unit (USD)	Total/SS (10 years)
Fish cage	10	10	$ 45,800	$ 458,000
Mussel line	20	5	$ 24,660	$ 986,400
Seaweed line	20	5	$ 24,660	$ 986,400
Cage processing equipment	1	10	$ 187,464	$ 187,464
Line processing equipment	1	10	$ 187,464	$ 187,464
Boat	2	10	$ 200,000	$ 400,000
Barge	1	10	$ 100,000	$ 100,000
Truck	2	10	$ 30,000	$ 60,000
Bins	10	10	$ 700	$ 7,000
Cooler	2	10	$ 10,000	$ 20,000
Buildings	1	50	$ 300,000	$ 300,000
Power generator	1	10	$ 100,000	$ 100,000
Computers	3	5	$ 7,500	$ 37,500
Office equipment	1	10	$ 7,000	$ 7,000

General Expenses

For general expenses in our cash flow analysis we have included all fixed labor, variable labor, administration, marketing, insurance, and monitoring expenses. These costs are considered to happen every month regardless of any output from our production schedule, and they will be compiled into total general costs and fixed cost for each species[7] for each time period. Table 2 presents a detail of all of our expenses not directly related the species production as listed before.

Table 2: Investment required for the E-Fishent Foods Startup Site (SS)

ITEM	Quantity (units)	Value/unit (USD)	Total/SS (1/ month)
Fixed labor			
Management	1	$ 5,000	$ 5,000
Administration	1	$ 4,000	$ 4,000
Consulting	1	$ 1,000	$ 1,000
Variable labor			
Cages	2	$ 2,500	$ 5,000
Lines (mussels)	1	$ 2,500	$ 2,500
Lines (seaweed)	1	$ 2,500	$ 2,500
Fixed costs			
Supplies	1	$ 2,000	$ 2,000
Utilities	1	$ 4,000	$ 4,000
Marketing	1	$ 2,000	$ 2,000
Insurance	1	$ 1,000	$ 1,000
Monitoring	1	$ 1,500	$ 1,500

Fish, Mussel and Seaweed Production

All expenses for the aquaculture production sections of our startup site are a direct result of the models specified in the previous section and are in concordance with both the size of production defined and the allocation of space for the 50 ha site. A detailed production schedule with expenses is provided in Table 3.

Table 3: Aquaculture production expenses per species

[7] In the case of variable labor.

	Area (ha)	Capacity (ton)	Production (ton)	Working Percent	Fixed cost ($/ton)	Variable cost ($/ton)
Fish	20	600	587.09	97.8%	$ 61	$ 3,746
Mussels	20	504	492.03	97.6%	$ 22	$ 1,764
Seaweed	10	277	272.25	98.2%	$ 24	$ 125

With these conditions we have calculated the overall profit profile for our startup site, using all the parameters specified before. A summary of all the relevant indicators for each species is presented in Table 4 and Appendix 10.3, Figure 12.

Table 4: Aquaculture production main finance indicators

	Marginal Cost ($/ton)	Revenue ($/ton)	Marginal profit ($/ton)	Total profit ($/cycle)	Profit contribution (%/cycle)
Fish	$ 3,808	$ 6,500	$ 2,691	$ 1,580,308	64.6%
Mussels	$ 1,707	$ 2,520	$ 1,733	$ 852,903	34.9%
Seaweed	$ 149	$ 200	$ 50	$ 13,795	0.6%

After analyzing the results we have estimated the total necessary investment at about $3.5 million with a total net present value of $5.7 million under a discount rate of 10 percent a year. Under the conditions that we evaluated our model, we can expect an internal rate of return of 34.2 percent a year. Figure 4 shows the evolution of the total net present value of the startup site, and an expected recover on all investment in year 4.

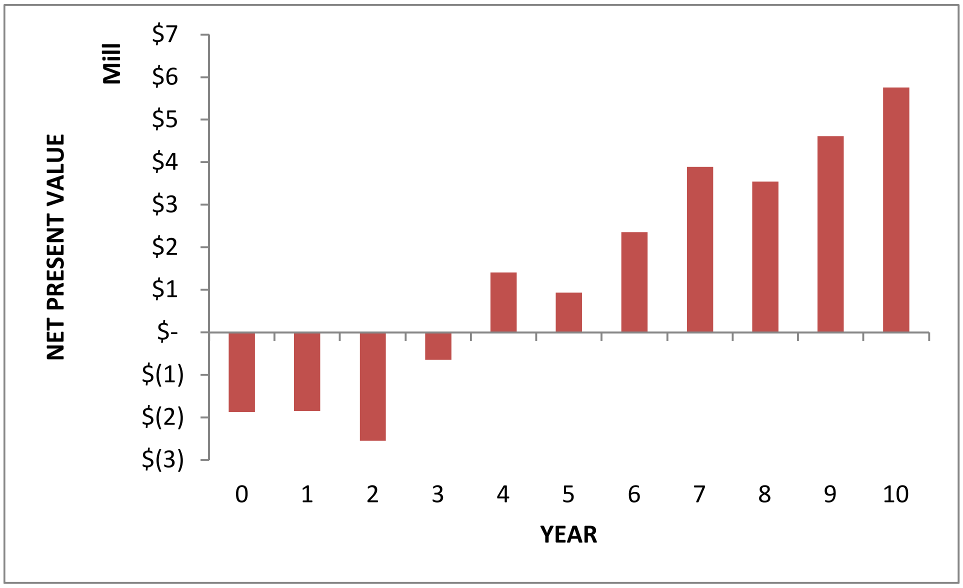


Figure 4: Net Present Value of the Startup Site over time

Finally, in order to account for any environmental variability or biological shrinkage in our production, we have conducted a Montecarlo analysis for our startup site. We defined two independent random shocks for both costs and revenues over each month for our ten year evaluation analysis. Costs are distributed with a negative exponential distribution with β=1 and a static value of 1; in other words 90 percent of the time the costs are likely to be increased as much as a 30 percent over the parameters specified before. At the same time, total revenue is subjected to a normally distributed shock of μ = 1 and standard deviation of 0.1, which means that 90 percent of the time the total revenue is likely to be between a 15 percent interval both positive and negative.

Figure 5 shows the summary of a 1000 simulations of our cash flow after adding the random shock to the total cost and total revenue values. We can see that results are apparently normally distributed with a mean of $3.3 million and a standard deviation of $700 thousand. From the figure it can be seen that 90 percent of the time we can expect to obtain $2.1 and $4.5 million, reinforcing our remarks about the financial viability of the business model.

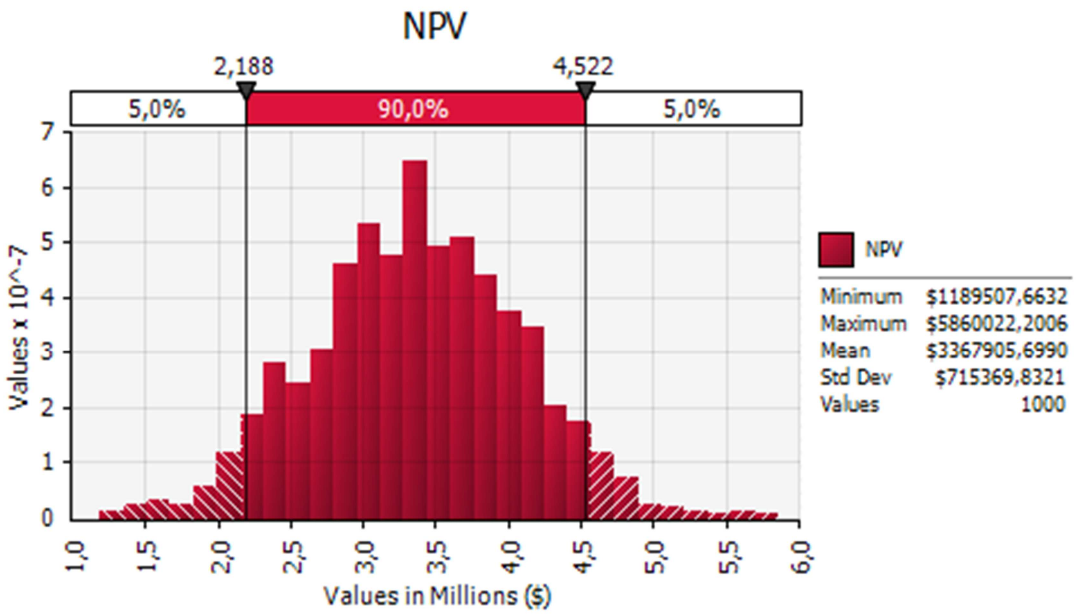


Figure 5: Results of the Montecarlo analysis for the Startup Site under random shock for both total cost and total revenue

Conclusions

After evaluation of the information available we have estimated the net present value of our 10 ha startup site to be $3.5 million for a 10 year evaluation period. Even under uncertainty we expect to obtain considerable profits as well. Despite these conclusions we are aware that the values used in the evaluation are compiled from different situations and may not be completely accurate, however we are confident that our estimations are close to the potential value generated by a multitrophic aquaculture system. Further research is needed in order to nail down the parameters used in the biological models as well as the market potential for seaweed. We are optimistic based on the favorable conditions in Central California and would propose that the actual returns on this venture can be greater than the ones we have shown in this analysis.

6 ENVIRONMENTAL BENEFITS

6.1 The Eco-E Opportunity

E-Fishent Foods represents an Eco-E opportunity because it provides high-demand products in a manner that produces numerous environmental benefits. The environmental benefits themselves in fact make our venture more profitable in many ways. The Eco-Entrepreneurship value lies in providing local and sustainable farm-raised seafood products, which is a viable alternative to an inconsistent supply of local seafood and the large proportion of imported seafood that dominates the market. Farming sustainable products will alleviate our reliance on over-fished wild stocks and degrading fishing practices (66). We will achieve this by farming finfish, mollusks, and seaweed in close proximity within an offshore aquaculture system. The result is: improved efficiency of resource use, reduced ecological impact, smaller carbon footprint, and sustained and enhanced profitability.

By utilizing multiple trophic levels, we will increase the overall efficiency and productivity of the system. The products will be uniquely and sustainably farmed within one system. This will benefit the environment by directly reducing waste and energy, and benefit the customer by providing them with reasonably priced, high quality, sustainably sourced seafood. This system is a revolutionary approach to providing sustainable seafood on the California coast. E-Fishent foods will be able to measure these environmental benefits directly through consistent monitoring of our system. Through thorough monitoring of nutrient, waste, and energy levels within the aquaculture system, we will be able to avoid the problem of over fertilization and eutrophication, while also ensuring that the energy intensity remains consistently less than current systems.

Low fuel and electricity requirements of our offshore system cut down on operating costs. The use of seaweed and mussels as biofilters for fish cultivation greatly increases the uptake of input resources, resulting in less waste and greater nutrient use efficiency (67). The E-Fishent Foods integrated design will greatly reduce waste to the environment and maximize organic nutrient uptake. This will minimize eutrophication effects on the local environment and impacts on the benthos (68). A portion of the mussels and seaweed may be reintegrated into the system and used to produce fish feed, reducing the reliance on wild caught fishmeal sources and the costs associated with purchasing feed. Growing three species within one system not only reduces the environmental impacts associated with aquaculture, but also increases the resilience of our system to environmental changes. This is because our system will be much healthier than intensified monoculture because of improved water quality and lower stocking density. This reduces the risk of production setbacks, and improves the reliability of our products allowing for a more consistent revenue stream (64). We will also greatly reduce the need for antibiotics because disease is much less likely in a lower intensity and healthier system. This reduces contamination to the environment and the costs needed to supply chemicals. Growing our species in suspended cages or on longlines, as supposed to on the substrate, minimizes the effect on the natural ecosystem below the farm. Currents are also higher in the mid waters; this increases waste dispersal and maximizes the growth rates of mussels and seaweed. Our system design therefore minimizes direct ecosystem impacts and increases production.

