

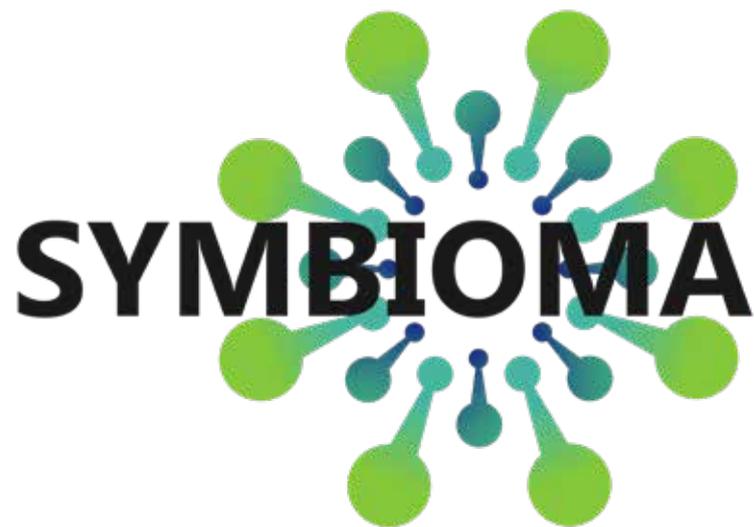


Northern Periphery and
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European Regional Development Fund



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

A photograph showing several fish, likely salmon, lying on a grey concrete surface. The fish are arranged in a row, with their heads pointing towards the left. The background is a dark, textured surface, possibly a wall or a different part of the concrete.

Circular economy cases and their business models in Finnish fish industry

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1 Fish industry in Finland

Fish catch in Finland annually is about 135 million kgs from marine fishing and 5,2 million kgs from inland fishing (Statistics database)¹. In Finnish marine waters, Baltic herring is the most important catch, in terms of both volume and sales value. The most important species of catch in commercial inland water fishing is vendace, which is caught in open water through trawling and in the winter with seines. While marine fishing is declining, inland fishing is growing. Marine fishing of salmon is being replaced by fish farms of various types, located in both marine and inland water areas, and in recirculated aquaculture facilities, in which the water used in the farming is recycled and cleaned.

Fish catch is mainly used for food (sold as whole, filets, preservatives or other edible forms), feed (mostly for fish farms and for fur farms) and production of fish oil.

Finnish enterprises processed 79 million kgs of fish for food in 2017, where 51 million kgs were of a domestic origin and 28 million kgs were imported. Most of imported fish is salmon from Norway (81% of total salmon processes and sold). A total of 21 million kgs mostly of herring and sprat were frozen as a whole fish and exported. Also, 38 million kgs of domestic and imported fish was processed into fillets and other fresh products. The rest is used for highly processed products, such as smoked or salted fish, canned fish products, ready cooked foods, etc.

In particular, Baltic herring and sprat are produced into fish meal. At the moment there is only one facility in South Finland (Kasnäs) producing fish meal and fish oil. Annually 30–40 million kgs of fish are processed. The fishmeal plant using fish caught in the Baltic Sea employs several circular economy practices.

Fish farming becomes load-neutral, as fish are fed with fish fodder made from fish in the same sea. Nutrients are thereby no longer added to the Baltic Sea, but the sea's nutrients are recycled. During the production of fishmeal and fish oil, foreign matter is removed. The fish is dried and boiled, oils are separated from the liquids, and

¹ Statistics database, <http://statdb.luke.fi/PXWeb/pxweb/fi/LUKE/?rxid=001bc7da-70f4-47c4-a6c2-c9100d8b50db>

dioxins and polychlorinated biphenyl (PCB) are removed from the resulting products (Prokala, 2018)².

In 2017 there were 143 fish processing enterprises in Finland, of which 23 processed more than half a million kgs. These accounted for 93% of the total volume of processed fish. Fish side streams/waste is generated along all the supply chain of fish from fishing to consumer. In this report we focus on waste and side streams which are generated in fishing harbours, where fish is initially pre-treated, fish farms and in fish processing plants.

1.1 Fish farming, NPA area

There were 151 fish farms in Finland in 2018, 54 fish food farms in NPA region and they produced 2,6 million kgs of food fish, mostly rainbow trout (Figure 2) (Fish Farming, 2017)³. It is estimated that numbers of aquaculture facilities will increase in a near future, which will also increase need for fish food.

