INvertebrateIT

Joint Roadmap and Investment Plan

Deliverable #1.3

This project has received funding from the European Union's Horizon EASME programme under grant agreement No.: EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

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Executive summary

INvertebrateIT project seeks to promote industrial and diversified use of invertebrate-based products for more sustainable and competitive aquaculture in the EU.

In the global context, insects and marine invertebrates can contribute to supply high quality, affordable and reliable feeds for fish. This RoadMap reviews the general context suggesting to allocate proportionate efforts to develop invertebrate-based solutions, including a review of regional specifities, gaps and opportunities for the EU Atlantic countries.

A Joint Vision follows, listing the main objectives, obstacles and priority actions, which will be assessed and ranked following stakeholder opinions, during the duration of this project, leading to a Roadmap for the EU Atlantic regions.

A general study of investment needs and sources has been carried out in from the International to the national level, and opportunities listed.

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Introduction

The **INvertebrateIT** project has set goals to find disruptive and forward-looking opportunities for competitive and sustainable aquaculture, to create circular economy and enhance the production of fish feed. The INvertebrateIT consortium consists of seven partners from five European countries. This consortium is formed by cluster organisations, public administration, business and research institutions that seek to promote and exploit the value chain of production of invertebrates, such as insects, for sustainable fish feeds, competitive aquaculture and integrated waste management. This responds to the global challenges of food security, marine environmental impact and resource efficiency, and to the regional challenges of EU aquaculture competitiveness, integrated management and Blue Growth accessibility, aiming to accelerate the transfer of technology towards disruptive leadership, developing industrial opportunities using invertebrates for feeds, value-added waste management, aquaculture diversification and other innovative value chains, equipping Atlantic coastal regions with strategic tools and real opportunities that are forward-looking, transversal, accessible and most adequate for growth and job creation in the area. **INvertebrateIT** strives to generate transnational PPPs to seize this opportunity and to develop 3 ready-to-invest demonstration projects.

The specific objectives behind this general approach are to:

- bring together at least 48 stakeholders from the public and private sectors, from at least 4 EU Atlantic MS, in online and face-to-face activities to **share knowledge and expertise to deliver a strategic joint vision and roadmap** in line with regional/EU priorities and common challenges
- promote the production of invertebrates for fish feeds for sustainable aquaculture, and contribute to the development of **commercial solutions and industrial leadership** within 2-10 years, in line with the related revision of EU legislation and market opportunities
- **plan, mobilise and coordinate strategic investment**, mapping public and private funding opportunities at regional, national, EU and international level, accelerate the commercialisation of **3 new bankable projects** in EU Atlantic regions
- better profit and manage waste to produce valuable animal proteins, integrating this towards **more diversified and resilient aquaculture value nets**
- **increase awareness and visibility**, build up critical mass, develop collaborative branding, engage consumers and align public and private understanding
- improve the **sustainability and competitiveness** of EU aquaculture, and its connection to a wide array of potential synergies in equally disruptive subsectors
- **further transfer capacity and technology** from aquaculture and invertebrate production towards RTD with other suitable new marine invertebrates (e.g. amphipods) and new growing substrates (e.g. algae and seafood by products

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Context

World population is projected to reach 8.5 billion by 2030[1], so food production will have to increase by 70% to meet demand[22], stressing the challenge to access animal protein. Considering the limits and environmental impact of conventional animal production, and the overexploitation of wild fisheries, aquaculture and other sustainable, efficient and innovative sources are needed to ensure food security and overall peace and stability.

Waste management is another global challenge, and is an intrinsic part of the above mentioned challenge: between 1/3 and 1/2 of all food currently produced is wasted (20% in the EU)[3]. Most organic waste generated along the whole commercial chain can be recycled into integrated production systems.

Contrary to worldwide growth (average 6.1% yearly[4]) EU aquaculture, despite its potential, is stagnant. Significant challenges are the lack of competitiveness, diversification and transversal support, with the growing cost and volatility of fish feeds standing as primary obstacles. With aquaculture expected to supply over 60% of fish by 2030, and with each percentual growth in EU aquaculture delivering 3000-4000 jobs in SMEs[5], its potential to contribute with growth in Atlantic coastal regions is very large, as well as to help better manage marine biological resources.

Insect protein can replace up to 100% of proteins in salmon diets[6]. With the global fish feed market expected to reach $129billion by 2019 (from $75b in 2016[7]), and prices of fishmeal expected to rise by 90%[8], the fish feed industry is primed for a major disruption[9] which the EU must tackle. These market trends, and estimations such that replacing just 5% of feeds for broilers in the Netherlands would allow 200 new SMEs to make profitable business[10], point towards the potential of invertebrate-based fish feeds to generate jobs and boost EU aquaculture. This would also reduce the reliance on increasingly costly and volatile fish flour and oils, which are furthermore a driving force for overexploitation. It also helps to valorise and recycle usable waste, reduces emissions, and hints towards a wide array of potential synergies in equally disruptive subsectors of the agro-food, bioeconomy[11] and blue economy industries, such as algal production, novel foods and feeds, aquaponics, organic products, biotechnology and pharma, fertilisers, Integrated Multi-Trophic Aquaculture, biofuels, seagrass litter management, and multi-use offshore platforms. According to FAO, chitin (found in the exoskeleton of arthropods) could also help to diminish the use of antibiotics

[1] http://www.un.org/en/development/desa/population/publications/pdf/trends/Population2030.pdf

[2] http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

[3] http://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf

[4] http://www.fao.org/3/a-i3720e.pdf

[5] Strategic Guidelines for the sustainable development of EU aquaculture. COM (2013) 229 final

[6] Federation of European Aquaculture Producers, Annual Report 2015

[7] What to feed fish? Demand for feed attracts innovators and investors. Impact Alpha. Investment news for a sustainable age. 21/10/2016

[8] Fish to 2030. Prospects for fisheries and aquaculture. World Bank Report No. 83177-GLB

[9] Fish 2.0 Market Report: Fish Feed. An Investor Update on Sustainable Seafood. Fish 2.0. Manta Consulting 2015

[10] http://www.protix.eu/wp-content/uploads/2014/07/20141029_Why-are-insects-not-allowed-in-animal-feed_Whitepaper_Insect_meal.pdf

[11] http://www.bioeconomyutrecht2016.eu/Static/bioeconomyutrecht2016.eu/Site/Manifest_revisie_13_juni.pdf

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in feeds[12]. Finally, technology developed for invertebrate production and aquaculture can be transferred to other suitable marine invertebrates and growing substrates, compatible to enrich management plans for wetlands and Marine Protected Areas. The necessary size and good prospects are particularly accessible and beneficial for SMEs in peripheral and rural areas, as well as for major innovation hubs, across the EU Atlantic basin.

Source http://insect-network.org/about-nice/

Food Security

The recent rises in food prices, throughout the world, have brought increasing focus on the importance of global food security and the need to ensure a sustainable food supply for all consumers. Climate change and bad weather conditions including drought, the effects of the increasing price of oil and fundamental long-term changes in the world demand for food, particularly in developing countries, have put increasing pressure on world food supplies. These events have shown that food security should not be taken for granted. Europe has to consider the role of its own agri-food sector in ensuring international food security, so that it can play its part in ensuring a high standard of quality food for future global food security[13]. On the other hand, current food production, especially the animal protein sector, contributes significantly to climate change, the stress on water resources, deforestation and the use of a wide variety of plague control and growth enhancement chemicals that can have persistent negative impact on the environment and human health.

Aquaculture Trends

[12] Insects as animal feed. In Edible insects: future prospects for food and feed security. FAO Forestry Paper 171, 2013

[13] DAFM. https://www.agriculture.gov.ie/agri-foodindustry/euinternationalpolicy/internationalfoodsecurity/

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The FAO states that an additional 42 million tonnes of farmed seafood will be needed by 2025. The rising global population and the shift in economic power towards the east, mean that seafood demand is set to rise sharply for the foreseeable future. Aquaculture, is considered the fastest growing food-producing sector. Aquaculture is a substantial sector in many European regions. With annual oscillations mainly caused by El Niño phenomena, fishmeal production has declined gradually since 2005, while overall demand has continued to grow, pushing prices to historic highs through late 2014. Fish-oil production is also declining, mainly because of lower production in South America, and more stringent quotas long-term fish oil prices are not expected revert to lower levels. Fishmeal and fish oil are still considered the most nutritious and digestible ingredients for farmed fish feeds[14], and is also intensively used for other livestock feeds. To offset their high prices, as feed demand increases, the amount of fishmeal and fish oil used in compound feeds for aquaculture has shown a clear downward trend, with their being more selectively used as strategic ingredients at lower concentrations and for specific stages of production, particularly hatchery, broodstock and finishing diets.

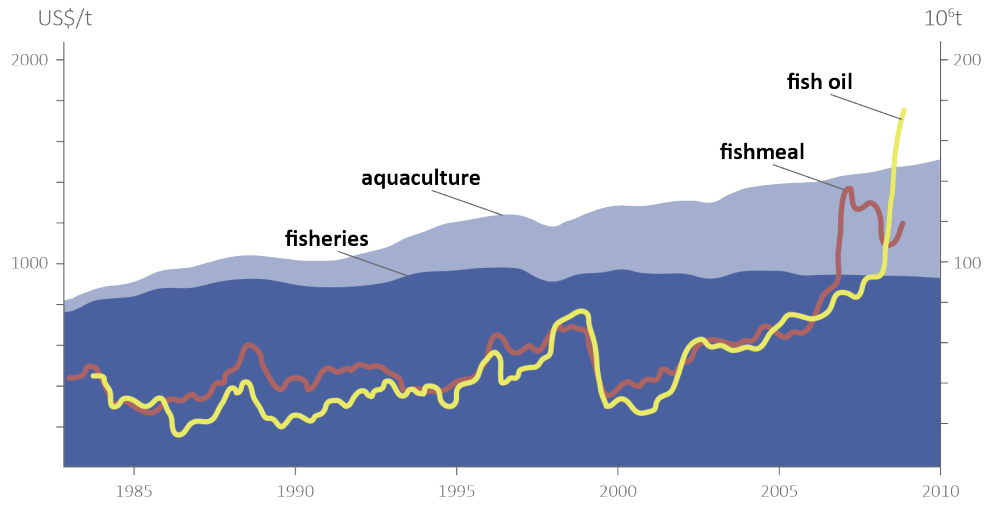

Figure 1 Increasing fishmeal market prices (left axis) and global aquaculture production. Adapted using data from Tacon and Metian, 2008[15] and UN-FAO, 2014

Global fisheries management is also a serious concern, with 90% of global fisheries fully or overexploited, and around 30% of global catches directly processed into fishmeal, depriving coastal communities and pelagic trophic webs of their nutritional base. Feed is widely regarded as becoming a major constraint to the growth of aquaculture production in many developing countries. Providing fish farmers with well-balanced feed at cost effective prices is a prerequisite for profitable production. Formulation issues, and in particular the provision of species-specific feeds that meet the nutritional requirements of different life stages of the farmed species, remain important topics for both commercial and farm-made feed production sectors. Most fish oil still goes into aquaculture feeds. Due to declining fishmeal and fish-oil production and their high prices, alternative sources of HUFAs

[14] FAO The State of the World Fisheries and Aquaculture 2016 http://www.fao.org/3/a-i5555e.pdf

[15] A. Tacon and M. Metian, 2008. "Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: trends and future prospects". Aquaculture Vol. 285 (1-4) https://doi.org/10.1016/j.aquaculture.2008.08.015

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are being explored, including large marine zooplankton stocks, such as Antarctic krill (*Euphausia superba*) and the copepod *Calanus finmarchicus*. However, the cost of zooplankton products is too high for them to be included as a general oil or protein ingredient in fish feed. Plant protein alternatives are also used, but are less digestible and their intensive production, and diversion towards animal food chains, also pose several sustainability challenges.

	Total Volume of Aquaculture (2013)	**Total Value**	**Share of the EU Production**	
	Tonnes	€ Million	% Volume	% Value
UK	203,260	896.7	16.8	22.3
Ireland	34,200	114.2	2.8	2.8
Portugal	7,870	53.8	0.7	1.2
France	200,332	693.1	16.5	17.0
Spain	262,222	429.4	18.7	10.7
Netherlands	46,610	110.1	3.8	2.7
Total	754,494	2297.3	**59.3**	**56.7**

Production Statistics for Project Partner Countries

Source https://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans_en

European aquaculture fish producer reached 2,350,278 tons, a very small 0.4% rise when compared to 2014. In contrast to previous years, the Norwegian salmon production stayed at a stable level. Cold water marine species now represent 71.4% of the total production, fresh water species 15.1% and the marine Mediterranean species 13.5%. Norway alone represents 58% of this total production; the other countries that produce more than 100,000t. annually are Turkey, United Kingdom and Greece. The main species: salmon, trout, seabream, seabass and carp represented 94% of the total European production in 2015[16]

The European Fisheries and Aquaculture Research Organisations propose in their vision for European aquaculture (blue growth) achievable in 2030, 2050 and beyond, that by 2030 “fed ingredients originate from sustainable sources (both terrestrial and marine) also that nutrients, in the form of microbes (microalgae, micro fungi and bacteria) and insects, constitute a significant part of the feed commodity market for farmed fish and shrimp. EFARO also recommend that “recapture based fish feed ingredients be transformed through open or closed bio generators (microbes), composts (insects) and filtration (micro and macro algae and bivalves).

[16] Commission Regulation (EU) 2017/893 of 24 May 2017 amending Annexes I and IV to Regulation (EC) No 999/2001 of the European Parliment and of the Council and Annexes X, XIV and XV to Commision Regulation (EU) No 142/2011 as regards the provisions on processed animal protein.

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Current Legislation

In a position paper presented to the EU Commissioner for Health and Food safety in April 2017 the International Platform of Insects for Food and Feed (IPIFF) stated that "insects will soon constitute a reliable alternative or addition to fishmeal feed formulae for aquaculture". On 24 May 2017 the European Commission formally approved Regulation (EU) 2017/893. This regulation authorizes the use of insect proteins in feed for aquaculture animals. This authorisation specifies the use 7 species namely, Common Housefly, House Cricket, Black Soldier Fly, Yellow Mealworm, Lesser Mealworm, Field Cricket and Banded Cricket[17]. These invertebrates should be fed with 'feed grade' substrates (i.e. vegetal origin materials or with a limited number of animal origin materials, including fishmeal, blood products from non-ruminants, egg and eggs products, milk and milk based products, honey, rendered fats).

As from 1 July 2017, processed proteins derived from insects are authorised in feed for farmed fish in the EU. FEFAC (European Feed Manufacturers' Federation) welcomes the authorisation[1] of this promising alternative source of proteins for animal feeding, in particular for fish farming which requires diet compositions with highly digestible proteins. In the long term, the inclusion of insect meal could further contribute to the sustainable development of EU aquaculture[18]. Within the current legal framework, the feeding of insects destined to be used as fish feed needs to comply with the same requirements as any conventionally farmed animal, meaning in particular that they may not be fed with e.g. catering waste or livestock manure.

FEFAC believes that this measure is in line with the present state of scientific knowledge and should facilitate the public and market acceptance of insect proteins used as feed. FEFAC would welcome further research into the safety of potential alternative substrates for insect farming, i.e. materials that are currently not directly useable for feeding fish, poultry or pigs, as also recommended by EFSA (European Food Safety Authority) in its opinion on the risk profile related to production and consumption of insects as food and feed in October 2015. This may create further added value to proteins derived from farmed insects in the context of boosting circular economies.

Potential

There is a growing understanding that insects, and other invertebrates, are part of the solution. Introducing up to 20% of insect meal into fish feed would mean a market potential of almost 1 million tonnes in the aquaculture sector already by 2020[19]. Insects as sources of protein for fish feed are underused globally, according to the International Feed Industry Federation. A review by FAO scientists of feeding trials - concluded that insect meal could replace between 25% and 100% of soymeal or fishmeal in the animals' diets with no adverse effects. Insects and invertebrates have very high conversion factors and productivity, fast life cycles and can grow on a wide variety of available substrates, yielding high quality and readily assimilated proteins and HUFA, as well as vitamins and functional compounds. They are an important part of natural fish diets, and will gain increasing and strategic importance in the food and feed sectors. Additional to food and feed, invertebrate production is increasing for other uses, such as biotechnology, environmental services (e.g. pest

[17] *Musca domestica, Hermetia illucens, Tenebrio molitor, Alphitobius diaperinus, Gryllus campestris* and *Gryllodes sigillatus,* respectively.

[18] http://www.fefac.eu/news.aspx?CategoryID=2063&EntryID=23797

[19] EU Business Innovation Observatory. New nutrient sources. Sustainable, Safe and Nutritious Food, Case Study 52

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control, pollination) and waste management (e.g. recycling, treatment, bioremediation), and therefore advance in any one sub-sector may serve as traction for the others.

FAO report on edible insects noted "the huge potential that insects offer for enhancing food security" bug-based diet could produce bigger and stronger livestock. Most insect meals were deficient in calcium and the amino acids methionine and lysine, but those can be added cheaply. Invertebrates, mainly insects can supplement traditional feed sources such as, grains, maize, soy and fishmeal. The larvae of the black soldier fly, the common housefly and the yellow mealworm are classed by the FAO as having the greatest immediate potential for large-scale feed production however other insect species are also being investigated for this purpose. Producers in the United States, South Africa, Spain and China are already rearing large quantities of flies for poultry and aquaculture feed by bio-converting organic waste[20].

A report published by the Dutch Bank ABN Amro stated that - the European feed markets for aquaculture are very promising, 80,000t if 10 per cent of the fishmeal in Europe is replaced (>Q2 2017), the conclusion is that in the short term, the potential market for insect proteins in feed is much bigger than the current supply. "It is expected that volumes will increase and prices decline in the case of further upscaling, mechanization and automation. This will enhance the competitive edge of breeders and improve economic perspectives in the long run"[21].

There is a significant and expanding global market for seaweed, with total output reaching 15.8 million tonnes in 2008, valued at $7.4 billion[22]. The use of seaweed in non-food applications is increasing, with clearly defined markets for seaweed as an aquaculture feed; as the basis of bioremediation and for use in cosmetics. Algae and algal by-products may also provide affordable substrates for competitive invertebrate production in the medium term.

