Northern Periphery and Arctic Programme
2014-2020

EUROPEAN UNION
Investing in your future
European Regional Development Func

SYMBIOMA

Technology Innovations and Business Models for Valorisation of Industrial Waste Biomass in Sparsely Located Enterprises

Circular economy cases and their business models in Irish fish industry

Dr. Ehiaze Ehimen, Dr. Leo Murray

Contents

1 Fish industry in Ireland

The clean, unpolluted waters around Irelands 7,500 km coastline contain some of the most productive fishing grounds and biologically sensitive areas in the EU. In 2018, the overall fishing opportunities (i.e. Total Allowable Catches (TACs) species) for stocks to which the Irish fleet has access to, were reported to be 1.3 million tonnes of fish, with an estimated landed value of €1.37 billion. Ireland's total share of these TAC's (2018) amounted to 215,511 tonnes with a value of € 222 million. In its Food Harvest 2020 report, the Irish Government outlined plans to double the value of Ireland's ocean wealth from all marine commodities to 2.4% of GDP by 2030 and increase the turnover from its ocean economy to exceed €6.4 billion by 2020.

The main activities in the Irish seafood industry are:
Fishing – Eight out of eleven of its finfish fishing ports are in Ireland's NPA region including Irelands top fishing ports Killybegs, Castletownbere and Dingle.

Fish farming – Aquaculture activity includes growing finfish, such as salmon and trout and shellfish farming, including the cultivation of mussels, oysters and scallops. Currently, 27 of its 32 aquaculture sites are located in Ireland's NPA region.

Processing – Seafood companies produce high-value products from salmon, whitefish, shellfish and pelagic fish species (e.g., herring, mackerel and horse mackerel) all of which generate substantial export earnings to the sector.

The industry is broadly divided into two main classifications:
Finfish: Comprising Demersal fish which live on or near the seabed (e.g. cod, haddock, hake, plaice) and Pelagic fish found in mid waters or near the surface (e.g. mackerel, herring, salmon).

Shellfish: Broadly divided into Molluscs (eg. mussels, oysters, scallops) and Crustaceans (e.g. prawn, shrimp, crab and lobster).

The 'Functional Foods' sector, through the development of new high added-value products using fish as a carrier for pro-biotics or health supplements has facilitated the establishment of niche markets and ancillary income from by-products that exist beyond the purely nutritional content of the fish.

Most animal by-products of fish origin in Ireland are classified as Category 3 under the Animal By-product (ABP) regulation which includes:

- Fish material that is not destined for human consumption
- Finfish by-products arising from processing activities (excluding mortalities)
- Shellfish that have been previously fit for human consumption but have now passed their shelf life

Additionally, many seaweed species grown in Irish waters which were commercially used as a raw material in the production of high-volume, low-value commodities (animal feed and raw material for alginate production) has witnessed an increased acceptance as a fast growing mineral-rich sea crop that can produce high-quality, high-value products for use in the cosmetic, pharmaceutical and human nutrition industries including Vitamin B12, omega-3 fatty acids and trace minerals.

Despite the excitement about seaweed's commercial potential as the next big thing in Irish food production, plans to develop a sizeable seaweed industry has been slow to become reality due to a variety of factors, most notably changes to licencing laws and constraints in technology.

The issue of marine plastics is particularly pertinent to Ireland. The fisheries sector is heavily reliant on plastic (for fishing gear, aquaculture equipment, fish crates, packaging, etc.). Due to its rot-proof nature, plastic have proved extremely effective in the marine environment. However, it is also a non-biodegradable material, made from fossil fuels, that can wreak havoc on marine ecosystems. A circular Economy approach to introducing better end-of-use systems by recycling plastics for gear such as fishing nets has witnessed up-cycling and net re-working enterprises cropping up around the country as a means to creating additional revenue streams in coastal communities. This has included the development of different types of biodegradable-compostable nets, obtained by extrusion melt spinning process (one-step process), for shellfish harvesting and packaging products.

