Fish feed target markets

Abstract
Bythos has produced a report on the identification of relevant target markets in the Fish feed sector

ABTG

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AquaBioTech Group

Market analysis
BYTHOS

Target market identification and adoptions for Fish feed

Malta

28-Sept-20

Interreg Italia-Malta Bythos

Context

Bythos - Interreg V-A Italia-Malta 2014-2020 cooperation project

Bythos is an Interreg V-A Italia-Malta 2014-2020 cooperation project which aims to use fish waste to increase investment in biotechnologies for human health and blue growth.

Project Number: BYT 01

Project File Code: \\FILESRV\Projects$\EU Projects\Interreg-BYTHOS\Implementation\Technical\Business Space\Deliverables\Reports\ABTG~Fish feed insertion~09-Sep-20.docx

Foreword

BYTHOS project's objective through this assignment is to investigate potential target market for the development of fish feed processed from an extremely valuable source: fish waste. The present report will help to develop Business models with the aim to use fish waste to increase investment in feed production. This market assessment reviews the commercial aspects of fish waste transformed into fish oil and fishmeal to obtain zero-waste.

AquaBioTech Group has evaluated the market feasibility of producing fishmeal and fish oil from fish waste.

AquaBioTech Group has been appointed to prepare a concise market and intelligence report that describes the current market worldwide and to specify target markets for Malta and Sicily. The report will also indicate opportunities, threats and bottlenecks while taking into consideration the regional and international environment.

With this assessment we aim to answer the pertinent questions and evaluate the investment of a market driven fish waste project.

The assessment is intended to support the investment team in making an informed investment, and to serve as a supporting document for business financing.

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Introduction

As the world population is expected to reach 9 billion by 2050, competition for limited natural resources to meet the demand of food supply naturally expand with an estimation of 70% increase by 2050. Sectors such as agriculture, forestry, fisheries, and aquaculture will also be directly affected by the impact of climate change, while their global greenhouse gases emissions are still increasing. Therefore, an optimal use of renewable biological resources is necessary to ensure a safe and secure food supply (European Commision, 2020b). FAO reports estimate around one third of all food produced for human consumption is lost or wasted (Gustavsson et al., 2011).

Fish waste is defined by "many fish species or by-catch products which have no or low commercial value, undersized or damaged commercial species as well as species of commercial value but not caught in sufficient amount to warrant sale" (Caruso G, 2015).

In fact, fish waste accounts for a loss of US$ 50billion per year. From fisheries and aquaculture, it is estimated to reach 130 million tonnes of fish waste through by-catch, on-board processing, transport, storage, retailers, and consumers. Around 17.9 to 39.5 million of tonnes of whole fish are estimated to be discarded by commercial fishing operations and up to 66% of a fish can be thrown away after preserving the fillets (Ghosh et al., 2016). In Europe, fish and seafood waste are estimated in the different stages of the supply chain stage with 9.4% coming from production, 0.5% from handling and storage, 6% from processing, 9% from distribution and retail and 11% from consumers (European Union, 2018a). In the Mediterranean Sea, considerable amounts of trammel net discards were reported representing a total of 137 species. In Greece and Portugal, discard range was estimated from 15 to 49% respectively (Gonçalves et al., 2007). Not only those losses are causing significant environmental impact, but also a potential value (Caruso G, 2015). It proves the clear need of cross-

departmental and cross-sectoral collaborations to establish initiatives and policies for an effective waste management at all stages (European Union, 2018a).

While it only represents 1% of the global biotechnology market, marine biotechnology market is expected to reach approximately $6.4billion by 2025 (Smithers, 2020). To reach this goal, the collaboration between industry, science, public and policy makers is necessary, among the use of high-throughput techniques. In 2014, marine biotechnology SMEs (micro) amount to 140 (Ecorys, 2014). Also, financial stability for research need to improve (Rotter et al., 2020).

By-products are defined as “all the raw material, edible or inedible, left over following the main product” (Stevens et al., 2018). There exists two type of by-products, the first one is easily degradable with high enzyme content mostly coming from viscera and blood. The second one is more stable, coming mainly from bones, head and skin (Khawli et al., 2019). Fish by-products are a potential source of protein and lipid necessary in fish feed for farmed fish, through fishmeal and fish oil. The production of fishmeal and fish oil used 15 million tons of fish caught in 2012 (Caruso G, 2015). Therefore, fish by-products are a valuable source for a more sustainable production of fish feed. There is also a growing market for their use in animal feed and pet food.

Moreover, a great number of bioactive compounds with an important value on the market can be obtained from fish by-products. Due to their beneficial health effects, the three most valuable compounds extracted are thatthelong-chainomega-3fattyacids (LC-PUFAs), eicosapentaenoicacid (EPA) and docosahexaenoic acid (DHA). Furthermore, collagen, chitin enzymes, gelatin, glycosaminoglycans, polyunsaturated fatty acids (PUFA), minerals, protein, peptides, and vitamins can be obtained. All those marine by-product derived compounds can be exploited in valuable markets such as pharmaceutical, nutraceutical, cosmetical and food industries (Figure 1) (Khawli et al., 2019).