Insect Products –

Insects can be presented whole (either as live feed or frozen) or processed into flours, oils and active compounds. This affects product specifications and durability, and the marketing strategies behind high-end, generally IP protected products, nutritional complements or commoditised ingredients for large volume feed manufacturing. Insects, and their derived products, depend on life stage specificities, being used in their egg, larvae, nymph, pupae and adult forms.

- Whole insects (live or frozen)
- proteins for fish meal, generally as flour
- fat as an oil
- active compounds for nutrition, biotechnology and pharma: e.g. gonad maturation and spawning using *Nereis diversicolor*

[20] FAO Edible insects - Future prospects for food and feed security

[21] ABN AMRO. December 2016

[22] FOA- Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations (2010), The State of World Fisheries and Aquaculture 2010

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- by products: e.g. chitin
- leachate as liquid fertiliser
- waste as bio-fertiliser
- services: e.g. waste treatment, bioremediation (note: this does not relate to feed but to other cost-reducing and sustainability enhancement opportunities for SMEs, who could e.g include invertebrate-based treatment of waste before disposal)

Insects are mainly composed of proteins, lipids and chitin, but there is a great variation in the nutritional composition of insects because it depends on several factors: the species, the diet and the metamorphic stage of the insect (larvae, etc.).
Xiaoming and al. (2010) [23] evaluated the protein content of 100 species from a number of insect orders (*Coleoptera, Lepidoptera, Hemiptera, Homoptera, Hymenoptera, Odonata, Orthoptera, Diptera …*). The results show that protein content was in the range 13–77 percent of dry matter and that there was large variation between and within insect orders. If we are interested in 7 species allowed in fish meal wich belong to *Coleoptera, Diptera, or Orthoptera* order, protein content is approximatively 55 percent.
Many edible insects are also rich in fat. For *Coleoptera, Diptera and Orthoptera,* fat content is approximatively 15 percent.

There can be several applications according to the compounds of interest: fish meal, petfood, human food, cosmetic, pharmaceuticals … Some examples are presented in the diagram below.

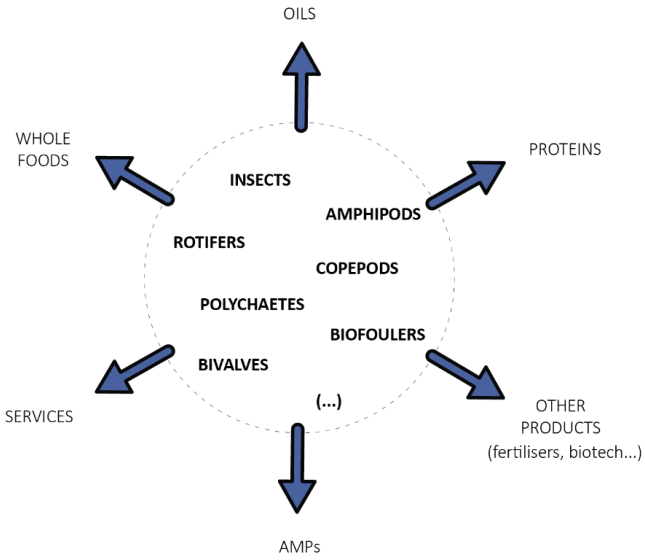

Figure 2 Range of applications of invertebrates for aquaculture feeds and other products.

There are others compounds of interest, which are not mentioned such as pigments or anti-microbial peptides.

[23] Xiaoming, C., Ying, F., Hong, Z. & Zhiyong, C. 2010. Review of the nuritive value of edible insects. In P.B. Durst, D.V. Johnson, R.L. Leslie. & K. Shono, eds. Forest insects as food: humans bite back, proceedings of a workshop on Asia-Pacific resources and their potential for development. Bangkok, FAO Regional Office for Asia and the Pacific

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Substrates

A wide range of organic materials can be used as source of nutrients or as substrates for rearing of invertebrates; substrate is the overall term that will be applied for these materials as invertebrate feed. Substrates to be included in the production depend on the legislative framework, availability and stable quality, the applicability in the specific farming system and the cost. Due to the different requirements, the substrate preference will differ among the different invertebrate species[24]. Important aspects are "capturing regionally scalable organic side-streams of relatively high-quality that are not currently being used for livestock production"[25] and research and exploitation of novel substrates, such as algae.

Substrates in use in the EU

Animals in the EU may be fed only with safe feed (Commission Regulation (EC) No 68/20136, Regulation (EC) No 178/2002 and Regulation (EC) No 767/2009). With respect to substrate for insects, Annex III to Regulation (EC) No 767/2009 prohibits the use of faeces and separated digestive tract content even though these materials are used in other parts of the world for insect production. According to Regulation (EC) No 1069/20097, insects are considered as 'farmed animals' and thus, for their feeding the use of certain substrates such as manure, catering waste or former foodstuff containing meat and fish, are not allowed. The main substrates currently applied in the European insect production include commercial animal feed, former foodstuffs not containing meat and fish (i.e. production surplus, misshapen products or foods with expired best-before-date that had been produced in compliance with EU food law) and co-products from primary production of food of non-animal origin.

Production technology

Although insects are often raised on grain and other animal feeds, on main advantage is their ability to convert waste, which can come directly from agriculture in the form of waste, failed crops, by products, end excess production. Usable waste is also generated all along the food production, commercialisation and consumption chain, in the form of waste and by-products (e.g. spent grains, slurries, peels), or faulty, gone-bad or non-used raw and processed products. Other sources may include excess feeds and by products from the aquaculture and seafood sector. Novel interesting substrates include marine resources, such as local and invasive algae. For long term viability, low-cost, good quality, traceable and reliable waste sources need to be secured, in a quantity and processed form adequate for the scale of invertebrate production.

[24] www.efsa.europa.eu/efsajournal 10 EFSA Journal 2015;13(10):4257

[25] Lundy ME, Parrella MP (2015) Crickets Are Not a Free Lunch: Protein Capture from Scalable Organic Side-Streams via High-Density Populations of *Acheta domesticus*. PLoS ONE 10(4): e0118785. https://doi.org/10.1371/journal.pone.0118785

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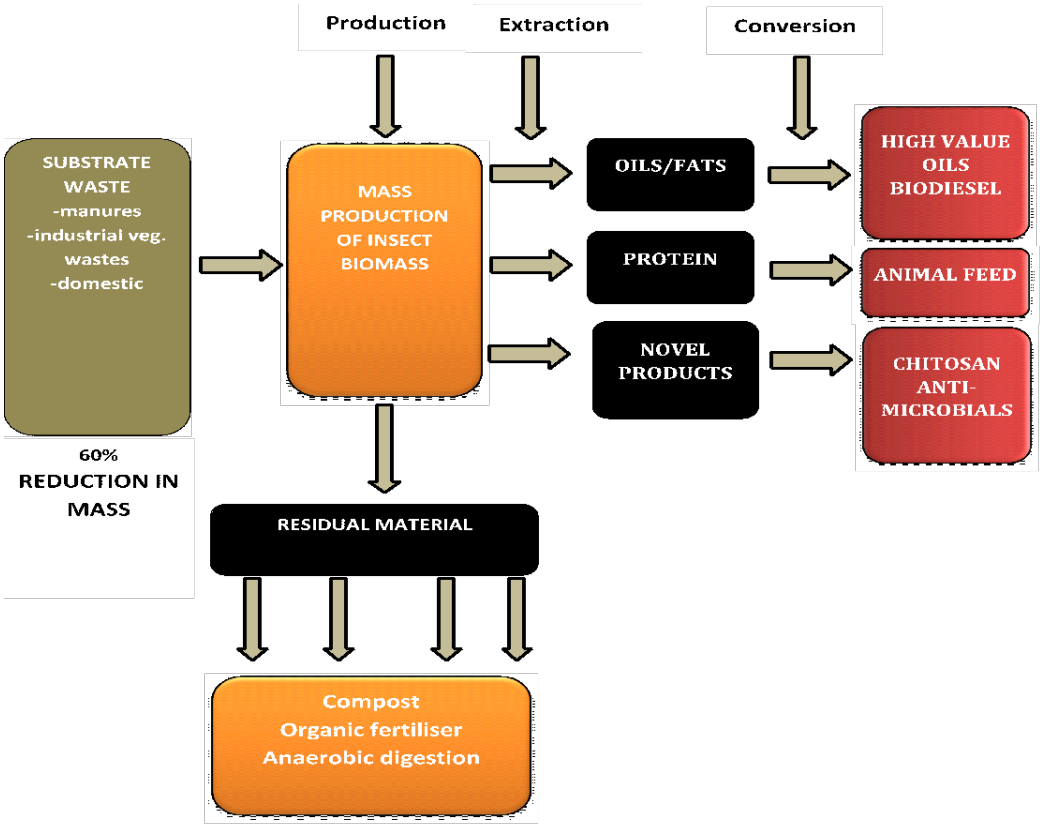
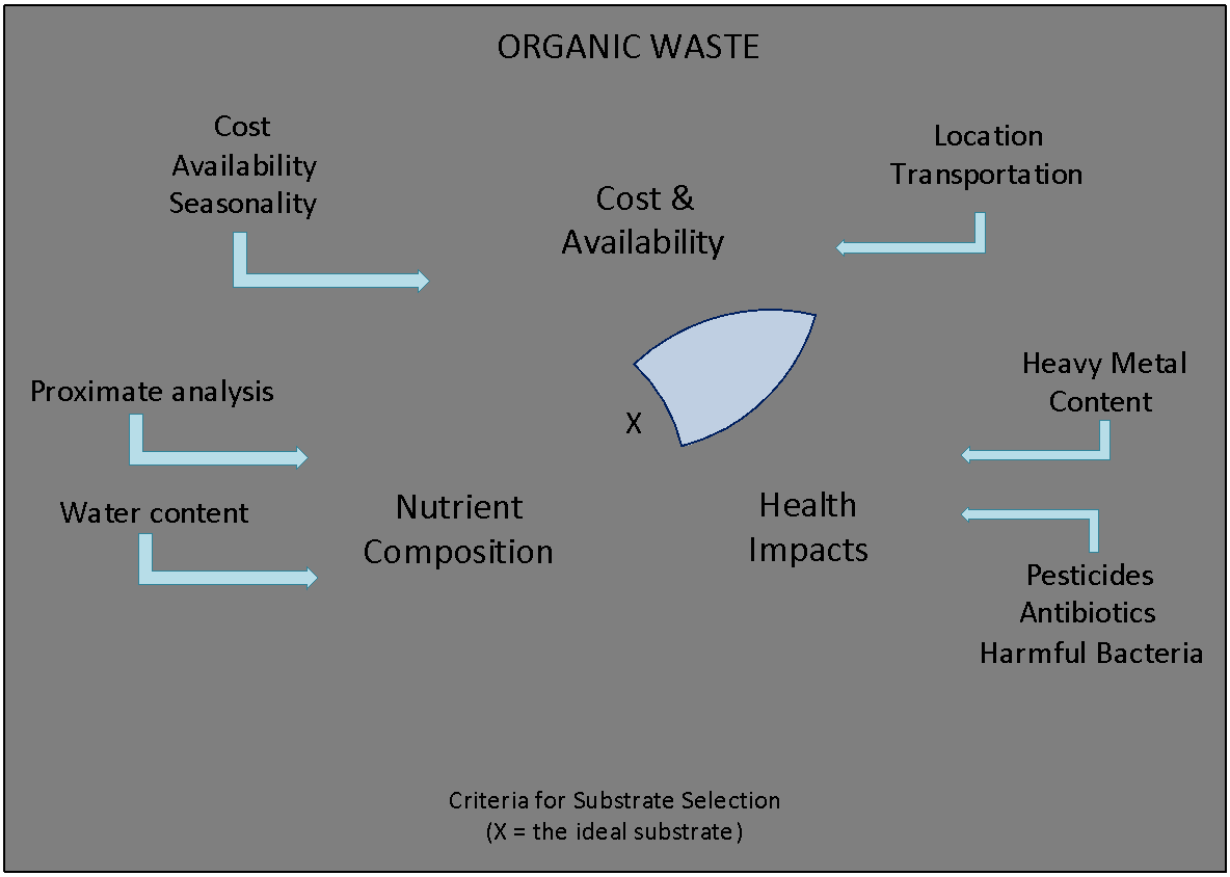
Integrated Waste Management and Bioconversion

Waste management and bio conversion - by rearing invertebrates such as fly larvae on organic waste, traceable fruits and vegetable waste from food distributors and agricultural waste. The bioconversion process generates an invertebrate-based protein for aquaculture feeds.



SOURCE: FERA

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.



Source: MAQUART P, Murray FJ, Newton RW, Leschen WA, Little DC. Potential for commercial scale insect-based transformation of organic waste for aquafeed and crop production in Ghana. Poster, Stirling, United Kingdom. 2016.

Public-private cooperation

Following the issues and perspective developed in the previous sections, public-private partnerships (PPP) seem appropriate tools to guide a market-driven transformation along the strategic axes most beneficial for the community and the environment in each of the target regions, as well as to drive cooperation and clustering at macro-regional level. On the one hand, opportunities are economically sound and stakeholders ready, on the other, disruptions are risky in the short term and transversal benefits add complexity but no direct return.

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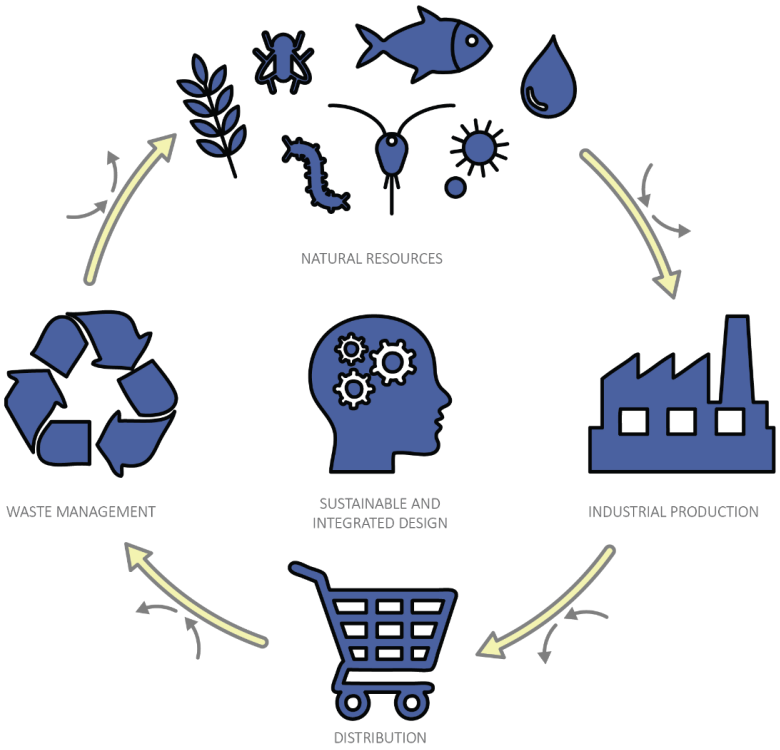

Figure 3 Circular economy. Waste can be collected for bioconversion by invertebrates all along the pre-sales industrial chain.

Marketing novel invertebrate resources for more sustainable aquaculture, especially when connected to integrated waste management and favouring employment is a case study for PPPs: facilitating leadership in return of positive externalities. While it is an accessible moment to engage, innovation is technically and financially challenging. Competition to supply such strategic market gap provokes a similar competition for visibility and funding to develop and market viable alternatives. However, considering the ingredient-based nature of feed formulation, the scope for synergies in more integrated production and provision systems, the diversity of farmed species and life-stage requirements, and the sheer volume of the growing market, should induce at least some stakeholders to favour cooperation and indirect added value. Indeed, a diverse and adaptable range of feed alternatives seems necessary to ensure accessibility, competitiveness, resilience... and consumer support. Under that light, and considering different sensitivities towards environmental and social challenges, public administrations are in a good position to participate in a wide range of forms to promote sustainable, integrated and inclusive growth linked to aquaculture (feeds) as part of the larger Blue Growth, Circular Economy and RIS3 policy.

Contribution of the project:

"Disruptive and forward-looking opportunities for competitive and sustainable aquaculture"

Aquaculture is a necessary part of the quest for solutions for sustainable growth, food security and environmental stewardship. This applies at global level, and is particularly understood in the EU. As such, it embodies Blue Growth and IMP policy, and is one of the RIS3 pillars across EU Atlantic regions. However, EU aquaculture, despite its quality and environmental standards, is stagnant. One of the

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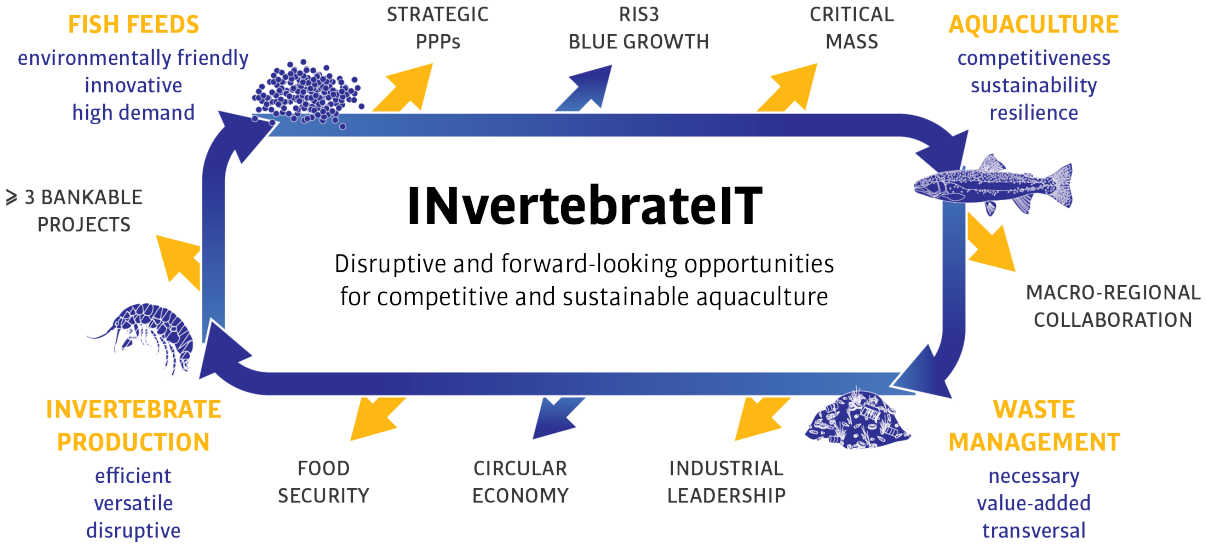
main challenges is the rising cost and volatility of fish feeds, which significantly reduces the competitiveness and resilience of ventures, mainly led by SMEs. On the other hand, aquaculture has the potential to provide many jobs in the region, including in rural and remote areas, which is a specific need of the EU Atlantic Basin regions. Invertebrates, such as insects, have been highlighted by top level institutions as a most promising and necessary part of food production chains, thanks to their high conversion factors, lesser environmental impact and unique assets for development led by SMEs. Waste management (agrifood and other) can be used to produce invertebrates that are particularly well suited for fish feed production, and the trends and gaps in global markets point towards them to imminently disrupt current conditions. In the EU, strategic intelligence has led to world leadership in insect production, especially in the Netherlands and France. The project INvertebrateIT unites 3 clusters, 1 National Agency and Marine Research Centre and 3 SMEs (experts in invertebrate production, aquaculture, entrepreneurship and access to funding) from 4 EU Atlantic Member States and the Netherlands to seize the opportunity and accelerate technology transfer in the value chain of "waste management and invertebrate production for fish feeds and sustainable aquaculture".