6.2 Benefits to the Environment

When compared to other livestock operations, aquaculture is extremely energy and resource efficient. The feed inputs required to produce one kg of fish are only one-third of that required to produce one kg of pork, or one-fifth of that required to produce a kg of beef. "Aquaculture is most likely to meet the growing demand for animal products with the least demand on ecosystems," said Sebastian Troëng of Conservation International (1). Currently, most seafood is fished using conventional methods that often over-exploit natural fisheries, and are associated with high costs to the environment. E-Fishent Foods can reduce our reliance on wild caught fish to meet our seafood demands, which would reduce the pressure on fisheries and the degredation due to fishing practices including habitat destruction, by-catch, and species endangerment.

Various open-ocean and onshore aquaculture techniques for fish and shellfish are currently in use to help meet the growing seafood demand, but come with issues regarding waste management, such as cultural eutrophication, and high energy costs (19). Furthermore, damages associated with environmental degradation may make the process even more costly to the producers and buyers. E-Fishent Foods will help alleviate these problems through the utilization of a less energy intensive system, while also taking pressure off of natural fisheries by providing another way of meeting market demand for seafood.

E-Fishent Foods' use of multitrophic aquaculture will provide several benefits to the environment. Farming fish, shellfish, and seaweed together in a closed system will significantly reduce waste and increase overall productivity per unit input (69). The fish feed is the only external nutrient input for the system, and the recycling of these nutrients significantly increases feed efficiency. The shellfish utilize the waste from the fish as their food source, and the seaweed grows with sunlight and utilizes the little nutrients it needs from the nutrient waste not captured by the shellfish (39). More specifically, fish feed is provided to the caged seabass, wherein a proportion is assimilated as biomass. Excess feed and particulate fish wastes are carried by currents to surrounding longlines where mussels filter-feed and incorporate the nutrients into their biomass (70). Simultaneously the dissolved nutrients are absorbed by seaweed growing on longlines thus removing them from the natural environment and adding to biomass production.

Approximately 70 percent of nutrient input into finfish aquaculture systems escapes into the surrounding environment as uneaten fish feed, particulate feces, and dissolved nutrients (12; 71). Filter feeder bivalves are essentially generalist consumers able to exploit organic matter from several sources as a function of its availability, and are thus extremely efficient at removing suspended particulate wastes from the water column (72). The use of stable isotopes in biogeochemistry analysis in an offshore fish cage-mussel aquaculture system was used to show that approximately 60 percent of the food source for the bivalves originated from the fish feed (73; 74). This varies seasonally with a higher contribution in autumn and lower contribution in summer.

It must be noted, that pseudofaeces from mussels continue to sink and can result in reduction of local sediments, thereby increasing oxygen consumption in organic-rich sediments, increasing ammonium effluxes, and decreasing denitrification rates (75). These ecosystem impacts, however, are an improvement over intensified finfish cultivation alone (40). In co-cultivation of fish and mussels, heavy feeding pulses and long-term seston concentrations are important for mussel growth, but the ambient concentration of nutrients and distance from the cages is of greater importance in controlling mussel growth, implying that fish wastes contribute most significantly during periods of low planktonic production (76; 77). Raising filter feeders near fish cage aquaculture systems can significantly reduce the amount of particulate wastes introduced into the natural environment, as well as increase overall system productivity and fish feed efficiency (78).

Seaweed in integrated aquaculture systems has been shown to be extremely effective at reducing the amount of nutrient loading into the natural environment (79). Approximately half of the waste from caged fish farms is in the form of dissolved nutrients (71), of which around 80 percent can be absorbed by nearby seaweed in open water systems (19; 39). Seaweed absorbs the majority of ammonium, nitrate, and phosphate while oxygenating the water column (80; 81). These nutrient-assimilating photoautotrophs can significantly reduce environmental impacts of aquaculture systems while producing another seafood product (82; 83). Integrating cultivation of seaweed, mussels, and fish into an offshore aquaculture system can greatly improve the sustainability and productivity of seafood farming on the West Coast.

The diagram presented in Figure 6 provides a summarized visual representation of the nutrient flow through trophic levels. About 30 percent of nitrogen, phosphorous, and carbon in feed is assimilated by the seabass. Around half of the existing waste is dispersed as particulate N and C, and half as dissolved nutrients (mainly ammonium, urea, and phosphate). Mussels absorb about 60 percent of particulate wastes, and seaweed absorbs about 80 percent of dissolved nutrient wastes. The result is a 4-10 times increase in biomass production and a significant reduction in nutrient loading.

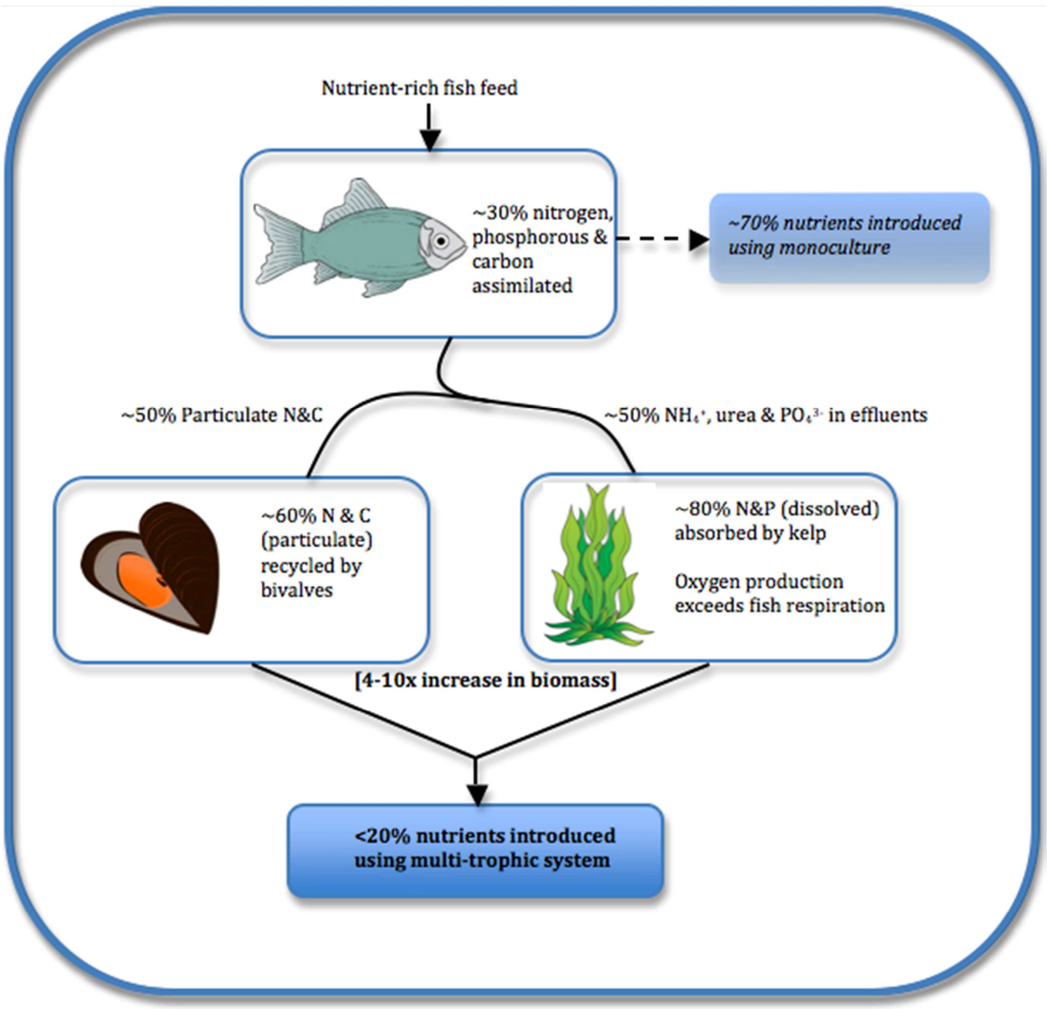


Figure 6: Nutrient Flow Diagram

The estimated total amount of nutrients introduced to the natural environment is about 20 percent of the initial input. The result is a system with three times less nutrient outflow than growing finfish alone, which significantly reduces the likelihood of cultural eutrophication and associated environmental concerns (69). The improvement on water quality from waste mitigation also increases the system's resilience to disease, which cuts down on the amount of antibiotics required. Fewer chemicals are therefore introduced into the natural environment as a result.

The distribution chain of E-Fishent Foods is another source of environmental benefits. By providing seafood products locally we reduce the reliance on seafood that is imported from foreign countries where less regulated fishing and aquaculture practices are common. Our system design will not only be more environmentally sustainable, but also eliminates food miles and emissions by reducing the need to import. Successfully reducing greenhouse gas emissions from transportation is "critical to meeting our national goals", according to a report from various federal agencies including the Environmental Defense Fund (84). Restricting our distribution to California and neighboring states further reduces the carbon footprint of our products.

Our initial site will span a 50 hectare area and produce approximately 1,300 tons of seafood annually, with the majority of product resulting from mussel and fish production. The annual reduction in waste to the natural environment is over 91 tons per year when compared to monoculture systems producing the same weigh in fish (approximately 600 tons). This waste reduction will significantly mitigate the effects of aquaculture on local ecosystem health and water quality. The location, system design, and distribution plan of E-Fishent Foods characterizes it as an environmentally friendly business that can help define the movement for a sustainable future for seafood.

7 FUTURE RESEARCH

The E-Fishent Foods team will need to pursue the following research and developments in order to successfully launch the business (items are listed in chronological order).

7.1 Apply for Permits from Necessary Agencies

The permitting process required to produce the E-Fishent Foods startup site is multi-tiered and lengthy. When the team decides to move forward with this business plan, beginning these applications should be of highest priority.

Authorization from the U.S. Army Core of Engineers (ACE) is required in order to begin extensive testing or construction at a particular site in federal waters. In order to complete the application process the team would have to procure an environmental impact report that proves the proposed aquaculture activities would have a negligible impact on the surrounding environment. While the ACE is the sole agency responsible for approving this application they will ask for consultation from the National Oceanic and Atmospheric Administration (NOAA).

In order to legally distribute food products to wholesalers, E-Fishent Foods will also be required to obtain permits from the United States Department of Agriculture (USDA) and FDA.

7.2 Solicit Investments

Investments from angel investors will provide the funds required to produce E-Fishent Foods'startup project. As Section 6 explains, there will be significant upfront costs associated with establishing the initial 50 ha site therefore the team will not be able to raise the necessary funds from friends and family alone. Although the rate of return on an investment is attractive, the time until return is too long to appeal to venture capitalists. For this reason we will pitch our business idea to angel investors who are interested in marine ecology, sustainable seafood, and the local food movement.

7.3 Refine Siting Analysis

As of February 2013 the E-Fishent Foods Team has identified three swaths of ocean in federal waters that fit the depth and distance from coast, oil rigs, shipping lanes, and MPAs parameters that are crucial to the success of the proposed operation. Each identified area is about 9 square miles in size. The next step in the process is to select the location for the initial 50 hectare operation somewhere within these eligible areas.