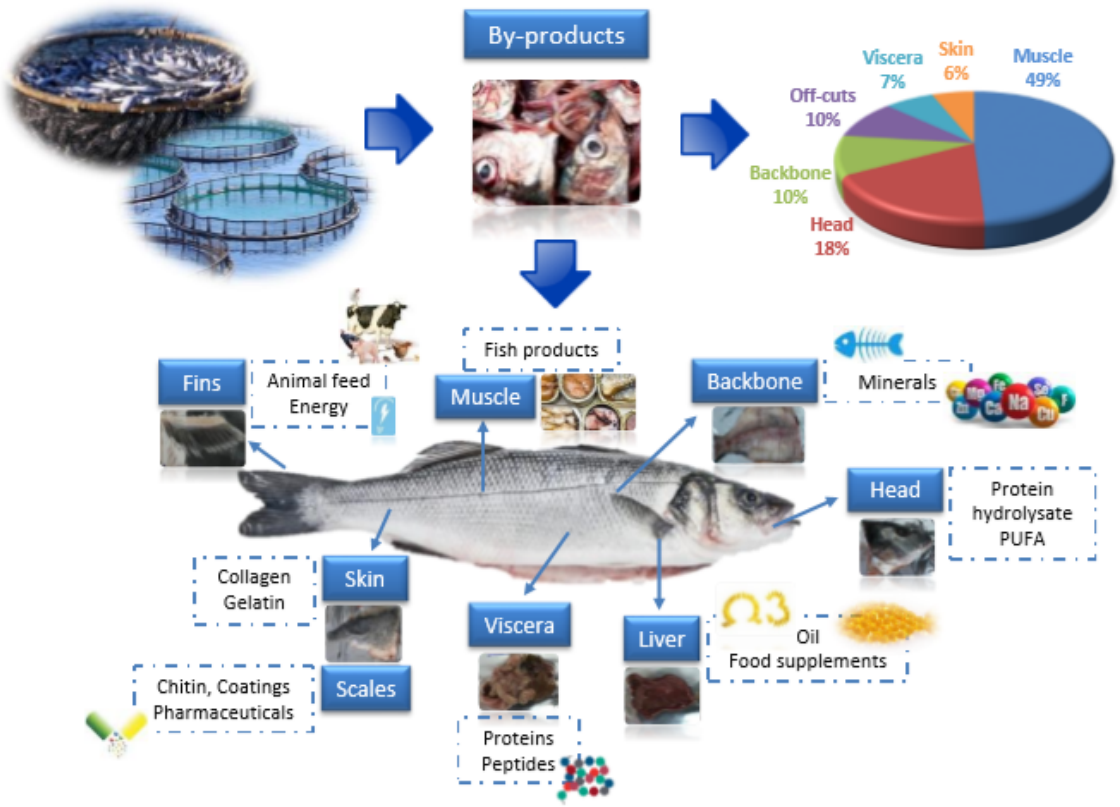


Figure 1: Fish processing by-product generation and end use opportunities (Al Khawli et al., 2019)

1. Blue biotechnology and Bioeconomy strategies

Europe

Bioeconomy correspond to Europe's response to key environmental challenges the world is facing. It is a new economic paradigm powered by biotechnological innovations to ensure resource-efficient processes and circular economy business models. Therefore, it helps on decreasing waste and increasing resources' life length. It covers all sectors and systems that rely on biological resources, as well as their functions and principles (Vieira et al., 2020).

Bioeconomy connects science, industry, and society together to meet socioeconomic, geopolitical, and environmental issues demands (Vieira et al., 2020). The EU Bioeconomy strategy aims to ensure food security, manage natural resources sustainably, reduce dependence on non-renewables resources, mitigate and adapt to climate change, create jobs, and maintain European competitiveness. To deliver a sustainable circular bioeconomy, the EU plans to strengthen and scale-up the bio-based sectors, unlock investments and market, then deploy local bioeconomies rapidly across Europe and understand the ecological boundaries of the bioeconomy. To achieve those goals, the Commission will for example launch 100 million Circular Bioeconomy Thematic Investment Platform, as well as develop standards and emerging market-based incentives, and improve labels (see the full strategy in European Commision, 2018).

The blue bioeconomy has flourished globally in the recent years with increasing potential, becoming a fast-growing field. It contributes to the economic growth while ensuring a responsible and sustainable use of marine ecosystems. Marine resources constitute an important source of protein worldwide, however they are not optimally used in the EU : there is potential for lower trophic levels and the various waste products (European Commision, 2018).

Error! Reference source not found. demonstrates the different industries where blue bioeconomy is applied.

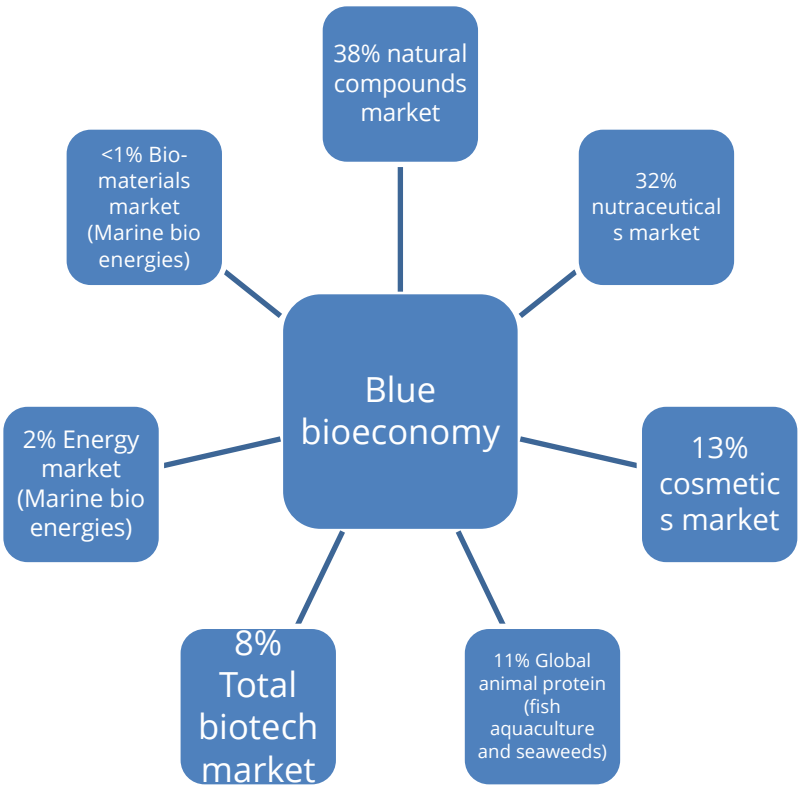
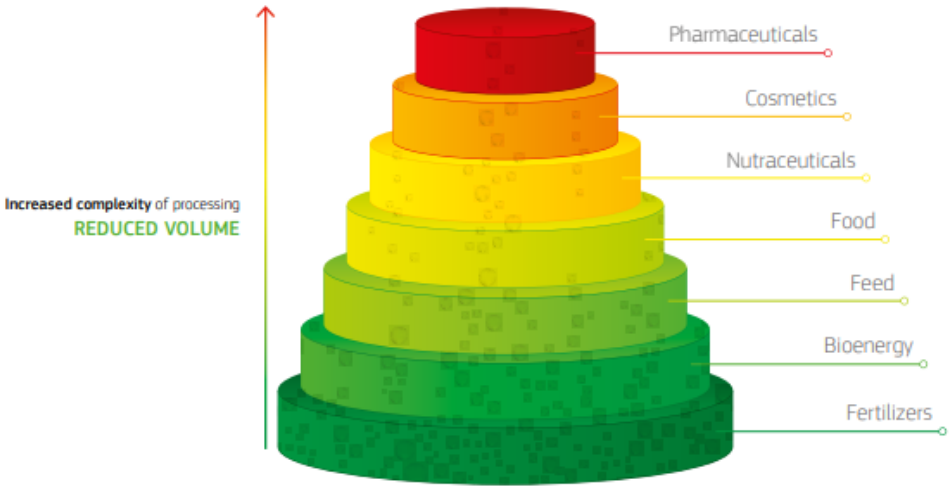