With available technology, identified market gaps, explicit interest from global stakeholders, and new legislation, now is the time to seize the opportunity, and to ensure this serves to integrate smart policy within profitable business models, paving the way for strategic Public-Private Partnerships (PPPs) and for industrial leadership in the EU Atlantic region, at all times synergic and coherent with EU policy (e.g. EU Atlantic Action plan, Circular economy) and investment. INvertebrateIT aims to build on previous and parallel efforts to exploit these real market and policy needs, transferring available technology and to build up regional capacity and deliver inclusive solutions, merging overarching public interests with promising business opportunities. To do this, INvertebrateIT will bring together industry players, research entities and public authorities to build a Joint Vision and Roadmap and outline an Investment Plan for its implementation. The project will increase awareness and a critical mass, assist stakeholders to build up transnational PPPs for the development and promotion of 3 bankable demonstration projects, and support SMEs to develop and launch innovative commercial

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ventures. This should result in strategic PPPs for industrial leadership, sustainable growth, and accessible jobs, with large potential for replication, upscaling and internationalisation, expressing smart and integrated policy

- Long-term strategic partnership

The consortium will be strategically enlarged by engaging other relevant stakeholders from the EU Atlantic Basin Member States, namely cluster organisations, business innovation networks, research and innovation actors and public stakeholders active in Sustainable Aquaculture for Blue Growth with particular focus on invertebrate production and waste management, Circular Economy and the implementation of RIS 3 or other existing related strategies. Additional partners will be invited to join the strategic partnership by signing a Memorandum of Understanding, committing themselves to support the development of the Joint Vision and Roadmap and Investment Plan, facilitate its dissemination and/or implementation or provide the strategic partnership with information or resources that contribute to promote and exploit the production and use of invertebrates for fish feed for a more competitive aquaculture and waste management in the EU Atlantic Basin.

- Investment opportunities

INvertebrateIT aims at mapping and pooling the available funding opportunities across the whole spectrum of public and private funds to allow the implementation of the roadmap. Taking into account the identified development opportunities in the Joint Vision and Roadmap.

- Demonstration projects

InvertebrateIT has the objective of engaging SMEs along the EU Atlantic basin to bring forward projects to commercially exploit opportunities combining sustainable aquaculture, invertebrate production and smart waste management, contributing to the common macro-regional RIS3 priorities, Blue Growth and the Circular Economy. The objective is to identify and select the three most promising projects to facilitate the creation of PPPs. An open contest is one of the most efficient solutions to foster participation, aiming to gather and identify valuable entrepreneurial proposals. Through the organisation of an open contest, INvertebrateIT focuses on engaging SMEs to present innovative solutions with the objective of selecting the most adequate and promising projects for the capacity building process around which the consortium, together with other relevant stakeholders, will facilitate suitable PPPs for commercial implementation within 2 to 10 years.

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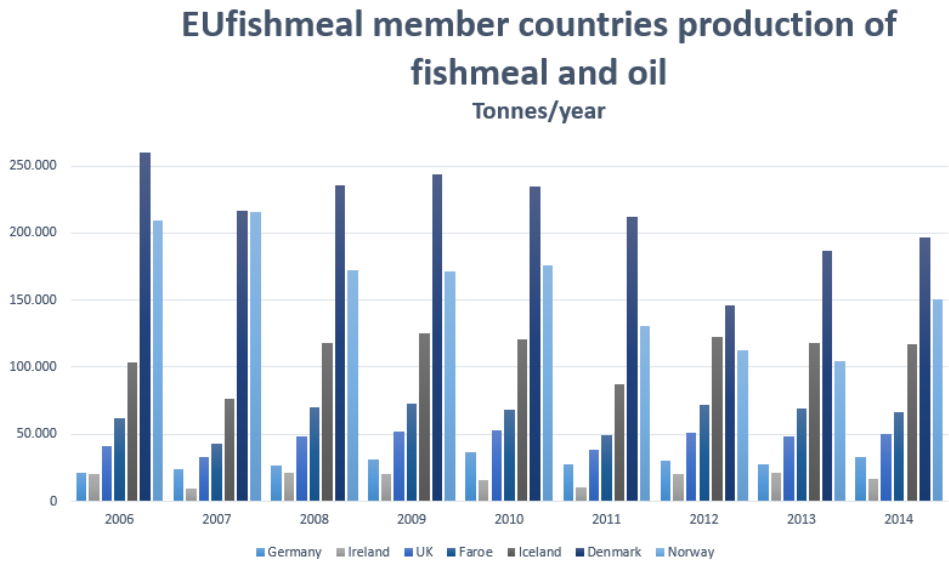
Fish feed for a Sustainable Aquaculture

Production

EU fishmeal represent:

- +600,000 tonnes of produce
- An export value of +€1000 mil
- An intake of 2 mill tonnes of raw material (fish and trimmings)
- +3000 direct jobs in coastal areas
- Numerous jobs in the fishing sector[26]

The total European production of fishmeal and fish oil is approximately 500.000 metric tonnes of fishmeal and 170,000 tonnes of fish oil a year and the total value of production is approximately 1000 million €/year. Exports go to a large variety of countries. Production is based on landings of small, oily, short-lived species such as blue whiting, capelin, sand eel, norway pout and sprat as well as by-products (trimmings) from the consumption fish processing sector. Production is based on a sustainable exploitation of resources and the sector meets the international standards and certifications applying to raw materials, production and traceability. Production varies according to the access of raw material but the overall trend over the last 5-10 years has been a fall in production.



Source EUFishmeal

[26] EUfishmeal. http://www.eufishmeal.org/

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Macro regional specificities

Aquaculture Statistics for each partner country and specifics of each countries national plan for aquaculture: -

UK

Salmon form the greater proportion of UK aquaculture production, producing 163,148t (81.5%)[27]. Freshwater trout hold 6.4% of the current production capacity producing 12,824t. Carp and Sea bass have a combined production of approximately 400t. the Growth objectives for the UK projecting to 2020 see an overall growth of 24% in the aquaculture sector, comprising a 22% growth in the finfish sector.

Enhance UK competitiveness:

- Promote partnerships between the devolved administrations, growers and research bodies to drive competitiveness in the sector.
- Focus on knowledge exchange e.g. the UK Aquaculture Forum and developing technical innovation.[1]

Coordinated spatial planning:

- Preparation of regional Marine Plans that actively incorporate aquaculture production areas for priority development.
- Co-ordinated and consistent input from the aquaculture industry via regional hubs to strengthen its effective representation within the marine planning process.

Level playing field:

- Encouragement to form an English Aquaculture Producer Organisation.
- Scottish initiatives to integrate aquaculture into a wider, market focused, food exporting culture amongst Scottish food and drink businesses.

Issues of relevance to UK aquaculture include:

Marine ingredients (fish meal and fish oil) are major constituents of UK farmed salmon and trout diets. The issues around use of marine ingredients (sustainability, availability, cost) are well known and substitution with by-products from fish processing, land animal protein sources (LAPs), and vegetable meals and oils often discussed. Despite legislatory changes facilitating substitution of fishmeal with LAPs, certification standards in the UK have been cited as barriers to substitution, due to the perception that finfish should be fed natural fish diets.

Ireland

After mussels (50%) Irelands largest aquaculture product is Atlantic salmon at 36% of the total production, 16,300t[28]. Freshwater trout makes up 1.6% of production with a tonnage of 705t. The

[27] 2013 Data. United Kingdom Multiannual National Plan for the Development of Sustainable Aquaculture. October 2015. www.gov.uk/defra

[28] Annual Aquaculture Survey. BIM. 2017

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projected growth for Irish aquaculture to 2023 is 123%. Currently there are 2 insect producers in Ireland working to produce insect protein and other by-products.

Enhance competitiveness:

- Provision of expert advice to improve environmental and business performance.
- Build capacity and scale in the industry through a commercial Aquaculture Development Scheme with investment support to SMEs.
- Enhance the skills base to foster a knowledge economy through networking, training, mentoring and the sharing of best practice.
- Applied research and collaborations between industry, scientific and development bodies.

Coordinated spatial planning:

- Aquaculture incorporated into an effective and equitable marine spatial planning system.
- Spatial mapping of aquaculture sites and exclusion areas.
- Commission a study to identify and provide guidance to farmers in developing tourism-related opportunities for producers.
- Study on integrated multi-trophic aquaculture and possible synergies with offshore wind farms or other marine renewable energy.

Level playing field:

- Aid shellfish producers affected by major biotoxin episodes.
- Promote organic aquaculture practices and certification.
- Support best husbandry and disease management practice.
- Develop an industry code of practice for invasive alien species[29].

Issues of relevance to Irish Aquaculture include:

Irelands National Plan for Sustainable Aquaculture does not specifically mention sustainable fish feed and the use of invertebrate protein however it seeks to enhance competitiveness. Also, it proposes to initiate a support scheme through the Seafood Development Programme 2014-2020, co-funded by the Exchequer and European Maritime and Fisheries Fund, to support the development of technical, scientific or organisational knowledge in aquaculture farms, which, in particular, reduces the impact on the environment, reduces dependence on fish meal and oil, fosters a sustainable use of resources in aquaculture, improves animal welfare or facilitates new sustainable production methods[28]

Portugal

Portugal farms 4 species of finfish, namely: freshwater trout which comprises 8.0% of overall aquaculture production in the country, turbot (24.4%), sea bream (12.4%) and sea bass (4.7%). The national growth objectives for Portugal are to expand production in the aquaculture sector from 2014 to 2022 from 10,317t to 35,000t an increase of 239%[1].

Enhance competitiveness:

- Increase in and diversification of production and supply of new products, including the installation of new units and / or modernization of existing ones.
- Investment in production methods to ensure high food safety standards.

[29] National Strategic Plan for Sustainable Aquaculture Development. DAFM. 2015

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- Research on offshore aquaculture, identifying coastal areas, species and suitable production systems;

Coordinated spatial planning:

- Improving the legal and regulatory framework for aquaculture in Portugal.
- Development of existing instruments for territorial management.
- Identification and creation of new aquaculture production areas.

Level playing field:

- Support for the creation, organisation and functioning of the Producer Organizations;
- Promoting partnerships between the sector, industry and distribution and marketing chains;
- Monitoring and improvement of statistical information[130].

Issues of relevance to Portuguese Aquaculture include:

The Strategic Plan for the Portuguese Aquaculture 2014-2020 does not address the use of invertebrate protein in aquaculture feed. The same is true for the National Operational Programme "Mar 2020" which provides financial support; one of the priorities identified under Mar 2020 is aquaculture, but the thematic is very diffuse in the measures that include: Promotion of environmentally sustainable, resource efficient, innovative, competitive and knowledge-based aquaculture; biological aquaculture (e.g. IMTA systems such as finfish-seaweed-bivalves, as part of the solution for bio mitigation). Some companies and research institutes have projects recently approved in this area (invertebrates and algae) but the Portuguese aquaculture sector is very small and there is not an integrated approach for the use of these new ingredients. In the case of insects, the main constraints are the substrates approved to feed them and the impact they will have on the quality of the ingredient; the fact that there are not many companies (little availability), most of which do not rendering (i.e., do not separate fat from protein - this presents difficulties in the formulation); the identification and knowledge of new organisms that can incorporate the nutrients; the traceability; the consumer preconception, etc. Availability and traceability issues are transversal. In the case of algae, for example, it is very complex to obtain the necessary quantities at a price that matches their nutritional value; to get high quantities we would have to go to the Asian market, which raises issues of traceability and food safety. Finally the feed sector itself is little attractive in the value chain compared with other sectors that compete for the same ingredients.

France

Freshwater trout production makeup the majority of framed fish in France at 16.9% of the overall aquaculture production, Sea bass and sea bream make up 2.2% and salmon make up 0.2% of overall production. The national growth objectives for France for 2014 to 2022 are to increase overall aquaculture production from 218,000t to 265,000, an increase of 22%. Freshwater farmed fish are targeted to rise in volume by 28% by 2020, while marine finfish production is to rise by 233% by 2020.

Enhance competitiveness:

- Promote sustainable exploitation of the aquatic environment through support to collective actions aimed at improving water quality.
- Improve aquaculture techniques to minimise environmental impacts.

[30] 2015. Strategic Plan for Aquaculture Portugal

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- Develop risk-management, sector resilience and product competitiveness.
- Support research and development (R&D) project identification through joint scientific-private-public coordinated approaches.
- Develop market opportunities through an improved image of aquaculture products, regional product identification and adding value to by-products.
- Foster the development of processing industries serving aquaculture production.

Coordinated spatial planning:

- Improved use of spatial planning to support aquaculture development in favourable environments.
- Improved knowledge of linkages between aquaculture activities and other regional activities to support inter- sectoral integration in regional development policies.

Level playing field:

- Develop attractiveness of jobs in the aquaculture industry, encourage evolution from part-time employment to full-time employment through diversification of activities, support installation of young entrepreneurs and improved access to training.
- Promote sanitary certification and safety of aquaculture products, e.g. with regard to the water quality or other external environmental factors.
- Respond to the specific research needs of the aquaculture sector in outermost regions[131].

Issues of relevance to French Aquaculture include:

There is a need to develop the acceptability by French industries and private sectors of the use of invertebrate. The potential hurdles of using insects in fish feeds (toxicity of insects through bioaccumulation, deficiencies in amino acids or fatty acids, chitin content, palatability, digestibility) need to be addressed. Identification of the available ways of avoiding these drawbacks (control of the dietary substrate of insects in mass rearing units, manipulation of the diet of insects, mixture of dietary proteins, use of aquatic insects, processing of insect meal). The aquaculture sector need to take advantage of the new EU legislation regarding the use of insects in fish feed. Increasing consumption of animal products expected by 2050 and necessity to highlight new solutions/increase in the prices of fishmeal and fish oil a need to work new solutions and opportunities at global scale. Competition of Asian and north American industrials for the development of the European insect production sector.

Spain

Aquaculture is an important sector in Spain, including intensive and extensive practices. In terms of volume, mussels are the principal product of Spanish aquaculture (225,307 tonnes in 2015[32], or 77.8%), followed by sea bass (21,324t; 7.36%), gilthead sea bream (16,231t; 5.6%) and rainbow trout (16,179t, 5.58%). These are followed by turbot, croaker, blue fin tuna (ranching). Clams, oysters, sole, eel and sturgeon are also produced.

Production volume is planned to increase 20% overall from 2012 (267 000 t) to 2020 (320 000 t), as part of a national strategy that also aims to increase value (+26% in 2020 from €436M in 2012) and finfish production targets: up 27% for freshwater species and 32% for marine ones[1].This includes

[31] National Plan for Aquaculture France

[32] APROMAR, 2017. La Acuicultura en España, 2017.

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world-leading research in bluefin tuna reproduction, high-end products as microalgae, organic aquaculture and e.g. sturgeon caviar, and environmental programmes such as those for European eel recovery. Diversification is also a top priority, and there are research and precommercial programmes for a variety of species, including invertebrates such as octopus, anemones and abalone, and fish such as hake, seriola, meagre and different sparids. Integrated Multitrophic Aquaculture also receives support, especially in the Atlantic. Crustacean production, mainly prawns, occurs in recirculating, continental premises. The Spanish seafood and aquaculture sector is present and well connected world-wide[1].

Enhance competitiveness:

- Spain will reinforce the transfer of R&D-derived knowledge, design a national plan and create a new financial instrument that boosts R&D in small to medium-sized enterprises.
- Boost eco-friendly aquaculture by financing the conversion of conventional infrastructures into ecologically-sensitive farms, reinforced by assessments of the environmental impact, carbon footprint and a full life cycle assessment, etc.
- Enhance animal welfare in Spanish aquaculture.
- Promote training and coordination between training entities and the sector, including promoting distance-learning through online platforms.

Coordinated spatial planning:

- Establish common criteria to identify areas of aquaculture interest in the different autonomous regions.
- Plan access to water resources for terrestrial fish farms and promote the reuse of inactive facilities.
- Develop a Geographical Information System (GIS) for the spatial planning of the Spanish aquaculture.
- Support productive investments in new sites and the creation of new aquaculture companies. Reinforce positive interactions within Natura 2000. Characterize the farms that are located inside Natura 2000 areas, their interactions and strengthen and replicate their positive impacts on the environment.

Level playing field:

- Improve the collaboration between different partners by co-financing activities for enhancing production and marketing.
- Promote the creation and acquisition of collective certificates.
- Improve the marketing of aquaculture products both at the national and international levels.

Issues of relevance to Spanish aquaculture include:

The Spanish multi-year strategic plan for Spanish aquaculture 2014- 2020 highlight important areas for future development and growth of production and technological advancement processes: Most of these species share the problems that create bottlenecks in food, especially in the larval stage, and feed conversion factors. Thus efforts should be directed to the search for substitutes for fish meal and oil, more efficient alternative formulations and ingredients, such as fish waste silage and vegetal meals, which reduce some of the costs of the inputs. There is not an existing strategy about insects,

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algae, marine invertebrates and polychaetes and waste management, for sustainable aquaculture in Spain[133].
In 2016 121,000 t of feed were used in aquaculture, which means an increase of 2.1% regarding the previous year. The 83% was used in marine species and the 17% in freshwater species.