² Prokala report: Finlands Fisheries Industry, 2018 <https://www.prokala.fi/wp-content/uploads/2018/04/Vedest%c3%a4-ruo-kap%c3%b6yt%c3%a4%c3%a4n-2018-engl.-keyytversio-FINAL.pdf>

³ Fish Farming in Finland, 2017 https://www.kalankasvatus.fi/wp-content/uploads/2017/08/Fish_farming.pdf

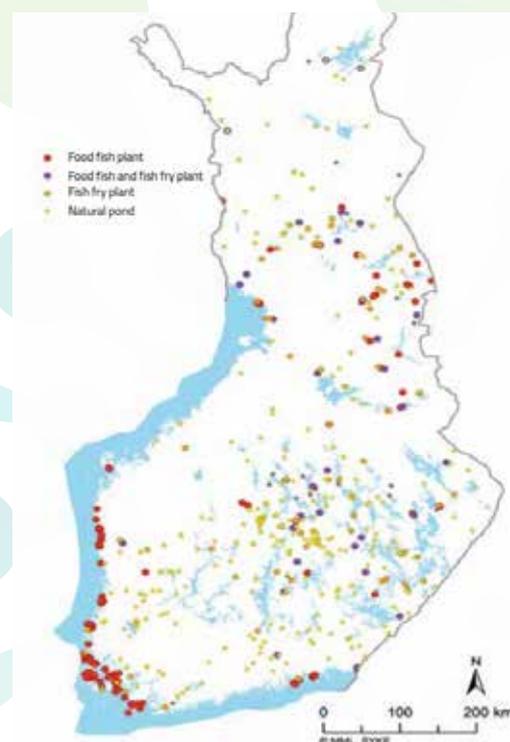


Figure 2 Aquaculture facilities in Finland

1.2 Case 1: Farm in sea water

(Lupapäätös, 2017)¹

Annual production of fish is 1 million kg. Feed consumed by fish is 1,1 million kg.

Fish before transporting to processing plant is cleaned onsite. For cleaning 1 000 m³ of sea water and 1 500 m³ of clean drinking water is used. Fat is separated from the wastewater before discharging to municipal sewage. Slurry (some 14 m³) is collected into tanks, formic acid is added for preservation and full tanks are delivered to biogas plant. Fish cleaning process generates about 15% solid waste (viscera mostly), i.e. 150 000 kg annually.

Some 3000-6000 kgs of fish are dying and are not suitable for food. At the moment it is transported for biogas production. The most of fish is sold to fish processor, who is taking whole fish.

1.3 Case 2: Fish processor 1.

This fish processor is one of the biggest in NPA area of Finland, turnover is about 110 million euros and company employees almost 200 people. The company converts 18 million kgs of fish into various fillet products. Salmon, whitefish are the main raw stock, also others in smaller amounts are processed.

Some 6 million kgs (33%) are by products which are not sold as a premium product. Fishing harbours very often have equipment for gutting big fish and therefore the company buys ready cleaned fish. The company has however also invested in small fish gutting machinery and can deal with supplied fish which is not cleaned.

Filleting waste is shared into various streams. Fish heads are frozen and sold to Asia, cut-offs suitable for food is separated from the stream and used in production of ready foods, and the rest is delivered to produce feed for fur animals. Company tried to remove oil from this waste, but it was not economically feasible, oil yield remained a couple of per cent of the expected 20.

¹ Lupapäätös Nro 32/2017/1 Dnro PSAVI/1977/2016 Annettu julkipanon jälkeen 10.5.2017. Extracted from https://tietopalvelu.ahtp.fi/Lupa/Lisatiedot.aspx?Asia_ID=1315590

1.4 Case 3: Fish processor 2

Company's raw stock is mostly small fish like vendace from inland fishermen. 400 000 kg of fish. Company's turnover in 2019 was some 1,7 million euros. Raw stock fish is gutted in company and waste is taken by animal feed producer (production plant situated some 25 km away) and processed into feed for fur animals.

1.5 Fish harbours in NPA (Botnia Bay) area (marine fishing)

Marine fish processing in Botnia Bay covers an area from Kokkola to Tornio (area 31 in Figure 3) and has some 40 fishing harbours (Nouseva Rannikoseutu, 2017)¹. 17 of these have covered halls and is suitable for some type of initial processing. 12 of fish halls comply with Food Hygiene Act. Most of harbours are owned by municipalities and municipalities are responsible for maintenance, including waste handling. The catch in Bothnia bay in 2018 was 3,2 million kg (2,4 % of all Finnish marine fishing catch), 1.68% of all catch is sold to wholesales, with the rest sold directly to consumers or to grocery shops. About 30 % of catch is sold without any pretreatment, 0,5% is cleaned and fileted, the rest is being cleaned by removing viscera. The adjoining region, the Botnian Sea (seen as area 30 in Figure 3), has an estimated catch of 76 million kg and it is almost half of all Finnish marine fishing.