Figure 2: Blue bioeconomy insertion, based on Bio Marine Organisation estimations

Blue biotechnology consists of the exploration and exploitation of marine organisms to develop new products (European Commision, 2020a). As the underwater world remains quite unexplored and unstudied, the capacity of marine organisms to provide inputs in the blue economy is only just beginning to be appreciated (European Commision, 2012). In Europe, the Blue Biotechnology sector has been estimated by the market research agency Global Industry Analysts in 2012 to reach € 3.5billion by the year 2018 which contributes to around 5% of the total Biotechnology industry. Due to the lack of official definition on Blue Biotechnology sector, quantifying the extent of the sector is challenging. In fact, Marine Biotechnology applies in several biotechnology industry sectors such as: energy (marine algal biofuels), pharmaceuticals, cosmetics, aquaculture, food and nutrition, environmental protection and depollution (Ecorys, 2014). Each sector has a value on the market, varying from moderate to very high. The focus has been so far mainly on the high-volume

part (moderate and medium market value), however there is an increasing focus towards the high-value part (European Union, 2019). According to the type of market chosen, the time to access the market, the cost of development, the resource availability and the skills and competencies necessary will differ (Figure 3).



Products	Time to market (Years)	Cost of development	Resource availability	Need for documentation	Potential market value	Skills and competencies
Pharmaceuticals	10 – 15+	Very high	Limited	Very high	Very high	Extensive medical and market
Cosmetics	3 – 5 +	Low to high	Fair	Medium	High	Toxicology, effects
Nutraceuticals	3 – 5 +	Medium to high	Fair	Medium to high	High	Nutrition and medicine
Food	2 – 5 +	Low to medium	Good	Medium	Medium to high	Nutrition, food science
Feed	2 – 5 +	Low to medium	Very good	Medium	Medium to high	Nutrition, animal science
Bioenergy	2 – 5 +	Low to medium	Very good	Low to medium	Moderate	Energy
Fertilizers	1 – 2	Low	Very good	Low to medium	Moderate	Agriculture, agronomy etc

Figure 3: Blue biotechnologies markets (European Union, 2019).

In the future, the feed sector will experience the largest growth. Also, even if they are more demanding, there is good potential for the high value markets. In terms of volume, oil, meal and concentrate products are expected to remain stable (European Union, 2019).

Italy

The Italian bioeconomy is estimated to currently making € 330 billion per year of turnover and 2 million jobs. With the purpose to increase by 15% by 2030, an Italian bioeconomy Strategy (BIT) was defined. The main three pillars of the Italian bioeconomy are blue economy, agri-food, and bio-based industry. The new BIT proposes a strategic positioning of the Italian regions, regarding the three main pillars. Six regions were selected for developing the blue economy: Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Veneto, Puglia, and Tuscany **(Figure 4)**. According to that map, Sicily does not appear to be a key region for the bioeconomy development of the country. With over 8 000 km of coastline and important sea-based resources, the Italian blue economy has been estimated at about € 45 billion per year and 835 000 employees. The blue economy in Italy is represented by different sectors such as fishery and aquaculture, exploitation of marine algae, microbes, enzymes, by-products, biowaste, biomonitoring and bioremediation. The country is ranked as the second biggest European fish producer and fourth in aquaculture production, however still 75% of the national consumption is covered by imports (Presidency of Council of Ministers, 2017).

Figure 4: Strategic positioning of the Regions according to the three main pillars of bioeconomy (Presidency of Council of Ministers, 2017)

The Marine Bioeconomy Strategy aims to develop stronger aquaculture supply chains while improving environmentally safe practices, intensify CO_2 fixation by marine habitats, connect tourism to ecosystem valorisation with new business models, preserved and valorise landscape and cultural heritage, and exploit marine bioenergy production potential (Presidency of Council of Ministers, 2017).

While Italy has recently developed a Marine Bioeconomy Strategy, it does not have a dedicated Marine Biotechnology strategy yet. However, a national

programme which promote marine research including biotechnologies named RITMARE exists, as well as several research funding schemes and programmes (Marine Biotechnology & ERA-NET, 2019). Italy has highlighted three marine biotechnology research priorities which are:

- Human, animal and environment health
- Industrial Biotechnologies
- Bioprospecting

A list of infrastructures able to support new initiatives is also available (Marine Biotechnology & ERA-NET, 2019).

Malta

Malta does not have a specific bioeconomy strategy, however, as an EU member state, it is part of the Union's blue economy initiative. Being an island, the sea can produce investment, jobs, and economic growth. In fact, in 2016, the blue economy sectors employed 10 400 persons and generated € 406million which contributed 4.7% to the Maltese economy while most of the countries presents an average of 1.3% (European Union, 2018b). Malta, together with 16 other countries has responded to the Cofund Call ERA-NET on the Blue Bioeconomy which aims to establish a coordinated R&D funding scheme that will strengthen Europe's position in the blue bioeconomy with a budget of € 30 million (The Malta Council for Science & Technology, 2020).

The new emerging activities are biotechnology and biofuels. Malta does not have a specific Marine Biotechnology strategy or policy. However, there is a strategy for Research and Innovation: Building and Sustaining the R&I Enabling Framework Malta Council for Science and Technology (MCST) (European Union, 2018a).

2. Fish feed

General info on fish feed

Along several other ingredients such as oats or wheat, fishmeal and fish oil are two important ingredients found in fish feed. It is possible to make fishmeal from almost any type of seafood, however it is currently mainly made from wild-caught small marine fish unsuitable for human consumption due to a high percentage of bones and oil. It is estimated that 71% of biomass from fish feed production comes from capture fish, 19.1% from by-products from wild capture and 9.9% from aquaculture (European Union, 2018a). Despite the use for aquaculture, fishmeal and oil provide nutrient rich feed ingredients for pig, poultry and also in the growing pet food market (IFFO - The marine ingredients Organisation, 2020).