Expanded Polystyrene (EPS), a closed-cell single-polymer foam used for both packaging and insulation purposes is widely used in the fish processing industry as it has proven to be the most cost-effective and efficient way of transporting fish over long distances. The Irish state agency tasked with the responsibility for developing the Irish marine fishing and aquaculture industries, Board Iascaigh Mhara (BIM)- Ireland's Seafood Development Agency has been working with primary producers, co-ops and processors to address major waste streams stemming from both marine plastics and EPS by conducting national research into the area of fish box EPS usage and disposal in Ireland, and to devise EPS recycle business models to encourage the development of alternative sustainable fish packaging solutions.

Likewise, many shellfish farmers are implementing strategies that will see them realise by-product opportunities as a result of the chemical composition of their waste shell accumulations. Value proposition exists in the potential for the Oyster's principle chemical component calcium carbonate ($CaCO_3$), (96%) to be repurposed into by-products for use across multiple sectors including eg. Bio-filtration & agricultural products for eutrophication control of soil pH to counteract calcium deficiencies, chicken feed, landscaping products, to hydroxyapatite synthesis (high value) potentials such as nutritional/health supplements and reagents to produce thermoplastic elastomer (TPE). What makes it innovative is its ability to produce the highest purity by comparison to mined limestone powder of other types of shells with less acid insoluble material and a more superior texture perception (see also Figure 1).

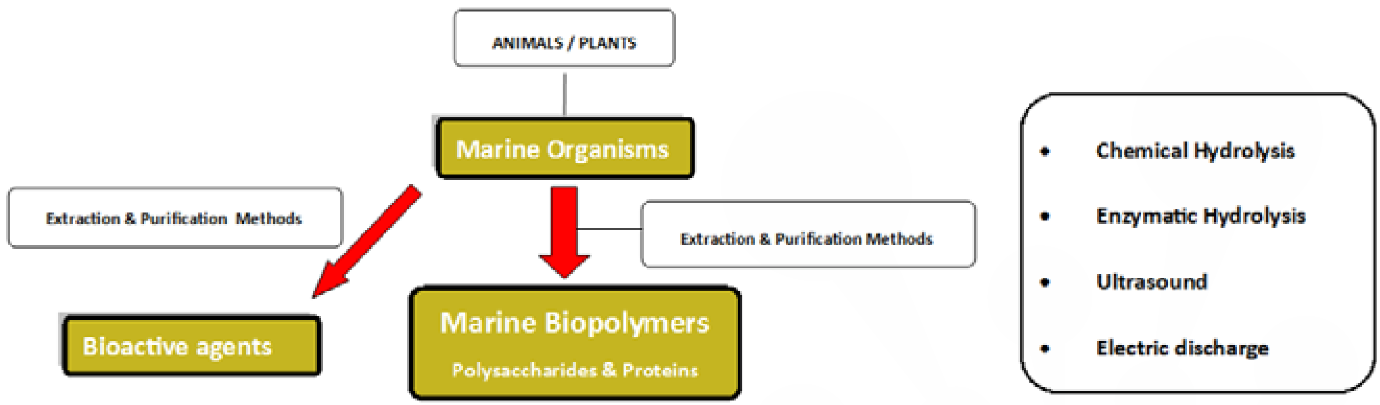

Figure 1 Valorisation of Marine Biomass

1.1 Case 1: Fish company

This company started as a national strategic research programme (spanning 2008-2015), which integrated Irish marine science and food science expertise and capabilities from 6 institutions throughout the island of Ireland to develop synergies for marine bioresources. The partnership provided the capability to establish and develop a coordinated approach for the exploitation of Irish marine resources to realise functional food and health by-product applications.
In 2017, the company became a 100% Irish owned and operated blue biotechnology company, located on the south-west coast of Ireland's NPA region. A leader in the blue revolution, it focuses on harnessing and extracting a range of highly bioactive ingredients from a variety of seaweed species to develop next generation phytochemical formulations.
Their flagship product is PureCoidan™, a high-purity, organically certified fucoidan powder for use as an ingredient in food, cosmetics and supplement products with benefits to immunomodulation, anti-oxidant, anti-microbial and anti-cancer effects. Their Alga-fibre product has anti-inflammatory properties and benefits for gut and digestive health.