In order to select the best site possible the team would require additional siting analyses. In-situ measurements for current speed, substrate type, light attenuation, phytoplankton concentrations, and temperature profiles would need to be obtained at different locations within the eligible areas. This information would serve to create specific profiles that could be matched with the ideal conditions for the multitropic system and the species involved. The best-paired profile would be the first site developed by E-Fishent Foods.

The site selection may also be restricted or denied by the ACE. E-Fishent Foods would need to work with ACE to find a site that is suitable under their restrictions.

7.4 Develop E-Fishent Foods Trademark

E-Fishent Foods will have to devote a significant amount of time and energy into helping customers and seafood consumers distinguish between the sustainably produced seabass and mussels originating from the E-Fishent Foods operation and the "farmed fish" that currently has a bad reputation with health and eco-conscious individuals. A strong trademark will help to do this, and if the initial site is successful, a good trademark will aid in scaling up the business.

The aquaculture industry is quickly changing and there are many government agencies interested in promoting aquaculture. If our trademark is well developed and recognized as a leader in this innovation then E-Fishent Foods may also benefit from the work done by other players in the industry as they promote the benefits of aquaculture.

7.5 Test Specific Species Interactions In-Situ

The current expectations for growth rates of the white seabass, black mussels, and seaweed have been extracted from literature, in-depth interviews, and various case studies where these species have been grown independent of one another. The growth parameters and expected waste produced by the E-Fishent Foods operation may very slightly depending on the site conditions and specific interactions between the three species.

7.6 Develop More Sustainable Feeds for Fish

In order to truly achieve the sustainability standards that E-Fishent Foods promises in the team's value proposition there is a great need for the operation to use feed that is also sustainable by nature. The reason aquaculture provides one of the most attractive alternatives to potentially unsustainable fishing practices is because it is a net producer of protein. An average aquaculture operation has a feed conversion ratio of 1:2; essentially using one ton of wild, whole, fish (main input of purchased feed) to produce two tons of seafood (25).

The problem is that the majority of aquaculture operations feed their fish with expensive, protein rich feed in order to maximize the growth rate of the species and ensure that the fish obtain all the essential amino acids and nutrients they need. The primary ingredient in these feeds is fishmeal made from low trophic level species, like anchoveta or sardines (25). Currently, global fishmeal production is approximately 5 billion metric tons, which in turn requires the direct harvest of 16.5 million tons of fish per year (66). Harvesting such a large proportion of select fish populations is negatively impacting marine foodwebs. In at least one recent study, scientists insisted that the catch for many forage fisheries should be reduced by half in order to protect the natural fish populations and the predators that feed upon them (85).

Conservationists, fishermen, fishmeal producers, and aquaculturists have been asked to determine how to source fishmeal in a sustainable way. Developing a viable substitute, in conjunction with continued monitoring and catch-shares programs, has the greatest potential to satisfy all stakeholder needs but only a few agencies have begun to investigate the options for fishmeal substitutes. Until very recently, most proposed substitutes for fishmeal have focused on utilizing land based crops (e.g. soy) as replacements, however agriculture also has limits to expansion and carries a significant environmental burden (land conversion, nutrient run-off, GHG production, etc.)

In order to produce the most sustainable and inexpensive product possible, E-Fishent Foods will have to find a feed producer that uses less fishmeal per unit produced or the team will have to partner with a feed producer to collaboratively develop one.

8 CONCLUSION

In summary, there is a significant market opportunity for aquaculture in California. The market represents an ever-growing demand for high quality, consistently available, California-produced seafood. There are both environmental and economic incentives for multi-trophic design. The emphasis on transparent labeling and public education for seafood products is apparent. The concept of integrated aquaculture constitutes an essential element in Coastal Zone Management, aimed at reducing, in an economically and socially beneficial manner, the adverse environmental impacts of aquaculture on the coastal environment. California must begin taking the necessary steps to alleviate the growing pressure on marine resources and improve seafood farming methods. This is an ideal location for an integrative system due to its nutrient rich coastal waters, the high demand for sustainable seafood, and open niche within the market. E-Fishent Foods is well positioned to meet these criteria and bring a new, innovative business to California.

9 REFERENCES

1. **Watts, Jonathan.** *Fish farming is answer to increasing global meat demands.* s.l. : The Guardian, UK.

2. *Future seascapes, fishing, and fish farming.* **Goldburg, R and Naylor, R.** 1, 2005, Frontiers in Ecology and the Environment, Vol. 3, pp. 21-28.

3. *Use of fishery resources as feed inputs for aquaculture development: trends and policy implications.* **Tacon, A.J.C., Hasan, M.R., & Subasinghe, R.P.** 2006, FAO Fisheries Report, Vol. 1018.

4. *Risks for self-pollution in aquaculture: evaluation and consequences.* **Braaten, B., Poppe, T., Jacobsen, P., Maroni, K.** 1988, In: Grimaldi, E., Rosenthal, H. (Eds.), Efficiency in Aquaculture Production. Disease Control., Vol. 24, pp. 139– 166.

5. *Waste production from aquaculture.* **Bergheim, A., Asgard T.** s.l. : Blackwell, Oxford, 1996, In: Baird, D.J, Beveridge, M.C.M., Kelly, L.A., Muir, J.F. (Eds.), Aquaculture and Water Resource Management., pp. 50-80.

6. *Aquaculture Production and Biodiversity Conservation.* **Diana, J.** 1, 2009, BioScience, Vol. 59, pp. 27–38.

7. **CI.** *Blue Frontiers: Managing the Environmental Costs of Aquaculture.* The WorldFish Center. 2011. p. 24, Policy Brief.

8. **Schubel, J. and Monroe, C.** *Is Offshore Finfish Aquaculture in the Southern California Bight an Idea Whose Time Has Come?* Aquarium of the Pacific's Marine Conservation Research Institute. 2008. p. 128, MCRI Aquatic Forum Report.

9. **Wallace, R. and Fletcher, K.** *Understanding Fisheries Management: A Manual for Understanding the Federal Fisheries Management Process, Including Analysis of the 1996 Sustainable Fisheries Act.* s.l. : Mississippi-Auburn Sea Grant Consortium, 1996.

10. *Applicability of integrated coastal aquaculture systems.* **Troell, M., Kautsky, N. and Folke, C.** s.l. : Elsevier, 1999, Ocean Coastal Management, Vol. 42, pp. 63-69.

11. *The role of aquatic biotechnology in aquaculture.* **Hew, C.L., Fletcher, G.L.** 2001, Aquaculture, Vol. 197, pp. 191-204.

12. *Chemical fluxes and mass balance in a marine fish cage farm: II. Phosphorus.* **Holby, O., Hall, P.O.J.** 1991, Marine Ecology, Vol. 70, pp. 263-272.

13. *Chemical fluxes and mass balance in a marine fish cage farm. : IV. Nitrogen.* **Hall, P.O.J., Holby, O., Kollberg, S., Samuelsson, M.-O.** 1992, Marine Ecology, Vol. 89, pp. 81-91.

14. *Marine aquaculture off Sardinia Island (Italy): Ecosystem effects evaluated through a trophic mass-balance model.* **Lopez, B., Bunke, M. and Shirai, J.** 2007, Ecological Modelling, Vol. 212, pp. 292-303.

15. *Clean Technology in Aquaculture: A Production Without Waste Products?* **Bodvin, T., et al., et al.** 1996, Hydrobiologia, Vol. 326, pp. 83-86.

16. *Aquatic polyculture and balanced ecosystems management: new paradigms in seafood production.* **McVey, J. P., et al., et al.** [ed.] R. R. Stickney and J. P. McVey. Oxon : CABI Publishing, 2002. Responsible Marine Aquaculture. pp. 91-104.

17. *Aquaculture with its environment: prospects for sustainability.* **Folke, C., Kautsky, N.** 1992, Ocean Coastal Management, Vol. 17, pp. 5-24.

18. *Integrated coastal food production systems - A review of current literature.* **Brzeski, V. and Newkirk, G.** s.l. : Elsevier, 1997, Ocean Coastal Management, Vol. 34, pp. 66-71.

19. *Integrated mariculture: its role in future aquaculture development.* **Troell, M.** 2008. FAO Fisheries Proceedings. Vol. 3, pp. 323-325.

20. *Ecological engineering in aquaculture—Potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems.* **Troell, M., Joyce, A., Chopin, T., Neori, A., Buschmann, A. H., & Fang, J. G.** 1, 2009, Aquaculture, Vol. 297, pp. 1-9.

21. **Bennett, J.** *Owner Brophy Bros.* Santa Barbara, November 18, 2011.

22. **Culver, C. and Selkoe, K.** The Santa Barbara Channel: A Seafood Mecca. *Edible Santa Barbara.* [Magazine]. Santa Barbara, California, USA : s.n., 2009. pp. 17-19.

23. **Greenberg, Paul.** *Four Fish: The Future of the Last Wild Food.* s.l. : Penguin, 2010.

24. **Packaged Facts.** *U.S. Market for Fish and Seafood, with a Focus on Fresh.* 2009. p. 175, Market Report.

25. *Aquaculture in the United States.* **NOAA.** s.l. : NOAA, March 2012, National Oceanic and Atmospheric Administration.

26. **FAO.** *FAO Presentation.* 2011.

27. *Sustainable Aquaculture: Net Profits.* **Abend, Lisa.** s.l. : Time Magazine, February 26, 2011.

28. *Biomass Yield and Morphological Features of the Seaweed Saccharina latissima Cultivated at Two Different Sites in a Coastal Bay in the Atlantic Coast of SPain.* **Peteiro, C. and Freire, O.** 2012, Journal of Applied Phycology.

29. **Friedman, Bernard.** Santa Barbara, February 24, 2012.

30. **Walsh, B.** The End of the Line. *TIME Magazine.* [Online] July 7, 2011. http://www.time.com/time/health/article/0,8599,2081796,00.html. http://www.time.com/time/health/article/0,8599,2081796,00.html.

31. **Culver, Carrie.** *California Sea Grant Advisor.* [interv.] James Benson and Gretchen Grebe. Santa Barbara, February 29, 2012.

32. **Facts, Packaged.** *"What's For Dinner 2011:Trends in Center of Plate Proteins (Meat, Poultry, Fish and Seafood).* 2011.

33. **Anonymous.** *Interviewed by James Benson. .* Santa Barbara, February 20, 2012.

34. **Hanson, K.** *Interviewed by Jeremy Rude .* Anahiem, November 22, 2011.

35. **Hill, B.** *Interviewed by Kiya Gornik and Whitney Wilkinson.* Portland, November 17, 2011.

36. **Macnaughton, G.** *Interviewed by Kiya Gornik.* Santa Barbara, November 16, 2011.

37. **Danigo, Philippe.** *Sol-Azul Mariculturist.* [interv.] Gretchen Grebe. 2012.

38. **Anonymous.** *Kanaloa Seafoods.* [interv.] James Benson. 2012.

39. *Ecological engineering in aquaculture: use of seaweeds for removing nutrients from intensive mariculture.* **Troell, M., Ronnback, P., Halling, C., Kautsky, N., Buschmann, A.** 1999, Journal of Applied Phycology, Vol. 11, pp. 89-97.

40. **Troell, M.** *Integrated Mariculture.* Department of Fisheries and Aquaculture, FAO. Rome : FAO, 2008. pp. 323-325, FAO Fisheries Proceedings.