Different sectors for fishmeal

Marine residues are mainly used to produce three different applications which are feeds, direct and indirect human consumption, and energy/biogas. When it comes to the production of fishmeal and fish oil from biobased residues in Europe, Norway is the most representative example. While the production of fur feed might not be relevant in every country, we can still get a clear idea on the potential feed markets for our targeted product. In fact, more than half goes to fish feed, a small quarter to livestock feed and around 15% for pet food (European Union, 2018a). The remaining 11% corresponding to fur feed, can be spread into the different sectors or might correspond to a specialize market according to the targeted country's need **(Figure 5).**

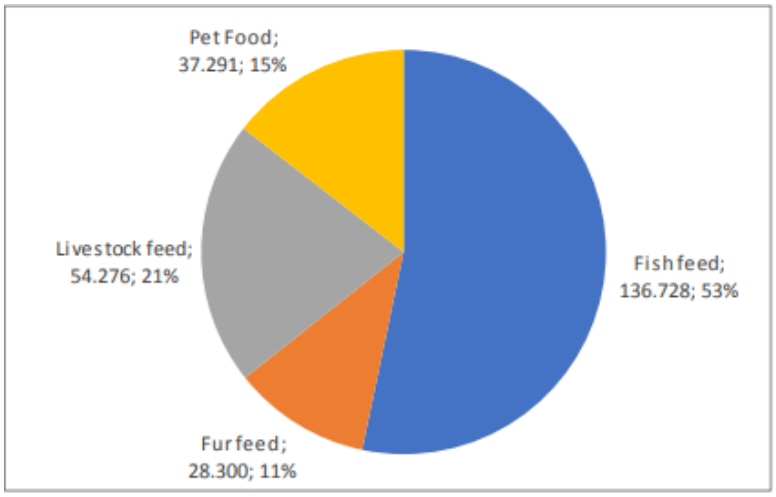


Figure 5: Norway's feed market distribution in 2016 (European Union, 2018a)

Market trends (Worldwide)

Converting fish waste into fishmeal products already exists in around ten major countries which are Canada, Chile, Denmark, Iceland, Japan, Mexico, Norway, Russian Federation, Thailand, and USA. However, only 25% of their fish waste are currently converted into fishmeal products. Japan already use fish waste to produce 90% of fish meals ingredients, with reprocessing costs being offset due to fishmeal's value (Ghosh et al., 2016).

The World Bank projects a growth of 4.2% for fisheries capture and 77% for aquaculture by 2030 compared to 2008. Therefore, while the captures are not expected to meet the need, there is a growing demand for fishmeal and fish oil in accordance with the growth of the aquaculture sector (European Union, 2018a). As it becomes limited resources, prices are expected to grow of 20% and 16% respectively (FAO, 2018). Despite the aquaculture sector, there is demand for the livestock food production and pet food industry (European Union, 2018a). In 2017, aquaculture feed consumed 70% of the global fishmeal, 22% was used in pig feed and 5% in poultry feed. The remaining 3% was used by other sectors.

In 2030, fish meal production from fish by-products will represent 34% of the world production, a 4% increase comparing to 2016 **(Figure 6)** (FAO, 2018).

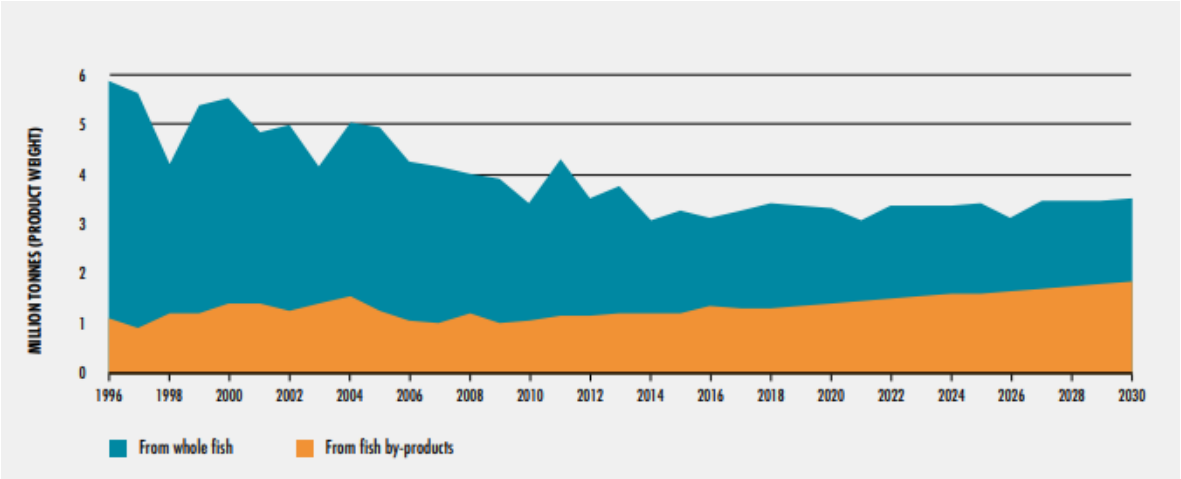


Figure 6: World fish meal production between 1996 and 2030 (FAO, 2018).

The Figure 7 is based on the study of Michael Lutz in 2009. The consumption in million tonnes was converted in percentage. While those data are from 2009, the overall picture stills remains (European Union, 2018a).