The Netherlands

Catfish are the most widely produced finfish in Dutch aquaculture producing 3,100t, 6.7% of aquaculture production. Ells make up 6.3% of production at 2,885t. National Growth Objectives (2014-2023) - Production value - a 3% increase in value by 2023[34].
Enhance competitiveness:

- Cooperation of producers and research institutes.
- Innovation to be promoted through setting up "knowledge circles" (groups where knowledge is exchanged, an approach earlier applied in agriculture and fisheries).
- Better cooperation of the fresh fish farming sector will be stimulated through provision of the necessary funding from EMFF.

Coordinated spatial planning:

- Use of multi-purpose space at sea, in particular in combination with offshore wind farming areas.

Level playing field:

- Better communication, certification and shortening of the production chain.
- Husbandry criteria are developed for species farmed in the Netherlands. These criteria are offered to ASC for further use

[33] National Plan for Aquaculture Spain- Apromar Report. La Acuicultura en España 2017

[34] National Plan for Aquaculture, The Netherlands

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Supporting policies, initiatives and existing strategies for sustainable aquaculture

EU Level

Blue Growth Strategy

Blue Growth is the long term strategy to support sustainable growth in the marine and maritime sectors as a whole. Seas and oceans are drivers for the European economy and have great potential for innovation and growth. It is the maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth. The 'blue' economy represents roughly 5.4 million jobs and generates a gross added value of almost €500 billion a year. However, further growth is possible in a number of areas which are highlighted within the strategy.

The strategy consists of three components:

1. Develop sectors that have a high potential for sustainable jobs and growth, such as: aquaculture (Fisheries website); coastal tourism; marine biotechnology; ocean energy; seabed mining.
2. Essential components to provide knowledge, legal certainty and security in the blue economy: marine knowledge to improve access to information about the sea; maritime spatial planning to ensure an efficient and sustainable management of activities at sea; integrated maritime surveillance to give authorities a better picture of what is happening at sea.
3. Sea basin strategies to ensure tailor-made measures and to foster cooperation between countries.

Common Fisheries Policy

Management of EU fisheries

The CFP is a set of rules for managing European fishing fleets and for conserving fish stocks. Designed to manage a common resource, it gives all European fishing fleets equal access to EU waters and fishing grounds and allows fishermen to compete fairly. Stocks may be renewable, but they are finite. Some of these fishing stocks, however, are being overfished. As a result, EU countries have taken action to ensure the European fishing industry is sustainable and does not threaten the fish population size and productivity over the long term. The CFP was first introduced in the 1970s and went through successive updates, the most recent of which took effect on 1 January 2014.

The CFP aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens. Its goal is to foster a dynamic fishing industry and ensure a fair standard of living for fishing communities.

Although it is important to maximise catches, there must be limits. We need to make sure that fishing practices do not harm the ability of fish populations to reproduce. The current policy stipulates that between 2015 and 2020 catch limits should be set that are sustainable and maintain fish stocks in the long term.

To this day, the impact of fishing on the fragile marine environment is not fully understood. For this reason, the CFP adopts a cautious approach which recognises the impact of human activity on all components of the ecosystem. It seeks to make fishing fleets more selective in what they catch, and to phase out the practice of discarding unwanted fish. The reform also changes the way in which the CFP is managed, giving EU countries greater control at national and regional level.

The CFP has 4 main policy areas: Fisheries management; International policy; Market and trade policy; Funding of the policy. The CFP also includes rules on aquaculture and stakeholder involvement

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EU Water (WFD) and Marine Strategy (MSFD) Framework Directives[35]

Aquaculture relies on, but does not consume, significant quantities of high quality water.
As regards WFD, aquaculture activities can potentially exert pressures and impacts upon aquatic ecosystems, for example through increased nutrient load, from concentrations of faecal matter and uneaten feed, from dispersal of cleaning agents and medicines. Aquaculture can itself be subject to pressures and impacts from other activities taking place in the aquatic ecosystem, for example pollution incidents, waste water treatment facilities upstream, and hydropeaking/flow variations. If properly managed, certain aquaculture practices can have positive effects on the natural environment.
The key issues in relation to MSFD are the spatial scale at which the environmental impacts from aquaculture are likely to occur and their cumulative impacts considered together with the impacts from other anthropogenic pressures. These need to be considered in relation to the specified quality elements for assessment under the different MSFD descriptors and at the spatial scales defined for the MSFD assessments.

EU2020

Europe 2020 is the European Union's ten-year jobs and growth strategy. It was launched in 2010 to create the conditions for smart, sustainable and inclusive growth.
Five headline targets have been agreed for the EU to achieve by the end of 2020. These targets cover employment; research and development; climate/energy; education; social inclusion and poverty reduction.
Progress towards the Europe 2020 targets is encouraged and monitored throughout the European Semester, the EU's yearly cycle of economic and budgetary coordination.
In March 2014, the Commission published a Communication taking stock of the Europe 2020 strategy, including an overview of progress on the 2020 targets.
The Commission held a public consultation on the strategy between May and October 2014, and published the results in a communication in March 2015.
In 2015, the Council adopted a new set for the Integrated guidelines – broad guidelines for the economic policies of the Member States and of the Union and guidelines for the employment policies of the Member States – that replace the 2010 Integrated Guidelines.

Horizon2020

[35] Commission Staff Working Document. SWD(2016)178 Final "On the application of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in relation to aquaculture. Brussels.

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Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020) – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market.
Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness.
Seen as a means to drive economic growth and create jobs, Horizon 2020 has the political backing of Europe's leaders and the Members of the European Parliament. They agreed that research is an investment in our future and so put it at the heart of the EU's blueprint for smart, sustainable and inclusive growth and jobs.
By coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation.
Horizon 2020 is open to everyone, with a simple structure that reduces red tape and time so participants can focus on what is really important. This approach makes sure new projects get off the ground quickly – and achieve results faster.
The EU Framework Programme for Research and Innovation will be complemented by further measures to complete and further develop the European Research Area. These measures will aim at breaking down barriers to create a genuine single market for knowledge, research and innovation.

Atlantic Action Plan
The Atlantic Action Plan aims to support the marine and maritime economy in the Atlantic Ocean area. It shows how the EU's Atlantic Member States, their regions and the Commission can help create sustainable growth in coastal regions and drive forward the "blue economy" while preserving the environmental and ecological stability of the Atlantic Ocean.
Promoting cooperation
The Action Plan encourages Member States to work together in areas where they were previously working individually. They will now be able to share information, costs, results and best practices, as well as generate ideas for further areas of cooperation of maritime activities. This includes both traditional activities, such as fisheries, aquaculture, tourism and shipping, as well as emerging ones such as offshore renewables and marine biotech.
Priorities
The Action Plan considers responses to the challenges of delivering growth, reducing the carbon footprint, using the sea's natural resources sustainably, responding effectively to threats and emergencies and implementing an "ecosystem" management approach in Atlantic waters. The priorities are to:
Promote entrepreneurship and innovation;
Protect, secure and enhance the marine and coastal environment;
Improve accessibility and connectivity;
Create a socially inclusive and sustainable model of regional development;
The agreed actions will focus on growing the tourism market, meeting the increasing demand for offshore installations, improving education and training in traditional and emerging maritime

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industries, as well as extending cooperation in the field of oceanic research in order to better assess climate change impacts.
The Plan follows from the Atlantic Strategy the Commission adopted in 2011 and will contribute to the EU's "Blue Growth" strategy.
The investment and research priorities identified in the Atlantic Action Plan could be considered for EU financing in the new programming period 2014-2020.

Circular Economy[36]

The European Commission has adopted an ambitious new Circular Economy Package to help European businesses and consumers to make the transition to a stronger and more circular economy where resources are used in a more sustainable way.
The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy. The plans will extract the maximum value and use from all raw materials, products and waste, fostering energy savings and reducing Green House Gas emissions.
The proposals cover the full lifecycle of products: from production and consumption to waste management and the market for secondary raw materials. This transition will be supported financially by the European Structural & Investment Funds (ESIF), which include €5.5 billion for waste management. In addition, support will be provided by €650 million under Horizon 2020 (the EU funding programme for research and innovation) and investments in the circular economy at national level.

UN Sustainable Development Goals[37]

The UN SDGs define priority areas for global action, focusing on the needs of a growing population, especially in developing countries, and on accumulated environmental impact. Increasing production and improving sustainability in aquaculture, better managing waste and a more efficient and sustainable use of marine resources are closely aligned with:

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. Especially as regards the connections of aquaculture with Target 4 *"By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality"*.

Goal 12: Ensure sustainable consumption and production patterns, especially as regards Targets 2, 3, 4, 5, 7, 8 and 9:
- *"By 2030, achieve the sustainable management and efficient use of natural resources"*

[36] https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/towards-circular-economy_en
[37] http://www.un.org/sustainabledevelopment/sustainable-development-goals/

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- "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses"
- "By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment"
- "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse"
- "Promote public procurement practices that are sustainable, in accordance with national policies and priorities"
- "By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature"
- "Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production"

Goal 14: Conserve and sustainably use the oceans, seas and marine resources, especially as regards Target 2 "By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans".

International Level

FAO Sustainable Development Goals – 2015 Fisheries, aquaculture, oceans and seas

Oceans, seas and coastal areas provide mankind with manifold goods and ecosystem services fundamental to human well-being, global food security and nutrition. They form an integrated and essential component of the Earth's ecosystem and are critical to sustainable development.
Fisheries and aquaculture offer ample opportunities to reduce hunger and improve nutrition, alleviate poverty, generate economic growth and ensure better use of natural resources.
If the current trend in unsustainable uses of marine resources is not reversed, the ability of our oceans to deliver food for future generations will be severely compromised.
Curbing overfishing while promoting responsible and sustainable fisheries and aquaculture practices and preserving healthy marine environments are among humankind's best opportunities to deliver highly nutritious food to a growing population.
Investing in Blue Growth - the sustainable management and use of aquatic resources and adoption of ecosystem approaches - can boost economic growth, increase food security, improve nutrition and reduce poverty.
The FAO Code of Conduct for Responsible Fisheries provides principles for promoting sustainable fisheries and aquaculture.

Key challenges

The bulk of capture fisheries production comes from coastal waters, where both the productivity and quality of fish stocks are severely affected by pollution. Capture fisheries and aquaculture are also threatened by competing demands from hydropower development and water diversion for industrial use. Furthermore, the vital contributions of fisheries and aquaculture to the world's well-being and prosperity remain constrained by poor governance, management and practices. Illegal, Unreported

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and Unregulated (IUU) Fishing continues to be an obstacle to achieving sustainable fisheries. Climate change is adding a further challenge.
Stresses caused by human activity on the oceans' life support systems are widely acknowledged to have reached unsustainable levels. Today, 61 percent of commercially important assessed marine fish stocks worldwide are fully fished, 29 percent are overfished. About 90 percent of large predatory fish stocks are already depleted. Our oceans and seas are under risk of irreversible damage to habitats, ecological functions, and biodiversity because of overfishing, climate change and ocean acidification, pollution, unsustainable coastal area development and the unwanted impacts from the extraction of non-living ocean resources.
If the current trend in unsustainable uses of marine resources is not reversed, their ability to deliver food for future generations will be severely compromised. At risk are hundreds of millions of people who depend on fisheries and aquaculture for their livelihoods, food security and nutrition, with small-scale coastal fishing communities particularly affected.

Joint Vision

"Disruptive and forward-looking opportunities for competitive and sustainable aquaculture"

Aquaculture is a necessary part of the quest for solutions for sustainable growth, food security and environmental stewardship. This applies at global level, and is particularly promising for across EU Atlantic regions, as part of Blue Growth and RIS3 policy. However, EU aquaculture, despite its quality and environmental standards, is stagnant. One of the main challenges is the rising cost and volatility of fish feeds, which significantly reduces the competitiveness and resilience of ventures, mainly led by SMEs. On the other hand, aquaculture has the potential to provide many jobs in the region, including in rural and remote areas, which is a specific need of the EU Atlantic Basin regions.

Invertebrates, such as insects, have been highlighted by top level institutions as a most promising and necessary part of food production chains, thanks to their high conversion factors, lesser environmental impact and unique assets for development led by SMEs. This offers opportunities for cross-cutting innovation, especially as regards a Circular Economy and overall Blue Growth.

The following is a list of indentified factors that new and enhanced valorisation of invertebrate resources for aquaculture, which will be evaluated, enriched and ranked during the INvertebrateIT project.

Context analysis

- New EU legislation encompasses the use of insect protein in aquaculture feeds

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- Invertebrate production for aquaculture feeds can be industrially connected to better waste management, natural resource diversification and environmental services.

Strengths	Weaknesses
- Invertebrates are the natural diet of farmed fish, especially for sub-adult forms - Invertebrates require less space, water, inputs and capital than other protein sources - Regions in the EU Atlantic produce over 50% of EU total aquaculture in both volume and value - technology for industrial production of insects is well developed - Marine invertebrates are already an important part of the aquaculture sector - There's a global and growing market demand for novel feed ingredients - All target regions identify marine resources as a priority for specialisation	- Support from producers and consumers is low - Production levels are too low - Knowledge and awareness are low - Only a few planktonic marine species are currently produced - Invertebrate-based products are currently too expensive for mainstream industry - Insects are not yet covered by organic production standards - Research and pre-commercial development are lengthy, uncertain and expensive processes
Opportunities	**Threats**
- Growing international market for invertebrate products - New legislation allows the use of insect protein and oils for aquaculture feeds - Diversification and innovation in products and services are currently accessible - Great scope for synergic horizontal and vertical integration - Invertebrates are very efficient bio-convertors of waste - All regions need to invest in a circular economy, reducing impact and improving waste management - There are good prospects for cooperation from the local to the macro-regional level - Advance in any related field related to bio-economy strengthens the others	- it may be cheaper and easier to produce in non-EU countries - previous scandals and unethical practices may drive consumers not to favour aquaculture - recycling waste may cause health and security concerns - artificial selection of invertebrate species may affect natural populations

Success factors

- There is a growing international market for invertebrate protein in aquaculture feed
- New EU legislation encompasses the use of insect protein in aquaculture feeds
- Invertebrate production for aquaculture feeds can be industrially connected to better waste management, natural resource diversification and environmental services.

Bottlenecks

- Research is a major obstacle as trials within research institutions are too costly
- Grant aid for this type of research is not sufficient
- End users should put more demands on the fish feed producer to use invertebrate protein
- There should be specific grants for innovation separate from start-up grants
- Sustainable feed is a bottleneck for sustainable aquaculture production
- In Spain, fish farms producers are not in favour of including insect protein in fish feeds.

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Challenges to tackle

- There is a consistent lack of awareness of the potential to use invertebrates such as insects to enhance the fish feed production industry, this is reflected in EU policy and at regional level.
- New sources of protein need to be developed to be used in aquaculture feed to allow for sustainability in to the future
- End users i.e. aquaculture producers need to become more aware of the potential use of protein from invertebrates as an alternative to fish meal. This could have significant cost savings as the prices of fish meal continue to rise commensurate with availability
- The reluctance of the market to incorporate non-traditional raw materials (such as protein from invertebrates) in the nutritional chain
- As current EU legislation on the use of insects in aquaculture feed is transposed into to national law, caution must be employed to ensure that restrictions are not implemented that are not reasonable
- National policies do not include invertebrate protein as a potential ingredient for fish feed
- Investment in innovation often requires IP protection more akin to high-end products, but not to bulk feed ingredients.

Collective ranking	Issue	Stakeholder agreement
1	New sources of protein need to be developed for a sustainable aquaculture	%
2	Innovation often requires IP protection more akin to high-end products, but not to bulk feed ingredients	%
3	National policies do not include invertebrate protein as a target ingredient for fish feed	%
4	Integrated systems at local to regional scale are scarce	%
5	Aquaculture producers need to understand the benefits of protein from invertebrates as an alternative to fish meal	%
6	Reluctance of market to incorporate non-traditional raw materials in the nutritional chain	%
7	Transposition of EU legislation on the use of insects in aquaculture feed into national law without addition of unreasonable restrictions	%
8	New feed ingredients need ensure enough quantity and quality to be used in aquaculture	%
9	Alternative models beyond mere bulk and cost are needed	%
10	Seed investment is needed for small SMEs, smart procurement and replication projects	%
11	Organic standards need to be defined for invertebrate production	%

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12	Aquaculture needs to be better integrated in regional and societal models	%
13	More consumer and industrial support is needed	%
14	Suitable waste needs to be defined and rendered available	%

Research needs

- Affordable and quality substrates
- Marine invertebrates, both micro (e.g. copepods for larval stages) and macro (e.g. amphipods and annelids replacing insects in marine food chains)
- Integrated systems at local to regional scale
- Processing, including suitability of live feeding certain species for enrichment and enhancement at critical phases.
- Selection and improvement
- Feed production and formulation, from nutritional balance to palatability
- Acceptance: market and opinion studies including producers, retailer and consumers.
- Diversification
- Potential impact of novel fisheries (e.g. Krill and copepods) on the marine environment

1	Processing of invertebrates for aquafeeds faces several technical hurdles like blackening (enzymatic browning, such as PPO oxidation)	%
2	Marine invertebrates, both micro (e.g. copepods for larval stages) and macro (e.g. amphipods and annelids replacing insects in marine food chains)	%
3	Processing, including suitability of live feeding certain species for enrichment and enhancement at critical phases	%
4	Affordable and quality substrates	%
5	Selection and improvement	%
6	Feed production and formulation, from nutritional balance to palatability	%
7	Acceptance: market and opinion studies including producers, retailer and consumers	%
8	Potential impact of novel fisheries (e.g. Krill and copepods) on the marine environment	%
9	Optimisation and small volume techniques need to be developed for remote regions	%
10	Mobile marine production plants to cater offshore industry	%
11	Reusability of biofouling organisms in aquaculture and infrastructures	

Obstacles

- The cost of patents is prohibitive for start-up businesses

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- Patents do not protect IP as all information is made publically available which hinders the advancement of the industry as companies are not willing to get patents and hence are not seen by large investors as bone fide ventures
- The requirement for a licence to handle waste
- The cost of waste
- The quality of waste
- Approval of waste types that can be used
- Consumer preconception
- Traceability
- Competition with Asian and north American industries
- Toxicity of insects through bioaccumulation, deficiencies in amino acids or fatty acids, chitin content, palatability, digestibility