41. **Blank, S. and Dorf, B.** *The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company.* s.l. : K & S Ranch, 2012. p. 571. Vol. 1. ISBN: 098499930.

42. **Edelman, Sam.** *General Manager SB certified Farmers Market Association.* [interv.] Whitney Wilkinson. 2011.

43. **Schott, Karen.** *Operations Management of Venture Certified Farmers Market Association.* [interv.] Whitney Wilkinson. 2011.

44. **Thor.** *Outback Steakhouse.* [interv.] Renato Molina and Phillip Zanoni. 2012.

45. **Gelcich, Stefan.** *Fisheries Expert.* [interv.] Renato Molina. 2012.

46. **Osborne, P.** *Arch Rock Fish Manager.* [interv.] Molly Troup. 2011.

47. **Toseland, Rebecca.** *Marine Science Institute.* [interv.] Gretchen Grebe. 2012.

48. **Ashe, Frank and Bjorndal, Trond.** *The Economics of Salmon Aquaculture.* 2. s.l. : John Wiley & Sons, 2012. p. 248. ISBN: 1119993377.

49. **Nordahl, Gunnar.** *Is the Aquaculture Industry Caught In a Fishmeal Trap?* Norwegian School of Economics and Administration. Bergen : s.n., 2011. p. 109, Master Thesis in Economic Analysis.

50. **Comin, Giovanni.** *Owner Central Coast Seafood.* [interv.] Whitney Wilkinson. 2011.

51. **Kramer, Jeff.** *Ellwood Canyon Farms.* [interv.] Gretchen Grebe. 2011.

52. *Feeding aquaculture in an era of finite resources.* **Naylor, R., et al., et al.** [ed.] T. Malone. 36, 2009, Proceedings of the National Academy of Sciences of the United States of America, Vol. 106, pp. 15103-15110.

53. **Anonymous.** *Boathouse Manager.* [interv.] Renato Molina and Phillip Zanoni. 2012.

54. —. *Arch Rock.* [interv.] Gretchen Grebe. 2012.

55. —. *Holdrens/Pastavino.* [interv.] Renato Molina and Phillip Zanoni. 2012.

56. **Doug.** *Abalone Aquaculture.* [interv.] Phillip Zanoni. 2012.

57. **Reyes, Ilse.** *UABCS Marine Biology Department.* [interv.] Phillip Zanoni. 2012.

58. **Lopez, Juan.** *UABCS Professor of Algae.* [interv.] Phillip Zanoni. 2012.

59. **Mutz, Stephanie.** *Commercial Fisherman of SB (CFSB) Department of Fish and Game.* [interv.] Gretchen Grebe. 2012.

60. **Richards, John.** *Sea Grant Advisor.* [interv.] James Benson. 2012.

61. **Whitney, Roger.** *Bay Fresh Seafoods.* [interv.] James Benson. 2012.

62. **Vultaggio, Tony.** *SB Fishing Charters.* [interv.] James Benson. 2012.

63. **Gonzalez, Jonathan.** *CSF.* [interv.] James Benson. 2012.

64. *Economic efficiency and optimum stocking densities in fish polyculture: an application of data envelopment analysis (DEA) to chinese fish darms.* **Sharma, K., Leung, P. and Peterson, A.** 3, 1999, Aquaculture, Vol. 180, pp. 207-221.

65. **Ridler, N., et al., et al.** *Integrated Multi-Trophic Aquaculture.* Global Aquaculture Advocate. 2007. pp. 49-52.

66. **FAO.** *The State of World Fisheries and Aquaculture, 2010.* Fisheries and Aquaculture Department, Food and Agriculture Organization. Rome : FAO, 2010. p. 218, Biennal Report.

67. *A proposed model for "environmentally clean" land-based culture of fish, bivalves and seaweeds.* **Shpigel, M., Neori, A., Popper, D.M., Gordin, H.** 1993, Aquaculture, Vol. 117, pp. 115-128.

68. *Developing Porphyra/salmon integrated aquaculture for bioremediation and diversification of the aquaculture industry.* **Chopin, T., Yarish, C., Wilkes, R., Belyea, E., Lu, S., Mathieson, A.** 1999, Journal of Applied Phycology, Vol. 11, pp. 463– 472.

69. *Physical models of integrated waste recycling– marine polyculture systems.* **Ryther, J H, Goldman, J.C., Gifford, C.E., Huguenin, J.E., Wing, A.S., Clarner, J.P., Williams, L.D., Lapointe, B.E.** 1975, Aquaculture, Vol. 5, pp. 163–177.

70. *Ecosystem Influences of Natural and Cultivated Populations of Suspension-feeding Bivalve Molluscs: A Review.* **Newell, R.** 1, 2004, Journal of Shellfish Research, Vol. 23, pp. 51-61.

71. *Nitrogen and phosphorus budget in coastal and marine cage aquaculture and impacts of effluent loading on ecosystem: review and analysis towards model development.* **Islam, M.** 2005, Marine Pollution Bulletin, Vol. 50, pp. 48-61.

72. *Growth and production of mussels (Mytilus edulis L.) suspended at salmon cages and shellfish farms in two Scottish sea lochs.* **Stirling, H P, and Okumus, I.** 1995, Aquaculture, Vol. 134, pp. 193–210.

73. **Deudero, S., Tor, A., Alomar, C., Valencia, J., Sarriera, P., Blanco, A.** Integrated Multitrophic Aquaculture: Filter Feeders Bivalves as Efficient Reducers of Wastes Derived from Coastal Aquaculture Assessed with Stable Isotope

Analysis. [book auth.] Barbara Sladonja. *Aquaculture and the Environment- A Shared Destiny.* s.l. : InTech, 2011, pp. 103-124.

74. *The effect of fish farming organic waste on food availability for bivalve molluscs (Gaeta Gulf, central Tyrrhenian, MED): stable carbon isotopic analysis.* **Mazzola, A and Sara, G.** 2001, Aquaculture, Vol. 192, pp. 361-379.

75. *Impacts of longline mussel farming on oxygen and nitrogen dynamics and biological communities of coastal sediments.* **Christensen, P., Glud, R., Dalsgaard, T., Gillespie, P.** 2003, Aquaculture, Vol. 218, pp. 567-588.

76. *Modelling output and retention of suspended solids in an integrated salmon-mussel culture.* **Troell, M, Norberg, J.** 1998, Ecological Modeling, Vol. 110, pp. 65–77.

77. **Cheshuk, B.W.** *The potential of integrated open-water mussel (Mytilus planulatus) and Atlantic salmon (Salmo salar) culture in North West Bay, Tasmania.* s.l. : University of Tasmania, Launceston, 2001. p. 281, PhD thesis.

78. *The pacific oyster, Crassostrea gigas, as a biological filter for marine fish aquaculture pond.* **Shpigel, M, Blaylock, R.A.** 1991, Aquaculture, Vol. 92, pp. 187–197.

79. *Integrating seaweeds into marine aquaculture systems: a key towards sustainability.* **Chopin, T, Buschmann, A.H., Halling, C., Troell, M., Kautsky, N., Neori, A., Kraemer, G.P., Zertuche-Gonzalez, J.A., Yarish, C., Neefus, C.** 2001, Journal of Phycology, Vol. 37, pp. 975– 986.

80. *Seaweed biofilters as regulators of water quality in integrated fish seaweed culture units.* **Neori, A., Krom, M.D., Ellner, S.P., Boyd, C.E., Popper, D., Rabinovitch, R., Davison, P.J., Dvir, O., Zuber, D., Ucko, M., Angel, D., Gordin, H.** 1996, Aquaculture, Vol. 141, pp. 183– 199.

81. *Laminaria culture for reduction of dissolved inorganic nitrogen in salmon farm effluent.* **Subandar, A., Petrell, R.J., Harrison, P.J.** 1993, Journal of Applied Phycology, Vol. 5, pp. 455– 463.

82. *Integrated Aquaculture: Rationale, Evolution andState of the Art Emphasizing Seaweed Biofiltration in Modern Mariculture.* **Neori, A., Chopin, T., Troell, C.D., Buschmanne, A., Kraemerf, G., Hallingd, C., Shpigela, M., Yarishg, C.** 2004, Aquaculture, Vol. 231, pp. 361-391.

83. *Mathematical model of Laminaria production near a British Columbian salmon sea cage farm.* **Petrell, R.J., Tabrizi, K.M., Harrison, P.J., Druehl, L.D.** 1993, Journal of Applied Phycology, Vol. 15, pp. 1-14.

84. **EDF.** *Cutting Transportation Emissions is "Critical" to achieving goals of House-passed Climate Bill.* Environmental Defense Fund. 2009. p. 4.

85. **Pikitch, E., et al., et al.** The global contribution of forage fish to marine fisheries and ecosystems. *Book and Fisheries.* s.l. : Blackwell Publishing, 2012, 10th, p. 22.

86. **Belton, B., Skladany, M.** *An Ex Ante Assessment of Coastal and Marine Aquaculture Development: Charting Comparative Strengths and Weaknesses of Low Trophic Species For Offshore Aquaculture in Developed Countries.* s.l. : Institute for Agriculture and Trade Policy, 2008. p. 29, 25th Annual Technical Report. Vol. 2.

87. **Center for Epidemiology and Animal Health.** *Overview of Aquaculture in the United States.* 1995.

88. **USDA, Agricultural Research Service.** *ARS National Research Program for Aquaculture.* 2010.

89. **United States Census Bureau.** *2011 Statistical Abstract, Health & Nutrition: Food Consumption and Nutrition.* 2011.

90. **Coves, D., et al., et al.** Culture of seabass (Dicentrarchus labrax. [ed.] McVey. *CRC Mariculture.* Boca Raton : Taylor and Francis Group, 1991, pp. 289-303.

91. *Dans le fond, n'est-ce pas une question de comportement?* **Coves, D.** s.l. : Blackwell, 1993, Aquaculture Research, Vol. 50, pp. 20-23.

92. *A model for the optimal management of seabass (Dicentrarchus labrax) aquaculture.* **Rizzo, G. and Spagnolo, M.** 1996, Marine Resources Economics, Vol. 11, pp. 267-286.

93. **Bjorndal, T.** *The Economics of Salmon Aquaculture.* 2nd. s.l. : Wiley-Blackwell, 1990. p. 248.

94. **Thomas, J.** *Management of the White Seabass (Cynoscion Nobilis) in California Waters.* Department of Fish and Game, The Resources Agency, State of California. 1978. p. 34, Fish Bulletin 142.

95. **Qualye, D. and Newkirk, G.** *Farming bivalve mollusks: methods for study and development.* World Aquaculture Society. 1989. p. 279, Advances in world aquaculture 1.

96. *Mussel culture in Galicia (N.W. Spain).* **Pérez Camacho, A., González, R. and Fuentes, J.** s.l. : Elsevier, 1991, Aquaculture, Vol. 94, pp. 263-278.

97. **FishSite.** Production Methods for New Zealand Mussels. *The Fish Site.* [Online] August 2009. http://www.thefishsite.com/articles/749/production-methods-for-new-zealand-mussels.

98. **Lovatelli, A., Farías, A. and Uriarte, I.** *Estado actual del cultivo y manejo de moluscos bivalvos y su proyección futura: factores que afectan su sustentabilidad en América Latina.* Fisheries and Aquaculture, Food and Agriculture Organization. Rome : FAO, 2008. p. 329, Taller Técnico Regional de la FAO 20-24 de Agosto de 2007, Puerto Montt, Chile. FAO actas de PEsca y Acuicultura.