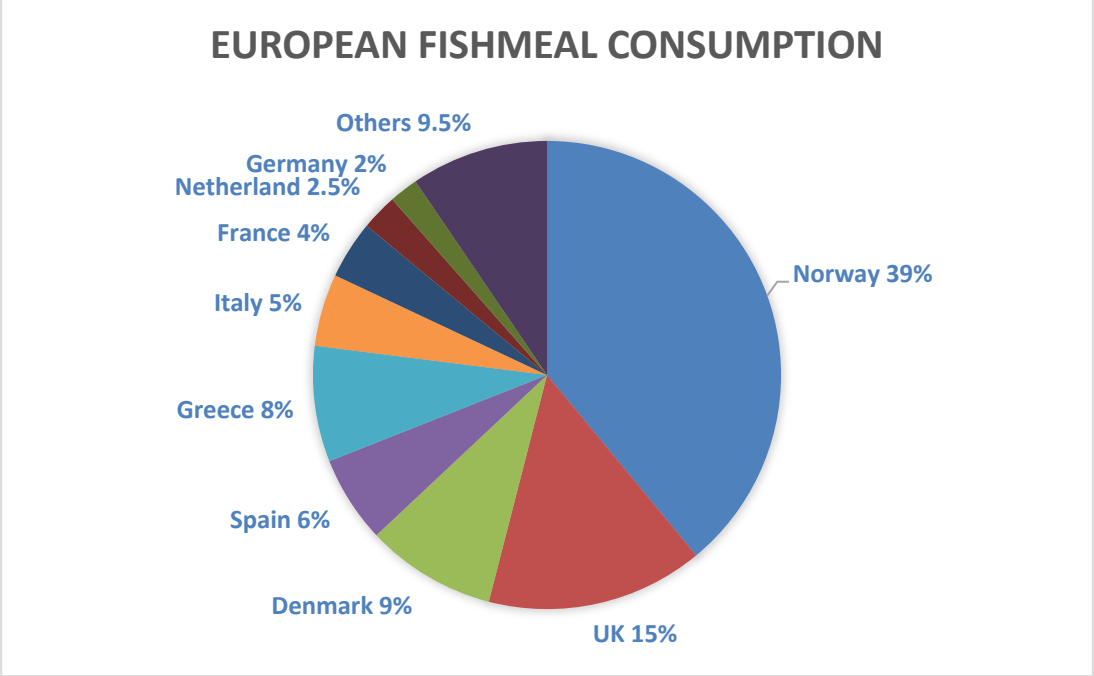


Figure 7: European fishmeal consumption in 2009

Norway is by far the biggest consumer (**Figure 7**) and producer of fishmeal in Europe. While Malta do not appear in those data, there is a potential market for

Italy which consumes 5% of the total European consumption, comparable with France (4%).

Fish by-products in France were estimated in 2004 by OFIMER (Office national interprofessionnel des produits de la mer et de l'aquaculture). The results show that 53% were converted to fishmeal and fish oils for animal feeds, 22% for pet foods, 21% was hydrolysed and 4% entered high-value markets.

In Norway, the distribution of products to the feed market is distributed like : 53% in fish feed, 21% in livestock feed, 15% in pet food and the remaining 11% in fur feed (European Union, 2018a). However, the feed market is not the only market for Rest Raw Material in Norway, while it is certainly the dominant one with 67%, another 21% goes to Bio gas/energy market and 12% in consumption (such as seafood products, cod liver oil and extracts). With laws encouraging the use of sea-food by-products, the country has developed streamlined modern processing facilities and is able to manage over 650 000tonnes of sea-food by-products per year with 90% being used by the Norwegian Atlantic Salmon industry (Stevens et al., 2018). Vietnam is also a great example as it uses Pangasius by-products for specific industries and is adopting new strategies for the use of finfish and shellfish species (Stevens et al., 2018).

Concerning fish oil, with 52% of the total world production, Peru is the biggest producer in the world followed by Chile with 13%. In Europe, the demand of fish oil is satisfied by Iceland and Norway, representing 7% of the world production (Caruso G, 2015). Other references mention Denmark as the biggest producer of fishmeal and fish oil in Europe, by hosting the two largest fish meal companies. However, Denmark's production is not known for by-products processing from aquaculture products. They use by-products from fisheries wastes for ensilage and composting manufacture (Lumino company) and is currently leading the biogas and biodiesel production from fish oil (European

Union, 2018a) . The fishing pressure on the species targeted for meal and oil could be reduce with the use of fishery by-products. France has estimated about 90% of 150 000tonnes of fish by-products are used for animal feed, manufactured mainly by the two main companies Copalis and Bioceval (European Union, 2018a).

On a global level, according to European Fishmeal And Fish Oil Producers which represent the countries Denmark, Faroe Islands, France, Germany, Iceland, Ireland, Norway, Spain and United Kingdom, Europe is producing 15% of the world's fish meal and 21% of the world's fish oil. They produce on average 575 000tonnes of fishmeal and 165 000tonnes of fish oil (**Figure 8**) exported to a large variety of countries and representing an annual value of approximately € 1billion (European fishmeal and fish oil producers, 2020).

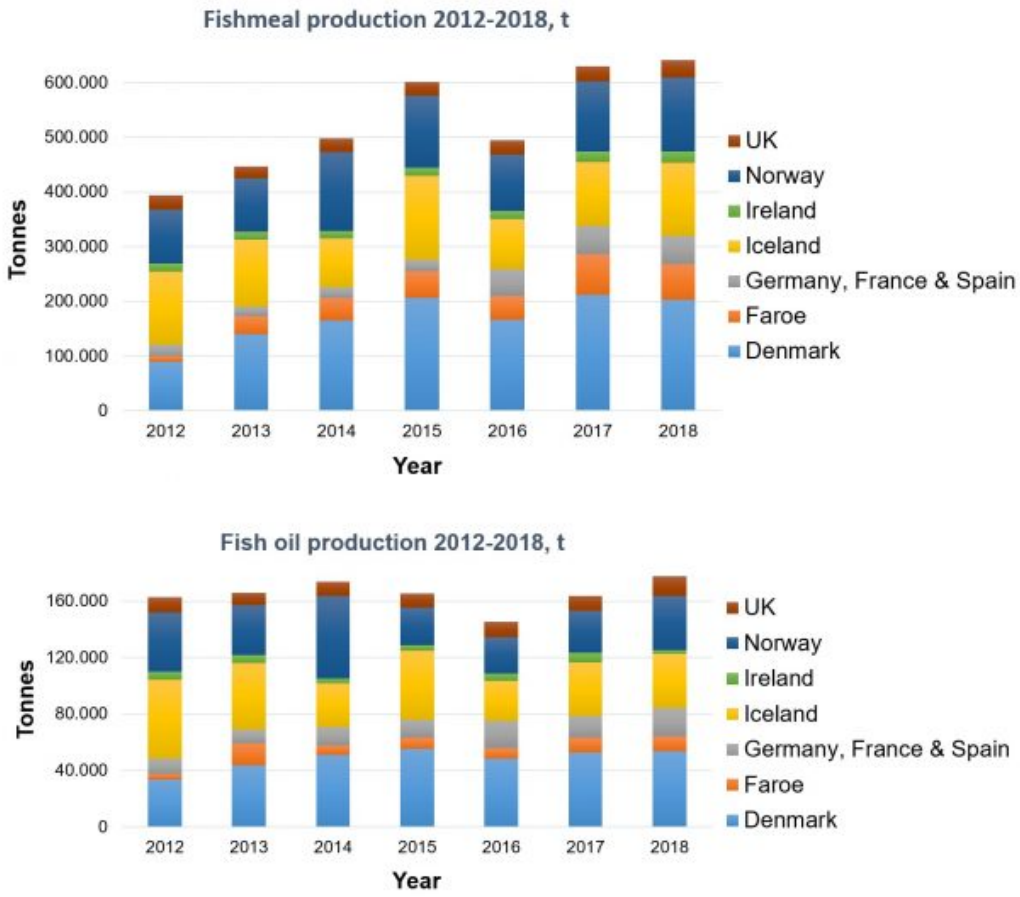


Figure 8: European fishmeal and fish oil production (2012-2018)

The use of by-products to produce fishmeal and fish oil seems to be promising towards the reduction of whole fish captures and the contribution of a more sustainable aquaculture production. Moreover, the prices of fishmeal and fish oil are expected to remain high (Figure 9: Perspectives for fishmeal and fish oil prices (Figure 9). An El Niño is a climate cycle with a global impact on weather pattern. It can reduce the upwelling of cold water and therefore can modify the migration of fish or even kill them. Consequently, it will affect prices of the products (**Figure 9**).