1	Research is a major obstacle as trials within research institutions are too costly	%
2	Grant aid for this type of research is not sufficient	%
3	End users should put more demands on the fish feed producer to use invertebrate protein	%
4	There should be specific grants for innovation separate from start-up grants	%
5	Sustainable feed is a bottleneck for sustainable aquaculture production	%
6	In Spain, fish farms producers are not in favour of including insect protein in fish feeds	%
7	Affordable, stable and quality substrates for insect production	%
8	The cost of organic by-products and waste	%
9	The quality of organic by-products waste	%
10	Approval of organic by-products waste types that can be used	%
11	The cost of patents is prohibitive for start-up businesses	%
12	Patents do not protect IP as all information is made publically available which hinders the advancement of the industry as companies are not willing to get patents and hence are not seen by large investors as bone fide ventures	%
13	The requirement for a licence to handle waste	%
14	The cost and quality of waste	%
15	Approval of waste types that can be used	%
16	Consumer preconceptions	%
17	Traceability	%
18	Competition with Asian and north American industries	%
19	Toxicity of insects through bioaccumulation	%
20	deficiencies in amino acids or fatty acids, chitin content, palatability, digestibility	%

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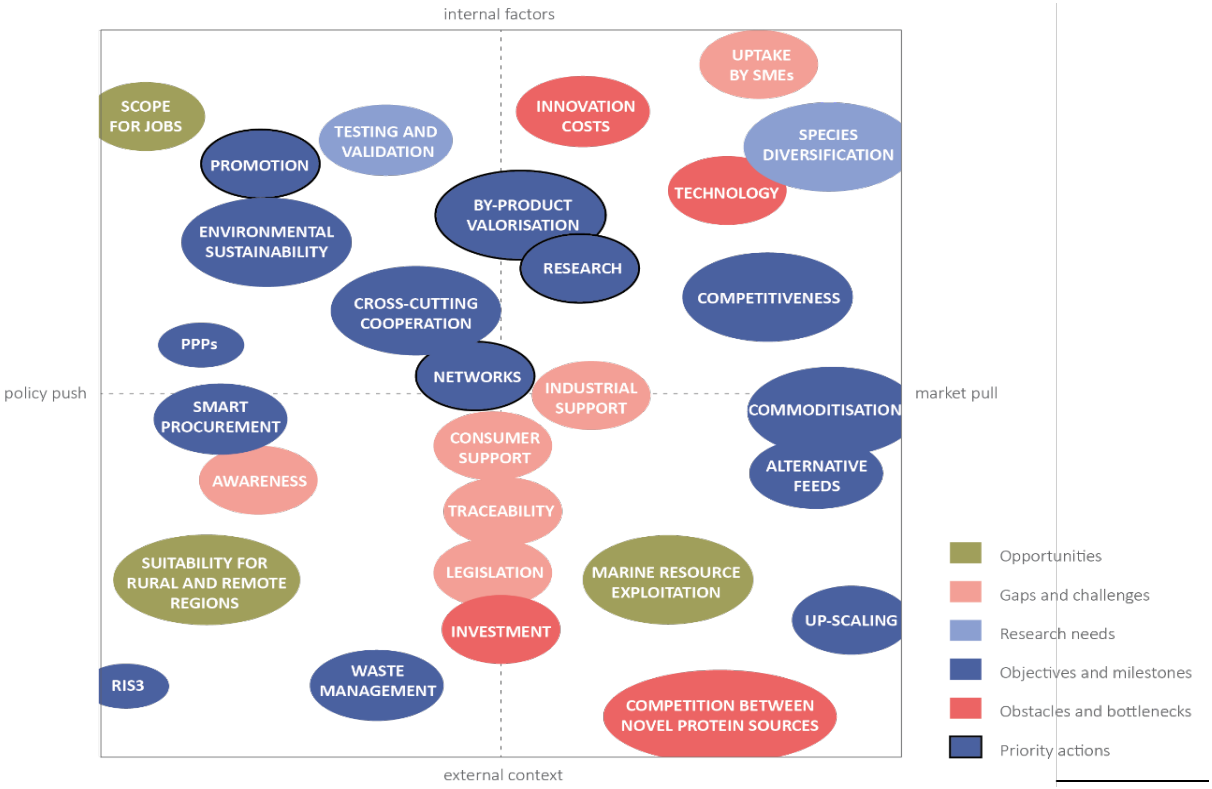

Figure 6 Map of issues requiring attention for the exploitation of invertebrate-based aquaculture feeds

In this section we review the main gaps, challenges and research needs as perceived by INvertebrateIT consortium partners and consulted stakeholders. Gaps are defined as voids in social, market and policy landscapes that are perceived to be accessible for action, but not necessarily urgent nor critical. Challenges are necessary transitions for which no clear or certain methodology is known, and therefore prove difficult or risky. Research needs are instrumental and well identified knowledge and technology shortages.

Perceptions cover three separate issues at once:

- as regards the production of insects for aquaculture feeds and their uptake by industry
- as regards the production of marine invertebrates for aquaculture feeds and their uptake by industry
- as regards public –private cooperation to promote the production of invertebrates for aquaculture feeds and complementary services in the EU Atlantic

Objectives and milestones

Objectives are here considered as specific results that are necessary and currently a priority. Milestones are a more general but conditional achievements, allowing for successive planning phases.

Main objectives and milestones

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1	Demonstrate commercially viable SME ventures	%
2	Set up PPPs to promote invertebrate production in EU Atlantic regions	%
3	Increase awareness fro SMEs, investors, administrations and consumers	%
4	Up-scale production	%
5	Diversify species (marine) and products	%
6	Promote regional cooperation and clustering	%
7	Improve breeds: development and growth, environmental requirements, nutritional profile	%
8	Improve products: nutritional balance, palatability…	%
9	Targeted communication campaigns	%
10	Smart public procurement schemes for remote regions	%

Stakeholders

The charts below show an initial assessment of stakeholders for the delivery of invertebrate-based solutions for EU aquaculture in the medium term (2-5 years).

Figure 8 Stakeholders assessment: Capacity Vs Support

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Figure 9 Stakeholders assessment: Influence Vs Relevance

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A Roadmap for the EU Atlantic

This Road Map aims at capitalising on the knowledge of Cluster organisations and business networks in collaboration with innovation/research entities, regional/national authorities and all relevant stakeholders to identify the needs and development opportunities for a medium to long-term (5-10 years) in the EU Atlantic Basin. Equally, this Road Map intends to set out the necessary actions and milestones to achieve INvertebrateITs' objectives and coordinate and pool investments for its implementation. In order to do so, strategic policy, business intelligence and environmental sustainability will be deeply embedded into the Joint Vision and Road Map, affecting ensuing business models.

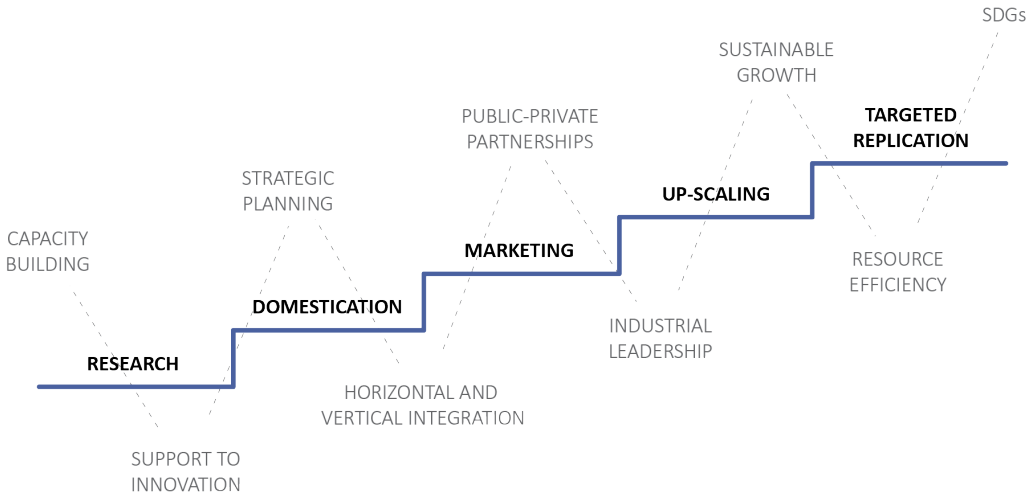

Figure 10 Model strategy for the achievement of the partial and end results promoted by INvertebrateIT

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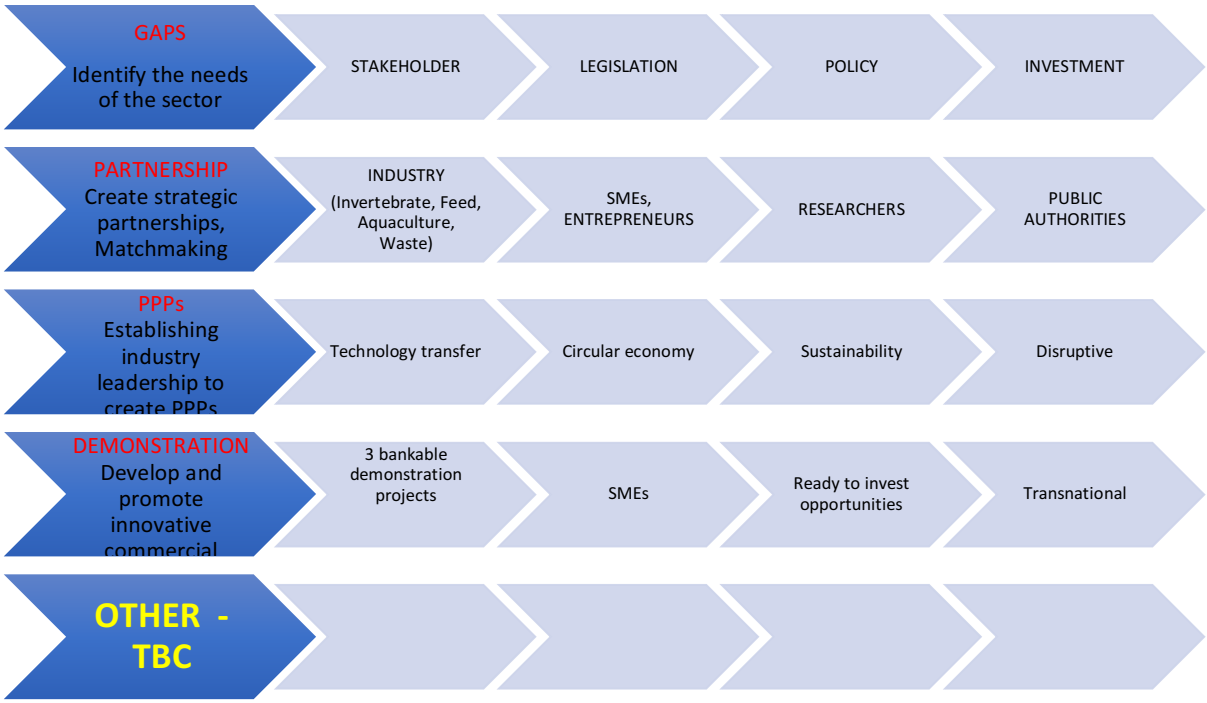
Overall strategy

- Enhance awareness of the potential of this industry approach both food fish feed development and also waste management
- Raise the level of engagement of stakeholder to promote this industry
- Influence policy and legislation, national and EU
- Create new opportunities for technology advancement
- Develop networks to promote the progress of this industry
- Harness and use waste effectively, efficiently and safely in the food chain



Priority actions

- Enhance awareness of the potential of this industry approach both food fish feed development and also waste management
- Raise the level of engagement of stakeholder to promote this industry
- Influence policy and legislation, national and EU
- Create new opportunities for technology advancement
- Develop networks to promote the progress of this industry
- Harness and use waste effectively, efficiently and safely in the food chain

Expected results

The main results and specific achievements expected from the project are:

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- Increased awareness
- Critical mass and visibility
- Collaboration across sectors and borders
- Mapping of funding opportunities
- Long-term strategic partnership
- Capacity building of three demonstration projects
- PPPs for pilot project implementation

Creation of a long-term strategic partnership

Objectives

- Targeted Stakeholders
- MoU
- Beyond the project lifetime

INvertebrateIT aims at capitalising on the knowledge of Cluster organisations and business networks in collaboration with innovation/research actors and regional/national authorities to conduct a thorough and strategic sectoral analysis of needs and development opportunities for a medium to long-term (5-10 years) in the EU Atlantic Basin. INvertebrateIT intends to set out the necessary actions and milestones to achieve these objectives and coordinate and pool investments for its implementation. In order to do so, strategic policy, business intelligence and environmental sustainability will be deeply embedded into the Joint Vision and Roadmap, affecting ensuing business models.

INvertebrateIT will bring together industry, research centres and local/regional authorities. As such, the project will capitalise on their expertise in joining and engaging different types of stakeholders for a joint and strategic vision.

The consortium will be strategically enlarged by engaging other relevant stakeholders from the EU Atlantic Basin Member States, namely cluster organisations, business innovation networks, research and innovation entities and public stakeholders active in Sustainable Aquaculture for Blue Growth with particular focus on invertebrate production and waste management, Circular Economy and the implementation of RIS 3 or other existing related strategies. Additional partners will be invited to join the strategic partnership by signing a Memorandum of Understanding (MoU) (Appendix 1), committing themselves to support the development of the Joint Vision and Roadmap and Investment Plan, facilitate its dissemination and/or implementation or provide the strategic partnership with information or resources that contribute to promote and exploit the production and use of invertebrates for fish feed for a more competitive aquaculture and waste management in the EU Atlantic Basin. In return, the partners of the strategic partnership will:

- Be consulted for specific activities
- Be informed about the project's progress and be invited to activities
- Be put in contact with other relevant stakeholders of the EU Atlantic Basin active in the area of their interest, responding to the lack of collaboration and need for more transnational collaboration and synergies in the Basin.

In order to ensure the long-term sustainability of the strategic partnership, the MoU will include a specific clause referring to the extension of the commitment to the development of the Joint Vision and Roadmap and Investment Plan beyond the execution of the project. These efforts will make sure

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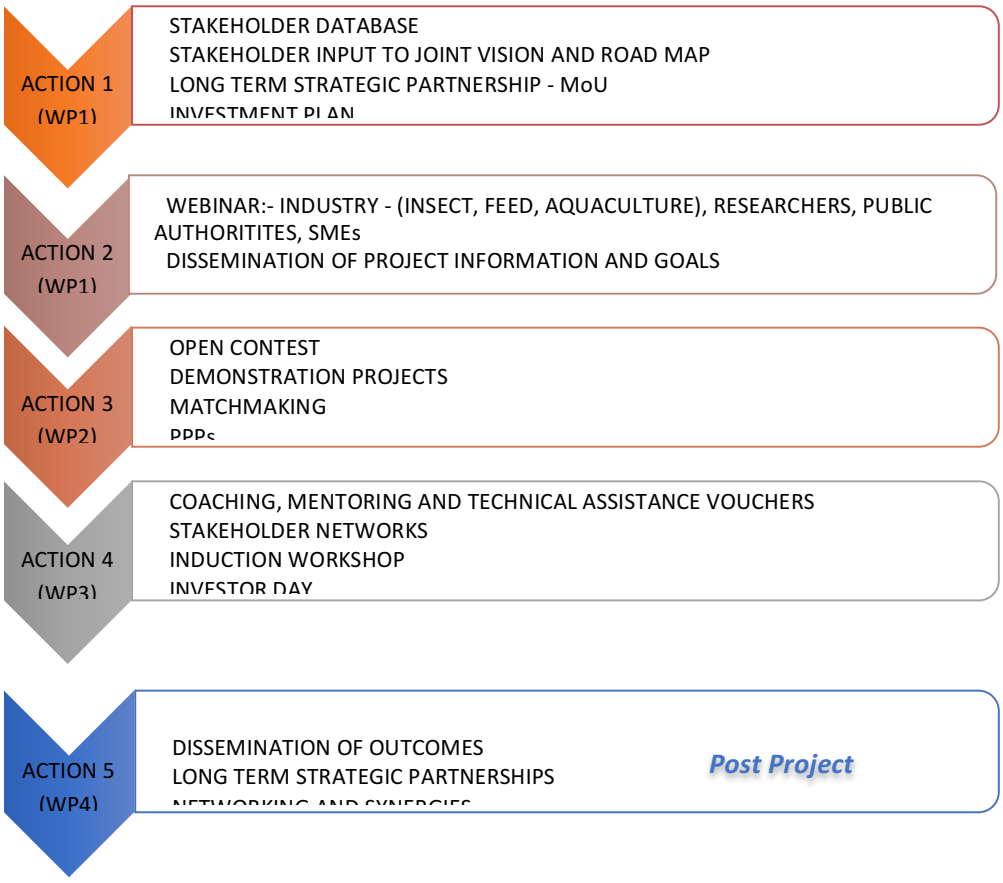
that the partners and their stakeholders continue to advance along the core principles of INvertebrateIT (invertebrate production, sustainable aquaculture and organic waste management), leading to the mentioned "virtual cluster of excellence" in the EU Atlantic region, and in collaboration with Norway.
Furthermore, a "Sustainability Committee" will be formed. During a period of 1 year beyond the project, 6-monthly virtual meetings will be organised by the Sustainability Committee and the partners of the strategic partnership will be invited to participate in order to do the follow up of the progress and to analyse potential synergies with other projects and EU initiatives in the same field.
To ensure the dissemination of the roadmap beyond the project and the access of the stakeholders to the results of INvertebrateIT, the project website will be maintained active for 1 year after the end of the project

Action plan



Milestones

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Database	Expand database of stakeholders
Information Gathering	Feedback from strategic partners and stakeholders
MoU	Circulation and completion
Webinar and workshop	Expand and validate Joint Vision and Road Map and Investment Plan
Joint Vision and Road Map	Finalise and publish
Demonstration Projects	Open contest, 3 secured demonstration projects
PPPs	Networking and brokerage event
Capacity Building	Coaching, mentoring and technical assistance
Investors Day	Stakeholder networks

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Investment Plan

For millions of people around the world, fisheries and aquaculture remain a vital resource for food, nutrition, employment and income. Several reports have recently been published by international organizations, experts or companies, and all point to the considerable contribution that oceans and inland waters can and especially will in the future bring to food security and nutrition for a global population expected to reach 9.7 billion by 2050.
In order to meet this challenge, international community made commitments in September 2015 by adopting the 2030 program with 17 objectives of sustainable development. The objective #14 is linked to oceans: conserve and sustainably exploit oceans, seas and marine resources for sustainable development.
The FAO launched in 2013 its initiative "Blue Growth". With it, FAO will help countries to develop and enforce programs for Blue Growth and Blue Economy. The "Blue Economy" concept focuses on conservation and sustainable management. It is based on the principle that healthy aquatic ecosystems are more productive and are essential for sustainable economies.