99. **QE Group.** The world's bests! Quality Equipment. *New Zealand Rope and Twine.* [Online] 2012. http://musselrope.co.nz/.

100. *Growth and Production of Mussels Mytilus edulis from Two Populations.* **Bayne, B. and C., Worrall.** s.l. : Wiley, 1980, Marine Ecology, Vol. 3, pp. 317-328.

101. **Shaw, W., Hassler, T. and Moran, D.** *Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)-- California sea mussel and bay mussel.* Fish and Wildlife Service, U.S. Army Corps of Engineers. 1988. p. 18.

102. **Bardach, J., Ryther, J. and McLarney, W.** *Aquaculture. The farming and husbandry of freshwater an marine organisms.* s.l. : John Miley & Sons, 1972. p. 884.

103. *Seaweed aquaculture.* **Mathieson, A.** 1, 1975, Marine Fisheries Review, Vol. 37, pp. 2-14.

104. *Cultivation technique for marine seaweeds allowing controlled and optimized conditions in the laboratory and ona pilotscale.* **Lignell, A. and Pedersen, M.** 5, 1987, Botanica Marina, Vol. 30, pp. 417-424.

105. *Some aspects of the growth and yield of Glacilaria tikvahiae in culture.* **Lapointe, B. and Ryther, J.** 3, 1978, Aquaculture, Vol. 15, pp. 185-193.

10 APPENDIX

10.1 Background information

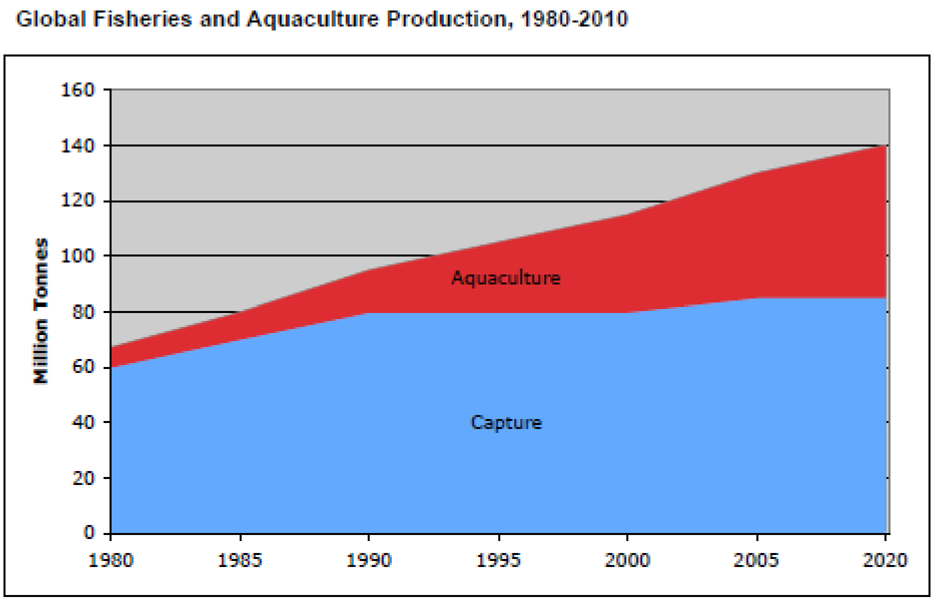


Figure 7: Global Fisheries and Aquaculture Production, 1980-2010.

Source: FAO Fishstat (66)

Table 5: US Aquaculture Production by State, Species, and Operation.
Source: Summary of the results provided by several authors (86; 87; 88).

State	Species	Type of Operation
CA	*Mussels, Striped Bass, California Yellow Tail, Pacific Halibut, Abalone*	Offshore (mussels) and experimental
HI	*Amberjack (Kahala) and Pacific Threadfin (Moi)*	Offshore
OR	*Oysters*	Offshore
ME	*Salmon*	Offshore
FL	*Pompano, Striped Bass, Cobia*	Offshore
NH	*Cod, Haddock, Atlantic Halibut, Summer Flounder, Sea Scallops*	Offshore and experimental (except mussels)
WA	*Sablefish, Oysters*	Offshore
ID	*Rainbow Trout*	Onshore
AL	*Many*	Hatchery
WI	*Yellow Perch*	Onshore
LA	*Catfish*	Onshore
AR	*Striped Bass, Catfish*	Onshore
AL	*Catfish*	Onshore
MS	*Catfish*	Onshore
WV	*Trout*	Onshore

Focus	Core Recommendation
1. Innovation	Continue to support innovation in the aquaculture sector, especially the development of productive technologies that make best use of land and water and feed resources and that minimize demands on environmental services.
2. Regulation	Ensure the regulatory environment keeps pace with sector development and support policy analysis and development that internalizes into aquaculture enterprises costs of environmental impacts
3. Monitoring and compliance	Develop capacity in national agencies for supporting the development of sector regulation and for monitoring and compliance.
4. Supply and demand analysis	Monitor carefully how supply and demand for fish is evolving to ensure that support and investment is appropriate to the market opportunity.

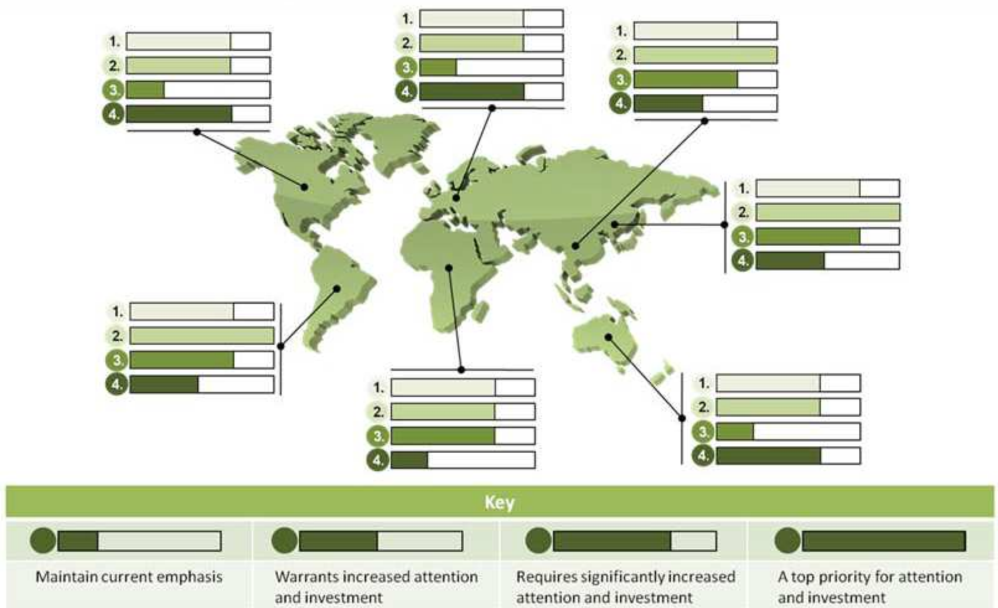


Figure 8: Diagram representing four principle FOCI for aquaculture development
Source: Blue frontiers: Managing the Environmental Cost of Aquaculture, (7).

Table 6: United States Census Bureau Per Capita Consumption of Fish and Shellfish 1980-2008. Source: U.S. Census Bureau, 2011 Statistical Abstract, Health & Nutrition: Food Consumption and Nutrition. (89)

Year	Average consumption
1980	5.64
1985	6.82
1990	6.77
1995	6.73
2000	6.91
2001	6.68
2002	7.09
2003	7.41
2004	7.50
2005	7.36
2006	7.50
2007	7.41
2008	7.27

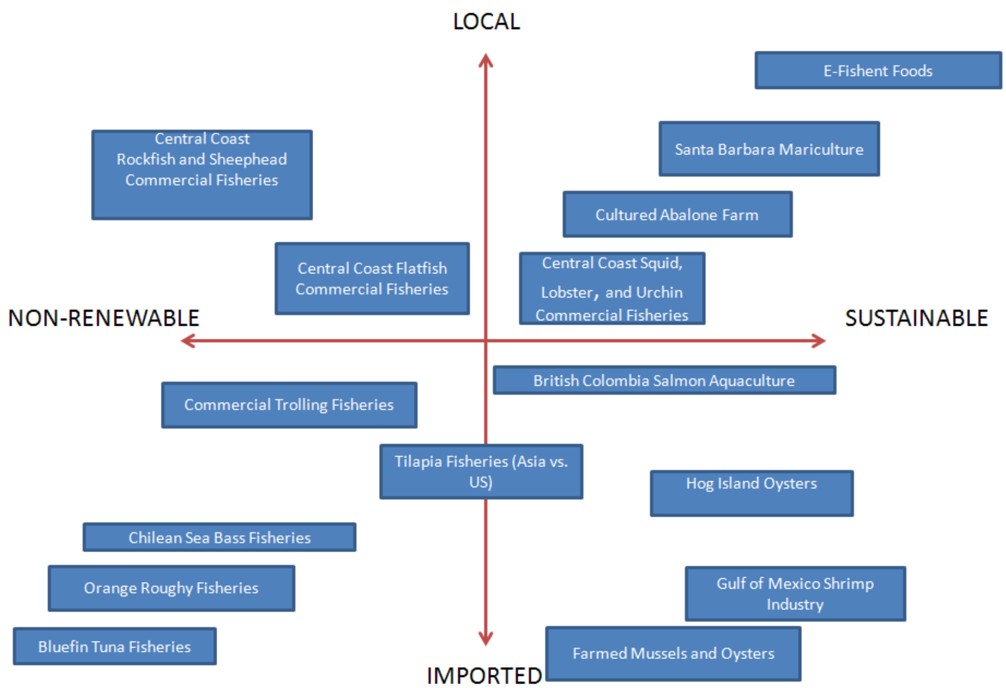


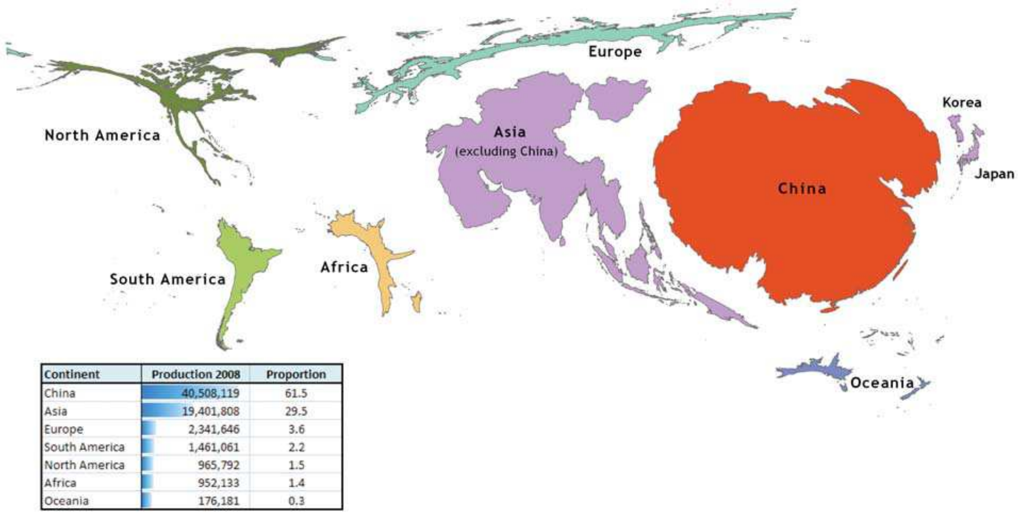
Figure 9: Conceptual Competitive Positioning Map

Table 7: Top Seafood Companies and Total Sales/Market Share
Source: Market Share for Fish and Seafood, with an Emphasis on Fresh, (24).