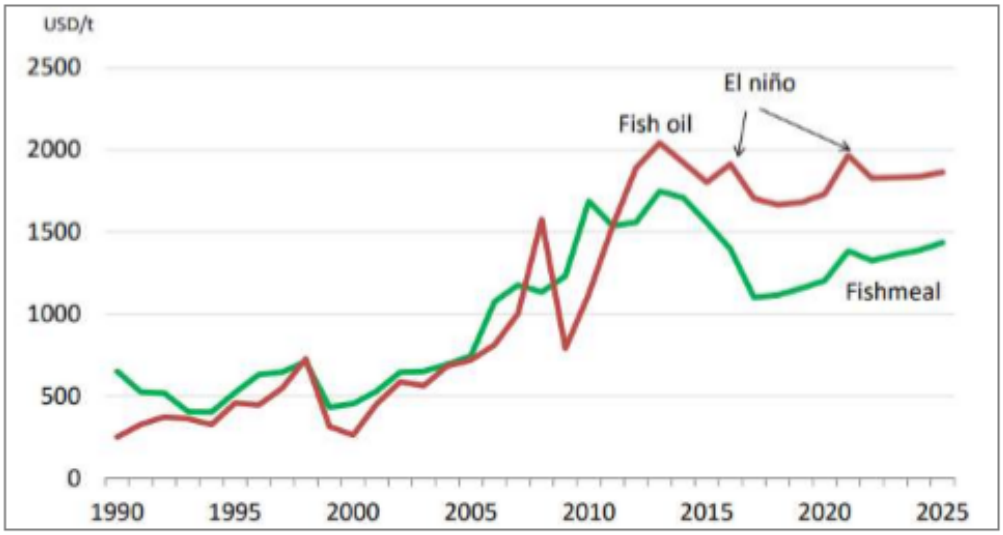


Figure 9: Perspectives for fishmeal and fish oil prices (Vannuccini, 2016).

It is possible to extract more details on yearly prices and market trends on fish oil and fishmeal market through GLOBEFISH, a multi-donor funded project within the FAO Fisheries and Aquaculture Department which provide up-to-date and market on fish and fishery products worldwide (FAO, 2020).

Italy's Market Shares in global exports for fishmeal is ranked 32nd, represented by 0.3%. Last year, exportation have been decreasing by 15.1% while importation have been increasing by 22.9%. Ranked 12th, importations represent 2.0% shares in global imports (**Figure 10**).

Figure 10: Import/Export overview fishmeal market in Italy

Leaders on that market

The following list provide an example of key players companies on the fish feed market. Two have their headquarters outside of Europe (BioMar and Cargill) and the following three are from Europe (Germany and France). Some are more focusing on by-products than others. This is a non-exhaustive list to serve as an example if their strategies are needed to be analysed.

BioMar

By supplying feed to around 50 countries and to more than 25 different fish, BioMar Group is one of the leading suppliers of high-performance feed to the aquaculture industry. It mainly provides feed products for salmon and trout species in Norway, the UK, and Chile. Concerning Europe, they provide feed materials for trout, eel, sea bass, and sea bream while in South and Central America they provide feed for shrimp and tilapia fish species (see Figure 11 for

specification of fish species supply). The closest feed factory from Malta is in Greece (Fish Info and Services Co.Ltd, 2020).

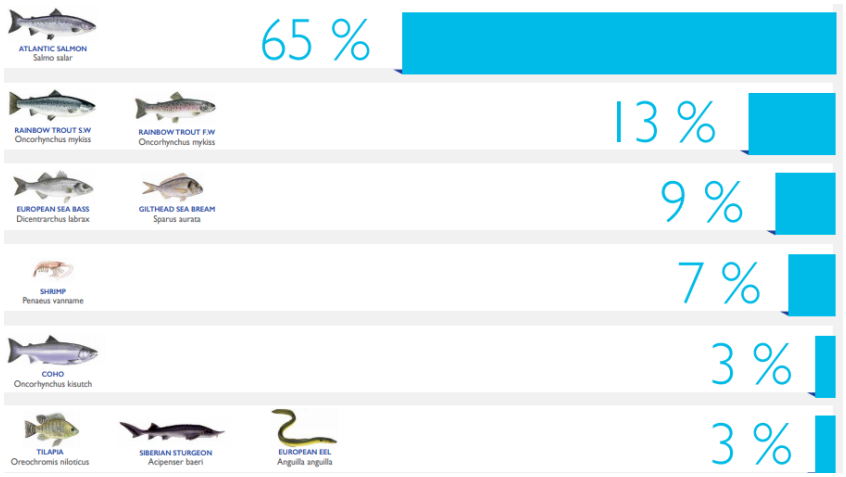


Figure 11: BioMar supplies feed according to the fish species (Fish Info and Services Co.Ltd, 2020).

Cargill

Cargill offers food, agriculture, financial, and industrial products and services across the Americas, Europe, and Asia. In October 2015, Cargill acquired EWOS and therefore becoming one of the largest global suppliers of aquatic feed. Currently, Cargill focus on three core species in 12 leading markets which are salmon in Norway, Chile, Scotland, and North America. As well, Tilapia in China, Indonesia, Thailand and Vietnam and shrimp in China, Thailand, Vietnam, Indonesia, Ecuador, India and Mexico (Fish Information & Services, 2020b). Whenever possible, Cargill has committed to use by-products from other food systems as raw materials for feed (Cargill, 2019). The company represents 38 specialized production facilities with more than 2 000 employees in 20 countries (Fish Information & Services, 2020b).

ADDCON

ADDCON is a German based company with offices worldwide that specializes in Green Chemistry. It offers organic acid and salts to promote the growth of fishes. ADDCON also use fish waste and by-products to produce fish silage (liquid product resulting from enzymatic hydrolysis), an ingredient used in animal feed. ADDCON serves customers worldwide (ADDCON, 2019).