In Europe, the same observation is made: **aquaculture is a major response to the food and environmental challenges of the twenty-first century**. Since 2009 the European Commission has declared its willingness to give a new impetus to the strategy for the development of European aquaculture [38]. With its financial instruments, European Union supports Research and Development for aquaculture to become a high-performance, more efficient, more integrated, more sustainable, and therefore less energy-consuming or water-consuming sector. Despite its efforts European aquaculture does not progress because Chinese competitiveness is strong (China produces 60 percent of global volumes versus 4 percent for European Union). European Union must highlight its excellence. The European aquaculture sector represents today 85 000 direct employments and involves 14 000 enterprises (Small and Medium Enterprises for the majority) and with innovative projects thousands employments are predictable.

In the future, aquaculture should grow up : increase of production, development in new environments (multi trophic aquaculture, offshore activities), and insertion of innovative breeding techniques that will be more resource efficient. One of the innovation tracks is the feeding of fish. Today the diet of the main species of farmed fish in Europe and in the world still relies mainly on fishmeal and fish oil from industrial fisheries. However, dependence on these ingredients, whose production is limited and prices pulled up by rising demand, can compromise the economic and environmental viability of the aquaculture sector. In order to meet the growing demand for fish without reliance on fish meal fishery, the European Commission wants to develop aquaculture while preserving its sustainability. In order to secure the future and enable the development of aquaculture in Europe, a number of

[38] Communication from the Commission to the European Parliament and the Council - Building a sustainable future for aquaculture - A new impetus for the Strategy for the Sustainable Development of European Aquaculture {SEC(2009) 453} {SEC(2009) 454} /* COM/2009/0162 final */ http://eur-lex.europa.eu/legal-content/FR/TXT/?uri=CELEX:52009DC0162.

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accompanying measures are needed. To support these initiatives, it is interesting to identify the means that support changes and innovation in this field. The associated partners of the INvertebrateIT project collected data about public and private funds in their respective countries. A focus has been made on programs linked to aquaculture and to circular economy.

Analysis of funding opportunities

International Level

Main opportunities regarding public funds are available through transnational partnerships. As for example, the initiative managed by the ERA Net Cofund *(European Research Area Network)* supports collaborative projects between Europe and Africa. This tool is funded by the European Commission. There are several bilateral initiatives at international level depending on the fact that countries have signed or not collaborations agreements. Eg. France and Québec/Canada.

There are other funding possibilities with private funds like World Business Angels Association or dedicated funds for aquaculture projects like Aquaspark. There are also international crowdfunding initiatives and NGOs for ocean's world like Ethra Fund.

European level

There are several interesting programmes. The most interesting one is the Horizon 2020 dedicated to Research and Innovation, with a specific focus for Blue Growth.

- ***Horizon 2020*** [39]

Horizon 2020 is the biggest EU Research and Innovation program ever with nearly **€80 billion of funding available over 7 years (2014 to 2020)** – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas **from the lab to the market**. This is the Europe's global competitiveness. By coupling research and innovation, Horizon 2020 is helping to achieve this with its emphasis on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. **Horizon 2020 is open to all organisations.** Three types of projects are eligible: **Research and Innovation Action** (RIA), **Innovation Action** (IA), **Cooperation and Support Action** (CSA).

- ***ERDF Interreg***

European Territorial Cooperation (ETC), better known as Interreg, is one of the two goals of cohesion policy and provides a framework for the implementation of joint actions and policy exchanges between national, regional and local actors from different member states. The overarching

[39] https://ec.europa.eu/programmes/horizon2020/

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objective of this program is to promote a harmonious economic, social and territorial development of the Union as a whole. The fifth programming period of Interreg (2014-2020) has a **budget of € 10.1 billion.**

The INTERREG program is indeed strongly linked to territorial issues. Therefore, the EU commission has defined different INTERREG programs linked to geographical areas. Regarding the implementation of the partner countries of the INvertebrateIT project (Spain, France, Portugal, Ireland and the Netherlands), we will target the most interesting of these INTERREG programmes that depend on specific geographical areas.

- **Interreg Atlantic Area** program[40] supports transnational cooperation projects, contributing to the achievement of economic, social and territorial cohesion of 37 Atlantic regions from five countries: the western part UK**, the northern and southern westernmost part of Spain, western France, Ireland and Portugal.** The **total budget** for this program **is € 185 million.** Projects are supported up to 75% ERDF. For the first time and the first call launched end 2016, this program has been also opened to private actors. Four priorities are targeted: Innovation and competitiveness, Resource efficiency, Risks of natural climate and human origin, biodiversity, natural and cultural assets. This program is open to: National, regional or local public bodies; education and research institutions; not-for-profit organizations; private companies; and international, transnational and cross border organizations.

- **Interreg North-West Europe** program[41] has the ambition to make the North-West Europe area a place with high levels of innovation, sustainability and cohesion. The total budget is € 370 million from the European Regional Development Fund (ERDF) for activities based in eight countries: Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland and the United Kingdom. Projects are supported up to 60% ERDF. The priorities selected for the 2014-2020 period mainly address smart and sustainable growth: Innovation : Helping enterprises innovate ; Low carbon: Supporting the shift towards a low carbon economy in all sectors and promoting sustainable transport ; Resource & materials efficiency: New ways to produce more value with fewer materials. Any organisation, public or private, can participate.

- **Interreg Europe** program[42] helps regional and local governments across Europe to develop and deliver better policy. By creating an environment and opportunities for sharing solutions, it aims to ensure that government investment, innovation and implementation efforts all lead to integrated and sustainable impact for people and place. Any actions developed with financial support from Interreg Europe must fall

[40] http://www.atlanticarea.eu/
[41] http://www.nweurope.eu/
[42] http://www.nweurope.eu/

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

into one of the following four categories: Research and innovation, SME competitiveness, Low-carbon economy, Environment and resource efficiency. The program is open to: Public authorities – local, regional and national, managing authorities/intermediate bodies - in charge of the Investment for Growth and Jobs programmes or European Territorial Cooperation, Agencies, research institutes, thematic and non-profit organisations. Organisations that work with Interreg Europe must also be based in one the 28 EU Member States, Switzerland or Norway. Projects are supported up to 85% ERDF for public entities and 75% for private ones.

- **Interreg SUDOE:** supports regional development in the South-western part of Europe. It promotes transnational cooperation to respond common issues, such as low investment in research and development, weak competitiveness of the small and medium-sized enterprises and exposure to climate change and environmental risks. Total budget is 141 million euros. The projects approved are based on public and/or private partnerships. The eligible regions are all the Spanish Autonomous Communities (except Canary Islands), the Southwestern regions of France (Auvergne, Nouvelle Aquitaine, Occitanie), all continental regions of Portugal, United Kingdom (Gibraltar) and the Principality of Andorra. The projects approved focus on one of the Programme's five priority axis, identified as the areas on which transnational cooperation has strongest impact in the context of Southwest Europe: Research and innovation, Competitiveness of SMEs, Low-carbon economy, Combating climate change, Environment and resource efficiency. All partners can be supported up to 75% ERDF of the eligible expenses.

- Other **crossborder INTERREG programmes** can be available, as for example the Channel program (France-England) enabling the northern western part of France to collaborate with Southern England. 2 types of tools are available: large projects (ERDF 69%) and micro-projects dedicated to SMEs and associations (ERDF 80%)

  - ***Eurostars***

Eurostars is a joint program between EUREKA and the European Commission designed to strengthen R&D-performing small and medium-sized enterprises (SMEs). The Eurostars program is supported by 36 Eurostars Participating States and Partner Countries. It is open to all SMEs, regardless of branch of industry, sector or technology area. The objective of the Eurostars project must be to develop a new product, process or service. This tool is transversal but addresses RTD performing SMEs (definition: at least 10% of the turnover is dedicated to R&D). The project has to be led by an SME. Regarding the grant, it depends on the different rules implemented in the partners countries contributing to the EUROSTARS tool. As for example, in France, SMEs are granted 40%, while Research partners will be limited to 100k€.

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

- ***EMFF*** [43]

European Maritime and Fisheries Fund[1] is one of the five European Structural and Investment Funds supporting the economic recovery of Europe until 2020. This is the biggest fund dedicated to fishing and aquaculture and this is the dedicated tool for the EU commission regarding the implementation of the Fishing and Aquaculture policy. Part of the fund is directly allocated to countries depending on their needs and lobby to participate in the fund (see repartition in the following table). Each country has to implement a dedicated managing and follow-up strategy of the allocations.

Sustainable aquaculture is the second priority (21 % of the fund) to make the sector more successful and competitive by focusing on quality, health and safety, as well as eco-friendly production; and to provide consumers with high-quality, highly nutritional and trustworthy products. The total budget of the fund is **€ 8.6 billion** (European Union + National) including Euros 6.4 billion by European Union contribution. This European contribution allocated in total from 2014-2020 is distributed between: 11% managed by the EU to support EU-wide objectives in maritime and coastal affairs: international governance, cooperation through exchange of informations and best practices, public information and support to networking platforms, marine knowledge, maritime spatial planning ; 89% managed by the member states, divided amongst EU countries, the fund are used for: reducing impact of fishing on the marine environment, more market tools for professionals and consumers, joint stewardship of protected areas and Natura 2000 sites, special support to small-scale fisherman.
The repartition is: 4.3 billion€ for sustainable fisheries, 580 million€ for control and enforcement, 520 million € for Data Collection and € 71 million for Blue Economy.
The beneficiaries are: Fisheries and aquaculture operators, professional organization, Fishery Local Action Group (FLAGs), Scientific/technical Public Law Bodies, Advisory Councils, and NGOs in partnership with fishermen or FLAGs, SME.

Country	Total budget and budget for aquaculture projects	Contribution of EU
Spain	**€ 1,5 milliard** **€ 205 million for aquaculture (13 %)**	**€ 1,1 milliard (amount 74 %)**
Portugal	**€ 506 million** **€ 59 million for aquaculture (~10 %)**	**€ 390 million (amount 77 %)**

[43] https://ec.europa.eu/fisheries/cfp/emff_en

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France	**€ 774 million** **€ 88 million for aquaculture (~11 %)**	**€ 587 million (amount 75 %)**
Ireland	**€ 239 million** **€ 30 million for aquaculture (~12 %)**	**€ 147 million (amount 60 %)**
The Netherlands	**€ 128 million** **€ 4, 9 million for aquaculture (~4 %)**	**€ 100 million (amount 78 %)**

For the first time in France, the initiative has been made by the State to allocate a part of the fund to the maritime regions.

- **Bio Based Industry Joint Undertaking (or BBI JU)**[44]

The BBI JU is a public-private partnership between the **European Union and the Bio-based Industries Consortium (BIC)**. BIC is an association established in 2012 to represent the private sector partners in the Joint Undertaking. It is host to a unique mix of sectors that currently include agriculture, agro-food, technology providers, forestry pulp and paper, chemicals, energy and end-users. The total budget is €3.7 billion investments in bio-based innovation from 2014-2020: €975 million of EU funds (Horizon 2020) and €2.7 billion of private investments. The objectives of the proposed JTI on bio-based industries are to :
- Demonstrate technologies that enable new chemical building blocks, new materials, and new consumer products from European biomass, which replace the need for fossil-based inputs
- Develop business models that integrate economic actors along the value chain from supply of biomass to biorefinery plants to consumers of bio-based materials, chemicals and fuels, including through creating new cross-sector interconnections and supporting cross-industry clusters; and
- Set-up flagship biorefinery plants that deploy the technologies and business models for bio-based materials, chemicals and fuels and demonstrate cost and performance improvements to levels that are competitive with fossil-based alternatives.

BBI JU organises **yearly calls** for proposals to support research, demonstration and deployment activities enabling the collaboration between stakeholders along entire value chains, covering primary production of biomass, processing industry and final use. It is open to academic or non-academic sector (including enterprises like SME) organisations established in a Member state or associated country. 3 types of actions are eligible for the call of proposals: Research and Innovation Actions, Innovation Actions and Coordination and Support Actions.

At macro-regional Level

For the analysis, several elements were taken into account :
- The national context for aquaculture with data about aquaculture (production, consumption …)

[44] https://www.bbi-europe.eu/

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- Public and private funds existing in the country
- A SWOT (*Strengths / Weaknesses / Opportunities/ Threats*) analysis applied to aquaculture (actors and financing).

SPAIN

Spain is the major aquaculture producer´s in Europe (289.821 t), however if the production value (first sale) is considered Spain ranks fourth with 407,2 million euros. **Mussels are the main production**, if mollusc are taken into account; however if we focus on fish, sea bass production reaches 225.307 t, followed by sea bream (16.231 t), rainbow trout (16.179t) and turbot (10.007t). **In 2015, 5,129 aquaculture farms were operating and producing in Spain**, which means that the aquaculture industry employs around 18.000 people and over 45.000 of indirect employment. **Regarding the consumption of feed, in 2016, 121,000 tonnes were used. 83.1% was administered to marine fish and 16.9% to inland species.**
In 2016, **the Spanish consumers spent a 13.25 % of their total food cost** on aquatic products; spending 202.44 euros per capita and consuming **25, 49 kg per person per year**. Spanish Government has develop an ambitious long-term Strategic Plan for the Spanish Aquaculture 2014-2020 which aims to increase not only the volume of aquaculture production but also the employment and the value of this product.

i. Public funds

*In Spain, **eight public initiatives** are available to support projects in aquaculture:*

- *European Maritime and Fisheries Fund (EMFF)*
- *European Regional Development Fund (ERDF) Atlantic Area Transnational Programme*
- *INTERREG Atlantic Area (ERDF), INTERREG SUDOE*
- *SME Initiative (ERDF)*
- *EIP-Agri (Rural Development Programes - FEADER)*
- *Technological Fund (PID projects) (ERDF)*
- *Technological Fund (FEDER-Innterconecta) (ERDF)*
- *Biodiversity Foundation*

- ***EMFF***

The allocated budget for Spain is **205 million€ for aquaculture**. **The national contribution is 68 million€ (18 % of EMFF allocation**). The main fishing and aquaculture regions are Galicia, and then Andalusia and Basque Country.

Eligible projects: The funds will go to achieving the objectives of the Spanish national strategic plan for aquaculture (PEAE) that aims at boosting the competitiveness and sustainability of the Spanish aquaculture sector. Actions will aim at minimising the environmental impact of production processes (such as re-circulation systems, closed-loop systems and offshore aquaculture); improving spatial planning by mapping sites suitable for aquaculture; and fostering technological innovation and investment capacity of aquaculture businesses.

Localisation: National and regional

This fund is managed by the Agriculture, Food and Environment Ministry.

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

- ***European Regional Development Fund - Atlantic Area Transnational Programme***

This Programme supports entrepreneurial and innovation networks, marine sustainability, transnational synergies and regional development and technical assistance. Projects are chosen following yearly calls for proposals.
Eligible projects: They must be collaborative projects.
Budget available: €140 million. Cofinancing rate: up to 76% depending on the field.
Beneficiaries: Public or Private entities in the target regions.
Localisation: Regional

- **INTERREG Atlantic Area (ERDF)**

This Programme supports innovation and Competitiveness, resource efficiency, resilience, biodiversity and natural assets. Projects are chosen following yearly calls for proposals.
Eligible projects: They must be collaborative projects.
Budget available: €185 million. Cofinancing rate: 75%
Beneficiaries: Public or Private entities in the target regions.
Localisation: Regional

- **SME Initiative (ERDF)**

This Programme supports SME competitiveness, access to regional, national and international markets and innovation. Projects are chosen following ongoing calls for proposals.
Eligible projects: They must be collaborative projects. Duration: up to 3 years
Budget available: €800 million. Cofinancing rate: up to 100%
Beneficiaries: SMEs
Localisation: National

- ***EIP-Agri (Rural Development Programmes - FEADER)***

This Programme supports resource efficiency, bioeconomy, biodiversity, environmental services, innovative products and services and consumers.
Projects are chosen following ongoing calls for proposals.
Budget per project up to 100.000€. Cofinancing rate: between 50%-100%
Beneficiaries: public and private sector.
Localisation: National and regional
This fund is managed at national level by the Rural Development National Programme and at regional level by the respective Rural Development Regional Programmes.

- ***Technological Fund (PID projects) (ERDF)***

This Programme supports technological cooperation at an international level.
Projects are chosen following ongoing calls for proposals.
Minimum budget per project 175.000€. Duration : between 12-36 months.
Beneficiaries: companies
Localisation: National

- ***Technological Fund (FEDER-Interconecta) (ERDF)***

This Programme supports general projects (no thematic is restricted). Projects are chosen following bi-annual calls for proposals.
Budget per project between €1 million-€4 million. Duration : between 2-3 years.