1.6 Case 4: Trullevi fish harbour in Kokkola

The harbour is owned and managed by the City of Kokkola. City is responsible also for waste management. Harbour has hall and fish cleaning equipment, hall complies with Food Hygiene Act and therefore almost all fish is cleaned (removed viscera) and washed. About 50% of cleaned fish is sold to retailer and the rest is sold in local supermarkets.

Waste is collected and kept in freezer before it is transported as biowaste. Biowaste from Kokkola region is produced to biogas and compost.

In Pietarsaari (about 35 km) there are few companies manufacturing feed for animals, also new fish farm in the see is planned. It is possible waste would be transported for feed production.

Kokkola city is responsible for waste management also in 4 more fishing harbours (all within

¹ Nouseva rannikoseutu ry, Perämeren rannikon kalasatamat nykytila - kehittämistarpeet, 2017. https://merijakalatalous.fi/wp-content/documents/Nouseva_rannikoseutu_ry_-

30 km distance).



Figure 3 Sea fishing areas in western Finland

1.7 Inland fishing, NPA

Inland commercial fishing in NPA region is 4,2million kg (80% of all Finnish inland commercial fishing) (calculated from Statistics database). Most of it is in South-Eastern part of Finland. If marine fishing catch for food was more big size fish, such as salmon and whitefish, inland fishing catch is mostly composed of small sized fish, vendace in particular. Marine fishing harbours are often equipped with big fish cleaning equipment, when inland harbours often lack any equipment. Processing industry often purchases from fisherman not cleaned fish, which means that there is more waste than in case of marine fish processing industry.

Majority of common utilisation of by products is for feed, especially for fur animals. Growing fur animals in Finland is however reducing, and it is expected it will be forbidden as has happened with most other European countries. The fish industry therefore needs to find new outlets to be able to utilise by products cost efficiently.

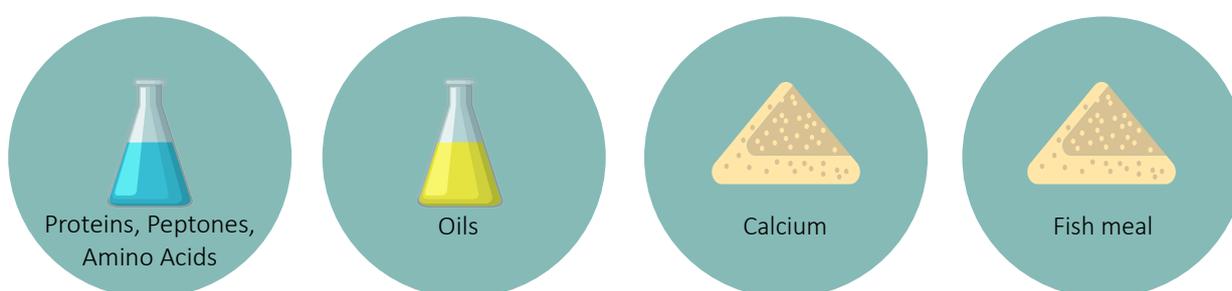
2 Future opportunities for waste handling

- Production of fish oil for human consumption (Hiidenhovi, 2017)
- Production of fish oil for diesel
- Production of fish oil for cosmetics industry
- Feed for animals or fish instead of biogas (it is higher in waste hierarchy)
- Fish proteins for human diets

FISH BY-PRODUCT POSSIBILITIES



Example of valuables from waste:



...that can be used e.g. in:



Figure 4 Possibilities of the fishing industry by-products

3 Bottlenecks/challenges for efficient waste handling

- Fish processing waste has clear use and it is even imported (e.g. cut-off from fillets) or as ready products, e.g. fishmeal for fur animals and artificial fish aqua culturing (Kalamarkkinakatsaus,2017). Waste handling at the moment does not seem to be an issue, however higher value products would be useful. This set though pressure on feed producers, if fish waste is not available it should be replaced with other sources.
- As most valuable products would be fish oil for human consumption. Fish oil production for human consumption requires fresh raw materials. It is possible to achieve if the processing plant is big and waste stream is continuous. In case of small-scale processing, waste needs to be preserved, e.g. by fast freezing.
- Technically, fish oil could be converted to biodiesel. Several reports though indicate that economically this it is less feasible.
- Biogas production from fish waste also seems to be not that economically attractive

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