Copalis

Copalis might not be one of the top 5 worldwide in the market, however it is a global supplier of marine based natural ingredients to the nutraceutics, food, animal nutrition and cosmetic markets. Copalis add value to the by-products generated by fisheries in Northern France since 1960. They produce fish meal and fish hydrolysates, but also marine bioactives since the development of new technologies (Fish Information & Services, 2020c).

Bioceval

Bioceval is a reliable partner to the fish processing industry in Europe. Based in Germany, the company has extensive experience of disposing fish trimmings and scarps to produce high-quality fish oil and fish meal. Their production is used for diverse applications such as feed or as ingredient in feed pig and chicken breeding, fish farms but also pet food (dogs, cats or ornamental fish) (Fish Information & Services, 2020a).

Potential barriers

Many obstacles can slow the process of launching a new product, often due to a lack of knowledge. It is important to identify the potential barriers your product might encounter to avoid unexpected surprises. Challenges can be due to the customer behaviour, regulations, costs, limited supporting infrastructure and

other reasons. Potential barriers were identified in the markets where bioactive molecules are applied.

Policy & regulations

As per previous information, fish by-products have many applications, however their use will depend on the volume and type of by-products. In fact, the disposal of animal by-products is tightly regulated in Europe: they are classified under three categories (ABP) with restriction on their use and disposal. To ensure biosecurity, eliminate contamination, and maintain general hygiene, the use of animal products which are not intended for human consumption are controlled under the European Animal By-Product Regulations (ABPR). As per example, due to fear of diseases development, the use of by-product from cultured fish turned into fishmeal in order to feed other cultured fish is banned (Newton et al., 2014). As well, the Scientific Steering Committee of the European Commission address the risks related to fish by-products with the need of feeding trials under controlled (Caruso G, 2015).

Technological and economic

The production of high-value products requires high investments costs (Figure 3) and the production of low-value products require important volume production to be economically viable. As per example, the traditional fishmeal and fish oil production requires a multistep, energy-demanding process. Investment and running costs will only be justified by processing a large amount of raw materials over a long period of time (Naylor et al., 2009). Large companies tend to be more successful. Storage and transportation can be a challenge compared to other industries, and appropriate infrastructure for logistics and transportation of biomass are essential for efficiency (European Union, 2019). Research is also a costly factor to be considered. Moreover, as a booming

industry, new processing companies will start growing and induce competition on the market. Most of the dedicated companies already cover global market around the world, while Sicily and Malta do not even appear on the list of potential blue economy markets.

Consumers acceptance

The consumer production of "blue" products is still unknown and research about their benefits is still limited. Ongoing debates about bio-based products are not helping their insertion (European Union, 2019). However, fish feed market should be less affected by customers' acceptance than fish by-products dedicated to the food (human consumption) or cosmetic industry.

Potential industries involved

Sicily

A few companies were identified to potentially be involved in the project of fish feed insertion from fish waste. Companies processing fish, fish farmers and fisheries were identified as possible waste sources. These corporations are listed below in Table 1.

Sicily was recognised to have a well-established market in the production of feed for livestock from fish meal.

Table 2 summarizes the companies operating in the before mentioned industry in Sicily.

Companies producing fish feed from fish meal could not be identified.

Table 1: Potential fish waste sources (companies that process fish, fish farms or fisheries) to be involved in Bythos project, in Sicily (Europages, 2020).

Company / Location	Company description
A & B FISH S.R.L. Based in Mazara Del Vallo.	A & B FISH S.R.L. is a Manufacturer/ Producer. It operates in the Shellfish and crustacean's industry as well as the fish, seafood and snails, preserved industries.
ACQUACOLTURA LAMPEDUSA S.R.L. Based in Lampedusa.	ACQUACOLTURA LAMPEDUSA S.R.L. is a Manufacturer/ Producer since 1995. It operates in the Shellfish and crustacean's industry as well as in the Fish and Miscellaneous products of animal origin industries.
ALPI ANNIBALE E C SRL Based in Bagheria (PA).	ALPI ANNIBALE E C SRL is a Manufacturer/ Producer. It operates in the Fish industry as well as seafood and snails, preserved and Fish, processing industries.
BALISTRERI GIROLAMO & C. Based in Bagheria.	BALISTRERI GIROLAMO & C. is a Manufacturer/ Producer since 1999. It operates in the Fish, seafood and snails, preserved industry as well as in the Fish and Freshwater crayfish industries.
BONFORTE BARRANO PELLEGRINO ANGELO Based in Mazara Del Vallo.	C.T.A. PESCA is a Manufacturer/ Producer since 1998. It operates in the Shellfish and crustacean's industry as well as the Fish and Fish, seafood and snails, preserved industries.
BOSCO S.P.A. Based in Palermo	BOSCO S.P.A. is a Manufacturer/ Producer since 1981. It operates in the Frozen and deep-frozen foods industry as well as the Shellfish, crustaceans, and Fish industries.
C.T.A. PESCA Based in Mazara Del Vallo.	C.T.A. PESCA is a Manufacturer/ Producer since 1998.It operates in the Shellfish and crustacean's industry as well as in the Fish and Fish, seafood and snails, preserved industries.

CENTRO SURGELATI S.R.L. **Based in Acireale.**	CENTRO SURGELATI S.R.L. is a Manufacturer/ Producer since 1994. It operates in the Shellfish and crustacean's industry, as well as in the Fish and Fish, seafood and snails, preserved industries.
GUSRMAND'S DI GUDDO SALVATORE & C. S.A.S. **Based in Palermo.**	GUSRMAND'S DI GUDDO SALVATORE & C. S.A.S. is a Manufacturer/ Producer since 1997. It operates in the Shellfish and crustacean's industry as well as in the Fish and Fish, seafood and snails, preserved industries.
LO RE ITTICA MARIO S.A.S. **Based in Lipari.**	LO RE ITTICA MARIO S.A.S. is a Manufacturer/ Producer since 2007. It operates in the Shellfish and crustacean's industry as well as in the Fish and Fish, seafood and snails, preserved industries.
MAESTRI DEL GUSTO S.R.L. **Based in Carini.**	MAESTRI DEL GUSTO S.R.L. is a Manufacturer/ Producer. It operates in the Shellfish and crustacean's industry as well as in the Fish and Fish, seafood and snails, preserved industries.
ORIGINAL GIUSEPPE CURRERI S.R.L. **Based in Sciacca.**	ORIGINAL GIUSEPPE CURRERI S.R.L. is a Manufacturer/ Producer since 1995. It operates in the Fish, seafood and snails, preserved industry as well as in the Shellfish and crustaceans and Fish industries.
SURGELATI S.R.L. **Based in Acireale.**	SURGELATI S.R.L. is a Manufacturer/ Producer since 2001.It operates in the Shellfish and crustacean's industry as well as in the Fish and Fish, seafood and snails, preserved industries.