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Beneficiaries: SMEs and large companies
Localisation: Regional (Andalucía, Asturias, Castilla La-mancha, Extremadura, Galicia, Murcia, Ceuta and Melilla)

- **Biodiversity Foundation**

This Programme supports biodiversity, climate change and sustainable development. Projects are chosen following ongoing calls for proposals.
Eligible projects: Budget per project between 55.000€ and 72.000€ depending on the field. Projects 12 months.
Budget available: €2 million. Cofinancing rate: between 70%-90%
Beneficiaries: Non profit associations, public research center
Localisation: National

ii. Private funds

- Business angels at national, regional and local level
- Crowdfunding
- Keiretsu Forum España
- Banks

iii. SWOT Analysis

Strengths		**Weaknesses**	
Actors	**Aquaculture** - Ideal environmental (aquatic) conditions - Main EU production and consumption market - Great interest in innovation and diversification - World leadership in alternative fish species like turbot, sole, meagres… -Complete production cycle -Good attitude of entrepreneurs towards R&D activities. - Established commercial channels. - Financial profitability.	*Actors*	**Aquaculture** -Reduced business sector to undertake intensive improvement programs. -Required specific training. -Sector dominated by bivalve growers, and tuna, seabass and gilthead farms mainly in the Mediterranean
Financing	EMFF Fund dedicated to aquaculture, andmanaged at national, regional and local level.	*Financing*	-Few financing opportunities targeting only aquaculture projects (EMFF). -Access to SMEs -Funding depends on national and regional operational programmes that are complex and time-consuming to approve
Opportunities		**Threats**	

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Actors	**Aquaculture** -Optimum natural environment to develop aquaculture. -Possibility to develop new aquaculture species, including marine invertebrates. -Strong tendency of consumption towards a "healthy diet". -World food crisis: Extractive fishing insufficient. -Existence of a long-term Strategic Plan for the Spanish Aquaculture 2014-2020. -Good connections with existing ventures in blue biotechnology and algal production -Excellent marine, coastal an on-land conditions for invertebrate production and aquaculture -Some areas (e.g. Canary Islands) combine excellent conditions with weak self-sufficiency, which could favour integrated systems at local level. -Growing concerns about water availability could favour production of insects and sea water species	*Actors*	**Aquaculture / Insect producers** -No planning regarding land use. -Lack of an updated legal aquaculture framework. -Slow administrative procedures. -Lack of specialized financial instruments for aquaculture. -Rejection of new protein sources by the population. -Competition with aquaculture products imported from third countries. -Intense competition for coastal space
Financing	-Several financing opportunities open to SMEs and Research centers. - Possibilities of collaborative project between SMEs and research center.	*Financing*	-Less public funds in the coming years

FRANCE

National context for aquaculture

In the world, aquaculture is in constant progression but in France this sector suffers from societal acceptance, from difficulties to access land and sea, from administrative delays… It should also be noted that for the last 20 years, no marine aquaculture enterprise has been inventoried. But November the 8th 2017, an enterprise obtained the authorization to put in a farming of trouts combined with algae in Brittany.
The demand for aquatic products is growing strongly, reaching **34 kg per person per year in France**. **France imports 86 % of its consumption from other countries** without guarantee about farming conditions (social, environmental, feed…).
France is **the second sea zone in the World** but it represents **only 0.2 percent of aquaculture activity**. There are also research organizations and training centers in the front line of progress in aquaculture (algae, crustaceans, mollusks, fish…). These key factors with funding opportunities suited to project can enable France to develop aquaculture on its territory. **Aquaculture industry is small in France (550 sites and around 400 enterprises SMEs for the majority) but it is involved in Research and Quality.** Compared to other regions of the world, it puts in place more controls: traceability from breeding to stall, incoming ingredients in fish feed, food security, rearing conditions, and authorized products. Professionals in the sector have put in place common specifications with a quality charter

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"aquaculture of our regions" and it should also be noted that the sector is already strongly committed to a sustainable development approach.

i. Public funds

In France, five public funds could be used to finance projects in aquaculture:
- 2 European funds that are managed by the member states: European Maritime and Fisheries Fund (EMFF) and EUROSTARS.
- 3 national and public funds: Fond Unique Interministériel (FUI), National Agency for Research (ANR) and Public Agency/Bank for Investment (BPI France).

- **EMFF**

The allocated budget for France is € 588 million for "sustainable development of fisheries, aquaculture, and coastal areas dependent on these activities". If we compare this budget to the previous period, it's an increase of seventy percent. The budget is shared between France, its regions and departments *(Local Development lead by local actors = DLAL*).
Eligible projects: 36 months; max € 1.5 million for eligible expenditures
Beneficiaries: Fisheries and aquaculture operators, professional organization, Fishery Local Action Group (FLAGs), Scientific/technical Public Law Bodies, Advisory Councils, NGOs in partnership with fishermen or FLAGs, SME.
Localisation: National, regional and local

- **EUROSTARS**

See paragraph "European level" . This fund is managed by each member state and own regulations.

- **Fonds Unique Interministériel (FUI)**[45]

The FUI is a national initiative created under the national policy for R&D Clusters in France. It supports collaborative applied-research projects to develop products, processes or services likely to be placed on the market in the short or medium term, usually five years. Projects are chosen following a one or twice-yearly calls for proposals. They must be certified beforehand by one or more competitiveness clusters.
Eligible projects: They must be collaborative and innovative, which means they involve at least two companies and one research or training center. Projects must be led by a company, 18-36 months, 1.5-6 millions €.
Beneficiaries: companies (all size), research or training center.
Localisation: National (ex. the project **NINAQUA**[46] for new formulations in feed for aquaculture

- **Agence Nationale de la Recherche (ANR)**[47]

ANR provides funding for project-based research in all fields of science - for both basic and applied research - to public research organisations and universities, as well as to private companies (including SMEs).
Beneficiaries: public research organisations and universities, private companies (including SMEs).

[45] http://competitivite.gouv.fr/les-financements-des-projets-des-poles/les-appels-a-projets-de-r-d-fui-375.html
[46] https://pole-mer-bretagne-atlantique.com/fr/ressources-biologiques-marines/project/2423
[47] http://www.agence-nationale-recherche.fr/

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Localisation: National

Example of project: **DESIRABLE**[48]; insects: alternative resources for animal food?

- **BPI France**[49]

The Public Investment Bank (BPI) is a public group in the service of the financing and development of companies, and acts in support of the policies implemented by the State and the Regions. Aimed at supporting sustainable growth, employment and competitiveness of the economy, the BPI:
- promotes innovation, creation, development, and internationalization, transfer/buy-out of companies, by contributing to their financing through loans and equity financing;
- preferentially focuses its action on small and medium-sized businesses and intermediate-sized businesses, with a special focus on the industrial sector;
- invests prudently to finance long-term projects;
- supports national industrial policy, to support development strategies for industrial sectors;
- contributes to the development of growth sectors, conversion to digital technology and the promotion of a socially responsible economy; …

Beneficiaries: companies (all size)
Localisation: national

ii. Private funds

- Business angels at national, regional and local level :
  - National
  - Regional : Breizh angels (federation of Armor Angels, Bretagne Sud Angels, Finistère Angels and Logoden.
  - Local : Finistère Angels (Biotechnology and health, Digital and softwares, electronic, industry, Invest from 100 to 500 k€
- Crowdfunding :
  - National : **Miimosa** (Beekeeping, Aquaculture & Fisheries, Alcoholic beverages, Soft drink, Breeding, Salty groceries, Sweet groceries, Horticulture, Innovation, Nature & Environment, Dairy products, Viticulture projects) **; Bluebees** (a crowdfunding platform serving the ecological transition) ; and others not specific platforms like Ulule, …
  - Regional (Brittany): Kengo, Gwenneg
- Private investment Fund :
  - National : Some targeted example : **Atalaya** (ACE management, Fisheries and aquaculture, naval construction, Research and development in the physical and natural sciences, food, nutrition, boating, naval, SMEs in the maritime and marine sectors, intervention from 500 000 to 2 millions of euros) ; **Alter equity 3P** (Activity with a positive impact on the environment and people, enterprises with a turnover

[48] http://www.projet-desirable.fr/
[49] http://www.bpifrance.fr/

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of more than 1 million of euros, a strong potential for profitable growth, example of enterprise : Innovafeed.

- ➢ Regional : **Go Capital Amorçage** (West of France : Normandie, Brittany and Pays de la Loire, fields of health and medical, technologies (hardware and software), digital and innovative services, companies with strong growth potential, intervention from 200 000 to 4 millions of euros).
- ➢ Local

➢ Banks

iii. SWOT Analysis

Strengths		**Weaknesses**	
Actors	**Aquaculture** - Ideal environment (second sea zone in the World) -Not many actors but organised in aquaculture channel with a quality and traceability charter *"aquaculture of our regions".* -Adapted trainings. -Research and development centers with global recognition (like Ifremer). -Good perception for "Made in France" **Insect producers** Several enterprises (>= 10) Many actors engaged for fish feed (for examples Ynsect, and Innovafeed)	*Actors*	**Aquaculture** -For the last 20 years, no marine aquaculture enterprise has been inventoried -Most are small producers (SMEs) but there are also some large groups. -Diversity of actors (fish/mussel/oyster/seaweed producers) and diversity of interest. **Insect producers** -SMEs: too small and not enough funds to industrialize or touch the international market. -Pet food market : Market prices are low for a high production cost -Several strategies for insect producers : . pet food market : in order to prepare facilities before opening of human food market In France *(ex : Ynsect)* . .export: because human food with insects in France is not authorized (waiting for Novel Food rule *(ex: Innoprotea or Jimini's).*
Financing	-EMFF Fund which is dedicated to aquaculture, and which is managed at national, regional and local level -regional initiatives like SMIDAP	*Financing*	-Not many financing opportunities targeting only aquaculture projects (EMFF). -Access for SMEs to financing

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Opportunities		Threats	
Actors	**Aquaculture** -An enterprise obtained the authorization to put in a farming of trouts combined with algae in Brittany (2017/11/08). -Strong market demand for aquatic products but not enough production in France. -Circular economy and co-activities like fish and algae or fish and insects. **Insect producers** -Authorisation for use of 7 insects in aquaculture feed in European Union (July 2017). -Big market and little competition	*Actors*	**Aquaculture / Insect producers** -Different constraints: environmental (Natura 2000 areas), sanitary -Acceptability by populations? : . for fish fed with insect meals . for aquaculture farms offshore or onshore -Administrative delays for projects and also financing - Competition with other marine activities -Competition with aquaculture products imported from third countries. -Fish diseases and parasites
Financing	-Several financing opportunities open to SMEs and Research centers. .Possibilities of collaborative project between SME and research center.	*Financing*	-Less public funds for next years

IRELAND

National context for aquaculture

Within the EU, aquaculture production has stagnated with little to no growth over the last 10 years. Member states, including Ireland have recognised the unsustainable position that the EU is in, with regards to seafood supply. Under the National Strategic Plan for Sustainable Aquaculture Development, Ireland has targeted future growth from aquaculture as a major priority over the remainder of this decade. It is a relatively diverse sector encompassing a substantial shellfish farming element, combined with a significant finfish element. After mussels (50%) Ireland's largest aquaculture product is Atlantic salmon at 36% of the total production, 16,300t. Freshwater trout makes up 1.6% of production with a tonnage of 705t[50].

There are currently 850 licensed operations in Ireland, covering 2000 sites. The number of active enterprises engaged in marine aquaculture has remained stable with a total of 292 enterprises currently trading[51]. Aquaculture in Ireland contributes to providing over 1,900 jobs, the majority of which are in rural communities, providing a vital source of employment and economic activity.

[50] Annual Aquaculture Survey 2017. BIM.

[51] Sustainable Development in Irish Aquaculture 2016, National Econmonic & Social Council

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The opportunities for growth in Ireland's aquaculture sector are evident, with a green image and reputation for quality foods, both the industry and research organisations are focused towards the development of a smart, green and clean image. In order for the Irish aquaculture to achieve future growth, it is important that the industry continues to innovate and incorporate the latest technology to improve production

i. Public funds

- **EMFF**

Project Category	Maximum support rate	Maximum Support amount
1. Industry Projects	50%	€200,000
2. Collective Projects	75%	€200,000
3. Public Projects	100%	€300,000

The Total Budget for Ireland is €239,265,133, with €30 million (12% of the total allocation) proposed to support the Irish National Strategic Plan for Aquaculture that aims at boosting the competitiveness of the aquaculture sector. Support will go towards three main areas: sustainable aquaculture production; knowledge, innovation and new technology; and more effective governance of marine planning[52].

Beneficiaries: Individual aquaculture enterprises, Collectives of aquaculture enterprises, Public bodies, BIM service projects

Localisation: National, regional and local

Example of project: Over €3 million in funding provided to aquaculture projects including, Upgrade of mussel handling facilities, Investment in oyster handling machinery, Private research on high-value bio-active compounds from seaweed, Public research on integrated multi trophic aquaculture[53]

- **Horizon 2020**

Running from 2014 to 2020 with a budget of just over €70 billion, Horizon 2020 is the EU's new programme for research and innovation and is part of the drive to create new growth and jobs in Europe. Horizon 2020 is a core part of Europe 2020 the Innovation Union and the European Research Area and is responding to the economic crisis to invest in future jobs and growth, addressing people's concerns about their livelihoods, safety and environment and strengthening the EU's global position in research, innovation and technology. Ireland is well positioned to benefit from Horizon 2020, building on our excellent performance in the last EU programme for research and development, the Seventh EU Framework Programme (FP7).

[52] http://www.bim.ie/schemes

[53] https://www.agriculture.gov.ie/press/pressreleases/2017/september/title,111270,en.html

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

Localisation: National

Example of project: ParaFishControl[54]

· **Innovation Partnership Programme**

The Innovation Partnership Programme[6] encourages Irish-based companies to work with Irish research institutes resulting in mutually beneficial co-operation and interaction. Companies can access expertise and resources to develop new and improved products, processes, services, and generate new knowledge and know-how.
Enterprise Ireland Innovation Partnership Programme provides grants of up to 80% towards eligible costs of the research project. Funding from Enterprise Ireland will normally not exceed €200,000. It is open to a manufacturing or internationally traded services company with an operating base in the Republic of Ireland. Must collaborate with one or more research institutes also based in the Republic of Ireland.
Eligible projects: Research work between companies and research institutes, in order to provide a new product, process or service. 6 months up to a max of 2 years.
Beneficiaries: A manufacturing or internationally traded services company with an operating base in the Republic of Ireland that wishes to collaborate with one or more research institutes, also based in the Republic of Ireland, is eligible to participate. The company must be a registered client of one of the following state development agencies: Enterprise Ireland, IDA Ireland, Local Enterprise Office (LEO), Údarás na Gaeltachta.
Localisation: National

. **EUROPEAN INNOVATION PARTNERSHIPS**[55] -Department Agriculture, Food and Marine

EIPs are a new source of EU funding, which will allow local groups and rural communities to access funding for innovative projects across the agri-food sector. The range of projects supported will be flexible. Successful projects will develop ideas, or take existing ideas or research and put them into practice. Improve productivity, enhance resource efficiency and pursue sustainable farming practices, The objectives of the EIPs are to:

- Increase efficiency in energy use in agriculture and food processing.
- Facilitating the supply and use of renewable sources of energy, of by-products, wastes and residues and of other non-food raw material, for the purposes of the bio economy.

A fundamental rule of EIPs is that a supported project shall be grant aided to promote forms of co-operation involving at least two entities
An overall funding package of €24 million has been set aside to support EIPs.
Localisation: National
Beneficiaries: farmers, scientists, advisors, NGOs and others

[54] http://www.parafishcontrol.eu/

[55] https://www.agriculture.gov.ie/press/pressreleases/2017/august/title,110732,en.html

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

· **Regional Enterprise Development Fund 2017-2020**[56]

The Scheme will support major new collaborative and innovative initiatives that can make a significant impact on enterprise development in the region/across regions or nationally to build the unique USP capabilities to grow the regions, ("the Projects"). This will be achieved by co-financing the development and implementation of collaborative and innovative projects that can sustain and add to employment at a national, regional and county level.

Eligible projects:

The Scheme has four streams:

- **Stream One** to support major regional, multi-regional or national sectoral initiative grants of €2m up to €5m per project in funding towards capital and current costs. These initiatives should be focussed on achieving defined enterprise development outputs and impacts.
- **Stream Two** to support significant county, regional or multi-regional sectoral and or enterprise initiative grants of €250k up to €2m per project in funding towards capital and current costs. These projects should be focussed on delivery of defined enterprise development outputs and impacts.
- **Stream Three** for local and community enterprise initiative grants of €50k up to €250k per project in funding towards capital and current costs. These projects should be focussed at a local, county or regional initiatives that have defined metrics for enterprise development in the area.
- **Stream Four** to support significant Industry Clustering initiatives with grants of €50k up to €250k per project in funding towards current costs. These projects should support industry-led groups to maximise the benefits of collaborative opportunities where the results of the activity will have some identifiable and measurable impact on their business.

Feasibility Grant. A feasibility grant of €22,500 or 50% of eligible costs, whichever is lesser, can be offered to candidates who are successful in this competitive call. The fund is to help promoters investigate the viability of the project and prepare final submissions for consideration.