1.2 Case 2: Fish company

The company are in the North-West region of Irelands NPA and have grown over a twenty-year period to become one of Irelands biggest exporters of the Crassostrea Gigas (Pacific Oyster) species. Oyster production in their region accounts for 16M to the local Donegal economy, €11M in terms of GVA and approximately 249 regional jobs created either directly or indirectly.
In Ireland, the Dept of Agriculture, Food and Marine policy states that the shellfish sector "must be responsive and adaptable to consumer demands and sustainable opportunities" (see also Figure 21). They report an additional €40M outcome from simple value-added activities (of which 80% has export potential) because it is an already established natural resource base activity, has very small associated import costs placing it "on the positive side of the trade balance. The company is seeking to implement a Circular and Bioeconomy strategy for the CaCo3 (Calcium Carbonate) rich Oyster shell waste which has not yet been exploited by the industry. Nationally, Oyster Shell waste accumulations report average stock mortalities of 20-30% per annuum. A more fundamental challenge exists with the threat to the biological security of the sector resulting from pathogens (eg. Ostreid Herpes virus-1 (OsHV-1) which can occur in 3-5 yearly cycles leading to mass stock mortalities of between 60-80% mortalities resulting in a significant waste issue for the industry. Legislation safeguarding the sustainable disposal of waste accumulations in accordance
with EU landfill directives has placed pressure, cost & onus on the industry to reduce organic waste volumes sent to landfill.
Currently, the vast majority of the world's calcium carbonate (CaCo3) comes from ecologically harmful and unsustainable limestone mining.
The CaCo3 composition of crushed oyster shell is approximately 96%. Reusing shell waste is a perfect example of a circular economy, particularly as shells are a valuable biomaterial that can improve the sustainability of the aquaculture industry moving forward. An opportunity exists for secondary economic benefits to be realised by the company through the establishment of an ancillary waste shell processing facility to develop multiple opportunities comprising low risk/low return (e.g. chicken feed, fertiliser products, landscaping) Medium risk / medium return (e.g. use as an absorbent for volatile organic compounds (VOC's) and sustainable bio-filtration products). High risk/high return (e.g. 'Functional Food & natural health supplements) products.

2 Future opportunities for waste handling

The majority of fish and shellfish processing operations in Ireland are carried out in shore-based processing facilities. The amount of waste produced during processing varies according to the species, type of raw material supplied, and the type of product being produced.

The component parts of demersal fish produce are broken down into specific ratios with edible product yields of 50% accomplished. The remaining 50% is discarded as waste material in the form of heads, viscera, frames, lugs, flaps and skin. Waste products from shellfish processing include shell and viscera with the shell ratios typically comprising 70-80% of full product weight.

Future fish waste potentials exist in the development of valuable oils, minerals, enzymes, pigments and flavours that have many alternatives uses in food, pharmaceutical, agricultural and industrial applications. In addition to fishmeal and oil production, there is potential in silage production, fertiliser, composting, fish protein hydrolysate and fish protein concentrate. Non-nutritional uses include chitin and chitosan, carotenoid pigments, enzyme extraction, leather, glue, pharmaceuticals, cosmetics, fine chemicals, collagen, gelatin and pearl essence.

Figure 2 Possibilities of the fishing industry by-products

3 Barriers/challenges for efficient waste handling

- Licensing: Transition through to added value chains within the seafood sector is happening gradually as the industry in its current state is quite focused on primary raw materials and products that require minimal processing. Future potential for the sector lies in higher value-added products such as functional ingredients and foods but is continually hampered by licensing and governance issues as well as a perceived lack of cooperation within the sector. This has caused a loss of confidence in the sector amongst financial lending institutions which in turn has starved the industry of investment. Delays of up to seven years in sourcing licenses are not uncommon and involve stringent and expensive environmental risk assessments which take time and money for companies to administrate.

- Regulation: The use of fish by–product material for human consumption, is subject to extensive food safety legislation, as are all fishery products for human consumption. Governed by strict EU regulations, seafood by-products are considered collectively with those from other animal sources. By-products are required to be treated according to risk and to a range of prescribed methods, from rendering and incineration to composting and anaerobic digestion. A Feasibility Report on the 'Use of Anaerobic Digestion within the Irish Seafood Processing Industry'. reports that the uptake of anaerobic digestion in Ireland is a treatment option with great growth potential but is encumbered by regulatory and financial hurdles preventing industry uptake.