Table 2 Companies that manufacture livestock feed from fish meal, in Sicily (Europage, 2020)

Company / Location	Company description
CINOZOO TRE R S.R.L **Based in Bisacquino**	Manufacturer/ Producer, since 1996. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.

MANGIMI DI PASQUALE Based in Avola	Manufacturer/ Producer, since in 1975. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries
LEOCATA MANGIMI S.P.A Based in Modica	Manufacturer/ Producer, sine 1981. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
MANGIMI LEONE S.P.A Based in Aci Sant'antonio	Since, 1995, which operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries
MANGIMI SANTAERA S.R.L. Based in Modica	Manufacturer/ Producer, since 1971. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
MANGIMIFICIO MONSOVILE Based in Ragusa	Manufacturer/ Producer, since 1975. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
VERDE ZOO DI LIUZZA DIEGO ROBERTO Based in Marsala	since 1998. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
BIOROMAN S.P.A. Based in Palermo	Manufacturer/ Producer, since 1973. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
CEREAL TRADING S.R.L. Based in Partinico	Manufacturer/ Producer, since 2004. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.

MANGIMIFICIO I.MA.R. S.R.L Based in Ragusa	Manufacturer/ Producer founded in 1987. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
COSTANZA PIETRO Based in Tusa	Since 1987. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries
PUGLISI GAETANO Based in San Teodoro	Since 1988. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
CASABIANCA DI FIDUCIA MARIANNA Based in Palazzolo Acreide	Since 1997. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
AGRI ZOO MARKET DI DRAGO SALVATORE Based in Capaci	Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
BAGLIERI FRATELLI Based in Modica	Since 1982. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
AMASTRA MANGIMI S.N.C. DEI F.LLI PELLEGRINO PLACIDO E MARIANO Based in Mistretta	Manufacturer/ Producer, since 2001. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
CONSORZIO F.AGR. AL. Based in Geraci Siculo	Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
FRUSTERI CHIACCHERA VINCENZO Based in Sant'agata Di Militello	Since 2006. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries

DI GIOVANNI ROBERTO MANGIMI E FORAGGI Based in San Filippo Del Mela	Since 2004. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
CENTRO AGROZOOTECNICO DI FAZIO SANDRA & C. S.N.C. Based in Capri Leone	Manufacturer/ Producer, since 2007. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
PUGLISI SALVATORE Based in Catania	Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
CAVALLO CARMELO E C. S.N.C Based in Rosolini	Since 1992. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
ZAPPALA' ROSARIO Based in San Giovanni La Punta	Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries
MANGIMI LICITRA S.R.L. Based in Ragusa	Manufacturer/ Producer, since 1962. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.
PRODALIMENTI Based in Barcellona Pozzo Di Gotto	Manufacturer/ Producer, since 1997. Operates in the Feeds for animal farming industry. It also operates in the Premix for livestock and poultry and Fish meal for livestock and poultry industries.

Malta

In Malta, the industry is much smaller and less developed than in Sicily. Some companies with potential application were recognized – see Table 3.

Table 3: Potential companies to be involved in Bythos project, in Malta

Company / Location	Company description	How to be involved
AQUABIOTECH GROUP Based in Mosta.	AquaBioTech Group is an international consulting company. It undertakes a variety of aquaculture, fisheries, marine surveying, aquarium and aquatic environmental projects through its regional offices and partners throughout the world.	Testing and R&D
AZZOPARDI FISHERIES Based in St Paul'S Bay.	AZZOPARDI FISHERIES is a Wholesaler since 1970. It operates in the Fish - import-export industry.	Processor of fish - waste
FISH AND FISH LTD Based in Zurrieq.	FISH AND FISH LTD is a Service Provider since 1992. It operates in the Fish, Aquaculture and pisciculture industries.	Fish farming and processing of fish - waste
KOPERATTIVA PRODUTTURI TAL-HALIB Based in Marsa	KOPERATTIVA PRODUTTURI TAL-HALIB is a Manufacturer/ Producer since 1958. It operates in the Feeds for animal farming industry.	Feed manufacturer
MARE BLU TUNA FARM LIMITED Based in Valletta.	MARE BLU TUNA FARM LIMITED operates in the Fish industry.	Fish farming - waste

PISCICULTURE MARINE DE MALTE LIMITED **Based in St. Paul's Bay.**	PISCICULTURE MARINE DE MALTE LIMITED is a Service Provider since 1990.It operates in the Fish, Aquaculture and pisciculture industries.	Fish farming - waste
PREGI DI SICILIA **Based in Mellieha.**	PREGI DI SICILIA is a Manufacturer/ Producer. It operates in the Smoked and salted fish industry.	Process fish - waste
VERNON'S FOOD MANUFACTURING & TRADING LTD **Based in Birkirkara.**	VERNON'S FOOD MANUFACTURING & TRADING LTD. is a Manufacturer/ Producer since 1966. It operates in the Condiments, extracts and spices industry. It also operates in the Fish, seafood, and snails, preserved and Extracts, food industries.	Process fish - waste

3. Conclusion

The study shows that there is a strong demand and future perspectives in the production of fishmeal and fish oil, as well as rising prices in the following decade. European strategies encourage the development of blue biotechnologies and waste management projects; however, they did not identify specifically Malta and Sicily as potential target for blue bioeconomy development in their strategies. The study also shows that there are better chances of success if the installations are large-scale, thus, important investments are necessary. A SWOT analysis was performed to identify the overall strengths, weaknesses, opportunities, and threats of the project (Table 4).

SWOT Analysis

Table 4: SWOT Analysis for fish feeds market from fish waste for BYTHOS project.

Strength	Weaknesses
• Fish waste available • Strong demand on the market • Rising prices of fishmeal and fish oil • Low cost technologies • Technological innovations	• Not profitable until large-scale production • Malta and Sicily are not pointed as main Blue Bioeconomy/Blue Biotechnologies areas of interest.
Opportunities	**Threats**
• Fishmeal and fish oil growing towards a high-value product (Olsen et al., 2014) • Growing awareness towards renewable biological resources • Development of European Blue Bioeconomy/Blue Biotechnologies strategies	• Competitors: Fishmeal/Fish oil international producers

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