Top Center-Plate Seafood Companies
by SymphonyIRI-Tracked Sales and Category Share: 2009 vs. 2010
(in millions of dollars)

Company	$ Sales 2009	$ Sales 2010	% Chg	Market Share
Trans-Ocean Products, Inc.	$31.2	$33.3	6.7%	9.2%
Vita Food Prods, Inc.	31.4	32.5	3.7	9.0
Ocean Beauty Seafoods, Inc.	16.2	18.6	14.9	5.1
Louis Kemp Seafood Company	18.2	16.6	-8.8	4.6
Acme Smoked Fish	15.7	16.5	5.1	4.6
Phillips Foods, Inc.	19.8	15.7	-20.9	4.3
North Coast Seafoods, Inc.	7.2	9.4	29.8	2.6
Sonoma Seafoods	8.7	8.8	1.7	2.4
Los Angeles Smoking and Curing	7.5	8.1	7.3	2.2
Seafood America	8.9	7.8	-12.1	2.2
Ducktrap River Fish Farm	7.3	7.7	6.7	2.1
Chicken of The Sea International	5.6	6.4	13.9	1.8
Spence & Company Ltd.	4.3	4.9	14.0	1.4
Salmolux, Inc.	4.0	4.6	13.6	1.3
Canadian Fish Expenditures, Inc.	4.1	4.4	7.8	1.2
Pacific Seafood Group, Inc.	4.3	3.8	-10.9	1.1
Heron Point Seafoods	2.9	3.7	28.0	1.0
Other	105.8	99.0	-6.3	27.3
Private Label	55.4	60.4	9.0	16.7
Total	**$358.5**	**$362.3**	**1.1%**	**100.0%**

Note: Figures are based on SymphonyIRI sales tracking through U.S. supermarkets, drugstores, and mass merchandisers (including Target and Kmart, but excluding Walmart) with annual sales of $2 million or more. 2009-2010 figures are based on sales in SymphonyIRI's refrigerated seafood category during the 52-week period through September 5, 2010.
Source: Compiled by Packaged Facts based on data from SymphonyIRI Group. This material is used with permission.



Continent	Production 2008	Proportion
China	40,508,119	61.5
Asia	19,401,808	29.5
Europe	2,341,646	3.6
South America	1,461,061	2.2
North America	965,792	1.5
Africa	952,133	1.4
Oceania	176,181	0.3

Figure 10: World Aquaculture Production by Country.
Source: Blue frontiers: Managing the Environmental Cost of Aquaculture, (7).

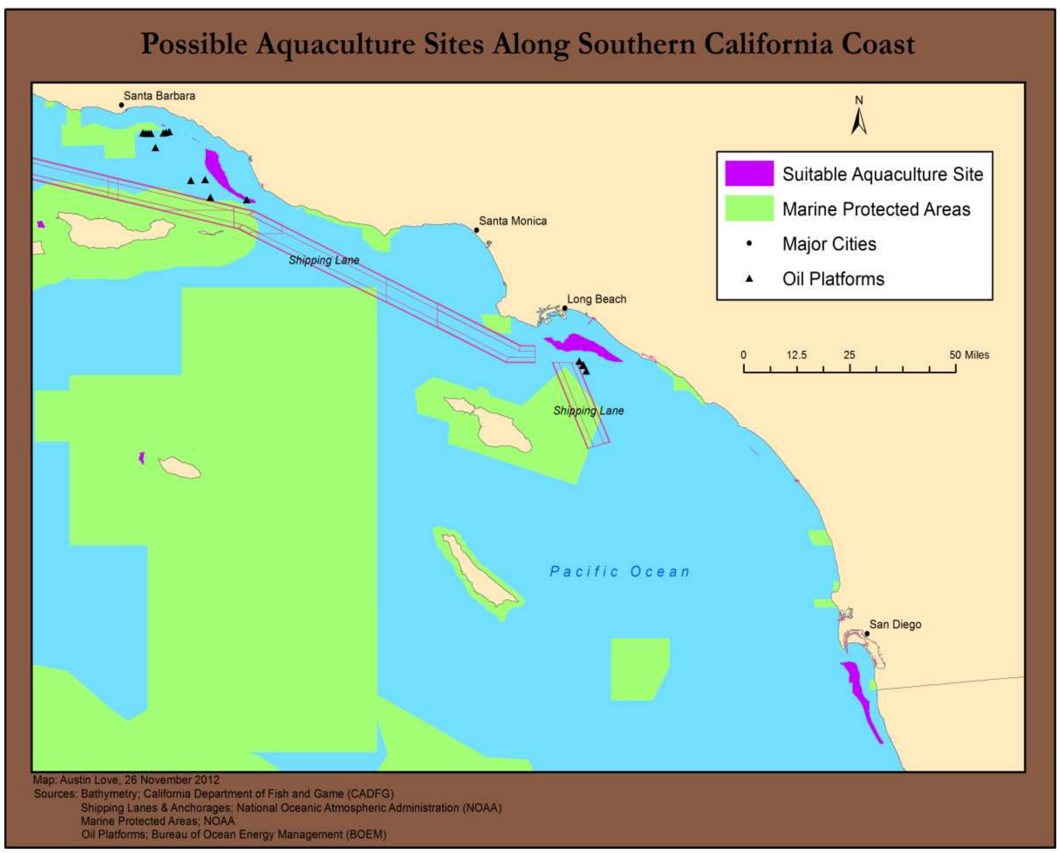


Figure 11: Suitable Aquaculture Sites along Southern California Coast.

10.2 Customer Research

Questionnaire Used to Interview Wholesalers (a)

Intro

Thank you for taking the time to speak with us today. We are master's students at the Bren School for Environmental Science and Management at the University of California, Santa Barbara. Our cohort is interested in learning more about the seafood industry and we believe that understanding the positioning of wholesalers is very important. We have some specific questions that we would like to ask you but please feel free to provide us with any other information that you think may be relevant.

Operations

How do you make decisions regarding which seafood products to purchase?

What steps does your product go through before it reaches you?

How do you find your supplier?

1. What requirements do you have of your suppliers?
2. What else would you like to see from your suppliers?

Do you process any of the fish or seafood that you purchase?

1. Do you contract out for processing?
2. If YES, how much does the processor charge?

Clients

How many clients do you routinely serve?

How would you describe these clients? (*Location, business type, purchasing patterns)*

How do you establish relationships with your clients?

Are there specific efforts you make to sustain your client relationships?

Products

How would you describe the products that you offer?

Do you know what percentage of your seafood is caught or produced within the state?

1. Within the U.S.?
2. From international locations?

Do you have any differentiated prices based on place of origin of the product?

What are your bestselling products?

Are you asked to sell specific species? *(If YES, which ones?)*

What is the most difficult aspect of keeping these species stocked?

Are there any species or products that you wouldn't want to serve year round?

Which species would you like to serve year round?

Which species would you be willing to acquire from farm raised aquaculture?

Traceability

Do you have any traceability programs with your products?

How does this compare with your competitors?

Wrap-Up

Can you refer us to any of the other wholesalers, processors, or distributors that you have worked with or currently work with?

Can we contact you again if we have additional questions?

Thank you for your time and valuable opinion. (This is how you can contact me…)

Questionnaire Used to Interview Restaurants (b)

Intro

Thank you for taking the time to speak with us today. We are master's students at the Bren School for Environmental Science and Management at the University of California, Santa Barbara. Our cohort is interested in learning more about the seafood industry and so we believe that understanding the positioning of restaurants is very important. We have some specific questions that we would like to ask you but please feel free to provide us with any other information that you think may be relevant.

Purchasing

Do you purchase and serve seafood products at your restaurant? If yes, what types?

What are the biggest factors influencing your decision to purchase a product?

What are your main sources of receiving your products? *Wholesalers (which type)? Processors? Seafood Markets? Or direct from fisherman?*

Why have you chosen this/these suppliers?

Do you ever have problems do you have obtaining your seafood products?

What are these problems?

Are there any types of seafood you would want to serve year round? *Can you name any specific species?*

Customers

Do customers influence your seafood purchasing decisions? How?

Do your customers ask for fish according to species type?

1a. If YES, which species do your customers demand more often?

1b. If NO, what trends do you notice regarding what customers ask for?

Do your customers ask specifically for farm-raised vs. wild-caught seafood?

Do your customers specifically demand sustainably produced and/or local seafood?

Product Origin

How easy is it for you to get information about where the seafood comes from?

How easy is it to get information about how the seafood was caught or raised?

Do you charge a premium for your products based on the origin or sustainability of the product? *(If so, how much?)*

In your opinion, what is a "local" product?

In your opinion, what is a sustainable product?

Wrap -Up

Can you recommend other restaurants that we might talk to?

Can we contact you again if we have additional questions?

Thank you for your time and valuable opinion. (This is how you can contact me…)

Table 8: Key findings from Industry Experts

Fisheries/Aquaculture Experts	Business Affiliation	Key Findings
Carrie Culver	*MSI, Sea Grant Advisor*	Aquaculture methods, permitting, local market, and industry structure
Kim Selkoe	*Santa Barbara Natural History Museum: Sustainable Seafood Project*	Sustainable seafood market and local competitors; demand for products
Beau Perry	*Executive Director of Olazul*	Installation of facility logistics
Stefan Gelcich	*Fisheries Expert*	Sustainability of fisheries
Phil Cruver	*Catalina Sea Farms*	Permitting/federal waters easier, and tierring of production
Steve Mendelson	*Installation Expert for Ocean Farm Technologies*	Installation costs
Ruben Flores	*Hatchery Expert*	Fish hatchery logistics/costs
Ernesto	*Aquaculture and Feed Expert*	Fish feed substitutes
Philippe Danigo	*Sol-Azul Mariculturist*	Dangers of monoculture
Geraldo	*Earth Ocean Farms Shrimp expert*	Construction of pods and maintenance
Felipe Hurtado	*Salmon aquaculture expert*	Challenges of reducing envt. impact
Jerry	*Crab Fisherman/Ventura*	Everything local shipped out
Ilse Reyes Medina	*UABCS Marine Biology Dept.*	Seaweed marketability
Juan Manuel Lopez Vivas	*UABCS Professor of Algae*	Seaweed research/industry
Omar Defeo	*Fisheries Expert*	Need for sustainable fish feed
David Chapman	*Mariculture Professor at UCSB*	Species interactions
Hendrickson, A.	*Director of Ty Warner Sea Center*	" "
John	*Local Fisherman*	Costs and site specifics
Alejandro Flores	*Noreste Sustentable*	Kelp prices and fish feed
Ronaldo Cavalli	*Aquaculture Dept. Head UFRPE*	Complex logistics for offshore finfish grow out period and cage construction
Randy Turner	*Founder of Santa Barbara Aquaponics*	Start-up logistics and demand for farm raised seafood
Justin Kanty	*Ty Warner Representative*	Sustainable seafood representative
Bernard Friedman	*Owner of Santa Barbara Mariculture*	Logistics of starting an aquaculture/regulations, and distribution process
Dale Kiefer	*USC at Wrigley*	Model to simulate interactions
Tony Vultaggio	*SB Fishing Charters*	Importance of local support
Scott Kennedy	*American Abalone*	Logistics of on-shore aquaculture maintenance
Jessie Beck	*Hog Island Oyster Co*	Aquaculture methods in the bay, demand, species preferences
Steve Gaines Lab	*Professor Bren/Researcher*	Potential considerations for sustainable aquaculture