- Capacity building: Technological bottlenecks exist particularly for micro-enterprise to realise new products from their waste streams. The justification for expenditure on technical solutions to overcome identified technological barriers is influenced by potential revenue outcomes anticipated-V's -waste volumes experienced-V's -anticipated specialist equipment installation and running costs. This can be problematic if by-products identified turn out to be of low volume / low value. For example: In the case of waste biomass (seaweed) a compromise between drying speed, efficiency and nutrient degradation needs to be reached. Technological solutions and post processing techniques adopted may need to be compatible with specific by-product value chains involving ie. food grade and feedstock sodium alginates, plant nutrition, pigments / fine chemicals and fermentation products. This may call for expensive direct (combustion) and indirect (heat exchanger) heating / drying techniques that use purpose built and/or modified chambers that need to work simultaneously with existing in-house processing operations, all of which can place a financial strain on existing operating costs and overheads for particularly micro sized SME's.

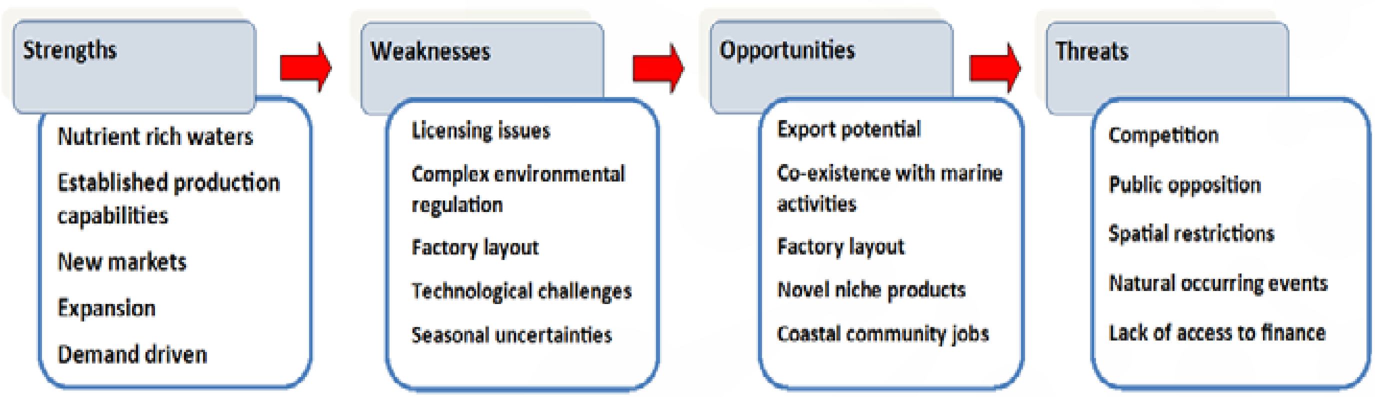

Figure 3 SWOT Analysis review for industrial symbiosis uptake within the fishing & Aquaculture sector

Acknowledgements

This report is produced with part funding of the European Union (EU) Northern Periphery and Artic (NPA) Programme under the programme priority Axis 1- Innovation.
This is in the report for the WP 1 deliverable T 1.1.1 of the SYMBIOMA project (Technology Innovations and Business Models for Valorisation of Industrial Waste Biomass in Sparsely Located Enterprises. Case: Industrial Symbiosis for Valorisation of Waste Biomass from Food and Beverage Industries) (Project No. 352)

The project partners:

Lead partner

Centria University of Applied Sciences, Finland (CENTRIA)

Other partners

Institute of Technology Sligo, Ireland (ITSligo)

Norwegian Institute of Bioeconomy Research, Norway (NIBIO)

Bottenvikens Bryggeri Ab, Sweden (Bottenvikens)

Luleå University of Technology, Sweden (LUT)

Hermanni Winery Ltd, Finland (Hermanni)