Beneficiaries: To be eligible all applicants must be registered as a Designated Activity Company, (DAC) or a Company Limited by Guarantee, (CLG) under the Companies Act 2014. Applicants can be promoted by private or public organisations, which for example might include: Higher Education Institutes, Semi State Commercial bodies, Local Enterprise Development Groups, Local Authorities

In addition, Industry Clusters must comprise of at least five companies. ***Localisation***: Dublin and Mid-East, South-East, Midlands, South, Mid-West & Kerry, West, North-West, North-East

ii. Private funds

- Ireland AgTech Fund (Partnership between Ireland Strategic Investment Fund and AgTech group Finistere Ventures)[57]
- Business Angels[58]

[56] https://www.enterprise-ireland.com/en/start-a-business-in-ireland/information-store-for-start-ups/regional- enterprise-development-fund.html

[57] http://finistere.com/ireland/

[58] https://www.enterprise-ireland.com/en/Invest-in-Emerging-Companies/Source-of-Private-Capital/Business-Angels-BES,-Angel-Networks-.html

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. Through Enterprise Ireland, Intertrade Ireland and the Business Innovation Centres
. Seed capital Fund[59]
. AIB Seed Capital Fund
. AIB Start-up Accelerator Fund
. Bank of Ireland Early Stage Equity Fund
. Bank of Ireland Start-up and Emerging Sectors Equity Fund
. IDA Research, Development & Innovation[60]
. Western Development commission Investment Fund[61]

iii. SWOT Analysis

Strengths		**Weaknesses**	
Actors	**Aquaculture** -Nutrient rich waters -Global recognition as a leading producer of organic species -Environmentally sustainable production techniques -Established production capabilities -Technically advanced systems -Experienced operators with proven track record	*Actors*	**Aquaculture** -Complex Environmental requirements leading to delays in licensing process -Insufficient investment in R&D -Insufficient product availability to meet market demand -Limited business planning for smaller operations
Financing		*Financing*	-Lack of private investment
Opportunities		**Threats**	
Actors	**Aquaculture** -Global demand for high-quality seafood -Off-shore aquaculture sites -Underutilised aquaculture sites -Novel species and niche products -Cost/efficiency benefits for consolidation -Employment potential in coastal communities	*Actors*	**Aquaculture** -Fish diseases and parasites -Co-existence with other marine activities -Public-opposition to industry -Spatial restrictions on aquaculture activities to protect Natura 2000 designated species and habitat -Increased competition from companies outside the EU -Climate change -Impact on aquaculture due to eutrophication of marine water

[59] https://www.enterprise-ireland.com/en/Invest-in-Emerging-Companies/Source-of-Private-Capital/Seed-Capital-Funds.html
[60] http://www.irdg.ie/research-development-innovation-programme/
[61] http://www.wdc.ie/wdc-investment-fund/

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Financing	-Use of Financial Instruments to leverage resources	*Financing*	-Lack of access to finance

PORTUGAL

National context for aquaculture

Although Portugal is one of the largest consumer of fish in the world (56,7 kg per capita), the weight of national aquaculture in the supply of fish to the Portuguese market is still very low. In a European context, the aquaculture in Portugal is a relatively recent primary activity whose productions have fallen short of the expectations created upon the entry of Portugal into the EU. In the 90's, the aquaculture production in Portugal was limited to two species, trout and clams. An important issue was the decrease in the abundance of the main commercial resources, and loss of fishing opportunities in areas traditionally operated by the fleet. In return, an accelerated increase of aquaculture activities has been observed and there is now a significant production of various species of fish and bivalves and a strong growth and modernisation of aquaculture of marine species[62]

Brackish and marine waters on the mainland (data for 2014): 1521 licensed establishments of which 1450 are active. Of these, 1343 are nurseries, 85 tanks, 21 floating structures and 1 hatchery. Most are family-owned production units. In 2014, the national aquaculture production was 10,791 tons, generating a revenue of 50.3 million euros. Production in brackish and marine waters continues to be the most important, corresponding to around 93% of total production. The production of fish in brackish and marine waters represents 48% of the production, the great majority (91.0%) being turbot and seabream. The bivalves represent 45% of the total production, the clams being the most relevant species, followed by mussels[63]

Floating structures and the possibility of using new technologies for offshore aquaculture, for production of fish and bivalves, are helping to alleviate some pressure on traditional production areas closer to the coast, where aquaculture competes with other economic activities, and is also less subject to environmental impact.

i. Public funds

- **Mar 2020**

To achieve the strategic objectives and priorities, MAR 2020, the Operational Programme for the European Maritime and Fisheries Fund (EMFF) in Portugal for 2014-2020 has an overall allocation of EUR 508 million, of which EUR 392 million corresponds to the EMFF and EUR 116 million to the national counterpart.

62 Plano Estratégico para a Aquicultura Portuguesa, 2014-2020

63 Plano Estratégico para a Aquicultura Portuguesa, 2014-2020

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Eligible projects: Variable; 30-100% maximum support depending on the beneficiary.

Beneficiaries: Depending on the typology, Research or Technical Centres (public or private); SMEs from the aquaculture sector, producers organizations or associations; single or collective persons.

Localisation: National, regional and local.

- **Fundo Azul/Blue Fund**

The Blue Fund is a financial mechanism established by the Government of Portugal, managed directly by the Minister of the Sea, to enhance the development of the blue economy, support scientific and technological research, promote the protection and monitoring of the marine environment and increase maritime safety**.** The Blue Fund is open for the establishment of financial partnerships with national and international public and private bodies. These arrangements facilitate the scaling-up of industrial investments, since it opens a wider range of financing solutions with better conditions, like access to European Investment Bank credit.

Eligible projects: Depending on the typology, the applications submitted through a consortium and which include business sector partners shall be favored, as well as start-up with services and/or products on technological maturity scales close to commercialization.

Beneficiaries: All types of entities, both private and public.

Localisation: National.

- **EEA Grants 2014-2021**

Under the EEA Agreement (through the Financial Mechanism of the European Economic Area 2014-2021), Iceland, Liechtenstein and Norway are part of the European internal market. The EEA Agreement sets out the common goal of working together to reduce social and economic disparities in Europe and strengthen cooperation between European countries. Iceland, Liechtenstein and Norway contribute to this through the EEA and Norway Grants. For the period 2014-2021, Portugal will receive a total contribution of EUR 102.7 million and a substantial part of this funding, EUR 38.0 million is earmarked for efforts to promote Blue Growth (Programme Blue Growth Innovation and SMEs).

Eligible projects: Depending on the typology, priority shall be given to bilateral partnerships offering added value.

Beneficiaries: The EEA Grants will focus on SMEs, prioritizing the support for profitable business solutions that promote positive environmental impacts, innovation initiatives and science endeavors.

Localisation: National.

ii. Private funds

- Business angels at national, regional and local level (e.g. Invicta Angels, Portugal Ventures

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- Venture Capital
- *Mermaid Investments*, and investment partner for seed and early-stage phase, focused on SMEs from the maritime economy sectors, with a scientific and technological basis.

iii. SWOT Analysis

Strengths		**Weaknesses**	
Actors	**Aquaculture** - Growing domestic and international demand for fish - Nutrient rich waters and good environmental status - Sustainable production techniques - The existence of research centres to support to the sector - Organisation of the sector: Portuguese Association of Aquaculture - National Strategic Plan for Aquaculture 2014-2020	*Actors*	**Aquaculture** - Small economic sector - Most companies are small family business with weak management and innovation capacity; some big players having a dominant position - Complexity of the licensing process of new units (but efforts have been made to improve the process) - Taxing is too high regarding the average size of the companies - Insufficient product availability to meet market demand - Constraints on the conditions of the open sea coast - No scale regarding insect producers
Financing	- EMFF/FEAMP - with a set of measures to support the sustainable development of aquaculture - National Operational Programme "Mar 2020" (establishes the financial support regulations for the aquaculture sector from the EU funds)	*Financing*	- Barriers to access credit

3. General Analysis

The sector of aquaculture in the European Union and more particularly in the five partner countries, benefits from environmental ideal conditions (Atlantic coasts) and a large number of actors (producers, research centers) on the whole value chain. these countries also benefit from

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a great Research (universities, research labs, …). The territories are aware of the necessity to a sustainable exploitation of the biomass, and therefore consider the approach of circular economy and of co-activities.
There are great opportunity to innovate in the domain, among them the exploitation of algae (large number of project at EU-level) and the production/use of insects for fish feeding (since July, 2017). Several firms have been created at international level and offer food based on proteins of insects to feed fish, mainly in France (more than 10 firms), but also in Spain and in the Netherlands.

A dedicated public programme for fishing and aquaculture activities exists: the EMFF (European Maritime and Fisheries Fund). The allocated budgets are differently distributed between European countries. Spain is the main beneficiary (€ 205 million for aquaculture).

Private funds are becoming more important but remain difficult to access, regarding other attractive domains and lack of competitiveness for aquaculture activities.

On the other hand there is a large range of financing programmes in Europe (Horizon 2020, Interreg, Eurostars, and Bio Based Industry Joint Undertaking) which deal with several general themes like innovation, environment resources efficiency, biodiversity.

In the different countries according to their strategical roadmap and policy, funding trends differ from each others.

Opportunities exist: new interests in healthy food and feed, awareness and opportunities in new biosources for proteins/lipids … (microalgaes, insects …), environmental issues (good sentinel), digitalization, better exploitation and more added-value.

But threats remain: environmental and health pressures (Natura 2000), risks of diseases (parasites), social acceptance regarding new planification for aquaculture, consumption of fish fed with insects, climatic impact, administrative delays for plans and financings.

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Conclusion

Aquaculture is called to supply an increasing world population with food, and to do so ensuring quality and sustainable products, contributing to manage marine resource wisely.

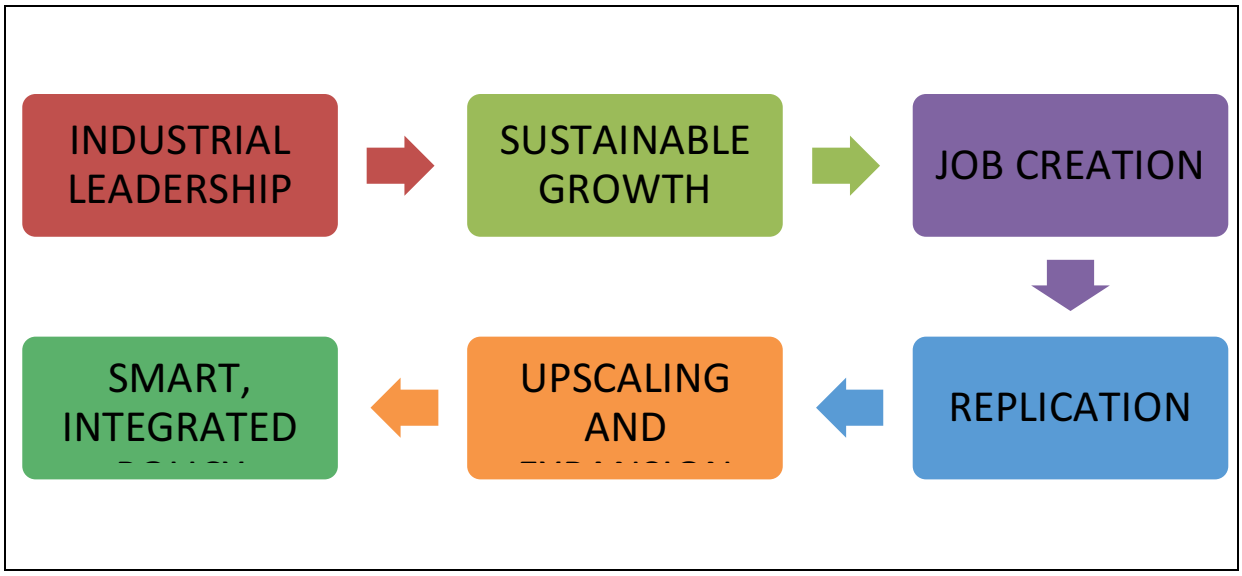
Invertebrates are part of the natural diet of fish, specially in larval stages, supplying essential nutrients. Invertebrates, both insects and incresingly marine species, can be produced in a very efficient way, with the potential of helping to manage waste from aquaculture farms and other organic residue. New technology and adapting legislation now allow to mass produce invertebrates, both in industrial and semi-traditional ways, and to process them into nutritive, reliable, durable and cost-efficient alternatives. Invertebrates can be used to complement, reduce or replace fish feed ingredients, in line with other promising sources such as algae and yeasts. These sustainable sources are called to reduce the importance of wild fishmeal and vegetal sources like soja, and their potential is untapped.

More awareness is needed to engage stakeholders (resarch, aquaculture, investment...) as well as consumers, in order to foster more research, new ventures and successful market applications. To do that, both public and private funding is needed, as well as increased collaboration across sectors and regions.

The main results and specific achievements expected from the project, including a set of KPIs, are:

- Increase awareness to exploit invertebrate production for Blue Growth and the Circular Economy
- Build up critical mass and visibility, “occupying” a new industrial niche
- Develop 3 demonstration projects and set up PPPs

Outcomes



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Appendices

Appendix 1

http://invertebrateitproject.eu/

DRAFT

Memorandum of Understanding for a

Competitive and Sustainable Aquaculture Strategic Transnational Partnership

1. Preamble

WHEREAS the Parties - as key stakeholders in the field of aquaculture activities – have agreed to develop a joint roadmap at sea basin level and collaborate through various means (events, initiatives, projects, etc…) that promote and exploit the value chain of production of invertebrates, for sustainable fish feeds, competitive aquaculture and integrated waste management; and

WHEREAS the parties have access to facilities, subject matter experts, scientific research, professional workforces, world-class universities and investment capital and contacts, and are - in some cases - creating or supporting incubators in their respective regions to support companies in the field of aquaculture; and

WHEREAS collaboration between the Parties would increase access to markets (nationally and internationally) further expand the opportunity for innovation, technology transfer, business development and shared resources; and

WHEREAS the Parties recognize the importance of creating a common vision and intend that this strategic alliance will enable the Parties to achieve greater visibility and impact through open dialogue, reciprocal assistance, cross promotion and sharing of new ideas, initiatives and opportunities in an expeditious manner; and

WHEREAS the Parties believe that the signing of this Memorandum of Understanding, hereinafter referred to as the MoU, will create a framework for joint actions to inspire businesses, academia and government from the representative regions to further collaborate.

NOW, THEREFORE we are announcing through this MoU that each Party will provide mutual assistance, when and however reasonably feasible, to create, advance, support and promote developments in the framework of a joint roadmap as described hereinafter.

2. Mission

This project has received funding from the European Union's EASME programme under Grant Agreement no. EASME/EMFF/2016/1.2.1.3/02/SI2.751532.

The mission that concerns the Parties aims at establishing a Strategic Transnational Partnership for Competitive and Sustainable Aquaculture at Atlantic Sea Basin level. In particular, this partnership will focus on invertebrate production and waste management, circular economy and the implementation of RIS 3 or other existing related strategies. To do so, a joint roadmap will be developed and will identify both strategic challenges related to (1) the production and use of invertebrates for fish feed and (2) the use waste management in the EU Atlantic Basin.

Overall, this Strategic Transnational Partnership should promote sustainable investment and growth of the knowledge-based aquaculture sector, to the mutual benefit of all Parties, through active regional, national and international collaboration. The Parties to this agreement will work together in identifying areas of the joint roadmap where they can share information, collaborate on research and development initiatives, and jointly pursue business development opportunities.

3. Objectives

The Competitive and Sustainable Aquaculture Strategic Transnational Partnership aims to:

- promote and exploit the value chain of production of invertebrates for sustainable fish feeds, competitive aquaculture and integrated waste management
- manage waste to produce valuable animal proteins, integrating this towards more diversified and resilient aquaculture value
- further transfer capacity and technology from aquaculture and insect production towards RTD with other suitable new marine invertebrates (e.g. amphipods) and new growing substrates (e.g. algae and seafood by products)
- gather key stakeholders from the public and private sectors (SMEs) to share knowledge and expertise
- provide a strategic joint vision and roadmap that identifies common challenges in line with regional/EU priorities at the Atlantic Sea Basin,
- contribute to the short and medium terms development of commercial solutions and industrial compliant with both EU legislation and market opportunities,
- promote and inform about strategic investment (public and private)
- improve the sustainability and competitiveness of EU aquaculture, and its connection to a wide array of potential synergies in equally disruptive subsectors

4. Scope

The Competitive and Sustainable Aquaculture Strategic Transnational Partnership will promote collaboration across key stakeholders in their relevant sector of activities including in particular:

- Innovative and sustainable Feeds for aquaculture
- Use of fish waste

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- Compliance with regulation
- Fish food production and end product manufacturing

The Competitive and Sustainable Aquaculture Strategic Transnational Partnership will aim to achieve its objectives by undertaking or catalyzing the following range of activities:

- Develop and promote active, mutually beneficial collaborations at business-to-business, business-to-university and cluster-to-cluster levels involving best available capabilities amongst the Parties
- Each Party is encouraged to maintain an inventory of projects and facilities within their sector(s), drawing data from all Parties, and using a common metadata structure.
- To the extent of funding being available, facilitate exchange of personnel between Parties (e.g. via internships, work experience) to deepen inter-cluster (or inter parties) understanding and levels of cooperation
- Exchange experience of successful interventions to encourage each party to adapt and adopt practices demonstrated to be effective and access channels to equity capital
- Exploit the credibility and brand value of each Party to create a compelling critical mass of capabilities across the Blue Economy, to underpin a common vision to promote the industry via media and to elected officials
- communicate position s to national/ international agencies and/or policy managers and/or decision makers
- strengthen the case for investment in each Party' s projects and more generally promote interest in investment in sustainable aquaculture and in the Blue Economy in general to create Blue Jobs
- Maintain interaction and coordination between the Parties by means of regular, scheduled conference calls (e.g. biannually) to plan activities, coordinate event calendars and schedule visits.

5. Governance

The MoU is a statement of intent and nothing herein shall be construed as creating any legal relationship between Parties and the Parties agree that this agreement is not enforceable in law in any jurisdiction.

The Parties agree that they are responsible for maintaining confidentiality of any information provided by another Party that is designated in writing as confidential subject to practice/laws in respective jurisdictions.

The Parties acknowledge and agree that IP developed by one or more of the Parties or arising from projects or activities undertaken by one or more of the Parties may be subject to terms and conditions of funding terms and/ or contracts applicable to such research or projects. The Parties

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acknowledge and agree that IP owned by a Party will remain their sole property unless appropriately agreed in writing and subject to practices, terms and conditions of funding agreements, policies and laws within respective jurisdictions.

In the event that one of the party decides to progress activities that require expenditure beyond voluntary support provided by the different parties, it may elect to request the introduction of a subscription fee for all Parties. This would require the unanimous agreement of all parties to the MoU. This MoU implies no financial obligation on the Parties beyond the commitments in the project agreement.

This MoU has an initial duration of 2 years from its launch, which will be the date on which the first parties have signed the MoU. Any Party may withdraw from the MoU upon 90-day written notice to the other Parties, which will not impact the continuation of this partnership.

1. Signatures

For	INNOGATE to EUROPE (PT)	**By** Title Date	
For	Marine Institute (IR)	**By** Title Date	[representative name] [dd-mmm-yy]
For	Pole Mer Bretagne Atlantique (FR)	**By** Tit le Date	[representative name] [dd-mmm -yy]
For	TQC (France)	**By** Title Date	[representative name] [dd-mmm -yy]
For	Forum Oceano (PT)	**By** Title Date	[representative name] [dd-mmm-yy]

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For	AQUA TT (UK)	**By**	[representative name]
		Title	
	_____	Date	[dd-mmm-yy]
For	NGN	**By**	[representative name]
		Title	
	_____	Date	[dd-mmm-yy]
For	CETGA	**By**	[representative name]
		Title	
		Date	[dd-mmm-yy]
For	STAKEHOLDER 1	**By**	[representative name]
		Title	
		Date	[dd-mmm-yy]
For	STAKEHOLDER 2	**By**	[representative name]
		Title	
		Date	[dd-mmm-yy]
For	STAKEHOLDER 3	**By**	[representative name]
		Title	
		Date	[dd-mmm-yy]
For	STAKEHOLDER …	**By**	[representative name]
		Title	
		Date	[dd-mmm-yy]
For		**By**	[representati ve name]
		Title	
		Date	[dd-mmm-yy]

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