Table 9: Key findings from Retailers/Wholesalers

Seafood Retailer/Wholesaler	Business Affiliation	Key Findings
Anonymous	*Kanaloa Seafoods*	Sustainable seafood market and industry potential
Watanabe, R.	*Quality and Control Manager for International Marine Products*	" "
Hanson, K.	*Sustainability Manager of Anderson Seafoods*	" "
Helene York	*Bon Appétit Management Company; Director of Sourcing*	Specify what type of wholesaler we are targeting
Alberto	*Santa Barbara Fish Market*	SB best spots for fresh fish
Johnathon Gonzalez	*CSF*	Community supported fisheries
Chris	*Santa Monica Seafood*	Sell 90% to restaurants
Al Ballabio	*Harbor Meat and Seafood*	Very little seafood caught locally
Marissa	*New Leaf Grocery Stores*	Consumer preferences
Elsie Tanadjaja	*Fishwise*	Startup costs and networking
Bill Alber	*Alber Seafoods*	Inconsistency in harvest makes it difficult
Roger Whitney	*Bay Fresh Seafoods*	Regulations hurting industry
Cisco	*Ocean Pride Wholesalers*	Sustainability not always important
Melissa	*Santa Barbara Shellfish Co*	Processing done somewhere else
Don Disraeli	*Kanaloa Seafood Founder*	Importance of quality
Guilda	*Sea Harvest*	Pricing structure
Marjorie Hoover	*Pacific Harvest Seafood*	US farmed fish too expensive
Sharon	*The Fish Lady Owner*	Cost estimates
Sam Edelman	*General Manager of SB certified farmers market associaton*	Demand for sustainable seafood
Doug	*Cultured Abalone*	Kelp feed for abalone
Karen Schott	*Operations Manager of Venture Certified Farmers Market Association*	Demand for sustainable seafood
Giovanni Comin	*Owner of Central Coast Seafood*	Distribution channels and sourcing
Jeff Kramer	*Ellwood Canyon Farms*	Distribution systems and seafood market

Table 10: Key findings from Restaurants

Restaurants	Business Affiliation	Key Findings
Hill, B.	*Chef at Bamboo Sushi*	Seafood sourcing
MacNaughton, G.	*Owner of Mac's Fish and Chips*	Sustainable sourcing in SB, and customer demand
Lopez-Hollis, C.	*Owner Dos Carlitos*	" "
Jaime Herrera	*Executive Chef UCSB Dining*	Seafood sourcing logistics
Thor	*Outback Steakhouse*	Demand for sustainable seafood
Anonymous	*Boathouse Mangager*	Historical relationships importance with wholesalers
Anonymous	*Blush manager*	Defining locality
Troy	*Pascucci Floor Manager*	Seafood sourcing
Blair	*Fish House*	Price and quality of importance
Anonymous	*Arch Rock*	Wholesaler relationships
Adrian	*Brew House*	Product origin
Robin	*Harbor Seafood*	Price and quality
Mark	*Hendry's Beach*	Owner supplies own fish
Anonymous	*Holdrens/Pastavino*	Wholesaler relationships
Victor	*Roadhouse Bar and Grill Manager*	Price and quality
David and Dustin	*Geisha Sushi Restaurant*	Sustainable sushi
Bud Kazali	*Chef at Ballards*	Importance of sustainability
Jun Isogai	*Restaurant Consultant*	Seafood preferences in the restaurant industry
Osborne, P.	*Arch Rock Fish Manager*	Seafood sustainability in restaurant business, customer support
Mausda, E.	*Anonymous Seafood Restaurant*	Demand trumps sustainability in high end market
Miguel	*Moby Dick*	Farm raised can be a turnoff
Bennet, J.	*Owner Brophy Bros*	Difficulties in sourcing sustainably, maintaining certification
"D"	*Manager Ca'Dario Restaurant*	Demand trumps sustainability in high end market

Table 11: Key findings from Marine Researchers

Marine Researchers	Business Affiliation	Key Findings
Stephanie Mutz	*Commercial Fisherman of SB (CFSB), Dept. of Fish and Game*	Permits and regulations, and local ecology
Craig Fosaro	*Eco-Mar*	Take advantage of naturally occurring bio fouling
Merit McCrea	*UCSB Researcher*	" "
Rebecca Toseland	*MSI/Steve Gaines Lab*	Aquaculture industry and potential problems
Sarah Teck	*MSI/Steve Gaines lab*	Marine ecological considerations and food webs
Stephanie Horii	*Bren Student*	Design and development

Table 12: Key findings from Policy Experts

Spatial Planning/Legal/Policy	Business Affiliation	Key Findings
Ben Halpern	*Center for Marine Assessment and Planning(CMAP)*	Permitting issues and case studies
John Richards	*Sea Grant Advisor*	Federal vs. state waters
Amanda Lindsay	*Envt. Justice Expert*	Incorporating envt. justice
Kristi Birney	*Envt. Defense Center*	Importance of sustainability
Naomi Schwartz	*CCC and SB Board of Supervisors (Retired)*	History of aquaculture locally
Kirsten Ramey	*Dept. of Fish and Game, Regional Aquaculture Coordinator*	CA good for aquaculture; no permitting setup
Dr. Bela Buck	*Marine Researcher and Spatial Planner*	IMTA production
Will McClintock	*MSI/Marine Map and Sea Sketch*	Spatial planning and stakeholders
Craig Shuman	*Coastal Policy Expert*	Lack of regulatory framework

10.3 Biological and Economical Model

After extensive research on the biological and economical aspects of a multitrophic aquaculture system, E-Fishent Foods has found several sources that indicate both associated biological and economical parameters for our target species namely white seabass, black mussels, and laminaria. Under these conditions we have modeled the dynamics of the production for each species in order to establish our startup site.

Fish

There is relevant research related with aquaculture experience of this species for Europe and Asia, where E-Fishent Foods found several documents that link biologic and technical factors for seabass aquaculture. These include the work by Coves *et al*. (90), Coves (91), the work published by Rizzo & Spagnolo (92) as well as the complete economic analysis on the cost structure for finfish aquaculture in the book "Economics for Salmon Aquaculture" by Bjorndal (93).

After this analysis, E-Fishent Foods has been able to determine several key factors to estimate both parameters and final results for the bioeconomic model of the fish production section of the business model. Through the key findings of this work E-Fishent Foods identified growth relationships, conversion factors, mortality rates under aquaculture conditions, and variable costs such as feeding, cages, equipment and harvest equipment. With this information it was possible to estimate the financial viability of the production using the most accurate estimation of values for both financial and other relevant variables that should be taken into account for this activity.

The biological model consists of three separate parts: length growth, weight and population dynamics (93). The growth relationship was reported by Thomas (94) in 1968 and is expressed by the following equation:

$$l_t = L_\infty \left(1 - e^{-K(t-t_0)}\right) \quad (1)$$

Where:

l: Individual length

L_∞ : Maximum expected length.

K : Constant proportional to the catabolic rate.

t: Actual age

t_0 : Hypothetical age at zero length

The weight relationship is described by the same author (94) and follows a typical von Bertalanffy's length-weight relationship:

$$W_t = aL_t^b \quad (2)$$

Where:

W : Individual weight.

a : Growth coefficient.

b : Allometric parameter of the species.

The population dynamics for aquaculture activities of seabass were reported by Rizzo & Spagnolo (92) with the following relationship:

$$m_t = \theta / t^{\gamma} \quad (3)$$

Where

m : Mortality at a given age.

θ: Mortality rate for the first month.

γ : Exponent rate for aquaculture conditions

The total population dynamics are modeled using the following expression (93):

$$N_t = N_{t-1}(1 - m_t) \quad (4)$$

$$B_t = N_t \bullet W_t \quad (5)$$

Where:

N : Total population.

B : Total biomass.

As the starting point for each cohort of fish, we will have a N_0 number of fingerlings entering the farming cycle depending on our desired production density and capacity. The seeding process is modeled using the following expression:

$$N_0 = \rho \bullet CV / W_0 \quad (6)$$

Where:

ρ : Farming density.

CV : Cage volume.

W_0 : Weight of fingerlings.

The total number of cages needed is provided by the final weight of the biomass at time of harvest T :

$$NC = B_T / \rho / CV \tag{7}$$

Where:

NC : Total number of cages required at time of harvest.

Following the estimation of the population dynamics we calculate feeding requirements by the equation proposed by Bjorndal (93):

$$FR_t = \left(\Delta W \bullet FCR\right) N_t \tag{8}$$

Where:

FR : Total feed requirements

FCR : Feed conversion rate

The economic model takes into account the inputs from the biological model in order to estimate the profit for each cycle of production. The costs of production directly[8] related with the production of fish will be estimated using feed and seed values as well as cage maintenance with fixed prices for these three inputs; such relationship is given by any of the following three expressions:

$$TFC_t = N_0 \bullet SC + N_t \bullet FR_t \bullet FEC + NC \bullet CM \tag{9}$$

$$TFC_t = N_t \bullet FR_t \bullet FEC + NC \bullet CM \tag{10}$$

$$TFC_t = N_T \bullet FR_T \bullet FEC + N_T \bullet HC + NC \bullet CM \tag{11}$$

---

[8] Since the production includes more than one species we have consider labor as an independent variable from an individual production as long as the labor input is high enough to maintain the production site.

Where:

TFC : Total cost of fish production

FEC : Cost of feed.

HC : Harvest cost.

CM : Cage maintenance cost.

Depending on the time of the cycle the fish cohort is at each month: (9) is applicable if the cycle is starting, (10) is used throughout the farming process after the fingerlings have been added to the process, and (11) when the cycle has been completed and the fish are harvested.

Finally, total revenue from fish is calculated using the expected yield at the end of the cycle using a constant price:

$$TFR = B_T \bullet FP \tag{12}$$

Where:

TFR : Total revenue from fish production per cycle

FP : Price of fish

Total profit from fish production can finally be calculated by the difference between total revenue and total costs:

$$\prod F = TFR - \sum_{t=1}^{T} TFC \tag{13}$$

Where:

$\prod F$: Total profit per cycle for fish production

A complete summary of all the parameters used for the fish production section can be found in Table 13.

Table 13: Parameters for the fish production section

ITEM	VALUE	UNITS
ρ	20	*kg/m*^{3}
Cage volume	3,000	*m*^{3}
Cycle length	17	*month*
Fingerling weight	18.2	*g*
Fingerling length	11.6	*cm*
Fingerling age	5	*month*
Weight slack	95	*%*
Seed price	0.50	*$/fish*
L_∞	1,465	*mm*
s K	0.128	*unitless*
t_0	-0.231	*time*
a	0.0107	*weight/length*
b	3.030	*unitless*
θ	0.07	*unitless*
γ	0.70	*unitless*
Feed Conversion Rate	1.6	*kg/kg*
Price of Feed	$ 1,000	*$/ton*
Harvest cost	$ 800	*$/ton*
Harvest price	$ 6,500	*$/ton*
Cage maintenance	$ 200	*$/cage/month*

Mussels

There are several articles that provide significant insights about the technical requirements for mussel aquaculture, specifically works such as the one provided by Quayle & Newkirk (95), the cultivation experience in Spain reported by Pérez Camacho *et al.* (96), New Zealand by FishSite (97), or the experience of Latin Amrica reported by Lovatelli *et al*. (98). In addition, E-Fishent Foods has collected information about the investment required to establish a production site including the costs of farming and processing units (99).

Subsequently, E-Fishent Foods determined several key factors to estimate both parameters and final results for the bioeconomic model of the mussel production section of our business proposition. Based on the key findings of this work, E-Fishent Foods identified growth relationships, conversion factors, mortality rates under aquaculture conditions, and variable costs such as long lines, harvest equipment and other relevant inputs of the process. With this information it was possible to estimate the financial viability of the production using the most accurate estimation of values for both financial and other relevant variables that should be taken into account for this activity.

The biological model consists of three separate parts: length growth, weight and population dynamics (100). The growth rate was reported by Shaw *et al.* (101) in 1988 and is expressed by the following equation:

$$l_t = L_\infty \left(1 - e^{-K(t-t_0)}\right) \quad (14)$$

Where:

l: Individual shell length

L_∞ : Maximum expected shell length.

K : Constant proportional to the catabolic rate.

t: Actual age

t_0 : Hypothetical age at zero length

The weight relationship was described by Bayne and Worrall for mussels (100) and follows a typical von Bertalanffy's length-weight relationship:

$$W_t = aL_t^{\,b} \quad (15)$$

Where:

W : Individual weight.

a : Growth coefficient.

b : Allometric parameter of the species.

The total population dynamics is modeled by the following expression modifying the previous approach for fish (93):

$$N_t = N_{t-1}(1 - m_t) \quad (16)$$

$$B_t = N_t \bullet W_t \quad (17)$$

Where:

N : Total population.

m : Mortality fraction over time.

B : Total biomass.

As the starting point for each cohort of mussels, we will have a N_0 number of seeds entering the farming cycle depending on our desired production density and capacity. The seeding process is modeled using the following expression:

$$N_0 = \rho \bullet LL / W_0 \quad (18)$$

Where:

ρ : Farming density.

LL : Line length.

W_0 : Weight of seeds.

The total number of lines needed depends on the final weight of the biomass at time of harvest T :

$$NLM = B_T / \rho / LL \quad (19)$$

Where:

NLM : Total number of mussel lines required at time of harvest.

The economic model takes into account the inputs from the biological model in order to estimate the profit for each cycle of production. The costs of production directly[9] related with the production of mussels is estimated using seed and maintenance values with fixed prices for both inputs; such relationship is given by any of the following three expressions:

$$TMC_t = N_0 \bullet SC + NLM \bullet LM \quad (20)$$

$$TMC_t = NLM \bullet LM \quad (21)$$

$$TMC_t = N_T \bullet HC + NLM \bullet LM \quad (22)$$

Where:

TMC : Total cost of mussel production.

[9] Since the production includes more than one species we have consider labor as an independent variable from an individual production as long as the labor input is high enough to maintain the production site.

HC : Harvest cost.

LM : Line maintenance cost.

Depending on the time of the cycle the mussels cohort is at each month: (20) is applicable if the cycle is starting, (21) is used throughout the farming process after the seeds have been added to the process, and (22) when the cycle has been completed and the mussels are harvested.

Finally, total revenue from mussels is calculated using the expected yield at the end of the cycle using a constant price:

$$TMR = B_T \bullet MP \tag{23}$$

Where:

TMR : Total revenue from mussel production per cycle

MP : Price of mussels

Total profit from mussel production can be finally calculated by the difference between total revenue and total costs:

$$\prod M = TMR - \sum_{t=1}^{T} TMC \tag{24}$$

Where:

$\prod M$: Total profit per cycle for mussel production

A complete summary of all the parameters used for the mussel production section can be found in Table 14.

Table 14: Parameters for the mussel production section

ITEM	VALUE	UNITS
ρ	6	*kg/m*
Line length	4,200	*M*
Cycle length	10	*month*
Seed weight	42.5	*g*
Seed length	2.9	*cm*
Seed age	36	*month*
Weight slack	60	*%*
Seed price	0.1	*$/mussel*
L_∞	9.38	*mm*
K	0.22	*unitless*
t_0	1.3	*month*
a	0.1270	*weight/length*
b	3.77	*unitless*
m	3	*%*
Harvest cost	$ 800	*$/ton*
Harvest price	$ 3,250	*$/ton*
Line maintenance	$ 50	*$/line/month*

<u>Seaweed</u>

E-Fishent Foods has been able to narrow down most of the financial parameters required for this seaweed cultivation by identifying both biological and economic data to use as input in the farm model.

After analyzing literature about most of the farming methods throughout the world (102; 103; 104), E-Fishent Foods has decided to use suspended long lines as the final method to farm seaweed (105). In order to identify related costs of production, E-Fishent Foods has incorporated a similar cost structure than the one used for mussel production, and therefore the same costs for most of the equipment required for farming. This information is referenced to Quality Equipment (99) for all suspended infrastructure. Finally with the compelled information about seaweed farming, E-Fishent Foods has implemented a biological and an economical model to evaluate the startup site of the production site.

The biological model now consists of a regular surplus model that takes into account only growth in weight (105). The growth function takes into account a fixed carrying capacity given by the lines available and a fixed growth rate until the seaweed is harvested at time T:

$$B_t = B_{t-1} + r\left(1 - {B_{t-1}}/{K}\right) \tag{25}$$

Where:

B : Total biomass.

r : Growth rate of the species.

K : Carrying capacity of the system.

Since, the carrying capacity of the system is given by the number of lines destined for seaweed, we estimate the total carrying capacity with the following expression:

$$K = \rho \bullet LL \bullet NLS \tag{26}$$

Where:

ρ : Farming density.

LL : Line length.

NLS : Number of lines destined for seaweed.

The economic model takes into account the inputs from the biological model in order to estimate the profit for each cycle of production. The costs of production directly[10] related with the production of seaweed are estimated using seed and maintenance values with fixed prices for both inputs; such relationship is given by any of the following three expressions:

$$TSC_t = B_0 \bullet SC + NLS \bullet LM \tag{27}$$

$$TSC_t = NLS \bullet LM \tag{28}$$

$$TSC_t = N_T \bullet HC + NLS \bullet LM \tag{29}$$

Where:

TSC : Total cost of seaweed production.

[10] Since the production includes more than one species we have consider labor as an independent variable from an individual production as long as the labor input is high enough to maintain the production site.

HC : Harvest cost.

LM : Line maintenance cost.

Depending on the time of the cycle the seaweed cohort is at each month: (27) is applicable if the cycle is starting, (28) is used throughout the farming process after the seeds have been added to the process, and (29) when the cycle has been completed and the seaweed is harvested.

Finally, total revenue from seaweed is calculated using the expected yield at the end of the cycle using a constant price:

$$TSR = B_T \bullet SP \tag{30}$$

Where:

TMR : Total revenue from mussel production per cycle

MP : Price of seaweed.

Total profit from mussel production can finally be calculated by the difference between total revenue and total costs:

$$\prod S = TSR - \sum_{t=1}^{T} TSC \tag{31}$$

Where:

$\prod S$: Total profit per cycle for seaweed production

A complete summary of all the parameters used for the seaweed production section can be found in Table 15.

Table 15: Parameters for the mussel production section

ITEM	VALUE	UNITS
ρ	7	*kg/m*
Line length	4,200	*m*
Cycle length	12	*month*
Seed weight	50	*G*
Weight slack	50	*%*
Seed price	0.1	*$/seed*
r	0.3	*ton/year*
Harvest cost	$ 100	*$/ton*
Harvest price	$ 200	*$/ton*
Line maintenance	$ 50	*$/line/month*

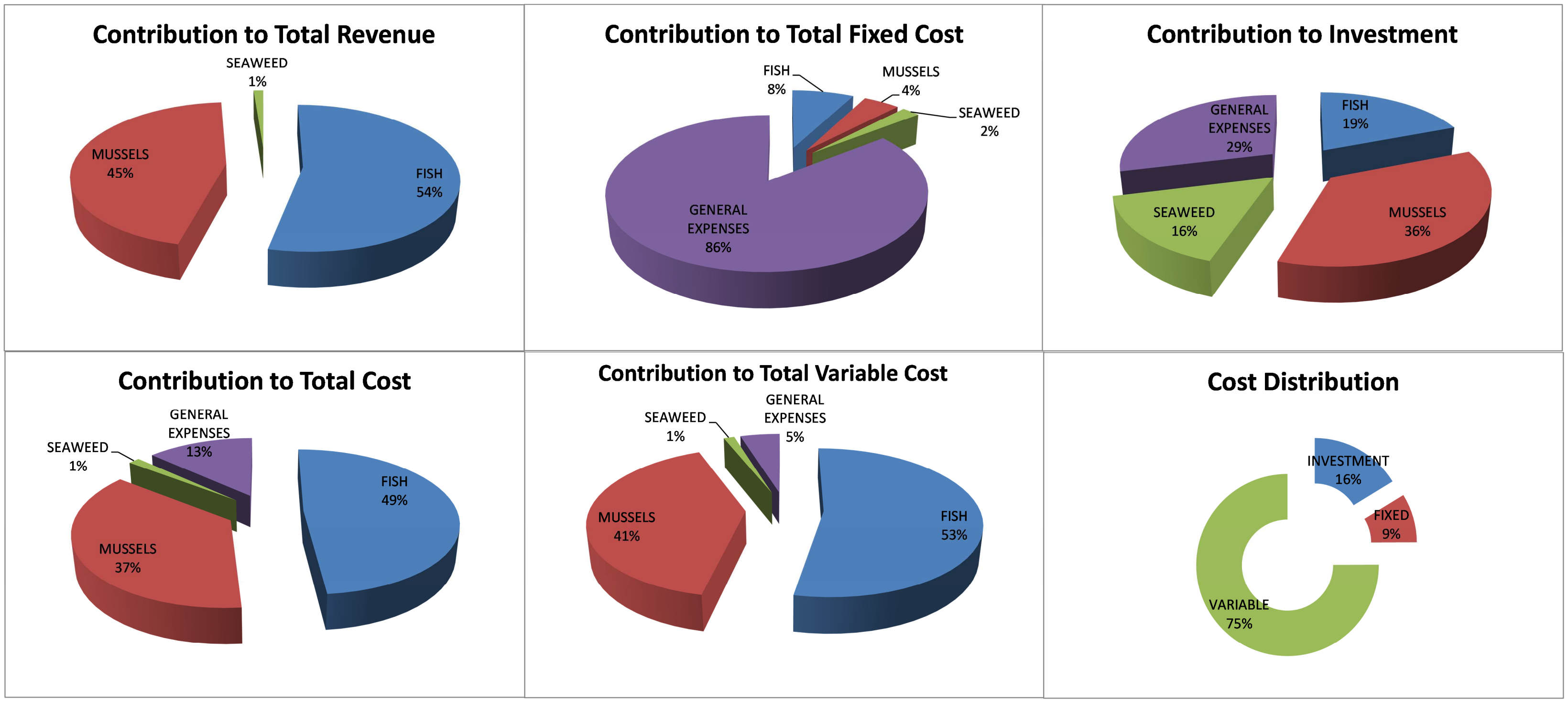


Figure 12: Revenue and Cost distribution of the startup site